Village of Lincolnwood
Introduction to Stormwater Report

The attached report is a detailed engineering study of a complex issue: sewer capacity. Lincolnwood has a history of sewers backing up (or surcharging) into the basements of homes because of a lack of capacity in the sewers to carry rainwater away. After many years of debate trying to quantify the extent of our sewer problem, or to determine if we even have a sewer problem, the Village decided to hire an expert; AB&H a Donahue Group, to complete a detailed model of our sewer system using the latest technology available which would allow the Village to have reliable and accurate information on the strengths/weaknesses of our sewer system.

The study was designed as a three phase process: The first phase was intended as a pass/fail analysis. After the model was complete, a series of simulated rain storms would be run through the model to determine if our sewers could handle the 10-year rain event (i.e. a storm of such severity that it has the statistical chance of occurring once every 10 years) before surcharging into homes. If Phase I resulted in failure, Phase II was intended to identify those system improvements (and estimated costs) that would be necessary to bring the sewer system up to the 10-year level of protection. Phase III would be to actually design and construct the identified system improvements.

It must be remembered that the results listed in the report are based on a model, and may not reflect a 100% accurate depiction of reality. Models, by definition, are a best estimate using all available data, to predict what will happen in real life. So, while we are confident that the model represents the most accurate prediction available of the performance of our storm sewer system, the results are always open to debate and interpretation.

For questions regarding the contents of the report you may contact Ashley Engelmann, Assistant to the Public Works Director at 847-675-0888. To review the report in its entirety **click here**.

Village of Lincolnwood, IL

6900 N Lincoln Ave, Lincolnwood, IL 60712

FINAL DRAFT – Phase II Sewer Modeling

Village of Lincolnwood, IL

November 2, 2012

Prepared by:

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DRAFT – Phase II Sewer Modeling
Village of Lincolnwood, IL

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EXECUTIVE SUMMMARY

Phase I (Phase I and Phase I-B collectively) of this study concluded that the Village's collection system does not have adequate capacity to provide the 10-year level of protection and that under existing conditions 84% of basements are at risk for backup during a storm of this magnitude. Phase II demonstrates that a 10-yeasr level of protection can be attained by a limited (as opposed to complete sewer separation) stormwater collection and detention system.

This study is intended as a planning level document to assist in preparing a Capital Improvement Plan (CIP). More detailed engineering is required to prepare plans and specifications before beginning construction. Therefore, to achieve the Village's desired 10-year level of protection, AB&H recommends that the Village proceed with Phase III of its Stormwater Management Program.

For this phase of the project (Phase II), AB&H enhanced and expanded the collection system model to include every pipe, manhole, catch basin, and inlet. The expansion also added the ability to simulate basement flooding, surface flows, and surface ponding. With this improved evaluation tool, AB&H was able to evaluate the level of basement flood protection provided by storing stormwater on streets, and/or conventional drainage improvement projects.

Two alternatives were evaluated for their effectiveness in reducing basement flooding. The first alternative determined the reduction in basement flooding that could be achieved by ponding stormwater on streets only. This technique attenuates, or spreads out, flows, thereby reducing peak flows and overloading of the collection system and the risk of basement backups. The total cost to implement this approach is approximately $5,592,060. It must be emphasized that this method of stormwater management builds upon the principles of the current stormwater management system. The principle of utilizing the street for storage during a stormwater event will continue to be employed. This study utilizes a more robust engineering analysis to improve its effectiveness. The modifications recommended herein reduce the likelihood and severity of basement backups while better utilizing available street storage and reducing the frequency and severity of surface flooding.

Street storage, while unconventional, is not without precedent. It has been employed with great success in the neighboring communities of Skokie and Wilmette. Chicago has implemented a similar program called "Rain Blocker". Cleveland, OH and Parma, OH are other examples of communities that use street storage to reduce basement backups. Most residents in these neighborhoods would agree that seeing water in the street is preferable to seeing it in their basements.While the number of homes at risk during a 10-year storm was greatly reduced under the street storage alternative, it did not meet the desired objective of providing the 10-year level of protection for all of Lincolnwood. The second alternative identified the infrastructure improvements that are required to provide the desired level of protection for the entire village.

While storing stormwater on streets is not typical and might be perceived as an inconvenience, the total cost of $5,592,060), is a cost-effective means of reducing basement flooding. However gaining public support of such a program will require an ambitious public education and outreach effort.

Street storage will provide protection to 73% of the properties within the Village during a 10-year storm. The estimated cost to do this is $5,592,060. It is important to not however that <u>all</u> homeowners will benefit from street storage because it reduces the burden on the combined system that all residents rely upon. While 27% of the Village would remain at risk during a 10-year storm, the risk of flooding in these areas for storms less than the 10-year event will be reduced and the severity of flooding for <u>all</u> events will also be reduced.

Providing the 10-year level-of-protection for the remaining 27% of the Village will require investing in stormwater conveyance and detention projects. The additional cost to protect these remaining areas is approximately $28,039,156.

CHAPTER I – INTRODUCTION

1.1 GLOSSARY

At-risk: There is a possibility of flooding during storms exceeding a particular magnitude.

Berms: A gently sloping section of asphalt or concrete intended to contain or direct stormwater on a street.

Catch Basin: A storm inlet/drain containing a sump to trap debris before it enters the sewer system.

Combined Sewer System: A type of sewer system that collects sanitary sewage and stormwater runoff in a single pipe system.

Detention System: Temporary storage system for stormwater intended to detain storm runoff and release it back into the combined sewer system at a controlled rate.

Flood Protection: Any of several methods of preventing combined sewage from backing up into homes. Examples include: standpipes, overhead plumbing, and check valves.

Inlet: Similar to a catch basin, but lacking a sump.

Inlet Restrictor: A mechanism used to control the flow of stormwater into a combined sewer pipe in order to reduce overload on the combined sewer pipe.

In-line Storage: Storage/conveyance of sewage within a buried pipe.

Level-of-Protection: Similar to level-of-service, it is the frequency or likelihood that the collection system serving a property is unable to do so, with a backup likely to occur.

10-Year Storm: A rainfall event with a 10% statistical probability of occurring in any given year.

Street Storage or Surface Ponding: A method of reducing basement backups by utilizing the street to briefly store stormwater and release it into the combined sewer system at a rate that does not exceed sewer capacity.

Time of Concentration: The time needed for water to flow from the most remote point in a watershed to the watershed outlet.

1.2 STORMWATER MANAGEMENT HISTORY

1.2.1 COLLECTION SYSTEM

The Village of Lincolnwood is served by a combined sewer system. During dry weather this system conveys sanitary sewage to the Metropolitan Water Reclamation District of Greater Chicago's (MWRD) interceptor near McCormick Blvd. MWRD conveys the sewage to its North Side Water Reclamation Plant on Howard St for treatment before discharging it to the North Shore Channel. Figure 1 depicts graphically how wastewater is collected and treated from both combined and separated systems.

During rainfall events, storm runoff drains into the combined sewer system. The mixture of sewage and runoff is conveyed to the MWRD. For small rainfall events, all the flow is treated. For modest events, flow in excess of the MWRD's treatment capacity is diverted into the TARP (Deep Tunnel) for storage and later treatment (Figure 2). Large storms (Figure 3) may result in combined sewage discharging directly into area waterways and backing up into the lowest point of the system i.e.basements.

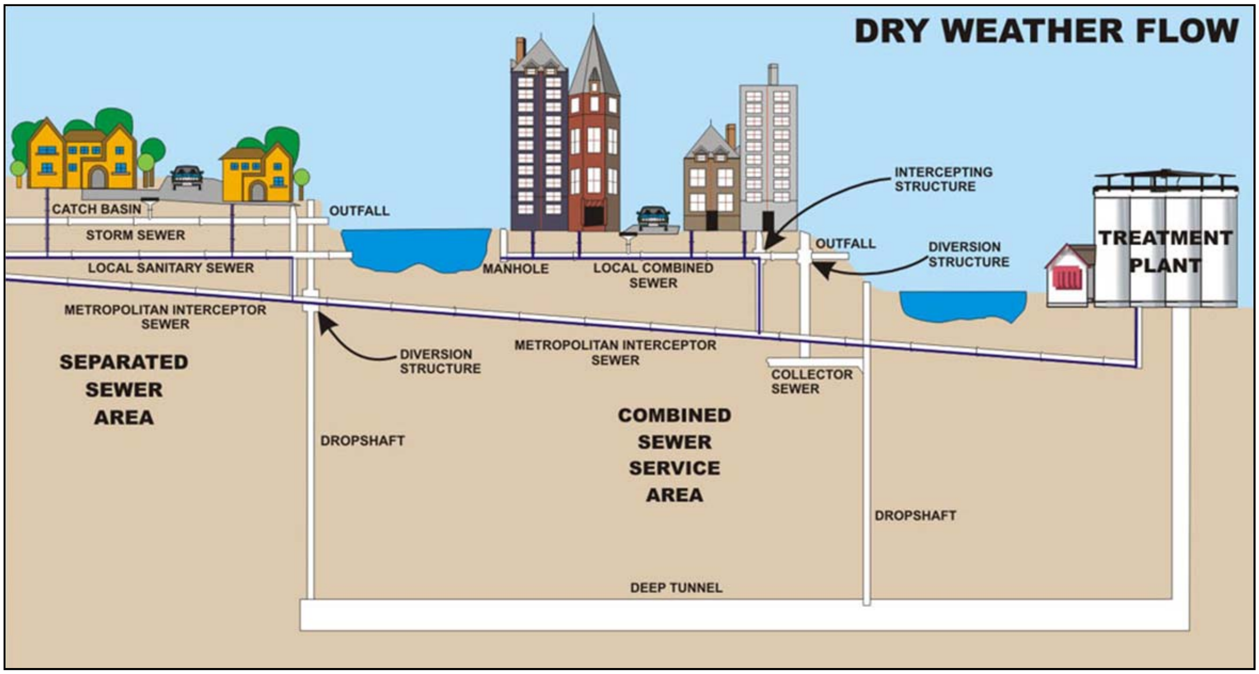

Figure 1 – Collection System Operation (Dry Weather) (MMSD, 2012)

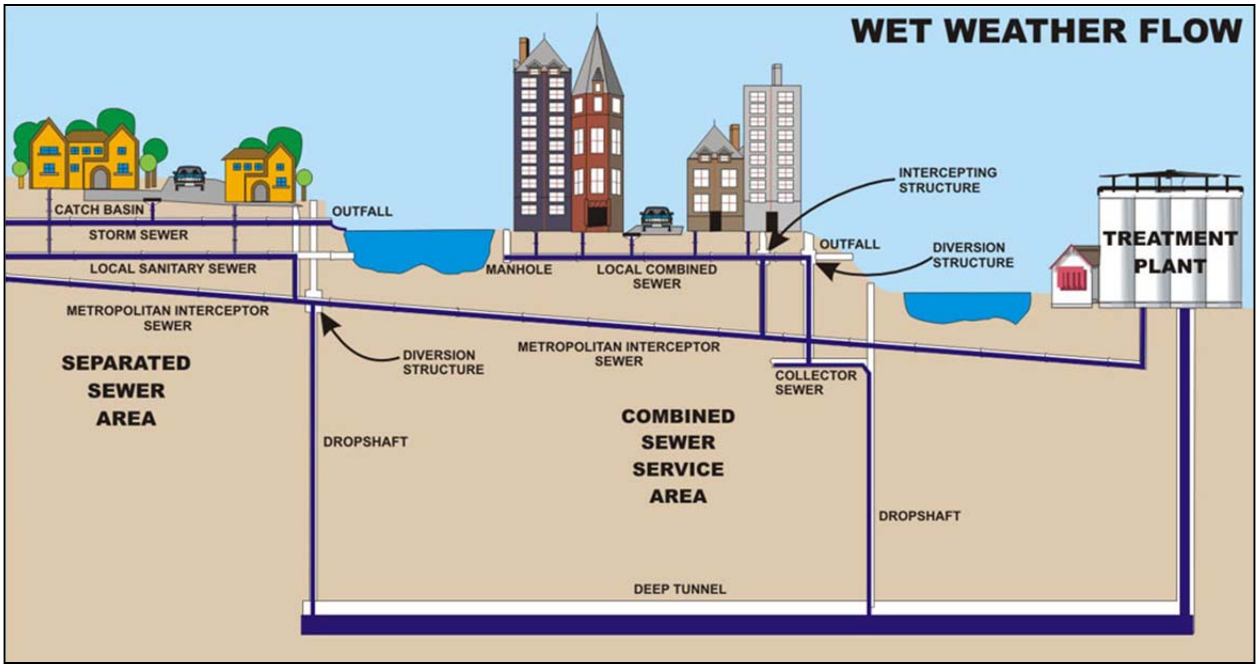

Figure 2 – Collection System Operation (Wet Weather)

The construction of new combined sewers is prohibited. However, combined sewers continue to operate as the expense of replacing them with separate systems wouldpose a significant financial burden on the community.

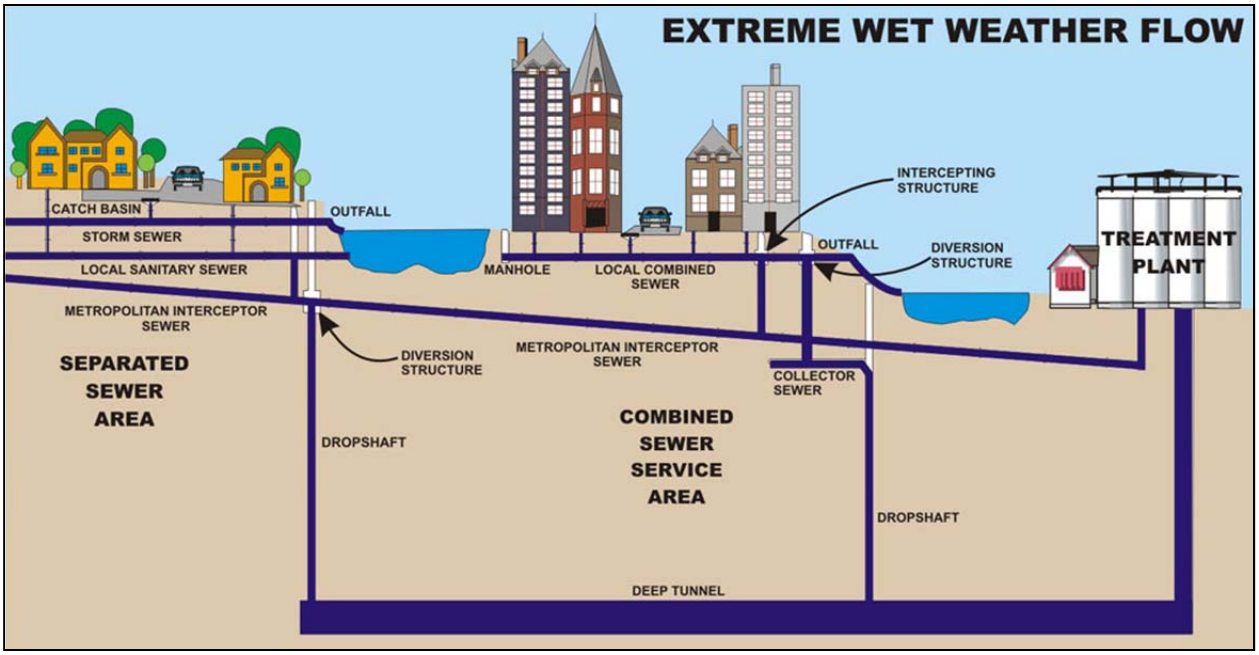

Figure 3 – Collection System Operation (Extreme Wet Weather)

All sewers have a limited conveyance capacity and carry the risk that a storm could occur that produces flows surpassing system capacity. When this capacity is exceeded, sewers can "surcharge", with water backing up into manholes and pressurizing the system. In particularly large events, those likely to occur only once every 2-3 years, Lincolnwood's sewers can surcharge to the point that combined sewage begins to back up into basements.

1.2.2 S TORMWATER HISTORY

The Village of Lincolnwood has a history of significant storms dating back to 1956 which have caused flooding problems throughout the Village. In 1986, in response to flooding issues the Village initiated an inlet restrictor program to control the rate that stormwater runoff enters the combined sewer system. These restrictors initially consisted of concrete "blocks" placed in catch basin outlet pipes. These restrictors proved to be a maintenance problem because the reduced outlet opening size was prone to clogging. Therefore, the concrete restrictors were removed and the Village began replacing them with steel restrictor plates that cover inlet and catch basin openings, thereby significantly reducing their opening areas. The Village has 2,994 inlets and catch basins, of which 1,350 (45%) are restricted.

In 1977 the Village created an Ordinance that requires all downspouts, rainwater leaders, cisterns and overflows to be disconnected from the Village's combined sewer system. This Ordinance was created to reduce the impact on the Village's sewer system and to encourage the runoff to enter pervious land.

On August 2, 2001 a 25-year rain event occurred which caused Village wide flooding and prompted the Village to survey all residents regarding the type of flood control devices that they may or may not have installed in their homes. In addition, at that time the Village Engineer estimated that the Village's system had the capacity to handle a 2-3 year rain event or 1.7 inches of stormwater in a 2hour period.

In 2004, the Village adopted a Stormwater Management Ordinance that requires new developments to control water on-site. The Ordinance includes bulk regulations that limit the size of structures and the amount of impervious surface on a lot.

The Village also received a grant in which 164 homeowners were provided grant funding to install flood control devices within their homes.The Village also constructed a new road in the Business Park (Northeast Parkway) which removed a large portion of the businesses from the combined sewer system. Throughout 2007 Village staff and the Village Board discussed the possibility of undertaking a comprehensive Stormwater Management Plan (SMP). Village staff recommended that the Board support the goal of developing a SMP that would result in the Village's storm sewers being capable of handling a 10-year rainfall event without discharging into homes, and that this protection would be achieved within 10 years.

There are no required standards that dictate an appropriate "level-of-protection" (LOP) for combined sewers. Most of the sewers in Lincolnwood were constructed during a population boom in the 1950's and predate current standards. Therefore the appropriate LOP is discretionary, and communities served by combined sewers may select an LOP that they feel is appropriate and/or affordable. The Village Board has selected the 10-year LOP, which is consistent with communities in the Chicagoland area and is generally considered a reasonable goal.

In 2010 the Village created a sewer user fee to aid in paying for maintenance of the Village's combined sewer system as well as to make improvements to the Village's stormwater management system.

1.3 Stormwater Modeling Project Strategy

On August 21, 2007, the Village Board directed Village staff to move forward with a SMP, with the first step being to secure the services of Mr. Robert Carr, of Water Resource Modeling, LLC (WRM), to assist the Village with securing an engineering consultant to construct a stormwater model.

Subsequently, a Request for Qualifications (RFQ) was developed by Mr. Carr and Village Staff to identify firms to complete the project. The RFQ specified the following three project phases:

- **Phase I –** Preparation of an un-calibrated model to be run under various rain scenarios. Determination if combined sewer system can convey a 10-year storm without system backups.
- **Phase II –** Identify combined sewer system bottlenecks through model calibration. Identify improvements to bring the system to a 10-year capacity.
- **Phase III –** Design of improvements and oversight of implementation.

Five firms responded to the RFQ. Mr. Carr and Village staff narrowed the list to three and Village staff, along with Mr. Carr, interviewed the top three candidates. On May 7, 2008 the Ad-Hoc Sewer Committee made a recommendation to engage AB&H, A Donohue Group (AB&H) to complete the project. On June 5, 2008 the Village Board approved a recommendation by the Ad-Hoc Sewer Committee to adopt a Resolution to authorize the Village Manager to execute a contract with AB&H to complete Phase I of the stormwater study. On January 7, 2011, the Village authorized a contract amendment for AB&H to complete the second phase of this project.

1.3.1 Phase I

On March 5, 2009 at a Committee of the Whole meeting, a draft Phase I report presentation was made to the Board by AB&H and Mr. Carr per the recommendation of the Ad Hoc Sewer Committee made on February 23, 2009.

The draft Phase I report (AB&H, 2009) concluded that the Village's sewer system could not handle a 10-year rain event. This conclusion was based on the assumption that the Village's sewer system is currently in perfect working order and free from blockages or flow issues.

Using this model, it was estimated that 75% of the service area would likely experience basement backups during a 10-year storm. The Village's current strategy of stormwater management employs surface restrictors without containment. The Phase I model predicted that if this approach were fully implemented. , the percentage of the service area subjected to basement backups during a 10-year storm would be reduced to 605%.

1.3.2 Phase I-B

Per the original Stormwater Study specifications, if the system failed during Phase I, the study would move to Phase II. Phase II was intended to identify system bottlenecks as well as identify potential improvements to bring the sewer system to a 10-year capacity. The Village initially decided to complete the Phase I analysis with an un-calibrated model.

However, the Ad-Hoc Sewer Committee felt that to ensure that the model's results in Phase I were accurate and to formally accept the results of the Phase I report, calibration of the model was necessary. Fine-tuning model parameters in a manner that provides a better correlation between measured and simulated flows for actual rainfall events was then completed. This effort improved model accuracy and increased the confidence of model predictions. The committee recommended that the following items take place under Phase I-B before moving forward with Phase II:

- Revise the draft Phase I report to address the comments of the committee;
- Support the Village's decision to televise the Village's sewers;
- Seek a bid for flow monitoring;
- Purchase weather monitoring stations;
- Hold a meeting of the Ad-Hoc Sewer Committee to discuss public education and the basis of a failure analysis;
- Calibrate the model with data from sewer televising and flow monitoring; and
- Present an updated Phase I report to the Village Board.

Upon receiving the Ad Hoc Sewer Committee's recommendation at the March 5, 2009 Committee of the Whole meeting, the Board directed staff to move forward with a competitive bid process to obtain proposals for the projects associated with Phase I-B.

Phase I-B consisted of calibrating the Village's Phase I stormwater model utilizing measured rainfall, flow, and water levels to calibrate the model, and update subsequent system capacity analyses. Prior to completion of Phase I-B, the Village cleaned and televised the entire sewer system and collected three months' of flow monitoring and rainfall data.

The calibrated Phase I-B model predicted that during a 10-year storm, 84% of the service area would be at-risk for basement flooding under existing conditions. With all permitted restrictors in place, 79% of the service area would likely be atrisk for basement flooding (AB&H, 2010). Therefore, Lincolnwood decided to proceed with Phase II of this project.

1.3.3 Phases II & III

This report documents the execution of Phase II of this project. Phase III, detailed design, has yet to be initiated.

CHAPTER II – ALTERNATIVE ANALYSIS

The Village's stated objective is to provide a 10-year level of protection from basement flooding for all of Lincolnwood. Two alternatives were considered for their effectiveness in meeting this goal.

The objective of Alternative 1 was to determine the maximum level of protection that could be achieved by street storage as the sole means of stormwater management. While not fundamentally different from the Village's current strategy, it did include the following modifications to the manner in which it is implemented:

- Replace surface restrictors with submerged restrictors
- Construct "berms" to contain stormwater to those streets conducive to doing so
- Meet the surface ponding criteria specified in Section 2.4.1.2

If Alternative 1 is unable to provide the 10-year level of protection for all of Lincolnwood, Alternative 2 is intended to identify additional infrastructure improvements that will meet the Village's stated goal of no basement flooding during the 10-year storm.

Before alternative analysis could begin, the model was updated, and the current level of protection reassessed.

2.1 ASSUMPTIONS & LIMITATIONS

- The model is sufficiently detailed for planning level analyses and preliminary design. Therefore while the model makes predictions regarding which areas are atrisk for particular events, these predictions are imprecise and are intended only for developing broad system modifications.
- All rain falls uniformly over the service area.
- All pipes are clean and in good condition (are able to convey their design capacities).
- All homes have basement floors 6 feet below street grade with the exception of;
- Homes adjacent to shallow sewers have half basements 3 feet below street grade.
- Basement footprints are equal to building footprints.
- No homes have basement flood protection.
- The MWRD interceptor is not surcharged into Lincolnwood's sewers.
- The SCS Type II 24-hour rainfall distribution was used for all design storms.
- All restrictors will be of the hanging trap variety or a type with similar hydraulic characteristics.
- All hanging trip orifices had a 2-inch diameter.
- All of the proposed inlet restrictors were presumed to be flowing freely.
- Average home price in the Towers neighborhood of $700,000 per home.
- Capital cost estimates do not include land acquisition.
- Subcatchments were presumed to be homogeneous.
- All homes were presumed to discharge their downspouts onto their lawns.

2.2 PHASE II MODEL UPDATE SUMMARY

The model developed for the Phase I analysis was overhauled to enable it to perform the detailed analysis required for Phase II. Overhaul steps included:

1. Increase sewer network detail – The model developed for Phase I only included larger diameter sewers, generally those 18 inches and larger. For Phase II, the model was updated to include every pipe and manhole.
2. Inlets & catch basins – Every inlet and catch basin is represented in the Phase II hydraulic model.
3. Basement "flooding" – When sewage backs up into basements, it impacts the hydraulics of the system. The model was enhanced to simulate this phenomenon.
4. Hydrologic model – Using rainfall as input, the hydrologic model predicts storm runoff entering the hydraulic model of the sewer network. The detail of the hydrologic model was increased to match the increased detail of the hydraulic model.
5. 2-Dimensional Surface Model – To accurately simulate flow and storage in the streets, a two-dimensional representation of Lincolnwood's topography was added to the model. This enabled engineers to predict both overland and sewer flows and the interaction thereof in a single dynamic model.

2.3 10-YEAR EXISTING CONDITIONS (NO CHANGES TO CURRENT SYSTEM)

Figure 4 indicates those areas that were found to be at risk for basement backups during a 10-year storm using the Phase I model (Phase I & I-B collectively). This analysis estimated that 84% of Lincolnwood, approximately 3,800 homes would be at risk for flooding during the 10-year event. Using the more detailed Phase II model, we can now say that 67% of the homes in Lincolnwood would be at risk during a 10-year rain event (Figure 5) with the existing system configuration.

There are several reasons for the reduction from 84% to 67%. The Phase I (Phase I & IB collectively) model was developed as a skeletal model (larger sewers only), and was primarily intended to determine whether or not the system is able to provide the 10-year level of protection. The collective results of Phase I and Phase I-B concluded that 84% of the system could not handle a 10 year rain event. However the Phase I model did not include every pipe and manhole, and it did not replicate the effect basement flooding has on system hydraulics. As such, in order to obtain a precise evaluation of the number of homes at risk, Phase II was necessary, and provides a more accurate estimate of the number of homes at risk.

The Phase II model provides a high level of precision regarding the number of homes at risk for flooding due to the fact that it includes every pipe and manhole as well as simulates the effect of basement flooding on the system hydraulics. However, there are still limitations (Section 5.1.5), and it is beyond the scope of this model to give a precise value as to the number of homes that would actually flood during a given rainfall event.

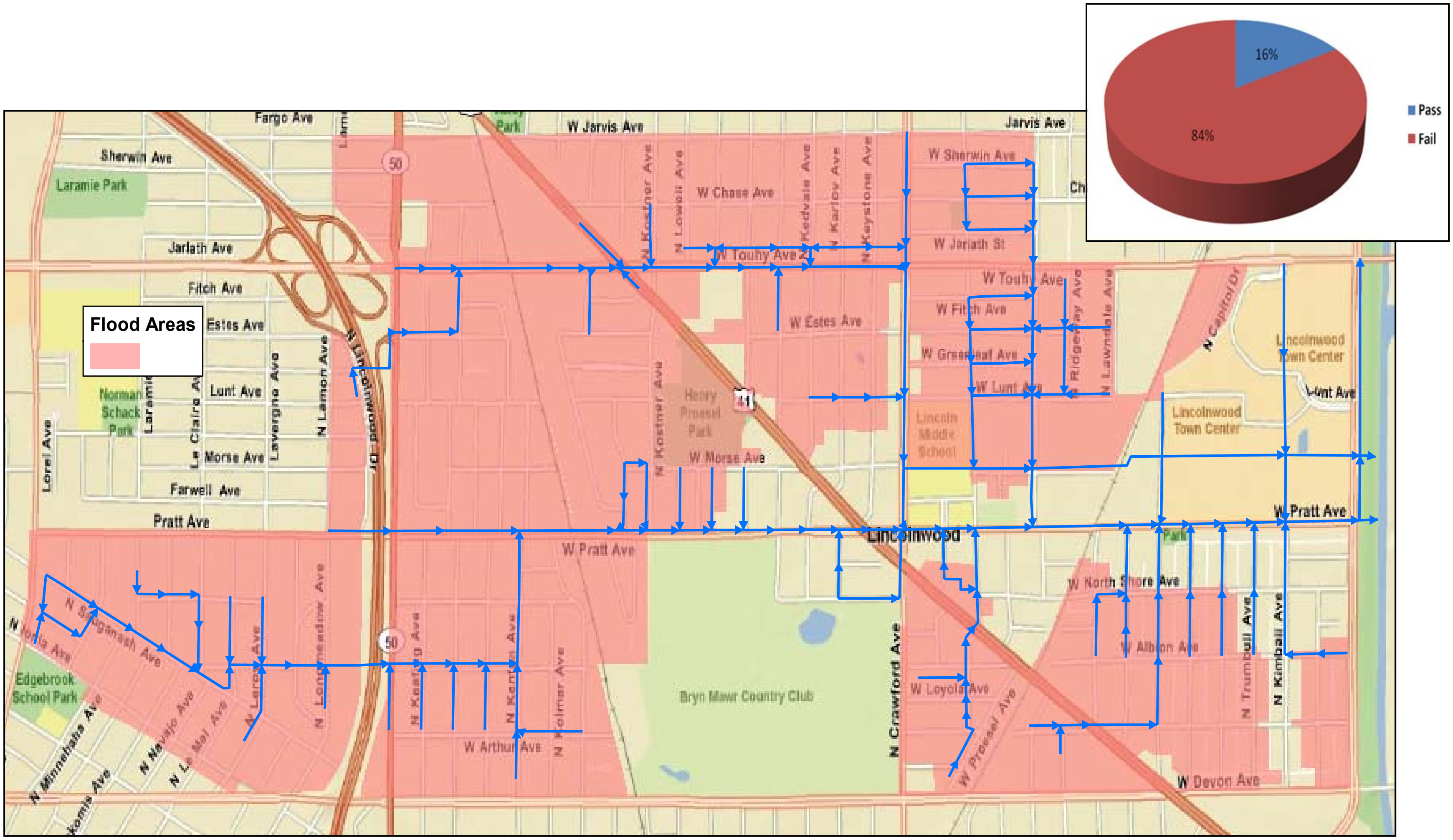

Figure 4 – Extent of Flooding, 10-Year Existing Condition, Phase I Model

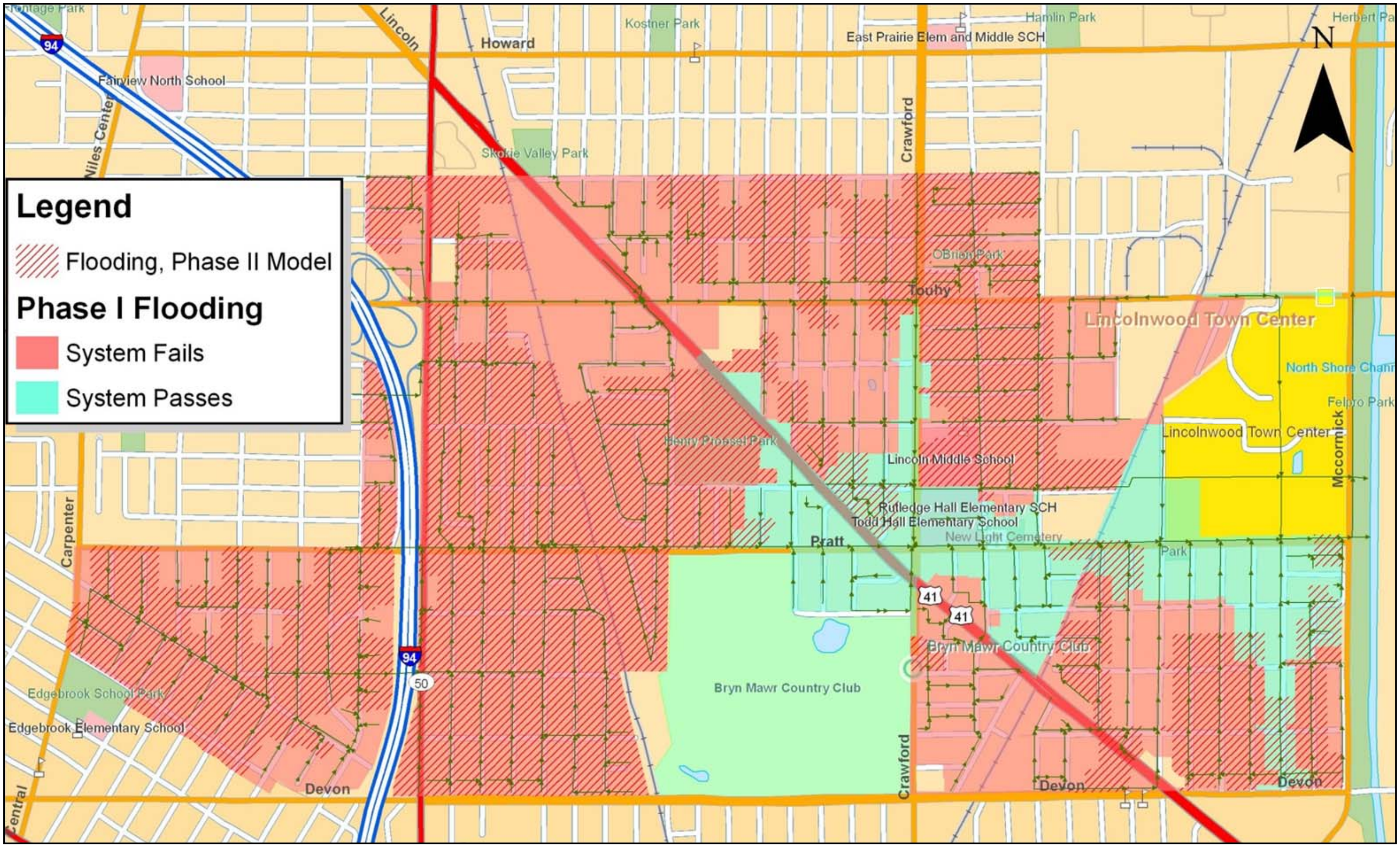

Figure 5 – Extent of Basement Flooding, Phase II Model, 10-Year Existing Conditions

2.4 Alternative 1 – Surface Storage

The objective of the first alternative was to determine the extent to which Lincolnwood could reduce basement flooding, if surface storage were the only method of stormwater management.

2.4.1 Proposed System Modifications

2.4.1.1 State/County Roads

The Village is prohibited from using any of the following six State / County roads which pass through Lincolnwood for storing stormwater: Crawford Ave, Touhy Ave, McCormick Ave, Lincoln Ave, Cicero Ave, and Devon Ave. The inlets along these roads were not restricted as part of this analysis.

2.4.1.2 Surface Storage Criteria

The Village specified the following surface storage criteria:

- Use of sub-surface inlet restrictors
- Minimum restrictor opening size: 2 inches
- Max ponding depth at residential road center line: 6 inches
- Max ponding depth at commercial road center line: 3 inches
- Max ponding depth at residential road gutter: 9 inches
- Max ponding depth at commercial road gutter: 6 inches
- Max ponding width for residential road: Back of sidewalk
- Max ponding width for commercial road: Top of curb
- Max ponding duration (after rain stops) for residential roads: 120 minutes
- Max Ponding duration (after rain stops) for commercial roads: 60 minutes

2.4.1.3 Inlet Restrictors

Inlet restrictors reduce and control the rate at which stormwater drains from the streets into the combined sewer system. Previous attempts to restrict runoff have included inserting concrete blocks into the outlet tiles from catch basins and inlets, however these were prone to clogging and required frequent cleaning.

The Village has since removed the concrete blocks, and has adopted a program of installing plates on the surface of the inlets and catch basins. These are also prone to clogging, but are much easier to clean. However, the hydraulics of these devices makes it difficult to control their discharge rates. A relatively minor increase in the depth of water on a surface restrictor will greatly increase its discharge rate, reducing its effectiveness in exploiting available surface storage.

Two restrictor designs were given consideration, shear gate restrictors similar to those preferred by Wilmette, and hanging traps similar to those used in Skokie. Shear gates are simple devices where catch basin tiles discharge into a combined sewer manhole. By re-routing all inlets and catch basins in an intersection through a single catch basin before discharging into a manhole, the total number of flow restrictors can be reduced and their sizes increased, providing the same hydraulic characteristics as the hanging trap devices while reducing the likelihood of clogging and the frequency of cleaning.

Hanging traps consist of a short length of PVC and an elbow inserted into the outlet tile from catch basins and inlets. The elbow points downward and has an orifice on the end of it to control the flow. These are upflow devices so as to reduce the likelihood of clogging with floatable debris; however clogging remains a major concern. The Village is currently field testing ten of these devices fitted with filters intended to further reduce the likelihood of clogging.

The Village can save approximately $6M in construction costs by using hanging traps rather than shear gates. Therefore program cost estimates will presume the use of hanging traps.

2.4.1.4 Containment Berms

Containment berms are essential to manage storing stormwater in streets. They are devices placed across roadways, intended to control where stormwater is stored on the surface and to what depth. These are typically asphalt berms that resemble wide "speed bumps". They are typically wide enough such that approaching vehicles need not slow significantly to pass over them. These cannot be placed across State / County roads.

The Village's current approach to stormwater management does not employ the use of berms. Without these, surface flows cannot be effectively contained. It will either collect in topographic depressions, which risks localized surface flooding, or migrate to the next unrestricted inlet where it quickly drains back into and overloads the combined sewer system.

2.4.2 Phase II Model Results – Surface Storage Only

2.4.2.1 10-Year Storm

Figure 7 indicates the extent of surface ponding and the buildings that remain at risk for basement backups during the 10-year storm. Surface storage will provide 10-year basement flood protection for approximately 1,700 homes currently at risk.

While the model results indicate 100 homes are at risk for surface flooding, upon closer inspection of the results, many of these were homes with tuck-under garages. These could be protected from flooding by re-grading the driveway. Some were also due to suspect topographic data. (See Section 5.1.5.) Assurance that these homes are not at risk for flooding is a design detail that will be addressed during Phase III of this project.

2.4.2.2 25-Year Storm

Figure 8 indicates the extent of surface ponding and the buildings that remain at risk for basement backups during the 25-year storm. Approximately 1,800 homes remain at risk during a storm of this magnitude.

2.4.3 Level of Protection

The current system can provide a 2-3 year level of protection. Storms of this magnitude present a risk of minor isolated basement flooding, whereas during the 10-year storm flooding is likely to be widespread with about 3,000 homes (Phase II results) at risk for basement backup under the current system. Some of these are likely to be severe with over 12 inches of water in some basements.

By utilizing surface storage, protection can be gained from basement flooding for approximately 1,700 of the 3,000 homes currently at risk during a 10-year storm. Table 1 summarizes the number of homes at risk under alternative 1 for a range of events. While the level of protection for all of Lincolnwood has been increased from 2-3 years to 4-5 years, it is important to note that there is a 55% reduction in the number of homes at risk for flooding during a 10-year storm (Figure 6). So while Alternative 1 creates a slight decrease in the frequency of basement backups, it provides a significant reduction in the widespread severity of basement flooding.

Table 1 – Level of Protection, Alternative 1

Storm Frequency (Years)	Percentage of Area Protected
1	100%
2	100%
5	85%
10	73%
25	62%

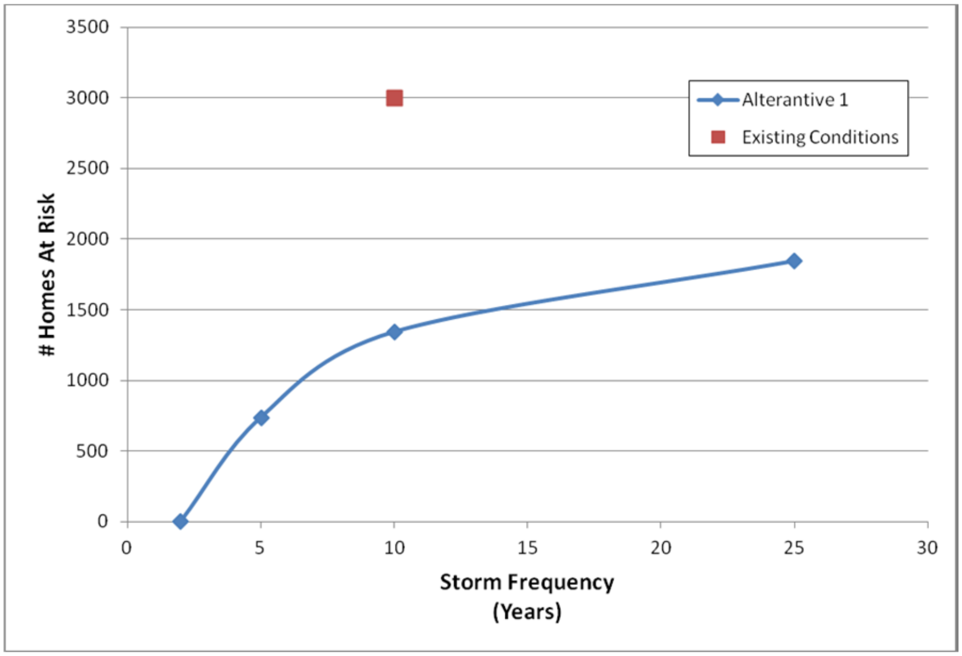

Figure 6 – Flood Risk, Alternative 1

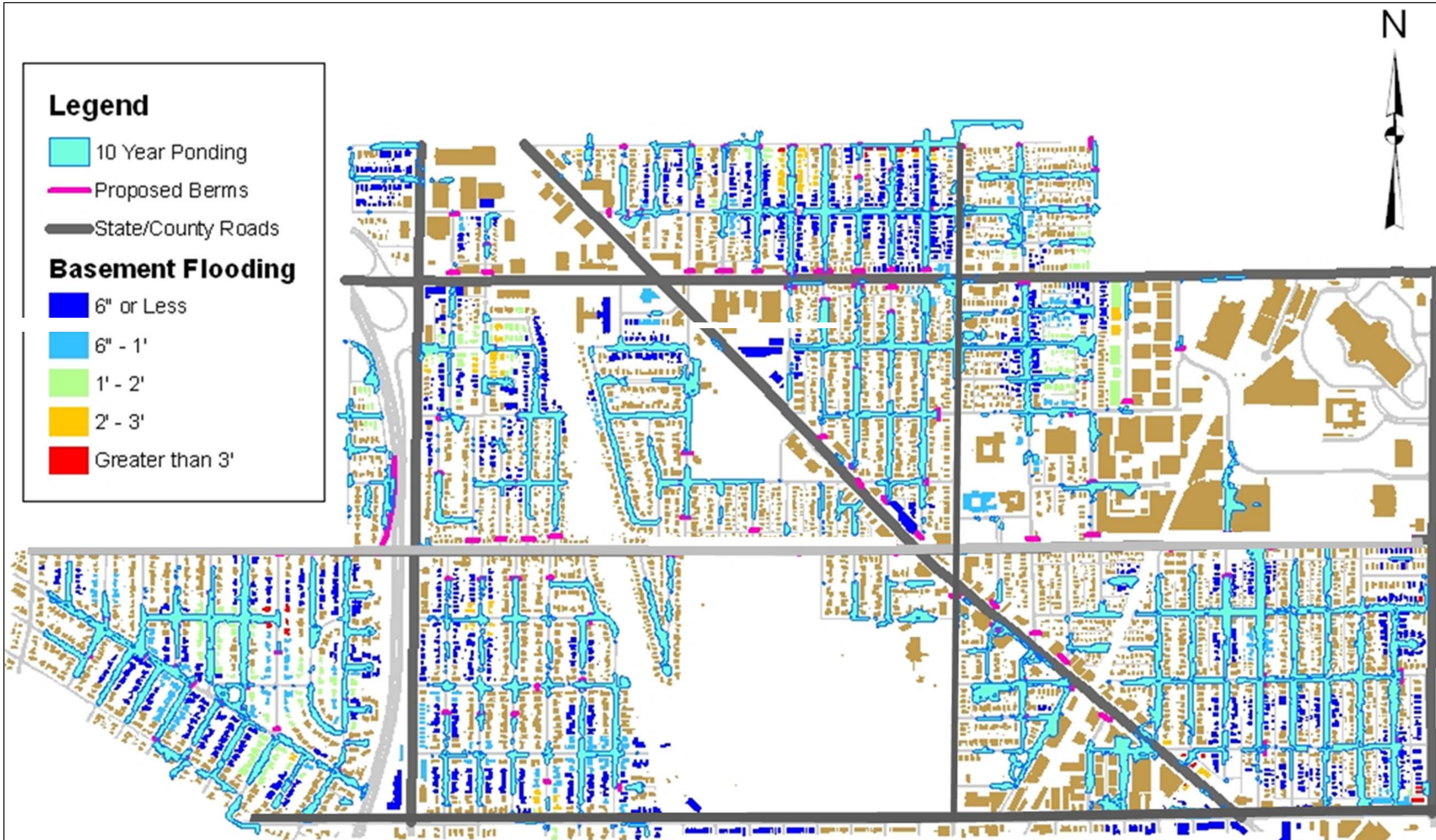

Figure 7 – Phase II Model Results, Alternative 1, 10-Year Storm

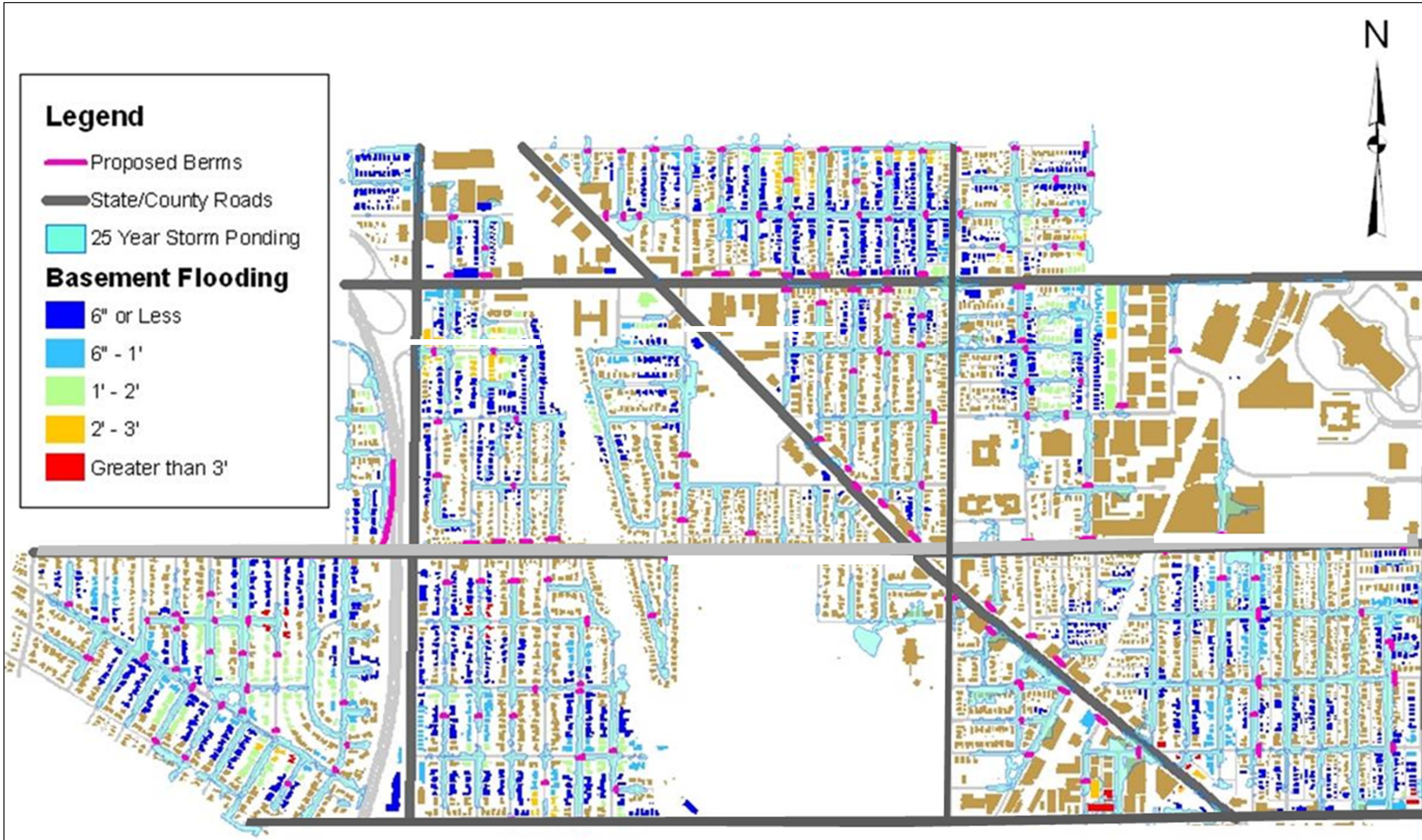

Figure 8 – Phase II Model Results, Alternative 1, 25-Year Storm

2.5 Alternative 2 – New Infrastructure

Surface storage fails to provide the 10-year level of protection for approximately 1,300 out of 3,000 homes currently at risk during a 10-year storm. Alternative 2 evaluated conventional infrastructure improvement alternatives that would provide the 10-year level of service for the entire Village. Methods given consideration include: stormwater detention, stormwater conveyance, and in-line storage.

2.5.1 Proposed System Improvements

Figure 9 indicates those system improvements that will provide the 10-year level of protection for virtually all of Lincolnwood. Specific projects include:

- Project #1 – The following three alternatives were given consideration to provide flood protection in The Towers neighborhood:
    - Project #1.1 – Detention pond in Polatan Park
    - Project #1.2 – In-line storage. Locations TBD.
    - Project #1.3 – Surface detention via detention storage
- Project #2 – 2,600 feet of 8 inch to 36 inch storm sewer and North ComEd detention facility;
- Project #3 – 3,350 feet of 15 inch to 48 inch storm sewer and South ComEd detention facility;
- Project #4 – 3,020 feet of 36 inch storm sewer;
- Project #5 – 2,000 feet of 18 inch to 60 inch storm sewer to South North Shore Channel Outlet;
- Project #6 – 1,860 feet of 21 inch to 36 inch storm sewer and Central ComEd detention facility;
- Project #7 – Upsize 750-foot section of existing combined sewer to 24 inch to 36 inch sewer (this project has been eliminated by extending Project #2 to west of Cicero);
- Project #8 – Upsize 1,000-foot section of combined sewer to 60 inch – 72 inch sewer;
- Project #9 – Three alternatives were given consideration as follows:
    - Project #9.1 – 11,400 feet of 24 inch to 60 inch storm sewer to North (Touhy) North Shore Channel Outlet.
    - Project #9.2 – Rather than construct a new storm sewer along Touhy to the North Shore Channel, direct storm runoff to in-line storage via twin 96 inch storm sewers under the abandoned Union Pacific ROW.
    - Project #9.3 – Rather than construct a new storm sewer along Touhy to the North Shore Channel, direct storm runoff to a detention pond along the abandoned Union Pacific ROW.

Several of these are discussed in more detail in the remainder of this section.

2.5.1.1 Towers Neighborhood Detention (Project #1)

Providing the 10-year level of protection to the Towers neighborhood is difficult because the sewers are shallow, so only a minor amount of sewer surcharging risks basement backups. In addition, while a significant volume of runoff will have to be stored here, there is little open space for detention ponds. To provide the 10-year level of protection, Lincolnwood must store approximately 3.84 acre-ft (1.25 MG) of stormwater west of the Edens. There are three options currently available, a 2.5 acre-feet detention pond in Polatan Park, in-line storage via oversized sewers, or approximately 4 acre-ft of detention dispersed over 8 properties currently for sale or in foreclosure. The unit costs of these three alternatives are summarized in Table 2. Any combination of these alternatives that provides a minimum of 3.84 acre-feet of detention would provide the 10-year level of protection. The remainder of this section explains these alternatives in more detail. The minimum total cost utilizing Polatan Park and removal of three homes and detention storage is about $6.25M.

Table 2 – Towers Detention Storage Alternatives

Alternative	Maximum Detention Storage (acre-ft)	Maximum Cost ($ x million)	$ / Gallon
Polatan Park Detention Pond	2.73	$3.91	$4.40
Home Removal & Detention[1]	4.00	$6.26	$4.80
In-Line Storage	3.84	$8.01	$6.40

1. Presumes average home sale price of $700,000.

2.5.1.1.1 Detention Pond In Polatan Park (Project #1.1)

Detention storage in Polatan Park is the most cost-effective option, presuming an agreement can be reached with neighboring Skokie. But, only 2.73 acre-feet of stormwater can be detained in the park and the connecting sewer, leaving approximately 1.34 acre-ft of stormwater needing to be stored via the remaining methods. Conveying stormwater from the Towers to Polatan Park would require a significant amount of sewer construction. The total volume of the pond would be approximately 3.51 acre-feet, but with about 2.5 feet of freeboard, only 2.48 acre-feet would actually be stored there. The pond would have a total depth of about 8.5 feet. The approximate layout of this pond is shown in Figure 13.

The total cost of the sewer and pond is approximately $3.91M. This project would provide 2.73 acre-ft (0.89 MG) of storage ($4.40/gallon).

2.5.1.1.2 Towers In-Line Storage (Project #1.2)

Due to the lack of open space, this must be done under streets via in-line storage at a cost of about $6.40/gallon (including 40% contingency and 15% engineering). Storing all 3.84 acre-feet using this method would cost approximately $8M. The optimal sizing and placement of storage would be determined during Phase III.

2.5.1.1.3 Detention Storage (Project #1.3)

There are eight properties currently for sale or in foreclosure (Figure 10) that the Village could purchase and use for detention. In general, the detention ponds are adjacent to areas with excessive ponding thereby allowing stormwater to spill into them directly from the street. However some minor sewer construction will be required to convey stormwater from some flood prone areas.

Each of the eight homes that might be torn down for storage could provide an average of 0.6 acre-feet of detention. Therefore, each home that can be acquired for less than $1.3M has a good potential to provide detention at a lower cost than an equal amount of in-line storage.

The eight properties indicated in Figure 10 are currently in foreclosure or for sale. These eight properties could provide a total of approximately 4 acre-feet of detention, sufficient to provide the 10-year level of protection without any detention in Polatan Park or via in-line storage. Assuming a fair-market-value (FMV) of $700,000 per home and $0.50/gal for detention construction, the total cost of this alternative is approximately $6.25M ($4.80/gallon). The Village might be able to purchase the homes in foreclosure for significantly less than FMV.

2.5.1.2 Jarvis Sewer (Project #4)

For a 90-acre area in Lincolnwood bounded roughly by Lincoln Ave on the west, Crawford Ave on the east, Touhy Ave on the south, and Jarvis Ave on the north, there is insufficient street storage to detain all the excess runoff during a 10-year storm. About 0.70 million gallons (MG) of water overtops the stormwater containment berms proposed along the border with Skokie and flows onto Jarvis. This excess runoff must be captured.

Two alternatives were considered for capturing this excess storm runoff. The first option, described in detail in Section 5.4.1, would store this excess volume under Jarvis Avenue in twin box culverts (large rectangular sewers). The stored water would discharge into the new Crawford storm sewer being constructed by Cook County. This sewer would take the storm flow from Crawford and Jarvis north where it would discharge into Skokie's storm system at Howard Ave. A flow regulator will control the rate at which stormwater is discharged into Skokie's sewer system.

There is also an area east of Crawford, bounded by Jarvis, Touhy, Crawford, and Hamlin, that is particularly flood prone. The ground slopes steeply east of Crawford, making it impossible to direct excess storm runoff from this area to the intersection of Jarvis and Crawford. On the other hand, the Jarvis sewer could be connected to Project #9 via a overflow structure at Crawford and Jarvis. Project #9 would also provide flood relief to the areas east of Crawford. In addition, since this is a conveyance rather than a storage alternative, the Jarvis sewer west of Crawford could be reduced from twin box culverts to a single 36-inch reinforced concrete pipe (RCP).

2.5.1.3 Storm Outlet to North Shore Channel (Projects #5)

The proposed improvement, labeled Project #5 in the map on Figure 9, would provide immediate flood relief to the southeastern highlighted area in Figure 9. In addition, by removing a significant amount of storm runoff that currently drains into the 84-inch trunk line along Pratt Ave, it would free up capacity in this line. Since much of Lincolnwood's combined sewerage must pass through the Pratt sewer, diverting storm flow from it provides a system-wide benefit, particularly to the more upstream reaches of the collection system.

2.5.1.4 Project #9

This project is intended to convey overflow from the diversion structure at Crawford and Jarvis, and to provide flood relief to the highlighted area bounded roughly by Jarvis to the north, Pratt to the south, Crawford to the west, and Hamlin to the east. Three alternatives (cost estimate below) were given consideration as described in the remainder of this section.

Table 3 – Project #9 Opinions of Probable Costs

Alternative	Description	Opinion of Probable Cost ($ x million)
9.3	Abandonded Union Pacific ROW Detention Storage	$9.4
9.1	Touhy North Shore Channel Outlet	$11.5
9.2	Abandonded Union Pacific ROW In-Line Storage	$16.4

2.5.1.4.1 Touhy North Shore Channel Outlet (Project #9.1)

This sewer would originate at the intersection of Crawford and Jarvis. To maximize utilization of the in-line storage the proposed Crawford sewer is intended to provide, a regulator chamber with an overflow weir should be installed. A weir is essentially a wall that directs the flow north until the water level in the chamber rises to the point that it overtops the wall, at which point the flow overtopping the wall is directed east. This chamber would direct flow north along Crawford into Skokie until the water begins to overtop the weir, at which point it would begin to discharge into the new North Shore Channel Outlet. This alternative would cost approximately $11.5M.

2.5.1.4.2 Abandoned Union Pacific ROW In-Line Storage (Project #9.2)

To avoid the inconvenience of constructing a major sewer along Touhy, this alternative conveys storm runoff to twin 96-inch concrete sewers 3200 feet in length that would store 2.4 MG of stormwater under the abandoned Union Pacific ROW (Figure 9). These would cross and drain into the existing 84" sewers at Northeast Parkway and Pratt. The in-line storage pipes would have to be broken into sections where they intersect these existing sewers. The sections would be connected by 36" sections passing over the existing 84" sewers. The estimated total cost for this alternative is approximately $16,400,000.

2.5.1.4.3 Abandoned Union Pacific ROW Detention Storage (Project #9.3)

This alternative is similar to the one above, however rather than burying the detention beneath the Abandoned Union Pacific ROW, a detention pond from Morse to Touhy with a bike path running through it would be excavated. The pond would be constructed in two sections with a culvert passing under Central Park Ave.

The typical detention cross section used in this analysis is indicated in Figure 11, with the bike path on a 25' wide portion of the cross section next to a drainage channel at the bottom. During a 10-year storm the bike path along the section from Morse to Touhy would be under about 2 feet of water. This is the least expensive cross section and was intended to demonstrate feasibility. There are a number of ways this cross section could be modified to improve safety and aesthetics at a slightly increased cost. Regardless of the final configuration, to prevent surface flooding, the maximum water level in the pond must be kept below an elevation of 593 and the cross sectional area of storage below this elevation must not be reduced from that indicated in Figure 11.

Figure 12 is a profile of the sewer along Jarvis, south along East Prairie and Hamlin, east along Morse, and northeast along the bike path. The water cannot be ponded any deeper in the detention pond without risking surface flooding along Hamlin.

The bulk of the cost of providing this detention would for the sewers to convey the stormwater to the detention pond. The total cost of this alternative is approximately $9.4M.

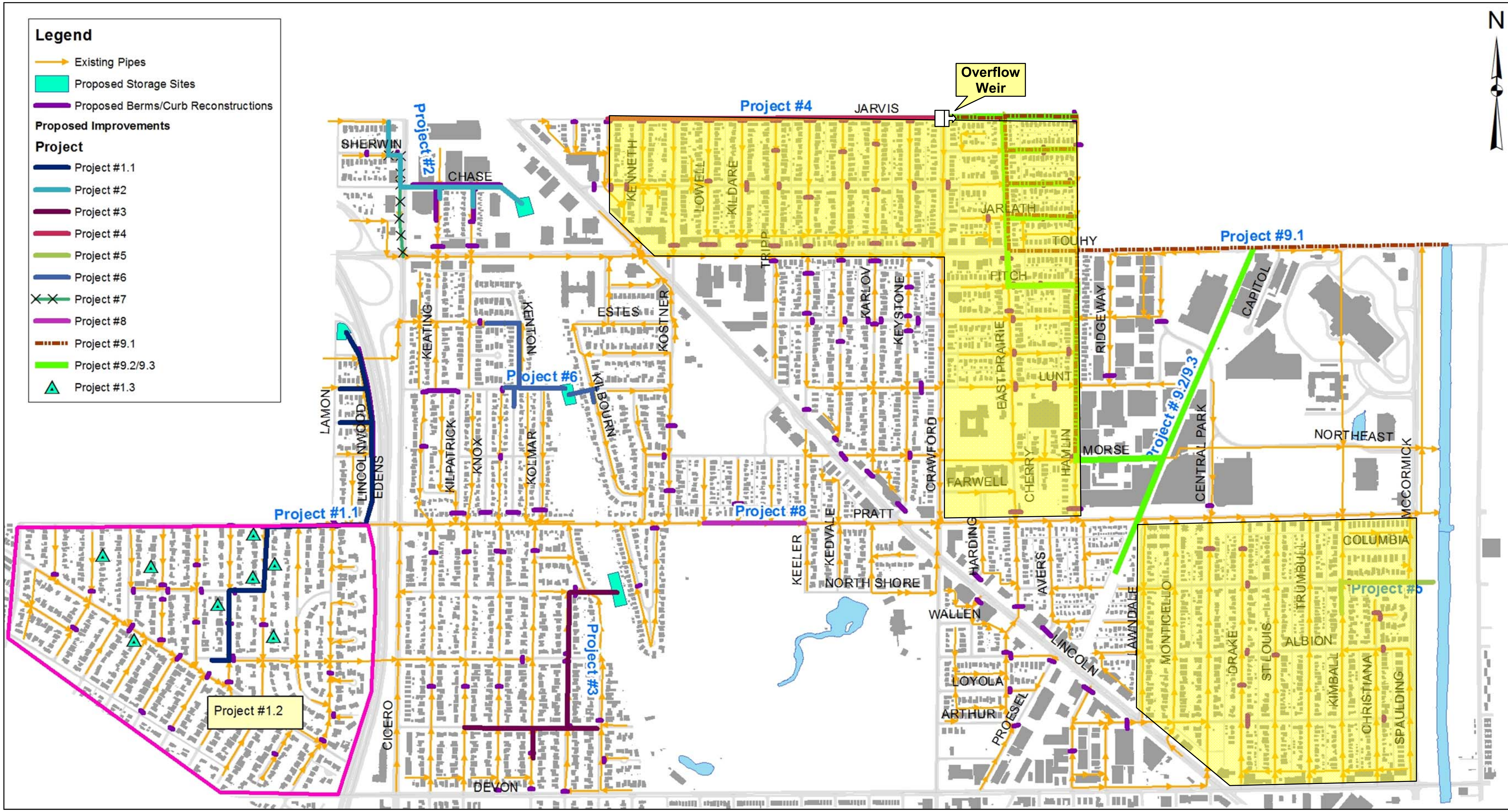

Figure 9 – Alternative 2 Sewer Improvements

Figure 10 – Potential Detention Sites

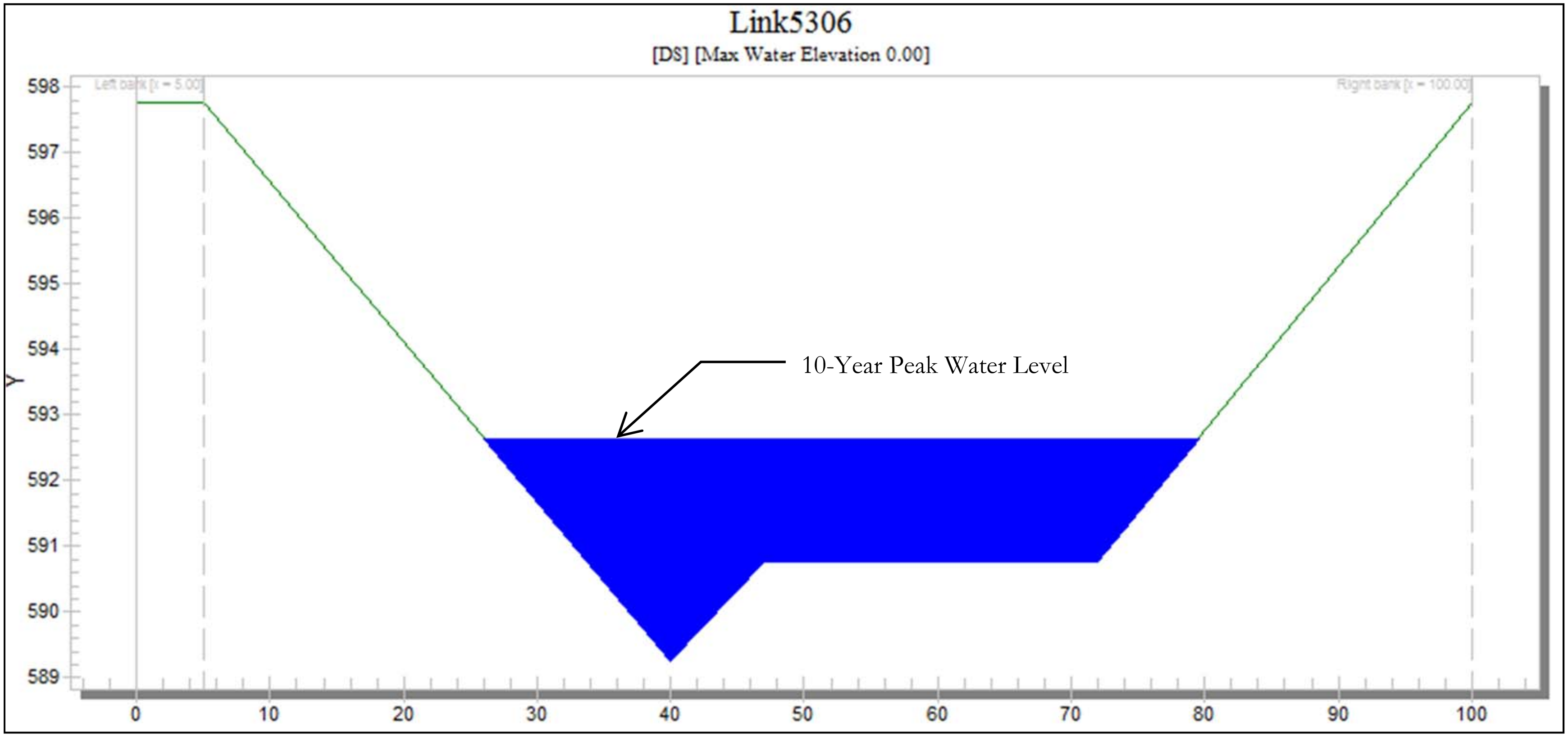

Figure 11 – Abandoned Union Pacific ROW Detention Cross Section

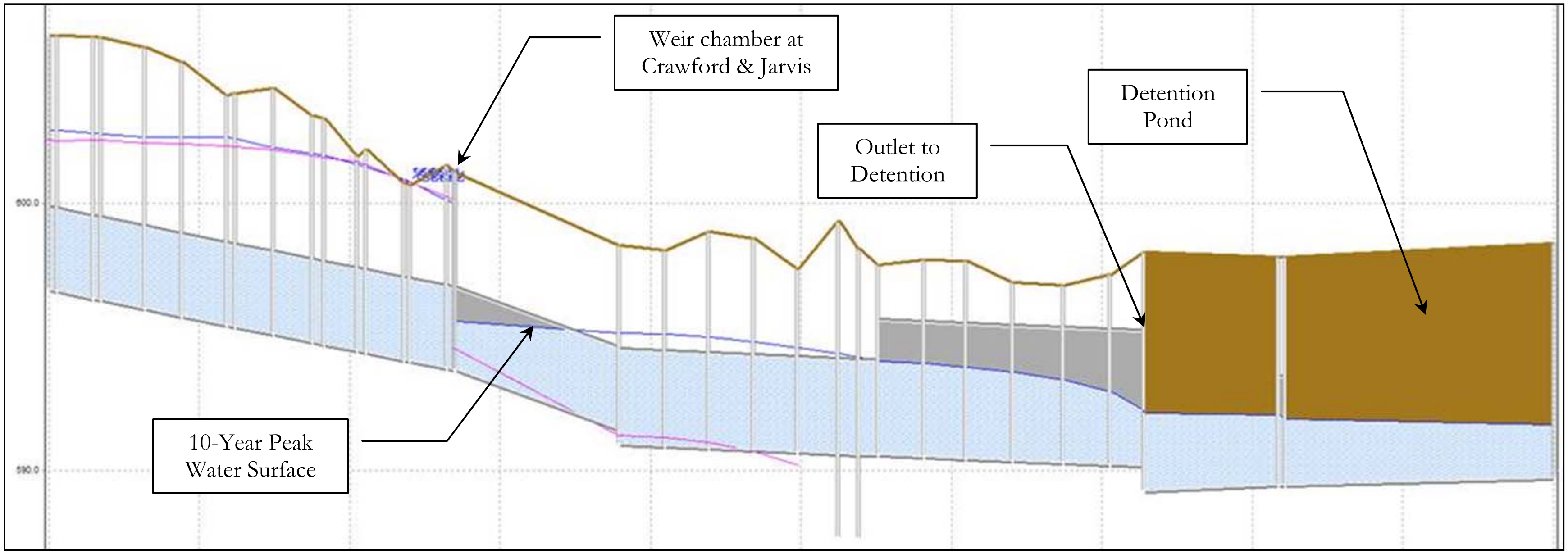

Figure 12 – Union Pacific Sewer and Detention Profile

2.5.1.5 Commonwealth Edison Stormwater Detention (Projects #2, #3, & #6)

Stormwater detention is an economical method of relieving overloaded sewers. Detention is basically a stormwater management technique that involves storing peak wet weather flows, then releasing the stored water at a reduced rate, preferably after the storm has passed. Street storage in roadways is the most economical form of detention in that it does not require any significant construction. However surface ponding in roadways can be perceived as an inconvenience and may risk surface flooding if not planned and designed carefully. Consideration must be given as to how to manage storm flows in excess of the design level of protection. There are currently two options under consideration for what to do with excess stormwater during storms greater than the 10-year level of protection; it can either be permitted to pond deeper and wider than the 10-year design parameters specify, or high-level overflows can be constructed to allow excess stormwater back into the combined system, increasing the risk of basement backups. A final determination of the preferred method is yet to be made.

The Alternative 1 analysis indicates that there is insufficient usable street storage available to provide the desired 10-year level of protection for all of Lincolnwood. Storm sewer and detention basin construction will be required to achieve the desired level of protection. On the other hand, even where streets do not provide adequate detention, they can still be used for conveyance. By using streets to convey storm runoff, smaller collector storm sewers are not required; only larger trunk storm sewers need to be constructed to convey excess storm runoff to offline storage facilities. A similar approach to stormwater management has been employed in Evanston, IL.

Commonwealth Edison (ComEd) owns vast quantities of open space that runs through the heart of Lincolnwood. These are ideal locations for offline stormwater detention. ComEd has already expressed a willingness to evaluate whether or not such facilities could be constructed on their property.

Figure 9 indicates three preferred detention pond locations totaling 4.7 acre-feet of detention. They would drain by gravity at a controlled rate back into the adjacent combined sewer system. Figure 13, Figure 14, Figure 15 are more detailed schematics of the pond footprints and inlet and outlet pipe locations. The pond storage volumes for the northern, central, and southern pond are 1.1, 2.4, and 1.2 acre-feet respectively.

These are the minimum storage volumes required to provide the 10-year level of protection. Making these ponds larger would provide an even higher level of flood protection.

2.5.2 TIME TO DRAIN

The table below summarizes the approximate volume stored and time to drain the recommended storage facilities once rainfall has ended. This is based on an available sewer capacity of 130 MGD.

Street Storage	41 acre*ft	2.48 hrs
Towers Storage	3.84 acre*ft	0.23 hrs
ComEd Storage	4.7 acre*ft	0.28 hrs
Union Pacific Storage	7.37 acre*ft	0.45 hrs
Total	**57 acre*ft**	**3.5 – 5 hours**

Figure 13 – ComEd North Detention Pond

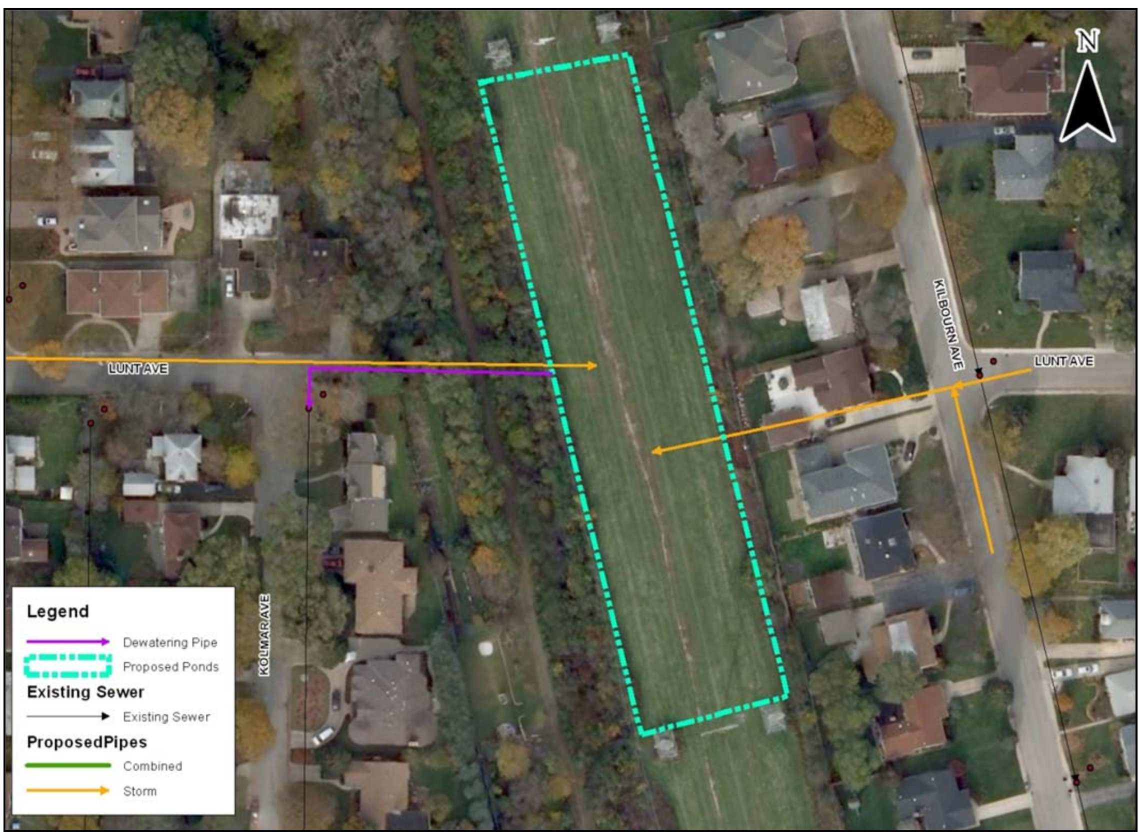

Figure 14 – ComEd Central Detention Pond

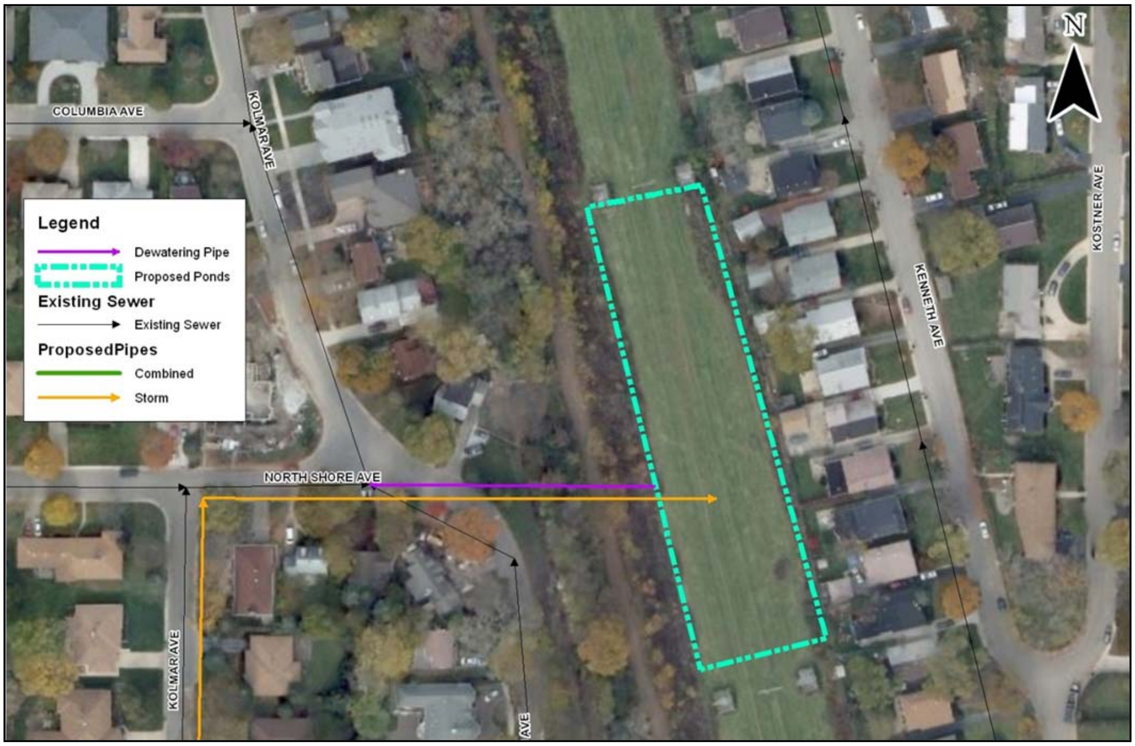

Figure 15 – ComEd South Detention Pond

Figure 16 – Polatan Park Pond

2.5.3 MODEL RESULTS

2.5.3.1 10-Year Storm

Figure 17 indicates the extent of surface flooding that the model predicts during the 10-year storm with the proposed improvements.

Virtually all surface ponding the model predicts meets the specified criteria (Section 2.4.1.2), however the model indicates some minor violations of these criteria. This is likely due, in large part, to imperfections in the topographic data that was used to construct the two-dimensional surface model. While generally very precise, the topographic data was created using remote sensing technology and may have imperfections (Section 5.1.5). Upon closer inspection, the majority of violations of the surface ponding criteria are due to suspect topographic data. While it would be impractical and prohibitively expensive to field verify topography in all these instances, that level of precision will be required and employed during Phase III, which would be the appropriate time to field verify model results.

2.5.3.2 25-Year Storm

The extent of flooding during the 25-year storm on the proposed system improvements is indicated in Figure 18. There are approximately 525 homes at risk for basement flooding. The extent of surface ponding is generally larger, and some homes are at increased risk for surface flooding.

2.5.4 REMAINING BASEMENT FLOODING

Even with the proposed improvements, there are a few homes which remain at risk for basement flooding. These homes generally lie in areas with shallow sewers that are barely more than six feet below grade. Only slight sewer surcharging is sufficient to put the adjacent homes at risk. Typically the depth of flooding that would occur during a 10-year storm would be less than four inches.

There are several alternatives the Village might employ to protect these remaining homes. First, the Village should inspect these homes and confirm they have full basements. If not, they are not at risk.

If they are at risk, the Village should consider reducing the minimum restrictor size to better regulate sewer flows and promote additional surface ponding. This should be evaluated further under Phase III. Alternatively, the Village could recommend, or mandate, that these homes have basement flood protection. Many of the homes in these areas, particularly the Towers neighborhood, may already have flood protection. If not, it can be accomplished with check valves or stand pipes. These methods, however, require maintenance and may fail during a storm. Overhead plumbing guarantees that the combined sewer cannot backup into the basement, but it is an expensive retrofit for those that do not already have it.

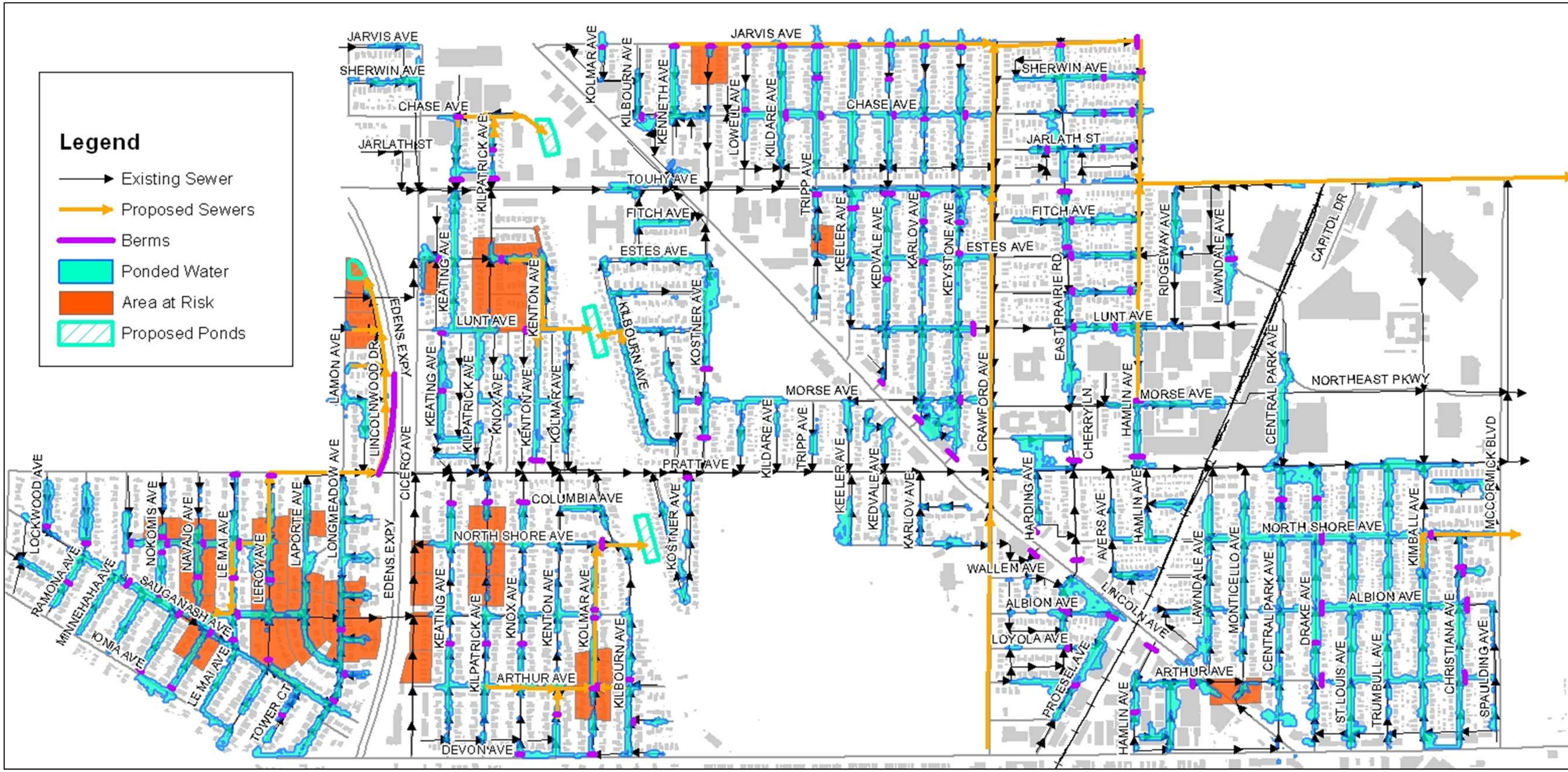

Figure 17 – Model Results, Alternative 2, 10-Year Storm

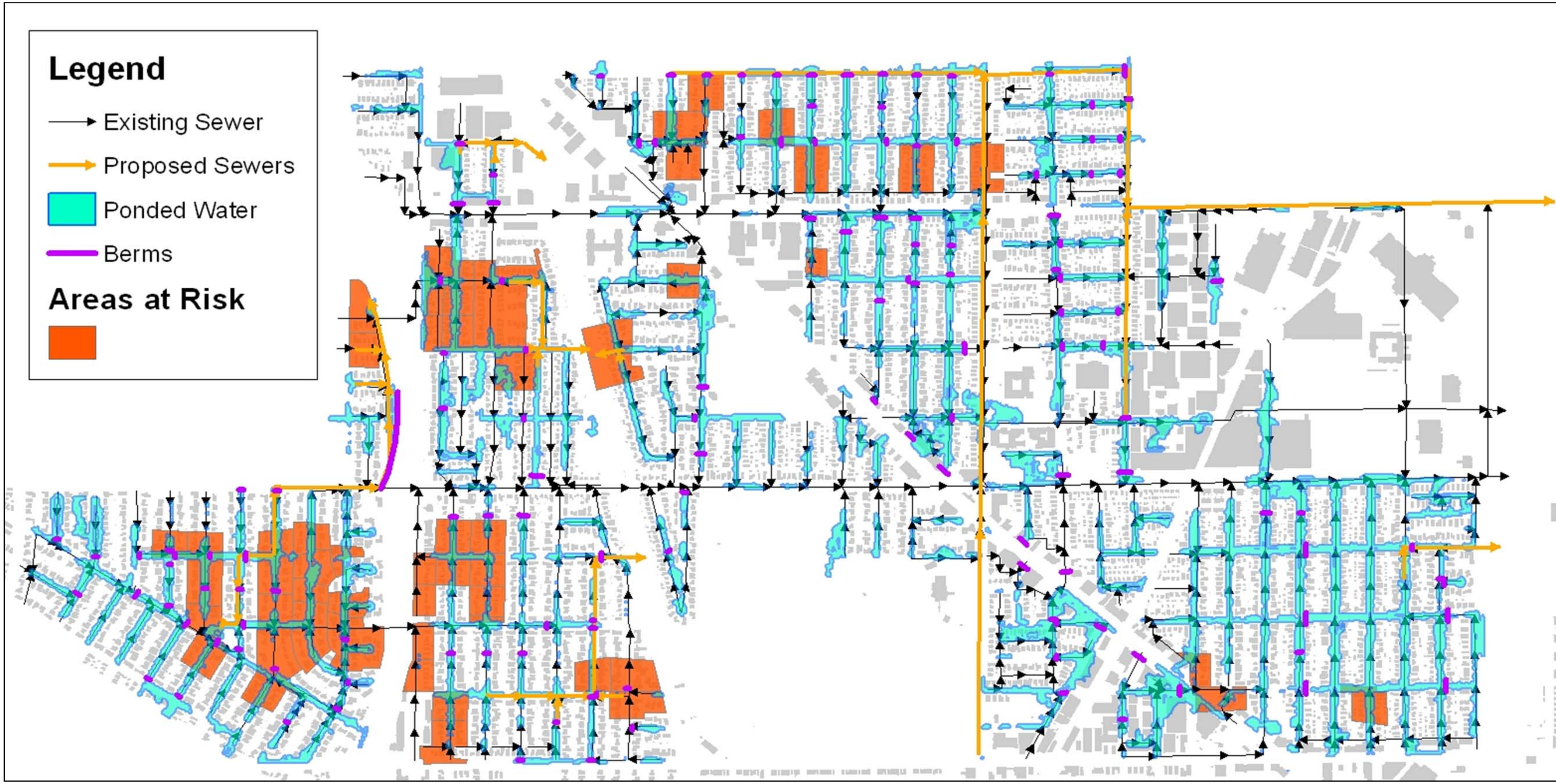

Figure 18 – Model Results, Alternative 2, 25-Year Storm

2.6 COST – BENEFIT ANALYSIS

The levels of protection that Alternatives 1 and 2 provide are summarized in Table 4.

Table 4 – Levels of Protection, Alternatives 1 & 2

System Configuration	Homes At Risk For Basement Flooding				Homes At Risk For Surface Flooding			
	1-Year	5-Year	10-Year	25-Year	1-Year	5-Year	10-Year	25-Year
Existing Conditions	0	-[1]	3,000	4,500[2]	0	0	0	0
Alternative 1	0	750	1,300	1,800	0	50	100	150
Alternative 2	0	0	250	500	0	0	75	100

1. This simulation was not within the project scope.
2. While this simulation was not run, the flood complaints from August 2, 2001, a 25-year event, indicated Village-wide flooding.

Table 5 is a cost-benefit analysis of both alternatives. The cost-effectiveness of street storage ($6,825/home) to reduce basement flooding is clear. However approximately 1,300 homes would remain at risk during a 10-year storm. The marginal cost for the remaining homes (the per home cost to provide the 10-year level of protection for these remaining homes by implementing Alternative 2) is approximately $23,269/home. In other words, it costs about $6,825/home to protect 1,700 of the 3,000 homes currently at risk during a 10-year storm, and an additional $23,269/home to protect the 1,050 of the remaining 1,300 homes that would still be at risk during a 10-year storm under Alternative 1.

Table 5 – Cost-Benefit Analysis, 10-Year Storm

	Existing Conditions	Alternative 1 (Street Storage)	Alternative 2 (Sewers & Detention)
Homes At Risk	3,000	1,300	250
Homes Protected	0	1,700	2,750
Cost	$0	$5,592,060	$28,039,156
Cost Per Home Protected	-	$3,289[1]	$12,230[2]
Marginal Cost Per Home Protected	-	$3,289	$26,704[3]

$$1 = \frac{Alternative\ 1\ Costs}{\#\ Homes\ Protected} = \frac{\$5{,}592{,}060}{1{,}700} = \$3{,}289\ per\ home\ protected$$

$$2 = \frac{Total\ Cost}{Total\ \#\ Homes\ Protected} = \frac{(\$28{,}039{,}156 + \$5{,}592{,}060)}{2{,}750} = \$12{,}230\ per\ home\ protected$$

$$3 = \frac{Incremental\ Cost}{Additional\ \#\ of\ Homes\ Protected} = \frac{\$28{,}039{,}156}{(2750 - 1700)} = \$26{,}704\ per\ additional\ home\ protected$$

CHAPTER III – SUMMARY & RECOMMENDATIONS

Phase I demonstrates that the Village's collection system does not have adequate capacity to provide the 10-year level of protection from basement backups. Phase II demonstrates that this level of protection can be attained with a capital improvement program. Therefore AB&H recommends that the Village proceed with Phase III of its Stormwater Management Program.

Street storage is an effective and inexpensive means of stormwater management (Table 5). It will reduce the severity of flooding during a 10-year storm by 55%. Therefore AB&H recommends that the Village proceed with the implementation of this approach. This will require more detailed engineering and analyses to optimize inlet restrictor sizing, containment berm placement and design.

Intentionally ponding storm runoff in streets is an unconventional method of stormwater management. Standing water in roadways may be perceived as an inconvenience by the public. Public support of street storage is critical for its success. Therefore the Village should begin by initiating a Public Education & Outreach Program. People that live in homes along streets that will be used for storage need to understand that it is in their best interest that the water pond in the street rather than in their basements. They should also understand the expense to the Village and property owners of having to construct a new storm drainage system to keep both streets and basements dry during rainfall events.

Should the Village move forward with street storage a public education campaign should be implemented. Affected parties are far more likely to support a program that they feel they have "ownership" of. The Village should form a stakeholder group with representatives from residential and commercial property owners from various regions within the Village. This group could engage with the Village's Stormwater Ad-Hoc Committee to disseminate information and solicit feedback and suggestions. The Village should also utilize local media, Village Board meetings, and mass mailings as a means of communicating with the public.

If the Village elects to proceed with the recommendations of Alternative 2, the Village should first prepare a Capital Improvement Plan (CIP) that prioritizes and schedules each improvement project within the context of the Village's overall Public Work's needs, expenses, and budget. Sewer construction projects should be coordinated with other Public Works projects including, but not limited to, street reconstruction, combined sewer replacement / rehabilitation, water, lighting, etc. The CIP should include a rate study to assess the Village's borrowing capacity, balance engineering and construction with available funding, and determine whether user fees will need to be adjusted to fund the program and service debt.

The list of improvement projects have been prioritized in Table 6 generally in order of decreasing cost-effectiveness. A CIP as described above will be required to schedule specific design and construction dates.

Table 6 – Engineer's Recommended Project Priority List

Priority	Project #	Description	Cost	Homes Protected	Cost per Home
1	Alternative 1	Flow restrictors & containment berms	$ 5,592,060	1,700	$ 3,289
2	5	New North Shore Chanel Storm Outlet	$ 1,335,398	210	$ 6,359
3	6	Storm sewer & ComEd Central detention pond	$ 1,710,210	152	$ 11,251
4	3	Storm sewer & ComEd South detention pond	$ 2,843,679	145	$ 19,612
5	9.3	8,000 feet of 24 inch to 60 inch storm sewer & abandoned Union Pacific ROW detention	$ 9,427,386	345	$ 34,269
6	4	3,020 feet of 36 inch storm sewer	$ 2,395,478		
7	2	Storm sewer & ComEd North detention pond	$ 2,137,650	44	$ 48,583
8	8	Upsize 1,000-foot section of combined sewer to 60 inch - 72 inch sewer along Pratt	$ 1,933,168	154	$ 53,178
9	1.1	Storm sewer & Polatan Park detention pond	$ 3,908,687		
10	1.3	Detention Storage (3 sites)	$ 2,347,500		
11	7	Upsize 750-foot section of existing combined sewer to 24 inch to 36 inch sewer (Merged with Project #2)			
		Grand Total	**$ 33,631,216**		

**All dollar values displayed to the nearest whole dollar amount.

CHAPTER IV – BIBLIOGRAPHY

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CHAPTER V –APPENDIX

5.1 MODEL UPDATE

The model developed for the Phase I analysis was completely overhauled to enable it to perform the detailed analysis required for Phase II. Steps in the overhaul included:

1. Increase sewer network detail – The model developed for Phase I only included larger diameters sewers, generally those 18 inches and larger. For Phase II, the model was updated to include every pipe and manhole.
2. Inlets & catch basins – Almost every inlet and catch basin is represented in the Phase II hydraulic model.
3. Basement flooding – When sewage backs up into basements, it does impact the hydraulics of the system. Therefore the model was enhanced to simulate this phenomenon.
4. Hydrologic model – Using rainfall as input, the hydrologic model predicts storm runoff entering the hydraulic model of the sewer network. The detail of the hydrologic model was increased to match the increased detail of the hydraulic model.
5. 2-Dimensional Surface Model – To accurately simulate flow and storage in the streets, a two-dimensional representation of Lincolnwood's topography was added to the model. This enabled engineers to predict both overland and sewer flows and the interaction thereof in a single dynamic model.

5.1.1 HYDRAULIC MODEL

The hydraulic model consists primarily of Lincolnwood's physical sewer system of pipes and manholes. The model developed for Phase I was "skeletal", containing only larger diameters sewers, generally those 18 inches and larger. The hydraulic model was overhauled and expanded for Phase II in order to include all sewers so as to provide the level of precision this analysis required.

5.1.1.1 Sewer Network

For Phase II the hydraulic model was updated to include every pipe and manhole. Lincolnwood's GIS utility geodatabase was the primary source of information for this update. In some cases the GIS data was either incomplete or inaccurate. In these cases modelers relied upon survey data collected during Phase I, or interpolated for missing/erroneous pipe/manhole inverts. All manhole rim elevations were taken from the triangulated irregular network (TIN) of surface topography.

5.1.1.2 Catch Basins & Inlets

To simulate overland flows and storage, the representation of the catch basins within the model was greatly enhanced. Doing so provided the ability to simulate inlet restrictors and the subsequent reduction in discharge and increase in surface ponding. However, modeling the restriction of all 4,000 inlets and catch basins greatly increased computational time and model instability. Therefore composite restrictors were created in the model. Each composite restrictor represents the cumulative capacities of all the inlets or catch basins near it, for example, all four catch basins in an intersection.

Figure 19 indicates how inlets, catch basins, and restrictors were typically represented in the model. While restrictors would likely be placed in every catch basin and inlet, in the model, they were all routed through a single restrictor. Since the model was developed, the Village made the decision to switch from hanging trap regulators in every catch basin to consolidating flows through a reduced number of shear gates. Therefore the proposed catch basin configuration will closely resemble the bottom schematic in Figure 19 after Alternative 1 is implemented.

To prevent clogging, Village staff specified a minimum restrictor size of two inches. A hydraulic analysis determined that if all restrictors were 2 inches, the total peak flow into the sewer system would generally match system capacity. Therefore all restrictors were initially given a two-inch diameter. During the analysis, the diameters of some restrictors were increased where the depth of extent of surface ponding exceeded the criteria specified in Section 2.4.1.2. The 2 inch minimum criteria was eliminated by the decision to use shear gates rather than hanging trap restrictors.

5.1.1.3 Basement Storage

When sewage backs up into basements, it impacts the hydraulics of the sewer system. Therefore the model was enhanced to simulate this phenomenon. This also provided the ability to better estimate the number of homes at risk during alternative analysis.

The model was configured to simulate basement storage using the following algorithm:

1. The centroid (center) of each home was located.
2. The first floor elevation of the building was taken from topography and assigned to the centroid.
3. The area of the building footprint was assigned to the centroid.
4. The total footprint areas of all the buildings associate with each manhole were calculated.
5. The maximum and minimum first floor elevations of all buildings associated with a manhole were assigned to that manhole.
6. Basement storage was presumed to begin 6 feet below the minimum first floor elevation.
7. Basement storage was presumed to increase linearly until it reached the total footprint area at 6 feet below the elevation of the maximum first floor elevation.
8. All homes were presumed to have basements equal in area to the building footprint, and were assumed to not have basement flood protection.
9. To improve model stability, basement storage was added to the manhole nodes themselves.

Homes served by shallow sewers were typically found either to have half basements or no basements. For these areas, it was assumed that basement storage began 3 feet below grade.

5.1.2 H YDROLOGIC MODEL

The hydrologic model takes rainfall as input, and simulates evaporation, soil infiltration, and surface runoff. It generates runoff hydrographs at each of the hydraulic model nodes that are then routed through the hydraulic model. Therefore model Subcatchments were subdivided to simulate runoff into the more detailed hydraulic model.

Major hydrologic model parameters generally include percent impervious, ground slope, and soil type. Percent impervious has the biggest impact on runoff rates. It was calculated using GIS software, by intersecting subcatchment boundaries with building, parking lot, and street layers. Buildings were tabulated separately because these are required to discharge onto lawns. They were modeled as "disconnected impervious areas". The resultant subcatchment percent impervious values are indicated in Figure 20.

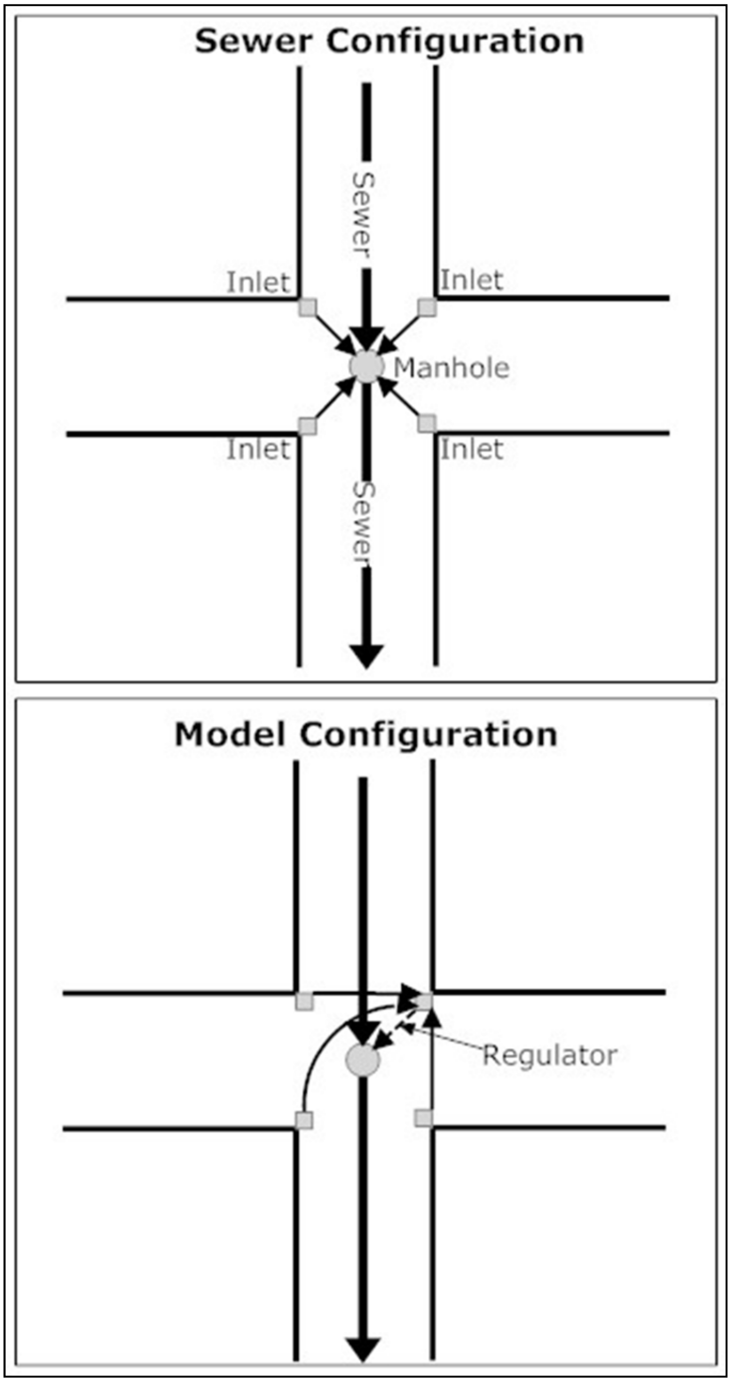


Figure 19 – Inlet / Catch Basin Configuration

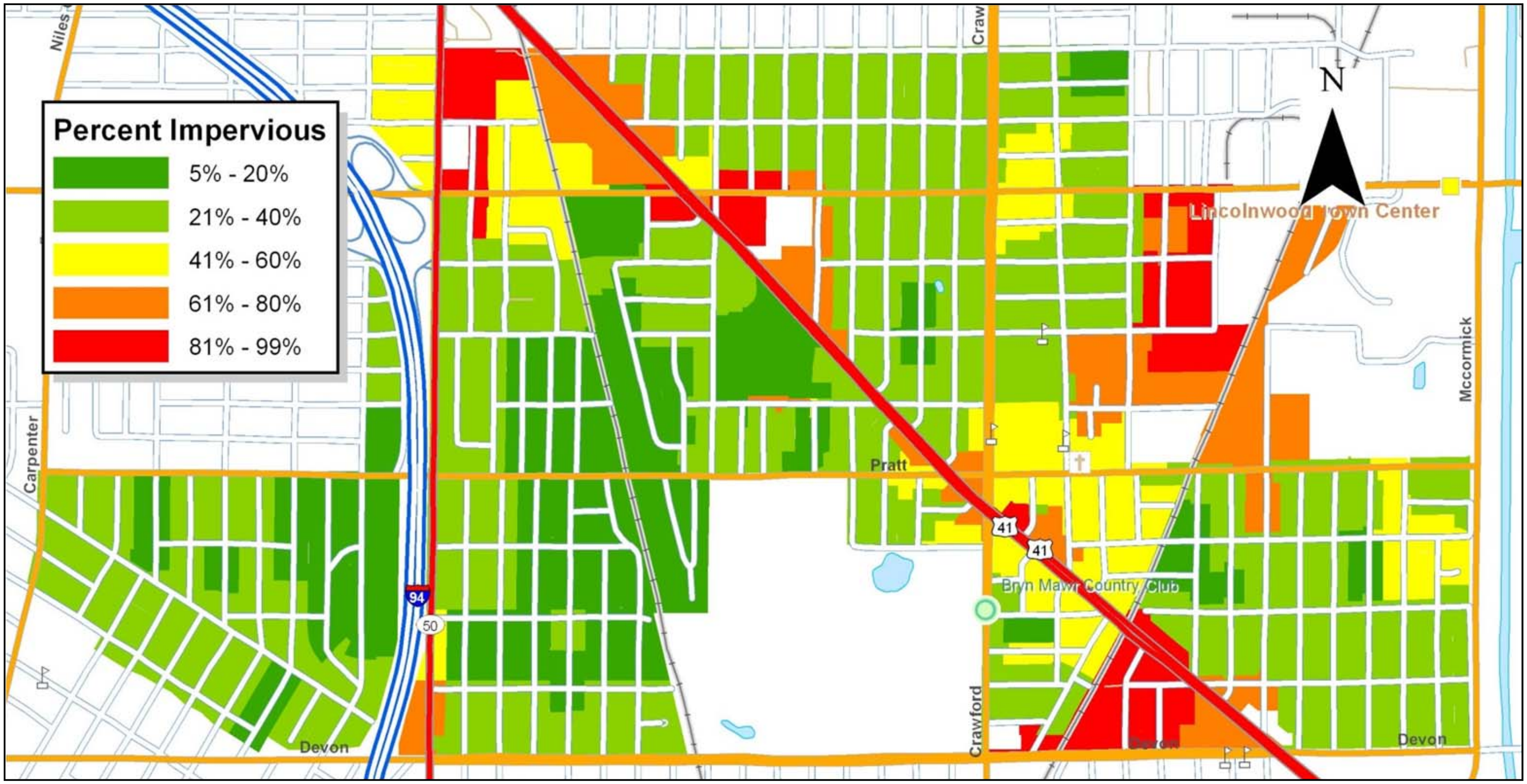


Figure 20 – Percent Impervious

5.1.3 2-DIMENSIONAL SURFACE MODEL

Under Phase I, surface and subsurface flows were both simulated using a 1-dimensional dual-drainage network model. While this was adequate for performing a PASS/FAIL analysis of the trunk sewers during a 10-year storm, it is not capable of performing the complex analyses required for evaluating street storage.

5.1.3.1 TUFLOW

In recent years, XP-SWMM has been enhanced by incorporating the FEMA approved TUFLOW 2-dimensional computational engine. TUFLOW is an overland flow module available for both **xpswmm** and **xpstorm**. This fully dynamic 2D flow capability, coupled with the 1D capability of **xpswmm** or **xpstorm**, allows simulation of flows in and out of urban drainage networks and river systems. It provides an incredibly accurate tool to predict the extent, depth, velocity and duration of flooding to evaluate flood mitigation technologies and management practices. Features supporting structural failures (dams, levees, floodwalls, etc.) allow detailed analysis of emergency response scenarios. A powerful feature of xp**swmm** or **xpstorm** with xp**2D** is its ability to dynamically link to any 1D (quasi-2D) model in an integrated fashion. The user sets up the model as a combination of 1D network domains linked to 2D domains as single model.

TUFLOW is a computer program for simulating depth-averaged, two and one-dimensional free-surface flows such as occurs from floods and tides. TUFLOW, originally developed for just two-dimensional (2D) flows, stands for Two-dimensional Unsteady FLOW. It now incorporates, the full functionality of the ESTRY 1D network or quasi-2D modeling system based on the full one-dimensional (1D) free-surface flow equations (see below). The fully 2D solution algorithm solves the full two-dimensional, depth averaged, momentum and continuity equations for free-surface flow. Advanced 2D/1D linking and GIS data management have greatly increased the power of TUFLOW.

TUFLOW is specifically orientated towards establishing flow patterns in coastal waters, estuaries, rivers, floodplains and urban areas where the flow patterns are essentially 2D in nature and cannot or would be awkward to represent using a 1D network model.

TUFLOW solves the depth averaged 2D shallow water equations (SWE). The SWE are the equations of fluid motion used for modeling long waves such as floods, ocean tides and storm surges. They are derived using the hypotheses of vertically uniform horizontal velocity and negligible vertical acceleration (ie. a hydrostatic pressure distribution). These assumptions are valid where the wave length is much greater than the depth of water. In the case of the ocean tide the SWE are applicable everywhere.

The 2-D SWE in the horizontal plane are described by the partial differential equations (next page) of mass continuity and momentum conservation in the X and Y directions for an in-plan cartesian coordinate frame of reference.

$$\frac{\partial \zeta}{\partial t} + \frac{\partial (Hu)}{\partial x} + \frac{\partial (Hv)}{\partial y} = 0 \qquad \text{(2D Continuity)}$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} - c_f\, v + g\frac{\partial \zeta}{\partial x} + g\, u\frac{\sqrt{u^2+v^2}}{C^2 H} - \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) + \frac{1}{\rho}\frac{\partial p}{\partial x} = F_x \qquad \text{(X Momentum)}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + c_f\, u + g\frac{\partial \zeta}{\partial y} + g\, v\frac{\sqrt{u^2+v^2}}{C^2 H} - \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right) + \frac{1}{\rho}\frac{\partial p}{\partial y} = F_y \qquad \text{(Y Momentum)}$$

where

ζ = *Water surface elevation*

u and v = *Depth averaged velocity components in X and Y directions*

H = *Depth of water*

t = *Time*

x and y = *Distance in X and Y directions*

c_f = *Coriolis force coefficient*

C = *Chezy coefficient*

μ = *Horizontal diffusion of momentum coefficient*

p = *Atmospheric pressure*

ρ = *Density of water*

F_x *and* F_y = *Sum of components of external forces (eg. wind) in X and Y directions*

The terms of the SWE can be attributed to different physical phenomena. These are propagation of the wave due to gravitational forces, the transport of momentum by advection, the horizontal diffusion of momentum, and external forces such as bed friction, rotation of the earth, wind, wave radiation stresses, and barometric pressure.

The computational procedure used is an alternating direction implicit (ADI) finite difference method involves two stages, each having two steps, giving four steps overall. Each step involves solving a tri-diagonal matrix.

Stage 1, step 1 solves the momentum equation in the Y-direction for the Y-velocities. The equation is solved using a predictor/corrector method, which involves two sweeps. For the first sweep, the calculation proceeds column by column in the Y-direction. If the signs of all velocities in the X-direction are the same the second sweep is not necessary, otherwise the calculation is repeated sweeping in the opposite direction.

The second step of Stage 1 solves for the water levels and X-direction velocities by solving the equations of mass continuity and of momentum in the X-direction. A tri-diagonal equation is obtained by substituting the momentum equation into the mass equation and eliminating the X-velocity. The water levels are calculated and back substituted into the momentum equation to calculate the X-velocities. This process is repeated for a recommended two iterations. Testing on a number of models showed there to be little benefit in using more than two iterations.

Stage 2 proceeds in a similar manner to Stage 1 with the first step using the X-direction momentum equation and the second step using the mass equation and the Y-direction momentum equation.

The solution has been enhanced and improved to provide much more robust wetting and drying of elements, upstream controlled flow regimes (eg. supercritical flow and upstream controlled weir flow), modifications to cells to model structure obverts (eg. bridge decks) and additional energy losses due to fine-scale features such as bridge piers.

5.1.3.2 Model Configuration

The Village of Lincolnwood owns a highly detailed triangulated irregular network (TIN) topographic data set (Figure 23). XP-SWMM, however, requires a grid-based digital elevation model (DEM) as input. Using GIS geoprocessing tools, the TIN was converted to a 5-foot DEM for import into XP-SWMM.

Once the DEM has been imported into XP-SWMM, a 2-dimensional grid cell size must be specified. The input DEM will be averaged according to the specified cell size. While matching the cell size of the input DEM (5-foot) would give highly precise results, the computational time and memory and hard disk requirements of this level of detail made this high of a resolution impractical. Therefore a 15-foot grid size was specified. This reduced computer computational requirements to a manageable level while providing sufficient for alternative analyses.

5.1.4 M ODEL VERIFICATION

The model that had been developed for Phase I had been calibrated to reproduce the flows and water levels of several measured storms (AB&H, 2010). Rather than recalibrate the model to these measured events, a hypothetical design storm was run through both the Phase I and Phase II models. If both models produced similar flows for the same event, one can assume the Phase II model is sufficiently accurate.

Figure 21 compares the flows at the same downstream location in both the Phase I and Phase II models. This comparison verifies the accuracy of the Phase II model.

5.1.5 M ODEL ASSUMPTIONS & LIMITATIONS

No model is perfect in that all models are mathematical representations of extremely complex real-world phenomena. Collection system models are certainly no different. While with additional time and expense model precision can be improved, it tends to follow a law of diminishing returns, where each incremental increase in cost results in a smaller incremental increase in precision. Therefore modelers must take care to develop a tool that is suitable for the problem that one is trying to solve or the question one is attempting to answer, without spending an inordinate amount of time and budget developing a model that is more detailed than what is appropriate.

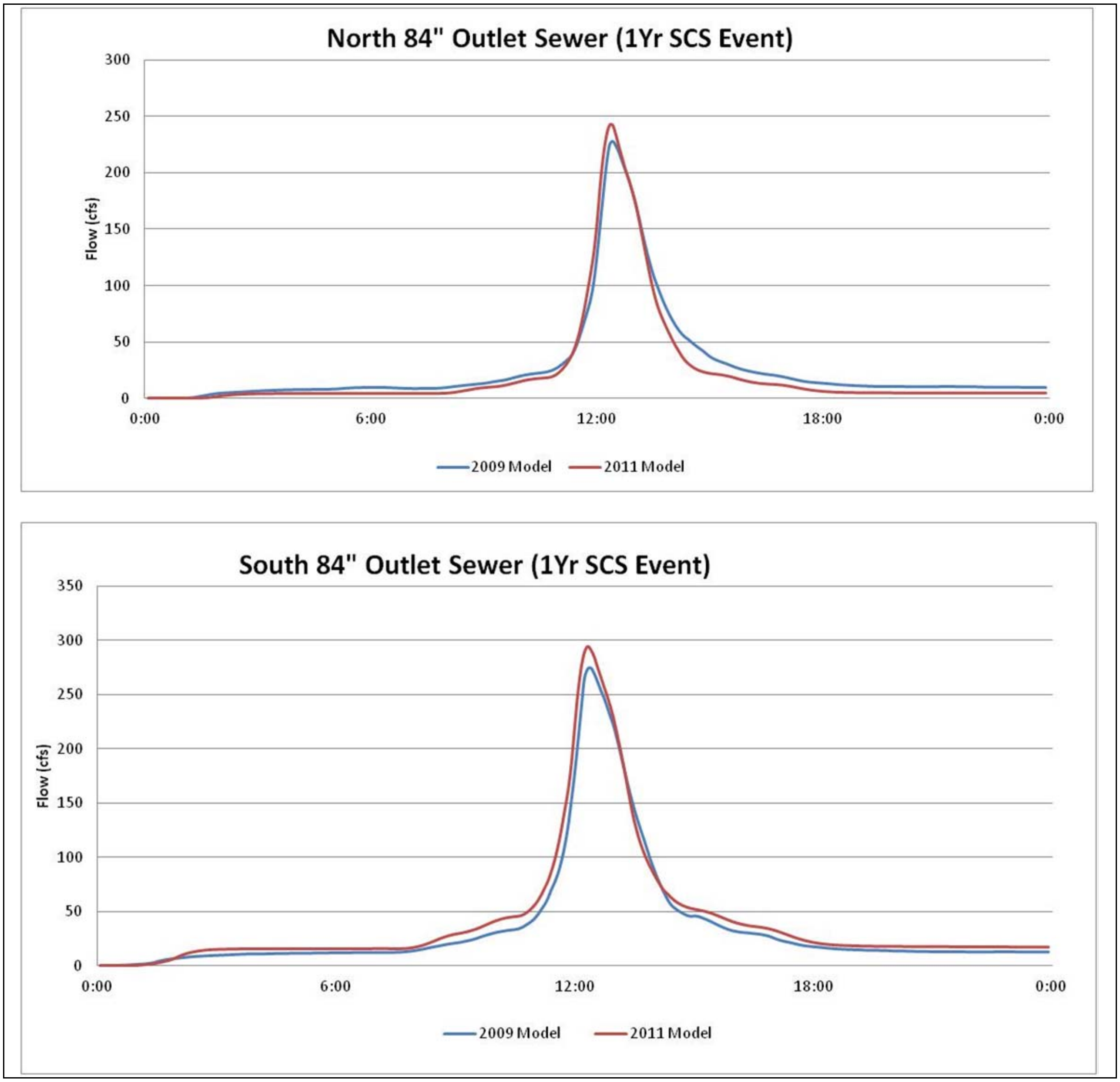


Figure 21 – Model Verification

Modelers must make many simplifying assumptions and understand the implications thereof in order to develop a model the produces reliable results. One must take care when interpreting model results to do so with an understanding of the models precision and limitations. While many assumptions and simplifications were made during model development, a list of the most significant follows:

- All sewers were assumed to be clean and in good conditions;
- Subcatchments were presumed to be homogeneous;
- Design rainfall events were presumed to fall uniformly over the entire service area;
- The MWRDGC interceptor was assumed not to be surcharged to the level of Lincolnwood's sewer system;
- All homes were presumed to have basements lacking flood protection;
- All homes' basement areas were assumed to be equal to the building footprint;
- All homes were presumed to discharge their downspouts onto their lawns;
- The topographic data was created using LIDAR, a remote sensing technology. While it is the most accurate topographic data available for a large-scale two-dimensional analysis, it may contain anomalies that incorrectly predict the extent of surface ponding.
- All of the proposed inlet restrictors were presumed to be flowing freely.

5.2 D ESIGN STORMS

The model requires a rainfall hyetograph as input. 24-hour rainfall volumes (Table 7) for a range of recurrence intervals were selected from Bulletin 71 (Midwestern Climate Center, 1992). These rainfall volumes were distributed over a 24-hour period using the SCS Type II distribution (Figure 22). Using this distribution eliminates the need to run a series of design storms of varying durations for each recurrence interval. Approximately 50% of the 24-hour rainfall total falls within the peak two hours of the distribution.

Table 7 – Design Storms

Recurrence Interval (Years)	Likelihood of Occurrence	24-Hour Volume (in)
1	-	2.51
2	50%	3.04
5	20%	3.80
10	10%	4.47
25	4%	5.51

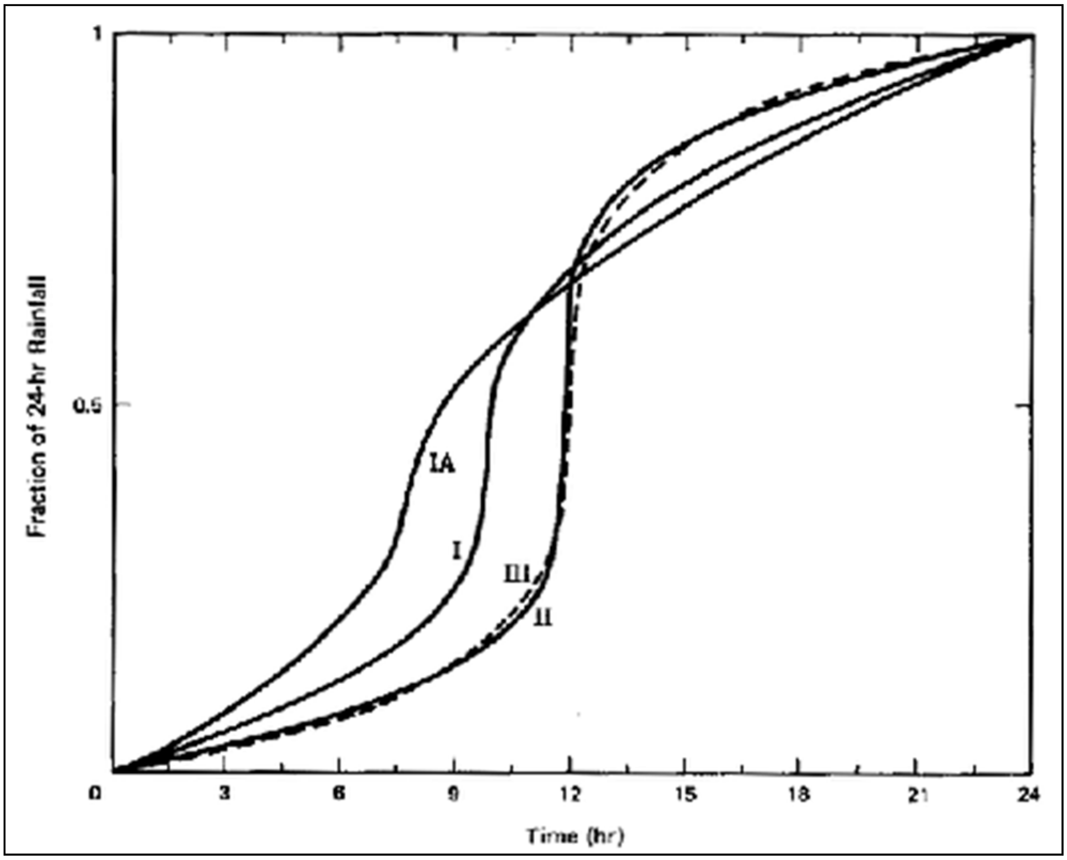


Figure 22 – SCS Rainfall Distributions

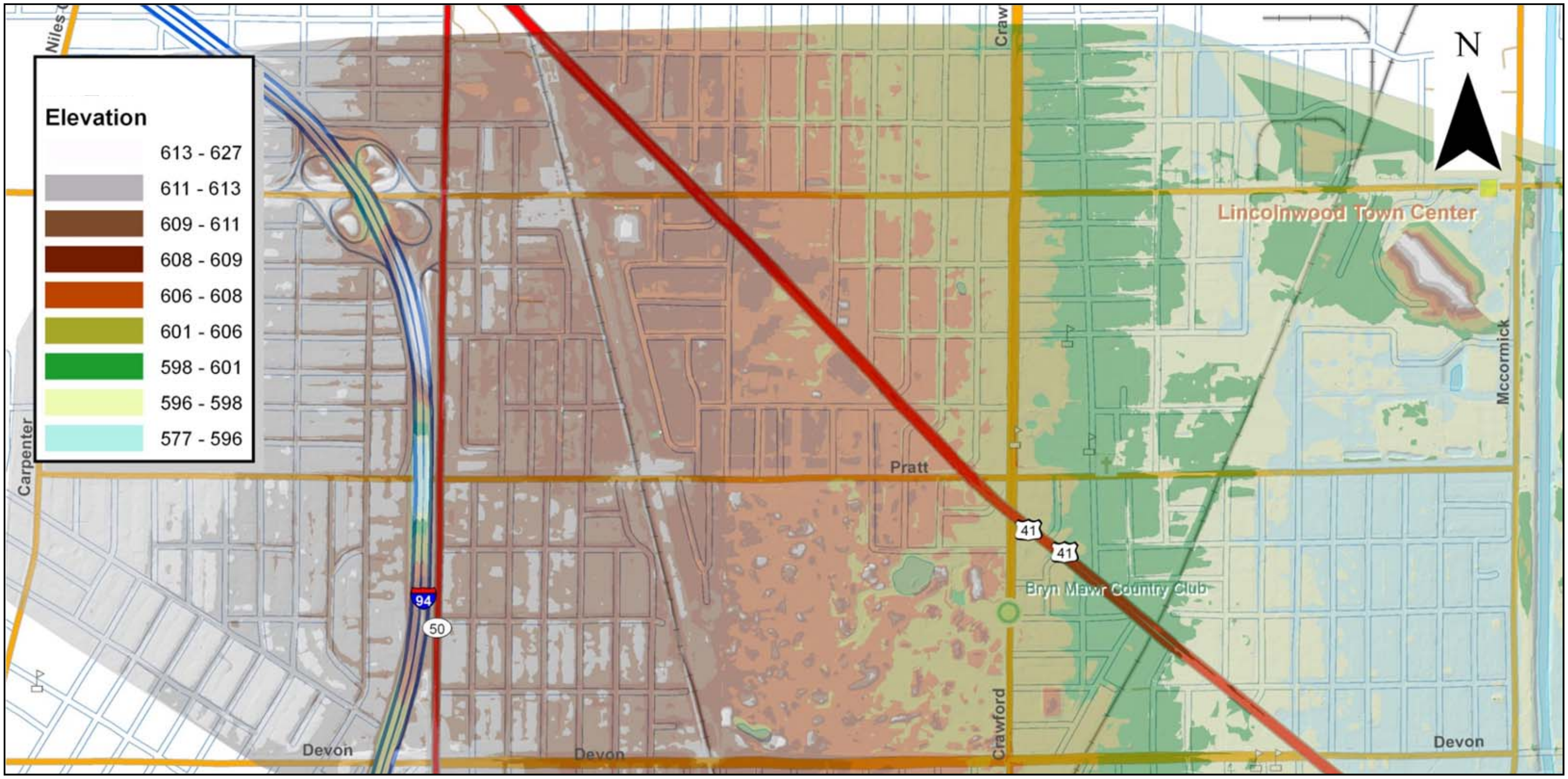


Figure 23 – Topography

5.3 DETAILED COST ESTIMATES

5.3.1 ALTERNATIVE 1

Alternative 1 has two primary cost components, berms and restrictors. The costs of the 152 berms and the hanging trap restrictors are provided in the table below:

Table 8 – Containment Berm & Hanging Trap Opinion of Probable Construction Cost

Item	QTY	Units	Unit Cost	Cost
Asphalt	13	CY	$100	$ 1,300
Curb & Gutter	60	LF	$10	$ 600
Inlet	2	EA	$1,300	$ 2,600
12" drain tile	30	LF	$40	$ 1,200
Sub-Total Cost per Berm				$ 5,700
Contingency			40%	$ 2,280
Total Cost per Berm				$ 7,980
Total # of Berms				152
Total Berm Cost				$ 1,212,960
Hanging Traps	3981	EA	$1,100	$4,379,100
Total Cost (Street Storage)				**$ 5,592,060**

For comparison, the cost of shear gate flow control devices similar to those used in Wilmette were developed. At each intersection, each catch basin currently ties in directly to the combined sewer manhole. The use of shear gates requires re-routing all of the catch basins in an intersection through a single catch basin which would be connected to the combined sewer. By consolidating multiple catch basins through a single regulator, the size of the regulator can be enlarged, reducing the likelihood of clogging. The combined sewer connection would have a shear gate to regulate the flow collected by all the inlets and catch basins in the intersection. The total cost to install the approximately 678 shear gates (with 2 re-routed catch basins per connection) is as follows:

Table 9 – Shear Gate Opinion of Probable Construction Cost

Item	QTY	Units	Unit Cost	Cost
Catch basin removal	3	EA	$150	$450
Inlet	2	EA	$1,300	$2,600
Catch basin	1	EA	$2,000	$2,000
12" inlet lead	30	LF	$40	$1,200
Asphalt removal	165	SY	$0.50	$83
3" Asphalt Pavement	165	SY	$25	$4,125
Shear Gate	1	EA	$500	$500
Sub-Total Cost Per Connection				$10,958
Contingency			25%	$2,739
Engineering			15%	$1,644
Total Cost Per Connection				$15,341
# of Connections				678
Total Shear Gate Installation Cost				$10,400,859

*All dollar values displayed to the nearest whole dollar amount.

Shear gates increase the cost of Alternative 1 by about $6M, so this study presumes the use of hanging trap restrictors. The Village is currently pilot testing filters which screen out leaves and debris by effectively increasing the effective area of the restrictor opening thereby reducing the likelihood of clogging.

5.3.2 Alternative 2

Table 10 is a summary of the estimates of probable costs of all the projects noted in Figure 9. Detailed estimates by project are in Table 11 through
.

Table 10 – Alternative 2 Summary of Opinions of Probable Costs, Alternative 2

Village of Lincolnwood Stormwater Modeling Project	
Project #1.1	$ 3,908,687
Project #1.3	$ 2,347,500
Project #2	$ 2,137,650
Project #3	$ 2,843,679
Project #4	$ 2,395,478
Project #5	$ 1,335,398
Project #6	$ 1,710,210
Project #7	
Project #8	$ 1,933,168
Project #9.3	$ 9,427,386
Total Cost	**$ 28,039,156**

*All dollar values displayed to the nearest whole dollar amount.

Table 11 – Project #1.1 Opinion of Probable Costs

Village of Lincolnwood					
Stormwater Modeling Project					
PROJECT #1.1 CONCEPTUAL LEVEL COST ESTIMATE					
ITEM	**Units**	**Quantity**	**Unit Cost ($)**	**Initial Cost ($)**
36" Pipe	LF	**4,560**	**470**	2,143,200
Subtotal				2,143,200
Contingency			**40%**	857,280
Subtotal				3,000,480
Total Sewer Construction Cost				**3,000,480**
Detention Pond	gal	1,138,223	$0.35	398,378
Total Construction Cost				3,398,858
Engineering			**15%**	509,829
Total Initial Cost				**3,908,687**

*All dollar values displayed to the nearest whole dollar amount.

Note: Costs do not include land acquisition.

Table 12 – Project #2 Opinion of Probable Costs

Village of Lincolnwood
Stormwater Modeling Project

PROJECT #2 CONCEPTUAL LEVEL COST ESTIMATE

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Installation depth <=4'				
8" diameter PVC pipe	LF	100	111	11,100
Installation depth >4'<=6'				
10" diameter PVC pipe	LF	50	156	7,800
24" diameter PVC Pipe	LF	1,143	270	308,610
Installation depth >6'<=10'				
12" diameter RCP pipe	LF	215	182	39,130
15" diameter RCP pipe	LF	50	226	11,300
21" diameter RCP pipe	LF	40	272	10,880
30" diameter RCP pipe	LF	319	427	136,213
36" diameter RCP pipe	LF	700	486	340,200
Subtotal				865,233
Contingency			40%	346,093
Total Sewer Construction Cost				**1,211,326**
Detention Pond	gal	1,850,000	$0.35	647,500
Total Construction Cost				1,858,826
Engineering			15%	278,824
Total Initial Cost				**2,137,650**

*All dollar values displayed to the nearest whole dollar amount.

Note: Costs do not include land acquisition.

Table 13 – Project #3 Opinion of Probable Costs

Village of Lincolnwood
Stormwater Modeling Project

PROJECT #3 CONCEPTUAL LEVEL COST ESTIMATE

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Installation depth >4'<=6'				
15" diameter RCP pipe	LF	300	205	61,500
Installation depth >6'<=10'				
15" diameter RCP pipe	LF	300	226	67,800
24" diameter RCP pipe	LF	300	294	88,200
30" diameter RCP pipe	LF	300	427	128,100
36" diameter RCP pipe	LF	1,760	486	855,360
48" diameter RCP pipe	LF	400	632	252,800
Subtotal				1,453,760
Contingency			40%	581,504
Total Sewer Construction Cost				**2,035,264**
Detention Pond	gal	1,250,000	$0.35	437,500
Total Construction Cost				2,472,764
Engineering			15%	370,915
Total Initial Cost				**2,843,679**

*All dollar values displayed to the nearest whole dollar amount.

Note: Costs do not include land acquisition.

Table 14 – Project #4 Opinion of Probable Costs

Village of Lincolnwood				
Stormwater Modeling Project				
ITEM	**Units**	**Quantity**	**Unit Cost ($)**	**Initial Cost ($)**
Installation depth >6'<=10'				
36" diameter RCP pipe	LF	3,018	493	1,487,874
Subtotal				1,487,874
Contingency			40%	595,150
Total Construction Cost				**2,083,024**
Engineering			15%	312,454
Total Initial Cost				**2,395,478**

*All dollar values displayed to the nearest whole dollar amount.

Table 15 – Project #5 Opinion of Probable Costs

Village of Lincolnwood Stormwater Modeling Project				
ITEM	**Units**	**Quantity**	**Unit Cost ($)**	**Initial Cost ($)**
18" diameter RCP pipe	LF	1,500	242	363,000
60" diameter RCP pipe	LF	552	845	466,440
Subtotal				829,440
Contingency			40%	331,776
Total Construction Cost				**1,161,216**
Engineering			15%	174,182
Total Initial Cost				**1,335,398**

*All dollar values displayed to the nearest whole dollar amount.

Table 16 – Project #6 Opinion of Probable Costs

Village of Lincolnwood				
Stormwater Modeling Project				
PROJECT #6 CONCEPTUAL LEVEL COST ESTIMATE				
ITEM	**Units**	**Quantity**	**Unit Cost ($)**	**Initial Cost ($)**
Installation depth >4'<=6'				
21" diameter RCP pipe	LF	533	249	132,717
30" diameter RCP pipe	LF	625	400	250,000
Installation depth >6'<=10'				
21" diameter RCP pipe	LF	50	272	13,600
30" diameter RCP pipe	LF	295	427	125,965
36" diameter RCP pipe	LF	360	486	174,960
Subtotal				697,242
Contingency			40%	278,897
Total Sewer Construction Cost				**976,139**
Detention Pond	gal	1,460,000	$0.35	511,000
Total Construction Cost				1,487,139
Engineering			15%	223,071
Total Initial Cost				**1,710,210**

*All dollar values displayed to the nearest whole dollar amount.

Note: Costs do not include land acquisition.

Table 17 – Project #7 Opinion of Probable Costs

Village of Lincolnwood
Stormwater Modeling Project

PROJECT #7 CONCEPTUAL LEVEL COST ESTIMATE

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Installation depth >6'<=10'				
24" diameter RCP pipe	LF	402	294	118,188
36" diameter RCP pipe	LF	330	486	160,380
Subtotal				278,568
Contingency			40%	111,427
Total Construction Cost				**389,995**
Engineering			15%	58,499
Total Initial Cost				**448,494**

*All dollar values displayed to the nearest whole dollar amount.

Table 18 – Project #8 Opinion of Probable Costs

Village of Lincolnwood
Stormwater Modeling Project

PROJECT #8 CONCEPTUAL LEVEL COST ESTIMATE

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
60" RCP pipe	LF	331	1,206	399,186
72" RCP pipe	LF	657	1,220	801,540
Subtotal				1,200,726
Contingency			40%	480,290
Total Construction Cost				**1,681,016**
Engineering			15%	252,152
Total Initial Cost				**1,933,168**

*All dollar values displayed to the nearest whole dollar amount.

Table 19 – Project #9.1 Opinion of Probable Costs

Village of Lincolnwood				
Stormwater Modeling Project				
PROJECT #9.1 CONCEPTUAL LEVEL COST ESTIMATE				
ITEM	**Units**	**Quantity**	**Unit Cost ($)**	**Initial Cost ($)**
24" Pipe	LF	**83**	**253**	20,999
36" Pipe	LF	**4,603**	**472**	2,172,616
42" Pipe	LF	**2,460**	**578**	1,421,880
48" Pipe	LF	**669**	**615**	411,435
60" Pipe	LF	**3628**	**859**	3,116,452
Subtotal				7,143,382
Contingency			**40%**	2,857,353
Total Construction Cost				**10,000,735**
Engineering			**15%**	1,500,110
Total Initial Cost				**11,500,845**

*All dollar values displayed to the nearest whole dollar amount.

Table 20 – Project #9.2 Opinion of Probable Costs

Village of Lincolnwood
Stormwater Modeling Project

PROJECT #9.2 CONCEPTUAL LEVEL COST ESTIMATE

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
24" Pipe	LF	83	253	20,999
36" Pipe	LF	2,717	479	1,301,443
42" Pipe	LF	2,383	551	1,313,033
48" Pipe	LF	719	626	450,094
60" Pipe	LF	1975	806	1,591,850
Subtotal				4,677,419
Contingency			40%	1,870,968
Total Sewer Construction Cost				**6,548,387**
96" Storage Pipe	LF	7,086	1,092	7,737,912
Total Construction Cost				**14,286,299**
Engineering			15%	2,142,945
Total Initial Cost				**16,429,244**

*All dollar values displayed to the nearest whole dollar amount.

Table 21 – Project #9.3 Opinion of Probable Costs

Village of Lincolnwood				
Stormwater Modeling Project				
PROJECT #9.3 CONCEPTUAL LEVEL COST ESTIMATE				
ITEM	**Units**	**Quantity**	**Unit Cost ($)**	**Initial Cost ($)**
24" Pipe	LF	83	253	20,999
36" Pipe	LF	2,717	479	1,301,443
42" Pipe	LF	2,383	551	1,313,033
48" Pipe	LF	719	626	450,094
60" Pipe	LF	1975	806	1,591,850
Subtotal				4,677,419
Contingency			40%	1,870,968
Total Sewer Construction Cost				**6,548,387**
Detention Pond	gal	4,712,400	0.35	1,649,340
Total Construction Cost				**8,197,727**
Engineering			15%	1,229,659
Total Initial Cost				**9,427,386**

*All dollar values displayed to the nearest whole dollar amount.

5.4 Supplemental Analyses

During the course of the study, two supplemental analyses were conducted. The Crawford Storm Sewer study was required to provide assurance to the Village Skokie that discharging storm runoff to a sewer being constructed along Crawford would not negatively impact their system. The July 23rd analysis was conducted in response to the storm that occurred this year, which raised concerns regarding the validity of the model. These two analyses have been included in their entireties.

5.4.1 Crawford Storm Sewer

5.4.1.1 Summary of Results

We have completed the hydraulic evaluation of the Skokie sewer and the impacts of increasing the proposed 18-in restrictor. Table 22 summarizes the impact a range of increases in restrictor size has on the Howard Avenue storm sewer. Sewer profiles including the peak hydraulic grade line (HGL) of the Crawford Avenue sewer to the Howard Avenue outfall for the various scenarios are also included. (See Table 23.)

The XP-SWMM model indicates that the Howard Avenue sewer has adequate capacity to accommodate the 10-year flows from Crawford Avenue as planned, using an 18" restrictor (Figure 25). With a restrictor of this size, the additional flow from Crawford Avenue raises the peak water level of the Howard Avenue sewer only 0.68' above existing conditions. Increasing the size of the restrictor to 25.5 inches increases its discharge rate by 30%, at which point the downstream Crawford Avenue sewer is approaching full pipe capacity, while the Howard Avenue sewer has available capacity (Figure 28). The capacity of the Crawford Avenue sewer appears to be what determines the maximum allowable restrictor discharge, not the Howard Avenue sewer.

5.4.1.2 Evaluation Methodology

The Howard Avenue sewer model was originally developed for the Federal Highway Administration (FHWA). The Village of Skokie provided the model to Water Resources Modeling, LLC. for this analysis, Water Resources Modeling, LLC. converted this model to XP-SWMM. Table 24 compares the results of the original and XP-SWMM models.

The model was initially run by Donohue using the configuration provided by Water Resources Modeling, LLC.. The model was then re-run using the 10-Year SCS Type II storm which produced slightly less flows and lower hydraulic grade lines (HGLs) than the original model predicted (Figure 1). Next, the Crawford Avenue sewer was added and the model was re-run. This verified that the Crawford

Avenue sewer was operating as the Cook County Highway Department intended (Figure 25). Table 25 lists peak flows in the Crawford Avenue and Howard Avenue sewers for each system configuration. The highlighted column is the recommended alternative.

Finally, the model was merged with the complete Lincolnwood model including 2D overland flow (Figure 26). This model included all recommended system improvements, including in-line storage along Jarvis Avenue, to accurately predict the volume of storage required along Jarvis Avenue for a range of restrictor sizes.

Next, a series of simulations were run where the size of the restrictor was increased to 20", 22" and 25.5", thereby increasing its area by 20%, 50%, and 100% respectively and resulting in discharges of 18 millions of gallons day (mgd), 19 mgd, and 21 mgd respectively. The orifice was not enlarged any further because at

25.5", the Crawford Avenue sewer downstream of the restrictor was reaching its capacity. Under the last scenario, with the 25.5" restrictor, the Howard Avenue sewer had capacity remaining.

While the orifice equation stipulates that discharge is linearly dependent on orifice area, this turned out to not be the case because the orifice does not flow freely. Increases in flows through the orifice caused increases in the downstream water surface elevation, reducing the orifice's discharge as compared to what to it would be under free discharge conditions.

5.4.1.3 Jarvis Avenue Box Culvert Sizing & Pricing

In order to provide basement flood protection for the area indicated in Figure 29, Donohue recommends installing in-line storage along Jarvis Avenue. The volume of in-line storage required is dependent upon the size and release rate of the restrictor on Crawford Avenue.

Using the XP-SWMM model, Donohue ran the 10-year design storm for each of the three restrictor sizes to assess how increasing the restrictor impacts the required storage volume. Hydrographs of the flow exiting the proposed Jarvis Avenue sewer are provided in Figure 30. The peak flow exiting the Jarvis Avenue sewer increases with increasing restrictor size.

Table 26 summarizes the required storage volumes, sizes, and costs resulting from the three restrictor sizes. Increasing the restrictor size does not significantly reduce the required Jarvis Avenue storage volume and does not reduce the size or cost of this storage. There are several reasons for this, the primary reason being that during a 10-year storm, runoff enters the Jarvis Avenue sewer at a rate so much faster than the restrictor can pass it, that only a small percentage of the runoff passes through the restrictor while the pipe is filling; the flow which the restrictor does not pass during this time must be stored. Furthermore, 60% of the additional discharge capacity a larger restrictor allows is taken by flows from the Crawford Avenue sewer. Finally, a small portion of the flow from the Crawford Avenue sewer backs up into the Jarvis Avenue sewer early in the event, however this volume is relatively small and does not affect the size of the proposed sewer. Therefore increasing the restrictor size does not significantly reduce the required storage volume.

5.4.1.4 Adjacent Flood-Prone Area

There is an area bounded by Crawford Avenue, Hamlin Avenue, Jarvis Avenue, and Touhy Avenue that is particularly flood-prone (Figure 31). The existing combined sewers here are shallow and undersized. Donohue is evaluating alternatives to provide a greater level of protection from flooding for this area within the context of the Village-wide stormwater management program. Alternatives include installing inlet restrictions and surface storage containment berms to maximize utilization of available surface storage while limiting flows into the combined sewer system to what it can safely convey. In addition, Donohue is currently considering conveying a portion of the surface runoff to the proposed storm sewers at Jarvis Avenue and Crawford Avenue. While this modification is currently under evaluation, it is not anticipated that this improvement will affect the sizing of the Crawford Avenue or Jarvis Avenue sewers.

5.4.1.5 Summar y & Recommendations

Donohue recommends that Lincolnwood request that the County provide a 36" stub extending to the west side of the Crawford Avenue project limits at Jarvis Avenue. In light of the more robust model results, Donohue recommends that Lincolnwood not request that Skokie increase the restrictor above 18". Doing so does not reduce the size of the in-line storage required along Jarvis Avenue. However, installing the recommended in-line storage at Jarvis Avenue and connecting it to the County storm sewer at Crawford Avenue provides the following benefits:

- Basement flood protection for up to the 10-year rainfall event for the area highlighted in Figure 6 by storing excess storm runoff that would otherwise overload the combined sewer system
- Discharging the proposed Jarvis Avenue sewer into the Crawford Avenue storm sewer diverts 9 mgd of flow away from the combined sewer system, providing a higher level of protection from basement backups for the region
- Discharging to the Crawford Avenue storm sewer will keep storm runoff out of Lincolnwood's combined sewer system, thereby reducing combined sewer overflows containing raw sewage into area waterways

Table 22 – Hydraulic Evaluation Summary

Scenario	Restrictor Size (in)	Peak Restrictor Discharge (mgd)	Peak HGL* (ft)	Avg Increase In Peak HGL* (ft)	Minimum Freeboard** (ft)	Jarvis Sewer Description
Existing Conditions (10 Year HYDRAIN Conversion)	NA	0	592.55	0.77	5.55	NA
Existing Conditions (10 Year SCS Storm)	N/A	0	591.78	0***	6.54	NA
Crawford storm sewer added, no surface storage	18	13.52	592.45	0.68	5.72	NA
Crawford storm sewer added, with surface storage	18	19.62	592.49	0.72	5.65	NA
Crawford & Jarvis storm sewers added, with surface storage	18	16.40	592.34	0.57	5.84	First 500' is 36" RCP followed by 2300 ft of 3'x6' Box Culvert (X2)
Crawford & Jarvis storm sewers added, with surface storage	20	17.85	592.41	0.63	5.77	First 500' is 36" RCP followed by 2300 ft of 3'x6' Box Culvert (X2)
Crawford & Jarvis storm sewers added, with surface storage	22	19.30	592.48	0.71	5.69	First 500' is 36" RCP followed by 2300 ft of 3'x6' Box Culvert (X2)
Crawford & Jarvis storm sewers added, with surface	25.5	21.20	592.58	0.81	5.62	First 500' is 36" RCP followed by 2300 ft of 3'x6' Box Culvert (X2)

* Intersection of Howard & Crawford
** Critical Manhole is DS of Crawford/Howard Connection
*** Baseline condition.

Table 23 – Summary of Sewer Profile Configurations

Figure	Configuration
Figure 1	Existing Conditions
Figure 2	Proposed Crawford Sewer Added, 18” Restrictor
Figure 3	Crawford & Jarvis Storm Sewers Added, 2D Flows, 18” Restrictor
Figure 4	Crawford & Jarvis Storm Sewers Added, 2D Flows, 22” Restrictor
Figure 5	Crawford & Jarvis Storm Sewers Added, 2D Flows, 25.5” Restrictor

Table 24 – Howard Avenue Storm Sewer Model Conversion Results

Pipe Flow (cfs) Hydrain					Pipe Flow (cfs) XP-SWMM					Pipe Flow Comparison				
15-min	30-min	60-min	120-min	Max	15-min	30-min	60-min	120-min	Max	15-min	30-min	60-min	120-min	Max
0.80	0.54	0.35	0.22	0.80	1.11	1.19	0.95	0.65	1.19	27.6%	54.8%	63.2%	66.3%	33.0%
7.18	4.89	3.11	1.96	7.18	7.91	7.75	6.46	4.99	7.91	9.2%	36.9%	51.8%	60.7%	9.2%
9.83	6.70	4.26	2.68	9.83	9.69	9.81	8.85	6.78	9.81	-1.4%	31.7%	51.9%	60.4%	-0.2%
13.50	9.40	5.98	3.76	13.50	12.80	13.56	12.30	9.36	13.56	-5.5%	30.7%	51.4%	59.8%	0.4%
16.35	11.99	7.63	4.80	16.35	15.43	16.89	15.52	11.90	16.89	-6.0%	29.0%	50.8%	59.7%	3.2%
16.69	12.22	7.77	4.89	16.69	15.38	17.02	15.69	12.08	17.02	-8.5%	28.2%	50.5%	59.5%	1.9%
18.81	14.74	9.38	5.90	18.81	16.96	19.02	17.78	14.08	19.02	-10.9%	22.5%	47.3%	58.1%	1.1%
20.32	16.46	10.47	6.59	20.32	17.15	19.48	18.54	15.29	19.48	-18.5%	15.5%	43.5%	56.9%	-4.3%
19.91	18.78	11.95	7.51	19.91	18.27	21.04	20.26	17.00	21.04	-9.0%	10.7%	41.0%	55.8%	5.4%
21.02	21.24	13.53	8.51	21.24	19.64	22.94	22.30	18.95	22.94	-7.0%	7.4%	39.3%	55.1%	7.4%
21.61	23.36	14.94	9.40	23.36	20.64	24.42	24.07	20.63	24.42	-4.7%	4.3%	37.9%	54.4%	4.3%
21.88	25.90	16.67	10.48	25.90	21.53	25.78	25.77	22.19	25.78	-1.6%	-0.5%	35.3%	52.8%	-0.5%
22.87	28.07	18.28	11.49	28.07	23.00	27.70	27.91	24.14	27.91	0.6%	-1.3%	34.5%	52.4%	-0.6%
23.86	30.33	20.02	12.59	30.33	24.54	29.77	30.25	26.32	30.25	2.8%	-1.9%	33.8%	52.2%	-0.3%
24.21	32.25	21.77	13.69	32.25	26.20	31.97	32.59	28.44	32.59	7.6%	-0.9%	33.2%	51.9%	1.0%
24.01	33.39	22.68	14.26	33.39	26.81	32.61	33.57	29.55	33.57	10.4%	-2.4%	32.4%	51.7%	0.5%

Table 25 – Peak Pipe Flows (10-Year SCS Type II Storm)

		Scenario					
Location	XP-SWMM Link Name	1-D Skokie System w/ 10yr SCS 24hr Storm Q_{max} (cfs)	1-D Crawford Sewer Only Q_{max} (cfs)	2-D Jarvis + Crawford Sewers 18 inch Orifice Q_{max} (cfs)	2-D Jarvis + Crawford Sewers 20 inch Orifice Q_{max} (cfs)	2-D Jarvis + Crawford Sewers 22 inch Orifice Q_{max} (cfs)	2-D Jarvis + Crawford Sewers 25.5 inch Orifice Q_{max} (cfs)
Crawford	Link1856	5.2	25.6	27.2	29.6	32.0	35.0
	Link1857	9.0	29.0	28.6	31.1	33.6	36.6
Howard from Crawford to the North Shore Channel	Link1844	34.7	53.5	50.2	52.1	54.1	56.8
	L50	36.2	54.8	51.4	53.4	55.4	58.0
	L47	37.7	56.3	52.8	54.7	56.7	59.4
	Link1847	40.5	58.9	55.4	57.3	59.3	61.9
	Link1848	43.2	61.4	57.9	59.8	61.7	64.4
	Link1859	45.7	63.8	60.3	62.2	64.0	66.6
	Link1858	45.7	63.8	60.3	62.2	64.0	66.6
	L27	48.3	66.2	62.7	64.6	66.4	68.9
	L28	48.3	66.2	62.7	64.6	66.4	69.0
	L31	48.4	66.3	62.8	64.6	66.5	69.0
	L34	48.4	66.3	62.8	64.6	66.5	69.0
	L37	48.4	66.3	62.8	64.6	66.5	69.0
	L13	50.4	68.1	64.6	66.4	68.3	70.8
	L9	50.4	68.1	64.6	66.5	68.3	70.8
	L5	50.4	68.1	64.6	66.5	68.3	70.8
	L3	50.4	68.1	64.6	66.4	68.3	70.8
	L2	50.4	68.1	64.6	66.4	68.3	70.8
	L15	50.4	68.1	64.6	66.5	68.3	70.8
	L1	50.4	68.1	64.6	66.4	68.3	70.8
	L22	50.5	68.2	64.7	66.5	68.3	70.8
	L23	50.5	68.2	64.7	66.5	68.4	70.9

Table 26 – Jarvis Sewer Sizing & Cost

Restrictor Size (in)	Peak Jarvis Sewer Discharge (mgd)	Peak Restrictor Discharge (mgd)	Jarvis Sewer Volume (MG)	Recommended Sewer Size	Approximate Sewer Cost
18	9.1	16.4	0.62	2300 L.F. of parallel 3' X 6' Box Culvert	$2,000,000
22	10.2	19.3	0.60	2300 L.F. of parallel 3' X 6' Box Culvert	$2,000,000
25.5	11.0	21.2	0.57	2300 L.F. of parallel 3' X 6' Box Culvert	$2,000,000

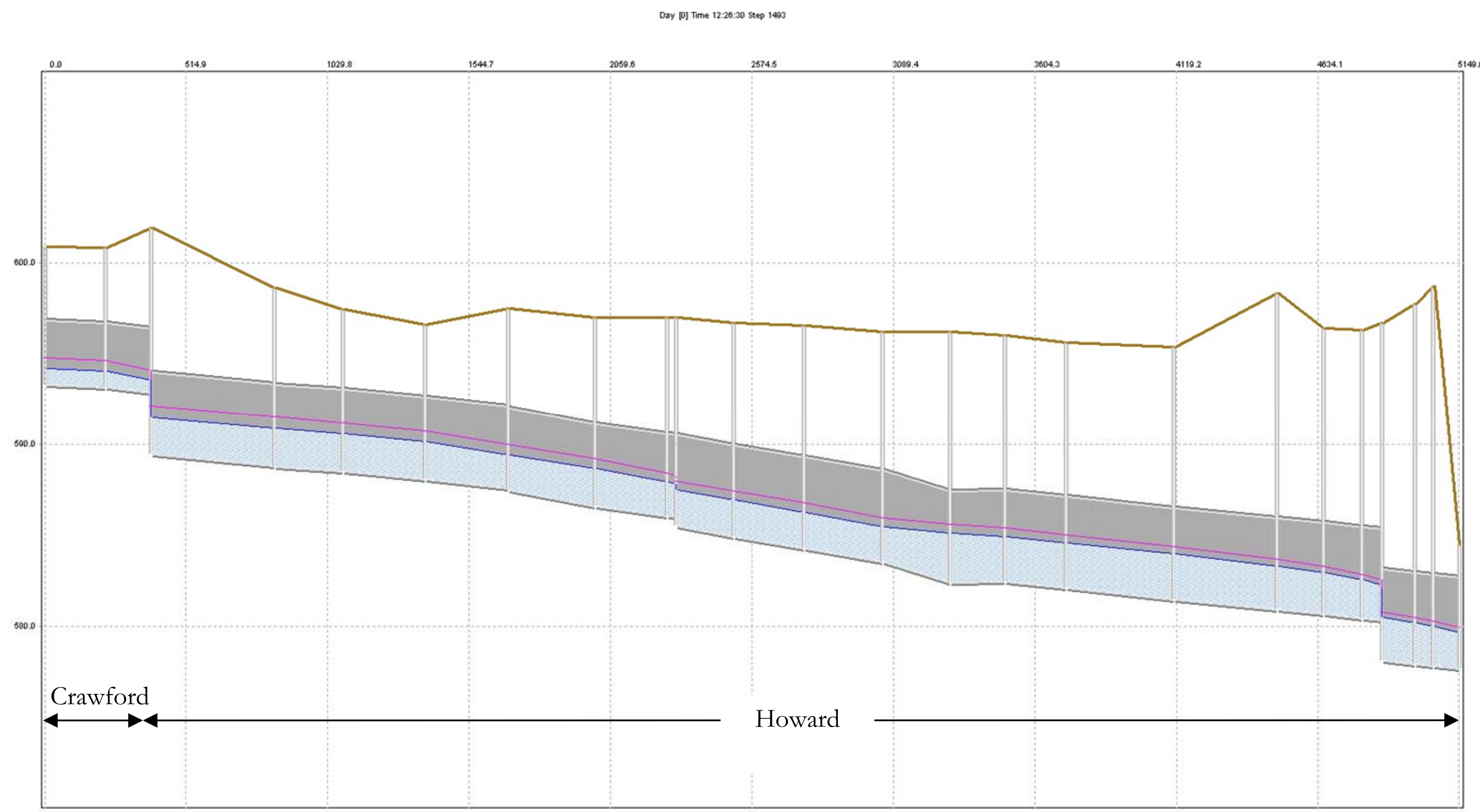


Figure 24 – Existing Conditions

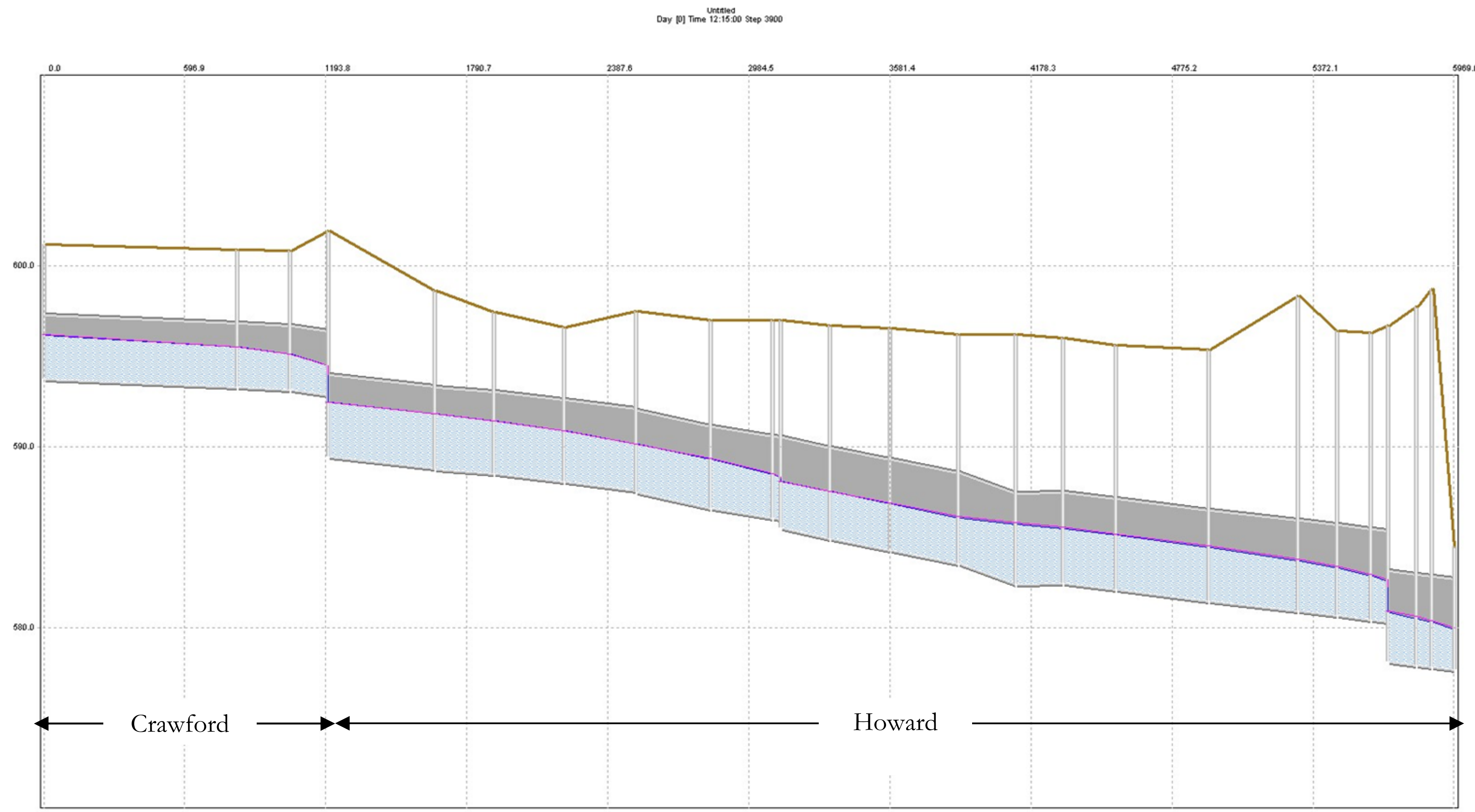


Figure 25 – Proposed Crawford Sewer Added, No Surface Storage Modeled

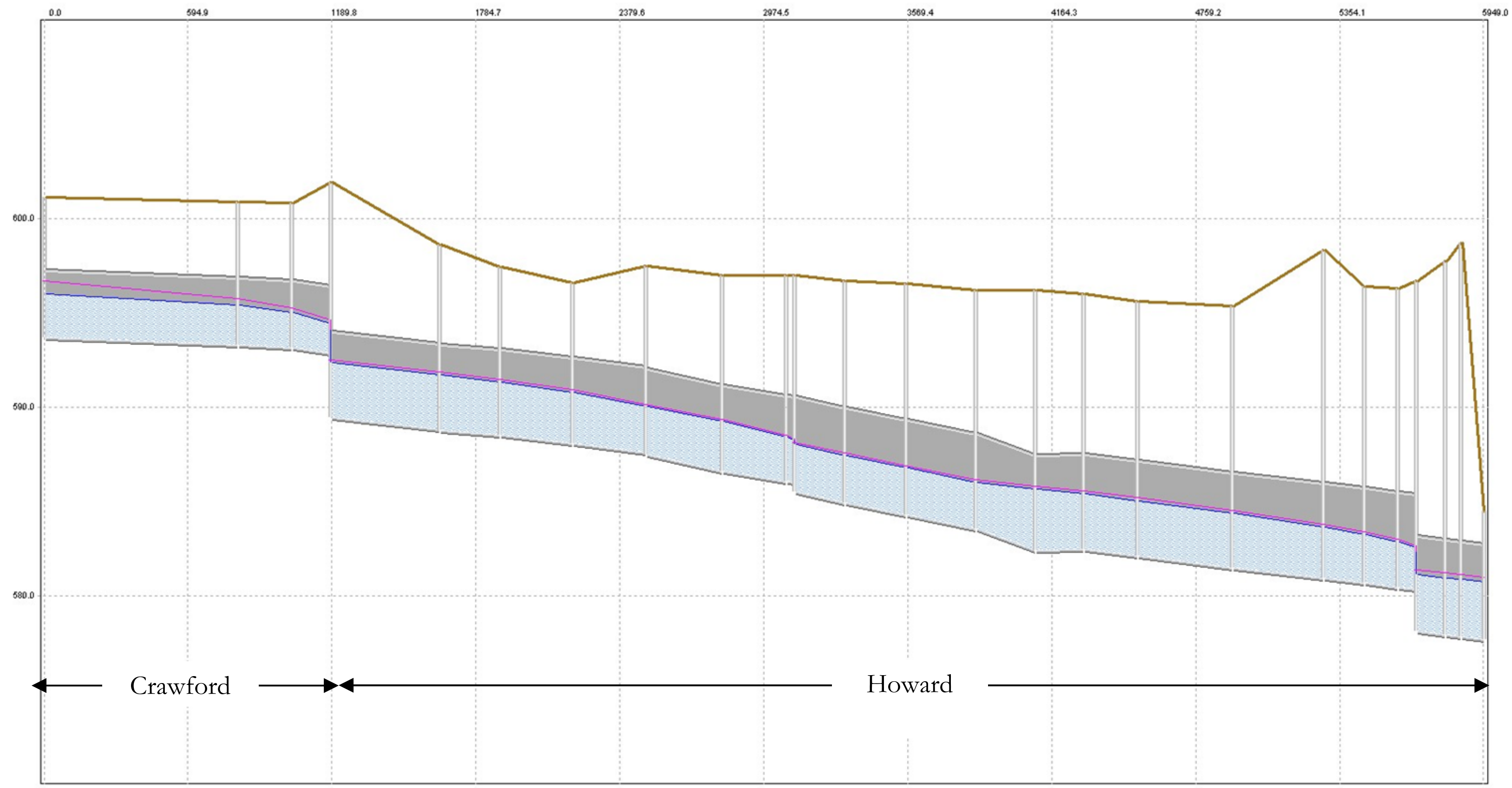


Figure 26 – Proposed Crawford and Jarvis Storm Sewers Added, Surface Storage Modeled with 18" Restrictor

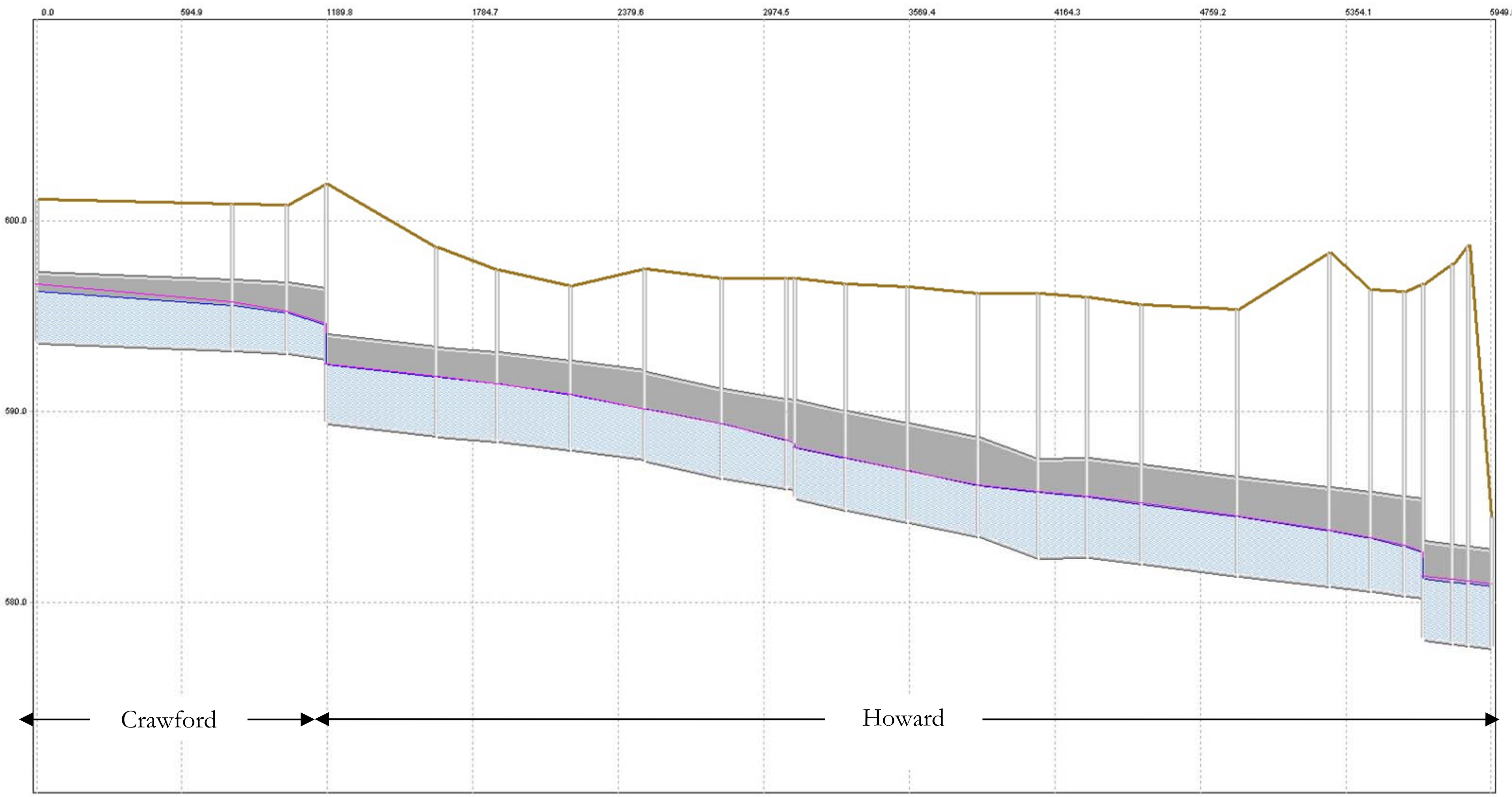


Figure 27 – Proposed Crawford and Jarvis Storm Sewers Added, Surface Storage Modeled with 22" Restrictor

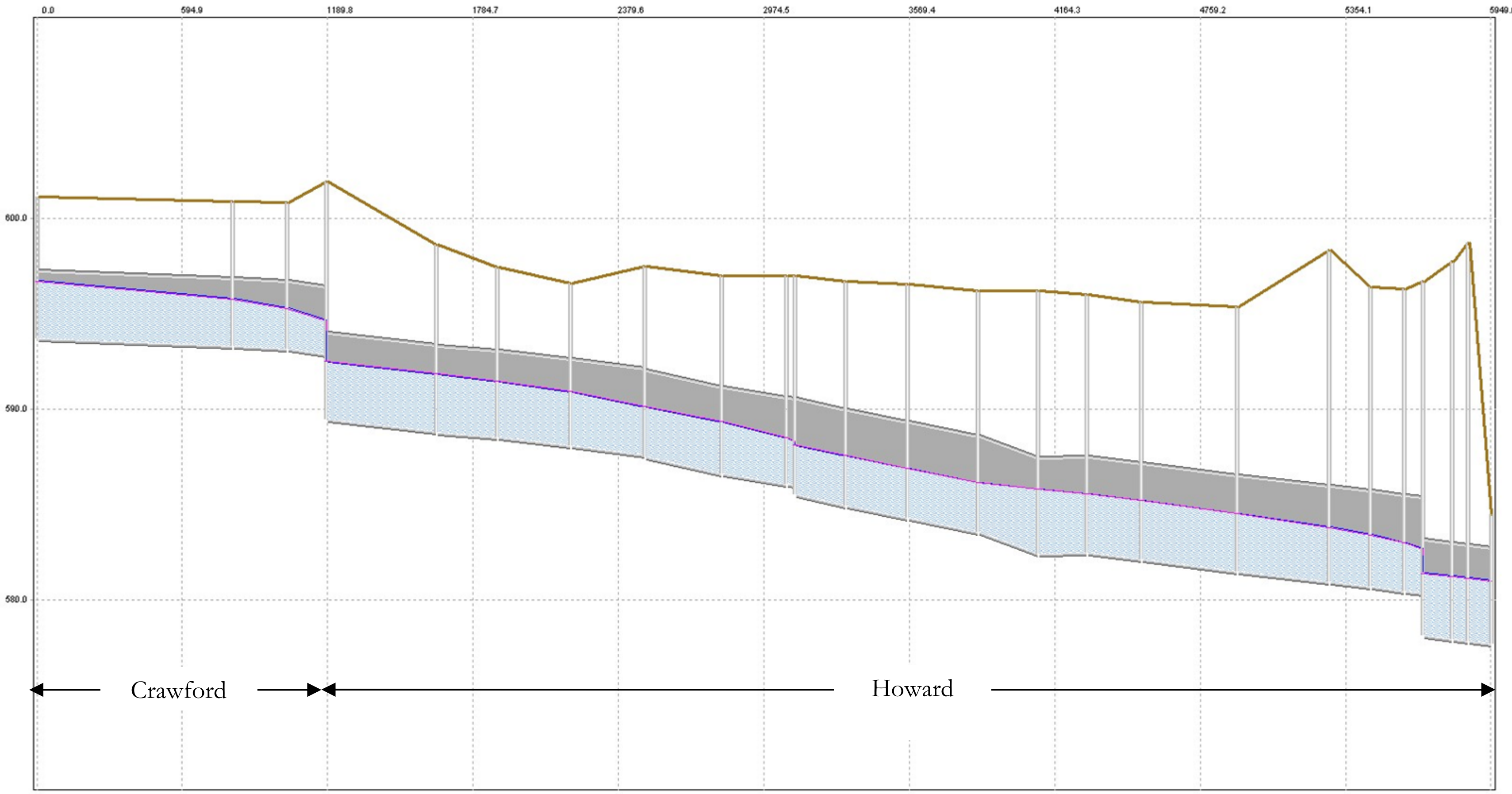


Figure 28 – Proposed Crawford and Jarvis Storm Sewers Added, Surface Storage Modeled with 25.5" Restrictor

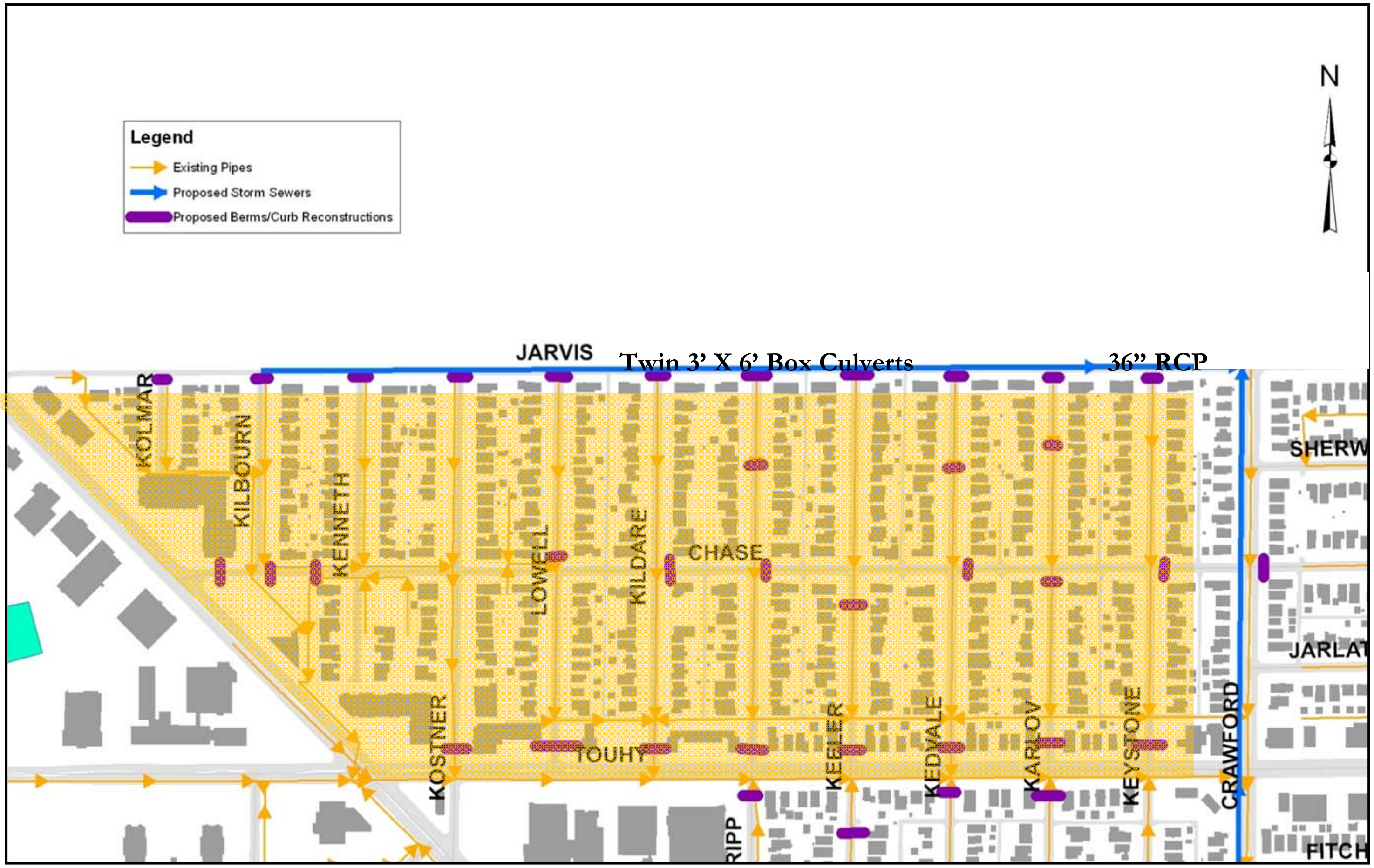


Figure 29 – Proposed Jarvis Sewer Location Map

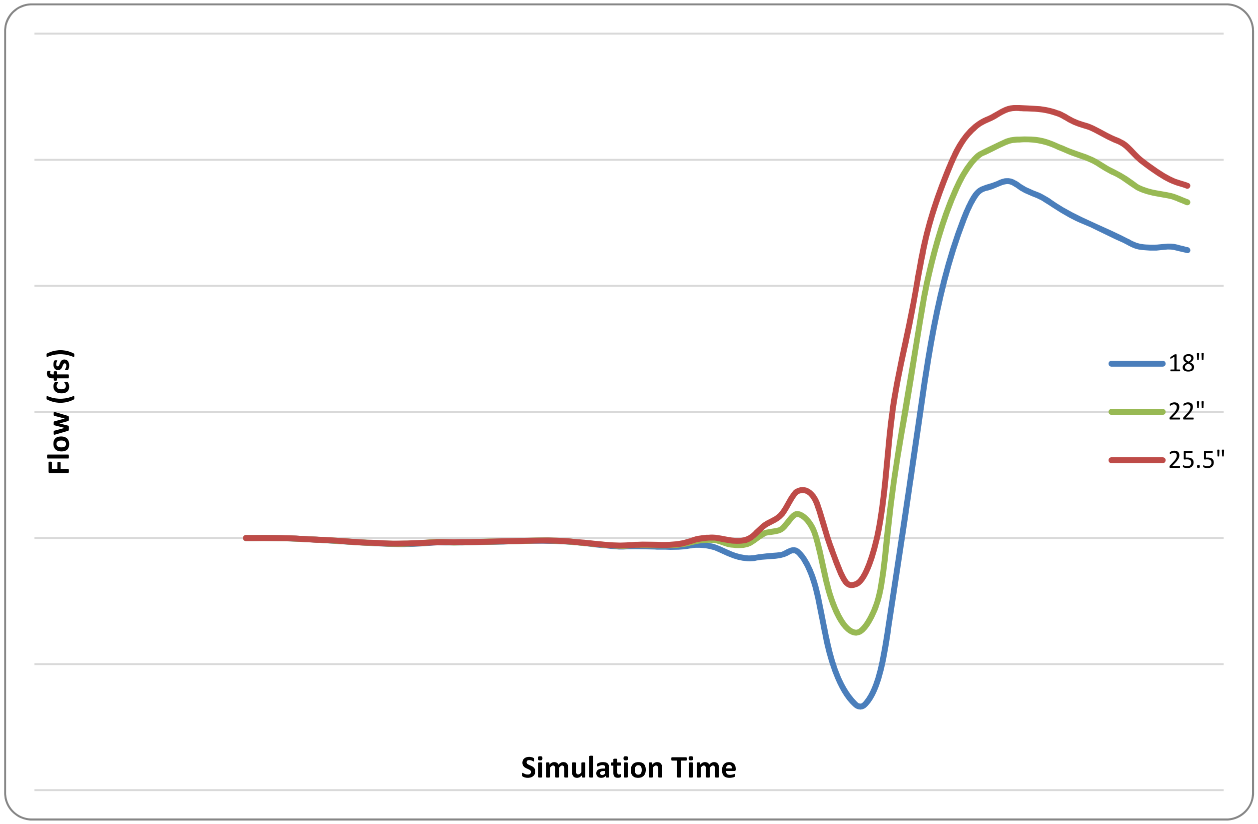


Figure 30 – Proposed Jarvis Sewer Discharge Hydrographs

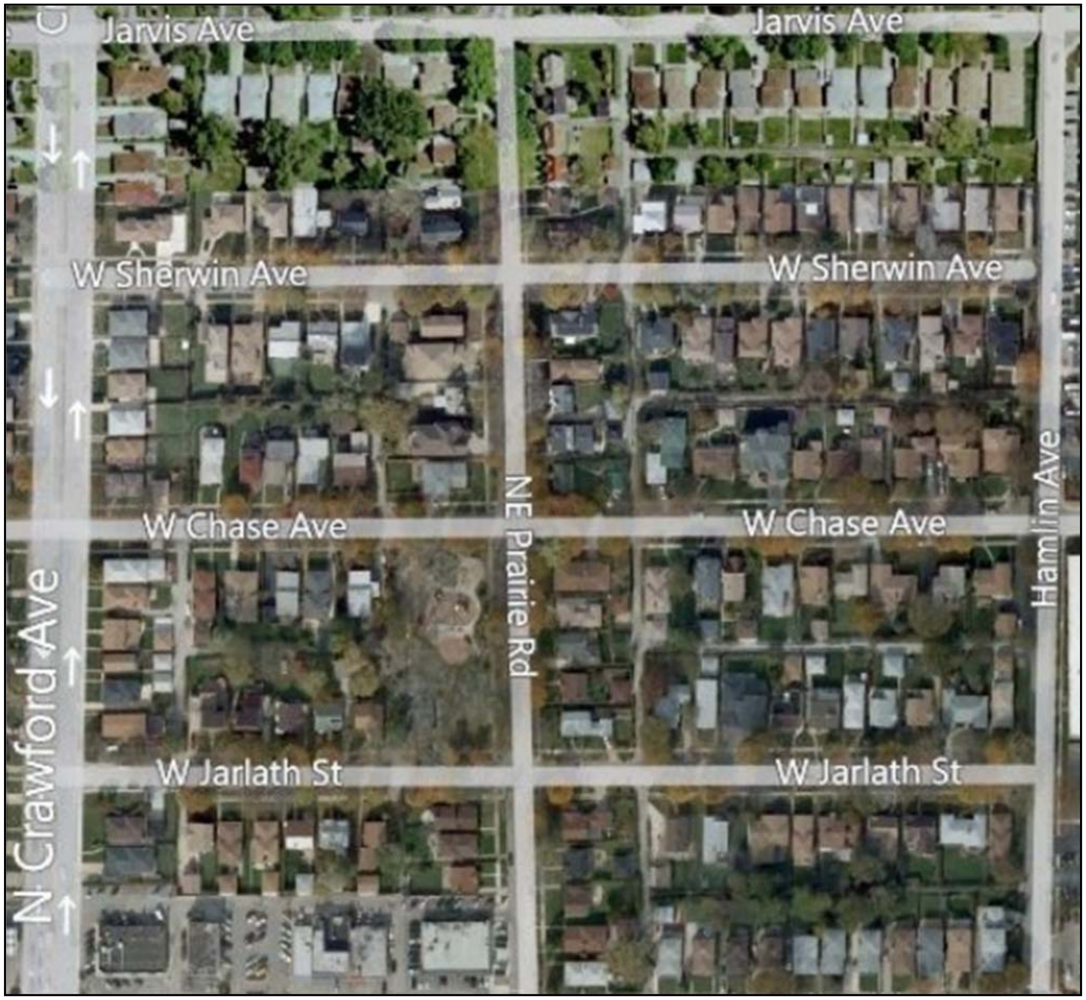


Figure 31 – Adjacent Flood-Prone Area

5.4.2 July 23, 2011 Storm

5.4.2.1 July 23, 2011 Storm

On July 23, 2011 the Village encountered a rain event in which 3.10" of rain fell. The Village received very few calls regarding flooding and/or basement back-ups as a result of the event. When evaluating the rainfall data from July 23, 2011 the following storm categories should be used to understand the severity of the event:

Table 27 – July 23rd Rainfall Frequency Table

Period of Time	Amount of Rainfall	Storm Category
5 minutes	0.35 inches	1 to 2 year
10 minutes	0.54 inches	~1 year
15 minutes	0.68 inches	1 year
30 minutes	1.07 inches	1 to 2 year
1 hour	**1.46 inches**	**~2 year**
2 hour	2.51 inches	5 to 10 year
3 hour	2.72 inches	5 to 10 year
6 hour	3.10 inches	5 to 10 year

The Village's stormwater model indicates that the Village's time of concentration for a rain event is less than 1 hour for 97% of the community. Time of concentration is a measurement used to describe how a watershed (area of land where all rainfall runs off of to the same place) responds to a rain event. Therefore, when evaluating a rain event within Lincolnwood, the peak one-hour period is the critical rainfall period to review in order to understand how a given rain event affects the Village's combined sewer system.

5.4.2.2 Discussion Regarding Time of Concentration

The time of concentration (t_C) is a concept used in hydrology to measure the response of a watershed to a rain event. It is defined as the time needed for water to flow from the most remote point in a watershed to the watershed outlet. It is a function of the topography, geology, and land use within the watershed.

Figure 32 shows the basic principle which leads to determination of the time-of-concentration. Much like a topographic map showing lines of equal elevation, a map with isolines can be constructed to show locations with the same travel time to the watershed outlet. In this simplified example, the watershed outlet is located at the bottom of the picture with a stream flowing through it. The time-of-concentration (t_C) for this watershed is 75 minutes. This is the time for a drop of water that falls on the most remote (upper) part of the watershed to reach the outlet. Moving up the map, we can say that rainfall which lands on all of the places along the first yellow line will take 5 minutes (75 – 70) to reach the watershed outlet. Water that falls on the next line will take 15 minutes (75-60) to reach the outlet. This is true for every yellow line, with each line further away from the outlet corresponding to a greater travel time for runoff traveling to the outlet, until one reaches the uppermost boundary of the watershed, where it will take 75 minutes for rain falling on this boundary to reach the outlet.

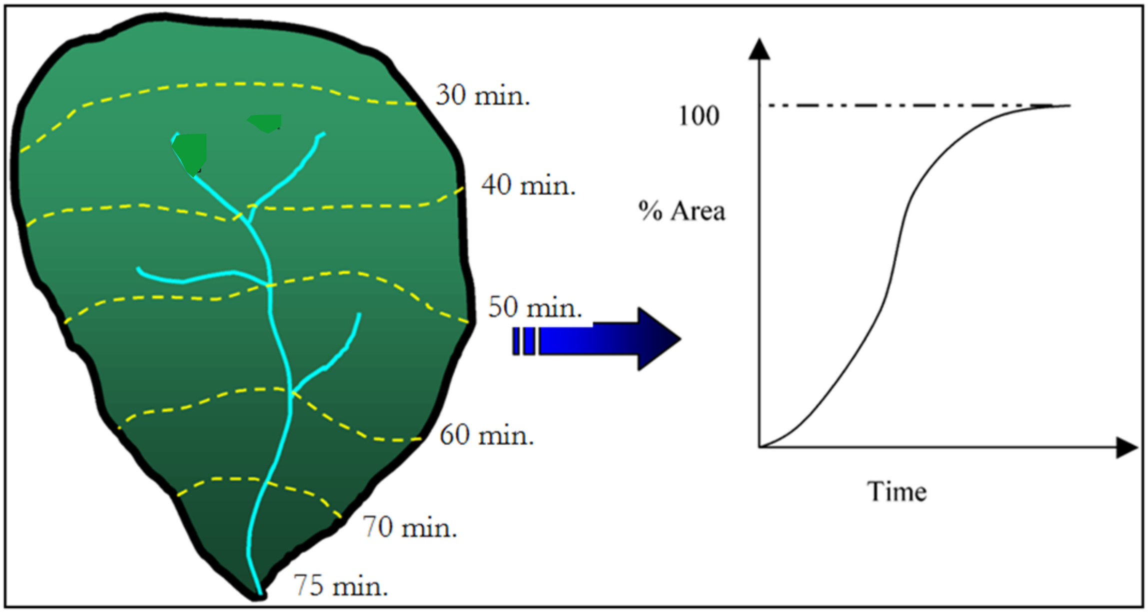


Figure 32 – Time-of-Concentration

As the graph on the right above shows, the spatial representation of travel times can be transformed into a cumulative distribution plot detailing how travel times are distributed throughout the area of the watershed. In other words, as the size of the upstream, or tributary, watershed increases, so does t_C.

5.4.2.3 Lincolnw ood's Combined Sewer System

Based on the stormwater model results the Village's collection system has adequate capacity to convey the peak flows produced by a 2-3 year rainfall event with minimal basement backups. The peak one-hour rainfall during the storm of July 23, 2011 was approximately a 2-year event (Table 27). This explains why there were little to no reports of basement backups during the event.

Donohue has run the July 23, 2011 storm through the model, which showed only a minor risk of basement backups in a few isolated areas (Figure 33). The model results appear to be representative of the real life event in that little to no calls were received regarding basement back-ups. The July 23, 2011 storm is a "threshold event", meaning that it just begins to reach the threshold where isolated basement flooding is imminent. When evaluating the results in Figure 33, one must know that the model presumes all homes have basements and no homes have flood protection. In addition, the depth of water that would back up into basements would be small, much of which would likely go unreported. The model also presumes the rainfall recorded at the rain gauge fell uniformly over the entire watershed, when in fact it may have varied in timing and intensity. Due to these limitations, the model should not be expected to perfectly predict the system response to this threshold event, yet it does so reasonably well.

Figure 39 indicates the t_C for each pipe within the Lincolnwood collection system. Since larger pipes tend to be further downstream and drain larger areas, the t_C generally increases with pipe diameter. This map is summarized in the cumulative distribution (Figure 38) which indicates that 97% of the Lincolnwood collection system has a t_C of less than 60 minutes.

Figure 33 – July 23rd, 2011 Model Results

Figure 34 – July 23, 2011 Model Results (NW Quadrant)

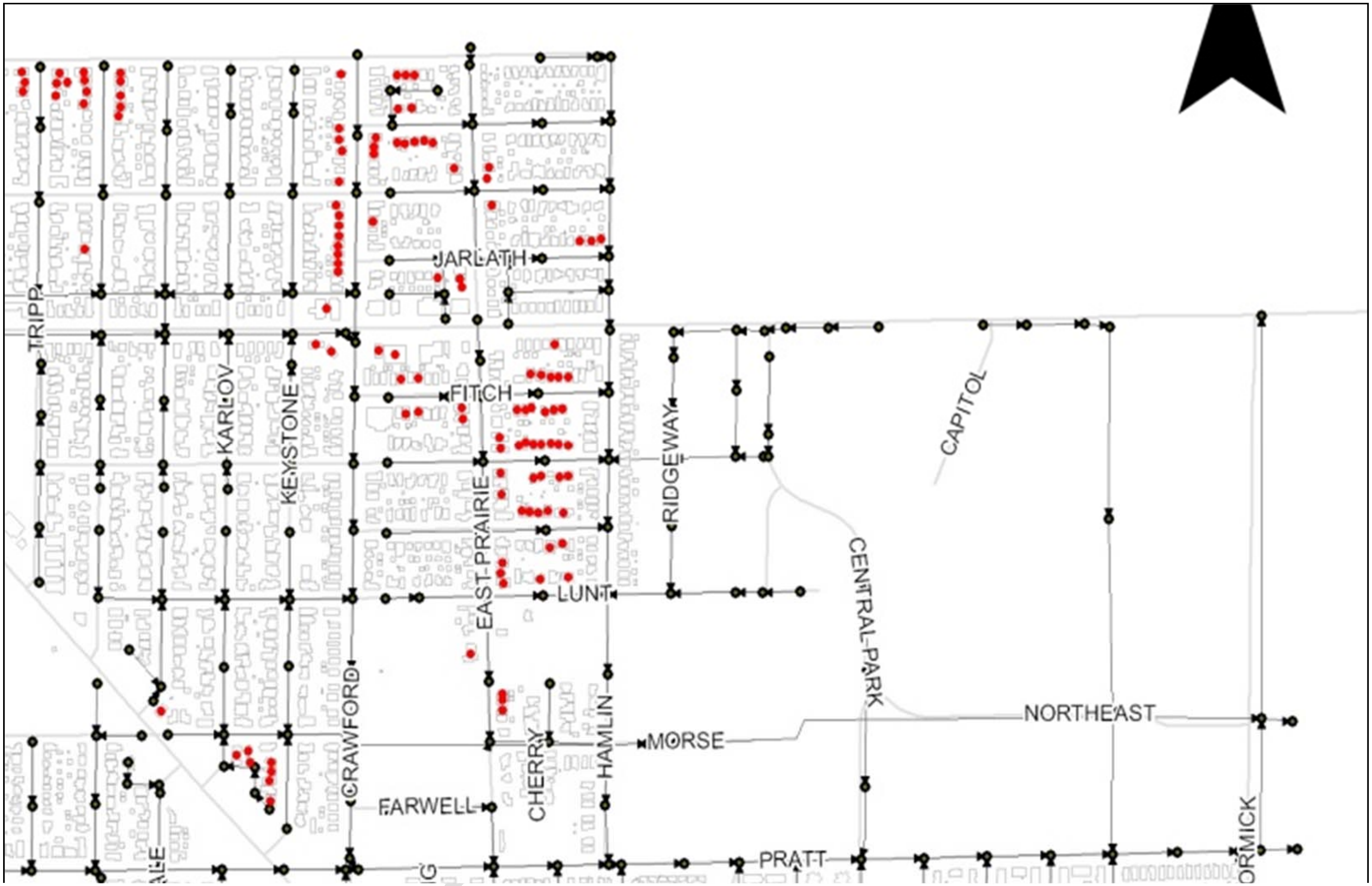


Figure 35 – July 23, 2011 Model Results (NE Quadrant)

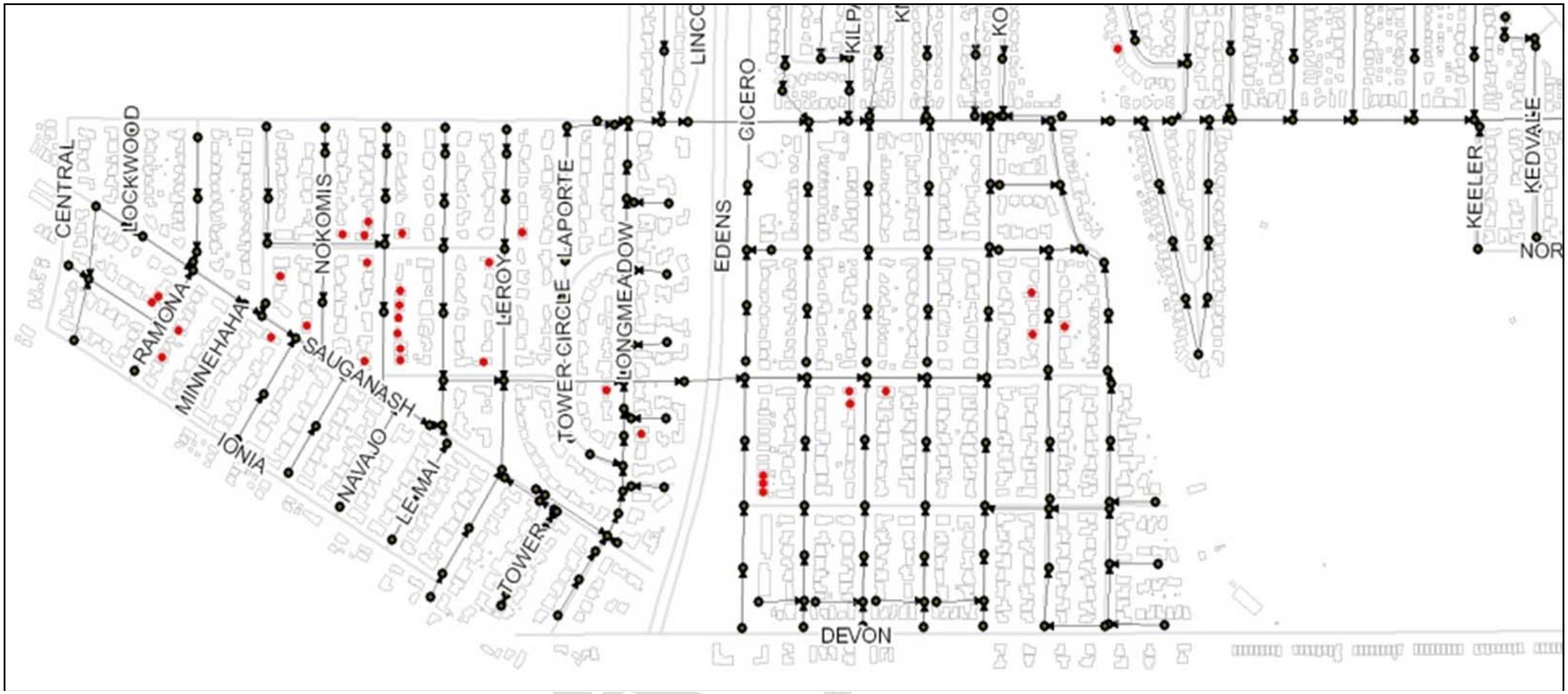


Figure 36 – July 23, 2011 Model Results (SW Quadrant)

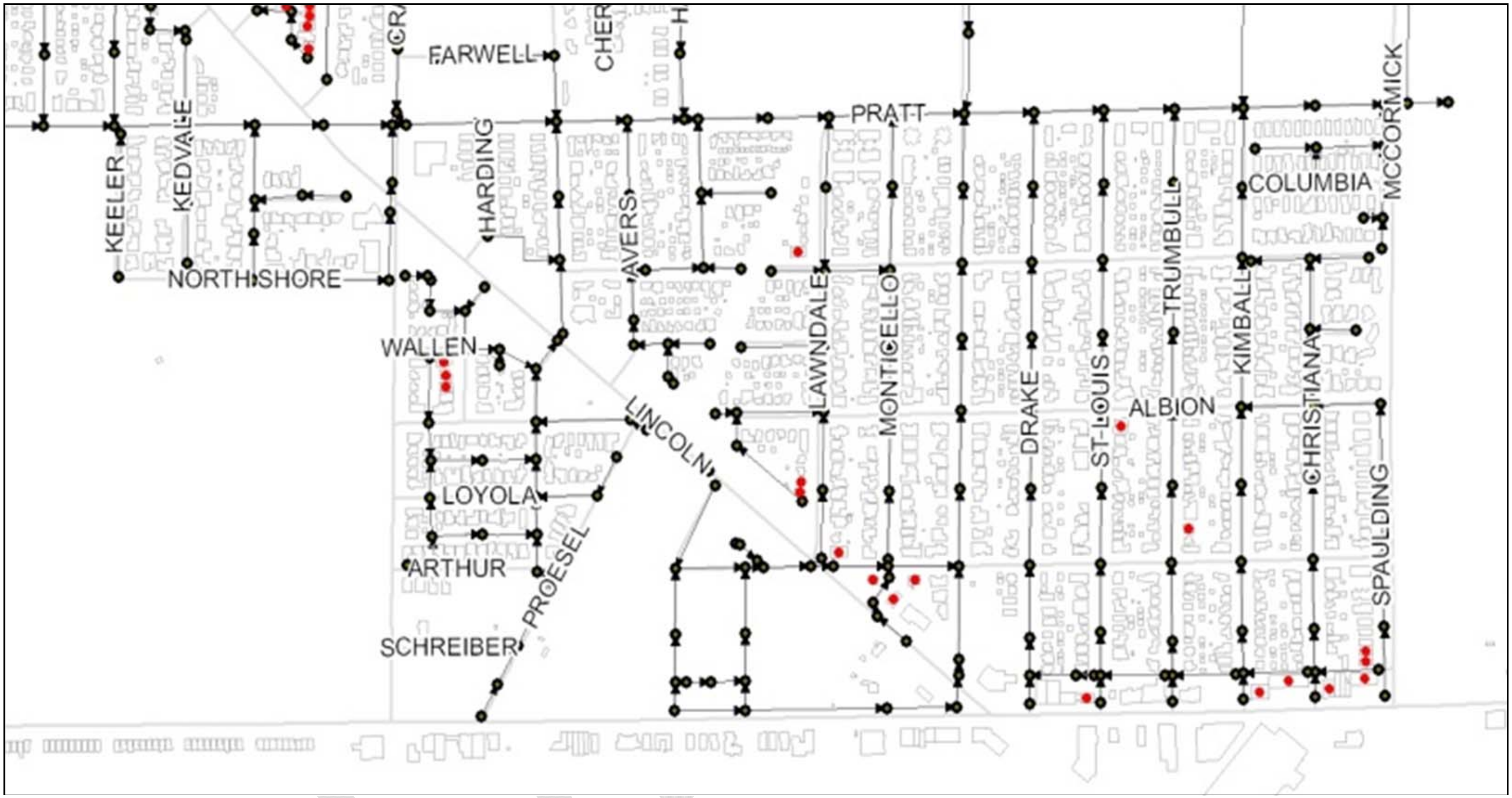


Figure 37 – July 23, 2011 Model Results (SE Quadrant)

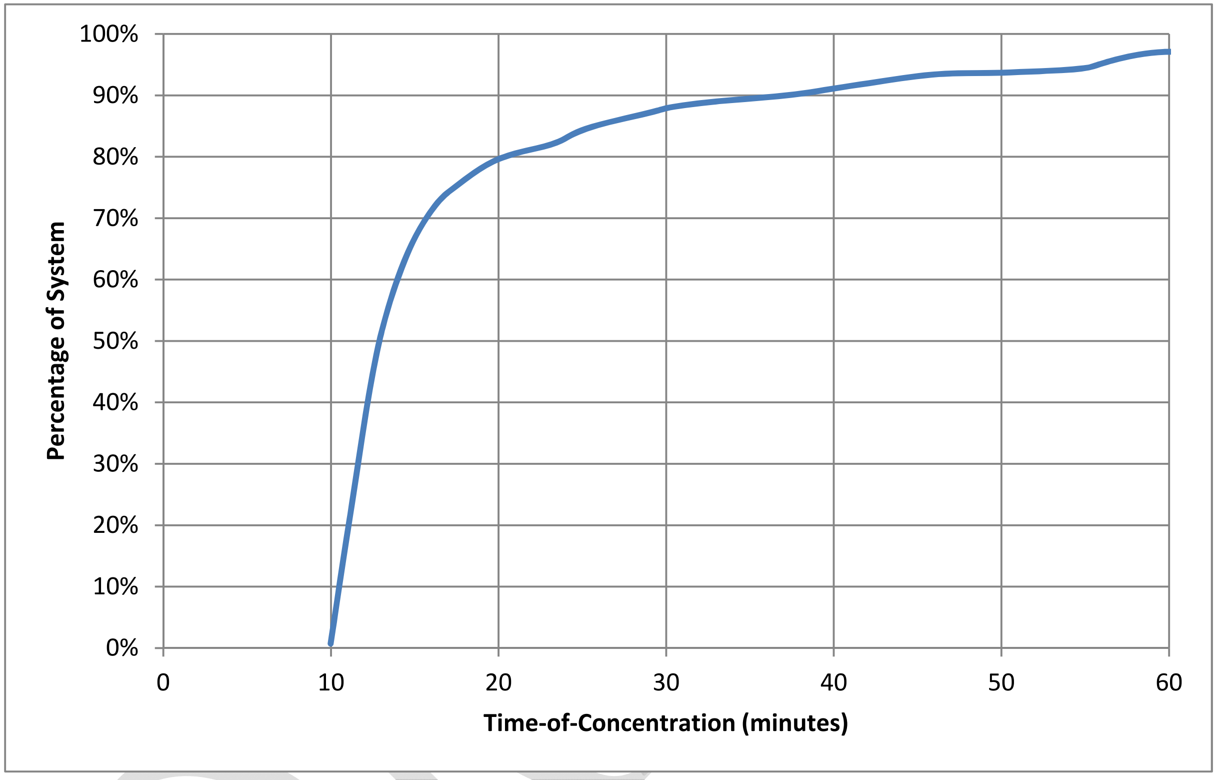


Figure 38 – Lincolnwood Time-of-Concentration Cumulative Distribution

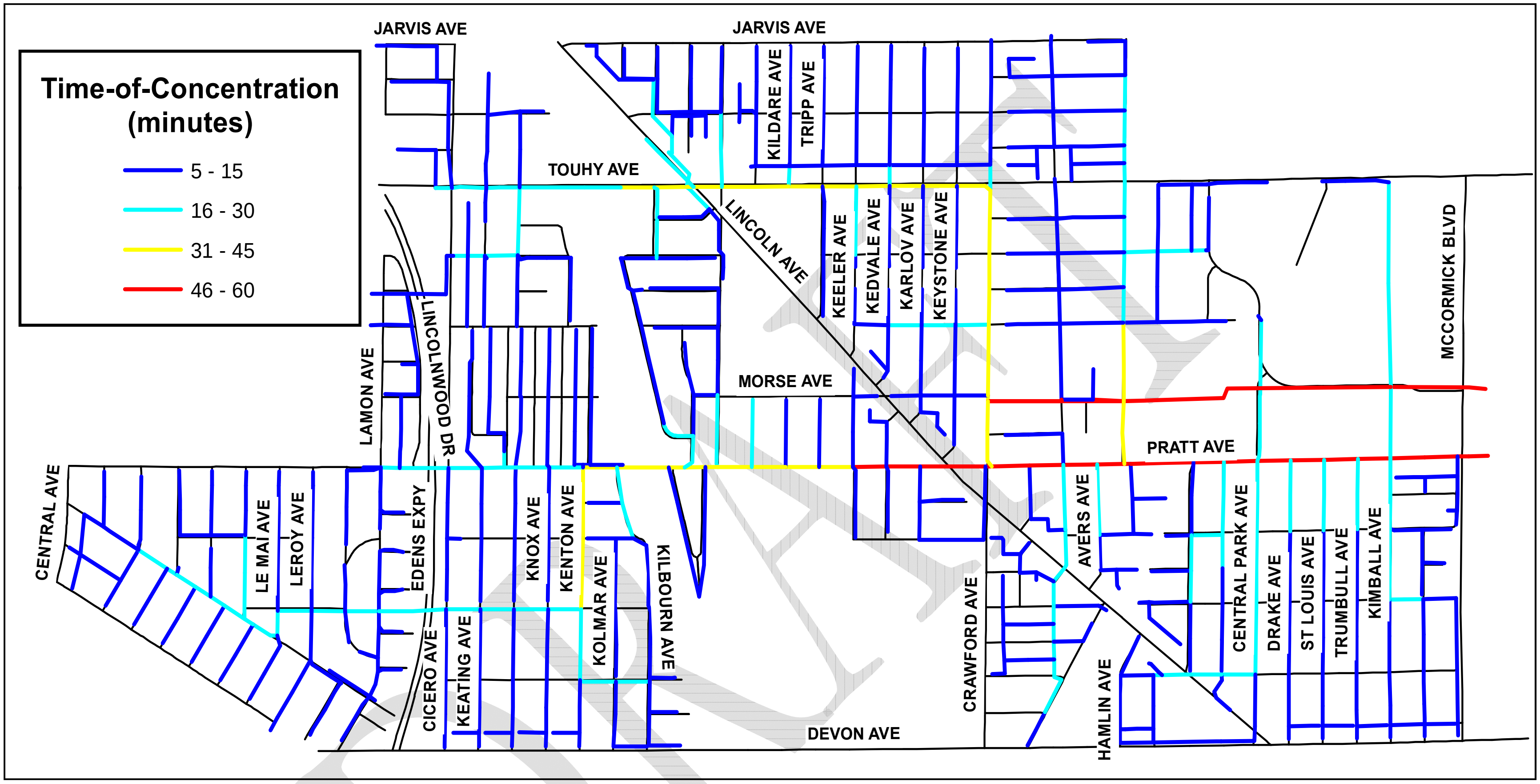


Figure 39 – Lincolnwood Time-of-Concentration Map

5.4.2.4 Rainfall Volumes, Durations, and Frequencies

In addition to time-of-concentration, one must evaluate the manner in which the rain fell on July 23, 2011. The recurrence interval, or frequency, of a rainfall event is dependent upon how much rain fell and over how long of a period of time, or duration, it fell. The figure below displays graphically, how the rain fell on July 23, 2011 in 5-minute increments.

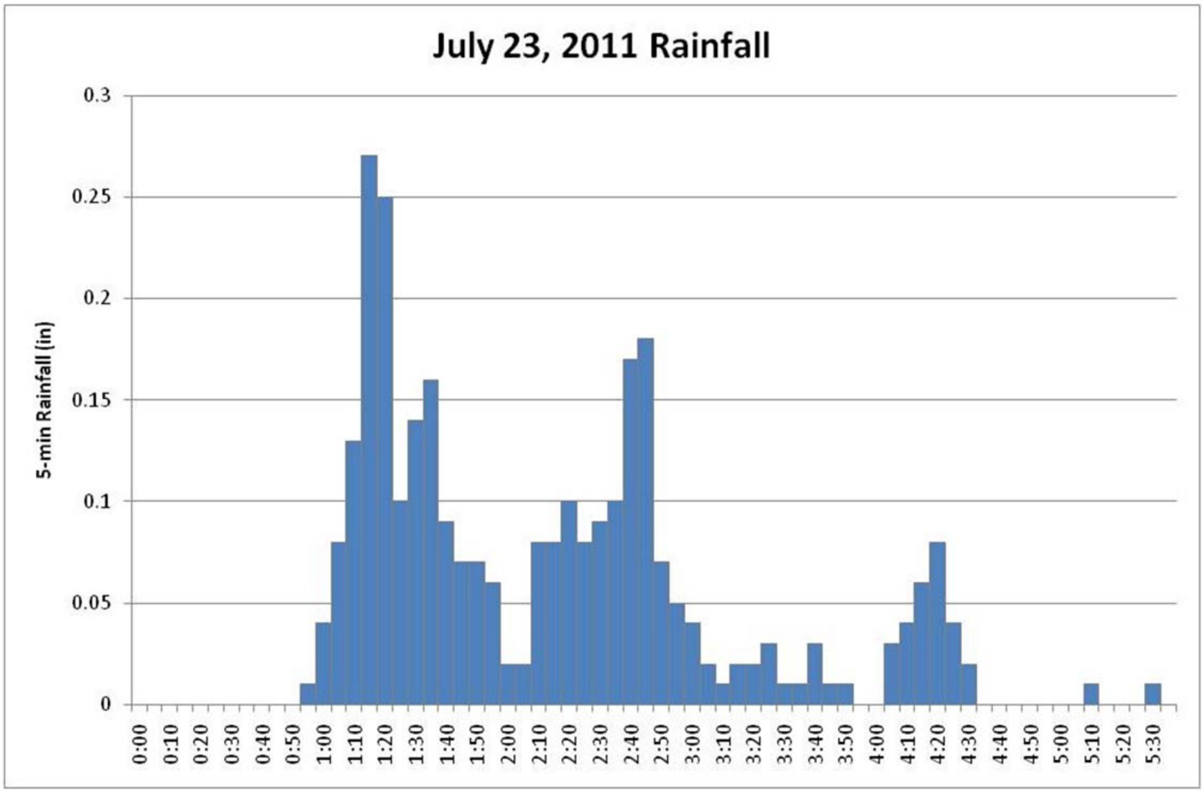


Figure 40 – July 23, 2011 Rainfall

The frequency of this event, as it relates to the Lincolnwood collection system, depends on one's point of reference, or where you are in the collection system. For example, if your point of reference is a pipe with a 15-minute time-of-concentration, then the peak 15-minute rainfall will be what determines the peak flow at that point. Likewise, if the point of reference is further downstream in the system, near the District interceptor for example, the time-of-concentration would be close to one-hour, hence the relevant peak rainfall period will be the peak one-hour rainfall. Figure 41 through Figure 44 on the following pages indicate the peak rainfall volumes for a range of durations from the July 23rd event. The peak 15-minute and 1-hour rainfall volumes were 0.65" and 1.46" respectively.

The Midwest Climatic Data Center publishes a document titled *Bulletin 71 – The Rainfall Frequency Atlas of the Midwest*. This document summarizes statistical analyses that relate a range of rainfall volumes and durations to their likelihood of occurring for a nine-state area in the Midwest. These correlations should be used to determine the likelihood with which the rainfall volumes presented in Figures 6 thru 9 are likely to occur. The results of this comparison are presented in Table 28.

Table 28 – July 23rd Rainfall Frequency Evaluation

Duration (min)	Rainfall (in)	Frequency (Years)
15	0.65	0.85
30	1.05	1.6
60	1.46	2.3
120	2.51	8.4

By comparing Table 28 to Figure 38, it shows that for 97% of the system the July 23rd storm was little more than a 2-year event.

5.4.2.5 Summar y & Recommendations

The model predicts very minor basement flooding in only a few isolated areas for the event of July 23, 2011. This is consistent with the lack of complaints of basement backups. Furthermore, as it relates to the Lincolnwood collection system, this was only a 2-year event. Therefore we recommend that the Village continue in its efforts to provide protection from basement flooding for the 10-year event, a storm that would be 50% larger than the one that occurred on July 23rd, 2011.

While the 120-minute (2 Hour) duration storm is about an 8.4-year storm event, the Lincolnwood Sewer System was able to convey that storm with only minor difficulties. Storms with higher rainfall intensity and shorter duration cause significant problems in the sewer system. Therefore, the July 23rd storm verifies that the current computer model is properly calibrated and duplicates the results as reported in the field.

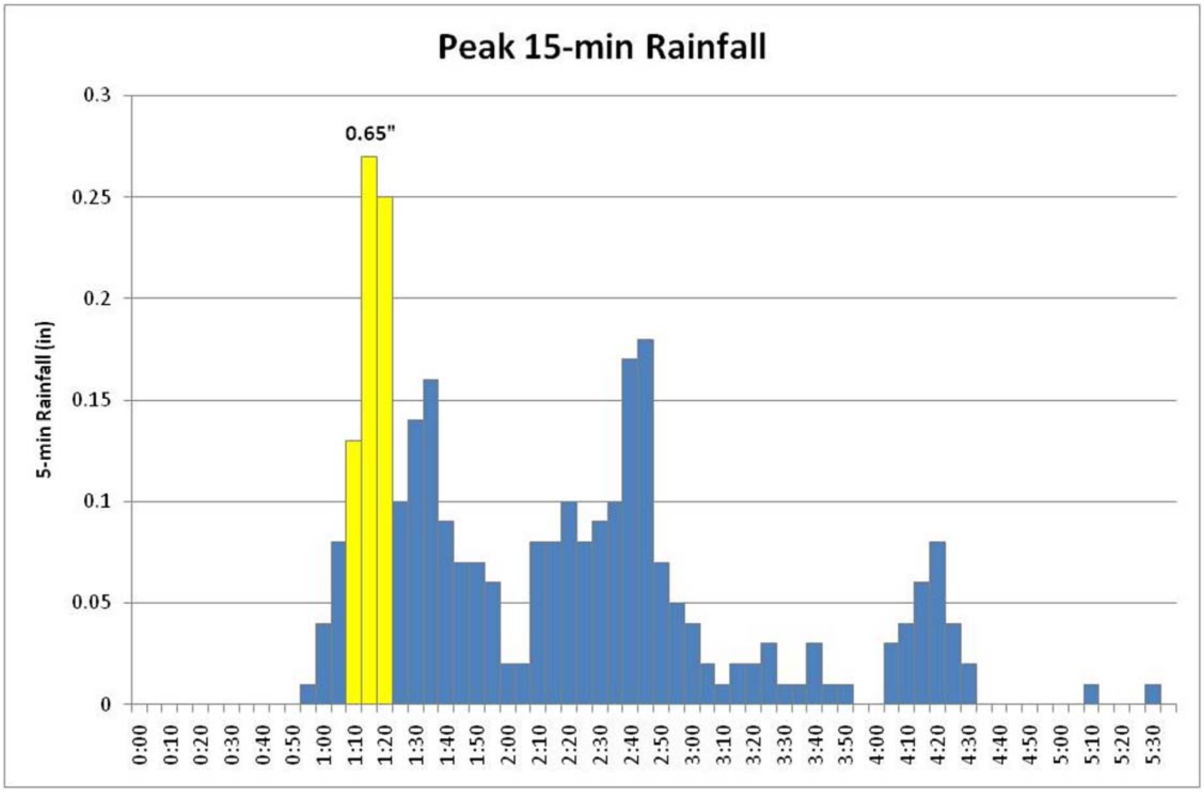


Figure 41 – July 23, 2011 Peak 15-min Rainfall

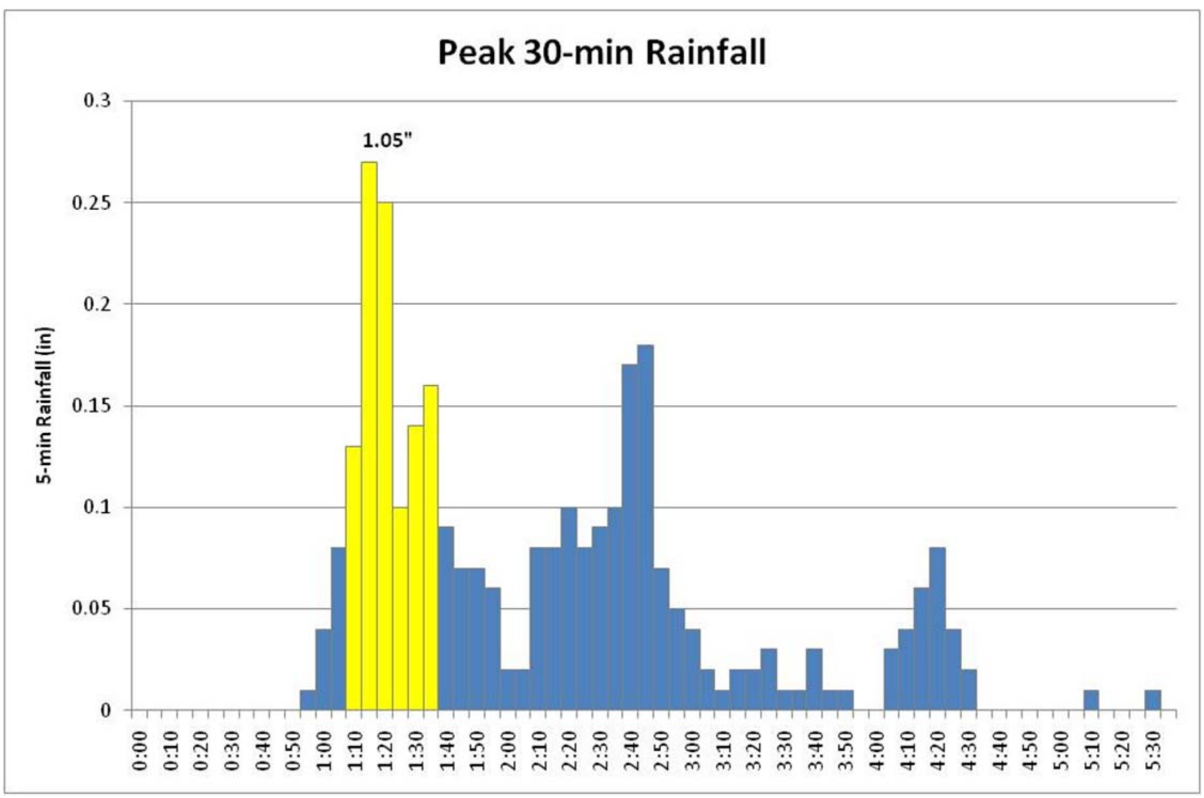


Figure 42 – July 23, 2011 Peak 30-min Rainfall

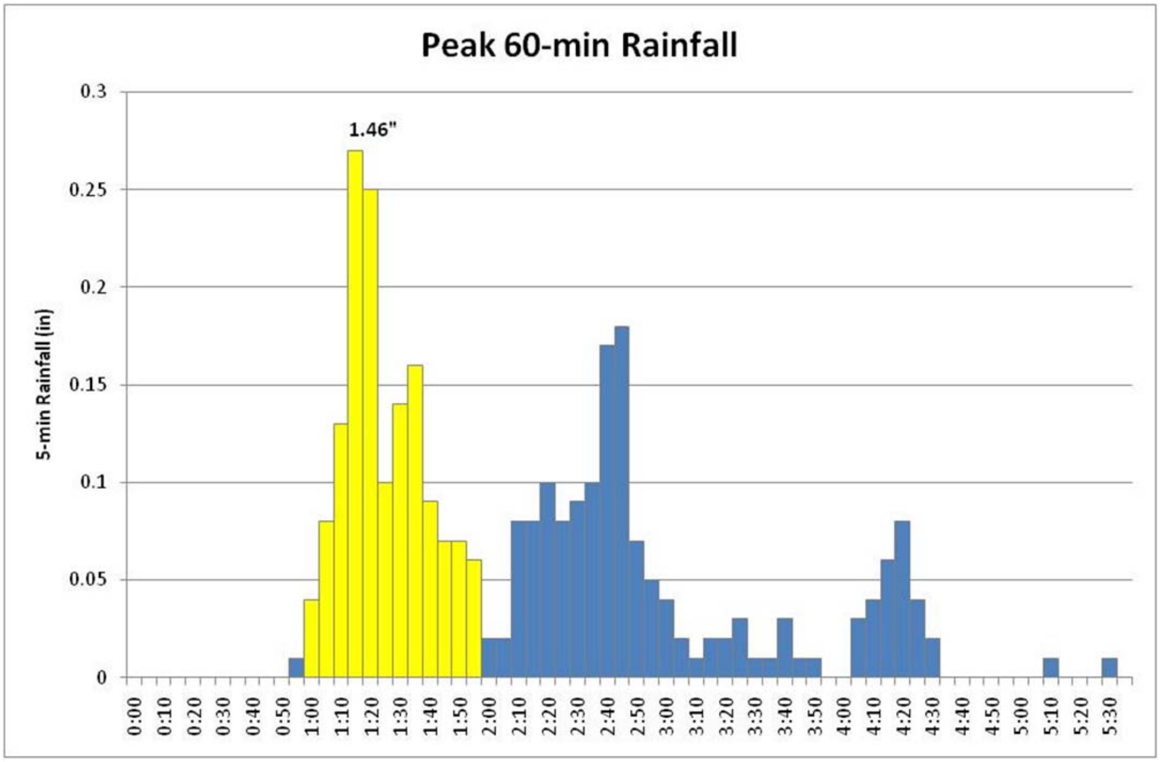


Figure 43 – July 23, 2011 Peak 60-min Rainfall

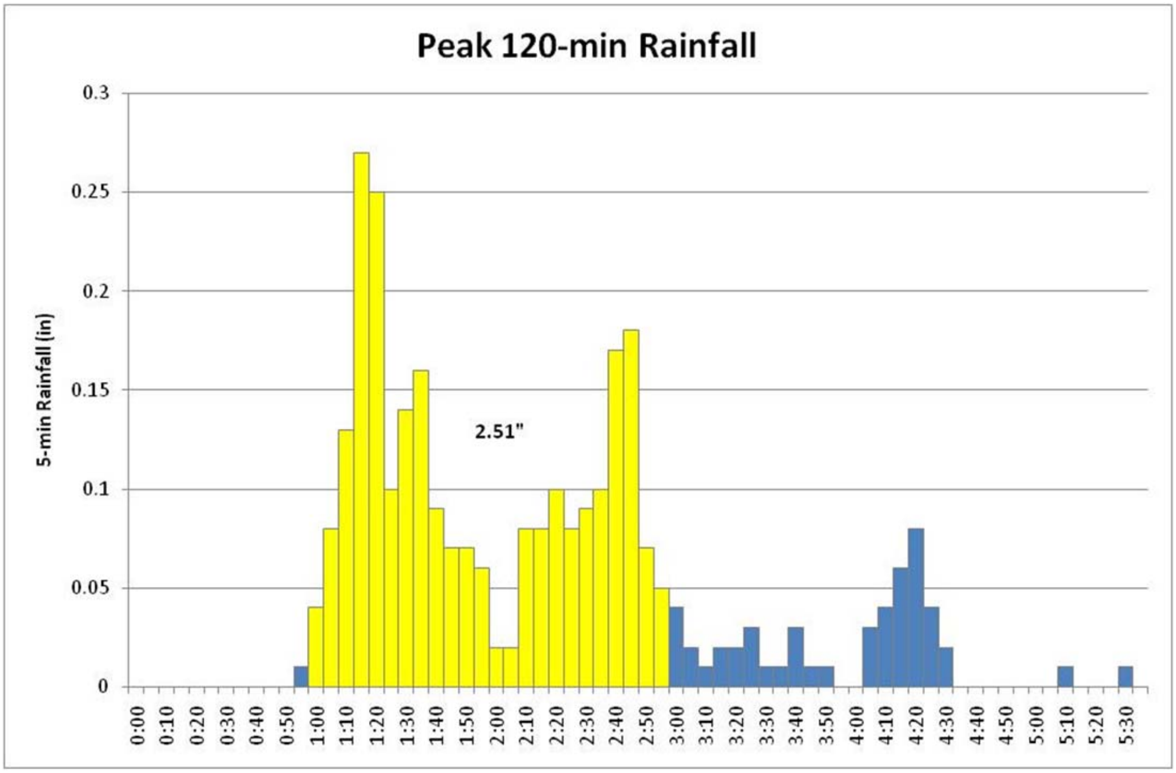


Figure 44 – July 23, 2011 Peak 120-min Rainfall

5.5 AD-HOC COMMITTEE COMMENTS & MEETING MINUTES

5.5.1 NOVEMBER 24, 2008 MEETING

VILLAGE OF LINCOLNWOOD
AD-HOC SEWER COMMITTTEE
UNAPPROVED MEETING MINUTES
November 24th 2008

CALL TO ORDER

Chairman Eisterhold called the Ad Hoc Sewer Committee Meeting to order at 7:07 p.m., Monday, November 24, 2008, in the Board Conference Room of the Village Hall located at 6900 N. Lincoln Avenue, Village of Lincolnwood, County of Cook and State of Illinois.

ROLL CALL

The following were:

PRESENT: Chairman Eisterhold; Paul Grant; Paul Gordan; Gus Dimas; Chris Martel; Barbara Copeland; Zvie Liberman;

ABSENT: None

Also present were: Gerald Turry, Mayor; Thomas Heidtke, Village Trustee; Timothy Wiberg, Village Administrator; Manuel Castaneda, Director of Public Works; Robert Carr, Water Resource Modeling; Steve Sticklen, AB&H Donohue; Craig Brunner, AB&H Donohue; and Ashley Dorsey, Public Works Management Analyst

APPROVAL OF MINUTES

The May 7, 2008 minutes were approved by voice vote.

Abstentions: Barbara Copeland

REGULAR BUSINESS

Steve Sticklen presented a draft presentation of results and conclusions regarding the Village's stormwater modeling study. He noted that it is a work in progress and that the purpose of the meeting was to comment on the results and conclusions so he could utilize them in his final report.

Mr. Sticklen presented an outline of his presentation which included:

- History
- Inlet Restrictor Program
- Project Scope
- Rainfall & Hydrology

- Model Development
- Preliminary Model Results
- Looking Ahead

Mr. Sticklen began the presentation by discussing the history of the Village's stormwater management. He discussed the Village's history of flooding, methods to control storm runoff and the history of the inlet restrictor program as he understood it.

History of Flooding
Mr. Sticklen reviewed the history of basement flooding complaints in the Village. Only 30% of residents responded to the survey sent out following the August 2001 flood event. The group discussed the fact that resident complaints are not a reliable means of ascertaining extent of flooding. Some residents do not report flood problems because they will have to report the flooding when selling there home. Others are used to flooding and don't report it.

History of Restrictor Program
Mr. Sticklen discussed the history of the restrictor program. The Village has approximately 3,000 inlets. Approximately 21% are state or county and 45% are restricted while 34% are unrestricted. Mr. Sticklen discussed the orifice opening of the restrictors and the steps taken to measure them.

Mr. Gordon stated that an orifice opening of 13 in^2 was used in the model when the actual opening is 11 in^2. He stated that this could result in a 20% error in the model. Mr. Gordon provided shop drawings of the restrictors to Mr. Sticklen. Mr .Gordon further stated that AB&H's proposal stated that they would perform physical hydraulic testing of the restrictors. Mr. Carr does not recommend hydraulic testing of the restrictors because it would have little effect on the results.

Mr. Sticklen reported that in some cases, the model predicted sufficient freeboard in locations where there were flood complaints. He stated that there may be a sewer maintenance problem that the model does not account for. It could also be due to not enough local sewer capacity.

Trustee Heidtke asked if AB & H had statistics from other communities regarding the percent of residents that do not report flooding. Mr. Sticklen stated that he did not. Ms. Copeland stated that she knew of residents that did not report flooding in their home during the September 13th 2008 event but did actually flood.

Project Scope
Mr. Sticklen reviewed the project scope which included (1) develop a computer model; (2) assess the ability of the system to accommodated a 10 year event under pre-existing, existing, and future conditions; and (3) failure analysis (optional).

Rainfall & Hydrology
Mr. Sticklen reviewed the key questions to answer. How does rainfall impact a combined sewer system? How much rainfall can the Village's system handle? and How often will the capacity of the Village's system be exceeded. Mr. Sticklen conducted a physical demonstration of a rainfall event and the sewers response. Mr. Sticklen noted that the key is to examine how much water falls in how large or small of a time period.

June 2007 Storm Event
Mr. Sticklen began reviewing the June 2007 storm event that occurred. He explained that it was important to look at the event using the rainfall hyetograph- i.e. rainfall over time.

Mr. Sticklen stated that there was a large volume of rain over a short period of time during this event. Data indicates that the mean rainfall intensity during the event was 1.76"/hr. He went on to further explain bullet 71 and its interpretation of the June 26, 2007 event.

Mr. Sticklen went on to discuss and explain Bulletin 71 and IDF curves. Bulletin 71 is a rainfall data atlas while IDF curve or intensity duration frequency relationship examines the relationship between the intensity of the rainfall and the frequency. Mr. Sticklen further explained the concept of "time of concentration" which defines the size of a system and long it can hold liquid. According to the IDF curves and Bulletin 71 the Village has not observed a 10 year rain event in Lincolnwood.

Mr. Gordon stated that the Skokie rain gauge reported data that indicates that Lincolnwood has had a 10 year rain event. He also commented that rain gauges often underreport what falls on the ground.

Model Preparation

Mr. Sticklen detailed the preparation of the model. He stated that sewers that were 18" or longer were highlighted in the model. A skeletal model was developed that simulates the sewers and streets. Approximately 300 street segments were used in the development.

A field survey was conducted and 65 manholes were surveyed. Utility data was also utilized. Mr. Liberman asked if we were sure the GIS data was correct.

In order to incorporate surface topography the Village's TIN topography was utilized to determine overland flow paths of water and where it collects. Subcatchment parameters were also utilized to accurately simulate how much rainfall is impervious.

Trustee Heidtke questioned how it is determined how many downspouts are disconnected in the Village. Mr. Sticklen stated that it is assumed that 100% are disconnected because of the Village's Ordinance that requires disconnection. Mr. Castaneda acknowledged that some homes might be connected, but did not think it was a significant amount. Mr. Sticklen stated that this would be a calibration parameter if the Village moves forward with phase 2 Mr. Eisterhold questioned whether it the Village should physically check the % disconnected in the community.

Preliminary Model Results

Mr. Sticklen began by explaining the concept of sewer surcharging. He explained utilizing a graphic the concepts of freeboard and ponding depth. These concepts are key parameters that are used when assessing a model for pass/fail.

Mr. Sticklen provided several maps of the model for existing conditions and future conditions. Mr. Sticklen noted that the model indicates that 74% of the system fails during a 10-year storm under current conditions and 62% fails under future conditions. The scope of Phase I of the contract does not include determining the maximum amount of water the system can handle.

Ms. Copeland stated that after the August 2001 storm she installed flood control berms near her home. In September 2008 she was close to flooding. Mr. Sticklen noted that the model predicts surface flooding near her home during the September 2008 storm.

Mr. Sticklen noted that the definition of failure that is used in the study is "if the freeboard is less than 4 ft. it equals failure."

Mr. Sticklen posited the question "why isn't it doing more?" Mr. Sticklen stated that in smaller storm events the system may perform better. Mr. Sticklen noted that some of the challenges with the current system stem from the areas that the Village cannot restrict (i.e. IDOT and County roads) which causes the flow path to be interrupted when an unrestricted area is met.

Mr. Martel questioned how far AB&H modeled over the curb. Mr. Sticklen noted that they went beyond the ROW 50 feet from the center of the road. Mr. Copeland stated that because the Village cannot pond well it cannot contain water well.

Mr. Gordon stated that in order to assist with ponding berms need to be installed. Mr. Copeland questioned if the street would need to be lowered.

Mr. Carr replied that you do not have to lower streets to build berms. The Village of Skokie was able to build berms without lowering the streets. Mr. Carr also noted that when street repairs occur the berms have to be removed and then built back up. Mr. Copeland questioned if this was something that could be completed during resurfacing. Mr. Carr noted that these were items that will be discussed during phase two of the project.

Mr. Martel commented that he questioned the model's data and wanted Mr. Sticklen to expand on the methods used to calibrate the model.

Mr. Martel stated that we have not done a sufficient job of collecting flooding data and that the Village needs to become more serious about collecting data in the future.

Mr. Sticklen and Mr. Carr agreed that the accuracy of the model cannot be verified without flow monitoring data, but that a decision had been made to calibrate the model using flood complaint records of actual events.

Ms. Dorsey and Mr. Castaneda noted that there is $120,000 in the 2008/2009 budget for flow monitoring. It was stated that flow monitoring will be completed during the Spring-Summer of 2009. Mr. Carr will work with Mr. Castaneda, Ms. Dorsey, and AB&H to develop a flow monitoring program. Mr. Carr recommended postponing Phase II of the project until the flow monitoring and sewer televising work is completed.

Mr. Martel asked whether part of the scope of work was to look at whether the Village's sewer has the capacity to hold a 10 year event. Mr. Sticklen noted that there is money in the budget for an optional failure analysis.

Mr. Martel stated that the committee needs to decide what the goal of the study is- is it can the sewers hold a 10 year storm? He went on to say that the Village should look at determining what the specific areas are that are deficient and the costs to upgrade the deficient areas. Mr. Castaneda clarified that the committee has direction from the Village Board to follow through with the phased approach approved by them. Mr. Wiberg further went on to clarify the direction of the Board: (1) Hire Mr. Carr; (2) Mr. Carr would assist the Village with the modeling process; and (3) Phase I model the system. If the model depicts failure the Board must approve phase II.

At this time Mr. Gordon asked if he could spend some time reporting on his observations of the modeling process thus far. Mr. Gordon stated the following things:

- The report is based on too few reliable rain gauges;
- Lincolnwood needs wind and rain gauges that properly monitored and maintained;
- The June 26th 2007 storm was originally stated as occurring on June 27th 2007;
- The report references Skokie's gauge but Skokie's gauge was not working at that time;

- The information from the June 26th 2007 storm came from the Monticello gauge which is a hobbyist gauge not a professional one. The gauge only has a 15% efficiency and does not make adjustments for wind. He stated that 50% of the rain fell on the ground due to wind which made the gauge readings inaccurate. Mr. Gordon further stated that if you made the correction for wind the June 26th 2007 storm would have been a 10 year storm;
- Mr. Gordon captured 2 ½ in of rain in a 5 gallon bucket during that storm
- Mr. Gordon stated that the August 23rd 2007 storm was similar to the June 26th 2007 storm. The Sauganash station reported that 4 ½" of rain fell per hour.
- The September 13th 2007 storm was rated using Skokie fire station data which does not allow accurate collection because of wind.
- The Village must have accurate rain gauge data and know the amount of water on the ground
- The Inlet restrictors were measured from photographs. Mr. Gordon will give shop drawings to Mr. Sticklen. Mr. Gordon stated that if Mr. Sticklen corrects the measurements there will be 20% more water entering the restrictor covers.
- AB&H did not conduct a hydraulic drainage test on the sewers
- Figure 6 from June 26th 2007 storm shows 5 feet of freeboard
- The Village needs an accurate weather station. We need 5 of them at $6,000 a piece.
- The model needs to be based on accurate storm data to assess it correctly.
- Mr. Gordon stated that the Village needs to start an education program to educate citizens and the public works department needs to learn how to respond and help the engineers

Mr. Martel stated that he believes the intensity of the events were higher then what Steve's report indicates. He further stated that this is important because we need to know if we survived a 10 year storm event.

Mr. Carr stated that the model that was run was a 10 year storm event. Pre, existing and future conditions were run. Mr. Carr went on to say that Mr. Gordon's points regarding rain gauges are well taken. Rainfall is often localized. Rain gauges are considered as part of the flow monitoring plan and will be used for phase 2 of the project.

Mr. Martel noted that a fixed set of points need to be identified for flow monitoring.

Mr. Carr stated that the size of the openings on the cover need to be verified and the model re-run. He also stated that a 20% difference may not make that much of a difference.

Mr. Eisterhold made a recommendation to:

1. Hold off on the failure analysis;
2. Begin sewer televising as soon as possible;
3. Begin flow metering in the Spring;
4. Investigate weather stations;
5. Ensure that the Pratt sewer is evaluated; and
6. Finalize the report.

Mr. Gordon will coordinate with Bob Carr to determine locations for weather stations.

Next Steps

Meet with the ad-hoc sewer committee in January or February after the draft report is submitted. Submit comments to Mr. Sticklen and have final report presentation at the end of February/beginning of March.

Mr. Martel made a motion to adjourn. Mr. Dimas seconded.

ADJOURNMENT

The meeting adjourned at 10:15 pm.

Respectfully Submitted,

Ashley R. Dorsey
Public Works Management Analyst

5.5.2 May 31, 2011 Meeting

Unapproved
Ad Hoc Sewer Meeting Minutes
May 31, 2011

CALL TO ORDER
Chairman Eisterhold called the Ad Hoc Sewer Committee Meeting to order at 7:00 p.m., Tuesday, May 31, 2011, in the Board Conference Room of the Village Hall located at 6900 N. Lincoln Avenue, Village of Lincolnwood, County of Cook and State of Illinois.

ROLL CALL
The following were:

PRESENT: Chairmen Paul Eisterhold, Mark Collens, Barbara Copeland, Gus Dimas, Zvie Liberman, Chris Martel and Paul Grant

ABSENT: None

Others in attendance: Bob Carr, Water Resources Modeling; Manuel Castaneda, Director of Public Works; Ashley Engelmann, Management Analyst; Tom Heidtke, Trustee; and Timothy Wiberg, Village Administrator; Steve Sticklen, AB&H / Donohue

APPROVAL OF MINUTES
The February 22, 2011 minutes were approved by voice vote.

REGULAR BUSINESS
Mr. Sticklen gave an introduction stating that the presentation this evening is a work in progress in which he will be presenting preliminary results.

An overview of the meeting outline was presented:

- Project Review
- Phase I Results
- Phase II Alternative 1 Results
- Preliminary Alternative 1 Costs
- Alternative 2 Potential Improvements

Mr. Sticklen reviewed the background on the project.

- 1986 – Inlet restrictor program begins
  - Concrete "blocks" on outlet pipes (prone to clogging)
  - Restrictor plates on surface
  - 45% of inlets are restricted
- Village's goal – Handle 10-year event

- Board directs Village staff to proceed with a stormwater management plan
- June 5, 2008 – Board approves hiring AB&H

Mr. Sticklen reviewed the phases of the study.

- Phase I – Pass/Fail Analysis
  - Develop un-calibrated model
  - Can system handle a 10-year event?
- Phase I-B – Update Pass/Fail Analysis
  - Collect flow & rainfall data
  - Calibrate model
  - May 31, 2011 analyses using calibrated model
- Phase II – Identify System Improvements
- Phase III – Design System Improvements

Mr. Sticklen presented a map of the existing conditions during a 10 yr rain event.
  - 84% at risk for basement back-up

Mr. Sticklen presented a map of the future conditions (surface restrictors & no containment berms) during a 10 yr rain event.
  - 79% still at risk in 10 yr event

Mr. Sticklen presented an overview of the goals of Phase II. Using street storage only- how far can we get by ponding water on the streets alone? AB&H is examining the following:
  - Adding berms and inlet restrictors
    - What level of protection will this provide?

Mr. Sticklen presented a map of the 25 year storm which shows flooding with the addition of berms and subsurface restrictors.
  - Pink lines show berms
  - Light blue show water ponding on the streets

Mr. Liberman stated that if we allow 9 inches at the curb, 6 inches at the center and the crown is no more then 3 inches- can we lower the crown to get more surface storage?

Mr. Martel asked how the model topography was developed.

Mr. Sticklen stated that the model is 2D; they used the surface terrain to create the model.

Mr. Martel asked if we used GIS or the TIN.

Mr. Sticklen stated that we used GIS because the TIN was so accurate so we were able to cut cross sections out of it.

Mr. Collens asked if there is a natural flow of stormwater in the Village.

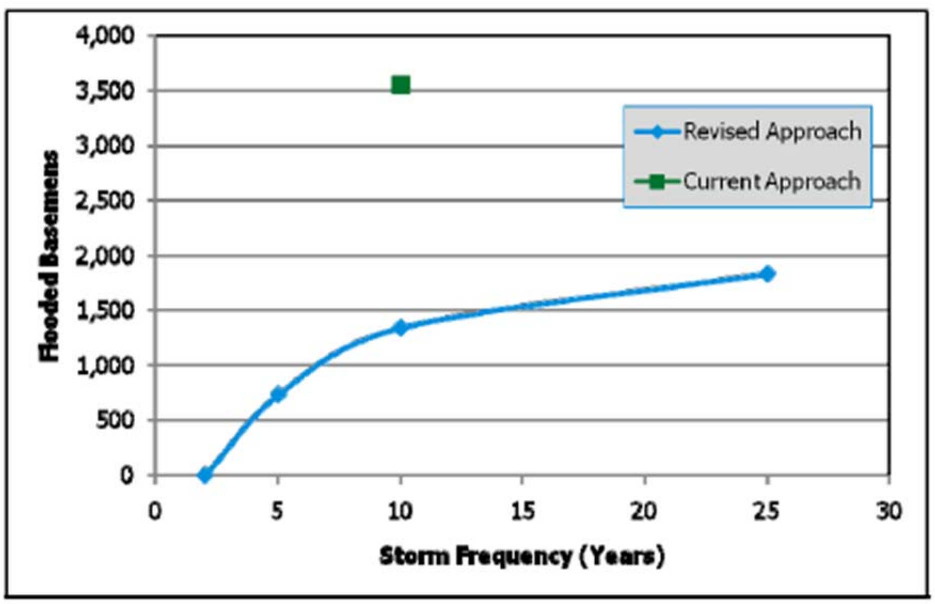
2

Mr. Castaneda noted that it generally flows from west to east.

Mr. Sticklen presented a slide indicating the flooding risk with the revised approach versus the current approach.

Storm Frequency (Years)	Basement Flooding			Surface Flooding
	Current Config.	Current Approach	Berms & Submerged Restrictors	
1	-	-	0	0
2	-	-	0	0
5	-	-	737	46
10	3,780	3,555	1,345	100
25	-	-	1,837	150

Mr. Sticklen presented a slide that graphically depicted the flowing risk with the revised approach versus the current approach.



3

- X axis number of homes at risk
- Y axis storm frequency
- Reduce the number of homes at risk for flooding by 62% during a 10 yr event

Mr. Sticklen noted that the assumption was made that all homes have basements and that none have flood control devices.

Mr. Martel asked how the model correlates to the Gewalt Hamilton survey after the 2001 event.

Mr. Sticklen stated that when there was a 25 yr event the entire system failed and the model predicted that everything would flood, which is consistent with the 2001 survey.

Mr. Sticklen presented a slide indicating preliminary costs for the berms and subsurface restrictors.

- Berms & Restrictors Only
  - Skokie $6M/10 mi2 (1999)
  - Skokie: $8.7M/10 mi2 (2011)
  - $871,000/mi2 (2011)
  - Lincolnwood = 2.7 mi2
  - Total Cost = $2,352,000

Mr. Martel asked if AB&H looked at a per berm and/or per restrictor cost.

Mr. Sticklen noted that will be included and looked at in the final report.

Mr. Sticklen presented the purpose of alternate-2.

- Subsurface Storage
- Detention Ponds
- Conveyance Improvements
- Sewer Separation
  - what methods can we use to get to the 10 yr level of protection since surface storage will not get us there

Mr. Sticklen showed a map of potential system improvements. These items have not been modeled by he wanted the committee to discuss whether or not these are avenues AB&H should explore.

- Look at least expensive approaches first
  - add stormwater outfall(s) to North Shore Channel.
  - detention storage- potential open space to create

4

        - ComEd ROW, parks, Bryn Mawr, etc.
    - inline storage
        - box culverts
            - potentially look at new stormwater sewer under Crawford- with the reconstruction project

Mr. Martel noted that we should ask CCHD or MWRD for preliminary responses regarding these ideas before doing model runs.

Chairman Eisterhold asked the group to recommend to staff how to proceed on the following:

Outfalls
Should talk to CCHD sooner then later about this option.

- directed staff to pursue conversations with Skokie and CCHD

Storm Outfalls
Should talk to MWRD regarding the stormwater outfalls

- directed staff to pursue conversations with MWRD regarding feasibility

Mr.Martel stated that we should have a cost per house benefit included in the final analysis.

Mr. Sticklen stated that AB&H would iteratively look at each solution, its cost, number of homes protected, and $/home protected.

Detention Storage

- school is out
- should pursue ComEd ROW
- park near the pump house
- parks in general
- Country club

Mr. Carr noted that staff needs to talk to ComEd, Skokie, MWRD, CCHD, Parks Dept., Bryn Mawr, to check into the feasibility of these items.

Mr. Sticklen stated that they all could have a great benefit.

Chairman Eisterhold noted that parks such as Proesel which was developed for programming should not be considered.

Mr. Sticklen noted that these would be dual-use facilities, and only storm water stored in them during large rainfall events.

Mr. Martel asked if we could increase the size of the detention pond at the mall.

5

Trustee Heidtke stated that we have made an assumption that all homes have basements and none have flood control devices- do you take into account how shallow sewers would affect the model?

Mr. Sticklen stated that they used Google Earth and realty websites to determine shallower basements which are included in the model-these assumptions were made so they were conservative, the impact would be that there would be extra water in basements because it has to go somewhere.

Mr. Wiberg asked what if every home in Lincolnwood had overhead sewers- what would happen to the water?

Mr. Sticklen noted that you would have massive overland flooding and sewage on the street because it would have to go somewhere.

Chairman Eisterhold asked if the Village did or will hire someone for this summer to complete a downspout connection inventory of the Village.

Mr. Wiberg stated that if the commission wants to recommend that staff do this he could go to the Village Board and ask for funds to hire someone.

Trustee Heidtke asked why there isn't a benefit to keeping some of the water on the surface- i.e. using both the submerged restrictors and the surface restrictors together.

Mr. Sticklen noted that we can control the flow better and prevent clogging by just using the submerged restrictors.

Mr. Carr and Mr. Sticklen have looked at some alternative ways to reduce clogging.

Mr. Wiberg noted that the good news is that there is a 62% reduction in basement flooding during a 10 yr event with just street storage, we may be able to modify some parameters and get better results with a smaller event such as a 5 yr.

Mr. Martel noted that if the goal is to achieve a 10 yr event then we don't really need to try and achieve a 5 yr event.

Chairman Eisterhold stated that we should also look at using the abandoned railroad as detention. He also asked when will we be able to know if we need to upsize existing sewers.

Mr. Sticklen noted that we won't know this until we are done with phase II.

Mr. Martel noted that we have not talked about upsizing sewers.

Mr. Sticklen stated that in terms of priority, financially that would be very expensive so we need to try to use other alternatives first.

Chairman Eisterhold stated that we are starting downstream and working our way back upstream.

Mr. Castaneda asked if we can we use rain gardens for detention.

Mr. Carr noted that they tend to be better for small events then large events.

Mr. Sticklen noted that they are also better for improving water quality.

Mr. Sticklen noted that within the next two months (end of July) they should have an idea of preliminary sizing and costs.

The group discussed potentially meeting in two months when preliminary results are complete for alternate 2 and also to talk about a public education campaign.

Ms. Copeland made a motion to adjourn. Mr. Grant seconded.

ADJOURNMENT

The meeting adjourned at 9:07 p.m.

Respectfully Submitted,

Ashley R. Engelmann
Assistant to the Public Works Director