

Village of Northbrook

Master Stormwater Management Plan

August 2011



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Civil Engineers • Structural Engineers • Land Surveyors

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Memorandum

From: Stormwater Management Commission Members

Date: August, 2011

Subject: New Master Stormwater Management Plan

A strong commitment needed to be undertaken by the Village's Board of Trustees, Stormwater Management Commission and Village staff to address the flooding problems that the Village is experiencing. Most recently on July 22-23 of this year the Village received 5.26-inches of rain, which by volume is the fourth largest since rain data has been collected. As part of this commitment, the Commission along with Village staff and consultant HLR, Inc. has developed a New Master Stormwater Management Plan for the Village. This New Plan will replace the previous Master Plan and the two subsequent editions. The purpose of the New Plan is to identify projects, programs and initiatives that are recommended to be undertaken to reduce flooding impacts throughout the Village. It will be the duty of the Village Board, Commission and Village staff to select and implement the recommended improvement projects contained in the New Plan in a timely manner and fair order to meet the expectations of the residential, business and industrial sectors in our community that they have a healthful, beneficial and prosperous existence. It also needs to be understood that the proposed projects will reduce, but not entirely eliminate the documented flooding conditions throughout the Village.

In reviewing the New Plan, the reader should be aware of the following:

- The **project rankings** were determined by the overall benefit-cost (B/C) ratio, number of structures benefitted and number of properties benefitted. The reduction of damages to structures was emphasized, first by considering the number of structures benefitted and then by the benefits in the B/C ratio, which are heavily weighted towards protecting structures from flood damages. If a tie resulted, the number of structures benefitted was the deciding factor.
- The Plan includes an **Optimum Level of Protection** for each improvement project, which is defined as the most cost effective project design that provides the most benefits for the given reoccurring storm event (10-year, 25-year, 50-year or 100-year).
- In order to ensure the intended project benefits are not diminished after construction, or flooding problems do not increase elsewhere in the Village, **limitations for increases in impervious coverage** and the **preservation of existing depressional storage and overland flood paths** should be strongly considered on a Village wide basis.
- A very important component of the New Plan is **education** that first starts at home in regards to proper lawn grading, downspout discharges, storm sump pump maintenance and not obstructing drainage paths and storm sewer structures. The Plan also contains many **property owner programs** that can be undertaken to reduce flooding impacts such as overhead sanitary sewer service conversions, lawn grading and low flow private storm sewer systems and auxiliary storm sump pump installations. The Village will continue to provide technical advice and may also continue to offer partial financial reimbursement in some instances.
- A **better understanding is needed** by everyone as to what constitutes inconvenience and actual flooding that threatens the health, safety and welfare of the public, which will then allow better comprehension of the goals and objectives of stormwater management in the Village. Street flooding is acceptable in extreme conditions so long as emergency vehicles can still gain access.
- There are many **external factors** that could possibly delay and/or change the order of implementation of the proposed improvement projects. These external factors include easements, property acquisitions and approvals from other agencies in the form of License or Intergovernmental Agreements. Several projects that are affected include the Shermer Road overflow sewer, Wescott Park storage, Keystone Road/Chartres Drive, Sunnyacres, Williamsburg Subdivision and Church Street.

New Master Stormwater Management Plan

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- The Commission recommends that the proposed **Wescott Park underground storage project** be further evaluated with at least one additional study due to its size, cost, complexity and potential additional benefits. The intent of the further evaluation is to identify additional benefits, refine costs, and explore additional funding opportunities and to determine if there are any additional ways to further value engineer the project. There was an identified need to include a project that addresses the flooding problems in the area roughly bordered by Illinois Road, Pfingsten Road, Farnsworth Lane and Shermer Road. Many alternative projects along with variations of the recommended project were evaluated. The mitigation (storage) concept was determined to be the most cost effective and resulting in the greatest number of benefits.

The stormwater management infrastructure is as important to the Village as good condition roadways, a safe water distribution system and an effective sanitary sewer system. Unfortunately its importance sometimes is only realized during major rainfall events. A firm commitment to appropriately invest in the stormwater management infrastructure is key to addressing the flooding problems in the community. The Stormwater Management Commission stands ready to assist the Village Board and staff to implement the recommended improvement projects in this new Plan.

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Mission Statement

The purpose of the New Master Stormwater Management Plan (MSMP) is to identify projects, programs and initiatives that will reduce flooding conditions within the Village by the most cost effective means and at the appropriate level of protection.

Executive Summary

The MSMP revises and updates the previous three versions of the MSMP, the first of which was published in 1993. The latest previous edition, dated 2002, identified many projects to help relieve the flooding that had been experienced at that time. In the nine years since the previous edition was adopted, the Village of Northbrook has experienced significant flooding. Much of the more recent flooding has occurred in areas that were not considered in the previous MSMP and updates. This could be attributable to a number of factors, including additional development or redevelopment in the past decade; the magnitude and number of occurrences of major rainfall events; and Village citizens have more proactively been asking for assistance with flooding problems than in the past. In order to recommend and prioritize improvements that will help alleviate current flooding conditions, it is necessary to understand the causes of the flooding.

Storm Events

Responding to citizens' service requests during and immediately after larger rainfall events represents a significant expenditure to the Village in terms of both money and resources. Some of the more notable recent rainfall events are listed in the following table:

<i>Date(s)</i>	<i>Rainfall (depth)</i>
7/22/82	6.5"
8/14/87	7.75"
6/24/94	5.2"
10/12/01 - 10/13/01	4.1"
8/21/02 - 8/22/02	4.3 "
9/13/08 - 9/14/08	6.4"
5/13/10	2.2"
7/22/11 – 7/23/11	5.25"

Service calls to the Public Works department totaled over 500 during and immediately after the September 2008 event (6.4"); the August 2002 event (4.3") generated over 110 calls. Service requests have increased for smaller rainfall events, as indicated by the over 230 calls for the May 2010 event (2.2").

Nine projects identified in previous MSMP and subsequently implemented are shown in Table 1 of the Appendix. The total construction cost for these nine projects were \$5,217,500. Had these improvements not been in place, there would have undoubtedly been more flooding and, therefore, greater response required by the Village during these most recent events. This MSMP represents the evolution of the previous MSMPs and the

Village's commitment to its citizens to reduce flooding in a methodic and responsible manner.

Factors Contributing to Flooding

Total depth of rainfall is not the only factor that determines the rate of runoff generated by a storm event. Storm intensity (inches per hour), duration, and degree of soil saturation are all natural aspects that impact the rate of runoff. Increased flooding and the resultant increase in service requests and flood damages are also influenced by physical characteristics of the watershed, such as increased impervious surfaces, blockage or absence of overland flow paths or outlets, redevelopment, and outdated storm drainage systems.

- **Increased Impervious Surface**

An increase in impervious surface reduces the potential for infiltration of rainfall and increases stormwater runoff from a site. Larger paved areas, increased roof areas, and patio additions are examples for which individual impacts may seem insignificant, but collectively contribute to flooding throughout the Village.

- **Non-existent or Blockage of Overland Flow Routes or Outlets**

Storm sewers are typically designed to carry the runoff from a 10-year storm event. For runoff that exceeds the conveyance capacity of the storm sewer, excess must either pond, travel overland to the outlet, or both. The overland flow route may be down roadways, through back yards or side yards between houses, or through swales, ditches and creeks. If an overland flow path does not exist or has been blocked, stormwater levels will rise and likely cause flooding.

- **Redevelopment**

Residential redevelopment, or "teardowns," which results in existing residential structures being removed and replaced by larger homes, contributes more to flooding conditions than the obvious increase in impervious (roof) area. These developments commonly result in compaction of soils due to construction activities, the loss of depressional storage areas, and possibly the obstruction of overland flow routes, all of which increase stormwater runoff from the site. As in the case with increased impervious surfaces, individual impacts may seem insignificant, but their cumulative consequences can be widespread.

- **Outdated Drainage Systems**

Many of the subdivisions in Northbrook were built on or before the 1950s, and some of the drainage systems serving these developments were designed to accommodate runoff only from their respective subdivision. As development, and therefore runoff, within individual watersheds has increased, many of these drainage systems have been subjected to runoff they were not designed to handle. In addition, older local drainage systems were designed to carry low flow stormwater runoff based upon less stringent design standards, using rainfall data that yields lower runoff rates than today's accepted values. In many instances, the existing systems have been modified through individual, isolated efforts accompanying redevelopment, resulting in "improvements" that may benefit one property but adversely impact the rest of the system. The result is that many of

the older drainage systems may only be capable of carrying runoff from 3 to 5-year storm events, as compared to the current 10-year design criteria.

Increases in impervious surfaces; loss of depressional storage; impairment of overland flow paths and outlets; and inadequate storm sewers, as well as flood stage levels in receiving rivers and floodplains, all contribute to flooding within the Village of Northbrook. Implementation of the improvements and programs identified and prioritized in this MSMP will help decrease flooding and prevent such occurrences from increasing in the future.

Project Categories

The recommendations presented in the MSMP are divided into three categories-Watershed Projects, Neighborhood Projects and Property Owner Programs-each of which identifies the problems and provides individual plans for reduction of flooding.

Watershed Projects target large drainage problems, typically involving large areas of flooding. Lack of sufficient conveyance capacity and/or overland flood routes are often the major factors contributing to flooding. These projects will generally provide benefits to the greatest number of residents and are expensive to implement.

Neighborhood Projects target smaller drainage problems. These typically involve areas of one or two blocks or less which experience repeated flooding. As with watershed projects, lack of conveyance capacity and/or overland flood routes contribute to the problem. These projects will benefit a smaller number of residents and are usually significantly less expensive to implement than watershed projects.

Property Owner Programs are used to encourage property owners to implement their own projects to reduce flooding to their own properties, often with a cost sharing or other benefit as incentive. These programs are independent of the projects described above and only directly benefit the property upon which they are implemented.

In identifying and ranking the proposed projects presented in this MSMP, the following hierarchy of goals, from high to low, was used:

- Elimination of structure damage
- Reduction in street and front yard flooding
- Management of back yard flooding
- Management of development/redevelopment so that it does not aggravate existing flooding conditions, with or without proposed improvements in place. A list of private properties to be acquired for strategic drainage easements and/or local stormwater detention was compiled.

Proposed Projects

This MSMP addresses and prioritizes 22 projects, 14 of which are new and 8 of which were identified in previous editions. The projects were chosen on the basis of flooding records and consultation with Village Staff. Likely causes of flooding were evaluated. The recommended projects are described in the individual project exhibit sections in the MSMP. Projects were compared against each other and prioritized accordingly to their respective benefit/cost ratio, number of structures benefited and number of residents benefitted. The results of the ranking process are included in Project Ranking – Table 1. The following projects were the 7 highest ranked projects:

<i>Project Rank</i>	<i>Project Number</i>	<i>Project</i>	<i>Properties Benefitted</i>	<i>Structures Benefitted</i>	<i>Total Estimated Cost</i>	<i>B/C Ratio</i>
1	3	Techny Drain Phase IV	82	10	\$798,000	10.57
2	2	Shermer Road Overflow Sewer	22	17	\$1,327,000	1.92
3	11	Northbrook East	29	11	\$718,000	2.18
4	1	Wescott Park Storage	91	12	\$8,200,000	0.33
5	10	Keystone Road /Chartres Drive	17	5	\$635,000	3.05
6	16	Sunny Acres	14	3	\$614,000	4.16
7	14	Shermer Road Outlet	42	0	\$13,000	0.85

Possible Funding Sources

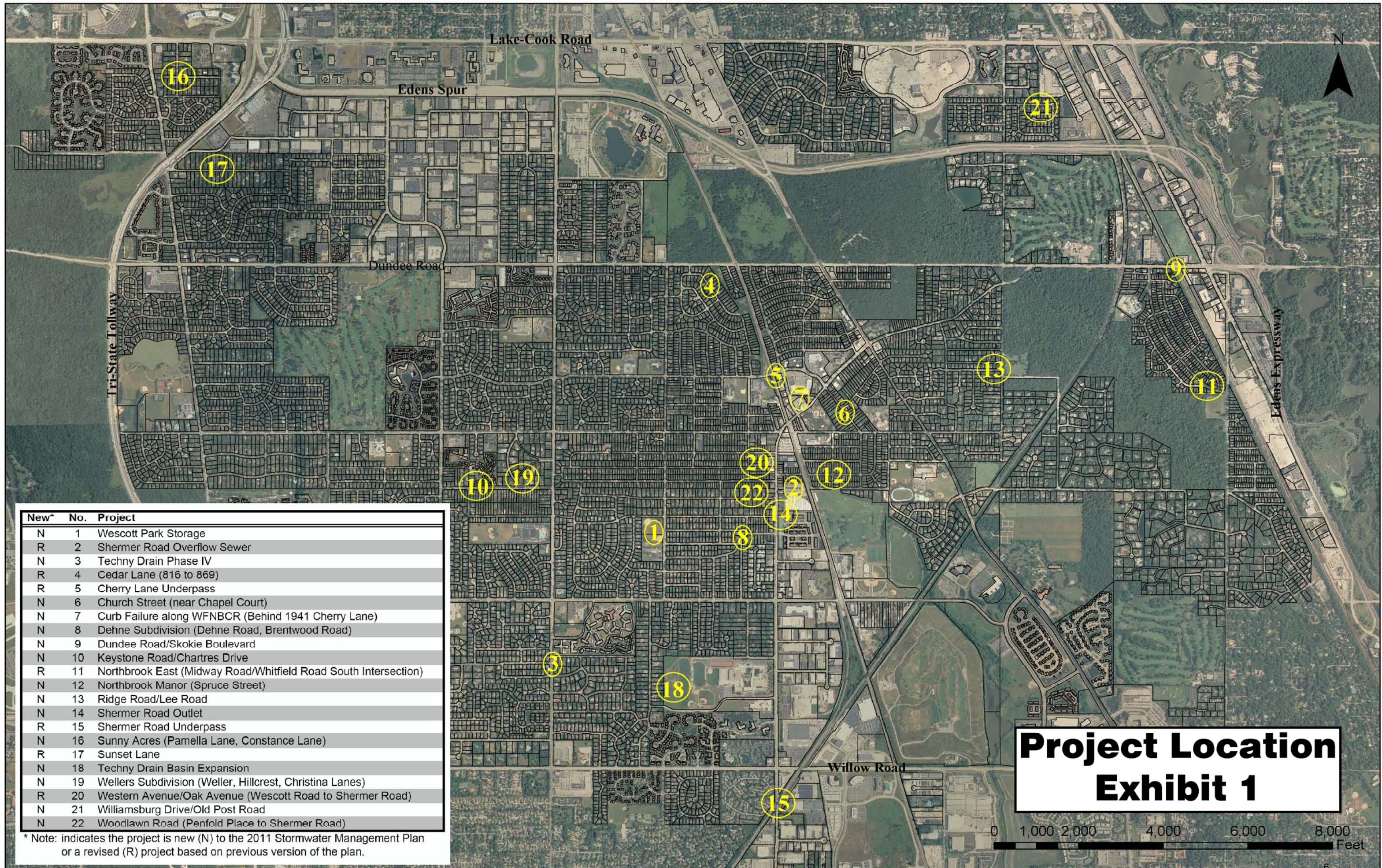
Possible funding sources, including grants, are included in the Appendix (Additional Initiatives-Funding).

Future of the MSMP

This MSMP is intended to be used as a guide to the Village for future improvements and associated budgeting. The Village has experienced past success in reducing flooding through previously implemented improvements; this MSMP is a guide to stimulate the continued implementation of such projects. This MSMP is intended to be a living document that should be revisited periodically to address flooding throughout the Village. The document should also be updated to acknowledge changes to federal, state and local laws, rules and regulations.

Major storm events should continue to be documented by Village Staff and residents. Photos and videos of actual flooding can aid in investigation into the causes. Documentation may indicate that simple maintenance could alleviate a flooding problem, or that infrastructure improvements are needed.

Changes to laws, rules, regulations and policies may require that the MSMP be revisited. The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) is Cook County's lead stormwater agency. It is anticipated that there will be no significant flood relief benefits to the Village from the MWRDGC projects that are part of their current Detailed Watershed Plan. The new Cook County Watershed Management Ordinance (WMO) has not yet been completed; comments on the Public Review Draft are being addressed in great detail. The new WMO will include regulations regarding isolated wetlands, depressional storage and credits for storage reduction based on implementation of Best Management Practices. When the WMO is adopted, this MSMP and Village ordinance should be re-examined to ensure compliance on a countywide basis.



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PROJECT RANKING TABLE	RANK ^{1,2}	SCORE	PROJECT NUMBER	PROJECT	OPTIMUM LEVEL OF PROTECTION (YEARS) ³									
					100	50	25	10	10	50	25	10	10	50
1	2.67	3	Techny Drain Phase IV		100	10.57	1	10	4	82	3	\$798,000	\$79,800	\$9,700
2	4.67	2	Shermer Road Overflow Sewer		50	1.92	6	17	1	22	7	\$1,327,000	\$78,100	\$60,300
2	4.67	11	Northbrook East (Midway Road/Whitfield Road South Intersection)		50	2.18	5	11	3	29	6	\$718,000	\$65,300	\$24,800
4	5.33	1	Wescott Park Storage		25	0.33	12	12	2	91	2	\$8,200,000	\$683,300	\$90,100
5	6	10	Keystone Road/Chartres Drive		10	3.05	4	5	5	17	9	\$635,000	\$127,000	\$37,400
6	6.33	16	Sunny Acres (Pamella Lane, Constance Lane)		10	4.16	2	3	6	14	11	\$614,000	\$204,700	\$43,900
7	7	14	Shermer Road Outlet		10	0.85	7	0	9	42	5	\$13,000	N/A	\$300
8	8	5	Cherry Lane Underpass		10	3.51	3	1	8	10	13	\$246,000	\$246,000	\$24,600
9	9.33	20	Western Avenue/Oak Avenue (Wescott Road to Shermer Road)		10	0.07	18	0	9	106	1	\$631,000	N/A	\$6,000
9	9.33	18	Techny Drain Basin Expansion		10	0.16	15	0	9	60	4	\$268,000	N/A	\$4,500
11	10	21	Williamsburg Drive/Old Post Road		10	0.16	15	2	7	18	8	\$270,000	\$135,000	\$15,000
12	10.33	12	Northbrook Manor (Spruce Street)		10	0.07	18	0	9	60	4	\$446,000	N/A	\$7,400
13	11	22	Woodlawn Road (Penfold Place to Shermer Road)		10	0.23	14	0	9	15	10	\$140,000	N/A	\$9,300
14	11.33	9	Dundee Road/Skokie Boulevard		10	0.84	8	0	9	4	17	\$51,000	N/A	\$12,800
15	11.67	6	Church Street (near Chapel Court)		10	0.54	10	0	9	5	16	\$80,000	N/A	\$16,000
16	12	4	Cedar Lane (816 to 869)		10	0.76	9	0	9	3	18	\$42,000	N/A	\$14,000
17	12.67	13	Ridge Road/Lee Road		10	0.35	11	0	9	3	18	\$60,000	N/A	\$20,000
18	13.33	8	Dehne Subdivision (Dehne Road, Brentwood Road)		10	0.10	17	0	9	8	14	\$109,000	N/A	\$13,600
19	13.67	17	Sunset Lane		10	0.05	20	0	9	13	12	\$432,000	N/A	\$33,200
20	14	7	Curb Failure along WFNBCR (Behind 1941 Cherry Lane)		10	0.27	13	0	9	1	20	\$41,000	N/A	\$41,000
21	15	19	Weller's Subdivision (Weller, Hillcrest, Christina Lanes)		10	0.04	21	0	9	7	15	\$784,000	N/A	\$112,000
22	16.67	15	Shermer Road Underpass		50	0.04	21	0	9	1	20	\$332,000	N/A	\$332,000
										TOTAL COST OF ALL PROJECTS		\$16,237,000		

NOTES:

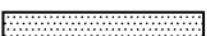
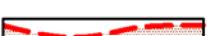
1. This table is a list of projects evaluated in the 2011 Master Stormwater Management Plan ordered by ranking. The score is the average of the benefit-cost ratio, number of structures benefited and number of properties benefited. The lower the score, the higher the rank.
2. For projects with identical scores, number of damaged structures benefited is the primary tie-breaker, followed by number of properties benefited.
3. The optimum level of protection refers to the storm event for which a project can reliably provide benefits to properties affected.
4. Structures and properties benefited receive flood reduction benefits but are not necessarily removed from flood risk.
5. Cost are based on 2011 dollars and may not reflect final cost.

Project Ranking
Table 1

ACRONYMS

BCR – Benefit Cost Ratio
BFE – Base Flood Elevations
CCFPD - Cook County Forest Preserve District
CCHD – Cook County Highway Department
CMAP - Chicago Metropolitan Agency for Planning (formerly NIPC)
CRS – Community Rating System
DEC-2 – DuPage Environmental Concerns BCR analysis tool
DWP – Detailed Watershed Plan (Cook County)
FEMA – Federal Emergency Management Agency
FIRM – Flood Insurance Rate Map
GBNHS – Glenbrook North High School
HEC-HMS – Hydraulic Engineering Corps- Hydrologic Modeling System
HEC-RAS – Hydraulic Engineering Corps- River Analysis System
IDNR-OWR – Illinois Department of Natural Resources/Office of Water Resources
IDOT - Illinois Department of Transportation
ICPR – Interconnected Channel and Pond Routing
IEPA – Illinois Environmental Protection Agency
MFNBCR – Middle Fork North Branch of Chicago River
MSMP – 2011 Master Stormwater Management Plan
MWRDGC – Metropolitan Water Reclamation District of Greater Chicago
NCSWCD – North Cook Soil and Water Conservation District
NFIP – National Flood Insurance Program
NIPC–Northeastern Illinois Planning Commission
NPDES – National Pollutant Discharge Elimination System
NRCS – Natural Resource Conservation Service
ROW – Right-of-Way
SWMP – 1993, 1996, and 2002 Stormwater Management Plan
TGM – Cook County Watershed Management Ordinance –Draft Technical Guidance
Manual – September 24, 2009
USACOE– US Army Corps of Engineers
WMO – Cook County Watershed Management Ordinance – Public Review Draft –
September 24, 2009
WFNBCR – West Fork North Branch of the Chicago River
WPC – Watershed Planning Council
WSEL – Water Surface Elevation

Project Legend

-  Existing Storm Sewer, Sewer Size and Drainage Structures
-  Edge of Pavement
-  Property Boundaries
-  FEMA Flood Insurance Rate Map 100-year Floodway
-  FEMA Flood Insurance Rate Map 100-year Floodplain
-  FEMA Flood Insurance Rate Map 500-year Boundary
-  Estimated Existing Flooding Boundary *
-  Estimated Proposed After Project Flooding Boundary *
-  Proposed Storm Sewer
-  Proposed Manhole
-  Proposed Catch Basin / Inlet
-  Direction of Flow
-  Flood Overflow

*Note: The existing and proposed flooding boundaries are not regulatory and are for informational purposes only.

Watershed Projects



ILLINOIS ROAD WATERSHED OVERVIEW

Statement of Conditions:

The watershed contains multiple storm sewer systems that lead to and cross Shermer Road and outlet to the West Fork North Branch of the Chicago River (WFNBCR). It includes Northbrook Park and Sunset Fields Subdivisions. The area is primarily served by a 40-50 year old drainage system that was intended to carry low flows based upon older, less stringent design standards. The system's conveyance capacity is limited to carrying approximately the 5-year storm event, consequently, flood overflows for larger storm events must travel over streets and properties on their path to the river. Flood waters flow through the Cattle Pass in the METRA railway embankment. The Cattle Pass Relief Swale was built in 2001 to convey flood overflows to the river around a residential area and minimize its flow through it. The 1996 Flapgate Improvement project installed backflow prevention devices on the Maple Avenue, Oak Avenue and Illinois Road storm sewers as a means of reducing flood risk to properties located between METRA and the river, however, the flapgate installations can reduce the capacity of the local drainage system. Stormwater has been observed to bubble out of a drainage structure on the existing 60" diameter outlet along Illinois Road during larger flood events.

Problem Identification:

Street, front yard, back yard and structure flooding along the overland flow paths to the WFNBCR

Project Considerations:

- Provide flood overflow routes by constructing relief storm sewers or controlled paths (i.e. the Cattle Pass Relief Swale)
- Construct "regional" stormwater storage facilities to accomplish the following:
 - Increase downstream storm sewer system ability to convey larger storm events by attenuating peak flows from upstream areas and/or
 - Mitigate increases in upstream conveyance improvements
- Develop independent projects to serve local area problems. These localized improvement projects would be dependent on the available outlet capacity of the existing drainage system, and would rely on mitigating increases in conveyance by providing stormwater detention on acquired private property or by constructing over sized storm sewers.

Recommended Plan (refer to related Watershed Projects and Neighborhood Projects):

- Construct flood overflow relief drainage system from Shermer Road to the WFNBCR
- Construct stormwater detention facility within Wescott Park property to improve the performance of downstream storm sewer system from Wescott Park to the WFNBCR and to provide mitigation for an upstream conveyance improvement.
- Construct conveyance improvement project from Sunnyside Circle to Wescott Park stormwater detention facility.

Project 1

Wescott Park Storage



Wescott Park



Northwest Corner of
Wescott Park

Wescott Park along
Farnsworth Lane



PROJECT 1 WESCOTT PARK STORAGE

Statement of Conditions:

This area is served by a 40-50 year old drainage system (Northbrook Park Subdivision, 1946; Sunset Fields Subdivision, May 1955-December 1967) that was intended to carry low flows based upon older, less stringent design standards. The system's conveyance capacity is likely limited to handling runoff from the 5-year storm event. Inspection of historic topographic flood maps indicates that as the previously farmed land was developed, overland flow routes were partially replaced with storm sewers. The areas that currently flood correspond closely to the areas that flooded prior to development. Flood flows that exceed the storm sewer capacity pond to depths such that streets are closed and property flooding occurs.

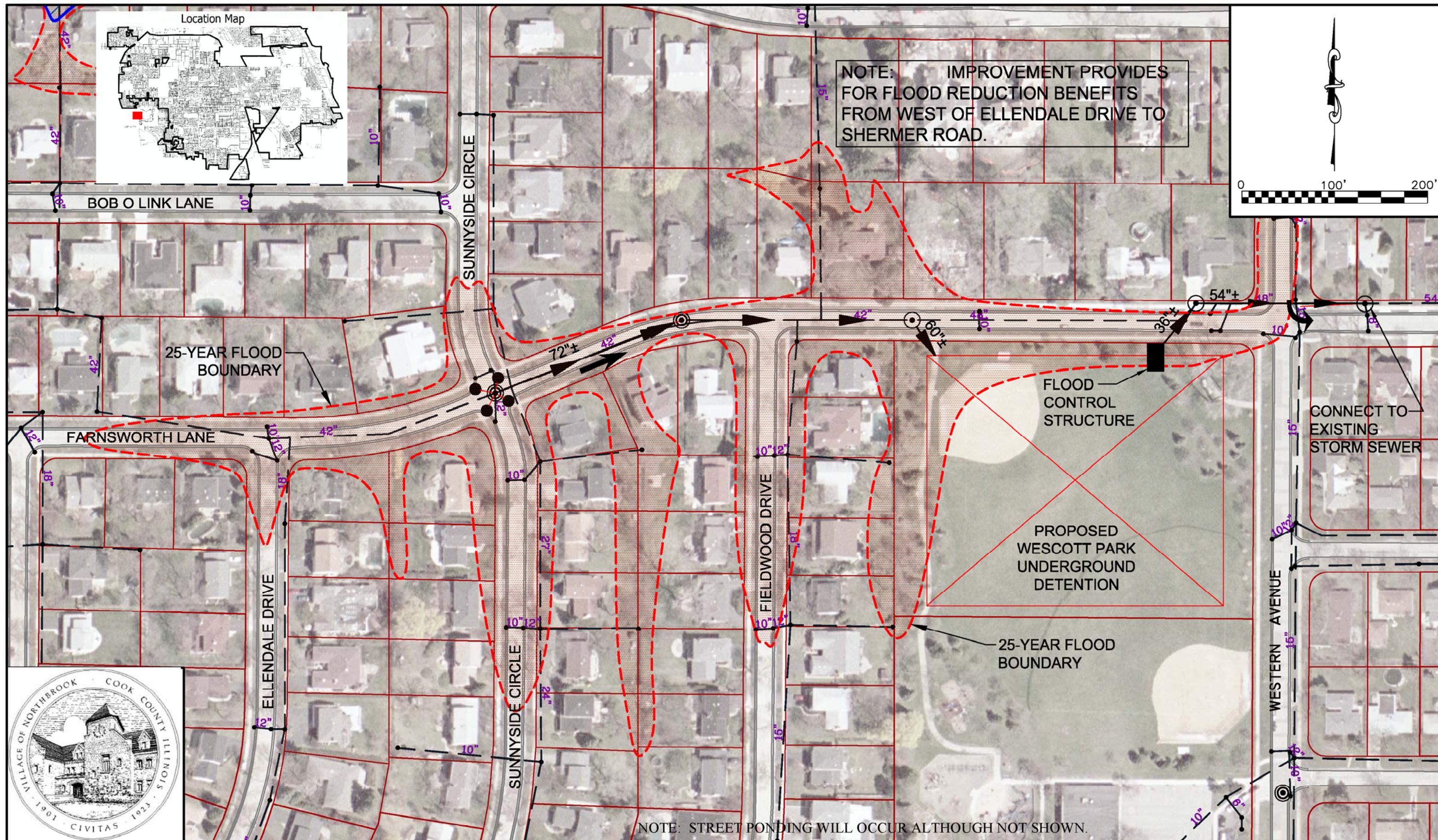
Problem Identification:

Street, front yard, back yard and structure flooding

Recommended Plan:

- Construct 20± acre-foot underground stormwater detention facility on Wescott Park property
- Construct large diameter storm sewer on Farnsworth Lane from Sunnyside Circle to Wescott Park to increase conveyance

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$8,200,000	\$7,100,000	N/A	\$1,100,000	0.33	25-yr



WESCOTT PARK STORAGE

PROJECT 1

Project 2 Shermer Road Overflow Sewer



Illinois and Shermer Intersection



Grainger Parking Lot

PROJECT 2
SHERMER ROAD OVERFLOW SEWER

Statement of Conditions:

The 50+ year old drainage system (Northbrook Manor Subdivision, recorded 1926) and its outlets, consisting of a combination of ditches, culverts and storm sewers, was intended to carry low flow runoff based on older, less stringent design standards. Over the years, runoff has increased due to properties being developed and redeveloped, and the system has been modified, often through individual, isolated efforts. The system cannot adequately convey runoff from storms of moderate to high intensities. The conveyance capacity of the drainage system is further reduced when WFNBCR is at flood stage.

The physical barrier formed by the METRA railroad embankment causes flood overflows to be funneled through the Cattle Pass structure located in the embankment. There is no other overland flood flow path to the WFNBCR for the almost one square mile Illinois Road Watershed. The 1999 Cattle Pass Stormwater Relief Swale was constructed to route flood overflows around Northbrook Manor Subdivision, rather than through it.

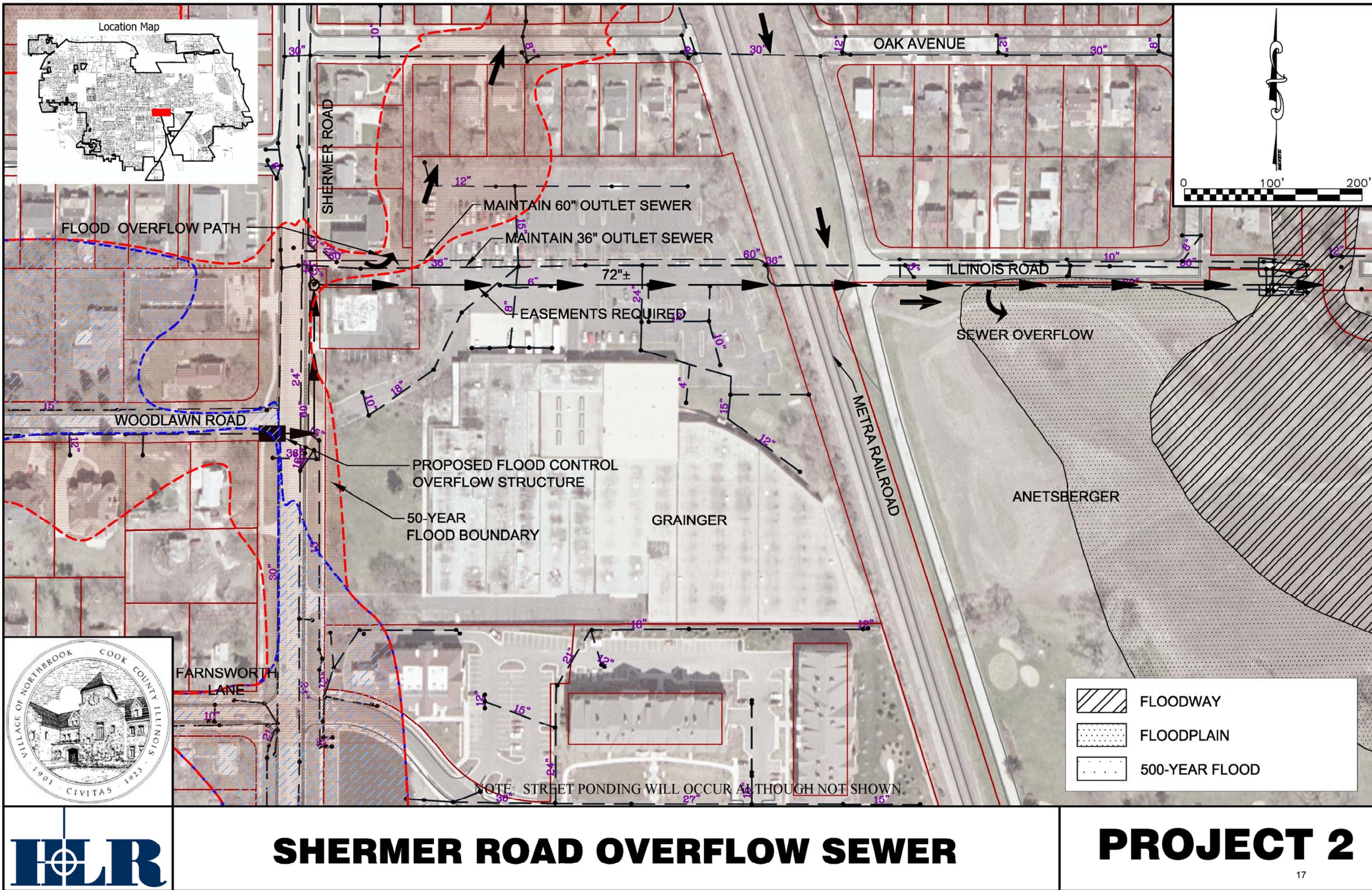
Problem Identification:

Street, parking lot, front yard, back yard, side yard and structure flooding

Recommended Plan:

- Improve flood overflow conveyance path by constructing a flood relief storm sewer from Shermer Road to the WFNBCR through the Grainger property. (Drainage easement through Grainger to be obtained at the time that the property redevelops)
- Construct flood overflow junction chamber at Shermer Road

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$1,327,000	\$1,145,000	N/A	\$182,000	1.92	50-yr



Project 3 Techny Drain Phase IV



2700 Block of Canterbury Drive

2100 Block of Greenview Road



2100 Block of
Greenview Road

PROJECT 3 TECHNY DRAIN PHASE IV

Statement of Conditions:

The existing drainage system, consisting of a combination of ditches and culverts, is over 50 years old (Willow Creek Development CO, recorded 1956; School Trustee Sub, recorded earlier), and runoff has increased due to property redevelopment. The system cannot adequately convey runoff from storms of moderate to high intensities. A segment of the South Fork ditch was enclosed between Greenview Road and Elm Ridge Road in 1973. The floodplain east of Pfingsten Road is a mapped FEMA floodplain and properties are subject to Flood Insurance requirement costs.

The Village adopted the February 2001 Techny Drain Stormwater Management Improvement Plan, consisting of four phases. Phases I & II have been completed. Detailed design plans for Phases III & IV are to be completed 2011. Phase IV predominantly provides flooding benefit to properties along the South Fork of Techny Drain.

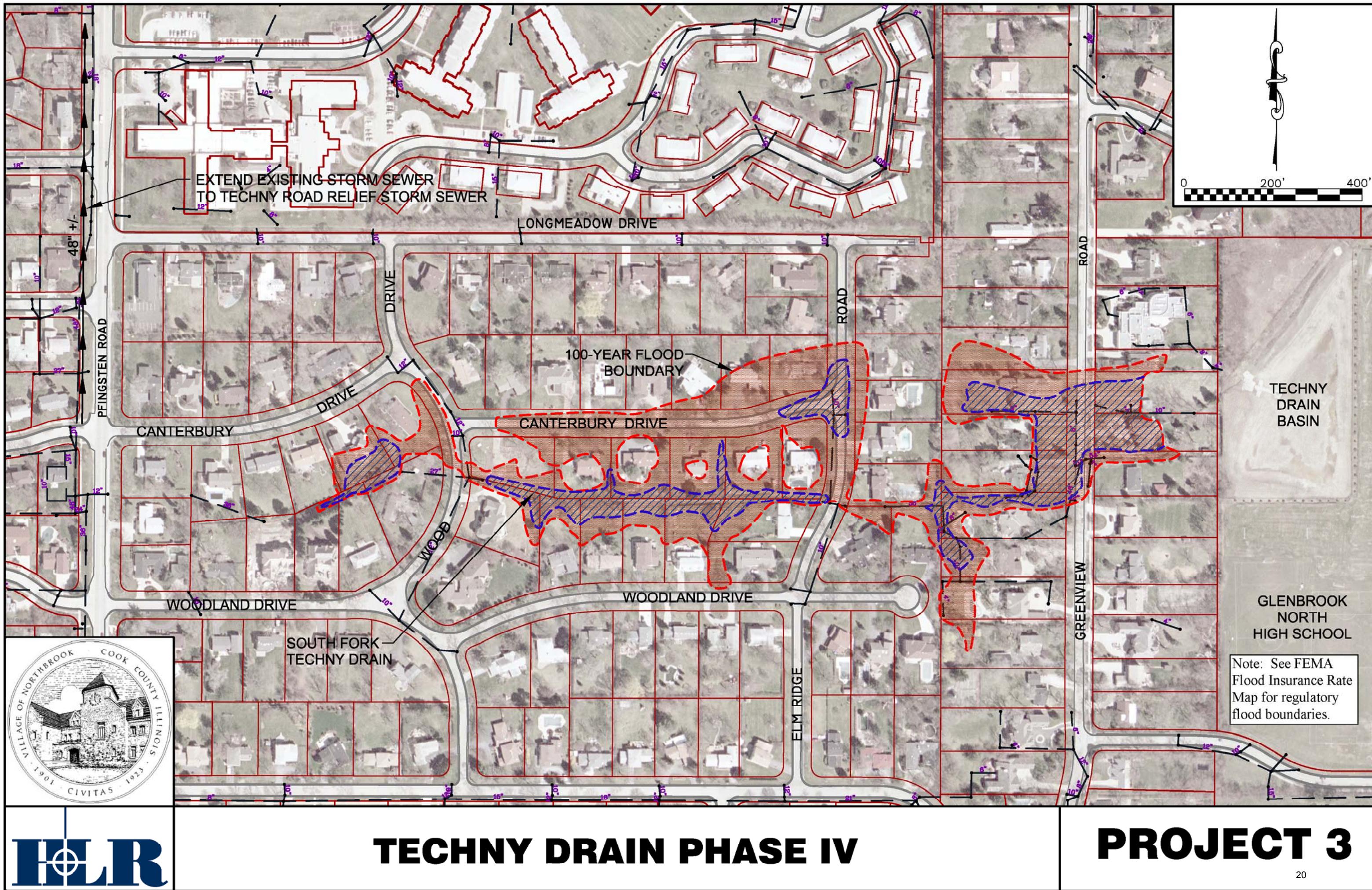
Problem Identification:

Street, front yard, back yard and structure flooding associated with the
South Fork Techny Drain

Recommended Plan:

- Reduce flooding by constructing the Phase IV relief storm sewer outlet along Pfingsten Road, and by increasing the Techny Road relief storm sewer diameter to 72" from Fieldwood Drive to Pfingsten Road
- Provide opportunity to reduce Flood Insurance requirements by processing Flood Insurance Rate Map revisions

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$798,000	\$694,000	N/A	\$104,000	10.57	100-yr



Neighborhood Projects



Project 4 Cedar Lane (816 to 869)



Cedar Lane Overflow Grate



Cedar Lane near Tot Lot



Cedar Lane Overflow Grate

PROJECT 4
CEDAR LANE (816 to 869)

Statement of Conditions:

Ponding occurs on Cedar Lane when existing inlet and/or sewer capacity is exceeded. During major storm events, overflow travels through a combination of a low flow storm sewer and overland to West Fork North Branch Chicago River.

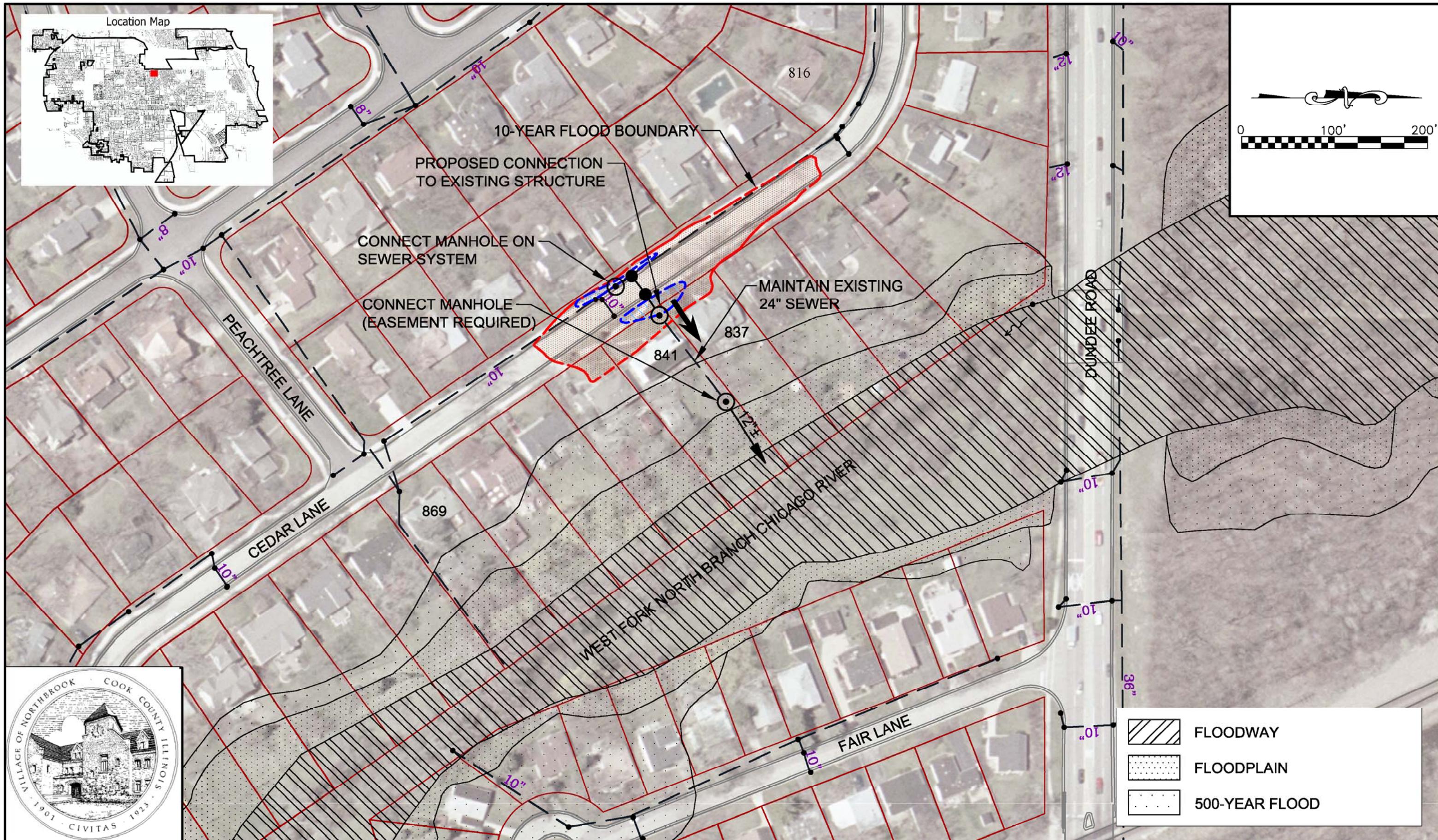
Problem Identification:

Street, front yard and side yard flooding

Recommended Plan:

- Improve drainage collection system by constructing additional inlets
- Improve outlet by connecting Cedar Lane drainage system to existing 24" flood overflow relief storm sewer and extend with 12" low flow storm sewer
- Re-grade parkway to provide positive overflow path between residential structures
- Acquire drainage easement(s) as necessary

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$42,000	\$28,000	\$10,000	\$4,000	0.76	10-yr



CEDAR LANE (816-869)

PROJECT 4

Project 5 Cherry Lane Underpass



Cherry Lane Underpass



Northeast Corner of Cherry Lane at Meadow Road



Cherry Lane Underpass

PROJECT 5 CHERRY LANE UNDERPASS

Statement of Conditions:

The underpass floods when WFNBCR reaches flood stage from long duration storms and/or when the storm sewer collection and conveyance system located east of the underpass surcharges due to localized high intensity storms and/or the pumps can't keep up with the incoming flow of water.

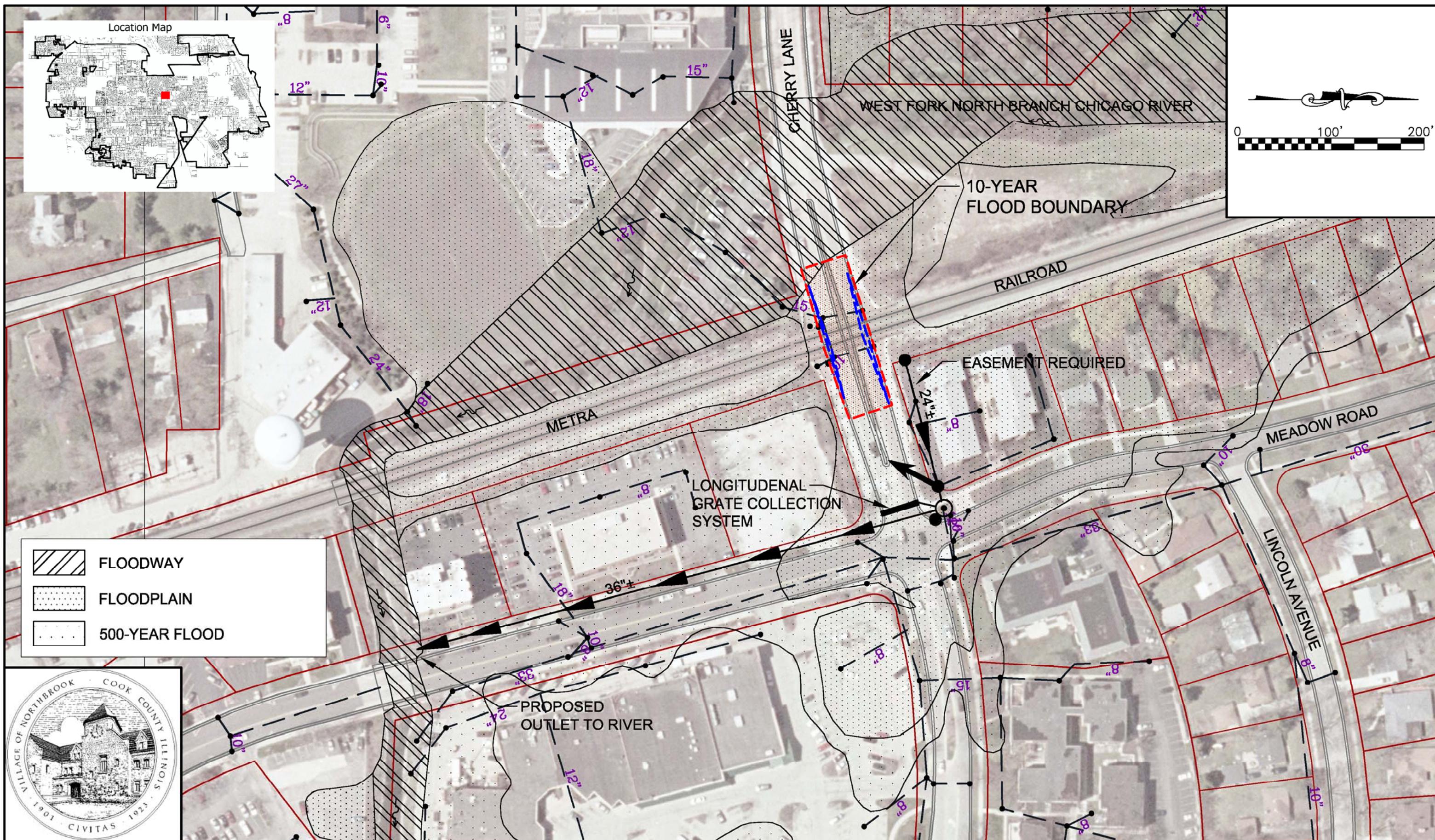
Problem Identification:

- Underground parking structure flooding identified.
- Underpass flooding results in disruption of traffic, including emergency vehicles, and requires Public Works effort to install and remove road closure signing and perform cleanup.
- Reduction in underpass flooding potential due to river flooding would require a major WFNBCR watershed project or underpass reconstruction.
- Local storm sewer system has been observed to overflow to underpass area.

Recommended Plan:

Construct additional inlets and conveyance storm sewer improvement from Cherry Lane southerly along Meadow Road to the WFNBCR

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$246,000	\$205,000	10,000	\$31,000	3.51	10-yr



Project 6 Church Street (Near Chapel Court)



1300 Block of Church Street



Inlet Drainage System in the
1300 Block of Church Street

Church Street Proposed
Easement Area



PROJECT 6
CHURCH STREET
(Near Chapel Court)

Statement of Conditions:

The existing drainage system, approximately 50 years old and intended to carry low flow stormwater runoff based upon older, less stringent standards, cannot adequately convey storms of moderate to high intensities. Conditions are further aggravated by recent development contributing increased runoff to that system.

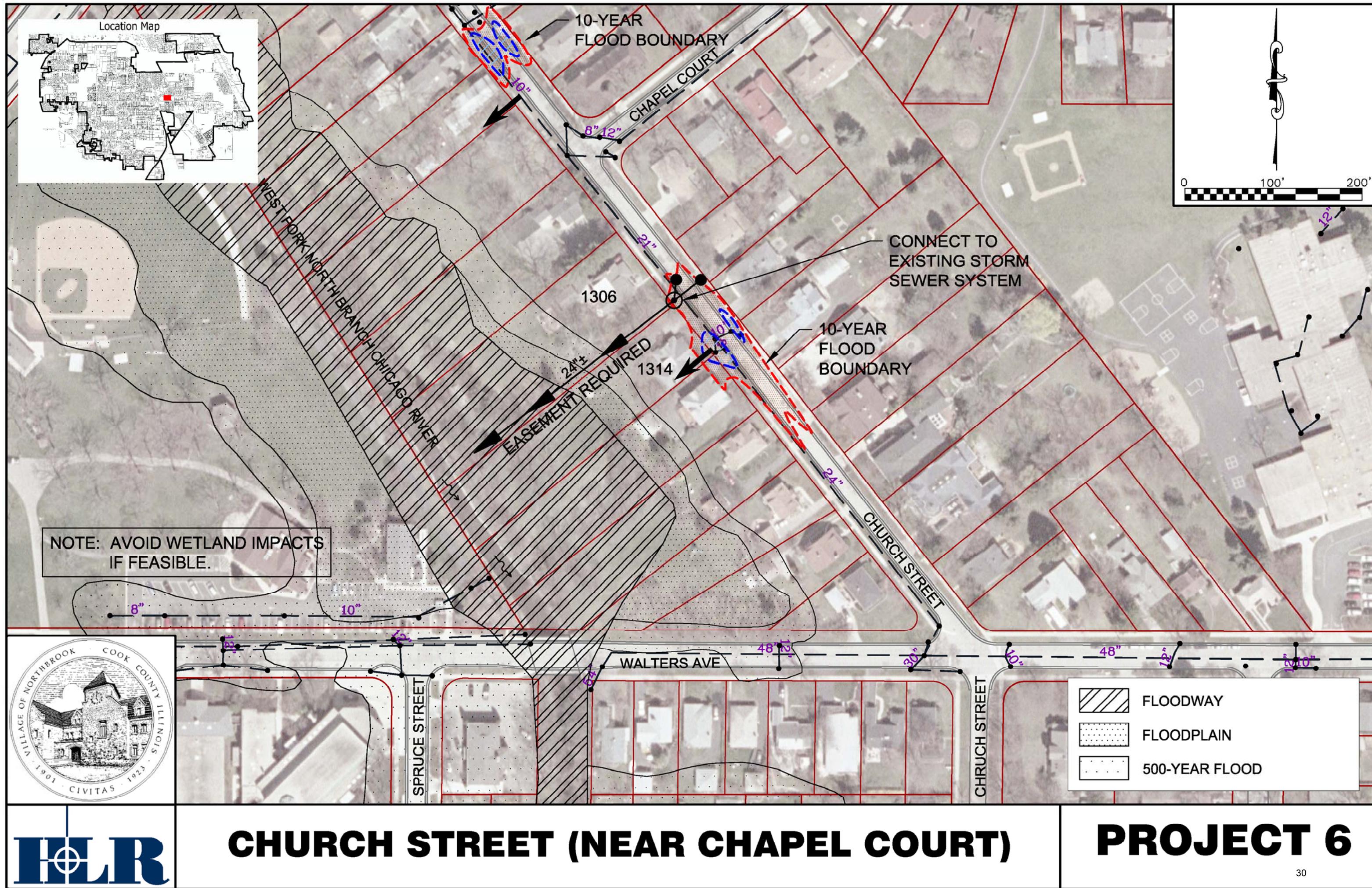
Problem Identification:

- Ponding occurs on Church Street in both directions from the Chapel Court intersection when existing inlet capacity is exceeded, resulting in street closure.
- During major storm events, overflows travel overland through the front and side yards of residential properties to WFNBCR.

Recommended Plan:

- Construct additional inlets to improve Church Street collection system inlet capacity
- Construct flood overflow storm sewer from the Church Street low area (southerly of Chapel Court) to WFNBCR channel on an acquired drainage easement

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$80,000	\$61,000	\$10,000	\$9,000	0.54	10-yr



Project 7
Curb Failure along WFNBCR
(Behind 1941 Cherry Lane)



Curb Failure Looking Easterly



Curb Failure Looking Westerly



WFNBCR Streambank

PROJECT 7
CURB FAILURE ALONG WFNBCR
(Behind 1941 Cherry Lane)

Statement of Conditions:

Curb and gutter section atop the steep bank of WFNBCR channel behind the shopping center at 1941 Cherry Lane has been settling. Contributing factors include weight of parked vehicles and weakened soil conditions due to saturation during channel flooding and spring thaws.

Problem Identification:

Pavement and channel bank slope deterioration will continue unless corrective action is taken. Major bank failure would result in restoration and permitting costs

Recommended Plan:

- Remove curb and gutter and replace with extended post guardrail
- Back pitch 2' \pm paved surface slope under guard rail to proposed lateral/slotted drain
- Install pipe underdrain system to intercept ground water and minor surface runoff from proposed lateral/slotted drain
- Stabilize disturbed channel bank areas with erosion control blanket and native plantings
- Discourage truck parking in 200' \pm critical area along channel bank

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$41,000	\$36,000	N/A	\$5,000	0.27	10-yr

Project 8

Dehne's Subdivision (Dehne Road, Brentwood Road)



Dehne and Brentwood Intersection



Brentwood and Shermer
Intersection



Dehne's Subdivision at
Summerton Place



2000 Block of Brentwood Road

PROJECT 8
DEHNE'S SUBDIVISION
(Dehne Road, Brentwood Road)

Statement of Conditions:

The existing drainage system, consisting of a combination of ditches and culverts, is 40 to 50 years old, and runoff has increased due to properties being redeveloped. The system cannot adequately convey runoff from storms of moderate to high intensities.

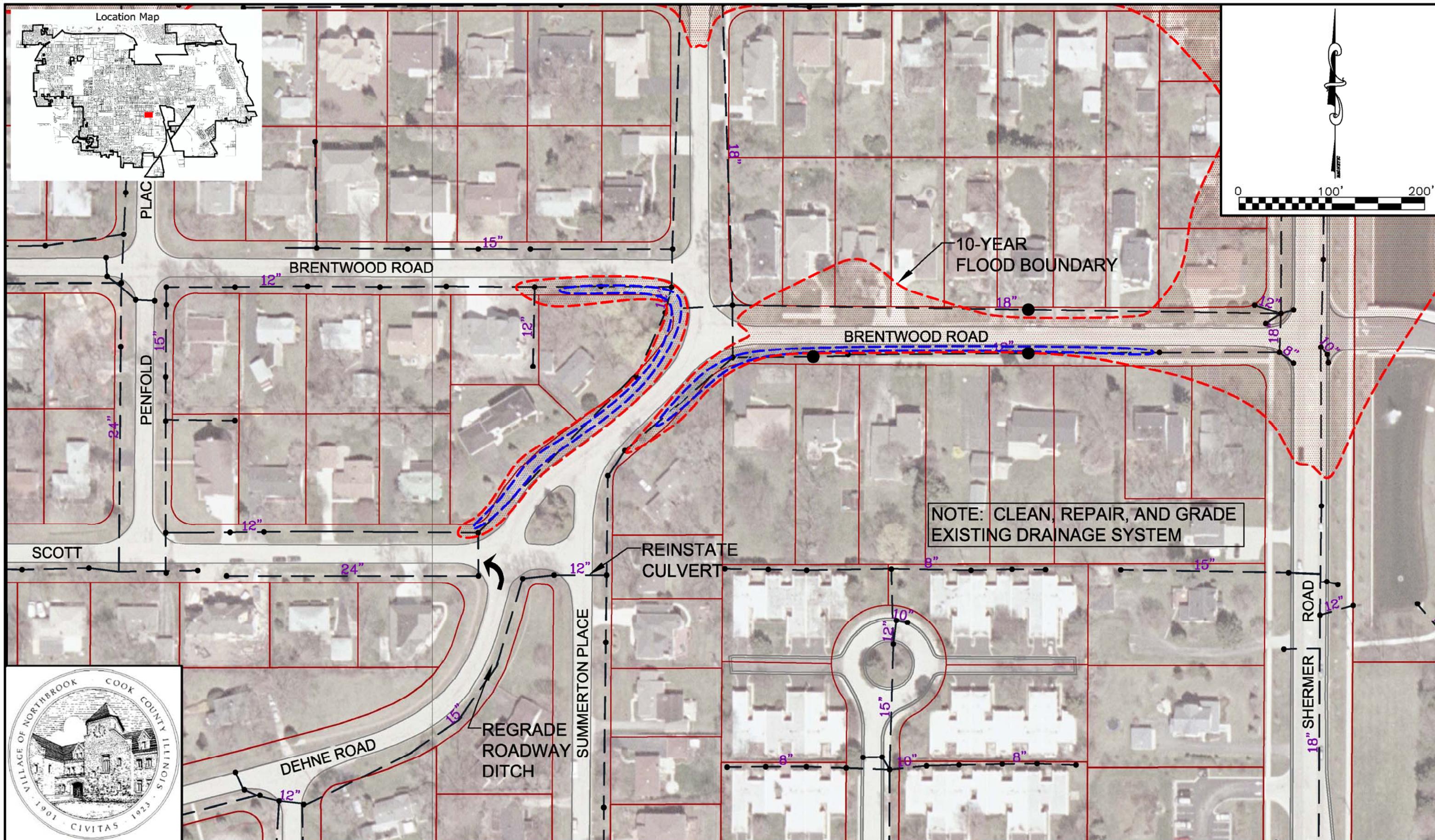
Problem Identification:

Front yard, rear yard and street flooding with water flowing across Dehne Road

Recommended Plan:

- Improve conveyance by replacing damaged culverts and regrading ditched along Dehne and Brentwood Roads
- Improve collection capacity by installing inlets along Brentwood Road

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$109,000	\$95,000	N/A	\$14,000	0.10	10-yr



DEHNE'S SUBDIVISION (DEHNE ROAD, BRENTWOOD ROAD)

PROJECT 8

Project 9

Dundee Road/Skokie Boulevard



Dundee Road and Skokie Boulevard Intersection



Outlet Box Culvert has Debris Impeding Conveyance

Outlet Channel is Heavily Vegetated



PROJECT 9
DUNDEE ROAD/SKOKIE BOULEVARD

Statement of Conditions:

The intersection is located within a low area. The Dundee Road storm sewer system outlets to a ditch that is heavily silted and has standing water near the top of the storm sewer outlet. The drainage system is likely intended to carry low flows based upon older, less stringent design standards. Outlet conditions reduce the overall capacity of the system.

Problem Identification:

Arterial street intersection and business property flooding

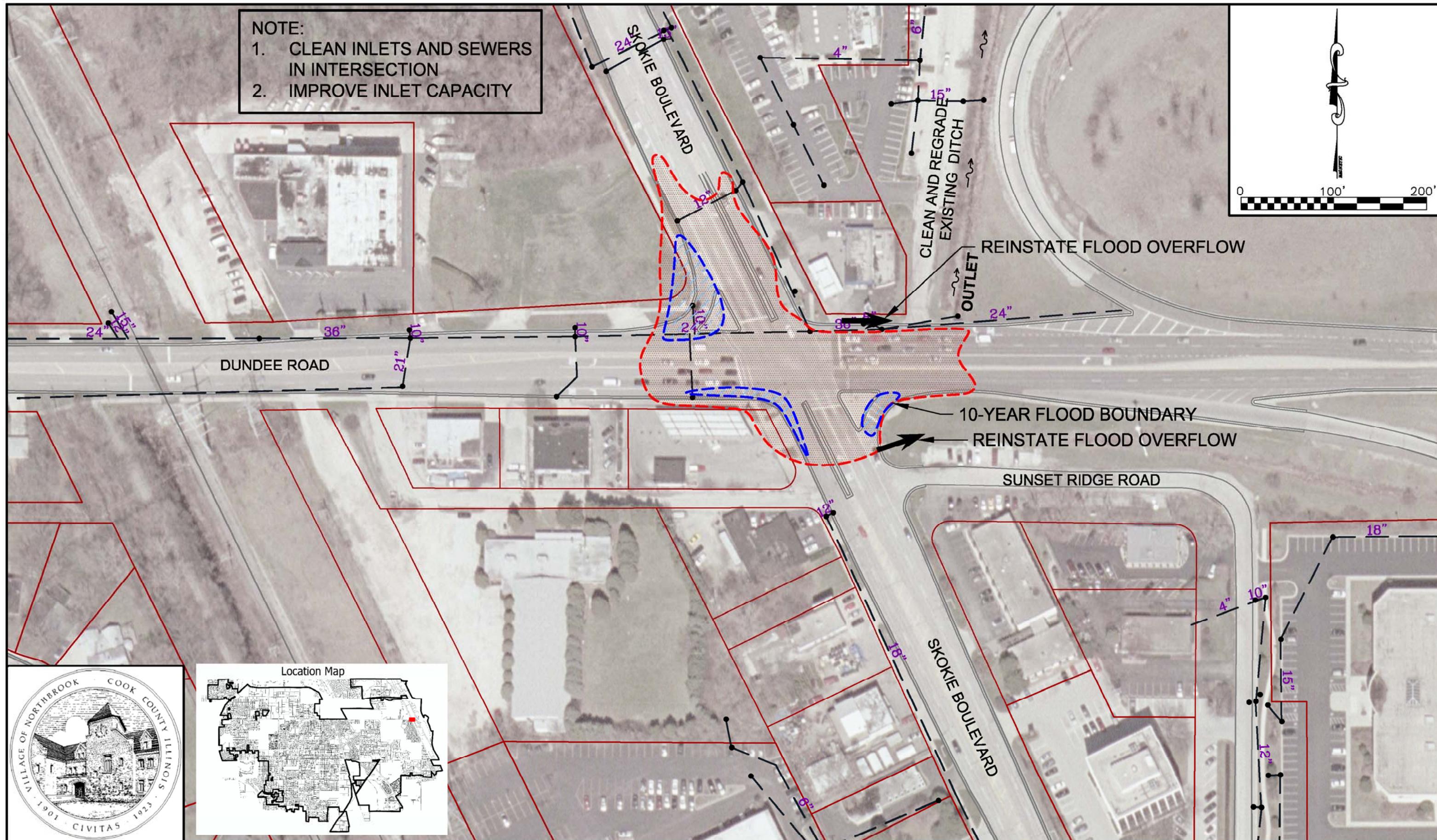
Recommended Plan:

- Coordinate and consult with the Illinois Department of Transportation regarding concerns and responsibilities along Dundee Road
- Improve drainage inlet capacity by constructing additional inlets and/or replacing existing inlets with higher capacity inlets
- Improve storm sewer conveyance and outlet conditions by removing sediment from the northerly drainage ditch
- Improve flood flow conveyance by reinstating the flood overflow paths along Dundee Road easterly (i.e. depress the driveway entrances on the north side of Dundee Road east of Skokie Boulevard)

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$51,000	\$44,000	N/A	\$7,000	0.84	10-yr

NOTE:

1. CLEAN INLETS AND SEWERS
IN INTERSECTION
2. IMPROVE INLET CAPACITY



DUNDEE ROAD / SKOKIE BOULEVARD

PROJECT 9

Project 10 Keystone Road/Chartres Drive



Keystone Road near Chartres Intersection



Keystone Road near Chartres Intersection

PROJECT 10
KEYSTONE ROAD/CHARTRES DRIVE

Statement of Conditions:

The existing low flow outlet is part of a 40 to 50 year old drainage system, and runoff has increased over the years due to properties being redeveloped. The system is a combination of ditches, culverts and storm sewers that cannot adequately convey storms of moderate to high intensities. Flood overflow occurs after ponding on streets and properties has reached the overflow elevation.

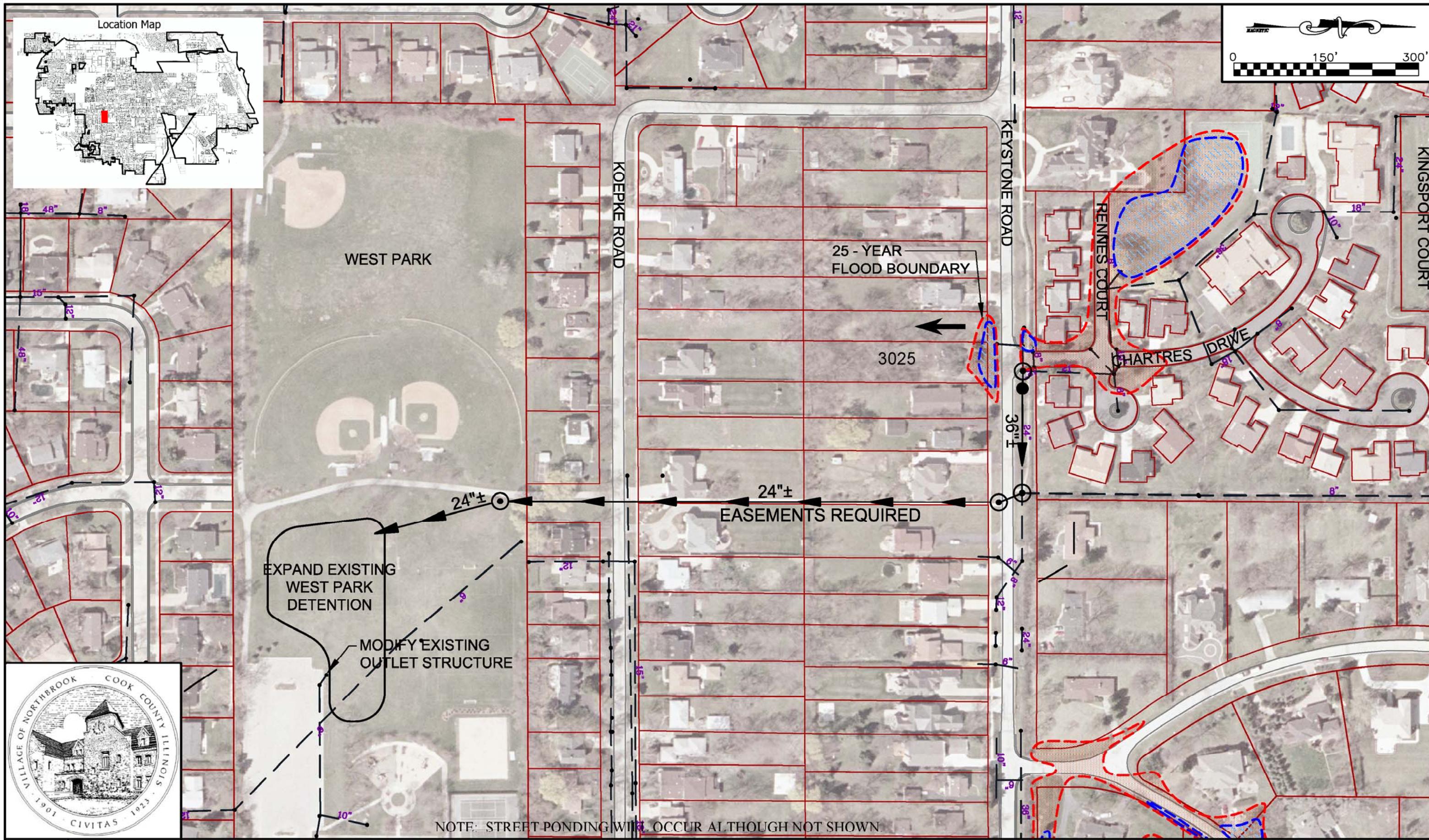
Problem Identification:

Intersection, front yard and structure flooding

Recommended Plan:

- Improve outlet by constructing a new low flow storm sewer from Keystone Road to West Park (Sports Center Complex) on acquired drainage easements
- Provide mitigation for the new outlet conveyance by providing an additional 6± acre-feet of stormwater detention within West Park
- Consult and coordinate plan with Northbrook Park District
- Consider improvements to Kingsport Court stormwater detention facility in conjunction with this project

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$635,000	\$535,000	\$20,000	\$80,000	3.05	10-yr



**Project 11
Northbrook East
(Midway Road/Whitfield Road South Intersection)**



Midway and Whitfield Intersection



Nearby Flooded Property



1100 Block of Dell Road

PROJECT 11
NORTHBROOK EAST
(Midway Road/Whitfield Road South Intersection)

Statement of Conditions:

The area is served by a 40-50 year old drainage system which was intended to carry low flows based upon older, less stringent design standards. The storm sewer that drains the southerly Midway/Whitfield intersection is located within side yard easements between 3 pairs of closely spaced homes and outlets to an old railroad ditch. During storm events that exceed the capacity of the low flow system, ponding and structure flooding can occur. The level of ponding and flooding is controlled by the overland flow path between those closely spaced structures. The outlet from the old railroad ditch is sensitive to any increase in flow rates or flooding levels.

Problem identification:

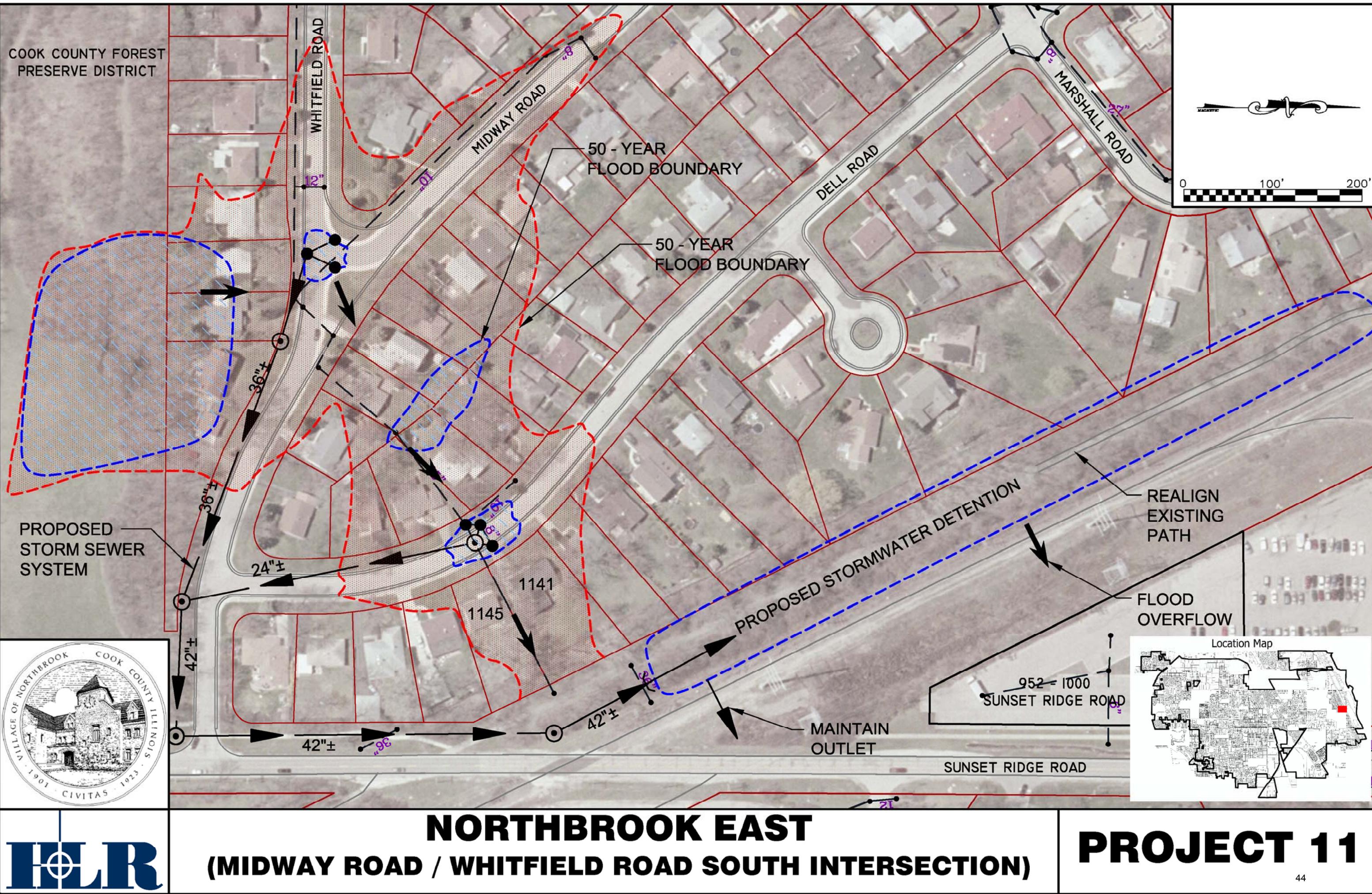
Structure, rear yard, front yard and street flooding

Recommended Plan:

- Install inlets to improve inlet capacity on Midway, Whitfield and Dell Roads
- Construct a new storm sewer system within the existing right of way from the southerly Midway/Whitfield intersection to the old railroad ditch
- In the event either 1141 or 1145 Dell Road property can be acquired, align storm sewer to traverse acquired property
- Construct 3.5± acre-foot stormwater detention facility on Village-owned property (abandoned railroad right of way)
- Determine whether any easements exist on properties located along old abandoned railroad right of way. If none exist, attempt to acquire additional drainage easements.

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$718,000	\$624,000	N/A	\$94,000	2.18	50-yr*

Note: Downstream outlet needs to be evaluated to ensure optimum protection.



Project 12 Northbrook Manor (Spruce Street)



Illinois Road between Railroad and WFNBCR



Illinois Road at Lorenze Drive with Cattle Pass Culvert

PROJECT 12
NORTHBROOK MANOR
(Spruce Street)

Statement of Conditions:

The existing drainage system is over 50 years old. Runoff has increased due to properties being redeveloped and the system cannot convey storms of moderate to high intensities. Recent improvement projects include the Flapgate (check valve) installation, constructed in 1996 to prevent backflow into the storm sewers from WFNBCR, and the Cattle Pass Relief Swale constructed in 2001 to provide a flood overflow path around Northbrook Manor Subdivision.

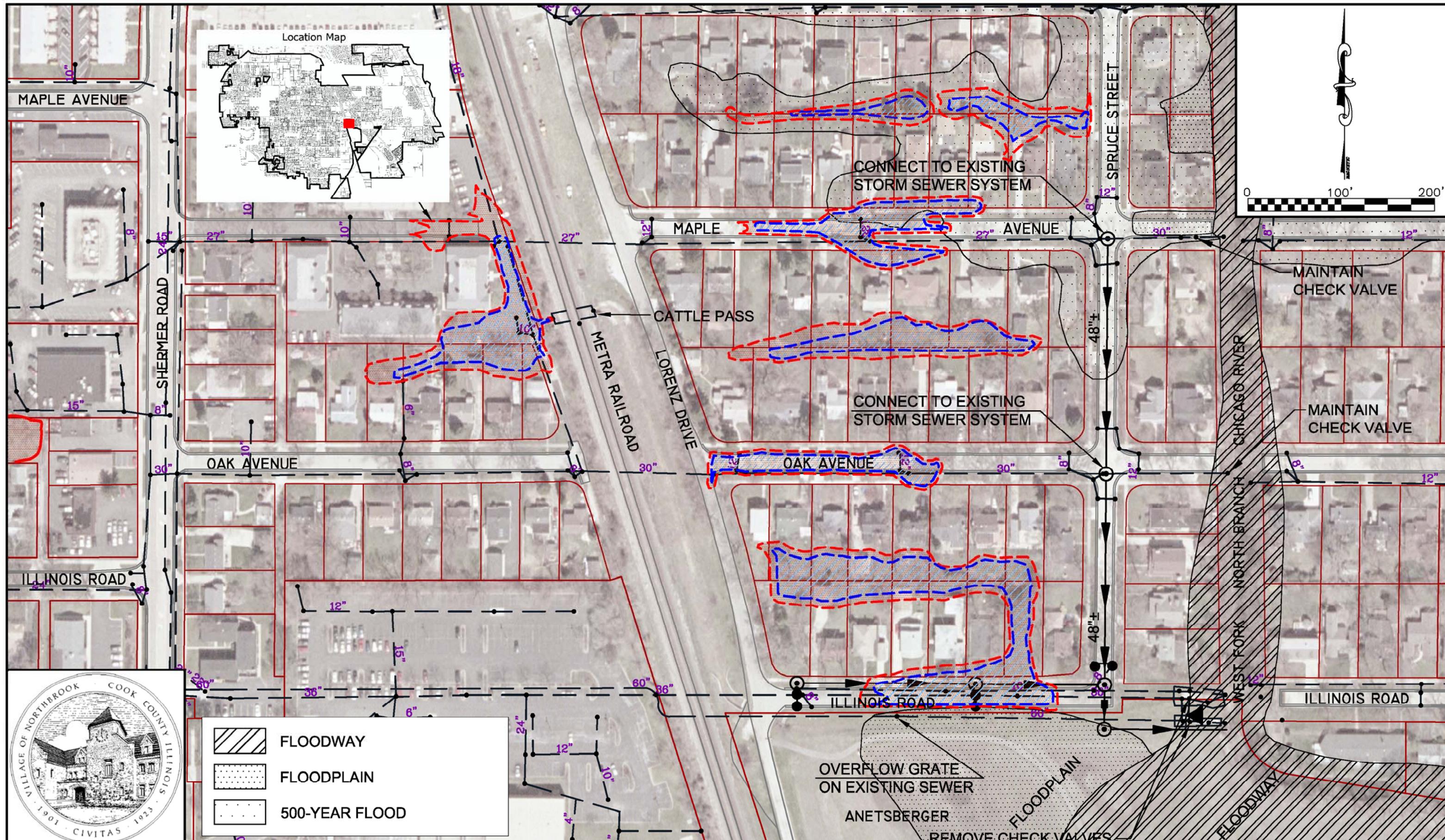
Problem Identification:

Street, front yard and back yard flooding

Recommended Plan:

- Improve outlets for Maple Avenue, Oak Avenue and Illinois Road by constructing a relief storm sewer along Spruce Street from Maple Avenue southerly through Illinois Road, outletting to WFNBCR
- Consider Shermer Road Outlet project in conjunction with this project

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$446,000	\$388,000	N/A	\$58,000	0.07	10-yr



Project 13 Ridge Road/Lee Road



Lee Road near Ridge Road



Lee Road at Ridge Road

PROJECT 13
RIDGE ROAD/LEE ROAD

Statement of Conditions:

A majority of the Ridge Road drainage system is 45-55 years old and cannot adequately convey storms of moderate to high intensities. Conditions are further aggravated by increased runoff due to more recent development that drains to that system. Flood overflows that exceed the system's capacity pond in a low area located just west of Lee Road.

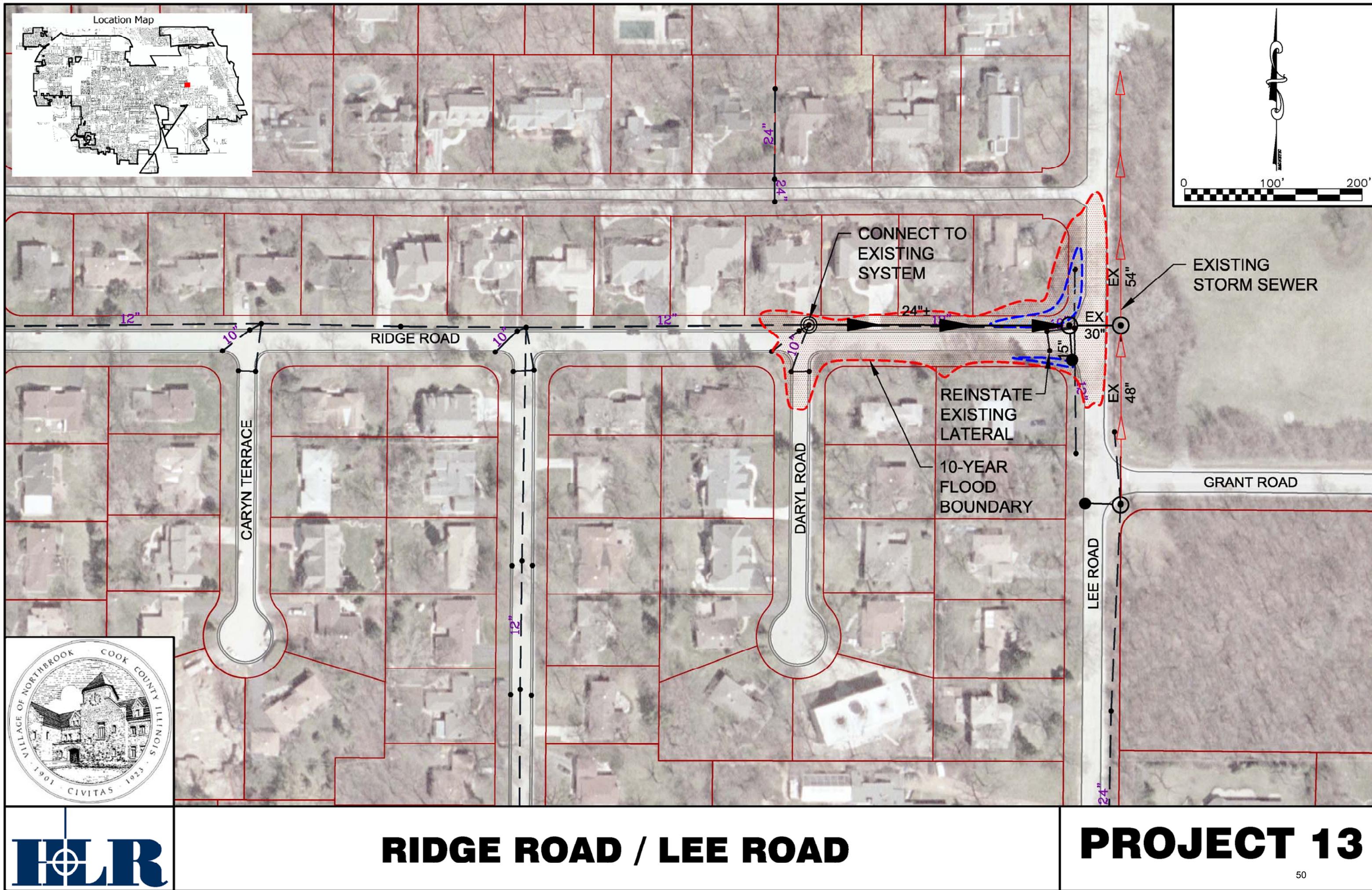
Problem Identification:

Street and front yard flooding

Recommended Plan:

- Improve inlet capacity along Ridge Road by constructing additional inlet structures at Daryl Road and Lee Road intersections
- Improve conveyance from Daryl Road to Lee Road by constructing a larger storm sewer
- Improve flood overflow conveyance at Lee Road by depressing curb and completing minor ditch re-grading

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$60,000	\$52,000	N/A	\$8,000	0.35	10-yr



Project 14 Shermer Road Outlet



Illinois Road at Shermer Road

Illinois Road
Sewer Surcharge



Check Valve

PROJECT 14
SHERMER ROAD OUTLET

Statement of Conditions:

More than one half mile of Shermer Road is served by a storm sewer system that was designed to carry runoff from a 10-year storm and was constructed in the mid 1990s. Nearby older, separate drainage systems cannot adequately convey storms of moderate to high intensities. The situation is further aggravated by increased runoff from property redevelopment (including Northbrook Park and Sunset Fields Subdivisions). Overflow from the older systems puts an additional demand on the Shermer Road drainage system. A backflow prevention device (check valve or flapgate) was installed in the Shermer Road outlet to the Illinois Road storm sewer to prevent flood flows generated by major storm events from backing into the Shermer Road system from the Illinois Road outlet.

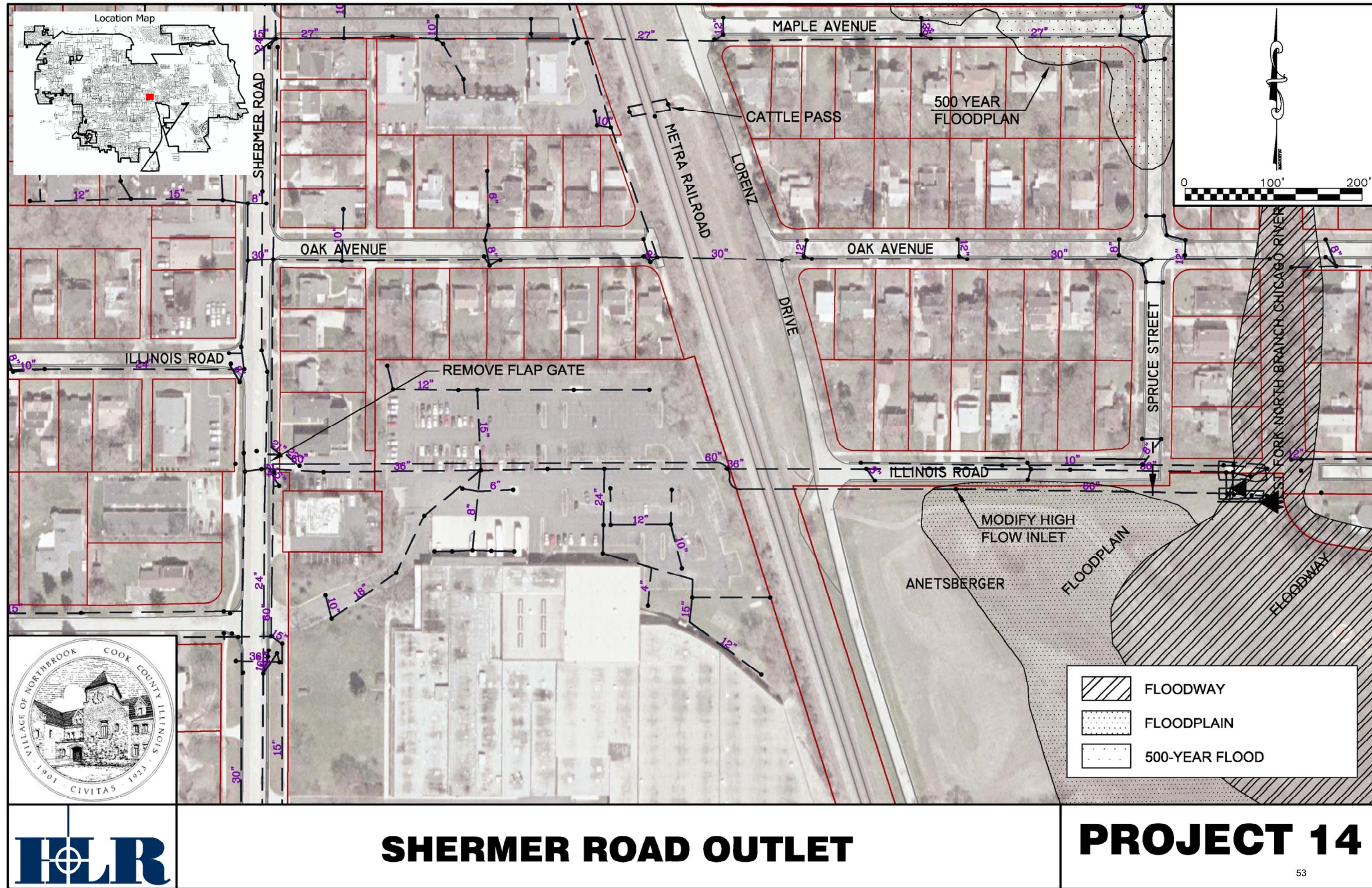
Problem Identification:

Street, property and structure flooding, predominantly on the west (upstream) side of Shermer Road

Recommended Plan:

- Improve storm sewer conveyance to the Illinois Road outlet for the more frequent, less intense storm events by removing the existing flapgate, recognizing that removal of flow restriction will be beneficial for the majority of storm events
- Consider Northbrook Manor project in conjunction with this project
- Improve inlet capacity to Illinois Road storm sewer.

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$13,000	\$11,000	N/A	\$2,000	0.85	10-yr



Project 15 Shermer Road Underpass



Shermer Road Underpass, Looking North



Shermer Road Underpass, Looking North

PROJECT 15
SHERMER ROAD UNDERPASS

Statement of Condition:

This location is included in the IDOT District One Pavement Flooding Prioritization 2009 Annual Report, Arterial Routes, Shermer Road at Willow Road (S/O @ Railroad Viaduct). The underpass drainage system is likely older than 50 years and cannot adequately convey storms of moderate to high intensities. Conditions are further aggravated by major storm flood overflows from more recent development which drains to that system. The underpass drains to a flat, heavily vegetated ditch located along the easterly side of the railroad embankment, outletting to the Willow Road drainage system.

Problem Identification:

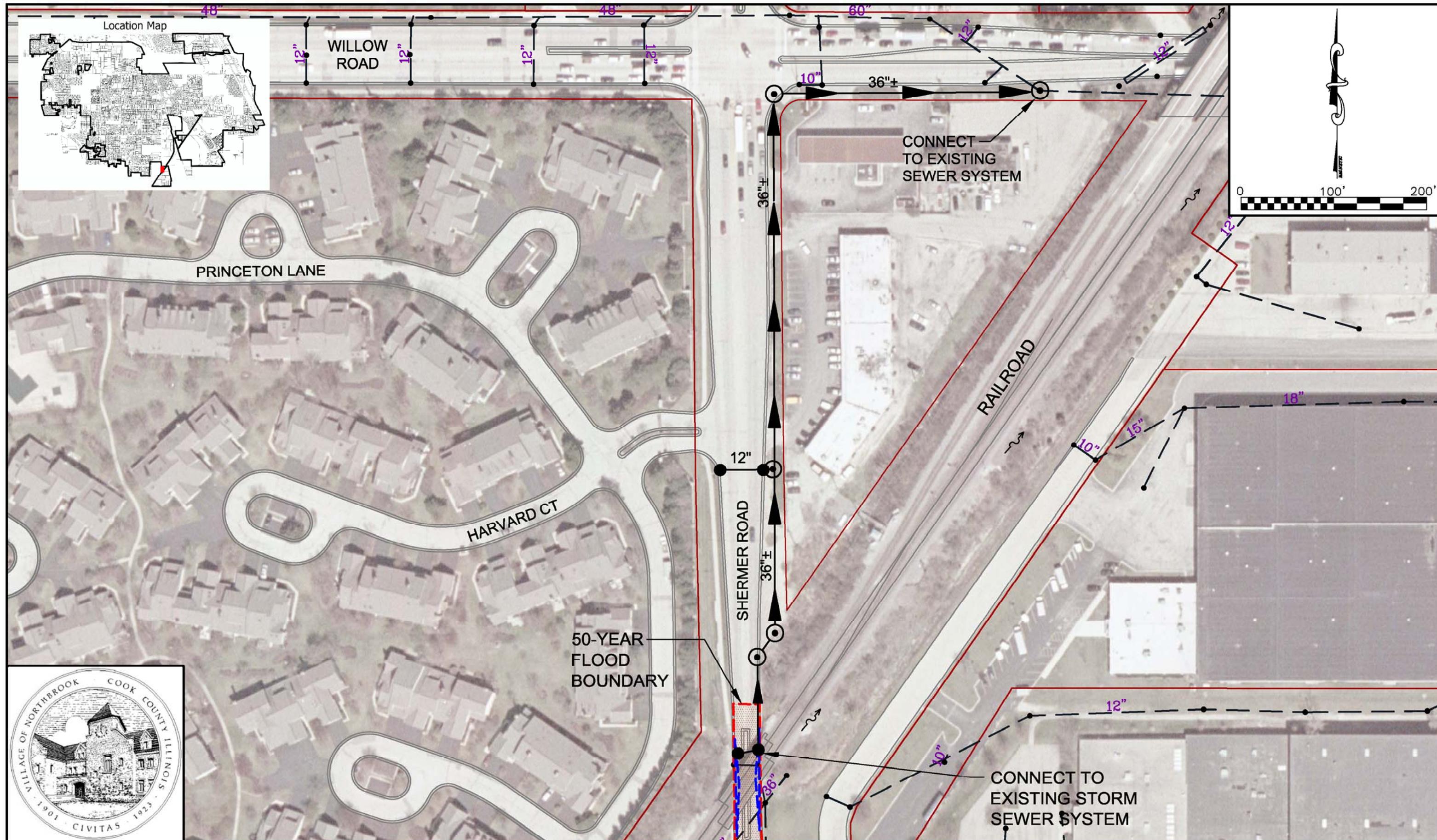
Underpass flooding requiring road closures (4 pavement flooding incidents reported since 1985)

Recommended Plan:

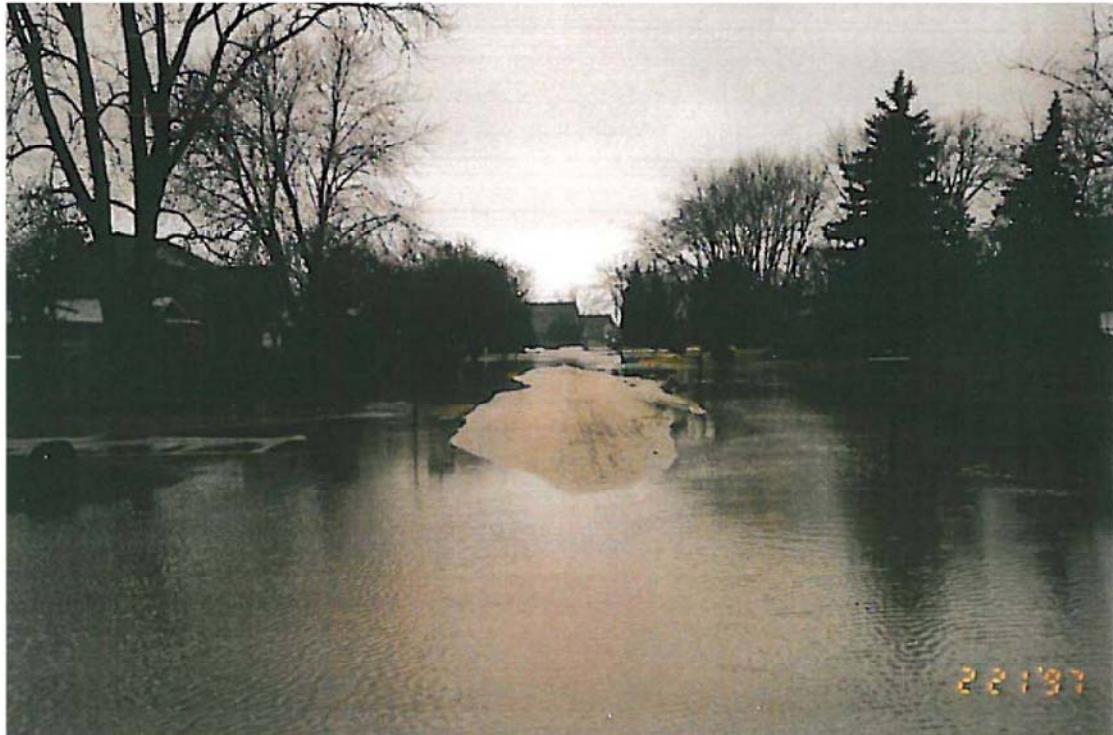
- Improve roadway collection system by constructing additional inlets and laterals
- Improve conveyance by constructing a new storm sewer to the Willow Road drainage system
- Continue to coordinate with IDOT to achieve recommended improvements

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$332,000	\$289,000	N/A	\$43,000	0.04	50-yr

Note: Costs should be paid by IDOT



Project 16
Sunny Acres (Pamella Lane, Constance Lane)



Pamella Lane Flooding



Property Flooding along Pamella Lane

PROJECT 16
SUNNY ACRES
(Pamella Lane, Constance Lane)

Statement of Conditions:

The existing drainage system, consisting of a combination of ditches and culverts, is over 50 years old, and runoff has increased due to properties being redeveloped. The system cannot adequately convey storms of moderate to high intensities. The original drainage outlets are small with respect to the large drainage area they serve. Flood overflow paths are limited and, consequently, low lying areas within the subdivision are subject to ponding.

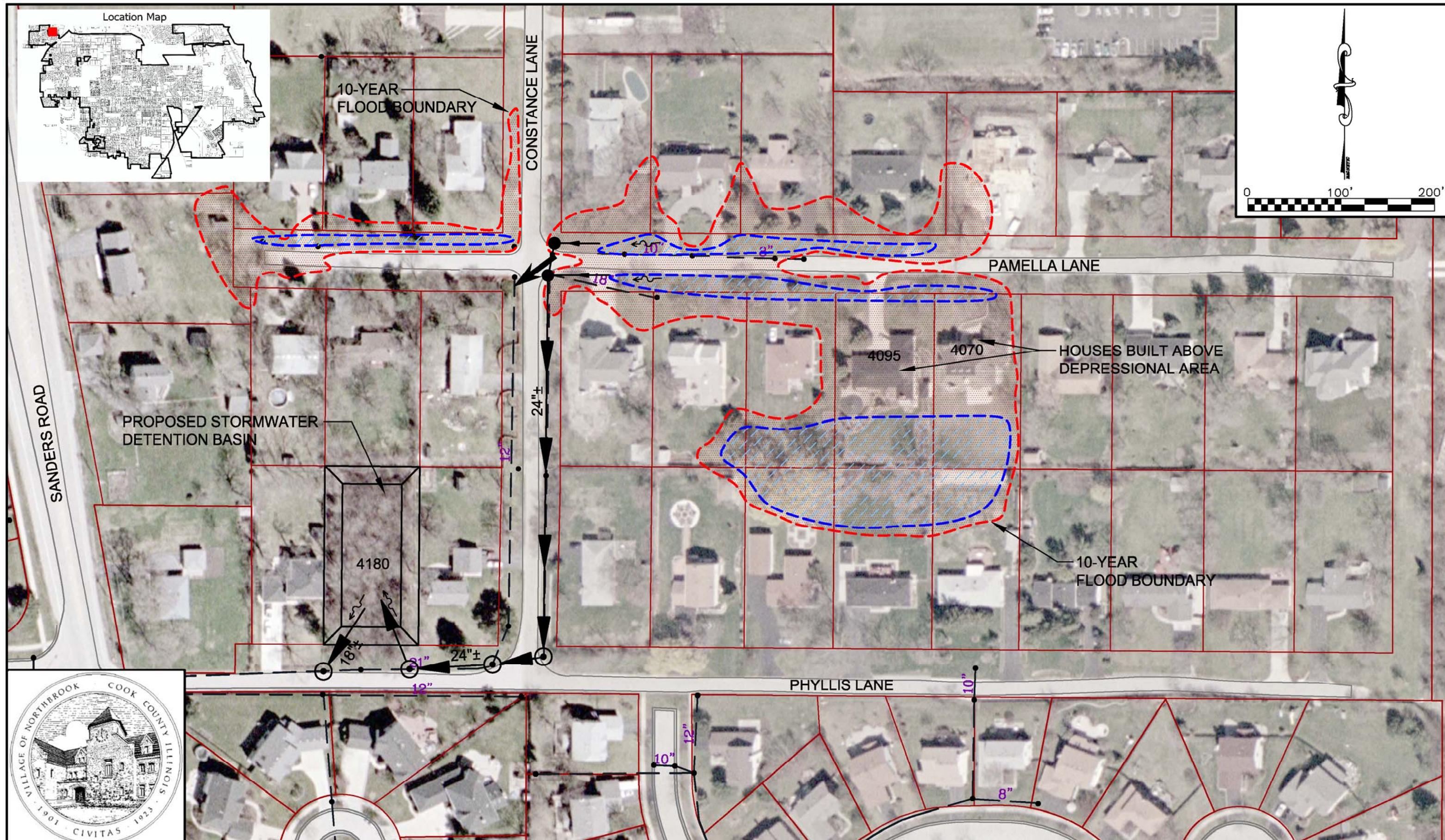
Problem Identification:

Street, front yard, back yard and structure flooding

Recommended Plan:

- Improve Pamella Lane outlet by constructing a low flow storm sewer down Constance Lane to proposed stormwater detention facility
- Construct a 1.0± acre-foot stormwater detention facility on vacant property at 4180 Phyllis Road
- Improve drainage collection system by providing additional inlets near Pamella/Constance intersection

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$614,000	\$186,000	\$400,000	\$28,000	4.16	10-yr



Project 17 Sunset Lane



3900 Block of Sunset Lane



Commercial Drive Basin



4000 Block of Sunset Lane

PROJECT 17
SUNSET LANE

Statement of Condition:

The existing drainage system and its outlet, consisting of a combination of ditches and culverts, is over 50 years old (Sunset View Estates, platted 1945) and runoff has increased due to redevelopment of properties. The system cannot adequately convey storms of moderate to high intensities; consequently, depressional areas located along the street are subject to ponding when the drainage system capacity is exceeded.

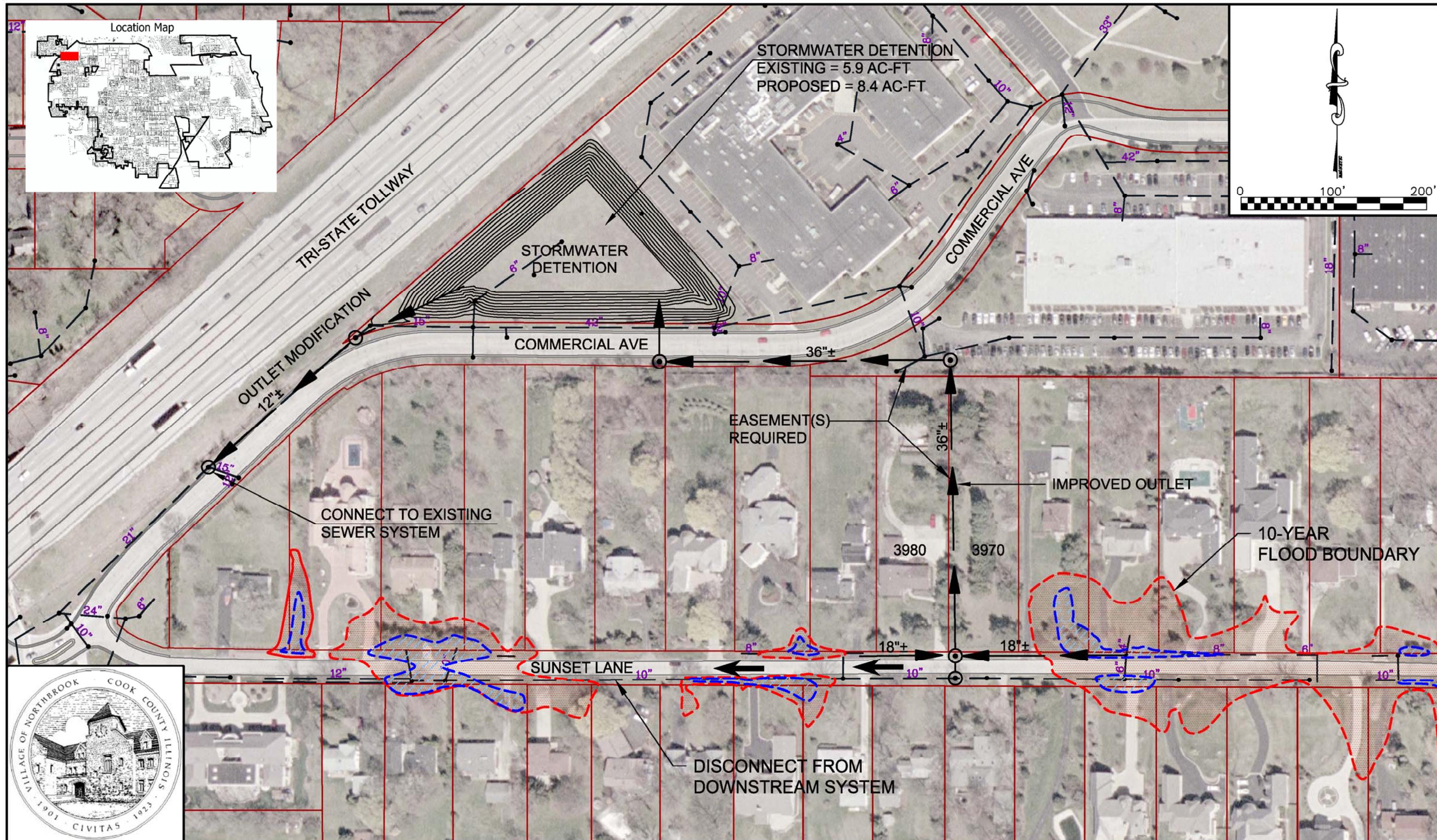
Problem Identification:

Street and front yard flooding

Recommended Plan:

- Improve outlet by constructing a low flow storm sewer from Sunset Lane to the Commercial Avenue stormwater detention facility
- Extend storm sewer along Sunset Lane to serve low areas east and immediately west of the new storm sewer outlet
- Reduce the flooding potential for the westerly low area by disconnecting the upstream portion of the existing storm sewer from the area along Sunset Lane that will be served by the new storm sewer
- Mitigate for the increased flows to the detention facility by increasing the storage volume by $2.5 \pm$ acre-feet and modifying its outlet

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$432,000	\$363,000	\$20,000	\$54,000	0.05	10-yr



Project 18

Techny Drain Basin Expansion



Techny Drain Basin



Techny Drain Basin

PROJECT 18
TECHNY DRAIN BASIN EXPANSION

Statement of Conditions:

The basin at Glenbrook North High School was constructed during 2003 as part of Phase 1 of the Techny Drain Stormwater Management Plan. The basin provides attenuation of peak flows in Techny Drain. The Techny plan benefits properties within the Techny Drain Floodplain by reducing their flooding risk potential. The Village and School District 225 have discussed partnering to enlarge the basin by 6+ acre-feet, by reshaping and expanding its boundaries onto school property as part of the District's athletic field synthetic turf improvement project.

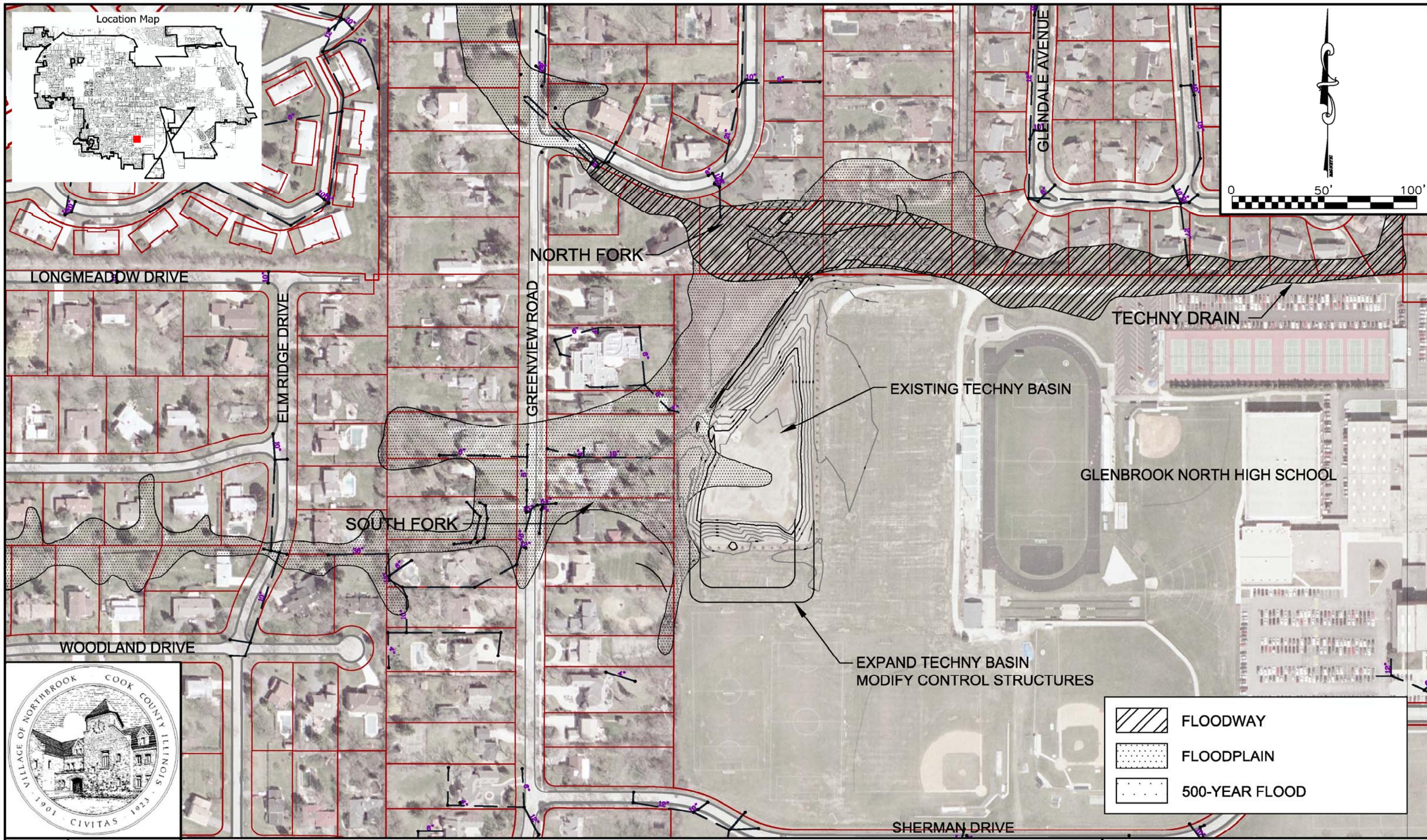
Problem Identification:

Street, front yard, back yard and structure flooding

Recommended Plan:

Continue partnering coordination with School District 225 to provide 2.5± acre-feet of detention beyond requirements for athletic field improvements

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$268,000	\$233,000	N/A	\$35,000	0.16	10-yr



Project 19
Weller's Subdivision
(Weller, Hillcrest, and Christina Lanes)



2900 Block of Weller Lane



2900 Block of Weller Lane

PROJECT 19
WELLER'S SUBDIVISION
(Weller, Hillcrest and Christina Lanes)

Statement of Conditions:

Weller's Subdivision was recorded in June 1946; the drainage system is 60+ years old and is a combination of ditches and culverts. Village records indicate the existence of a Weller Lane midblock outlet that traverses through seven private properties on its path to the Keystone Road drainage system at Pfingsten Road. Over time, runoff has increased due to properties being redeveloped, the midblock outlet has deteriorated and is in need of replacement and these systems cannot adequately convey storms of moderate to high intensities.

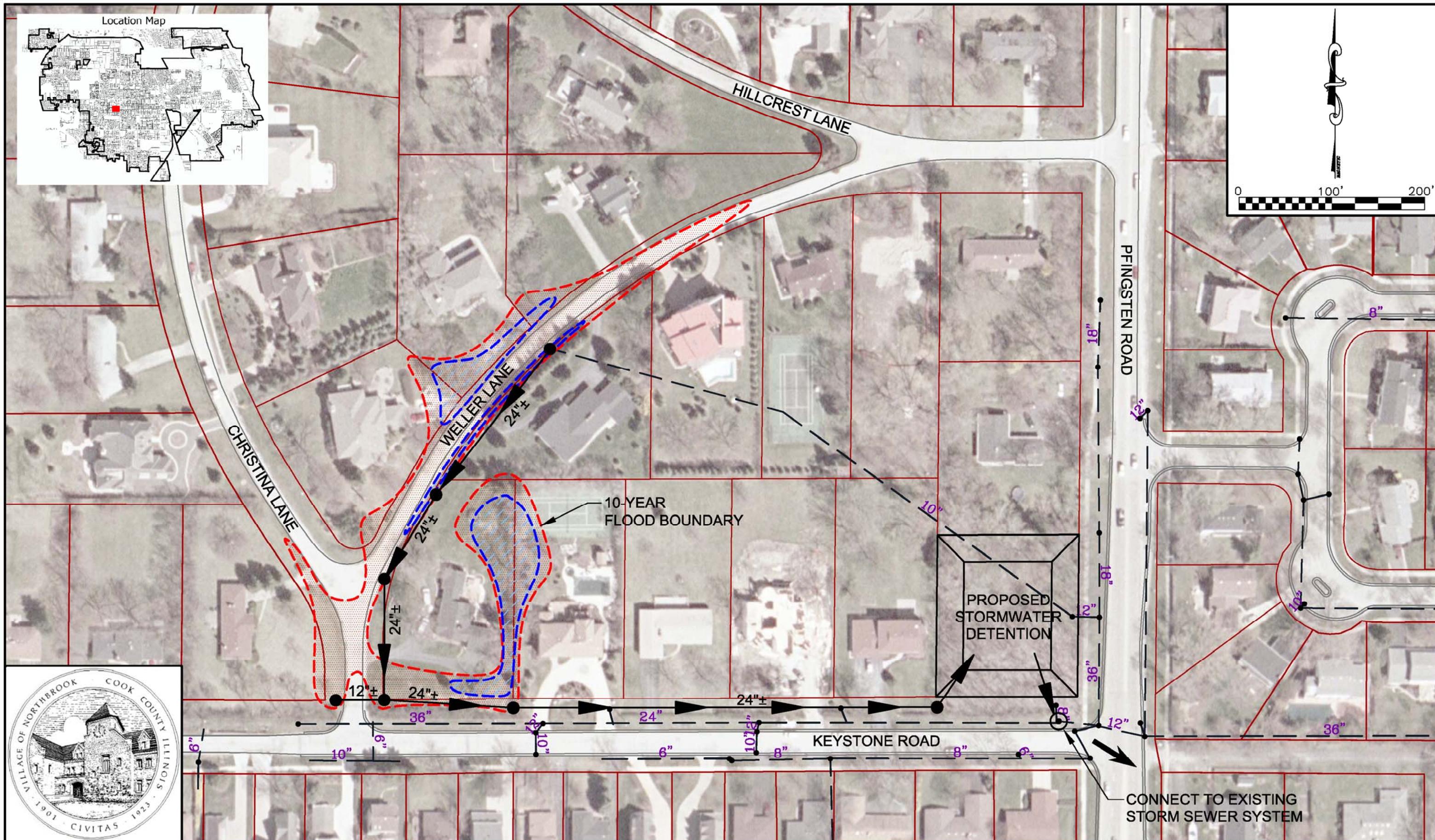
Problem Identification:

Street and intersection, front yard and back yard flooding

Recommendation Plan:

- Improve outlet by constructing a replacement low flow storm sewer from midblock Weller Lane to Keystone Road and extending the sewer easterly to the northwest corner of Pfingsten and Keystone Roads
- Improve drainage collection system by adding inlets
- Acquire vacant lot at northwest corner of Pfingsten and Keystone Roads
- Provide mitigation for increased flow conveyance by constructing a $1.8 \pm$ acre-foot stormwater detention facility on vacant lot

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$784,000	\$273,000	\$400,000	\$41,000	0.04	10-yr



WELLER'S SUBDIVISION (WELLER, HILLCREST AND CHRISTINA LANES)

PROJECT 19

Project 20
Western Avenue/Oak Avenue
(Wescott Road to Shermer Road)



2400 Block of Oak Avenue



2400 Block of Oak Avenue

PROJECT 20
WESTERN AVENUE/OAK AVENUE
(Wescott Road to Shermer Road)

Statement of Conditions:

The existing drainage system is over 50 years old (Northbrook Manor Subdivision, recorded August 1924), and runoff has increased due to properties being redeveloped. The system cannot adequately convey storms of moderate to high intensities. The outlet to WFNBCR is controlled by a flapgate.

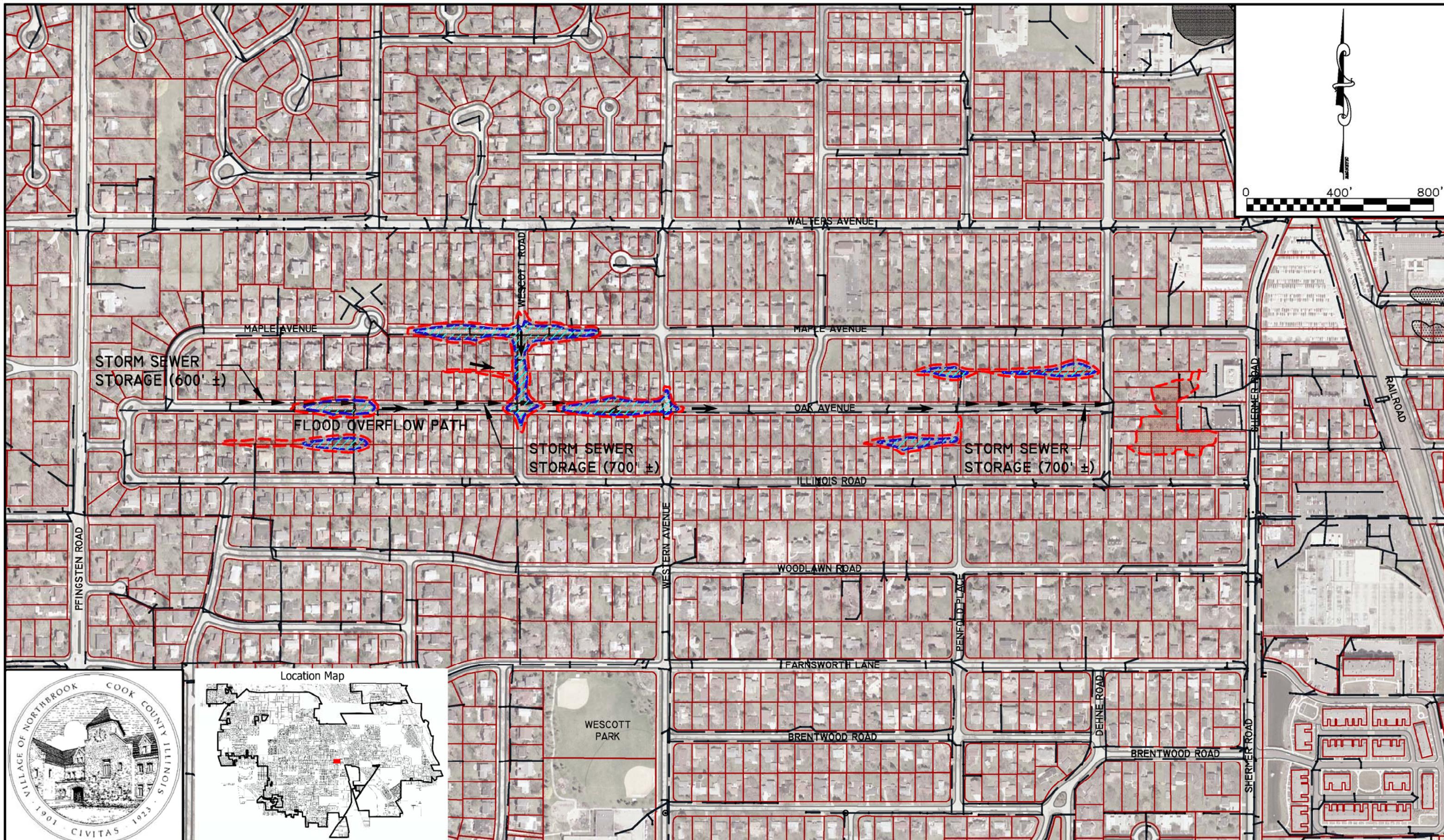
Problem Identification:

Street, front yard and backyard flooding

Recommended Plan:

- Construct sections of oversized storm sewer along Oak Street at strategically designed locations to function as storm water detention facilities.
- Improve drainage collection system by constructing additional Oak Street drainage inlets.
- Mitigate improved outlet impacts by constructing a $4 \pm$ acre-foot sized stormwater detention facility on acquired properties

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$631,000	\$548,000	N/A	\$83,000	0.07	10-yr



WESTERN AVENUE / OAK AVENUE (WESCOTT ROAD TO SHERMER ROAD)

Project 21 Williamsburg Drive/Old Post Road



Williamsburg Drive / Old Post Intersection



Old Post Road

PROJECT 21
WILLIAMSBURG DRIVE/OLD POST ROAD

Statement of Conditions:

The existing drainage system is over 40 years old (Williamsburg Square Subdivision, recorded March 1968) and runoff has increased due to property redevelopment. The system cannot adequately convey storms of moderate to high intensities. Flood flow relief is limited by the capacity of the downstream drainage system and floodwater elevation in the Revere Basin.

Problem Identification:

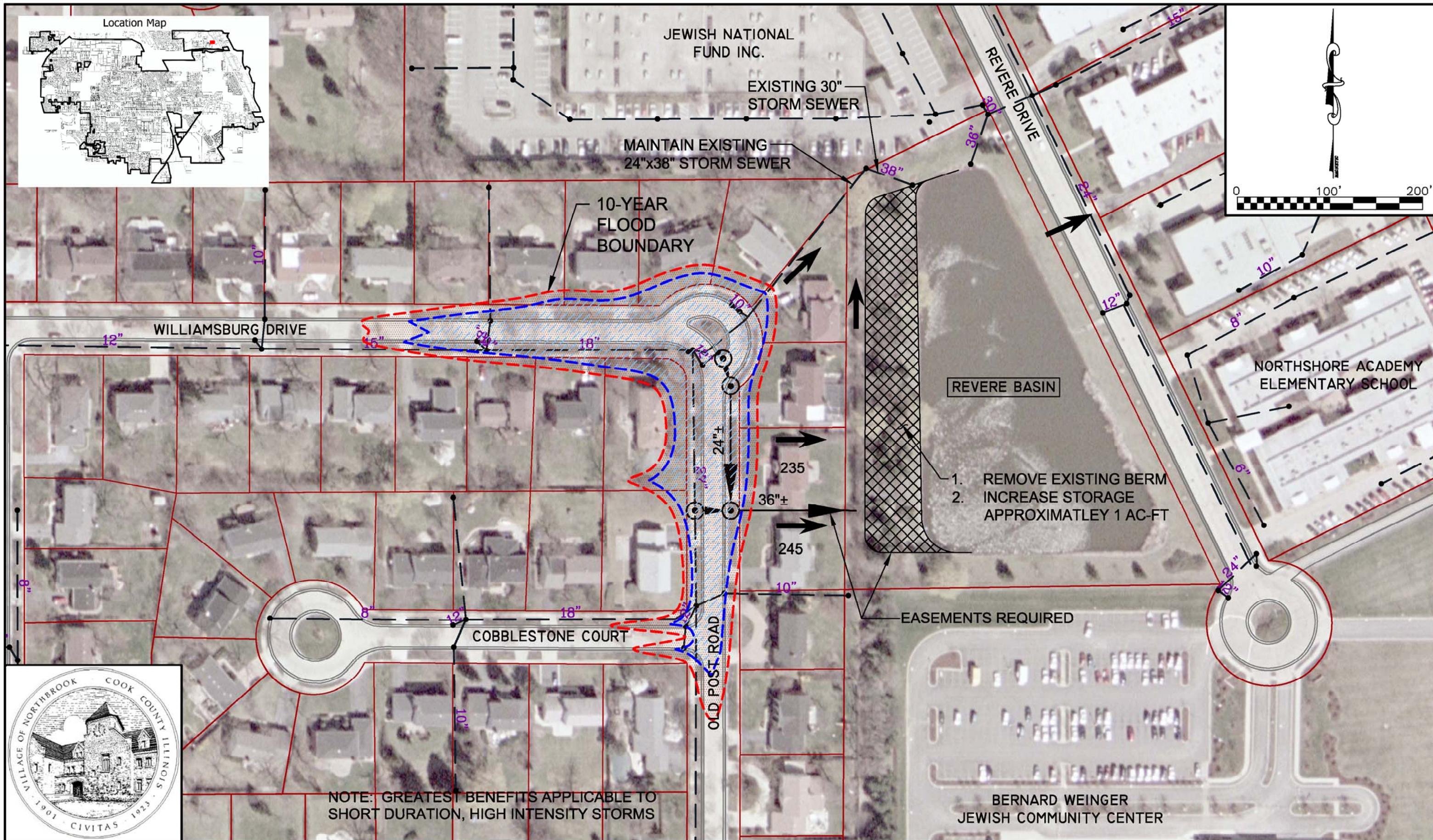
Street, front yard and structure flooding

Recommendations Plan:

- Acquire easement(s) between Old Post Road and Revere Basin
- Improve outlet by constructing flood overflow relief storm sewer from Old Post Road to Revere Basin on new drainage easements
- Improve conveyance by constructing a new storm sewer from Williamsburg/Old Post cul-de-sac to proposed relief sewer
- Mitigate increased conveyance impacts by increasing detention volume in the Revere Basin by approximately $1\pm$ acre-foot
- Improve cul-de-sac drainage collection system by providing new inlets

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$270,000	\$217,000	\$5,000	\$33,000	0.16	10-yr*

Note: Downstream outlet needs to be evaluated to ensure optimum protection.

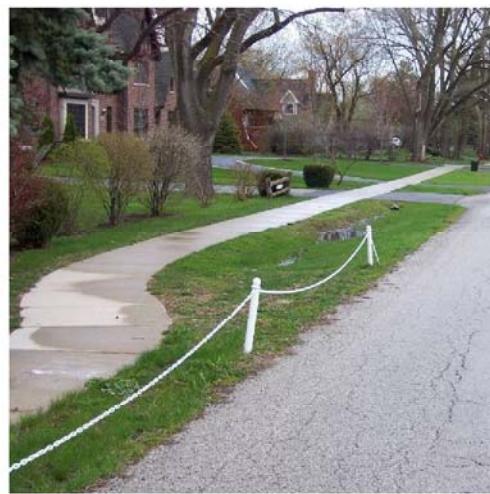


**Project 22
Woodlawn Road
(Penfold Place to Shermer Road)**



2000 Block of Woodlawn Road

2000 Block of Woodlawn Road



2100 Block of Woodlawn Road

PROJECT 22
WOODLAWN ROAD
(Penfold Place to Shermer Road)

Statement of Conditions:

The existing drainage system, a collection of ditches and culverts, is over 50 years old (Northbrook Park Subdivision, recorded 1946), and runoff has increased due to properties being redeveloped. The system cannot adequately convey storms of moderate to high intensities. This system also serves as the outlet for Sunset Fields and areas of Northbrook Park Subdivisions.

Problem Identification:

Street, front yard and back yard flooding

Recommended Plan:

- Improve drainage collection system by adding inlet structures
- Improve low flow conveyance by regrading ditches and replacing damaged, crushed and nonstandard undersized driveway culverts

Estimated Total Cost	Construction Cost	Property Cost	Engineering Cost	B/C Ratio	Optimum Protection
\$140,000	\$122,000	N/A	\$18,000	0.23	10-yr

