Final Report

Detailed Watershed Plan for the North Branch of the Chicago River and Lake Michigan Watershed: Volume 1

Prepared for

Metropolitan Water Reclamation District of Greater Chicago

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HDR

Detailed Watershed Plan for the North Branch of the Chicago River and Lake Michigan Watershed

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Metropolitan Water Reclamation District of Greater Chicago

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Acronyms and Abbreviations

ABM	Articulated Block Mat
AMC	Antecedent Moisture Conditions
B/C	Benefit to Cost Ratio
CAWS	Chicago Area Waterway System
CBBEL	Christopher B. Burke Engineering, Ltd.
CCHD	Cook County Highway Department
CCPN	Cook County Precipitation Network
CCSMP	Cook County Stormwater Management Plan
CCTA	Cook County Tax Assessor
cfs	cubic feet per second
CIP	Capital Improvement Program
CMAP	Chicago Metropolitan Agency for Planning
CN	Curve Number
CWA	Clean Water Act
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
District	Metropolitan Water Reclamation District of Greater Chicago
DWP	Detailed Watershed Plan
FEMA	Federal Emergency Management Agency
FFE	first floor elevation
FGCS	Federal Geodetic Control Subcommittee
FIS	Flood Insurance Study
FPDCC	Forest Preserve District of Cook County
GIS	Geographic Information System
GPS	Geographic Positioning System
H&H	Hydrologic and Hydraulic
HARN	High Accuracy Reference Network
HEC-DSS	Hydrologic Engineering Center Data Storage System
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
IDNR	Illinois Department of Natural Resources
IDOT	Illinois Department of Transportation
IEPA	Illinois Environmental Protection Agency
ISWS	Illinois State Water Survey
LCSMC	Lake County Stormwater Management Commission
LiDAR	Light Detection and Ranging
LM	Lake Michigan

LOMR	Letter of Map Revision
MWH	MWH Americas, Inc.
NAVD 88	North American Vertical Datum, 1988
NBCR	North Branch Chicago River
NED	National Elevation Dataset
NFIP	National Flood Insurance Program
NGS	National Geodetic Survey
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSC	North Shore Channel
NWI	National Wetlands Inventory
PCB	Polychlorinated Biphenyl
ROW	Right-of-Way
SCS	Soil Conservation Service
STATSGO	State Soil Geographic
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WMO	Watershed Management Ordinance
WPC	Watershed Planning Council
WSEL	Water Surface Elevation

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Executive Summary

Background

The Metropolitan Water Reclamation District of Greater Chicago (District) has authority for regional stormwater management within Cook County as granted by the Illinois General Assembly in Public Act 93-1049 (the Act). The Act requires the District to develop watershed plans for six Cook County watersheds, which include the North Branch of the Chicago River, Lower Des Plaines River, Calumet-Sag Channel, Little Calumet River, Poplar Creek, and Upper Salt Creek. The District published the *Cook County Stormwater Management Plan* (CCSMP) in February 2007 to identify stormwater management goals and to outline the District's approach to watershed planning. Chapter 6 of the CCSMP defines the District's approach to and standards for Detailed Watershed Plans (DWPs), which address regional stormwater problems in Cook County. The six major watersheds for which DWPs are being developed cover approximately 730 square miles in Cook County. The primary goals of the DWPs are as follows:

- Document stormwater problem areas.
- Evaluate existing watershed conditions using hydrologic and hydraulic (H&H) models.
- Produce flow, stage, frequency, and duration information about flood events along regional waterways.
- Estimate damages associated with regional stormwater problems.
- Evaluate potential solutions to regional stormwater problems.

The North Branch of the Chicago River (NBCR) and Lake Michigan (LM) DWP was developed to meet the goals for the NBCR and LM watersheds as described in the CCSMP. The Act required the formation of Watershed Planning Councils (WPCs) to advise the District during development of its countywide stormwater management program; therefore, the DWPs were developed in coordination with the WPCs. Membership of the WPCs consists of the chief elected official of each municipality and township in each watershed, or their designees. Many municipalities and townships are represented by engineers, elected officials, or public works directors. WPC meetings are also open to the public. Frequent coordination with WPCs was performed to ensure that local knowledge is integrated into the DWP and the DWP reflects the communities' understanding of watershed issues as well as the practicability of proposed solutions.

Detailed Watershed Plan Scope

The scope of the NBCR and LM DWP includes the development of stormwater improvement projects to address regional problem areas along open waterways. Regional problems are defined as problems associated with waterways whose watersheds encompass multiple jurisdictions and drain an area greater than 0.5 square miles. Problems arising from capacity issues on local systems, such as storm sewer systems and minor open channel ditches, even if they drain more than one municipality, were considered local and beyond the scope of this study. Erosion problems addressed in this plan were limited to active erosion along regional waterways that pose an imminent risk to structures or critical infrastructure. Interstate highways, U.S. highways, state routes, county roads with four or more lanes, and smaller roads providing critical access that are impacted by overbank flooding of regional waterways at depths exceeding 0.5 feet were also considered regional problems.

Watershed Overview

The NBCR and LM watersheds are located in northeastern Cook County and drain an area of over 120 square miles that includes 20 communities. Figure ES.1 is an overview of the NBCR and LM watersheds.

The NBCR watershed area is a heavily urbanized area, characterized by low relief, with small portions of forest preserve and park areas. It is drained principally by the West and Middle Forks of the NBCR, the Skokie River, and the North Shore Channel, which all discharge into and/or combine to form the NBCR. The downstream limit of the NBCR is at the confluence with the Chicago River and South Branch of the Chicago River near West Lake Street in downtown Chicago.

The LM watershed within Cook County is located along the west coast of LM and generally extends west to the ridge along Green Bay Road. This watershed area is heavily developed and characterized by greater topographic relief. The LM watershed consists of seven ravines which drain east into Lake Michigan. The LM watershed ravines are included, along with the NBCR and the tributaries that flow into and/or combine to form it, within the scope of NBCR and LM DWP.

Existing Conditions Evaluation

Locations with historic flooding and stream bank erosion problems on regional waterways exist throughout the watershed. Information on existing problem areas was solicited from WPC members as well as federal and state agencies and other stakeholders during the data collection and evaluation phase of the DWP development, which also included the collection of data regarding the watershed and evaluation of the data's acceptability for use. Responses from stakeholders were used to help identify locations of concern, and where field assessment or surveys were needed to support hydrologic and hydraulic modeling.

Hydrologic models were developed to represent runoff generated by rainfall throughout the NBCR watershed. The runoff was then routed through hydraulic models, which were created for the major open channel waterways within the watershed. Design rainfall events were simulated for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval events based upon Bulletin 71 rainfall data (ISWS, 1992). The simulated water surface profiles were overlaid upon a ground elevation model of the study area to identify structures at risk of flooding.

Property damages due to flooding were estimated using a methodology consistent with the U.S. Army Corps of Engineers (USACE) Flood Damage Assessment program. Estimated flood damage resulting from a storm was considered in combination with the probability of the event occurring to estimate an expected annual damage. Erosion damages were assessed for structures or infrastructure at risk of loss due to actively eroding stream banks. Damages reported within this document refer to economic damages estimated over a 50-year period

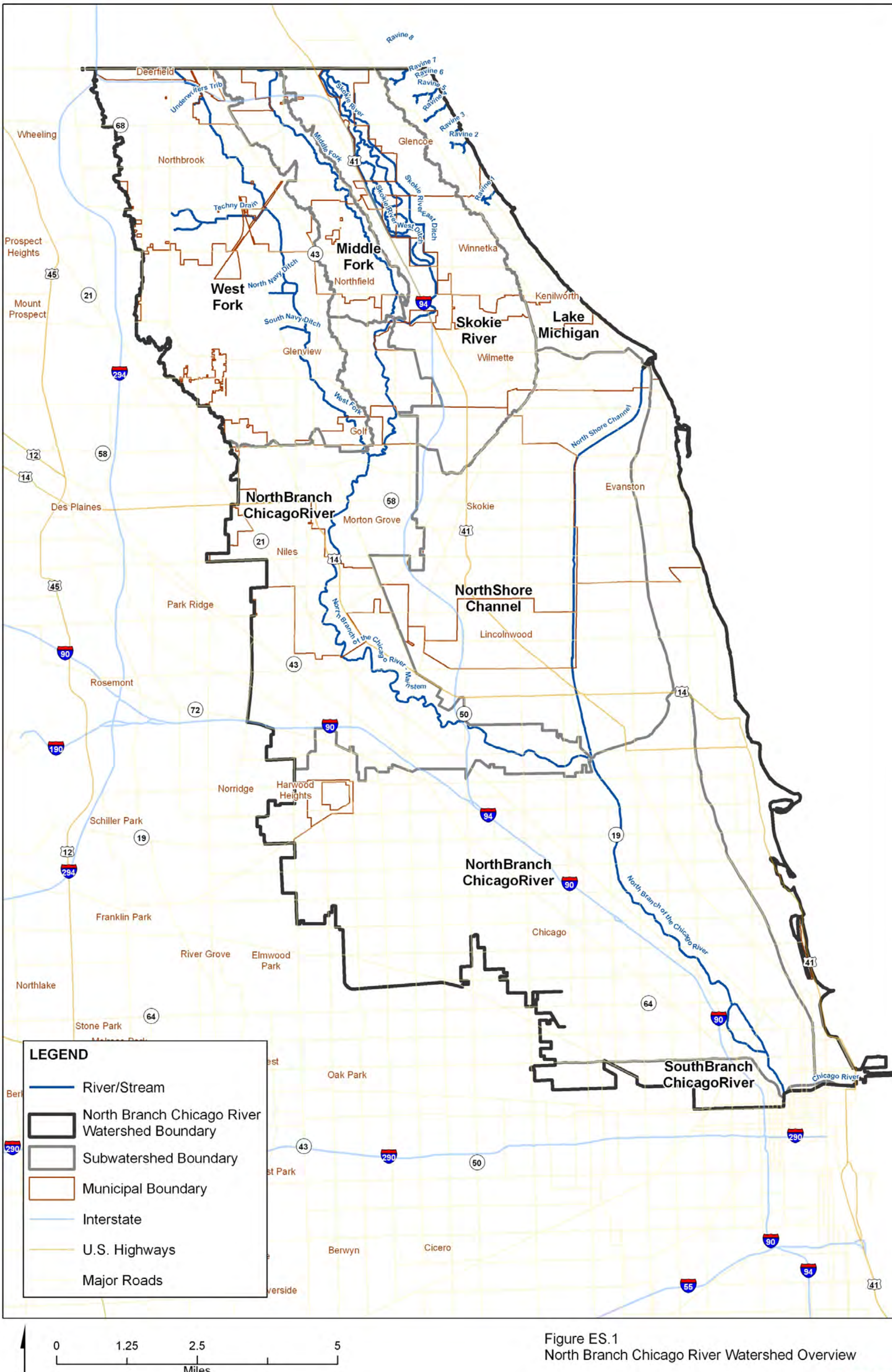

Figure ES.1
North Branch Chicago River Watershed Overview

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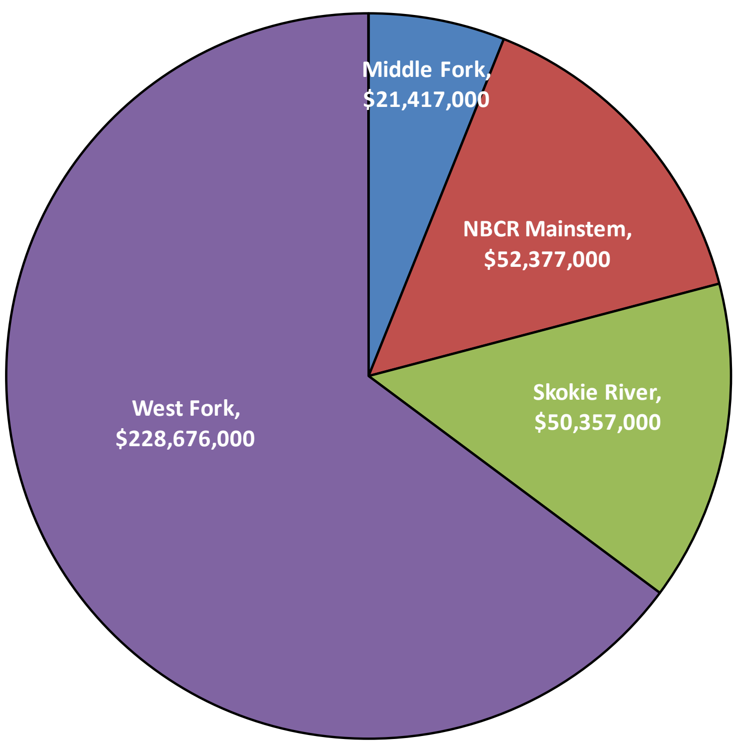
of analysis that result from regional overbank flooding or erosion of a regional waterway. Additional damages throughout the watershed exist, including damages due to flooding from local waterways and storm sewer systems, and also damages not easily quantified in financial terms such as water quality, wetland, riparian, and habitat impact, loss of emergency access, and loss of business or operations due to limited transportation access.

Figure ES.2 summarizes the distribution of existing conditions damages within the NBCR and LM watersheds over a fifty-year planning period. The LM watershed does not have regional damages related to overbank flooding and erosion problems on regional waterways. The West Fork of the NBCR and its tributary waterways comprise of roughly 60 percent of the existing conditions damage within the watershed. The West Fork reach has the second largest tributary area within the watershed, and the relatively dense development within the area subject to flooding combined with the very flat topography of the area resulted in significant damages.

The estimated damages summarized in Figure ES.2 include calculated regional damages related to overbank flooding and erosion problems on regional waterways that threaten structures only and transportation damages. Localized problems, such as storm-sewer capacity issues, are not included in this estimate. Reported problems classified as local are presented in Table 2.2.1 in Section 2.2.1. Also provided in Table 2.2.1 is the reasoning behind classifying the problems as local or regional.

FIGURE ES.2
Summary of Existing Conditions Damages within the North Branch of the Chicago River and Lake Michigan Watersheds over 50-Year Period of Analysis



Evaluation of Alternatives

Stormwater improvements, or alternatives, were developed to address regional stormwater problems along intercommunity waterways. WPC members participated in the alternative development process by providing input on possible solutions and candidate sites for new stormwater infrastructure. It should be noted that the alternatives presented in the DWP are developed at a conceptual level of feasibility.

Hydrologic and hydraulic models were used to determine the benefit of alternative stormwater improvement projects. Models were run and damages were calculated for the existing conditions evaluation. Benefits were calculated for each project as the difference between existing and alternative conditions damages. Only regional financial benefits (e.g., relief of flooding due to a regional problem as defined above) were considered. Local benefits (e.g., improved sewer drainage due to reduced outlet elevation) and non-economic benefits (e.g. improved emergency access, improved wetland, riparian, and habitat, and improved access to businesses) are not included in the benefits. The alternative stormwater improvement projects may have significant local and non-economic benefits. Local benefits are not reported in the DWP, which focuses on regional benefits.

Conceptual level cost estimates were produced to represent the estimated costs for design, construction, and maintenance of a specific alternative over a 50-year period of analysis. The cost estimates were developed using standard unit cost items located within a District database and used for all six watershed plans. In addition, standard markups on the estimated capital costs, such as utility relocation, design and engineering costs, profit and contingency were included.

A benefit-to-cost (B/C) ratio was developed for each alternative, which represents the ratio of estimated benefits to costs. The B/C ratios calculated may be used to rank the alternatives in a relative manner as the District's Board of Commissioners prioritizes the implementation of recommended stormwater improvement projects. Only regional financial benefits were considered in determination of the B/C ratios. The B/C ratios do not include local and non-economic benefits and should not be interpreted to be the sole measure of justification of an alternative. In addition to the B/C ratio, noneconomic criteria such as water-quality impact, number of structures protected, and impact on wetland and riparian areas were noted for each alternative. These criteria may also be considered along with the calculated B/C ratios as the District's Board of Commissioners prioritizes the implementation of recommended stormwater improvement projects.

Recommendations

Alternatives were recommended based upon consideration of their ability to reduce stormwater damages and to address problems reported by communities. Table ES.1 lists the recommended alternatives, their costs, and regional financial benefits. Note that additional benefits to the local systems and non-economic benefits will result from the recommended alternative projects.

Figure ES.3 summarizes the extent to which recommended alternatives address existing regional financial damages within each stream reach, ordered by increasing existing conditions damages. The two line series illustrated on the graph represent existing condition

TABLE ES.1
Recommended Alternatives Summary for the North Branch of the Chicago River and Lake Michigan Watersheds

Project	Category	Description	B/C Ratio	Total Benefits	Total Project Cost	Probable Construction Cost	Cumulative Structures Protected	Communities Involved
WF-03	Erosion Stabilization	Hard armoring of WF east bank along Metra Milwaukee North District RR and Fair Lane between Dundee Road and Cherry Lane.	0.77	$1,550,000	$2,022,000	$1,097,000	3	Metra and Northbrook
WF-06	Detention/Conveyance	Techny Reservoir 32A Expansion into Anetsberger Golf Course and steepening existing side slopes to 3H:1V. Includes inlet weir and restrictor barrel revisions. Adds approximately 1,100 ac-ft of detention storage.	1.26	$146,484,000	$116,088,000	$87,422,000	216	Northbrook Park District, Northbrook, Glenview, Golf, Unincorp. Cook Co.
MF-04	Levee	Flood wall on the east bank of the MF through the Fair Acres/Waters Edge subdivision. Compensatory storage proposed for adjacent Forest Preserve District property (approximately 5 ac-ft).	0.12	$178,000	$1,495,000	$736,000	4	Forest Preserve District of Cook County (FPDCC), Northbrook, Unincorp. Cook Co.
MF-06	Erosion Stabilization	Hard armoring of both banks of MF along Robin Hood Lane, New Willow Road, and Northfield Road.	4.59	$7,391,000	$1,610,000	$873,000	7	Northfield
MF-07	Erosion Stabilization	Hard armoring of MF at Meadowbrook Drive.	1.65	$1,600,000	$971,000	$526,000	3	Northfield
SR-08[1]	Levee	I-94 at Winnetka Road Levees. Construct approximately 1,700 ft of levee along both sides of I-94 near Winnetka Road.[1]	1.35	$7,760,000	$5,761,000	$3,512,000	0	Northfield, IDOT, FPDCC, Cook County Highway Department
MS-10[2]	Levee	Albany Park Floodwall Project. Construct approximately 6,300 ft of floodwall along NBCR between Foster Avenue and Kimball Avenue.	1.51	$24,746,000	$16,402,000	$4,176,000	329	Chicago, Chicago Park District, FPDCC, Private Property Owners
MS-14[3]	Detention/Conveyance	Combination of Alternative Projects MS-12 + MS-13 (Wilmette Golf Course Reservoir + Channel Modification on Main Stem). Addition of a new reservoir on the Wilmette Golf Course (approximately 2,800 ac-ft of storage). Channel modification widens the Main Stem channel by approximately 100 feet (50 ft per side) from the Middle Fork to the West Fork, approximately 18,500 ft.	0.25	$64,431,000	$260,121,000	$185,117,000	1,153	Wilmette Park District, Wilmette, FPDCC, Glenview

1 - SR-08 project addresses overbank flooding of the Skokie River near I-94 (Edens Expressway) and Winnetka Road. For purposes of benefit calculation for SR-08, no other temporary closure of I-94 due to overbank flooding is assumed.
2 - The City of Chicago has expressed a preference for Alternative MS-07, which is described in Section 3.4.3.5. Alternative MS-10 yields a higher B/C ratio and was therefore selected as the recommended alternative for the DWP.
3 - MS-14 project's total benefits includes benefits to the Middle Fork, Skokie River, and Main Stem NBCR subwatersheds. FPDCC and Wilmette Park District have indicated their unwillingness to provide land for this alternative.

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damages and benefits, respectively, for each stream reach. The columns indicate the extent to which recommended alternatives address estimated damages, while the red B/C symbols indicate the combined B/C ratio for alternatives associated with each stream reach. As an example, the recommended West Fork alternatives, WF-03 and WF-06, address roughly 65 percent of estimated damages along the West Fork (indicated by the column), which corresponds to a benefit of approximately $148,034,000. In contrast, the recommended alternative that benefits the Skokie River, MS-14, addresses over 90 percent of the estimated damages along the Skokie River, but this project results in only about $46,996,000 of benefit for the Skokie River reach. Stated simply, areas with lower existing regional financial damages typically show lower benefits from flood control projects.

FIGURE ES.3
North Branch of the Chicago River Watershed Alternative Summary

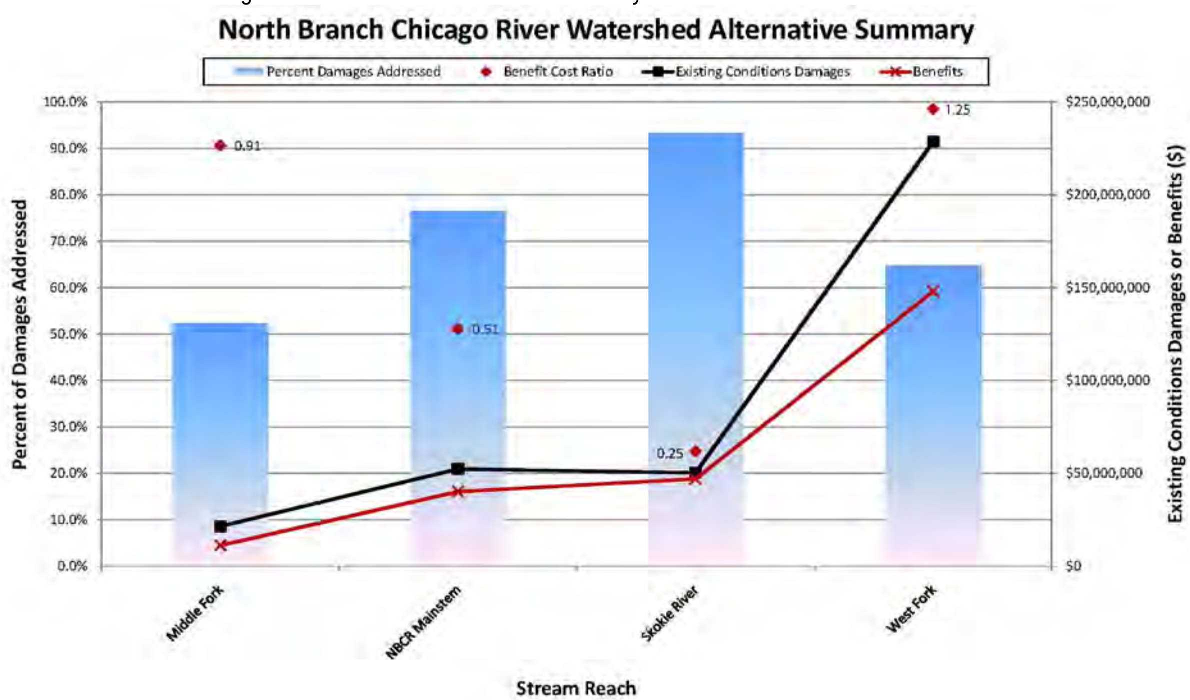


Figure ES.3 Notes:

1. Skokie River stream reach only includes benefits and damages addressed for the MS-14 project due to overlapping benefit with the SR-08 benefit.
2. Benefits, project costs, and damages addressed for the Middle Fork, NBCR Mainstem, and Skokie River stream reaches include results from the MS-14 project. Project costs have been prorated among the three reaches based on benefit percentage to each respective stream reach.

In Figure ES.3, the Skokie River stream reach only reports the MS-14 project's benefits, costs, and percent damages addressed on the Skokie River. MS-14 is the only project reported for the Skokie River stream reach since the Skokie River subwatershed benefits provided by this project are more comprehensive than the SR-08 project, which has been included as a recommended project to serve as an alternative feasible solution to the I-94 at Winnetka Road overbank flooding problem should the MS-14 project not be implemented.

Because the MS-14 project provides benefits to the Middle Fork, Skokie, and NBCR Mainstem stream reaches, the benefits provided by MS-14 for each stream reach were incorporated into the percent damages addressed and B/C ratio for each stream reach. Distribution of project costs for MS-14 between the associated stream reaches was estimated by prorating the MS-14 project costs among the three reaches based on benefit percentage provided by

MS-14 to each respective stream reach. It should be noted that approximately 2,800 acre-feet of stormwater storage is required to realize the benefits of MS-14. The property owners, namely FPDCC and Wilmette Park District, of the potential storage locations have expressed an unwillingness to allow the storage to be provided on their respective properties.

The NBCR DWP integrated stormwater data from a large number of sources in order to identify and prioritize solutions to existing stormwater problems. An extensive data collection effort undertaken for the DWP development included surveying of streams, bridges, and culverts throughout the entire watershed. Field reconnaissance was performed throughout the watershed to understand conditions unique to the watershed. This compilation of current, accurate data was used by the District to document and identify existing stormwater problems throughout the study area.

A large number of alternatives were developed and evaluated for their effectiveness in reducing regional damages within the NBCR watershed. The alternatives listed in Table ES.1 were identified as the most effective improvements for reducing expected damages due to flooding within the watershed. In some tributaries, greater opportunities to reduce regional flooding were identified than in others. Factors such as the lack of availability of land and location of structures relative to stream channels limited the practicality of alternative projects to eliminate all flooding damages for all design storms evaluated.

While some recommended alternatives involve the use of FPDCC property, it is noted that the enabling legislation (70 ILCS 2605/7h (g)) for the District's stormwater management program states "the District shall not use Cook County Forest Preserve District land for stormwater or flood control projects without the consent of the Forest Preserve District of Cook County (FPDCC)"; therefore proposed projects involving FPDCC property cannot be implemented without FPDCC's permission. The District will work collaboratively with FPDCC to develop multi-objective projects beneficial to both agencies along with our constituents and also consistent with our individual missions.

The data provided in the NBCR DWP will be used by the District, along with consistently developed data in DWPs for the other five major Cook County Watersheds, to prioritize the implementation of stormwater improvement projects.

1. Introduction

The North Branch Chicago River and Lake Michigan watersheds, located in northeastern Cook County, Illinois, drain an area of over 120 square miles that includes 20 communities. Figure ES.1 shows an overview of the North Branch Chicago River (NBCR) and Lake Michigan (LM) watersheds.

The NBCR watershed is a heavily urbanized area with small portions of forest preserve and park areas, and is generally characterized by low relief. The headwaters of the three major tributaries, the Skokie River, the Middle Fork, and the West Fork, are located in Lake County, IL. These tributaries flow south into Cook County at Lake Cook Road and combine with the Main Stem of the NBCR at Beckwith Road within Chick Evans golf course. Another tributary, the North Shore Channel (NSC), enters the Main Stem of the NBCR near Albany Avenue in Chicago, adjacent to the North Branch Dam at Albany Park. The downstream limit of the NBCR is at the confluence with the Chicago River and South Branch of the Chicago River near W. Lake Street in downtown Chicago. Locations of historic flooding mainly exist on the West Fork, the Skokie River and the NBCR, and upstream of the North Branch Dam; while locations of streambank erosion exist primarily on the West Fork, Middle Fork, and Main Steam of the NBCR upstream of the North Branch Dam.

The Lake Michigan watershed within Cook County is located along the west coast of Lake Michigan and generally extends west to the topographic ridge along Green Bay Road. The Lake Michigan watershed consists of seven ravines which drain east into Lake Michigan. The Lake Michigan watershed shows no signs of historic flooding problems or signs of streambank erosion. Soil erosion does occur along the bluffs of the Lake Michigan shoreline and, to a lesser extent, along the ravines. However, this DWP does not address bluff/ravine erosion, but rather active erosion along regional waterways that pose an imminent risk to structures or critical infrastructure and / or threaten public safety.

The NBCR and Lake Michigan Detailed Watershed Plan (DWP) was developed by the Metropolitan Water Reclamation District of Greater Chicago (District) with the participation of the NBCR Watershed Planning Council (WPC) which provided local input to the District throughout the development process. The DWP was developed to accomplish the following goals:

- Document stormwater problem areas.
- Evaluate existing watershed conditions using hydrologic and hydraulic (H&H) models.
- Produce flow, stage, frequency, and duration information along regional waterways.
- Estimate damages associated with regional stormwater problems.
- Evaluate solutions to regional stormwater problems.

Regional problems are defined as problems associated with waterways whose watersheds encompass multiple jurisdictions and drain an area greater than 0.5 square miles. Problems arising from capacity issues on local systems, such as storm sewer systems and minor open channel ditches, even if they drain more than one municipality, were considered local and beyond the scope of this regional stormwater management program. Erosion problems addressed in this plan were limited to active erosion along regional waterways that pose an imminent risk to structures or critical infrastructure and/or threaten public safety. Interstate highways, U.S. highways, state routes, county roads with four or more lanes, and smaller roads providing critical access that are impacted by overbank flooding of regional waterways at depths exceeding 0.5 feet were also considered regional problems.

1.1 Scope and Approach

The DWP scope included data collection and evaluation, H&H modeling, development and evaluation of alternatives, and recommendation of alternatives. The data collection and evaluation task included collection and evaluation of existing H&H models, geospatial data, previous studies, reported problem areas, and other data relevant to the watershed plan. H&H models were developed to produce inundation mapping for existing conditions for the 100-year storm event and to evaluate stormwater improvement project alternatives. Stormwater improvement project alternatives were developed and evaluated to determine their effectiveness in addressing regional stormwater problems. Estimates of damage reduction, or benefits, associated with proposed projects were considered along with conceptual cost estimates and noneconomic criteria to develop a list of recommended improvement projects for the NBCR and Lake Michigan watersheds.

1.2 Data Collection and Evaluation

The data collection and evaluation phase (Phase A) of the DWP focused on obtaining data regarding the watershed and evaluation of the material's acceptability for use. The District contacted all WPC members as well as federal and state agencies and other stakeholders requesting relevant data. Coordination with WPC members took place throughout development of the DWP. Existing and newly developed data was evaluated according to criteria of use defined in Chapter 6 of the *Cook County Stormwater Management Plan* (CCSMP), included in Appendix B. Where data was unavailable or insufficient to complete the DWP, additional data was collected. This report includes information on all data collected and evaluated as a part of the DWP development. Table 1.2.1 lists key dates of coordination activities including meetings with WPC members throughout DWP development.

1.3 Hydrologic and Hydraulic Modeling

This section of the report provides a description of H&H modeling completed to support the DWP development. H&H models were developed for all tributaries within the watershed containing open waterways. Most models were developed independently of any past H&H modeling efforts. There were several locations, however, where existing models or studies were used. For the Techny Drain tributary, a hydrologic study was used to assist with subbasin delineation and flow diversion modeling. For the Underwriter's Tributary, a hydrologic and hydraulic study was used to assist with subbasin delineation and storage modeling. Data from existing regulatory hydraulic models was used for supplementing the newly developed DWP HEC-RAS hydraulic models for the West Fork, Middle Fork, Skokie River and Main Stem of the NBCR. The United States Army Corps of Engineers's (USACE's) recent hydraulic model of the Chicago Area Waterway System (CAWS) was used to develop the water surface profiles of the North Shore Channel and the Main Stem of the NBCR downstream of the North Branch Dam.

Although hydraulic model extent was defined based upon the extent of detailed study for effective Digital Flood Insurance Rate Maps (DFIRMs), models were extended further, where appropriate, to aid evaluation of damages associated with regional stormwater problems. Appendix A includes a comparison of FEMA's revised DFIRM panels with inundation areas developed for DWP modeling purposes. Tables comparing DWP inundation area to FEMA floodplain mapping by community and subwatershed are also included in Appendix A.

H&H models were developed to be consistent with the protocols defined in Chapter 6 of the CCSMP. In numerous instances, models included additional open channel or other drainage facilities not strictly required by Chapter 6, to aid the evaluation of community reported problem areas. Available monitoring data, including USGS stream gage data, District facility data and high water marks observed following storm events were used to perform model verification and calibration consistent with Chapter 6 guidelines. All H&H modeling data and documentation of the data development are included in the appendices referenced in the report sections below.

TABLE 1.3.1
WPC Coordination Activities

Description of Activity		Date
07-029-5C NBCR and Lake Michigan Detailed Watershed Plan - Phase A - Contract start date		January 15, 2008
08-033-5C NBCR and Lake Michigan Detailed Watershed Plan - Phase B - Contract start date		September 11, 2008
Information Gathering		
Data Request (Forms A and B) sent out as part of Phase A		August 17, 2007
Watershed field visit and meetings with various municipalities		September 2008 to September 2010
Open meetings with Watershed representatives during Phase A to discuss Forms A and B		January 30, 2008
District phone calls and emails to communities after the September 13th and 14th, 2008 storm event		September 2008
NBCR and Lake Michigan Watershed Planning Council Meetings (20)		
October 26, 2005	March 7, 2006	June 6, 2006
September 5, 2006	December 5, 2006	March 6, 2007
June 5, 2007	September 4, 2007	December 4, 2007
March 4, 2008	June 3, 2008	September 2, 2008
December 2, 2008	March 3, 2009	June 2, 2009
September 1, 2009	December 1, 2009	March 2, 2010
June 1, 2010	September 7, 2010	

TABLE 1.3.1
WPC Coordination Activities

Modeling Results and Alternatives Review Meetings		
Initial Model Review Workshop		September 17, 2009 and May 20, 2010
Preliminary Alternatives Review Workshop		June 29, 2010
Final Alternatives Presentation Workshop		August 12, 2010
MWRDGC Board of Commissioners' Study Sessions		
January 10, 2006	April 27, 2006	October 2, 2008

1.3.1 Model Selection

H&H models were developed within the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) Version 3.1.0 modeling application and Hydrologic Engineering Center-River Analysis System (HEC-RAS) Version 4.0. These applications were identified as acceptable in Tables 6.10 and 6.11 of the CCSMP. The Soil Conservation Service (SCS) curve number (CN) loss module was used with the Clark's unit hydrograph methodology within HEC-HMS to model basin hydrology. The dynamic unsteady flow routing methodology was used within HEC-RAS. Both applications have an extensive toolkit to interface with geographic information systems (GIS) software to produce input data and display model results.

1.3.2 Model Setup and Unit Numbering

1.3.2.1 Hydrologic Model Setup

Hydrologic model data was primarily developed within the GeoHMS (Version 4.2) extension to Arc GIS Version 9.3.1. The extension provides an interface to geoprocessing functions used to characterize subbasin parameters within the hydrologic model. GeoHMS was used to calculate the CN for each basin; to define the longest flow path, basin slope, and longest flow path slope; and to establish a network connecting hydrologic elements (e.g., subbasins, reservoirs, reaches, and inflow locations) to the outlet of the system. HEC-HMS was used to create and sometimes route stormwater runoff hydrographs to the upstream extent of hydraulic models developed within HEC-RAS. Hydrologic model data was transferred between HEC-HMS and HEC-RAS through HEC-DSS files.

Subbasin Delineation. Within Cook County, each major tributary model (West Fork, Middle Fork, Skokie River, etc.) was divided into subbasins roughly 320 acres (0.5 square miles) in size to form the basis of the hydrologic model and was modeled assuming a unified response to rainfall based on land use characteristics and soil type. Elevation data provided by Cook County, described in Section 2.3.4, was the principal data source used for subbasin delineation. Drainage divides were established based upon consideration of the direction of steepest descent from local elevation maxima, and refined in some instances to reflect modifications to topographic drainage patterns caused by stormwater management infrastructure (storm sewer systems, culverts, etc.). Subbasin boundaries were modified to encompass areas with similar development patterns. Finally, boundaries were defined to most accurately represent the area tributary to specific modeled elements, such as constrictions caused by crossings, and reservoirs. GIS data was developed for all subbasins delineated and used for hydrologic model data development. In the upper extents of the watershed, within Lake County, a more generalized delineation approach with the USGS's 10 meter National Elevation Dataset (NED) was used for contouring, and basins were delineated to a size of approximately one square mile.

Runoff Volume Calculation. The SCS CN loss model uses the empirical CN parameter to calculate runoff volumes based on landscape characteristics such as soil type, land cover, imperviousness, and land use development. *Areas characterized by saturated or poorly infiltrating soils, or impervious development, have higher CN values, converting a greater portion of rainfall volume into runoff. The SCS methodology uses Equation 1.1 to compute stormwater runoff volume for each time step:*

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad (1.1)$$

Where:

Q	=	runoff volume (in.)
P	=	precipitation (in.)
S	=	storage coefficient (in.)
I_a	=	initial abstractions (in.)

Rainfall abstractions due to ponding and evapotranspiration can be simulated using an initial abstractions (I_a) parameter. In the NBCR DWP, the commonly used default value of I_a, estimated as $0.2 \times S$, where S is the storage coefficient for soil in the subbasin. S is related to CN through Equation 1.2:

$$S = \frac{1000}{CN} - 10 \qquad (1.2)$$

where:

CN	=	curve number (dimensionless)
S	=	storage coefficient (in,)

Table 1.3.2 describes the input data used to develop the CN values throughout the watershed.

TABLE 1.3.2
Description of Curve Number Input Data

Variable Used to Determine CN	Approach for Definition of Variable for NBCR and Lake Michigan Watershed Hydrologic Modeling
Ground cover	Chicago Metropolitan Agency for Planning (CMAP) 2001 land use inventory (v.1.2 2006) is used to define land use. A lookup table was developed to link CMAP categories to categories for which CN values have been estimated.

TABLE 1.3.2
Description of Curve Number Input Data

Variable Used to Determine CN	Approach for Definition of Variable for NBCR and Lake Michigan Watershed Hydrologic Modeling
Soil type	The Natural Resources Conservation Service (NRCS) publishes county soil surveys that cover portions of the watershed except areas within the City of Chicago and other lower basin areas. The NRCS surveys include a hydrologic classification of A, B, C, or D. Generally a soil classification of A will represent soils with the highest infiltration potential, whereas a classification of D will represent the lowest infiltration potential. If a soil group's infiltration capacity is affected by a high water table, it is classified as, for instance, "A/D," meaning the drained soil has "A" infiltration characteristics, undrained "D." It was assumed that half of these soil groups (by area) are drained. Soil types outside of the NRCS soil survey areas were determined through use of the NRCS's STATSGO dataset. It was assumed that half of the STATSGO soil groups, by area, are drained.
Antecedent moisture condition	Antecedent Moisture Conditions (AMC) reflects the initial soil storage capacity available for rainfall. For areas within Northeastern Illinois, it is typical to assume an AMC of II.

Specific combinations of land use and soil type were linked to CN values using a lookup table based on values recommended in Table 1.3.3 excerpted from *TR-55: Urban Hydrology for Small Watersheds* (U.S. Department of Agriculture [USDA], 1986). The CN matrix includes assumptions about the imperviousness of land use classes, and therefore, percent impervious does not need to be explicitly considered as the SCS runoff volume calculation. Since the CMAP land-use data does not correspond to the categories in Table 1.3.3, development of a mapping process between TR-55 land use categories and CMAP land use categories was necessary. This process is detailed in Appendix C, which includes a technical memorandum detailing the process used to develop CN values for the NBCR watershed and Lake Michigan watershed.

The GeoHMS tool was used to develop an area-weighted average CN for each subbasin.

Runoff Hydrograph Production.

The runoff volume produced for a subbasin is converted into a basin-specific hydrograph by using a standard unit hydrograph and an estimate of subbasin time of concentration. The standard unit hydrograph method used for the NBCR watershed was the Clark unit hydrograph method, and the SCS unit hydrograph method was used for the Lake Michigan Watershed. Estimates of subbasin time of concentration values were performed using SCS methodologies.

The time of concentration is the time it takes for a drop of water to travel from the hydraulically furthest point in a watershed to the outlet. Using SCS methodologies, the time of concentration is estimated as the sum of the travel time for three different segments of flow, split-up by flow type in each subbasin.

TABLE 1.3.3
Runoff Curve Numbers for Urban Areas

Cover Type and Hydrologic Condition	Avg. % Impervious Area	A	B	C	D
Fully developed urban areas (vegetation established)					
Open Space (lawns, parks, golf courses, cemeteries, etc.)					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50 to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious Areas					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western Desert Urban Areas					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin barriers		96	96	96	96
Urban Districts					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential Districts by Average Lot Size					
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing Urban Areas					
Newly Graded Areas (pervious areas only, no vegetation)		77	86	91	94

Note: Average runoff condition, and $I_a = 0.2S$.

Note: Source of table is *TR-55: Urban Hydrology for Small Watersheds* (U.S. Department of Agriculture [USDA], 1986)

Thus Equation 1.3:

$$T_c = T_{sheet} + T_{shallow} + T_{channel} \qquad (1.3)$$

where:

T_{sheet} = sheet flow; flow occurring across the land area headwater areas prior to flow accumulation

$T_{shallow}$ = shallow flow; occurs where sheet flow begins to accumulate into more concentrated patterns, but prior to transitioning into open channel flow

$T_{channel}$ = flow within natural or manmade drainage facilities within each subwatershed prior to the point of discharge

GeoHMS was used to determine the route of the longest flow path, and that flow path's length and slope. The basin parameter estimates were exported to a spreadsheet to support calculation of T_c.

Comparison of HEC-HMS results to gage data was initially performed using the Clark Method and SCS Method unit hydrographs. This comparison evaluation indicated that the Clark Method unit hydrographs produced more representative results for the North Branch of the Chicago River, West Fork, Middle Fork, and Skokie River subwatersheds.

The storage coefficient for the Clark methodology was estimated using equation 1.4.

$$\frac{R}{Tc + R} = C \qquad (1.4)$$

The value for C was determined using USGS Water Resources Investigation Report 00-4184. The value for C and estimated subbasin Tc values were used to calculate R values for each subbasin. The values of Tc originally calculated appeared reasonable based on the topography of the subbasins, and subsequent review of hydrograph comparisons confirmed that overall timing of the watershed as indicated by the model was representative of actual conditions.

As described above, the Clark unit hydrograph method was used for the NBCR Watershed; however, the SCS unit hydrograph method was used for the Lake Michigan Watershed. Due to the steepness of terrain and relative lack of channel storage in the Lake Michigan Watershed, the SCS unit hydrograph method was more applicable and provided more reasonable results. The SCS unit hydrograph method converts the runoff volume produced for a specific subbasin into a basin specific hydrograph using a standard SCS unit hydrograph and an estimate of subbasin lag time. The lag time is defined as the time elapsed between the mass centroid of precipitation and peak of the runoff hydrograph at the outlet of the subbasin. Lag times for the Lake Michigan watershed were estimated according to Equation 1.5, provided in the HEC-HMS Technical Reference Manual (USACE, 2006):

$$T_{lag} = 0.6T_c \qquad (1.5)$$

where:

T_{lag} = Lag time
T_c = Time of Concentration

Time of concentration estimates for the Lake Michigan Watershed were performed using the same SCS method described in the text above and Equation 1.3.

Rainfall Data. Observed and design event rainfall data was used to support modeling evaluations for the DWP. Monitored rainfall data is described in Section 2.3.1. Design event rainfall data was obtained from Bulletin 71, *Rainfall Frequency Atlas of the Midwest* (Huff, 1992). Design event rainfall depths obtained from Bulletin 71 were used to support design event modeling performed for existing and proposed conditions assessment.

1.3.3 Storm Duration

A critical-duration analysis was performed to determine the storm duration that generally results in higher water surface estimates for a range of tributary sizes within the NBCR watershed. The 24-hour duration storm was identified as the critical duration for streams within the NBCR watershed. A third quartile storm is recommended for storms of this duration (Huff, 1992). Table 1.3.4 summarizes rainfall depths for the 24-hour duration storm.

1.3.4 Areal Reduction Factor

The rainfall depths presented in Table 1.3.4 summarize expected point rainfall accumulation for modeled recurrence intervals. The probability of uniform rainfall across a subwatershed decreases with increasing watershed size. Table 21 of Bulletin 71 relates areal mean rainfall depth to rainfall depth at a point (Huff, 1992). After review of subwatershed (West Fork, Middle Fork, Skokie River, and Main Stem of the NBCR) sizes, and modeling sensitivity, it was determined that a reduction factor is not appropriate within the NBCR watershed. Bulletin 71 also provides rainfall distributions that vary according to watershed size (point distribution, 10 to 50 square mile area, 50 to 100 square mile, etc). The rainfall distribution used was a point distribution in order to provide more accurate results for smaller tributaries and the upper portion of the watershed. Review of modeling sensitivity indicates that use of the 10 to 50 square mile area distribution results in insignificant changes to peak flow rates within the watersheds main stream reaches.

TABLE 1.3.4
Rainfall Depths

Recurrence Interval	24-hr Duration Rainfall Depth
2-year	3.04
5-year	3.80
10-year	4.47
25- year	5.51
50- year	6.46
100-year	7.58
500-year	10.90[a]

[a]500-year rainfall depth was determined based on a logarithmic relationship between rainfall depth and recurrence interval.

1.3.5 Hydrologic Routing

Stormwater runoff hydrographs were routed within HEC-HMS in upstream areas where the resolution of subbasins defined was greater than the hydraulic model extent. In areas where a channel cross section could be identified from topographic data, Muskingum-Cunge routing was performed using the approximate channel geometry from a representative cross section of the modeled hydrologic reach. To account for reach storage effects, lateral inflow hydrographs produced within HEC-HMS, were input to the HEC-RAS unsteady-state hydraulic model. For the portions of the Middle Fork and Skokie River within Lake County, modified puls storage-discharge relationships from the existing hydrologic models (effective FIS models) were incorporated into the new HEC-HMS modeling developed for this DWP.

1.3.6 Hydraulic Model Setup

Hydraulic model data was typically developed through field surveys with some additional definition of channel overbank areas and roadway crests defined using Cook County 2003 topographic LiDAR data. Cross section locations were developed in HEC GeoRAS, and surveyed channel geometry was inserted into topographically generated cross sectional data. Cross sections were generally surveyed at intervals of 500 to 1,000 feet. Interpolated cross sections were added at many locations to the models to increase stability and reduce errors. Bridges, culverts, and other major hydraulic structures were surveyed within the hydraulic model extent. The locations of all surveyed and modeled cross sections, bridges, culverts, and other structures are shown in Appendix D.

1.3.6.1 Bridges, Culverts, and Hydraulic Structures

Bridges, culverts, and hydraulic structures were surveyed consistent with FEMA mapping protocol as identified in *Guidelines and Specifications for Flood Hazard Mapping Partners*, "Guidance for Aerial Mapping and Surveying" (FEMA 2003). A State of Illinois licensed professional land surveyor certified each location as FEMA compliant. Documentation of certifications is provided in Appendix D. Bridges, culverts, and hydraulic structures were surveyed consistent with the NAVD 1988 datum using 5-centimeter or better GPS procedures (as specified in NGS-58 for local network accuracy) or third-order (or better) differential leveling, or trigonometric leveling for short distances. In a few cases, information from construction as-built plans was used in lieu of surveying. Ineffective flow areas were placed at cross sections upstream and downstream of crossings, assuming a contraction ratio of 1:1 and an expansion ratio of 2:1. Contraction and expansion coefficients generally were increased to 0.3 and 0.5, respectively, at cross sections adjacent to crossings and in areas where severe meandering occurred along the reach.

1.3.6.2 Cross-Sectional Data

Cross-sectional data was surveyed consistent with FEMA mapping protocol as identified in *Guidelines and Specifications for Flood Hazard Mapping Partners*, "Guidance for Aerial Mapping and Surveying" (FEMA 2003).

All survey work, including survey of cross sections, was certified as compliant to FEMA mapping protocol by a licensed professional land surveyor. Documentation of certifications is provided in Appendix D. Cross sections were surveyed consistent with the North American Vertical Datum, 1988 (NAVD 1988) using 5-centimeter or better GPS procedures (as specified in NGS-58 for local network accuracy) or third-order (or better) differential leveling, or trigonometric leveling for short distances. Cross sections were interpolated at many locations within the hydraulic models, to aid model stability and reduce errors.

1.3.6.3 Boundary Conditions

The perimeter of District jurisdiction, watershed geographic considerations, and modeling methodologies were used to determine the appropriate boundary conditions for hydraulic modeling.

The USACE's model of the CAWS provided tailwater conditions for the hydraulic models upstream of the North Branch Dam within the Main Stem of the NBCR.

Within the Lake Michigan watershed, a downstream boundary condition was only required for Ravine 1 since this was the only Ravine modeled within the study. Due to the relatively steep nature of the ravine that generates supercritical flows; downstream water surface elevations did not have significant backwater effects on the upstream portions of the ravine. For this reason, the hydraulic analysis of Ravine 1 assumed critical flow depth at the downstream end of the hydraulic model.

1.3.7 Model Run Settings

All hydraulic model simulations were carried out using the fully dynamic, unsteady flow simulation settings within HEC-RAS. The Saint-Venant equations, or the continuity and momentum balance equations for open channel flow, were solved using implicit finite difference scheme. HEC-RAS has the ability to model storage areas and hydraulic connections between storage areas and between stream reaches. The computational time step for model runs was generally 15 seconds.

1.3.8 Model Calibration and Verification

The hydrologic and hydraulic models developed for the DWP were calibrated and verified in order to create modeling that is representative of watershed stormwater runoff response for a range of storm magnitudes. Calibration, as used in this DWP, is to be defined as the adjustment of modeling parameters to cause a model to be more representative of recorded data. Verification, as used in this DWP, refers to running a model using an independent storm event and checking that the results produced are representative of recorded data. In the case of this DWP, the September 13-14, 2008 storm event was used as the basis for calibration. The October 14-16, 2001 storm event was used for verification.

Output from the HEC-HMS hydrologic model was used as input to the HEC-RAS hydraulic model. Within the DWP project area (south of the Cook-Lake County line), the hydrologic model used Muskingum Cunge channel routing which does not take into account the flow attenuation that occurs in the channel and overbank areas. Attenuation was accounted for in the unsteady HEC-RAS model. As a result, adjustments to the HEC-HMS model, for purposes of calibration, could only be made after comparison of HEC-RAS hydrographs to river gage hydrographs. This comparison was performed at the Main Stem river gage location in the community of Niles and it was determined that the HEC-HMS model was providing representative lateral hydrograph inputs for both the 2008 and 2001 storm events. Peak runoff rates and volumes were within 30% as required by District criteria. Detailed calibration results are presented in subwatershed subsections, including hydrographs and comparisons of stage and runoff volume.

Approximately 40% of the NBCR watershed area is located north of the DWP project area (north of the Lake-Cook County line). Although HEC-1 modeling existed for this area, the HEC-HMS model created for the DWP was extended northward to include this area. For the Middle Fork and Skokie River, modified puls data from the HEC-1 models was incorporated into the HEC-HMS models, and modeling parameter adjustments (Curve Number and storage coefficient) were made to make the HEC-HMS model representative of existing land use conditions. Evaluation of HEC-1, HEC-HMS, and river gage hydrographs at the county line indicated that the HEC-HMS produced hydrographs were appropriate for use as a boundary condition for the Middle Fork and Skokie River. Due to the locations of existing gages and the presence of the Deerfield Reservoir near the county line, the HEC-1 hydrograph for the West Fork was used as a boundary condition.

Water surface elevation output from the 2008 HEC-RAS model were compared against known elevations at river gages, reservoir bubbler locations, and at surveyed flood elevation locations. The elevations are compared in subwatershed subsections and indicate compliance with the CCSMP's Chapter 6 criteria to be within 6" of known elevations. No modeling adjustments (such as modification of Manning's n values) were required in order to meet elevation criteria.

The Lake Michigan Ravines watersheds are not monitored by river gages or other recording equipment or methods. As a result, the hydrologic modeling parameters of the HEC-HMS models were based on analysis of land use and topography. No modeling parameter adjustments were made to modify results to match recorded flow or elevation data.

Hydraulic modeling of Lake Michigan Ravine 1 was not calibrated due to lack of recorded flooding information. It is assumed that calibration and validation of the North Shore Channel modeling (downstream of the North Branch Dam) was performed by the USACE.

1.3.9 Flood Inundation Mapping

Flood inundation maps were produced to display the inundation areas associated with the 100-year event. The flood inundation maps were produced by overlaying the results of the hydraulic modeling on the ground elevation model of the watershed, which was derived from Cook County LiDAR data. In some areas, adjustments were made to the limits of inundation based on aerial photography and Cook County 2-foot contour data provided by the District.

1.3.10 Discrepancies between Inundation Mapping and Regulatory Flood Maps

Discrepancies may exist between inundation mapping produced under this DWP and regulatory flood maps. Discrepancies may be the result of updated rainfall data, more detailed topographic information, updated land use data, and differences in modeling methodology. A discussion of discrepancies is included in Appendix A.

1.3.11 Model Review

The hydrologic and hydraulic models developed under this DWP were independently reviewed by Christopher B. Burke Engineering, Ltd (CBBEL). CBBEL's review of the hydrologic models included a general verification of drainage areas, sub-basin divides, and hydrologic model parameters such as Curve Number and Time of Concentration. CBBEL's review of the hydraulic models included a general verification of roughness values, bank stations, ineffective flow areas, hydraulic structures, boundary conditions and connectivity with the hydrologic model output files. Recommendations from the independent review have been addressed in the hydrologic and hydraulic models developed to support the DWP.

1.4 Development and Evaluation of Alternatives

1.4.1 Problem Area Identification

Problem area data was generated from two sources. The first was community, agency and stakeholder response data that identified flooding, erosion, water quality, and maintenance problems recognized by the communities. In addition, problem areas were identified by overlaying the results of H&H modeling on the ground elevation model of the watershed to identify structures at risk of flooding along regional waterways. Modeled flood problems generally corroborated the communities' reported problems; however, in many instances, the model results also showed additional areas at risk of flooding for larger magnitude events. A secondary source of problem area identification was the existing FEMA FIRM panel maps. Areas shown within FEMA floodplain were carefully considered in H&H modeling and communication with communities in order to identify problem areas.

1.4.2 Economic Analysis

1.4.2.1 Flood Damages

Property damages due to flooding were assessed based upon the intersection of inundation areas for modeled recurrence intervals (2-, 5-, 10-, 25-, 50-, and 100-year) with the Cook County parcel data, considering ground elevation data, to calculate estimated flood depths. Damages were estimated using a methodology consistent with one developed by the USACE that estimates structure and contents damage as a fraction of structure value and based upon the estimated depth of flooding (USACE 2003). The general procedure estimating property damage due to flooding is outlined in Appendix F of the CCSMP. This method of damage calculation requires estimating a number of parameters for properties at risk of flooding which are detailed below.

Property damage values due to flooding are derived from the 2006 Cook County Tax Assessor (CCTA) data multiplied by a standard factor derived from a statistical analysis comparing recent sales data to the CCTA property values. The CCTA data includes tax assessed value of land, improvements, total tax assessed value, structure class (residential single family, multi-family, industrial etc.), number of stories, basement information, land area (square footage), and other data fields not relevant to this study.

1.4.2.2 Identification of Parcels at Risk of Flooding

Parcel boundaries were converted to points within the GIS application, and then the points were moved to the low side of structures at risk of flooding. Intersection of floodplain boundaries with parcel data was then performed for each modeled recurrence interval storm and used to identify parcels within the subwatershed that may, based upon their zero-damage elevations, be subject to property damage due to flooding for a particular recurrence interval.

1.4.2.3 Parcel Zero Damage Elevation

Structures do not incur damage due to flooding until the water surface exceeds the *zero-damage elevation,* at which water is assumed to begin flowing into the structure and cause damages. For most structures, the zero-damage elevation is the ground surface. Floodwaters exceeding the ground surface may enter the structure through doorways, window wells, and other openings within the structure. The zero-damage elevation was assumed to be the ground elevation for all parcels within the NBCR Watershed. The ground elevation estimate was obtained at the point representing the parcel, generally on the lower, stream-side of the actual structure.

1.4.2.4 Parcel First Floor Elevation

USACE depth-damage curves relate flooding depths to the first floor elevation of the structure, a value not provided within the CCTA data. First floor elevations (FFE) generally were not surveyed as it would require several thousand measurements. In general, a sample of several hundred field measurements of the FFE offset from ground elevation were collected to document expected values and variability of this component of the damage analysis. Based upon review of the collected first floor elevations, it was not possible to identify a pattern to predict the first floor elevation based upon factors such as subwatershed, estimated age of structure, or structure type. Furthermore, it was noted from pictures viewed on the CCTA website, that the average first floor elevation offset was roughly 18 inches, or slightly lower for structures that did not have basements. Based upon the data collected, first floor elevation offsets from ground elevation were estimated throughout the watershed as 18 inches for structures with basements, and 12 inches for structures without.

The only exception to the derivation of FFE presented above was the use of IDNR field survey of FFE for structures along the Middle Fork and Skokie River to calculate damages in areas that were shown as inundated through DWP modeling. It is noted that the IDNR FFE were used only where IDNR survey data was available; the previously described procedure of using 12 or 18 inch offsets from ground elevation was used to determine the remaining FFE for the Middle Fork and Skokie River reaches.

1.4.2.5 Structure Estimated Value

The estimated value of flooded structures is an input to damage calculations. The CCTA data included data that identified values for the land value as well as the improvement value (i.e., building, garage, etc.). The values in the CCTA data are assessed valuations of the estimated property value, which require a factor to bring the value, depending on the structure's use, to the CCTA estimation of property value. For example, residential structures receive an assessed valuation factor of 16 percent, thus the value identified by CCTA is the CCTA estimated value divided by a standardized 0.16. The adjusted CCTA data (reported values divided by the assessed valuation factor) was then compared with recent sales data throughout the county to statistically derive a multiplier that brings the 2006 CCTA estimated value of the properties to 2008 market value of properties. This multiplier was calculated to be 1.66. Since this plan analyzes damage to the structure, the land component of the property value was removed from the analysis. The value of the structure was computed by applying the assessed valuation multiplier and the District calculated market value multiplier to the improvement value identified in the CCTA data. This method was used on all property types to generate information to be used in the damage calculations.

1.4.2.6 Depth-Damage Curves

Six residential depth-damage curves were obtained from the USACE technical guidance memorandum EGM 04-01 (USACE, 2003) to relate estimated structure and contents damage to structure replacement value as a function of flooding depth. These damage curves are one story, two-story, and split-level resident structures, either with or without basements. For nonresidential structures, a depth-damage curve representing the average of structure and contents depth damage curves for a variety of structure types, generated by the Galveston District of the USACE was selected for use. Appendix F contains the depth-damage curves used to calculate property damage due to flooding. CCTA data was analyzed to identify the number of stories on residential structures and the presence or absence of a basement.

1.4.2.7 Property Damage Calculation

The estimated structure value, flooding depth, and depth-damage curve information were used to estimate the property damage from flooding for a specific structure due to a storm of given recurrence interval. Higher magnitude events, such as the 100-year event, cause higher damages for flooded properties but also have a lower likelihood of occurring in a given year. Figure 1.4.1 shows the hypothetical relationship between expected damage and modeled recurrence interval. Estimated annual damages were calculated according to Appendix F of Chapter 6 of the CCSMP, essentially weighting the expected annual damages by their annual probability of occurrence. Damages were then capitalized over a 50-year period of analysis, consistent with the period of analysis over which maintenance and replacement costs were calculated, using the federal discount rate for 2008 of 4.875 percent.

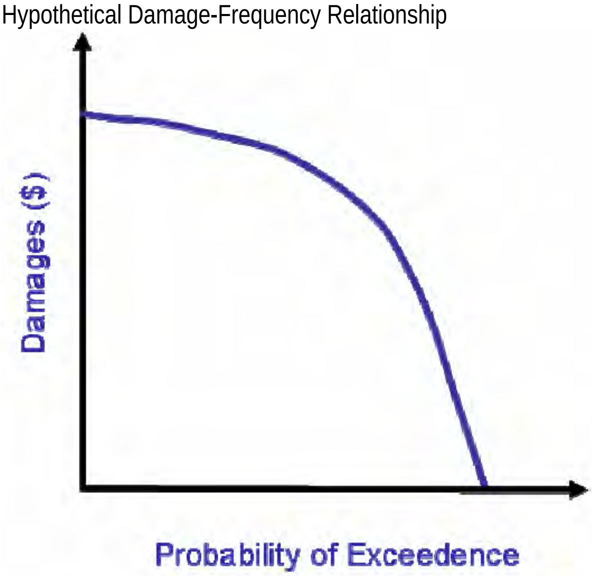
1.4.2.8 Erosion Damages

Locations of streambank erosion were identified through community response data. The CCSMP contains direction that erosion damages be estimated as the full value of structures at "imminent risk" of damage due to stream bank erosion, and that erosion damages not be assessed for loss of land. Field visits to areas identified as erosion problems were performed. Properties and infrastructure were judged to be at imminent risk if they were located within 30 feet of a site of *active erosion*, characterized by exposed earth, lack of vegetation, or collapsing banks. The estimated market value of the structure derived from CCTA data was used to estimate erosion damages for structures deemed at imminent risk. For infrastructure at risk other than property, such as roads and utilities, an estimate of the replacement value of these structures was used to assess erosion damages.

1.4.2.9 Transportation Damages

Transportation damage generally was estimated as 15 percent of property damage due to flooding. In some specific instances, significant transportation damages may occur in absence of attendant property damage due to flooding. For the NBCR watershed, specific transportation damages were calculated when flooding fully blocked all access to a specific area in the watershed and these damages were not

FIGURE 1.4.1
Hypothetical Damage-Frequency Relationship



adequately captured as a fraction of property damages. In such instances, transportation damages were calculated according to FEMA guidance in the document "What Is a Benefit?" (FEMA, 2001). The duration of road closure was estimated for the modeled storms, and transportation damage was calculated according to a value of $39.82 (based on FEMA recommended rate of $32.23 in 2000 and brought forward to 2008 dollars using a 3.068% discount rate) per hour of delay per vehicle based on average traffic counts and the estimated time to detour around each flooded location.

1.4.3 Alternative Development and Evaluation

Potential stormwater improvements, referred to within the DWP as alternatives, were developed using a systematic procedure to screen, develop, and evaluate technologies consistently. Tributary-specific technologies were screened and evaluated in consideration of the stormwater problems identified through community response data and modeling. An alternative is a combination of the technologies developed to address the identified stormwater problems. In many instances, communities had suggestions regarding potential resolution of their stormwater problems, and their input was solicited during workshops and subsequent comment periods and was considered during alternative development.

Alternatives were evaluated with respect to their ability to reduce flooding, erosion, and other damages under existing conditions. The reduction in expected damages for an alternative is called a *benefit*. Conceptual level costs were developed for each alternative using countywide unit cost data that considered expected expenses such as excavation, land-acquisition, pipe costs, channel lining, etc. Standard countywide markups were used to account for the cost of utility relocation, profit, design engineering and construction management costs, and contingency. Expected maintenance and replacement costs were considered over a 50-year design period. Detailed design studies are required to confirm details associated with the feasibility of construction and precise configuration of proposed facilities.

Additional non-economic factors, such as the number of structures protected, the expected water-quality benefit, and the impact on wetland or riparian areas were considered in alternative development and evaluation.

1.4.3.1 Streambank Stabilization

Erosion control alternatives were developed to address problem areas where erosion problems on regional waterways were determined to threaten structures. Damages were calculated based on the value of the threatened structures. Erosion control alternatives considered a full range of alternative technologies as summarized in Table 1.4.2.

1.4.3.2 Flood Control

Flood control technologies were considered during the development of alternatives for addressing flooding problems, as summarized in Table 1.4.1. Conceptual alternatives were developed after selection of an appropriate technology or technologies for a problem area, and review of information provided by communities and/or obtained from other sources (such as aerial photography and parcel data) regarding potentially available land.

Hydrologic or hydraulic models for alternative conditions were created to analyze the effect of the conceptual alternatives. Initial model runs were performed to determine whether an alternative significantly affected water surface elevation (WSEL) near the target problem area, or had negative impacts in other parts of the tributary area. For models that resulted in significant reduction in WSEL, a full set of alternative conditions model runs was performed, and expected damages due to flooding were evaluated for the alternative conditions. Benefits were calculated based on damages reduced from existing to proposed conditions.

1.4.3.3 Floodproofing and Acquisition

Alternatives consisting of structural flood control measures may not feasibly provide a 100-year level of protection for all structures. The DWP identifies areas that will experience flooding at the 100-year event, even if recommended alternatives are implemented. Floodproofing and/or acquisition of such structures are nonstructural flood control measures that may reduce or eliminate damages during flood events, which is why these measures are listed in Table 1.4.1. However, due to the localized nature of implementing such solutions, the District may look to address structures that are candidates for nonstructural flood control measures under separate initiatives, outside of the Capital Improvement Program (CIP).

1.4.3.4 Water Quality

The potential effect of alternatives on water quality was considered qualitatively. Most detention basins built for flood control purposes have an ancillary water quality benefit because pollutants in sediment will settle out while water is detained. Sediments can be removed as a part of maintenance of the detention basin, preventing the pollutants from entering the waterway. Detention basins typically have a sediment forebay specifically designed for this purpose. Some detention basins could be designed as created wetland basins with wetland plants included which could naturally remove pollutants and excess nutrients from the basin. Streambank stabilization alternatives can help address water quality problems through reduction of sedimentation.

TABLE 1.4.1
Flood Control Technologies

Flood Control Option	Description	Technology Requirements
Detention/Retention		
Detention facilities (Dry basins)	Impoundments to temporarily store stormwater in normally dry basins.	Open space, available land. Only an upstream option.
Retention facilities (Wet basins)	Impoundments that include a permanent pool which stores stormwater and removes it through infiltration and evaporation. Retention facilities generally have an outfall to the receiving waterway that is located at an elevation above the permanent pool.	Open space, available land. Only an upstream option.
Pumped detention	Similar to detention or retention facilities, but includes a portion of the impoundment which cannot be drained by gravity and must be pumped out.	Open space, available land. Only an upstream option. Best applied when significant area is available to allow for filling only during large storms.
Underground detention	A specialized form of storage where stormwater is detained in underground facilities such as vaults or tunnels. Underground detention may also be pumped.	Space without structures, available land. Only an upstream option. Significantly more expensive than above ground facilities. Surface disruption must be acceptable during construction.

TABLE 1.4.1
Flood Control Technologies

Flood Control Option	Description	Technology Requirements
Bioretention	Decentralized microbasins distributed throughout a site or watershed to control runoff close to where it is generated. Runoff is detained in the bioretention facilities and infiltrated into the soil and removed through evapotranspiration.	Open space, multiple available opportunities for various sizes of open space.
Conveyance Improvement		
Culvert/bridge replacement	Enhancement of the hydraulic capacity of culverts or bridges through size increase, roughness reduction, and removal of obstacles (for example, piers).	Applicable only if restricted flow and no negative impact upstream or downstream. May require compensatory storage to prevent negative downstream impact. Permitting requirements and available adjacent land.
Channel improvement	Enhancement of the hydraulic capacity of the channels by enlarging cross sections (for example, floodplain enhancement), reducing roughness (for example, lining), or channel realignment.	No negative upstream or downstream impact of increased conveyance capacity. Permitting requirements and available adjacent land. Permanent and/or construction easements.
Flood Barriers		
Levees	Earth embankments built along rivers and streams to keep flood waters within a channel.	Permitting requirements and available adjacent land. Wide floodplains will be analyzed. Requires 3 feet of freeboard to remove structures behind levees from regulatory floodplain. Often requires compensatory storage.
Floodwalls	Vertical walls typically made of concrete or other hard materials built along rivers and streams to keep flood waters within a channel.	Permitting requirements and available adjacent land. Permanent and/or construction easements.
Acquisition	Acquisition and demolition of properties in the floodplain to permanently eliminate flood damages. In some cases, acquired property can be used for installation of flood control facilities.	Severe flooding, repetitive losses, other alternatives are not feasible.
Floodproofing		
Elevation	Modification of a structure's foundation to elevate the building above a given flood level. Typically applied to houses.	Severe flooding, repetitive losses, other alternatives are not feasible
Dry Floodproofing	Installation of impermeable barriers and flood gates along the perimeter of a building to keep flood waters out. Typically deployed around commercial and industrial buildings that cannot be elevated or relocated.	Better suited for basement or shallow flooding. Need the ability to provide closure of openings in walls or levees. Plan for emergency access to permit evacuation.
Wet Floodproofing	Implementation of measures that do not prevent water from entering a building but minimize damages; for example, utility relocation and installation of resistant materials.	Most applicable for larger buildings where content damage due to flooding can be minimized. Waterproofing sealant applied to walls and floors, a floor drain and sump pump.

TABLE 1.4.2
Erosion Control Technologies

Erosion Control Option	Description	Technology Requirements
Natural (vegetated or bioengineered) stabilization	The stabilization and protection of eroding overland flow areas or stream banks with selected vegetation using bioengineering techniques. The practice applies to natural or excavated channels where the stream banks are susceptible to erosion from the action of water, ice, or debris and the problem can be solved using vegetation. Vegetative stabilization is generally applicable where bankfull flow velocity does not exceed 5 ft/sec and soils are more erosion resistant, such as clayey soils. Combinations of the stabilization methods listed below and others may be used.	Requires stream bank slopes flat enough to prevent slope failure based upon underlying soils. Channels with steep banks with no room for expansion or high bank full velocities (> 5 ft/sec) should avoid these technologies.
Vegetating by sodding, seeding, or planting	Establishing permanent vegetative cover to stabilize disturbed or exposed areas. Required in open areas to prevent erosion and provide runoff control. This stabilization method often includes the use of geotextile materials to provide stability until the vegetation is established and able to resist scour and shear forces.	
Vegetated armoring (joint planting)	The insertion of live stakes, trees, shrubs, and other vegetation in the openings or joints between rocks in riprap or articulated block mat (ABM). The object is to reinforce riprap or ABM by establishing roots into the soil. Drainage may also be improved through extracting soil moisture.	
Vegetated cellular grid (erosion blanket)	Lattice-like network of structural material installed with planted vegetation to facilitate the establishment of the vegetation, but not strong enough to armor the slope. Typically involves the use of coconut or plastic mesh fiber (erosion blanket) that may disintegrate over time after the vegetation is established.	
Reinforced grass systems	Similar to the vegetated cellular grid, but the structural coverage is designed to be permanent. The technology can include the use of mats, meshes, interlocking concrete blocks, or the use of geocells containing fill material.	
Live cribwall	Installation of a regular framework of logs, timbers, rock, and woody cuttings to protect an eroding channel bank with structural components consisting of live wood.	
Structural stabilization	Stabilization of eroding stream banks or other areas by use of designed structural measures, such as those described below. Structural stabilization is generally applicable where flow velocities exceed 5 ft/sec or where vegetative stream bank protection is inappropriate.	Applicable to areas with steep stream bank slopes (> 3:1) and no room for channel expansion, or areas with high velocities (> 5 ft/sec) can benefit from this technology.
Interlocking concrete	Interlocking concrete may include A-Jacks®, ABM, or similar structural controls that form a grid or matrix to protect the channel from erosion. A-Jacks armor units may be assembled into a continuous, flexible matrix that provides channel toe protection against high velocity flow. The matrix of A-Jacks can be backfilled with topsoil and vegetated to increase system stability and to provide in-stream habitat. ABM can be used with or without joint planting with vegetation. ABM is available in several sizes and configurations from several manufacturers. The size and configuration of the ABM is determined by the shear forces and site conditions of the channel.	
Riprap	A section of rock placed in the channel or on the channel banks to prevent erosion. Riprap typically is underlain by a sand and geotextile base to provide a foundation for the rock, and to pre-	

TABLE 1.4.2
Erosion Control Technologies

Erosion Control Option	Description	Technology Requirements
	vent scour behind the rock.	
Gabions	Gabions are wire mesh baskets filled with river stone of specific size to meet the shear forces in a channel. Gabions are used more often in urban areas where space is not available for other stabilization techniques. Gabions can provide stability when designed and installed correctly, but failure more often is sudden rather than gradual.	
Grade Control	A constructed concrete channel designed to convey flow at a high velocity (greater than 5 ft/sec) where other stabilization methods cannot be used. May be suitable in situations where downstream areas can handle the increase in peak flows and there is limited space available for conveyance.	
Concrete channels	Prevent stream bank erosion from excessive discharge velocities where stormwater flows out of a pipe. Outlet stabilization may include any method discussed above.	

2. Watershed Characteristics

2.1 General Watershed Description

The NBCR watershed is located in northeastern Cook County, Illinois. The headwaters of the three major tributaries, the West Fork, the Middle Fork, and the Skokie River, are located in Lake County. These tributaries flow south and combine with the NBCR at two separate confluence points. Another tributary, the NSC, enters the system near Albany Avenue in Chicago. Twenty municipalities are located entirely, or in part, in the watershed, and the entire watershed is approximately 141 square miles. The downstream limit of the NBCR is at the confluence with the Chicago River and South Branch near West Lake Street. This reach has been widened and dredged, with widths up to 300 feet and depths of 10 to 15 feet. For the next seven miles upstream to the North Branch Dam, the river is about 90 feet wide with a depth of 10 feet.

The NSC flows into the NBCR near Albany Avenue. The channel is a nearly 8-mile long manmade canal constructed in the early 1900s to carry wastewater from the northern suburbs away from LM. With a depth of 15 feet, and a width of 30 feet, its conveyance capacity was 2,000 cfs when constructed. The flow and water surface elevation in the NSC are controlled by the Wilmette Pumping Station at the upstream end.

The Skokie River flows from Waukegan south to its confluence with the NBCR just south of Winnetka Road. Near the county line, the Botanical Garden Diversion, about 1 mile in length, diverts flow around the Chicago Botanic Gardens located north of Dundee Rd. Proceeding south to Willow Road, the river is divided into several parallel components: the Skokie Lagoons, the Skokie River, the Skokie River West Diversion Ditch, and the Skokie River East Diversion Ditch. The east and west diversion ditches were first created in the 1930s to help keep impure water in the Skokie River from flowing into the Skokie Lagoons, a group of 7 lagoons created by the dam at Willow Road. The Skokie Lagoons were created in 1933 by the Civilian Conservation Corps as an effort to drain the Skokie Marsh. The Skokie Marsh was converted to the Skokie Lagoons to minimize flooding in the western part of town.

The Middle Fork begins in Libertyville and flows south through Northbrook and Northfield to the confluence with the NBCR. The Middle Fork and the Skokie River combine about a ¼ mile downstream of Happ Road to form the NBCR.

The West Fork flows from Everett Road in Lake County through portions of Deerfield, Northbrook, and Glenview. Tributaries include: the Underwriters Tributary, the South and North Forks of the Techny Drain, the Techny Drain, and the North and South Navy Ditches. The West Fork combines with the NBCR just upstream of Beckwith Road in Niles.

The LM watershed includes areas tributary to LM in Wisconsin, Illinois, Indiana, and Michigan. The portion of the watershed included in this report is located in eastern Cook County south of Lake-Cook Road and north of the Chicago River. The watershed is generally less than 1¼ miles wide and in some locations is about ½ mile wide.

The NSC connects LM to the NBCR watershed. During normal operation, the channel is an outlet for local stormwater flows, which flow downstream to the confluence with the North Branch. The channel also provides diversion of Lake Michigan flows at Wilmette Pumping Station. The controlling works regulate the amount of Lake Michigan flows diverted to the North Branch through a vertical lift gate. During large storm events, when the combined sewer system capacity is exceeded, flows may be diverted into Lake Michigan at this location.

Figure ES.1 shows the municipal boundaries and the major streams within the NBCR and LM watersheds. Figure ES.1 also shows the subwatershed divides for the major streams within the NBCR watershed. Table 2.1.1 lists the municipalities within the NBCR and LM watersheds. Table 2.1.2 lists the stream lengths of major streams and tributaries to the NBCR.

TABLE 2.1.1
Municipalities in the NBCR and LM Watersheds within Cook County

Municipality	% of Municipality Area within NBCR & LM Watershed	% of NBCR & LM Watershed Area by Municipality	Municipality	% of Municipality Area within NBCR & LM Watershed	% of NBCR & LM Watershed Area by Municipality
Chicago	26	43.5	Niles	74	3.1
Deerfield	9	0.5	Norridge	31	0.4
Evanston	100	5.4	Northbrook	87	7.8
Glencoe	100	2.7	Northfield	100	2.0
Glenview	88	7.5	Park Ridge	<1	<0.1
Golf	100	0.3	Skokie	100	7.1
Harwood Heights	48	0.3	Wilmette	100	3.8
Kenilworth	100	0.4	Winnetka	100	2.7
Lincolnwood	100	1.9	Unincorporated	2	4.5
Morton Grove	100	3.6			

TABLE 2.1.2
NBCR and LM Watersheds Open Channel Stream Lengths

Open Channel Name	Length (miles)
North Branch	24.6
North Shore Channel	7.7
West Fork	9.5
Underwriter's Tributary	0.3
Techny Drain	2.2
South Fork Techny Drain	0.6
North Navy Ditch	0.5
North Navy Ditch Diversion	0.2
South Navy Ditch	0.5
Skokie River	3.6
Skokie Lagoons	6.4
Skokie River West Ditch	3.3
Skokie River East Ditch	3.9
Skokie River Botanic Garden Diversion	2.0
Middle Fork	6.5
Ravine 1	0.7

TABLE 2.1.2
NBCR and LM Watersheds Open Channel Stream Lengths

Open Channel Name	Length (miles)
Ravine 2	0.7
Ravine 3	0.1
Ravine 4	0.6
Ravine 5	0.9
Ravine 6	0.3
Ravine 7	0.3
Ravine 8	1.8
Total	**75.5**

NOTE: Stream Lengths given are only for Cook County portions of the individual reaches

Table 2.1.3 lists the subwatersheds each municipality drains to, with subwatersheds listed in decreasing order based upon the area within the municipality. Although municipalities contribute stormwater to the listed subwatersheds, the actual stream may not be included within the municipality's boundaries.

TABLE 2.1.3
Municipality and Subwatersheds within the Municipality Boundary

Municipality	Subwatersheds within Municipality Boundary (square miles)
Chicago	Mainstem (49.21), Lake Michigan(7.81), North Shore Channel(7.11)
Deerfield	West Fork(0.51), Middle Fork[b]
Evanston	North Shore Channel(4.91), Lake Michigan (2.60), Skokie River (0.13)
Glencoe	Skokie River(1.91), Lake Michigan(1.82)
Glenview	West Fork(9.39), Mainstem (1.97), Middle Fork(0.34), Skokie River[b]
Golf	West Fork(0.34), Mainstem(0.11)
Harwood Heights	Mainstem(0.38)
Kenilworth	Lake Michigan(0.60), Skokie River[b]
Lincolnwood	North Shore Channel(2.68)
Morton Grove	Mainstem(4.99), West Fork[b], North Shore Channel[b]
Niles	Mainstem(4.06), North Shore Channel(0.28), West Fork[b]
Norridge	Mainstem(0.56)
Northbrook	West Fork(7.77), Middle Fork(2.16), Skokie River(1.38)
Northfield	Middle Fork(1.95), Skokie River(1.08), West Fork(0.19)
Park Ridge	Mainstem[b]
Skokie	North Shore Channel(8.68), Skokie River(1.34), Mainstem[b]
Wilmette	Skokie River(3.03), North Shore Channel(1.32), Lake Michigan(0.83), Mainstem(0.15)
Winnetka	Skokie River(2.49), Lake Michigan(1.34)
Unincorporated	Skokie River(2.05), West Fork(1.08), Mainstem(0.81), Middle Fork(0.56), Lake Michigan[b]

[b]Less than 0.1 square miles within municipality contributes to subwatershed

2.2 Stormwater Problem Data

To support DWP development, the District solicited input from stakeholders within the watershed. Municipalities, townships, and countywide, statewide, and national agencies such as Cook County Highway Department (CCHD), Illinois Department of Natural Resources (IDNR), Illinois Department of Transportation (IDOT), and the USACE, for example, were asked to fill out two forms with information to support DWP development. Organizations such as ecosystem partnerships were also contacted by the District as part of this information-gathering effort. Form A included questions on stormwater data and regulations, Form B questions on known flooding, erosion, and stream maintenance problem areas. In addition to problem areas reported by municipalities, townships, public agencies and other stakeholders, results of H&H modeling performed as a part of DWP development identified stormwater problem areas. The H&H modeling process is described in general in Section 1.3 and specifically for each modeled reach in Section 3.

Figure 2.2.1 and Table 2.2.1 summarize the responses to Form B questions about flooding, erosion, and stream maintenance problem areas. Table 2.2.1 also includes the problem areas identified during the workshops with the WPC. As noted, the scope of the DWP addresses regional problems along open channel waterways. The definition of regional problems was provided in Section 1.

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-NBCD-CH-FL-01	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm water sewer flow restriction. City sewer improvements are often focused towards areas of the most complaints.	Local	5
NB-NBCD-CH-FL-02	City of Chicago	Intracommunity (local) flooding	Illinois Rt 19 at Ravenswood Pkwy (both sides)	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-03	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at California Ave	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-04	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Edens Junction (Montrose to Wilson)	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-05	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Addison St (NWB & SEB)	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-06	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Fullerton Ave	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-07	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Ogden Ave	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-08	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Augusta Blvd (Lane 3) NB	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-09	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at IL Rt 50 (Cicero Ave) Lane 3	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-10	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Damen Ave (Lane 1) NB	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-11	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Division St	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-12	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at IL Rt 64 (North Ave) Lane 1 NB	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-13	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Diversey Ave	IDOT Pavement flooding	Local	5

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-NBCD-CH-FL-14	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Kimball (Exit 4)	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-15	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Ashland Ave (Lane 1) NB	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-16	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Montrose Ave	IDOT Pavement flooding	Local	6
NB-NBCD-CH-FL-17	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Kostner Ave	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-18	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Logan Blvd	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-19	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Armitage Ave (Lane 1) NB	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-20	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at IL Rt 19 (Irving Park Rd) Lane 1 SB	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-21	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Pulaski Rd entrance ramp	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-22	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Willow St (W/O)	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-23	City of Chicago	Intracommunity (local) flooding	Interstate Rt 94 (Edens) at Wilson Rd (N/O Kennedy)	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-24	City of Chicago	Intracommunity (local) flooding	Illinois Route 43 at IL Rt 72 (Higgins Rd) Lane 2	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-25	City of Chicago	Intracommunity (local) flooding	Lawrence Ave at C, M & St. Paul Rd (viaduct) W/O I-94	IDOT Pavement flooding	Local	5
NB-NBCD-CH-FL-26	City of Chicago	Intracommunity (local) flooding	Lawrence Ave at Milwaukee Ave	IDOT Pavement flooding	Local	5

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-NBCD-CH-WQ-27	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm sewer flow restriction, water quality (pollution). The City sewer improvements are often focused towards areas of the most complaints.	Local	5
NB-NBCU-CH-ER-28	City of Chicago	Streambank erosion on intercommunity waterways	LaBagh Woods - Bryn Mawr & Kostner Ave	FPDCC reported off-site stormwater volumes are causing downcutting in a ditch, thereby lowering the water table in the adjacent natural wetland areas.	Regional	1
NB-NBCU-CH-FL-29	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm water sewer flow restriction throughout area. City sewer improvements are often focused towards areas of the most complaints.	Local	5
NB-NBCU-CH-FL-30	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Central Ave	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-31	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Milwaukee Ave (Lane 3)	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-32	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90/94 at Jefferson, Park Tunnel (NR Ainslie St) Lane 3	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-33	City of Chicago	Intracommunity (local) flooding	Interstate Rt 94 (Edens) at N Elston Ave (SB)	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-34	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90 at Austin Ave	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-35	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90 at Lawrence Ave	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-36	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90 at Bryn Mawr Ave	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-37	City of Chicago	Intracommunity (local) flooding	Interstate Rt 90 at Nagle Ave (NB ramp)	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FR-38	City of Chicago	Intercommunity (regional) flooding	Albany Park	FPDCC reported off-site stormwater volumes are causing downcutting in a ditch, thereby lowering the water table in the adjacent natural wetland areas - (ponding checked on form B)	Regional	1
NB-NBCU-CH-WQ-39	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm sewer flow restriction, water quality (pollution) throughout area. The City sewer improvements are often focused towards areas of the	Local	5

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
				most complaints		
NB-NBCU-CH-WQ-40	City of Chicago	Intracommunity (local) flooding	Throughout Chicago wetland areas	FPDCC reported off-site stormwater volumes are causing downcutting in a ditch, thereby lowering the water table in the adjacent natural wetland areas - (wetland issue considered WQ)	Local	4
NB-NSCH-CH-FL-41	City of Chicago	Intracommunity (local) flooding	Interstate Rt 94 at Peterson/Caldwell Ave	IDOT Pavement flooding	Local	5
NB-NSCH-CH-FL-42	City of Chicago	Intracommunity (local) flooding	Interstate Rt 94 at US Rt 14	IDOT Pavement flooding	Local	5
NB-NSCH-CH-FL-43	City of Chicago	Intracommunity (local) flooding	Devon Ave @ 2570 Devon Ave	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FL-44	City of Chicago	Intracommunity (local) flooding	Central Avenue at South of Devon Avenue	IDOT Pavement flooding	Local	5
NB-NBCU-CH-FR-45	City of Chicago	Intercommunity (regional) flooding	Albany Park	Overbank flooding throughout the community	Regional	1
LM-EV-SM-01	City of Evanston	Streambank erosion on intracommunity waterways	Lake Michigan Beachfront	Erosion at outfall at beach - maintenance	Local	6
NB-NSCH-EV-FL-02	City of Evanston	Intracommunity (local) flooding	Various locations in Evanston	Map of the pavement flooding for the September 2008 storm.	Local	5
NB-NSCH-EV-FL-03	City of Evanston	Intracommunity (local) flooding	Various locations in Evanston	Map of the basement flooding for the September 2008 storm.	Local	5
NB-NSCH-EV-FL-04	Village of Skokie, City of Evanston	Intracommunity (local) flooding	McCormick Blvd at Golf Rd (1/4 mile N/O)	IDOT Pavement flooding	Local	5
NB-NSCH-EV-FL-05	City of Evanston	Intracommunity (local) flooding	McCormick Boulevard at Bridge Street (Northwest Corner)	IDOT Pavement flooding	Local	5
LM-GC-EL-01	Village of Glencoe	Streambank erosion on intracommunity waterways	Ravines	Erosion in ravines	Local	6

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-SKED-GC-FL-02	Village of Glencoe	Intracommunity (local) flooding	Dundee Rd storm sewer (60" dia Sewer)	Dundee Road storm sewer Most flooding localized to intersections and private properties	Local	3,5
NB-NBCU-GV-FL-01	Village of Glenview	Intracommunity (local) flooding	Sunset Ridge Rd - East Lake Ave to Skokie Rd	Pavement flooding	Local	5
NB-NBCU-GV-FL-02	Village of Glenview	Intracommunity (local) flooding	East of Harm Road South of Lake Avenue	Pavement flooding	Local	5
NB-NVDN-GV-ER-03	Village of Glenview	Streambank erosion on intracommunity waterways	John's Drive at Willow Rd	Stream bank destabilization, erosion and sedimentation, and wetland/riparian areas at risk. Trees along channels continually contribute to log jams. Invasive species degrade habitat.	Regional	1
NB-NVDN-GV-SM-04	Village of Glenview	Stream maintenance	North Navy Ditch beginning at John's Dr. Navy Ditch confluence with West Fork	Following removal of buckthorn/brush from North Navy Ditch, remaining large cottonwood/box elder trees exposed to greater wind force, causing limb breakage/tree failure and minor re-blockage of channel	Regional	1
NB-NVDS-GV-ER-05	Village of Glenview	Streambank erosion on intercommunity waterways	Lehigh Road and Chestnut	Stream bank destabilization, erosion and sedimentation, and wetland/riparian areas at risk. Trees along channels continually contribute to log jams. Invasive species degrade habitat.	Regional	1
NB-NVDS-GV-FR-06	Village of Glenview	Intercommunity (regional) flooding	Tall Trees Subdivision	Overbank Flooding	Regional	1
NB-NVDS-GV-SM-07	Village of Glenview	Stream maintenance	South Navy Ditch beginning at LeHigh Rd. South Navy Ditch confluence with West Fork	South Navy Ditch beginning at Lehigh Rd, Ongoing aging and breakage of trees along the South Navy Ditch eventually contributes to small log jams.	Regional	1
NB-NBCU-GV-FL-08	Village of Glenview	Intracommunity (local) flooding	Village of Glenview - Villagewide	Ponding and storm sewer flow restriction village-wide. Numerous areas in the Village developed prior to the 1980s have inadequate storm water conveyance and detention	Local	5
NB-WFNB-GV-FR-09	Village of Glenview	Intercommunity (regional) flooding	Techny Basin 32C Glenview	Overbank flooding - Techny Basin 32C provides bulk of the Village's upstream storm water protection storage within the West Fork NBCR watershed. Recent storms brought risk of extreme flooding.	Regional	1

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-WFNB-GV-SM-10	Village of Glenview	Stream maintenance	Willow Rd & Ravine Ave, Techny Basin 32C	Maintenance necessary at the MWRD maintained spillway that has been identified for years at the biannual inspections.	Regional	1
NB-WFNB-GV-FL-11	Village of Glenview	Intracommunity (local) flooding	Illinois Tool Works Detention Pond	Local overbank flooding of existing detention pond due to debris collection at restrictor. Problem causing overbank flooding of local residents backyards and local power outages.	Local	6
NB-WFNB-GV-ER-12	Village of Glenview	Streambank erosion on intercommunity waterways	River between Glenview Rd and Waukegan Rd	Stream bank destabilization, erosion and sedimentation, wetland/riparian areas at risk. Significant erosion and undermined turf on East bank of West Fork (400 linear ft).	Regional	1
NB-WFNB-GV-ER-13	Village of Glenview	Streambank erosion on intercommunity waterways	Village of Glenview -Lot 16 Bank Stabilization	Stream bank destabilization, erosion and sedimentation, wetland/riparian areas at risk. Channel clogged primarily by woody debris. Banks unstable/choked with invasive species, particularly buckthorn.	Regional	1
NB-WFNB-GV-ER-14	Village of Glenview	Streambank erosion on intercommunity waterways	1201 Long Valey Road	Regional erosion occurring within 30 ft of residence on the west streambank.	Regional	1
NB-NBCU-GV-FL-15	Village of Glenview	Intracommunity (local) flooding	Village of Glenview	Ponding/storm sewer flow restriction in ~30% Village that is completely/partially non-storm-sewered. Village Storm Water Study: inadequate storm water detention/conveyance, inlet capacity.	Local	5
NB-NBCU-GV-FL-16	Village of Glenview	Intracommunity (local) flooding	Illinois Rt 43 at C, M, & St Paul RR	IDOT Pavement flooding	Local	5
NB-WRNB-GV-FL-17	Village of Glenview	Intracommunity (local) flooding	Greenwood Ave at S/O West Lake Ave	IDOT Pavement flooding	Local	5
NB-WFNB-GV-FL-18	Village of Glenview	Intracommunity (local) flooding	Pfingston Rd North of Glenview Road, South of Knollwood Lane	Pavement flooding	Local	5
NB-WFNB-GV-FL-19	Village of Glenview	Intracommunity (local) flooding	Shermer Rd North of Central Road, South of Robincrest Lane	Pavement flooding	Local	5
NB-WFNB-GV-FL-20	Village of Glenview	Intracommunity (local) flooding	Harlem Ave North of Lake Street, West of Robincrest Lane	Pavement flooding	Local	5

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-WFNB-GV-FL-21	Village of Glenview	Intracommunity (local) flooding	Spruce Drive South of Lake St, West of LeHigh Ave	Pavement flooding	Local	5
NB-WFNB-GV-FL-22	Village of Glenview	Intracommunity (local) flooding	Locust Lane and Rolwind Road	Pavement flooding	Local	5
NB-WFNB-GV-FL-23	Village of Glenview	Intracommunity (local) flooding	Country Lane and North Branch Rd	Pavement flooding	Local	5
NB-WFNB-GV-FL-24	Village of Glenview	Intercommunity (regional) flooding	Tall Trees Subdivision	Overbank flooding along West Fork	Regional	1
NB-WFNB-GV-SM-25	Village of Glenview	Stream maintenance	West Fork at Willow Rd & Ravine Wayand at Chestnut Ave	Log jam flow obstruction, continuing onwards to river S of Loyola Academy athletic campus. Trash/woody debris in dry former river channel to N of Lot 16.	Regional	1
NB-WFNB-GV-ER-26	Village of Glenview	Streambank erosion on intercommunity waterways	East side of West Fork NBCR, South of Glenview Rd; East side of West Fork NBCR, North of Waukegan Rd	Streambank Erosion	Regional	1
NB-WFNB-GV-WQ-27	Village of Glenview	Streambank erosion on intercommunity waterways	Village of Glenview	Stream bank destabilization, erosion and sedimentation, water quality affected by pollution, wetland/riparian areas at risk. East bank (400 linear ft) shows significant erosion and undermined turf.	Regional	1
NB-WFNB-GV-FL-28	Village of Morton Grove, Village of Glenview, Village of Golf	Intracommunity (local) flooding	Golf Rd E/O IL Rt 43 (Metra Viaduct)	IDOT Pavement flooding	Local	5
NB-WFNB-GV-FL-29	Village of Golf, Village of Glenview, Village of Morton Grove	Intracommunity (local) flooding	Golf Rd/Simpson St at C, M, & St Paul RR (viaduct)	IDOT Pavement flooding	Local	5
NB-WFNB-GV-ER-30	Village of Glenview	Streambank erosion on intercommunity waterways	Raleigh Road from York Road to Baffin Road	Streambank Erosion	Regional	1
NB-WFNB-GV-FL-31	Village of Glenview	Intracommunity (local) flooding	Illinois Route 43 at S/O Lake Avenue (Block 1200)	IDOT Pavement flooding	Local	5

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
LM-KW-SM-01	Village of Kenilworth	Stream maintenance	Green Bay Road at Metra North Line	48" culvert silted up and deteriorating - no flooding	Local	5
LM-KW-SM-02	Village of Kenilworth	Stream maintenance	Sheridan Road - North of Kenliworth	Concrete pad surrounding MWRD interceptor is cracked and deteriorating	Local	5
NB-NSCH-LW-FL-01	Village of Lincolnwood	Intracommunity (local) flooding	Various locations throughout the Village of Lincolnwood	Basement flooding/ponding/water quality pollution. Sewer/floor drain back ups, street flooding, overland flooding entering through window wells, etc. Insufficient capacity of combined sewer system.	Local	5,6
NB-NSCH-LW-FL-02	Village of Lincolnwood	Intracommunity (local) flooding	Interstate Rt 94 (Edens) at Pratt Ave	IDOT Pavement flooding	Local	5
NB-NSCH-LW-FL-03	Village of Lincolnwood	Intracommunity (local) flooding	US Rt 41 at Crawford Ave	IDOT Pavement flooding	Local	5
NB-NSCH-LW-FL-04	Village of Lincolnwood	Intracommunity (local) flooding	Touhy Ave at Crawford Ave	IDOT Pavement flooding	Local	5
NB-NSCH-LW-WQ-05	Village of Lincolnwood	Intracommunity (local) flooding	Various locations throughout the Village of Lincolnwood	Basement flooding/ponding/water quality pollution. Sewer/floor drain back ups, street flooding, overland flooding entering through window wells, etc. Insufficient capacity of combined sewer system.	Local	5,6
NB-NSCH-LW-FL-06	City of Chicago, Village of Lincolnwood	Intracommunity (local) flooding	McCormick Blvd at Devon Ave (50 ft north)	IDOT Pavement flooding	Local	5
NB-NBCU-MG-ER-01	Village of Morton Grove	Streambank erosion on intercommunity waterways	Linne Woods, Village of Morton Grove	Tree impeding flow, failing streambank stabilization	Regional	1
NB-NBCU-MG-FL-02	Village of Morton Grove, Village of Glenview	Intracommunity (local) flooding	Illinois Rte 43 at IL Rt 58	IDOT Pavement flooding	Local	5
NB-NBCU-MG-FL-03	Unincorp Cook County, Village of Morton Grove, Village of Golf	Intracommunity (local) flooding	Golf Rd at West of Harms Rd	IDOT Pavement flooding	Local	5
NB-WFNB-NB-ER-01	Village of Northbrook	Streambank erosion on intercommunity waterways	Middle Fork adjacent to properties on Red Coach Lane	Red Coach Lane - Bank erosion and sedimentation. There is severe erosion along the east bank of the Middle Fork NBCR adjacent to the properties on Red Coach Lane.	Regional	1

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-WFNB-NB-FR-02	Village of Northbrook	Intercommunity (regional) flooding	Il Rt 68 at Waukegan Rd to Lee St/Shermer Rd	IDOT Pavement flooding due to overbank flooding of Middle Fork	Regional	1
NB-WFNB-NB-FR-03	Village of Northbrook	Intercommunity (regional) flooding	Dundee at Timber Ln, Northbrook	IDOT Pavement flooding	Regional	1
NB-WFNB-NB-FL-04	Village of Northbrook	Intracommunity (local) flooding	Illinois Rt 68 at Interstate Rt 94 (E/O @ Skokie Blvd)	IDOT Pavement flooding	Local	5
NB-WFNB-NB-FL-05	Village of Northbrook	Intracommunity (local) flooding	Interstate Rt 94 (Edens) at Il Rt 68 (Dundee Rd)	IDOT Pavement flooding	Local	5
NB-WFNB-NB-FR-06	Village of Northbrook	Intercommunity (regional) flooding	From Fieldwood Dr and Techny Rd to Techny Drain near its confluence with West Fork	Flooding within backwater influence of West Fork NBCR extending approx 2000ft upstream along Techny Drain. Property/structure flooding within the backwater influence for short localized storms	Regional	1
NB-WFNB-NB-ER-07	Village of Northbrook	Streambank erosion on intercommunity waterways	Between Dundee Rd & Cherry Ln	Bank erosion and sedimentation. Severe bank erosion along both sides of West Fork NBCR	Regional	1
NB-WFNB-NB-ER-08	Village of Northbrook	Streambank erosion on intercommunity waterways	Fair Lane near Dundee Road/Western Ave. intersection	Banks along the West Fork of the North Branch are severely eroded behind Fair Lane.	Regional	1
NB-WFNB-NB-FR-09	Village of Northbrook	Intercommunity (regional) flooding	Somme Prairie Grove Forest Preserve - Dundee & Waukegan Rd	FPDCC reported that the West Fork often overtops its banks and spills warm urban runoff into preserve degrading wetland and native habitats adjacent to the river.	Regional	1
NB-WFNB-NB-WQ-10	Village of Northbrook	Intercommunity (regional) flooding	Somme Prairie Grove Forest Preserve - Dundee & Waukegan Rd	FPDCC reported that the West Fork often overtops its banks and spills warm urban runoff into preserve degrading wetland and native habitats adjacent to the river.	Regional	1
NB-MFNB-NB-FR-11	Village of Highland Park, Village of Northbrook, Village of Deerfield	Intercommunity (regional) flooding	Northbrook Court, Deerfield, Highland Park	Overbank flooding, storm sewer flow restriction, insufficient river capacity. Regional detention at Northbrook Court fills and backs up river to overflowing. Stream rises into street inlets, street floods	Regional	1
NB-WFNB-NB-FR-12	Village of Northbrook	Intercommunity (regional) flooding	Techny Basin 32A (Meadowhill Park)	Overbank flooding, storm sewer flow restriction. Diversion culverts (triple elliptical pipes) prone to clogging during high flow events and do not allow a sufficient amount of water to pass through.	Regional	1

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-WFNB-NB-FR-13	Village of Northbrook, Unincorp Cook County	Intercommunity (regional) flooding	Techny Basin 32A (Meadowhill Park)	Overbank flooding. The Village of Northbrook's major storm sewer outfalls are submerged and conveyance problems result.	Regional	1
NB-WFNB-NB-FR-14	Village of Glenview	Intercommunity (regional) flooding	Techny Basin 32B	Overbank flooding	Regional	1
NB-WFNB-NB-FR-15	Unincorp Cook County, Village of Northbrook	Intercommunity (regional) flooding	Village of Northbrook, Unincorporated Cook Co	Overbank flooding, and storm sewer flow restriction. Overbank flooding and reduced conveyance capacity of sewers that get submerged.	Regional	1
NB-WFNB-NB-SM-16	Unincorp Cook County, Village of Northbrook	Stream maintenance	Techny Rd – Western Ave to Waukegan Rd	CCHD reported that structure number 016-3234 over West Fork NBCR - some debris accumulation at the center pier.	Regional	1
NB-WFNB-NB-FR-17	Northbrook, Unincorporated Cook County	Intercommunity (regional) flooding	Northbrook, Unincorporated Cook Co	Overbank Flooding	Regional	1
NB-SKRV-NB-FL-18	Village of Northbrook	Intracommunity (local) flooding	Interstate Rt 94 (Edens) at Lake Cook Road	IDOT Pavement flooding	Local	5
NB-WFNB-NB-FL-19	Village of Northbrook	Intracommunity (local) flooding	Illinois Route 43 at Techny Road to Sherman Road	IDOT Pavement flooding	Local	5
NB-WFNB-NB-FL-20	Village of Northbrook	Intracommunity (local) flooding	Willow Road, East of Sherman Road (railroad Viaduct)	IDOT Pavement flooding	Local	5
NB-MFNB-NB-ER-21	Village of Northbrook	Streambank erosion on intercommunity waterways	Pebblebrook Rd	Regional erosion occurring greater than 30 ft from residences on west and east streambanks	Regional	1
NB-MFNB-NF-FR-01	Village of Northfield	Intercommunity (regional) flooding	N Bristol & Robinhood Ln	Willow Hill Condos - Basement and local road flooding due to overbank flooding	Regional	1
NB-MFNB-NF-ER-02	Village of Northfield	Intercommunity (regional) flooding	Robin Hood Ln	Complaints about bank erosion/scouring on Middle Fork along Robin Hood Lane. Bank erosion threatening to wash away road.	Regional	1
NB-MFNB-NF-ER-03	Village of Northfield	Streambank erosion on intercommunity waterways	Meadowbrook Drive to Sunset Lane	Regional erosion occurring within 30 ft of residences and utility poles on west and east streambanks.	Regional	1
NB-MFNB-NF-ER-04	Village of Northfield	Streambank erosion on intercommunity waterways	2094 Middle Fork Road, Northfield, IL	Regional erosion occurring within 30 ft of residence on the west stream bank.	Regional	1

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-MFNB-NF-ER-05	Village of Northfield	Streambank erosion on intercommunity waterways	Willow Road to Abbot Court	Regional erosion occurring within 30 ft of residences on the west and east streambank of Middle Fork from Willow Road to Abbot Court.	Regional	1
NB-MFNB-NF-FL-06	Village of Northfield	Intracommunity (local) flooding	East of Wagner Road, South of Willow Road	Pavement flooding	Local	5
NB-MFNB-NF-FR-07	Village of Northfield	Intercommunity (regional) flooding	Interstate Rt 94 at Winnetka Ave to Skokie Rd (NB & SB)	IDOT Pavement flooding	Regional	1
NB-MFNB-NF-FR-08	Village of Northfield	Intercommunity (regional) flooding	S side of Willow Rd over Middle Fork	Basement and local flooding due to Overbank flooding	Regional	1
NB-MFNB-NF-FR-09	Village of Northfield	Intercommunity (regional) flooding	N side of Willow Rd over Middle Fork	Basement and local flooding due to Overbank flooding	Regional	1
NB-SKRV-NF-FR-10	Village of Northfield	Intercommunity (regional) flooding	Interstate Rt 94 (Edens) at Skokie River	IDOT Pavement flooding	Regional	1
NB-SKWD-NF-FL-11	Village of Northfield	Intracommunity (local) flooding	Willow Rd from Happ Rd to Interstate Rt 94	IDOT Pavement flooding	Local	5
NB-SKWD-NF-FL-12	Village of Northfield	Intracommunity (local) flooding	Willow Rd at Central Ave Pavement flooding	IDOT Pavement flooding	Local	5
NB-SKWD-NF-FR-13	Village of Northfield	Intercommunity (regional) flooding	Interstate Rt 94 (Edens) at Willow Rd (NB & SB)	IDOT Pavement flooding	Regional	1
NB-MFNB-NF-FL-14	Village of Northbrook, Village of Northfield, Village of Glenview, Unincorp Cook County	Intracommunity (local) flooding	Sunset Ridge Rd - East Lake Ave to Skokie Rd	CCHD reported that the 36" corrugated metal pipe West Side, 36" C.P. East Side, 1/4 mile North of Rolling Ridge Rd - some debris accumulation at the East end.	Local	2, 6
NB-MFNB-NF-FR-15	Village of Northfield, Unincorp Cook County	Intercommunity (regional) flooding	Winnetka Rd - Wagner Rd to Happ Rd	CCHD reported that the creek floods the surrounding property in this area.	Regional	1
NB-SKRV-NF-FR-16	Unincorp Cook County, Village of Northfield	Intercommunity (regional) flooding	Village of Northfield, Unincorporated Cook County	Unincorporated Cook County on Skokie River Downstream overbank flooding due to inefficient use of storage.	Regional	1

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-MFNB-NF-ER-17	Village of Northfield	Streambank erosion on intercommunity waterways	North of Winnetka Road along West side of Northfield Road	Streambank Erosion within 30ft of Northfield Road	Regional	1
NB-WFNB-NF-FL-18	Village of Northfield	Intracommunity (local) flooding	Illinois Route 43 at Willow Road to Winnetka Road	IDOT Pavement flooding	Local	5
NB-SKRV-NF-FR-19	Village of Northfield	Intercommuntity (regional) flooding	Willow heading East to I-94	Overbank Flooding	Regional	1
NB-NBCU-NL-FL-01	Village of Niles	Intracommunity (local) flooding	US Rt 14 at Illinois Rte 21 (Milwaukee Area)	IDOT Pavement flooding	Local	5
NB-NBCU-NL-FL-02	Village of Niles	Intracommunity (local) flooding	Illinois Route 21 at Main St (S/O US Rt 14)	IDOT Pavement flooding	Local	5
NB-NBCU-NL-FL-03	Village of Niles	Intracommunity (local) flooding	Illinois Rte 43 at Oakton St	IDOT Pavement flooding	Local	5
NB-NBCU-NL-FL-04	Village of Niles	Intracommunity (local) flooding	Dempster Street East of Harlem Avenue	Pavement flooding	Local	5
NB-NBCU-NL-FR-05	Village of Niles	Intercommunity (regional) flooding	Tam Golf Course	During major storm events, overbank flooding of the adjacent golf course - Tam Golf Course and/or its buildings owned by the Niles Park District.	Regional	1
NB-NBCU-NL-FR-06	Village of Niles	Intercommunity (regional) flooding	Harts Rd & Riverside Drive, Niles	Overbank flooding in areas of the intersection during severe storm events.	Regional	1
NB-NBCU-NL-FL-07	Village of Niles	Intracommunity (local) flooding	IL Route 58 at Washington	IDOT Pavement flooding	Local	5
NB-NBCU-NL-FL-08	City of Chicago, Village of Niles	Intracommunity (local) flooding	Illinois Rte 43 at Howard St (N/O)	IDOT Pavement flooding	Local	5
NB-NBCU-NL-FL-09	Village of Skokie, Village of Niles	Intracommunity (local) flooding	Gross Point Rd at 7500 Gross Point Rd	IDOT Pavement flooding	Local	5
NB-NBCU-NL-ER-10	Village of Niles	Streambank erosion on intercommunity waterways	Wood River Drive	Severe erosion problem along the NBCR for the townhouses located at 6620, 6622, 6624, 6626, 6628, 6630, 6632, 6634, 6636, 6638, and 6640 Wood River Drive.	Regional	1

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-NBCU-SK-FL-01	Village of Skokie	Intracommunity (local) flooding	Interstate Rt 94 at IL Rt 58	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-02	Village of Skokie	Intracommunity (local) flooding	US Rt 41 at Gross Point Rd	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-03	Village of Skokie	Intracommunity (local) flooding	Gross Point between Emerson & Kenton	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-04	Village of Skokie	Intracommunity (local) flooding	Church Rd at Gross Point Rd	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-05	Village of Skokie	Intracommunity (local) flooding	Harms Flatwoods Forest Preserve -Old Orchard Rd and Harms Rd	FPDCC reported that off-site stormwater volumes from adjacent properties modifies the hydrology in this ecologically significant flatwoods community with endangered and threatened plant species.	Local	6
NB-NBCU-SK-WQ-06	Village of Skokie	Intracommunity (local) flooding	Harms Flatwoods Forest Preserve -Old Orchard Rd and Harms Rd	FPDCC reported that off-site stormwater volumes from adjacent properties modifies the hydrology in this ecologically significant flatwoods community with endangered and threatened plant species.	Local	6
NB-NBCU-SK-FL-07	Village of Skokie	Intracommunity (local) flooding	US Rt 41 at Skokie Swift (S/O Oakton St)	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-08	Village of Skokie	Intracommunity (local) flooding	Church Rd at Central Park (construction zone)	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-09	Village of Skokie	Intracommunity (local) flooding	Church St at E/O US Rt 41 (Skokie Blvd)	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-10	Village of Skokie	Intracommunity (local) flooding	Oakton St at Skokie Blvd to McCormick Blvd	IDOT Pavement flooding	Local	5
NB-NBCU-SK-FL-11	City of Evanston, Village of Skokie	Intracommunity (local) flooding	US Rt 41 @ Old Orchard Rd to Golf Rd	IDOT Pavement flooding	Local	5
NB-NSCH-SK-FL-12	Village of Skokie, Village of Lincolnwood	Intracommunity (local) flooding	Interstate Rt 94 (Edens) at Touhy Ave (NB & SB)	IDOT Pavement flooding	Local	5

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-NSCH-SK-FL-13	Village of Skokie, Village of Lincolnwood	Intracommunity (local) flooding	McCormick Blvd at Touhy Ave to Howard Street	IDOT Pavement flooding	Local	5
NB-NSCH-SK-FL-14	Village of Skokie, City of Evanston	Intracommunity (local) flooding	McCormick Blvd at Emerson St	IDOT Pavement flooding	Local	5
NB-NSCH-SK-FL-15	Village of Skokie, City of Evanston	Intracommunity (local) flooding	McCormick Blvd at Oakton St (S/O)	IDOT Pavement flooding	Local	5
NB-NSCH-SK-FL-16	Village of Skokie, City of Evanston	Intracommunity (local) flooding	Crawford Ave at N/O Golf Rd	IDOT Pavement flooding	Local	5
NB-NBCU-UC-ER-01	Unincorporated Cook County	Streambank erosion on intercommunity waterways	Harms Flatwoods Forest Preserve -West of Old Orchard Rd and Harms Rd	FPDCC reported that properties on the west side of the preserve discharge stormwater directly to forest preserve with impacts of erosion, sedimentation, and habitat degradation.	Regional	1
NB-NBCU-UC-WQ-02	Unincorporated Cook County	Intracommunity (local) flooding	Harms Flatwoods Forest Preserve -West of Old Orchard Rd and Harms Rd	FPDCC reported that properties on the west side of the preserve discharge stormwater directly to forest preserve with impacts of erosion, sedimentation, and habitat degradation.	Regional	1
LM-WK-EL-01	Village of Winnetka	Streambank erosion on intracommunity waterways	Ravines	General streambank erosion ravines	Local	6
NB-SKRV-WK-FL-02	Village of Winnetka	Intracommunity (local) flooding	Skokie Ditch	Flooding due to poorly defined overflow routes and inadequate capacity of Skokie Ditch storm sewers.	Local	6
LM-WK-ER-03	Village of Winnetka, Village of Glencoe	Streambank erosion on intercommunity waterways	Lake Michigan Waterfront	Bluff erosion	Regional	1
NB-NBCU-WM-FL-01	Village of Wilmette	Intracommunity (local) flooding	Various locations west of Ridge Rd in the Village of Wilmette	Ponding/storm sewer flow restriction after rain events in isolated low areas/storm restrictions. Storm sewer surcharging by high river water levels results in yard ponding/depressed driveways/garages	Local	5
NB-NBCU-WM-FL-02	Village of Wilmette	Intracommunity (local) flooding	US Rt 41 at N/O Hibbard Rd	Pavement flooding	Local	5
NB-NBCU-WM-FL-03	Village of Wilmette	Intracommunity (local) flooding	Interstate Rt 94 (Edens) at Glenview Rd	Pavement flooding	Local	5

TABLE 2.2.1
Summary of Responses to Form B Questionnaire

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Reason for Classification
NB-NBCU-WM-FL-04	Village of Wilmette	Intracommunity (local) flooding	Various locations in Wilmette	Map of the local ponding for the September 2008 Storm	Local	5
NB-NBCU-WM-FL-05	Village of Wilmette	Intracommunity (local) flooding	Various locations in Wilmette	Map of the local basement flooding for the September 2008 storm	Local	5
NB-NBCU-WM-FR-06	Village of Wilmette	Intercommunity (regional) flooding	Wilmette Golf Course	Flooding and ponding at the Wilmette Golf Course after rain events. High water levels in the river causes stormwater to back up within the golf course.	Regional	1
LM-MM-ER-01	Village of Winnetka, Village of Glencoe	Streambank erosion on intercommunity waterways	Lake Michigan Waterfront	Bluff erosion	Regional	1

Reasons for Regional / Local Classifications:
1. Located on an open channel waterway with greater than 0.5 square mile drainage area
2. Roadway culvert (two-lane road)
3. Roadway culvert (greater than two-lane road)
4. Located in headwater area (less than 0.5 square mile drainage area)
5. Located with storm sewer system (regardless of drainage area)
6. Located beyond immediate area of regional waterway and/or problem occurs on a local waterway

2.3 Watershed Analysis Data

2.3.1 Monitoring Data

2.3.1.1 USGS Gage Data

The U.S. Geological Survey (USGS) owns and maintains a nationwide network of stream gages used to record real-time measurements of the monitored stream's water surface elevations. Rating curves developed through periodic paired stage and flow measurements are used to develop rating curves for the stream, relating estimated flow to measured stage.

There are five primary USGS stream gages that were used for stage and flow calibration and verification. The West Fork gage at Dundee Road (05535500), Middle Fork gage at Lake-Cook Road (05534500), and Skokie River gage at Clavey Road (05535070) were used to hydrologically calibrate the flows entering the Cook County portion of the watershed from Lake County. Stage and flow comparisons were made at the Mainstem of the North Branch gages at Touhy Avenue (05536000) and Albany Avenue (05536105) for the calibration and verification events to ensure that they met District criteria for flow, volume, and stage.

For the NSC and Mainstem downstream of the North Branch Dam, the USACE used a number of USGS and MWRD elevation gages to calibrate and verify the CAWS model. More detail on this gage data usage can be found within the USACE report entitled, "Chicago Downtown Flooding Study Final Report."

TABLE 2.3.1
USGS Gage Data in the NBCR Watershed

Description	Stream Gage Site Data		Stream Gage Site Data	
USGS GAGE #	05534500		05535500	
Location	North Branch Chicago River at Deerfield, IL		WF of NB Chicago River at Northbrook, IL	
Latitude	42°09'10"		42°08'18"	
Longitude	87°49'07" NAD83		87°50'05" NAD83	
	Lake County, Hydrologic Unit 07120003		Cook County, Hydrologic Unit 07120003	
Contributing drainage area:	19.7 square miles		11.5 square miles	
Datum of gauge:	638.88 ft above sea level NGVD29		637.98 ft above sea level NGVD29	
Data Type	**Begin Date**	**End Date**	**Begin Date**	**End Date**
Real-time	This is a real-time site.		This is a real-time site.	
Peak stream flow	03/15/1953	12/27/2008	03/14/1953	03/08/2009
Daily Data				
Discharge, ft^3/sec	08/01/1952	Current	08/08/1952	Current
Gage height, ft	11/30/1993	Current	04/14/1994	Current
Daily Statistics				
Discharge, ft^3/sec	08/01/1952	09/30/2009	08/08/1952	09/30/2009
Gage height, ft	11/30/1993	09/30/2009	04/14/1994	09/30/2009

Monthly Statistics				
Discharge, ft^3/sec	08/1952	09/2009	08/1952	09/2009
Gage height, ft	11/1993	09/2009	09/1994	09/2009
Annual Statistics				
Discharge, ft^3/sec	1952	2009	1952	2009
Gage height, ft	1994	2009	1994	2009
Field/lab water quality samples	10/02/1974	04/29/1997	10/02/1974	08/09/1983

TABLE 2.3.1
USGS Gage Data in the NBCR Watershed

Description	Stream Gage Site Data		Stream Gage Site Data	
USGS GAGE #	05536000		05536105	
Location	North Branch Chicago River at Niles, IL		NB Chicago River at Albany Avenue at Chicago, IL	
Latitude	42°00'44"		41°58'27"	
Longitude	87°47'45" NAD83		87°42'21" NAD83	
	Cook County, Hydrologic Unit 07120003		Cook County, Hydrologic Unit 07120003	
Contributing drainage area:	100 square miles		113 square miles	
Datum of gauge:	601.99 ft above sea level NGVD29		580.67 ft above sea level NGVD29	
Data Type	**Begin Date**	**End Date**	**Begin Date**	**End Date**
Real-time	This is a real-time site.		This is a real-time site.	
Peak stream flow	05/11/1951	06/19/2009	05/10/1990	06/19/2009
Daily Data				
Discharge, ft^3/sec	10/01/1950	Current	10/01/1989	Current
Gage height, ft	10/01/1991	Current	10/01/1993	Current
Daily Statistics				
Discharge, ft^3/sec	10/01/1950	09/30/2009	10/01/1989	09/30/2009
Gage height, ft	10/02/1991	09/30/2009	10/01/1993	09/30/2009
Monthly Statistics				
Discharge, ft^3/sec	10/1950	09/2009	10/1989	09/2009
Gage height, ft	10/1991	09/2009	10/1993	09/2009
Annual Statistics				
Discharge, ft^3/sec	1951	2009	1990	2009
Gage height, ft	1992	2009	1994	2009
Field/lab water quality samples	10/03/1974	04/29/1997	none	none

TABLE 2.3.1
USGS Gage Data in the NBCR Watershed

Description	Stream Gage Site Data	
USGS GAGE #	05535070	
Location	Skokie River near Highland Park, IL	
Latitude	42°09'35"	
Longitude	87°47'53" NAD83	
	Lake County, Hydrologic Unit 07120003	
Contributing drainage area:	21.1 square miles	
Datum of gauge:	622.83 ft above sea level NGVD29	
Data Type	**Begin Date**	**End Date**
Real-time	This is a real-time site.	
Peak stream flow	06/10/1967	12/27/2008
Daily Data		
Discharge, ft^3/sec	08/21/1967	Current
Gage height, ft	10/01/1993	Current
Daily Statistics		
Discharge, ft^3/sec	08/21/1967	09/30/2009
Gage height, ft	10/01/1993	09/30/2009
Monthly Statistics		
Discharge, ft^3/sec	08/1967	09/2009
Gage height, ft	10/1993	09/2009
Annual Statistics		
Discharge, ft^3/sec	1967	2009
Gage height, ft	1994	2009
Field/lab water quality samples	10/01/1974	08/08/1983

2.3.1.2 Rainfall Data

Numerous sources of rain gage data were evaluated in order to build a gage network that would allow for complete coverage of the NBCR and LM watersheds. The final gage network consisted of four Cook County Precipitation Network (CCPN) gages and one Lake County Stormwater Management Commission (LCSMC) gage. The CCPN is a series of six mile grid spaced gages recorded at a 10-minute interval; the LCSMC gage network is a series of five mile grid spaced gages recorded at a 5-minute interval. Figure 2.3.1 shows locations where rainfall gage data was available to support the DWP. The subbasins for all four main reaches are shown on Figure 2.3.1 color-coded to indicate which subbasins were associated with which rainfall gages during the calibration process, which is discussed in detail in Section 3.

Information on the precipitation data used to calibrate the USACE CAWS model can be found in the report referenced in section 2.3.1.1.

2.3.1.3 Stage Data

No additional stage data, outside of the USGS gage data was used to calibrate the NBCR models or LM models. Information on the stage data used to calibrate the USACE CAWS model can be found in the report referenced in section 2.3.1.1.

2.3.2 Subwatershed Delineation

The NBCR watershed and LM watershed was divided into subwatersheds representing areas tributary to the waterways in the study area. Elevation data provided by Cook County, described further in Section 2.3.4, was the principal data source used for subwatershed delineation. Drainage divides were established based upon consideration of the direction of steepest descent from local elevation maxima. Occasionally, Cook County elevation data contains constructed structures that do not represent surface hydrology, for instance, raised roadways that do not restrict overland flow. The delineation in these areas was modified to best represent surface hydrology. The storm-sewer network was also considered in the delineation of some areas, particularly in the low gradient areas of the lower Mainstem of the NBCR where ground slope was slight or inconclusive. Finally, reference of previous studies and consultation with community representatives helped resolve subwatershed boundaries in areas of question.

Following the definition of subwatersheds, tributaries studied in detail were divided into smaller subbasins, represented in the hydrologic model as having a unified response to rainfall. The size of subbasins varied based upon the drainage network density and proximity to the hydraulically modeled waterway. Subbasin boundaries were modified to generally encompass areas with similar development patterns. Boundaries were defined to most accurately represent the actual area tributary to specific modeled elements, such as constrictions caused by crossings, and reservoirs.

Figure 2.3.2 shows the subwatersheds and subbasins developed for the DWP. Subbasins were not defined for areas that were not modeled in detail. Subbasins in the NSC and Mainstem downstream of the North Branch Dam watersheds are part of the USACE CAWS model, and are not included in Figure 2.3.2. The subbasin delineations for these reaches can be found in the USACE report referenced in section 2.3.1.1.

2.3.3 Drainage Network

The principal waterways of the NBCR watershed and LM watershed were defined during Phase A of the watershed study. Initial identification of the stream centerline was made using planimetry data obtained from Cook County. Stream centerlines were reviewed against aerial photography and Cook County contour data at a 1:500 scale, and modified to best represent existing conditions. These streamlines were included in the topographic model of the NBCR watershed and LM watershed (see Section 2.3.4), and collect runoff from upland drainage areas. Secondary drainage ways that were not modeled were identified based upon review of contour data. In flat, heavily sewered areas, consultation of sewer atlases and discussion with community representatives helped to identify significant drainage paths. Secondary drainage ways were used to help define flow paths in the hydrologic models for individual tributaries.

Figure 2.3.3 shows the major drainage ways within the NBCR watershed and LM watershed superimposed upon an elevation map of the watershed.

2.3.4 Topography and Benchmarks

The NBCR watershed is generally defined by areas of high relief at the tributary headwaters in Lake County, and areas of very low relief as the NBCR combines with the North Shore Channel. The areas of low relief primarily occur in the City of Chicago, which is a heavily storm-sewered municipality.

Topographic data for the NBCR and LM watersheds were developed from Cook County light detection and ranging (LiDAR) data generated from a 2003 LiDAR mission (Cook County, 2003). The LiDAR data was obtained along with break lines from Cook County. A digital elevation model (DEM) was developed for the NBCR and LM watersheds based upon a subset of filtered elevation points. Figure 2.3.3 shows elevations within the watershed.

Stream channel cross section and stream crossing structure (such as bridge and culvert) topographic data was collected during field survey work conducted primarily between November 2008 and June 2009 to support the DWP. Additional field survey was performed in February 2010 and June 2010.

The reference benchmarks created during the Cook County aerial mapping project completed in 2003 were used to establish first-order control for field survey work. One hundred thirty-five control points were established during the mapping project. Of those, 25 are National Geodetic Survey (NGS)/High Accuracy Reference Network (HARN) control stations within Cook County and environs. The remaining points were either existing or new points identified as photo control specifically for the mapping project. 71NGS monuments within the region surrounding the NBCR and LM watersheds were observed, referenced to HARN, and used to establish first-order control, meeting the horizontal and vertical accuracy standards specified in FEMA's *Guidelines and Specifications for Flood Hazard Mapping,* "Guidance for Aerial Mapping" (FEMA 2003). The horizontal ground control was established by GPS technology, and horizontal positioning accuracy meets the specifications of the Federal Geodetic Control Subcommittee (FGCS) Second Order Class One.

2.3.5 Soil Classifications

NRCS soil data representative of 2002 conditions was obtained for Cook County. The NRCS soil data includes hydrologic soil group, representing the minimum infiltration rate of the soil after wetting. Table 2.3.2 summarizes the hydrologic soil groups. The NRCS provides two types of soil datasets for the area. One type is the Soil Survey Geographic, or SSURGO, dataset[1]. The SSURGO dataset is available for select areas and is a detailed soil survey. The City of Chicago is not included in the SSURGO dataset, although portions of the North Branch upper basin are included.

A second type of soils dataset developed by the NRCS is the U.S. General Soil Map (formerly the State Soil Geographic dataset), also known as STATSGO or STATSGO2[2]. STATSGO is more general than SSURGO and is based on a wide range of available soil literature. The City of

[1] http://soils.usda.gov/survey/geography/ssurgo/
[2] http://soils.usda.gov/survey/geography/statsgo/

Chicago and portions of the North Branch lower basin are mapped in the STATSGO dataset. The SSURGO dataset areas in the upper basin (the Skokie River, Upper North Branch, and a portion of the West Fork) are at a smaller, more refined scale than STATSGO. While SSURGO is the preferred dataset, the additional use of STATSGO in the lower basin shows soils with HSG ranging from "A" (low runoff potential) to "C" (moderately high runoff potential). The STATSGO soil dataset will be used to supplement SSURGO data, rather than assuming a uniform soil type. The STATSGO and SSURGO datasets can both be classified under the A-D hydrologic soil groups shown in Table 2.3.2.

TABLE 2.3.2
Hydrologic Soil Groups

Hydrologic Soil Group	Description	Texture	Infiltration Rates (in./hr)
A	Low runoff potential and high infiltration rates even when wetted	Sand, loamy sand, or sandy loam	> 0.30
B	Moderate infiltration rates when wetted	Silt loam or loam	0.15–0.30
C	Low infiltration rates when wetted	Sandy clay loam	0.05–0.15
D	High runoff potential and very low infiltration when wetted	Clay loam, silty clay loam, sandy clay, silty clay, or clay	0–0.05

All data from *Technical Release 55, Urban Hydrology for Small Watersheds*, NRCS, June 1986

Soil groups with drainage characteristics affected by a high water table are indicated with a "/D" designation, where the letter preceding the slash indicates the hydrologic group of the soil under drained conditions. Thus, an "A/D" indicates that the soil has characteristics of the A soil group if drained but the D group if not. Because of the difficulty of establishing the extent of drainage of these soils for each mapped soil polygon, it was assumed that 50 percent (by area) of the soil types are drained. Table 2.3.3 summarizes the distribution of hydrologic soil type throughout the NBCR and LM watersheds. Figure 2.3.4 shows the distribution of soil types throughout the watersheds.

TABLE 2.3.3
Hydrologic Soil Group Distribution

Hydrologic Soil Group	% of NBCR & LM Watershed
Unmapped	0.5
A/B	17.8
B	0.8
B/C	57.7
B/D	1.6
C	19.4
D	2.2

2.3.6 Land Use

Land use has a significant effect on basin hydrology, affecting the volume of runoff produced by a given area and the speed of runoff delivered to the receiving system. Impervious areas restrict infiltration and produce more runoff, which is often delivered to receiving systems more rapidly through storm sewer networks. Land use was one of two principal inputs into the calculation of CN for the NBCR and LM watersheds, detailed more extensively in Section 1.3.2.

A 2001 land use inventory for the Chicago metropolitan area was received from CMAP in GIS format. The data was used to characterize existing conditions land use within the NBCR and LM watersheds. The data include 49 land use classifications, grouped into seven general categories for summarizing land use within the DWP. Table 2.3.4 summarizes the land use distribution within the NBCR and LM watersheds. Figure 2.3.5 shows the distribution of general land use categories throughout the watersheds.

TABLE 2.3.4
Land Use Distribution within the NBCR & LM Watersheds

Land Use Type	Area (mi^2)	Area (%)
Residential	82.2	58.4
Forest/Open Land	21.5	15.3
Commercial/Industrial	24.8	17.6
Water/Wetland	1.3	1
Agricultural	0.3	0.2
Transportation/Utility	3.7	2.6
Institutional	6.9	4.9

2.3.7 Anticipated Development and Future Conditions

Anticipated development within the NBCR and LM Watershed was analyzed using population projection data. Projected future conditions land use data for the NBCR and LM watersheds are unavailable from CMAP or other regional agencies. Projected 2030 population data for Cook County was obtained from CMAP. Population data was overlaid upon subwatershed boundaries to identify the potential for increases in subwatershed populations. Table 2.3.5 shows subwatersheds with a projected population increase from the year 2000 population. Projected increases in population along with current subwatershed land use conditions make it likely that there will also be a corresponding increase in impervious surface area. This potential change in impervious surface area could contribute to higher flow rates and volumes of stormwater runoff drained by those tributaries.

TABLE 2.3.5
Projected Population Increase by Subwatershed

Name	2000 Population	2030 Population	Population Change	% Increase
West Fork	101,441	112,691	11,250	11
Middle Fork	50,747	57,273	6,526	13
Skokie River	131,887	135,499	3,612	3
Mainstem	205,077	218,931	13,854	7
Lake Michigan	441,175	486,120	44,945	10

Management of future development may be regulated through both local ordinances and the Cook County Watershed Management Ordinance (WMO) as described below in Section 2.3.9. This regulation would be an effort to prevent an increase in peak flows, via the construction of site-specific stormwater controls. The impact of the modified hydrologic and hydraulic characteristics of the subwatersheds due to changing land use over time may require the recommended projects to be re-evaluated under the conditions at the time of implementation to refine the details of the final design. To accomplish this, it is recommended that at the time projects are implemented, if updated land use and topographic information is available, the H&H models be rerun incorporating this new data.

2.3.8 Wetland and Riparian Areas

Wetland areas within the NBCR and LM Watershed were identified using National Wetlands Inventory (NWI) mapping. NWI data includes approximately 2.6 square miles of wetland areas in the NBCR and LM Watershed. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provide flood management, habitat, and water quality enhancement. Identified riparian areas defined as part of the DWP offer potential opportunities for restoration. Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR and LM Watershed, respectively.

2.3.9 Management of Future Conditions through the Regulations of Site Stormwater Management

The District regulates the discharge of stormwater runoff from development projects located within separate sewer areas within the District's corporate boundaries through its Sewer Permit Ordinance. Currently, development projects meeting certain thresholds must provide stormwater detention in an effort to restrict the post-development flow rate to the pre-development flow rate. A number of communities enforce standards beyond the District's currently required standards and thresholds. This DWP supports the continued regulation of future development through countywide stormwater management.

The Cook County WMO is under development and is proposed to provide uniform minimum countywide standards for site stormwater runoff for events up to and including the 100-year event that are appropriate for Cook County. This effort seeks to prevent post-development flows from exceeding pre-development conditions. The WMO is proposed to be a comprehensive ordinance addressing site runoff, floodplains, floodways, wetlands, soil erosion and sedimentation, water quality, and riparian environments.

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3. Tributary Characteristics and Analysis

3.1 West Fork of the NBCR

The West Fork, the northwestern most tributary in the NBCR watershed, has a total stream length of 20.7 miles and a total drainage area of approximately 28 square miles. Table 3.1.1 summarizes the land area of communities within the West Fork subwatershed. The West Fork subwatershed consists primarily of residential and commercial areas and includes a large portion of forest preserve area located in the northern part of the subwatershed. Table 3.1.2 summarizes the land use distribution within the West Fork.

Figures 3.1.1a and 3.1.1b are an overview of the tributary area of the West Fork subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

TABLE 3.1.1
Communities Draining to the West Fork[1]

Community/Tributary	Tributary Area (mi^2)
Glenview	9.39
Northbrook	7.77
Deerfield	2.88
Unincorporated	2.01
Riverwoods	1.55
Lincolnshire	1.22
Lake Forest	1.08
Bannockburn	0.82
Deerfield	0.51
Golf	0.34
Mettawa	0.23
Northfield	0.19

[1] Includes communities/area in Lake County

3.1.1 Sources of Data

3.1.1.1 Previous Studies

Data from the 1998 and 2000 FIS regulatory models (HEC-2) were utilized to supplement the newly developed DWP HEC-RAS model for the West Fork. For the Techny Drain tributary, the Village of Northbrook's "Techny Drain Hydrology and Hydraulics" (2007) study was used to assist with subbasin delineation and flow diversion modeling. Additionally, for the Underwriter's Tributary, the 2000 FIS regulatory model was used to assist with subbasin delineation and storage modeling.

TABLE 3.1.2
Land Use Distribution for the West Fork[1]

Land Use Category	Area (acres)	%
Residential	10,061	55.9
Forest/Open Land	3,076	17.1
Commercial/Industrial	3,053	17.0
Institutional	851	4.7
Transportation/Utility	376	2.1
Water/Wetland	294	1.6
Agricultural	280	1.6

[1] Includes land uses in Lake County

3.1.1.2 Water Quality Data

The Illinois Environmental Protection Agency (IEPA) has three Ambient Water Quality Monitoring Network sites on the West Fork. The West Fork, IL-HCCB-05, is identified as impaired in the IEPA's 2008 Integrated Water Quality Report, which includes the Clean Water Act (CWA) 303(d) and 305(b) lists, for Chloride, DDT, Dissolved Oxygen, Phosphorous (Total), Total Suspended Solids (TSS), and

Fecal Coliform. No total maximum daily loads (TMDLs) have been established for the West Fork. TMDLs are currently being developed for chloride and fecal coliform. According to a water permit discharge query from the U.S. Environmental Protection Agency (USEPA), there are three National Pollutant Discharge Elimination System (NPDES) permits issued by IEPA to Prairie Material Sales, Inc. in Northbrook, Underwriters Lab, Inc. in Northbrook, and Village of Golf CSOs for discharges to the West Fork. Municipalities discharging to the West Fork are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was instituted to improve water quality by requiring that municipalities develop six minimum control measures for limiting runoff pollution to receiving systems.

3.1.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes approximately 150 acres of wetland areas in the West Fork tributary area. Restoration and enhancement of wetlands are included as part of the recommended alternatives described in the sub-sections below. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provides flood management, habitat, and water quality enhancement. Identified riparian environments offer potential opportunities for restoration.

3.1.1.4 Floodplain Mapping

Flood inundation areas supporting the National Flood Insurance Program (NFIP) were revised in 2008 as a part of FEMA's Map Modernization Program. Floodplain boundaries were revised based upon updated Cook County topographic information, but the effective models used to estimate flood levels generally were not updated. Localized Letters of Map Revisions (LOMRs) were incorporated in the revised floodplains. The effective FIS H&H analysis was performed in 1994. The hydrologic modeling was performed by using HEC-1 and Regression Equation 79; Hydraulic routing was performed using HEC-2.

Appendix A includes a comparison of FEMA's effective floodplain mapping from updated DFIRM panels with inundation areas developed for the DWP.

3.1.1.5 Stormwater Problem Data

Table 3.1.3 summarizes reported problem areas reviewed as a part of the DWP development. The problem area data was obtained primarily from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.1.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.1.1.6 Near-Term Planned Projects

Watershed communities, agencies, and stakeholders were asked about near-term planned projects so that the implementation of near-term flood control projects by others is considered in development of the DWP. Several studies are currently underway in the West Fork subwatershed; however, no near-term planned flood control projects by others have been identified for this area.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GV-FL-08	Village of Glenview	Intracommunity (local) flooding	Village of Glenview - Villagewide	Ponding and storm sewer flow restriction village-wide. Numerous areas in the Village developed prior to the 1980s have inadequate storm water conveyance and detention	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-11	Village of Glenview	Intracommunity (local) flooding	Illinois Tool Works Detention Pond, Glencoe	Local overbank flooding of existing detention pond due to debris collection at restrictor. Problem causing overbank flooding of local residents' backyards and local power outages.	Local	Problem not located on a regional waterway. This is a local maintenance problem.
GV-ER-03	Village of Glenview	Streambank erosion on intracommunity waterways	John's Dr at Willow Road	Stream bank destabilization, erosion and sedimentation, and wetland/riparian areas at risk. Trees along channels continually contribute to log jams. Invasive species degrade habitat.	Regional	Erosion problem does not threaten structures or conveyance of West Fork. Not addressed by DWP.
GV-SM-04	Village of Glenview	Stream maintenance	North Navy Ditch beginning at John's Dr. Navy Ditch confluence with West Fork	Following removal of buckthorn/brush from North Navy Ditch, remaining large cottonwood/box elder trees exposed to greater wind force, causing limb breakage/tree failure and minor re-blockage of channel	Regional	Maintenance and debris removal recommended in Section 4.
GV-ER-05	Village of Glenview	Streambank erosion on intercommunity waterways	Lehigh Avenue and Chestnut Avenue	Stream bank destabilization, erosion and sedimentation, and wetland/riparian areas at risk. Trees along channels continually contribute to log jams. Invasive species degrade habitat.	Regional	Erosion problem does not threaten structures or conveyance of West Fork. Not addressed by DWP.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GV-FR-06	Village of Glenview	Intercommunity (regional) flooding	Tall Trees Subdivision	Overbank Flooding in Tall Trees Subdivision.	Regional	The recommend alternative for this problem is WF-06.
GV-SM-07	Village of Glenview	Stream maintenance	South Navy Ditch beginning at Lehigh Avenue South Navy Ditch confluence with West Fork	South Navy Ditch beginning at Lehigh Rd, Ongoing aging and breakage of trees along the South Navy Ditch eventually contributes to small log jams.	Regional	Maintenance and debris removal recommended in Section 4.
NB-FR-12	Village of Northbrook	Intercommunity (regional) flooding	Techny Basin 32A (Meadowhill Park)	Overbank flooding, storm sewer flow restriction. Diversion culverts (triple elliptical pipes) prone to clogging during high flow events and do not allow a sufficient amount of water to pass through.	Regional	The recommend alternative for this problem is WF-06.
NB-FR-13	Village of Northbrook, Unincorp Cook County	Intercommunity (regional) flooding	Techny Basin 32A (Meadowhill Park)	Techny Basin 32A Overbank flooding. The Village of Northbrook's major storm sewer outfalls are submerged and conveyance problems result.	Regional	The recommend alternative for this problem is WF-06.
NB-FR-14	Village of Glenview	Intercommunity (regional) flooding	Techny Basin 32B	Overbank flooding	Regional	The recommend alternative for this problem is WF-06.
GV-FR-09	Village of Glenview	Intercommunity (regional) flooding	Techny Basin 32C	Overbank flooding - Techny Basin 32C provides bulk of the Village's upstream storm water protection storage within the West Fork NBCR watershed. Recent storms brought extreme flooding.	Regional	The recommend alternative for this problem is WF-06.
GV-SM-10	Village of Glenview	Stream maintenance	Willow Road & Ravine Avenue Techny Basin 32C	Techny Basin 32C maintenance necessary at the MWRD maintained spillway that has been identified for years at the biannual inspections.	Regional	Maintenance activities recommended in Section 4.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NB-FR-06	Village of Northbrook	Intercommunity (regional) flooding	From Fieldwood Drive and Techny Road to Techny Drain near its confluence with West Fork	Flooding within backwater influence of West Fork NBCR extending approx 2000ft upstream along Techny Drain. Property/structure flooding within the backwater influence for short localized storms	Regional	The recommend alternative for this problem is WF-06.
GV-ER-12	Village of Glenview	Streambank erosion on intercommunity waterways	River between Glenview Road and Waukegan Road	Stream bank destabilization, erosion and sedimentation, wetland/riparian areas at risk. Significant erosion and undermined turf on East bank of West Fork (400 linear ft).	Regional	Confirmed with Village of Glenview that local project to mitigate erosion already implemented.
GV-ER-13	Village of Glenview	Streambank erosion on intercommunity waterways	Lot 16 Bank Stabilization	Streambank destabilization, erosion and sedimentation, wetland/riparian areas at risk. Channel clogged primarily by woody debris. Banks unstable/choked with invasive species, particularly buckthorn.	Regional	Erosion problem does not threaten structures or conveyance of West Fork. Not addressed by DWP.
GV-ER-14	Village of Glenview	Streambank erosion on intercommunity waterways	1201 Long Valley Road	Regional erosion occurring within 30 ft of residence on the west streambank.	Regional	Erosion problem not immediately threatening structure. Not addressed by DWP.
GV-FL-15	Village of Glenview	Intracommunity (local) flooding	Village-wide	Ponding/storm sewer flow restriction in 30% of Village that is partially non-storm-sewered. Village Storm Water Study: inadequate storm water detention/conveyance, inlet capacity.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GV-FL-16	Village of Glenview	Intracommunity (local) flooding	Illinois Route 43 at C, M, & St Paul RR	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-17	Village of Glenview	Intracommunity (local) flooding	Greenwood Avenue at S/O West Lake Avenue	IDOT Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-18	Village of Glenview	Intracommunity (local) flooding	Pfingston Road North of Glenview Road, South of Knollwood Lane	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-19	Village of Glenview	Intracommunity (local) flooding	Shermer Road North of Central Road, South of Robincrest Lane	Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-20	Village of Glenview	Intracommunity (local) flooding	Harlem Avenue North of Lake Street, West of Robincrest Lane	Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GV-FL-21	Village of Glenview	Intracommunity (local) flooding	Spruce Drive South of Lake Street, West of Lehigh Avenue	Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-22	Village of Glenview	Intracommunity (local) flooding	Locust Lane & Rolwind Road	Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-23	Village of Glenview	Intracommunity (local) flooding	Country Lane and North Branch Road	Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FR-24	Village of Glenview	Intercommunity (regional) flooding	Tall Trees Subdivision	Overbank flooding along West fork	Regional	The recommend alternative for this problem is WF-06.
GV-SM-25	Village of Glenview	Stream maintenance	West Fork at Willow Road & Ravine Way and at Chestnut Avenue	Log jam flow obstruction, continuing onwards to river south of Loyola Academy athletic campus. Trash/woody debris in dry former river channel to north of Lot 16.	Regional	Maintenance and debris removal recommended in Section 4.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GV-ER-26	Village of Glenview	Stream maintenance on intercommunity waterways	East side of West Fork NBCR, South of Glenview Road; East side of West Fork NBCR, North of Waukegan Road	Streambank Erosion	Regional	Confirmed with Village of Glenview that local project to mitigate erosion already implemented.
GV-WQ-27	Village of Glenview	Streambank erosion on intercommunity waterways	River between Glenview Road and Waukegan Road	Stream bank destabilization, erosion and sedimentation, water quality affected by pollution, wetland/riparian areas at risk. East bank (400 linear ft) shows significant erosion and undermined turf.	Regional	Confirmed with Village of Glenview that local project to mitigate erosion already implemented.
GV-FL-28	Village of Morton Grove, Village of Glenview, Village of Golf	Intracommunity (local) flooding	Golf Road E/O IL Route 43 (Metra Viaduct)	IDOT Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
GV-FL-29	Village of Golf, Village of Glenview, Village of Morton Grove	Intracommunity (local) flooding	Golf Road/Simpson Street at C, M, & St Paul RR (viaduct)	IDOT Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GV-ER-30	Village of Glenview	Streambank erosion on intercommunity waterways	Raleigh Road from York Road to Baffin Road	Streambank Erosion	Regional	Erosion problem does not threaten structures or conveyance of West Fork. Not addressed by DWP.
GV-FL-31	Village of Glenview	Intracommunity (local) flooding	Illinois Route 43 at S/O Lake Avenue (Block 1200)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NB-FR-15	Unincorp Cook County, Village of Northbrook	Intercommunity (regional) flooding	Village of Northbrook, Unincorporated Cook County	Overbank flooding, and storm sewer flow restriction. Overbank flooding and reduced conveyance capacity of sewers that get submerged.	Regional	The recommend alternative for this problem is WF-06.
NB-SM-16	Unincorp Cook County, Village of Northbrook	Stream Maintenance	Techny Road – Western Avenue to Waukegan Road	CCHD reported that structure number 016-3234 located over West Fork has some debris accumulation at the center pier.	Regional	Maintenance and debris removal recommended in Section 4.
NB-FR-17	Northbrook, Unincorporated Cook County	Intercommunity (regional) flooding	Northbrook, Unincorporated Cook County	Overbank Flooding	Regional	The recommend alternative for this problem is WF-06.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NB-FL-19	Village of Northbrook	Intracommunity (local) flooding	Illinois Route 43 at Techny Road to Sherman Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NB-FL-20	Village of Northbrook	Intracommunity (local) flooding	Willow Road, East of Sherman Road (railroad Viaduct)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NB-ER-07	Village of Northbrook	Streambank erosion on intercommunity waterways	Between Dundee Road & Cherry Lane	Bank erosion and sedimentation. Severe bank erosion along both sides of West Fork NBCR	Regional	The recommend alternative for this problem is WF-03.
NB-ER-08	Village of Northbrook	Streambank erosion on intercommunity waterways	Fair Lane near Dundee Road\Western Avenue Intersection	Banks along the West Fork of the North Branch are severely eroded behind Fair Lane.	Regional	The recommend alternative for this problem is WF-03.
NB-FR-09	Village of Northbrook	Intercommunity (regional) flooding	Somme Prairie Grove Forest Preserve - Dundee & Waukegan Road	FPDCC reported that the West Fork often overtops its banks and spills warm urban runoff into preserve degrading wetland and native habitats adjacent to the river.	Regional	The focus of this DWP is to recommend regional flood control projects to mitigate damage to structures.

TABLE 3.1.3
Community Response Data for the West Fork

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NB-WQ-10	Village of Northbrook	Intercommunity (regional) flooding	Somme Prairie Grove Forest Preserve - Dundee & Waukegan Road	FPDCC reported that the West Fork often overtops its banks and spills warm urban runoff into preserve degrading wetland and native habitats adjacent to the river.	Regional	Water quality problem not addressed by DWP. The focus of this DWP is to recommend regional flood control projects to mitigate damage to structures.
NF-FL-18	Village of Northfield	Intracommunity (local) flooding	Illinois Route 43 at Willow Road to Winnetka Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

[1] All Problem IDs begin with either NB-WFNB- , NB-NVDN-, or NB-NVDS- as all problems are within the North Branch - West Fork, North Navy Ditch, or South Navy Ditch subwatersheds.

3.1.2 Watershed Analysis

3.1.2.1 Hydrologic Model Development

Subbasin Delineation. The West Fork tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The watershed boundaries of the West Fork (western edge) and Des Plaines River (eastern edge) were compared, and discrepancies were identified. Discrepancies generally were minor and resolved by manual review of topographic data and consultation with the Des Plaines River DWP consultant, Christopher B. Burke Engineering.

Hydrologic Parameter Calculations. Table 3.1.4 summarizes the total drainage area, number of modeled subbasins, and average subbasin size for West Fork and its major tributaries.

TABLE 3.1.4
West Fork System Subbasin Summary

Subbasin	Drainage Area (mi^2)	Number of Modeled Subbasins	Average Modeled Subbasin Size (acres)
West Fork	19.3	42	300
Major Tributaries to West Fork			
Underwriters Tributary	0.5	4	85
Techny Drain	2.0	12	105
North Navy Ditch	4.4	5	562
South Navy Ditch	0.3	2	82

Curve Numbers (CNs) were estimated for each subbasin based upon NRCS soil data and 2001 CMAP land use data. This method is further described in Section 1.3.2, with lookup values for specific combinations of land use and soil data presented in Appendix C. An area-weighted average of the CN was generated for each subbasin. The Clark unit hydrograph method was used to convert SCS CN runoff volumes into subbasin-specific hydrographs. Time of concentration (Tc) and storage coefficient (R) parameters for the Clark unit hydrograph method were estimated as described in Section 1.3.2. Appendix G provides a summary of the hydrologic parameters used for subbasins in each subwatershed.

3.1.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met the District criteria for use in the DWP, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Field surveys of the West Fork and bridge crossings were performed to characterize the channel and near overbank geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the field surveyed channel cross sections. Field visits were performed to assess channel and overbank roughness characteristics, which were combined with information from photographs and aerial photography to assign modeled Manning's *n* roughness coefficients along the modeled stream length.

Boundary Conditions. The downstream boundary condition for the West Fork is the stage of the Mainstem of the NBCR at the confluence of the two reaches. The unsteady model produces water surface elevations at each time step, therefore providing a downstream boundary condition at each time step of the simulation. The maximum existing conditions 100 year water surface elevation (WSEL) at this junction is 621.33 feet in vertical elevation datum NAVD 88.

3.1.2.3 Calibration and Verification

Observed Data. As in shown in Figure 2.3.1, three thiessen polygons, based on three different precipitation gages, allow for complete coverage of the West Fork subwatershed. The northernmost thiessen polygon is based on the LCSMC "Riverwoods" gage; the middle and lower portions of the West Fork are covered by CCPN gages 1 and 4, respectively. Data for the September 2008 and October 2001 storms were gathered for calibration and verification of the hydrologic and hydraulic models.

The only USGS stream gage on the West Fork, gage number 05535500, is located at the Dundee Road crossing. Supplemental information on this stream gage can be found in Table 2.3.1. Peak flow information for the calibration and verification events can be found in Table 3.1.5. The Deerfield Reservoir is located immediately south of the Cook County line and upstream of the Dundee Road gage. The location of this reservoir, which significantly attenuates flows, reduced the sensitivity of adjustments made in the hydrologic model upstream of the Cook County line. The HEC-HMS hydrographs (without any adjustments to modeling parameters) were initially used as a boundary condition to the HEC-RAS model. The HEC-RAS model indicated, however, that the Deerfield Reservoir was completely filling with water in the 100-year event, and that a significant amount of flow was leaving the reservoir through the auxiliary spillway. This was not considered representative of reservoir performance, so the HEC-1 hydrograph from the Lake County regulatory model was incorporated as the boundary condition for the HEC-RAS model for modeling design storms.

TABLE 3.1.5
Flow Events at USGS gage 05535500

Date	Peak Monitored Flow (cfs)
9/13/2008	703
10/13/2001	848

Figure 3.1A shows superimposed comparisons of the HEC-RAS and USGS gage hydrographs (river gage 05535500) at the gage location for the 2008 event. Figure 3.1B shows these same hydrographs for the 2001 event. Figures 3.1C and 3.1D show the stage curve comparisons for the September and October events, respectively. Although the HEC-RAS hydrographs show peaks that are lower than the USGS gage peaks, the difference between the observed and calibrated model flows and water surface elevations were generally considered to be within an acceptable margin of error.

FIGURE 3.1A
West Fork flow comparison for September 13, 2008 storm

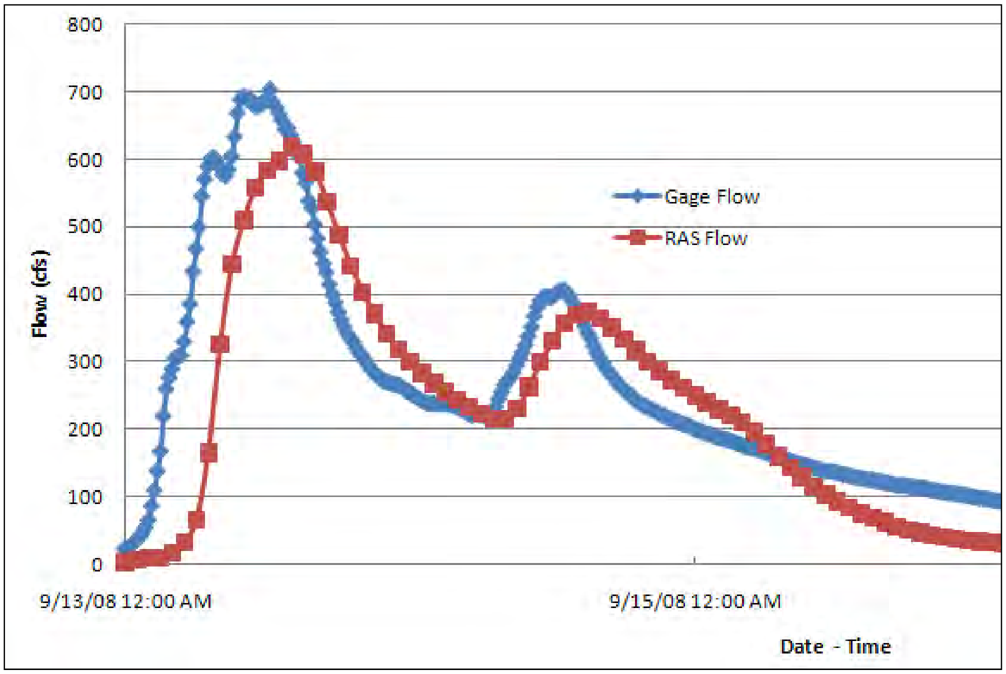


FIGURE 3.1B
West Fork flow comparison for October 13, 2001 storm

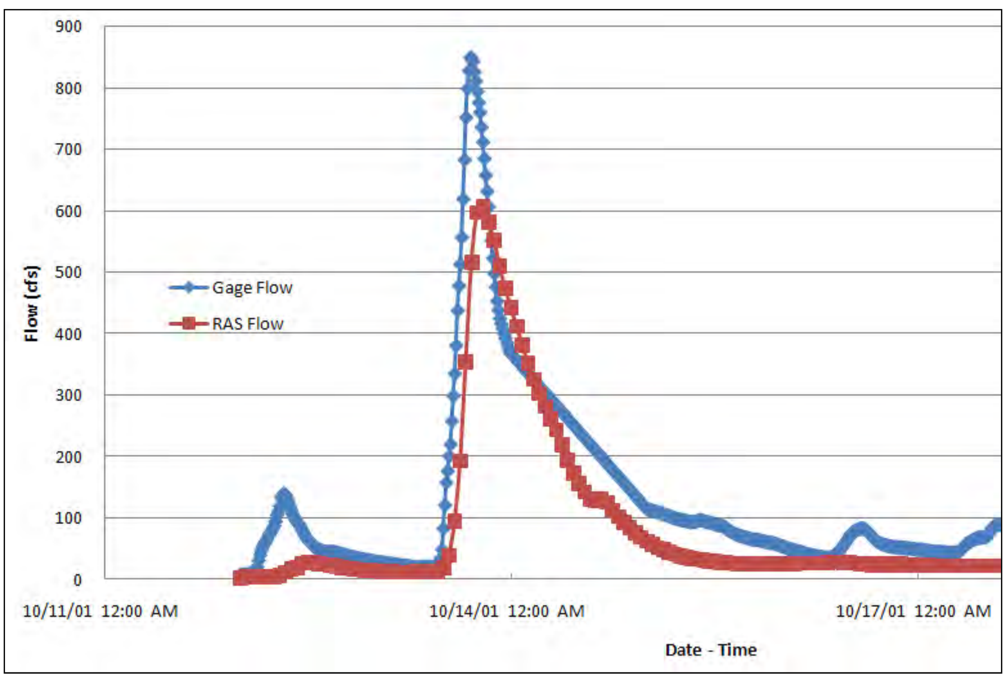


FIGURE 3.1C
West Fork stage comparison for September 13, 2008 storm

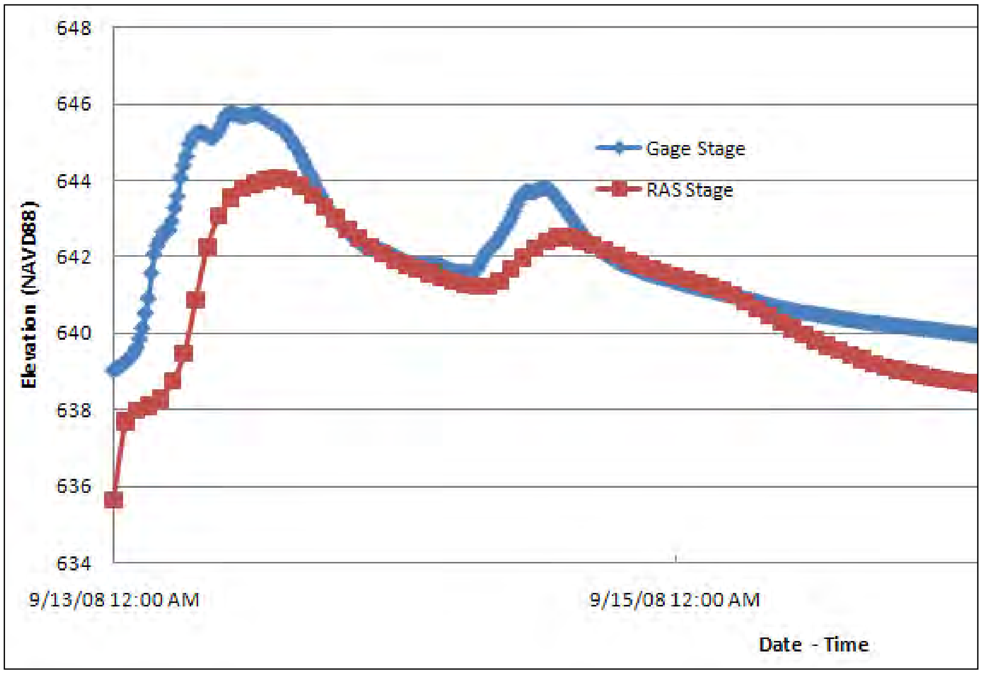
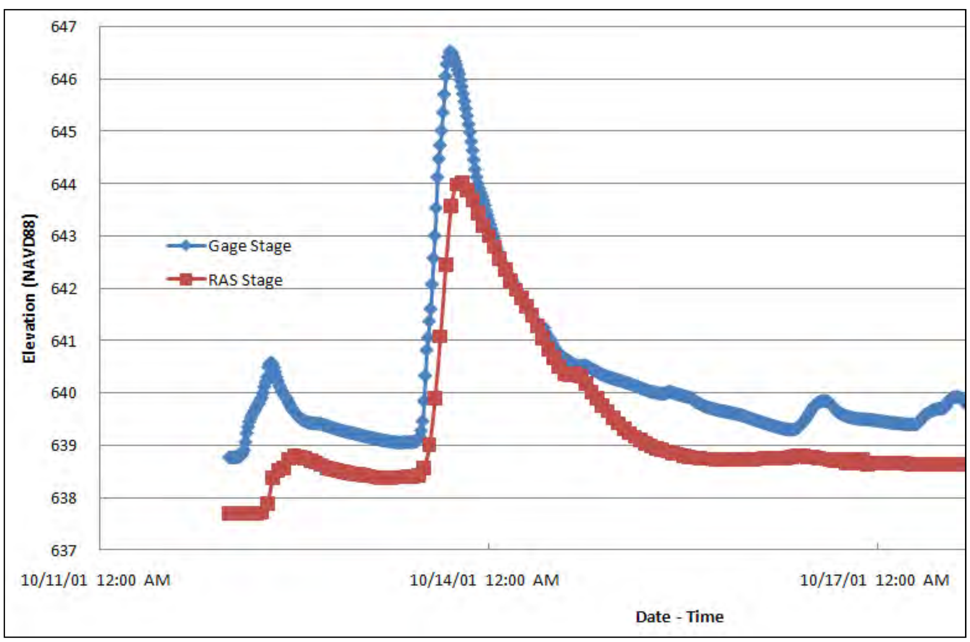


FIGURE 3.1D
West Fork stage comparison for October 13, 2001 storm



Calibration Results. The aforementioned location and operation of the Deerfield Reservoir and associated attenuation of flows upstream of the Dundee Road gage significantly impacts the effects of hydrologic adjustments made upstream. With the results of the HEC-RAS and gage hydrograph comparisons being similar with regard to flow, stage, and hydrograph shape, no modifications were made to the upstream hydrology. Flow, volume, and stage were checked at the Mainstem gages at Touhy Avenue and Albany Avenue, in order to verify the model met CCSMP criteria. The Mainstem gage comparisons can be found in section 3.4.2.5.

3.1.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figures 3.1.1a and 3.1.1b show inundation areas produced by the hydraulic model for the 100-year, 24-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the West Fork reach. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.1.3 Development and Evaluation of Alternatives

3.1.3.1 Modeled Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.1.6 summarizes major problem areas identified through hydraulic modeling of the West Fork.

TABLE 3.1.6
Modeled Problem Definition for the West Fork

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Problem from Table 3.1.3
MPWF1	Between Walters Avenue and Illinois Road	100	NB-FR-12
MPWF2	The Techny Drain just south of Techny Road between the two crossing sets of railroad tracks near the confluence with the West Fork	100	NB-FR-06
MPWF3	The South Navy Ditch and the west overbank of the West Fork between Chestnut Avenue and Lake Avenue	25, 50, 100	GV-FR-06
MPWF4	West overbank of the West Fork between Lake Avenue and Glenview Road	5, 10, 25, 50,100	GV-FR-24
MPWF5	Both overbanks of the West Fork between Glenview Road and Long Valley Road	25, 50, 100	GV-FR-24

Damage Assessment. Damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No recreation damages due to flooding were identified for the West Fork. Transportation damages were estimated as 15 percent of property damages plus $200,000 of Metra RR damages due to erosion. Erosion damages were determined for active erosion problems that threaten structures along the banks of the West Fork. For streambank erosion to qualify as threatening, the erosion must occur within 30 feet of a structure.

TABLE 3.1.7
Estimated Damages for the West Fork

Damage Category	Estimated Damage ($)	Note
Property	197,501,000	Structures at risk of flooding
Erosion - structures	1,350,000	Structures at risk due to erosion
Transportation	29,825,000	Assumed as 15% of property damage due to flooding plus Metra RR transportation damages

3.1.3.2 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in the West Fork subwatershed. Increased regional storage was identified as the principal solution for addressing stormwater problems in the West Fork.

3.1.3.3 Alternative Development

Stormwater improvement alternatives were developed to address regional stormwater problems identified in Table 3.1.3, with the aim of reducing damages due to stormwater.

Flood Control Alternatives. Alternative solutions to regional flooding and streambank erosion problems were developed and evaluated consistent with the methodology described in Section 1.4 of this report. Table 3.1.8 summarizes flood and erosion control alternatives developed for the West Fork. Based on the feedback from watershed communities, a review of previous studies, and a consideration of available open tracts of land, stormwater detention alternatives developed for the West Fork were focused primarily on expanding and optimizing existing regional flood control reservoirs.

TABLE 3.1.8
Flood Control and Erosion Control Alternatives for the West Fork

Alternative	Location	Description
WF-01	The Deerfield (USACE 29A) Reservoir, just south of Lake-Cook Road	Raise the overflow weir at the reservoir in order to utilize the full storage capacity
WF-02	The Dundee Road bridge crossing	Reduce the bridge opening in order to restrict flow and store water upstream of the bridge
WF-03	Between Dundee Road and Cherry Lane along the Milwaukee District North Railroad line	Hard armoring of the east bank for stabilization

TABLE 3.1.8
Flood Control and Erosion Control Alternatives for the West Fork

Alternative	Location	Description
WF-04	The Techny 32A Reservoir, just north of Techny Road	Steepen existing side slopes of reservoir to 3(H):1(V); adds approximately 80 acre-ft of storage
WF-05	The Techny 32A Reservoir, just north of Techny Road	Expand 32A Reservoir into the adjacent Anetsberger Golf Course, in addition to WF-04; adds approximately 995 acre-ft of storage
WF-06	The Techny 32A Reservoir, just north of Techny Road	WF-05 Alternative with alterations to the inlet weir and restrictor barrels in order to fully utilize the additional storage
WF-07	The Techny 32B Reservoir, just north of Willow Road	Expansion of 32B in-line storage
WF-08	The Techny 32B Reservoir, just north of Willow Road	WF-07 plus raising the elevation of the Willow Road dam
WF-09	The Techny 32B Reservoir, just north of Willow Road	Techny 32B dam alteration
WF-10	West Fork stream banks from Willow Road to Chestnut Avenue	Streambank stabilization
WF-11	The Techny 32C Reservoir, just south of Willow Road	Techny 32C expansion into the mobile home park at South Branch Road; adds approximately 700 acre-ft of storage
WF-12	The Techny 32C Reservoir, just south of Willow Road	Techny 32C expansion into Lot 16, an open parcel just south of the reservoir; adds approximately 110 acre-ft of storage
WF-13	The Techny 32C Reservoir, just south of Willow Road	Overflow weir adjustment in order to fully utilize existing storage
WF-14	Along the North and South Navy ditches	Erosion stabilization along both ditches
WF-15	Lake Glenview; east of the North Navy Ditch at Lehigh Ave.	Expand the lake in order to reduce discharge into the North Navy Ditch
WF-16	West Fork banks from Glenview Road to Waukegan Road	Erosion Stabilization along both banks
WF-17	West Fork banks from Glenview Road to Old Orchard Road	Erosion Stabilization along both banks
WF-18	West bank of the West Fork at Long Valley Road	Erosion Stabilization of west bank

TABLE 3.1.8
Flood Control and Erosion Control Alternatives for the West Fork

Alternative	Location	Description
WF-19	The Techny 32C Reservoir, just south of Willow Road	Combination of WF-11 and WF-12 storage alternatives
WF-20	32A location and 32C location	Combination of WF-06 and WF-19 storage alternatives
WF-21	The Techny 32B Reservoir, just north of Willow Road	WF-07 plus expansion into the current 'wetland pods'

Erosion Control Alternatives. Six erosion control alternatives, WF-03, -10, -14, -16, -17, and -18, were investigated for the West Fork in order to address the erosion problems that were reported. Alternative WF-03 was recommended based on infrastructure within 30 feet of active streambank erosion. Alternative WF-03 will provide hard armoring of the east streambank where erosion is occurring. See section 3.1.3.5 below for more detail on WF-03. The armoring is conceptually developed to include costs consistent with traditional approaches to armoring, such as concrete walls. As an alternative to using concrete, there are other hard-armoring erosion protection techniques available to stabilize the West Fork that will give a more natural appearance than concrete. For example, the use of riprap in conjunction with geotextile fabric is a hard-armoring protection alternative that can be designed to provide protection to the streambank while providing a more aesthetically pleasing improvement. The protection treatment will be provided along the existing West Fork alignment along the existing east bank slopes and keyed-in at toe of bank slope.

3.1.3.4 Alternative Evaluation and Selection

WF-01 considered raising the elevation of the overflow spillway on the Deerfield (29A) Reservoir. The elevation was raised from 652 to 654 in order to fully utilize existing storage within the basin. While this alternative did reduce WSELs by 0.35 feet over a few hundred feet of stream length, the amount of storage gained was not significant enough to make an impact on any of the regional flooding problems. This alternative is not recommended.

WF-02 considered reducing the Dundee Road bridge opening from 380 square feet to 75 square feet in order to store water in the adjacent upstream forest preserve. A WSEL decrease of 0.6 feet did occur, but this decrease did not extend downstream far enough to positively impact any of the regional flooding problems. Increases in WSELs occurred upstream of the bridge ended, adversely impacting the Underwriter's Tributary. This alternative is not recommended.

WF-03 considered hard armoring the east bank of the West Fork between Dundee Road and Cherry Lane. There are two segments of erosion protection being proposed, the first is a 450 ft by 70 ft area that protects infrastructure, including utility poles and residences, southwest of Fair Lane. The second area is 30 ft by 970 ft; this segment protects Metra's Milwaukee District North railroad embankment and rail infrastructure and includes utility pole relocations. See Figure 3.1.2 for a conceptual plan of this project. This alternative is recommended.

WF-04 considered steepening the side slopes of the Techny 32A reservoir. The current side slopes are approximately 6H:1V and this alternative would steepen side slopes to 3H:1V in order to gain a minimal amount of additional storage. The alternative adds approximately 80 acre-ft of storage, which doesn't reduce WSELs dramatically. The WF-04 alternative is not recommended by itself, but it has been added on to WF-06.

WF-05 considered expanding the Techny 32A reservoir to the west into Northbrook Park District's Anetsberger Golf Course. A buyout of the golf course, combined with the storage gained from WF-04, would allow for approximately an additional 995 acre-ft of storage to be added to the reservoir. This alternative, as is, did not allow for complete utilization of the additional storage because too much in-stream flow was bypassing the reservoir. This alternative, independently, is not recommended.

WF-06 considered reducing the bypass flow around the Techny 32A reservoir and allowing more flow to enter the reservoir described in alternative WF-05. The restrictor barrels on the east side of the reservoir were reduced from 3-66 inch pipes to 1-66 inch pipe, which allows the flow in the channel to back up and increase flow into the inlet weir. As a part of this alternative, the inlet weir length was increased from 90 feet to 200 feet. This increase in weir length allows for flow to enter the reservoir at a higher rate, while reducing the increase in WSEL upstream of the restrictor barrels. In total, this alternative steepens the existing side slopes to 3:1, expands the 32A reservoir into the Anetsberger Golf Course, removes two restrictor barrels, and extends the inlet weir by 110 feet. These proposed changes reduced WSELs in the MPWF1 through MPWF5 modeled problem areas. While the WSEL reductions do not completely eliminate flood damages in these areas, this alternative does improve the regional flooding situation. See Figure 3.1.3a for a conceptual plan of this project. This alternative is recommended as the most beneficial flood control project to mitigate overbank flooding of the West Fork.

WF-07 considered excavation of open space in the northeast corner of the Techny 32B inline reservoir. The alterative involves excavation of approximately 245 acre-ft of open space. The additional storage yields a range of WSEL reductions with a maximum reduction of just over 0.3 feet. The 0.3 ft WSEL reduction does not extend very far downstream and there are minor reductions in inundation, therefore this alternative is not recommended.

WF-08 considered raising the elevation of the Willow Road Dam, which is the inline weir that restricts flow exiting from the Techny 32B reservoir. Raising this weir by 1.7 feet should allow for increased storage in the reservoir, but flows are high enough to overtop the weir at this revised elevation. Raising the weir increases WSEL upstream of the dam while having no positive downstream impact. This alternative is not recommended.

WF-09 considered raising the elevation of the Willow Road Dam to the maximum elevation allowed by the surrounding topography, with the thought that eliminating weir overtop would reduce flow delivered to the downstream channel. Raising the weir height by approximately 6 feet still does not eliminate weir overtop, and the small decrease in downstream WSELs does not justify the large increase in upstream WSELs with negative impacts to the Techny Drain. This alternative is not recommended.

WF-10 considered erosion stabilization along the West Fork banks from Willow Road to Chestnut Avenue. Field review determined that there were no structures within 30 feet of this active streambank erosion, and therefore, this alternative is not recommended.

WF-11 considered expanding the Techny 32C reservoir east into the mobile home park located at the southeast corner of the reservoir. The proposed expansion would create approximately 700 acre-ft of additional storage. This alternative yields a maximum WSEL decrease of 1.3 feet and it addresses modeled problem areas MPWF3 through MPWF5. Because this alternative does not utilize an open parcel in the vicinity of this reservoir, the mobile home buyout by itself is not ideal. This alternative is not recommended.

WF-12 considered using the “Lot 16” parcel for flood storage by tying it into the Techny 32C reservoir system. Lot 16 is an open parcel located in between the 32C reservoir and the Valley Lo Golf Club; the parcel is owned by the Village of Glenview and is available for use. Excavation of this lot and hydraulically connecting it to the 32C reservoir adds approximately 100 acre-ft of storage to the system. Utilization of Lot 16 only yields a maximum of one-third of a foot in WSEL reduction, and considering the cost of construction, this alternative alone would not be worth the cost. This alternative is not recommended.

WF-13 considered raising the 32C overflow weir. Much like the WF-01 alternative, the WF-13 alternative does reduce downstream WSELs, but does not extend far enough to have any realized impact on problem areas with potential structure damages. This alternative is not recommended.

WF-14 considered erosion stabilization along both banks of the North and South Navy Ditches. A field review of the reported erosion problems found no structures within 30 feet of active bank erosion. This alternative is not recommended.

WF-15 considered a possible expansion of Lake Glenview, which is located just upstream of the North Navy Ditch. The outflow from Lake Glenview is the main source of West Fork inflow downstream of the Techny 32C reservoir. Increasing the storage capacity of this lake and restricting the outflow to the West Fork would reduce WSELs in the lower portion of the reach, but in discussing this alternative with the Village of Glenview, the project was deemed to be infeasible at this time. The area surrounding Lake Glenview is fully developed with commercial and recreational infrastructure surrounding the lake, which would make increasing storage capacity of the lake infeasible from design and construction perspectives. This alternative is not recommended.

WF-16 considered erosion stabilization along both banks of the West Fork from Glenview Road to Waukegan Road. A field review of the reported erosion problems found a recently implemented erosion stabilization project, including but not limited to riprap, geostabilization, seeding, and plantings. Upon coordination with the Village of Glenview, the erosion problem was confirmed as mitigated through a local erosion stabilization project implemented by the Village.

WF-17 considered erosion stabilization along both banks of the West Fork from Glenview Road to approximately Long Valley Road. A field review of the reported erosion problem area found that there were no structures within 30 feet of this active streambank erosion, and therefore, this alternative is not recommended.

WF-18 considered erosion stabilization along the west bank of the West Fork near Long Valley Road. A field review of the reported erosion problem area found one residential structure within 30 feet of bank erosion that appeared to be protected by dumped riprap and not at imminent risk of erosion damage. This erosion problem should continue to be monitored for imminent risk to the residential structure at 1201 Long Valley Drive. Due to lack of imminent risk of erosion damage, this alternative is not recommended at this time.

WF-19 considered combining the 32C Reservoir alternatives, WF-11 and WF-12. This alternative included the buyout and excavation of the Sunset Village mobile home park, as well as the utilization of the "Lot 16" parcel for storage. The approximate 814 acre-ft of storage added yields a maximum WSEL decrease of approximately 1.4 feet. This alternative addresses problem areas MPWF3 through MPWF5, but does not completely resolve flooding in these areas. After DWP cost analysis and generation of B/C ratios, this alternative is not recommended as the most cost effective solution to overbank flooding of the West Fork.

WF-20 considered combining the recommended 32C storage alternative with the recommended 32A storage alternative (WF-06 + WF-19.) Based on inquiries from several communities and subsequent direction from the District, this combined alternative was investigated to determine what additional benefits, if any, would occur with the implementation of both projects. Because neither alternative completely eliminates the modeled problem areas on its own, an attempt was made to combine the relative impacts of each reservoir expansion. The result of the combination of these two alternatives is very similar to the result of the 32A reservoir expansion (WF-06) on its own. The 32A expansion attenuates a large portion of the flow within the West Fork reach until the point in the reach where the North Navy Diversion Ditch combines with the West Fork and increases flow values. The 32C reservoir is located north (upstream) of this confluence, and therefore, does not attenuate the peak flows from the North Navy Diversion Ditch that floods areas downstream. This alternative is listed in the DWP as an alternative due to the requested investigation of this combined solution. However, given the very similar benefits as WF-06 and the subsequent B/C ratio that is much lower than WF-06, the recommendation, from a flood mitigation perspective, is to implement WF-06 in lieu of this combined alternative.

WF-21 considered combining the excavation of open space to the northeast of the Techny 32B inline reservoir (WF-07) with excavation of the three existing wetland pods within the reservoir. The alterative involves excavation of approximately 425 total acre-ft. The additional storage yields a range of WSEL reductions with a maximum reduction of just over 0.6 feet. The WSEL reductions address modeled problem areas MPWF3 through MPWF5; while this alternative does not completely resolve flooding issues at these problem areas, it does have a significant positive impact. However, after DWP cost analysis and generation of B/C ratios, this alternative is not recommended as the most cost effective solution to overbank flooding of the West Fork.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.1.9.A provides a comparison of the modeled maximum WSEL and modeled flow at the time of peak at representative locations along the waterway for the recommended alternative WF-06. Tables 3.1.9.B through 3.1.9.D provide a comparison of the modeled maximum WSEL and modeled flow at the time of peak at representative locations along the waterway for the alternatives that are not recommended and are provided for informational purposes only.

A number of properties are at risk of shallow flooding during the 100-year flood event under existing conditions or recommended alternative conditions. In addition, due to their locations, other properties' risk of flooding cannot be feasibly mitigated by structural measures. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition. These measures may be considered to address damages that are not fully addressed by capital projects recommended in the North Branch of the Chicago River DWP.

Table 3.1.9A provides a comparison of peak flow and stage for existing and proposed conditions for the WF-06 alternative, 32A Reservoir expansion into the Anetsberger Golf Course.

TABLE 3.1.9.A
Recommended Alternative WF-06 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		WF-06	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
West Fork crossing at Techny Road	31035	636.05	1322	634.51	257
West Fork crossing at Willow Road	26572	630.97	1782	629.56	862
West Fork crossing at Chestnut Avenue	18626	628.77	1382	627.05	782
West Fork crossing at East Lake Avenue	15392	627.56	1461	626.22	1002
West Fork crossing at Glenview Road	11870	626.06	1466	624.99	1085
West Fork crossing at Long Valley Road	6664	623.06	1588	622.56	1383
West Fork crossing at Golf Road	1976	622.23	1587	621.74	1329

Table 3.1.9.B provides a comparison of peak flow and stage for existing and proposed conditions for the WF-19 alternative, 32C Reservoir expansion into “Lot 16” parcel and the Sunset Village mobile home park.

TABLE 3.1.9.B
Non-Recommended Alternative WF-19 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		WF-19	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
West Fork crossing at Chestnut Avenue	18626	628.77	1382	627.03	778
West Fork crossing at East Lake Avenue	15392	627.56	1461	626.20	997
West Fork crossing at Glenview Road	11870	626.06	1466	624.98	1080
West Fork crossing at Long Valley Road	6664	623.06	1588	622.55	1377
West Fork crossing at Golf Road	1976	622.23	1587	621.72	1324

Table 3.1.9.C provides a comparison of peak flow and stage for existing and proposed conditions for the WF-20 alternative (WF-06 + WF-19 combined, including reservoir expansions at both Techny 32A + Techny 32C).

TABLE 3.1.9.C
Non-Recommended Alternative WF-20 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		WF-20	
Location	Station	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)
West Fork crossing at Chestnut Avenue	18626	628.77	1382	627.03	778
West Fork crossing at East Lake Avenue	15392	627.56	1461	626.20	997
West Fork crossing at Glenview Road	11870	626.06	1466	624.98	1080
West Fork crossing at Long Valley Road	6664	623.06	1588	622.55	1377
West Fork crossing at Golf Road	1976	622.23	1587	621.72	1324

Table 3.1.9.D provides a comparison of peak flow and stage for existing and proposed conditions for the WF-21 alternative (32B Reservoir expansion into open space and the current wetland pod areas).

TABLE 3.1.9.D
Non-Recommended Alternative WF-21 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		WF-21	
Location	Station	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)
West Fork crossing at Willow Road	26572	630.97	1782	630.80	1613
West Fork crossing at Chestnut Avenue	18626	628.77	1382	628.12	1202
West Fork crossing at East Lake Avenue	15392	627.56	1461	626.83	1272
West Fork crossing at Glenview Road	11870	626.06	1466	625.33	1273
West Fork crossing at Long Valley Road	6664	623.06	1588	622.73	1433
West Fork crossing at Golf Road	1976	622.23	1587	621.93	1411

3.1.3.5 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the alternatives studied in detail. Table 3.1.10 lists the alternatives analyzed in detail; however, only alternatives WF-03 and WF-06 are recommended and the other alternatives are provided for informational purposes only. Figures 3.1.3a, 3.1.3b, 3.1.3c and 3.1.3d show a comparison of existing conditions to alternative conditions 100 year inundation mapping with the implementation of alternatives WF-06, WF-19, WF-20, and WF-21, respectively. Figure 3.1.2 displays the location and approximate extents of the WF-03 erosion control alternative.

TABLE 3.1.10
West Fork Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Water Quality Benefit	Recommended	Communities Involved
WF-03	Hard armoring of east bank along Metra Milwaukee North District RR & Fair Lane between Dundee Road and Cherry Lane	0.77	1,550,000	2,022,000	3	Slightly Positive	Yes	Northbrook
WF-06	Expand Techny 32A reservoir into Anetsberger Golf Course and steepen existing reservoir side slopes to 3H:1V	1.26	146,484,000	116,088,000	216	Slightly Positive	Yes	Northbrook, Glenview, Golf, Unincorporated Cook County
WF-19	Expand Techny 32C into Sunset Village Mobile Home Park and Lot 16	0.32	29,692,000	94,210,000	48	Slightly Positive	No	Glenview, Unincorporated Cook County
WF-20	Combine Techny 32A and 32C reservoir expansions into one project	0.70	146,484,000	210,297,000	216	Slightly Positive	No	Northbrook, Glenview, Golf, Unincorporated Cook County
WF-21	Techny 32B expansion of in-line storage	0.60	30,235,000	50,416,000	101	No Impact	No	Northbrook, Glenview

3.2 Middle Fork of the NBCR

The Middle Fork, the second tributary (from west to east) in the NBCR watershed, has a total stream length of 20.9 miles and a total drainage area of 24.6 square miles. Table 3.2.1 summarizes the land area of communities within the Middle Fork subwatershed. The Middle Fork subwatershed consists primarily of residential areas and includes two large portions of forest preserve area in Cook County. The forest preserve areas in Cook County occur from the I-94 crossing to the Sunset Ridge Road crossing and from Winnetka Road to the confluence with the Skokie River. Table 3.2.2 summarizes the land use distribution within the Middle Fork.

TABLE 3.2.1
Communities Draining to the Middle Fork[1]

Community/Tributary	Tributary Area (mi^2)
Lake Forest	6.60
Unincorporated	4.54
Green Oaks	2.62
Northbrook	2.16
Deerfield	2.09
Northfield	1.95
Waukegan	1.39
Bannockburn	1.23
Highland Park	0.81
Mettawa	0.79
Glenview	0.34
North Chicago	Less than 0.1

[1] Includes communities/area in Lake County

Figure 3.2.1 is an overview of the tributary area of the Middle Fork subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

3.2.1 Sources of Data

3.2.1.1 Previous Studies

Data from the 1998 and 2000 FIS regulatory models (HEC-2) were utilized for supplementing the newly developed DWP HEC-RAS model for the Middle Fork.

TABLE 3.2.2
Land Use Distribution for the Middle Fork[1]

Land Use Category	Area (acres)	%
Residential	7,422	47.2
Forest/Open Land	4,631	29.4
Commercial/Industrial	1,673	10.6
Institutional	573	3.6
Agricultural	561	3.6
Water/Wetland	526	3.3
Transportation/Utility	341	2.2

[1] Includes land use areas in Lake County

3.2.1.2 Water Quality Data

The IEPA has two Ambient Water Quality Monitoring Network sites on the Middle Fork. Two reaches of the Middle Fork are identified as impaired in the IEPA's 2008 Integrated Water Quality Report, which includes the CWA 303(d) and 305(b) lists. No TMDLs have been established for the Middle Fork. TMDLs are currently being developed for dissolved oxygen, chloride, and fecal coliform. According to a water permit discharge query from the USEPA, there are no NPDES permits issued by IEPA for discharges to the Middle Fork. Municipalities discharging to the Middle Fork are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was instituted to improve water quality by requiring that municipalities develop six minimum control measures for limiting runoff pollution to receiving systems.

3.2.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR watershed. Wetland areas were identified using NWI mapping. NWI data includes 120 acres of wetland areas in the Middle Fork tributary area. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provides flood management, habitat, and water quality enhancement. Identified riparian environments offer potential opportunities for restoration.

3.2.1.4 Floodplain Mapping

Flood inundation areas supporting the NFIP were revised in 2008 as a part of FEMA's Map Modernization Program. Floodplain boundaries were revised based upon updated Cook County topographic information, but the effective models used to estimate flood levels generally were not updated. LOMRs were incorporated in the revised floodplains. The effective FIS H&H analysis was performed in 1994. The hydrologic modeling was performed by using HEC-1 and Regression Equation 79; Hydraulic routing was performed using HEC-2.

Appendix A includes a comparison of FEMA's effective floodplain mapping from updated DFIRM panels with inundation areas developed for the DWP.

3.2.1.5 Stormwater Problem Data

Table 3.2.3 summarizes reported problem areas reviewed as a part of the DWP development. The problem area data was obtained primarily from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.2.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.2.1.6 Near-Term Planned Projects

Watershed communities, agencies, and stakeholders were asked about near-term planned projects so that the implementation of near-term flood control projects by others is considered in development of the DWP. No near-term planned flood control projects by others have been identified in the Middle Fork Subwatershed.

TABLE 3.2.3
Community Response Data for the Middle Fork

Problem ID[2]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NF-FL-14	Village of Northbrook, Village of Northfield, Village of Glenview, Unincorp Cook County	Intracommunity (local) flooding	Sunset Ridge Road - East Lake Ave to Skokie Road	36" corrugated metal pipe West Side, 36" C.P. East Side, 1/4 mile North of Rolling Ridge Rd - some debris accumulation at the East end.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NB-FR-11	Village of Highland Park, Village of Northbrook, Village of Deerfield	Intercommunity (regional) flooding	Northbrook Court, Deerfield, Highland Park	Overbank flooding, storm sewer flow restriction, insufficient river capacity. Regional detention at Northbrook Court fills/backs up river to overflowing. Stream rises into street inlets, street floods	Regional	Regional stormwater solution MF- 03 was investigated but deemed infeasible. Impacted structures would require flood proofing and/or acquisition
NF-FR-15	Village of Northfield, Unincorp Cook County	Intercommunity (regional) flooding	Winnetka Road - Wagner Road to Happ Road	CCHD reported that the creek floods the surrounding property in this area.	Regional	Regional stormwater solution MS-14 addresses overbank flooding of the Middle Fork along Winnetka Road.
NB-ER-01	Village of Northbrook	Streambank erosion on intercommunity waterways	Middle Fork adjacent to properties on Red Coach Lane	Red Coach Lane - Bank erosion and sedimentation. There is severe erosion along the east bank of the Middle Fork NBCR adjacent to the properties on Red Coach Lane.	Regional	The recommended alternative for this problem is MF-06.

TABLE 3.2.3
Community Response Data for the Middle Fork

Problem ID[2]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NB-FR-02	Village of Northbrook	Intercommunity (regional) flooding	Illinois Route 68 at Waukegan Road to Lee Street / Shermer Road	IDOT Pavement Flooding	Regional	IL Route 68 pavement flooding depth due to overbank flooding is less than 0.5 ft. Based on DWP criteria, no alternative recommended for minor roadway flooding.
NB-FR-03	Village of Northbrook	Intercommunity (regional) flooding	Dundee at Timber Lane	IDOT Pavement Flooding	Regional	Modeled and DFIRM inundation areas do not impact this reported location. Problem appears to be a local storm sewer problem.
NB-ER-21	Village of Northbrook	Streambank erosion on intercommunity waterways	Pebblebrook Rd	Regional erosion occurring greater than 30 ft from residences on west and east streambanks	Regional	Erosion problem not immediately threatening structure. Not addressed by DWP
NF-FR-01	Village of Northfield	Intercommunity (regional) flooding	N Bristol & Robin Hood Lane	Willow Hill Condos - Basement and local road flooding due to overbank flooding	Regional	Regional stormwater solution MF-05 was investigated but deemed infeasible due to minimal impact on flooding. Recommend floodproofing and/or acquisition

TABLE 3.2.3
Community Response Data for the Middle Fork

Problem ID[2]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NF-ER-02	Village of Northfield	Intercommunity (regional) flooding	Robin Hood Lane	Complaints about bank erosion/scouring along the North Branch of the Chicago River along Robin Hood Land.	Regional	The recommend alternative for this problem is MF-06.
NF-ER-03	Village of Northfield	Streambank erosion on intercommunity waterways	Meadowbrook Drive to Sunset Lane	Regional erosion occurring within 30 ft of residences and utility poles on west and east streambanks.	Regional	The recommended alternative for this problem is MF-07.
NF-ER-04	Village of Northfield	Streambank erosion on intercommunity waterways	2094 Middle Fork Road	Regional erosion occurring within 30 ft of residence on the west stream bank.	Regional	Erosion problem not immediately threatening structure. Not addressed by DWP
NF-ER-05	Village of Northfield	Streambank erosion on intercommunity waterways	Willow Road to Abbot Court	Regional erosion occurring within 30 ft of residences on the west and east streambanks immediately south of Willow Road.	Regional	The recommended alternative for this problem is MF-07.
NF-ER-17	Village of Northfield	Streambank erosion on intercommunity waterways	North of Winnetka Road along West side of Northfield Road	Streambank Erosion within 30ft of Northfield Road	Regional	The recommended alternative for this problem is MF-07.
NF-FL-18	Village of Northfield	Intracommunity (local) flooding	Illinois Route 43 at Willow Road to Winnetka Road	IDOT Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NF-FR-07	Village of Northfield	Intercommunity (regional) flooding	Interstate Rt 94 at Winnetka Ave to Skokie Road	IDOT Pavement Flooding	Regional	The recommended alternative for this problem is SR-08.

TABLE 3.2.3
Community Response Data for the Middle Fork

Problem ID[2]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NF-FL-06	Village of Northfield	Intracommunity (local) flooding	East Wagner Road, South of Willow	Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NF-FR-08	Village of Northfield	Intercommunity (regional) flooding	South side of Willow Road over Middle Fork	Basement and local flooding due to Overbank flooding	Regional	Regional stormwater solution MF-05 was investigated but deemed infeasible due to minimal impact on flooding. Recommend floodproofing and/or acquisition
NF-FR-09	Village of Northfield	Intercommunity (regional) flooding	North side of Willow Road over Middle Fork	Basement and local flooding due to Overbank flooding	Regional	Regional stormwater solution MF-05 was investigated but deemed infeasible due to minimal impact on flooding. Recommend floodproofing and/or acquisition

[1] All Problem IDs begin with NB-MFNB- as all problems are within the North Branch – Middle Fork subwatershed.

3.2.2 Watershed Analysis

3.2.2.1 Hydrologic Model Development

Subbasin Delineation. The Middle Fork tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The watershed boundaries of the West Fork (western edge) and Skokie River (eastern edge) were compared, and discrepancies were identified. Discrepancies generally were minor and resolved by manual review of topographic data.

Hydrologic Parameter Calculations. Curve Numbers (CNs) were estimated for each subbasin based upon NRCS soil data and 2001 CMAP land use data. This method is further described in Section 1.3.2, with lookup values for specific combinations of land use and soil data presented in Appendix C. An area-weighted average of the CN was generated for each subbasin. The Clark unit hydrograph method was used to convert SCS CN runoff volumes into subbasin-specific hydrographs. Time of concentration (Tc) and storage coefficient (R) parameters for the Clark unit hydrograph method were estimated as described in Section 1.3.2. Appendix G provides a summary of the hydrologic parameters used for subbasins in each subwatershed.

3.2.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met the District criteria for use in the DWP, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Field surveys of the Middle Fork and bridge crossings were performed to characterize the channel and near overbank geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the field surveyed channel cross sections. Field visits were performed to assess channel and overbank roughness characteristics, which were combined with information from photographs and aerial photography to assign modeled Manning's *n* roughness coefficients along the modeled stream length.

Boundary Conditions. The downstream boundary condition for the Middle Fork is its confluence with the Skokie River as the two reaches form the Mainstem of the NBCR. The unsteady model produces water surface elevations at each time step, therefore providing a downstream boundary condition at each time step of the simulation. The maximum existing conditions 100 year WSEL at this junction is 624.18 feet in vertical elevation datum NAVD 88.

Subbasin Delineation. The Middle Fork tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The watershed boundaries of the West Fork (western edge) and Skokie River (eastern edge) were compared, and discrepancies were identified. Discrepancies generally were minor and resolved by manual review of topographic data.

3.2.2.3 Calibration and Verification

Observed Data. As in shown in Figure 2.3.1, three thiessen polygons, based on three different precipitation gages, allow for complete coverage of the Middle Fork subwatershed. The northernmost thiessen polygon is based on the LCSMC "Riverwoods" gage; the middle and lower portions of the Middle Fork are covered by CCPN gages 1 and 2, respectively. Data for the September 2008 and October 2001 storms were referenced for calibration and verification of the hydrologic and hydraulic models.

The only USGS stream gage on the Middle Fork, gage number 05534500, is located at the county line on the Lake-Cook Road Bridge. Supplemental information on this stream gage can be found in Table 2.3.1. Peak flow information for the calibration and verification events can be found in Table 3.2.4. Because the USGS gage is outside of the limits of the hydraulic study area, HEC-HMS hydrographs were used for comparison to the gage hydrographs.

TABLE 3.2.4
Flow Events at USGS gage 05534500

Date	Peak Monitored Flow (cfs)
9/13/2008	727
10/13/2001	787

Figure 3.2A shows superimposed comparisons of the HEC-HMS and USGS gage hydrographs (river gage 05534500) at the gage location for the 2008 event. Figure 3.2B shows these same hydrographs for the 2001 event.

FIGURE 3.2A
Middle Fork flow comparison for September 13, 2008 storm

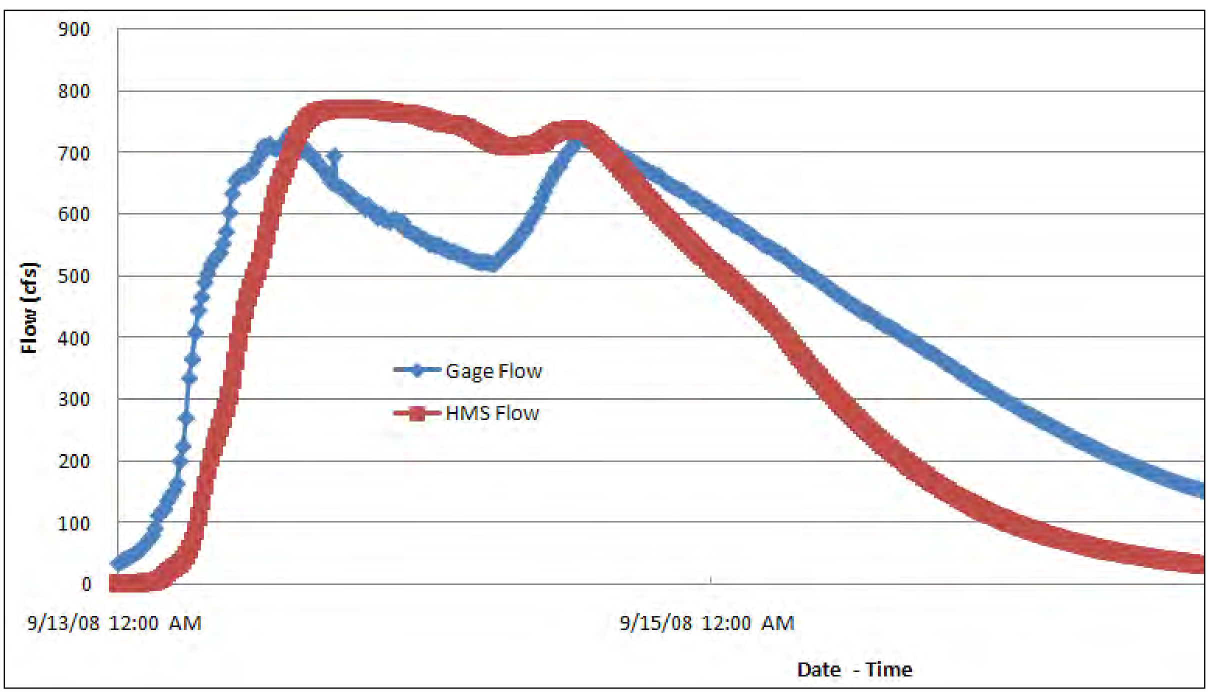
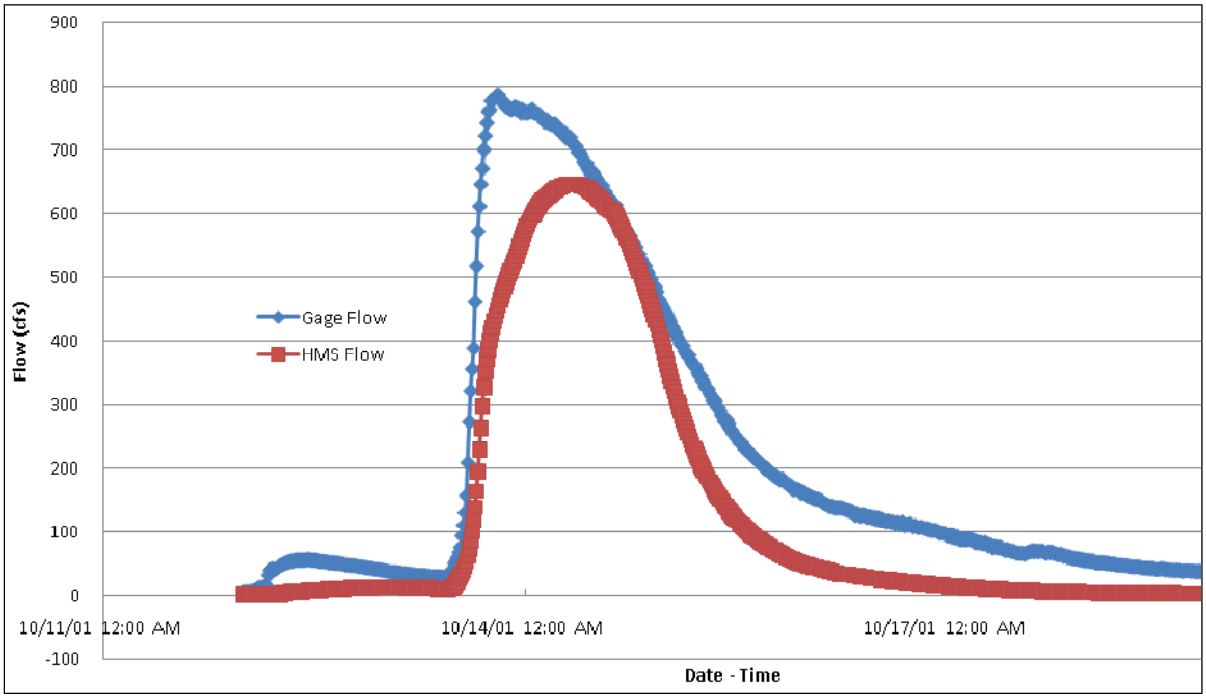


FIGURE 3.2B
Middle Fork flow comparison for October 13, 2001 storm



Calibration Results. With the results of the HEC-HMS and gage hydrograph comparisons being similar with regard to flow, volume, and hydrograph shape, no modifications were made to the upstream hydrology; the difference between the observed and calibrated model flows and water surface elevations were generally considered to be within an acceptable margin of error. Flow, volume, and stage were checked at the Mainstem gages at Touhy Avenue and Albany Avenue, in order to verify the model met CCSMP criteria. The Mainstem gage comparisons can be found in section 3.4.2.5.

3.2.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.2.1 shows inundation areas produced by the hydraulic model for the 100-year, 24-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the West Fork reach. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.2.3 Development and Evaluation of Alternatives

3.2.3.1 Modeled Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.2.5 summarizes major problem areas identified through hydraulic modeling of the Middle Fork.

TABLE 3.2.5
Modeled Problem Definition for the Middle Fork

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Problem from Table 3.2.3
MPMF1	Northbrook Court Mall parking lot just south of Lake-Cook Road	100	
MPMF2	The Fairview Acres subdivision just southeast of I-94	50, 100	
MPMF3	Roadway inundation at the Dundee Road and Lee Road intersection due to overbank flooding	50, 100	NB-FR-02
MPMF4	Just upstream of the Sunset Ridge Road crossing	50, 100	
MPMF5	Meadowbrook Drive to Old Willow Road	25, 50, 100	
MPMF6	New Willow Road to Winnetka Road	100	

3.2.3.2 Damage Assessment

TABLE 3.2.6
Estimated Damages for the Middle Fork

Damage Category	Estimated Damage ($)	Note
Property	10,805,000	Structures at risk of flooding
Erosion - structures	8,876,000	Structures at risk due to erosion
Transportation	1,736,000	Assumed as 15% of property damage due to flooding plus Northfield Road damage

Damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No recreation damages due to flooding were identified for the Middle Fork. Transportation damages were estimated as 15 percent of property damages plus $115,000 of Northfield Road damages due to erosion. Erosion damages were determined for active erosion problems that threaten structures along the banks of the Middle Fork. For streambank erosion to qualify as threatening, the erosion must occur within 30 feet of a structure.

3.2.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in the Middle Fork subwatershed. Increased regional storage was identified as the principal solution for addressing stormwater problems in the Middle Fork.

3.2.3.4 Alternative Development

Stormwater improvement alternatives were developed to address regional stormwater problems identified in Table 3.2.3, with the aim of reducing damages due to stormwater.

Flood Control Alternatives. Alternative solutions to regional flooding and streambank erosion problems were developed and evaluated consistent with the methodology described in Section 1.4 of this report. Table 3.2.7 summarizes flood and erosion control alternatives developed for the Middle Fork.

TABLE 3.2.7
Flood Control and Erosion Control Alternatives for the Middle Fork

Alternative	Location	Description
MF-01	200-400 Red Coach Lane	Erosion Stabilization on the east bank of the Middle Fork, along Red Coach Lane
MF-02	The Middle Fork Reservoir , located between the Northbrook Court Mall and I-94	Raise the reservoir overflow weir
MF-03	The Middle Fork Reservoir , located between the Northbrook Court Mall and I-94	Expand the NB Court Reservoir into southern portion of the NB Court mall parking lot; adds approximately 200 acre-ft of storage
MF-04	Rosemary Lane and Waters Edge Lane, just southeast of I-94	Construct a short levee along the east bank of the Middle Fork to prevent overbank flooding into the Fair Acres/Waters Edge subdivision
MF-05	Forest Preserve just upstream of the Dundee Road crossing	Add a new regional flood control reservoir at this location; approximately 600 acre-ft of new storage
MF-06	Robin Hood Lane, just upstream of the New Willow Road crossing	Erosion stabilization along both banks upstream and downstream of New Willow Road
MF-07	Meadowbrook Drive crossing	Erosion stabilization along both banks from upstream of Meadowbrook Drive to Sunset Drive
MF-08	Middlefork Road crossing	Erosion stabilization along the west bank, south of Middlefork Road

Erosion Control Alternatives. Four erosion control alternatives, MF-01, -06, -07, and -08 were investigated for the Middle Fork in order to address the erosion problems that were reported. Alternatives MF-06 and MF-07 are recommended based on infrastructure at imminent risk of erosion damage due to structure being within 30 feet of active streambank erosion. Alternative MF-06 will provide hard armoring of the southern streambank where erosion is occurring. Alternative MF-07 will provide hard armoring of both streambanks where erosion is occurring. The armoring is conceptually developed to include costs consistent with traditional approaches to armoring, such as concrete walls. As an alternative to using concrete, there are other hard-armoring erosion protection techniques available to stabilize the Middle Fork that will give a more natural appearance than concrete. For example, the use of riprap in conjunction with geotextile fabric is a hard-armoring protection alternative that can be designed to provide protection to the streambank while providing a more aesthetically pleasing improvement. The protection treatment will be provided along the existing Middle Fork alignment along the existing east bank slopes and keyed-in in at toe of bank slope.

3.2.3.5 Alternative Evaluation and Selection

MF-01 considered hard armoring the east bank of the Middle Fork along the length of Red Coach Lane. A field review determined that there are no structures within 30 feet of this stream bank erosion, and therefore, this alternative is not recommended.

MF-02 considered raising the elevation of the overflow spillway on the Northbrook Court (Middle Fork) Reservoir. The elevation was raised from 649.3 to 651.5 in order to fully utilize existing storage within the basin. While this alternative did reduce WSELs by 0.18 feet over a few hundred feet of stream length, the amount of storage gained was not significant enough to make an impact on any of the regional flooding problems. This alternative is not recommended.

MF-03 considered expanding the Northbrook Court Reservoir to the north past Northbrook Court Drive and into a portion of the south parking lot. This alternative added 200 acre-ft of additional storage to the reservoir, and reduced WSELs by 0.42 feet, but the reductions spanned very few cross sections downstream and were negligible downstream of the I-94 crossing. This alternative is not recommended.

MF-04 considered constructing a levee on the east bank of the Middle Fork downstream of I-94, just west of Rosemary Lane and Waters Edge Lane. The levee has a maximum height of 2.5 ft. and it protects the Fair Acres/Waters Edge subdivision from overbank flooding during a 100 year design event. See Figure 3.2.2 for a conceptual plan of this project. This alternative is a feasible solution to modeled problem MPMF2, and is recommended.

Because other evaluated alternatives were unable to resolve model problems MPMF3 through MPMF6, alternative MF-05 considered constructing a new regional flood control reservoir on Cook County Forest Preserve. The proposed 600 acre-ft reservoir would be located just northwest of the intersection of Lee Road and Dundee Road, on the west side of the Middle Fork. The reservoir decreases WSELs by 0.27 feet over a short length of stream reach; this decrease does not have much positive impact on the modeled problem areas. This alternative is not recommended. Furthermore, levee projects in these modeled problem areas are not feasible due to the dense development that makes compensatory storage impractical. As such, roadways affected by Middle Fork overbank flooding would need to be raised to eliminate flooding from the Middle Fork and infrastructure affected by Middle Fork overbank flooding would require flood proofing and/or acquisition.

MF-06 considered erosion stabilization on the west bank of the Middle Fork, along Robin Hood Lane, from Bristol Avenue to Abbott Court, and on the east bank from 200 feet upstream of New Willow Road down to Abbott Court. Additionally, this alternative considered erosion stabilization repair along the east bank of the Middle Fork along Northfield Road immediately north of Winnetka Road. This alternative protects structures along each bank that are within 30 feet of the active streambank erosion. See Figure 3.2.3 for a conceptual plan of this project. This alternative is recommended.

MF-07 considered erosion stabilization on the west bank of the Middle Fork from 300 feet upstream of Meadowbrook Drive to approximately 400 feet downstream of Meadowbrook Drive and on the east bank from 200 feet upstream of Meadowbrook Drive downstream to Sunset Drive. This alternative protects structures along each bank that are within 30 feet of active streambank erosion. See Figure 3.2.4 for a conceptual plan of this project. This alternative is recommended.

MF-08 considered 340 feet of erosion stabilization on the west bank of the Middle Fork starting just downstream of Middlefork Road and running along the 2094 Middle Fork Road property. A field review of the reported erosion problem area found one residential structure within 30 feet of bank erosion, but was not at imminent risk of erosion damage. This erosion problem should continue to be monitored for imminent risk to the residential structure at 2094 Middle Fork Road. Due to lack of imminent risk of erosion damage, this alternative is not recommended at this time.

A number of properties are at risk of shallow flooding during the 100-year flood event under existing conditions or recommended alternative conditions. In addition, due to their locations, other properties' risk of flooding cannot be feasibly mitigated by structural measures. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition. These measures may be considered to address damages that are not fully addressed by capital projects recommended in the NBCR River DWP.

3.2.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the alternatives studied in detail. Table 3.2.8 lists the alternatives analyzed in detail. Figure 3.2.2 shows a comparison of existing conditions to alternative conditions 100 year inundation mapping with the implementation of alternative MF-04. Figures 3.2.3 and 3.2.4 display the locations and approximate extents of the MF-06 and MF-07 alternatives, respectively.

TABLE 3.2.8
Middle Fork Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Water Quality Benefit	Recommended	Communities Involved
MF-04	Construct flood wall and compensatory storage to eliminate overbank flooding in this area	0.12	178,000	1,495,000	4	None	Yes	Northbrook, Unincorporated Cook County
MF-06	Hard armor both stream banks at Willow Road, along Robin Hood Lane, and east bank along Northfield Road	4.59	7,391,000	1,610,000	7	Slightly Positive	Yes	Northfield
MF-07	Hard armor both stream banks at Meadowbrook Drive	1.65	1,600,000	971,000	3	Slightly Positive	Yes	Northfield

3.3 Skokie River

The Skokie River, the eastern most tributary in the NBCR watershed, has a total stream length of 36.8 miles and a total drainage area of 35.3 square miles. Table 3.3.1 summarizes the land area of communities within the Skokie River subwatershed. The Skokie River subwatershed consists primarily of residential areas and includes a large portion of forest preserve area located in the central portion of the subwatershed. Table 3.3.2 summarizes the land use distribution within the Skokie River.

Figure 3.3.1 shows an overview of the tributary area of the Skokie River subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

3.3.1 Sources of Data

3.3.1.1 Previous Studies

Data from the 1998 and 2000 FIS regulatory models (HEC-2) were utilized for supplementing the newly developed DWP HEC-RAS model for the Skokie River.

3.3.1.2 Water Quality Data

The Illinois Environmental Protection Agency (IEPA) has two Ambient Water Quality Monitoring Network sites on the Skokie River. Two reaches of the Skokie River are identified as impaired in the IEPA's 2008 Integrated Water Quality Report, which includes the CWA 303(d) and 305(b) lists. No TMDLs have been established for the Skokie River. TMDLs are currently being developed for dissolved oxygen and fecal coliform. According to a water permit discharge query from the USEPA, there are no NPDES permits issued by IEPA for discharges to the Skokie River. Municipalities discharging to the Skokie River are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was instituted to improve water quality by requiring that municipalities develop six minimum control measures for limiting runoff pollution to receiving systems.

TABLE 3.3.1
Communities Draining to the Skokie River[1]

Community/Tributary	Tributary Area (mi^2)
Highland Park	7.59
Lake Forest	5.17
North Chicago	3.12
Wilmette	3.03
Winnetka	2.49
Unincorporated	3.50
Glencoe	1.91
Waukegan	1.79
Lake Bluff	1.55
Northbrook	1.38
Skokie	1.34
Northfield	1.08
Park City	0.76
Highwood	0.26
Gurnee	0.17
Evanston	0.13
Glenview	Less than 0.1
Kenilworth	Less than 0.1

[1] Includes communities/area in Lake County

TABLE 3.3.2
Land Use Distribution for the Skokie River[1]

Land Use Category	Area (acres)	%
Residential	9,949	44.0
Forest/Open Land	6,588	29.1
Commercial/Industrial	2,879	12.7
Transportation/Utility	1,205	5.3
Institutional	1,116	4.9
Water/Wetland	659	2.9
Agricultural	216	1.0

[1] Includes land uses in Lake County

3.3.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR Watershed. Wetland areas were identified using NWI mapping. NWI data includes approximately 747 acres of wetland areas in the Skokie River tributary area. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provides flood management, habitat, and water quality enhancement. Identified riparian environments offer potential opportunities for restoration.

3.3.1.4 Floodplain Mapping

Flood inundation areas supporting the NFIP were revised in 2008 as a part of FEMA's Map Modernization Program. Floodplain boundaries were revised based upon updated Cook County topographic information, but the effective models used to estimate flood levels generally were not updated. LOMRs were incorporated in the revised floodplains. The effective FIS H&H analysis was performed in 1980. The hydrologic modeling was performed by using HEC-1 and hydraulic modeling was performed using both HEC-2 and FEQ.

Appendix A includes a comparison of FEMA's effective floodplain mapping from updated DFIRM panels with inundation areas developed for the DWP.

3.3.1.5 Stormwater Problem Data

Table 3.3.3 summarizes reported problem areas reviewed as a part of the DWP development. The problem area data was obtained primarily from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.3.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.3.1.6 Near-Term Planned Projects

Watershed communities, agencies, and stakeholders were asked about near-term planned projects so that the implementation of near-term flood control projects by others is considered in development of the DWP. Several studies are currently underway in the Skokie River Subwatershed; however, no near-term planned flood control projects by others have been identified in the Skokie River subwatershed.

TABLE 3.3.3
Community Response Data for the Skokie River

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GC-FL-02	Village of Glencoe	Intracommunity (local) flooding	Dundee Road storm sewer (60" dia Sewer)	Dundee Road storm sewer. Most flooding localized to intersections and private properties	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NF-FR-16	Unincorp Cook County, Village of Northfield	Intercommunity (regional) flooding	Village of Northfield, Unincorporated Cook County	Unincorporated Cook County on Skokie River. Downstream overbank flooding due to inefficient use of storage.	Regional	The recommended alternative for this problem is MS-14.
NB-FL-18	Village of Northbrook	Intracommunity (local) flooding	Interstate Route 94 (Edens) at Lake Cook Road	IDOT Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NF-FR-10	Village of Northfield	Intercommunity (regional) flooding	Interstate Route 94 (Edens) at Skokie River	IDOT Pavement Flooding	Regional	The recommended alternative for this problem is MS-14.
NF-FR-19	Village of Northfield	Intercommunity (regional) flooding	From Willow Road heading south to I-94	Overbank Flooding	Regional	The recommended alternative for this problem is MS-14.
WK-FL-02	Winnetka	Intracommunity (local) flooding	Skokie Ditch	Flooding due to poorly defined overflow routes and inadequate capacity of Skokie Ditch storm sewers.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.3.3
Community Response Data for the Skokie River

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NB-FL-04	Village of Northbrook	Intracommunity (local) flooding	Illinois Route 68 at Interstate Route 94 (E/O @ Skokie Boulevard)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NB-FL-05	Village of Northbrook	Intracommunity (local) flooding	Interstate Route 94 (Edens) at Il Route 68 (Dundee Road)	IDOT Pavement Flooding	Local	The recommended alternative for this problem is MS-14.
NF-FR-13	Village of Northfield	Intercommunity (regional) flooding	Interstate Route 94 (Edens) at Willow Road (NB & SB)	Interstate Rt 94 (Edens) at Willow Rd (NB + SB) Pavement flooding	Regional	This DWP includes one recommended regional flood control alternative that addresses this problem: MS-14.
NF-FL-11	Village of Northfield	Intracommunity (local) flooding	Willow Road from Happ Road to Interstate Route 94	IDOT Pavement Flooding Willow Rd from Happ Rd to Interstate Rt 94 Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NF-FL-12	Village of Northfield	Intracommunity (local) flooding	Willow Road at Central Ave Pavement flooding	IDOT Pavement Flooding Willow Rd at Central Ave Pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

[1] All Problem IDs begin with NB-SKRV-, NB-SKWD-, or NB-SKED- as all problems are within the North Branch – Skokie River (Skokie River, Skokie West Ditch, or Skokie East Ditch) subwatershed.

3.3.2 Watershed Analysis

3.3.2.1 Hydrologic Model Development

Subbasin Delineation. The Skokie River tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The watershed boundaries of LM (eastern edge) and the Middle Fork (western edge) were compared, and any discrepancies were resolved.

Hydrologic Parameter Calculations. Table 3.3.4 summarizes the total drainage area, number of modeled subbasins, and average subbasin size for Skokie River and its major tributaries. CNs were estimated for each subbasin based upon NRCS soil data and 2001 CMAP land use data. This method is further described in Section 1.3.2, with lookup values for specific combinations of land use and soil data presented in Appendix C. An area-weighted average of the CN was generated for each subbasin. The Clark unit hydrograph method was used to convert SCS CN runoff volumes into subbasin-specific hydrographs. Time of concentration (Tc) and storage coefficient (R) parameters for the Clark unit hydrograph method were estimated as described in Section 1.3.2. Appendix G provides a summary of the hydrologic parameters used for subbasins in each subwatershed.

TABLE 3.3.4
Skokie River System Subbasin Summary

Subbasin	Drainage Area (mi^2)	Number of Modeled Subbasins	Average Modeled Subbasin Size (acres)
Skokie River	13.41	13	660
Major Tributaries to Skokie River			
East Ditch	2.82	2	904
West Ditch	2.22	3	474

3.3.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met the District criteria for use in the DWP, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Field surveys of the Skokie River and bridge crossings were performed to characterize the channel and near overbank geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the field surveyed channel cross sections. Field visits were performed to assess channel and overbank roughness characteristics, which were combined with information from photographs and aerial photography to assign modeled Manning's *n* roughness coefficients along the modeled stream length.

Boundary Conditions. The downstream boundary condition for the Skokie River is the stage of the confluence of Middle Fork and the Skokie River. The unsteady model produces water surface elevations at each time step, therefore providing a downstream boundary condition at each time step of the simulation. The maximum existing conditions 100 year WSEL at this junction is 624.18 feet in vertical elevation datum NAVD 88.

3.3.2.3 Calibration and Verification

Observed Data. As in shown in Figure 2.3.1, two thiessen polygons, based on two different precipitation gages, allow for complete coverage of the Skokie River subwatershed. The bulk of the watershed is covered by CCPN gage number 2, and a few subbasins in the southern portion of the watershed are covered by CCPN gage number 4. Data for the September 2008 and October 2001 storms were gathered for calibration and verification of the hydrologic and hydraulic models.

The only USGS stream gage on the Skokie River, gage number 05535070, is located approximately 2500 feet upstream of the Lake/Cook county line at the Clavey Road crossing. Supplemental information on this stream gage can be found in Table 2.3.1. Peak flow information for the calibration and verification events can be found in Table 3.3.5. Because the USGS gage is outside of the limits of the hydraulic study area, HEC-HMS hydrographs were used for comparison to the gage hydrographs.

TABLE 3.3.5
Flow Events at USGS gage 05535070

Date	Peak Monitored Flow (cfs)
9/13/2008	1150
10/14/2001	1230

Figure 3.3A shows superimposed comparisons of the HEC-HMS and USGS gage hydrographs (river gage 05535070) at the gage location for the 2008 event. Figure 3.3B shows these same hydrographs for the 2001 event.

FIGURE 3.3A
Skokie River flow comparison for September 13, 2008 storm

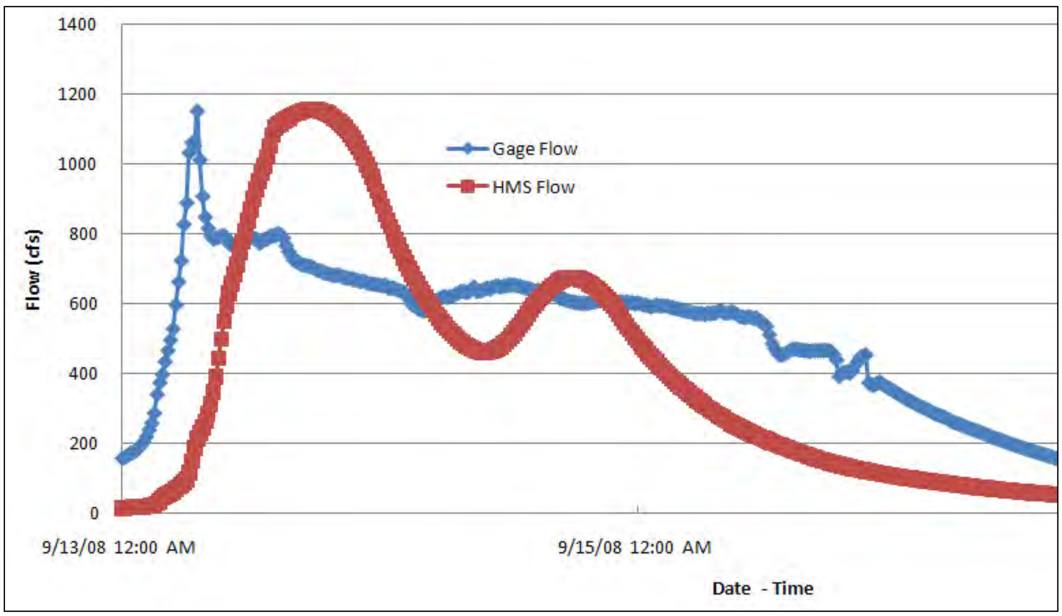
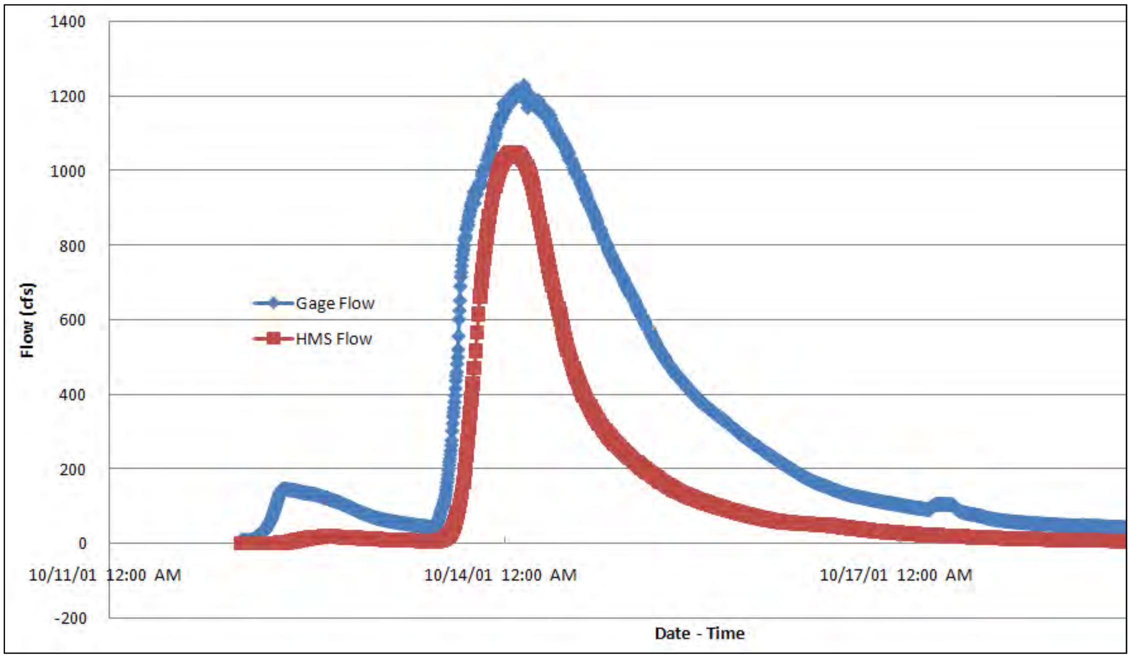


FIGURE 3.3B
Skokie River flow comparison for October 14, 2001 storm



Calibration Results. The September 2008 comparison shown in Figure 3.3A displays a difference in hydrograph shape. The irregular shape of the gage hydrograph is most likely due to either a blockage issue that is causing temporary storage and a reduced flow rate, or an issue with the gage recording itself. Although the September 2008 gage hydrograph could not be duplicated with traditional calibration techniques, the hydrographs compare well for flow and volume. With the results of the HEC-HMS and gage hydrograph comparisons for both events being similar with regard to flow and volume, no modifications were made to the upstream hydrology; the difference between the observed and calibrated model flows and water surface elevations were generally considered to be within an acceptable margin of error. Flow, volume, and stage were checked at the Mainstem gages at Touhy Avenue and Albany Avenue, in order to verify the model met CCSMP criteria. The Mainstem gage comparisons can be found in section 3.4.2.3.

3.3.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.3.1 shows inundation areas produced by the hydraulic model for the 100-year, 24-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the Skokie River reach. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.3.3 Development and Evaluation of Alternatives

3.3.3.1 Modeled Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.3.6 summarizes major problem areas identified through hydraulic modeling of the Skokie River.

TABLE 3.3.6
Modeled Problem Definition for the Skokie River

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Problem from Table 3.3.3
MPSK1	East Ditch from Tower to Willow Road	10, 25 50, 100	
MPSK2	Both banks of SKRV from Willow Road to Happ Road	10, 25, 50, 100	
MPSK3	I-94 underpass @ Willow Road	100	NF-FR-13
MPSK4	SKRV crossing @ I-94	50, 100	NF-FR-10

3.3.3.2 Damage Assessment

Damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No recreation damages due to flooding were identified for the Skokie River. Transportation damages were estimated as 15 percent of property damages plus I-94 (Edens Expressway) damages of $7,760,000. No erosion damages were reported for this reach.

TABLE 3.3.7
Estimated Damages for the Skokie River

Damage Category	Estimated Damage ($)	Note
Property	37,041,000	Structures at risk of flooding
Transportation	13,316,000	Assumed as 15% of property damage due to flooding plus I-94 transportation damage

3.3.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in the Skokie River subwatershed. Increased regional storage was identified as the principal solution for addressing stormwater problems in the Skokie River.

3.3.3.4 Alternative Development

Stormwater improvement alternatives were developed to address regional stormwater problems identified in Table 3.3.3, with the aim of reducing damages due to stormwater.

Flood Control Alternatives. Alternative solutions to regional flooding problems were developed and evaluated consistent with the methodology described in Section 1.4 of this report. Table 3.3.8 summarizes flood control alternatives developed for the Skokie River. Based on the feedback from watershed communities, a review of previous studies, and a consideration of available open tracts of land, regional flood control alternatives focused on optimizing existing flood control infrastructure and development of a new reservoir.

TABLE 3.3.8
Flood Control and Erosion Control Alternatives for the Skokie River

Alternative	Location	Description
SR-01	I-94 at Voltz Road (due west of the Skokie Country Club)	Construct a new reservoir on a tract of high ground adjacent to the West Ditch of the Skokie River. The 480 acre-ft facility would store water from the West Ditch.
SR-02	I-94 at Voltz Road (due west of the Skokie Country Club)	Construct a new reservoir on a tract of high ground adjacent to the Skokie River/Lagoons. The 480 acre-ft facility would store water from the Skokie River/Lagoons.
SR-03	East Ditch at Tower Road and Forestway Drive	Redirect the East ditch under Forestway Drive and into the Skokie Lagoons
SR-04	Tower Road Dam, Glencoe Road Dam	Relocation of the Tower Road Dam and lowering of the Glencoe Road Dam
SR-05	Willow Road Dam, just north of the Skokie River crossing at Willow Road	Reduce the number of high flow gates from 7 to 3
SR-06	Willow Road Dam, just north of the Skokie River crossing at Willow Road	Remove the low flow gate
SR-07	Willow Road Dam, just north of the Skokie River crossing at Willow Road	Remove all 8 of the current gates and replace them with 1 small gate
SR-08	I-94 (Edens Expressway) at Winnetka Road	Construct 2 levees, one on each side of the I-94 underpass at Winnetka Road

Erosion Control Alternatives. No regional erosion problems were reported for the Skokie River, therefore, no erosion control alternatives are recommended.

3.3.3.5 Alternative Evaluation and Selection

SR-01 considered constructing a regional flood control reservoir on a tract of land located between the Skokie River and I-94. This 480 acre-ft facility would store water from the West Diversion Ditch which runs parallel to the Skokie River from Dundee Road to Willow Road. This alternative does reduce WSELs by 0.74 feet, but this reduction occurs over only a few hundred feet of the West Ditch. Because the reservoir does not address any of the modeled problem areas, this alternative is not recommended.

SR-02 considered constructing the reservoir from SR-01 and using it to store flow from the Skokie River instead of the West Ditch. Through analysis of the hydraulic model, it was determined that the primary source of flooding in the Skokie River Watershed is a backwater effect stemming from the confluence of Skokie River and the Middle Fork. The storage gained from this alternative does not have an impact on the backwater issue and does not resolve any of the modeled problem areas. This alternative is not recommended.

SR-03 considered redirecting the East Diversion Ditch into the Skokie Lagoons with the thought that flow from the East Ditch would be stored in the Lagoons as opposed to in the large eastern floodplain. Currently, the headwater of the East Ditch is located approximately 2,100 feet south of Lake-Cook Road; the reach flows parallel to the Skokie

River until it combines with the Skokie River just north of Willow Road. SR-03 proposes rerouting the east ditch westward into the Skokie Lagoons just upstream of Tower Road in order to reduce inundation downstream of this point. A review of the hydraulic model shows this alternative to be ineffective for 2 reasons: 1) the stage of the Skokie Lagoons is higher than that of the East Ditch causing water to backflow into the East Ditch and 2) The Skokie River backwater impact still causes flooding on the East Ditch south of Tower Road. This alternative has no positive impact and is not recommended.

SR-04 considered relocating the Tower Road Dam from its location upstream of the Skokie Lagoons reach to a new location downstream of the confluence of the Skokie River and the Skokie Lagoons. The relocation would be accompanied by raising the elevation of the dam by two feet. In addition to these alterations, the alternative considered lowering the Glencoe Road dam, located approximately 6,000 feet north of the Tower Road Dam, by approximately two feet. The idea behind performing these changes was that the Tower Road Dam would restrict flow from two reaches instead of just one, and that the Glencoe Road Dam, which was being overtopped, would be dropped to store flow from low flow events while water from high flow events would be restricted and stored by the Tower Road Dam. Due to the backwater effect mentioned in paragraphs for alternatives SR-02 and SR-03, the storage gained from this configuration does not have an impact on the downstream problem areas. This alternative is not recommended.

SR-05 considered reducing the number of high flow gates on the Willow Road Dam from seven to three in order to reduce flow being released to the Skokie River downstream of Willow Road. Currently, the Willow Road Dam has one 8 foot by 7 foot low flow gate, and seven 3.2 foot by 17 foot high flow gates. A reduction in the number of high flow gates from seven to three does decrease the flow released downstream, but this reduction does not yield any decrease in WSELs. This alternative is not recommended.

SR-06 considered removing the low flow gate on the Willow Road Dam. The invert of the low flow gate is approximately 6.5 feet lower than the inverts of the high flow gates. The low flow gate was removed in order to delay and reduce the flow being released downstream. Removal of the low flow gate does decrease the flow released downstream, but this reduction does not yield any decrease in WSELs. This alternative is not recommended.

SR-07 considered reducing the number of gates on the Willow Road Dam to one, resizing that gate to 3.2 foot by 10 foot, and raising the gate invert by six feet. These changes reduce gate discharge by 66%, but this flow reduction has a very minimal impact on downstream WSELs due to the aforementioned Skokie River backwater effect. This alternative is not recommended.

SR-08 considered constructing two small levees around the I-94 underpass at Winnetka Road. The east of I-94 levee is a two foot high, 400 foot long, earthen levee that would be constructed from just east of E. Frontage Road to the I-94 embankment. The west of I-94 levee involves raising 1,400 feet of W. Frontage Road by 2 feet in height; this 1,400 foot segment starts approximately 400 feet south of Winnetka Road. In addition to the levees, an 8 acre area located on the east side of the Skokie River and due east of the two levees will be used for compensatory storage. While storm sewer flooding may still occur in the underpass, this alternative would completely eliminate overbank flooding from the Skokie

River at only at I-94 and Winnetka Road, which partially resolves modeled problem area MPSK4. It should be noted that this project does not address overbank flooding along I-94 at Willow Road and the Skokie River crossing. See Figure 3.3.2 for a conceptual plan of this alternative. This alternative is recommended.

The Skokie River alternative trials yielded no recommended projects that would resolve any of the modeled problem areas. The backwater effect on the Skokie River does not allow for efficient usage of additional upstream flood storage. Section 3.4 addresses this backwater effect and provides recommended alternatives which reduce its impact as well as overbank flooding from the Skokie River. Alternatives that reduce WSELs on the Mainstem reach have a much more significant impact on the Skokie River than the alternatives investigated and described above for the Skokie reach itself.

A number of properties are at risk of flooding during the 100-year flood event under existing conditions and recommended alternatives. In addition, due to their locations, other properties' risk of flooding cannot be feasibly mitigated by structural measures. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition. These measures may be considered to address damages that are not fully addressed by capital projects recommended in the North Branch of the Chicago River DWP.

3.3.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the alternatives studied in detail. Table 3.3.9 lists the alternative analyzed in detail. Figure 3.3.2 shows a comparison of existing conditions to alternative conditions 100 year inundation mapping with the implementation of alternative SR-08.

TABLE 3.3.9
Skokie River Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Water Quality Benefit	Recommended	Communities Involved
SR-08[1]	Construct I-94 at Winnetka Road levees and associated compensatory storage to eliminate overbank flooding in this immediate area	1.35	7,760,000	5,761,000	0	None	Yes	Northfield, Unincorporated Cook County, FPDCC, IDOT, Cook County Highway Department

1 - SR-08 project addresses overbank flooding of the Skokie River near I-94 (Edens Expressway) and Winnetka Road. For purposes of benefit calculation for SR-08, no other temporary closure of I-94 due to overbank flooding is assumed.

3.4 Mainstem of the NBCR Upstream of the North Branch Dam

The Mainstem of the North Branch of the Chicago River, which runs from the confluence of the Skokie River and the Middle Fork down to the North Branch Dam at the confluence with the North Shore Channel, has a stream length of 15.6 miles and a drainage area of 21.5 square miles. Table 3.4.1 summarizes the land area of communities within the Mainstem subwatershed. The Mainstem subwatershed consists primarily of residential area and includes with a large portion of forest preserve area being located throughout the bulk of its stream length. Table 3.4.2 summarizes the land use distribution within the Mainstem.

Figures 3.4.1a, 3.4.1b, and 3.4.1c are an overview of the tributary area of the Mainstem subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

TABLE 3.4.1
Communities Draining to the Mainstem Upstream

Community/Tributary	Tributary Area (mi^2)
Chicago	9.53
Morton Grove	4.99
Niles	4.06
Glenview	1.97
Unincorporated	0.60
Wilmette	0.15
Golf	0.11
Skokie	Less than 0.1
Park Ridge	Less than 0.1

TABLE 3.4.2
Land Use Distribution for the Mainstem Upstream

Land Use Category	Area (acres)	%
Residential	7,602	55.3
Forest/Open Land	3,349	24.4
Commercial/Industrial	1,911	13.9
Institutional	575	4.2
Transportation/Utility	301	2.2
Agricultural	Less than 1	0
Water/Wetland	Less than 1	0

3.4.1 Sources of Data

3.4.1.1 Previous Studies

Data from the 1997 FIS regulatory model (HEC-2) were utilized for supplementing the newly developed DWP HEC-RAS model for the Main Stem.

3.4.1.2 Water Quality Data

The IEPA has eight Ambient Water Quality Monitoring Network sites on the Mainstem. Three reaches of the Mainstem are identified as impaired in the IEPA's 2008 Integrated Water Quality Report, which includes the CWA 303(d) and 305(b) lists. No TMDLs have been established for the Mainstem. TMDLs are currently being developed for dissolved oxygen, chloride, and fecal coliform. According to a water permit discharge query from the USEPA, there are twelve NPDES permits issued by IEPA to the Chicago Tribune, Ozinga Bros., Inc., Metal Management Midwest, Inc., Orange Crush Recycle, Ltd., Apparel Center, Finkl, A. and Sons Company, all in Chicago, and MWRDGC-Perini/Ica/O&G Joint of Morton Grove, Castwell Products, Inc. of Skokie, Unocal Corp. of Northfield, Village of Morton Grove, Village of Skokie, and City of Chicago, for discharges to the Mainstem. Municipalities discharging to the Mainstem are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was instituted to improve water quality by requiring that municipalities develop six minimum control measures for limiting runoff pollution to receiving systems.

3.4.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR Watershed. Wetland areas were identified using NWI mapping. NWI data includes approximately 343 acres of wetland areas in the Mainstem tributary area. Restoration and enhancement of wetlands are included as part of the recommended alternatives described in the sub-sections below. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provides flood management, habitat, and water quality enhancement. Identified riparian environments offer potential opportunities for restoration.

3.4.1.4 Floodplain Mapping

Flood inundation areas supporting the NFIP were revised in 2008 as a part of FEMA's Map Modernization Program. Floodplain boundaries were revised based upon updated Cook County topographic information, but the effective models used to estimate flood levels generally were not updated. LOMRs were incorporated in the revised floodplains. The effective FIS H&H analysis was performed in both 1978 and 1980 depending on the portion of the river that was modeled. The hydrologic modeling was performed by using HEC-1, TR-20, and I-PTIII with Regression Equation 79; Hydraulic routing was performed using both HEC-2 and WSP2.

Appendix A includes a comparison of FEMA's effective floodplain mapping from updated DFIRM panels with inundation areas developed for the DWP.

3.4.1.5 Stormwater Problem Data

Table 3.4.3 summarizes reported problem areas reviewed as a part of the DWP development. The problem area data was obtained primarily from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.4.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.4.1.6 Near-Term Planned Projects

Watershed communities, agencies, and stakeholders were asked about near-term planned projects so that the implementation of near-term flood control projects by others is considered in development of the DWP. Several studies are currently underway in the Mainstem Subwatershed; however, no near-term planned flood control projects by others have been identified in the Mainstem Subwatershed.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-ER-28	City of Chicago	Streambank erosion on intercommunity waterways	LaBagh Woods - Bryn Mawr & Kostner Avenue	FPDCC reported off-site stormwater volumes are causing downcutting in a ditch, thereby lowering the water table in the adjacent natural wetland areas.	Regional	Erosion problem does not threaten structures or conveyance of Mainstem. Not addressed by DWP.
CH-FL-29	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm water sewer flow restriction throughout area. City sewer improvements are often focused towards areas of the most complaints.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-30	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Central Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-31	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Milwaukee Avenue (Lane 3)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-32	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Jefferson Park Tunnel (NR Ainslie Street) Lane 3	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FL-33	City of Chicago	Intracommunity (local) flooding	Interstate Route 94 (Edens) at North Elston Avenue (SB)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-34	City of Chicago	Intracommunity (local) flooding	Interstate Route 90 at Austin Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-35	City of Chicago	Intracommunity (local) flooding	Interstate Route 90 at Lawrence Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-36	City of Chicago	Intracommunity (local) flooding	Interstate Route 90 at Bryn Mawr Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-37	City of Chicago	Intracommunity (local) flooding	Interstate Route 90 at Nagle Avenue (NB ramp)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FR-38	City of Chicago	Intercommunity (regional) flooding	LaBagh Woods	FPDCC reported off-site stormwater volumes are causing downcutting in a ditch, thereby lowering the water table in the adjacent natural wetland areas - (ponding checked on form B)	Regional	Problem is not caused by overbank flooding. Not addressed by DWP.
CH-WQ-39	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm sewer flow restriction, water quality (pollution) throughout area. The City sewer improvements are often focused towards areas of the most complaints	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-WQ-40	City of Chicago	Intracommunity (local) flooding	Throughout Chicago wetland areas	FPDCC reported off-site stormwater volumes are causing downcutting in a ditch, thereby lowering the water table in the adjacent natural wetland areas - (wetland issue considered WQ)	Local	Problem not located on a regional waterway. Not addressed by DWP.
CH-FL-44	City of Chicago	Intracommunity (local) flooding	Central Avenue at South of Devon Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FR-45	City of Chicago	Intracommunity (regional) flooding	Albany Park	Overbank flooding throughout the community	Regional	The recommended alternative is MS-10.
GV-FL-01	Village of Glenview	Intracommunity (local) flooding	Sunset Ridge Road - East Lake Avenue to Skokie Road	Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
GV-FL-02	Village of Glenview	Intracommunity (local) flooding	East of Harms Road South of Lake Avenue	Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
MG-ER-01	Village of Morton Grove	Streambank erosion on intercommunity waterways	Linne Woods, Village of Morton Grove	Tree impeding flow, failing streambank stabilization	Regional	Upon field visit, erosion problem does not threaten structures or conveyance of Mainstem and existing stabilization appeared to be adequate. Not addressed by DWP.
NL-FL-08	City of Chicago, Village of Niles	Intracommunity (local) flooding	Illinois Route 43 at Howard Street (N/O)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
MG-FL-02	Village of Morton Grove, Village of Glenview	Intracommunity (local) flooding	Illinois Route 43 at Illinois Route 58	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
SK-FL-11	City of Evanston, Village of Skokie	Intracommunity (local) flooding	US Route 41 @ Old Orchard Road to Golf Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
MG-FL-03	Unincorp Cook County, Village of Morton Grove, Village of Golf	Intracommunity (local) flooding	Golf Rd at West of Harms Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NL-FL-09	Village of Skokie, Village of Niles	Intracommunity (local) flooding	Gross Point Road at 7500 Gross Point Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NL-FL-01	Village of Niles	Intracommunity (local) flooding	US Route 14 at Illinois Route 21 (Milwaukee Area)	IDOT Pavement flooding US RT 14 at Illinois Rte 21 (Milwaukee Ave)	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NL-FL-02	Village of Niles	Intracommunity (local) flooding	Illinois Route 21 at Main Street (S/O US Route 14)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NL-FL-03	Village of Niles	Intracommunity (local) flooding	Illinois Route 43 at Oakton Street	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NL-FL-04	Village of Niles	Intracommunity (local) flooding	Dempster Street, East of Harlem Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
NL-FR-05	Village of Niles	Intercommunity (regional) flooding	Tam Golf Course, Niles	Tam Golf Course Flooding- During major storm events, overbank flooding of the adjacent golf course - Tam Golf Course and/or its buildings owned by the Niles Park District.	Regional	This DWP includes one investigated regional flood control alternative that addresses this problem: MS-02
NL-FR-06	Village of Niles	Intercommunity (regional) flooding	Harts Road & Riverside Drive, Niles	Overbank flooding in areas of the intersection of Harts Rd and Riverside Drive during severe storm events.	Regional	This DWP includes one investigated regional flood control alternative that addresses this problem: MS-02. Recommend raising road to eliminate pavement flooding.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
NL-ER-10	Village of Niles	Streambank erosion on intercommunity waterways	Wood River Drive	Erosion problem along the NBCR for the townhouses located at 6620, 6622, 6624, 6626, 6628, 6630, 6632, 6634, 6636, 6638, and 6640 Wood River Drive.	Regional	Erosion problem does not immediately threaten structures or conveyance of Mainstem. Not addressed by DWP.
SK-FL-01	Village of Skokie	Intracommunity (local) flooding	Interstate Route 94 at Illinois Route 58	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-02	Village of Skokie	Intracommunity (local) flooding	US Route 41 at Gross Point Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-03	Village of Skokie	Intracommunity (local) flooding	Gross Point between Emerson & Kenton	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-04	Village of Skokie	Intracommunity (local) flooding	Church Road at Gross Point Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
SK-FL-05	Village of Skokie	Intracommunity (local) flooding	Harms Flatwoods Forest Preserve - Old Orchard Road and Harms Road	FPDCC reported that off-site stormwater volumes from adjacent properties modify the hydrology in this ecologically significant flatwoods community with endangered and threatened plant species.	Local	Problem not located on a regional waterway.
SK-WQ-06	Village of Skokie	Intracommunity (local) flooding	Harms Flatwoods Forest Preserve - Old Orchard Road and Harms Road	FPDCC reported off-site stormwater volumes from adjacent properties modify the hydrology in this ecologically significant flatwoods community with endangered and threatened plant species.	Local	Erosion problem does not threaten structures or conveyance of West Fork. Not addressed by DWP.
UC-ER-01	Uninc. Cook County	Streambank erosion on intercommunity waterways	Harms Flatwoods Forest Preserve - West of Old Orchard Road and Harms Road	FPDCC reported properties on the west side of the forest preserve discharge stormwater directly to forest preserve with impacts of erosion, sedimentation, and habitat degradation.	Local	Erosion problem does not threaten structures or conveyance of Mainstem. Not addressed by DWP.
UC-WQ-02	Uninc. Cook County	Intracommunity (local) flooding	Harms Flatwoods Forest Preserve - West of Old Orchard Road and Harms Road	FPDCC reported properties on the west side of the forest preserve discharge stormwater directly to forest preserve with impacts of erosion, sedimentation, and habitat degradation	Local	Problem not located on a regional waterway.
WM-FL-01	Village of Wilmette	Intracommunity (local) flooding	Wilmette Golf Course at Lake and Harms	Ponding/storm sewer flow restriction after rain events in isolated low areas/storm restrictions. Storm sewer surcharging by high river water levels results in yard ponding/depressed driveways/garages	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.4.3
Community Response Data for the Mainstem Upstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
WM-FL-02	Village of Wilmette	Intracommunity (local) flooding	US Route 41 at N/O Hibbard Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
WM-FL-03	Village of Wilmette	Intracommunity (local) flooding	Interstate Route 94 (Edens) at Glenview Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
WM-FL-04	Village of Wilmette	Intracommunity (local) flooding	Various locations in Wilmette	Map of the local ponding throughout area during the September 2008 storm	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
WM-FL-05	Village of Wilmette	Intracommunity (local) flooding	Various locations Wilmette	Map of the basement Flooding throughout area during September 2008 storm	Local	Problem not located on a regional waterway.
WM-FR-06	Village of Wilmette	Intercommunity (regional) flooding	Wilmette Golf Course	Flooding and ponding at the Wilmette Golf Course after rain events. High water levels in the river causes stormwater to back up within the golf course.	Regional	The recommended alternative is MS-14.

[1] All Problem IDs begin with NB-NBCU- as all problems are within the North Branch – Upstream of the North Branch Dam subwatershed.

3.4.2 Watershed Analysis

3.4.2.1 Hydrologic Model Development

Subbasin Delineation.
The Mainstem tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The watershed boundaries of the Des Plaines River (western edge) and LM (eastern edge) were compared, and discrepancies were identified. Discrepancies generally were minor and resolved by manual review of topographic data and consultation with Des Plaines River DWP consultant, Christopher B. Burke Engineering.

Hydrologic Parameter Calculations. Table 3.4.4 summarizes the total drainage area, number of modeled subbasins, and average subbasin size for the Mainstem and its major tributaries.

TABLE 3.4.4
Mainstem Upstream System Subbasin Summary

Subbasin	Drainage Area (mi^2)	Number of Modeled Subbasins	Average Modeled Subbasin Size (acres)
Mainstem	21.49	21	655
Major Tributaries to Mainstem			
West Fork	19.70	42	300
Middle Fork	5.01	10	321
Skokie River	13.41	13	660

CNs were estimated for each subbasin based upon NRCS soil data and 2001 CMAP land use data. This method is further described in Section 1.3.2, with lookup values for specific combinations of land use and soil data presented in Appendix C. An area-weighted average of the CN was generated for each subbasin. The Clark unit hydrograph method was used to convert SCS CN runoff volumes into subbasin-specific hydrographs. Time of concentration (Tc) and storage coefficient (R) parameters for the Clark unit hydrograph method were estimated as described in Section 1.3.2. Appendix G provides a summary of the hydrologic parameters used for subbasins in each subwatershed.

3.4.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met the District criteria for use in the DWP, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Field surveys of the Mainstem and bridge crossings were performed to characterize the channel and near overbank geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the field surveyed channel cross section. Field visits were performed to assess channel and overbank roughness characteristics, which were combined with information from photographs and aerial photography to assign modeled Manning's *n* roughness coefficients along the modeled stream length.

Boundary Conditions. The downstream boundary condition for the Mainstem is the stage of the NSC; however, this downstream boundary condition can be more appropriately described as the rating curve of the North Branch Dam as it is impacted by the stage of the NSC. The USACE CAWS hydraulic model was utilized to determine the downstream boundary condition of the Mainstem. The calculation of this boundary condition is further described in Appendix E.

3.4.2.3 Calibration and Verification

Observed Data. As in shown in Figure 2.3.1, two thiessen polygons, based on two different precipitation gages, allow for complete coverage of the Mainstem subwatershed. The upstream-most thiessen polygon is based on CCPN gage number 4; the downstream-most portion of the Mainstem is covered by CCPN gage number 6. Data for the September 2008 and October 2001 storms were gathered for calibration and verification of the hydrologic and hydraulic models.

Chapter 6 of the CCSMP states that calibration and verification comparisons with gage data must come within: 30% for peak flow, 30% for hydrograph volume, and 0.5 feet for peak stage. Both USGS stream gages on the Mainstem were used for calibration and verification of the North Branch of the Chicago River and its tributaries. Mainstem gage 0553600 is located at Touhy Avenue in Niles, and Mainstem gage 05536105 is located at Albany Avenue in Chicago. Tables 3.4.5 and 3.4.6 display monitored peak flow for the September 2008 calibration and October 2001 verification events. An initial check at these gages showed that the existing conditions hydraulic model met 5 of the 6 criterion for CCSMP compliance. The one value that initially did not meet CCSMP criteria was the stage of the Albany Avenue gage. With the hydraulic model displaying accuracy at the Touhy Avenue gage, and showing accuracy for flow and volume at the Albany gage, it was determined that the issue with the Albany stage was most likely hydraulic in nature. The rating curve for the North Branch Dam was adjusted by applying an increase in the weir coefficient of discharge from 3.1 to 3.8, in order to reduce the stage to a compliant level.

TABLE 3.4.5
Flow Events at USGS gage 05536000

Date	Peak Monitored Flow (cfs)
9/13/2008	3,340
10/14/2001	1,710

TABLE 3.4.6
Flow Events at USGS gage 05536105

Date	Peak Monitored Flow (cfs)
9/14/2008	4,310
10/14/2001	1,700

Calibration Results.
Figures 3.4A through 3.4H display stage and flow comparisons between HEC-RAS hydrographs and gage hydrographs at each Mainstem gage, for the calibration and verification events. Tables 3.4.6, 3.4.7, and 3.4.8 depict how the HEC-RAS model matches up with the gage model with regard to peak flow, volume, and peak stage, respectively.

TABLE 3.4.7

Gage and Model Peak Flow Comparison

Gage Number	Gage Peak Flow (cfs)	Model Peak Flow (cfs)	% Difference	Meets CCSMP Req. (30%)
September 2008				
05536000	3,340	3,130	6.3	YES
05536105	4,310	3,573	17.1	YES
October 2001				
05536000	1,710	1,733	1.3	YES
05536105	1,700	1,786	5.1	YES

TABLE 3.4.8

Gage and Model Volume Comparison

Gage Number	Gage Volume (acre-ft)	Model Volume (acre-ft)	% Difference	Meets CCSMP Req. (30%)
September 2008				
05536000	20,548	20,736	0.9	YES
05536105	26,907	22,932	14.8	YES
October 2001				
05536000	12,361	10,853	12.2	YES
05536105	12,909	11,691	9.4	YES

TABLE 3.4.9

Gage and Model Peak Stage Comparison

Gage Number	Gage Elevation (ft)	Model Elevation (ft)	Difference (ft)	Meets CCSMP Req. (<0.5ft)
September 2008				
05536000	613.9	613.6	0.3	YES
05536105	588.3	588.6	0.3	YES
October 2001				
05536000	611.0	611.4	0.4	YES
05536105	586.5	586.8	0.3	YES

*All elevations are given in NAVD88

FIGURE 3.4A
Mainstem flow comparison at the Niles gage (05536000) for September 13, 2008 storm

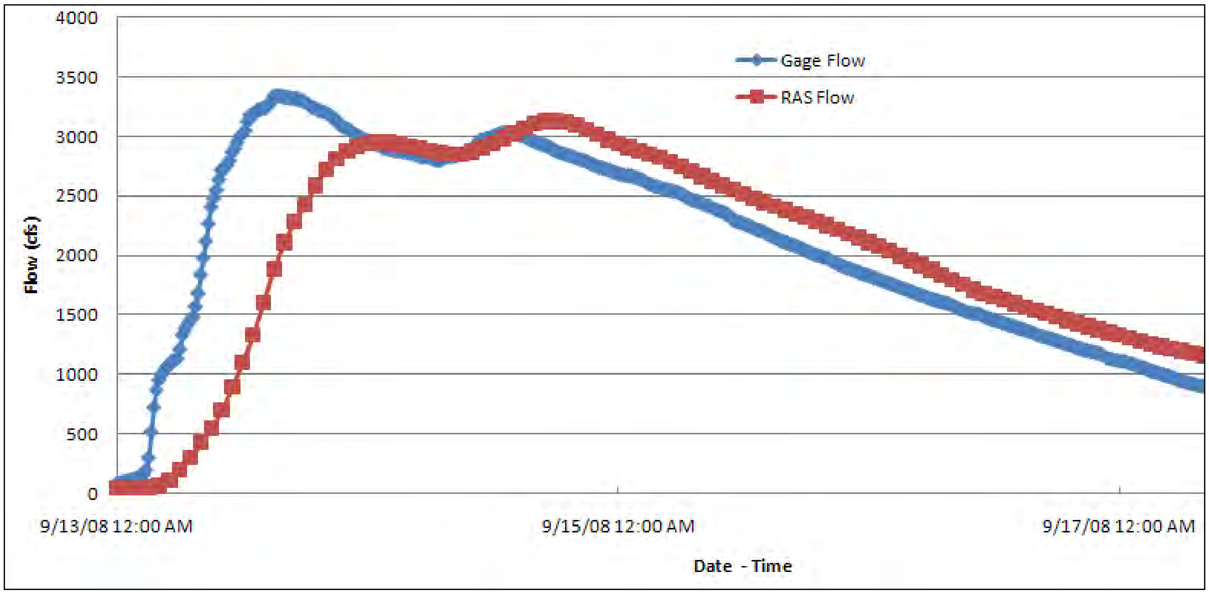


FIGURE 3.4B
Mainstem flow comparison at the Albany gage (05536105) for September 13, 2008 storm

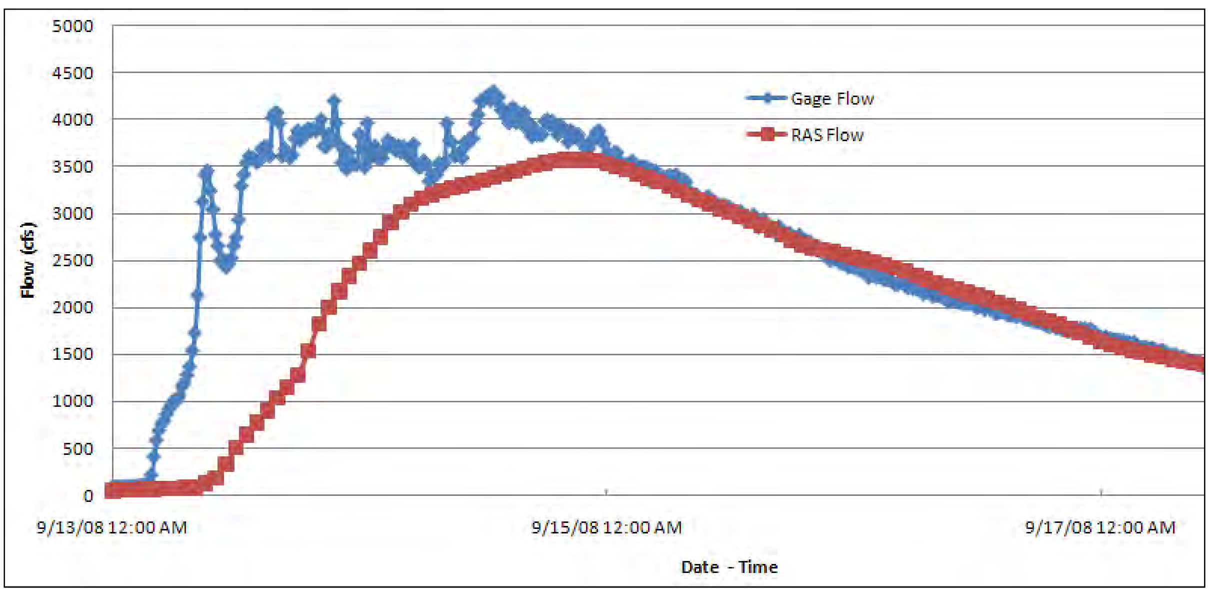


FIGURE 3.4C
Mainstem stage comparison at the Niles gage (05536000) for September 13, 2008 storm

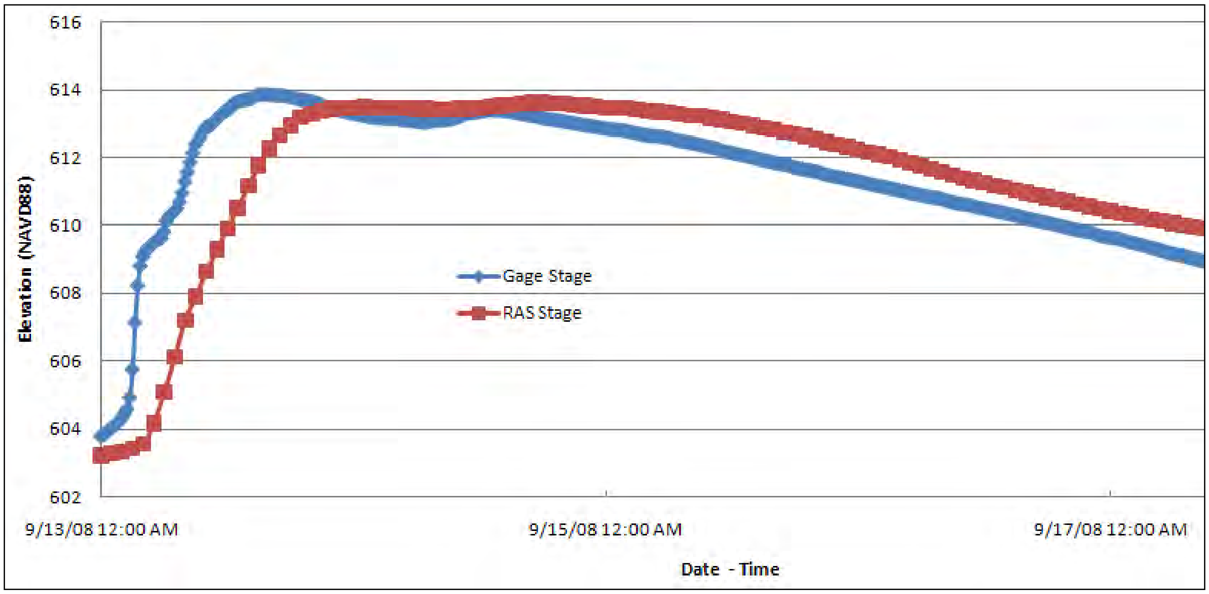


FIGURE 3.4D
Mainstem stage comparison at the Albany gage (05536105) for September 13, 2008 storm

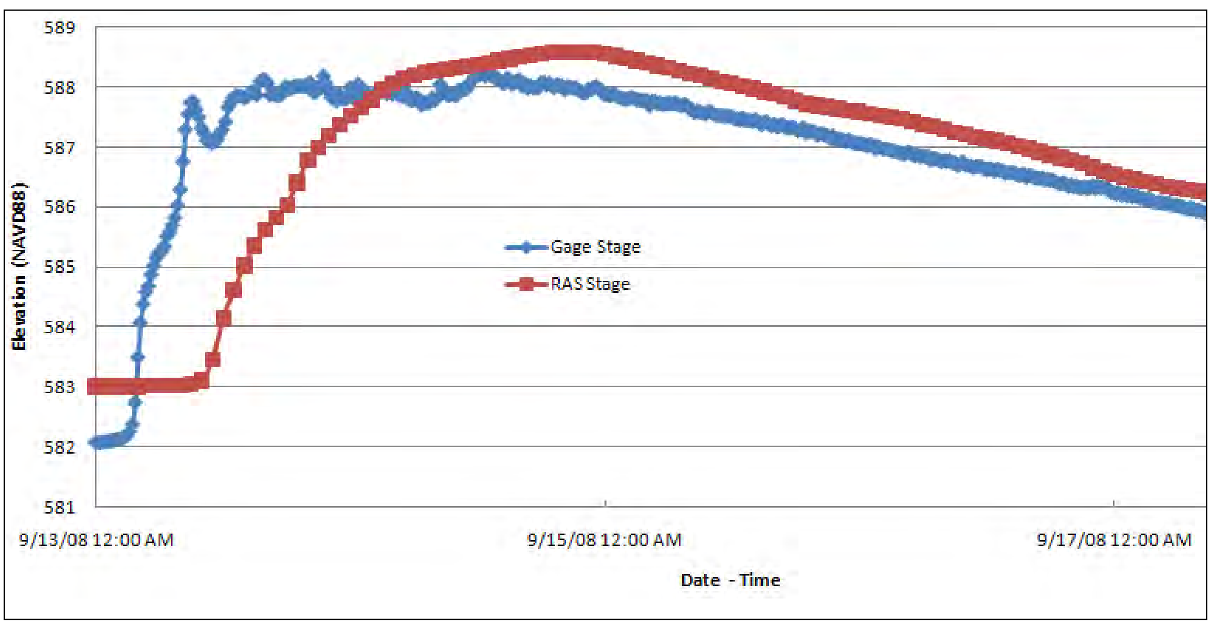


FIGURE 3.4E
Mainstem flow comparison at the Niles gage (05536000) for October 13, 2001 storm

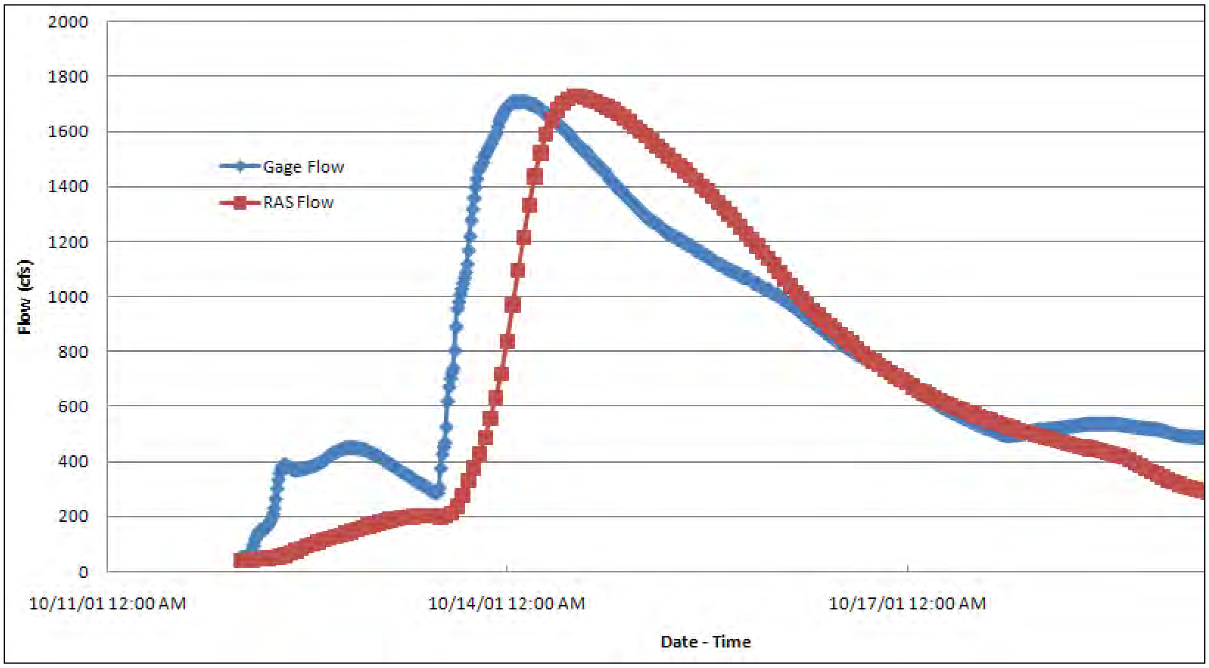


FIGURE 3.4F
Mainstem flow comparison at the Albany gage (05536105) for October 13, 2001 storm

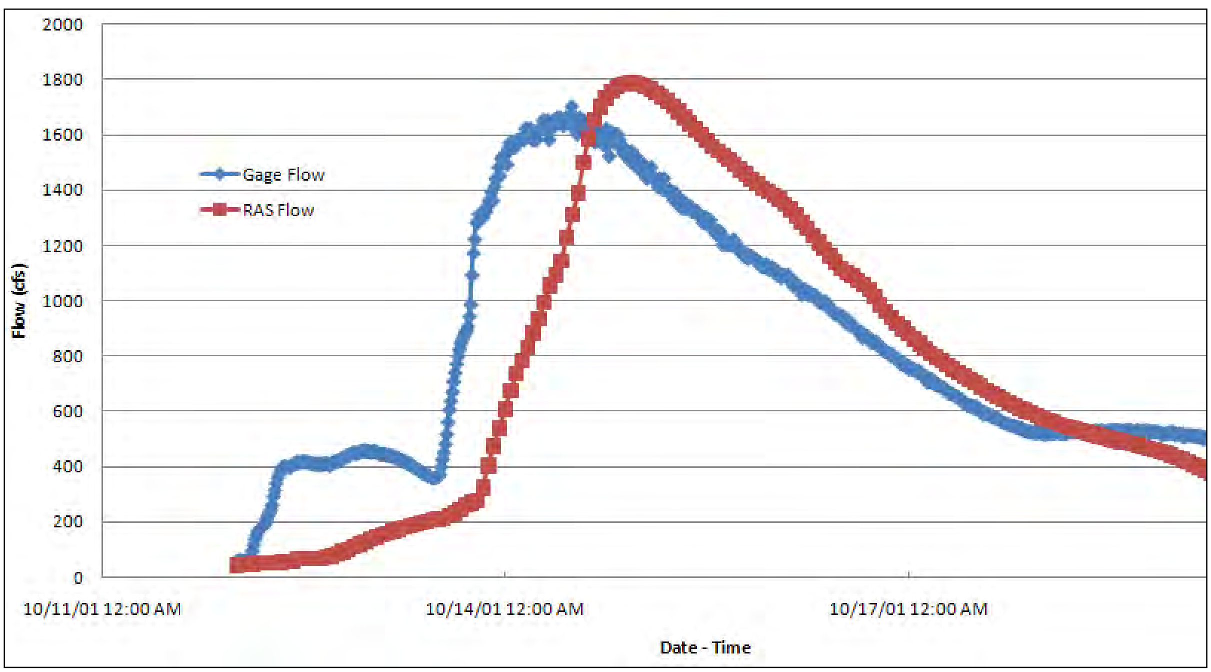


FIGURE 3.4G
Mainstem stage comparison at the Niles gage (05536000) for October 13, 2001 storm

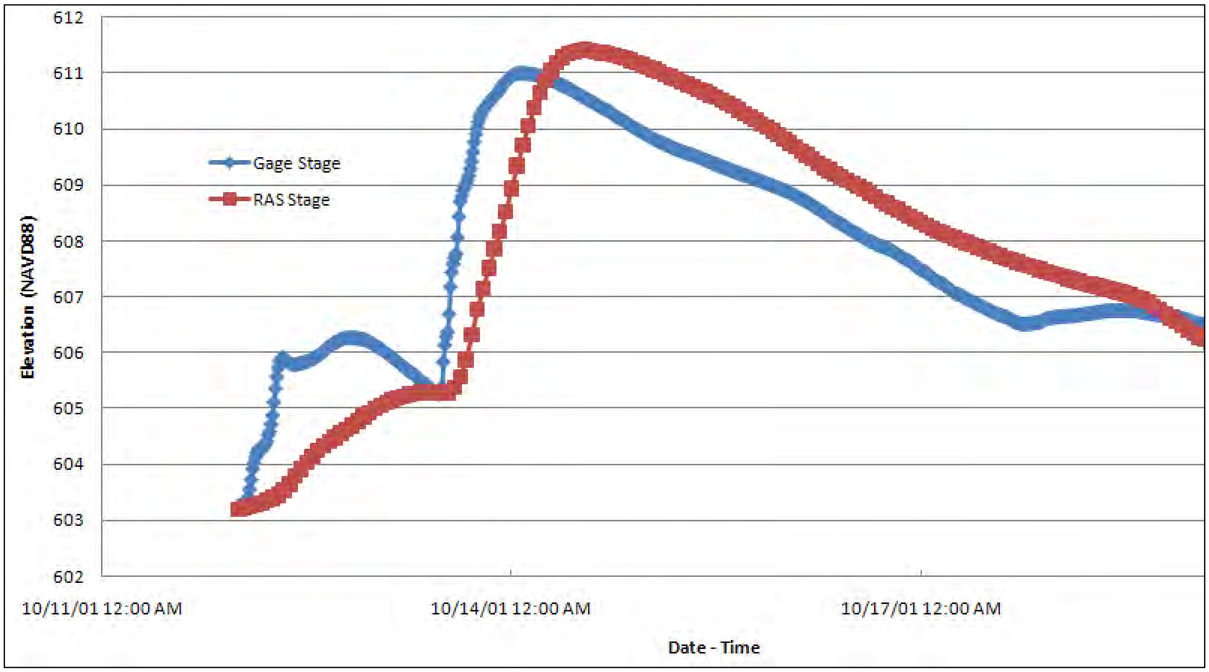
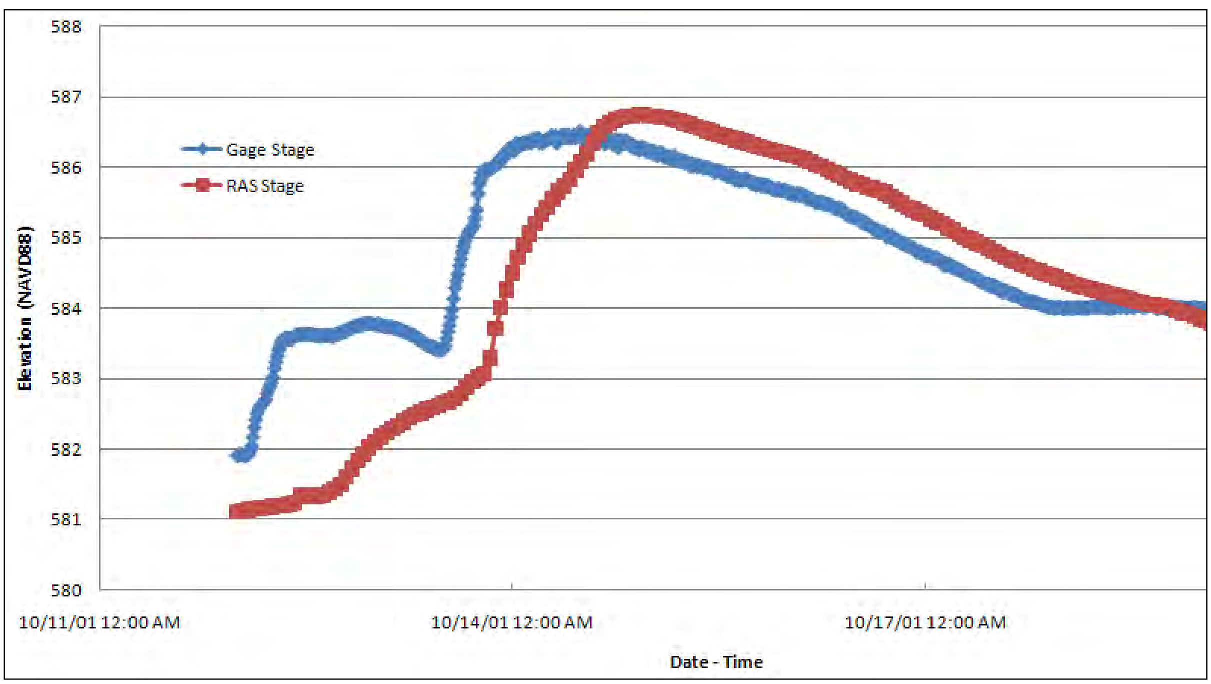


FIGURE 3.4H
Mainstem stage comparison at the Albany gage (05536105) for October 13, 2001 storm



3.4.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figures 3.4.1a-c show inundation areas produced by the hydraulic model for the 100-year, 24-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the Mainstem reach. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.4.3 Development and Evaluation of Alternatives

3.4.3.1 Modeled Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.4.9 summarizes major problem areas identified through hydraulic modeling of the Mainstem.

TABLE 3.4.10
Modeled Problem Definition for the Mainstem Upstream

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Problem from Table 3.1.3
MPMS1	East overbank flooding hydraulically connected to the subdivision between Glenview Road and Old Orchard Road	10, 25, 50, 100	
MPMS2	East overbank flooding from Howard Street to Harts Road	25, 50, 100	NL-FR-06
MPMS3	Overbank flooding from Foster Avenue to Kedzie Avenue	10, 25,50, 100	CH-FL-29

3.4.3.2 Damage Assessment

Damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No recreation damages due to flooding were identified for the Mainstem. Transportation damages were estimated as 15 percent of property damages. No erosion damages were calculated because no active streambank erosion was reported within 30 feet of any infrastructure.

TABLE 3.4.11
Estimated Damages for the Mainstem Upstream

Damage Category	Estimated Damage ($)	Note
Property	45,545,000	Structures at risk of flooding
Transportation	6,832,000	Assumed as 15% of property damage due to flooding

3.4.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in the Mainstem subwatershed. A variety of flood control technologies are used in the recommended alternatives including: regional flood control reservoirs, channel modification, levee construction, and flow diversion tunnels.

3.4.3.4 Alternative Development

Stormwater improvement alternatives were developed to address regional stormwater problems identified in Table 3.4.3, with the aim of reducing damages due to stormwater.

Flood Control Alternatives. Alternative solutions to regional flooding problems were developed and evaluated consistent with the methodology described in Section 1.4 of this report. Table 3.4.11 summarizes flood control alternatives developed for the Mainstem. Based on the feedback from watershed communities, a review of previous studies, and a consideration of available open tracts of land, stormwater detention alternatives developed for the Mainstem were focused primarily on new reservoir construction on open parcels.

TABLE 3.4.12
Flood Control and Erosion Control Alternatives for the Mainstem Upstream

Alternative	Location	Description
MS-01	Approximately 2,500 feet upstream of the Mainstem crossing at Dempster St	Repair/stabilize a section of streambank in which prior erosion stabilization has failed
MS-02	1,600 feet north of the intersection of Lehigh Ave and Dempster St	Construct a new reservoir on the open parcel at this location
MS-03	Cook County Forest Preserve from Harts Road to I-94	Construct several small in-channel restrictions which would increase floodplain storage on FPDCC land
MS-04	Edgebrook Golf Course, located between Devon Ave and N Central Ave	Construct a new reservoir on the 18 hole golf course
MS-05	Billy Caldwell Golf Course, located northwest of the intersection of N Leader Ave and N Lansing Ave	Construct a new reservoir on the 9 hole golf course
MS-06	LaBagh Woods, approximately 900 ft east of the parking lot	Erosion stabilization along a ditch that runs from a wetland area to the Mainstem
MS-07	Foster Ave. from Avers Ave. to the North Shore Channel	Construct an 18 foot diameter diversion tunnel along Foster Avenue that diverts flow from the Mainstem to the NSC
MS-08	Foster Ave and Pulaski Road	Construct a new reservoir on the open parcels in this area
MS-09	Ridgeway Ave ped bridge	Remove Ridgeway Ave ped bridge to improve channel hydraulics through this area
MS-10	Foster Ave crossing to Kimball Ave crossing	Construct a floodwall to protect the Albany Park neighborhood from overbank flooding
MS-11	Confluence of the Mainstem and the North Shore Channel	Analyze the floodplain impacts of a possible canoe chute addition to the North Branch Dam
MS-12	Wilmette Golf Course, just northeast of the Lake Ave Mainstem crossing	Construct a new regional flood control reservoir on the golf course property
MS-13	Mainstem channel from the Middle Fork confluence to the West Fork confluence	Construct a channel modification that widens the existing channel and increases conveyance for the modified cross sections
MS-14	MS-12 and MS-13 locations	Construct the Wilmette GC reservoir (MS-12) and perform the MS-13 channel modification

Erosion Control Alternatives.

Two erosion control alternatives, MS-01 and MS-06, were investigated for the Mainstem in order to address the erosion problems that were reported. None of these alternatives were selected because no infrastructure is present within 30 feet of active streambank erosion on the Mainstem.

3.4.3.5 Alternative Evaluation and Selection

MS-01 considered erosion stabilization on a section of streambank approximately 2,500 feet upstream of the Mainstem crossing at Dempster Street. Currently, a system of AJAX is in place to stabilize the streambank, but this system is beginning to fail in several locations. Field review of this problem determined that the repair/stabilization area is not within 30 feet of existing infrastructure and the existing stabilization is in fair condition. This alternative is not recommended at this time.

MS-02 considered constructing a new flood control reservoir on an open parcel located just east of Lehigh Ave, between Beckwith Road and Dempster Street. In addition to the construction of the approximate 570 acre-ft reservoir, a restriction culvert would be added to the Mainstem in order to allow for flow to backup into the reservoir. This alternative results in full utilization of the reservoir and utilization of additional storage in the Cook County Forest Preserve floodplain due to the restricted flow backup. While MS-02 does decrease WSELs as much as 1.6 feet in some areas, and as much as 1.2 feet in the Albany Park neighborhood, the alternative causes large WSEL increases on the order of 2 feet through the FPDCC. With the negative impact on FPDCC property and on local neighborhood storm sewer outfalls, this alternative was deemed infeasible. This alternative is not recommended.

MS-03 considered constructing a series of 6 dams on the Mainstem from just upstream of Devon Avenue to just upstream of the LaBagh Woods railroad crossing. The idea behind these storage steps was to restrict flow at each of the dams which would increase WSELs through FPDCC land and allow for additional storage in the Forest Preserve floodplain. The six dams varied in height from 7 to 9 feet and included a small box culvert to bypass low flows. The storage steps do increase WSELs through the forest preserve area, but these upstream increases do not result in any downstream decreases. Because the forest preserve is already storing a significant amount flow in its floodplain, the additional storage is minimal by comparison. This alternative is not recommended.

MS-04 considered constructing a regional flood control reservoir on the Edgebrook Golf Course, located in the Mainstem floodplain from Devon Avenue to North Central Avenue. This proposed 1,730 acre-ft facility would remove 11 holes from the Edgebrook GC and would require a restriction culvert to be built on the Mainstem. This alternative is effective as it reduces WSELs by as much as 1.1 feet the Albany Park neighborhood. Based upon District coordination with the FPDCC, it was determined that storage would be allowed to be built on the golf course to increase its playability; however, a reservoir large enough to mitigate downstream flooding would take up the majority of the land area of the golf course and was not considered feasible by FPDCC. The acreage needed to make an impact on the MPMS3 problem area is not available due to these restrictions. This alternative is not recommended.

MS-05 considered constructing a regional flood control reservoir on the Billy Caldwell Golf Course, located northwest of the intersection of North Leader Avenue and North Lansing Avenue. This proposed 1,700 acre-ft facility would remove all 9 holes from the Billy Caldwell GC and would require a restriction culvert to be built on the Mainstem. This alternative is effective as it reduces WSELs by as much as 1.6 feet in the Albany Park neighborhood. Based upon District coordination with the FPDCC, it was determined that storage would be allowed to be built on the golf course to increase its playability; however, a reservoir large enough to mitigate downstream flooding would take up the majority of the land area of the golf course and was not considered feasible by FPDCC. The acreage needed to make an impact on the MPMS3 problem area is not available due to these restrictions. This alternative is not recommended.

MS-06 considered erosion stabilization on a ditch that conveys water from a wetland area, in the LaBagh Woods Forest Preserve, to the Mainstem. It was reported that down-cutting in this ditch causes the wetland to drain prematurely. Field review of this area determined that streambank erosion does not occur within 30 feet of a structure. This alternative is not recommended.

MS-07 considered constructing a 14 foot diameter diversion tunnel which would run under Foster Avenue from its intersection with Avers Avenue until its discharge into the North Shore Channel. The 14 foot diameter tunnel, which would divert flow from the Mainstem to the North Shore Channel, was originally recommended by MWH Americans, Inc. (MWH) in their January 22, 2010 pre-feasibility evaluation. MWH determined that a 14 foot diameter tunnel would be large enough to divert enough flow to keep the Mainstem within bank for a 100 year event through the Albany Park neighborhood. Based on the DWP hydraulic model, it was determined that, while a 14 foot tunnel would greatly reduce the inundated area, an 18 foot diameter tunnel would come much closer to eliminating overbank flooding through the Albany Park neighborhood. The proposed 18 foot diameter tunnel almost completely resolves the MPMS3 problem area with the exception of a small amount of street flooding in a few locations. However, after the cost analysis performed in this DWP, this alternative is not recommended as the most cost effective solution for the Albany Park neighborhood overbank flooding. The recommended alternative for mitigating Albany Park neighborhood overbank flooding is MS-10. It is noted that the City of Chicago supports the MS-07 alternative in lieu of MS-10. The City of Chicago supports MS-07 because the tunnel would reduce flooding without buyouts, relocations, or construction of a wall through the neighborhood.

MS-08 considered utilizing open parcels near the intersection of Foster Avenue and Pulaski Road for regional flood control. A review of the open parcels showed there was approximately 30 acre-ft of storage to be gained, which is not large enough to have any impact on WSELs. This alternative is not recommended.

MS-09 considered removing the Ridgeway Avenue pedestrian bridge in order to increase conveyance through this area. Because the 2008 FIS profile of the Mainstem shows a positive head differential at the Ridgeway pedestrian bridge, the bridge removal was considered in an attempt to reduce upstream WSELs. The removal of the bridge in the hydraulic model had no impact on WSELs. This alternative is not recommended.

MS-10 considered constructing a floodwall through the heavily inundated overbanks in the Albany Park neighborhood. The proposed south floodwall runs from Foster Avenue, just east of Pulaski Road, to the Kimball Avenue crossing. The north floodwall runs from the southeastern most point of Eugene Field Park down to the Kimball Avenue crossing. This alternative does raise WSELs outside of the limits of the floodwall for a few hundred feet along the stream centerline; the structures impacted by these increases would be candidates for flood proofing and/or acquisition. The floodwall protects approximately 329 structures from overbank flooding. See Figure 3.4.2a for a conceptual plan of this project. This alternative is recommended.

MS-11 considered constructing a canoe chute/fish passage alteration to the North Branch Dam. A study was performed by the University of Illinois with regard to the design of a canoe chute at the dam. The dam geometry from this study was placed into the DWP hydraulic model to see if it had any positive impact on WSELs. The implementation of the canoe chute causes increases in WSELs, and while it may have merits outside of the scope of this DWP, this alternative is not recommended.

MS-12 considered constructing a new reservoir on the existing Wilmette Golf Course which is located on the east overbank of the Mainstem, just downstream of the confluence of the Middle Fork and Skokie River. Full utilization of the golf course land allows for the construction of a 2,800 acre-ft regional flood control reservoir. The proposed reservoir reduces WSELs as much as 1 foot in some areas and provides partial relief for modeled problem areas MPMS2 and MPMS3. MS-12 makes its biggest impact by helping to relieve the aforementioned Skokie River backwater effect. The reduction of backwater on the Skokie River and Middle Fork, due to this alternative, causes partial relief for modeled problem areas MPSK1, MPSK2, MPSK3, and MPMF6. However, this alternative is not recommended as the most cost effective solution to the overbank flooding in these modeled problem areas.

MS-13 considered a channel modification on the Mainstem from its confluence with the West Fork up to the confluence of the Middle Fork and Skokie River. This alternative attempted to relieve the aforementioned backwater issue at the confluence of the Middle Fork and Skokie River. The channel modification includes widening the existing channel by 70 feet on each side in order to increase conveyance in the area of the WSEL backup. This alternative does reduce WSELs by as much as 0.7 feet in portions of the lower Skokie River and Middle Fork, but it increases downstream WSELs by as much as 0.3 feet in the area of MPMS2. Because MS-13 does have a negative impact on another problem area, the alternative is not recommended as an independent project.

MS-14 considered combining alternatives MS-12 and MS-13 in order to increase positive impact on the Skokie River and Middle fork, while eliminating any net negative impact downstream of the channel modification. This alternative results in WSEL decreases by as much as 1.7 feet and does not cause any increases in WSELs. See Figure 3.4.3a for a conceptual plan of this project. This alternative is recommended as the most cost effective solution to overbank flooding to the modeled problem areas MPMS2, MPMS3, MPSK1, MPSK2, MPSK3, and MPMF6. MS-14 provides the approximate 2,800 ac-ft of storage required to mitigate the aforementioned modeled problem areas; however, the FPDCC and Wilmette Park District have indicated their unwillingness to provide land for this alternative.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.4.13.A provides a comparison of the modeled maximum WSEL and modeled flow at the time of peak at representative locations along the waterway for the recommended alternative MS-14. Tables 3.4.13.B through 3.4.13.D provide a comparison of the modeled maximum WSEL and modeled flow at the time of peak at representative locations along the waterway for the alternatives that are not recommended and are provided for informational purposes only.

A number of properties are at risk of shallow flooding during the 100-year flood event under existing conditions or recommended alternative conditions. In addition, due to their locations, other properties' risk of flooding cannot be feasibly mitigated by structural measures. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition. These measures may be considered to address damages that are not fully addressed by capital projects recommended in the NBCR DWP.

Table 3.4.13.A provides a comparison of peak flow and stage for existing and proposed conditions for the Albany Park Flood Wall alternative.

TABLE 3.4.13.A
Recommended Alternative MS-10 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		MS-10	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
Mainstem crossing at Edgebrook cart path	27788	605.41	3639	605.52	3623
Mainstem crossing at Edgebrook cart path	26955	605.24	3637	605.36	3622
Mainstem crossing at Central Avenue	23231	604.47	3803	604.64	3782
Mainstem crossing at the Soo-Line RR	20413	603.79	3796	604.00	3777
Mainstem crossing at Forest Glen Avenue	16129	602.61	3791	602.87	3773
Mainstem crossing at I-94	15202	601.74	3815	602.03	3796
Mainstem crossing at Cicero Avenue	14902	601.35	3846	601.66	3827
Mainstem crossing at LaBagh Woods	11312	600.76	3845	601.14	3826
Mainstem crossing at Foster Avenue	8385	599.78	3844	600.30	3826
Mainstem crossing at Pulaski Road	7647	598.86	3896	599.59	3877
Mainstem crossing at Foster Avenue	7278	598.07	3895	599.04	3877
Mainstem crossing at Foster Avenue	6268	597.18	3895	598.43	3880
Mainstem crossing at Ridgeway Avenue	5542	597.14	3895	598.08	3880
Mainstem crossing at Carmen Avenue	4855	596.83	3895	597.66	3880
Mainstem crossing at Central Park Avenue	4448	596.45	3895	597.31	3880

Mainstem crossing at Bernard Street	3322	595.54	3895	595.77	3880
Mainstem crossing at Kimball Avenue	2961	595.02	3895	594.98	3880
Mainstem crossing at Spaulding Avenue	2066	594.26	3895	594.23	3880
Mainstem crossing at Kedzie Avenue	1254	591.75	3895	591.69	3880
Mainstem crossing at Albany Avenue	541	589.73	3715	589.72	3688

Table 3.4.13.B provides a comparison of peak flow and stage for existing and proposed conditions for the Wilmette Golf Course plus channel modification alternative.

TABLE 3.4.13.B
Recommended Alternative MS-14 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		MS-14	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
West Ditch of the Skokie River @ Tower Road	WD 9339	625.72	82	625.72	82
East Ditch of the Skokie River @ Forest Way (1)	ED 13447	624.61	39	623.48	41
East Ditch of the Skokie River @ Tower Road	ED 7000	624.59	39	623.44	42
East Ditch of Skokie River @ Forest Way (2)	ED 500	624.58	36	623.42	39
Skokie River crossing at Willow Road	SK 9266	624.57	746	623.41	1000
Skokie River crossing at Winnetka Road	SK 6467	624.46	840	623.14	1088
Skokie River crossing at I-94	SK 3768	624.33	961	622.87	1069
Skokie River crossing at Happ Road	SK 1618	624.25	953	622.75	1042
Middle Fork crossing at New Willow Road	MF 5932	626.71	1176	626.67	1178
Middle Fork crossing at Winnetka Road	MF 2887	624.40	1091	624.02	1217
West Fork crossing at Long Valley Road	WF 6664	623.06	1588	622.90	1596
West Fork crossing at Golf Road	WF 1977	622.23	1587	621.95	1592
Mainstem crossing at Lake Avenue	MS 77565	623.69	1976	622.00	1882
Mainstem crossing at Golf Road	MS 65959	621.77	1625	621.07	1312
Mainstem crossing at Dempster Street	MS 57266	620.60	3333	620.21	3107
Mainstem crossing at Howard Street	MS 46884	616.92	3544	616.68	3388
Mainstem crossing at Devon Avenue	MS 31366	606.61	3680	606.41	3593
Mainstem crossing at Central Avenue	MS 23231	604.47	3803	604.11	3658
Mainstem crossing at I-94	MS 15202	601.74	3815	601.46	3672
Mainstem crossing at Pulaski Road	MS 7647	598.86	3896	598.54	3764
Mainstem crossing at Central Park Avenue	MS 4448	596.45	3895	596.15	3766
Mainstem crossing at Kedzie Avenue	MS 1254	591.75	3895	591.28	3765

Table 3.4.13.C provides a comparison of peak flow and stage for existing and proposed conditions for the Foster Avenue Tunnel Diversion.

TABLE 3.4.13.C
Non-Recommended Alternative MS-07 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		MS-07	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
Mainstem crossing at Foster Avenue	6268	597.18	3895	593.71	1888
Mainstem crossing at Ridgeway Avenue	5542	597.14	3895	593.62	1888
Mainstem crossing at Carmen Avenue	4855	596.83	3895	593.06	1888
Mainstem crossing at Central Park Avenue	4448	596.45	3895	592.72	1888
Mainstem crossing at Bernard Street	3322	595.54	3895	591.89	1768
Mainstem crossing at Kimball Avenue	2961	595.02	3895	591.63	1766
Mainstem crossing at Spaulding Avenue	2066	594.26	3895	590.76	1760
Mainstem crossing at Kedzie Avenue	1254	591.75	3895	589.72	1760
Mainstem crossing at Albany Avenue	541	589.73	3715	589.29	1762

Table 3.4.13.D provides a comparison of peak flow and stage for existing and proposed conditions for the Wilmette Golf Course Reservoir.

TABLE 3.4.13.D
Non-Recommended Alternative MS-12 Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		MS-12	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
West Ditch of the Skokie River @ Tower Road	WD 9339	625.72	82	625.72	82
East Ditch of the Skokie River @ Forest Way (1)	ED 13447	624.61	39	623.89	39
East Ditch of the Skokie River @ Tower Road	ED 7000	624.59	39	623.86	39
East Ditch of Skokie River @ Forest Way (2)	ED 500	624.58	36	623.85	35
Skokie River crossing at Willow Road	SK 9266	624.57	746	623.84	684
Skokie River crossing at Winnetka Road	SK 6467	624.46	840	623.73	766
Skokie River crossing at I-94	SK 3768	624.33	961	623.60	872
Skokie River crossing at Happ Road	SK 1618	624.25	953	623.54	872
Middle Fork crossing at New Willow Road	MF 5932	626.71	1176	626.68	1179
Middle Fork crossing at Winnetka Road	MF 2887	624.40	1091	624.04	1162

West Fork crossing at Long Valley Road	WF 6664	623.06	1588	622.79	1601
West Fork crossing at Golf Road	WF 1977	622.23	1587	621.76	1594
Mainstem crossing at Lake Avenue	MS 77565	623.69	1976	622.91	1734
Mainstem crossing at Golf Road	MS 65959	621.77	1625	620.92	1138
Mainstem crossing at Dempster Street	MS 57266	620.60	3333	619.98	2980
Mainstem crossing at Howard Street	MS 46884	616.92	3544	616.54	3294
Mainstem crossing at Devon Avenue	MS 31366	606.61	3680	606.32	3541
Mainstem crossing at Central Avenue	MS 23231	604.47	3803	603.91	3577
Mainstem crossing at I-94	MS 15202	601.74	3815	601.31	3590
Mainstem crossing at Pulaski Road	MS 7647	598.86	3896	598.37	3690
Mainstem crossing at Central Park Avenue	MS 4448	596.45	3895	596.01	3693
Mainstem crossing at Kedzie Avenue	MS 1254	591.75	3895	591.03	3692

3.4.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for alternatives studied in detail. Table 3.4.14 lists the alternatives analyzed in detail; however, only alternatives MS-10 and MS-14 are recommended and the other alternatives are provided for informational purposes only. Figures 3.4.2a, 3.4.2b, 3.4.3a, and 3.4.3b show a comparison of existing conditions to alternative conditions 100 year inundation mapping with the implementation of alternatives MS-10, MS-07, MS-14, and MS-12, respectively.

TABLE 3.4.14
Mainstem Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Water Quality Benefit	Recommended	Communities Involved
MS-07	Construct 18 ft diameter tunnel diversion from Foster Rd and Pulaski Rd to Foster Rd and the North Shore Channel	0.47	25,920,000	55,702,000	336	No Impact	No	Chicago
MS-10[1]	Construct floodwall through Albany Park Neighborhood	1.51	24,746,000	16,402,000	329	No Impact	Yes	Chicago
MS-12	Construct new reservoir at Wilmette Public Golf Course	0.24	53,239,000	223,725,000	765	Slightly Positive	No	Chicago, Niles, Morton Grove, Golf, Glenview, Wilmette, Northfield, Unincorporated Cook County, Winnetka
MS-14[2]	Construct new reservoir at Wilmette Public Golf Course along with channel widening from Middle Fork to West Fork	0.25	64,431,000	260,121,000	1,153	Slightly Positive	Yes	Chicago, Niles, Morton Grove, Golf, Glenview, Wilmette, Northfield, Unincorporated Cook County, Winnetka

1 - The City of Chicago has expressed a preference for Alternative MS-07, which is described in Section 3.4.3.5. Alternative MS-10 yields a higher B/C ratio and was therefore selected as the recommended alternative for the DWP. The City of Chicago supports Alternative MS-07 in lieu of Alternative MS-10 because the tunnel would reduce flooding without buyouts, relocations, or construction of a wall through the Albany Park neighborhood.
2 - MS-14 project's total benefits includes benefits to the Middle Fork, Skokie River, and Main Stem NBCR subwatersheds. FPDCC and Wilmette Park District have indicated their unwillingness to provide land for this alternative.

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3.5 North Shore Channel

The NSC, a constructed tributary in the NBCR watershed, enters the Main Stem of the NBCR near Albany Avenue in Chicago, has a stream length of 7.7 miles and a drainage area of 25 square miles. Table 3.5.1 summarizes the land area of communities within the NSC subwatershed. The NSC subwatershed consists primarily of residential areas. Table 3.5.2 summarizes the land use distribution within the NSC.

TABLE 3.5.1
Communities Draining to the North Shore Channel

Community/Tributary	Tributary Area (mi^2)
Skokie	8.68
Chicago	7.11
Evanston	4.91
Lincolnwood	2.68
Wilmette	1.32
Niles	0.28
Morton Grove	0.03

Figure 3.5.1 shows an overview of the tributary area of the NSC subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

TABLE 3.5.2
Land Use Distribution for the North Shore Channel

Land Use Category	Area (acres)	%
Residential	10,150	63.0
Commercial/Industrial	2,688	16.7
Forest/Open Land	1,741	10.8
Institutional	870	5.4
Transportation/Utility	563	3.5
Water/Wetland	83	0.5
Agricultural	13	0.1

3.5.1 Sources of Data

3.5.1.1 Previous Studies

The NSC was modeled in HEC-RAS by the USACE as part of their larger CAWS model. This model was utilized as part of the NBCR DWP development.

3.5.1.2 Water Quality Data

The IEPA has seven Ambient Water Quality Monitoring Network sites on the NSC. Two reaches of the NSC are identified as impaired in the IEPA's 2008 Integrated Water Quality Report, which includes the CWA 303(d) and 305(b). The NSC reach IL_HCCA-02 is listed as impaired for Nickel, Dissolved Oxygen, Phosphorous (Total), Zinc, Polychlorinated biphenyls, and Fecal Coliform. NSC reach IL_HCCA-04 is listed as impaired for Mercury and Polychlorinated biphenyls. No TMDLs have been established for the North Shore Channel. According to a water permit discharge query by the),USEPA, there are six NPDES permits issued by IEPA to MWRDGC-North Side WWTP in Skokie, Evanston CSOs, Lincolnwood CSOs, Niles CSOs, Wilmette CSOs, and Chicago CSOs for discharges to the NSC. Municipalities discharging to the NSC are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was instituted to improve water quality by requiring that municipalities develop six minimum control measures for limiting runoff pollution to receiving systems.

3.5.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR Watershed. Wetland areas were identified using NWI mapping. NWI data includes approximately 83 acres of wetland areas in the NSC tributary area. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provides flood management, habitat, and water quality enhancement. Identified riparian environments offer potential opportunities for restoration.

3.5.1.4 Floodplain Mapping

Flood inundation areas supporting the NFIP were revised in 2008 as a part of FEMA's Map Modernization Program. Floodplain boundaries were revised based upon updated Cook County topographic information, but the effective models used to estimate flood levels generally were not updated. LOMRs were incorporated in the revised floodplains. The NSC is mapped as a FEMA Zone A floodplain, determined by approximate methods; therefore, no documented effective FIS H&H analysis was performed on the North Shore Channel.

Appendix A includes a comparison of FEMA's effective floodplain mapping from updated DFIRM panels with inundation areas developed for the DWP.

3.5.1.5 Stormwater Problem Data

Table 3.5.3 summarizes reported problem areas reviewed as a part of the DWP development. The problem area data was obtained primarily from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.5.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.5.1.6 Near-Term Planned Projects

Watershed communities, agencies, and stakeholders were asked about near-term planned projects so that the implementation of near-term flood control projects by others is considered in development of the DWP. Several studies are currently underway in the NSC Subwatershed; however, no near-term planned flood control projects by others have been identified in the NSC subwatershed.

TABLE 3.5.3
Community Response Data for the North Shore Channel

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FL-41	City of Chicago	Intracommunity (local) flooding	Interstate Route 94 at Peterson/Caldwell Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-42	City of Chicago	Intracommunity (local) flooding	Interstate Route 94 at US Route 14	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-43	City of Chicago	Intracommunity (local) flooding	Devon Avenue at 2750 Devon Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
EV-FL-02	City of Evanston	Intracommunity (local) flooding	Various locations in Evanston	Map of the pavement flooding for the September 2008 storm.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
EV-FL-03	City of Evanston	Intracommunity (local) flooding	Various locations in Evanston	Map of the basement flooding for the September 2008 storm.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
LW-FL-01	Village of Lincolnwood	Intracommunity (local) flooding	Various locations throughout the Village of Lincolnwood	Basement flooding/ponding/water quality pollution. Sewer/floor drain back ups, street flooding, overland flooding entering through window wells, etc. Insufficient capacity of combined sewer system.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.5.3
Community Response Data for the North Shore Channel

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
LW-FL-02	Village of Lincolnwood	Intracommunity (local) flooding	Interstate Route 94 (Edens) at Pratt Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
LW-FL-03	Village of Lincolnwood	Intracommunity (local) flooding	US Route 41 at Crawford Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
LW-FL-04	Village of Lincolnwood	Intracommunity (local) flooding	Touhy Avenue at Crawford Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
LW-WQ-05	Village of Lincolnwood	Intracommunity (local) flooding	Village of Lincolnwood	Basement flooding/ponding/water quality pollution. Sewer/floor drain back ups, street flooding, overland flooding entering through window wells, etc. Insufficient capacity of combined sewer system.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-12	Village of Skokie, Village of Lincolnwood	Intracommunity (local) flooding	Interstate Route 94 (Edens) at Touhy Avenue (NB & SB)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-13	Village of Skokie, Village of Lincolnwood	Intracommunity (local) flooding		IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.5.3
Community Response Data for the North Shore Channel

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
SK-FL-14	Village of Skokie, City of Evanston	Intracommunity (local) flooding	McCormick Boulevard at Emerson Street	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
LW-FL-06	City of Chicago, Village of Lincolnwood	Intracommunity (local) flooding	McCormick Boulevard at Devon Avenue (50 ft north)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
EV-FL-04	Village of Skokie, City of Evanston	Intracommunity (local) flooding	McCormick Boulevard at Golf Road (1/4 mile N/O)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
EV-FL-05	City of Evanston	Intracommunity (local) flooding	McCormick Boulevard at Bridge Street (Northwest Corner)	IDOT Pavement flooding	Local	
SK-FL-15	Village of Skokie, City of Evanston	Intracommunity (local) flooding	McCormick Boulevard at Oakton Street (S/O)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-16	Village of Skokie, City of Evanston	Intracommunity (local) flooding	Crawford Avenue at N/O Golf Road	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.5.3
Community Response Data for the North Shore Channel

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
SK-FL-07	Village of Skokie	Intracommunity (local) flooding	US Route 41 at Skokie Swift (S/O Oakton Street)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-08	Village of Skokie	Intracommunity (local) flooding	Church Road at Central Park (construction zone)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-09	Village of Skokie	Intracommunity (local) flooding	Church Street at E/O US Route 41 (Skokie Boulevard)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
SK-FL-10	Village of Skokie	Intracommunity (local) flooding	Skokie	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

[1] All Problem IDs begin with NB-NSCH- as all problems are within the North Branch – North Shore Channel subwatershed.

3.5.2 Watershed Analysis

3.5.2.1 Hydrologic Model Development

The North Shore Channel tributary area was hydrologically modeled by the USACE CAWS model. No DWP hydrologic model was generated for the North Shore Channel subwatershed.

3.5.2.2 Hydraulic Model Development

The North Shore Channel was hydraulically modeled by the USACE CAWS model. No DWP hydraulic model was generated for the North Shore Channel.

3.5.3 Development and Evaluation of Alternatives

There were no regional problem areas reported or identified through the USACE CAWS model of the North Shore Channel; therefore, no alternatives were developed for this subwatershed.

3.6 Mainstem of the NBCR Downstream of the North Branch Dam

The Mainstem of the NBCR downstream of the North Branch Dam (Mainstem Downstream) has a stream length of 9.0 miles and a drainage area of 38.5 square miles. Table 3.6.1 summarizes the land area of communities within the Mainstem Downstream subwatershed. The Mainstem Downstream subwatershed consists primarily of residential and commercial/industrial areas. Table 3.6.2 summarizes the land use distribution within the Mainstem Downstream.

TABLE 3.6.1
Communities Draining to the Mainstem Downstream

Community/Tributary	Tributary Area (mi^2)
Chicago	37.33
Norridge	0.56
Harwood Heights	0.38
Unincorporated	0.21

Figure 3.6.1 shows an overview of the tributary area of the Mainstem Downstream subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

TABLE 3.6.2
Land Use Distribution for the Mainstem Downstream

Land Use Category	Area (acres)	%
Residential	15,360	62.4
Commercial/Industrial	5,818	23.6
Forest/Open Land	1,459	5.9
Institutional	1,178	4.8
Transportation/Utility	640	2.6
Water/Wetland	179	0.7
Agricultural	0	0.0

3.6.1 Sources of Data

3.6.1.1 Previous Studies

The Mainstem Downstream was modeled in HEC-RAS by the USACE as part of their larger CAWS model. This model was utilized as part of the NBCR DWP development.

3.6.1.2 Water Quality Data

See DWP Section 3.4.1.2 for water quality data related to the Mainstem downstream of the North Branch Dam.

3.6.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR Watershed. Wetland areas were identified using NWI mapping. NWI data includes approximately 83 acres of wetland areas in the Mainstem upstream and downstream of the North Branch Dam tributary area. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provides flood management, habitat, and water quality enhancement. Identified riparian environments offer potential opportunities for restoration.

3.6.1.4 Floodplain Mapping

Flood inundation areas supporting the NFIP were revised in 2008 as a part of FEMA's Map Modernization Program. Floodplain boundaries were revised based upon updated Cook County topographic information, but the effective models used to estimate flood levels generally were not updated. LOMRs were incorporated in the revised floodplains. The Mainstem downstream of the North Branch dam is mapped as a FEMA Zone A floodplain, determined by approximate methods; therefore, no documented effective FIS H&H analysis was performed on the Mainstem downstream of the North Branch dam.

Appendix A includes a comparison of FEMA's effective floodplain mapping from updated DFIRM panels with inundation areas developed for the DWP.

3.6.1.5 Stormwater Problem Data

Table 3.6.3 summarizes reported problem areas reviewed as a part of the DWP development. The problem area data was obtained primarily from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.6.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.6.1.6 Near-Term Planned Projects

Watershed communities, agencies, and stakeholders were asked about near-term planned projects so that the implementation of near-term flood control projects by others is considered in development of the DWP. Several studies are currently underway in the Mainstem Downstream Subwatershed; however, no near-term planned flood control projects by others have been identified in the Mainstem Downstream Subwatershed.

TABLE 3.6.3
Community Response Data for the Mainstem Downstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FL-01	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm water sewer flow restriction. City sewer improvements are often focused towards areas of the most complaints.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-02	City of Chicago	Intracommunity (local) flooding	Illinois Route 19 at Ravenswood Parkway (both sides)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-03	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at California Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-04	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Edens Junction (Montrose to Wilson)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-05	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Addison Street (NWB & SEB)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-06	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Fullerton Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.6.3
Community Response Data for the Mainstem Downstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FL-07	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Ogden Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-08	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Augusta Blvd (Lane 3) NB	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-09	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Illinois Route 50 (Cicero Ave) Lane 3	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-10	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Damen Avenue (Lane 1) NB	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-11	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Division Street	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-12	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Illinois Route 64 (North Ave) Lane 1 NB	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.6.3
Community Response Data for the Mainstem Downstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FL-13	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Diversey Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-14	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Kimball (Exit 4)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-15	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Ashland Avenue (Lane 1) NB	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-16	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Montrose Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-17	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Kostner Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-18	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Logan Boulevard	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.6.3
Community Response Data for the Mainstem Downstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FL-19	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Armitage Avenue (Lane 1) NB	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-20	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Illinois Route 19 (Irving Park Rd) Lane 1 SB	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-21	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Pulaski Road entrance ramp	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-22	City of Chicago	Intracommunity (local) flooding	Interstate Route 90/94 at Willow Street (W/O)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-23	City of Chicago	Intracommunity (local) flooding	Interstate Route 94 (Edens) at Wilson Road (N/O Kennedy)	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-24	City of Chicago	Intracommunity (local) flooding	Illinois Route 43 at Illinois Route 72 (Higgins Rd) Lane 2	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

TABLE 3.6.3
Community Response Data for the Mainstem Downstream

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CH-FL-25	City of Chicago	Intracommunity (local) flooding	Lawrence Avenue at C, M & St. Paul Road (viaduct) W/O I-94	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-26	City of Chicago	Intracommunity (local) flooding	Lawrence Avenue at Milwaukee Avenue	IDOT Pavement Flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
CH-FL-27	City of Chicago	Intracommunity (local) flooding	Citywide	Basement flooding, storm sewer flow restriction, water quality (pollution). The City sewer improvements are often focused towards areas of the most complaints.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

[1] All Problem IDs begin with NB-NBCU- as all problems are within the North Branch – Downstream of the North Branch Dam subwatershed.

3.6.2 Watershed Analysis

3.6.2.1 Hydrologic Model Development

The Mainstem Downstream tributary area was hydrologically modeled by the USACE CAWS model. No DWP hydrologic model was generated for the Mainstem Downstream subwatershed.

3.6.2.2 Hydraulic Model Development

The Mainstem Downstream was hydraulically modeled by the USACE CAWS model. No DWP hydraulic model was generated for the Mainstem Downstream.

3.6.3 Development and Evaluation of Alternatives

There were no regional problem areas reported or identified through the USACE CAWS model of the Mainstem Downstream, so no alternatives were developed for this subwatershed.

3.7 Lake Michigan Watershed

The LM watershed has a series of eight ravines within Cook County, with a total stream length of 5.3 miles and a drainage area of 15.1 square miles. Table 3.7.1 summarizes the land area of communities within the LM watershed. The LM watershed consists primarily of residential areas. Table 3.7.2 summarizes the land use distribution within the Lake Michigan Watershed.

TABLE 3.7.1
Communities Draining to Lake Michigan Watershed

Community/Tributary	Tributary Area (mi^2)
Chicago	7.85
Evanston	2.60
Glencoe	1.82
Winnetka	1.36
Wilmette	0.86
Kenilworth	0.60

Figures 3.7.1a and 3.7.1b shows an overview of the tributary area of the Lake Michigan Watershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

TABLE 3.7.2
Land Use Distribution for Lake Michigan Watershed

Land Use Category	Area (acres)	%
Residential	5,907	60.7
Forest/Open Land	1,536	15.8
Commercial/Industrial	1,312	13.5
Institutional	621	6.4
Transportation/Utility	288	3.0
Water/Wetland	64	0.7
Agricultural	0	0.0

3.7.1 Sources of Data

3.7.1.1 Previous Studies

The Lake Michigan Watershed has no known previous studies for use in DWP H&H modeling.

3.7.1.2 Water Quality Data

The IEPA has two Ambient Water Quality Monitoring Network sites for the LM Watershed. Fourteen locations along the shore of LM, including locations in Cook County, are identified as impaired in the IEPA's 2008 Integrated Water Quality Report, which includes the CWA 303(d) and 305(b) lists. No TMDLs have been established for LM. According to a water permit discharge query by the USEPA, there are six NPDES permits issued by IEPA to Chicago South WTP, Chicago-Jardine Water Plant, McCormick Place West Hall, Metro Pier & Expo Authority, Northwestern University Central Utility Plant, and Winnetka Electric Plant for discharges to LM. Municipalities discharging to LM are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was instituted to improve water quality by requiring that municipalities develop six minimum control measures for limiting runoff pollution to receiving systems.

3.7.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the NBCR Watershed. Wetland areas were identified using NWI mapping. NWI data includes approximately 64 acres of wetland areas in the Lake Michigan tributary area. Riparian areas are defined as vegetated areas between aquatic and upland ecosystems adjacent to a waterway or body of water that provides flood management, habitat, and water quality enhancement. Identified riparian environments offer potential opportunities for restoration.

3.7.1.4 Floodplain Mapping

FIRMs were obtained from FEMA for the northern Cook County portion of the Lake Michigan Watershed. A review of the maps showed that there are no mapped floodplains except for Lake Michigan.

For Lake Michigan, the USACE developed a storm surge-elevation-frequency relationship based on stillwater elevations due to tide and wind setup to determine the Base Flood Elevation (BFE) for the lake. Wave action was not included in the analysis. The BFE, also known as the 100-year annual chance flood elevation, is 585.0 feet, according to the NAVD 88, along the entire shoreline within Cook County.

3.7.1.5 Stormwater Problem Data

Table 3.7.3 summarizes reported problem areas reviewed as a part of the DWP development. The problem area data was obtained primarily from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.7.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.7.1.6 Near-Term Planned Projects

Watershed communities, agencies, and stakeholders were asked about near-term planned projects so that the implementation of near-term flood control projects by others is considered in development of the DWP. Several studies are currently underway in the LM watershed; however, no near-term planned flood control projects by others have been identified in the LM watershed.

TABLE 3.7.3
Community Response Data for the Lake Michigan Watershed

Problem ID[1]	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
EV-SM-01	Village of Evanston	Streambank erosion on intracommunity waterways	Lake Michigan Beachfront	Erosion at outfall at beach - maintenance	Local	Erosion problem not immediately threatening structure. Not addressed by DWP
GC-EL-01	Village of Glencoe	Streambank erosion on intracommunity waterways	Ravines	Erosion in ravines	Local	Erosion problem not immediately threatening structure. Not addressed by DWP
KW-SM-01	Village of Kenilworth	Stream maintenance	Green Bay Road at Metra North Line	48" culvert silted up and deteriorating - no flooding	Local	Maintenance activities recommended in Section 4.
KW-SM-02	Village of Kenilworth	Stream maintenance	Sheridan Road, North of Kenilworth Ave	Concrete pad surrounding MWRD interceptor is cracked and deteriorating	Local	Maintenance activities recommended in Section 4.
WK-ER-01	Village of Winnetka, Glencoe	Streambank erosion on intercommunity waterways	Lake Michigan Waterfront	Bluff erosion	Regional	Erosion problem not immediately threatening structure. Not addressed by DWP
WK-EL-03	Village of Winnetka	Streambank erosion on intracommunity waterways	Ravines	General streambank erosion	Local	Erosion problem not immediately threatening structure. Not addressed by DWP

[1] All Problem IDs begin with LM- as all problems are within the Lake Michigan watershed.

3.7.2 Watershed Analysis

3.7.2.1 Hydrologic Model Development

Subbasin Delineation. The Lake Michigan ravine subbasins were delineated based upon LiDAR topographic data developed by Cook County in 2003. Table 3.7.4 below displays the results of the subbasin delineations. Based MWRDGC's CCSMP requirement that H&H modeling be performed for all subbasins greater than 0.5 square miles in area and the results from Table 3.7.3, Ravine 1 was the only reach modeled in the Lake Michigan Watershed.

TABLE 3.7.4
Lake Michigan Ravine Subbasin Areas within Cook County

Ravine Number	Area, acres (mi^2)
1	415 (0.648)
2	150 (0.234)
3	28 (0.044)
4	175 (0.273)
5	194 (0.303)
6	31 (0.048)
7	44 (0.069)
8	185 (0.289)[1]

[1] Tributary area of Ravine #8 within Cook County.

Hydrologic Parameter Calculations. CNs were estimated for each subbasin based upon NRCS soil data and 2001 CMAP land use data. This method is further described in Section 1.3.2, with lookup values for specific combinations of land use and soil data presented in Appendix C. An area-weighted average of the CN was generated for each subbasin. Using SCS unit hydrograph methodology, the lag time, used to convert excess precipitation into a runoff hydrograph, was assumed to be 0.6 times the time of concentration for all subbasins. The time of concentration, or time of travel from the hydrologically most distant part of the subbasin, was estimated by using standard procedures assuming a length of sheet flow, shallow concentrated flow, and channel flow. In some instances, modification to parameter estimates was necessary to more accurately characterize very flat or heavily sewered subwatersheds. Appendix G provides a summary of the hydrologic parameters used for subbasins in each subwatershed.

3.7.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met the District criteria for use in the DWP, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Cross-sectional geometry of Ravine #1 was obtained solely from Cook County topographic data. Field visits were performed to assess channel and overbank roughness characteristics, which were combined with information from photographs and aerial photography to assign modeled Manning's n roughness coefficients along the modeled stream length.

Initial attempts to model Ravine 1 were performed using unsteady state analysis. After setting up the HEC-RAS model geometry and several attempts to execute the model, it became apparent that unsteady state analysis would not be feasible for this ravine. Ravine 1 has steep slopes combined with low Manning's n values, which results in high velocity, super critical flow. The HEC-RAS unsteady state analysis does not execute under supercritical conditions. Therefore, modeling analysis was successfully performed using the HEC-RAS steady state analysis with a supercritical flow regime specified.

Boundary Conditions. The downstream boundary condition for Ravine 1 is its outfall at Lake Michigan. The maximum existing conditions 100 year WSEL at this outfall is approximately 585.0 feet in vertical elevation datum NAVD 88.

3.7.2.3 Calibration and Verification

Lake Michigan Ravine 1 does not have stream gages to monitor flow and stage along the ravine and historical high water elevations were not available; therefore, this hydraulic model was unable to be calibrated and verified.

3.7.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.7.1a shows inundation areas produced by the hydraulic model for the 100-year, 24-hour duration design storm for Ravine 1.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in Lake Michigan Ravine 1. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.7.3 Development and Evaluation of Alternatives

The one regional erosion problem reported for the Lake Michigan watershed, bluff erosion along the Lake Michigan waterfront, was investigated. No active bluff erosion was identified within 30 feet of existing infrastructure; therefore, no regional erosion stabilization project was recommended as part of this DWP.

No additional regional flood control problem areas were reported or identified through modeling of Lake Michigan Ravine 1; therefore, no flood control alternatives were developed for this watershed.

4. Watershed Action Plan

This section summarizes the DWP recommendations. The recommendations and supporting information will be considered by the District's Board of Commissioners in their prioritization of a countywide Stormwater CIP. The recommendations within the DWP consist of maintenance activities (Section 4.1) and recommended capital improvements (Section 4.2).

4.1 Watershed Maintenance Activities

Review of reported stormwater problem data indicated that certain types of maintenance activities would be helpful in preventing these stormwater problems. The District, through its maintenance activities, has been actively removing blockages such as tree limbs and woody debris from channels throughout Cook County. Local communities have reported benefits from these maintenance activities. It is recommended that the District maintenance activities be continued to address ongoing future maintenance needs.

Dredging of stream channels was investigated as part of the DWP. While dredging is considered a watershed maintenance activity, extensive re-grading and shaping of the stream channel would be required with this activity. Additionally, dredging limits proved difficult to establish both along the stream centerline and channel depth. Dredging of the stream channel would require a downstream tie-in location to match existing stream bed elevations. The extremely flat stream bed profiles on all watershed stream reaches makes matching existing stream bed elevations impractical. Additionally, dredging depths are difficult to establish due to limited historical data on original stream bed elevations and, thus, rely solely on approximations of dredging depths. In general, minor dredging operations in localized areas will provide little to no improvement to conveyance, particularly during larger storm events where additional storage or channel modifications would be required to significantly reduce water surface elevations. Due to the aforementioned reasons as well as dredging being considered a maintenance activity that would provide only temporary benefits to localized areas, dredging is not recommended as a regional stormwater management solution.

Sedimentation is a dynamic process that is affected by soil protective measures taken in upland tributary areas and changing streambank conditions. The District's Watershed Management Ordinance will define standard practices for erosion protection on construction sites. Best management practices in upland areas should be paired with stream maintenance measures to reduce sediment delivered to waterways to reduce the need for extensive dredging programs.

Stormwater improvement projects recommended in the NBCR and LM DWP including detention basins, channel diversions, or erosion control armoring will require ongoing maintenance after construction. Costs associated with maintenance over a 50-year life-cycle period were included in cost estimates. It is recommended that the District develop maintenance plans for capital improvements, and where applicable, execute agreements with local governments that delegate certain maintenance responsibilities. It is intended that maintenance agreements will follow current District practice, where the District is responsible for operation and maintenance of structural, electrical, and mechanical facilities and grounds are the responsibility of partnering organizations.

Table 4.1.1 lists all problem area locations where standard stream maintenance activities are recommended including debris and blockage removal, removal of silt from culverts, and removal of sediment from stream channels.

TABLE 4.1.1
Summary of Problem Areas where Debris Removal or Other Maintenance is Recommended

Problem Area ID	Tributary	Location	Type of Maintenance Activity Required
LM-EV-SM-01	Lake Michigan	Beachfront Outfalls in City of Evanston	Remove debris and clear outfalls of sedimentation
LM-KW-SM-01	Lake Michigan	48" culvert located under Green Bay Road and Metra North Line just south of intersection of Roger Avenue/Sterling Road/Green Bay Road in Kenilworth	Remove debris and clear 48" culvert of sedimentation
NB-NVDN-GV-SM-04	North Navy Ditch	North Navy Ditch from John's Drive to confluence with West Fork in Glenview	Remove debris and blockages along channel
NB-NVDS-GV-SM-07	South Navy Ditch	South Navy Ditch from Lehigh Road to confluence with West Fork in Glenview	Remove debris and blockages along channel
NB-WFNB-GV-SM-10	West Fork	Techny 32C Reservoir Spillway in Glenview	Remove debris and siltation along spillway and repair spillway
NB-WFNB-GV-SM-25	West Fork	West Fork from Willow Road to Chestnut Avenue in Glenview	Remove debris and clear channel
NB-WFNB-NB-SM-16	West Fork	Accumulation of debris at CCHD's structure number 016-3234	Remove debris and clear channel

4.2 Recommended Capital Improvements

Table 4.2.1 lists all recommended improvements for the NBCR and LM DWP. The District will use data presented here to support prioritization of a countywide stormwater CIP.

4.3 Implementation Plan

In general, alternatives listed in Table 4.2.1 can be constructed independently. One exception to this independence of alternatives is SR-08 and MS-14. SR-08 is an alternative targeted specifically for overbank flooding only at I-94 and Winnetka Road, while MS-14 addresses overbank flooding of I-94 at Winnetaka Road, Willow Road, and Skokie River crossing, and provides additional benefits along the Middle Fork, Skokie, and Mainstem reaches; therefore, the SR-08 alternative is only recommended if MS-14 is not implemented. Furthermore, because of the interaction of impacts between alternatives, the benefits associated with constructing several alternatives in a reach or subwatershed may exceed the sum of the benefits of the individual alternatives, or vice versa.

The data presented in Table 4.2.1, along with noneconomic factors, will allow the District to prioritize its CIP and to implement projects. A number of alternatives in Table 4.2.1 require the acquisition of land that currently may be unavailable. It is recommended that upon selecting an alternative for implementation, the District identify land acquisition needs and procedures. For example, the enabling legislation (70 ILCS 2605/7h (g)) for the District's stormwater management program states "the District shall not use Cook County Forest Preserve District land for stormwater or flood control projects without the consent of the Forest Preserve District of Cook County (FPDCC)"; therefore proposed projects involving FPDCC property cannot be implemented without FPDCC's permission. The District will work collaboratively with FPDCC to develop multi-objective projects beneficial to both agencies along with our constituents and also consistent with our individual missions.

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TABLE 4.2.1
NBCR and LM Watersheds' Prioritization Matrix

Project	B/C Ratio	Total Benefits ($)	Total Project Cost ($)	Probable Construction Cost ($)	Relative Damage Averted 25% 50% 75%	Acreage Removed from Inundation Area	Wetland or Riparian Areas Impacted (acres)	Cumulative Structures Protected	Implementation Time (months)[1]	Water Quality Benefit	Communities Involved
WF-03	0.77	$1,550,000	$2,022,000	$1,097,000		N/A	-	3	18	Slightly Positive	Metra and Northbrook
WF-06	1.26	$146,484,000	$116,088,000	$87,422,000		137	5	216	48	Slightly Positive	Northbrook Park District, Northbrook, Glenview, Golf, Unincorp. Cook Co.
MF-04	0.12	$178,000	$1,495,000	$736,000		5	3	4	12	No Impact	Forest Preserve District of Cook County (FPDCC), Northbrook, Unincorp. Cook Co.
MF-06	4.59	$7,391,000	$1,610,000	$873,000		N/A	-	7	18	Slightly Positive	Northfield
MF-07	1.65	$1,600,000	$971,000	$526,000		N/A	-	3	18	Slightly Positive	Northfield
SR-08[2]	1.35	$7,760,000	$5,761,000	$3,512,000		11	3	0	18	No Impact	Northfield, IDOT, FPDCC, Cook County Highway Department
MS-10[3]	1.51	$24,746,000	$16,402,000	$4,176,000		40	6	329	36	No Impact	Chicago, Chicago Park District, FPDCC, Private Property Owners
MS-14[4]	0.25	$64,431,000	$260,121,000	$185,117,000		1,051	90	1,153	60	Slightly Positive	Wilmette Park District, Wilmette, FPDCC, Glenview

1 - Implementation time includes anticipated construction timeframes. Additional time will be required for land acquisition, permitting, and design activities.

2 - SR-08 project addresses overbank flooding of the Skokie River near I-94 (Edens Expressway) and Winnetka Road. For purposes of benefit calculation for SR-08, no other temporary closure of I-94 due to overbank flooding is assumed.

3 - The City of Chicago has expressed a preference for Alternative MS-07, which is described in Section 3.4.3.5. Alternative MS-10 yields a higher B/C ratio and was therefore selected as the recommended alternative for the DWP.

4 - MS-14 project's total benefits includes benefits to the Middle Fork, Skokie River, and Main Stem NBCR subwatersheds. FPDCC and Wilmette Park District have indicated their unwillingness to provide land for this alternative.

Property Damage
Erosion
Transportation
Recreation

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5. Summary and Conclusions

The NBCR and LM DWP were developed in coordination with the North Branch of the Chicago River WPC. The coordination focused on integrating community knowledge of stormwater problems and ideas for feasible solutions into the District's regional stormwater plan. All stormwater problem data received from stakeholders was recorded in a spatial database, and classified as local or regional according to the criteria defined in Section 1. Hydrologic and hydraulic models were developed to estimate flow and stage along regional waterways and assess the frequency and depth of flooding problems for a range of modeled recurrence intervals. Inundation mapping was developed for the 2-, 5-, 10-, 25-, 50-, 100-year, and 500-year modeled storm events, identifying areas estimated to be at risk of flooding. Modeled water depths and inundation mapping were used to help estimate damages due to flooding within each tributary.

Stormwater improvements were developed to address regional problems throughout the NBCR watershed. Appropriate tributary-specific technologies were screened considering their applicability for addressing problem areas, constructability in the area required, and regulatory feasibility. H&H models were modified to represent possible future conditions. Damage estimates for proposed alternatives were performed to evaluate the alternative's effectiveness at reducing regional stormwater damages. The difference in damages between existing and alternative conditions was quantified as the alternative's benefit. In addition to numeric (monetary) benefits, several other criteria were noted for each alternative, such as the number of structures protected, water-quality benefit, and wetland/riparian areas affected. Conceptual level opinions of probable costs were developed to estimate the construction and maintenance cost of proposed alternatives over a 50-year period. The estimated benefits were divided by the conceptual costs to develop a B/C ratio for each alternative.

Figure 5.1 summarizes the extent to which recommended alternatives address existing regional financial damages within each stream reach, ordered by increasing existing conditions damages. The two line series illustrated on the graph represent existing condition damages and benefits, respectively, for each stream reach. The columns indicate the extent to which recommended alternatives address estimated damages, while the red B/C symbols indicate the combined benefit-cost ratio for alternatives associated with each stream reach. As an example, the recommended West Fork alternatives, WF-03 and WF-06, address roughly 65 percent of estimated damages along the West Fork (indicated by the column), which corresponds to a benefit of approximately $148,034,000. In contrast, the recommended alternative that benefits the Skokie River, MS-14, addresses over 90 percent of the estimated damages along the Skokie River, but this project results in only about $46,996,000 of benefit for the Skokie River reach.

In Figure 5.1, the Skokie River stream reach only reports the MS-14 project's benefits, project costs, and percent damages addressed on the Skokie River. MS-14 is the only project reported for the Skokie River stream reach since the Skokie River subwatershed benefits provided by this project are more comprehensive than the SR-08 project. However, due the low B/C ratio of MS-14, the SR-08 project has been included as a recommended project to serve as an alternative feasible solution to the I-94 at Winnetka Road overbank flooding problem should the MS-14 project not be implemented. SR-08 is an alternative targeted specifically for overbank flooding only at I-94 and Winnetka Road, while MS-14 addresses overbank flooding of I-94 at Winnetaka Road, Willow Road, and Skokie River crossing, and provides additional benefits along the Middle Fork, Skokie, and Mainstem reaches; therefore, the SR-08 alternative is only recommended if MS-14 is not implemented. It should be noted that SR-08 addresses overbank flooding only at I-94 and Winnetka Road; however, this project does not address overbank flooding along I-94 at Willow Road and Skokie River crossing.

Figure 5.1
North Branch of the Chicago River Watershed Alternative Summary

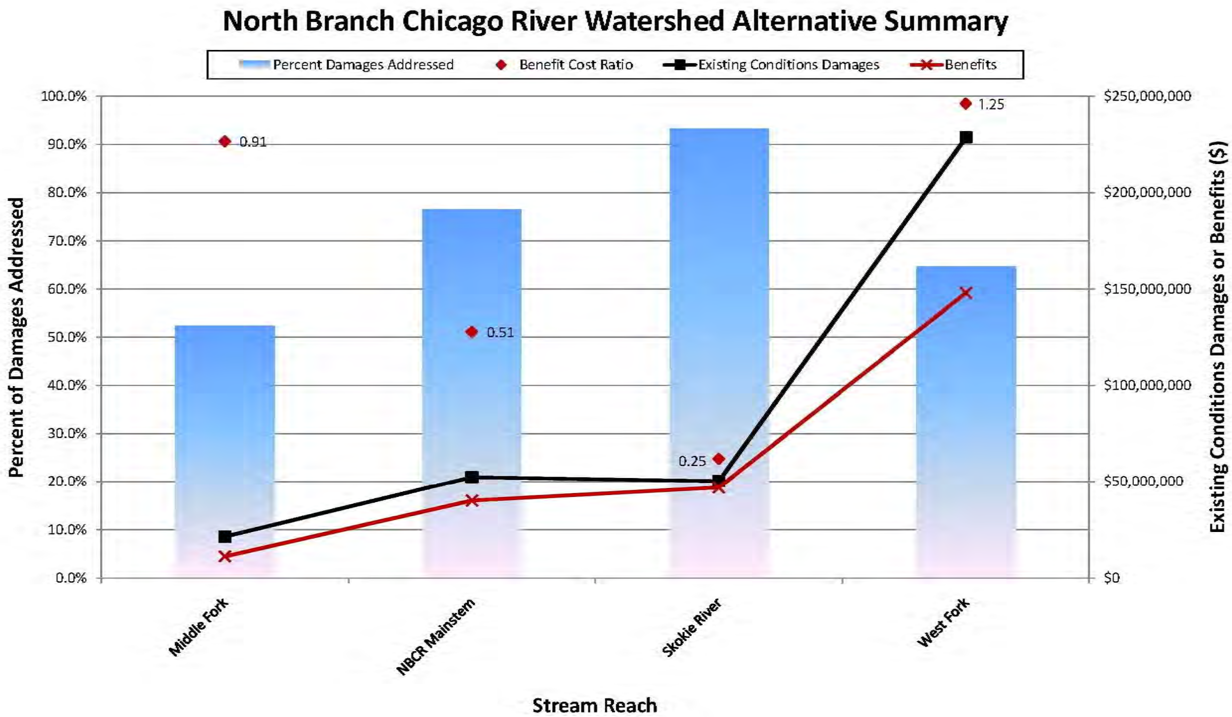

Figure 5.1 Notes:

1. Skokie River stream reach only includes benefits and damages addressed for the MS-14 project due to overlapping benefit with the SR-08 benefit.
2. Benefits, project costs, and damages addressed for the Middle Fork, NBCR Mainstem, and Skokie River stream reaches include results from the MS-14 project. Project costs have been prorated among the three reaches based on benefit percentage to each respective stream reach.

Because the MS-14 project provides benefits to the Middle Fork, Skokie, and NBCR Mainstem stream reaches, the benefits provided by MS-14 for each stream reach were incorporated into the percent damages addressed and B/C ratio for each stream reach. Distribution of project costs for MS-14 between the associated stream reaches was estimated by prorating the MS-14 project costs among the three reaches based on benefit percentage provided by MS-14 to each respective stream reach.

In general, the recommended alternatives listed in Table 4.2.1 can be constructed independently. However, in the case of SR-08 and MS-14, the alternatives and associated benefits are not independent. In this case, the SR-08 alternative is only recommended if MS-14 is not implemented. Because of the interaction of impacts between alternatives, the benefits associated with constructing several alternatives in a reach or subwatershed may exceed the sum of the benefits of the individual alternatives, or vice versa. Furthermore, by the nature that streambank stabilization projects completely protect structures at imminent risk, all potential erosion damages are addressed with this type of project.

Estimated damage reductions result from proposed stormwater improvements that increase stormwater storage in the watershed, thereby reducing peak flows and stage, increasing conveyance to receiving systems (only if increased flows do not cause downstream damages), or channel protection measures to reduce erosion damages. Floodproofing alternatives, though feasible for addressing isolated shallow flooding issues, are not included in the summary statistics below due to the individualized way in which such measures would be implemented.

Benefits from proposed project alternatives are not distributed evenly throughout the NBCR watershed, but are generally concentrated in subwatersheds with greater existing conditions damages where capital improvement projects address these damages. Differences in the amount of available open land for stormwater alternatives also contribute to uneven distribution of benefits among subwatersheds. Recommended project alternatives do not generally address all existing damages from the 100-year design inundation areas, as sufficient open land is not always present in locations that can reduce floodwaters to the level that eliminates inundation of structures along regional waterways. In particular, it is noted that the enabling legislation (70 ILCS 2605/7h (g)) for the District's stormwater management program states "the District shall not use Cook County Forest Preserve District land for stormwater or flood control projects without the consent of the Forest Preserve District of Cook County (FPDCC)"; therefore proposed projects involving FPDCC property cannot be implemented without FPDCC's permission. The District will work collaboratively with FPDCC to develop multi-objective projects beneficial to both agencies along with our constituents and also consistent with our individual missions.

At the time of this report, the FPDCC and Wilmette Park District have indicated their unwillingness to provide land for the MS-14 alternative. It is also noted that, while MS-10 yields a higher B/C ratio, the City of Chicago supports the MS-07 alternative (Foster Avenue tunnel) in lieu of MS-10. The City of Chicago supports MS-07 because the tunnel would reduce flooding without buyouts, relocations, or construction of a wall through the neighborhood.

Regional stormwater problems, whether identified by stakeholders or identified by modeling of intercommunity waterways, indicate a need for regional stormwater management solutions throughout the NBCR watershed. Although regional stormwater problems are concentrated in more extensively developed and flatter areas of the NBCR watershed, significant regional stormwater problems are present throughout the watershed. If selected and constructed, the recommended capital improvement projects in Table 4.2.1 are expected to significantly reduce existing stormwater damages, although damages are expected to persist within the watershed even following construction of recommended projects. However, implementation of the recommended projects should reduce the number of homes and businesses adversely impacted by flooding and minimize severity of existing damages.

The regional stormwater management solutions recommended in this report have the potential to provide regional benefit to the watershed by reducing overbank flooding for a range of storm events. While current and recommended stormwater management focuses on providing protection for larger storm events, such as the 100 year frequency event, many of the recommended alternatives would provide a level of protection for more frequent smaller storm events. Reduction in overbank flooding would not only provide benefits by reducing damages to infrastructure, but may also provide benefits of increased mobility to the general public and opportunities for enhancing water quality and recreation. Communities and regulatory agencies can continue to work toward mitigation of stormwater damages by ensuring development is responsibly managed with special consideration given to potential stormwater impacts and the existing stormwater problems present within the watershed.

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Final Report

Detailed Watershed Plan for the North Branch of the Chicago River and Lake Michigan Watershed: Volume 2

Prepared for

Metropolitan Water Reclamation District of Greater Chicago

January 2011

HDR

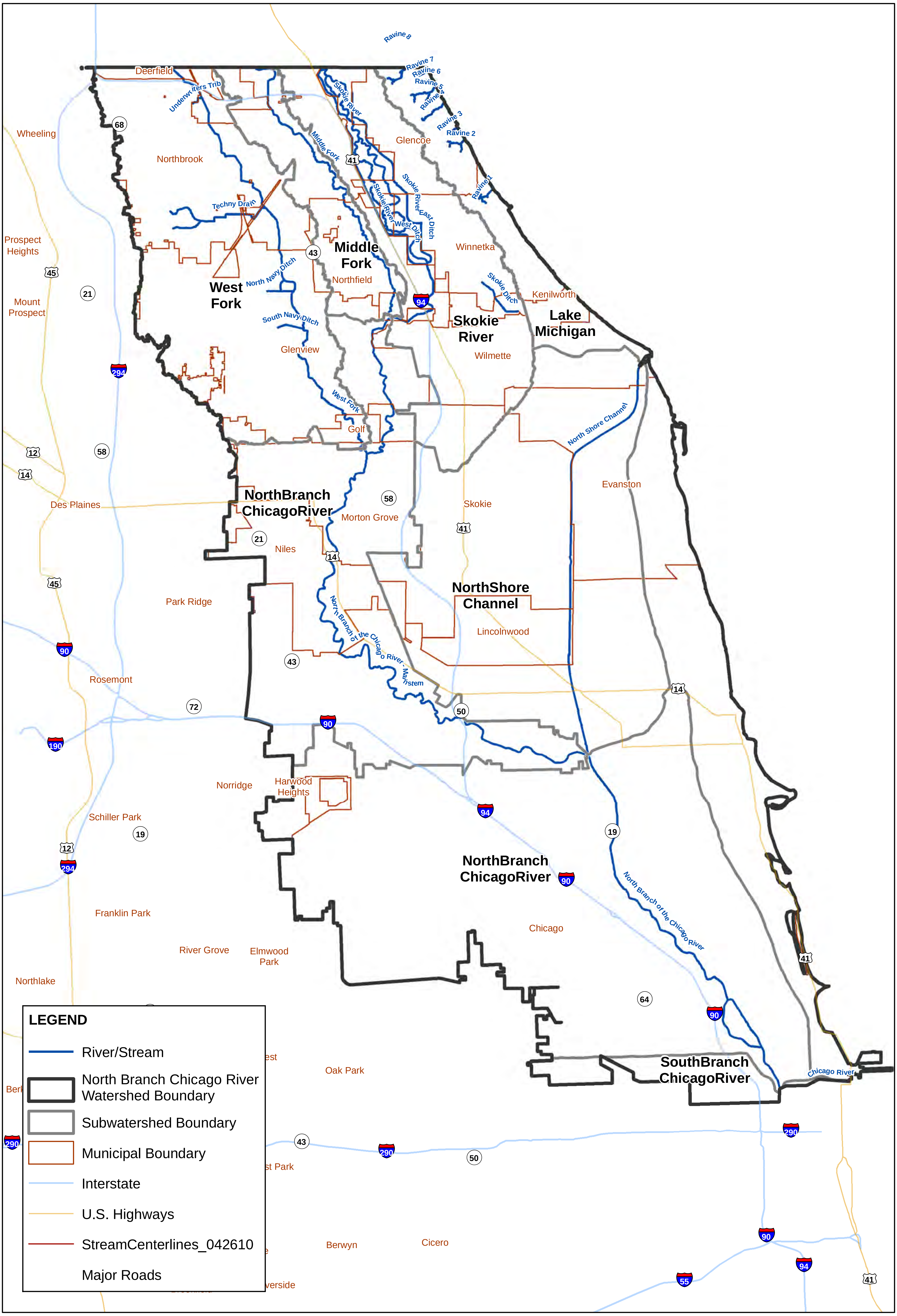


Figure ES.1
North Branch of the Chicago River Watershed Overview

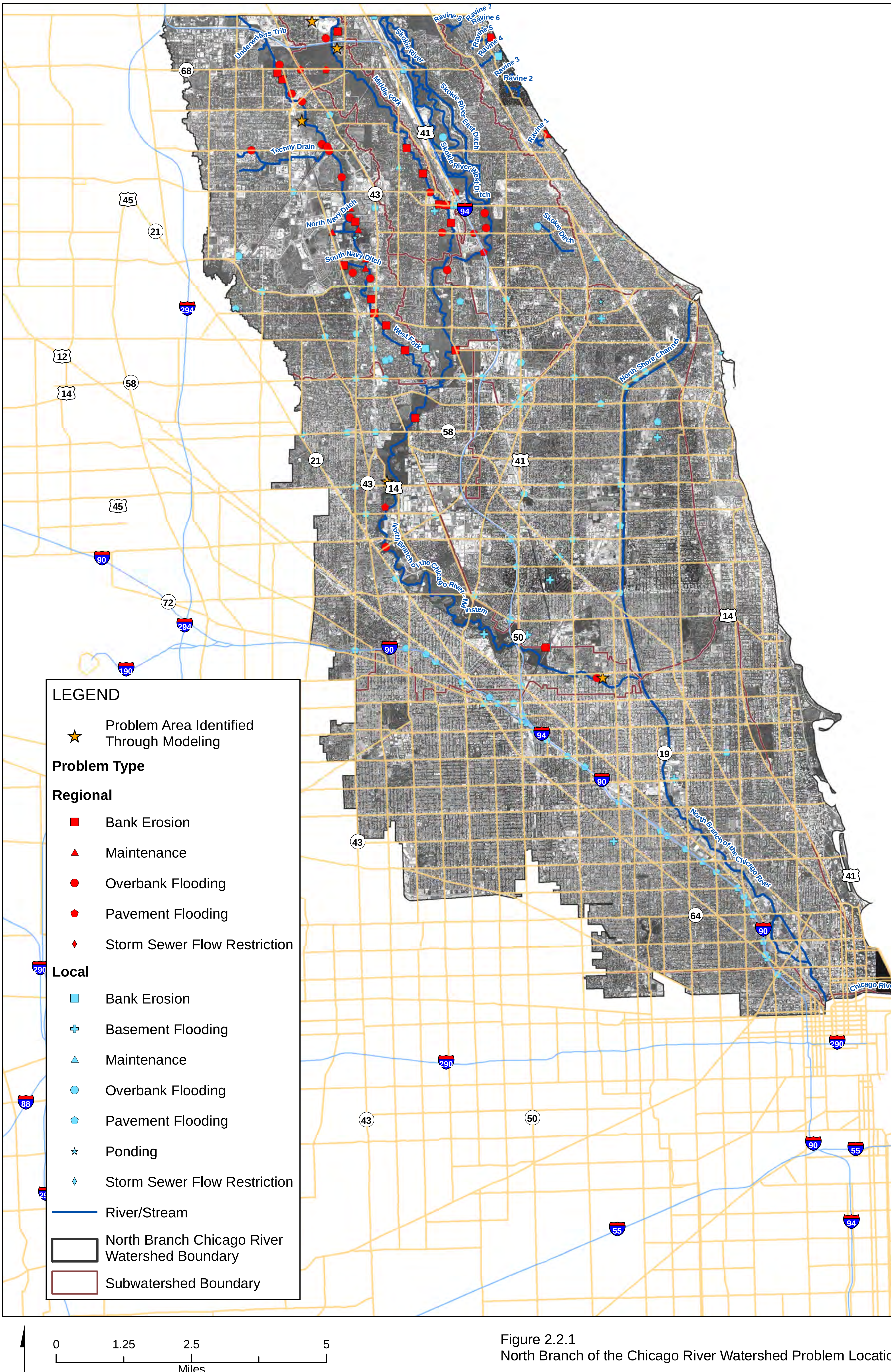


Figure 2.2.1
North Branch of the Chicago River Watershed Problem Locations

HDR

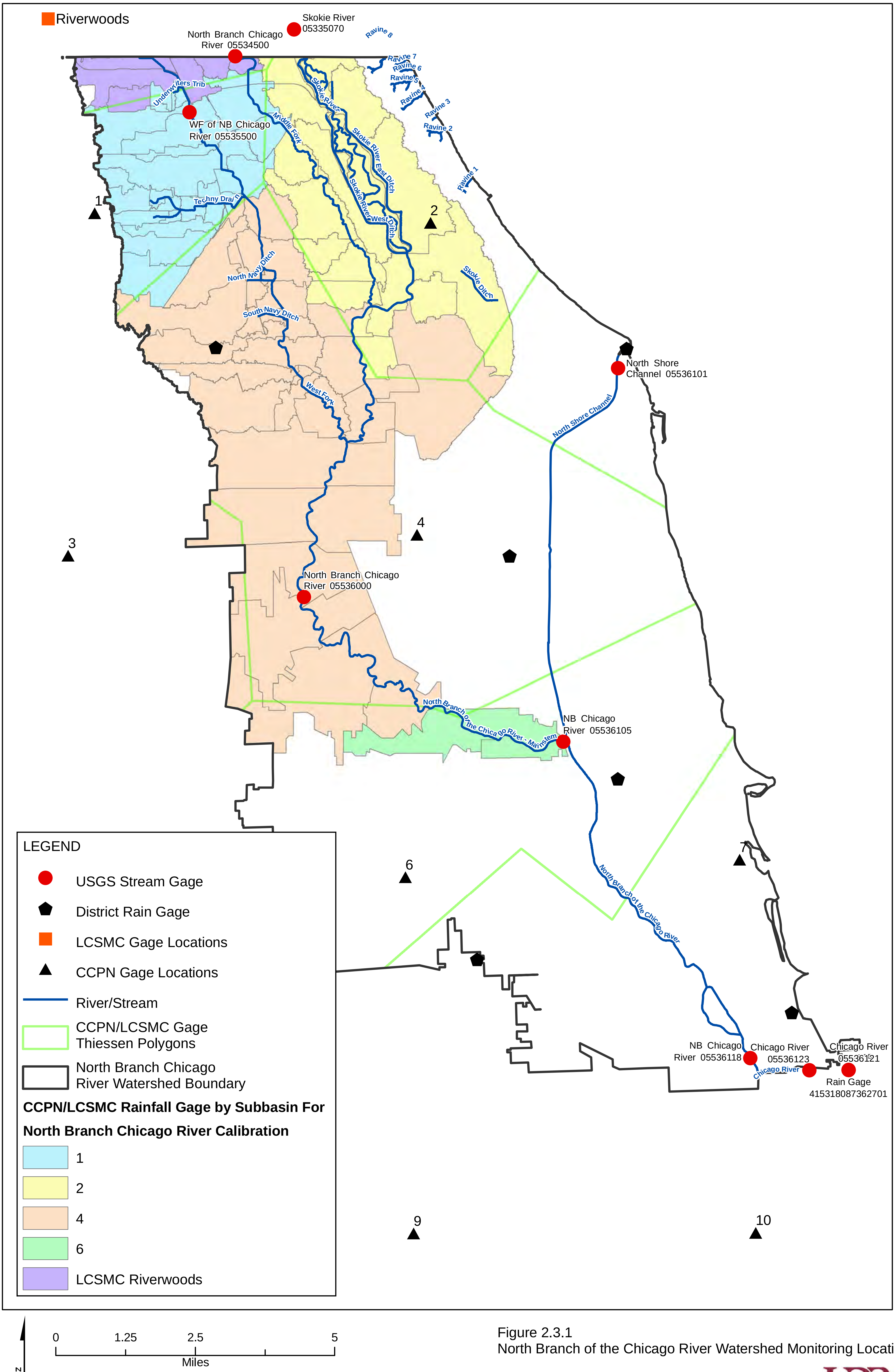
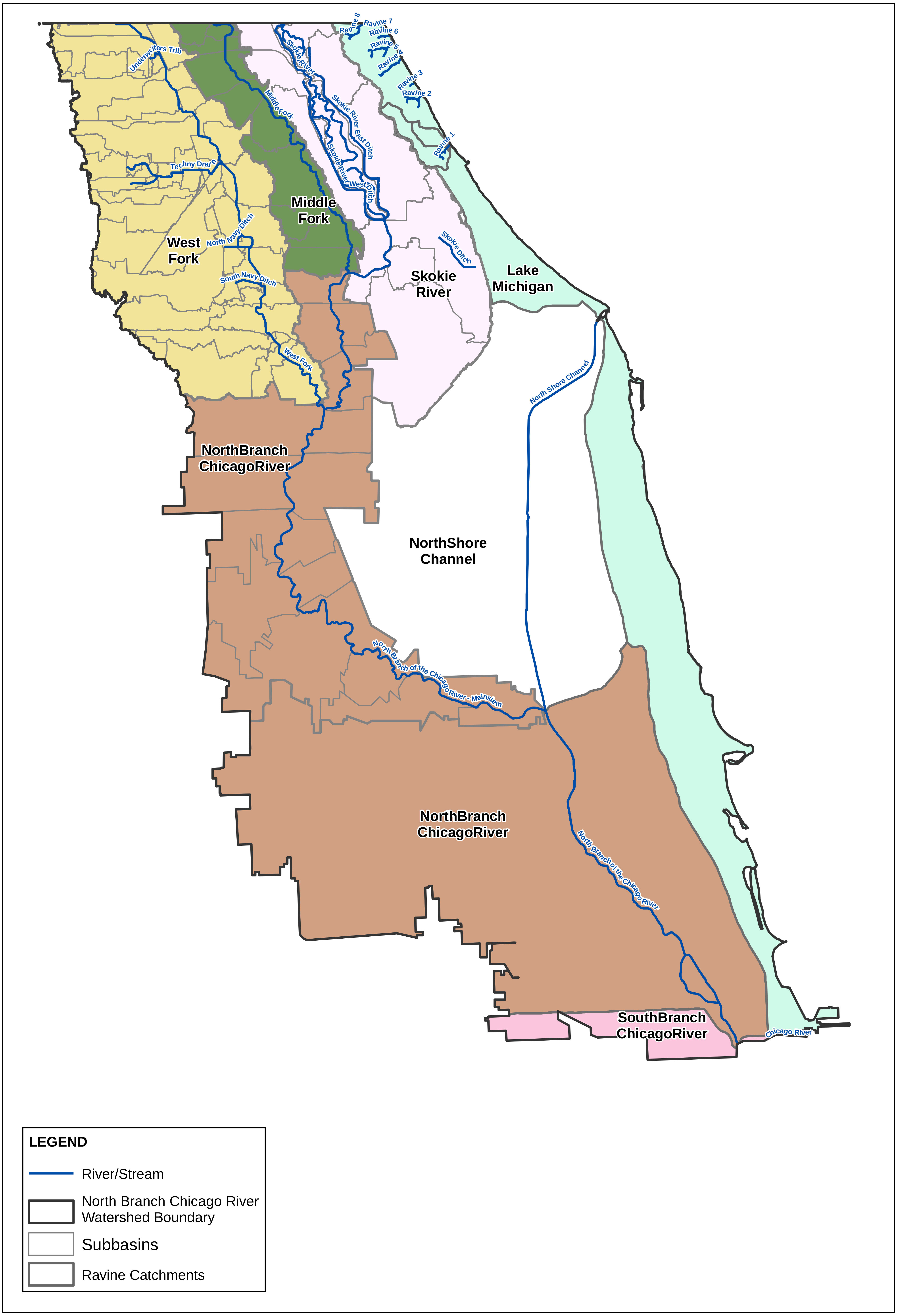


Figure 2.3.1
North Branch of the Chicago River Watershed Monitoring Locations



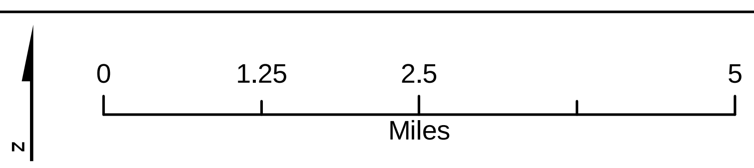


Figure 2.3.2
North Branch of the Chicago River Subwatersheds

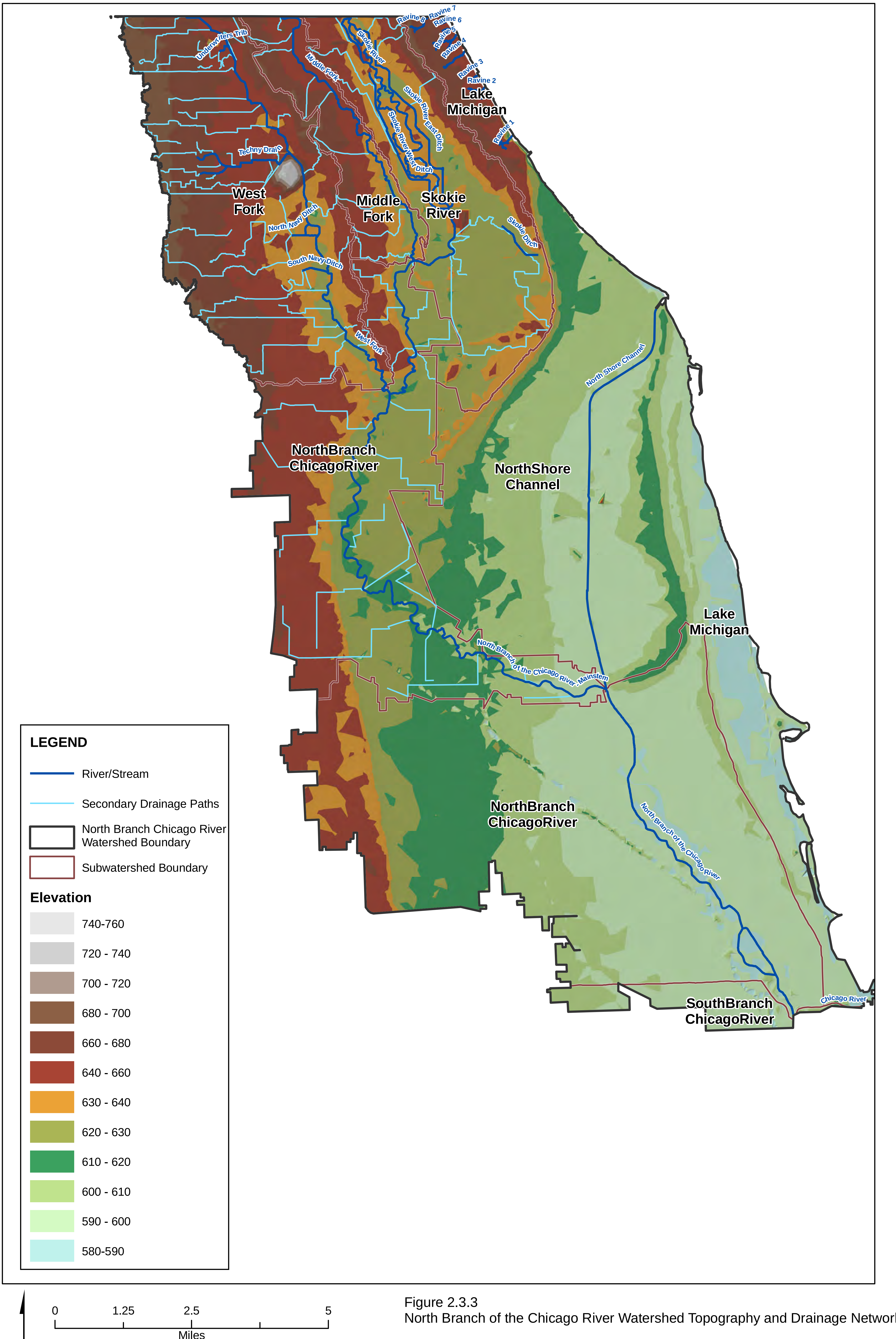


Figure 2.3.3
North Branch of the Chicago River Watershed Topography and Drainage Network

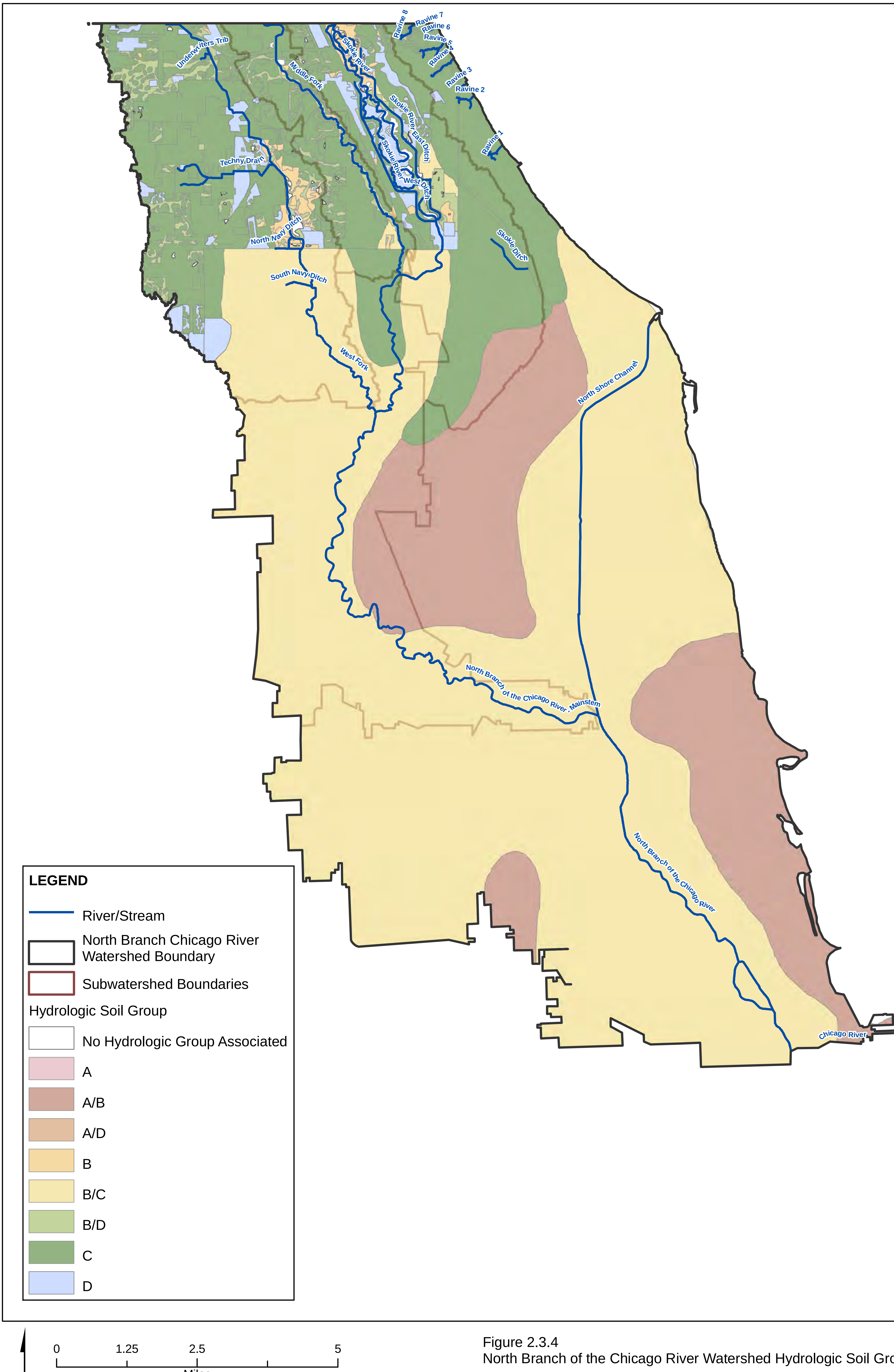


Figure 2.3.4
North Branch of the Chicago River Watershed Hydrologic Soil Groups

HDR

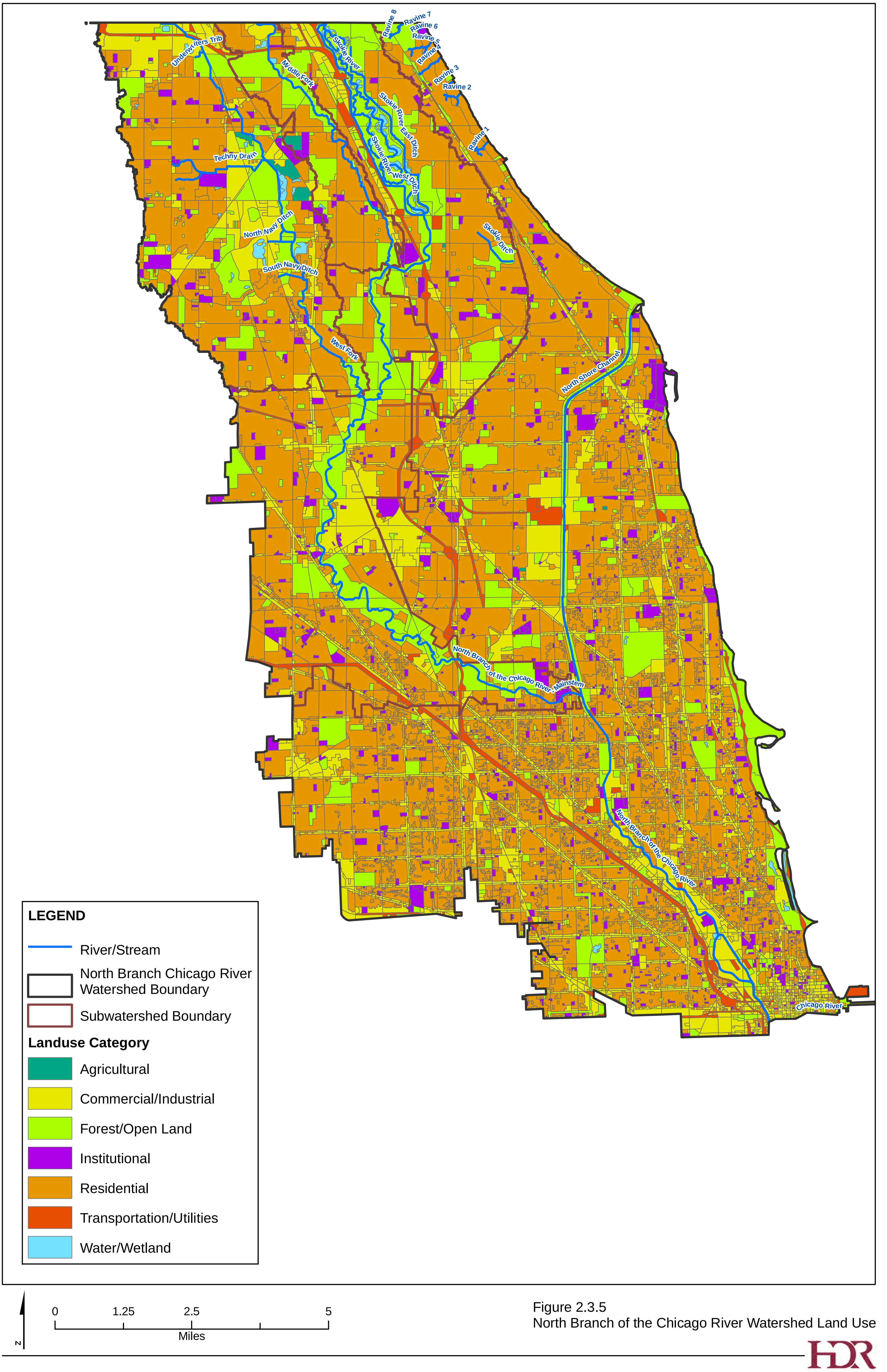


Figure 2.3.5
North Branch of the Chicago River Watershed Land Use

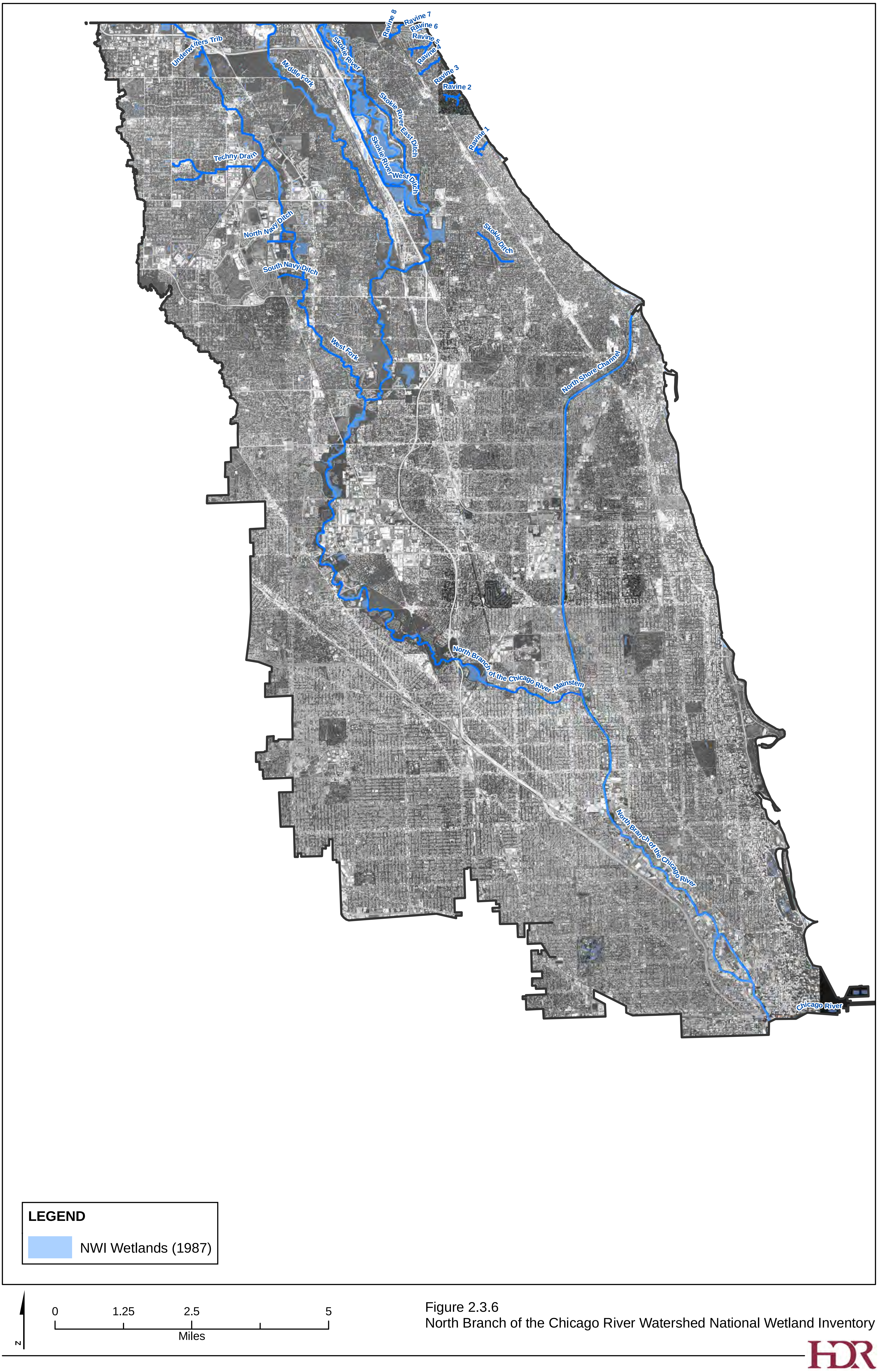
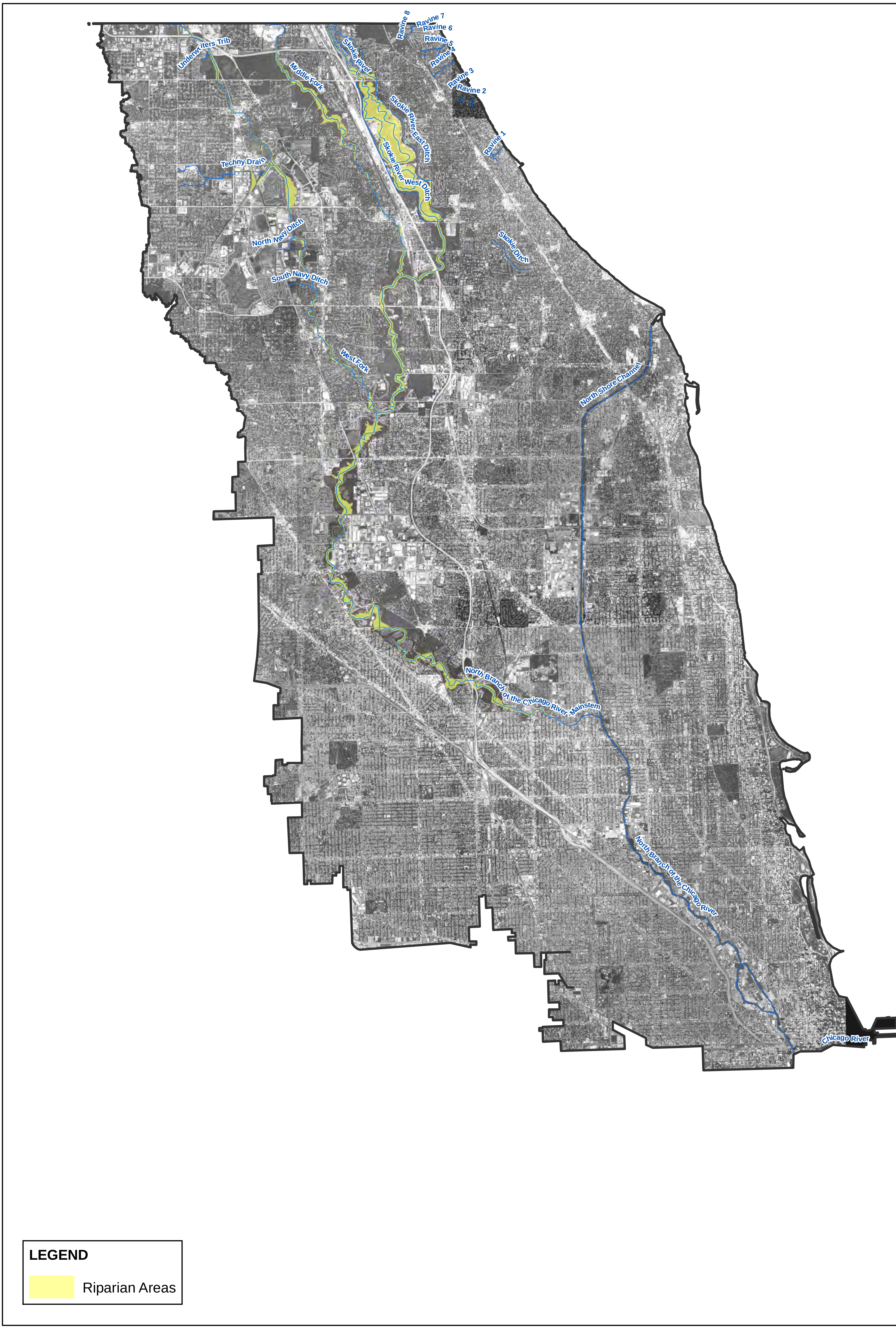


Figure 2.3.6
North Branch of the Chicago River Watershed National Wetland Inventory



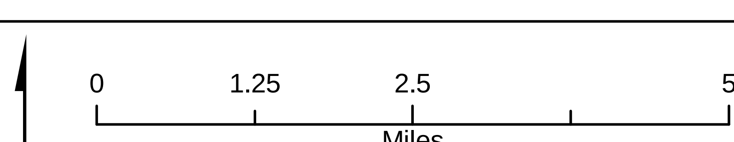


Figure 2.3.7
North Branch of the Chicago River Watershed Riparian Areas

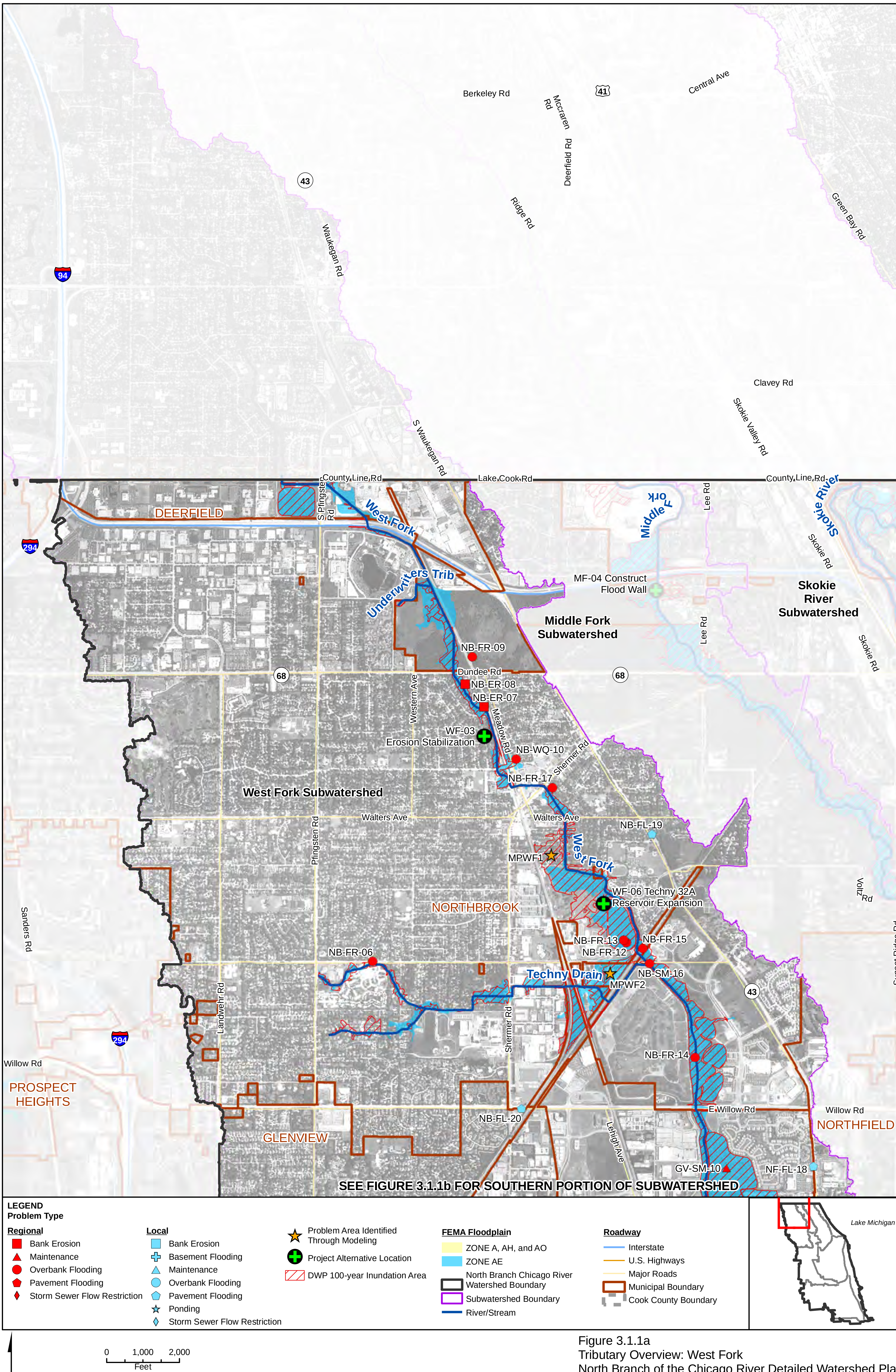
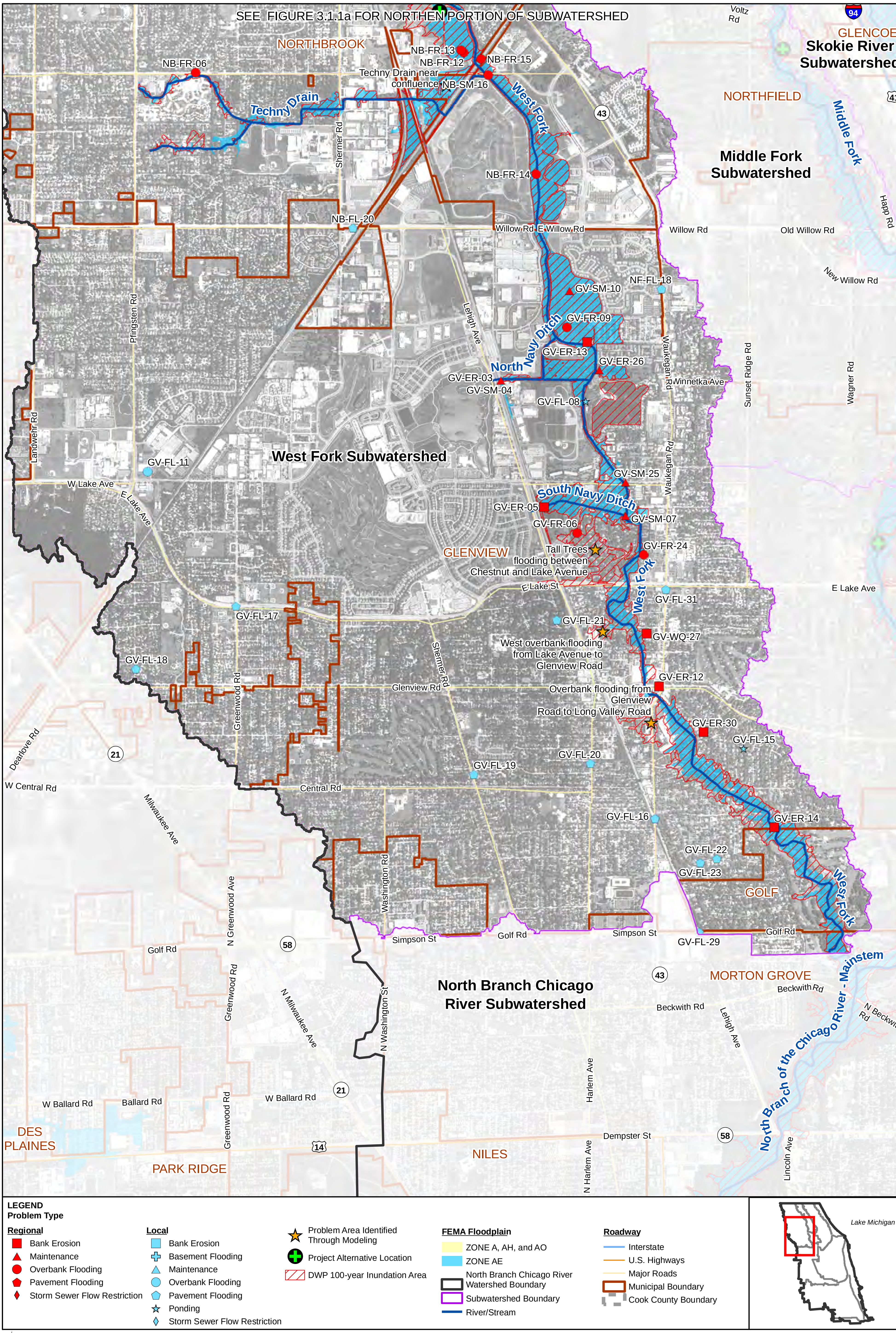


Figure 3.1.1a
Tributary Overview: West Fork
North Branch of the Chicago River Detailed Watershed Plan

HDR



N

0 1,000 2,000
Feet

Figure 3.1.1b
Tributary Overview: West Fork
North Branch of the Chicago River Detailed Watershed Plan

HDR

Subwatershed: West Fork

District Database Alternative: NBCR-WF-SC-01

Alternative Description:

Hard armoring of WF east bank along Metra Milwaukee North District RR and Fair Lane between Dundee Road and Cherry Lane

Conceptual Level Cost: $ 2,022,000 Benefits: $ 1,550,000

B/C Ratio: 0.77

LEGEND

- Project Alternative Location
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

- Interstate
- U.S. Highway
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 100 200 Feet

RECOMMENDED ALTERNATIVE

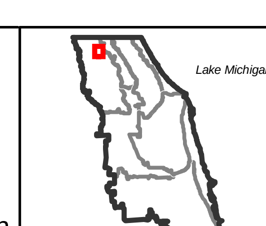
Figure 3.1.2

West Fork

Alternative WF-03

Existing and Alternative Inundation Areas

North Branch of the Chicago River Detailed Watershed Plan



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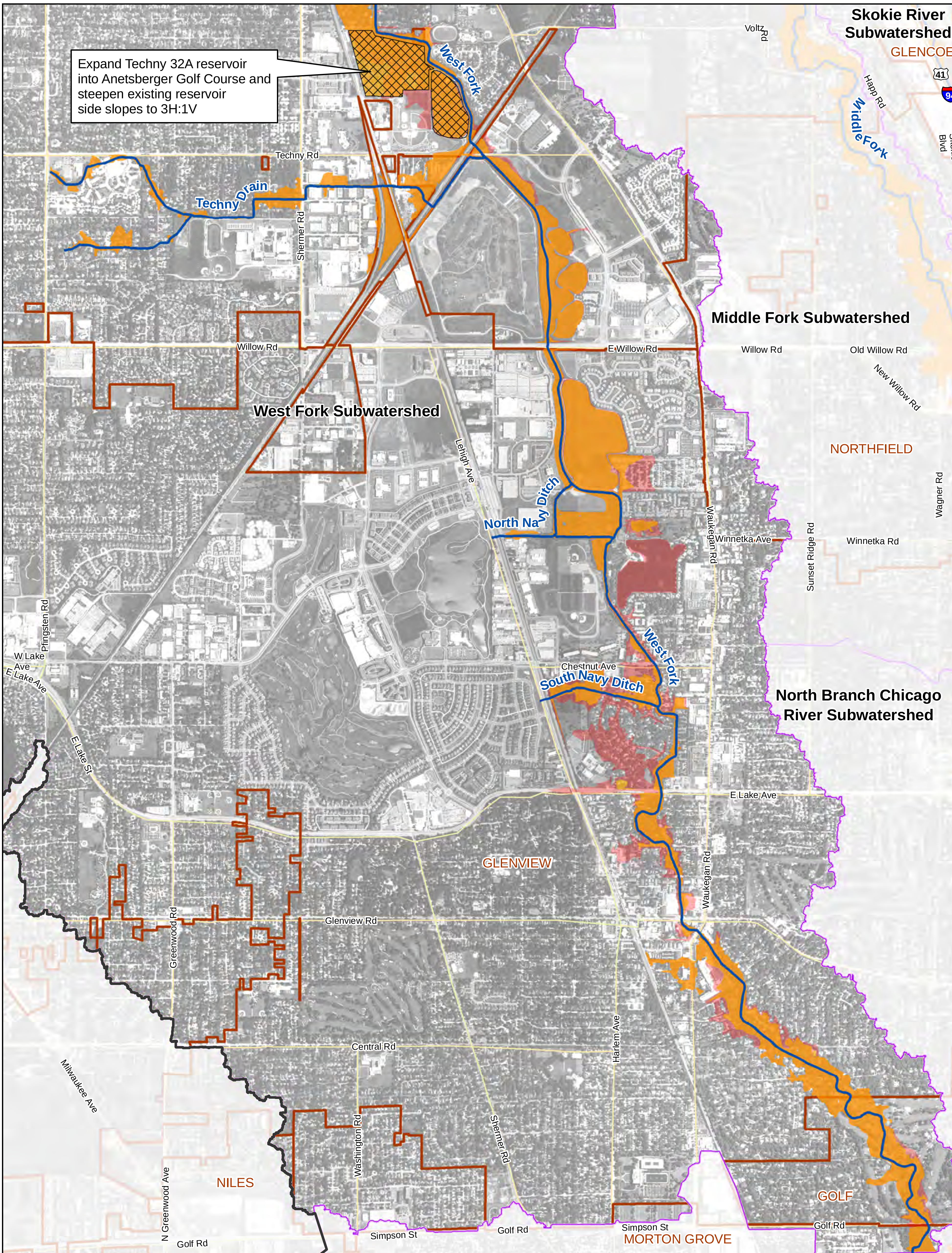


Subwatershed: West Fork

District Database Alternative: NBCR-WF-ST-01

Alternative Description:

Techny Reservoir 32A Expansion into Anetsberger Golf Course and steepening existing side slopes to 3H:1V. Includes inlet weir and restrictor barrel revisions. Adds approximately 1,100 ac-ft of detention storage

Conceptual Level Cost: $ 116,088,000 Benefits: $ 146,484,000 B/C Ratio: 1.26

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 500 1,000 Feet

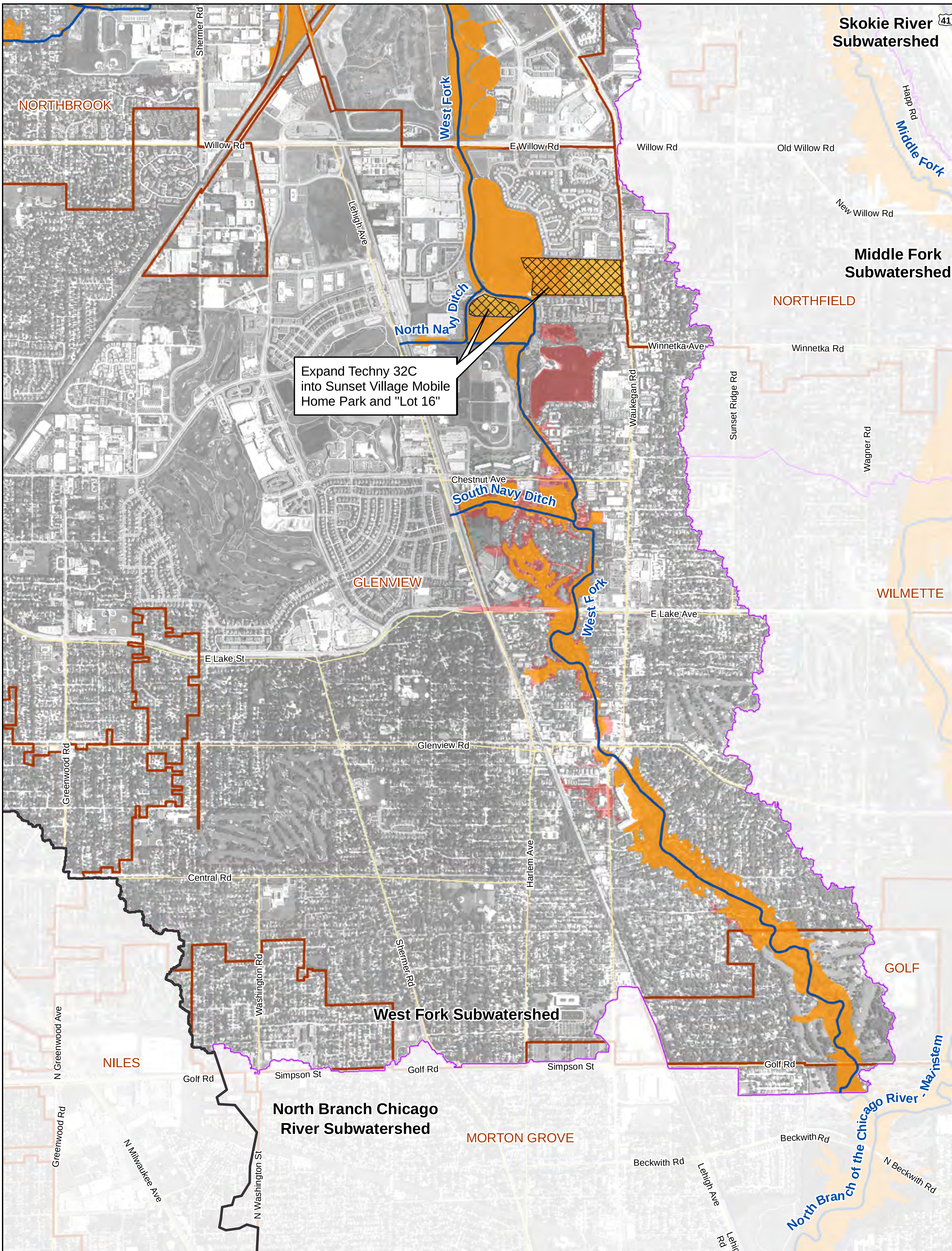
N

RECOMMENDED ALTERNATIVE

Figure 3.1.3a
West Fork
Alternative WF-06
Existing and Alternative Inundation Areas
North Branch of the Chicago River Detailed Watershed Plan

Lake Michigan

HDR



Subwatershed: West Fork

District Database Alternative: NBCR-WF-ST-02

Alternative Description:

Techny Reservoir 32C Expansion into Mobile Home Park in SE corner of Reservoir and utilization of lot 16 for storage.
Add approximately 800 ac-ft of detention storage

Conceptual Level Cost: $ 94,210,000 Benefits: $ 29,692,000 B/C Ratio: 0.32

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

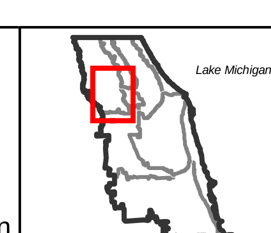
Roadway

- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 500 1,000 Feet

N

NON- RECOMMENDED ALTERNATIVE
Figure 3.1.3b
West Fork
Alternative WF-19
Existing and Alternative Inundation Areas
North Branch of the Chicago River Detailed Watershed Plan



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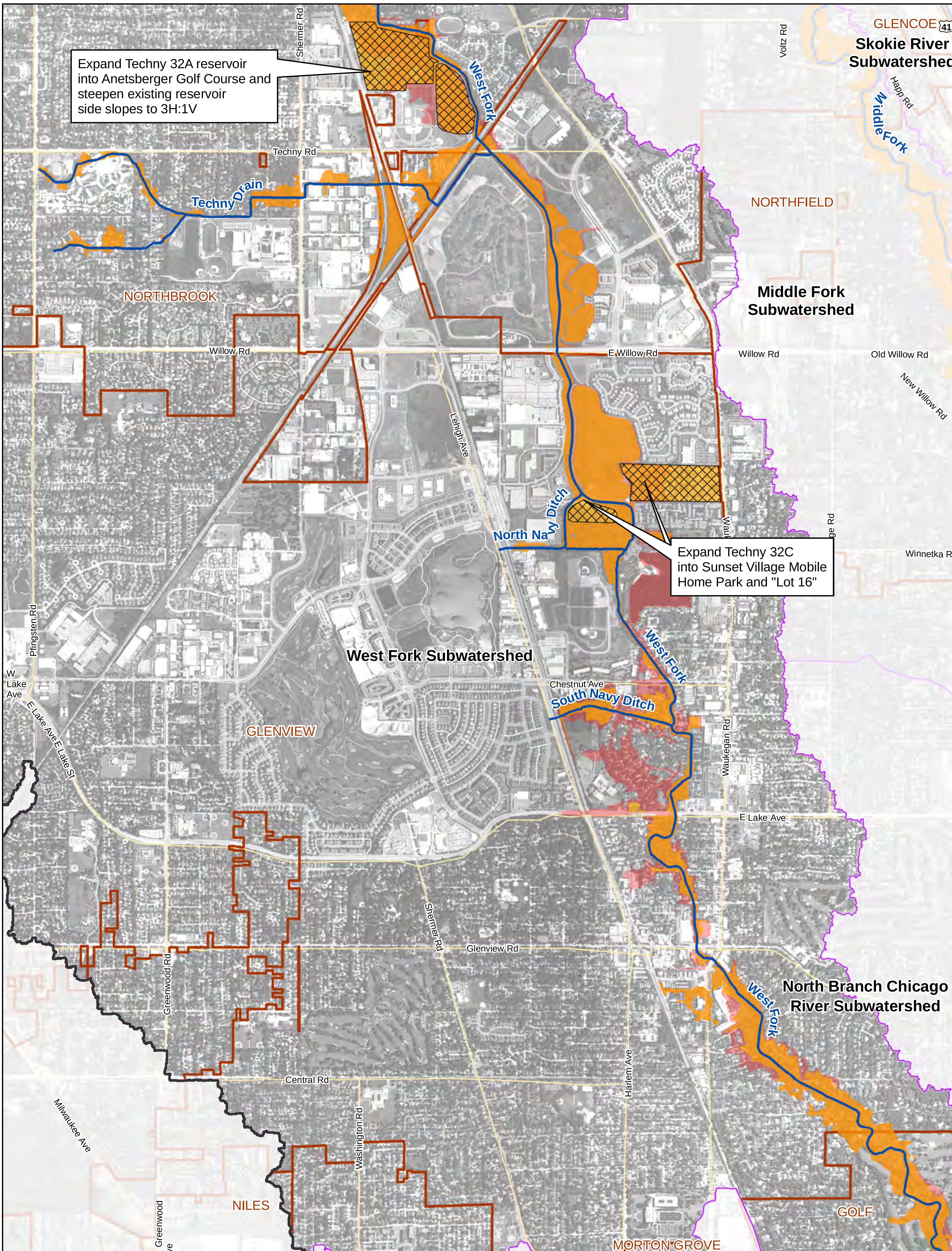


Subwatershed: West Fork

District Database Alternative: NBCR-WF-ST-03

Alternative Description:

Combination of Alternative Projects WF-06 + WF-19 (Techny 32A + Techny 32C Alternatives) - expansion of Techny Reservoir 32A into Anetsberger Golf Course and Techny Reservoir 32C into Mobile Home Park and Lot 16. Adds approximately 1,900 ac-ft of detention storage.

Conceptual Level Cost: $ 210,297,000 Benefits: $ 146,484,000 B/C Ratio: 0.70

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

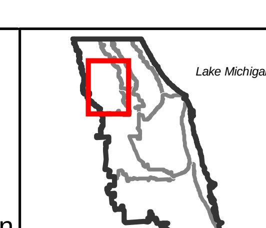
- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

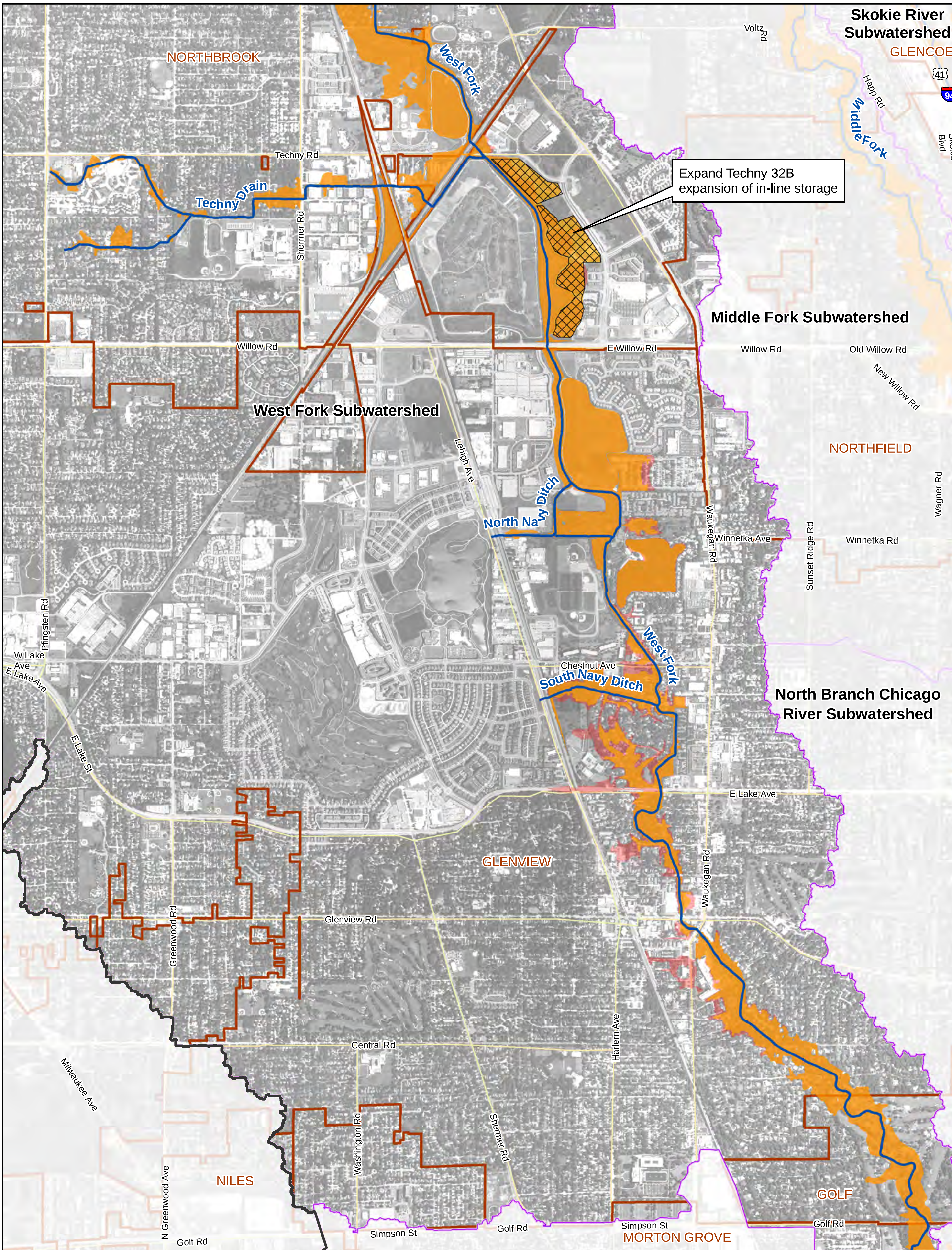
0 500 1,000
Feet

N

NON-RECOMMENDED ALTERNATIVE

Figure 3.1.3c
West Fork
Alternative WF-20
Existing and Alternative Inundation Areas
North Branch of the Chicago River Detailed Watershed Plan





Subwatershed: West Fork

District Database Alternative: NBCR-WF-ST-04

Alternative Description:

Techny Reservoir 32B Storage Addition. Utilize open space to the east of the 32B reservoir, including the excavation of the wetland pods. Adds approximately 425 ac-ft of detention storage.

Conceptual Level Cost: $ 50,416,000 Benefits: $ 30,235,000 B/C Ratio: 0.60

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

- Interstate
- U.S. Highway
- Major Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 500 1,000
Feet

NON-RECOMMENDED ALTERNATIVE
Figure 3.1.3d
West Fork
Alternative WF-21
Existing and Alternative Inundation Areas
North Branch of the Chicago River Detailed Watershed Plan

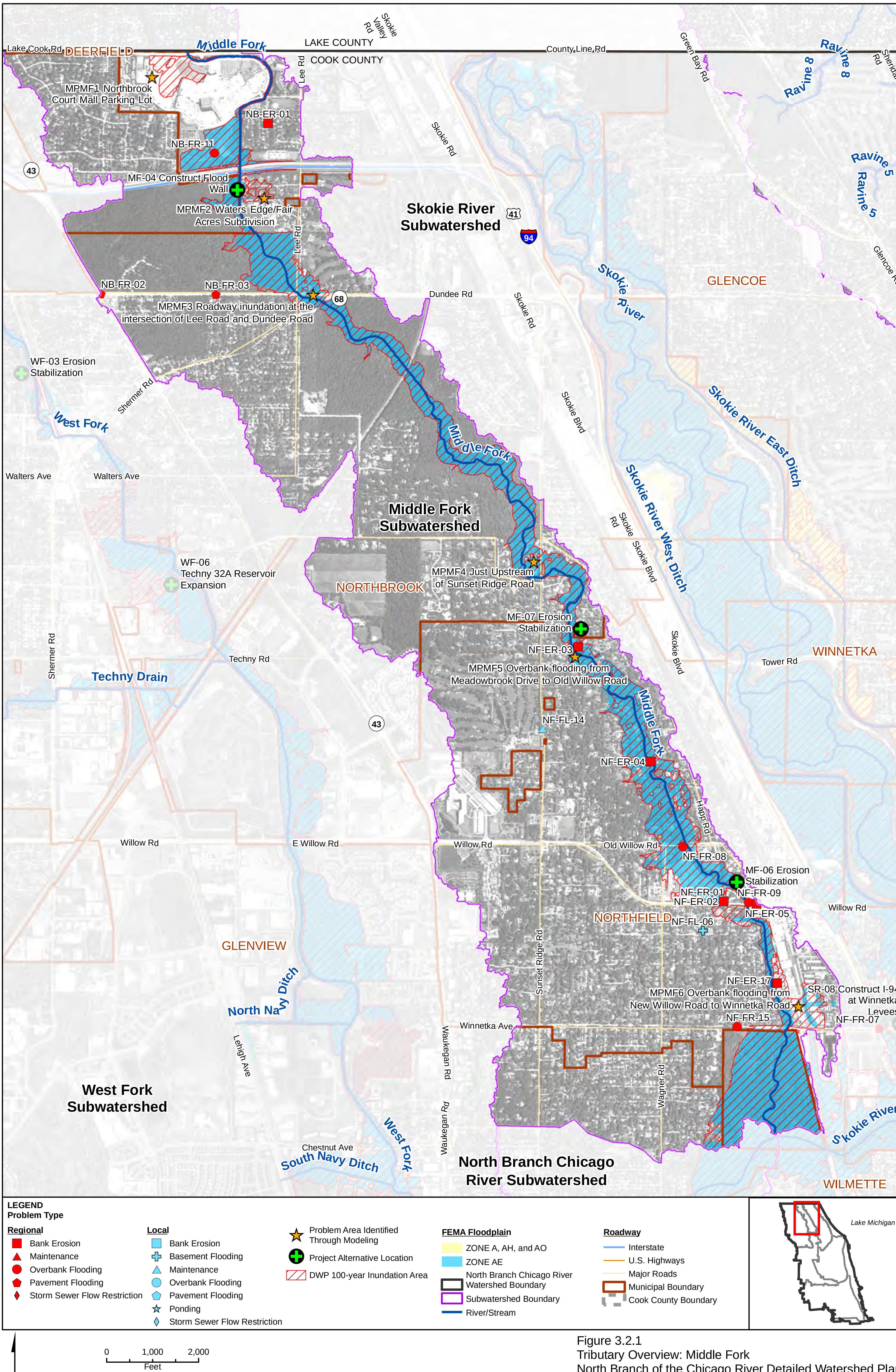
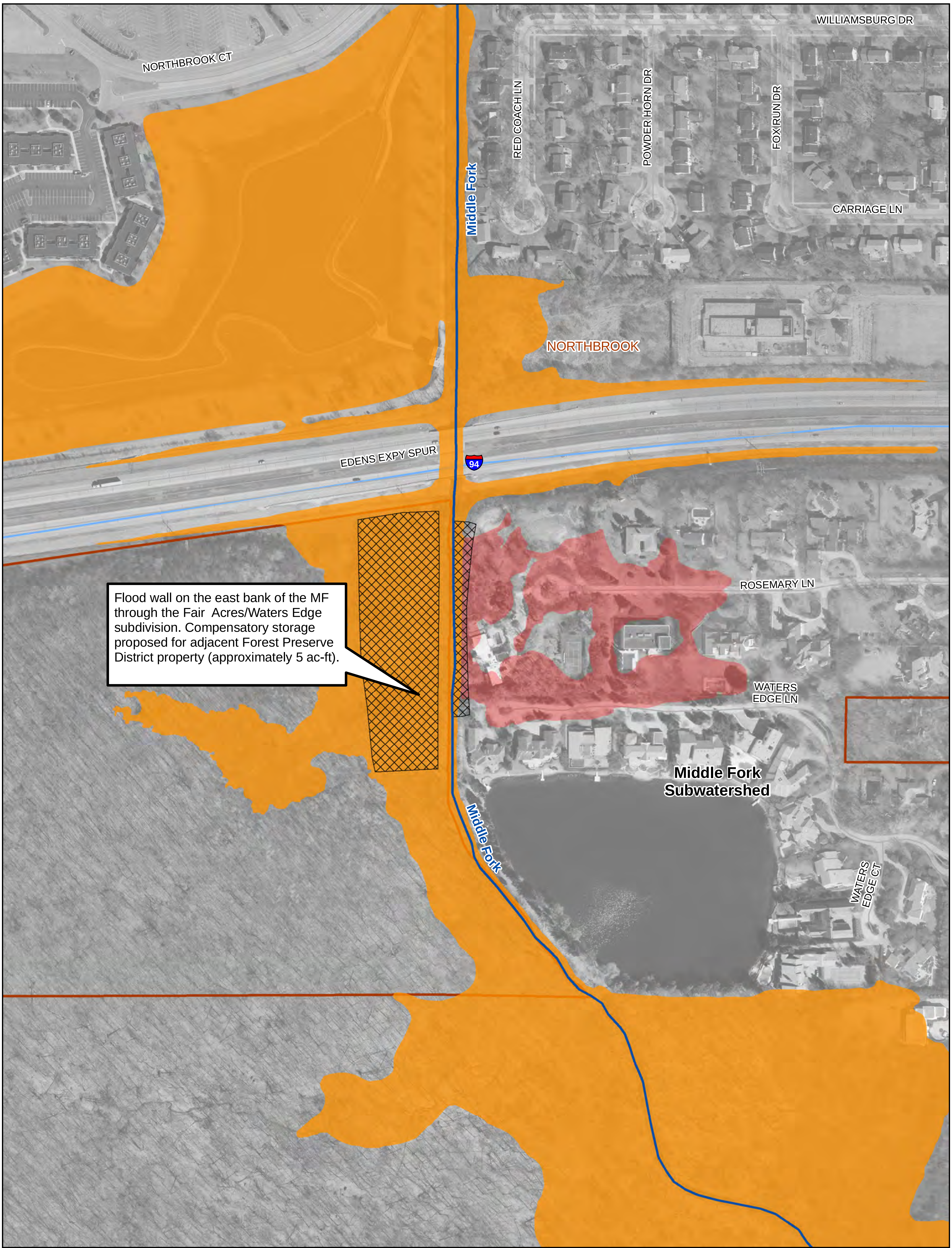


Figure 3.2.1
Tributary Overview: Middle Fork
North Branch of the Chicago River Detailed Watershed Plan

HDR



Subwatershed: MiddleFork

District Database Alternative: NBCR-MF-LV-01

Alternative Description:

Flood wall on the east bank of the MF through the Fair Acres/Waters Edge subdivision.

Compensatory storage proposed for adjacent Forest Preserve District property (approximately 5 ac-ft).

Conceptual Level Cost: $ 1,495,000 Benefits: $ 178,000 B/C Ratio: 0.12

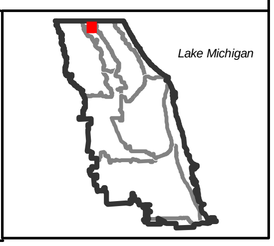
LEGEND
- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway
- Interstate
- U.S. Highway
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 50 100
Feet

N

RECOMMENDED ALTERNTIVE
Figure 3.2.2
Middle Fork
Alternative MF-04
Existing and Alternative Inundation Areas
North Branch of the Chicago River Detailed Watershed Plan



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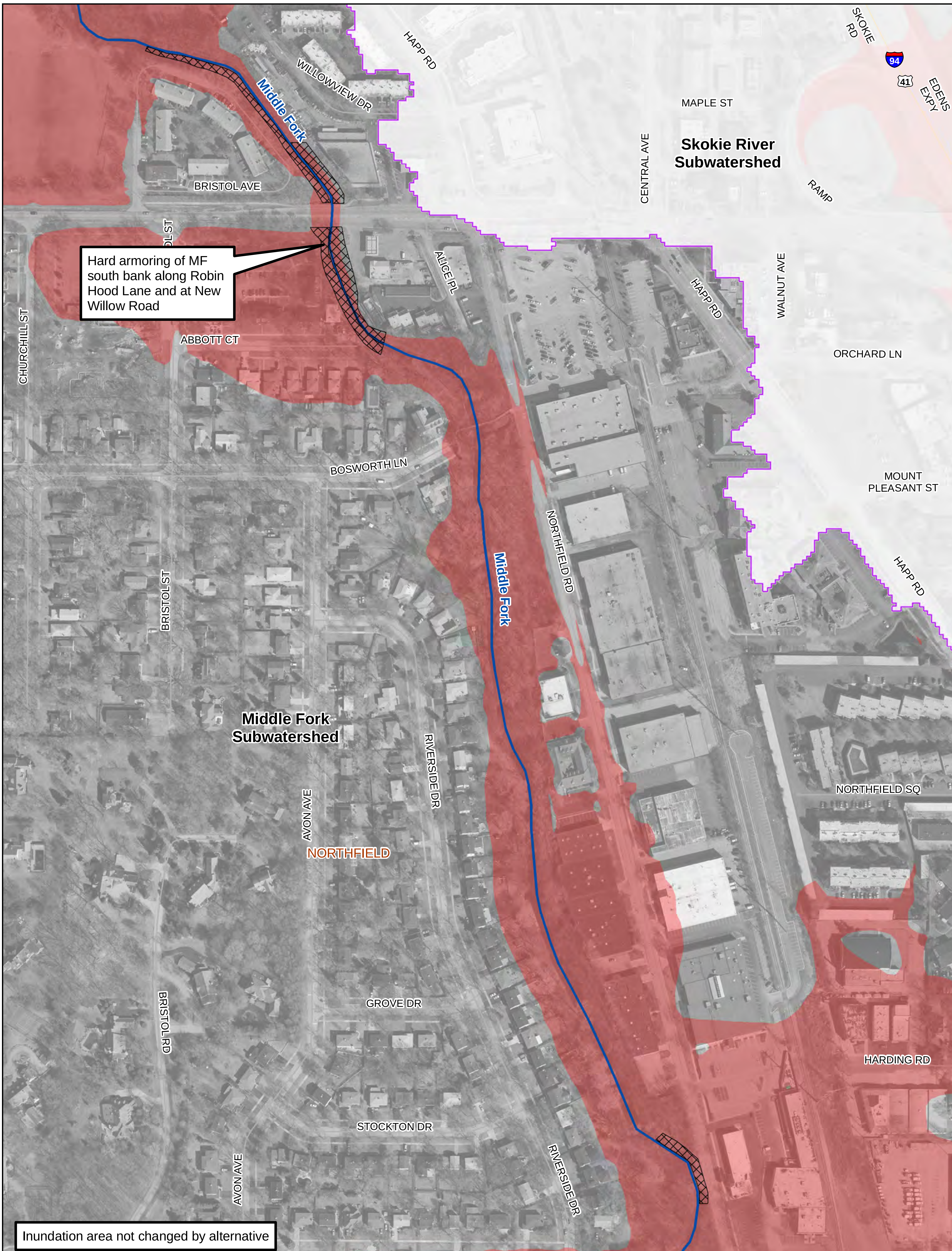


Subwatershed: Middle Fork

District Database Alternative: NBCR-MF-SC-03

Alternative Description:
Hard armoring of MF south bank along Robin Hood Lane and at New Willow Road.
Conceptual Level Cost: $ 1,610,000 Benefits: $ 7,391,000
B/C Ratio: 4.59

LEGEND
- Project Alternative Location
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway
- Interstate
- U.S. Highway
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

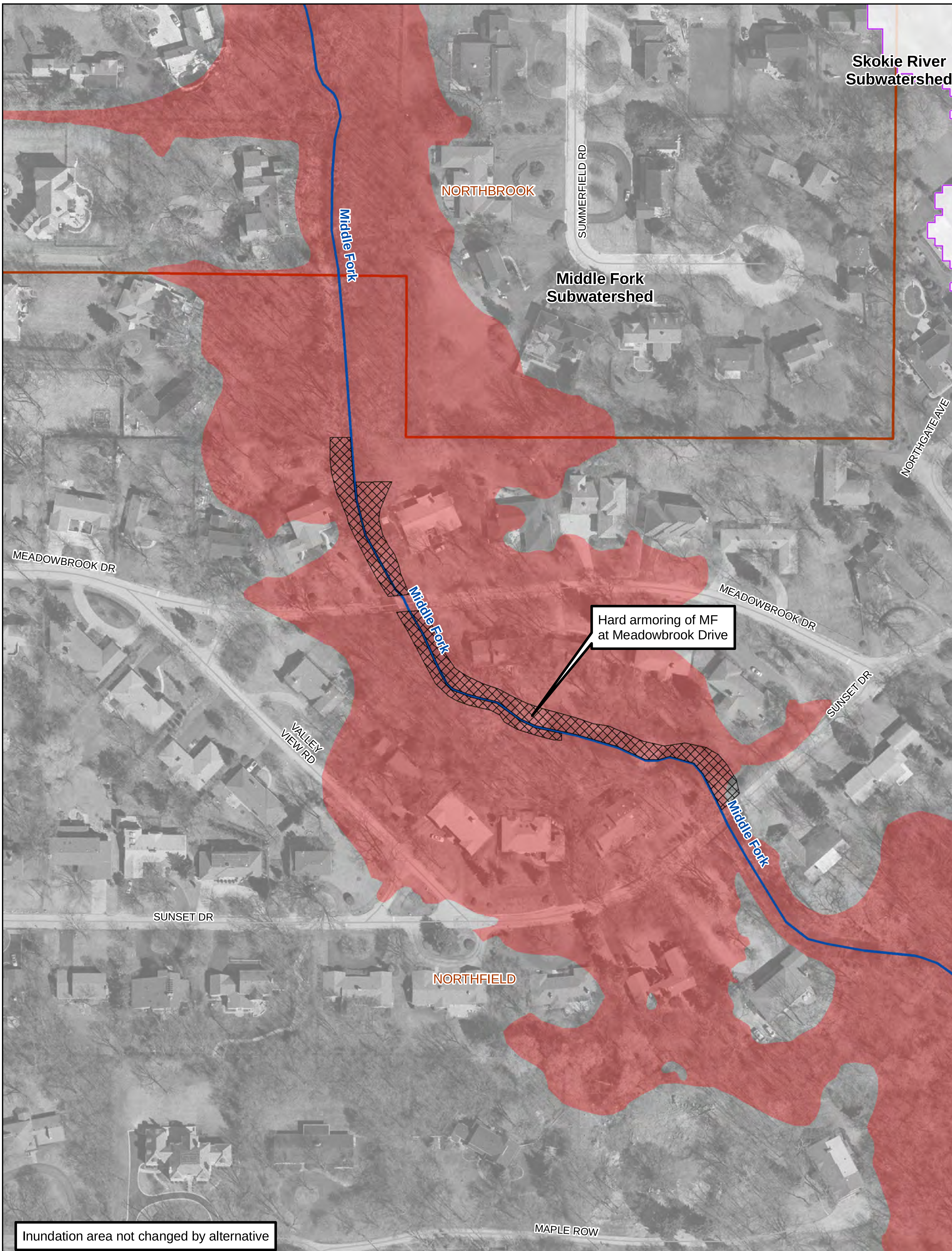
0 50 100 Feet

N

RECOMMENDED ALTERNATIVE
Figure 3.2.3
Middle Fork
Alternative MF-06
Existing and Alternative Inundation Areas
North Branch of the Chicago River Detailed Watershed Plan

Lake Michigan

HDR



Subwatershed: Middle Fork
Alternative Description:
Hard armoring of MF at Meadowbrook Drive
Conceptual Level Cost: $ 971,000 Benefits: $ 1,600,000
B/C Ratio: 1.65

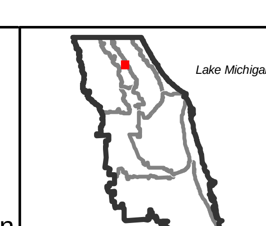
District Database Alternative: NBCR-MF-SC-01

LEGEND
- Project Alternative Location
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway
- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 50 100
Feet

RECOMMENDED ALTERNATIVE
Figure 3.2.4
Middle Fork
Alternative MF-07
Existing and Alternative Inundation Areas
North Branch of the Chicago River Detailed Watershed Plan



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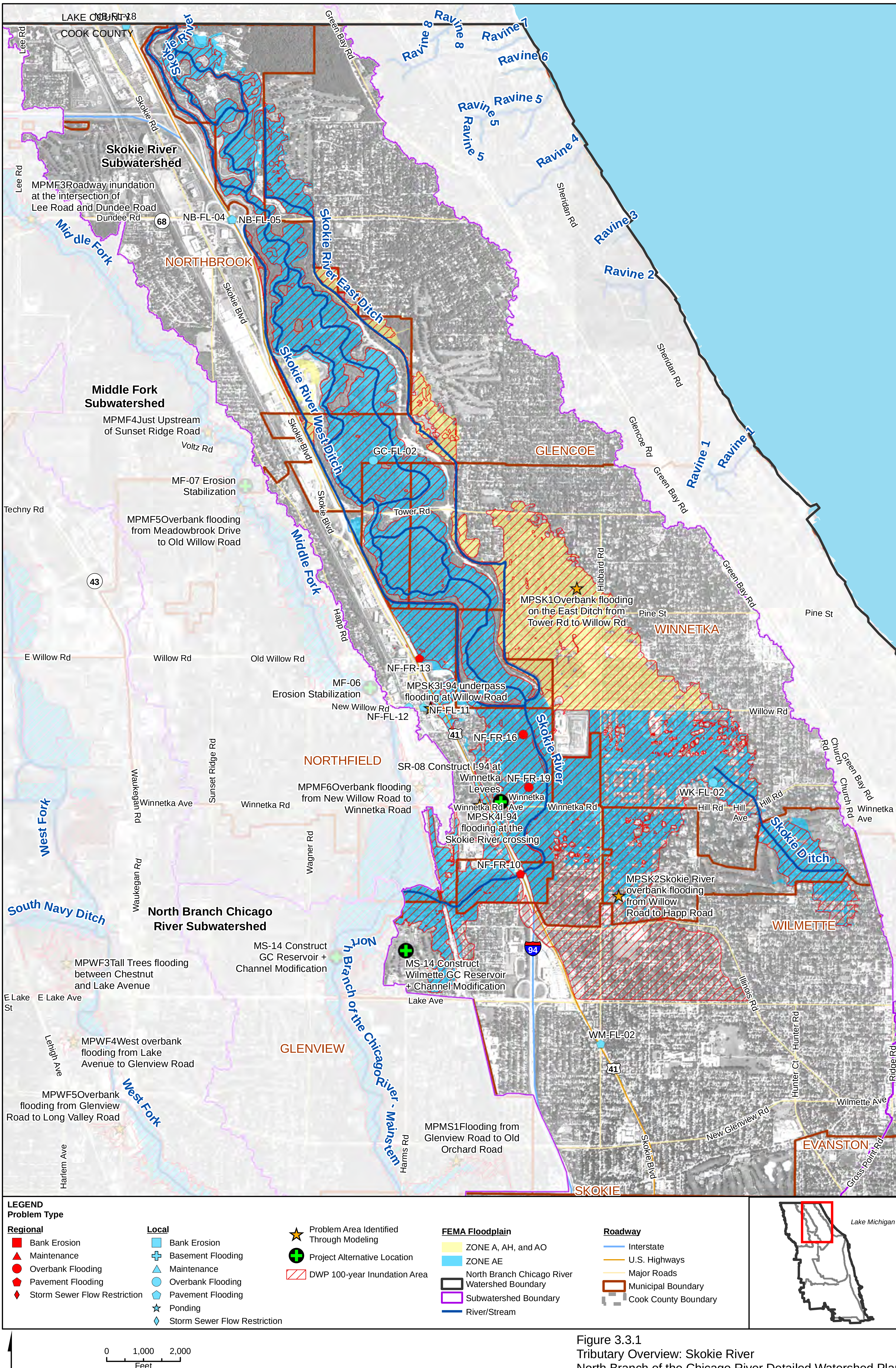
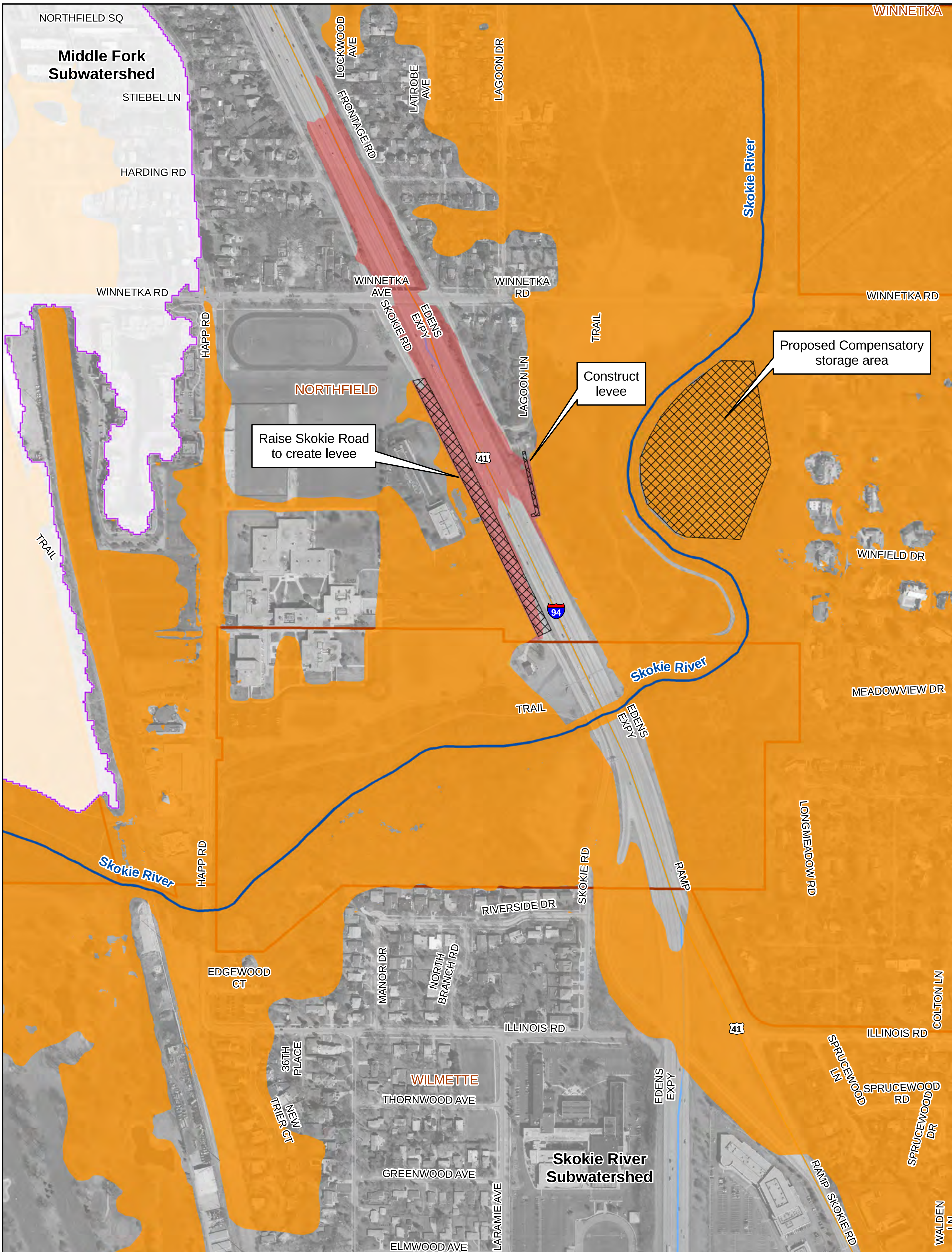


Figure 3.3.1
Tributary Overview: Skokie River
North Branch of the Chicago River Detailed Watershed Plan

HDR



Subwatershed: Skokie River

District Database Alternative: NBCR-SR-08

Alternative Description:

I-94 at Winnetka Rd Levees. Construct approximately 1,700 ft of levee along both sides of Interstate.

B/C Ratio: 1.35 Conceptual Level Cost: $ 5,761,000 Benefits: $ 7,760,000

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

- Interstate
- U.S. Highway
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 50 100 200
Feet

RECOMMENDED ALTERNATIVE

Figure 3.3.2

Skokie River

Alternative SR-08

Existing and Alternative Inundation Areas

North Branch of the Chicago River Detailed Watershed Plan

Lake Michigan

HDR

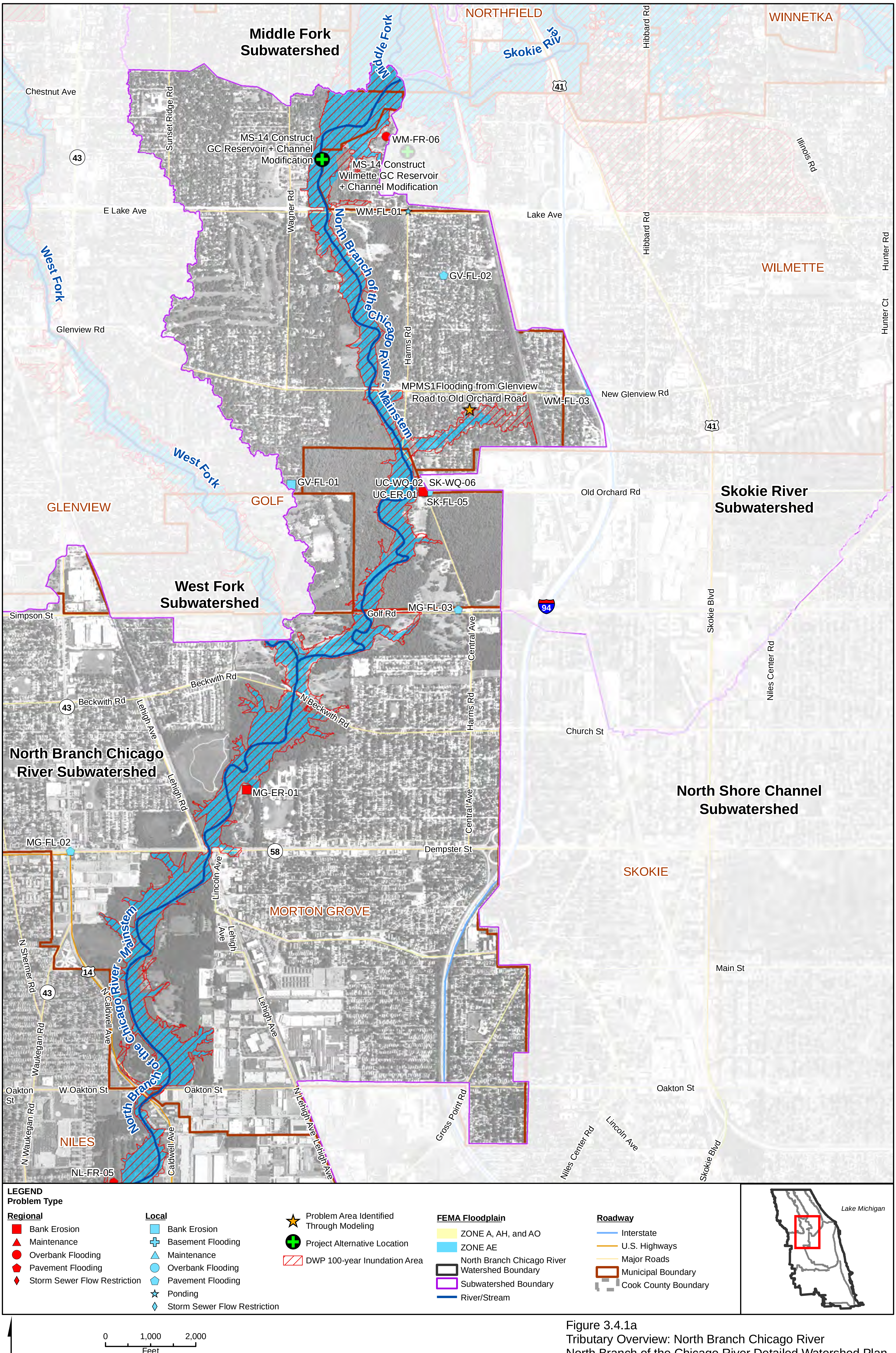
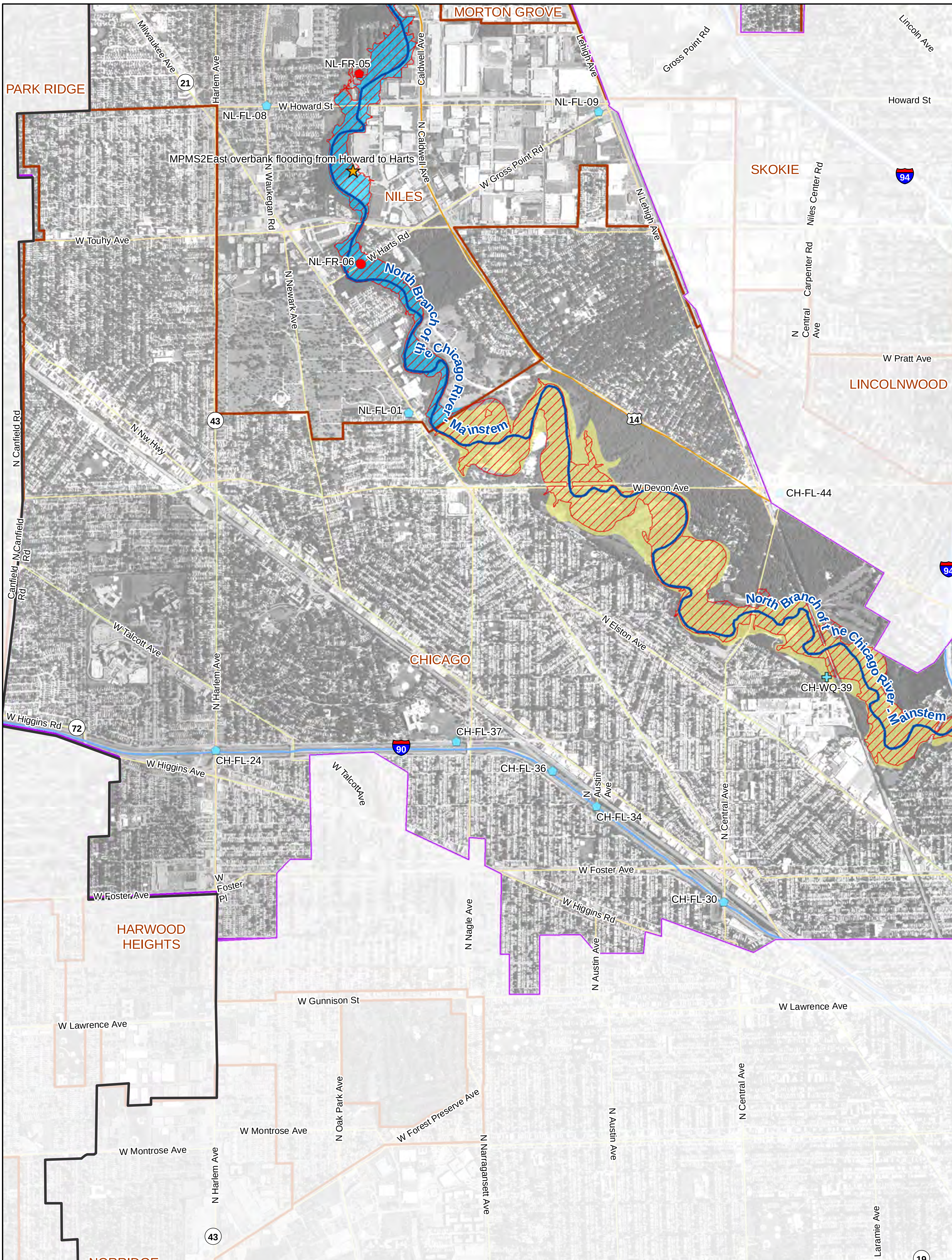


Figure 3.4.1a
Tributary Overview: North Branch Chicago River
North Branch of the Chicago River Detailed Watershed Plan

HDR



LEGEND
Problem Type

Regional
- Bank Erosion
- Maintenance
- Overbank Flooding
- Pavement Flooding
- Storm Sewer Flow Restriction

Local
- Bank Erosion
- Basement Flooding
- Maintenance
- Overbank Flooding
- Pavement Flooding
- Ponding
- Storm Sewer Flow Restriction

- Problem Area Identified Through Modeling
- Project Alternative Location
- DWP 100-year Inundation Area

FEMA Floodplain
- ZONE A, AH, and AO
- ZONE AE
- North Branch Chicago River Watershed Boundary
- Subwatershed Boundary
- River/Stream

Roadway
- Interstate
- U.S. Highways
- Major Roads
- Municipal Boundary
- Cook County Boundary

Lake Michigan

0 1,000 2,000
Feet

N

Figure 3.4.1b
Tributary Overview: North Branch Chicago River
North Branch of the Chicago River Detailed Watershed Plan

HDR

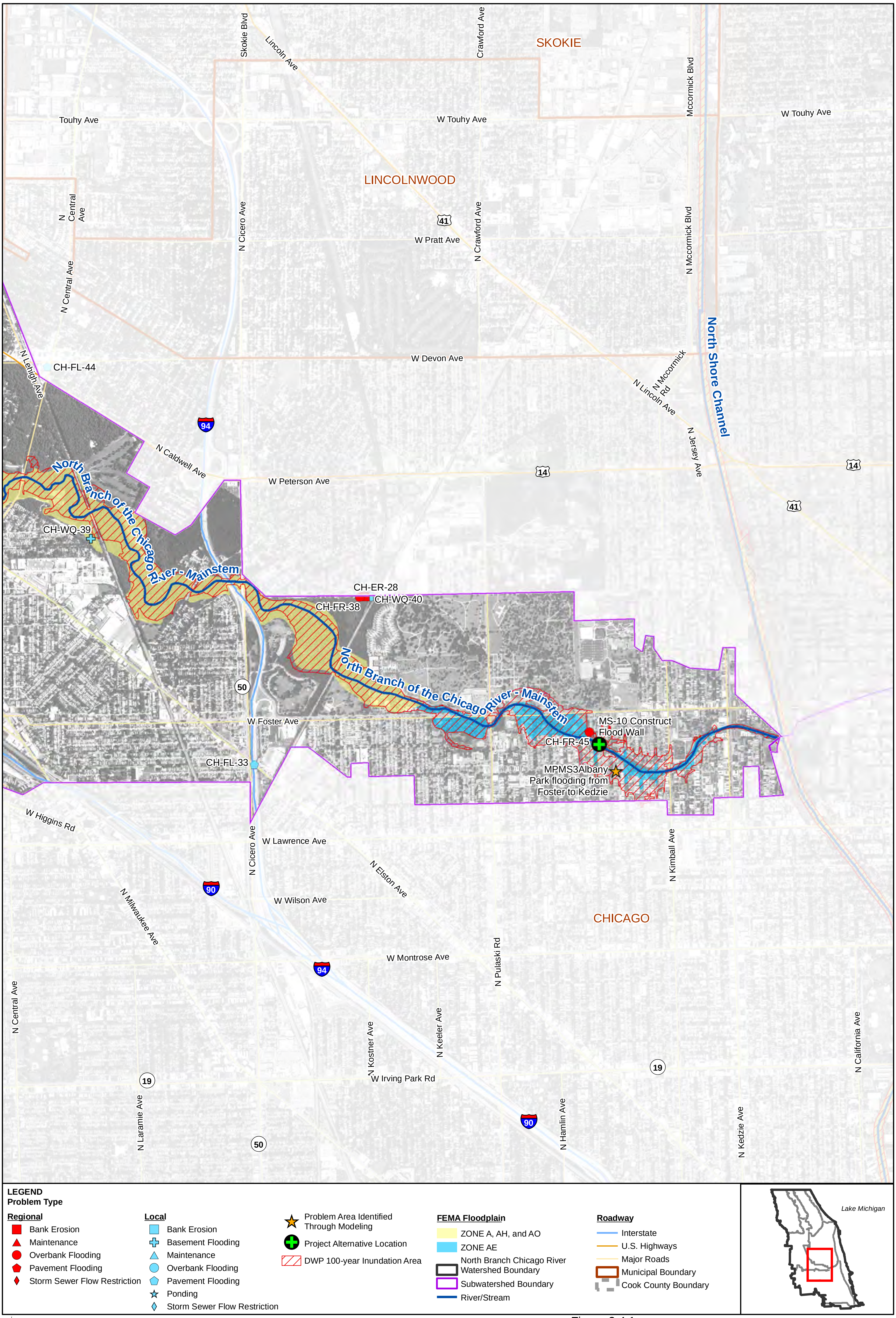
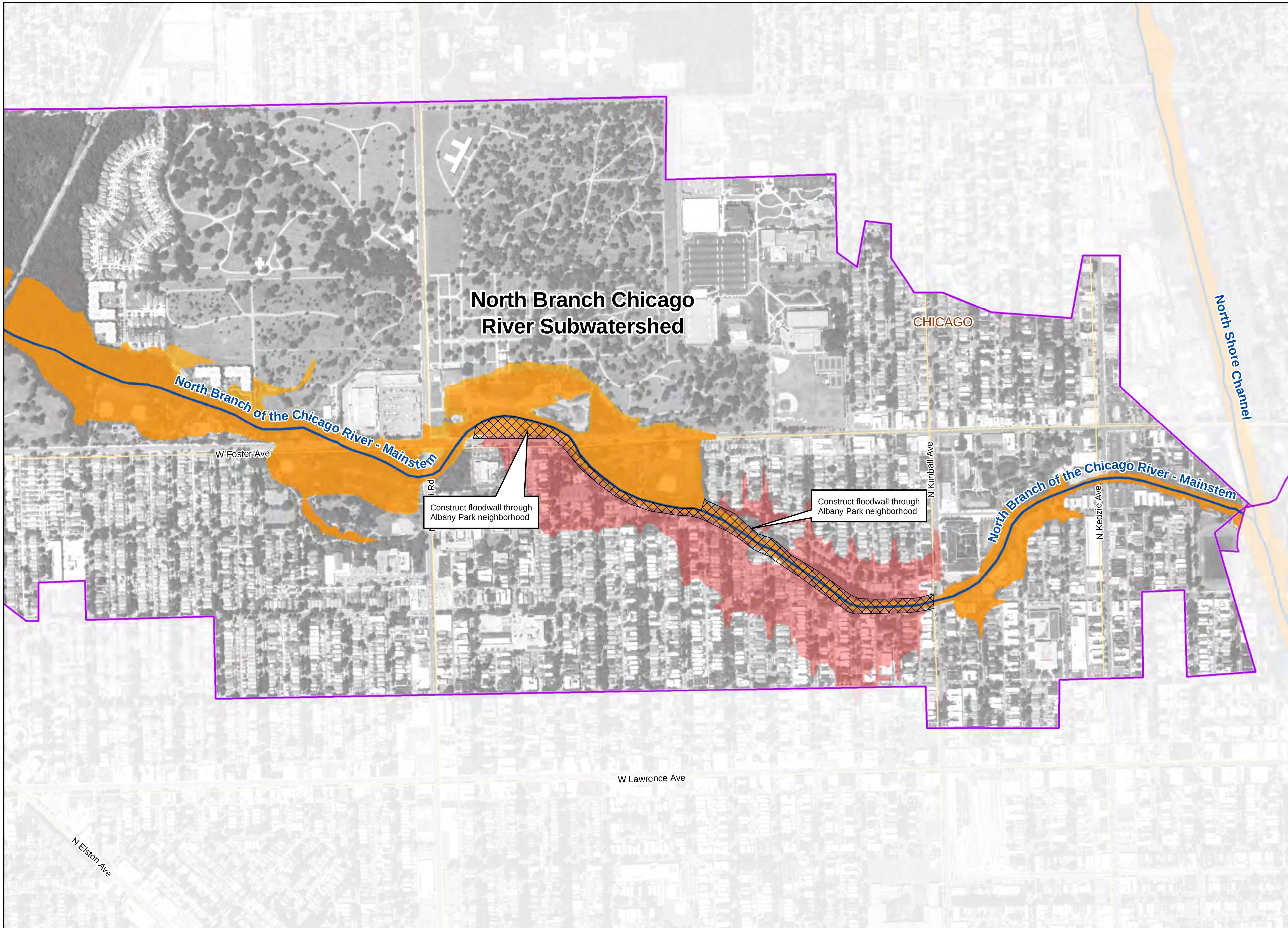


Figure 3.4.1c
Tributary Overview: North Branch Chicago River
North Branch of the Chicago River Detailed Watershed Plan

HDR



RECOMMENDED ALTERNATIVE

Figure 3.4.2a
North Branch Chicago River
Mainstem Alternative MS-10
Existing and Alternative
Inundation Areas
North Branch of the Chicago River
Detailed Watershed Plan

District Database
Alternative: NBCR-MAIN-LV-01
Subwatershed: Mainstem
Alternative Description:
Albany Park Floodwall Project.
Construct approximately 6,300 ft of floodwall along NBCR between Foster Avenue and Kimball Avenue

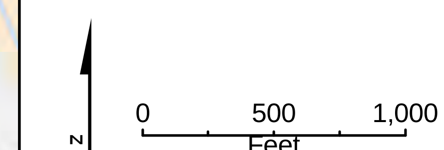
Conceptual Level Cost: $ 16,402,000
Benefits: $ 24,746,000
B/C Ratio: 1.51

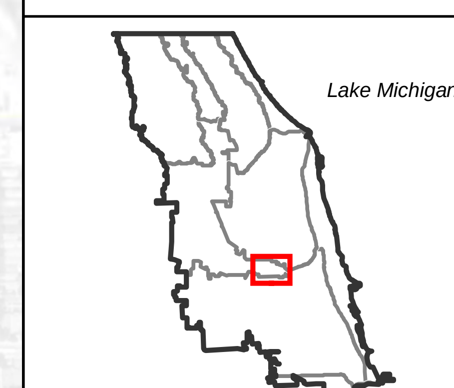
LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

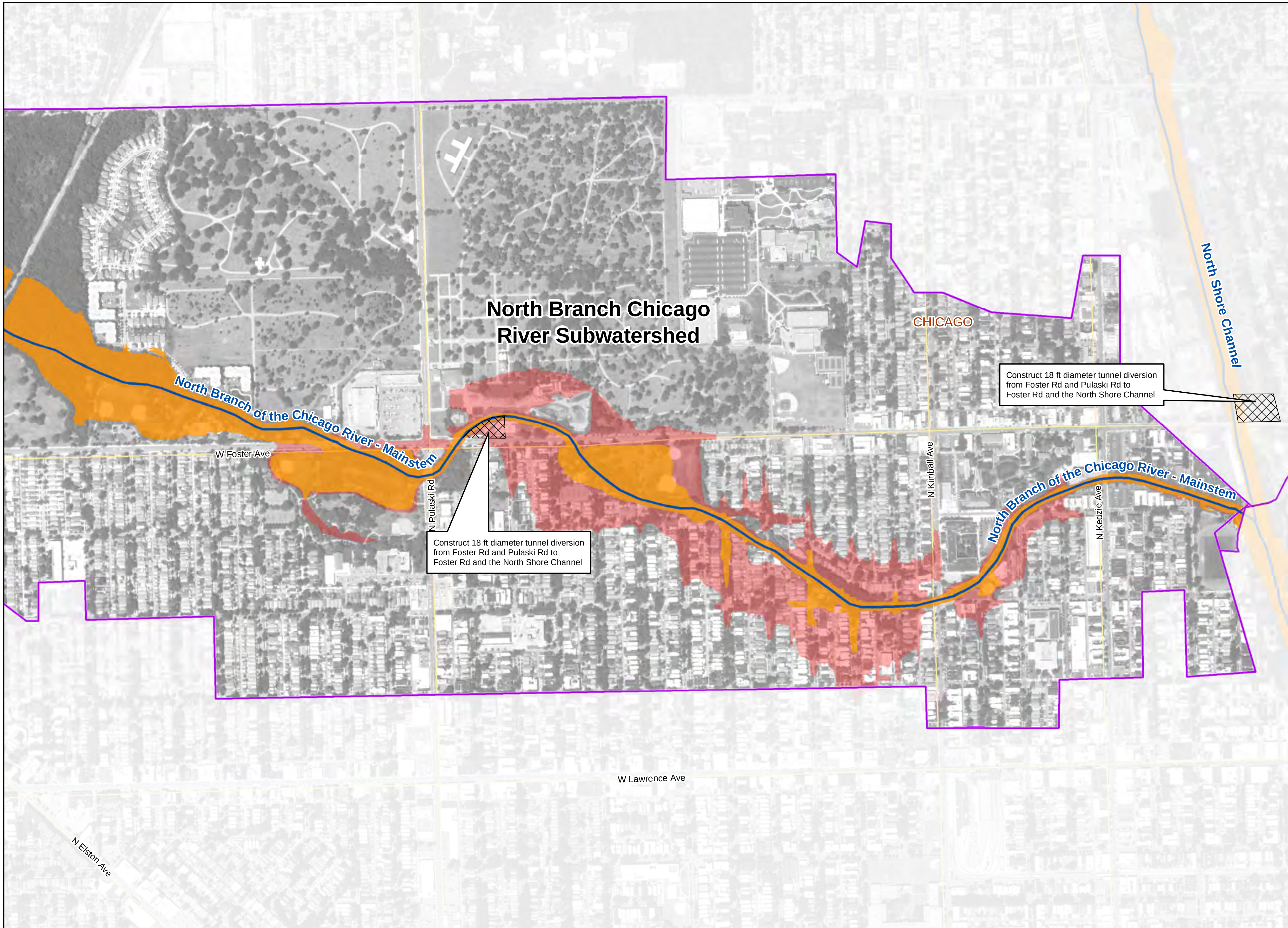
- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary





NON-RECOMMENDED ALTERNATIVE

Figure 3.4.2b
North Branch Chicago River
Mainstem Alternative MS-07
Existing and Alternative Inundation Areas
North Branch of the Chicago River
Detailed Watershed Plan



District Database
Alternative: NBCR-MAIN-DV-02
Subwatershed: Mainstem
Alternative Description:
Foster Avenue Tunnel diversion from NBCR main stem to North Shore Channel using 18-ft diameter tunnel. Tunnel size estimated to keep 100-yr flows within streambank based on tunnel capacities estimated by MWH in CDOT Pre-Feasibility Evaluation

Conceptual Level Cost: $ 55,702,000
Benefits: $ 25,920,000
B/C Ratio: 0.47

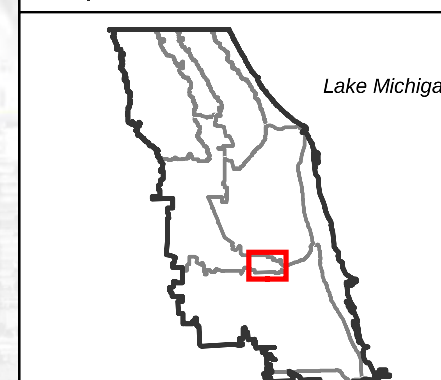
LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

N
0 500 1,000
Feet



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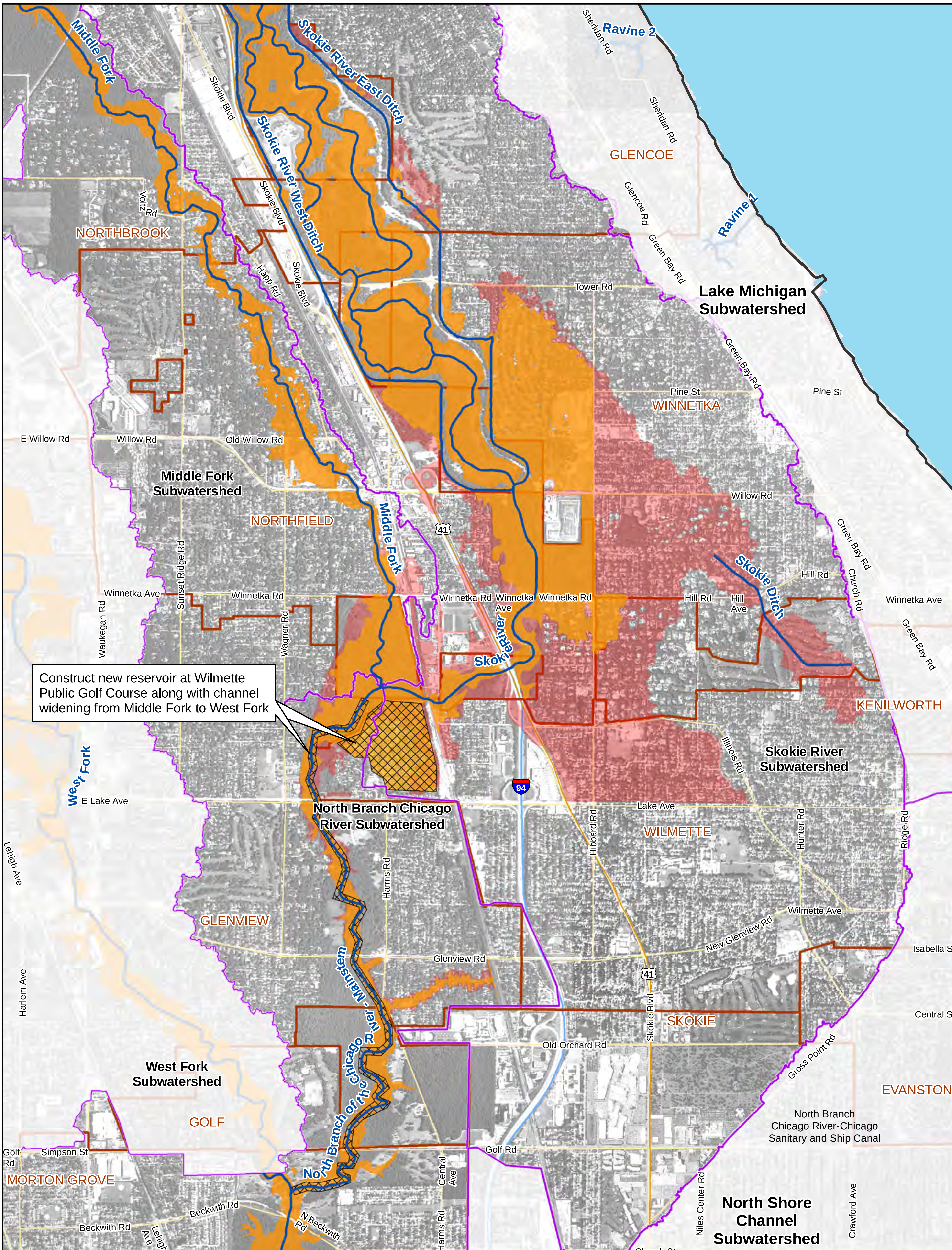


Subwatershed: Mainstem, Skokie River, & Middle Fork

District Database Alternative: NBCR-MAIN-ST-02

Alternative Description:

Construct new reservoir at Wilmette Public Golf Course along with channel widening from Middle Fork to West Fork

Conceptual Level Cost: $ 260,121,000 Benefits: $ 64,431,000

B/C Ratio: 0.25

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 500 1,000 Feet

N

RECOMMENDED ALTERNATIVE

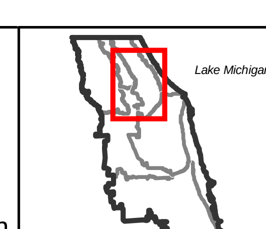
Figure 3.4.3a

Mainstem, Skokie River, & Middle Fork

Alternative MS-14

Existing and Alternative Inundation Areas

North Branch of the Chicago River Detailed Watershed Plan



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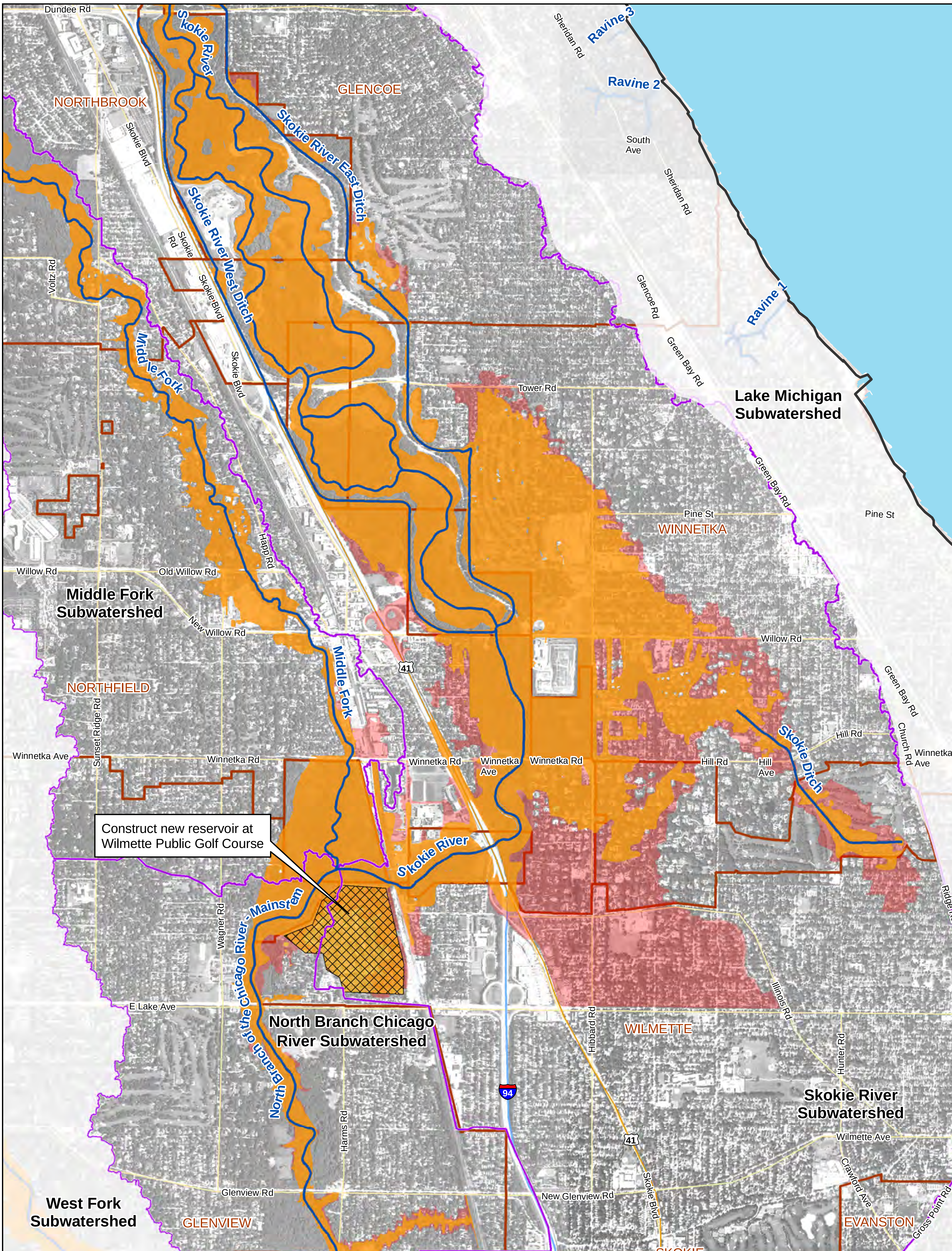


Subwatershed: Mainstem, Skokie River, & Middle Fork

District Database Alternative: NBCR-MAIN-ST-01

Alternative Description:

Addition of a new reservoir on the Wilmette Golf Course. Adds approximately 2,800 ac-ft of storage detention

Conceptual Level Cost: $ 223,725,000 Benefits: $ 53,239,000

B/C Ratio: 0.24

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- North Branch Chicago River Watershed Boundary

Roadway

- Interstate
- U.S. Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 500 1,000 Feet

N

NON-RECOMMENDED ALTERNATIVE

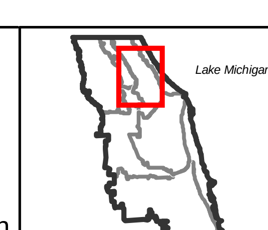
Figure 3.4.3b

Mainstem, Skokie River, & Middle Fork

Alternative MS-12

Existing and Alternative Inundation Areas

North Branch of the Chicago River Detailed Watershed Plan



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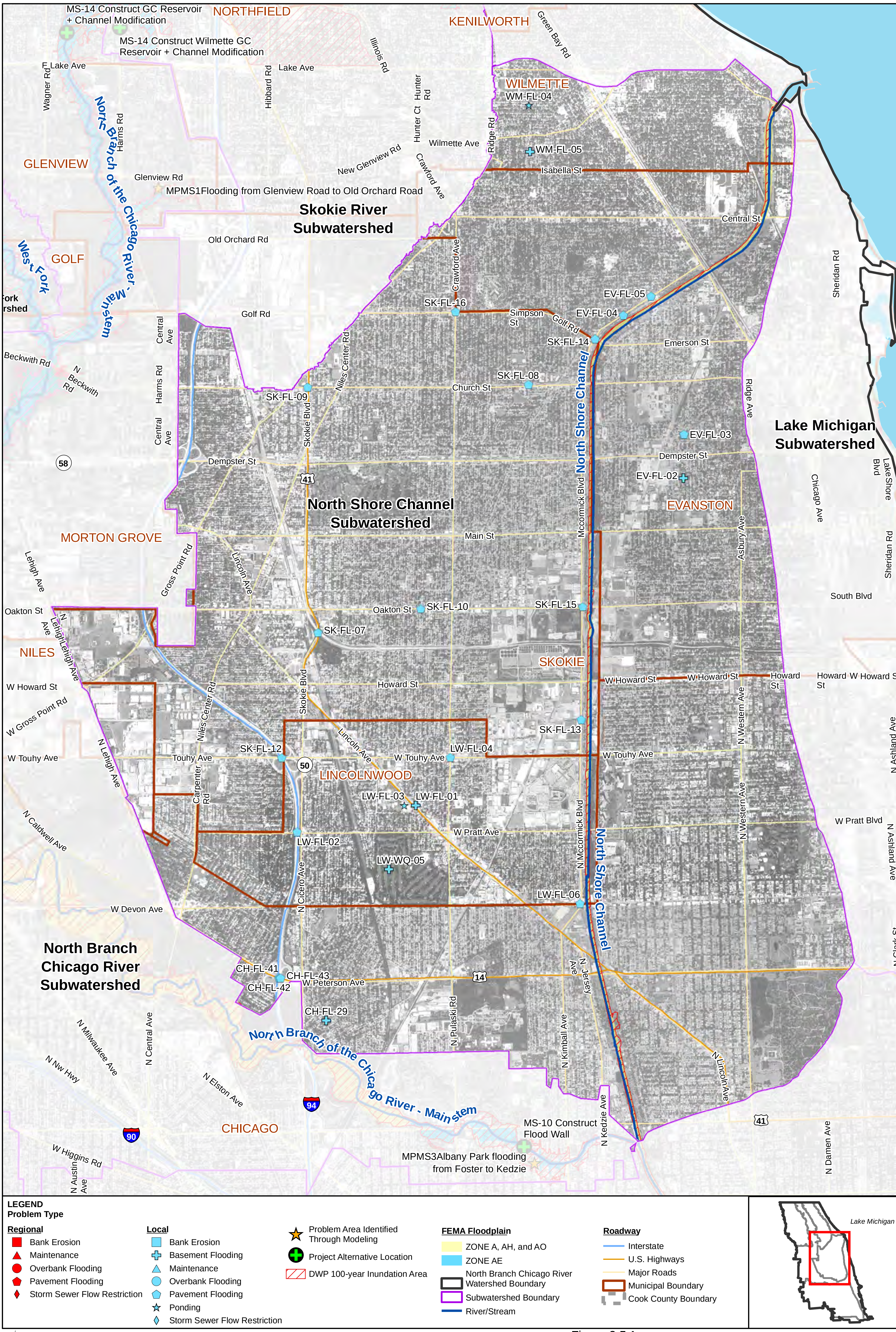


Figure 3.5.1
Tributary Overview: North Shore Channel
North Branch of the Chicago River Detailed Watershed Plan

HDR

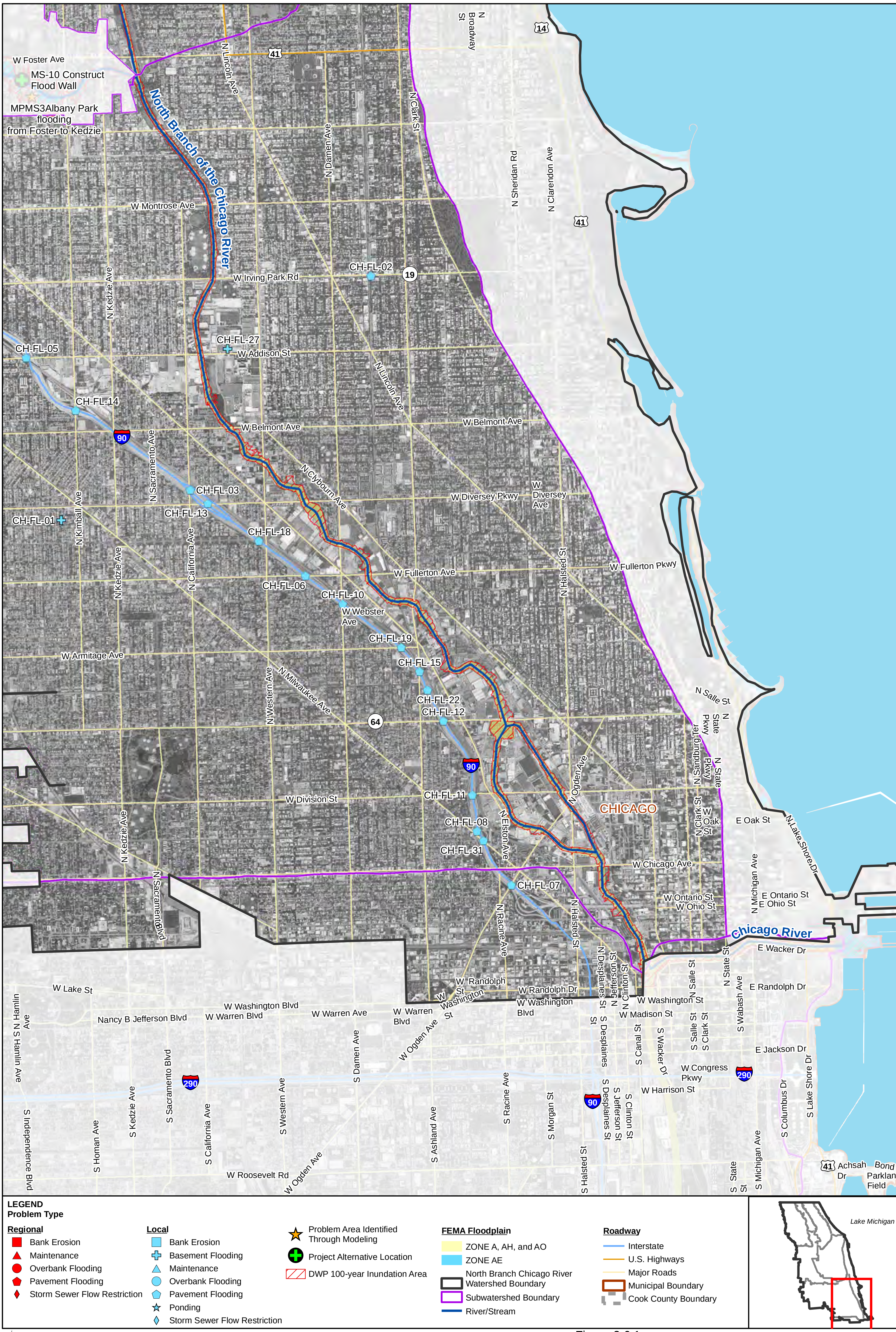


Figure 3.6.1
Tributary Overview: North Branch Chicago River
North Branch of the Chicago River Detailed Watershed Plan

HDR

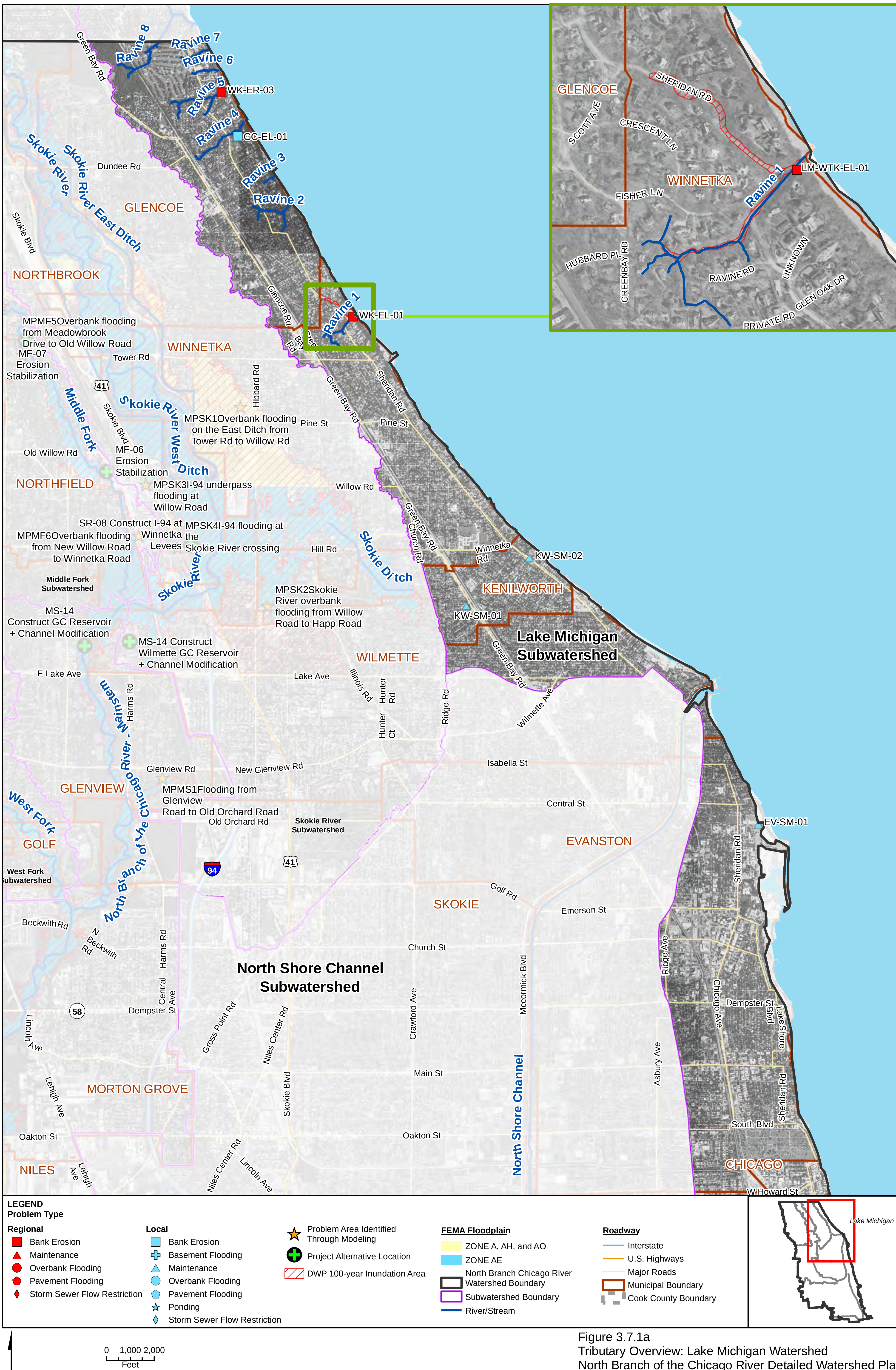


Figure 3.7.1a
Tributary Overview: Lake Michigan Watershed
North Branch of the Chicago River Detailed Watershed Plan

HDR

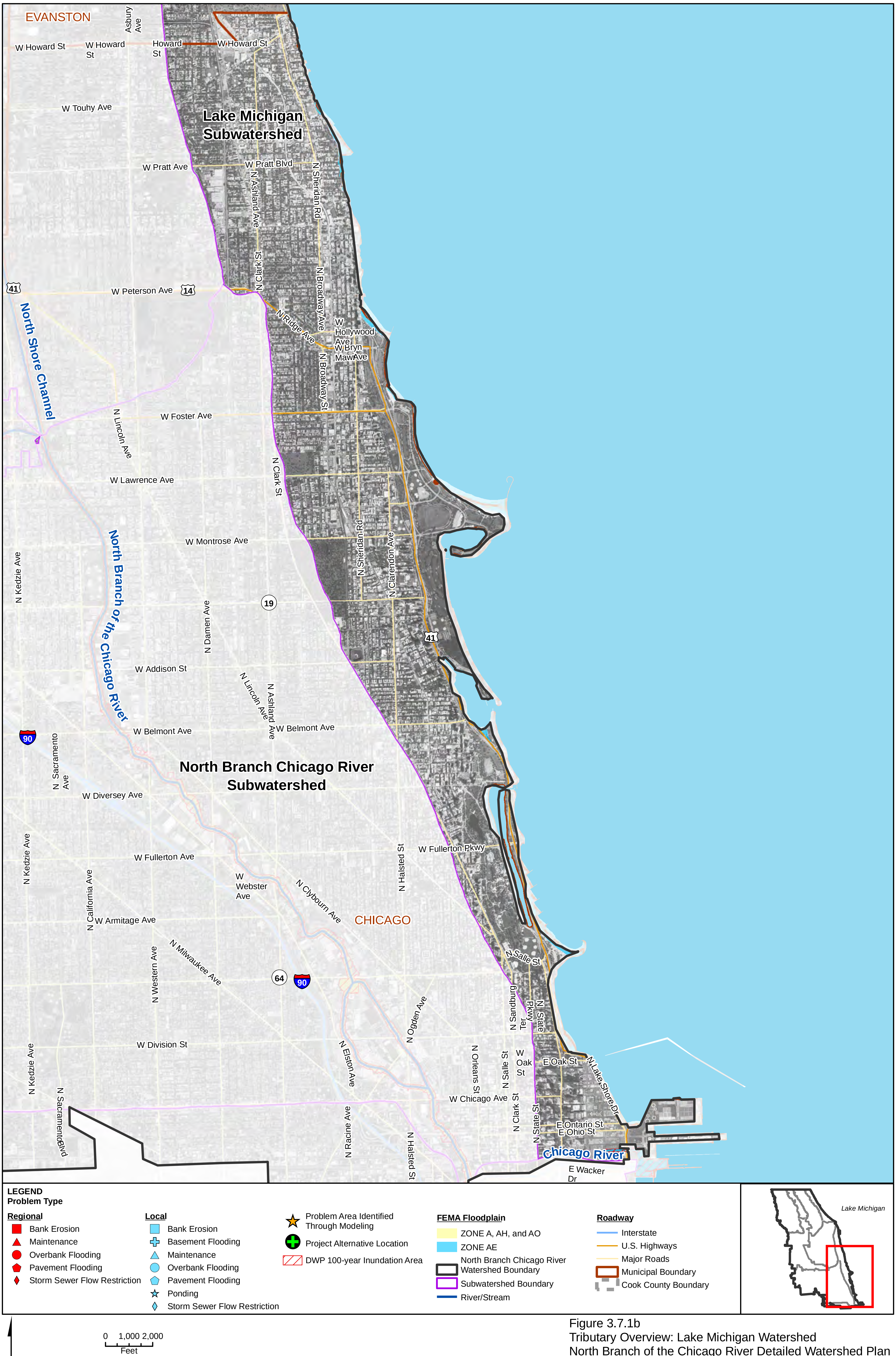


Figure 3.7.1b
Tributary Overview: Lake Michigan Watershed
North Branch of the Chicago River Detailed Watershed Plan

Introduction

As part of the North Branch Chicago River (NBCR) DWP development, inundation mapping was produced based on hydrologic and hydraulic modeling. Tables 1 and 2 include a comparison of the inundation mapping created for this DWP to the effective FEMA floodplain mapping, revised August 19, 2008 as part of the FEMA Map Modernization program. Only detailed study Zone AE and limited detail Zone A special flood hazard areas (SPHA) are included in the comparison. FEMA Zone A SFHA exists in a portion of the Forest Preserve within the Mainstem of the NBCR, the Mainstem downstream of the dam, portions of the Skokie River, and the entire North Shore Channel. Additionally, the Lake Michigan Watershed does not contain any FEMA designated flood zones.

In some locations, other discrepancies exist between this DWP inundation area maps and the FEMA floodplain maps, which may be attributed to differences in hydrologic and hydraulic modeling, as described in more detail in the following paragraphs.

Hydrologic Modeling Methodology

Hydrologic modeling methodologies utilized for the District's DWP are fundamentally different than those performed for DFIRM mapping, thus estimated peak flow rates may be significantly different. DFIRM hydrology was primarily based on regression equations and older hydrologic models (HEC-1, TR-20, etc.) while this DWP utilized the current hydrologic model, HEC-HMS. Consequently, different approaches to channel and reservoir routing have been taken, which may result in magnitude and timing differences.

Parameters of each hydrologic model may be quite different. This DWP computed NRCS Curve Numbers based on the latest CMAP land use maps and NRCS soil maps. Contrarily, hydrologic methods utilized by the DFIRM mapping, likely referenced older land use and soil data. Additionally, different methodologies may have been used to calculate subbasin times of concentration.

This DWP utilized current ISWS Bulletin 71 rainfall data while previous hydrologic studies used for DFIRM mapping may have used older Technical Paper-40 rainfall data. Bulletin 71 rainfall data generally yields higher rainfall depths than Technical Paper-40. For example, Technical Paper-40 specifies a 100-year 24 hour duration rainfall depth of approximately 6.0 inches while Bulletin 71 specifies a corresponding rainfall depth of approximately 7.6 inches. Additionally, this DWP utilizes depth-area adjustments, which may not have been utilized in the DFIRM mapping.

Subbasin delineation is likely different between this DWP and the DFIRM mapping, as this DWP utilized the latest Cook County LiDAR data for topographic information to support subbasin delineation.

Difference in hydrologic modeling approaches may yield different flow rates, which will likely yield different flood surface profiles in the hydraulic model results.

Hydraulic Modeling Methodology

Hydraulic modeling methodologies utilized for this DWP are fundamentally different than those performed for DFIRM mapping, thus their associated flood surface profiles may be significantly different. Steady-state hydraulic modeling was generally performed in support of DFIRM mapping; this DWP utilized dynamic unsteady flow simulation. The difference in approaches between steady and unsteady hydraulic modeling may contribute to discrepancies between flood surface profiles.

Channel cross sections in the hydraulic models differ between this DWP and previous modeling. Cross sections developed under this DWP were generally obtained from field surveys and LiDAR data. Hydraulic models produced in support of DFIRM mapping may have used different cross section data, which may reflect outdated channel geometries. Likewise, bridge section geometries may also vary from previous modeling. Differences in model cross sections may contribute to discrepancies between flood surface profiles.

Hydraulic model calibration may also contribute to discrepancies in flood surface profiles between this DWP and DFIRM mapping. This DWP was calibrated to recent storm events that have occurred since the development of DFIRM modeling. The calibration may contribute to discrepancies between flood surface profiles.

DWP and FEMA Floodplain Area Comparison

Table 1 below lists for comparison the floodplain area within each subwatershed as determined by the NBCR DWP and DFIRM mapping (for both FEMA Zone AE, and FEMA Zone A).

TABLE 1

Comparison of DWP Inundation Area and FEMA Floodplain by Subwatershed

Subwatershed	DWP Floodplain Area (acres)	FEMA Zone AE Area (acres)	FEMA Zone A Area (acres)
West Fork	666.1	563.0	0
Middle Fork	444.1	386.8	0
Skokie River	2,303.2	1,498.3	447.2
Mainstem	951.5	487.7	404.1
North Shore Channel	129.7	0	149.4
Mainstem D/S of the Dam	241.2	0	223.5
TOTAL	**4,735.8**	**2,935.7**	**1,224.1**

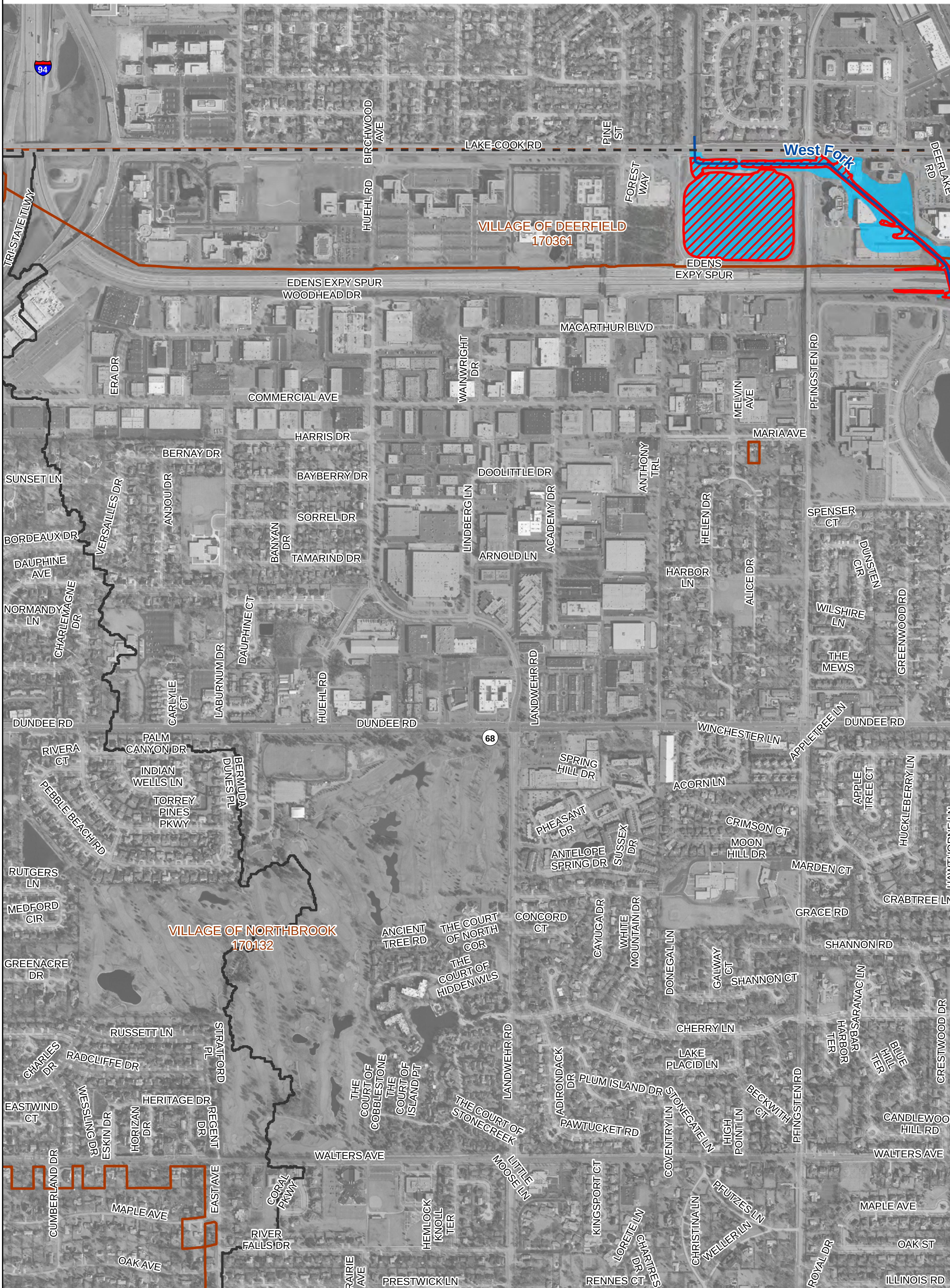
*The Lake Michigan Watershed does not contain any designated FEMA Flood Zones

Table 2 below lists for comparison the floodplain area within each community within the NBCR watershed as determined by the NBCR DWP and the DFIRM mapping (for both FEMA Zone AE, and FEMA Zone A).

TABLE 2

Comparison of DWP Inundation Area and FEMA Floodplain by Community

Subwatershed	DWP Floodplain Area (acres)	FEMA Zone AE Area (acres)	FEMA Zone A Area (acres)
Chicago	713.7	86.2	657.5
Cook County Unincorporated Areas	957.3	920.2	58.5
Deerfield	21.5	33.2	0
Evanston	37.4	3.2	48.9
Glencoe	161.9	132.8	40.8
Glenview	473.6	336.4	0
Golf	45.5	32.1	0
Kenilworth	0	0.1	0
Lincolnwood	16.9	0	17.0
Morton Grove	214.5	177.1	0
Niles	101.2	100.5	0
Northbrook	412.3	366.1	3.4
Northfield	506.0	421.4	0
Skokie	39.0	0	41.2
Wilmette	328.7	83.5	13.0
Winnetka	710.0	298.2	344.8
TOTAL	**4,739.5**	**2,991.0**	**1,225.1**



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

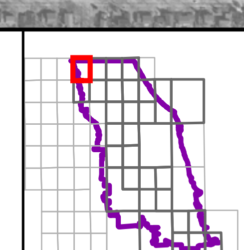
ZONE AE

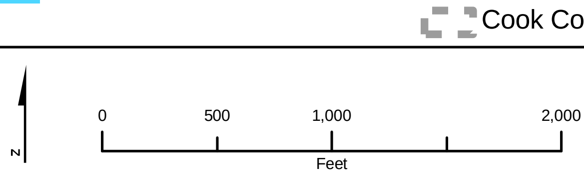
North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



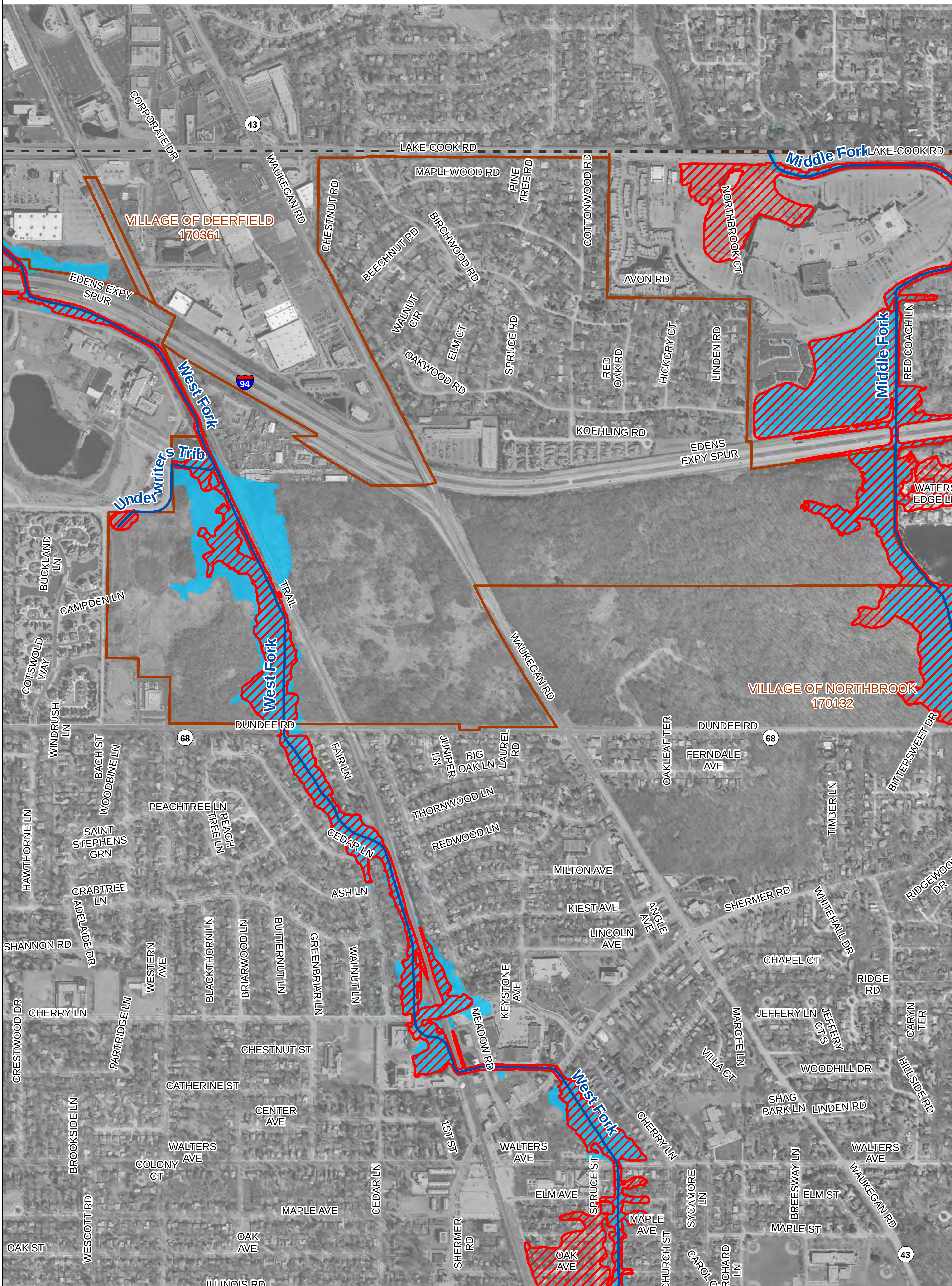


FIRM Panel: 17031C0088J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

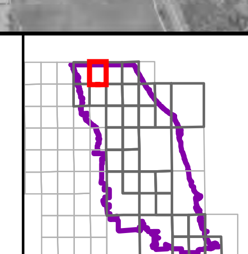
North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

- DWP 100-year Inundation Area
- **FEMA Floodplain**
  - ZONE A, AH, and AO
  - ZONE AE
- North Branch Chicago River Watershed
- River/Stream
- Municipal Boundary
- Cook County Boundary



0 500 1,000 2,000
Feet

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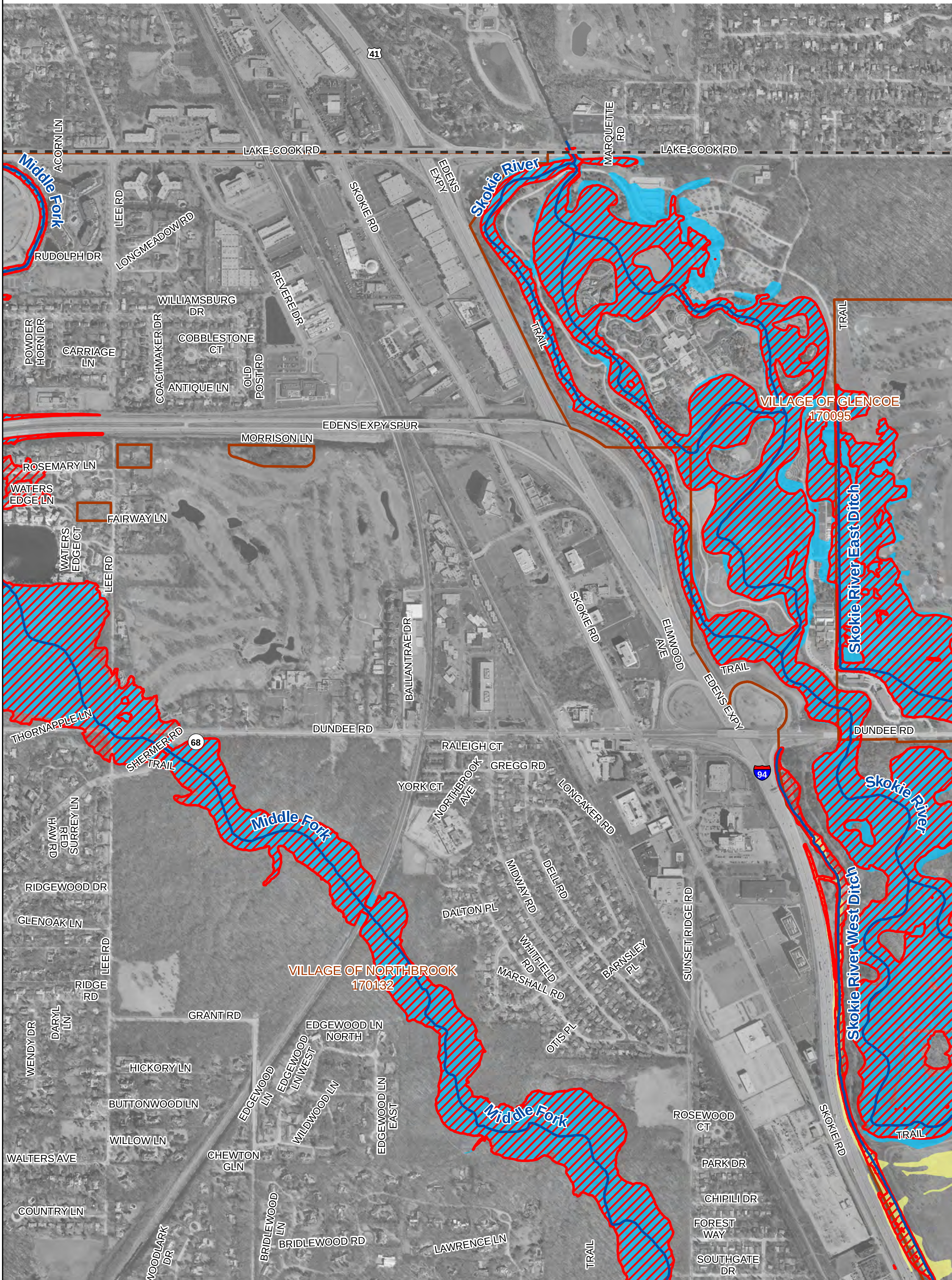
North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

- DWP 100-year Inundation Area

FEMA Floodplain

- ZONE A, AH, and AO
- ZONE AE
- North Branch Chicago River Watershed
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

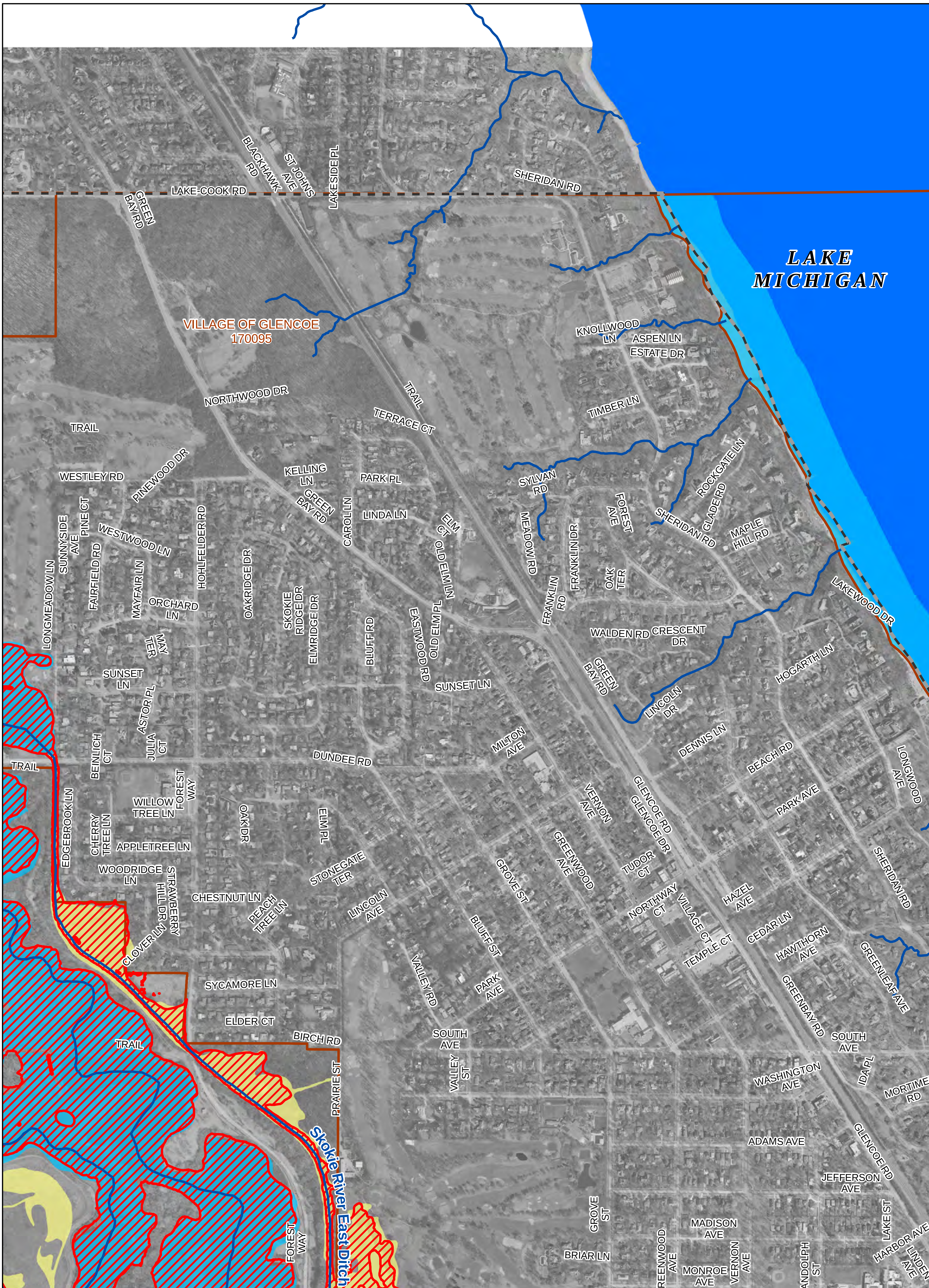
0 500 1,000 2,000
Feet

FIRM Panel: 17031C0093J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

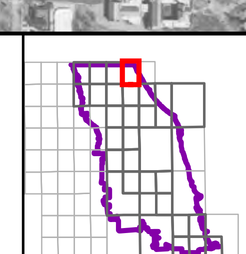
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

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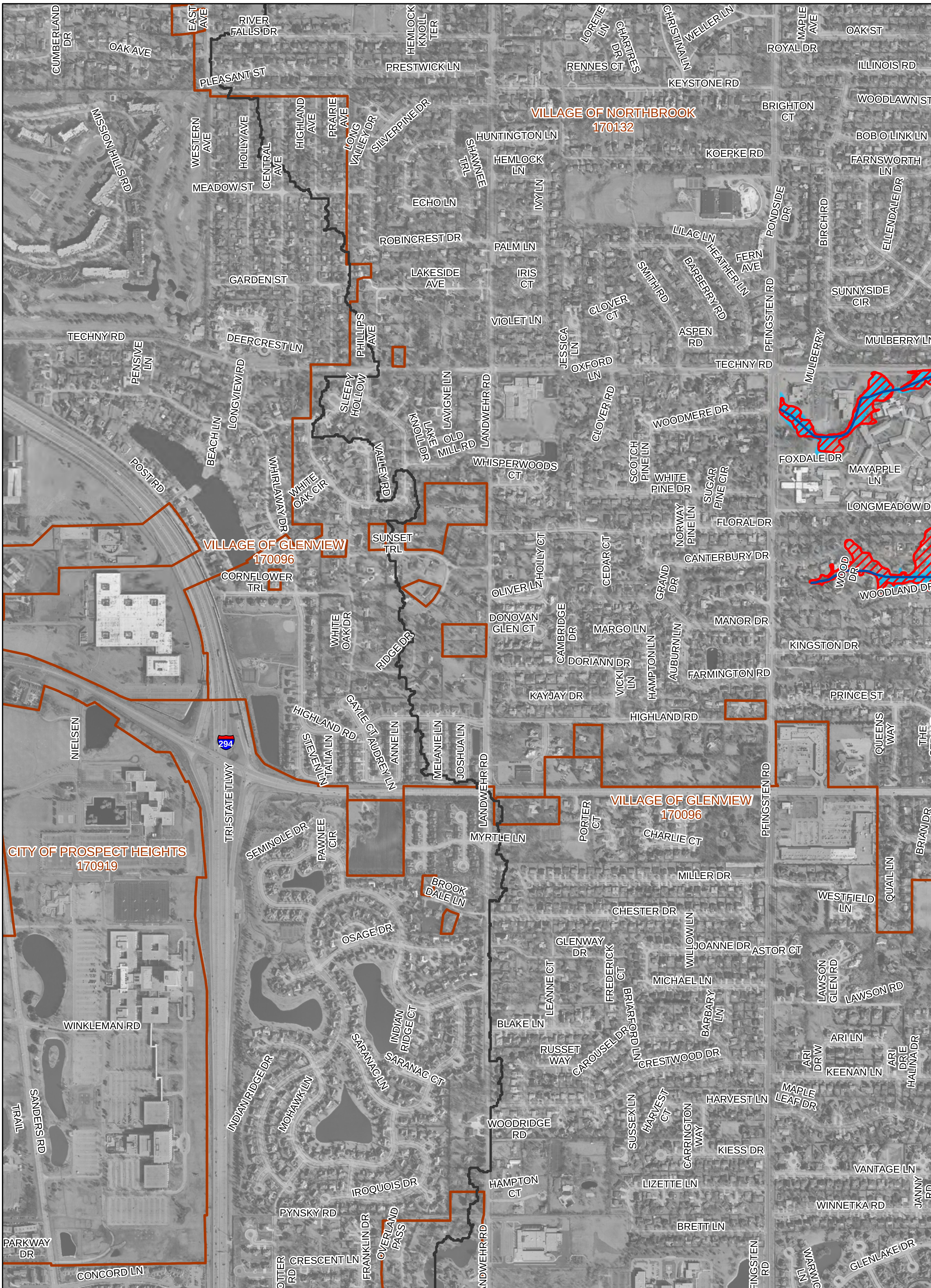
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

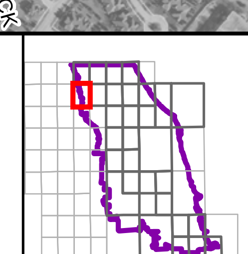
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



0 500 1,000 2,000

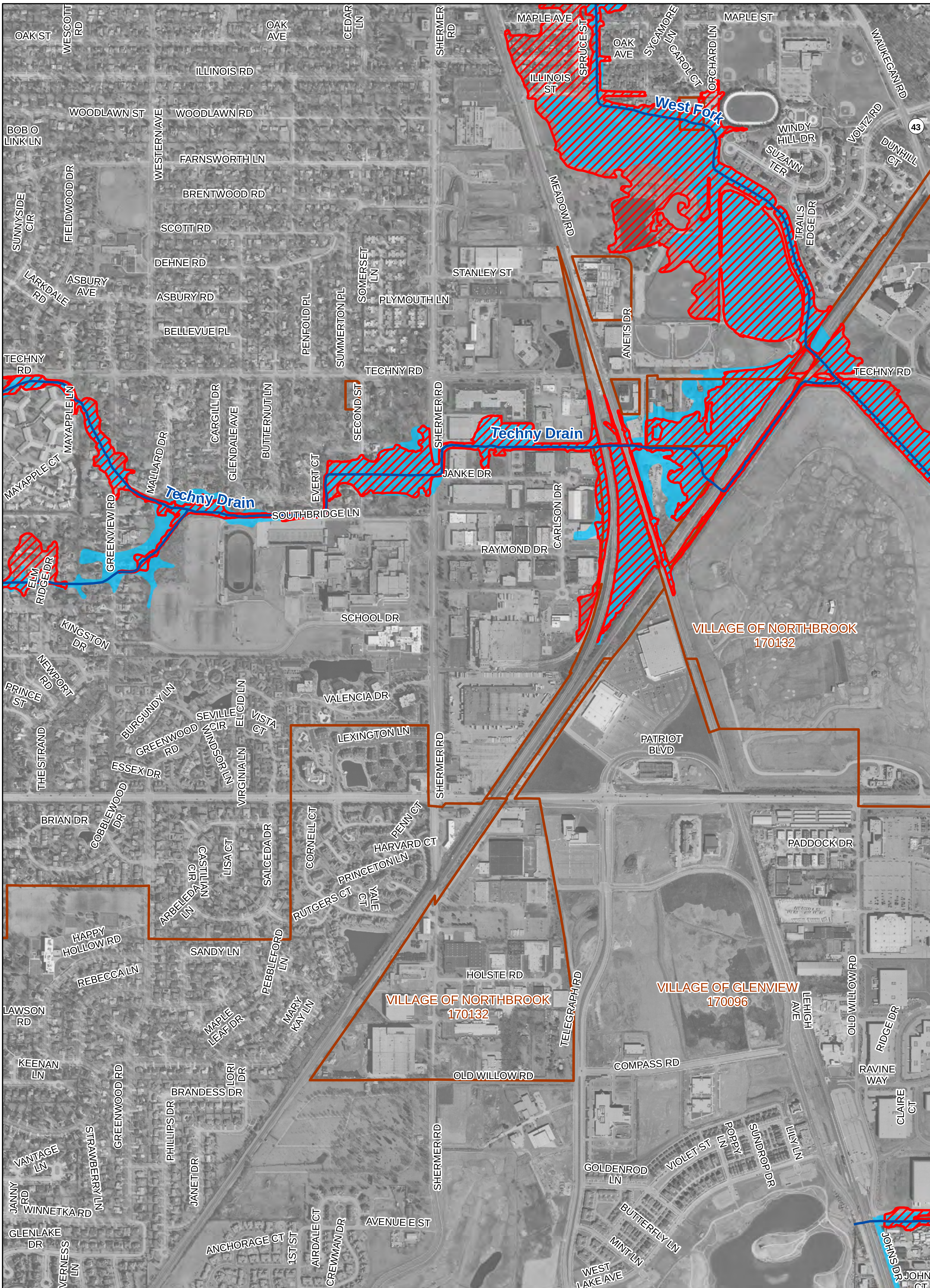
Feet

FIRM Panel: 17031C0226J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR

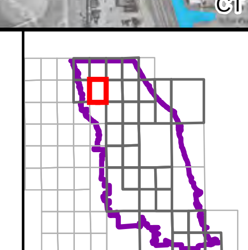


LEGEND

- DWP 100-year Inundation Area

FEMA Floodplain

- ZONE A, AH, and AO
- ZONE AE
- North Branch Chicago River Watershed
- River/Stream
- Municipal Boundary
- Cook County Boundary



N

0 500 1,000 2,000

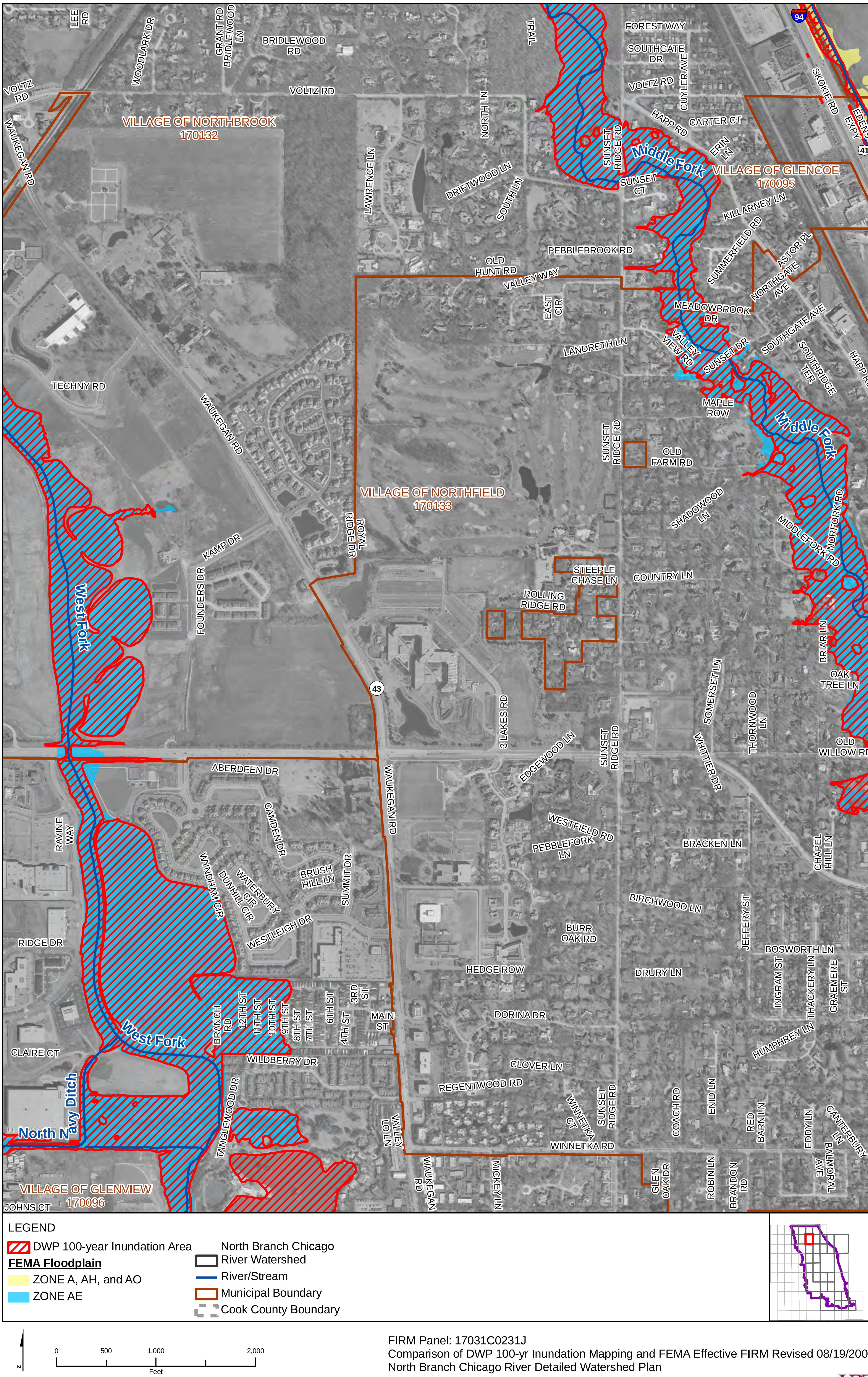
Feet

FIRM Panel: 17031C0227J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



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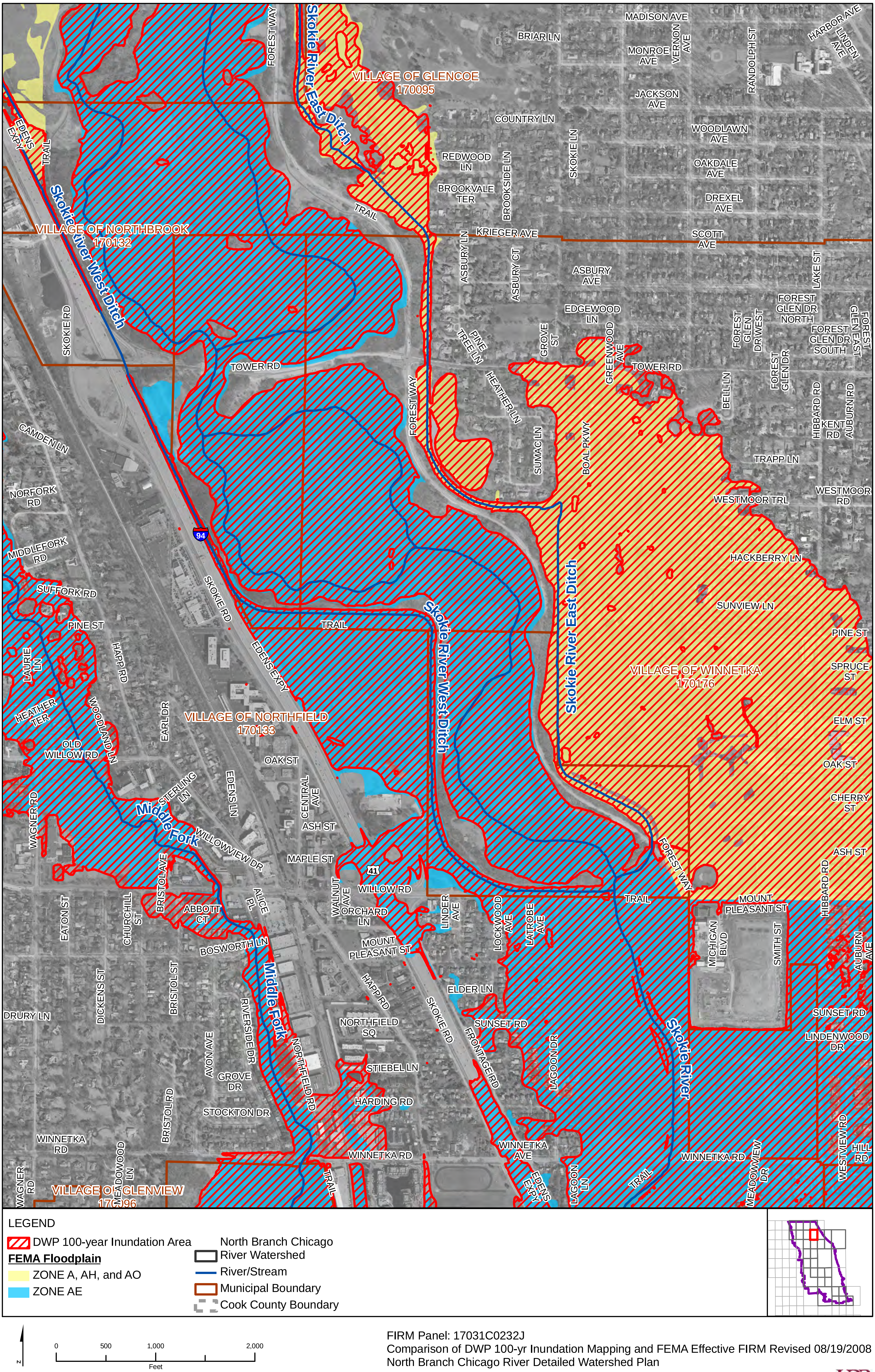
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan



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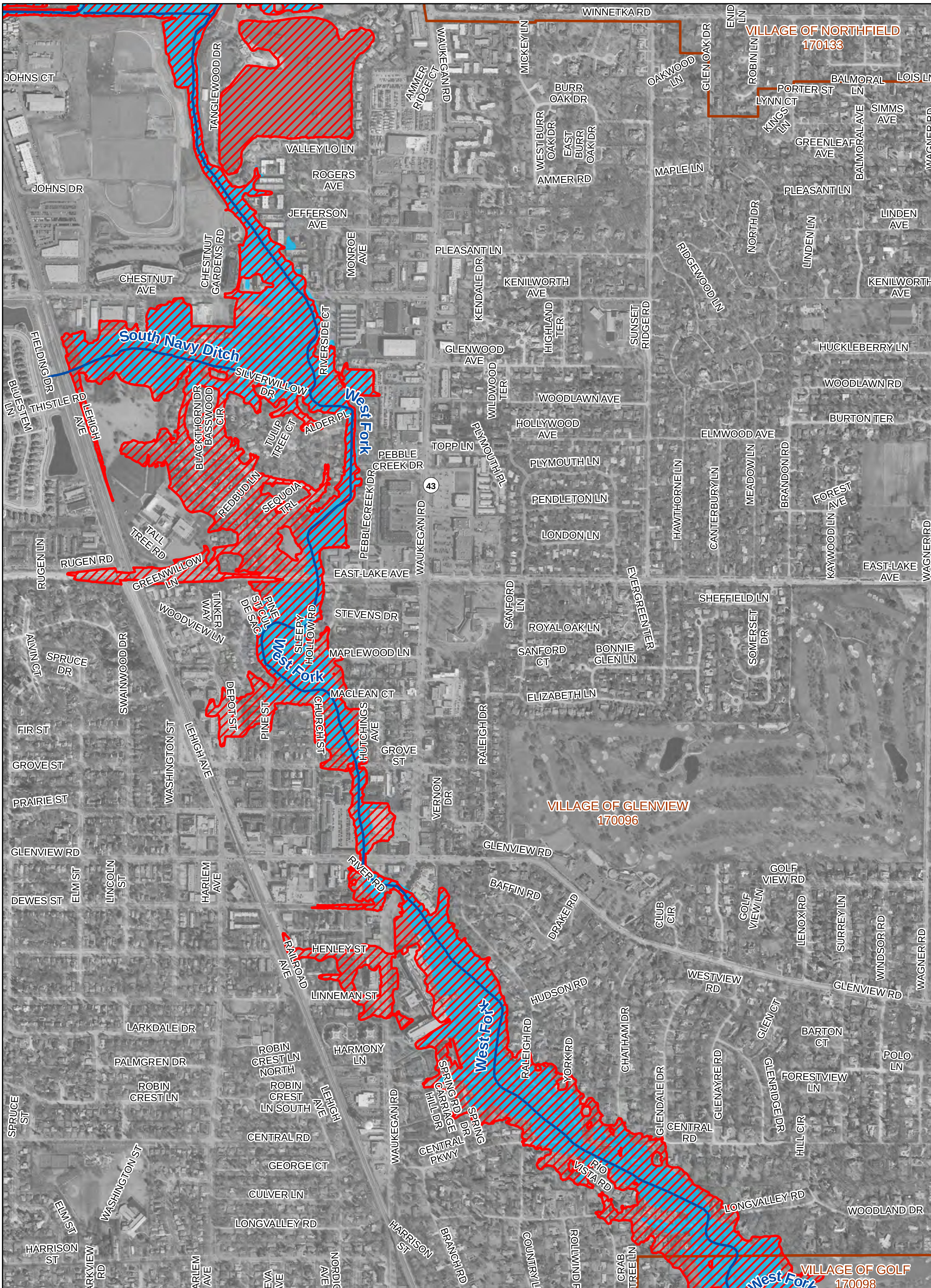
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008
North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

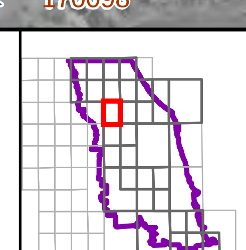
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



N

0 500 1,000 2,000

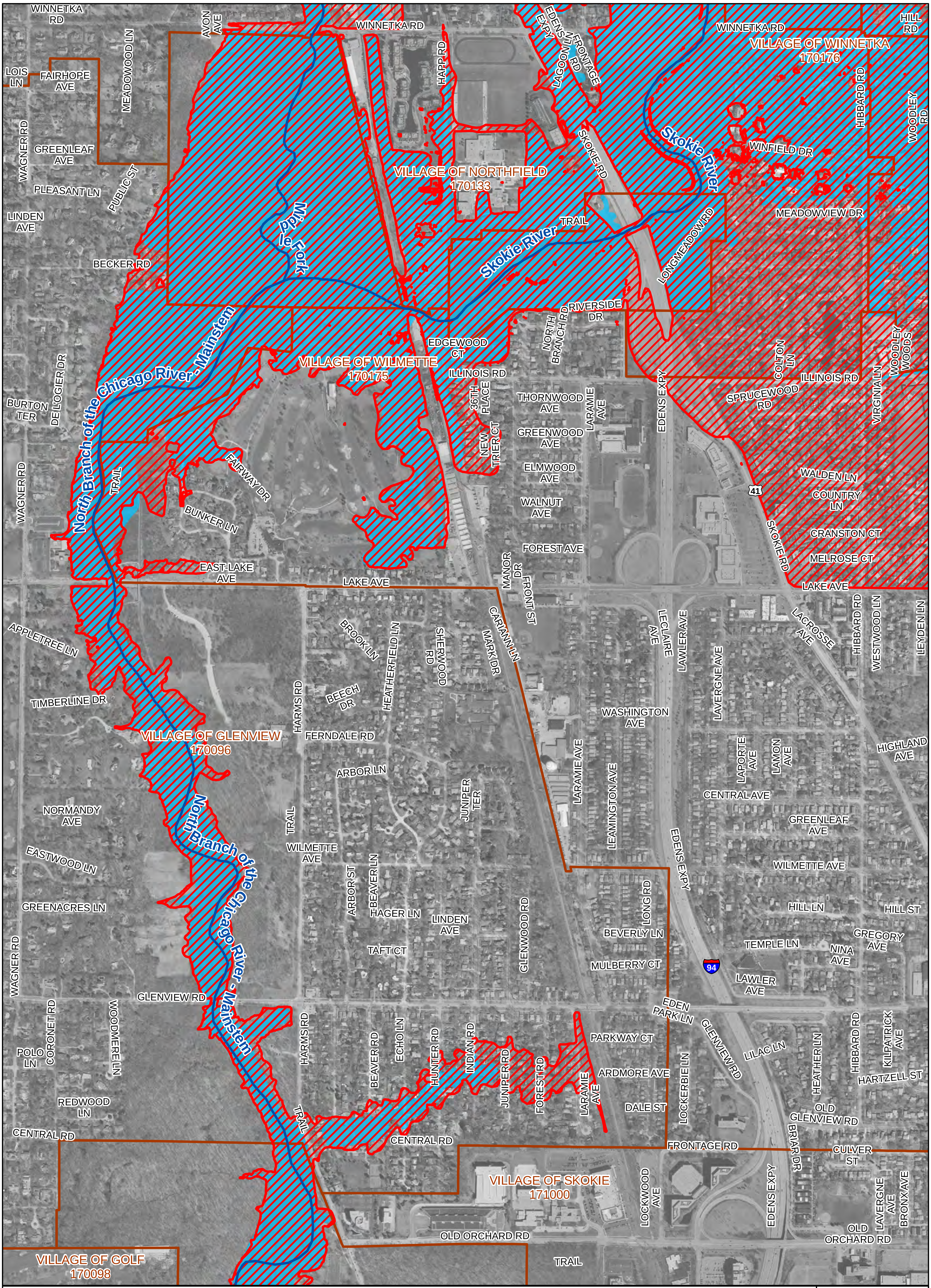
Feet

FIRM Panel: 17031C0233J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

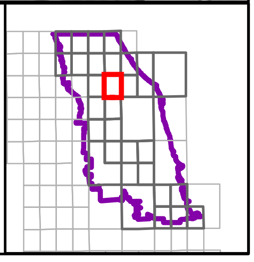
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



0 500 1,000 2,000

Feet

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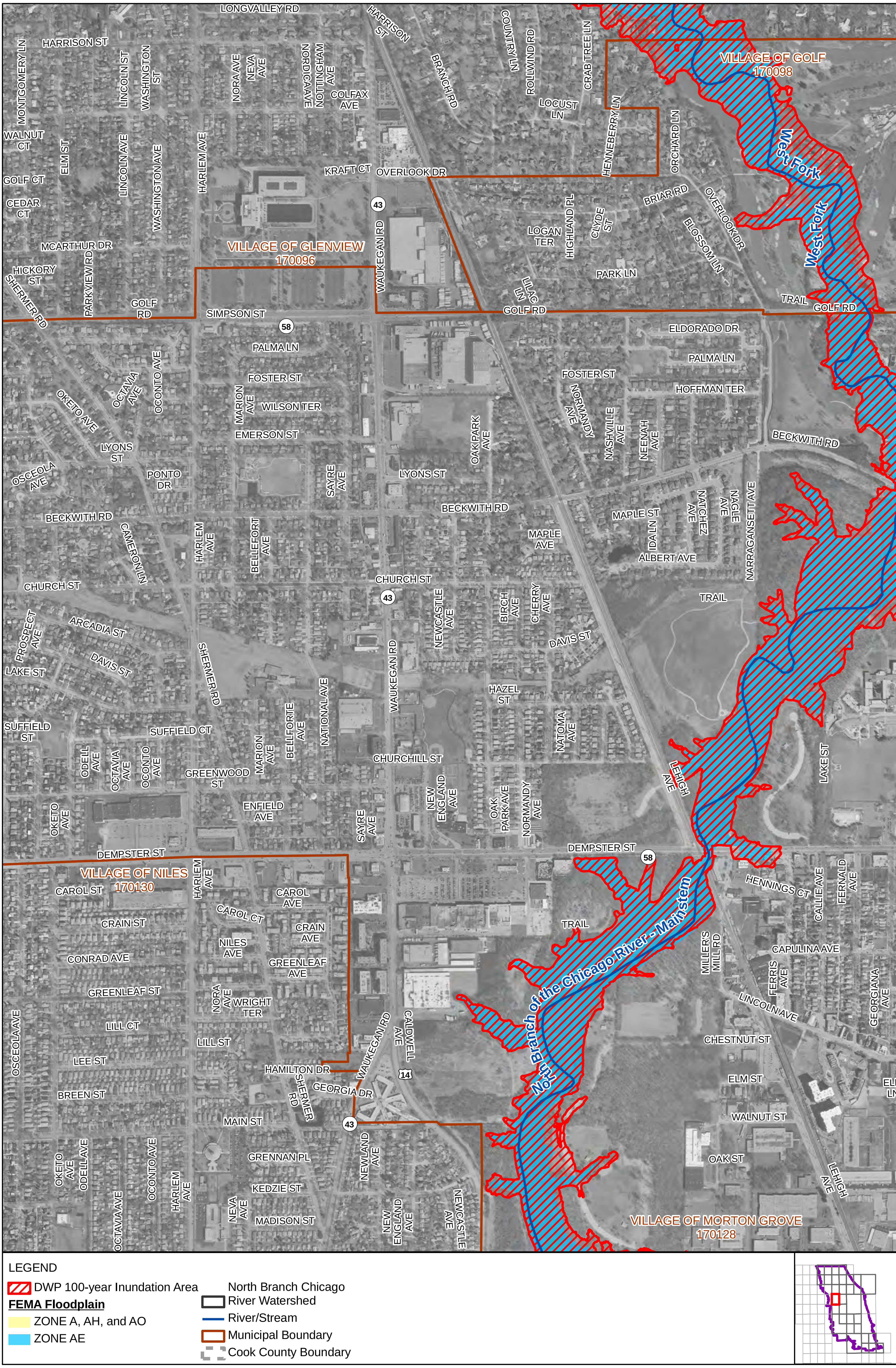
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



N

0 500 1,000 2,000

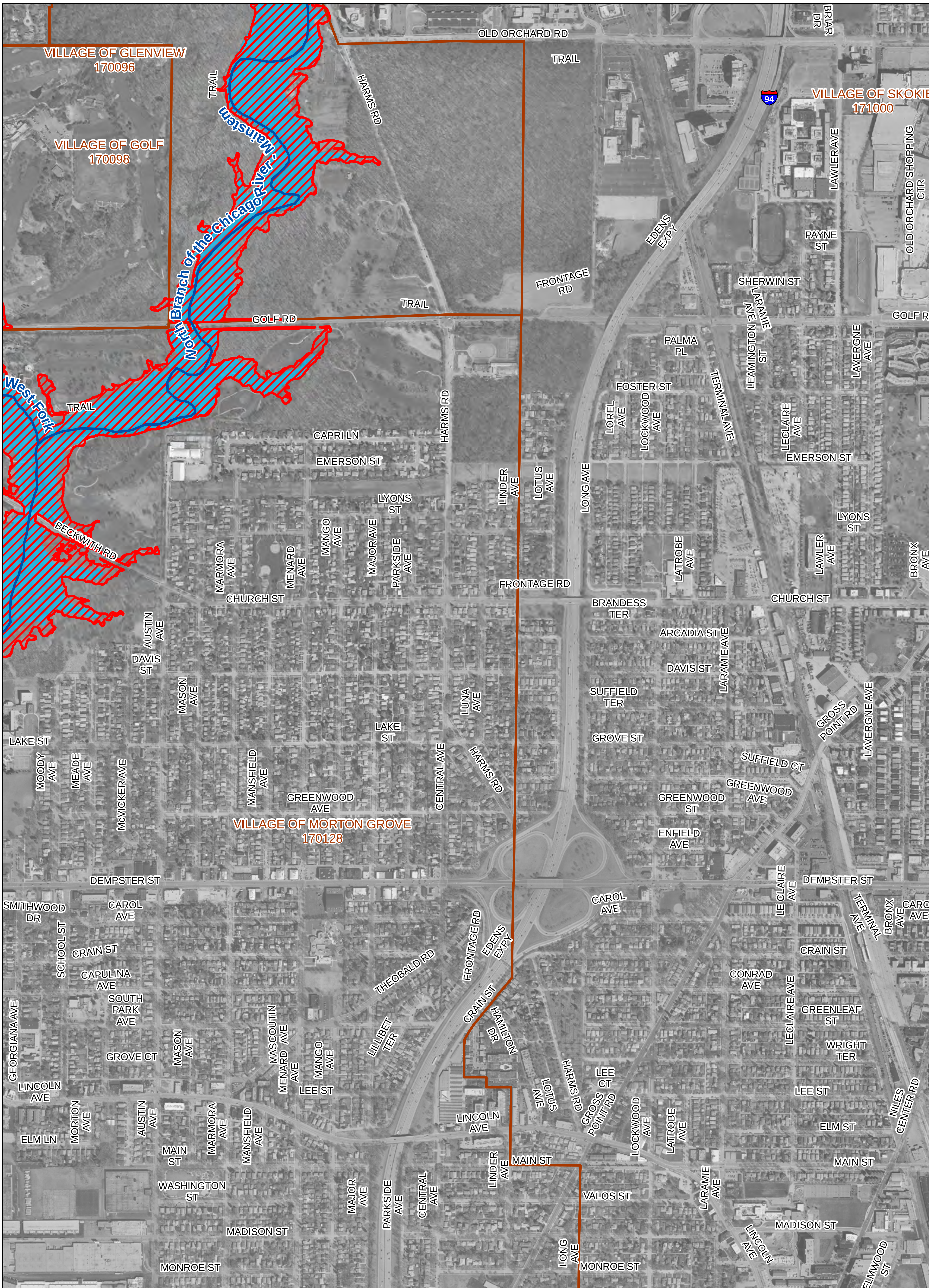
Feet

FIRM Panel: 17031C0241J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

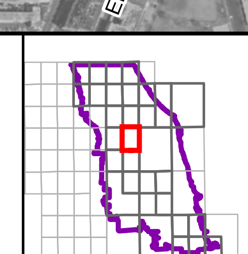
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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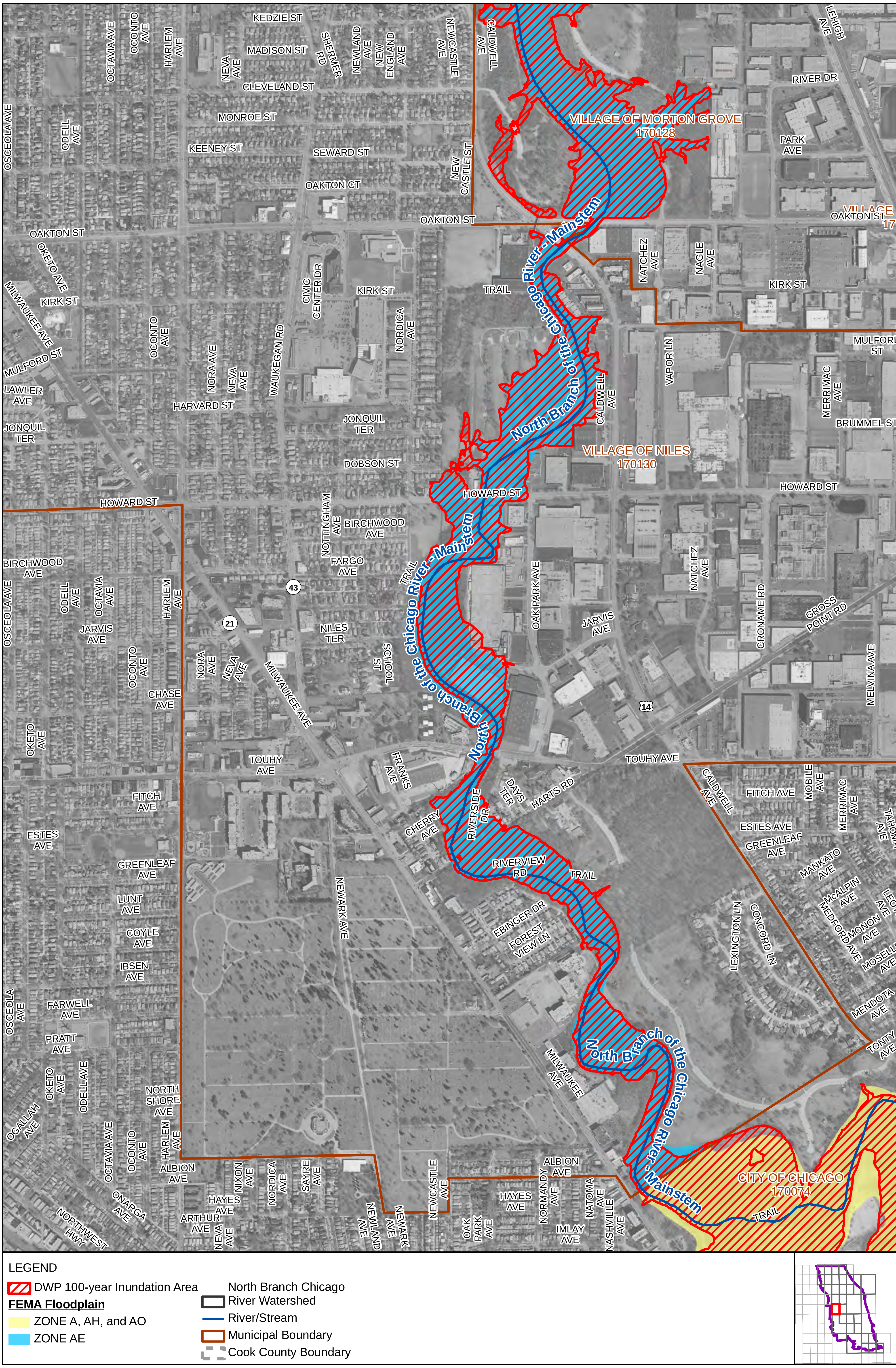
Feet

FIRM Panel: 17031C0242J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR

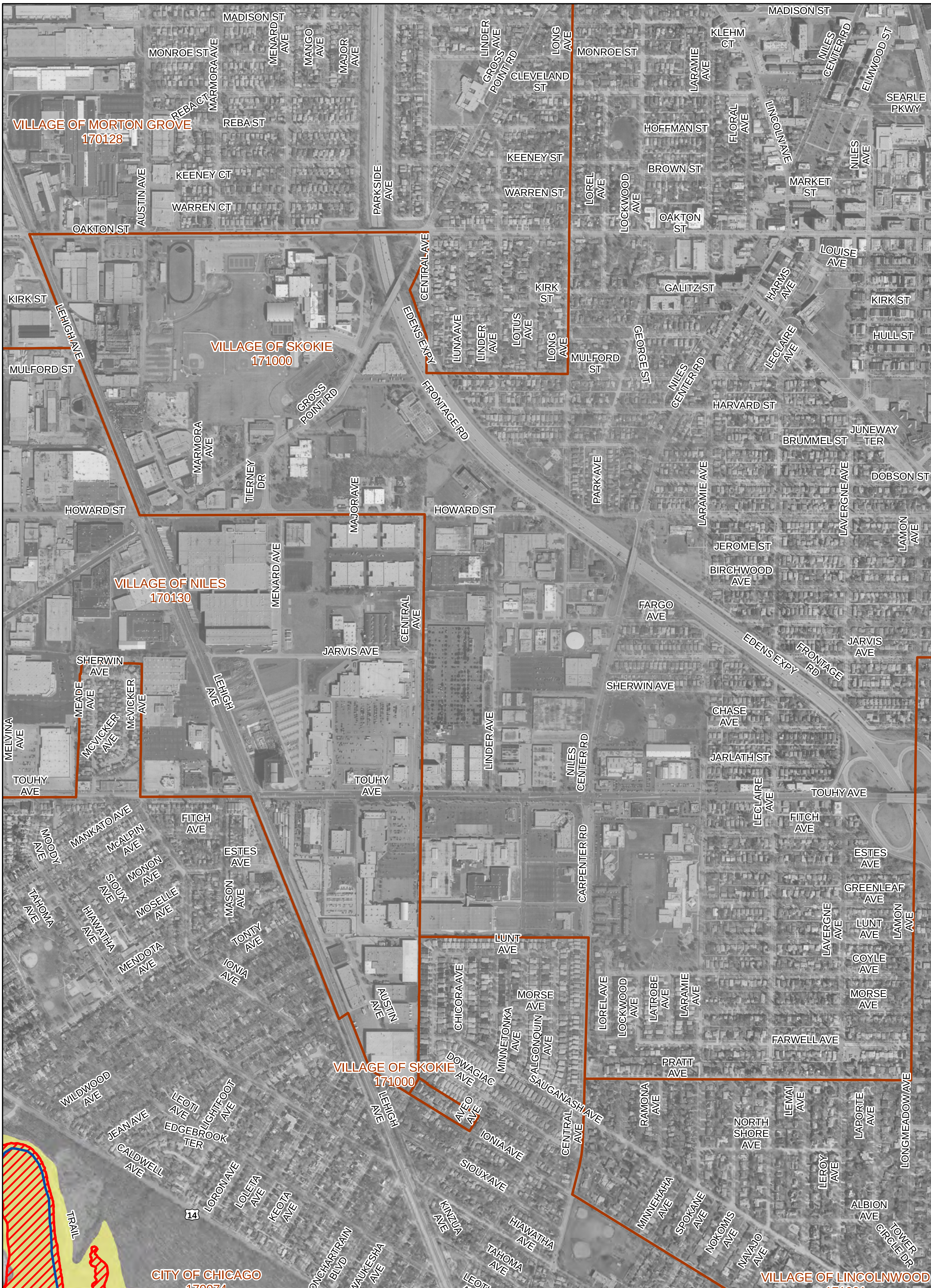


FIRM Panel: 17031C0243J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary

N

0 500 1,000 2,000

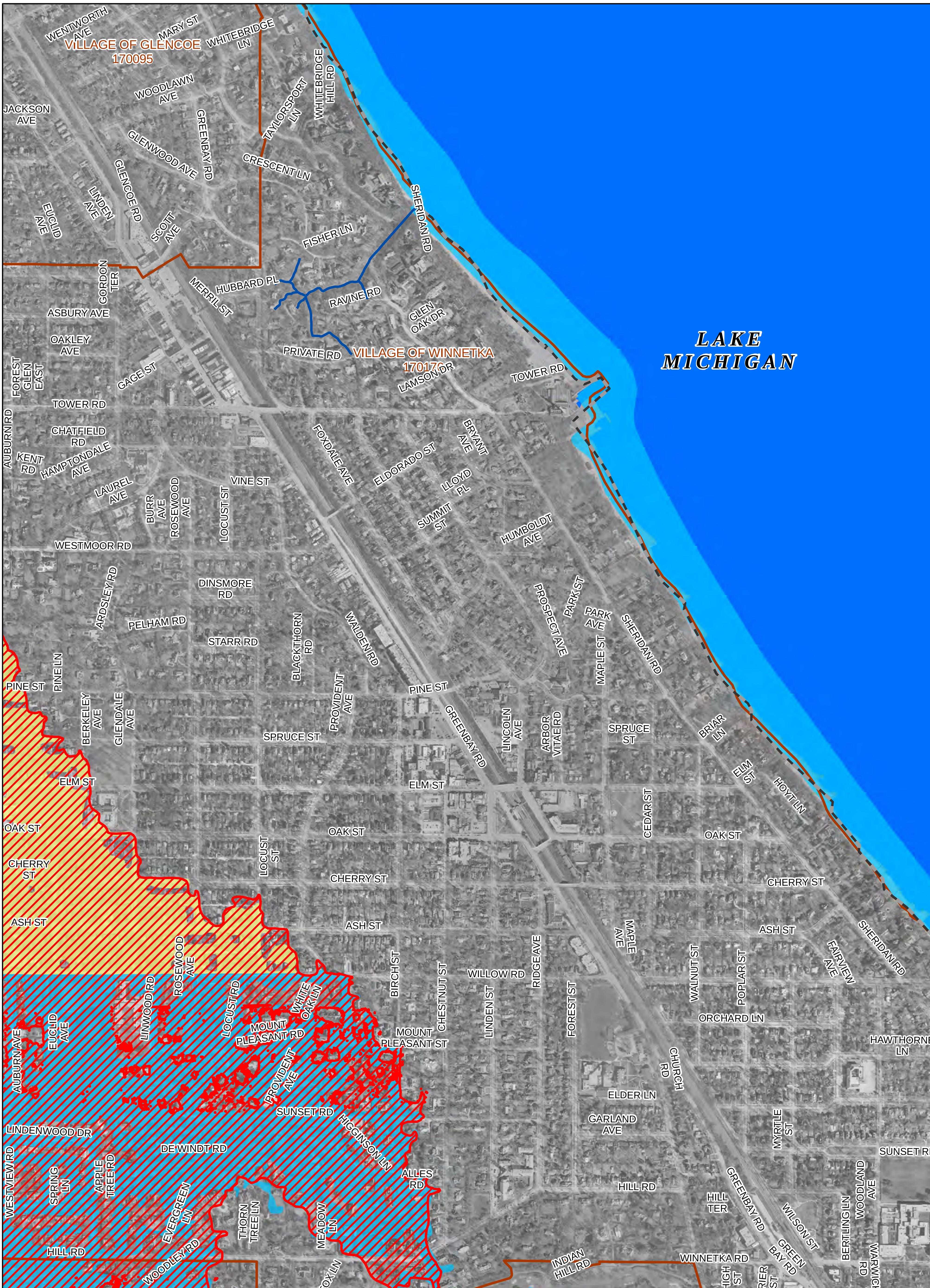
Feet

FIRM Panel: 17031C0244J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

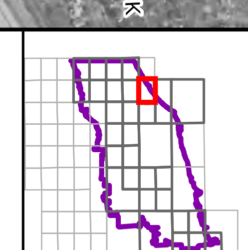
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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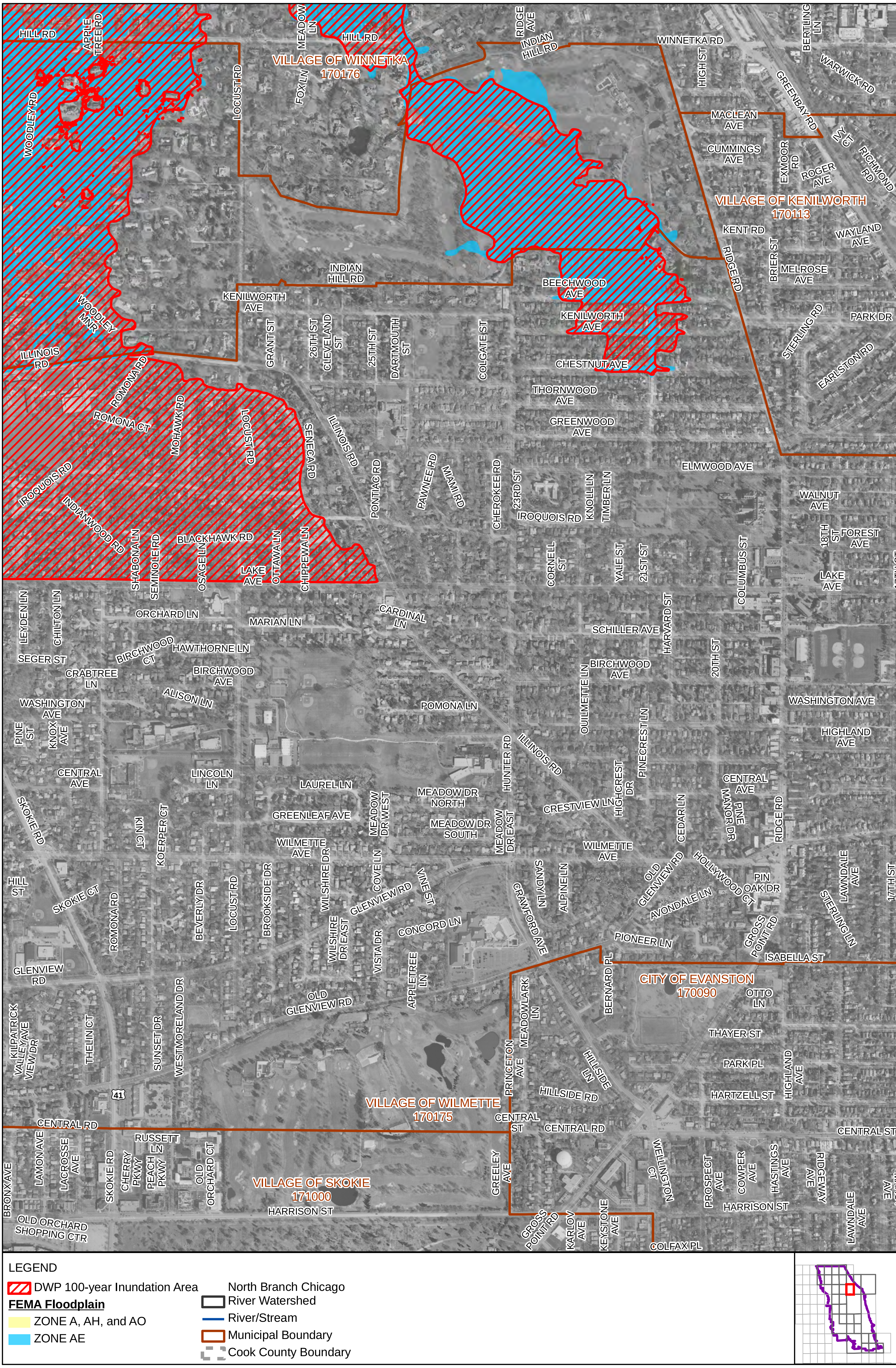
Feet

FIRM Panel: 17031C0251J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



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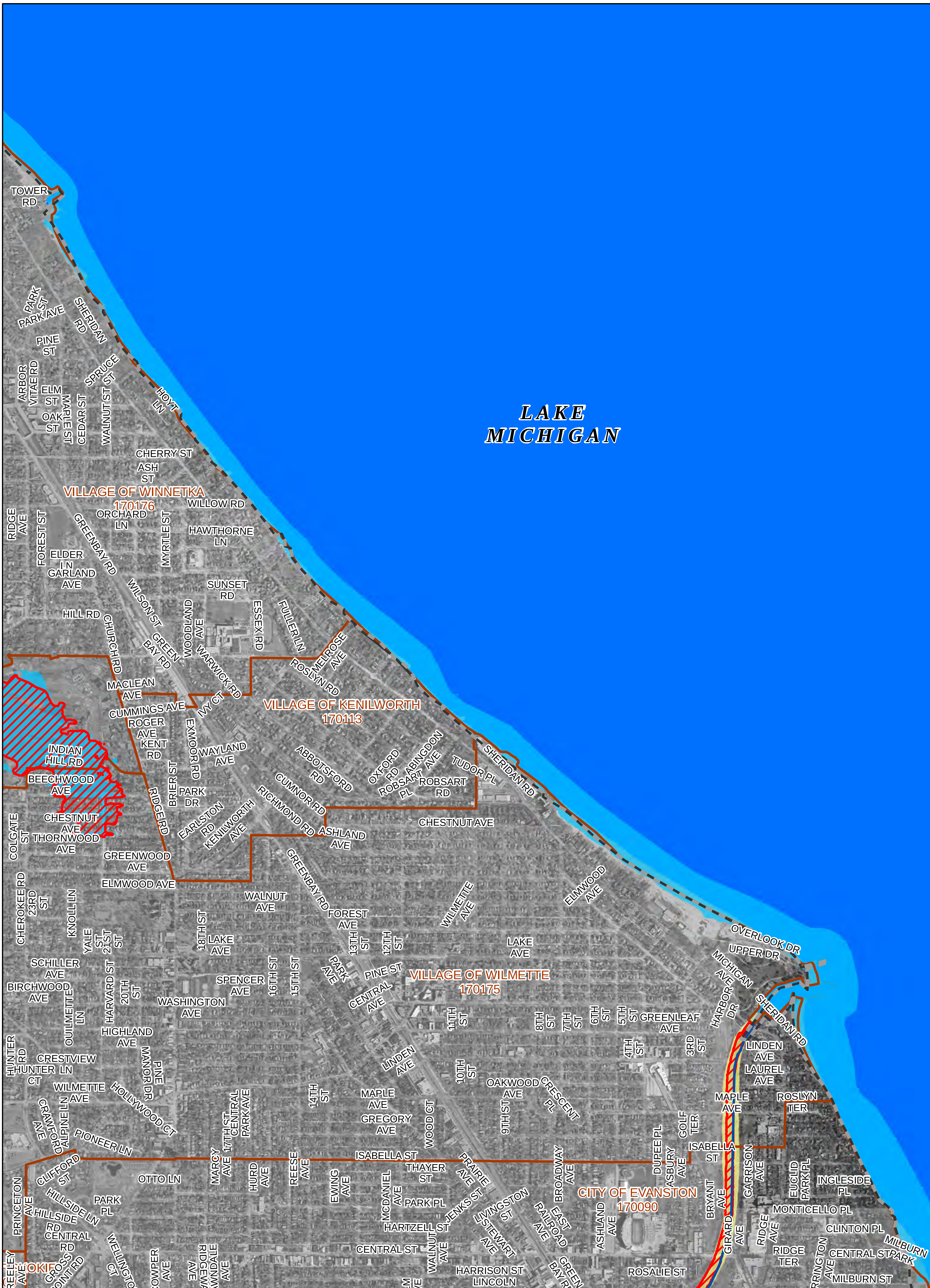
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

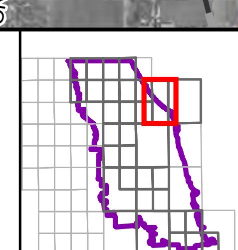
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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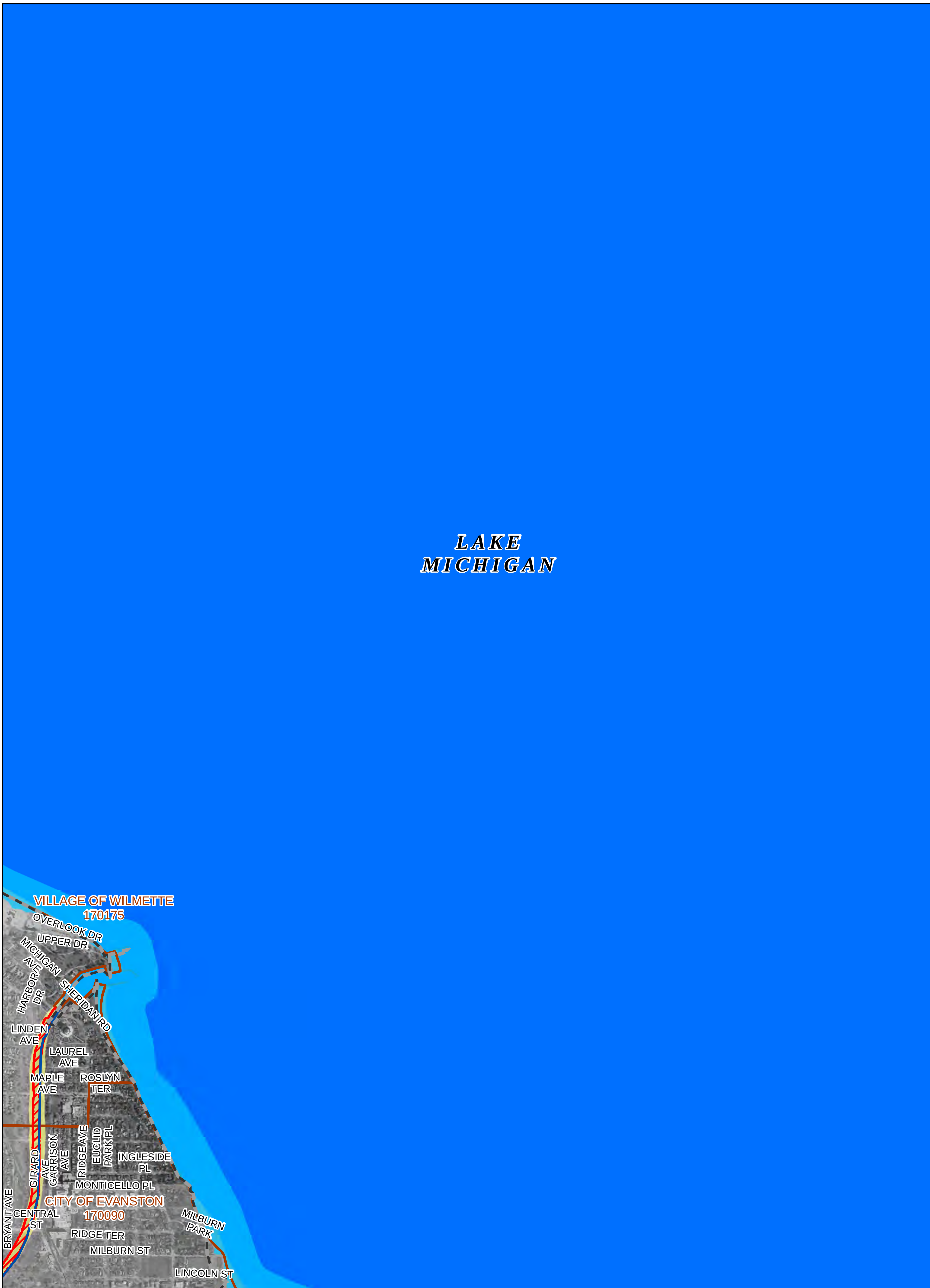
North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

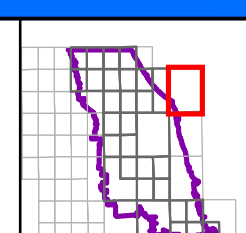
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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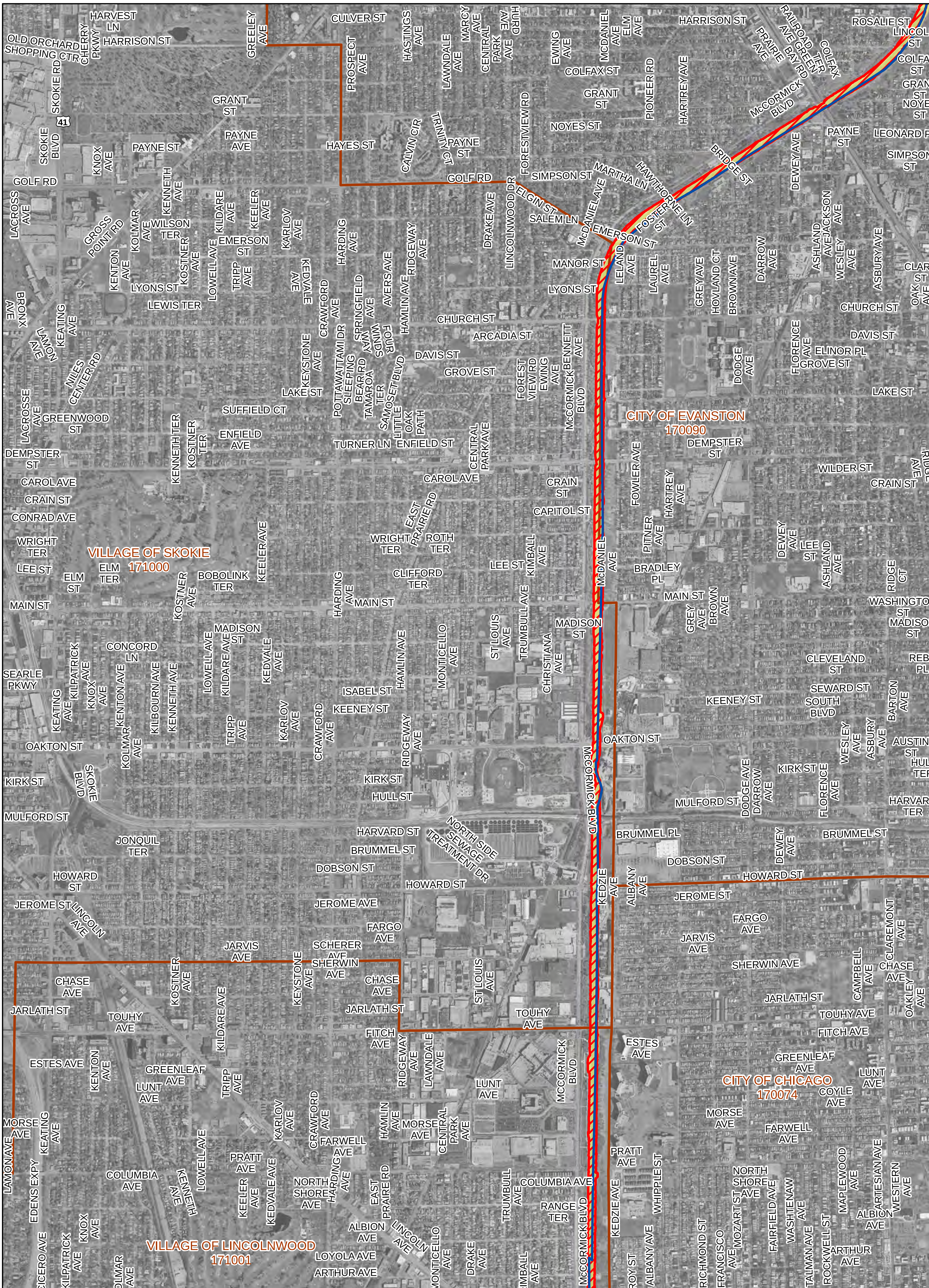
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

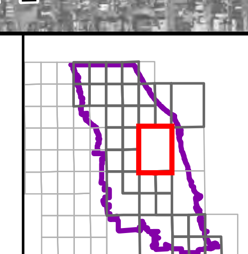
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



0 500 1,000 2,000

Feet

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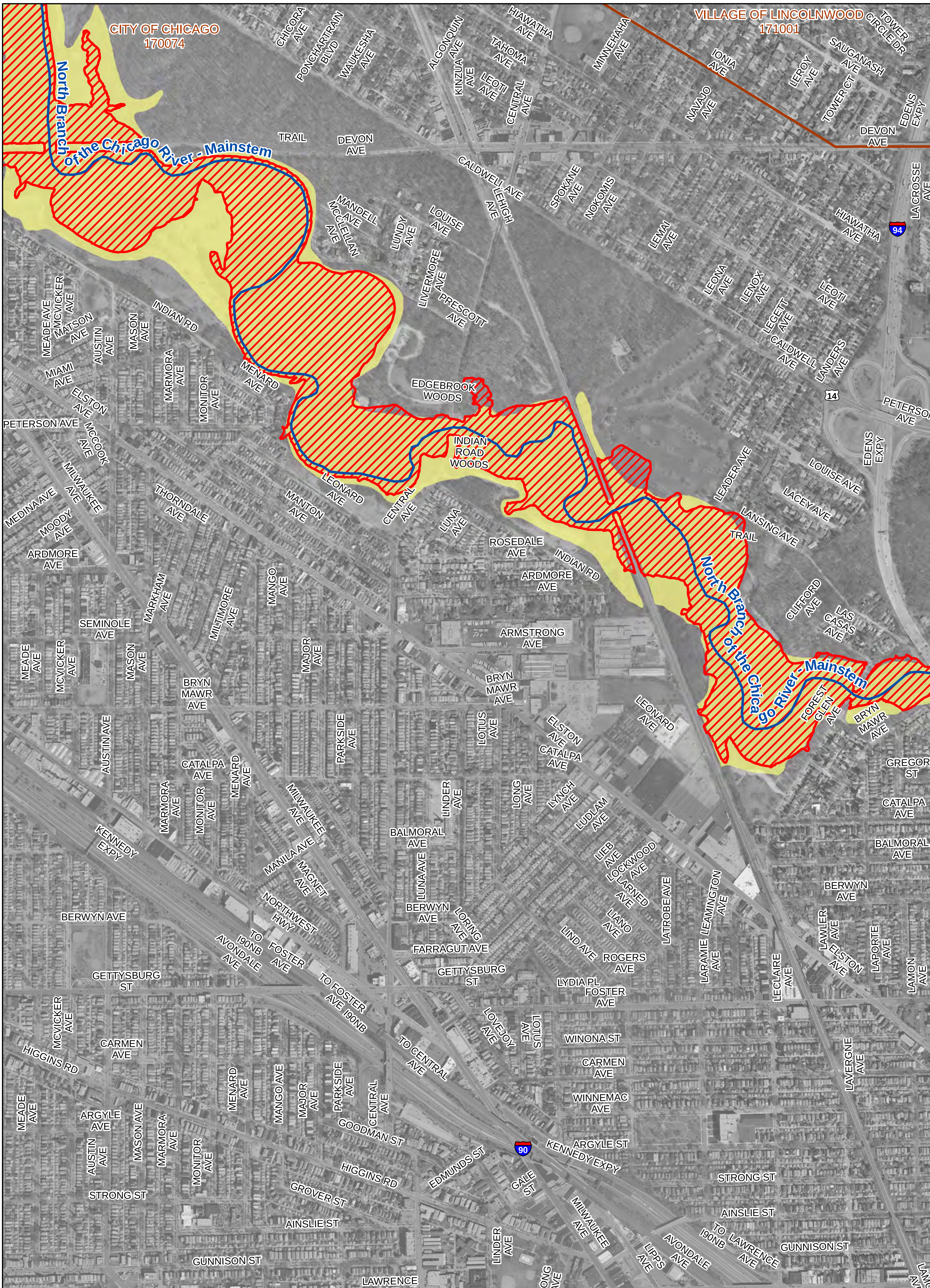
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary

0 500 1,000 2,000 Feet

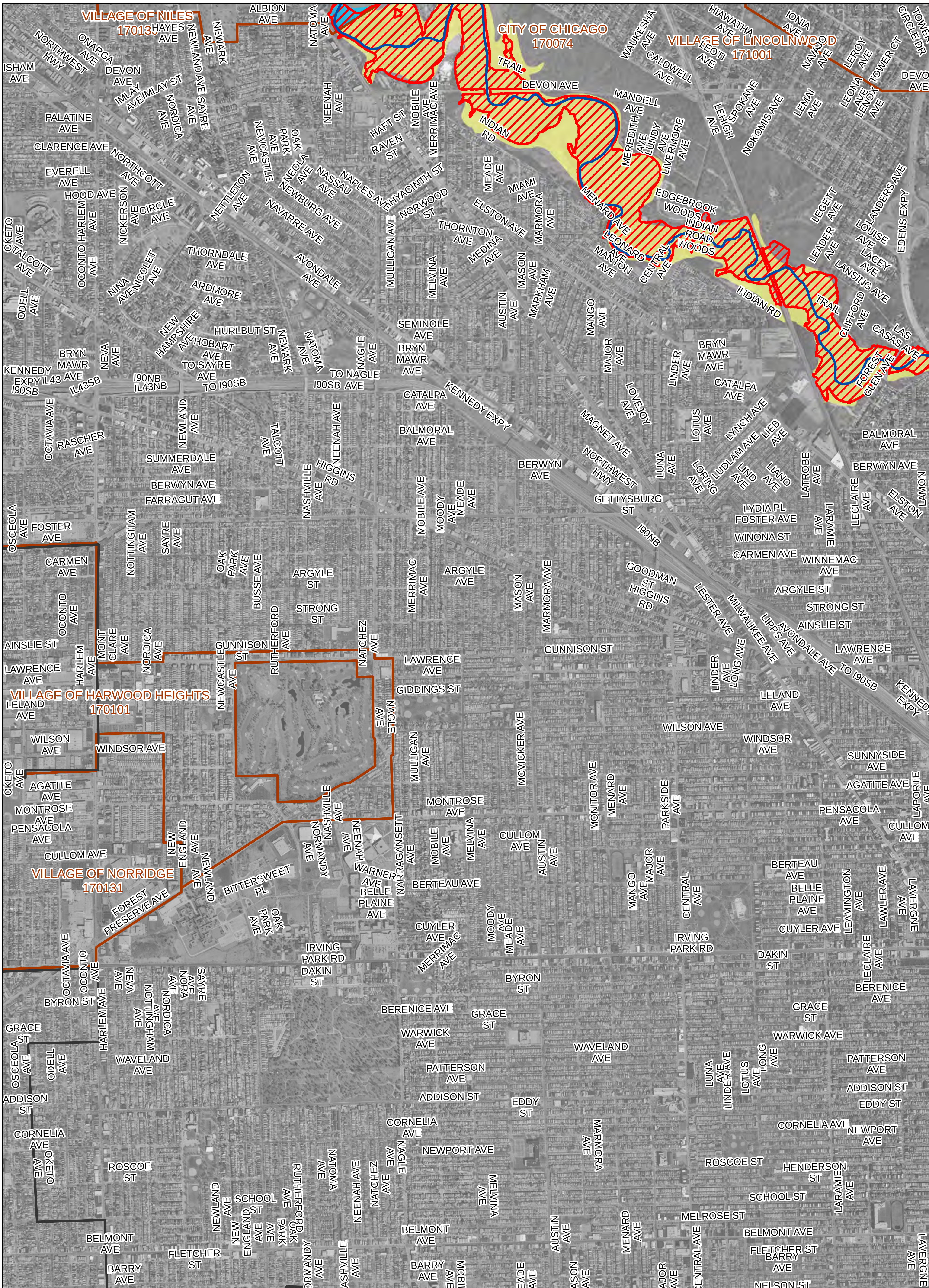
N

FIRM Panel: 17031C0382J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR

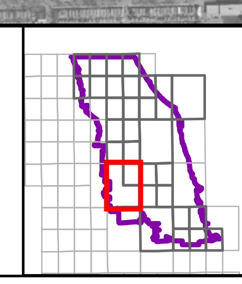


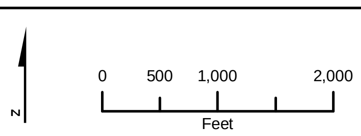
LEGEND

- DWP 100-year Inundation Area

FEMA Floodplain

- ZONE A, AH, and AO
- ZONE AE
- North Branch Chicago River Watershed
- River/Stream
- Municipal Boundary
- Cook County Boundary





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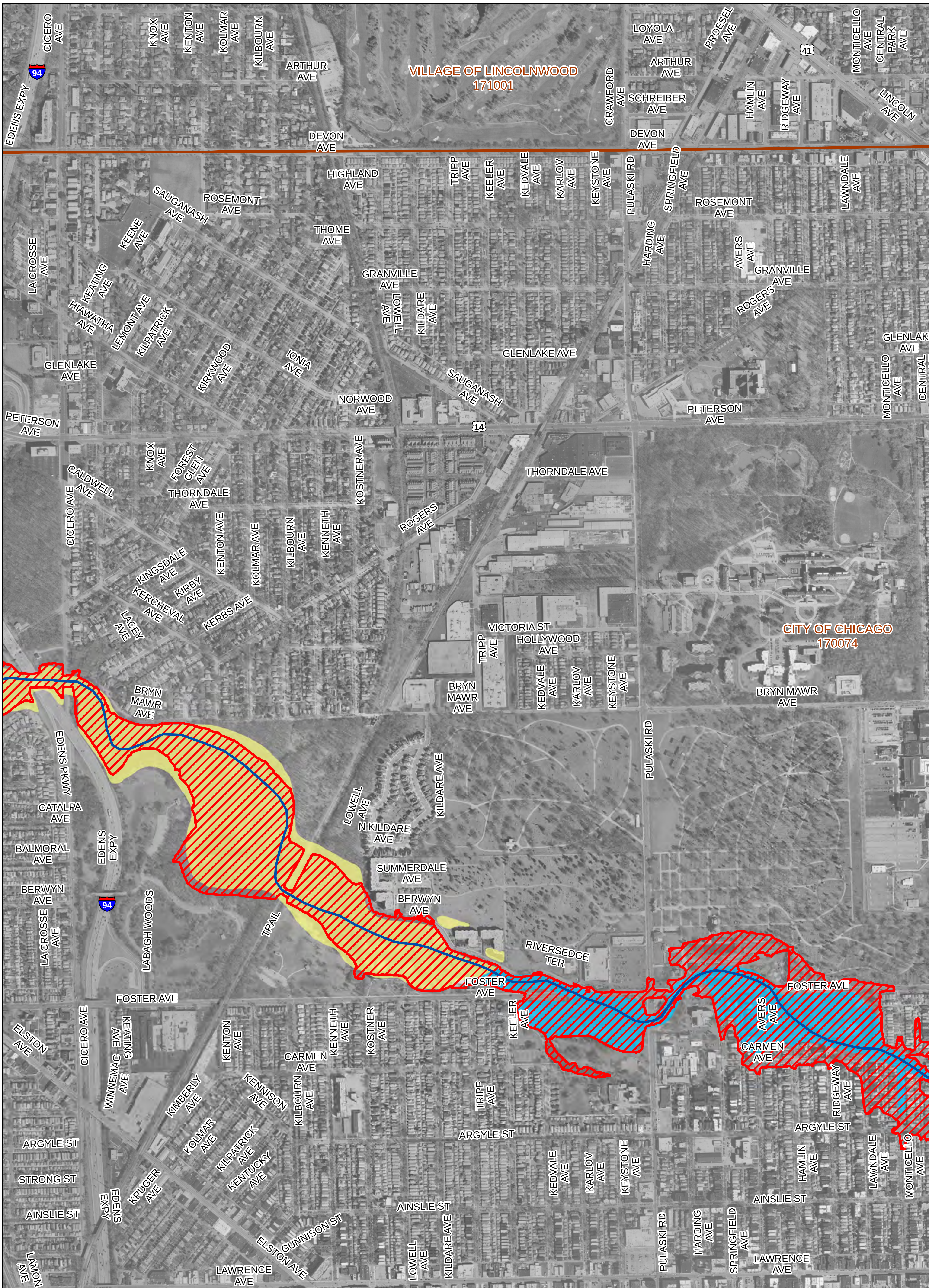
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan



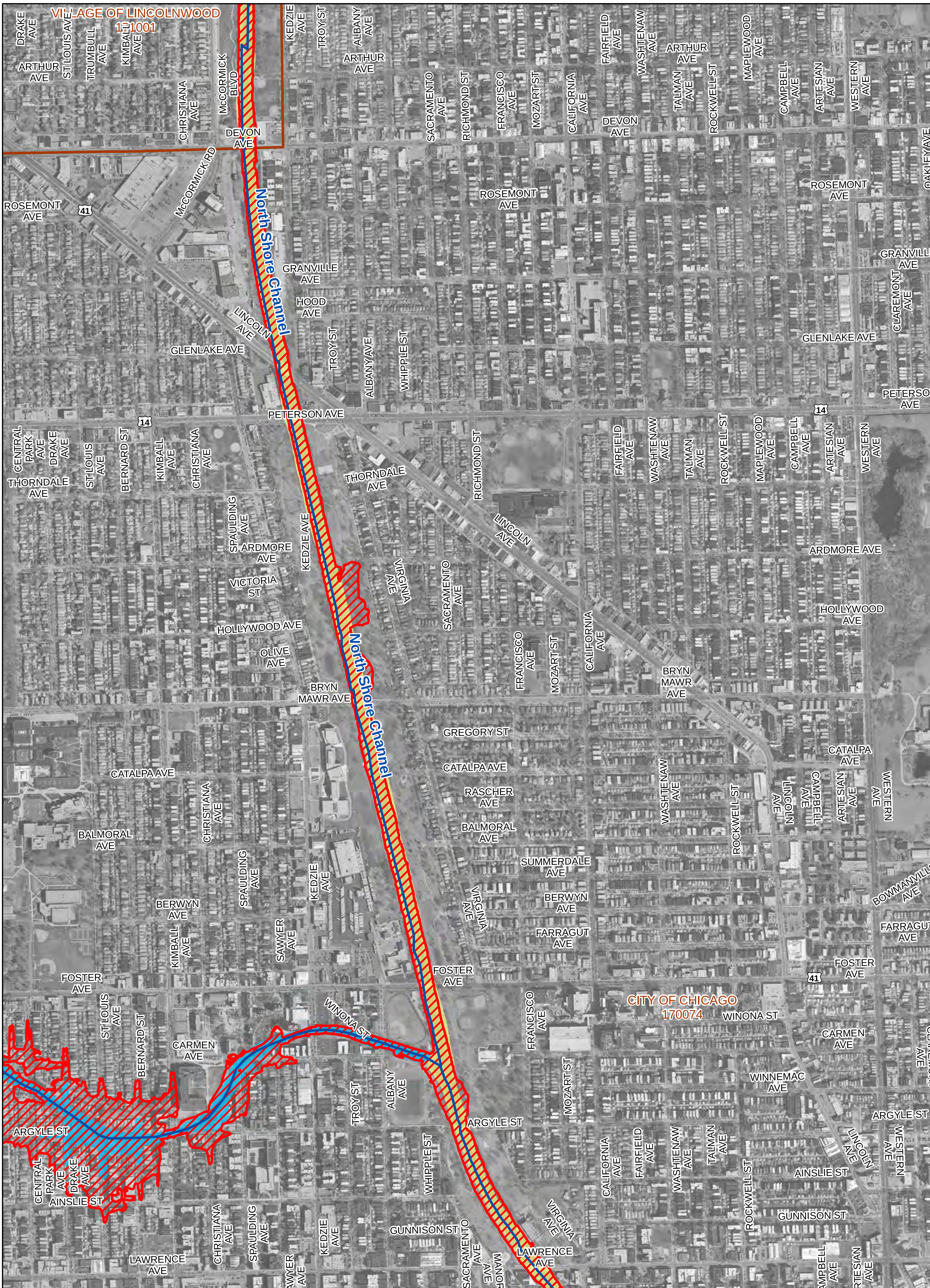
LEGEND

- DWP 100-year Inundation Area
- **FEMA Floodplain**
- ZONE A, AH, and AO
- ZONE AE
- North Branch Chicago River Watershed
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 500 1,000 2,000
Feet

FIRM Panel: 17031C0401J
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008
North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

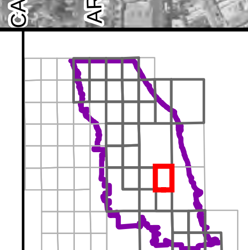
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



0 500 1,000 2,000

Feet

FIRM Panel: 17031C0402J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

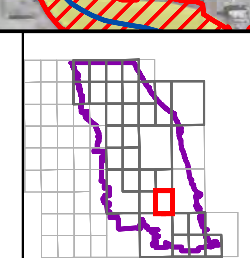
HDR

LEGEND

- DWP 100-year Inundation Area

FEMA Floodplain

- ZONE A, AH, and AO
- ZONE AE
- North Branch Chicago River Watershed
- River/Stream
- Municipal Boundary
- Cook County Boundary



N

0 500 1,000 2,000

Feet

FIRM Panel: 17031C0404J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

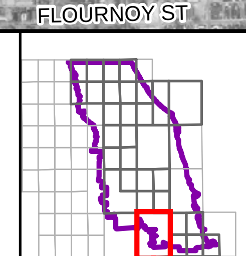
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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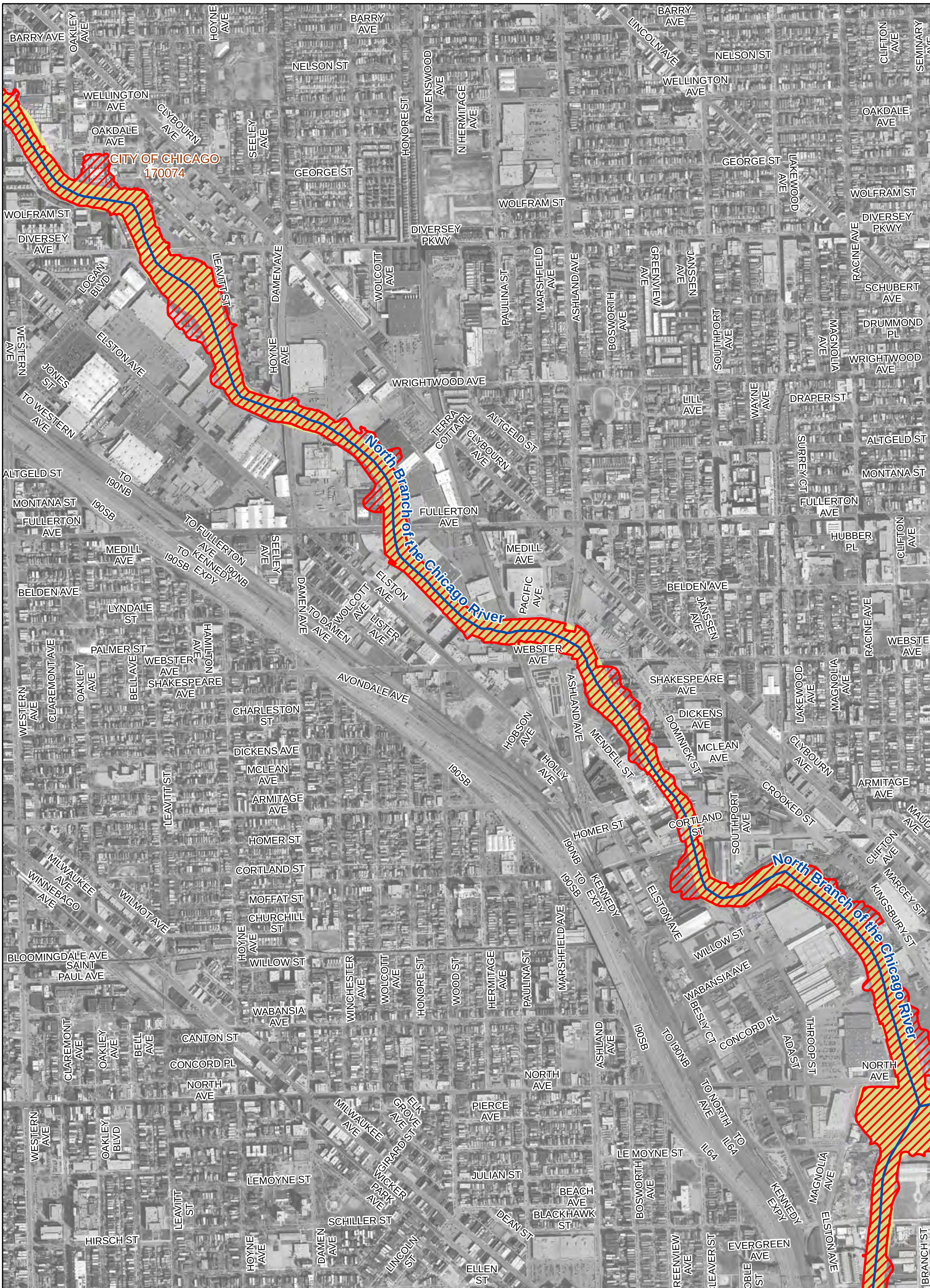
FIRM Panel: 17031C0415J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

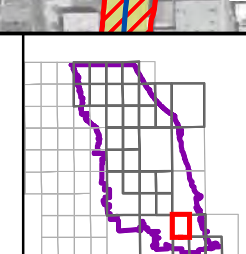
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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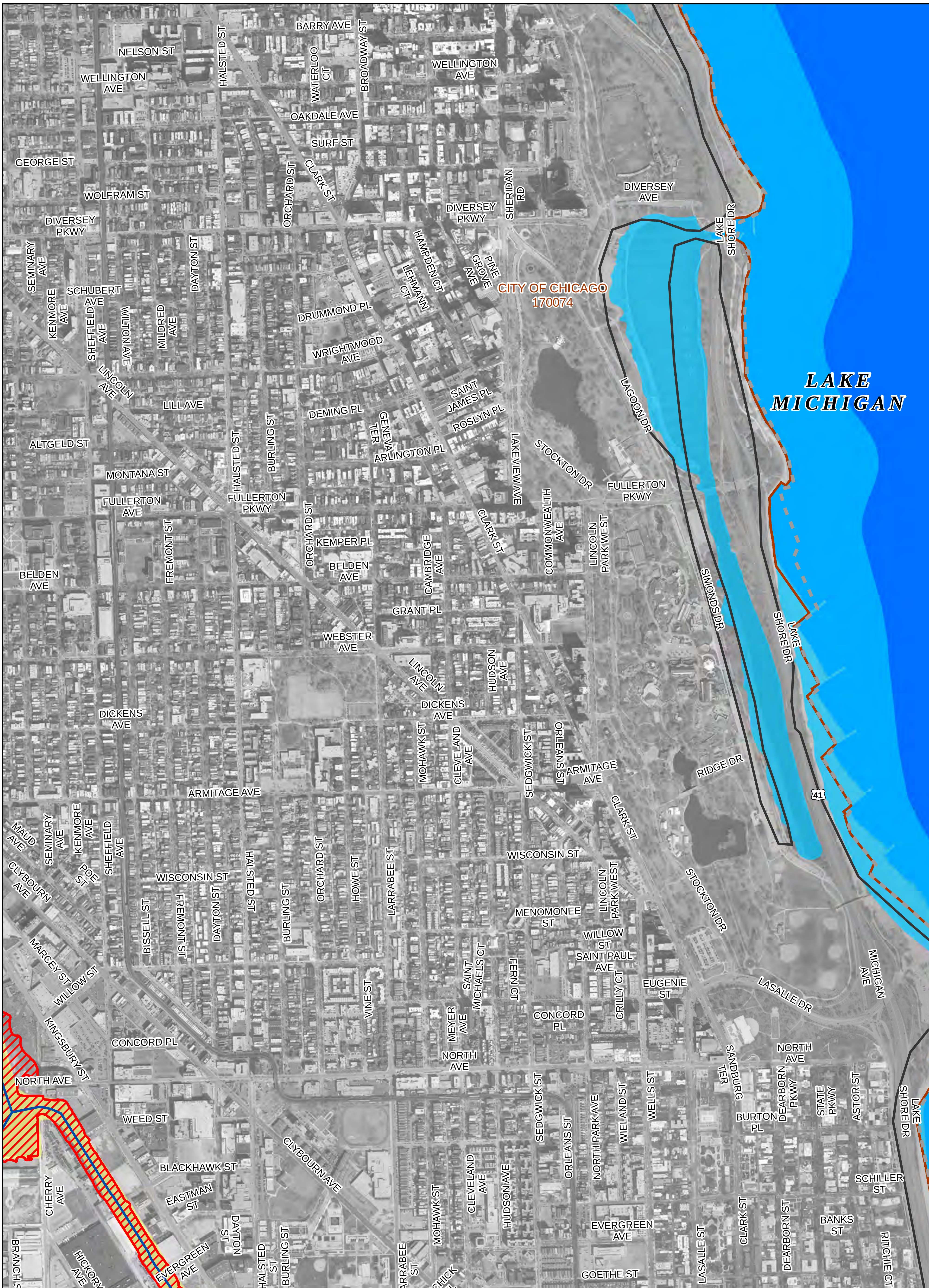
Feet

FIRM Panel: 17031C0416J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

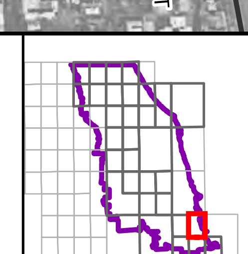
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



N

0 500 1,000 2,000

Feet

FIRM Panel: 17031C0417J

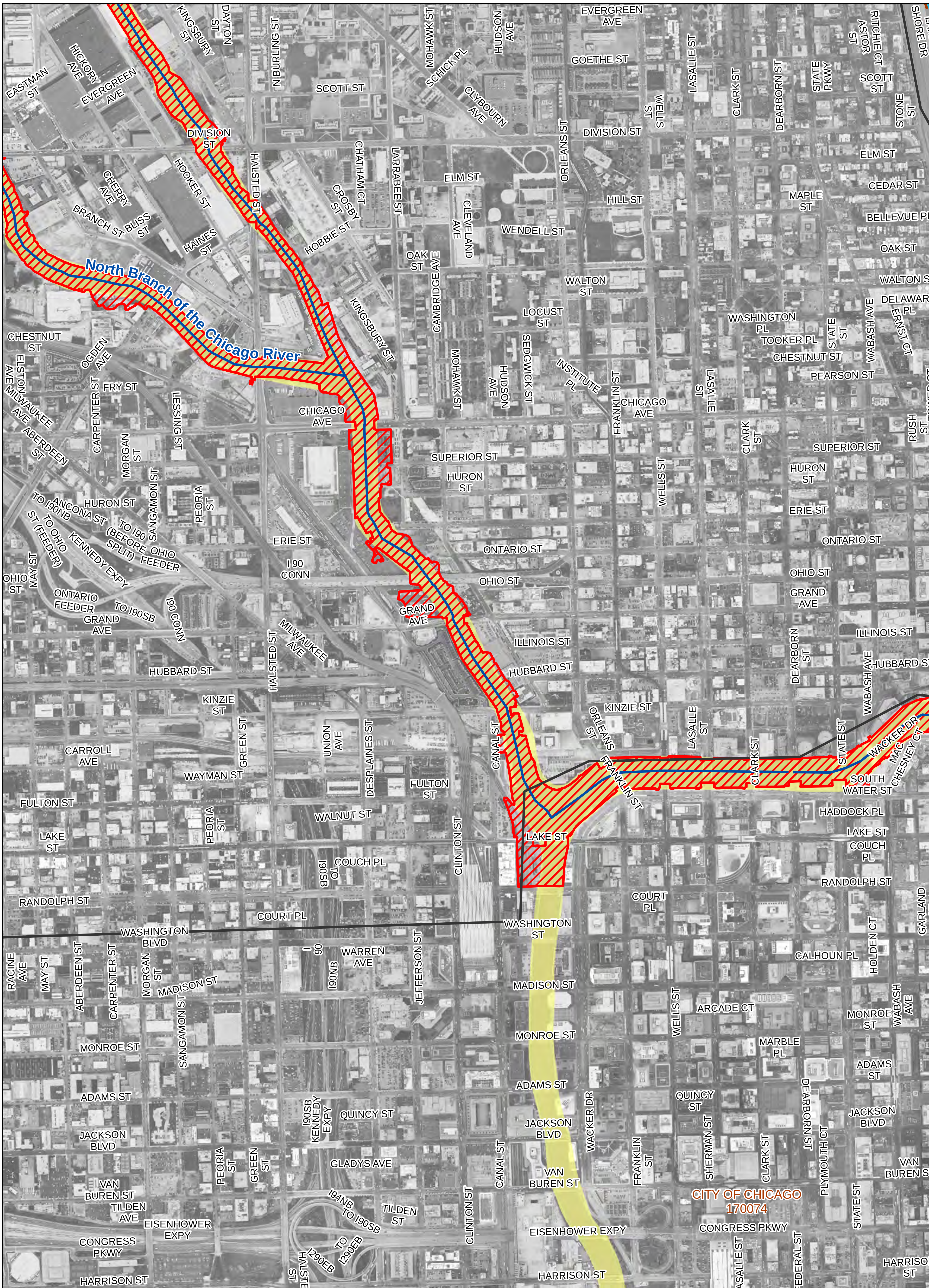
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR

FIRM Panel: 17031C0418J
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008
North Branch Chicago River Detailed Watershed Plan

HDR



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

ZONE A, AH, and AO

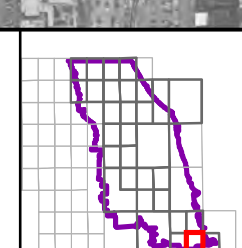
ZONE AE

North Branch Chicago River Watershed

River/Stream

Municipal Boundary

Cook County Boundary



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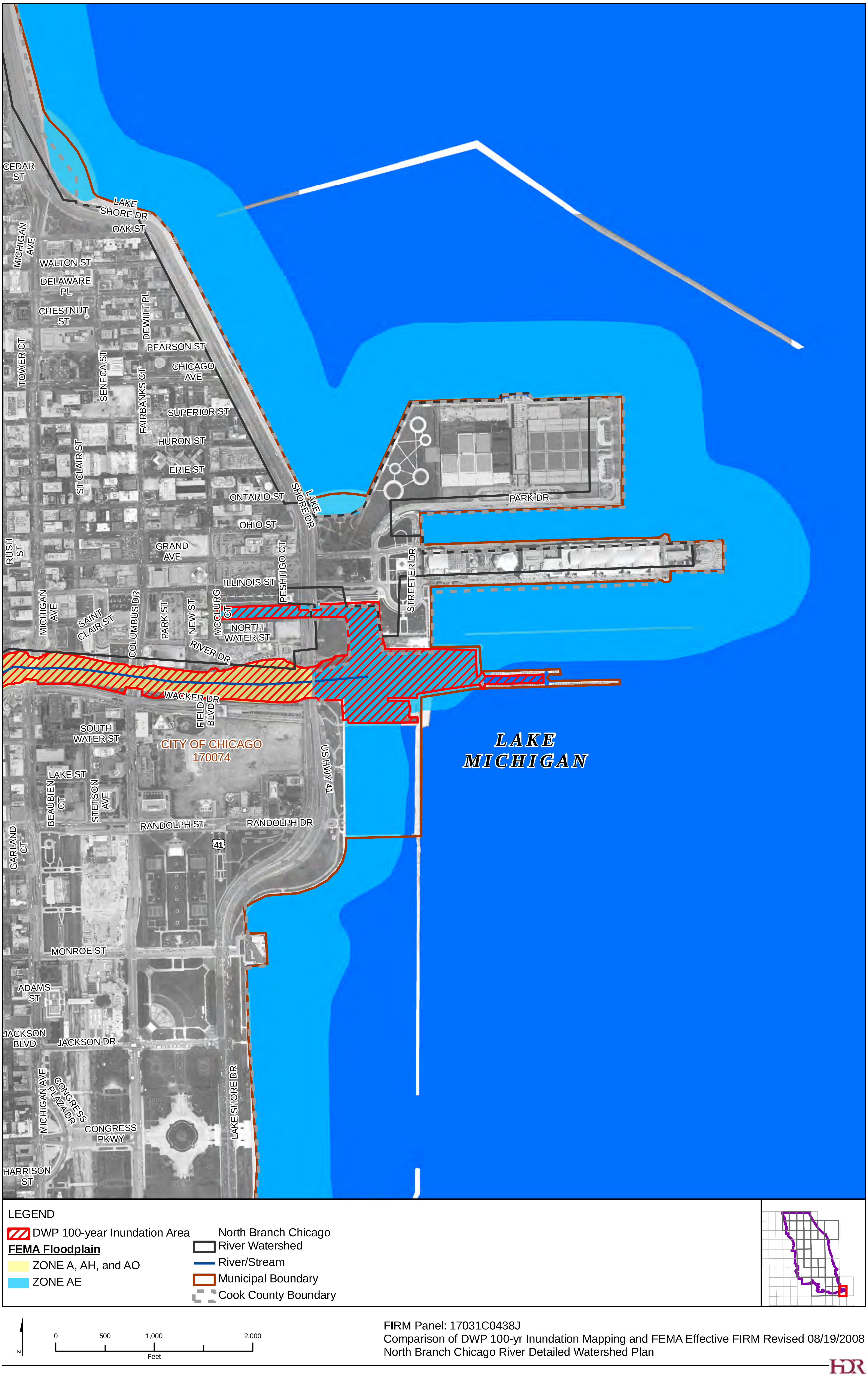
Feet

FIRM Panel: 17031C0419J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008

North Branch Chicago River Detailed Watershed Plan

HDR



FIRM Panel: 17031C0438J
Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 08/19/2008
North Branch Chicago River Detailed Watershed Plan

CHAPTER 6
WATERSHED PLANNING

Acronyms used in Chapter 6:

AA_B	Average Annual Benefits
AA_C	Average Annual Costs
AA_D	Average Annual Damages
ABM	Articulated Block Mat
BC	Benefit-to-Cost
CCSMP	Cook County Stormwater Management Plan
CDSA	Critical Duration Storm Analysis
CIP	Capital Improvement Program
CMAP	Chicago Metropolitan Agency for Planning
CUDD	Calumet Union Drainage District
DTM	Digital Terrain Model
DWP	Detailed Watershed Plan
FDA	Flood Damage Assessment
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GIS	Geographic Information Systems
HEC	Hydrologic Engineering Center
H&H	Hydrologic and Hydraulic
HSPF	Hydrologic Simulation Program-Fortran
IDNR-OWR	Illinois Department of Natural Resources - Office of Water Resources
IDNR-SWS	Illinois Department of Natural Resources – State Water Survey
IDOT	Illinois Department of Transportation
IEMA	Illinois Emergency Management Agency
IEPA	Illinois Environmental Protection Agency
LCSMC	Lake County Stormwater Management Commission
NB	Net Benefits
NCDC	National Climactic Data Center
NRCS	Natural Resource Conservation Service
NWI	National Wetland Inventory
O&M	Operation and Maintenance
PV	Present Value
PV_B	Present Value of Benefits
PV_C	Present Value of Costs
RAS	River Analysis System
SCS	Soil Conservation Service
UAA	User Attainability Analysis
UDV	Unit Day Value
UNET	Unsteady NETwork Model
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WPC	Watershed Planning Council

CHAPTER 6

WATERSHED PLANNING

6.1 Introduction

A standardized approach to watershed planning is required throughout Cook County to coordinate the District's efforts to implement its Cook County Stormwater Management Plan (CCSMP). Detailed Watershed Plans (DWPs) will be developed for all major watersheds and will serve as standardized documents to help guide the District as it develops a Capital Improvement Program (CIP). Previous planning efforts have been conducted by various organizations, and will be used in the development of DWPs where applicable. This chapter provides guidance for merging findings from previous flood remediation efforts in Cook County with new data and evaluations done to develop effective and consistent DWPs.

6.2 Status of Watershed Planning in Cook County

Local, state, and federal agencies have conducted comprehensive stormwater planning (Table 6.1) efforts as a part of their watershed planning programs for the following watersheds within Cook County: the North Branch of the Chicago River, Lower Des Plaines Tributaries, Calumet-Sag Channel, Little Calumet River, Poplar Creek and Upper Salt Creek. Where possible, previous planning information should be included and built upon in developing DWPs to take advantage of earlier efforts.

6.3 Planning Methodology

6.3.1 Organization of Detailed Watershed Plans

DWPs will serve as the supporting documentation to the District's Stormwater Management CIP. The watershed planning methodologies and standards described herein will be used to develop a DWP for each major watershed in Cook County. The objective is to supply the District with information on existing conditions, stormwater problems, alternative improvements considered to address stormwater problems, and other relevant information necessary to prioritize projects on a countywide level. Table 6.2 is a standard outline of the content to be provided within DWPs.

6.3.2 Data Collection and Review

The initial step in DWP development is the collection and review of existing data. Data that will be collected and reviewed include stormwater problem data, existing watershed studies and models, monitoring data, geographic information systems (GIS) data and other sources of useful watershed mapping.

6.3.3 Use of Existing Data for Detailed Watershed Studies

The DWP report will include a summary of existing watershed data and information. As a part of DWP development, the District will collect and review watershed data from member communities, Watershed Planning Councils (WPCs), applicable state and federal agencies, available complaint records, and other relevant watershed stakeholders. Relevant stormwater data will be compiled within the DWP report. The following subsections provide means of summarizing data regarding stormwater problems (detailed in Section 6.3.3.1) and available studies that have compiled some of the existing stormwater data (detailed in Section 6.3.3.2).

Table 6.1 Summary of Watershed Planning In Cook County

Agency	Description of Watershed Planning
Illinois Department of Natural Resources, Office of Water Resources (IDNR-OWR)	At the request of local governments, IDNR-OWR performs flood control studies to identify flooding problems, analyze alternative solutions, and determine the economic feasibility of those solutions. Plans developed by IDNR-OWR focus on structural flood control measures, but nonstructural flood mitigation alternatives are also examined. IDNR-OWR administers other funding assistance. It has a small-projects program that is often used to address local drainage problems and can fund flood related improvements up to $100,000. A less rigorous quantification of benefits is allowed under this program. Its flood mitigation program administers funds for the acquisition of flood-prone structures and flood mitigation planning. IDNR-OWR is involved in assisting FEMA with the map modernization for Cook County, as explained further in Section 2.5.1.
Illinois Environmental Protection Agency (IEPA)	IEPA collects water quality and biological data on streams and lakes throughout the state. The data are reported in the biannual *Illinois Water Quality Report,* which documents the level to which water bodies are supporting their designated uses (such as swimming, aquatic life). IEPA also maintains the Illinois Water Quality Management Plan, which offers recommendations for stormwater, soil erosion and sediment control, and stream and wetland best management practices (BMPs). IEPA also provides grants annually for implementation of nonpoint source control plans and demonstration projects. These projects can include BMPs to curtail urban runoff and also instream activities to reduce erosion, sedimentation, and degradation of water quality, as detailed in Section 319 of the Clean Water Act. On the preventive side, activities such as ordinance implementation and workshops on stormwater BMPs have been funded by IEPA. The IEPA Illinois Clean Lakes Program provides annual grants for lake remediation projects where there is a realistic opportunity for restoration and protection for high quality lakes. IEPA encourages a watershed approach in addressing lake remediation and protection.
Federal Emergency Management Agency (FEMA)	FEMA has several flood hazard mitigation funding programs, administered by the Illinois Emergency Management Agency (IEMA) and described in Section 2.5.8. Some FEMA regulatory floodplain maps for Cook County are inadequate. They do not include water surface elevations or they are out of date because of significant land use and other topographic changes. FEMA has initiated a Flood Insurance Rate Map (FIRM) Modernization Program, which compiles hydrologic and hydraulic (H&H) modeling data for selected map panels in Cook County. IDNR-OWR serves as a local sponsor for this project. The data will be included in a countywide modernization of floodplain maps.
Chicago Metropolitan Agency for Planning (CMAP)	CMAP has historically performed watershed planning, including the Area Wide Water Quality Management Plan developed for all the major watersheds in northeastern Illinois under Section 208 of the Clean Water Act. CMAP assists local governments in developing watershed planning. CMAP has produced a watershed inventory (http://www.nipc.org/environment/sustainable/water/watershed/) that includes a list of watershed plans from various sources and active watershed groups.
IDNR, State Water Survey (IDNR-SWS)	IDNR-SWS runs research centers that gather and maintain scientific data resources used in watershed planning. IDNR-SWS is also involved in planning activities for FEMA map modernization.
U.S. Army Corps of Engineers (USACE)	USACE administers a program for cost-sharing funding for the study, design, and construction of flood control projects. These projects generally are limited to structural flood control measures. If a reconnaissance level study shows that a project is likely to be cost-effective, USACE proceeds with a project analysis, which must be funded locally by 50% matching funds. For approved projects, USACE funds up to

Table 6.1 Summary of Watershed Planning In Cook County

Agency	Description of Watershed Planning
	65% of design and construction costs; the remaining costs are funded by a local or nonfederal sponsor. Sponsors must furnish all required lands, easements, rights-of-way and utility relocations, and also operate and maintain the completed project in perpetuity. Cost-sharing agreements must be negotiated individually with USACE on a project-by-project basis. USACE also provides design services for floodproofing of residences as part of an overall flood control project. This work and most USACE studies are performed with in-house staff.
U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS)	NRCS has planned, designed, and constructed flood control facilities to address overbank flooding in the Chicago metropolitan region with local sponsors, including the District. It also has performed floodplain management studies and updated floodplain mapping for local governments. In an effort partially funded by Section 319 of the Clean Water Act under the IEPA's direction, NRCS developed the *Illinois Urban Manual,* a technical reference for developers, planners, engineers, government officials and others involved in land use planning, building site development, and natural resource conservation. Applicable in rural, urban, and developing areas, the manual includes BMPs for soil erosion and sediment control, stormwater management, and special area protection. The manual was updated in 2002.
The District	The District designed and constructed the Tunnel And Reservoir Plan to address combined sewer overflow in the combined sewer areas of Cook County. The District has also been involved in many federal and state flood control projects, serving as the local sponsor or providing other forms of cost-sharing.
Municipalities and Townships	Most stormwater planning within a municipality is performed by the municipality itself or completed under its direction. Planning assistance on larger waterways may be initiated by state and federal agencies. Capital improvement projects that address local drainage problems are typically implemented by municipalities. Many communities within Cook County have ongoing stormwater planning efforts that could contribute to the development of DWPs.
Soil and Water Conservation Districts (SWCD)	Cook County has two Soil and Water Conservation Districts (SWCDs); the North Cook County Soil and Water Conservation District and the Will-South Cook Soil and Water Conservation District. The purpose of the SWCDs is to provide information, education and guidance on the conservation and wise use of natural resources.
Lake County Stormwater Management Commission (LCSMC)	SMC conducted a watershed assessment in conjunction with the Friends of the Chicago River. The watershed assessment pertains to the North Branch of the Chicago River within Cook County.
U.S. Geological Survey (USGS)	Through a cooperative program, in which the District participates, the USGS (Illinois Water Science Center) maintains a stream gauging network and publishes an annual report containing daily streamflow data and water quality information for selected sites around the state. The USGS administers funding for site-specific hydrologic and water quality data collection and analysis. Additionally, the USGS provides streamflow, stream elevations, and precipitation data in real-time at http://il.water.usgs.gov/nwis-w/IL/. Some mapping efforts may be fundable through the USGS. USGS funds up to 50% of a project's in-house labor and expenses. On this reimbursable basis, USGS provides technical assistance in developing watershed models and other hydrologic and water quality related assistance. In the past, the USGS has researched and completed studies on emerging technologies in the water resources field.
U.S. Environmental Protection Agency (USEPA)	USEPA provides grants for water quality related planning and demonstration projects under Section 319(h) and 104(b)(3) of the Clean Water Act, as discussed under IEPA's roles and resources in Section 2.5.7. USEPA routinely holds national conferences on stormwater-related topics.

Table 6.2 DWP Standard Outline

1. Executive Summary
2. Introduction
    - 2.1 Scope and Approach
    - 2.2 Goals and Objectives
    - 2.3 Jurisdictional Responsibilities
    - 2.4 Organization of Detailed Watershed Study
    - 2.5 Summary of Problem Areas
    - 2.6 Coordination with Watershed Planning Councils
3. Watershed Characteristics
    - 3.1 General Watershed Description
    - 3.2 Sources of Data
        - 3.2.1 Previous Studies
        - 3.2.2 Floodplain Mapping
        - 3.2.3 Wetland and Riparian Areas Data
            - 3.2.3.1 Wetland Areas
            - 3.2.3.2 Riparian Areas
        - 3.2.4 Water Quality Data
            - 3.2.4.1 Monitoring Data
            - 3.2.4.2 National Pollutant Discharge Elimination System (NPDES) Permits
            - 3.2.4.3 Impaired Waterways
            - 3.2.4.4 Nonpoint-Source Pollution
            - 3.2.4.5 Total Maximum Daily Load (TMDLs)
        - 3.2.5 Stormwater Problem Data
            - 3.2.5.1 Problem Data
            - 3.2.5.2 Watershed Planning Council Coordination
        - 3.2.6 Watershed Analysis Data
            - 3.2.6.1 Monitoring Data
            - 3.2.6.2 Sub-watershed Delineation
            - 3.2.6.3 Drainage Network
            - 3.2.6.4 Topography and Benchmarks
            - 3.2.6.5 Soil Classifications
            - 3.2.6.6 Land use
            - 3.2.6.7 Anticipated Development
        - 3.2.7 Model Selection
4. Watershed Analysis
    - 4.1 Hydrologic Model Development
        - 4.1.1 Sub-area Delineation
        - 4.1.2 Hydrologic Parameter Measurements and Calibration
        - 4.1.3 Model Setup and Unit Numbering
    - 4.2 Hydraulic Model Development
        - 4.2.1 Field Data, Investigation and Existing Modeling Data
        - 4.2.2 Physical Modeling Assumptions and Computational Settings
        - 4.2.3 Model Setup and Unit Numbering
    - 4.3 Calibration and Verification
        - 4.3.1 Gauge Data
        - 4.3.2 Modifications to Model Input Data
        - 4.3.3 Calibration Results
    - 4.4 Existing Conditions Evaluation
        - 4.4.1 Floodplain Delineation
        - 4.4.2 Hydraulic Profiles

Table 6.2 DWP Standard Outline

	4.5 Future Conditions Evaluation
5.	Development and Evaluation of Alternatives
	5.1 Problem Definition and Damage Assessment
	5.1.1 Flood Damage Curves
	5.1.2 Erosion Damage Curves
	5.2 Technology Screening
	5.3 Alternative Development
	5.3.1 Flood Control Alternatives
	5.3.2 Erosion Control Alternatives
	5.3.3 Water Quality Improvement Alternatives
	5.3.4 Natural Resources and Environment Improvement Alternatives
	5.3.5 Alternative Cost Development Data
	5.4 Alternative Evaluation and Selection
	5.4.1 Data Required for Countywide Prioritization of Watershed Projects
6.	Action Plan
	6.1 Recommended Improvements
	6.2 Implementation Plan
7.	Summary and Conclusions

6.3.3.1 Stormwater Problem Data

DWPs will include a comprehensive summary of stormwater problem data within a standardized table. Table 6.3 summarizes the typical fields required within the DWP watershed problem summary table. The watershed problem summary table will include relevant stormwater problem data compiled as part of DWP development, and recommendations on the use of stormwater problem data. Table 6.4 provides descriptions of standard problem categories to be used as a part of the watershed problem summary table. Additional problem categories may arise and will be considered by the District as necessary during the watershed planning process, however problem categories will generally be consistent with those listed in Table 6.4.

Table 6.3 Structure of Watershed Problem Summary Table for DWPs

Table Field	Description
Problem Category	*Refer to Table 6.4 for list of categories.*
Source of Information	Sources of problem information such as member communities, published reports, state and federal agencies, watershed stakeholders, complaints.
Date	Date upon which data were compiled or published.
Project Planned or Underway	In some cases, efforts are planned or underway to address the problem. Identify this in the table as a consideration on the path forward.
Resolution or Action Required	Describe how the data will be acted upon. Describe resolution or planned resolution of problem.

Table 6.4 Problem Category Description

Problem Category	Description
Intercommunity (regional) flooding	Flooding problems that affect more than one community.
Intracommunity (local) flooding	Flooding problems within a community that affect only part of a single community.
Streambank erosion on intercommunity waterways	Streambank erosion along regional waterways that threatens a structure or human health and safety.
Streambank erosion on intracommunity (local) waterways	Streambank erosion along local waterways that threatens a structure or human health and safety.
Stream maintenance problems	Debris jams, system failure, restrictions on waterways, etc.
Water quality problems	Observed water quality problems such as odor, spill-related pollution, aesthetically objectionable debris (such as toilet waste), etc.
Environmental degradation issues	Wetland or riparian impacts observed by watershed stakeholders.

6.3.3.2 Existing Watershed Studies

Several local, state, and federal agencies have completed watershed studies and modeling for watersheds within Cook County. Studies and the models used to support them may contain data useful to the development of DWPs. Table 6.5 summarizes some known watershed studies developed by agencies such as IDNR-OWR, USACE, IEPA, or the Illinois Department of Transportation (IDOT). These studies and others will be reviewed as a part of DWP development.

Watershed modeling has been performed for many of the studies listed in Table 6.5. The models may be useful for the development of DWPs or other watershed planning activities to be coordinated by watershed stakeholder groups. Table 6.6 summarizes some of the existing models that were identified for watersheds within Cook County.

IDNR-OWR and IDNR-SWS personnel have identified several other models that have been developed for Cook County watersheds. Many of the models include data that are not fully documented to allow for a complete evaluation of their applicability to DWP development. As a part of developing each DWP, the District will review and discuss the usefulness of existing watershed models for supporting the definition of problem areas, the development and evaluation of improvement projects and possible floodplain mapping revisions. Table 6.7 lists key criteria to be considered in defining the scope of DWP modeling activities.

Table 6.5 Existing Watershed Studies Identified

Watershed	Subwatershed	Title of Study	Agencies	Date	Summary
Calumet-Sag	Stony Creek	Stony Creek, Oak Lawn, Illinois Detailed Project Report	USACE	October 2001	Completed USACE's planning process for a project to reduce overbank flooding along Stony Creek in Oak Lawn. The recommended plan consists of flow diversion, removal of a small weir, and channel clearing downstream.
Calumet-Sag	(Report addresses tributaries)	Calumet-Sag Watershed Floodwater Management Plan Environmental Assessment	The District, NRCS, IDOT (Division of Water Resources)	June 1979	The study estimates floodwater damage in the watershed due to urbanization. It addresses erosion problems, lack of open space and recreational facilities, wetlands, and channel maintenance. Although somewhat dated, the report may be most useful in providing relevant background information.
Chicago River	Chicago River and Waterway System	Draft Use Attainability Analysis (UAA)	IEPA	November 2004	The UAA will help the IEPA understand the changing circumstances of the Chicago River and Waterway System in order to better set water quality standards for the system.
Des Plaines River	Upper Des Plaines River	Final Feasibility Report and Environmental Impact Statement	USACE	June 1999	Evaluated feasibility of, and federal interest in, implementation of a flood damage reduction plan for the Upper Des Plaines watershed located within Lake and Cook Counties. Recommended a plan consisting of the construction of two levee units, expansion of two reservoirs, construction of one lateral storage area, and modification of one earthen dam to add flood storage.
Des Plaines River	Salt Creek TMDLs	Total Maximum Daily Loads for Salt Creek, Illinois	IEPA	October 2004	Describes methods and procedures used to develop chloride and dissolved oxygen TMDLs for Salt Creek. The focus of the report is on water quality, but it contains rainfall, hydrologic, hydraulic, and stream flow information. Salt Creek and its watershed span both Cook and DuPage counties.
Des Plaines River	Farmers/Prairie Creek	Farmers/Prairie Creek Preliminary Strategic Planning Study	IDNR-OWR	October 2005	Studied alternatives for relieving flooding on Farmers/Prairie Creek, a tributary to the Des Plaines River with a watershed in areas of Des Plaines, Park Ridge, Niles, Glenview, and unincorporated Maine Township.
Des Plaines River	Addison Creek	Addison Creek Flood Control Study	IDOT (Division of Water Resources)	1993	Studied existing conditions and alternatives for relieving flooding on Addison Creek, a tributary of Lower Salt Creek. The affected area for the study includes Bellwood, Bensenville, Broadview, Elmhurst, Hillside, Maywood, Melrose Park, North Lake, North Riverside, Stone Park, and Westchester.

Table 6.5 Existing Watershed Studies Identified

Watershed	Subwatershed	Title of Study	Agencies	Date	Summary
Des Plaines River	(Report addresses tributaries)	Des Plaines River Watershed Floodwater Management Plan Environmental Assessment	The District, NRCS, IDOT (Division of Water Resources)	January 1976	The purpose of the study was to reduce flood damage, reduce erosion and sedimentation, protect wildlife habitat, improve water quality, enhance fisheries, provide additional recreation sites and open space. The study includes Lower Salt Creek, located primarily in DuPage County. Recommended flood control facilities, some of which have since been built, are described, as are anticipated impacts. The report contains useful background information.
Little Calumet River	(Report addresses tributaries)	Little Calumet River Watershed Floodwater Management Plan and Environmental Assessment	The District, NRCS, U.S. Forest Service, Illinois Department of Conservation	May 1975	The purpose of the study was to reduce flood damages, provide increased water based recreation, and provide watershed protection and environmental enhancement. Background information may be useful.
Little Calumet River	(Report addresses tributaries)	Little Calumet River Watershed Plan and Environmental Impact Statement	The District, Will-South Cook SWCD, Calumet-Union Drainage District (CUDD), Cook County Board of Commissioners, Villages, Park Districts, IDNR-OWR, NRCS, U.S. Forest Service	November 1978	This study was developed to achieve goals similar to those of the May 1975 study. Planned projects and their impacts are described. Some of the projects have been implemented. Discussion of project impacts is included. Background information is potentially useful.
Lower Des Plaines Tributaries	(Report addresses tributaries)	Lower Des Plaines Tributaries Final Watershed Plan – EIS	The District, SWCDs, NRCS, U.S. Forest Service, Municipalities	September 1987	The purpose of the study was to solve flooding and associated erosion and sedimentation problems, and to address the shortage of water-based recreation. Structural and nonstructural improvement measures are recommended, several of which have been built. Background information may be useful.
North Branch Chicago River	(Report addresses tributaries)	North Branch Chicago River Floodwater Management Plan	The District, NRCS, IDNR-OWR	October 1974	The purpose of the study was to reduce flood damages, provide increased recreational uses, and provide watershed protection and environmental enhancement. The southern limit of the study is Touhy Ave. Alternatives are suggested, including construction of flood control reservoirs that have now been built. The report may be most useful in providing relevant background information.

Table 6.5 Existing Watershed Studies Identified

Watershed	Subwatershed	Title of Study	Agencies	Date	Summary
North Branch Chicago River	(Report addresses tributaries)	North Branch Chicago River Open Space (Green Infrastructure) Plan	LCSMC, Friends of the Chicago River, IDNR-OWR	June 2005	Identifies high quality natural resources recommended for preservation, and open lands suitable for watershed improvement projects. Study is based on analysis of individual parcels. Includes listing of funding sources for land preservation and restoration.
Poplar Creek	(Report addresses tributaries)	Poplar Creek Watershed Floodwater Management Plan Environmental Assessment	The District, NRCS, IDOT (Division of Water Resources)	May 1976	The study estimates floodwater damage in the watershed due to urbanization. It addresses erosion problems, lack of open space and recreational facilities, wetlands, and channel maintenance. Some flood control measures are recommended. Although somewhat dated, the report may be most useful in providing relevant background information.
Upper Salt Creek	(Report addresses tributaries)	Upper Salt Creek Watershed Floodwater Management Plan	The District, North Cook SWCD, Forest Preserve District of Cook County, Villages, Park Districts, IDOT (Division of Water Resources)	May 1973	The purpose of the study was to reduce flood damages and create water related recreation facilities. Five flood control facilities, one multipurpose facility, and channel improvements were recommended and have been implemented. The report contains useful background information.

Table 6.6 Existing Modeling Data For Watersheds Within Cook County

Watershed	Subwatershed	Model Description
Chicago River	Chicago River and Chicago Waterway System	Unsteady flow and water quality model of entire 76-mile navigable waterway system, developed by Marquette University. More information is available at http://www.chicagoareawaterways.org/ Unsteady NETwork Model (UNET) and Hydrologic Simulation Program-Fortran (HSPF) model developed by the USACE.
Des Plaines River	Des Plaines River	Hydrologic Engineering Center-1 (HEC) and HEC-River Analysis System (RAS)
Des Plaines River	Farmers/Prairie Creek	HEC-1 and HEC-RAS
Chicago River	North Branch	HEC-1 and HEC-2
Chicago River	Middle Fork and West Fork	HEC-1 and HEC-2
Little Calumet River	Little Calumet River	HEC-1 and Unsteady-RAS; Illinois Department of Natural Resources-State Water Survey (IDNR-SWS) is updating
Little Calumet River	Stony Creek	HEC-1 and UNET

Table 6.7 Existing Model Use Criteria for DWPs

Category	Criteria for Use in DWPs
Date developed	Model must have been developed reflecting current conditions or have been updated to reflect current conditions unless otherwise accepted by the District to be used for DWPs.
Regulatory acceptance	Model must be the current regulatory model for watershed or otherwise accepted by the District to be used as a part of DWPs.
Data development requirements	Documentation of H&H model data are available and show that the data were developed to be consistent with District and IDNR-OWR minimum standards.
Calibration requirements	Must have been calibrated to a network of rainfall and stream monitoring gauges. Calibration must be documented and show that minimum District standards were met. Alternatively, radar derived precipitation could be used as approved by the District. Exceptions to the calibration requirement must be approved by the District.
Consistency with District modeling application requirements	Must have been developed using a modeling application that meets the District's minimum requirements, or is otherwise approved by the District.

Existing Monitoring Data. Rainfall, stream flow (and stage), and water quality data are available for all the major watersheds within Cook County. Some of the data may be used to support DWP modeling evaluations. Table 6.8 summarizes sources of existing monitoring data. In addition to the data listed, the District collects monitoring data that will be reviewed and utilized as appropriate as a part of DWP development.

Descriptions of USGS stream flowmeters and National Climactic Data Center (NCDC) rain gauge data are provided in Appendixes C and D, respectively.

Geographic Information Systems Data. Several sources of GIS data exist and are available to support watershed planning activities that will occur as a part of DWP development. One primary source of GIS data is Cook County. GIS data from Cook County will be obtained and used as appropriate as a part of DWP development. Section 6.4 identifies several Cook County GIS data sets to be used in DWP development.

Table 6.8 Sources of Existing Monitoring Data

Data	Owning Agency	Description
USGS Stream Flow Data	USGS	USGS stream flow data are available at http://waterdata.usgs.gov/nwis/sw. Appendix C contains a comprehensive list of gauge locations.
IDNR-OWR Stage Data	IDNR-OWR	The IDNR-OWR maintains a network of stage gauges that may have data useful for model calibration.
Rain Gauge Data	IDNR-SWS, NCDC, and USGS	The Cook County Precipitation Network is a dense rain gauge network that the IDNR-SWS has operated in Cook County since the fall of 1989 to provide accurate precipitation data for use in simulating runoff for Lake Michigan diversion accounting. The network consists of 25 rain gauges throughout Cook County, approximately every 5 to 7 miles and representative of the various watersheds within the county. The data are available in digital format at hourly increments from 1989 through 2000, and at 10-minute increments from 2001 to the present. There are 74 locations of rainfall gauges for which data are available within Cook County through the NCDC. Some gauges are no longer active, but past data are available. The time increments of the data vary from gauge to gauge. Table B-1 in Appendix D lists all gauges and information related to the type of data available. Information about obtaining data from all these gauges and associated fees can be found at the NCDC website: http://www.ncdc.noaa.gov. The USGS operates and publishes data from approximately 42 rain gauges in northeastern Illinois, of which 6 are located in Cook County. This data, almost all available in real-time, together with data from other agency rain gauges can be found at http://il.waterdata.usgs.gov/nwis/current/?type=precip&group-key=NONE.
Water Quality Monitoring Data	IEPA	Available from the IEPA Ambient Water Quality Monitoring Network of 213 monitoring sites. More information is available at: http://www.epa.state.il.us/water/surface-water/river-stream-mon.html

6.4 Watershed Data Development

New data developed for DWPs must meet the District standards and specifications described in Table 6.9.

Table 6.9 Watershed Data Development Standards And Specifications

Data Type	Standards Documentation	Summary
GIS Data	District GIS Data Development Standards	Data developed to support DWPs will be consistent with latest available District GIS Standards and Specifications.
Survey Data	District Vertical Datum	Survey data will be developed using the NAD 1983 coordinate system with the Chicago City Datum (CCD) for vertical coordinates (579.48 feet above 1925 mean sea level). DWPs will contain a survey standards document subject to District review prior to initiating any field surveys. If necessary, the District may allow changes to these standards in order to be consistent with unique conditions in watersheds such as those that have upstream or downstream boundary condition models that have been developed in a different coordinate system.
Survey Data	FEMA Guidelines	Survey standards will be consistent with FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A, "Guidance for Aerial Mapping and Surveying*," available at WWW.FEMA.GOV/FHM/DL_CGS.SHTML
DWP Data	Cook County Stormwater Management Plan	All data developed to support DWPs will be consistent with standards provided as a part of this document, or other scoping documents provided by the District.

6.4.1 Watershed Analysis and Floodplain Mapping

The District has developed the following goals for watershed analysis and floodplain mapping that will be applied to the development of DWPs. It is understood that meeting some of these goals may not be possible as a part of DWP development. These goals will be considered and applied wherever the District deems applicable:

- H&H analyses must be consistent with IDNR-OWR and FEMA map revision requirements.
- Hydrology for watershed plans will be determined by a hydrologic model that, where necessary, considers online and offline storage, infiltration, interflow, depressional storage, overland flow, nonuniform rainfall distribution, evapotranspiration, and soil moisture. The output from the hydrologic model must be compatible with the hydraulic model.
- Hydrologic analyses may require cooperative plans for water bodies that cross the District's corporate boundaries, such as the North Branch Chicago River, Little Calumet River, Des Plaines River, Poplar Creek, and Upper Salt Creek.
- Hydraulic conditions for the major watershed plans will be determined by a model that can, at a minimum, analyze the effects of floodplain encroachment, online and offline storage, diversions, channel improvements, bridges, culverts, dams, weirs, and other impediments to flow. The input to the hydraulic model will be compatible with the output from the hydrologic model. Fully dynamic models will be used when channel conditions are extremely flat (for example, slope is less than 5 feet per 1,000) and subject to backwater conditions that make it difficult to approximate storage accurately.

6.4.2 Watershed Modeling

The object of a DWP is to support the development and documentation of a countywide CIP. Understanding stormwater problems and evaluating scenarios to correct them requires the use of models and other watershed analysis tools. The following includes standards for application selection, data development, and calibration of H&H models.

Several steps are involved in applying models to the development of DWPs. First, a model of existing conditions is developed to support calibration and an understanding of existing problems. Second, a baseline conditions model is developed to reflect the conditions expected to be current when the District begins to implement the countywide CIP. This may include modifications to the existing conditions model that reflect projects that are under way and near completion. Finally, the model is modified to evaluate the effectiveness of alternative improvement projects. The guidance provided in Section 6.4.2 applies to all these steps.

6.4.2.1 Screening Considerations

Several H&H modeling applications in the public and private domain are accepted by FEMA and IDNR-OWR to determine floodplain and floodway areas for the National Flood Insurance Program. The applications are summarized in Tables 6.10 and 6.11. Table 6.12 summarizes considerations in the selection of H&H modeling applications. For DWPs, the District will specify the most appropriate H&H modeling application based on the considerations listed in Table 6.12 and specific watershed modeling requirements. In some cases, it may be acceptable to use two or more separate H&H modeling applications within the same DWP.

6.4.2.2 Hydrologic Model Data Development

Hydrologic model data developed as a part of a DWP will be consistent with minimum District standards. District standards have been developed to be consistent with the countywide stormwater management program needs and wherever possible with IDNR-OWR preferences.

Subarea Delineations. Subarea Delineations will be performed using the best available topographic mapping to a level necessary to accurately simulate hydrologic conditions within the watershed. The best available topographic data are those developed by Cook County. Cook County GIS photogrammetry data includes a digital, geospatial GIS file that depicts (through the use of a digital terrain model (DTM), and modeled by a triangulated irregular network) a general surface description for Cook County with a 300-foot buffer beyond the county boundary. The data have been made available to the District and will be used to support Subarea Delineations.

Table 6.10 Hydrologic Models Accepted by FEMA for the National Flood Insurance Program

Type	Program	Developer	Public Domain?
Single event	HEC-1 4.0.1 and upa (May 1991)	USACE	Yes
	HEC-HMS 1.1 and up (March 1998)	USACE	Yes
	MIKE 11 UHM	DHI Water and Environment	No
	PondPack v.8	Haestad Methods, Inc.	No
	SWMM (RUNOFF) 4.30 (May 1994), and 4.31 (January 1997)	USEPA and Oregon State University	Yes

Table 6.10 Hydrologic Models Accepted by FEMA for the National Flood Insurance Program

Type	Program	Developer	Public Domain?
	SWMM 5 Version 5.0.005 (May 2005)	USEPA	Yes
	TR-20 (February 1992)	USDA NRCS	Yes
	TR-20 Win 1.00.002 (Jan. 2005)	USDA NRCS	Yes
	TR-55 (June 1986)	USDA NRCS	Yes
	WinTR-55 1.0.08, (Jan. 2005)	USDA NRCS	Yes
	XP-SWMM 8.52 and up	XP Software	No
Continuous event	DR3M	USGS	Yes
	HSPF 10.10 and up	USEPA, USGS	Yes
	MIKE 11 RR	DHI Water and Environment	No
	PRMS Version 2.1	USGS	Yes
Interior drainage	HEC-IFH 1.03 and up	USACE	Yes

[a]Enhancement of these programs in editing and graphical presentation can be obtained from several private companies.

Note: FEMA periodically updates its list of approved hydrologic models.

Table 6.11 Hydraulic Modeling Applications Accepted by FEMA for the National Flood Insurance Program

Type	Program	Developer	Public Domain?
One-dimensional steady flow models	Culvert Master v.2.0	Haestad Methods, Inc.	No
	HEC-2 4.6.2a(May 1991)	USACE	Yes
	HEC-RAS 3.1.1 and up	USACE	Yes
	HY8 4.1 and up (November 1992)	U.S. Department of Transportation, Federal Highway Administration	Yes
	PondPack v.8	Haestad Methods, Inc.	No
	QUICK-2 1.0 and up (January 1995)	FEMA	Yes
	StormCAD v.4 and v.5	Haestad Methods, Inc.	No
	WSPGW 12.96 (October 2000)	Los Angeles Flood Control District and Joseph E. Bonadiman & Associates, Inc.	No
	WSPRO (June 1988 and up)	USGS, Federal Highway Administration	Yes
	XP-SWMM 8.52 and up	XP Software	No

Table 6.11 Hydraulic Modeling Applications Accepted by FEMA for the National Flood Insurance Program

Type	Program	Developer	Public Domain?
One-dimensional unsteady flow models	FEQ 9.98 and FEQUTL 5.46 (2005, both), FEQ 8.92 and FEQUTL 4.68 (1999, both)	Delbert D. Franz of Linsley, Kraeger Associates; and Charles S. Melching, USGS	Yes
	FLDWAV (November 1998)	National Weather Service	Yes
	FLO-2D v. 2003.6 (July 2003) and 2004.10 (November 2004)	Jimmy S. O'Brien	No
	HEC-RAS 3.1.1 and up	USACE	Yes
	ICPR 2.20 (October 2000) and 3.02 (November 2002)	Streamline Technologies, Inc.	No
	MIKE 11 HD	DHI Water and Environment	No
	Storm Water Management Model (SWMM) 4.30 and 4.31	USEPA and Oregon State University	Yes
	SWMM 5.0.005 (May 2005)	USEPA	Yes
	UNET 4.0	USACE	Yes
	XP-SWMM 8.52 and up	XP Software	No
Two-dimensional steady/unsteady flow models	FESWMS 2DH 1.1 and up	USGS	Yes
	FLO-2D v. 2003.6 (July 2003) and 2004.10 (November 2004)	Jimmy S. O'Brien	No
	MIKE Flood HD 2002 D and 2004	DHI Water and Environment	No
	TABS RMA2 v.4.3 RMA4 v4.5	USACE	Yes
Floodway analysis	PSUPRO	Pennsylvania State University/USACE/FEMA	Yes
	SFD	USACE/FEMA	Yes

[a] Enhancement of these programs in editing and graphical presentation can be obtained from several private companies.

Note: FEMA periodically updates its list of approved hydraulic models.

Table 6.12 H&H Modeling Application Selection Considerations

Consideration	Description
Familiarity to regulatory community	FEMA requirements for modeling to support regulatory floodplain mapping do not exclude the use of many models, but it is clear that many are more acceptable to regulatory review staff than others. The familiarity of regulatory staff at IDNR-OWR and FEMA will be considered as a part of specific H&H modeling application selection.
User base for consistent type of projects	It is common for modelers to look to a broader community of users for advice and support as a part of modeling projects. For example, a SWMM users' e-mail group is commonly used to troubleshoot problems with the application and draw upon the experience of a broad group of users. SWMM users commonly are focused on the application of SWMM to sewer system evaluations. Similar user groups exist for Hydrologic Engineering Center (HEC) modeling applications. Local, regional, and national training seminars and conferences focus on some applications more than others. The existence of an active user base will be considered in the selection of a modeling application.
History of use on floodplain mapping projects	This will be considered as part of the modeling application selection to project ease of permitting for any regulatory activities. The use of an application for projects similar to those faced by the District likely will lead to tools and support programs developed by others that will benefit the District. HEC is the most commonly used national tool for supporting flood control programs similar to the District.
Number of options for simulating open channel hydraulics	Having several options for modeling open channel hydraulics allows for a more accurate representation of field conditions. HEC applications have extensive bridge and culvert crossing options that allow users to develop confidence in results through the application of alternative hydraulic simulation approaches.
Consistency with data developed for existing regulatory models	It may be important to integrate new modeling with existing models. The ability of model output to be used between models may be important. Conversations with IDNR-OWR and experience in the area confirms that HEC software is the most commonly applied modeling application for flood control projects and regulatory floodplain mapping. This is an important consideration in the selection of any modeling application for the District's Stormwater Management Program.
Ability to perform fully dynamic unsteady flow analysis	This may be an important feature that could affect the model results and magnitude of flood control projects identified as a part of this program. Because of the flat terrain of Cook County and surrounding areas, the regulatory floodplains and floodways contain significant storage volumes. Traditional modeling applications use approaches that simulate this storage in a simplified and typically conservative manner. Fully dynamic unsteady flow modeling applications allow for a more explicit simulation of this storage that often leads to results showing more accurate lower floodway elevations.
Availability of vendor provided proprietary interface applications that enhance usability of product	Some models include proprietary modules to increase the functionality of the model. This may be useful as modeling exercises become more complex.
GIS interface capabilities	An important component of watershed modeling will be to integrate the application with GIS software. Most modeling applications listed in Tables 6.10 and 6.11 have GIS interfaces that have been developed to support data development and visualization.

Subarea boundaries will be developed as closed polygons with attribute data that at a minimum include their watershed designation, model name, total area and source of data used for delineation and any other fields specified by the District. Subarea delineation data will be in a format compatible with the District's stormwater GIS. The overall watershed delineation developed as a part of DWPs will be used as the District's official watershed delineation for administrative as well as technical purposes.

Rainfall Data. Observed and design event rainfall data may be used to support H&H modeling performed as a part of a DWP. Observed rainfall data are used as a part of hydrologic model data calibration. Two approaches are typically used to define observed rainfall data. These are the use of rain gauge data or rainfall data developed using radar technology. Both approaches are acceptable and will be used where appropriate as a part of DWPs developed by the District. Table 6.13 specifies how observed rainfall data will be used. Design event rainfall data are used to define flood damages, evaluate alternative improvement projects, and recommend capital improvements. Observed and design event rainfall data developed and used as a part of a DWP will be organized in a database format. Fields required in the table where rainfall data are stored will include year, month, day, hour, minute, and depth (inches).

GIS applications will be used to determine influence areas for rainfall data. For rain gauges, GIS applications will be used to develop Theissen polygon areas that can be intersected with subarea delineations to assign rainfall data for hydrologic modeling. Theissen polygon areas will be created in a GIS format consistent with District standards. If radar derived rainfall data are used, influence areas of rainfall data sets will be provided to the District in a GIS format consistent with District standards.

Table 6.13 Observed Rainfall Data Utilization Criteria

Source of Observed Rainfall Data	Criteria for Application
Rain gauges	Rain gauges that log rainfall data on a 10- to 15-minute increment will be used to support hydrologic model data calibration during storms where spatial distribution of rainfall appears to be adequately captured by the rain gauge network in place. The Cook County Precipitation Network operated by IDNR-SWS records data at 10-minute increments at 25 rain gauges (see Table 6.8). Research was developed to determine the appropriate minimum spacing and coverage requirements, which determined the locations of the rain gauges.
Radar-derived rainfall data	Radar derived rainfall data may be used in large watersheds where the rain gauge network in place is unlikely to sufficiently define the spatial distribution of rainfall occurring over the watershed. The District will review the existing and proposed rain gauge network and historic spatial rainfall distribution patterns to provide justification for the use of radar derived rainfall data.

Design Event Rainfall Data. Design event rainfall data are used as a part of the H&H modeling that is performed to support the identification of flooding problem areas, flood damage curves and the development and evaluation of alternative improvement projects. The standard source of rainfall depth and distribution data for H&H model evaluations will be the sectional frequency distribution of rainfall for given recurrence intervals as listed in Bulletin 70 or Bulletin 71 with Huff Distribution or the data most recently adopted by IDNR-OWR for use in hydrologic modeling. Bulletin 71 provides guidance on which Huff distribution will be used (1st, 2nd, 3rd, or 4th quartiles) with storms of various durations.

To determine the critical or most extreme duration storm for each recurrence interval storm considered as a part of DWP development, a critical duration analysis will be conducted. To be consistent with IDNR-OWR requirements, the critical duration analysis must include at least the simulations of 1-, 3-, 6-, 12- and 24-hour duration storms.

Infiltration Rates and Capacities. The most common method used to determine loss rates and runoff volumes in Cook County has been the Soil Conservation Service (SCS) Curve Number method. The method is acceptable for the hydrologic modeling that is performed as part of a DWP. Other methods may be used when appropriate at the discretion of the District. When using the SCS Curve Number method, the modeler will follow guidance contained in Urban Hydrology for Small Watersheds (USDA NRCS, TR-55, June 1986) or as approved by the District.

Runoff and Overland Flow Parameters (Existing and Future). Impervious area coverage, aerial photography, topographic mapping, soils groups mapping and other soils data, land use mapping, and other land use data all will be used to determine watershed areas, flow paths, slopes, lengths, time of concentration, and any other parameters necessary to support developing stormwater runoff hydrographs consistent with the guidance within USDA NRCS TR-55 or as approved by the District.

Unit Hydrograph/Routing. Unit hydrographs acceptable for routing runoff include SCS dimensionless, Clark, or Snyder. A user-specified unit hydrograph may be used for a watershed if enough quality data are available for it to be properly derived from observed rainfall and runoff.

6.4.2.3 Hydraulic Model Data Development

Channel Cross Section Data. Channel cross sections used within hydraulic modeling applications will be obtained through field surveys that meet survey standards described in Table 6.9. Field survey efforts will include the determination of the appropriate Manning's roughness parameters based on observations of characteristics that include surface roughness, vegetation, channel size, channel shape, channel alignment, and obstructions. If observed water surface profile information is available in the form of gauge data, calibration of Manning's "n" values is possible and desirable.

Open Channel Hydraulics by V. T. Chow (McGraw-Hill 1959; reissued 1988) contains excellent guidance for determining Manning's "n" values for a wide range of rivers and streams. The USGS Illinois Water Science Center has computed Manning's "n" values at many representative urban and rural sites in Illinois, available at http://il.water.usgs.gov/proj/nvalues/. Figure E-1 in Appendix E is an example of the type of form to be used to document Manning's "n" values in the field. Separate Manning's "n" values are generally appropriate to be used for the channel and the overbanks. The typical channel cross section template form in Figure E-2 in Appendix E is an example of the type of form that will be used to gather cross-sectional data during a survey.

Bridge and Culvert Crossings. Bridges and culverts generally will be modeled as existing. For the baseline conditions model, bridge or culvert replacement projects that are under construction or in the late stages of the planning process and unlikely to be revised may be modeled as proposed. The model must account for bridge deck, piers, abutments, and embankment side slopes.

Storage Areas. Storage areas that are simulated as a part of hydraulic modeling will be represented with stage-area or stage-volume relationships developed from best available topographic information and discharge rating curves developed according to hydraulic properties of the controlling device.

Downstream Boundary Conditions. Downstream boundary conditions for hydraulic analysis will be based on known water surface elevations when available. If the water surface elevation is unknown at the downstream end of the study reach, normal depth will be used at a location further downstream so as not to have influence on the profile. To test whether the starting cross section is sufficiently downstream for a given discharge, the distance is varied until the water elevation at the project boundary does not change appreciably, which indicates that the profile will not be affected by the starting elevation.

6.4.2.4 Steady State vs. Unsteady Flow Analysis

If there is reason to believe that a steady-state model would inadequately represent actual hydraulic conditions, such as extremely flat slopes (Froude number < 0.1) or flow restrictions that may cause significant storage within the channel or situations with reverse flow, then unsteady-state modeling will be considered and used where necessary.

6.4.2.5 Critical Duration Storm Analysis

A critical duration storm analysis (CDSA) will be performed and documented as a part of design event simulations performed to develop flood damage curves. A CDSA is performed for each problem area to identify the duration storm that produces the critical water surface elevation and level of damage. CDSA involves running a range of duration storm events for a given recurrence interval to determine which duration storm is critical. Generally, this duration is somewhere near the time of concentration of the watershed tributary to a given point. The IDNR-OWR generally requires a CDSA as a part of the regulatory map revision process.

6.4.2.6 Model Calibration and Verification

Calibration must be performed in developing defensible H&H models representative of actual conditions. High water marks, historic floods, or other stream gauge data will be used to compare with model results and adjust model parameters, typically the roughness coefficients. The final calibrated model must not contain model parameters outside their “reasonable” bounds, although it may be permitted when performing model sensitivity analyses. If enough data exist, the model will be validated by comparing calibrated model results to a set of data that was not included in the calibration.

H&H model data will be calibrated to a point where the runoff volume and stream flow rates are within roughly 30 percent of the data recorded at stream gauges. Water surface elevations will match within 6 inches. In some cases, where rain gauge data are used to support calibration, it is not possible to adjust H&H model data with confidence when the spatial distribution of rainfall appears to be inadequately captured and reflected in the model.

6.4.3 Floodplain Mapping

To ensure that H&H modeling performed as a part of a DWP can be utilized for future FEMA FIRM remapping efforts, the District will require that all modeling performed be consistent with current IDNR-OWR and FEMA standards. Both agencies have published standards that will be followed: *Floodplain Map Revision Manual* (March 1996) published by IDNR-OWR and *Guidelines and Specifications for Flood Hazard Mapping Partners* published by FEMA, available at http://www.fema.gov/fhm/gs_main.shtm. It is not a specific goal of the DWPs to replace or revise the current FEMA FIRM maps. However, if a substantial error in the current regulatory maps is identified during a DWP, the District may consider requesting a map revision from FEMA. As the CIP progresses, a decision will be made as to whether the District or the benefiting local government entity will pursue map revisions necessary to reflect the implementation of future flood control projects.

6.5 Problem Area Identification

Stormwater problem areas will be identified through stakeholder involvement, such as WPC meetings, discussion with other agencies, and logs of complaints. They will also be identified and confirmed as a part of the DWP. DWP reports will summarize relevant and known stormwater problem areas and also watershed analyses to confirm the magnitude of flooding problems.

6.5.1 Flooding Problem Areas

Flooding problems are defined as flooding of residential, commercial, industrial and public buildings, or transportation facilities that are critical to the economy and emergency services. H&H models will be the primary method for evaluating flooding problem areas. H&H models will be used to define water surface elevations for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms. These elevations will be compared with top of foundation and first floor elevations for properties within the floodplain to develop flood damage curves. The methodology for developing flood damage curves and data required to support them are described in Section 6.6.

In some instances flooding may result from non-riverine sources, such as depressions in the ground surface that are inundated by the water table. The majority of such depressional flooding instances are expected to be confined to a single community, and therefore will not be addressed in a DWP. However, cases where depressional inundation results in inter-community flooding will be addressed with the DWP, in conjunction with the District, on a case by case basis.

6.5.2 Erosion Problem Areas

Erosion problems are defined as streambank erosion along waterways that could result in property damage or a risk to human health and safety. As part of a DWP, the District will require an evaluation of streambank conditions to generally identify areas where erosion appears to meet these criteria. Special attention will be paid to areas where the District or other stakeholders have received complaints about erosion problems that are threatening structures or posing a risk to human health and safety. The District will visit the erosion problem areas identified and document existing conditions to support the evaluation of alternatives. Site visits will include the collection of survey data that is necessary to prepare conceptual level plans and cost estimates for alternative improvement scenarios.

6.5.3 Maintenance Problem Areas

Maintenance problems are defined as restrictions on drainage caused by accumulation of debris. They will be identified through field visits by District staff or through stakeholder identification. Further information on maintenance can be found in Section 5.4. Efforts to identify the agencies responsible for maintenance within the watershed will be undertaken in the DWPs.

6.5.4 Water Quality Problem Areas

Water quality problem areas are identified in the IEPA's 303d Report. As discussed in Chapter 4, the report provides a comprehensive summary of waterways within the state of Illinois where water quality standards or listing criteria are not met. Water quality benefits provided by projects planned as a part of DWPs will be shown in qualitative terms as a part of the documentation of improvement projects identified. During development of the draft CCSMP, the District went to great lengths to identify methods accepted by other agencies, such as the USACE and the IDNR-OWR, for determining the economic value of ecosystem impacts and water quality improvement to no avail. Therefore, until an acceptable method is identified and approved by the District, the water quality improvement and ecosystem impact facets of a project will be considered as non-economic factors.

6.5.5 Wetlands, Floodplains, and Riparian Environment at Risk

Wetland, floodplain, and riparian areas will be identified as a part of a DWP. Wetland areas are identified on National Wetland Inventory (NWI) mapping. GIS data for NWI mapping are available on the Web (http://www.fws.gov/nwi/) for download and incorporation into DWPs. Floodplain areas are delineated for many of the Cook County regional waterways and will be summarized as a part of a DWP.

Riparian zones generally are not delineated for Cook County waterways and will be defined as a part of a DWP. Wherever possible, a desktop evaluation of aerial photography or other available field data will be the method for identifying riparian zones. Riparian zones generally are defined as the interfaces between terrestrial and aquatic ecosystems. For the purpose of DWP development, riparian areas will be defined as any vegetated area adjacent to a waterbody that is occasionally inundated by floodwaters resulting in periodic hydric soil conditions. The frequency of inundation impacts the nutrient loads of riparian areas, as well as the soil conditions and plant community composition. The 10-yr delineated floodplain will be used to characterize inundation. For stream reaches where flood frequency data is not available, riparian delineation will attempt to capture the functional relationship between periodic inundation and species diversity in the floodplain.

6.6 Estimates of Existing Damage

Estimating existing damages is the first step in defining the extent of problem areas. Damage estimates defined as a part of a DWP will focus on the economic damages caused by flooding and streambank erosion. Economic damages are estimated by summing damages from four categories:

- Property damage resulting from flooding (residential and commercial)
- Streambank erosion damage
- Transportation damage
- Recreation damage

The following subsections provide guidance on the economic valuation of damages and benefits that will be included as a part of DWP development.

6.6.1 Property Damage

Property damage caused by flooding includes structural damage to buildings (residential, commercial, industrial, and public) and loss of building contents (equipment, furnishings, raw materials, and inventory). The extent of property damage depends on the severity of the flood. For riverine flooding typical of Cook County, severity is dictated primarily by flooding levels and by high flow velocities and the duration of flooding. A floodplain inventory is necessary to understand the assets that are at risk. H&H modeling is used to define water surface elevations for several storm events of varying probability of occurrence and to understand the impact on properties within the floodplain.

Table 6.14 summarizes data requirements for this analysis and suggested data sources. Several public domain applications are available to support the development of average annual damages (AA_D) curves using the data listed in Table 6.14 and consistent with the USACE's National Economic Development (NED) methodology.

Table 6.14 Property Damage Calculations

Data Requirement	Source
Flood stage elevations for 2-, 5-, 10-, 25-, 50-, and 100-year storms.	H&H modeling based on guidance contained in Section 6.4. For DWPs, flood stage elevation (floodplain boundaries) will be developed consistent with GIS standards and specifications provided by the District.
Surveyed property and structure Locations	Based on surveys performed during DWP development or acceptable estimates based on topographic data and visual inspections.
Zero-damage elevations for each structure	Based on surveys performed during DWP development or acceptable estimates based on topographic data and visual inspections.
Assessed value of each asset	Cook County tax parcel data.
Valuation of contents of structures	Recommended assumptions: For residential structures, contents are 50% of the replacement value of the structure. For commercial, industrial, or public facilities, contents are 90% of the replacement value of the structure. More specific information can be substituted, if it can be easily obtained through interviews or additional data gathering.

In general, based on the flood stage calculated using H&H models, damages are calculated for six storm events: 2-, 5-, 10-, 25-, 50-, and 100-year. Once the damages are calculated, a damage curve is developed by plotting the value of damages versus the exceedance probability. The AA_D value, which can be determined by calculating the area under the damage curve, is essentially the sum of all the damages weighted by their probability of occurrence.

Appendix F contains a more detailed description of the NED methodology for determining property damages including the development of damage curves and performing benefit-to-cost (BC) analysis.

6.6.2 Streambank Erosion Damage

Streambank erosion damage will be calculated in a manner similar to property damage calculations. Surveys performed by the District will determine where streambank erosion is likely to cause property damage. In such cases, the valuation of the structure and the contents of structures deemed to be at imminent risk will be included. Therefore, frequency determinations are unnecessary, and evaluations will focus on effectiveness for the full range of expected flows, particularly bank full-flow ranges. Only actual property damage to structures will be included in the damage calculation. Loss of land will not be considered.

6.6.3 Transportation Damage

The following damages in the transportation category will be quantified for the purposes of damage assessment:

- Physical damages to roads, bridges, traffic signal installations, and sewers
- Emergency response costs
- Traffic delay or disruption

Transportation damages will be calculated using the following tiered approach:

Tier 1—If avoided transportation damages are not expected to be a significant component of the project, then a 15 percent markup of total property damage should be used to account for indirect damages. This methodology is consistent with the IDNR-OWR's common approach to damage assessment, which includes physical damages, emergency response costs, and traffic delays or disruptions, and is intended to cover such costs as public works staff time, lost wages for residents, and other associated damages.

Tier 2—If the traffic delay component of the project is expected to be more significant, then a more detailed traffic delay analysis will be performed and included as an addition to the 15 percent markup. The methodology used for this analysis will be site-specific and will be approved by the District.

Tier 3—If historic information obtained during DWP preparation shows that flooding in the area has been known to cause significant transportation damage, then project-specific transportation damage curves will be developed in place of the 15 percent markup. An example of this may be that bridges in a particular project area are of high value and vulnerable to flood damages; therefore, the 15 percent markup would not be high enough to account for the damage expected to these bridges. These project-specific damages will be calculated using the formula

$$D_x = F_x Q_x$$

where:

D_x = the monetary damages derived from a particular flood event; e.g., damages for a 2-year flood

F_x = multiplication factor incorporating cost; e.g., cost of project-specific bridge replacement

Q_x = the quantity of the particular facility affected by the flood event; e.g., number of bridges affected by the flood

Specific cost factors and inputs to be used to calculate damages for each transportation cost component will be developed using historic information. As with property damages, transportation damages will be calculated for each flooding event, developed into a damage curve, and then converted into an AA_D. The AA_D is determined by calculating the area under the damage curve. Appendix F contains a detailed explanation of this procedure.

6.6.4 Recreation Damages and Benefits

Recreation damages are incurred through the loss of the use of parks, forest preserves, or other recreational facilities. Recreation benefits can accrue from damages avoided and by the creation of recreation areas as part of a flood control project. Several methods have been developed to calculate recreational damage/benefit. The unit day value (UDV) method will be used for recreational damage or benefit calculation as a part of DWPs. The UDV method relies on annually published studies by the USACE that estimate dollar damages per day ($ person-day) that are accrued based on a point rating. The point rating system includes five criteria related to: available activities, facilities, relative scarcity, ease of access, and aesthetics. Appendix G contains USACE's 2006 published study, which is updated annually. The general formula for calculating damages is:

$$D_x = F_x V_x L_x$$

where:

D_x = the monetary damages derived from a particular flood
F_x = multiplication factor incorporating the UDV
V_x = the average number of daily visitors to a recreational facility
L_x = Length of impact in days

Unless site-specific information can be readily developed, the values contained in Appendix H (Table H-1) will be used to calculate recreational damages or benefits. This table will be evaluated annually to determine if updates are required.

Similar to property and transportation damages, recreation damages must be calculated for each flood event, developed into a damage curve, and then converted into an AA_D for recreation facilities. The AA_D can be determined by calculating the area under the damage curve. Appendix F contains a detailed explanation of the procedure.

6.6.5 Final Calculation

Once damages are calculated for each flood event, a damage curve will be developed for the sum of all damages from each category, and then converted into an overall AA_D. The AA_D can be determined by calculating the area under the damage curve. Appendix F contains a more detailed explanation of this procedure. Table 6.15 summarizes the valuation of damages and benefits proposed in the sections above.

Table 6.15 Summary Recommendation for Economic Valuation

Type of Damage and Benefit	Description	Valuation Method
Property Damage from Flooding		
Residential property —structural damage	Avoided structural damage to residences.	Follow USACE NED guidance. Use HEC-Flood Damage Assessment (FDA) or IDNR-OWR's damages model. Property valuation will be based on assessed value obtained from Cook County tax records.
Residential property—contents	Avoided damage to contents within residences.	Assume 50% of structural damage to account for residential contents.
Industrial commercial property—structural damage	Avoided structural damage to industrial/commercial property.	Follow USACE NED guidance. Use HEC-FDA software or IDNR-OWR's damages. Research individual building types through interviews and other data collection.
Industrial/ commercial property—contents	Avoided damage to contents within industrial/commercial property.	Assume 90% of structural damage unless information can be obtained through interviews and other data collection.

Table 6.15 Summary Recommendation for Economic Valuation

Type of Damage and Benefit	Description	Valuation Method
Streambank Erosion Damage		
Erosion damage	Damages from erosion.	Similar to structural damage, except include damage in areas where erosion is the cause of structural damage rather than flooding. Only structural damage will be included in the valuation, loss of land will not be considered.
Transportation Damage		
Transportation—physical damage and emergency response costs	Physical damage to roads, bridges, and utilities, as well as damages resulting from police, fire and emergency rescue costs.	Assume 15% of property damages (structural plus contents) for indirect transportation damages (this includes both physical damage and emergency response costs).
Transportation damage—operation and delay costs	Damage from additional vehicle operation, and loss of productivity.	Operational delay is considered when the flood elevation reaches 0.5 foot above the low roadway elevation. If significant, estimate damages based on estimated cost of delay.
Transportation damage—vehicles	Damage to vehicles.	Not included for District transportation damage calculations. Assume most vehicles will be removed from flooded areas before damage can occur.
Other damages—income loss	Damage from lost wages of workers that cannot be transferred out of a flooded area.	Not included. Assume that work can be transferred out of the flooded area. (*Note:* The likelihood of an event extreme enough to cause income loss is small.)
Other damages — relocation costs	Damages from additional living expenses of residences required to temporarily relocate.	Not included for District transportation damage calculations. Assume that living expenses are small relative to property damage.
Recreation Damage and Benefit		
Parks and forest preserves	Damage incurred from the loss of use of parks, forest preserves, or other recreation areas. Benefits accrued from the development of new recreation areas created by an alternative will be valued (see Section 6.6.4)	USACE Economics Guidance Memorandum, 07-03 dated November 20, 2006, unit day values for recreation, fiscal year 2007, which estimates $/person-recreation day. This calculation can be used to calculate damages in recreation areas as well as benefit from recreation area created.
Wetland and Riparian Areas		
Wetlands and riparian habitat	Existing damage to wetlands and riparian habitats will not be included in the baseline damages valuation. Damage caused by an alternative will be mitigated and included in the overall cost of an alternative. Benefit from additional wetlands or riparian habitat created by an alternative will be valued (see Section 6.7.3.1).	Not included in damage calculation. For benefit calculations use the market rate of wetlands and riparian habitat from a wetland bank in the appropriate watershed.
Water Quality		
Water quality	Damages from impaired water quality, both ecological and regulatory.	Not included until an acceptable method is developed.

6.7 Alternative Development and Evaluation

Once problem areas are defined (Section 6.5) and damages quantified (Section 6.6), then alternatives to reduce the damages associated with the problems will be developed and evaluated. Several alternatives will be developed and evaluated for each problem area. For flooding problem areas, alternatives will provide a varying level of protection. In other words, some alternatives will address lower recurrence interval storms such as the 15-year storm, and others will address higher recurrence interval storms such as the 100-year storm. Once alternatives are developed, they will be evaluated based on their BC ratio or net benefit.

The enacting legislation, Public Act 93-1049, in which authority was granted to the District for the responsibilities of stormwater management for Cook County, stipulates that BC analysis is required during deliberations for capital project selection. However, the District's Board of Commissioners is not required to select projects solely on BC analysis. They may also decide to consider noneconomic criteria in the selection of alternatives for each problem areas. Information about noneconomic criteria will be summarized for each project so that it can be included as a consideration in the countywide prioritization of stormwater improvement projects. The ultimate decision for funding of any capital project is at the discretion of the District's Board of Commissioners.

Section 6.7 is generally organized according to the steps to be followed as a part of alternative development and evaluation. Alternative development and evaluation will be performed as a part of DWPs. Table 6.16 summarizes the general steps for development and evaluation of alternatives.

Table 6.16 Summary of Alternative Development Sections

CCSMP Section Number	Alternative Development and Evaluation Step	General Overview
6.5	Define problem areas	Use guidance in Section 6.5 to identify and define the magnitude of problem areas.
6.7.1	Identify alternatives	Use technology guidance provided in Section 6.7.1 and information on watershed to identify alternatives that can help resolve problems in problem areas.
6.7.2	Evaluate alternatives	Evaluate alternatives for effectiveness addressing problem areas. This will primarily focus on the evaluation of the effectiveness of flood control alternatives using H&H modeling consistent with protocol established in Section 6.4. Streambank erosion control alternatives will focus on bank-full conditions.
6.7.3	Estimate conceptual cost of alternatives	Use unit costs, markups, and other guidance provided by the District to estimate the conceptual cost of alternatives.
6.7.3	Evaluate cost-effectiveness of alternatives	Use the damages defined in Section 6.6 and the conceptual cost estimates to determine the BC ratio for each alternative. Use the BC ratio to determine whether alternatives address problem areas cost-effectively.
6.8	Summarize recommended projects for each problem area and define noneconomic criteria	Develop lists of projects recommended throughout the watershed for each problem area. Alternatives that have the highest BC ratio (net benefit) generally will be recommended for each problem area. Also summarize noneconomic data for each problem area to be used as a part of District's countywide prioritization of improvement projects.

6.7.1 Technology Guidance and Alternative Identification

Many acceptable technologies can be used alone or in combination to form project alternatives to remediate existing stormwater problems. Where opportunities exist, projects funded by the District will incorporate BMPs that provide secondary water quality benefits. Section 6.7.1 provides guidance on the use of technologies in developing alternatives to remediate flooding and erosion problems.

6.7.1.1 Flood Control Technologies

As described in Section 6.5, flooding problems occur when flood waters reach structures, transportation facilities, utilities, critical facilities, or recreation areas. Damages arise from the effects on the facilities and their contents, as well as the consequences of loss of service. Table 6.17 contains descriptions of technologies that can remediate flooding problems and also general guidance on their use for the development of alternatives. The technologies will be used as appropriate for the development of flood control alternatives as a part of a DWP.

Technologies listed in Table 6.17 are summarized in terms of their ability to remediate flooding problems. It is assumed that these technologies would be implemented along with a regulatory program that requires measures to prevent future flooding problems. Without measures to prevent future flooding problems, such as site discharge restrictions, the technologies may not prove as effective in the future as when they originally were designed and implemented.

Table 6.17 Summary of Flood Control Options

Flood Control Option	Description
Detention/Retention	
Detention facilities	Impoundments to temporarily store stormwater. This centralized technology includes wet basins, stormwater wetlands, regional facilities, and flood control reservoirs.
Retention facilities (Wet basins)	Impoundments to permanently store stormwater and remove it through infiltration and evaporation. Retention facilities generally have an outfall to the receiving waterway that is located at an elevation above the permanent pool.
Underground detention	A specialized form of storage where stormwater is detained in underground facilities such as vaults or tunnels.
Bioretention	Decentralized microbasins distributed throughout a site or watershed to control runoff close to where it is generated. Runoff is detained in the bioretention facilities and infiltrated into the soil and removed through evapotranspiration.
Conveyance Improvement	
Culvert/bridge re-placement	Enhancement of the hydraulic capacity of culverts or bridges serving as stream crossings through size increase, roughness reduction, and removal of obstacles (for example, piers).
Channel improvement	Enhancement of the hydraulic capacity of channels by enlarging cross sections (for example, floodplain enhancement), reducing roughness (for example, lining), or channel realignment.
Flood Barriers	
Levees	Earth embankments built along rivers and streams to keep flood waters within the channel.
Floodwalls	Vertical walls typically made of concrete or other hard materials built along rivers and streams to keep flood waters within the channel.
Relocation	
Buyouts	Acquisition and demolition of properties in the floodplain to eliminate flood damages.
Building relocation	Relocation of buildings (typically houses) to higher ground to remove them from the floodplain. This technology requires purchasing new land and transporting buildings to new locations.
Elevation	Modification of a structure's foundation to elevate the building above a given flood level. Typically applied to houses.
Floodproofing	
Dry floodproofing	Installation of impermeable barriers and flood gates along the perimeter of a building to keep flood waters out. Typically deployed around commercial and industrial build-ings that cannot be elevated or relocated.
Wet floodproofing	Implementation of measures that do not prevent water from entering a building but minimize damages; for example, utility relocation and installation of water resistant materials.

Note that sometimes applications of flood control technologies to address problems in one location may aggravate problems in another location (for example, conveyance improvements reduce flooding upstream but may worsen conditions downstream). Therefore, the potential applications of flood control technologies to address problems will not be analyzed in isolation. No alternative recommended as a part of a DWP may create negative impacts within the watershed or outside of the watershed, including areas lying outside of Cook County.

6.7.1.2 Erosion Control Technologies

As described in Section 6.5, streambank erosion can result in property damage or a risk to human health and safety. Damages arise from the effects on the facilities and their contents, as well as the consequences of loss of service. A description of appropriate technologies that can remediate existing streambank erosion problems and general guidance on their utilization for the development of alternatives, is presented in Table 6.18.

Table 6.18 Streambank Erosion Control Options

Control Option	Description
Natural (vegetated or bioengineered) stabilization	The stabilization and protection of eroding overland flow areas or streambanks with selected vegetation using bioengineering techniques. The practice applies to natural or excavated channels where the streambanks are susceptible to erosion from the action of water, ice, or debris and the problem can be solved using vegetation. Vegetative stabilization is generally applicable where bankfull flow velocity does not exceed 5 ft/sec and soils are more erosion resistant, such as clayey soils. Combinations of the stabilization methods listed below and others may be used.
Vegetating by sodding, seeding or planting	Establishing permanent vegetative cover to stabilize disturbed or exposed areas. Required in open areas to prevent erosion and provide runoff control. This stabilization method often includes the use of geotextile materials to provide stability until the vegetation is established and able to resist scour and shear forces.
Vegetated armoring (joint planting)	The insertion of live stakes, trees, shrubs and other vegetation in the openings or joints between rocks in a riprap or articulated block mat (ABM). The object is to reinforce riprap or ABM by establishing roots into the soil. Drainage may also be improved through extracting soil moisture.
Vegetated cellular grid (erosion blanket)	Lattice-like network of structural material installed with planted vegetation to facilitate the establishment of the vegetation, but not strong enough to armor the slope. Typically involves the use of coconut or plastic mesh fiber (erosion blanket) that may disintegrate over time after the vegetation is established.
Reinforced grass systems	Similar to the vegetated cellular grid, but the structural coverage is designed to be permanent. The technology can include the use of mats, meshes, interlocking concrete blocks, or the use of geocells containing fill material.
Live cribwall	Installation of a regular framework of logs, timbers, rock, and woody cuttings to protect an eroding channel bank with structural components consisting of live wood.
Structural stabilization	Stabilization of eroding streambanks or other areas by use of designed structural measures. Structural stabilization is generally applicable where flow velocities exceed 5 ft/sec or where vegetative streambank protection is inappropriate.
Riprap	A section of rock placed in the channel or on the channel banks to prevent erosion. Riprap typically is underlain by a sand and geotextile base to provide a foundation for the rock, and to prevent scour behind the rock.
Interlocking concrete	Interlocking concrete may include A-Jacks®, ABM, or similar structural controls that form a grid or matrix to protect the channel from erosion. A-Jacks armor units may be assembled into a continuous, flexible matrix that provides channel toe protection against high velocity flow. The matrix of A-Jacks can be backfilled with topsoil and vegetated to increase system stability and to provide in-stream habitat. ABM can be used with or without joint planting with vegetation. ABM is available in several sizes and configurations from several manufacturers. The size and configuration of the ABM is determined by the shear forces and site conditions of the channel.

Table 6.18 Streambank Erosion Control Options

Control Option	Description
Gabions	Gabions are wire mesh baskets filled with river stone of specific size to meet the shear forces in a channel. The gabions are used more often in urban areas where space is not available for other stabilization techniques. Gabions can provide stability when designed and installed correctly.
Grade Control	Grade control measures may be used to prevent stream incision into the channel bed or upstream nickpoint migration. Grade control measures involve some means of stabilizing the channel bed at a desired elevation with natural materials such as rocks or logs, or in some situations concrete. Rock vortex weirs, rock cross vanes, and log drops are means of grade control that impede channel incision and often result in scour pools developing downstream of the grade control measure.
Concrete channels	A constructed concrete channel designed to convey flow at a high velocity (greater than 5 ft/sec) where other stabilization methods cannot be used. May be suitable in situations where downstream areas can handle the increase in peak flows and there is limited space available for conveyance.
Outlet stabilization	Prevent streambank erosion from excessive discharge velocities where stormwater flows out of a pipe. Outlet stabilization may include any method discussed above.

USDA NRCS and IEPA. *Illinois Urban Manual.* 2002

Sometimes applications of streambank erosion control technologies to address problems in one location may aggravate problems in another location (for example, lining a channel in one location may exacerbate streambank erosion at another location). Therefore, application of streambank erosion or grade control technologies to address problems must not be analyzed in isolation. As stated previously, no alternative recommended as a part of a DWP may create negative impacts in the watershed or outside of the watershed including areas outside of Cook County.

Bioengineering techniques for stabilizing water body shorelines provide more natural solutions than hard armoring. Hard armoring, which protects the bank with concrete, riprap, or other nonnatural materials, is sometimes necessary when a bioengineered solution will not provide the necessary level of protection or cannot withstand flow velocities. In preparing a DWP, consideration will be made to allow only the minimum necessary amount of hard armoring. The DWP will consider the use of bioengineering techniques where appropriate. A combination of treatments will likely be suggested to maximize durability.

6.7.2 Alternative Evaluation

Alternatives developed to address flooding will be evaluated using H&H modeling consistent with methodologies described in Section 6.4. Modeling will determine the avoided damages or benefit for each alternative. The avoided damage or benefit will be used to calculate the BC ratio for each alternative.

Frequency determinations are unnecessary in evaluating alternatives developed to address erosions problems. Evaluations will focus on effectiveness for the full range of expected flows, particularly the bank full flow ranges. Costs will be considered, but not using the multistorm approach applied for flood damages.

6.7.3 Evaluating Cost Effectiveness of Alternatives

BC ratio is determined by calculating the benefit of a project in terms of avoided damages or benefit added, and the construction and operation and maintenance (O&M) costs associated with a project. Section 6.6 provides a description of the process to be followed to determine the benefit or damages for problem areas. Benefits are then divided by the cost to obtain an indicator of the cost effectiveness of each project. Net benefit can also be calculated by subtracting the cost from the benefit.

6.7.3.1 Benefit Calculation

In economic terms, benefit is the dollar value of the damages avoided because of implementation of an alternative (flood control project, soil stabilization project, buyouts). Benefits are calculated by determining damages without a project minus damages with a project; that is, damages avoided. Benefits can include the added value of recreation facilities, wetlands, or riparian areas. As explained in Appendix F, benefits can be expressed as a present value, PV_B, or can be annualized to obtain the average annual benefits AA_B.

Recreation Areas. If the project creates recreation areas, the value will be included as a benefit to the project using the economic valuation method described in Section 6.6.4. Recreation benefit, once created, can be assumed to accrue annually over the life of the project.

Wetlands and Riparian Areas. If the project creates wetlands or riparian areas, their value will be included as an economic benefit of the project. The value of wetlands and riparian areas is calculated based on the market rate of wetlands in the watershed. Appendix H provides the 2006 market rate for wetlands by watershed (Table H-2). The values are variable and will be confirmed annually.

6.7.3.2 Costing Assumptions

Project costs involve all expenditures necessary for implementation. For traditional flood control projects such as levees or reservoirs, they include study, design, land acquisition, construction, and O&M costs. For a residential buyout, there is a one-time cost to purchase structures in the floodplain, including demolition of the structures, restoration of the land, relocation and closing costs. Floodproofing costs may be represented by one-time costs of utility relocation and the occasional complete replacement of flood shields.

Flood protection projects provide benefits throughout a defined period of time that depends on the useful life of a project. A levee may have a useful life of 50 years, whereas relocation of a house outside the floodplain is a permanent solution. Every year that the project performs its functions, it provides benefits and, in principle, requires some expenditure, although most of the cost is incurred during construction. Therefore, the concept of annualizing is applied to compare these unevenly distributed benefits and costs.

Annualizing benefits and costs is a basic concept of engineering economics that accounts for the time value of money. To calculate the annual payment, benefits accrued and the costs incurred every year are discounted using compound interest procedures. The typical discount rate is set by the federal government and is also used by IDNR-OWR. Recently it has varied between 3 and 7 percent. In 2005, the value used by IDNR-OWR for discounting was 5.375 percent. The District will validate the discount rate annually. If the life expectancy of facilities is less than the period for which benefits are calculated, then replacement costs must be incorporated to account for the total cost of facilities for the entire time period.

Standard engineering economics textbooks provide formulas for converting a present value or a future value into a uniform series of "payments." For example, a capital expenditure can be converted into an annual payment using the formula

$$AAc = PV \frac{i(1+i)^n}{(1+i)^n - 1}$$

where:

AAc = annual cost
n = useful life of the project in years
PV = total cost or benefit in the present
i = discount rate

To calculate costs accurately, it is necessary to have an assumption of the life expectancy of a project. Table 6.19 lists the standard assumptions to be used to estimate project life for purposes of alternative evaluation.

Table 6.19 Life Expectancy and O&M Requirements for Alternative Evaluation

Project	Life Expectancy (yr)	Inspection and Routine O&M (yr)	Additional O&M (YR)
Flood Control Projects			
Detention pond	50	Every 2-3	Every 10
Underground detention	50	Every 2-3	Every 5
Levee with detention	100	Every 3	Every 15
Channel enlargement with detention	50	Every 2-3	Every 5
Floodproofing	20	Every 1	Every 2
Buyouts	Permanent		
Detention pond	50	Every 2-3	Every 10
Underground detention	50	Every 2-3	Every 5
Soil Stabilization Projects			
Natural stabilization	30	Every 1	Every 2
Riprap	30	Every 2-3	Every 5
Reno gabions	30	Every 1	Every 5
Basket gabions	30	Every 1	Every 5
Sloped vertical concrete wall	30	Every 2-3	Every 5
Rectangular concrete channel	50	Every 2-3	Every 5
Trapezoidal concrete channel	50	Every 2-3	Every 5

6.7.3.3 Unit Costs for Alternative Development

The District will develop a current list of unit costs to use as part of alternative cost estimation. Unit cost items will be developed by the District and evaluated annually to determine if updates are required. In addition to the list of unit costs, the District will also establish consistent markups for items such as mobilization, engineering, and contingencies. Unless a customized or site-specific approach to include these costs is approved by the District, standard unit cost items and markups will be used for DWP alternative development to provide for consistency during the countywide prioritization of projects.

6.7.3.4 Calculating Benefit-to-Cost Ratio

Once the average annual benefits (AA_B) and average annual cost (AA_C) have been estimated, the BC ratio is computed using the formula:

$$BC = \frac{AA_B}{AA_C}$$

where:

AA_B = the average annual benefit
AA_C = the average annual costs

Note that the BC ratio can also be computed using benefits and costs expressed as present values:

$$BC = \frac{PV_B}{PV_C}$$

where:

PV_B = the present value of the benefits
PV_C = the present value of the costs

The BC ratio will be used to evaluate whether a project is cost-effective. If the BC ratio is greater than one, the project benefits exceed the costs and the project can be considered cost-effective. Other factors may be considered that would favor a project that did not have a BC ratio greater than one.

Similarly, the net benefits of the project are equal to:

$$NB = PV_B - PV_C$$

If the net benefits are positive, the project is cost-effective and the BC ratio greater than one.

6.7.4 Alternative Selection for Problem Area

As stated previously, the District is required to consider the BC ratio when selecting projects for implementation. In addition the District will consider noneconomic criteria in selecting alternatives. All projects which meet the District's absolute requirements for capital project funding will be prioritized on a countywide basis, with final decision for funding made at the discretion of the District's Board of Commissioners.

6.8 Summary of Recommended Alternatives

Recommended projects will be summarized to describe the economic and noneconomic data to be used as a part of the District's countywide prioritization of improvements. The economic data will focus on the BC ratio defined for each problem area, consistent with the documentation provided in Sections 6.6 and 6.7. Noneconomic data to be developed for each project are summarized in Section 6.8.1.

Exhibit 6.1 depicts the documentation that will be prepared as a part of each DWP to support the countywide prioritization of projects. Only alternatives that meet the District's minimum criteria for funding (see Chapter 1) will be developed and evaluated. For each project that meets the minimum criteria, a BC analysis will be developed, as will information on the development of noneconomic data. That information will be summarized in a manner consistent with what is shown in Exhibit 6.1 for incorporation into the District's countywide prioritization of improvement projects. Note that all costs and net benefits shown in Exhibit 6.1 shall be expressed as present values.

6.8.1 Other Noneconomic Evaluation Criteria

In addition to the BC ratio, the following information will be compiled for the District to use as a part of the countywide prioritization of projects:

- Total cost to the District
- Area (in acres) removed from the floodplain
- Number of structures protected
- Probability that funding will be provided by outside agencies (identify funding source, and percent of project to be funded, if known)
- Implementation time (in months)
- Water quality benefit, based on the qualitative scale described in Section 6.8.2
- Cook County communities involved
- Wetland or riparian area protected (ac)

6.8.2 Water Quality Benefit

To determine the water quality benefit of a flood control or erosion control project, the following questions must be addressed:

- Does the project contribute to the implementation of a TMDL established for the watershed?
- Does the project improve water quality concerns identified as a part of an NPDES Phase II Stormwater Permit?
- Does the project improve water quality related to a pollutant or pollution identified in the state's 303(d) Report?
- Does the project have an effect on habitat?

Once these questions are addressed, water quality benefit will be evaluated qualitatively using the scale in Table 6.20.

Table 6.20 Water Quality Benefit Evaluation Scale

Rating	Description
No Impact	No notable impact on water quality.
Slightly Positive	Project partly addresses or affects an NPDES Phase II Stormwater Permit, a TMDL established for the watershed, violations in water quality standards or listing criteria, or habitat.
Positive	Project fully addresses or impacts an NPDES Phase II Stormwater Permit, a TMDL established for the watershed, violations in water quality standards or listing criteria, or habitat.

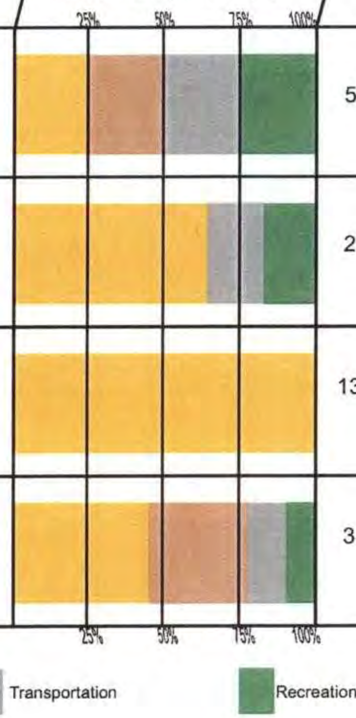
6.9 Implementation Plan

Each DWP will include an implementation plan that identifies issues critical to implementation of watershed recommendations. The recommendations will include stormwater improvement projects to address watershed problems, data management needs and responsibilities, special coordination requirements identified as a part of DWP development, scheduled updates to DWPs, and any other issues identified as critical to the District.

Exhibit 6-1 Example CIP Prioritization Matrix

Metropolitan Water Reclamation District of Greater Chicago
Example Prioritization Matrix

	B/C Ratio	Total Benefits ($)	Total Project Cost ($)	Total Cost To MWRDGC ($)	Relative Damage Averted (%)	Area Removed from Floodplain (ac)	Wetland or Riparian Area Protected (ac)	Number of Structures Protected	Possibility of Funding Provided by Outside Agencies	Implementation Time (months)	Water Quality Benefit	Communities Involved
Project A	1.25	5.0 M	4.0 M	3.2 M		5.0	40	6	Very Likely	6	Positive	Oak Park Berwyn Cicero
Project B	2.5	7.5 M	3.0 M	3.0 M		2.6	8	10	Not Likely	28	Slightly Positive	Park Ridge Des Plaines Mount Prospect
Project C	1.2	12.0 M	10.0 M	7.8 M		13.0	0	50	Somewhat Likely	3	No Impact	Oak Lawn Chicago Ridge
Project D	1.0	15.0 M	15.0 M	14.0 M		3.9	15	25	Not Likely	24	Slightly Postive	Buffalo Grove Wheeling Des Plaines Mount Prospect Prospect Heights



Note: This prioritization matrix may be expanded to include additional non-economic criteria. All values are hypothetical and for demonstration purposes only.

North Branch of the Chicago River SCS Curve Number Generation

This technical memorandum describes HDR's approach for generating SCS Curve Number data for the watersheds comprising the North Branch of the Chicago River (herein referred to as the "North Branch").

1. Approach

Previous approaches for Detailed Watershed Plan (DWP) SCS curve number generation are the "Calumet-Sag Watershed SCS Curve Number Generation" technical memorandum[a] authored by CH2M Hill (dated August 14, 2007 and herein referred to as the "CH2M Hill Memo") and "Comments on CH2MHill Curve Numbers"[b] email authored by CTE (dated September 14, 2007 and herein referred to as the "CTE email"). HDR will incorporate these approaches, with the following changes or refinements:

- The use of an additional Natural Resources Conservation Service (NRCS) soil survey for the City of Chicago;
- Analysis of the affects of minor soil types;
- Review and revisions of land use information;
- Use of existing remote sensing datasets to estimate impervious areas;
- GIS dataset preparation.

2. NRCS Soil Survey

The CH2M Hill Memo noted that NRCS soils datasets covered portions of the watersheds but did not include the City of Chicago. In place of this, the CH2M Hill Memo recommended assuming a uniform hydrologic soil group (HSG) of "C", representing moderately high runoff potential soils. The NRCS provides two types of soil datasets for the area. One type is the Soil Survey Geographic, or SSURGO, dataset[c]. The SSURGO dataset is available for select areas and is a detailed soil survey. The City of Chicago is not included in the SSURGO dataset, although portions of the North Branch upper basin are included.

A second type of soils dataset developed by the NRCS is the U.S. General Soil Map (formerly the State Soil Geographic dataset), also known as STATSGO or STATSGO2[d]. STATSGO is more general than SSURGO and is based on a wide range of available soil literature. The City of Chicago and portions of the North Branch lower basin are mapped in the STATSGO dataset. Figure 1 shows combined SSURGO and STATSGO soils information for the North Branch. The SSURGO dataset areas in the upper basin (the Skokie River, Upper North Branch, and a portion of the West Fork) are at a smaller, more refined scale than STATSGO. While SSURGO is the

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[a] pw://pwappoma001:NorthCentral_Omaha/Documents/D{6758c9b5-6371-46df-b1c9-ebcb8deb7223}
[b] pw://pwappoma001:NorthCentral_Omaha/Documents/D{8a9f643d-bd6c-496d-b4c7-c6e97ea73e08}
[c] http://soils.usda.gov/survey/geography/ssurgo/
[d] http://soils.usda.gov/survey/geography/statsgo/

preferred dataset, the additional use of STATSGO in the lower basin shows soils with HSG ranging from “A” (low runoff potential) to “C” (moderately high runoff potential). The STATSGO soil dataset will be used to supplement SSURGO data, rather than assuming a uniform soil type.

3. Minor Soil Types

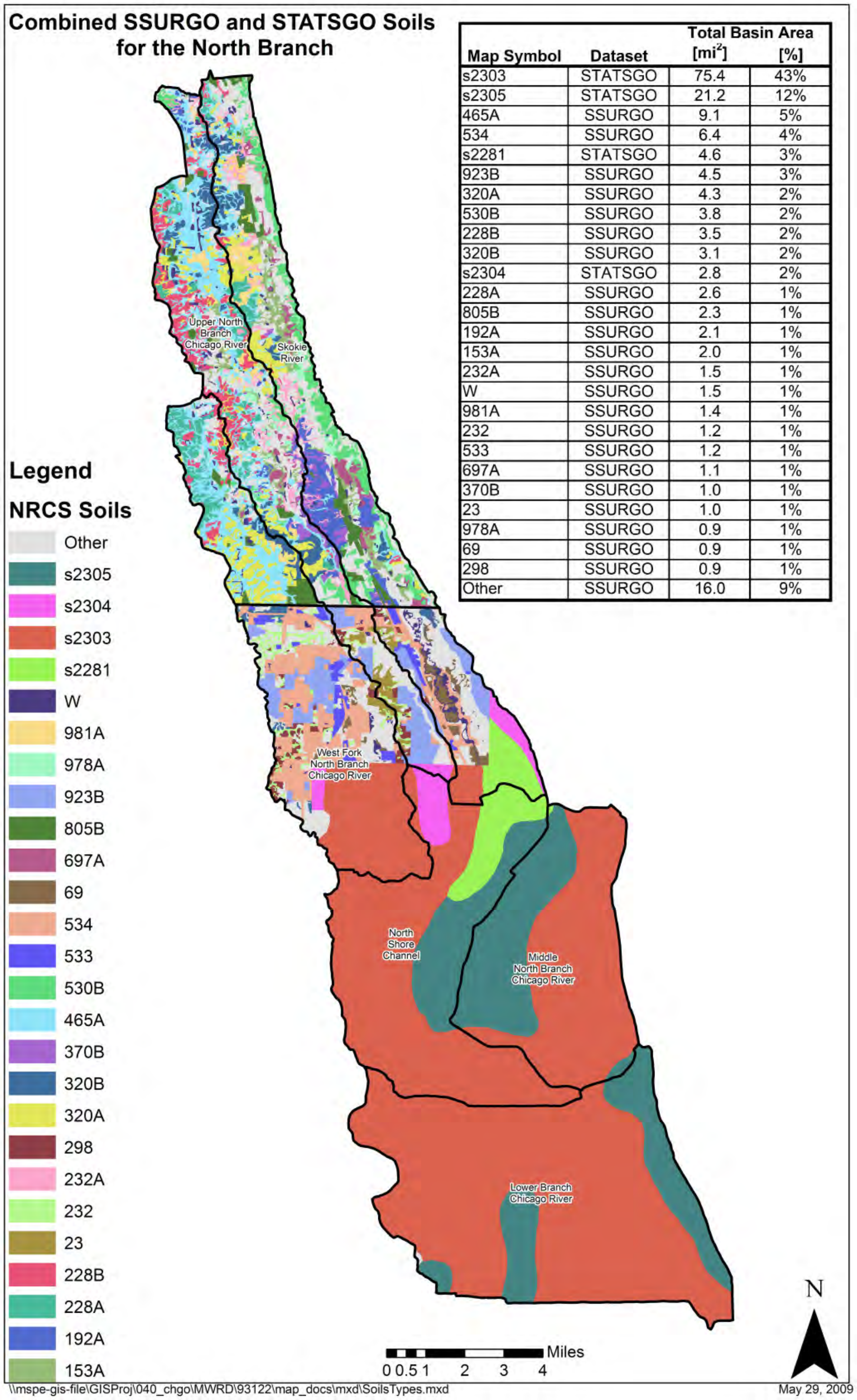
The HSG designations of soils within the North Branch watershed are a key input to hydrologic modeling. Within each SSURGO or STATSGO GIS database, the NRCS has developed polygons (map units) that group soils. NRCS states:

> ***Map Unit Delineations are closed polygons that may be dominated by a single soil or miscellaneous area component plus allowable similar or dissimilar soils, or they can be geographic mixtures of groups of soils or soils and miscellaneous areas.***[e]

This does not mean that each map unit represents a homogenous (that is, the same) soil type. Instead, there may be multiple soil types (called soil components) occurring within a given map unit. The map unit is a common geographic feature that can potentially contain many different types of soils.

In most cases, each map unit will have a single HSG designation. This occurs when a single soil component is predominant (generally making up 90% or more of the map unit) or when the multiple soil components all have the same or similar HSG characteristic. The default soil database query will select this predominant HSG classification for use in hydrologic modeling. There can be cases where there are significant soil variations that require further examination to determine a proper HSG classification.

[e] Metadata for Soil Survey Geographic (SSURGO) database for Cook County, Illinois, March 2007.



Map Symbol	Dataset	Total Basin Area [mi^2]	[%]
s2303	STATSGO	75.4	43%
s2305	STATSGO	21.2	12%
465A	SSURGO	9.1	5%
534	SSURGO	6.4	4%
s2281	STATSGO	4.6	3%
923B	SSURGO	4.5	3%
320A	SSURGO	4.3	2%
530B	SSURGO	3.8	2%
228B	SSURGO	3.5	2%
320B	SSURGO	3.1	2%
s2304	STATSGO	2.8	2%
228A	SSURGO	2.6	1%
805B	SSURGO	2.3	1%
192A	SSURGO	2.1	1%
153A	SSURGO	2.0	1%
232A	SSURGO	1.5	1%
W	SSURGO	1.5	1%
981A	SSURGO	1.4	1%
232	SSURGO	1.2	1%
533	SSURGO	1.2	1%
697A	SSURGO	1.1	1%
370B	SSURGO	1.0	1%
23	SSURGO	1.0	1%
978A	SSURGO	0.9	1%
69	SSURGO	0.9	1%
298	SSURGO	0.9	1%
Other	SSURGO	16.0	9%

Figure 1. Combined SSURGO and STATSGO Soils for the North Branch

As an example, consider the soil report for map unit 989A in Figure 2. The Elliot soil component is HSG "C" and makes up 45% of the map unit, while the Mundelein soil is HSG "B" and makes up an additional 45% of the map unit. The remaining 10% of the map unit is split between two other soil components (Ashkum and Pellla) of HSG C and B respectively. As a map unit is the basic descriptive area, there is no further additional information within GIS that indicates the distribution of the B and C HSG soils. The default GIS query is to report the map unit as HSG C, only because the Elliot soil appears before the Mundelein soil in the database.

A technique is required to determine a single HSG for each map unit. The goal of the technique is to 1) improve hydrologic modeling accuracy by weighting the aggregate HSG in favor of a predominant value, and 2) to provide consistent and defensible HSG classifications.

RUSLE2 Related Attributes

Lake County, Illinois

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
989A:							
Elliott	45	C	.24	4	8.1	66.9	25.0
Mundelein	45	B	.28	5	9.0	67.5	23.5
Ashkum	---	C	.20	5	8.0	55.0	37.0
Pella	---	B	.24	5	9.0	60.0	31.0

Figure 2. Example NRCS Soil Map Unit

In classifying a HSG for a given soil, the NRCS uses various soil parameters as documented in Chapter 7 of the Hydrology chapter in the National Engineering Handbook (NRCS, May 2007). Essentially, two parameters are used in HSG classification: 1) the depth to a water impermeable layer, such as clay or bedrock, or high water table; and 2) the most restrictive saturated hydraulic conductivity within the first 40 inches of the soil column. Figure 3 provides the decision matrix used in HSG classification.

The first step in the HSG assignment is to determine if the water impermeable layer or high water table is less than 40 inches from the surface. This information can be obtained from the NRCS soil database "Soil Features" and "Water Features" reports, or as a narrative from the "Map Unit Description" report. When the Map Description Report for map unit 989A is reviewed (Figure 4), the Elliot soil has root restrictive layer of approximately less than 40 inches.

The soil also has a water table for more than one month of the year at a depth of less than 40 inches. The Mundelein soil root restrictive depth is more than 60 inches but has a high water table of less than 40 inches. The NRCS Table 7-1 criteria are applied for both soils.

Table 7–1 Criteria for assignment of hydrologic soil groups when a water impermeable layer exists at a depth between 50 and 100 centimeters [20 and 40 inches]

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>40.0 μm/s (>5.67 in/h)	≤40.0 to >10.0 μm/s (≤5.67 to >1.42 in/h)	≤10.0 to >1.0 μm/s (≤1.42 to >0.14 in/h)	≤1.0 μm/s (≤0.14 in/h)
	and	and	and	and/or
Depth to water impermeable layer	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	<50 cm [<20 in]
	and	and	and	and/or
Depth to high water table	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	<60 cm [<24 in]

Table 7–2 Criteria for assignment of hydrologic soil groups when any water impermeable layer exists at a depth greater than 100 centimeters [40 inches]

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>10 μm/s (>1.42 in/h)	≤10.0 to >4.0 μm/s (≤1.42 to >57 in/h)	≤4.0 to >0.40 μm/s (≤0.57 to >0.06 in/h)	≤0.40 μm/s (≤0.06 in/h)
	and	and	and	and/or
Depth to water impermeable layer	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]
	and	and	and	and/or
Depth to high water table	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]

Figure 3. NRCS HSG Classification Criteria

Map Unit Description (Brief, Generated)

Lake County, Illinois

[Minor map unit components are excluded from this report]

Map unit: 989A - Mundelein and Elliott silt loams, 0 to 2 percent slopes

Component: Elliott (45%)

The Elliott component makes up 45 percent of the map unit. Slopes are 0 to 2 percent. This component is on ground moraines. The parent material consists of Thin mantle of loess or other silty material and in the underlying till. Depth to a root restrictive layer, densic material, is 20 to 45 inches. The natural drainage class is somewhat poorly drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. A seasonal zone of water saturation is at 16 inches during January, February, March, April, May. Organic matter content in the surface horizon is about 4 percent. Nonirrigated land capability classification is 2w. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 7 percent.

Component: Mundelein (45%)

The Mundelein component makes up 45 percent of the map unit. Slopes are 0 to 2 percent. This component is on lake plains. The parent material consists of Loess or other silty material and in the underlying outwash. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is somewhat poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. A seasonal zone of water saturation is at 18 inches during January, February, March, April, May. Organic matter content in the surface horizon is about 4 percent. Nonirrigated land capability classification is 1. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent.

Figure 4. Example NRCS Map Unit Description Report

Next, the range of most restrictive saturated hydraulic conductivity is determined. The most restricted layer is the layer having the lowest saturated hydraulic conductivity. Based on NRCS criteria only the first 40 inches of the soil profile are considered, regardless of the depth to the impermeable layer. This information is provided in the NRCS "Physical Soil Properties" report. Figure 5 shows an example report for map unit 989A. The most restricted saturated hydraulic conductivity for the Elliot soil is 0.42 to 4.23 µm/sec with a midpoint value of 2.32 µm/sec. For Mundelien it is 4.23 to 14.11 µm/sec, with a midpoint value of 9.17 µm/sec.

Physical Soil Properties

Lake County, Illinois

[Entries under "Erosion Factors--T" apply to the entire profile. Entries under "Wind Erodibility Group" and "Wind Erodibility Index" apply only to the surface layer. Absence of an entry indicates that data were not estimated]

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensi-bility	Organic matter	Erosion factors			Wind erodi-bility group	Wind erodi-bility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
989A:														
Elliott	0-6	2-15	58-78	20-27	1.25-1.45	4.23-14.11	0.22-0.24	0.0-2.9	3.5-5.0	.24	.24	4	6	48
	6-11	2-15	50-71	27-35	1.20-1.40	4.23-14.11	0.19-0.22	3.0-5.9	2.5-4.0	.20	.20			
	11-16	1-20	30-61	40-50	1.40-1.60	0.42-4.23	0.10-0.13	6.0-8.9	0.5-1.5	.32	.32			
	16-41	5-20	40-65	27-40	1.50-1.70	0.42-4.23	0.14-0.18	3.0-5.9	0.1-0.5	.37	.37			
	41-60	5-20	45-65	27-35	1.70-1.90	0.42-1.41	0.05-0.10	0.0-2.9	0.0-0.5	.43	.43			
Mundelein	0-17	0-15	58-80	20-27	1.15-1.30	4.23-14.11	0.22-0.24	0.0-2.9	3.0-5.0	.28	.28	5	6	48
	17-31	0-15	50-75	25-35	1.20-1.45	4.23-14.11	0.18-0.20	3.0-5.9	0.5-2.0	.37	.37			
	31-42	10-60	10-75	15-30	1.40-1.55	4.23-14.11	0.12-0.18	0.0-2.9	0.2-0.5	.32	.32			
	42-60	10-87	2-80	5-25	1.50-1.70	4.23-42.34	0.05-0.15	0.0-2.9	0.0-0.2	.28	.28			

Figure 5. Example NRCS Physical Soil Properties Report

Referring to NRCS Table 7-1, the saturated hydraulic conductivity of the Elliot soil partially falls into the HSG C and D range and Mundelien falls into HSG B and C. A weighted saturated hydraulic conductivity using each soils' midpoint values and the percent of map unit is calculated. For the map unit 989A example this is:

$$[(0.45 * 2.32\ \mu m/sec) + (0.45 * 9.17\ \mu m/sec)] / (0.45 + 0.45) = 5.74\ \mu m/sec$$

The weighted value in this case falls into HSG C. The map unit is characterized as HSG C indicating that under the high water table conditions both soils are closer to a HSG C than HSG B.

When a soil component is classified as a drained and undrained HSG[f], this approach will be applied to both cases. The first weighted average will include the drained component assuming that the water table and impermeable layer is more than 40 inches from the surface. The second weighted average will use the undrained component assuming that the water table and impermeable layer is less then 40 inches. This will produce a weighted HSG classification with drained and undrained elements.

Figure 6 provides a flowchart illustrating the weighting approach.

[f] For example, a B/D HSG classification indicates the soil acts as HSG B under drained conditions and HSG D under undrained conditions.

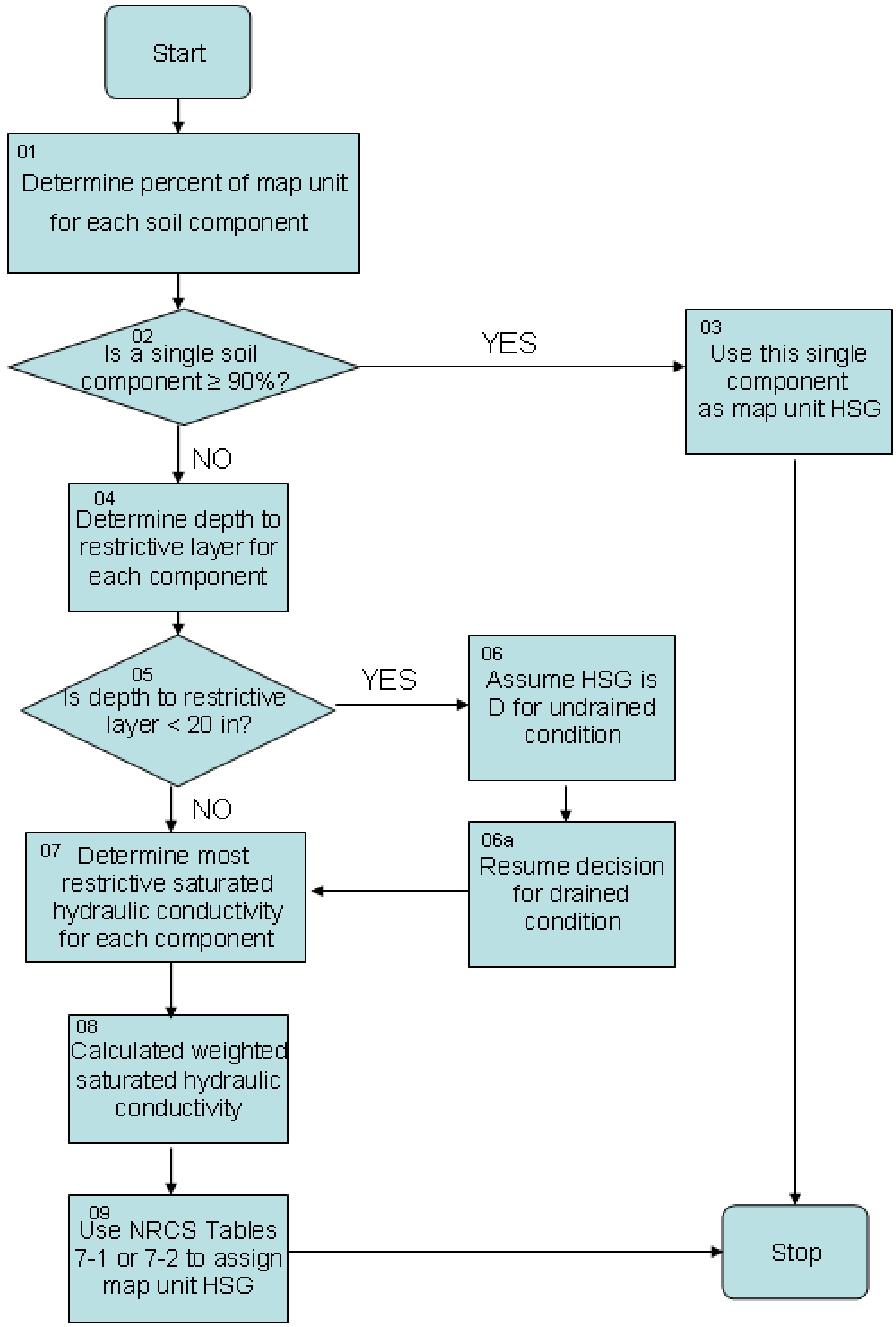


Figure 6 - HSG Weighting Flowchart

Based on this weighting approach, HDR reviewed and weighted the HSG for soil map units within the North Branch watershed. The NRCS map units in Table 1 were adjusted. Figure 7 and Figure 8 provide the HSG classifications over the North Branch basin for drained and undrained conditions, respectively.

Table 1. Adjusted Soil HSG Based on Multiple Soil Components

Map Unit	Original HSG	Adjusted based on Soil Components	
		Drained HSG	Undrained HSG
840B	B and C	C	C
840C2	C and B	C	C
923B	C and B/D	C	C
924	B/D and C	C	C
925B	C and D	D	D
926B	B/D and B	B	C
978A	C and B	C	C
978B	C and B	C	C
979A	B and C	C	C
979B	B and C	C	C
981A	B and D	C	C
981B	B and D	C	C
982A	B and D	C	C
982B	B and D	C	C
983B	B and D	C	C
989A	C and B	C	C
s2247	B/D and B	B	C
s2279	C and D	D	D
s2281	C and B/D	C	C
s2303	B/D and C	B	C
s2304	C and B/D	C	C
s2305	A and B/D	A	B

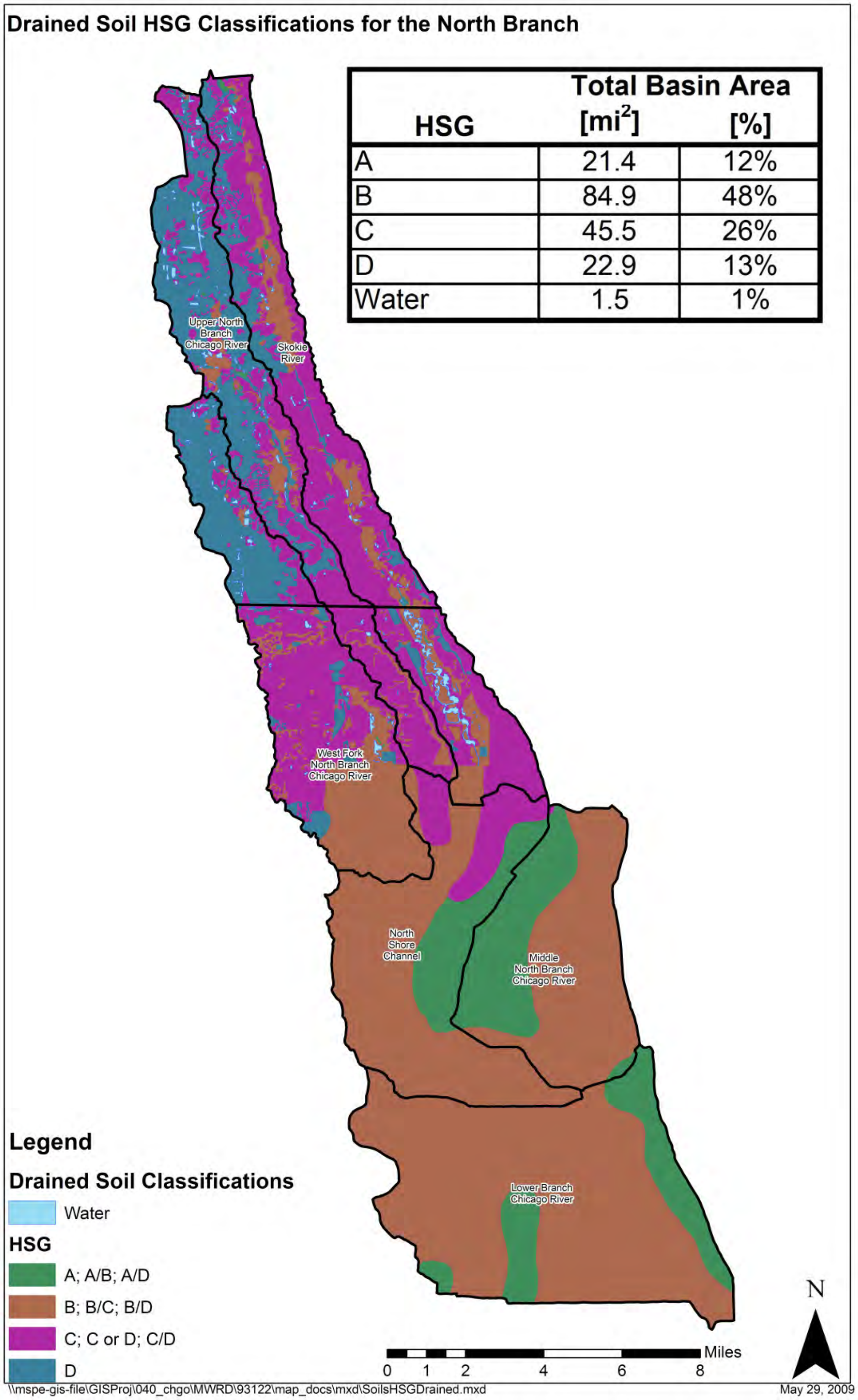


Figure 7. Drained Soil Classifications

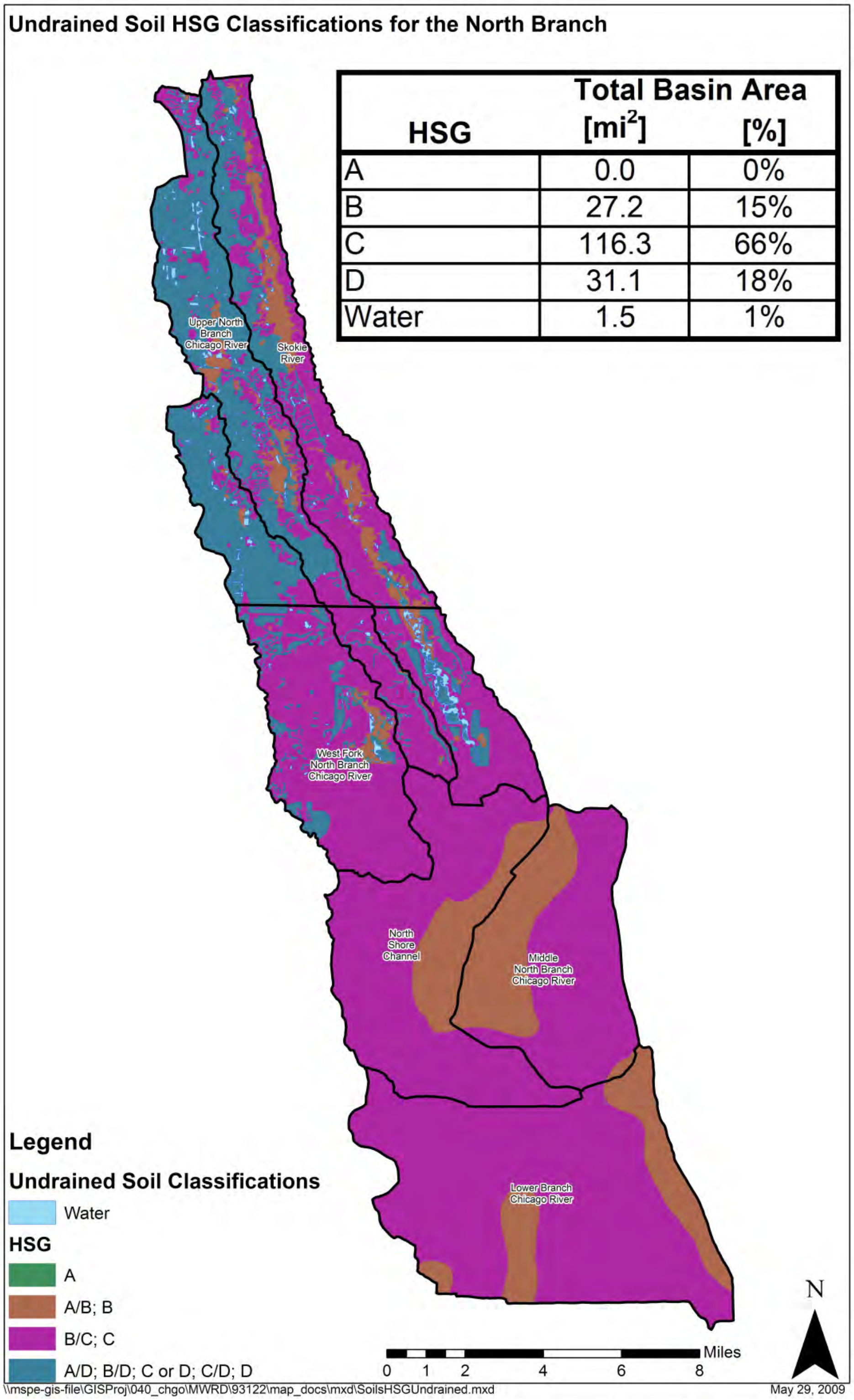


Figure 8. Undrained soil classifications

4. Land Use Information

The primary land use information used by HDR is the 2001 Land-use Inventory published by the Chicago Metropolitan Agency for Planning (CMAP), which was formerly the Northeastern Illinois Planning Commission (NIPC). CMAP publishes spatial land use information every five years, with the 2001 data (published May 2006) being the most recent at the time of this writing[g].

The CMAP dataset was developed at a scale of 1:24,000. The dataset was compiled using a variety of reference sources, including aerial photographs, georeferenced plat books, commercial datasets of shopping and manufacturing areas, and state, county, and city natural resources databases. Each area in this dataset is coded with a number representing type of land use. The overall classes of land use are:

- 1100 Series - Residential
- 1200 Series - Commercial and Services
- 1300 Series - Institutional
- 1400 Series - Industrial, Warehousing and Wholesale Trade
- 1500 Series - Transportation, Communication, and Utilities
- 2000 Series - Agricultural Land
- 3000 Series - Open Space
- 4000 Series - Vacant, Wetlands, or Under Construction
- 5000 Series - Water

A visual review of the CMAP dataset was performed by comparing the 2001 landuse data to 2007 aerial imagery[h]. Any land use data not matching the aerial information was revised to accurately represent land use conditions throughout the watershed. HDR found many parcels coded in the 4200 series (residential construction) that have since been developed to the 1100 series (residential). There were also some parcels in the 2000 series (agricultural) that appeared to be miscoded or subsequently developed. These were changed to various different land use types including residential, open space, retail center, and golf course. Table 2 summarizes the revised land uses made by HDR to the CMAP dataset. The total adjusted area amounts to 3.0 mi^2, or approximately 1.5% of the basin area. Table 3 summarizes the total land uses in the basin based on 2007 data, while Figure 9 maps this land use data.

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[g] 2005 land use data was published by CMAP on January 2009. However, HDR had already updated the 2001 data to 2007 conditions by this time.

[h] USDA-FSA Aerial Photography Field Office, File "ortho_1-1_1n_il031_2007_1", Published August 23, 2007.

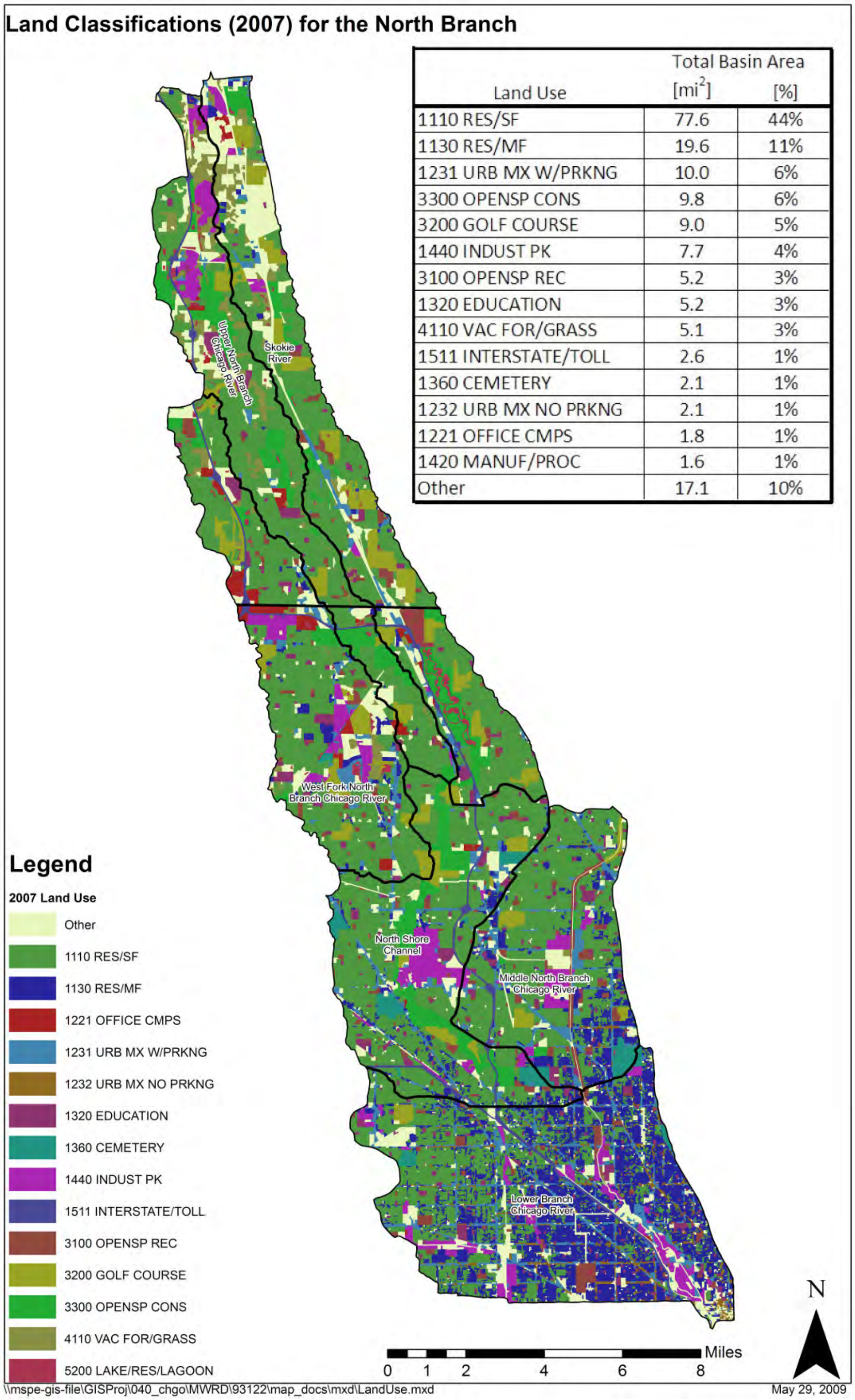
Table 2. HDR Revised Land Uses (Subset of CMAP dataset)

Revised Land Use		Revised Basin Area
As of 2001	**As of 2007**	**[mi^2]**
1110 (RES/SF)	3100 (OPENSP REC)	0.002
1350 (RELIGOUS)	1110 (RES/SF)	0.037
1520 (OTH LINEAR TRAN)	1223 (BUS. PARK)	0.008
2100 (CROP...)	1211 (MALL)	0.069
3100 (OPENSP REC)	1110 (RES/SF)	0.055
	1130 (RES/MF)	0.007
	1222 (SINGL OFFICE)	0.006
	1223 (BUS. PARK)	0.002
	3500 (OPENSP LINEAR)	0.019
3300 (OPENSP CONS)	1221 (OFFICE CMPS)	0.016
	1440 (INDUST PK)	0.011
4110 (VAC FOR/GRASS)	1110 (RES/SF)	0.184
	1130 (RES/MF)	0.011
	1212 (RETAIL CNTR)	0.026
	1221 (OFFICE CMPS)	0.220
	1222 (SINGL OFFICE)	0.003
	1223 (BUS. PARK)	0.033
	1231 URB MX W/PRKNG	0.003
	1430 (WAREH...)	0.044
	1440 (INDUST PK)	0.078
	1520 (OTH LINEAR TRAN)	0.011
	1540 (AUTO PRK)	0.016
	4210 (CONST RES)	0.049
4210 (CONST RES)	1110 (RES/SF)	0.599
	1130 (RES/MF)	0.222
	1222 (SINGL OFFICE)	0.079
	1232 (URB MX NO PRKNG)	0.006
4220 (CONST NONRES)	1130 (RES/MF)	0.048
	1221 (OFFICE CMPS)	0.215
	1222 (SINGL OFFICE)	0.066
	1223 (BUS. PARK)	0.191
	1231 (URB MX PRKNG)	0.255
	1232 (URB MX NO PRKNG)	0.006
	1440 (INDUST PK)	0.014
	3600 (OPENSP OTHER)	0.024
4300 (OTHER VACANT)	1110 (RES/SF)	0.018
	1130 (RES/MF)	0.072
	1211 (MALL)	0.060
	1212 (RETAIL CNTR)	0.028
	1221 (OFFICE CMPS)	0.012
	1222 (SINGL OFFICE)	0.045
	1223 (BUS. PARK)	0.020
	1231 (URB MX PRKNG)	0.014
	1232 (URB MX NO PRKNG)	0.006
	1320 EDUCATION	0.002
	1440 (INDUST PK)	0.087
	1540 (AUTO PRK)	0.014
	3600 (OPENSP OTHER)	0.030

Table 3. Land Uses (2007) in the North Branch Basin

Code	Description	Total Basin Area	
		[mi^2]	[%]
1100 Series	RESIDENTIAL		
1110	Single, Duplex and Townhouse Units	77.6	44%
1120	Farmhouse	<0.1	<1%
1130	Multi-Family	19.6	11%
1140	Mobile Home Parks and Trailer Courts	0.1	<1%
1200 Series	COMMERCIAL AND SERVICES		
1211	Shopping Malls	0.3	<1%
1212	Retail Centers	1.1	1%
1221	Office Campus/Research Park	1.8	1%
1222	Single-Structure Office Building	1.1	1%
1223	Business Park	1.2	1%
1231	Urban Mix With Dedicated Parking	10.0	6%
1232	Urban Mix, No Dedicated Parking	2.1	1%
1240	Cultural and Entertainment	0.8	<1%
1250	Hotel/Motel	0.2	<1%
1300 Series	INSTITUTIONAL		
1310	Medical and Health Care Facilities	1.0	1%
1320	Educational Facilities	5.2	3%
1330	Governmental Administration and Services	1.3	1%
1340	Prison and Correctional Facilities	n/a	n/a
1350	Religious Facilities	1.4	1%
1360	Cemeteries	2.1	1%
1370	Other Institutional	0.2	0%
1400 Series	INDUSTRIAL, WAREHOUSING AND WHOLESALE TRADE		
1410	Mineral Extraction	0.1	<1%
1420	Manufacturing and Processing	1.6	1%
1430	Warehousing/Distribution Center and Wholesale	0.7	<1%
1440	Industrial Park	7.7	4%
1500 Series	TRANSPORTATION, COMMUNICATION, AND UTILITIES		
1510 Series	Automotive Transportation	3.0	1%
1520	Other Linear Transportation with Associated Facilities	1.1	1%
1530	Aircraft Transportation		
1540	Independent Automobile Parking	0.2	<1%
1550	Communication	<0.1	<1%
1560	Utilities and Waste Facilities	1.1	1%
2000 Series	AGRICULTURAL LAND		
2100	Row Crops, Grains, And Grazing	1.4	1%

Code	Description	Total Basin Area	
		[mi²]	[%]
2200	Nurseries, Greenhouses, Orchards, Tree Farms And Sod Farms	0.2	0%
2300	Agricultural, Other	n/a	n/a
3000 Series	OPEN SPACE		
3100	Open Space, Primarily Recreation	5.2	3%
3200	Golf Courses	9.0	5%
3300	Open Space, Primarily Conservation, Including Forest Preserves And Nature Preserves	9.8	6%
3400	Hunting Clubs, Scout Camps, And Private Campgrounds	0.1	<1%
3500	Linear Open-Space Corridors	0.2	<1%
3600	Other Open Space	0.1	<1%
4000 Series	VACANT, WETLANDS, OR UNDER CONSTRUCTION		
4110	Vacant Forest and Grassland	5.1	3%
4120	Wetlands Greater Than 2.5 Acres	0.9	1%
4210	Under Construction, Residential	0.1	<1%
4220	Under Construction, Non-Residential	<0.1	<1%
4300	Other Vacant	<0.1	<1%
5000 Series	WATER		
5100	Rivers, Streams, and Canals	0.4	<1%
5200	Lakes, Reservoirs, and Lagoons	1.3	1%
5300	Lake Michigan	<0.1	<1%



Land Use	Total Basin Area [mi^2]	[%]
1110 RES/SF	77.6	44%
1130 RES/MF	19.6	11%
1231 URB MX W/PRKNG	10.0	6%
3300 OPENSP CONS	9.8	6%
3200 GOLF COURSE	9.0	5%
1440 INDUST PK	7.7	4%
3100 OPENSP REC	5.2	3%
1320 EDUCATION	5.2	3%
4110 VAC FOR/GRASS	5.1	3%
1511 INTERSTATE/TOLL	2.6	1%
1360 CEMETERY	2.1	1%
1232 URB MX NO PRKNG	2.1	1%
1221 OFFICE CMPS	1.8	1%
1420 MANUF/PROC	1.6	1%
Other	17.1	10%

Figure 9. Map of Land Uses in the North Branch Basin

5. Imperviousness Estimate

Past storm-water management studies in the Chicago area have used remotely sensed data for estimating imperviousness.[i] An impervious dataset is available through the National Land Cover Database (NLCD)[j]. The impervious datasets use the LandSat ETM+ satellites with a classification algorithm to derive percent impervious data for a 30 meter size cell. Research has indicated that the correlation between the remotely sensed impervious data and measured is between 0.82 to 0.91 with a relative error of 8.8 to 11.4%[k].

HDR randomly selected nine parcels from the CMAP land use database to estimate the accuracy of the NLCD impervious data. Parcels were not selected if HDR identified a change in land use from 2001 to 2007. Parcels were selected based on two criteria: size and estimated imperviousness. The breakpoints between each classification were based on the statistical distribution of the parcels.

Parcels were grouped into the following sizes ranges:

- Small (less than 9 ac)
- Medium (9 to 62 ac)
- Large (more than 62 ac)

Impervious estimates were based on the NLCD data. Impervious criteria were:

- Low (less than 50% impervious area)
- Medium (between 50% and 80% impervious area)
- High (between 80% and 100% impervious area)

For each parcel, HDR estimated impervious area from the 2007 aerial image. Table 4 compares the measured and NLCD estimated impervious values. Figure 10 plots the measured errors for the sample parcels. The average error was -5% with a correlation of 0.88. The errors from the sample parcels appear to be random, with no apparent trend in errors as a function of parcel size or imperviousness.

The NLCD impervious dataset was intersected with the CMAP 2007 adjusted land use. Average and standard deviations of area-weighted imperviousness for each land use is provided in Table 5. Comparing these basin estimates with NRCS curve number guidance[l] shows a close fit. NRCS assumes 85% imperviousness for commercial and business district curve numbers; the GIS data

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[i] For example: The City of Chicago Green Infrastructure Mapping Program.

[j] USGS, “National Land Cover 2001 Database Zone 49 Imperviousness Layer”, published September 2003. Online at: http://www.mrlc.gov/nlcd.php

[k] Yang,Limin et al, "An approach for mapping large-area impervious surfaces: Synergistic use of Landsat 7 ETM+ and high spatial resolution imagery", USGS/Canadian Journal of Remote Sensing, <<date>>

[l] See section 6 of this memo.

estimates Malls (land use 1211) as 81% ± 13%; Retail Centers (land use 1212) as 81% ± 11%; and Urban Mix with no Parking (land use 1232) as 85 % ± 9%. NRCS assumes industrial areas are 72% impervious; the GIS dataset estimates Industrial Parks (land use 1440) as 74% ± 19%; Warehouses (land use1430) as 66% ± 19%; Manufacturing (land use 1420) as 79% ± 15%; and Urban Mix with Parking (land use 1231) as 76% ± 13%. Other types of open space land use also appear reasonable, such as golf courses (land use 3200) at 15% ± 13%.

Figure 11 maps the NLCD impervious dataset for the North Branch basin.

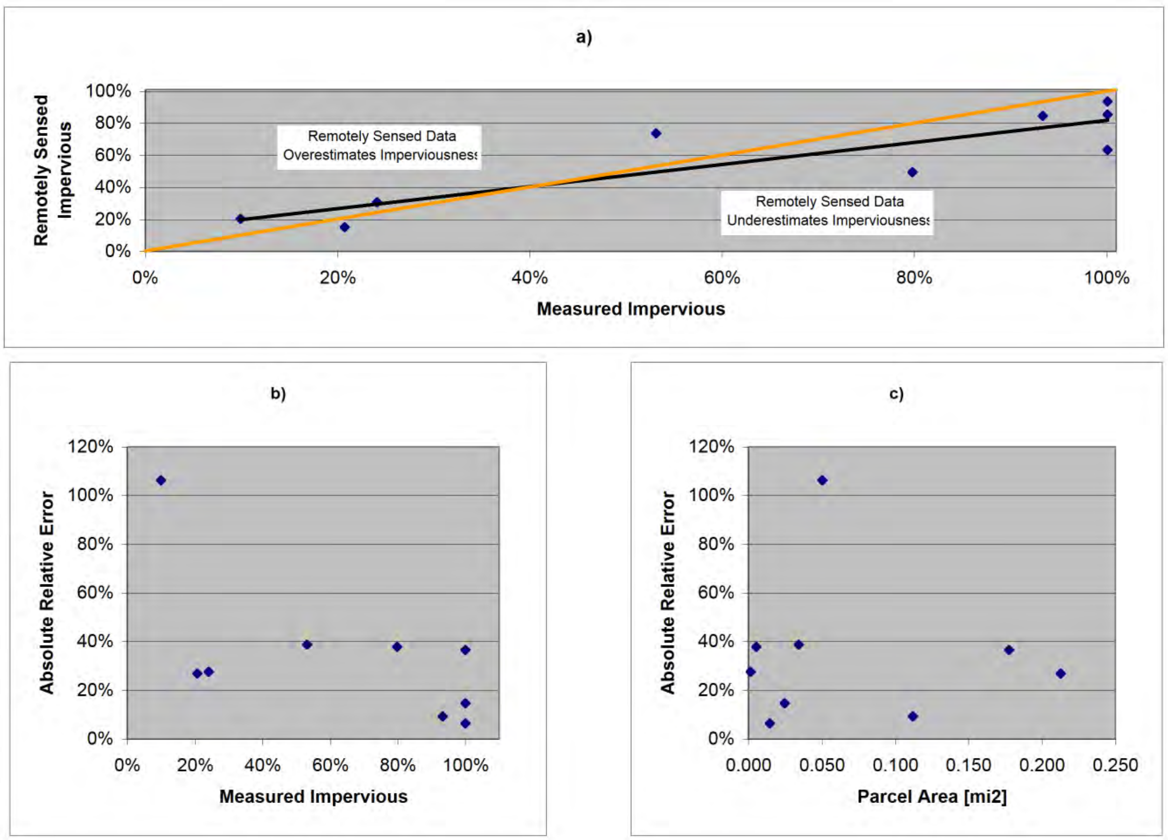


Figure 10. Impervious Measured versus Remotely Sensed Errors.

Notes:

Figure 10a. Measured versus Remotely Sensed Imperviousness

Figure 10b. Remotely Sensed Imperviousness error versus measured imperviousness.

Figure 10c. Remotely Sensed Imperviousness error versus parcel size.

Table 4. Measured and Remotely Sensed Imperviousness for Nine Parcels

Parcel		Categories		Impervious Area [%]		Error
ID	Description	Size	Imperviousness	Measured	NLCD	[%]
28303	Farm west of N Bradley Road and north of Indian Ridge Road	Small	Low	24%	31%	-28%
26334	Multifamily housing north of Dundee Rd and west of Pfingsten Rd	Small	Medium	80%	50%	38%
94604	Urban Mix south of W North Ave and east of W Grand Ave	Small	High	100%	94%	6%
24728	Vacant Grassland south of N Westmoreland Rd and east of N Waukegan Rd	Medium	Low	10%	21%	-106%
61875	Multifamily housing near N Claremount Ave and W Birchwood Ave	Medium	Medium	53%	74%	-39%
94854	Industrial Park near Hartland Ct and W Schubert Ave	Medium	High	100%	85%	15%
26480	Single family housing near E Onwentsia Rd and S Green Bay Rd	Large	Low	21%	15%	27%
56338	Single family housing near W Wellington Ave adn N Melvina Ave	Large	Medium	100%	63%	37%
44623	Industrial park near W Gross Point Rd and N Lehigh Ave	Large	High	93%	85%	9%

Notes:

Size: Small (less than 9 ac); Medium (9 to 62 ac); Large (more than 62 ac)

Impervious: Low (less than 50% impervious area); Medium (between 50% and 80% impervious area); High (between 80% and 100% impervious area)

Table 5. Area-Weighted Imperviousness by Land Use Category

Land Use	Total Area [mi^2]	Area-Weighted Imperviousness	
		Average [%]	StdDev [%]
1110 RES/SF	87.8	36	11
1120 RES/FARM	< 0.1	28	15
1130 RES/MF	24.0	65	14
1140 RES/MOBILE HM	0.1	55	17
1211 MALL	0.3	81	13
1212 RETAIL CNTR	1.2	81	11
1221 OFFICE CMPS	1.8	42	22
1222 SINGL OFFICE	1.2	62	18
1223 BUS. PARK	1.2	51	28
1231 URB MX W/PRKNG	11.2	76	13
1232 URB MX NO PRKNG	2.5	85	9
1240 CULT/ENT	1.1	46	19
1250 HOTEL/MOTEL	0.2	74	14
1310 MEDICAL	1.2	62	17
1320 EDUCATION	6.2	48	21
1330 GOVT	1.7	58	21
1350 RELIGOUS	1.7	50	14
1360 CEMETERY	2.5	26	14
1370 INST/OTHER	0.2	59	16
1410 MINERAL EXT	0.1	80	19
1420 MANUF/PROC	1.6	79	15
1430 WAREH/DIST/WHOL	0.7	66	19
1440 INDUST PK	7.8	74	19
1511 INTERSTATE/TOLL	2.6	63	19
1512 OTHER ROADWY	0.7	57	19
1520 OTH LINEAR TRAN	1.3	63	14
1540 INDEP AUTO PRK	0.3	79	10
1550 COMMUNICATION	<0.1	63	23
1560 UTILITIES/WASTE	1.1	53	23
2100 CROP/GRAIN/GRAZ	1.0	6	12
2200 NRSRY/GRNHS/ORC	0.2	22	18
3100 OPENSP REC	7.2	29	18
3200 GOLF COURSE	9.7	15	13
3300 OPENSP CONS	9.9	5	11
3400 OPENSP PRIVATE	0.2	20	13
3500 OPENSP LINEAR	0.3	38	12
3600 OPENSP OTHER	0.1	28	19
4110 VAC FOR/GRASS	5.2	15	14
4120 WETLAND	0.9	5	9
4210 CONST RES	<0.1	70	10
4300 OTHER VACANT	0.1	69	14

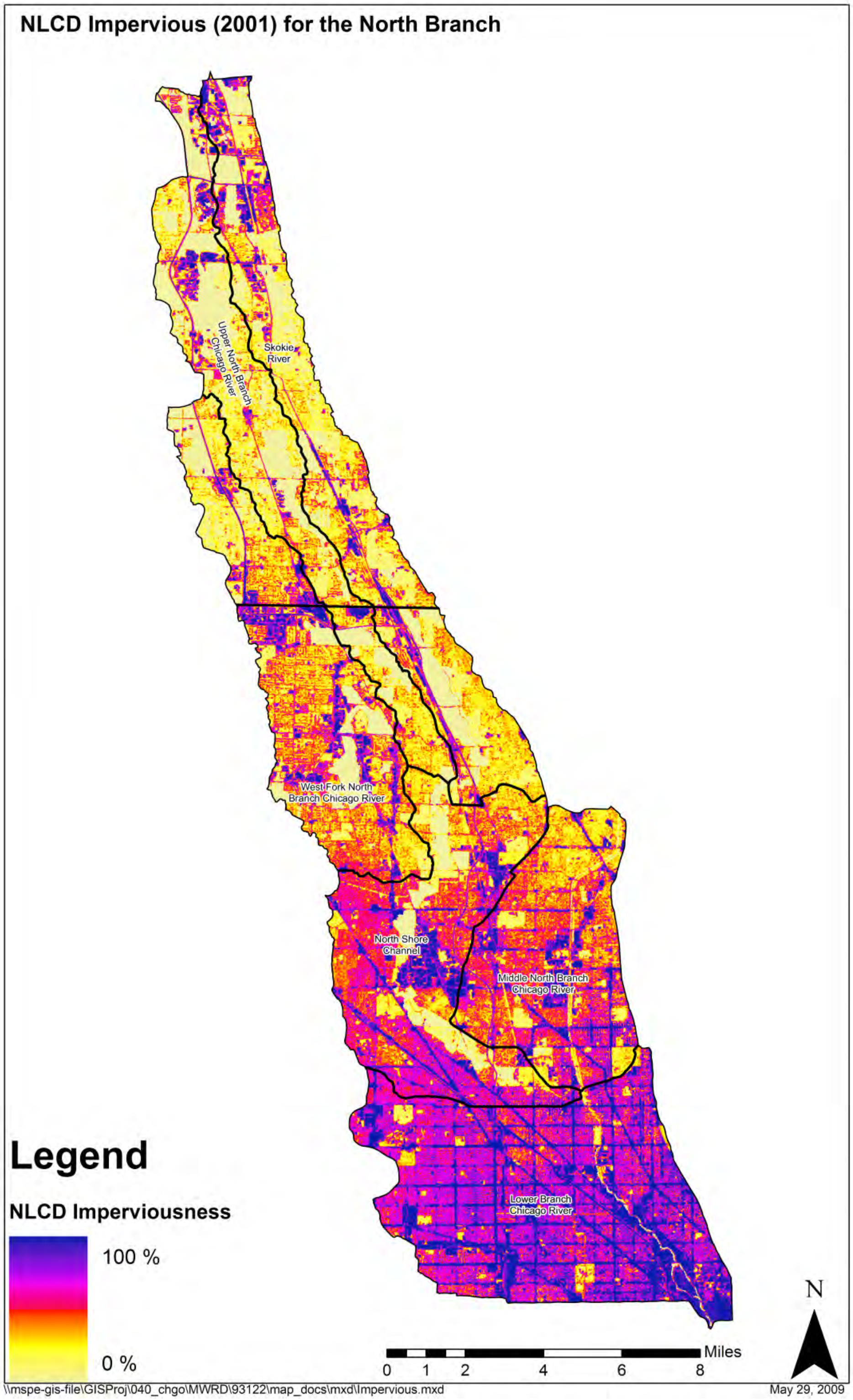


Figure 11. Impervious dataset for the North Branch

6. Curve Number Dataset Generation

NRCS has suggested curve numbers for a variety of land use types, hydrologic soil groups, and assumed conditions[m]. Figure 12 to Figure 14 shows the suggested curve numbers for agricultural and urban areas. Urban curve numbers are generally based on an adjustment of an open space condition based on the extent of impervious area. This adjustment given by:

$CN_c = CN_p + \left(\frac{P}{100}\right)\left(98 - CN_p\right)$ (Equation 1)

Where:

CN_c is the composite runoff curve number;

CN_p is the pervious runoff curve number, in this case the curve number for open space in a good hydrologic condition;

P is the percent imperviousness of an area.

For example, the curve number for a HSG C soil for open space (good condition) is 74. NRCS assumes that Commercial and Business land use has an average impervious area of 85%. To compute the curve number for this land use and a HSG C soil:

$$CN_c = 74 + \left(\frac{85}{100}\right)(98 - 74) = 94$$

This composite curve number is reported for the Commercial and Business land use for HSG C in Figure 14. As percent imperviousness approaches 100%, the curve number approaches 98.

HDR developed two GIS datasets of curve numbers based on either drained or undrained soil conditions shown in Figure 7 and Figure 8. The average impervious area for each type of land use (Table 5) was compared to NRCS assumed impervious areas to select a suggested set of curve numbers from Figure 14. Aerial photographs were also examined for assessing agricultural land uses or to refine hydrologic conditions for certain types of urban open space.

In some cases, land use types did not match a NRCS suggested set of curve numbers. A significant instance of this is residential land uses. The CMAP land use dataset generally defines residential areas on the basis of subdivisions and not individual homes. Further, a single family residential area could vary from a stand alone home with yard (with relatively low impervious area) to a condominium complex (with a relatively high impervious area). Institutional land uses, such as educational facilities, could vary from a relatively highly impervious single building and associated parking, to a campus containing open space, to a recreational facility mostly consisting of open space. In these cases, an open space condition with good grass cover was

[m] NRCS, “National Engineering Handbook, Part 630, Chapter 9 Hydrologic Soil-Cover Complexes”, July 2004.

assumed. The curve number was then adjusted based on Equation 1 using the remotely sensed average impervious area taken over each specific parcel.

Table 6 lists the approach used to calculate curve number for each land use. Figure 15 and Figure 16 show the resulting curve numbers for drained and undrained soil conditions, respectively.

Based on guidance documents provided in the CH2M Hill Memo, the final curve numbers will be the average between drained and undrained soil conditions. Figure 17 provides the average drained and undrained soil condition curve numbers. An average curve number from this latter dataset will be computed for each subbasin drainage area previously delineated by HDR. The Geo-HMS software will create final HEC-HMS model code which incorporates the curve number information.

Table 9–1 Runoff curve numbers for agricultural lands [1]

Cover description: cover type	treatment [2]	hydrologic condition [3]	CN for hydrologic soil group: A	B	C	D
Fallow	Bare Soil	---	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80

Figure 12. NRCS Suggested Curve Numbers for Cultivated Agricultural Lands

Table 9–1 Runoff curve numbers for agricultural lands 1/ — Continued

Cover description: cover type	treatment 2/	hydrologic condition 3/	CN for hydrologic soil group: A	B	C	D
Pasture, grassland, or range-continuous forage for grazing 4/		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		Good	30	58	71	78
Brush-brush-forbs-grass mixture with brush the major element 5/		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30 6/	48	65	73
Woods-grass combination (orchard or tree farm) 7/		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods 8/		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmstead--buildings, lanes, driveways, and surrounding lots		---	59	74	82	86
Roads (including right-of-way):						
Dirt		---	72	82	87	89
Gravel		---	76	85	89	91

1/ Average runoff condition, and $I_a = 0.2s$.

2/ Crop residue cover applies only if residue is on at least 5 percent of the surface throughout the year.

3/ Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥20%), and (e) degree of surface toughness.
Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better then average infiltration and tend to decrease runoff.
For conservation tillage poor hydrologic condition, 5 to 20 percent of the surface is covered with residue (less than 750 pounds per acre for row crops or 300 pounds per acre for small grain).
For conservation tillage good hydrologic condition, more than 20 percent of the surface is covered with residue (greater than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

4/ Poor: < 50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

5/ Poor: < 50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

6/ If actual curve number is less than 30, use CN = 30 for runoff computation.

7/ CNs shown were computed for areas with 50 percent woods and 50 percent grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

8/ Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed, but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Figure 13. NRCS Suggested Curve Numbers for Non-Cultivated Agricultural Lands

Table 9–5 Runoff curve numbers for urban areas [1/]

Cover description cover type and hydrologic condition	Average percent impervious area [2/]	-- CN for hydrologic soil group -- A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65 — 51.5	77	85	90	92
1/4 acre	38 — 34	61	75	83	87
1/3 acre	30 — 27.5	57	72	81	86
1/2 acre	25 — 22.5	54	70	80	85
1 acre	20 — 16	51	68	79	84
2 acres	12 — 0	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94

1/ Average runoff condition, and $I_a = 0.2S$.

2/ The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

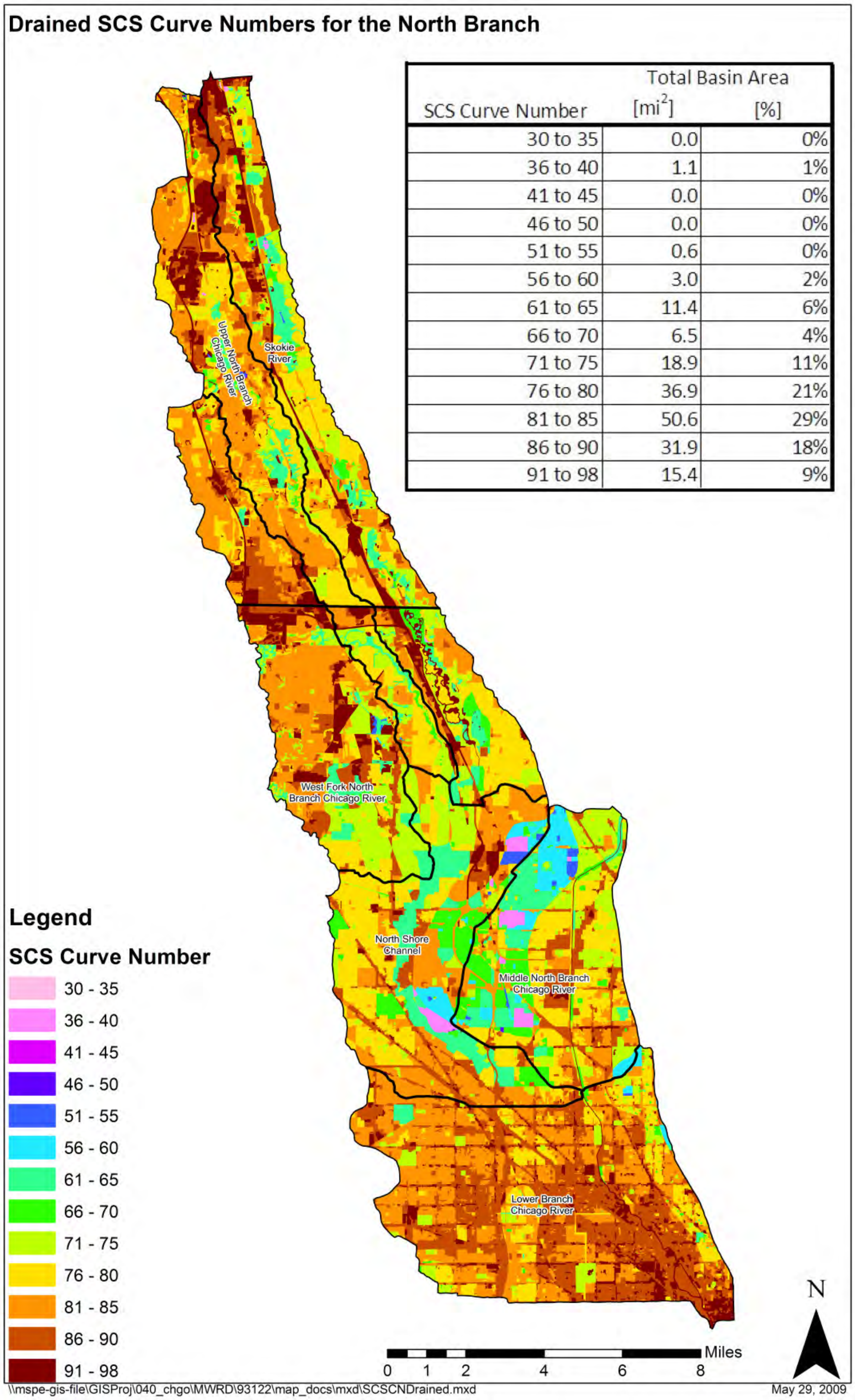
3/ CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space type.

4/ Composite CNs for natural desert landscaping should be computed using figures 9–3 or 9–4 based on the impervious area percentage (CN=98) and the pervious area CN. The pervious area CNs are assumed equivalent to desert shrub in poor hydrologic condition.

Figure 14. NRCS Suggested Curve Numbers for Urban Areas

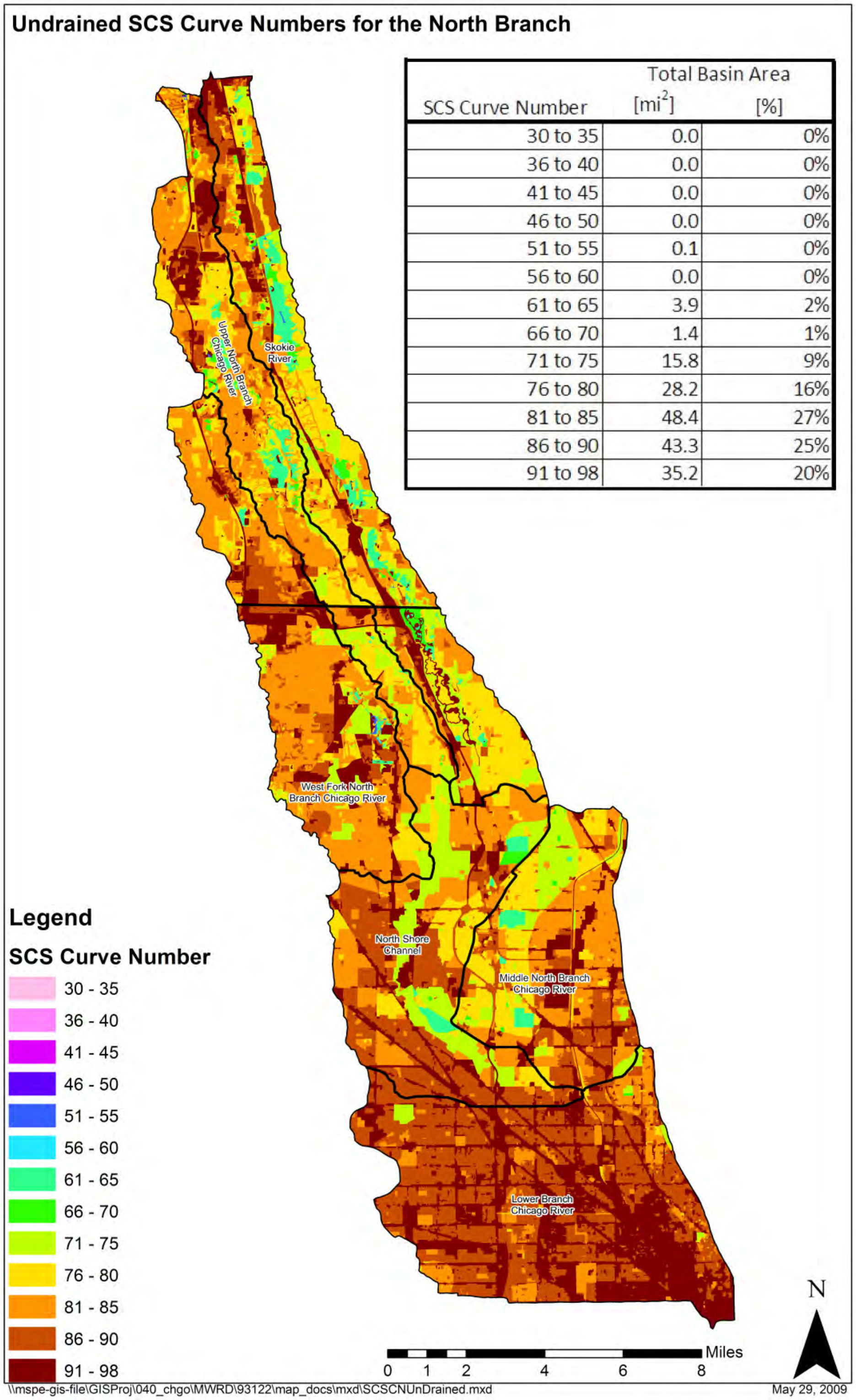
Table 6. Curve Number Calculation Method by Land Use

Land Use	Curve Number Data Source
1110 RES/SF	Impervious adjustment from open space, good condition
1120 RES/FARM	Impervious adjustment from open space, good condition
1130 RES/MF	Impervious adjustment from open space, good condition
1140 RES/MOBILE HM	Impervious adjustment from open space, good condition
1211 MALL	Commercial and business
1212 RETAIL CNTR	Commercial and business
1221 OFFICE CMPS	Impervious adjustment from open space, good condition
1222 SINGL OFFICE	Impervious adjustment from open space, good condition
1223 BUS. PARK	Impervious adjustment from open space, good condition
1231 URB MX W/PRKNG	Industrial
1232 URB MX NO PRKNG	Commercial and business
1240 CULT/ENT	Impervious adjustment from open space, good condition
1250 HOTEL/MOTEL	Industrial
1310 MEDICAL	Impervious adjustment from open space, good condition
1320 EDUCATION	Impervious adjustment from open space, good condition
1330 GOVT	Impervious adjustment from open space, good condition
1350 RELIGOUS	Impervious adjustment from open space, good condition
1360 CEMETERY	Impervious adjustment from open space, good condition
1370 INST/OTHER	Impervious adjustment from open space, good condition
1410 MINERAL EXT	Industrial
1420 MANUF/PROC	Industrial
1430 WAREH/DIST/WHOL	Industrial
1440 INDUST PK	Industrial
1511 INTERSTATE/TOLL	Streets and Roads; Paved; open ditches
1512 OTHER ROADWAY	Streets and Roads; Paved; open ditches
1520 OTH LINEAR TRAN	Streets and Roads; Paved; open ditches
1540 INDEP AUTO PRK	Paved parking lots
1550 COMMUNICATION	Impervious adjustment from open space, good condition
1560 UTILITIES/WASTE	Impervious adjustment from open space, good condition
2100 CROP/GRAIN/GRAZ	Row crops, straight rows
2200 NRSRY/GRNHS/ORC	Impervious adjustment from open space, good condition
3100 OPENSP REC	Impervious adjustment from open space, good condition
3200 GOLF COURSE	Open space, good condition
3300 OPENSP CONS	Open space, good condition
3400 OPENSP PRIVATE	Impervious adjustment from open space, good condition
3500 OPENSP LINEAR	Impervious adjustment from open space, good condition
3600 OPENSP OTHER	Impervious adjustment from open space, good condition
4110 VAC FOR/GRASS	Impervious adjustment from open space, good condition
4120 WETLAND	Woods, Good condition
4210 CONST RES	Impervious adjustment from open space, good condition
4300 OTHER VACANT	Open space, poor condition
5100 RIVERS/CANALS	CN=98
5200 LAKE/RES/LAGOON	CN=98
5300 LAKE MICHIGAN	CN=98



SCS Curve Number	Total Basin Area [mi^2]	[%]
30 to 35	0.0	0%
36 to 40	1.1	1%
41 to 45	0.0	0%
46 to 50	0.0	0%
51 to 55	0.6	0%
56 to 60	3.0	2%
61 to 65	11.4	6%
66 to 70	6.5	4%
71 to 75	18.9	11%
76 to 80	36.9	21%
81 to 85	50.6	29%
86 to 90	31.9	18%
91 to 98	15.4	9%

Figure 15. Curve Numbers based on Drained Soil Conditions



SCS Curve Number	Total Basin Area [mi^2]	[%]
30 to 35	0.0	0%
36 to 40	0.0	0%
41 to 45	0.0	0%
46 to 50	0.0	0%
51 to 55	0.1	0%
56 to 60	0.0	0%
61 to 65	3.9	2%
66 to 70	1.4	1%
71 to 75	15.8	9%
76 to 80	28.2	16%
81 to 85	48.4	27%
86 to 90	43.3	25%
91 to 98	35.2	20%

Figure 16. Curve Numbers based on Undrained Soil Conditions

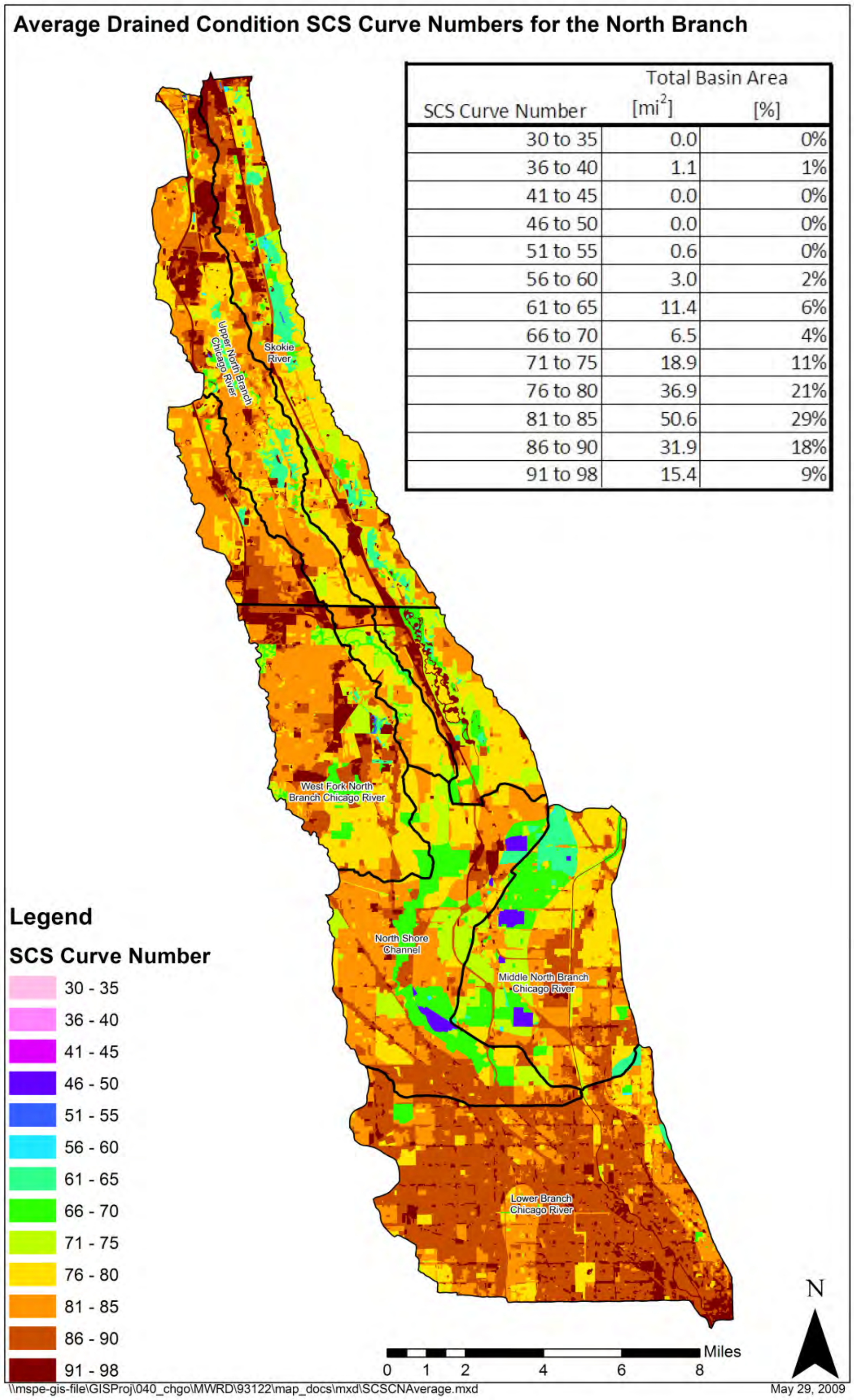


Figure 17. Curve Numbers based on Average Drained and Undrained Soil Conditions

Calumet-Sag Watershed SCS Curve Number Generation

PREPARED FOR: Jonathan Grabowy \ MWRDGC

PREPARED BY: Mason Throneburg \ CH2M HILL

DATE: August 14, 2007

SCS hydrology uses the empirical curve number (CN) parameter as a part of calculating runoff volumes based on landscape characteristics such as soil type, land cover, imperviousness, and land-use development. Areas characterized by saturated or poorly infiltrating soils, or impervious development, have higher CN values, converting a greater portion of rainfall volume into runoff. The principle data sources used to develop CN values for the Calumet-Sag watershed are the Natural Resource Conversation Service (NRCS) soil data for Cook County and the 2001 Northeast Illinois Planning Commission (NIPC) land-use mapping for Cook County. This technical memorandum documents the procedure used to develop a CN grid for use in hydrologic modeling for the Calumet-Sag watershed and the assumptions inherent in this procedure.

Approach

CN values are dependent on a number of factors, including the soil infiltration characteristics and condition, as well as land cover characteristics such as directly connected impervious area and cover type. Therefore both soil data and land-use data are required to estimate CN. The best available soil and land-use data for Cook County are the NRCS soil data and NIPC land-use data. Table 1 lists curve numbers based on combinations of land-use data and soil data for small urban watersheds.

Table A.1 Curve Number Generation for Small Urban Watersheds

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94

Table excerpted from Technical Release 55, Urban Hydrology for Small Watersheds, June 1986

A slightly modified version of this table will be used for curve number generation in the Calumet-Sag watershed, shown in table A.2. Both the NRCS soil data and the land use data require preprocessing before generating curve numbers using the lookup table.

Table A.2 Modified Curve Number Generation for Calumet-sag Watershed.

Description	Average % Impervious	Curve Number by Hydrologic Soil Group				Typical Land Uses
		A	B	C	D	
Residential (High Density)	65	77	85	90	92	Multi-family, Apartments, Condos, Trailer Parks
Residential (Med. Density)	30	57	72	81	86	Single-Family, Lot Size ¼ to 1 acre
Residential (Low Density)	15	48	66	78	83	Single-Family, Lot Size 1 acre and Greater
Commercial	85	89	92	94	95	Strip Commercial, Shopping Ctrs, Convenience Stores
Industrial	72	81	88	91	93	Light Industrial, Schools, Prisons, Treatment Plants
Disturbed/Transitional	5	76	85	89	91	Gravel Parking, Quarries, Land Under Development
Agricultural	5	67	77	83	87	Cultivated Land, Row crops, Broadcast Legumes
Open Land – Good	5	39	61	74	80	Parks, Golf Courses, Greenways, Grazed Pasture
Meadow	5	30	58	71	78	Hay Fields, Tall Grass, Ungrazed Pasture
Woods (Thick Cover)	5	30	55	70	77	Forest Litter and Brush adequately cover soil
Woods (Thin Cover)	5	43	65	76	82	Light Woods, Woods-Grass combination, Tree Farms
Impervious	95	98	98	98	98	Paved Parking, Shopping Malls, Major Roadways
Water	100	100	100	100	100	Water Bodies, Lakes, Ponds, Wetlands

Data from
http://gis2.esri.com/library/userconf/proc00/professional/papers/PAP657/p657.htm

Data is for average antecedent moisture condition II- dormant season (5-day) rainfall averaging from 0.5 to 1.1 inches and growing season rainfall from 1.4 to 2.1 inches

NRCS Soil data

Soil mapping for Cook County was downloaded from the NRCS website at http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/, representing 2002 conditions. The data downloaded includes a GIS shapefile of the soil groups and numerous text files that can be imported into an Access database and linked to the GIS data via a field called 'Mapunit Key.' The data field most relevant for SCS hydrology is the 'Hydrologic Group.' The hydrologic soil group (HSG) indicates the minimum infiltration of a specific soil group following wetting, and represented by four soil groups, shown in Table A.3.

TABLE A.3. HYDROLOGIC SOIL GROUPS

Hydrologic Soil Group	Description	Texture	Infiltration Rates (in/hr)
A	Low runoff potential and high infiltration rates even when wetted	Sand, loamy sand, or sandy loam	> 0.30
B	Moderate infiltration rates when wetted	Silt loam or loam	0.15 – 0.30
C	Low infiltration rates when wetted	Sandy clay loam	0.05 – 0.15
D	High runoff potential and very low infiltration when wetted	Clay loam, silty clay loam, sandy clay, silty clay, or clay	0 – 0.05
		clay, or clay	

All data from Technical Release 55, Urban Hydrology for Small Watersheds, June 1986

Soil groups with drainage characteristics impacted by a high water table are indicated with a '/D' designation, where the letter preceding the slash indicates the hydrologic group of the soil under drained conditions. Thus an 'A/D' indicates that the soil has characteristics of the A soil group if drained, but the D soil group if not drained. 'A/D', 'B/D', or 'C/D', occur throughout the Calumet-Sag study area and represent a cumulative area of 9.11 mi^2 of the 152 square-mile watershed. Due to the difficulty of establishing the extent of drainage of these soils for each mapped soil polygon, it was assumed that 50% (by area) of these soil types were drained.

The City of Chicago is not mapped within the NRCS data set and thus does not have an assigned HSG. Based on previous studies, a minimum infiltration rate of 0.1 in/hr is reasonable in much of Chicago which corresponds to a 'C' HSG. In addition, a number of other soil features lacked HSG data, however these were generally open water or unmapped areas, for which CN values would not be stratified by HSG. When intersected with land-use data, the CN values are averaged across A, B , C and D values for the specified land-use type to estimate CN.

NIPC Land Use Data

NIPC land-use data contains delineation of land-use categories at an average scale of 0.10 acres for features in the Calumet-Sag watershed. To generate CN values, these land-use categories must be converted to analogous land-use categories for which CN data has previously been developed. Table A.4 demonstrates the field mapping used to convert NIPC land-use categories into categories for which CN data exists.

Table A.4. NIPC field mapping to land use field.

NIPC Code	NIPC Land USE	SCS Land Use	A	B	C	D	A/D	B/D	C/D	NULL
1110	1110 RES/SF	Residential (High Density)	77	85	90	92	84.5	88.5	91	86
1120	1120 RES/FARM	Residential (Low Density)	48	66	78	83	65.5	74.5	80.5	68.75
1130	1130 RES/MF	Residential (Med. Density)	57	72	81	86	71.5	79	83.5	74
1140	1140 RES/MOBILE HM	Residential (High Density)	77	85	90	92	84.5	88.5	91	86
1211	1211 MALL	Commercial	89	92	94	95	92	93.5	94.5	92.5
1212	1212 RETAIL CNTR	Commercial	89	92	94	95	92	93.5	94.5	92.5
1221	1221 OFFICE CMPS	Commercial	89	92	94	95	92	93.5	94.5	92.5
1222	1222 SINGL OFFICE	Commercial	89	92	94	95	92	93.5	94.5	92.5
1223	1223 BUS. PARK	Commercial	89	92	94	95	92	93.5	94.5	92.5
1231	1231 URB MX W/PRKNG	Commercial	89	92	94	95	92	93.5	94.5	92.5
1232	1232 URB MX NO PRKNG	Industrial	81	88	91	93	87	90.5	92	88.25
1240	1240 CULT/ENT	Commercial	89	92	94	95	92	93.5	94.5	92.5
1250	1250 HOTEL/MOTEL	Commercial	89	92	94	95	92	93.5	94.5	92.5
1310	1310 MEDICAL	Industrial	81	88	91	93	87	90.5	92	88.25
1320	1320 EDUCATION	Industrial	81	88	91	93	87	90.5	92	88.25
1330	1330 GOVT	Commercial	89	92	94	95	92	93.5	94.5	92.5
1340	1340 PRISON	Industrial	81	88	91	93	87	90.5	92	88.25
1350	1350 RELIGOUS	Commercial	89	92	94	95	92	93.5	94.5	92.5
1360	1360 CEMETERY	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
1370	1370 INST/OTHER	Residential (Low Density)	48	66	78	83	65.5	74.5	80.5	68.75
1410	1410 MINERAL EXT	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
1420	1420 MANUF/PROC	Industrial	81	88	91	93	87	90.5	92	88.25
1430	1430 WAREH/DIST/WHOL	Industrial	81	88	91	93	87	90.5	92	88.25
1440	1440 INDUST PK	Industrial	81	88	91	93	87	90.5	92	88.25

NIPC Code	NIPC Land USE	SCS Land Use	A	B	C	D	A/D	B/D	C/D	NULL
1511	1511 INTERSTATE/TOLL	75 % Impervious/25 % Open Land	83.25	88.75	92.00	93.50	88.38	91.13	92.75	89.38
1512	1512 OTHER ROADWY	75 % Impervious/25 % Open Land	83.25	88.75	92.00	93.50	88.38	91.13	92.75	89.38
1520	1520 OTH LINEAR TRAN	I75 % Impervious/25 % Open Land	83.25	88.75	92.00	93.50	88.38	91.13	92.75	89.38
1530	1530 AIR TRANSPORT	50 % Impervious/ 50% Open Lands	68.50	79.50	86.00	89.00	78.75	84.25	87.50	80.75
1540	1540 INDEP AUTO PRK	Commercial	89	92	94	95	92	93.5	94.5	92.5
1550	1550 COMMUNICATION	Agricultural	67	77	83	87	77	82	85	78.5
1560	1560 UTILITIES/WASTE	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
2100	2100 CROP/GRAIN/GRAZ	Agricultural	67	77	83	87	77	82	85	78.5
2200	2200 NRSRY/GRNHS/ORC	Agricultural	67	77	83	87	77	82	85	78.5
2300	2300 AG/OTHER	Agricultural	67	77	83	87	77	82	85	78.5
3100	3100 OPENSP REC	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3200	3200 GOLF COURSE	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3300	3300 OPENSP CONS	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3400	3400 OPENSP PRIVATE	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3500	3500 OPENSP LINEAR	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3600	3600 OPENSP OTHER	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
4110	4110 VAC FOR/GRASS	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
4120	4120 WETLAND	Meadow	30	58	71	78	54	68	74.5	59.25
4210	4210 CONST RES	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
4220	4220 CONST NONRES	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
4300	4300 OTHER VACANT	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
5100	5100 RIVERS/CANALS	Water	100	100	100	100	100	100	100	100
5200	5200 LAKE/RES/LAGOON	Water	100	100	100	100	100	100	100	100
5300	5300 LAKE MICHIGAN	Water	100	100	100	100	100	100	100	100
9999	9999 OUT OF REGION	Water	100	100	100	100	100	100	100	100

Note: not all NIPC land use types exist within the Calumet-Sag watershed.

Steps for Generating Curve Number Grid

Following the preparation of the land-use and soil data is described in the preceding two sections, three steps are followed to generate the CN Grid

1) Perform an intersection of the NRCS soil mapping polygon feature class with the NIPC land use polygon feature class. This produces a polygon feature class that has both land-use type and HSG. This feature class was output into a personal geodatabase so that Access queries could be performed on it.

2) Add a field called CurveNumber to the intersected feature class

3) Assign a CN value to each intersected polygon feature based upon HSG and land use. This was performed using an Access update query on the CurveNumber field. The soil groups impacted by high water table (e.g. 'A/D') were estimated to be 50% drained, using the average of the D CN and the drained (e.g. A) CN.

4) Use the "feature to raster" function in ArcToolbox to create a CN grid based on the CurveNumber value at the center of each grid pixel. A 20 ft x 20 ft grid, the same resolution as digital terrain model uses for watershed delineation, was used for this purpose.

The included figure shows the final CN grid for the Calumet-Sag watershed.

CERTIFICATION OF COMPLIANCE

Project Name:	MWRDGC – North Branch of the Chicago River and Lake Michigan Watershed Plan, Phase B
Statement/Agreement Date:	Technical Memo. Guidelines 8/10/07
Certification Date:	Oct 8, 2010

Tasks/Activities Covered by This Certification (Check All That Apply)

☐	**Entire Project**
☒	**Survey**
☐	**Topographic Data Development**
☐	**Hydrologic and/or Hydraulic Analyses**
☐	**Coastal Flood Hazard Analyses**
☐	**Floodplain Mapping**
☐	**Other (Specify):**

This is to certify that the work summarized above was completed in accordance with the statement/ agreement cited above and all amendments thereto, together with all such modifications, either written or oral, as directed by HDR Engineering, Inc., as such modifications affect the statement/agreement, and that all such work has been accomplished to meet accuracy guidelines contained in FEMA's "Guidelines and Specifications for Flood Hazard Mapping Partners" cited in the survey scope of work document, and in accordance with sound and accepted engineering practices within the contract provisions for respective phases of the work. The attached technical memo. describes the survey procedures to be followed for this project. By signing this document, the project surveyor agrees that complying with the survey procedures outlined in the technical memo will meet or exceed the final accuracy results specified in the FEMA guidelines and further confirm that their field surveyors have complied with procedures outlined in said technical memo.

Name: George Woods

Title: Professional Land Surveyor

Firm/Agency Represented: Lin Engineering, LTD.

Registration No.: 035-3015 EXPIRES 11-30-2010

Signature: George L Woods

PROFESSIONAL LAND SURVEYOR
GEORGE L. WOODS
3015
CHATHAM
ILLINOIS
STATE OF ILLINOIS

This form must be signed, stamped, and dated by the surveyor in responsible charge from the firm contracted to perform the work who is registered as a Professional Land Surveyor in the State of Illinois.

To:	Metropolitan Water Reclamation District of Greater Chicago Attention: Michael Cosme, P.E.
From:	Jeffrey Dailey, HDR Engineering, Inc. Joseph Spradling, HDR Engineering, Inc. George Woods, Lin Engineering, Ltd.
CC:	Fred Lin, Lin Engineering, Ltd.
Date:	May 11, 2009 Job No: 08-033-5C

Summary of Survey Procedures

Purpose

The purpose of this technical memorandum is to summarize the general procedures utilized during the hydraulic survey.

These survey procedures have been used to meet the requirements as set forth in the Cook County Stormwater Management Plan (CCSMP), Table 6.9. Additionally, these procedures have been used to meet the positional accuracy requirements detailed in the Federal Emergency Management Agency (FEMA) *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A, "Guidance for Aerial Mapping and Surveying".*

Procedures

Since several other Cook County Detailed Watershed Plans (DWPs) have utilized Real Time Kinematic Global Positioning System (RTK GPS) methods, the North Branch Chicago River DWP has utilized this method to achieve the positional horizontal and vertical accuracies required by the aforementioned FEMA report. This memorandum outlines the proposed methods of using RTK GPS, in addition to more traditional survey methods, such as total station, to establish control information.

1. Virtual Reference System Verification

Control information established for surveying hydraulic cross-sections on this project have been completed using RTK GPS methods employing a local Virtual Reference System (VRS). A VRS consists of a network of multiple continuously operating reference base stations used to simultaneously calculate the horizontal and vertical position of a point occupied by a mobile RTK GPS receiver in the field.

As part of the survey for the North Branch Chicago River DWP, HDR Engineering, Inc. and Lin Engineering, Ltd. have verified the accuracy of the VRS. To verify the accuracy of the VRS, a procedure using the standard deviation of a discrete random variable or data set was implemented. The standard deviation of a discrete random variable is defined as the root mean square deviation (RMSD) of its values (observations) from the mean (National

Geodetic Survey (NGS)-published elevations). In other terms, this method is computing the standard deviation of the survey observations from the NGS-published elevations for each NGS monument. The equation below calculates this standard deviation or RMSD, which accounts for multiple observations at each NGS monument.

$$RMSD = \sqrt{\left(\frac{1}{N}\right)\sum_{i=1}^{N}(M-R)^2}$$

where

RMSD = Root Mean Square Deviation

R = NGS-published coordinate value

M = Measured (observed) coordinate value

N = Number of Observations

Upon calculation of the RMSD for each NGS monument, the RMSD value is compared to accepted accuracy values for horizontal and vertical coordinates as outlined in the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A, "Guidance for Aerial Mapping and Surveying".* If RMSD values are within accepted accuracy values, the VRS is considered acceptable for use in the hydraulic survey.

The VRS calibration was performed using a VRS subscription from Precision Midwest Co. This subscription expired and was unavailable at the time the survey work was started for the West Fork cross sections. A new VRS service was purchased from KARA Co. Several control points that had been set for the North Branch survey using the Precision Midwest Company's VRS system were observed using the KARA Co. VRS RTK GPS system and the elevations were correlated to match the previously approved VRS calibration.

2. Secondary Control Points

Secondary control points have been established throughout the project at all hydraulic cross-section locations. Like the cross-sections, the secondary control points are spaced no more than 1,000 feet apart. Horizontal and vertical coordinate values of these points have been established by RTK GPS and checked with traditional total station survey methods. RTK GPS produces a vertical accuracy of +/- 0.06 ft.

3. Hydraulic Cross-Sections

Hydraulic cross-sections throughout the watershed have been surveyed using conventional Total Station surveying procedures. Cross-sections have been surveyed according to the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix N: Data Capture Guidelines.*

Cross-sections were spaced at 1,000 feet or less along the individual stream reaches. Spacing was optimized by surveyors in the field due to site conditions. Hydraulic cross-sections completed as part of the bridge structure surveys are separate from those spaced at 1,000 feet or less along the stream reaches.

4. Bridge Surveys

Bridge surveys have been conducted according to the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix N: Data Capture Guidelines.* Specifically, bridge sketches, survey text files, and photographs have been generated for specified bridge crossings along the North Branch Chicago River and its tributaries, which include the West Fork, Middle Fork, and Skokie River. The bridge surveys have been completed using both RTK GPS methods as well as conventional closed-loop survey methods.

5. Survey Data

Upon the completion of the hydraulic survey, all digital survey documentation from Lin Engineering, Ltd. will be appended to this Technical Memorandum.

Appendix A

Digital Survey Documentation

(To be appended upon completion of hydraulic survey)

Appendix D.1
North Branch Chicago River Watershed Survey Points

HDR

MEMORANDUM

Evaluation and Incorporation of USACE HEC-RAS Model of Chicago Waterway System into the Development of the North Branch DWP

TO:	Joseph Spradling, PE, HDR
FROM:	Steven Vassos, PE, FluidClarity
DATE:	October 13, 2010
PROJECT NUMBER:	FCL 9002B

PURPOSE

This memorandum summarizes the procedures and data that were used to incorporate the United States Army Corps of Engineers' (USACE) Chicago Area Waterway System (CAWS) HEC-RAS model as a downstream boundary condition for the North Branch Chicago River (NBCR) Detailed Watershed Plan (DWP) model.

BACKGROUND

Previously, FluidClarity worked with HDR to produce an unsteady HEC-RAS model for the North Shore Channel (NSC) along with the lower reaches of the NBCR downstream of the North Branch dam. Please refer to the Figure 1 for a watershed overview. The original FluidClarity model was developed from the USACE's UNET model and was updated with new information, including georeferenced cross-sections and channels. Flow data analysis was improved and boundary conditions were updated. This model was developed for the 2-, 5-, 10-, 20-, 50- and 100-yr storm events. A stage hydrograph for the confluence of the NBCR and the NSC was created for use as a downstream boundary condition for the model developed for the NBCR DWP.

A parallel study was being conducted by the USACE, which updated the entire CAWS model, including NSC and NBCR from its confluence with the NSC, to its confluence with the Chicago River. The District determined that this USACE model should be used in lieu of the FluidClarity-developed model, in part because the USACE model uses updated information and can be considered the best available data for the waterway system. HDR and FluidClarity performed additional work to extract the information required from the new USACE model for use in the NBCR DWP, as described below.

METHODOLOGY

FluidClarity performed the following steps to incorporate the USACE model into the NBCR DWP:

FluidClarity
1144 West Lake Street, Suite 303, Oak Park, IL 60301
Tel. (708)383-3500 Fax: (708)383-3549 e-mail: Admin@FluidClarity.com

(1) Verified and ran the new USACE model.

Once the new USACE HEC-RAS model was acquired by HDR and FluidClarity, the model was reviewed to become familiar with the updated geometry, boundary conditions, and input hydrology .dss files. The geometry of the North Branch Dam, which has been included in the USACE model but was not included in the original USACE UNET model, was reviewed to determine whether the updated geometry of the dam was modeled appropriately, including the presence of a mid-flow weir. The model was revised to include the updated geometry at this location, as necessary. The model was run for the 20-, 50-, 100- and 500-year storm events. Results were compared to the results in the *Downtown Chicago Flooding Study, Draft Final Report,* by AECOM, September 2009, as a QA/QC measure. The model was compared to the original FluidClarity HEC-RAS model to determine the level of discrepancies between the two.

(2) Revised the new USACE model for incorporation into DWP.

The new USACE model was revised to replace the inflow hydrographs located upstream of the North Branch Dam with flows produced by the model from HDR created for the District's DWP. Inflow hydrographs along the NBCR which needed to be removed and replaced within the USACE model were identified. The .dss file was adjusted to include the hydrographs from the 20-, 50-, 100- and 500-year storm events from the District's NBCR model which were then incorporated into the USACE model.

Since the District's NBCR model produced a 25-year hydrograph and not a 20-year hydrograph that correlates with the USACE model, a probability analysis was run and a 25-year hydrograph was interpolated between the 20-year and 50-year USACE results. This was then run and verified versus the relationships demonstrated by the FluidClarity model. A sensitivity analysis at UNBCR cross-section 333.11 demonstrated that the flows and stages for the 20-yr to 25-yr were successful.

The USACE's hydrographs from July 10 to 12th (3 day), were adjusted to enable incorporation into HDR's timespan from July 11 to 15 (5 day). Results were compared and verified.

Through an iterative process, the results from the District's HEC-RAS model were input into the USACE model, and USACE results back into the District model, until there was acceptable agreement between the results of the two models.

The 2-, 5- and 10-year storm events were not included as part of the newly revised USACE model. To determine the downstream boundary condition to be used in the District's NBCR model, the results of the USACE model's 20-year stage hydrograph immediately downstream of the dam was evaluated.

A stage hydrograph was produced by extrapolating down the results of the peak stage of the 20-, 50-, 100- and 500-year storm events generated from the previous

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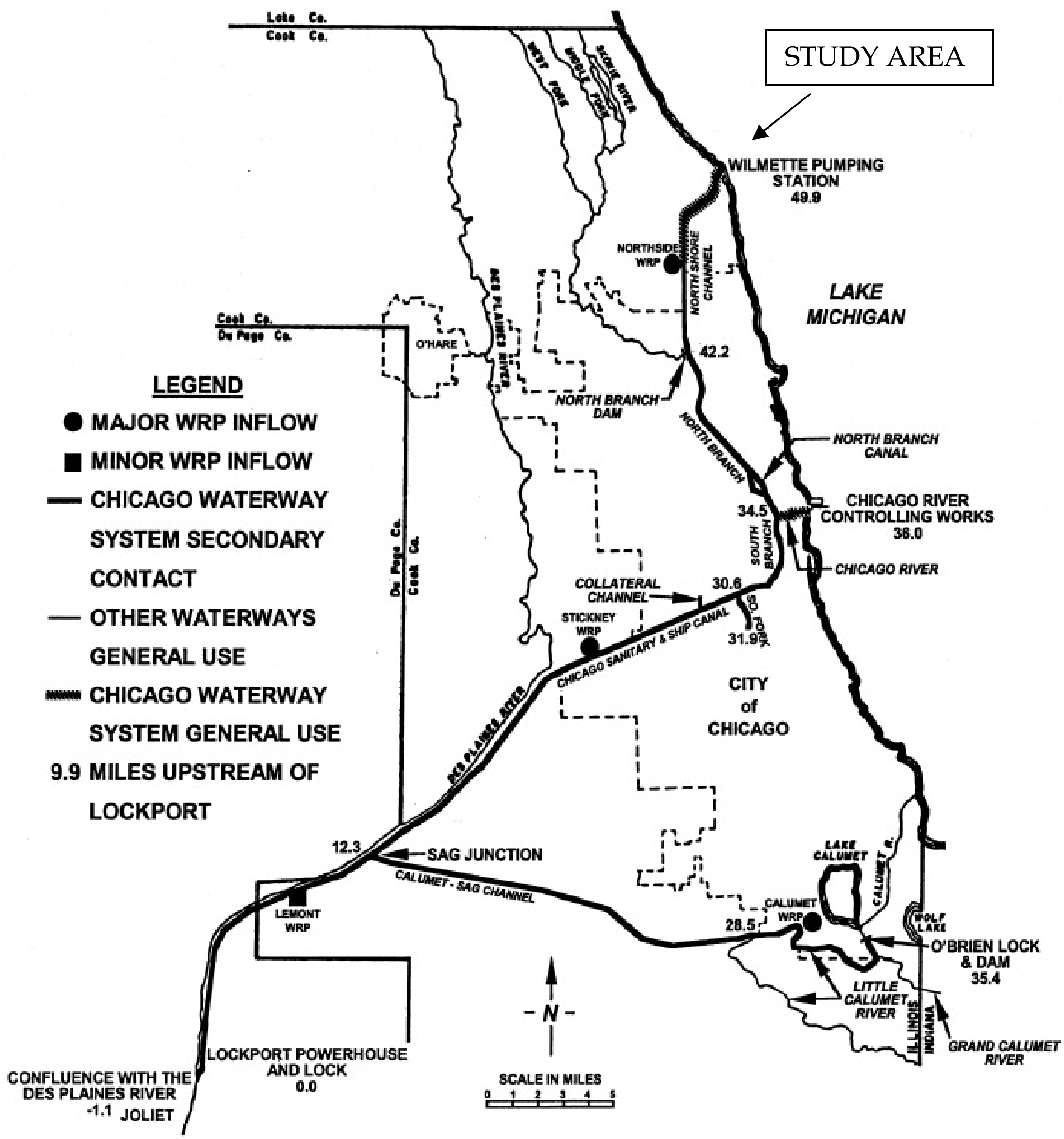
runs. The shape of the 20-year stage hydrograph was retained for 2-through 10-year storm events, and the stages were reduced by a percentage equivalent to the percentage by which the peak flow was reduced for each duration, as a result of the statistical analysis. The original FluidClarity model was used as a guide for determining the amplitude shifting of the lower storm events; since this was an actual model of the study area, it was determined to provide better results and a simple regression analysis.

(3) QA/QC

QA/QC was performed on the model by comparing the unaltered USACE model results to the newly updated USACE results to verify that similar results were produced. Similarly, comparisons were done with the original FluidClarity model results to ensure that riverine characteristics remained intact, with emphasis on the events extrapolated beyond the unaltered USACE model.

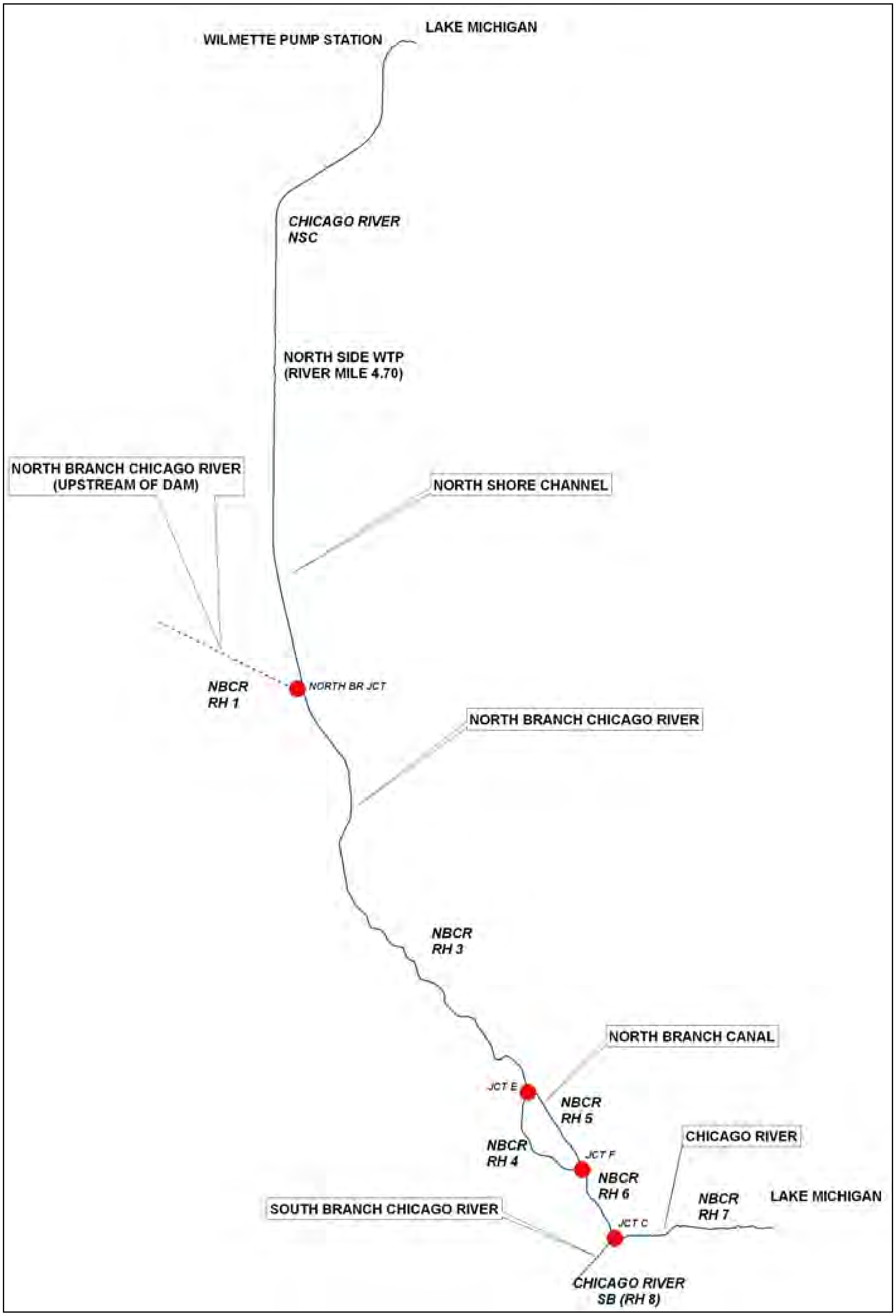
As part of the QA/QC, a sensitivity analysis for varying starting water surface elevations of Lake Michigan was performed for 3.8 CCD and 0.8 CCD. The critical points chosen were cross-sections located at the start of NBCR, the confluence with NSC, and downstream of the Wilmette Pumping Station. The locations were chosen because they encompassed the area affected. Regarding the 3ft drop in WSEL of the Lake caused by changing from the medium height to the low level WSEL scenario, there was no change at the upstream portion of NBCR cross-section located downstream of the dam. There was a 0.2 - 0.5 ft drop at the confluence of NBCR & NSC, and there was a 0.1 - 0.25 ft drop at the 1st cross section south of the Wilmette Pumping Station.

FIGURE 1: CHICAGO WATERWAY SYSTEM



From MWRD R&D Report No. 08-15R

FIGURE 2: HEC-RAS MODEL LAYOUT



CECW-PG 10 October 2003

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements.

1. Purpose. The purpose of this memorandum is to release, and provide guidance for the use of, generic depth-damage curves for use in U.S. Army Corps of Engineers flood damage reduction studies.

2. Background. Proper planning and evaluation of flood damage reduction projects require knowledge of actual damage caused to various types of properties. The primary purpose of the Flood Damage Data Collection Program is to meet that requirement by providing Corps district offices with standardized relationships for estimating flood damage and other costs of flooding, based on actual losses from flood events. Under this program, data have been collected from major flooding that occurred in various parts of the United States from 1996 through 2001. Damage data collected are based on comprehensive accounting of losses from flood victims' records. The generic functions developed and provided in this EGM represent a substantive improvement over other generalized depth-damage functions such as the Flood Insurance Administration (FIA) Rate Reviews.

3. Results. Generic damage functions are attached for one-story homes with basement, two or more story homes with basement, and split-level homes with basement. Generic damage functions for similar structures without basements were published in 2000 and are included as enclosure 1 for ready reference.

a. Regression analysis was used to create the damage functions. While several independent variables, such as flood duration and flood warning lead-time, were examined in building the models, the models that were most efficient in explaining the percent damage to structure and contents were quadratic and cubic forms with depth as the only independent variable.

b. Content damage was modeled with the dependent variable being content damage as a percentage of structure value. This differs from the previous technique of first developing content valuations and then content damage relationships as a function of content valuations. The generic content damage models are statistically significant and their use eliminates the need to establish content-to-structure ratios through surveys.

c. While the data collected include information on all aspects of National Economic Development (NED) losses, only results and recommendations related to the structure and content damages for homes with basements are included in this EGM.

Direct costs for cleanup expenses, unpaid hours for cleanup and repair, emergency damage prevention actions, and other flood-related costs are not included in these damage functions. Information on other residential flood costs, beyond those included in these damage functions will found the summary report, discussed in paragraph 5. These costs should be developed using site-specific historical information.

4. Application. The following paragraphs provide information on the application of the generic curves within the HEC-FDA damage calculation program.

a. The economic section of HEC-FDA divides the quantification of flood damages into a direct method and an indirect method. The direct method allows the user to directly enter a stage-damage relationship for any structure. This approach is commonly used for large or unique properties such as industrial or pubic buildings. The indirect method quantifies the stage-damage relationship for a group of structures that have significant commonality. Typically damage to residential structures is calculated using the indirect method. The procedures described in the following paragraphs apply only when using the indirect method to determine the stage-damage relationship.

b. The traditional approach to quantifying damage to contents by the indirect method relies on three pieces of information: 1) structure value; 2) content-to-structure value ratio; and 3) the content depth-damage relationship. The content-to-structure value ratio and content depth-damage relationship are unique to the structure occupancy type to which a structure is assigned. The content depth-damage relationship provides the estimate of content flood damage as a percentage of content value. Thus, to calculate a content stage-damage function for an individual structure, the structure value for an individual structure is first multiplied by the content-to-structure value ratio to provide an estimate of the content value. This content value is then multiplied by each percent damage value of the content depth-damage relationship.

c. The new content depth-damage functions provided herein are different from those used by the Corps in the past in one important aspect. The new functions calculate content damage as a percent of structure value rather than content value. Using these functions within HEC-FDA requires care in specifying a content-to-structure value ratio. To understand the requirements for using the new content depth-damage functions requires a basic understanding of how HEC-FDA calculates content damage.

(1). To calculate damages by the indirect method, each structure must be assigned to a structure occupancy type. For each structure occupancy type a content-to-structure value ratio and content depth-damage relationship are defined. These data for calculating content damage within HEC-FDA is entered on the “Study Structure Occupancy Type” screen. As long as a content value is not entered for a structure in the Structure Inventory Data, HEC-FDA calculates the content stage-damage by first calculating content using the structure value multiplied by the content-to-structure value ratio.

In some instances, however, analysts develop unique estimates of content values for a structure, which are entered for the individual structure on the Structure Inventory Data screen. For each structure that has a content value entered, calculating a content value by using the content-to-structure value ratio is ignored and the user entered content value is used to calculate content damage.

(2). The new content depth-damage functions do not require this intermediate step of calculating content values. Therefore, the content-to-structure value ratio for each structure occupancy type using the new content depth-damage relationships must be set to one hundred percent (100). This forces the content depth-damage function to be multiplied by the structure value as required. Also, the "Error Associated with Content/Structure Value" on the "Study Structure Occupancy Type" screen should be left blank. This implies that the error in content-to-structure value ratio is part of the new content depth-damage relationship.

(3). Because entering a content value on the Structure Inventory Data window overrides the content-to-structure value ratio, the new content depth-damage relationships should not be used for structures that have separately entered content values.

(4). Questions concerning the use of the generic curves within the HEC-FDA model can be addressed to Dr. David Moser, Institute of Water Resources (IWR), (703) 428-8066.

5. Report. A report summarizing the data collection effort and analyses performed to derive these curves will shortly be available on the IWR website. More information may be obtained by contacting the program's principal investigator, Stuart Davis, (703) 428-7086.

6. Waiver to Policy. These curves are developed for nation-wide applicability in flood damage reduction studies. When using these curves, the requirement to develop site-specific depth-damage curves contained in ER 1105-2-100, E-19q.(2) is waived. Additionally, the requirement to develop content valuations and content-to-structure ratios based on site-specific or comparable floodplain information, ER 1005-2-100, E-19q.(1)(a), is also waived. Note these waivers currently apply only to single-family homes with and without basements for which generic curves have been published, and not other categories of flood inundation damages for which no generic curves exist. Feasibility reports must state the generic curves are being used in the flood damage analysis for residential structures with and/or without basements. Use of these curves is optional and analysts should always endeavor to use the best available information to accurately quantify the damages and benefits in inundation reduction studies.

7. Point of Contact. Administrators of the Flood Damage Data Collection Program continue to collect and analyze flood-related damages to both residential and commercial properties. The HQUSACE program monitor is Lillian Almodovar, (202) 761-4233, who can address any questions concerning the program.

FOR THE COMMANDER:

/s/

Encl

WILLIAM R. DAWSON, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

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DAMAGE FUNCTIONS
FOR SINGLE FAMILY RESIDENTIAL
STRUCTURES WITH BASEMENTS

Structure Depth-Damage

Table 1 Structure One Story, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0%	0
-7	0.7%	1.34
-6	0.8%	1.06
-5	2.4%	0.94
-4	5.2%	0.91
-3	9.0%	0.88
-2	13.8%	0.85
-1	19.4%	0.83
0	25.5%	0.85
1	32.0%	0.96
2	38.7%	1.14
3	45.5%	1.37
4	52.2%	1.63
5	58.6%	1.89
6	64.5%	2.14
7	69.8%	2.35
8	74.2%	2.52
9	77.7%	2.66
10	80.1%	2.77
11	81.1%	2.88
12	81.1%	2.88
13	81.1%	2.88
14	81.1%	2.88
15	81.1%	2.88
16	81.1%	2.88

Table 2 Structure Two or More Stories, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	1.7%	2.70
-7	1.7%	2.70
-6	1.9%	2.11
-5	2.9%	1.80
-4	4.7%	1.66
-3	7.2%	1.56
-2	10.2%	1.47
-1	13.9%	1.37
0	17.9%	1.32
1	22.3%	1.35
2	27.0%	1.50
3	31.9%	1.75
4	36.9%	2.04
5	41.9%	2.34
6	46.9%	2.63
7	51.8%	2.89
8	56.4%	3.13
9	60.8%	3.38
10	64.8%	3.71
11	68.4%	4.22
12	71.4%	5.02
13	73.7%	6.19
14	75.4%	7.79
15	76.4%	9.84
16	76.4%	12.36

Table 3 Structure Split Level, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8		
-7		
-6	2.5%	1.8%
-5	3.1%	1.6%
-4	4.7%	1.5%
-3	7.2%	1.6%
-2	10.4%	1.6%
-1	14.2%	1.6%
0	18.5%	1.6%
1	23.2%	1.7%
2	28.2%	1.9%
3	33.4%	2.1%
4	38.6%	2.4%
5	43.8%	2.6%
6	48.8%	2.9%
7	53.5%	3.2%
8	57.8%	3.4%
9	61.6%	3.6%
10	64.8%	3.9%
11	67.2%	4.2%
12	68.8%	4.8%
13	69.3%	5.7%
14	69.3%	5.7%
15	69.3%	5.7%
16	69.3%	5.7%

Content Depth-Damage

Table 4 Content One Story, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0.1%	1.60
-7	0.8%	1.16
-6	2.1%	0.92
-5	3.7%	0.81
-4	5.7%	0.78
-3	8.0%	0.76
-2	10.5%	0.74
-1	13.2%	0.72
0	16.0%	0.74
1	18.9%	0.83
2	21.8%	0.98
3	24.7%	1.17
4	27.4%	1.39
5	30.0%	1.60
6	32.4%	1.81
7	34.5%	1.99
8	36.3%	2.13
9	37.7%	2.25
10	38.6%	2.35
11	39.1%	2.45
12	39.1%	2.45
13	39.1%	2.45
14	39.1%	2.45
15	39.1%	2.45
16	39.1%	2.45

Table 5 Content Two or More Stories-With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0%	0
-7	1.0%	2.27
-6	2.3%	1.76
-5	3.7%	1.49
-4	5.2%	1.37
-3	6.8%	1.29
-2	8.4%	1.21
-1	10.1%	1.13
0	11.9%	1.09
1	13.8%	1.11
2	15.7%	1.23
3	17.7%	1.43
4	19.8%	1.67
5	22.0%	1.92
6	24.3%	2.15
7	26.7%	2.36
8	29.1%	2.56
9	31.7%	2.76
10	34.4%	3.04
11	37.2%	3.46
12	40.0%	4.12
13	43.0%	5.08
14	46.1%	6.39
15	49.3%	8.08
16	52.6%	10.15

Table 6 Content Split-Level-With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0.6%	2.09
-7	0.7%	1.49
-6	1.4%	1.14
-5	2.4%	1.01
-4	3.8%	1.00
-3	5.4%	1.02
-2	7.3%	1.03
-1	9.4%	1.04
0	11.6%	1.06
1	13.8%	1.12
2	16.1%	1.23
3	18.2%	1.38
4	20.2%	1.57
5	22.1%	1.76
6	23.6%	1.95
7	24.9%	2.13
8	25.8%	2.28
9	26.3%	2.44
10	26.3%	2.44
11	26.3%	2.44
12	26.3%	2.44
13	26.3%	2.44
14	26.3%	2.44
15	26.3%	2.44
16	26.3%	2.44

ENCLOSURE
DAMAGE FUNCTIONS
FOR SINGLE FAMILY RESIDENTIAL

STRUCTURES WITHOUT BASEMENTS

Structure One Story, No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	2.5%	2.7%
0	13.4%	2.0%
1	23.3%	1.6%
2	32.1%	1.6%
3	40.1%	1.8%
4	47.1%	1.9%
5	53.2%	2.0%
6	58.6%	2.1%
7	63.2%	2.2%
8	67.2%	2.3%
9	70.5%	2.4%
10	73.2%	2.7%
11	75.4%	3.0%
12	77.2%	3.3%
13	78.5%	3.7%
14	79.5%	4.1%
15	80.2%	4.5%
16	80.7%	4.9%

Structure Two or More Stories-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	3.0%	4.1%
0	9.3%	3.4%
1	15.2%	3.0%
2	20.9%	2.8%
3	26.3%	2.9%
4	31.4%	3.2%
5	36.2%	3.4%
6	40.7%	3.7%
7	44.9%	3.9%
8	48.8%	4.0%
9	52.4%	4.1%
10	55.7%	4.2%
11	58.7%	4.2%
12	61.4%	4.2%
13	63.8%	4.2%
14	65.9%	4.3%
15	67.7%	4.6%
16	69.2%	5.0%

Structure Split-Level-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	6.4%	2.9%
0	7.2%	2.1%
1	9.4%	1.9%
2	12.9%	1.9%
3	17.4%	2.0%
4	22.8%	2.2%
5	28.9%	2.4%
6	35.5%	2.7%
7	42.3%	3.2%
8	49.2%	3.8%
9	56.1%	4.5%
10	62.6%	5.3%
11	68.6%	6.0%
12	73.9%	6.7%
13	78.4%	7.4%
14	81.7%	7.9%
15	83.8%	8.3%
16	84.4%	8.7%

Content One Story, No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	2.4%	2.1%
0	8.1%	1.5%
1	13.3%	1.2%
2	17.9%	1.2%
3	22.0%	1.4%
4	25.7%	1.5%
5	28.8%	1.6%
6	31.5%	1.6%
7	33.8%	1.7%
8	35.7%	1.8%
9	37.2%	1.9%
10	38.4%	2.1%
11	39.2%	2.3%
12	39.7%	2.6%
13	40.0%	2.9%
14	40.0%	3.2%
15	40.0%	3.5%
16	40.0%	3.8%

Content Two or More Stories-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	1.0%	3.5%
0	5.0%	2.9%
1	8.7%	2.6%
2	12.2%	2.5%
3	15.5%	2.5%
4	18.5%	2.7%
5	21.3%	3.0%
6	23.9%	3.2%
7	26.3%	3.3%
8	28.4%	3.4%
9	30.3%	3.5%
10	32.0%	3.5%
11	33.4%	3.5%
12	34.7%	3.5%
13	35.6%	3.5%
14	36.4%	3.6%
15	36.9%	3.8%
16	37.2%	4.2%

Content Split-Level-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	2.2%	2.2%
0	2.9%	1.5%
1	4.7%	1.2%
2	7.5%	1.3%
3	11.1%	1.4%
4	15.3%	1.5%
5	20.1%	1.6%
6	25.2%	1.8%
7	30.5%	2.1%
8	35.7%	2.5%
9	40.9%	3.0%
10	45.8%	3.5%
11	50.2%	4.1%
12	54.1%	4.6%
13	57.2%	5.0%
14	59.4%	5.4%
15	60.5%	5.7%
16	60.5%	6.0%

Appendix F - Depth Damage Curves

TABLE 1.
Residential, One Story with Basement.

Structure			Content		
Depth	Mean of Damage	Standard Deviation of Damage	Depth	Mean of Damage	Standard Deviation of Damage
-8	0%	0	-8	0.10%	1.6
-7	0.70%	1.34	-7	0.80%	1.16
-6	0.80%	1.06	-6	2.10%	0.92
-5	2.40%	0.94	-5	3.70%	0.81
-4	5.20%	0.91	-4	5.70%	0.78
-3	9.00%	0.88	-3	8.00%	0.76
-2	13.80%	0.85	-2	10.50%	0.74
-1	19.40%	0.83	-1	13.20%	0.72
0	25.50%	0.85	0	16.00%	0.74
1	32.00%	0.96	1	18.90%	0.83
2	38.70%	1.14	2	21.80%	0.98
3	45.50%	1.37	3	24.70%	1.17
4	52.20%	1.63	4	27.40%	1.39
5	58.60%	1.89	5	30.00%	1.6
6	64.50%	2.14	6	32.40%	1.81
7	69.80%	2.35	7	34.50%	1.99
8	74.20%	2.52	8	36.30%	2.13
9	77.70%	2.66	9	37.70%	2.25
10	80.10%	2.77	10	38.60%	2.35
11	81.10%	2.88	11	39.10%	2.45
12	81.10%	2.88	12	39.10%	2.45
13	81.10%	2.88	13	39.10%	2.45
14	81.10%	2.88	14	39.10%	2.45
15	81.10%	2.88	15	39.10%	2.45

TABLE 1.
Residential, One Story with Basement.

Structure			Content		
16	81.10%	2.88	16	39.10%	2.45

TABLE 2.
Residential, Two or More Stories, With Basement

Structure			Content		
Depth	Mean of Damage	Standard Deviation of Damage	Depth	Mean of Damage	Standard Deviation of Damage
-8	1.70%	2.7	-8	0%	0
-7	1.70%	2.7	-7	1.00%	2.27
-6	1.90%	2.11	-6	2.30%	1.76
-5	2.90%	1.8	-5	3.70%	1.49
-4	4.70%	1.66	-4	5.20%	1.37
-3	7.20%	1.56	-3	6.80%	1.29
-2	10.20%	1.47	-2	8.40%	1.21
-1	13.90%	1.37	-1	10.10%	1.13
0	17.90%	1.32	0	11.90%	1.09
1	22.30%	1.35	1	13.80%	1.11
2	27.00%	1.5	2	15.70%	1.23
3	31.90%	1.75	3	17.70%	1.43
4	36.90%	2.04	4	19.80%	1.67
5	41.90%	2.34	5	22.00%	1.92
6	46.90%	2.63	6	24.30%	2.15
7	51.80%	2.89	7	26.70%	2.36
8	56.40%	3.13	8	29.10%	2.56
9	60.80%	3.38	9	31.70%	2.76
10	64.80%	3.71	10	34.40%	3.04
11	68.40%	4.22	11	37.20%	3.46
12	71.40%	5.02	12	40.00%	4.12
13	73.70%	6.19	13	43.00%	5.08
14	75.40%	7.79	14	46.10%	6.39
15	76.40%	9.84	15	49.30%	8.08
16	76.40%	12.36	16	52.60%	10.15

TABLE 3.
Residential, Split Level, With Basement

Structure			Content		
Depth	Mean of Damage	Standard Deviation of Damage	Depth	Mean of Damage	Standard Deviation of Damage
-8			-8	0.60%	2.09
-7			-7	0.70%	1.49
-6	2.50%	1.80%	-6	1.40%	1.14
-5	3.10%	1.60%	-5	2.40%	1.01
-4	4.70%	1.50%	-4	3.80%	1
-3	7.20%	1.60%	-3	5.40%	1.02
-2	10.40%	1.60%	-2	7.30%	1.03
-1	14.20%	1.60%	-1	9.40%	1.04
0	18.50%	1.60%	0	11.60%	1.06
1	23.20%	1.70%	1	13.80%	1.12
2	28.20%	1.90%	2	16.10%	1.23
3	33.40%	2.10%	3	18.20%	1.38
4	38.60%	2.40%	4	20.20%	1.57
5	43.80%	2.60%	5	22.10%	1.76
6	48.80%	2.90%	6	23.60%	1.95
7	53.50%	3.20%	7	24.90%	2.13
8	57.80%	3.40%	8	25.80%	2.28
9	61.60%	3.60%	9	26.30%	2.44
10	64.80%	3.90%	10	26.30%	2.44
11	67.20%	4.20%	11	26.30%	2.44
12	68.80%	4.80%	12	26.30%	2.44
13	69.30%	5.70%	13	26.30%	2.44
14	69.30%	5.70%	14	26.30%	2.44
15	69.30%	5.70%	15	26.30%	2.44
16	69.30%	5.70%	16	26.30%	2.44

TABLE 4.
Residential, One Story, No Basement

Structure			Content		
Depth	Mean of Damage	Standard Deviation of Damage	Depth	Mean of Damage	Standard Deviation of Damage
-2	0%	0%	-2	0%	0%
-1	2.50%	2.70%	-1	2.40%	2.10%
0	13.40%	2.00%	0	8.10%	1.50%
1	23.30%	1.60%	1	13.30%	1.20%
2	32.10%	1.60%	2	17.90%	1.20%
3	40.10%	1.80%	3	22.00%	1.40%
4	47.10%	1.90%	4	25.70%	1.50%
5	53.20%	2.00%	5	28.80%	1.60%
6	58.60%	2.10%	6	31.50%	1.60%
7	63.20%	2.20%	7	33.80%	1.70%
8	67.20%	2.30%	8	35.70%	1.80%
9	70.50%	2.40%	9	37.20%	1.90%
10	73.20%	2.70%	10	38.40%	2.10%
11	75.40%	3.00%	11	39.20%	2.30%
12	77.20%	3.30%	12	39.70%	2.60%
13	78.50%	3.70%	13	40.00%	2.90%
14	79.50%	4.10%	14	40.00%	3.20%
15	80.20%	4.50%	15	40.00%	3.50%
16	80.70%	4.90%	16	40.00%	3.80%

TABLE 5.
Residential, Two of More Stories, No Basement

Structure			Content		
Depth	Mean of Damage	Standard Deviation of Damage	Depth	Mean of Damage	Standard Deviation of Damage
-2	0%	0%	-2	0%	0%
-1	3.00%	4.10%	-1	1.00%	3.50%
0	9.30%	3.40%	0	5.00%	2.90%
1	15.20%	3.00%	1	8.70%	2.60%
2	20.90%	2.80%	2	12.20%	2.50%
3	26.30%	2.90%	3	15.50%	2.50%
4	31.40%	3.20%	4	18.50%	2.70%
5	36.20%	3.40%	5	21.30%	3.00%
6	40.70%	3.70%	6	23.90%	3.20%
7	44.90%	3.90%	7	26.30%	3.30%
8	48.80%	4.00%	8	28.40%	3.40%
9	52.40%	4.10%	9	30.30%	3.50%
10	55.70%	4.20%	10	32.00%	3.50%
11	58.70%	4.20%	11	33.40%	3.50%
12	61.40%	4.20%	12	34.70%	3.50%
13	63.80%	4.20%	13	35.60%	3.50%
14	65.90%	4.30%	14	36.40%	3.60%
15	67.70%	4.60%	15	36.90%	3.80%
16	69.20%	5.00%	16	37.20%	4.20%

TABLE 6.
Residential, Split Level, No basement

Structure			Content		
Depth	Mean of Damage	Standard Deviation of Damage	Depth	Mean of Damage	Standard Deviation of Damage
-2	0%	0%	-2	0%	0%
-1	6.40%	2.90%	-1	2.20%	2.20%
0	7.20%	2.10%	0	2.90%	1.50%
1	9.40%	1.90%	1	4.70%	1.20%
2	12.90%	1.90%	2	7.50%	1.30%
3	17.40%	2.00%	3	11.10%	1.40%
4	22.80%	2.20%	4	15.30%	1.50%
5	28.90%	2.40%	5	20.10%	1.60%
6	35.50%	2.70%	6	25.20%	1.80%
7	42.30%	3.20%	7	30.50%	2.10%
8	49.20%	3.80%	8	35.70%	2.50%
9	56.10%	4.50%	9	40.90%	3.00%
10	62.60%	5.30%	10	45.80%	3.50%
11	68.60%	6.00%	11	50.20%	4.10%
12	73.90%	6.70%	12	54.10%	4.60%
13	78.40%	7.40%	13	57.20%	5.00%
14	81.70%	7.90%	14	59.40%	5.40%
15	83.80%	8.30%	15	60.50%	5.70%
16	84.40%	8.70%	16	60.50%	6.00%

TABLE 7.
Non-residential, Commercial and Industry

Structure		Contents	
Depth	Combined Commercial Industrial	Depth	Combined Commercial Industrial
-8		-8	
-7		-7	
-6		-6	
-5		-5	
-4	0.00%	-4	0.00%
-3	0.00%	-3	0.00%
-2	0.00%	-2	0.00%
-1	0.00%	-1	0.00%
0	0.68%	0	2.75%
1	10.21%	1	19.50%
2	14.21%	2	33.73%
3	17.46%	3	45.16%
4	20.92%	4	55.26%
5	24.02%	5	62.08%
6	27.35%	6	66.93%
7	30.50%	7	70.34%
8	33.72%	8	73.19%
9	36.89%	9	75.46%
10	39.86%	10	77.21%
11	43.52%	11	79.60%
12	46.85%	12	81.10%
13	49.45%	13	82.40%
14	51.85%	14	83.64%
15	54.31%	15	84.28%
16	56.53%	16	84.82%

Note: This curve was created by USACE, Galveston District

References:

Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements.

United States Army Corp of Engineers, Galveston District, HAZUS application.

Subbasin	Tributary	County	Description	Basin Area (mi^2)	Initial Abstraction (in)	Curve Number	Time of Concentration (hr)	Clark Storage Coefficient (hr)
W-MS-IN-1	Main Stem	Cook County	Inflow to Main Stem	0.44	0.55	78.3	1.3	3.1
W-MS-IN-2	Main Stem	Cook County	Inflow to Main Stem	0.12	0.66	75.1	0.9	2.1
W-MS-IN-3	Main Stem	Cook County	Inflow to Main Stem	0.67	0.64	75.7	2.1	4.8
W-MS-IN-4	Main Stem	Cook County	Inflow to Main Stem	0.45	0.60	77.0	1.8	4.3
W-MS-IN-5	Main Stem	Cook County	Inflow to Main Stem	0.36	0.58	77.6	2.1	4.9
W-MS-IN-6	Main Stem	Cook County	Inflow to Main Stem	0.35	0.89	69.2	2.7	6.4
W-MS-IN-7	Main Stem	Cook County	Inflow to Main Stem	0.36	0.91	68.6	3.2	7.4
W-MS-IN-8	Main Stem	Cook County	Inflow to Main Stem	0.83	0.60	76.8	2.9	6.7
W-MS-IN-9	Main Stem	Cook County	Inflow to Main Stem	2.28	0.44	81.8	3.6	8.5
W-MS-IN-10	Main Stem	Cook County	Inflow to Main Stem	1.94	0.46	81.4	2.4	5.6
W-MS-IN-11	Main Stem	Cook County	Inflow to Main Stem	1.64	0.57	77.9	6.2	14.4
W-MS-IN-12	Main Stem	Cook County	Inflow to Main Stem	1.20	0.43	82.4	2.3	5.4
W-MS-IN-13	Main Stem	Cook County	Inflow to Main Stem	0.73	0.35	85.0	3.0	7.1
W-MS-IN-14	Main Stem	Cook County	Inflow to Main Stem	2.00	0.43	82.2	2.1	4.9
W-MS-IN-15	Main Stem	Cook County	Inflow to Main Stem	0.73	0.86	70.0	4.3	10.1
W-MS-IN-16	Main Stem	Cook County	Inflow to Main Stem	3.18	0.40	83.4	5.2	12.2
W-MS-IN-17	Main Stem	Cook County	Inflow to Main Stem	0.78	0.39	83.7	3.7	8.6
W-MS-IN-18	Main Stem	Cook County	Inflow to Main Stem	1.00	1.09	64.7	5.1	12.0
W-MS-IN-19	Main Stem	Cook County	Inflow to Main Stem	1.20	0.40	83.3	4.9	11.4
W-MS-IN-20	Main Stem	Cook County	Inflow to Main Stem	0.83	0.55	78.4	2.0	4.6
W-MS-IN-21	Main Stem	Cook County	Inflow to Main Stem	0.42	0.36	84.8	1.5	3.6
W-MF-MC-1	Middle Fork	Cook County	Middle Fork Main Channel	0.59	0.56	78.2	2.6	6.0
W-MF-MC-2	Middle Fork	Cook County	Middle Fork Main Channel	0.58	0.47	80.8	2.5	5.9
W-MF-MC-3	Middle Fork	Cook County	Middle Fork Main Channel	1.13	0.52	79.5	2.4	5.5
W-MF-MC-4	Middle Fork	Cook County	Middle Fork Main Channel	0.57	0.64	75.8	1.0	2.3
W-MF-MC-5	Middle Fork	Cook County	Middle Fork Main Channel	0.45	0.61	76.7	1.2	2.7
W-MF-MC-6	Middle Fork	Cook County	Middle Fork Main Channel	0.70	0.65	75.5	1.6	3.6
W-MF-MC-7	Middle Fork	Cook County	Middle Fork Main Channel	0.23	0.35	85.0	1.5	3.4
W-MF-MC-8	Middle Fork	Cook County	Middle Fork Main Channel	0.14	0.17	92.0	1.2	2.8
W-MF-MC-9	Middle Fork	Lake & Cook	Middle Fork Main Channel	0.78	0.48	72.5	1.4	5.7
W-MF-MC-10	Middle Fork	Lake County	Middle Fork Main Channel	0.96	0.43	74.1	1.8	7.4

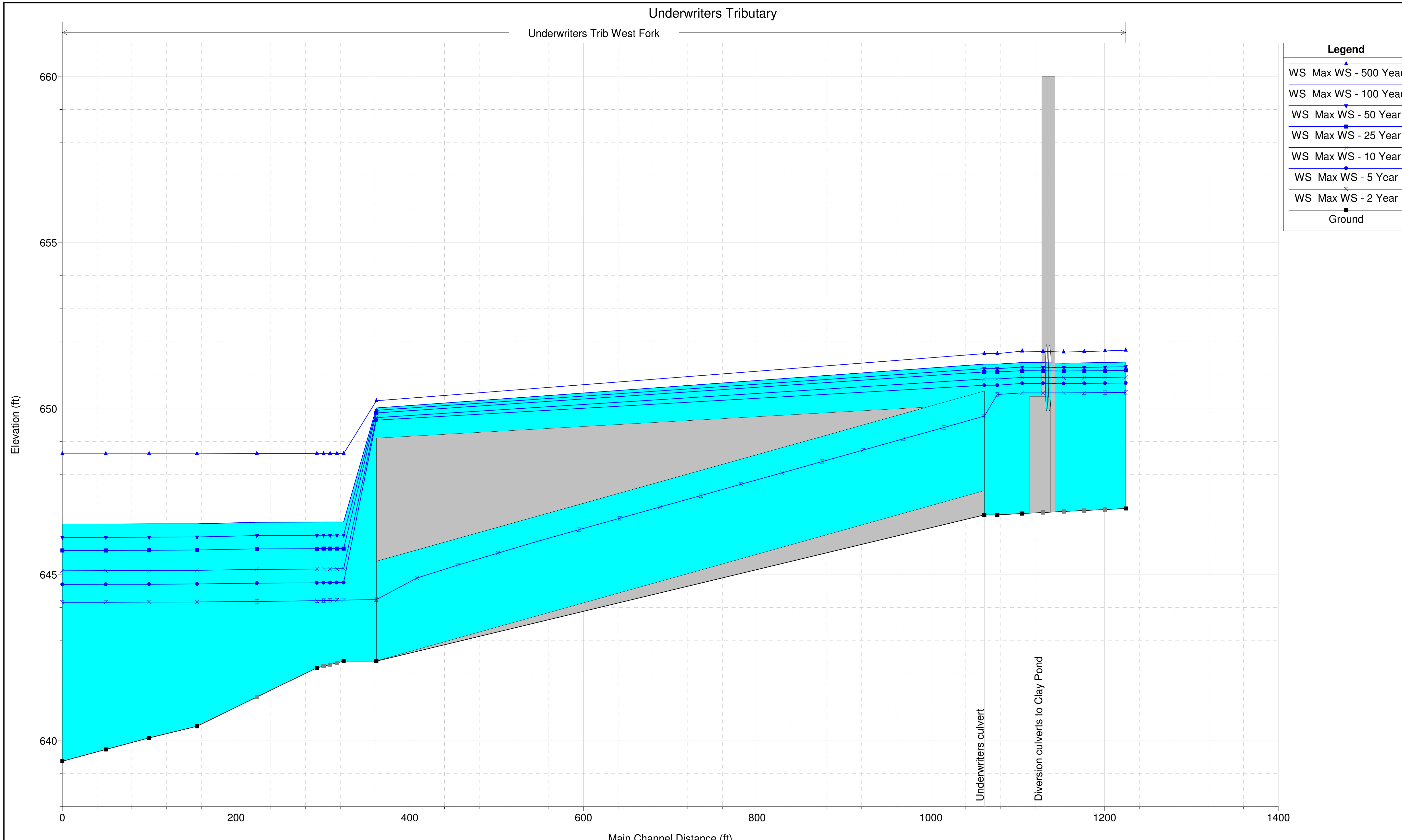
Subbasin	Tributary	County	Description	Basin Area (mi^2)	Initial Abstraction (in)	Curve Number	Time of Concentration (hr)	Clark Storage Coefficient (hr)
W-MF-MC-11	Middle Fork	Lake County	Middle Fork Main Channel	0.93	0.44	73.7	1.8	7.4
W-MF-MC-12	Middle Fork	Lake County	Middle Fork Main Channel	1.26	0.60	69.3	2.1	8.3
W-MF-MC-13	Middle Fork	Lake County	Middle Fork Main Channel	1.12	0.65	67.9	3.0	12.2
W-MF-MC-14	Middle Fork	Lake County	Middle Fork Main Channel	0.90	0.45	73.5	1.8	7.1
W-MF-MC-15	Middle Fork	Lake County	Middle Fork Main Channel	1.40	0.48	72.7	1.4	5.6
W-MF-MC-16	Middle Fork	Lake County	Middle Fork Main Channel	1.19	0.46	73.1	2.3	9.2
W-MF-MC-17	Middle Fork	Lake County	Middle Fork Main Channel	0.45	0.53	71.2	1.0	4.2
W-MF-MC-18	Middle Fork	Lake County	Middle Fork Main Channel	0.50	0.37	75.8	2.1	8.6
W-MF-MC-19	Middle Fork	Lake County	Middle Fork Main Channel	0.31	0.48	72.5	1.6	6.3
W-MF-MC-20	Middle Fork	Lake County	Middle Fork Main Channel	0.91	0.28	78.9	2.2	8.9
W-MF-MC-21	Middle Fork	Lake County	Middle Fork Main Channel	0.37	0.23	80.9	1.9	7.6
W-MF-MC-22	Middle Fork	Lake County	Middle Fork Main Channel	0.51	0.27	79.4	0.9	3.7
W-MF-MC-23	Middle Fork	Lake County	Middle Fork Main Channel	0.55	0.18	82.6	1.0	4.0
W-MF-MC-24	Middle Fork	Lake County	Middle Fork Main Channel	1.25	0.36	76.3	1.4	5.7
W-MF-MC-25	Middle Fork	Lake County	Middle Fork Main Channel	0.93	0.36	76.3	2.3	9.4
W-MF-IN-1	Middle Fork	Cook County	Middle Fork West Inflow Basin	0.43	0.48	80.7	2.7	6.3
W-MF-IN-2	Middle Fork	Lake County	Middle Fork West Inflow Basin	0.57	0.44	73.7	2.1	8.4
W-MF-IN-3	Middle Fork	Lake County	Middle Fork West Inflow Basin	0.48	0.49	72.3	1.6	6.5
W-MF-IN-4	Middle Fork	Lake County	Middle Fork West Inflow Basin	0.61	0.41	74.6	1.2	4.7
W-MF-IN-5	Middle Fork	Lake County	Middle Fork West Inflow Basin	1.04	0.48	72.6	2.4	9.6
W-MF-IN-6	Middle Fork	Lake County	Middle Fork West Inflow Basin	0.78	0.41	74.8	1.2	4.8
W-MF-IN-7	Middle Fork	Lake County	Middle Fork East Inflow Basin	0.21	0.22	81.0	1.6	6.4
W-MF-IN-8	Middle Fork	Lake County	Middle Fork West Inflow Basin	1.75	0.41	74.8	6.5	26.0
W-SK-ED-1.1	Skokie River	Cook County	East diversion channel	0.88	0.55	78.4	2.8	6.5
W-SK-ED-1.2	Skokie River	Cook County	East diversion channel	1.95	0.58	77.5	2.4	5.6
W-SK-ED-2	Skokie River	Cook County	East diversion channel	0.58	0.61	76.6	1.6	3.8
W-SK-In-1.1	Skokie River	Cook County	Diversion channel, east.	3.45	0.53	79.1	9.8	22.8
W-SK-In-1.2	Skokie River	Cook County	Diversion channel, east.	0.57	0.54	78.8	3.1	7.2
W-SK-In-2	Skokie River	Cook County	Diversion channel, east.	2.39	0.52	79.5	13.1	30.6
W-SK-WD-1.1	Skokie River	Cook County	West diversion channel	0.67	0.40	83.3	2.4	5.6
W-SK-WD-1.2	Skokie River	Cook County	West diversion channel	1.01	0.37	84.4	4.8	11.3

Subbasin	Tributary	County	Description	Basin Area (mi^2)	Initial Abstraction (in)	Curve Number	Time of Concentration (hr)	Clark Storage Coefficient (hr)
W-SK-WD-2	Skokie River	Cook County	West diversion channel	0.54	0.29	87.5	1.4	3.2
W-SK-WC-3	Skokie River	Lake County	West diversion channel	1.18	0.51	71.8	2.5	10.2
W-SK-WD-4	Skokie River	Lake County	West diversion channel	1.41	0.38	75.8	4.0	16.0
W-SK-MC-1	Skokie River	Cook County	Main Channel	0.70	0.60	76.8	2.0	4.6
W-SK-MC-2	Skokie River	Cook County	Main Channel, lagoons.	0.99	0.37	84.5	5.6	13.1
W-SK-MC-3	Skokie River	Cook County	Main channel	0.05	0.62	76.4	0.4	0.9
W-SK-MC-4	Skokie River	Cook County	Main channel	0.04	0.73	73.1	0.5	1.3
W-SK-MC-5	Skokie River	Lake & Cook	Main channel	0.77	0.59	69.6	0.9	3.6
W-SK-MC-6	Skokie River	Lake County	Main Channel	2.33	0.51	71.8	2.7	11.0
W-SK-MC-7	Skokie River	Lake County	Main Channel	0.87	0.46	73.3	2.4	9.8
W-SK-MC-8	Skokie River	Lake County	Main channel	0.50	0.64	68.2	1.3	5.1
W-SK-MC-9	Skokie River	Lake County	Main channel	2.00	0.55	70.5	1.3	5.0
W-SK-MC-10	Skokie River	Lake County	Main channel	1.05	0.51	71.7	1.3	5.1
W-SK-MC-11	Skokie River	Lake County	Main channel	1.38	0.55	70.6	3.2	13.0
W-SK-MC-12	Skokie River	Lake County	Main channel	1.74	0.64	68.2	1.1	4.3
W-SK-MC-13	Skokie River	Lake County	Main channel	2.05	0.55	70.5	2.2	8.9
W-SK-MC-14	Skokie River	Lake County	Main channel	1.36	0.38	75.5	2.5	10.1
W-SK-MC-15	Skokie River	Lake County	Main channel	1.13	0.44	73.7	1.4	5.7
W-SK-MC-16	Skokie River	Lake County	Main channel	1.30	0.37	76.1	4.4	17.4
W-SK-MC-17	Skokie River	Lake County	Main channel	1.10	0.37	75.9	1.7	6.8
W-SK-MC-18	Skokie River	Lake County	Main channel	1.34	0.35	76.6	3.1	12.2
W-WF-MC-1	West Fork	Cook County	West Fork Main Channel	0.73	0.70	74.0	0.8	1.8
W-WF-MC-2	West Fork	Cook County	West Fork Main Channel	0.34	0.53	79.1	1.3	3.1
W-WF-MC-3	West Fork	Cook County	West Fork Main Channel	0.05	0.61	76.7	0.4	1.0
W-WF-MC-4	West Fork	Cook County	West Fork Main Channel	0.72	0.53	79.2	1.5	3.6
W-WF-MC-5	West Fork	Cook County	West Fork Main Channel	1.15	0.44	82.1	4.2	9.7
W-WF-MC-6	West Fork	Cook County	West Fork Main Channel	0.44	0.40	83.5	0.8	1.9
W-WF-MC-8	West Fork	Cook County	West Fork Main Channel	0.85	0.38	84.0	1.2	2.7
W-WF-MC-9	West Fork	Cook County	West Fork Main Channel	0.67	0.58	77.6	1.2	2.8
W-WF-MC-10	West Fork	Cook County	West Fork Main Channel	0.57	0.49	80.4	0.7	1.5
W-WF-MC-11	West Fork	Cook County	West Fork Main Channel	1.34	0.42	82.7	3.5	8.2

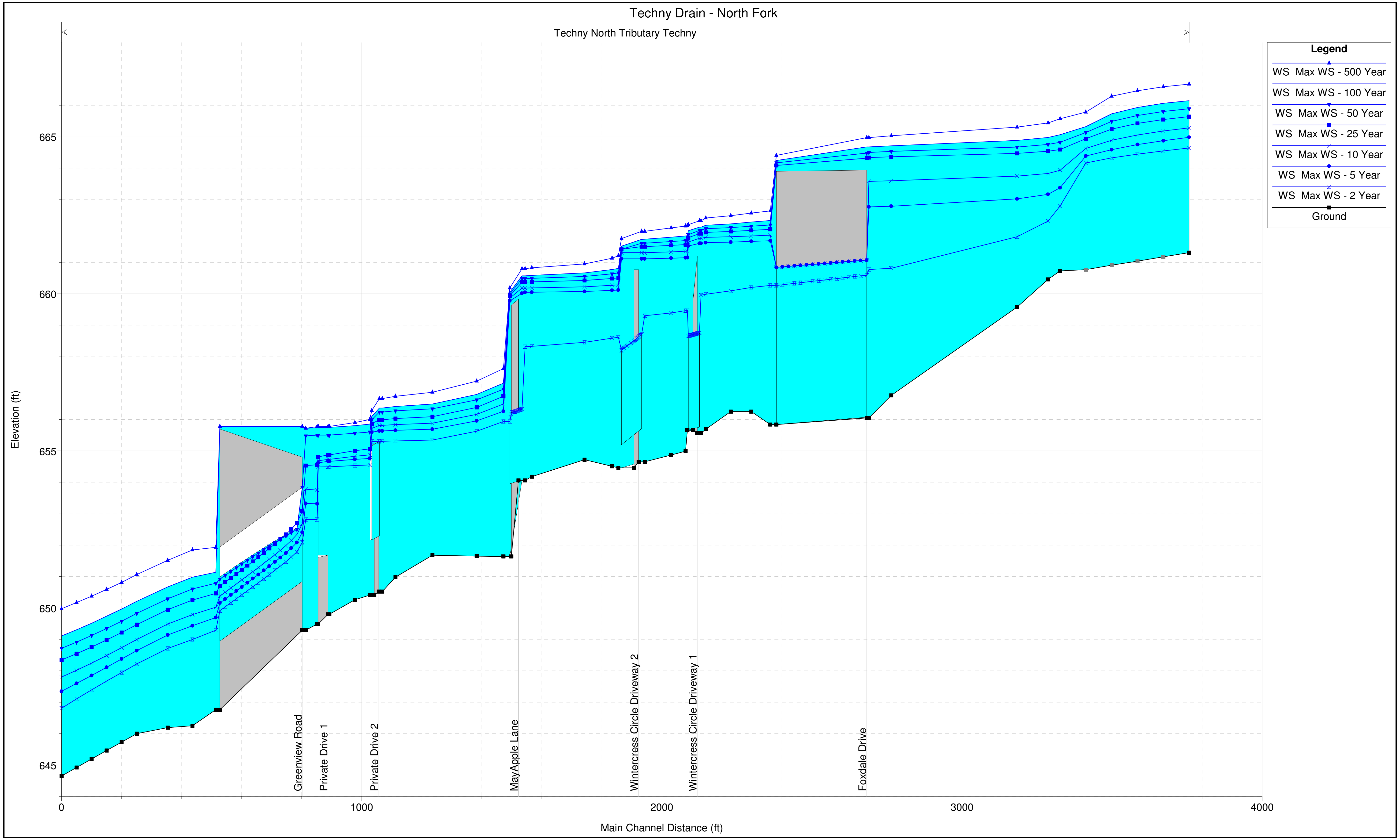
Subbasin	Tributary	County	Description	Basin Area (mi^2)	Initial Abstraction (in)	Curve Number	Time of Concentration (hr)	Clark Storage Coefficient (hr)
W-WF-MC-12	West Fork	Cook County	West Fork Main Channel	0.37	0.38	84.0	2.2	5.1
W-WF-MC-13	West Fork	Cook County	West Fork Main Channel	0.80	0.47	80.9	1.7	3.9
W-WF-MC-14	West Fork	Cook County	West Fork Main Channel	0.77	0.50	80.1	2.4	5.6
W-WF-MC-15	West Fork	Cook County	West Fork Main Channel	0.06	0.77	72.3	0.8	1.8
W-WF-MC-16	West Fork	Cook County	West Fork Main Channel	0.67	0.25	89.0	2.9	6.7
W-WF-MC-17	West Fork	Cook County	West Fork Main Channel	0.61	0.24	89.4	1.6	3.7
W-WF-MC-18	West Fork	Lake & Cook	West Fork Main Channel	1.44	0.31	86.7	4.0	9.3
W-WF-MC-19	West Fork	Lake County	West Fork Main Channel	1.75	0.34	85.3	3.1	7.2
W-WF-MC-20	West Fork	Lake County	West Fork Main Channel	1.29	0.44	82.1	2.3	5.4
W-WF-MC-21	West Fork	Lake County	West Fork Main Channel	1.10	0.40	83.2	1.8	4.2
W-WF-MC-22	West Fork	Lake County	West Fork Main Channel	0.55	0.35	85.1	1.8	4.3
W-WF-MC-23	West Fork	Lake County	West Fork Main Channel	0.94	0.41	83.0	2.0	4.6
W-WF-MC-24	West Fork	Lake County	West Fork Main Channel	1.40	0.43	82.2	1.8	4.3
W-WF-In-1	West Fork	Cook County	Inflow to the West Fork	1.33	0.53	79.2	3.9	9.1
W-WF-In-2	West Fork	Cook County	Inflow to the West Fork	0.69	0.51	79.6	3.4	8.0
W-WF-In-5	West Fork	Cook County	Inflow to the West Fork	0.39	0.31	86.7	1.6	3.8
W-WF-NND-1	West Fork	Cook County	North Navy Ditch	0.29	0.37	84.3	1.4	3.4
W-WF-NND-2	West Fork	Cook County	North Navy Ditch	1.58	0.48	80.6	6.5	15.2
W-WF-NND-3	West Fork	Cook County	North Navy Ditch	0.97	0.44	82.0	3.7	8.5
W-WF-NND-4	West Fork	Cook County	North Navy Ditch	0.79	0.37	84.4	2.2	5.2
W-WF-NND-5	West Fork	Cook County	North Navy Ditch	0.75	0.37	84.3	2.4	5.5
W-WF-SND-1	West Fork	Cook County	South Navy Ditch	0.11	0.52	79.3	0.6	1.5
W-WF-SND-2	West Fork	Cook County	South Navy Ditch	0.15	0.73	73.4	2.0	4.6
W-WF-TD-1	West Fork	Cook County	Techny Drain	0.10	0.64	75.7	1.1	2.6
W-WF-TD-10	West Fork	Cook County	Techny Drain	0.22	0.40	83.3	1.4	3.2
W-WF-TD-11	West Fork	Cook County	Techny Drain	0.02	0.20	91.0	0.3	0.7
W-WF-TD-12	West Fork	Cook County	Techny Drain	0.35	0.36	84.7	3.7	8.7
W-WF-TD-2	West Fork	Cook County	Techny Drain	0.08	0.26	88.3	0.6	1.4
W-WF-TD-3	West Fork	Cook County	Techny Drain	0.25	0.20	90.7	1.1	2.5
W-WF-TD-4	West Fork	Cook County	Techny Drain	0.17	0.39	83.6	0.6	1.3
W-WF-TD-5	West Fork	Cook County	Techny Drain	0.10	0.38	84.1	0.8	2.0

Subbasin	Tributary	County	Description	Basin Area (mi^2)	Initial Abstraction (in)	Curve Number	Time of Concentration (hr)	Clark Storage Coefficient (hr)
W-WF-TD-6	West Fork	Cook County	Techny Drain	0.10	0.36	84.8	0.7	1.7
W-WF-TD-7	West Fork	Cook County	Techny Drain	0.34	0.42	82.5	1.5	3.4
W-WF-TD-8	West Fork	Cook County	Techny Drain	0.18	0.44	82.0	1.6	3.8
W-WF-TD-9	West Fork	Cook County	Techny Drain	0.06	0.43	82.3	0.5	1.2
W-WF-UW-1	West Fork	Cook County	Underwriters Tributary	0.04	0.59	77.2	0.4	1.0
W-WF-UW-2	West Fork	Cook County	Underwriters Tributary	0.13	0.42	82.7	1.4	3.3
W-WF-UW-3	West Fork	Cook County	Underwriters Tributary	0.32	0.28	87.7	1.4	3.2
W-WF-UW-4	West Fork	Cook County	Underwriters Tributary	0.03	0.43	82.3	0.4	1.0

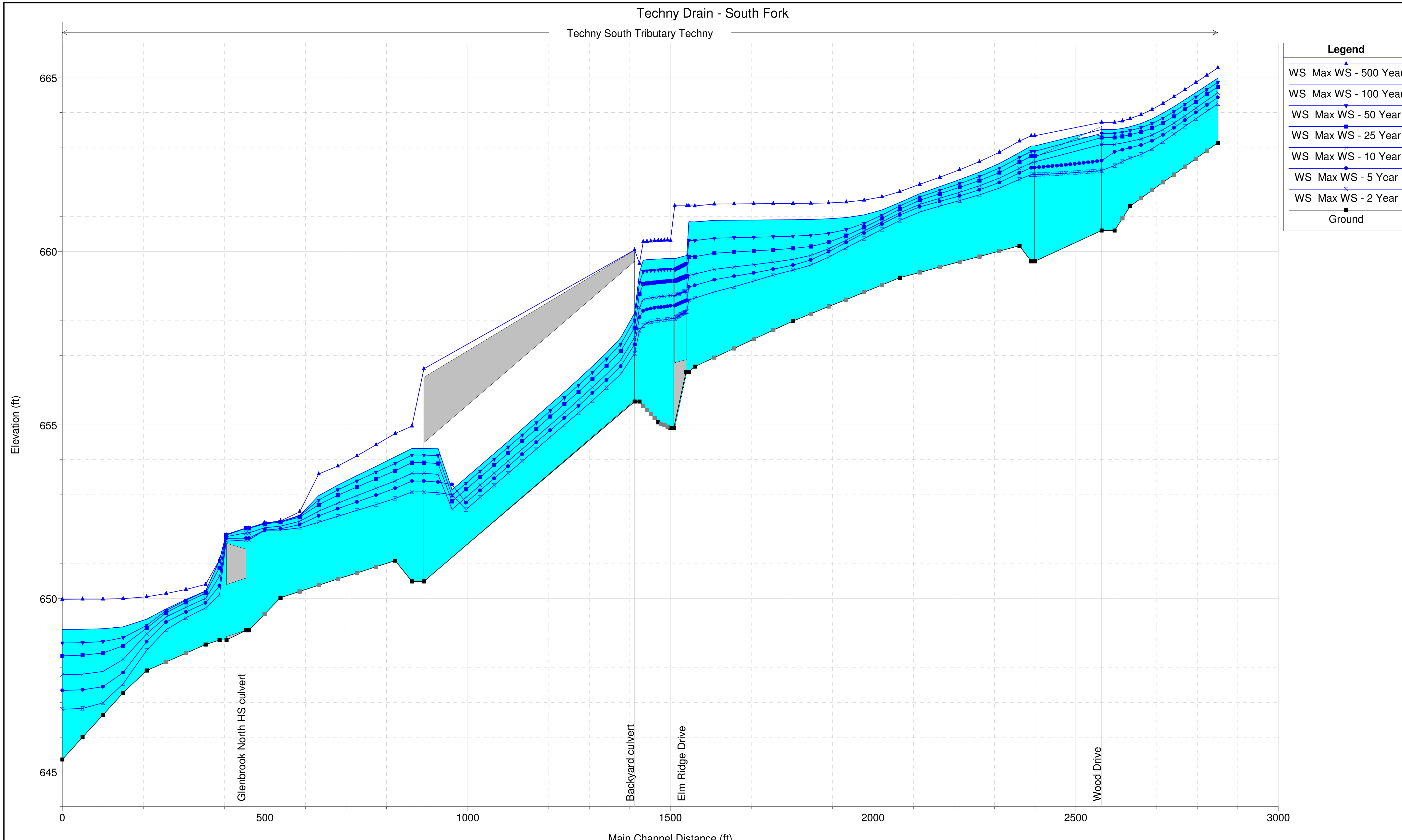
Subbasin	Tributary	County	Description	Basin Area (mi^2)	Initial Abstraction (in)	Curve Number	Basin Lag Time (hr)	Clark Storage Coefficient (hr)
23	Lake Michigan	Cook County	Ravine 1 - North Fork	0.40	N/A	82.0	0.3	N/A
26	Lake Michigan	Cook County	Ravine 1 - South Fork	0.25	N/A	83.0	1.1	N/A



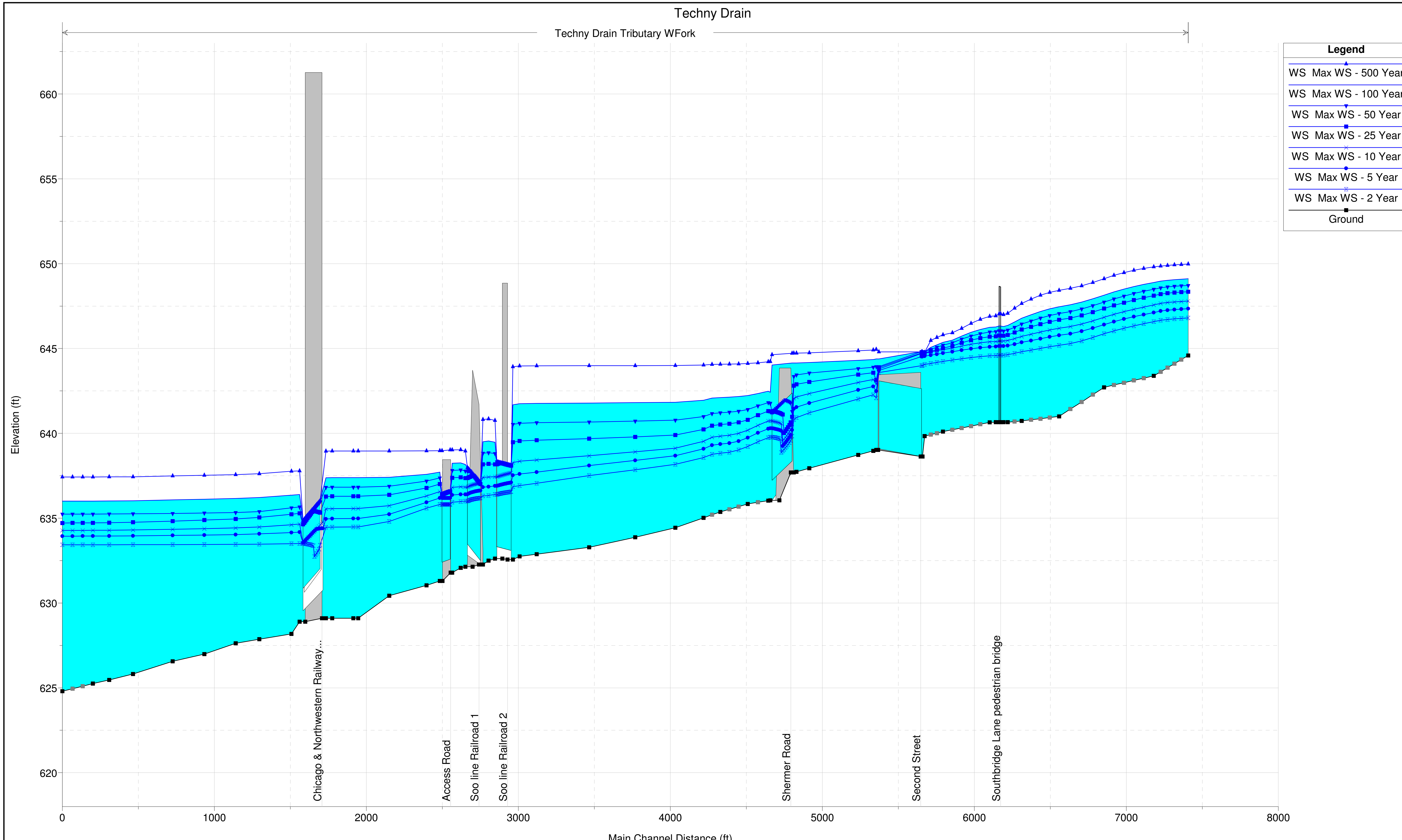
Underwriters Tributary from Bach Street to confluence with the West Fork



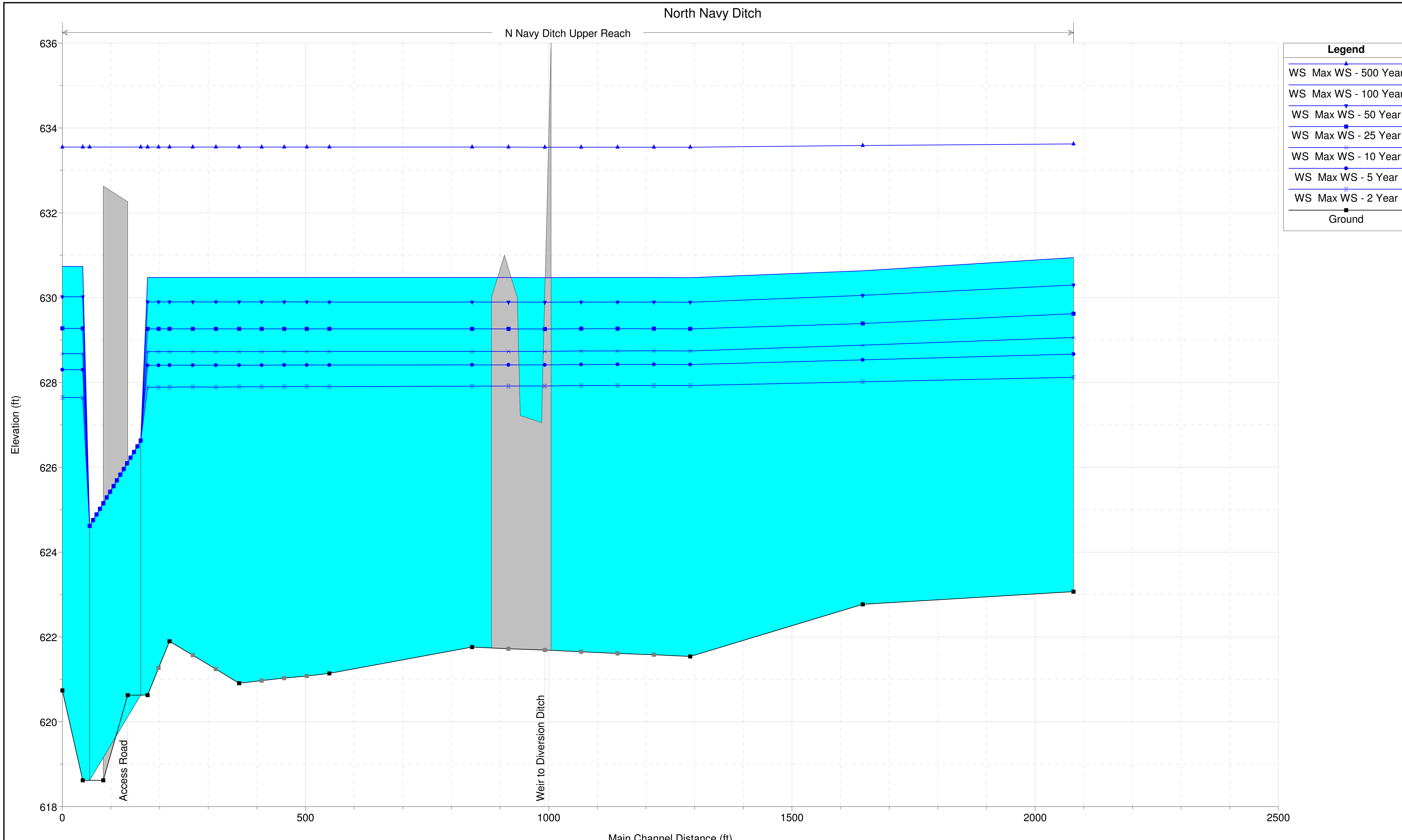
North Fork of the Techny Drain from its headwater to confluence with the South Fork of the Techny Drain



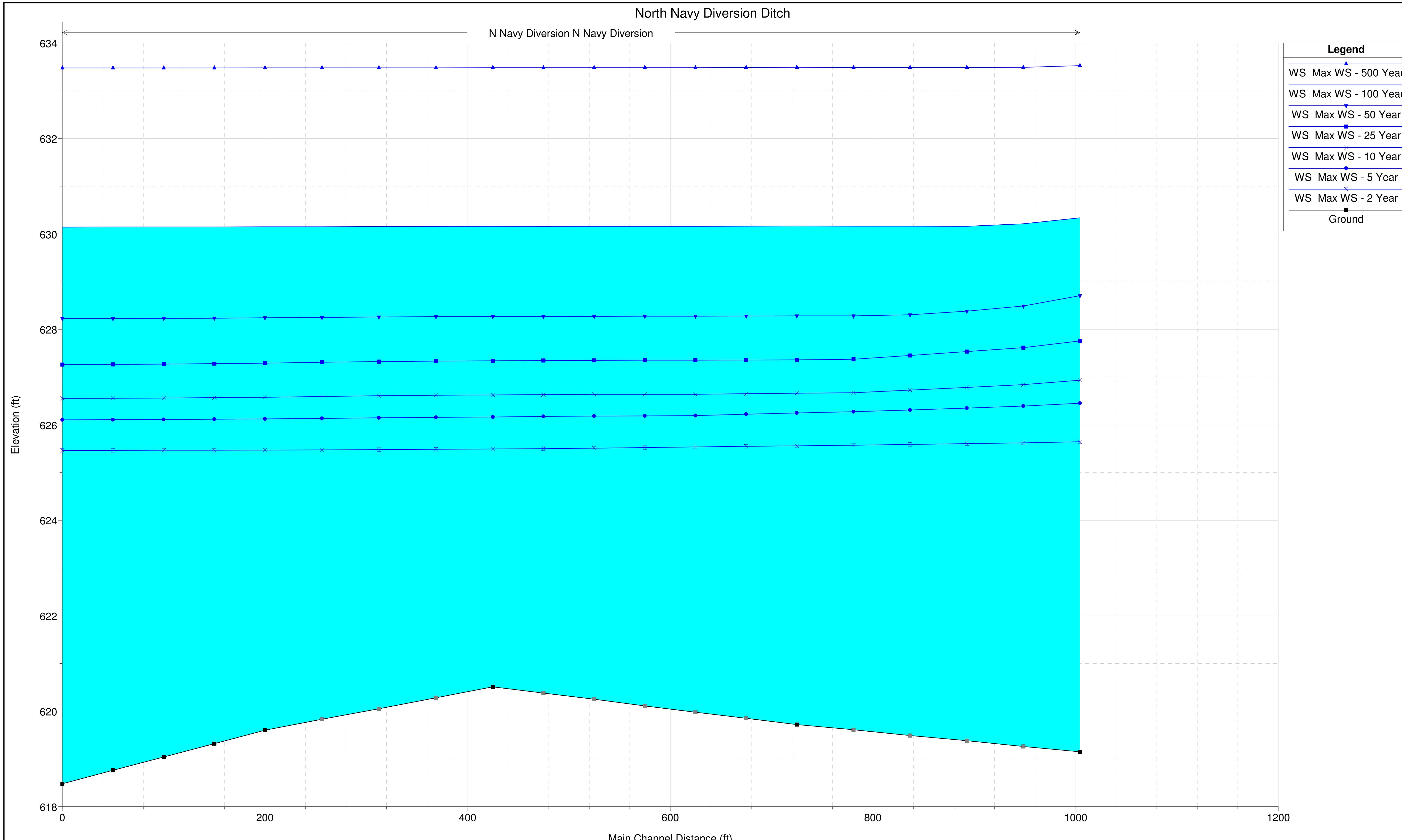
South Fork of the Techny Drain from its headwater to confluence with the North Fork of the Techny Drain



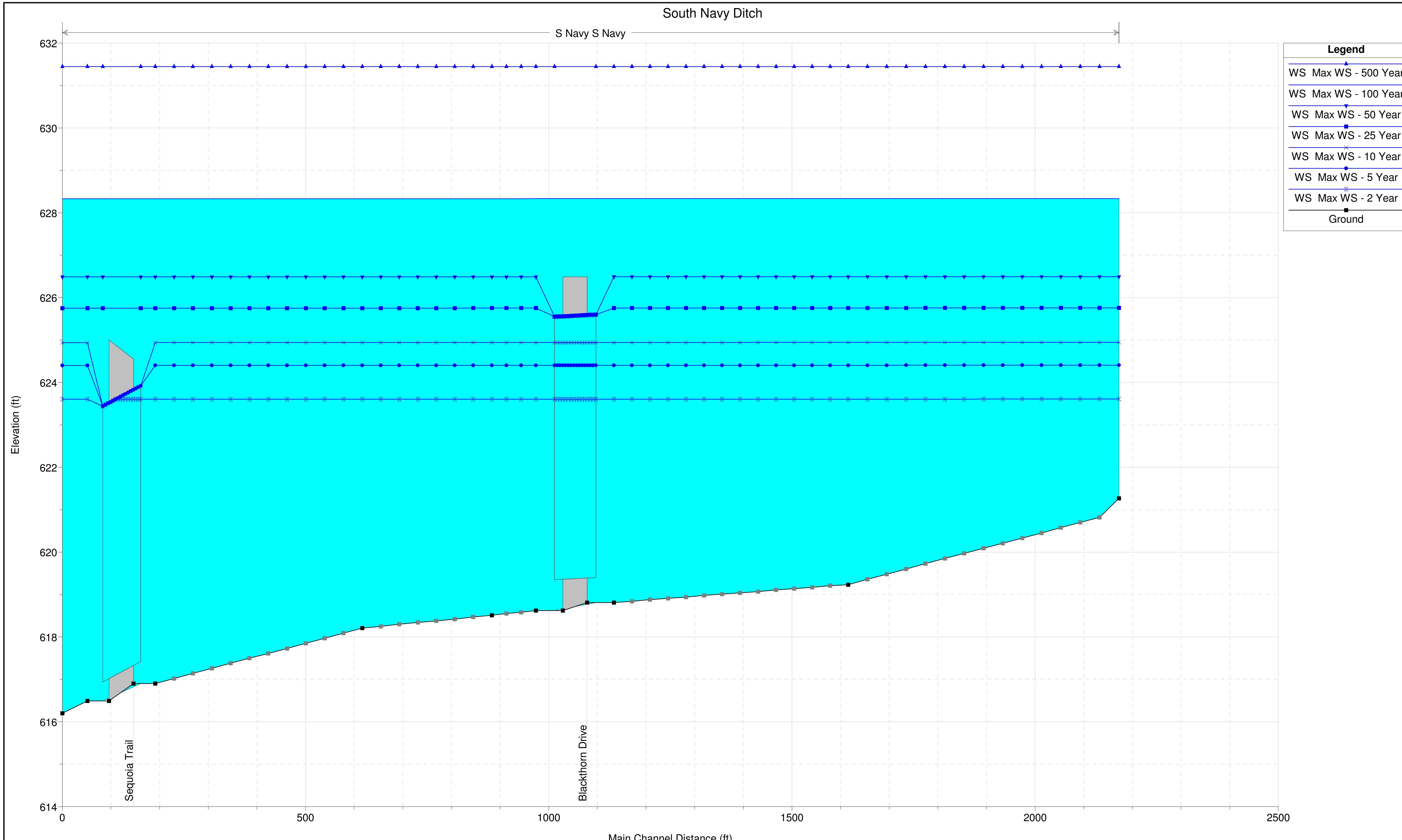
Techny Drain from confluence of the North and South Forks to confluence with the West Fork



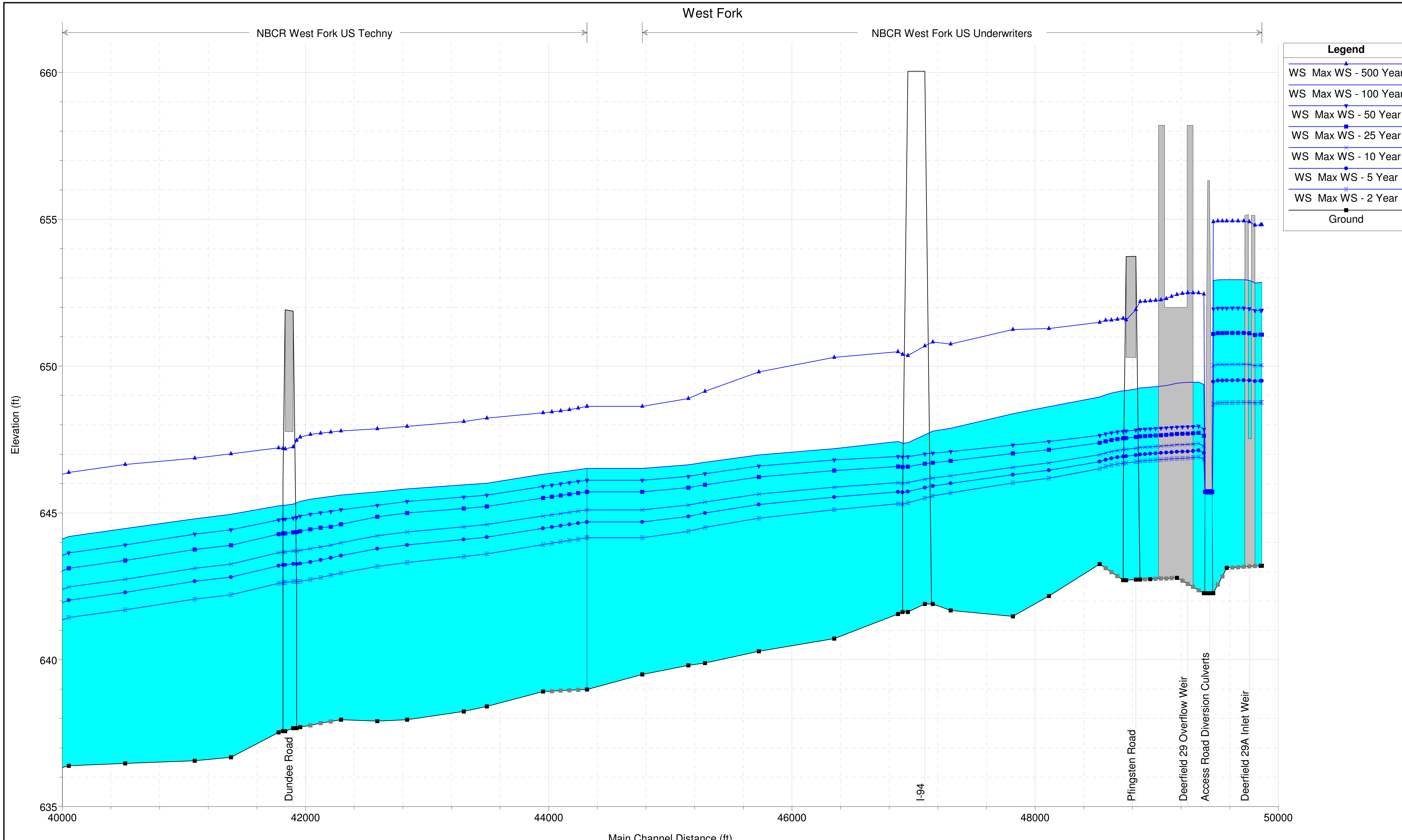
North Navy Ditch from Lehigh Avenue to confluence with the West Fork



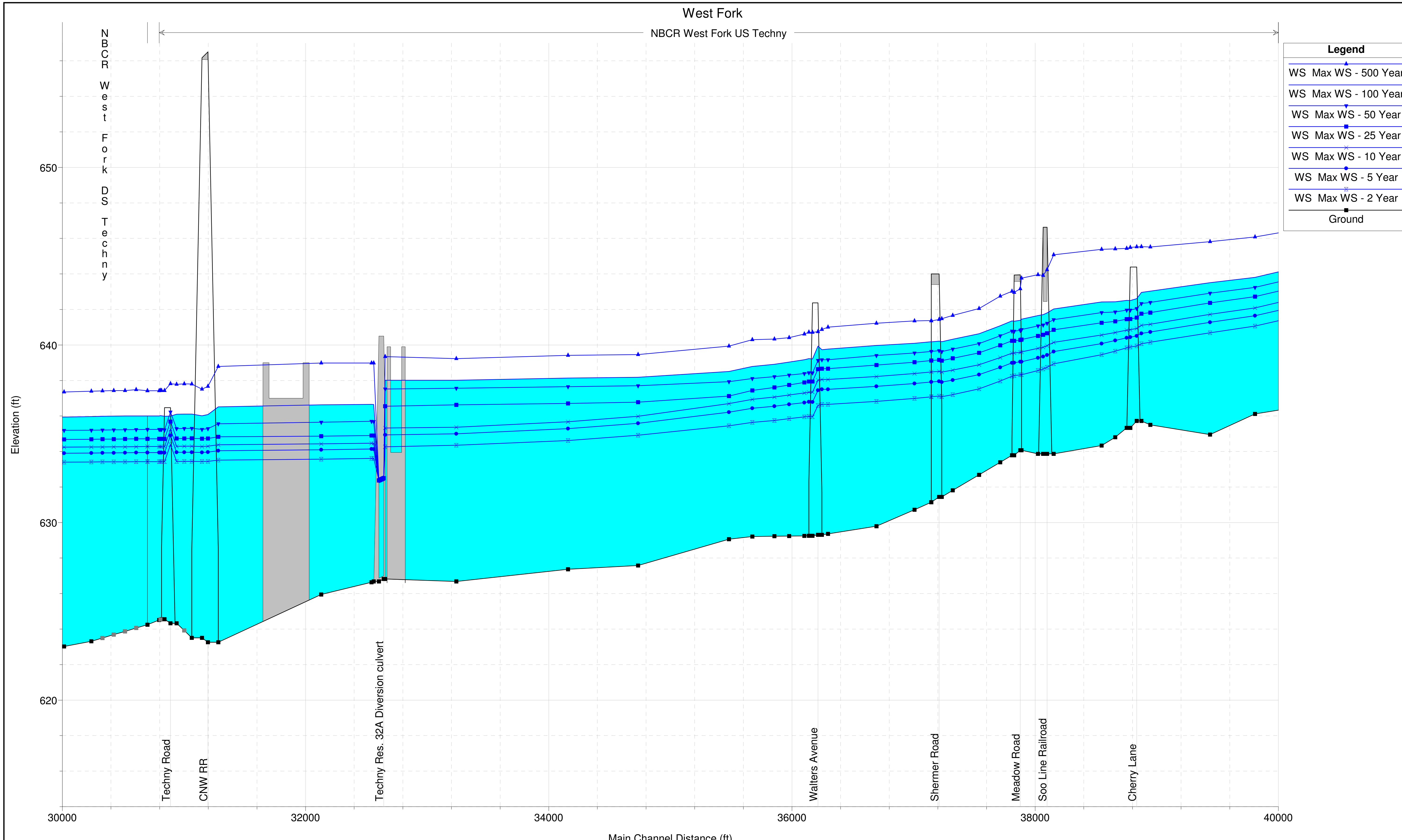
North Navy Diversion Ditch from North Navy Ditch station 1350 to confluence with the West Fork



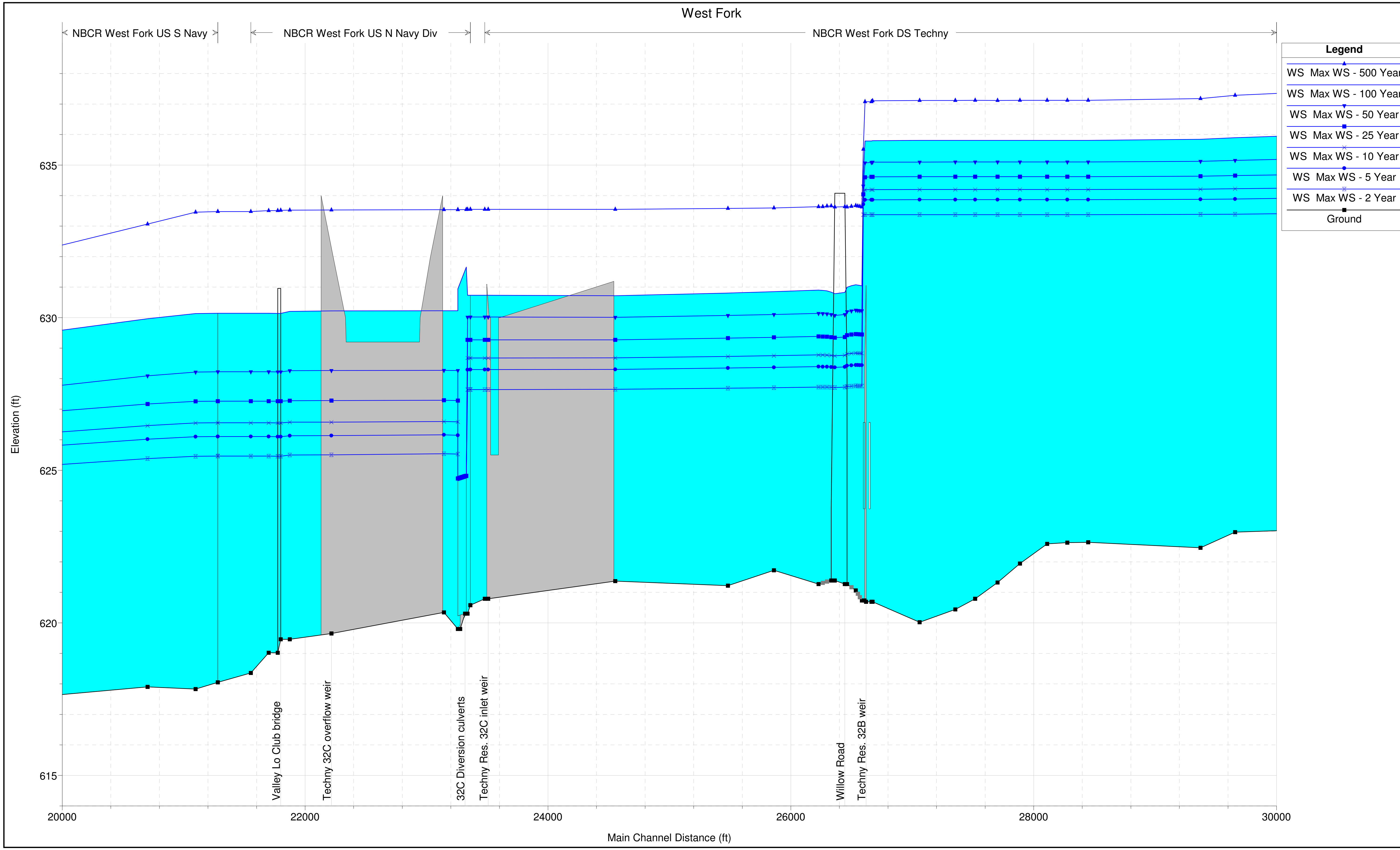
South Navy Ditch from Lehigh Avenue to confluence with the West Fork



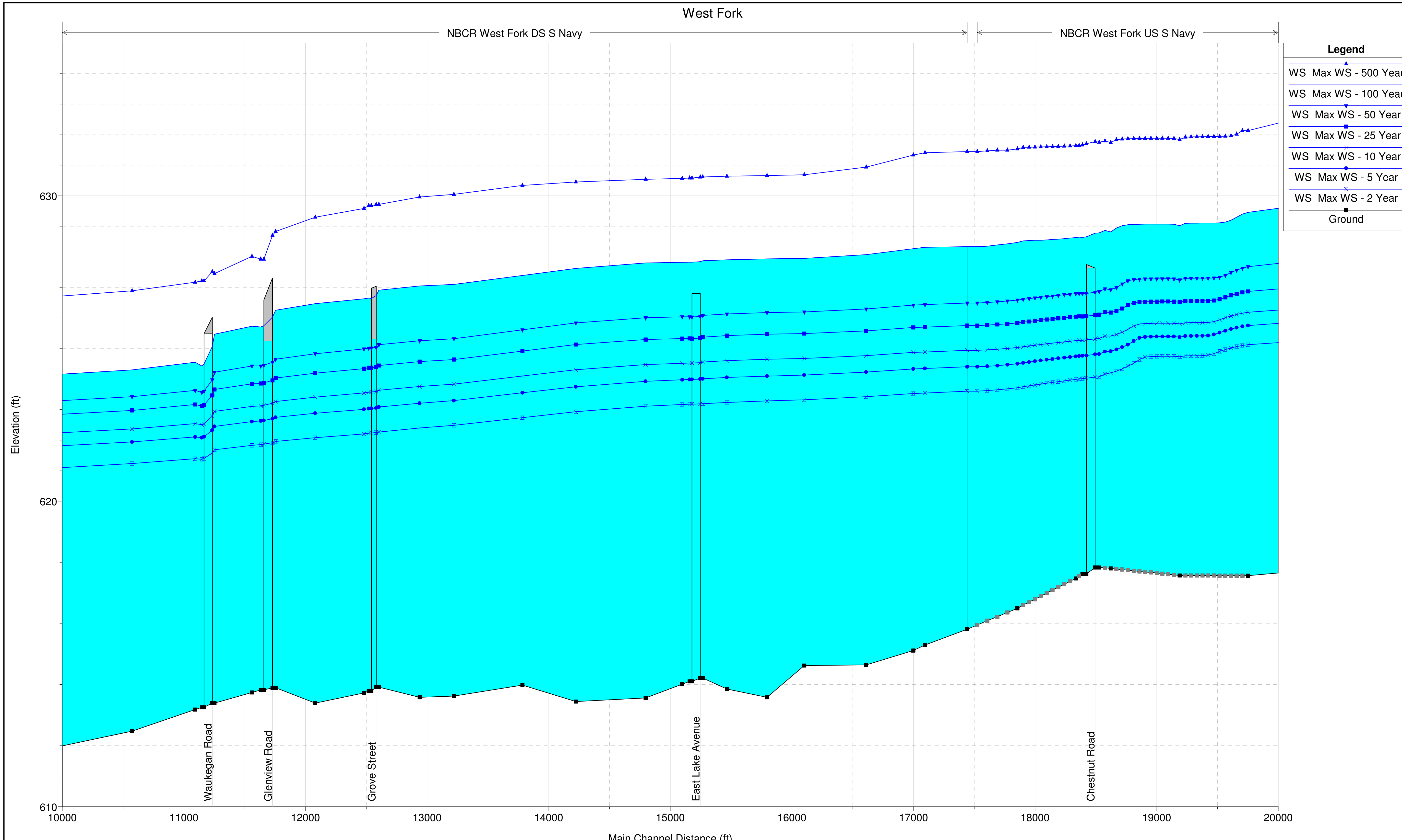
West Fork from Lake-Cook Road to Dundee Road



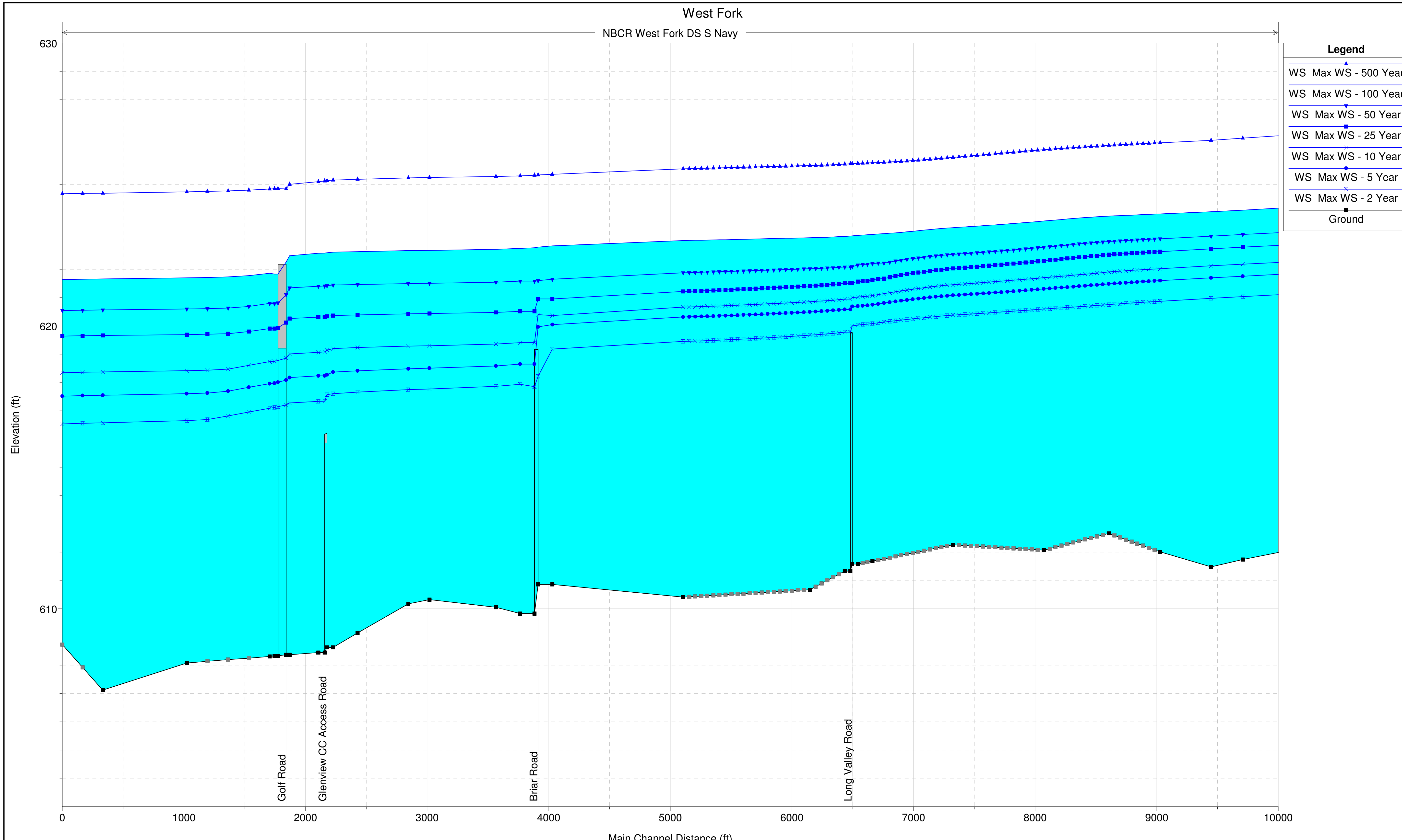
West Fork from Cherry Lane to Techny Road



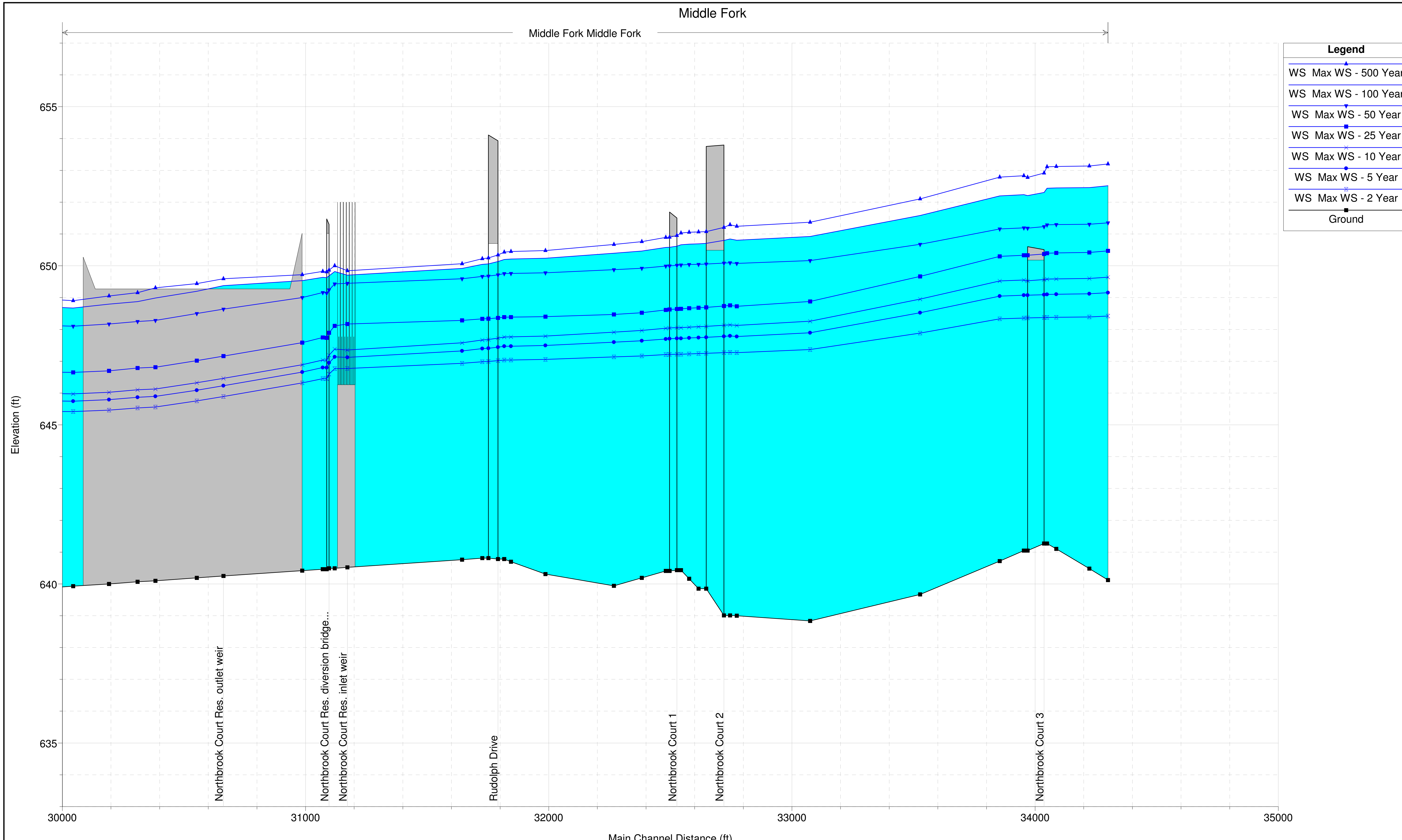
West Fork from Techny Reservoir 32B to confluence with the North Navy Diversion Ditch



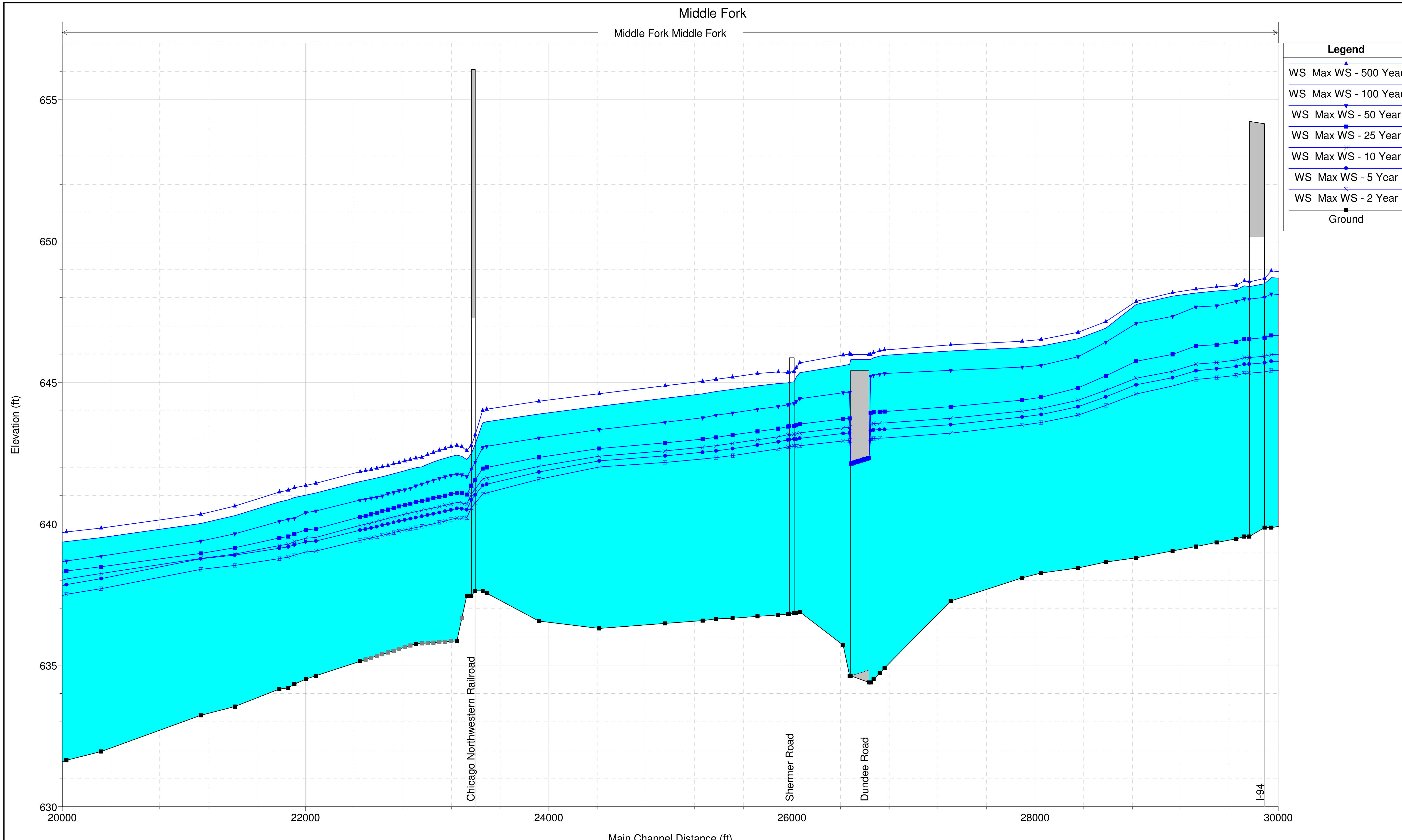
West Fork from Chestnut Road to Waukegan Road



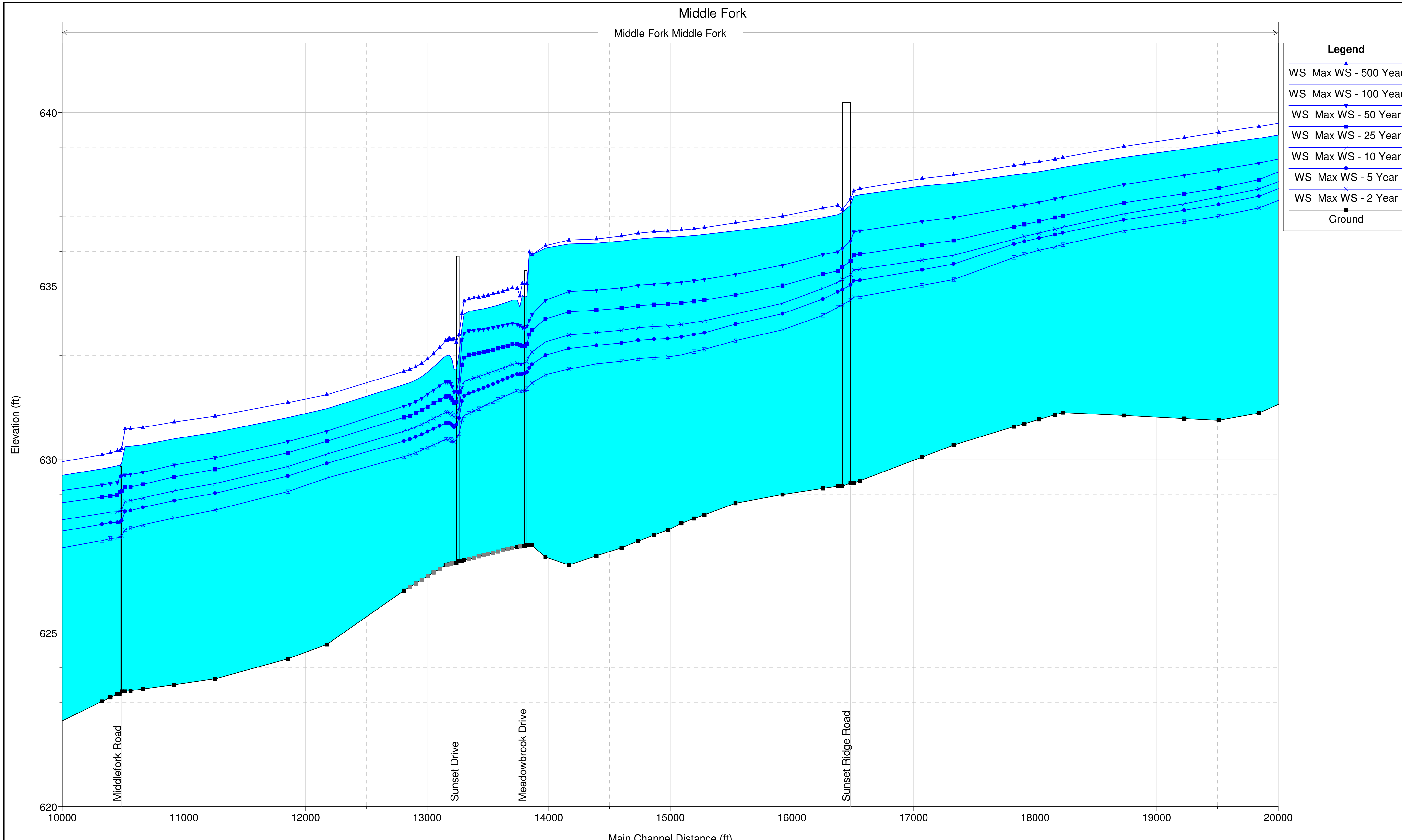
West Fork from Riverside Park to confluence with the Mainstem of the NBCR



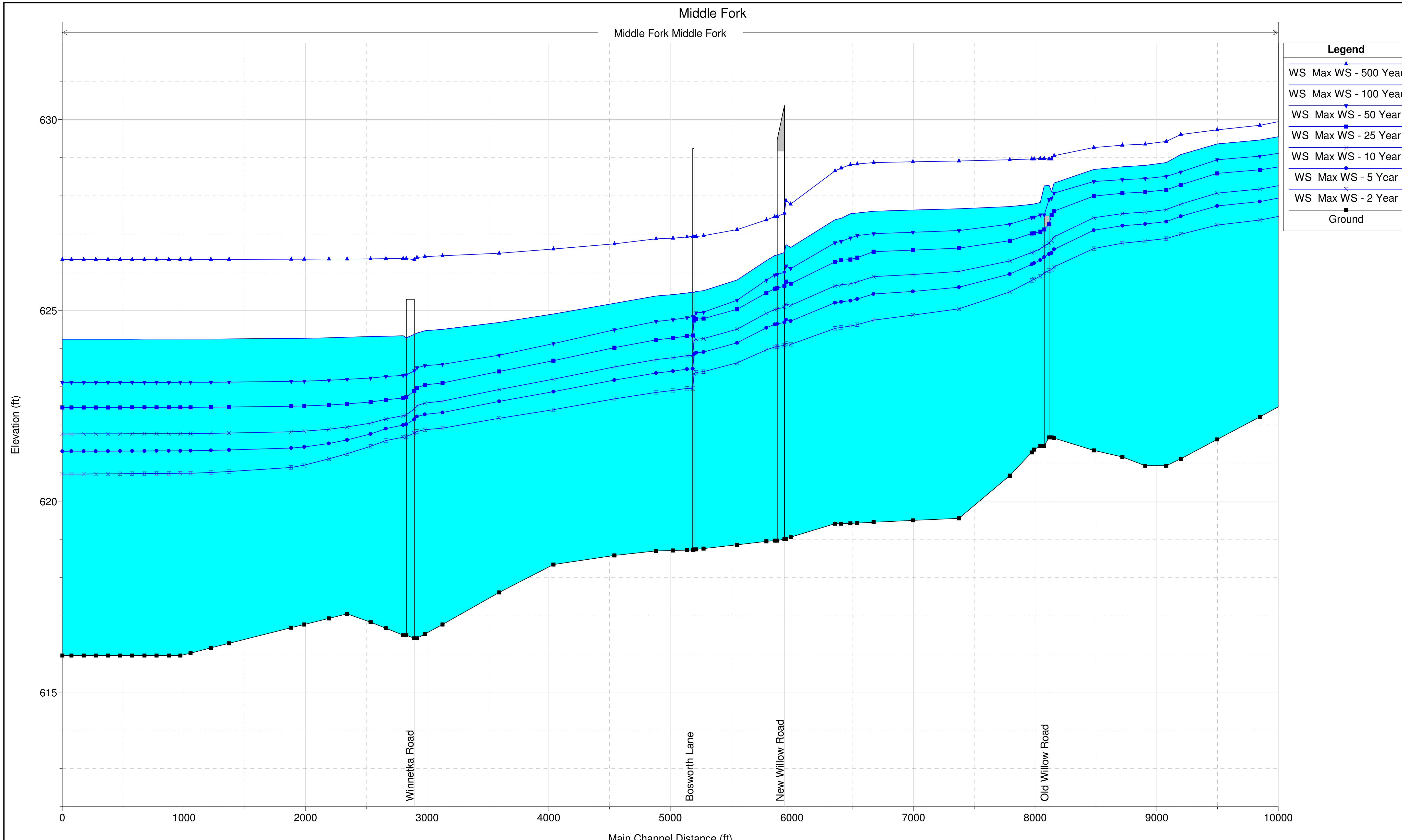
Middle Fork from Lake-Cook Road to just U/S of I-94



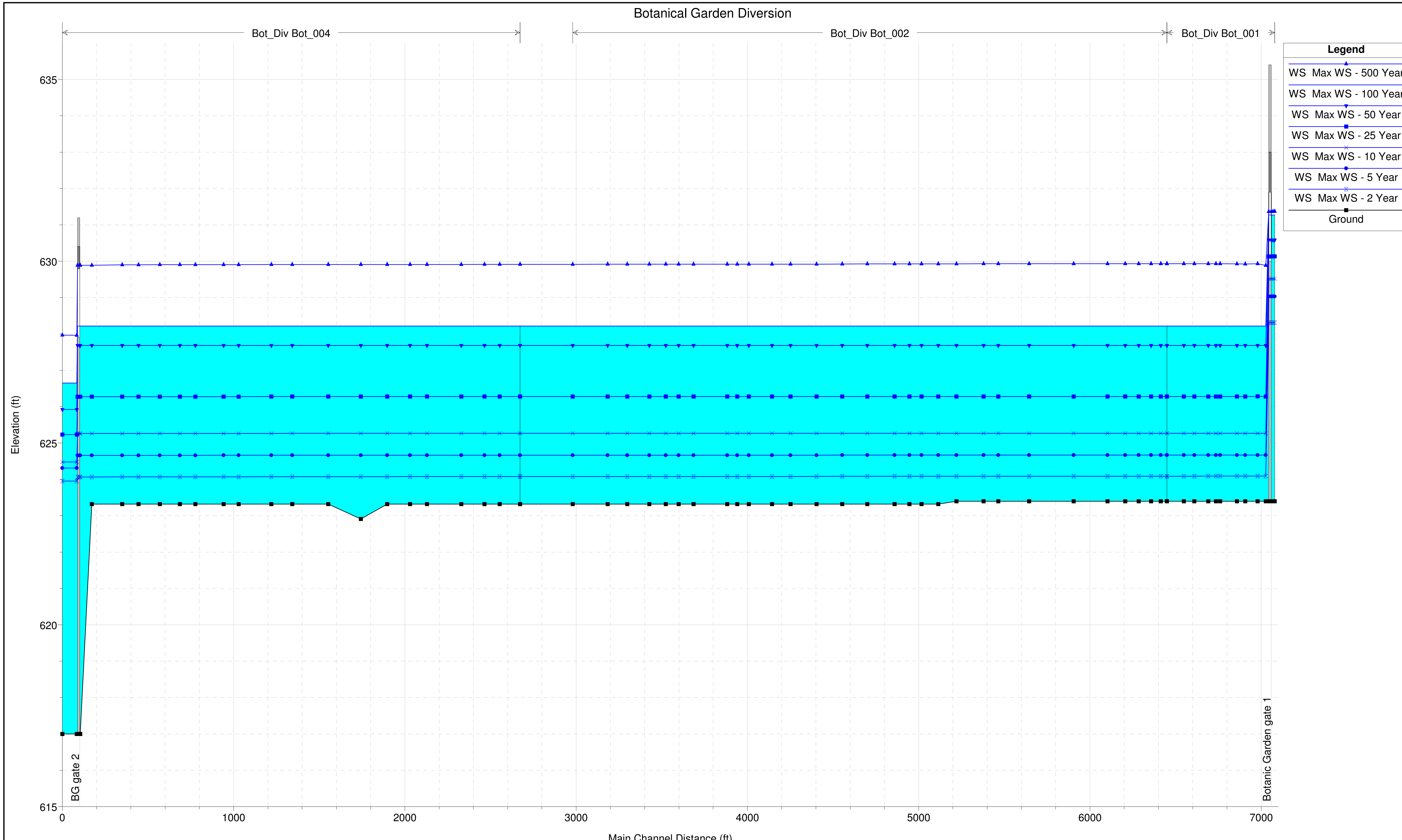
Middle Fork from I-94 to 3,000 feet D/S of the Chicago Northwestern Railroad



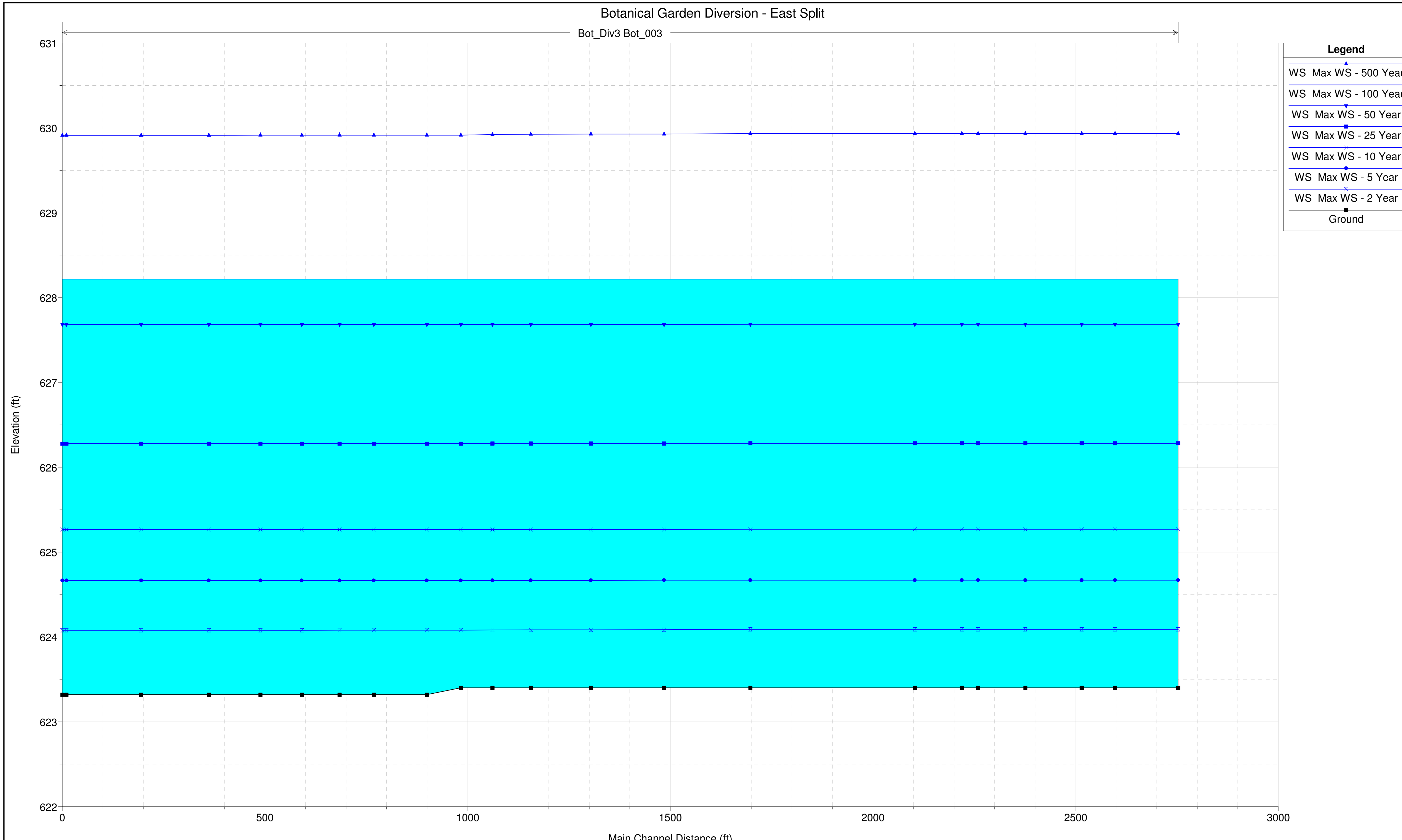
Middle Fork from 3,500 feet U/S of Sunset Ridge Road to Middlefork Road



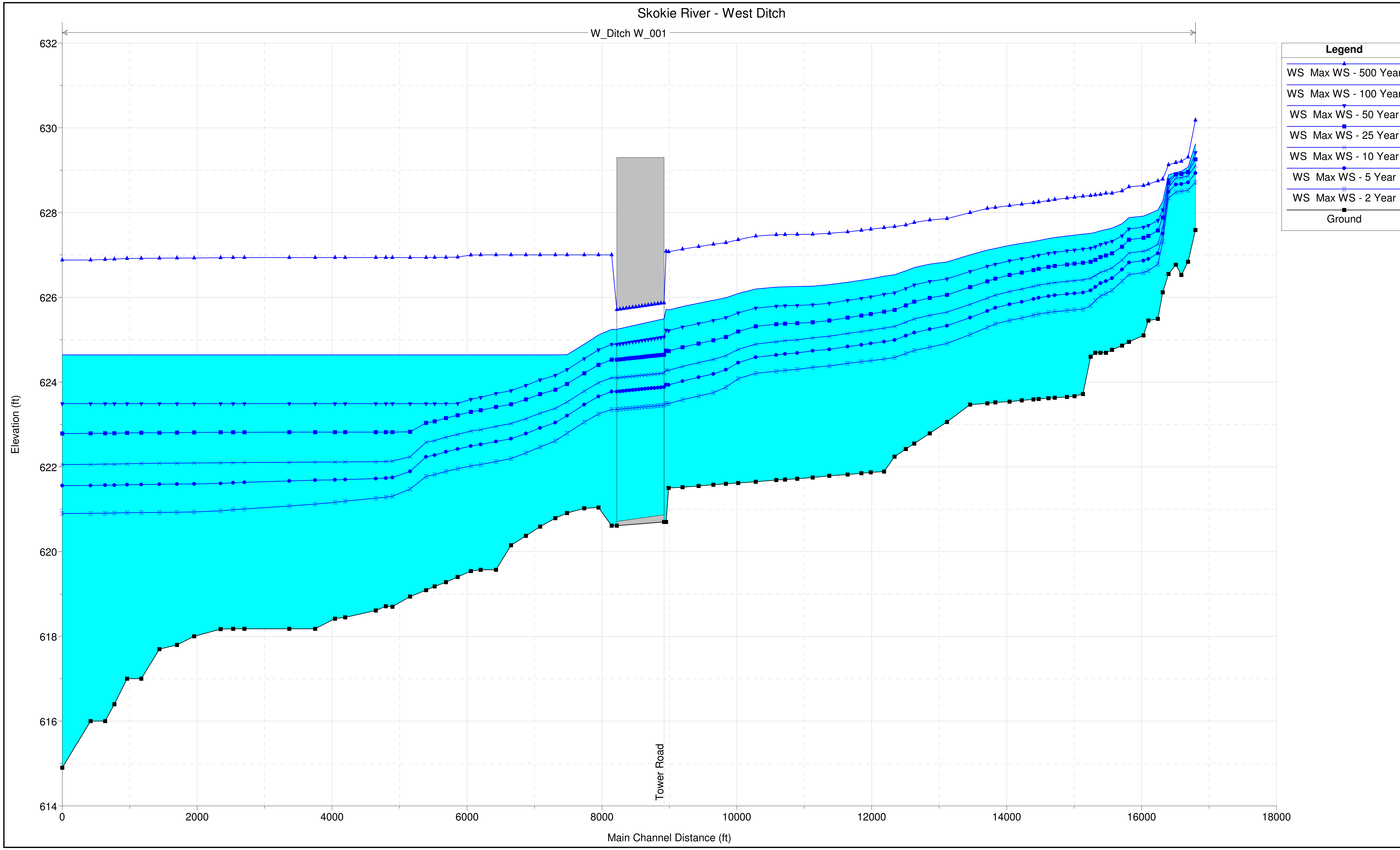
Middle Fork from 2,000 feet U/S of Old Willow Road to confluence with the Skokie River



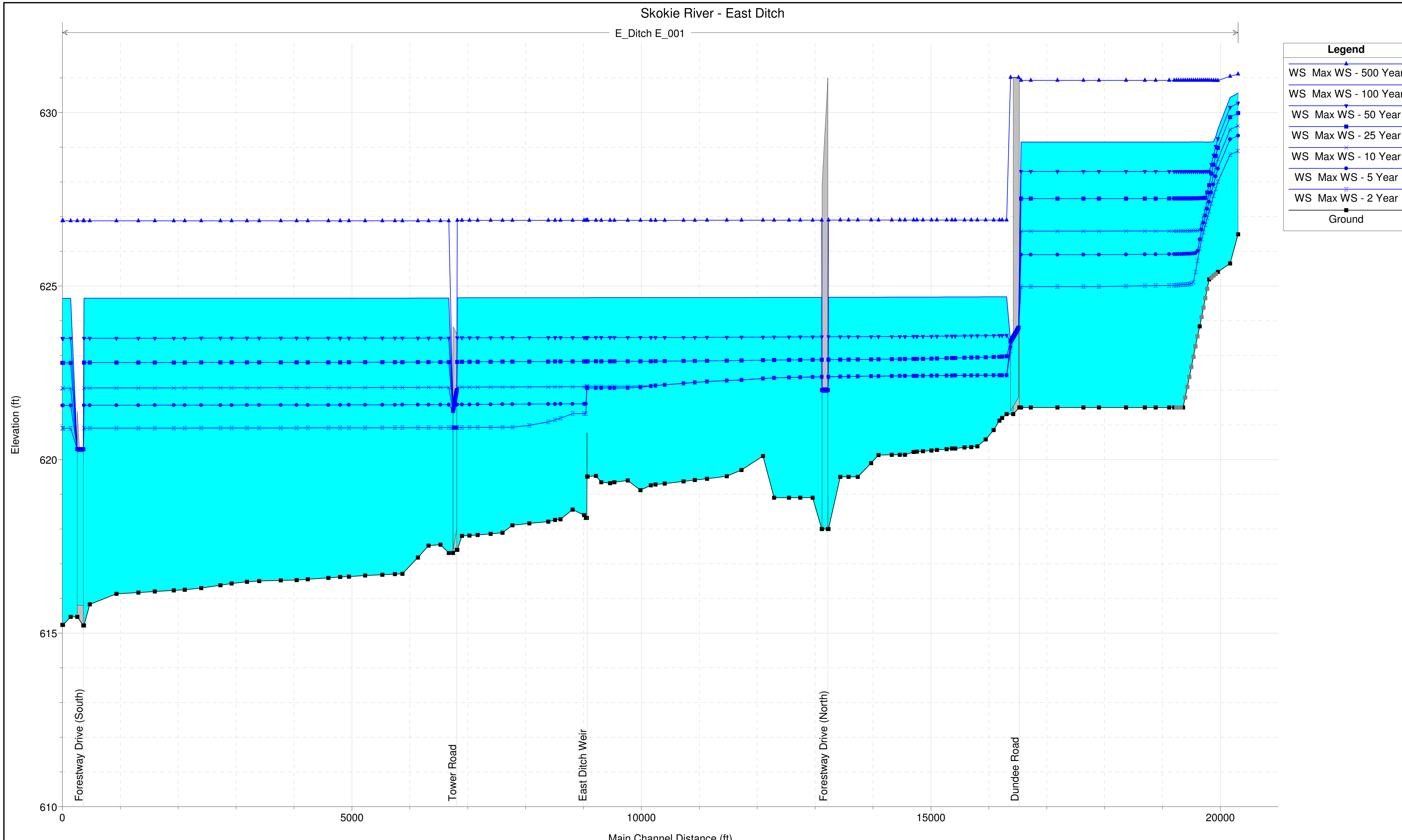
Botanical Garden Diversion from Lake-Cook Road to confluence with the Skokie River



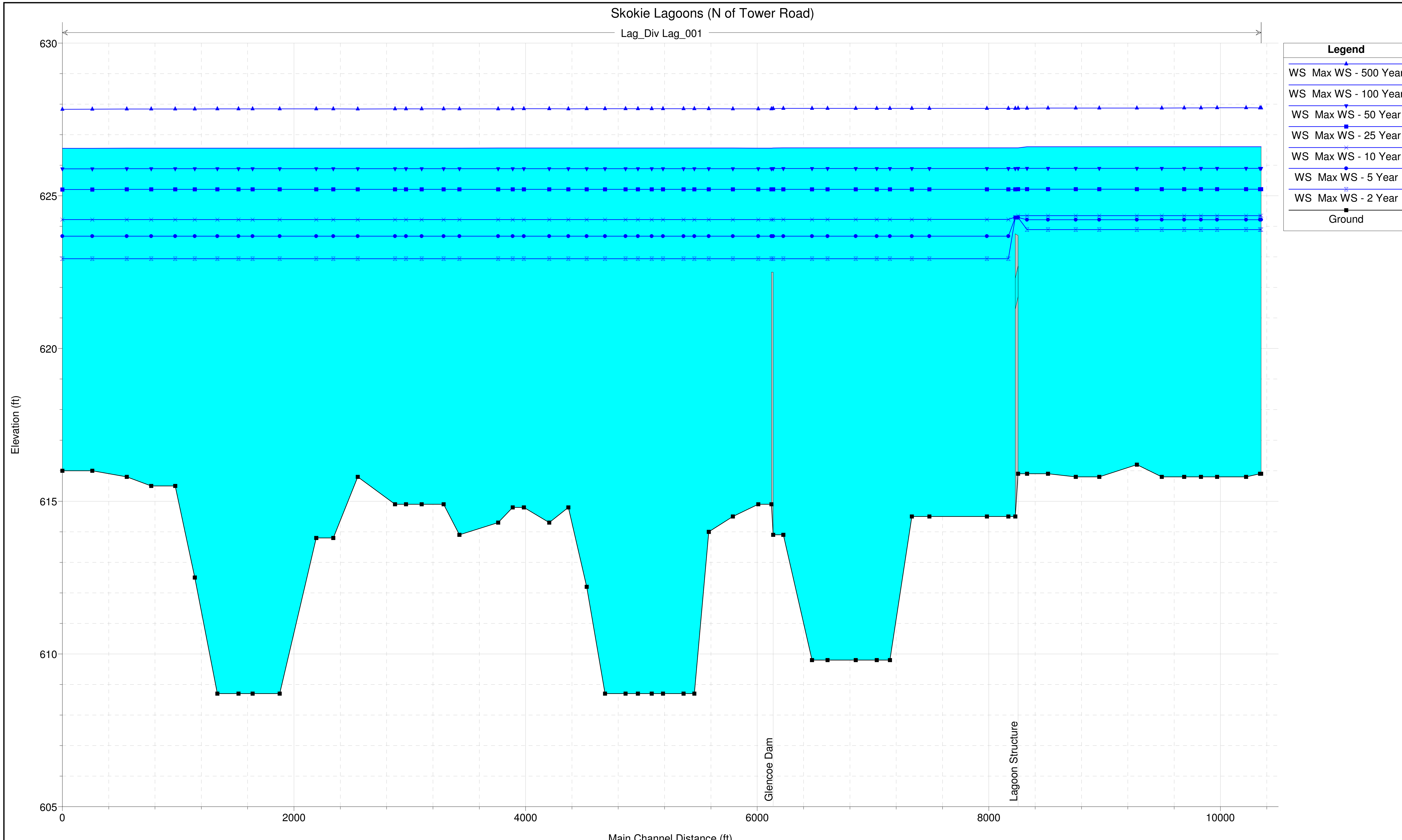
Botanical Garden Diversion - East Split from reach Bot_001 to reach Bot_004



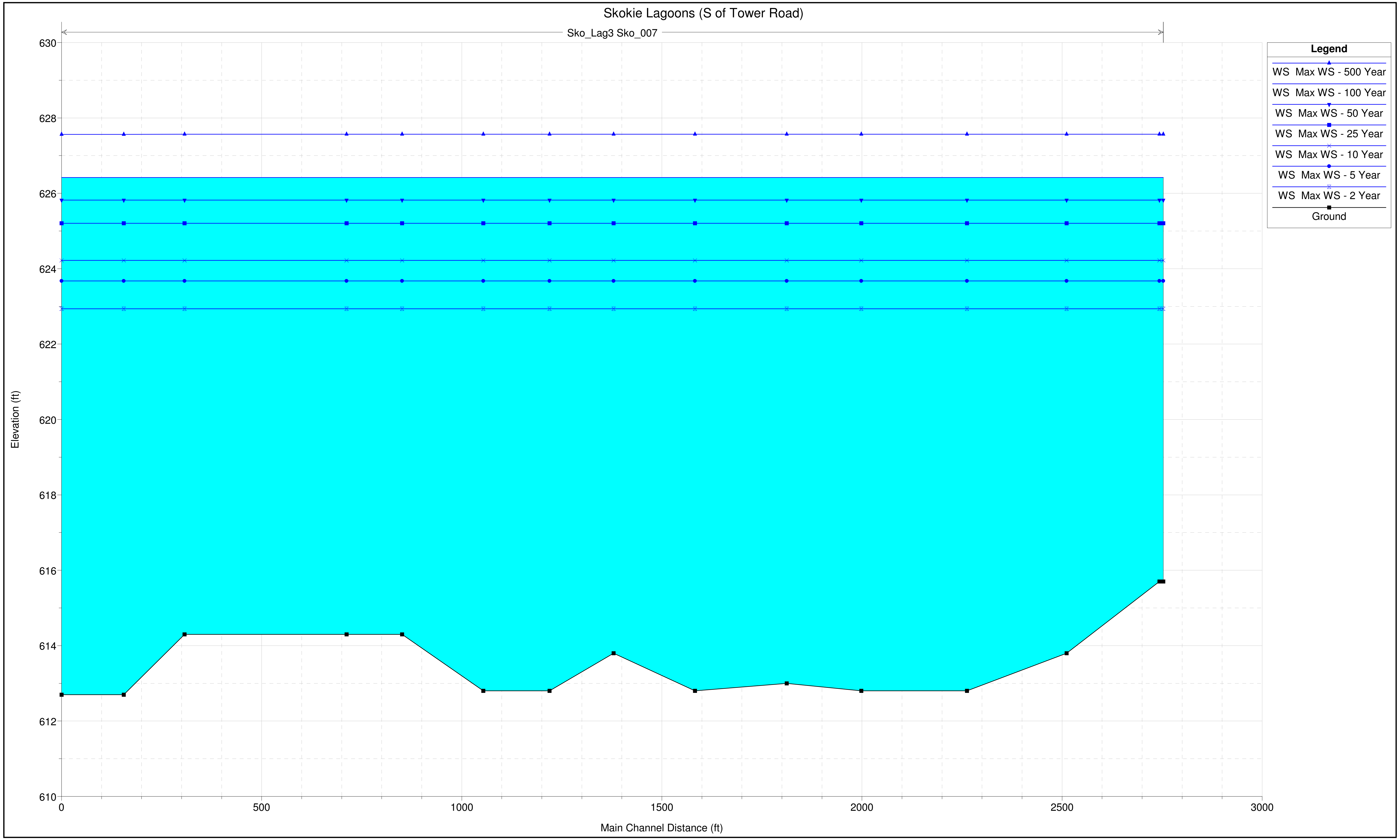
Skokie River West Ditch from Dundee Road to confluence with the Skokie River



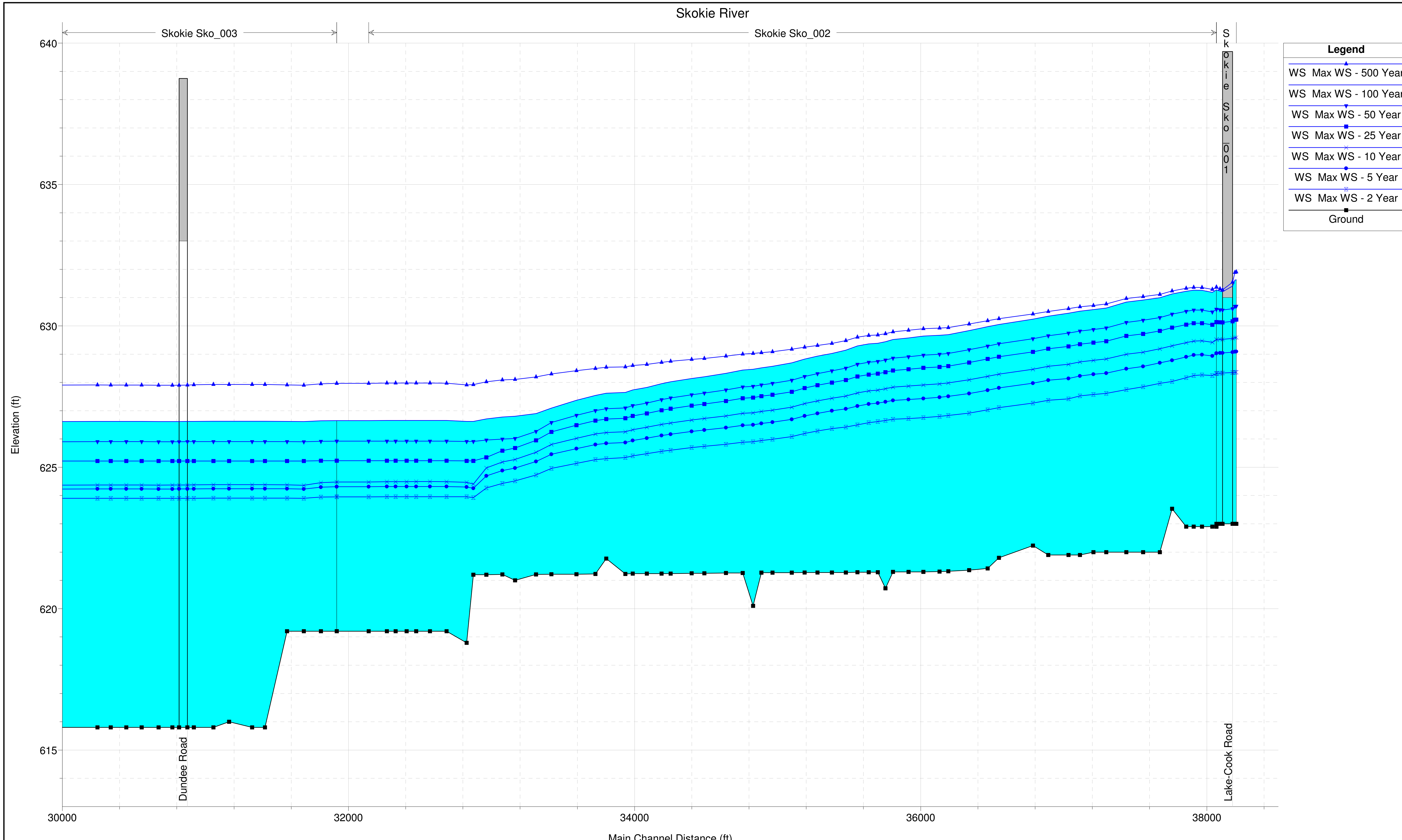
Skokie River East Ditch from its headwater to confluence with the Skokie River



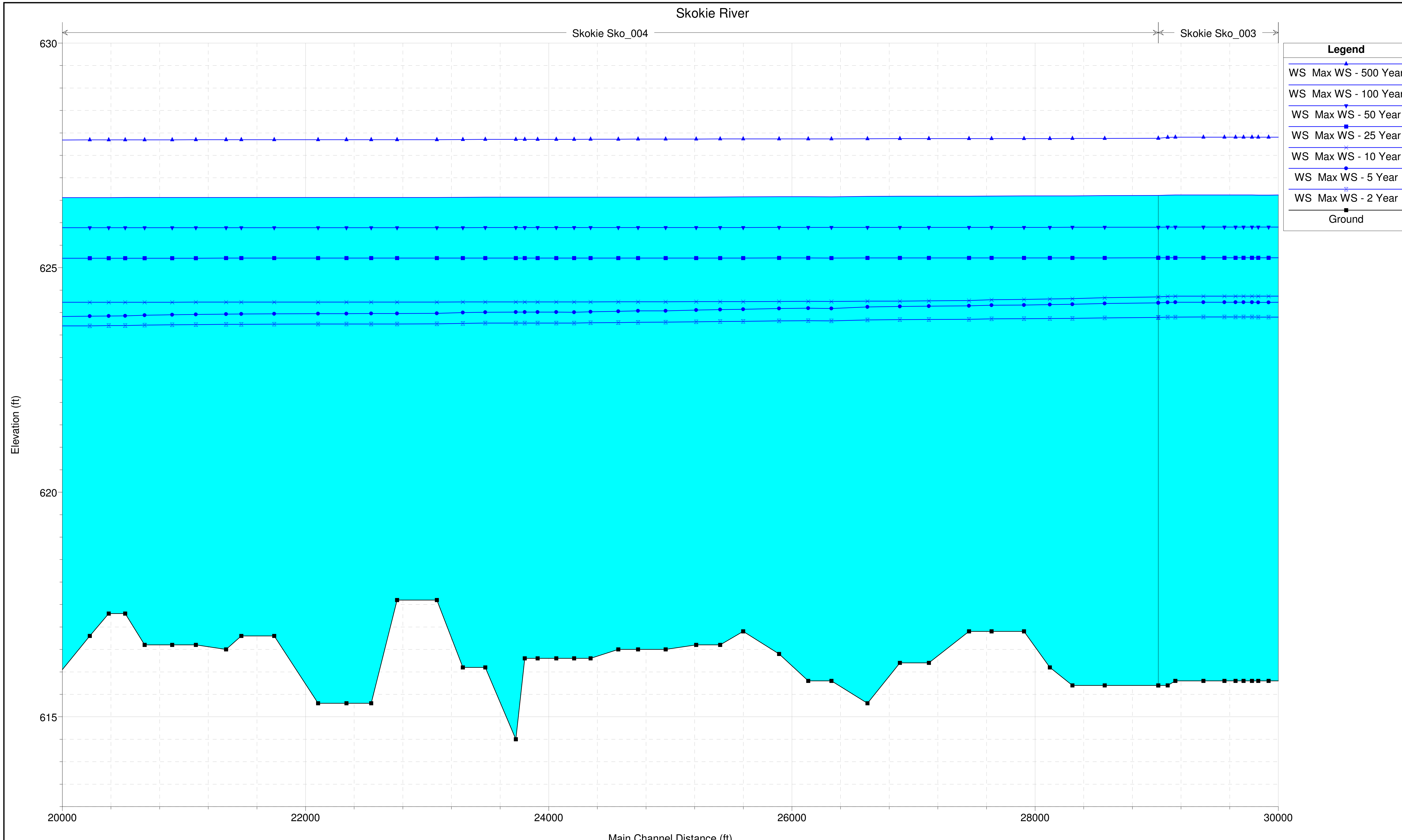
Skokie Lagoons from just D/S of Dundee Road to Tower Road



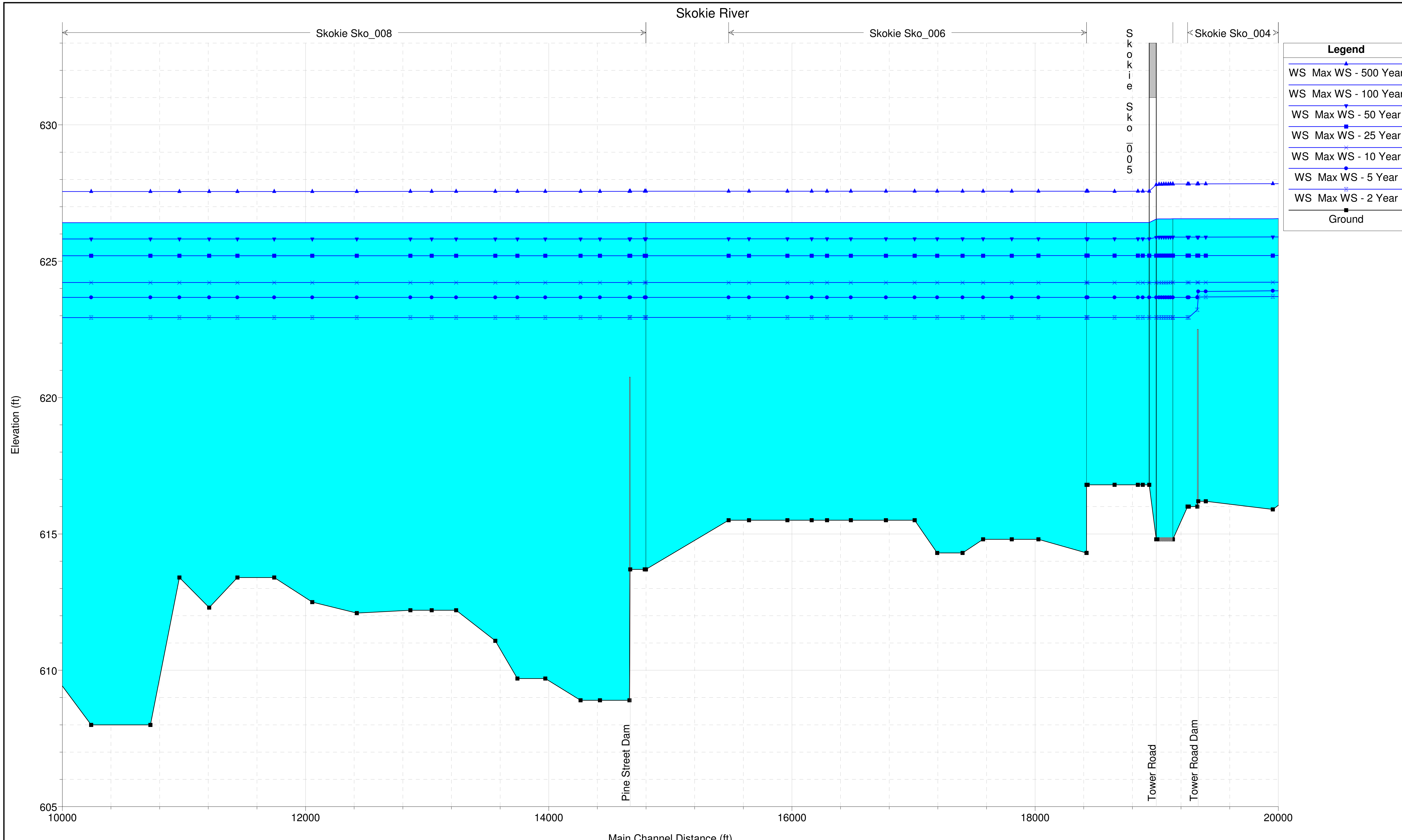
Skokie Lagoons from just D/S of Tower Road to confluence with the Skokie River at reach SKO_008



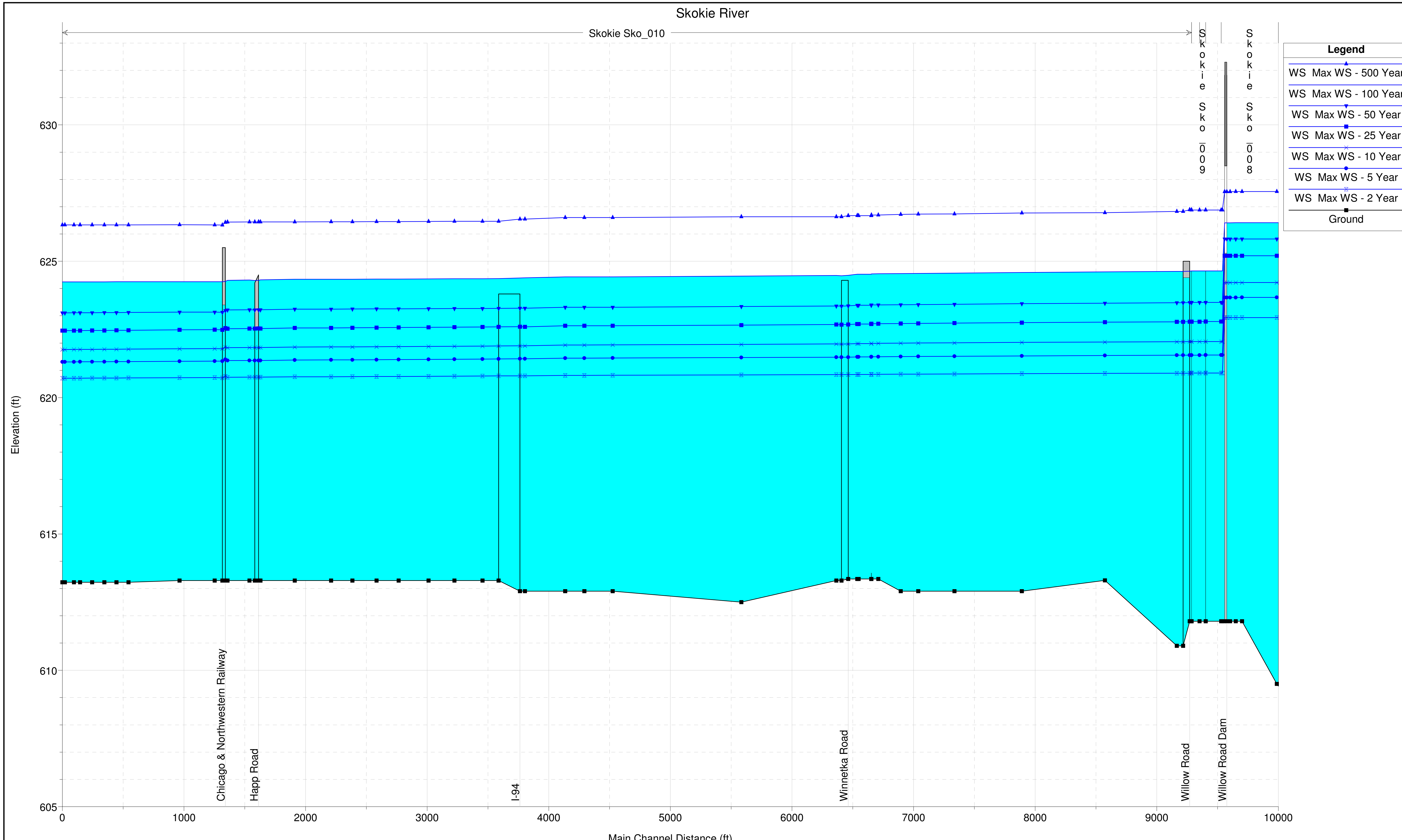
Skokie River from Lake-Cook Road to Dundee Road



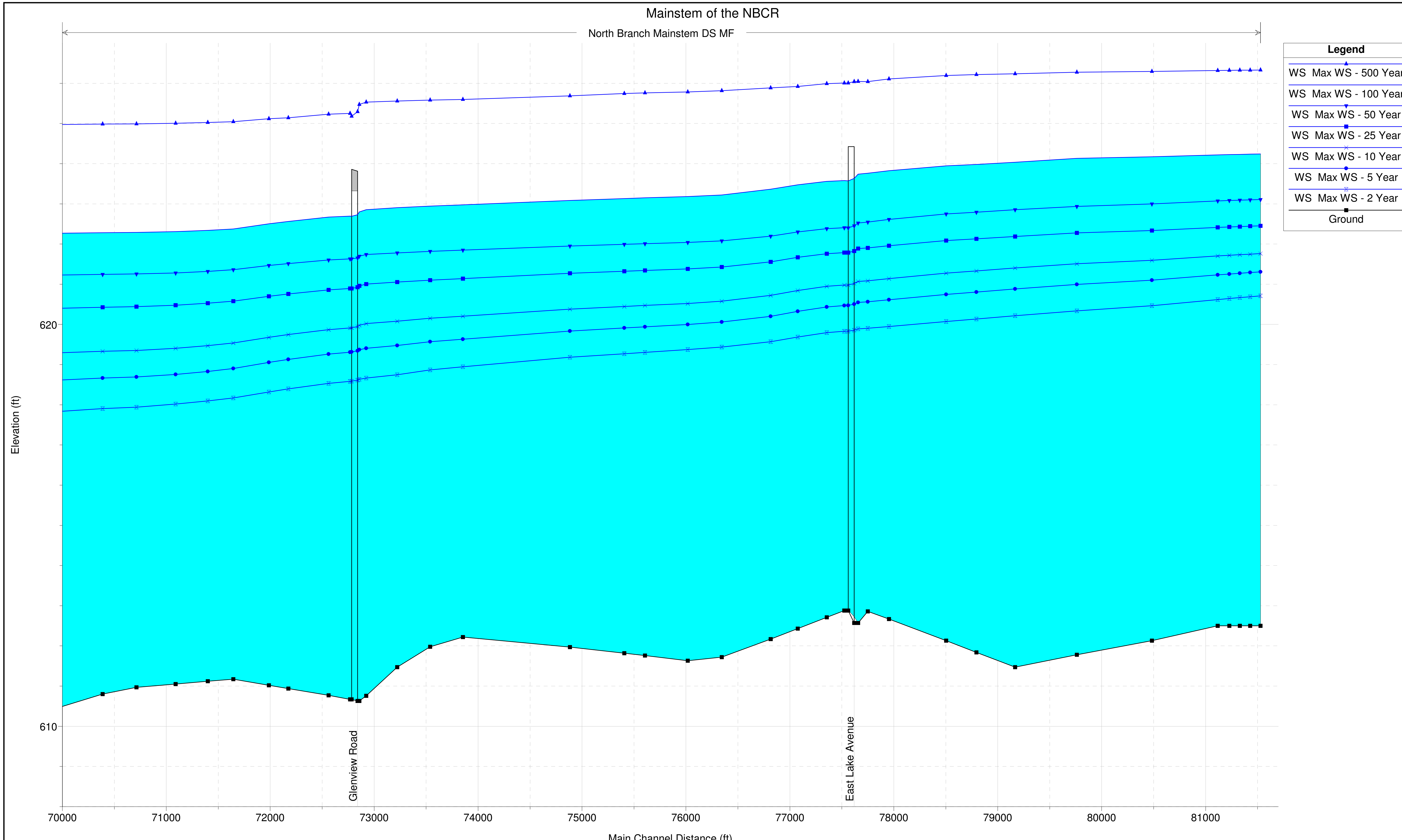
Skokie River from just D/S of Dundee Road to just U/S of Tower Road



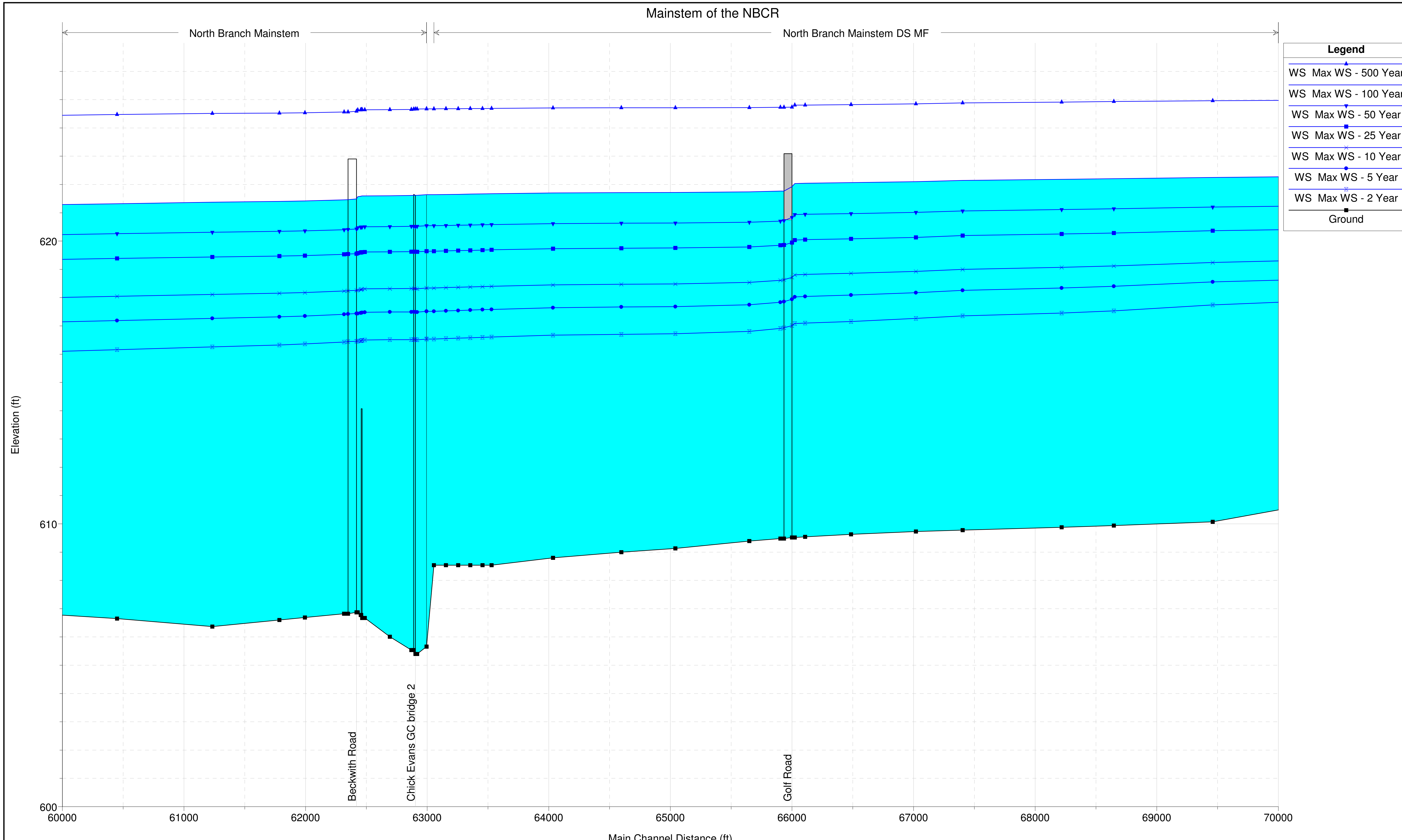
Skokie River from Tower Road dam to just U/S of Willow Road Dam



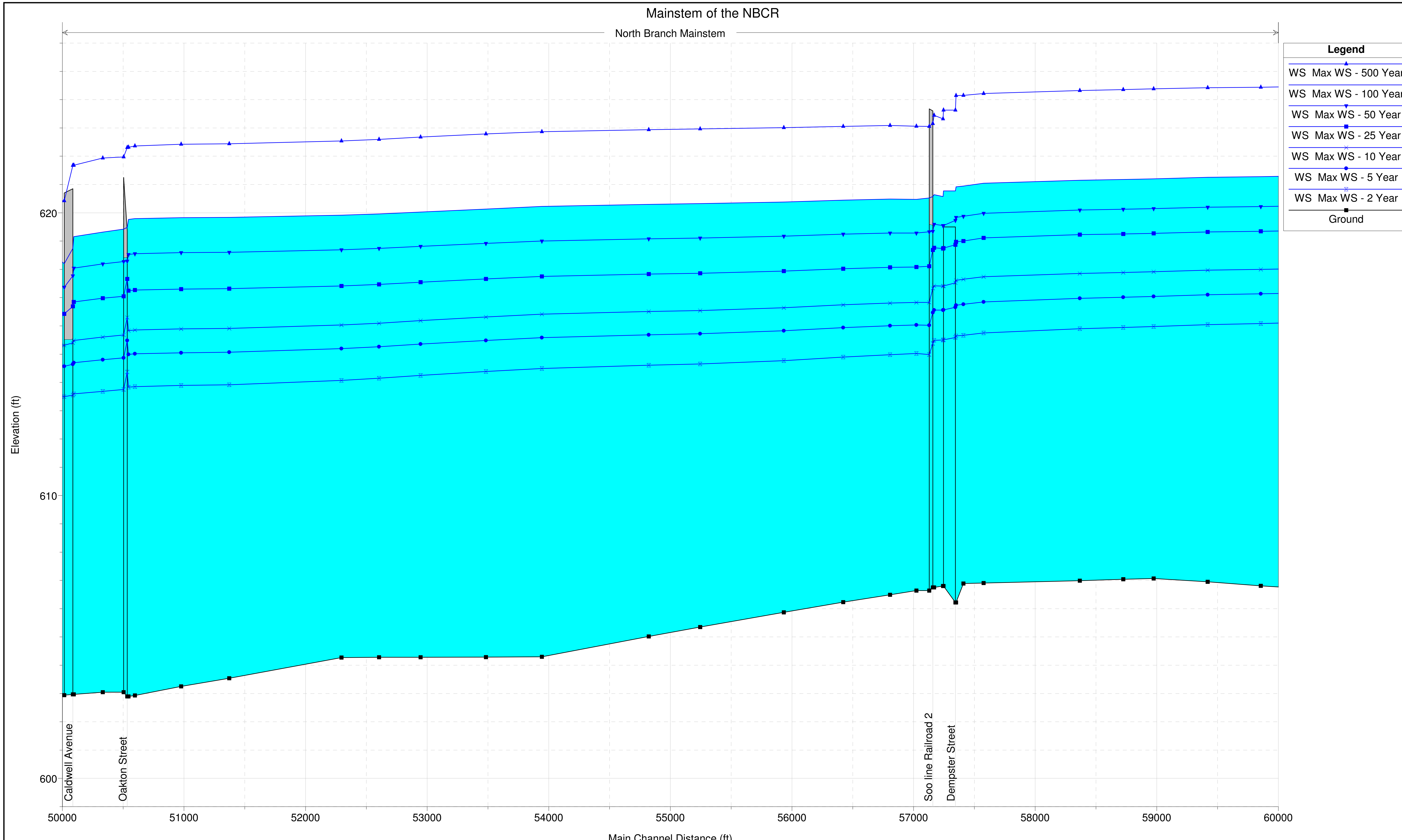
Skokie River from Willow Road Dam to confluence with the Middle Fork



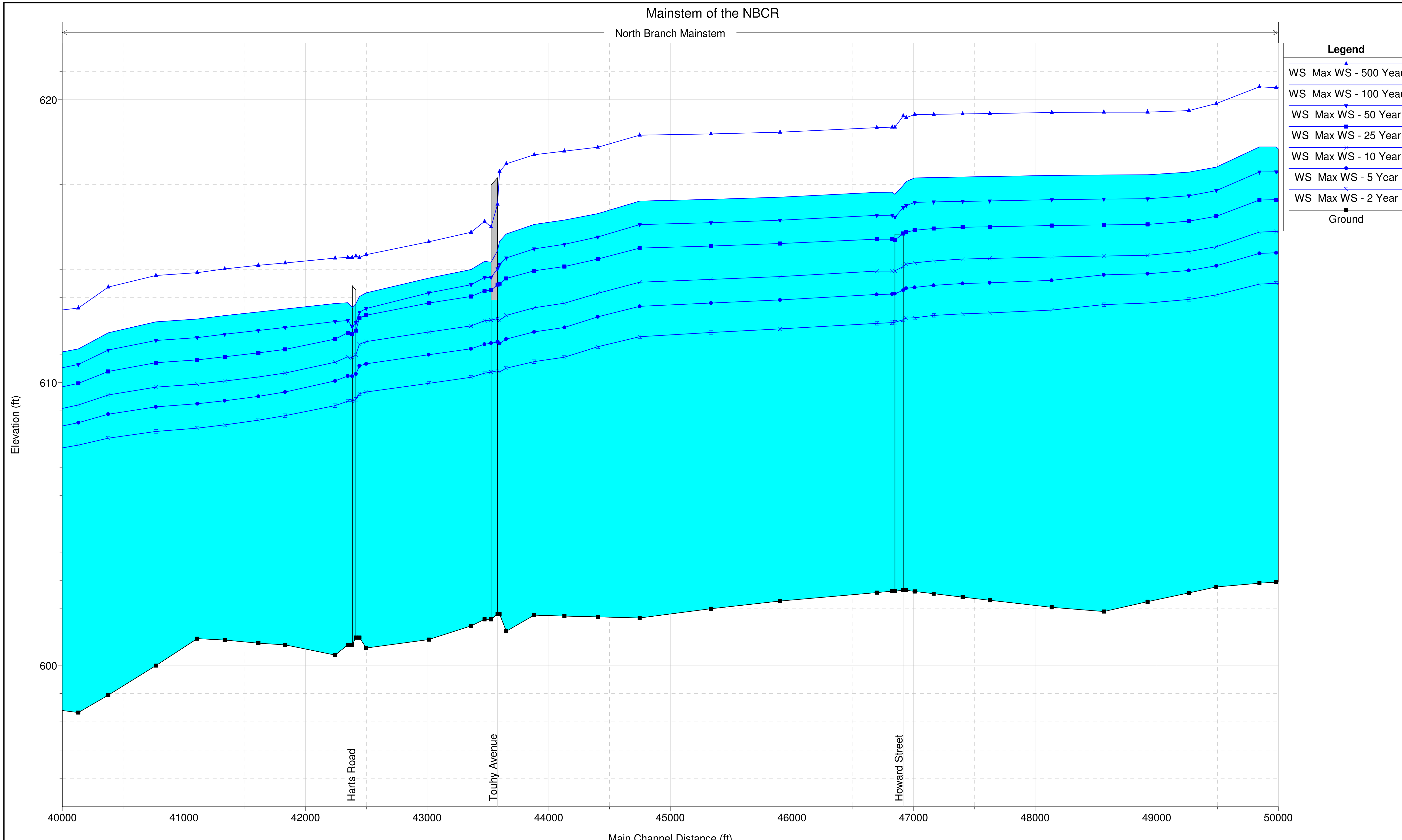
Mainstem of the NBCR from confluence of the Skokie River and Middle Fork to 3,000 feet D/S of Glenview Road



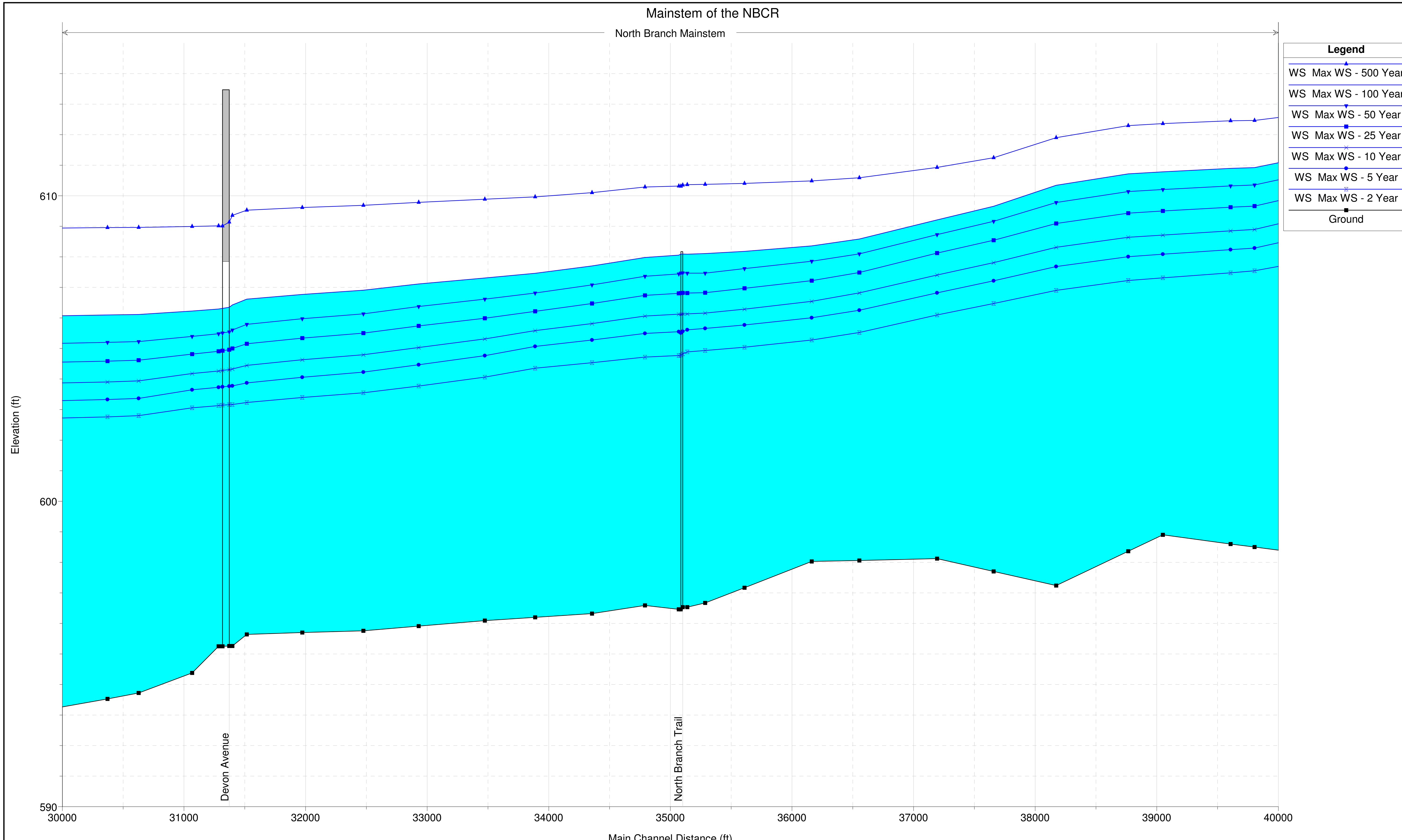
Mainstem of the NBCR from 4,000 feet U/S of Golf Road to 2,500 feet D/S of Beckwith Road



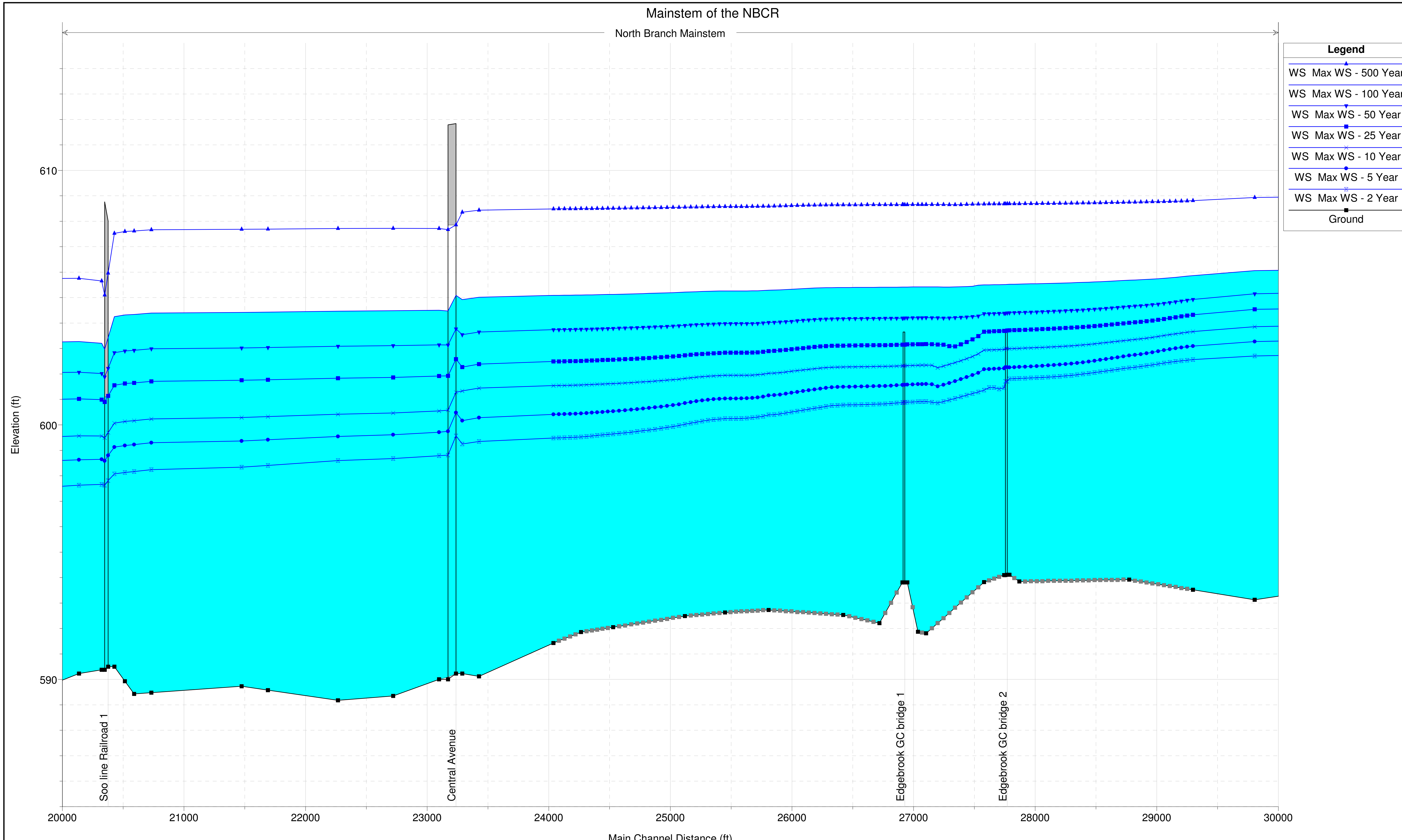
Mainstem of the NBCR from 2,700 feet U/S of Dempster Street to Caldwell Avenue



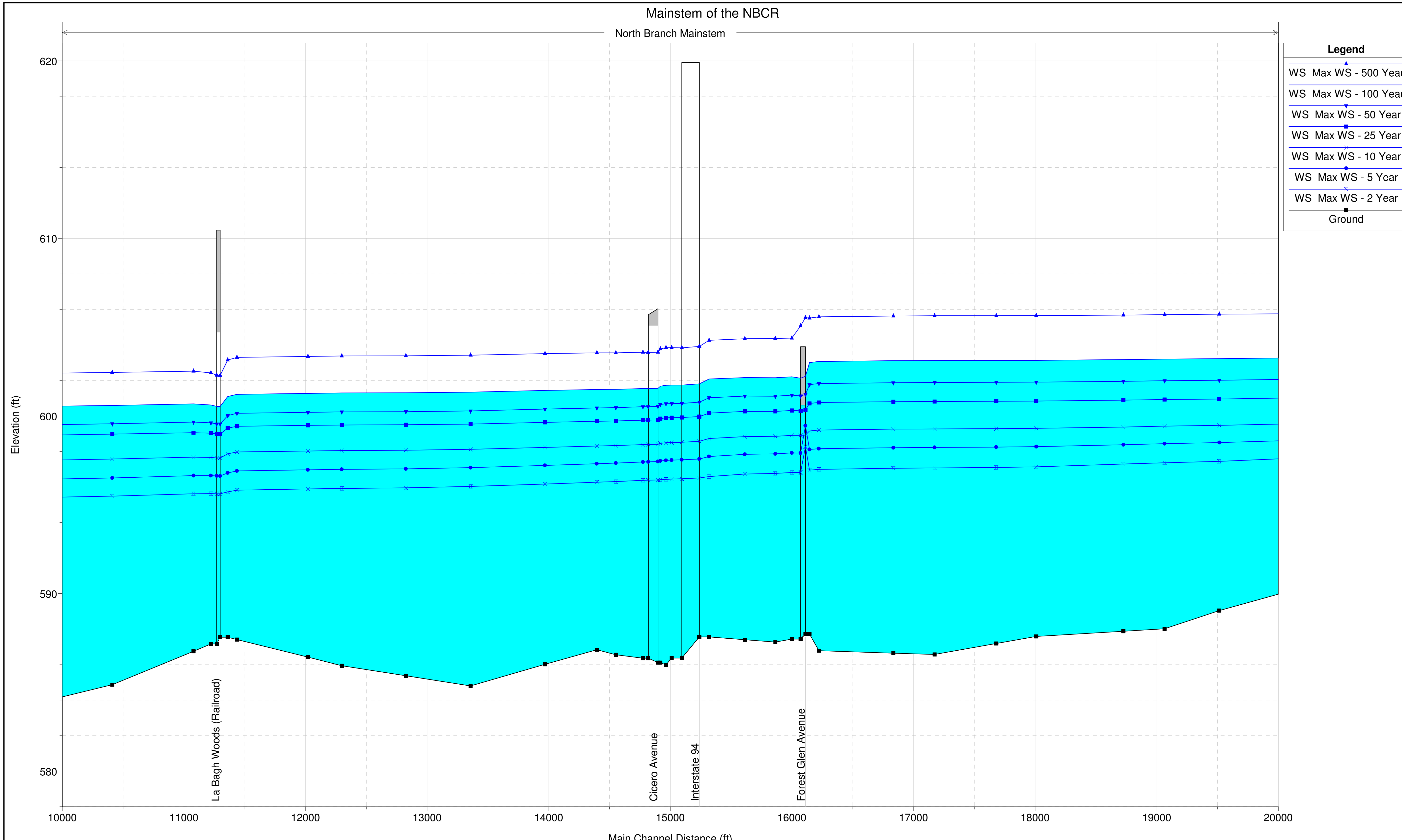
Mainstem of the NBCR from 3,000 feet U/S of Howard Street to 2,400 feet D/S of Harts Road



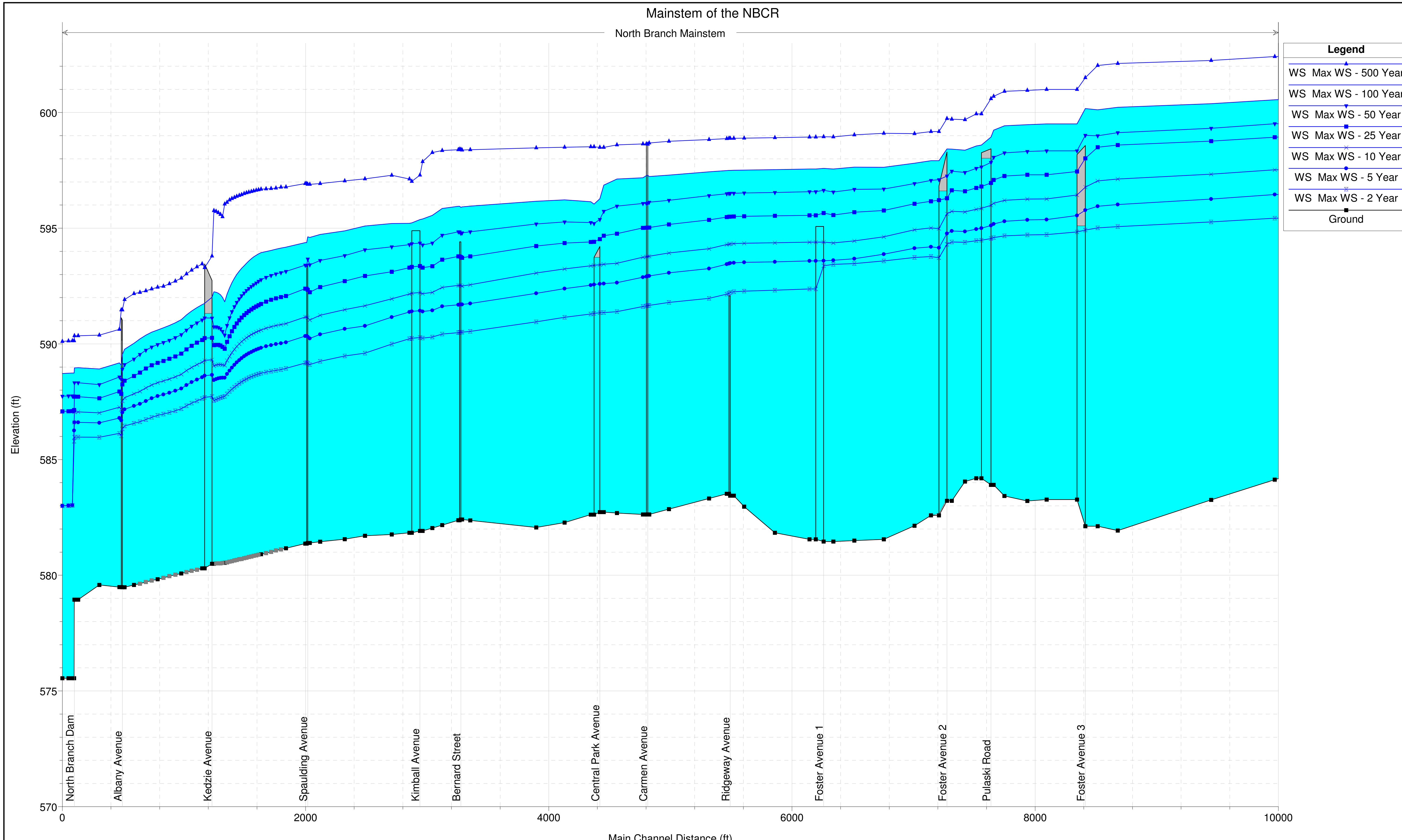
Mainstem of the NBCR from 5,000 feet U/S of North Branch Trail to 1,400 feet D/S of Devon Avenue



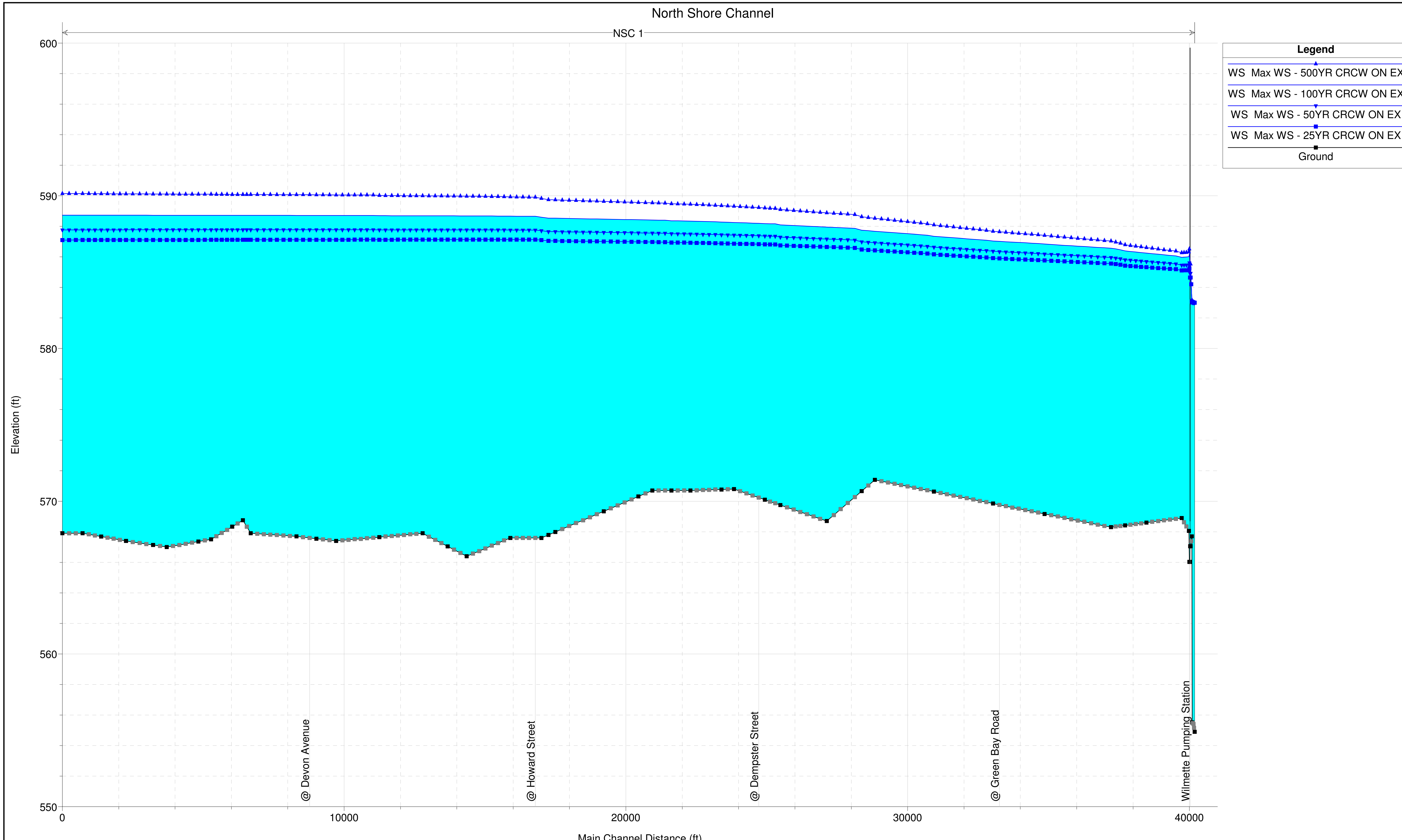
Mainstem of the NBCR from the Edgebrook Golf Course to the Soo line Railroad



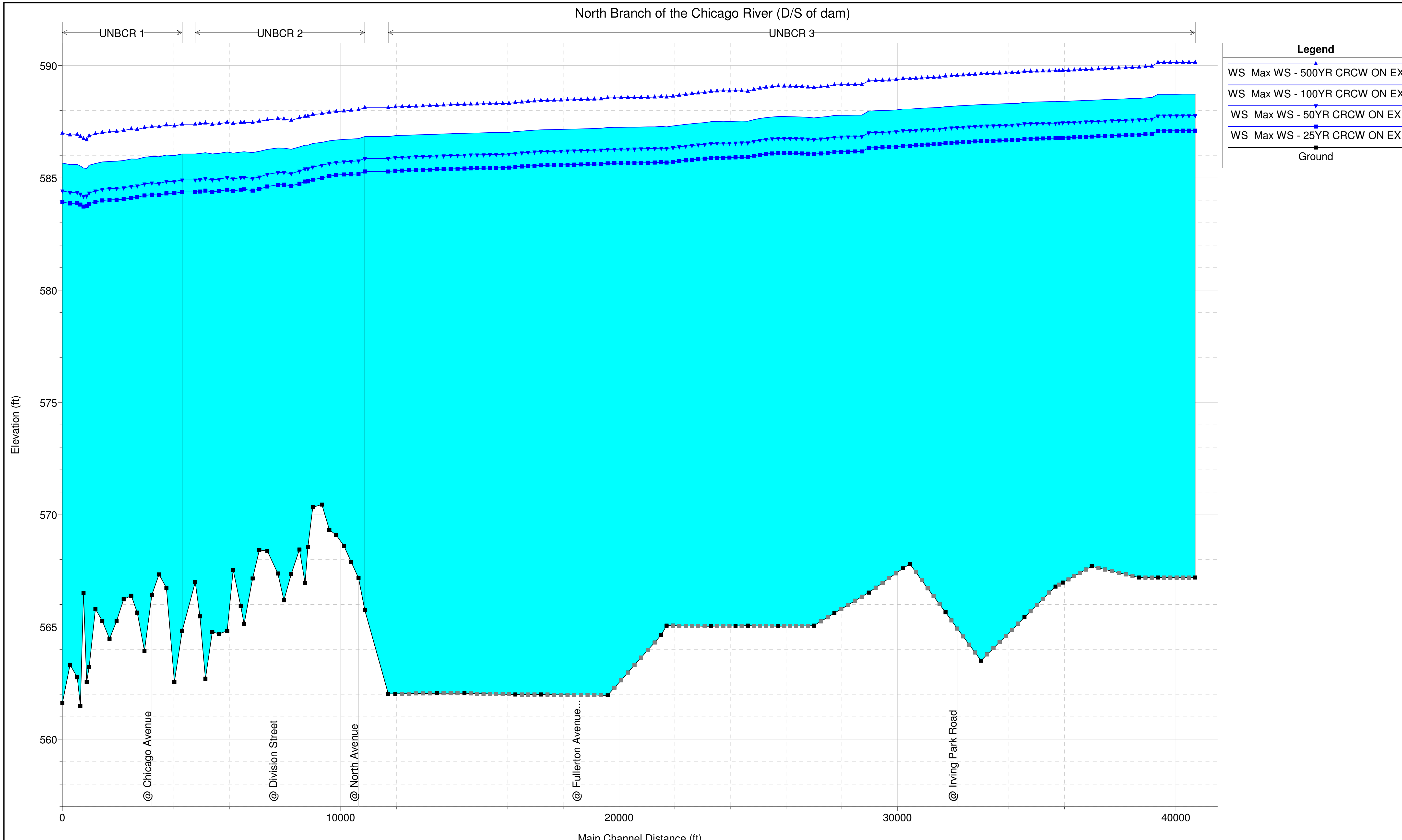
Mainstem of the NBCR from 4,000 feet U/S of Forest Glen Avenue to LaBagh Woods



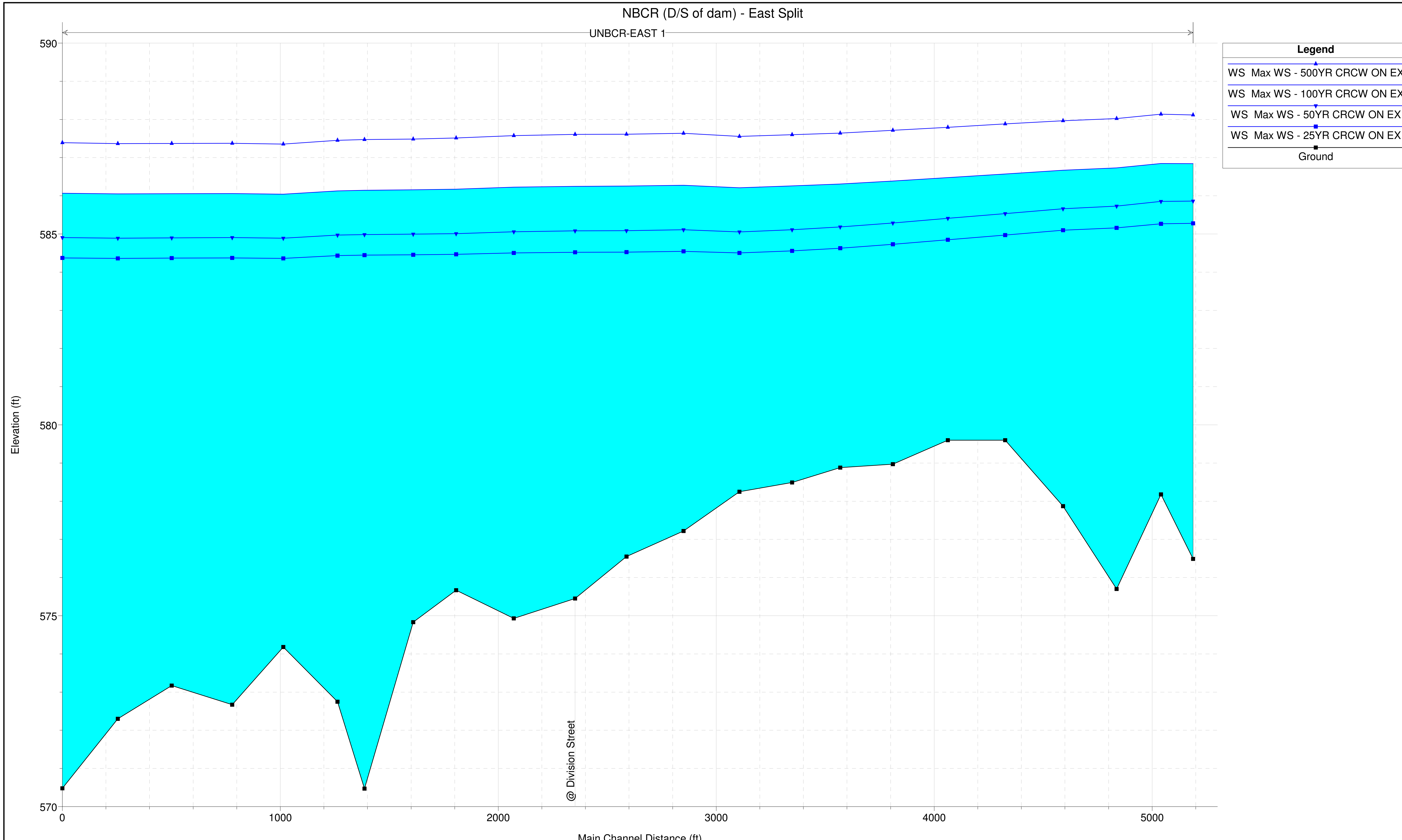
Mainstem of the NBCR from 1,500 feet U/S of Foster Avenue to confluence with the North Shore Channel just D/S of the North Branch Dam



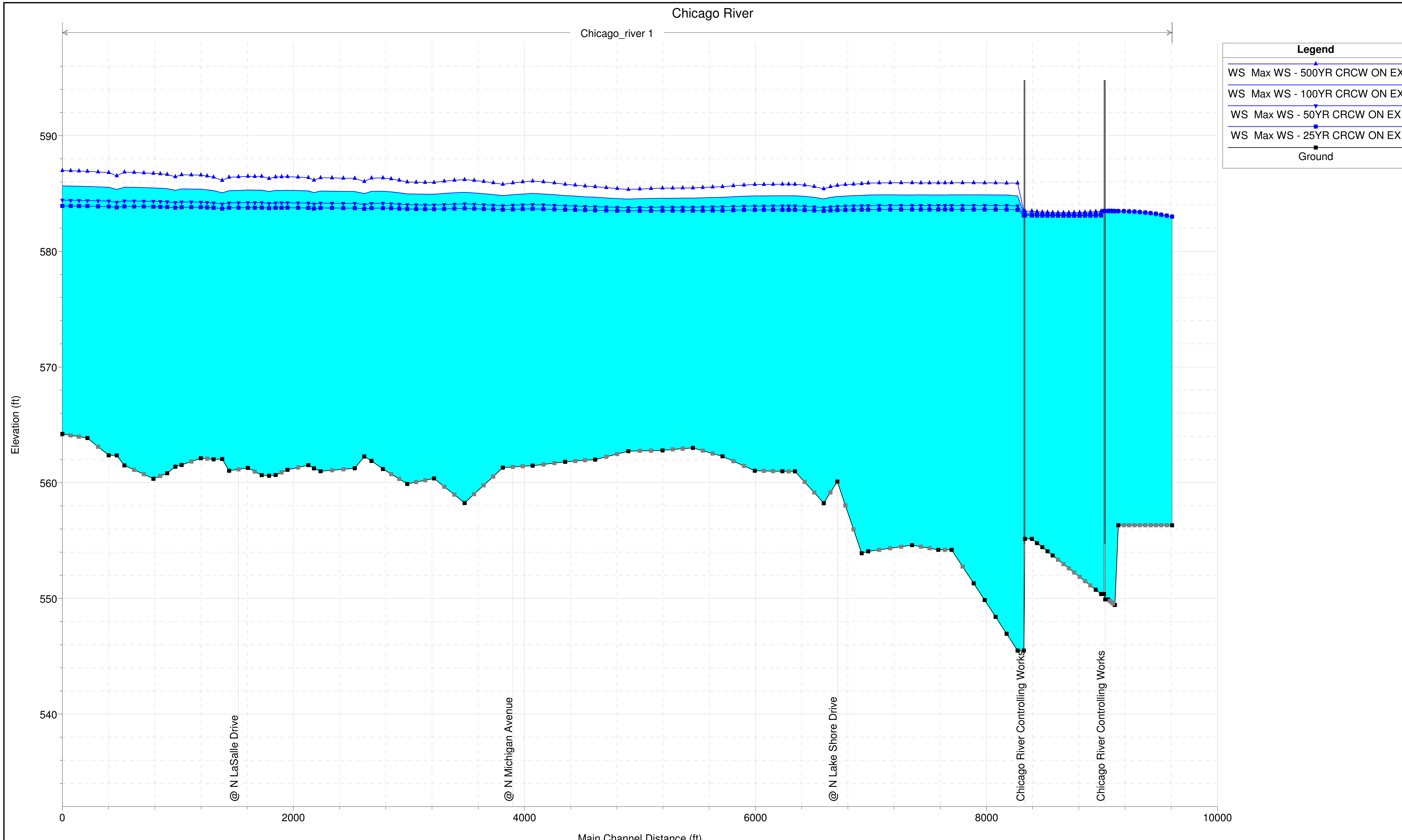
North Shore Channel from the Wilmette Pumping Station to confluence with the Mainstem of the NBCR



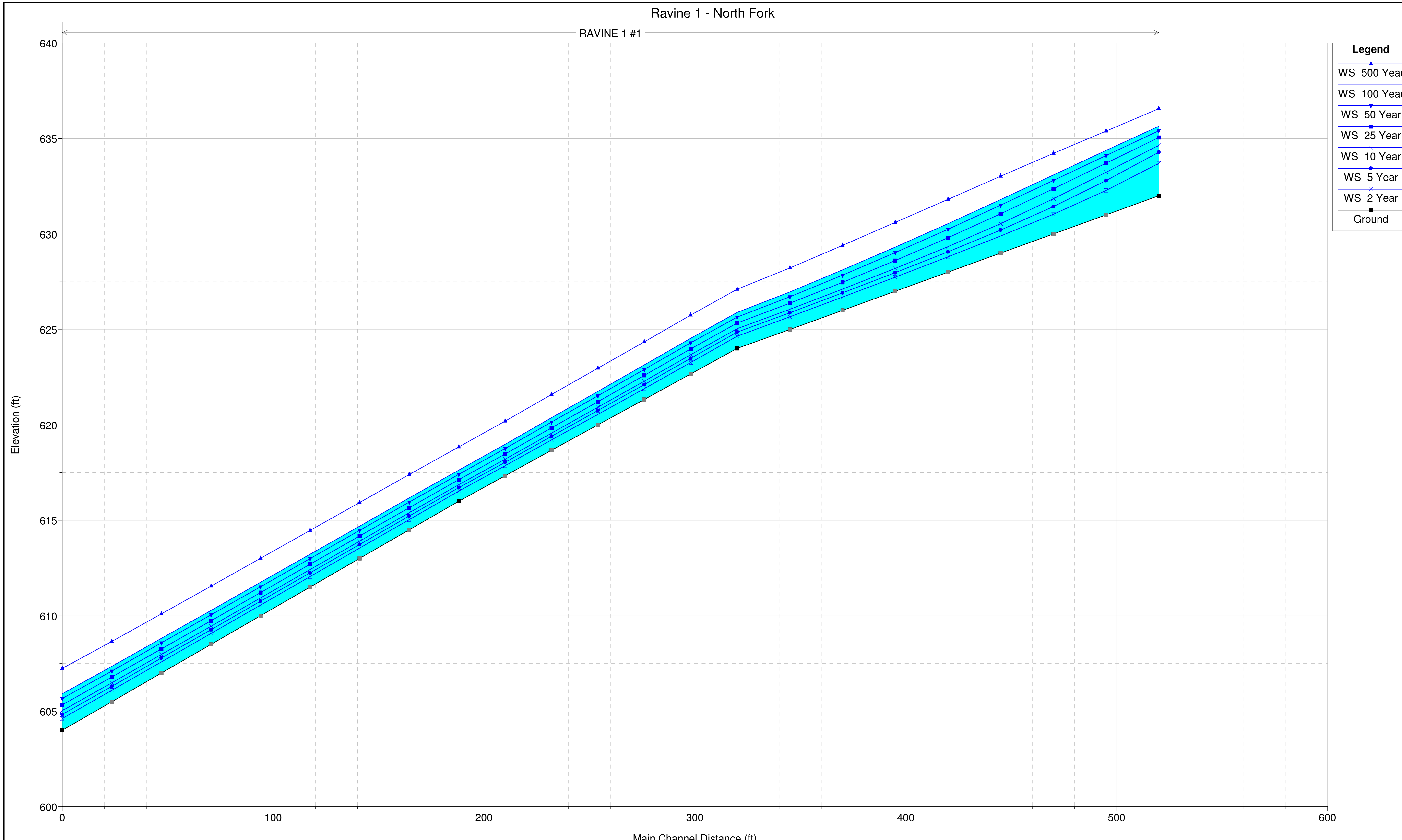
North Branch of the Chicago River from D/S of the North Branch Dam to confluence with the Chicago River



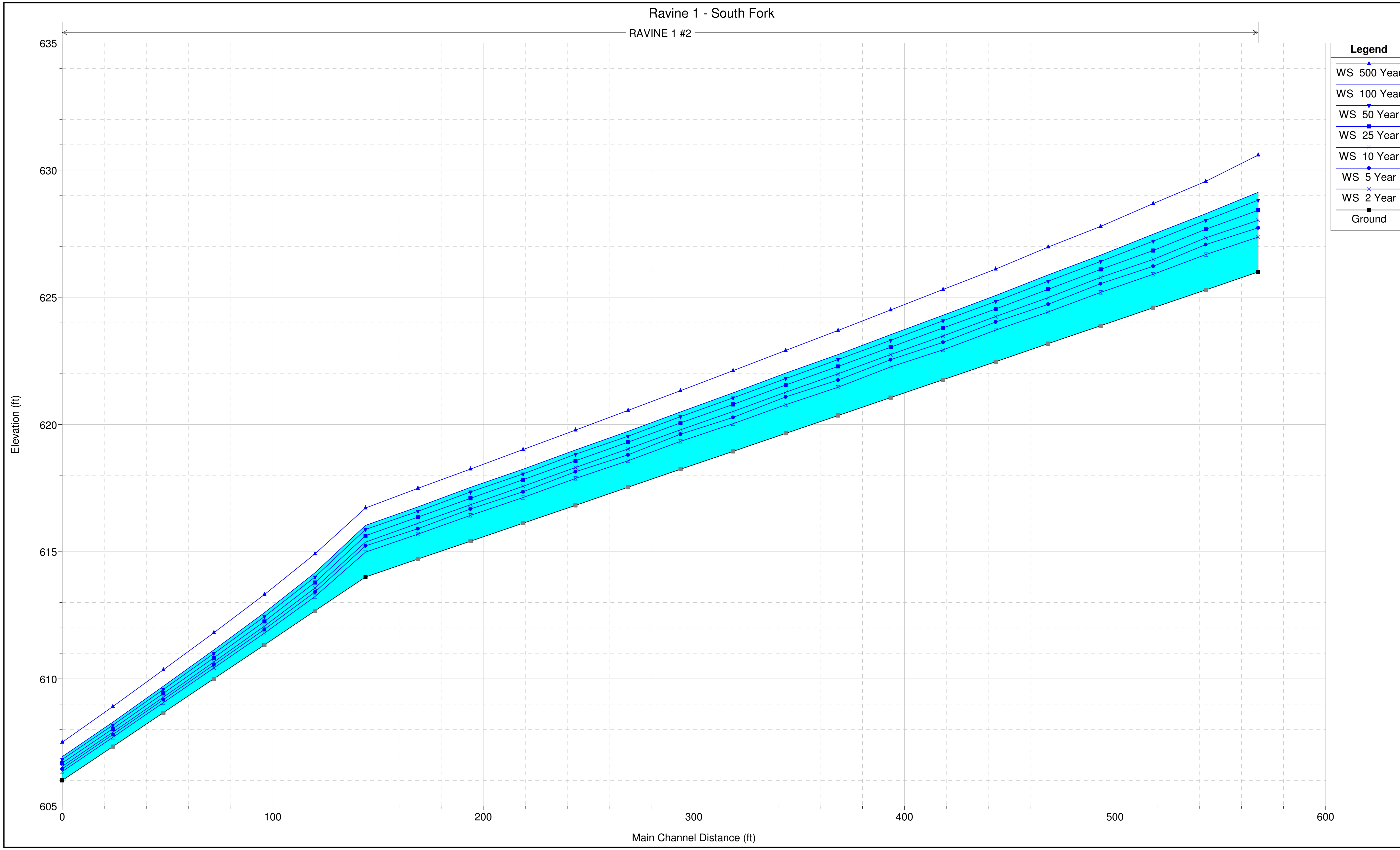
North Branch of the Chicago River - East split from North Avenue to Chicago Avenue



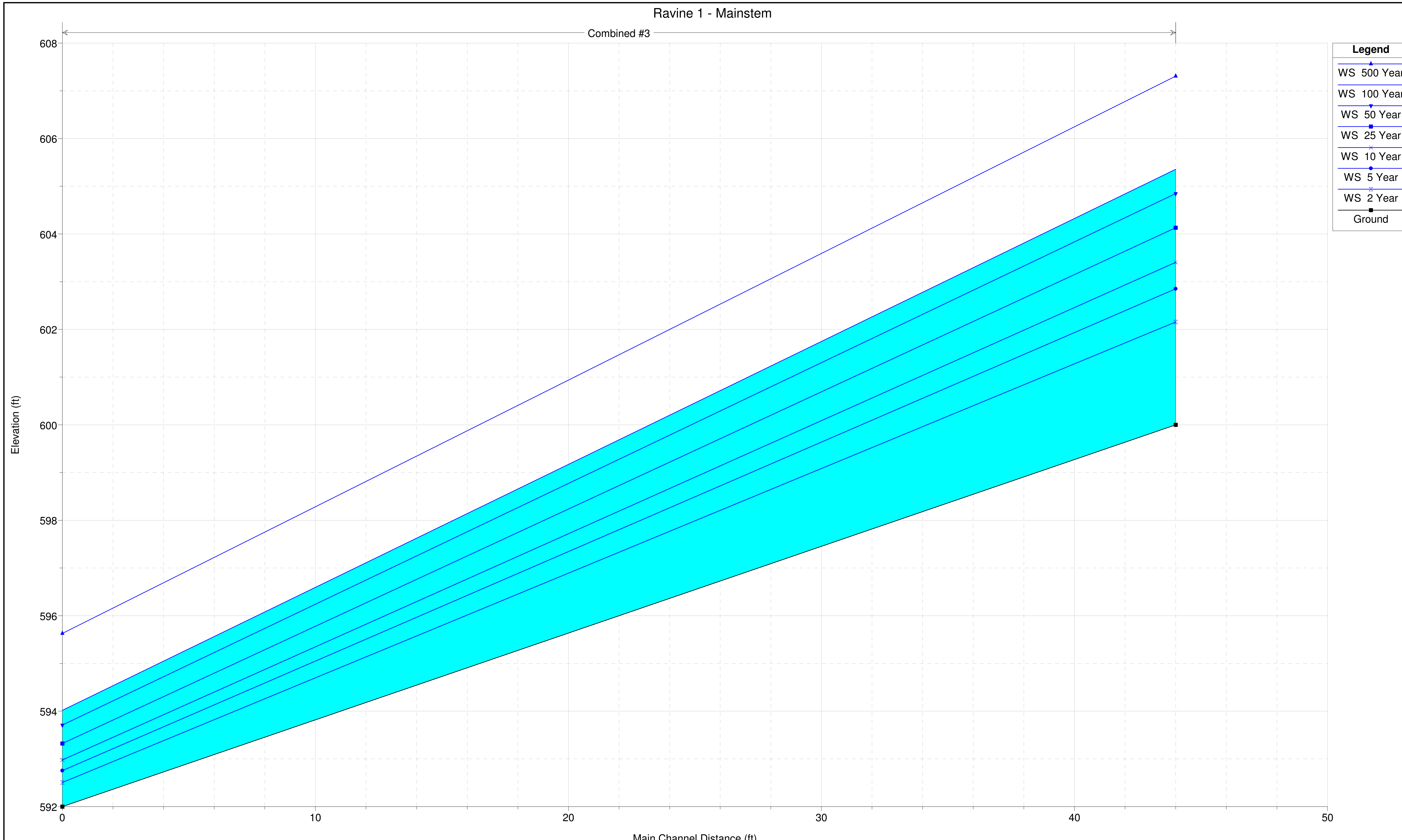
Chicago River from Chicago River Controlling Works to confluence with the North Branch



North Fork of Ravine 1 from its headwater to confluence with the South Fork of Ravine 1 at Sheridan Road



South Fork of Ravine 1 from its headwater to confluence with North Fork of Ravine 1 at Sheridan Road



Mainstem of Ravine 1 from Sheridan Road to its outlet into Lake Michigan

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name NBCR_MF_LV_01

Problem Description Middle Fork overbank flooding at the Fair Acres subdivision.

Strategy MF-04: Construct flood wall and compensatory storage to eliminate overbank flooding in this area.

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	750	$10.68	$8,010.00	$0	$0	Assumes 4 ft avg depth, 4 ft avg bottom width, 1.5H:1V side slopes, app. 500 ft length. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	750	$11.75	$8,812.50	$0	$0	Assume all excavated material will be hauled offsite
Concrete: Cast in place	yd3	120	$250.00	$30,000.00	$0	$0	Concrete wall footing, 3 ft avg width, 2 ft avg thickness, app. 500 ft length
Concrete: Cast in place	yd3	260	$250.00	$65,000.00	$0	$0	Flood wall, app. 500 ft length, app. 9 ft total height, 1.5 ft width
Channel treatment: Excavation	yd3	8070	$10.68	$86,187.60	$0	$0	5 acre-ft of compensatory storage on FPD land. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	8070	$11.75	$94,822.50	$0	$0	Assume all excavated material to be removed from the site.
Land Acquisition: Permanent Easement *	dollar	450000	$1.00	$450,000.00	$0	$0	3 acres at $150,000 per acre for permanent easement
Channel treatment: Soil stabilization and vegetative cover	yd2	14520	$13.88	$201,537.60	$187,427	$48,259	Soil stab. and vegetative cover for 3 acres at comp. storage site.

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Alternative Name	NBCR_MF_LV_01
Problem Description	Middle Fork overbank flooding at the Fair Acres subdivision.
Strategy	MF-04: Construct flood wall and compensatory storage to eliminate overbank flooding in this area.
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)							
Subtotal (direct costs)				**$494,370**	**$187,427**	**$48,259**	
Utility Relocation			4 %	$19,775			
Mobilization \ General Conditions			5%	$24,719			
Subtotal with Percent Allowances				**$538,864**			
Contingency			30%	$161,659			
Profit			5%	$35,026			
Probable Construction Cost Estimate				**$735,549**			
Design Engineering, Geotechnical, and Construction Management			10%	$73,555			
Property Acquisition Cost:				$450,000			
Total Conceptual Cost Estimate				**$1,494,789**			

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	NBCR_MF_SC_03
Problem Description	Streambank erosion along MF at Willow Road and Northfield Road.
Strategy	MF-06: Hard armor both streambanks at Willow Road and the east streambank at Northfield Road.
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Reinforced one sided concrete wall	yd3	820	$587.35	$481,627.00	$447,906	$115,327	From plan area, app. 33,221 sq ft, 8 inch thickness, both banks
Channel treatment: Excavation	yd3	1230	$10.68	$13,136.40	$0	$0	Excavation of both banks to allow for construction of concrete slope wall embedded in banks, app. 33,221 sq ft, 1 ft depth, on both banks. Quantity assumes no bulking/expansion of material upon excava
Channel treatment: Material to be hauled offsite	yd3	1230	$11.75	$14,452.50	$0	$0	Assume all excavated material to be hauled offsite
Channel treatment: Reinforced one sided concrete wall	yd3	125	$587.35	$73,418.75	$68,278	$17,580	From plan area, app. 5,015 sq ft, 8 inch thickness, east bank only along Northfield Rd.
Channel treatment: Excavation	yd3	190	$10.68	$2,029.20	$0	$0	Excavation of east bank, adjacent to Northfield Road, to allow for construction of concrete slope wall embedded in bank, app. 5,015 sq ft, 1 ft. Quantity assumes no bulking/expansion of material upon
Channel treatment: Material to be hauled offsite	yd3	190	$11.75	$2,232.50	$0	$0	Assume all excavated material to be hauled offsite

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$586,896**	**$516,184**	**$132,907**
Utility Relocation	4 %	$23,476		
Mobilization \ General Conditions	5%	$29,345		
Subtotal with Percent Allowances		**$639,717**		
Contingency	30%	$191,915		
Profit	5%	$41,582		
Probable Construction Cost Estimate		**$873,214**		
Design Engineering, Geotechnical, and Construction Management	10%	$87,321		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$1,609,626**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	NBCR_MF_SC_01
Problem Description	Streambank erosion of Middle Fork at Meadowbrook Drive
Strategy	MF-07: Hard armor both streambanks
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Reinforced one sided concrete wall	yd3	570	$587.35	$334,789.50	$311,349	$80,166	From total plan area, app. 22,951 sq ft, 8 inch thickness, both banks
Channel treatment: Excavation	yd3	850	$10.68	$9,078.00	$0	$0	App. 22,951 sq ft, 1 ft depth, both banks. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	850	$11.75	$9,987.50	$0	$0	Assume all excavated material will be removed from site

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$353,855**	**$311,349**	**$80,166**
Utility Relocation	4 %	$14,154		
Mobilization \ General Conditions	5%	$17,693		
Subtotal with Percent Allowances		**$385,702**		
Contingency	30%	$115,711		
Profit	5%	$25,071		
Probable Construction Cost Estimate		**$526,483**		
Design Engineering, Geotechnical, and Construction Management	10%	$52,648		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$970,647**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan

Total Conceptual Cost Report

Alternative Name NBCR_MAIN_DV_02

Problem Description Albany Park overbank flooding

Strategy MS-07: Construct 18 ft diameter tunnel diversion from Foster Road and Pulaski Road to Foster Road and the

District Minimum Criteria for Funding: Not Met

Recommended No

	Uni	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Tunnel Excavation (rock): In tunnel (20 ft diameter)	yd3	63050	$437.84	$27,605,812.00	$0	$0	App. 5,700 ft length, App. 19.5 ft diam. overall tunnel opening, rock material identified in MWH feasibility study, assumes unit price includes app. 1.5 ft thick concrete lining. Quantity assumes no bulking of excavated material.
Pump Station: 10ac-ft per day interior drainage	each	1	$800,000.00	$800,000.00	$743,988	$0	Proposed in MWH report. Total cost assumes no replacement of pumps within 50 years.
Tunnel Excavation (mix rock & earth): In tunnel (20 ft diameter)	yd3	1400	$720.83	$1,009,162.00	$0	$0	Upstream dropshaft, app. 120 ft length, app. 20 ft diameter, assumes unit price includes app. 1.5 ft thick concrete lining. Quantity assumes no bulking/expansion of material upon excavation.
Tunnel Excavation (mix rock & earth): In tunnel (20 ft diameter)	yd3	3150	$720.83	$2,270,614.50	$0	$0	Downstream riser shaft, app. 120 ft length, app. 30 ft diameter, assumes unit price includes app. 1.5 ft thick concrete lining. Quantity assumes no bulking/expansion of material upon excavation.
Concrete: Cast in place	yd3	2200	$250.00	$550,000.00	$0	$0	Inlet structure estimated from MWH report
Concrete: Cast in place	yd3	2200	$250.00	$550,000.00	$0	$0	Outlet structure estimated from MWH report
Channel treatment: Material to be hauled offsite	yd3	67600	$11.75	$794,300.00	$0	$0	Assume all excavated material from tunnel and shafts will be hauled offsite.
Land Acquisition: Permanent Easement *	dollar	1	$1.00	$1.00	$0	$0	easement for the dropshafts on City property and for tunnel on Foster Avenue. Based on past deep tunnel projects using public right-of-way, the easement was practically

no cost.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$33,579,889**	**$743,988**	**$0**
Utility Relocation	4 %	$1,343,196		
Mobilization \ General Conditions	5%	$1,678,994		
Subtotal with Percent Allowances		**$36,602,078**		
Contingency	30%	$10,980,624		
Profit	5%	$2,379,135		
Probable Construction Cost Estimate		**$49,961,837**		
Design Engineering, Geotechnical, and Construction Management	10%	$4,996,184		
Property Acquisition Cost:		$1		
Total Conceptual Cost Estimate		**$55,702,010**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan

Total Conceptual Cost Report

Alternative Name NBCR_MAIN_LV_01

Problem Description Floodwall

Strategy MS-10: Construct floodwall through Albany Park neighborhood.

District Minimum Criteria for Funding: Met

Recommended Yes

	Uni	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Floodproofing: Industry	2,500 ft2	2	$21,358.02	$42,716.04	$39,725	$16,472	Bohemia National Cemetery dome building. Protect half of the building.
Floodproofing: Residence	each	6	$21,358.02	$128,148.12	$119,176	$49,415	6 condos of the North Riversedge Terrace building.
Floodproofing: Industry	2,500 ft2	1	$21,358.02	$21,358.02	$19,863	$8,236	Bohemia National Cemetery maintenance building.
Floodproofing: Industry	2,500 ft2	2	$21,358.02	$42,716.04	$39,725	$16,472	Bohemia National Cemetery residence
Channel treatment: Material to be hauled offsite	yd3	9340	$11.75	$109,745.00	$0	$0	Assume all excavated material to be hauled offsite.
Concrete: Cast in place	yd3	1400	$250.00	$350,000.00	$0	$0	Concrete wall footing, 3 ft avg width, 2 ft avg thickness, app. 6,300 ft length.
Land Acquisition: Permanent Easement *	dollar	5200000	$1.00	$5,200,000.00	$0	$0	App. 13 acres of flood easement at $400,000 per acre.
Land Acquisition: Purchase of Property *	dollar	3600000	$1.00	$3,600,000.00	$0	$0	8 single family homes at 450,000 per home.
Land Acquisition: Purchase of Property *	dollar	2700000	$1.00	$2,700,000.00	$0	$0	1 apartment building, assumes 6 units at 450,000 per unit.
Concrete: Cast in place	yd3	7670	$250.00	$1,917,500.00	$0	$0	App. 138,000 sq ft profile/elevation area, 1.5 ft avg. width.
Channel treatment: Excavation	yd3	18200	$10.68	$194,376.00	$0	$0	Assume average excavation depth of 6 ft, avg width of 4 ft, 1.5H:1V side slopes, app. 6,300 ft length. Quantity assumes no bulking/expansion of material upon excavation.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$2,806,559**	**$218,489**	**$90,595**
Utility Relocation	4 %	$112,262		
Mobilization \ General Conditions	5%	$140,328		
Subtotal with Percent Allowances		**$3,059,150**		
Contingency	30%	$917,745		
Profit	5%	$198,845		

Probable Construction Cost Estimate		**$4,175,739**
Design Engineering, Geotechnical, and Construction Management	10%	$417,574
Property Acquisition Cost:		$11,500,000
Total Conceptual Cost Estimate		**$16,402,397**

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan

Total Conceptual Cost Report

Alternative Name NBCR_MAIN_ST_01

Problem Description Main Stem overbank flooding.

Strategy MS-12: Construct new reservoir at Wilmette Public Golf Course.

District Minimum Criteria for Funding: Not Met

Recommended No

	Uni	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	4581870	$10.68	$48,934,371.60	$0	$0	App. 2,840 acre-ft excavation calculated from HEC-RAS. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	4581870	$11.75	$53,836,972.50	$0	$0	Assume all excavated material to be hauled offsite.
Pipe in earth (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	1500	$303.28	$454,920.00	$423,069	$0	Inlet barrels, 3-72" RCPs, app. 500 ft length each.
Concrete: Cast in place	yd3	1600	$250.00	$400,000.00	$0	$0	Inlet overflow weir, app. 200 ft wide x app. 215 ft length (which includes ramp along side slope), 1 ft thickness.
Land Acquisition: Purchase of Property *	dollar	34400000	$1.00	$34,400,000.00	$0	$0	App. 86 acres for aquisition at $400,000 per acre.
Channel treatment: Vegetative cover only	yd2	416240	$8.54	$3,554,689.60	$3,305,807	$851,180	Assume new reservoir will require seeding.
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	4	$60,000.00	$240,000.00	$223,196	$0	Approximate size of existing wetlands on golf course. Assume wetland could be built within project limits.
Pump Station: 300 cfs Pump Station with Flap Gate	each	1	$3,970,000.00	$3,970,000.00	$2,215,224	$0	Assume 1 pump station with a capacity of 300 cfs. Total cost assumes no replacement of pumps within 50 years.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$111,390,954**	**$6,167,295**	**$851,180**
Utility Relocation	4 %	$4,455,638		
Mobilization \ General Conditions	5%	$5,569,548		
Subtotal with Percent Allowances		**$121,416,140**		
Contingency	30%	$36,424,842		
Profit	5%	$7,892,049		
Probable Construction Cost Estimate		**$165,733,030**		
Design Engineering, Geotechnical, and Construction Management	10%	$16,573,303		
Property Acquisition Cost:		$34,400,000		
Total Conceptual Cost Estimate		**$223,724,809**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan

Total Conceptual Cost Report

Alternative Name NBCR_MAIN_ST_02

Problem Description Main Stem overbank flooding.

Strategy MS-14: Construct new reservoir at Wilmette Public Golf Course along with channel widening from Middle

District Minimum Criteria for Funding: Met

Recommended Yes

	Uni	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	4581870	$10.68	$48,934,371.60	$0	$0	App. 2,840 acre-ft excavation calculated from HEC-RAS. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	4581870	$11.75	$53,836,972.50	$0	$0	Assume all excavated material to be hauled offsite.
Pipe in earth (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	1500	$303.28	$454,920.00	$423,069	$0	Inlet barrels, 3-72" RCPs, App. 500 ft length each.
Concrete: Cast in place	yd3	1600	$250.00	$400,000.00	$0	$0	Inlet overflow weir, app. 200 ft width x app. 215 ft length (which includes ramp down side slope), 1 ft thickness.
Land Acquisition: Purchase of Property *	dollar	34400000	$1.00	$34,400,000.00	$0	$0	App. 86 acres for Golf Course aquisition at $400,000 per acre.
Channel treatment: Excavation	yd3	440800	$10.68	$4,707,744.00	$0	$0	Channel widening of app. 100 ft wide x app. 18,500 ft in length along Main Stem from Middle Fork to West Fork. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	440800	$11.75	$5,179,400.00	$0	$0	Assume all material will be hauled offsite.
Channel treatment: Vegetative cover only	yd2	367840	$8.54	$3,141,353.60	$2,921,411	$752,205	Assume all channel widening will require seeding.
Channel treatment: Vegetative cover only	yd2	416240	$8.54	$3,554,689.60	$3,305,807	$851,180	Assume new reservoir will require seeding.
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	4	$60,000.00	$240,000.00	$223,196	$0	Approximate size of existing wetlands on golf course. Assume wetland could be built within project limits.
Land Acquisition: Permanent Easement *	dollar	11400000	$1.00	$11,400,000.00	$0	$0	App. 76 acres of Cook Co FPD land at $150,000 per acre.
Pump Station: 300 cfs Pump Station with Flap Gate	each	1	$3,970,000.00	$3,970,000.00	$2,215,224	$0	Assume 1 pump station with a capacity of 300 cfs. Total cost assumes no replacement of pumps within 50 years.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$124,419,451**	**$9,088,706**	**$1,603,385**
Utility Relocation	4 %	$4,976,778		
Mobilization \ General Conditions	5%	$6,220,973		

Subtotal with Percent Allowances		**$135,617,202**
Contingency	30%	$40,685,161
Profit	5%	$8,815,118
Probable Construction Cost Estimate		**$185,117,481**
Design Engineering, Geotechnical, and Construction Management	10%	$18,511,748
Property Acquisition Cost:		$45,800,000
Total Conceptual Cost Estimate		**$260,121,320**

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	SR-08
Problem Description	I-94 at Winnetka Road overbank flooding
Strategy	SR-08: Construct levees on west and east sides of I-94 to block overbank flooding of I-94 at Winnetka Road.
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Embankment construction, grading and restoration: Material hauled from offsite	yd3	600	$10.68	$6,408.00	$0	$0	East levee construction assuming app. 2ft height, app. 10 ft top width, and 5:1 side slopes. Length of app. 400 ft. Quantity assumes no shrinkage upon placement.
Embankment construction, grading and restoration: Compaction of fill	yd3	600	$5.34	$3,204.00	$0	$0	Place fill for levee on east side of I-94. Quantity assumes no shrinkage upon placement.
Embankment construction, grading and restoration: Compaction of fill	yd3	600	$5.34	$3,204.00	$0	$0	Compact levee material for levee on east side of I-94. Quantity assumes no shrinkage upon placement.
Channel treatment: Vegetative cover only	yd2	1350	$8.54	$11,529.00	$10,722	$2,761	Seed east levee surface; app. 400 ft L x (app. 10ft + app. 10ft + app. 10ft) W
Pipe in earth (city): 36 inches or less	lf	50	$216.78	$10,839.00	$10,080	$0	Pipe through levee to maintain I-94 ditch drainage
Outlet structures (Headwall): 36 inches or less	each	1	$2,600.34	$2,600.34	$2,418	$0	East side levee. Includes flap gate on stream side.
Land Acquisition: Permanent Easement *	dollar	750000	$1.00	$750,000.00	$0	$0	East side levee. Permenant drainage easment from CCFPD for levee and compensatory storage. App. 5 acres at $150,000/acre.
Embankment construction, grading and restoration: Material hauled from offsite	yd3	3860	$10.68	$41,224.80	$0	$0	West side levee construction assuming app. 2ft height, app. 30 ft top width, and 5:1 side slopes. Length of app. 1,300 ft
Embankment construction, grading and restoration: Compaction of fill	yd3	3860	$5.34	$20,612.40	$0	$0	Place fill for levee on west side of I-94. Quantity assumes no shrinkage upon placement.

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Alternative Name SR-08

Problem Description I-94 at Winnetka Road overbank flooding

Strategy SR-08: Construct levees on west and east sides of I-94 to block overbank flooding of I-94 at Winnetka Road.

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Embankment construction, grading and restoration: Compaction of fill	yd3	3860	$5.34	$20,612.40	$0	$0	Compact levee material for levee on west side of I-94. Quantity assumes no shrinkage upon placement.
Channel treatment: Vegetative cover only	yd2	2900	$8.54	$24,766.00	$23,032	$5,930	Seed west levee surface; app. 1,300 ft L x (app. 10ft +app. 10ft) W
Pipe under pavement (city): 36 inches or less	lf	100	$304.35	$30,435.00	$28,304	$0	Pipe under frontage road to maintain I-94 west ditch drainage
Inlet structures (Headwall): 36 inches or less	each	1	$2,600.34	$2,600.34	$2,418	$0	West side levee.
Outlet structures (Headwall): 36 inches or less	each	1	$2,600.34	$2,600.34	$2,418	$0	West side levee. Includes flap gate on stream side.
Inlet structures (Headwall): 36 inches or less	each	1	$2,600.34	$2,600.34	$2,418	$0	East side levee.
Land Acquisition: Permanent Easement *	dollar	300000	$1.00	$300,000.00	$0	$0	West side levee. Permenant drainage easement. App. 2 acres at $150,000/acre.
Paving: Asphalt Pavement Installation (24 ft wide, 2 ft C&G, 1 ft Excavation	lf	1500	$148.47	$222,705.00	$207,112	$0	West side levee. Frontage road reconstruction to raise roadway to create levee.
Channel treatment: Excavation	yd3	66150	$10.68	$706,482.00	$0	$0	App. 41 ac-ft of compensatory storage through CCFPD property.Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	66150	$11.75	$777,262.50	$0	$0	Assume all excavated material to be hauled offsite.
Channel treatment: Soil stabilization and vegetative cover	yd2	33900	$13.88	$470,532.00	$437,588	$112,670	Soil stab. and vegetative cover for app. 7 acres of compensatory storage site.

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Alternative Name	SR-08
Problem Description	I-94 at Winnetka Road overbank flooding
Strategy	SR-08: Construct levees on west and east sides of I-94 to block overbank flooding of I-94 at Winnetka Road.
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)				**$2,360,217**	**$726,511**	**$121,361**	
Utility Relocation			4 %	$94,409			
Mobilization \ General Conditions			5%	$118,011			
Subtotal with Percent Allowances				**$2,572,637**			
Contingency			30%	$771,791			
Profit			5%	$167,221			
Probable Construction Cost Estimate				**$3,511,650**			
Design Engineering, Geotechnical, and Construction Management			10%	$351,165			
Property Acquisition Cost:				$1,050,000			
Total Conceptual Cost Estimate				**$5,760,686**			

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	NBCR_WF_SC_01
Problem Description	Streambank erosion WF east bank along Metra Milwaukee North District RR and Fair
Strategy	WF-03: Hard armor left bank, from toe of bank to top of bank, to protect existing railroad.
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Reinforced one sided concrete wall	yd3	520	$587.35	$305,422.00	$284,038	$73,134	App. 970 ft length, App. 21.5 ft width on east bank at 1V:2.5H slope, 8 inch thickness
Channel treatment: Excavation	yd3	775	$10.68	$8,277.00	$0	$0	Excavation of east bank to allow construction of sloped wall embedded in east bank. App. 970 ft length, App. 21.5 ft width, 1 ft depth. Quantity assumes no bulking/expansion of material upon excavati
Channel treatment: Material to be hauled offsite	yd3	775	$11.75	$9,106.25	$0	$0	Assume all excavated material will be removed from site.
Channel treatment: Reinforced one sided concrete wall	yd3	667	$587.35	$391,762.45	$364,333	$93,809	App. 450 ft length by app. 60 ft width by 8 inch thickness on east bank
Channel treatment: Excavation	yd3	1000	$10.68	$10,680.00	$0	$0	App. 450 ft length by app. 60 ft width by 1 ft depth on east bank. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	1000	$11.75	$11,750.00	$0	$0	Assume all excavated material will be removed from site.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$736,998**	**$648,371**	**$166,943**
Utility Relocation	4 %	$29,480		
Mobilization \ General Conditions	5%	$36,850		
Subtotal with Percent Allowances		**$803,327**		
Contingency	30%	$240,998		
Profit	5%	$52,216		
Probable Construction Cost Estimate		**$1,096,542**		
Design Engineering, Geotechnical, and Construction Management	10%	$109,654		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$2,021,510**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan

Total Conceptual Cost Report

Alternative Name NBCR_WF_ST_01

Problem Description Techny 32A Anetsberger Extension

Strategy WF-06: Expand Techny 32A reservoir into Anetsberger Golf Course and steepen existing reservoir side

District Minimum Criteria for Funding: Met

Recommended Yes

	Uni	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	2355467	$10.68	$25,156,387.56	$0	$0	1,460 acre-ft additional volume generated from HEC-RAS. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	2355467	$11.75	$27,676,737.25	$0	$0	Assume no excavation could be wasted onsite since entire area is being utilized for expansion.
Concrete: Cast in place	yd3	408	$250.00	$102,000.00	$0	$0	Concrete inlet weir expansion. Approximate 110 ft
Channel treatment: Vegetative cover only	yd2	188760	$8.54	$1,612,010.40	$1,499,145	$386,000	39 acre site would require vegetative cover.
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	4	$60,000.00	$240,000.00	$223,196	$0	Approximate size of existing wetland on golf course. Assume wetland could be built within project limits.
Land Acquisition: Purchase of Property *	dollar	15600000	$1.00	$15,600,000.00	$0	$0	Based on Cook Co. Assessors data of a similar sized private GC.
Pump Station: 300 cfs Pump Station with Flap Gate	each	1	$3,970,000.00	$3,970,000.00	$2,215,224	$0	Additional pump station to accommodate expanded reservoir. Total cost assumes no replacement of pumps within 50 years.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$58,757,135**	**$3,937,565**	**$386,000**
Utility Relocation	4 %	$2,350,285		
Mobilization \ General Conditions	5%	$2,937,857		
Subtotal with Percent Allowances		**$64,045,277**		
Contingency	30%	$19,213,583		
Profit	5%	$4,162,943		
Probable Construction Cost Estimate		**$87,421,804**		
Design Engineering, Geotechnical, and Construction Management	10%	$8,742,180		
Property Acquisition Cost:		$15,600,000		
Total Conceptual Cost Estimate		**$116,087,549**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan

Total Conceptual Cost Report

Alternative Name	NBCR_WF_ST_02
Problem Description	Techny 32C expansion into Sunset Village Mobile Home Park and "Lot 16"
Strategy	WF-19: Expand Techny 32C into Sunset Village Mobile Home Park and "Lot 16".
District Minimum Criteria for Funding:	Not Met
Recommended	No

	Uni	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Land Acquisition: Purchase of Property *	dollar	11000000	$1.00	$11,000,000.00	$0	$0	Total assessed value from Cook Co Assessors data
Channel treatment: Excavation	yd3	1855334	$10.68	$19,814,967.12	$0	$0	App. 1,150 acre-ft additional volume generated from HEC-RAS. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	1854084	$11.75	$21,785,487.00	$0	$0	Assume only app. 1,250 CY retained onsite. no additional excavation could be wasted onsite since entire area is being utilized for expansion.
Pipe under pavement (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	630	$291.54	$183,670.20	$170,810	$0	RCP connecting two expanded portions of reservoir (Mobile Home Park and Lot 16). Est. at higher unit price since it is assumed to be jacked in place.
Channel treatment: Compaction	yd3	1250	$7.48	$9,350.00	$0	$0	On-site fill compaction required to raise app. 800 ft of outlet weir access road app. 3 ft. Assume app. 14 ft. width. Quantity assumes no shrinkage upon compaction.
Channel treatment: Vegetative cover only	yd2	145200	$8.54	$1,240,008.00	$1,153,188	$296,923	App. 30 acre site would require vegetative cover.
Pipe in tunnel: 42 to 66 inches	lf	630	$1,495.06	$941,887.80	$875,941	$0	Jacked in place RCP connecting two expanded portions of reservoir (Mobile Home Park and Lot 16). Est. at higher unit price since it is assumed to be jacked in place, not in tunnel.
Embankment construction, grading and restoration: Additional fill	yd3	1250	$13.88	$17,350.00	$0	$0	On-site fill placement required to raise app. 800 ft of outlet weir access road app. 3 ft. Assume app. 14 ft. width. Quantity assumes no shrinkage upon placement.
Pump Station: 300 cfs Pump Station with Flap Gate	each	1	$3,970,000.00	$3,970,000.00	$2,215,224	$0	Total cost assumes no replacement of pumps within 50 years.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$47,962,720**	**$4,415,164**	**$296,923**
Utility Relocation	4 %	$1,918,509		
Mobilization \ General Conditions	5%	$2,398,136		
Subtotal with Percent Allowances		**$52,279,365**		
Contingency	30%	$15,683,809		
Profit	5%	$3,398,159		
Probable Construction Cost Estimate		**$71,361,333**		
Design Engineering, Geotechnical, and Construction Management	10%	$7,136,133		
Property Acquisition Cost:		$11,000,000		
Total Conceptual Cost Estimate		**$94,209,553**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding

Metropolitan Water Reclamation District of Greater Chicago
NBCR Watershed Detailed Watershed Plan

Total Conceptual Cost Report

Alternative Name NBCR_WF_ST_04

Problem Description West Fork overbank flooding

Strategy WF-21: Techny 32B expansion of in-line storage.

District Minimum Criteria for Funding: Not Met

Recommended No

	Uni	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	688800	$10.68	$7,356,384.00	$0	$0	Quantity derived from HEC-RAS cross sections. Quantity assumes no bulking/expansion of material upon excavation.
Channel treatment: Material to be hauled offsite	yd3	688800	$11.75	$8,093,400.00	$0	$0	Assume all excavated material will be hauled offsite
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	45	$60,000.00	$2,700,000.00	$2,510,959	$0	Wetland pods measured in GIS
Land Acquisition: Purchase of Property *	dollar	18200000	$1.00	$18,200,000.00	$0	$0	Based on Cook Co Assessors data of nearby parcels. 45.5 total acres at $400,000 per acre

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$18,149,784**	**$2,510,959**	**$0**
Utility Relocation	4 %	$725,991		
Mobilization \ General Conditions	5%	$907,489		
Subtotal with Percent Allowances		**$19,783,265**		
Contingency	30%	$5,934,979		
Profit	5%	$1,285,912		
Probable Construction Cost Estimate		**$27,004,156**		
Design Engineering, Geotechnical, and Construction Management	10%	$2,700,416		
Property Acquisition Cost:		$18,200,000		
Total Conceptual Cost Estimate		**$50,415,530**		

Additional Comments

Note: Small differences between the base cost and the reported product of quantity and unit cost due to rounding