Final Report

Detailed Watershed Plan for the Calumet-Sag Channel Watershed: Volume 1

Prepared for

Metropolitan Water Reclamation District of Greater Chicago

August 2009

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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 Calumet-Sag Channel DWP was developed to meet the goals for the Calumet-Sag Channel Watershed 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 Calumet-Sag Channel 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 Calumet-Sag Channel Watershed is located in southwestern Cook County and drains an area of 151 square miles that includes 27 communities. Figure ES.1 is an overview of the Calumet-Sag Channel Watershed. The watershed area north of the Calumet-Sag Channel is heavily developed and characterized by low relief. It is drained principally by the East and West branches of Stony Creek, which both discharge into the Calumet-Sag Channel. Several smaller streams discharge westward into the I&M Canal or southward into the Calumet-Sag Channel. The watershed area south of the Calumet-Sag Channel is less intensely developed and characterized by greater topographic relief. Spring Creek, Long Run Creek, and Marley Creek all drain southwest into Will County and are tributary to Hickory Creek, which drains to the Lower Des Plaines River. These streams are included, along with tributaries that flow north to the Calumet-Sag Channel and several tributaries that flow west to the I&M Canal, within the scope of the Calumet-Sag Channel 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 Calumet-Sag Channel 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 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.

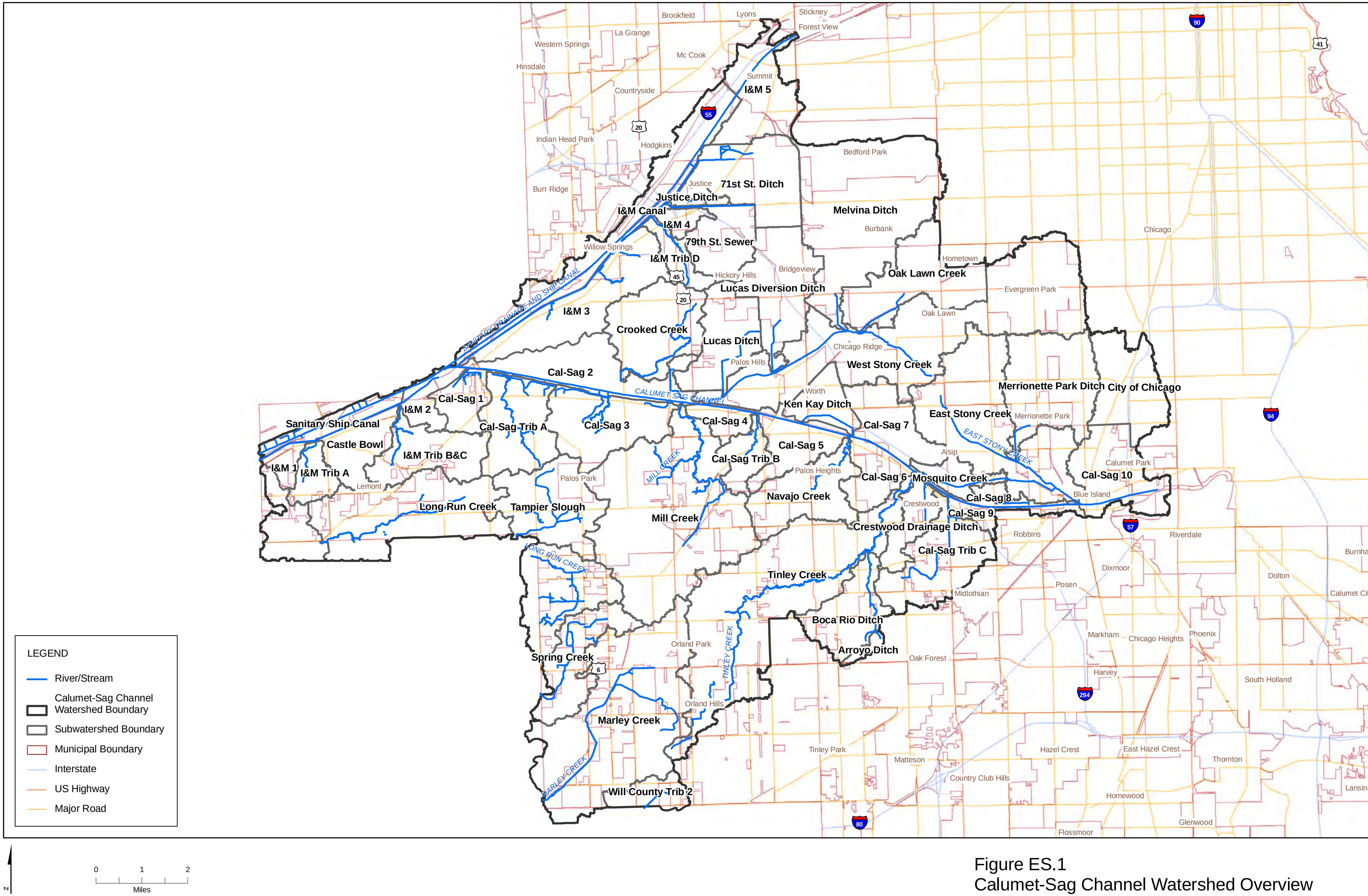

Figure ES.1
Calumet-Sag Channel Watershed Overview

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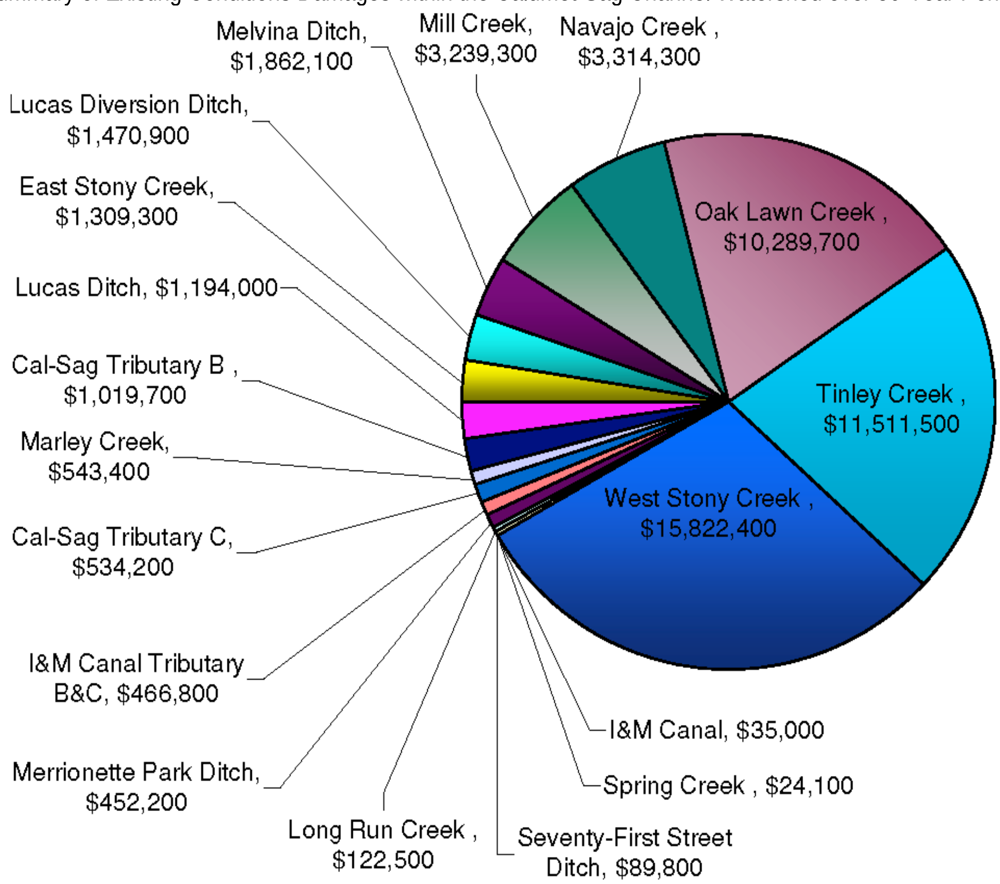
Figure ES.2 summarizes the distribution of existing conditions damages within the Calumet-Sag Channel Watershed over a planning period of analysis of 50 years. Stony Creek and its tributary waterways comprise roughly 61 percent of the existing conditions damage within the watershed. The Stony Creek system has the 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, erosion problems on regional waterways that threaten structures, and transportation damages. Localized problems, such as storm-sewer capacity related problems, 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 Calumet-Sag Channel Watershed 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 each alternative over a 50-year period of analysis. The cost estimates were developed using standard unit cost items within a District database 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 the impact on wetland and riparian area 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.

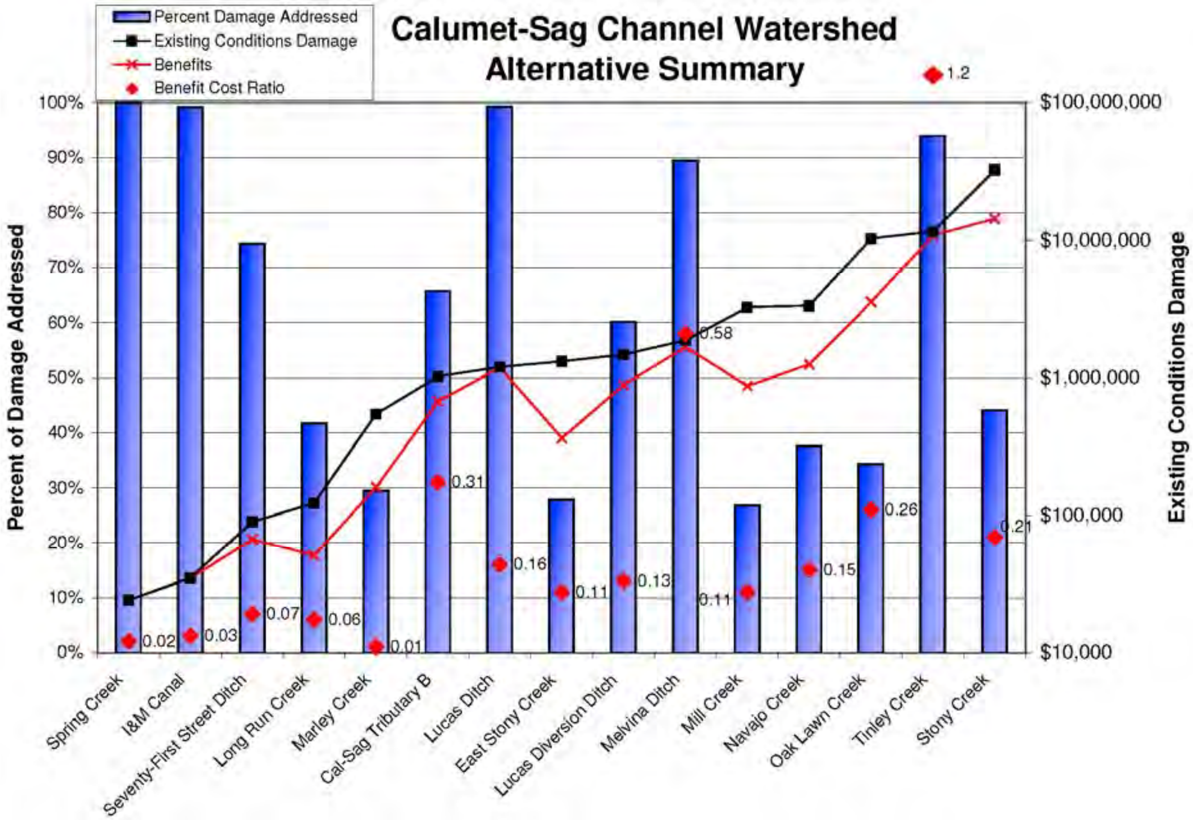
Figure ES.3 summarizes the extent to which recommended alternatives address existing regional financial damages within each tributary, ordered by increasing existing conditions damages. A logarithmic scale is used so that the wide range of estimated damages, ranging from $24,100 for Spring Creek to $32,400,500 for Stony Creek, can be displayed on a single graph. The columns indicate the extent to which recommended alternatives address estimated damages, while the red B/C symbols indicate the B/C ratio. As an example, the recommended Stony Creek alternatives address roughly 45 percent of estimated damages (indicated by the column), which corresponds to a benefit of $14,498,600 (this excludes benefits from projects on tributaries to Stony Creek). In contrast, roughly 66 percent of the damages along Calumet-Sag Tributary B are addressed, but this results in only $669,700 of benefit, or 4.6 percent of benefits of the recommended Stony Creek alternatives. Stated simply, areas with lower existing regional financial damages show lower benefits from flood control projects.

TABLE ES.1
Recommended Alternatives Summary for the Calumet-Sag Channel Watershed

Project	Category	Description	B/C Ratio	Total Benefits	Total Project Cost	Probable Construction Cost	Cumulative Structures Protected	Communities Involved
SFDT-1	Detention	60 ac-ft Detention Pond	0.07a	$395,400	$5,452,100	$3,635,800	12	Justice, Bridgeview, Hickory Hills, Bedford Park
SFDT-2	Conveyance	Additional outlet to I&M Canal	0.04	$31,400	$716,700	$434,600	14	Justice, Bridgeview, Hickory Hills, Bedford Park
CSTB-3	Detention/Conveyance	Add 10 ac-ft of additional detention and increase conveyance	0.31	$669,700	$2,131,500	$786,600	6	Palos Park
IMCA-1	Conveyance	Construct new outlets to Chicago Sanitary and Shipping Canal	0.03	$34,700	$1,043,800	$707,300	3	Lemont
LRCR-5	Conveyance	Raise 143rd Street	0.06	$51,100	$862,700	$590,900	0	Orland Park
LDDT-3	Detention/Conveyance	Three detention basins with 63 ac-ft of storage and channel clearing south of 103rd St	0.13	$885,200	$6,765,000	$4,499,800	56	Bridgeview, Palos Hills
LUDT-5	Levee	Levee at confluence with Stony Creek and compensatory storage	0.27	$845,200	$3,136,900	$1,961,500	4	Palos Hills
LUDT-7	Detention/Conveyance	Dredge Lucas Ditch upstream of 103rd Street and provide roughly 60 ac-ft of detention on golf course	0.08	$340,200	$4,472,600	$813,000	54	Palos Hills, Hickory Hills, Bridgeview
MACR-1	Detention	Construct 117 ac-ft detention basin	0.01	$160,100	$15,985,700	$8,990,000	3	Orland Park
MEDT-1	Erosion Stabilization	Hard-armoring of eroding streambank	0.58	$1,665,900	$2,854,500	$1,564,200	8	Chicago Ridge, Oak Lawn
MICR-2	Levee	Levee and storage	0.20	$409,600	$2,003,400	$1,404,700	6	Palos Park
MICR-4	Detention/Conveyance	32 ac-ft of storage and increased downstream conveyance	0.10	$459,000	$5,918,100	$4,208,200	2	Orland Park
NVCR-3	Detention	Raise Lake Arrowhead berm three feet to provide one-foot of additional storage and two feet of freeboard	0.69	$98,700	$143,900	$96,800	15	Palos Heights
NVCR-5	Conveyance	Harlem Avenue channel diversion	0.15	$1,148,300	$7,903,100	$4,581,300	29	Palos Heights
OLCR-1	Detention	Expand Lake Oak Lawn by 30 ac-ft	0.07	$450,000	$6,306,100	$4,971,300	35	Oak Lawn
OLCR-3	Erosion Stabilization	Stabilize Oak Lawn Creek between Mayfield Ave and Central Ave	0.42	$3,081,000	$7,299,200	$4,306,800	15	Oak Lawn
SPCR-1	Conveyance	Raise 157th street	0.02	$24,100	$1,053,800	$738,300	0	Orland Township
STCR-2	Detention	400 ac-ft detention pond at St. Casimir Cemetery	0.25	$12,203,700	$48,496,800	$30,267,700	666	Alsip, Oak Lawn, Chicago
STCR-3	Detention	87 ac-ft detention pond at Wolfe Wildlife Refuge	0.10	$735,100	$7,691,000	$6,537,600	55	Alsip, Oak Lawn, Chicago
STCR-4	Detention	39 ac-ft detention pond at K-Mart site	0.05	$206,600	$4,327,300	$3,179,500	20	Alsip, Oak Lawn, Chicago
STCR-7	Conveyance	Enlarge California Avenue culvert	0.11	$364,200	$3,428,900	$2,007,300	86	Palos Hills
STCR-8	Conveyance	Construct closed-conduit diversion along ComEd ROW	0.18	$1,146,600	$6,286,400	$3,413,200	44	Palos Hills
STCR-10	Erosion Stabilization	Stabilization of erosion problem area near Stony Creek and Oak Lawn Creek confluence	b	b	$2,754,800	$1,658,000	0	Oak Lawn
TICR-3	Levee	Levees on both sides of TICR just upstream of the crossing of Central Ave, and flood easement from Cook County Forest Preserve	0.72	$1,982,000	$2,764,400	$1,536,300	42	Crestwood, Alsip, Unincorporated Cook County
TICR-5	Conveyance	Dredge sediment in channel between 88th Avenue and Lake Lorin	1.26	$142,600	$112,800	$94,600	4	Orland Hills, Orland Park
TICR-7	Erosion Stabilization	Stabilize Tinley Creek between Oriole Court and 151st Street to prevent erosion	1.03	$1,524,700	$1,479,700	$873,021	6	Orland Park
TICR-8	Erosion Stabilization	Stabilize Tinley Creek between 160th Street and 86th Avenue to prevent erosion	1.55	$7,164,900	$4,627,200	$2,730,486	8	Orland Park

a- Benefits include 6 acres of wetland restoration
b- Project does not include existing regional financial benefits, but is recommended as a preventative measure because further bank failure risks a severe channel flow restriction within Stony Creek.

FIGURE ES.3
Calumet-Sag Channel Watershed Alternative Summary



Note: Stony Creek includes entire Stony Creek system as some alternative projects reduce damages on tributaries.

The Calumet-Sag Channel 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 Calumet-Sag Channel 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.

The data provided in the Calumet-Sag Channel 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.

Contents

Tables

Figures

Note: Figures not embedded in the chapters are contained in Volume 2.

Appendices

Acronyms and Abbreviations

ABM	Articulated Block Mat
AMC	Antecedent Moisture Conditions
B/C	Benefit to Cost Ratio
CCHD	Cook County Highway Department
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
CSSC	Chicago Sanitary and Shipping Canal
CWA	Clean Water Act
CWS	Chicago Waterway System
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
District	Metropolitan Water Reclamation District of Greater Chicago
DTM	Digital Terrain Model
DWP	Detailed Watershed Plan
FEMA	Federal Emergency Management Agency
FFE	First Floor Elevation
FGCS	Federal Geodetic Control Subcommittee
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
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
I&M	Illinois and Michigan
IDNR	Illinois Department of Natural Resources
IDOT	Illinois Department of Transportation
IEPA	Illinois Environmental Protection Agency
IMTT	International-Matex Tank Terminals
ISWS	Illinois State Water Survey
LiDAR	Light Detection and Ranging
LOMR	Letter of Map Revision
L-PTIII	Log-Pearson Type III
M&O	Maintenance and Operations
NAVD 88	North American Vertical Datum, 1988

NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act of 1994
NGS	National Geodetic Survey
NIPC	Northeastern Illinois Planning Commission
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
OWR	Office of Water Resources
PCB	Polychlorinated Biphenyl
ROW	Right-of-Way
SCS	Soil Conservation Service
SFHA	Special Flood Hazard Area
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
WPC	Watershed Planning Council
WSEL	Water Surface Elevation
WSP	Water Surface Profile

1. Introduction

The Calumet-Sag Channel Watershed in southwestern Cook County drains an area of 151 square miles that includes 27 communities. Figure ES.1 shows an overview of the Calumet-Sag Channel Watershed. The watershed area north of the Calumet-Sag Channel generally is heavily developed and characterized by low relief and is drained principally by the East and West branches of Stony Creek and their tributaries. Both East and West Stony Creek discharge into the Calumet-Sag Channel. The area north of the Calumet-Sag Channel also has several smaller streams that discharge westward into the Illinois and Michigan (I&M) Canal, or southward-into the Calumet-Sag Channel. The watershed area south of the Calumet-Sag Channel is less developed and characterized by greater topographic relief. Spring, Long Run, and Marley creeks all drain southwest into Will County and are tributary to Hickory Creek which eventually discharges into the Des Plaines River. These streams are included, along with tributaries that flow north to the Calumet-Sag Channel and several tributaries that flow west to the I&M Canal, within the scope of the Calumet-Sag Channel Detailed Watershed Plan (DWP). Locations with historic flooding and stream bank erosion problems due to regional waterways exist throughout the watershed.

The Calumet-Sag Channel DWP was developed by the Metropolitan Water Reclamation District of Greater Chicago (District) with the participation of the Calumet-Sag Channel 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 a 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. 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 Calumet-Sag Channel 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 Calumet-Sag Channel Watershed.

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 to support the DWP took place throughout development of the DWP. Existing and newly developed data was evaluated according to use criteria 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 Calumet-Sag Channel DWP development. Table 1.3.1 lists key dates of coordination activities including meetings with WPC members prior to and 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 independent of any past H&H modeling efforts. In one case (East and West Stony Creek), data from previously developed models was used to support development of the Calumet-Sag Channel DWP. Hydraulic model extent was defined based upon the extent of detailed study for effective Flood Insurance Rate Maps (FIRMs). Revised Digital Flood Insurance Rate Map (DFIRM) data produced by the Federal Emergency Management Agency's (FEMA's) Map Modernization Program was unavailable at the time of model definition. Models 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 appendixes referenced in the report sections below.

TABLE 1.3.1
Calumet-Sag Channel DWP WPC Coordination Activities

Description of Activity		Date
06-712-5C Calumet-Sag Channel Detailed Watershed Plan - Phase A - Contract start date		October 19, 2006
07-713-5C Calumet-Sag Channel Detailed Watershed Plan - Phase B - Contract start date		May 17, 2007
Information Gathering		
Data Request (Forms A and B) sent out as part of Phase A		November 24, 2006
Watershed field visit and meetings with various municipalities		January 23, 2007
Open meetings with Watershed representatives during Phase A to discuss Forms A and B		February 14, 2007
District phone calls to communities after the September 13th and 14th, 2008 storm event		September 15, 2008
Calumet-Sag Channel Watershed Planning Council Meetings (16)		March 29, 2006
June 26, 2006	September 12, 2006	November 29, 2006
January 30, 2007	April 30, 2007	July 30, 2007
September 25, 2007	November 29, 2007	January 30, 2008
April 29, 2008	July 29, 2008	September 30, 2008
November 24, 2008	January 28, 2009	April 29, 2009
Modeling Results and Alternatives Review Meetings		
Calumet-Sag Channel / Little Calumet River coordination		April 2, 2008
Initial Model Review Workshop		June 4 and 5, 2008
Preliminary Alternatives Review Workshop		August 14 and 15, 2008
Final Alternatives Presentation Workshop		September 24, 2008
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 SCS 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 extension to Arc GIS Version 9.2. 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. Each major tributary model (Tinley Creek, Melvina Ditch, etc.) was subdivided into subbasins roughly 100 acres in size to form the basis of the hydrologic model and 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.

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 Calumet-Sag Channel DWP, the commonly used default value of I_a, estimated as 0.2 × 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 Calumet-Sag Channel 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.
Soil type	The Natural Resources Conservation Service (NRCS) publishes county soil surveys that include a hydrologic classification of A, B, C, or D. 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.
Antecedent moisture condition	Antecedent Moisture Conditions (AMC) reflect 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, a mapping 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 Calumet-Sag Channel 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 basin lag time. The lag time is defined as the time elapsed between the centroid, by mass, of the precipitation event and the peak of the runoff hydrograph at the outlet of the subbasin. The lag time was estimated according to Equation 1.3, provided in the HEC-HMS Technical Reference Manual (USACE, 2006):

$$T_{lag} = 0.6T_c \qquad (1.3)$$

where:

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

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: Table Source is *TR-55: Urban Hydrology for Small Watersheds* (U.S. Department of Agriculture, 1986)

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. 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.

Thus Equation 1.4:

$$T_c = T_{sheet} + T_{shallow} + T_{channel} \qquad (1.4)$$

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-derived T_c estimates were not considered accurate; however, GeoHMS also produced a definition of the longest flow path, its length, and slope. The basin parameter estimates were exported to a spreadsheet to support calculation of T_c.

An alternative method of lag time calculations is the CN-based method, characterized in Equation 1.5 (SCS, 1978):

$$T_{lag} = L^{.8} \frac{(S+1)^{.7}}{(1900Y^{.5})} \qquad (1.5)$$

Where:

L	=	hydraulic length of the subbasin
Y	=	subbasin slope
S	=	storage coefficient (in.)

These two approaches to calculation of lag time were performed for each subbasin and reviewed. The quasi-physical estimate of lag time described in Equation 1.4 was generally used for most subbasins. For some subbasins with very low relief, the CN-based method was used as it was considered most representative of the runoff response of the watershed.

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 Calumet-Sag Channel Watershed. The 12-hour duration storm was identified as the critical duration for streams within the Calumet-Sag Channel Watershed. A second quartile storm is recommended for storms of this duration (Huff, 1992). Table 1.3.4 summarizes rainfall depths for the 12-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 in Bulletin 71 relates areal mean rainfall depth to rainfall depth at a point (Huff, 1992). Subwatersheds in the Calumet-Sag Channel watershed that were large enough to warrant use of an areal reduction factor are Tinley, Long Run, and Stony Creeks. Modeled rainfall depths were multiplied by approximately 0.98 to account for the expected decrease in probability of uniform rainfall. In addition, the rainfall distribution was modified to the Quartile II distribution for basins 10 to 50 square miles in area, as recommended in Bulletin 71 (Huff, 1992).

TABLE 1.3.4
Rainfall Depths

Recurrence Interval	12-hr Duration Rainfall Depth
2-year	2.64
5-year	3.31
10-year	3.89
25- year	4.79
50- year	5.62
100-year	6.59
500-year	8.96[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 sometimes 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. In most of the watershed, it was impossible to identify channel cross sections in upstream areas. In those cases, a kinematic wave routing approximation was performed.

1.3.6 Hydraulic Model Setup

Hydraulic model data typically was developed through field surveys with some additional definition of channel overbank areas and roadway crests defined using Cook County topographic data. Cross section locations were developed in HEC GeoRAS, and surveyed channel geometry were 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 a figure within Appendix D.

The Stony Creek hydraulic model was developed using data from a model developed by the USACE in 2001. USACE calibrated the model, which is considered representative of existing conditions along Stony Creek. As part of the DWP, several cross sections were surveyed at locations where the USACE model had cross sections to compare and confirm that the model data reflected current conditions. This comparison concluded that the survey data in the USACE model of Stony Creek was generally consistent, and that the USACE model was valid for defining inundation areas and evaluation of alternative improvement projects.

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 plans was used for recently constructed bridges in lieu of surveying. Ineffective flow areas were placed at cross sections upstream and downstream of crossings, generally 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.

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 State of Illinois 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

Estimated water surface elevations along the major receiving systems were compared to normal depth of tributaries at the confluence. In most instances, normal depth estimates exceeded the elevation of the receiving system (i.e., Calumet-Sag Channel or Chicago Sanitary Ship Canal). This indicates that the downstream water surface elevation for the waterways is not controlled by the receiving system, as often occurs at stream confluences, but by the ability of the tributary to convey the flows produced in the upstream tributary area. The fact that both the Chicago Sanitary Ship Canal (CSSC) and the Calumet-Sag Channel are manmade, controlled waterways likely contributes to their relatively lower stage compared to their tributaries. Levels of the CSSC and the Calumet-Sag Channel are controlled by the District as required to support navigation and control flooding through operation of the Lockport Lock and Dam.

In cases where the estimated water surface elevation of a channel was required, this data was taken from the Chicago Waterway System (CWS) UNET model, which was obtained from the USACE and converted to HEC-RAS to support DWP development. The I&M Canal was assumed to be represented by water surface elevations along the CSSC as the two water bodies are parallel and directly connected. The specific boundary conditions used for each model are summarized in the tributary sections. Appendix E contains a detailed summary of the Calumet-Sag Channel hydraulic conditions and methods used to estimate water surface elevation along the CSSC and Calumet-Sag Channel.

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 varied between 10 and 60 seconds, as necessary for model stability.

1.3.8 Model Calibration and Verification

Model calibration and verifications were performed for tributaries where monitoring data was available to ensure that the hydrologic and hydraulic models accurately predict stormwater runoff response for a range of storm magnitudes. Available monitoring data used for calibration is described in Section 2.3.1. Initial model runs were performed for Tinley Creek, Stony Creek, Mill Creek, Calumet-Sag Tributary B, and Navajo Creek subwatersheds using hydrologic and hydraulic parameters estimated from available GIS data (land-use, soils, topography) and field reconnaissance. Stages (or peak water surface elevation) and runoff volumes were compared to modeled values for a variety of storms. Then, hydrologic and hydraulic parameters with uncertainty were modified within a reasonable range to better represent monitored parameters. Stage was used as the primary calibration variable, since stage directly impacts stormwater damages due to flooding. Stage is also the measured value, both for high-water marks and the USGS gage, which uses a field-measured stage-flow relationship to calculate flow. Runoff volume was also considered, where monitoring data was available.

Initial calibration model results generally over-predicted stage, volume and peak flow rates for Stony Creek and Tinley Creek. Modification to lag time and curve number estimates, in the hydrologic model, and the roughness coefficient in the hydraulic model, were considered to address observed differences. Modification of the lag time was observed to have a minor impact on model results. While discrepancies in stage could be addressed by lowering the roughness coefficient on Tinley Creek, this would increase the over-prediction of peak flow, and would not address the over-prediction of runoff volume. Furthermore, stage was also over-predicted on Stony Creek for its initial calibration runs, and the Stony Creek roughness coefficients were already at the lower end of the acceptable range of values. Although no flow data was available, initial roughness coefficients were considered relatively low. For these reasons, the reduction of curve number values was considered the best method of achieving better correspondence between observed and modeled parameters. A 10 percent curve number reduction from the originally calculated values resulted in the best fit with monitored values for the storms considered.

Detailed calibration results are presented in subwatershed subsections, including hydrographs and comparisons of stage and, where available, runoff volume. Subwatersheds with available calibration data represent a subset of the Calumet-Sag Channel Watershed. Calibration data was available for both the northern part of the watershed, with its flatter topography and higher-density development, and the southern part of the watershed with more varied topography and less dense suburban development. The 10 percent reduction of curve number was applied to un-gaged subwatersheds since it was found to be necessary for similar gaged areas of the watershed.

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.

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. A significant recommendation from the independent review was to calibrate the models to a large storm event which occurred in the Calumet-Sag Channel watershed over the period September 13th to 14th, 2008. This and other recommendations from the independent review have been addressed in the hydrologic and hydraulic models developed to support the Calumet-Sag Channel DWP.

1.4 Development and Evaluation of Alternatives

1.4.1 Problem Area Identification

Problem area data for the Calumet-Sag Channel Watershed was generated from two sources. The first was community response data that identified flooding, erosion, water quality, and maintenance problems recognized by the communities to be problems. 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.

The foundation for property damage values due to flooding is 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 Calumet-Sag Channel 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 for the Calumet-Sag Channel DWP, as that would require several thousand measurements. A sample of several hundred field measurements of the FFE offset from ground elevation were collected in the Calumet-Sag Channel Watershed 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 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. This is consistent with the elevation offsets used by the USACE in its study of Stony Creek (USACE, 1996).

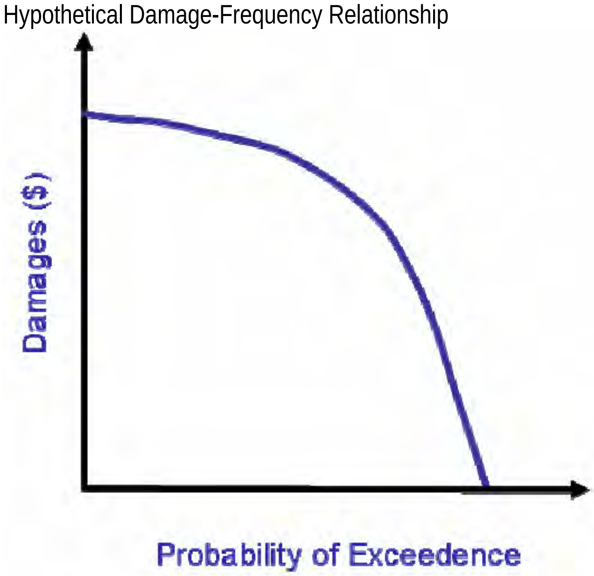
1.4.2.5 Structure Estimated Value

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 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 by applying the assessed valuation multiplier and the District calculated market value multiplier to the improvement value identified in the CCTA data to produce a value of the structure. 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.

FIGURE 1.4.1
Hypothetical Damage-Frequency Relationship



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 potential erosion risk 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 Calumet-Sag Channel Watershed, specific transportation damages were calculated when flooding fully blocked all access to a specific area in the watershed and these damages were not 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 $32.23 per hour of delay per vehicle based on average traffic counts.

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 throughout the Calumet-Sag Channel Watershed. 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 ideas or suggestions regarding potential resolution of their stormwater problems, and these ideas were solicited during workshops and subsequent comment periods and were 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 the 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 Flood Control

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

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.

1.4.3.2 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).

1.4.3.3 Erosion Control

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.

1.4.3.4 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. Erosion control 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.
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.

TABLE 1.4.1
Flood Control Technologies

Flood Control Option	Description	Technology Requirements
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.	

TABLE 1.4.2
Erosion Control Technologies

Erosion Control Option	Description	Technology Requirements
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 prevent 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.	

1.4.3.5 Potential Funding Sources

Projects identified in the Calumet-Sag Channel DWP may be eligible for funding through one of several different USACE programs. The following is a summary of the USACE programs that may be available for DWP identified flood and erosion control projects:

- Section 205 of the Water Resources Development Act of 2005 allows the USACE to participate in funding small flood control projects of up to $7,000,000 (in federal costs), with a local cost-share requirement of 35 percent of the total project cost. USACE funding beyond the maximum limit set for Section 205 projects is possible, but would require study authority and specific authorization for construction.
- Section 219 of the Water Resources Development Act of 2005 allows the USACE to participate in environmental infrastructure projects. Section 219 does not have a maximum project cost limit and requires a 25 percent local share of cost participation.
- Section 14 of the 1946 Flood Control Act allows the USACE to participate in projects to make emergency streambank repairs up to an amount of $1.5 million. Section 14 requires a 35 percent local share of cost participation and can only be used to protect public infrastructure. Private property is not eligible for Section 14 funding.

In addition to the USACE, FEMA is also a potential federal partner for funding projects. The Flood Mitigation Assistance (FMA) program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP). FEMA provides FMA funds to assist States and communities in implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program. Project grants are available to states and communities to implement measures to reduce flood losses, such as elevation, acquisition, or relocation of NFIP-insured structures. States are encouraged to prioritize FMA funds for applications that include repetitive loss properties; these include structures with 2 or more losses each with a claim of at least $1,000 within any 10-year period since 1978. More information about FMA funding is available at http://www.fema.gov/government/grant/fma/index.shtm

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2. Watershed Characteristics

2.1 General Watershed Description

The Calumet-Sag Channel Watershed is in the southwestern part of Cook County. The major receiving water body for the watershed—the Calumet-Sag Channel—was constructed in 1922 and later widened to improve shipping capacity. It connects in Calumet Park with the Little Calumet River and in Lemont with the CSSC. The largest tributaries to the Calumet-Sag Channel include Tinley Creek, Mill Creek, and Stony Creek. The District has established boundaries of the Calumet-Sag Channel Watershed for purposes of its stormwater management program. Figure ES.1 shows the location and the District's established boundaries of the Calumet-Sag Channel Watershed. It should be noted that in some areas, the boundaries established by the District differ with natural watershed boundaries. For example, the boundary extends to the Cook-Will County line, which includes the upstream parts of Spring Creek, Long Run Creek, Marley Creek, and Tampier Slough, although these waterways drain southwest into Will County, and are tributary to the Hickory Creek Watershed which eventually drains to the Des Plaines River. The scope of the Calumet-Sag Channel DWP includes these waterways and also some that drain to the I&M Canal, in addition to those draining to the Calumet-Sag Channel.

Figure ES.1 shows the municipal boundaries and the major streams within the Calumet-Sag Channel Watershed. Figure ES.1 also shows the subwatershed divides for the major streams within the Calumet-Sag Channel Watershed. Table 2.1.1 lists the municipalities within the Calumet-Sag Channel Watershed. Table 2.1.2 lists the major streams and tributaries to the Calumet-Sag Channel and stream lengths. Each stream is briefly described with a narrative in the following subsection.

TABLE 2.1.1
Municipalities in the Calumet-Sag Channel Watershed

Municipality	% of Municipality Area within Calumet-Sag Channel Watershed	% of Calumet-Sag Channel Watershed Area by Municipality	Municipality	% of Municipality Area within Calumet-Sag Channel Watershed	% of Calumet-Sag Channel Watershed Area by Municipality
Alsip	100	4.2	Midlothian	19	0.4
Bedford Park	98	3.8	Oak Forest	27	1.0
Blue Island	71	1.9	Oak Lawn	100	5.7
Bridgeview	100	2.7	Orland Hills	82	0.6
Burbank	100	2.8	Orland Park	92	11.6
Chicago	3	4.9	Palos Heights	100	2.5
Chicago Ridge	100	1.5	Palos Hills	100	2.7
Crestwood	96	1.9	Palos Park	100	2.5
Evergreen Park	98	2.0	Robbins	23	0.2
Hickory Hills	100	1.9	Summit	76	1.0
Hometown	53	0.2	Tinley Park	6	0.6
Justice	99	1.9	Willow Springs	48	1.2
Lemont	85	3.6	Worth	100	1.6
Merrionette Park	100	0.3			

TABLE 2.1.2
Calumet-Sag Channel Watershed Open Channel Stream Lengths

Open Channel Name	Length (miles)	Open Channel Name	Length (miles)
Calumet-Sag Channel	15.8	Calumet-Sag Tributary C	1.6
I & M Canal	15.4	I & M Canal Tributary A	1.6
Tinley Creek	9.3	Oak Lawn Creek	1.4
Mill Creek	6.7	Ken Kay Ditch	1.4
West Stony Creek	5.9	I & M Canal Tributary B	1.4
Marley Creek[a]	5.9	Boca Rio Ditch	1.1
Long Run Creek [a]	4.4	Melvina Ditch	1.0
East Stony Creek	4.0	Calumet-Sag Tributary B	1.0
Spring Creek[a]	3.3	Justice Ditch	0.9
Crooked Creek	2.9	Crestwood Drainage Ditch	0.9
Calumet-Sag Tributary A	2.5	I & M Canal Tributary D	0.8
Tampier Slough[a]	2.4	Merrionette Park Ditch	0.7
Mosquito Creek	2.4	71st Street Ditch	0.6
Lucas Ditch	2.1	Calumet-Sag Tributary AA	0.6
Navajo Creek	2.1	I & M Canal Tributary C	0.5
Mill Creek West Branch	1.9	Arroyo Ditch	0.2
Lucas Diversion Ditch	1.7	**Total**	**104.4**

[a]Stream drains southwest into Will County.

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)
Alsip	Stony Creek East(3.21), Cal-Sag 7(1.49), Mosquito Creek(0.91), Cal-Sag 8(0.51), Cal-Sag 6 (0.24), Cal-Sag 9[b], Merrionette Park Ditch[bc], Ken Kay Ditch[b], Stony Creek[b], Tinley Creek[b]
Bedford Park	Stony Creek(2.57), Melvina Ditch(2.57[c]), I&M Canal(1.17), I&M 5(0.93), 71st St. Ditch(0.42)
Blue Island	Cal-Sag 10(1.77), Stony Creek East(1.14), Merrionette Park Ditch(0.14[c]), Cal-Sag 9[b], Cal-Sag 8[b]
Bridgeview	Stony Creek(2.14), 71st St. Ditch(1.93), Lucas Diversion Ditch(1.9[c]), Melvina Ditch(0.21[c]), 79th St. Ditch[b], I&M 5[b]
Burbank	Stony Creek(4.12), Melvina Ditch(3.76[c]), Oak Lawn Creek(0.36[c])
Calumet Park	Cal-Sag 10(0.81)
Chicago	Stony Creek East(4.12), Merrionette Park Ditch(3.07[c]), City of Chicago Combined Sewer(2.9), Stony Creek(0.91), Melvina Ditch[bc], I&M 5[b], Cal-Sag 10[b]
Chicago Ridge	Stony Creek(2.2), Melvina Ditch(0.18[c]), Oak Lawn Creek(0.18[c]), Cal-Sag 7[b], Lucas Diversion Ditch[bc]
Crestwood	Cal-Sag Trib C(1.56), Crestwood Drainage Ditch(0.76), Cal-Sag 9(0.25), Tinley Creek(0.14), Cal-Sag 6[b], Cal-Sag 8[b]
Evergreen Park	Stony Creek(3.09), Merrionette Park Ditch[bc], Stony Creek East[b]
Forest View	I&M 5[b]

TABLE 2.1.3
Municipality and Subwatersheds within the Municipality Boundary

Municipality	Subwatersheds within Municipality Boundary (square miles)
Hickory Hills	Stony Creek(1.46), 79th St. Ditch(1.07), Lucas Diversion Ditch(0.96[c]), Lucas Ditch(0.5[c]), I&M Trib D(0.22), Crooked Creek[b]
Hodgkins	I&M Canal(0.49)
Hometown	Stony Creek[b], Oak Lawn Creek[bc]
Justice	71st St. Ditch(1.08), 79th St. Ditch(0.91), Justice Ditch(0.3), I&M Canal(0.26), I&M 4(0.18), Stony Creek(0.12), Lucas Diversion Ditch(0.12[c])
Lemont	Long Run Creek(1.69), Castle Bowl(1.5), I&M Trib A(0.9), I&M Trib B&C(0.6), Sanitary Ship Canal (0.58), Cal-Sag 1(0.3), I&M 2(0.27), I&M 1(0.22), I&M Canal[b], Cal-Sag 2[b], I&M 3[b], Tampier Slough[b]
Lyons	I&M 5[b]
Matteson	Boca Rio Ditch(0.1), Arroyo Ditch[b]
Mc Cook	I&M 5[b], I&M Canal[b]
Merrionette Park	Stony Creek East(0.39), Merrionette Park Ditch(0.38[c])
Midlothian	Cal-Sag Trib C(0.85)
Oak Forest	Boca Rio Ditch(1.0), Cal-Sag Trib C(0.45), Arroyo Ditch(0.17)
Oak Lawn	Stony Creek(7.47), Oak Lawn Creek(3.08[c]), Melvina Ditch(1.51[c]), Stony Creek East(1.05), Lucas Diversion Ditch[bc], Cal-Sag 7[b]
Orland Hills	Tinley Creek(0.86), Marley Creek[b]
Orland Park	Marley Creek(6.12), Tinley Creek(4.16), Mill Creek(3.4), Spring Creek(1.75), Long Run Creek(1.56), Will County Trib 2(0.38), Boca Rio Ditch(0.21), Tampier Slough(0.13), Navajo Creek[b]
Palos Heights	Navajo Creek(2.21), Cal-Sag 5(1.44), Cal-Sag 6(0.51), Tinley Creek(0.13), Cal-Sag 7[b], Cal-Sag Trib B[b], Ken Kay Ditch[b]
Palos Hills	Stony Creek(3.96), Lucas Ditch(2.0[c]), Lucas Diversion Ditch(0.38[c]), Crooked Creek(0.32), Cal-Sag 5[b], Cal-Sag 4[b], Cal-Sag 2[b]
Palos Park	Mill Creek(1.52), Cal-Sag Trib B(0.97), Tampier Slough(0.46), Cal-Sag 4(0.32), Cal-Sag 5(0.19), Cal-Sag 3[b], Navajo Creek[b]
Riverdale	Cal-Sag 10(0.15)
Robbins	Cal-Sag 9(0.25), Cal-Sag Trib C[b]
Summit	I&M 5(1.18), I&M Canal[b]
Tinley Park	Tinley Creek(0.59), Will County Trib 2(0.17), Arroyo Ditch[b], Boca Rio Ditch[b]
Unincorporated/ ForestPres	Mill Creek(5.7), Long Run Creek(5.02), Tinley Creek(4.53), Cal-Sag 2(3.38), I&M 3(3.32), Cal-Sag 3(3.21), Marley Creek(3.2), Crooked Creek(3.13), Cal-Sag Trib A(2.96), Tampier Slough(2.9), I&M Trib B&C(1.94), Stony Creek East(1.23), Boca Rio Ditch(1.08), Cal-Sag 1(0.94), Spring Creek(0.85), Cal-Sag 6(0.69), Stony Creek(0.66), I&M Canal(0.61), Navajo Creek(0.56), Merrionette Park Ditch(0.54[c]), I&M 2(0.51), I&M Trib D(0.49), Crestwood Drainage Ditch(0.49), Sanitary Ship Canal(0.47), Cal-Sag Trib C(0.46), Cal-Sag 4(0.46), Cal-Sag 7(0.41), Will County Trib 2(0.39), I&M 1(0.32), Lucas Ditch(0.28c), Cal-Sag 10(0.2), Castle Bowl(0.19), Melvina Ditch(0.13c), Justice Ditch(0.11), Cal-Sag Trib B(0.11), Cal-Sag 5[b], I&M 4[b], Cal-Sag 9[b], Cal-Sag 8[b], I&M Trib A[b], 79th St. Ditch[b], Ken Kay Ditchb, I&M 5[b]
Willow Springs	I&M Canal(1.34), I&M 3(0.66), I&M 4(0.27), I&M Trib D(0.19), 79th St. Ditch[b]
Worth	Ken Kay Ditch(1.21), Stony Creek(0.82), Cal-Sag 7(0.2), Cal-Sag 5(0.12)

[a]Subwatersheds are ordered in decreasing order of area within municipality
[b]Less than 0.1 square miles within municipality contributes to subwatershed
[C]Subwatershed area also included in Stony Creek system

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 tributary 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. As noted, the scope of the DWP addresses regional problems along open channel waterways. The definition of regional problems was provided in Section 1.

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 two USGS surface water data monitoring sites within the Calumet-Sag Channel Watershed: "05536500" located on Tinley Creek near Palos Park, Illinois, and "05537500" located on Long Run near Lemont, Illinois. Table 2.3.1 summarizes the data available from these sites.

The Tinley Creek gage is located in the downstream part of the watershed, near the crossing of 135th Street. The Long Run Creek gage is located at Long Run Creek's crossing of State Street, just north of the Will County border.

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
AL1	Alsip	Bank erosion, sedimentation	115th St. and Stony Creek culvert, just west of Cicero Ave.	Severe erosion at northeast embankment, wing wall partially restricting opening of east barrel of culvert	Regional	1
AL2	Alsip	Pavement flooding	Route 50 (Cicero Ave.) at 119th St.	IDOT reported pavement flooding	Local	4, 5
AL3	Alsip	Storm sewer flow restriction, bank erosion, sedimentation	113th St. and Lamon Ave.	Siltation of East Stony Creek from 115th St. north to 11200 South interferes with drainage of a dry detention pond contributing to a mosquito breeding problem	Regional	1
BR1	Bremen Township	Maintenance	Ridgeland Avenue from 135th St. to 147th St.	Debris and siltation of box culvert due to alignment of Tinley Creek (CCHD)	Regional	1
BR2	Bremen Township	Maintenance	143rd St. from 82nd Ave. to Harlem Ave.	Overbank flooding due to lack of maintenance in Forest Preserve	Local	3, 4
BR3	Bremen Township	Basement flooding, ponding, water quality, storm sewer capacity	Linder Ave. between Midlothian Pike and 143rd St.	Natural basin collects stormwater, flooding yards and houses and causing septic system failure	Local	4
BR4	Bremen Township	Maintenance, ponding	Ridgeland Ave. 1/8 mile north of 147th St.	Culvert box submerged (CCHD)	Local	3, 4
BU1	Burbank	Overbank flooding, storm sewer capacity	87th St. and Natchez Ave.	Overbank flooding and ponding has historically occurred surrounding the Melvina Ditch Reservoir. District made improvements to reservoir and coordination with Bedford Park, with no problems at the reservoir reported since.	Local	5
BU2	Burbank	Pavement flooding	Route 50 (Cicero Ave.) at Keller Dr. (77th Street Viaduct)	IDOT reported pavement flooding	Local	4, 5
BV1	Bridgeview	Overbank flooding, pavement flooding, storm sewer capacity	Route 43 (Harlem Ave.) at 86th St.	IDOT reported flooding problems (southbound)	Local	4, 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
BV2	Bridgeview	Basement flooding, ponding, storm sewer capacity	100th Pl. between 76th Ave. and Harlem Ave.	Excessive ponding occurs at 100th Place between 76th Ave. and Harlem Ave. due to drainage problems.	Local	5
BV3	Bridgeview, Burbank	Pavement flooding	Route 43 (Harlem Ave.) at 79th St.	IDOT reported pavement flooding	Local	4, 5
BV4	Justice, Bridgeview	Storm sewer capacity	Roberts Rd. between 79th St. and 83rd St.	Frequent roadway flooding due to under-sized storm sewer Roberts Road storm sewer lacking sufficient capacity	Local	4, 5
BV5	Bridgeview, Chicago Ridge	Pavement flooding	Route 43 (Harlem Ave.) at I-294	IDOT reported pavement flooding	Local	5
CP1	Calumet Park	Pavement flooding	I-57 at 127th St. (Burr Oak Ave.)	IDOT reported pavement flooding	Local	5
CP2	Calumet Park, Chi-cago	Pavement flooding	I-57 at 119th St.	IDOT reported pavement flooding	Local	4, 5
CR1	Chicago Ridge	Maintenance, pond-ing	Melvina Ditch at West Stony Creek	Maintenance problem at Melvina Ditch con-fluence with Stony Creek. Previously re-ported maintenance request (Nov. 2006) at confluence with Stony Creek	Regional	1
CR2	Chicago Ridge, Oak Lawn	Bank erosion, sedi-mentation	Melvina Ditch along Chicago Ridge Mall (between 95th St. and West Stony Creek)	Sediment and erosion problems, lack of maintenance, High flows released from res-ervoir cause erosion.	Regional	1
CR3	Chicago Ridge	Overbank flooding	Confluence of Melvina Ditch with Stony Creek	The adverse confluence angle of Melvina Ditch with Stony Creek is perceived to con-tribute to higher flood stages along West Stony Creek	Regional	1
CW1	Crestwood	Pavement flooding	Route 50 (Cicero Avenue) at 135th St.	IDOT reported pavement flooding	Local	5
CW2	Crestwood	Maintenance	Central Ave. from 127th St. to 135th St.	Embankments need repair and debris in embankment and waterway	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
CW3	Alsip, Crestwood, Worth Township	Overbank flooding, basement flooding	Between 129th St. and Calumet-Sag Channel, west of Central Ave.	Overbank flooding during heavy rain, attributed in part to double bend in Tinley Creek just downstream of Central Ave.	Regional	1
FP1	Forest Preserve District	Overbank flooding, ponding, water quality, wetland and riparian area degradation	LaGrange and 167th St.	High runoff and salt from roads has degraded habitat and water quality	Local	4
HH1	Hickory Hills	Overbank flooding, basement flooding, ponding, bank erosion, maintenance	98th St. at 7700 West	Drainage ditches have insufficient capacity to convey storm flows, resulting in ponding and basement flooding. Possible maintenance issues related to Lucas Ditch.	Regional	1
HH2	Hickory Hills, Justice	Overbank flooding, basement flooding, ponding, storm sewer capacity, pavement flooding	85th St. at 8900 West	During heavy rains there is insufficient storm sewer capacity in Justice resulting in yard flooding.	Local	4, 5
HH3	Hickory Hills	Basement flooding, ponding, storm sewer capacity	85th St to 83rd St at 8600 West	Insufficient downstream capacity in Justice backs up flow	Local	4, 5
HH4	Hickory Hills	Basement flooding, ponding, storm sewer capacity	Roberts Road between 90th and 95th St.	Roberts Road storm sewer has insufficient capacity to convey moderate floods. Cook County will not allow additional connections to the Roberts Road storm sewer	Local	4, 5
HH5	Hickory Hills	Ponding, storm sewer capacity, maintenance	91st Pl. at Kean Ave.	The storm sewer to the forest preserve is typically full, and during rainfall events, the catch basin ponds back up to a property in the subwatershed. Maintenance issue related to a ditch in Forest Preserve. The storm sewer to the forest preserve is habitually inundated, but during rainfall events, the catch basin starts ponding, backing up to one resident's front door. Maintenance issue related to ditch in Forest Preserve.	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
HH6	Hickory Hills	Overbank flooding, basement flooding, ponding, bank erosion	95th St. at 84th Ct. (Flamingo Apartments)	Runoff from forest preserves exceeds outflow drains and thus results in flooding two apartment buildings to the first floor. Erosion on forest preserve property.	Local	4
JU1	Justice	Pavement flooding	Route 171 (Archer) at I-294 (Ramp to SB)	IDOT reported pavement flooding	Local	4, 5
JU2	Justice	Ponding	East of Cork Avenue between 73rd Pl. and 75th St.	Depressional area has no natural outlet. Drains to 71st Street Ditch through undersized storm sewer.	Local	4, 5
JU3	Justice	Overbank flooding, basement flooding, ponding, storm sewer capacity	71st Street Ditch	Insufficient capacity in 71st Street Ditch to convey flows from upstream communities	Regional	1
JU4	Justice	Storm sewer capacity	Under Tri-State Tollway between 86th and 87th Ave.	Storm sewer under Tri-State Tollway has insufficient capacity to convey flows from Hickory Hills and Justice	Local	4, 5
LE1	Lemont	Ponding	Cass Street and Lemont St., downtown Lemont	During major storm events, sewer system in downtown Lemont surcharges and overflows, flooding basements, and first floors of commercial buildings, industrial buildings, and residences	Local	5
LT1	Lemont Township	Pavement flooding	Route 171 (Archer Ave.) between Castlewood and Route 83	IDOT reported pavement flooding	Local	2, 4
LT3	Lemont Township	Pavement flooding	Route 171 (Archer Ave.) at 131st St.	IDOT reported pavement flooding	Local	2, 4
LT4	Lemont Township	Bank erosion, sedimentation	Stephen St. and north of Talcott St.	Tree branches and limbs are fallen in to I&M Canal and block flowage	Regional	1
LT5	Lemont Township	Pavement flooding, ponding	McCarthy Rd. between Bell Rd. and Will-Cook Rd., near Equestrian Estates neighborhood	McCarthy Road and nearby yards flood, including property that contains large pond. Pond has insufficient storage volume and/or outlet capacity to contain flows.	Local	2, 4

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
LYT1	Lyons Township	Overbank flooding	Tributary to I&M Canal Crossing La Grange Rd.	Pavement flooding due to high stages in the channel, 8 known occurrences	Regional	1, 3
ME1	Merrionette Park, Chicago	Pavement flooding	Kedzie between 119th St. to 126th St.	IDOT reported pavement flooding	Local	4, 5
OF3	Oak Forest	Maintenance, overbank flooding, sedimentation, bank erosion	Property just north of 151st St. and Boca Rio Dr.	Private property owner in Bremen Township denies access to allow Oak Forest to maintain channel, resulting in significant sedimentation and upstream flooding	Regional	1
OH1	Orland Hills	Overbank flooding, ponding, water quality, bank erosion, wetland and riparian area degradation	Tinley Creek at 88th Ave.	Culvert and channel downstream of 88th Avenue have sediment and vegetation which reduces conveyance	Regional	1
OH2	Orland Hills	Overbank flooding, ponding, water quality, bank erosion, wetland and riparian area degradation	Lake Lorin and along 167th Street between 91st Ave. and Haven Ave.	Lake Lorin vegetation, sedimentation, and outlet condition reduces Tinley Creek conveyance in this area	Regional	1
OL1	Oak Lawn	Maintenance	Central Ave., 1/4 mile south of 103rd St.	Siltation observed in south culvert barrel	Regional	1
OL2	Oak Lawn	Bank erosion	Stony Creek between 103rd St. and Central Ave.	Resident reports erosion, District field staff observed several exposed outfalls	Regional	1
OL3	Oak Lawn, Chicago	Pavement flooding	Pulaski Road and 102nd St.	IDOT reported pavement flooding	Local	4, 5
OL4	Oak Lawn, Chicago	Pavement flooding	Pulaski Rd. and 104th St.	IDOT reported pavement flooding	Local	4, 5
OL5	Oak Lawn	Overbank flooding, basement flooding, ponding, water quality, storm sewer capacity	99th Street to 103rd St. between Cicero Ave. and Central Ave.	High water elevations on West Stony Creek may limit drainage capacity of Oak Lawn sewers	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
OL6	Oak Lawn	Sedimentation, bank erosion, maintenance	102nd St. and Merrimac Ave. (near Metra tracks)	Severe bank erosion, bank collapse, and sedimentation at confluence of Oak Lawn Creek and Stony Creek	Regional	1
OL7	Oak Lawn	Severe bank erosion, sedimentation, maintenance, water quality	Oak Lawn Creek between Mayfield Ave. and Central Ave. (near 99th St. and Menard Ave.)	Severe bank erosion such that residential structures are threatened along Oak Lawn Creek	Regional	1
OL8	Oak Lawn	Storm sewer capacity, bank erosion, sedimentation, water quality	Oak Lawn Lake along East and West Shore Dr.	Severe bank erosion such that shorelines, adjacent walks, and structures risk failing. Poorer water quality and loss of wildlife habitat due to increased sedimentation from bank erosion.	Regional	1
OL9	Oak Lawn	Overbank flooding, storm sewer capacity, bank erosion, sedimentation, water quality	Wolfe Wildlife Refuge (from Cicero Ave. and 111th St. to Central Ave. and 105th St.)	Bank erosion along Stony Creek West in wildlife preserve causes additional sedimentation, reducing storm sewer capacity and contributing to overbank flooding in the area	Regional	1
OP1	Orland Park	Pavement flooding	Southwest Highway and 135th St.	Flooding several times per year	Regional	1, 3
OP2	Orland Park	Pavement flooding	Route 43 (Harlem Ave.) between 151st St. and 153rd St.	IDOT reported pavement flooding	Local	3, 4
OP3	Orland Park	Overbank flooding, bank erosion, sedimentation, maintenance, wetland and riparian area degradation	Marley Creek at Cameron Parkway and Norfolk Southern R.R.	Flooding on Wolf Road due to restricted conveyance in Marley Creek, seems to be caused primarily by debris and sedimentation causing blockages in conveyance	Regional	1
OP4	Orland Park	Pavement flooding	Southwest Highway at 151st St.	IDOT reported pavement flooding	Local	2, 4
OP5	Orland Park	Bank erosion, sedimentation	151st Street and Orland Brook Dr.	Significant erosion and sedimentation results in flow restriction	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
OP6	Orland Park	Maintenance, sedimentation, bank erosion	Marley Creek at Anthony Dr. to Meade St.	Flooding on 104th Avenue due to restricted conveyance in Marley Creek, seems to be caused primarily by debris and sedimentation causing blockages in conveyance	Regional	1
OP7	Orland Park	Ponding	Strawberry Lane (Parkview Estates)	Flooding due to offsite flows from outside village	Regional	1
OP8	Orland Park	Overbank flooding	Tinley Creek at 82nd Avenue	Overbank flooding due to undersized culvert along Tinley Creek and lack of maintenance downstream	Regional	1
OP9	Orland Park	Overbank flooding	Long Run Creek Crossing 143rd Street (West of Wolf Road)	Pavement flooding due to high stages in the channel, 18 known occurrences	Regional	1
OP10	Orland Park	Bank erosion, sedimentation	Deluga Woods subdivision between 155th and 159th St.	Lack of maintenance in unincorporated area results in overbank flooding	Regional	1
OP11	Orland Park	Bank erosion, sedimentation	143rd St. and Wolf Rd.	Erosion/sedimentation causes flow restriction resulting in flooding	Regional	1
OP12	Orland Park	Bank erosion, sedimentation	108th Ave. at Marley Creek crossing	Silt in three 10-foot by 8-foot box culvert where Marley Creek crosses 108th Avenue	Regional	1
OP13	Orland Park	Pavement flooding	Route 7 (Southwest Hwy) at Route 45 (La Grange Rd.)	IDOT reported pavement flooding	Regional	1
OP14	Orland Park	Pavement flooding	Route 7 at 145th St. to 148th St.	IDOT reported pavement flooding	Local	2, 4
OP15	Orland Park	Sedimentation, overbank flooding	167th St. and 88th Ave. (Fernway area)	Sedimentation and culvert restrictions result in frequent overbank flooding of the Fernway area. Village has contracted engineering for culvert replacement and sediment removal	Regional	1
OT1	Orland Township	Overbank flooding, ponding	114th Court and 157th Street	Heavy rains cause overflow of Spring Creek into adjacent subdivision	Regional	1
OT2	Orland Township	Bank erosion, sedimentation	Will-Cook Road at Long Run Creek crossing	Silt in culvert, and severe erosion along southeast embankment	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
PH1	Palos Heights	Overbank flooding	135th St. from Harlem Avenue to Ridgeland Avenue	Pavement flooding due to high stages in the channel, 28 known occurrences	Local	2, 4
PH2	Palos Heights	Ponding	12605 Melvina Avenue	Ponding in ROW about 2 to 5 times a year	Local	4
PH3	Palos Heights	Ponding	Palos Meadows Subdivision near 131st Street and 71st Avenue (includes 13013 Oak Park Avenue)	Flooding throughout neighborhood 2 to 5 times a year	Regional	1
PH4	Palos Heights	Ponding	12500 McCarthy Rd. and on Carmichael Dr. west of 76th Ave.	Storm sewer restriction at McCarthy Rd. and ponding at nearby school detention pond	Local	4
PH5	Palos Heights	Ponding	21 Country Squire Court near 76th Avenue and College Drive	Ponding in ROW and front yard, 2 to 5 times a year	Local	4
PH6	Palos Heights	Ponding	12601 Harold Ave., 12542 74th Ave., and 12542 75th Ave.	Ponding in ROW 2 to 5 times a year	Local	4, 5
PH7	Palos Heights	Ponding	124th Avenue and 69th Court; and 12217 68th Court	Ponding in ROW 2 to 5 times a year	Local	4, 5
PH8	Palos Heights	Basement flooding, ponding	12002 Harold Avenue	Basement and backyard flooding due to narrow conveyance of overflow from 76th Avenue	Local	4
PH9	Palos Heights	Ponding	12102,12232, 12303, and 12312 71st Avenue	Ponding in ROW 2 to 5 times a year	Local	5
PH10	Palos Heights	Ponding	12333 69th Avenue near Navajo Creek and Oak Park Avenue and College Drive	Flooding in street right-of-way (ROW) in front of residence, about 2 to 5 times a year	Local	4, 5
PH11	Bremen Township, Palos Heights	Pavement flooding	Route 43 (Harlem Avenue) at 135th Street	IDOT reported pavement flooding	Local	4, 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
PH12	Palos Heights	Ponding	12911 71st Court	Sewer backup caused by high Navajo Creek elevation 2 to 5 times a year	Local	5
PH13	Palos Heights	Ponding	13032 71st Avenue	Flooding in backyard 2 to 5 times a year	Regional	1
PH14	Palos Heights	Ponding	6843 Evergreen Avenue	Ponding in right-of-way (ROW) 2 to 5 times a year	Local	4, 5
PH15	Palos Heights	Ponding	Approximately 150 ft west of 76th Avenue on north side of McIntosh Drive	Flooding 2 to 5 times a year	Local	4
PH16	Palos Heights	Flooding	11938 68th Court	Flooding in ROW 2 to 5 times a year	Local	4
PH17	Palos Heights	Overbank flooding, basement flooding	Nashville Avenue and 125th Street	Flooding in ROW 2 to 5 times a year	Regional	1
PH18	Palos Heights	Flooding	127th Street and 70th Avenue	Navajo Creek elevation affects this area	Regional	1
PH19	Palos Heights	Basement flooding, ponding, storm sewer capacity	Approximately 150 ft north of 131st Street on west side of Cypress Lane	Flooding 2 to 5 times a year	Local	5
PH20	Palos Heights	Ponding, pavement flooding	12001 73rd Ct., 12151 73rd Ave., and 12412 73rd Ave.	Flooding in ROW 2 to 5 times a year	Local	5
PH21	Palos Heights	Storm sewer capacity	7350 Choctaw Rd.	Flooding in backyard 2 to 5 times a year	Local	5
PH22	Palos Heights	Ponding	12224 Cheyenne Dr.	Ponding in ROW 2 to 5 times a year	Local	5
PH23	Palos Heights	Ponding	12250 76th Ave. and 12223 Richard Ave.	Ponding in ROW 2 to 5 times a year	Local	5
PHI1	Palos Hills	Overbank flooding, basement flooding, ponding	100th Place and 78th Avenue	Lucas Diversion Ditch has insufficient capacity, overflowing into existing undersized detention area and nearby homes.	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
PHI2	Palos Hills	Ponding, storm sewer capacity	82nd Avenue and Eleanor Avenue	Sedimentation in Lucas Ditch upstream of 103rd Street restricts Lucas Ditch capacity.	Regional	1
PHI3	Palos Hills	Overbank flooding, basement flooding, bank erosion	111th Street and 86th Avenue (11118 Spathis Drive)	Lucas Ditch floods adjacent buildings when Stony Creek is high, sometimes resulting in erosion as well. Former study recommended building a levee wall to isolate the floodplain.	Regional	1
PHI4	Palos Hills, Bridgeview	Basement flooding, ponding, storm sewer capacity, bank erosion, maintenance	Lucas Diversion Ditch from 102nd Street to 105th Street	Debris and sediment build up restricts flow in Lucas Diversion Ditch causing basement flooding north of 103rd Street in Bridgeview/ Palos Hills	Regional	1
PHI5	Palos Hills	Overbank flooding, ponding	Kean Avenue and Los Palos Lane	Flows in Hickory Hills have no retention, and the Los Palos Hills reservoir has insufficient capacity to capture larger storms. Overflows flood the intersection. In 100-year floodplain. Palos Hills wants larger outlet to forest preserve.	Regional	1
PHI6	Palos Hills	Bank erosion, sedimentation	101st Street and Roberts Road	Debris at upstream end of culvert, far upstream portion of Lucas Ditch, where it crosses Roberts Road	Local	4, 5
PHI7	Palos Hills	Overbank flooding, ponding	88th Avenue and 99th Street	Localized flooding in sewered headwaters of Lucas Ditch. Previous studies have identified need for additional storage and increased conveyance.	Local	4, 5
PHI8	Palos Hills	Overbank Flooding, storm sewer capacity, bank erosion, wetland and riparian area degradation	96th Street and Arrowhead Drive	Flooding and erosion problems due to high flows. The buildings threatened by erosion are actually in Hickory Hills. Plan developed to address erosion, increase conveyance, and add retention in Forest Preserve	Local	4, 5
PHI9	Palos Hills, Bridgeview	Basement flooding, ponding, storm sewer capacity, bank erosion, maintenance	Lucas Diversion Ditch from 103rd Street to 105th Street	Sediment and debris buildup in Lucas Diversion Ditch	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
PP1	Palos Park	Overbank flooding, ponding, storm sewer capacity, bank erosion, wetland and riparian area degradation	McCarthy Road, between Oak Ridge and 79th Avenue	Floodwaters exceed capacity, damaging homes, 2+ times per year	Local	4
PP2	Palos Park	Overbank flooding, basement flooding, ponding, storm sewer capacity, bank erosion	80th Ave. between 126th St. and 127th St.	Floodwaters exceed capacity resulting in damage to homes. Occurs 2+ times per year	Local	4
PP3	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	119th Street and Timber Lane	Floodwaters exceed capacity of box culvert under 119th Street	Regional	1, 2
PP4	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	SW Hwy between S. Woodland Trail and 121st Street	Diversion from Mill Creek is conveyed along RR ROW. This flow leaves RR ROW and spills into SW Hwy at this location. Closes SW Hwy, and flooding several homes along RR ROW	Regional	1, 3
PP5	Palos Park	Overbank flooding, basement flooding, water quality, storm sewer capacity, bank erosion, wetland and riparian area degradation, maintenance	123rd Street between Hobart Avenue and Elm Street	Floodwater exceeds conveyance capacity, also erosion affecting northern Groundhog Slough	Regional	1, 2
PP6	Palos Park	Overbank flooding, basement flooding, ponding, storm sewer capacity, bank erosion	Southwest Highway between 131st Street and 135th Street	Flooding due to insufficient capacity reduces or prevents access to businesses in this area	Regional	1, 2

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
PP7	Palos Park	Overbank flooding, storm sewer capacity, bank erosion	127th Street and 86th Avenue	Mill Creek diverts to RR ROW ditch at this location. Insufficient capacity to convey water under 86th Avenue results in flooding of SW Hwy	Regional	1, 2
PP8	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	Kinvarra Drive and Wild Cherry Lane (9845 Wild Cherry Lane)	Excessive floodwaters result in flooding of a number of houses at least 3 times in the last 10 years. Stream maintenance is required downstream to address sedimentation and debris.	Regional	1, 2
PP9	Palos Park	Pavement flooding	Route 7 at 123rd Street	IDOT reported pavement flooding	Local	2, 4
PP10	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	116th Avenue and 123rd Street	Floodwaters exceed capacity, 1 time per year	Local	4
PT1	Palos Township	Ponding	127th Street and Deerwood Drive	Ponding	Local	4
PT2	Palos Township	Ponding	Halfway between 104th Ave. and Indian Trail Dr. on Lakeland Dr.	Ponding	Local	4
PT3	Palos Township	Ponding	West end of Bernice Drive near 104th Avenue and 131st Street	Ponding	Local	4
PT4	Palos Township	Ponding	Intersection of Stephen Drive and Walter Drive	Ponding	Local	4
PT5	Palos Township	Pavement flooding	Kean Ave. at 100th Street to 111th Street	IDOT reported pavement flooding	Regional	1, 2
PT6	Palos Township	Overbank flooding, water quality, wetland and riparian area degradation	U.S. Route 45 at Crooked Creek	Flooding overtops the banks and decreases water quality	Regional	1, 3
PT7	Palos Township	Ponding	Intersection of Bernice Drive and Adsit Road	Ponding	Local	4

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
PT8	Palos Township	Maintenance	North and East of intersection of 111th Street (Route 83) and 104th Avenue	CCHD reported flooding due to debris blockages within a poorly maintained ditch on Forest Preserve property	Local	4
SU1	Chicago, Village of Summit	Pavement flooding	Route 43 (Harlem Avenue) at 63rd Street to 65th Street	IDOT reported pavement flooding	Local	3, 4
SU4	Summit	Pavement flooding	Route 171 at 63rd Street	IDOT reported pavement flooding	Local	4, 5
WO1	Worth	Pavement flooding	Ridgeland Avenue at 111th Street	IDOT reported pavement flooding	Local	4
WO2	Worth	Bank erosion	Stony Creek between Oak Lawn and 76th Avenue	Stream bank is in need of stabilization and debris removal to restore the natural conveyance of Stony Creek	Regional	1
WO3	Worth	Ponding, bank erosion	Ken Kay Ditch at 116th Street and Harlem Avenue	Creek is in need of sediment removal. Ponding occurs in the village and within IDOT ROW adjacent to the creek.	Local	4
WO4	Worth	Ponding, pavement flooding	75th Avenue at 109th Street	Pavement flooding and property flooding	Local	4, 5
WS1	Willow Springs	Pavement flooding	Archer Avenue at LaGrange Road	IDOT reported pavement flooding	Local	4
WS2	Willow Springs	Overbank flooding	I&M Canal Crossing Rte 171	Pavement flooding due to high stages in the channel, three known occurrences	Local	5
WS3	Willow Springs	Overbank flooding, ponding	Willow Drive and Archer Road	Channel draining Renaissance Development along Metra tracks near I&M Canal does not drain sufficiently	Local	4, 5

Reasons for Regional / Local Classifications:
1. Located on a regional 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 within storm sewer system (regardless of drainage area)

TABLE 2.3.1
USGS Gage Data in the Calumet-Sag Channel Watershed

Description	USGS 5536500		USGS 05537500	
Location	Tinley Creek near Palos Park		Long Run near Lemont	
Latitude	41°38'48"		41°38'33"	
Longitude	87°45'59" NAD27		87°59'57" NAD27	
	Cook County, Hydrologic Unit 07120004: Des Plaines Watershed		Cook County, Hydrologic Unit 07120004: Des Plaines Watershed	
Contributing drainage area:	11.20 square miles		20.9 square miles	
Datum of gauge:	607.40 ft above sea level NGVD29		637.20 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	09/26/1951	04/25/2007	09/27/1951	08/24/2007
Daily Data				
Discharge, cubic ft per second (ft^3/sec)	07/11/1951	09/30/2008	07/01/1951	03/30/2009
Gage height, ft	10/1/1993	03/30/2009	10/01/1991	03/30/2009
Daily Statistics				
Discharge, ft^3/sec	07/11/1951	09/30/2008	07/01/1951	09/30/2007
Gage height, ft	10/01/1993	09/30/2008	10/01/1991	09/30/2007
Monthly Statistics				
Discharge, ft^3/sec	1951–07	2008–09	1951–07	2007–09
Gage height, ft	1993–10	2008–09	1991–10	2007–09
Annual Statistics				
Discharge, ft^3/sec	1951	2008	1951	2007
Gage height, ft	1994	2008	1992	2007
Field/lab water quality samples	10/09/1974	07/13/2000	10/09/1974	08/30/1983

2.3.1.2 Rainfall Data

The Illinois State Water Survey (ISWS) owns and maintains 25 rain gages in or near Cook County. Nine ISWS rain gages—11, 12, 13, 15, 16, 17, 18, 20, and 21—cover the Calumet-Sag Channel Watershed. Rainfall is recorded continuously at 10-minute intervals, processed by the ISWS to ensure quality, and available for purchase. ISWS rainfall data was obtained for specific gages and dates to support calibration of the Tinley Creek model and model verification for streams for which high water mark information was available. The District owns and maintains two rain gages in the Calumet-Sag Channel Watershed that record rainfall at 10-minute intervals. One gage is located in Lemont, and the other is located at the Melvina Ditch Reservoir. District rainfall data was used for qualitative comparison against ISWS gage data. Figure 2.3.1 shows locations where rainfall gage data was available to support the Calumet-Sag Channel Watershed DWP. The Tinley Creek subbasins 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 3.29.2.

2.3.1.3 Stage Data

The wet well elevation of Melvina Ditch Reservoir is recorded continuously on paper charts. These charts were obtained for the storms on September 11, 2000, August 23, 2007, and September 13-14, 2008, to support model calibration efforts for the Melvina Ditch model. Figure 2.3.1 shows locations where monitoring data was available to support the Calumet-Sag Channel Watershed DWP. It shows the subbasins in the Tinley Creek watershed color-coded to identify the ISWS rain gage used in the hydrologic model used for calibration. Thiessen polygons, which divide the watershed into areas closest to each ISWS rain gage, are also shown.

2.3.2 Subwatershed Delineation

The Calumet-Sag Channel 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 north of the Calumet-Sag Channel 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.

2.3.3 Drainage Network

The principal waterways of the Calumet-Sag Channel 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 Calumet-Sag Channel Watershed (see Section 2.3.4), and collect runoff from upland drainage areas. Secondary drainageways 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 drainageways were used to help define flow paths in the hydrologic models for individual tributaries. Figure 2.3.3 shows the major drainageways within the Calumet-Sag Channel Watershed superimposed upon an elevation map of the watershed.

2.3.4 Topography and Benchmarks

The topography of the Calumet-Sag Channel Watershed boundary is defined by the geologic history of the area. The southernmost extent of glacial Lake Chicago extended roughly to the location of the Calumet-Sag Channel. The Stony Creek drainage system, which comprises both natural and constructed waterways, exists upon the very topography of the former lake plain. Moraine formations to the west of the Stony Creek system, and in the south portion of the watershed, demarcate the southernmost boundary of the most recent glacial extent. Areas south of the Calumet-Sag Channel are characterized by greater topographic relief.

Topographic data for the Calumet-Sag Channel watershed was 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 Calumet-Sag Channel Watershed model 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 August 2007 and February 2008 to support the DWP. (Some additional field survey work was performed between March 2008 and June 2008, and in January 2009.)

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. Twelve NGS monuments within the region surrounding the Calumet-Sag Channel Watershed 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 except for unmapped areas (which include the City of Chicago and some portions of nearby communities). Morley silt loam is the predominating soil type in the study area, which has a clayey and silty subsoil. Along Stony Creek, the Muskego and Houghton mucks were also identified, which are poorly drained, organic soils. Other types of silt loams and urban altered soils are also found in the watershed.

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.

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 Calumet-Sag Channel Watershed. Figure 2.3.4 shows the distribution of soil types throughout the watershed.

TABLE 2.3.3
Hydrologic Soil Group Distribution

Hydrologic Soil Group	% of Calumet-Sag Channel Watershed
Unmapped	51.4
A	0.3
A/D	1.6
B	4.6
B/D	9.2
C	31.5
C/D	0.2
D	1.2

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 Calumet-Sag Channel Watershed, 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 Calumet-Sag Channel Watershed. 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 Calumet-Sag Channel Watershed. Figure 2.3.5 shows the distribution of general land use categories throughout the watershed.

2.3.7 Anticipated Development and Future Conditions

Anticipated development within the Calumet-Sag Channel Watershed was analyzed using population projection data. Projected future conditions land use data for the Calumet-Sag Channel Watershed 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 2.3.4
Land Use Distribution within the Calumet-Sag Channel Watershed

Land Use Type	Area (mi^2)	Area (%)
Residential	63	40
Forest/Open Land	52	33
Commercial/Industrial	16	10
Water/Wetland	7	5
Agricultural	7	5
Transportation/Utility	5	3
Institutional	5	3

TABLE 2.3.5
Projected Population Increase by Subwatershed

Name	2000 Population	2030 Population	% Change	Population Change
71st St. Ditch	10,120	10,385	3	265
79th St. Ditch	13,654	14,036	3	383
Cal-Sag 1	167	707	324	540
Cal-Sag 10	19,209	19,586	2	377
Cal-Sag 2	69	73	6	4
Cal-Sag 3	129	248	92	119
Cal-Sag 4	1,406	1,433	2	27
Cal-Sag 5	4,364	5,159	18	795
Cal-Sag 6	4,496	4,784	6	288
Cal-Sag 7	2,366	2,731	15	365
Cal-Sag 8	1,032	1,201	16	168
Cal-Sag 9	1,643	1,740	6	97
Cal-Sag Trib A	1,166	3,937	238	2,771
Cal-Sag Trib B	1,913	2,008	5	95
Cal-Sag Trib C	10,656	11,704	10	1,048
Castle Bowl	5,188	7,194	39	2,006
City of Chicago	22,185	23,931	8	1,746

TABLE 2.3.5
Projected Population Increase by Subwatershed

Name	2000 Population	2030 Population	% Change	Population Change
Crestwood Drainage Ditch	4,446	5,088	14	642
Crooked Creek	1,436	1,504	5	67
I&M 1	634	1,381	118	747
I&M 2	15	533	3,423	518
I&M 3	1,312	1,894	44	582
I&M 4	739	1,068	44	329
I&M Canal	2,136	2,646	24	510
I&M Trib A	3,072	3,363	9	291
I&M Trib B&C	2,094	4,373	109	2,279
Justice Ditch	2,018	2,156	7	139
Ken Kay Ditch	5,333	5,562	4	229
Long Run Creek	14,041	19,675	40	5,634
Lucas Ditch	10,353	10,591	2	238
Marley Creek	15,296	22,457	47	7,161
Merrionette Park Ditch	28,435	28,818	1	383
Mill Creek	17,103	19,518	14	2,415
Mosquito Creek	2,399	2,638	10	240
Navajo Creek	7,574	8,529	13	955
Oak Lawn Creek	21,446	22,633	6	1,187
Sanitary Ship Canal	545	2,173	299	1,627
Spring Creek	2,235	5,669	154	3,434
Stony Creek	152,749	153,960	1	1,211
Stony Creek East	61,251	63,945	4	2,693
Tampier Slough	1,350	1,697	26	347
Tinley Creek	32,882	34,780	6	1,898
Will County Trib 2	960	2,545	165	1,585

Management of future development may be regulated through both local ordinances and the 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 Calumet-Sag Channel Watershed were identified using National Wetlands Inventory (NWI) mapping. NWI data includes approximately 9.9 square miles of wetland areas in the Calumet-Sag Channel 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 Calumet-Sag Channel Watershed.

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 Watershed Management Ordinance (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.

3. Tributary Characteristics and Analysis

3.1 71st Street Ditch

The 71st Street Ditch is a manmade waterway in the northwestern part of the Calumet-Sag Channel Watershed that discharges into the I&M Canal. The 71st Street Ditch is about 5,000 feet long, draining an area of 3.43 square miles. Table 3.1.1 lists the communities draining to the 71st Street Ditch. Although the Village of Hickory Hills is not included in the drainage area in Table 3.1.1, a maximum discharge of 7.5 cubic feet per second (cfs) is pumped from the Hickory Hills Reservoir to the 71st Street Ditch through the Roberts Road Storm Sewer.

TABLE 3.1.1
Communities Draining to 71st Street Ditch

Community	Tributary Area (mi^2)
Bridgeview	1.93
Justice	1.08
Bedford Park	0.42

Table 3.1.2 summarizes the land use distribution within the 71st Street Ditch subwatershed. Figure 3.1.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown on the figure, and are discussed in the following subsections.

TABLE 3.1.2
Land Use Distribution for 71st Street Ditch

Land Use Category	Area (acres)	%
Residential	883.9	40.3
Forest/Open Land	689.6	31.4
Commercial/Industrial	523.7	23.9
Institutional	49.6	2.3
Transportation/Utility	43.4	2
Agricultural	4	0.2

3.1.1 Sources of Data

3.1.1.1 Previous Studies

The IDNR completed a study focusing on flooding problems in the Cork Avenue localized depressional area (IDNR 2000). H&H analyses were performed along with a damage analysis of the flooded properties. The principal recommendation of the study was to increase the size of the storm sewer from the Cork Avenue depressional area to the 71st Street Ditch and to construct a larger culvert under the Illinois Central Railroad for conveying the additional flows to the I&M Canal. The B/C ratio of the project as determined by IDNR for its study is 0.34. The Village of Justice has noted the following concerns with the proposed project:

- Ground cover at the northern end of Cork Avenue may be insufficient for installing a 48-inch pipe.
- The increase in pipe size at the railroad crossing is constrained by existing utilities and may require village land acquisition.

A study by Patrick Engineering to investigate the drainage capabilities of the Roberts Road storm sewer from Archer Avenue to 111th Street revealed that the sewer is significantly undersized for much of the part draining north to the 71st Street Ditch (Patrick Engineering

2006). Replacement of the system with an upsized, larger proposed system was recommended.

3.1.1.2 Water Quality Data

The Illinois Environmental Protection Agency (IEPA) does not have any sites in the Ambient Water Quality Monitoring Network on the 71st Street Ditch. There are also no reaches 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. No total maximum daily loads (TMDLs) have been established for the 71st Street Ditch. According to a water permit discharge query by the U.S. Environmental Protection Agency (USEPA), there are no National Pollutant Discharge Elimination System (NPDES) permits issued by IEPA for discharges to the 71st Street Ditch. Municipalities discharging to the 71st Street Ditch 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 Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 24.5 acres of wetland areas in the 71st Street Ditch subwatershed. Restoration and enhancement of wetlands were included as part of alternatives described below. Approximately 21.3 acres of private property in Bedford Park, immediately north of 71st Street Ditch, has been identified by WPC participants as wetland habitat. 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; however, the effective models, which are used to estimate flood levels, were generally not updated. Localized Letters of Map Revisions (LOMRs) were incorporated into revised floodplain areas.

The 71st Street Ditch is mapped in detail in the DFIRM mapping update, with Zone AE floodplain shown across the length of the 71st Street Ditch. The original H&H analysis was performed in 1979 using TR-20 and 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 2.2 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. No near-term planned projects by others have been identified for the 71st Street Ditch subwatershed.

TABLE 3.1.3
Community Response Data for the 71st Street Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
BV3	Bridgeview, Burbank	Pavement flooding	Route 43 (Harlem Ave.) at 79th St.	IDOT reported pavement flooding	Local	Problem not located along intercommunity waterway.
BV4	Justice, Bridgeview	Storm sewer capacity	Roberts Rd. between 79th St. and 83rd St.	Frequent roadway flooding due to undersized storm sewer, Roberts Road storm sewer lacking sufficient capacity	Local	Although this is a local problem, recommended alternative SFDT-1 may provide additional capacity for upsizing Roberts Rd. storm sewer in the future.
JU2	Justice	Overbank flooding, basement flooding, ponding, storm sewer capacity	East of Cork Ave between 73rd Pl. and 75th St.	Depressional area has no natural outlet. Drains to 71st Street Ditch through undersized storm sewer	Local	Although this is a local problem, recommended alternative SFDT-2 provides additional discharge capacity to I&M Canal, which is a component of IDNR plan to address local problem.
JU3	Justice	Overbank flooding, basement flooding, ponding, storm sewer capacity	71st Street Ditch	Insufficient capacity in 71st Street Ditch to convey flows from upstream communities	Regional	Recommended alternative SFDT-1 and SFDT-2 reduce stage along 71st Street Ditch

3.1.2 Watershed Analysis

3.1.2.1 Hydrologic Model Development

Subbasin Delineation. The 71st Street Ditch drainage area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Through review of past studies and discussion with representatives from the Village of Bridgeview, the southern extent of the 71st Street Ditch tributary area in Bridgeview was defined as 83rd Street. The oil plant north of 71st Street Ditch has its own collection system for treating and discharging stormwater to the I&M canal. The depressional area around problem JU2 was included in the 71st Street

Ditch watershed, since it drains to the ditch through a 24-inch storm sewer. Twenty-two subbasins, averaging 99.8 acres in size, were identified for the 71st Street Ditch.

Hydrologic Parameter Calculations. CNs were estimated for each subbasin based upon Natural Resources Conservation Service (NRCS) soil data and 2001 Chicago Metropolitan Agency for Planning (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 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.

The depressional area near JU2 just east of Cork Avenue was modeled as a reservoir within HEC-HMS with a 24-inch outlet. A simulated overland flow outlet at an elevation of 596.5 feet was included in the model to represent the interbasin flow to Justice Ditch. This flow was loaded to the Justice Ditch hydraulic model.

3.1.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Surveys of 71st Street Ditch and all 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 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 I&M Canal, which the 71st Street Ditch discharges into, was assumed to be hydraulically connected to the CSSC and to have roughly the same stage as the CSSC. Modeled elevation of the CSSC for the modeled recurrence interval storms is summarized in Appendix E. The estimated elevation for the 100-year storm at the outlet of the 71st Street Ditch was 585.37 feet NAVD 88, roughly 2.2 feet above the invert of the 71st Street Ditch near its confluence with the I&M Canal. This relatively shallow depth indicates that the downstream stage of 71st Street Ditch is controlled not by the receiving system, but by its own capacity to convey flows received from its tributary area. Therefore, normal depth, assuming a friction slope of 0.001, was used as a downstream boundary condition for the 71st Street Ditch.

3.1.2.3 Calibration and Verification

No monitored or observed data was available for the 71st Street Ditch. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.1.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.1.1 shows inundation areas along the 71st Street Ditch produced by the hydraulic model for the 100-year, 12-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the 71st Street Ditch system. 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 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.1.4 summarizes problem areas identified through hydraulic modeling of the 71st Street Ditch.

TABLE 3.1.4
Modeled Problem Definition for 71st Street Ditch

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA31	Along 71st Street Ditch to the south, west of Cork Ave.	25, 50, 100	JU3	Recommended alternatives SFDT-1 and SFDT-2 reduce stage along 71st Street Ditch
MPA32	Along 71st Street Ditch to the south, east of Cork Ave.	100	JU3	Recommended alternatives SFDT-1 and SFDT-2 reduce stage along 71st Street Ditch

3.1.3.2 Damage Assessment

Damages were assessed for the 71st Street Ditch over a 50-year period using the methodology outlined in Section 1.4.2 of this report and Section 6.6 of the CCSMP. Estimated damages are listed in Table 3.1.5.

TABLE 3.1.5
Estimated Damages for 71st Street Ditch

Damage Category	Estimated Damage	Note
Property	$78,100	
Erosion	0	
Transportation	$11,700	Assumed as 15% of property damage due to flooding
Recreation	0	

3.1.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems along the 71st Street Ditch. Increased conveyance, storage, and levees were identified as potential technologies for addressing flooding problems along the 71st Street Ditch.

3.1.3.4 Alternative Development

Flood Control Alternatives. Two flood control alternatives were developed to address overbank flooding problems from the 71st Street Ditch. The alternatives are summarized in Table 3.1.6.

Erosion Control Alternatives. No erosion control alternatives were developed for the 71st Street Ditch.

TABLE 3.1.6
Flood Control Alternatives for 71st Street Ditch

Alternative	Location	Description
SFDT-1	Between Archer Ave. and Roberts Rd.	Construct a 60-acre-foot detention pond including some wetland habitat on the northeast corner of Resurrection Cemetery between Archer Avenue and Roberts Road.
SFDT-2	71st St. extended along underneath railroad tracks	Jack additional 48-inch outlet beneath railroad tracks to convey additional flow to I&M Canal.

3.1.3.5 Alternative Evaluation and Selection

SFDT-1 proposes a 60 acre-foot detention basin on the northern corner of Resurrection Cemetery, north of the existing 71st Street Ditch drainage channel from Bridgeview. It is proposed that the site grading for the proposed SFDT-1 improvement be designed to support wetlands. Inclusion of wetland in the detention area would provide water quality and habitat benefits in addition to helping address downstream flooding.

SFDT-2 proposes that an additional 48-inch outlet from the 71st Street Ditch be jacked beneath the existing railroad, providing additional conveyance to the I&M Canal. Although this alternative lowers the WSEL more than SFDT-1 in the vicinity of the crossing, its upstream impacts are less, resulting in fewer benefits than SFDT-1.

Damages shown in Table 3.1.5 are associated only with regional overbank flooding. They do not include localized damages that may also be reduced through the construction of the alternatives summarized in Table 3.1.6. Both SDFT-1 and SFDT-2 have the potential to improve local problem areas. As described in Section 3.1.1.1, the IDNR previously recommended a flood control alternative that consisted of a 48-inch storm sewer relieving the depressed area adjacent to problem location JU2 and discharging to the 71st Street Ditch. It also included a new outlet to the I&M Canal, which is consistent with SFDT-2 summarized in Table 3.1.6. The average annual damages computed by the IDNR were $16,100 ($299,700 over 50 years using the discount rate of this study) and include local and regional damages. The recommended alternative for the 71st Street Ditch may facilitate the implementation of the IDNR proposed plan. Only regional benefits are reported in Table 3.1.8, however, for consistency in countywide prioritization of stormwater improvements.

Alternative SFDT-1, shown in Figure 3.1.2, may also help to address local flooding of the Roberts Road storm sewer reported by both Justice and Bridgeview in Problem BV4. If the storm sewer were upsized, as recommended in the Patrick Engineering report referenced in Section 3.1.1.1, without compensatory storage, overbank flooding along the 71st Street Ditch would worsen. Construction of SFDT-1 would enable increasing conveyance along the Roberts Road sewer without exacerbating existing flooding problems along the 71st Street Ditch.

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 Calumet-Sag Channel DWP.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.1.7 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

TABLE 3.1.7
71st Street Ditch Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		SFDT-1		SFDT-2	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
Arbor Ln and Skyline Dr.	4783	594.11	52.07	594.11	52.07	594.11	52.07
71st St. and 86th Ave.	3373	591.44	329.99	591.26	312.17	591.40	331.20
Cork Ave.	1978	589.65	466.50	589.43	427.35	589.33	474.08
200-ft downstream of Blackstone and Oak Grove Ave.	822	589.00	211.62	588.72	188.45	588.27	154.26
Confluence with I&M Canal	152	587.73	210.84	587.52	188.19	587.18	154.02

3.1.3.6 Data Required for Countywide Prioritization of Watershed Project

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.1.8 lists the total estimated cost, benefits, and B/C ratio for each alternative. Figures 3.1.2 and 3.1.3 show the recommended alternatives for the 71st Street Ditch and a comparison of the existing conditions inundation mapping and inundation mapping for recommended alternative SFDT-1 and SFDT-2, respectively.

TABLE 3.1.8
71st Street Ditch Project Alternative Matrix to Support District Capital Improvement Program (CIP) Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
SFDT-1	60 ac-ft Detention Pond	0.07a	395,400	5,452,100	12		Positive	Yes	Justice, Bridgeview, Hickory Hills
SFDT-2	Additional outlet to I&M Canal	0.04	31,400	716,700	14	IDNR	No Impact	Yes	Justice, Bridgeview, Hickory Hills, Bedford Park

[a]B/C ratio includes estimated benefits of $60,000 per acre for additional wetland area associated with detention facility.
Note: Net Benefits values do not include local benefits or non-economic benefits.

3.2 79th Street Sewer

The 79th Street Sewer is located in southwestern Cook County, near the northwestern boundary of the Calumet-Sag Channel Watershed. The primary conveyance within this tributary area is the 79th Street Sewer, which begins at Roberts Road and flows west, paralleling I-294 for 0.6 mile before discharging into the I&M canal. The sewer drains 2.08 square miles of tributary area. Closed conduit systems, such as the 79th Street Ditch, were not modeled or evaluated for stormwater improvements as a component of the Calumet-Sag Channel DWP. Table 3.2.1 summarizes the communities that are tributary to the 79th Street Sewer. Land use within the drainage area of the 79th Street Sewer is predominately residential as shown in Table 3.2.2.

TABLE 3.2.1
Communities Draining to 79th Street Sewer

Community/Tributary	Tributary Area (mi^2)
Hickory Hills	1.07
Justice	0.91
Unincorporated/Forest Preserve	0.05
Bridgeview	0.03
Willow Springs	0.02

TABLE 3.2.2
Land Use Distribution for 79th Street Sewer

Land Use Category	Area (acres)	%
Residential	996.8	75.3
Forest/Open Land	125.9	9.5
Commercial/Industrial	82	6.2
Transportation/Utility	56.6	4.3
Institutional	38.9	2.9
Water/Wetland	24.9	1.9

An area of 0.8 square mile of Hickory Hills drains to the 203 acre-foot Hickory Hills Reservoir. This reservoir was sized to provide 100-year flood protection (Stanley Consultants, 1987). Discharges from the reservoir are limited to 15 cfs, which is generally split equally between the 79th Street Sewer and the Roberts Road Sewer (discharging into 71st Street Ditch) depending on the capacity of each sewer, which is monitored by telemetry.

Figure 3.2.1 provides an overview of the tributary area of the subwatershed and reported stormwater problem areas.

3.2.1 Sources of Data

3.2.1.1 Previous Studies

The report entitled *Project Planning for Flood Control*, developed by Stanley Consultants in 1987, summarized the final design for the Hickory Hills reservoir. The volume elevation relationship for the reservoir, confirmation of tributary area, and discharge characteristics were obtained from this report and included in the hydrologic model.

3.2.1.2 Water Quality Data

The 79th Street Sewer is an enclosed waterway, and therefore, it is not eligible for IEPA's Ambient Water Quality Network, the *Integrated Water Quality Report*, or NPDES point source discharge permits. Municipalities discharging to the 79th Street Sewer are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the 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 watershed. Wetland areas were identified using NWI mapping. NWI data includes roughly 20.5 acres of wetland area in the 79th Street Sewer watershed. 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

Floodplain mapping for the 79th Street Sewer includes the Hickory Hills Reservoir, as well as 10 acres of Zone AH flooding west of the Hickory Hills Reservoir. Effective flooding results are based on modeling from 1978, although hydrologic or hydraulic modeling methods are not specified in the Flood Insurance Study (FIS). 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

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.2.3 lists reported problems within the 79th Street Sewer subwatershed.

TABLE 3.2.3
Community Response Data for the 79th Street Sewer

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
BV4	Justice, Bridgeview	Storm sewer capacity	Roberts Rd. between 79th St. and 83rd St.	Frequent roadway flooding due to undersized storm sewer. Roberts Rd. storm sewer lacking sufficient capacity.	Local	Although this is a local problem, alternative SFDT-1 may provide capacity for upsizing Roberts Rd. storm sewer in the future.
HH3	Hickory Hills	Basement flooding, ponding, storm sewer capacity	85th St to 83rd St at 8600 West	Insufficient downstream capacity in Justice backs up flow.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
JU1	Justice	Pavement flooding	Route 171 (Archer) at I-294 (ramp to southbound)	IDOT reported pavement flooding.	Local	Problem not located along intercommunity waterway.
JU4	Justice	Storm sewer capacity	Under tollway between 86th and 87th Ave.	Storm sewer under tollway has insufficient capacity for conveying flows from Hickory Hills and Justice.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem

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 projects by others have been identified for the 79th Street Sewer subwatershed.

3.2.2 Watershed Analysis

3.2.2.1 Hydrologic Model Development

Subbasin Delineation. The 79th Street Sewer drainage area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Plans of the IDOT storm sewer along 79th Street were not available, and assumptions were made to define subwatershed boundaries for this area. Sixteen (16) subbasins, averaging 82.94 acres in size, were delineated within the 79th Street Sewer subwatershed area.

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.

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.

3.2.2.2 Hydraulic Model Development

No hydraulic model was developed for the closed conduit drainage system of the 79th Street Sewer.

3.2.2.3 Calibration and Verification

No measured or observed flows or stage data was available for the 79th Street Sewer subwatershed. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.2.2.4 Existing Conditions Evaluation

No flood inundation areas or hydraulic models were developed for the 79th Street Sewer.

3.2.3 Development and Evaluation of Alternatives

The 79th Street Sewer, as well as several storm sewers discharging to it, is reported to be undersized and contributing to flooding within the communities of Justice and Hickory Hills. The scope of the Calumet-Sag Channel DWP does not include evaluating of storm sewer networks. A hydraulic analysis of the 79th Street Sewer, and the tributary local sewers, would be required to calculate damages created by a lack of conveyance and to develop and evaluate alternative improvement projects. No alternatives were developed for the 79th Street Sewer.

3.3 Arroyo Ditch

Arroyo Ditch is a small manmade waterway, about 0.2 mile long, tributary to Boca Rio Ditch in the Tinley Creek subwatershed, south of the Calumet-Sag Channel in southwestern Cook County. Three communities have areas tributary to Arroyo Ditch, as described in Table 3.3.1. The area tributary to Arroyo Ditch is principally residential, with a significant amount of open land and forest preserve property as listed in Table 3.3.2.

TABLE 3.3.1
Communities Draining to Arroyo Ditch

Community/Tributary	Tributary Area (mi^2)
Oak Forest	0.17
Matteson	0.07
Tinley Park	0.01

Figure 3.3.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are also shown on the figure and discussed in the following subsections.

TABLE 3.3.2
Land Use Distribution for Arroyo Ditch

Land Use	Area (acres)	%
Residential	101.6	64.8
Forest/Open Land	52.3	33.3
Commercial/Industrial	3	1.9

As a tributary to Boca Rio Ditch, Arroyo Ditch is a component of the Tinley Creek system. Despite its small tributary area, development of a hydraulic model for Arroyo Ditch was necessary to properly represent peak stormwater flows in this area.

3.3.1 Sources of Data

3.3.1.1 Previous Studies

No studies of Arroyo Ditch were identified for consideration as a component of DWP development.

3.3.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Arroyo Ditch. There are also no reaches 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 Arroyo Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to the Arroyo Ditch. Municipalities discharging to Arroyo Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

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 Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 1.4 acres of wetland areas within the Arroyo Ditch subwatershed. 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 per updated Cook County topographic information. However, the effective models, which are used to estimate flood levels, generally were not updated. LOMRs were incorporated into the revised floodplains. Arroyo Ditch is not mapped in detail in the DFIRM mapping update, although backwater from Boca Rio Ditch is extended as Zone AE flooding along Arroyo Drive. 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

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted District Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. No Form B responses related to Arroyo Ditch were submitted.

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. No near-term planned projects by others have been identified for the Arroyo Ditch subwatershed.

3.3.2 Watershed Analysis

3.3.2.1 Hydrologic Model Development

Subbasin Delineation. The Arroyo Ditch tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The topographic delineation generally was representative of drainage patterns in the Arroyo Ditch basin; however, some modifications were required to reflect manmade modifications to drainage patterns. Part of the basin is adjacent to the Little Calumet Watershed. The Calumet-Sag and Little Calumet boundaries were compared, and minor discrepancies were identified. Discrepancies were resolved through additional review of topographic data, consultation with local communities, and coordination with other watershed planning consultants.

Table 3.3.3 summarizes the total drainage area, number of subbasins, and average subbasin size for Arroyo Ditch and its tributaries.

TABLE 3.3.3
Arroyo Ditch Subbasin Summary

Drainage Area (mi^2)	Number of Modeled Subbasins	Average Modeled Subbasin Size (acres)
0.25	1	156.87

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.

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 each subwatershed.

3.3.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that meet District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Arroyo Ditch and all crossings were surveyed 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 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 Manning's *n* roughness coefficients along the modeled stream length.

Boundary Conditions. The Arroyo Ditch hydraulic model was run as a component of the larger Tinley Creek hydraulic model, with downstream water surface elevations defined by the Boca Rio Ditch tributary model.

3.3.2.3 Calibration and Verification

No measured or observed flows or stage data was available for Arroyo Ditch for comparison with modeled values. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

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, 12-hour duration Huff Quartile II design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the Arroyo Ditch system. 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

No regional stormwater problems were identified in the Arroyo Ditch subwatershed. The hydraulic model of Arroyo Ditch does not predict any overbank property damage due to flooding for any of the modeled design events. Flooding along Arroyo Drive and Las Flores Drive was predicted for events of a 25-year magnitude or greater, but did not extend to homes along those drives. No stormwater improvements were developed for Arroyo Ditch. Alternative improvements to address regional problems are not recommended for Arroyo Ditch.

3.4 Boca Rio Ditch

Boca Rio Ditch is a tributary to Tinley Creek located south of the Calumet-Sag Channel in the southeastern portion of the Calumet-Sag Channel Watershed. The drainage area of Boca Rio Ditch is roughly 2.3 square miles. Table 3.4.1 lists the communities draining to Boca Rio Ditch. Table 3.4.2 summarizes the land use distribution within the Boca Rio Ditch tributary area. The upstream part of Boca Rio Ditch generally is residential, with the downstream part draining through Cook County Forest Preserve property. Figure 3.4.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are also shown on the figure, and are discussed in the following subsections.

TABLE 3.4.1
Communities Draining to Boca Rio Ditch

Community/Tributary	Tributary Area (mi^2)
Unincorporated/Forest Preserve	1.0
Oak Forest	1.0
Orland Park	0.2
Matteson	0.1

TABLE 3.4.2
Land Use Distribution for Boca Rio Ditch

Land Use Category	Area (acres)	%
Forest/Open Land	696.1	47.3
Residential	563.5	38.3
Commercial/Industrial	96.1	6.5
Agricultural	55	3.7
Institutional	32	2.2
Water/Wetland	21.6	1.5
Transportation/Utility	7.5	0.5

3.4.1 Sources of Data

3.4.1.1 Previous Studies

No studies of Boca Rio Ditch were identified for consideration as a component of DWP development.

3.4.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on the Boca Rio Ditch. There are also no reaches 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 Boca Rio Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to the Boca Rio Ditch. Municipalities discharging to Boca Rio Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the 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 Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 67.3 acres of wetland areas in the Boca Rio Ditch subwatershed. 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, however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. Regression equations from 1973 and WSP-2 were used for the effective hydrologic and hydraulic Boca Rio Ditch models, respectively. The models were developed in 1977. 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

Communities, regional agencies (e.g., IDOT, CCHD), and stakeholders submitted District Form B questionnaire response data summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1 of the report. Table 3.4.3 summarizes Form B data for Boca Rio Ditch.

TABLE 3.4.3
Community Response Data for Boca Rio Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
BR4	Bremen Township	Maintenance, ponding	Ridgeland Avenue 1/8 mile north of 147th Street	Culvert box submerged (CCHD)	Local	Problem not located along a regional waterway
OF3	Oak Forest	Maintenance, overbank flooding, sedimentation, bank erosion	Property just north of 151st Street and Boca Rio Drive	Property owner in Bremen Township denies access to allow Oak Forest to maintain channel, resulting in significant sedimentation and upstream flooding.	Regional	Access to private property must be granted to allow Oak Forest to perform stream maintenance in this area. Capital improvement project not created for this area.

Problem OF3 is a continuing maintenance concern for the Village of Oak Forest, which has repeatedly been denied access to 1,800 feet of Boca Rio Ditch by the property owner. Routine maintenance to remove debris and other obstructions is important for preserving the conveyance capacity of streams and to avoid causing upstream damages. Although not included as a capital project within the DWP, it is imperative that the Village of Oak Forest or the District be granted access to the property to perform stream maintenance. Failure to properly maintain this waterway will ultimately result in severe flow restriction and may cause upstream property damage during a significant rain event.

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. No near-term planned projects by others have been identified for the Boca Rio Ditch subwatershed.

3.4.2 Watershed Analysis

3.4.2.1 Hydrologic Model Development

Subbasin Delineation. The Boca Rio Ditch tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The topographic delineation was generally representative of drainage patterns in the Boca Rio Ditch subwatershed; however, subwatersheds sometimes were split or modified to reflect manmade modifications to topographic drainage patterns.

Part of the Boca Rio Ditch basin is adjacent to the Little Calumet Watershed. Initial boundaries of the Calumet-Sag and Little Calumet Watersheds were compared, and discrepancies identified. Discrepancies were generally minor and were resolved by manual review of topographic data and consultation with local communities.

Table 3.4.4 summarizes the total drainage area, number of subbasins, and average subbasin size for Boca Rio Ditch and its tributaries.

TABLE 3.4.4
Boca Rio Ditch Subbasin Summary

Subbasin	Drainage Area (mi^2)	Number of Modeled Subbasins	Average Modeled Subbasin Size (acres)
Boca Rio Ditch	2.30	13	112.85
Major Tributaries to Boca Rio Ditch			
Arroyo Ditch	0.25	1	156.87
Total	2.55	14	115.99

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.

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.

3.4.2.2 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 identified as available to directly contribute to the development of the Calumet-Sag Channel DWP. Surveys of the open channel part of the Boca Rio Ditch and all 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 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 Boca Rio Ditch model was run as a component of the Tinley Creek system model, with downstream water surface elevations defined by the dynamic modeled water surface of the Tinley Creek hydraulic model developed as a part of the Calumet-Sag Channel DWP.

3.4.2.3 Calibration and Verification

No measured or observed flows or stage data was available for Boca Rio Ditch for comparison with modeled values. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.4.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.4.1 shows inundation areas along Boca Rio Ditch produced by the hydraulic model for the 100-year, 12-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the Boca Rio Ditch system. 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

No regional stormwater problems were identified in the Boca Rio Ditch subwatershed. The hydraulic model of Boca Rio Ditch does not predict any overbank property damage due to flooding for any of the modeled design events. Flooding is predicted along 151st Street and Las Flores Drive, but is confined to roadways. No stormwater improvements were developed for Boca Rio Ditch. Alternative improvements to address regional problems are not recommended for Boca Rio Ditch.

3.5 Calumet-Sag Tributary A

Calumet-Sag Tributary A is located in southwestern Cook County, south of the Calumet-Sag Channel, in the western part of the Calumet-Sag Channel Watershed. Table 3.5.1 summarizes the areas of communities that drain to Calumet-Sag Tributary A. Calumet-Sag Tributary A is a natural open-channel stream draining 2.96 square miles that discharges into the Calumet-Sag Channel. The Calumet-Sag Tributary A subwatershed contains a mix of suburban development and available open land. Most of the open land within the watershed is Cook County Forest Preserve property. Table 3.5.2 lists the land use breakdown by area within the Calumet-Sag Tributary A subwatershed.

TABLE 3.5.1
Communities Draining to Calumet-Sag Tributary A

Community	Tributary Area (mi^2)
Unincorporated/ Forest Preserve	2.96

TABLE 3.5.2
Land Use Distribution for Calumet-Sag Tributary A

Land Use	Area (acres)	%
Forest/Open Land	1,055.8	55.8
Residential	612.4	32.3
Agricultural	119.8	6.3
Water/Wetland	85.9	4.5
Institutional	17	0.9
Commercial/Industrial	2.9	0.2

Figure 3.5.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are also shown on the figure, and are discussed in the following subsections.

3.5.1 Sources of Data

3.5.1.1 Previous Studies

No studies of Calumet-Sag Tributary A were identified for consideration as a component of DWP development.

3.5.1.2 Water Quality Data

The IEPA does not have any site in the Ambient Water Quality Monitoring Network for Calumet-Sag Tributary A. There are also no reaches identified as impaired in the IEPA's 2008 *Integrated Water Quality Report*, which includes the 303(d) and 305(b) lists. No TMDLs have been established for Calumet-Sag Tributary A. According to a USEPA water permit discharge query, one point source discharge location was identified on Calumet-Sag Tributary A at the Holy Family Villa Nursing Home in Lemont Township (IL0024678). Municipalities discharging to the Calumet-Sag Channel are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which seeks 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 Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 209.8 acres of wetland areas in the Calumet-Sag Tributary A subwatershed. 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains.

Calumet-Sag Tributary A is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of Calumet-Sag Tributary A. According to the FIS, the original hydrologic and hydraulic analysis was performed in 1976. The hydrologic modeling was performed using Regression Equations 73 and 75 and Log-Pearson Type III (L-PTIII). Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

Communities, regional agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1. Table 3.5.3 shows reported problems along Calumet-Sag Tributary A.

TABLE 3.5.3
Community Response Data for Calumet-Sag Tributary A

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
LT5	Lemont Township	Pavement flooding, ponding	McCarthy Rd. between Bell Rd. and Will-Cook Rd., near Equestrian Estates neighborhood	McCarthy Rd. and nearby yards flood, including property that contains a large pond. Pond has insufficient storage volume and/or outlet capacity to contain flows.	Local	Problem not located on a regional waterway. This is a local problem.

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. No near-term planned projects by others have been identified for the Calumet-Sag Tributary A subwatershed.

3.5.2 Watershed Analysis

3.5.2.1 Hydrologic Model Development

Subbasin Delineation. The Calumet-Sag Tributary A tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Eighteen subbasins were delineated for the Calumet-Sag Tributary A area, with an average subbasin area of 105.3 acres and a total drainage area of 2.96 square miles.

Hydrologic Parameter Calculations. CNs were estimated for each subbasin based upon NRCS soil data and 2001 CMAP land use data, described further 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 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.

3.5.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Calumet-Sag Tributary A and all crossings were surveyed 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 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 coefficient to the stream.

Boundary Conditions. Boundary condition elevations for the Calumet-Sag Channel are based on output from the CWS model and are included in Appendix E. The elevation produced by the CWS model for the 100-year storm at the outlet of Calumet-Sag Tributary A was 584.22 feet (NAVD 88), which is higher than the water surface elevation generated using a normal depth based upon the channel slope. The downstream stages from the CWS model were used for the downstream boundary conditions of the various storms.

3.5.2.3 Calibration and Verification

No measured or observed stages were available for Calumet-Sag Tributary A to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.5.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.5.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.5.3 Development and Evaluation of Alternatives

No regional stormwater problems were identified in the Calumet-Sag Tributary A sub-watershed. The hydraulic model of Calumet-Sag Tributary A does not predict any overbank property damage due to flooding for any of the modeled design events. No stormwater improvements were developed for Calumet-Sag Tributary A. Alternative improvements to address regional problems are not recommended for Calumet-Sag Tributary A.

3.6 Calumet-Sag Tributary B

Calumet-Sag Tributary B is a regional waterway in southwestern Cook County, south of the Calumet-Sag Channel and in the central part of the Calumet-Sag Channel Watershed. The total drainage area for Calumet-Sag Tributary B is 1.1 square miles. Table 3.6.1 provides a summary of the communities draining to the Calumet-Sag Tributary B subwatershed. The Calumet-Sag Tributary B subwatershed is largely residential. Table 3.6.2 provides a summary of the land use distribution within the Calumet-Sag Tributary B subwatershed.

TABLE 3.6.1
Communities Draining to Calumet-Sag Tributary B

Community	Tributary Area (mi^2)
Palos Park	0.97
Unincorporated/Forest Preserve	0.11
Palos Heights	0.03

TABLE 3.6.2
Land Use Distribution for Calumet-Sag Tributary B

Land Use Category	Area (acres)	%
Residential	662.5	92.9
Institutional	16.6	2.3
Transportation/ Utility	13.7	1.9
Commercial/ Industrial	10	1.4
Forest/Open Land	5.7	0.8
Water/Wetland	4.4	0.6

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

3.6.1 Sources of Data

3.6.1.1 Previous Studies

No previous studies of Calumet-Sag Tributary B were identified for use in the development of DWPs.

3.6.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Calumet-Sag Tributary B. No reaches 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 Calumet-Sag Tributary B. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Calumet-Sag Tributary B. Municipalities discharging to Calumet-Sag Tributary B are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

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 Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes 12.4 acres of wetland area in the Calumet-Sag Tributary B subwatershed. 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; however, the effective models, which are used to estimate flood levels, generally were not updated. LOMRs were incorporated into revised floodplain areas.

Calumet-Sag Tributary B is mapped in detail in the DFIRM mapping update, with Zone AE floodplain shown from Southwest Highway in Palos Park to the Calumet-Sag Channel. The original hydrologic and hydraulic analysis was performed in 1976. Hydrologic modeling was performed using Regression Equations 73 and 75. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

Communities, regional agencies (IDOT, CCHD), and stakeholders submitted District Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1 of the report. Table 3.6.3 summarizes the Form B data for Calumet-Sag Tributary B.

3.6.1.6 Near-Term Planned Project

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 projects by others have been identified for the Calumet-Sag Tributary B subwatershed.

3.6.2 Watershed Analysis

3.6.2.1 Hydrologic Model Development

Subbasin Delineation. The Calumet-Sag Tributary B subwatershed area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The area was reviewed and area southeast of Southwest Highway was added to the original delineation based on contour data and aerials. Nine subbasins were delineated for the Calumet-Sag Tributary B tributary area, with an average subbasin area of 80 acres.

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.

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.

TABLE 3.6.3
Community Response Data for Calumet-Sag Tributary B

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PP3	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	119th St. and Timber Ln.	Floodwaters exceed capacity of box culvert under 119th St.	Regional	Proposed alternative CSTB-3 addresses flooding in this area.
PP4	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	SW Hwy between S. Woodland Trail and 121st St.	Diversion from Mill Creek is conveyed along RR Row. This flow leaves RR ROW and spills into SW Hwy at this location. Closes SW Hwy, and flooding several homes along RR ROW.	Regional	Field assessment identified no structural damages associated with bank erosion. Project MICR-4 will reduce flow to the railroad ditch from MICR to this area.
PP7	Palos Park	Overbank flooding, storm sewer capacity, bank erosion	127th St. and 86th Ave.	Mill Creek diverts to RR ROW ditch at this location. Insufficient capacity to convey water under 86th Avenue results in flooding of SW Hwy.	Regional	Project MICR-4 addresses this problem.
PP9	Palos Park	Pavement flooding	Route 7 at 123rd St.	IDOT reported pavement flooding.	Local	Problem not located on a regional waterway. This is a local problem.

Flow Diversions. There is a flow diversion located southwest of the intersection of 86th Avenue and 127th Street that can result in stormwater from the Mill Creek subwatershed overtopping the subwatershed divide and flowing into the Calumet-Sag Tributary B subwatershed under some conditions. A railway ditch intersects what was once a natural drainage divide between the Mill Creek and Calumet-Sag Tributary B subwatersheds at this location. When water surface elevations in Mill Creek reach an elevation of approximately 667 feet NAVD 88, Mill Creek overflows into the railroad ditch, which flows to Calumet-Sag

Tributary B. The overflow hydrograph generated in the Mill Creek hydraulic model was used as input to Calumet-Sag Tributary B hydrologic model to properly represent existing conditions. This flow diversion results in an inundation area crossing the subwatershed divide in this location as shown on Figure 3.6.1.

3.6.2.2 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 identified for the Calumet-Sag Tributary B subwatershed. The open channel of Calumet-Sag Tributary B and all crossings were surveyed 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 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. Appendix E contains boundary condition elevations determined for the Calumet-Sag Channel based on output from the CWS model. The elevation produced by the CWS model for the 100-year storm at the outlet of Calumet-Sag Tributary B was 584.83 feet NAVD 88, less than 2 feet above the invert of Calumet-Sag Tributary B near its confluence with the Calumet-Sag Channel. The shallow depth indicates that the downstream stage on Calumet-Sag Tributary B is controlled not by the receiving system but by its own capacity to convey flow received from its tributary area. Normal depth assuming a friction slope of 0.0216 was used as a downstream boundary condition for Calumet-Sag Tributary B.

3.6.2.3 Calibration and Verification

In the hours following the August 20, 2007 storm, a high water elevation mark was observed at the downstream side of the Autobahn Drive South bridge at the downstream end of Calumet-Sag Tributary B. The rainfall data from ISWS gage 16, which is the rainfall gage closest to the observed high water elevation, was obtained for this time period. Gage 16 recorded 1.2 inches of rainfall over a 7-hour period.

Table 3.6.4 lists the location and elevation of the field-observed water surface elevation and the peak modeled water surface elevation. The model results are listed for both initial (pre-calibration) model results and calibrated model results (with the 10 percent reduction applied to the curve number values). The difference between the observed and calibrated model water surface elevations are generally considered to be acceptable due to the margin of error associated with high water mark elevation data. High water elevations were taken at a point in time when it is not certain that the peak water elevation occurred.

TABLE 3.6.4
Comparison of Observed and Model Result Water Surface Elevations for August 20, 2007 Storm Event

Location	Observed High Water Surface Elevation (ft)	Initial Model Results Water Surface Elevation (ft)	Calibrated Model Results Water Surface Elevation (ft)
Autobahn Drive South	598.7	600.89	599.81

3.6.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Flood inundation areas were developed based on HEC-RAS water surface elevations and Cook County topographic data. Figure 3.6.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.6.3 Development and Evaluation of Alternatives

3.6.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.6.5 provides a summary of major problem areas identified through modeling of Calumet-Sag Tributary B.

TABLE 3.6.5
Modeled Problem Definition for Calumet-Sag Tributary B

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA1	Area southeast of culvert, at 119th Street and Timber Lane	25, 50, 100, 500	PP-3	Proposed alternative CSTB-3 addresses flooding in this area.
MPA2	Area east of tributary near Autobahn Drive South crossing	25, 50, 100, 500		Sufficient land was not available in the area for potential capital projects that could address problem. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA3	Area upstream of Timber Lane near 121st Street and Southwest Hwy	2, 5, 10, 25, 50, 100, 500	PP-4	Field assessment identified no structural damages associated with bank erosion. Project MICR-4 will reduce flow to the railroad ditch from MICR to this area.

3.6.3.2 Damage Assessment

Damages due to flooding were calculated for Calumet-Sag Tributary B in accordance with the methodology described in Section 1.4.2 and are listed in Table 3.6.6.

3.6.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in Calumet-Sag Tributary B. Storage and increased conveyance were the two primary alternatives considered. Levees were not considered because of proximity of structures to the channel.

TABLE 3.6.6
Estimated Damages for Calumet-Sag Tributary B

Damage Category	Estimated Damage ($)	Note
Property	886,700	
Erosion	0	
Transportation	133,000	Assumed as 15% of property damage due to flooding
Recreation	0	

3.6.3.4 Alternative Development

Flood Control Alternatives. Alternative solutions for regional flooding were developed and evaluated consistent with the methodology described in Section 1.4 of this report. Table 3.6.7 summarizes the flood control alternatives developed for Calumet-Sag Tributary B. Potential stormwater detention basin sites under Alternatives CSTB-2, CSTB-3, and CSTB-5 require buyouts of developed and undeveloped residential properties that are within inundation areas for the site of the proposed alternatives.

Stormwater detention alternatives were modeled for Calumet-Sag Tributary B with the goal of reducing flood damages upstream of 119th Street. Sufficient land was not found to be available for detention alternatives that would address the flooding downstream of 119th Street.

TABLE 3.6.7
Flood Control Alternatives for Calumet-Sag Tributary B

Alternative Number	Location	Description
CSTB-1	Calumet-Sag Tributary B downstream of Timber Ln.	Construct 3 ac-ft stormwater detention basin
CSTB-2	Calumet-Sag Tributary B upstream of Timber Ln.	Construct 2.1 ac-ft stormwater detention basin. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
CSTB-3	Calumet-Sag Tributary B between Southwest Hwy and 119th St.	Construct two detention basins for a total of 10 ac-ft of storage; expand one existing detention basin, and increase conveyance capacity of two culvert crossings
CSTB-4	119th St. and Calumet-Sag Tributary B	Enlarge culvert size. This alternative caused increased downstream water surface elevations, thus benefits and costs were not developed.
CSTB-5	Timber Ln. and Calumet-Sag Tributary B	Total of 14 ac-ft of detention basins both upstream and downstream of Timber Lane. This alternative did not effectively reduce water surface elevations in the flooding problem area to any greater extent than CSTB-3, thus benefits and costs were not developed.

Erosion Control Alternatives. No erosion alternatives have been developed for Calumet-Sag Tributary B. An erosion problem was reported as PP4, but since it does not threaten any structures, it does not have any damages.

3.6.3.5 Alternative Evaluation and Selection

Alternatives included in Table 3.6.7 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damages. Modeling analysis concluded that CSTB-2 did not effectively lower water surface elevations, primarily because it is located too far upstream of problem areas. CSTB-4 caused downstream water surface elevations to increase. CSTB-5 did not lower water surface elevations significantly more than CSTB-3.

For these reasons, benefits and costs were calculated only for Alternatives CSTB-1 and CSTB-3. Alternative CSTB-3 was most effective in lowering flood depths and damages. Table 3.6.9 provides a summary of B/C ratio, net benefits, total project costs, number of structures protected, and other relevant alternative data. Alternatives that did not produce a significant change in inundation areas are not listed as benefits were negligible, and thus costs were not calculated for these alternatives.

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 Calumet-Sag Channel DWP.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.6.8 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

TABLE 3.6.8
Calumet-Sag Tributary B Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		CSTB-3	
Location	Station	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)
40-ft upstream of Timber Ln.	4086	619.56	172.89	619.50	160.70
100-ft upstream of 119th St.	2858	614.34	278.56	612.91	279.36
150-ft downstream of Calumet-Sag Rd.	1803	609.03	406.10	609.03	405.95
Confluence with Calumet-Sag Channel	194	586.60	430.94	586.59	429.59

3.6.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.6.9 lists the total estimated cost, benefits, and B/C ratio for each alternative.

Table 3.6.9 summarizes the alternatives analyzed. Figure 3.6.2 shows the location of recommended alternative CSTB-3 and a comparison of the inundation mapping for existing conditions and with the recommended alternative CSTB-3.

TABLE 3.6.9
Calumet-Sag Tributary B Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
CSTB-1	Construct a detention basin just DS of Timber Ln.	0.03	18,100	649,100	1		Slightly Positive	No	Palos Park
CSTB-3	Add 10 ac-ft of additional detention and increase conveyance	0.31	669,700	2,131,500	6		Slightly Positive	Yes	Palos Park

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.7 Calumet-Sag Tributary C

The Calumet-Sag Tributary C is located in southwestern Cook County, south of the Calumet-Sag Channel and in the eastern part of the Calumet-Sag Channel Watershed. Table 3.7.1 lists the areas of communities draining to the subwatershed. The drainage area is 3.35-square-miles. Calumet-Sag Tributary C is a natural open-channel stream until it reaches the Midlothian Turnpike, where it enters a storm sewer system that conveys flow along Cicero Avenue and discharges into the Calumet-Sag Channel. Table 3.7.2 lists the land use breakdown by area within the subwatershed.

TABLE 3.7.1
Communities Draining to Calumet-Sag Tributary C

Community	Tributary Area (mi^2)
Crestwood	1.56
Midlothian	0.85
Unincorporated/Forest Preserve	0.46
Oak Forest	0.45
Robbins	0.03

Figure 3.7.1 is an overview of the tributary area of the subwatershed. It also shows reported stormwater problem areas and flood inundation areas, which are discussed in the following subsections.

TABLE 3.7.2
Land Use Distribution for Calumet-Sag Tributary C

Land Use	Area (acres)	%
Residential	1,035.5	48.3
Commercial/Industrial	486.7	22.7
Forest/Open Land	471.5	22
Institutional	59.6	2.8
Agricultural	57.8	2.7
Transportation/Utility	30.7	1.4

3.7.1 Sources of Data

3.7.1.1 Previous Studies

No studies of Calumet-Sag Tributary C were identified for consideration as a part of the Calumet-Sag Channel DWP development.

3.7.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Calumet-Sag Tributary C. No reaches 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 Calumet-Sag Tributary C. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Calumet-Sag Tributary C. Municipalities discharging to Calumet-Sag Tributary C are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the 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 Calumet-Sag Channel Watershed. Wetland areas were identified using NWI mapping. NWI data includes roughly 23.6 acres of wetland areas in the Calumet-Sag Tributary C subwatershed. 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

Floodplain 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. The Calumet-Sag Tributary C is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of Calumet-Sag Tributary C.

According to the FIS, the original hydrologic and hydraulic analysis was performed in 1976. The hydrologic modeling was performed using Regression Equations 73 and 75. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.7.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.7.3 lists problems reported along Calumet-Sag Tributary C.

TABLE 3.7.3
Community Response Data for Calumet-Sag Tributary C

Problem ID	Municipality	Problems List	Location	Problem Description	Local/ Regional	Resolution in DWP
BR3	Bremen Township	Basement flooding, ponding, water quality, storm sewer capacity	Linder Ave. between Midlothian Pike and 143rd St.	Natural basin collects stormwater, flooding yards and houses and causing septic system failure	Local	Problem not located on a regional waterway. This is a local problem.
CW1	Crestwood	Pavement flooding	Route 50 (Cicero Ave.) at 135th St.	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

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. No near-term planned projects by others have been identified for the Calumet-Sag Tributary C subwatershed.

3.7.2 Watershed Analysis

3.7.2.1 Hydrologic Model Development

Subbasin Delineation. The Calumet-Sag Tributary C area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Twenty-one subbasins were delineated for the Calumet-Sag Tributary C area, with an average area of 102 acres each, and a total drainage area of 3.4 square miles. Part of the basin is adjacent to the Little Calumet Watershed. The Calumet-Sag and Little Calumet boundaries were compared, and minor discrepancies were identified. Discrepancies were resolved through additional review of topographic data, consultation with local communities, and coordination with other watershed planning consultants.

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.

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 District criteria, as identified in Section 6.3.3.2 of the CCSMP, were identified for the Calumet-Sag Tributary C subwatershed. The open channel of Calumet-Sag Tributary C and all crossings were surveyed 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 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 coefficient to the stream.

3.7.2.3 Boundary Conditions

The downstream boundary condition of the Calumet-Sag Tributary C model is the upstream end of a 42- by 84-inch elliptical pipe that carries flows from the subwatershed to the Calumet-Sag Channel. This storm sewer starts at the Midlothian Turnpike and discharges to the Calumet-Sag Channel west of Cicero Avenue. A rating curve was defined to represent the inflow capacity to this storm sewer.

3.7.2.4 Calibration and Verification

No measured or observed stages were available for Calumet-Sag Tributary C to compare model results to support making calibration modifications to the model. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8. The model results are consistent with anecdotal reports from local communities that the stormwater detention basin at 143rd Street and Linder Avenue frequently overtops.

3.7.2.5 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.7.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the Calumet-Sag Tributary C system. 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

3.7.3.1 Problem Definition

Table 3.7.4 summarizes problem areas identified through hydraulic modeling of Calumet-Sag Tributary C. Though no Form Bs were submitted related to the modeled problem areas listed in Table 3.7.4, communities did confirm that Problem IDs MPA4 and MPA5 do correspond to known flooding areas.

TABLE 3.7.4
Modeled Problem Definition for Calumet-Sag Tributary C

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA4	Area at 143rd Street and Linder Avenue	50, 100, 500		Sufficient land was not available in the area for potential capital projects that could address the problem. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA5	Area between tributary and Lavergne Avenue from 143rd Street to Midlothian Turnpike	2, 5, 10, 25, 50, 100, 500		Sufficient land was not available in the area for potential capital projects that could address the problem. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.

3.7.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No erosion or recreation damages due to flooding were identified for Calumet-Sag Tributary C. Transportation damages were estimated as 15 percent of property damages. Table 3.7.5 lists the damage assessment for existing conditions.

TABLE 3.7.5
Estimated Damages for Calumet-Sag Tributary C

Damage Category	Estimated Damage ($)	Note
Property	464,500	
Erosion	0	
Transportation	69,700	Assumed as 15% of property damage due to flooding

3.7.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in Calumet-Sag Tributary C. Increased conveyance or storage was identified as the principal technologies applicable for addressing stormwater problems in Calumet-Sag Tributary C.

3.7.3.4 Alternative Development

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 3.7.6 summarizes flood control alternatives developed for Calumet-Sag Tributary C.

Local communities suggested several potential locations for detention facilities for flood damage reduction alternatives. These included Cook County Forest Preserve property online with Calumet-Sag Tributary C just upstream of Central Avenue, and a floodplain area with homes just north of 143rd Street at Linder Avenue. WPC participants suggested that the Central Avenue storm sewer system that discharges to Calumet-Sag Tributary C may be contributing to high flows. Therefore, the sewer was routed to the proposed pond upstream of Central Avenue in the alternatives analysis.

Alternative CSTC-1 is an in-line pond at the headwaters of the tributary providing approximately 37 ac-ft of detention. A moderate amount of excavation is needed to construct the stormwater detention facility. The storm sewer along Central Avenue from 147th Street will be diverted across Central Avenue to the proposed facility, since it has been identified as a source of flooding. Alternatives CSTC-2 and CSTC-3 are conveyance improvement alternatives that reduce hydraulic restrictions.

TABLE 3.7.6
Flood Control Alternatives for Calumet-Sag Tributary C

Alternative Number	Location	Description
CSTC-1	West of Central Avenue	Construct a 37 acre-feet detention pond on Cook County Forest Preserve property at Central Avenue between 147th Street and Midlothian. Also, the existing Central Avenue storm sewer should be diverted into a pond.
CSTC-1b	West of Central Avenue	Construct a 12 acre-feet detention pond on Cook County Forest Preserve property at Central Avenue between 147th Street and Midlothian. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
CSTC-2	Linder Avenue and 143rd Street	Increase dimensions of culverts at two road crossings to a 3.5-foot by 6-foot- elliptical pipe at Linder Avenue and two 2.5-foot by 3.75-foot elliptical pipes at 143rd Street. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
CSTC-3	Linder Avenue 143rd Street, and Midlothian Turnpike	Alternative CSTC-2, plus increase the downstream boundary culvert size (currently 42-inch by 84-inch elliptical pipe) to double current capacity. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.

3.7.3.5 Alternative Evaluation and Selection

Alternatives included in Table 3.7.6 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damage reduction. Table 3.7.7 provides a summary of B/C ratio, net benefits, total project costs, number of structures protected, and other relevant alternative data. Alternatives that did not produce a significant change in inundation areas are described in this report, but benefits were negligible and conceptual level costs were not developed for these alternatives. CSTC-1 was evaluated at a size of 37 acre-feet, which required excavation incurring significant cost while only reducing damages significantly to two properties, which resulted in a low B/C ratio. CSTC-1b, a variation on CSTC-1, was also considered, in which a control structure would restrict flow from the area without significant excavation, relying on about 12 acre-feet of existing depressional area. This was modeled, and determined to have no benefit to the affected structures. Model analysis concluded that CSTC-1b, CSTC-2, and CSTC-3 were not effective in reducing flood damages.

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 Calumet-Sag Channel DWP.

3.7.3.6 Data Required for Countywide Prioritization of Watershed Projects

Table 3.7.7 lists alternatives evaluated in detail.

TABLE 3.7.7
Calumet-Sag Tributary C Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
CSTC-1	37 ac-ft detention pond	0.05	196,900	4,355,700	8		Positive	No	Crestwood, Midlothian

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.8 Castle Bowl

Castle Bowl is located in southwestern Cook County, south of the I&M Canal, in the western portion of the Calumet-Sag Channel Watershed. Table 3.8.1 lists the areas of communities that drain to Castle Bowl. The population density of the Castle Bowl subwatershed is relatively high with a mix of suburban development and little available open land. Most of the open land within the watershed is Cook County Forest Preserve property. The drainage area is 1.7-square-miles.

TABLE 3.8.1
Communities Draining to Castle Bowl

Community	Tributary Area (mi^2)
Lemont	1.5
Unincorporated/ Forest Preserve	0.2

TABLE 3.8.2
Land Use Distribution for Castle Bowl

Land Use	Area (acres)	%
Residential	638.2	59
Forest/Open Land	244	22.6
Institutional	130.9	12.1
Commercial/Industrial	37.1	3.4
Water/Wetland	13.7	1.3
Agricultural	13.1	1.2

The Castle Bowl area, shown in Figure 3.8.1 is tributary to the Hillview Ditch, which is an open-channel stream until it reaches the School Gully Culvert and then flows through a concrete channel leading to the downtown Village of Lemont storm sewer system. The storm sewer system discharges into the I&M Canal. Table 3.8.2 lists land use by area within the Castle Bowl subwatershed.

A detailed hydraulic model was not developed for Hillview Ditch as only the Village of Lemont is tributary to the open channel portion of the ditch. Thus, any potential stormwater problem on this portion of the ditch would be classified as a local problem. Areas entirely drained by storm sewers such as the downtown Lemont were generally not studied in detail as a part of the Calumet-Sag Detailed Watershed Plan development.

3.8.1 Sources of Data

3.8.1.1 Previous Studies

One study of Castle Bowl was identified for consideration as a component of DWP development—a report titled *Construction and Maintenance of Dams: Dam Safety Permit for Castle Bowl Retention Facility*, prepared for the Village of Lemont by Engineering Resource Associates, Inc. (2006). The report includes information on the proposed Castle Bowl retention facility.

3.8.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Hillview Ditch. No reaches 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 Hillview Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Hillview Ditch. Municipalities discharging to Hillview Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.8.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes 18.1 acres of wetland area in the Castle Bowl subwatershed. 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.

3.8.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. Castle Bowl and Hillview Ditch were not mapped in detail in the DFIRM mapping update. According to the FIS, no hydrologic or hydraulic analyses have been performed.

3.8.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.8.3 lists reported problems within the Castle Bowl subwatershed.

TABLE 3.8.3
Community Response Data for Castle Bowl

Problem ID	Municipality	Problem as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
LT4	Lemont Township	Bank erosion, sedimentation	Stephen St. and North of Talcott St.	Tree branches and debris in I&M Canal block flow	Regional	Maintenance and debris removal recommended.
LE1	Lemont	Ponding	Cass Street and Lemont Street, downtown Lemont	During major storms, sewer system in downtown Lemont surcharges, flooding basements, and first floors of commercial, industrial, and residential buildings	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

3.8.1.6 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 projects by others have been identified for the Castle Bowl subwatershed.

3.8.2 Watershed Analysis

3.8.2.1 Hydrologic Model Development

Subbasin Delineation. The Castle Bowl tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Eleven subbasins were delineated for the Castle Bowl area, with an average subbasin area of 107.6 acres and a total drainage area of 1.85 square miles.

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.

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.

3.8.2.2 Hydraulic Model Development

A detailed hydraulic model was not developed for Hillview Ditch as only the Village of Lemont is tributary to the open channel portion of the ditch. Thus, any potential stormwater problem on this portion of the ditch would be classified as a local problem. Heavily sewered areas such as the downtown Lemont storm sewer system were generally not studied in detail in the Calumet-Sag Detailed Watershed Plan.

3.8.3 Development and Evaluation of Alternatives

No regional problem areas were identified in the Castle Bowl subwatershed, so no alternatives were developed. The proposed Castle Bowl detention basin was analyzed in terms of benefits that it provided to regional problems located on the I&M Canal downstream of Castle Bowl. It was determined that the implementation of the Castle Bowl detention basin produces negligible benefits to regional problems, as discussed in Section 3.11.3.4.

3.9 Crestwood Drainage Ditch

Crestwood Drainage Ditch is a manmade waterway located in southwestern Cook County, south of the Calumet-Sag Channel, in the eastern part of the Calumet-Sag Channel Watershed. The 0.9-mile-long stream drains a contributing area of 1.3 square miles. Table 3.9.1 summarizes the communities that are tributary to Crestwood Drainage Ditch. Figure 3.9.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas, and flood inundation areas are also shown and are discussed in the following subsections.

The upstream part of the Crestwood Drainage Ditch subwatershed is principally Cook County Forest Preserve land, with a mixture of residential and commercial/industrial land use north and east of Central Avenue. Table 3.9.2 summarizes the land use distribution for areas draining to Crestwood Drainage Ditch.

TABLE 3.9.1
Communities Draining to Crestwood Drainage Ditch

Community	Tributary Area (mi^2)
Crestwood	0.76
Unincorporated/ Forest Preserve	0.49

TABLE 3.9.2
Land Use Distribution for Crestwood Drainage Ditch

Land Use	Area (acres)	%
Residential	386.2	47.7
Forest/Open Land	274.1	33.8
Commercial/ Industrial	79.4	9.8
Institutional	58.2	7.2
Agricultural	8.7	1.1
Water/Wetland	2.8	0.3
Transportation/ Utility	0.5	0.1

3.9.1 Sources of Data

3.9.1.1 Previous Studies

No studies of Crestwood Drainage Ditch were identified for consideration as a component of DWP development.

3.9.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Crestwood Drainage Ditch. No reaches 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 Crestwood Drainage Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Crestwood Drainage Ditch. Municipalities discharging to Crestwood Drainage Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.9.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 9.2 acres of wetland areas in the Crestwood Drainage Ditch subwatershed. 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.

3.9.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. Crestwood Drainage Ditch is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of Crestwood Drainage Ditch. According to the FIS, the original H&H analysis was performed in 1979. The hydrologic modeling was performed using regression equations from 1975 and L-PTIII. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.9.1.5 Stormwater Problem Data

Communities, regional agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. No problems were reported by communities related to the Crestwood Drainage Ditch.

3.9.1.6 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 projects by others have been identified for the Crestwood Drainage Ditch subwatershed.

3.9.2 Watershed Analysis

3.9.2.1 Hydrologic Model Development

Subbasin Delineation. The Crestwood Drainage Ditch tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Ten subbasins were delineated for the Crestwood Drainage Ditch area, with an average subbasin area of 81 acres and a total drainage area of 1.27 square miles.

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.

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.

3.9.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Crestwood Drainage Ditch and all crossings were surveyed 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 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 coefficient to the stream.

Boundary Conditions. Boundary condition elevations for the Calumet-Sag Channel based on output from the CWS model are included in Appendix E. The elevation produced by the CWS model for the 100-year storm at the outlet of Crestwood Drainage Ditch was 585.10 feet NAVD 88, 3 feet above the invert of Crestwood Drainage Ditch near its confluence with the Calumet-Sag Channel. This relatively shallow depth indicates that downstream stage on Crestwood Drainage Ditch is controlled, not by the receiving system, but by its own capacity to convey flows received from its tributary area. Normal depth assuming a friction slope of 0.002 was used as a downstream boundary condition for the Crestwood Drainage Ditch, which resulted in a WSEL 4.5 feet higher than the CWS model outlet elevation.

3.9.2.3 Calibration and Verification

No measured or observed stages were available for Crestwood Drainage Ditch to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.9.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.9.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm. The existing FEMA floodplain from the adjacent Tinley Creek subwatershed extends into the Crestwood Drainage Ditch subwatershed as flow from Tinley Creek may reach this area when the subwatershed divide is overtopped. A berm now exists along Tinley Creek in this area, which hydraulic model results have shown to largely prevent floodwaters from Tinley Creek from extending into the Crestwood Drainage Ditch subwatershed.

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

3.9.3 Development and Evaluation of Alternatives

Crestwood Drainage Ditch is predicted to remain in its banks for the 100-year event, with the exception of the detention area at the north end of the stream near its confluence with the Calumet-Sag Channel. No modeled problem locations or damages are predicted for Crestwood Drainage Ditch. Therefore, no alternatives were developed for Crestwood Drainage Ditch.

3.10 Crooked Creek

Crooked Creek is located in southwestern Cook County, north of the Calumet-Sag Channel, in the northwestern part of the Calumet-Sag Channel Watershed. Table 3.10.1 summarizes areas of communities that drain to Crooked Creek. The population density of the Crooked Creek subwatershed is low with a relatively small area of suburban development in the upper tributary area, and the subwatershed has a significant amount of open land within Cook County Forest Preserve property. The drainage area is 3.5 square miles. Crooked Creek is a natural open-channel stream that begins at the Belly Deep Slough, drains through the Saganashkee Slough, and discharges into the Calumet-Sag Channel. Table 3.10.2 lists the land use breakdown by area within the Crooked Creek subwatershed. Figure 3.10.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are also shown on the figure, and are discussed in the following subsections.

TABLE 3.10.1
Communities Draining to Crooked Creek

Community	Tributary Area (mi^2)
Unincorporated/Forest Preserve	3.13
Palos Hills	0.32
Hickory Hills	0.07

TABLE 3.10.2
Land Use Distribution for Crooked Creek

Land Use	Acres	%
Forest/Open Land	1,979.1	88.7
Residential	126.1	5.7
Water/Wetland	107	4.8
Commercial/Industrial	19.1	0.9

3.10.1 Sources of Data

3.10.1.1 Previous Studies

No studies of Crooked Creek were identified for consideration as a component of DWP development.

3.10.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Crooked Creek. No reaches are identified as impaired in the IEPA's 2008 *Integrated Water Quality Report*, which includes the CWA 303(d) and 305(b) lists. Crooked Creek is the main tributary to the Saganashkee Slough, an impaired water body per the IEPA 303(d) Report (ILH-01_RHH). The Saganashkee Slough's designated use is for fish consumption and is impaired by suspended solids, nickel, phosphorus, sedimentation, siltation, silver, and polychlorinated biphenyls (PCBs). There are no TMDLs established for Crooked Creek or Saganashkee Slough. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Crooked Creek or Saganashkee Slough. Municipalities discharging to Crooked Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.10.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 225.1 acres of wetland areas in the Crooked Creek subwatershed. 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.

3.10.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. Crooked Creek is not mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of Crooked Creek. The DFIRM contains only the Belly Deep Slough and Saganashkee Slough portions of the creek, and those sloughs are marked as Unnumbered Zone A.

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

3.10.1.5 Stormwater Problem Data

Communities, regional agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.10.3 lists reported problems along Crooked Creek.

3.10.1.6 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 projects by others have been identified for the Crooked Creek subwatershed.

3.10.2 Watershed Analysis

3.10.2.1 Hydrologic Model Development

Subbasin Delineation. The Crooked Creek tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Nineteen subbasins were delineated for the Crooked Creek area, with an average subbasin area of 118.2 acres and a total drainage area of 3.5 square miles.

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.

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.

TABLE 3.10.3
Community Response Data for Crooked Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PHI5	Palos Hills	Overbank flooding, ponding	Kean Ave. and Los Palos Ln.	Flows in Hickory Hills have no retention, and the Los Palos Hills reservoir has insufficient capacity to capture larger storms. Overflows flood the intersection. In 100-year event.	Regional	Model results did not show property damage due to flooding in this area. Previous observations may have been the result of a condition already remedied, downstream debris or maintenance issue, or a local issue.
PT5	Palos Township	Pavement flooding	Kean Ave. at 100th St. to 111th St.	IDOT reports pavement flooding	Regional	Model results did not confirm roadway flooding due to a regional problem in this area. Previous observations may have been the result of a condition already remedied or a local issue.
PT6	Palos Township	Overbank flooding, water quality, wetland riparian	U.S. Rte 45 at Crooked Creek	Flooding overtops the banks and decrease water quality	Regional	Model results did not confirm roadway flooding due to a regional problem in this area. Previous observations may have been the result of a condition already remedied or a local issue.

3.10.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Thirteen structures were surveyed. Since a detailed study was not required, cross-sectional geometry 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 coefficient to the stream.

Boundary Conditions. Appendix E contains boundary condition elevations for the Calumet-Sag Channel based on output from the CWS model. As Crooked Creek flows into the Saganashkee Slough before reaching the Calumet-Sag Channel, the CWS model output water surface elevation was not used to define the downstream boundary condition in this case. Downstream stage was assumed to be controlled by the capacity of Crooked Creek to convey flows received from its tributary area. A normal depth with a friction slope of 0.002 was evaluated as the downstream boundary condition for Crooked Creek and resulted in a WSEL about 3 feet higher than the normal pool level of the Saganashkee Slough.

3.10.2.3 Calibration and Verification

No measured or observed stages were available for Crooked Creek to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.10.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.10.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.10.3 Development and Evaluation of Alternatives

There were no problem areas identified through hydraulic modeling of Crooked Creek, so no alternatives were developed. While three reported problem areas were classified as regional problems based on the information reported, hydraulic model results did not confirm existence of these problems. Previous observations may have been the result of a condition already remedied or a local issue.

3.11 Illinois and Michigan Canal

TABLE 3.11.1
Communities Draining to I&M Canal

Community	Tributary Area (mi^2)
Unincorporated/Forest Preserve	3.21
Lemont	3.49

TABLE 3.11.2
Land Use Distribution for I&M Canal

Land Use	Acres	%
Commercial/Industrial	216.3	8.1
Forest/Open Land	999.2	37.5
Institutional	0.7	0
Residential	121.1	4.5
Transportation/Utility	773.8	29
Water/Wetland	555.5	20.8

The I&M Canal is located in southwestern Cook County in the western part of the Calumet-Sag Channel Watershed. The I&M Canal south of the Calumet-Sag Channel was modeled in detail. The I&M Canal north of the channel was modeled in limited detail. The part of the I&M Canal discussed in this subsection is that south of the Calumet-Sag Channel. Table 3.11.1 lists the areas of communities that drain to the I&M Canal. The population density of the I&M Canal subwatershed is low with a mix of suburban development and a high amount of open land. Most of the open land within the watershed is Cook County Forest Preserve Property.

The drainage area is roughly 6.7 square miles. The I&M Canal is a manmade canal that has been dammed and blocked at two locations. It receives flow from I&M Tributary A and I&M Tributary B & C (also known as Convent Creek) near Lemont, as well as from the Castle Bowl subwatershed (also known as School Gully and Hillview Ditch) in Lemont. It discharges to the CSSC through a channel on the International-Matex Tank Terminals (IMTT) industrial property. Table 3.11.2 lists the land use breakdown by area within the I&M Canal subwatershed. Figure 3.11.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas and proposed alternative projects are also shown on the figure, and are discussed in the following subsections.

3.11.1 Sources of Data

3.11.1.1 Previous Studies

Christopher B. Burke Engineering conducted a study detailed in the *Flood Mitigation Studies Final Report* prepared for the Village of Lemont (Christopher B. Burke Engineering, 1997). The study recommended increasing the culvert size on a channel on the IMTT property through which the I&M Canal discharges to the CSSC and constructing a new outlet to the CSSC at the KA Steel property in Lemont.

3.11.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on the I&M Canal. No reaches 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 I&M Canal. Table 3.11.3 lists point source NPDES discharge permits identified through a USEPA water permit discharge query for facilities in the I&M Canal subwatershed area. IMTT's permits list the receiving water as the Calumet-Sag Channel, but the permits are included in this list since this particular property is discussed in this section.

TABLE 3.11.3
Point Source Dischargers in I&M Canal Area

Name	NPDES	Community	Receiving Waterway
IMTT—Lemont	IL0005126	Lemont	Calumet-Sag Channel
IMTT—Lemont SW discharge only	IL0061182	Lemont	Calumet-Sag Channel
KA Steel and Chemicals, Inc.	IL0022934	Lemont	I&M Canal, CSSC
Cook Composite and Polymers	IL0002399	Lemont	I&M Canal

Note: NPDES facilities were identified from the USEPA Water Discharge Permits Query Form at http://www.epa.gov/enviro/html/pcs/pcs_query_java.html.

Municipalities discharging to the I&M Canal are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.11.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 843 acres of wetland areas in the I&M Canal subwatershed. 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.

3.11.1.4 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, which are used to estimate flood levels, generally were not updated. LOMRs were incorporated in the revised floodplains. I&M Canal is not mapped in detail in the DFIRM mapping update but does have Zone A floodplain defined for the length of I&M Canal. Appendix A includes a comparison of FEMA's effective floodplain mapping from updated DFIRM panels with inundation areas developed for the DWP.

3.11.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdiction. Table 3.11.4 shows reported problems within the I&M Canal subwatershed.

3.11.1.6 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 projects by others have been identified for the I&M Canal subwatershed.

TABLE 3.11.4
Community Response Data for I&M Canal

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
LT4	Lemont Township	Bank erosion, sedimentation	Stephen Street and North of Talcott St.	Tree branches and debris in I&M Canal block flow	Regional	Maintenance and debris removal recommended.
LT1	Lemont Township	Pavement flooding	Route 171 (Archer Ave.) between Castlewood and Rte 83	IDOT reported pavement flooding.	Local	Roadway flooding issue not located on a regional waterway. This is a local problem.
LE1	Lemont	Ponding	Cass St. and Lemont St., downtown Lemont	During major storms, the sewer system in downtown Lemont surcharges and overflows, flooding basements, and first floors of buildings and residences.	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
WS1	Willow Springs	Overbank flooding	I&M Canal Crossing Rte 171	Pavement flooding due to high stages in the channel, three known occurrences	Local	Problem not located on a regional waterway. This is a local problem.
WS2	Willow Springs	Overbank flooding, ponding	Willow Drive and Archer Road	Channel draining Renaissance Development along Metra tracks near I&M Canal does not drain sufficiently	Local	Problem not located on a regional waterway. This is a local problem.

3.11.2 Watershed Analysis

3.11.2.1 Hydrologic Model Development

Subbasin Delineation. The I&M Canal subwatershed was delineated based upon LiDAR topographic data developed by Cook County in 2003. Forty-three subbasins, with an average area of 106 acres, were delineated for the I&M Canal area, which has a total drainage area of 6.7 square miles.

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.

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.

3.11.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Because the I&M Canal is dammed and blocked on both its upstream and downstream ends, it functions as a level-pool reservoir that is appropriately modeled as such within the hydrologic model. No hydraulic models were required to analyze flooding of the KA Steel and IMTT properties located near the I&M Canal since water surface elevations were produced through hydrologic modeling.

Boundary Conditions. Boundary condition elevations for the Calumet-Sag Channel based on output from the CWS model are included in Appendix E. The elevation produced by the CWS model for the 100-year storm at the outlet of I&M Canal was 583.92 feet NAVD 88.

3.11.2.3 Calibration and Verification

No measured or observed stages were available for the I&M Canal to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.11.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.11.1 shows inundation areas produced for the 100-year, 12-hour duration storm.

Hydraulic Profiles. Hydraulic profiles were not produced as hydraulic modeling was not performed.

3.11.3 Development and Evaluation of Alternatives

3.11.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.11.5 summarizes problem areas identified through hydrologic modeling of the I&M Canal.

TABLE 3.11.5
Modeled Problem Definition for the I&M Canal

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA47	KA Steel and Chemicals, 15185 Main Street, Lemont	25, 50, 100		Project IMCA-1 addresses this flooding.
MPA48	IMTT, 13589 Main Street, Lemont	100		Project IMCA-1 addresses this flooding.

3.11.3.2 Damage Assessment

Damages were defined following the protocol established in Chapter 6.6 of the CCSMP. Water surface elevations produced by the hydrologic model for the level-pool reservoir that represented the I&M Canal were used to define damages. No erosion damages or recreation damages due to flooding were identified for the I&M Canal. Transportation damages were estimated as 15 percent of property damages. Although no Form B was submitted, WPC participants did confirm the existence of problems at the KA Steel and IMTT sites (Problem IDs MPA47 and MPA48). Estimated Damages for the I&M Canal are listed in Table 3.11.6.

TABLE 3.11.6
Estimated Damages for the I & M Canal

Damage Category	Estimated Damage ($)	Note
Property	30,400	
Erosion	0	
Transportation	4,600	Assumed as 15% of property damage due to flooding

3.11.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in the I&M Canal. Increased conveyance or storage was identified as the principal technologies applicable for addressing stormwater problems in the I&M Canal.

3.11.3.4 Alternative Development

Flood Control Alternatives. Alternative solutions to regional flooding problems were developed and evaluated consistent with the methodology described in Section 1.4. Table 3.11.7 summarizes flood control alternatives developed for the I&M Canal. Based on community feedback, alternatives developed for the I&M Canal were taken from two previous studies: *Flood Mitigation Studies Final Report* by Christopher B. Burke Engineering, Ltd. and *Construction and Maintenance of Dams: Dam Safety Permit for Castle Bowl Retention Facility* by Engineering Resource Associates.

TABLE 3.11.7
Flood Control Alternatives for I&M Canal

Alternative	Location	Description
IMCA-1	IMTT and KA Steel sites	Construct new outlet channel at KA Steel site, and replace two 48-inch culverts at IMTT site with three 5- by 10-foot box culverts.
IMCA-2	Castle Bowl	Construct 18 acre-foot Castle Bowl detention basin. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.

3.11.3.5 Alternative Evaluation and Selection

Alternatives included in Table 3.11.7 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damages. Recommended alternative IMCA-1 results in reduced stage of the I&M Canal sufficient to address all existing conditions damages due to flooding. Table 3.11.8 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak on the I&M Canal.

TABLE 3.11.8
I&M Canal Existing and Alternative Condition Flow and WSEL Comparison

Location	Existing Conditions		IMCA-1	
	100 Yr WSEL (ft)	Max Flow (cfs)	100 Yr WSEL (ft)	Max Flow (cfs)
I&M Canal	584.5	2203	581.6	2155

Table 3.11.9 provides a summary B/C ratio, net benefits, total project costs, number of structures protected, and other relevant alternative data. Analysis showed that IMCA-2 did not reduce existing conditions damages, thus this alternative does not appear in Table 3.11.9.

3.11.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternative. Table 3.11.9 lists the alternative analyzed in detail. The recommended alternative, IMCA-1, consists of construction of a new outlet channel at the KA Steel site and replacement of the two 48-inch culverts at the IMTT site with three 5- by 10-foot box culverts. Figure 3.11.2 shows the location of recommended alternative IMCA-1 and a comparison of the inundation mapping for existing conditions and with the recommended alternative IMCA-1.

TABLE 3.11.9
I&M Canal 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	Involved Community
IMCA-1	Construct new outlets	0.03	34,700	1,043,800	3	No Impact	Yes	Lemont

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.12 Illinois and Michigan Canal Tributary A

The I&M Canal Tributary A is located in southwestern Cook County, south of the Calumet-Sag Channel, in the western part of the Calumet-Sag Channel Watershed. Table 3.12.1 summarizes the areas of communities that drain to I&M Tributary A. The I&M Tributary A subwatershed contains a mix of suburban development and some available open land. The drainage area is 0.95 square miles. I&M Tributary A is a natural open-channel stream that drains into the I&M Canal in Lemont. Table 3.12.2 lists the land use breakdown by area within the I&M Tributary A subwatershed. Figure 3.12.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are also shown on the figure, and are discussed in the following subsections.

TABLE 3.12.1
Communities Draining to I&M Tributary A

Community	Tributary Area (mi^2)
Lemont	0.9
Unincorporated/Forest Preserve	0.05

TABLE 3.12.2
Land Use Distribution for I&M Tributary A

Land Use	Acres	%
Residential	373.4	61.1
Forest/open land	118.3	19.3
Commercial/industrial	60.3	9.9
Institutional	39.4	6.4
Agricultural	15.5	2.5
Transportation/utility	4.6	0.7

3.12.1 Sources of Data

3.12.1.1 Previous Studies

Christopher B. Burke Engineering conducted a study for the Village of Lemont (Christopher B. Burke Engineering, 1997). The study recommended increasing the Main Street, New Avenue, and railroad crossings of I&M Tributary A to 8-foot-high by 12-foot-wide culverts. Because these are the sizes of the culverts at Main Street and the railroad crossing, and the culverts appear to have been constructed recently, it is believed that the recommendations for these two culverts from this study were implemented. The New Avenue structure consists of a 6- by 10-foot box culvert and a 5- by 8-foot box culvert.

3.12.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on I&M Tributary A. No reaches 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 I&M Tributary A. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to I&M Tributary A. Municipalities discharging to I&M Tributary A are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.12.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory

(NWI) mapping. NWI data includes roughly 1.8 acres of wetland areas in the I&M Tributary A subwatershed. 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.

3.12.1.4 Floodplain Mapping

Floodplain 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, which are used to estimate flood levels, generally were not updated. LOMRs were incorporated in the revised floodplains. I&M Tributary A is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of I&M Tributary A. According to the FIS, the original hydrologic and hydraulic analysis was performed in 1988. The hydrologic modeling was performed using Regression Equations 73 and 75. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.12.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. No problems were reported along I&M Tributary A.

3.12.1.6 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 projects by others have been identified for the I&M Tributary A subwatershed.

3.12.2 Watershed Analysis

3.12.2.1 Hydrologic Model Development

Subbasin Delineation. The I&M Tributary A tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Eight subbasins were delineated for the I&M Tributary A area, with an average subbasin area of 76.5 acres and a total drainage area of 0.95 square mile.

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.

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.

3.12.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of I&M Tributary A and all crossings were surveyed 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 surveyed channel cross section 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 coefficient to the stream.

Boundary Conditions. Boundary condition elevations determined for tributaries to the Calumet-Sag Channel based on output from the CWS model are included in Appendix E. The elevation produced by the CWS model for the 100-year storm at the outlet of I&M Tributary A was 581.32 feet NAVD 88, roughly 2 feet above the invert of I&M Tributary A near its confluence with the Calumet-Sag Channel. This shallow depth indicates that downstream stage on I&M Tributary A is not controlled by the receiving system, but by its own capacity to convey flows received from its tributary area. Normal depth at the downstream most cross section of the I&M Tributary A hydraulic model assuming a friction slope of 0.032 was used as a downstream boundary condition for I&M Tributary A.

3.12.2.3 Calibration and Verification

No measured or observed stages were available for I&M Tributary A to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.12.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.12.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the I&M Tributary A system. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.12.3 Development and Evaluation of Alternatives

There were no regional problem areas reported or identified through hydraulic modeling of I&M Tributary A, so no alternatives were developed.

3.13 Illinois and Michigan Canal Tributary B and C

I&M Tributary B & C is located in southwestern Cook County, south of the Calumet-Sag Channel, in the western part of the Calumet-Sag Channel Watershed. The areas of communities that drain to I&M Tributary B & C are summarized in Table 3.13.1. I&M Tributary B & C is a natural open-channel stream that drains approximately a 2.5 square mile area, discharging into the I&M Canal. The population density of the I&M Tributary B & C subwatershed is low with a mix of suburban development and a high portion of open land. Most of the open land within the watershed is Cook County Forest Preserve property. Table 3.13.2 lists the land use breakdown by area within the I&M Tributary B & C subwatershed. Figure 3.13.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are also shown on the figure, and are discussed in the following subsections.

TABLE 3.13.1
Communities Draining to I&M Tributary B & C

Community	Tributary Area (mi^2)
Unincorporated/Forest Preserve	1.94
Lemont	0.6

TABLE 3.13.2
Land Use Distribution for I&M Tributary B & C

Land Use	Area (acres)	%
Forest/ Open Land	759.2	46.9
Residential	442.9	27.3
Water/Wetland	195.1	12.1
Agricultural	176.4	10.9
Institutional	30	1.9
Commercial/ Industrial	15.8	1

3.13.1 Sources of Data

3.13.1.1 Previous Studies

No studies of I&M Tributary B & C were identified for consideration as a component of DWP development.

3.13.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on I&M Tributary B & C. There are no reaches 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 I&M Tributary B & C. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to I&M Tributary B & C. Municipalities discharging to I&M Tributary B & C are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.13.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 83.5 acres of wetland areas in the I&M Tributary B & C subwatershed. 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.

3.13.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. I&M Tributary B & C is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of I&M Tributary B & C. According to the FIS, the original hydrologic and hydraulic analysis was performed in 1988. The hydrologic modeling was performed using Regression Equations 73 and 75. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.13.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. No problems were reported along I&M Tributary B & C.

3.13.1.6 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 projects by others have been identified for the I&M Tributary B & C subwatershed.

3.13.2 Watershed Analysis

3.13.2.1 Hydrologic Model Development

Subbasin Delineation. The I&M Tributary B & C subwatershed was delineated based upon LiDAR topographic data developed by Cook County in 2003. Fourteen subbasins were delineated for the I&M Tributary B & C area, with an average subbasin area of 116 acres and a total drainage area of 2.5 square miles.

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.

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.

3.13.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of I&M Tributary B & C and all crossings were surveyed 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 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 coefficient to the stream.

Boundary Conditions. Boundary condition elevations for the Calumet-Sag Channel based on output from the CWS model are included in Appendix E. The elevation produced by the CWS model for the 100-year storm at the outlet of I&M Tributary B & C was 582.32 feet NAVD 88, which is about 10 feet below the invert of I&M Tributary B & C near its confluence with the I&M Channel because there is a drop spillway at the outlet of the tributary. This negative tailwater situation indicates that downstream stage on I&M Tributary B & C is controlled not by the receiving system, but by its own capacity to convey flows received from its tributary area. Normal depth assuming a friction slope of 0.003 was thus used as a downstream boundary condition for I&M Tributary B & C.

3.13.2.3 Calibration and Verification

No measured or observed stages were available for I&M Tributary B & C to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.13.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.13.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the I&M Tributary B & C system. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.13.3 Development and Evaluation of Alternatives

3.13.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.13.3 summarizes problem areas identified through hydraulic modeling of I&M Tributary B & C.

TABLE 3.13.3
Modeled Problem Definition for I&M Tributary B & C

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA6	Area along eastern bank of tributary at downstream end north of Main St.	25, 50, 100, 500		Risk of flooding cannot be feasibly mitigated by structural measures. Such properties are candidates for protection using nonstructural flood control measures, such as floodproofing or acquisition.

3.13.3.2 Damage Assessment

Damages were defined following the protocol established in Chapter 6.6 of the CCSMP. No erosion damages or recreation damages due to flooding were identified for I&M Tributary B & C. Transportation damages were estimated as 15 percent of property damages.

TABLE 3.13.4
Estimated Damages for I&M Tributary B & C

Damage Category	Estimated Damage ($)	Note
Property	405,900	
Erosion	0	
Transportation	60,900	Assumed as 15% of property damage due to flooding

3.13.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in I&M Tributary B & C. Increased conveyance or storage were identified as the principal technologies applicable for addressing stormwater problems in I&M Tributary B & C.

3.13.3.4 Alternative Development

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. Flood control alternatives developed for I&M Tributary B & C were focused towards on-line detention facilities and channel conveyance improvements and are summarized in Table 3.13.5.

3.13.3.5 Alternative Evaluation and Selection

Alternatives included in Table 3.13.5 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damages. None of the detention or levee alternatives analyzed effectively reduced flood damages.

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

TABLE 3.13.5
Flood Control Alternatives for I&M Tributary B & C

Alternative	Location	Description
IMTBC–1	Along creek from Walker Road to Main Street	On-line detention facility constructed by excavating the right overbank to create an additional 24 acre-feet of storage
IMTBC–2	Along creek from Main Street north to railroad	On-line detention facility constructed by excavating the right overbank to create an additional 6.9 acre-feet of storage
IMTBC–3	Along creek near outfall	An on-line detention facility added to the Alternative IMTBC-2 model constructed by excavating the left overbank to create an additional 3.2 acre-feet of storage
IMTBC–4	Along right overbank from railroad to outfall of creek	Levee on the right overbank as well as the southern property line of the industrial facility located east of the outfall of the creek to protect the site from floodwater

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 Calumet-Sag Channel DWP.

3.13.3.6 Data Required for Countywide Prioritization of Watershed Projects

None of the alternatives analyzed were effective in reducing flood damages, and therefore, benefits and costs are not presented for these alternatives. No alternatives are recommended for I&M Tributary B & C.

3.14 Illinois and Michigan Canal Tributary D

I&M Tributary D is located in southwestern Cook County, north of the Calumet-Sag Channel, in the northern part of the Calumet-Sag Channel Watershed. Table 3.14.1 summarizes the areas of communities that drain to I&M Canal Tributary D. I&M Tributary D is a natural open-channel stream draining 0.9 square miles of area before discharging into the I&M Canal. The land-use distribution within the subwatershed is a mixture of suburban development and open land, most of which is Cook County Forest Preserve property. Table 3.14.2 lists the land use breakdown by area within the I&M Canal subwatershed.

Figure 3.14.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are also shown on the figure, and are discussed in the following subsections.

TABLE 3.14.1
Communities Draining to I&M Tributary D

Community	Tributary Area (mi^2)
Unincorporated/ Forest Preserve	0.49
Hickory Hills	0.22
Willow Springs	0.19

TABLE 3.14.2
Land Use Distribution for I&M Tributary D

Land Use	Acres	%
Forest/Open Land	360	62.8
Residential	205.1	35.8
Commercial/Industrial	8.5	1.5
Institutional	0.1	0

3.14.1 Sources of Data

3.14.1.1 Previous Studies

No studies of I&M Tributary D were identified for consideration as a component of DWP development.

3.14.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on I&M Tributary D. There are no reaches 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 I&M Tributary D. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to I&M Tributary D. Municipalities discharging to I&M Tributary D are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.14.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. NWI data includes roughly 24.8 acres of wetland areas in the I&M Tributary D subwatershed. 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.

3.14.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. I&M Tributary D is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of I&M Tributary D. According to the FIS, the original H&H analysis was performed in 1979. The hydrologic modeling was performed using Regression Equation 73. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.14.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.14.3 shows reported problems along I&M Tributary D.

TABLE 3.14.3
Community Response Data for I&M Tributary D

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
HH5	Hickory Hills	Ponding, storm sewer capacity, maintenance	91st Pl. at Kean Ave.	The storm sewer to the forest preserve is typically full due to a restricted outfall in the forest preserve, and during rainfall events, the catch basin ponds back up to a property in the subwatershed.	Regional	Although model results did not show property damage, DWP includes recommendation that Forest Preserve regrade channel to allow positive drainage.
LYT1	Lyons township	Overbank flooding	Tributary to I&M Canal Crossing La Grange Rd.	Pavement flooding due to high stages in the channel, 8 known occurrences	Regional	Model results did not confirm roadway flooding due to a regional problem in this area. Previous observations may have been the result of a condition already remedied or a local issue.
WS1	Willow Springs	Pavement flooding	Archer Avenue at La-Grange Road	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem.

3.14.1.6 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 projects by others have been identified for the I&M Tributary D subwatershed.

3.14.2 Watershed Analysis

3.14.2.1 Hydrologic Model Development

Subbasin Delineation. The I&M Tributary D area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Five subbasins were delineated for the I&M Tributary D area, with an average subbasin area of 114.8 acres and a total drainage area of 0.9 square mile.

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.

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.

3.14.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of I&M Tributary D and all crossings were surveyed 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 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 coefficient to the stream.

Boundary Conditions. Appendix E contains boundary condition elevations for the Calumet-Sag Channel based on output from the CWS model. The elevation produced by the CWS model for the 100-year storm at the outlet of I&M Tributary D was 587.69 feet NAVD 88, about 3 feet above the invert of I&M Tributary D near its confluence with the I&M Canal. This shallow depth indicates that the downstream stage on I&M Tributary D is controlled not by the receiving system, but by its own capacity to convey flows received from its tributary area. Normal depth assuming a friction slope of 0.0025 was thus used as a downstream boundary condition for I&M Tributary D, resulting in a 100-year elevation of 587.69 feet at the confluence.

3.14.2.3 Calibration and Verification

No measured or observed stages were available for I&M Tributary D to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.14.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.14.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

Hydraulic Profiles. Appendix H contains hydraulic profiles of existing conditions in the I&M Tributary D system. Profiles are shown for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval design storms.

3.14.3 Development and Evaluation of Alternatives

There were no damages identified through hydraulic modeling of I&M Canal Tributary D, so no alternatives were developed. Modeling did not confirm pavement flooding where reported by IDOT through the Form B. Previous observations may have been the result of a condition already remedied or a local issue. It is recommended that the problem reported by Hickory Hills regarding flooding at 95th Street and Kean Avenue be addressed through improving maintenance practices on Forest Preserve property. This recommendation is discussed further in Section 4, Maintenance.

3.15 Justice Ditch

Justice Ditch is located in southwestern Cook County, north of the Calumet-Sag Channel, in the northern part of the Calumet-Sag Channel Watershed. The drainage area of Justice Ditch is 0.42 square miles. Approximately 0.31 square mile of that area drains to the open channel part of Justice Ditch. The remaining 0.11-square-mile area to the west of Garden Lane is drained by a network of sewers and shallow, overland flow. Communities tributary to Justice Ditch are described in Table 3.15.1.

TABLE 3.15.1
Communities Draining to Justice Ditch

Community	Tributary Area (mi^2)
Justice[a]	0.31
Unincorporated Cook County	0.11

[a]All flows tributary to the modeled open channel of Justice Ditch are contributed from within Justice.

The area draining to Justice Ditch is largely residential, with part of Bethania Cemetery draining from the upstream, easternmost section of the subwatershed. Table 3.15.2 summarizes the land use distribution within the Justice Ditch subwatershed.

TABLE 3.15.2
Land Use Distribution for Justice Ditch

Land Use Category	Area (acres)	%
Residential	178.4	66.9
Commercial/Industrial	6.3	2.3
Forest/Open Land	70.8	26.6
Institutional	4.6	1.7
Transportation/Utility	4.4	1.7
Water/Wetland	2	0.7

Figure 3.15.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas, and flood inundation areas are also shown on the figure, and are discussed below.

The modeled waterway is roughly 2,300 feet long upstream of Garden Lane, with enclosed conduits making up roughly 1,165 feet of that length. Justice Ditch discharges into a 60-inch storm sewer that conveys flows under Garden Lane and discharges to the I&M Canal west of Jocare Drive. The storm sewer is not part of the hydraulic model of the Justice Ditch.

During intense rainfall, the Justice Ditch subwatershed receives some flows from a depressional area bounded roughly by 73rd Place and 75th Street to the north and south, and Cork Avenue and 88th Avenue, to the west and east. This area was included in the 71st Street Ditch drainage area and is drained by a 24-inch sewer to the 71st Street Ditch. However, during intense rainfall events, runoff exceeds the capacity of this small sewer and reaches an elevation of about 596.5 feet, where it then overflows towards Justice Ditch, resulting in interbasin flow.

The existence of the interbasin flow, and the stormwater problem associated with it, led to the need to develop a hydraulic model for Justice Ditch to properly analyze the effects of the interbasin flow.

3.15.1 Sources of Data

3.15.1.1 Previous Studies

A 1980 IDOT study examined numerous stormwater improvements to Justice Ditch. These included channel improvements, various channel diversion alignments, and combinations of both. The 60-inch storm sewer under Garden Lane, which was designed to provide a 10-year level of service, was constructed as a result of this study (IDOT, 1980).

3.15.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Justice Ditch. There are also no reaches 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 Justice Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Justice Ditch. Municipalities discharging to Justice Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.15.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes no wetland areas in the Justice Ditch 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.

3.15.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. TR-20 and HEC-2 were used for the effective hydrologic and hydraulic Justice Ditch models, respectively. According to the FIS, the original H&H analysis was performed in 1979.

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

3.15.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.15.3 lists reported problems for Justice Ditch. JU2 is in the 71st Street Ditch Watershed, but is included below because resolution of the problem there would help both subwatersheds. The Village of Justice has indicated that, since the installation of a 36-inch lateral sewer connected to the Garden Lane sewer, overbank flooding associated with Justice Ditch has not been a problem.

3.15.1.6 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 consid-

TABLE 3.15.3
Community Response Data for Justice Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
JU2[a]	Justice	Ponding	East of Cork Ave. between 73rd Pl. and 75th St.	Depressional area has no natural outlet. Presently drains to 71st Street Ditch through an undersized storm sewer.	Local	Although this is a local problem, recommended alternative SFDT-2 provides additional discharge capacity to I&M Canal, which is a component of the IDNR plan to address local problems.

[a]Problem located in 71st Street Ditch Watershed, but affects Justice Ditch for larger storms.

ered in development of the DWP. No near-term planned projects by others have been identified for the Justice Ditch subwatershed.

3.15.2 Watershed Analysis

3.15.2.1 Hydrologic Model Development

Subbasin Delineation. The Justice Ditch tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. The area draining to problem area JU2 was included in the original delineation of Justice Ditch. However, further review of the 1980 IDOT study and the contour data in this area suggested that this location would drain to the 71st Street Ditch for small- to medium-sized storms, with inter-basin flow to Justice Ditch occurring when water levels exceed an elevation of 596.5 feet. Further cause for inclusion of this area in the 71st Street Ditch drainage basin is the proposed solution for local drainage issues in this area, which would increase discharge to the 71st Street Ditch through an enlarged sewer.

Three subbasins were delineated for the Justice Ditch tributary area, with an average subbasin area of 89 acres. Subbasin W540 drains a mobile home park area west of Garden Lane, and was modeled exclusively hydrologically as a tributary to the CSSC.

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.

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.

Inflow. Interbasin flow from the 71st Street Ditch to the Justice Ditch subwatershed begins to occur when water surface elevations in the area surrounding problem JU2 exceed an elevation of 596.5 feet, which is where overland flow to Justice Ditch occurs. The overland flows exiting the 71st Street Ditch tributary area were loaded into the Justice Ditch model.

3.15.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Justice Ditch and all crossings were surveyed, along with the intake structure for the Garden Lane channel diversion, 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 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 coefficient to the stream.

Boundary Conditions. The Justice Ditch model was extended slightly downstream of Garden Lane. The pipe discharging into the drop structure to the Garden Lane sewer is restrictive, and results in an increased stage at the upstream face of a structure located at the Justice Ditch intersection with Garden Lane. The simulated water surface elevation upstream of Garden Lane thus functions as the boundary condition for the Justice Ditch.

3.15.2.3 Calibration and Verification

No measured or observed stages were available for Justice Ditch to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.15.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.15.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.15.3 Development and Evaluation of Alternatives

3.15.3.1 Problem Definition

Model results show that overbank flooding along the Justice Ditch is significant for every recurrence interval storm evaluated as a part of the Calumet-Sag Channel DWP. Stormwater conveyed to the Justice Ditch originates within the Village of Justice and problems associated with the flooding of Justice Ditch have been classified as local. WPC participants familiar with the area have noted that flooding along Justice Ditch has not been a problem since the Garden Lane sewer was installed along with the 36-inch lateral sewer beneath 76th Place connecting to the Garden Lane sewer. The existing conditions hydraulic model developed for the DWP indicates that parts of the Justice Ditch tributary area are at risk of flooding, even with these changes in place. Differences between model results and local understanding of flood problems may result from the impact of unmodeled or simplified storm sewers and culverts that may significantly affect routing of flows in the small drainage area of Justice Ditch. Table 3.15.4 provides a summary of problem areas identified through modeling of Justice Ditch.

TABLE 3.15.4
Modeled Problem Definition for Justice Ditch

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA7	Along Justice Ditch, between Garden Lane and Banks Street	2, 5, 10, 25, 50, 100		Although this is a local problem, recommended alternative SFDT-2 provides additional discharge capacity to I&M Canal, which is a component of the IDNR plan to address local problems.
MPA8	Between 76th Place and 75th Street and Cork Avenue and Banks Street	2, 5, 10, 25, 50, 100		Although this is a local problem, recommended alternative SFDT-2 provides additional discharge capacity to I&M Canal, which is a component of the IDNR plan to address local problems.

Since problem areas within the Justice Ditch subwatershed are classified as local, no damages have been assigned for Justice Ditch. No alternatives have therefore been developed for the Justice Ditch subwatershed.

3.16 Ken Kay Ditch

Ken Kay Ditch is located in southwestern Cook County, north of the Calumet-Sag Channel, in the center of the Calumet-Sag Channel Watershed. Table 3.16.1 summarizes the areas of communities that drain to Ken Kay Ditch. The subwatershed consists mostly of suburban residential development with some open land.

TABLE 3.16.1
Communities Draining to Ken Kay Ditch

Community	Tributary Area (mi^2)
Worth	1.21
Unincorporated/Forest Preserve	0.03
Alsip	0.02
Palos Heights	0.01

The drainage area is 1.3 square miles. Ken Kay Ditch is an open-channel stream that serves as a lateral drainage ditch parallel to the Calumet-Sag Channel, which it discharges into at both ends of Ken Kay Ditch. Table 3.16.2 lists the land use breakdown by area within the Calumet-Sag subwatershed. Figure 3.16.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas are also shown on the figure, and are discussed in the following subsections.

TABLE 3.16.2
Land Use Distribution for Ken Kay Ditch

Land Use	Area (acres)	%
Residential	534.5	65.8
Forest/Open Land	177.2	21.8
Commercial/Industrial	70	7.5
Transportation/Utility	23.5	2.9
Institutional	15.6	1.9
Water/Wetland	0.3	0
Agricultural	0.1	0

No hydraulic model was developed for Ken Kay Ditch. All areas tributary to Ken Kay Ditch are drained through storm sewer systems that are completely within the Village of Worth. Problems along Ken Kay Ditch are classified as local.

3.16.1 Sources of Data

3.16.1.1 Previous Studies

No studies of Ken Kay Ditch were identified for consideration as a component of DWP development.

3.16.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Ken Kay Ditch. There are no reaches 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 Ken Kay Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Ken Kay Ditch. Municipalities discharging to Ken Kay Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.16.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 31.1 acres of wetland areas in the Ken Kay Ditch subwatershed. 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.

3.16.1.4 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; however, the effective models, which are used to estimate flood levels, generally were not updated. LOMRs were incorporated in the revised floodplains. Ken Kay Ditch is not mapped in detail in the DFIRM mapping update, and so there was no known model that meets the criteria established in Chapter 6 of the CCSMP for use in the development of DWPs.

3.16.1.5 Stormwater Problem Data

Communities, agencies (IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.16.3 shows one reported problem along Ken Kay Ditch. This problem had a readily apparent solution because the problem is related to channel maintenance. Poor grading of the channel was identified as a potential hazard to human health and safety caused by mosquito breeding in shallow stagnant waters. This problem is classified as local, however, and has not been attributed to any flood damages along the Ken Kay Ditch.

TABLE 3.16.3
Community Response Data for Ken Kay Ditch

Problem ID	**Municipality**	Problems as Reported by Local Agency	**Location**	**Problem Description**	**Local/ Regional**	**Resolution in DWP**
WO3	Worth	Ponding, bank erosion	Ken Kay Ditch at 116th Street and Harlem Avenue	Creek is in need of sediment removal. Ponding occurs in the village and within IDOT ROW adjacent to the creek.	Local	Field assessment identified the need for maintenance and grading to aid drainage.

3.16.1.6 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 projects by others have been identified for the Ken Kay Ditch subwatershed.

3.16.2 Watershed Analysis

3.16.2.1 Hydrologic Model Development

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 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.

3.16.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. No hydraulic model was developed for Ken Kay Ditch because there is only one community with significant amount of drainage area within the Ken Kay Ditch watershed. Any potential stormwater problem along Ken Kay Ditch would be classified as a local problem.

3.16.2.3 Calibration and Verification

No measured or observed stages were available for Ken Kay Ditch to compare model results to observed flows or stage. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.16.3 Development and Evaluation of Alternatives

There were no regional problems reported or damages identified in the Ken Kay Ditch subwatershed, so no alternatives were developed.

3.17 Long Run Creek

Long Run Creek is a regional waterway located in southwestern Cook County, in the southern part of the Calumet-Sag Channel Watershed. There are three distinct areas within Cook County that each drain to three waterways tributary to Long Run Creek. From west to east, the three subwatershed areas are an area that drains primarily to Long Run Creek Tributary B, the Tampier Slough drainage area, and the area that drains to Long Run Creek Tributary A and the main branch of Long Run Creek. From its headwaters located roughly southwest of the intersection of Wolf Road and 143rd Street in Orland Park, Long Run Creek flows roughly northwest and crosses into Will County near the intersection of Will-Cook Road and 139th Street. Long Run Creek Tributary A discharges into this stretch of Long Run Creek northwest of the intersection of Wolf Road and 143rd Street. Long Run Creek flows for approximately 4.8 miles within Will County, before crossing briefly back into Cook County near the intersection of State Street and Archer Avenue south of Lemont, where Long Run Creek Tributary B discharges into Long Run Creek. Near this location, Long Run Creek then flows back into Will County.

TABLE 3.17.1
Communities Draining to Long Run Creek

Community	Tributary Area (mi^2)
Unincorporated/ Forest Preserve	7.93
Lemont	1.70
Orland Park	3.40
Palos Park	0.92

TABLE 3.17.2
Land Use Distribution for Long Run Creek

Land Use Category	Area (acres)	%
Agricultural	1120.0	12.6
Commercial/Industrial	159.4	1.8
Forest/Open Land	2792.8	31.5
Institutional	82.1	0.9
Residential	3904.6	44.1
Transportation/Utility	90.3	1.0
Water/Wetland	708.3	8.0

The total drainage area to Long Run Creek within Cook County to the point where flow returns to Will County near Lemont is 13.8 square miles. Table 3.17.1 lists the communities within Cook County that drain to Long Run Creek.

The Long Run Creek subwatershed contains a mix of suburban development with open space and agricultural area. Table 3.17.2 summarizes the land use distribution within the Long Run Creek subwatershed.

Figures 3.17.1a and b show an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown on the figure and discussed in the following subsections.

3.17.1 Sources of Data

3.17.1.1 Previous Studies

Will County recently created H&H models of existing conditions in Long Run Creek to examine floodplain areas and channel improvements for the part of Long Run Creek in Will County. The extent of the H&H model does not include the parts of Long Run Creek in Cook County, and so it did not contribute directly to the development of the Calumet-Sag Channel DWP.

3.17.1.2 Water Quality Data

Monitoring Data. The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Long Run Creek. No reaches are identified as impaired in the IEPA's 2008 *Integrated Water Quality Report*, which includes the CWA Sections 303(d) and 305(b) lists. Tampier Slough, which is a wetland area draining to Long Run Creek from the north, is on the IEPA's 303(d) report because of total phosphorus and total suspended solids (TSS). No TMDLs have been established for Long Run Creek. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Long Run Creek. Municipalities discharging to Long Run Creek are regulated by the IDNR's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.17.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes 773.8 acres of wetland area in the Long Run Creek subwatershed area within Cook County. Tampier Slough accounts for 370 acres of this 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.

3.17.1.4 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, which are used to estimate flood levels, generally were not updated. LOMRs were incorporated into revised floodplain areas.

Long Run Creek is mapped in detail in the DFIRM mapping update, with Zone AE floodplain shown across the length of Long Run Creek. The original hydrologic and hydraulic analysis was performed in 1979. The hydrologic modeling was performed using L-PTIII and Regression Equations 73 and 75. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.17.1.5 Stormwater Problem Data

Communities, agencies (IDOT, CCHD), and stakeholders submitted District Form B questionnaire response data to the District summarizing stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1 of the report. Table 3.17.3 summarizes the Form B data for Long Run Creek.

3.17.1.6 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 projects by others have been identified for the Long Run Creek subwatershed.

3.17.2 Watershed Analysis

3.17.2.1 Hydrologic Model Development

Subbasin Delineation. The Long Run Creek subwatershed was delineated based upon LiDAR topographic data developed by Cook County in 2003. The subwatershed drainage area includes 9.5 square miles of area in Will County that drain into Cook County. The area within Will County was delineated using USGS maps showing 10-foot contours where LiDAR data was unavailable. Inclusion of this area was necessary to account for total flow volumes into Long Run Creek.

TABLE 3.17.3
Community Response Data for Long Run Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
LT3	Lemont Township	Pavement flooding	Route 171 (Archer Avenue) at 131st Street	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem.
OP11	Orland Park	Bank erosion, sedimentation	143rd Street and Wolf Road	Erosion/sedimentation causes flow restriction and flooding	Regional	Sedimentation not noted in field survey. May have been addressed by recent maintenance activities.
OP9	Orland Park	Overbank flooding	Long Run Creek Crossing 143rd Street (West of Wolf Road)	Pavement flooding due to high stages in the channel, 18 known occurrences	Regional	Project LRCR-5 will raise 143rd Street to address transportation damages.
OT2	Orland Township	Bank erosion, sedimentation	Will-Cook Road at Long Run Creek crossing	Silt in culvert, and severe erosion along southeast embankment	Regional	Erosion area visited and determined not to threaten any structures. Siltation not noted in field survey; may have been addressed by recent maintenance.
PP10	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	116th Avenue and 123rd Street	Floodwaters exceed capacity, 1 time per year	Local	Problem not located on a regional waterway. This is a local problem.

Eighty subbasins were delineated for the Long Run Creek tributary area, with an average subbasin area of 180 acres, including those delineated within Will County. Excluding Will County subbasins, the average size is 127.47 acres.

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.

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.

For Will County subwatershed areas tributary to Long Run Creek where LiDAR data was missing, drainage paths and lag times were approximated using USGS data and available aerial photography. This was adjusted based on the historic gage record explained in more detail in Section 3.17.2.3.

3.17.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Long Run Creek and all crossings were surveyed 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 surveyed channel cross section. Stream sections in Will County were not modeled hydraulically. 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 coefficient to the stream.

Boundary Conditions. Long Run Creek was modeled in two separate reaches: Long Run Creek upstream of Will-Cook Road and Long Run Creek Tributary B. Normal depth was set as the boundary condition for both reaches of Long Run Creek at each point of discharge into Will County. A slope of 0.0026 was used for Long Run Creek upstream of Will-Cook Road, and a slope of 0.0015 was used for Long Run Creek Tributary B where it discharges into Long Run Creek. These values are based on the slopes of the streams at each location.

3.17.2.3 Calibration and Verification

USGS Gage 05537500 is located on Long Run Creek at its crossing of State Road in southwestern Cook County, near Lemont. The gage records instantaneous stage and flow data for Long Run Creek. The data is available on the USGS Web site in "real-time," meaning usually within hours from the time that it was recorded. Summarized daily, monthly, and yearly data is also available. The drainage area of Long Run Creek to the gage location is 20.9 square miles, including 9.5 square miles within Will County. The gage record spans from 1951 to the present.

An event-based calibration of Long Run Creek was not performed because the Will County part of Long Run Creek, approximately 4.8 miles of Long Run Creek draining 16.8 acres, was not modeled hydraulically. At least one in-line reservoir is present on the Will County portion of Long Run Creek, based upon review of aerial photographs. The hydrologic model for the Will County tributary area of Long Run Creek was also of limited detail.

The absence of hydraulic routing in the Will County part of Long Run Creek initially resulted in an overprediction of flows by the model at the downstream reach of Long Run Creek. A hydrologic routing element was added to the model to account for the storage and flood routing attenuation in this area. Flood quartiles for modeled recurrence intervals from *Estimating Flood-Peak Discharge Magnitude and Frequencies for Rural Streams in Illinois* (USGS, 2004) were used to calibrate the hydrologic model. Table 3.17.4 compares the gaged and modeled flows for the range of recurrence intervals.

The comparison of modeled and gaged flows for the range of modeled design events are generally in close agreement, particularly for the larger magnitude events. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

TABLE 3.17.4
Modeled Peak Flow versus Gage Record Flow

Recurrence Interval	Modeled Peak Flow (cfs)	Gage Record Flow (cfs)	% Difference
2	611	602	1
5	1,039	1,090	-5
10	1,461	1,510	-3
25	2,011	2,140	-6
50	2,508	2,700	-7
100	3,033	3,340	-9
500	5,040	5,160	-2

3.17.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Flood inundation areas were developed based on HEC-RAS water surface elevations and Cook County topographic data. Figures 3.17.1a and b show inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.17.3 Development and Evaluation of Alternatives

3.17.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.17.5 summarizes major problem areas identified through modeling of Long Run Creek.

TABLE 3.17.5
Modeled Problem Definition for Long Run Creek

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA10	Area south of 139th Street and Will-Cook Road	10, 25, 50, 100	OT2	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.

3.17.3.2 Damage Assessment

Damages due to flooding were calculated for Long Run Creek in accordance with the methodology described in Section 1.4 and are summarized in Table 3.17.6. Transportation damages were calculated for flooding overtopping 143rd Street at the Long Run Creek crossing.

TABLE 3.17.6
Estimated Damages for Long Run Creek

Damage Category	Estimated Damage ($)	Note
Property	62,000	
Erosion	0	
Transportation	60,500	Assumed as 15% of property damage plus damages due to overtopping of 143rd Street
Recreation	0	

3.17.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in Long Run Creek. Storage, levees, and increased conveyance were considered as possible alternatives.

3.17.3.4 Alternative Development

Flood Control Alternatives. Alternative solutions to regional flooding were developed and evaluated consistent with the methodology described in Section 1.4 of this report. Table 3.17.7 summarizes flood control alternatives developed for Long Run Creek.

Erosion Control Alternatives. No erosion control alternatives were developed for Long Run Creek. Reported erosion problems were determined not to threaten any structures.

3.17.3.5 Alternative Evaluation and Selection

Five alternatives were developed for Long Run Creek to reduce damages associated with problems MPA10 and OP9. LRCR-1 consists of a levee coupled with compensatory storage in the opposite bank of the problem area near Will-Cook Road, and model results show that this alternative reduced flooding for the 25-year storm. Limited land availability in the right overbank area to provide compensatory storage prevented provision of a higher level of service, and floodwaters are predicted to circumvent the levee and cause damages for storm events larger than the 25-year storm. This alternative was not recommended because it only

TABLE 3.17.7
Flood Control Alternatives for Long Run Creek

Alternative Number	Location	Description
LRCR-1	Long Run Creek at Will-Cook Road crossing	A 300-foot levee in left overbank area with excavation in right overbank area to provide compensatory storage
LRCR-2	Long Run Creek at Will-Cook Road crossing	Increased conveyance with compensatory storage downstream of Will-Cook Road. This alternative was considered infeasible because land was not available for compensatory storage, thus benefits and costs were not developed.
LRCR-3	Long Run Creek and Long Run Creek Tributary A confluence	47 acre-foot detention basin; this alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
LRCR-4	Long Run Creek at Ruggles Court	6 acre-foot detention basin; this alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
LRCR-5	Long Run Creek at 143rd Street	Raise 143rd Street approximately four feet and construct culverts and weir structure to mimic existing hydraulic conditions up to the 100-year storm event.

protects two structures for smaller storms, resulting in a low B/C ratio with no local or ancillary benefits.

LRCR-2 involves increasing conveyance through the culvert under Will-Cook Road which discharges into Will County. This alternative was found to be effective at lowering WSELs in the vicinity of problem MPA10. However, this alternative is not considered viable because there is not enough upstream land available to provide compensatory storage to prevent flood stages from increasing downstream in Will County.

Large parcels of land were unavailable near the modeled flood problem MPA10, but were available farther upstream, such as at the area north of 131st Street between Parker Road and Bell Road. Two such locations were modeled as LRCR-3 and LRCR-4. While these storage alternatives lowered the WSEL locally, that they are located too far upstream of the problem areas to be effective in reducing flooding damages.

LRCR-1 was shown to reduce damages in the Long Run Creek subwatershed while being feasible from a regulatory perspective, although it is not recommended for the reasons provided above.

LRCR-5 consists of raising 143rd Street to prevent road overtopping. The concept for LRCR-5 includes a new culvert and weir structure designed to mimic existing hydraulic conditions up to the 100-year storm, with two orifices at the invert and of the size of the existing culverts, the weir at the elevation of the existing road, and a new culvert underneath the raised 143rd Street sized to sufficiently convey the 100-year storm event flows without increasing peak flows or WSELs upstream or downstream.

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 Calumet-Sag Channel DWP.

Table 3.17.8 below provides a summary of the depth of road flooding at 143rd Street for existing conditions and with recommended alternatives.

TABLE 3.17.8
Long Run Creek Road Overtopping Summary

Road Crossing	Road Elevation	2-yr Depth of Flooding	5-yr Depth of Flooding	10-yr Depth of Flooding
143rd Street	692.9	0.5	0.5	0.8
143rd Street (with alternative LRCR-5)	696.9			
Road Crossing	**Road Elevation**	**25-yr Depth of Flooding**	**50-yr Depth of Flooding**	**100-yr Depth of Flooding**
143rd Street	692.9	1.9	2.4	2.4
143rd Street (with alternative LRCR-5)	696.9			

Note: Blank entry indicates that road crossing does not overtop for that particular storm event.

3.17.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternative. Table 3.17.9 lists benefits and costs for LRCR-5. Alternatives LRCR-1 through LRCR-4 are not listed in Table 3.17.9 because they did not effectively reduce water surface elevations. LRCR-5 is recommended as raising 143rd Street will effectively address transportation damages at this location. The recommended alternative LRCR-5 is shown in Figure 3.17.2. A comparison of the existing conditions and alternative conditions inundation mapping is included in these figures.

TABLE 3.17.9
Long Run Creek Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
LRCR-5	Raise 143rd Street	0.06	51,100	862,700	0		None	Yes	Orland Park

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.18 Lucas Ditch

Lucas Ditch is a manmade tributary to Stony Creek in southwestern Cook County, north of the Calumet-Sag Channel, in the central part of the Calumet-Sag Channel Watershed. The ditch is roughly 2.0 miles long and drains an area of 2.7 square miles. Table 3.18.1 summarizes the communities draining to Lucas Ditch.

TABLE 3.18.1
Communities Draining to Lucas Ditch

Community	Tributary Area (mi^2)
Palos Hills	1.96
Hickory Hills	0.46
Unincorporated/Forest Preserve	0.28

The Lucas Ditch subwatershed contains a mix of urban development and little available open land in the upstream part of the subwatershed. Much of the area is drained by storm sewers or roadside ditches. Table 3.18.2 summarizes the land use distribution within the subwatershed.

TABLE 3.18.2
Land Use Distribution for Lucas Ditch

Land Use Category	Area (acres)	%
Residential	961.7	55.6
Forest/Open Land	484.7	28
Institutional	187.7	10.9
Commercial/Industrial	90.6	5.2
Water/Wetland	3.3	0.2
Transportation/Utility	1.9	0.1

The Lucas Ditch drainage system interacts with the Lucas Diversion Ditch drainage system to the east. No natural divide separates the manmade Lucas and Lucas Diversion Ditches, and the two drainage systems were modeled as hydraulically connected by overland flow during significant storms. Roberts Road forms the boundary between the tributary areas of Lucas Ditch and Lucas Diversion Ditch. Roughly 577 acres of the Lucas Ditch watershed drains into the Roberts Road storm sewer at its intersection with 99th Street, and ultimately to Stony Creek. An overflow outlet at 101st Street discharges to the headwaters of Lucas Ditch. Figure 3.18.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown on the figure, and are discussed in the following subsections.

3.18.1 Sources of Data

3.18.1.1 Previous Studies

The following studies relevant to parts of the Lucas Ditch drainage system were reviewed and considered as a part of the Calumet-Sag Channel DWP development.

Drainage Investigation: Patrick Engineering (2006) / Cook County Highway Department: Study of Roberts Road Storm Sewer from Archer Avenue to 111th Street. The study of the Roberts Road storm sewer found the sewer significantly undersized through Palos Hills, which resulted in pavement flooding. Significant offsite flows are generated from the upstream parts of the Lucas Ditch watershed, contributing to the frequent surcharge of the sewer. The report recommended increasing the size of parts of the storm sewer from 84 to 96 inches. This proposed improvement has not been implemented.

Detention Study: Knight Infrastructure Cook County Highway Department and Illinois Department of Natural Resources: Study of Proposed Detention. This study examined the effect of two proposed stormwater detention basins on flooding problems in the upstream part of the Lucas Ditch watershed. It recommends a project to expand a detention pond at 96th Street east of 88th Avenue from 2.2 to 4.4 acre-feet. A detention basin is proposed on a 0.9-acre site at the intersection of 88th Avenue and 99th Street. Gabion basket check dams are proposed in the Forest Preserve to retard flows discharging to the Roberts Road Storm sewer and to reduce streambank erosion.

3.18.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on the Lucas Ditch. No reaches 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 Lucas Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Lucas Ditch. Municipalities discharging to the Lucas Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.18.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI includes roughly 17.6 acres within the Lucas Ditch subwatershed. 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.

3.18.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. Localized Letters of Map Revisions (LOMRs) were incorporated into revised floodplain areas. The original FEMA hydrologic and hydraulic modeling was performed in 1979 using HEC-1 and WSP-2.

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

3.18.1.5 Stormwater Problem Data

Communities, agencies (IDOT, CCHD), and stakeholders submitted District Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1.4 of the report. Table 3.18.3 summarizes the Form B data for Lucas Ditch.

3.18.1.6 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 projects by others have been identified for the Lucas Ditch subwatershed.

TABLE 3.18.3
Community Response Data for Lucas Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
HH6	Hickory Hills	Overbank flooding, basement flooding, ponding, bank erosion	95th St. at 84th Ct. (Flamingo Apartments)	Runoff from forest preserves exceeds outflow drains and results in flooding two apartment buildings to the first floor. Erosion on forest preserve property.	Local	Building not identified as at imminent risk per field visit to location. Reported flooding upstream of modeled waterway. This is a local problem.
PHI2	Palos Hills	Ponding, storm sewer capacity	82nd Avenue and Eleanor Avenue	Sedimentation in Lucas Ditch upstream of 103rd St. restricts Lucas Ditch capacity.	Regional	Project LUDT-7 address sedimentation in this area. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as floodproofing or acquisition.
PHI3	Palos Hills	Overbank flooding, basement flooding, bank erosion	111th Street and 86th Avenue (11118 Spathis Drive)	Lucas Ditch floods adjacent buildings when Stony Creek is high, sometimes resulting in erosion as well. Former study recommended building a levee wall to isolate the floodplain.	Regional	Project LUDT-5 will protect properties from flooding
PHI6	Palos Hills	Bank erosion, sedimentation	101st Street and Roberts Road	Debris at upstream end of culvert, far upstream portion of Lucas Ditch, where it crosses Roberts Road.	Local	Although this is a local problem, it is addressed as part of dredging project LUDT-7

TABLE 3.18.3
Community Response Data for Lucas Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PHI7	Palos Hills	Overbank flooding, ponding	88th Avenue and 99th Street	Localized flooding in sewered headwaters of Lucas Ditch. Previous studies have identified need for additional storage and increased conveyance.	Local	Not addressed in DWP. CCHD has proposed plan to address problems at this location.
PHI8	Palos Hills	Overbank flooding, storm sewer capacity, bank erosion, wetland riparian	96th Street and Arrowhead Drive	Flooding and erosion problems due to high flows. The buildings threatened by erosion are actually in Hickory Hills.	Local	Not addressed in DWP. CCHD has proposed plan to address problems at this location.

3.18.2 Watershed Analysis

3.18.2.1 Hydrologic Model Development

Subbasin Delineation. The Lucas Ditch tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. The initial delineation based on topographic data was then reviewed and modified to reflect manmade alterations to the watershed in some locations where storm sewer data was available. One specific example of these modifications includes changes made to direct flows from the Hickory Hills Country Club and upstream areas to drain into the Roberts Road storm sewer at 98th Place.

Fourteen subbasins were delineated for the Lucas Ditch tributary area, with an average subbasin area of 124 acres and a total drainage area of 2.7 square miles.

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.

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.

Flow Diversions. The Roberts Road storm sewer has a hydraulic capacity of 384 cfs (Patrick Engineering, 2006), and an overflow outlet into Lucas Ditch at 101st Street. A simplified hydraulic model of the portion of the Roberts Road storm sewer south of 98th Street was constructed using information from the Patrick Engineering study, with one outlet to Stony Creek and another representing the overflow to Lucas Ditch. The 500-year flow produced in the 577-acre area within Lucas Ditch tributary to the storm sewer was input into the model, producing a diversion rating curve into Lucas Ditch when the inflow exceeds the capacity of the Roberts Road storm sewer. Although not fully representing the dynamics of the Roberts Road storm sewer, this method of developing a flow diversion curve is believed to more accurately represent the system hydraulics than more simplified methods, such as taking the ratio of the pipe cross-sectional area to divert flow. This diversion curve was used for all storms to split flow between Lucas Ditch and the Roberts Road sewer.

3.18.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Surveys of the open channel part of Lucas Ditch and all crossings were performed to characterize the channel and near overbank channel geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the 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 Lucas Ditch model was run as a component of the larger Stony Creek hydraulic model, with downstream boundary conditions defined by Stony Creek WSELs. A lateral structure representing the overland flow path between Lucas Ditch and Lucas Diversion Ditch was defined using a weir height of 594 feet, based upon topography in the area. This lateral structure allows interbasin flow between Lucas Ditch and Lucas Diversion Ditch if WSELs exceeds the overland flow height and a head differential exists between the two waterways.

3.18.2.3 Calibration and Verification

No measured or observed flows or stage data was available for Lucas Ditch for comparison with modeled values. Lucas Ditch is tributary to Stony Creek, which was calibrated using high-water mark elevation data. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.18.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.18.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.18.3 Development and Evaluation of Alternatives

3.18.3.1 Modeled Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.18.4 summarizes problem area locations identified through modeling.

TABLE 3.18.4
Modeled Problem Definition for Lucas Ditch

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA12	Between 103rd Street and 105th Street, and 83rd Avenue and 84th Street	50, 100	PHI2	Project LUDT-7 addresses flooding in this area.
MPA13	Area bounded by 103rd Street, Lucas Ditch, and Roberts Road	25, 50, 100		Project LUDT-7 addresses flooding in this area.
MPA14	Between 111th Street and West Stony Creek Confluence	50, 100	PHI3	Project LUDT-5 addresses flooding in this area.

3.18.3.2 Damage Assessment

Damages due to flooding were calculated for Lucas Ditch in accordance with the methodology described in Section 1.4 and are summarized in Table 3.18.5.

3.18.3.3 Technology Screening

TABLE 3.18.5
Estimated Damages for Lucas Ditch

Damage Category	Estimated Damage ($)	Note
Property	1,038,300	
Erosion	0	
Transportation	155,700	Assumed as 15% of property damage (excluding damaged parcels at the confluence)
Recreation	0	

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems along Lucas Ditch. Stormwater detention was identified as an integral component of any damage reduction strategy, with conveyance improvements, and levees (in the downstream part of Lucas Ditch) also potentially feasible technologies for addressing flood damages along Lucas Ditch. It is noted that conveyance improvement alternatives would require storage, either within the Lucas Ditch watershed or downstream in the Stony Creek corridor to avoid negative downstream impact.

3.18.3.4 Alternative Development

Stormwater improvement alternatives were developed to address flooding problems in Lucas Ditch and adjacent Lucas Diversion Ditch, which are hydraulically connected during heavy storms. The alternatives listed in Table 3.18.6 have a primary benefit in Lucas Ditch, though may result in additional damage reductions along the Lucas Diversion Ditch. For this reason, benefits are presented for Lucas Diversion Ditch as well. Flood control alternatives are listed in Table 3.18.6. No erosion control alternatives were developed for Lucas Ditch.

TABLE 3.18.6
Flood Control Alternatives for Lucas Ditch

Alternative	Location	Description
LUDT-1	Hickory Hills Golf Course	Excavate roughly 60 acre-feet of storage to reduce discharge to Roberts Road Storm Sewer/Lucas Ditch.
LUDT-2	Hickory Hills Golf Course	Impound roughly 60 acre-feet of storage on to reduce discharge to Roberts Road Storm Sewer/Lucas Ditch.
LUDT-3	From Lucas Ditch to Stony Creek along 83rd Avenue and Palos Drive	Construct 96-inch channel diversion to increase conveyance from Lucas Ditch to Stony Creek. Construct 28 ac-ft detention basin.
LUDT-4	From Lucas Ditch to Stony Creek along 83rd Avenue and Palos Drive	Construct 96-inch channel diversion to increase conveyance from Lucas Ditch to Stony Creek. Impound roughly 60 acre-feet of storage on Hickory Hills Golf Course
LUDT-5	Lucas Ditch and West Stony Creek confluence	Construct levee to restrict floodwaters from inundating structures east of Lucas Ditch at Stony Creek confluence. Construct roughly 9.5 ac-ft of compensatory storage.
LUDT-6	Lucas Ditch upstream of 103rd Street	Dredge Lucas Ditch upstream of 103rd Street, combined with 96-inch channel diversion to Stony Creek
LUDT-7	Lucas Ditch upstream of 103rd Street and Hickory Hills Golf Course	Dredge Lucas Ditch upstream of 103rd Street and impound roughly 60 acre-feet of storage on Hickory Hills Golf Course to reduce discharge to Roberts Road Storm Sewer/Lucas Ditch

3.18.3.5 Alternative Evaluation and Selection

Both LUDT-1 and LUDT-2 propose stormwater detention volumes of roughly 60 acre-feet to relieve flooding in both the Lucas Ditch and Lucas Diversion Ditch subwatersheds and Roberts Road corridor. LUDT-1 is significantly more expensive to construct, because of the cost of excavating a significant quantity of overburden material above the proposed overflow elevation (624 feet for LUDT-1) to obtain the necessary storage volume. Roughly 2 cubic yards of land must be excavated for each cubic yard of storage obtained in the area. LUDT-2, shown in Figure 3.18.2, requires more land acquisition but uses the natural topography of the area to provide the necessary storage volume. Roughly 8 acre-feet of excavation is included in this alternative to obtain fill material to for the earthen dam used to retain floodwaters. Both alternatives assume availability of land at the Hickory Hills Country Club. It may be found that this volume of detention, required to reduce the damages indicated in Table 3.18.5, is obtainable in locations other than the Hickory Hills Country Club. Costs associated with the impoundment of flows at the Hickory Hills Country Club may not reflect all engineering costs associated with regulations of dam design and construction.

Both LUDT-1 and LUDT-2 are ideally located to intercept significant flows that contribute to flooding in Lucas Ditch, and to a lesser extent Lucas Diversion Ditch, as well as the undersized storm sewer beneath Roberts Road. Damages associated with storm sewer systems such as Roberts Road are local and are not included in regional damages.

LUDT-3 proposes a 96-inch channel diversion to divert some flows from Lucas Ditch south to Stony Creek along 83rd Court and Palos Lane. Approximately 28 ac-ft of detention is also included in this alternative, so that increased flow into Stony Creek does not adversely impact properties adjacent to Stony Creek. Although water surfaces are lowered substantially, the only property damage due to flooding predicted in this area is near MPA12, comprising a relatively small fraction of overall Lucas Ditch damages. LUDT-4 combines the channel diversion from alternative LUDT-3 with the storage associated with alternative LUDT-2, resulting in more significant damage reduction than either alternative individually. Regulatory approval from regulatory agencies such as IDNR and the USACE would be required for LUDT-3 or LUDT-4. The increased conveyance would involve a new outfall with additional flow to Stony Creek. Other alternatives recommended in the DWP within the Stony Creek subwatershed include storage and will result in lower peak flow rates on Stony Creek following implementation. All flows from individual tributaries are relatively small in comparison to total flow within the Calumet-Sag Channel.

LUDT-5 protects several parcels at the confluence of Lucas Ditch with Stony Creek that are predicted to be inundated during minor storms and to have flood depths up to 2.49 feet for the 100-year storm. Construction of a levee along the east bank of Stony Creek is recommended to protect the structures from inundation. Since inundation in the area is a result of backwater from Stony Creek, the construction of a levee does not raise upstream stages on Lucas Ditch. To compensate for loss of current floodplain storage, the conceptual cost estimate for LUDT-5 includes roughly 9.5 acre-feet of storage upstream in the Stony Creek watershed. Interior drainage behind the proposed levee was assumed to need a discharge capacity roughly equal to 10 acre-feet in a 24-hour period.

LUDT-6 includes the dredging of Lucas Ditch upstream of 103rd Street. Sedimentation has reduced culvert openings and decreased channel capacity in Lucas Ditch north of 103rd Street by 1 to 1.5 feet, according to the field survey. Initial model runs including solely a dredging component reduced water surface elevation north of 103rd Street, however increased flows and predicted water surface levels downstream. Therefore, it was necessary either to reduce upstream flows by storage, or to increase downstream conveyance also to avoid exacerbating downstream flooding. LUDT-6 includes LUDT-3 with the channel diversion proposed in LUDT-3. LUDT-7 pairs the channel dredging component of LUDT-6 with the storage on Hickory Hills golf course proposed in LUDT-2.

LUDT-5, shown in Figure 3.18.3, is recommended to address significant predicted damages at the confluence of Lucas Ditch with Stony Creek. LUDT-7 is recommended to reduce flooding damages in Lucas Ditch and Lucas Diversion Ditch, including potential local benefits in the Roberts Road corridor, and to help reduce overbank flooding in Lucas Ditch upstream of 103rd street. The land necessary for construction of detention basin on the Hickory Hills golf course may not be currently available for use as a stormwater facility, however should be considered for this purpose in the event of future development, given its ideal location to intercept flows to an area with significant damages.

TABLE 3.18.7
Lucas Ditch Existing and Alternative Condition Flow and WSEL Comparison

Location	Station	Existing Conditions		LUDT-7	
		100 Yr WSEL (ft)	Max Flow (cfs)	100 Yr WSEL (ft)	Max Flow (cfs)
Roughly 200-ft downstream of Roberts Road	10561.6	593.12	143.31	592.87	92.92
Roughly 300-ft downstream of 82nd Ave.	8968.99	591.94	174.39	591.13	123.16
Roughly 200-ft downstream of 103rd St.	7650.485	591.15	209.64	590.54	140.01
Just upstream of Winter Park Dr.	4719	589.90	282.31	589.41	250.02
Roughly 230-ft downstream of 107th St.	3251.408	588.71	298.07	588.41	263.77
Roughly 250-ft upstream of the confluence with West Stony Creek	343.5076	587.43	372.29	587.35	310.19

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.18.7 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway. LUDT-5, although recommended, is not included in this table because it results in no impact on the water surface elevations.

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 Calumet-Sag Channel DWP.

3.18.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.18.8 lists alternatives analyzed in detail. Based on a comparison of B/C ratios, the recommended alternatives are LUDT-5 and LUDT-7, and are shown in Figures 3.18.2 and 3.18.3. A comparison of the existing conditions and alternative conditions inundation mapping is included in these figures.

TABLE 3.18.8
Lucas Ditch Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
LUDT-1	Storage on Hickory Hills golf course created by excavation	0.02	276,200	12,584,400	49		Slightly Positive	No	Hickory Hills, Palos Hills, Bridgeview
LUDT-2	Storage on Hickory Hills golf course created by impoundment	0.06	276,200	4,282,700	49		Slightly Positive	No	Hickory Hills, Palos Hills, Bridgeview
LUDT-3	96-inch channel diversion to Stony Creek	0.01	75,000	6,720,300	9		Slightly Negative	No	Palos Hills
LUDT-4	LUDT-2 and LUDT-3	0.03	259,100	8,080,900	45		No Impact	No	Palos Hills, Hickory Hills, Bridgeview
LUDT-5	Levee at confluence with Stony Creek, and compensatory storage	0.27	845,200	3,136,900	4		No Impact	Yes	Palos Hills
LUDT-6	Dredging upstream of 103rd Street combined with 96-inch channel diversion beneath Palos Lane	0.02	144,500	6,910,300	26		No Impact	No	Palos Hills, Hickory Hills, Bridgeview
LUDT-7	Dredge Lucas Ditch upstream of 103rd Street and provide roughly 60 ac-ft of detention on Hickory Hills golf course	0.08	340,200	4,472,600	54		Slightly Positive	Yes	Palos Hills, Hickory Hills, Bridgeview

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.19 Lucas Diversion Ditch

The area tributary to Lucas Diversion Ditch is generally flat and drained almost entirely by storm sewers. Interpretation of storm sewer data was used in conjunction with topographic data to define the subwatershed boundaries with 71st Street Ditch to the north, Melvina Ditch to the east, and Lucas Ditch to the west. Table 3.19.1 summarizes the communities that drain to the Lucas Diversion Ditch.

TABLE 3.19.1
Communities Draining to Lucas Diversion Ditch

Community	Tributary Area (mi^2)
Bridgeview	1.89
Hickory Hills	0.96
Palos Hills	0.38
Justice	0.1
Oak Lawn	0.05
Chicago Ridge	0.03

The 3.4 square miles tributary area to Lucas Diversion Ditch is heavily developed, with predominantly residential and commercial/industrial development. Table 3.19.2 summarizes the land use distribution within the Lucas Diversion Ditch subwatershed.

TABLE 3.19.2
Land Use Distribution for Lucas Diversion Ditch

Land Use Category	Area (acres)	%
Residential	1,043.8	47.8
Commercial/Industrial	636.7	29.2
Transportation/Utility	212	9.7
Forest/Open Land	208	9.5
Institutional	73.8	3.4
Water/Wetland	7.1	0.3

The drainage system of Lucas Diversion Ditch is interconnected with the Lucas Ditch system. No natural divide separates the manmade Lucas and Lucas Diversion Ditches, and the two drainage systems were modeled as hydraulically connected by overland flow during significant storms. Roberts Road was defined as the boundary between the tributary areas of Lucas Ditch and Lucas Diversion Ditch.

I-294 bisects the Lucas Diversion Ditch watershed, providing a barrier to stormwater runoff tributary to the Lucas Diversion Ditch. A large part of the area north of the I-294 collects stormwater runoff through storm sewers up to 72 inches in diameter that discharge into two detention ponds northeast of the intersection of 95th Street and I-294. A storm sewer discharges from the detention ponds to Lucas Diversion Ditch. Additional flows from the area north of I-294 drain south through either the Harlem Avenue storm sewer or overland flow routes into Stony Creek. Figure 3.19.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown on the figure, and are discussed in the following subsections.

3.19.1 Sources of Data

3.19.1.1 Previous Studies

No studies of Lucas Diversion Ditch were found to exist. An ongoing study being performed by Robinson Engineering was identified in the community response data from Bridgeview, but the study report was not obtained. The IDOT study, *Strategic Planning Study for Flood Control*, Justice, (1980) and the Patrick Engineering Roberts Road Drainage Investigation study (2006) were both useful in confirming drainage patterns at boundaries of the Lucas Diversion Ditch subwatershed.

The Patrick Engineering study found the Roberts Road storm sewer to be significantly undersized through Palos Hills and to cause pavement flooding. Significant offsite flows are generated from the upstream part of the Lucas Ditch Watershed, contributing to the frequent surcharge of this sewer. The report recommended upsizing parts of the Roberts Road storm sewer from 84 to 96 inches. The proposed improvement has not yet been implemented.

3.19.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Lucas Diversion Ditch. There are also no reaches 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 Lucas Diversion Ditch. According to a USEPA water permit discharge query, no NPDES permits were issued by IEPA for discharges to Lucas Diversion Ditch. Municipalities discharging to Lucas Diversion Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.19.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data include roughly 11.9 acres of wetland areas in the Lucas Diversion Ditch subwatershed 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.

3.19.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. Localized Letters of Map Revisions (LOMRs) were incorporated into revised floodplain areas. The original FEMA hydrologic and hydraulic analysis was performed in 1979 using HEC-1 and HEC-RAS.

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

3.19.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Community response data from Bridgeview, Palos Hills, and Hickory Hills were used to help define stormwater problems related to Lucas Diversion Ditch. Problems were classified as local or regional based upon the criteria described in Section 1. Table 3.19.3 provides a summary of Form B data for Lucas Diversion Ditch.

3.19.1.6 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 projects by others have been identified for the Lucas Diversion Ditch subwatershed.

3.19.2 Watershed Analysis

3.19.2.1 Hydrologic Model Development

Subbasin Delineation. The Lucas Diversion Ditch tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Twenty-five subwatersheds areas were defined with an average size of 87.6 acres. The topographic delineation was reviewed and modified in some locations to reflect manmade alterations to the watershed. The delineation was modified at the crossing of Harlem Avenue and I-294 to allow the upstream part of Lucas Diversion Ditch watershed to drain to Stony Creek.

TABLE 3.19.3
Community Response Data for Lucas Diversion Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
BV1	Bridgeview	Overbank flooding, pavement flooding, storm sewer capacity	Route 43 (Harlem Ave.) at 86th St.	IDOT reported flooding problems (southbound)	Local	Problem not located along a regional waterway.
BV2	Bridgeview	Basement flooding, ponding, storm sewer capacity	100th Pl. between 76th Ave. and Harlem Ave.	Excessive ponding occurs at 100th Pl. between 76th Ave. and Harlem Ave. due to drainage problems.	Local	Although this is a local problem, it may benefit from project LDDT-3.
BV5	Bridgeview, Chicago Ridge	Pavement flooding	Route 43 (Harlem Ave.) at I-94	IDOT reported pavement flooding.	Local	Problem not located along a regional waterway.
HH1	Hickory Hills	Overbank flooding, basement flooding, ponding, bank erosion, maintenance	98th St. at 7700 West	Drainage ditches have insufficient capacity to convey storm flows, resulting in ponding and basement flooding. Possible maintenance issues related to Lucas Ditch.	Regional	Project LDDT-3 will lower water elevations in downstream waterway for local sewers in this area.
HH4	Hickory Hills	Basement flooding, ponding, storm sewer capacity	Roberts Rd. between 90th and 95th Streets	Roberts Road storm sewer has insufficient capacity to convey moderate floods. Cook County will not allow additional connections to the Robert Rd. storm sewer.	Local	LUDT-7 will increase conveyance of overflow from Roberts Rd. sewer.

TABLE 3.19.3
Community Response Data for Lucas Diversion Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PHI1	Palos Hills	Overbank flooding, basement flooding, ponding	100th Pl. and 78th Ave.	Lucas Diversion Ditch has insufficient capacity, overflowing into existing undersized detention area and nearby homes.	Regional	Project LDDT-3 provides stormwater detention to address problem. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
PHI4	Palos Hills, Bridgeview	Basement flooding, ponding, storm sewer capacity, bank erosion, maintenance	Lucas Diversion Ditch from 102nd Street to 105th St.	Debris and sediment build up restricts flow in Lucas Diversion Ditch causing basement flooding north of 103rd St. in Bridgeview/ Palos Hills.	Regional	LDDT-3 includes clearing/dredging downstream of 103rd Street.
PHI6	Palos Hills	Bank erosion, sedimentation	101st St. and Roberts Rd.	Debris at upstream end of culvert, far upstream part of Lucas Ditch, where it crosses Roberts Rd.	Local	Problem not located along a regional waterway.
PHI9	Palos Hills, Bridgeview	Basement flooding, ponding, storm sewer capacity, bank erosion, maintenance	Lucas Diversion Ditch from 103rd St. to 105th St.	Sediment and debris buildup in Lucas Diversion Ditch	Regional	Project LDDT-3 addresses accumulation of sediment and debris downstream of 103rd Street.

The northern boundary of the Lucas Diversion Ditch tributary area was set at 83rd Street, based upon information from a previous study (IDOT, 1980). The delineation was modified along a part of Roberts Road to force flows from the Hickory Hills Country Club and upstream areas to drain into the Roberts Road storm sewer at 98th Place. The areas are classified as being within the Lucas Ditch watershed, but they may drain to Lucas Diversion Ditch during heavy rainfalls.

Hydrologic Parameter Calculations. CNs were estimated for each subbasin based upon NRCS soil data and 2001 CMAP land use data. This method is 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 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.

Flow Diversion. Stormwater from north of I-294 is understood to drain into the Lucas Diversion Ditch through a storm sewer beneath the interstate that discharges from detention ponds north of the interstate. Inflow into the Lucas Diversion hydraulic model was limited to 80 cfs, based upon the estimated capacity of the 60-inch pipe flowing southwest beneath the tollway. Review of contour data suggests that excess flow drains beneath the Tri-State Tollway along Harlem Avenue to the West Branch of Stony Creek, either within a storm sewer or overland.

3.19.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Surveys of the open channel part of Lucas Ditch and all crossings were performed to characterize the channel and near overbank channel geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the 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. A lateral structure representing the overland flow path between Lucas Ditch and Lucas Diversion Ditch was defined using a weir height of 594 feet, based upon topography in the area. This lateral structure allows interbasin flow between Lucas Ditch and Lucas Diversion Ditch if WSELs exceed the overland flow height and a head differential exists between the two waterways.

The Lucas Diversion Ditch model was run as a component of the larger Stony Creek hydraulic model, with downstream water surface defined by the Stony Creek water surface elevation.

3.19.2.3 Calibration and Verification

No measured or observed stages were available for Lucas Diversion Ditch to compare model results to observed flows or stage. Lucas Diversion Ditch is tributary to Stony Creek, which was calibrated using high-water mark elevation data. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.19.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.19.1 shows inundation areas along Lucas Diversion Ditch produced by the hydraulic model for the 100-year, 12-hour duration design storm.

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

3.19.3 Development and Evaluation of Alternatives

3.19.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.19.4 summarizes problem area locations determined through modeling.

TABLE 3.19.4
Modeled Problem Definition for Lucas Diversion Ditch

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA9	Roberts Road to Lucas Diversion Ditch, north of 103rd Street	10, 25, 50, 100	PHI1	Project LDDT-3 addresses flooding in this area. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.

3.19.3.2 Damage Assessment

Damages due to flooding were calculated for Lucas Diversion Ditch in accordance with the methodology described in Section 1.4, as summarized in Table 3.19.5.

TABLE 3.19.5
Estimated Damages for Lucas Diversion Ditch

Damage Category	Estimated Damage ($)	Note
Property	1,279,100	
Erosion	0	
Transportation	191,900	Assumed as 15% of property damage (excluding damaged parcels at the confluence)
Recreation	0	

3.19.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in the Lucas Diversion Ditch. Stormwater detention and conveyance improvements were also identified as potential technologies for addressing flood damages in Lucas Ditch. It is noted that conveyance improvements would require storage, either within the Lucas Diversion Ditch watershed or upstream of Lucas Diversion Ditch's confluence with Stony Creek, to avoid translating flood problems downstream.

TABLE 3.19.6
Flood Control Alternatives for Lucas Diversion Ditch

Alternative	Location	Description
LDDT-1	ComEd ROW	Excavate 17 acre-feet of detention at existing baseball diamond.
LDDT-2	ComEd ROW and along 76th Avenue north of 103rd Street	Construct three detention basins of 17, 10, and 36 acre-feet.
LDDT-3	ComEd ROW, along 76th Avenue north of 103rd Street, and LDDT south of 103rd Street	Construct detention per LDDT-2 along with channel clearing/dredging downstream of 103rd Street.
LDDT-4	ComEd ROW and along 76th Avenue north of 103rd Street	Construction of four detention basins of 17, 10, and 36 acre-feet, and 32 acre-feet. Construct berm around wetland area in lower Bridgeview area.
LDDT-5	Along 76th Avenue north of 100th Place	Construct 36 acre-ft detention basin

3.19.3.4 Alternative Development

Flood control alternatives for Lucas Diversion Ditch are listed in Table 3.19.6. No erosion control alternatives were developed for Lucas Diversion Ditch.

3.19.3.5 Alternative Evaluation and Selection

LDDT-1 consists of increasing the detention from the ComEd right-of-way, and converting a baseball field north of the property to detention. The alternative was designed to reduce damages from smaller storms causing flood damage (10- to-25-year recurrence interval) and provides limited benefits for higher magnitude events.

LDDT-2 and LDDT-3 provide significantly more stormwater detention in the Lucas Diversion Ditch subwatershed. Increasing the available conveyance capacity downstream of 103rd Street, in combination with increased detention, results in more benefits and a higher benefit-cost ratio than detention alone. Although LDDT-4 has the highest benefits of the modeled alternatives, the benefit-cost ratio is less than that of LDDT-3. Two other noneconomic considerations prevent the recommendation of LDDT-4:

- Proposed additional detention on Concord homes property is near a low-lying area where Bridgeview experiences flooding problems. The Village has expressed concern with collecting additional stormwater runoff into an already problematic location.
- Proposed additional detention on Concord homes property is currently designated as wetland area, and regulation may prohibit significant modification for stormwater detention purposes. Palos Hills has noted that the area may be a designated habitat for a species of snake.

Finally, LDDT-5 includes just the 36 ac-ft detention basin proposed on private property near the upstream extent of Lucas Diversion Ditch. Land availability and/or overall cost may cause this alternative to be more feasible than the set of detention basins comprising LDDT-3.

The predicted benefits for the Lucas Diversion Ditch alternatives occur predominantly upstream of 103rd Street. However, the modeled alternatives also result in reduced downstream flows, and also have a benefit on Stony Creek.

Recommended alternative LDDT-3 results in reduced stage and flow along the modeled waterway. Table 3.19.7 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

TABLE 3.19.7
Lucas Diversion Ditch Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		LDDT-3	
Location	Station	100 Yr WSEL (ft)	Max Flow (cfs)	100 Yr WSEL (ft)	Max Flow (cfs)
500-ft downstream of 76th Ave.	6045	594.60	641.85	594.15	450.05
400-ft upstream of 103rd St.	4153	594.06	647.37	593.50	458.38
Intersection of 104th Pl. and Vicky Ln.	2804	592.27	317.89	591.77	370.69
Just upstream of 107th St.	1042	591.95	290.51	591.03	379.08

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 Calumet-Sag Channel DWP.

3.19.3.6 Data Required for Countywide Prioritization of Watershed Projects

Based upon consideration of the B/C ratio and noneconomic criteria, LDDT-3, shown in Figures 3.19.2 is recommended to address damages due to flooding along the Lucas Diversion Ditch. The project also has benefits outside the Lucas Diversion Ditch watershed due to reduced flow to Stony Creek. Appendix I presents conceptual level cost estimates for alternatives discussed in Section 3.19.3.5. Table 3.19.8 lists the total estimated cost, benefits, and B/C ratio for each alternative. A comparison of the existing conditions and alternative conditions inundation mapping is included in Figure 3.19.2.

TABLE 3.19.8
Lucas Diversion Ditch Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
LDDT-1	One detention basin with 17 ac-ft of storage	0.09	160,900	1,883,400	8		Slightly Positive	No	Bridgeview, Palos Hills
LDDT-2	Three detention basins with 63 ac-ft of storage	0.13	848,300	6,325,500	59		Slightly Positive	No	Bridgeview, Hickory Hills, Palos Hills
LDDT-3	Three detention basins with 63 ac-ft of storage and channel clearing south of 103rd St.	0.13	885,200	6,765,000	56		Slightly Positive	Yes	Bridgeview, Hickory Hills, Palos Hills
LDDT-4	Four detention basins with 95 ac-ft of storage	0.1	1,109,000	11,648,400	65		Slightly Positive	No	Bridgeview, Hickory Hills, Palos Hills
LDDT-5	36 ac-ft detention basin	0.13	523,300	3,959,300	34		Slightly Positive	No	Bridgeview, Hickory Hills, Palos Hills

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.20 Marley Creek

Marley Creek is a regional waterway located in southwestern Cook County, in the southern portion of the Calumet-Sag Channel Watershed. The 9.91-square-mile drainage area includes 0.58 square miles of drainage area from Will County. Table 3.20.1 provides a summary of the communities within Cook County that drain to Marley Creek. Figure 3.20.1 provides an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown on the figure, and are discussed in the following subsections.

TABLE 3.20.1
Communities Draining to Marley Creek

Community	Tributary Area (mi^2)
Orland Park	6.1
Unincorporated/Forest Preserve	3.2
Orland Hills	0.03
Will County	0.58

The Marley Creek subwatershed contains a mix of suburban development, open space, and agricultural area. Table 3.20.2 summarizes the land use distribution within the Marley Creek subwatershed.

TABLE 3.20.2
Land Use Distribution for Marley Creek

Land Use Category	Area (acres)	%
Forest/Open Land	1,875	30.0
Residential	1,835	29.4
Agricultural	1,500	24.0
Commercial/Industrial	603	9.6
Water/Wetland	316	5.1
Institutional	105	1.7
Transportation/Utility	15	0.2

3.20.1 Sources of Data

3.20.1.1 Previous Studies

Will County recently created H&H models of existing conditions in Marley Creek to examine floodplain areas and channel improvements for the part of Marley Creek in Will County. The extent of the H&H model did not contain the part of Marley Creek in Cook County, and so it did not contribute directly to the development of the Calumet-Sag Channel DWP.

3.20.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Marley Creek. No reaches are identified as impaired in the IEPA's 2008 *Integrated Water Quality Report*, which includes the CWA 303(d) and 305(b) lists. Lake Sedgewick, which is a reservoir draining to the upstream end of Marley Creek from the North, is on the IEPA's 303(d) list due to total mercury and TSS. No TMDLs have been established for Marley Creek. According to a USEPA water permit discharge query, there is an NPDES permit issued by IEPA to the Andrew Corporation, located in Orland Park, for discharges to Marley Creek. Municipalities discharging to Marley Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.20.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 297 acres of wetland area in the Marley Creek 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.

3.20.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated into revised floodplain areas.

Marley Creek is mapped in detail in the DFIRM mapping update, with Zone AE floodplain shown across the length of Marley Creek. The original hydrologic and hydraulic analysis developed to produce floodplain mapping was completed in 1976. The hydrologic modeling was performed using Regression Equations 73 and 75. Steady state hydraulic routing was was performed using the WSP-2 modeling application.

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

3.20.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1 of the report. Table 3.20.3 summarizes the Form B data for Marley Creek.

3.20.1.6 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 projects by others have been identified for the Marley Creek subwatershed.

3.20.2 Watershed Analysis

3.20.2.1 Hydrologic Model Development

Subbasin Delineation. The Marley Creek subwatershed was delineated based upon LiDAR topographic data developed by Cook County in 2003. The subwatershed drainage area includes 0.56 square mile in Will County that drains into Cook County. The area within Will County was delineated using USGS maps showing 10-foot contours. Forty-six subbasins

TABLE 3.20.3
Community Response Data for Marley Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
FP1	Forest Preserve District	Overbank flooding, ponding, water quality, wetland riparian	LaGrange and 167th Street	High runoff and salt from roads has degraded habitat and water quality.	Local	Problem not located on a modeled, regional waterway
OP12	Orland Park	Bank erosion, sedimentation	108th Avenue at Marley Creek crossing	Silt in three 10- by 8-foot box culverts where Marley Creek crosses 108th Avenue.	Regional	Maintenance recommended to address problem, not associated with property damages. Sediment was observed in the box culverts.
OP3	Orland Park	Overbank flooding, bank erosion, sedimentation, maintenance, wetland riparian	Marley Creek at Cameron Parkway and Norfolk Southern R.R.	Flooding on Wolf Road due to restricted conveyance in Marley Creek, seems to be caused primarily by debris and sedimentation causing blockages in conveyance.	Regional	Stream maintenance and debris removal recommended to address problem. Sediment was not observed in Marley Creek in this area during field visit. Adjacent property damage due to flooding addressed by project MACR-1.
OP6	Orland Park	Maintenance, sedimentation, bank erosion	Marley Creek at Anthony Drive to Meade Street	Flooding on 104th Avenue due to restricted conveyance in Marley Creek, seems to be caused primarily by debris and sedimentation causing blockages in conveyance.	Regional	Stream maintenance and debris removal recommended to address problem. Debris was observed in Marley Creek in this area. No property damage due to flooding.

were delineated for the Marley Creek Tributary area, with an average subbasin area of 138 acres.

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.

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.

For Will County subbasins tributary to Marley Creek, drainage paths and lag times were approximated using available USGS data and available aerial photography.

3.20.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Surveys of the open channel part of Marley Creek and all crossings were performed to characterize the channel and near overbank channel geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the surveyed channel cross section. Stream sections in Will County were not modeled hydraulically. 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 coefficient to the stream.

Boundary Conditions. Normal depth with a friction slope of 0.002 was used as the boundary condition for Marley Creek at the point of discharge into Will County.

3.20.2.3 Calibration and Verification

No measured or observed stages were available for Marley Creek to compare model results. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.20.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Flood Inundation areas were developed based on HEC-RAS water surface elevations and Cook County topographic data. Figure 3.20.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.20.3 Development and Evaluation of Alternatives

3.20.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.20.4 summarizes major problem areas identified through modeling of Marley Creek.

3.20.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No erosion or recreation damages due to flooding were identified for Marley

Creek. Transportation damages were estimated as 15 percent of property damages. Table 3.20.5 lists the damage assessment for existing conditions.

TABLE 3.20.4
Modeled Problem Definition for Marley Creek

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA15	Area near West Dr. and Centennial Dr. intersection	100, 500		Model results show roadway flooding, but no property damage. Due to the availability of alternative routes, a resolution to transportation damages has been deemed unnecessary.
MPA16	Area north of 173rd St. and Wolf Rd.	25, 50, 100, 500		Project MACR-1 addresses flooding in this area
MPA17	Area north of 175th St. and 110th Ct.	5, 10, 25, 50, 100, 500		Project MACR-1 addresses flooding in this area
MPA18	Homes on Marley Brook Ct.	100, 500	OP3	Project MACR-1 addresses flooding in this area

3.20.3.3 Technology Screening

Flood control technologies were screened to identify appropriate technologies for addressing the flooding problems in Marley Creek. Storage was the primary potential technology considered for addressing flooding problems along Marley Creek. Levees were not considered as the properties with flood damages were located far apart and the existing inundation area is rather large with deep flood elevations.

TABLE 3.20.5
Estimated Damages for Marley Creek

Damage Category	Estimated Damage ($)	Note
Property	472,500	
Erosion	0	
Transportation	70,900	Assumed as 15% of property damage
Recreation	0	

3.20.3.4 Alternative Development

Flood Control Alternatives. Alternative solutions to regional flooding were developed and evaluated consistent with the methodology described in Section 1.3.8 of this report. Table 3.20.6 summarizes flood control alternatives developed for Marley Creek.

TABLE 3.20.6
Flood Control Alternatives for Marley Creek

Alternative Number	Location	Description
MACR-1	Marley Creek at Wolf Road crossing	117 acre-feet detention upstream of flooding problems with overflow pipe and overflow weir
MACR-2	Long Run Creek at Will-Cook Road crossing	Three detention basins, 117 acre-feet, 21acre-feet, 8 acre-feet, each with low flow pipe and overflow weirs. This alternative did not effectively reduce water surface elevations beyond reduction caused by MACR-1 in the flooding problem area, thus benefits and costs were not developed.

Stormwater detention alternatives were modeled for Marley Creek to relieve the flooding in the areas around Wolf Road (listed in Table 3.20.4 as modeled flooding problem areas MACR2 and MACR3). Alternative MACR-1, a detention basin on large, vacant parcels just upstream of 171st Street and Wolf Road was effective in lowering flooding damages. One major parcel of open land considered for stormwater detention is owned by the Archdiocese, near the intersection of Marley Creek and Wolf Road.

Erosion Control Alternatives. No erosion control alternatives were developed for Marley Creek.

3.20.3.5 Alternative Evaluation and Selection

The alternatives listed in Table 3.20.6 were evaluated to determine their effectiveness and to produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damages. MACR-2 did not result in additional WSEL reduction as compared to MACR-1. A summary of B/C ratios, net benefits, total project costs, number of structures protected, and other relevant alternative data is provided in Section 3.20.3.6. Alternatives that did not produce a significant reduction in water surface are not listed in this table.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.20.7 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

TABLE 3.20.7
Marley Creek Existing and Alternative Condition Flow and WSEL Comparison

	Existing Conditions			MACR-1	
Location	Station	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)
104th Ave and 159th St.	20877	686.07	159.38	686.07	159.87
100-ft upstream of 108th Ave.	16990	685.19	560.94	685.17	561.69
Downstream of Wolf Rd.	11480	679.64	672.33	679.18	609.32
NE of 175th St. and Wolf Rd.	7271	677.18	903.94	676.69	775.04

TABLE 3.20.7
Marley Creek Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		MACR-1	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
104th Ave and 159th St.	20877	686.07	159.38	686.07	159.87
500-ft downstream of Marley Creek Tributary B confluence	5177	677.02	1442.96	676.34	1215.68
400-ft downstream of 179th St.	2690	673.06	1560.01	672.68	1304.69
Cook-Will County line	266	670.50	1708.14	670.08	1440.32

It is recognized that alternative MACR-1 is a large capital project that results in benefits to a few structures, and a low B/C ratio. When isolated structures require such a large capital project to address flood damages, flood-proofing may be a more cost-effective alternative. 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 Calumet-Sag Channel DWP.

Although not contributing to modeled damages, channel maintenance downstream of 108th Avenue is recommended to address debris and sedimentation in this portion of the creek.

3.20.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.20.8 lists alternatives analyzed in detail. The recommended alternative MACR-1 is shown in Figure 3.20.2. A comparison of the existing conditions and alternative conditions inundation mapping is included in this figure.

TABLE 3.20.8
Marley Creek Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
MACR-1	Construct 117 ac-ft detention basin	0.01	160,100	15,985,700	3		Slightly Positive	Yes	Orland Park

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.21 Melvina Ditch

Melvina Ditch is tributary to Stony Creek in southwestern Cook County, north of the Calumet-Sag Channel, in the northern portion of the Calumet-Sag Channel Watershed. The open channel portion of Melvina Ditch is just less than one mile long; however, it drains a heavily sewered tributary area of 8.5 square miles. Seven communities are tributary to Melvina Ditch (Table 3.21.1), with principal sources of flow from Bedford Park, Burbank, and Oak Lawn.

TABLE 3.21.1
Communities Draining to Melvina Ditch

Community/Tributary	Tributary Area (mi^2)
Burbank	3.76
Bedford Park	2.57
Oak Lawn	1.51
Bridgeview	0.21
Chicago Ridge	0.18
Unincorporated/Forest Preserve	0.13
Chicago	0.09

The Melvina Ditch tributary area is almost entirely developed, with large amounts of impervious area associated with residential and commercial development. The distribution of land use within Melvina Ditch tributary area is summarized in Table 3.21.2.

TABLE 3.21.2
Land Use Distribution for Melvina Ditch

Land Use Category	Area (acres)	%
Residential	2,883.1	53.3
Commercial/ Industrial	1,353	25
Transportation/Utility	525.8	9.7
Forest/Open Land	404.6	7.5
Institutional	240.5	4.4
Water/Wetland	7.1	0.1

Two reservoirs within the Melvina Ditch tributary area provide significant storage for the watershed. At the upstream part of the tributary area, the 300 acre-feet Bedford Park reservoir detains flows from Bedford Park. The outlet from this reservoir is controlled by a sluice gate that is closed during rainfall events to protect downstream areas. The Melvina Ditch Reservoir, located in Burbank, provides 165 acre-feet of stormwater detention. During a storm, the reservoir can be pumped up to a rate of 200 cfs discharging to Melvina Ditch. A significant part of the watershed downstream of Melvina Ditch Reservoir has no significant stormwater detention. Figure 3.21.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown on the figure, and are discussed in the following subsections.

3.21.1 Sources of Data

3.21.1.1 Previous Studies

No recent studies of Melvina Ditch are known to exist. The report *Preliminary Report on Melvina Ditch* (Consoer, Townsend & Associates/District, 1968) was reviewed to obtain information relevant to the Calumet-Sag Channel DWP development. It examines the capacity of Melvina Ditch to accept flows discharged from the Melvina Ditch Reservoir. No data from the report was used to support modeling or the development and evaluation of alternatives for the Calumet-Sag Channel DWP.

3.21.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Melvina Ditch. No reaches 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 Melvina Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Melvina Ditch. Municipalities discharging to Melvina Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.21.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes 87.2 acres of wetland areas in the Melvina Ditch subwatershed. 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.

3.21.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains.

Melvina Ditch is mapped in detail in DFIRM mapping update, with Zone AE floodplain defined for the length of the ditch. The original hydrologic and hydraulic analysis was performed in 1979. Hydrologic modeling was performed by using TR-20 in combination with regression equations from 1974. Steady state hydraulic routing was performed using the WSP-2 modeling application.

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

3.21.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1 of the report. Table 3.21.3 summarizes the Form B data.

3.21.1.6 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 projects by others have been identified for the Melvina Ditch subwatershed.

TABLE 3.21.3
Community Response Data for Melvina Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
BU1	Burbank	Overbank flooding, storm sewer capacity	87th St. and Natchez Ave.	Overbank flooding and ponding has historically occurred surrounding the Melvina Ditch Reservoir. The District made improvements to the reservoir and coordinated with Bedford Park, with no problems at the reservoir reported since.	Local	Problem not located on a regional waterway.
BU2	Burbank	Pavement flooding	Route 50 (Cicero Ave.) at Keller Dr. (77th Street Viaduct)	IDOT reported pavement flooding	Local	Problem not located on a regional waterway
CR1	Chicago Ridge	Maintenance, ponding	Melvina Ditch at West Stony Creek	Previously reported maintenance request (Nov 2006) at confluence with Stony Creek	Regional	Removal of debris to be addressed by stream maintenance
CR2	Chicago Ridge, Oak Lawn	Bank erosion, sedimentation	Melvina Ditch along Chicago Ridge Mall (between 95th St. and West Stony Creek)	Sediment and erosion problems, lack of maintenance	Regional	Project MEDT-1 addresses erosion problems between 95th and 99th Street
CR3	Chicago Ridge	Overbank flooding	Confluence of Melvina Ditch with Stony Creek	The adverse confluence angle of Melvina Ditch with Stony Creek is perceived to contribute to higher flood stages along West Stony Creek	Regional	Impact of Melvina Ditch junction angle was considered, and analysis concluded that the adverse angle has no significant impact on flooding.

3.21.2 Watershed Analysis

3.21.2.1 Hydrologic Model Development

Subbasin Delineation. The Melvina Ditch tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Forty subbasins were defined with an average size of 146.4 acres. The Melvina Ditch tributary area is flat and generally drained by storm sewer systems. Significant modifications to the initial topographic delineation were required to accurately characterize drainage patterns into the Bedford Park and Melvina Ditch Reservoirs based upon available storm sewer data.

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.

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.

Reservoirs. The Bedford Park and Melvina Ditch reservoirs each were represented as reservoirs in the Melvina Ditch subwatershed hydrologic model. The depth-volume relationship of the 165 acre-foot Melvina Ditch reservoir and the 277 acre-foot Bedford Park reservoir were obtained from Cook County topographic data. The Bedford Park reservoir drains by gravity through a 4-foot sluice gate. District M&O personnel reported that the gate is closed during storms to maximize storage in the reservoir and to reduce downstream flow to the Melvina Ditch Reservoir. The Melvina Ditch Reservoir is drained by three stormwater pumps, each with a capacity of 66 cfs (District *M&O Facilities Handbook,* 2006). The maximum pumped discharge rate from Melvina Ditch Reservoir is 200 cfs.

Flow Restrictions. Most of the tributary area represented in the Melvina Ditch hydrologic model is sewered. The storm sewer network and the hydraulic capacity generally are not represented in the hydrologic model. Where surface topography is very flat, indicating limited overland flow, it was necessary to limit the flow conveyed within the hydrologic model to the estimated conveyance capacity of the sewer. The 120-inch pipe influent to the Melvina Ditch Reservoir was limited to 600 cfs capacity. In addition, an 84-inch storm sewer in Oak Lawn flows east into the discharge pipe from Melvina Ditch Reservoir at the intersection of 93rd Street and Nashville Avenue. The conveyance capacity of this pipe was limited to roughly 200 cfs. Approximately 1.5 square miles of Oak Lawn discharges to Melvina Ditch through a number of storm sewers downstream of the Melvina Ditch Reservoir, including 42-inch and 84-inch storm sewers along 93rd Street (upstream of the open channel portion of Melvina Ditch). Peak flows from this heavily developed area of Oak Lawn are estimated as approximately 540 cfs, which is more than twice the peak discharge from the Melvina Ditch Reservoir.

Combined Sewer. Roughly 320 acres of the Melvina Ditch tributary area in Bedford Park is served by combined sewers. The combined sewers convey an estimated 0.25 cfs/acre of runoff out of the Melvina Ditch subwatershed through the District interceptor. Runoff in excess of 0.25 cfs/acre was routed through the Melvina Ditch hydrologic model.

3.21.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Surveys of the open channel part of Melvina Ditch and all crossings were performed to characterize the channel and near overbank channel geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the 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 Melvina Ditch model is a component of the larger Stony Creek hydraulic model, with downstream water surface defined by the Stony Creek water surface elevation.

3.21.2.3 Calibration and Verification

Observed Data. The wet well elevation of Melvina Ditch Reservoir is recorded continuously on paper charts, which were obtained and compared with model results for the storm events of September 13, 2008 and August 23, 2007. Reservoir elevations were extracted from the chart at hourly intervals, and typical values and patterns preceding and following the storm were noted. An elevation of 3.5 feet was observed to be the average wet well elevation when the reservoir is dry. Therefore, 3.5 feet was subtracted from charted wet-well elevations for comparison with the hydrologic model results. For the August 23, 2007 event, a dry weather flow value of 7.5 ft was subtracted from the recorded level to represent a baseflow observed on the paper charts.

Verification Results. The hydrologic and hydraulic models were evaluated using the revised curve numbers reduced by 10 percent from the originally calculated values, as described in Section 1.3.8. This adjustment was based upon calibration evaluations in other subwatersheds that had gage data available. Figures 3.21.2 and 3.21.3 show model results for the reservoir depth compared with the monitoring data. Peak depths are summarized in Table 3.21.4.

TABLE 3.21.4
Peak Depths

Rainfall Event	Recorded Reservoir Depth (ft)	Modeled Wet-Well Depth (ft)	Difference (ft)
08/23/2007	10.5	10.87	0.33
09/13/2008	19	19.7	0.7

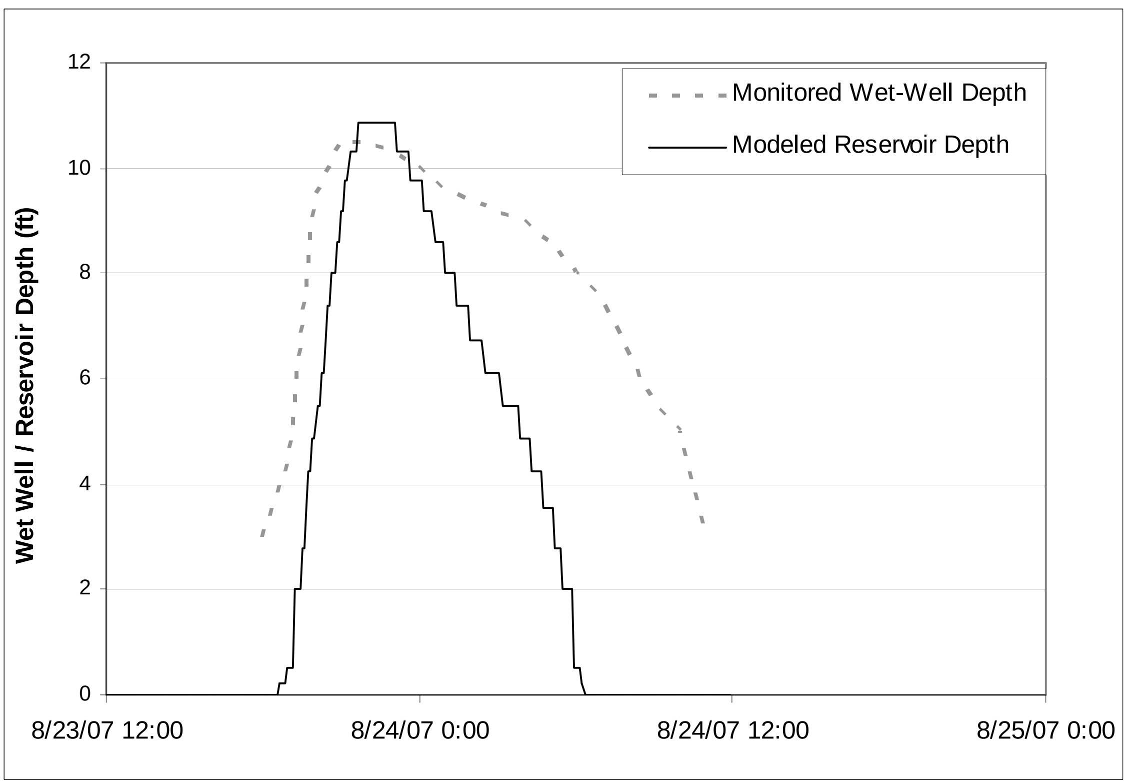
As Figures 3.21.2 and 3.21.3 demonstrate, the Melvina Ditch hydrologic model is generally accurate in predicting reservoir depths for the historic rainfall events considered. It is likely that operational decisions of the pumps discharging from Melvina Ditch Reservoir, or operation of the sluice gate regulating discharge from the Bedford Park Reservoir, contribute to some of the observed discrepancy. Some of the variables potentially impacting the ability to simulate Melvina Ditch Reservoir inflows and outflows include the following:

- **Reservoir Operation—**Actual operation of the Melvina Ditch Reservoir, or the upstream Bedford Park Reservoir, may deviate from generalized understanding of typical operating procedures. The Bedford Park sluice gate is kept closed in the hydrologic model, although in reality, the gate is opened following the storm to allow discharge to the Melvina Ditch Reservoir.
- **Monitoring Accuracy—**Recorded wet well elevation data include some atypical patterns that may not be accurate.

- **Rainfall Variability—**A single rain gage (ISWS Gage 12) was used to represent rainfall in the 8.47-square-mile tributary area of Melvina Ditch for modeled events. Variability in timing and intensity of actual rainfall within the tributary area is likely. Likely variability of rainfall data is evident during the 9/14 storm event when recorded stage data in the Melvina Ditch Reservoir showed an increase that did not correspond to the recorded rainfall data at ISWS Gage 12. District rain gage data was also reviewed and determined to be consistent with ISWS gage data.
- **Hydraulics of Tributary System—**The hydrologic model delivering flows to Melvina Ditch Reservoir has a limited ability to model hydraulic restrictions in storm sewers within the area tributary to the reservoir. Inflow into the Melvina Ditch Reservoir was limited to 600 cfs based upon hydraulic limitations of the primary pipe discharging into the reservoir. However, the hydrologic model does not generally reflect hydraulic restrictions in within the local Burbank and Bedford Park storm sewer systems.

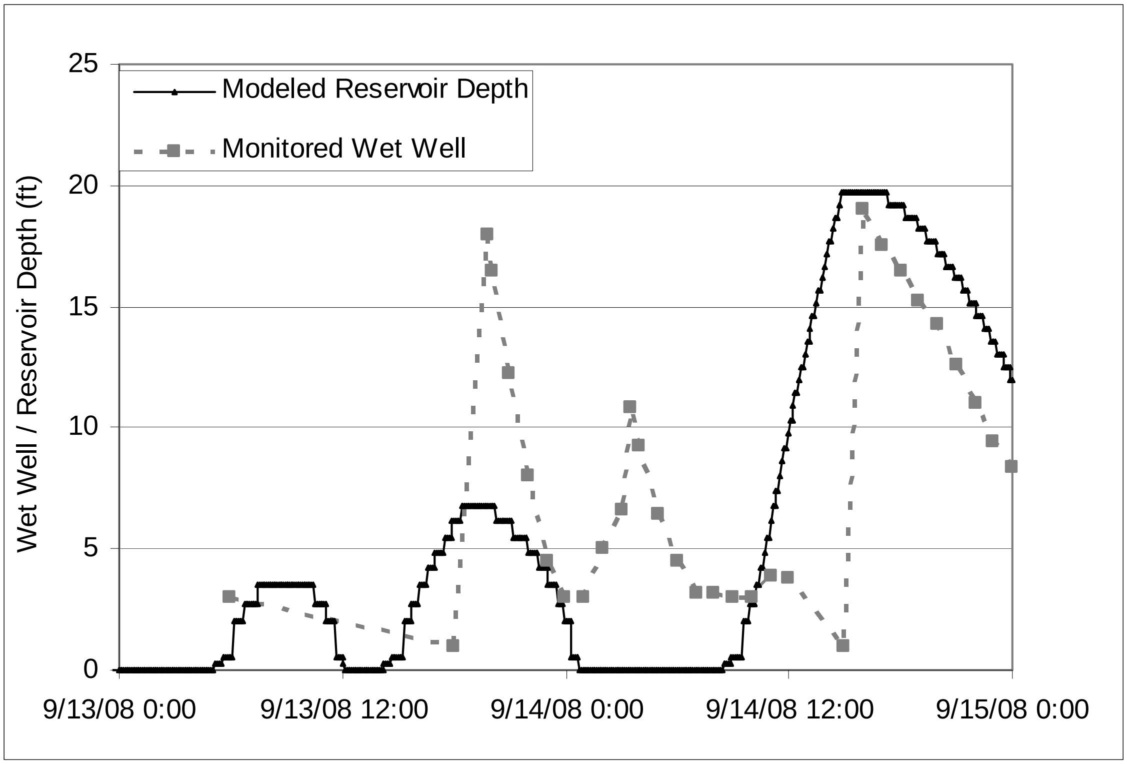
Modifications to Model Input. Curve numbers in the Melvina Ditch subwatershed were reduced by 10 percent from the originally calculated values based upon the calibration effort described in Section 1.3.8.

FIGURE 3.21.2
Modeled vs. Monitored Melvina Ditch Reservoir Depth during August 23, 2007 Storm



* Average recorded dry weather flow wet-well depth of 7.5 feet subtracted from monitored wet well depth

FIGURE 3.21.3
Modeled vs. Monitored Melvina Ditch Reservoir Depth during September 13, 2008 Storm



* Average recorded dry weather flow wet-well depth of 3.5 feet subtracted from monitored wet well depth

3.21.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.21.1 shows inundation areas along Melvina Ditch produced by the hydraulic model for the 100-year, 12-hour duration design storm. Flooding at the downstream end of Melvina Ditch is due to backwater from Stony Creek.

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

3.21.3 Development and Evaluation of Alternatives

3.21.3.1 Modeled Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.21.5 summarizes problem areas identified through hydraulic modeling of Melvina Ditch.

TABLE 3.21.5
Modeled Problem Definition for Melvina Ditch

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA19	Between 99th Street and 98th Street, between Melvina Ditch and the railroad tracks	25, 50, 100		Projects STCR-3 and STCR-8 will reduce flooding in this area

3.21.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. Erosion damages were determined based on the values of structures located within 30-feet of areas of active erosion. Other damages also included in erosion damages for Melvina Ditch include damage to the Nashville Avenue roadway and utilities and the temporary relocation of households for which Nashville Avenue is the only means of access. No recreation damages due to flooding were identified for Melvina Ditch. Transportation damages were estimated as 15 percent of property damage due to flooding. Table 3.21.6 lists the damage assessment for existing conditions.

TABLE 3.21.6
Estimated Damages for Melvina Ditch

Damage Category	Estimated Damage ($)	Note
Property	170,600	
Erosion	340,300	6615 West 95th Street in Oak Lawn at imminent risk of damage due to erosion
Transportation	25,600	Assumed as 15% of property damage due to flooding
Other – Road/Utility Repair/Replacement	1,220,600	Damage to road along Nashville Avenue
Other – Temporary Relocation of Residents	105,000	Temporary relocation of seven households with only Nashville Avenue as means of access to home

3.21.3.3 Technology Screening

Erosion control measures were considered for Melvina Ditch to protect buildings and adjacent infrastructure from damage due to erosion. Due to the steep banks of Melvina Ditch, hard armoring and structural stabilization were considered the most feasible erosion protection measures.

3.21.3.4 Alternative Development

Flood Control Alternatives. No flood control alternatives were developed for Melvina Ditch.

Table 3.21.7 summarizes the two erosion control alternatives developed for Melvina Ditch. The cost estimate for MEDT-1 includes hard armoring of the west bank of Melvina Ditch between 95th and 99th Streets, as well as biostabilization of half of the east bank of the channel, which may be conservative since some locations might not need lining. Some parts of the ditch do not show signs of active erosion and may not require stabilization. The extent of stabilization required to address damages should be confirmed through a detailed evaluation of site conditions conducted during a design study.

TABLE 3.21.7
Erosion Control Alternatives for Melvina Ditch

Alternative	Location	Description
MEDT-1	Between 95th and 99th Street	Hard armoring of west channel banks for both channel banks between 95th and 99th Streets. Reinforced concrete walls were used in cost estimates, however, in some locations, softer channel protection measures may be appropriate and will be determined during the project design phase. Some excavation is required to avoid reduction of channel conveyance capacity. Some excavated material may be replaced within the channel to provide a low flow channel with variable habitat.
MEDT-2	Between 95th and 99th Streets	Enclose Melvina Ditch in two 102-inch pipes (the dimensions of 99th Street crossing). Fill in above pipes and provide vegetative cover for area

3.21.3.5 Alternative Evaluation and Selection

Both MEDT-1 and MEDT-2 propose channel modifications that address all damages associated with erosion problems between 95th Street and 99th Street. The benefits for MEDT-2 include roughly $200,000 in benefits (over a 50-year time horizon) for property damage due to flooding and associated transportation damages. These benefits occur in a location where Oak Lawn has not indicated historic flooding problems. MEDT-1, shown in Figure 3.21.5, is more cost-effective for addressing the erosion problems actively threatening a structure in Chicago Ridge, a 2,200-foot stretch of Nashville Avenue, and associated utilities north of 99th Street. Four additional noneconomic considerations favor MEDT-1 as the recommended alternative to address damages between 95th and 99th streets:

- **USACE Section 14 Funding—**The USACE provides financial support for channel-lining projects that protect public infrastructure from damage due to erosion.
- **Downstream Impacts—**Increased velocity within the enclosed conduit proposed in MEDT-2 would require dissipation downstream to avoid creating erosion damages further downstream. Installation of such a structure could reduce channel conveyance.
- **Aquatic Habitat—**Enclosure of Melvina Ditch reduces aquatic habitat within the Calumet-Sag Channel Watershed. The 2,800-foot stretch of Melvina Ditch upstream of 99th Street is part of the only open channel aquatic environment within the 8.47 square mile watershed.
- **Regulatory Feasibility—**Enclosure of Melvina Ditch may present a greater permitting obstacle than lining of the channel, because of the potential downstream impact combined with loss of aquatic habitat.

MEDT-1 is recommended as a lower cost, feasible improvement to address erosion damages that will continue to worsen without corrective action.

MEDT-1 does not address shallow flooding predicted by the existing conditions in Melvina Ditch subwatershed. 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 Calumet-Sag Channel DWP.

3.21.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.21.8 lists the total estimated cost, benefits, and B/C ratio for each alternative. The recommended alternative MEDT-1 is shown in Figure 3.21.4. A comparison of the existing conditions and alternative conditions inundation mapping is included in this figure.

TABLE 3.21.8
Melvina Ditch Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
MEDT-1	Hard-armoring of eroding streambank	0.58	1,665,900	2,854,500	8	USACE	Slightly Positive	Yes	Chicago Ridge, Oak Lawn
MEDT-2	Enclosure of channel upstream of 99th Street	0.24	1,862,100	7,743,300	8	USACE	Slightly Negative	No	Chicago Ridge, Oak Lawn

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.22 Merrionette Park Ditch

Merrionette Park Ditch is located in southwestern Cook County, north of the Calumet-Sag Channel, in the northern part of the Calumet-Sag Channel Watershed. The areas of communities that drain to Merrionette Park Ditch are summarized in Table 3.22.1. The population density of the Merrionette Park Ditch subwatershed is relatively high with a mix of urban development and little available open land. Figure 3.22.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas and flood inundation areas are shown and are discussed in the following subsections.

The 4.2-square-mile drainage area is heavily sewered and relatively flat, and discharges to East Stony Creek. Merrionette Park Ditch consists of a manmade channel located in line with Central Park Avenue along the Alsip municipal boundary. The ditch alignment is located directly above a District sanitary sewer interceptor. Table 3.22.2 provides a summary of land use distribution within the Merrionette Park Ditch subwatershed.

TABLE 3.22.1
Communities Draining to Merrionette Park Ditch

Community	Tributary Area (mi^2)
Chicago	3.07
Unincorporated/ Forest Preserve	0.54
Merrionette Park	0.38
Blue Island	0.14
Alsip	0.08
Evergreen Park	0.01

TABLE 3.22.2
Land Use Distribution for Merrionette Park Ditch

Land Use Category	Area (acres)	%
Residential	1742.5	64.6
Forest/Open Land	673.4	25
Commercial/Industrial	197.82	7.3
Institutional	77.8	2.9
Water/Wetland	6.4	0.2

3.22.1 Sources of Data

3.22.1.1 Previous Studies

No existing studies of Merrionette Park Ditch were identified for consideration as a component of DWP development.

3.22.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Merrionette Park Ditch. There are no reaches 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 Merrionette Park Ditch. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Merrionette Park Ditch. Municipalities discharging to Merrionette Park Ditch are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.22.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 13.8 acres of wetland areas within the Merrionette Park Ditch subwatershed. 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.

3.22.1.4 Floodplain Mapping

Flood inundation areas supporting the NFIP were revised in 2008 as part of the FEMA's Map Modernization Program. Floodplain boundaries were revised based upon updated Cook County topographic information; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains.

Merrionette Park Ditch is mapped in detail in DFIRM mapping update, with Zone AE floodplain defined for the length of Merrionette Park Ditch. According to the FIS, the original hydrologic and hydraulic analysis was performed in 1978. The hydrologic modeling was performed by using Regression Equation 73. Steady state hydraulic modeling was performed using the WSP-2 modeling application.

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

3.22.1.5 Stormwater Problem Data

Table 3.22.3 summarizes reported problem areas reviewed as a part of the DWP development. This reported problem area data was primarily obtained from Form B questionnaire response data provided by watershed communities, agencies, and stakeholders to the District. Problems are classified in Table 3.22.3 as regional or local. This classification is based on a process described in Section 1 of this report.

TABLE 3.22.3
Community Response Data for Merrionette Park Ditch

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
ME1	Merrionette Park, Chicago	Pavement flooding	Kedzie Avenue between 119th St. and 126th St.	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem.

3.22.1.6 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 projects by others have been identified for the Merrionette Park Ditch subwatershed.

3.22.2 Watershed Analysis

3.22.2.1 Hydrologic Model Development

Subbasin Delineation. The Merrionette Park Ditch tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Twenty-five subbasins were delineated for the Merrionette Park Ditch area, with an average subbasin area of 108 acres and a total drainage area of 4.2 square miles.

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.

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.

3.22.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Merrionette Park Ditch and all crossings were surveyed 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 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 to the stream.

Boundary Conditions. The Merrionette Park Ditch model was combined with the Stony Creek model, with Merrionette Park Ditch directly tributary to East Stony Creek. The downstream boundary condition of Merrionette Park Ditch was defined by East Stony Creek WSEL.

3.22.2.3 Calibration and Verification

No measured or observed stages were available for Merrionette Park Ditch to compare model results to observed flows or stages. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.22.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.22.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.22.3 Development and Evaluation of Alternatives

3.22.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.22.4 summarizes problem areas identified through hydraulic modeling of Merrionette Park Ditch.

TABLE 3.22.4
Modeled Problem Definition for Merrionette Park Ditch

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA24	Area around 121st and Lawndale, flooding expands south for larger storms	50, 100, 500		Risk of flooding cannot be feasibly mitigated by structural measures. Affected properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.

3.22.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No erosion or recreation damages due to flooding were identified for Merrionette Park Ditch. Transportation damages were estimated as 15 percent of property damages. Table 3.22.5 shows the damage assessment for existing conditions.

3.22.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in Merrionette Park Ditch. Increased conveyance or storage was identified as the principal technologies applicable for addressing stormwater problems in Merrionette Park Ditch.

TABLE 3.22.5
Estimated Damages for Merrionette Park Ditch

Damage Category	Estimated Damage ($)	Note
Property	393,200	
Erosion	0	
Transportation	59,000	Assumed as 15% of property damage due to flooding

3.22.3.4 Alternative Development

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 3.22.6 summarizes flood and erosion control alternatives developed for Merrionette Park Ditch. No feedback from watershed communities was received related to stormwater detention alternatives developed for Merrionette Park Ditch.

Erosion Control Alternatives. No erosion control alternatives were developed for Merrionette Park Ditch.

TABLE 3.22.6
Flood Control Alternatives for Merrionette Park Ditch

Alternative Number	Location	Description
MPDT-1	Oak Hill Cemetery	Construct 37 acre-feet of stormwater detention on Oak Hill Cemetery property at the southeast corner of Central Park Avenue and 119th Street. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
MPDT-2	Merrionette Park Ditch at 123rd Street	Increase size of 123rd Street culvert to 5- by 18-foot box culvert. Adequate land for compensatory storage for this alternative was not available, thus benefits and costs were not developed.

3.22.3.5 Alternative Evaluation and Selection

Alternatives included in Table 3.22.6 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were evaluated through H&H modeling to evaluate their impact on water elevations and flood damages. There was not sufficient available space for a detention basin larger than the 37 acre-feet in volume at the Oak Hill Cemetery property location, evaluated as MPDT-1. The 37 acre-foot volume was not large enough to reduce flood damages downstream. Alternative MPDT-2 reduced flood damages in the area of Merrionette Park Ditch, but increased flow downstream to Stony Creek, as compensatory storage locations were not available. Because MPDT-1 was not effective and MPDT-2 lacked potential compensatory storage locations, benefits and costs were not developed for these alternatives.

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 Calumet-Sag Channel DWP.

3.22.3.6 Data Required for Countywide Prioritization of Watershed Projects

No alternatives are recommended for Merrionette Park Ditch.

3.23 Mill Creek

Mill Creek is a regional waterway located in southwestern Cook County, in the southern portion of the Calumet-Sag Channel Watershed. The 10.6-square-mile drainage area for Mill Creek includes 3.1 square miles of the tributary area from Mill Creek West Branch, which drains to Mill Creek near where Mill Creek crosses 123rd Street. Table 3.23.1 provides a summary of the land area of communities within the Mill Creek subwatershed. Figure 3.23.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown on the figure and are discussed in the following subsections.

TABLE 3.23.1
Communities Draining to Mill Creek

Community	Tributary Area (mi^2)
Unincorporated/ Forest Preserve	5.7
Orland Park	3.4
Palos Park	1.5

The Mill Creek subwatershed contains a mix of suburban development with large areas of open land and forest preserve. Table 3.23.2 summarizes the land use distribution within the subwatershed.

TABLE 3.23.2
Land Use Distribution for Mill Creek

Land Use Category	Area (acres)	%
Residential	2,801	41.1
Forest/Open Land	2,708	39.7
Water/Wetland	485	7.1
Agricultural	299	4.4
Commercial/Industrial	256	3.8
Institutional	179	2.6
Transportation/Utility	86	1.3

3.23.1 Sources of Data

3.23.1.1 Previous Studies

Mill Creek Model (IDNR). The HEC-1 and HEC-2 models developed by the IDNR simulated a small tributary of the Mill Creek subwatershed (0.05 square mile). The segment of the creek modeled is about 1,000 feet long from 135th Street to Pine Street in the Village of Orland Park. The purpose of the modeling was to size pumps for an existing levee. The size of the area modeled and extent of data documented prevented use of the model as a part of Calumet-Sag Channel DWP development.

Mill Creek Model (IDOT). A study was completed by Mackie Consultants for IDOT on an upstream tributary to Mill Creek that runs along Southwest Highway (Mackie Consultants, 2008). This study was performed to address flooding issues along Southwest Highway. The modeling extent of this study did not meet the District's requirements for use as a part of the Mill Creek model; however, the results of this model and suggested alternatives were reviewed and considered as a part of the Calumet-Sag Channel DWP development.

3.23.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Mill Creek. No reaches 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 Mill Creek. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Mill Creek. Municipalities discharging to Mill

Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.23.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using NWI mapping. NWI data includes 760 acres of wetland area in the Mill Creek subwatershed in Cook County. 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.

3.23.1.4 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, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated into revised floodplain areas.

Mill Creek is mapped in detail in the DFIRM mapping update, with Zone A and Zone AE floodplain shown across portions of Mill Creek. The original H&H analysis was performed in 1979. The hydrologic modeling was performed using TR-20, L-PTIII, and Regression Equations 73, 75, and 77. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.23.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1 of the report. Table 3.23.3 summarizes the Form B data for Mill Creek.

3.23.1.6 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. The Village of Orland Park is in the design phase of improvements to existing stormwater detention basins located upstream of Mill Creek near 135th Street and 86th Avenue. Models were not available at the time of DWP development, so the improvements were not included in baseline conditions in the H&H models. The improvements are intended to address reported problem OP7, and this is noted in the DWP.

3.23.2 Watershed Analysis

3.23.2.1 Hydrologic Model Development

Subbasin Delineation. The Mill Creek tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. The original delineation of Mill Creek was reviewed against the Cook County topographic data and aerials. No modification to the subwatershed boundary was necessary. Forty-five subbasins were delineated for the Mill Creek tributary area, with an average subbasin area of 152 acres.

TABLE 3.23.3
Community Response Data for Mill Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
OP1	Orland Park	Pavement flooding	Southwest Highway and 135th St.	Flooding several times per year	Regional	Project MICR-4 addresses this problem.
OP13	Orland Park	Pavement flooding	Rte 7 (Southwest Hwy) at Rte 45 (La Grange Rd.)	IDOT reported pavement flooding	Regional	Project MICR-4 addresses this problem.
OP14	Orland Park	Pavement flooding	Route 7 at 145th St. to 148th St.	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem.
OP7	Orland Park	Ponding	Strawberry Ln. (Parkview Estates)	Flooding due to off-site flows from outside village	Regional	Village has contracted with CBBEL to develop a project to address this problem.
PP5	Palos Park	Overbank flooding, basement flooding, water quality, storm sewer capacity, bank erosion, wetland riparian, maintenance	123rd St. between Hobart Avenue and Elm Street	Floodwater exceeds conveyance capacity, and erosion is also affecting northern Groundhog Slough	Regional	Model results show roadway flooding, but no property damage. Due to the availability of alternative routes, a resolution to transportation damages has been deemed unnecessary.
PP6	Palos Park	Overbank flooding, basement flooding, ponding, storm sewer capacity, bank erosion	Southwest Hwy between 131st St. and 135th St.	Flooding due to insufficient capacity reduces or prevents access to businesses in this area	Regional	Project MICR-4 addresses this problem.

TABLE 3.23.3
Community Response Data for Mill Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PP8	Palos Park	Overbank flooding, basement flooding, storm sewer capacity, bank erosion	Kinvarra Drive and Wild Cherry Lane (9845 Wild Cherry Lane)	Excessive floodwaters result in flooding of a number of houses at least 3 times in the last 10 years. Stream maintenance is required downstream to address sedimentation and debris.	Regional	Project MICR-2 addresses this problem.
PT2	Palos Township	Ponding	Halfway between 104th Ave. and Indian Trail Dr. on Lakeland Dr.	Ponding	Local	Problem not located on a regional waterway. This is a local problem.
PT3	Palos Township	Ponding	West end of Bernice Dr. near 104th Ave. and 131st St.	Ponding	Local	Problem not located on a regional waterway. This is a local problem.
PT4	Palos Township	Ponding	Intersection of Stephen Dr. and Walter Dr.	Ponding	Local	Problem not located on a regional waterway. This is a local problem.
PT8	Palos Township	Maintenance	North and East of intersection of 111th Street (Route 83) and 104th Avenue	CCHD reported flooding due to debris blockages within a poorly maintained ditch on Forest Preserve property	Local	Problem not located on a regional waterway. This is a local problem.

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.

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.

3.23.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. Surveys of the open channel part of Mill Creek and all crossings were performed to characterize the channel and near overbank channel geometry. Cross-sectional geometry in the non-surveyed overbank area was obtained from Cook County topographic data and combined with the 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. Boundary condition elevations determined for the Calumet-Sag Channel based on output from the CWS model are included in Appendix E. The elevation produced by the CWS model for the 100-year storm at the outlet of Mill Creek was 584.64 feet NAVD 88, and was used as the downstream boundary condition for the Mill Creek model.

Inflow. The drainage system of Calumet-Sag Tributary B interacts with the Mill Creek drainage system. A railway ditch crosses what was previously a natural drainage divide between the Mill Creek and Calumet-Sag Tributary B subwatersheds. When water surface elevations in Mill Creek reach an elevation of 667 feet NAVD 1988, Mill Creek overflows into the railroad ditch, which flows to Calumet-Sag Tributary B. The overflow hydrograph generated in the Mill Creek hydraulic model was used as input to Calumet-Sag Tributary B hydrologic model to properly represent existing conditions. This overflow results in flow of floodwaters across the subwatershed divide and is reflected in an inundation area that crosses the subwatershed divide in this location.

3.23.2.3 Calibration and Verification

In the hours following the August 20, 2007 storm, evidence of high water elevation marks was observed at four locations on Mill Creek West Branch. The rainfall data from ISWS gage 16, which is the rainfall gage closest to the observed high water elevation, was obtained for this time period. Gage 16 recorded 1.2 inches of rainfall over a 7-hour period. High water marks during the September 13th – 14th, 2008 storm event were not recorded on the Mill Creek watershed.

Table 3.23.4 lists the locations and elevations of the field-observed water surface elevations. The model results are listed for both initial (pre-calibration) model results and calibrated model results (with the 10 percent reduction of the curve number values applied). The difference between the observed and calibrated model water surface elevations are generally considered to be acceptable due to the margin of error associated with high water mark elevation data. High water elevations are taken at a point in time when it is not certain that the peak water elevation occurred. The comparison of observed and model result water surface elevations for the August 20, 2007 storm for the Mill Creek subwatershed serves as a verification of the curve number reduction made watershed-wide based on the calibration to the September 13th – 14th, 2008 storm event.

TABLE 3.23.4
Comparison of Observed and Model Result Water Surface Elevations for August 20, 2007 Storm

Location	Observed High Water Surface Elevation (ft)	Initial Model Results Water Surface Elevation (ft)	Calibrated Model Results Water Surface Elevation (ft)
Mill Creek West Branch at Creek Road	678.1	680.37	679.79
Mill Creek West Branch at Wild Cherry Lane	675.6	677.21	676.47
Mill Creek West Branch at Windsor Drive	674.2	675.43	675.07
Mill Creek West Branch at Hobart Drive	658.2	660.48	659.24

3.23.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Flood inundation areas were developed based on HEC-RAS water surface elevations and Cook County topographic data. Figure 3.23.1, the tributary overview figure, shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.23.3 Development and Evaluation of Alternatives

3.23.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.23.5 summarizes major problem areas identified through modeling of Mill Creek.

TABLE 3.23.5
Modeled Problem Definition for Mill Creek

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA20	Area along the Southwest Hwy between LaGrange Road and 135th Street	25, 50, 100, 500	PP6, OP1	Project MICR-4 will reduce flooding in this area.
MPA21	Area around 87th Avenue and 127th Street	50, 100, 500		Project MICR-4 will reduce flooding in this area.
MPA22	Area around 96th Avenue and Wild Cherry Lane	25, 50, 100, 500	PP8	Project MICR-2 will reduce flooding in this area.
MPA23	Area around Wild Cherry Lane and Windsor Drive	25, 50, 100, 500	PP8	Sufficient land was not available in the area for potential capital projects that could address the problem. Such properties are candidates for protection using nonstructural flood control measures, such as floodproofing or acquisition.

3.23.3.2 Damage Assessment

Damages due to flooding were calculated for Mill Creek in accordance with the methodology described in Section 1.4 and are summarized in Table 3.23.6.

TABLE 3.23.6
Estimated Damages for Mill Creek

Damage Category	Estimated Damage ($)	Note
Property	2,390,000	
Erosion	0	
Transportation	849,300	Includes 15% applied to property damage and transportation damages calculated for flooding of Southwest Highway
Recreation	0	

3.23.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in Mill Creek. Stormwater detention and conveyance improvements, along with levees, were identified as potential technologies for addressing flood damages in the Mill Creek watershed. No damages were associated with the reach of Mill Creek downstream of where Mill Creek West Branch discharges to the main branch of Mill Creek.

3.23.3.4 Alternative Development

Flood Control Alternatives. Alternative solutions to regional flooding were developed and evaluated consistent with the methodology described in Section 1.4 of this report. Table 3.23.7 summarizes flood control alternatives developed for Mill Creek.

TABLE 3.23.7
Flood Control Alternatives for Mill Creek

Alternative Number	Location	Description
MICR-1	Flooding along Southwest Highway	53 acre-feet detention basin at LaGrange Road and Southwest Highway, 32 acre-feet detention basin at 131st Street and Southwest Highway, and increased conveyance capacity through replacing 7 existing undersized culverts with 5-foot by 10-foot box culverts between the two detention ponds
MICR-2	Flooding along right overbank of WBMC	Levee off houses along right overbank to prevent flooding on Mill Creek West Branch, provide compensatory storage on open land adjacent to left overbank
MICR-3	Flooding along MICR just upstream of confluence with WBMC	46 acre-feet detention along Mill Creek near 127th Street and 87th Avenue. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
MICR-4	Flooding along Southwest Highway	32 acre-feet detention basin at 131st Street and Southwest Highway, and increased conveyance capacity through replacing 7 existing undersized culverts with 5-foot by 10-foot box culverts between the two detention ponds

Stormwater detention alternatives were modeled to address flooding problems along Mill Creek and Mill Creek West Branch. Alternative MICR-1 consists of two detention basins: one located at the northeast corner of Southwest Highway and LaGrange Road and one located at the southeast corner of 131st Street and Southwest Highway. A tributary to Mill Creek flows along Southwest Highway between these two areas. This tributary flows through seven culverts, all of which are frequently overtopped during storm events. Alternative MICR-1 replaces all seven culverts with 5-foot by 10-foot box culverts to increase conveyance capacity. Alternative MICR-1 addresses the flooding described as problem area MPA20 in Table 3.23.5. This alternative was effective at reducing flood damages in the area and significantly reducing the frequency of overtopping of Southwest Highway. This alternative is similar to the solution proposed in an IDOT report, but includes more storage in order to address the 100-year storm event (Mackie Consultants, 2008).

Alternative MICR-2 consists of a levee in the right overbank to prevent flooding in problem area MPA22. The levee would require compensatory storage, which is proposed in an area in the left overbank opposite the levee. Model results showed that the alternative was effective in protecting flooded structures in the right overbank area while preventing any increase in upstream or downstream water elevations.

Alternative MICR-3 consists of 46 acre-feet of detention along Mill Creek near 127th Street and 87th Avenue. Model results showed that this alternative and other similar storage alternatives analyzed in nearby available areas were not effective in significantly lowering WSELs along Mill Creek. Also, the existing nearby diversion of flows from Mill Creek to Calumet-Sag Tributary B limits the effectiveness of alternatives in this area as lowering the WSEL of Mill Creek just upstream of the diversion causes less diverted flow to Calumet-Sag Tributary B, and does not lower Mill Creek WSELs downstream of the diversion. Downstream of Southwest Highway, Mill Creek enters Cook County Forest Preserve property. Hydraulic model results determined that the 90th Avenue culvert in this area creates a backwater which contributes to the MPA21 flooding problem area. The culvert size could not be increased without increasing downstream WSELs or providing a significant amount of detention in the area. The area was not considered for detention alternatives as it was on Cook County Forest Preserve property.

Alternative MICR-4 was analyzed as an alternative to MICR-1. This alternative consists of the same seven culvert replacements along Southwest Highway and the same 32-acre-feet detention basin located at the corner of 131st Street and Southwest Highway without the 53-acre-feet detention basin at Southwest Highway and LaGrange Road that was proposed as a part of MICR-1. This alternative was nearly as effective at reducing flood damages in the area and reducing the frequency of overtopping of Southwest Highway as MICR-1 at a much lower cost.

Erosion Control Alternatives. No erosion control alternatives were developed for Mill Creek.

3.23.3.5 Alternative Evaluation and Selection

Modeling analysis concluded that MICR-3 could not provide effective stormwater detention resulting in flood damage reduction partly because of the diversion to Calumet-Sag Tributary B. Both the MICR-2 and MICR-4, shown in Figures 3.23.2 and 3.23.3 respectively, alternatives did lower WSEL and are recommended.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.23.8 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

TABLE 3.23.8
Mill Creek Existing and Alternative Condition Flow and WSEL Comparison

Location	Existing Conditions		MICR-2		MICR-4	
	100-yr WSEL (ft)	100-yr Flow (cfs)	100-yr WSEL (ft)	100-yr Flow (cfs)	100-yr WSEL (ft)	100-yr Flow (cfs)
Mill Creek West Branch just upstream of Wild Cherry Ln.	679.97	509.83	679.97	509.83	679.97	509.82
Mill Creek West Branch upstream of Powell Rd. and 96th Ave.	678.33	569.83	678.33	569.83	678.33	569.69
Mill Creek 100-ft upstream of 135th St.	673.91	347.97	673.91	347.97	673.46	312
Mill Creek 100-ft upstream of Southwest Hwy	669.2	470.77	669.2	470.77	669.04	463.99
Mill Creek 60-ft upstream of 123rd St.	652.11	524.58	652.11	524.58	652.06	510.99
Mill Creek 50-ft upstream of 119th St.	628.29	1386.42	628.29	1386.42	628.16	1352.78

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 Calumet-Sag Channel DWP.

The alternatives listed in Table 3.23.7 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damages. A summary of B/C ratios, net benefits, total project costs, number of structures protected, and other relevant alternative data is provided in Table 3.23.9. Alternatives that did not produce a significant change in inundation areas are not listed as benefits were negligible, and thus costs were not calculated for these alternatives.

3.23.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.23.9 lists alternatives analyzed in detail. The recommended alternatives are MICR-2 and MICR-4, and are shown in Figures 3.23.2, and 3.23.3. A comparison of the existing conditions and alternative conditions inundation mapping is included in these figures.

TABLE 3.23.9
Mill Creek Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
MICR-1	Increased convey-ance and storage	0.04	601,900	14,541,200	3	IDOT	Slightly Positive	No	Orland Park
MICR-2	Levee and storage	0.2	409,600	2,003,400	6		Slightly Positive	Yes	Palos Park
MICR-4	Increased convey-ance and storage	0.1	459,000	5,918,100	3	IDOT	Slightly Positive	Yes	Orland Park

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.24 Mosquito Creek

Mosquito Creek is located in southwestern Cook County, north of the Calumet-Sag Channel, in the eastern part of the Calumet-Sag Channel Watershed. Table 3.24.1 summarizes the areas of communities that drain to Mosquito Creek, which is also known as the Alsip Drainage Ditch. The Mosquito Creek subwatershed contains a mix of suburban development and a moderate amount of available open land. Most of the open land within the watershed is cemetery. The drainage area is 0.9-square-miles. Figure 3.24.1 provides an overview of the tributary area of the subwatershed.

Mosquito Creek is a mixture of open channel and long sections of closed-conduit, and a considerable portion of the original tributary area has been diverted through sewer pipes to the Calumet-Sag Channel. Table 3.24.2 lists the land use breakdown by area within the Mosquito Creek subwatershed.

TABLE 3.24.1
Communities Draining to Mosquito Creek

Community	Tributary Area (mi^2)
Alsip	0.91

TABLE 3.24.2
Land Use Distribution for Mosquito Creek

Land Use	Area (acres)	%
Commercial/Industrial	185.9	32
Forest/Open Land	171.7	29.6
Residential	141.2	24.3
Transportation/Utility	81	13.9
Institutional	1.2	0.2
Water/Wetland	0.1	0

3.24.1 Sources of Data

3.24.1.1 Previous Studies

No existing studies of Mosquito Creek were identified.

3.24.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Mosquito Creek. There are no reaches identified as impaired in the IEPA's 2008 *Integrated Water Quality Report*, which includes the 303(d) and 305(b) lists. No TMDLs have been established for Mosquito Creek. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Mosquito Creek. Municipalities discharging to Mosquito Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.24.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes 6.2 acres of wetland areas in the Mosquito Creek subwatershed. 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.

3.24.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated in the revised floodplains. Mosquito Creek is not mapped in detail in the DFIRM mapping update; it is currently mapped as an unnumbered Zone A labeled as the Alsip Drainage Ditch. Therefore, there was no known model that meets the criteria established in Chapter 6 of the CCSMP for use in the development of DWPs.

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

3.24.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. There were no reported problems along Mosquito Creek.

3.24.1.6 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 projects by others have been identified for the Mosquito Creek subwatershed.

3.24.2 Watershed Analysis

3.24.2.1 Hydrologic Model Development

Because of the drainage pattern of Mosquito Creek, with a series of local drainageways intermittent with sewers, but no continuous defined open channel, the subwatershed was modeled with hydrologic modeling only. 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 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.

3.24.3 Development and Evaluation of Alternatives

There were no regional problem areas reported or identified through modeling of Mosquito Creek, so no alternatives were developed.

3.25 Navajo Creek

Navajo Creek is located in southwestern Cook County, south of the Calumet-Sag Channel, in the central part of the Calumet-Sag Channel Watershed. Table 3.25.1 lists the areas of communities that drain to Navajo Creek. Figure 3.25.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown, and are discussed in the following subsections.

The population density of the Navajo Creek subwatershed is relatively high with a mix of suburban development and little available open land. The drainage area is roughly 2.9 square miles and heavily sewered. Navajo Creek is a natural open-channel stream, except in areas located between 76th Avenue and Harlem Avenue where it passes through a City of Palos Heights storm sewer system. Navajo Creek discharges into the Calumet-Sag Channel. Table 3.25.2 lists the land use breakdown by area within the Navajo Creek subwatershed.

TABLE 3.25.1
Communities Draining to Navajo Creek

Community	Tributary Area (mi^2)
Palos Heights	2.21
Unincorporated/Forest Preserve	0.56
Orland Park	0.08
Palos Park	0.02

TABLE 3.25.2
Land Use Distribution for Navajo Creek

Land Use Category	Area (acres)	%
Residential	1,175.8	64.1
Forest/Open Land	462.8	25.2
Institutional	104.5	5.7
Commercial/Industrial	48.7	2.7
Transportation/Utility	29.2	1.6
Water/Wetland	12.7	0.7

3.25.1 Sources of Data

3.25.1.1 Previous Studies

No studies of Navajo Creek were identified for consideration as a component of DWP development.

3.25.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Navajo Creek. There are no reaches identified as impaired in the IEPA's 2008 *Integrated Water Quality Report*, which includes the 303(d) and 305(b) lists. No TMDLs have been established for Navajo Creek. Lake Arrowhead is located within the Navajo Creek Watershed. It is an upstream lake that is tributary to Navajo Creek. Lake Arrowhead is listed as impaired for mercury in the IEPA's 2008 *Integrated Water Quality Report*. Its identification number is IL_RHZE and its designated use is fish consumption. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Navajo Creek. Municipalities discharging to Navajo Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.25.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 52.3 acres of wetland areas in the Navajo Creek subwatershed. 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.

3.25.1.4 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.

Navajo Creek is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of Navajo Creek. According to the FIS, the original hydrologic and hydraulic analysis was performed in 1978. The hydrologic modeling was performed by using Regression Equations 73 and L-PTIII. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.25.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.25.3 lists reported problems along Navajo Creek. In several cases, separate Form B entries submitted by Palos Heights were combined into a single problem area. This was typically done with individual properties located in the same vicinity that were listed in multiple locations on Form B questionnaires.

3.25.1.6 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 projects by others have been identified for the Navajo Creek subwatershed.

3.25.2 Watershed Analysis

3.25.2.1 Hydrologic Model Development

Subbasin Delineation. The Navajo Creek tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Thirteen subbasins were delineated for the Navajo Creek area, with an average subbasin area of 143 acres and a total drainage area of 2.9 square miles. Storage provided by Lake Arrowhead was included in the hydrologic model.

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.

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.

TABLE 3.25.3
Community Response Data for Navajo Creek

Problem ID	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PH2	Ponding	12605 Melvina Ave.	Ponding in ROW about 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local problem.
PH3	Ponding	Palos Meadows Subdivision near 131st Street and 71st Avenue (includes 13013 Oak Park Avenue).	Flooding throughout neighborhood 2 to 5 times a year	Regional	Project NVCR-3 addresses this problem.
PH4	Ponding	12500 McCarthy Rd. and on Carmichael Dr. west of 76th Ave.	Storm sewer restriction at McCarthy Rd. and ponding at nearby school detention pond	Local	Problem not located on a regional waterway. This is a local problem.
PH5	Ponding	21 Country Squire Ct. near 76th Ave. and College Dr.	Ponding in ROW and front yard, 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local problem.
PH6	Ponding	12601 Harold Ave., 12542 74th Ave., and 12542 75th Ave.	Ponding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local problem.
PH7	Ponding	124th Avenue and 69th Court; and 12217 68th Court	Ponding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local problem.
PH8	Basement flooding, ponding	12002 Harold Ave.	Basement and backyard flooding due narrow conveyance of overflow from 76th Avenue	Local	Problem not located on a regional waterway. This is a local problem.

TABLE 3.25.3
Community Response Data for Navajo Creek

Problem ID	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PH9	Ponding	12102,12232, 12303, and 12312 71st Avenue	Ponding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local problem.
PH10	Ponding	12333 69th Ave. near Navajo Creek and Oak Park Ave. and College Dr.	Flooding in street ROW in front of residence, about 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local problem.
PH12	Ponding	12911 71st Court	Sewer backup caused by high Navajo Creek Elevation 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local problem.
PH13	Ponding	13032 71st Ave.	Flooding in backyard 2 to 5 times a year	Regional	Project NVCR-3 addresses this problem.
PH14	Ponding	6843 Evergreen Ave.	Ponding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.
PH15	Ponding	Approximately 150 ft west of 76th Avenue on north side of McIntosh Drive	Flooding 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.
PH16	Flooding	11938 68th Ct.	Flooding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.
PH17	Overbank flooding, basement flooding	Nashville Ave. and 125th St.	Flooding in ROW 2 to 5 times a year	Regional	Project NVCR-5 will reduce flooding in this area.
PH18	Flooding	127th Street and 70th Avenue	Navajo Creek elevation affects this area	Regional	Project NVCR-5 will reduce flooding in this area.
PH19	Basement flooding, ponding, storm sewer capacity	Approximately 150 ft north of 131st Street on west side of Cypress Lane	Flooding 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.
PH20	Ponding, pavement flooding	12001 73rd Ct., 12151 73rd Ave., and 12412 73rd Ave.	Flooding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.

TABLE 3.25.3
Community Response Data for Navajo Creek

Problem ID	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
PH21	Storm sewer capacity	7350 Choctaw Rd.	Flooding in backyard 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.
PH22	Ponding	12224 Cheyenne Dr.	Ponding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.
PH23	Ponding	12250 76th Ave. and 12223 Richard Ave.	Ponding in ROW 2 to 5 times a year	Local	Problem not located on a regional waterway. This is a local storm sewer problem.

3.25.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Navajo Creek and all crossings were surveyed 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 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 coefficient to the stream. Field survey information is available in Appendix D.

Boundary Conditions. Appendix E contains boundary condition elevations determined for the Calumet-Sag Channel based on output from the Chicago Waterway model. The elevation produced by the CWS model for the 100-year storm at the outlet of Navajo Creek was 585.02 feet NAVD 88, roughly 4 feet above the invert of Navajo Creek near its confluence with the Calumet-Sag Channel. This relatively shallow depth indicates that the downstream stage on Navajo Creek is controlled not by the receiving system, but by its own capacity to convey flows received from its tributary area. Normal depth assuming a friction slope of 0.005 was used as a downstream boundary condition for Navajo Creek.

3.25.2.3 Calibration and Verification

In the hours following the August 20, 2007 storm, evidence of a high water elevation was observed at the downstream end of Navajo Creek, 240 feet downstream of College Drive. The rainfall data from ISWS gage 16, which is the rainfall gage closest to the observed high water elevation, was obtained for this time period. Gage 16 recorded 1.2 inches of rainfall over a 7-hour period. High water marks during the September 13th – 14th, 2008 storm event were not recorded on the Navajo Creek watershed.

Table 3.25.4 lists the location and elevation of the field-observed water surface elevation and the peak modeled water surface elevation. The model results are listed for both initial (pre-calibration) model results and calibrated model results (with the 10 percent reduction of curve number values applied). The difference between the observed and calibrated model water surface elevations are generally considered to be acceptable due to the margin of error associated with high water mark elevation data. High water elevations are taken at a point in time when it is not certain that the peak water elevation occurred. The comparison of observed and model result water surface elevations for the August 20th, 2007 storm for the Navajo Creek subwatershed serves as a verification of the curve number reduction made watershed-wide based on the calibration to the September 13th – 14th, 2008 storm event.

TABLE 3.25.4
Comparison of Observed and Model Result Water Surface Elevations for August 20, 2007 Storm Event

Location	Observed High Water Surface Elevation (ft)	Initial Model Results Water Surface Elevation (ft)	Calibrated Model Results Water Surface Elevation (ft)
240 feet downstream of College Drive	585.0	586.01	585.69

3.25.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.25.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.25.3 Development and Evaluation of Alternatives

3.25.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.25.5 summarizes problem areas identified through hydraulic modeling of Navajo Creek.

TABLE 3.25.5
Modeled Problem Definition for Navajo Creek

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA25	Area east of Harlem Avenue, around 127th Street	5, 10, 25, 50, 100, 500	PH18	Project NVCR-5 will reduce flooding in this area.
MPA26	Area around S. Oak Park Avenue north of W. 125th Street	25, 50, 100, 500	PH17	Project NVCR-5 will reduce flooding in this area.

TABLE 3.25.5
Modeled Problem Definition for Navajo Creek

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA27	Northeast side of Trinity Christian College	500		Project NVCR-5 will reduce flooding in this area.

3.25.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No erosion or recreation damages due to flooding were identified for Navajo Creek. Transportation damages were estimated as 15 percent of property damages. Table 3.25.6 lists the damage assessment for existing conditions.

TABLE 3.25.6
Estimated Damages for Navajo Creek

Damage Category	Estimated Damage ($)	Note
Property	2,817,200	
Erosion	0	
Transportation	497,100	Assumed as 15% of property damage due to flooding

3.25.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in Navajo Creek. Increased conveyance or storage was identified as the principal technologies applicable for addressing stormwater problems in Navajo Creek.

3.25.3.4 Alternative Development

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 3.25.7 provides a summary of flood and erosion control alternatives developed for Navajo Creek.

Based on community feedback, flood damage reduction alternatives developed for Navajo Creek were focused on detention facilities and channel diversions. The City of Palos Heights suggested several potential locations for detention facilities. These included a Lake Arrowhead expansion by raising an existing forest preserve pathway by one additional foot, a steep ravine area near Misty Meadow Drive and Kirkcaldy Court, and along a downstream portion of Navajo Creek on Trinity Christian College property. The City of Palos Heights also suggested Harlem Avenue, 70th Avenue, and Oak Park Avenue as potential channel diversion alignment locations.

Alternatives are described in Table 3.25.7. Figure 3.25.2 shows the locations and a summary of the alternatives described in Table 3.25.7. Alternatives NVCR-1, NVCR-2, and NVCR-4 involve large amounts of excavation to construct stormwater detention facilities. Alternative NVCR-3 does not involve significant excavation, but rather is a minor modification to an existing pond to provide a small amount of additional detention volume. Alternatives NVCR-5, NVCR-6, NVCR-7, and NVCR-8 require significant conveyance infrastructure to deliver flows from Navajo Creek to the Calumet-Sag Channel. Regulatory approval from regulatory agencies such as IDNR and the USACE would be required. The increased conveyance would involve new outfalls with additional flow to the Calumet-Sag Channel. Other alternatives recommended in the DWP include storage and will result in lower peak discharge rates at points where tributaries discharge to the Calumet-Sag Channel. All flows from individual tributaries are relatively small in comparison to total flow within the Calumet-Sag Channel.

Erosion Control Alternatives. There were no erosion control alternatives analyzed for Navajo Creek.

3.25.3.5 Alternative Evaluation and Selection

Alternatives included in Table 3.25.7 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damages. Table 3.25.10 provides a summary of B/C ratio, net benefits, total project costs, number of structures protected, and other relevant alternative data.

Alternatives that did not produce a significant change in inundation areas (NVCR-1, NVCR-2, NVCR-4, NVCR-6, and NVCR-9) are not listed as benefits were negligible, and thus costs were not calculated for these alternatives. NVCR-3 consists of expanding Lake Arrowhead by raising an existing forest preserve pathway by a height of one additional foot. Hydrologic model results demonstrated that this alternative effectively prevents the 100-year storm event from overtopping, thus preventing flooding problems related to Lake Arrowhead overtopping immediately downstream of Lake Arrowhead.

Although alternative NVCR-8 has a higher B/C ratio, alternative NVCR-5 is recommended because there is the potential of cost-sharing with the City of Palos Heights, which indicated through community feedback that an alignment along Harlem Avenue may provide a potential opportunity for the City to address its local problems. NVCR-7 is not recommended because it addresses the same problem area as NVCR-5, which has a better B/C ratio. NVCR-11, which is the combination of NVCR-5 and NVCR-8, was analyzed separately in order to determine the benefits realized by the construction of both diversions. NVCR-11 resulted in a lower B/C ratio than NVCR-5, so NVCR-5 alone was recommended.

TABLE 3.25.7
Flood Control Alternatives for Navajo Creek

Alternative Number	Location	Description
NVCR-1	Harlem Avenue and Navajo Creek	Proposed 23 acre-foot detention pond at Harlem Avenue near Navajo Creek outfall from City of Palos Heights storm sewer in a current area of open space. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
NVCR-2	Trinity Christian College (between Menomonee Parkway and 122nd Street)	Two online ponds totaling 180 acre-feet of detention on Trinity Christian College property. Considered concurrently with Alternative NVCR-1. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
NVCR-3	Lake Arrowhead Expansion on Cook County Forest Preserve property southeast of 131st Street and Harlem Avenue	Expansion of Lake Arrowhead by raising existing forest preserve pathway by 1 foot, creating 16 acre-feet of additional detention.
NVCR-4	Area northeast of Misty Meadow Drive and Kirkcaldy Court	Proposed 22 acre-feet pond located upstream of Navajo Creek and cut into a steep ravine in a residential area. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
NVCR-5	Harlem Avenue	Channel diversion at intersection of creek and Harlem Avenue. The pipe diameter was maximized to fit along entire route to Navajo Creek, while maintaining a minimum 2 feet of cover.
NVCR-6	76th Avenue	Channel diversion at intersection of creek and 76th Avenue. The pipe diameter was maximized to fit along entire route to Navajo Creek, while maintaining a minimum 2 feet of cover. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
NVCR-7	70th Avenue	Channel diversion at intersection of creek and 70th Avenue. The pipe diameter was maximized to fit along entire route to Navajo Creek, while maintaining a minimum 2 feet of cover.
NVCR-8	Oak Park Avenue	Channel diversion at intersection of creek and Oak Park Avenue. The pipe diameter was maximized to fit along entire route to Navajo Creek, while maintaining a minimum 2 feet of cover
NVCR-9	Between Harlem Ave and Menominee Parkway	Increase various combinations of culvert sizes within the problem area in attempt to reduce flooding. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
NVCR-11	Between Harlem Ave and Menominee Parkway	Channel diversions along Harlem Ave and Channel diversion along Oak Park Ave

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.25.8 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

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 Calumet-Sag Channel DWP.

TABLE 3.25.8
Navajo Creek Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		NVCR-3		NVCR-5	
Location	Station	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)
Lake Arrowhead	N/A	630.2	228.9	630.6*	18.3	630.2	228.9
Upstream of 76th Ave.	14417	634.17	326.23	634.17	326.23	634.17	326.29
Upstream of 70th Ave.	8914	617.87	859.99	617.87	859.99	617.52	650.54
230-ft downstream of Oak Park Ave.	6218	612.33	1027.11	612.33	1027.11	611.83	801.22
230-ft upstream of College Dr.	974	596.19	1139.85	596.19	1139.85	595.78	891.08
Confluence with Calumet-Sag Channel	272	585.99	1149.00	585.99	1149.00	585.37	896.16

* Alternative NVCR-3 consists of raising the berm elevation at Lake Arrowhead from 630 ft to 631 ft to contain the 100-year storm event within Lake Arrowhead.

Hydraulic modeling results identified two roadway crossings (state route, US highway, or four-lane road or greater) where Navajo Creek overtops for storm events of 100-year recurrence interval and below. Table 3.25.9 below lists the two locations and provides a summary of the depth of road flooding for existing conditions and with recommended alternatives. Limited available land and topography prevented the reduction of flooding of College Drive to less than 0.5 feet of depth under alternative conditions.

TABLE 3.25.9
Navajo Creek Road Overtopping Summary

Road Crossing	Road Elevation	50-yr Depth of flooding	100-yr Depth of flooding
127th Street	618.9	0.5	0.8
127th Street (with alternative NVCR-5)	618.9	0.1	0.4
College Drive	594.6	0.2	1.0
College Drive (with alternative NVCR-5)	594.6		0.6

Note: Blank entry indicates that road crossing does not overtop for that particular storm event. Although College Drive experiences overtopping greater than 0.5 feet under alternative conditions, alternate routes are available.

3.25.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.25.10 lists alternatives analyzed in detail. The recommended alternatives are NVCR-3, raising of the berm downstream of Lake Arrowhead and NVCR-5, construction of a channel diversion from Navajo Creek to the Calumet-Sag Channel beneath Harlem Avenue. The location of NVCR-3 is shown in Figure 3.25.2 and the location of NVCR-5 is shown in Figure 3.25.3. A comparison of the existing conditions and alternative conditions inundation mapping is included in these figures.

TABLE 3.25.10
Navajo Creek Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
NVCR-3	Raise Lake Arrowhead berm three feet to provide one-foot of additional storage and two feet of freeboard	0.69	98,700	143,900	15		No Impact	Yes	Palos Heights
NVCR-5	Harlem Avenue channel diversion	0.15	1,148,300	7,903,100	29		No Impact	Yes	Palos Heights
NVCR-7	70th Avenue channel diversion	0.12	693,500	5,721,300	19		No Impact	No	Palos Heights
NVCR-8	Oak Park Avenue channel diversion	0.21	873,600	4,085,000	19		No Impact	No	Palos Heights
NVCR-11	Channel diversion along Harlem Ave and Channel diversion along Oak Park Ave	0.14	1,678,000	11,988,100	33		No Impact	No	Palos Heights

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.26 Oak Lawn Creek

Oak Lawn Creek is located in southwestern Cook County, north of the Calumet-Sag Channel, in the northern part of the Calumet-Sag Channel Watershed. Table 3.26.1 lists the area of each community tributary to Oak Lawn Creek. The population density of the Oak Lawn Creek subwatershed is relatively high with a mix of urban development and little available open land. Figure 3.26.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown in the figure and discussed in the following subsections.

The drainage area is 3.7 square miles. A stormwater detention pond, known as Lake Oak Lawn, is located at the upstream end of the open-channel part of Oak Lawn Creek, which consists primarily of a manmade channel parallel to the Norfolk and Western Railroad. Oak Lawn Creek discharges into West Stony Creek. Table 3.26.2 lists the land use breakdown by area within the Oak Lawn Creek subwatershed.

TABLE 3.26.1
Communities Draining to Oak Lawn Creek

Community	Tributary Area (mi^2)
Oak Lawn	3.08
Burbank	0.36
Chicago Ridge	0.18
Hometown	0.05

TABLE 3.26.2
Land Use Distribution for Oak Lawn Creek

Land Use Category	Area (acres)	%
Residential	1,582	67.5
Commercial/Industrial	499	21.3
Institutional	144.5	6.2
Forest/Open Land	94.8	4.0
Transportation/Utility	21.5	0.9
Water/Wetland	1.9	0.1

3.26.1 Sources of Data

3.26.1.1 Previous Studies

No studies of Oak Lawn Creek were identified for consideration as a component of DWP development.

3.26.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Oak Lawn Creek. There are no reaches 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 Oak Lawn Creek. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Oak Lawn Creek. Municipalities discharging to Oak Lawn Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.26.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes 3.4 acres of wetland areas in the Oak Lawn Creek subwatershed. 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.

3.26.1.4 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.

Oak Lawn Creek is mapped in detail in the DFIRM mapping update, with Zone AE floodplain defined for the length of Oak Lawn Creek. According to the FIS, the original hydrologic and hydraulic analysis was performed in 1979. The hydrologic modeling was performed by using Regression Equations 73 and 74, and L-PTIII. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

3.26.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.26.3 lists reported problems along Oak Lawn Creek, which include flooding and erosion problems. Problem OL7 includes bank erosion that threatens residential structures. There are about 12 homes in the area within 30 feet of the eroding stream bank and another 3 homes where the bank is actively eroding but still farther than 30 feet from structures. The channel bank has a slope of approximately 2:1 and a 16-foot depth, creating significant shear stresses during flooding conditions when the creek overtops the banks. Several residents have relocated fences a distance of at least 5 feet numerous times due to loss of land.

TABLE 3.26.3
Community Response Data for Oak Lawn Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
OL7	Oak Lawn	Severe bank erosion, sedimentation, maintenance, water quality, overbank flooding	Oak Lawn Creek between Mayfield and Central avenues (near 99th Street and Menard Avenue)	Severe bank erosion such that residential structures are threatened along Oak Lawn Creek.	Regional	Project OLCR-3 will address this erosion problem on a regional waterway that threatens structures by stabilizing stream banks.

TABLE 3.26.3
Community Response Data for Oak Lawn Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
OL8	Oak Lawn	Storm sewer capacity, bank erosion, sedimentation, water quality, overbank flooding	Lake Oak Lawn along East and West Shore Drive	Severe bank erosion such that shorelines, adjacent walks, and structures risk failing. Poorer water quality and loss of wildlife habitat due to increased sedimentation from bank erosion.	Regional	Project OLCR-1 expansion of Lake Oak Lawn will include addressing existing erosion and sedimentation problems within Lake Oak Lawn, and reduce flooding.

3.26.1.6 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 projects by others have been identified for the Oak Lawn Creek subwatersheds.

3.26.2 Watershed Analysis

3.26.2.1 Hydrologic Model Development

Subbasin Delineation. The Oak Lawn Creek tributary area was delineated based upon LiDAR topographic data developed by Cook County in 2003. Twenty-one subbasins were delineated for the Oak Lawn Creek area, with an average subbasin area of 112 acres and a total drainage area of 3.7 square miles.

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.

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.

3.26.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Oak Lawn Creek and all crossings were surveyed 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 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 coefficient to the stream. Storage provided by Lake Oak Lawn was included in the hydraulic modeling.

Boundary Conditions. The Oak Lawn Creek model was combined with the Stony Creek model, with Oak Lawn Creek directly tributary to West Stony Creek.

3.26.2.3 Calibration and Verification

No measured or observed stages were available for Oak Lawn Creek to support model calibration. Calibration and verification of the Stony Creek model is discussed in Section 3.28.2.3. Results of the hydraulic model did show overbank flooding of areas consistent with past observed flooding in the Village of Oak Lawn. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.26.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.26.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm.

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

3.26.3 Development and Evaluation of Alternatives

3.26.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.26.4 summarizes problem areas identified through hydraulic modeling of Oak Lawn Creek.

TABLE 3.26.4
Modeled Problem Definition for Oak Lawn Creek

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA28	Area surrounding Lake Oak Lawn (bounded by Central Avenue, 95th Street, 54th Avenue, and Edison Avenue)	100	OL8	Project OLCR-1 will include addressing existing erosion and sedimentation problems within Lake Oak Lawn, and reduce flooding. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using non-structural flood control measures, such as flood-proofing or acquisition.
MPA29	Area between Mayfield Avenue and 54th Avenue, south of Oak Lawn Creek, and north of 101st Street	25, 50, 100		Sufficient land was not available to reduce flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA30	Area between Ridgeland Avenue and Central Avenue, north of Oak Lawn Creek, and south of 97th Street	25, 50, 100		Projects STCR-2 and STCR-3 will reduce flooding in this area.

3.26.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No recreation damages due to flooding were identified for Oak Lawn Creek. Erosion damages were determined based on the values of structures located within 30-feet of areas of active erosion. Transportation damages were estimated as 15 percent of property damages. Table 3.26.5 lists the damage assessment for existing conditions.

TABLE 3.26.5
Estimated Damages for Oak Lawn Creek

Damage Category	Estimated Damage ($)	Note
Property	6,268,400	
Erosion	3,081,000	
Transportation	940,300	Assumed as 15% of property damage due to flooding

3.26.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in Oak Lawn Creek. Increased conveyance or storage was identified as the principal technologies applicable for addressing stormwater problems in Oak Lawn Creek.

TABLE 3.26.6
Flood Control and Erosion Control Alternatives for Oak Lawn Creek

Alternative	Problem Addressed	Location	Description
OLCR-1	Flooding	Lake Oak Lawn	Construct 30 acre-feet of additional stormwater detention by expanding Lake Oak Lawn further north to 95th Street through existing park land and one commercial property on 95th Street.
OLCR-2	Flooding	Lake Oak Lawn	Construct 80 acre-feet of additional stormwater detention by expanding Lake Oak Lawn further north to 95th Street through existing park land and one commercial property on 95th Street. This alternative also assumes property acquisition of 24 neighboring homes. This alternative was deemed infeasible based on community feedback, thus benefits and costs were not developed.
OLCR-3	Erosion	Oak Lawn Creek between Mayfield Avenue and Central Avenue	Stabilize banks of Oak Lawn Creek at its confluence with Stony Creek to prevent structural failure of channel banks.

3.26.3.4 Alternative Development

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 3.26.6 summarizes flood and erosion control alternatives developed for Oak Lawn Creek.

Based on community feedback, stormwater detention alternatives developed for Oak Lawn Creek were focused on the area surrounding Lake Oak Lawn and also within a park at 99th Street and Meade Avenue. Modeling showed that detention at the 99th Street and Meade Avenue location did not significantly lower WSELs in Oak Lawn Creek. Modeling showed that alternative OLCR-1, which consists of a 30 acre-feet expansion of Lake Oak Lawn, did reduce WSELs and flood damages.

In conjunction with the expansion of Lake Oak Lawn, the existing erosion problems in the area will also be addressed through proper stabilization of the expanded lake. The 30 acre-feet expansion assumes that the lake can be widened by taking a portion of both West Shore Drive and East Shore Drive and making the streets narrower for one-way traffic only. It is also possible to expand the lake an additional 30 acre-feet without taking a portion of the streets, but this would involve taking all park land to the north. Alternative OLCR-2 was modeled, but was not considered further due to community feedback regarding the requirement of land currently occupied by 24 existing residences.

Erosion Control Alternative. The alternative proposed to address the erosion problems along Oak Lawn Creek will provide hard armoring of the bank where erosion is occurring. Roughly 2,200 feet of armoring is required to address the problem area. This 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 Oak Lawn Creek that will give a more natural appearance than concrete. Given its urban setting with limited space available, the straight alignment of Oak Lawn Creek will likely have to remain. However, through the use of rock and geotextile fabric, a hard-armoring protection technique can be designed to protect the slope in a more aesthetically pleasing way. This type of bank treatment will be keyed-in for toe-of-slope protection and there will be transitions to the natural slope at the downstream end of the problem area near the Stony Creek Golf Course. The treatment will be scaled to the gradient of the slope and the shear stresses to which the slope is exposed.

3.26.3.5 Alternative Evaluation and Selection

Alternatives included in Table 3.26.6 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were evaluated through H&H modeling to evaluate their effect on water elevations and flood damages. Erosion control alternatives were evaluated through field investigations to recommend appropriate stream bank stabilization alternatives. Table 3.26.9 provides a summary B/C ratio, net benefits, total project costs, number of structures protected, and other relevant alternative data. Alternatives that did not produce a significant change in inundation areas are not listed as benefits were negligible, and thus costs were not calculated for these alternatives.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.26.7 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

TABLE 3.26.7
Oak Lawn Creek Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		OLCR-1	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
Southeast corner of 95th St. and 54th St.	5771	605.65	919.28	605.35	901.56
Parkside Ave and Edison Ave	4856	598.26	875.52	598.17	857.05
99th St and Mayfield Ave.	2823	595.74	623.85	595.73	618.45
Confluence with Stony Creek	155	595.22	526.02	595.20	531.18

Hydraulic modeling results identified one roadway crossing (state route, US highway, or four-lane road or greater) where Oak Lawn Creek overtops for storm events of 100-year recurrence interval and below by a depth of 0.5 feet or greater. Table 3.26.8 below provides a summary of the depth of road flooding for existing conditions and with recommended alternatives. Following implementation of alternative OLCR-1, the model results show that there will be a minimal decrease in the depth of flooding for each storm event. Lack of available space and the topography of the area prevented the development of alternatives that could further reduce the flooding.

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 Calumet-Sag Channel DWP.

TABLE 3.26.8
Oak Lawn Creek Road Overtopping Summary

Road Crossing	Road Elevation	5-yr Depth of flooding	10-yr Depth of flooding	25-yr Depth of flooding	50-yr Depth of flooding	100-yr Depth of flooding
Central Avenue	594.6	0.5	1.5	2.8	3.6	4.4
Central Avenue (with alternative)	594.6	0.3	1.4	2.7	3.5	4.3

Note: Although Central Avenue experiences overtopping, alternate routes are available.

3.26.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.26.9 lists recommended alternatives analyzed in detail. The recommended alternatives are OLCR-1 and OLCR-3, shown in Figures 3.26.2 and 3.26.3 respectively. A comparison of the existing conditions and alternative conditions inundation mapping is included in these figures.

TABLE 3.26.9
Oak Lawn Creek Project Alternative Matrix to Support District CIP Prioritization

Alternative	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
OLCR-1	Lake Oak Lawn Expansion (30 additional ac-ft)	0.07	450,000	6,306,100	35		Slightly Positive	Yes	Oak Lawn
OLCR-3	Stabilize Oak Lawn Creek between Mayfield Ave and Central Ave	0.42	3,081,000	7,299,200	15		Slightly Positive	Yes	Oak Lawn

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.27 Spring Creek

Spring Creek is a regional waterway located in southwestern Cook County, in the southern part of the Calumet-Sag Channel Watershed. The total drainage area of the Spring Creek subwatershed is 2.6 square miles, which includes some drainage area from Will County. Table 3.27.1 summarizes the communities within Cook County that drain to Spring Creek. Figure 3.27.1 is an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

TABLE 3.27.1
Communities Draining to Spring Creek

Community	Tributary Area (mi^2)
Orland Park	1.75
Unincorporated/Forest Preserve	0.85

The Spring Creek subwatershed contains a mix of suburban development with some open space. Table 3.27.2 summarizes the land use distribution within the Spring Creek subwatershed.

TABLE 3.27.2
Land Use Distribution for Spring Creek

Land Use Category	Area (acres)	%
Agricultural	651	32.6
Commercial/Industrial	90	4.5
Forest/Open Land	453	22.7
Institutional	44	2.2
Residential	612	30.6
Water/Wetland	147	7.4

3.27.1 Sources of Data

3.27.1.1 Previous Studies

Will County recently created H&H models of existing conditions in Spring Creek to examine floodplain areas and channel improvements for part of Spring Creek in Will County. The model extent does not contain the part of Spring Creek in Cook County and does not begin at the county line, and therefore, did not contribute directly to the development of the Calumet-Sag Channel DWP.

3.27.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Spring Creek. Spring Creek is identified as impaired in the IEPA's 2008 *Integrated Water Quality Report*, which includes the 303(d) and 305(b) lists. Spring Creek is on the IEPA's 303(d) list due to total manganese, total phosphorous, sedimentation and siltation. No TMDLs have been established for Spring Creek. According to a USEPA water permit discharge query, there is one NPDES permit issued by IEPA to the Andrew Corporation in Orland Park for discharges to Spring Creek. Municipalities discharging to Spring Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.27.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data for 2001 identify 181.6 acres of wetland areas in the Spring Creek 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.

3.27.1.4 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 into revised floodplain areas.

Spring Creek is mapped in detail in the DFIRM mapping update, with Zone AE floodplain shown across the length of Spring Creek. The original hydrologic and hydraulic analyses were performed in 1976. The hydrologic modeling used Regression Equations 73 and 75. The hydraulic routing was steady state and used the WSP-2 modeling application.

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

3.27.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Stormwater problems were classified as regional or local based upon the criteria described in Section 1 of the report. Table 3.27.3 summarizes the Form B data for Spring Creek.

TABLE 3.27.3
Community Response Data for Spring Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
OT1	Orland Township	Overbank flooding, ponding	114th Court and 157th Street	Heavy rains cause overflow of Spring Creek into adjacent subdivision	Regional	Project SPCR-1 will raise 157th Street to reduce frequency of transportation damage
OP10	Orland Park	Maintenance, overbank flooding	Deluga Woods subdivision between 155th and 159th Streets	Lack of maintenance in unincorporated area results in overbank flooding	Regional	Model results did not show property damage due to flooding from a regional waterway in this area. Stream maintenance is recommended.
OP4	Orland Park	Pavement flooding	Southwest Highway at 151st Street	IDOT reported pavement flooding	Local	Problem not located along a regional waterway. This is a local problem

3.27.1.6 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 projects by others have been identified for the Spring Creek subwatershed.

3.27.2 Watershed Analysis

3.27.2.1 Hydrologic Model Development

Subbasin Delineation. The Spring Creek subwatershed was delineated based upon LiDAR topographic data developed by Cook County in 2003. The subwatershed drainage area includes 0.07 square mile of area in Will County that drain into Cook County. This area had available LiDAR topographic data and was delineated in the same manner as the drainage area within Cook County.

Fifteen subbasins were delineated for the Spring Creek Tributary area, with an average area of 111 acres and a total drainage area of 2.6 square miles.

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.

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.

3.27.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. No hydraulic models that met District criteria, as identified in Section 6.3.3.2 of the CCSMP, were available for DWP development. The open channel of Spring Creek and all crossings were surveyed 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 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 coefficient to the stream. Appendix D contains field survey information in digital form.

Boundary Conditions. The downstream extent of the Spring Creek model is the point at which Spring Creek drains into Will County. The slope of the main channel there is 0.00083. Normal depth based on this slope was set as the boundary condition for Spring Creek at the point of discharge into Will County.

3.27.2.3 Calibration and Verification

No measured or observed stages were available for Spring Creek to compare model results. Curve numbers were reduced by 10 percent for existing and alternative conditions analysis based upon the calibration of streams with monitoring data as described in Section 1.3.8.

3.27.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Flood inundation areas were developed based on HEC-RAS water surface elevations and Cook County topographic data. Figure 3.27.1 shows inundation areas for the 100-year, 12-hour duration design storm.

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

3.27.3 Development and Evaluation of Alternatives

3.27.3.1 Model Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. No property damage due to flooding was identified in the Spring Creek subwatershed. Overtopping of 157th Street, which provides the only means of access to a subdivision west of Spring Creek, was identified as a modeled problem area, as shown in Table 3.27.4. The overtopping of this local road was considered a regional problem because as the only means of access to a subdivision, overtopping of this road by flooding would cut off emergency access to the entire subdivision.

TABLE 3.27.4
Modeled Problem Definition for Spring Creek

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA33	157th Street crossing of Spring Creek	10, 25, 50, 100	OT1	Project SPCR-1 will raise 157th Street to reduce frequency of transportation damage

3.27.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No property damage due to flooding is predicted based upon existing conditions H&H modeling analysis. No erosion or recreation damages were identified for Spring Creek. Transportation damages were explicitly calculated for Spring Creek as the crossing of 157th Street was identified by modeling and WPC members as a frequent flooding issue preventing the only means of access to a subdivision west of Spring Creek. Transportation damages were calculated using the method outlined in “What is a Benefit?” was used (FEMA 2001), using the same period of analysis and discount rate used for property damage due to flooding calculations. Table 3.27.5 lists the existing conditions damages for Spring Creek.

3.27.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in the Spring Creek subwatershed. Conveyance improvements, increased storage, and levees were considered to address the MPA33 problem at the 157th Street crossing.

TABLE 3.27.5
Estimated Damages for Spring Creek

Damage Category	Estimated Damage ($)	Note
Property	0	
Erosion	0	
Transportation	24,100	Specific transportation damages calculated for emergency access restrictions at 157th Street.
Recreation	0	

3.27.3.4 Alternative Development

Flood Control Alternatives. Alternative solutions to regional flooding were developed and evaluated to address the damages estimated in Table 3.27.5 consistent with the methodology described in Section 1.4 of this report. Table 3.27.6 summarizes the flood control alternatives developed for Spring Creek.

TABLE 3.27.6
Flood Control Alternatives for Spring Creek

Alternative	Location	Description
SPCR-1	Spring Creek at 157th Street	Raise 157th Street to prevent overtopping, replace culvert with larger culvert, and construct upstream restrictor and weir with same hydraulics as existing conditions.
SPCR-2	Spring Creek from 157th Street to 159th Street	Dredge Spring Creek to increase conveyance. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
SPCR-3	Spring Creek at 157th Street	Raise Road and provide in-line storage to lower downstream WSEL and prevent 157th Street from flooding. This alternative caused an increase in upstream water surface elevations, thus benefits and costs were not developed.

Erosion Control Alternatives. No erosion control alternatives were developed for Spring Creek.

3.27.3.5 Alternative Evaluation and Selection

Alternative SPCR-1 addresses transportation damages associated with the overtopping of 157th Street by raising the road. The hydraulic structure at the crossing would be designed to maintain existing hydraulic conditions upstream and downstream of 157th Street. The culvert would be replaced with two large box culverts with capacity to convey the 100-year design storm. Upstream of the road, a weir is proposed to be built to the existing elevation of the road, with a low flow pipe equal in size to the existing culvert. Noneconomic criteria is a significant factor in development and consideration of this alternative for recommendation as community feedback from Orland Township indicated that frequent flooding of 157th Street cuts off emergency access to an Orland Township neighborhood.

SPCR-2 involves dredging parts of Spring Creek, as suggested by WPC members. This alternative had little impact on modeled WSELs because downstream restrictions limited conveyance capacity. Damages and a cost estimate were not defined for this alternative.

Model results determined that SPCR-3 increased upstream stage, and therefore cannot be recommended in the DWP.

Alternatives included in Table 3.27.6 were evaluated to determine their effectiveness and produce data required for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water elevations and flood damages. Table 3.27.8 provides a summary B/C ratio, net benefits, total project costs, number of structures protected, and other relevant alternative data. Alternatives that did not produce a significant change in inundation areas are not listed, as benefits were negligible, and so costs were not calculated for these alternatives.

Table 3.27.7 below provides a summary of the depth of road flooding for the 157th Street crossing for existing conditions and with recommended alternatives.

TABLE 3.27.7
Spring Creek Road Overtopping Summary

Road Crossing	Road Elevation	25-yr Depth of Flooding	50-yr Depth of Flooding	100-yr Depth of Flooding
157th Street	690.1	0.6	1.2	1.6
157th Street (with alternative SPCR-1)	693.1			

Note: Blank entry indicates that road crossing does not overtop for that particular storm event.

3.27.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.27.8 lists alternatives analyzed in detail. Alternative SPCR-1 is recommended to address transportation damages. Figure 3.27.2 shows the location of recommended alternative SPCR-1 and a comparison of the inundation mapping for existing conditions and with the recommended alternative.

TABLE 3.27.8
Spring Creek Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
SPCR-1	Raise 157th street	0.02	24,100	1,053,800	0	Orland Township	No Impact	Yes	Orland Township

Note: Net Benefits values do not include local benefits or non-economic benefits.

3.28 Stony Creek

Stony Creek, which consists of an East and West Branch, is located in southwestern Cook County, north of the Calumet-Sag Channel and in the northern part of the Calumet-Sag Channel Watershed. East Stony Creek and West Stony Creek are connected at their upstream extent through the Cicero Avenue storm sewer. The area is near 111th Street and Cicero Avenue in Alsip. Five major tributaries discharge into Stony Creek, making up a 40.5 square mile area. Oak Lawn Creek, Melvina Ditch, Lucas Diversion Ditch, and Lucas Ditch flow into West Stony Creek. Merrionette Park Ditch flows into East Stony Creek. Each tributary waterway was analyzed in detail and is discussed separately in this report. Mosquito Creek also flows into East Stony Creek, but it was not analyzed in detail since most of that area is drained by storm sewer systems.

Figures 3.28.1a, 3.28.1b, and 3.28.1c show the areas directly tributary to Stony Creek (but do not include major tributary subwatersheds, which are addressed in separate sections of this report). Table 3.28.1 lists the communities located in areas directly tributary to the Stony Creek subwatershed. Areas directly tributary to Stony Creek in general are heavily drained by storm sewer systems. Figures 3.28.1a, 3.28.1b, and 3.28.1c show an overview of the tributary area of the subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections. Table 3.28.2 lists the land use breakdown by area within the Stony Creek subwatershed.

TABLE 3.28.1
Communities Draining to Stony Creek

Community	Tributary Area (mi^2)
Oak Lawn	8.52
Burbank	4.12
Palos Hills	3.96
Evergreen Park	3.10
Bedford Park	2.57
Chicago Ridge	2.2
Bridgeview	2.14
Hickory Hills	1.46
Chicago	5.03
Worth	0.82
Unincorporated/Forest Preserve	1.89
Justice	0.12
Hometown	0.05
Alsip	3.22
Blue Island	1.14
Merrionette Park	0.39

Note: This list includes community areas tributary to the entire Stony Creek system. It includes upstream major tributaries, such as Melvina Ditch, which are also discussed separately in this report.

TABLE 3.28.2
Land Use Distribution for Stony Creek

Land Use Category	Area (acres)	%
Residential	14,916	57.5
Commercial/Industrial	4,506.8	17.4
Forest/Open Land	3,971	15.3
Institutional	1,404	5.4
Transportation/Utility	889.2	3.4
Water/Wetland	180	0.7
Agricultural	69	0.3

3.28.1 Sources of Data

3.28.1.1 Previous Studies

The USACE produced an extensive study of Stony Creek in 2001. The study included the development of a hydrologic (HEC-1) and hydraulic (UNET) model of Stony Creek. The USACE's hydrologic model was referred to during the development of an updated hydrologic model for the Calumet-Sag Channel DWP. The USACE's hydraulic model was obtained and converted to HEC-RAS and used to support the DWP development.

The USACE study analyzed several project alternatives to address flooding in the Stony Creek basin, but none is known to be implemented. The alternatives analyzed by the USACE as a part of its study were reviewed, and the information was used in conceptualizing alternatives for the DWP. In some cases, alternatives described in this report include features consistent with those developed and evaluated by the USACE.

3.28.1.2 Water Quality Data

The IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Stony Creek. There are also no reaches 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 Stony Creek. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Stony Creek. Municipalities discharging to Stony Creek are regulated by IEPA's NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.28.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. Wetland areas were identified using National Wetlands Inventory (NWI) mapping. NWI data includes roughly 295.5 acres of wetland areas in the Stony Creek subwatershed (including Stony Creek tributaries described with additional detail in this report such as the Melvina Ditch tributary). 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.

3.28.1.4 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; however, the effective models, which are used to estimate flood levels, were generally not updated. LOMRs were incorporated into revised floodplain areas. Stony Creek is mapped in detail in the DFIRM mapping update, with Zone AE floodplain shown across the length of Stony Creek. The original H&H analysis was performed between 1978 and 1980. The hydrologic modeling was performed by using Regression Equations 73 and 74, L-PTIII, and TR-20. Hydraulic routing performed was steady state and used the WSP-2 modeling application.

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

TABLE 3.28.3
Community Response Data for Stony Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
CP1	Calumet Park	Pavement flooding	I-57 at 127th St. (Burr Oak Ave.)	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem.
CP2	Calumet Park, Chicago	Pavement flooding	I-57 at 119th St.	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem.
OL1	Oak Lawn	Maintenance	Central Avenue, 1/4 mile south of 103rd Street	Siltation observed in south culvert barrel	Regional	Siltation may be addressed through maintenance activities
OL2	Oak Lawn	Bank Erosion	Stony Creek between 103rd Street and Central Avenue	Resident reports erosion, District field staff observed several exposed outfalls	Regional	Erosion problem does not threaten structures or conveyance of Stony Creek. Not addressed by DWP.
OL3	Oak Lawn, Chicago	Pavement Flooding	Pulaski Road and 102nd Street	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem.
OL5	Oak Lawn	Overbank Flooding, Basement Flooding, Ponding, Water Quality, Storm Sewer Capacity	99th Street to 103rd Street between Cicero Avenue and Central Avenue	High water stages on West Stony Creek may limit drainage capacity of Oak Lawn sewers	Local	Problem not located on a regional waterway. This is a local problem.
OL6	Oak Lawn	Sedimentation, Bank Erosion, Maintenance	102nd Street and Merrimac Avenue (near Metra tracks)	Severe bank erosion, bank collapse, and sedimentation at confluence of Oak Lawn Creek and Stony Creek	Regional	Project STCR-10 will address erosion problem that threatens conveyance capacity of Stony Creek by stabilizing banks, removing sediment, and repairing culvert.
OL9	Oak Lawn	Overbank Flooding, Storm Sewer Capacity, Bank Erosion, Sedimentation, Water Quality	Wolfe Wildlife Refuge (from Cicero Avenue and 111th Street to Central Avenue and 105th Street)	Bank erosion along Stony Creek West in wildlife preserve causes additional sedimentation, reducing storm sewer capacity and contributing to overbank flooding in the area	Regional	Project STCR-3 (expansion of Wolfe Wildlife Refuge detention) will reduce flooding in this area.

TABLE 3.28.3
Community Response Data for Stony Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
WO1	Worth	Pavement flooding	Ridgeland Avenue at 111th Street	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
WO2	Worth	Bank Erosion	Stony Creek between Oak Lawn and 76th Avenue	Stream bank is in need of stabilization and debris removal to restore the natural conveyance of Stony Creek	Regional	Removal of debris to be addressed by stream maintenance. Field assessment did not find erosion problem.
WO4	Worth	Ponding, pavement flooding	75th Avenue at 109th Street	Pavement flooding and property flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
AL1	Alsip	Bank Erosion, Sedimentation	115th Street and Stony Creek culvert, just west of Cicero Avenue	Severe erosion at northeast embankment, wing wall partially restricting opening of east barrel of culvert	Regional	This is a maintenance issue. No structural damages associated with bank erosion.
AL2	Alsip	Pavement Flooding	Route 50 (Cicero Ave) at 119th Street	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.
AL3	Alsip	Storm Sewer Flow Restriction, Bank Erosion, Sedimentation	113th Street and Lamon Avenue	Siltation of East Stony Creek from 115th Street North to 11200 Street interferes with drainage of a dry detention pond contributing to a mosquito breeding problem	Regional	Field assessment identified no structural damages associated with bank erosion. Alternatives STCR-4 and STCR-7 will reduce stage in ditch, reducing extent of problem.
OL4	Oak Lawn, Chicago	Pavement Flooding	Pulaski Road and 104th Street	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local storm sewer system problem.

3.28.1.5 Stormwater Problem Data

Communities, agencies (e.g., IDOT, CCHD), and stakeholders submitted Form B questionnaire response data to the District summarizing known stormwater problems within their jurisdictions. Table 3.28.3 summarizes reported problem areas reviewed as a part of the DWP development. Problems are classified in Table 3.28.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.28.1.6 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 projects by others have been identified for the Stony Creek subwatershed.

3.28.2 Watershed Analysis

3.28.2.1 Hydrologic Model Development

Subbasin Delineation. The Stony Creek tributary area was delineated based primarily upon 2003 Cook County LiDAR generated topographic data. Delineated basins were spot checked against available storm sewer mapping to confirm drainage patterns. Table 3.28.4 summarizes the total drainage area, number of subbasins, and average subbasin size for East and West Stony Creek and subwatersheds that drain to them.

TABLE 3.28.4
Stony Creek System Subbasin Summary

Subbasin	Drainage Area (mi^2)	Number of Modeled Subbasins	Average Modeled Subbasin Size (acres)
East Stony Creek[a]	6.9	34	130
West Stony Creek[a]	11.2	55	130
Total	**18.1**	**89**	
Major Tributaries to Stony Creek (in addition to directly tributary areas)			
Merrionette Park Ditch	4.2	25	108
Melvina Ditch	8.4	37	146
Oak Lawn Creek	3.7	21	112
Lucas Ditch	2.7	14	124
Lucas Diversion Ditch	3.4	25	87
Total	**22.4**	**122**	

[a]Areas directly tributary to East and West Stony Creek. They do not include areas drained by other tributary areas summarized in report.

Significant parts of the Merrionette Park Ditch, Melvina Ditch, and East Stony Creek subwatersheds are drained by combined sewer systems. These areas were included in the hydrologic model with diversions created to simulate the approximate interceptor capacity of sewers. Where available, interceptor capacities were assumed based on information obtained from hydraulic models of the City of Chicago's combined sewer system developed in 2008 as a part of the city's citywide H&H Modeling Program. These areas appear to have been excluded from hydrologic models developed to support the production of FEMA regulatory floodplain mapping.

There are two significant reservoirs in the Melvina Ditch subwatershed: Melvina Ditch reservoir and Bedford Park reservoir. Both reservoirs were included in the hydrologic model. Storage provided by Lake Oak Lawn and two ponds within the St. Casimir Cemetery property were included in the hydraulic modeling.

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.

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.

3.28.2.2 Hydraulic Model Development

Field Data, Investigation, and Existing Model Data. The existing USACE hydraulic model of Stony Creek met District criteria, as identified in Section 6.3.3.2 of the CCSMP, and was therefore used to support DWP development. Three cross sections were surveyed on Stony Creek and compared with cross-sectional data included in the USACE's model. The surveyed cross sections were located near Lucas Ditch and Lucas Diversion Ditch confluences in Palos Hills. It was determined that there was a good correlation between recently surveyed cross-sectional data and cross-sectional data included in the USACE model. Field visits were performed to assess channel and overbank roughness characteristics at several locations along Stony Creek. These were then compared with information on photographs and aerial photography to review and accept modeled Manning's n roughness coefficients included in the USACE model.

Boundary Conditions. The Stony Creek hydraulic model has two downstream boundary conditions defined at the downstream ends of East and West Stony Creek, where they discharge into the Calumet-Sag Channel. Fixed water surface elevations for each of the various design storms modeled were established as downstream boundary conditions. The water surface elevations were based on model output from the District's CWS model. Appendix E contains a summary of the boundary conditions analysis performed to support DWP model development.

Calibration and Verification. Stony Creek model results are compared in Table 3.28.5 below with stream crest gage results provided by the IDNR Office of Water Resources (OWR) from the storm that occurred on September 13th-14th, 2008. Curve numbers were reduced by 10 percent for existing and alternative conditions based upon the calibration of streams with monitoring data as described in Section 1.3.8. The model results are listed for both initial (pre-calibration) model results and calibrated model results (with the 10 percent reduction of curve number values applied). The difference between the observed and calibrated model water surface elevations are generally considered to be within an acceptable margin of error.

High water elevations are taken at a point in time when it is not certain that the peak water elevation occurred.

TABLE 3.28.5
Comparison of Observed and Predicted Stage for Stony Creek, 9/13/2008 Storm Event

Location Description	HEC-RAS River Station	HWM or Gage Peak WSE (ft)	Unmodified Simulated Peak WSE (ft)	Difference between observed and unmodified WSE (ft)	Simulated peak WSE (ft) with CNs modified to 0.9 * CNs	Difference between observed and modified WSE (ft)	Source of HWM
West Stony Creek 80' downstream of railroad bridge near confluence with Oak Lawn Creek	3.842	591.55	592.69	1.14	592.16	0.61	IDNR Gage 5
West Stony Creek at Virginia Road	3.166	590.60	591.34	0.74	590.82	0.22	IDNR Gage 3
West Stony Creek at Roberts Road	1.412	587.75	588.38	0.63	587.93	0.18	IDNR Gage 1
East Stony Creek at 115th Street	3.617	588.78	588.51	-0.27	588.19	-0.59	IDNR Gage 8
East Stony Creek at Kostner Avenue	2.688	587.47	588.14	0.67	587.75	0.28	IDNR Gage 9
Oak Lawn Creek, at Lake Oak Lawn	5771	598.88	599.72	0.84	599.34	0.46	Village of Oak Lawn observation

Note: Stony Creek river stations are in miles, and Oak Lawn Creek river stations are in feet

As a further verification step, DWP Stony Creek hydraulic model results were also compared with USACE Stony Creek hydraulic model results. Table 3.28.6 summarizes the water surface elevations identified by both the DWP and USACE Stony Creek hydraulic models. The elevations identified in DWP modeling are generally consistent with the USACE model results for the 100-year design storm, with higher elevations in some areas and lower elevations in other areas.

3.28.2.3 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.28.1 shows inundation areas produced by the DWP's hydraulic model for the 100-year, 12-hour duration design storm. The FEMA DFIRM modeling had a total drainage area to Stony Creek of 31.3 square miles as compared to the DWP drainage area which was 40.5 square miles. The difference in drainage area likely contributes greatly to the difference between DWP inundation areas and the FEMA DFIRM floodplain areas.

TABLE 3.28.6
Comparison of DWP and USACE Model Results for 100-Year Design Storm

Location	Model River Station	DWP HEC-RAS Model Results WSEL (ft)	Army Corps UNET Model Results WSEL (ft)
80th Avenue (Roberts Road)	1.376	590.5	590.5
Harlem Avenue	2.507	592.1	592.9*
Virginia Avenue	3.166	593.4	594.2
About 420 feet downstream of Ridgeland Avenue	Approx. 3.561	593.6	594.4
About 940 feet upstream of Ridgeland Avenue	Approx. 3.832	595.1	595.2*
Central Avenue	4.769	595.4	595.6
Wolfe Wildlife Refuge	5.331	595.4	595.7
115th Street	3.67	592.2	591.9
Kostner Avenue	2.688	592.1	591.1

*Interpolated from nearby cross-sectional values.

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

3.28.3 Development and Evaluation of Alternatives

3.28.3.1 Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.28.7 summarizes major problem areas identified through hydraulic modeling of Stony Creek.

TABLE 3.28.7
Modeled Problem Definition for Stony Creek

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA34	Area bounded by Kedzie Avenue Burr Oak Avenue, California Avenue and Vermont Street	25, 50, 100, 500		Project STCR-7 will reduce flooding in this area.
MPA35	Area along East Stony Creek between Kedzie Avenue and Merrionette Park Ditch	25, 50, 100, 500		Project STCR-7 will reduce flooding in this area.
MPA36	Area along East Stony Creek between Kostner Avenue and Crawford Avenue, north of 123rd Street	100, 500		Project STCR-7 will reduce flooding in this area.

TABLE 3.28.7
Modeled Problem Definition for Stony Creek

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA37	Area near 111th and Cicero Avenue at East and West Stony confluence	25, 50, 100, 500	AL1	Project STCR-2 will reduce flooding in this area. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA38	Area bounded by 107th Street, Laramie Avenue, 101st Street, and Marshall Avenue	25, 50, 100, 500	OL1, OL2, OL9	Projects STCR-2, STCR-3, and STCR-4 will reduce flooding in this area. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA39	Area south of 99th Street between Oak Lawn Creek and Melvina Ditch	25, 50, 100, 500	CR1, CR3, OL6	Projects STCR-3 and STCR-8 will reduce flooding in this area. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA40	Area between Melvina Ditch and Tri-State Tollway	50, 100, 500		Projects STCR-3 and STCR-8 will reduce flooding in this area. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA41	Area between Tri-State Tollway and Lucas Diversion Ditch	5, 10, 25, 50, 100, 500	WO2	Project STCR-8 will reduce flooding in this area. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.

TABLE 3.28.7
Modeled Problem Definition for Stony Creek

Problem ID	Location	Recurrence Interval (yr) of Flooding	Associated Form B	Resolution in DWP
MPA14	Area between Lucas Ditch confluence and West Stony Creek confluence with Calumet-Sag Channel	5, 10, 25, 50, 100, 500	PHI3	Project LUDT-5 will protect properties from flooding. Sufficient land was not available to address all flooding in this area. Such properties are candidates for protection using non-structural flood control measures, such as flood-proofing or acquisition.

3.28.3.2 Damage Assessment

Economic damages were defined following the protocol defined in Chapter 6.6 of the CCSMP. No erosion or recreation damages due to flooding were identified for Stony Creek. Transportation damages were estimated as 15 percent of property damages. Table 3.28.8 lists the damage assessment for existing conditions.

TABLE 3.28.8
Estimated Damages for Stony Creek

Damage Category	Estimated Damage ($)	Note
Property	24,046,400	
Erosion	0	
Transportation	3,607,000	Assumed as 15% of property damage due to flooding

3.28.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate for addressing the flooding problems in the Stony Creek subwatershed. Increased conveyance or storage was identified as the principal technologies applicable for addressing stormwater problems in Stony Creek.

3.28.3.4 Alternative Development

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 3.28.9 summarizes flood and erosion control alternatives developed for Stony Creek. Based on the feedback from watershed communities, a review of previous studies, and a consideration of large open tracts of land, stormwater detention alternatives developed for Stony Creek were focused on areas surrounding the intersection of 111th Street and Cicero Avenue. The area contains parts of St. Casimir Cemetery, a retail development that includes a K-Mart store, and the Wolfe Wildlife Refuge.

TABLE 3.28.9
Flood Control and Erosion Control Alternatives for Stony Creek

Alternative Number	Problem Addressed	Location	Description
STCR-1	Flooding	St. Casimir Cemetery	Construct 850 acre-feet of stormwater detention and conveyance facilities required to collect West and East Stony Creek flows. Construct detention area 12 feet deep to allow gravity dewatering. This alternative requires significant conveyance facilities to collect flows into the stormwater detention basin. The Kilpatrick and Cicero Avenue existing sewers would be rerouted to the stormwater detention basin as a part of this alternative. This alternative was considered to be beyond the limits of feasible constructability, thus benefits and costs were not developed.
STCR-2	Flooding	St. Casimir Cemetery	Construct 400 acre-feet of stormwater detention and conveyance facilities required to collect West and East Stony Creek flows. Construct detention area 12 feet deep to allow gravity dewatering. This alternative requires significant conveyance facilities to collect flows into the stormwater detention basin. The Kilpatrick and Cicero Avenue existing sewers would be rerouted to the stormwater detention basin as a part of this alternative.
STCR-3	Flooding	Wolfe Wildlife Refuge	Expand Wolfe Wildlife Refuge Lake by 87 acre-feet. This includes excavation in two locations along West Stony Creek between Central Avenue and Cicero Avenue in Oak Lawn. Construct levees along Stony Creek (at elevation 597 feet, from Lawler Avenue west to Long Avenue, and at elevation 595 feet from Long Avenue to Central Avenue, and possibly low level levee along the south side of Stony Creek).
STCR-4	Flooding	K-Mart Parking Lot near 111th Street and Cicero Avenue	Incorporate stormwater detention facility into redevelopment of K-Mart parking lot area near intersection of 111th Street and Cicero Avenue. Construct 39 acre-feet of stormwater detention at this site.
STCR-5	Flooding	Melvina Ditch and West Stony Creek confluence	Construct closed conduit diversion that conveys part of the flows from Melvina Ditch to Stony Creek and relieves flooding along Stony Creek through a more hydraulically efficient alignment. This alternative is consistent with one developed and evaluated by the USACE. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
STCR-6	Flooding	Melvina Ditch and West Stony Creek confluence	Construct open channel diversion that conveys part of the flows from Melvina Ditch to Stony Creek and relieves flooding along Stony Creek through a more hydraulically efficient alignment. This was modeled with proposed detention basins adjacent to the realigned stream to mitigate for increased peak flows to Stony Creek from increased conveyance capacity.
STCR-7	Flooding	California Avenue Culvert	Enlarge an existing conduit that crosses underneath California Avenue to convey part of the flows from Stony Creek to the Calumet-Sag Channel.
STCR-8	Flooding	Harlem Avenue and Stony Creek	Construct closed conduit diversion that conveys part of the flows from Stony Creek to the Calumet-Sag Channel.
STCR-9	Flooding	ComED ROW and Stony Creek	Construct closed conduit diversion that conveys part of the flows from Stony Creek to the Calumet-Sag Channel.
STCR-10	Erosion	Confluence of Oak Lawn Creek and Stony Creek	Stabilize banks of Oak Lawn Creek at its confluence with Stony Creek to prevent structural failure of channel banks and flooding damages and excavate sediment where bank has fallen into Stony Creek creating a blockage of flow.
STCR-11	Flooding	Confluence of Lucas Ditch and Stony Creek	Construct levee along north side of Stony Creek downstream of Lucas Ditch to protect against area flooding.

Alternatives STCR-1 through STCR-4, summarized in Table 3.28.9, were evaluated individually and together to determine their effectiveness in reducing flooding along Stony Creek and the downstream end of other major tributaries. They were considered as critical parts of conveyance improvement alternatives developed for the East Stony Creek, West Stony Creek, Lucas Ditch, and Lucas Diversion Ditch subwatersheds.

The alternatives described in Table 3.28.9 require significant conveyance infrastructure to deliver flows to the alternative stormwater detention facilities and make several assumptions on feasibility of construction. Alternatives 1 through 4 require significant conveyance infrastructure to deliver flows to proposed stormwater detention facilities. Alternatives STCR-5 through STCR-9 are conveyance improvement alternatives that divert flows to the Calumet-Sag Channel. Regulatory approval from regulatory agencies such as IDNR and the USACE would be required. Other alternatives recommended in the DWP include storage and will result in lower peak discharge rates at points where tributaries discharge to the Calumet-Sag Channel. All flows from individual tributaries are relatively small in comparison to the total flow within the Calumet-Sag Channel.

Erosion Control Alternative. The alternative proposed to address the erosion problems near the confluence of Oak Lawn Creek and Stony Creek will provide hard armoring of the bank where erosion is occurring. Roughly 1,000 feet of armoring is required to address the problem area. 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 Stony Creek that will give a more natural appearance than concrete. Given the limited space available, the existing alignment of Stony Creek will likely have to remain. However, through the use of rock and geotextile fabric, a hard-armoring protection technique can be designed to protect the slope in a more aesthetically pleasing way. This type of bank treatment will be keyed-in for toe-of-slope protection and there will be transitions to the natural slope at the downstream end of the problem area near the confluence with Oak Lawn Creek. The treatment will be scaled to the gradient of the slope and the shear stresses to which the slope is exposed. This alternative also includes costs for the removal of sediment buildup at the problem area caused by eroding stream banks.

3.28.3.5 Alternative Evaluation and Selection

Alternatives listed in Table 3.28.9 were evaluated to determine their effectiveness and to produce data for the countywide prioritization of watershed projects. Flood control alternatives were modeled to evaluate their impact on water surface elevations and flood damages. Erosion control alternatives were evaluated through field investigations to recommend appropriate streambank stabilization alternatives. Table 3.28.12 provides a summary B/C ratio, net benefits, total project costs, number of structures protected, and other relevant alternative data.

Hydraulic modeling results identified four roadway crossings (state route, US highway, or four-lane road or greater) where Stony Creek overtops for storm events of 100-year recurrence interval and below by a depth of greater than 0.5 feet. Table 3.28.10 lists the four locations and provides a summary of the depth of road flooding for existing conditions and with recommended alternatives. Following implementation of alternatives STCR-4, STCR-7, and STCR-8, model results show that two roadway crossings will have a 100-year depth of flooding of less than 0.5 feet of depth. The remaining two roadway crossings will have reduced depths of flooding, but limited available space and topography in the area prevented alternatives from further reducing the depth of flooding.

TABLE 3.28.10
Stony Creek Road Overtopping Summary

Road Crossing	Road Elevation	25-yr Depth of Flooding	50-yr Depth of Flooding	100-yr Depth of Flooding
Crawford Avenue	590.2		0.1	1.7
Crawford Avenue (with alternatives)	590.2			
111th Street	594.0		0.5	1.4
111th Street (with alternatives)	594.0			0.4
Central Avenue	592.1	1.2	2.3	3.2
Central Avenue (with alternatives)	592.1		0.9	2.3
Ridgeland Avenue	592.2	0.5	1.6	2.6
Ridgeland Avenue (with alternatives)	592.2		0.4	1.8

Note: Blank entry indicates that road crossing does not overtop for that particular storm event.
Note: Although Ridgeland Avenue and Central Avenue experience overtopping with alternatives, alternative routes are available.

Modeling analysis concluded that STCR-1, STCR-2, STCR-3, STCR-4, STCR-7, STCR-8, and STCR-9 were effective at reducing flood damages. STCR-1 was not considered further because the 850 acre-foot size is at the limits of feasibility. A more detailed analysis to determine the optimal size of a detention basin at the St. Casimir Cemetery site should be carried out during the design process should STCR-2 be selected for implementation. If STCR-2, STCR-3, and STCR-4 are selected for implementation and will be constructed at the same time, it is recommended that they are planned, engineered, and constructed as one combined project. This will save on mobilization costs and ensure that each project is properly coordinated given their adjacent locations and that the projects may involve construction of new pipes leading to and from the proposed ponds. The combined alternative is listed in Table 3.28.12 as STCR-2b.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.28.11 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

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 Calumet-Sag Channel DWP.

3.28.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.28.12 lists alternatives analyzed in detail as part of DWP development.

The recommended alternatives for Stony Creek are alternatives STCR-2, STCR-3, STCR-4, STCR-7, STCR-8, and STCR-10. STCR-8 is recommended over STCR-9 because of better construction feasibility. As the B/C ratios of both STCR-8 and STCR-9 are similar, it is recommended that the route of a diversion for this area of West Stony Creek be determined during a more detailed design study. This set of alternatives includes more than 500 acre-feet of stormwater detention, two major conveyance projects, and one streambank stabilization project. STCR-6 is not recommended because the benefits associated with straightening Melvina Ditch were found to be minimal.

Figures 3.28.2 through 3.28.7 show the locations and a summary of the recommended alternatives described in Table 3.28.12. Figures 3.28.2 through 3.28.7 also show comparisons of the existing condition and alternative condition inundation areas. Additional alternatives were analyzed within the major tributaries to East Stony Creek and West Stony Creek, such as Oak Lawn Creek and Lucas Ditch. Those alternatives are discussed in each individual tributary section. Alternatives that did not produce a significant change in inundation areas are not listed as benefits were negligible, and thus costs were not calculated for these alternatives.

TABLE 3.28.11
Stony Creek Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		STCR-2		STCR-3		STCR-4		STCR-7		STCR-8	
Location	**Station**	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)	Max WSEL (ft)	Max Flow (cfs)
Upstream end of Stony Creek West	5.68	595.39	329.65	594.67	91.59	595.37	29.04	595.35	45.90	595.38	319.74	595.37	329.57
400-ft upstream of Central Ave.	4.88	595.36	709.14	594.66	478.25	595.33	718.60	595.32	698.91	595.35	704.13	595.33	737.79
Major Ave. and Edge Lake Dr.	4.65	595.34	746.45	594.63	525.80	595.31	755.21	595.30	742.58	595.33	743.31	595.31	775.20
Downstream of Oaklawn Creek confluence	3.84	595.08	1273.05	594.44	1122.64	595.05	1264.62	595.04	1263.48	595.07	1271.24	595.03	1312.72
Downstream of Melvina Ditch confluence	3.58	593.55	1795.76	593.12	1640.54	593.53	1790.47	593.52	1787.03	593.55	1793.12	593.42	1692.53
300-ft downstream of Southwest Hwy	2.96	593.16	1702.53	592.77	1574.89	593.12	1689.39	593.13	1685.79	593.16	1700.07	593.04	1738.85
Downstream of Lucas Diversion Ditch confluence	1.64	591.00	2458.27	590.75	2315.10	590.96	2431.15	590.97	2440.00	591.00	2456.31	590.50	2185.84
300-ft downstream of Roberts Rd.	1.34	590.41	2481.43	590.17	2339.45	590.37	2456.67	590.38	2465.00	590.41	2480.10	589.95	2211.51
Downstream of Lucas Ditch confluence	0.41	587.40	2960.64	587.24	2829.51	587.37	2936.08	587.38	2944.97	587.40	2959.60	587.09	2706.45
150-ft upstream of 115th St.	3.72	592.21	95.98	592.05	64.93	592.18	95.86	592.19	98.33	591.35	160.54	592.21	97.72
1000-ft downstream of Kostner Ave.	2.54	592.12	310.27	591.97	383.67	592.09	307.96	592.10	307.28	591.15	411.00	592.12	309.92
Downstream of Merrionette Park Ditch confluence	1.54	591.75	840.82	591.54	846.04	591.72	837.11	591.73	837.93	590.22	1053.87	591.75	840.65
Southeast of Kedzie Ave. and 127th St.	0.95	591.18	919.14	590.96	912.79	591.16	914.00	591.17	915.86	589.00	1183.08	591.18	918.80
Downstream end of Stony Creek East	0.30	590.92	1051.46	590.70	1029.15	590.90	1043.67	590.91	1047.02	588.17	1478.52	590.92	1051.30

TABLE 3.28.12
Stony Creek Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
STCR-2	400 ac-ft reservoir at St. Casimir Cemetery	0.25	12,203,700	48,496,800	666	USACE	Positive	Yes	Alsip, Oak Lawn, Chicago
STCR-2b	STCR-2, STCR-3, and STCR-4 combined	0.22	13,364,900	60,515,100	804	USACE, Village of Oak Lawn	Positive	No	Alsip, Oak Lawn, Chicago
STCR-3	87 ac-ft detention pond at Wolfe Wildlife Refuge	0.1	735,100	7,691,000	55	USACE	Positive	Yes	Alsip, Oak Lawn, Chicago
STCR-4	39 ac-ft detention pond at K-Mart site	0.05	206,600	4,327,300	20	USACE, Village of Oak Lawn	Slightly Positive	Yes	Alsip, Oak Lawn, Chicago
STCR-6	Realign Melvina Ditch confluence with Stony Creek	0.01	86,100	10,983,600	21	USACE	No Impact	No	Chicago Ridge, Oak Lawn
STCR-7	Enlarge California Avenue culvert	0.11	364,200	3,428,900	86	USACE	No Impact	Yes	Palos Hills
STCR-8	Construct closed-conduit diversion along ComEd ROW	0.18	1,146,600	6,286,400	44	USACE	No Impact	Yes	Palos Hills
STCR-9	Construct Harlem Ave channel diversion	0.2	2,654,800	13,597,300	160	USACE	No Impact	No	Palos Hills
STCR-10	Stabilization of erosion problem area near Stony Creek and Oak Lawn Creek confluence	*	*	2,754,800	0		Positive	Yes	Oak Lawn
STCR-11	Levee downstream of Lucas Ditch – West Stony Creek confluence	0.02	63,800	3,219,600	3	USACE	No Impact	No	Palos Hills

Notes: Net Benefits values do not include local benefits or non-economic benefits.
Alternative STCR-10 is recommended because it is an erosion problem that if left to continue threatens to significantly constrict Stony Creek flow.

3.29 Tinley Creek

Tinley Creek is located in southwestern Cook County, south of the Calumet-Sag Channel, in the southeastern part of the Calumet-Sag Channel Watershed. The drainage area of the Tinley Creek is 12.91 square miles, with 2.3 square miles in Boca Rio Ditch and 0.25 square mile in Arroyo Ditch. Table 3.29.1 summarizes the land area of communities within the Tinley Creek subwatershed. The middle of Tinley Creek, including the confluence with Boca Rio Ditch, is within Cook County Forest Preserve. The upstream part, as well as its tributaries Boca Rio Ditch and Arroyo Ditch, is largely residential. Table 3.29.2 summarizes the land use distribution within Tinley Creek.

Figures 3.29.1a and 3.29.1b are an overview of the tributary area of the Tinley Creek subwatershed. Reported stormwater problem areas, flood inundation areas, and proposed alternative projects are also shown and discussed in the following subsections.

TABLE 3.29.1
Communities Draining to Tinley Creek

Community/Tributary	Tributary Area (mi^2)
Unincorporated/Forest Preserve	5.62
Orland Park	4.2
Oak Forest	1.18
Orland Hills	0.86
Tinley Park	0.6
Matteson	0.17
Crestwood	0.14
Palos Heights	0.13
Alsip	0.01

Note: Includes areas tributary to Boca Rio Ditch and Arroyo Ditch

TABLE 3.29.2
Land Use Distribution for Tinley Creek

Land Use Category	Area (acres)	%
Forest/Open Land	4,002.9	48.5
Residential	3,352.9	40.6
Commercial/Industrial	487.8	5.9
Water/Wetland	135.1	1.6
Agricultural	126.3	1.5
Institutional	95	1.2
Transportation/Utility	58.7	0.7

Note: Area includes Boca Rio Ditch and Arroyo Ditch

3.29.1 Sources of Data

3.29.1.1 Previous Studies

An HSPF model of the Tinley Creek watershed is under development by the USGS to predict runoff volumes and use in a water-quality analysis of the Tinley Creek subwatershed. The model was not available during the DWP development.

3.29.1.2 Water Quality Data

IEPA does not have any sites in the Ambient Water Quality Monitoring Network on Tinley Creek. The IEPA’s 2008 *Integrated Water Quality Report*, which includes the CWA 303(d) and 305(b) lists Tinley Creek as impaired for its designated use supporting aquatic life, with the cause of impairment listed as unknown. No TMDLs have been established for Tinley Creek. According to a USEPA water permit discharge query, there are no NPDES permits issued by IEPA for discharges to Tinley Creek. Municipalities discharging to Tinley Creek are regulated by IEPA’s NPDES Phase II Stormwater Permit Program, which was created to improve the water quality of stormwater runoff from urban areas, and requires that municipalities obtain permits for discharging stormwater and implement the six minimum control measures for limiting runoff pollution to receiving systems.

3.29.1.3 Wetland and Riparian Areas

Figures 2.3.6 and 2.3.7 contain mapping of wetland and riparian areas in the Calumet-Sag Channel Watershed. NWI data includes 517 acres of wetland areas in the Tinley Creek 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.

3.29.1.4 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 original H&H analysis was performed in 1976. The hydrologic modeling was performed by using L-PTIII and Regression Equation 77. Hydraulic routing was performed using the WSP-2 modeling application.

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

3.29.1.5 Stormwater Problem Data

Table 3.29.3 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 3.29.3 as regional or local. This classification is based on a process described in Section 1 of this report.

3.29.1.6 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. The Village of Orland Park noted that engineering services had been contracted for replacement of culverts and sediment removal in the Fernway area, which is just downstream of 88th Avenue. The Village reiterated at the June 4, 2008, WPC coordination meeting that several culverts will be replaced in kind. In fall 2007, sediment was observed at some culverts during a field survey in this extent of Tinley Creek. This sediment was not included in the baseline model.

3.29.2 Watershed Analysis

3.29.2.1 Hydrologic Model Development

Subbasin Delineation. The Tinley Creek tributary area was delineated based primarily upon LiDAR topographic data developed by Cook County in 2003. Part of the Tinley Creek basin is adjacent to the Little Calumet watershed. Initial boundaries of the Calumet-Sag boundary and Little Calumet boundary were compared, and discrepancies identified. Discrepancies generally were minor and resolved by manual review of topographic data and consultation with local communities and other watershed planning consultants.

TABLE 3.29.3
Community Response Data for Tinley Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
BR1	Bremen Township	Maintenance	Ridgeland Ave. from 135th St. to 147th St.	Debris and siltation of box culvert due to alignment of Tinley Creek (CCHD)	Regional	Siltation not noted in field survey. May have been addressed through maintenance activities.
BR2	Bremen Township	Maintenance	143rd St. from 82nd Ave. to Harlem Ave.	Overbank flooding due to lack of maintenance in Forest Preserve	Local	Problem not located on a regional waterway.
CW2	Crestwood	Maintenance	Central Ave. from 127th St. to 135th St.	Embankments need repair and debris in embankment and waterway	Regional	Project TICR-3 recommends the construction of a levee upstream of Central Avenue.
CW3	Alsip, Crestwood, Worth Township	Overbank flooding, basement flooding	Between 129th St. and Calumet-Sag Channel, west of Central Ave.	Overbank flooding during heavy rain, attributed in part to double bend in Tinley Creek just downstream of Central Avenue	Regional	TICR-3 protects downstream structures from damages due to flooding. Modification of channel alignment would increase downstream flooding, and cause erosion risk due to increased velocity.
OH1	Orland Hills, Orland Park	Overbank flooding, ponding, water quality, bank erosion, wetland riparian	Tinley Creek at 88th Ave.	Culvert and channel downstream of 88th Avenue have sediment and vegetation which reduces conveyance	Regional	TICR-5 addresses sedimentation upstream of 188th Street
OH2	Orland Hills	Overbank flooding, ponding, water quality, bank erosion, wetland riparian	Lake Lorin and along 167th Street between 91st Ave. and Haven Ave.	Lake Lorin vegetation, sedimentation, and outlet condition reduces Tinley Creek conveyance in this area	Regional	Maintenance of Lake Lorin recommended to preserve storage capacity. Sufficient land was not available in the area for potential capital projects that could address problem. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.

TABLE 3.29.3
Community Response Data for Tinley Creek

Problem ID	Municipality	Problems as Reported by Local Agency	Location	Problem Description	Local/ Regional	Resolution in DWP
OP15	Orland Park	Sedimentation, Overbank flooding	167th St. and 88th Ave. (Fernway area)	Sedimentation and culvert restrictions result in frequent overbank flooding of the Fernway area. Village has contracted engineering for culvert replacement and sediment removal	Regional	Orland Park has planned solution to replace culverts and remove sediment in this region. Included in baseline model conditions.
OP2	Orland Park	Pavement flooding	Route 43 (Harlem Ave.) between 151st St. and 153rd St.	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem
OP5	Orland Park	Bank erosion, sedimentation	151st St. and Orland Brook Dr.	Significant erosion and sedimentation results in flow restriction	Regional	TICR-7 will stabilize banks to address this erosion problem on a regional waterway that threatens structures.
OP8	Orland Park	Overbank flooding	Tinley Creek at 82nd Ave.	Overbank flooding due to undersized culvert along Tinley Creek and lack of maintenance downstream	Regional	Model results did not confirm that roadway flooding in this area is associated with regional waterways. Previous observations of flooding in this area may be the result of a condition already addressed or associated with local drainage problems.
PH1	Palos Heights	Overbank flooding	135th St. from Harlem Ave. to Ridgeland Ave.	Pavement flooding due to high stages in the channel, 28 known occurrence	Local	Problem not located on a regional waterway. This is a local problem
PH11	Bremen Township, Palos Heights	Pavement flooding	Route 43 (Harlem Ave.) at 135th St.	IDOT reported pavement flooding	Local	Problem not located on a regional waterway. This is a local problem

Table 3.29.4 summarizes the total drainage area, number of modeled subbasins, and average subbasin size for Tinley Creek and its tributaries.

TABLE 3.29.4
Tinley Creek System Subbasin Summary

Subbasin	Drainage Area (mi^2)	Number of Modeled Subbasins	Average Modeled Subbasin Size (acres)
Tinley Creek	10.37	55	120.35
Major Tributaries to Tinley Creek			
Boca Rio Ditch	2.29	15	99.11
Arroyo Ditch	0.25	1	156.87
Total	12.91	71	116.37

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. 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.

3.29.2.2 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. Surveys of the open channel part of Tinley Creek and all 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 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. Tinley Creek is tributary to the Calumet-Sag Channel. Appendix E summarizes the modeled elevation of the Calumet-Sag Channel for the modeled recurrence interval storms. The estimated elevation for the 100-year storm at the outlet of Tinley Creek was 585.18 feet NAVD 88, roughly 4 feet above the invert of Tinley Creek near its confluence with the Calumet-Sag channel. This relatively shallow depth indicates that downstream stage on Tinley Creek is controlled not by the receiving system but by its own capacity to convey flows received from its tributary area. Normal depth assuming a friction slope of 0.001 was thus used as a downstream boundary condition for Tinley Creek.

3.29.2.3 Calibration and Verification

Observed Data. USGS Stream Gage 5536500 is located on Tinley Creek at its 135th Street crossing. Approximately 11.2 square miles of the Tinley Creek system is tributary to this gage location. The gage record spans from September 26, 1951 to the present. The record was reviewed to identify recent storms of significant intensity for comparison with model results. Based upon a review of recorded flows, several generally discrete rainfall events that resulted in significant flows were identified for use in model calibration. Only events within the last 10 years were considered to minimize differences due to watershed development. Table 3.29.5 summarizes selected flow events.

Four ISWS rain gages are located in the Tinley Creek subwatershed area. Thiessen polygons were used to assign rain gages to each subwatershed. Figure 2.3.1 shows the Tinley Creek subwatersheds and their assigned ISWS rainfall gage. Table 3.29.6 summarizes the 12-hour rainfall accumulation and associated recurrence interval storm approximation for each gage and modeled storm.

TABLE 3.29.5
Flow Events

Date	Peak Monitored Flow (cfs)	Note
6/10/2006	385	No rainfall in the month preceding the event
9/13/2006	1,210	Four significant rainfall events in preceding 15 days.
8/23/2007	584	Larger, second event of August 2007.
9/13/2008	906	Four significant rainfall events in preceding 15 days.

TABLE 3.29.6
Summary of 12-Hour Rainfall Accumulation and Associated Recurrence Interval Storm Approximations

		6/10/2006		9/13/2006		8/23/2007		9/13/2008	
Gage	Area	Depth (in)	Recurrence	Depth (in)	Recurrence	Depth (in)	Recurrence	Depth (in)	Recurrence
16	2.28	2.65	2 yr	1.59	4 month	1.48	4 month	3.21	5-yr
17	2.56	2.11	< 1 yr	1.9	< 9 month	1.25	2 month	3.59	5-10 yr
20	4.45	2.29	1 yr	2.64	2 yr	1.41	3-month	n/a	n/a
21	3.63	2.52	2yr	1.23	2 month	1.48	4 month	3.08	2-5 yr

The four events listed in Table 3.29.6 were reviewed to determine each event's suitability for use in calibration. The review determined that the 9/13/2006 and 8/23/2007 events were not suitable for use in calibration because of extreme rainfall variability, high antecedent moisture conditions evident in the comparison of stream flow with runoff volume (80 percent of rainfall was measured as streamflow), and multiple peak events are difficult to simulate accurately using SCS hydrology. The 6/10/2006 and the 9/13/2008 events had less rainfall variability, span a range of storm magnitudes, and were single-peaked events well- suited to simulation with SCS hydrology. These events were considered for calibration and are summarized below.

Calibration Results. The September 13, 2008 storm was evaluated using the existing conditions model. The event lasted for approximately two days, and consisted of three periods of more intense rainfall.

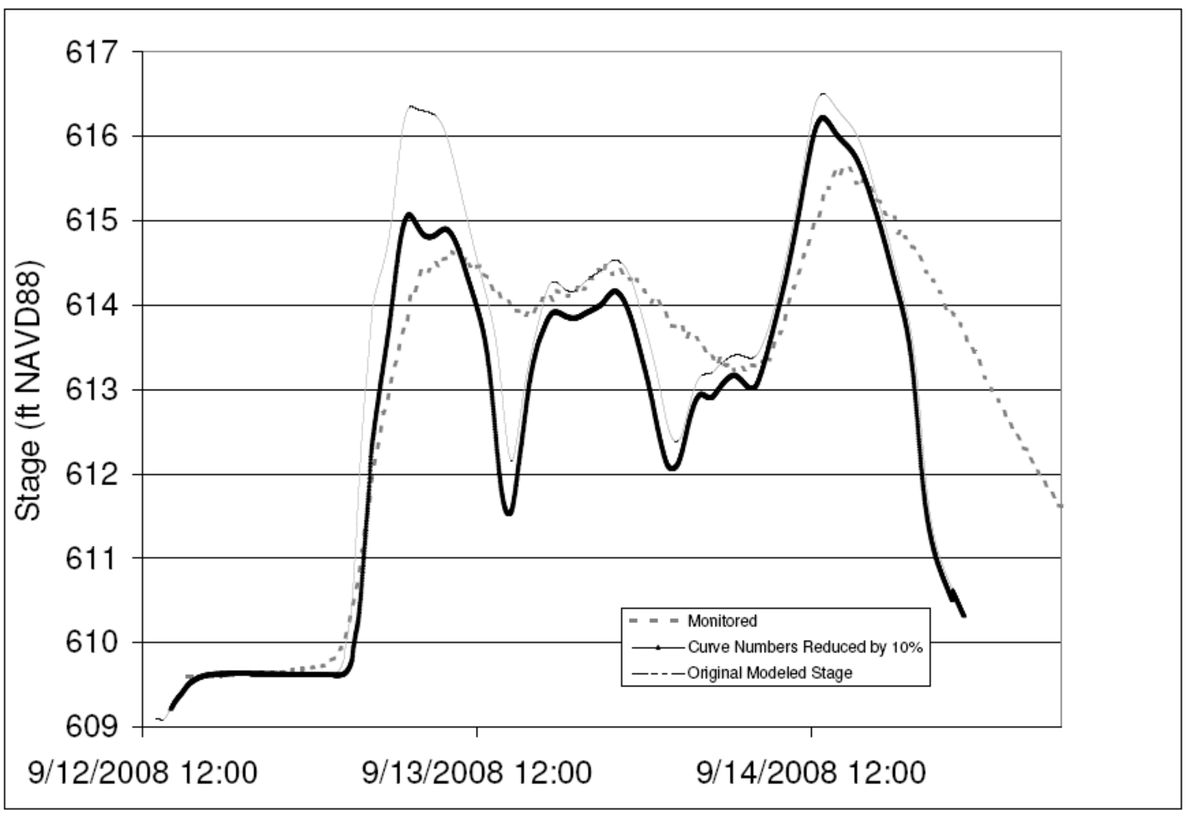
TABLE 3.29.7
9/13/2008 Monitored and Modeled Flow and Stage for Tinley Creek

Model Run	Peak Stage (ft)	Runoff Volume (ac-ft)	Difference in Peak Stage (ft)	Difference in Runoff Volume (ac-ft)
Monitored	615.6	1995.4	N/A	N/A
Original Model	616.5	2780.5	-0.9	39.3%
Revised Model	616.1	2277.2	-0.5	14.1%

The highest stage was reported, coinciding with the third peak.

A comparison of modeled and recorded stage and flow indicated that the model was over predicting these parameters. Modification of hydrologic and hydraulic variables that affect stage and flow were considered as described in Section 1.3.8. As described, the model curve numbers were reduced by 10 percent from the originally calculated values. This resulted in an improved correlation between the modeled and monitored runoff volume and stage. Table 3.29.7 provides a comparison of monitored and modeled stage and runoff volume, including both the original and revised hydrologic model results. Figure 3.29.2 provides a comparison of modeled and monitored stage for the same event.

FIGURE 3.29.2
Tinley Creek Calibration for September 13, 2008 Storm



The calibrated model results show a better correlation of stage, particularly for the two most intense portions of the events. For the first peak, the original model over predicts stage by approximately 1.5 ft, and this difference is reduced to less than half a foot with the revised model. In the periods of less rainfall, the modeled stage decreases more rapidly than the monitored stage. This behavior may be due in part to the shape of the standard SCS unit hydrograph. Hydraulic routing attenuates the unit hydrograph shape, but not to the extent that the model hydrograph at the gage location matches the receding limb.

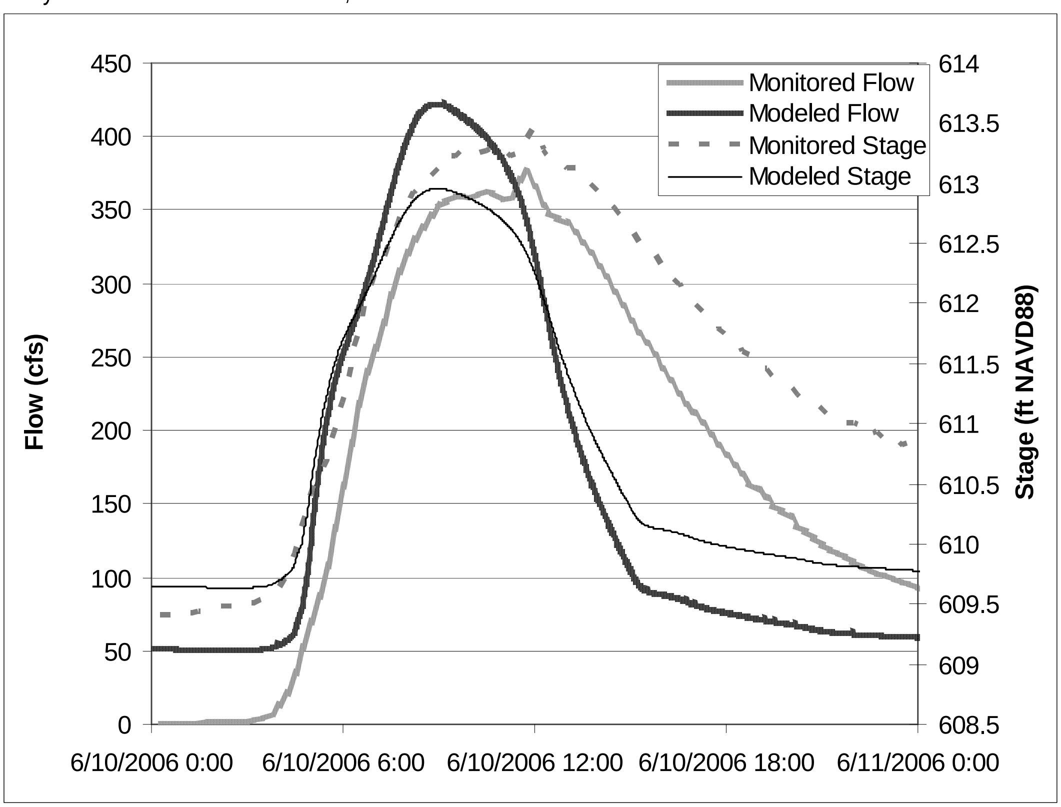
The June 10, 2006 storm was utilized for model calibration because it was a relatively isolated, single peaked event causing significant flow in Tinley Creek. The recurrence interval of the rainfall data recorded ranges from 2 months to 2 years for the gages utilized for the Tinley Creek hydrologic model. Based upon the 9/13/2008 calibration event, the model was evaluated using the model with curve numbers reduced by 10 percent from the originally calculated values, as described below.

TABLE 3.29.8
6/10/2006 Monitored and Modeled Flow and Stage for Tinley Creek

Model Run	Peak Stage (ft)	Runoff Volume (ac-ft)	Difference in Peak Stage (ft)	Difference in Runoff Volume (ac-ft)
Monitored	613.47	434.5	N/A	N/A
Revised Model	612.95	384.3	-0.52	-11.6%

Figure 3.29.3 shows the monitored and revised model flows and stage for the June 10, 2006 storm. Table 3.29.8 summarizes the difference between monitored and modeled flow and stage for the June 10, 2006 storm.

FIGURE 3.29.3
Tinley Creek Calibration for June 10, 2006 Storm



Modeled stage is under-predicted by roughly 0.5 ft, with flow slightly under-predicted as well. The period preceding the June 10, 2006 was very dry, and initial abstractions based resulting from dry soil may contribute to the slight under-prediction. The small difference between modeled and monitored stage suggests that the Tinley Creek model generally provides accurate stage and flow estimates for smaller events like the June 10, 2006 storm.

Modifications to Model Input. As shown in Tables 3.29.7 and 3.29.8 and in Figures 3.29.2 and 3.29.3, a revised model with curve number values reduced by 10 percent from the original values was found to best represent stage and overall runoff volume for the storms considered. Although this resulted in a slight under-prediction of flow and stage for the 6/10/2006 event, relatively dry antecedent conditions may have resulted in slightly less runoff than would be generally expected. The revised model was used for design event simulation and alternative evaluation.

3.29.2.4 Existing Conditions Evaluation

Flood Inundation Areas. Figure 3.29.1 shows inundation areas produced by the hydraulic model for the 100-year, 12-hour duration design storm.

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

3.29.3 Development and Evaluation of Alternatives

3.29.3.1 Modeled Problem Definition

Hydraulic model results were reviewed with inundation mapping to identify locations where property damage due to flooding is predicted. Table 3.29.9 summarizes problem areas identified through hydraulic modeling of Tinley Creek.

TABLE 3.29.9
Modeled Problem Definition for Tinley Creek

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA42	Between 127th Street and 129th Street, west of Central Ave.	50,100	CW2, CW3	Project TICR-3 addresses the flooding in this area.
MPA43	Several hundred feet upstream and downstream of Tee Brook Drive crossing	100		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.
MPA44	Along Tinley Creek between 88th Ave. and Laurel Drive	10, 25, 50, 100	OH1, OP15	Project TICR-5 addresses sedimentation problem in this area.

TABLE 3.29.9
Modeled Problem Definition for Tinley Creek

Problem ID	Location	Recurrence Interval of Flooding (yr)	Associated Form B	Resolution in DWP
MPA45	Upstream of 167th and downstream of Hobart Ave.	25, 50, 100	OH2	Maintenance of Lake Lorin recommended to preserve storage capacity. Sufficient land was not available in the area for potential capital projects that could address problem. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.
MPA46	Along Tinley Creek between Hobart Avenue and 94th Ave.	25, 50, 100		Maintenance of Lake Lorin recommended to preserve storage capacity. Sufficient land was not available in the area for potential capital projects that could address problem. Such properties are candidates for protection using nonstructural flood control measures, such as flood-proofing or acquisition.

Problem MPA42 at Tinley Creek's crossing of Central Avenue is located just upstream of where Tinley Creek makes two significant bends. The HEC-RAS modeling software used for existing conditions and alternatives analysis is a one-dimensional model, which does not consider energy or momentum losses due to rapid change in transverse channel geometry or flow direction. The 1D model may not fully account for these losses.

3.29.3.2 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 Tinley Creek. Transportation damages were estimated as 15 percent of property damages. Erosion damages were determined for erosion problems that threaten structures along Tinley Creek between 160th Street and 151st Street in Orland Park. Five homes and one structure within an apartment complex were determined to be threatened by erosion because these structures were located within thirty feet of an active erosion zone.

TABLE 3.29.10
Estimated Damages for Tinley Creek

Damage Category	Estimated Damage ($)	Note
Property	2,438,200	
Erosion - structures	8,457,800	Structures at risk due to erosion
Erosion – roadway and utilities: Orlan Brook Drive	249,700	Cost to replace Orlan Brook Drive and utilities between 160th Street and 159th Street threatened by erosion of Tinley Creek
Transportation	365,700	Assumed as 15% of property damage due to flooding
Recreation	0	

3.29.3.3 Technology Screening

Flood control technologies were screened to identify those most appropriate to address the flooding problems in the Tinley Creek subwatershed. Increased conveyance or storage was identified as the principal technologies applicable for addressing stormwater problems in Tinley Creek. Levees were also identified as a potential technology for protecting properties.

3.29.3.4 Alternative Development

Stormwater improvement alternatives were developed to address regional stormwater problems identified in Tables 3.29.11 and 3.29.13, with the aim of reducing damages due to stormwater.

Flood Control Alternatives. Alternative solutions to regional flooding and streambank erosion were developed and evaluated consistent with the methodlogy described in Section 1.4 of this report. Table 3.29.11 summarizes flood and erosion control alternatives for Tinley Creek.

TABLE 3.29.11
Flood Control and Erosion Control Alternatives for Tinley Creek

Alternative	Location	Description
TICR-1	12900 South Central Avenue	Construct 96-inch channel diversion under Central Avenue to Calumet-Sag Channel
TICR-2	Forest Preserve near intersection of Justamere Road and 143rd Street	Create weir/impoundment to reduce downstream flows.
TICR-3	12900 South Central Avenue	Construct 4.5-foot levee 1,200 feet long on northwest channel bank and construct 4.5-foot levee 2,000 feet long on southeast channel bank of Tinley Creek approaching Central Avenue. Obtain flood easement on Cook County Forest Preserve property.
TICR-3B	12900 South Central Avenue	Construct 4.5-foot levee 1,200 feet long on northwest channel bank of Tinley Creek approaching Central Avenue. Obtain easement and construct a 45 acre-feet detention pond on Cook County Forest Preserve property to offset lost floodplain area
TICR-4	12900 South Central Avenue	Repair, as necessary, 1,400-foot embankment along east side of Tinley Creek downstream of Central Avenue. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
TICR-5	88th Avenue Upstream of Lake Lorin	Dredge sediment in channel between 88th Avenue and Lake Lorin.
TICR-6	Lake Lorin	Increase storage potential of Lake Lorin. This alternative did not effectively reduce water surface elevations in the flooding problem area, thus benefits and costs were not developed.
TICR-7	Tinley Creek between Oriole Court and 151st Street	Stabilize using hard-armoring or other acceptable technology to prevent erosion problems that threaten structures between Oriole Court and 151st Street.
TICR-8	Tinley Creek between 160th Street and 86th Avenue	Stabilize using hard-armoring or other acceptable technology to prevent erosion problems that threaten structures between 160th Street and 86th Avenue.

Erosion Control Alternatives. Two erosion control alternatives, TICR-7 and TICR-8, were developed for Tinley Creek to address the erosion problems that threaten structures along Tinley Creek between 160th Street and 151st Street in Orland Park. The alternatives proposed to address the erosion problems along Tinley Creek will provide hard armoring of the bank where erosion is occurring. For TICR-7, the project includes 700 feet of armoring upstream of Tee Brooke Drive on both sides of Tinley Creek, and 300 feet of armoring on one side of Tinley Creek within the Quail Hollow Drive apartment complex just south of 151st Street in Orland Park. For TICR-8, the project includes 450 feet of armoring on one side of Tinley Creek along Orlan Brook Drive between 160th Street and 159th Street, and 1,550 feet of armoring on both sides of Tinley Creek downstream of 159th Street to 86th Avenue. For both alternatives, 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 Tinley Creek that will give a more natural appearance than concrete. Given its suburban setting with limited space available, and structures located nearby, the current alignment of Tinley Creek will likely have to largely remain. However, through the use of rock and geotextile fabric, a hard-armoring protection technique can be designed to protect the slope in a more aesthetically pleasing way. This type of bank treatment will be keyed-in for toe-of-slope protection and there will be transitions to the natural slope at the upstream and downstream ends of each project area. The treatment will be scaled to the gradient of the slope and the shear stresses to which the slope is exposed.

3.29.3.5 Alternative Evaluation and Selection

TICR-1 considered construction of a channel diversion beneath Central Avenue to divert flow and lower flood stages in and around problem MPA42. Some agencies familiar with the area had noted the possibility of an existing 48-inch diversion pipe in this location. Field reconnaissance and communication with the Village of Crestwood determined that no such diversion exists. Modeling analysis showed that while the construction of a channel diversion would reduce flood stages, the embankment on the north side of Tinley Creek approaching Central Avenue would still overtop during a 100-year design storm. As this alternative would only partially address damages, other alternatives were considered and this alternative is not recommended.

TICR-2 considered the impact of impounding Tinley Creek to an elevation of 645 feet within the Forest Preserve. The effectiveness of an impoundment is predicted to be greater than TICR-1. A much smaller volume of floodwater is estimated to overtop the embankment north of Tinley Creek approaching Central Avenue during a 100-year design storm. This project is not recommended because TICR-3 addresses the same problem area and provides complete protection, addressing all damages.

TICR-3 includes a levee roughly 4.5 feet high on the north side of Tinley Creek approaching Central Avenue. In addition, a second 4.5-foot high levee is proposed on the south side of Tinley Creek to protect structures at risk of flooding. Both proposed levees provide three feet of freeboard above the modeled 100-yr WSEL, protecting the residential area north of Tinley Creek and problem area MPA42 from damages. A small pumping station is also recommended to dewater the area behind the levee to the south of Tinley Creek. In the absence of compensatory measures, the water surface upstream of the levee would rise slightly, but the upstream land includes one school, protected by the proposed levee, and areas within the Cook County Forest Preserve. The rise in WSEL in this area may be contained within a floodplain easement as allowed under IDNR regulation 3708.70.d.12. TICR-3 is recommended in favor of TICR-3B, described below, because it provides increased benefits, while minimizing impact on upstream Cook County Forest Preserve lands. Coordination with the Forest Preserve may result in cooperation to achieve both regional flood control and Forest Preserve priorities in the area.

The volume of lost floodplain storage was estimated to be 45 acre-feet, based on a rough estimate of 1.5 feet of flooding over a 30-acre downstream area. TICR-3b includes the cost of the levee and the cost to construct a 45 acre-feet detention facility to provide compensatory storage. Since the Tinley Creek subwatershed boundaries are very narrow at the proposed levee location, and land use transitions to the Forest Preserve 2,000 feet upstream, this storage location is proposed within the Forest Preserve. The site was chosen because the low slope in the area reduces the excavation volume required, and the space is relatively more open than nearby more densely forested areas. Alternative locations providing sufficient compensatory storage could not be identified outside of Cook County Forest Preserve. The proposed storage location is not online of Tinley Creek, but in the overbank area, and unlike TICR-2 does not impound Tinley Creek itself, or raise the WSEL of Tinley Creek within the Cook County Forest Preserve. TICR-3b is not a recommended alternative in this area because of the impact to the forest preserve caused by the compensatory storage is required.

TICR-4 involves the repair of the embankment along the east bank of Tinley Creek on the downstream side of Central Avenue. No damages were estimated in the overbank region in this area, due in part to the modeled impact of the existing embankment in this area, and so TICR-4 was not considered in detail. If this embankment were allowed to degrade, floodwaters could escape the right overbank region of Tinley Creek and cause roadway flooding.

TICR-5 considered the removal of accumulated sediment from a 1,500-foot reach of Tinley Creek between the outlet of Lake Lorin and 88th Avenue. Survey data obtained 350 feet downstream of the Lake Lorin outlet indicate a channel invert of 697.61 feet, roughly 1 ft above the lower of the surveyed invert of 696.61 feet on the discharge pipe from Lake Lorin. Reported problems OH1 and OP15 refer to sedimentation in 88th avenue and downstream, which were not included in the modeled baseline conditions because of the Village of Orland Park has plans to address this issue, which was consequently not included in baseline conditions. Dredging between 88th Avenue and Lake Lorin results in the most significant WSEL reductions along the dredged reach, although property damage due to flooding has not been reported adjacent to the dredged reach. Minor reductions in peak WSEL (approximately 0.1 ft) are predicted in this and adjacent reaches. One structure is estimated to be removed from the 100-year inundation area due to TICR-5, with other damages associated with minor peak WSEL reductions for the modeled storms.

TICR-6 includes several scenarios considering expansion of the storage volume of Lake Lorin. The most aggressive alternative would involve clearing some of the vegetation restricting flow along with the addition of roughly 16 acre-feet of storage on the baseball field northwest of the lake. Preliminary evaluation of these alternatives indicated very minor impacts on calculated damages. Damages upstream of 167th Street are located along a stretch of Tinley Creek with significant gradient, and the stream rises quickly above the level defined at the 167th Street crossing controlled by Lake Lorin. Downstream damages are not significantly reduced either, as Lake Lorin is still predicted to overtop for high magnitude rainfall events. The relative ineffectiveness of additional storage is most likely because it is online with Tinley Creek. The 12-hour duration storm used for analysis within the Calumet-Sag Channel Watershed results in significant storage being used within Lake Lorin before the peak of the storm. It is possible that additional storage in Lake Lorin would provide more significant benefits for high magnitude events of shorter duration.

TICR-7 is recommended to address erosion damages associated with erosion problems that threaten structures between Oriole Court and 151st Street in Orland Park. TICR-8 is recommended to address erosion damages associated with erosion problems that threaten structures between 160th Street and 86th Avenue in Orland Park.

WPC member feedback suggested the idea of pumping Lake Lorin to provide additional storage. The grade of Tinley Creek downstream of Lake Lorin does not permit lowering the outlet pipe to provide additional storage, but the lake could be pumped in advance of storms to make additional storage capacity available for flood attenuation. Although technically feasible, this alternative is complicated logistically, as operators would be required to identify pumping thresholds based on weather forecasts to provide the additional storage. The high maintenance cost for this suggestion, combined with logistical difficulty, excluded it from further consideration.

Recommended alternatives result in reduced stage and/or flow along the modeled waterway. Table 3.29.12 provides a comparison of the modeled maximum WSEL, and modeled flow at the time of peak at representative locations along the waterway.

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 Calumet-Sag Channel DWP.

3.29.3.6 Data Required for Countywide Prioritization of Watershed Projects

Appendix I presents conceptual level cost estimates for the recommended alternatives. Table 3.29.13 lists alternatives analyzed in detail. TICR-3, levves with a flood easement, and TICR-5, the dredging of a 1,500 ft length of Tinley Creek are recommended, and shown in Figures 3.29.4 and 3.29.5, respectively. These figures also show a comparison of the existing conditions to the alternative conditions inundation mapping with the implementation of TICR-3 and TICR-5. Figures 3.29.6 and 3.29.7, respectively, show the recommended erosion control alternatives TICR-7 and TICR-8.

TABLE 3.29.12
Tinley Creek Existing and Alternative Condition Flow and WSEL Comparison

		Existing Conditions		TICR-3		TICR-5	
Location	**Station**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**	**Max WSEL (ft)**	**Max Flow (cfs)**
Tinley Creek 100-ft downstream of 167th St.	58572	702.53	174.20	702.53	174.21	702.38	202.83
Tinley Creek crossing at 163rd St.	52956	697.76	184.77	697.76	184.81	697.67	178.76
Tinley Creek 170-ft downstream of 86th Ave.	48131	683.56	667.97	683.56	667.97	683.54	662.28
Tinley Creek 50-ft upstream of 151st St.	43469	672.34	920.21	672.34	920.19	672.32	913.56
Tinley Creek 50-ft downstream of 82nd Ave.	37894	661.70	1578.47	661.70	1578.50	661.68	1571.85
Tinley Creek 130-ft upstream of Ridgeland Ave.	18787	628.95	1908.13	629.34	2130.52	628.95	1906.67
Tinley Creek 100-ft upstream of Central Ave.	3565	604.87	2712.00	604.78	2660.19	604.86	2704.08
Tinley Creek 70-ft downstream of Calumet-Sag Rd. and 127th St.	462	592.88	2946.70	592.82	2918.71	592.86	2936.66

TABLE 3.29.13
Tinley Creek Project Alternative Matrix to Support District CIP Prioritization

Project	Description	B/C Ratio	Net Benefits ($)	Total Project Cost ($)	Cumulative Structures Protected	Funding Possibilities	Water Quality Benefit	Recommended	Communities Involved
TICR-1	Channel Diversion	0.05	244,300	4,957,900	5	USACE	No Impact	No	Crestwood, Alsip, Unincorporated Cook County
TICR-2	Forest preserve impoundment	0.54	1,682,900	3,104,200	28	USACE	Mixed	No	Crestwood, Alsip, Unincorporated Cook County
TICR-3	Levee	0.72	1,982,000	2,764,400	42	USACE	No Impact	Yes	Crestwood, Alsip, Unincorporated Cook County
TICR-3B	Levee and compensatory storage	0.32	1,933,700	6,032,300	40	USACE	Slightly Positive	No	Crestwood, Alsip, Unincorporated Cook County
TICR-5	Dredge sediment in channel between 88th Avenue and Lake Lorin	1.26	142,600	112,800	4	USACE	No Impact	Yes	Orland Hills, Orland Park
TICR-7	Stabilize erosion of Tinley Creek between Oriole Court and 151st Street	1.03	1,524,700	1,479,700	6		Slightly Positive	Yes	Orland Park
TICR-8	Stabilize erosion of Tinley Creek between 160th Street and 86th Avenue	1.55	7,164,900	4,627,200	8	USACE	Slightly Positive	Yes	Orland Park

Note: Net Benefits values do not include local benefits or non-economic benefits.

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 Capital Improvement Program (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 the 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.

Modeling analysis performed as part of the DWP generally revealed that dredging accumulated sediment was not effective in significantly reducing damages due to regional overbank flooding problems. In a few cases where dredging was found to have a regional benefit, it was recommended as a part of the DWP's CIP. Significant regulatory challenges exist with dredging projects. Sedimentation is a dynamic process that is affected by soil protective measures taken in upland tributary areas as well as dynamic 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 Calumet-Sag Channel 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, delegating certain maintenance responsibilities. 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. There is one location that has been identified within the watershed where a stream within the Cook County Forest Preserve has not been properly maintained, causing conveyance restrictions that could indirectly contribute to flooding of residences. It is recommended that the District work with the Forest Preserve to ensure that a proper grade is maintained on these channels to avoid potential problems in the future. This will require debris removal, and may require some dredging. The location is listed below in

Table 4.1.1 along with the approximate gradient to be maintained. If dredging is performed, permits may be required from regulatory agencies such as USACE and IDNR and downstream impact must be considered.

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
OF3	Boca Rio Ditch	Boca Rio Ditch at 151st Street in Oak Forest	Remove debris and clear channel Private property owner refuses access
LT4	I&M Canal	Stephen Street and north of Talcott Street in Lemont Township	Remove debris and clear channel
HH5	I&M Tributary D	I&M Tributary D between Kean Avenue and 87th Street	Regrade channel to a slope of 0.35% on Cook County Forest Preserve Property
OP11	Long Run Creek	143rd Street and Wolf Road in Orland Park	Remove debris and clear channel of sedimentation
OP12	Marley Creek	Marley Creek at 108th Avenue in Orland Park	Remove debris and silt from box culverts and surrounding area
OP3	Marley Creek	Marley Creek near Cameron Parkway in Orland Park	Remove debris and clear channel
OP6	Marley Creek	Marley Creek from Anthony Drive to Meade Street in Orland Park	Remove debris and clear channel
CR1	Melvina Ditch	Melvina Ditch and West Stony Creek confluence in Chicago Ridge	Remove debris and clear channel
OP8	Tinley Creek	Tinley Creek at 82nd Ave	Remove debris downstream
OP10	Spring Creek	Spring Creek just upstream of 155th Street and between 155th Street and 159th Street in Orland Township	Remove debris and clear channel
OL1	Stony Creek	Stony Creek near Central Avenue, ¼ mile south of 103rd Street in Oak Lawn	Remove debris and clear channel, including silt in and around culverts
WO2	Stony Creek	Stony Creek between Oak Lawn and 76th Avenue in Worth	Remove debris and clear channel
AL1	Stony Creek	Stony Creek at 115th Street	Remove debris and clear channel; and repair streambank

4.2 Recommended Capital Improvements

Table 4.2.1 lists all recommended improvements for the Calumet-Sag Channel DWP. The District will use data presented here to support prioritization of a countywide stormwater CIP.

4.3 Implementation Plan

Alternatives listed in Table 4.2.1 can be constructed independently. However, in some cases, benefits associated with construction of several alternatives within a subwatershed will exceed the sum of the benefits of individual alternatives. 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.

TABLE 4.2.1
Calumet-Sag Channel Watershed 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 (ac)	Cumulative Structures Protected	Implementation Time (months)	Water Quality Benefit	Communities Involved
SFDT-1	0.07a	0.4 M	5.45 M	3.64 M		14	-	12	18	Positive	Justice, Bridgeview, Hickory Hills, Bedford Park
SFDT-2	0.04	0.03 M	0.72 M	0.43 M		18	-	14	12	No Impact	Justice, Bridgeview, Hickory Hills, Bedford Park
CSTB-3	0.31	0.67 M	2.13 M	0.79 M		2	-	6	6	Slightly Positive	Palos Park
IMCA-1	0.03	0.03 M	1.04 M	0.71 M		N/A	-	3	6	No Impact	Lemont
LRCR-5	0.06	0.05 M	0.86 M	0.59 M		N/A	-	0	6	No Impact	Orland Park
LDDT-3	0.13	0.89 M	6.77 M	4.5 M		33	-	56	6	Slightly Positive	Bridgeview, Palos Hills
LUDT-5	0.23	0.85 M	3.65 M	2.39 M		4	-	4	6	No Impact	Palos Hills
LUDT-7	0.08	0.34 M	4.47 M	0.81 M		28	-	54	12	Slightly Positive	Palos Hills, Hickory Hills, Bridgeview
MACR-1	0.01	0.16 M	15.99 M	8.99 M		19	-	3	15	Slightly Positive	Orland Park
MEDT-1	0.58	1.67 M	2.85 M	1.56 M		N/A	-	8	18	No Impact	Chicago Ridge, Oak Lawn
MICR-2	0.20	0.41 M	2 M	1.4 M		21	3	6	6	Slightly Positive	Palos Park
MICR-4	0.10	0.46 M	5.92 M	4.21 M		64	-	2	6	Slightly Positive	Orland Park
NVCR-3	0.69	0.1 M	0.14 M	0.1 M		34	-	15	6	No Impact	Palos Heights
NVCR-5	0.15	1.15 M	7.9 M	4.58 M		7	-	29	8	No Impact	Palos Heights
OLCR-1	0.07	0.45 M	6.31 M	4.97 M		1	-	35	7	Slightly Positive	Oak Lawn
OLCR-3	0.42	3.08 M	7.3 M	4.31 M		N/A	-	15	17	Slightly Positive	Oak Lawn
SPCR-1	0.02	0.02 M	1.05 M	0.74 M		N/A	-	0	6	No Impact	Orland Township
STCR-2	0.25	12.2 M	48.5 M	30.27 M		87	6	666	18	Positive	Alsip, Oak Lawn, Chicago
STCR-3	0.10	0.74 M	7.69 M	6.54 M		1	7	55	18	Positive	Alsip, Oak Lawn, Chicago
STCR-4	0.05	0.21 M	4.33 M	3.18 M		1	-	20	6	Positive	Alsip, Oak Lawn, Chicago
STCR-7	0.11	0.36 M	3.43 M	2.01 M		67	-	86	6	No Impact	Palos Hills
STCR-8	0.18	1.15 M	6.29 M	3.41 M		6	-	44	6	No Impact	Palos Hills
STCR-10	b	b	2.75 M	1.66 M		N/A	-	0	8	Positive	Oak Lawn
TICR-3	0.72	1.98 M	2.76 M	1.54 M		36	-	42	8	No Impact	Crestwood, Alsip, Unincorporated Cook County
TICR-5	1.26	0.14 M	0.11 M	0.09 M		2	-	4	6	No Impact	Orland Hills, Orland Park
TICR-7	1.03	1.52 M	1.48 M	0.87 M		N/A	-	6	18	Slightly Positive	Orland Park
TICR-8	1.55	7.16 M	4.63 M	2.73 M		N/A	-	8	18	Slightly Positive	Orland Park

Property Damage Erosion Transportation Recreation

a- Benefits include 6 acres of wetland restoration
b- Project does not include existing regional financial benefits, but is recommended as a preventative measure because further bank failure risks a severe channel flow restriction within Stony Creek.

5. Summary and Conclusions

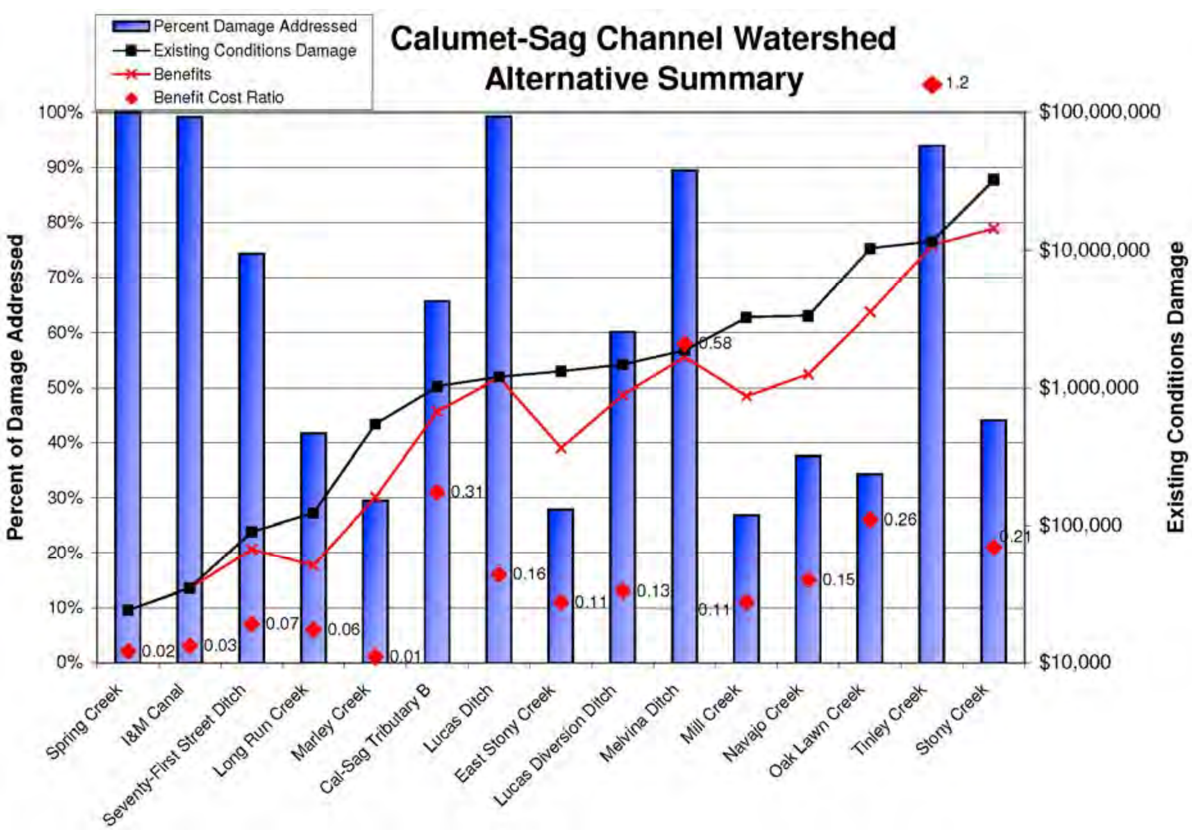
The Calumet-Sag Channel DWP was developed in coordination with the Calumet-Sag Channel WPC. The coordination focused on integrating community knowledge of stormwater problems and ideas for feasible solutions into the District's regional stormwater plan. All stormwater problem data received from stakeholders 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 Calumet-Sag Channel Watershed. Appropriate tributary-specific technologies were screened considering their applicability for addressing problem areas, constructability in the area required, and regulatory feasibility. The potential impact of future development conditions on recommended alternatives was considered. 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 benefits, several other criteria were noted for each alternative, such as the number of structures protected, water-quality benefit, and wetland and riparian areas affected. Conceptual level cost estimates 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 cost to develop a B/C ratio for each alternative.

Figure 5.1 illustrates the potential of alternatives within the DWP to address regional damages throughout the watershed, ordered by increasing existing conditions damages. A logarithmic scale is used so that the wide range of estimated damages, ranging from $24,100 for Spring Creek to $32,400,500 for Stony Creek, can be displayed on a single graph. The columns indicate the extent to which recommended alternatives address estimated damages, while the red B/C symbols indicate the B/C ratio. As an example, the recommended Stony Creek alternatives address 45 percent of estimated damages (indicated by the column), which corresponds to a benefit of $14,498,600. In contrast, 66 percent of the damages along Calumet-Sag Tributary B are addressed, but this results in $669,700 of benefit, or 4.6 percent of benefits of recommended Stony Creek alternatives.

Recommended alternatives are estimated to reduce regional damages by $36,220,000 over a 50-year period, at an estimated cost of $159,018,400. Estimated damage reductions result from proposed stormwater improvements that increase 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 projects are not distributed evenly throughout the watershed, but generally concentrated in subwatersheds with greater existing conditions damages where capital improvement projects are able to address greater existing conditions damages. Differences in the amount of available land for storage alternatives also contribute to differences in benefits between subwatersheds. Recommended solutions do not generally address all damages from the 100-year inundation areas, as sufficient land is not always present in locations that can reduce floodwaters to eliminate inundation of structures along regional waterways.

FIGURE 5.1
Calumet-Sag Channel Watershed Alternative Summary



Stormwater problems, whether identified by stakeholders or identified by modeling of intercommunity waterways, indicate a need for regional stormwater management solutions throughout the Calumet-Sag Channel Watershed. Although problems are concentrated in the more intensively developed, flatter northern section of the watershed, significant stormwater problems exist throughout the watershed. If constructed, the recommended alternatives in Table 4.2.1 are expected significantly to reduce stormwater damages, although damages are expected to persist within the watershed even following construction of those projects. However, implementation of the recommended projects should reduce the number of homes and businesses adversely affected by flooding, and also the severity of damages. Communities can continue to work toward reducing stormwater damage by ensuring that development is responsibly managed with consideration given to potential stormwater impacts and the existing stormwater problems within the watershed.

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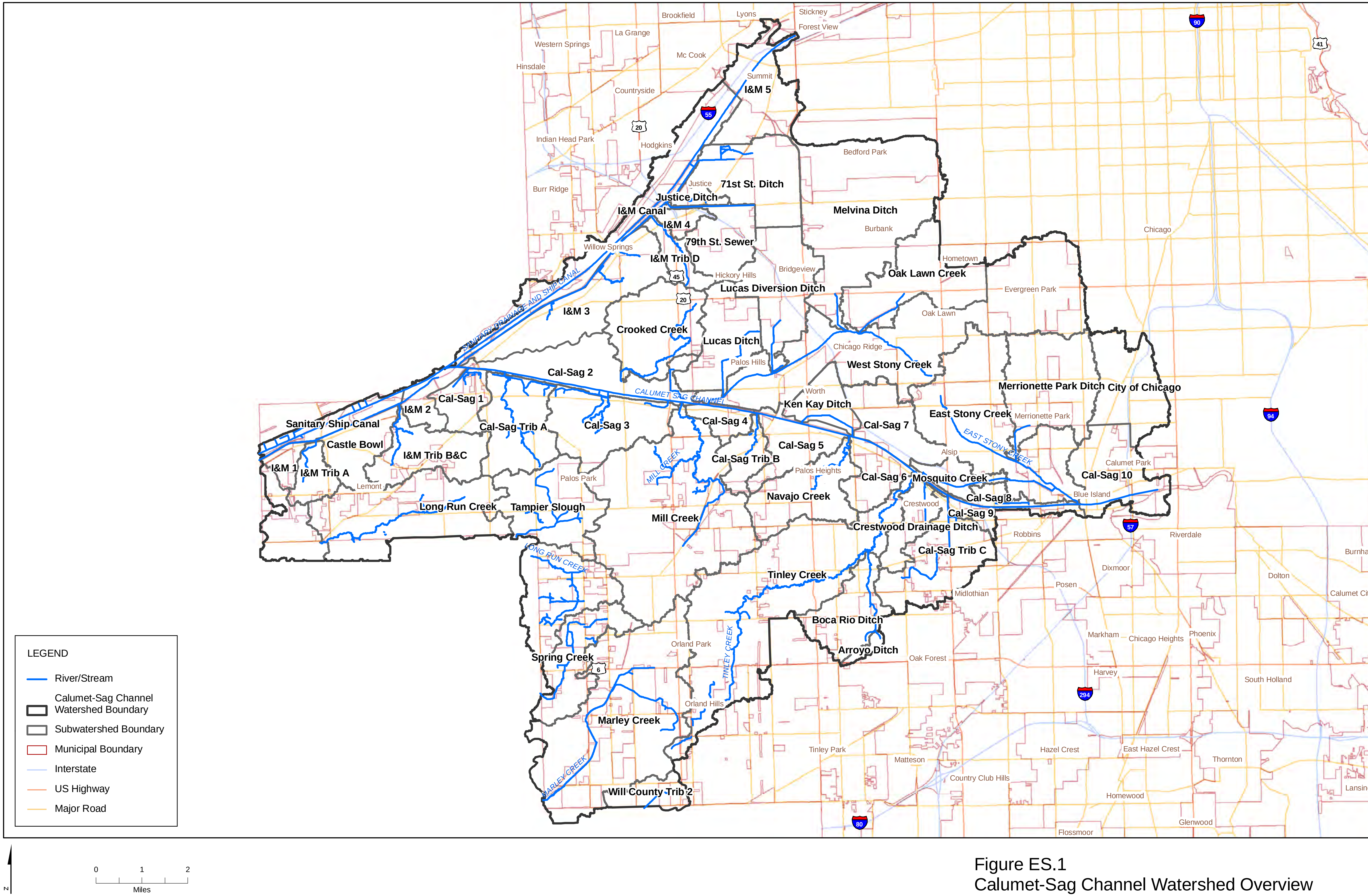


Figure ES.1
Calumet-Sag Channel Watershed Overview

CH2MHILL

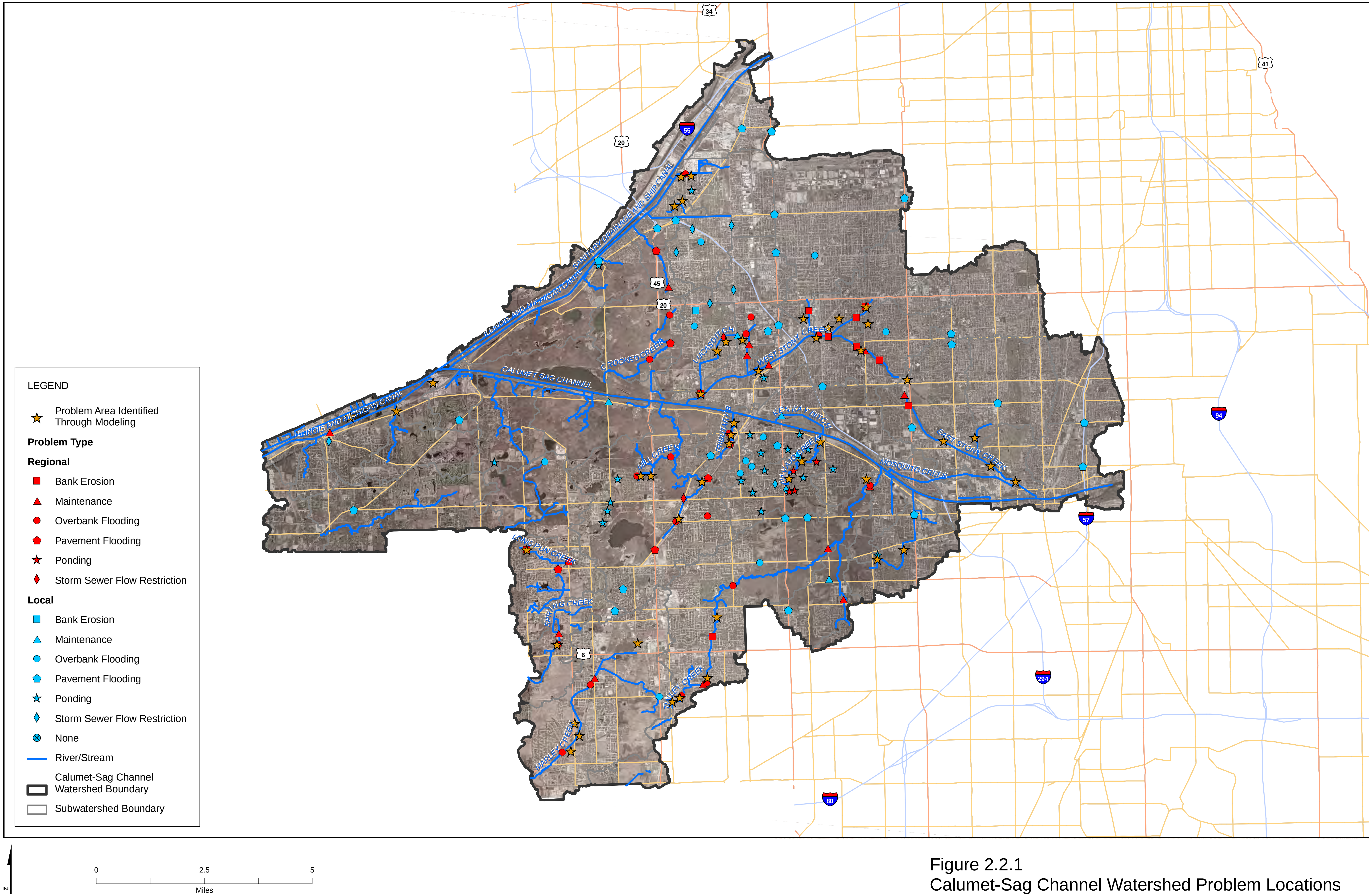


Figure 2.2.1
Calumet-Sag Channel Watershed Problem Locations

CH2MHILL

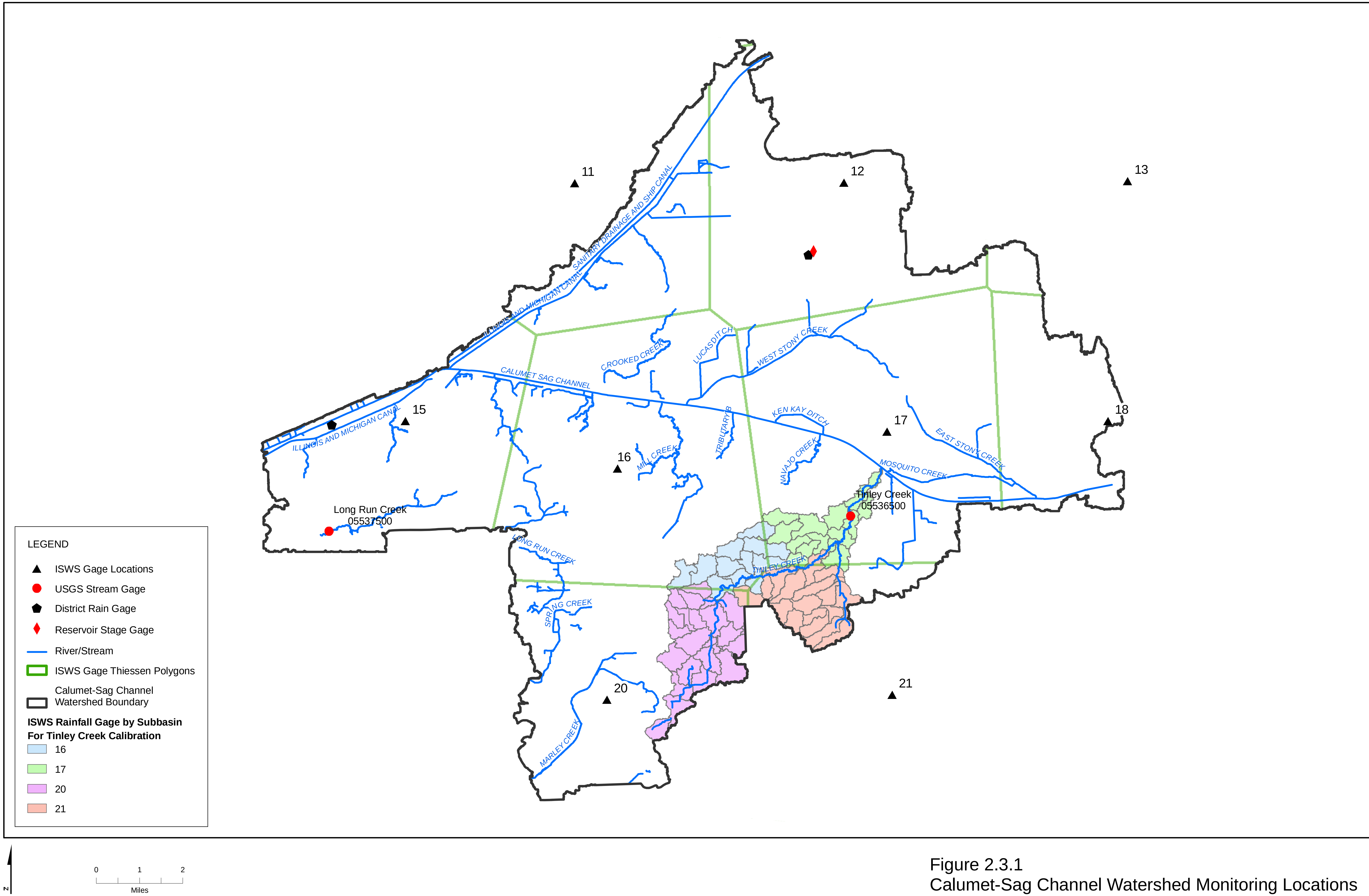


Figure 2.3.1
Calumet-Sag Channel Watershed Monitoring Locations

CH2MHILL

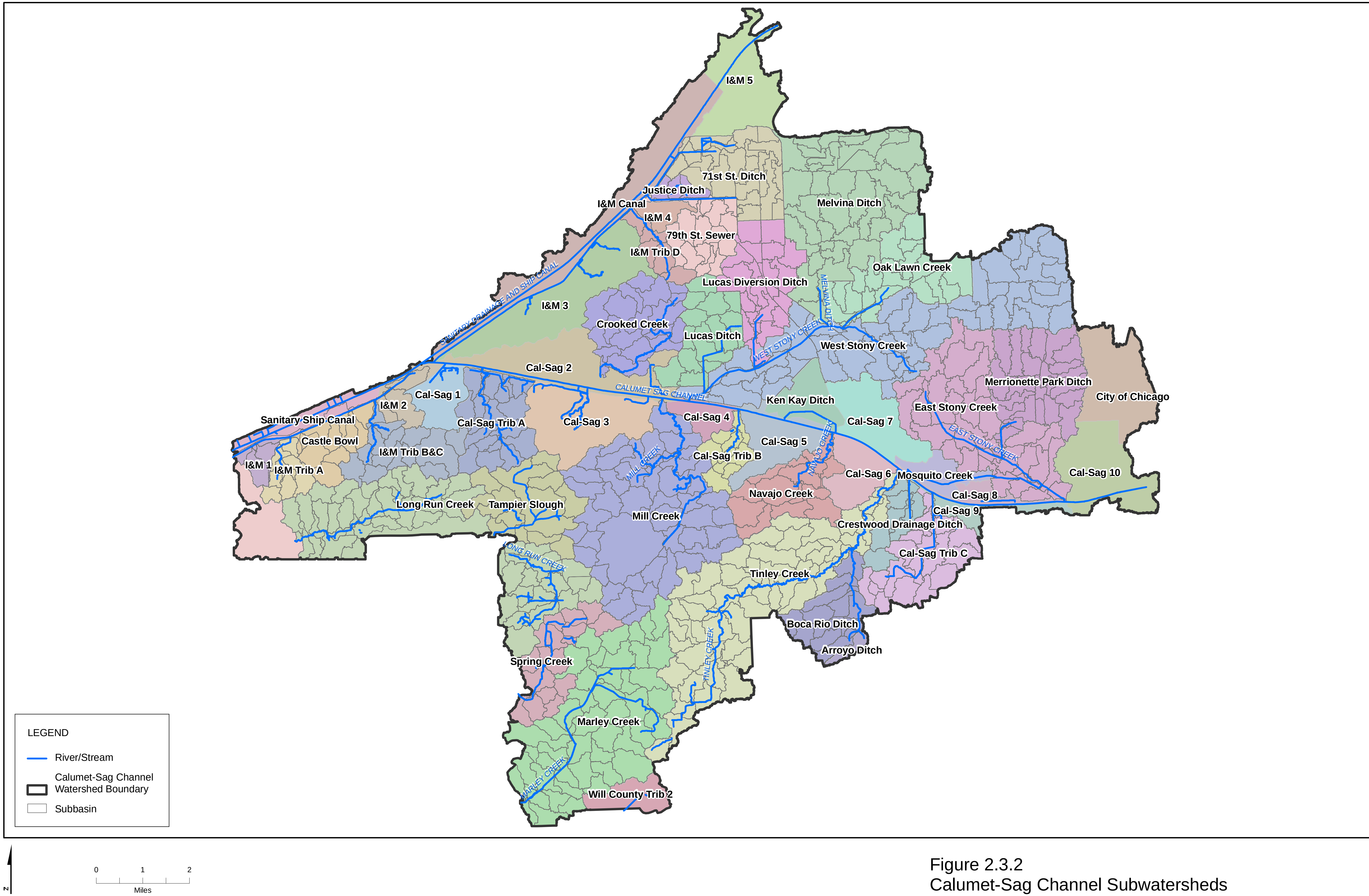


Figure 2.3.2
Calumet-Sag Channel Subwatersheds

CH2MHILL

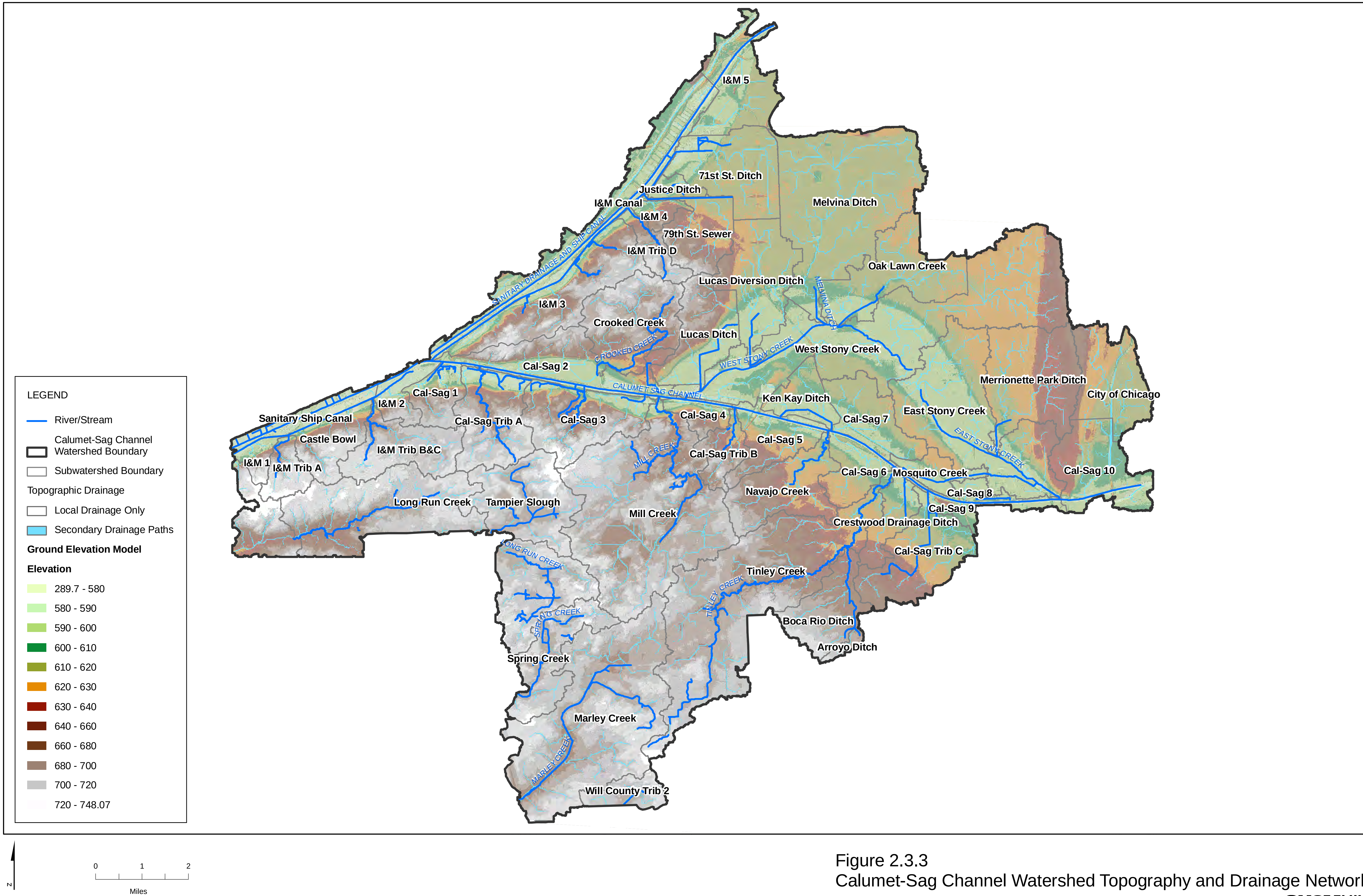


Figure 2.3.3
Calumet-Sag Channel Watershed Topography and Drainage Network

CH2MHILL

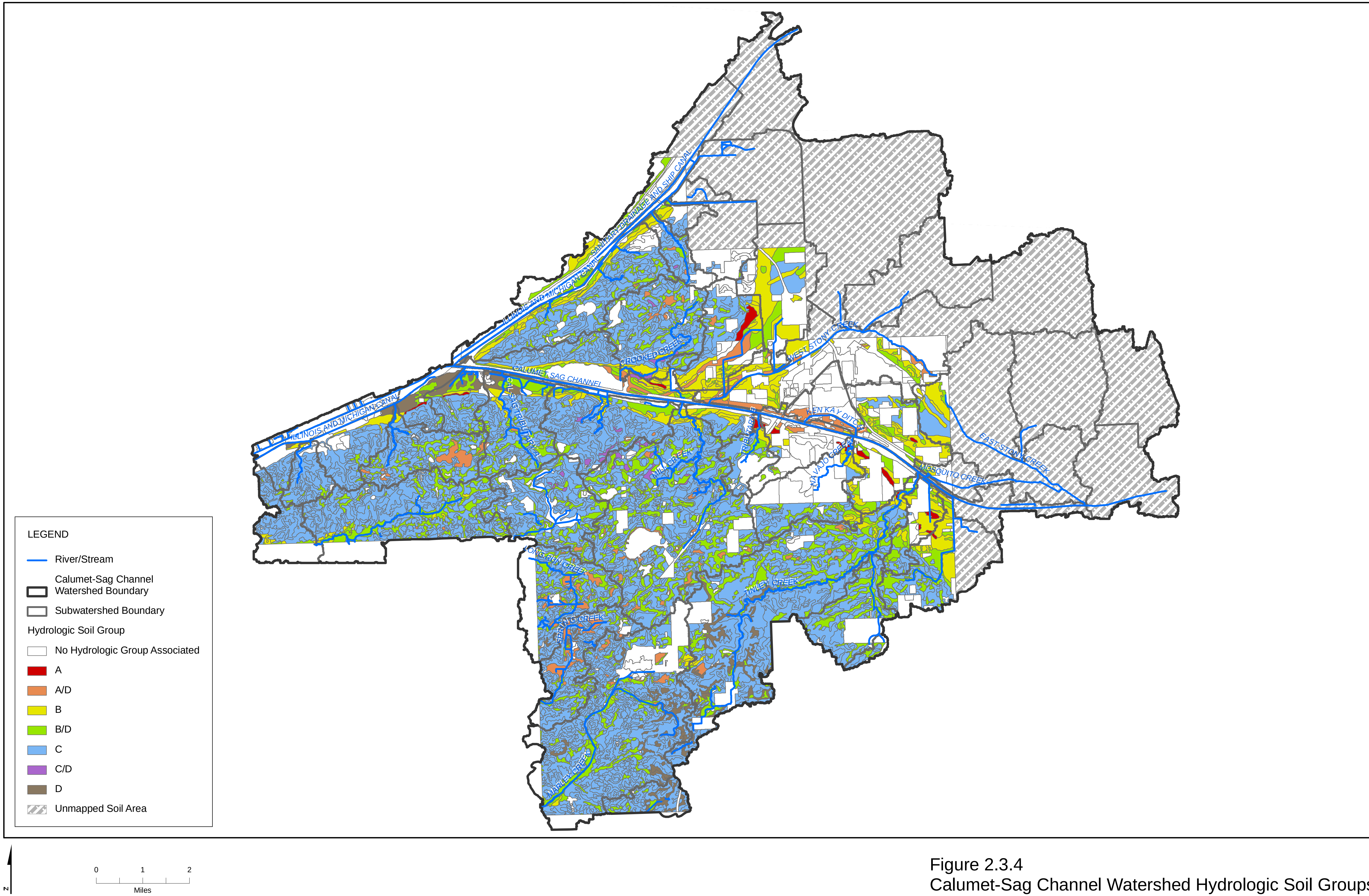


Figure 2.3.4
Calumet-Sag Channel Watershed Hydrologic Soil Groups

CH2MHILL

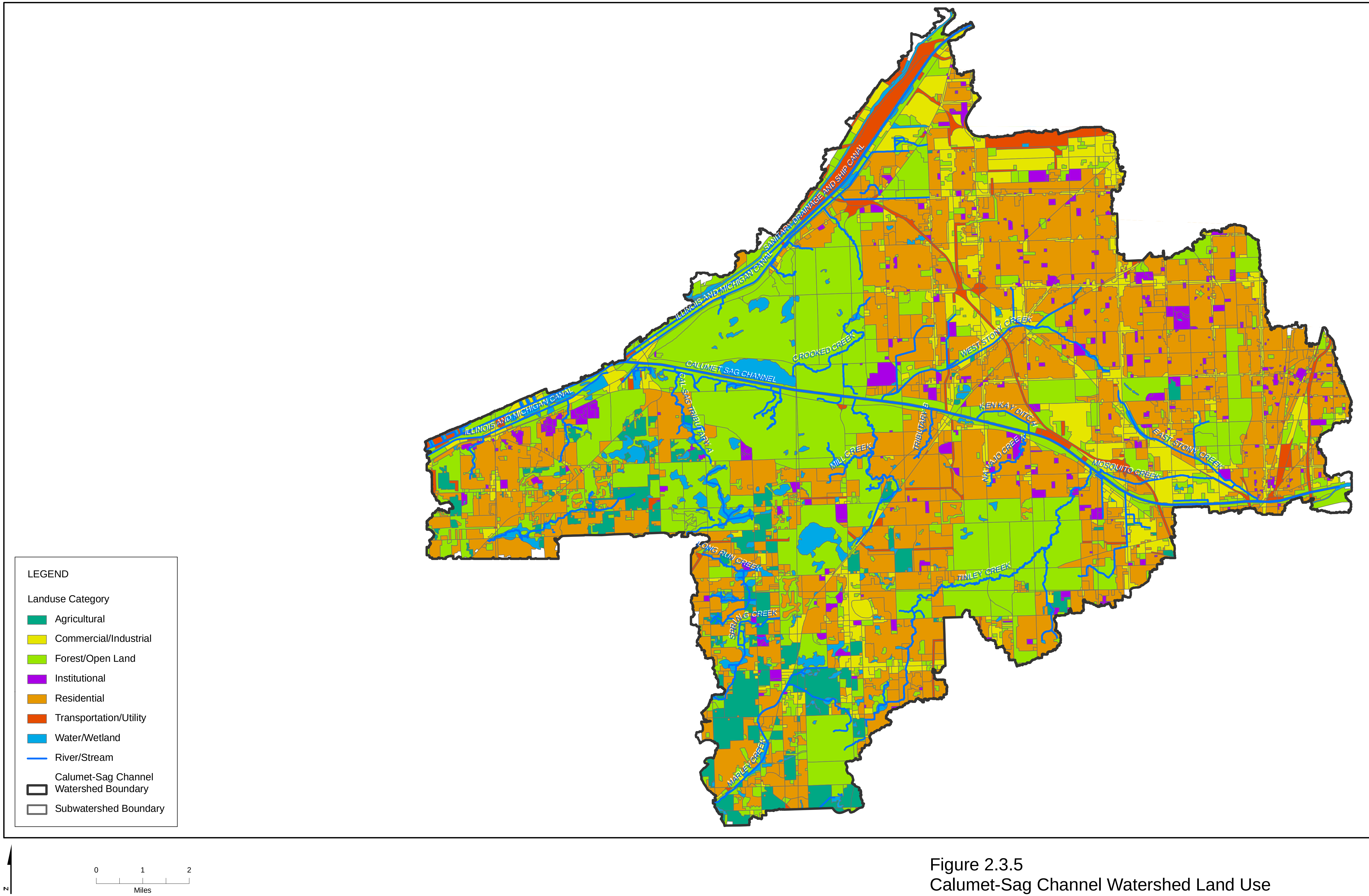


Figure 2.3.5
Calumet-Sag Channel Watershed Land Use

CH2MHILL

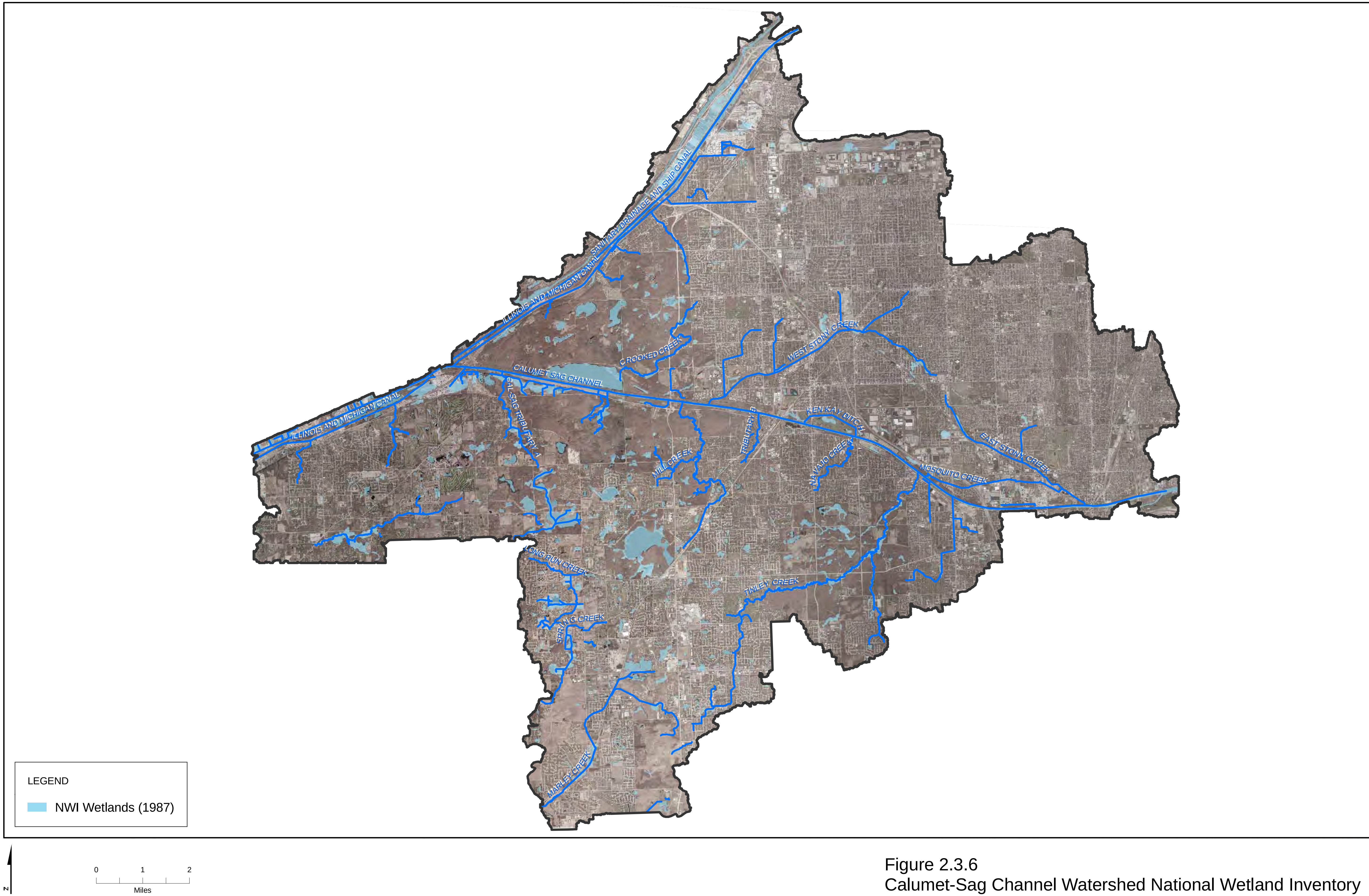


Figure 2.3.6
Calumet-Sag Channel Watershed National Wetland Inventory

CH2MHILL

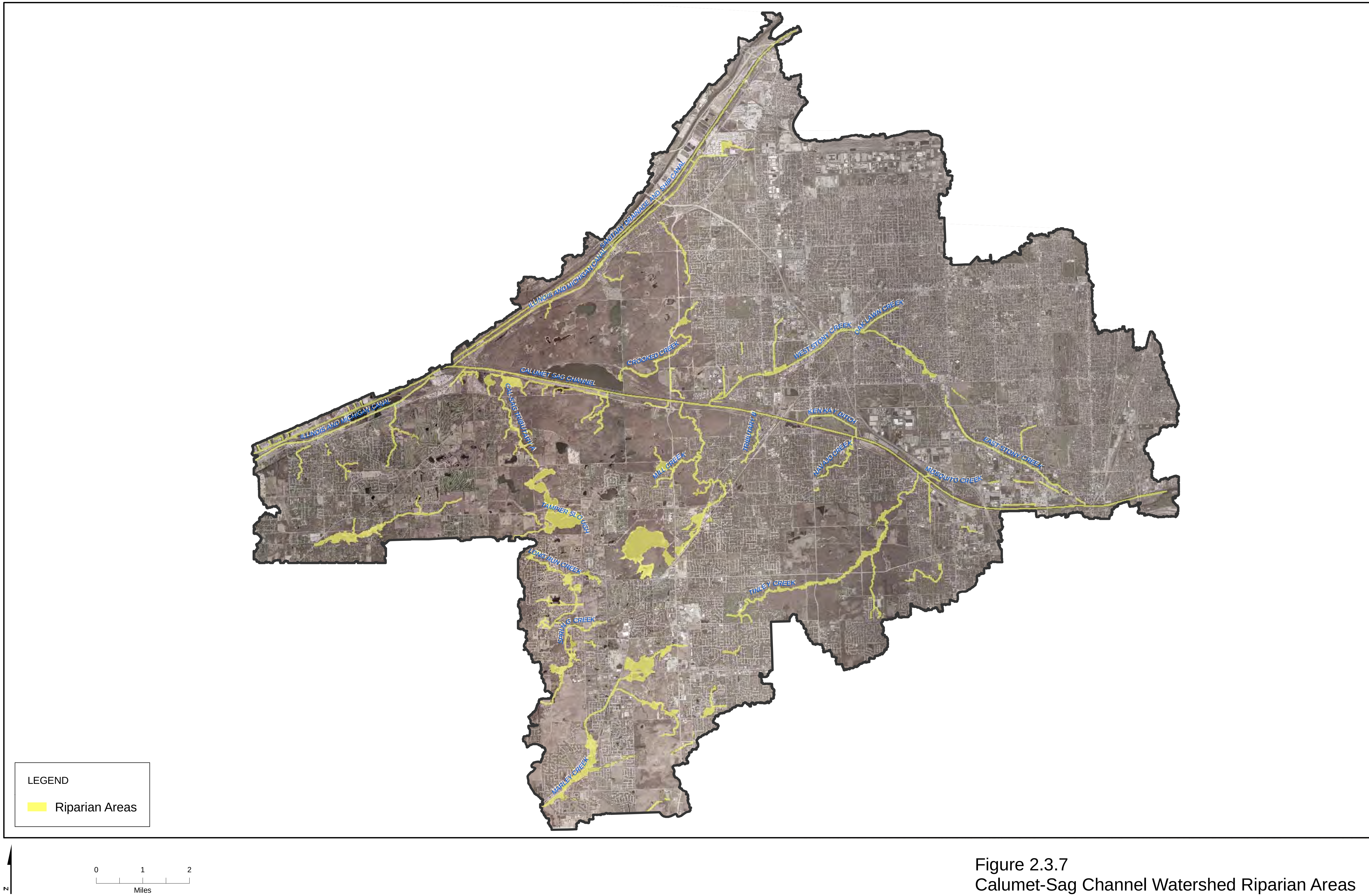
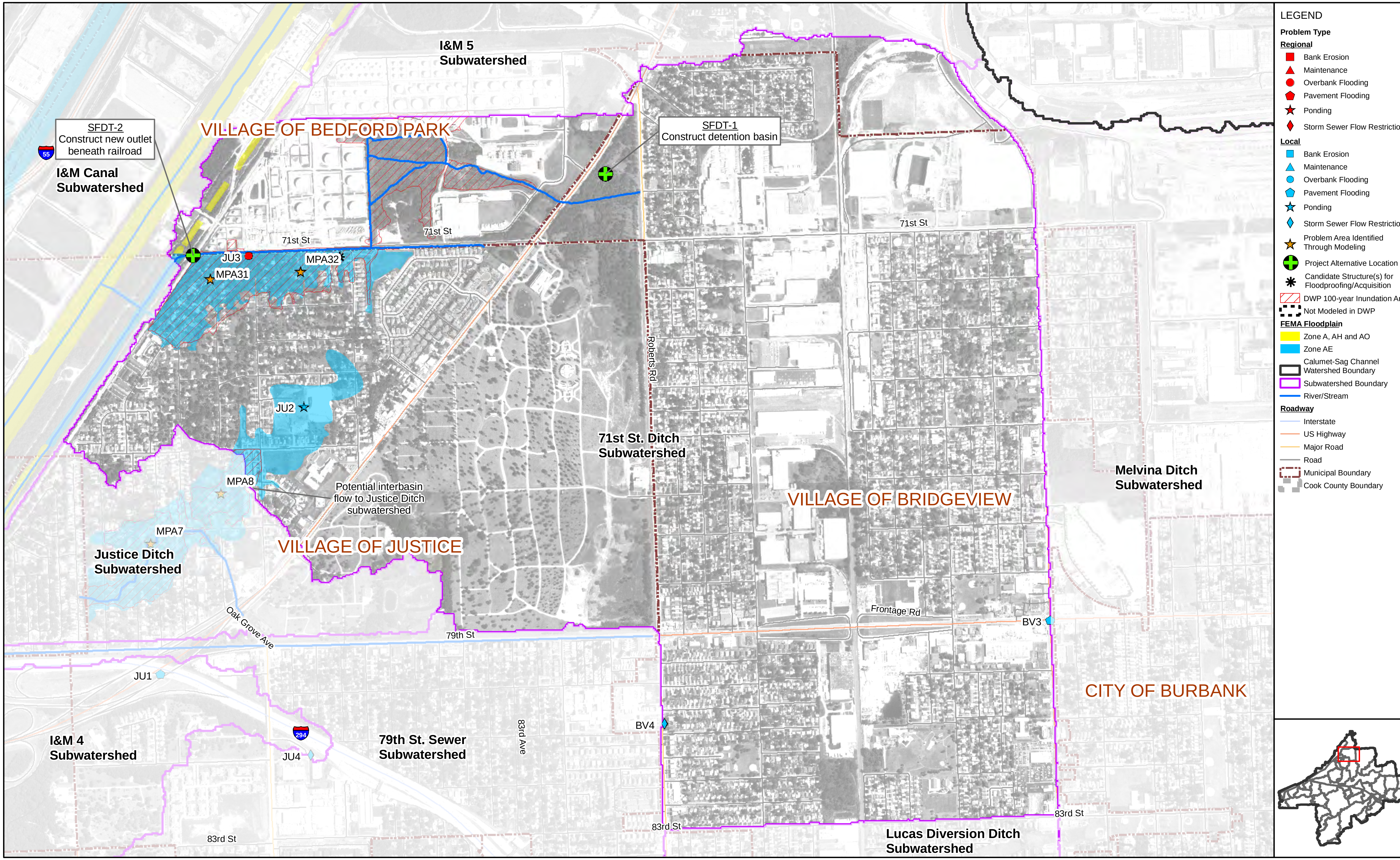


Figure 2.3.7
Calumet-Sag Channel Watershed Riparian Areas

CH2MHILL



N

0 1,000 2,000
Feet

Figure 3.1.1
Tributary Overview: 71st St. Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

Subwatershed: Seventy-First Street Ditch

Alternative: SFDT-1

Alternative Description:

Construct detention pond and include wetland habitat

Conceptual Level Cost: $ 5,452,100

Benefits: $ 395,400

B/C Ratio: 0.07

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

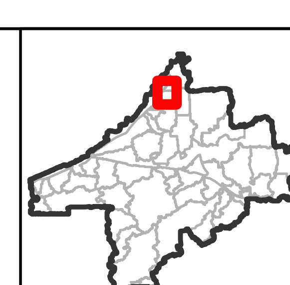
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 290 580

Feet

Figure 3.1.2
Seventy-First Street Ditch
Alternative SFDT-1
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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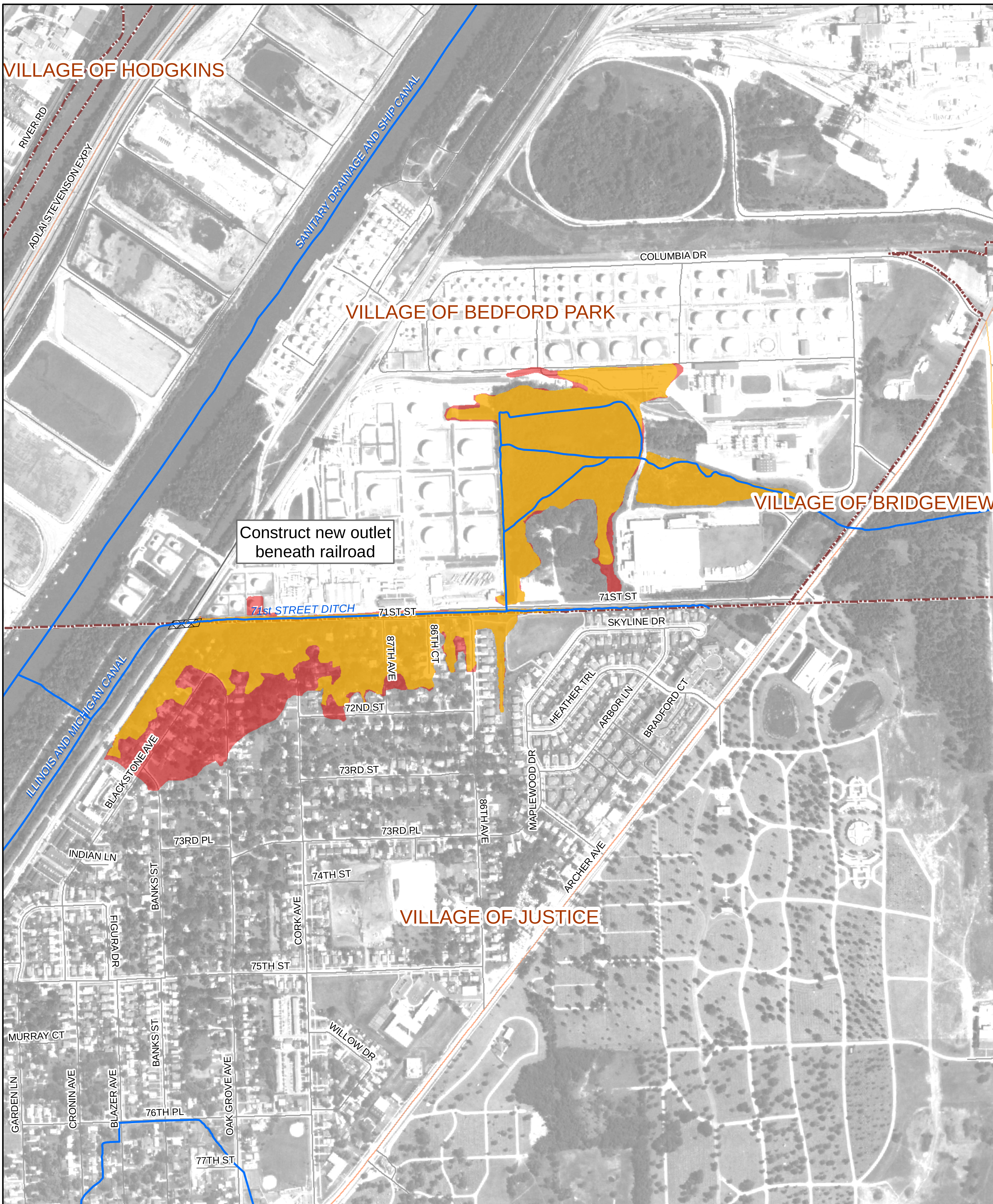


Subwatershed: Seventy-First Street Ditch

Alternative: SFDT-2

Alternative Description:

Increase conveyance capacity of culvert beneath railroad tracks to I&M Canal

Conceptual Level Cost: $ 716,700

Benefits: $ 31,400

B/C Ratio: 0.04

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

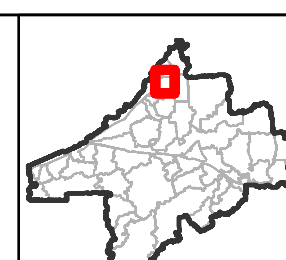
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 270 540

Feet

Figure 3.1.3
Seventy-First Street Ditch
Alternative SFDT-2
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



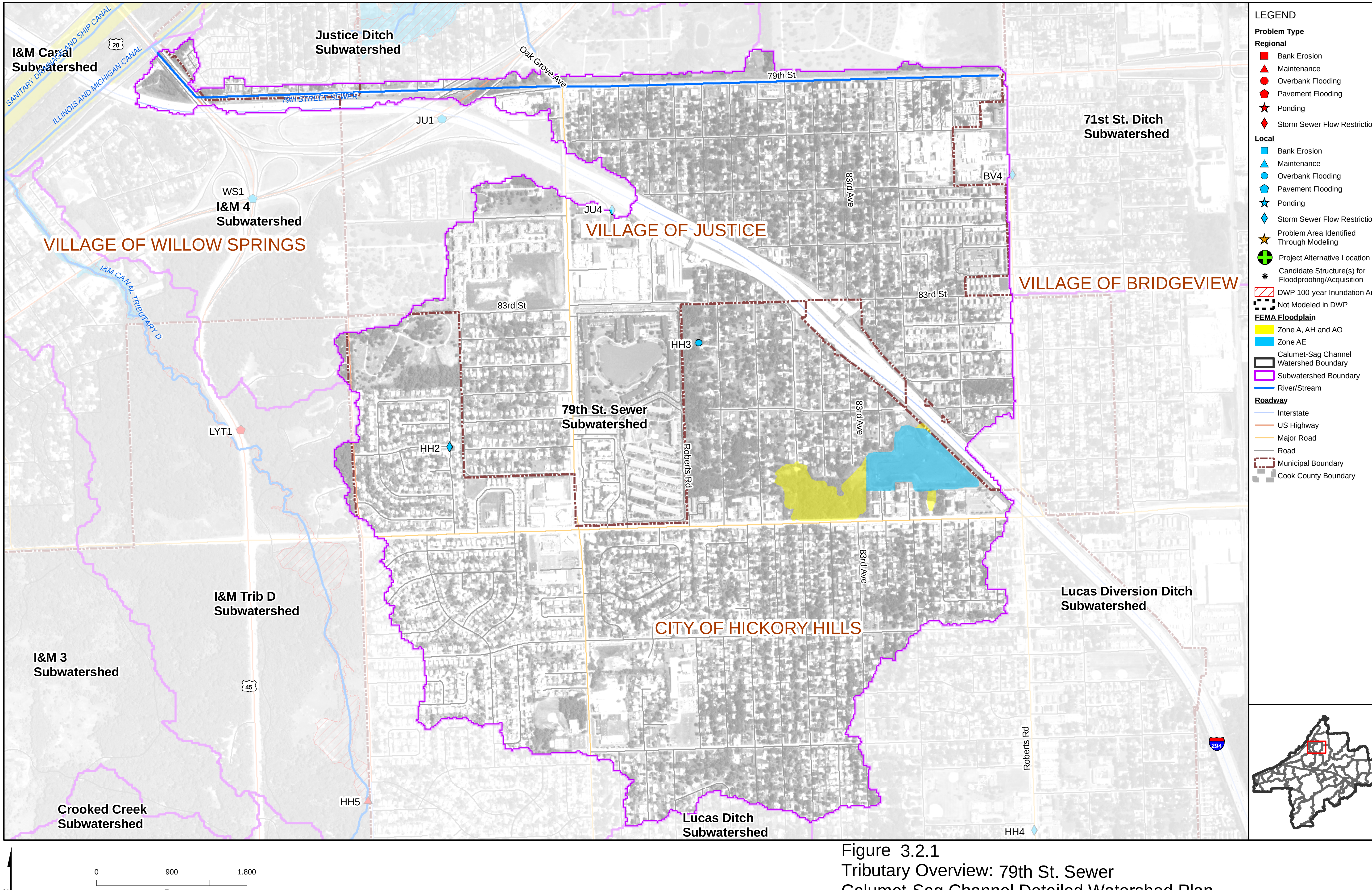


Figure 3.2.1
Tributary Overview: 79th St. Sewer
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

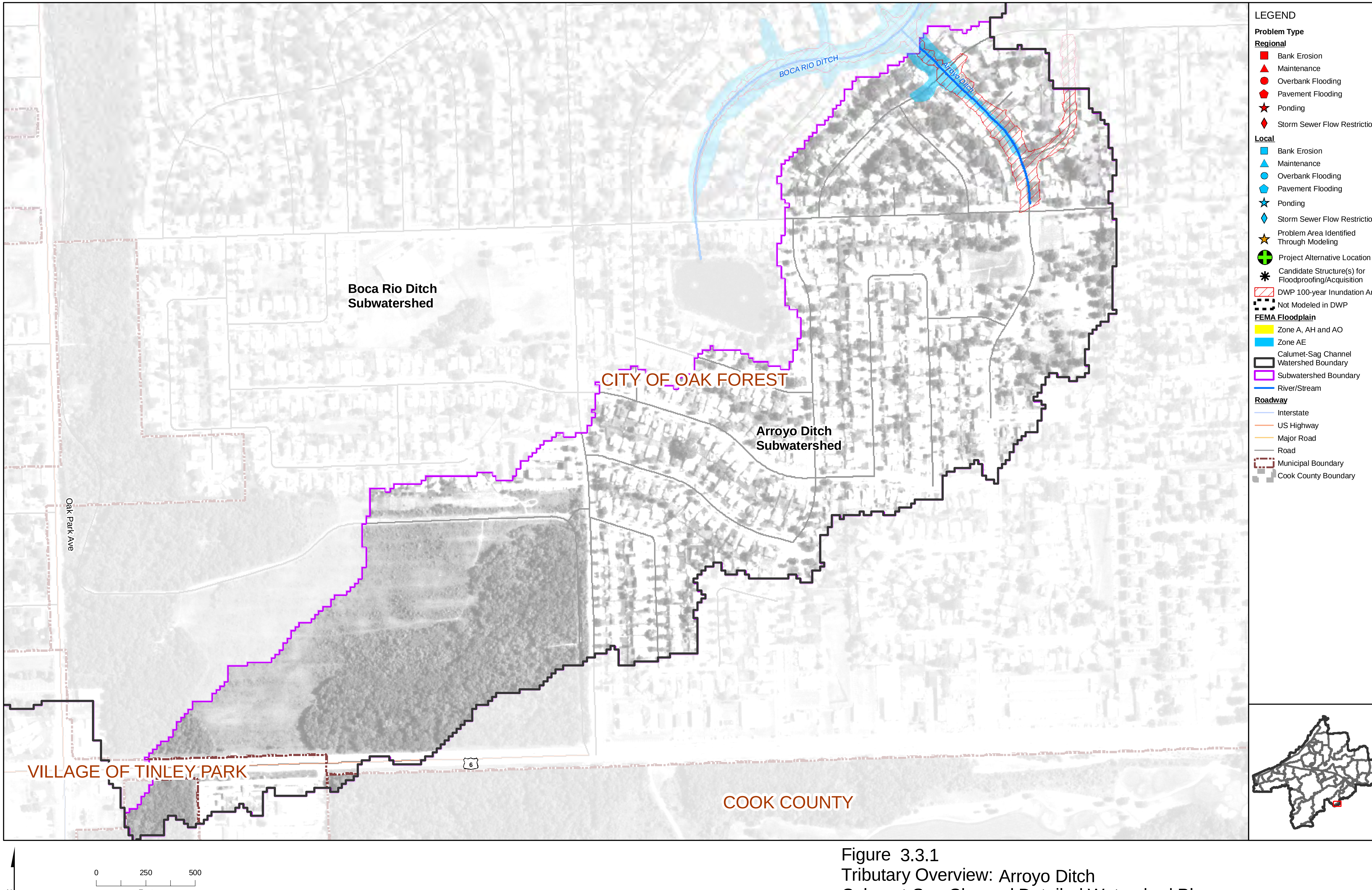


Figure 3.3.1
Tributary Overview: Arroyo Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

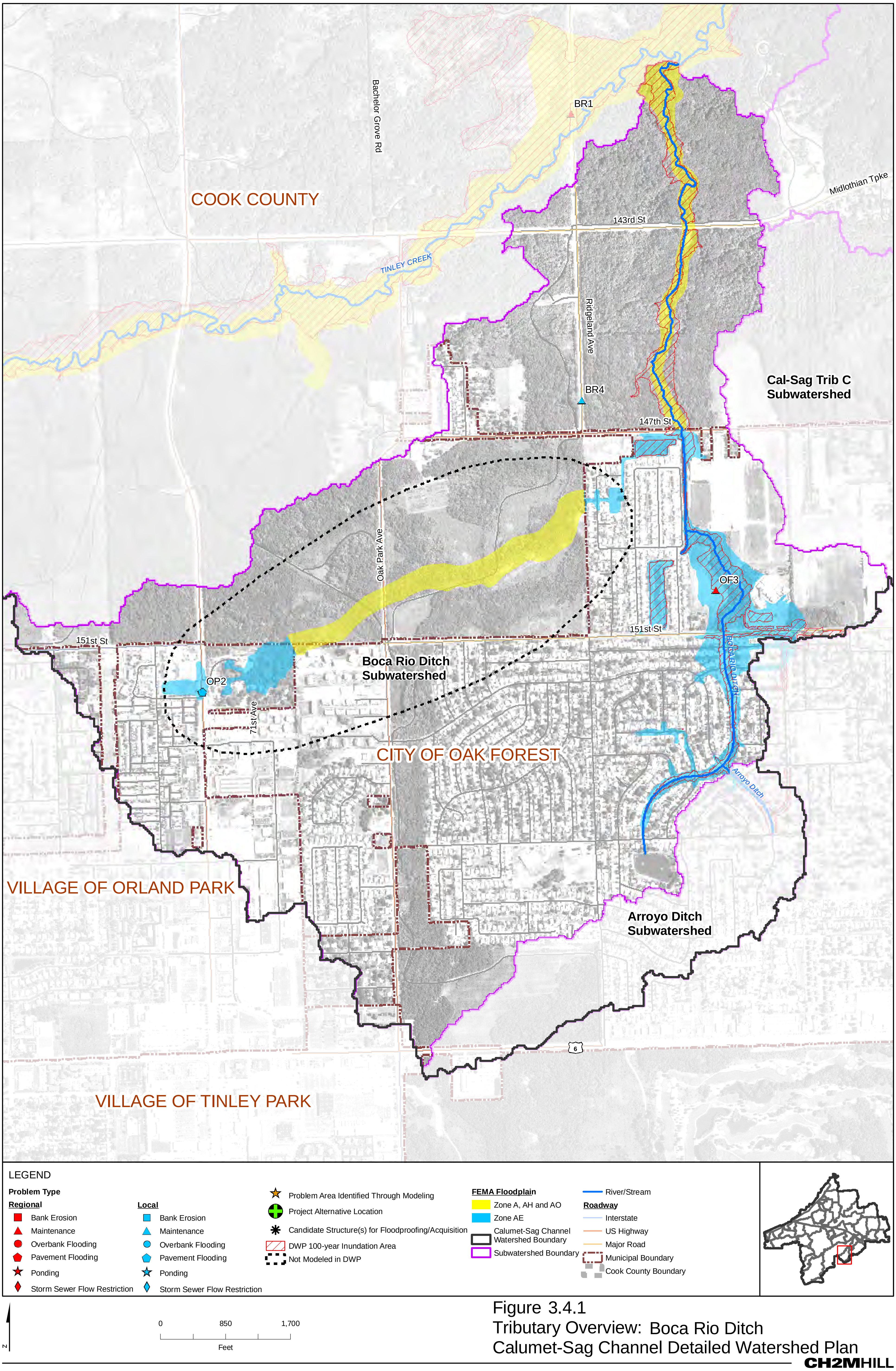


Figure 3.4.1
Tributary Overview: Boca Rio Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

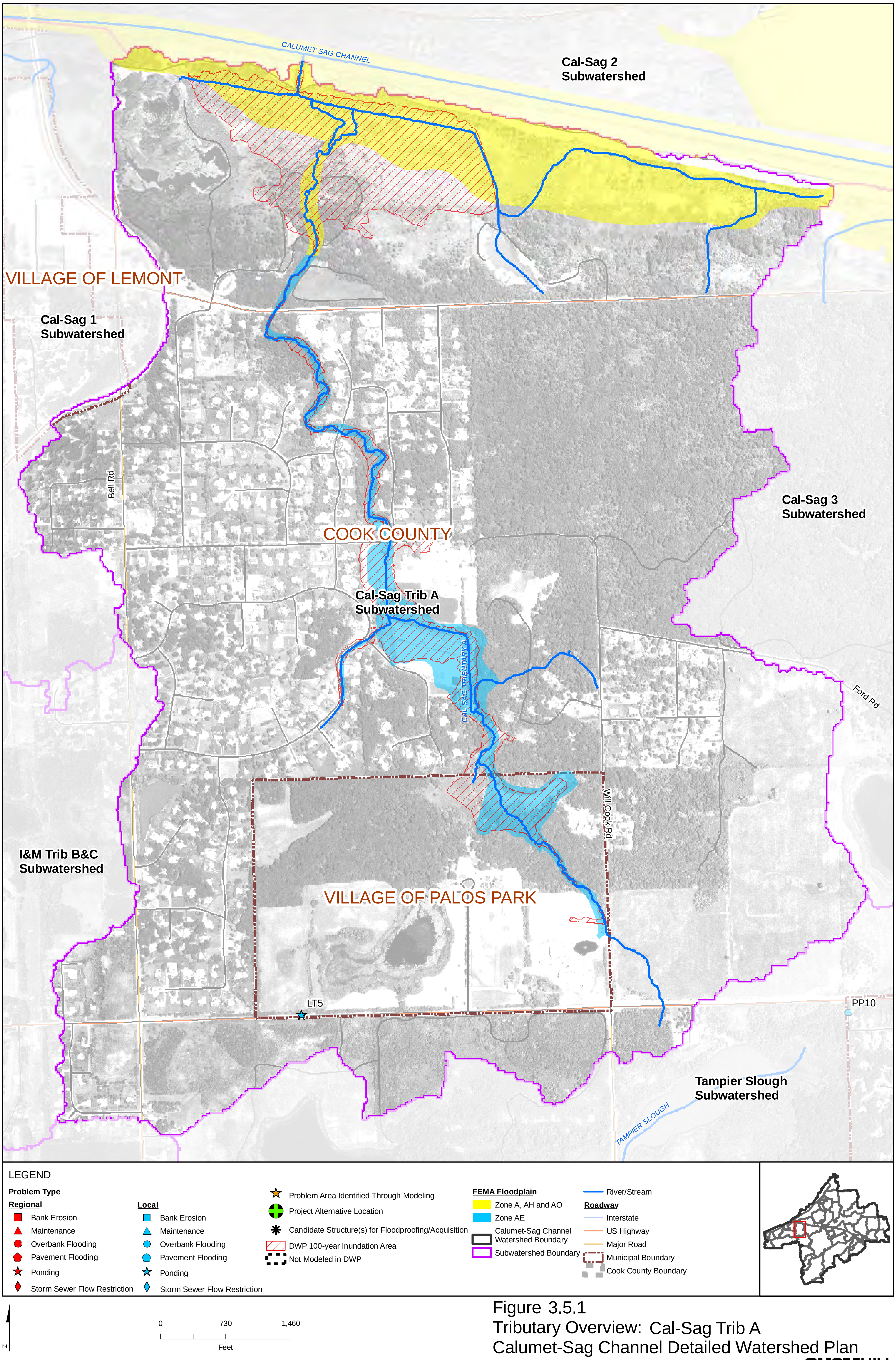


Figure 3.5.1
Tributary Overview: Cal-Sag Trib A
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

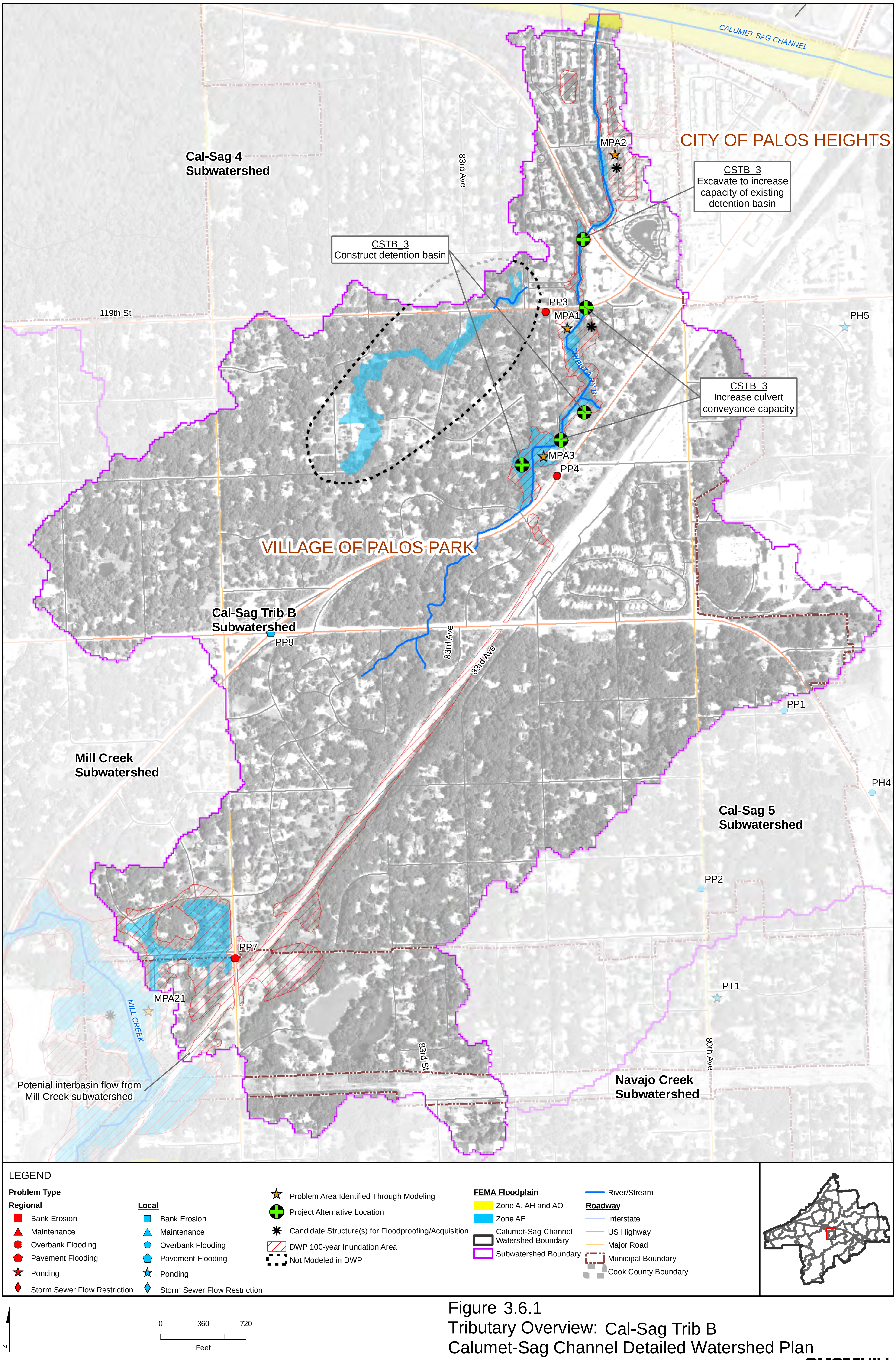
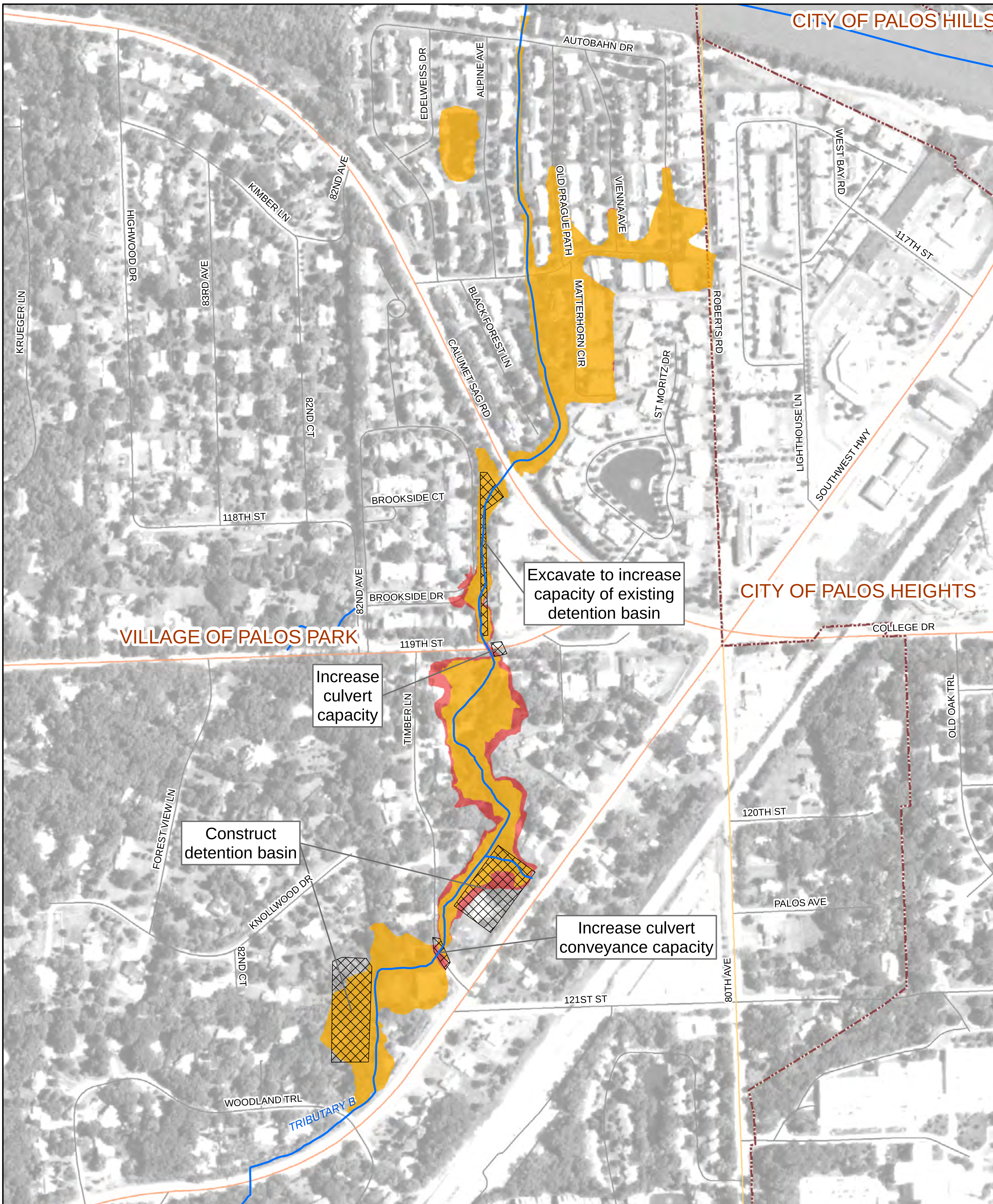


Figure 3.6.1
Tributary Overview: Cal-Sag Trib B
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Cal-Sag Tributary B

Alternative: CSTB-3

Alternative Description:

Construct two detention basins, expand existing detention basin, and increase conveyance capacity of two culverts

Conceptual Level Cost: $ 2,131,500

Benefits: $ 669,700

B/C Ratio: 0.31

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

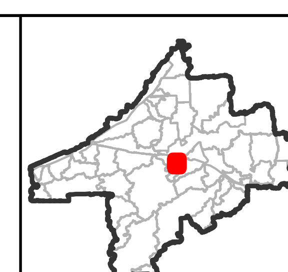
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 250 500

Feet

Figure 3.6.2
Cal-Sag Tributary B
Alternative CSTB-3
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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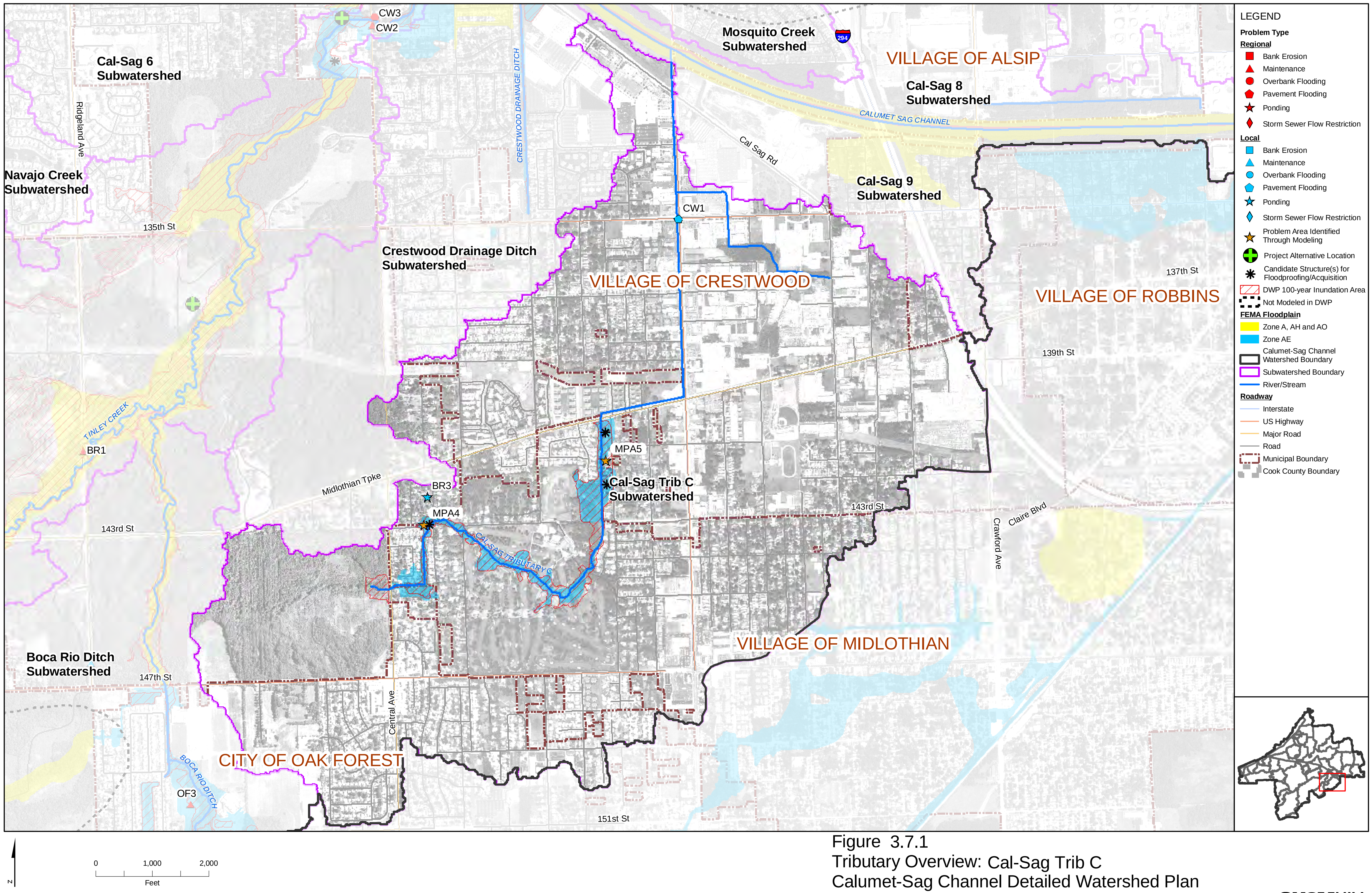


Figure 3.7.1
Tributary Overview: Cal-Sag Trib C
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

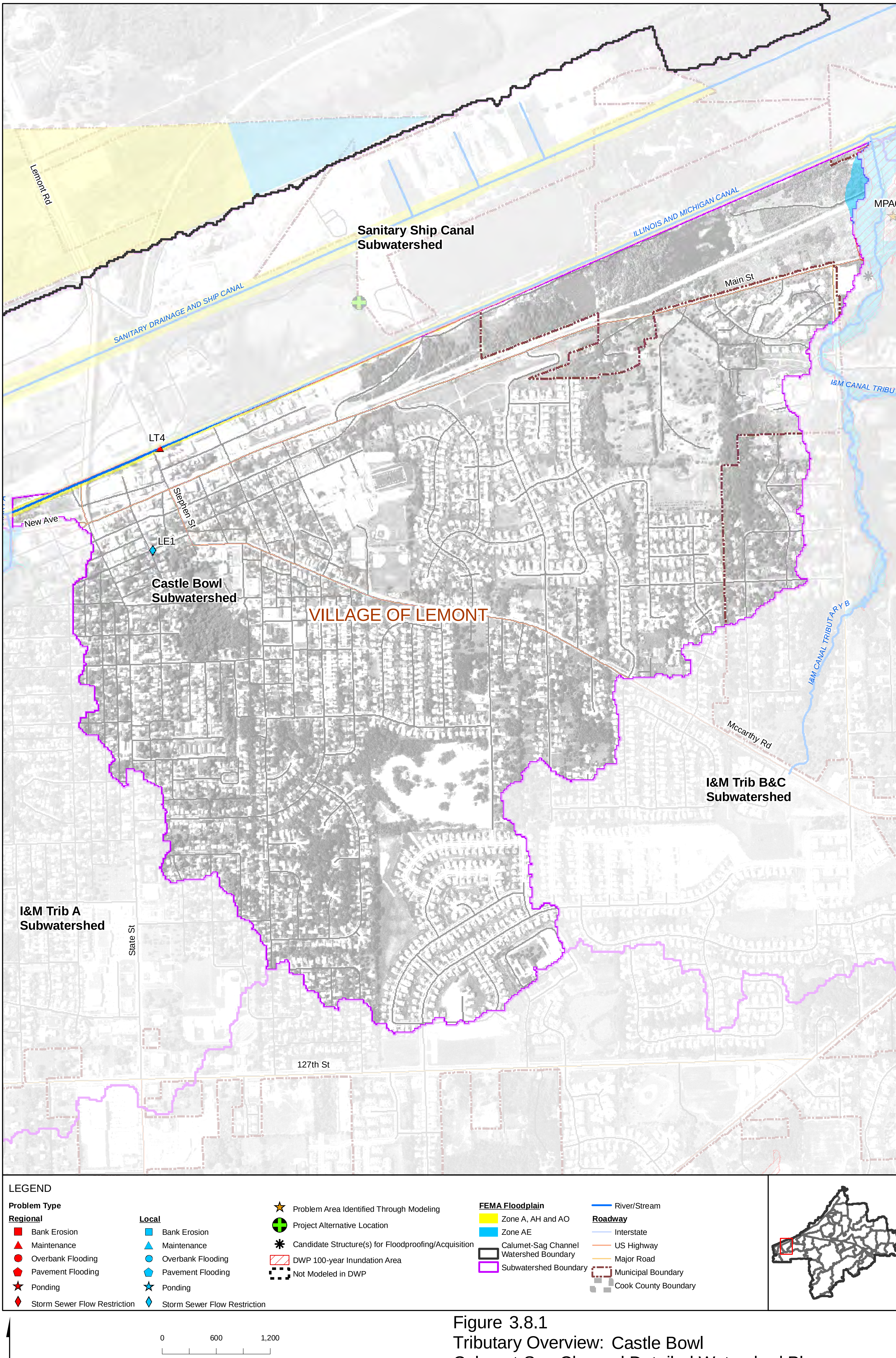
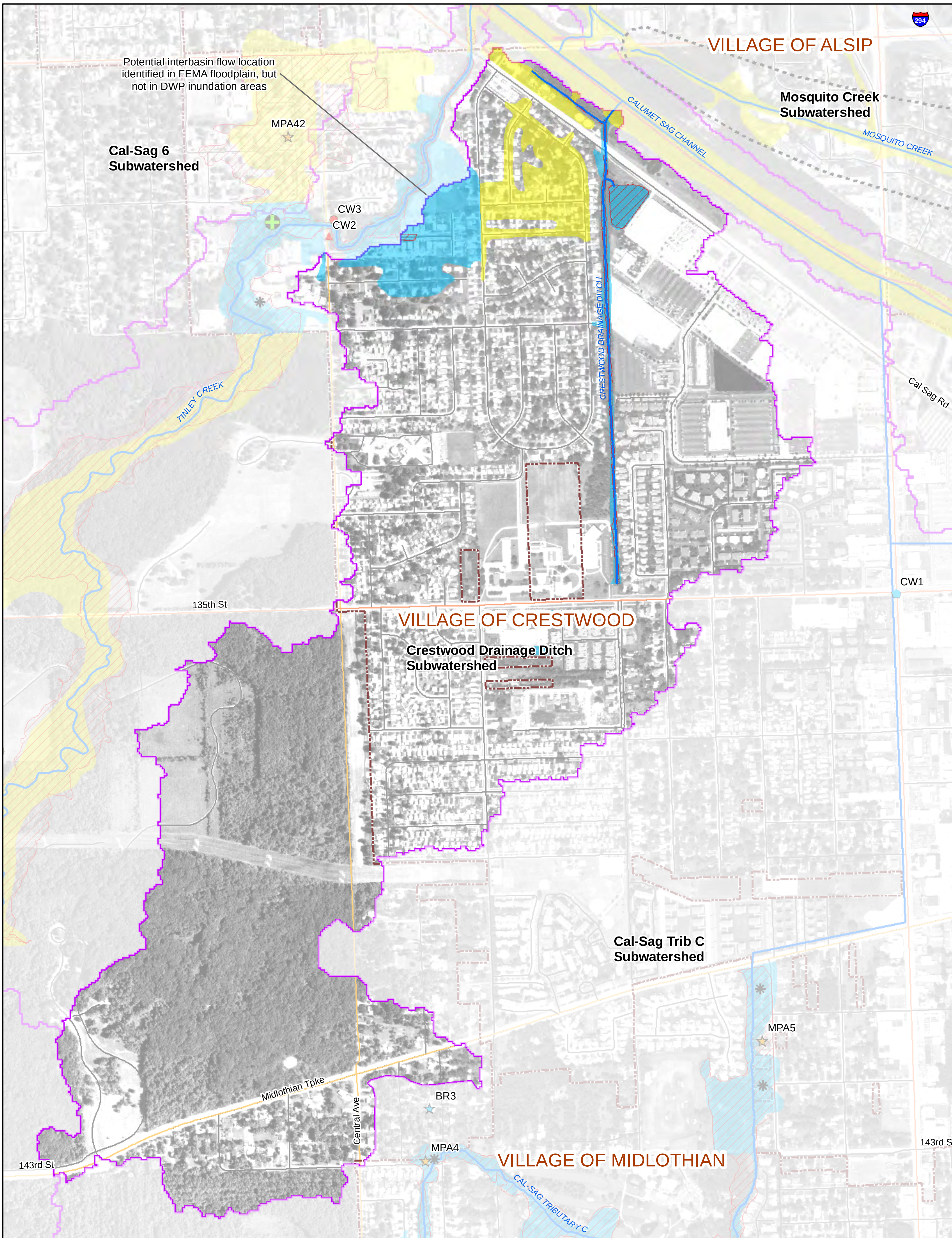


Figure 3.8.1
Tributary Overview: Castle Bowl
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



LEGEND

Problem Type

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

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

- Problem Area Identified Through Modeling
- Project Alternative Location
- Candidate Structure(s) for Floodproofing/Acquisition
- DWP 100-year Inundation Area
- Not Modeled in DWP

FEMA Floodplain
- Zone A, AH and AO
- Zone AE
- Calumet-Sag Channel Watershed Boundary
- Subwatershed Boundary

- River/Stream

Roadway
- Interstate
- US Highway
- Major Road
- Municipal Boundary
- Cook County Boundary

N

0 500 1,000

Feet

Figure 3.9.1
Tributary Overview: Crestwood Drainage Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

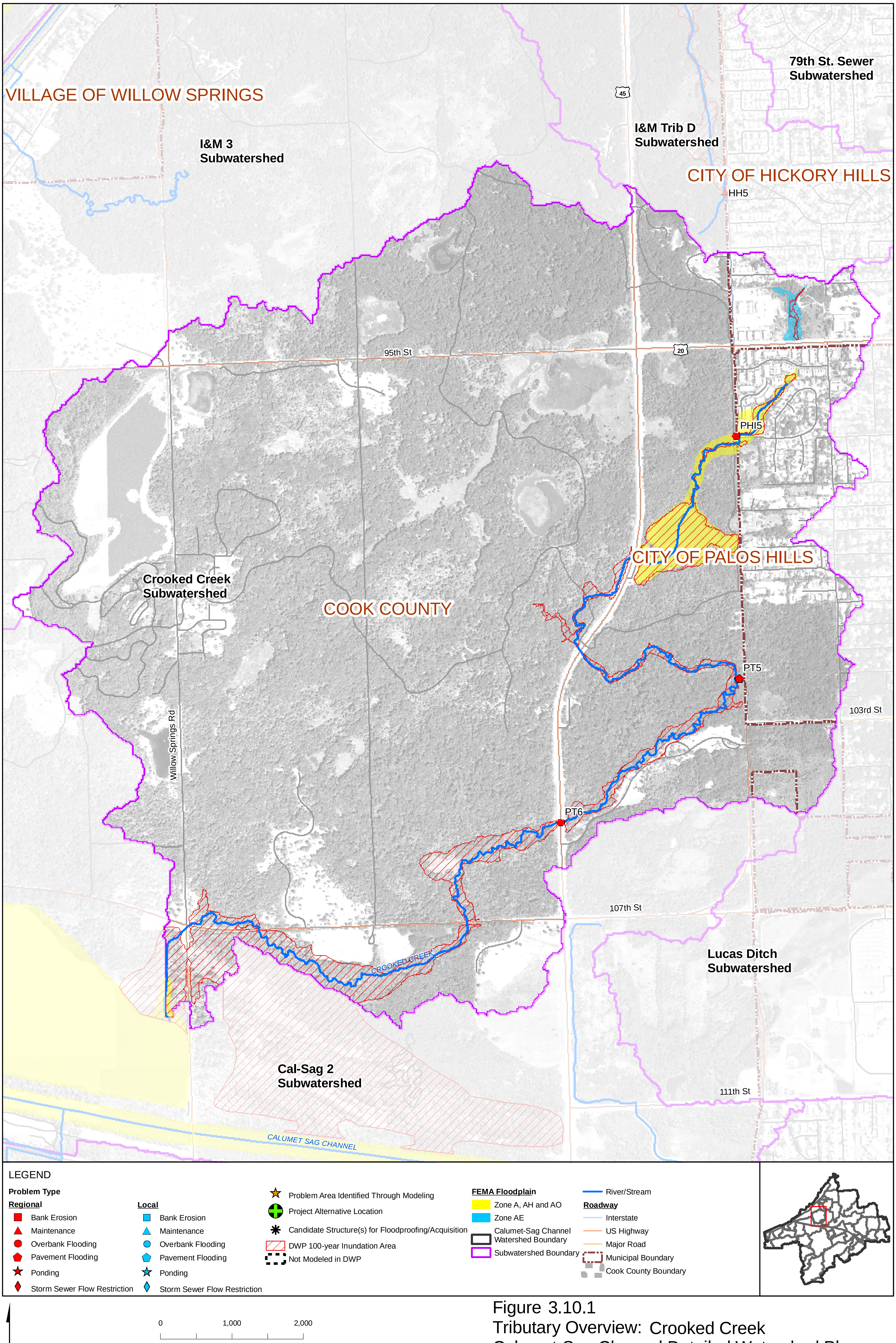


Figure 3.10.1
Tributary Overview: Crooked Creek
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

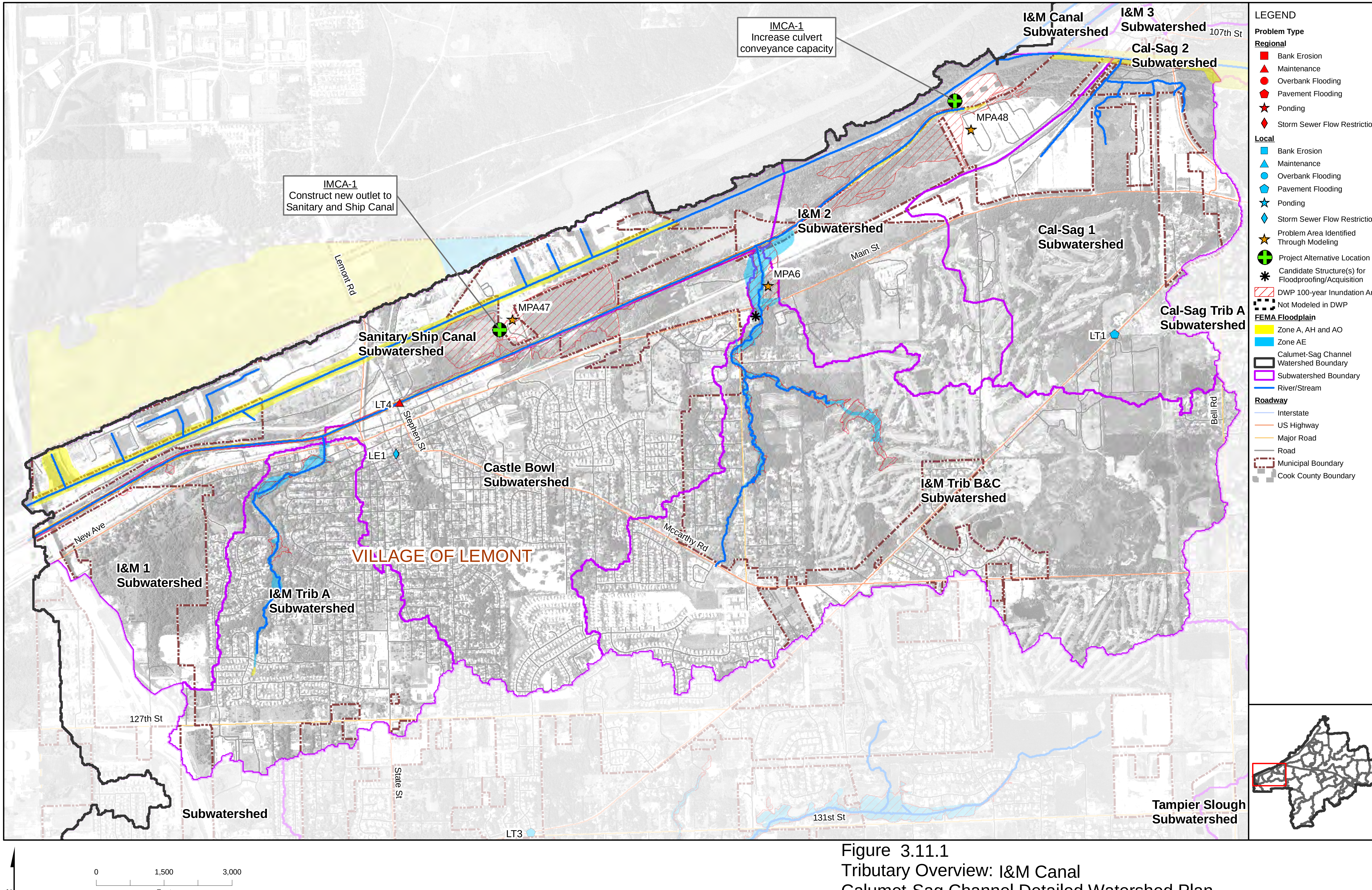
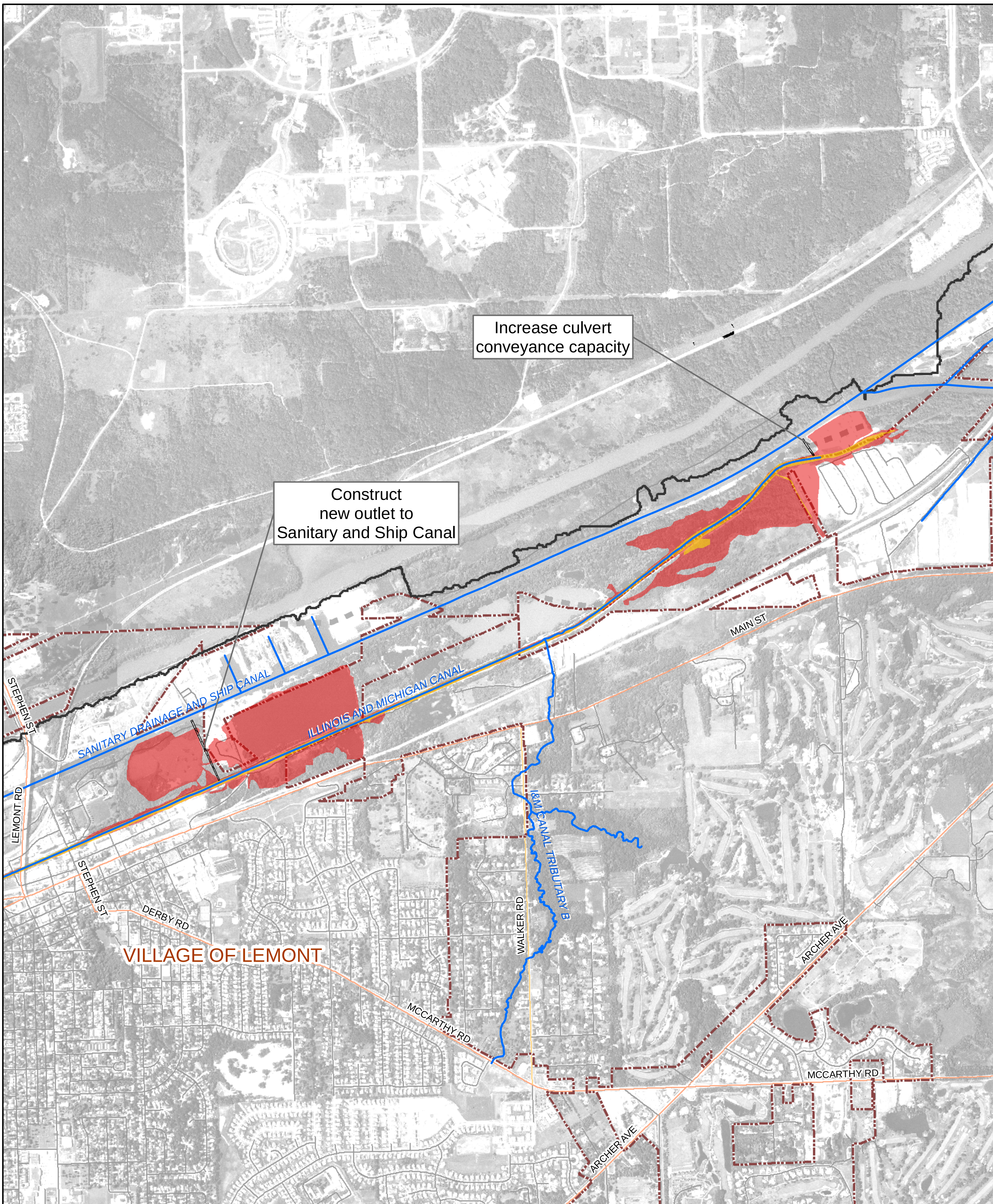


Figure 3.11.1
Tributary Overview: I&M Canal
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: I&M Canal

Alternative: IMCA-1

Alternative Description:

Construct new outlet to Sanitary and Ship Canal and increase culvert conveyance capacity

Conceptual Level Cost: $ 1,043,800

Benefits: $ 34,700

B/C Ratio: 0.03

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway
- Interstate
- US Highway
- Major Road
- Road

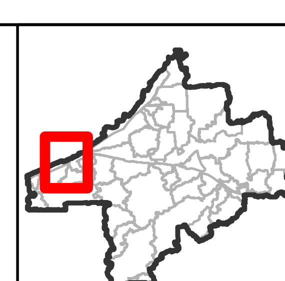
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 1,300 2,600

Feet

N

Figure 3.11.2
I&M Canal
Alternative IMCA-1
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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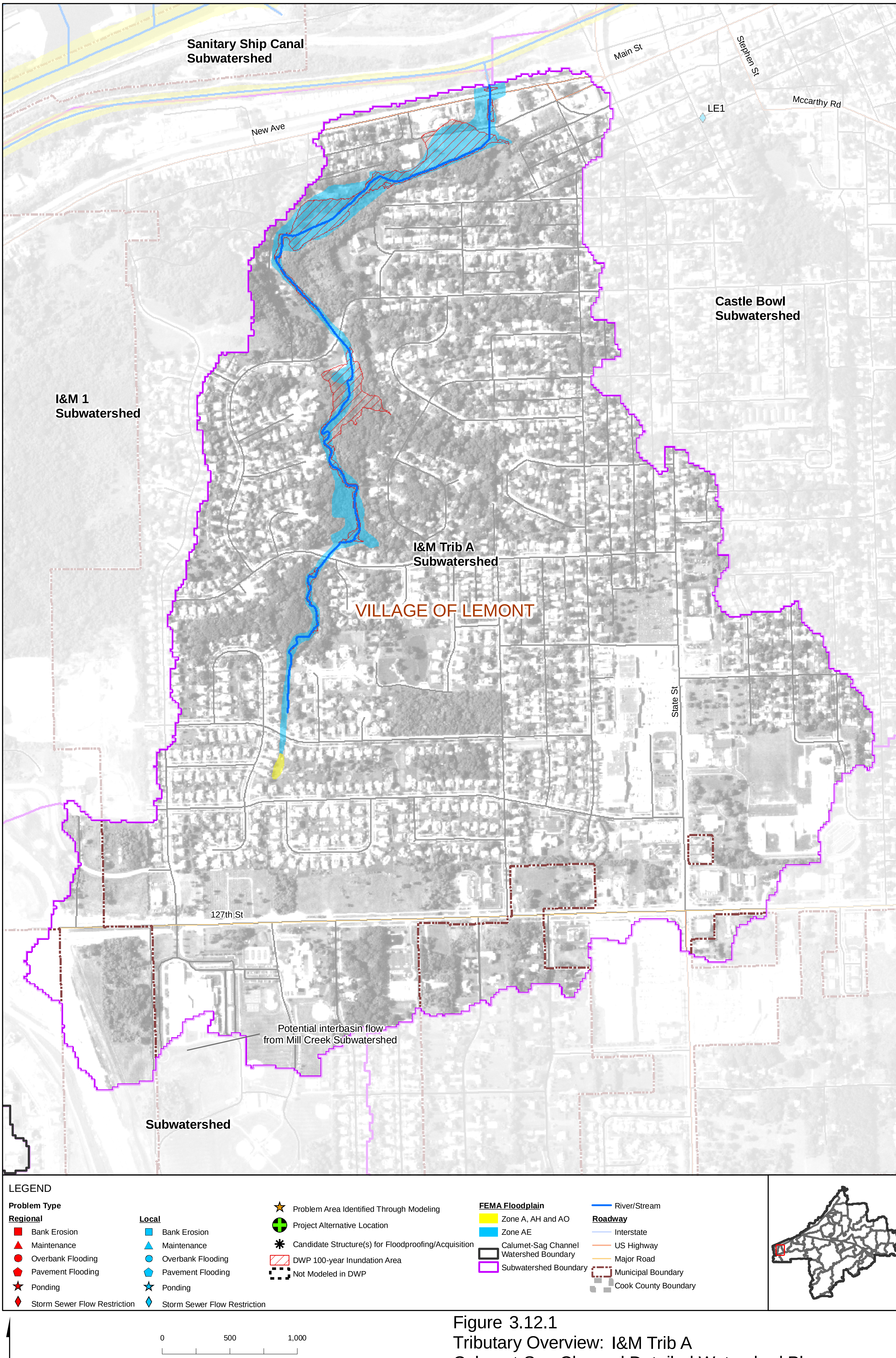


Figure 3.12.1
Tributary Overview: I&M Trib A
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

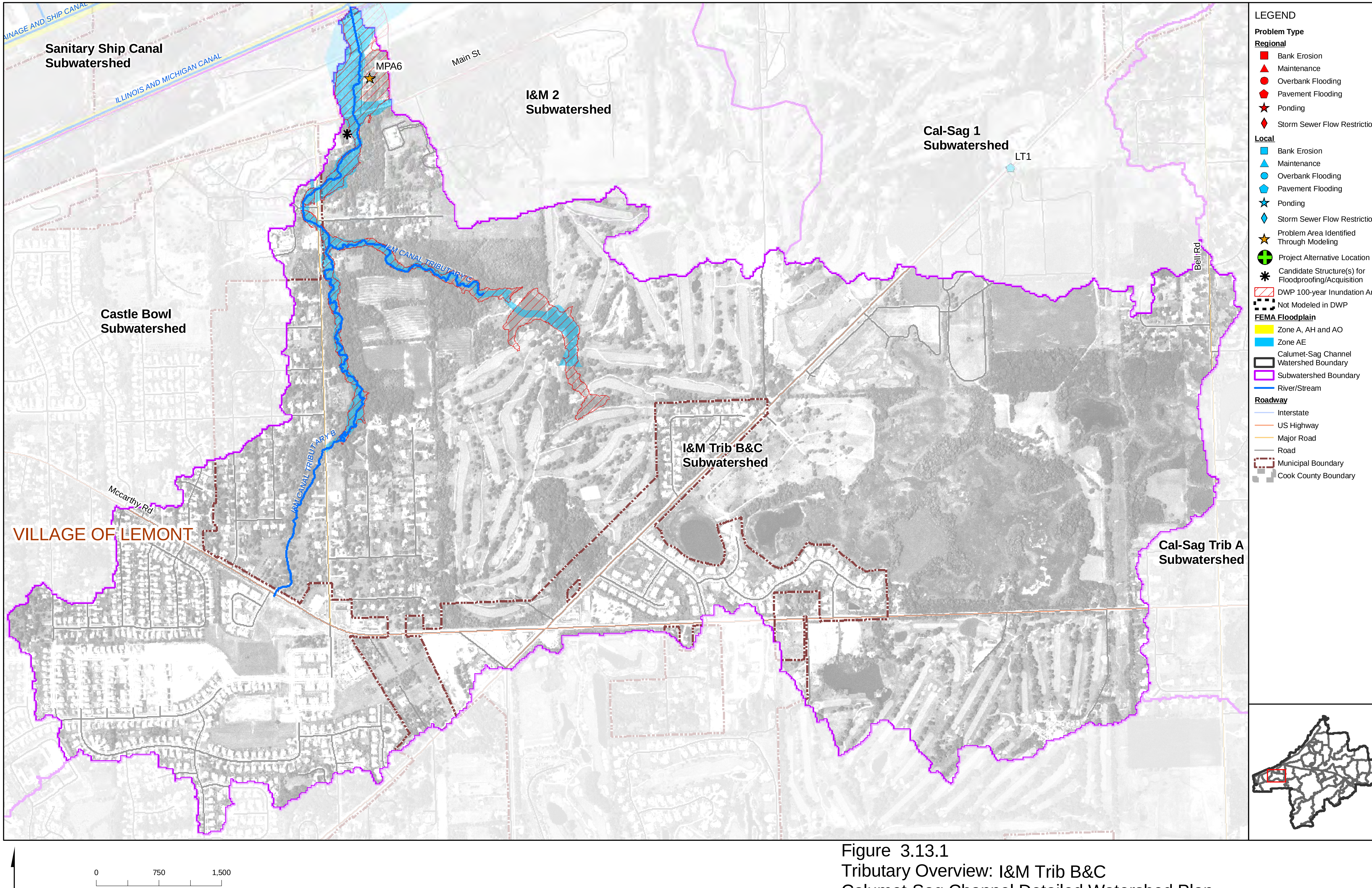


Figure 3.13.1
Tributary Overview: I&M Trib B&C
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

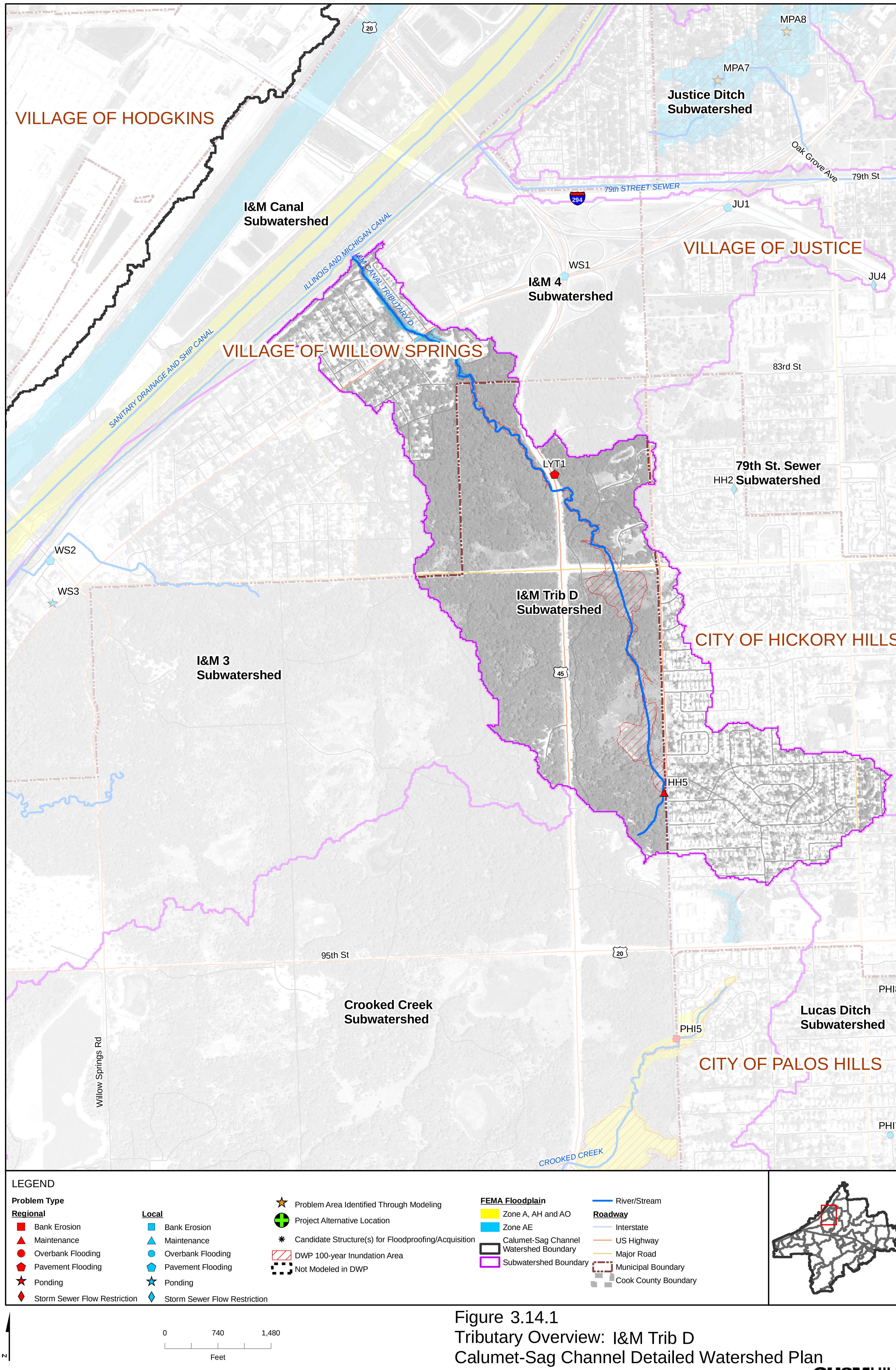


Figure 3.14.1
Tributary Overview: I&M Trib D
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

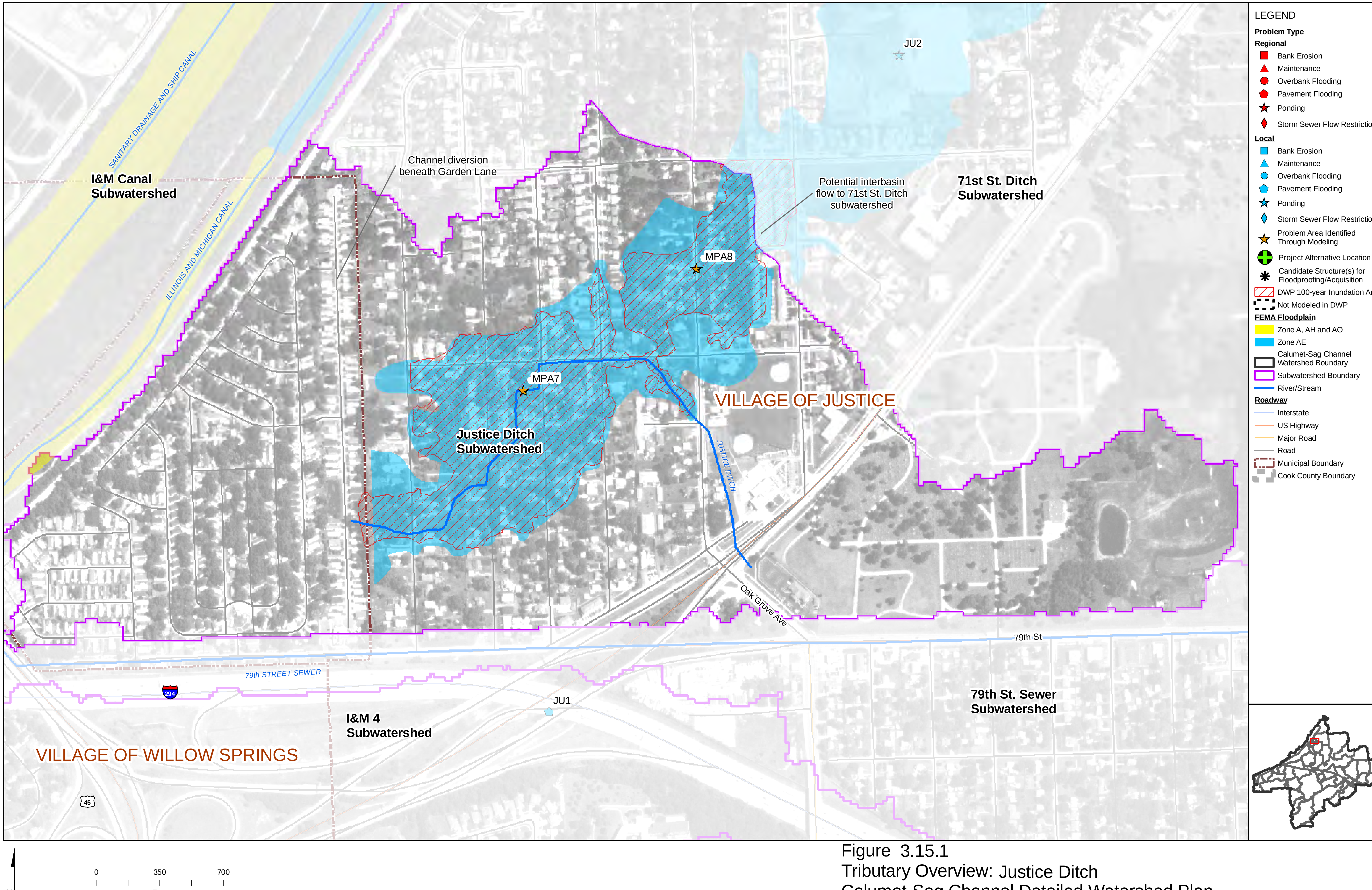


Figure 3.15.1
Tributary Overview: Justice Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

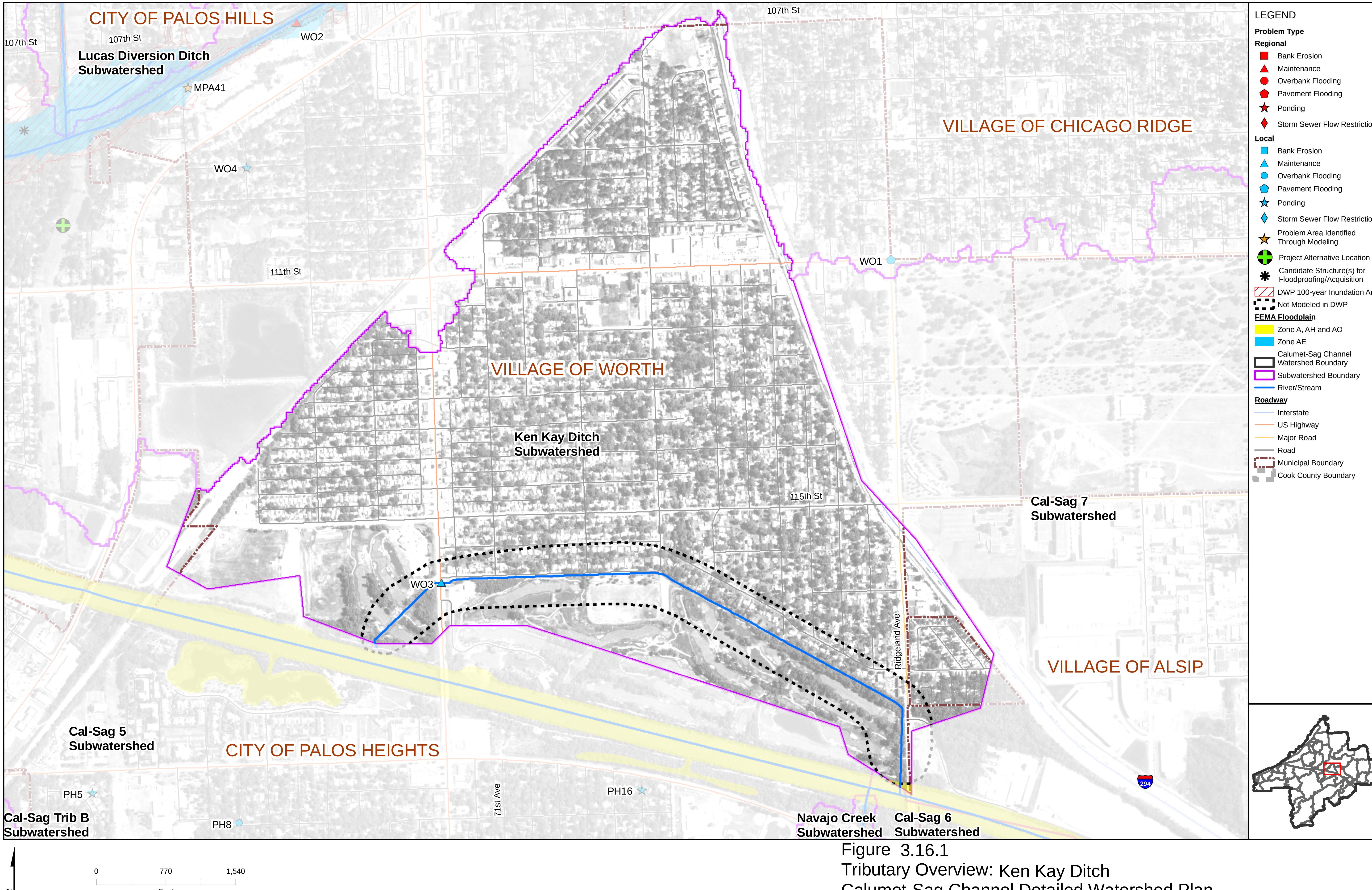


Figure 3.16.1
Tributary Overview: Ken Kay Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

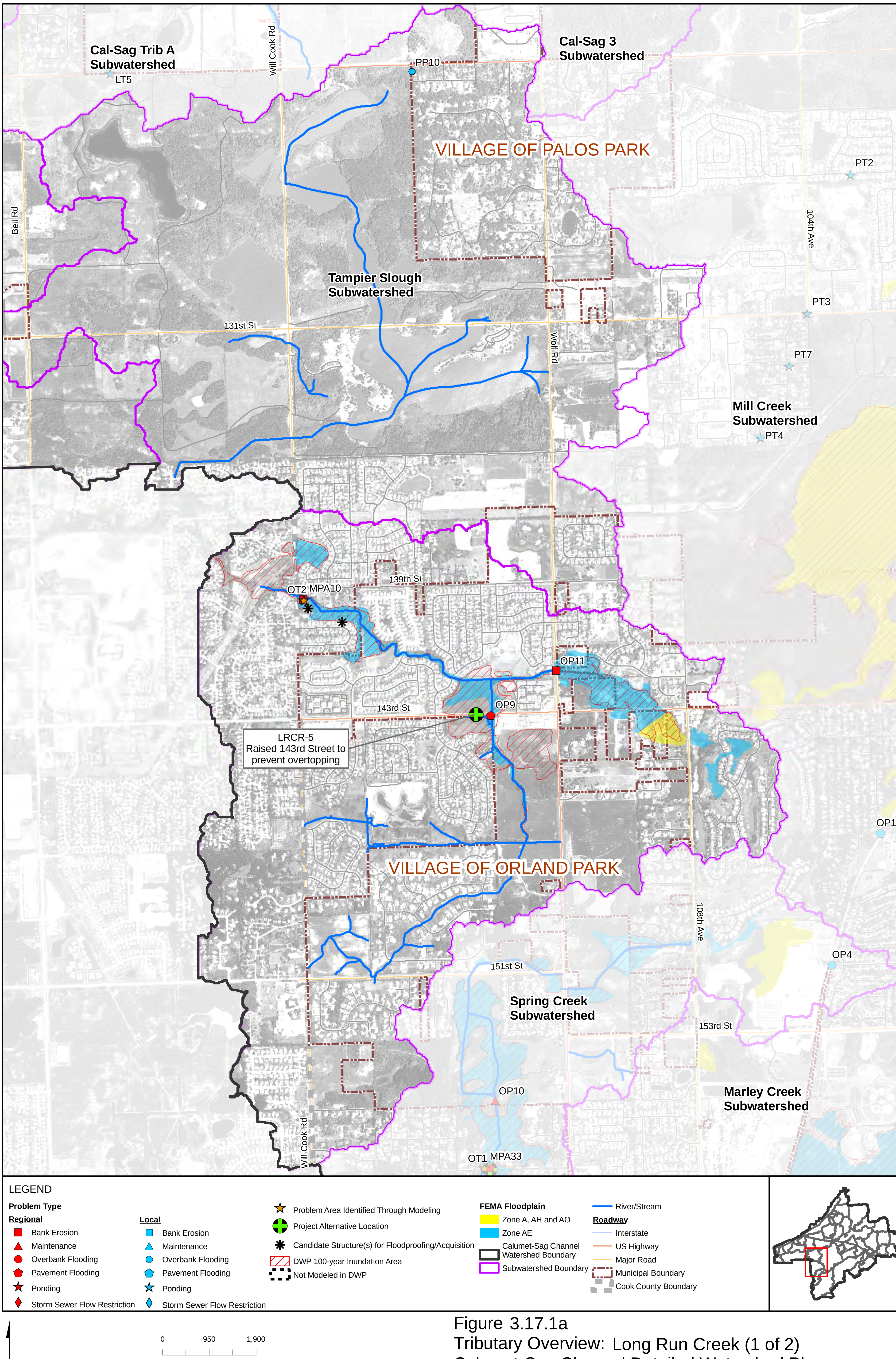


Figure 3.17.1a
Tributary Overview: Long Run Creek (1 of 2)
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

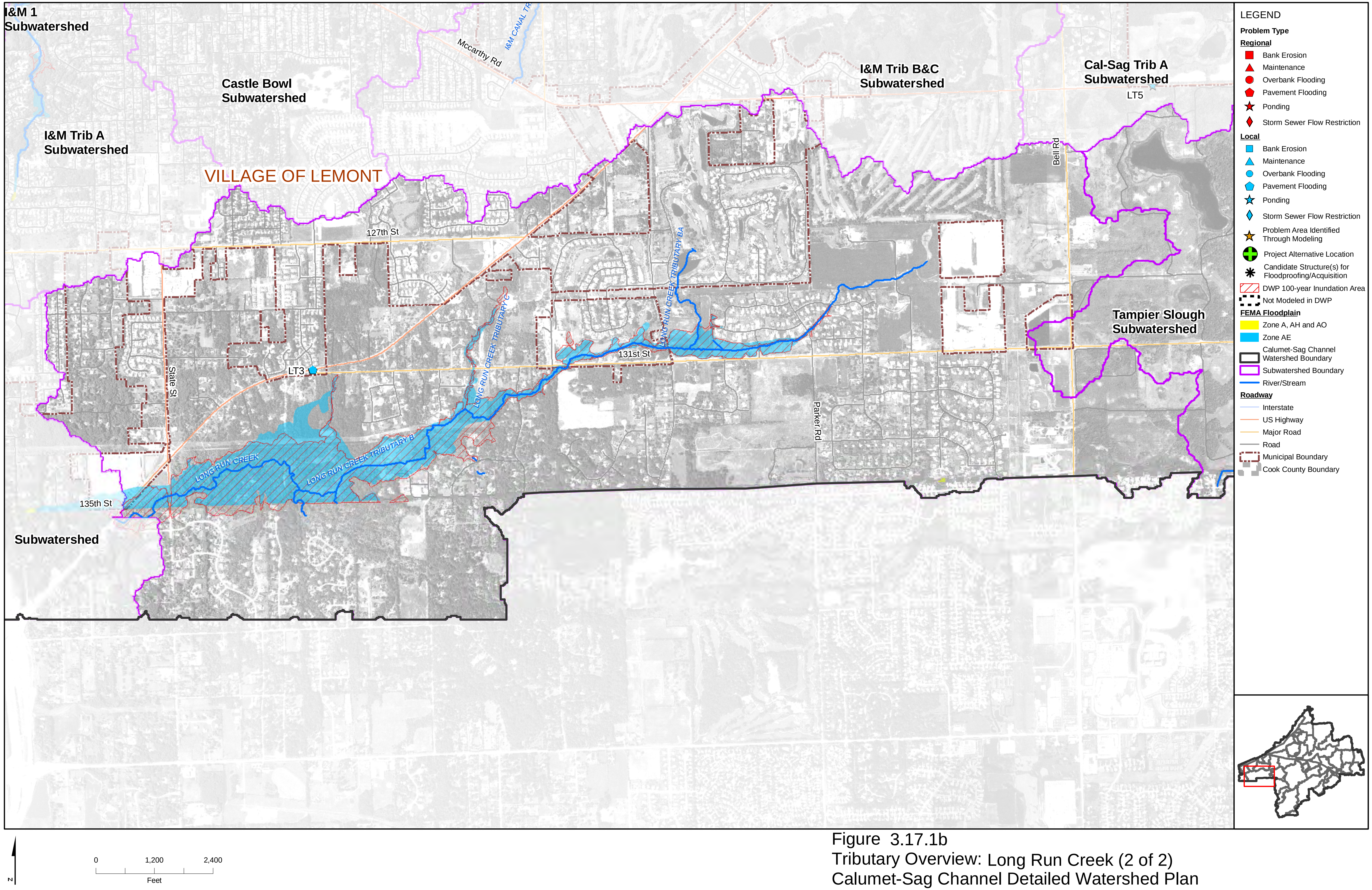
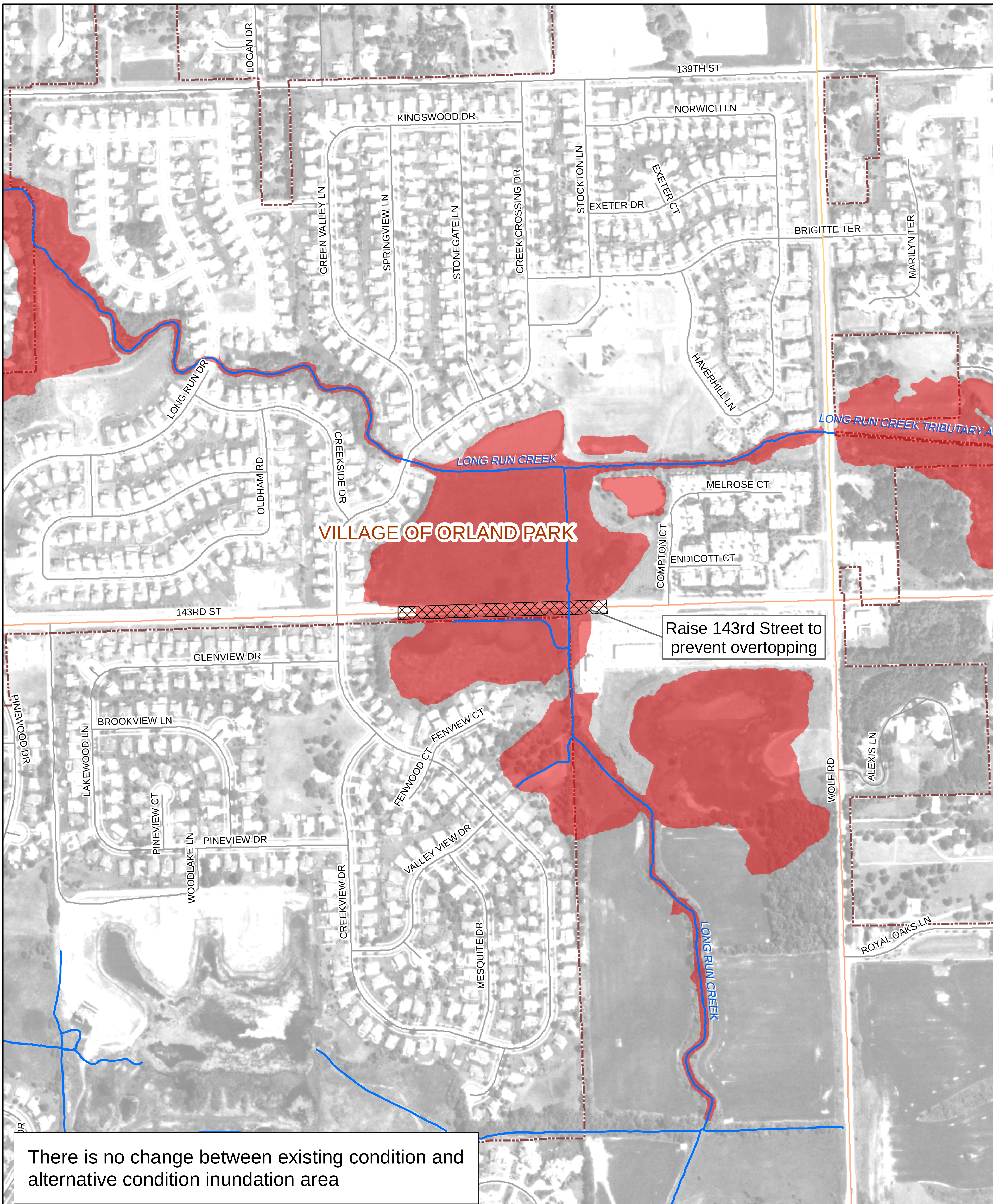


Figure 3.17.1b
Tributary Overview: Long Run Creek (2 of 2)
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Long Run Creek

Alternative: LRCR-5

Alternative Description:

Raise 143rd Street and construct weir

Conceptual Level Cost: $ 862,668

Benefits: $ 51,147

B/C Ratio: 0.06

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

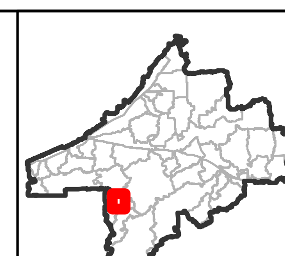
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 290 580

Feet

Figure 3.17.2
Long Run Creek
Alternative LRCR-5
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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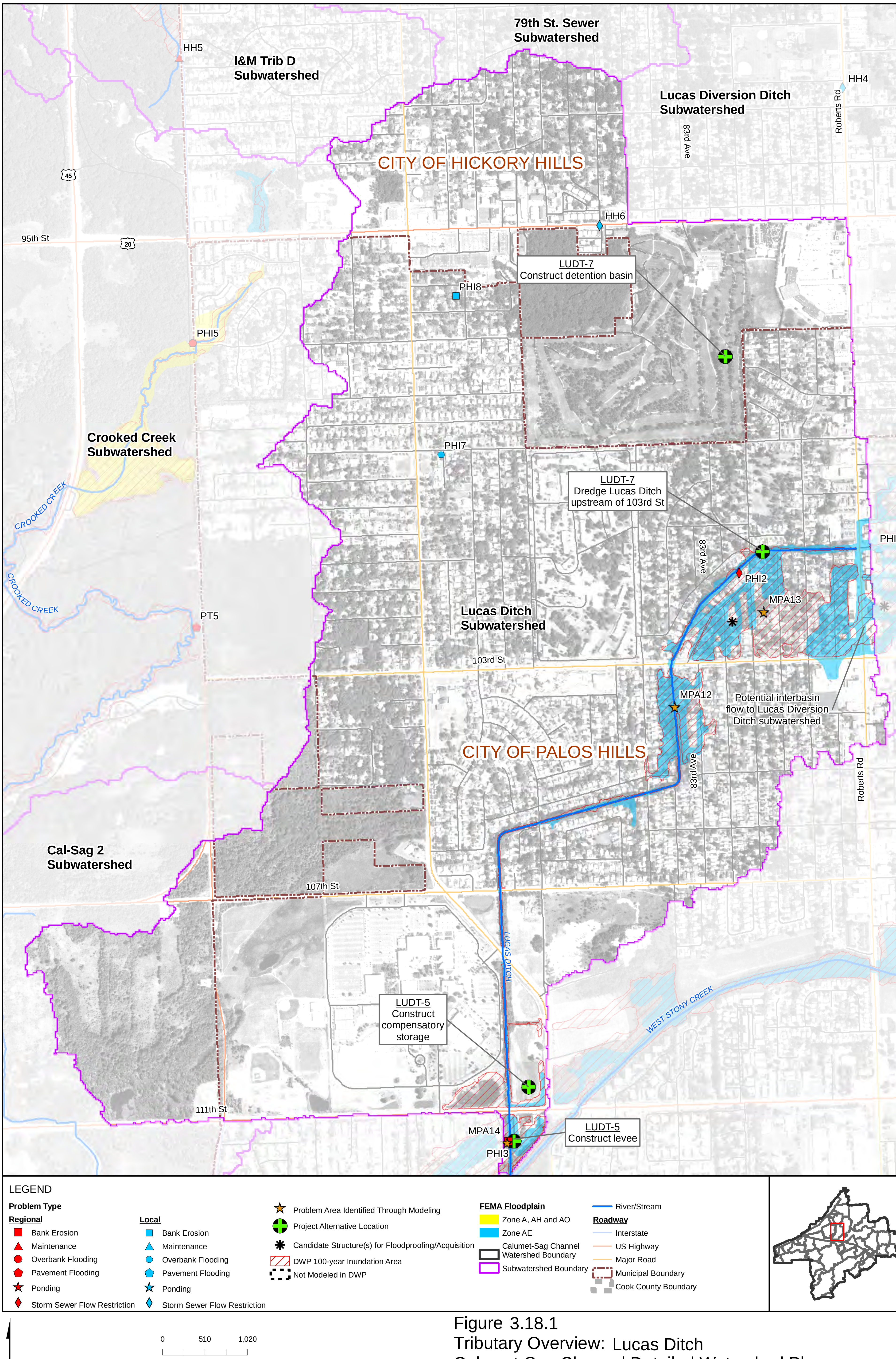


Figure 3.18.1
Tributary Overview: Lucas Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

Subwatershed: Lucas Ditch

Alternative: LUDT-5

Alternative Description:

Construct levee

Conceptual Level Cost: $ 3,136,900

Benefits: $ 845,200

B/C Ratio: 0.27

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway
- Interstate
- US Highway
- Major Road
- Road

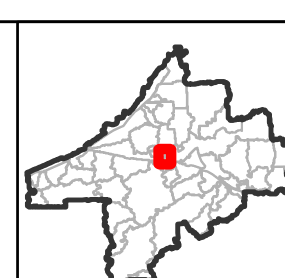
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 300 600

Feet

N

Figure 3.18.2
Lucas Ditch
Alternative LUDT-5
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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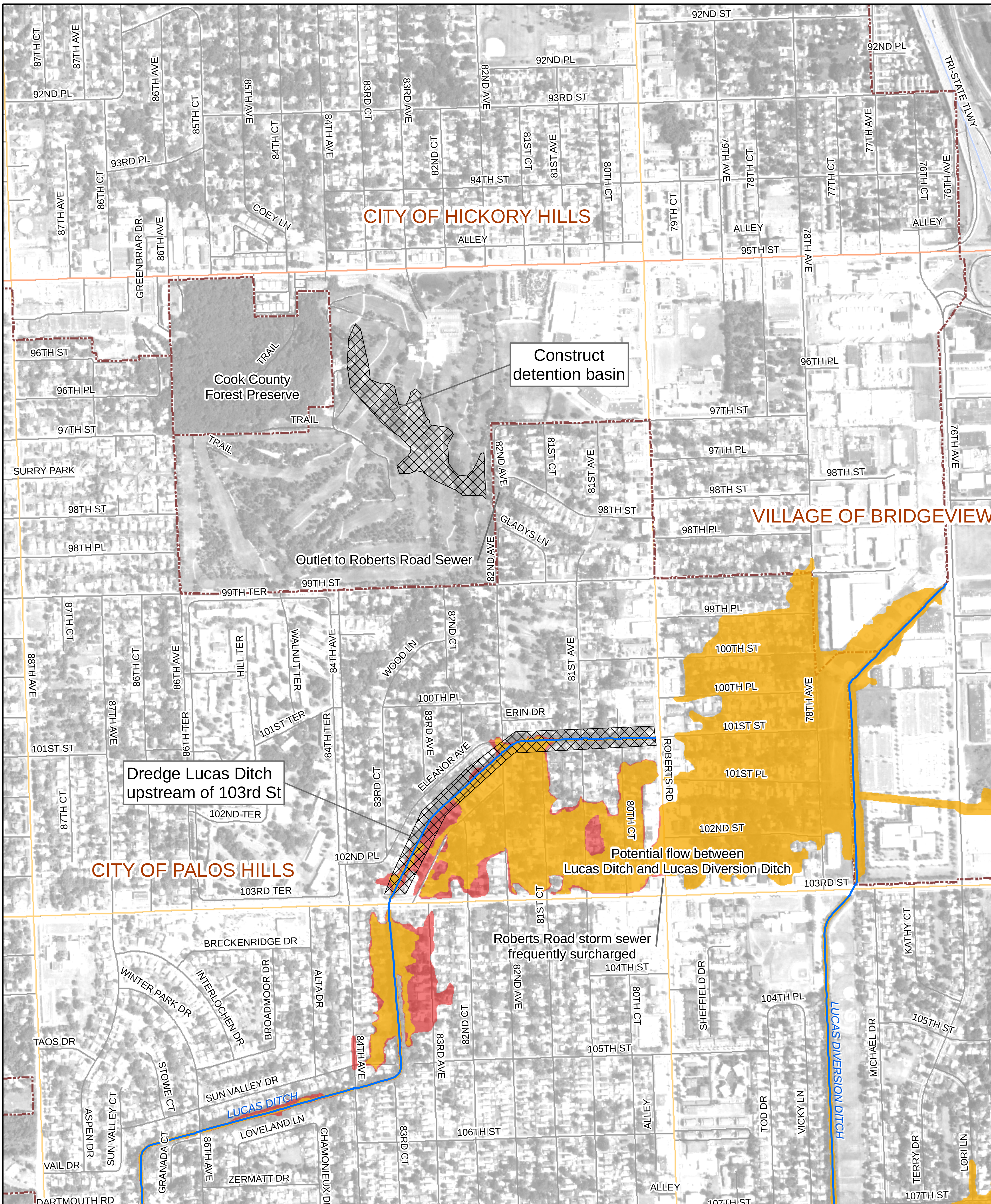


Subwatershed: Lucas Ditch

Alternative: LUDT-7

Alternative Description:

Dredge Lucas Ditch upstream of 103rd street and provide roughly 60 ac-ft of detention on golf course

Conceptual Level Cost: $ 4,472,600

Benefits: $ 340,200

B/C Ratio: 0.08

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway
- Interstate
- US Highway
- Major Road
- Road

- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 500 1,000

Feet

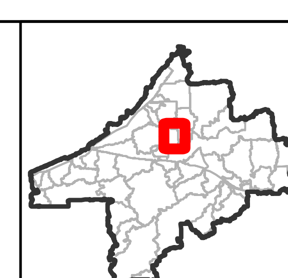


Figure 3.18.3
Lucas Ditch
Alternative LUDT-7
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

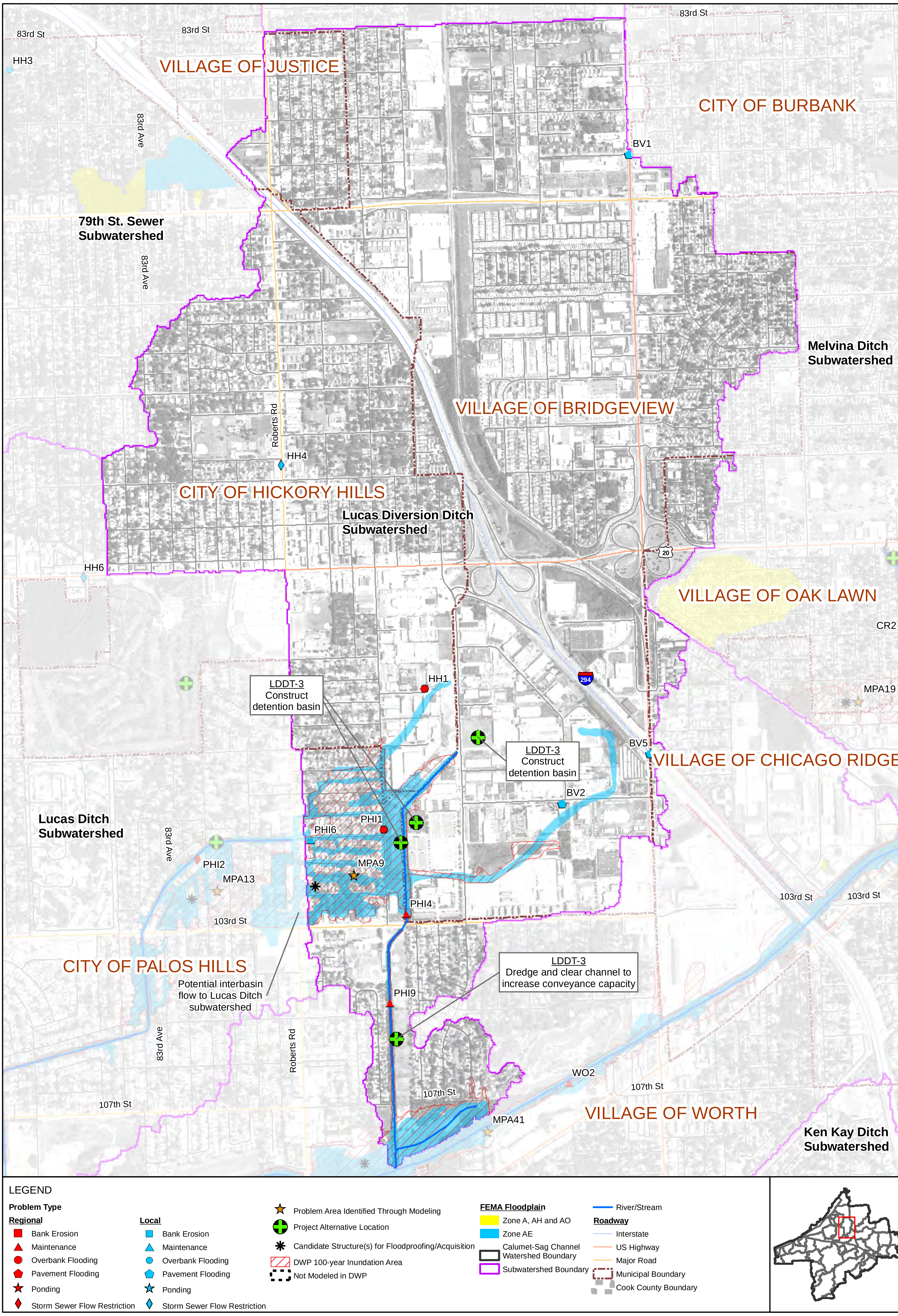
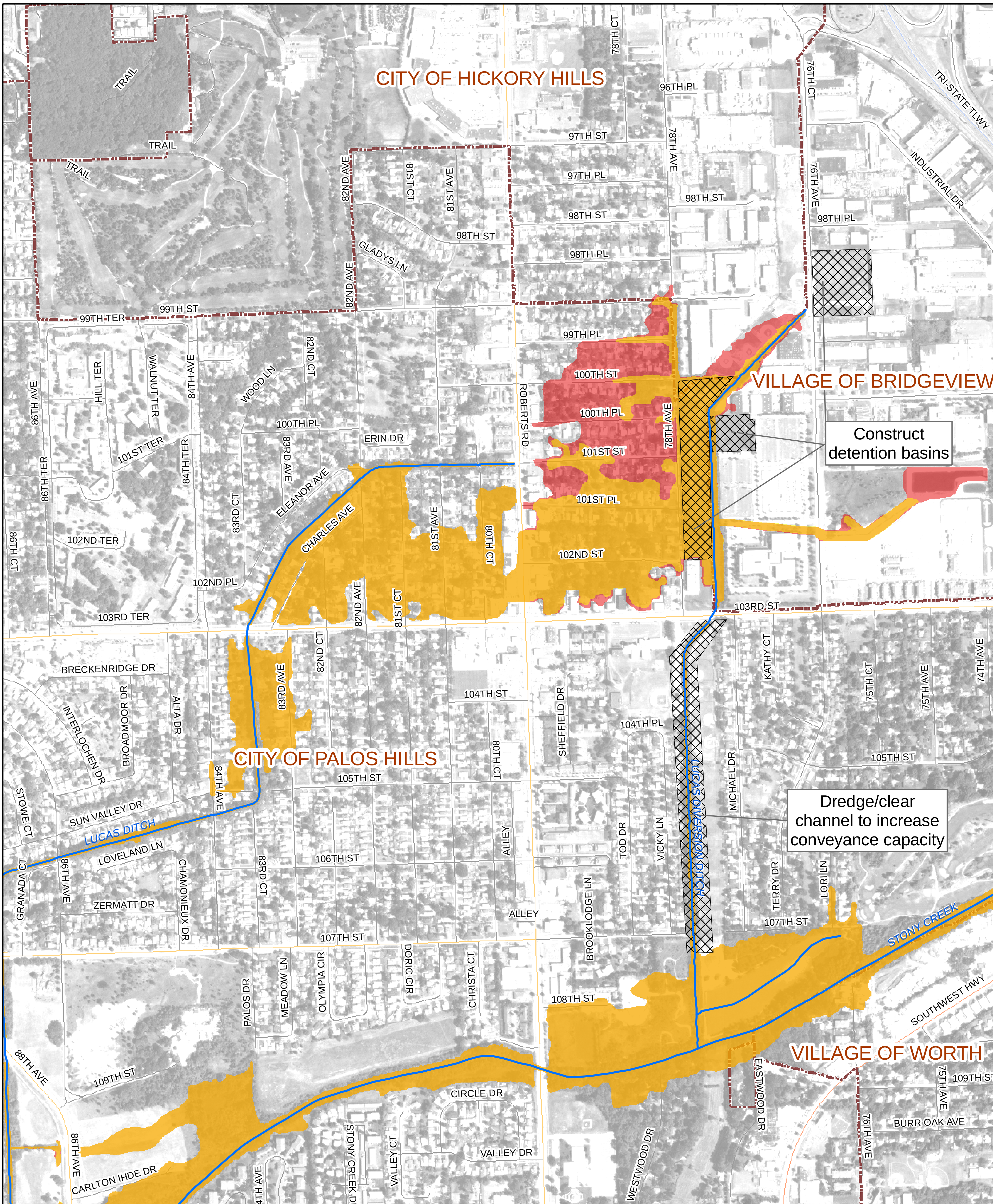


Figure 3.19.1
Tributary Overview: Lucas Diversion Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Lucas Diversion Ditch

Alternative: LDDT-3

Alternative Description:

Construct three detention basins and clear channel

Conceptual Level Cost: $ 6,765,000

Benefits: $ 885,200

B/C Ratio: 0.13

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

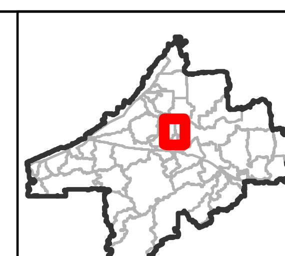
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 410 820

Feet

Figure 3.19.2
Lucas Diversion Ditch
Alternative LDDT-3
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



CH2MHILL

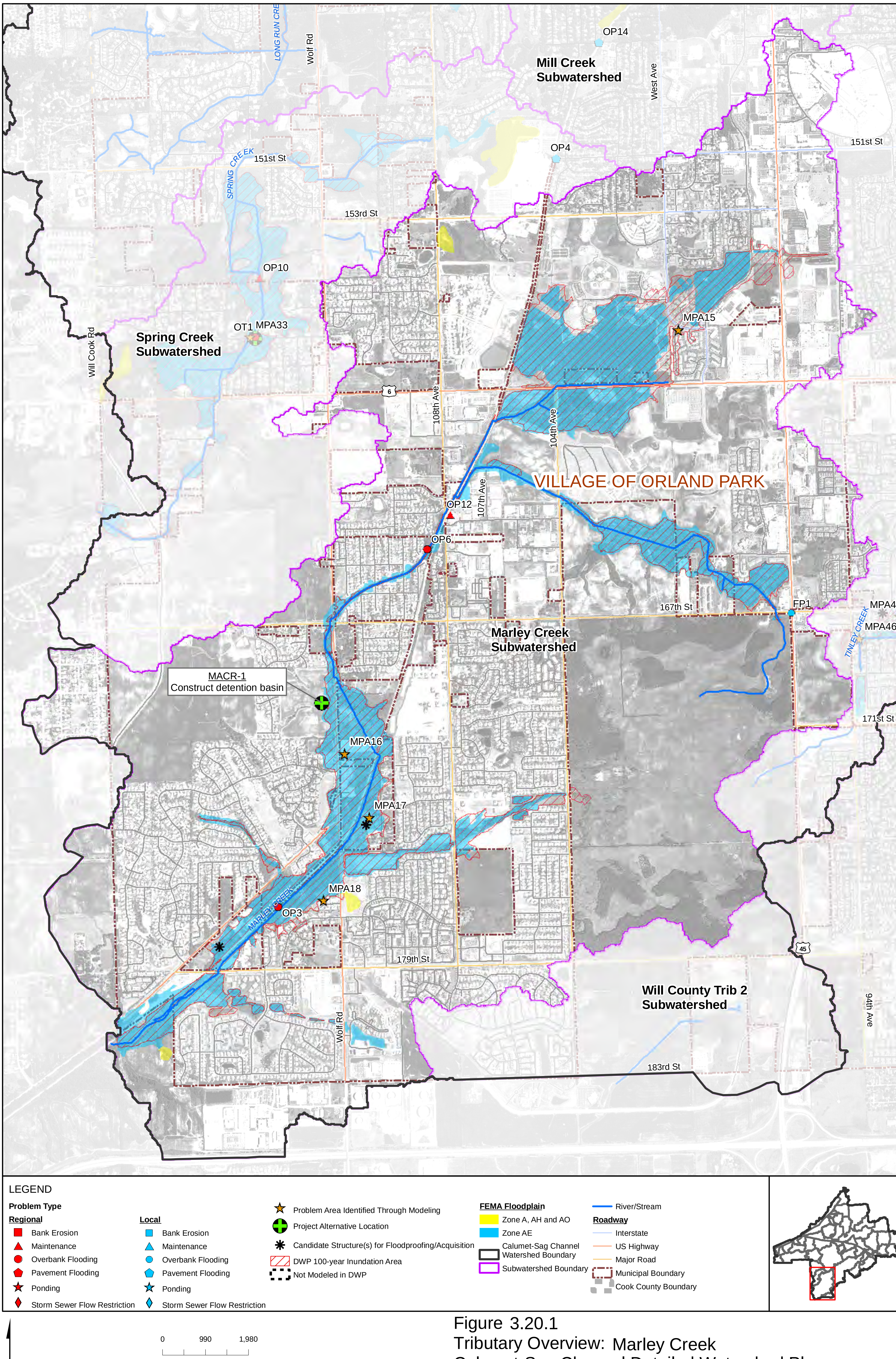
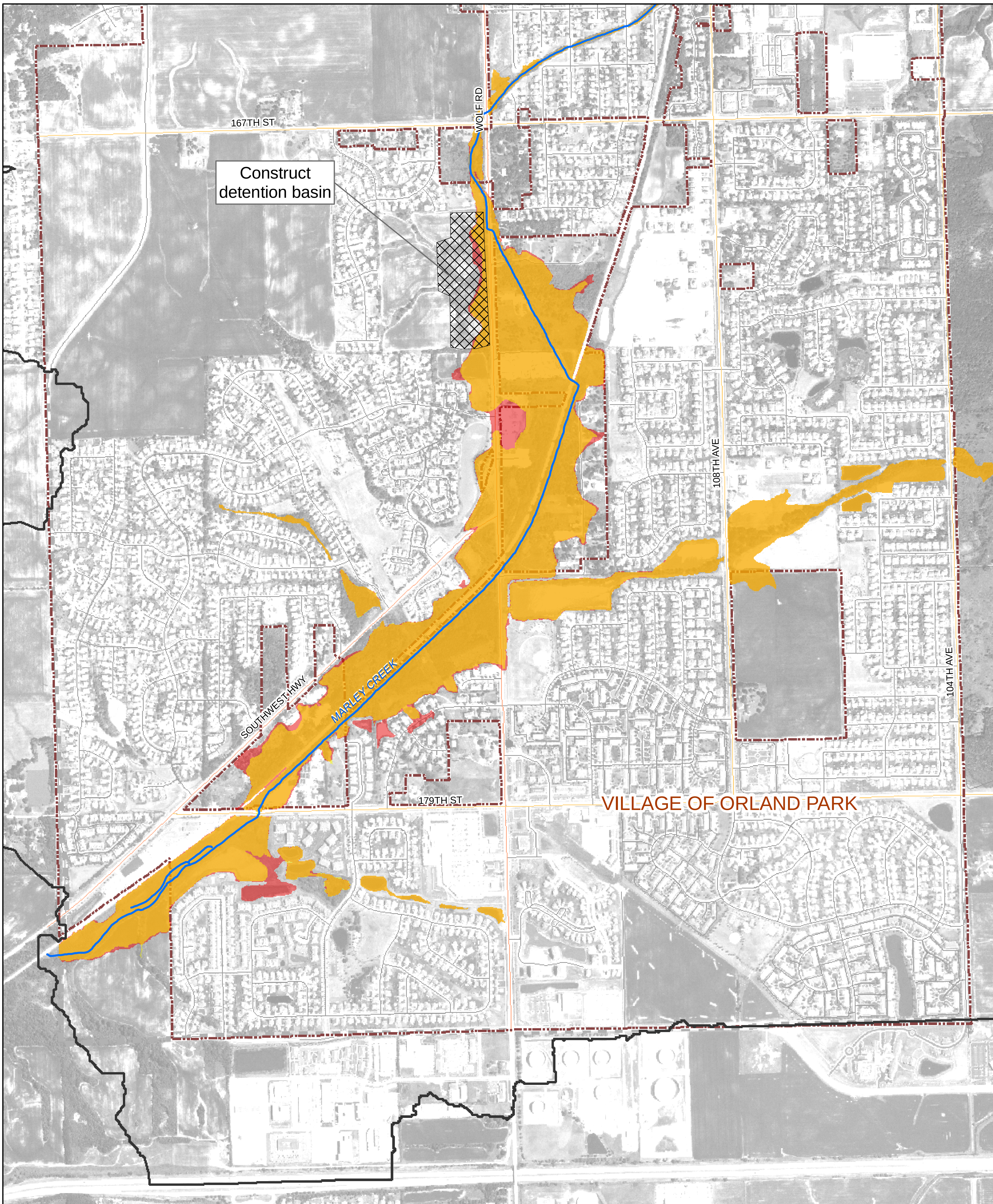


Figure 3.20.1
Tributary Overview: Marley Creek
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Marley Creek

Alternative: MACR-1

Alternative Description:

Costruct detention basin

Conceptual Level Cost: $ 15,985,700

Benefits: $ 160,100

B/C Ratio: 0.01

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

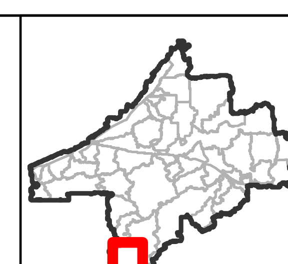
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 750 1,500

Feet

Figure 3.20.2
Marley Creek
Alternative MACR-1
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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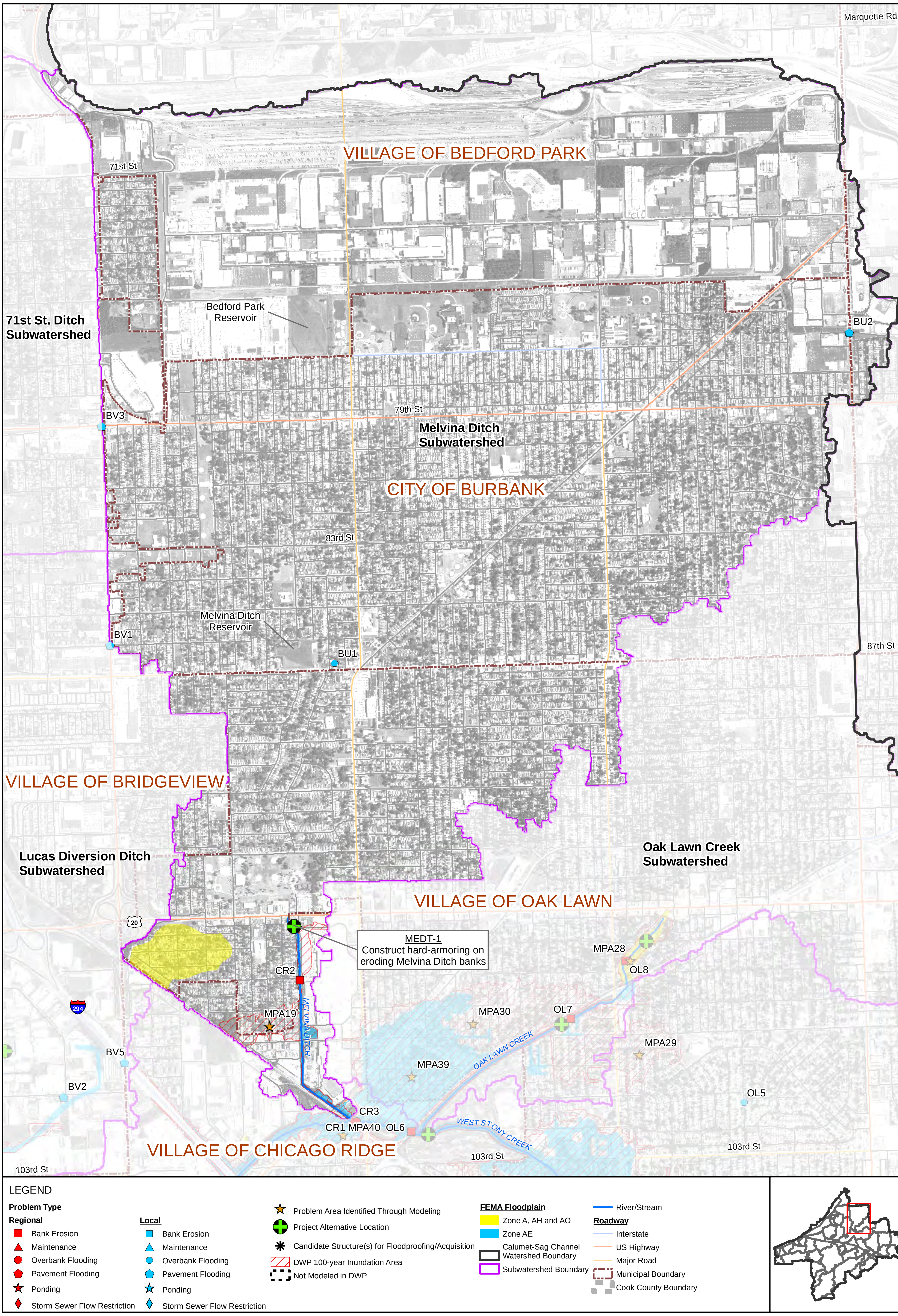
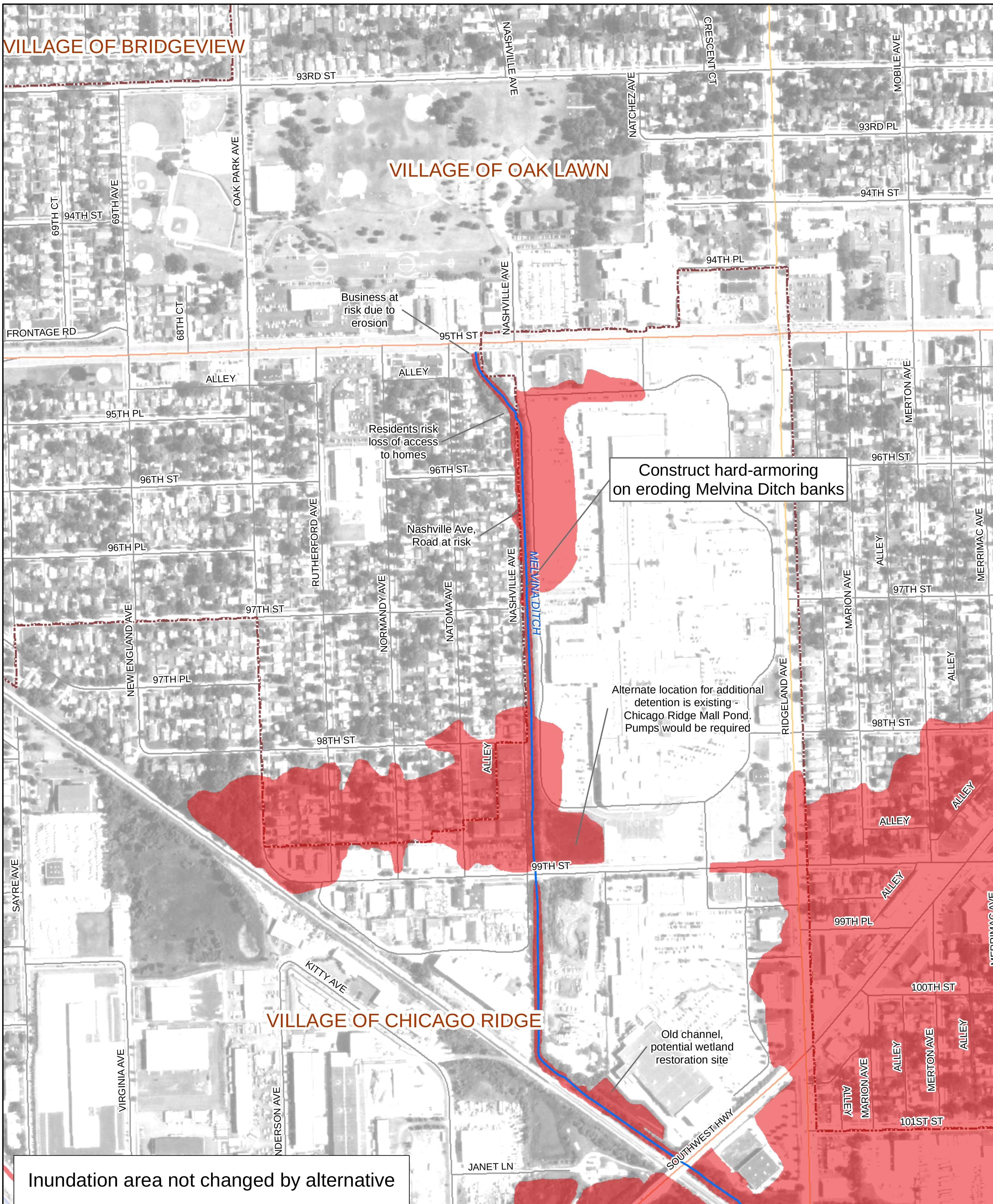


Figure 3.21.1
Tributary Overview: Melvina Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Melvina Ditch

Alternative: MEDT-1

Alternative Description:

Stabilize Melvina Ditch with hard-armoring of eroding streambanks

Conceptual Level Cost: $ 2,854,500

Benefits: $ 1,665,900

B/C Ratio: 0.58

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway
- Interstate
- US Highway
- Major Road
- Road

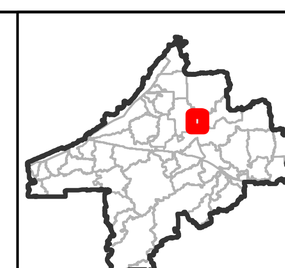
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 300 600

Feet

Figure 3.21.4
Melvina Ditch
Alternative MEDT-1
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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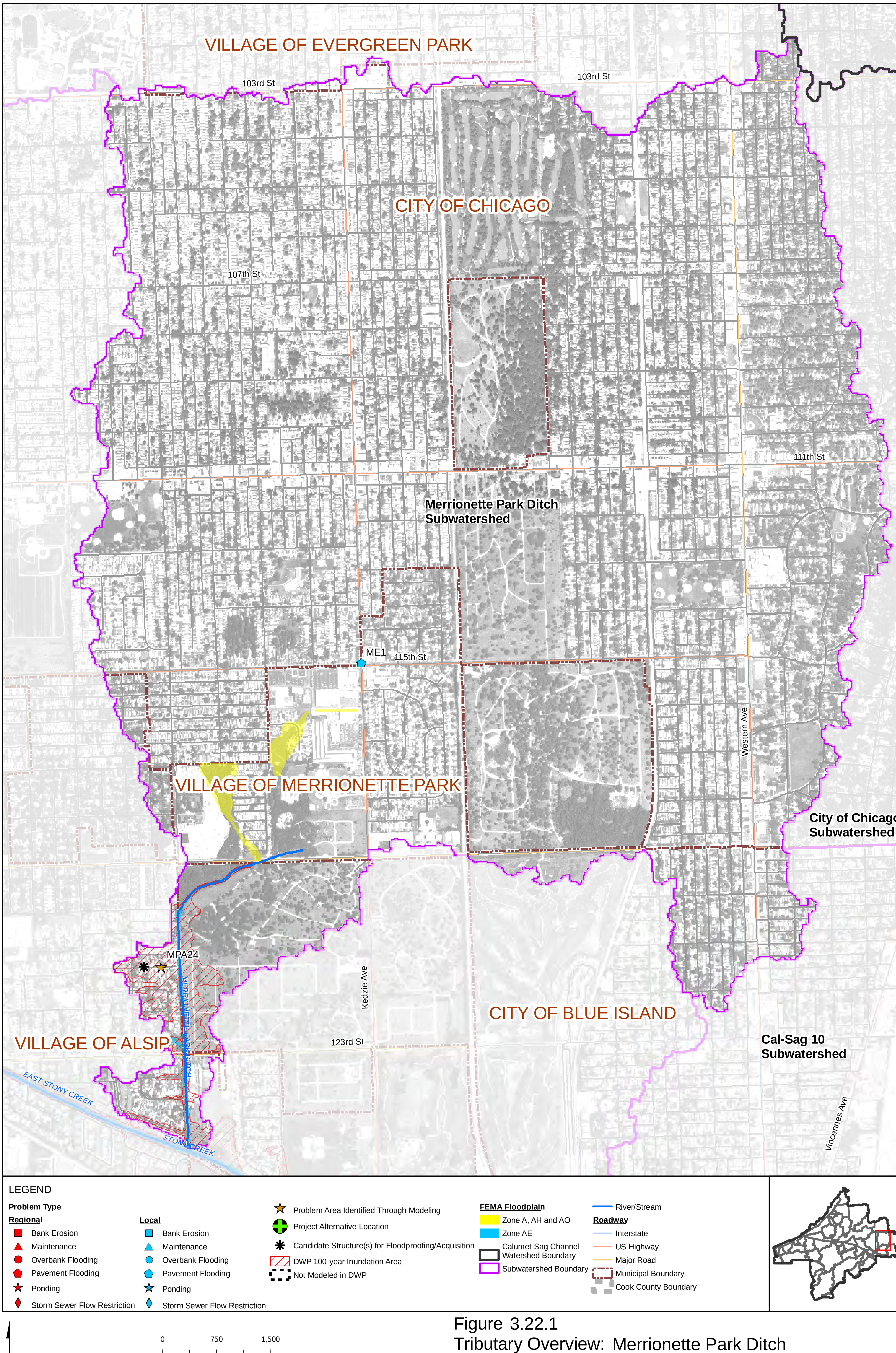


Figure 3.22.1
Tributary Overview: Merrionette Park Ditch
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

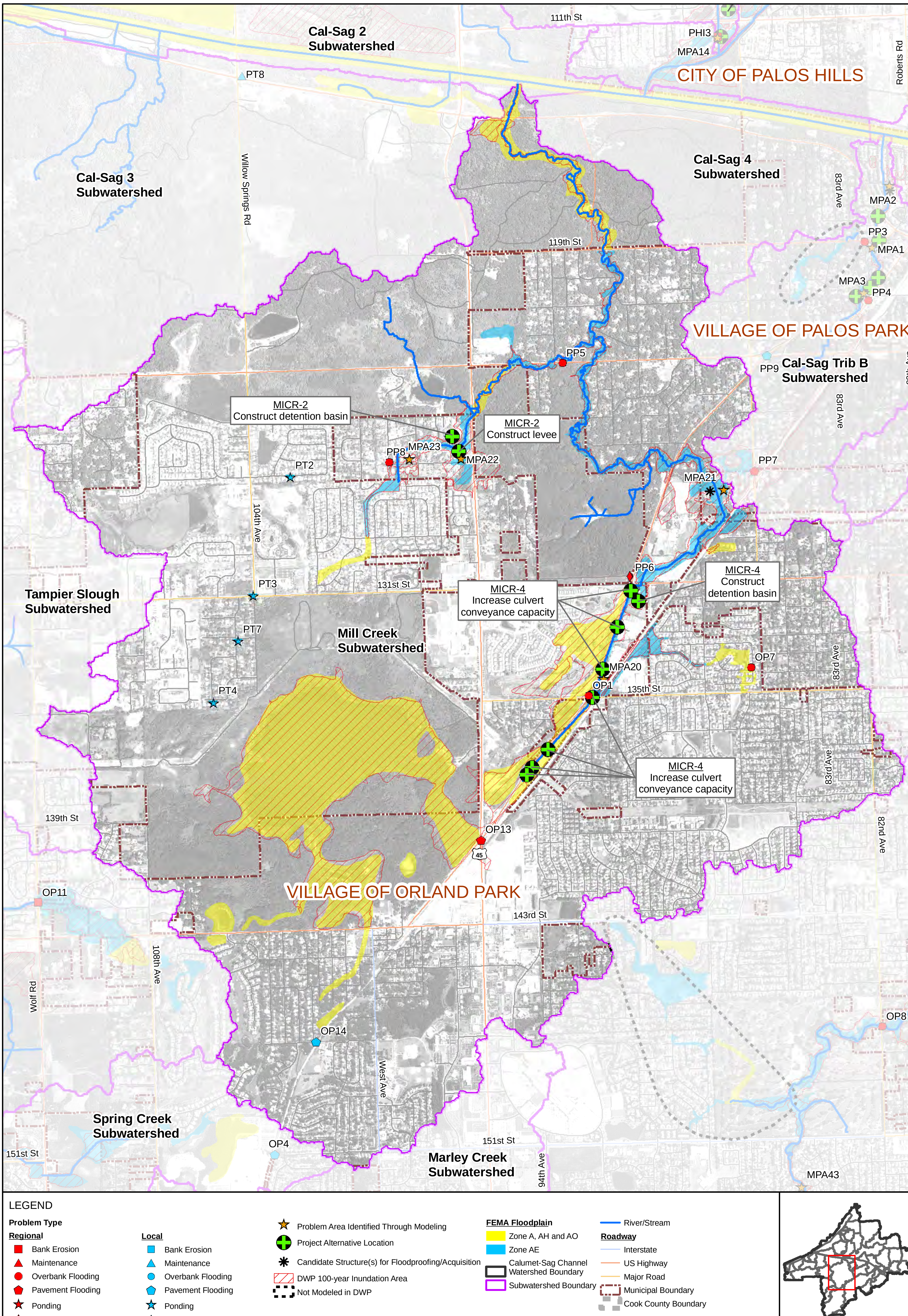
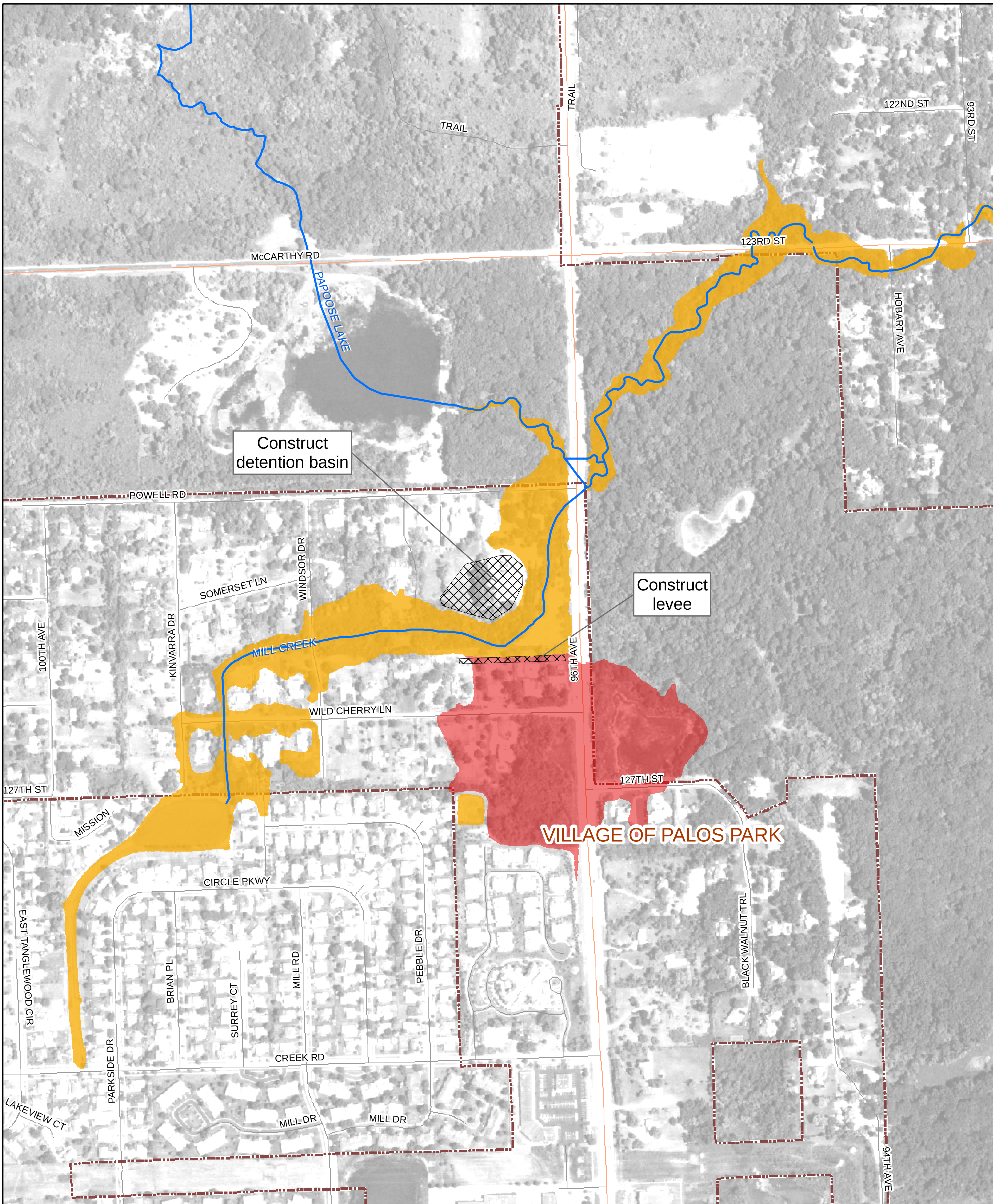


Figure 3.23.1
Tributary Overview: Mill Creek
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Mill Creek

Alternative: MICR-2

Alternative Description:

Construct levee and compensatory storage

Conceptual Level Cost: $ 2,003,400

Benefits: $ 409,600

B/C Ratio: 0.2

LEGEND

Project Alternative Location
100-year Inundation Area With Project
100-year Inundation Area Without Project
Calumet-Sag Channel Watershed Boundary

Roadway

Interstate
US Highway
Major Road
Road

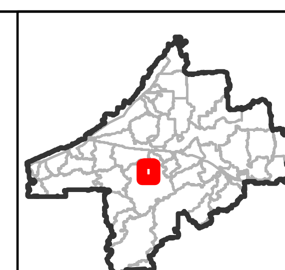
River/Stream
Municipal Boundary
Cook County Boundary

0 300 600

Feet

N

Figure 3.23.2
Mill Creek
Alternative MICR-2
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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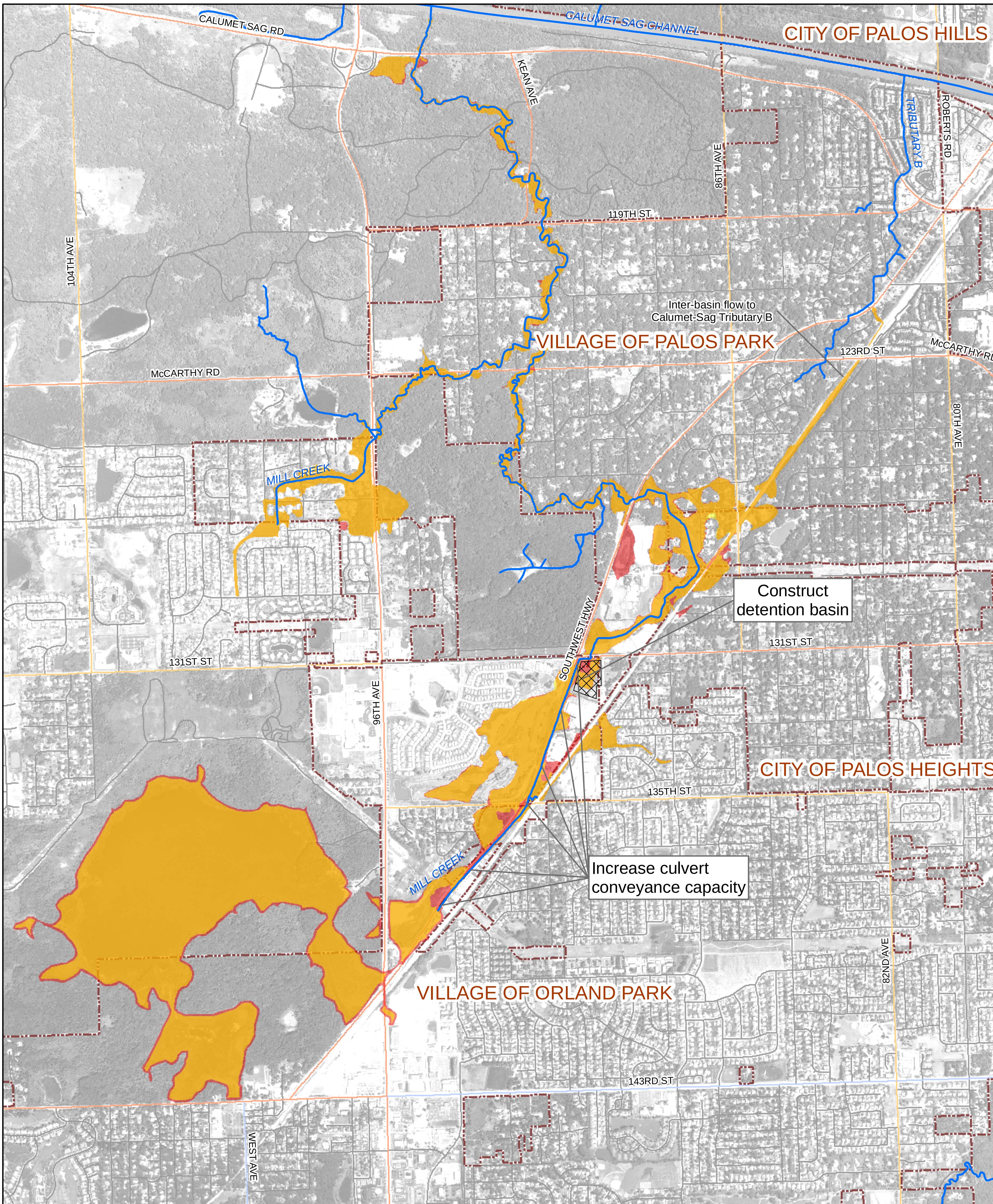


Subwatershed: Mill Creek

Alternative: MICR-4

Alternative Description:

Increase conveyance capacity of seven culverts and construct detention basin

Conceptual Level Cost: $ 5,918,100

Benefits: $ 459,000

B/C Ratio: 0.1

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

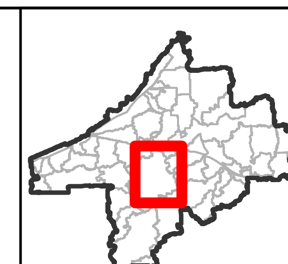
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 1,100 2,200

Feet

N

Figure 3.23.3
Mill Creek
Alternative MICR-4
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



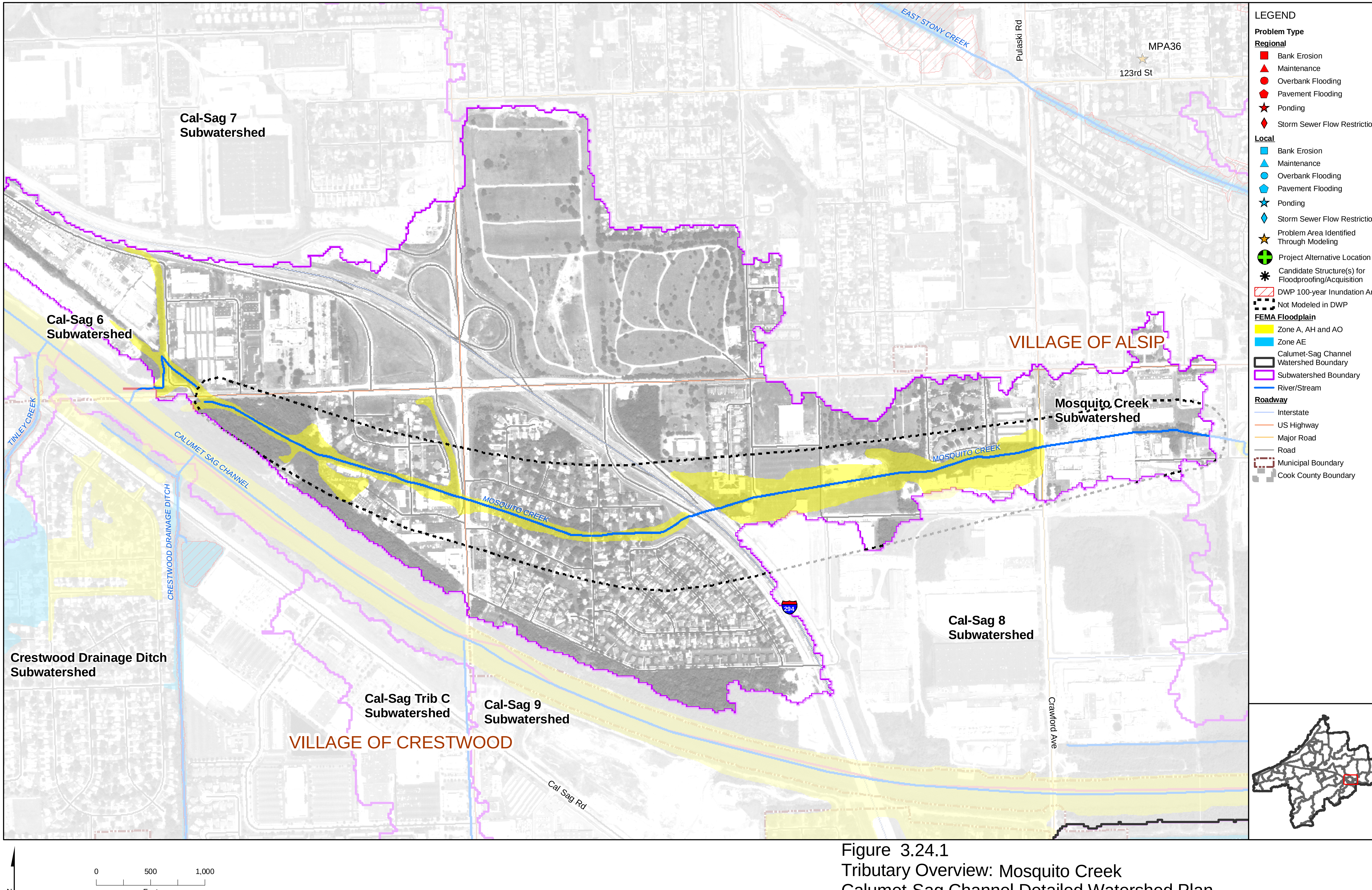


Figure 3.24.1
Tributary Overview: Mosquito Creek
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

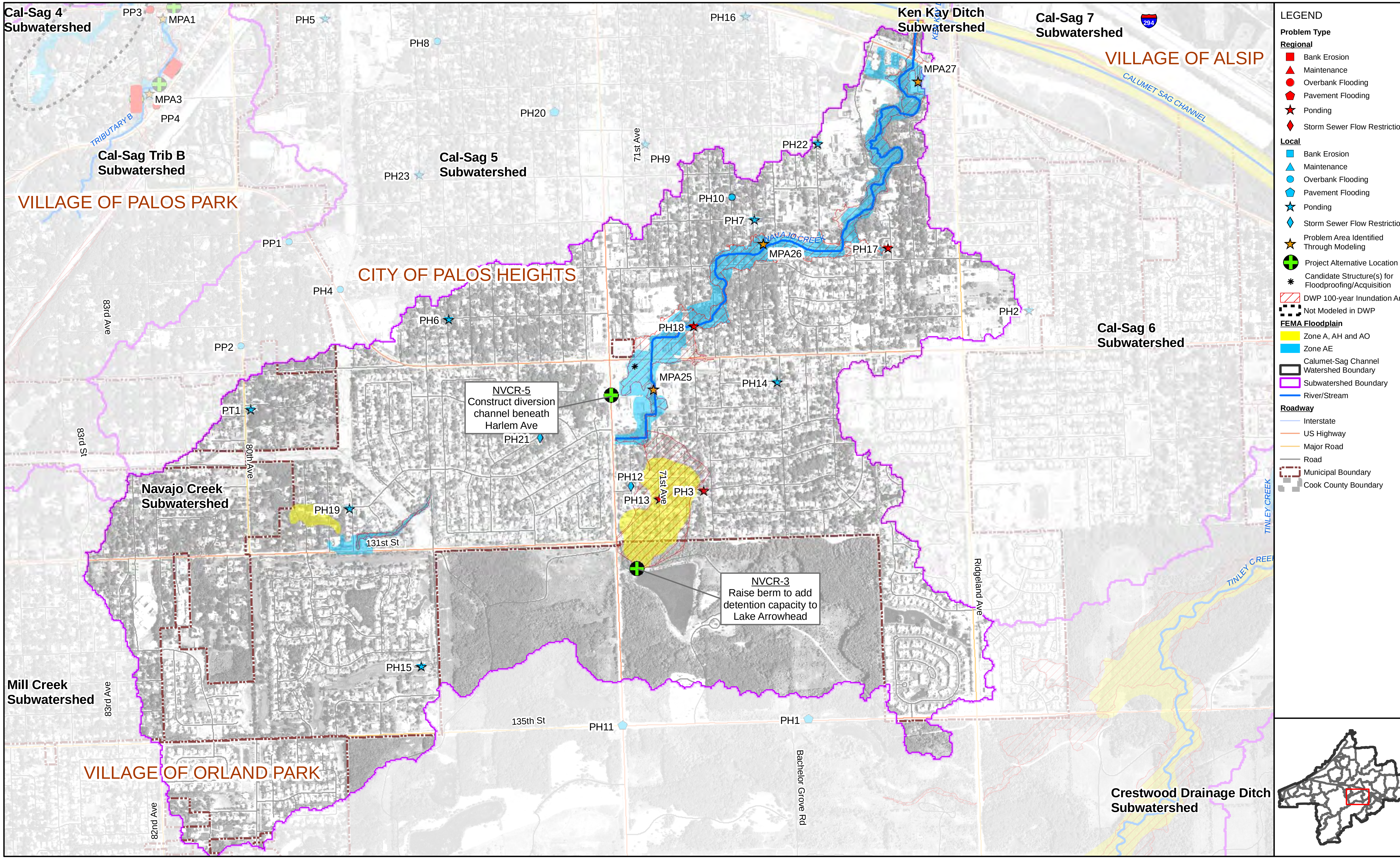
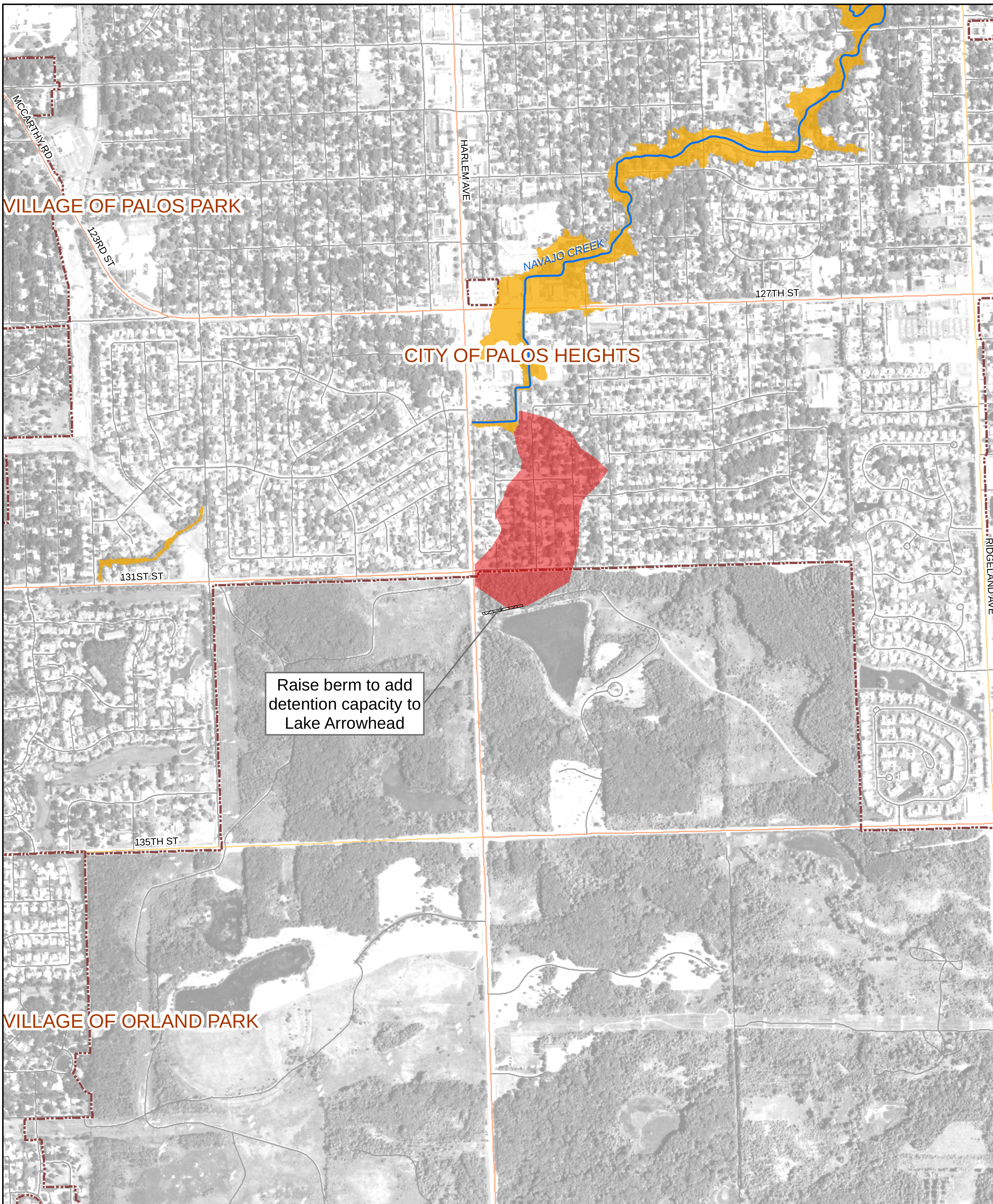


Figure 3.25.1
Tributary Overview: Navajo Creek
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Navajo Creek

Alternative: NVCR-3

Alternative Description:

Raise Lake Arrowhead berm three feet to provide one-foot of additional storage and two feet of freeboard

Conceptual Level Cost: $ 143,900

Benefits: $ 98,700

B/C Ratio: 0.69

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

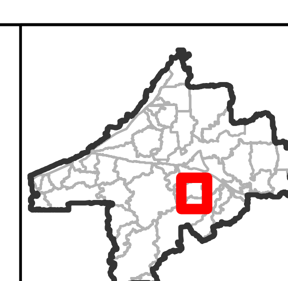
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 600 1,200

Feet

Figure 3.25.2
Navajo Creek
Alternative NVCR-3
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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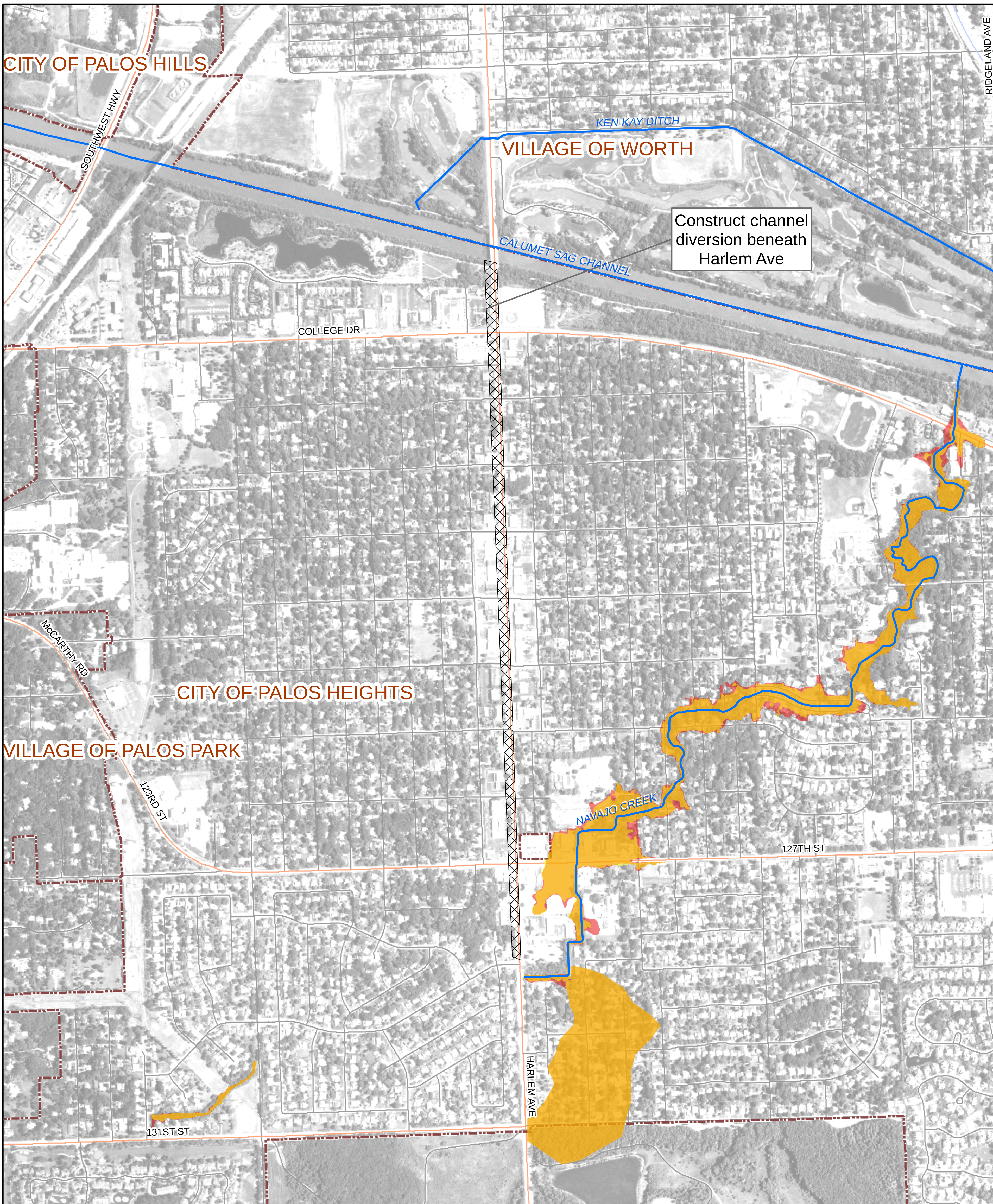


Subwatershed: Navajo Creek

Alternative: NVCR-5

Alternative Description:

Construct channel diversion beneath Harlem Ave

Conceptual Level Cost: $ 7,903,100

Benefits: $ 1,148,300

B/C Ratio: 0.2

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

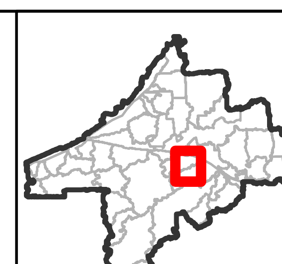
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 600 1,200

Feet

Figure 3.25.3
Navajo Creek
Alternative NVCR-5
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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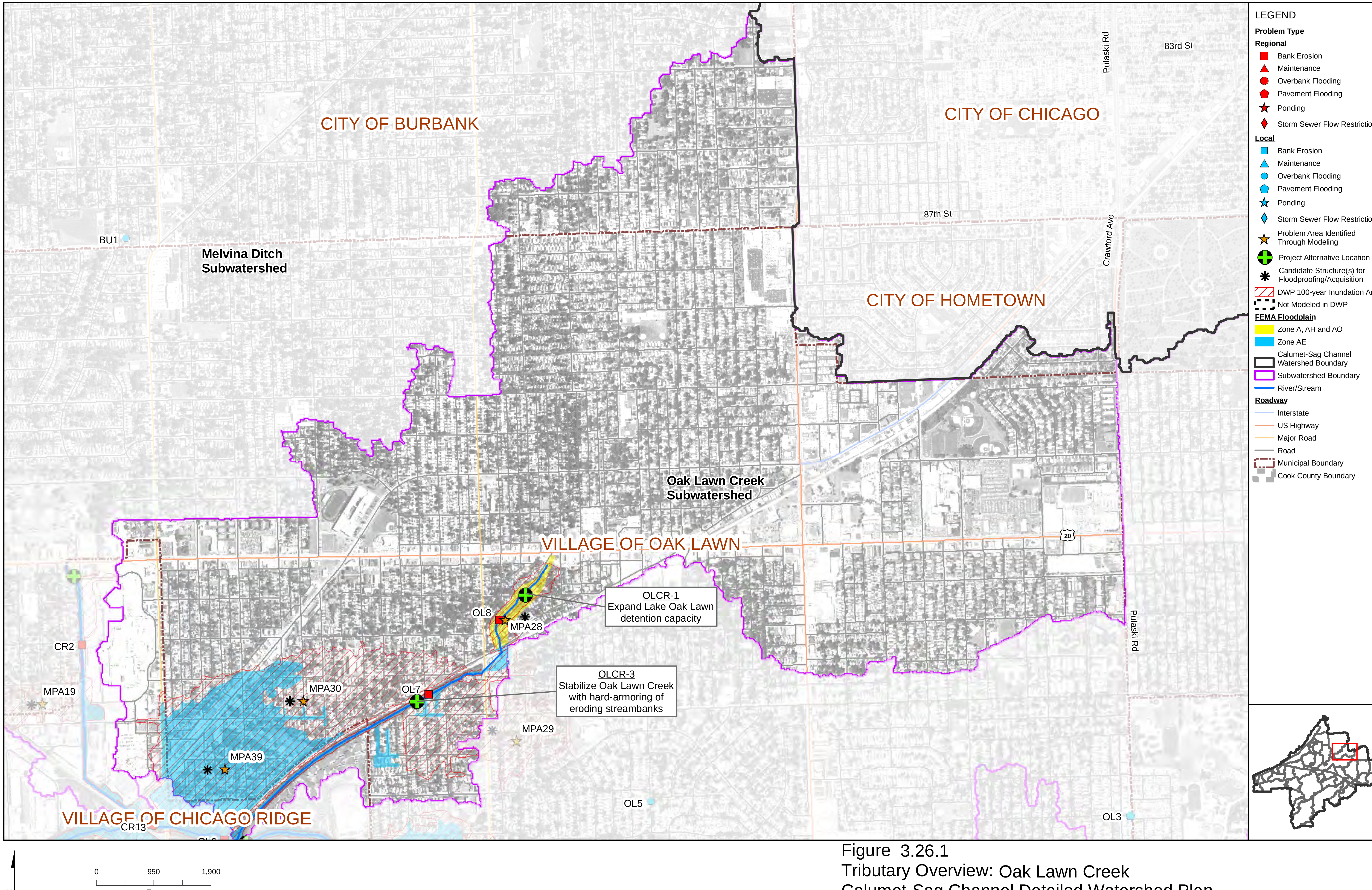
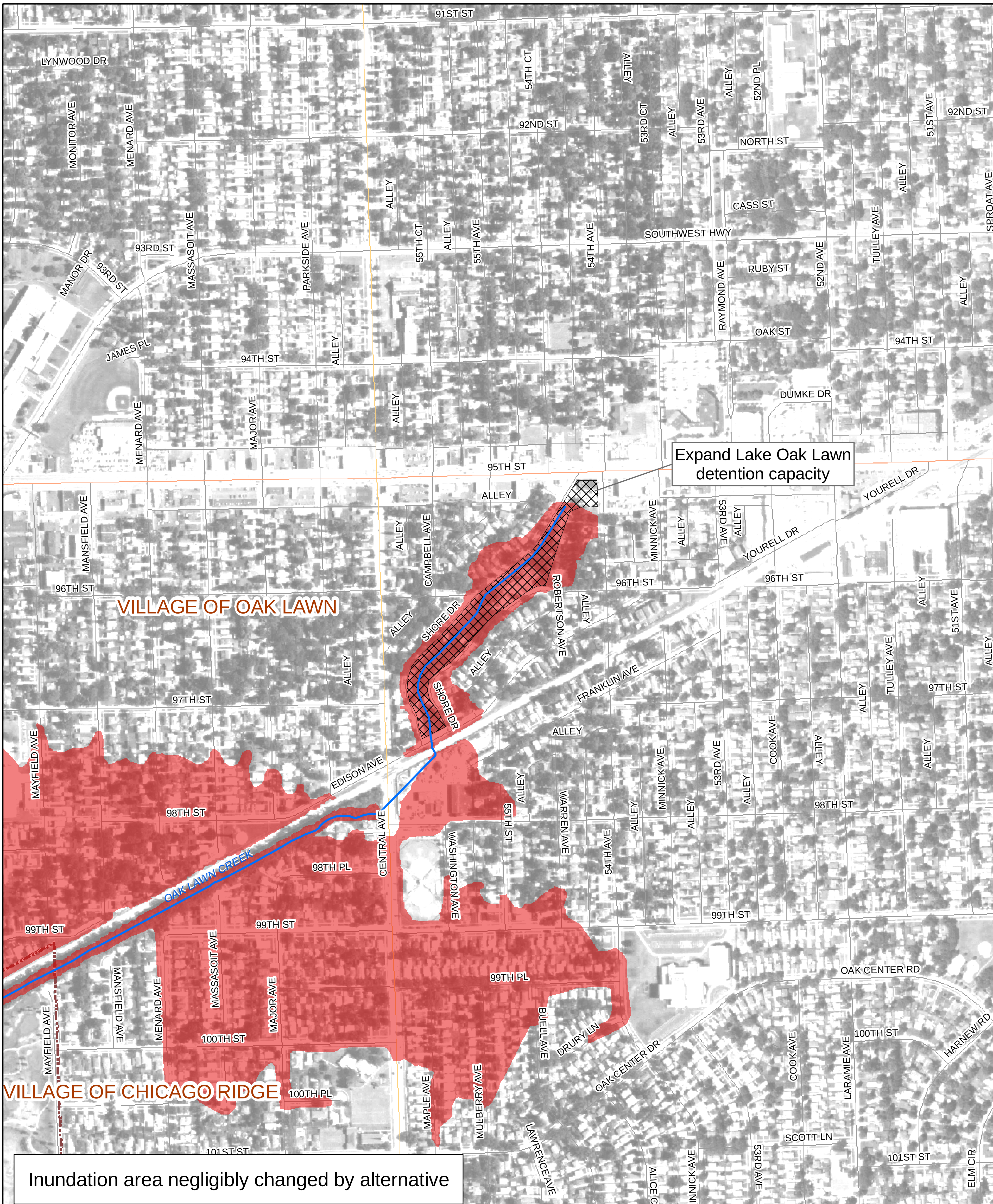


Figure 3.26.1
Tributary Overview: Oak Lawn Creek
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Stony Creek/Oak Lawn Creek

Alternative: OLCR-1

Alternative Description:

Expand Lake Oak Lawn detention capacity

Conceptual Level Cost: $ 6,306,100

Benefits: $ 450,000

B/C Ratio: 0.07

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

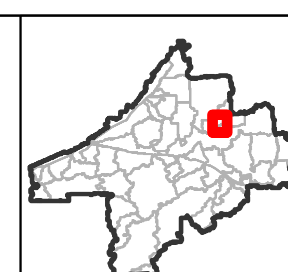
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 350 700

Feet

Figure 3.26.2
Stony Creek/Oak Lawn Creek
Alternative OLCR-1
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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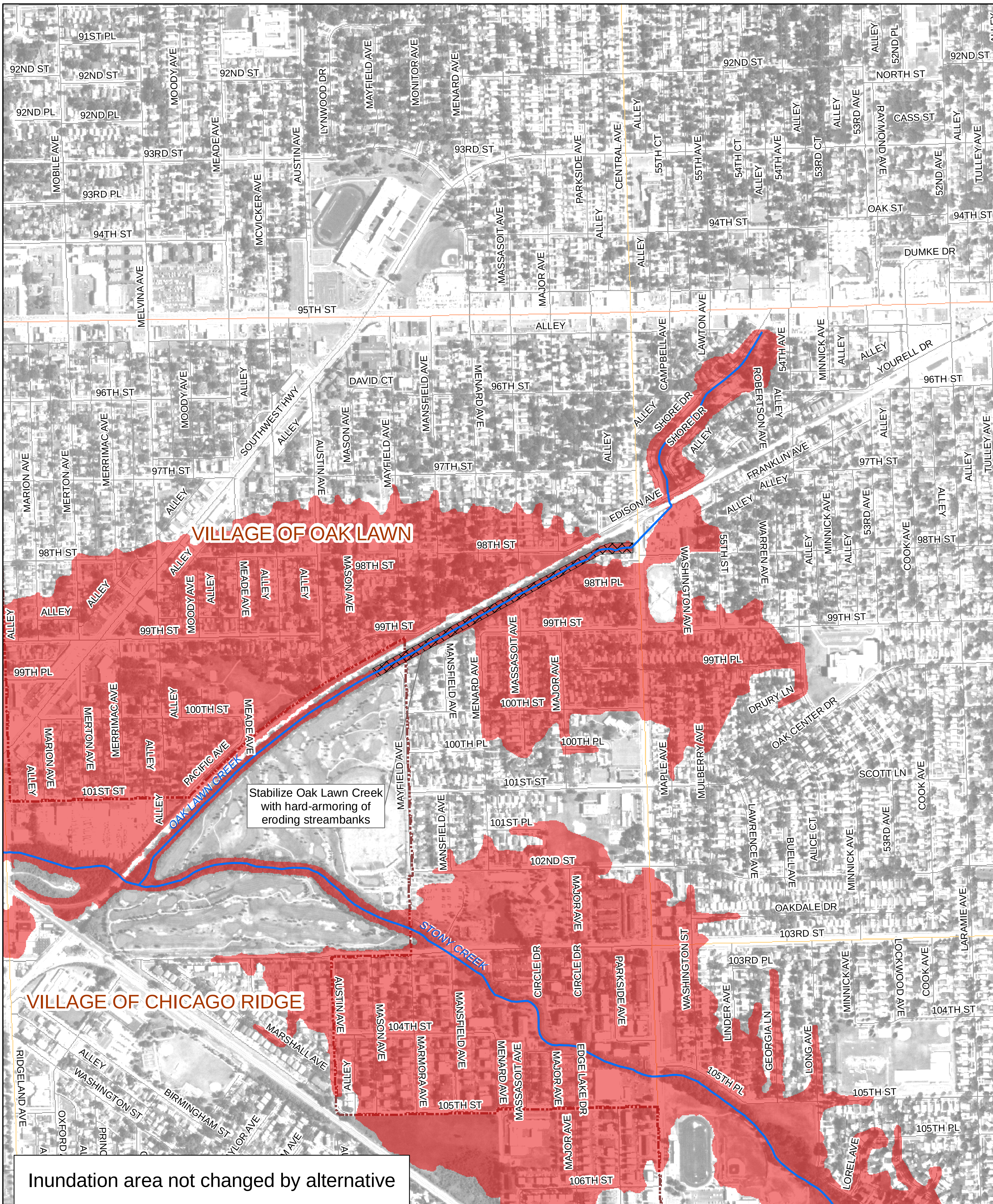


Subwatershed: Stony Creek/Oak Lawn Creek

Alternative: OLCR-3

Alternative Description:

Stabilize Oak Lawn Creek with hard-armoring of eroding streambanks

Conceptual Level Cost: $ 7,299,200

Benefits: $ 3,081,000

B/C Ratio: 0.42

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

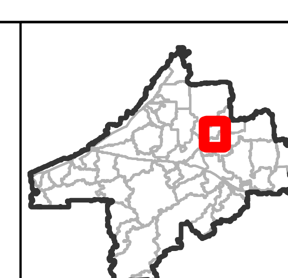
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 500 1,000

Feet

Figure 3.26.3
Stony Creek/Oak Lawn Creek
Alternative OLCR-3
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



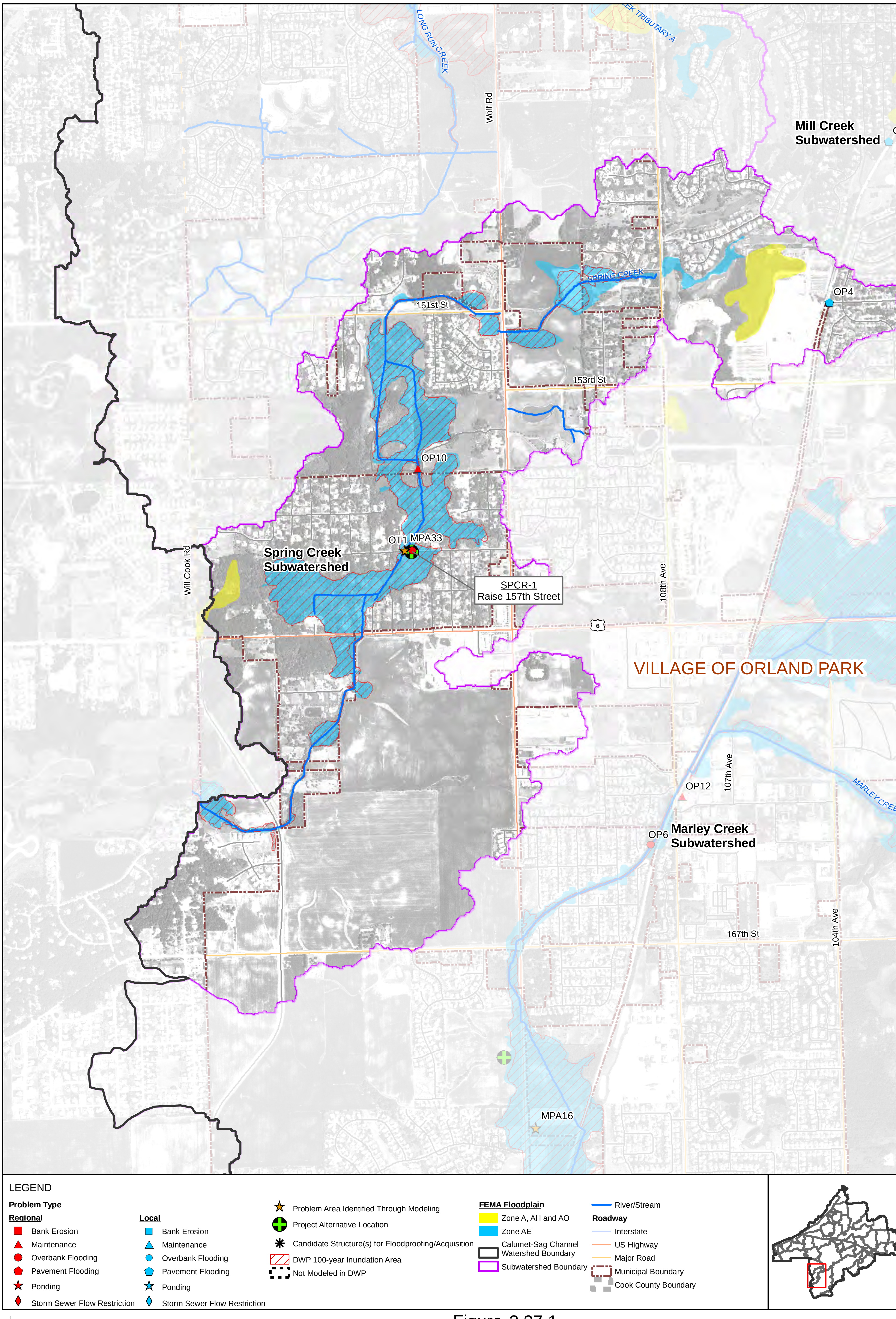
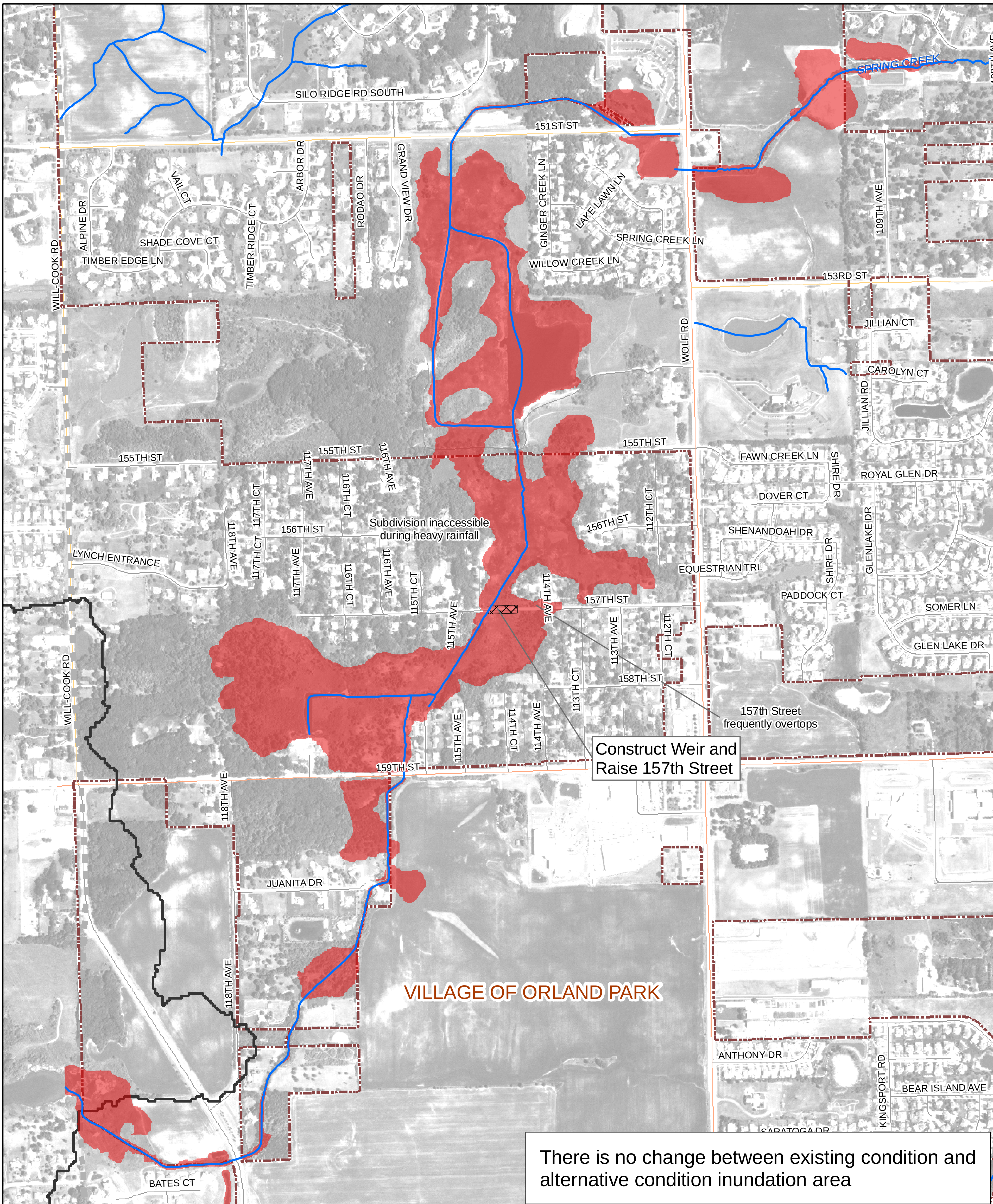


Figure 3.27.1
Tributary Overview: Spring Creek
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Spring Creek

Alternative: SPCR-1

Alternative Description:

Raise 157th street and construct weir to maintain existing flow conditions

Conceptual Level Cost: $ 1,053,800 Benefits: $ 24,100

B/C Ratio: 0.02

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

- River/Stream
- Municipal Boundary
- Cook County Boundary

0 350 700

Feet

Figure 3.27.2
Spring Creek
Alternative SPCR-1
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

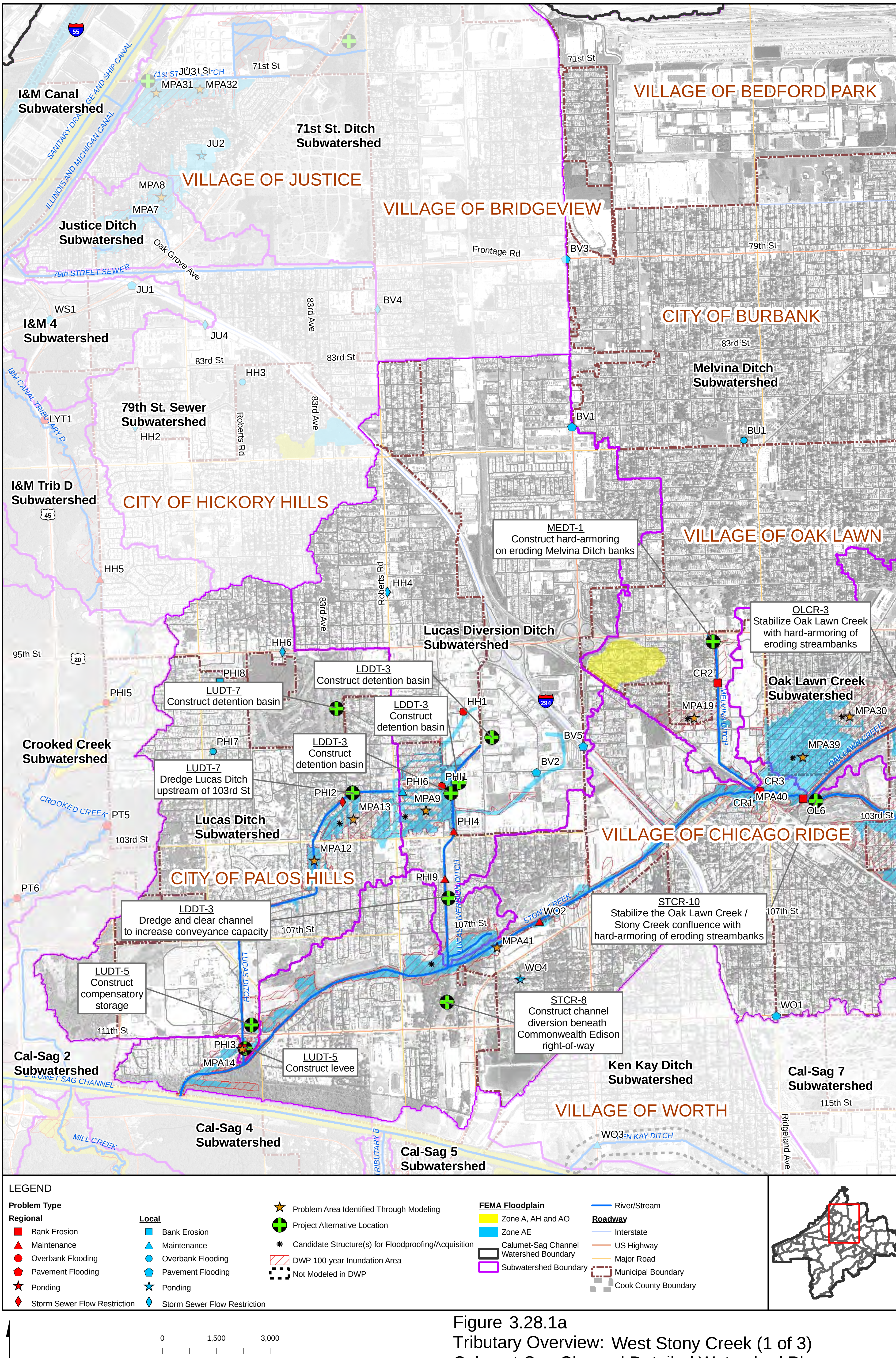


Figure 3.28.1a
Tributary Overview: West Stony Creek (1 of 3)
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

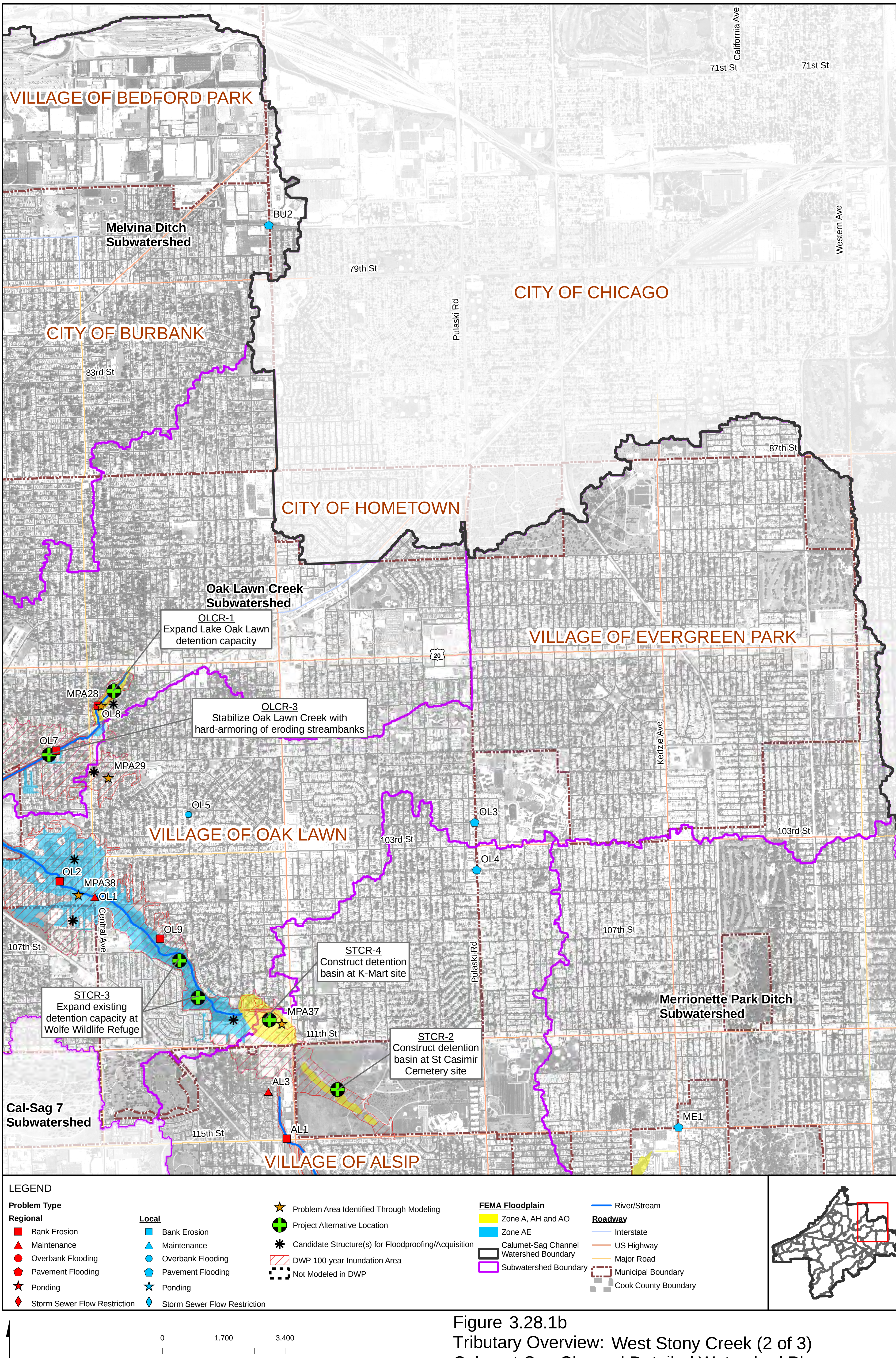


Figure 3.28.1b
Tributary Overview: West Stony Creek (2 of 3)
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

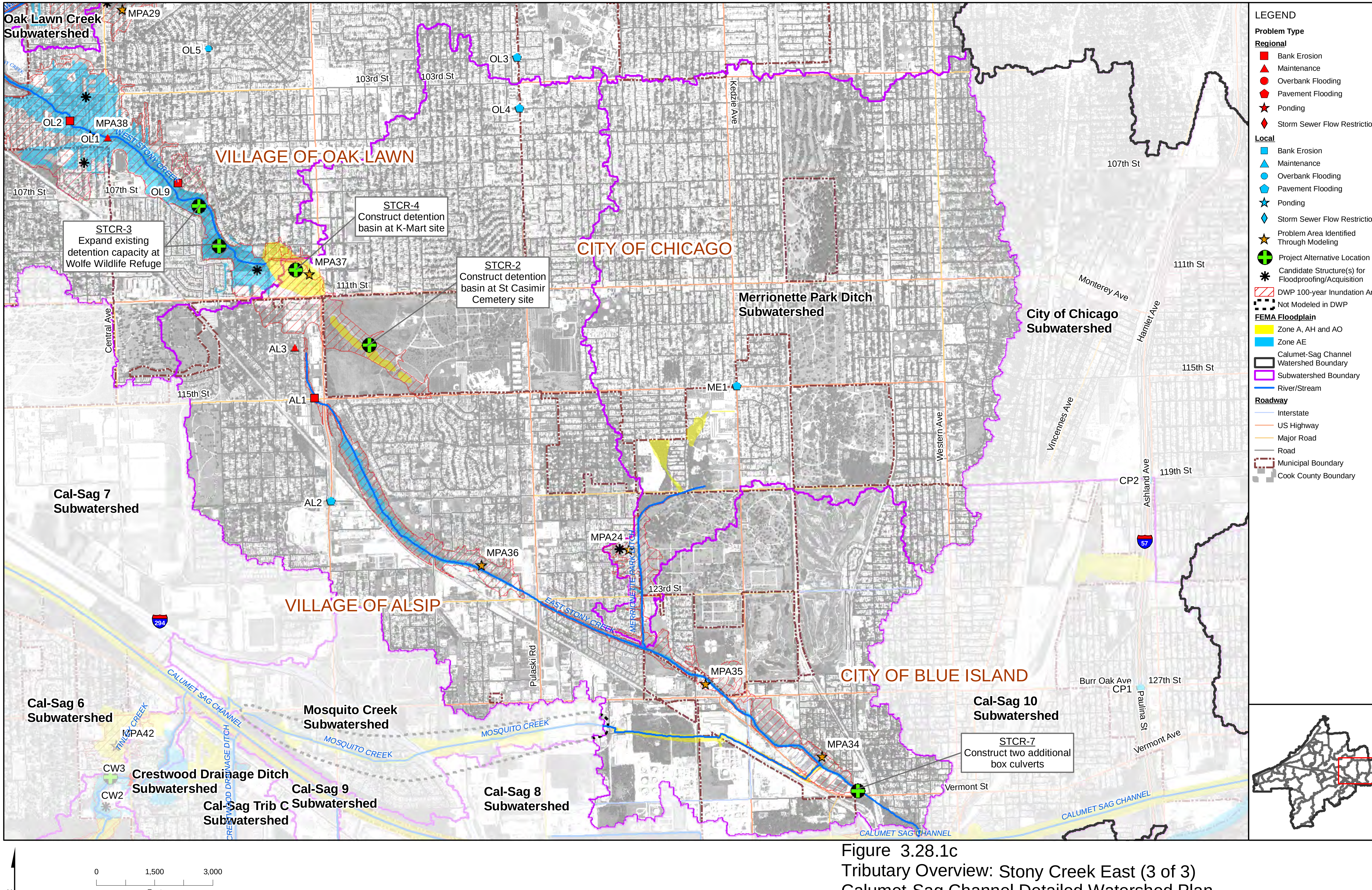
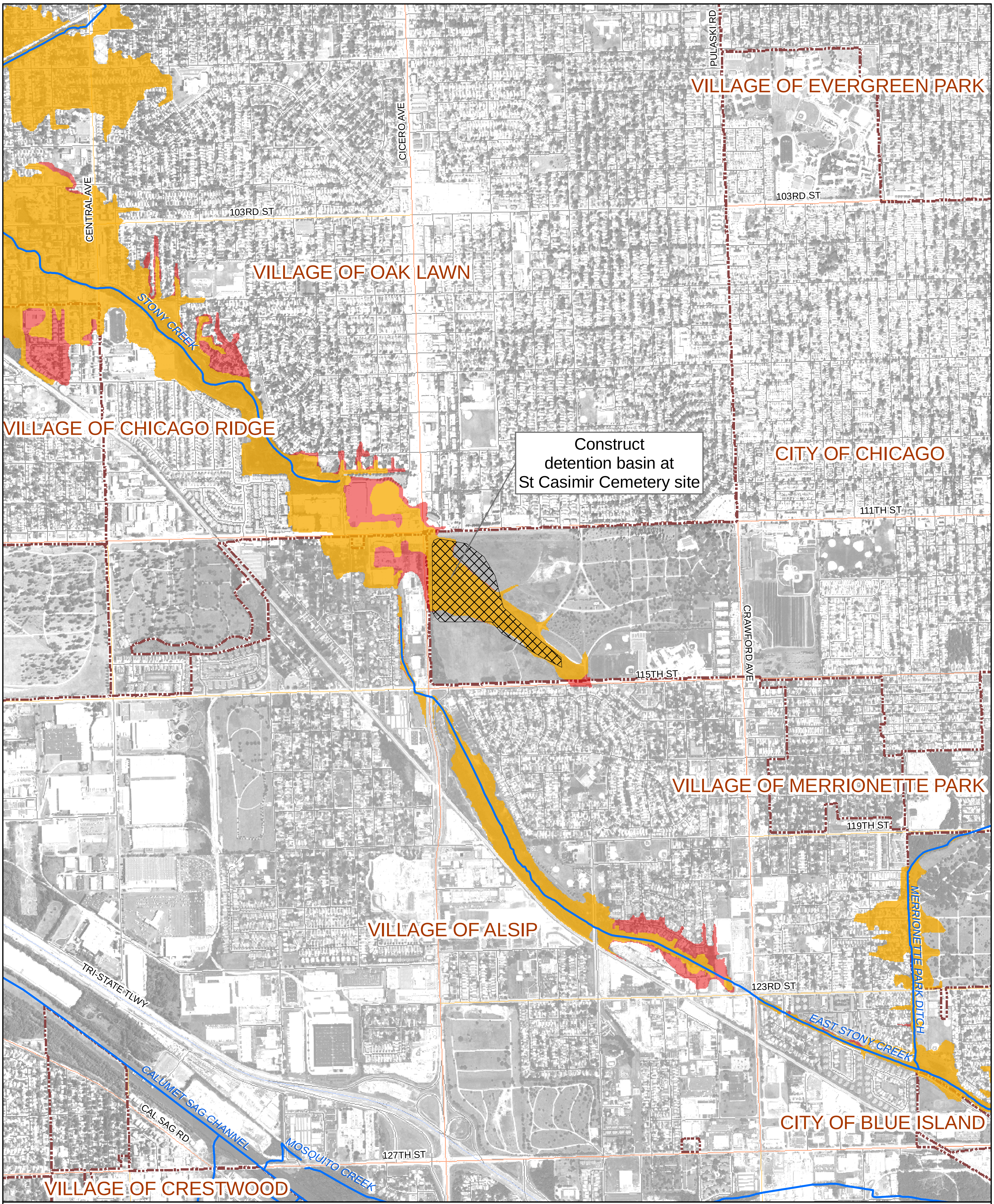


Figure 3.28.1c
Tributary Overview: Stony Creek East (3 of 3)
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Stony Creek

Alternative: STCR-2

Alternative Description:

Construct detention basin on undeveloped St Casimir Cemetery property

Conceptual Level Cost: $ 48,496,800

Benefits: $ 12,203,700

B/C Ratio: 0.25

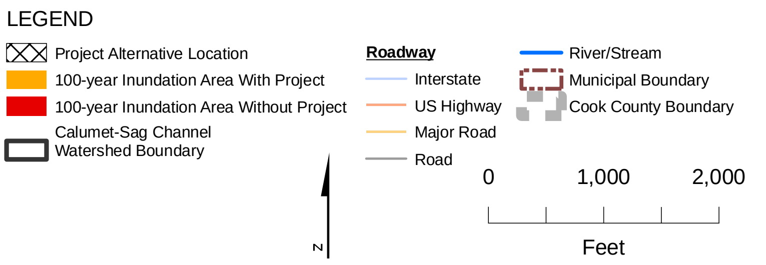
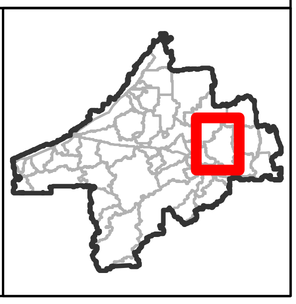


Figure 3.28.2
Stony Creek
Alternative STCR-2
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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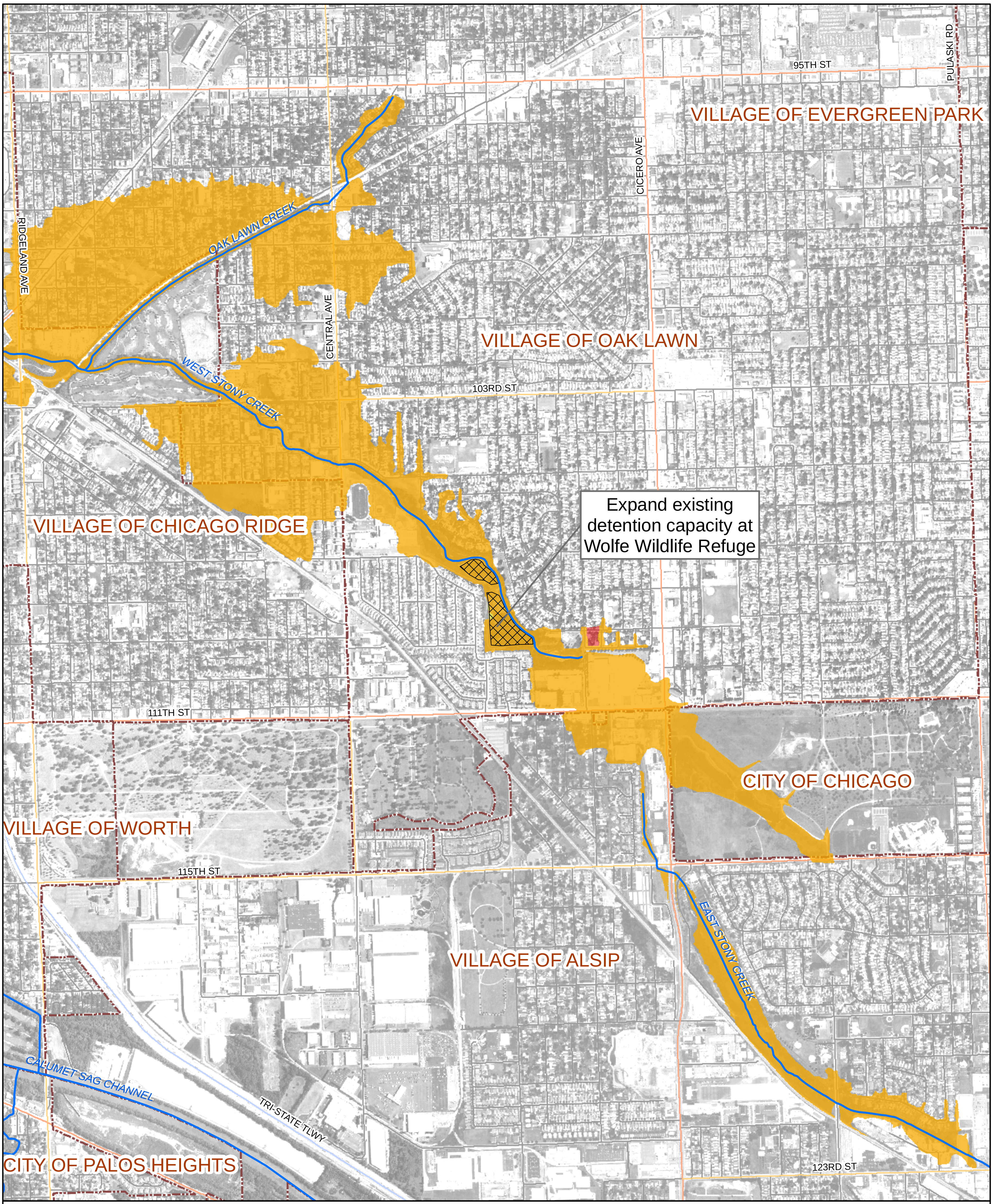


Subwatershed: Stony Creek

Alternative: STCR-3

Alternative Description:

Expand Wolfe Wildlife Refuge detention capacity

Conceptual Level Cost: $ 7,691,000

Benefits: $ 735,100

B/C Ratio: 0.1

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

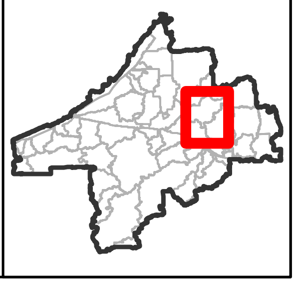
Roadway
- Interstate
- US Highway
- Major Road
- Road

- River/Stream
- Municipal Boundary
- Cook County Boundary

0 1,000 2,000 Feet

N

Figure 3.28.3
Stony Creek
Alternative STCR-3
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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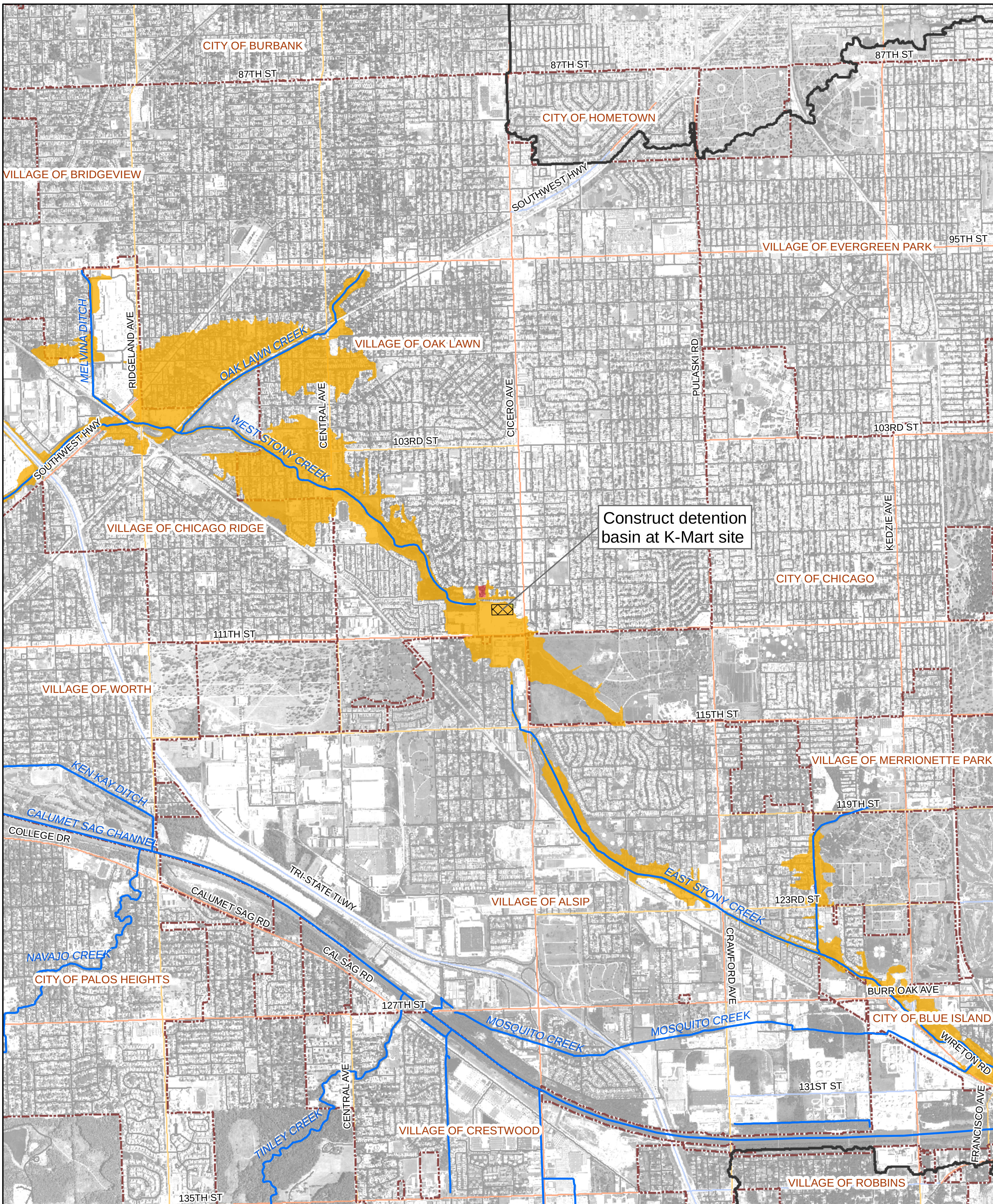


Subwatershed: Stony Creek

Alternative: STCR-4

Alternative Description:

Construct detention basin on a portion of K-Mart parking lot site

Conceptual Level Cost: $ 4,327,300

Benefits: $ 206,600

B/C Ratio: 0.05

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

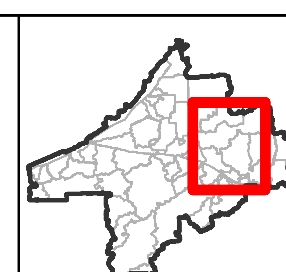
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 1,700 3,400

Feet

Figure 3.28.4
Stony Creek
Alternative STCR-4
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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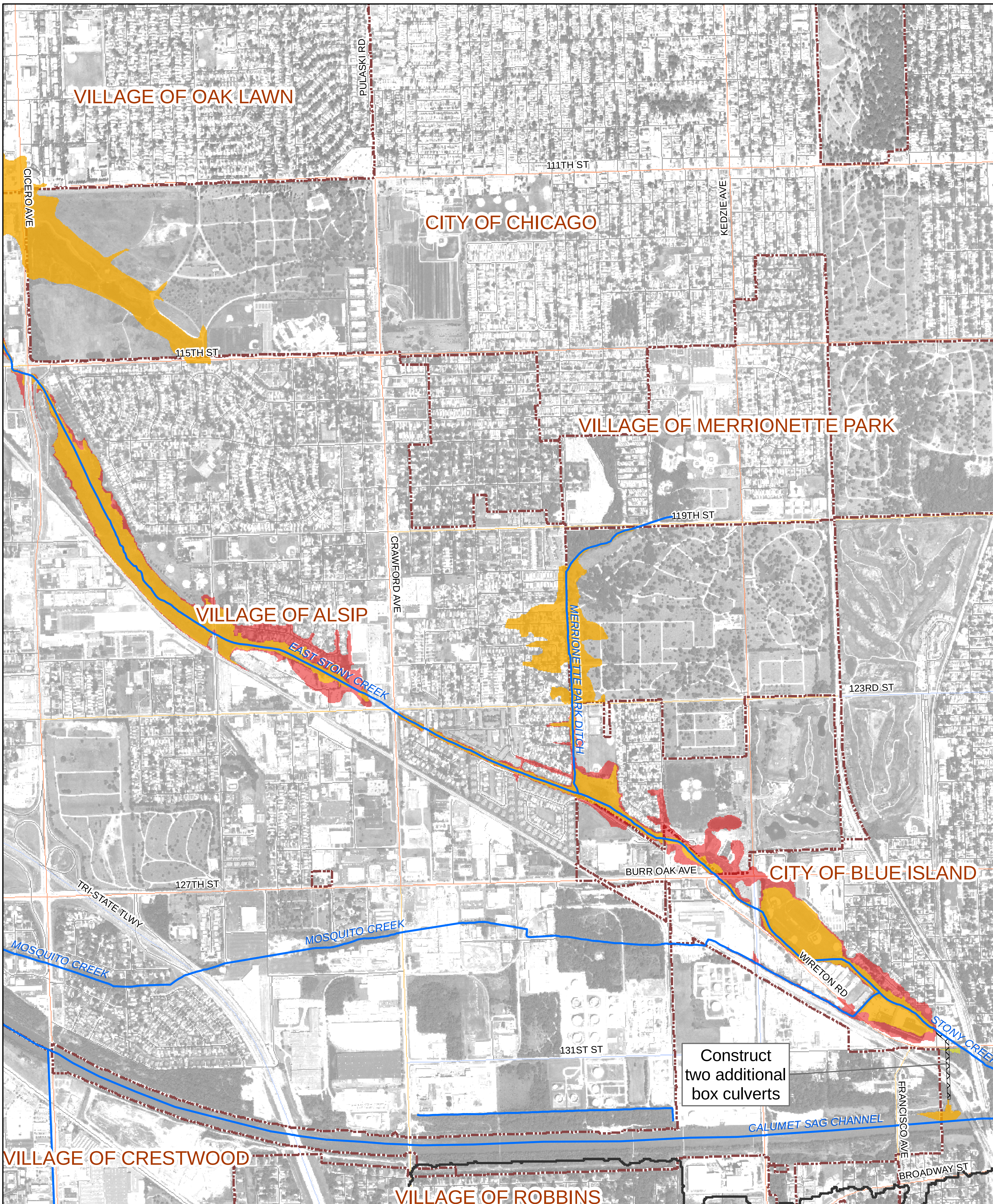


Subwatershed: Stony Creek

Alternative: STCR-7

Alternative Description:

Increase California Ave culvert conveyance capacity

Conceptual Level Cost: $ 3,428,900

Benefits: $ 364,200

B/C Ratio: 0.11

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 800 1,600

Feet

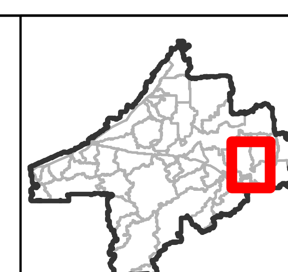
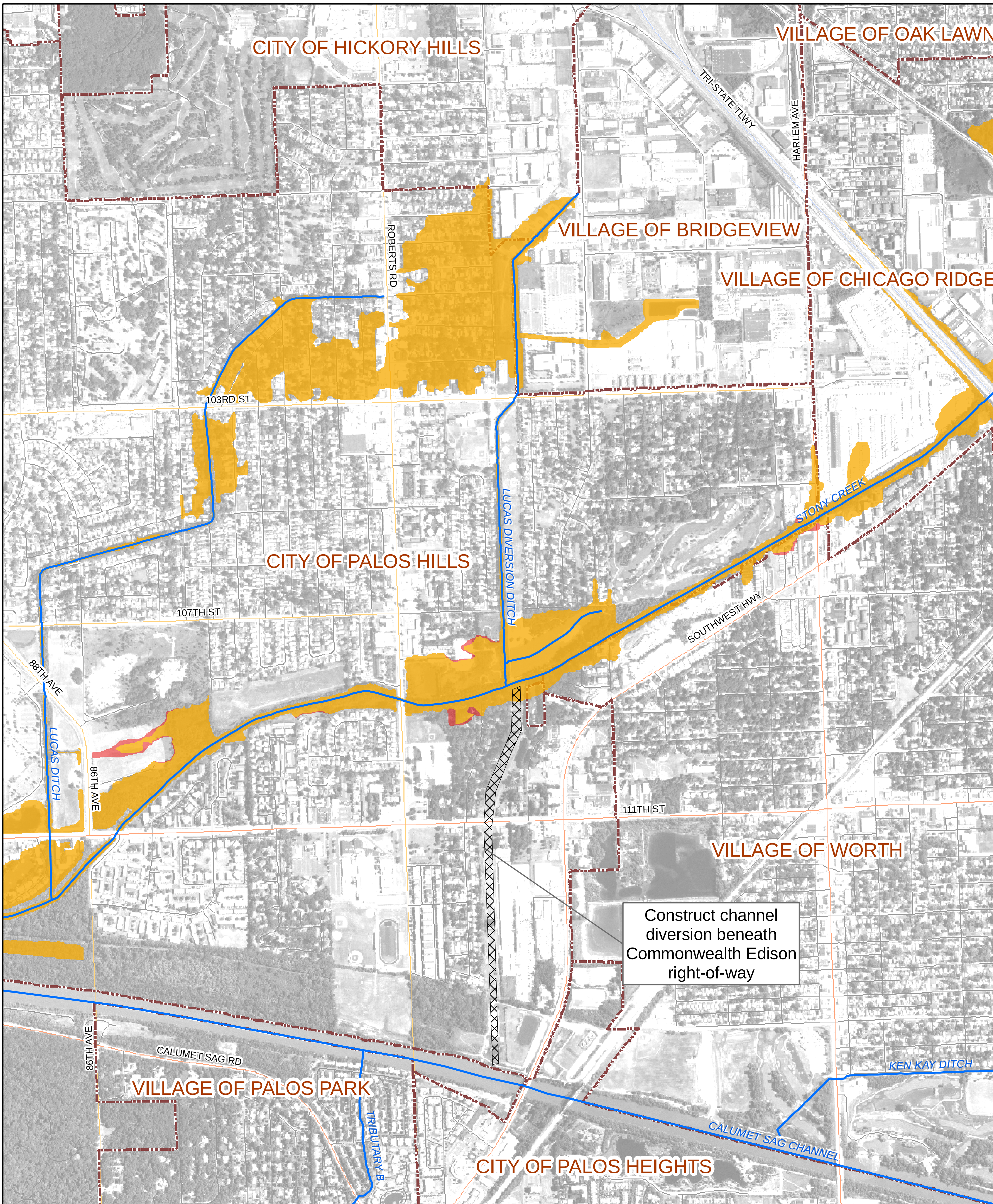


Figure 3.28.5
Stony Creek
Alternative STCR-7
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Stony Creek

Alternative: STCR-8

Alternative Description:

Construct channel diversion beneath Commonwealth Edison right-of-way

Conceptual Level Cost: $ 6,286,400

Benefits: $ 1,146,600

B/C Ratio: 0.18

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

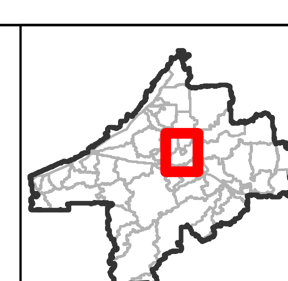
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 660 1,320

Feet

Figure 3.28.6
Stony Creek
Alternative STCR-8
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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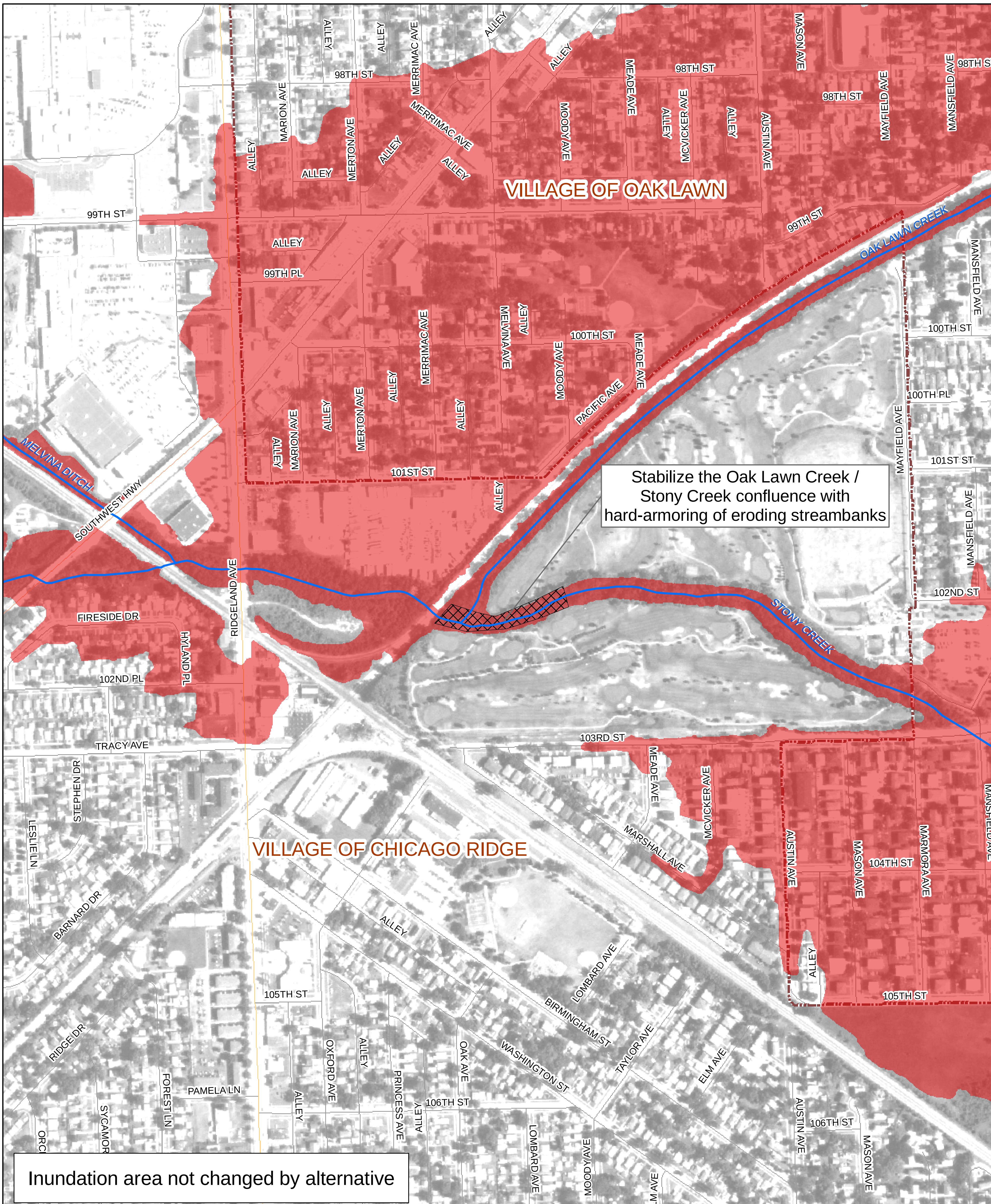


Subwatershed: Stony Creek/Oak Lawn Creek

Alternative: STCR-10

Alternative Description:

Stabilize the Oak Lawn Creek / Stony Creek confluence with hard-armoring of eroding streambanks

Conceptual Level Cost: $ 2,754,800

Benefits: $ 0

B/C Ratio: 0

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

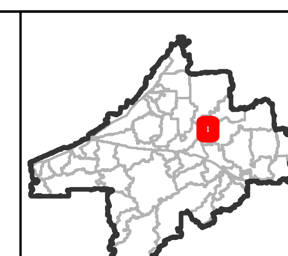
Roadway

- Interstate
- US Highway
- Major Road
- Road
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 225 450

Feet

Figure 3.28.7
Stony Creek/Oak Lawn Creek
Alternative STCR-10
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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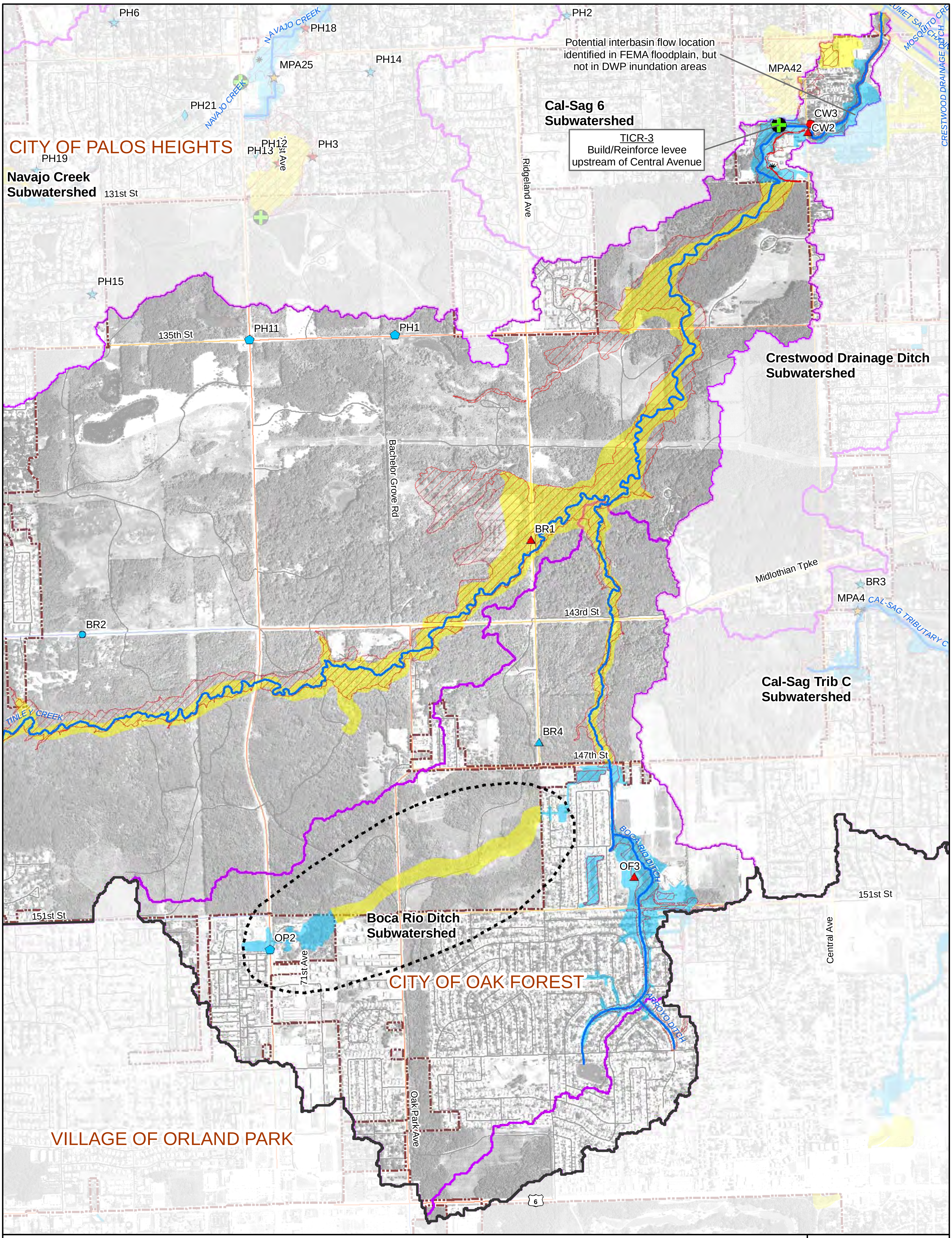


LEGEND

Problem Type

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

Problem Area Identified Through Modeling
Project Alternative Location
Candidate Structure(s) for Floodproofing/Acquisition
DWP 100-year Inundation Area
Not Modeled in DWP

FEMA Floodplain
Zone A, AH and AO
Zone AE
Calumet-Sag Channel Watershed Boundary
Subwatershed Boundary

River/Stream

Roadway
Interstate
US Highway
Major Road
Municipal Boundary
Cook County Boundary

0 1,000 2,000
Feet

N

Figure 3.29.1a
Tributary Overview: Tinley Creek (1 of 2)
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL

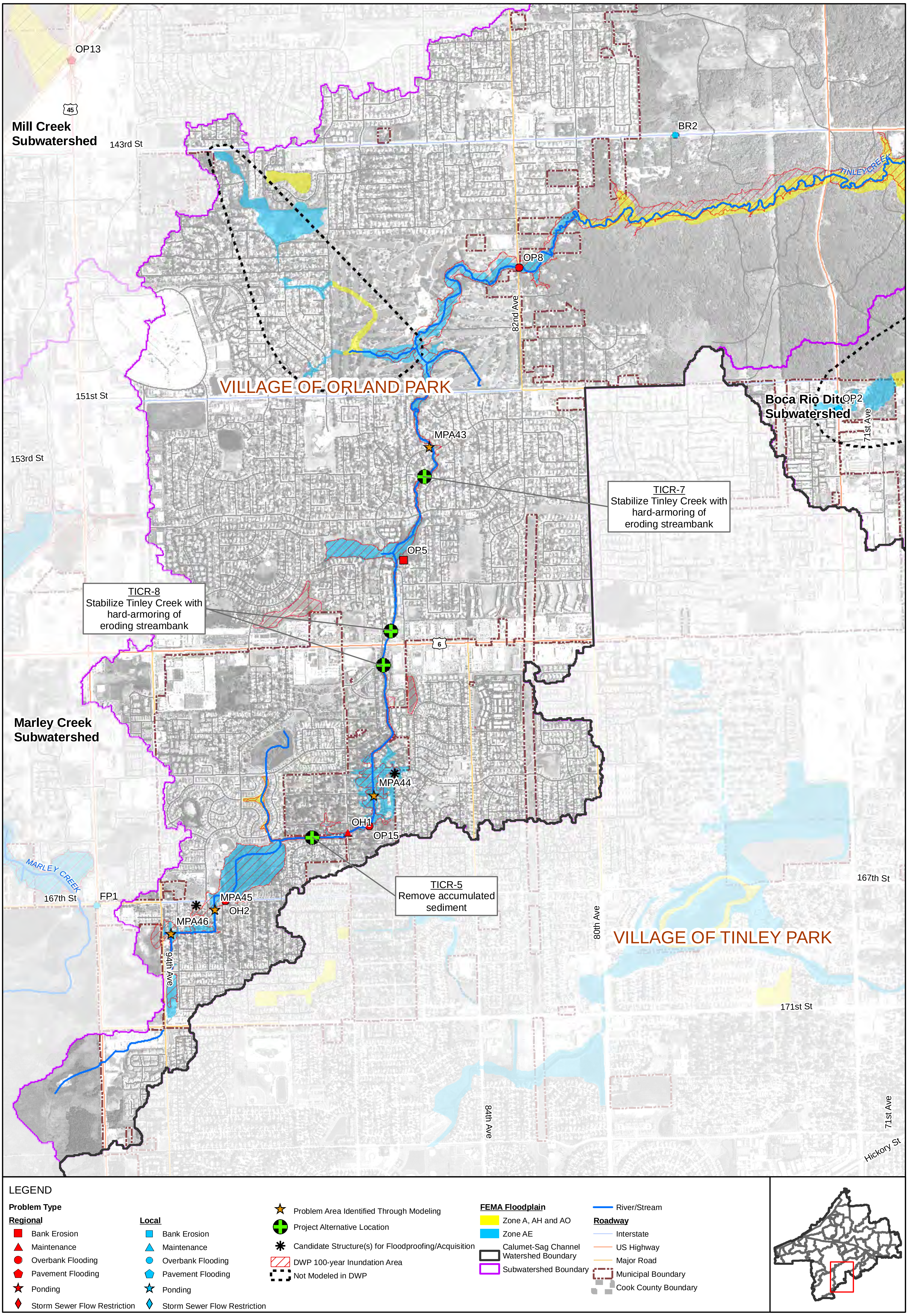
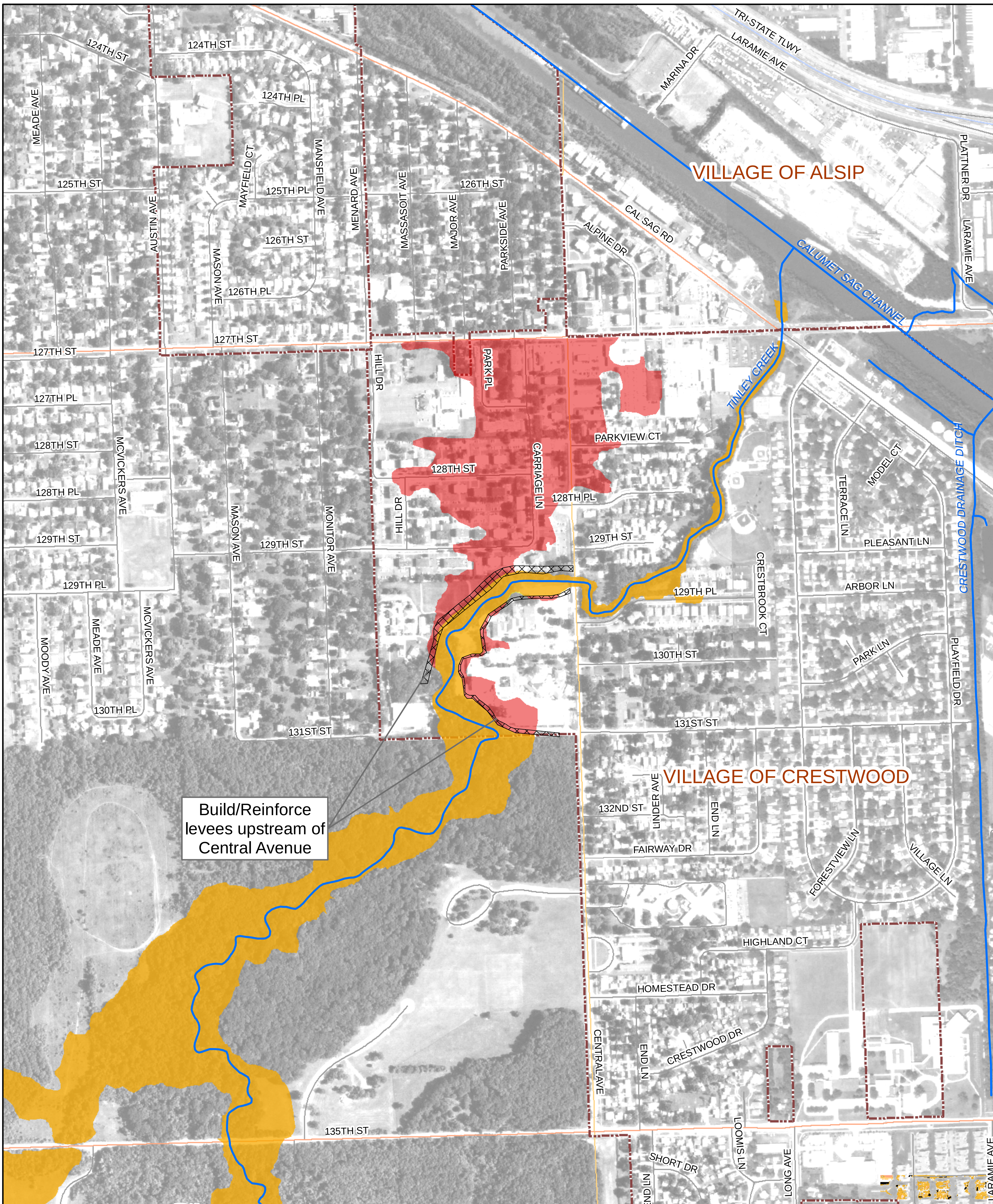


Figure 3.29.1b
Tributary Overview: Tinley Creek (2 of 2)
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Tinley Creek

Alternative: TICR-3

Alternative Description:

Levee along north bank of Tinley Creek approaching Central Avenue

Conceptual Level Cost: $ 2,764,400

Benefits: $ 1,982,000

B/C Ratio: 0.72

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

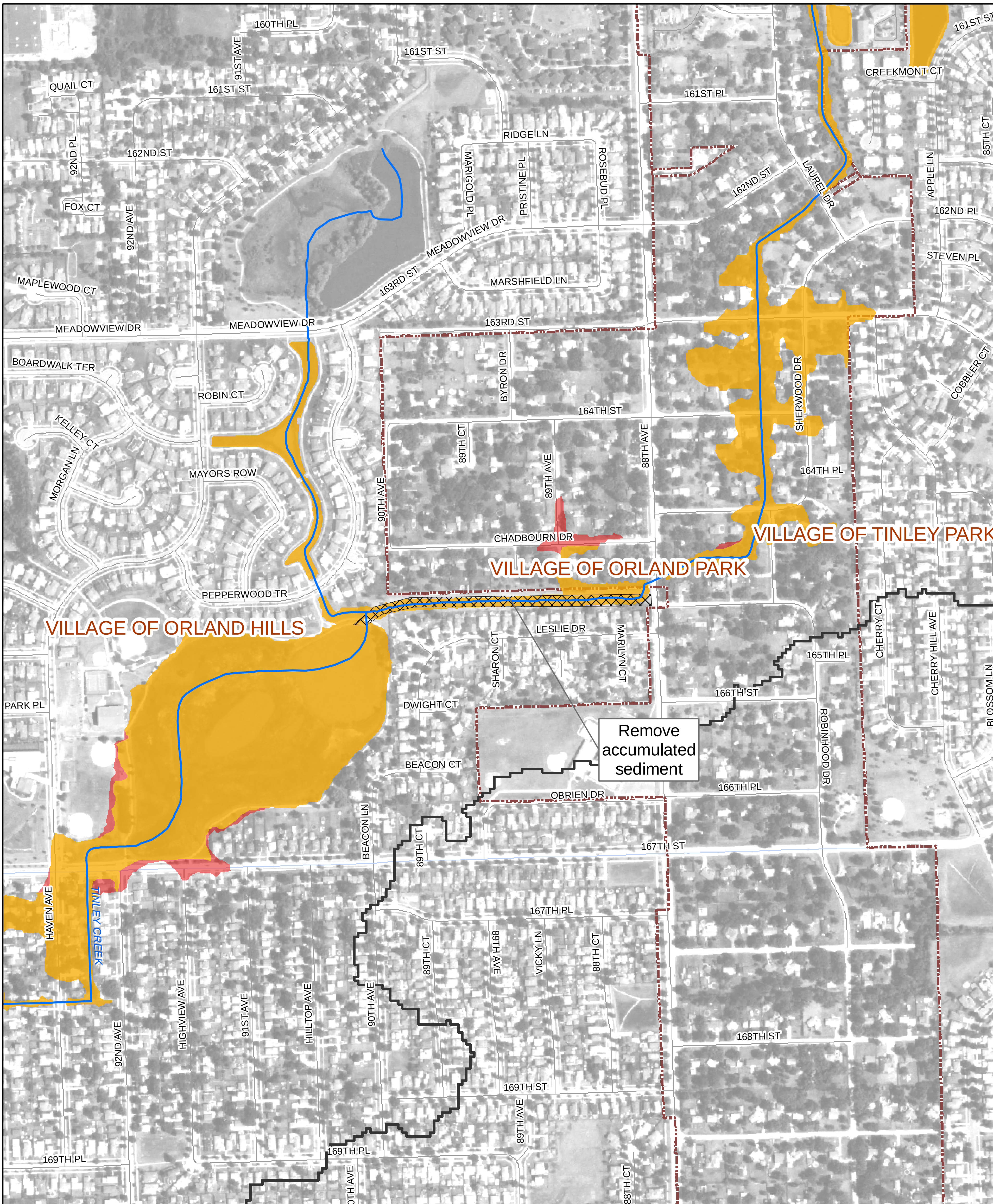
Roadway
- Interstate
- US Highway
- Major Road
- Road

- River/Stream
- Municipal Boundary
- Cook County Boundary

0 430 860 Feet

Figure 3.29.4
Tinley Creek
Alternative TICR-3
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Tinley Creek

Alternative: TICR-5

Alternative Description:

Improve / dredge Tinley Creek between 88th Avenue and Lake Lorin

Conceptual Level Cost: $ 112,800

Benefits: $ 142,600

B/C Ratio: 1.26

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

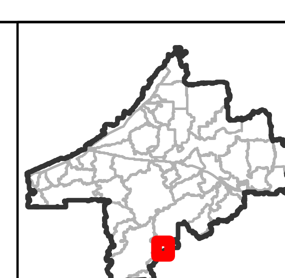
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 250 500

Feet

N

Figure 3.29.5
Tinley Creek
Alternative TICR-5
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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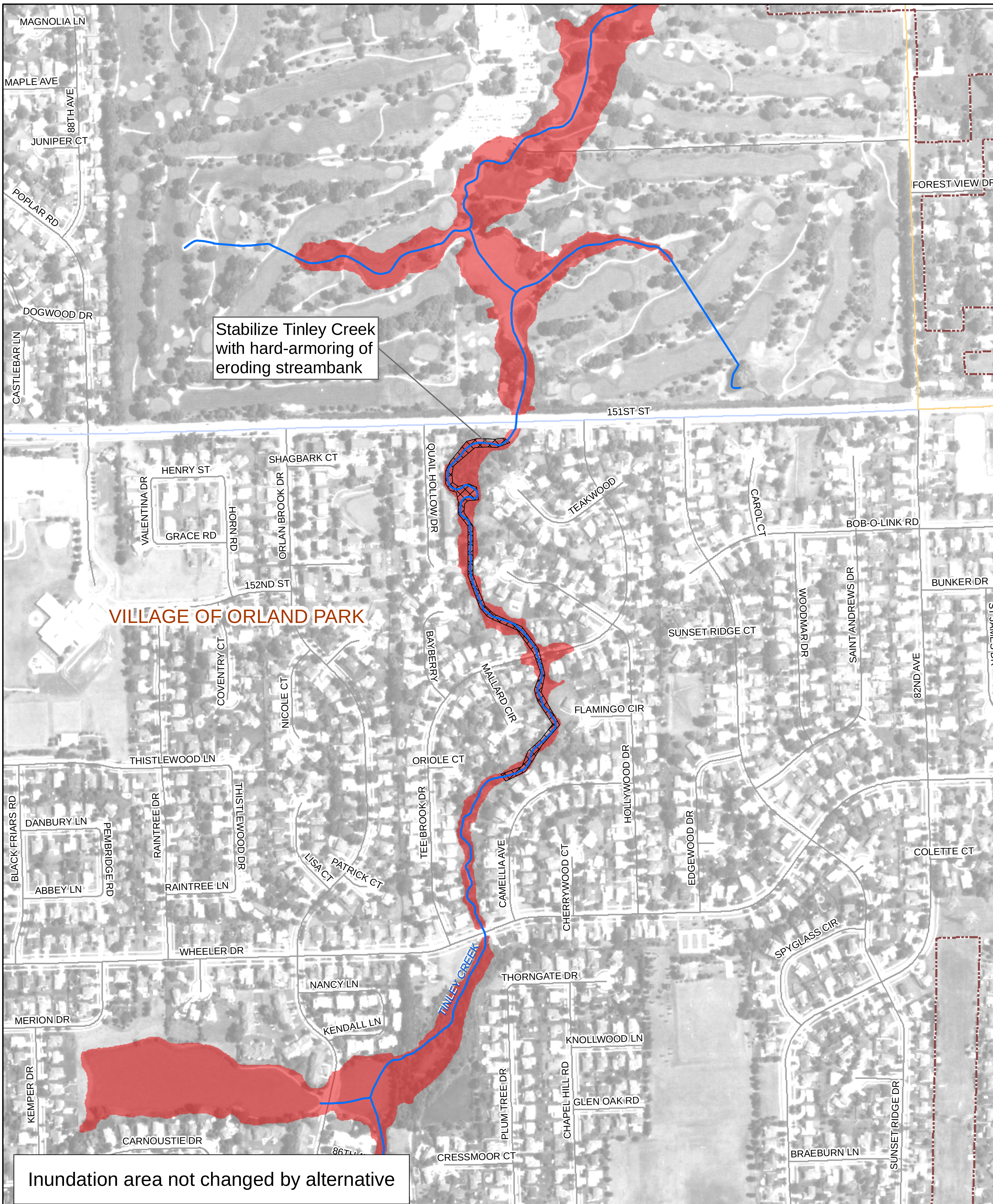


Subwatershed: Tinley Creek

Alternative: TICR-7

Alternative Description:

Stabilize Tinley Creek to prevent erosion

Conceptual Level Cost: $ 1,479,736

Benefits: $ 1,524,702

B/C Ratio: 1.03

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 280 560

Feet

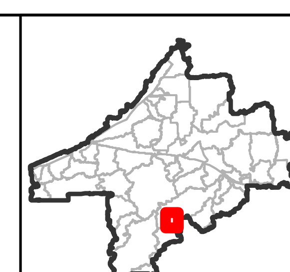
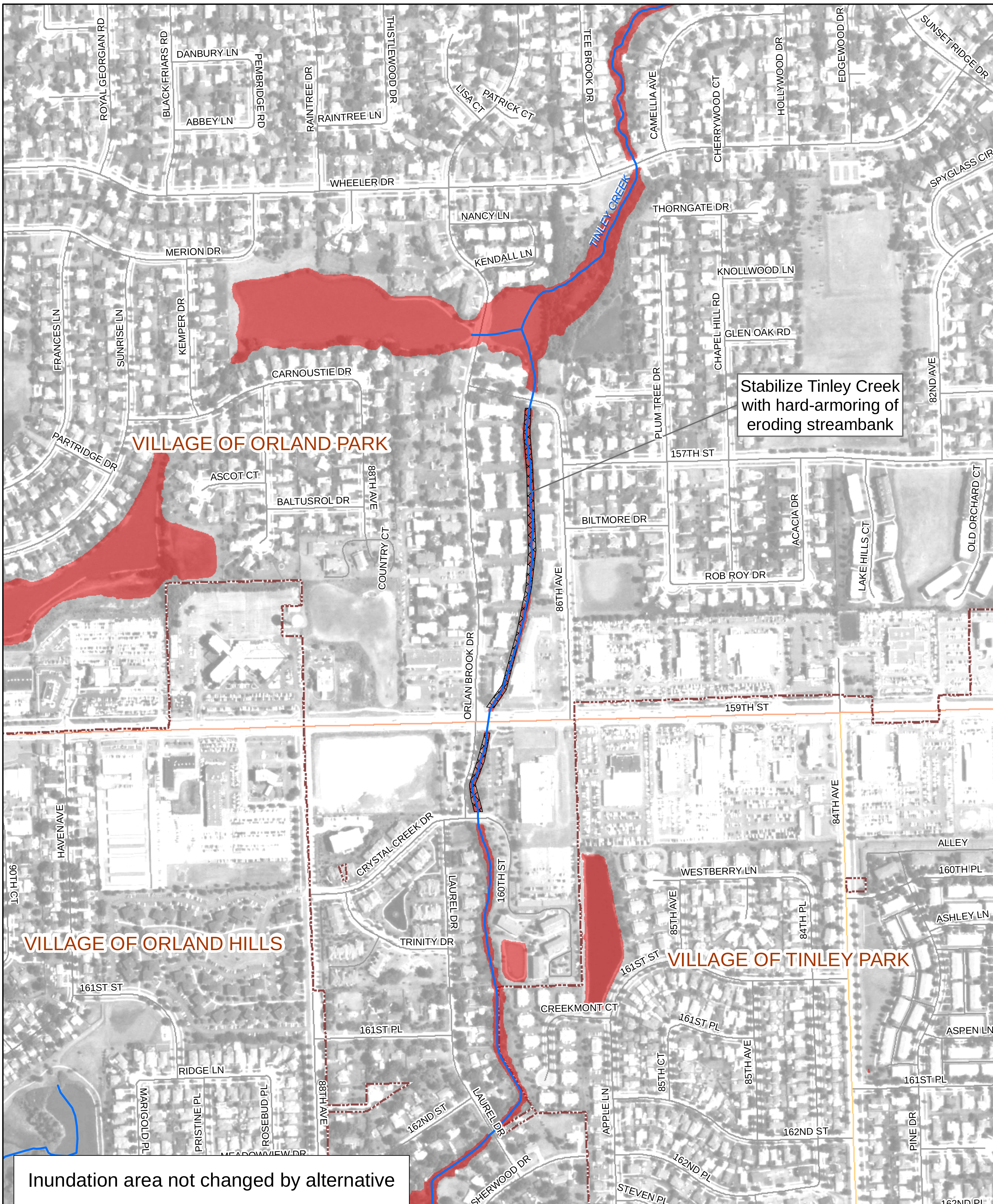


Figure 3.29.6
Tinley Creek
Alternative TICR-7
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan

CH2MHILL



Subwatershed: Tinley Creek

Alternative: TICR-8

Alternative Description:

Stabilize Tinley Creek to prevent erosion

Conceptual Level Cost: $ 4,627,200

Benefits: $ 7,164,900

B/C Ratio: 1.55

LEGEND

- Project Alternative Location
- 100-year Inundation Area With Project
- 100-year Inundation Area Without Project
- Calumet-Sag Channel Watershed Boundary

Roadway

- Interstate
- US Highway
- Major Road
- Road

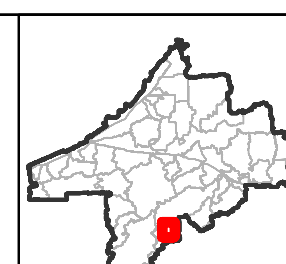
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 250 500

Feet

Figure 3.29.7
Tinley Creek
Alternative TICR-8
Existing and Alternative Inundation Areas
Calumet-Sag Channel Detailed Watershed Plan



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Introduction

As part of the Calumet-Sag Channel 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 study Zone A special flood hazard areas (SFHA) are included in the comparison. Caution should be exercised when evaluating the numbers in both tables, as some differences in inundation area may result from differences in the extent of detailed hydraulic modeling. For instance, the increased extent of detailed study of Tinley Creek through the Cook County Forest Preserve land results in a significantly higher inundation area in comparison with FEMA Zone AE area. FEMA Zone A SFHA exists in the Forest Preserve within the Tinley Creek subwatershed. Additionally, the Calumet-Sag Channel, the Chicago Sanitary and Shipping Canal, and the I&M Canal area waterways that were not modeled in this DWP and have no DWP inundation area, although they are mapped by FEMA as Zone A flooding areas.

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 a current hydrologic model (HEC-HMS). Consequently, different approaches to channel and reservoir routing may 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 7.60 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.

Differences 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. In a few cases, recent hydraulic models were available and modified under this DWP. If recent hydraulic models were used, several cross sections were verified with field surveying. 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 Calumet-Sag Channel DWP and the 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)
71st St. Ditch	97.5	78.5	3.4
Arroyo Ditch *	3.0	1.5	
Boca Rio Ditch *	51.3	75.1	56.7
Cal-Sag 2	155.2		618.7
Cal-Sag 4	0.6		45.3
Cal-Sag 5	1.9		92.5
Cal-Sag 6	28.4	1.8	41.4
Cal-Sag 8	1.7		69.6
Cal-Sag Trib A	139.5	54.3	123.1
Cal-Sag Trib B	44.9	19.7	0.7
Cal-Sag Trib C	45.4	42.2	

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)
Castle Bowl	0.6	2.9	5.1
Crestwood Drainage Ditch	5.8	28.2	4.4
Crooked Creek	114.4	3.2	37.1
I&M 1			6.8
I&M 2	2.2	5.5	7.2
I&M 5	1.4		243.3
I&M Canal	213.5		386.9
I&M Trib A	10.8	17.7	0.3
I&M Trib B&C	39.0	32.2	
I&M Trib D	24.8	5.0	
Justice Ditch	35.8	48.7	
Long Run Creek	316.3	302.9	8.7
Lucas Ditch *	74.5	54.8	
Lucas Diversion Ditch *	104.4	80.2	
Marley Creek	635.7	634.0	8.4
Melvina Ditch *	35.5	11.7	42.8
Merrionette Park Ditch *	38.7	4.3	12.5
Mill Creek	676.1	125.4	520.5
Navajo Creek	87.9	66.5	25.2
Oak Lawn Creek *	237.3	115.6	10.0
Spring Creek	157.6	176.6	27.7
Stony Creek West	976.1	580.2	53.0
Stony Creek East	296.6	45.5	40.2
Tinley Creek	506.9	265.1	305.5
Totals	**4,369.6**	**2,584.8**	**3,108.1 ** **

* Subwatershed is a component of a larger system (e.g. Melvina Ditch is contained within the Stony Creek system) and thus excluded from the totals.

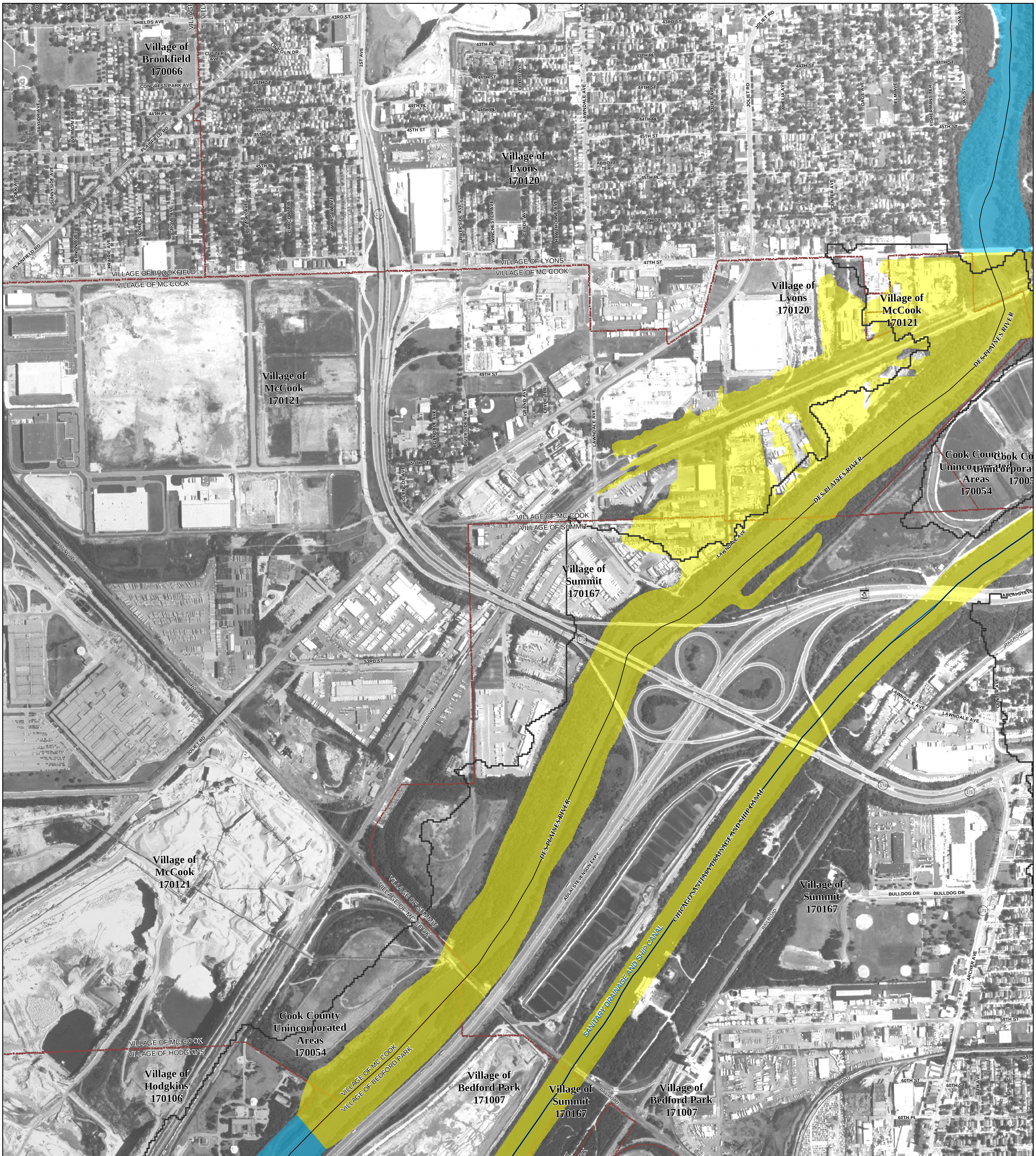
** Subwatersheds with no DWP mapping were not included in the table. Some FEMA Zone A does exist in these locations.

Table 2 below lists for comparison the floodplain area within each community within the Calumet-Sag Channel watershed as determined by the Calumet-Sag Channel 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

Community	DWP Floodplain Area (acres)	FEMA Zone AE Area (acres)	FEMA Zone A Area (acres)
Alsip	156.0	37.9	163.4
Bedford Park	51.3	1.9	202.1
Blue Island	57.5	11.3	98.1
Bridgeview	11.6	15.8	
Chicago	43.7		11.2
Chicago Ridge	177.7	103.5	0.9
Cook County Unincorporated Areas	1,849.2	809.0	1,727.9
Crestwood	61.3	64.0	52.7
Hickory Hills	5.6	25.9	
Justice	83.3	125.3	14.4
Lemont	186.1	41.2	86.0
Midlothian	33.1	31.7	
Oak Forest	24.3	47.9	
Oak Lawn	530.6	268.0	52.1
Orland Hills	45.5	41.8	3.3
Orland Park	741.9	609.7	198.3
Palos Heights	91.5	67.1	101.3
Palos Hills	263.6	178.2	11.7
Palos Park	135.0	93.5	24.2
Tinley Park	3.1	1.0	
Willow Springs	2.0	4.8	128.9
Worth	9.3	6.6	3.6
Total	**4,369.6**	**2,586.0**	**3,180.1 ***

* Communities with no DWP inundation area mapping were omitted from the table, although some did have FEMA Zone A area. Contributing FEMA Zone A areas were included in the total.



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

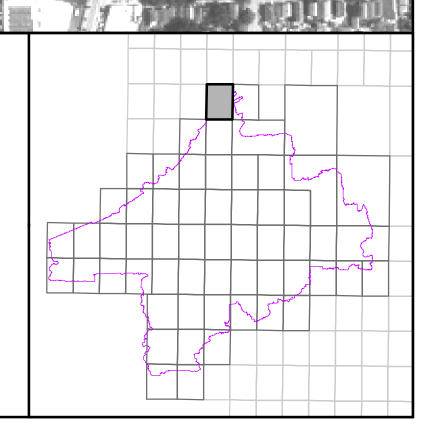
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0487J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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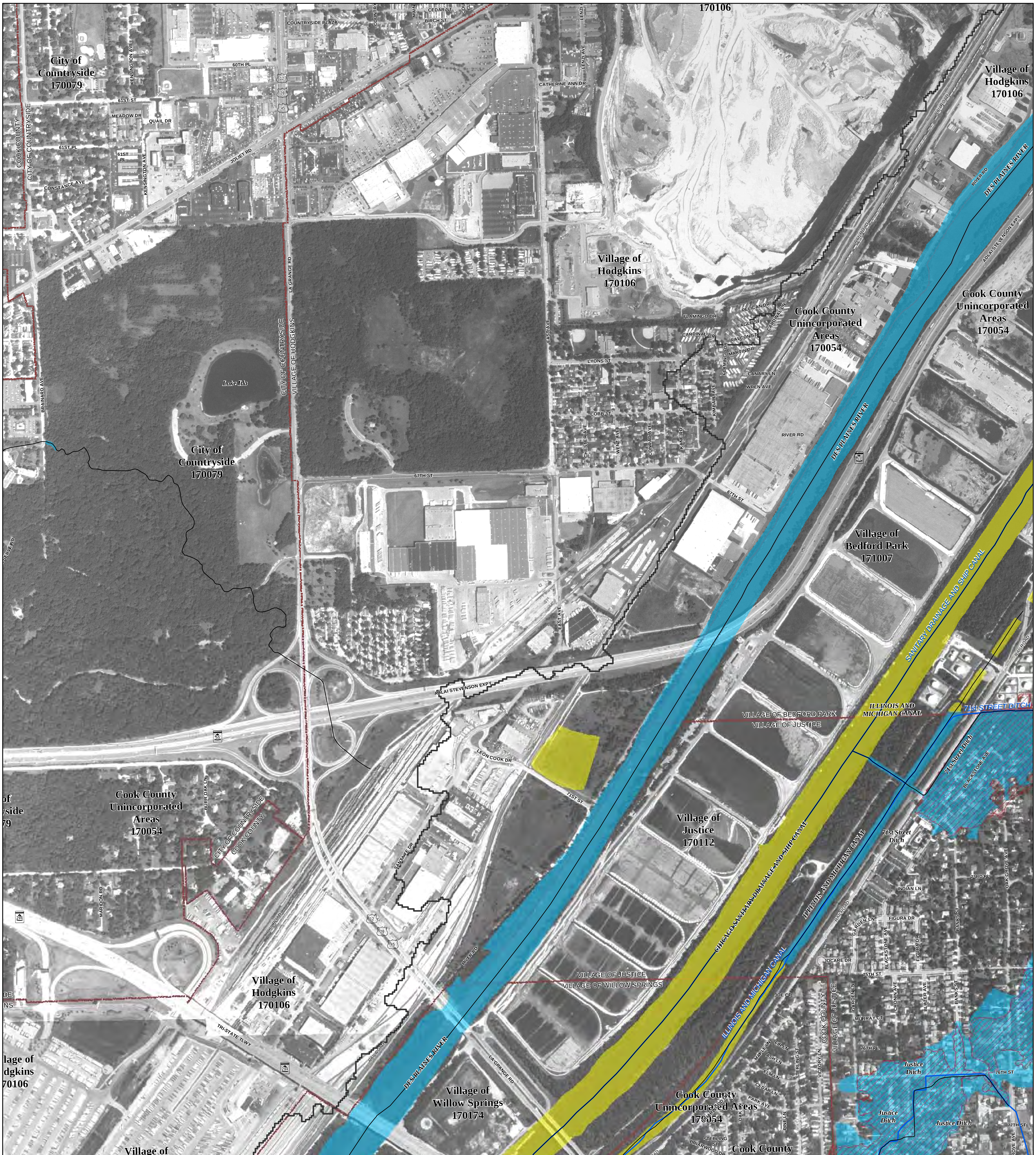


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

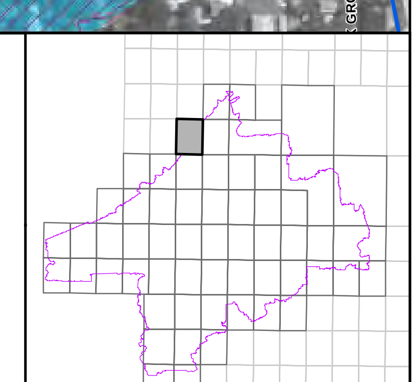
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Calumet-Sag Detailed Watershed Plan

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

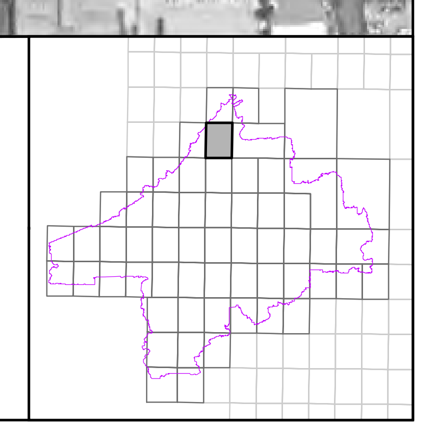
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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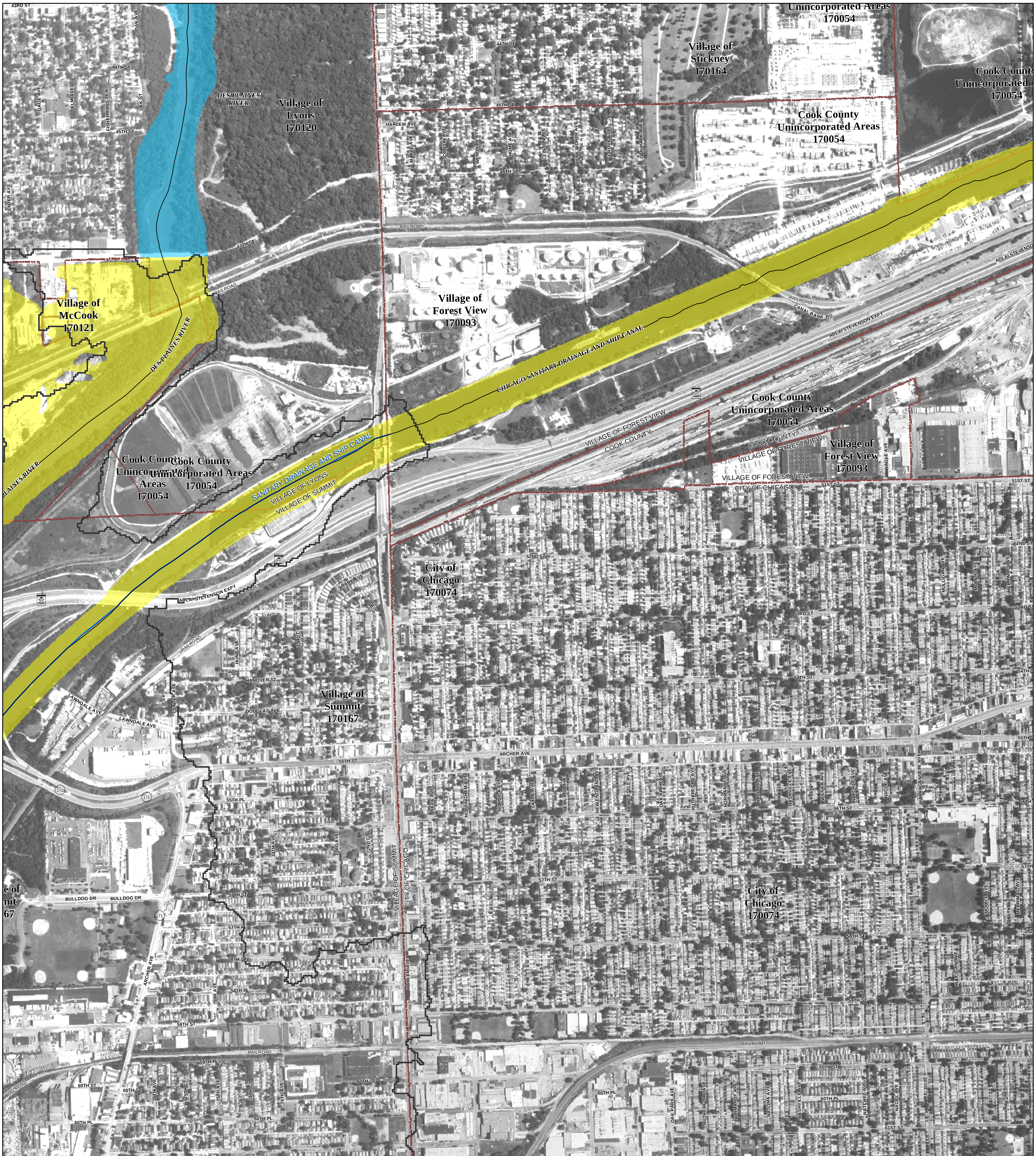


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

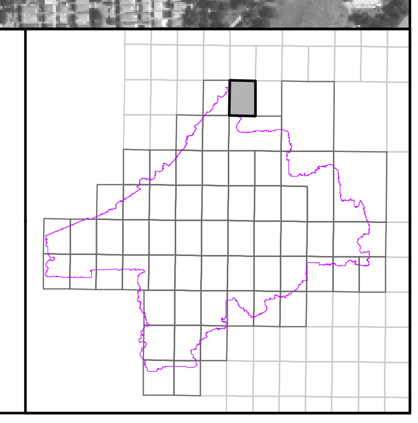
Zone AE

Calumet-Sag Watershed Boundary

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 10/19/2008

Calumet-Sag Detailed Watershed Plan

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

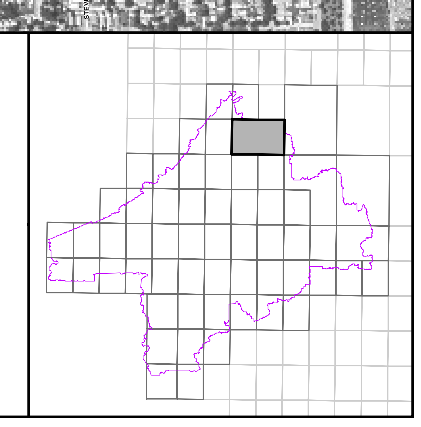
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0495J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

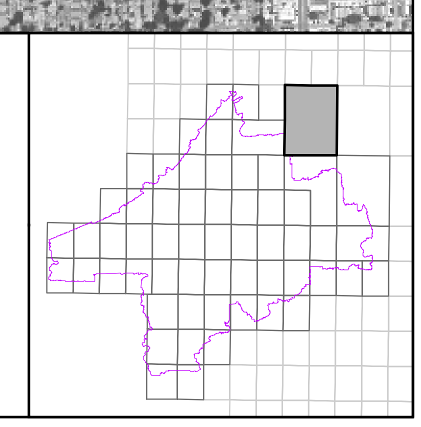
Zone AE

Calumet-Sag Watershed Boundary

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 10/19/2008

Calumet-Sag Detailed Watershed Plan

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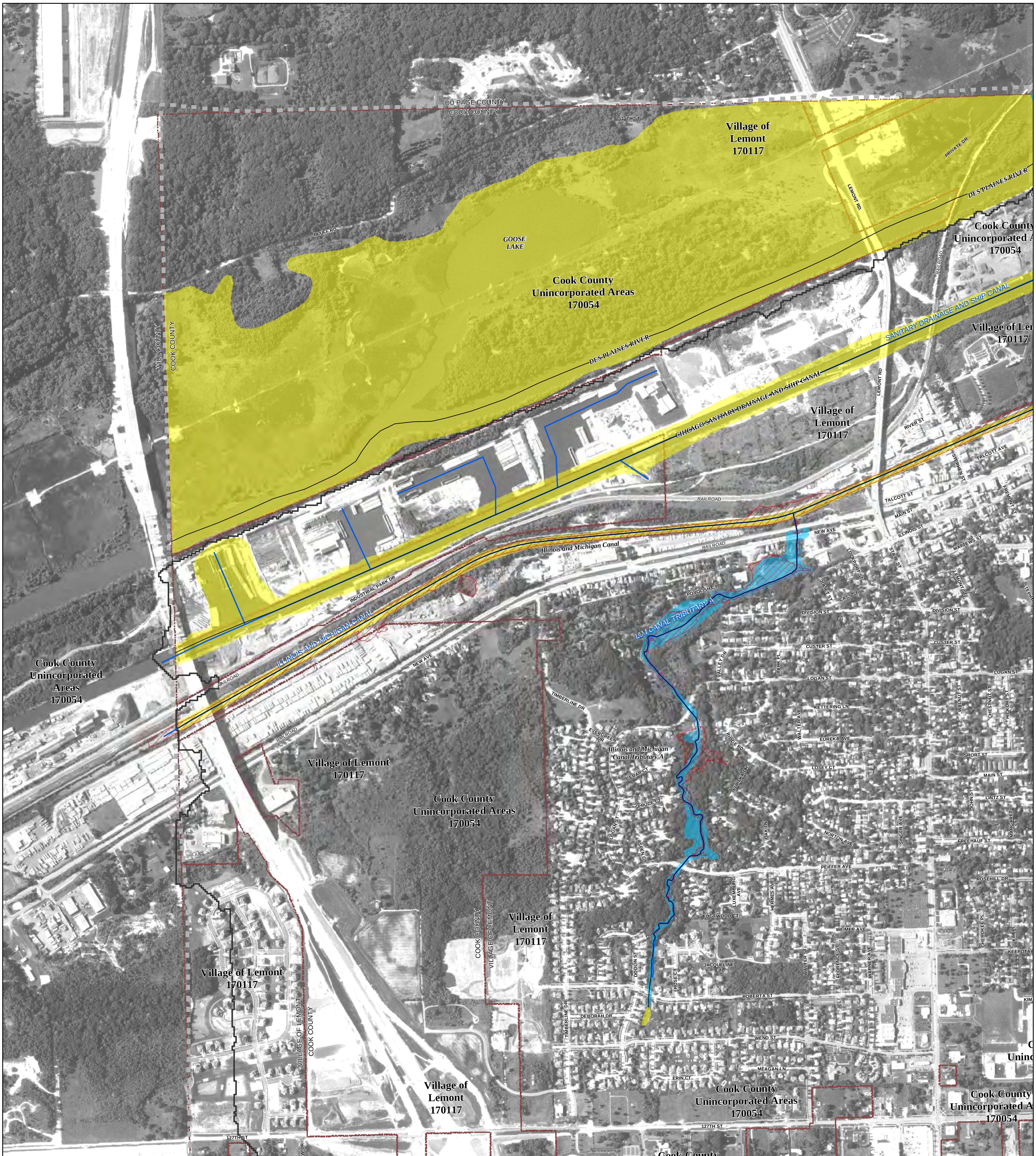


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

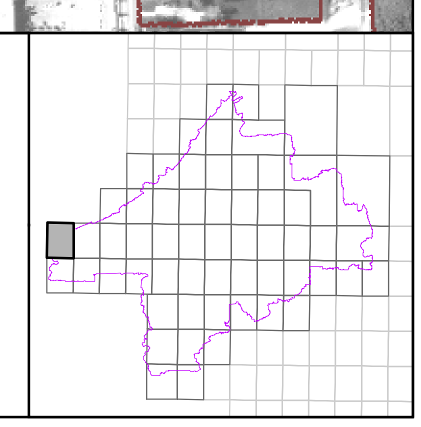
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0567J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

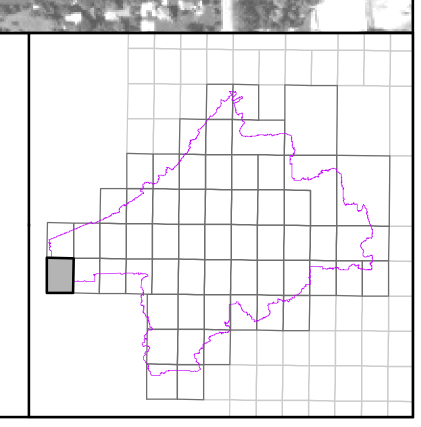
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0569J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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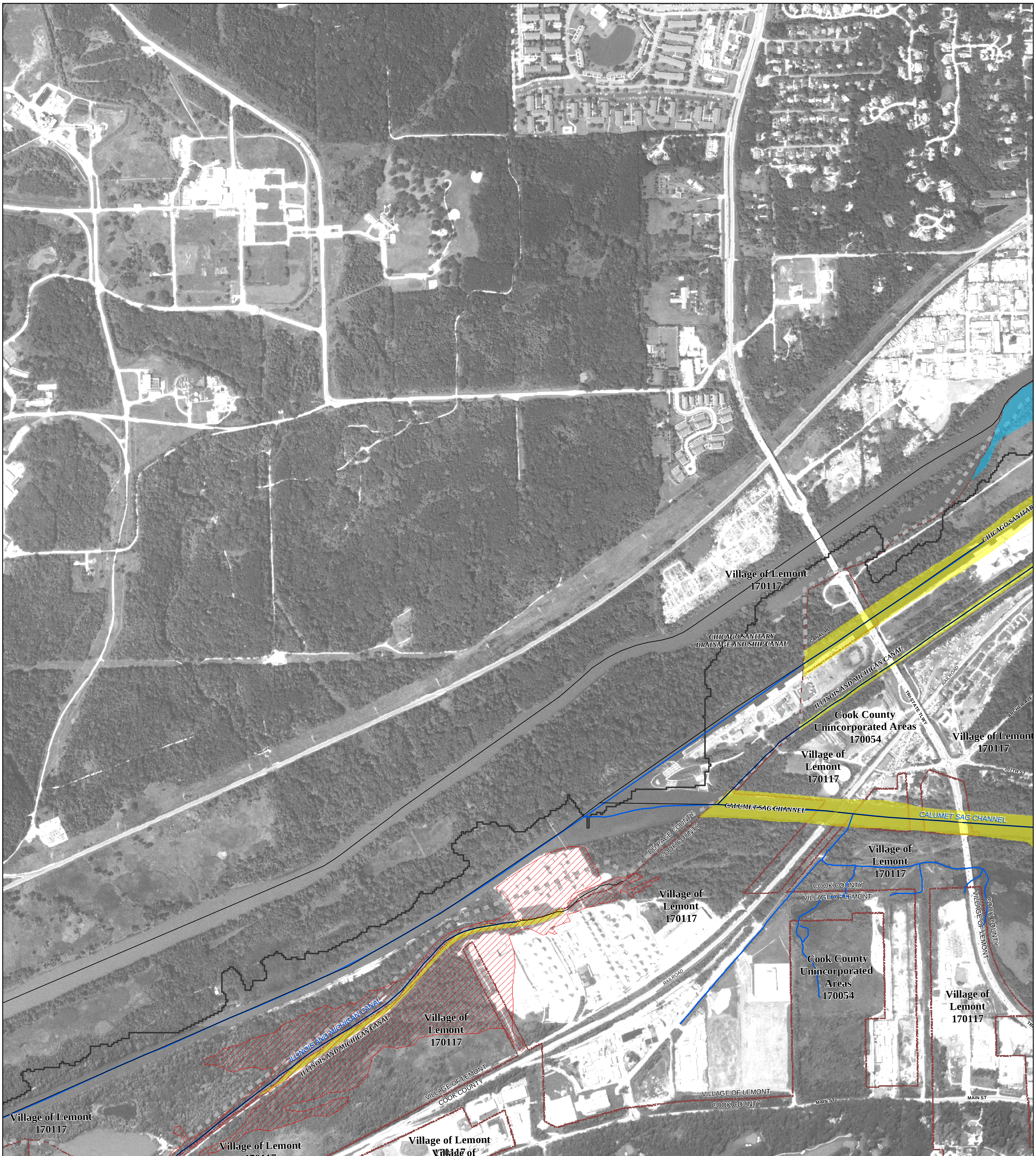

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

0 500 1,000

Feet

N

FIRM Panel: 17031C0579J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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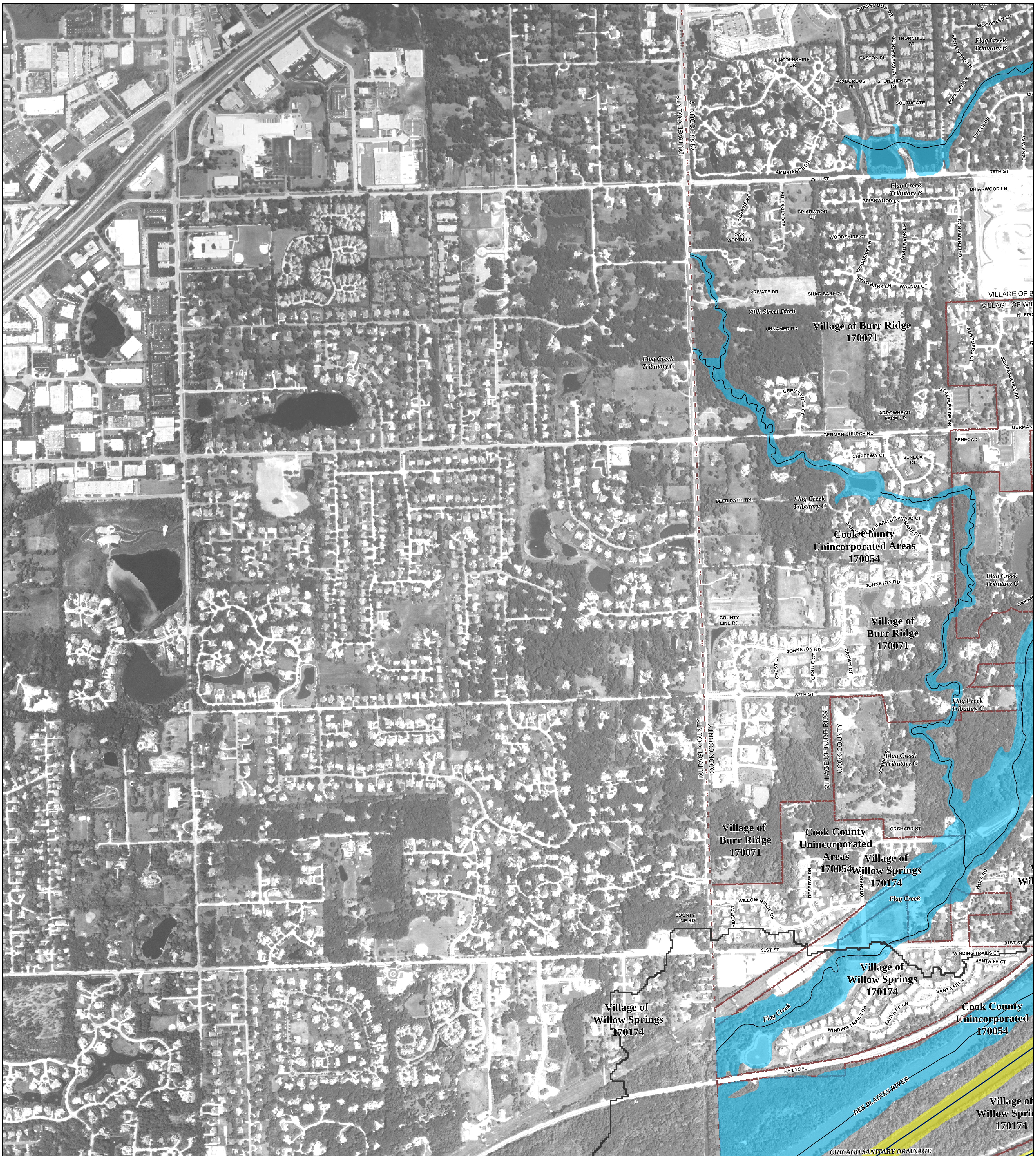


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

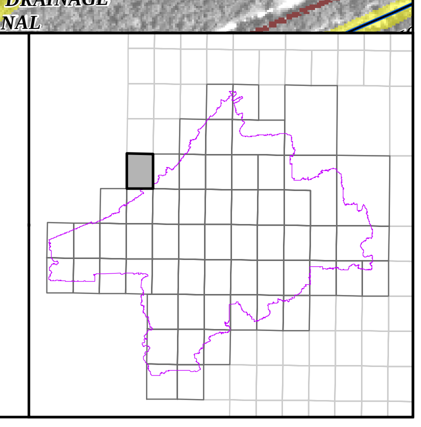
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



N

0 500 1,000

Feet

FIRM Panel: 17031C0581J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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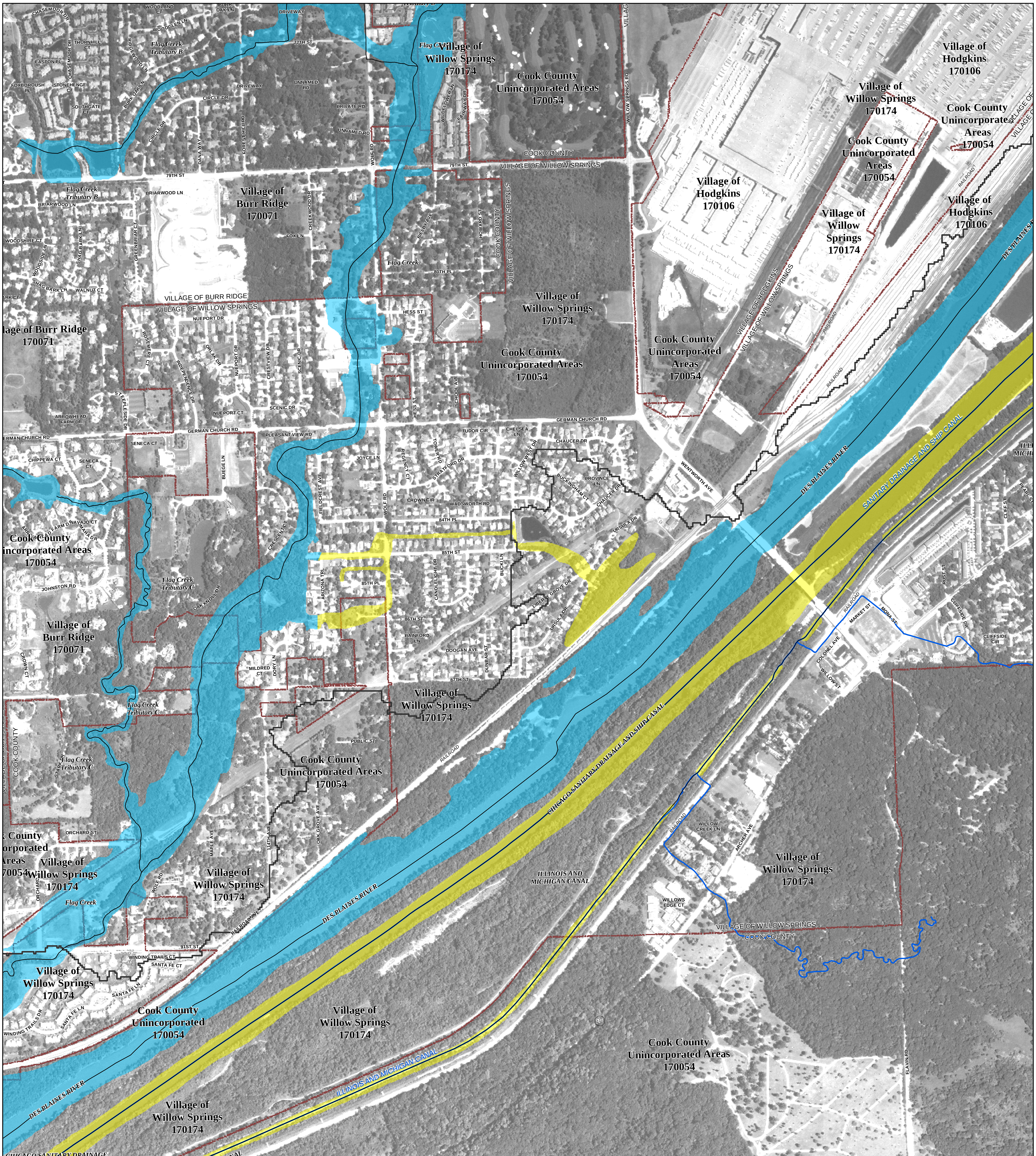


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

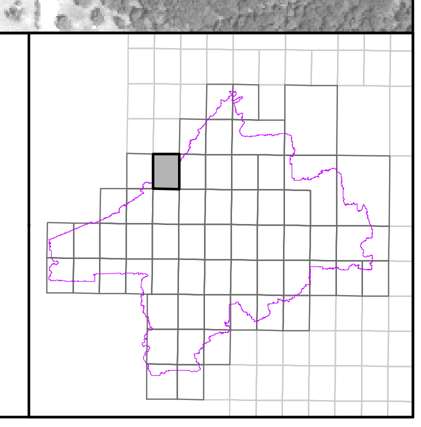
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



N

0 500 1,000

Feet

FIRN Panel: 17031C0582J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

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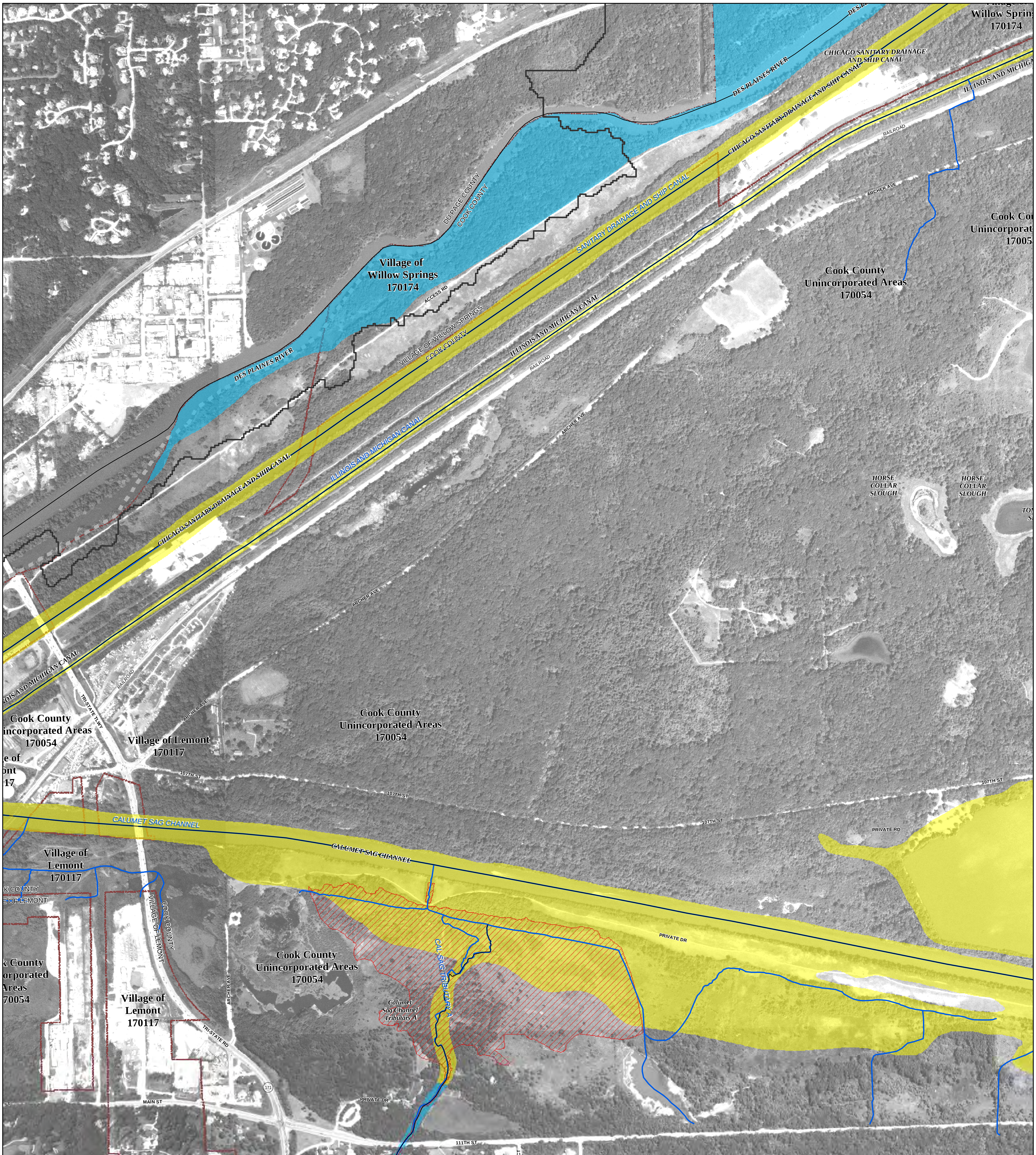


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

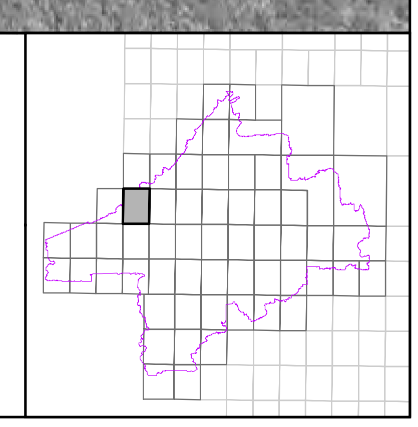
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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0 500 1,000

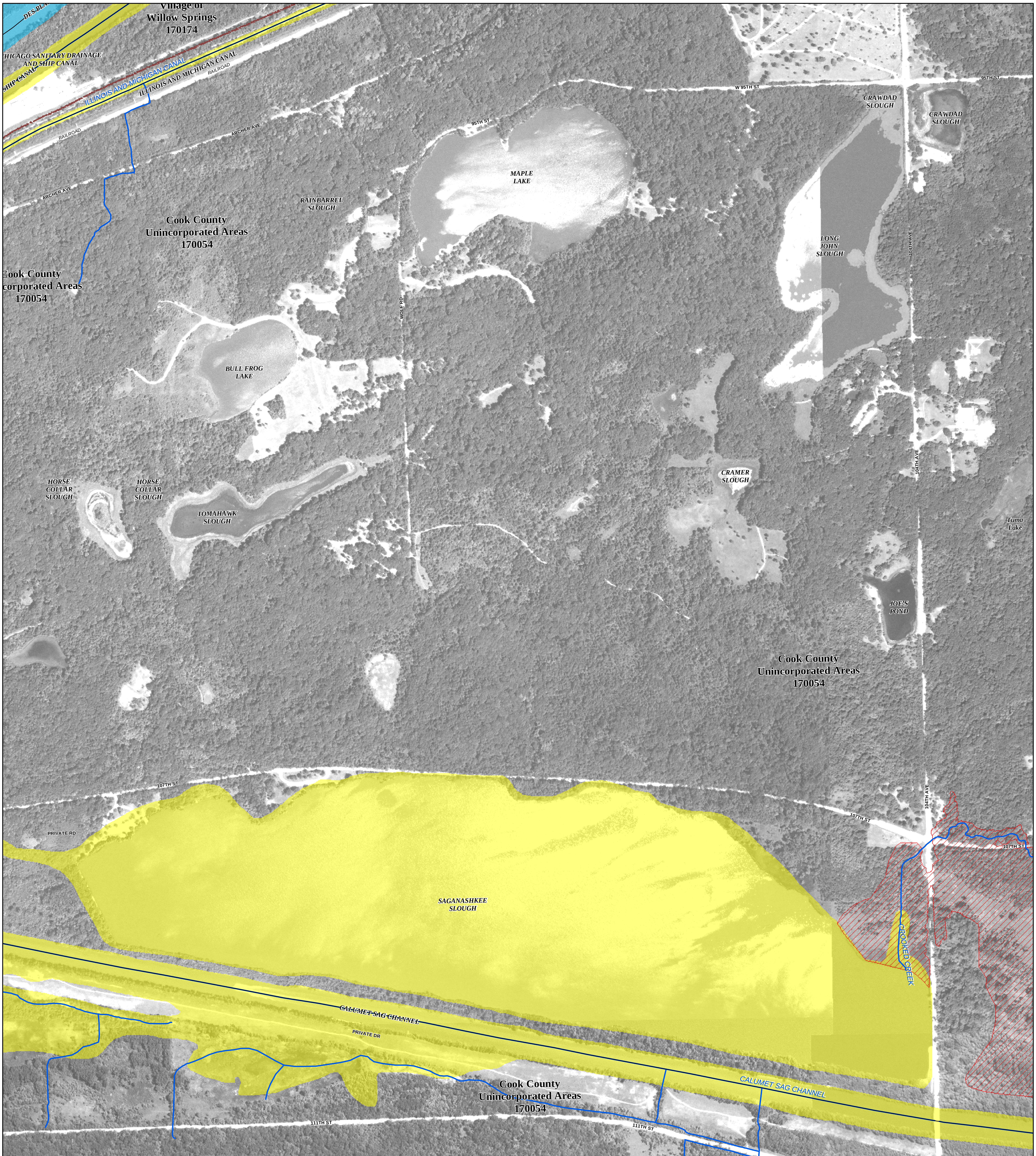
Feet

FIRM Panel: 17031C0583J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

0 500 1,000

Feet

FIRM Panel: 17031C0584J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

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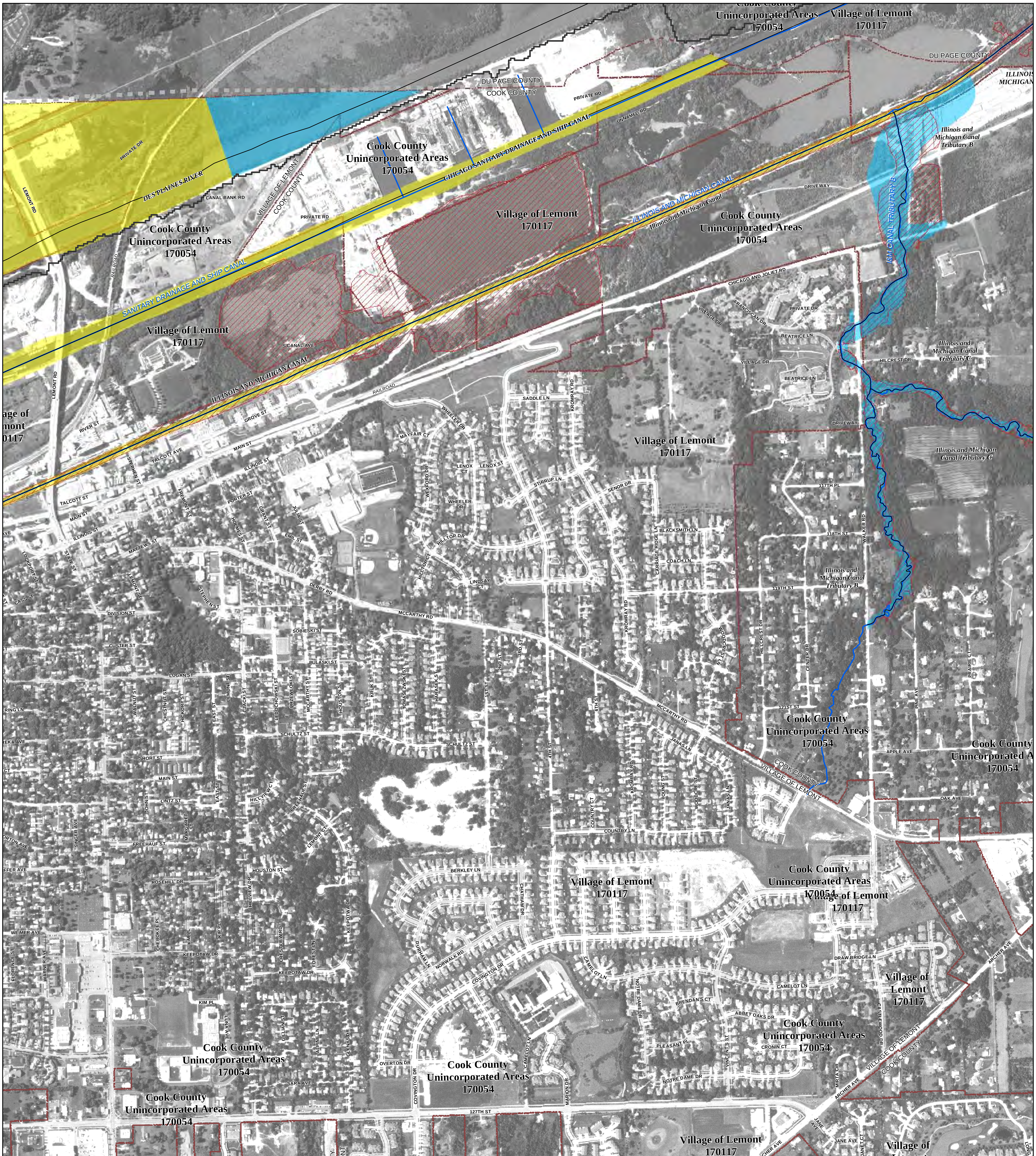

LEGEND

- DWP 100-year Inundation Area

FEMA Floodplain

- Zone A, AH and AO
- Zone AE
- Calumet-Sag Watershed Boundary
- River/Stream
- Municipal Boundary
- Cook County Boundary

0 500 1,000

Feet

N

FIRM Panel: 17031C0586J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

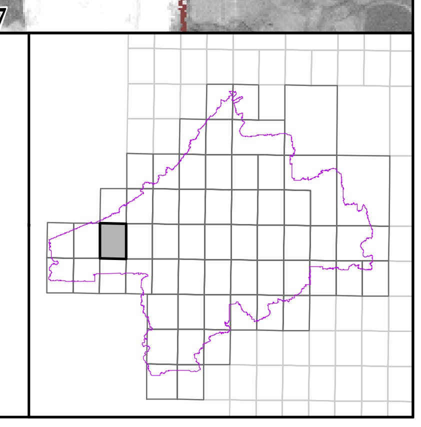
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

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FIRM Panel: 17031C0587J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

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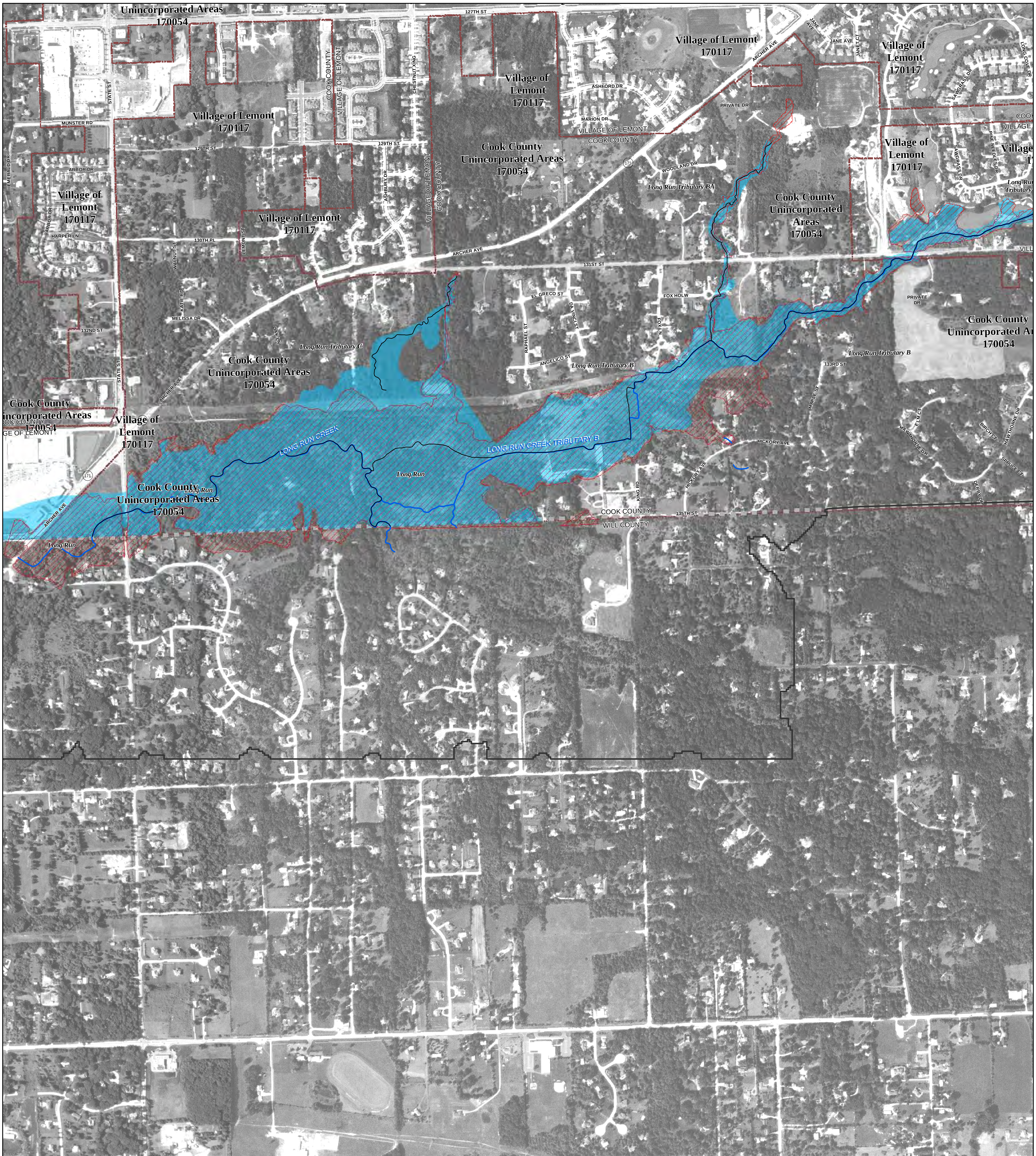


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

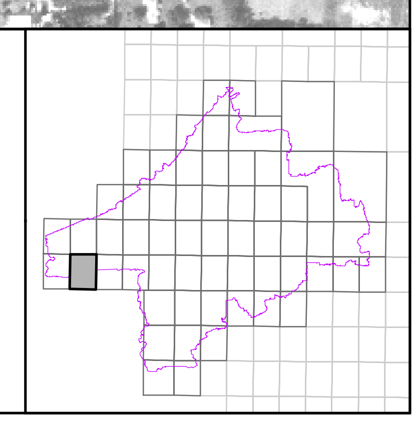
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0588J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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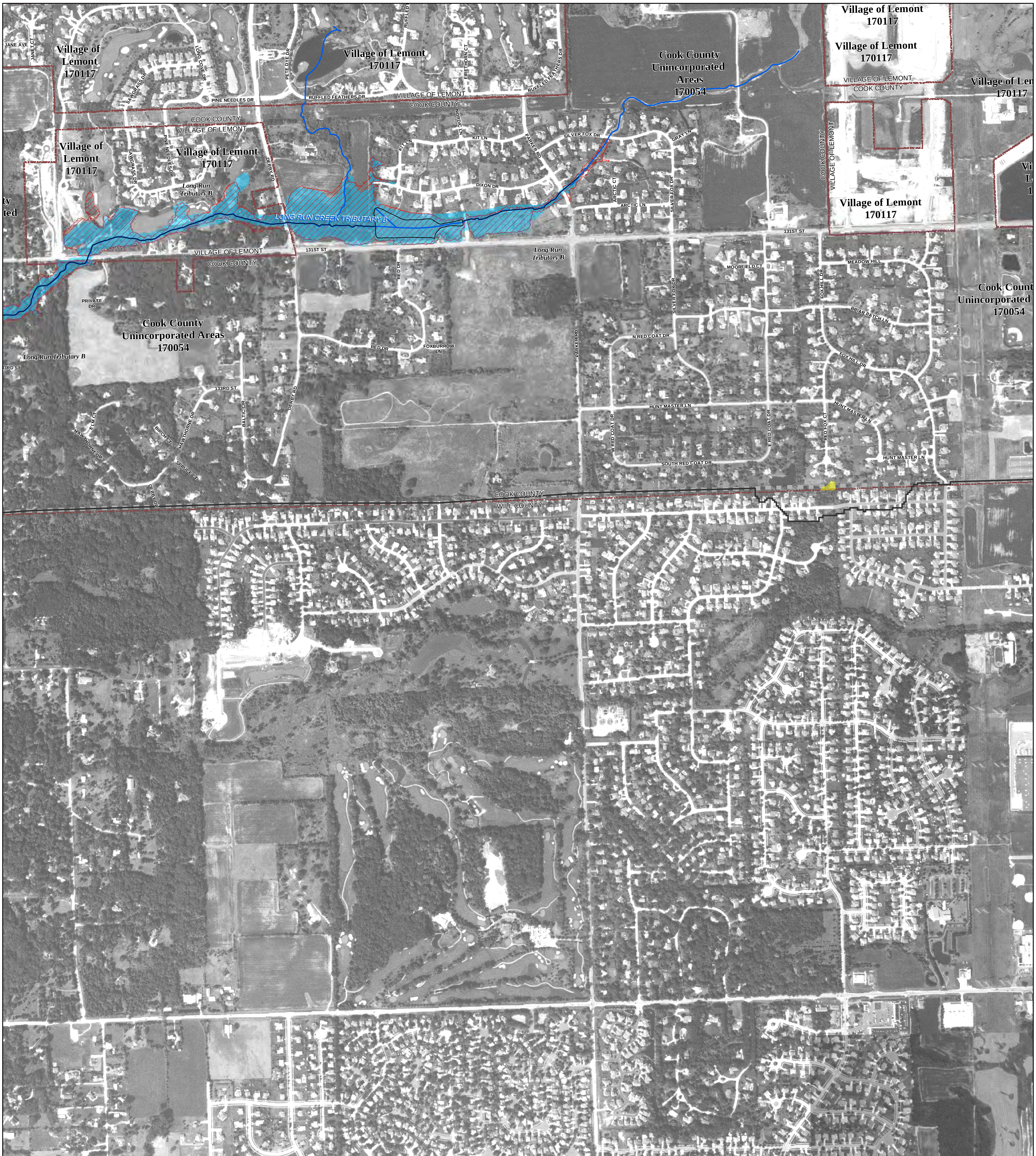


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

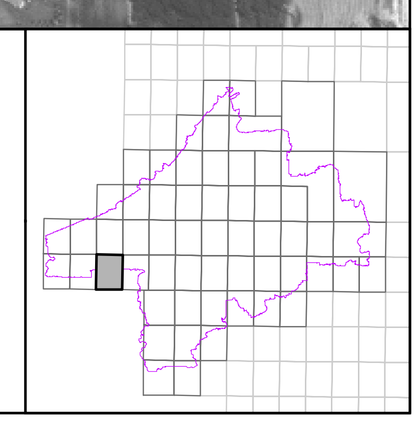
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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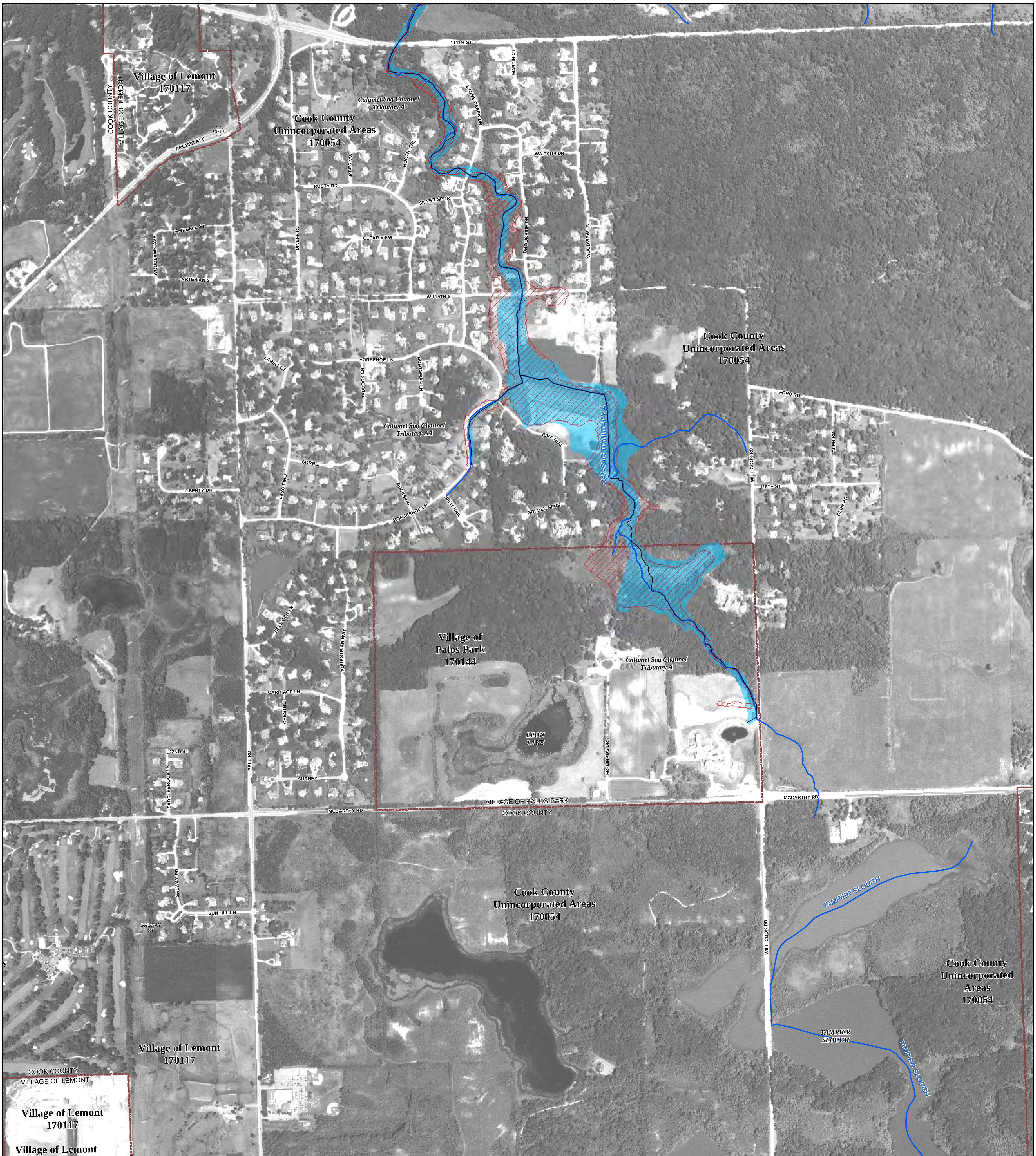
Feet

FIRM Panel: 17031C0589J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

0 500 1,000

Feet

FIRM Panel: 17031C0591J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

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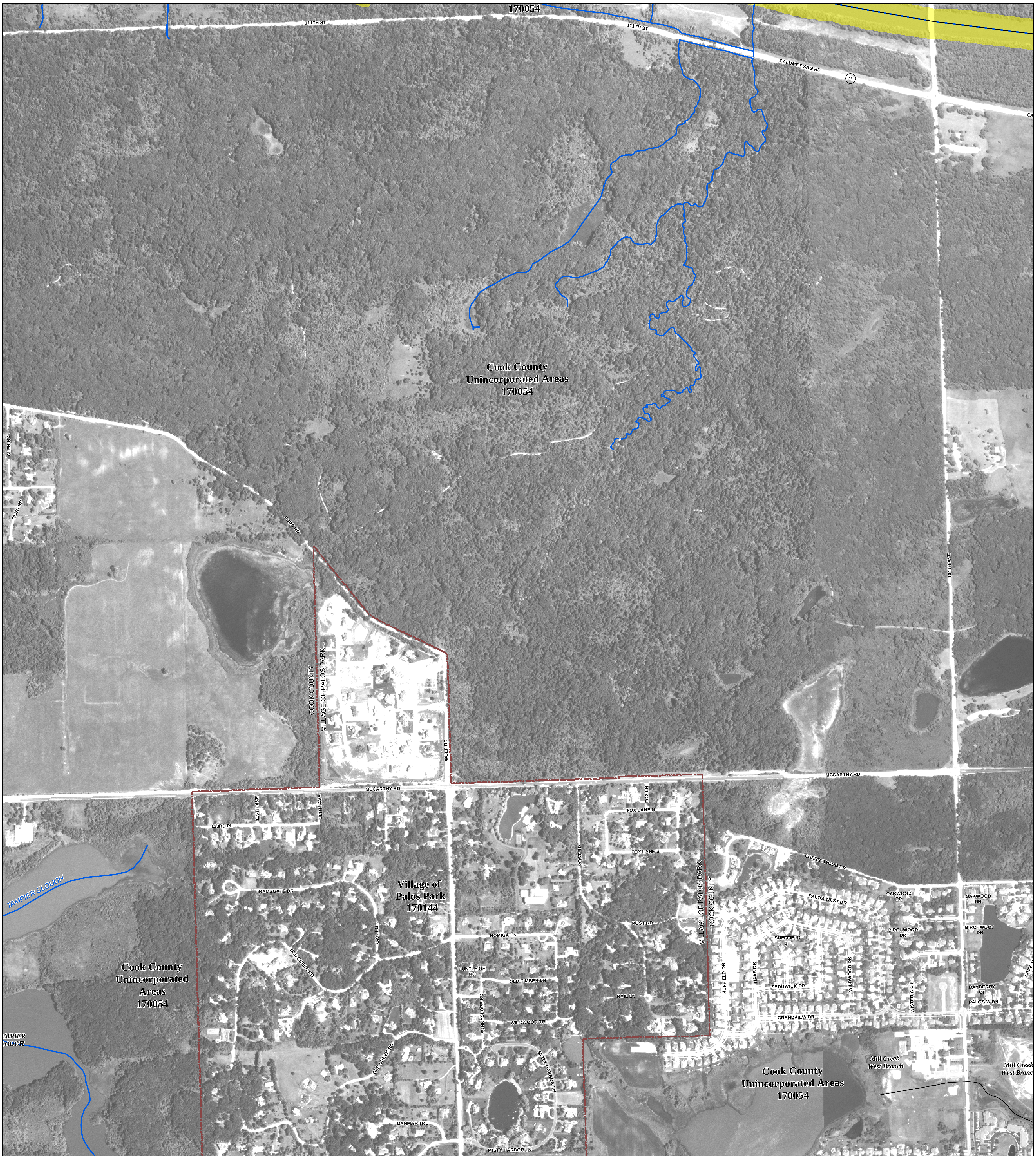


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

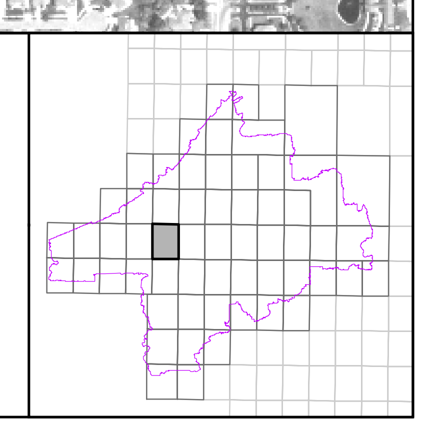
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0592J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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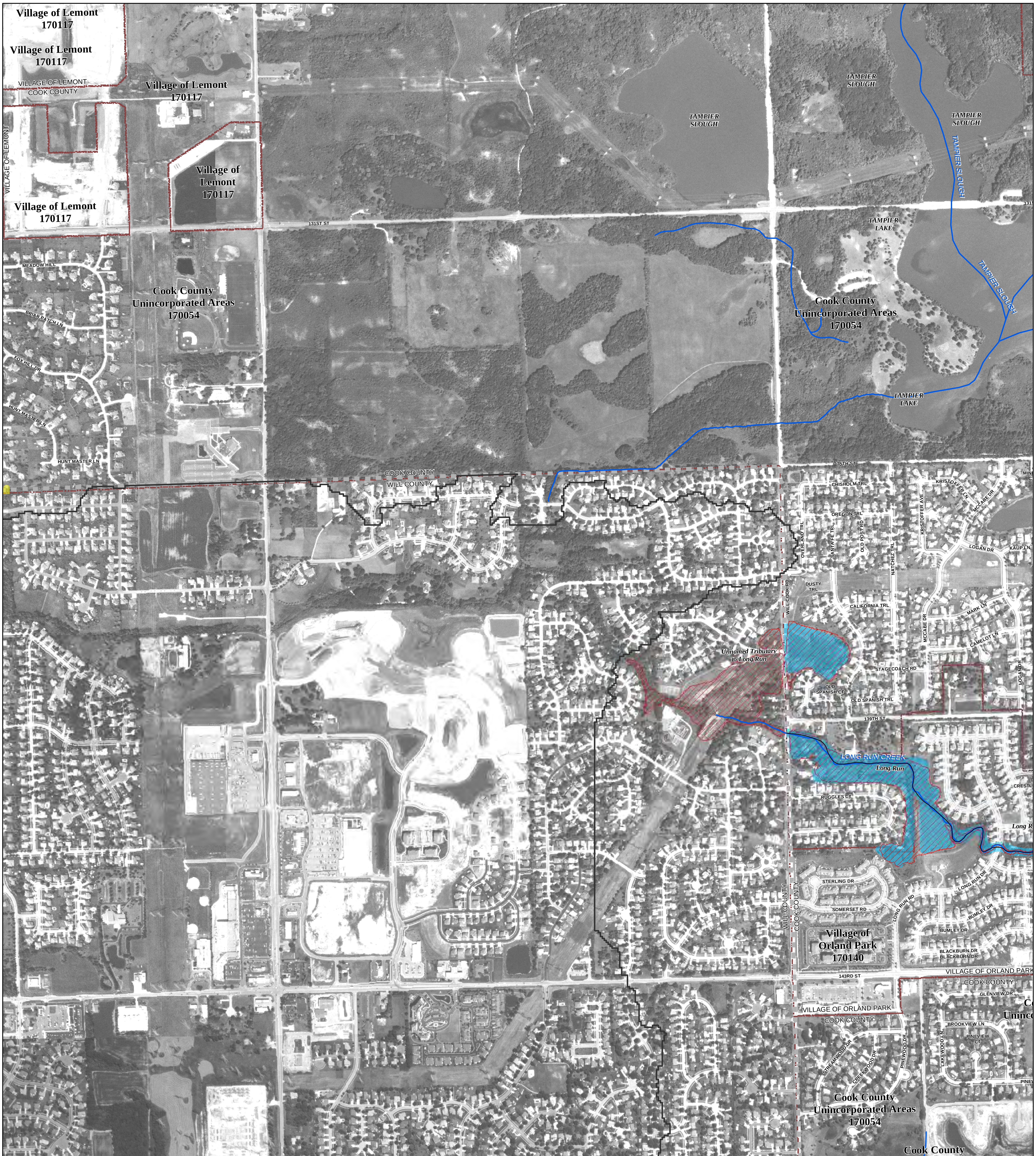
CH2MHILL



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

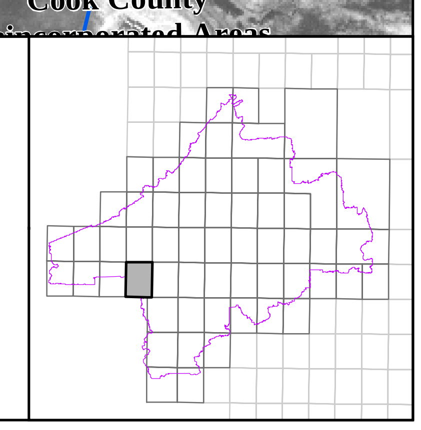
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0593J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

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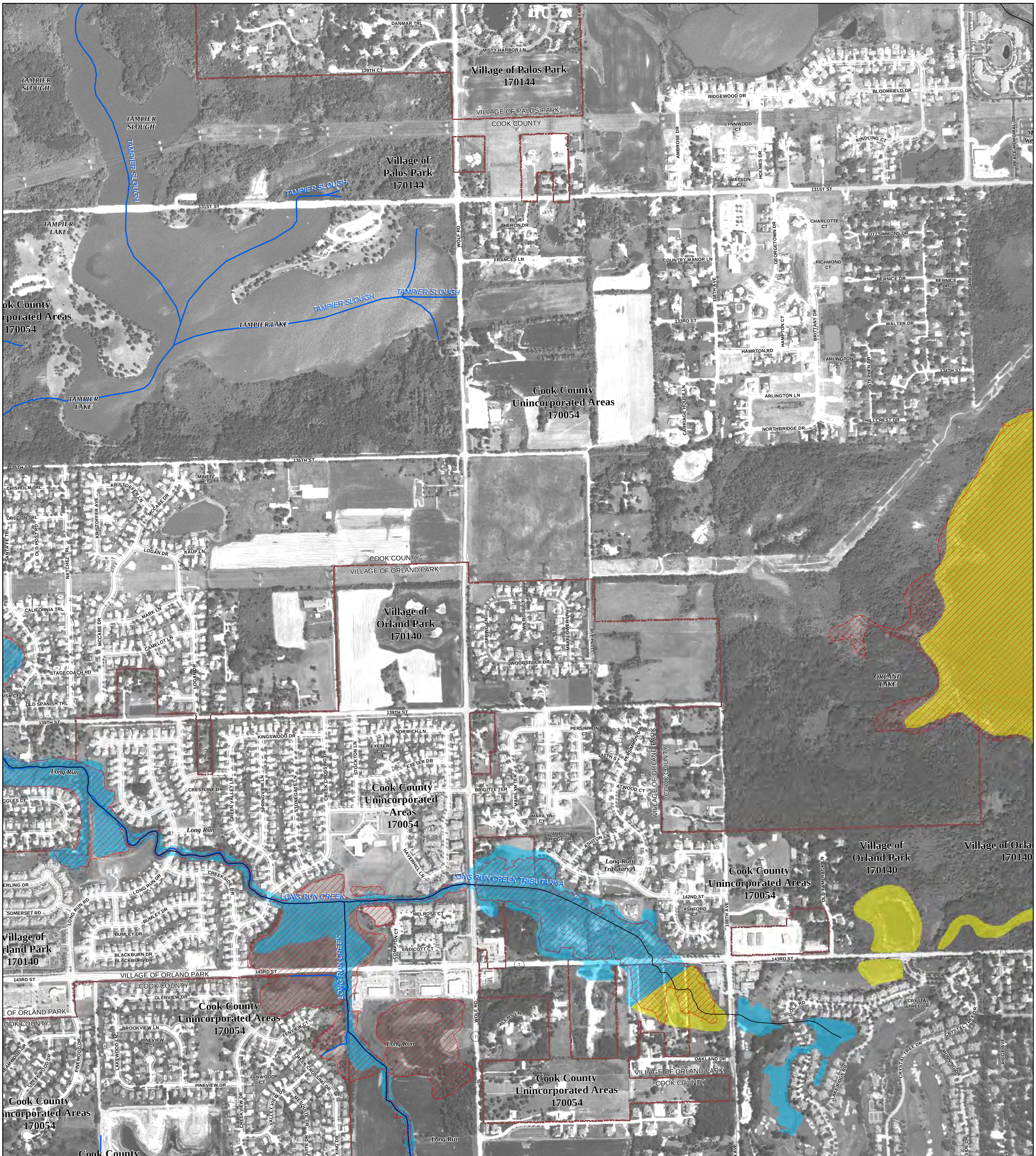


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

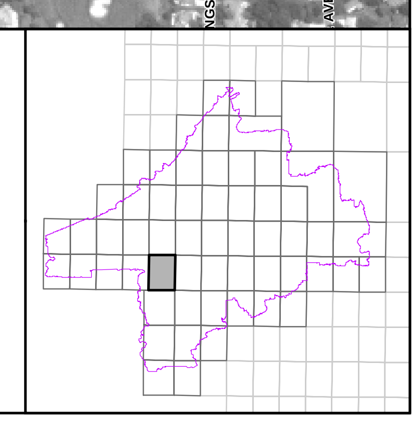
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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0 500 1,000

Feet

FIRM Panel: 17031C0594J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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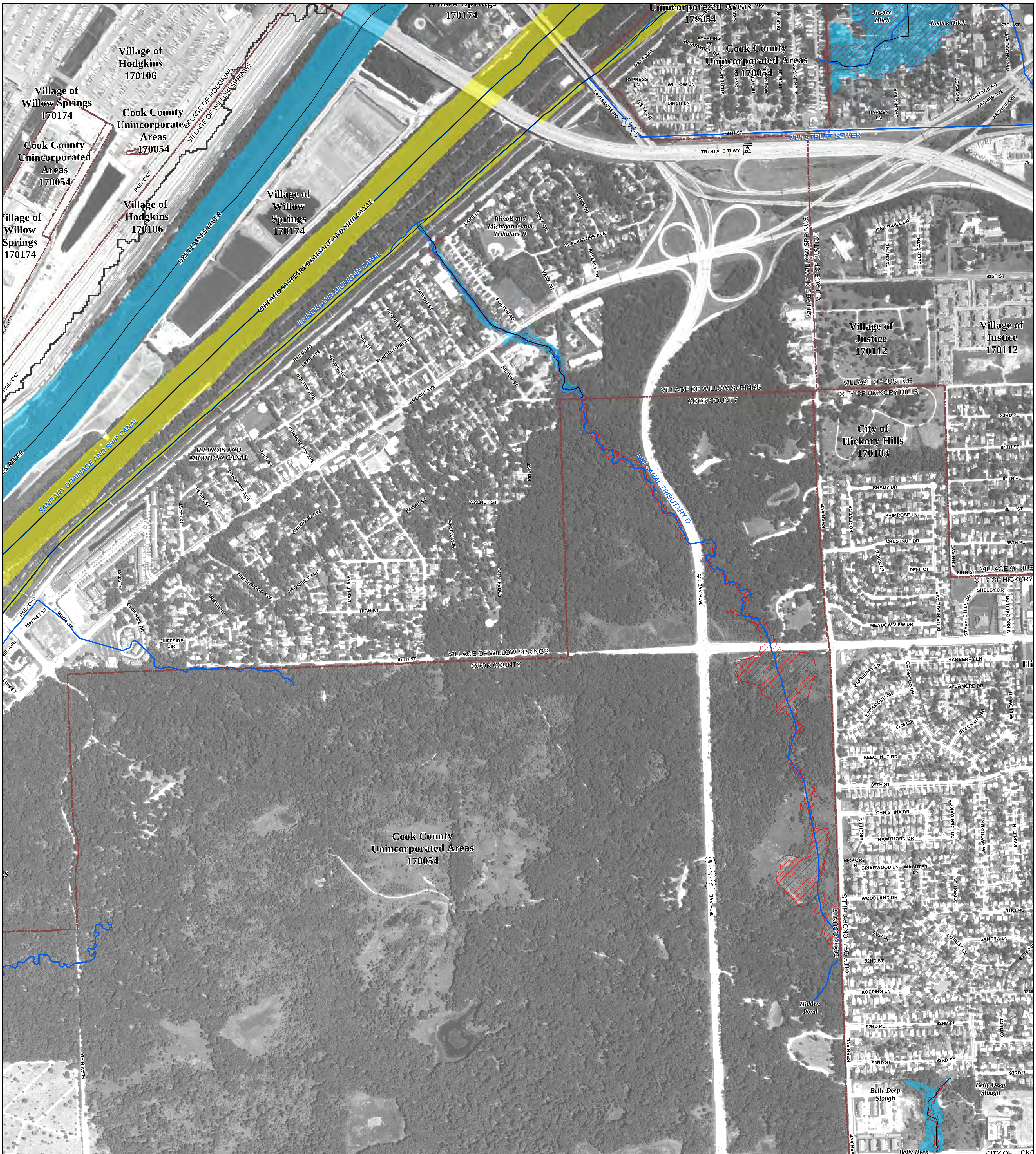


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

N

0 500 1,000

Feet

FIRM Panel: 17031C0601J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

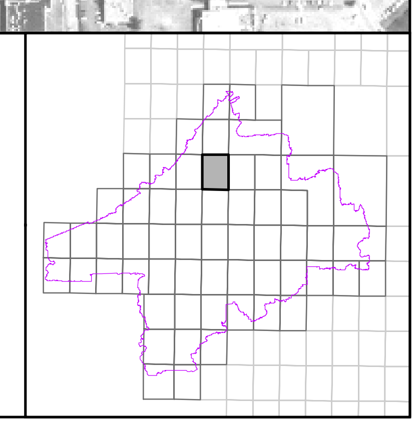
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

N

FIRM Panel: 17031C0602J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

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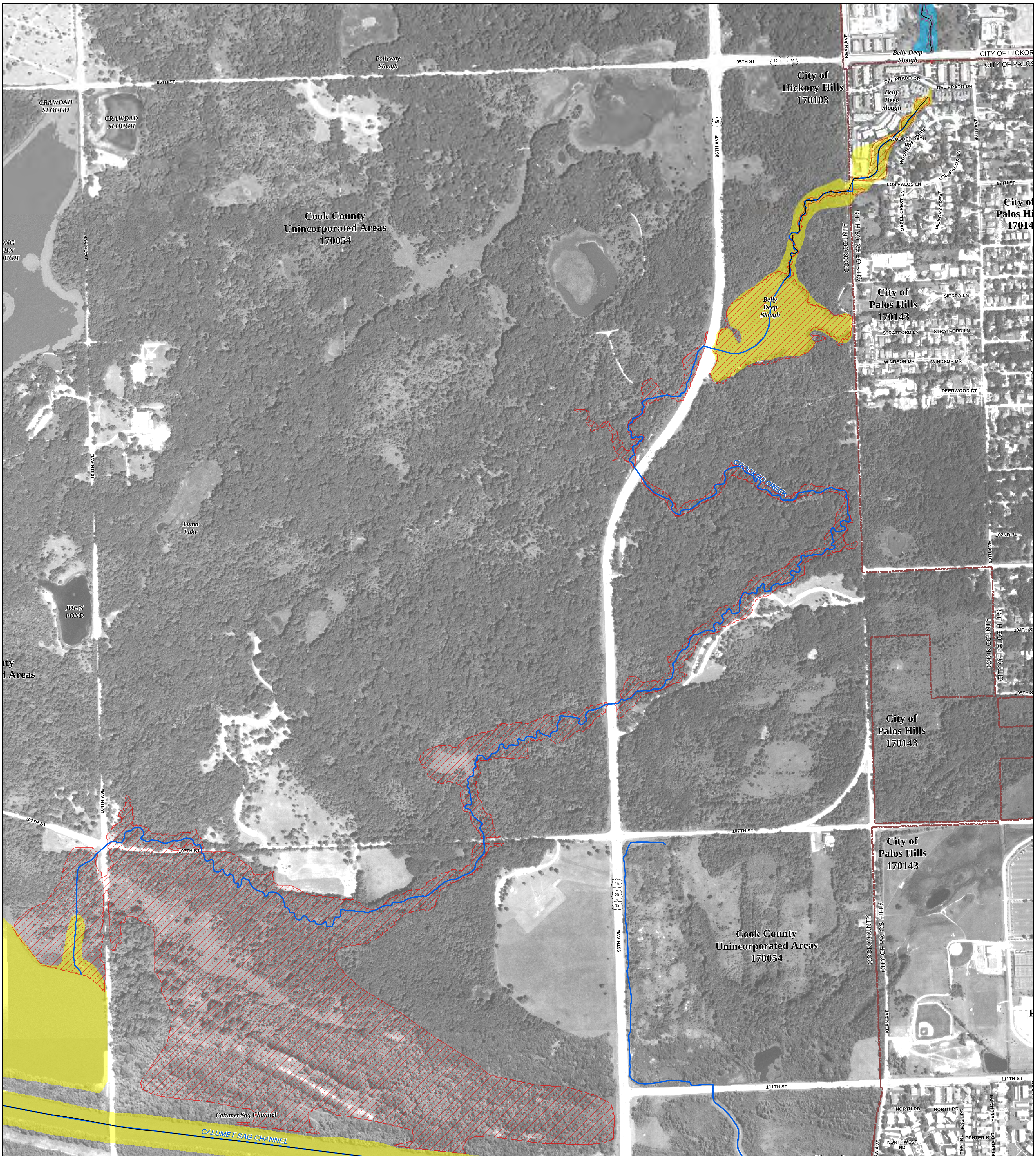


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

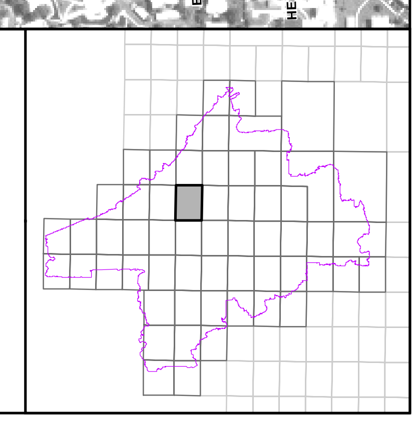
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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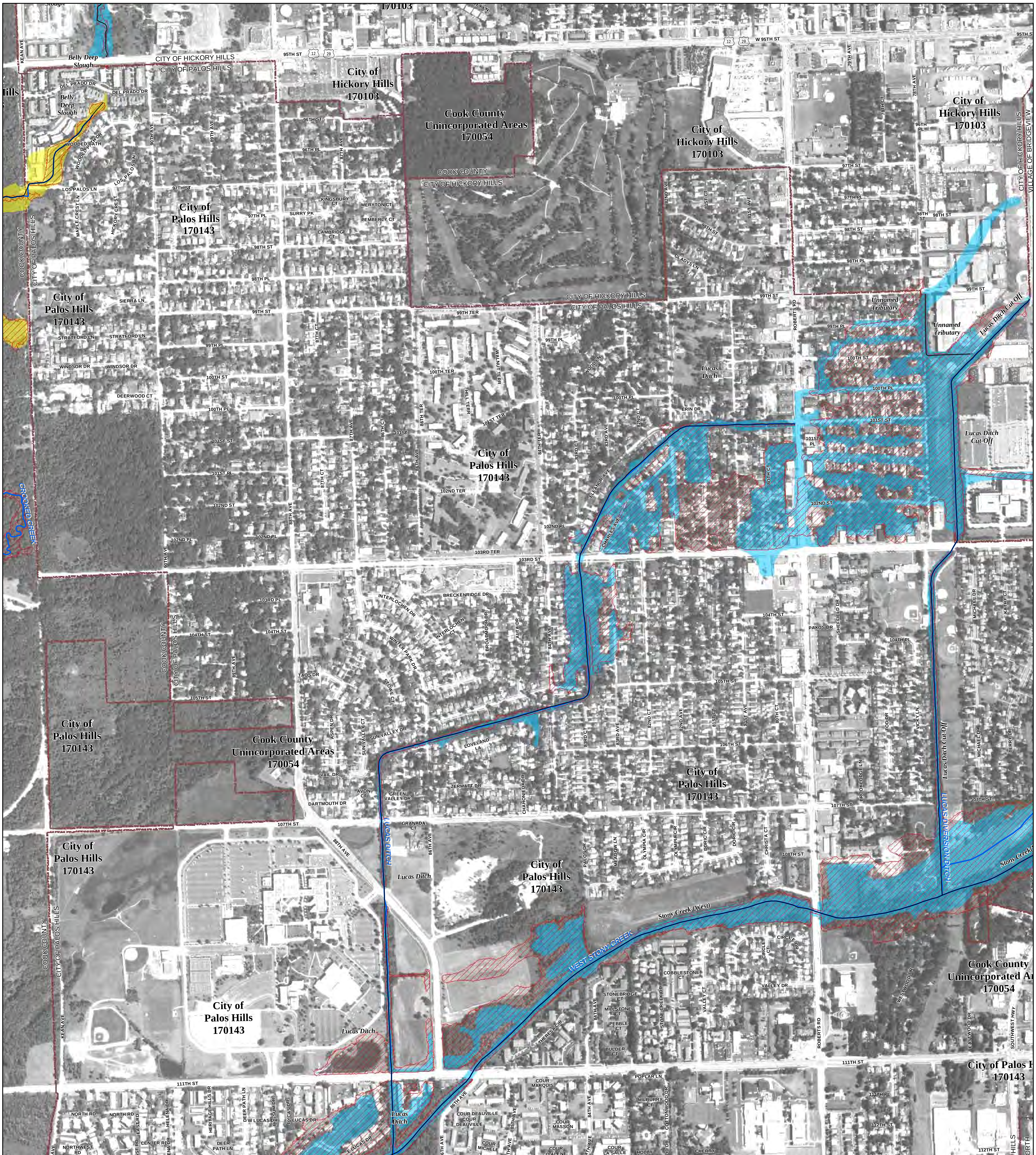
Feet

FIRM Panel: 17031C0603J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

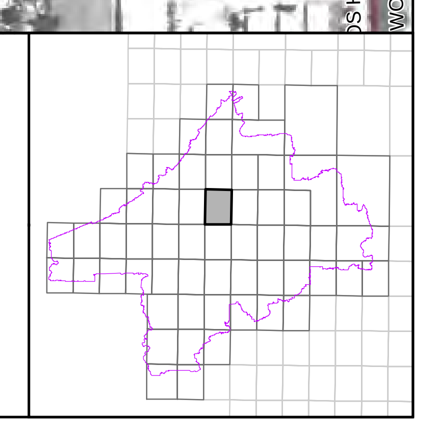
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0604J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

File Path: Q:\Project_Data\GIS\WorkingMaps\FEMA\Panels.mxd, Date: February 27, 2009 11:22:55 AM, User: KBUCKVOL

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

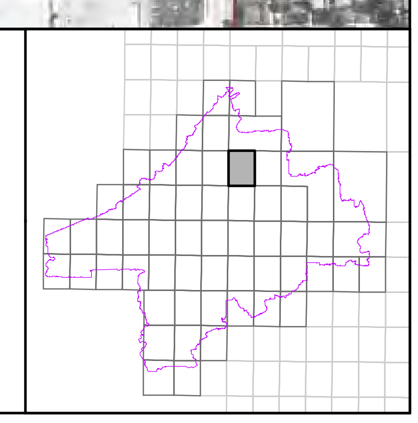
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

FIRM Panel: 17031C0606J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

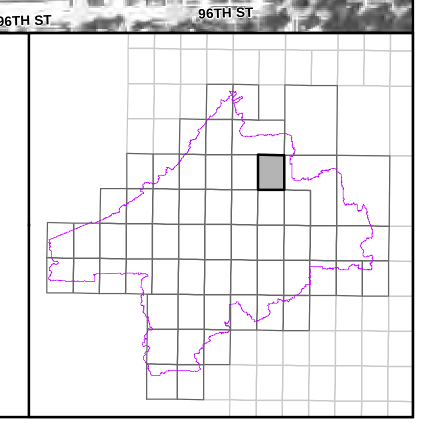
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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0 500 1,000

Feet

FIRM Panel: 17031C0607J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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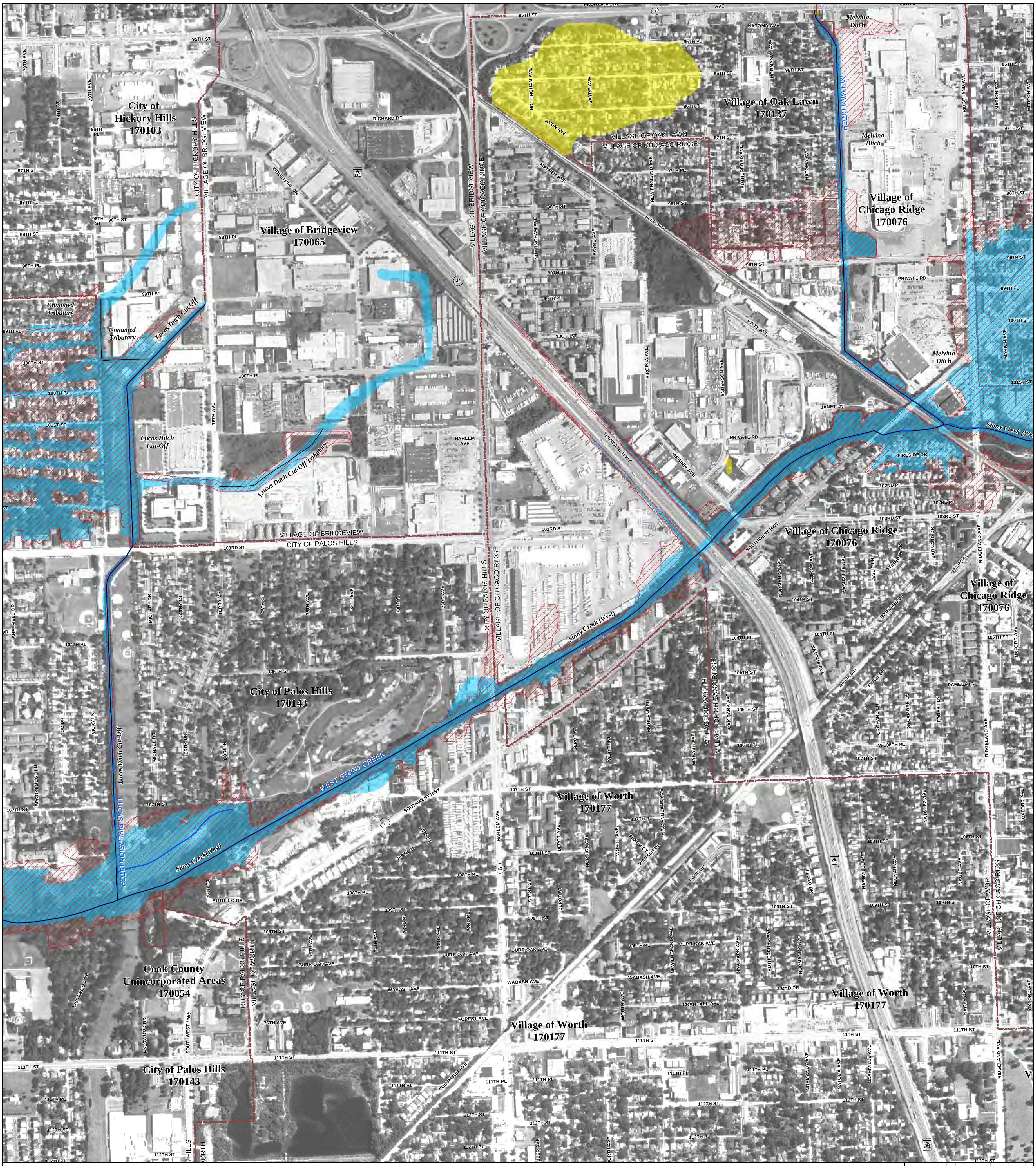
CH2MHILL



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

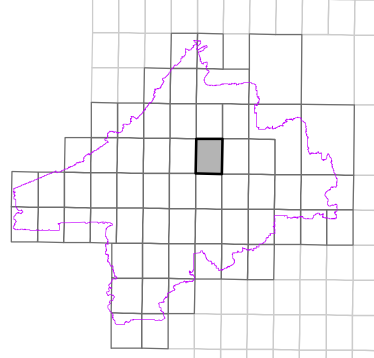
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Feet

N

FIRM Panel: 17031C0608J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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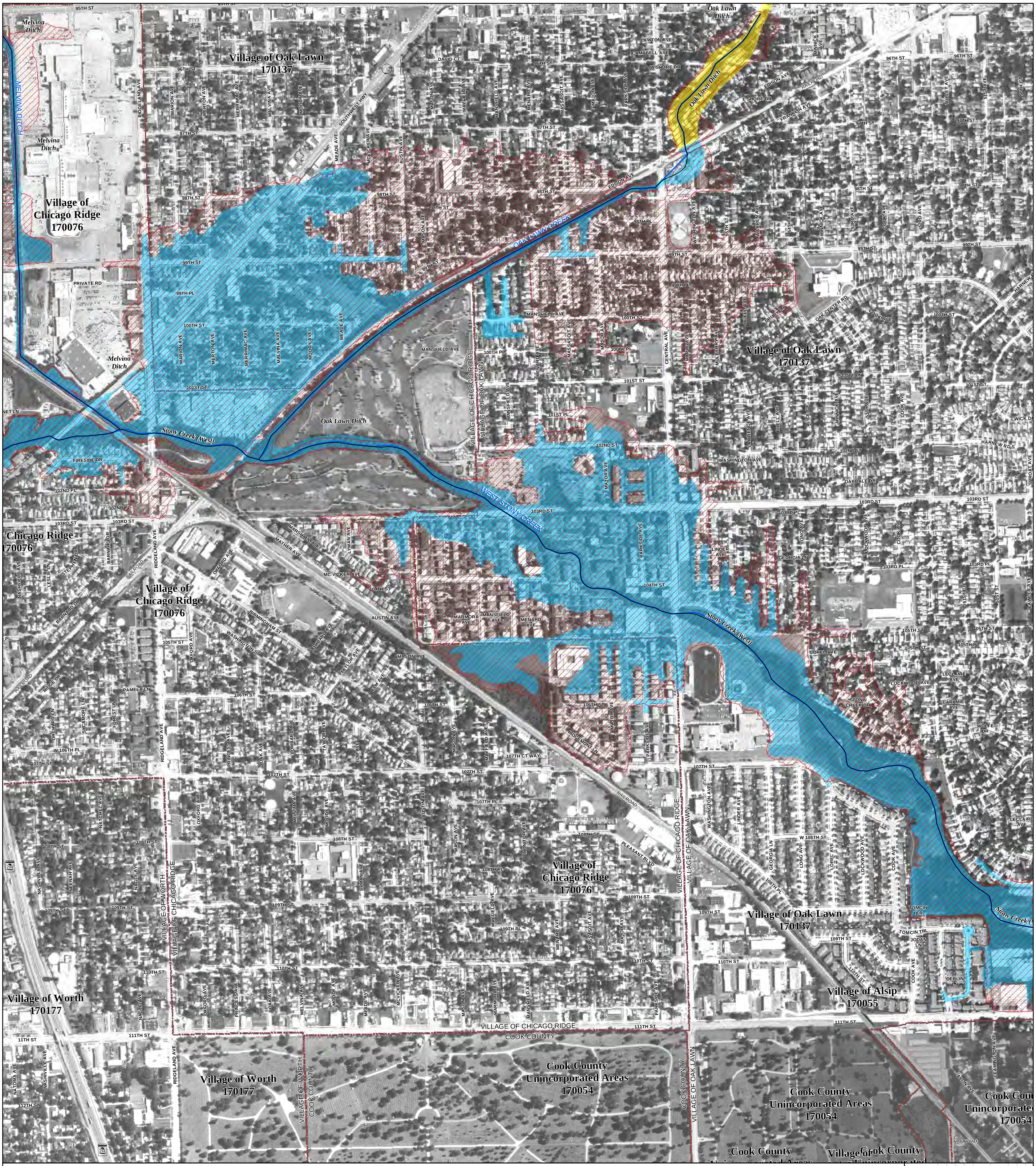


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

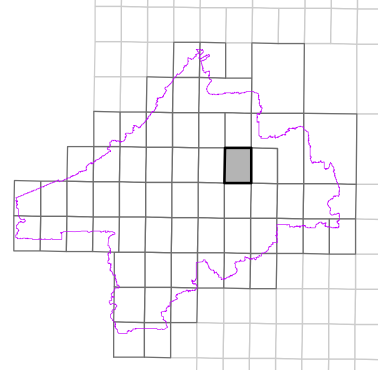
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



N

0 500 1,000

Feet

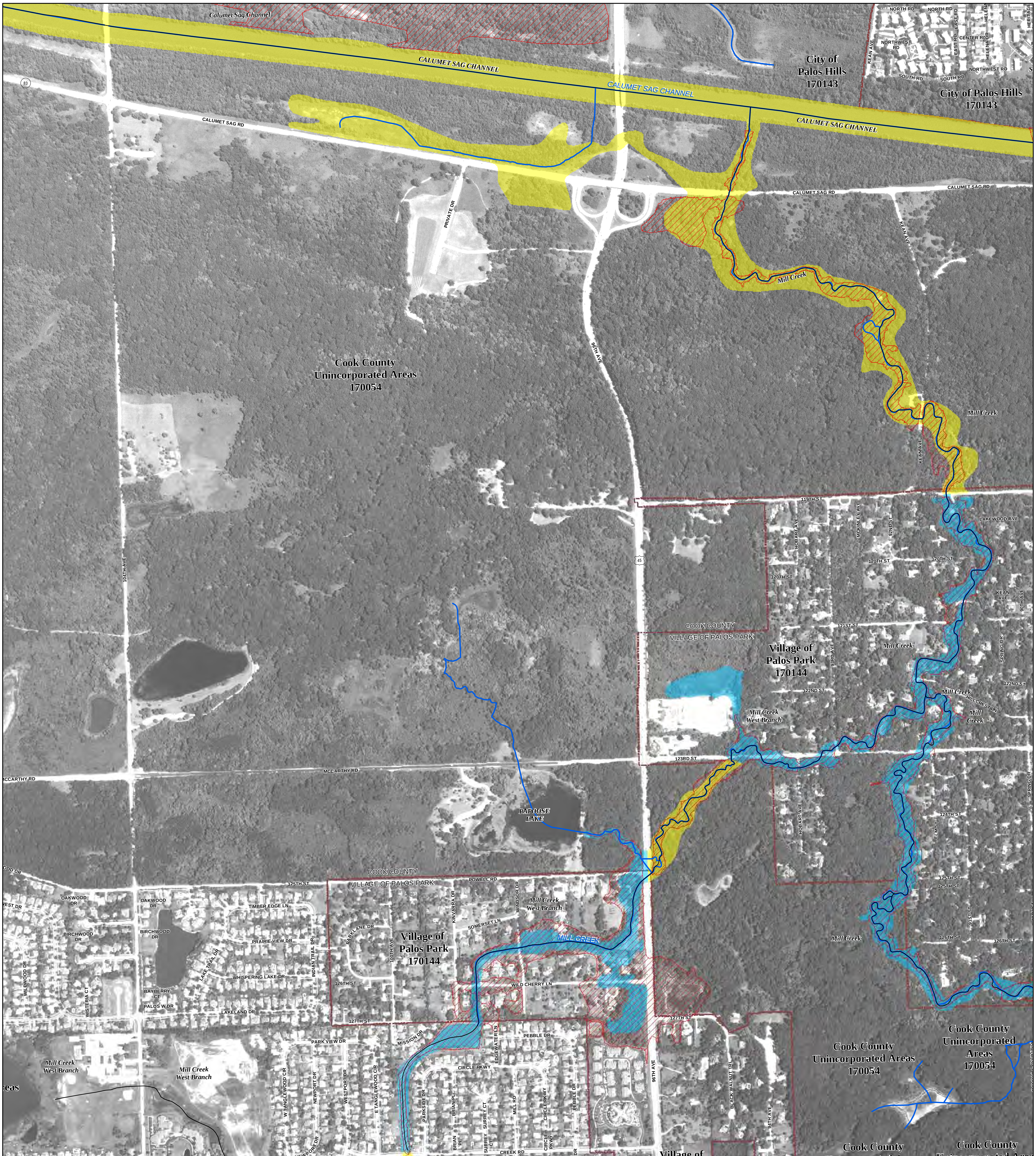
FIRM Panel: 17031C0609J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

File Path: Q:\Project_Data\GIS\WorkingMaps\FEMA\Panels.mxd, Date: February 27, 2009 11:22:55 AM, User: KBUCKVOL



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

0 500 1,000

Feet

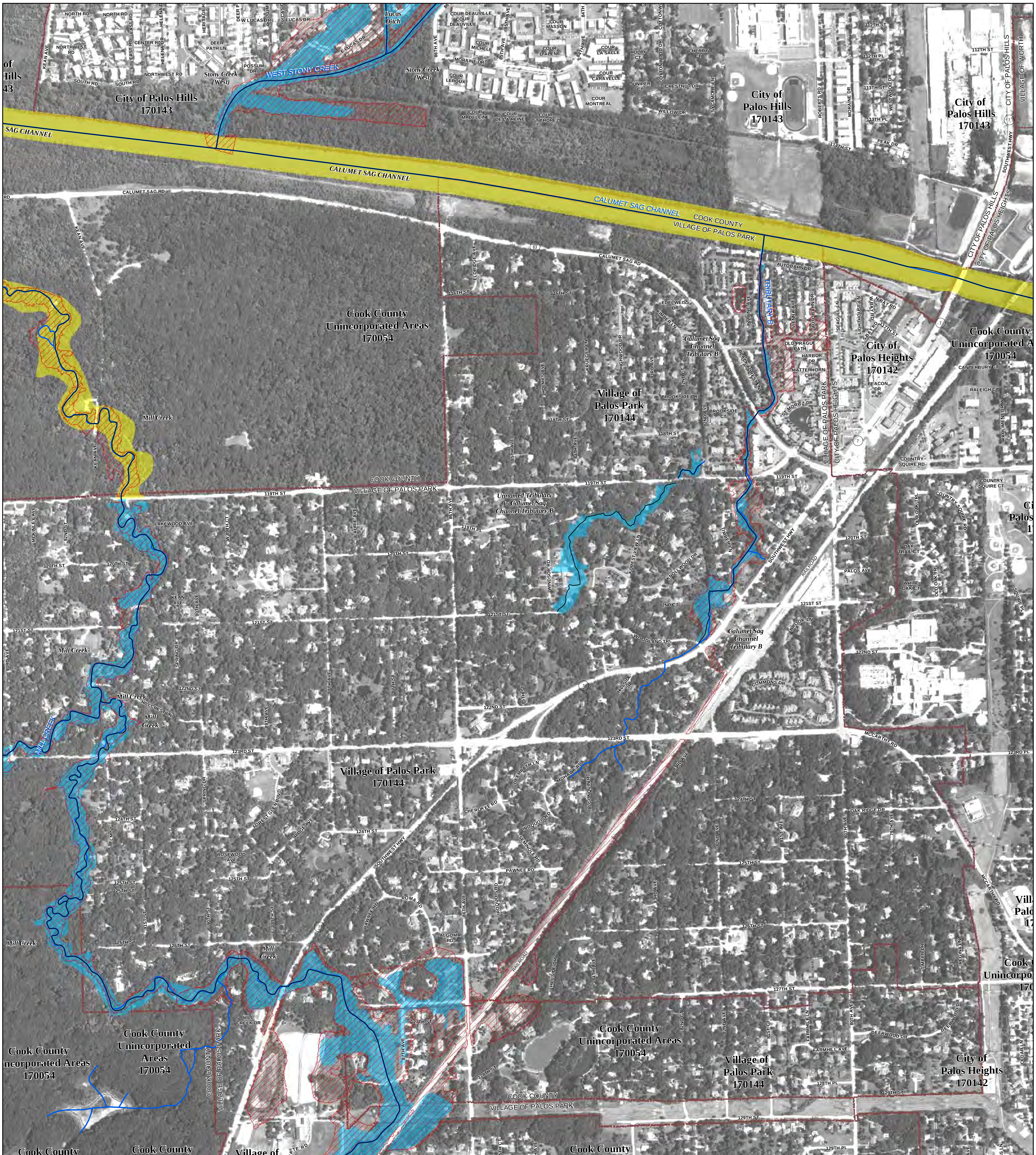
N

FIRM Panel: 17031C0611J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

N

0 500 1,000

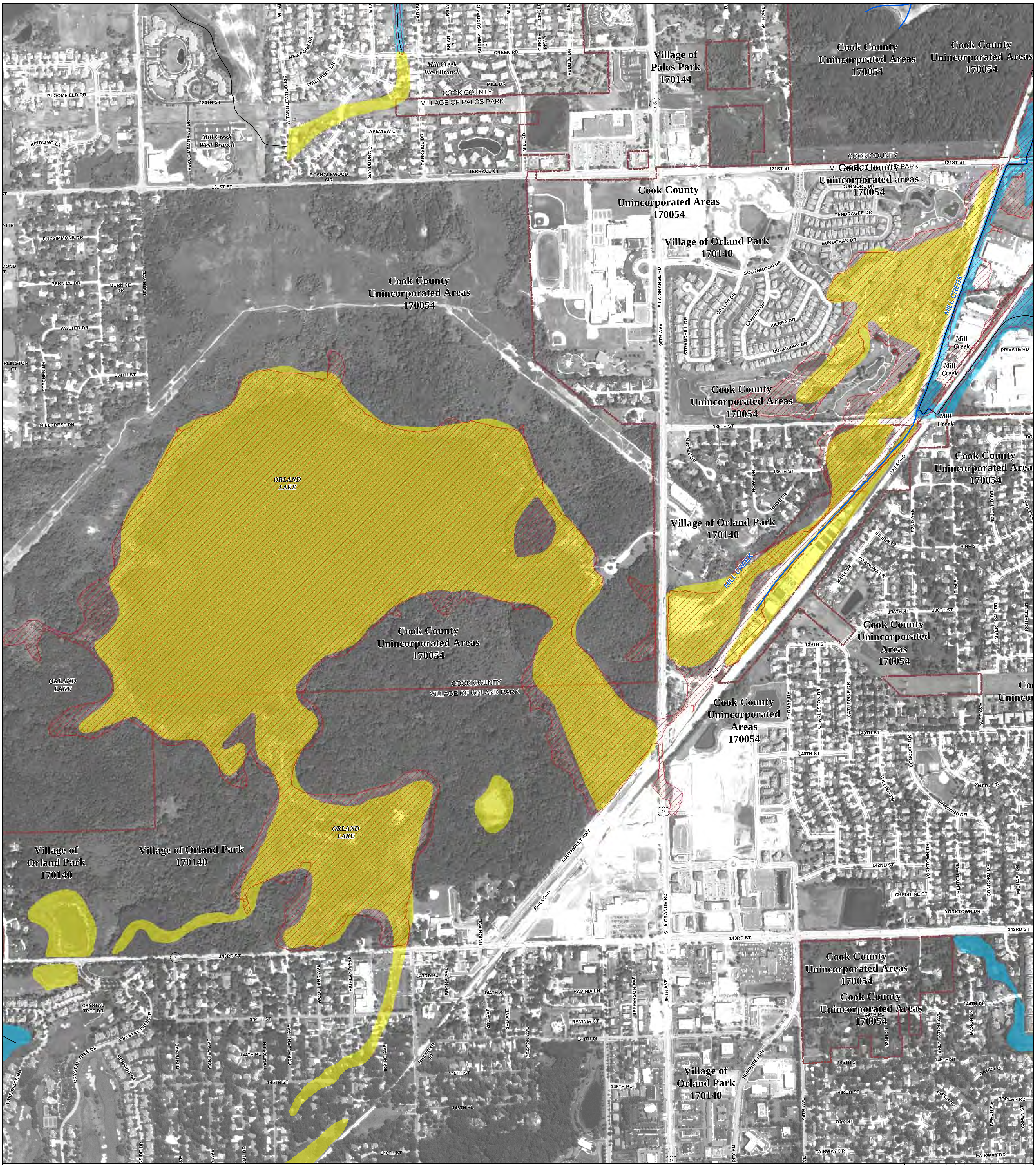
Feet

FIRM Panel: 17031C0612J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL



LEGEND

- DWP 100-year Inundation Area
- **FEMA Floodplain**
- Zone A, AH and AO
- Zone AE
- Calumet-Sag Watershed Boundary
- River/Stream
- Municipal Boundary
- Cook County Boundary

N

0 500 1,000

Feet

FIRM Panel: 17031C0613J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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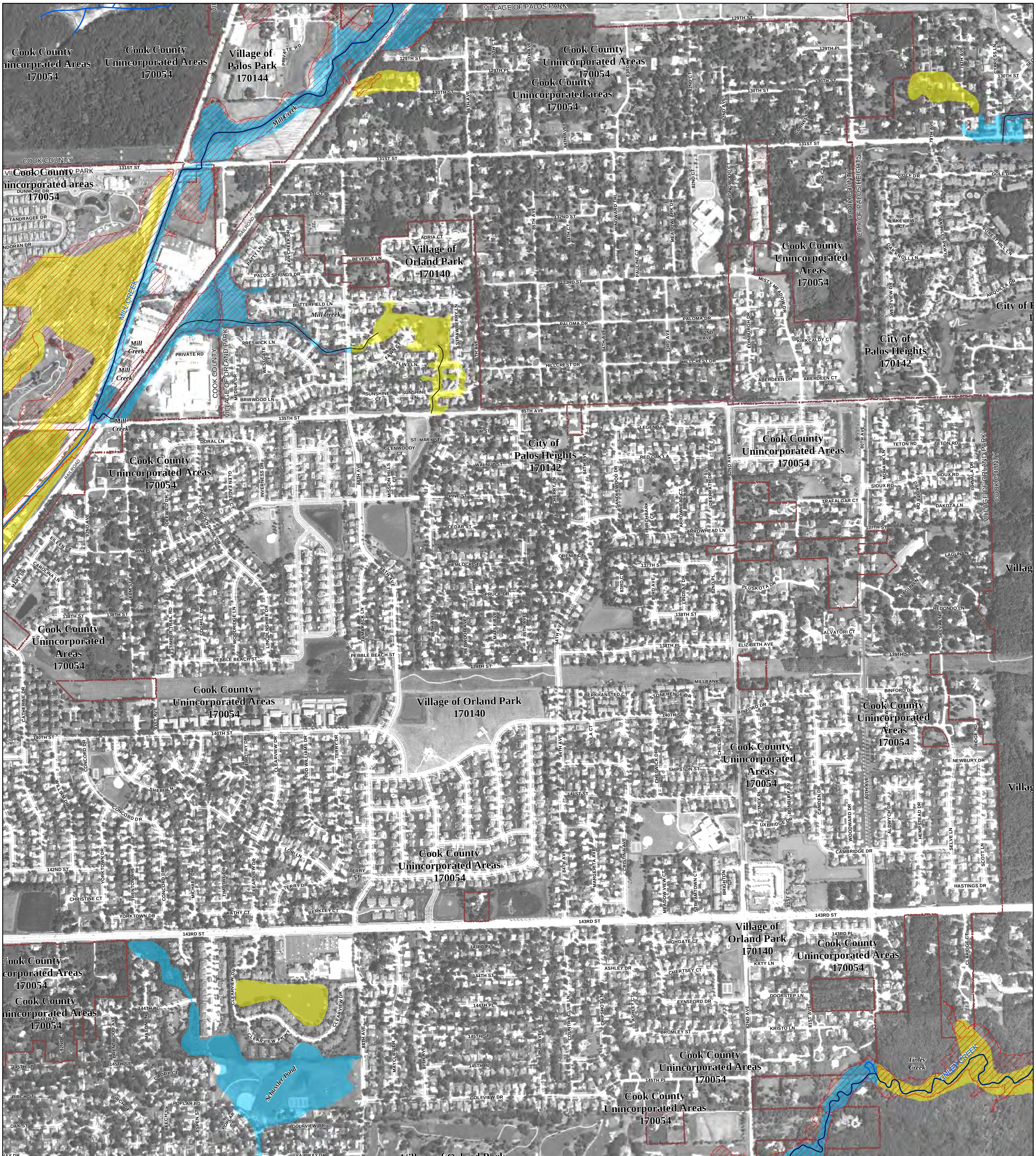
CH2MHILL

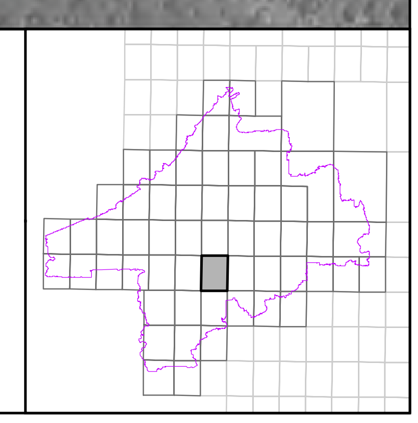


LEGEND

- DWP 100-year Inundation Area

FEMA Floodplain

- Zone A, AH and AO
- Zone AE
- Calumet-Sag Watershed Boundary
- River/Stream
- Municipal Boundary
- Cook County Boundary



N

0 500 1,000

Feet

FIRM Panel: 17031C0614J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

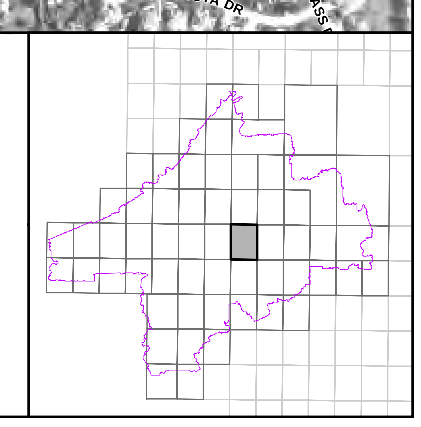
Calumet-Sag Detailed Watershed Plan

CH2MHILL

File Path: Q:\Project_Data\GIS\WorkingMaps\FEMA\Panels.mxd, Date: February 27, 2009 11:22:55 AM, User: KBUCKVOL

LEGEND

- DWP 100-year Inundation Area
- **FEMA Floodplain**
- Zone A, AH and AO
- Zone AE
- Calumet-Sag Watershed Boundary
- River/Stream
- Municipal Boundary
- Cook County Boundary



N

0 500 1,000

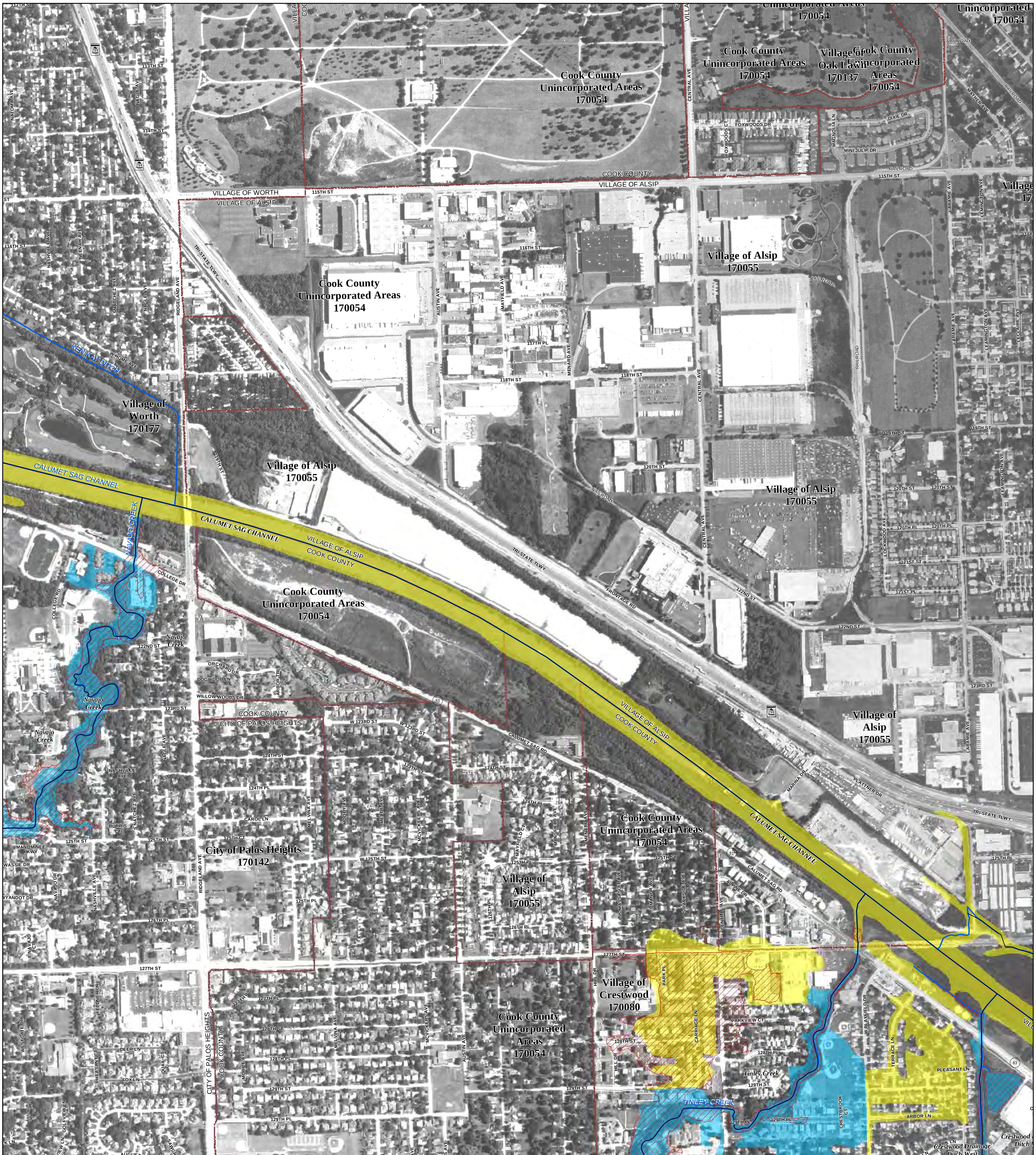
Feet

FIRM Panel: 17031C0616J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

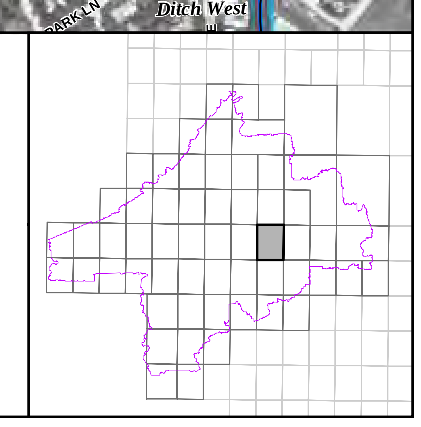
Calumet-Sag Detailed Watershed Plan

CH2MHILL



LEGEND

- DWP 100-year Inundation Area
- **FEMA Floodplain**
- Zone A, AH and AO
- Zone AE
- Calumet-Sag Watershed Boundary
- River/Stream
- Municipal Boundary
- Cook County Boundary



N

0 500 1,000

Feet

FIRM Panel: 17031C0617J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

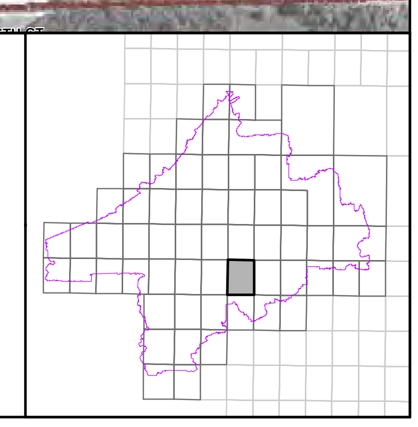
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



0 500 1,000

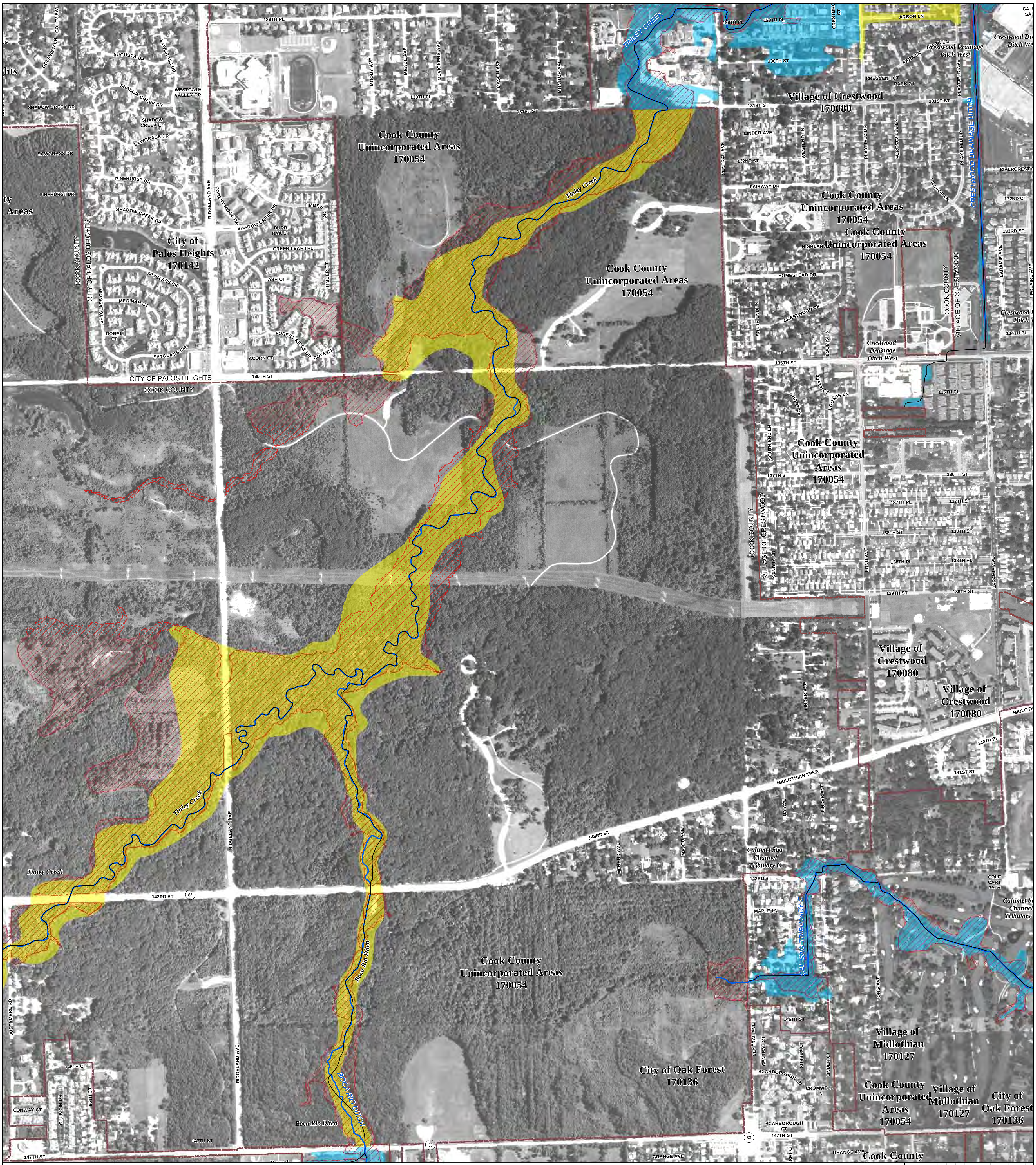
Feet

FIRM Panel: 17031C0618J

Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

CH2MHILL



LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

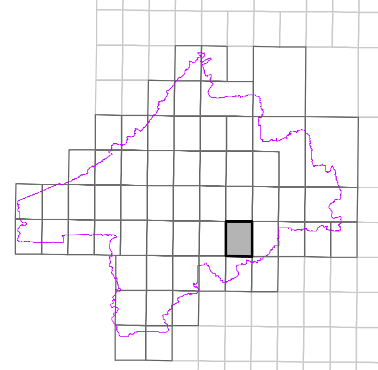
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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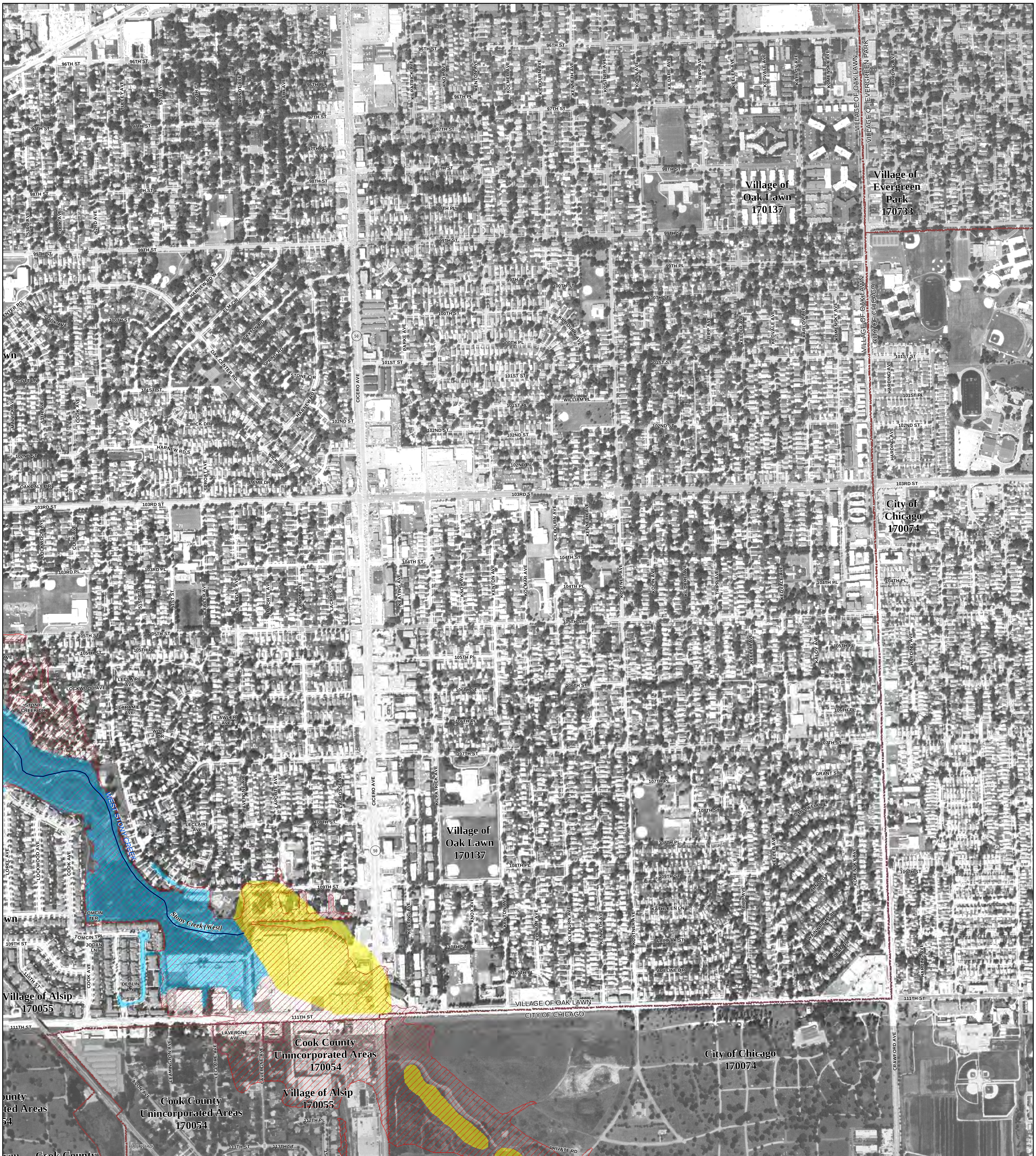
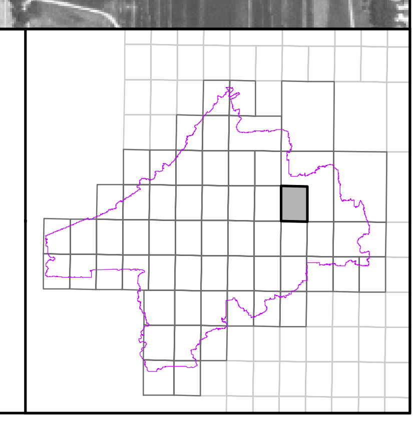


LEGEND

- DWP 100-year Inundation Area
- **FEMA Floodplain**
- Zone A, AH and AO
- Zone AE
- Calumet-Sag Watershed Boundary
- River/Stream
- Municipal Boundary
- Cook County Boundary



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Calumet-Sag Detailed Watershed Plan

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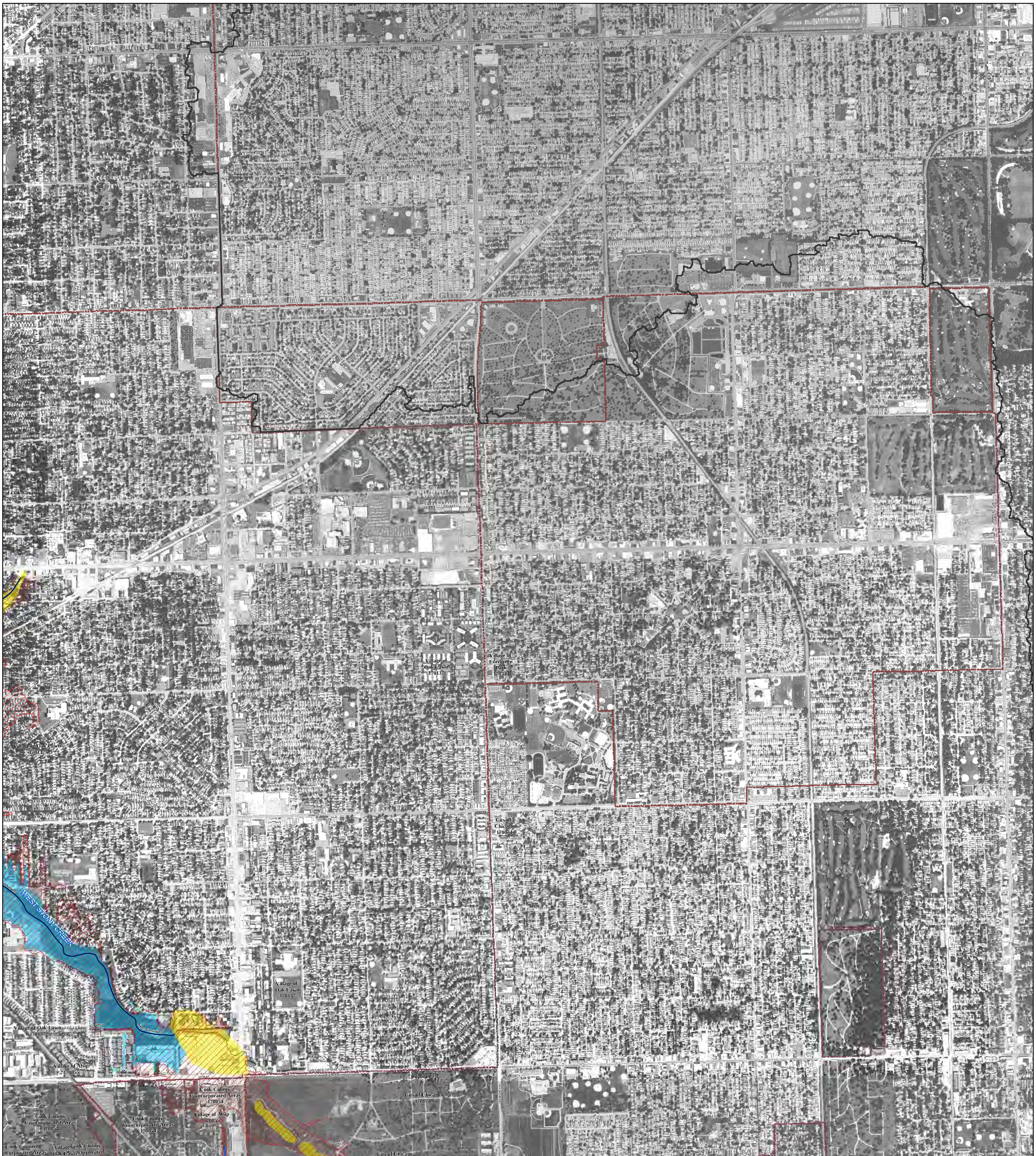


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

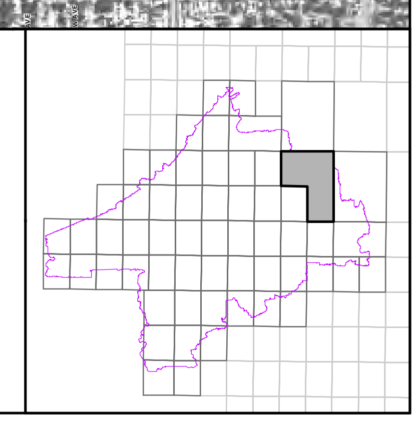
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

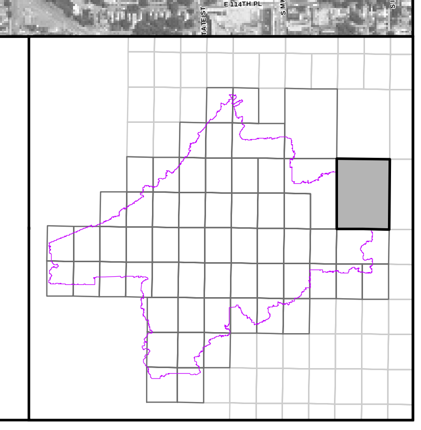
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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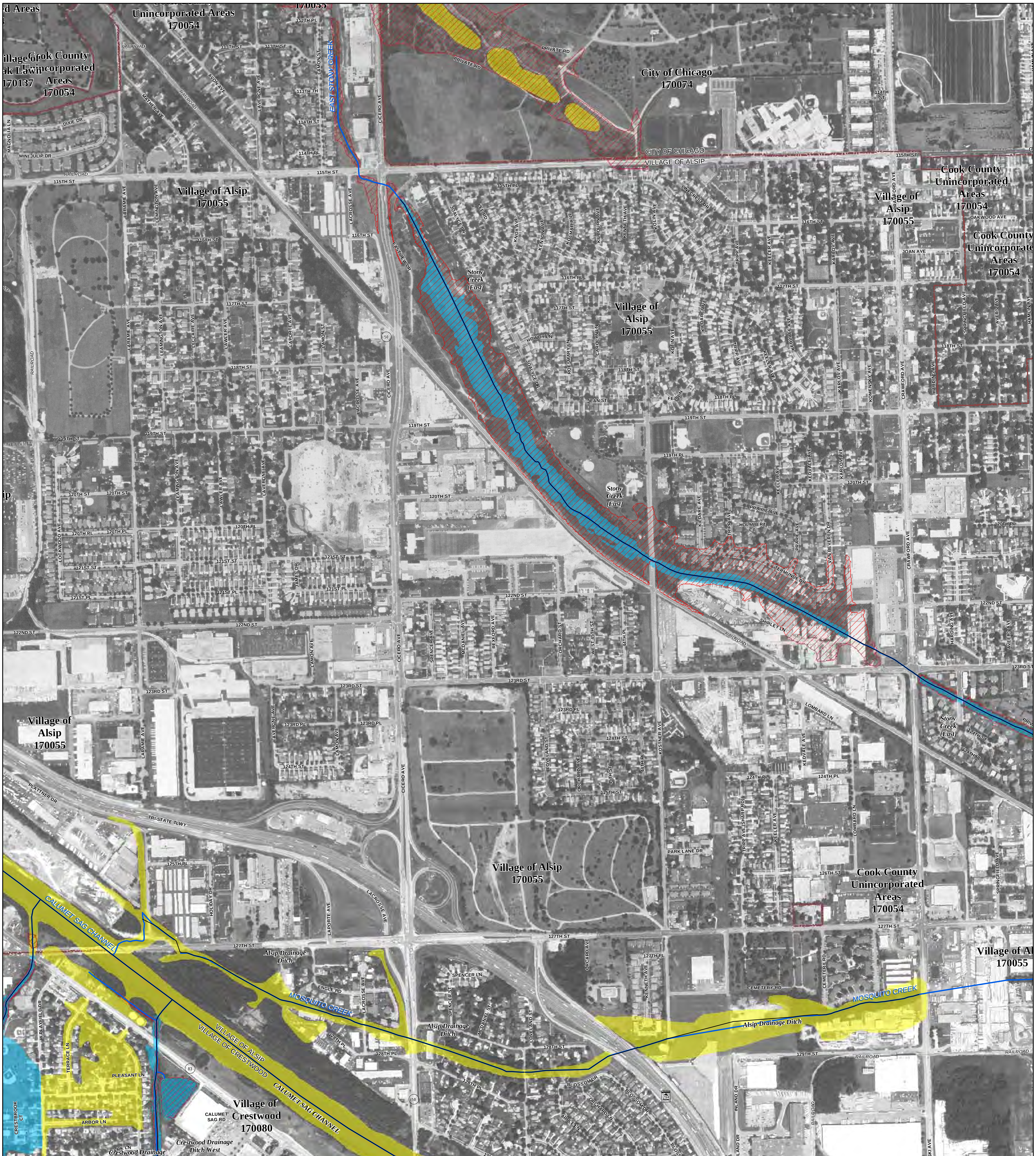

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

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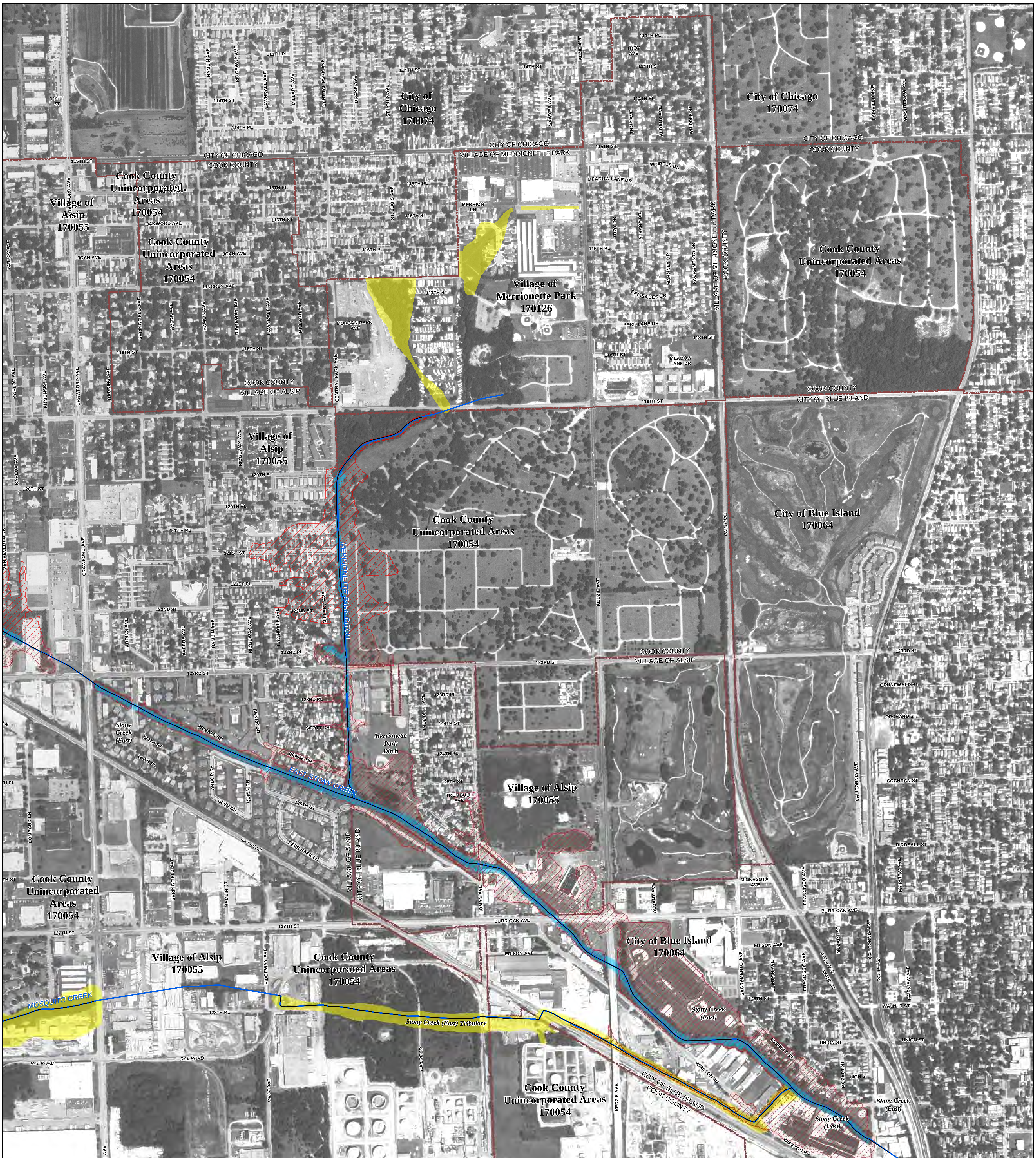


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

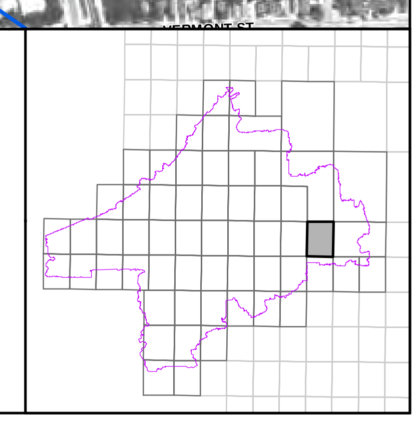
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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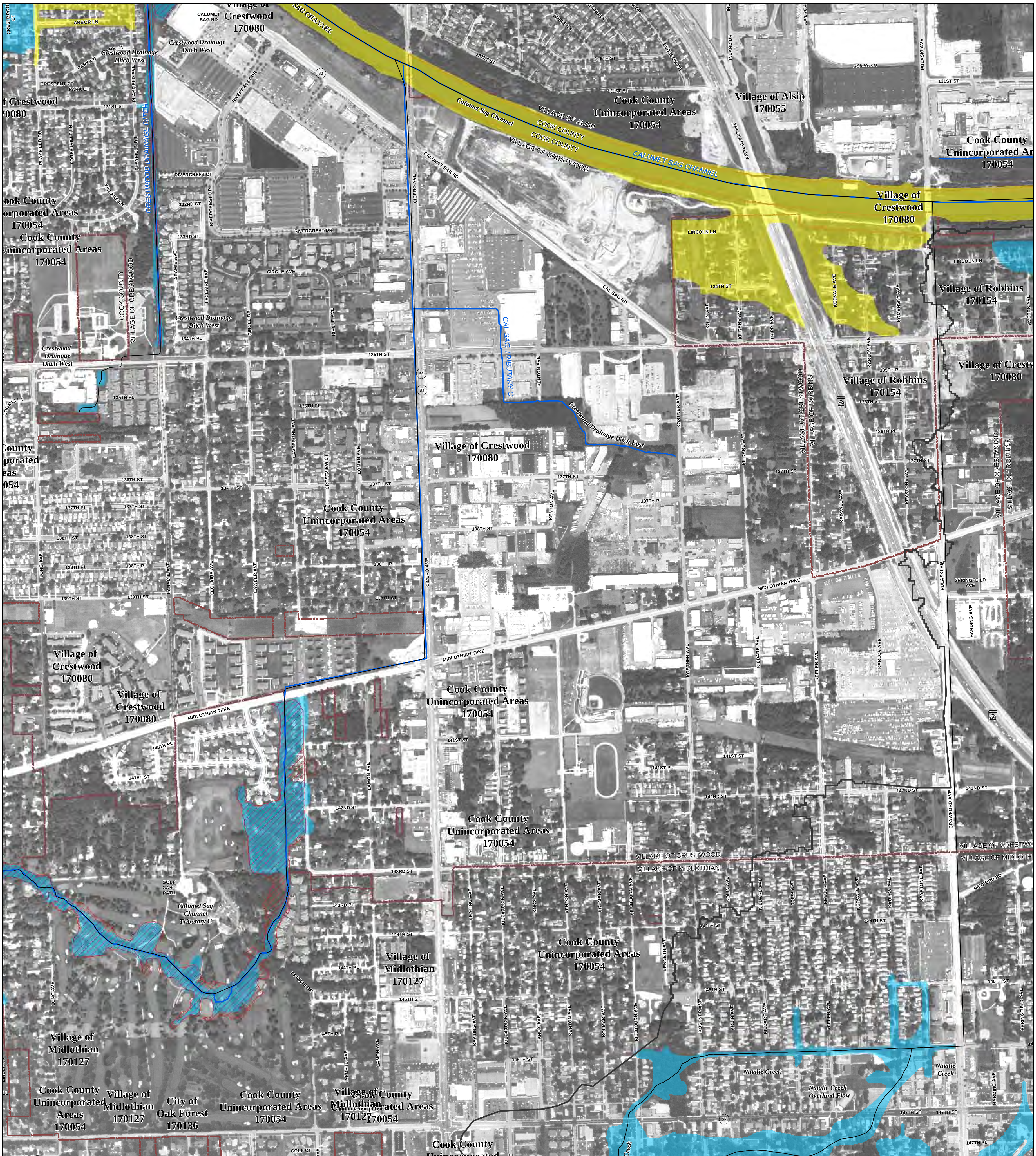


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

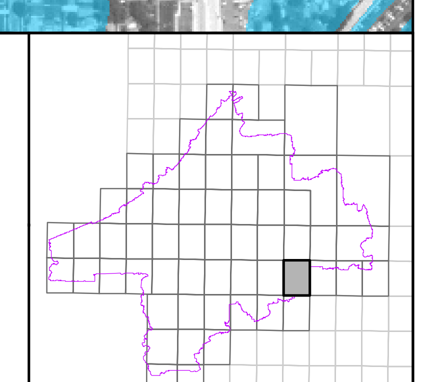
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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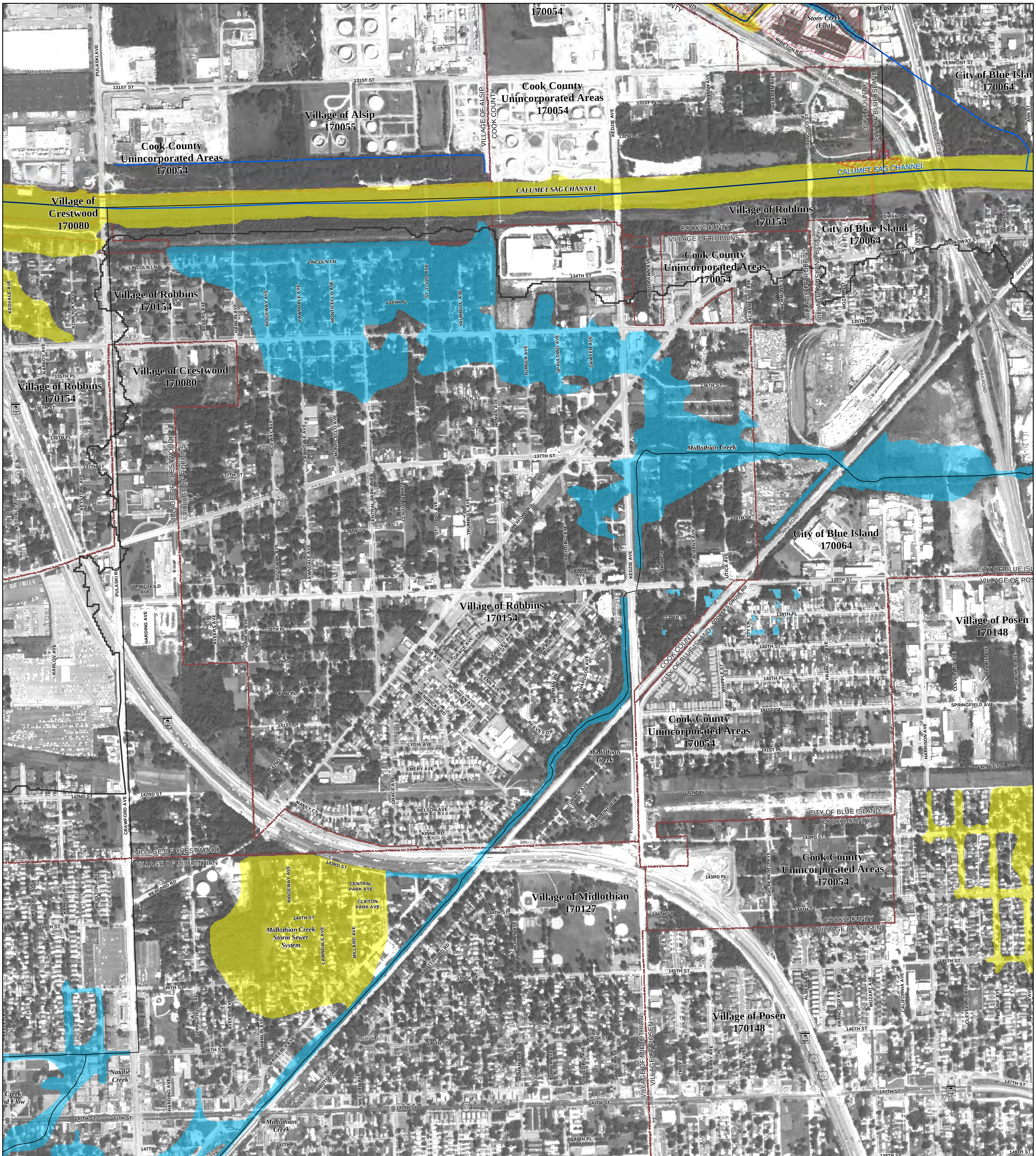

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

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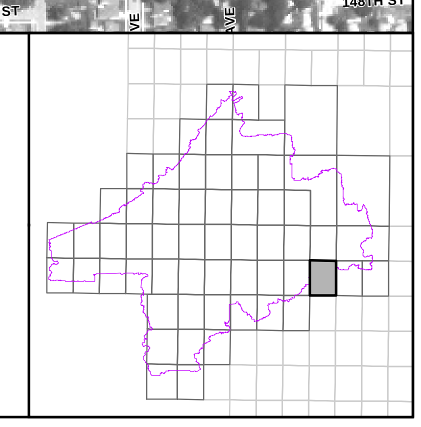
Cook County Boundary



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Calumet-Sag Detailed Watershed Plan

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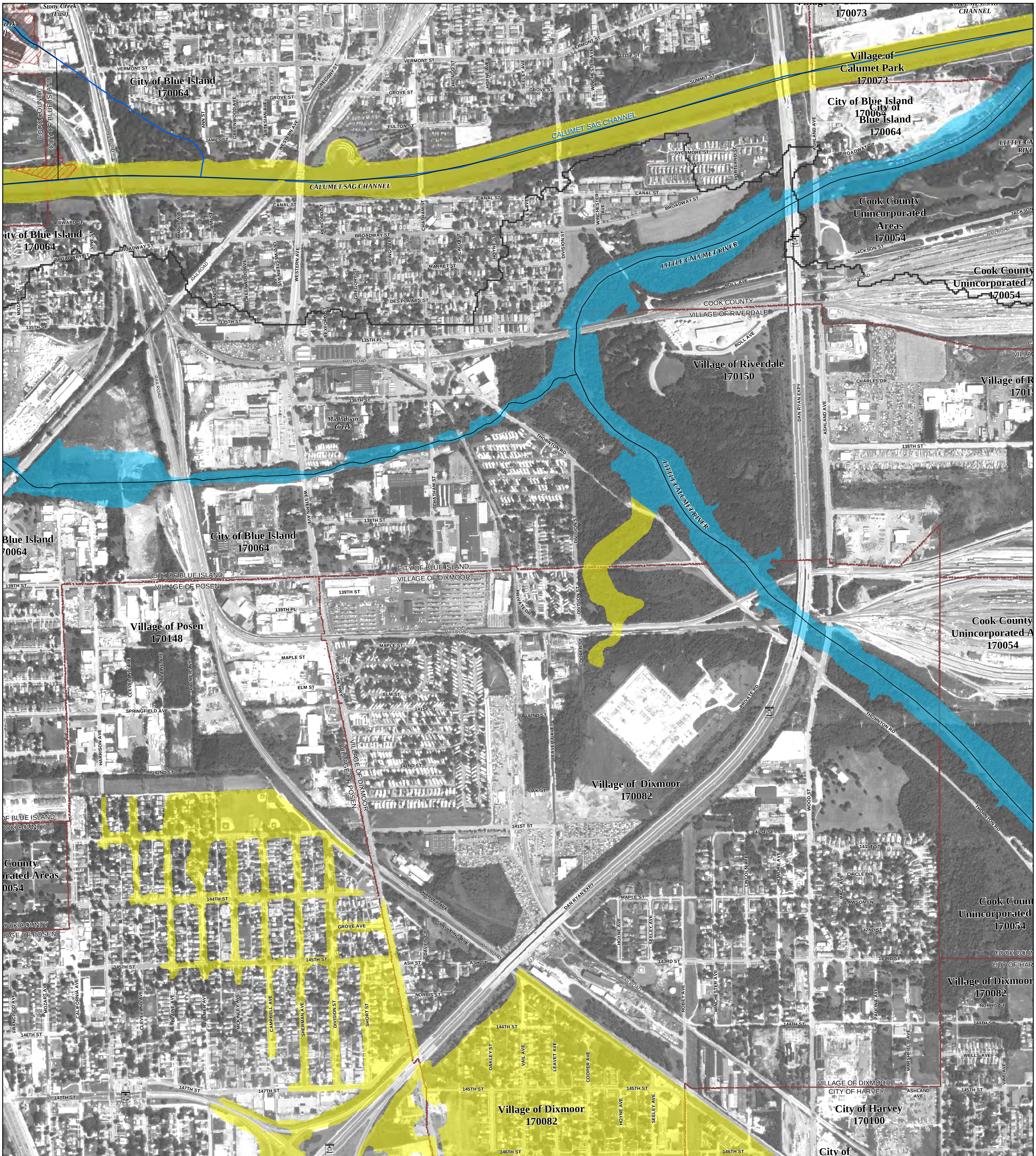


LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

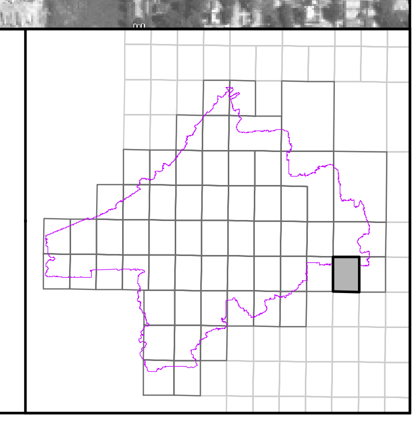
Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary



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Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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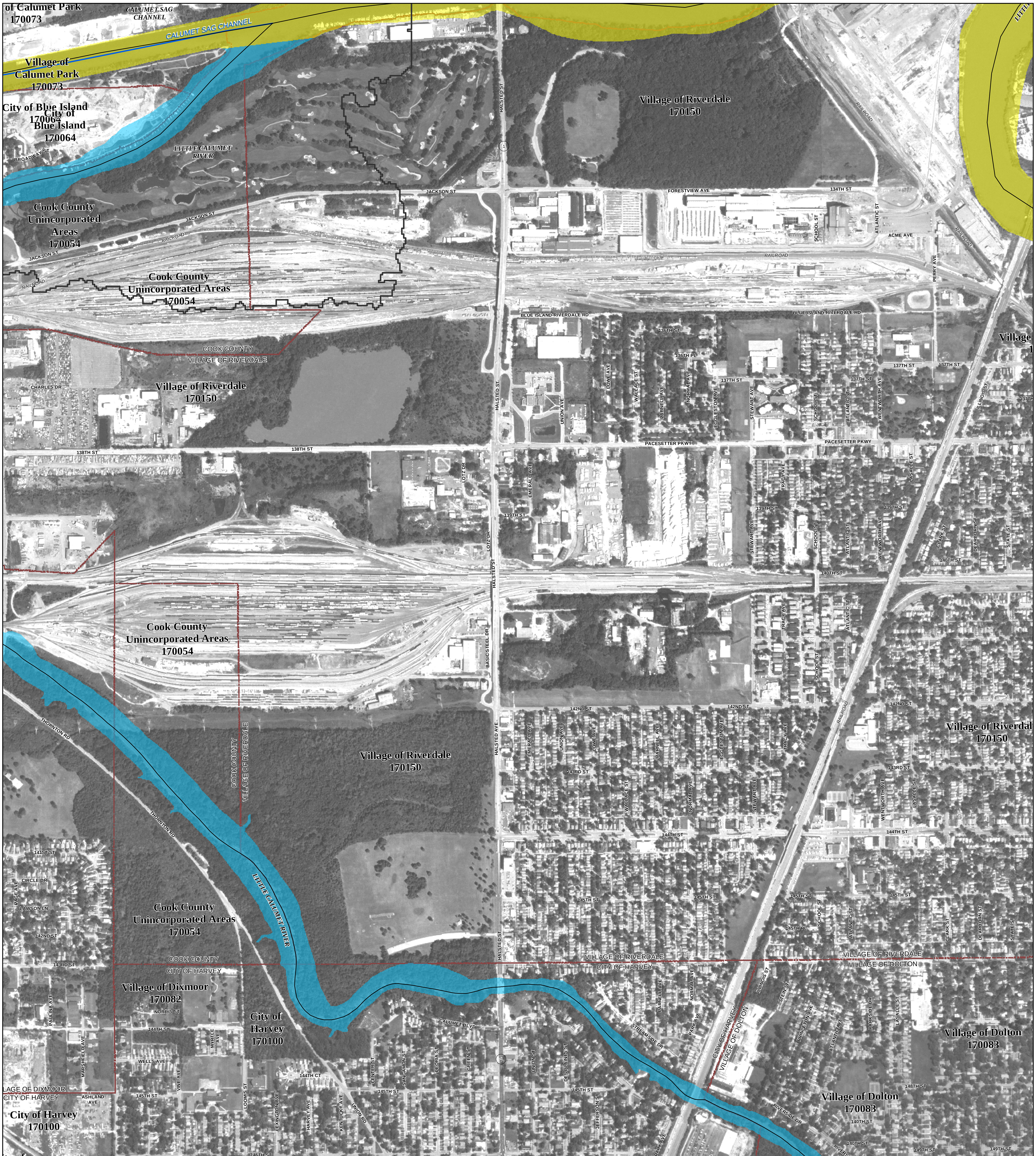

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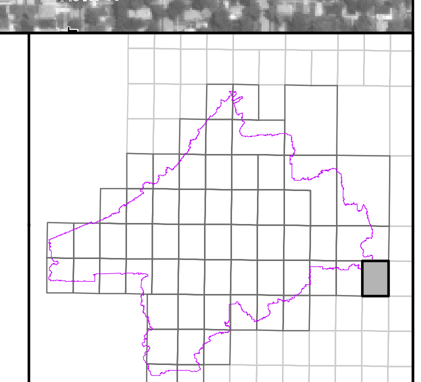

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Comparison of DWP 100-yr Inundation Mapping and FEMA Effective FIRM Revised 10/19/2008

Calumet-Sag Detailed Watershed Plan

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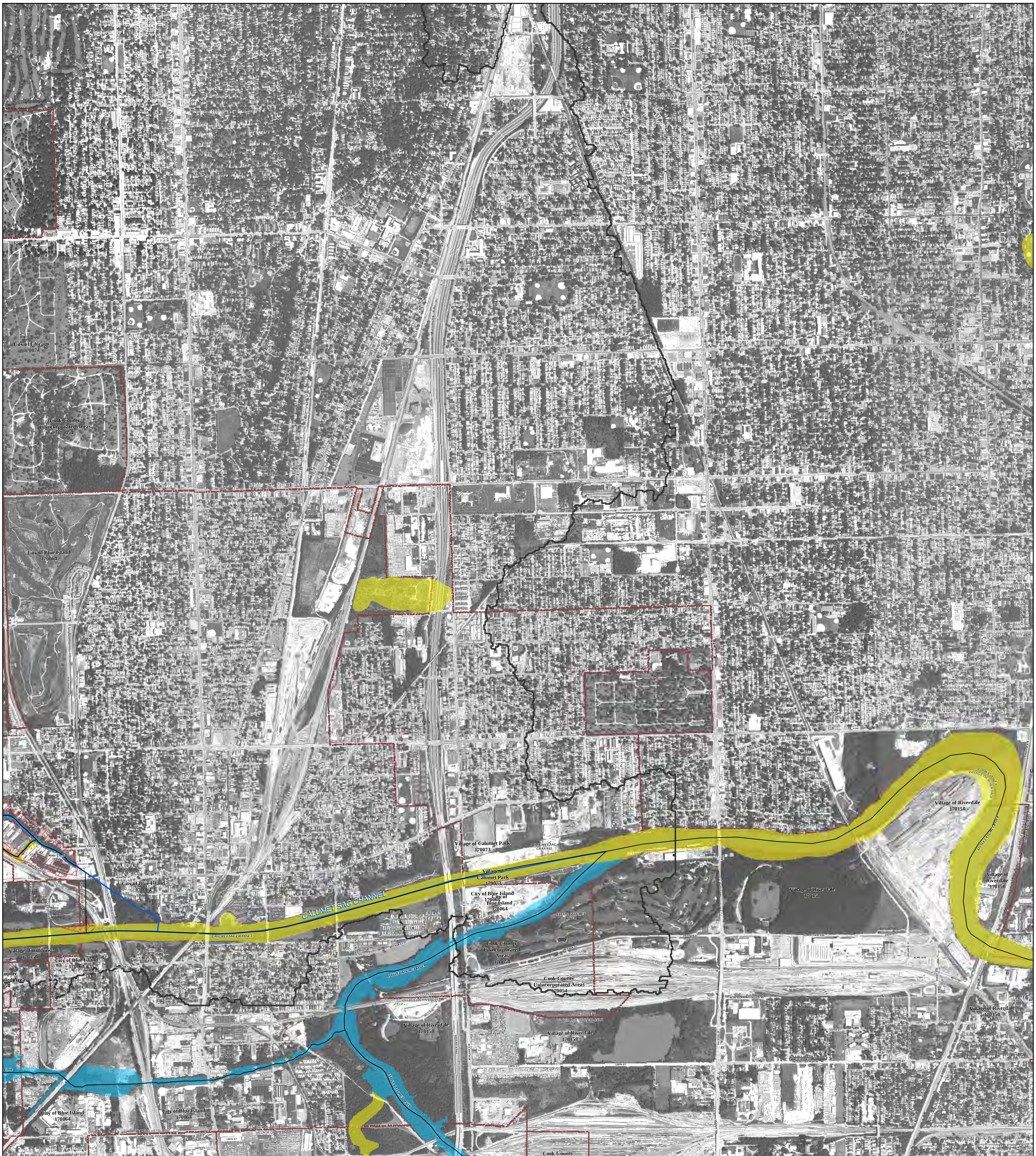

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

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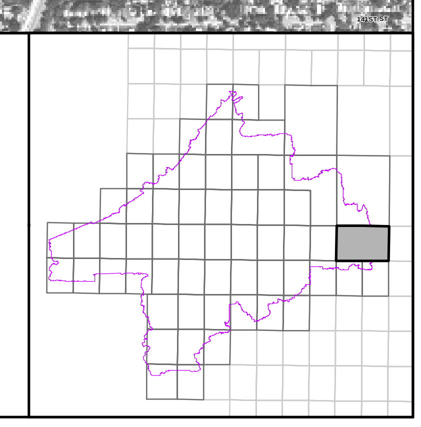

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Calumet-Sag Detailed Watershed Plan

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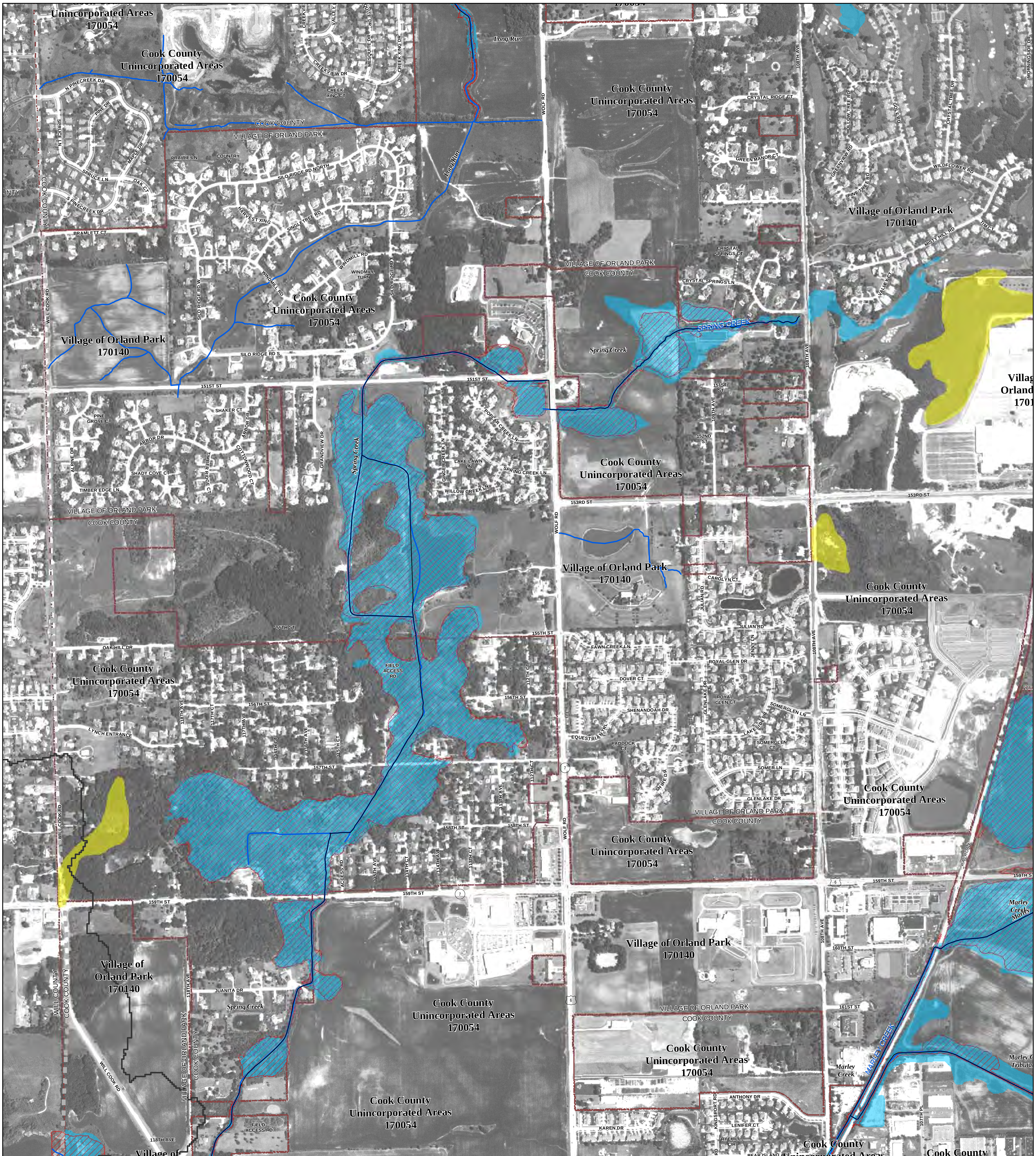

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

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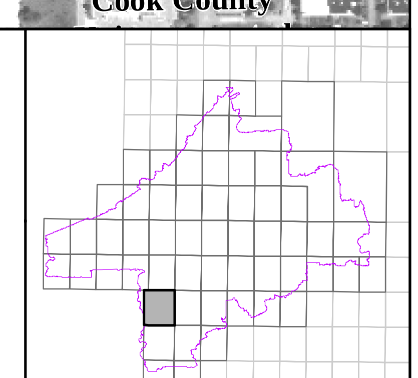

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Calumet-Sag Detailed Watershed Plan

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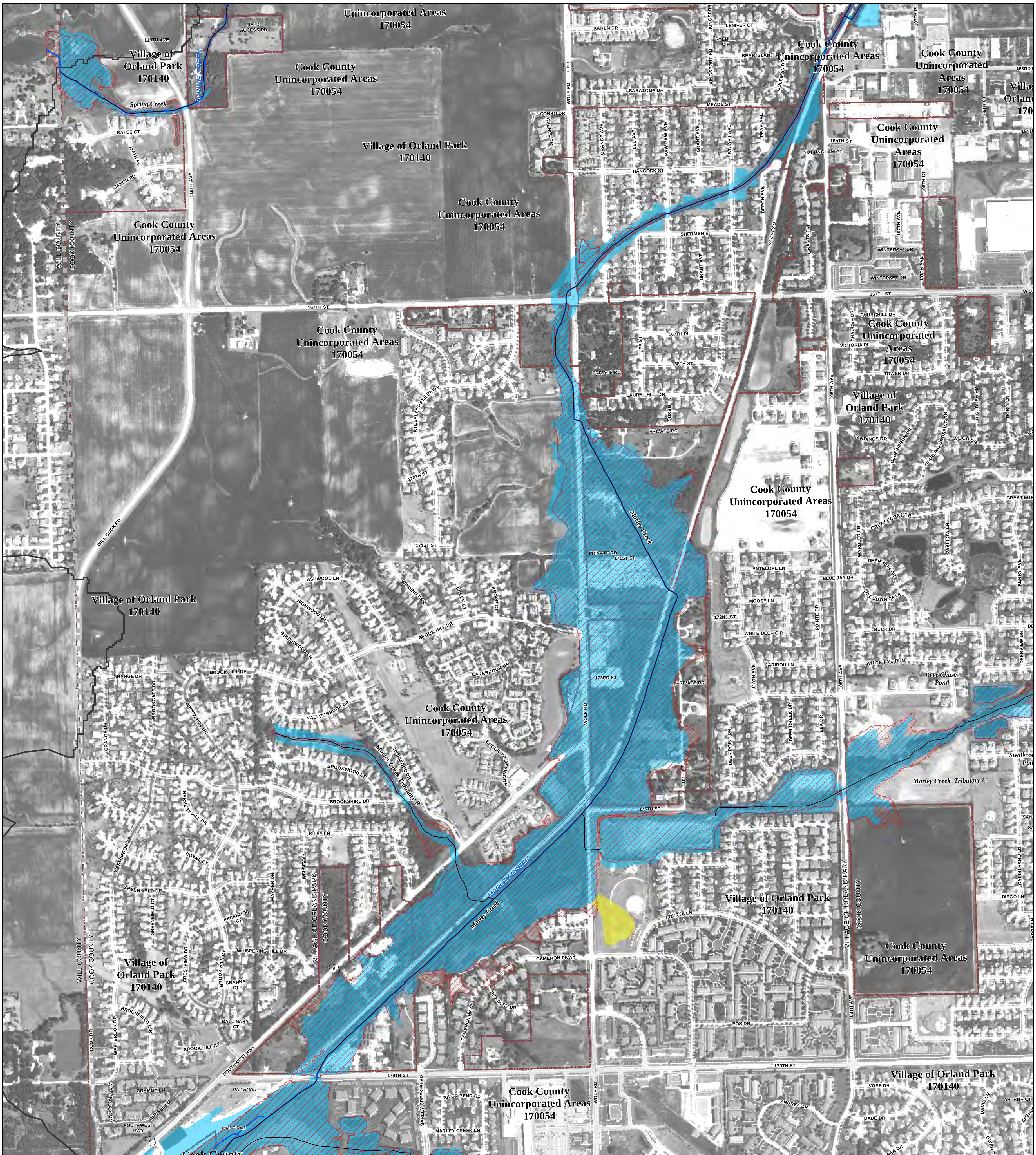

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

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Calumet-Sag Watershed Boundary

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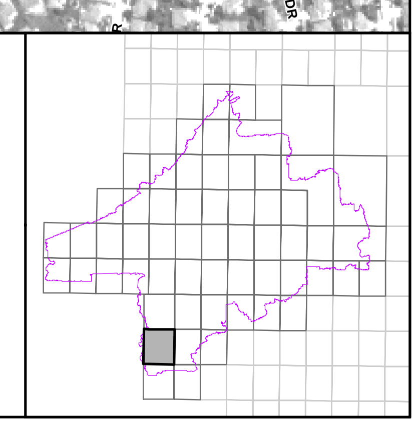

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

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Calumet-Sag Watershed Boundary

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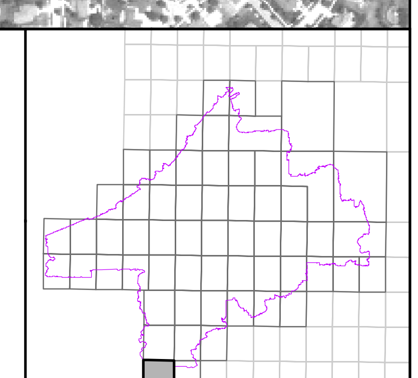
Cook County Boundary



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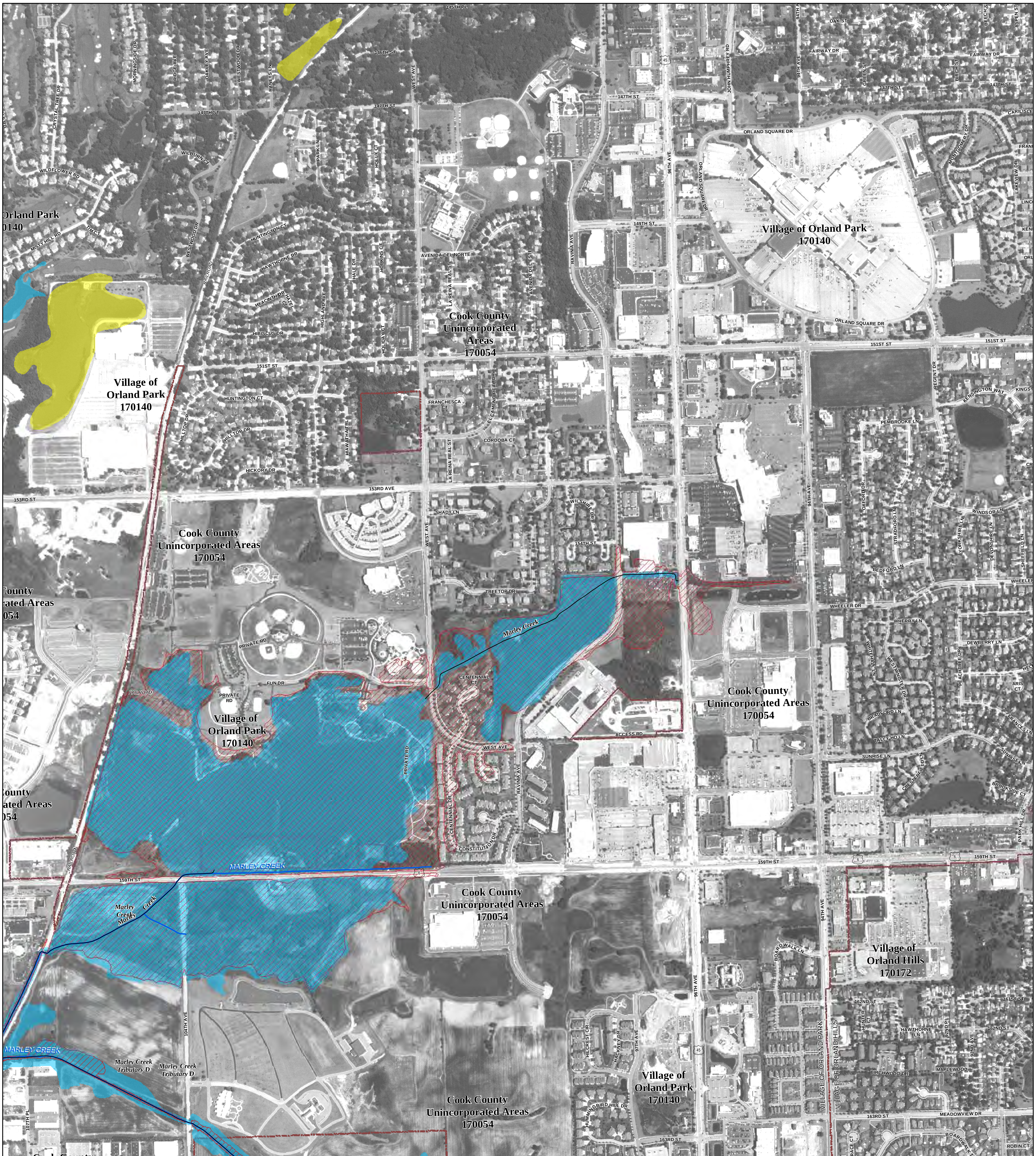

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

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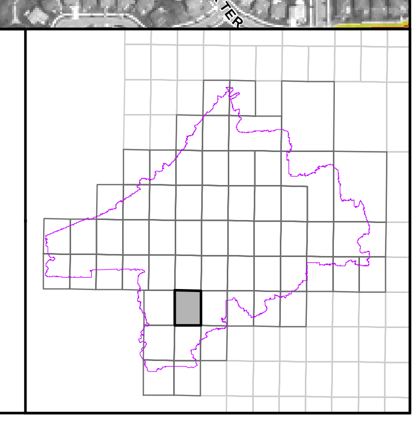
Municipal Boundary

Cook County Boundary



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Calumet-Sag Detailed Watershed Plan

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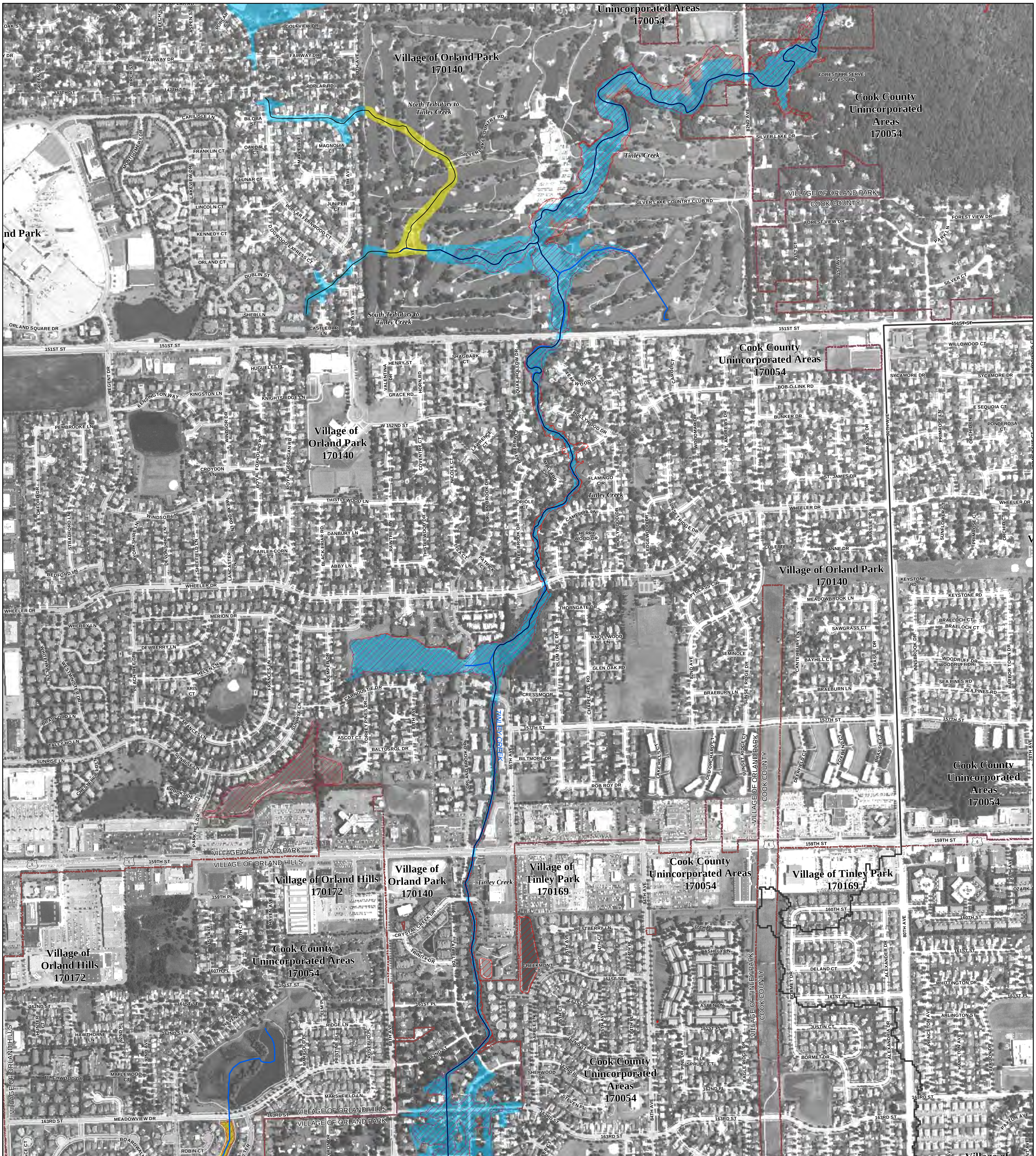

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

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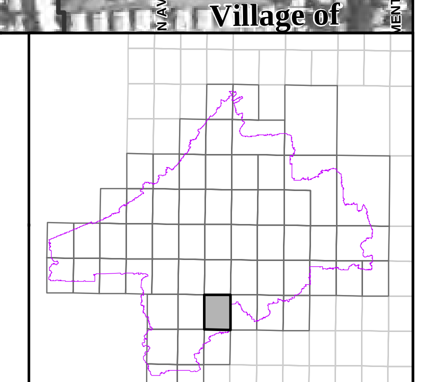

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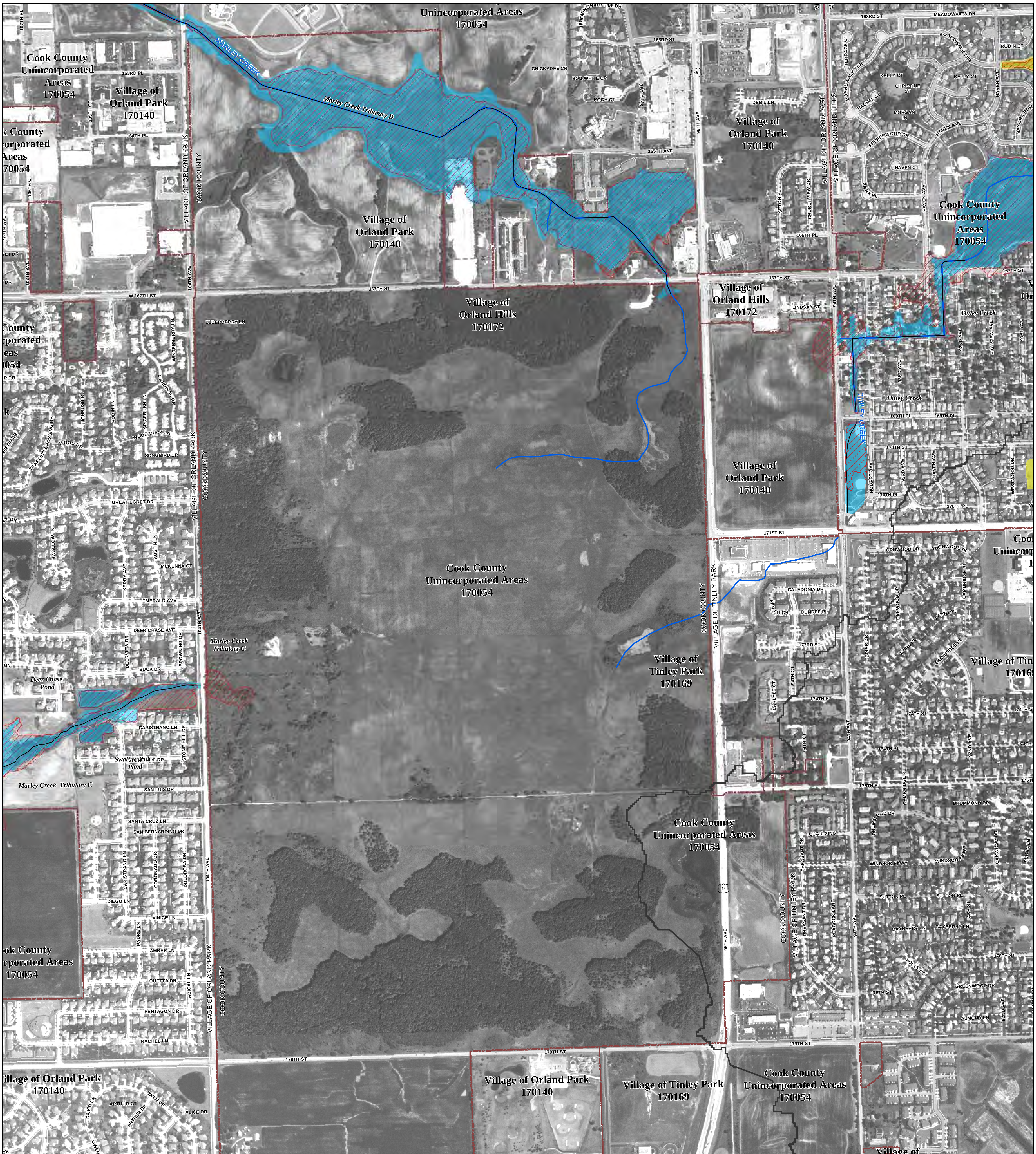

LEGEND

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FEMA Floodplain

- Zone A, AH and AO
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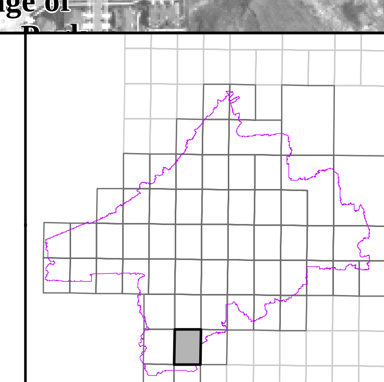

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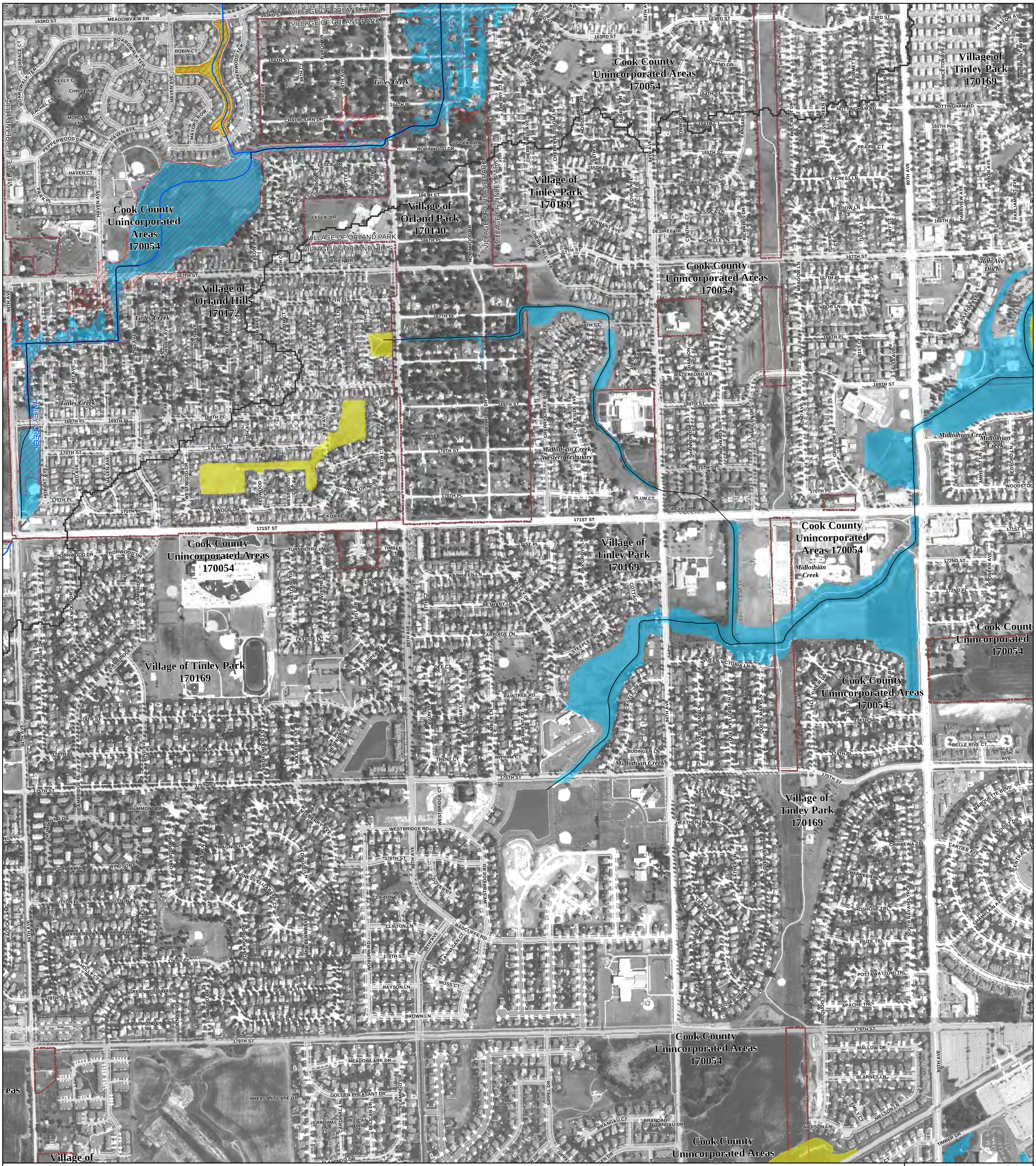

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

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Calumet-Sag Watershed Boundary

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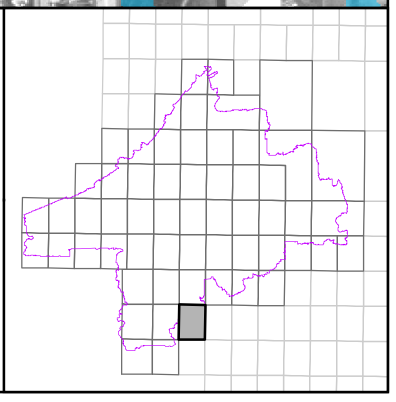

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

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Calumet-Sag Watershed Boundary

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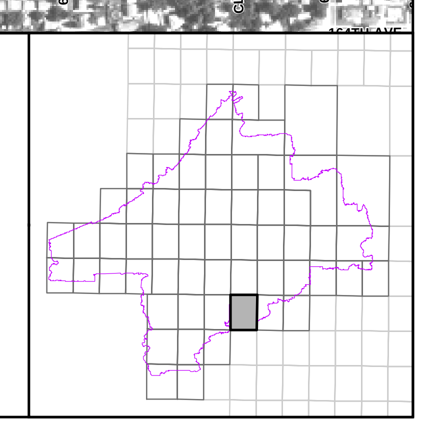
Cook County Boundary



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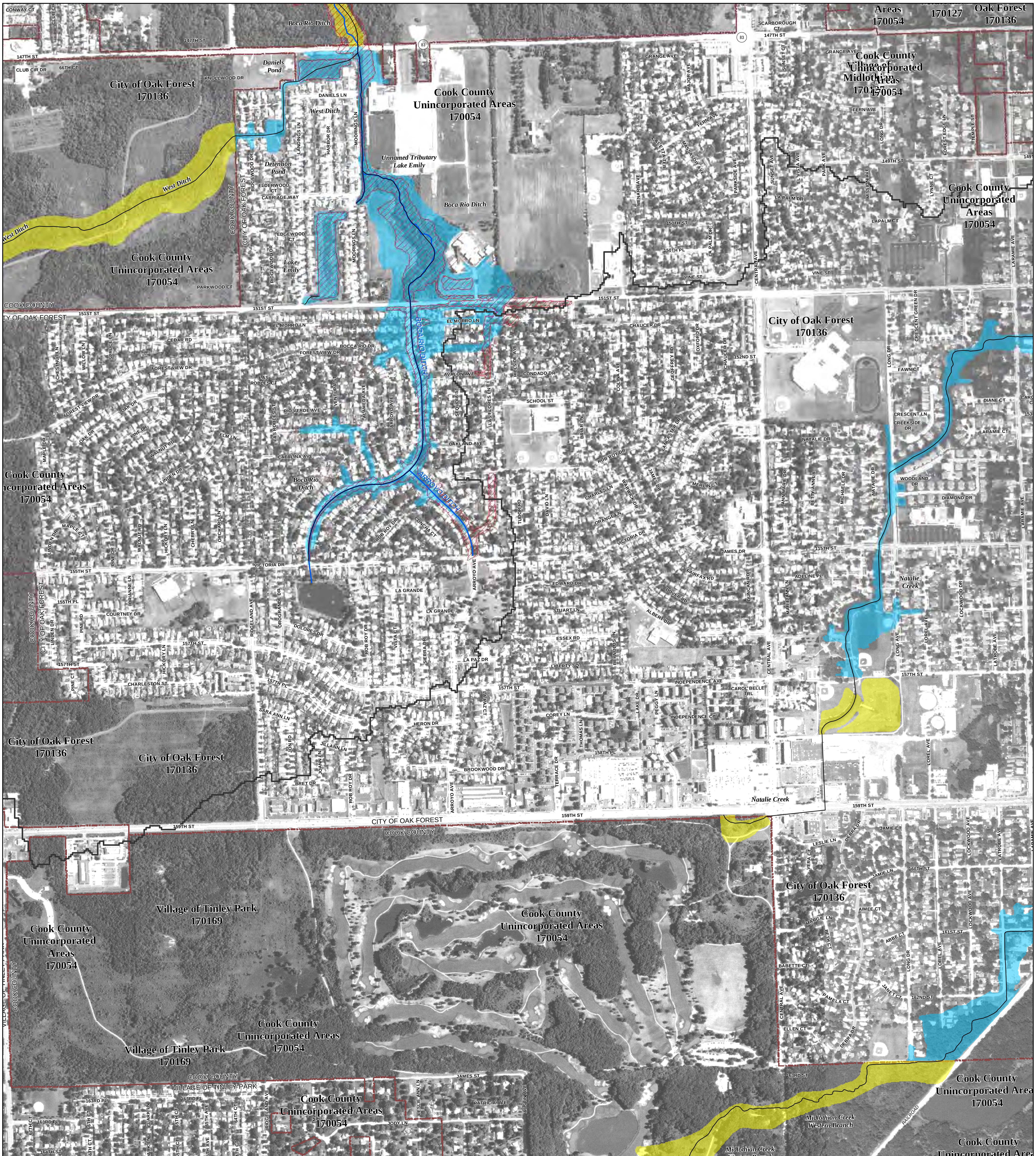

LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

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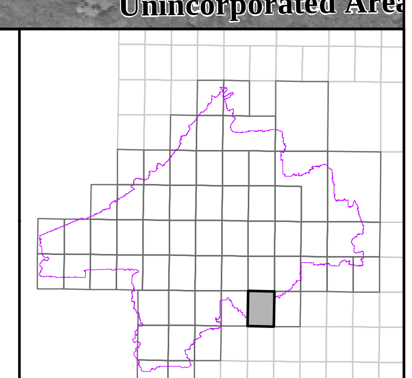

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LEGEND

DWP 100-year Inundation Area

FEMA Floodplain

Zone A, AH and AO

Zone AE

Calumet-Sag Watershed Boundary

River/Stream

Municipal Boundary

Cook County Boundary

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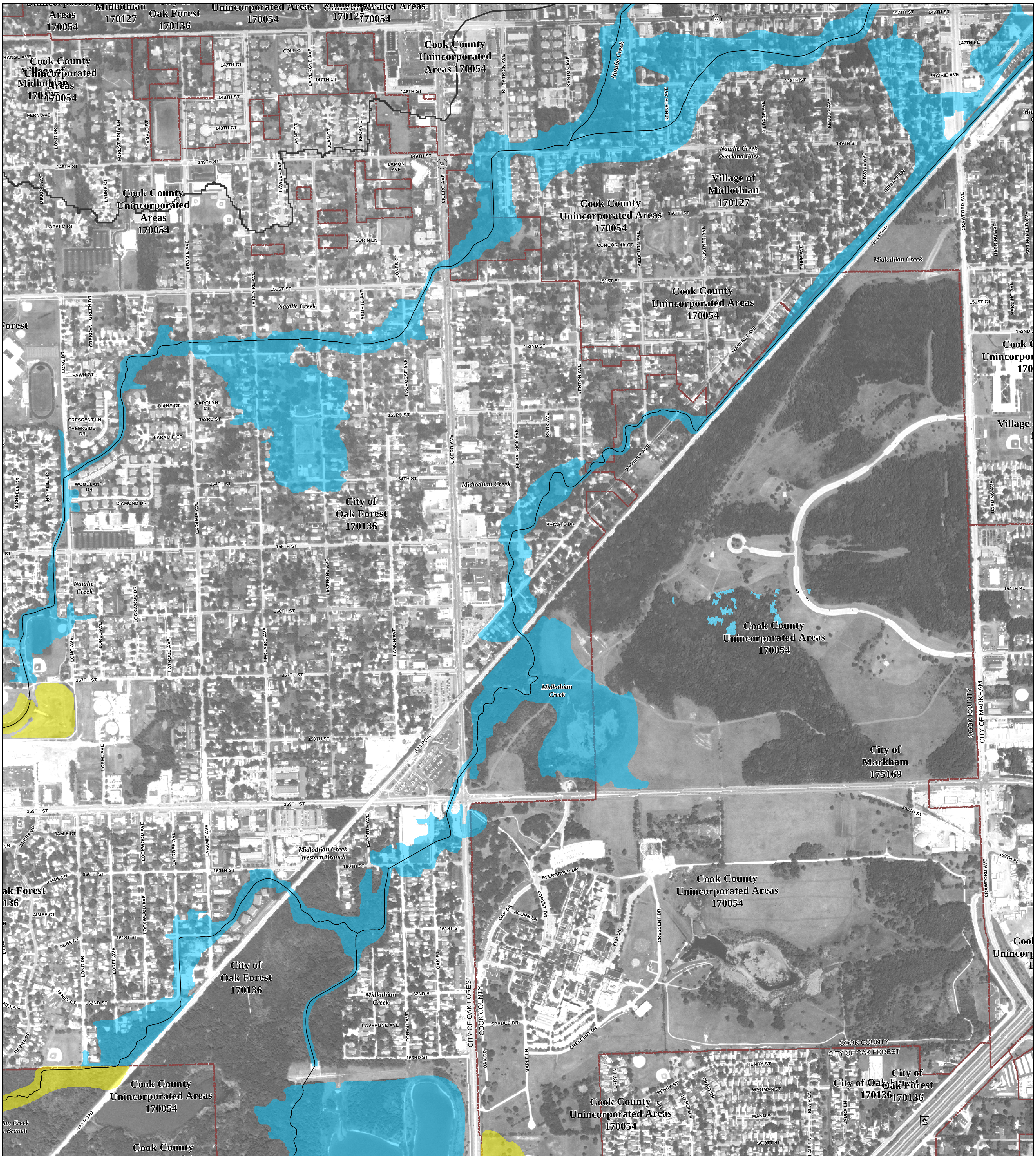

LEGEND

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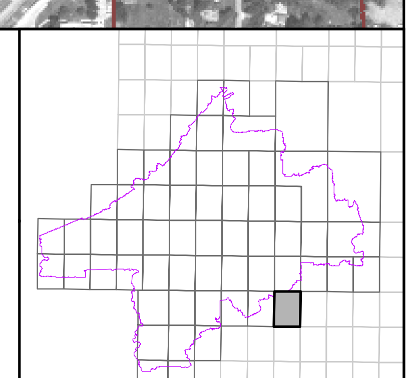

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Calumet-Sag Detailed Watershed Plan

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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 improve-ments 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.

Calumet-Sag Watershed SCS Curve Number Generation

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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

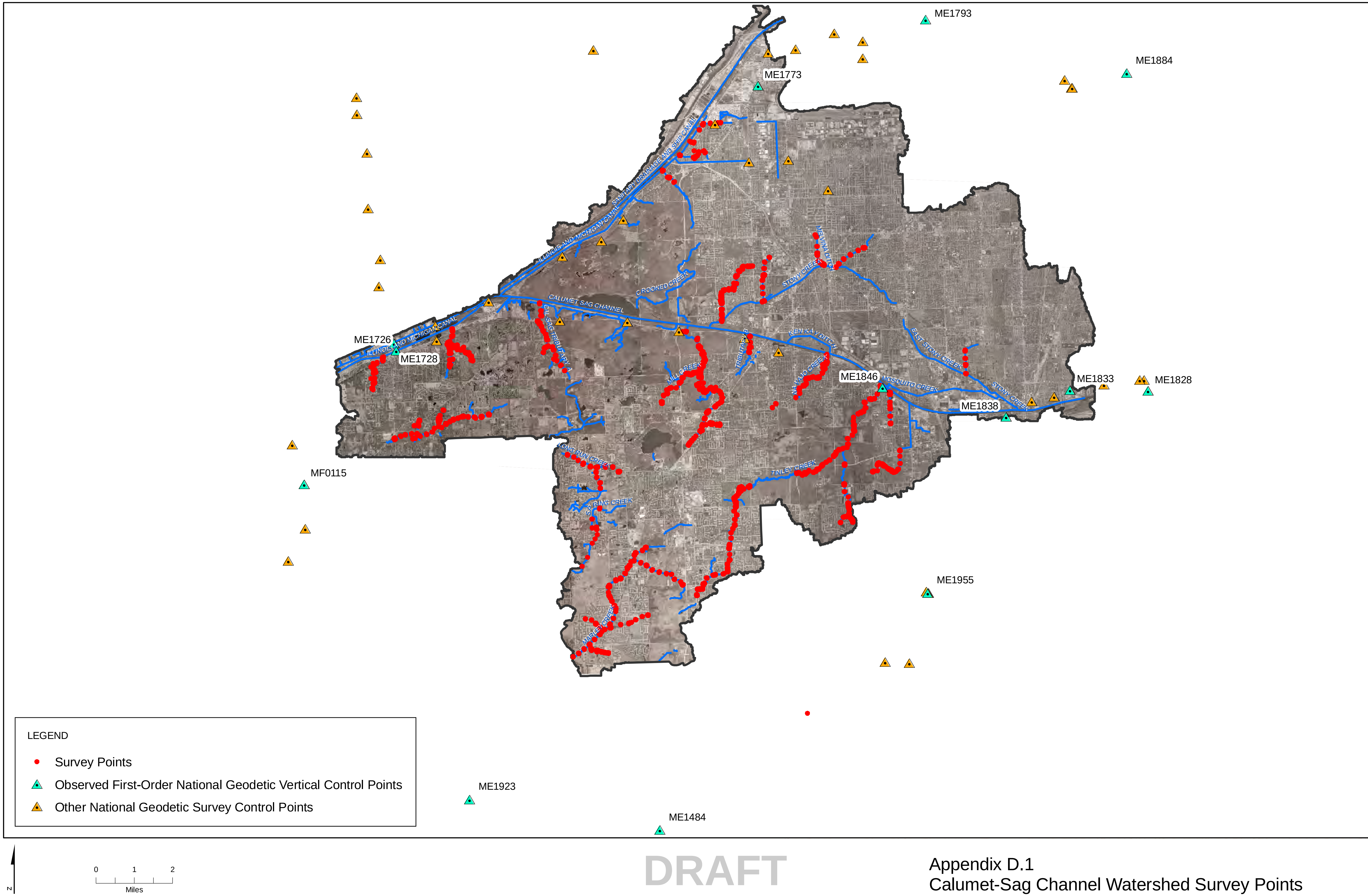
Note: not all NIPC land use types exist within the Calumet-Sag watershed.

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.



Appendix D.1
Calumet-Sag Channel Watershed Survey Points

CH2MHILL

CERTIFICATION OF COMPLIANCE

Project Name:	MWRDGC - Calumet-Sag Watershed Plan Phase B
Statement/Agreement Date:	07/08/2007
Certification Date:	

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 CH2M HILL, as such modifications affect the statement/agreement, and that all such work has been accomplished to meet accuracy guidelines contained in *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. A discussion between CH2M HILL and NGS regarding NOAA NGS-58 occurred prior to the initiation of field surveys for this project. The discussion is documented in an internal technical memo (attached) which describes the survey procedures to be followed for this project. NGS stated that NOAA NGS 58 is a guideline, and that more recent developments in GPS technology permit the use of other techniques to achieve the same results; therefore, 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 the procedures outlined in the technical memo.

Name: Thomas J. Galbreath

Title: Survey Department Manager

Firm/Agency Represented: DB Sterlin Consultants, Inc.

Registration No.: 035-3134 Expires: 11/30/2008

Signature: [signature] 03-05-2008

THOMAS J. GALBREATH 035-003134 PROFESSIONAL LAND SURVEYOR STATE OF ILLINOIS AURORA, IL

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.

CERTIFICATION OF COMPLIANCE

Project Name:	Calumet-Sag Watershed Plan
Statement/Agreement Date:	Technical Memorandum guidelines August 10, 2007 (modified by EDI as attached)
Certification Date:	March 10, 2008

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 CH2M HILL, as such modifications affect the statement/agreement, and that all such work has been accomplished to meet accuracy guidelines contained in *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. A discussion between CH2M HILL and NGS regarding NOAA NGS-58 occurred prior to the initiation of field surveys for this project. The discussion is documented in an internal technical memo (attached) which describes the survey procedures to be followed for this project. NGS stated that NOAA NGS 58 is a guideline, and that more recent developments in GPS technology permit the use of other techniques to achieve the same results; therefore, 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 the procedures outlined in the technical memo.

Name: **Keith W. Stoddard**

Title: **Professional Land Surveyor**

Firm/Agency Represented: Environmental Design International inc.

Registration No.: **3122**

Signature: Keith W. Stoddard 3/10/08

PROFESSIONAL LAND SURVEYOR
KEITH W.
STODDARD
NO. 3122
CHICAGO
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.

Calumet-Sag Watershed Plan: Summary of Survey Procedures

PREPARED FOR: Metropolitan Water Reclamation District of Greater Chicago

PREPARED BY: R. Douglas Briggs/CH2M HILL
Phil Blonn/CH2M HILL

COPIES: Lance Vinsel/EDI
Brad Hattendorf/DB Sterlin
Bill Fox/CH2M HILL

DATE: August 10, 2007

PROJECT NUMBER: 3060905.01.01

Purpose of the Technical Memo:

The purpose of this technical memo is to summarize basic procedures of the proposed ground survey.

These procedures will be used to meet the positional accuracy requirements as outlined in the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A; Guidance for Aerial Mapping and Surveying.*

Due to recent advances in Real Time Kinematic (RTK) GPS methods, it seems clear that the positional horizontal and vertical accuracies required by the referenced FEMA report for field surveys can be achieved using this method. The Calumet-Sag survey team has discussed the referenced NOA NGS 58 report with Mr. Dave Conner of NGS, who agrees with this assessment, and has offered us the explanation that this document is to be used as a guide that does not prohibit the use of other newer technically acceptable methods to achieve the same results. Therefore, this document outlines the proposed method of using RTK GPS, as well as more traditional methods used to establish the control information.

1. Verification of the Virtual Reference System

The survey control for measuring the cross-sections on this project will be done using GPS Real Time Kinematic (RTK) methods employing a local Virtual Reference System (VRS). VRS is technology that utilizes a network of several continuously operating reference base stations to simultaneously calculate a GPS position on a point occupied by a GPS RTK rover receiver in the field. Accuracies of 1-cm horizontal and 2-cm vertical can be easily achieved using this methodology. These accuracies are well within those specified in the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A; Guidance for Aerial Mapping and Surveying.*

Because this is relatively new technology and is not specifically mentioned in the FEMA guidelines as an acceptable methodology for field surveying we feel integrity checks on this local VRS network are necessary. These integrity checks will help support our position that the accuracies obtained using this methodology is within FEMA guidelines.

The integrity check will consist of observing National Geodetic Survey (NGS) control monuments while connected to the VRS and comparing our measured coordinate values against the published coordinate values. A minimum of ~~ten (10)~~ [TWENTY (20) AS] NGS monuments will be included in this survey, ~~a minimum of six horizontal control monuments of "B"~~ [VERTICAL AND] order or better~~, of the same epoch date and a minimum of 4 vertical control monuments of Second Order or better. The horizontal control monuments should be located such that 4 surround the project area and the other two (2) are evenly spaced in the approximated center of the project. The four vertical control monuments should be located such that they surround the entire project area.~~ [KS]

~~A minimum of four independent GPS RTK observations on each NGS monument will be conducted. These observations should take place on two different days. Two observations on each NGS monument will be conducted on each day with observations being at least 6 hours apart.~~ [KS SEE EXHIBIT A VERIFICATION OF FEMA'S ACCURACY STANDARDS]

Residuals will be computed using the difference between each measured ~~coordinate~~ [ELEVATION] value and the published ~~coordinate~~ [ELEVATION] value for each NGS monument. ~~Residuals for the X-coordinate, the Y-coordinate and elevations will be computed separately. Root Mean Square Error (RSME) will be calculated for each coordinate component (i.e. X-coordinate, Y-coordinate, and Elevation). Only the X coordinate, and Y coordinate RSME needs to be calculated for the horizontal control monuments and~~ [KS] only the elevation RSME needs to be calculated for the vertical control monuments.

RSME will be calculated as follows:

$$\text{RSME} = \text{Square Root of } (\text{Sum}(R-M)^2)$$

Where:

RSME = root mean squared error

R = Published coordinate value

M = Measured coordinate value

These RSME values will then be used to assess the integrity of the VRS network. If the RSME values are less than ~~2~~ [2.5] cm the VRS will be deemed satisfactory for use on this project. If the RSME values are greater than ~~2~~ [2.5] cm then a more conventional GPS static network will be necessary to control the survey and the VRS will not be used. [SEE EXHIBIT B FOR RESULTS. EXHIBITS A & B ATTACHED HERETO AND MADE A PART OF]

1a. Alternate Static Control Method

In the event that the VRS system proves unworthy for use as control on this project an alternative Static GPS network will be established. Static GPS observations will be made on approximately thirty (30) control monuments spaced across the proposed watershed. A minimum of eight (8) of these monuments will be chosen so they are near the perimeter of the entire survey. The others will be selected so that they are approximately evenly spaced within the interior of the project. These monuments will be picked from the NGS data sheets. The final group of monuments that will be used will meet or exceed the criteria as outlined in the referenced FEMA guideline.

Once the Static GPS observations have been obtained and processed a minimally constrained least squares adjustment will be performed to test for the network integrity. If the results are within the 2-cm accuracy requirement the values of the minimally constrained adjustment will be applied to the primary control monuments and used for the remainder of the survey. The monument or monuments held will be provided so that the results of the minimally constrained adjustment may be replicated in the future.

When the final positions for the NGS monuments are established the monuments will then be observed with RTK GPS methods employing the VRS. Differences in the values obtained will then be incorporated into an adjustment factor for the VRS values. This adjustment factor will then be applied to all RTK GPS observations employing the VRS system.

In addition, a combined factor, or project adjustment factor will be calculated for the project to permit a seamless conversion between state plane grid and ground coordinates.

2. Secondary Control.

Secondary control points will be required on the project to survey the cross sections at the required interval along each stream. These points will be no greater than 1000 feet apart. The surveyors will use RTK GPS to establish the horizontal and vertical coordinate values on at least two (2) secondary control points along each stream. This information will be checked against the traditional total station methodology that will likely be used to set much of the secondary control network. These monuments will consist of a 5/8" diameter iron pipe or rebar 30" in length with a 2 ½" diameter aluminum cap installed on the top stating "Cal Sag Watershed Survey Traverse Point".

In some cases these secondary control points will also be verified with a closed loop differential level survey to the nearest acceptable NGS vertical control monument.

In instances where, due to obstructions such as tree cover, RTK GPS can only be utilized on one of the secondary control points along a reach of stream, then a traditional closed loop survey utilizing only total stations will need to be peformed to determine whether the survey is within the horizontal and vertical tolerances permitted by the project. This work will be checked to assure that it meets third-order surveying requirements as outlined in the scope of services.

The surveyors will also determine a second value on two of the secondary control points [1] using RTK GPS while either performing the survey an adjacent stream, or in a during a separate event. This will be performed to create a more complete network of verified control throughout the site, and to confirm whether the accuracy meets or exceeds the project requirements.

When several of the secondary control points are located in areas that are unobstructed, then the field surveyors will take measurements on the control points with RTK GPS twice, at least two (2) hours apart, to check the positional accuracy of the control points. While this more closely follows the procedure outlined in the FEMA guideline, this is an unlikely option due to the large amount of tree cover found at the site that will obstruct the satellite coverage and inhibit the use of RTK GPS.

3. Cross-sections

The stream cross-sections will be measured using conventional (Total Station) survey methods. Electronic data collectors will be used to record all survey data acquired during these surveys.

The total station will first be set up on the nearest secondary control point (section 2). A backsight will be made on another secondary or sub-control point. ~~The survey crew will then determine the location of the anchor point on the opposite side of the stream for that cross-section and read the horizontal and vertical coordinates of that point. They will then measure the horizontal angle to that point twice, both with the scope upright and inverted (double angles).~~ SECONDARY POINT SYNONYMOUS WITH ANCHOR POINT

Since the values established on these cross sections will be project adjusted state plane coordinates, and therefore can be easily replicated, the project team feels they will serve sufficiently as the anchor points without setting additional monuments at those locations. The project team is proposing this method because of the fact that most of the cross sections will generally not exceed 200 feet.

Measurements will then be made on the cross-section as outlined in FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A; Guidance for Aerial Mapping and Surveying.*

The next cross section will be determined by moving to the next secondary control point, taking a backsight on the previous control point, and repeating the previously described process.

Slope distances, vertical angles, horizontal distances, and vertical distances will all be reported for this process.

[1] Collecting RTK GPS survey information for only one of the subcontrol points is acceptable in instances where tree cover does not permit collecting survey information on another point.

ATTACHMENT A

Calumet-Sag Watershed Plan Phase B

Topographic Data to Support Hydrologic and Hydraulic Modeling

Field Survey

Introduction

The field survey efforts described within this scope of work involve the collection of topographic and other physical data to support the development of hydrologic and hydraulic models for the evaluation of approximately 70 miles of streams and waterways located within the Calumet-Sag Watershed in southern Cook County.

Description of Work

The survey work for this project includes the following tasks outlined below. The **surveyor** shall comply with all further instructions by CH2M HILL during the life of the project. The major survey tasks shall include the following:

1. Use specific previously established Benchmarks from a list to be provided by CH2M HILL to establish control for all areas of the project to be surveyed. This should be done for each area of the project immediately prior to conducting the survey for that area. A control verification specification section has been added to this scope to provide guidance regarding the accuracy, precision, and type of control that is acceptable to this project. If additional control monuments need to be added, we have included a section specifying requirements for those monuments.

2. Perform transects (cross-sections) of each stream or waterway at the locations and for the extents indicated on mapping provided by CH2M HILL. The information provided by CH2M HILL will include approximate x and y coordinates of the point where each cross-section crosses the stream or waterway. The cross-section shall include x, y, and z coordinates of all "breakline" points along the cross-section. The cross-sections shall be taken such that they are perpendicular to the direction of flow. The cross-sections shall extend at least approximately 10-feet on either side of the channel overbanks. The cross-sections shall include stream channel bottoms that are under water (bathymetric survey). For small streams this could be accomplished by standing on the bank and placing the rod in the stream. For larger streams, this may require a boat and/or other equipment necessary for bathymetric surveys.

3. Collect bridge and hydraulic structure information including top of bridge elevations, low chord elevations, pier locations and pier width, bridge deck width, and other information as directed by CH2M HILL.

4. Take digital photographs of surveyed areas as directed by CH2M HILL.

5. Collect field notes recording other observed information as directed by CH2M HILL.

6. Provide all field notes, digital photographs, and data collected to CH2M HILL on a weekly basis as requested by CH2M HILL.

The surveyor shall then perform the following tasks:

1. Complete the remaining survey effort to the specifications outlined in this scope and in further direction provided by CH2M HILL
2. Provide all final deliverables for the project

Field survey work shall commence on 07/30/2007.

General Guidelines

Concerning the work outlined in this SOW, the **Surveyor** shall adhere to the following general guidelines:

1. The **Surveyor** shall take all reasonable precautions to prevent damage to public and private property, and shall restore the site to the condition existing prior to the **Surveyors'** entry.
2. All work shall be completed under the direction of a **Professional Land Surveyor** registered in the state where the work is being performed. It is the responsibility of the supervising **Land Surveyor** to ensure that all work under this agreement complies with all state and local regulations~~. All documents submitted shall bear the Surveyor's seal, signature, and a certificate that all work was done under the Surveyor's supervision and that all information contained in the document is true and is accurately shown.~~ KS
3. The **Surveyor** is responsible for quality assurance for the survey work performed on this project. The **Surveyor** shall provide a quality management plan (QMP) prior to the commencement of work for the project. The quality management plan should include field work checks, equipment calibration, office calculations, and a final peer review.
4. All work shall be conducted using equipment, personnel, and procedures that will ensure compliance with the accuracy standards as defined below.

Specifications of Work

Control Verification

The **Surveyor** shall determine and report the datum system of the previously established benchmarks provided by CH2M HILL. The survey shall conform to **NAD 83 (Latest Adjustment)** and **NAVD 88, Illinois State Plane Coordinate System, East Zone, 1201.**

Vertical Control work shall be Second Order Class II, as outlined in the **FGDC Geospatial Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management.**

Horizontal Control work can be done using either standard surveying techniques or Global Positioning System (GPS) system techniques meeting the specification requirements outlined in this scope. If standard surveying techniques are used, all horizontal control work shall comply with Third Order Class I, as outlined in the **FGDC Geospatial**

Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Construction (A/E/C), and Facility Management.

If GPS is used, the relative horizontal accuracy shall conform to the **FGDC Geospatial Positioning Accuracy Standards, Part 2: National Standard for Spatial Data Accuracy for surveys having a positional accuracy of 1 cm.**

The **Surveyor** shall provide coordinates of all points X, Y, and Z to the nearest .01 foot, regardless of the accuracy of the survey.

THE UNITS OF MEASUREMENT FOR THIS PROJECT SHALL BE IN US SURVEY FEET.

Control Survey Scope of Work

1. Develop maps showing locations of control points (northings and eastings) with respect to key features, either manmade or natural, on the ground. In addition to the locations, also show ties with bearings and distances to existing control points that may be in the area.

2. The **Surveyor** shall provide all X, Y, and Z coordinates provided to the nearest 0.01 foot as specified above. The **Surveyor** shall confirm the relative accuracy of any existing benchmarks, and site control; and reestablish the project control to the accuracy standards outlined above.

3. ~~**The Surveyor shall set or identify a minimum of four control points. The monuments set or identified shall be equally spaced approximating an approximate rectangle within the project area, but toward the perimeter of the survey if possible. The monuments shall meet the specified accuracy requirements for control monuments listed above. The monuments shall be 5/8 inch diameter iron pins 30-inches long with a plastic cap showing the Surveyor's registration number. Any federal, state, or local requirements may supersede this requirement. CH2M HILL must be notified immediately of any change.**~~ KS

4. A CH2M HILL representative may be present at any time to coordinate survey activities and identify points and features to be located.

Transect and Bathymetric Survey

Specifications of Work

Vertical survey work for this part shall be Third Order, as outlined in the **FGDC Geospatial Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management.**

Horizontal and vertical survey work can also be performed using either standard surveying techniques or Global Positioning System (GPS) system techniques meeting the specification requirements outlined in this scope.

If standard surveying techniques are used, all horizontal control work shall comply with Third Order Class II, as outlined in the **FGDC Geospatial Positioning Accuracy Standards,**

Part 4: Standards for Architecture, Engineering, Construction (A/E/C), and Facility Management.

If GPS is used, the relative horizontal accuracy shall conform to the FGDC **Geospatial Positioning Accuracy Standards, Part 2: National Standard for Spatial Data Accuracy, for surveys having a positional accuracy of 2 cm.**

The **Surveyor** shall provide coordinates in the **NAD 83 (Latest Adjustment)** and **NAVD 88, Illinois State Plane Coordinate System, South Zone, 1201** in use at this project. The **Surveyor** shall provide coordinates of all points X, Y, and Z to the nearest .01 foot, regardless of the accuracy of the survey.

The units of measurement for this project shall be in US Survey Feet.

Transect and Bathymetric Survey

Scope of Work

1. Conduct cross-section transect surveys along each stream at locations to be specified by CH2M HILL. Each transect shall be surveyed perpendicular to the flow of the stream at the location where the cross section is taken. The **Surveyor** shall locate three-dimensional coordinates at all break points along the reach of each stream. These cross sections shall include the following points:
    - **a.** Thalweg or flow line elevation
    - **b.** The edge of water
    - **c.** Water surface
    - **d.** Bottom of Bank
    - **e.** Top of Bank
    - **f.** 10-feet beyond the top of the bank, or to the next logical field determined breakline
2. In addition, at locations where structures such as bridges and large culverts cross the streams, the **Surveyor** shall:
    - **a.** Verify the existing structures for hydraulic calculations, this includes the following:
        - i. Elevation of flow lines,
        - ii. Size of openings
        - iii. Location of wing walls
        - iv. Type of material along flow line
        - v. Elevation of top of bridge

vi. Elevation of bridge low chord

vii. Pier widths and locations

viii. Other information as directed by CH2M HILL

3. The **Surveyor** shall also include X, Y, and Z coordinates shown as listed in the specification section of this scope, and in accordance with the above specified grid.

Bathymetric Survey Alternative

At locations where the streams are sufficiently large to preclude the use of standard survey methods, a bathymetric survey shall be provided.

General guidelines for the bathymetric survey have been outlined below:

1. The **Surveyor** shall supply CH2M HILL with the equipment type and specifications prior to commencing work on the bathymetric survey.

2. The proposed methodology for the bathymetric survey includes the use of RTK GPS, and aquatic depth finding equipment that meets the specifications for the positional accuracy and precision outlined within the topographic transect survey portion of the scope.

3. The bathymetric **Surveyor** shall determine the existing stream elevation at the day of the bathymetric survey. The information shall be properly correlated to determine the accuracy of the combination of below water surface and above water surface.

Field Survey Deliverables

1. The **Surveyor** shall provide a coordinate printout of all requested information, as listed in the description of work, in Excel format with all X, Y, and Z coordinates listed to the nearest 0.01 foot. The collected field information shall be provided in both Excel, and ASCII format; and shall contain the station ID and the horizontal and vertical coordinate information. All information shall be tied to the **Illinois State Plane Coordinate System, East Zone 1201.** ~~A project adjustment factor shall be provided and the final coordinate system shall be converted to ground.~~ KS

2. The **Surveyor** shall set and note the location of any additional control survey monuments required by the specification section of this scope.

3. All survey information shall be provided in a native MicroStation version 8 electronic drawing. The drawing shall show all information established and provided to the mapping consultant where applicable. All electronic drawing symbology shall conform to the **National CAD Standards (NCS), as published for the National Institute of Building Sciences.** If the **Surveyor** is unable to provide information to CH2M HILL in MicroStation Version 8 format, the CH2M HILL project manager shall be notified immediately.

4. The **Surveyor** shall provide their proposed feature codes to CH2M HILL one week prior to commencing work on the project. The feature codes will be reviewed to assure

conformance to the **National CAD Standards, FEMA** guidelines, and other project requirements. Any revisions to the proposed feature codes, by CH2M HILL or the project client, shall not constitute reason for additional compensation to the **Surveyor**.

5. The **Surveyor** shall provide two digital photographs taken at each cross-section surveyed (one looking upstream and one looking downstream). The **Surveyor** shall also provide at least two digital photographs of each bridge, culvert, or other structure surveyed (one photograph of the upstream side of the bridge, culvert, or other structure, and one photograph of the downstream side of the bridge, culvert, or other structure, and additional photographs as needed.

6. The **Surveyor** shall provide all field notes taken that document work performed and observations made while performing field survey work.

Additional Reference and Guideline Section

The field survey shall also meet or exceed the **Flood Emergency Management Agency's Guidelines and Specifications for Flood Hazard Mapping Partners**, Final, May of 2005.

Specific sections of particular importance are listed below:

Appendix N: Data Capture Standards

Appendix N: Data Capture Guidelines

Appendix A: Guidance for Aerial and Mapping Surveying

Health and Safety Requirements

The **Surveyor** shall provide and assume responsibility for adequate health and safety protection for onsite personnel. CH2M HILL requires contracted **Surveyors** to provide evidence of having received OSHA-specified training to conduct work on potentially hazardous sites. The specific content of the training requirements is outlined in 29 CFR 1910.120(e). Standard personal safety equipment including: hardhat, safety glasses, steel-toed boots, gloves, and coveralls are recommended for all project activities.

The **Surveyor** shall provide CH2M HILL's office with copies of current training and medical certifications, and shall insure that this documentation accompanies their personnel onto job sites for any work authorized under this agreement.

All **Surveyor** on-site personnel will be required to attend a brief (30-minute) on-site health and safety meeting on the first day of work and will be required to review, sign, and follow the CH2M HILL health and safety plan developed specifically for this project. The CH2M HILL health and safety plan will address standards to be followed regarding traffic safety, working near or in water, encountering dogs or wildlife, and general field work safety procedures.

Surveyor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employer will be notified. **Surveyor** personnel under the influence of prescription or over-the-counter medication that may impair their ability to safely and correctly operate the equipment necessary to do their job are required to identify this condition to CH2M HILL or their employer. It is expected that the **Surveyor** will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

DRAFT - Calumet-Sag Detailed Watershed Plan Field Survey Standards and Guidance

Introduction

The purpose of this document is to provide the necessary surveying methods and standards information required for the execution and completion of field survey data collection for the Calumet-Sag Detailed Watershed Plan project.

This document is not intended to replace the actual scope of services, but is intended to supplement the scope in order to clarify the CH2M HILL's project expectations regarding the proposed survey procedures.

This project when completed will reduce property damage and road closures due to flooding. The surveying information gathered will entered as input for models used to locate flood prone areas and evaluate alternative improvement projects.

Field Notes

Information required to properly model stream flow and flooding conditions are elevations to create a profile of the cross-section of the stream and photographs of the condition and vegetation for each cross-section. Provide survey notes and photos regarding observations of any obstructions in the floodplain (including structures such as houses or barns), general description of vegetation type (e.g. 12-inch tall grass, dense blackberry cover, willow sprigs, etc.), bent locations and type (rounded, square, columns, etc.), high water marks, evidence of erosion or scouring. Record size and elevation data for any upstream or downstream culverts or bridge structures on the study channel. Call if you have questions about whether something might be important to survey. Make note or take photo of observed conditions if the budget or time doesn't allow surveying them.

The following should be included in field notes:

- Starting location of day (first cross-section #)
- Control points
- Vegetation surrounding each cross-section
- Land use or description of buildings surrounding each cross-section
- Note any buildings or obstructions within channel or floodplain area

Benchmark and Control

Preferably, the reference benchmarks created during the Cook County aerial mapping project that was completed in 2003 should be used. A total of 135 control points were established. Of these, 25 are National Geodetic Survey (NGS)/High Accuracy Reference

Network (HARN) control stations that are located within Cook County and its vicinity. The remaining points were either existing or new points identified as photo control specifically for the mapping project. Existing NGS monuments within the region were reviewed and referenced to HARN.

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. The Cook County Mapping Services department maintains a GIS shapefile containing all of the ground control points.

As stated in the scope, the surveyor is expected to confirm the datum used by Cook County, and provide calibration and post-processing reports of the referenced benchmarks so that the accuracy and precision of the benchmarks can be determined, as well as the relative positional accuracy between the benchmarks.

Datum

Survey standards should be consistent with FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners*, Appendix A, "Guidance for Aerial Mapping and Surveying".

Field surveys performed to support Phase B of the Calumet-Sag DWP development will be consistent with survey requirements identified in Chapter 6 of the CCSMP. However, it should be noted that." FEMA survey standards require the horizontal control/datum to be the National American Datum of 1983 (NAD1983) and the vertical datum to be the North American Vertical Datum of 1988 (NAVD). If models developed as a part of District DWP development are utilized for future floodplain mapping activities, some conversion may be required to be consistent with FEMA standards.

All points surveyed shall be georeferenced so that the data can be brought into GIS.

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 DWP will be consistent with latest available District GIS Standards and Specifications.
Survey Data	District Vertical Datum	DWP 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," located in Appendix D and available at www.fema.gov/fhm/dl_cgs.shtml
DWP Data	Cook County Stormwater Management Plan	All data developed to support DWP will be consistent with standards provided as a part of this document, or other scoping documents provided by the District.

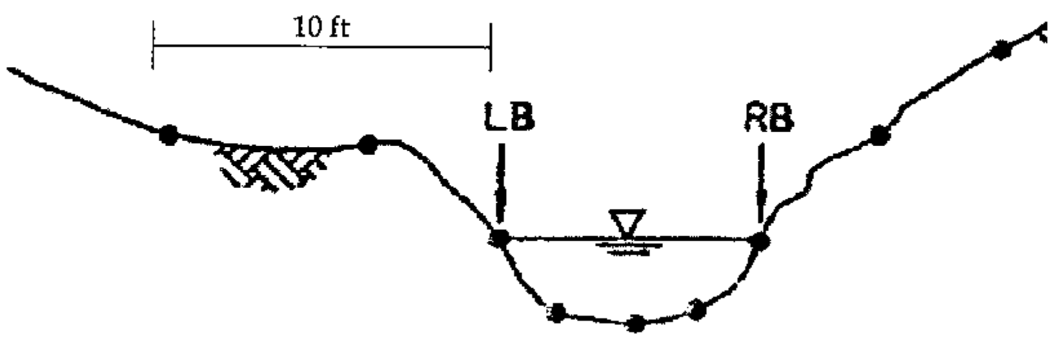
It should be noted that within the above referenced FEMA guidelines, and also within our scope, the documents that are referenced for survey accuracy, precision, and survey procedures are:

- FGDC **Geospatial Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management**
- FGDC **Geospatial Positioning Accuracy Standards, Part 2: National Standard for Spatial Data Accuracy**

Stream Cross-Section Surveys

For each stream, a map has been provided marking preferred locations where cross-sections are to be surveyed along with approximate x and y coordinates. The map should be used as a guideline for surveying locations. If any points along the stream have a significant change in geometry or characteristics, these points should be surveyed as well. Each cross-section survey should contain ID #, significant elevations to depict the cross-section, a photograph and rough sketch depicting the cross section and its location which includes a north arrow and direction of flow. Vegetation in the area should be noted along with any nearby buildings, and any other general notes on the condition of the stream (erosion, scouring, excessive amounts of debris). Surveys should be conducted to define the main channel of the stream only and should extend at least approximately 10 feet beyond the channel overbank.

ORIENTATION LOOKING DOWNSTREAM

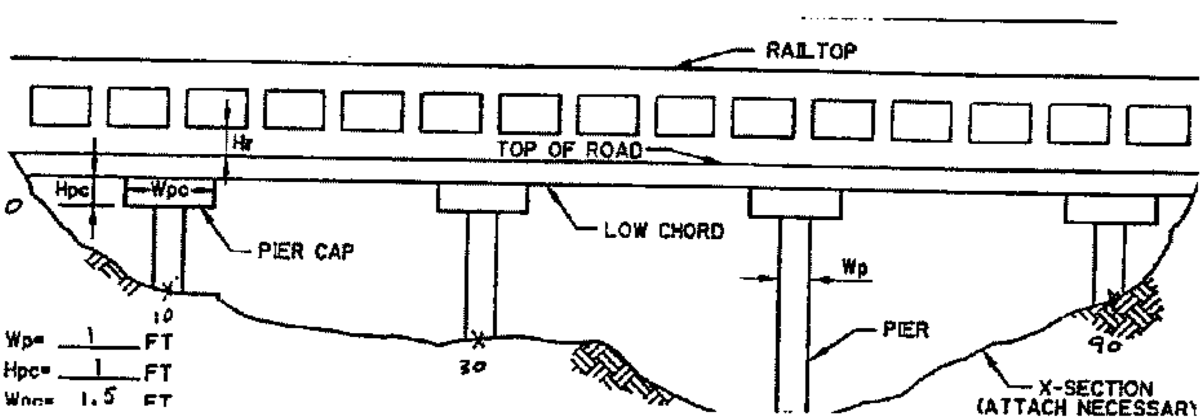


Smaller streams can use a GPS surveying method or simply submerging the surveying rod from the bank. With larger streams it is recommended the bathymetric method be used.

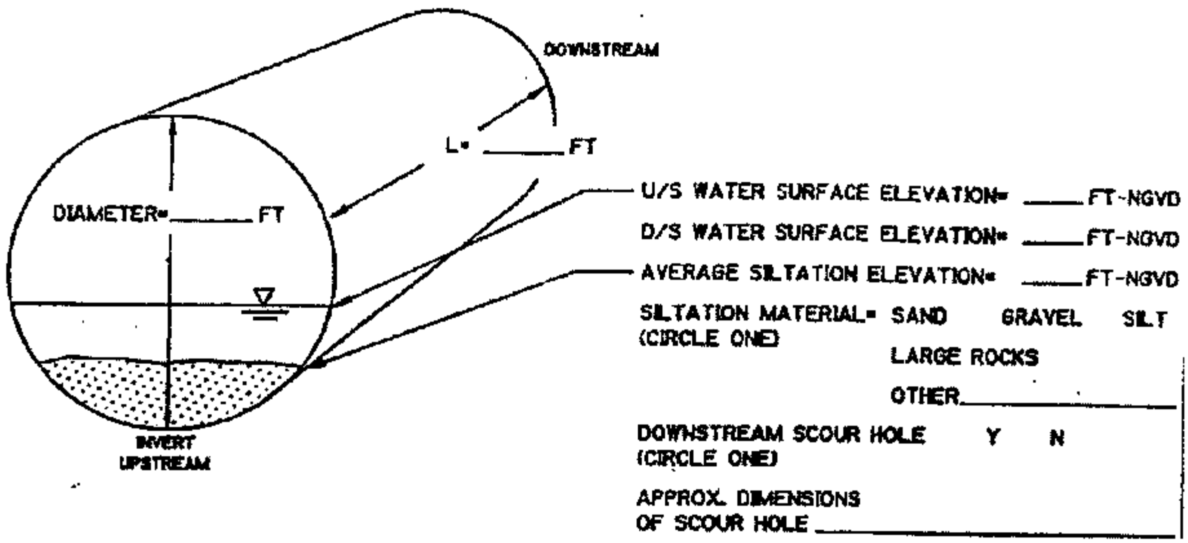
Bridge and Culvert Surveys

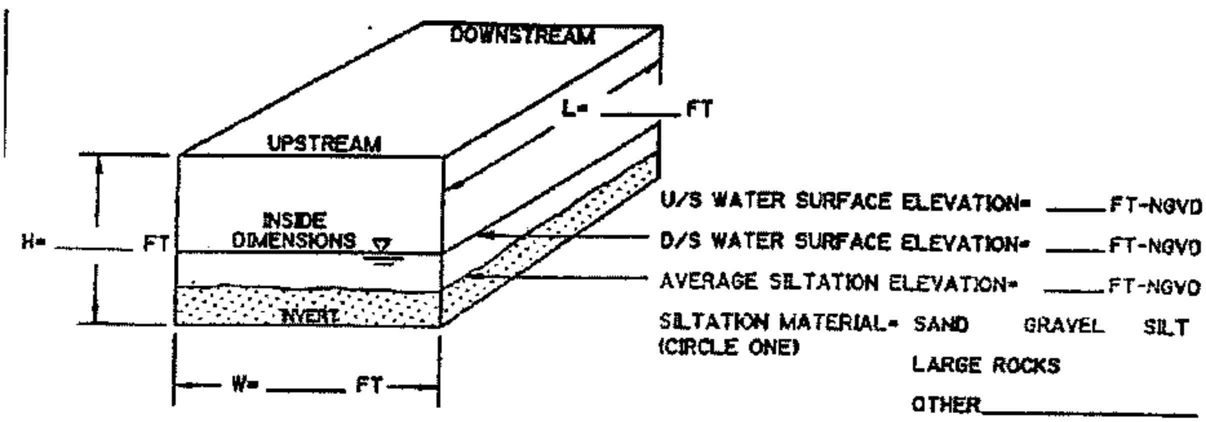
Generally, cross-sections of the stream should be taken directly upstream and downstream and downstream four bridge/culvert widths and upstream one bridge/culvert width (see map for locations) of all bridges and culverts. The location of these sections can be modified to capture important stream characteristics such as changes in slope, channel bottom width, vegetation, tributary confluences, etc. The four sections immediately surrounding the bridge should be kept close to the configuration described above.

- Take measure of the opening on the upstream and downstream side of the bridge at 5′ or 10′ intervals.
- Must get accurate stream bed profile.
- Get lowest elevation of the low chord.
- Measure and describe abutments, wingwalls, aprons, etc.
- Take elevations at highest point of bridge. This is most likely either the centerline or rail top.
- A sketch (copy) should be attached to this report.
- Note characteristics of streambed material. Is there a portion of rip-rap or concrete section of channel under the bridge?



When surveying typical circular or box culverts include the invert elevations for both the upstream and downstream ends, water surface elevation, upstream and downstream, and average siltation elevation. Also include diameter or height and width of opening if there are identical culverts, only the dimensions of one need to be included along with the number of identical culverts. Survey the head wall elevation and note the material, condition, and type of head wall (upstream). If any scour hole exists downstream the dimensions of the hole should be noted. Any general observations made out in the field not mentioned above that may affect the flow of water such as overgrown vegetation or excessive debris should be included as well. See the diagrams below as a basic guideline for dimensions.





Photographs

Surveyors should take digital photographs at each cross-section location. These photos if possible should include a whiteboard indicating the ID number of the cross-section along with a survey rod for scale to help identify which photos belong to each section. Each photograph should include a description of the item(s) shown. Photographs of all existing structures including culverts, bridges, or any other structure that could restrict the flow of water in the event of high water levels looking at the structure from both an upstream and downstream position and additional photos of any points of erosion/scour or possible problem areas should also be included as well.

Quality Assurance Plan:

The surveyor shall develop a quality assurance/quality control plan describing proposed survey methods to be used at the site.

Specifically, the surveyor shall describe proposed methods to back check their field work. These methods will include, but are not limited to the use of closed loops and check shots.

Once the data is collected, the surveyor shall also perform office checks of the data before presenting it to CH2M HILL. This again should involve, but is not limited to cross checking plan information against the field notes, and verifying how well their loops and check shots closed. If closure errors are found in excess of those specified by the scope, the surveyor is expected to correct those errors before continuing with additional survey work.

Also, it is strongly recommended that each day a minimum of three points from the previous day's work be reshot and confirmed prior to beginning the new day's field work.

If for some reason the surveyor cannot reconcile discrepancies noted in the quality assurance process, CH2M HILL shall be notified immediately.

Deliverables

Specifics regarding deliverables are outlined in the survey scope.

As outlined in the survey scope, the surveyor shall provide weekly deliverables and a diary of events from the previous week.

The surveyor is expected to contact CH2M HILL for guidance if he or she experiences difficulties or needs clarification on specific items to be located that are not directly stated within the scope of services.

EXHIBIT A

Verification of FEMA's Accuracy Standards

It is the Client's desire that the survey data meet the accuracy requirements of FEMA's *Guidelines and Specifications for Flood Hazard Mapping, Appendix A: Guidance for Aerial Mapping (FEMA Appendix A).*

FEMA Appendix A has three basic requirements for ground control surveys; NSRS, Horizontal Control, Vertical Control.

NSRS - All data must be connected to the National Spatial Reference System (NSRS).

> Our survey is connected to a system of continuously Operating Reference Stations (CORS) by way of *GPS SpiderNET/VRS.* These CORS stations and the SpiderNET/VRS itself are supplying the latest data for the NSRS.

Horizontal Control - The horizontal control must be to NGS second order or better accuracy.

> As stated in *FEMA Appendix A,* these accuracies are easily obtainable when the required vertical accuracies are obtained.

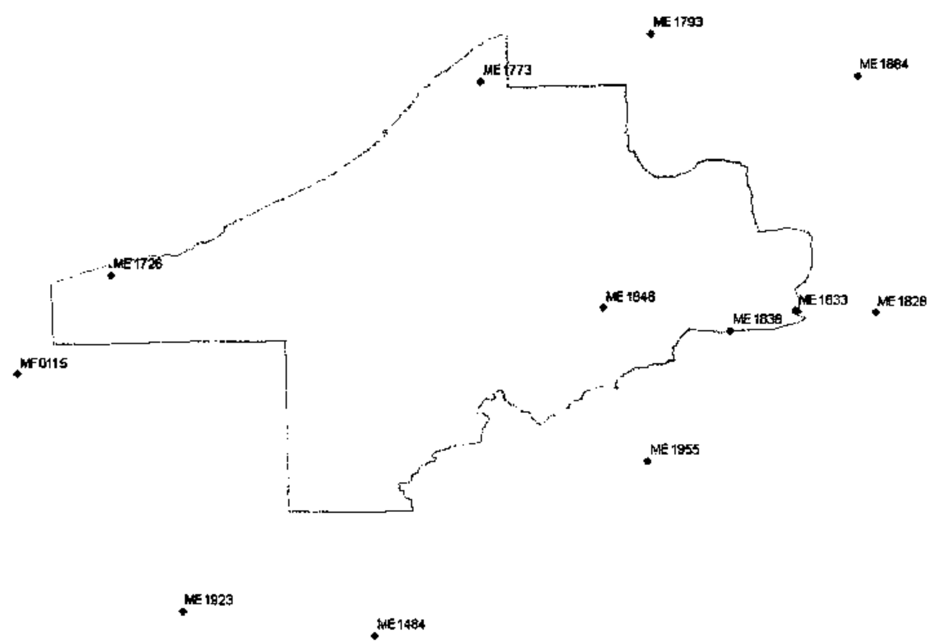
Vertical Control - The vertical control must use 5-centimeter or better GPS procedures.

> *FEMA Appendix A* states that the procedures specified in *NOAA Technical Memorandum NOS NGS-58* (NGS-58) need to be followed to achieve 5-centimeter accuracies.
>
> Since the writing of *FEMA Appendix A* and *NGS-58,* GPS technology has advanced considerably. With the advent of multiple CORS stations, High Accuracy Network RTK (SpiderNET/VRS) and more accurate geoid models (GEOID03), 5-centimeter accuracy is obtainable by the use of Real-Time Kinematic (RTK) methods in areas of good CORS coverage.
>
> We used SpiderNET/VRS to set all of the control for the ground surveys on this project. No technical paper is available to specify the procedures necessary to obtain 5-centimeter accuracies using SpiderNET/VRS. We determined to demonstrate that the SpiderNET/VRS systems provide 5-centimeter accuracies for the project area.
>
> We tested our methods by using the procedure outlined in *Part 3: National Standard for Spatial Data Accuracy (NSSDA).*

5-centimeter Accuracy Test

As specified in NSSDA, a minimum of 20 points need to be tested to achieve the required 95% confidence level. Our test uses twelve first order benchmarks. Most of the benchmarks were observed twice with exception of ME1793 and ME1884 which were only surveyed once due to problems getting a GPS signal. The test involved 22 total observations. Duplicate observations were taken on different days and at different times of the day as specified in NGS-58.

These tests were made using the same procedures used for the Local Control Points established for the project cross-sections. The first order benchmarks were distributed in and around the project as shown.



The method of surveying the Local Control Stations requires that each point be surveyed twice with different satellite configurations. If the difference in elevation between the two values is more than 10cm, the point is surveyed again until a less than 10cm difference is established between two readings. An average of the two elevations is then used as the Local Control Station Elevation.

Similarly, the test observations followed the same method until two readings were within 10cm. No two test observations were more than 10cm apart, both values were used in the accuracy calculations. The accuracy calculations analyzed the difference between each observed elevation and the NSRS published values for the benchmarks. A spreadsheet similar to the examples in NSSDA was used for the analysis (see attached Exhibit B).

Therefore, the accuracy value according to the NSSDA, at 95% confidence, is 5 centimeters. Of the twenty two observations tested, only ME1838 has a positional error that exceeds 5 cm.

Each observation in the test was analyzed. For the project local control points (secondary /anchor points) the two observations were averaged, thereby obtaining even more accurate results.

EXHIBIT B

	Point Id	Monument NAVD 88 Published Orthometric Elevation (m)	Monument NAVD 88 Calculated Orthometric Elevation (ft)	Project NAVD 88 Leveled Orthometric Elevation (Project BM or Original BM) (ft)	RTK Observed Orthometric Height (ft)	Difference (ft)	Difference (cm) (Positional Error)	Difference Squared (cm)
1	ME1484	231.362	759.060	759.060	759.207	-0.147	-4.5	20.1
2	ME1484 B	231.362	759.060	759.060	759.150	-0.090	-2.7	7.4
3	ME1726	182.107	597.463	595.186	595.122	0.064	1.9	3.8
4	ME1726 B	182.107	597.463	595.186	595.104	0.082	2.5	6.2
5	ME1773	183.610	602.394	601.682	601.733	-0.051	-1.6	2.4
6	ME1773 B	183.610	602.394	601.682	601.678	0.004	0.1	0.0
7	ME1793	183.569	602.259	601.421	601.394	0.027	0.8	0.7
8	ME1828	180.255	591.387	590.537	590.532	0.004	0.1	0.0
9	ME1828 B	180.255	591.387	590.537	590.559	-0.022	-0.7	0.4
10	ME1833	184.394	604.966	603.563	603.494	0.069	2.1	4.5
11	ME1833 B	184.394	604.966	603.563	603.548	0.015	0.5	0.2
12	ME1838	181.772	596.364	594.294	594.058	0.236	7.2	51.7
13	ME1838 B	181.772	596.364	594.294	594.227	0.067	2.0	4.1
14	ME1846	183.854	603.194	603.194	603.128	0.066	2.0	4.1
15	ME1846 B	183.854	603.194	603.194	603.206	-0.012	-0.4	0.1
16	ME1884	185.841	609.713	609.713	609.782	-0.068	-2.1	4.3
17	ME1923	214.366	703.299	703.299	703.258	0.041	1.3	1.6
18	ME1923 B	214.366	703.299	703.299	703.219	0.080	2.4	6.0
19	ME1955	209.188	686.311	686.311	686.442	-0.131	-4.0	15.9
20	ME1955 B	209.188	686.311	686.311	686.407	-0.096	-2.9	8.6
21	MF0115	185.747	609.405	609.405	609.469	-0.064	-1.9	3.8
22	MF0115 B	185.747	609.405	609.405	609.316	0.089	2.7	7.4

Sum	153.3
Average	7.0
RMSE (cm)	2.6
Accuracy (cm)	5

Chicago Waterways Tail Water Conditions Modeling

TO:	Tim Coleman, Phil Bonn, CH2MHILL
FROM:	Marion Kessy, FLUIDCLARITY
DATE:	June 1, 2008
PROJECT NUMBER:	FCL 7000

Purpose

This memorandum is a follow-up to the previous, October 12, 2007 memorandum which discussed methodologies for developing appropriate boundary conditions in the Cal-Sag Channel (CSC).
This memorandum expands on that discussion to include, in addition to the CSC, the Chicago Sanitary and Ship Canal (CSSC), the Illinois-Michigan Canal (I&M), and the South Branch of the Chicago River (SBCR). All of these waterways are components of the Chicago Waterways System (CWS) within the Cal-Sag watershed which do not have established Base Flood Elevations (i.e. unstudied Zone A floodplains).

Flood stages in these waterways can be used as tail water conditions for modeling the tributaries or developing inundation maps for the waterways. This memorandum presents the methodology and hydraulic models FluidClarity developed to establish flood stages in these waterways.

Existing Chicago Waterways Watershed Study

The U.S. Army Corps of Engineers (USACE) developed hydrologic and hydraulic models of the Chicago Waterways System (CWS) as part of the Chicagoland Underflow McCook Reservoir Plan in 1999. The location and extent of the CWS system are depicted in the attached Exhibit 1, Enclosure 1-a. A schematic of the modeled reaches and limits is included in Exhibit 1, Enclosure 1-b. The CWS hydraulic models were based on the USACE UNET model which does not meet the MWRD criteria. The cross section data incorporated in the UNET model were field surveyed.

According to the USACE design report, the flows into the CWS were assembled from three sources:

- Overflows from the combined sewer drop shafts connected to the Underflow System otherwise called TARP
- Discharges from Sanitary Treatment Plants
- Runoff from ungaged areas of the watershed (i.e. direct runoff)

A variety of hydrologic models were employed to determine the flows into the CWS. Because of the complex hydrology of the watershed, some specialized models that may not meet the MWRD criteria were used to determine flows. Flows from the ungaged watersheds were calculated by the USACE HEC-1 model. The sewer outflows were calculated by a combination of the EPA's HSPF continuous simulation model and the locally developed sewer capacity model called SCALP. The SCALP model does not meet MWRD criteria, however, it is a simple model that has been specifically developed for the combined sewer system to calculate over-flows to TARP.
As part of the McCook Reservoir design study, the USACE employed the 'standard project flood' (SPF) methodology to evaluate design alternatives.

The SPF is a synthetic hydrograph that is expected to result from the most severe combination of meteorological and hydrologic conditions which are reasonably characteristic of the watershed, excluding extremely rare combinations. Developing the SPF involves calibration of a synthetic hydrograph to historical records and empirical runoff-relations for the watershed. The advantage of this approach is its simplicity and consistency for evaluating design alternatives.
The USACE calibrated the hydraulic and hydrologic models with meteorological, stage, and flow records collected in the period 1951-1988. For the CWS watershed, the SPF flood was based on a 1957 large flood that extended from January 1 through January 20, 1957. Accordingly, flow and stage hydrographs derived from this SPF have a temporal span of about 20 days. For our modeling needs, we have shifted these dates to the year 2008.

The UNET hydraulic models and hydrologic models for the CWS are described in detail in the project report prepared by the U.S. Army Corps of Engineers (USACE, 1999).

Recommended Methodology

FluidClarity recommends adopting the USACE' existing conditions or baseline models as the basis for stages in the CWS waterways because no major changes have occurred in the watershed since the completion of the USACE CWS study. The merits of adopting the USACE models are:

- Flood stages are derived from a unified hydrology of the whole CWS watershed and associated control structures. The computed flood stages in the CWS and in the associated tributary models will therefore be consistent throughout the watershed. This aspect may be important since the USACE would be a key agency involved in developing and implementing flood mitigation alternatives in the tributaries.

- The HEC-RAS models are derived from the most comprehensive and detailed study of the CWS available. The methodology and approach for the hydrologic and hydraulic conditions are well documented.

- The models contain flood stages for flood-frequencies including the 2-, 5-, 10-, 20-, 50-, 100-, and 500-year floods that are important for developing the DWP.

The CWS UNET base line models are unsteady flow models. For the purposes of establishing flood stages in the CSSC, SBCR and Cal-Sag Channels, FluidClarity recommends developing steady HEC-RAS BC models rather than unsteady models. This recommendation is based on several considerations:

- In FluidClarity's opinion, the benefits of the unsteady flow formulation for the network of waterways do not justify the level of effort required. This especially so since the CWS models are primarily intended to provide tail water conditions for modeling the tributaries.
- Steady flow flood stages along the CWS for various flood frequency contain sufficient information for developing inundation maps that meet FEMA criteria.

- Inflow hydrographs from the ungaged areas of the Des Plaines, Calumet and Cal-Sag watersheds were apparently missing from the input HEC-DSS database obtained from USACE. These missing flows however, were incorporated in the UNET model runs. Using the peak flows from the UNET model results would overcome this limitation.

- As shown in Table 1, a comparison of the UNET unsteady flood stages and steady-flow HECRAS flood stages indicated that they were reasonably close. This agreement is expected because, as shown on the flow profiles, the Lockport dam plays a key role in maintaining water levels in the CSSC, the SBCR and CSC channels.

FluidClarity thus developed steady HEC-RAS models from the UNET models in the following steps.

1. We imported the UNET model into HEC-RAS and then removed all the reaches that were not of interest in this study (See Exhibit 1). The downstream limits of the model were Lockport. The upstream limits were the Little Calumet River and the North Branch of the Chicago River.

2. The cross sections imported into HEC-RAS were georeferenced using the Cook County topographic maps, USGS maps and aerial photographic maps. The Manning's roughness values in the main channel were maintained.

3. The UNET Baseline model stages at Lockport were imposed as downstream boundary conditions. Flood stages for the 2-, 5-, 10-, 20-, 50-, 100-, and 500-year frequency storms were obtained from the UNET model results.

4. Peak flows corresponding to the 2-, 5-, 10-, 20-, 50-, 100-, and 500-year frequency storms were applied at appropriate locations along the waterways. The flows were obtained from the USACE UNET results which accounted for tributary flows and all other sources.

Assumptions

The following assumptions apply in developing the CWS HEC-RAS and tributary modeling.

- The baseline, project flood is representative of conditions in the channel for design purposes.
- Tributary and CWS conditions may be treated independently under most conditions since tributaries flood response is shorter compared to that of the CWS waterways.
- The I&M Canal has little hydraulic impact on flow conditions in the CSSC.
- The I&M Canal elevations are represented by the CSSC elevations.

During very large storm events, the tributary and CWS flow conditions may not be dependent of each other, and timing effects may be difficult to evaluate. A sensitivity analysis using the various tail water elevations from the steady flow models should indicate if there are significant unsteady flow effects. However, as discussed, since the primary interest of the study are flood stages in the CWS rather than flow volumes, unsteady flow effects are anticipated to play a minor role.

Findings

The HEC-RAS models for the CSSC, SBCR and CSC and I&M waterways were used to calculate flood stages for the 2-, 5-, 10-, 20-, 50-, 100-, and 500-year flood frequencies. The results are presented in Table 2. The 10-, 50-, 100-, and 500-year flood stages are required if detailed Flood Insurance Rate Maps for the flooding sources would be needed. The 2-, 5-, 20-year profiles are useful for project formulation purposes such as developing flood damage mitigation alternatives.

For reference purposes Table A-11 of Exhibit 1 is an excerpt from the USACE project report that shows a comparison of the UNET baseline model results, historical records, and results that were obtained by continuous simulation using UNET for the period 1951-1988.

Conclusion and Recommendations

HEC-RAS models for simulating flood stages in the CSSC, SBCR and the Cal-Sag Canal were derived from UNET models that the USACE developed for the purposes of developing flood mitigation alternatives in the CWS. The USACE models constitute the best available information in the CWS watershed. The steady-state HEC-RAS models are thus adequate for purposes of developing the Detailed Watershed Plan (DWP). In particular, for purposes identifying alternatives, constant tail water conditions appear adequate for comparing alternatives. The fact that flood-stages of a wide range of flood frequencies are available allows considerable modeling flexibility to fit project needs. This approach is simple and allows focus to be on the unsteady modeling of the tributaries where the problems are.

More detailed approaches, possibly including unsteady flow analyses for the CWS waterways, may be warranted for detailed project design; however, detailed design tasks have been considered outside the scope of the DWP.

Sources of Information

1. U.S. Army Corps of Engineers (USACE). Design Documentation Report, Chicagoland Underflow, McCook Reservoir Plan, 1999.

2. USACE UNET models input and output files

3. Cook County 2-ft contour topographic maps (2005)

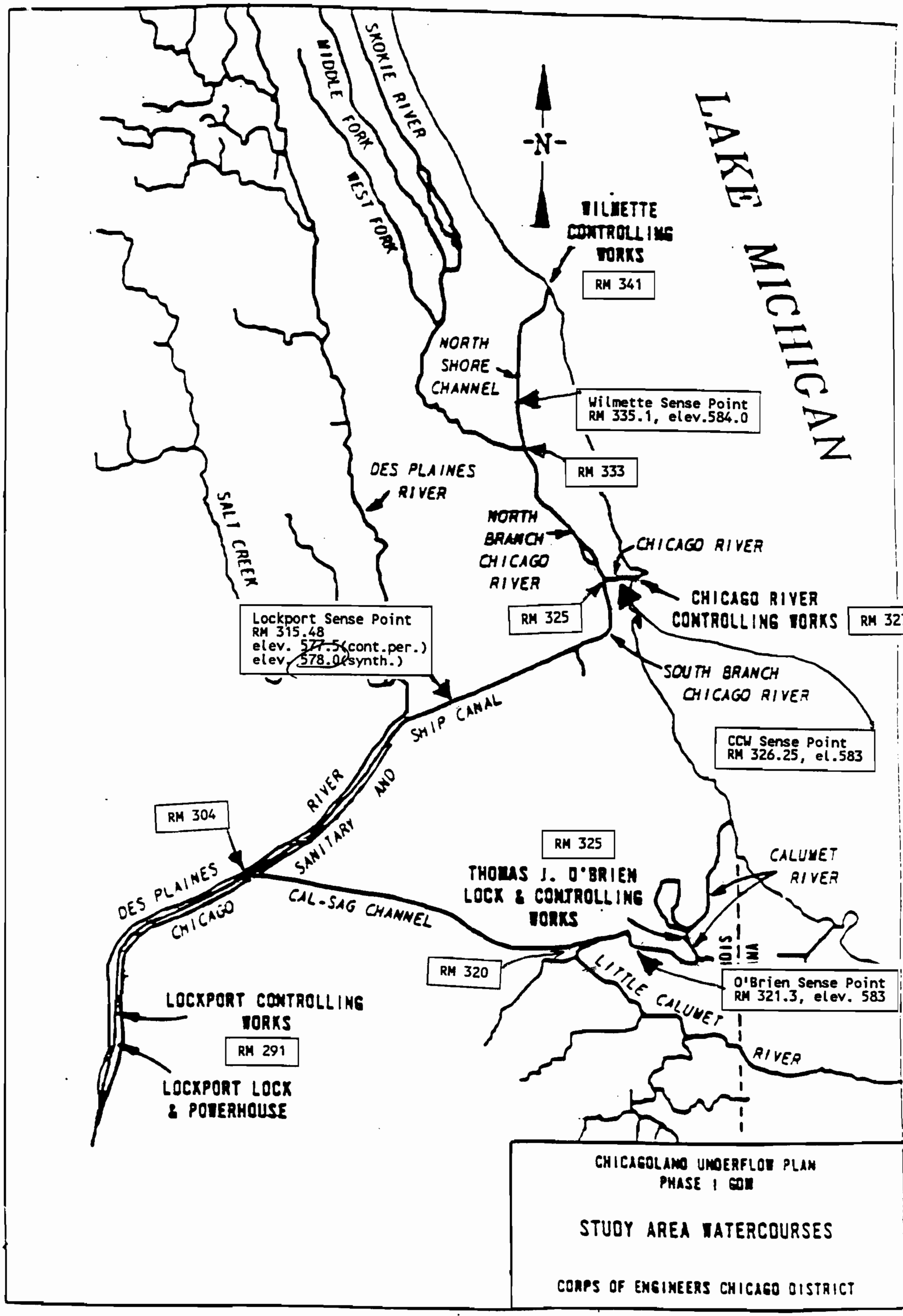
4. USACE, Publication EM 1110-2-1411: STANDARD PROJECT FLOOD DETERMINATIONS , March 1965

Acknowledgement

Rick Ackerman and Dave Kiel of the USACE Chicago District gave invaluable assistance in searching; collating and furnishing the UNET models and various other documents that were used to prepare the HEC-RAS models discussed in this memorandum.

Attachments
EXHIBIT 1

HEC-RAS Models : These have been separately submitted.



Enclosure 1-a

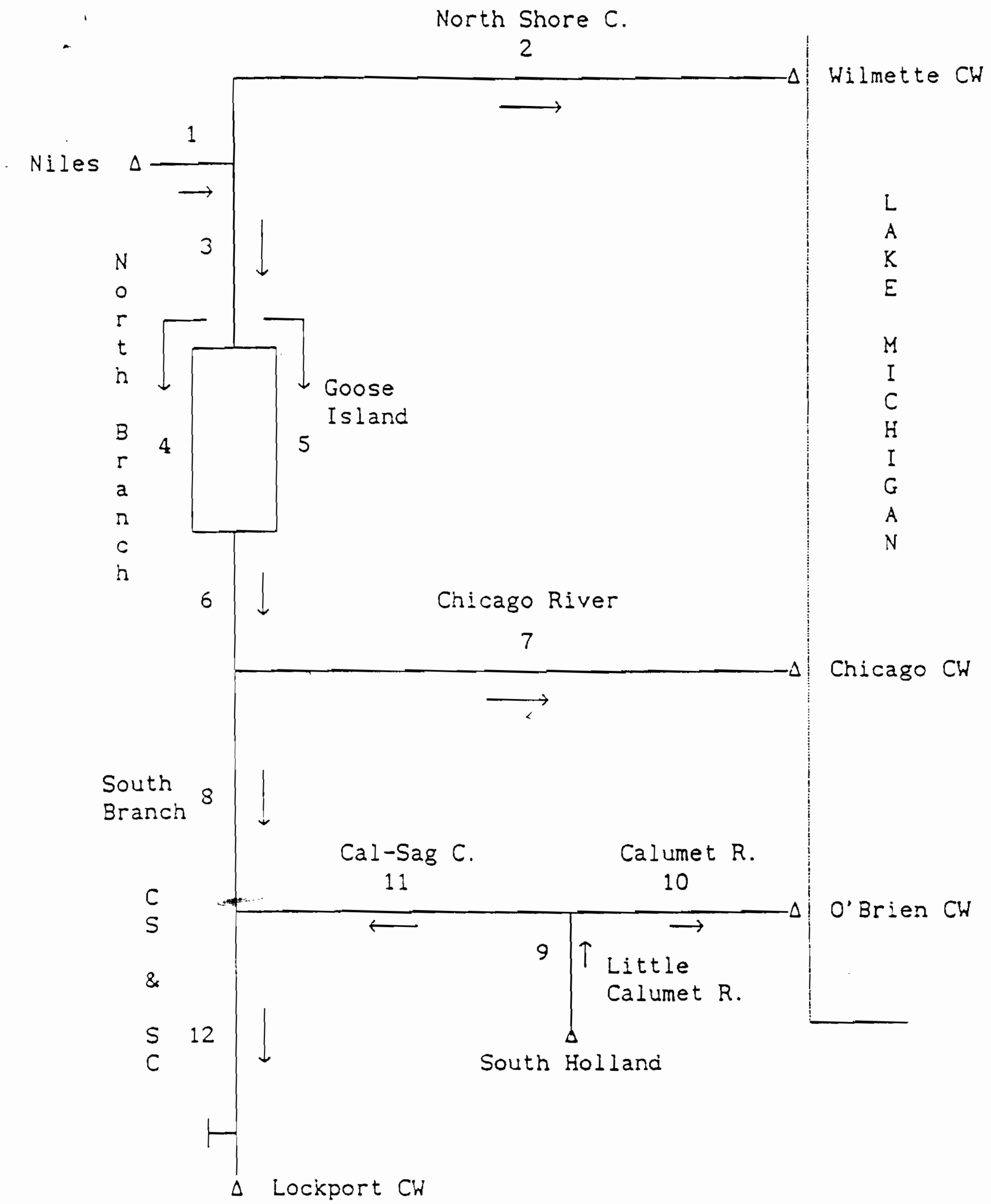


Figure 2.2. Reach numbering scheme for the Chicago Canal model.

Enclosure 1-b

Table A-11. Canal System Observed and Modeled Maximum Water Surface Elevations

		Maximum Water Surface Elevation (ft NGVD)						
			Modeled for Water Years 1951-1988			*Modeled 1% Chance Exceedance Event*		
Location	**Approx. River Mile**	**Observed, 1965 to present (Date)**	**Existing (Date)**	**Stage 1 Project (Date)**	**Stage 2 Project (Date)**	**Existing**	**Stage 1 Project**	**Stage 2 Project**
Wilmette - NSC @ Sheridan Rd.	341.2	586.7 (4/18/75)	592.6 (7/57)	591.3 (7/57)	590.5 (7/57)	589.4	589.1	587.6
North Side SW - NSC @ Howard St.	336.8	588.4 (8/14/87)	594.9 (7/57)	593.1 (7/57)	592.6 (7/57)	591.8	590.9	589.5
North Branch PS - NSC @ Lawrence St.	333.0	588.8 (8/16/97)	594.6 (7/57)	592.2 (7/57)	592.2 (7/57)	591.7	589.8	588.4
Chicago River Controlling Works - Chicago River @ Lk Michigan*	325.6	583.6 (8/16/97)	589.1 (7/57)	585.3 (10/54)	583.9 (10/54)	588.2	585.0	583.2
31st & Western - CS&SC @ Willow Springs Rd.	320.5	583.6 (6/30/77)	589.6 (7/57)	585.4 (10/54)	583.9 (10/54)	588.7	585.1	583.0
Willow Springs - CS&SC @ Willow Springs Rd.	307.9	582.7 (7/18/96)	587.2 (7/57)	584.0 (10/54)	583.0 (10/54)	586.7	584.1	582.4
Sag Junction - Confluence of CS&SC and CSC	304.2	582.2 (7/18/96)	585.0 (7/57)	582.6 (10/54)	581.9 (10/54)	584.7	582.8	581.6
O'Brien Lock - Calumet River Downstream (south) of O'Brien Lock	325.8	583.8 (7/18/96)	585.0 (7/57)	584.6 (7/57)	584.6 (7/57)	584.7	584.0	583.8
Southwest Highway - CSC @ Southwest Hwy	310.8	583.7 (7/18/96)	585.0 (7/57)	584.3 (10/54)	584.3 (10/54)	585.0	583.5	583.1

*The approximated river mile is for the junction of the Chicago River and its North and South Branch.

NSC = North Shore Channel
CS&SC = Chicago Sanitary and Ship Canal
CSC = Calumet Sag Channel

Table A-12. Index of Major Bridges and Confluences for Chicago Canal Model

Reach Scheme (Canal Model)	Tributary Stream	Bridge Name	River Mile
2	North Shore Channel	Sheridan Road Lock	341.2 1/
2	"	Central Street	340.4
2	"	Green Bay Road	339.8
2	"	Church Street	338.7
2	"	Dempster, Il 58	338.2
2	"	Oakton Street	337.2
2	"	Touhy Avenue	336.2
2	"	Devon Avenue	335.2
2	"	Peterson, US 14	334.7
2	"	Foster Avenue	333.6
2	"	Jct. North Branch	333.5
1	North Branch	Touhy	51.4 2/
1		(05536000 gage)	
1	"	Devon Avenue	49.2
1	"	Edens Expwy.	46.2
1	"	Cicero Avenue	46.1
1	"	Foster Avenue	44.5
1	"	Kimball Avenue	43.9
1	"	Kedzie Avenue	43.6
1	"	Jct. North Shore Channel	43.3
3	"	Jct. North Shore Channel	333.5
3	"	Lawrence Ave.	333.1
3	"	Montrose Ave.	332.5
3	"	Irving Park Rd.	332.0
3	"	Addison Street	331.4
3	"	Belmont Ave.	330.9
3	"	Western Ave.	330.6
3	"	Diversy Ave.	330.2
3	"	Damen Ave.	329.9
3	"	Fullerton Ave.	329.5
3	"	Ashland Ave.	329.1
3	"	Cortland Street	328.6
3	"	North Ave.	327.9
4	North Br. (Goose Island West)	Division Street	327.4
4	"	Ogden Ave.	326.9
4	"	Halsted Street	326.6
5	North Br. (Goose Island East)	Division Street	327.0
5	"	Ogden Ave.	326.9
5	"	Halsted Street	326.85
6	North Branch	Chicago Ave.	326.4
6	"	Ohio/Kennedy Expwy.	326.1
6	"	Grand Ave.	326.0
6	"	Kinzie Street	325.8
6	"	Jct. South Branch	325.6
7	Chicago River	Franklin Street	325.65
7	"	Wells Street	325.7
7	"	LaSalle Street	325.8
7	"	Clark Street	325.9
7	"	Dearborn Street	326.0
7	"	State Street	326.1
7	"	Wabash Ave.	326.3
7	"	Michigan Ave.	326.4
7	"	Lake Shore Drive	326.9
8	South Branch	Lake Street	325.6
8	"	Randolph Street	325.5
8	"	Washington Street	325.4
8	"	Madison Street	325.3
8	"	Monroe Street	325.1
8	"	Adams Street	325.0

Table A-12. Index of Major Bridges and Confluences for Chicago Canal Model (cont'd)

Reach Scheme (Canal Model)	Tributary Stream	Bridge Name	River Mile
8	South Branch (cont.)	Jackson Blvd.	324.9
8	"	Eisenhower Expwy.	324.7
8	"	Roosevelt Road	324.2
8	"	18th Street	323.6
8	"	Canal Street	323.3
8	"	Cermak Road	323.1
8	"	Halsted Street	322.6
8	"	Loomis Ave.	321.8
8	"	Damen Ave.	321.0
8	Chicago Sanitary Ship Canal	Western Ave.	320.5
8	"	California Ave.	319.9
8	"	Kedzie Ave.	319.4
8	"	Pulaski Road	318.3
8	"	Cicero Ave.	317.2
8	"	Central Ave.	316.2
8	"	Harlem Ave.	313.9
8	"	Stevenson Expwy.	313.3
8	"	US Hwy 45	309.3
8	"	Willow Springs Rd.	307.7
8	"	IL Rt. 83	304.0
8	"	Jct. Cal. Sag Channel	303.3
9	L. Calumet River	Cottage Grove Ave. (So. Holland 05536290)	6.81
9	"	Indiana Ave.	5.21
9	"	147th Street	4.35
9	"	Halsted Street	3.45
9	"	Ashland Ave.	2.09
9	"	Roll Ave.	1.15
9	"	Jct. Cal. Sag Channel	0.00
10	Calumet River	Jct. Cal. Sag Channel	319.6
10	"	Halsted Street	320.1
10	"	Calumet Expressway	324.8
10	"	Thomas O'Brien L&D	326.4
11	Calumet Sag Channel	Jct. Chi. San. Ship	303.3
11	"	IL Rt. 83	303.9
11	"	104th Ave.	307.3
11	"	US Hwy 45	308.3
11	"	Southwest Hwy 7	310.7
11	"	Harlem Ave.	311.5
11	"	Richland Ave.	312.5
11	"	Cicero Ave.	314.9
11	"	Crawford	316.0
11	"	Kedzie	317.0
11	"	Ashland Ave.	319.0
11	"	Jct. L. Cal. R.	319.6
12	Chicago Sanitary Ship Canal	Jct. Cal. Sag Channel	303.3
12	"	Stephen Street	300.4
12	"	Romeoville Road	296.1
12	"	Jct. Controlling Wks.	293.2
12	"	IL Hwy 7	292.7
12	"	Lockport Lock & Dam	291.0

1/ miles upstream of the Illinois R. confluence with the Mississippi at Grafton, IL

2/ miles upstream of the Des Plaines R. confluence with the Chicago Sanitary Ship Canal at Joliet, IL

TABLE 1 — **A Comparison of UNET and HEC-RAS Models Flood Stages along the Cal-Sag Channel**

No.	Location Along Cal-Sag Channel	XSECTION STATION		PREDICTED ELEVATION (FT, NAVD 88)								
				2-YR			5-YR			10-YR		
		UNET	HEC-RAS	UNET	HEC-RAS	DIFF*	UNET	HEC-RAS	DIFF*	UNET	HEC-RAS	DIFF*
1	Jct. Little Calumet River	RS 319.6	RS 84463.18	580.80	580.22	-0.58	582.16	581.70	-0.46	582.88	582.66	-0.22
2	East Stoney Creek	RS 317.6	RS 73903.18	580.67	580.04	-0.63	582.03	581.50	-0.53	582.77	582.44	-0.33
3	Midlothian Creek	RS 314.6	RS 58063.18	580.47	579.78	-0.69	581.81	581.20	-0.61	582.55	582.14	-0.41
4	Tinley Creek	RS 314.6	RS 58063.18	580.47	579.69	-0.78	581.81	581.10	-0.71	582.55	582.03	-0.52
5	Navajo Creek	RS 312.6	RS 47503.18	580.31	579.60	-0.71	581.62	580.99	-0.63	582.37	581.93	-0.44
6	Cal-Sag Channel - Tributary B	RS 310.6	RS 36943.18	580.12	579.40	-0.72	581.40	580.76	-0.64	582.16	581.70	-0.46
7	West Stoney Creek	RS 309.6	RS 31663.18	580.02	579.30	-0.72	581.27	580.65	-0.62	582.04	581.58	-0.46
8	Mill Creek	RS 308.6	RS 26383.18	579.94	579.16	-0.78	581.13	580.48	-0.65	581.90	581.42	-0.48
9	Sag Jct. (CSC @ CS&SC)	RS 304.2	RS 2079.42	579.51	578.28	-1.23	580.31	579.45	-0.86	581.08	580.45	-0.63
10	Confluence CS&SC	RS 303.6	RS 0.00	579.47	578.20	-1.27	580.22	579.36	-0.86	580.99	580.37	-0.62

No.	Location Along Cal-Sag Channel	XSECTION STATION		PREDICTED ELEVATION (FT, NAVD 88)								
				20-YR			50-YR			100-YR		
		UNET	HEC-RAS	UNET	HEC-RAS	DIFF*	UNET	HEC-RAS	DIFF*	UNET	HEC-RAS	DIFF*
1	Jct. Little Calumet River	RS 319.6	RS 84463.18	583.86	584.15	0.29	584.39	584.85	0.46	584.92	585.58	0.66
2	East Stoney Creek	RS 317.6	RS 73903.18	583.81	583.90	0.09	584.37	584.67	0.30	584.91	585.43	0.52
3	Midlothian Creek	RS 314.6	RS 58063.18	583.65	583.56	-0.09	584.28	584.41	0.13	584.84	585.18	0.34
4	Tinley Creek	RS 314.6	RS 58063.18	583.65	583.44	-0.21	584.28	584.32	0.04	584.84	585.10	0.26
5	Navajo Creek	RS 312.6	RS 47503.18	583.49	583.32	-0.17	584.18	584.23	0.05	584.77	585.02	0.25
6	Cal-Sag Channel - Tributary B	RS 310.6	RS 36943.18	583.31	583.06	-0.25	584.05	584.04	-0.01	584.67	584.83	0.16
7	West Stoney Creek	RS 309.6	RS 31663.18	583.20	582.93	-0.27	583.98	583.94	-0.04	584.61	584.74	0.13
8	Mill Creek	RS 308.6	RS 26383.18	583.09	582.79	-0.30	583.89	583.83	-0.06	584.54	584.64	0.10
9	Sag Jct. (CSC @ CS&SC)	RS 304.2	RS 2079.42	582.37	582.02	-0.35	583.39	583.23	-0.16	584.13	584.13	0.00
10	Confluence CS&SC	RS 303.6	RS 0.00	582.29	581.96	-0.33	583.33	583.19	-0.14	584.09	584.10	0.01

No.	Location Along Cal-Sag Channel	XSECTION STATION		PREDICTED ELEVATION (FT, NAVD 88)								
				500-YR						**25-YR** ***		
		UNET	HEC-RAS	UNET	HEC-RAS	DIFF*				UNET	HEC-RAS	DIFF*
1	Jct. Little Calumet River	RS 319.6	RS 84463.18	587.65	588.46	0.81				583.90	584.18	0.28
2	East Stoney Creek	RS 317.6	RS 73903.18	587.65	588.39	0.74				583.87	583.95	0.08
3	Midlothian Creek	RS 314.6	RS 58063.18	587.61	588.25	0.64				583.74	583.67	-0.07
4	Tinley Creek	RS 314.6	RS 58063.18	587.61	588.20	0.59				583.74	583.56	-0.17
5	Navajo Creek	RS 312.6	RS 47503.18	587.56	588.16	0.60				583.58	583.45	-0.13
6	Cal-Sag Channel - Tributary B	RS 310.6	RS 36943.18	587.49	588.06	0.57				583.44	583.29	-0.14
7	West Stoney Creek	RS 309.6	RS 31663.18	587.45	588.01	0.56				583.34	583.12	-0.22
8	Mill Creek	RS 308.6	RS 26383.18	587.40	587.95	0.55				583.17	583.02	-0.15
9	Sag Jct. (CSC @ CS&SC)	RS 304.2	RS 2079.42	587.10	587.64	0.54				582.58	582.26	-0.32
10	Confluence CS&SC	RS 303.6	RS 0.00	587.07	587.62	0.55				582.53	582.22	-0.32

Note:
* DIFF = ELEVATION $_{HEC\text{-}RAS}$ - ELEVATION $_{UNET}$
CSC = Cal-Sag Channel
CS&SC = Chicago Sanitary and Ship Canal
Jct. = Junction
NAVD 88 (North American Vertical Datum 1988, FT) = NGVD 29 (National Geodetic Vertical Datum of 1929, FT) - 0.29 FT, in this case. Refer to: http://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl

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TABLE 2 **FLOOD STAGES (FT, NAVD 88) IN THE CHICAGO WATERWAYS SYSTEM WITHIN THE CAL-SAG WATERSHED***

Cal-Sag Channel

No.	Location Descriptions**	Stationing	2-Yr	5-Yr	10-Yr	20-Yr	50-Yr	100-Yr	500-Yr	25-Yr
1	Jct. Little Calumet River	84463.18	580.22	581.70	582.66	584.15	584.85	585.58	588.46	584.18
2		79183.18	580.11	581.59	582.53	584.02	584.76	585.52	588.45	584.07
3		78655.74	580.10	581.58	582.52	584.00	584.74	585.50	588.44	584.07
4	East Stoney Creek	73903.18	580.04	581.50	582.44	583.90	584.67	585.43	588.39	583.95
5		68623.18	579.95	581.40	582.34	583.79	584.58	585.35	588.34	583.84
6		63343.18	579.87	581.30	582.24	583.68	584.50	585.26	588.30	583.79
7	Midlothian Creek/ Tinley Creek	58063.18	579.78	581.20	582.14	583.56	584.41	585.18	588.25	583.67
8		52783.18	579.69	581.10	582.03	583.44	584.32	585.10	588.20	583.56
9	Navajo Creek	47503.18	579.60	580.99	581.93	583.32	584.23	585.02	588.16	583.45
10		42223.18	579.50	580.88	581.82	583.20	584.14	584.93	588.11	583.34
11		37998.92	579.42	580.79	581.72	583.09	584.06	584.85	588.07	583.29
12	Cal-Sag Channel - Tributary B	36943.18	579.40	580.76	581.70	583.06	584.04	584.83	588.06	583.29
13	West Stoney Creek	31663.18	579.30	580.65	581.58	582.93	583.94	584.74	588.01	583.12
14	Mill Creek	26383.18	579.16	580.48	581.42	582.79	583.83	584.64	587.95	583.02
15		21103.18	578.99	580.29	581.24	582.64	583.71	584.54	587.89	582.86
16		15823.18	578.82	580.08	581.05	582.49	583.59	584.44	587.83	582.71
17		10543.18	578.64	579.86	580.84	582.33	583.47	584.33	587.77	582.56
18		5263.18	578.44	579.63	580.62	582.16	583.33	584.22	587.70	582.42
19	Sag Jct. (CSC @ CS&SC)	2079.42	578.28	579.45	580.45	582.02	583.23	584.13	587.64	582.26
20	Confluence CS&SC	CSSC Jct	578.20	579.36	580.37	581.96	583.19	584.10	587.62	582.22

South Branch of Chicago River (SBCR)

No.	Location Descriptions	Stationing	2-Yr	5-Yr	10-Yr	20-Yr	50-Yr	100-Yr	500-Yr	25-Yr
1	U/S of SBCR	190341	583.94	585.09	585.52	586.82	588.81	590.08	593.87	587.38
2		187913	583.93	585.08	585.52	586.81	588.80	590.08	593.86	587.38
3	(~ Jackson Blvd, RS 324.9)	187649	583.92	585.08	585.52	586.81	588.80	590.08	593.86	586.85
4	(~ Roosevelt Rd, RS 324.2)	184903	583.91	585.07	585.51	586.80	588.79	590.07	593.86	587.38
5	(~ 18th Street, RS 323.6)	181629	583.90	585.06	585.50	586.79	588.78	590.06	593.85	587.38
6	(~ Canal ST, RS 323.3)	178197	583.88	585.04	585.49	586.78	588.77	590.05	593.85	587.38
7	(~ Cermak Rd, RS 323.1)	177933	583.88	585.04	585.48	586.78	588.77	590.05	593.85	587.32
8	(~ Halsted ST, RS 322.6)	175979	583.87	585.03	585.48	586.77	588.76	590.05	593.84	587.32
9		172917	583.86	585.03	585.47	586.77	588.76	590.04	593.84	587.32
10		172653	583.85	585.03	585.47	586.77	588.76	590.04	593.84	587.32
11	(~ Loomis Ave, RS 321.8)	170066	583.84	585.01	585.45	586.75	588.75	590.03	593.83	587.26
12	(~ Damen Ave, RS 321.0)	166159	583.80	584.97	585.42	586.72	588.73	590.02	593.82	587.26
13	Western Ave	163836	583.78	584.95	585.41	586.71	588.71	590.00	593.81	587.26
14		163572	583.77	584.95	585.40	586.70	588.71	590.00	593.81	587.20
15		163044	583.76	584.93	585.39	586.70	588.70	590.00	593.81	587.20
16	(~ California Ave, RS 319.9)	161143	583.73	584.90	585.36	586.67	588.68	589.98	593.79	587.15
17		158292	583.69	584.85	585.33	586.64	588.65	589.96	593.76	587.15
18	(~ Kedzie Ave, RS 319.4)	158028	583.68	584.85	585.32	586.63	588.65	589.95	593.75	587.09
19		155282	583.64	584.80	585.28	586.60	588.62	589.93	593.73	587.03
20		152748	583.58	584.75	585.23	586.55	588.58	589.90	593.68	586.97
21	(~ Pulaski Rd, RS 318.3)	152484	583.58	584.74	585.23	586.55	588.58	589.89	593.68	586.97
22		150372	583.55	584.71	585.20	586.53	588.56	589.88	593.66	586.97
23		147890	583.52	584.69	585.18	586.51	588.54	589.86	593.64	586.91
24	(~ Cicero Ave, RS 317.2)	147626	583.51	584.67	585.17	586.49	588.52	589.83	593.60	586.91
25		144986	583.44	584.59	585.10	586.43	588.45	589.74	593.50	587.04
26		142082	583.33	584.48	584.99	586.35	588.34	589.62	593.36	586.98
27	(~ Central Ave, RS 316.2)	139812	583.26	584.41	584.93	586.29	588.28	589.54	593.27	586.92
28		137067	583.18	584.32	584.85	586.23	588.20	589.44	593.16	586.81
29	LCWCP	136803	583.18	584.32	584.85	586.22	588.19	589.44	593.16	586.86
30		133213	583.05	584.17	584.72	586.11	588.05	589.27	592.98	586.56
31	(~ Harlem Ave, RS 313.9)	129463	582.91	584.02	584.58	585.99	587.90	589.11	592.81	586.44
32		125239	582.78	583.87	584.44	585.88	587.75	588.94	592.63	586.32
33	(~ Stevenson Expwy., RS 313.3)	124975	582.78	583.87	584.44	585.87	587.75	588.94	592.62	586.32
34		120487	582.64	583.72	584.30	585.75	587.59	588.76	592.44	586.21
35		116844	582.56	583.63	584.22	585.67	587.49	588.65	592.32	586.15
36		116580	582.55	583.62	584.21	585.66	587.48	588.64	592.31	586.15
37		111722	582.46	583.52	584.13	585.58	587.38	588.53	592.19	585.90
38		109612	582.32	583.39	584.01	585.46	587.25	588.40	592.06	585.84
39		102114	581.80	582.88	583.54	585.02	586.76	587.89	591.54	585.37
40	(~ US Hwy 45, RS 309.3)	101850	581.78	582.87	583.53	585.00	586.74	587.87	591.53	585.37
41	(IM Trib D)	99000	581.60	582.69	583.37	584.85	586.58	587.69	591.36	585.26
42		96783	581.44	582.54	583.23	584.72	586.42	587.53	591.19	585.14
43	Willow Springs	94463	581.27	582.37	583.08	584.58	586.27	587.38	591.04	584.96
44		87283	580.50	581.63	582.41	583.94	585.54	586.62	590.27	584.25
45		85330	580.25	581.38	582.19	583.72	585.28	586.33	589.97	584.07
46		81898	579.81	580.95	581.79	583.34	584.82	585.84	589.45	583.59
47		79153	579.43	580.57	581.45	583.00	584.42	585.41	588.98	583.17
48		76408	578.99	580.14	581.06	582.62	583.96	584.92	588.46	582.88
49	(~ IL Rt. 83, RS 304.0)	73558	578.55	579.71	580.68	582.25	583.52	584.44	587.95	582.40
50		71078	578.19	579.36	580.37	581.94	583.14	584.03	587.52	582.04
51	D/S of SBCR	70708	578.14	579.30	580.32	581.90	583.08	583.97	587.45	581.98

Chicago Ship & Sanitary Canal, IM& Canal

No.	Location Descriptions	Stationing	2-Yr	5-Yr	10-Yr	20-Yr	50-Yr	100-Yr	500-Yr	25-Yr
1	U/S of CS&SC	70707	578.12	579.27	580.27	581.83	583.03	583.92	587.39	581.92
2		68667	577.91	579.05	580.03	581.58	582.77	583.65	587.09	581.75
3		63387	577.31	578.43	579.38	580.89	582.05	582.91	586.27	580.98
4	(IM Trib B)	59217	576.85	577.95	578.87	580.35	581.48	582.32	585.62	580.57
5	(~ Stephan Street, RS 300.4) (IM Trib A)	52792	576.07	577.13	578.00	579.43	580.52	581.32	584.52	579.82
6		46142	575.22	576.23	577.06	578.42	579.46	580.23	583.31	578.45
7		41282	574.56	575.53	576.31	577.62	578.63	579.36	582.34	577.81
8		36002	573.65	574.58	575.30	576.54	577.50	578.18	581.05	576.57
9	AVM Site (~ Romeoville Rd, RS 296.1)	31802	572.89	573.78	574.45	575.64	576.56	577.21	579.98	575.64
10		24872	571.60	572.40	573.01	574.10	574.92	575.52	578.07	574.12
11		20482	570.69	571.42	571.97	572.98	573.74	574.28	576.68	573.11
12	RM 293.5	17542	569.99	570.68	571.19	572.14	572.85	573.34	575.62	572.28
13	(~ Jct. Controlling Wks, RS 293.2)	16132	569.84	570.53	571.04	572.00	572.72	573.22	575.53	572.11
14		15332	568.96	569.60	570.07	570.97	571.63	572.09	574.28	571.10
15	(~ IL Hwy 7, RS 292.7)	13240	567.91	568.55	569.03	569.92	570.53	570.96	572.85	570.06
16		11900	566.81	567.45	567.93	568.79	569.40	569.82	571.56	569.19
17		10540	565.58	566.17	566.61	567.37	567.96	568.37	569.96	567.51
18		6540	562.01	562.38	562.66	563.13	563.51	563.77	564.81	563.16
19	Lockport CW	5840	558.90	559.12	559.28	559.56	559.79	559.95	560.61	559.63
20	(~ Lockport Lock & Dam, RS 291.0)	4840	538.97	539.11	539.22	539.44	539.64	539.79	540.46	539.49
21		2640	538.56	538.62	538.68	538.79	538.88	538.96	539.32	538.82
22	D/S Limit of CS&SC	800	538.21	538.21	538.21	538.21	538.21	538.21	538.21	538.21

*Source: USACE McCook Reservoir, Final Design Report, 1999, Appendix A

** ( ) RS are approximate stationing close to the described feature

*** 25-Yr data are interpolated data

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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.

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%

Tributary	Subbasin	Area (sq. mi)	Curve Number	Lag Time (min)
71st St. Ditch	SFDT_1	0.10	76.7	40.8
71st St. Ditch	SFDT_10	0.11	73.0	28.1
71st St. Ditch	SFDT_11	0.16	74.5	36.8
71st St. Ditch	SFDT_12	0.15	76.2	28.4
71st St. Ditch	SFDT_13	0.35	67.0	73.1
71st St. Ditch	SFDT_14	0.21	70.1	55.6
71st St. Ditch	SFDT_15	0.13	70.8	29.4
71st St. Ditch	SFDT_16	0.04	69.3	17.8
71st St. Ditch	SFDT_17	0.11	71.6	27.7
71st St. Ditch	SFDT_18	0.13	75.7	19.0
71st St. Ditch	SFDT_19	0.31	74.4	74.0
71st St. Ditch	SFDT_2	0.22	70.8	30.7
71st St. Ditch	SFDT_20	0.18	75.5	33.4
71st St. Ditch	SFDT_21	0.06	80.5	33.1
71st St. Ditch	SFDT_22	0.19	75.0	25.0
71st St. Ditch	SFDT_3	0.15	73.3	41.2
71st St. Ditch	SFDT_4	0.13	76.2	59.6
71st St. Ditch	SFDT_5	0.19	76.2	45.9
71st St. Ditch	SFDT_6	0.12	82.1	42.0
71st St. Ditch	SFDT_7	0.17	74.5	37.5
71st St. Ditch	SFDT_8	0.09	68.3	23.6
71st St. Ditch	SFDT_9	0.13	76.5	59.2
79th St. Ditch	W100	0.04	85.7	19.7
79th St. Ditch	W120	0.18	82.5	33.0
79th St. Ditch	W200	0.18	77.6	33.3
79th St. Ditch	W260	0.10	75.1	27.0
79th St. Ditch	W280	0.11	75.1	27.7
79th St. Ditch	W340	0.15	80.0	30.9
79th St. Ditch	W360	0.03	75.1	17.7
79th St. Ditch	W400	0.11	74.9	28.3
79th St. Ditch	W440	0.12	81.6	29.0
79th St. Ditch	W460	0.14	82.4	30.6
79th St. Ditch	W500	0.10	86.1	27.0
79th St. Ditch	W510	0.17	82.9	32.3
79th St. Ditch	W550	0.23	80.5	36.1
79th St. Ditch	W560	0.23	77.4	36.0
79th St. Ditch	W620	0.09	82.0	26.4
79th St. Ditch	W90	0.10	85.1	34.2
Castle Bowl	W110	0.08	73.3	14.6
Castle Bowl	W115	0.27	72.1	29.0
Castle Bowl	W120	0.15	72.4	36.9
Castle Bowl	W130	0.27	73.2	29.8
Castle Bowl	W140	0.06	74.9	14.2
Castle Bowl	W150	0.17	73.2	16.0
Castle Bowl	W160	0.17	70.4	18.9
Castle Bowl	W170	0.20	66.6	16.5
Castle Bowl	W180	0.17	72.8	33.9
Castle Bowl	W190	0.14	72.9	24.9
Castle Bowl	W210	0.17	72.9	17.0

Crooked Creek	W280	0.22	66.2	31.0
Crooked Creek	W310	0.12	66.6	38.2
Crooked Creek	W320	0.15	66.2	35.9
Crooked Creek	W330	0.13	67.9	31.6
Crooked Creek	W360	0.20	65.9	36.0
Crooked Creek	W370	0.15	67.7	33.0
Crooked Creek	W380	0.11	66.2	24.5
Crooked Creek	W390	0.05	56.9	22.3
Crooked Creek	W400	0.31	65.6	41.3
Crooked Creek	W410	0.33	74.0	42.2
Crooked Creek	W460	0.16	67.2	37.8
Crooked Creek	W500	0.14	64.3	49.0
Crooked Creek	W510	0.28	63.5	31.3
Crooked Creek	W560	0.18	65.3	29.1
Crooked Creek	W600	0.29	60.0	46.4
Crooked Creek	W610	0.25	65.8	35.7
Crooked Creek	W650	0.32	69.9	35.0
Crooked Creek	W700	0.07	71.3	7.0
Crooked Creek	W720	0.08	67.9	27.6
Crestwood Drainage Ditch	W2443340	0.12	67.5	27.4
Crestwood Drainage Ditch	W2443370	0.06	74.8	23.0
Crestwood Drainage Ditch	W2443390	0.13	67.9	29.8
Crestwood Drainage Ditch	W2443400	0.16	71.2	31.6
Crestwood Drainage Ditch	W2443410	0.02	77.3	12.6
Crestwood Drainage Ditch	W2443490	0.25	68.0	60.0
Crestwood Drainage Ditch	W2443530	0.12	70.8	38.6
Crestwood Drainage Ditch	W2443540	0.22	63.1	60.0
Crestwood Drainage Ditch	W2443680	0.06	73.1	20.7
Crestwood Drainage Ditch	W2443690	0.13	67.5	34.0
Cal-Sag Trib. A	W1530	0.06	68.3	16.2
Cal-Sag Trib. A	W1540	0.20	72.8	34.3
Cal-Sag Trib. A	W1580	0.10	68.6	13.9
Cal-Sag Trib. A	W1590	0.21	70.1	16.9
Cal-Sag Trib. A	W220	0.16	70.7	18.6
Cal-Sag Trib. A	W230	0.22	67.9	25.4
Cal-Sag Trib. A	W250	0.28	66.0	38.5
Cal-Sag Trib. A	W290	0.20	69.8	23.8
Cal-Sag Trib. A	W300	0.19	68.6	33.8
Cal-Sag Trib. A	W310	0.19	72.5	18.8
Cal-Sag Trib. A	W360	0.25	66.6	37.1
Cal-Sag Trib. A	W410	0.16	61.6	31.6
Cal-Sag Trib. A	W450	0.17	66.4	32.4
Cal-Sag Trib. A	W470	0.06	62.1	22.7
Cal-Sag Trib. A	W510	0.10	67.1	26.9
Cal-Sag Trib. A	W550	0.05	65.2	22.2
Cal-Sag Trib. A	W600	0.13	71.0	16.5
Cal-Sag Trib. A	W610	0.24	72.2	18.4

Cal-Sag Trib. B	W2440	0.11	71.5	18.4
Cal-Sag Trib. B	W2450	0.07	68.0	12.5
Cal-Sag Trib. B	W260	0.12	69.3	16.8
Cal-Sag Trib. B	W360	0.11	71.1	27.1
Cal-Sag Trib. B	W370	0.18	71.1	19.1
Cal-Sag Trib. B	W420	0.19	71.8	24.7
Cal-Sag Trib. B	W480	0.08	66.6	18.1
Cal-Sag Trib. B	W530	0.06	69.5	11.3
Cal-Sag Trib. B	W580	0.19	70.3	18.3
Cal-Sag Trib. C	W1200	0.26	75.4	39.2
Cal-Sag Trib. C	W1250	0.26	74.3	38.1
Cal-Sag Trib. C	W1260	0.18	71.8	23.3
Cal-Sag Trib. C	W1300	0.15	69.4	30.1
Cal-Sag Trib. C	W1350	0.10	64.9	28.5
Cal-Sag Trib. C	W1360	0.23	69.6	28.8
Cal-Sag Trib. C	W1400	0.24	69.2	33.7
Cal-Sag Trib. C	W1410	0.12	65.4	40.2
Cal-Sag Trib. C	W1460	0.17	67.2	23.6
Cal-Sag Trib. C	W1500	0.03	82.1	14.9
Cal-Sag Trib. C	W1510	0.13	71.1	33.2
Cal-Sag Trib. C	W1550	0.06	69.2	32.3
Cal-Sag Trib. C	W1560	0.12	67.2	29.2
Cal-Sag Trib. C	W1600	0.01	83.2	14.5
Cal-Sag Trib. C	W1610	0.14	80.1	27.0
Cal-Sag Trib. C	W870	0.08	76.9	24.3
Cal-Sag Trib. C	W890	0.01	83.3	14.7
Cal-Sag Trib. C	W920	0.29	79.2	30.8
Cal-Sag Trib. C	W930	0.29	75.7	40.1
Cal-Sag Trib. C	W970	0.28	69.3	25.5
Cal-Sag Trib. C	W980	0.18	69.7	46.1
Illinois & Michigan Trib. 1	W100	0.08	71.8	5.0
Illinois & Michigan Trib. 1	W110	0.01	73.6	5.0
Illinois & Michigan Trib. 1	W120	0.16	68.0	16.2
Illinois & Michigan Trib. 1	W130	0.09	71.1	13.0
Illinois & Michigan Trib. 1	W90	0.26	67.8	23.9
Illinois & Michigan Trib. 2	W70	0.42	70.9	41.9
Illinois & Michigan Trib. 2	W80	0.14	75.0	15.1
Illinois & Michigan Trib. 2	W90	0.23	63.1	36.8
Illinois & Michigan Trib. A	W140	0.11	72.2	23.8
Illinois & Michigan Trib. A	W150	0.13	71.3	30.9
Illinois & Michigan Trib. A	W190	0.09	72.9	23.4
Illinois & Michigan Trib. A	W200	0.15	72.5	28.7
Illinois & Michigan Trib. A	W240	0.11	72.9	25.3
Illinois & Michigan Trib. A	W250	0.17	78.5	27.7
Illinois & Michigan Trib. A	W290	0.11	72.1	21.7
Illinois & Michigan Trib. A	W300	0.09	70.9	21.1

Illinois & Michigan Tribs. B & C	W150	0.10	72.2	22.3
Illinois & Michigan Tribs. B & C	W240	0.23	73.7	31.0
Illinois & Michigan Tribs. B & C	W250	0.16	72.5	30.8
Illinois & Michigan Tribs. B & C	W260	0.16	71.1	27.0
Illinois & Michigan Tribs. B & C	W270	0.11	73.8	18.2
Illinois & Michigan Tribs. B & C	W320	0.17	67.7	37.8
Illinois & Michigan Tribs. B & C	W370	0.20	66.5	39.3
Illinois & Michigan Tribs. B & C	W420	0.58	63.0	56.9
Illinois & Michigan Tribs. B & C	W460	0.14	69.6	27.3
Illinois & Michigan Tribs. B & C	W470	0.13	67.9	23.0
Illinois & Michigan Tribs. B & C	W510	0.12	66.9	45.5
Illinois & Michigan Tribs. B & C	W520	0.13	69.9	39.5
Illinois & Michigan Tribs. B & C	W660	0.19	67.2	44.7
Illinois & Michigan Tribs. B & C	W680	0.11	72.4	27.5
Illinois & Michigan Trib. D	W380	0.14	65.4	44.4
Illinois & Michigan Trib. D	W400	0.24	66.0	38.2
Illinois & Michigan Trib. D	W410	0.21	67.0	26.2
Illinois & Michigan Trib. D	W450	0.15	67.2	17.4
Illinois & Michigan Trib. D	W460	0.16	66.5	18.0
Justice Ditch	W500	0.16	71.1	29.4
Justice Ditch	W540	0.13	76.6	49.5
Justice Ditch	W550	0.13	72.0	33.7
Long Run Creek	W2560	0.08	71.1	25.2
Long Run Creek	W2580	0.09	71.0	27.4
Long Run Creek	W2600	0.25	72.3	43.6
Long Run Creek	W2610	0.25	77.9	35.6
Long Run Creek	W2620	0.12	76.4	26.5
Long Run Creek	W2640	0.21	67.1	38.0
Long Run Creek	W2660	0.16	71.5	24.0
Long Run Creek	W2680	0.21	72.2	37.8
Long Run Creek	W2690	0.15	71.5	33.1
Long Run Creek	W2700	0.37	71.3	32.8
Long Run Creek	W3050	0.20	71.7	30.9
Long Run Creek	W3110	0.20	69.4	38.9
Long Run Creek	W3200	0.20	69.7	27.8
Long Run Creek	W3250	0.15	68.5	33.3
Long Run Creek	W3290	0.21	69.9	40.9
Long Run Creek	W3350	0.10	71.0	23.9
Long Run Creek	W3410	0.15	72.2	30.7
Long Run Creek	W350	0.19	70.1	41.6
Long Run Creek	W360	0.15	68.6	54.5
Long Run Creek	W370	0.29	69.9	61.8
Long Run Creek	W380	0.18	74.8	34.3
Long Run Creek	W390	0.12	70.7	35.0
Long Run Creek	W400	0.17	72.8	46.3
Long Run Creek	W410	0.17	71.4	35.0
Long Run Creek	W420	0.34	72.4	47.6
Long Run Creek	W430	0.14	72.2	27.6
Long Run Creek	W440	0.17	72.5	37.0
Long Run Creek	W440_2	0.10	72.2	18.4
Long Run Creek	W450	0.06	71.2	43.5
Long Run Creek	W460	0.21	72.0	30.7
Long Run Creek	W470	0.16	71.8	32.2
Long Run Creek	W490	0.06	70.6	18.1
Long Run Creek	W500	0.13	72.4	31.5
Long Run Creek	W510	0.03	67.5	21.1
Long Run Creek	W520	0.22	73.6	37.0
Long Run Creek	W530	0.18	71.9	31.7
Long Run Creek	W540	0.13	71.4	28.9
Long Run Creek	W550	0.03	70.9	13.4
Long Run Creek	W560	0.23	73.4	35.5
Long Run Creek	W570	0.17	71.1	33.7
Long Run Creek	W580	0.14	67.4	30.7
Long Run Creek	W590	0.10	65.5	38.0
Long Run Creek	W5910	0.21	71.2	37.8
Long Run Creek	W5960	0.12	67.8	35.9
Long Run Creek	W5970	0.19	65.8	46.8
Long Run Creek	W6000	0.09	72.2	27.0
Long Run Creek	W6010	0.15	65.9	34.5
Long Run Creek	W6030	1.39	72.5	117.2
Long Run Creek	W6040	0.28	71.0	46.9

Long Run Creek	W610	0.06	65.8	31.5
Long Run Creek	W6100	0.22	73.8	27.1
Long Run Creek	W6190	0.16	71.1	30.7
Long Run Creek	W6230	0.14	72.9	35.5
Long Run Creek	W6240	0.19	72.5	27.6
Long Run Creek	W6280	0.22	73.3	21.3
Long Run Creek	W6290	0.18	68.7	44.3
Long Run Creek	W630	0.14	66.0	43.9
Long Run Creek	W640	0.12	70.3	31.0
Long Run Creek	W660	0.27	66.6	41.6
Long Run Creek	W670	0.17	72.9	29.4
Long Run Creek	W710	0.13	70.6	28.3
Long Run Creek	W720	0.22	70.0	31.2
Long Run Creek	W7980	0.06	74.3	17.1
Long Run Creek	W8000	0.68	73.8	43.5
Long Run Creek	W8010	1.30	74.3	35.3
Long Run Creek	W8020	0.83	74.3	55.9
Long Run Creek	W8030	0.79	63.9	34.2
Long Run Creek	W8040	0.90	63.9	40.7
Long Run Creek	W8050	0.62	69.8	50.6
Long Run Creek	W8060	1.02	68.9	51.4
Long Run Creek	W8070	1.38	75.1	125.0
Long Run Creek	W8080	1.02	75.1	86.3
Long Run Creek	W8090	0.14	71.1	25.3
Long Run Creek	W9000	0.43	73.6	46.5
Long Run Creek	W9010	0.11	75.2	31.1
Long Run Creek	W9020	0.39	73.6	67.1
Lucas Ditch	W146260	0.14	66.5	31.0
Lucas Ditch	W146370	0.09	63.4	22.1
Lucas Ditch	W146380	0.30	67.4	35.0
Lucas Ditch	W146470	0.24	66.5	28.5
Lucas Ditch	W146480	0.14	73.6	14.9
Lucas Ditch	W146520	0.19	68.3	26.2
Lucas Ditch	W146540	0.11	72.5	19.1
Lucas Ditch	W146580	0.19	75.1	41.1
Lucas Ditch	W146590	0.28	59.7	54.0
Lucas Ditch	W146630	0.24	69.1	19.2
Lucas Ditch	W146690	0.18	70.7	15.2
Lucas Ditch	W146790	0.21	68.2	18.3
Lucas Ditch	W146830	0.17	64.9	19.0
Lucas Ditch	W146880	0.23	66.6	14.4

Lucas Diversion Ditch	W1010	0.10	70.9	23.9
Lucas Diversion Ditch	W1020	0.18	69.4	27.1
Lucas Diversion Ditch	W360	0.02	78.8	18.4
Lucas Diversion Ditch	W370	0.05	72.9	19.9
Lucas Diversion Ditch	W410	0.15	74.6	33.3
Lucas Diversion Ditch	W440	0.03	79.7	17.0
Lucas Diversion Ditch	W450	0.12	71.6	27.4
Lucas Diversion Ditch	W460	0.01	80.8	20.2
Lucas Diversion Ditch	W470	0.17	66.7	24.8
Lucas Diversion Ditch	W500	0.17	67.8	42.0
Lucas Diversion Ditch	W550	0.13	78.2	16.2
Lucas Diversion Ditch	W560	0.11	76.8	21.7
Lucas Diversion Ditch	W620	0.24	76.0	43.4
Lucas Diversion Ditch	W670	0.25	76.9	52.0
Lucas Diversion Ditch	W710	0.25	77.3	42.5
Lucas Diversion Ditch	W720	0.24	75.8	43.6
Lucas Diversion Ditch	W760	0.15	75.6	35.6
Lucas Diversion Ditch	W770	0.16	79.1	54.3
Lucas Diversion Ditch	W810	0.09	75.5	30.8
Lucas Diversion Ditch	W820	0.15	77.2	28.8
Lucas Diversion Ditch	W860	0.16	77.2	26.6
Lucas Diversion Ditch	W910	0.07	70.8	29.7
Lucas Diversion Ditch	W920	0.18	67.8	25.0
Lucas Diversion Ditch	W960	0.06	72.7	22.6
Lucas Diversion Ditch	W970	0.19	65.8	22.4
Marley Creek	W21190	0.25	69.2	37.0
Marley Creek	W21200	0.24	71.3	31.8
Marley Creek	W21210	0.26	72.4	37.0
Marley Creek	W21220	0.28	76.4	38.4
Marley Creek	W21230	0.22	67.5	45.4
Marley Creek	W21240	0.24	71.0	32.3
Marley Creek	W21250	0.45	67.4	45.0
Marley Creek	W21260	0.10	75.2	21.5
Marley Creek	W21270	0.18	73.2	33.2
Marley Creek	W21290	0.19	72.3	34.5
Marley Creek	W21300	0.15	69.3	33.7
Marley Creek	W21310	0.16	73.3	31.6
Marley Creek	W21320	0.09	71.3	33.2
Marley Creek	W21330	0.21	74.2	45.5
Marley Creek	W21340	0.27	82.7	37.2
Marley Creek	W21360	0.13	75.4	30.5
Marley Creek	W21370	0.13	73.2	33.1
Marley Creek	W21400	0.34	75.7	70.4
Marley Creek	W21410	0.21	70.7	27.0
Marley Creek	W21430	0.28	73.1	54.7
Marley Creek	W21490	0.13	75.8	26.1
Marley Creek	W21510	0.20	73.2	35.8
Marley Creek	W21520	0.29	72.4	53.1
Marley Creek	W21540	0.20	75.6	36.2
Marley Creek	W21550	0.25	74.4	36.5
Marley Creek	W21570	0.20	72.4	29.7
Marley Creek	W21580	0.34	71.4	44.0
Marley Creek	W21590	0.28	76.8	31.4
Marley Creek	W21610	0.30	72.8	31.7
Marley Creek	W21630	0.22	73.4	38.6
Marley Creek	W21650	0.25	72.8	29.5
Marley Creek	W21670	0.45	74.0	50.1
Marley Creek	W21690	0.23	67.5	43.7
Marley Creek	W21700	0.26	72.5	28.2
Marley Creek	W21710	0.15	73.3	26.3
Marley Creek	W21720	0.15	72.7	33.6
Marley Creek	W21730	0.12	71.5	38.5
Marley Creek	W21750	0.26	73.8	35.7
Marley Creek	W21790	0.17	69.2	31.7
Marley Creek	W21800	0.16	72.8	41.8
Marley Creek	W21810	0.21	72.0	40.4
Marley Creek	W21830	0.13	72.6	28.2
Marley Creek	W21840	0.22	72.8	36.7
Marley Creek	W21860	0.16	71.7	36.1
Marley Creek	W25340	0.15	75.2	33.2
Marley Creek	W25350	0.07	74.0	29.5

Melvina Ditch	W_830_2	0.06	80.4	22.7
Melvina Ditch	W1080	0.63	80.6	107.1
Melvina Ditch	W1090	0.23	81.7	45.9
Melvina Ditch	W1150	0.34	80.8	48.2
Melvina Ditch	W1160	0.11	82.8	21.7
Melvina Ditch	W440	0.16	82.8	56.8
Melvina Ditch	W450	0.13	81.4	32.7
Melvina Ditch	W470	0.12	82.7	45.0
Melvina Ditch	W490	0.11	80.7	36.9
Melvina Ditch	W500	0.34	77.3	76.8
Melvina Ditch	W510	0.10	81.9	34.3
Melvina Ditch	W520	0.24	79.3	58.5
Melvina Ditch	W540	0.05	80.8	34.1
Melvina Ditch	W550	0.14	81.4	46.6
Melvina Ditch	W570	0.30	75.5	68.2
Melvina Ditch	W580	0.19	72.9	35.5
Melvina Ditch	W590	0.18	75.9	44.9
Melvina Ditch	W590_BedfordPark	0.23	78.6	52.1
Melvina Ditch	W600	0.39	75.3	91.8
Melvina Ditch	W610	0.47	73.6	80.7
Melvina Ditch	W620	0.23	73.8	96.0
Melvina Ditch	W630	0.13	77.4	56.9
Melvina Ditch	W640	0.41	73.4	50.6
Melvina Ditch	W650	0.18	73.5	61.4
Melvina Ditch	W660	0.21	72.9	72.2
Melvina Ditch	W670	0.13	74.2	31.9
Melvina Ditch	W690	0.26	73.1	64.5
Melvina Ditch	W700	0.06	77.4	21.5
Melvina Ditch	W710	0.10	72.9	30.9
Melvina Ditch	W710_Burbank	0.21	74.2	68.9
Melvina Ditch	W720	0.00	72.9	12.6
Melvina Ditch	W750	0.19	76.9	39.4
Melvina Ditch	W780	0.37	73.1	36.7
Melvina Ditch	W790	0.13	72.9	35.4
Melvina Ditch	W830	0.32	72.8	50.2
Melvina Ditch	W840	0.35	73.9	73.2
Melvina Ditch	W930	0.19	73.1	67.8
Melvina Ditch	W940	0.18	73.5	34.2
Melvina Ditch	W980	0.16	73.7	34.9
Melvina Ditch	W990	0.16	73.4	58.6

Mill Creek	W16640	0.30	72.0	27.0
Mill Creek	W16650	0.22	66.5	37.6
Mill Creek	W16740	0.23	71.7	37.9
Mill Creek	W16820	0.20	71.9	35.9
Mill Creek	W16850	0.16	69.4	32.1
Mill Creek	W16860	0.20	72.5	27.5
Mill Creek	W16880	0.32	72.6	25.1
Mill Creek	W16940	0.29	68.3	38.8
Mill Creek	W17180	0.40	61.7	47.7
Mill Creek	W17380	0.20	69.9	28.1
Mill Creek	W17490	0.03	70.7	13.2
Mill Creek	W17530	0.23	72.3	24.4
Mill Creek	W17590	0.13	69.3	19.0
Mill Creek	W17630	0.13	75.4	18.1
Mill Creek	W17680	1.59	73.5	38.4
Mill Creek	W17730	0.16	67.7	32.5
Mill Creek	W17790	0.18	69.7	23.9
Mill Creek	W17840	0.13	74.0	20.4
Mill Creek	W17880	0.22	77.2	27.6
Mill Creek	W17890	0.20	73.9	27.2
Mill Creek	W17930	0.16	70.6	18.0
Mill Creek	W17940	0.28	71.0	26.1
Mill Creek	W17990	0.16	68.3	44.1
Mill Creek	W18090	0.22	73.2	32.1
Mill Creek	W18140	0.13	71.5	29.7
Mill Creek	W18180	0.27	70.8	34.8
Mill Creek	W18190	0.26	68.6	50.8
Mill Creek	W18240	0.24	75.4	24.4
Mill Creek	W18340	0.14	69.7	36.4
Mill Creek	W18380	0.24	64.7	54.1
Mill Creek	W18390	0.16	69.0	30.8
Mill Creek	W18530	0.21	72.8	30.0
Mill Creek	W18540	0.33	67.7	42.7
Mill Creek	W18580	0.30	72.4	24.1
Mill Creek	W18590	0.22	71.8	24.3
Mill Creek	W18640	0.23	69.3	27.1
Mill Creek	W18680	0.28	73.9	40.5
Mill Creek	W18740	0.15	68.7	34.0
Mill Creek	W18790	0.28	71.6	27.9
Mill Creek	W18940	0.30	73.6	33.8
Mill Creek	W18980	0.21	69.1	39.5
Mill Creek	W18990	0.07	67.7	29.4
Mill Creek	W19000	0.18	71.5	33.1
Mill Creek	W21920	0.05	71.2	21.5
Mill Creek	W21930	0.08	71.1	34.7
Merrionette Park Ditch	W20810	0.29	73.2	96.9
Merrionette Park Ditch	W20830	0.25	74.6	91.9
Merrionette Park Ditch	W20850	0.17	71.8	21.2
Merrionette Park Ditch	W20860	0.23	74.1	28.6
Merrionette Park Ditch	W20870	0.29	73.1	42.7
Merrionette Park Ditch	W20880	0.11	69.5	28.3
Merrionette Park Ditch	W20890	0.14	73.7	26.6
Merrionette Park Ditch	W20900	0.30	72.9	66.0
Merrionette Park Ditch	W20920	0.17	74.6	36.2
Merrionette Park Ditch	W20960	0.19	74.0	39.1
Merrionette Park Ditch	W20970	0.22	74.0	31.5
Merrionette Park Ditch	W20980	0.16	73.3	24.9
Merrionette Park Ditch	W21050	0.07	69.0	20.2
Merrionette Park Ditch	W21100	0.02	67.8	8.3
Merrionette Park Ditch	W21140	0.11	74.4	50.1
Merrionette Park Ditch	W21150	0.21	67.8	25.0
Merrionette Park Ditch	W21190	0.17	73.1	30.1
Merrionette Park Ditch	W21240	0.17	67.0	34.6
Merrionette Park Ditch	W21250	0.27	74.1	43.9
Merrionette Park Ditch	W21290	0.11	66.7	14.6
Merrionette Park Ditch	W21300	0.09	66.6	17.6
Merrionette Park Ditch	W21340	0.06	73.9	18.4
Merrionette Park Ditch	W21350	0.12	67.7	20.3
Merrionette Park Ditch	W21390	0.14	76.4	22.4
Merrionette Park Ditch	W21400	0.17	74.3	39.8

Navajo Creek	W210	0.15	76.2	37.9
Navajo Creek	W220	0.18	77.8	40.1
Navajo Creek	W230	0.14	77.5	26.2
Navajo Creek	W240	0.15	77.9	32.7
Navajo Creek	W250	0.29	78.6	21.7
Navajo Creek	W270	0.43	76.2	32.9
Navajo Creek	W290	0.18	77.0	24.3
Navajo Creek	W310	0.37	77.9	28.8
Navajo Creek	W330	0.22	77.4	37.5
Navajo Creek	W370	0.06	73.0	24.5
Navajo Creek	W380	0.23	67.8	32.5
Navajo Creek	W420	0.15	77.5	39.0
Navajo Creek	W430	0.31	69.7	49.4
Oak Lawn Creek	W47970	0.31	73.4	102.6
Oak Lawn Creek	W47980	0.20	74.1	48.7
Oak Lawn Creek	W47990	0.14	73.3	49.6
Oak Lawn Creek	W48000	0.40	76.6	76.4
Oak Lawn Creek	W48020	0.15	75.4	58.7
Oak Lawn Creek	W48110	0.02	69.2	16.9
Oak Lawn Creek	W48140	0.25	79.3	43.4
Oak Lawn Creek	W48150	0.04	71.3	16.3
Oak Lawn Creek	W48180	0.20	78.4	40.1
Oak Lawn Creek	W48240	0.14	77.2	36.8
Oak Lawn Creek	W48280	0.19	75.2	30.9
Oak Lawn Creek	W48290	0.15	76.3	27.4
Oak Lawn Creek	W48330	0.13	73.1	21.2
Oak Lawn Creek	W48430	0.14	74.8	23.6
Oak Lawn Creek	W48490	0.17	76.0	22.2
Oak Lawn Creek	W48530	0.10	73.4	25.9
Oak Lawn Creek	W48540	0.17	74.8	40.4
Oak Lawn Creek	W48580	0.09	73.5	32.6
Oak Lawn Creek	W48590	0.33	74.7	58.9
Oak Lawn Creek	W48630	0.20	78.3	41.2
Oak Lawn Creek	W48640	0.18	77.5	63.2
Spring Creek	W240	0.18	64.8	19.4
Spring Creek	W250	0.27	71.3	22.3
Spring Creek	W260	0.17	74.8	38.6
Spring Creek	W270	0.11	74.4	17.2
Spring Creek	W280	0.12	74.5	16.8
Spring Creek	W360	0.21	75.3	25.6
Spring Creek	W450	0.18	72.4	18.8
Spring Creek	W460	0.19	75.3	20.8
Spring Creek	W510	0.17	69.9	20.8
Spring Creek	W560	0.15	70.6	17.5
Spring Creek	W610	0.12	72.7	18.0
Spring Creek	W610_2	0.05	81.8	7.8
Spring Creek	W700	0.27	67.9	28.9
Spring Creek	W760	0.12	70.9	21.4
Spring Creek	W800	0.27	68.9	29.8

Stony Creek	W28530	0.30	70.8	44.5
Stony Creek	W28580	0.18	74.2	46.9
Stony Creek	W28790	0.15	75.3	41.3
Stony Creek	W28850	0.23	74.8	80.9
Stony Creek	W28860	0.29	74.0	128.2
Stony Creek	W28910	0.24	75.0	150.2
Stony Creek	W28940	0.18	74.4	79.7
Stony Creek	W28960	0.27	74.6	75.9
Stony Creek	W28990	0.29	76.5	71.4
Stony Creek	W29030	0.16	74.3	73.8
Stony Creek	W29080	0.16	81.3	59.1
Stony Creek	W29120	0.20	73.3	86.0
Stony Creek	W29190	0.29	74.3	36.0
Stony Creek	W29220	0.19	74.9	22.5
Stony Creek	W29230	0.18	66.7	41.0
Stony Creek	W29240	0.05	74.9	22.1
Stony Creek	W29270	0.18	75.7	50.0
Stony Creek	W29290	0.14	68.5	51.5
Stony Creek	W29310	0.16	71.7	49.2
Stony Creek	W29320	0.05	67.9	15.4
Stony Creek	W29360	0.10	68.9	34.2
Stony Creek	W29380	0.12	71.2	31.2
Stony Creek	W29400	0.20	66.3	49.9
Stony Creek	W29410	0.15	69.9	56.9
Stony Creek	W29420	0.27	69.6	64.6
Stony Creek	W29450	0.17	67.3	76.8
Stony Creek	W29480	0.36	74.5	21.7
Stony Creek	W29500	0.13	68.4	45.5
Stony Creek	W29520	0.10	63.9	25.2
Stony Creek	W29540	0.21	67.1	62.9
Stony Creek	W29590	0.14	68.5	35.9
Stony Creek	W29600	0.21	73.0	57.0
Stony Creek	W29630	0.16	62.9	32.9
Stony Creek	W29660	0.08	56.0	74.8
Stony Creek	W32630	0.33	74.7	50.2
Stony Creek	W32640	0.20	74.2	49.2
Stony Creek	W32690	0.20	70.5	68.8
Stony Creek	W32740	0.17	74.1	101.9
Stony Creek	W32780	0.14	75.4	100.0
Stony Creek	W32790	0.41	72.1	94.9
Stony Creek	W32900	0.34	71.0	60.9
Stony Creek	W32910	0.40	67.0	69.3
Stony Creek	W32960	0.18	73.5	54.1
Stony Creek	W33000	0.32	73.3	67.1
Stony Creek	W33010	0.31	74.3	71.3

Stony Creek	W33050	0.24	73.3	55.0
Stony Creek	W33060	0.25	74.1	50.5
Stony Creek	W33110	0.12	60.8	42.1
Stony Creek	W33150	0.09	64.0	26.4
Stony Creek	W33160	0.12	72.3	30.1
Stony Creek	W33210	0.17	69.5	22.6
Stony Creek	W33250	0.14	62.9	22.9
Stony Creek	W33260	0.21	67.1	26.8
Stony Creek	W33300	0.37	69.0	44.5
Stony Creek	W33310	0.13	74.1	42.2
Stony Creek	W38840	0.29	68.2	80.0
Stony Creek	W38870	0.26	72.1	40.2
Stony Creek	W39000	0.16	75.4	32.2
Stony Creek	W39010	0.16	74.9	34.8
Stony Creek	W39050	0.20	79.2	40.9
Stony Creek	W39060	0.09	73.3	24.3
Stony Creek	W39090	0.23	73.4	55.0
Stony Creek	W39120	0.24	73.9	45.6
Stony Creek	W39180	0.15	75.2	23.8
Stony Creek	W39190	0.14	78.4	27.6
Stony Creek	W39420	0.09	81.9	31.2
Stony Creek	W39480	0.23	73.1	63.3
Stony Creek	W39520	0.23	72.4	47.4
Stony Creek	W39530	0.17	68.9	54.1
Stony Creek	W39630	0.18	79.1	36.2
Stony Creek	W39640	0.21	74.5	42.4
Stony Creek	W39680	0.24	72.4	44.2
Stony Creek	W39690	0.29	66.9	70.1
Stony Creek	W39730	0.35	76.1	55.2
Stony Creek	W39740	0.20	72.0	33.3
Stony Creek	W39950	0.12	67.4	46.3
Stony Creek	W39960	0.29	72.1	65.2
Stony Creek	W40010	0.12	73.5	34.3
Stony Creek	W40060	0.26	69.9	58.3
Stony Creek	W40160	0.15	76.0	46.4
Stony Creek	W40200	0.14	74.4	36.2
Stony Creek	W40210	0.17	75.8	32.6
Stony Creek	W40250	0.24	75.0	52.7
Stony Creek	W40260	0.24	73.2	40.6
Stony Creek	W40310	0.27	73.3	72.1
Stony Creek	W40360	0.44	73.3	67.6
Stony Creek	W40400	0.18	65.6	73.7
Stony Creek	W40410	0.21	77.5	51.2

Tinley Creek	W-10	0.04	66.6	20.4
Tinley Creek	W21030	0.13	66.8	30.0
Tinley Creek	W21050	0.14	64.5	42.8
Tinley Creek	W21060	0.12	62.8	33.7
Tinley Creek	W21100	0.26	64.1	36.4
Tinley Creek	W21110	0.14	65.0	27.2
Tinley Creek	W21120	0.12	64.8	27.8
Tinley Creek	W21130	0.13	64.9	21.0
Tinley Creek	W21140	0.06	64.9	23.9
Tinley Creek	W21160	0.35	67.1	44.8
Tinley Creek	W21170	0.24	66.6	50.8
Tinley Creek	W21180	0.22	73.9	32.4
Tinley Creek	W21190	0.20	67.3	26.9
Tinley Creek	W21200	0.09	65.7	26.3
Tinley Creek	W21210	0.14	74.1	21.6
Tinley Creek	W21220	0.21	72.8	33.3
Tinley Creek	W21240	0.05	65.2	18.2
Tinley Creek	W21250	0.29	66.3	38.2
Tinley Creek	W21260	0.29	72.7	43.2
Tinley Creek	W21270	0.15	71.6	31.2
Tinley Creek	W21280	0.23	66.1	45.0
Tinley Creek	W21290	0.02	65.1	12.9
Tinley Creek	W21300	0.24	73.1	37.8
Tinley Creek	W21320	0.24	73.5	37.9
Tinley Creek	W21330	0.25	67.9	39.6
Tinley Creek	W21340	0.24	70.6	36.6
Tinley Creek	W21350	0.16	68.5	31.5
Tinley Creek	W21370	0.05	67.3	19.6
Tinley Creek	W21380	0.16	71.8	24.8
Tinley Creek	W21390	0.31	72.0	38.2
Tinley Creek	W21400	0.29	72.5	42.2
Tinley Creek	W21410	0.03	66.6	17.0
Tinley Creek	W21420	0.13	80.1	19.9
Tinley Creek	W21430	0.11	66.6	21.6
Tinley Creek	W21440	0.18	71.1	28.0
Tinley Creek	W21450	0.08	76.9	29.3
Tinley Creek	W21460	0.13	75.5	32.1
Tinley Creek	W21470	0.17	77.5	23.2
Tinley Creek	W21490	0.12	69.0	26.2
Tinley Creek	W21500	0.19	69.3	32.7
Tinley Creek	W21510	0.15	74.7	27.7
Tinley Creek	W21520	0.13	74.3	58.6
Tinley Creek	W21530	0.20	71.0	30.6
Tinley Creek	W21540	0.25	69.2	39.3
Tinley Creek	W21570	0.09	73.8	21.2
Tinley Creek	W21580	0.21	73.3	36.9
Tinley Creek	W21590	0.03	81.1	15.7
Tinley Creek	W21610	0.01	82.2	22.8
Tinley Creek	W21620	0.38	74.6	58.9
Tinley Creek	W21630	0.23	74.9	36.3
Tinley Creek	W24620	0.19	71.6	29.5
Tinley Creek	W24670	0.24	71.0	32.0
Tinley Creek	W24680	0.20	69.1	26.8
Tinley Creek	W24720	0.17	74.4	32.3
Tinley Creek	W24770	0.32	74.2	51.6
Tinley Creek	W24780	0.28	77.6	29.0
Tinley Creek	W24820	0.24	74.8	41.1
Tinley Creek	W24830	0.24	69.5	35.0
Tinley Creek	W24870	0.25	64.9	33.5
Tinley Creek	W24880	0.16	66.4	41.1
Tinley Creek	W24920	0.16	67.9	26.3
Tinley Creek	W24930	0.21	67.2	25.2
Tinley Creek	W24970	0.26	65.9	34.5
Tinley Creek	W25020	0.24	66.9	28.9
Tinley Creek	W25030	0.28	64.3	38.5
Tinley Creek	W25070	0.21	67.0	41.9
Tinley Creek	W25080	0.23	68.0	25.9
Tinley Creek	W25120	0.16	64.4	36.4
Tinley Creek	W25130	0.18	65.2	24.6
Tinley Creek	W25170	0.14	66.7	19.8
Tinley Creek	W25180	0.16	66.8	25.1

CalSag_1	W260	0.22	70.88	38.94658793
CalSag_1	W450	0.09	74.98	23.7179587
CalSag_1	W460	0.10	65.00	23.81748869
CalSag_1	W500	0.12	68.54	26.02076807
CalSag_1	W510	0.12	67.74	21.90422475
CalSag_1	W550	0.02	68.14	16.90436103
CalSag_1	W560	0.21	76.47	31.04716803
CalSag_1	W610	0.21	66.86	38.67013799
CalSag_3W	W1090	0.16	62.58	34.969
CalSag_3W	W1670	0.32	65.85	42.8495205
CalSag_3W	W1710	0.26	67.28	34.747
CalSag_3W	W1720	0.15	66.60	24.594
CalSag_3E	W130	0.24	64.01	22.273
CalSag_3E	W140	0.22	67.01	36.618
CalSag_3E	W150	0.28	66.60	25.55
CalSag_3E	W180	0.09	62.34	24.753
CalSag_3E	W200	0.07	67.13	12.528
CalSag_3E	W240	0.16	67.27	25.548
CalSag_3E	W260	0.09	71.18	17.336
CalSag_3E	W300	0.09	71.85	25.4844636
CalSag_3E	W320	0.10	78.18	23.838
Hydrologic Only	591	0.18771522	77.4	56.0
Hydrologic Only	593	0.204990243	74.7	57.7
Hydrologic Only	595	0.269097222	78.3	63.2
Hydrologic Only	596	0.282641758	75.6	64.3
Hydrologic Only	597	0.192693985	75.6	56.5
Hydrologic Only	599	0.390725436	77.4	71.7
Hydrologic Only	600	0.177198118	75.6	54.9
Hydrologic Only	602	0.173008494	80.1	54.5
Hydrologic Only	603	0.15639348	77.4	52.7
Hydrologic Only	604	0.130581382	80.1	49.6
Hydrologic Only	605	0.29265668	76.5	65.0
Hydrologic Only	606	0.02093377	77.4	26.8
Hydrologic Only	607	0.029973026	75.6	30.2
Hydrologic Only	608	0.148659894	73.8	51.8
Hydrologic Only	609	0.244303834	76.5	61.2
Hydrologic Only	610	0.139434114	76.5	50.7
Hydrologic Only	611	0.208534206	78.3	58.0
Hydrologic Only	612	0.009240129	72.9	20.4
Hydrologic Only	613	0.194458792	78.3	56.7
Hydrologic Only	614	0.173467631	80.1	54.6
Hydrologic Only	615	0.294794536	78.3	65.2
Hydrologic Only	616	0.175505051	81.9	54.8
Hydrologic Only	617	0.228076217	76.5	59.8
Hydrologic Only	618	0.20639635	80.1	57.8
Hydrologic Only	619	0.265051079	81	62.9
Hydrologic Only	620	0.27579775	74.7	63.8
Hydrologic Only	621	0.316488751	81	66.8
Hydrologic Only	622	0.34702135	74.7	68.9
Hydrologic Only	623	0.128400482	80.1	49.3
Hydrologic Only	624	0.005796602	86.4	17.4
Hydrologic Only	625	0.168790174	81.9	54.1
Hydrologic Only	632	0.124641299	79.2	48.8
Hydrologic Only	647	0.171358471	78.3	54.3
Hydrologic Only	648	0.004950069	71.1	16.5
Hydrologic Only	654	0.041967975	59.4	33.9
Hydrologic Only	665	0.139563246	76.5	50.7
Hydrologic Only	670	0.022626837	56.7	27.5
Hydrologic Only	673	0.214402548	78.3	58.6
Hydrologic Only	674	0.016313705	62.1	24.7
Hydrologic Only	675	0.10392275	76.5	45.9
Hydrologic Only	676	0.038022268	77.4	32.8
Hydrologic Only	677	0.017275023	57.6	25.1
Hydrologic Only	678	0.123149105	65.7	48.6
Hydrologic Only	679	0.116118572	81	47.7
Hydrologic Only	680	0.257417929	71.1	62.3
Hydrologic Only	683	0.285726584	72.9	64.5
Hydrologic Only	684	0.123091713	74.7	48.6
Hydrologic Only	685	0.16177399	67.5	53.3
Hydrologic Only	686	0.043259298	57.6	34.2
Hydrologic Only	687	0.130079201	73.8	49.5

Hydrologic Only	691	0.312887397	68.4	66.5
Hydrologic Only	697	0.02027376	61.2	26.5
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Hydrologic Only	704	0.235565886	70.2	60.5
Hydrologic Only	709	0.584552916	67.5	82.1
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Hydrologic Only	717	0.129060491	67.5	49.4
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Hydrologic Only	727	0.154313017	60.3	52.5
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Hydrologic Only	752	0.153452135	72.9	52.4
Hydrologic Only	753	0.376520891	70.2	70.8
Hydrologic Only	754	0.088254706	60.3	43.5
Hydrologic Only	763	0.08910124	0	43.6
Hydrologic Only	773	0.243356864	68.4	61.1
Hydrologic Only	774	0.15195994	69.3	52.2
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Hydrologic Only	780	0.220457415	61.2	59.1
Hydrologic Only	781	0.125975666	65.7	49.0
Hydrologic Only	798	0.358901515	0	69.7
Hydrologic Only	799	0.157024793	73.8	52.8
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Hydrologic Only	869	0.125473485	63.9	48.9
Hydrologic Only	876	0.008537075	73.8	19.8
Hydrologic Only	877	0.209825528	74.7	58.2
Hydrologic Only	878	0.74535124	70.2	89.0
Hydrologic Only	881	0.046501951	72.9	35.1
Hydrologic Only	888	0.277462121	64.8	63.9
Hydrologic Only	894	0.039127066	72.9	33.1
Hydrologic Only	896	1.741735537	90	118.4
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Hydrologic Only	899	0.132590106	73.8	49.8
Hydrologic Only	905	0.351210973	72.9	69.2
Hydrologic Only	907	0.177743343	73.8	55.0
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Hydrologic Only	927	0.22885101	57.6	59.9
Hydrologic Only	931	0.327651515	63	67.6
Hydrologic Only	933	0.142633724	54	51.1
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Hydrologic Only	941	0.05901343	72.9	38.0
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Hydrologic Only	947	0.080334596	63	42.1
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Hydrologic Only	991	0.137525826	69.3	50.5
Hydrologic Only	992	0.009125344	61.2	20.3
Hydrologic Only	993	0.126922635	71.1	49.1
Hydrologic Only	996	0.355127984	68.4	69.4
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Hydrologic Only	1000	0.479453627	73.8	76.8
Hydrologic Only	1002	0.238449839	75.6	60.7
Hydrologic Only	1007	0.402160813	0	72.4
Hydrologic Only	1008	0.29346017	76.5	65.1
Hydrologic Only	1009	0.161587466	0	53.3
Hydrologic Only	1012	0.017303719	60.3	25.1
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Hydrologic Only	1027	0.254706152	73.8	62.1
Hydrologic Only	1029	0.134240129	64.8	50.1
Hydrologic Only	1063	0.007044881	82.8	18.6
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Hydrologic Only	1077	0.018064164	57.6	25.5
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Hydrologic Only	1104	0.012482782	73.8	22.5
Hydrologic Only	1106	0.177427686	77.4	55.0
Hydrologic Only	1107	0.016141529	66.6	24.6
Hydrologic Only	1108	0.121786042	66.6	48.4
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Hydrologic Only	1110	0.018107208	75.6	25.5
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Hydrologic Only	1114	0.146048554	71.1	51.5
Hydrologic Only	1124	0.310993457	72	66.4
Hydrologic Only	1126	0.061696511	72.9	38.5
Hydrologic Only	1130	0.12165691	72	48.4
Hydrologic Only	1132	0.436997819	72	74.4
Hydrologic Only	1141	0.251693067	79.2	61.8
Hydrologic Only	1145	0.385603191	75.6	71.4
Hydrologic Only	1149	0.119906451	74.7	48.2
Hydrologic Only	1150	0.333448118	73.8	68.0
Hydrologic Only	1151	0.129993113	79.2	49.5
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Hydrologic Only	1164	0.19084309	73.8	56.3
Hydrologic Only	1165	0.124182163	74.7	48.8

Hydrologic Only	1175	0.237058081	77.4	60.6
Hydrologic Only	1181	0.48641242	78.3	77.1
Hydrologic Only	1186	0.000286961	90	6.3
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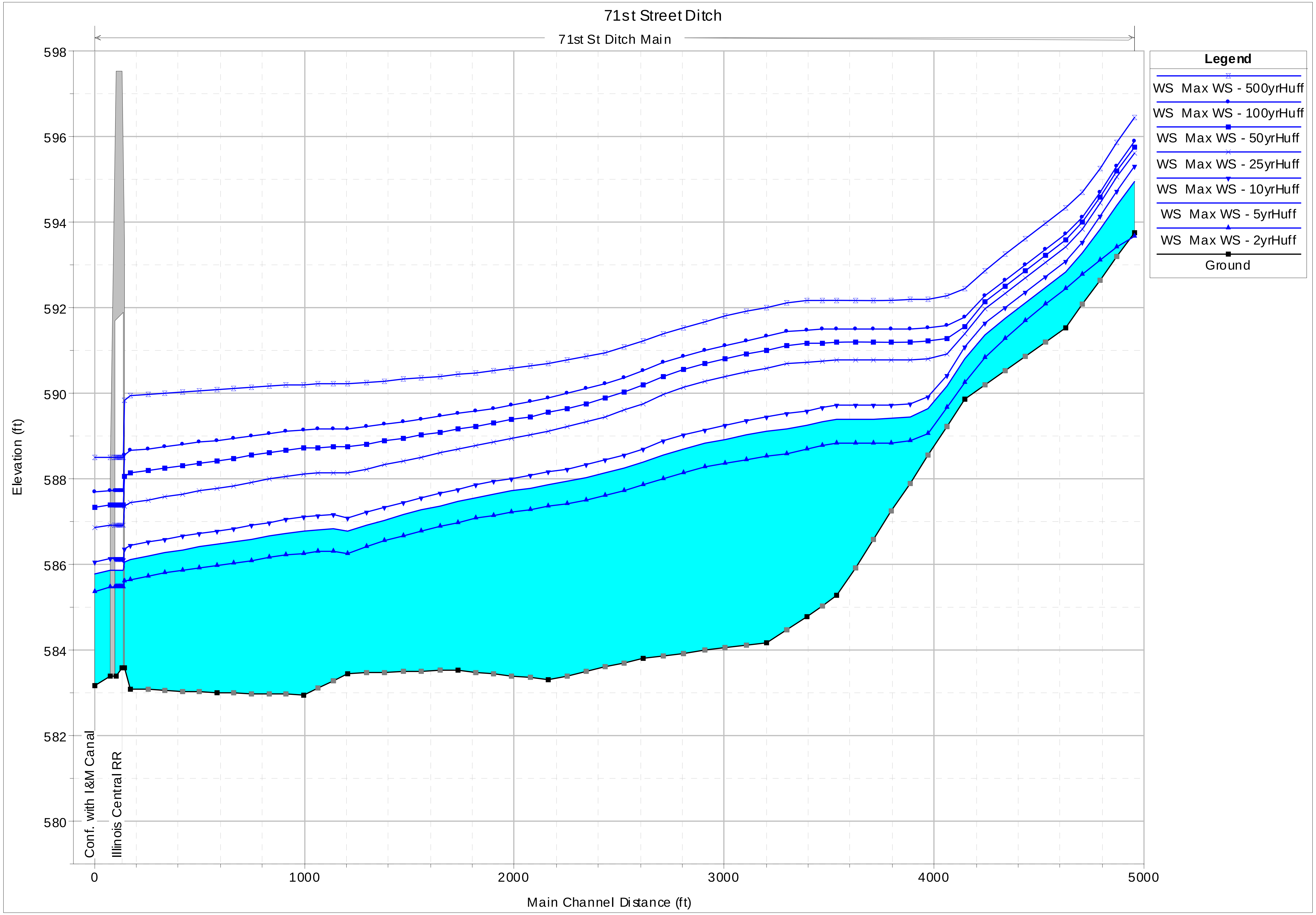
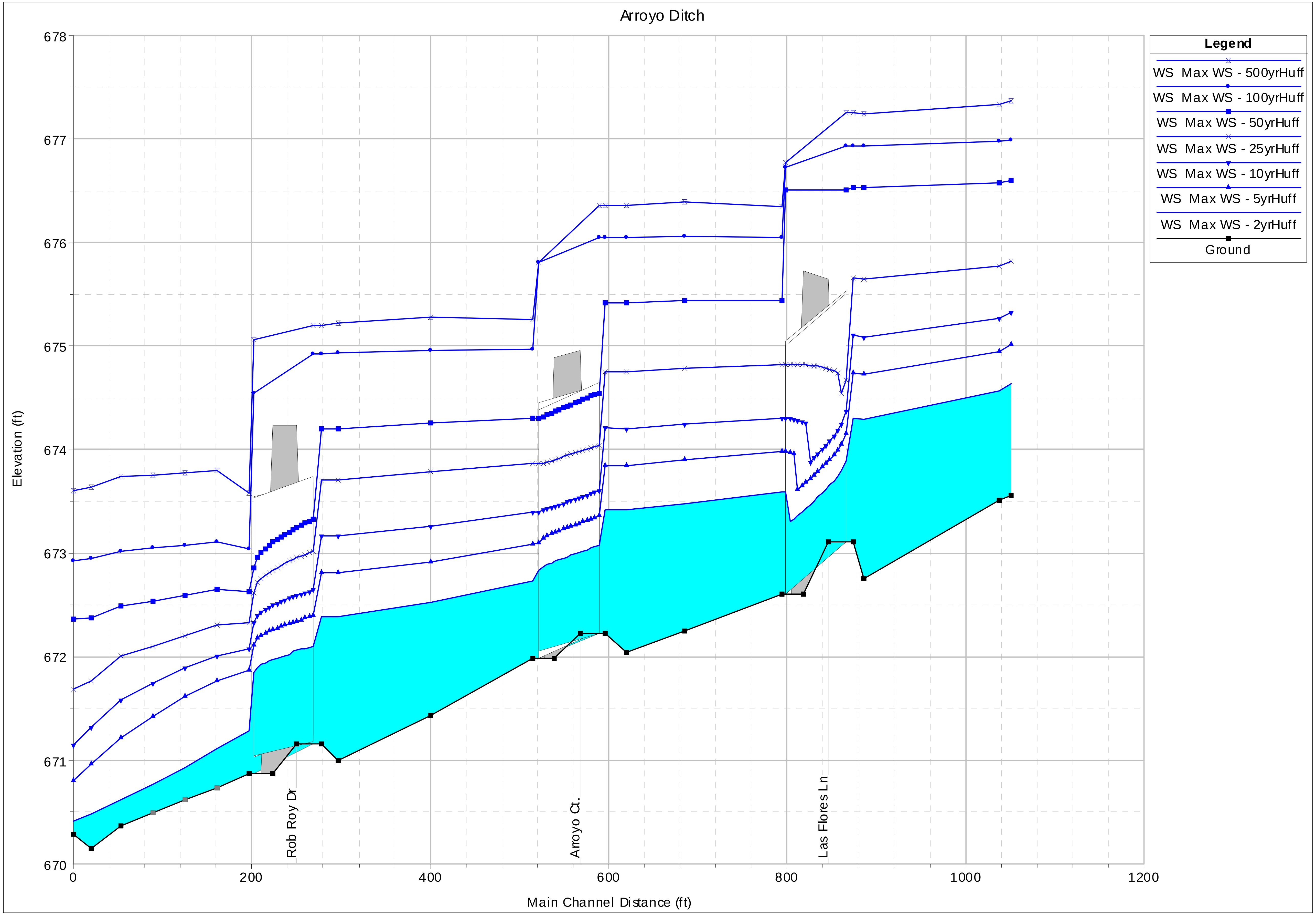
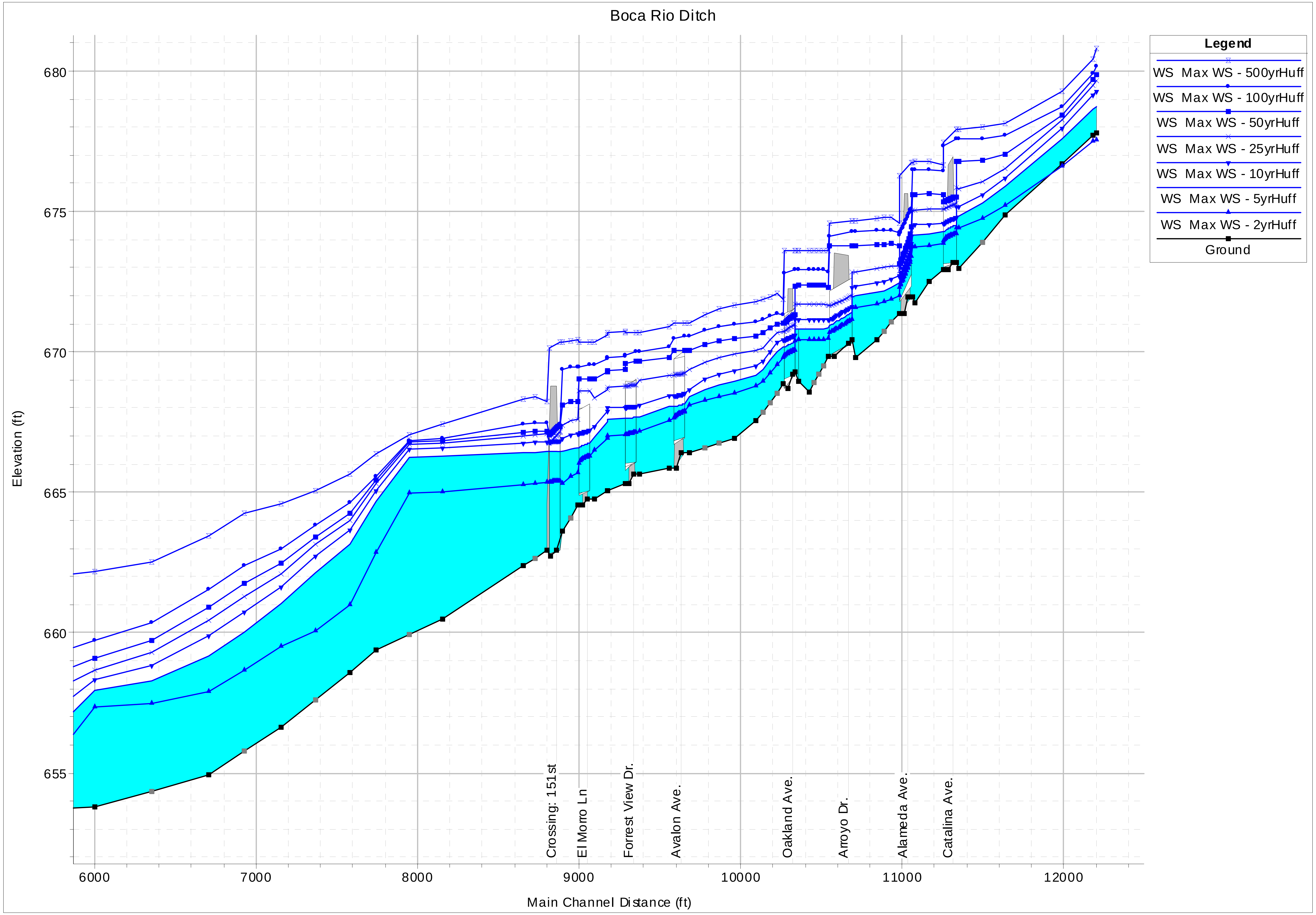
Hydrologic Only	1201	0.163194444	72	53.5
Hydrologic Only	1203	0.1515295	72	52.1
Hydrologic Only	1214	0.339043848	73.8	68.3
Hydrologic Only	1268	0.29346017	72.9	65.1
Hydrologic Only	1284	0.163768365	72.9	53.5
Hydrologic Only	1418	0.217315197	71.1	58.8
Hydrologic Only	1421	0.150855142	71.1	52.1
Hydrologic Only	1423	0.006987489	71.1	18.5



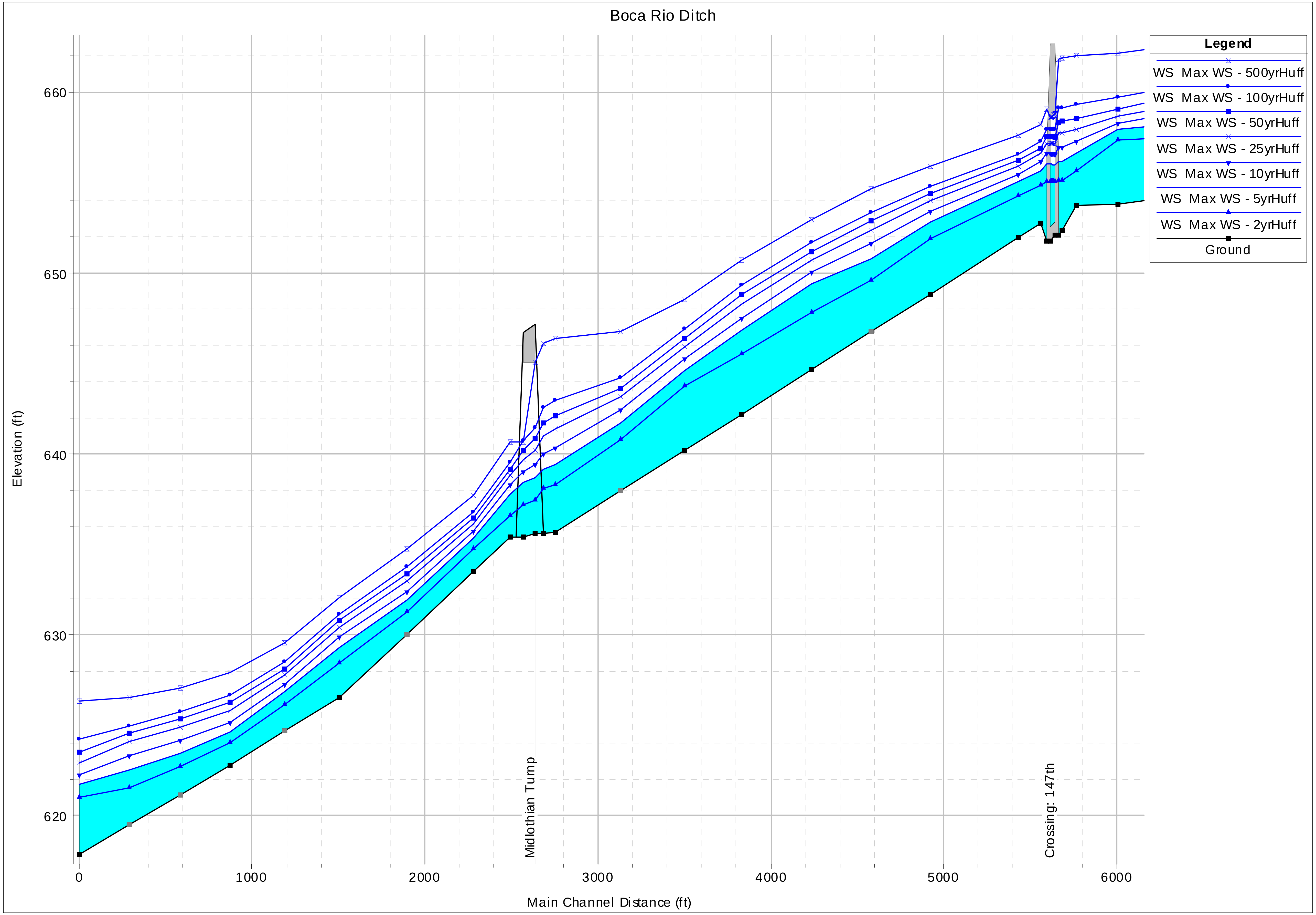
71st Street Ditch from Archer Ave. to confluence with I&M Canal.



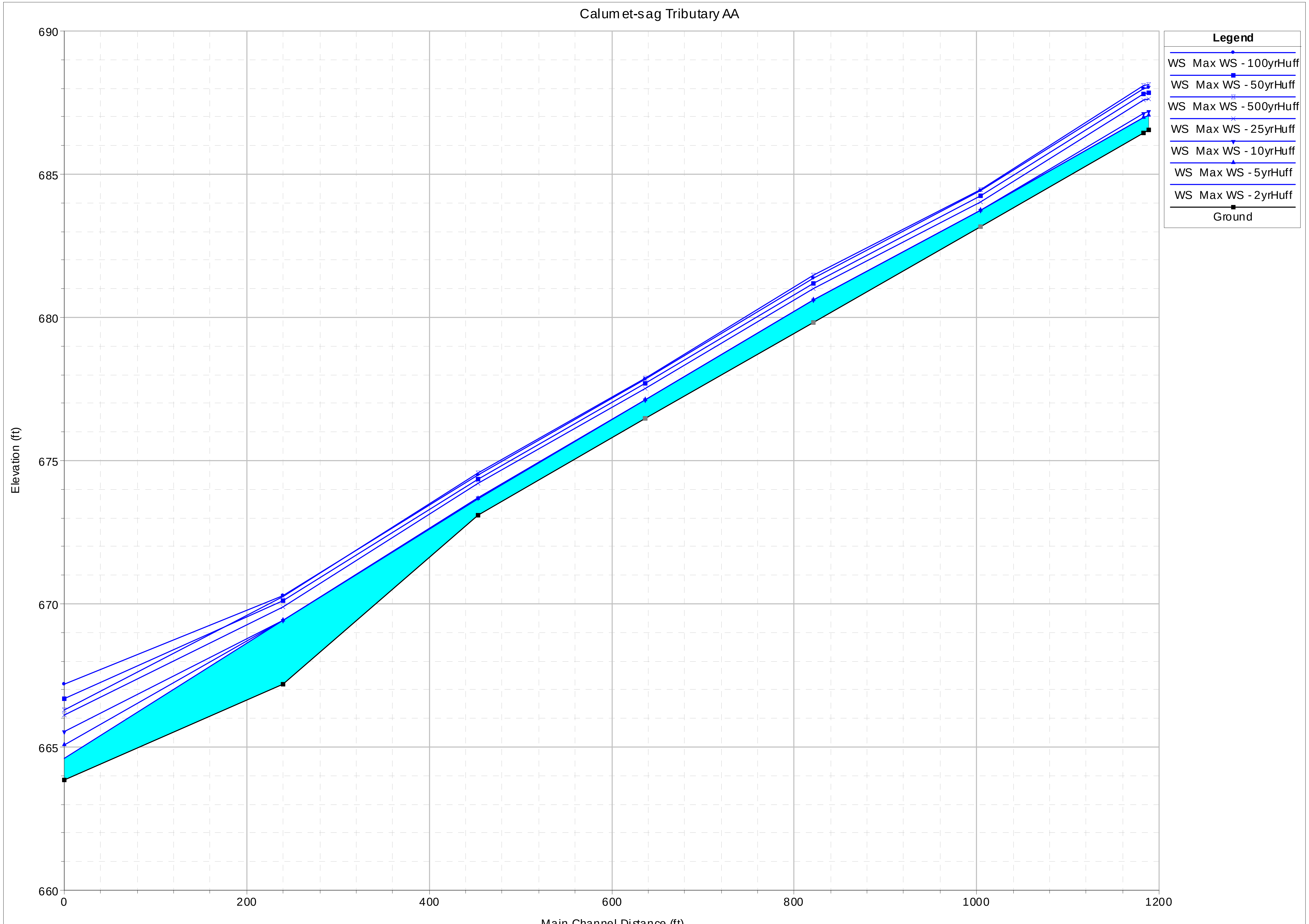
Arroyo Ditch from Victoria Dr. to confluence with Boca Rio Ditch.



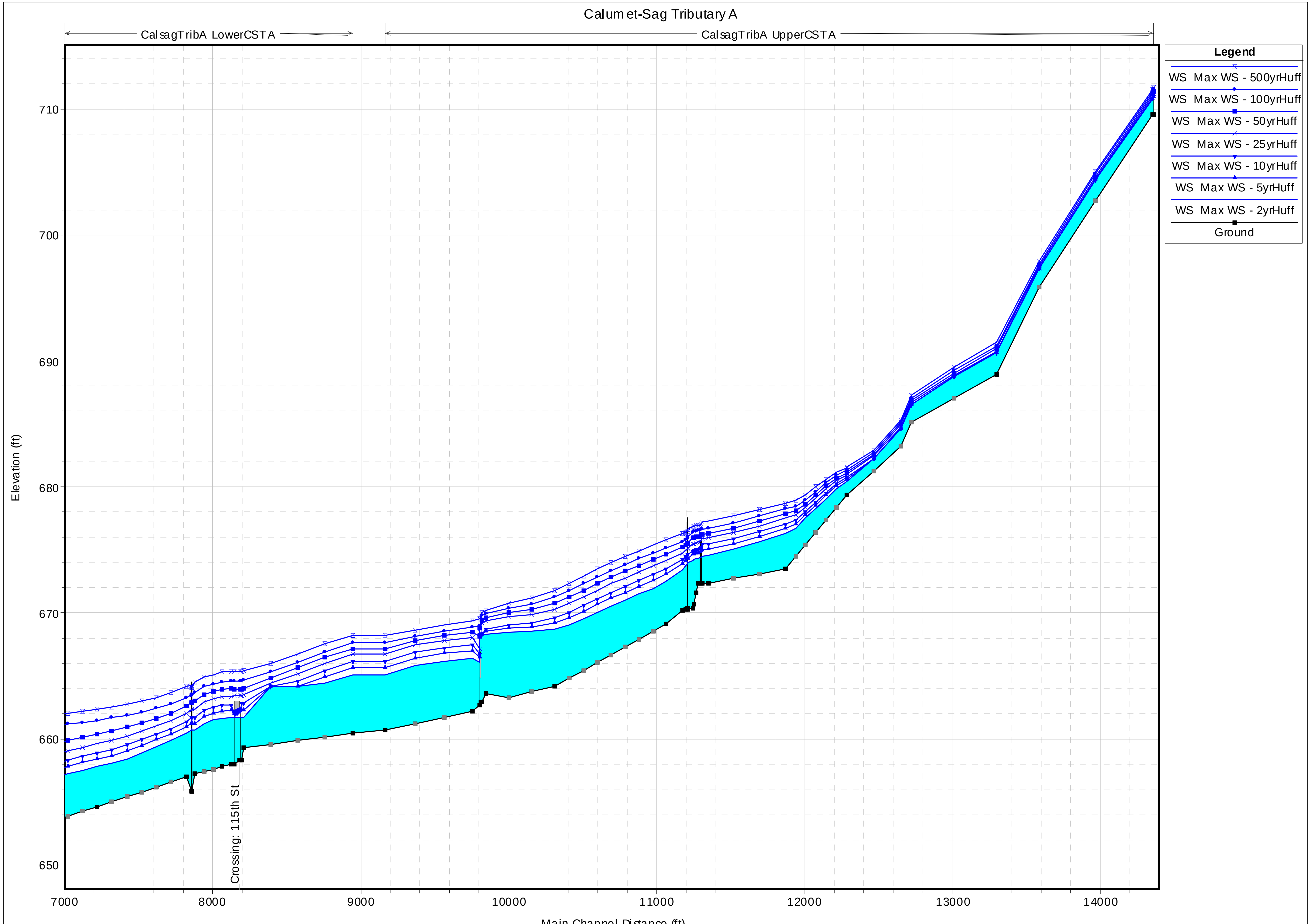
Boca Rio Ditch from Victoria Dr. to just upstream of 147st St. crossing.



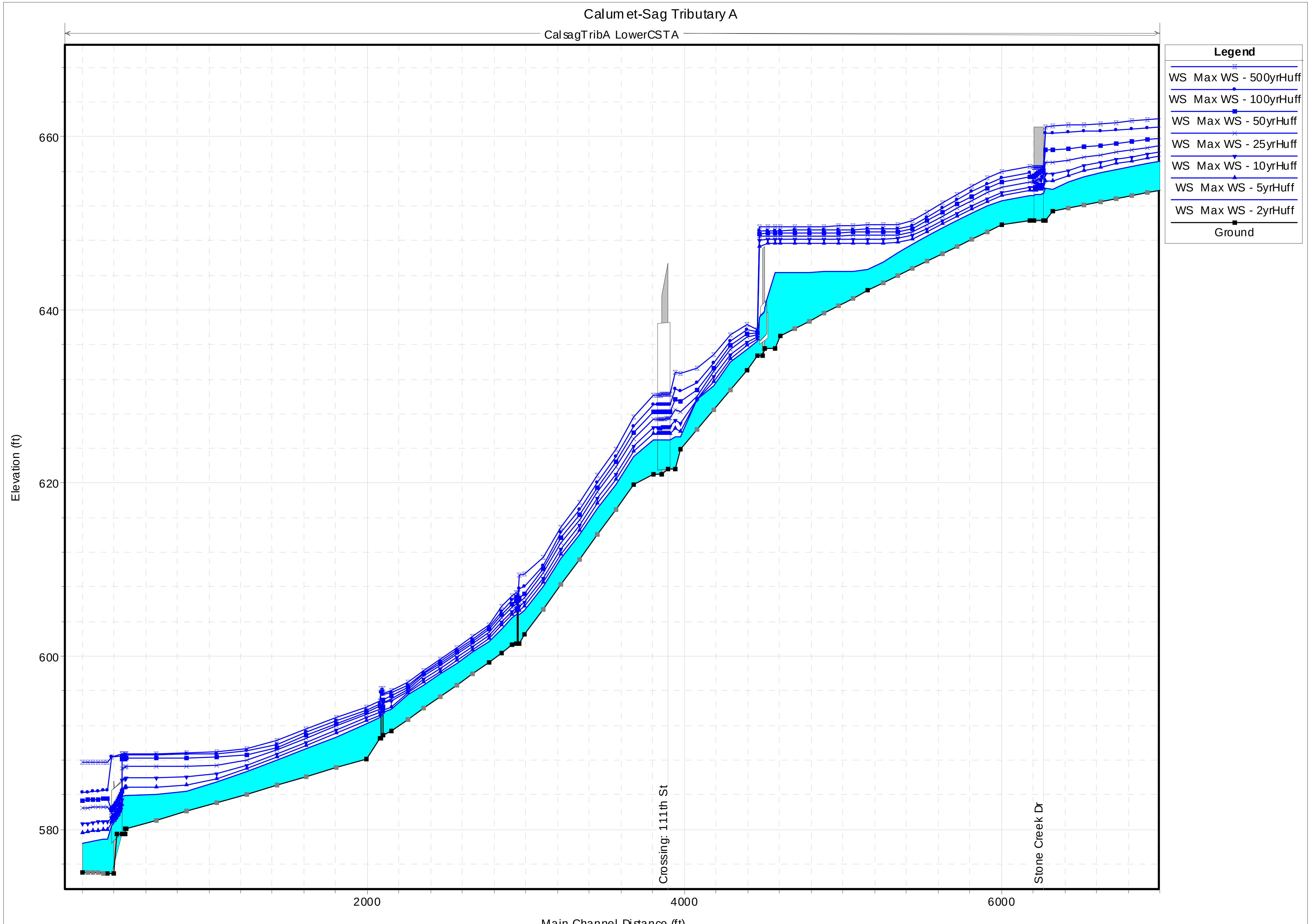
Boca Rio Ditch from 147th St. crossing to confluence with Tinley Creek



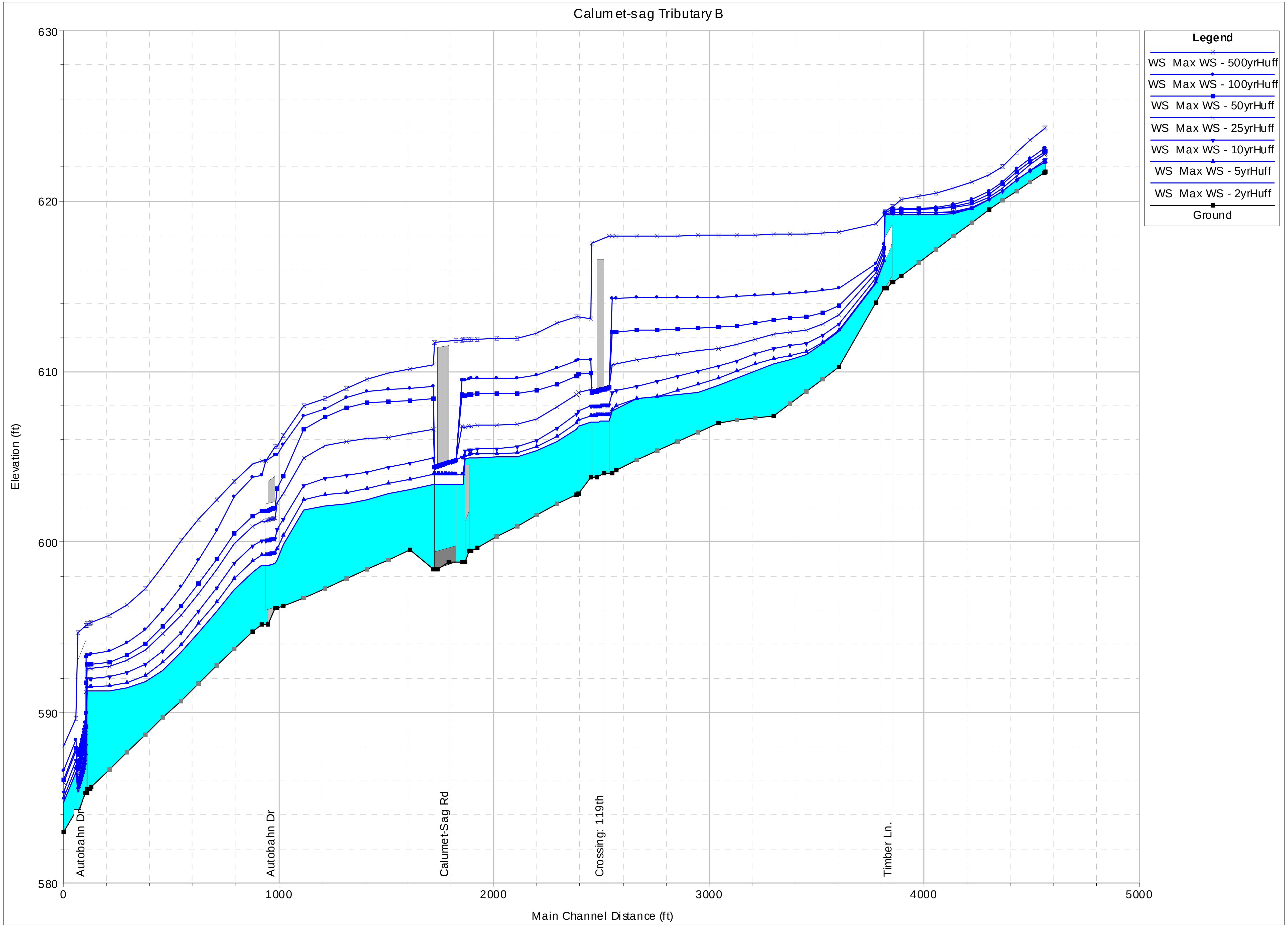
Calumet-Sag Tributary AA from Split Rail Dr. to confluence with Calumet-Sag Tributary A



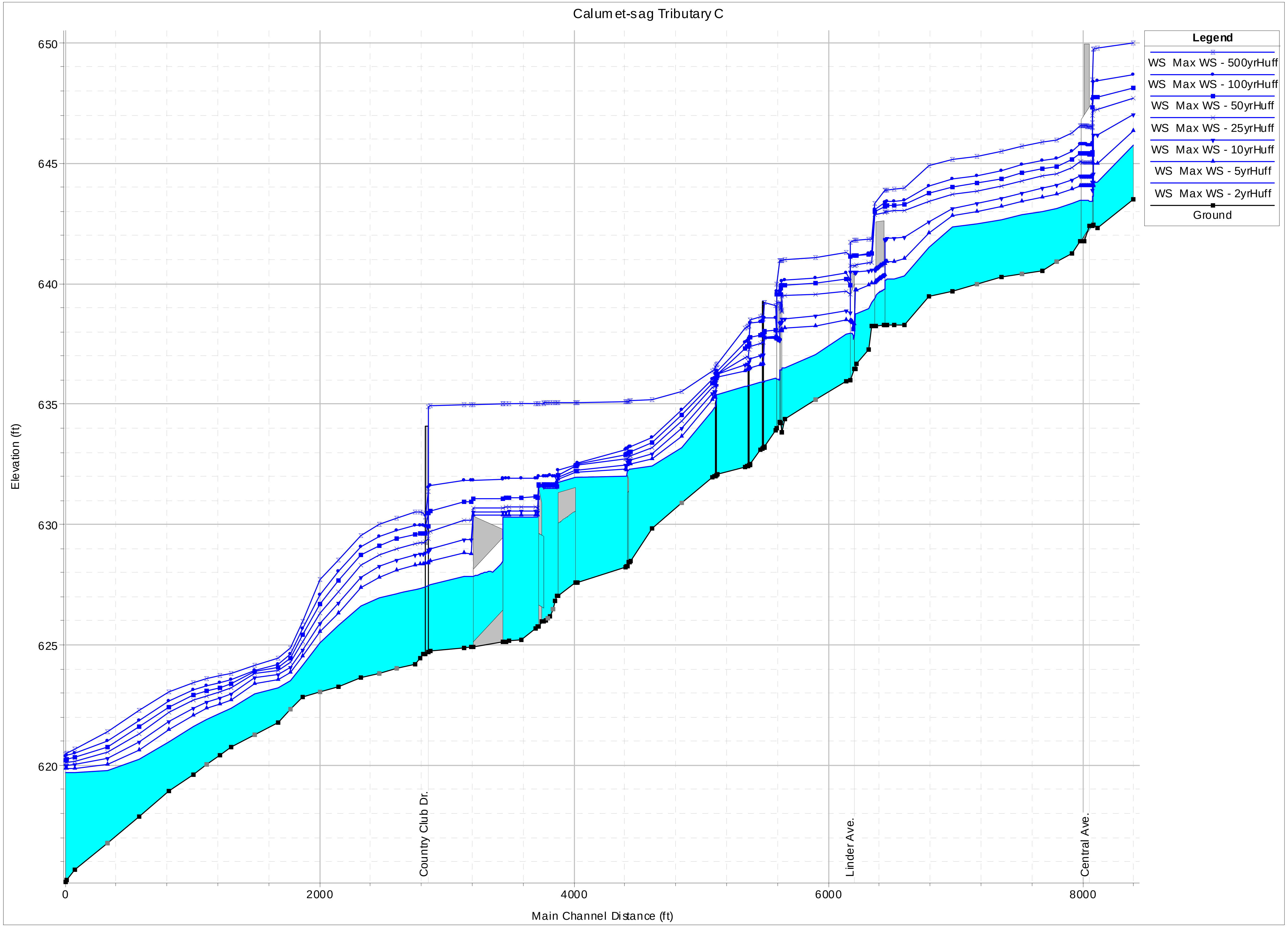
Calumet-Sag Tributary A from McCarthy Rd & Will-Cook Rd to Silver Spur Dr. & Stone Creek Dr.



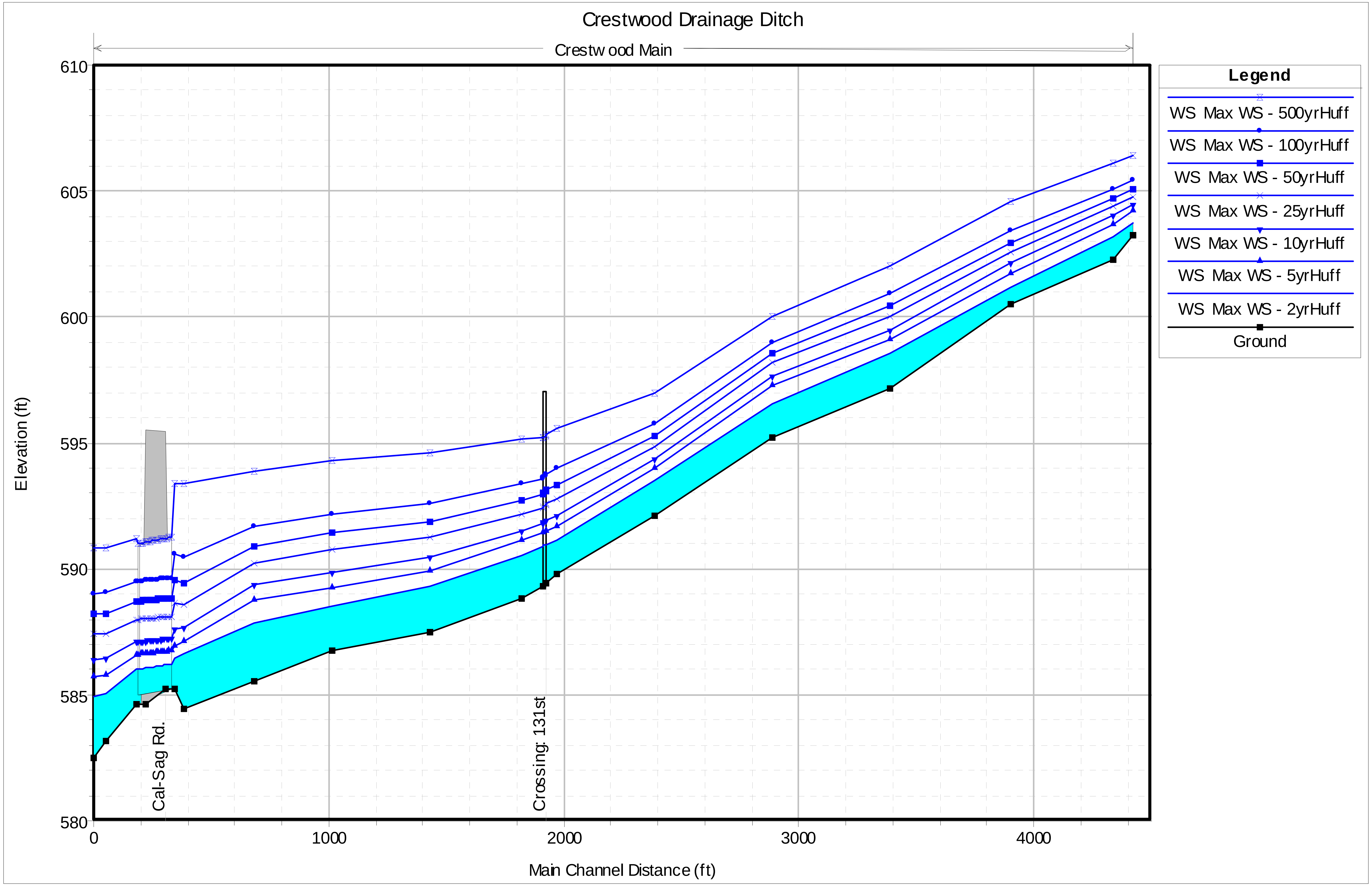
Calumet-Sag Tributary A from Silver Spur Dr. & Stone Creek Dr. to confluence with Calumet-Sag Channel



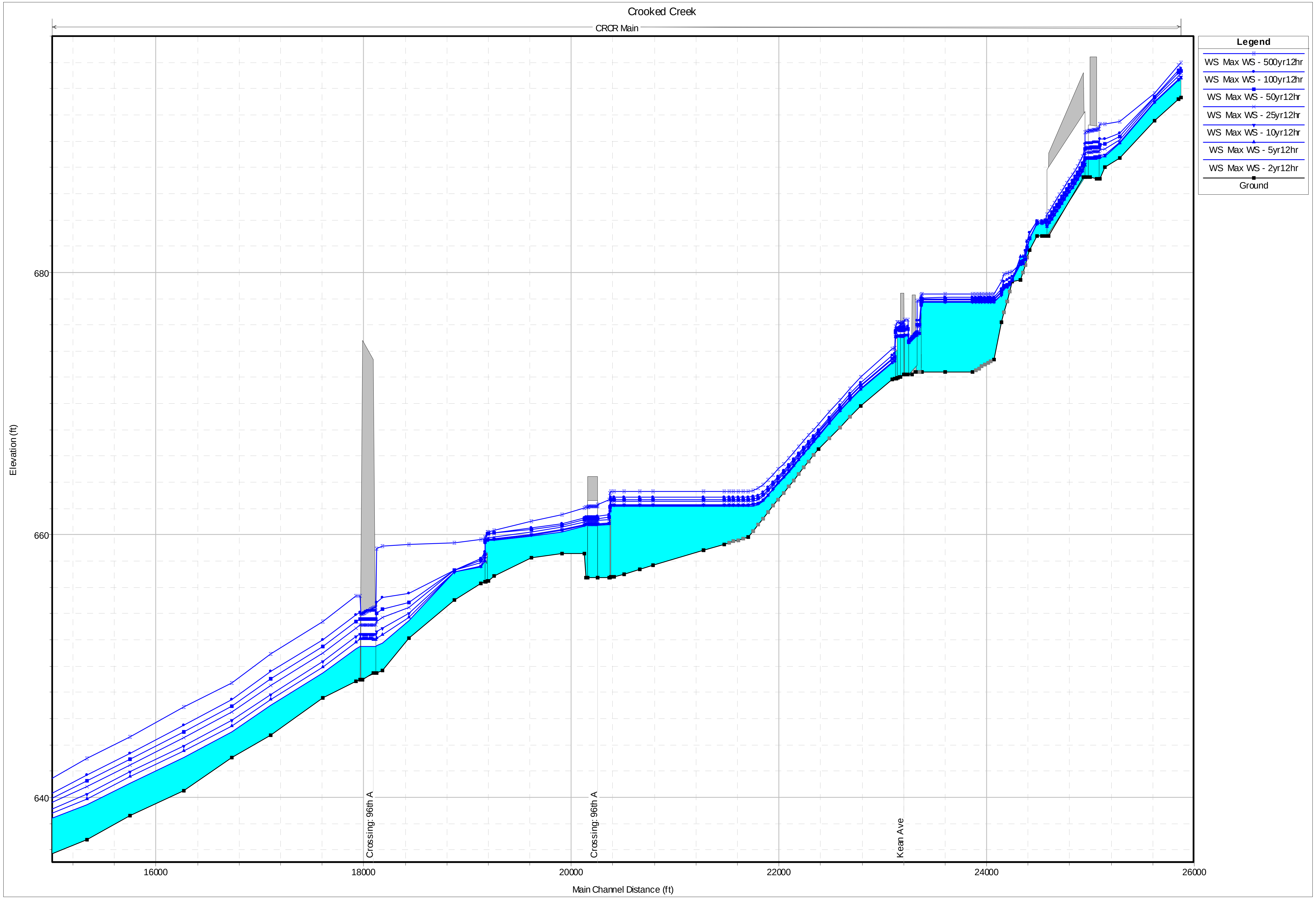
Calumet-Sag Tributary B from Southwest Hwy. & Woodland Tr. to confluence with Calumet-Sag Channel



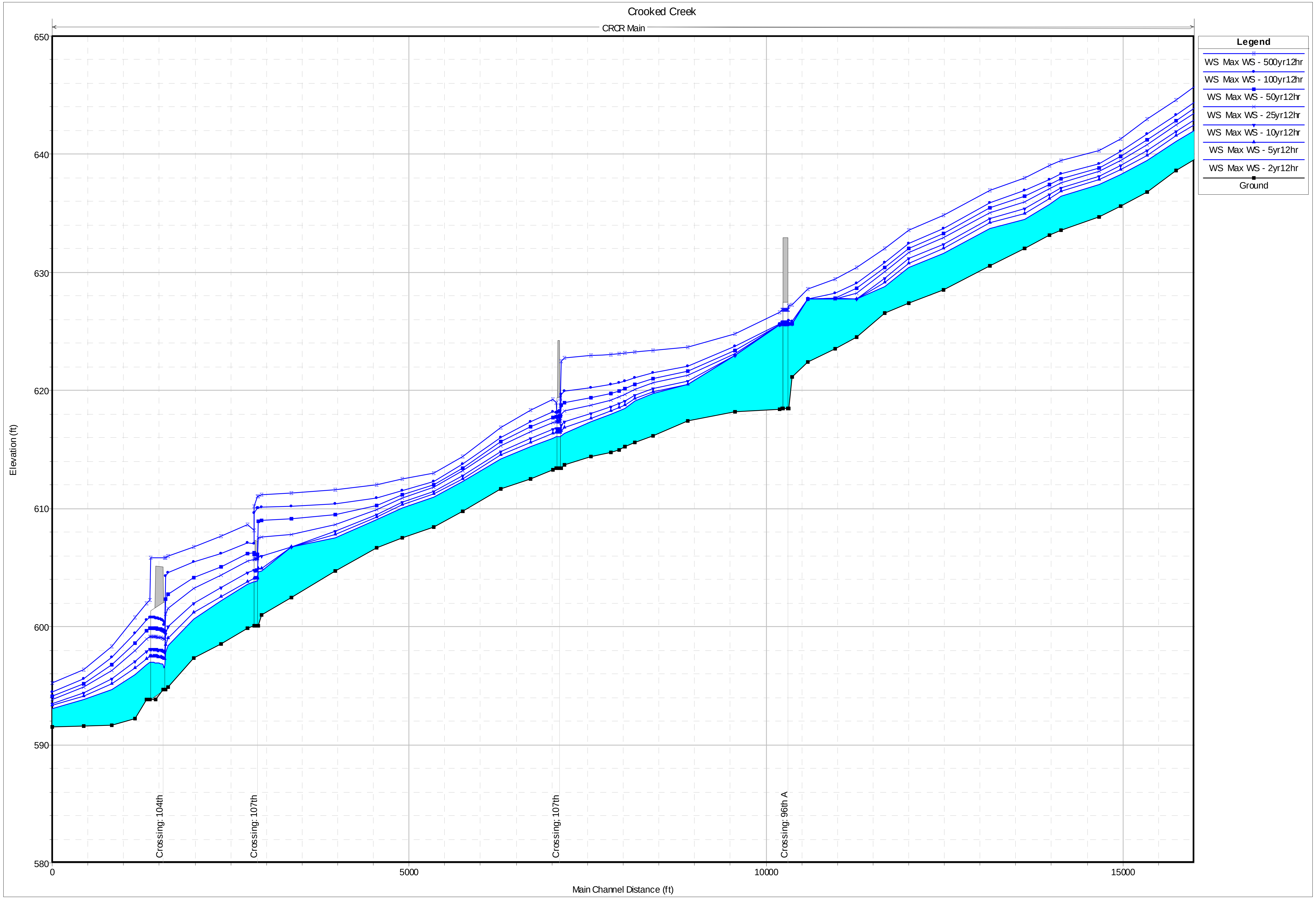
Calumet-Sag Tributary C from Central Ave. & Maple Ln. to Midlothian Turnpike



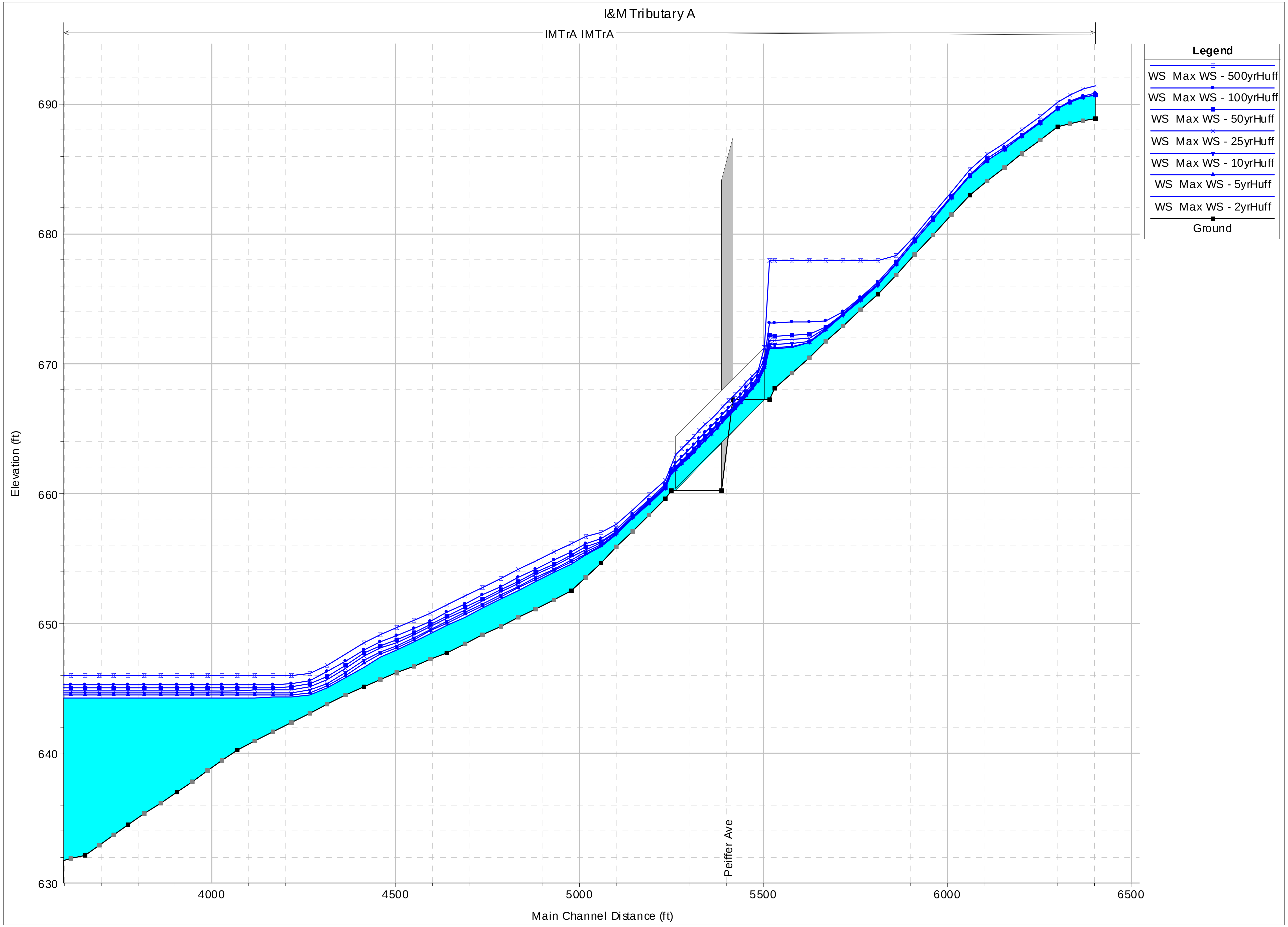
Crestwood Drainage Ditch from 135th St. and Laramie Ave. to confluence with Calumet-Sag Channel



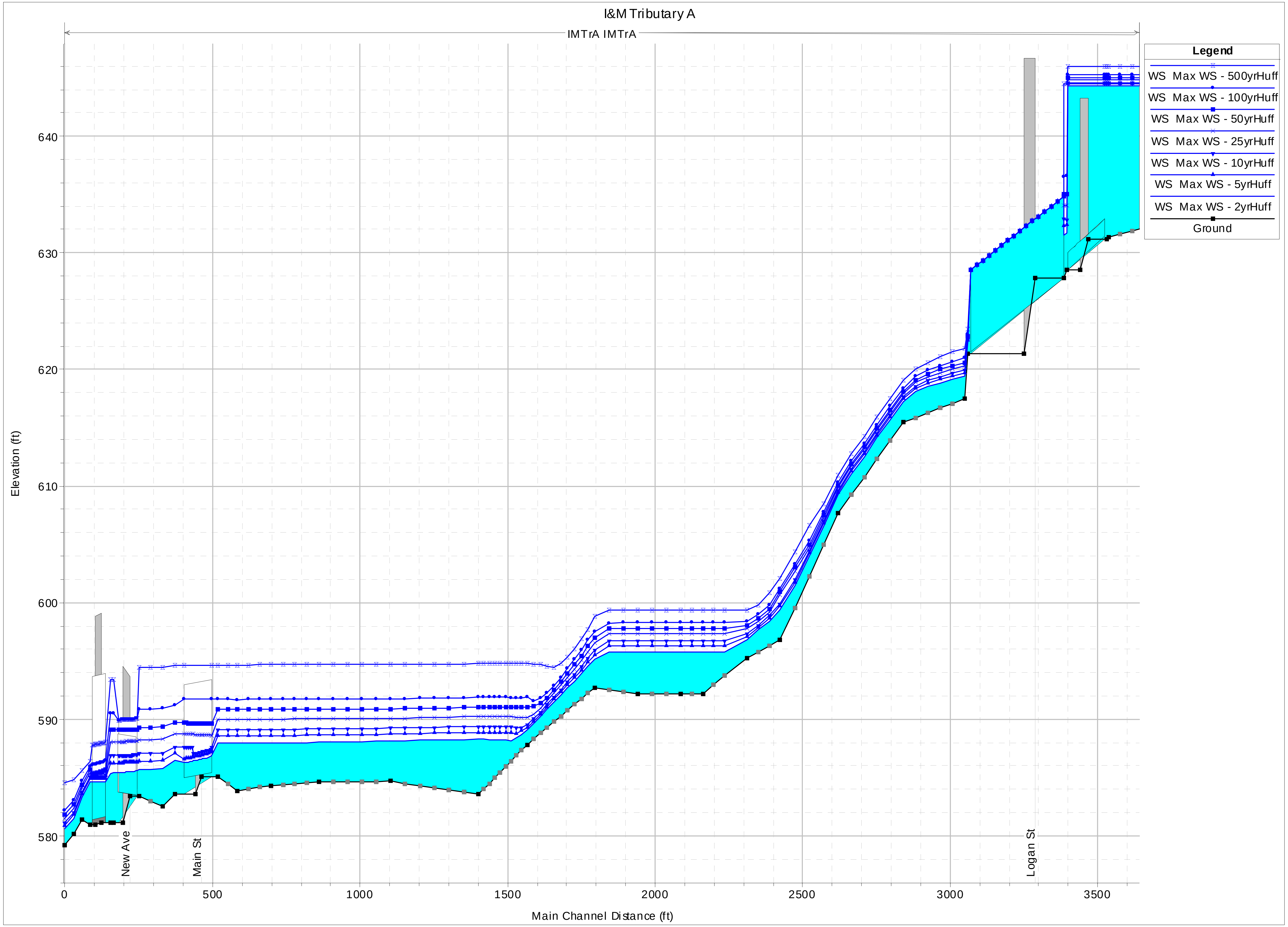
Crooked Creek from 93rd St. and 90th Ave. to Cook County Forest Preserve



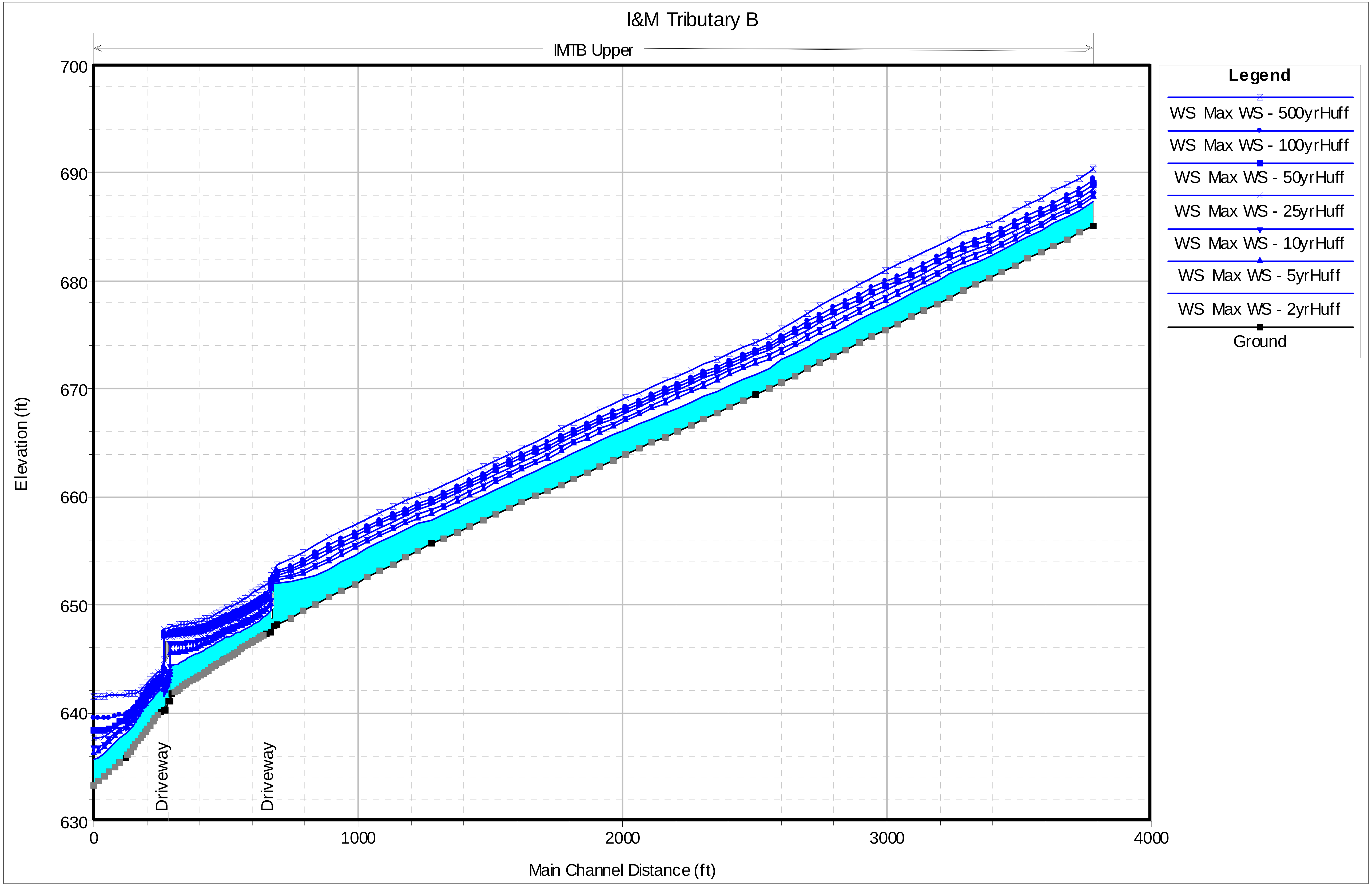
Crooked Creek from Cook County Forest Preserve to confluence with Calumet-Sag Channel



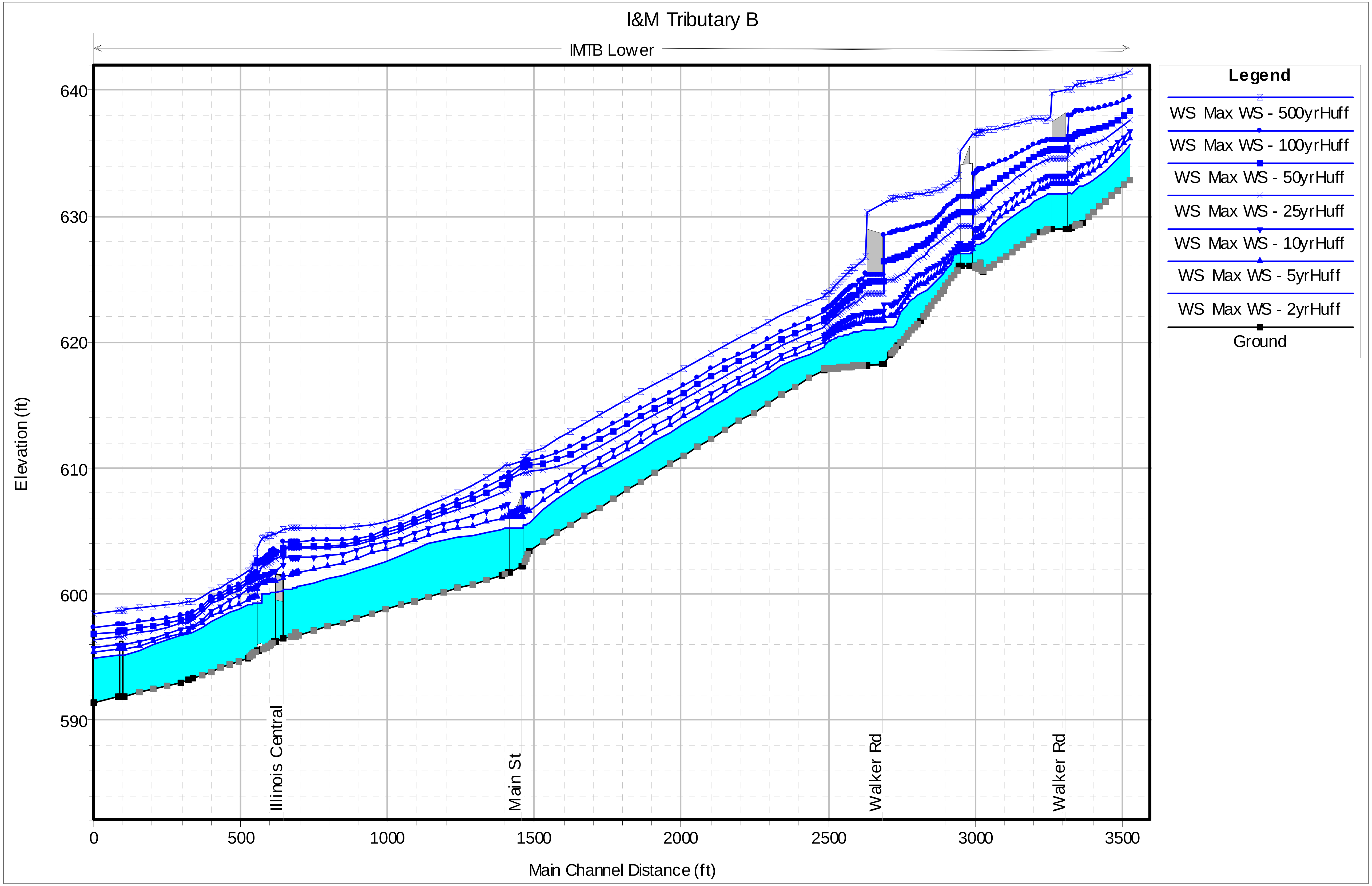
I&M Tributary A from Roberta St. & Rose Ct. to Logan St. Culvert



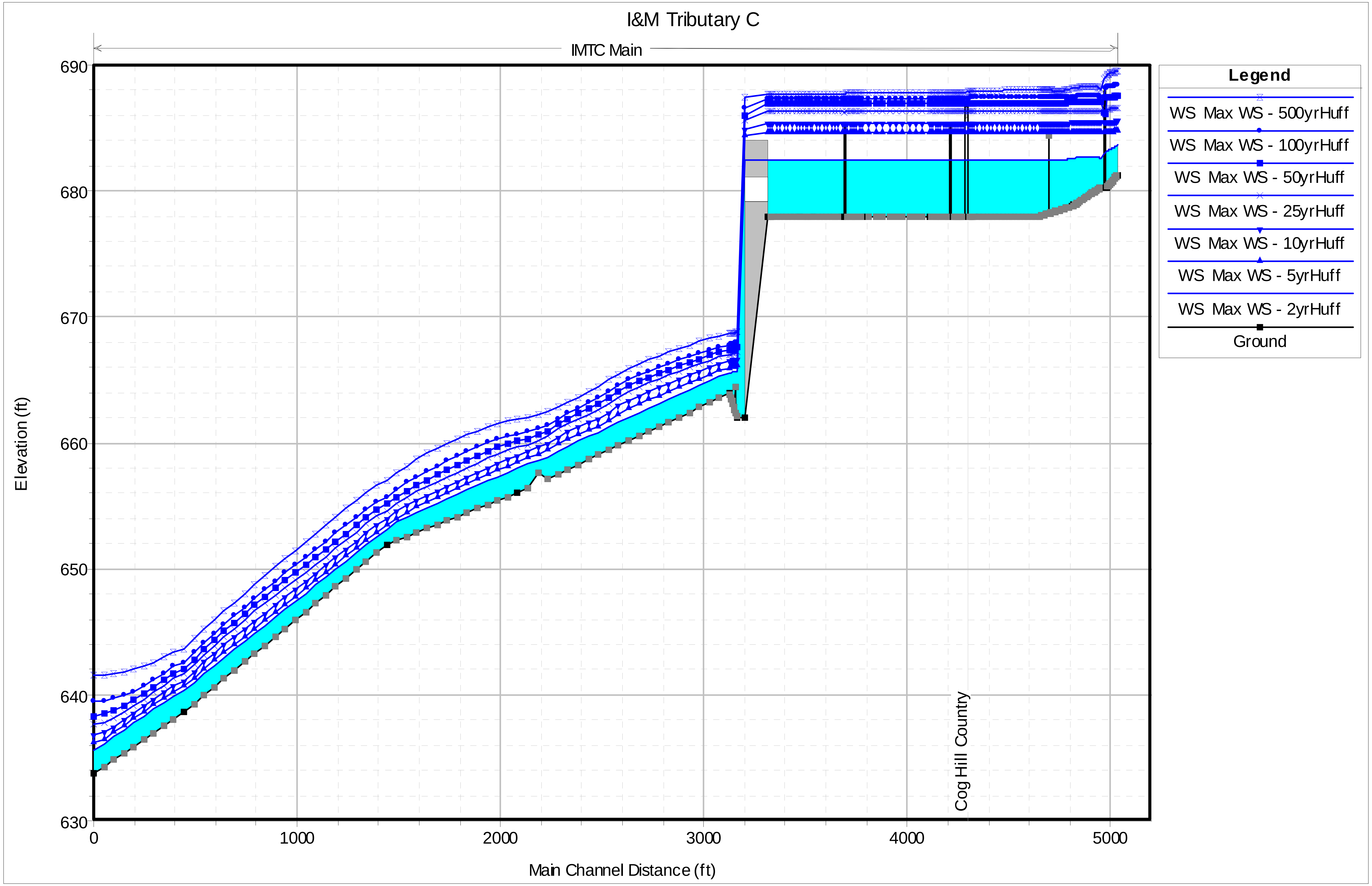
I&M Tributary A from Logan St. Culvert to confluence with Calumet-Sag Channel



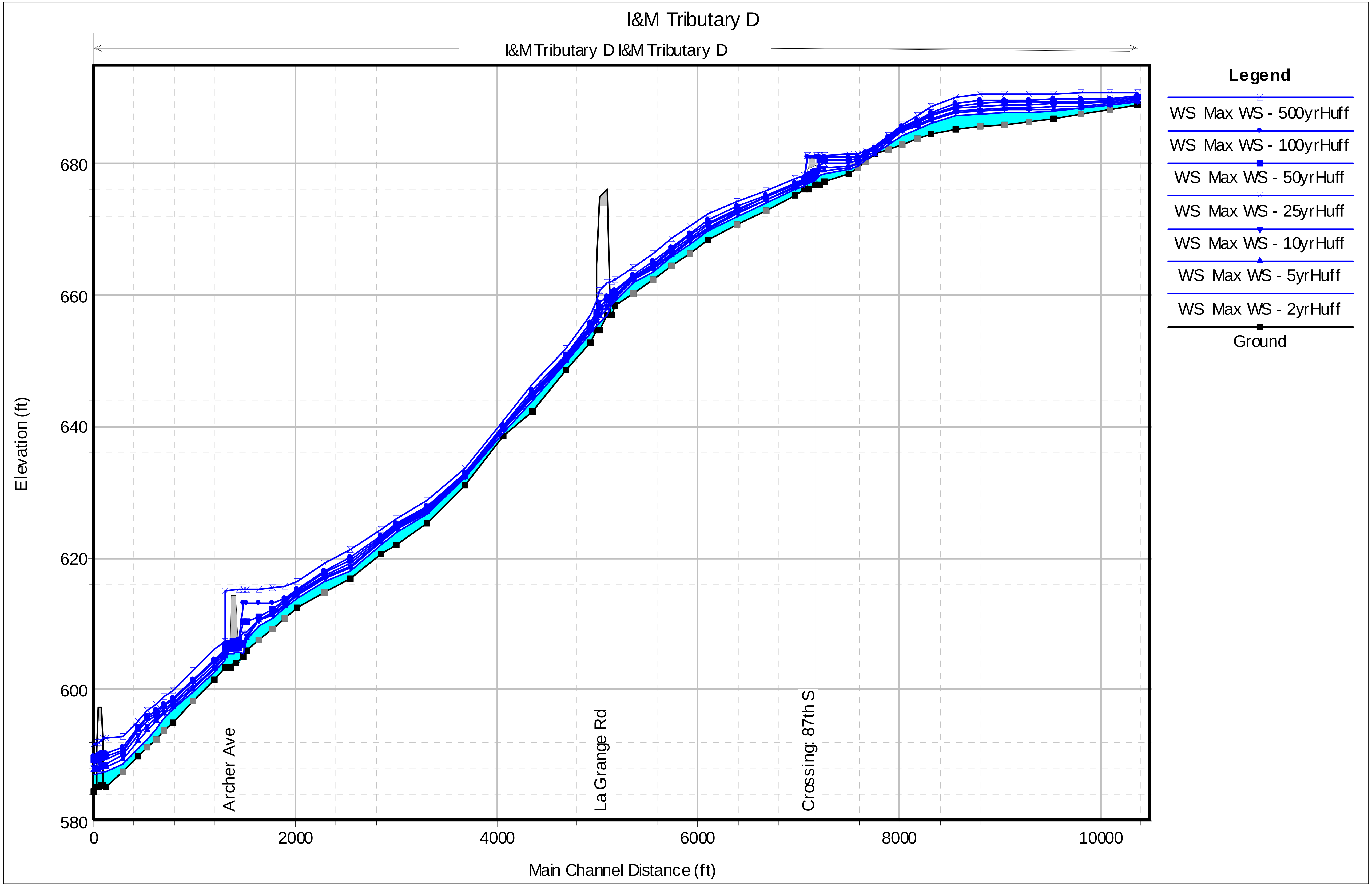
I&M Tributary B from 119th St. & Walker Rd. to Confluence with I&M Tributary C



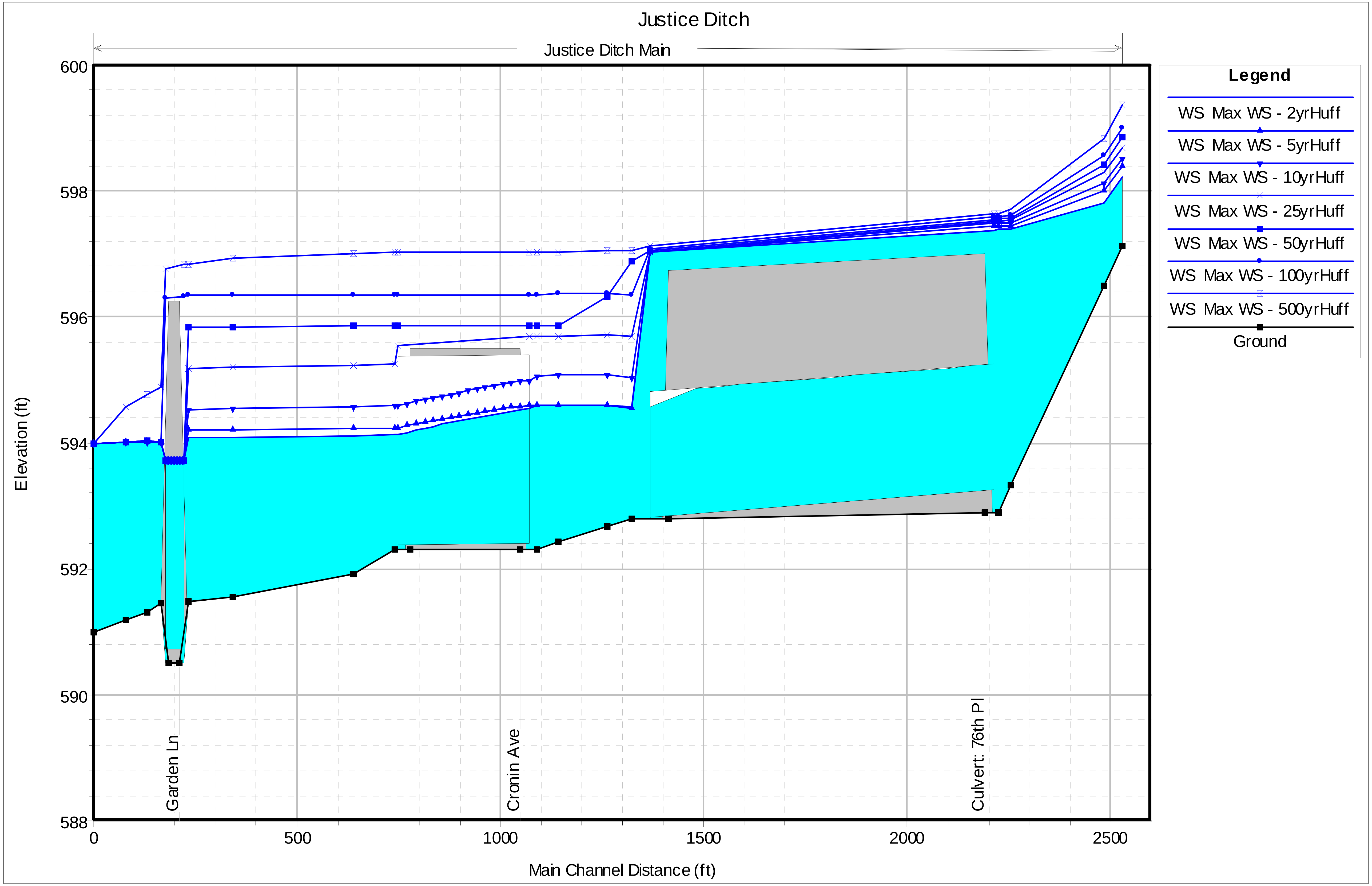
I&M Tributary B from confluence with I&M Tributary C to confluence with Calumet-Sag Channel



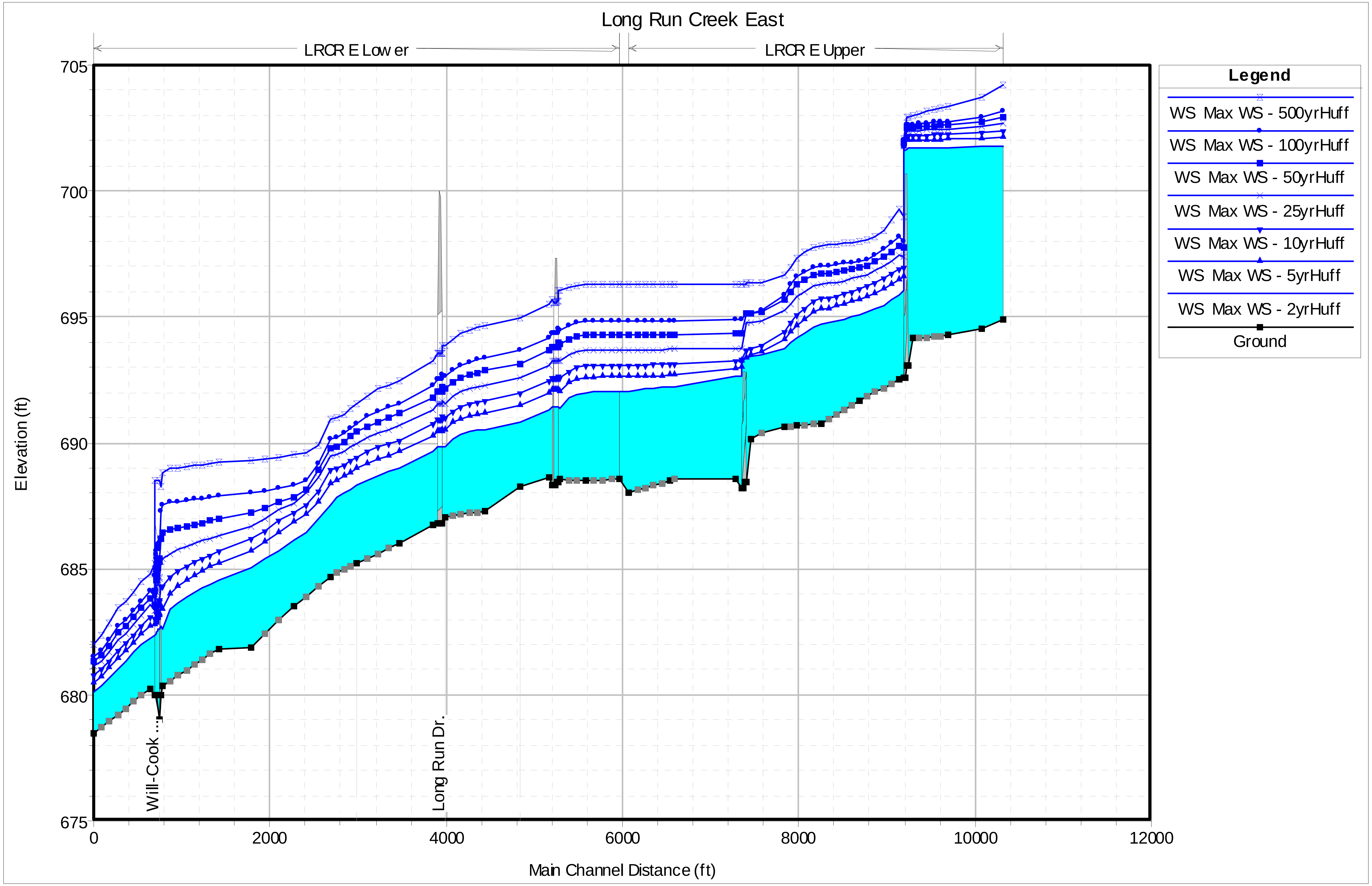
I&M Tributary C from Country Club Rd to confluence with I&M Tributary B



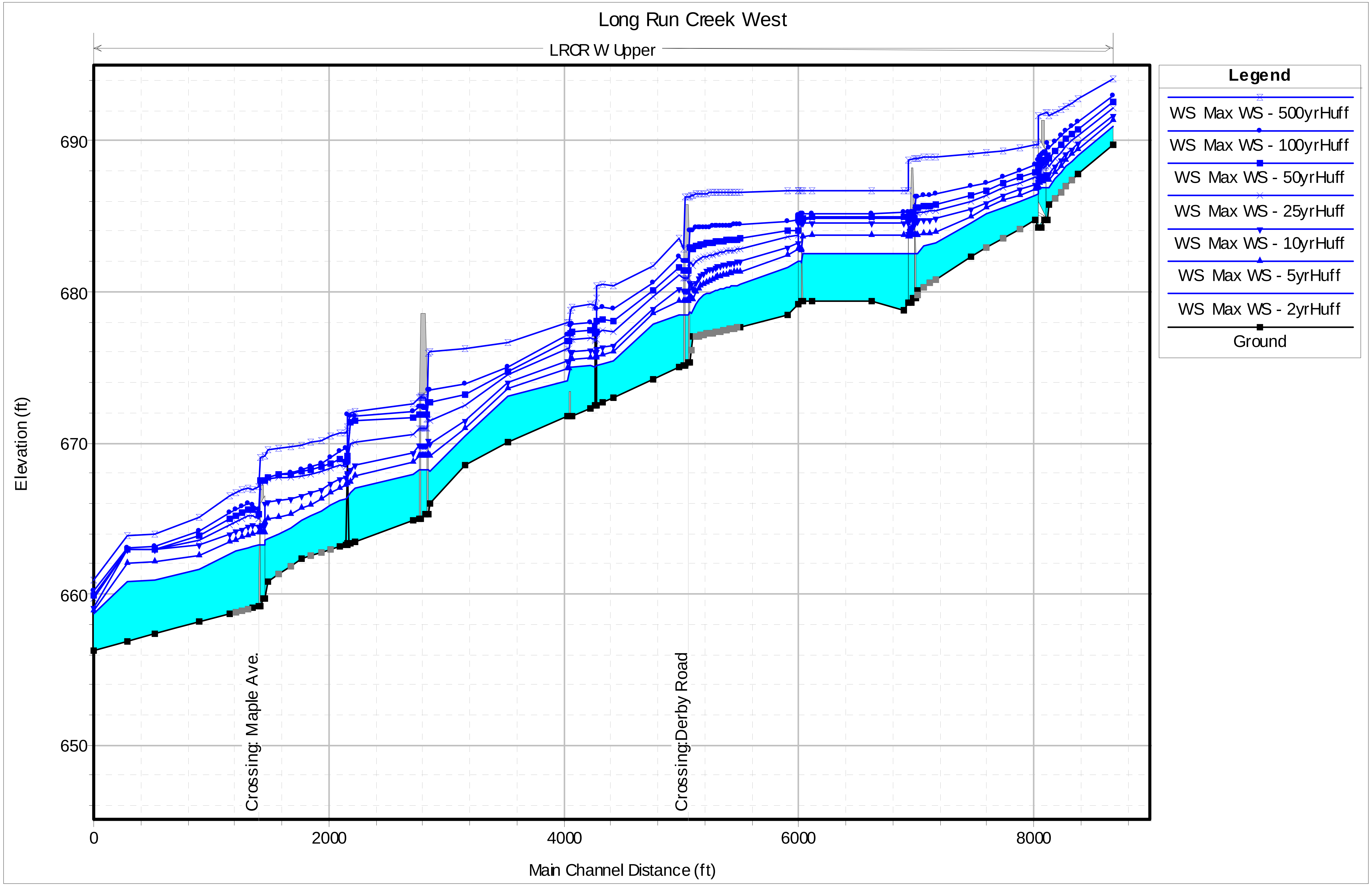
I&M Tributary D from Kean Ave. & 91st Pl. to confluence with I&M Channel



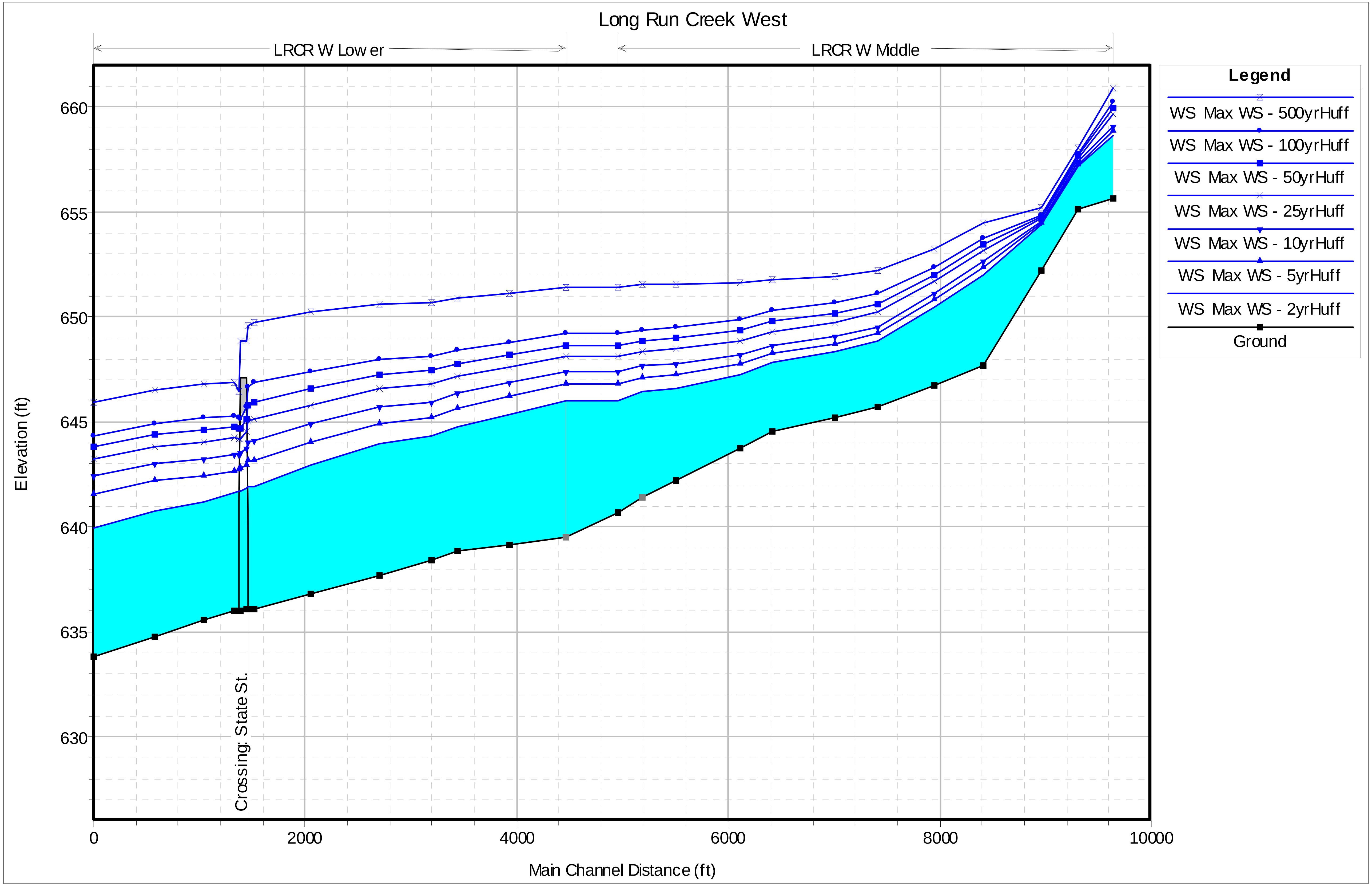
Justice Ditch from 76th Pl. & Oak Grove Ave. to confluence with culvert at Garden Ln.



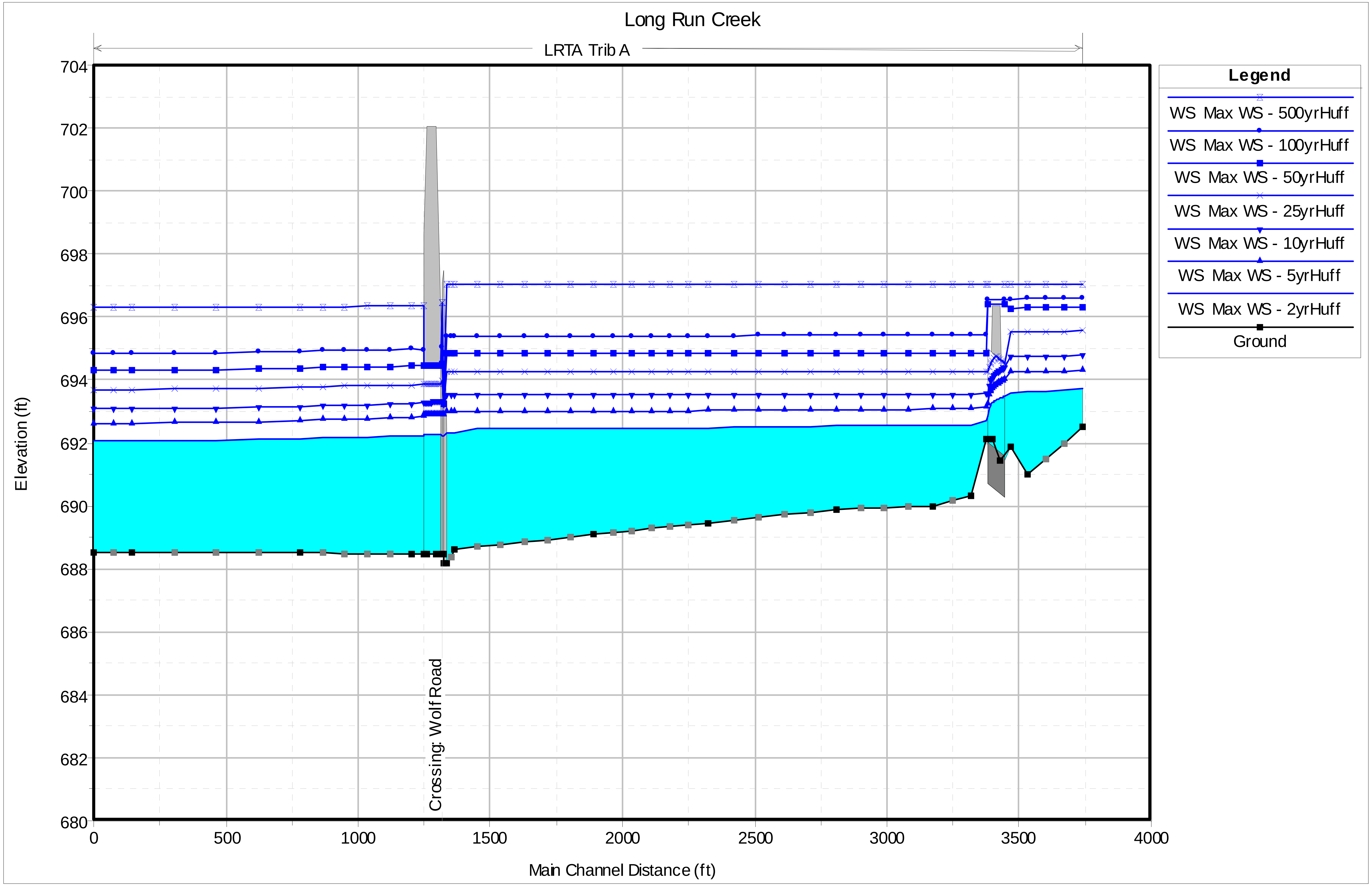
Long Run Creek from South of 143rd St. & Wolf Road to Will-Cook Rd.



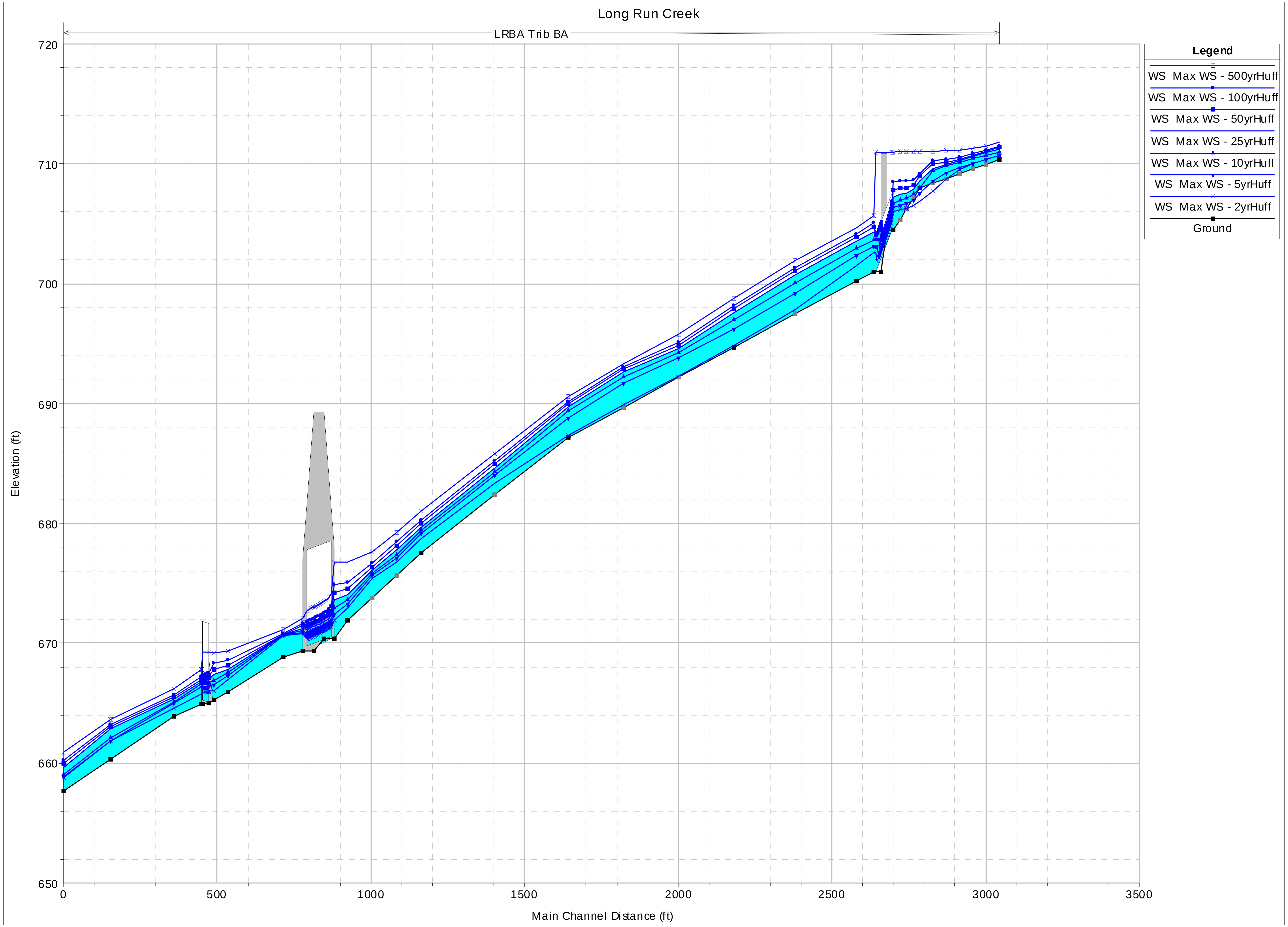
Long Run Creek Tributary B from Parker Rd. & Silver Fox Dr. to Maple Ave. & 131st St.



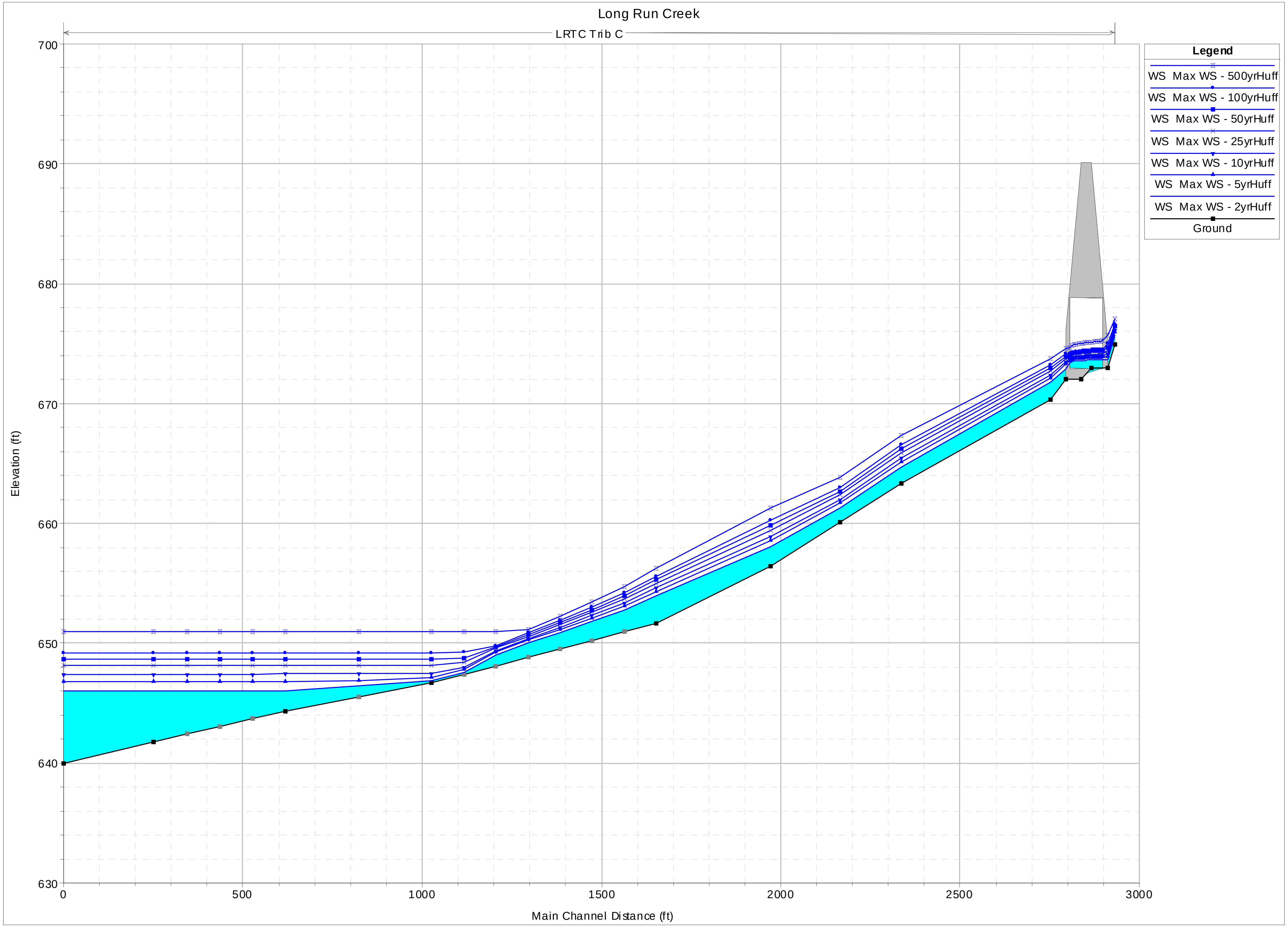
Long Run Creek from Maple Ave. & 131st St. to State St. & Archer Ave.



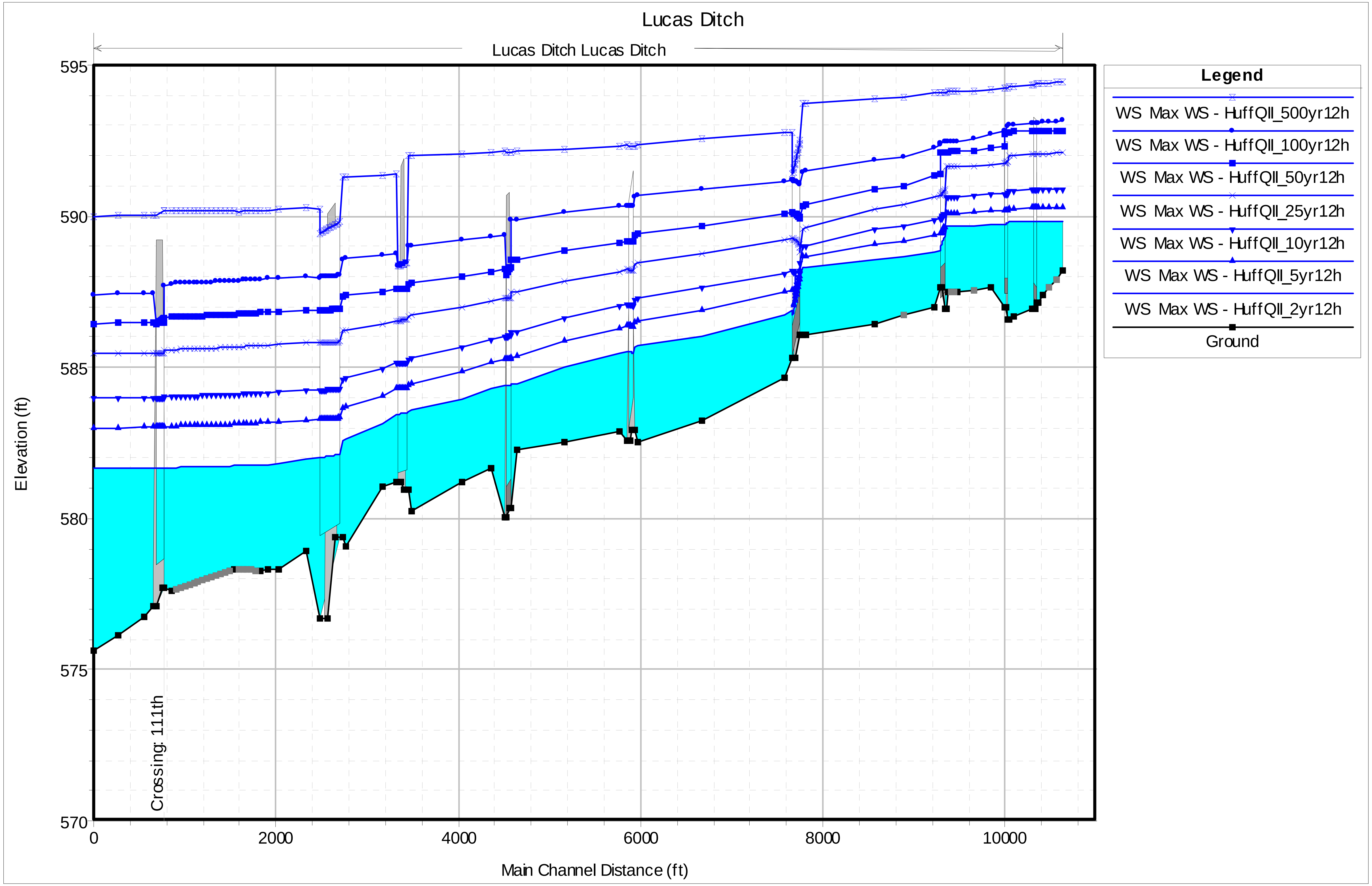
Long Run Creek Tributary A from 143rd St. & 108th Ave. to confluence with Long Run Creek



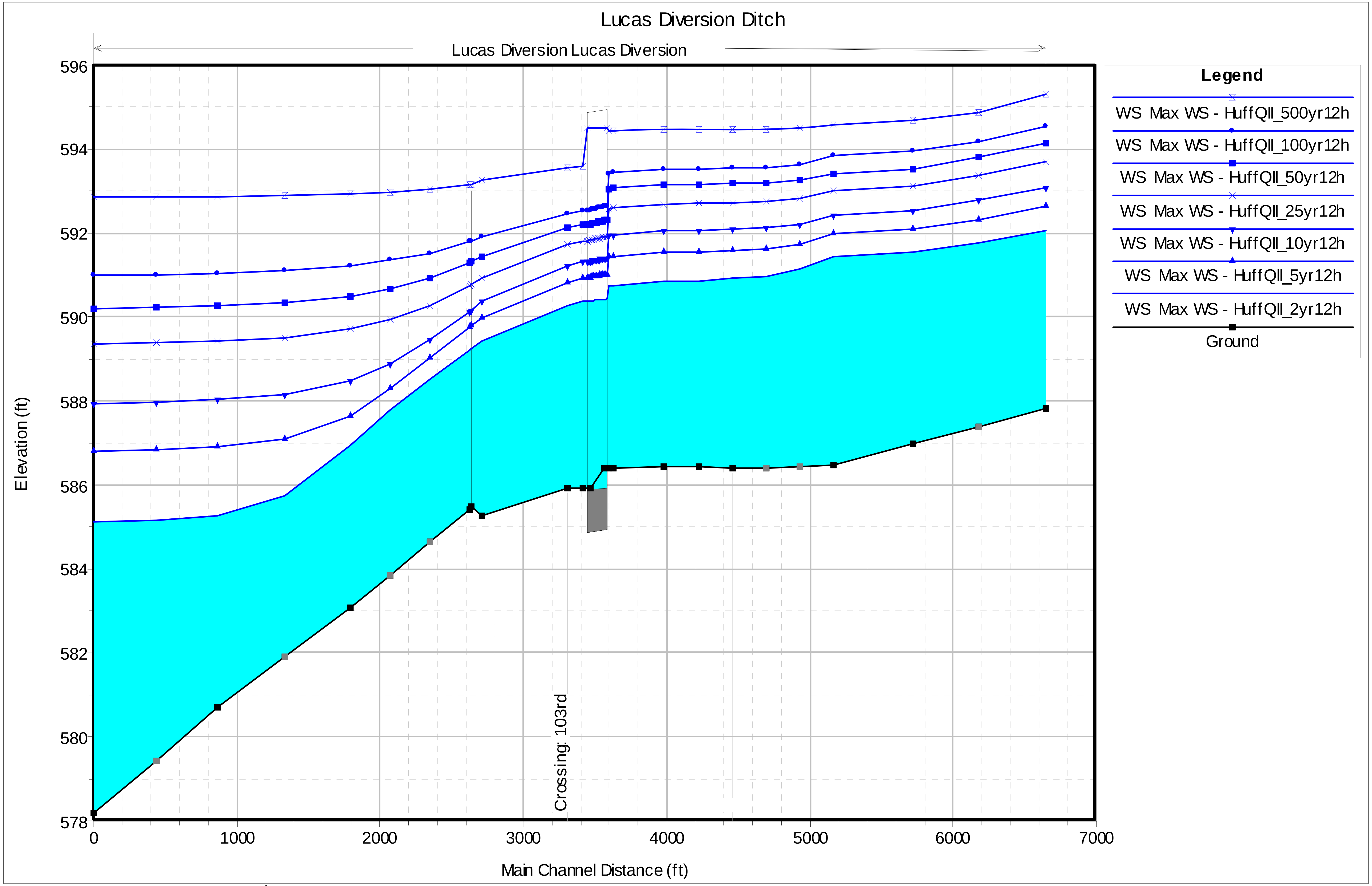
Long Run Creek Tributary BA from south of Jane Ave. & Archer Ave. to confluence with Long Run Creek Tributary B



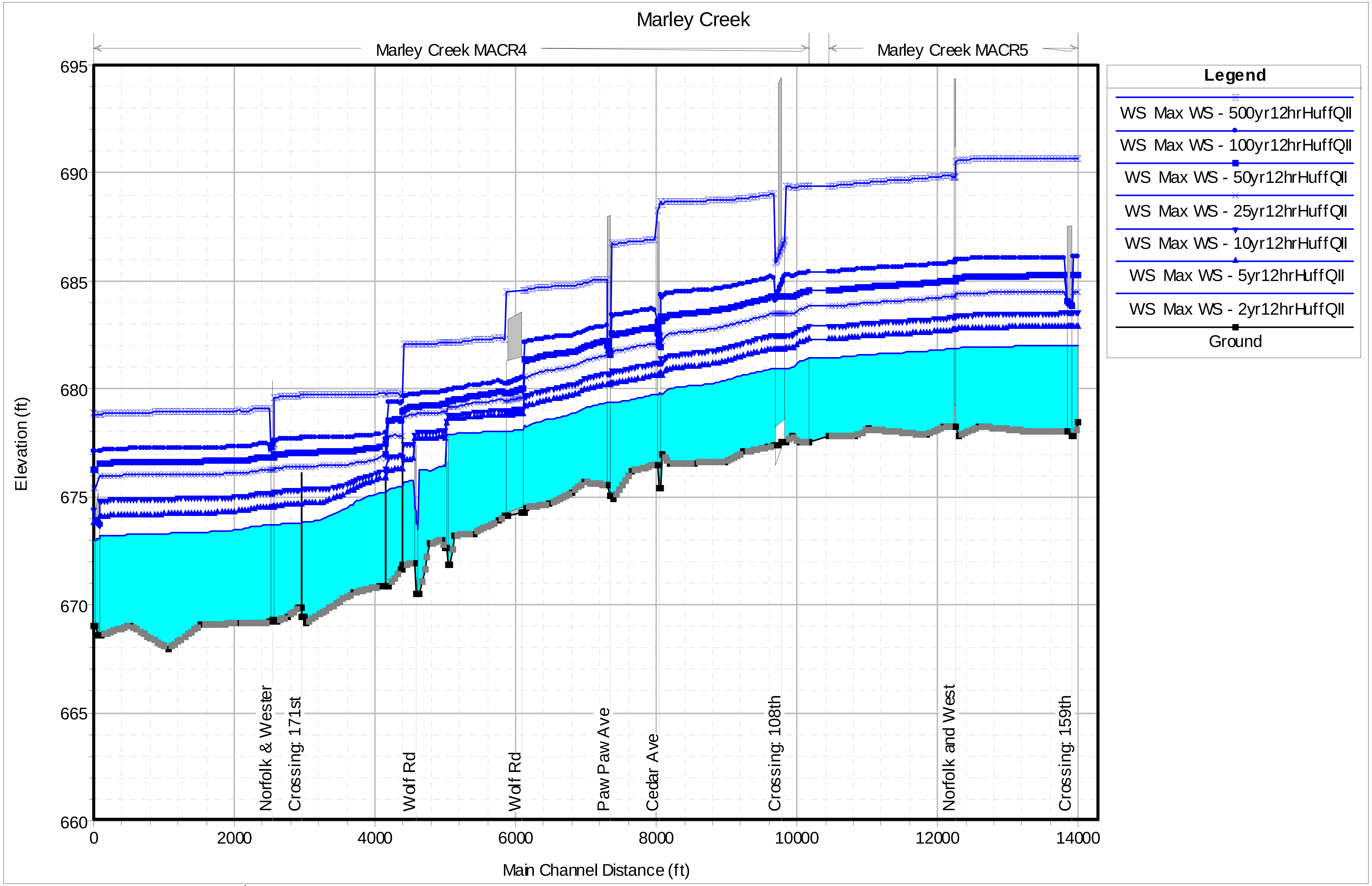
Long Run Creek Tributary C from 131st St. & Archer Ave. to confluence with Long Run Creek



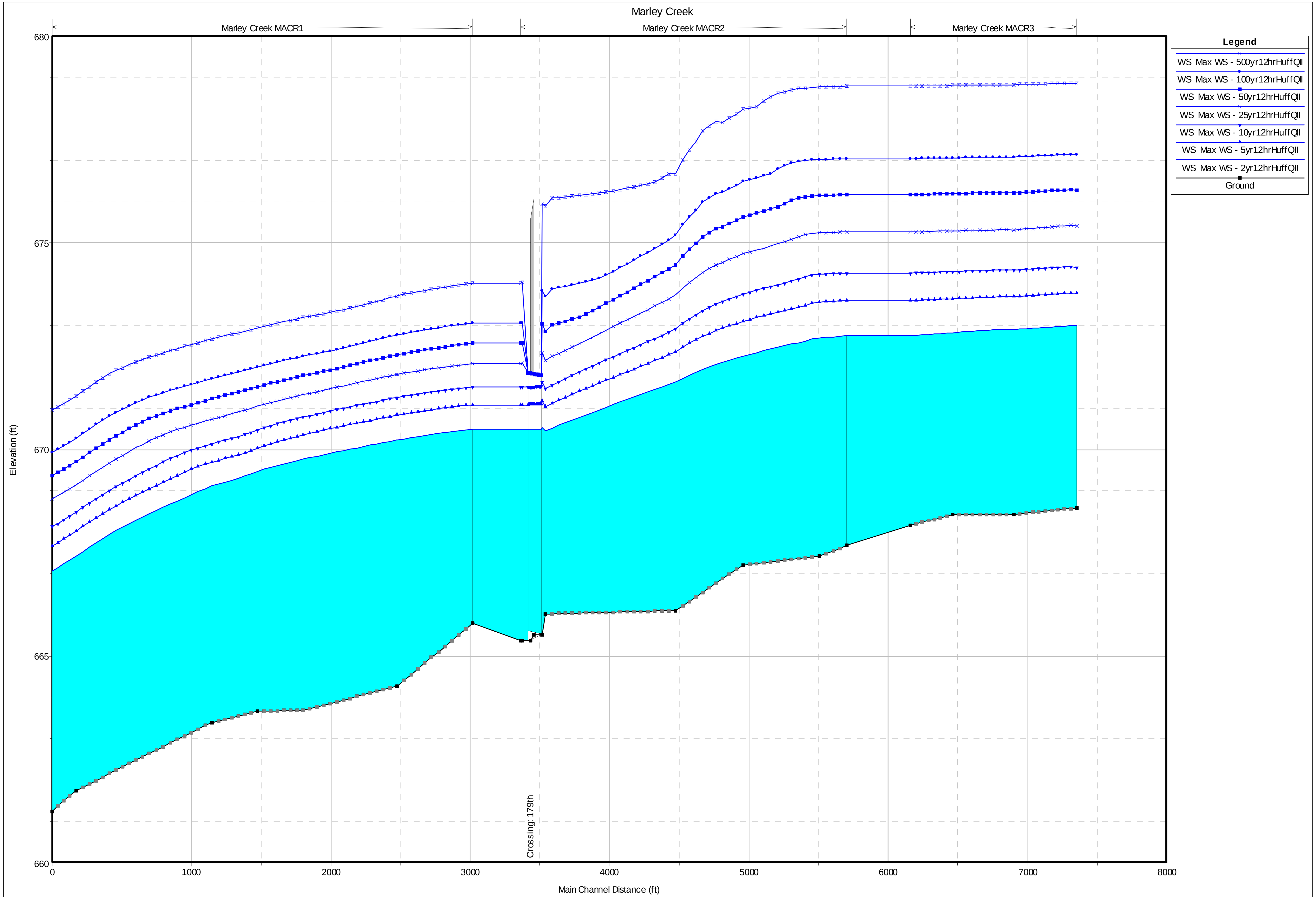
Lucas Ditch from Roberts Road to confluence with Stony Creek West.



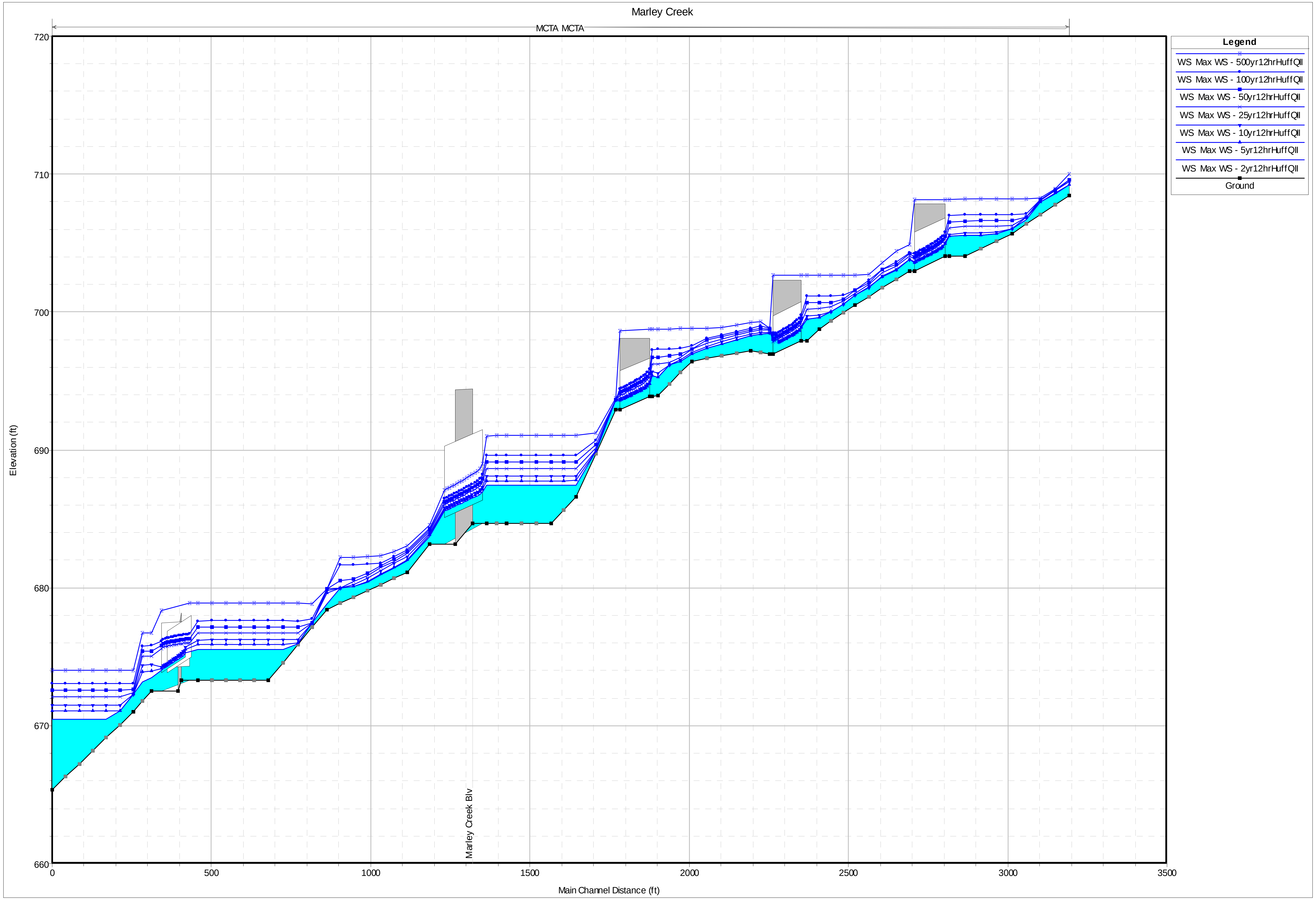
Lucas Diversion Ditch 76th Ave. to confluence with Stony Creek West.



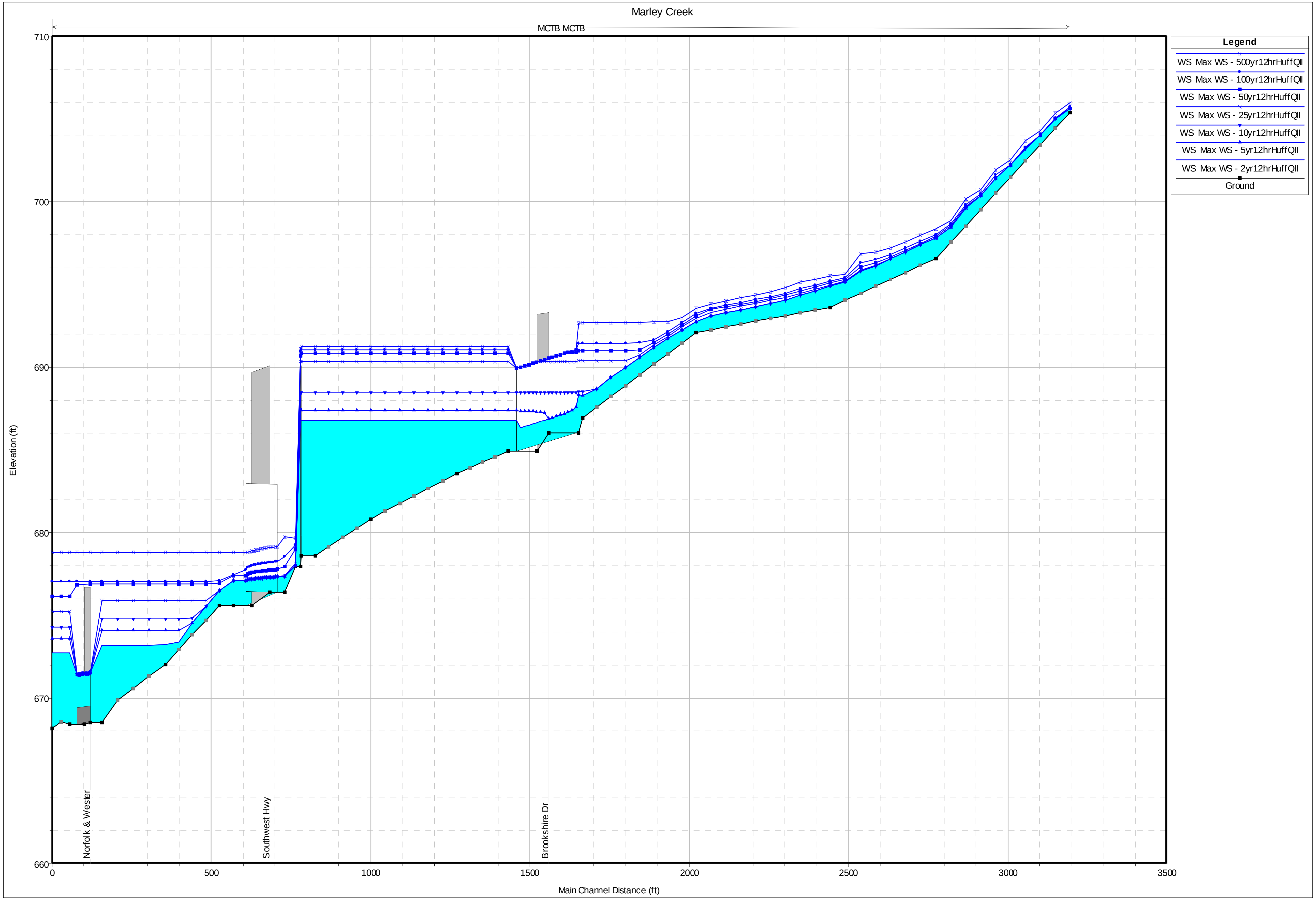
Marley Creek from 159th Street to confluence with Marley Creek Tributary C.



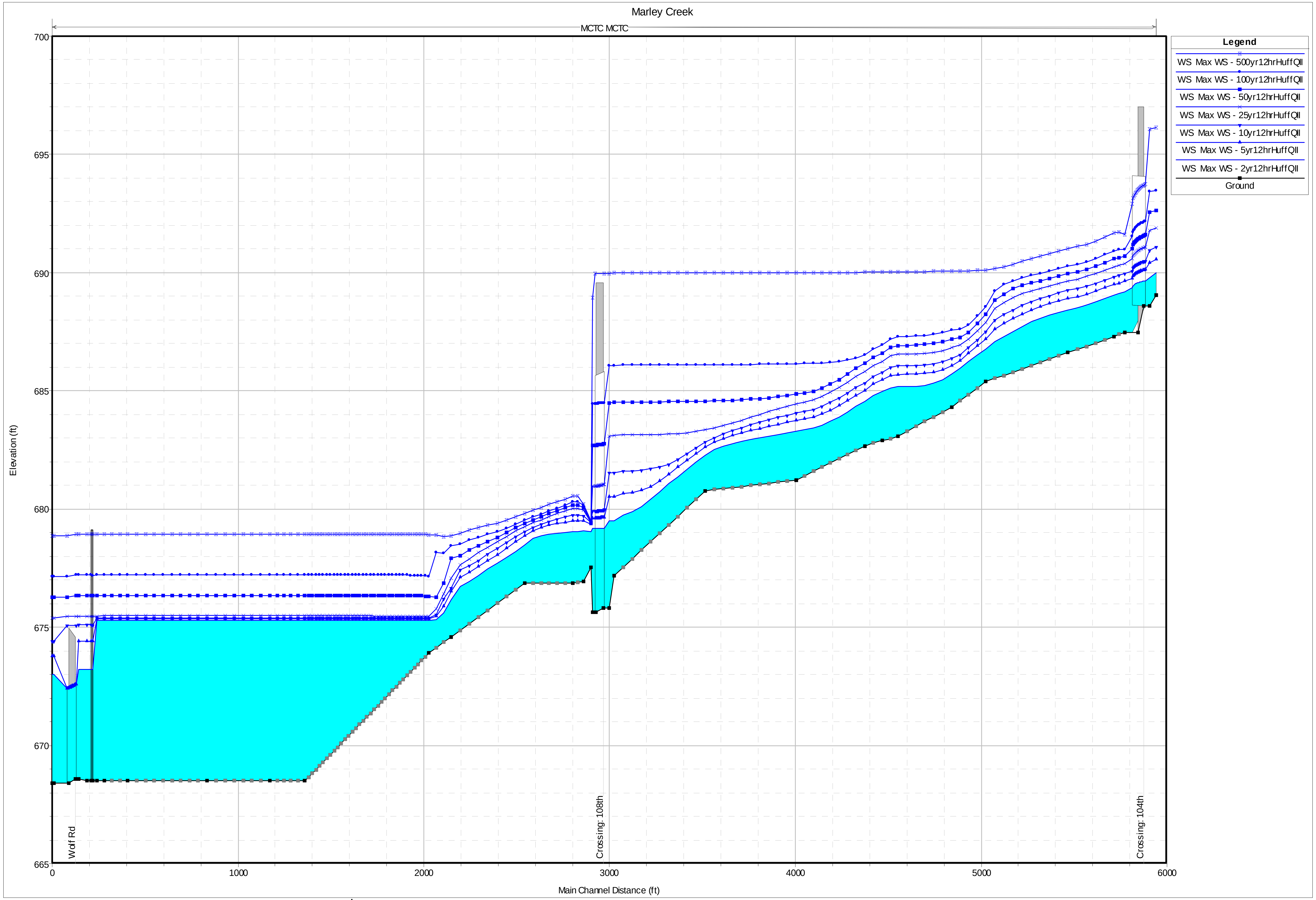
Marley Creek from confluence with Marley Creek Tributary C to Will-Cook County border.



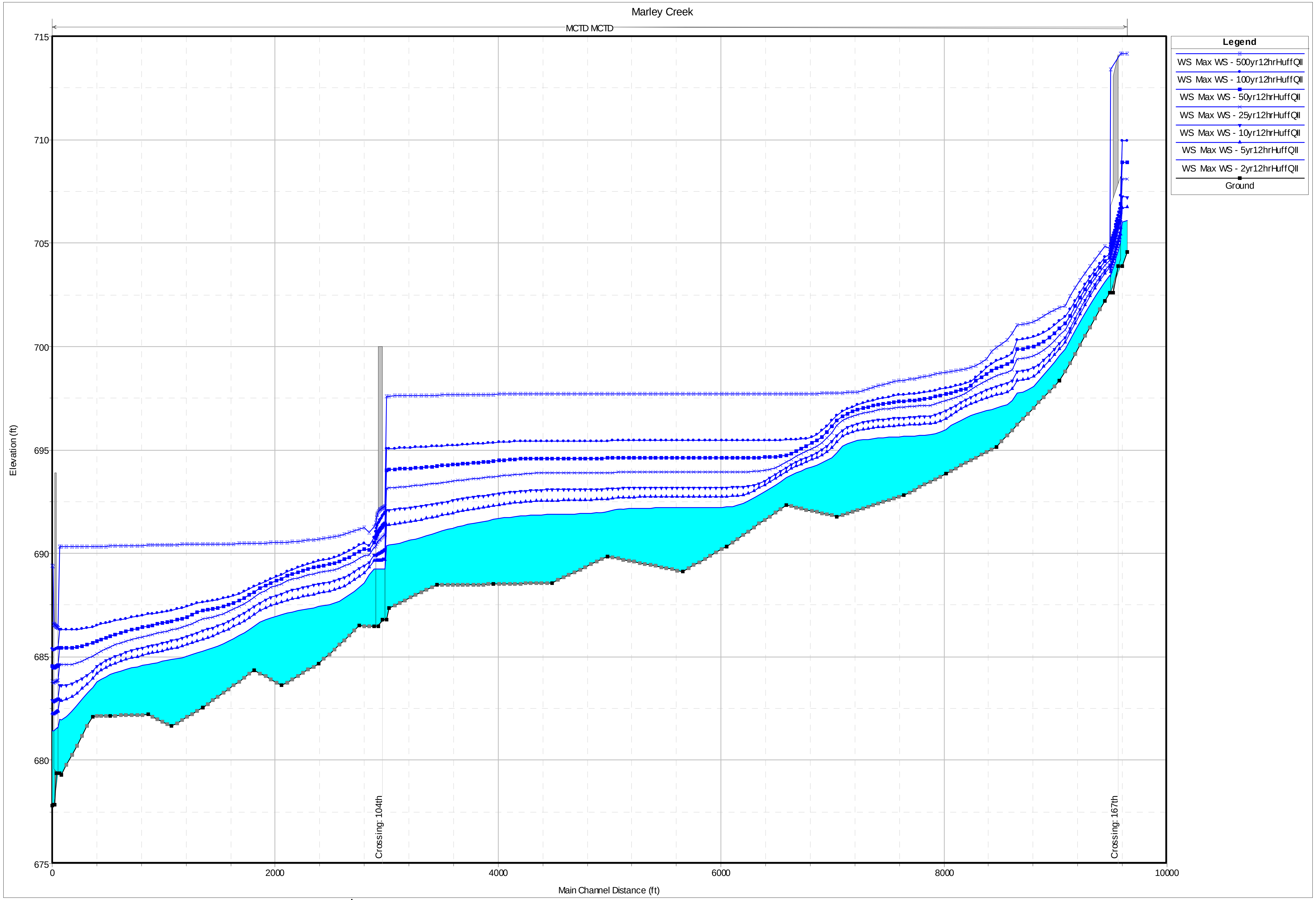
Marley Creek Tributary A to confluence with Marley Creek.



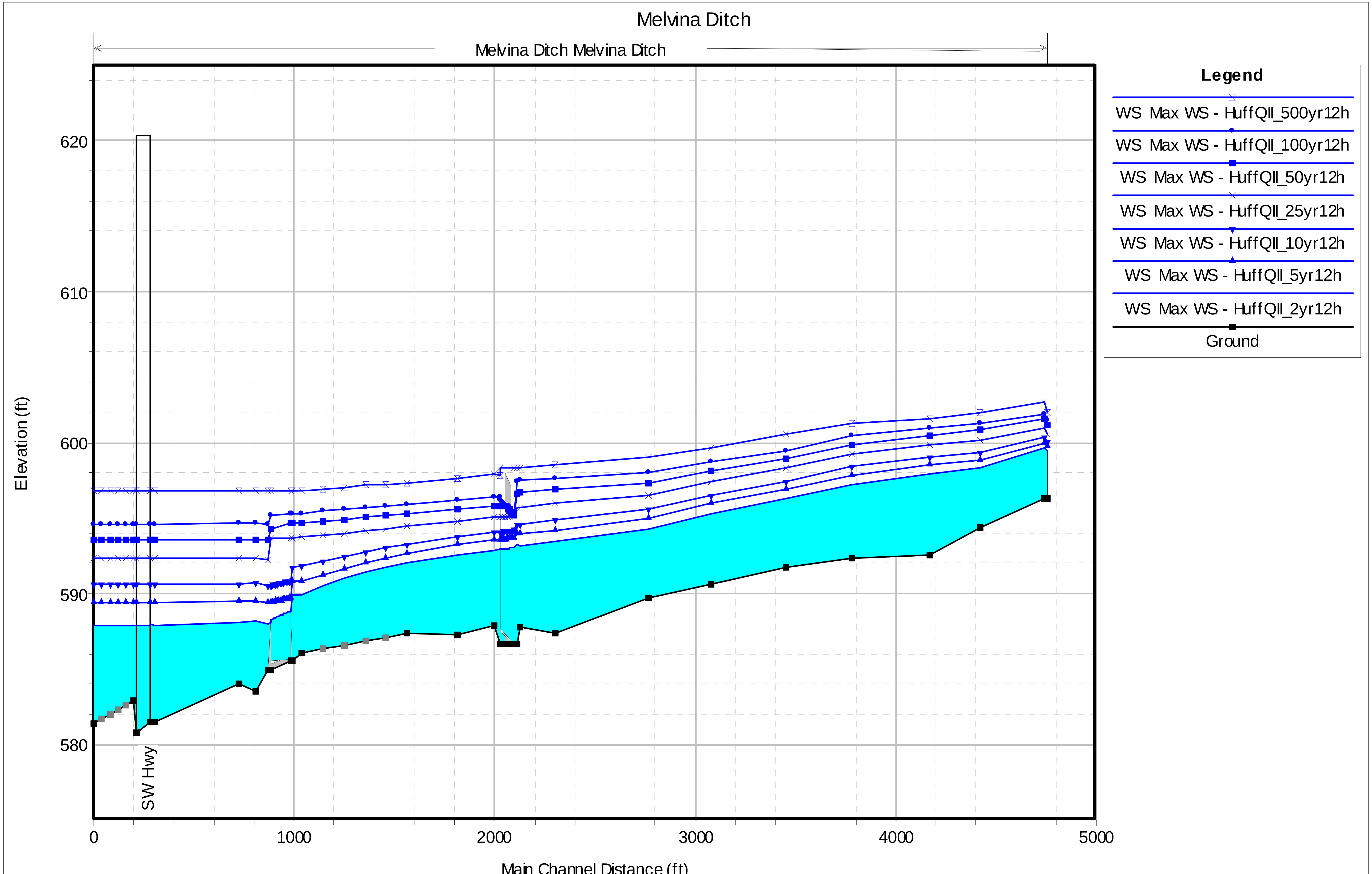
Marley Creek Tributary B to confluence with Marley Creek.



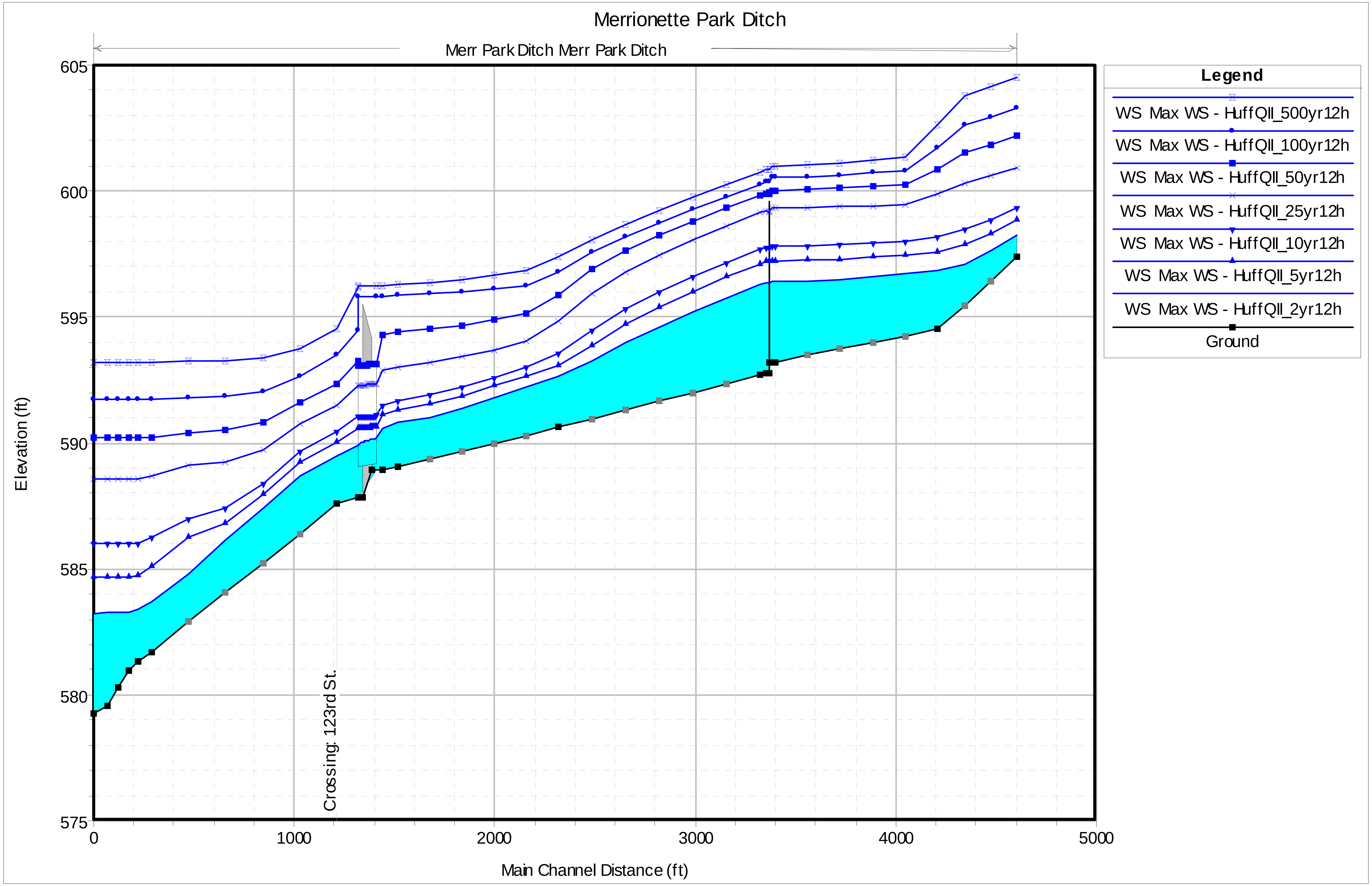
Marley Creek Tributary C from 104th St. to confluence with Marley Creek.



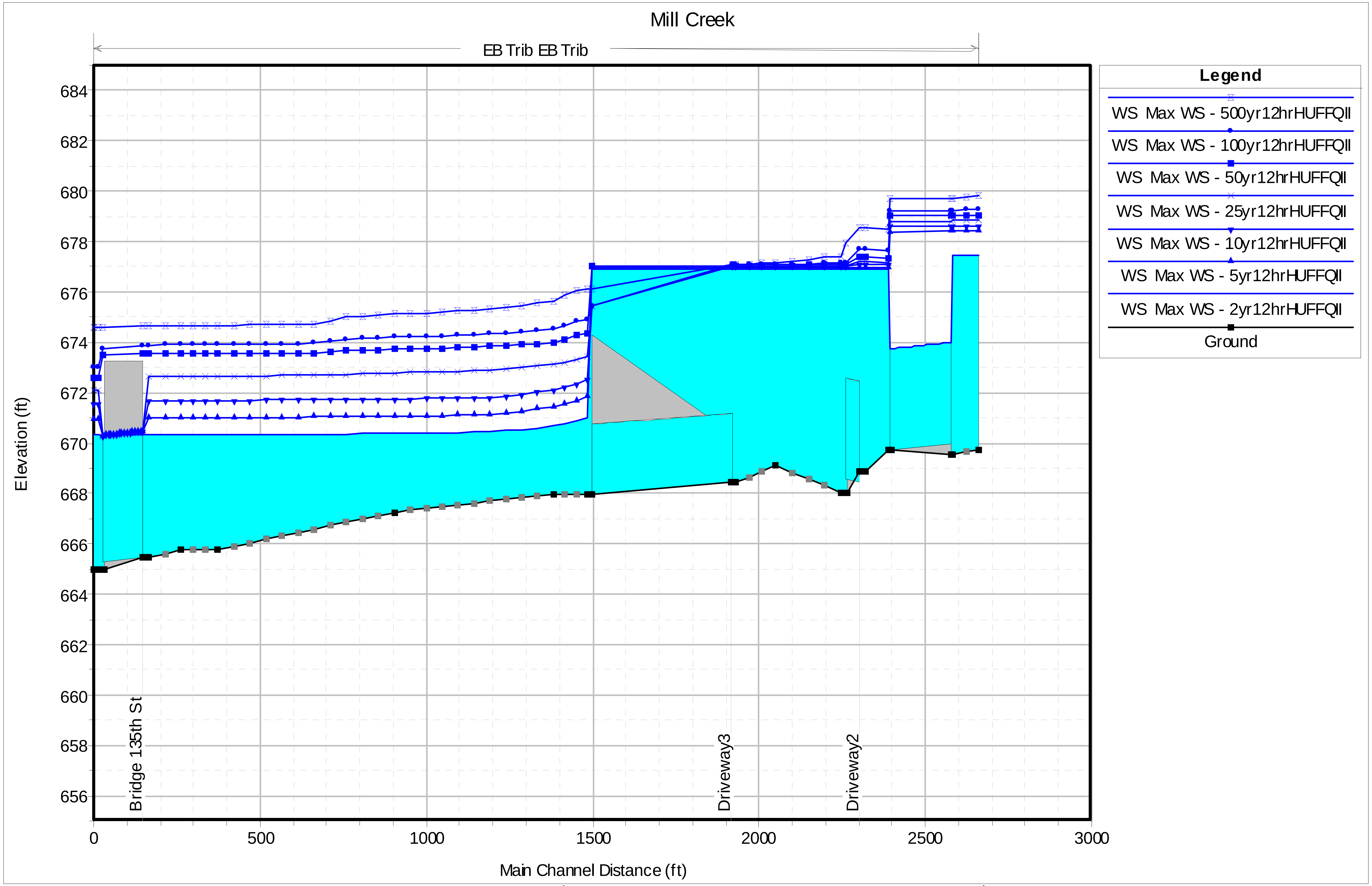
Marley Creek Tributary D from 167th St. to confluence with Marley Creek.



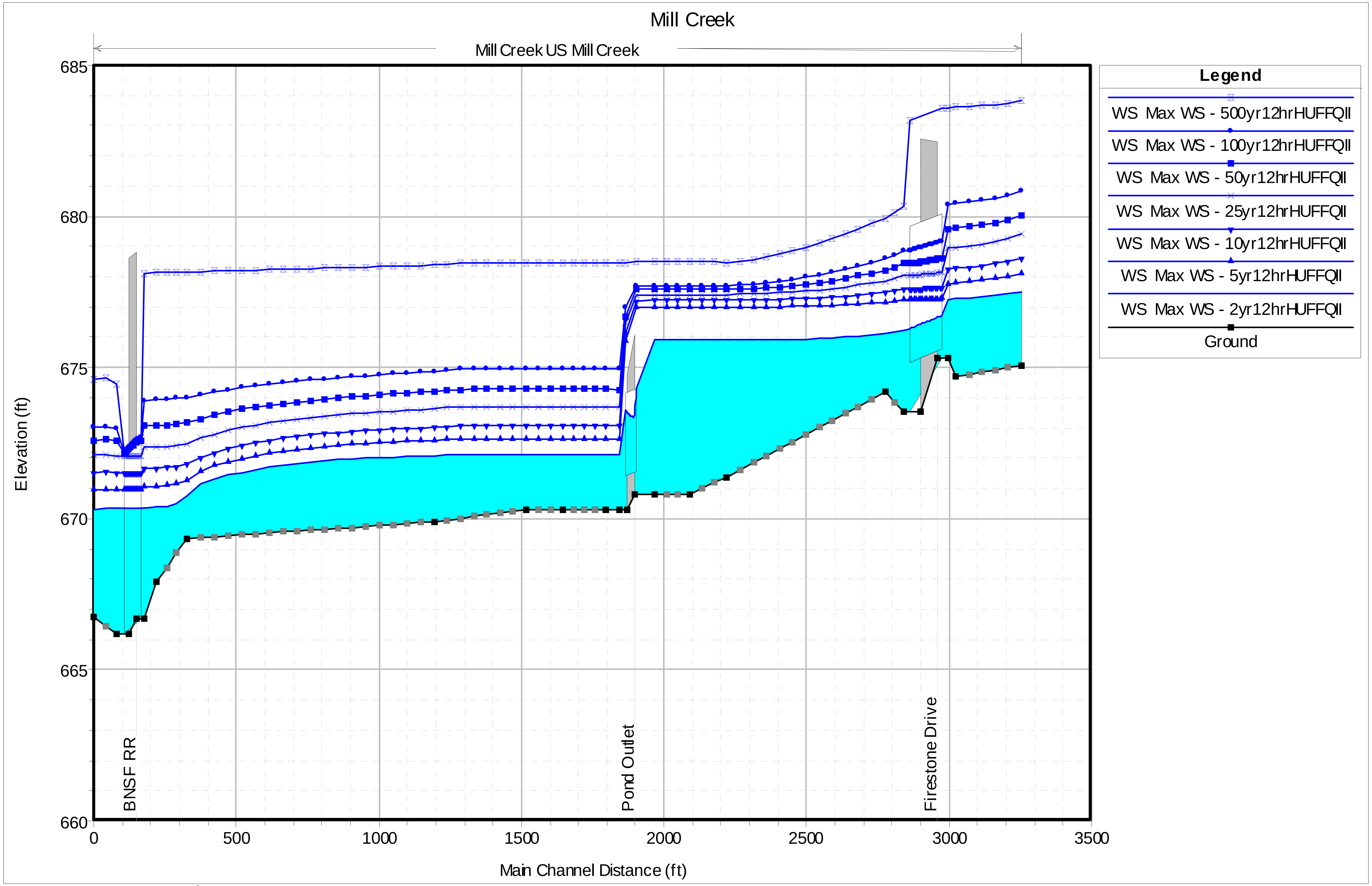
Melvina Ditch to confluence with Stony Creek West.



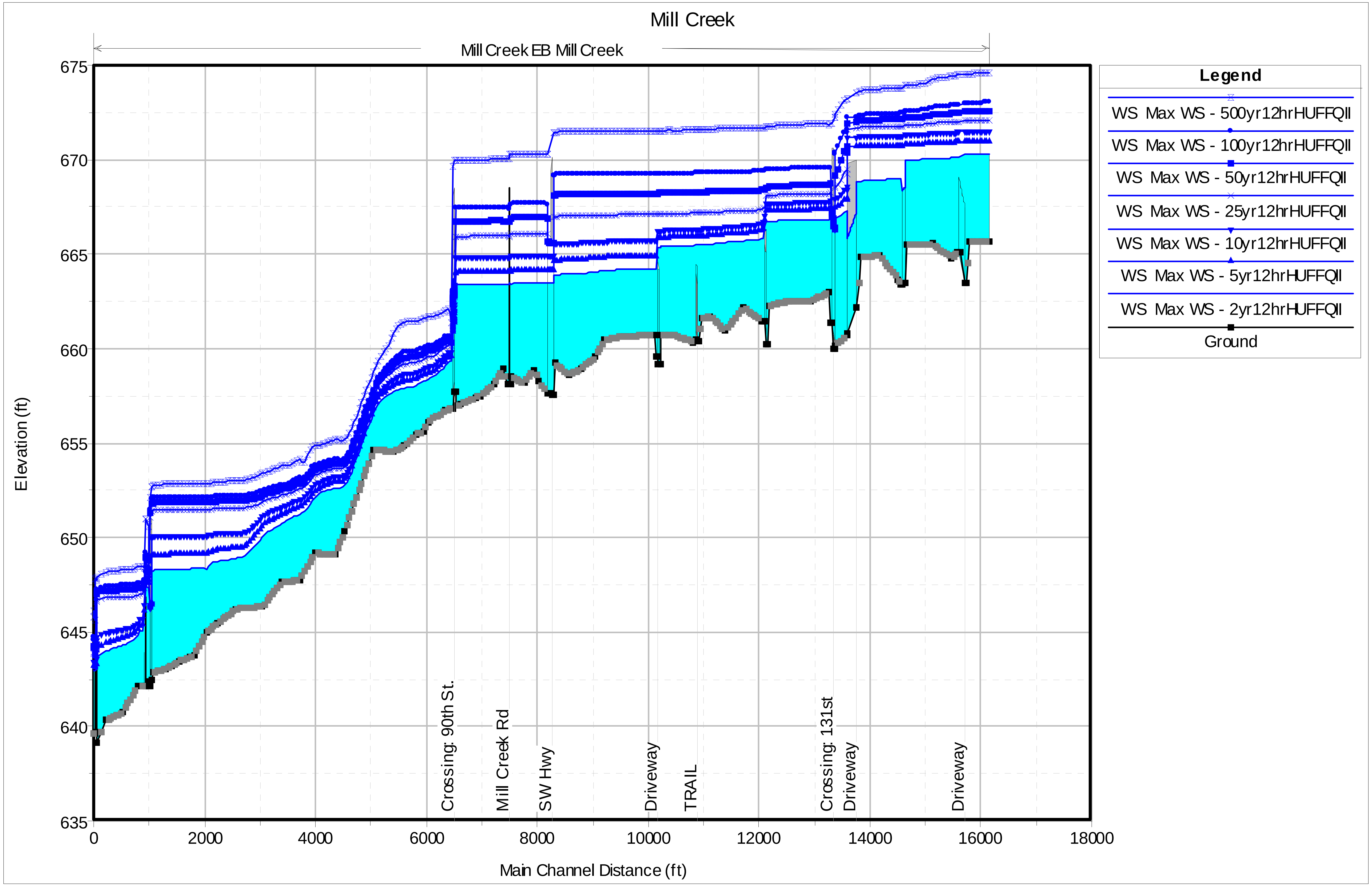
Merrionette Park Ditch to confluence with Stony Creek East.



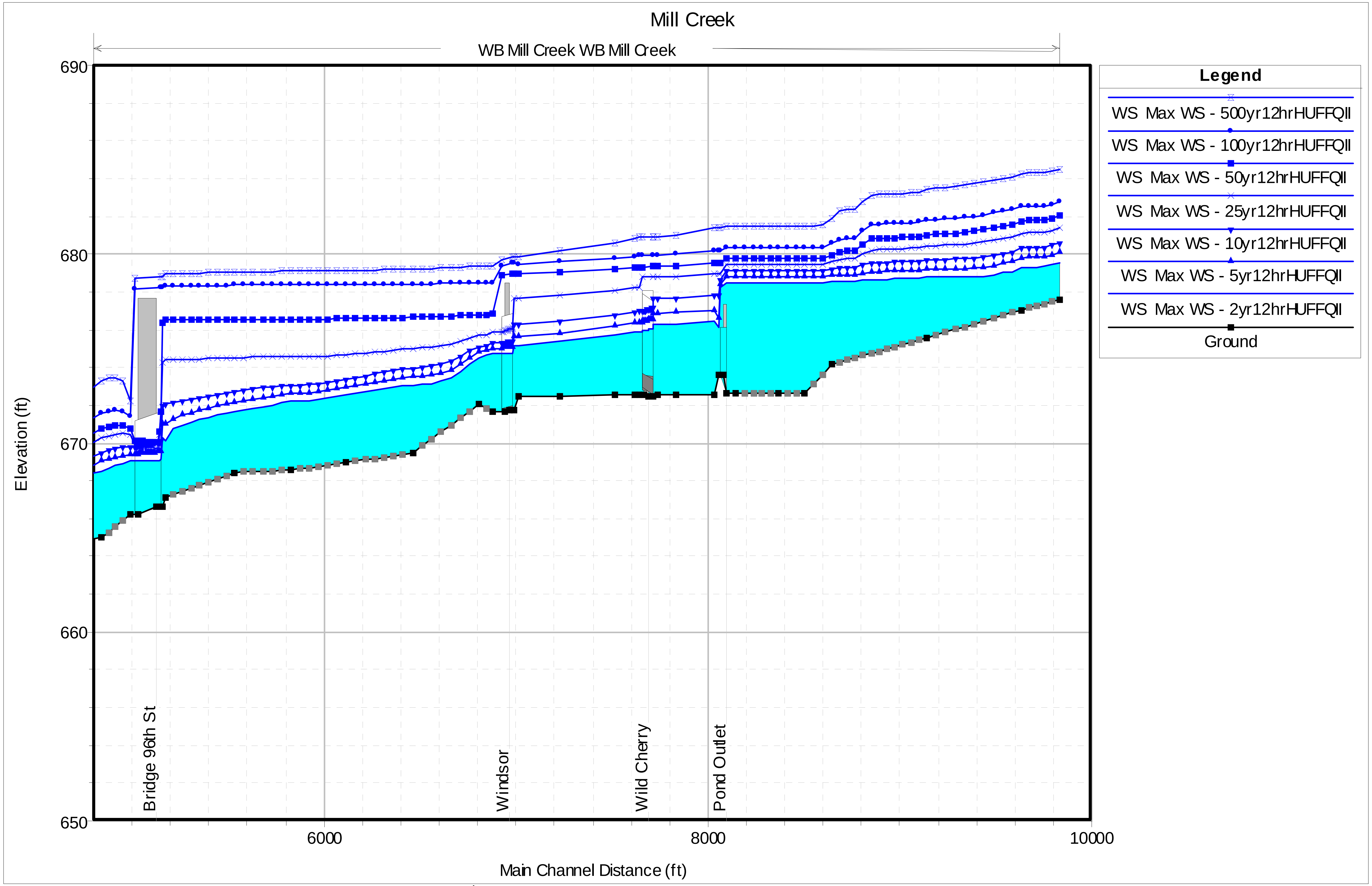
Tributary to Mill Creek along Southwest Hwy from 139th St. to confluence with Mill Creek at 135th St.



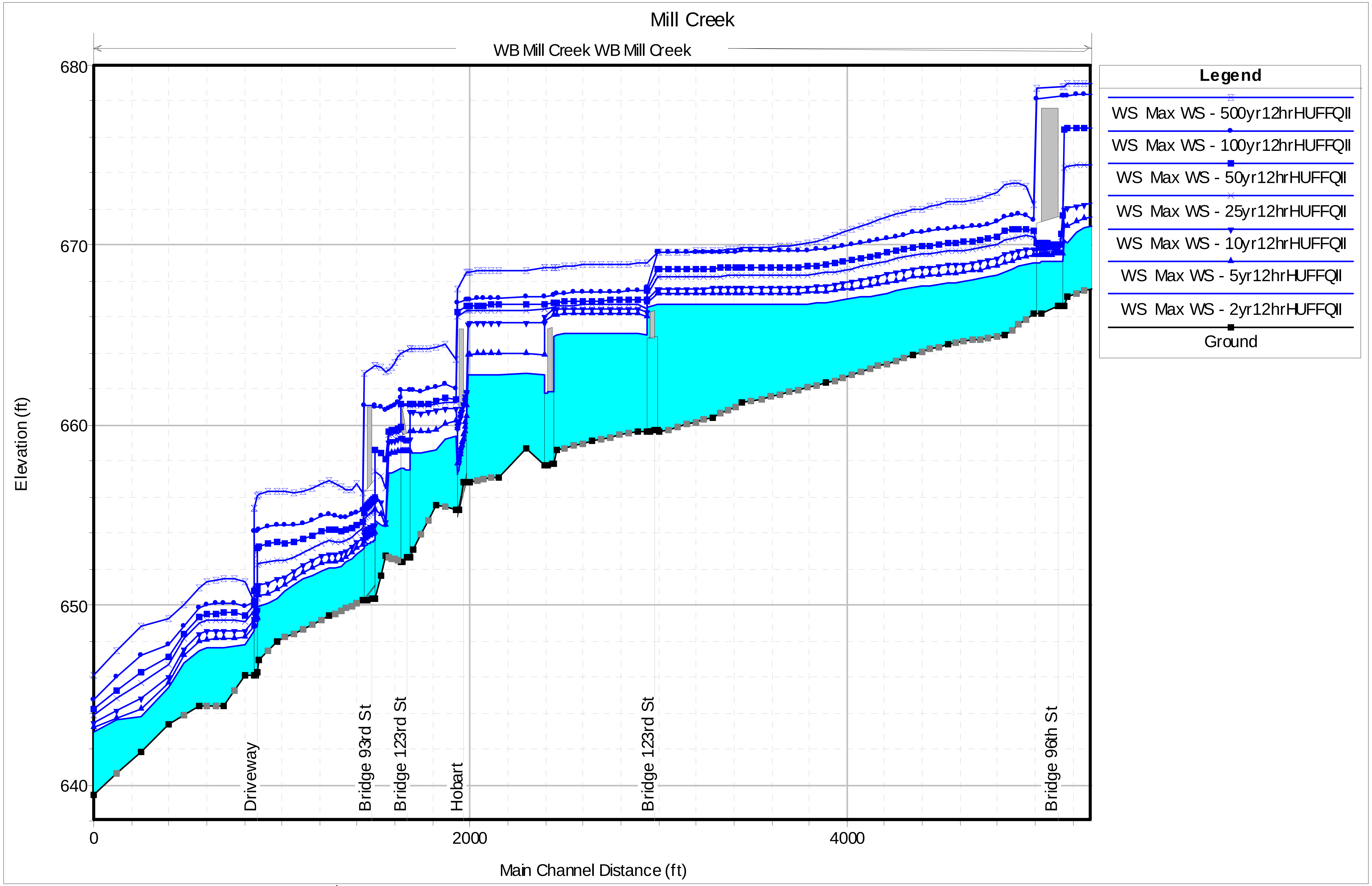
Mill Creek from 88th Ave to BNSF Railroad.



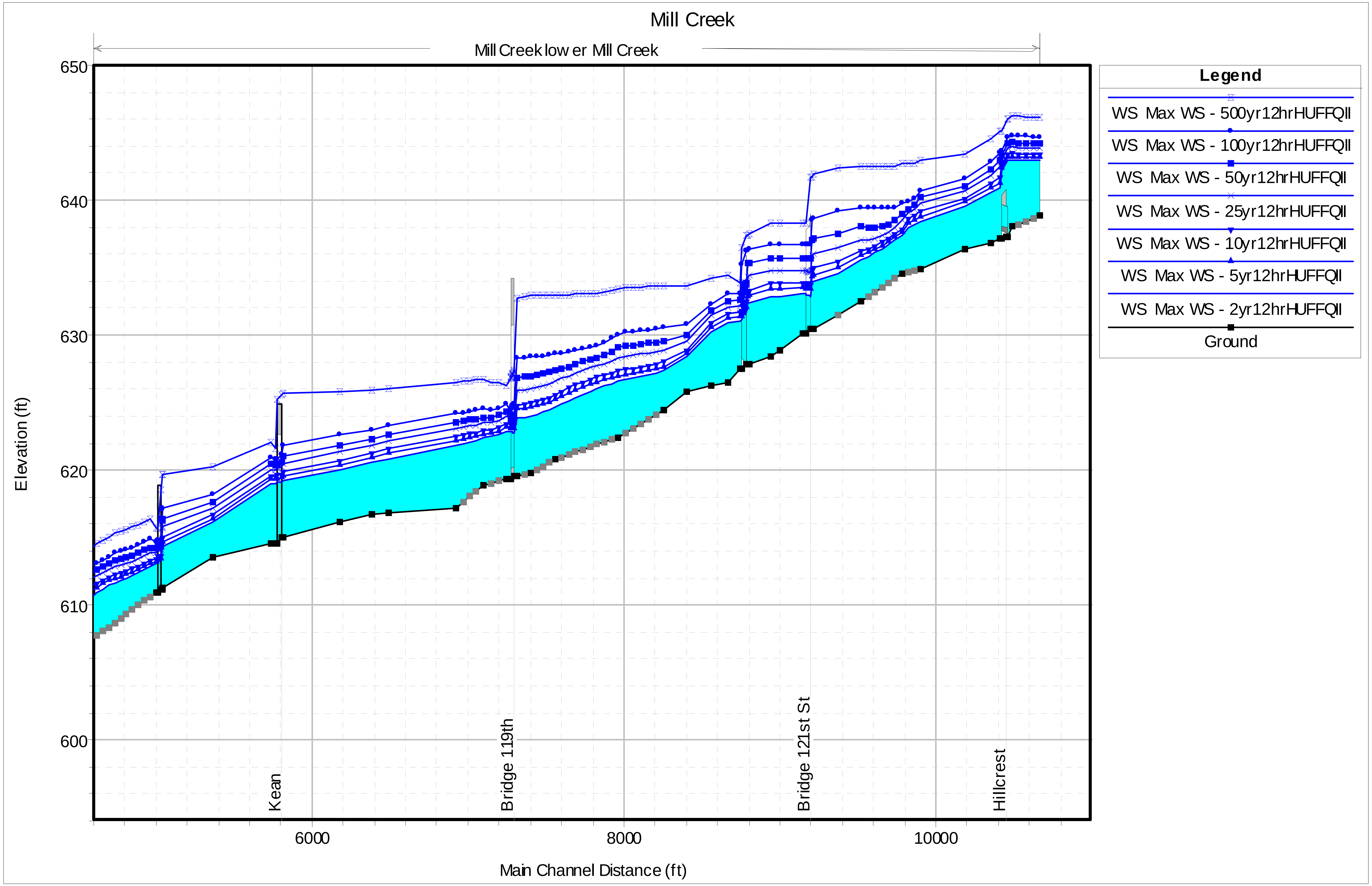
Mill Creek from BNSF Railroad to confluence with West Branch Mill Creek.



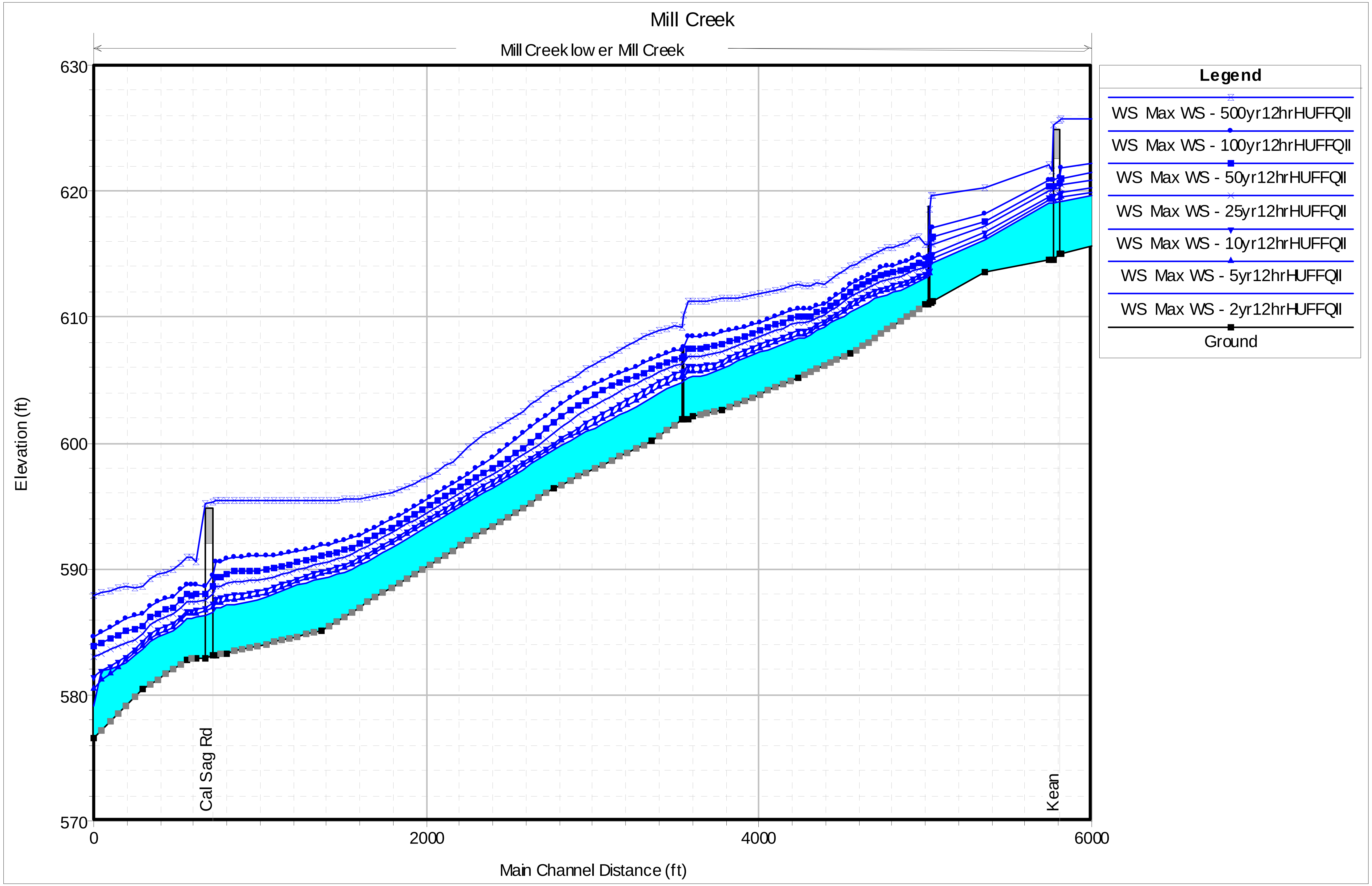
Mill Creek West Branch from Creek Rd. to 96th St.



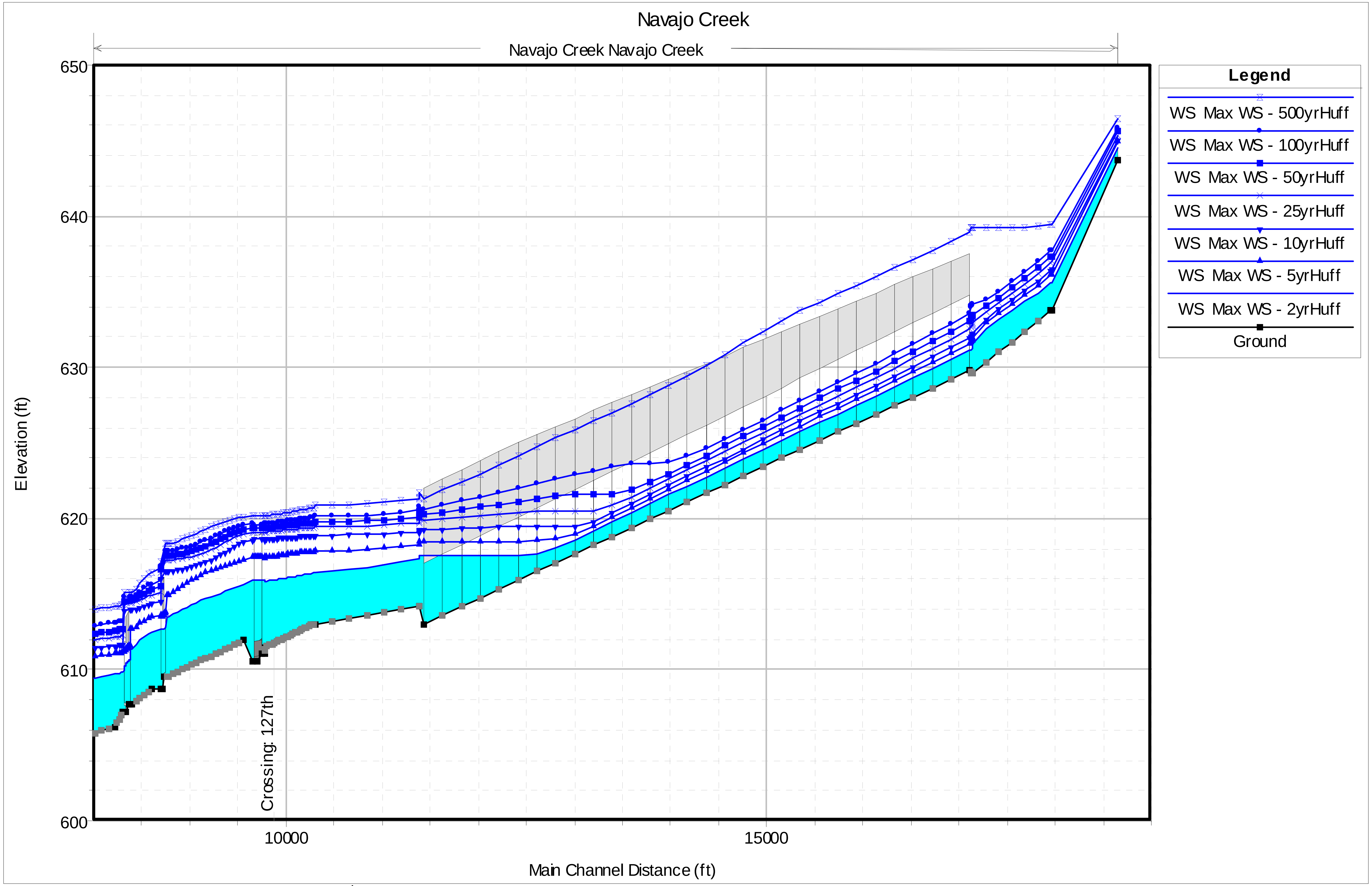
Mill Creek West Branch from 96th St to confluence with East Branch of Mill Creek



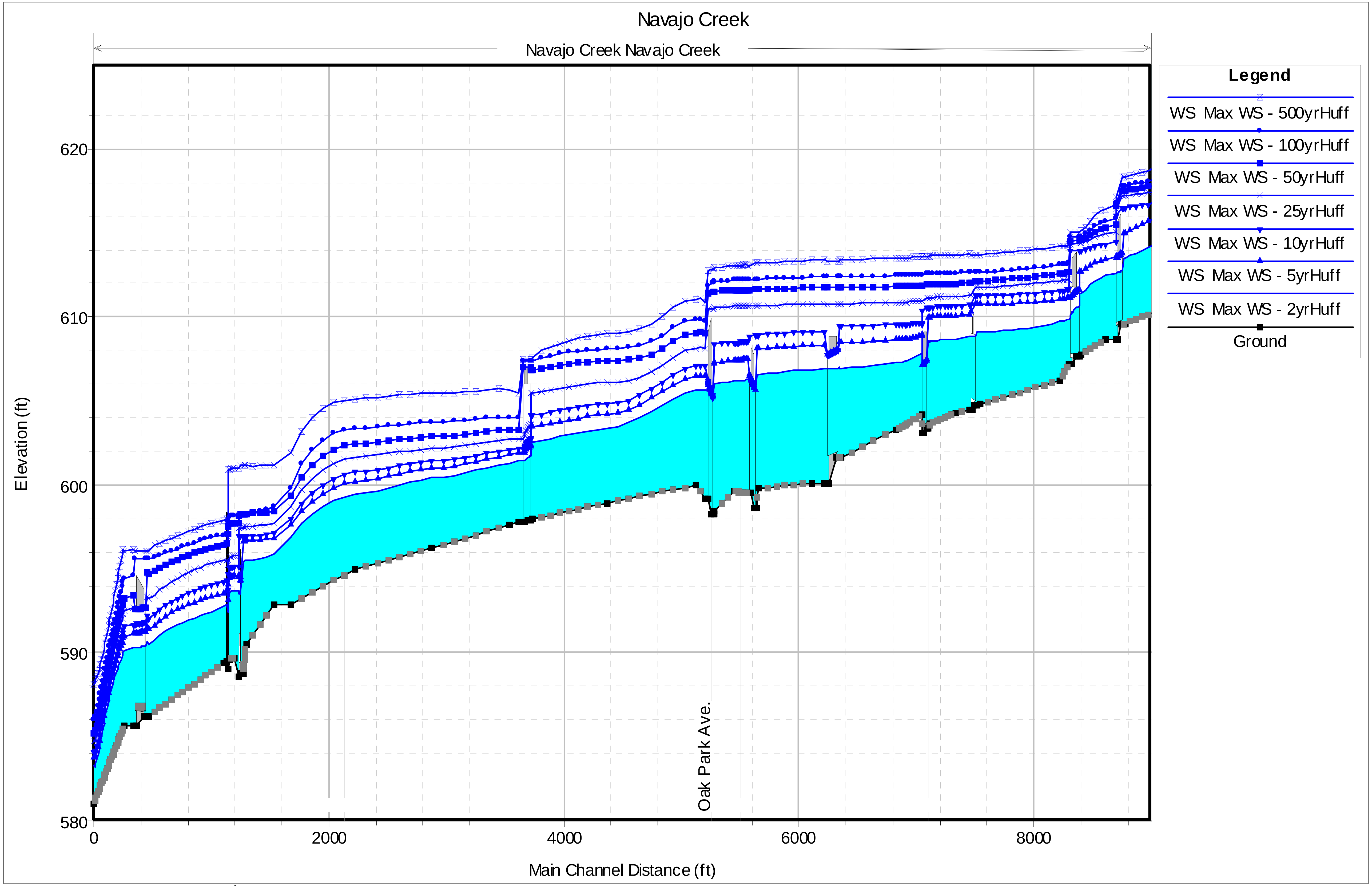
Mill Creek from confluence of Mill Creek West Branch to 11800 South.



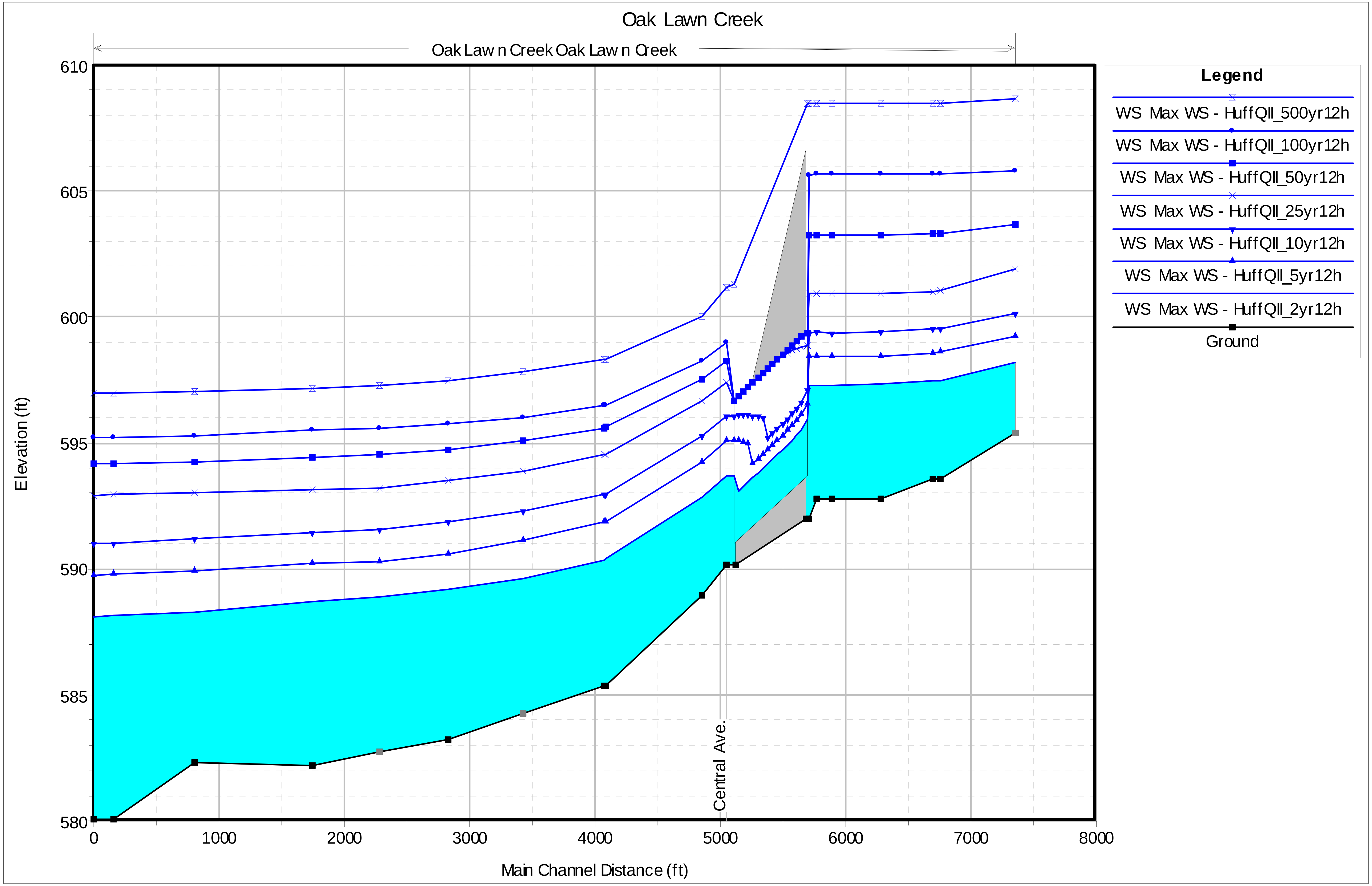
Mill Creek from 11800 South to confluence with Calumet-Sag Channel.



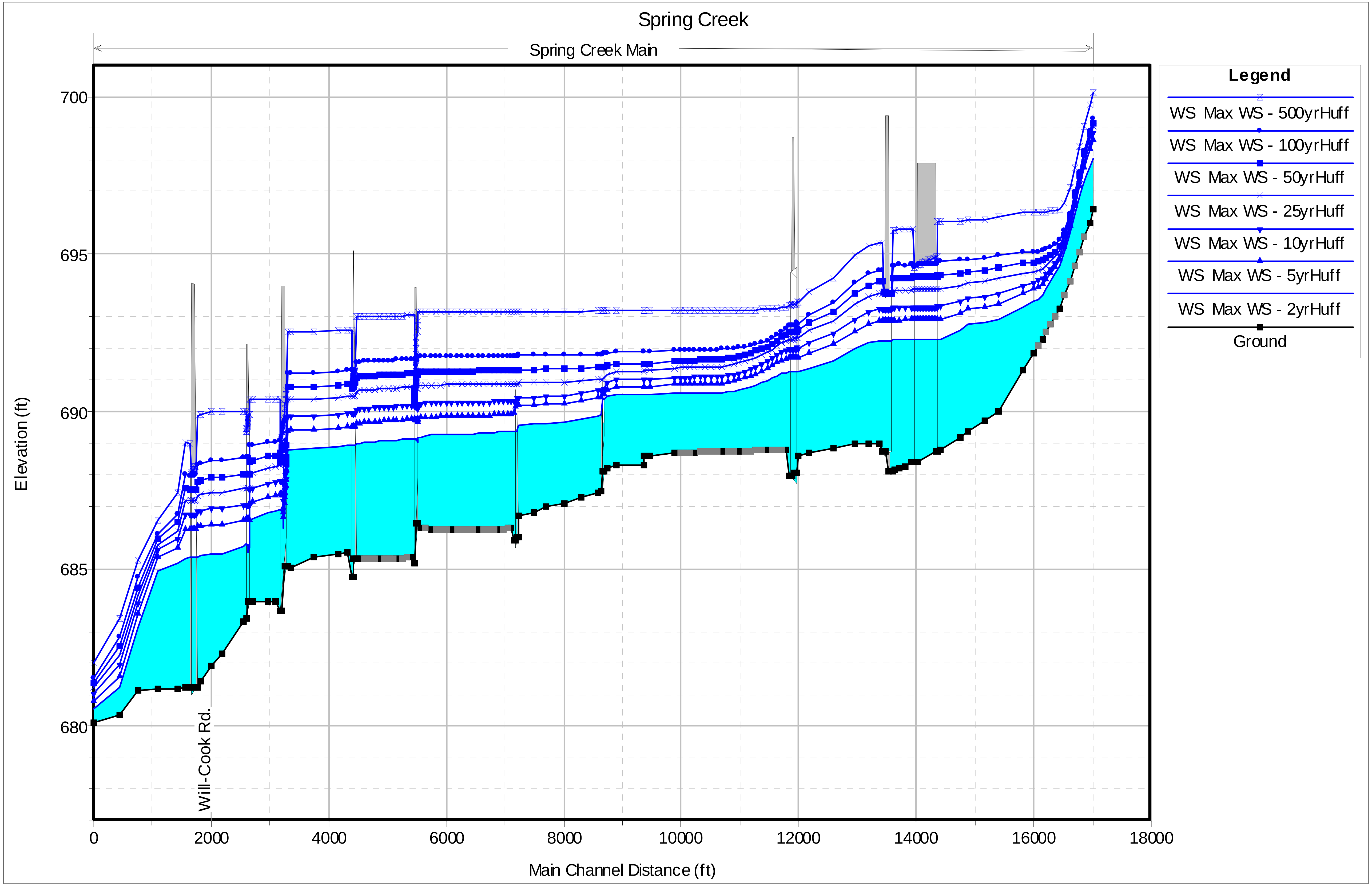
Navajo Creek from 131st St. to 69th Ct.



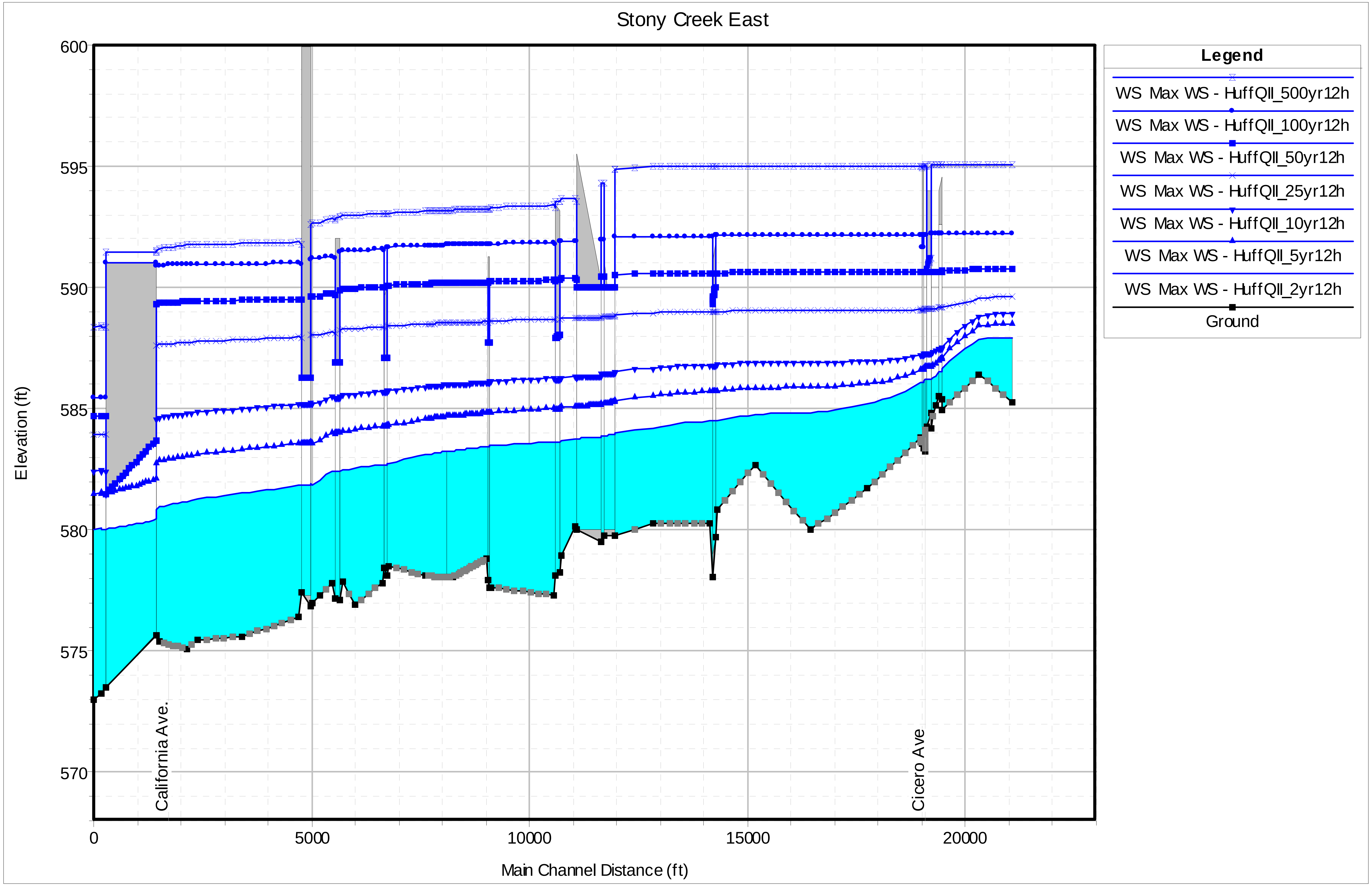
Navajo Creek from 69th Ct. to confluence with Calumet-Sag Channel.



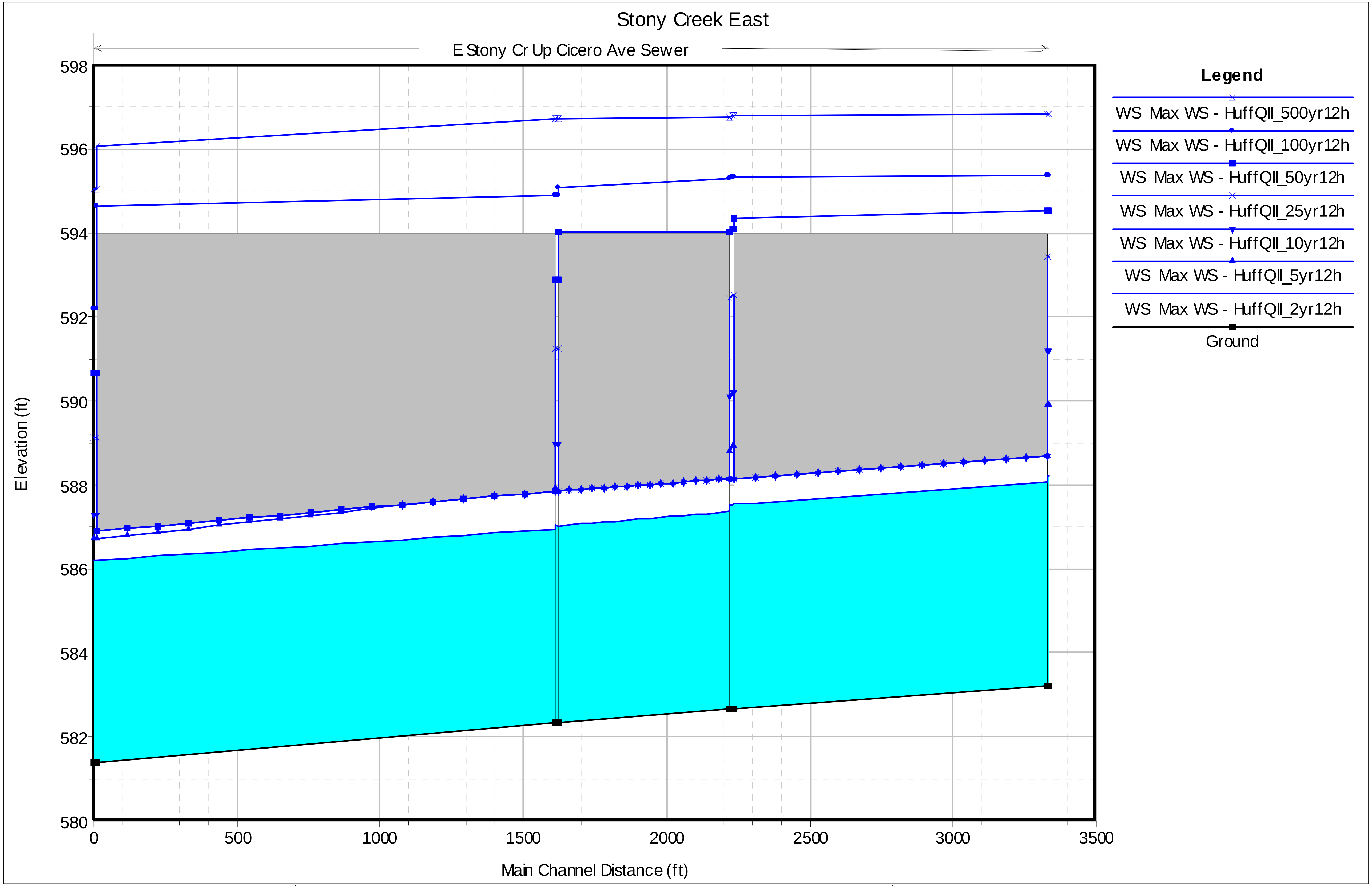
Oak Lawn Creek to confluence with Stony Creek West.



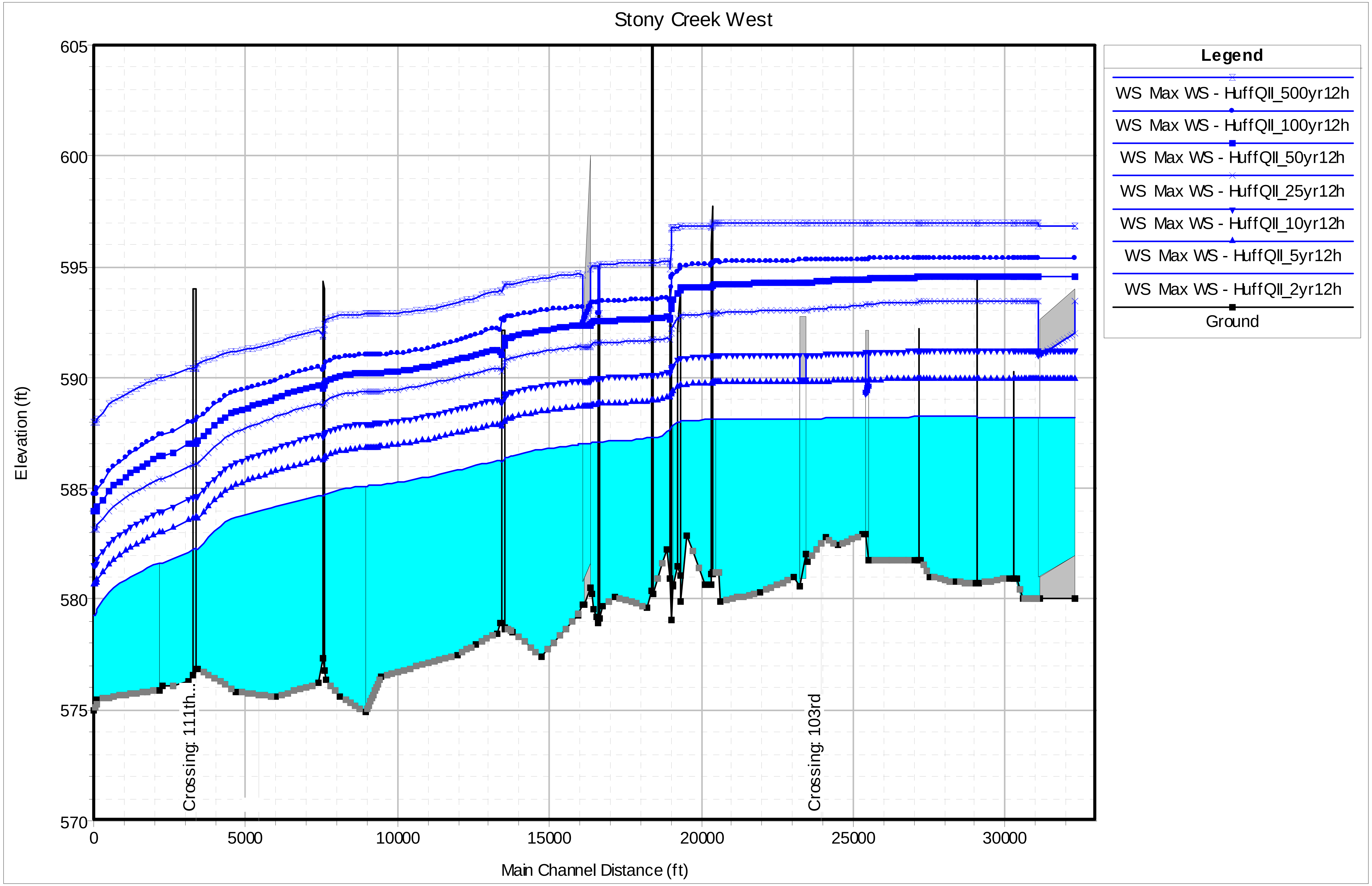
Spring Creek to Will-Cook County line.



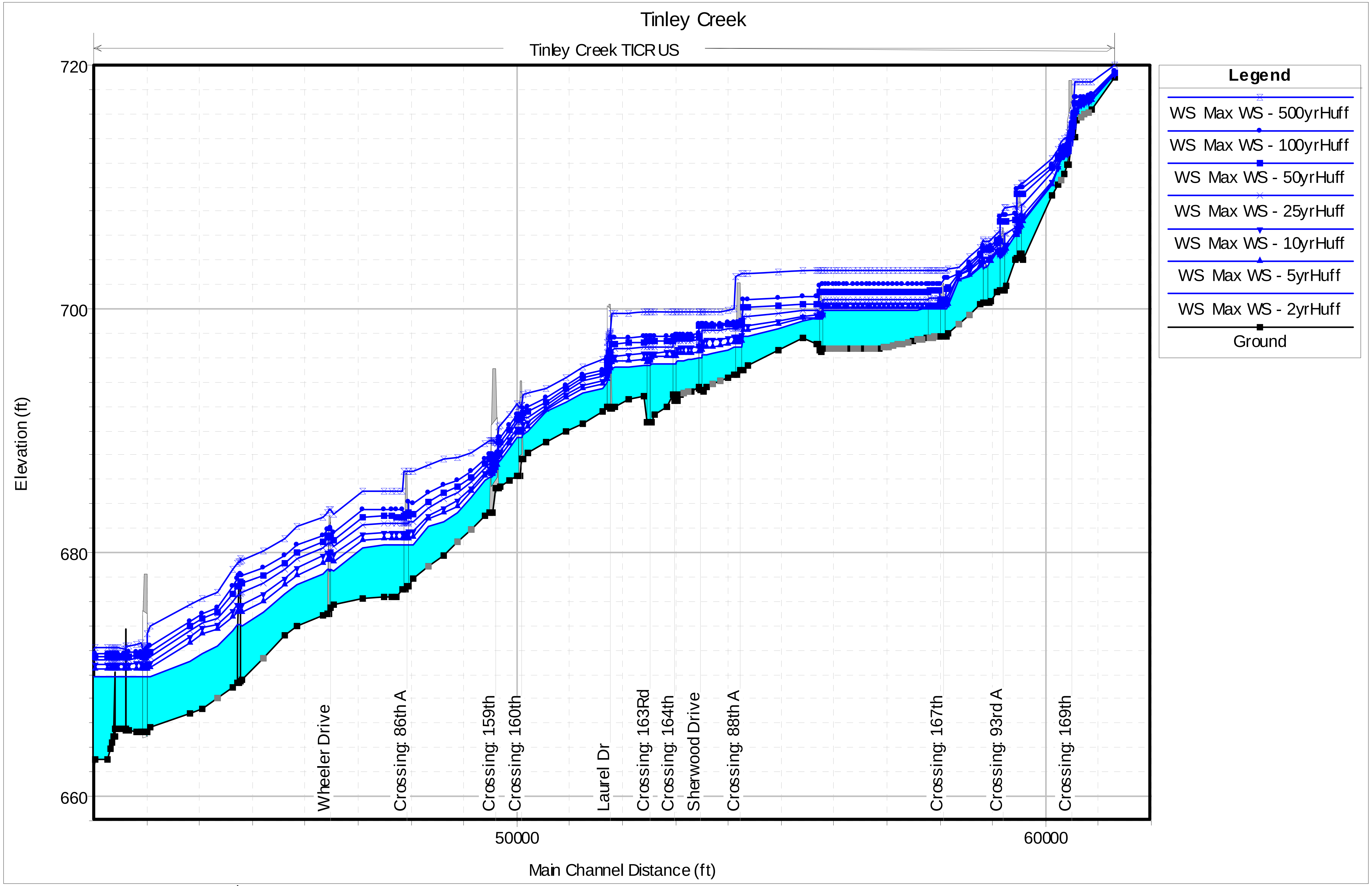
Stony Creek East to confluence with Calumet-Sag Channel.



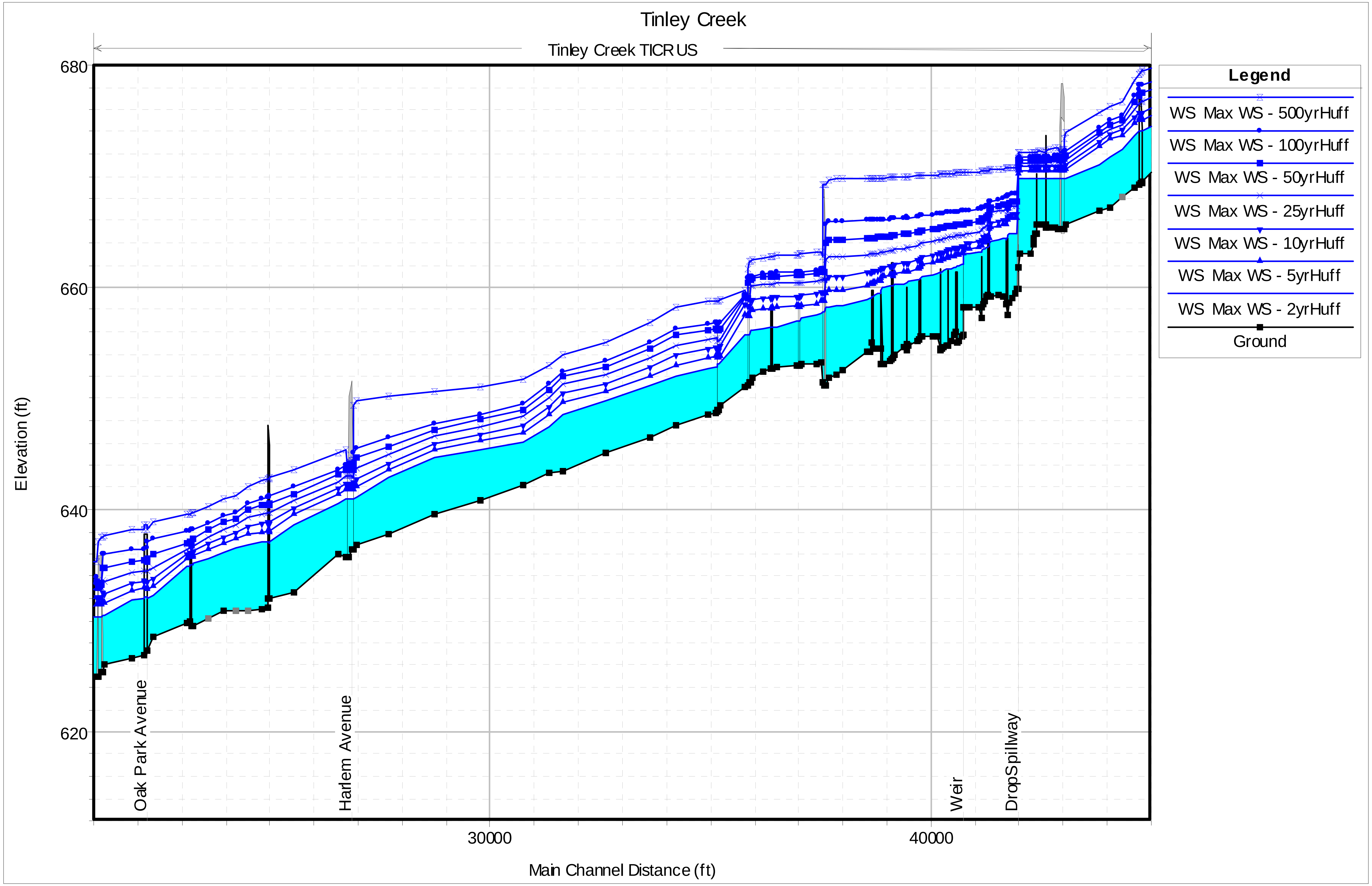
Cicero Ave. sewer from 110th St to confluence with Stony Creek East just south of 115th St.



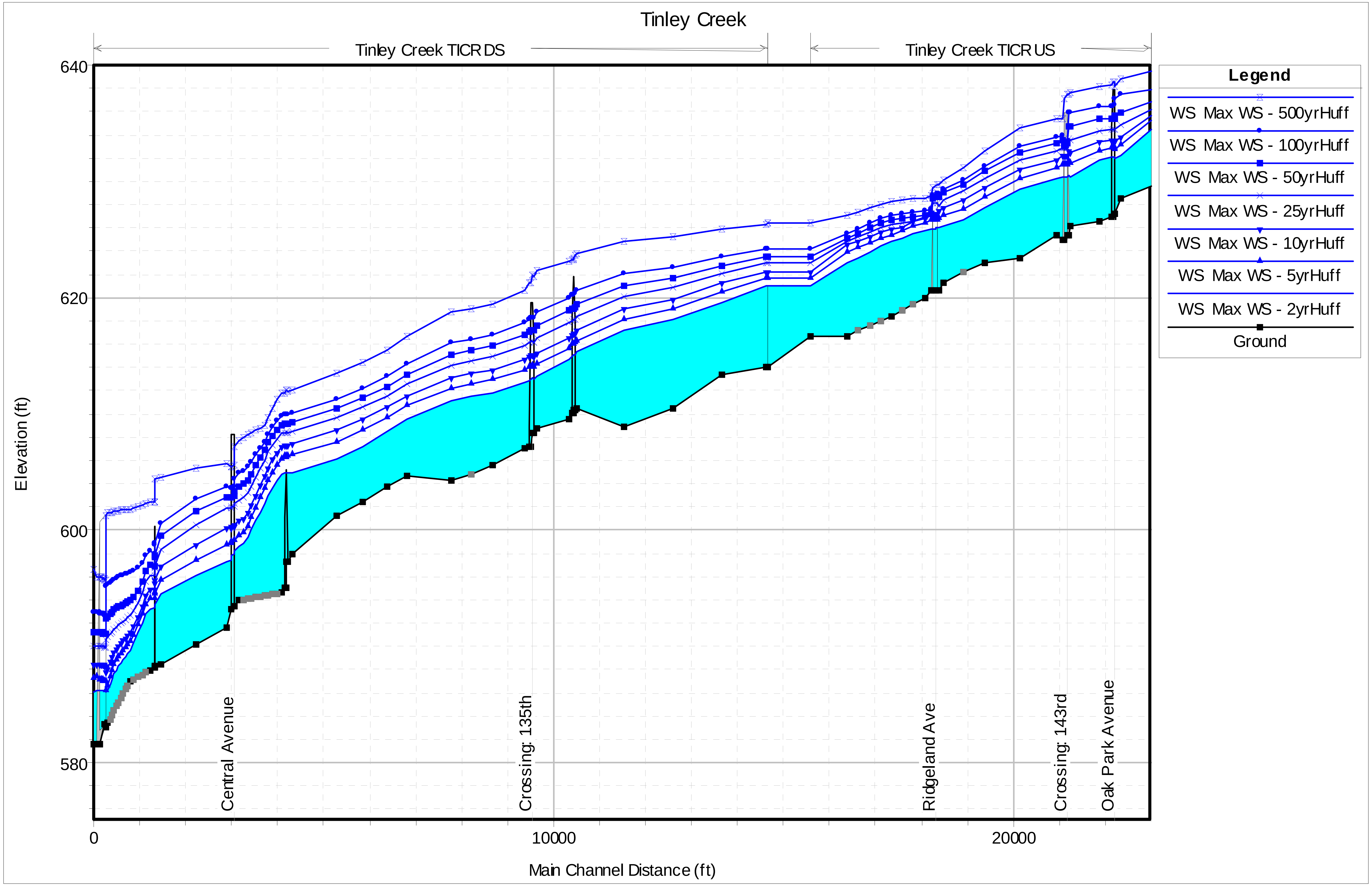
Stony Creek West to confluence with Calumet-Sag Channel.



Tinley Creek from 169th St to 151st St.



Tinley Creek from 151st St. to Oak Park Ave.



Tinley Creek from Oak Park Ave. to confluence with Calumet-Sag Channel.

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	CSTB-1
Problem Description	Overbank flooding along Cal Sag Tributary B
Strategy	Add detention basin downstream of Timber Ln.
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	8443	$11	$90,171	$0	$0	6 ft deep, side slope of 3:1, pond footprint 164 ft x 276 ft
Channel treatment: Material to be hauled offsite	yd3	7101	$12	$83,437	$0	$0	Volume of excavation minus that used for embankment
Embankment construction, grading and restoration: Compaction of fill	yd3	1342	$5	$7,166	$0	$0	build up berm on 3 sides 604 ft long, 3:1 slope, top width of 3ft , 4 ft high
Pipe in earth (city): 36 inches or less	lf	20	$217	$4,336	$4,032	$0	outlet/inlet pipe, 3ft diameter
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	US headwall
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	DS headwall
Channel treatment: Soil stabilization and vegetative cover	yd2	1703	$14	$23,643	$21,988	$5,661	Perimeter of 808 LF, width of 19 LF
Outlet structures: Concrete swale	yd2	100	$98	$9,825	$9,137	$0	weir, length of 50 LF, width of 6 LF
Land Acquisition: Purchase of Property *	dollar	237174	$1	$237,174	$0	$0	1.64 acres at $144,618/acre for detention basin

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$223,779**	**$39,994**	**$5,661**
Utility Relocation	4 %	$8,951		
Mobilization \ General Conditions	5%	$11,189		
Subtotal with Percent Allowances		**$243,919**		
Contingency	30%	$73,176		
Profit	5%	$15,855		
Probable Construction Cost Estimate		**$332,949**		
Design Engineering, Geotechnical, and Construction Management	10%	$33,295		
Property Acquisition Cost:		$237,174		
Total Conceptual Cost Estimate		**$649,073**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name CSTB-3

Problem Description

Strategy 2 new detention basins, increase sizes of 2 culverts, and expand one existing detention basin

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	8443	$11	$90,171	$0	$0	Pond downstream of Timber Lane; 6 LF deep, side slope of 3:1, pond footprint 164 LF x 276 LF
Channel treatment: Material to be hauled offsite	yd3	7101	$12	$83,437	$0	$0	Pond downstream of Timber Lane; volume of excavation minus that used for embankment
Embankment construction, grading and restoration: Compaction of fill	yd3	1342	$5	$7,166	$0	$0	Pond downstream of Timber Lane; berm on 3 sides 604 LF long, 3:1 slope, top width of 3 LF, 4 LF high
Pipe in earth (city): 36 inches or less	lf	30	$217	$6,503	$6,048	$0	Pond downstream of Timber Lane; outlet pipe, 2 ft diameter
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond downstream of Timber Lane; US headwall
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond downstream of Timber Lane; DS headwall
Channel treatment: Soil stabilization and vegetative cover	yd2	1703	$14	$23,643	$21,988	$5,661	Pond downstream of Timber Lane; perimeter of 810 LF x 19 LF wide area vegetated
Outlet structures: Concrete swale	yd2	100	$98	$9,825	$9,137	$0	Pond downstream of Timber Lane; weir for inlet from stream to pond, length of 50 LF, width of 6 LF
Pipe in earth (city): 36 inches or less	lf	20	$217	$4,336	$4,032	$0	Pond upstream of Timber Lane; Outlet pipe, 12 in diameter pipe
Channel treatment: Material to be hauled offsite	yd3	4451	$12	$52,299	$0	$0	Pond upstream of Timber Lane; excavation minus embankment
Embankment construction, grading and restoration: Compaction of fill	yd3	2477	$5	$13,228	$0	$0	Pond upstream of Timber Lane; 530.8 length berm, 7 LF high, 2 sides, 3 LF top width, 3:1 side slope
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond upstream of Timber Lane; Inlet Structure
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond upstream of Timber Lane; Outlet Structure
Channel treatment: Soil stabilization and vegetative cover	yd2	2268	$14	$31,482	$29,278	$7,539	Perimeter of 1100 LF x 19 LF wide area vegetated

Alternative Name	CSTB-3
Problem Description	
Strategy	2 new detention basins, increase sizes of 2 culverts, and expand one existing detention basin
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (county): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	78	$609	$47,479	$44,154	$0	Replace 119th Street culvert with 5 ft x 6 ft box culvert
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Replace 119th Street culvert with 5 ft x 6 ft box culvert
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Replace 119th Street culvert with 5 ft x 6 ft box culvert
Land Acquisition: Purchase of Property *	dollar	41108	$1	$41,108	$0	$0	0.64 acres required for detention, $61,458/acre
Buyout: Property *	dollar	322310	$1	$322,310	$0	$0	Buyout of residence for detention
Buyout: Property *	dollar	235782	$1	$235,782	$0	$0	Buyout of residence for detention
Buyout: Property *	dollar	235782	$1	$235,782	$0	$0	Buyout of residence for detention
Land Acquisition: Purchase of Property *	dollar	237174	$1	$237,174	$0	$0	1.64 acres required for detention, $144,618/acre
Pipe under pavement (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	35	$292	$10,204	$9,489	$0	Replace Timber Lane culvert with 3.5-ft diameter culvert
Channel treatment: Excavation	yd3	244	$11	$2,606	$0	$0	For existing detention basin expansion
Channel treatment: Material to be hauled offsite	yd3	244	$12	$2,867	$0	$0	For existing detention basin expansion
Channel treatment: Vegetative cover only	yd2	733	$9	$6,260	$5,822	$1,499	For existing detention basin expansion
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	For existing detention basin expansion
Channel treatment: Excavation	yd3	7873	$11	$84,084	$0	$0	Pond upstream of Timber Lane; 4.88 ac-ft of storage
Outlet structures: Concrete swale	yd2	100	$98	$9,825	$9,137	$0	Pond upstream of Timber Lane; weir for inlet from stream to pond, length of 50 LF, width of 6 LF
Pipe in earth (city): 36 inches or less	lf	20	$217	$4,336	$4,032	$0	Pond upstream of Timber Lane; inlet pipe, 1 ft x 2 ft box culvert
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Replace Timber Lane culvert with 3.5-ft diameter culvert
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Replace Timber Lane culvert with 3.5-ft diameter culvert

Alternative Name	CSTB-3
Problem Description	
Strategy	2 new detention basins, increase sizes of 2 culverts, and expand one existing detention basin
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)				**$528,696**	**$179,337**	**$14,699**	
Utility Relocation			4 %	$21,148			
Mobilization \ General Conditions			5%	$26,435			
Subtotal with Percent Allowances				**$576,279**			
Contingency			30%	$172,884			
Profit			5%	$37,458			
Probable Construction Cost Estimate				**$786,621**			
Design Engineering, Geotechnical, and Construction Management			10%	$78,662			
Property Acquisition Cost:				$1,072,156			
Total Conceptual Cost Estimate				**$2,131,475**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name CSTC-1

Problem Description Throughout the system downstream

Strategy Provide 37 ac-ft of detention upstream of Central Ave. Lower and widen channel into an online pond

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	55000	$11	$587,400	$0	$0	Excavation of pond with exception of existing channel, 7.5 acres, 5 ft deep
Channel treatment: Material to be hauled offsite	yd3	55000	$12	$646,250	$0	$0	Haul away excess material
Channel treatment: Biostabilization	yd2	850	$64	$54,460	$50,647	$13,040	low flow channel restoration, 750 ft long, 10 ft wide
Channel treatment: Soil stabilization and vegetative cover	yd2	33500	$14	$464,980	$432,424	$111,341	finished grading, topsoil and seeding, 7 acres
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	100	$425	$42,502	$39,526	$0	New outlet for Central Ave sewer
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	New outlet for Central Ave sewer
Land Acquisition: Permanent Easement *	dollar	745609	$1	$745,609	$0	$0	Permanent Easement for pond area, 7.5 acres at $198,829/acre

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,805,107**	**$531,446**	**$124,381**
Utility Relocation	4 %	$72,204		
Mobilization \ General Conditions	5%	$90,255		
Subtotal with Percent Allowances		**$1,967,566**		
Contingency	30%	$590,270		
Profit	5%	$127,892		
Probable Construction Cost Estimate		**$2,685,728**		
Design Engineering, Geotechnical, and Construction Management	10%	$268,573		
Property Acquisition Cost:		$745,609		
Total Conceptual Cost Estimate		**$4,355,736**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name IMCA-1

Problem Description

Strategy IMTT and KA Steel outlets

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (county): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	150	$661	$99,155	$92,212	$0	IMTT; 3 - 50 LF 5 ft x 10 ft box culverts
Outlet structures: Concrete swale	yd2	444	$98	$43,666	$40,609	$0	IMTT headwall structures - 2 @ 50 ft wide by 20 ft deep x 6 ft tall
Channel treatment: Excavation	yd3	8889	$11	$94,933	$0	$0	KA Steel - excavate an 8 ft deep, 30 ft wide, 1000 ft long channel
Channel treatment: Material to be hauled offsite	yd3	8889	$12	$104,444	$0	$0	KA Steel - assume all excavated material must be hauled offsite
Pipe under pavement (county): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	100	$661	$66,103	$61,475	$0	KA Steel; 2 - 50 LF 5 ft x 10 ft box culverts
Outlet structures: Concrete swale	yd2	296	$98	$29,111	$27,073	$0	KA Steel headwall structures - 2 @ 33 ft wide by 20 ft deep x 6 ft tall
Channel treatment: Vegetative cover only	yd2	4444	$9	$37,956	$35,298	$9,089	vegetated cover for surface of channel - 40 ft wide by 1,000 ft long

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$475,369**	**$256,667**	**$9,089**
Utility Relocation	4 %	$19,015		
Mobilization \ General Conditions	5%	$23,768		
Subtotal with Percent Allowances		**$518,152**		
Contingency	30%	$155,446		
Profit	5%	$33,680		
Probable Construction Cost Estimate		**$707,277**		
Design Engineering, Geotechnical, and Construction Management	10%	$70,728		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$1,043,761**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LDDT-1

Problem Description Flooding between Lucas Diversion Ditch and Robets Road

Strategy Increase detention potential of ComEd and some Park District land to the West of Lucas Diversion Ditch

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	27426	$11	$292,910	$0	$0	Pond LDDT_915- excavation of 17 acre ft of additional detention
Channel treatment: Material to be hauled offsite	yd3	27426	$12	$322,256	$0	$0	Pond LDDT_915- material to be hauled off site
Channel treatment: Vegetative cover only	yd2	17230	$9	$147,144	$136,842	$35,234	Vegetation of LDDT_915
Land Acquisition: Permanent Easement *	dollar	450340	$1	$450,340	$0	$0	Permanent easement on 3.56 acres of land valued at $253,000/acre
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_915
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Inlet Structure for pond LDDT_915

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$767,510**	**$141,678**	**$35,234**
Utility Relocation	4 %	$30,700		
Mobilization \ General Conditions	5%	$38,376		
Subtotal with Percent Allowances		**$836,586**		
Contingency	30%	$250,976		
Profit	5%	$54,378		
Probable Construction Cost Estimate		**$1,141,940**		
Design Engineering, Geotechnical, and Construction Management	10%	$114,194		
Property Acquisition Cost:		$450,340		
Total Conceptual Cost Estimate		**$1,883,386**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LDDT-2

Problem Description Overbank flooding between Lucas Diversion Ditch and Roberts Road

Strategy Detention Facilities to shave flow peak from Lucas Diversion Ditch

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	27426	$11	$292,910	$0	$0	Pond LDDT_915- excavation of 17 acre ft of additional detention
Channel treatment: Material to be hauled offsite	yd3	27426	$12	$322,256	$0	$0	Pond LDDT_915- material to be hauled off site
Channel treatment: Vegetative cover only	yd2	17230	$9	$147,144	$136,842	$35,234	Vegetation of LDDT_915
Land Acquisition: Permanent Easement *	dollar	450340	$1	$450,340	$0	$0	Permanent easement on 3.56 acres of land valued at $253,000 / acre
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_915
Channel treatment: Excavation	yd3	16133	$11	$172,300	$0	$0	Pond LDDT_917- 10 acre ft
Channel treatment: Material to be hauled offsite	yd3	16133	$12	$189,563	$0	$0	Pond LDDT_917, 10 acre ft hauled away
Channel treatment: Vegetative cover only	yd2	11301	$9	$96,511	$89,753	$23,110	Pond LDDT_917: topsoil & seeding
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_917
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_917
Pipe in earth (city): 36 inches or less	lf	90	$217	$19,510	$18,144	$0	Pond LDDT_917
Outlet structures: Concrete swale	yd2	10	$98	$983	$914	$0	Pond LDDT_917: overflow weir
Land Acquisition: Permanent Easement *	dollar	207000	$1	$207,000	$0	$0	Land acquisition of 2.3 acres valued at $180,000/acre
Channel treatment: Excavation	yd3	58080	$11	$620,294	$0	$0	Pond LDDT_71- Excavation of 36 acre ft detention location
Channel treatment: Material to be hauled offsite	yd3	58080	$12	$682,440	$0	$0	Pond LDDT_71, 36 acre ft hauled away
Channel treatment: Vegetative cover only	yd2	30008	$9	$256,268	$238,326	$61,364	Pond LDDT_71: topsoil & seeding of 6.2 acres
Inlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: pipes from pond, enough for two openings
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: discharge pipes, enough for two openings
Pipe in earth (city): 36 inches or less	lf	180	$217	$39,020	$36,288	$0	Pond LDDT_71: twin 90ft long pipes
Land Acquisition: Permanent Easement *	dollar	334800	$1	$334,800	$0	$0	Acquisition of 6.2 acres valued at $108,000 per acre

Alternative Name	LDDT-2
Problem Description	Overbank flooding between Lucas Diversion Ditch and Roberts Road
Strategy	Detention Facilities to shave flow peak from Lucas Diversion Ditch
District Minimum Criteria for Funding:	Met
Recommended	No

	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)				**$2,857,401**	**$537,195**	**$119,708**	
Utility Relocation			4 %	$114,296			
Mobilization \ General Conditions			5%	$142,870			
Subtotal with Percent Allowances				**$3,114,567**			
Contingency			30%	$934,370			
Profit			5%	$202,447			
Probable Construction Cost Estimate				**$4,251,385**			
Design Engineering, Geotechnical, and Construction Management			10%	$425,138			
Property Acquisition Cost:				$992,140			
Total Conceptual Cost Estimate				**$6,325,566**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LDDT-3

Problem Description Overbank flooding between Lucas Diversion Ditch and Roberts Road

Strategy Detention Facilities to shave flow peak from Lucas Diversion Ditch and conveyance improvement

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_915
Channel treatment: Excavation	yd3	27426	$11	$292,910	$0	$0	Pond LDDT_915- excavation of 17 acre ft of additional detention
Channel treatment: Material to be hauled offsite	yd3	27426	$12	$322,256	$0	$0	Pond LDDT_915- material to be hauled off site
Channel treatment: Vegetative cover only	yd2	17230	$9	$147,144	$136,842	$35,234	Vegetation of LDDT_915
Land Acquisition: Permanent Easement *	dollar	450340	$1	$450,340	$0	$0	Permanent easement on 3.56 acres of land valued at $253,000 / acre
Channel treatment: Excavation	yd3	16133	$11	$172,300	$0	$0	Pond LDDT_917- 10 acre ft
Channel treatment: Material to be hauled offsite	yd3	16133	$12	$189,563	$0	$0	Pond LDDT_917, 10 acre ft hauled away
Channel treatment: Vegetative cover only	yd2	11301	$9	$96,511	$89,753	$23,110	Pond LDDT_917: topsoil & seeding
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_917
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_917
Pipe in earth (city): 36 inches or less	lf	90	$217	$19,510	$18,144	$0	Pond LDDT_917
Outlet structures: Concrete swale	yd2	10	$98	$983	$914	$0	Pond LDDT_917: overflow weir
Land Acquisition: Permanent Easement *	dollar	207000	$1	$207,000	$0	$0	Land acquisition of 2.3 acres valued at $180,000/acre
Channel treatment: Excavation	yd3	58080	$11	$620,294	$0	$0	Pond LDDT_71- Excavation of 36 acre ft detention location
Channel treatment: Material to be hauled offsite	yd3	58080	$12	$682,440	$0	$0	Pond LDDT_71, 36 acre ft hauled away
Channel treatment: Vegetative cover only	yd2	30008	$9	$256,268	$238,326	$61,364	Pond LDDT_71: topsoil & seeding of 6.2 acres
Inlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: pipes from pond, enough for two openings
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: discharge pipes, enough for two openings
Pipe in earth (city): 36 inches or less	lf	180	$217	$39,020	$36,288	$0	Pond LDDT_71: twin 90ft long pipes
Land Acquisition: Permanent Easement *	dollar	334800	$1	$334,800	$0	$0	Acquisition of 6.2 acres valued at $108,000 per acre

Alternative Name	LDDT-3
Problem Description	Overbank flooding between Lucas Diversion Ditch and Roberts Road
Strategy	Detention Facilities to shave flow peak from Lucas Diversion Ditch and conveyance improvement
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
maintenance: Large Channel Maintenance	lf	1400	$100	$140,000	$130,198	$33,523	2800 ft of "medium channel maintenance"- thus reduced the quantity by half
Channel treatment: Material to be hauled offsite	yd3	2074	$12	$24,370	$0	$0	Assume removal of debris and sediment for 2800 ft x 1 ft in depth x 20 ft width
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Inlet Structure for LDDT_915

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$3,024,371**	**$669,811**	**$153,231**
Utility Relocation	4 %	$120,975		
Mobilization \ General Conditions	5%	$151,219		
Subtotal with Percent Allowances		**$3,296,565**		
Contingency	30%	$988,969		
Profit	5%	$214,277		
Probable Construction Cost Estimate		**$4,499,811**		
Design Engineering, Geotechnical, and Construction Management	10%	$449,981		
Property Acquisition Cost:		$992,140		
Total Conceptual Cost Estimate		**$6,764,974**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LDDT-4

Problem Description throughout LDDT & LUDT

Strategy Detention facilities gather overflow from LDDT to shave off peak flows and reduce flooding in both creeks.

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Material to be hauled offsite	yd3	58080	$12	$682,440	$0	$0	Pond LDDT_71, 36 acre ft hauled away
Channel treatment: Vegetative cover only	yd2	30008	$9	$256,268	$238,326	$61,364	Pond LDDT_71: topsoil & seeding of 6.2 acres
Inlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: pipes from pond, enough for two openings
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: discharge pipes, enough for two openings
Pipe in earth (city): 36 inches or less	lf	180	$217	$39,020	$36,288	$0	Pond LDDT_71: twin 90ft long pipes
Land Acquisition: Permanent Easement *	dollar	334800	$1	$334,800	$0	$0	acquisition of 6.2 acres at 108,000 per acre
Channel treatment: Excavation	yd3	41400	$11	$442,152	$0	$0	Pond LDDT_916 Excavation of material
Channel treatment: Material to be hauled offsite	yd3	40660	$12	$477,755	$0	$0	Pond LDDT_916: Haul away equals excavation minus berm material
Embankment construction, grading and restoration: Additional fill	yd3	740	$14	$10,271	$0	$0	Pond LDDT_916 berm placement: 1,200 ft long, top width 5 ft, 4:1 side slopes, 1.5 vertical feet above existing bank elevation.
Embankment construction, grading and restoration: Compaction of fill	yd3	740	$5	$3,952	$0	$0	Pond LDDT_916 berm compaction
Channel treatment: Vegetative cover only	yd2	30108	$9	$257,122	$239,120	$61,569	Pond LDDT_916: topsoil & seeding
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_916
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	LDDT_916
Pipe in earth (city): 36 inches or less	lf	95	$217	$20,594	$19,152	$0	Piping into LDDT_916
Outlet structures: Concrete swale	yd2	10	$98	$983	$914	$0	Pond LDDT_916: overflow weir
Land Acquisition: Permanent Easement *	dollar	690000	$1	$690,000	$0	$0	Pond LDDT_916, 9.2 acres for parcel including potential pond, valued at $150,000 per acre
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_915 Outlet Structure
Channel treatment: Excavation	yd3	27426	$11	$292,910	$0	$0	Pond LDDT_915- excavation of 17 acre ft of additional detention

Alternative Name LDDT-4

Problem Description throughout LDDT & LUDT

Strategy Detention facilities gather overflow from LDDT to shave off peak flows and reduce flooding in both creeks.

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Material to be hauled offsite	yd3	27426	$12	$322,256	$0	$0	Pond LDDT_915- material to be hauled off site
Land Acquisition: Permanent Easement *	dollar	450340	$1	$450,340	$0	$0	Permanent easement on 3.56 acres of land valued at $253,000 / acre
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_915
Channel treatment: Vegetative cover only	yd2	17230	$9	$147,144	$136,842	$35,234	Vegetation of LDDT_915
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_917
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Pond LDDT_917
Pipe in earth (city): 36 inches or less	lf	90	$217	$19,510	$18,144	$0	Pond LDDT_917
Outlet structures: Concrete swale	yd2	10	$98	$983	$914	$0	Pond LDDT_917: overflow weir
Land Acquisition: Permanent Easement *	dollar	207000	$1	$207,000	$0	$0	Land acquisition of 2.3 acres valued at $180,000 / acre
Channel treatment: Excavation	yd3	58080	$11	$620,294	$0	$0	Pond LDDT_917, 10 acre-ft
Channel treatment: Material to be hauled offsite	yd3	58080	$12	$682,440	$0	$0	Pond LDDT_917, 10 acre-ft hauled away
Pump Station: 10ac-ft per day interior drainage	each	1	$800,000	$800,000	$743,988	$0	Proposed pump station to evacuate LDDT_916

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$5,102,097**	**$1,457,870**	**$158,167**
Utility Relocation	4 %	$204,084		
Mobilization \ General Conditions	5%	$255,105		
Subtotal with Percent Allowances		**$5,561,286**		
Contingency	30%	$1,668,386		
Profit	5%	$361,484		
Probable Construction Cost Estimate		**$7,591,156**		
Design Engineering, Geotechnical, and Construction Management	10%	$759,116		
Property Acquisition Cost:		$1,682,140		
Total Conceptual Cost Estimate		**$11,648,448**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	LDDT-5
Problem Description	Overbank flooding between Lucas Diversion Ditch and Roberts Road
Strategy	Detention Facilities reduce peak flows in Lucas Diversion Dtich and channel clearing downstream.
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Land Acquisition: Permanent Easement *	dollar	207000	$1	$207,000	$0	$0	Land acquisition of 2.3 acres valued at $180,000/acre
Channel treatment: Excavation	yd3	58080	$11	$620,294	$0	$0	Pond LDDT_71- Excavation of 36 acre ft detention location
Channel treatment: Material to be hauled offsite	yd3	58080	$12	$682,440	$0	$0	Pond LDDT_71, 36 acre ft hauled away
Channel treatment: Vegetative cover only	yd2	30008	$9	$256,268	$238,326	$61,364	Pond LDDT_71: topsoil & seeding of 6.2 acres
Inlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: pipes from pond, enough for two openings
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Pond LDDT_71: discharge pipes, enough for two openings
Pipe in earth (city): 36 inches or less	lf	180	$217	$39,020	$36,288	$0	Pond LDDT_71: twin 90ft long pipes
Land Acquisition: Permanent Easement *	dollar	334800	$1	$334,800	$0	$0	Acquisition of 6.2 acres valued at $108,000 per acre
maintenance: Large Channel Maintenance	lf	1400	$100	$140,000	$130,198	$33,523	2800 ft of "medium channel maintenance"- thus reduced the quantity by half
Channel treatment: Material to be hauled offsite	yd3	2074	$12	$24,370	$0	$0	Assume removal of debris and sediment for 2800 ft x 1 ft in depth x 20 ft width
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Inlet Structure for LDDT_915

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,775,394**	**$416,903**	**$94,887**
Utility Relocation	4 %	$71,016		
Mobilization \ General Conditions	5%	$88,770		
Subtotal with Percent Allowances		**$1,935,180**		
Contingency	30%	$580,554		
Profit	5%	$125,787		
Probable Construction Cost Estimate		**$2,641,520**		
Design Engineering, Geotechnical, and Construction Management	10%	$264,152		
Property Acquisition Cost:		$541,800		
Total Conceptual Cost Estimate		**$3,959,263**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LRCR-1

Problem Description Long Run Creek overbank flooding just near Will-Cook road

Strategy Construct levee along Long Run Creek near 139th and Will Cook - Raise bank elevation to keep flow in

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Embankment construction, grading and restoration: Material hauled from offsite	yd3	1000	$11	$10,680	$0	$0	Levee construction assuming 4ft height, 3ft top width, and 3:1 side slope. Length (450ft) approximated with GIS.
Embankment construction, grading and restoration: Compaction of fill	yd3	1000	$5	$5,340	$0	$0	Place fill for levee
Embankment construction, grading and restoration: Compaction of fill	yd3	1000	$5	$5,340	$0	$0	Compact levee material
Channel treatment: Vegetative cover only	yd2	1415	$9	$12,084	$11,238	$2,894	Seed levee surface
Land Acquisition: Purchase of Property *	dollar	26031	$1	$26,031	$0	$0	0.09 acres required at $289,236/acre
Channel treatment: Excavation	yd3	4455	$11	$47,579	$0	$0	Volume calculated using GIS length approximation, 3:1 slopes (H:V) and depth of 7ft (using 685ft as bottom elevation).
Channel treatment: Material to be hauled offsite	yd3	4455	$12	$52,346	$0	$0	
Channel treatment: Soil stabilization and vegetative cover	yd2	1905	$14	$26,441	$24,590	$6,331	
Land Acquisition: Permanent Easement *	dollar	115694	$1	$115,694	$0	$0	Aquire land north of Long Run Creek. 0.4 acres required at $289,236/acre

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$159,811**	**$35,828**	**$9,225**
Utility Relocation	4 %	$6,392		
Mobilization \ General Conditions	5%	$7,991		
Subtotal with Percent Allowances		**$174,194**		
Contingency	30%	$52,258		
Profit	5%	$11,323		
Probable Construction Cost Estimate		**$237,775**		
Design Engineering, Geotechnical, and Construction Management	10%	$23,778		
Property Acquisition Cost:		$141,725		
Total Conceptual Cost Estimate		**$448,331**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name	LRCR-5
Problem Description	143rd road flooded
Strategy	raise road to preventflooding and include culvert and weir to keep hydraulics of stream the same.
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Demolition: Brick, concrete, or stone construction	ft2	1070	$4	$4,569	$0	$0	1010 of roadway length at 1 deep and culvert area (60)
Embankment construction, grading and restoration: Additional fill	yd3	5413	$14	$75,132	$0	$0	1010 of roadway length, 24 wide and 4 of additional depth plus an additional amount of fill for a 3V:1H side slope along both sides and additional amount for culvert. culvert = 2x 15x24
Embankment construction, grading and restoration: Compaction of fill	yd3	5413	$5	$28,905	$0	$0	1010 of roadway length, 24 wide and 4 of additional depth plus an additional amount of fill for a 3V:1H side slope along both sides and additional amount for culvert. culvert = 2x 15x24
Embankment construction, grading and restoration: Material hauled from offsite	yd3	5413	$11	$57,811	$0	$0	1010 of roadway length, 24 wide and 4 of additional depth plus an additional amount of fill for a 3V:1H side slope along both sides and additional amount for culvert. culvert = 2x 15x24
Paving: Asphalt Pavement Installation (24 ft wide, 2 ft C&G, 1 ft Excavation	lf	1010	$148	$149,955	$139,456	$0	2 lane rd. 1010 long
Pipe under pavement (county): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	98	$609	$59,653	$55,476	$0	Two 49 LF 7.5 by 5 culverts side by side.
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	DS headwall for box culvert
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	US headwall for box culvert
Concrete: Cast in place	yd3	9	$250	$2,125	$0	$0	weir 2 deep, 25 wide, 4.72 tall with 2 2 diameter orifices

Alternative Name LRCR-5

Problem Description 143rd road flooded

Strategy raise road to preventflooding and include culvert and weir to keep hydraulics of stream the same.

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)				**$397,180**	**$212,629**	**$0**	
Utility Relocation			4 %	$15,887			
Mobilization \ General Conditions			5%	$19,859			
Subtotal with Percent Allowances				**$432,926**			
Contingency			30%	$129,878			
Profit			5%	$28,140			
Probable Construction Cost Estimate				**$590,944**			
Design Engineering, Geotechnical, and Construction Management			10%	$59,094			
Property Acquisition Cost:				$0			
Total Conceptual Cost Estimate				**$862,668**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LUDT-1

Problem Description Shallow flooding north of 103rd Street between Lucas Ditch and Lucas Diversion Ditch

Strategy Excavated storage on Hickory Hills Golf Course to reduce discharge to Roberts Road Storm Sewer / Lucas

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	283688	$11	$3,029,788	$0	$0	7 acre site excavated to bottom elevation of 614
Embankment construction, grading and restoration: Material hauled from offsite	yd3	283688	$11	$3,029,788	$0	$0	7 acre site excavated to bottom elevation of 614
Channel treatment: Vegetative cover only	yd2	33880	$9	$289,335	$269,077	$69,282	7 acre of vegetative cover
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	
Pipe in earth (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	120	$208	$24,989	$23,239	$0	Pipe connecting storage area to overland flow route to Roberts Road Sewer
Land Acquisition: Purchase of Property *	dollar	1771000	$1	$1,771,000	$0	$0	7 acres @ 253,000 dollars per acre
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Inlet structure for detention basin

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$6,381,701**	**$299,571**	**$69,282**
Utility Relocation	4 %	$255,268		
Mobilization \ General Conditions	5%	$319,085		
Subtotal with Percent Allowances		**$6,956,054**		
Contingency	30%	$2,086,816		
Profit	5%	$452,143		
Probable Construction Cost Estimate		**$9,495,013**		
Design Engineering, Geotechnical, and Construction Management	10%	$949,501		
Property Acquisition Cost:		$1,771,000		
Total Conceptual Cost Estimate		**$12,584,368**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	LUDT-2
Problem Description	Shallow flooding north of 103rd Street between Lucas Ditch and Lucas Diversion Ditch
Strategy	Impounded storage on Hickory Hills Golf Course to reduce discharge to Roberts Road Storm Sewer / Lucas
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	13000	$11	$138,840	$0	$0	Excavate berm material in proposed storage area to provide additional storage
Channel treatment: Compaction	yd3	13000	$7	$97,240	$0	$0	Compaction of berm
Channel treatment: Vegetative cover only	yd2	14520	$9	$124,001	$115,319	$29,692	Revegation of 3 acre excavated area
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Double pipe exiting reservoir
Pipe in earth (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	120	$208	$24,989	$23,239	$0	Pipe connecting flow to overland flow route to Roberts Road Sewer
Land Acquisition: Purchase of Property *	dollar	3289000	$1	$3,289,000	$0	$0	13 acres @ $253,000 dollars per acre
Channel treatment: Vegetative cover only	yd2	6000	$9	$51,240	$47,652	$12,270	600 ft long; 42 ft wide on the 1:3 side slopes and 6 ft wide on the top of the embankment
Concrete: Cast in place	yd3	33	$250	$8,333	$0	$0	Concrete spillway: 50 ft in length by 6 ft in width by 3 ft in depth
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	Inlet structure outlet pipe from storage area

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$459,358**	**$199,896**	**$41,962**
Utility Relocation	4 %	$18,374		
Mobilization \ General Conditions	5%	$22,968		
Subtotal with Percent Allowances		**$500,700**		
Contingency	30%	$150,210		
Profit	5%	$32,546		
Probable Construction Cost Estimate		**$683,455**		
Design Engineering, Geotechnical, and Construction Management	10%	$68,346		
Property Acquisition Cost:		$3,289,000		
Total Conceptual Cost Estimate		**$4,282,659**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LUDT-3

Problem Description Lucas Ditch Overbank Flooding

Strategy Diversion conduit to increase conveyance to Stony Creek. Construct 28 ac-ft of storage to mitigate

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1240	$609	$754,849	$701,998	$0	96"Pipe along 83rd Ave
Pipe in earth (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1560	$435	$678,038	$630,565	$0	96" Pipe along Palos Drive
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	Outlet structure to Stony Creek; 96" item not available; markup via quantity
Channel treatment: Excavation	yd3	2647	$11	$28,270	$0	$0	Assume that elevations above 594 ft require excess excavation; calculate south of 107th street assuming 10 ft wide cut
Channel treatment: Compaction	yd3	2647	$7	$19,800	$0	$0	Assume that elevations above 594 ft are excavated and then compacted; calculate south of 107th street assuming 10 ft wide cut
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	Inlet for Diversion Conduit
Land Acquisition: Permanent Easement *	dollar	16500	$1	$16,500	$0	$0	1600 ft x 60 ft easement for pipe (2.2 acre). Adjacent undeveloped land value = $14,972 / acre
Land Acquisition: Permanent Easement *	dollar	600000	$1	$600,000	$0	$0	Permanent easement of 4 acres valued based upon nearby property value of $300,000 / acre
Channel treatment: Excavation	yd3	45173	$11	$482,448	$0	$0	Excavation of 28 ac ft of storage
Channel treatment: Material to be hauled offsite	yd3	45173	$12	$530,783	$0	$0	Haul excavated materials offsite
Channel treatment: Vegetative cover only	yd2	19360	$9	$165,334	$153,758	$39,590	Vegetative cover on 4 acre excavated area for detention
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Inlet structure for pipe connecting Stony Creek to detention Pond
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Outlet structure for pipe connecting Stony Creek to detention Pond
Pipe in earth (city): 36 inches or less	lf	315	$217	$68,286	$63,505	$0	36" pipe connecting flow from STCR to detention pond

Alternative Name	LUDT-3
Problem Description	Lucas Ditch Overbank Flooding
Strategy	Diversion conduit to increase conveyance to Stony Creek. Construct 28 ac-ft of storage to mitigate
District Minimum Criteria for Funding:	Met
Recommended	No

	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)				**$2,747,280**	**$1,567,936**	**$39,590**	
Utility Relocation			4 %	$109,891			
Mobilization \ General Conditions			5%	$137,364			
Subtotal with Percent Allowances				**$2,994,536**			
Contingency			30%	$898,361			
Profit			5%	$194,645			
Probable Construction Cost Estimate				**$4,087,541**			
Design Engineering, Geotechnical, and Construction Management			10%	$408,754			
Property Acquisition Cost:				$616,500			
Total Conceptual Cost Estimate				**$6,720,321**			

Additional Comments

Increased conveyance to STCR- requires implementation with STCR storage alt

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	LUDT-4
Problem Description	Shallow flooding north of 103rd street between Lucas Ditch and Lucas Diversion Ditch.
Strategy	Storage in the portion of Lucas Ditch watershed tributary to Roberts Road, combined with a 96" diversion
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	13000	$11	$138,840	$0	$0	Excavate fill for earthen berm to impound area west of 82nd Ave. Excavated material provides approximately 8 ac-ft of additional storage
Channel treatment: Compaction	yd3	13000	$7	$97,240	$0	$0	Compact soil to form earthen berm with top elevation of 637 ft. 6 ft wide at top with 3:1 side slopes
Channel treatment: Vegetative cover only	yd2	6000	$9	$51,240	$47,652	$12,270	600 ft long; 42 ft wide on the bottom, 1:3 side slopes and 6 ft wide on the top of the embankment
Channel treatment: Vegetative cover only	yd2	14520	$9	$124,001	$115,319	$29,692	vegetative stabilization of 3 acre excavation area
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Outlet structure from reservoir to overland flow route
Pipe in earth (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	120	$208	$24,989	$23,239	$0	Pipe connecting flow to overland flow route to Roberts Road Sewer
Land Acquisition: Purchase of Property *	dollar	3289000	$1	$3,289,000	$0	$0	13 acres $ 253,000 dollars per acre for property on Hickory Hills golf course
Concrete: Cast in place	yd3	33	$250	$8,333	$0	$0	Concrete spillway: 50 ft in length by 6 ft in width by 3 ft in depth
Pipe under pavement (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1240	$609	$754,788	$701,941	$0	96" Pipe along 83rd Ave
Pipe in earth (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1560	$435	$678,038	$630,565	$0	96" Pipe along Palos Drive
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	Outlet structure to Stony Creek; 96" item not available; markup via quantity
Channel treatment: Excavation	yd3	2647	$11	$28,270	$0	$0	Assume that elevations above 594 ft require excess excavation; calculate south of 107th street assuming 10 ft wide cut

Alternative Name	LUDT-4
Problem Description	Shallow flooding north of 103rd street between Lucas Ditch and Lucas Diversion Ditch.
Strategy	Storage in the portion of Lucas Ditch watershed tributary to Roberts Road, combined with a 96" diversion
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Compaction	yd3	2647	$7	$19,800	$0	$0	Assume that elevations above 594 ft are excavated and then compacted; calculate south of 107th street assuming 10 ft wide cut
Land Acquisition: Permanent Easement *	dollar	16500	$1	$16,500	$0	$0	1600 ft x 60 ft easement for pipe (2.2 acre). Adjacent undeveloped land value = $14,972 / acre
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	Inlet for diversion conduit
Inlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Inlet structure for outlet from detention area

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,950,212**	**$1,541,663**	**$41,962**
Utility Relocation	4 %	$78,008		
Mobilization \ General Conditions	5%	$97,511		
Subtotal with Percent Allowances		**$2,125,731**		
Contingency	30%	$637,719		
Profit	5%	$138,173		
Probable Construction Cost Estimate		**$2,901,623**		
Design Engineering, Geotechnical, and Construction Management	10%	$290,162		
Property Acquisition Cost:		$3,305,500		
Total Conceptual Cost Estimate		**$8,080,910**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name	LUDT-5
Problem Description	Flooding of properties near confluence of Lucas Ditch
Strategy	Build levee with 3' freeboard to restrict floodwaters from inundating structures near Stony Creek confluence
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: Additional fill	yd3	584	$14	$8,106	$0	$0	Embankment Construction along STCR/LUDT
Embankment construction, grading and restoration: Compaction of fill	yd3	584	$5	$3,119	$0	$0	Embankment Construction along east bank of LUDT near conflunece
Embankment construction, grading and restoration: Material hauled from offsite	yd3	584	$11	$6,237	$0	$0	Embankment Construction along east bank of LUDT near conflunece
Land Acquisition: Permanent Easement *	dollar	51652	$1	$51,652	$0	$0	Permanent Easement: 600 ft long by 50 ft wide estimated at $150,00 / acre
Channel treatment: Excavation	yd3	15327	$11	$163,692	$0	$0	Construction of 9.5 ac-ft detention pond to offset lost floodplain storage
Channel treatment: Material to be hauled offsite	yd3	15327	$12	$180,092	$0	$0	Construction of 9.5 ac-ft detention pond to offset lost floodplain storage
Channel treatment: Vegetative cover only	yd2	18392	$9	$157,068	$146,071	$37,610	Cover for approximately 3.8 acres of detention
Pump Station: 10ac-ft per day interior drainage	each	1	$800,000	$800,000	$743,988	$0	Pump Station- 2 20 hp pumps for interior drainage behind levee

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,318,314**	**$890,058**	**$37,610**
Utility Relocation	4 %	$52,733		
Mobilization \ General Conditions	5%	$65,916		
Subtotal with Percent Allowances		**$1,436,962**		
Contingency	30%	$431,089		
Profit	5%	$93,403		
Probable Construction Cost Estimate		**$1,961,453**		
Design Engineering, Geotechnical, and Construction Management	10%	$196,145		
Property Acquisition Cost:		$51,652		
Total Conceptual Cost Estimate		**$3,136,919**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LUDT-6

Problem Description Lucas Ditch Overbank Flooding

Strategy Diversion conduit to increase conveyance to Stony Creek combined with dredging upstream of 103rd Street

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1240	$609	$754,849	$701,998	$0	96"Pipe along 83rd Ave
Pipe in earth (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1560	$435	$678,038	$630,565	$0	96" Pipe along Palos Drive
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	Outlet structure to Stony Creek; 96" item not available; markup via quantity
Channel treatment: Excavation	yd3	2647	$11	$28,270	$0	$0	Assume that elevations above 594 ft require excess excavation; calculate south of 107th street assuming 10 ft wide cut
Channel treatment: Compaction	yd3	2647	$7	$19,800	$0	$0	Assume that elevations above 594 ft are excavated and then compacted; calculate south of 107th street assuming 10 ft wide cut
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	Inlet for Diversion Conduit
Land Acquisition: Permanent Easement *	dollar	16500	$1	$16,500	$0	$0	1600 ft x 60 ft easement for pipe (2.2 acre). Adjacent undeveloped land value = $14,972 / acre
Channel treatment: Excavation	yd3	2074	$11	$22,150	$0	$0	Dredging of creek- 2800 ft by 20 ft by 1 ft in depth
Channel treatment: Material to be hauled offsite	yd3	2074	$12	$24,370	$0	$0	Haul dredged material from site
maintenance: Small Channel Maintenance (Brush and debris removal)	lf	2800	$5	$14,000	$13,020	$3,352	removal of debris along dredged area
Channel treatment: Vegetative cover only	yd2	3111	$9	$26,568	$24,708	$6,362	revegetation along dredged area. 2800 ft by 10 ft
Land Acquisition: Permanent Easement *	dollar	600000	$1	$600,000	$0	$0	Permanent easement of 4 acres valued based upon nearby property value of $300,000 / acre
Channel treatment: Excavation	yd3	45173	$11	$482,448	$0	$0	Excavation of 28 ac ft of storage
Channel treatment: Material to be hauled offsite	yd3	45173	$12	$530,783	$0	$0	Haul excavated materials offsite
Channel treatment: Vegetative cover only	yd2	19360	$9	$165,334	$153,758	$39,590	Vegetative cover on 4 acre excavated area for detention

Alternative Name	LUDT-6
Problem Description	Lucas Ditch Overbank Flooding
Strategy	Diversion conduit to increase conveyance to Stony Creek combined with dredging upstream of 103rd Street
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Inlet structure for pipe connecting Stony Creek to detention Pond
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Outlet structure for pipe connecting Stony Creek to detention Pond
Pipe in earth (city): 36 inches or less	lf	315	$217	$68,286	$63,505	$0	36" pipe connecting flow from STCR to detention pond

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$2,834,368**	**$1,605,664**	**$49,304**
Utility Relocation	4 %	$113,375		
Mobilization \ General Conditions	5%	$141,718		
Subtotal with Percent Allowances		**$3,089,461**		
Contingency	30%	$926,838		
Profit	5%	$200,815		
Probable Construction Cost Estimate		**$4,217,115**		
Design Engineering, Geotechnical, and Construction Management	10%	$421,711		
Property Acquisition Cost:		$616,500		
Total Conceptual Cost Estimate		**$6,910,294**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name LUDT-7

Problem Description Shallow flooding north of 103rd Street between Lucas Ditch and Lucas Diversion Ditch

Strategy Impounded storage on Hickory Hills Golf Course to reduce discharge to Roberts Road Storm Sewer / Lucas

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	13000	$11	$138,840	$0	$0	Excavate berm material in proposed storage area to provide additional storage
Channel treatment: Compaction	yd3	13000	$7	$97,240	$0	$0	Compaction of berm
Channel treatment: Vegetative cover only	yd2	14520	$9	$124,001	$115,319	$29,692	Revegation of 3 acre excavated area
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Double pipe exiting reservoir
Pipe in earth (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	120	$208	$24,989	$23,239	$0	Pipe connecting flow to overland flow route to Roberts Road Sewer
Land Acquisition: Purchase of Property *	dollar	3289000	$1	$3,289,000	$0	$0	13 acres @ $253,000 dollars per acre
Channel treatment: Vegetative cover only	yd2	6000	$9	$51,240	$47,652	$12,270	600 ft long; 42 ft wide on the bottom, 1:3 side slopes and 6 ft wide on the top of the embankment
Concrete: Cast in place	yd3	33	$250	$8,333	$0	$0	Concrete spillway: 50 ft in length by 6 ft in width by 3 ft in depth
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	Inlet structure outlet pipe from storage area
Channel treatment: Excavation	yd3	2074	$11	$22,150	$0	$0	Dredging of creek- 2800 ft by 20 ft by 1 ft in depth
Channel treatment: Material to be hauled offsite	yd3	2074	$12	$24,370	$0	$0	Haul dredged material from site
maintenance: Small Channel Maintenance (Brush and debris removal)	lf	2800	$5	$14,000	$13,020	$3,352	removal of debris along dredged area
Channel treatment: Vegetative cover only	yd2	3111	$9	$26,568	$24,708	$6,362	revegetation along dredged area. 2800 ft by 10 ft

Alternative Name	LUDT-7
Problem Description	Shallow flooding north of 103rd Street between Lucas Ditch and Lucas Diversion Ditch
Strategy	Impounded storage on Hickory Hills Golf Course to reduce discharge to Roberts Road Storm Sewer / Lucas
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)				**$546,446**	**$237,623**	**$51,676**	
Utility Relocation			4 %	$21,858			
Mobilization \ General Conditions			5%	$27,322			
Subtotal with Percent Allowances				**$595,626**			
Contingency			30%	$178,688			
Profit			5%	$38,716			
Probable Construction Cost Estimate				**$813,029**			
Design Engineering, Geotechnical, and Construction Management			10%	$81,303			
Property Acquisition Cost:				$3,289,000			
Total Conceptual Cost Estimate				**$4,472,631**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name MACR-1

Problem Description

Strategy 117 ac-ft detention basin

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	257232	$11	$2,747,238	$0	$0	17 acre area footprint of top of pond, 10 ft deep, with side slopes of 4:1. Additional 19.7 ac-ft of excavation needed on west side to slope down to detention basin
Channel treatment: Material to be hauled offsite	yd3	257129	$12	$3,021,266	$0	$0	excavated material minus material used for embankment
Embankment construction, grading and restoration: Compaction of fill	yd3	103	$5	$550	$0	$0	build up berm on east side 127 LF, 4:1 slope, top width of 3 ft, 2 ft high
Embankment construction, grading and restoration: Material hauled from offsite	yd3	0	$11	$0	$0	$0	used material from excavation
Pipe in earth (city): 36 inches or less	lf	30	$217	$6,503	$6,048	$0	outlet/inlet pipe, 3ft diameter
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	US headwall
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	DS headwall
Channel treatment: Soil stabilization and vegetative cover	yd2	18842	$14	$261,527	$243,216	$62,623	Perimeter of 4100 ft, width of 40 ft of vegetated area
Land Acquisition: Purchase of Property *	dollar	5780000	$1	$5,780,000	$0	$0	17 acres at $340,000/acre

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$6,042,285**	**$254,101**	**$62,623**
Utility Relocation	4 %	$241,691		
Mobilization \ General Conditions	5%	$302,114		
Subtotal with Percent Allowances		**$6,586,090**		
Contingency	30%	$1,975,827		
Profit	5%	$428,096		
Probable Construction Cost Estimate		**$8,990,013**		
Design Engineering, Geotechnical, and Construction Management	10%	$899,001		
Property Acquisition Cost:		$5,780,000		
Total Conceptual Cost Estimate		**$15,985,738**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name MEDT-1

Problem Description Erosion threatening structure, infrastructure, and channel banks along Melvina Ditch

Strategy Combination of hard and soft armoring to address erosion problem

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	900	$587	$528,615	$491,604	$126,578	2700 ft length, 8 inch thick concrete wall and 13.5 ft high channel on west side of the channel
Channel treatment: Excavation	yd3	3200	$11	$34,176	$0	$0	Excavation of west channel to allow construction of vertical wall embedded in the west bank
Channel treatment: Compaction	yd3	2400	$7	$17,952	$0	$0	75 % of fill excavated channel material placed back in channel following construction of concrete walls
Channel treatment: Material to be hauled offsite	yd3	800	$12	$9,400	$0	$0	Hauling of excess extracted material from site
Channel treatment: Biostabilization	yd2	2700	$64	$172,989	$160,877	$41,423	Assume half of the east bank of Melvina Ditch can be secured using biostabilization only
Channel treatment: Reno gabions	yd3	900	$267	$240,282	$223,459	$57,536	Assume half of the east bank of Melvina Ditch can be secured using reno gabions (1 ft x 1350 ft x 18 ft)
Channel treatment: Excavation	yd3	900	$11	$9,612	$0	$0	Excavation of 1 ft along half of the east bank
Channel treatment: Material to be hauled offsite	yd3	900	$12	$10,575	$0	$0	Hauling of Excavated land from site
Channel treatment: Vegetative cover only	yd2	3244	$9	$27,704	$25,764	$6,634	Revegetation of the portion of the channel excavated on west bank of channel

Alternative Name	MEDT-1
Problem Description	Erosion threatening structure, infrastructure, and channel banks along Melvina Ditch
Strategy	Combination of hard and soft armoring to address erosion problem
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)				**$1,051,305**	**$901,704**	**$232,171**	
Utility Relocation			4 %	$42,052			
Mobilization \ General Conditions			5%	$52,565			
Subtotal with Percent Allowances				**$1,145,922**			
Contingency			30%	$343,777			
Profit			5%	$74,485			
Probable Construction Cost Estimate				**$1,564,184**			
Design Engineering, Geotechnical, and Construction Management			10%	$156,418			
Property Acquisition Cost:				$0			
Total Conceptual Cost Estimate				**$2,854,477**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	MEDT-2
Problem Description	Road and structures at risk due to erosion
Strategy	Enclose Melvina Ditch in double barrel 102" sewer
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	1684	$11	$17,985	$0	$0	The difference between the 2-102 inch pipes with 1.5 feet clearance on each side between the trench wall and the pipe and 1 foot separation between the two pipes.
Pipe in earth (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	5600	$435	$2,433,984	$2,263,568	$0	Twin 102" pipes installed in existing Melvina Ditch
Outlet structures (Headwall): 42 to 66 inches	each	4	$4,758	$19,030	$17,698	$0	Twin 102" pipes must be made to join with with existing bridge crossing 99th Street
Embankment construction, grading and restoration: Material hauled from offsite	yd3	20591	$11	$219,912	$0	$0	Assume 2800 ft of channel 12 ft wide at bottom, 40 at top. Subtract area of pipes, and subtract the excavated material on either side of the pipes
Channel treatment: Additional fill	yd3	20591	$14	$285,803	$0	$0	Assume 2800 ft of channel 12 ft wide at bottom, 40 at top. Subtract area of pipes, and subtract the excavated material on either side of the pipes
Channel treatment: Compaction	yd3	18907	$7	$141,424	$0	$0	Compaction of material above newly placed pipes
Channel treatment: Vegetative cover only	yd2	14311	$9	$122,216	$113,659	$29,265	46 feet wide, 2800 feet long. Includes a buffer outside of the existing channel.
Channel treatment: Dumped rock	yd3	82	$67	$5,517	$5,131	$1,321	Riprap placed 22 ft long, 2 ft deep, 50 ft longon downstream side of 99th street crossing as erosion protection

Alternative Name	MEDT-2
Problem Description	Road and structures at risk due to erosion
Strategy	Enclose Melvina Ditch in double barrel 102" sewer
District Minimum Criteria for Funding:	Met
Recommended	No

	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)				**$3,245,871**	**$2,400,055**	**$30,586**	
Utility Relocation			4 %	$129,835			
Mobilization \ General Conditions			5%	$162,294			
Subtotal with Percent Allowances				**$3,538,000**			
Contingency			30%	$1,061,400			
Profit			5%	$229,970			
Probable Construction Cost Estimate				**$4,829,370**			
Design Engineering, Geotechnical, and Construction Management			10%	$482,937			
Property Acquisition Cost:				$0			
Total Conceptual Cost Estimate				**$7,742,948**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name MICR-1

Problem Description

Strategy Multiple detention ponds and conveyance increase

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Vegetative cover only	yd2	6684	$9	$57,085	$53,088	$13,669	3760 ft perimeter times 16 ft width for south pond
Channel treatment: Excavation	yd3	165303	$11	$1,765,436	$0	$0	South pond
Channel treatment: Material to be hauled offsite	yd3	82280	$12	$966,790	$0	$0	South pond; assume half of excavation hauled offsite
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	South pond outlet structure
Pipe under pavement (city): 36 inches or less	lf	500	$304	$152,175	$141,520	$0	2 - 4 ft diameter pipes from outlet of south pond to discharge point on Mill Creek tributary
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	840	$425	$357,017	$332,020	$0	Pipes at inlet to south pond
Land Acquisition: Purchase of Property *	dollar	1639256	$1	$1,639,256	$0	$0	For south pond
Pipe under pavement (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1060	$609	$645,222	$600,047	$0	Replace 7 culverts along Southwest Highway with 5-ft x 10-ft box culverts
Channel treatment: Vegetative cover only	yd2	3555	$9	$30,360	$28,234	$7,270	2000 ft perimeter times 16 ft width for north pond
Channel treatment: Excavation	yd3	95582	$11	$1,020,816	$0	$0	For north pond
Channel treatment: Material to be hauled offsite	yd3	47590	$12	$559,183	$0	$0	For north pond; assume half of spoil must be hauled away
Channel treatment: Compaction	yd3	82280	$7	$615,454	$0	$0	For south pond; assume half of spoil can remain on site
Channel treatment: Compaction	yd3	47590	$7	$355,973	$0	$0	For north pond; assume half of spoil can remain on site
Pipe under pavement (city): 36 inches or less	lf	55	$304	$16,739	$15,567	$0	North pond outlet pipe
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	140	$425	$59,503	$55,337	$0	North pond inlet pipe
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	North pond outlet structure
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	South pond inlet structure
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	North pond inlet structure
Land Acquisition: Purchase of Property *	dollar	451930	$1	$451,930	$0	$0	For north pond

Alternative Name	MICR-1
Problem Description	
Strategy	Multiple detention ponds and conveyance increase
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Inlet structures (Headwall): 42 to 66 inches	each	14	$4,758	$66,605	$61,942	$0	Replace 7 culverts along Southwest Highway with 5-ft x 10-ft box culverts; assumed two inlet structures per culvert to account for larger size needed
Outlet structures (Headwall): 42 to 66 inches	each	14	$4,758	$66,605	$61,942	$0	Replace 7 culverts along Southwest Highway with 5-ft x 10-ft box culverts; assumed two inlet structures per culvert to account for larger size needed

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$6,757,036**	**$1,370,225**	**$20,939**
Utility Relocation	4 %	$270,281		
Mobilization \ General Conditions	5%	$337,852		
Subtotal with Percent Allowances		**$7,365,169**		
Contingency	30%	$2,209,551		
Profit	5%	$478,736		
Probable Construction Cost Estimate		**$10,053,456**		
Design Engineering, Geotechnical, and Construction Management	10%	$1,005,346		
Property Acquisition Cost:		$2,091,186		
Total Conceptual Cost Estimate		**$14,541,152**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name MICR-2

Problem Description

Strategy Construct levee to protecting houses and construct compensatory storage

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: Additional fill	yd3	2333	$14	$32,387	$0	$0	6ft high, 3:1 slope, 3ft top width, 500 length
Embankment construction, grading and restoration: Compaction of fill	yd3	2333	$5	$12,460	$0	$0	6ft high, 3:1 slope, 3ft top width, 500 length
Embankment construction, grading and restoration: Material hauled from offsite	yd3	2333	$11	$24,920	$0	$0	6ft high, 3:1 slope, 3ft top width, 500 length
Channel treatment: Vegetative cover only	yd2	2275	$9	$19,427	$18,067	$4,652	6ft high, 3:1 slope, 3ft top width, 500 length
Land Acquisition: Purchase of Property *	dollar	71582	$1	$71,582	$0	$0	500 of length, footprint of 19,500 ft.
Channel treatment: Vegetative cover only	yd2	3794	$9	$32,400	$30,131	$7,758	1030ft top perimeter, 10ft deep
Channel treatment: Excavation	yd3	26577	$11	$283,845	$0	$0	
Channel treatment: Material to be hauled offsite	yd3	26577	$12	$312,282	$0	$0	16.08 acre storage plus excavation to get down to that level.
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	12in diameter pipe
Inlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	12in diameter pipe
Pipe in earth (city): 36 inches or less	lf	190	$217	$41,188	$38,304	$0	12in diameter pipe
Land Acquisition: Purchase of Property *	dollar	115510	$1	$115,510	$0	$0	2.13 acres of land for detention at $54230/acre
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	3	$60,000	$180,000	$167,397	$0	

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$944,109**	**$258,736**	**$12,410**
Utility Relocation	4 %	$37,764		
Mobilization \ General Conditions	5%	$47,205		
Subtotal with Percent Allowances		**$1,029,079**		
Contingency	30%	$308,724		
Profit	5%	$66,890		
Probable Construction Cost Estimate		**$1,404,692**		
Design Engineering, Geotechnical, and Construction Management	10%	$140,469		
Property Acquisition Cost:		$187,092		
Total Conceptual Cost Estimate		**$2,003,400**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name MICR-4

Problem Description

Strategy Multiple detention ponds and conveyance increase

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	1060	$609	$645,222	$600,047	$0	Replace 7 culverts along Southwest Highway with 5-ft x 10-ft box culverts
Channel treatment: Vegetative cover only	yd2	3555	$9	$30,360	$28,234	$7,270	2000 ft perimeter times 16 ft width for north pond
Channel treatment: Excavation	yd3	95582	$11	$1,020,816	$0	$0	For north pond
Channel treatment: Material to be hauled offsite	yd3	47590	$12	$559,183	$0	$0	For north pond; assume half of spoil must be hauled away
Channel treatment: Compaction	yd3	47590	$7	$355,973	$0	$0	For north pond; assume half of spoil can remain on site
Pipe under pavement (city): 36 inches or less	lf	55	$304	$16,739	$15,567	$0	North pond outlet pipe
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	140	$425	$59,503	$55,337	$0	North pond inlet pipe
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	North pond outlet structure
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	North pond inlet structure
Land Acquisition: Purchase of Property *	dollar	451930	$1	$451,930	$0	$0	For north pond
Inlet structures (Headwall): 42 to 66 inches	each	14	$4,758	$66,605	$61,942	$0	Replace 7 culverts along Southwest Highway with 5-ft x 10-ft box culverts; assumed two inlet structures per culvert to account for larger size needed
Outlet structures (Headwall): 42 to 66 inches	each	14	$4,758	$66,605	$61,942	$0	Replace 7 culverts along Southwest Highway with 5-ft x 10-ft box culverts; assumed two inlet structures per culvert to account for larger size needed

Alternative Name MICR-4

Problem Description

Strategy Multiple detention ponds and conveyance increase

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)				**$2,828,363**	**$829,911**	**$7,270**	
Utility Relocation			4 %	$113,135			
Mobilization \ General Conditions			5%	$141,418			
Subtotal with Percent Allowances				**$3,082,916**			
Contingency			30%	$924,875			
Profit			5%	$200,390			
Probable Construction Cost Estimate				**$4,208,180**			
Design Engineering, Geotechnical, and Construction Management			10%	$420,818			
Property Acquisition Cost:				$451,930			
Total Conceptual Cost Estimate				**$5,918,108**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name NVCR-11

Problem Description Overbank flooding along Navajo Creek

Strategy Harlem Ave and Oak Park Ave Diversion Conduits in combination

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	3700	$425	$1,572,574	$1,462,470	$0	Oak Park Ave, 3700 LF, 6 ft diameter RCP
Inlet structures (Headwall): 42 to 66 inches	each	4	$4,758	$19,030	$17,698	$0	2 units chosen for each conduit because there was not a large enough single structure in the list
Outlet structures (Headwall): 42 to 66 inches	each	4	$4,758	$19,030	$17,698	$0	2 units chosen for each conduit because there was not a large enough single structure in the list
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	7200	$425	$3,060,144	$2,845,887	$0	Harlem Ave, 7200 LF, 7 ft diameter RCP

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$4,670,778**	**$4,343,752**	**$0**
Utility Relocation	4 %	$186,831		
Mobilization \ General Conditions	5%	$233,539		
Subtotal with Percent Allowances		**$5,091,148**		
Contingency	30%	$1,527,344		
Profit	5%	$330,925		
Probable Construction Cost Estimate		**$6,949,417**		
Design Engineering, Geotechnical, and Construction Management	10%	$694,942		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$11,988,111**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name NVCR-3

Problem Description Lake Arrowhead overflow flooding

Strategy Raise berm along bike path to prevent Lake Arrowhead from overtopping for 100-year storm event

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: Additional fill	yd3	933	$14	$12,950	$0	$0	
Embankment construction, grading and restoration: Compaction of fill	yd3	933	$5	$4,982	$0	$0	
Embankment construction, grading and restoration: Material hauled from offsite	yd3	933	$11	$9,964	$0	$0	
Paving: Asphalt Pavement Installation (24 ft wide, 2 ft C&G, 1 ft Excavation	lf	167	$148	$24,794	$23,059	$0	
Channel treatment: Soil stabilization and vegetative cover	yd2	889	$14	$12,339	$11,475	$2,955	

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$65,031**	**$34,534**	**$2,955**
Utility Relocation	4 %	$2,601		
Mobilization \ General Conditions	5%	$3,252		
Subtotal with Percent Allowances		**$70,883**		
Contingency	30%	$21,265		
Profit	5%	$4,607		
Probable Construction Cost Estimate		**$96,756**		
Design Engineering, Geotechnical, and Construction Management	10%	$9,676		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$143,920**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name	NVCR-5
Problem Description	Overbank flooding along Navajo Creek
Strategy	Harlem Ave Diversion Conduit
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	7200	$425	$3,060,144	$2,845,887	$0	7200 LF, 7 ft diameter RCP
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	2 units chosen because there was not a large enough single structure in the list
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	2 units chosen because there was not a large enough single structure in the list

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$3,079,174**	**$2,863,585**	**$0**
Utility Relocation	4 %	$123,167		
Mobilization \ General Conditions	5%	$153,959		
Subtotal with Percent Allowances		**$3,356,300**		
Contingency	30%	$1,006,890		
Profit	5%	$218,159		
Probable Construction Cost Estimate		**$4,581,349**		
Design Engineering, Geotechnical, and Construction Management	10%	$458,135		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$7,903,069**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name NVCR-7

Problem Description

Strategy 70th Ave Diversion Conduit

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	2 units chosen because 1 unit was not large enough
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	2 units chosen because 1 unit was not large enough
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	5200	$425	$2,210,104	$2,055,363	$0	5200 LF, 4 ft diameter RCP

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$2,229,134**	**$2,073,060**	**$0**
Utility Relocation	4 %	$89,165		
Mobilization \ General Conditions	5%	$111,457		
Subtotal with Percent Allowances		**$2,429,756**		
Contingency	30%	$728,927		
Profit	5%	$157,934		
Probable Construction Cost Estimate		**$3,316,617**		
Design Engineering, Geotechnical, and Construction Management	10%	$331,662		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$5,721,339**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name NVCR-8

Problem Description Overbank flooding along Navajo Creek

Strategy Oak Park Ave Diversion Conduit

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	3700	$425	$1,572,574	$1,462,470	$0	3700 LF, 6 ft diameter RCP
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	2 units chosen because there was not a large enough single structure in the list
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	2 units chosen because there was not a large enough single structure in the list

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$1,591,604**	**$1,480,167**	**$0**
Utility Relocation	4 %	$63,664		
Mobilization \ General Conditions	5%	$79,580		
Subtotal with Percent Allowances		**$1,734,848**		
Contingency	30%	$520,455		
Profit	5%	$112,765		
Probable Construction Cost Estimate		**$2,368,068**		
Design Engineering, Geotechnical, and Construction Management	10%	$236,807		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$4,085,042**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name OLCR-1

Problem Description

Strategy Lake Oak Lawn Expansion, 30 ac-ft additional storage

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Land Acquisition: Purchase of Property *	dollar	475000	$1	$475,000	$0	$0	0.5 acres @ $950K/acre
Channel treatment: Sheet piling	yd2	4444	$303	$1,347,776	$0	$322,729	2000 ft (along additional shoreline), 20 ft height
Channel treatment: Vegetative cover only	yd2	2222	$9	$18,976	$17,647	$4,544	2000 ft surrounding additional length, 10 ft width
Demolition: Brick, concrete, or stone construction	ft2	76600	$4	$327,082	$0	$0	Sum of areas that include park equipment and buildings, commercial property, and miscellaneous concrete.
Channel treatment: Excavation	yd3	72600	$11	$775,368	$0	$0	Excavation of 30 acre-ft for pond, and 15 acre-ft for normal water pool
Channel treatment: Material to be hauled offsite	yd3	72600	$12	$853,050	$0	$0	Assume all material needs to be hauled offsite
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	Assume new inlet structures needed
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	Assume new outlet structures needed

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$3,341,282**	**$35,345**	**$327,273**
Utility Relocation	4 %	$133,651		
Mobilization \ General Conditions	5%	$167,064		
Subtotal with Percent Allowances		**$3,641,998**		
Contingency	30%	$1,092,599		
Profit	5%	$236,730		
Probable Construction Cost Estimate		**$4,971,327**		
Design Engineering, Geotechnical, and Construction Management	10%	$497,133		
Property Acquisition Cost:		$475,000		
Total Conceptual Cost Estimate		**$6,306,077**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	OLCR-3
Problem Description	
Strategy	Channel Stabilization
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Reinforced trapezoidal concrete channel	yd3	4672	$587	$2,744,099	$2,551,970	$0	8" depth concrete wall, 86 ft width (perimeter of trapezoidal channel), 2200 ft length
Channel treatment: Vegetative cover only	yd2	978	$9	$8,352	$7,767	$2,000	2 ft wide buffer at top of bank, 2200 ft length (X 2 sides)
Channel treatment: Compaction	yd3	3504	$7	$26,210	$0	$0	6" depth, 86 ft width (perimeter of trapezoidal channel), 2200 ft length, compacted earth for stabilized base underneath concrete
Channel treatment: Excavation	yd3	7007	$11	$74,835	$0	$0	1 ft depth, 86 ft width (perimeter of trapezoidal channel), 2200 ft length
Channel treatment: Material to be hauled offsite	yd3	3503	$12	$41,160	$0	$0	Difference between excavation and compaction.

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$2,894,656**	**$2,559,738**	**$2,000**
Utility Relocation	4 %	$115,786		
Mobilization \ General Conditions	5%	$144,733		
Subtotal with Percent Allowances		**$3,155,175**		
Contingency	30%	$946,553		
Profit	5%	$205,086		
Probable Construction Cost Estimate		**$4,306,814**		
Design Engineering, Geotechnical, and Construction Management	10%	$430,681		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$7,299,233**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name	SFDT-1
Problem Description	Overbank flooding along 71st Street Ditch
Strategy	Convert existing detention on Resurrection Cemetery to wetland to detain flows from Bridgeview storm sewer
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	96800	$11	$1,033,824	$0	$0	Assume 60 ac-ft of excavation
Channel treatment: Material to be hauled offsite	yd3	87120	$12	$1,023,660	$0	$0	Assume 90 % of excavated materials to be hauled off site
Demolition: Brick, concrete, or stone construction	ft2	960	$4	$4,099	$0	$0	Remove existing 120 ft of culvert beneath Archer Ave; Assume 120 ft * 8 ft wide
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Inlet structure into detention basin
Pipe under pavement (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	250	$292	$72,885	$67,782	$0	Cost for two (2) CMP pipes across Archer Ave
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Outlet structure from detention basin
Land Acquisition: Purchase of Property *	dollar	1086000	$1	$1,086,000	$0	$0	6 acres valued at approximately $181,000 per acre
Channel treatment: Vegetative cover only	yd2	29040	$9	$248,002	$230,638	$59,385	Revegetation of disturbed soils on 6 acre site
Embankment construction, grading and restoration: Compaction of fill	yd3	9680	$5	$51,691	$0	$0	Compaction / regrading of 10% of excavated materials to provide berms / habitat

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$2,443,676**	**$307,268**	**$59,385**
Utility Relocation	4 %	$97,747		
Mobilization \ General Conditions	5%	$122,184		
Subtotal with Percent Allowances		**$2,663,607**		
Contingency	30%	$799,082		
Profit	5%	$173,134		
Probable Construction Cost Estimate		**$3,635,823**		
Design Engineering, Geotechnical, and Construction Management	10%	$363,582		
Property Acquisition Cost:		$1,086,000		
Total Conceptual Cost Estimate		**$5,452,059**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name	SFDT-2
Problem Description	Overbank flooding along SFDT
Strategy	Additional conveyance to I&M Canal from SFDT to lower WSELs
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	
Pipe in tunnel: 42 to 66 inches	lf	162	$1,495	$242,200	$225,242	$0	162 ft is the length of the existing culvert
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	
Channel treatment: Excavation	yd3	2222	$11	$23,733	$0	$0	Assume 100 ft x 100 ft x 6 ft excavation for jacking pit
Channel treatment: Compaction	yd3	2222	$7	$16,622	$0	$0	Compact 100 ft x 100 ft x 6 ft of material excavated for jacking pit
Land Acquisition: Purchase of Property *	dollar	4600	$1	$4,600	$0	$0	0.23 acres valued at $200,000 utilized as temporary easement

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$292,070**	**$234,091**	**$0**
Utility Relocation	4 %	$11,683		
Mobilization \ General Conditions	5%	$14,603		
Subtotal with Percent Allowances		**$318,356**		
Contingency	30%	$95,507		
Profit	5%	$20,693		
Probable Construction Cost Estimate		**$434,556**		
Design Engineering, Geotechnical, and Construction Management	10%	$43,456		
Property Acquisition Cost:		$4,600		
Total Conceptual Cost Estimate		**$716,703**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name SPCR-1

Problem Description

Strategy Raise 157th street to prevent flooding, place bike path upstream which acts hydraulically as the old road

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Demolition: Brick, concrete, or stone construction	ft2	750	$4	$3,203	$0	$0	750 ft of roadway length at 1 ft deep
Embankment construction, grading and restoration: Additional fill	yd3	6776	$14	$94,051	$0	$0	750 ft of roadway length, 24 ft wide and 4 ft of additional depth plus an additional amount of fill for a 3V:1H side slope along both sides and additional amount for culvert
Embankment construction, grading and restoration: Compaction of fill	yd3	6776	$5	$36,184	$0	$0	750 ft of roadway length, 24 ft wide and 4 ft of additional depth plus an additional amount of fill for a 3V:1H side slope along both sides and additional amount for culvert
Embankment construction, grading and restoration: Material hauled from offsite	yd3	6776	$11	$72,368	$0	$0	750 ft of roadway length, 24 ft wide and 4 ft of additional depth plus an additional amount of fill for a 3V:1H side slope along both sides and additional amount for culvert
Paving: Asphalt Pavement Installation (24 ft wide, 2 ft C&G, 1 ft Excavation	lf	750	$148	$111,353	$103,556	$0	
Pipe under pavement (county): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	82	$609	$49,913	$46,419	$0	Two 41 ft 6 ft by 6 ft culverts side by side.
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	DS headwall for box culvert
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	US headwall for box culvert
Paving: Asphalt Pavement Installation (24 ft wide, 2 ft C&G, 1 ft Excavation	lf	100	$148	$14,847	$13,807	$0	Calculated equivalent pavement for 300 LF bike path (assumed 8 ft wide bike path)
Embankment construction, grading and restoration: Additional fill	yd3	2450	$14	$34,006	$0	$0	berm volume = 2450 yd3, 300 long
Embankment construction, grading and restoration: Compaction of fill	yd3	2450	$5	$13,083	$0	$0	berm volume = 2450 yd3, 300 long
Embankment construction, grading and restoration: Material hauled from offsite	yd3	2450	$11	$26,166	$0	$0	berm volume = 2450 yd3, 300 long
Pipe in earth (county): 42 to 66 inches / box culvert (15-27 ft2)	lf	60	$208	$12,494	$11,620	$0	low flow pipe, 5ft diameter

Alternative Name SPCR-1

Problem Description

Strategy Raise 157th street to prevent flooding, place bike path upstream which acts hydraulically as the old road

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	low flow pipe, 5ft diameter
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	low flow pipe, 5ft diameter
Land Acquisition: Permanent Easement *	dollar	39766	$1	$39,766	$0	$0	0.4 acres, $198829/acre

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$496,212**	**$201,948**	**$0**
Utility Relocation	4 %	$19,848		
Mobilization \ General Conditions	5%	$24,811		
Subtotal with Percent Allowances		**$540,871**		
Contingency	30%	$162,261		
Profit	5%	$35,157		
Probable Construction Cost Estimate		**$738,289**		
Design Engineering, Geotechnical, and Construction Management	10%	$73,829		
Property Acquisition Cost:		$39,766		
Total Conceptual Cost Estimate		**$1,053,833**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-10

Problem Description Erosion/Sedimentation near confluence of Stony Creek with Oak Lawn Creek

Strategy Concrete Stabilization (assume hard-armored natural stabilization techniques would work as well)

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Reinforced trapezoidal concrete channel	yd3	1698	$587	$997,320	$927,493	$0	8" depth concrete wall, 86 ft width (perimeter of trapezoidal channel), 800 ft length
Channel treatment: Vegetative cover only	yd2	356	$9	$3,037	$2,824	$727	2 ft wide buffer at top of bank, 800 ft length (X 2 sides)
Channel treatment: Compaction	yd3	1274	$7	$9,530	$0	$0	6" depth, 86 ft width (perimeter of trapezoidal channel), 800 ft length, compaction for soil beneath concrete
Channel treatment: Excavation	yd3	2548	$11	$27,213	$0	$0	1 ft depth, 86 ft width (perimeter of trapezoidal channel), 800 ft length, excavation for concrete
Channel treatment: Material to be hauled offsite	yd3	1273	$12	$14,958	$0	$0	Difference between excavation and compaction.
Channel treatment: Excavation	yd3	2777	$11	$29,658	$0	$0	Excavation of material that has fallen into Stony Creek and is causing blockage; very rough estimate based on field observation and cross-section information
Channel treatment: Material to be hauled offsite	yd3	2777	$12	$32,630	$0	$0	Hauling of material that has fallen into Stony Creek and is causing blockage

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,114,345**	**$930,317**	**$727**
Utility Relocation	4 %	$44,574		
Mobilization \ General Conditions	5%	$55,717		
Subtotal with Percent Allowances		**$1,214,636**		
Contingency	30%	$364,391		
Profit	5%	$78,951		
Probable Construction Cost Estimate		**$1,657,978**		
Design Engineering, Geotechnical, and Construction Management	10%	$165,798		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$2,754,820**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-11

Problem Description

Strategy Stony Levee

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Embankment construction, grading and restoration: Additional fill	yd3	4702	$14	$65,264	$0	$0	Embankment Construction along STCR/LUDT
Embankment construction, grading and restoration: Compaction of fill	yd3	4702	$5	$25,109	$0	$0	Embankment Construction along STCR/LUDT
Embankment construction, grading and restoration: Material hauled from offsite	yd3	4702	$11	$50,217	$0	$0	Embankment Construction along STCR/LUDT
Pipe in earth (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	75	$208	$15,618	$14,525	$0	Pipe to maintain outlet to Stony Creek from proposed levee
Channel treatment: Excavation	yd3	34848	$11	$372,177	$0	$0	Construction of 16.45 ac-ft detention pond to offset lost floodplain storage
Channel treatment: Material to be hauled offsite	yd3	34848	$12	$409,464	$0	$0	Construction of 16.45 ac-ft detention pond to offset lost floodplain storage
Channel treatment: Vegetative cover only	yd2	69696	$9	$595,204	$553,530	$142,523	Cover for approximately 4.7 acres of detention

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,533,052**	**$568,055**	**$142,523**
Utility Relocation	4 %	$61,322		
Mobilization \ General Conditions	5%	$76,653		
Subtotal with Percent Allowances		**$1,671,027**		
Contingency	30%	$501,308		
Profit	5%	$108,617		
Probable Construction Cost Estimate		**$2,280,952**		
Design Engineering, Geotechnical, and Construction Management	10%	$228,095		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$3,219,625**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-2

Problem Description Extensive overbank flooding along Stony Creek

Strategy Add approximately 400 ac-ft of detention on St. Casimir Cemetery property

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Land Acquisition: Permanent Easement *	dollar	8315348	$1	$8,315,348	$0	$0	40 acres at $415,000/acre, 50% of value for permanent easement
Channel treatment: Vegetative cover only	yd2	30400	$9	$259,616	$241,439	$62,166	7200 ft perimeter (1200 ft wide x 1400 ft long) length, 38 ft width
Concrete: Cast in place	yd3	1333	$250	$333,250	$0	$0	Need 3 very large structures for inlet and outlet pipes (to accommodate up to 2 - 10 ft by 16 ft boxes)
Pipe under pavement (city): Box culvert (51 to 60 ft2)	lf	9200	$661	$6,081,476	$5,655,680	$0	Assumes 1400 LF from West Stony Creek and Cicero Ave, plus 2000 LF from Kilpatrick. 9200 ft is equivalent length of pipe to account for pipe area (10 x 16 ft box) and 2 barrels.
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	1500	$425	$637,530	$592,893	$0	Outlet Pipe
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	6	$60,000	$360,000	$334,794	$0	Wetland mitigation 6 acres @ $60,000
Channel treatment: Excavation	yd3	624360	$11	$6,668,165	$0	$0	307 ac-ft for pond, and 100 ac-ft for normal water pool
Channel treatment: Compaction	yd3	312180	$7	$2,335,106	$0	$0	Assume half of excavated material can be disposed of onsite
Channel treatment: Material to be hauled offsite	yd3	312180	$12	$3,668,115	$0	$0	Assume half of excavated material needs to be hauled offsite

Alternative Name	STCR-2
Problem Description	Extensive overbank flooding along Stony Creek
Strategy	Add approximately 400 ac-ft of detention on St. Casimir Cemetery property
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)				**$20,343,258**	**$6,824,806**	**$62,166**	
Utility Relocation			4 %	$813,730			
Mobilization \ General Conditions			5%	$1,017,163			
Subtotal with Percent Allowances				**$22,174,151**			
Contingency			30%	$6,652,245			
Profit			5%	$1,441,320			
Probable Construction Cost Estimate				**$30,267,717**			
Design Engineering, Geotechnical, and Construction Management			10%	$3,026,772			
Property Acquisition Cost:				$8,315,348			
Total Conceptual Cost Estimate				**$48,496,809**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name	STCR-3
Problem Description	Extensive overbank flooding along Stony Creek
Strategy	Add approximately 87 ac-ft of detention at Wolfe Wildlife Refuge
District Minimum Criteria for Funding:	Met
Recommended	Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	183301	$11	$1,957,652	$0	$0	Volume of pond plus volume of normal pool, and excavation for vegetated cover
Channel treatment: Material to be hauled offsite	yd3	148427	$12	$1,744,013	$0	$0	Material excavated minus what is needed for embankments
Embankment construction, grading and restoration: Compaction of fill	yd3	32267	$5	$172,304	$0	$0	Assumed only material required for embankments can remain on-site.
Outlet structures (Headwall): 36 inches or less	each	2	$2,600	$5,201	$4,837	$0	Outlet structures from ponds to return flow to Stony Creek
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	Inlet structures to take flow from Stony Creek
Pipe under pavement (city): 72 to 84 inches / box culvert (28 to 38 ft2)	lf	100	$425	$42,502	$39,526	$0	Pipes to convey flow to and from Stony Creek
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	7	$60,000	$396,000	$368,274	$0	6 acres of wetland mitigation at $60,000/acre
Land Acquisition: Purchase of Property *	dollar	0	$1	$0	$0	$0	Land acquisition provided by Village of Oak Lawn and Oak Lawn Park District at no cost, 11.6 acres at $0/acre
Channel treatment: Vegetative cover only	yd2	7822	$9	$66,802	$62,125	$15,996	4400 ft perimeter length, 16 ft width

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$4,393,989**	**$483,610**	**$15,996**
Utility Relocation	4 %	$175,760		
Mobilization \ General Conditions	5%	$219,699		
Subtotal with Percent Allowances		**$4,789,448**		
Contingency	30%	$1,436,834		
Profit	5%	$311,314		
Probable Construction Cost Estimate		**$6,537,596**		
Design Engineering, Geotechnical, and Construction Management	10%	$653,760		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$7,690,962**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-4

Problem Description Extensive overbank flooding along Stony Creek

Strategy Construct 39 acre-ft detention pond

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Vegetative cover only	yd2	7600	$9	$64,904	$60,360	$15,541	1800 ft perimeter x 38 ft width for vegetation
Channel treatment: Excavation	yd3	91960	$11	$982,133	$0	$0	Assumes 39 acre-feet for pond, 18 acre-ft for normal water pool
Channel treatment: Material to be hauled offsite	yd3	89960	$12	$1,057,030	$0	$0	Excavation minus material remaining on site
Embankment construction, grading and restoration: Compaction of fill	yd3	2000	$5	$10,680	$0	$0	Assumes 1800 ft long embankment around pond, 3 ft high, by 10 ft wide
Outlet structures (Headwall): 36 inches or less	each	1	$2,600	$2,600	$2,418	$0	Outlet structure from pond
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Inlet structure to pond
Pipe under pavement (city): 42 to 66 inches / box culvert (15 to 27 ft2)	lf	25	$292	$7,289	$6,778	$0	Pipe to pond
Pipe under pavement (city): 36 inches or less	lf	25	$304	$7,609	$7,076	$0	Outlet pipe from pond
Land Acquisition: Permanent Easement *	dollar	733213	$1	$733,213	$0	$0	4 acres, land value estimated at $366K/acre, 50% for perm easement

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$2,137,002**	**$81,057**	**$15,541**
Utility Relocation	4 %	$85,480		
Mobilization \ General Conditions	5%	$106,850		
Subtotal with Percent Allowances		**$2,329,332**		
Contingency	30%	$698,800		
Profit	5%	$151,407		
Probable Construction Cost Estimate		**$3,179,538**		
Design Engineering, Geotechnical, and Construction Management	10%	$317,954		
Property Acquisition Cost:		$733,213		
Total Conceptual Cost Estimate		**$4,327,303**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-6

Problem Description Overbank flooding along Stony Creek

Strategy Rerouting of Melvina Ditch at confluence with Stony Creek

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Land Acquisition: Purchase of Property *	dollar	200000	$1	$200,000	$0	$0	1.0 acres for Melvina re-route, property purchase, $200K/acre
Land Acquisition: Purchase of Property *	dollar	2680000	$1	$2,680,000	$0	$0	13.4 acres for ponds, property purchase, $200K/acre
Channel treatment: Excavation	yd3	8318	$11	$88,836	$0	$0	Excavation for channel only, 212 ft to pond and 370 ft after pond = 572 ft total length, assume channel is 5 ft wide at bottom and 10 ft deep with 3:1 side slopes
Channel treatment: Material to be hauled offsite	yd3	8318	$12	$97,737	$0	$0	Haul excavated material from site
Channel treatment: Vegetative cover only	yd2	4203	$9	$35,896	$33,383	$8,595	channel is 65 ft wide top of slope to top of slope
Channel treatment: Excavation	yd3	183920	$11	$1,964,266	$0	$0	Excavation for ponds, 114 acre-feet of excavation for ponds plus normal water pool
Channel treatment: Material to be hauled offsite	yd3	176587	$12	$2,074,897	$0	$0	Excavation minus embankment
Channel treatment: Vegetative cover only	yd2	20000	$9	$170,800	$158,841	$40,899	Revegetation for ponds for side slope of ponds
Embankment construction, grading and restoration: Compaction of fill	yd3	7333	$5	$39,158	$0	$0	Embankment for ponds, assume 5500 ft total length of embankments, 6 ft high by 4 ft wide with 3:1 side slopes (area = 36 sf)
Outlet structures (Headwall): 42 to 66 inches	each	4	$4,758	$19,030	$17,698	$0	Outlet structures for each of four ponds
Pipe under pavement (city): Box culvert (51 to 60 ft2)	lf	93	$661	$61,694	$57,374	$0	80 LF of 7 ft x10 ft box culvert (crosses under Janet Lane), multiplied by 70/60 to account for larger pipe area than largest box culvert in unit cost data
Pipe under pavement (city): Box culvert (51 to 60 ft2)	lf	128	$661	$84,810	$78,872	$0	2 - 55 ft long 7 ft by 10 ft box culverts, cross under railroad, multiplied by 70/60 to account for larger pipe area than largest box culvert in unit cost data

Alternative Name	STCR-6
Problem Description	Overbank flooding along Stony Creek
Strategy	Rerouting of Melvina Ditch at confluence with Stony Creek
District Minimum Criteria for Funding:	Met
Recommended	No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Excavation	yd3	2222	$11	$23,731	$0	$0	Assume 100 ft x 100 ft x 6 ft excavation for jacking pit
Channel treatment: Compaction	yd3	2222	$7	$16,621	$0	$0	Compact 100 ft x 100 ft x 6 ft of material excavated for jacking pit
Land Acquisition: Temporary Easement *	dollar	3742	$1	$3,742	$0	$0	0.23 acres valued at $162,700 utilized as temporary easement @ 10%
Inlet structures (Headwall): 42 to 66 inches	each	4	$4,758	$19,030	$17,698	$0	Inlet structures for each of four ponds

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$4,696,506**	**$363,866**	**$49,494**
Utility Relocation	4 %	$187,860		
Mobilization \ General Conditions	5%	$234,825		
Subtotal with Percent Allowances		**$5,119,191**		
Contingency	30%	$1,535,757		
Profit	5%	$332,747		
Probable Construction Cost Estimate		**$6,987,696**		
Design Engineering, Geotechnical, and Construction Management	10%	$698,770		
Property Acquisition Cost:		$2,883,742		
Total Conceptual Cost Estimate		**$10,983,568**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-7

Problem Description Overbank flooding along East Stony Creek

Strategy Add two additional 7.1' by 8' box culverts to California Ave culvert at downstream end of East Stony Creek

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	Outlet Structures
Pipe under pavement (city): Box culvert (51 to 60 ft2)	lf	1050	$661	$694,082	$645,485	$0	525 LF of culvert under California Ave or pavement x 2 culverts
Pipe in earth (city): Box culvert (51 to 60 ft2)	lf	1262	$472	$595,677	$553,970	$0	631 LF of culvert under earth x 2 culverts
Channel treatment: Excavation	yd3	2222	$11	$23,731	$0	$0	Assume 100 ft x 100 ft x 6 ft excavation for jacking pit
Channel treatment: Compaction	yd3	2222	$7	$16,621	$0	$0	Compact 100 ft x 100 ft x 6 ft of material excavated for jacking pit
Land Acquisition: Temporary Easement *	dollar	3742	$1	$3,742	$0	$0	0.23 acres valued at $162,700 utilized as temporary easement @ 10%
Land Acquisition: Permanent Easement *	dollar	0	$1	$0	$0	$0	Assume existing easement is wide enough for additional pipes
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$9,515	$8,849	$0	Inlet Structures

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$1,349,140**	**$1,217,153**	**$0**
Utility Relocation	4 %	$53,966		
Mobilization \ General Conditions	5%	$67,457		
Subtotal with Percent Allowances		**$1,470,562**		
Contingency	30%	$441,169		
Profit	5%	$95,587		
Probable Construction Cost Estimate		**$2,007,317**		
Design Engineering, Geotechnical, and Construction Management	10%	$200,732		
Property Acquisition Cost:		$3,742		
Total Conceptual Cost Estimate		**$3,428,944**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-8

Problem Description Overbank flooding along Stony Creek

Strategy Construct 8' by 8' box culvert to Cal-Sag Channel along COM ED right-of-way

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Land Acquisition: Purchase of Property *	dollar	398366	$1	$398,366	$0	$0	50 ft wide x 4800 ft long permanent easement in Com-Ed right of way. Property value estimated at $144,607/acre
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	
Pipe under pavement (city): Box culvert (51 to 60 ft2)	lf	100	$661	$66,103	$61,475	$0	Diversion conduit crosses four lane road to Cal Sag channel
Pipe in earth (city): Box culvert (51 to 60 ft2)	lf	4700	$472	$2,218,447	$2,063,122	$0	Diversion conduit to Cal Sag Channel
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$2,294,065**	**$2,133,445**	**$0**
Utility Relocation	4 %	$91,763		
Mobilization \ General Conditions	5%	$114,703		
Subtotal with Percent Allowances		**$2,500,531**		
Contingency	30%	$750,159		
Profit	5%	$162,535		
Probable Construction Cost Estimate		**$3,413,225**		
Design Engineering, Geotechnical, and Construction Management	10%	$341,322		
Property Acquisition Cost:		$398,366		
Total Conceptual Cost Estimate		**$6,286,358**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name STCR-9

Problem Description

Strategy Construct 8' by 8' box culvert to Cal-Sag Channel under Harlem Ave

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): Box culvert (51 to 60 ft2)	lf	8000	$661	$5,288,240	$4,917,982	$0	8 ft x 8 ft box culvert under Harlem Avenue
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Outlet Structure
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	Inlet Structure

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

		Base Cost	Maint. Cost	Replacement Cost
Subtotal (direct costs)		**$5,297,755**	**$4,926,831**	**$0**
Utility Relocation	4 %	$211,910		
Mobilization \ General Conditions	5%	$264,888		
Subtotal with Percent Allowances		**$5,774,553**		
Contingency	30%	$1,732,366		
Profit	5%	$375,346		
Probable Construction Cost Estimate		**$7,882,265**		
Design Engineering, Geotechnical, and Construction Management	10%	$788,226		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$13,597,322**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name TICR-1

Problem Description Tinley Creek overbank flooding

Strategy 96" Relief Sewer Under Central Avenue - Increasing conveyance from Tinley Creek to Cal-Sag Channel

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Pipe under pavement (city): 90 to 96 inches / box culvert (39 to 50 ft2)	lf	3150	$609	$1,917,405	$1,783,157	$0	Length approximated using GIS
Inlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	96" item not available; markup via quantity
Outlet structures (Headwall): 42 to 66 inches	each	2	$4,758	$7,136	$6,637	$0	96" item not available; markup via quantity

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,931,678**	**$1,796,431**	**$0**
Utility Relocation	4 %	$77,267		
Mobilization \ General Conditions	5%	$96,584		
Subtotal with Percent Allowances		**$2,105,528**		
Contingency	30%	$631,659		
Profit	5%	$136,859		
Probable Construction Cost Estimate		**$2,874,046**		
Design Engineering, Geotechnical, and Construction Management	10%	$287,405		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$4,957,882**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name TICR-2

Problem Description Reduce peak flow downstream
Strategy Impoundment in Forest Preserve upstream of Oak Park Ave
District Minimum Criteria for Funding: Met
Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Outlet structures: Concrete swale	yd2	130	$98	$12,773	$11,878	$0	overflow weir with concrete drop structure, 60 ft wide weir with 4:1 side slopes up 4ft and a concrete slide down to channel 6 ft vertical at 4:1 side slopes
Pipe in earth (county): Box culvert (51 to 60 ft2)	lf	100	$472	$47,201	$43,896	$0	base flow pipe, 5x5 box culvert
Inlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	upstream headwalls
Outlet structures (Headwall): 42 to 66 inches	each	1	$4,758	$4,758	$4,424	$0	downstream headwalls
Land Acquisition: Permanent Easement *	dollar	750000	$1	$750,000	$0	$0	Assume 10 acre site for area subject to two year inundation (estimated only). Land valued at $150,000 per acre.
Channel treatment: Excavation	yd3	9457	$11	$101,001	$0	$0	Excavation of material from upstream in Forest Preserve (roughly equivalent in cost to hauling from offsite, too)
Channel treatment: Soil stabilization and vegetative cover	yd2	4444	$14	$61,689	$57,370	$14,772	Seed weir embankment ; stabilize structure
Embankment construction, grading and restoration: Additional fill	yd3	9457	$14	$131,263	$0	$0	Impoundment upstream of Oak Park Ave; Volume calculated based on 50 ft wide structure up to elevation 645 ft.
Embankment construction, grading and restoration: Compaction of fill	yd3	9457	$5	$50,500	$0	$0	Compaction of impoundment;
Wetland: Construct / Mitigate wetland outside Des Plaines watershed	acre	10	$60,000	$600,000	$557,991	$0	10 acres of wetland habitat may be impacted by proposed impoundments

Alternative Name	TICR-2
Problem Description	Reduce peak flow downstream
Strategy	Impoundment in Forest Preserve upstream of Oak Park Ave
District Minimum Criteria for Funding:	Met
Recommended	No

	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)	**$1,013,942**	**$679,984**	**$14,772**
Utility Relocation	4 %	$40,558	
Mobilization \ General Conditions	5%	$50,697	
Subtotal with Percent Allowances		**$1,105,196**	
Contingency	30%	$331,559	
Profit	5%	$71,838	
Probable Construction Cost Estimate		**$1,508,593**	
Design Engineering, Geotechnical, and Construction Management	10%	$150,859	
Property Acquisition Cost:		$750,000	
Total Conceptual Cost Estimate		**$3,104,208**	

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name TICR-3

Problem Description Tinely Creek overbank flooding north to Cal-Sag 6

Strategy Build/Reinforce levee with 3' freeboard on both sides of bank upstream of Central Ave - Raise bank elevation

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	3700	$11	$39,516	$0	$0	Levee construction assuming 4.5 ft height, 5ft top width, and 3:1 side slope. Length (1200ft) approximated with GIS.
Embankment construction, grading and restoration: Additional fill	yd3	3700	$14	$51,356	$0	$0	Place fill for levee
Embankment construction, grading and restoration: Compaction of fill	yd3	3700	$5	$19,758	$0	$0	Compact levee material
Channel treatment: Vegetative cover only	yd2	3196	$9	$27,294	$25,383	$6,536	Seed levee surface
Land Acquisition: Permanent Easement *	dollar	72715	$1	$72,715	$0	$0	1400 ft x 25 ft levee easement on propety estimated at value of $181,000
Embankment construction, grading and restoration: Material hauled from offsite	yd3	2186	$11	$23,346	$0	$0	Construct levee on SE side of river roughly 2,000 ft in length with average height of 1.8 ft (range 0-5) with average width of 16 ft, providing 3 ft of freeboard above estimated 100 yr WSEL
Embankment construction, grading and restoration: Additional fill	yd3	2186	$14	$30,342	$0	$0	Place fill for levee
Embankment construction, grading and restoration: Compaction of fill	yd3	2186	$5	$11,673	$0	$0	Compact levee material
Channel treatment: Vegetative cover only	yd2	3427	$9	$29,267	$27,217	$7,008	Seed levee surface
Land Acquisition: Permanent Easement *	dollar	191660	$1	$191,660	$0	$0	Permanent Easement 2000 ft in length by roughly 40 ft wide (avg width + 25 ft) (1.87 ac estimated at $180,000)
Pump Station: 10ac-ft per day interior drainage	each	1	$800,000	$800,000	$743,988	$0	Pumping station on SE side of stream to dewater area on other side of levee

Alternative Name	TICR-3
Problem Description	Tinely Creek overbank flooding north to Cal-Sag 6
Strategy	Build/Reinforce levee with 3' freeboard on both sides of bank upstream of Central Ave - Raise bank elevation
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)				**$1,032,552**	**$796,588**	**$13,544**	
Utility Relocation			4 %	$41,302			
Mobilization \ General Conditions			5%	$51,628			
Subtotal with Percent Allowances				**$1,125,481**			
Contingency			30%	$337,644			
Profit			5%	$73,156			
Probable Construction Cost Estimate				**$1,536,282**			
Design Engineering, Geotechnical, and Construction Management			10%	$153,628			
Property Acquisition Cost:				$264,375			
Total Conceptual Cost Estimate				**$2,764,418**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name TICR-3B

Problem Description Flooding upstream of Tinley Creek's crossing of 127th Street

Strategy Build/Reinforce 3' levee upstream of Central Ave with additional compensatory storage

District Minimum Criteria for Funding: Met

Recommended No

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Embankment construction, grading and restoration: Material hauled from offsite	yd3	3700	$11	$39,516	$0	$0	Levee construction assuming 4.5 ft height, 5ft top width, and 3:1 side slope. Length (1200ft) approximated with GIS.
Embankment construction, grading and restoration: Additional fill	yd3	3700	$14	$51,356	$0	$0	Place fill for levee
Embankment construction, grading and restoration: Compaction of fill	yd3	3700	$5	$19,758	$0	$0	Compact levee material
Channel treatment: Vegetative cover only	yd2	3196	$9	$27,294	$25,383	$6,536	Seed levee surface
Land Acquisition: Permanent Easement *	dollar	72715	$1	$72,715	$0	$0	1400 ft x 25 ft levee easement on propety estimated at value of $181,000
Channel treatment: Excavation	yd3	112933	$11	$1,206,124	$0	$0	Excavation of 45 ac-ft of storage to mitigate for lost floodplain storage. Selected site requires 70 ac-ft of excavation
Channel treatment: Material to be hauled offsite	yd3	56466	$12	$663,476	$0	$0	Assume half of excavted materials are hauled off site, and the remainder regraded in adjacent areas
Channel treatment: Vegetative cover only	yd2	53240	$9	$454,670	$422,836	$108,872	Vegetation of 11 acre site
Land Acquisition: Permanent Easement *	dollar	675000	$1	$675,000	$0	$0	Assume 9 acres necessary, at $150,000 per acre
Channel treatment: Compaction	yd3	56466	$7	$422,366	$0	$0	Half of excavated material is compacted in surrounding area

Alternative Name	TICR-3B
Problem Description	Flooding upstream of Tinley Creek's crossing of 127th Street
Strategy	Build/Reinforce 3' levee upstream of Central Ave with additional compensatory storage
District Minimum Criteria for Funding:	Met
Recommended	No

	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)				**$2,884,559**	**$448,219**	**$115,408**	
Utility Relocation			4 %	$115,382			
Mobilization \ General Conditions			5%	$144,228			
Subtotal with Percent Allowances				**$3,144,169**			
Contingency			30%	$943,251			
Profit			5%	$204,371			
Probable Construction Cost Estimate				**$4,291,791**			
Design Engineering, Geotechnical, and Construction Management			10%	$429,179			
Property Acquisition Cost:				$747,715			
Total Conceptual Cost Estimate				**$6,032,312**			

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Total Conceptual Cost Report

Alternative Name TICR-5

Problem Description

Strategy Dredge approximately 1500 ft downstream of Lake Lorin

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
maintenance: Small Channel Maintenance (Brush and debris removal)	lf	1500	$5	$7,500	$6,975	$1,796	removal of any derbis
Channel treatment: Excavation	yd3	2500	$11	$26,700	$0	$0	Assume 30 ft wide by 1.5 ft deep by 1500 ft long
Channel treatment: Material to be hauled offsite	yd3	2500	$12	$29,375	$0	$0	Remove excavated material

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$63,575**	**$6,975**	**$1,796**
Utility Relocation	4 %	$2,543		
Mobilization \ General Conditions	5%	$3,179		
Subtotal with Percent Allowances		**$69,297**		
Contingency	30%	$20,789		
Profit	5%	$4,504		
Probable Construction Cost Estimate		**$94,590**		
Design Engineering, Geotechnical, and Construction Management	10%	$9,459		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$112,820**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name TICR-7

Problem Description TICR erosion problem, concrete stabilization

Strategy stabilize bank to prevent erosion for a total of 850 LF; 700 LF of stabilation on both sides of stream upstream

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Reinforced trapezoidal concrete channel	yd3	944	$587	$554,458	$515,638	$0	1 depth concrete wall, 30ft width (perimeter of trapezoidal channel), 2300 ft length
Channel treatment: Vegetative cover only	yd2	378	$9	$3,228	$3,002	$773	2 ft wide buffer at top of bank, 2300 ft length (x 2 sides)
Channel treatment: Compaction	yd3	633	$7	$4,735	$0	$0	underneath concrete 1.5 ft depth, 30 ft width (perimeter of trapezoidal channel)
Channel treatment: Excavation	yd3	1417	$11	$15,134	$0	$0	2300 ft length
Channel treatment: Material to be hauled offsite	yd3	784	$12	$9,212	$0	$0	difference between excavation and compaction

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$586,767**	**$518,640**	**$773**
Utility Relocation	4 %	$23,471		
Mobilization \ General Conditions	5%	$29,338		
Subtotal with Percent Allowances		**$639,576**		
Contingency	30%	$191,873		
Profit	5%	$41,572		
Probable Construction Cost Estimate		**$873,021**		
Design Engineering, Geotechnical, and Construction Management	10%	$87,302		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$1,479,736**		

Additional Comments

Metropolitan Water Reclamation District of Greater Chicago
Cal Sag Watershed Detailed Watershed Plan
Table X-X Total Conceptual Cost Report

Alternative Name TICR-8

Problem Description TICR erosion problem

Strategy stabilize bank to prevent erosion. Total length of 1,775 LF of stabilization required: 450 LF upstream of 159th St

District Minimum Criteria for Funding: Met

Recommended Yes

	Unit	Quantity	Unit Cost	Base Cost	Maint. Cost	Replacement Cost	Notes/Issues
Channel treatment: Reinforced trapezoidal concrete channel	yd3	2958	$587	$1,737,381	$1,615,738	$0	1 depth concrete wall, 45ft width (perimeter of trapezoidal channel), 1,775 ft length
Channel treatment: Vegetative cover only	yd2	789	$9	$6,738	$6,266	$1,613	2 ft wide buffer at top of bank, 1775 ft length, compacteed earth for stabilized base
Channel treatment: Compaction	yd3	1982	$7	$14,825	$0	$0	underneath concrete 1.5 ft depth, 45 ft width (perimeter of trapezoidal channel)
Channel treatment: Excavation	yd3	4438	$11	$47,398	$0	$0	1775 ft length
Channel treatment: Material to be hauled offsite	yd3	2455	$12	$28,846	$0	$0	difference between excavation and compaction

* Indicates item excluded from subtotal (e.g. land acquisition, buyouts)

Subtotal (direct costs)		**$1,835,189**	**$1,622,004**	**$1,613**
Utility Relocation	4 %	$73,408		
Mobilization \ General Conditions	5%	$91,759		
Subtotal with Percent Allowances		**$2,000,356**		
Contingency	30%	$600,107		
Profit	5%	$130,023		
Probable Construction Cost Estimate		**$2,730,486**		
Design Engineering, Geotechnical, and Construction Management	10%	$273,049		
Property Acquisition Cost:		$0		
Total Conceptual Cost Estimate		**$4,627,152**		

Additional Comments