CMAP Stormwater Planning Concept
December 2014

Planning-Level Stormwater Management Approach

Introduction

A stormwater management approach integrated with comprehensive land use planning can help articulate problem areas and causes and begin to identify on-the-ground opportunities for improvements that can reduce flooding. The following planning approach was developed to standardize the identification of potential flooding issues and solutions for communities in Cook County. The approach uses a data-driven process at the planning level to integrate stormwater management into decisions about land use and development. It does not include hydrologic and hydraulic (H&H) modeling, which is cost intensive and beyond the typical scope of general comprehensive plans. This approach, however, will conduct a needs and opportunities assessment to identify potential project locations for further analysis. This approach provides a holistic approach to stormwater management and seeks to address localized projects in a regional context.

Flooding is a term that refers to the detrimental effects of the excess flow of water. Stormwater flooding is flooding that is induced by heavy rainfall or snowmelt (as opposed to infrastructure failures such as dam breaks and watermain breaks, which can also cause severe and dangerous flooding). Stormwater flooding can cause serious problems in urban areas including damage to residential and commercial structures, disruption of traffic flow, and delay of emergency services. Flooding can also be a nuisance when it leads to debris deposits, persistent standing water, and damage to landscaping. Repair and clean-up of nuisance flooding diverts municipal resources from beneficial functions.

In urban areas, stormwater flooding can be one of the following types:

<u>Riverine flooding</u> – flooding that occurs when excess flow causes a river or stream to overflow its banks

<u>Ponding and overland flow</u> – flooding that occurs when local drainage capacity is not adequate to convey stormwater runoff to the receiving stream or when the local topography does not support positive drainage of runoff

<u>Basement back-up</u> – structure flooding caused by combined or separate sanitary sewers that have been overloaded by rainfall or snowmelt induced inflow

While these types of flooding have disparate causes and potential solution strategies, it is important that a stormwater management planning process recognize all of them, both to maximize service to the community and to assure that the solution to one flooding issue does not exacerbate another.

During recent years, studies have indicated that climate change has been leading to an increase in the severity and frequency of extreme storms (Karl et al, 2009, p.18). There is further evidence that this has been and will be particularly true in the upper Midwest, including the Northeast Illinois region. Solution strategies developed in this stormwater management approach should be adaptive and resilient to accommodate the likelihood of further changes in storm characteristics. It is anticipated that existing flooding problems will be made worse by the impacts of climate change due to the noted increase in storm frequency and intensity. While this approach cannot predict whether areas that have never flooded will flood in the future, it can identify solutions to mitigate existing problem areas.

Purpose

The purpose of this approach is to inform stakeholders and decision makers about potential flooding mitigation options, including green infrastructure (GI). It is meant as a cost-effective planning tool to assess flooding issues and identify potential land use opportunities for distributed GI and site-specific mitigation solutions. It is not meant to identify specific engineered structural solutions (grey infrastructure) to any of the identified problems. Problems and solutions related to grey infrastructure would require advanced engineering analysis, either by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) or consultants.

It is important to note that severe flooding problems require both grey and green infrastructure solutions. Land use solutions can mitigate many flooding issues; however, they are only a part of the total solution. Furthermore, GI has its limitations and is not intended to solve severe flooding problems; GI is typically sized to capture the first half-inch to inch of rainfall and is, therefore, best suited for the more frequent and smaller storm events. There may be opportunities or the need to coordinate with local stormwater management agencies in order to achieve efficiencies and create the best outcomes considering both grey and green infrastructure practices.

Approach

The proposed stormwater management planning approach consists of three main tasks: data collection and development of a GIS database, data analysis to identify problems and opportunities in the community, and preparation of the proposed plan and implementation strategy. Each of these tasks is described below. Within each task, it is critical to receive input from stakeholders and municipal operations personnel as these individuals are most familiar with the specific characteristics and root causes of flooding issues in the community. No amount of technical data can duplicate the definitive information provided by on-site observations.

Data Collection

The initial task involves collection of readily available spatial data and development of a GIS database. MWRDGC's Detailed Watershed Plans (DWPs) should also be referenced to compile applicable runoff rates for various storms and other information from completed modeling. Additional data sources may be added to account for site-specific concerns and constraints. Also, general knowledge of the study area, such as whether the sewer system is combined or separated, should be included to strengthen the analysis and recommendations. Table 1 lists several types of data that can be analyzed to identify flooding problems, solutions, and constraints for those solutions.

Data Analysis

The second task is to analyze the collected spatial data to identify potential drainage problem areas and opportunity areas. This analysis includes mapping multiple datasets in GIS, performing spatial intersections of the data, and developing a scoring methodology to prioritize areas.

As a first step in the analysis, a surface drainage assessment can be conducted using topographic data to identify surface flow paths and potential ponding areas, and also to delineate general areas tributary to those ponding areas and the potential severity of the problem. Any available FEMA repetitive loss property data, historical stream mapping, or reported problem area information can supplement the surface drainage assessment and further identify flooding problems.

Table 1: GIS Data Needs		
Data	**Source**	**Scale**
Data Needs for Identifying Flooding Problems		
Topography (land surface elevations and slopes)	USGS DEM (3-meter resolution)[1]; LiDAR (2011) to supplement where more detail is required	Watershed
Floodplains	FEMA DFIRM	Municipal
Repetitive/Severe Repetitive Loss Properties	*FEMA*	*Cluster of properties*
Historical stream mapping	*Georeferenced USGS quad or other*	*Any; ¼-mile buffer should be applied*
Reported problem areas	*Community meetings/interviews*	*¼-mile buffer should be applied*
Data Needs for Identifying Flooding Solutions		
Land use data	CMAP Land Use Inventory	Municipal
Parcel data	CMAP Land Use Inventory	Municipal
Data Needs for Identifying Constraints in Siting GI and Identifying Solutions		
Areas of shallow groundwater	*May be available from university research or based on municipality experience*	
Underground infrastructure	*Community GIS system*	*Municipal*

Notes:
1. DEM subwatershed boundary data does not consider stormwater infrastructure and related capacity in its mapping, but rather it provides a general understanding of surface drainage patterns and what may happen when existing stormwater infrastructure capacity is exceeded.
2. *Data in italics are optional, if available*

Building from the surface drainage assessment, the second step in the analysis includes the identification of opportunities for the implementation of drainage improvements and flooding solutions, with a focus on GI. This step in the analysis uses land use and parcel data and focuses on characteristics such as zoning, current uses, and ownership, prioritizing publicly-owned land, vacant land, and street rights-of-way, particularly alleys. If available, the drainage improvement opportunity areas can be further refined based on potential site-specific constraints to siting solutions such as areas of shallow groundwater or apparent utility conflicts.

In addition to technical data and geographical mapping characteristics, prioritizing drainage improvement opportunity areas will also depend on political, economic, and community realities. Thus opportunity areas should be further prioritized based on the ability to expand upon existing GI, planned street or sewer separation projects, availability of funding, potential partnership opportunities, and community greening needs.

Determining how best to score and rank the various data is critical to siting GI and identifying solutions. Based on the variables identified in Table 1, a two-tiered scoring methodology was developed to first identify and rank drainage problem areas, and then identify and rank GI drainage improvement opportunity areas. To develop scores and rankings, subwatersheds in the community are used as the analysis areas. Subwatershed boundaries are based on USGS DEM data as described in Table 1. As one would expect, in many instances subwatersheds span multiple communities and do not align with city boundaries and thus land use development and stormwater drainage patterns in one community may impact flooding locations and exacerbate problems in other communities. However, for the purposes of this analysis, only the portions of subwatersheds within a particular community will be included in the scoring and ranking to allow for community specific use of this stormwater planning concept approach.

For each of the variables used to identify potential drainage problem areas, a range of values was developed and from there a numeric score is developed for each subwatershed. This approach allows for comparison across the subwatersheds to identify the subwatersheds with the highest score, equating to the greatest potential for flooding problems. The variables, corresponding values, and scores are shown in Table 2.

The top 5 to 10 subwatersheds with the greatest potential flooding problems are carried forward for further analysis. In addition, subwatersheds adjacent and upstream of the top subwatersheds are also carried forward because they present potential opportunity areas to capture stormwater and reduce downstream flooding in the subwatersheds most likely prone to flooding. As such, the areas of these subwatersheds are added to the top subwatersheds and carried forward as “analysis areas” for further analysis.

To score and rank potential drainage improvement opportunity locations within these analysis areas, the relevant land use and parcel data is scored. The parcels within the community consisting of schools, vacant land, public buildings/grounds, parks/open space, and alleys are tallied for each of the top analysis areas. The analysis area with the most area corresponding to the relevant land uses is identified as having the highest potential opportunities for the implementation of drainage improvements and flooding solutions. Where data is available, the analysis areas are further refined based on areas with shallow groundwater and potential utility conflicts. Land use and parcel data and site-specific constraint variables are considered of primary importance while political, economic, and community characteristics are considered to be of secondary importance. As such, a weighting factor is applied. See Table 2 for variables, corresponding values, scores, and weighting factors.

Test Case Analysis

The City of Berwyn was used as a test case analysis to illustrate the application of the planning level stormwater management approach. To identify potential flooding problems, DEM subwatershed topography was mapped to identify low areas in the community. In addition, reported problem flooding area information was georeferenced and mapped across subwatersheds. Figure 1 provides a graphical representation of this information.

Based on the value structure described in Table 2, a composite score of the low areas and reported problem areas for each subwatershed was calculated, indicating which subwatersheds have the most potential for flooding. Figure 2 shows the subwatersheds with the most potential for flooding.

As shown in Figure 2, there are 7 subwatersheds that have the greatest potential for flooding problems. In addition, portions of subwatersheds upstream of these top 7 subwatersheds contribute flow to these top subwatersheds. As such, the areas of these upstream subwatersheds that are within the city limits of Berwyn are added to the top 7 subwatersheds and together carried forward as “analysis areas” for further analysis. Figure 3 shows these expanded analysis areas, labeled A through F.

In the case of Berwyn, land use and parcel data for schools, vacant land, public buildings/grounds, parks/open space, and alleys, the land uses publicly owned and with most potential as drainage improvement opportunity locations, was readily available. The area of each land use type in analysis areas A through F is shown in Table 3. Figure 4 shows these land uses across the analysis areas, depicted at a parcel level.

Table 2: Scoring Methodology			
Variable	**Value**	**Score**	**Weighting Factor**
Drainage Problem Areas Identification			
Surface Drainage Assessment Data			
Low areas based on topographic data	No low areas Minor (0.5 - < 1 acre) Major (> 1 acre)	0 5 10	1
Repetitive loss/severe repetitive loss data	Not containing or adjacent Contains or adjacent	0 10	1
Historic stream locations that intersect with developed areas	Not containing or adjacent Contains or adjacent	0 10	1
Reported drainage problem areas (based on citizen complaints and stakeholder input)[1]	Low Medium High	0 5 10	1
Drainage Improvement Opportunity Areas Identification			
Land Use and Parcel Data			
schools, vacant land, public buildings/grounds, parks/open space, and alleys[1]	Low Medium High	2.5 5 10	1
Site-Specific Constraints			
Areas of shallow groundwater	Greater than or equal to 50% of area 25% to < 50% 10% to < 25% < 10%	0 2.5 5 10	
Utility conflicts	Major (>1 conflict) Minor (1 conflict) No conflicts	0 5 10	1
Political, Economic, and Community Characteristics			
Areas with existing GI strategies to expand capacity	Not containing or adjacent Contains or adjacent	0 10	0.5
Planned street/sewer separation projects	Not containing or adjacent Contains or adjacent	0 10	0.5
Grant and funding opportunities	No Yes	0 10	0.5
Potential for partnerships	No Yes	0 10	0.5
Community greening needs	No Yes	0 10	0.5

Notes:

1. The three classes of low, medium, and high values are based on natural breaks in the data and will vary from community to community

Table 3: GIS Land Uses, Areas and Percentages											
Analysis Areas	Total Area	Schools		Vacant Land		Public Buildings/Grounds		Open Space/Park		Alleys	
		Area	%	Area	%	Area	%	Area	%	Area	%
A	428,038	-	-	-	-	-	-	-	-	23,482	5.49
B	1,280,713	6,807	0.53	1,815	0.14	-	-	-	-	777	0.06
C	4,319,996	85,612	1.98	-	-	53,972	1.25	575,566	13.32	179,002	4.14
D	94,400	-	-	-	-	-	-	-	-	5,810	6.15
E	3,582,533	60,858	1.70	11,232	0.31	-	-	-	-	149,466	4.17
F	6,040,786	-	-	3,475	0.06	-	-	-	-	324,183	5.37
G	79,080	-	-	-	-	-	-	-	-	-	-

Notes:
1. All area measurements are in square feet.
2. Percentages represent the percentage of a particular land use in an analysis area. For example, 13.32 % of Analysis Area C consists of parks or open space.

A composite total area of relevant land uses with drainage improvement opportunity locations - schools, vacant land, public buildings/grounds, parks/open space, and alleys – was calculated for each of the analysis areas. Based on the composite areas, the analysis areas were ranked from most to least based on potential for implementation of drainage improvements and flooding solutions. The composite scores are shown in Table 4 and mapped in Figure 5.

Table 4: Composite Score and Ranking of Analysis Areas Based on Land Uses with Drainage Improvement Opportunity Locations				
Analysis Areas	Total Area	Composite Land Use Area	%[2]	Ranking[3]
A	428,038	23,482	5.49	4
B	1,280,713	9,399	0.73	6
C	4,319,996	894,152	20.70	1
D	94,400	5,810	6.15	3
E	3,582,533	221,555	6.18	2
F	6,040,786	327,658	5.42	5
G	79,080	-	-	7

Notes:
1. All area measurements are in square feet.
2. Percentages represent the percentage of the combined land use in an analysis area that include drainage improvement opportunity locations. For example, 20.70 % of Analysis Area C consists of land uses identified as having opportunity locations for drainage improvements.
3. A ranking of 1 corresponds as having the most potential for implementation of drainage improvements; a ranking of 7 has the least.

As seen in Figure 5, Analysis Area C presents the most potential for drainage improvement in the areas of Berwyn that show signs of the most flooding problems.

Prepare Proposed Plan and Implementation Strategy

The final task is to develop a proposed comprehensive plan and implementation strategy that incorporates the findings of the data analysis. Table 5 illustrates how the steps would be integrated into CMAP's standard process for developing comprehensive plans.

Table 5: Comprehensive Plan Integration	
Comprehensive Planning Process	***Enhanced Stormwater Planning Steps***
Community outreach and engagement – CMAP engages municipal staff, elected officials, residents, business owners, and others in the planning process through public meeting, online surveys, focus groups, and stakeholder interviews	Gather municipal and resident feedback on problem areas within the community
Existing conditions analysis – CMAP compiles information on the existing conditions of the community; including review of the historical context, previous planning efforts, demographics, land use, housing, transportation, and natural resources	Gather GIS data and conduct analysis. Prepare maps illustrating the types, locations, and extent of identified problems in the community
Vision development – CMAP works with community to develop a shared vision of the community; informed by the existing conditions analysis and public engagement steps	Develop a menu of community-appropriate mitigation measures to include distributed and centralized GI, land use controls, and targeted buy-outs, and establish when each can be used
Draft plan – CMAP prepares a memo describing key recommendations expected to be contained in the final plan. After reaching consensus, CMAP then develops a draft plan with recommendations on various topics, such as housing, land use, transportation, etc. The plan also outlines an implementation strategy.	• Overlay problem areas with opportunity areas and use the overlay to identify potential improvement sites • Evaluate each potential improvement based on stakeholder criteria (aesthetics, consistency with adjacent land uses, potential adverse effects) as well as other planning objectives • Identify problems that require engineered structural solutions, that is, problems that cannot be mitigated or solved with land use controls or GI • Formulate a recommended improvement plan and prepare a list of implementation steps and needs
Plan adoption process	

Future Applications

The land uses chosen for the Berwyn test case analysis did not include commercial, industrial, residential or other privately owned land. Depending on the community, individual property owners, specifically owners of larger parcels, may be amenable to green infrastructure projects. Thus, it might make sense for certain communities to expand this analysis to include private land uses. In addition, the analysis of Berwyn did not rank one land use over another and did not weight one land use or other variable higher than another. In certain communities, parks may be more heavily weighted as drainage improvement areas then alleys, for example. Input from stakeholders and municipal operations personnel can help inform this prioritization. Lastly, the Berwyn analysis did not take into account the ability to expand upon existing GI, planned street or sewer separation projects, availability of funding, potential partnership opportunities, and community greening needs. These variables should be considered when available in determining potential GI projects.

Future application of the GIS database developed through this approach may also include the addition of grey infrastructure data sources (channels, pipes, reservoirs, stormwater inlets, etc.) and high inflow and infiltration (I/I) areas to evaluate drainage system capacity limitations, identify grey infrastructure solutions, and better site green infrastructure.

References

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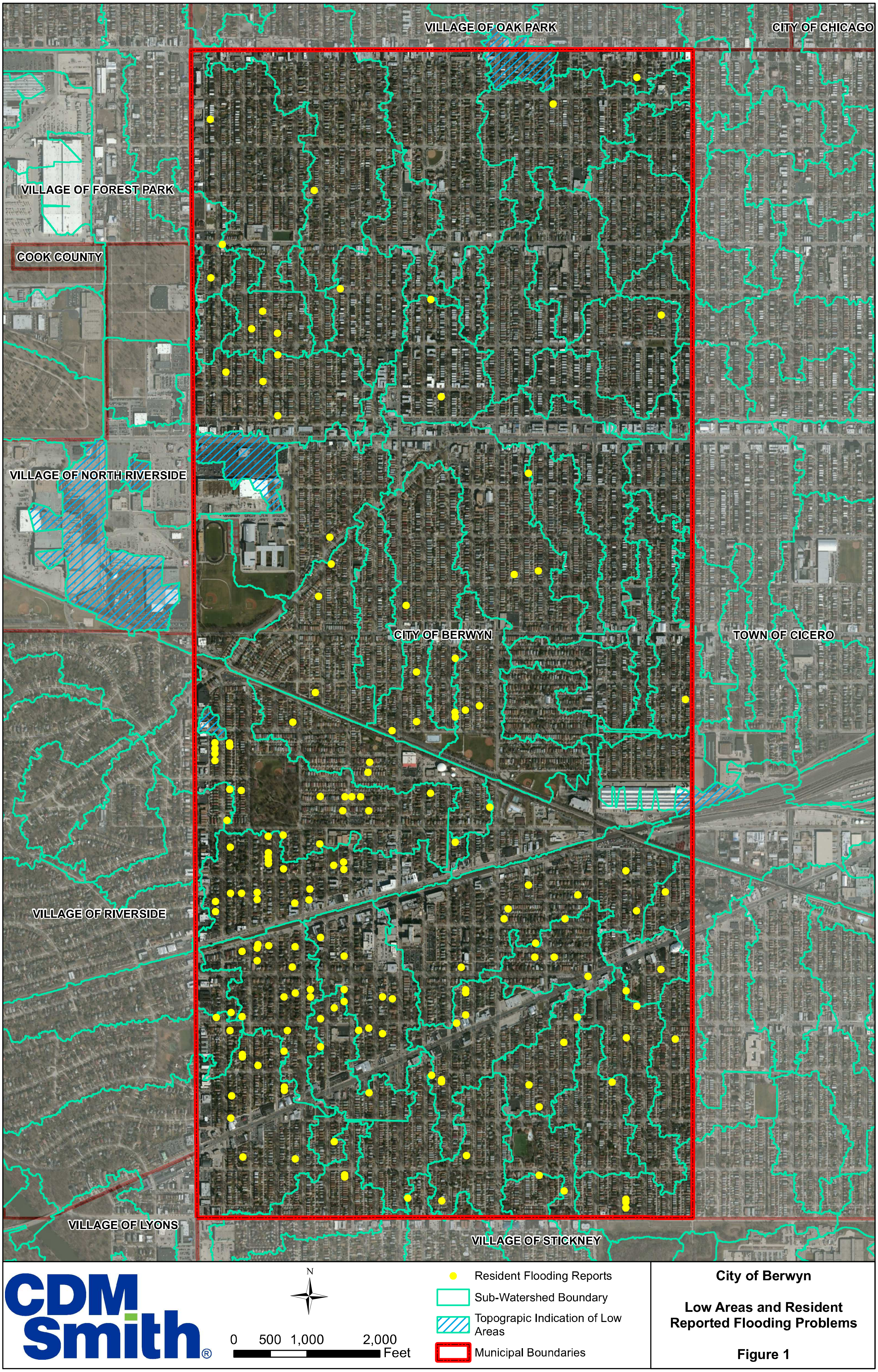
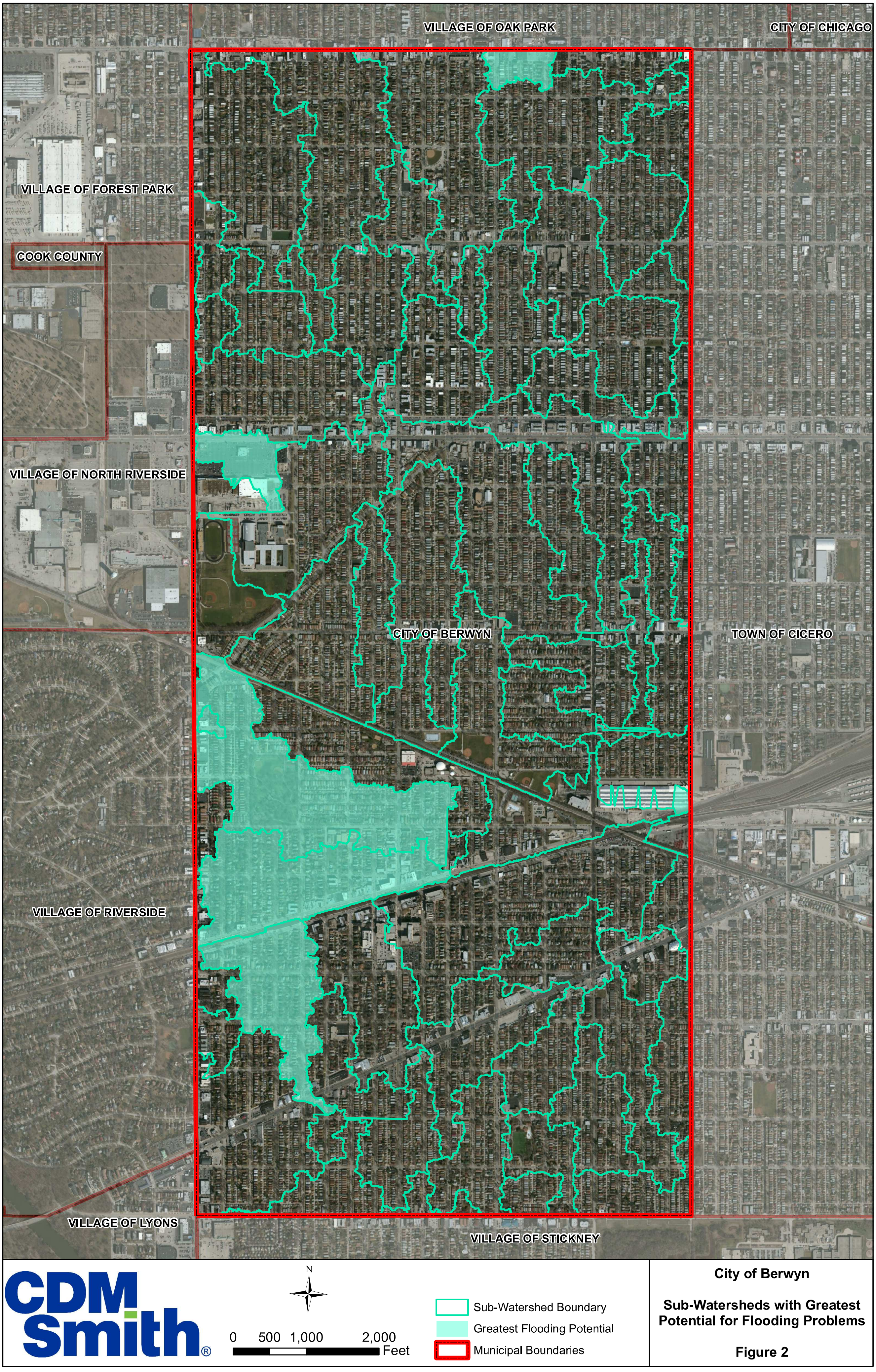


CDM Smith

City of Berwyn

Low Areas and Resident Reported Flooding Problems

Figure 1



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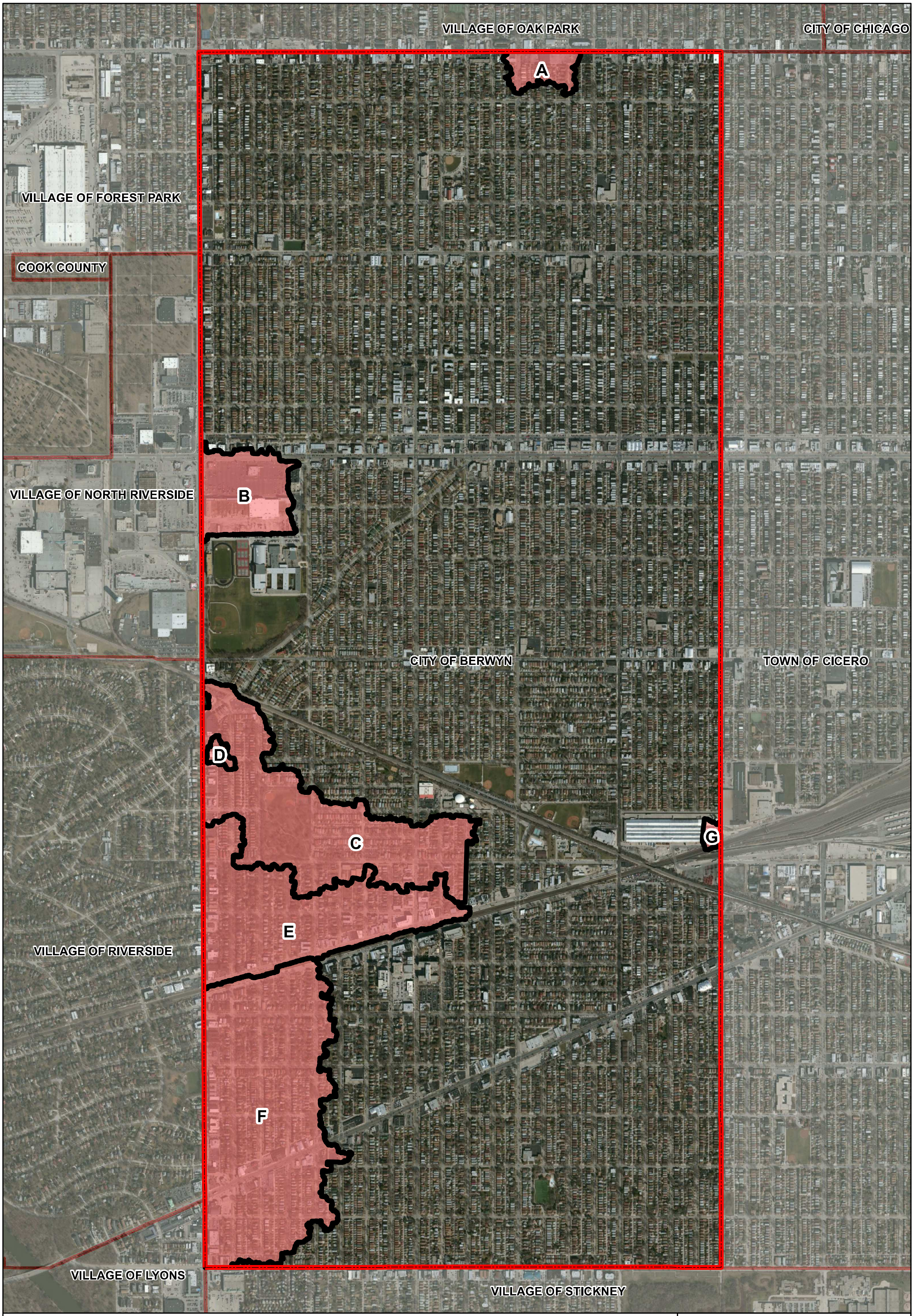
Sub-Watersheds with Greatest Potential for Flooding Problems

Figure 2



CDM Smith

N

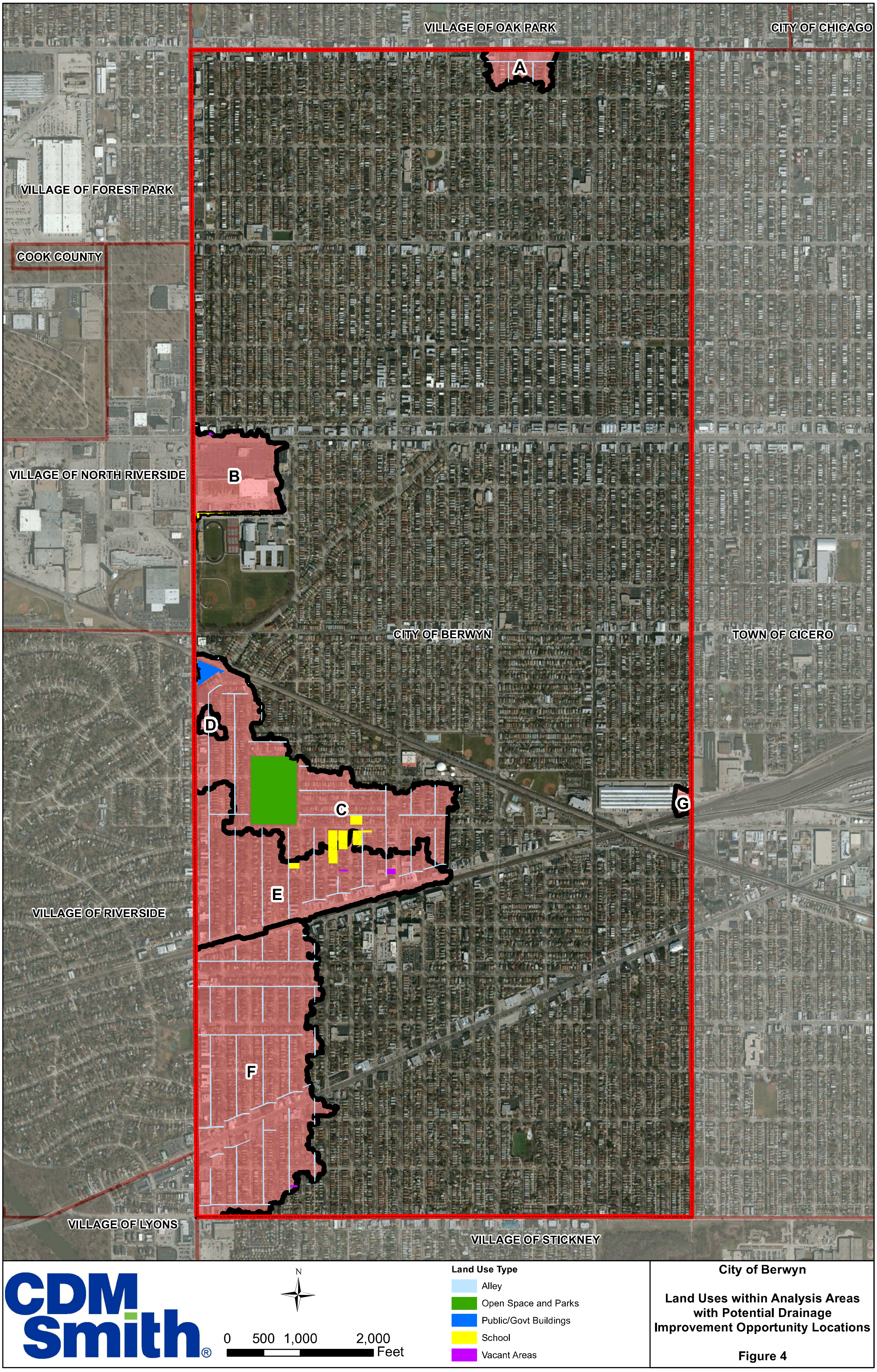
0 500 1,000 2,000 Feet

Greatest Potential for Flooding Problems

City of Berwyn

Analysis Areas with Greatest Potential for Flooding Problems

Figure 3



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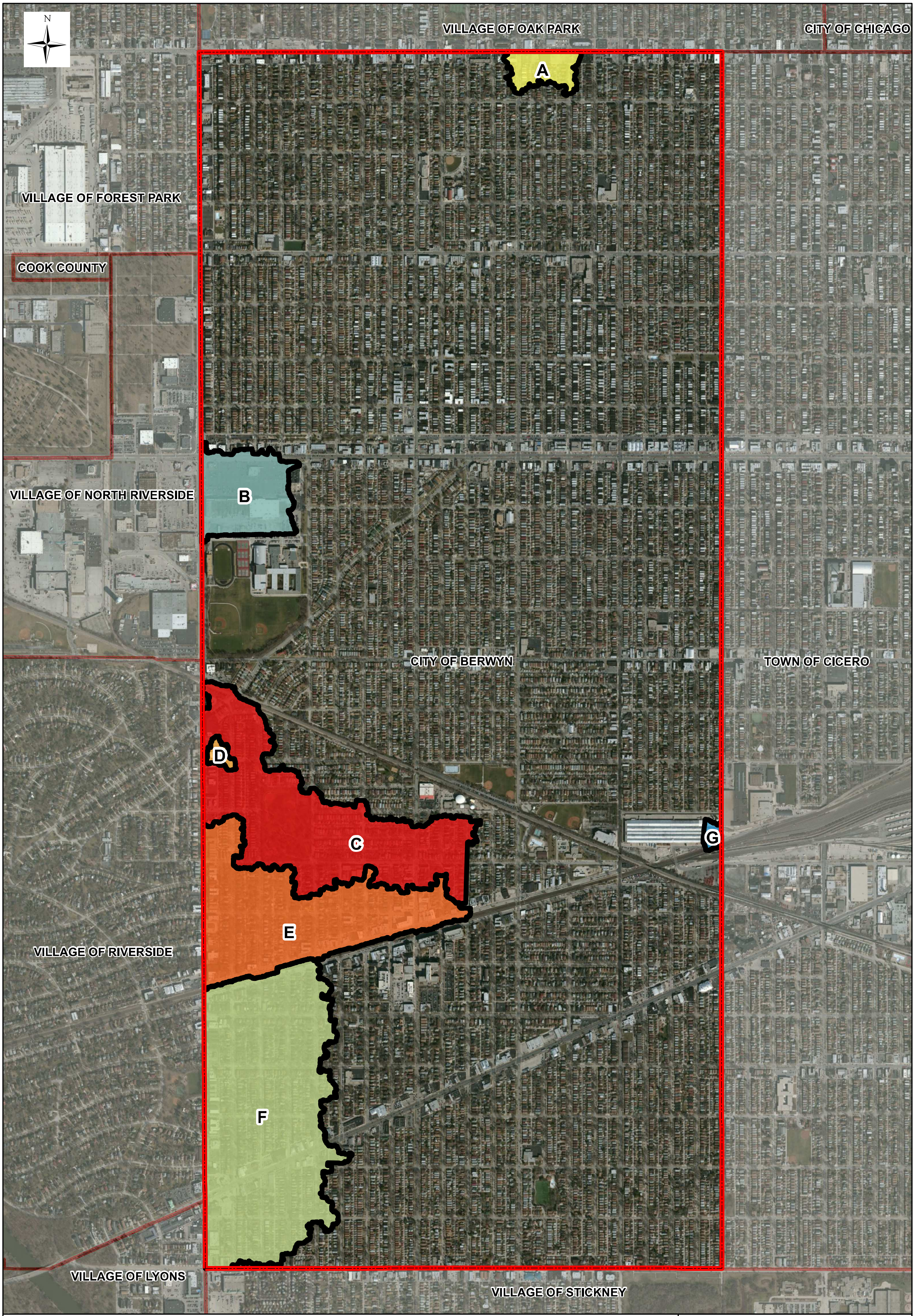
Land Uses within Analysis Areas with Potential Drainage Improvement Opportunity Locations

Figure 4



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Potential for GI Ranking

- 1
- 2
- 3
- 4
- 5
- 6
- 7

City of Berwyn

Potential for Green Infrastructure Final Ranking

Figure 5