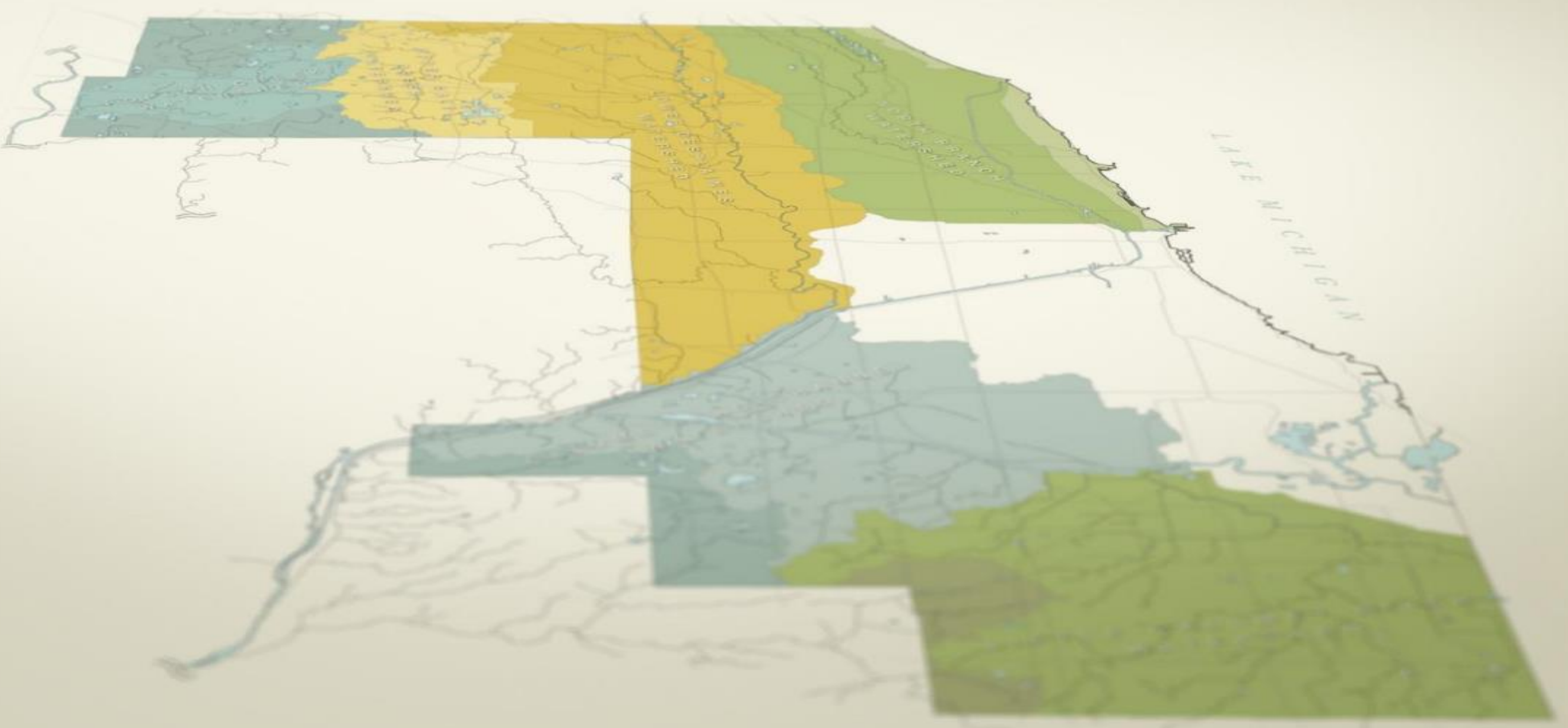
Impact of Watershed Specific Release Rates on Disproportionately Impacted Communities in Cook County



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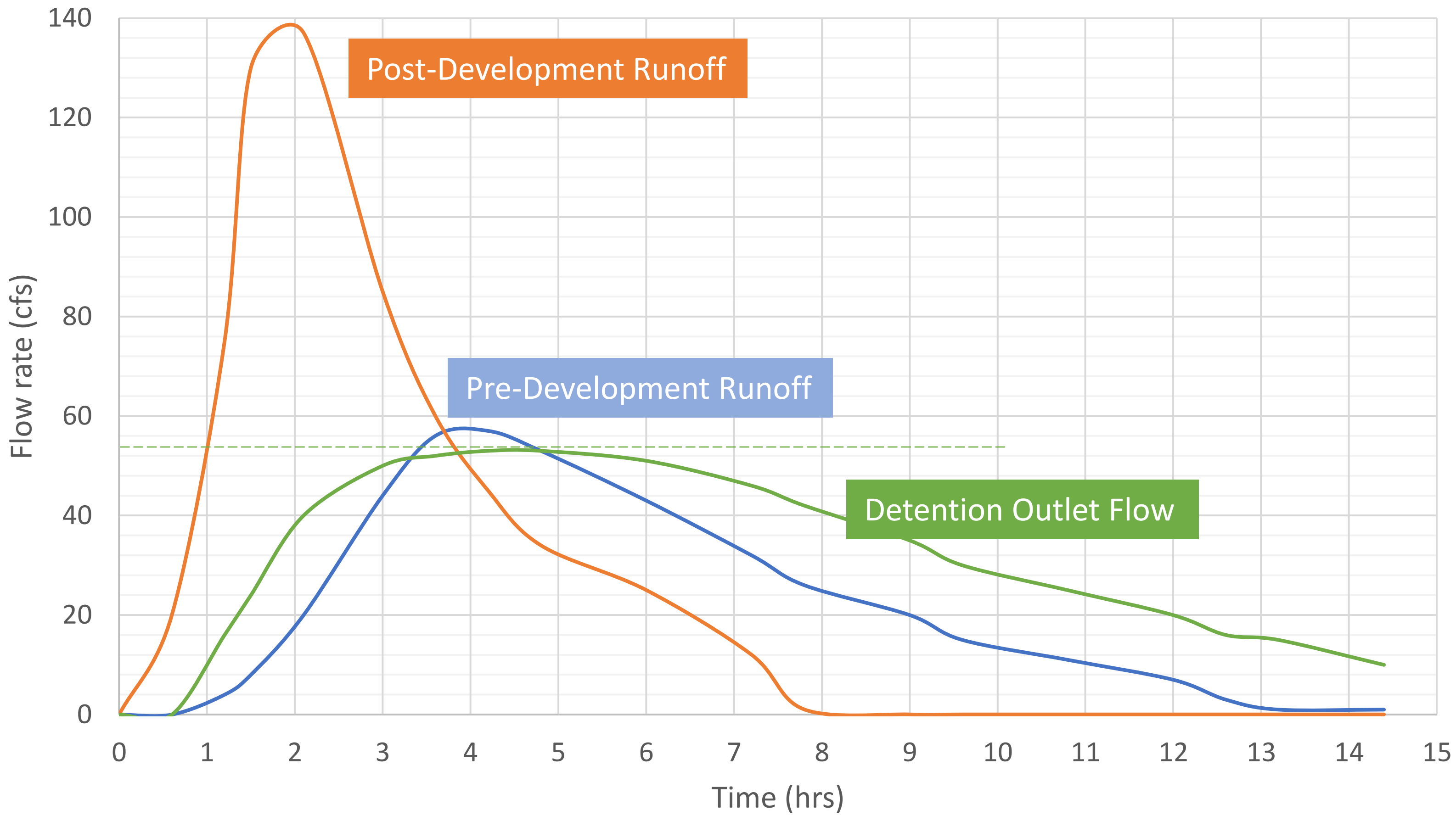
Nikhil Sangwan
Gregory Byard

IAFSM
March 14, 2023

Background: Previous Phases

Impact of development on hydrology



Phase I/II Release Rate selection objective:

Determine regulatory release rates that mitigate the impacts of development by maintaining the 1% annual-chance flood event elevations at or below current levels.

Phase I and II Study

Contract Report 2019-06
March 2019

Watershed-Specific Release Rate Analysis: Cook County, Illinois

Amanda Flegel, Gregory Byard, Sally McConkey, Christopher Hanstad, Nicole Gaynor, Zoe Zaloudek

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Illinois State Water Survey-
- Carried out the study and released ISWS Contract Report 2019-06 in March 2019

MWRD Board of Commissioners-
- May 16, 2019 update to the Water Management Ordinance (WMO)
    - Adopted recommended release rates, effective Jan 1, 2020
    - Update also included provisions for additional future studies related to watershed specific release rates under WMO Article 208

APPENDIX B

Watershed Specific Release Rates

Watershed Planning Area	Gross Allowable Release Rate
Poplar Creek Watershed	0.25 cfs/acre
Upper Salt Creek Watershed	0.20 cfs/acre
Lower Des Plaines Watershed	0.20 cfs/acre
North Branch Watershed	0.30 cfs/acre
Calumet Sag Channel Watershed	0.30 cfs/acre
Little Calumet River Watershed	0.25 cfs/acre

Phase III Study

Water Management Ordinance (WMO) Section 208

“ The District shall initiate a study…The study shall include the following areas:

1. **…**
2. **Impacts of watershed specific release rates on disproportionately impacted communities;**
3. **Impacts of release rates under existing and future development scenarios in collar counties on watersheds in the District;**
4. **Impact of volume control and watershed specific release rates on stream erosion and related water quality effects such as turbidity and sedimentation…"**

Motivation for Section 208.2

Motivation

Inequities in flood risk:

- Low-income and marginalized communities suffer disproportionately[1,2]
- Flood risk heterogeniety due to variability in its constituent elements viz. flood hazard probability, exposure and vulnerability…
- Low-income urban communities tend to occupy more flood-prone areas[3,4]
- Flood risk inequity gap is expected to grow even wider in the future[5,6]

RISK = HAZARD x EXPOSURE x VULNERABILITY

Adapted from World Bank

[1]Wing et al. 2022; [2]Hallegatte 2016
[3]Frank 2020; [4]Fielding 2018
[5]IPCC 2022; [6]USGCRP 2018

Motivation

Flood risk inequities in the Cook County:

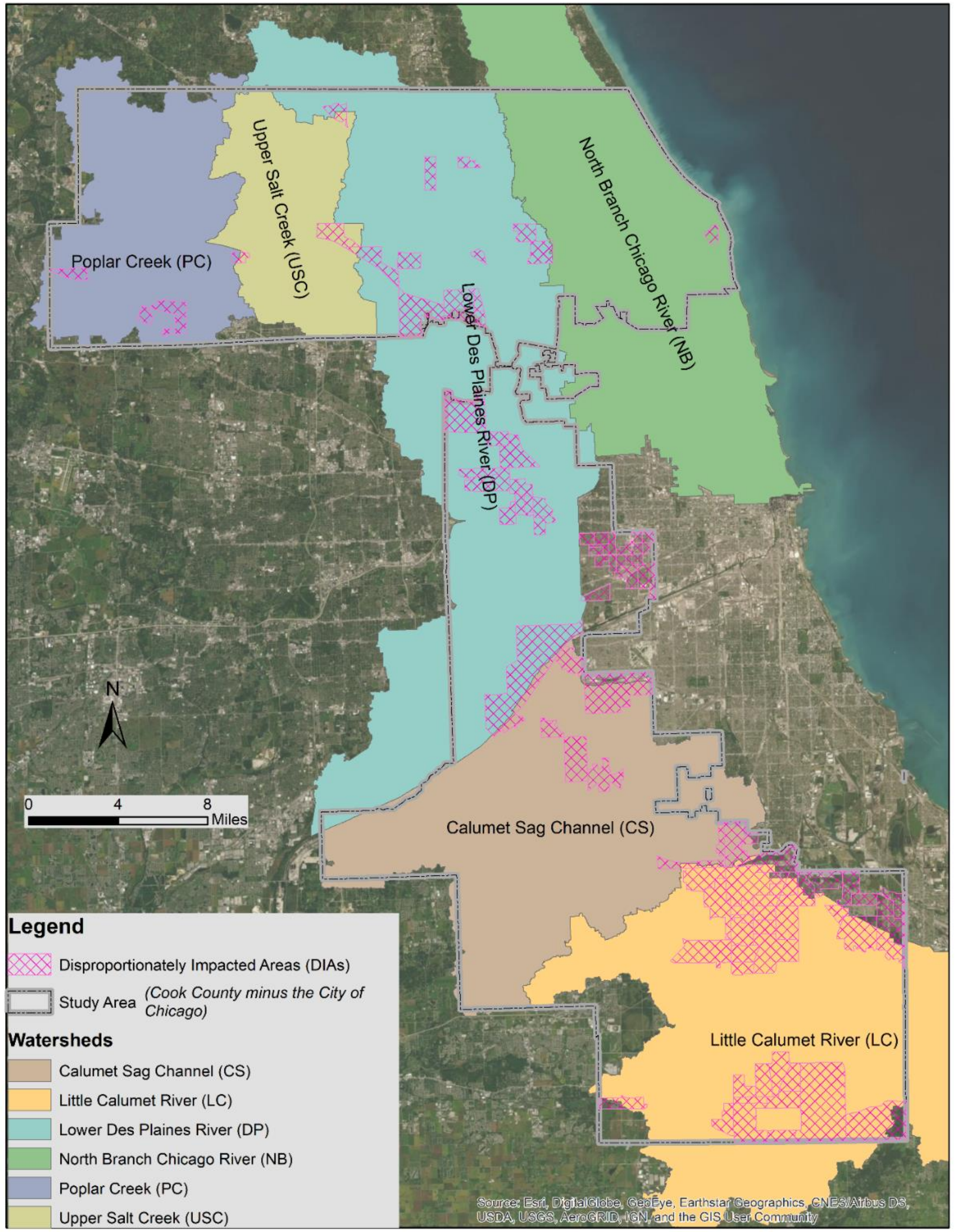
- 87% of the insurance claim payments (2007-2017): Households located in communities of color (typically low income)[7]
- Strong inverse relationship between the # of claims and median household income of a community[8]
- More frequent, heavier precipitation predicted in the future[9]
- Cognizance of inequities and advocacy efforts by communities, governments and NGOs at various levels towards environmental justice

[7]Keenan et al. 2019
[8]Wuebbles et al. 2021
[9]Angel et al. 2020

- Disproportionately impacted areas (DIA) defined by MWRD as "areas with:
  - CMAP Urban or Riverine Flood Susceptibility Index = 5-10, AND
  - Low to Moderate Income level as defined by the U.S. Department of Housing and Urban Development (HUD)".

Study Objectives

Compare the impacts of watershed specific release rates on DIAs and Non-DIAs in terms of
(a) detention storage requirements, and
(b) reduction in peak water surface elevations during a 1% annual chance flood event.



CMAP=Chicago Metropolitan Agency for Planning

Methodology

Methodology

- HEC-HMS and HEC-RAS models from Detailed Watershed Plans (DWP)
- Models updated in 2019 to reflect current watershed hydrology/hydraulics (referred to as base conditions)

Hydrology

- HMS subbasins split 40/60 to simulate 40% future land development scenario
- 100-year 24-hour design storm runoff from developed components routed through a detention basin to meet WMO volume control and release rate requirements

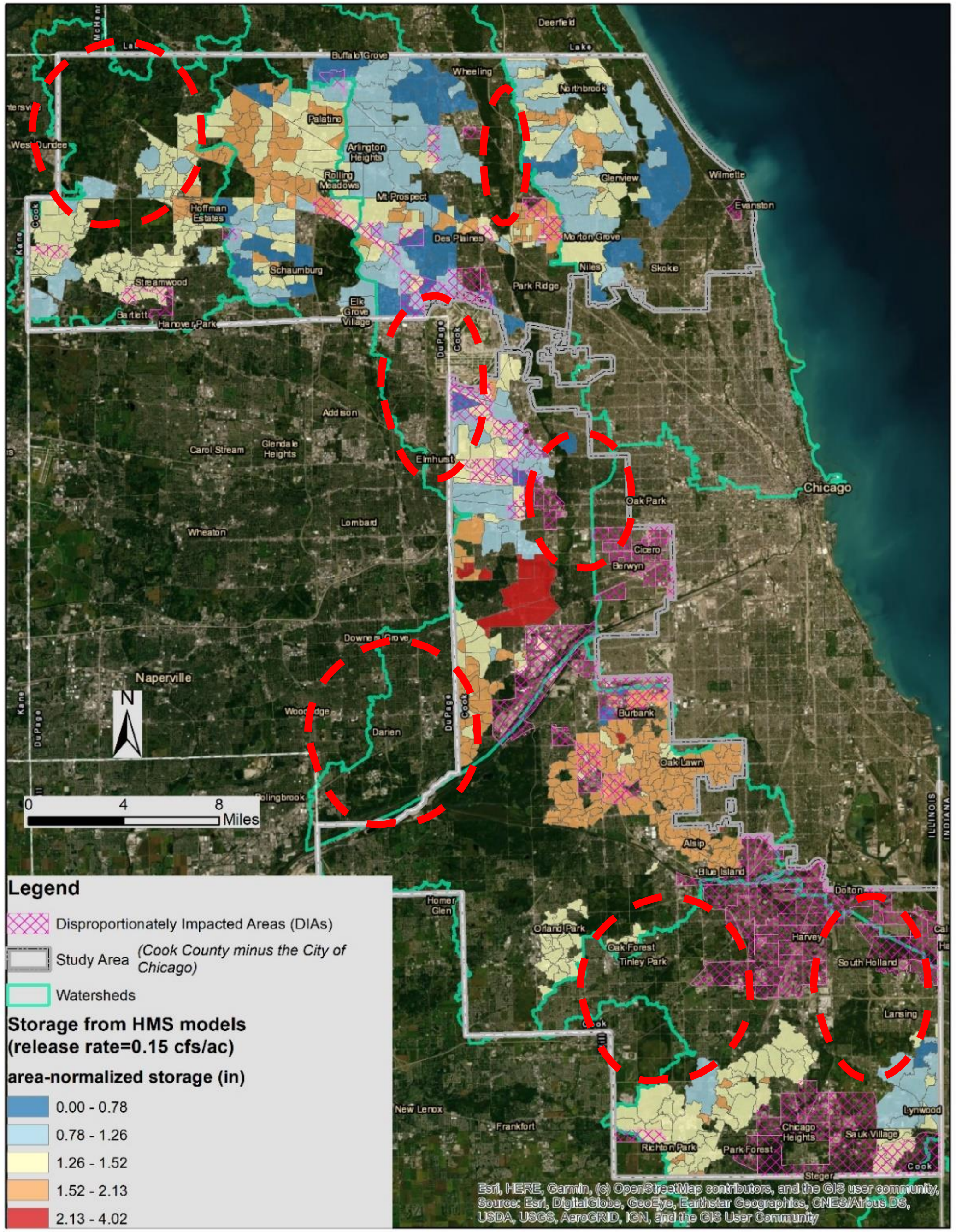
Hydraulics

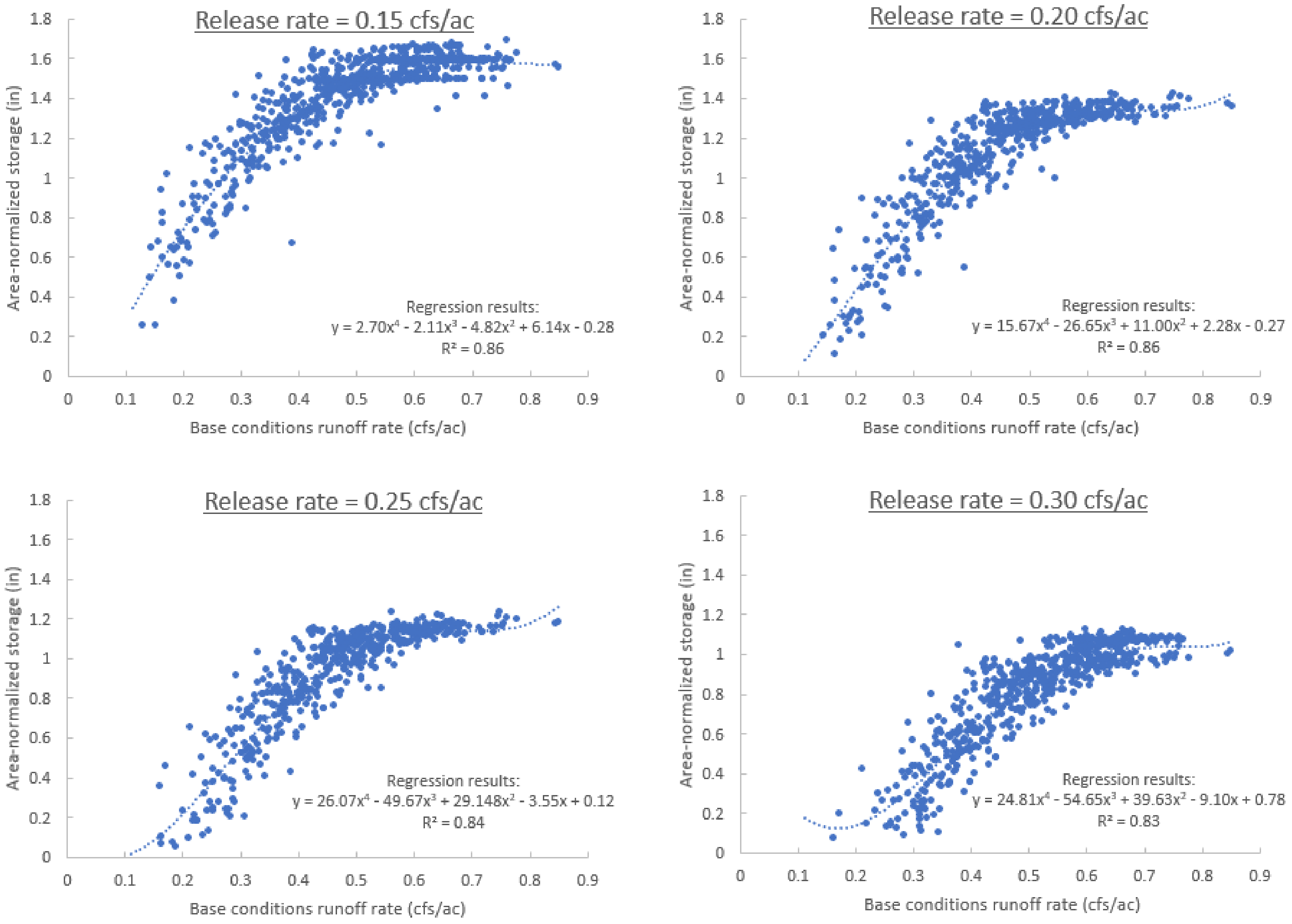
- HEC-HMS flows routed through HEC-RAS unsteady state hydraulic models to obtain peak water surface elevation at various cross-sections

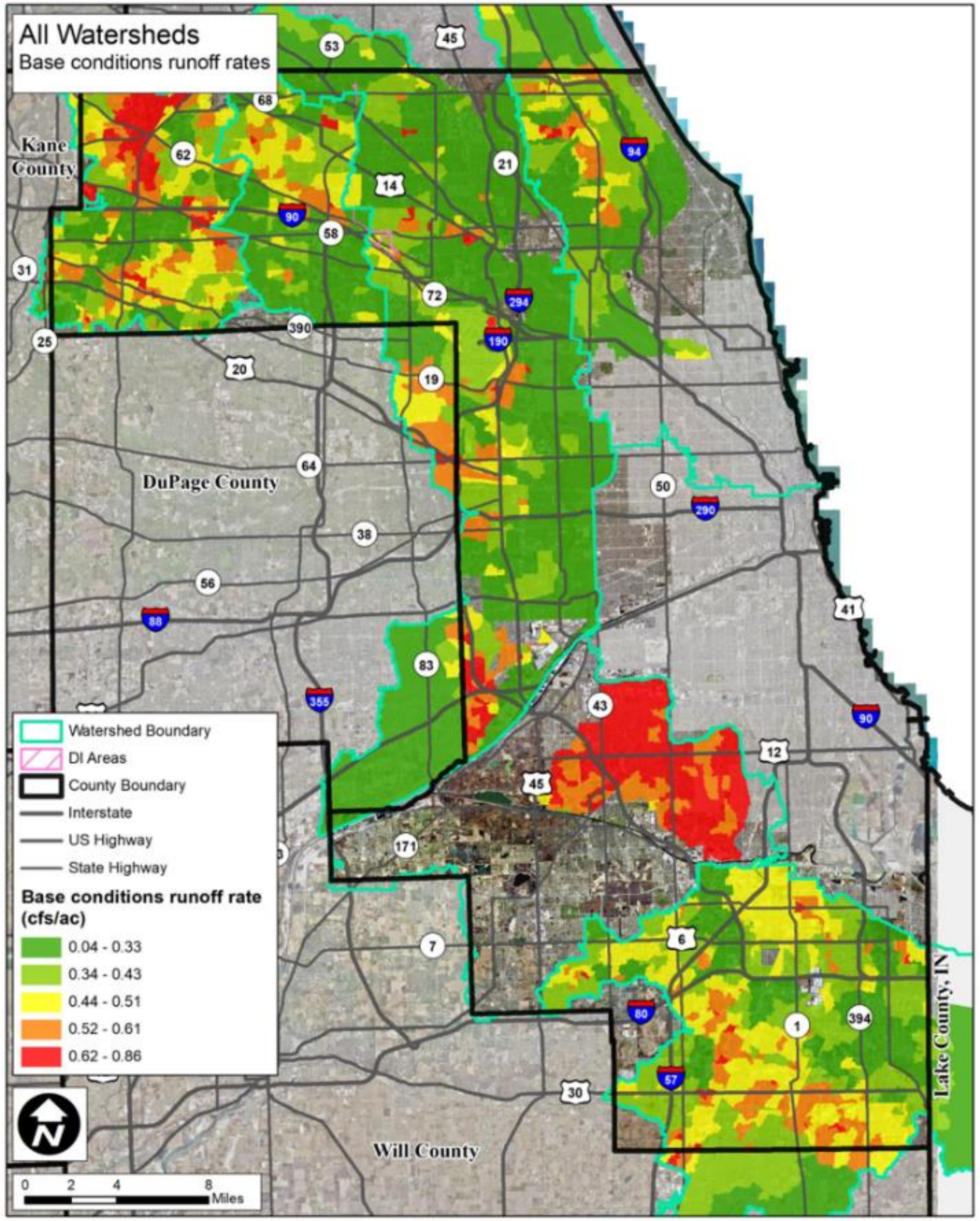
Analyses (Detention storage and peak WSE reduction)

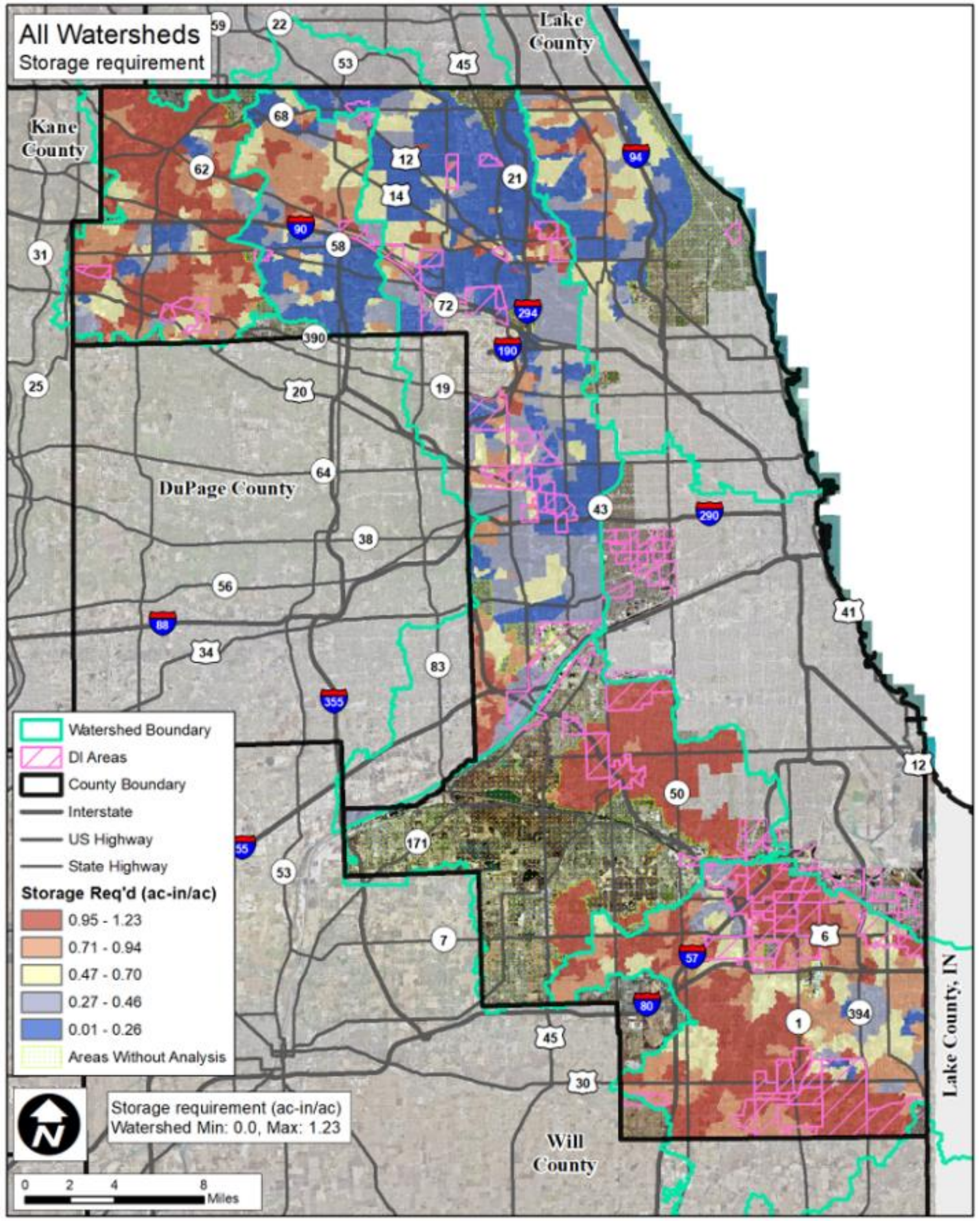
- Four release rate scenarios analyzed: 0.15 cfs/ac, 0.20 cfs/ac, 0.25 cfs/ac and 0.30 cfs/ac

Detention Storage Requirements






All Watersheds
Base conditions runoff rates
Watershed Boundary
DI Areas
County Boundary
Interstate
US Highway
State Highway
Base conditions runoff rate (cfs/ac)
0.04 - 0.33
0.34 - 0.43
0.44 - 0.51
0.52 - 0.61
0.62 - 0.86
Kane County
DuPage County
Will County
Lake County, IN
Miles

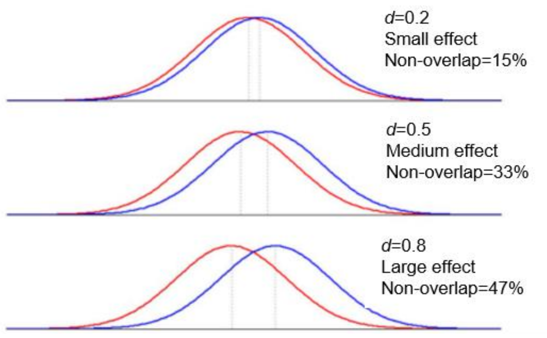

All Watersheds
Storage requirement
Watershed Boundary
DI Areas
County Boundary
Interstate
US Highway
State Highway
Storage Req'd (ac-in/ac)
0.95 - 1.23
0.71 - 0.94
0.47 - 0.70
0.27 - 0.46
0.01 - 0.26
Areas Without Analysis
Storage requirement (ac-in/ac)
Watershed Min: 0.0, Max: 1.23
Lake County
Kane County
DuPage County
Will County
Lake County, IN
Miles

Results

Detention storage requirements

A. Storage Requirement Analysis at Watershed Level

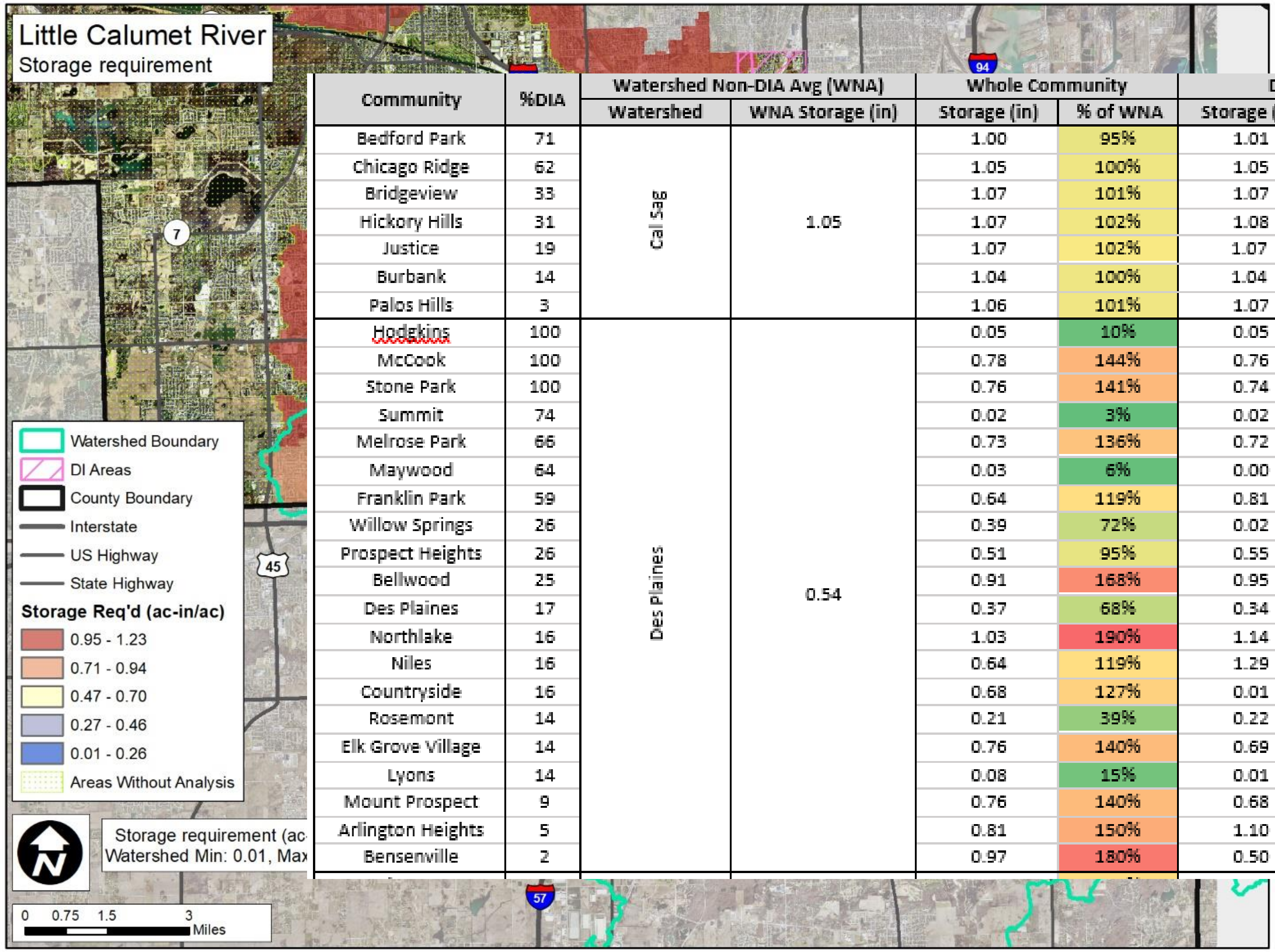
Watershed	DIA (mean storage, in)	Non-DIA (mean storage, in)	Effect size (Cohen's d)
Cal Sag	1.06	1.05	Small (0.2)
Des Plaines	0.57	0.54	Small (0.1)
Little Calumet	0.91	0.82	Med (0.4)
North Branch (NB)	-	0.44	-
Poplar Creek	0.95	0.86	Med (0.4)
Upper Salt Creek	1.05	0.92	Med (0.4)
Overall (excluding NB)	**0.82**	**0.77**	**Small (0.2)**



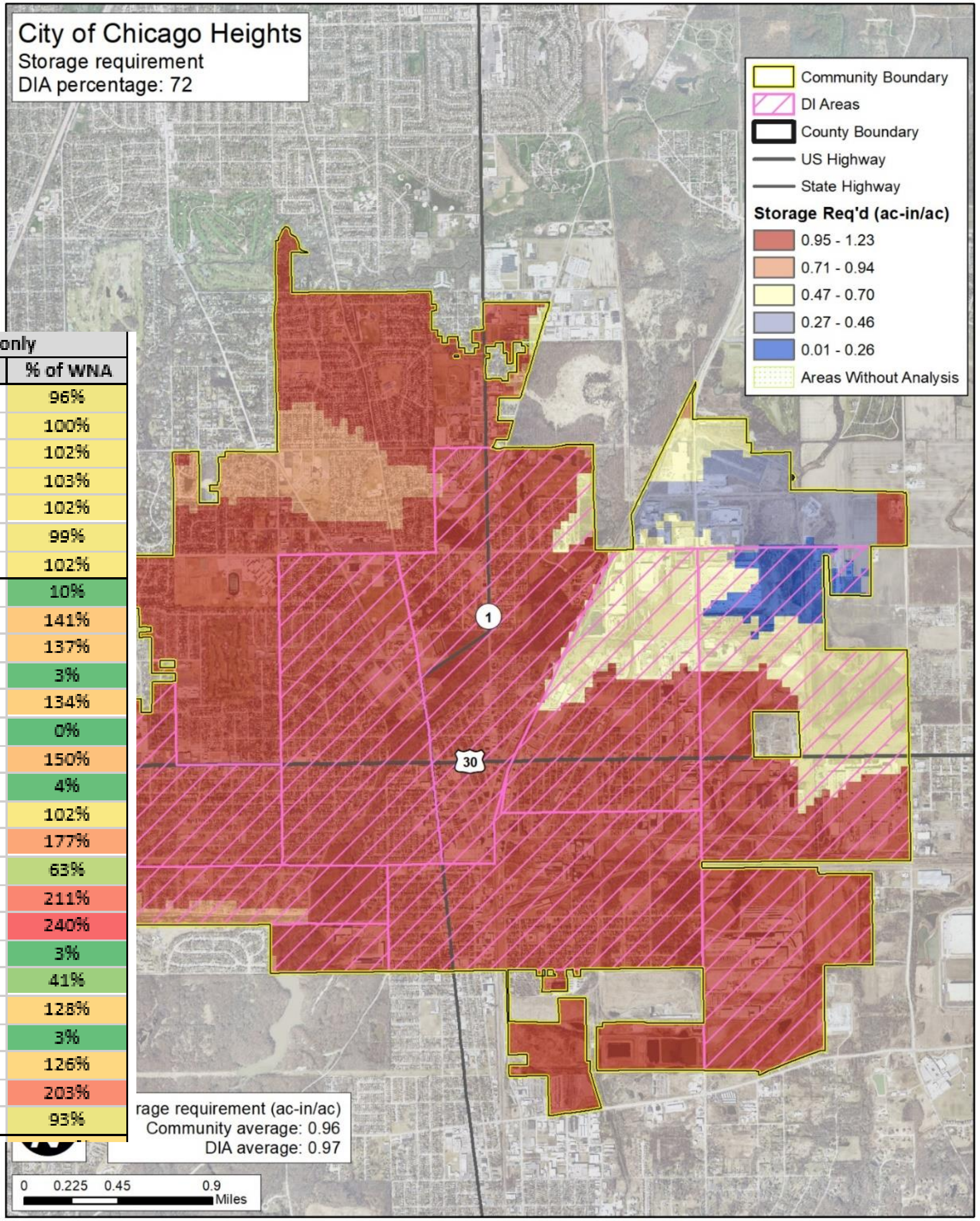
Sullivan and Fienn 2012; Coe 2002

Watershed	DIA (storage, cu. yards/ac)	Non-DIA (storage, cu. yards/ac)	Δ% $\left(\frac{\text{DIA} - NonDIA}{NonDIA}\right)$
Cal Sag	356	354	1%
Des Plaines	192	183	6%
Little Calumet	307	276	11%
North Branch	-	148	-
Poplar Creek	320	289	10%
Upper Salt Creek	354	309	14%
Overall (excluding NB)	**276**	**258**	**6%**

Map Exhibits at Watershed and Community Levels

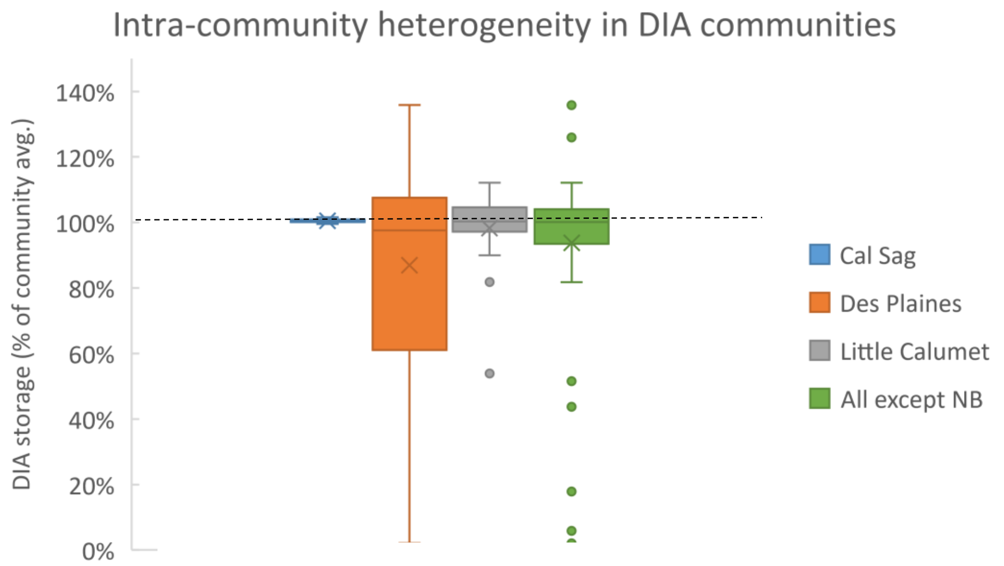


Community	%DIA	Watershed Non-DIA Avg (WNA)		Whole Community		DIAs only	
		Watershed	WNA Storage (in)	Storage (in)	% of WNA	Storage (in)	% of WNA
Bedford Park	71	Cal Sag	1.05	1.00	95%	1.01	96%
Chicago Ridge	62			1.05	100%	1.05	100%
Bridgeview	33			1.07	101%	1.07	102%
Hickory Hills	31			1.07	102%	1.08	103%
Justice	19			1.07	102%	1.07	102%
Burbank	14			1.04	100%	1.04	99%
Palos Hills	3			1.06	101%	1.07	102%
Hodgkins	100	Des Plaines	0.54	0.05	10%	0.05	10%
McCook	100			0.78	144%	0.76	141%
Stone Park	100			0.76	141%	0.74	137%
Summit	74			0.02	3%	0.02	3%
Melrose Park	66			0.73	136%	0.72	134%
Maywood	64			0.03	6%	0.00	0%
Franklin Park	59			0.64	119%	0.81	150%
Willow Springs	26			0.39	72%	0.02	4%
Prospect Heights	26			0.51	95%	0.55	102%
Bellwood	25			0.91	168%	0.95	177%
Des Plaines	17			0.37	68%	0.34	63%
Northlake	16			1.03	190%	1.14	211%
Niles	16			0.64	119%	1.29	240%
Countryside	16			0.68	127%	0.01	3%
Rosemont	14			0.21	39%	0.22	41%
Elk Grove Village	14			0.76	140%	0.69	128%
Lyons	14			0.08	15%	0.01	3%
Mount Prospect	9			0.76	140%	0.68	126%
Arlington Heights	5			0.81	150%	1.10	203%
Bensenville	2			0.97	180%	0.50	93%



B. Storage Analysis at Community Level

WNA=Watershed Non-DIA Average



Highlights:

- Overall, most DIA communities have DIA storage requirements between 90% and 125% of WNA.
- The Des Plaines River Watershed has the widest range in the deviation from WNA.

Highlights:

- Overall, only mild heterogeneity seen within DIA communities
- Cal Sag Watershed DIA communities are remarkably homogeneous. Des Plaines exhibit wide variation.

Results

Flood Mitigation Levels

A. Flood Mitigation Levels (dW) Analysis at Watershed Level

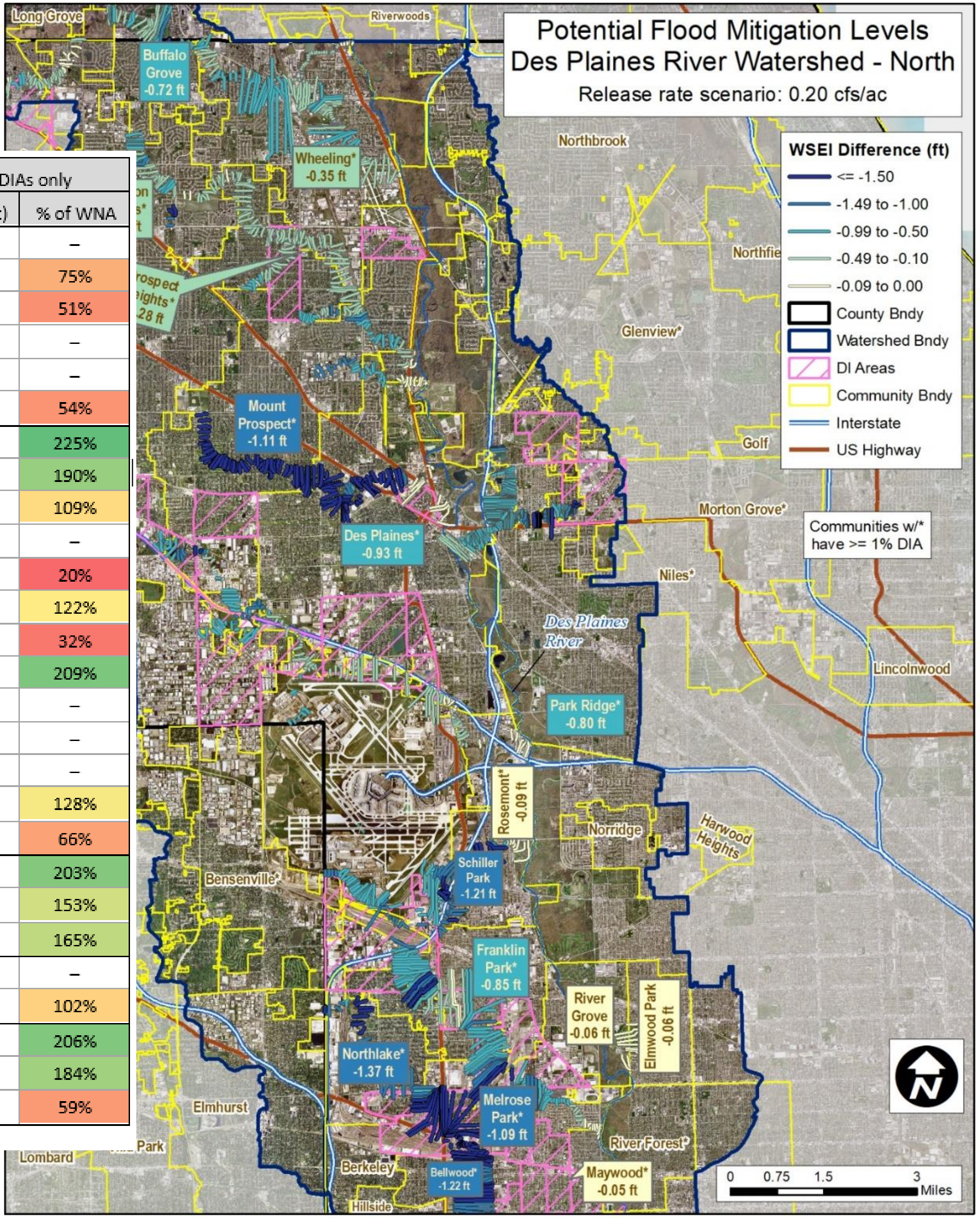
Watershed	DIA (dW, ft)	Non-DIA (dW, ft)	Effect size (Cohen's *d*)
Cal Sag	-0.56	-0.80	Large (-0.7)
Des Plaines	-0.89	-0.78	Small (0.2)
Little Calumet	-0.63	-0.32	Large (1.0)
North Branch	-	-0.32	-
Poplar Creek	-0.30	-0.30	Zero (0.0)
Upper Salt Creek	-0.64	-0.41	Large (0.8)
Overall (excluding NB)	**-0.75**	**-0.51**	**Med (0.4)**

Potential Flood Mitigation Level, $dW_{rr} = WSE_{rr} - WSE_{base}$

Map Exhibits: Flood Mitigation Levels

DIA Community	%DIA	Watershed Non-DIA Avg. (WNA)		Whole Community		DIAs only	
		Watershed	WNA dW (ft)	dW (ft)	% of WNA	dW (ft)	% of WNA
Blue Island	76	Cal Sag	-0.80	-1.03	129%	–[1]	–
Chicago Ridge	62			-0.62	77%	-0.60	75%
Bridgeview	33			-0.41	51%	-0.41	51%
Crestwood	8			-0.66	82%	–	–
Oak Forest	4			-0.37	46%	–	–
Palos Hills	3			-0.59	74%	-0.43	54%
Stone Park	100	Des Plaines	-0.78	-1.76	225%	-1.76	225%
Melrose Park	66			-1.09	140%	-1.48	190%
Franklin Park	59			-0.85	109%	-0.85	109%
Willow Springs	26			-0.91	117%	–	–
Prospect Heights	26			-0.28	36%	-0.16	20%
Bellwood	25			-1.22	156%	-0.95	122%
Des Plaines	17			-0.93	119%	-0.25	32%
Northlake	16			-1.37	176%	-1.63	209%
Countryside	16			-0.54	69%	–	–
Rosemont	14			-0.09	11%	–	–
Lyons	14			-0.21	27%	–	–
Mount Prospect	9			-1.11	142%	-1.00	128%
Arlington Heights	5			-0.47	60%	-0.51	66%
Sauk Village	63	Little Calumet	-0.32	-0.51	160%	-0.65	203%
Matteson	6			-0.42	131%	-0.49	153%
Niles	16	N. Branch/DP[2]	-0.32	-0.18	57%	-1.30	165%
Streamwood	13	Poplar Creek	-0.30	-0.45	150%	–	–
Elgin	1			-0.17	56%	-0.31	102%
Rolling Meadows	22	Upper Salt Ck.	-0.41	-0.62	150%	-0.85	206%
Elk Grove Village	14			-0.32	77%	-0.76	184%
Palatine	3			-0.50	122%	-0.24	59%

[1] En dash (–) implies that cross section data is not available in these areas.

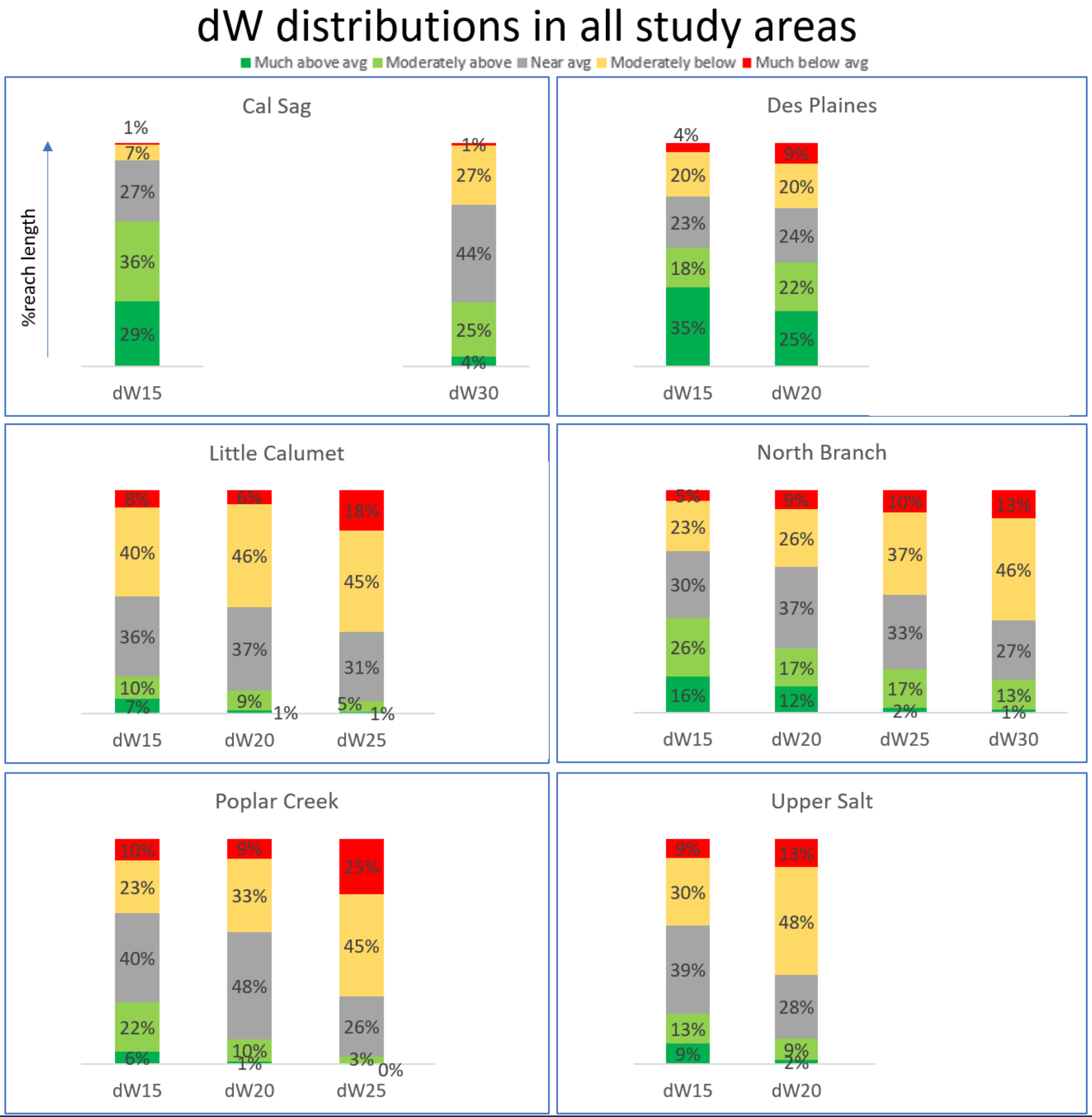


B. Potential Flood Mitigation Levels in DIA Communities

- Cal-Sag: Much lower mitigation levels than watershed average (50-75% of WNA)
- Little Calumet and Upper Salt: Higher mitigation levels (150-200% of WNA)
- Des Plaines (and globally): Wide variation, median 112% of WNA
- Sparse cross section data, except for Des Plaines

WNA=Watershed Non-DIA Average

C. Flood Mitigation Benefits with more restrictive Release Rates



$dW_{rr} = WSE_{rr} - WSE_{base}$ Potential risk mitigation	Lower Limit	Upper Limit
Much below average	-0.1 ft	∞
Moderately below avg.	-0.5 ft	-0.1 ft
Near average	-1.0 ft	-0.5 ft
Moderately above avg.	-1.5 ft	-1.0 ft
Much above average	-∞	-1.5 ft

- Cal Sag and Upper Salt: Substantial benefits
- Des Plaines: Moderately sensitive
- Little Calumet and Poplar Creek:
  - Considerable benefits at 0.20 cfs/ac
  - Only marginal additional gains at 0.15 cfs/ac
- North Branch: Highly sensitive throughout
- Similar analysis also carried exclusively for DIAs

Summary and Conclusions

Key Takeaways

- Overall, DIAs generally require **marginally higher** (~6% more) **detention storage,** but enjoy **moderately higher flood mitigation levels** (~0.24 ft more) than Non-DIAs
- Unlike flood mitigation levels, differences in storage requirements between DIA and non-DIA at watershed and community levels are generally mild.

Watershed	Δ Detention Storage	Δ Flood mitigation level
Cal Sag	1% more (marginal)	0.24 ft less (significant)
Des Plaines	6% more (marginal, hetero)	0.11 ft more (marginal, hetero)
Little Calumet	11% more (moderate)	0.31 ft more (significant)
Poplar Creek	10% more (moderate)	Same
Upper Salt Creek	14% more (moderate)	0.23 ft more (significant)

- Significantly more reaches would attain peak flood level reduction above 0.5 ft on moving to the next more restrictive release rate…except in the case of Des Plaines River watershed.
- Policy implications

Phase III Study

Project Team

<u>**Article 208.2**</u>

Impacts of watershed specific release rates on disproportionately impacted communities

Nikhil Sangwan – *Illinois State Water Survey*

<u>**Article 208.3**</u>

Impacts of release rates under existing and future development scenarios in collar counties on watersheds in the District

Gregory Byard (PI) – *Illinois State Water Survey*

<u>**Article 208.4**</u>

Impact of volume control and watershed specific release rates on stream erosion and related water quality effects such as turbidity and sedimentation

Dr. Bruce Rhoads – *Department of Geography and Geographic Information Sciences*
Tasneem Meem

Dr. Arthur Schmidt – *Department of Civil and Environmental Engineering*
Maggie Gardner, Leo Fouts

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Hunter Gross, Armando Zavalza

Dr. Walt Kelly – *Illinois State Water Survey Groundwater Section Head*
Cecilia Cullen, Devin Mannix

Illinois State Water Survey Contract Report 2022-03
December 2022

https://www.ideals.illinois.edu/items/126093

Watershed-Specific Release Rate Analysis Phase III: Cook County, Illinois

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Thank You!
Q&A

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Illinois State Water Survey
PRAIRIE RESEARCH INSTITUTE

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