Current Changes in Illinois Weather Patterns and their Effect on Hydrologic Analysis

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Presentation Objectives

- Review rainfall analysis milestones to-date
  - TP-40
  - Bulletin 70/71
- Discuss general evolution of detention requirements in northeastern Illinois
- Discuss next steps in rainfall analysis

Pre-TP 40

- Pre-1950s: Yarnell
  - Generalized maps for several durations and return periods
  - Derived from approx 200 gage stations
- More gages added
- 1950s: TP 24 by the USCOE
  - Showed higher amounts of short-duration rainfall

Technical Paper No. 40 (1961)

U.S. DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary

WEATHER BUREAU
F. W. REICHELDERFER, Chief

TECHNICAL PAPER NO. 40

RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

Prepared by
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for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

WASHINGTON, D.C.
May 1961
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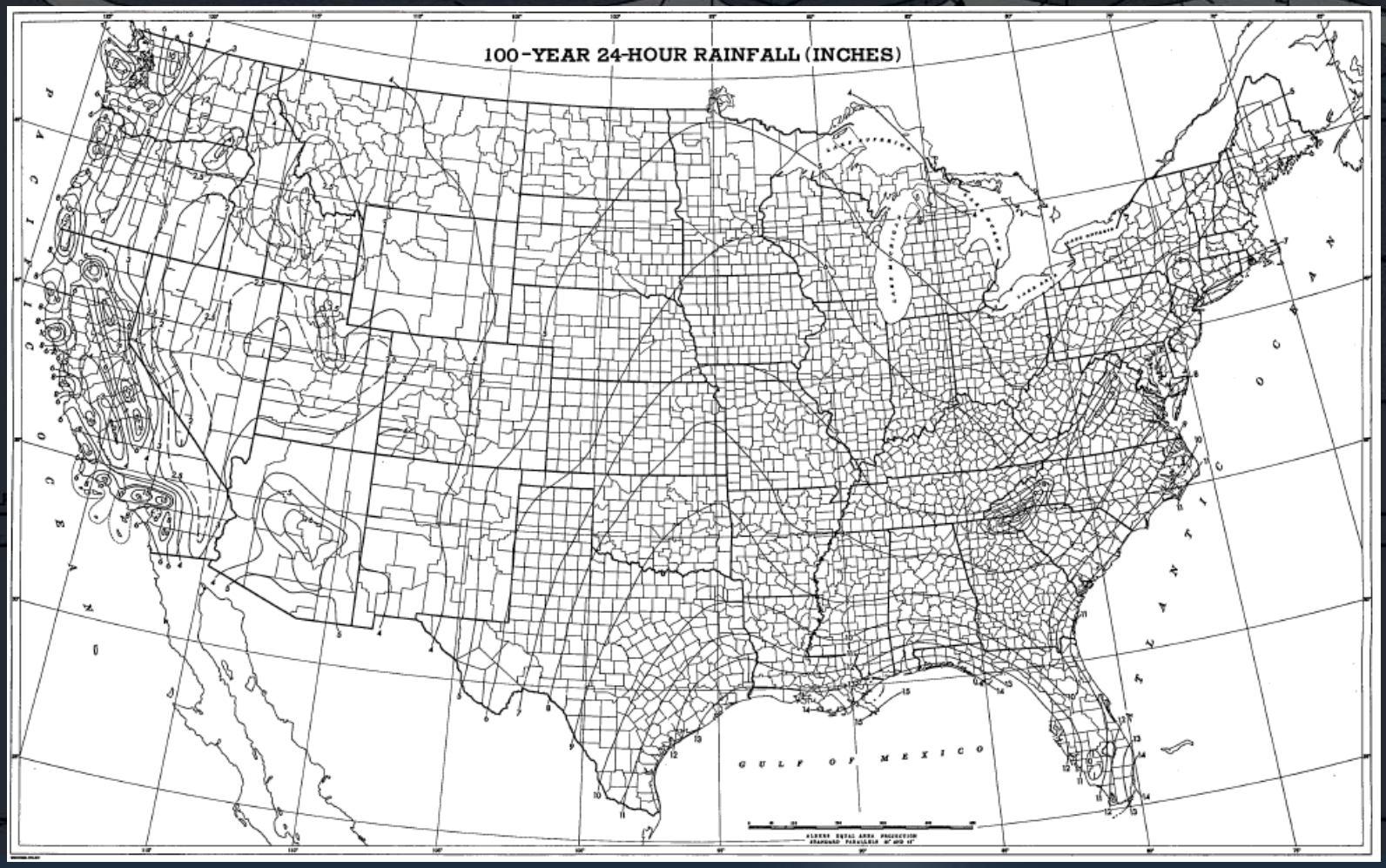
Technical Paper No. 40 (1961)

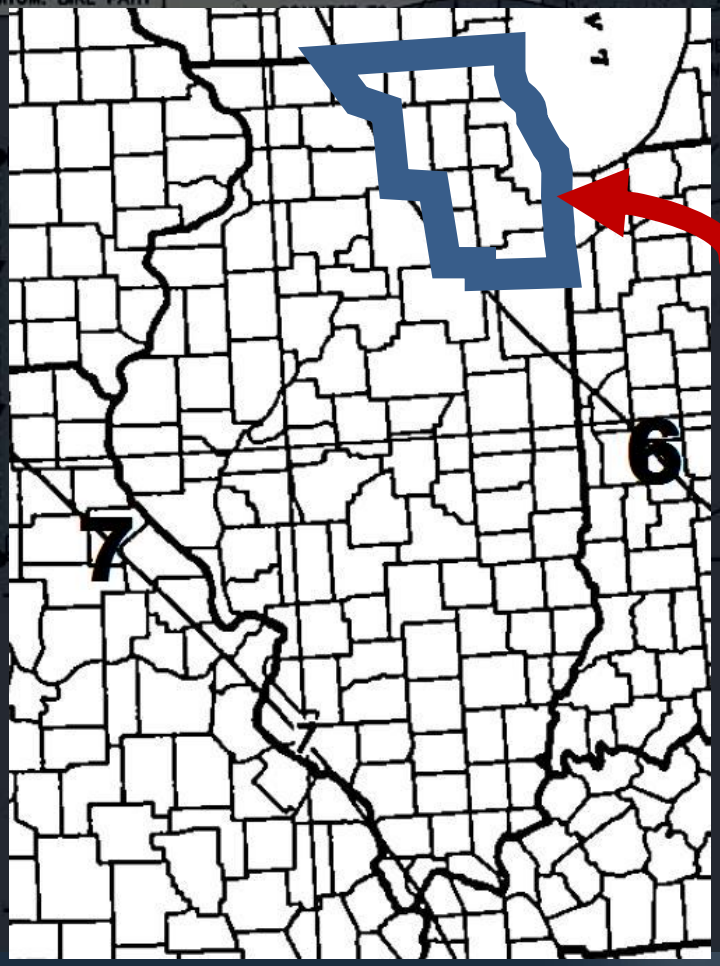
TABLE 1.—*Sources of point rainfall data*

Duration	No. of stations	Average length of record (yr.)
30-min. to 24-hr	200	48
Hourly	2081	14
Daily (recording)	1350	16
Daily (nonrecording)	3409	15
Daily (nonrecording)	1426	47

Technical Paper No. 40 (1961)



Technical Paper No. 40 (1961)

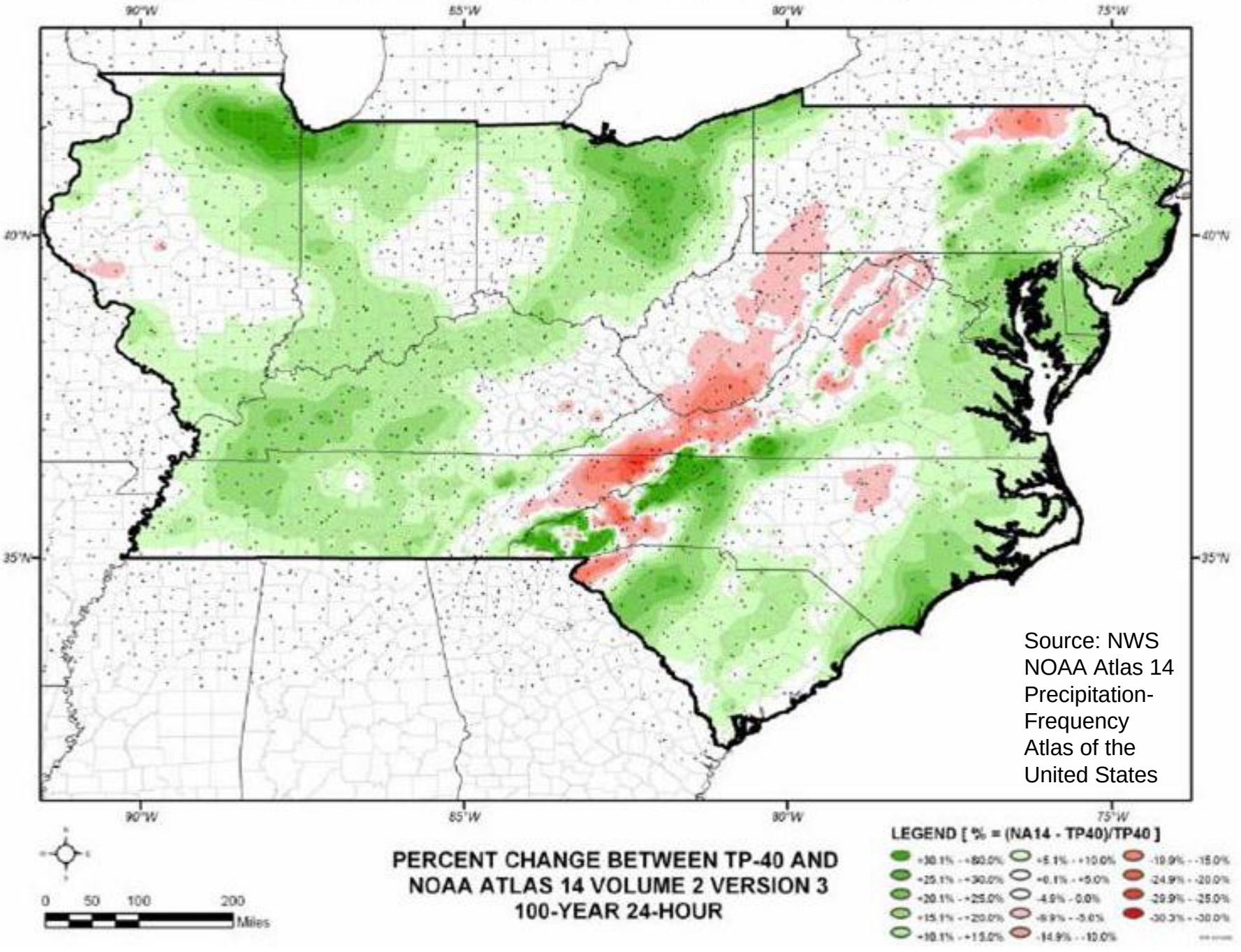


5.8”

TP 40 → NOAA Atlas 14

- Update in 2004 by NWS for Ohio River Basin: NOAA Atlas 14, Vol 2 (2004)
  - Rainfall was measured for specific durations (6-, 12-, 24-, 96-hours) as opposed to collecting for individual storms.

Figure 7.1. Differences between NOAA Atlas 14 Volume 2 and Technical Paper 40 estimates.



Source: NWS NOAA Atlas 14 Precipitation-Frequency Atlas of the United States

Pre-Bulletin 70

- TP 40
- Additional analysis during 1960s-70s
- Technical Letter 13
  (predecessor to Bulletin 70)

Bulletin 70

- Based on an 83-year sample period
  - Including 61 Illinois gages
- Specific needs for study:
  - Frequency relations had not been updated
  - Further study of longer records of data
  - Increased flooding in northern Illinois
  - Seasonal frequency variations

Bulletin 70

Table 1. Number of Times the 24-Hour, 100-Year Value from Technical Paper 40 Is Exceeded by State

	(a) *Number of stations*	*(b)* *Average length of record*	*(c)* *Number of times exceeded*	*(d)* *Number of times expected*	*Ratio (c)/(d)*
Illinois	61	87	69	36	1.92
Indiana	41	64	17	20	0.85
Iowa	43	80	20	24	0.83
Kentucky	25	67	11	12	0.92
Michigan*	46	60	71	21	3.38
Minnesota	25	67	14	12	1.17
Missouri	44	62	4	20	0.20
Ohio	41	60	27	19	1.42
Wisconsin	13	78	13	7	1.86
Midwest			246	171	1.43

*From Sorrell and Hamilton, 1990

Bulletin 70

Figure 3. Illinois climatic sections adopted by the National Weather Service

Table 13. Sectional Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years

Storm codes

1 – 10 days
2 – 5 days
3 – 72 hours
4 – 48 hours
5 – 24 hours
6 – 18 hours
7 – 12 hours
8 – 6 hours
9 – 3 hours
10 – 2 hours
11 – 1 hour
12 – 30 minutes
13 – 15 minutes
14 – 10 minutes
15 – 5 minutes

Sectional (zone) codes

1 – Northwest
2 – Northeast
3 – West
4 – Central
5 – East
6 – West Southwest
7 – East Southeast
8 – Southwest
9 – Southeast
10 – South

Rainfall (inches) for given recurrence interval

Storm code	*Zone code*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
1	1	2.14	2.60	2.97	3.50	4.02	4.37	5.23	6.30	7.14	8.39	9.64	11.09
1	2	2.02	2.48	2.80	3.30	3.79	4.12	4.95	6.04	6.89	8.18	9.38	11.14
1	3	2.27	2.78	3.13	3.68	4.23	4.60	5.60	6.91	7.89	9.24	10.36	11.90
1	4	2.10	2.58	2.92	3.43	3.93	4.29	5.12	6.27	7.10	8.19	9.10	10.18
1	5	2.13	2.62	2.96	3.48	4.00	4.35	5.15	6.21	6.97	8.04	8.90	9.92
1	6	2.16	2.65	2.99	3.52	4.05	4.40	5.35	6.62	7.45	8.66	9.79	11.26
1	7	2.30	2.80	3.16	3.70	4.27	4.64	5.58	6.80	7.61	8.66	9.70	10.87
1	8	2.22	2.74	3.09	3.63	4.18	4.54	5.54	6.80	7.80	9.20	10.44	11.81
1	9	2.30	2.88	3.23	3.80	4.33	4.75	5.74	7.09	8.07	9.54	10.68	11.79
1	10	2.55	3.15	3.58	4.21	4.84	5.26	6.36	7.81	8.90	10.34	11.36	12.50
2	1	1.76	2.12	2.38	2.76	3.17	3.45	4.13	5.10	5.91	7.21	8.36	9.97
2	2	1.66	1.98	2.24	2.60	2.99	3.25	3.93	4.91	5.70	6.93	8.04	9.96
2	3	1.92	2.30	2.56	2.97	3.41	3.71	4.57	5.80	6.65	7.90	8.95	10.50
2	4	1.77	2.12	2.37	2.78	3.20	3.48	4.17	5.11	5.84	6.76	7.98	9.21
2	5	1.75	2.10	2.37	2.75	3.15	3.42	4.12	4.96	5.67	6.76	7.65	8.78
2	6	1.77	2.13	2.39	2.78	3.19	3.47	4.19	5.32	6.20	7.44	8.53	9.93
2	7	1.85	2.22	2.50	2.90	3.31	3.63	4.34	5.33	6.11	7.28	8.37	9.65
2	8	1.85	2.21	2.49	2.90	3.31	3.62	4.40	5.46	6.34	7.68	8.88	10.68
2	9	1.90	2.29	2.59	3.00	3.45	3.75	4.48	5.57	6.50	7.91	9.16	10.57
2	10	2.09	2.52	2.83	3.29	3.77	4.10	4.99	6.20	7.21	8.45	9.45	10.82
3	1	1.58	1.90	2.11	2.45	2.82	3.06	3.73	4.67	5.42	6.59	7.64	8.87
3	2	1.57	1.83	2.02	2.34	2.70	2.93	3.55	4.44	5.18	6.32	7.41	8.78

Bulletin 70

- Findings:
  - Wetter, especially in northeastern Illinois
  - Intensity of rainstorms over the state had increased
  - Rainfall depths revised
    - Not a great difference for events smaller than 10-yr
    - 5.8” → 7.58” for 100-year 24-hour storm in NE IL

5	1	1.40	1.64	1.80	2.08	2.36	2.57	3.11	3.95	4.63	5.60	6.53	[illegible]
5	2	1.38	1.61	1.76	2.03	2.31	2.51	3.04	3.80	4.47	5.51	6.46	7.58
5	3	1.53	1.77	1.95	2.24	2.56	2.79	3.45	4.29	4.93	6.07	7.04	[illegible]
5	4	1.39	1.63	1.80	2.04	2.32	2.52	3.02	3.76	4.45	5.32	6.08	6.92
5	5	1.36	1.58	1.75	2.00	2.27	2.47	3.01	3.71	4.26	5.04	5.8[illegible]	6.61
5	6	1.42	1.66	1.84	2.10	2.38	2.59	3.11	3.93	4.65	5.57	6.46	7.45
5	7	1.40	1.63	1.78	2.07	2.35	2.55	3.03	3.80	4.44	5.37	6.23	7.41
5	8	1.49	1.73	1.90	2.20	2.48	2.71	3.28	4.13	4.76	6.02	7.07	8.21
5	9	1.44	1.68	1.85	2.12	2.41	2.62	3.16	4.00	4.62	5.79	6.71	7.73
5	10	1.63	1.91	2.10	2.41	2.74	2.97	3.62	4.51	5.21	6.23	7.11	8.27

Rainfall Distribution

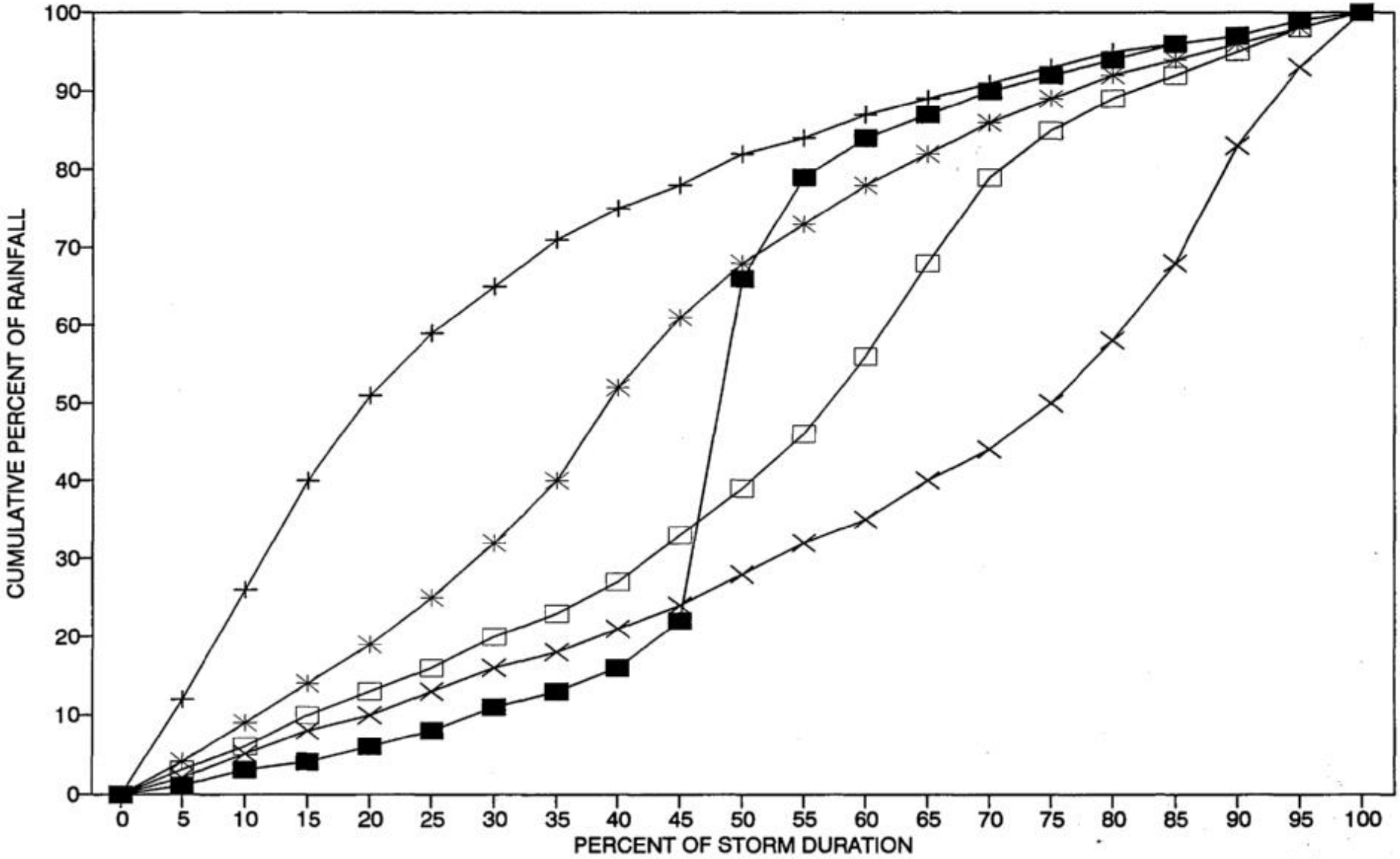
- Huff Distribution:

Storm Duration (x)	Distribution
x <= 6 hrs	1st Quartile
6 > x >= 12 hrs	2nd Quartile
12 > x >= 24 hrs	3rd Quartile
x > 24 hrs	4th Quartile

Source: Illinois State Water Survey Circular 173, “Time Distributions of Heavy Rainstorms in Illinois”, 1990

RAINFALL DISTRIBUTION COMPARISON

Huff Distributions and SCS Distribution



Source: “Investigation of Hydrologic Design Methods for Urban Development in Northeastern Illinois”, 1991

Rainfall Distribution

- SCS Type II vs. Huff Quartile Distribution
  - SCS Type II distribution intended to be used only with 24-hour events
  - SCS Type II generally more conservative runoff results

Rainfall Distribution

- SCS Type II vs. Huff (continued)
  - Huff distributions designed to represent actual typical rainfall patterns
  - Important to use critical duration with the Huff distribution

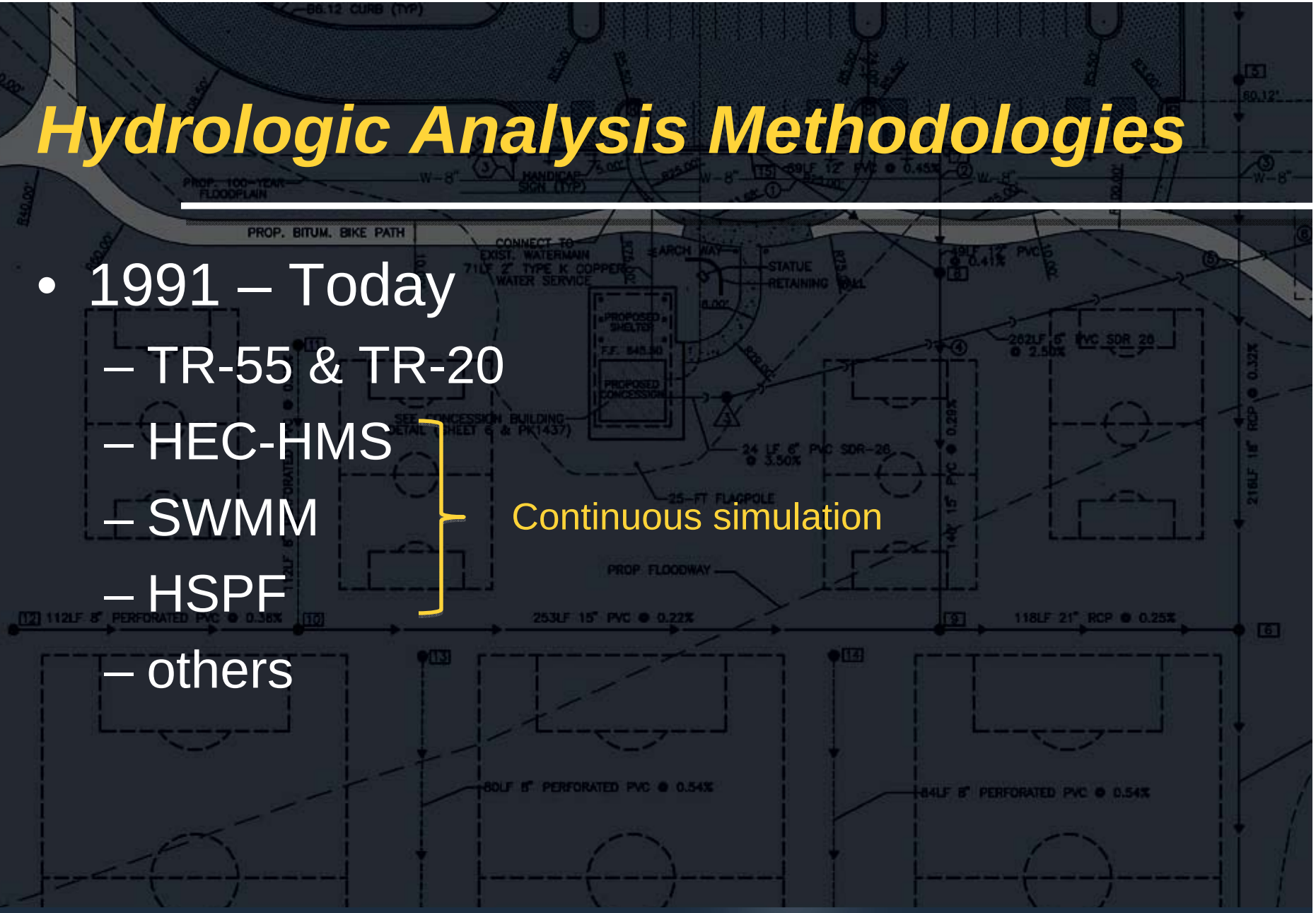
Hydrologic Analysis Methodologies

- Pre-1991
  - (Modified) Rational Method
  - TR-55
  - TR-20
  - HEC-1
  - ILLUDAS
  - HSPF (continuous simulation)

Hydrologic Analysis Methodologies

- 1991 – Today
  - TR-55 & TR-20
  - HEC-HMS
  - SWMM
  - HSPF
  - others

Continuous simulation

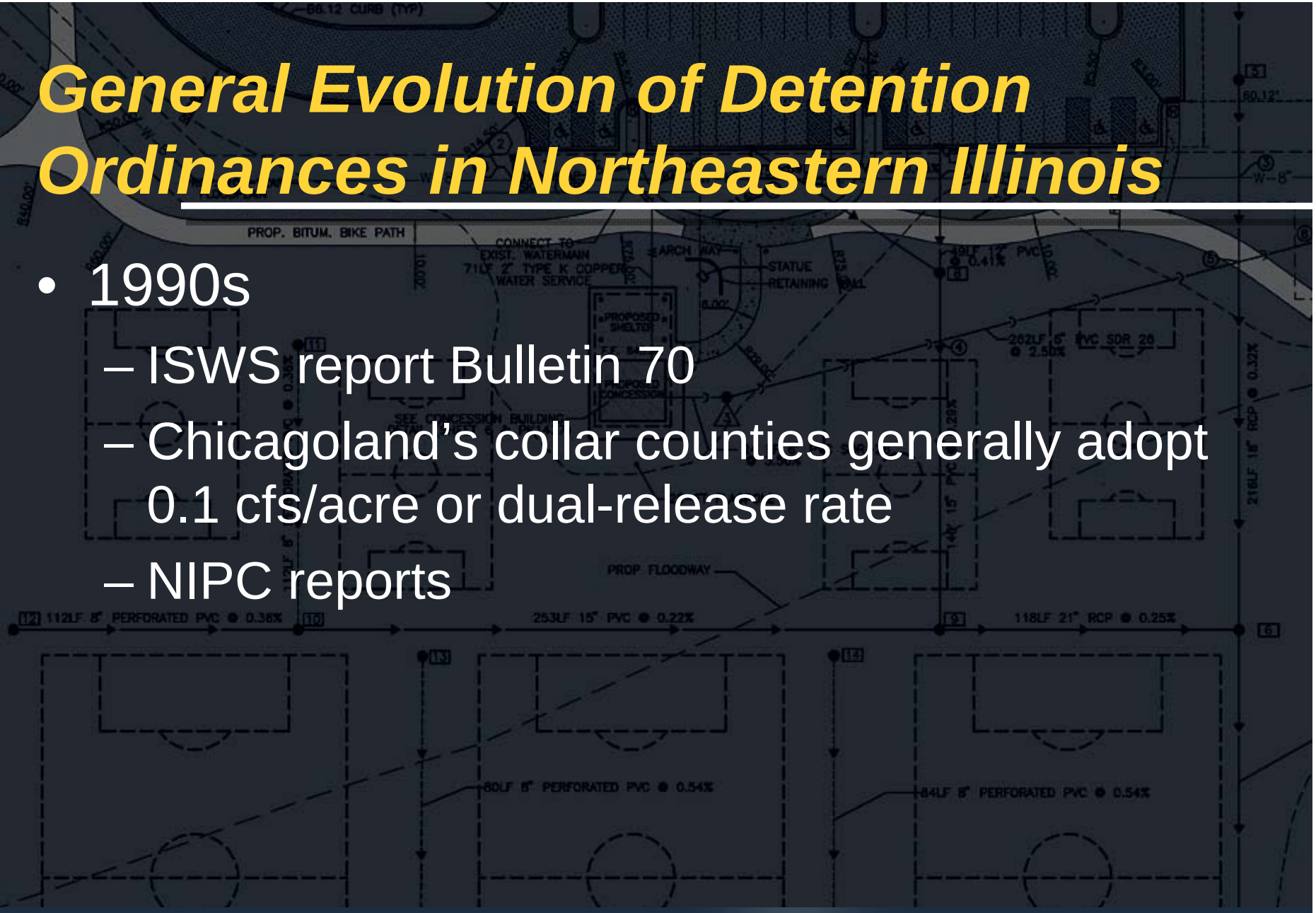


General Evolution of Detention Ordinances in Northeastern Illinois

- 1970s, Using TP 40 rainfall amounts:
  - MWRD: Rational Method
    - Restrict to 3-year undeveloped
  - DuPage County
    - TR-55 and restrict to 0.1 cfs/acre

General Evolution of Detention Ordinances in Northeastern Illinois

- 1990s
  - ISWS report Bulletin 70
  - Chicagoland's collar counties generally adopt 0.1 cfs/acre or dual-release rate
  - NIPC reports



General Evolution of Detention Ordinances in Northeastern Illinois

- NIPC Reports – Conclusions:
  - Reality of watershed is a factor.
  - Outlet control needed to limit post-development flooding and erosion.

General Evolution of Detention Ordinances in Northeastern Illinois

- NIPC Reports – Conclusions (continued):
  - Actual storm events vs. theoretical design
  - Net effect of random detention locations in conjunction with the increased flow volume from new development.

General Evolution of Detention Ordinances in Northeastern Illinois

- NIPC Reports – Conclusions (continued):
  - 2-year flow control
    - prevent erosion
    - limit depth fluctuations for more frequent events
  - Wet-bottom basins (+)
    Dry-bottom basins (–)

General Evolution of Detention Ordinances in Northeastern Illinois

- NIPC Reports – Conclusions (continued):
  - Use Bulletin 70 rainfall & 0.1 cfs/ac.
  - Evaluated hydrologic design methodologies
    - Continuous simulation model on 40 years of data as a benchmark to compare the other methodologies (Upper Salt Creek watershed).
    - Developed “unit area” detention chart for determining required detention based on landuse.

Sources: “Evaluation of Stormwater Detention Effectiveness in Northeastern Illinois”, NIPC, 1991
“Investigation of Hydrologic Design Methods for Urban Development in Northeastern Illinois”, NIPC, 1991
“Unit Area Detention Volumes Based on Continuous Simulation Recommended for Use With the DuPage Countywide Stormwater Management Ordinance”, NIPC, 1997

General Evolution of Detention Ordinances in Northeastern Illinois

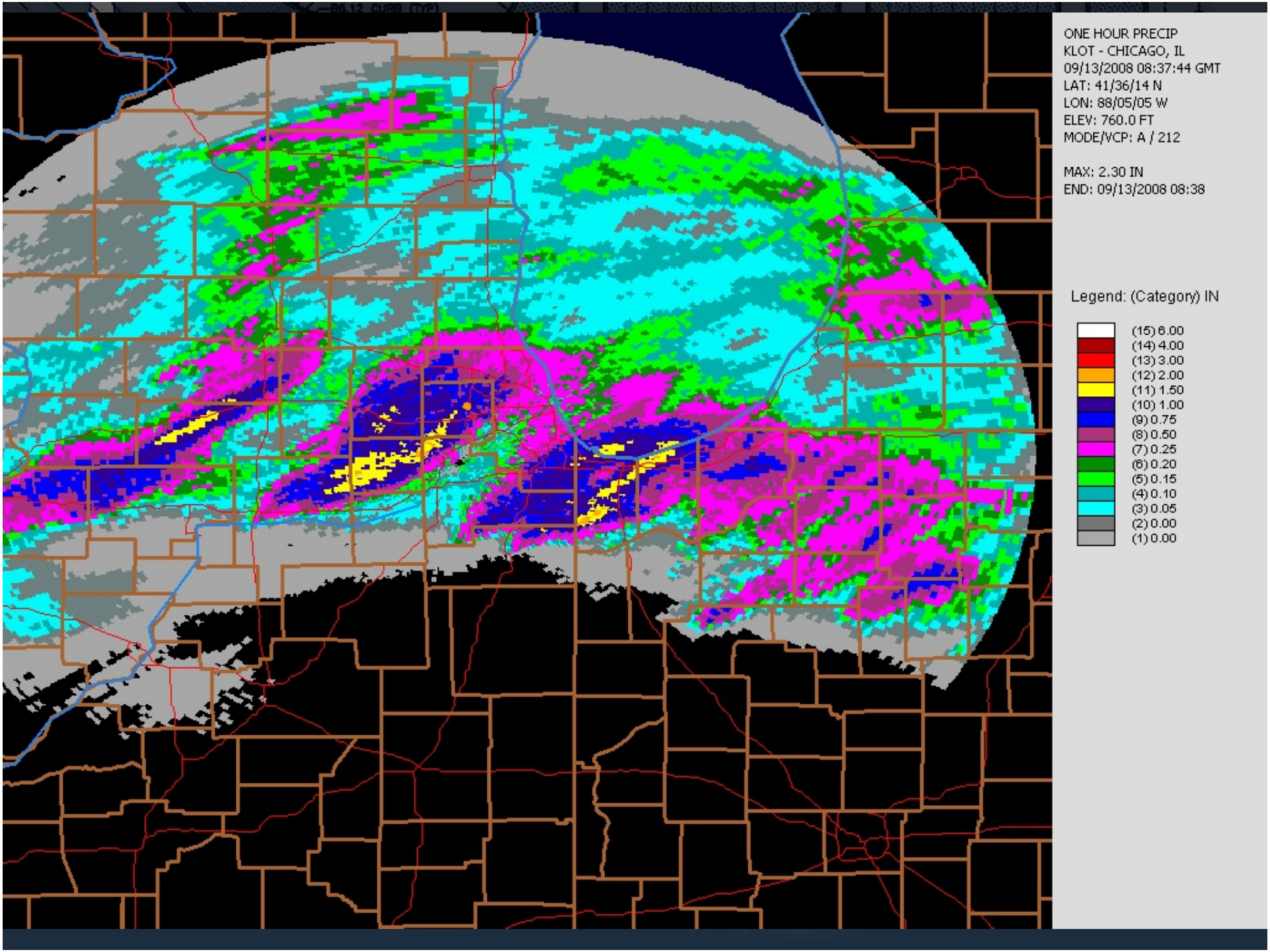
- Today
  - Flooding is down, quality is up.
    - Result of ordinance regulations
    - Northeastern Illinois ahead of the national curve
  - BMPs
  - Volume Control
    - Concept of infiltration through extended detention

General Evolution of Detention Ordinances in Northeastern Illinois

- Today (continued)
  - Changes since 1991
    - Progression of technology
    - Additional data

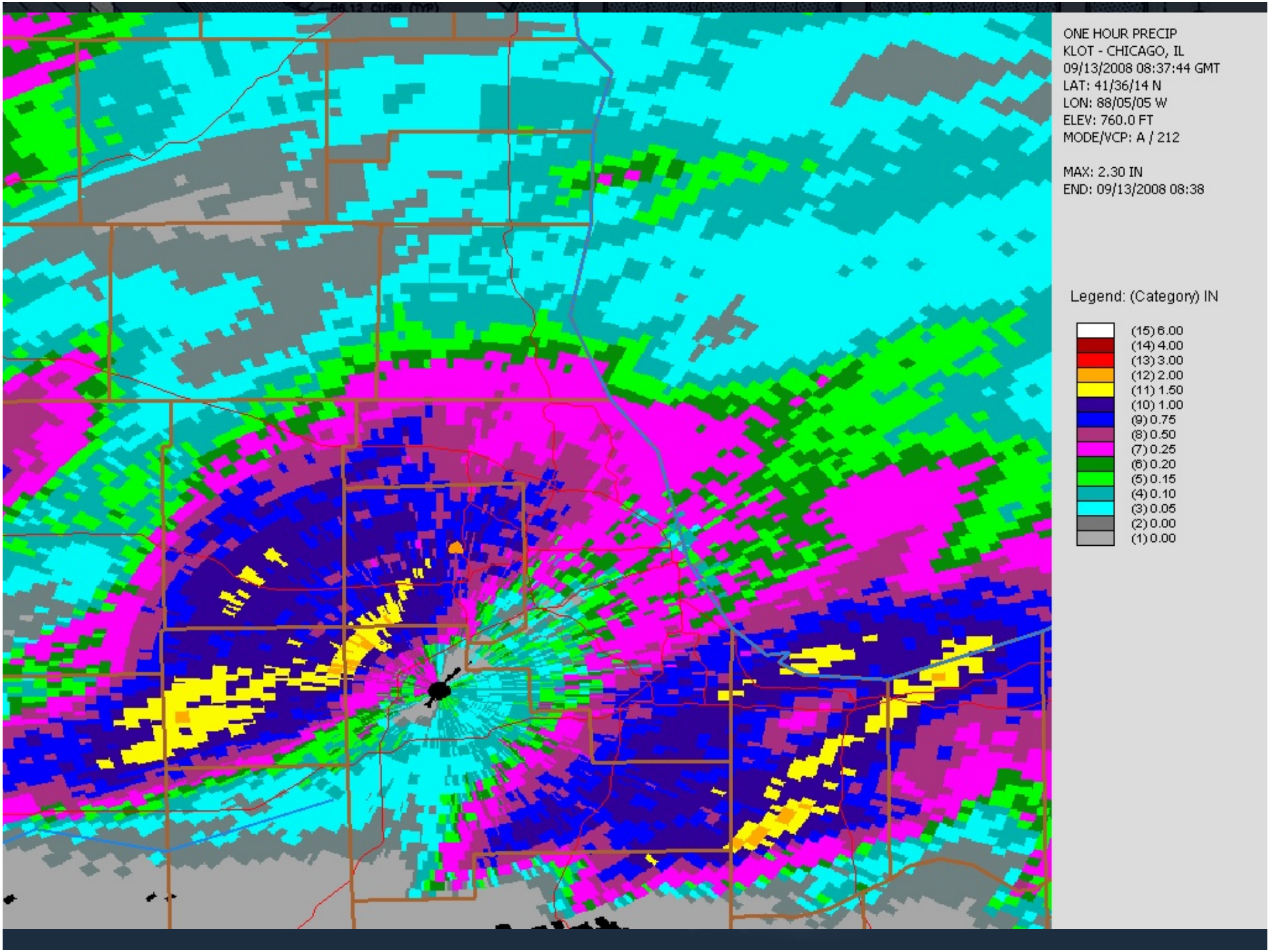
Progressing Technology

- Current Technologies for Gathering Rainfall Data
  - Rain Gage Stations
  - NEXRAD (Next Generation Weather Radar)
    - Weather Surveillance Radar-88 Doppler


ONE HOUR PRECIP
KLOT - CHICAGO, IL
09/13/2008 08:37:44 GMT
LAT: 41/36/14 N
LON: 88/05/05 W
ELEV: 760.0 FT
MODE/VCP: A / 212
MAX: 2.30 IN
END: 09/13/2008 08:38
Legend: (Category) IN
(15) 6.00
(14) 4.00
(13) 3.00
(12) 2.00
(11) 1.50
(10) 1.00
(9) 0.75
(8) 0.50
(7) 0.25
(6) 0.20
(5) 0.15
(4) 0.10
(3) 0.05
(2) 0.00
(1) 0.00

Progressing Technology

- Advantages of Radar-Rainfall for Data Collection (over rain gages)
  - Spatial and Temporal Mapping
  - Point rainfall depths are not representative of the spatial distribution of a storm event
  - High Resolution (relative)
  - Real Time Flood Forecasting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(7) 0.25
(6) 0.20
(5) 0.15
(4) 0.10
(3) 0.05
(2) 0.00
(1) 0.00

Progressing Technology

- Current Disadvantage of Radar-Rainfall Data Usage
  - Oldest recorded data: 1993
  - NEXRAD data must be ground-truthed

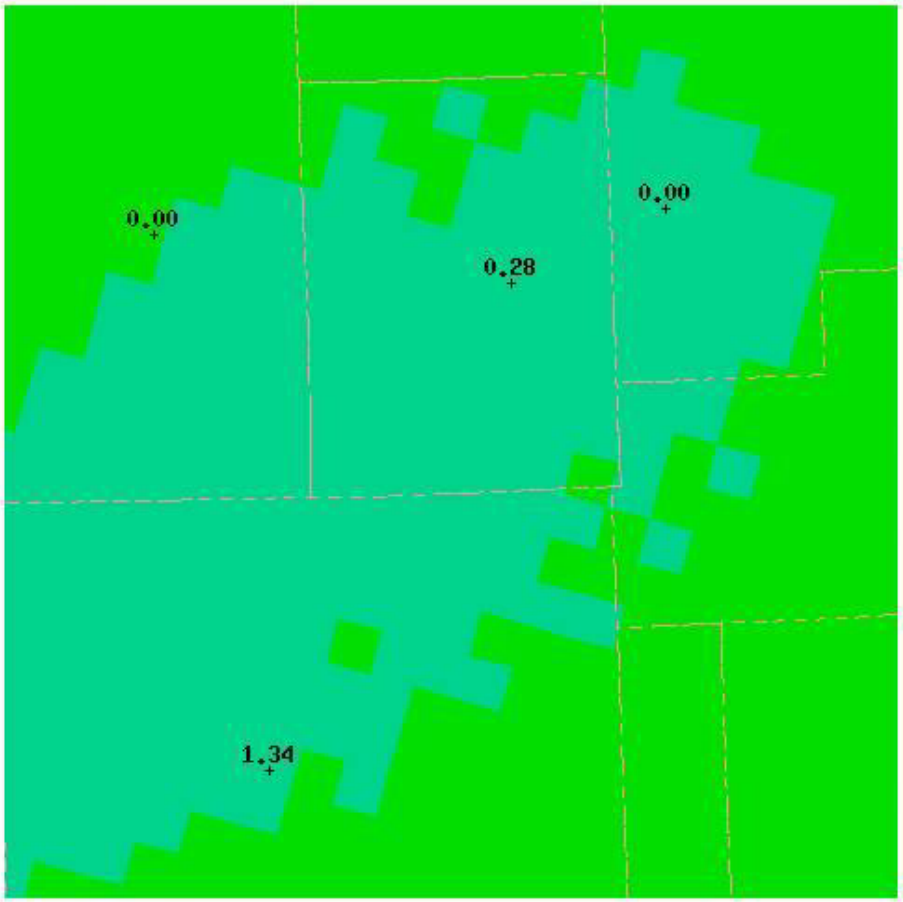
http://munster.er.usgs.gov/rainfall/

Rainfall MapServer Application

Information and data presented were obtained from various Federal, State, and local agencies and are subject to revision. The data are released on the condition that neither the USGS nor Government may be held liable for any damages resulting from their use.

More information about the quality of precipitation data is available.

Map



Map Options

Recenter/Zoom map

Either select a Zoom Factor and click on the map, or draw a box on the map, then click "Redraw" button.

Zoom Factor

Recenter Map

Select Map Display Layers

Background Layers

State Lines
County Lines
IL County Names

USGS Station Locations

Rain Gages
Stream Gages

Rain Gage Totals

No Rain Gages Selected

NWS NEXRAD (MPE) Totals

No Image Selected

Redraw

Location Map within Illinois.

Legend

24-hr MPE = 0 (inches)
0.0-0.1
0.1-0.25
0.25-0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-4.0
4.0-5.0
5.0-6.0
6.0-7.0
7.0-8.0
24-hr MPE >8.0 (inches
County Lines
State Lines
\+ 24-hr gage total (inch
\+ Rainfall Stations

Data Updates (CST)

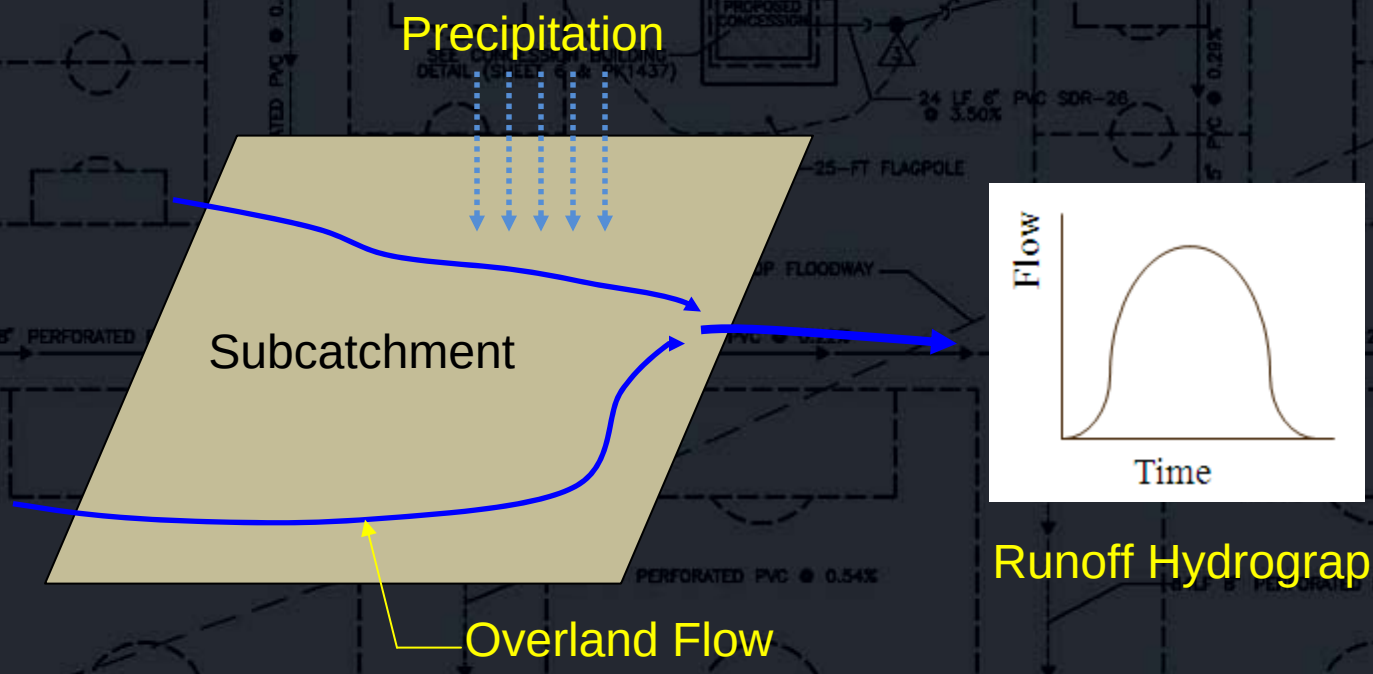
MPE: March 10, 2009 04:00
RAIN-GAGE: March 10, 2009 04:45

Progressing Technology

- Current Technologies for Gathering Hydrologic Data
  - Landsat Thematic Mapper (map inundated areas)
  - Remote Sensing (soil moisture content, elevation, water body inventories, water quality parameters, etc)

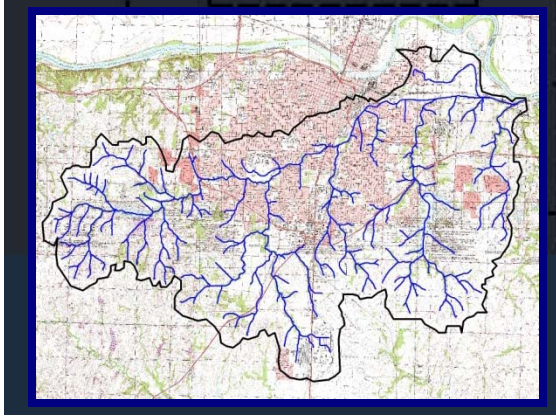
Progressing Technology

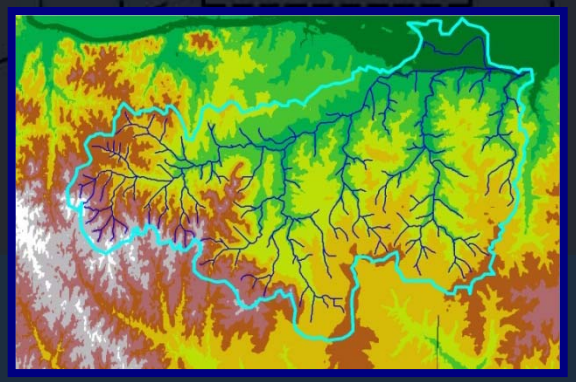
- Advances in Watershed Modeling



Progressing Technology

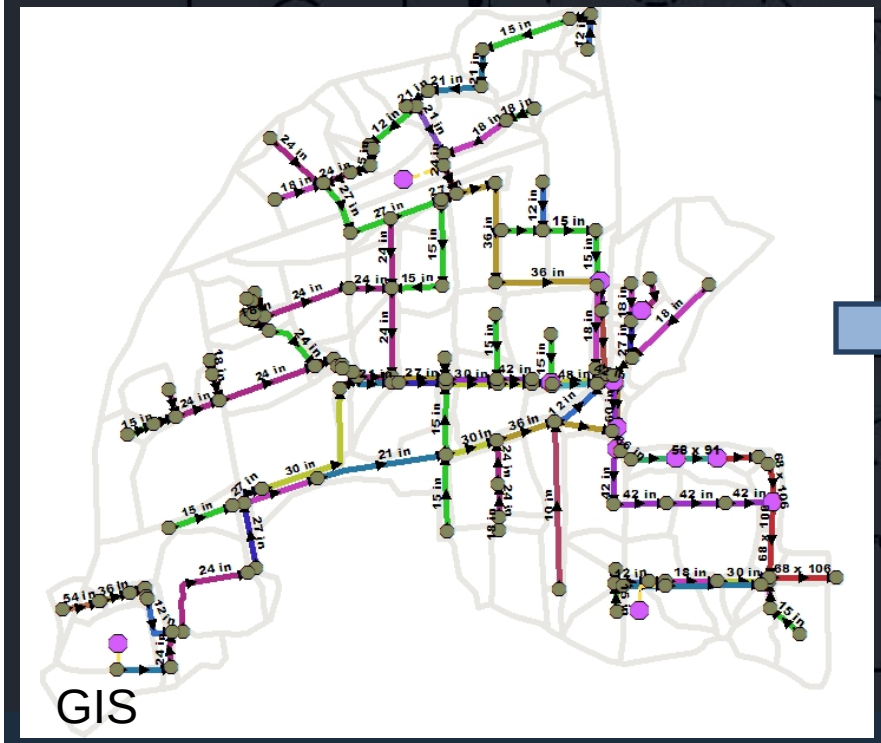
- Advances in Watershed Modeling (cont'd)
  - Calibration with NEXRAD
  - Digital elevation/terrain models (DEMs)
  - GIS and remote sensed data
  - Database management
  - More powerful processors

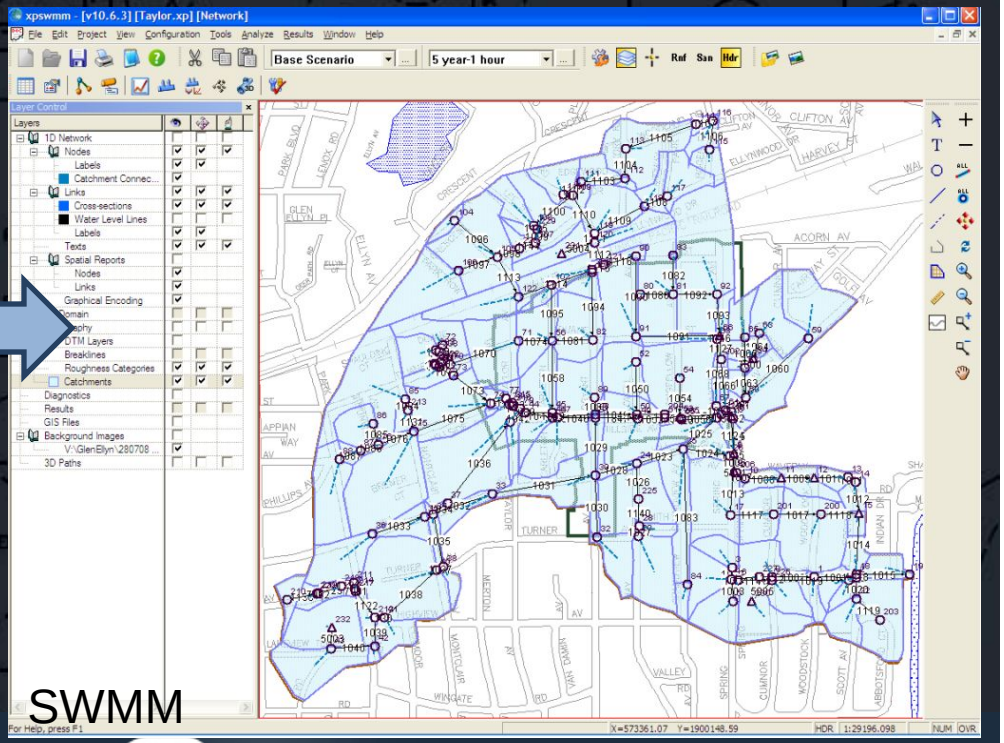




Progressing Technology

- Advances in Watershed Modeling (cont'd)
  - GIS link to H & H modeling

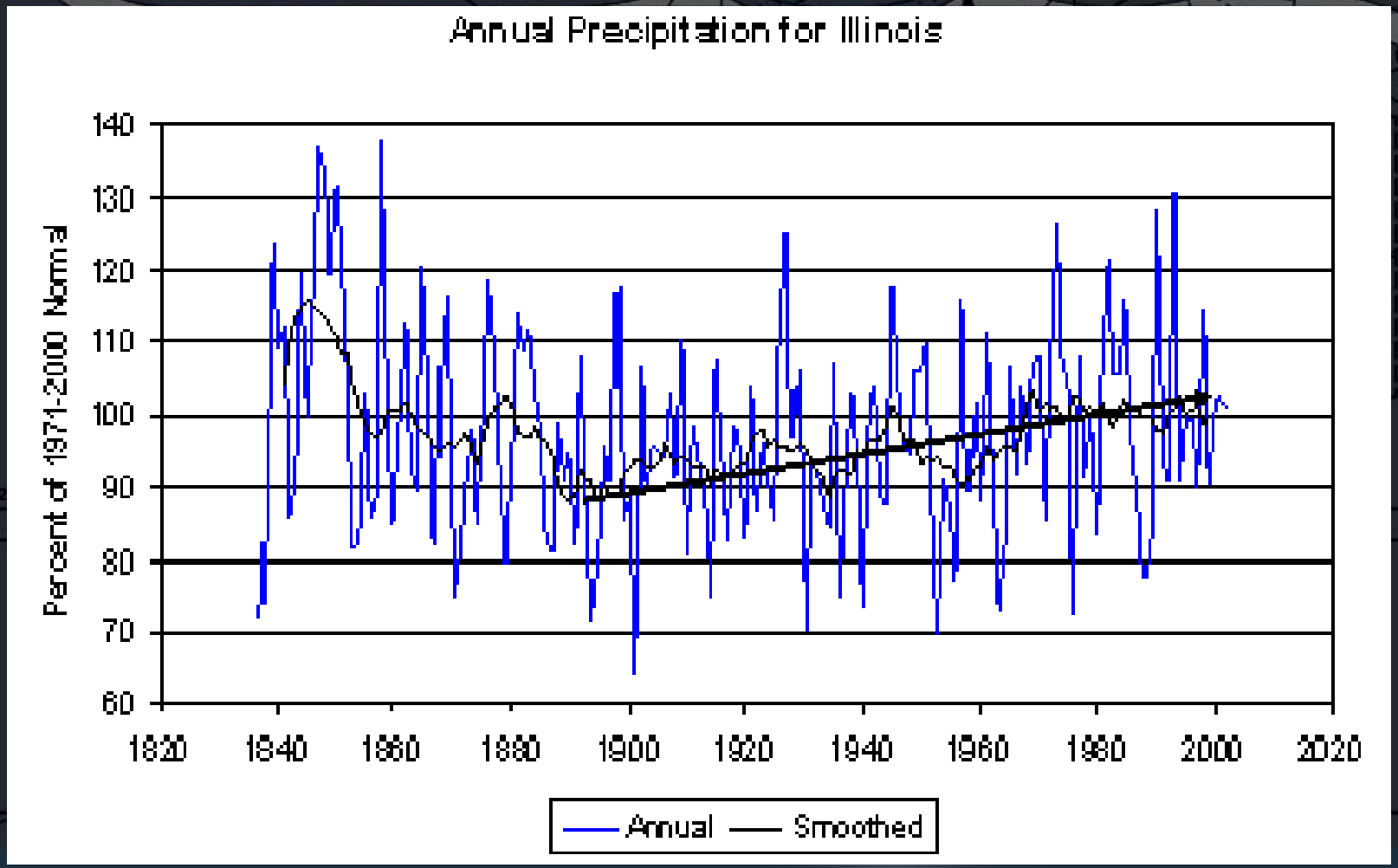




Progressing Data Collection

- Illinois State Water Survey continues to collect precipitation data
  - 20 years have passed since last rainfall depths assigned in Bulletin 70
  - 1970 to mid-1990s: Northeastern Illinois has experienced a wetter climate.

Illinois State Water Survey Data



Source: "Future Climate in Illinois", presentation by J. Angel, S. Changnon, et.al, ISWS and IDNR

Thoughts Looking Back

- Is the increase in precipitation an anomaly or a trend?
- What do we do in a period of climate change?
- Everything changes over time.
  - Maybe the rainfall intensities are changing.

Thoughts Moving Forward

- Watershed vs. Regional
  - Watershed characteristics are important.
  - Comprehensive storm water management plans that incorporate calibration and flood forecasting are much simpler now to implement, monitor and update.

Thoughts Moving Forward

- Continuous simulation incorporates weather pattern changes.
  - Calibration of model based on hydrologic parameters
- With technology today, data is quicker, better, and we can do more with it.

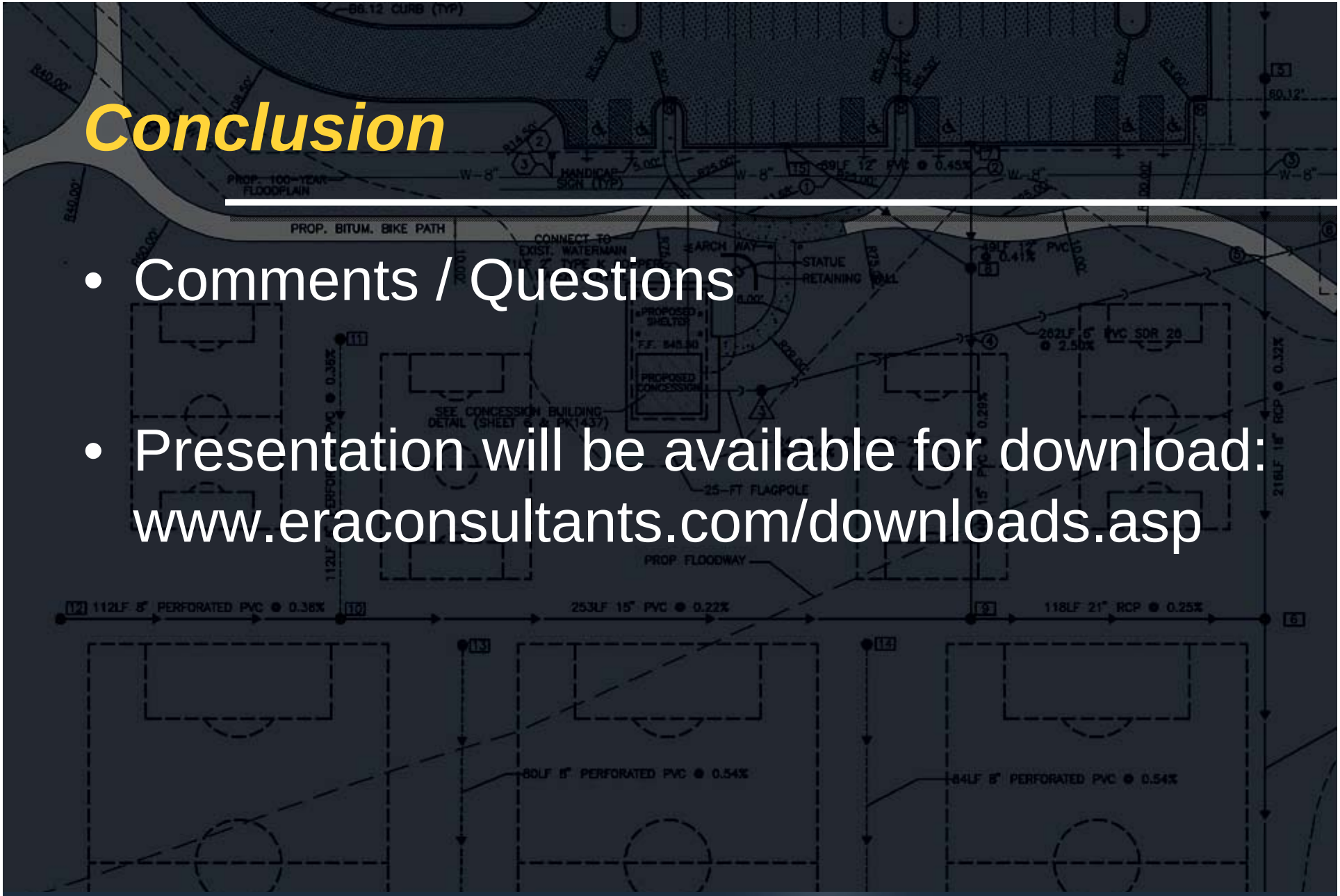
Thoughts Moving Forward

- We have more and more accurate and efficient ways for modeling reality.

- We can take advantage of additional data and more progressive modeling that is within our reach to enhance old assumptions.

Conclusion

- Comments / Questions
- Presentation will be available for download: www.eraconsultants.com/downloads.asp



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