Climate Adjusted Rainfall

Hydrologic Design for Illinois' Future

Loren Wobig, P.E., CFM

Wes Cattoor, P.E., CFM

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

An Examination of Bulletin 70

* Background
* Limitations
* Adjusting Rainfall Quantities
  * Does climate change have significant impact?
* Updating Bulletin 70
* Implementing the update

Bulletin 70 Background

* Published in 1988, revised in 1989
* 61 precipitation stations sampled
* 83-year record (1901-1983)
* Included climate trends
* Provides a static result

Shortcoming for design

* Last 33 years of data is not included
* Should be designed for full project life?
  * Bulletin 70 data year midpoint ~ 1942
  * 50yr Design life = 2067
* 125-years difference (1942 – 2067)

Bulletin 70 Climate Trends

Table 1. Ratios of 1941-1980 to 1901-1940 24-Hour Maximum Rainfall Amounts for Selected Recurrence Intervals in NWS Climatic Sections of Illinois

Recurrence interval (yrs)	*Average* ratio *for* given recurrence interval								
	NW	NE	W	c	*E*	*w s w*	*ESE*	SW	*SE*
2	1.12	1.12	1.07	1.08	1.04	1.09	0.98	0.96	0.95
5	1.13	1.16	1.07	1.09	1.06	1.11	0.96	0.97	0.95
10	1.14	1.16	1.07	1.06	1.03	1.14	0.98	0.99	1.00
25	1.17	1.20	1.01	1.02	1.04	1.11	1.05	0.99	1.04
Mean	1.14	1.16	1.06	1.06	1.04	1.11	0.99	0.98	0.98

* 1901-1940 vs. 1941-1980
  * Up to 20% increase northern Illinois
  * Up to 5% decrease in southern Illinois

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

Adjusting for Today's Project

* Project in Roanoke, IL for HUD NDRC
  * Central region (CD 4)
  * 24hr critical duration
  * 50-year project design life – 2067

* Adjust for climate change with best available data
  * Utilized regional annual rainfall trend data
  * Assume total annual rainfall trends = frequency event changes

Bulletin 70 Climate Trends

* Adjustment ratios gave more weight to latter 40 year period

Table 9. Adjustment Factors for Climatic Trend by Section and Storm Period

	Avemge ratio for given storm duration in each section					
Climatic section	***24 hrs***	***48 hrs***	***72 hrs***	***5 days***	***10 days***	***Combiried***
Northwest	1.06	1.05	1.06	1.04	1.04	1.05
Northeast	1.07	1.04	1.05	1.03	1.02	1.04
West	1.05	1.03	1.05	1.05	1.05	1.05
Central	1.02	1.03	1.04	1.03	1.03	1.03
East	1.02	1.04	1.05	1.04	1.04	1.04
West Southwest	1.04	1.04	1.05	1.01	1.01	1.03
East Southeast	0.99	0.99	0.99	1.01	1.01	1.00
Southwest	0.98	0.98	0.98	0.99	0.99	0.98
Southeast	0.99	0.98	0.98	1.00	1.00	0.99
South	0.99	0.98	0.98	1.00	1.00	0.99

Adjusting for Today's Project

	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942		-1.96%							
Published data			0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52

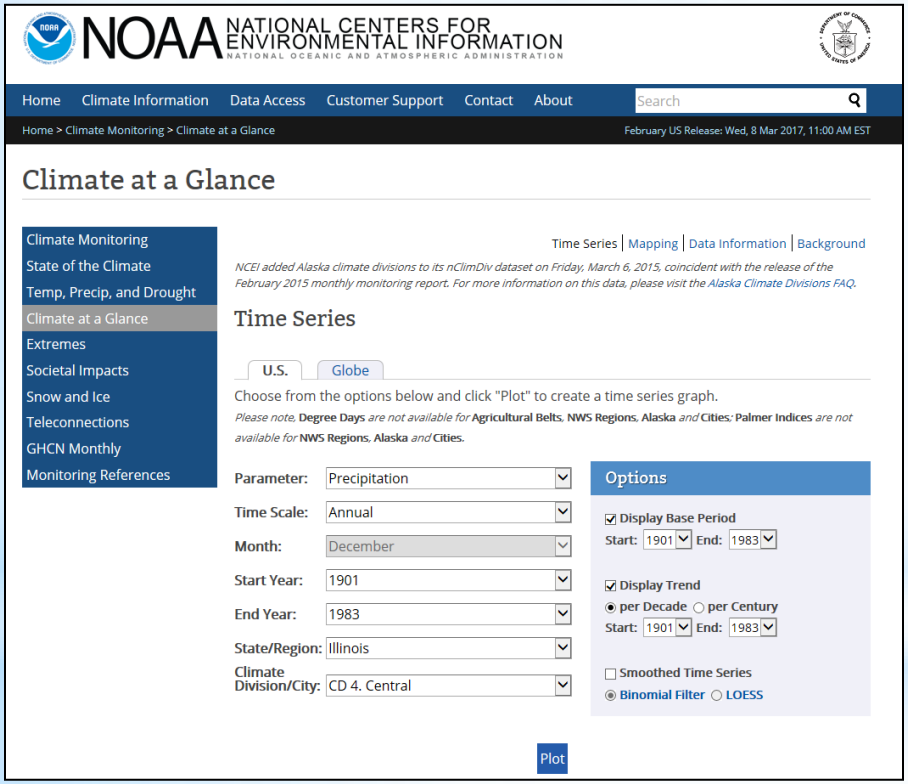
What we know from Bulletin 70 Data

Adjusting for Today's Project

	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942		-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data			0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52

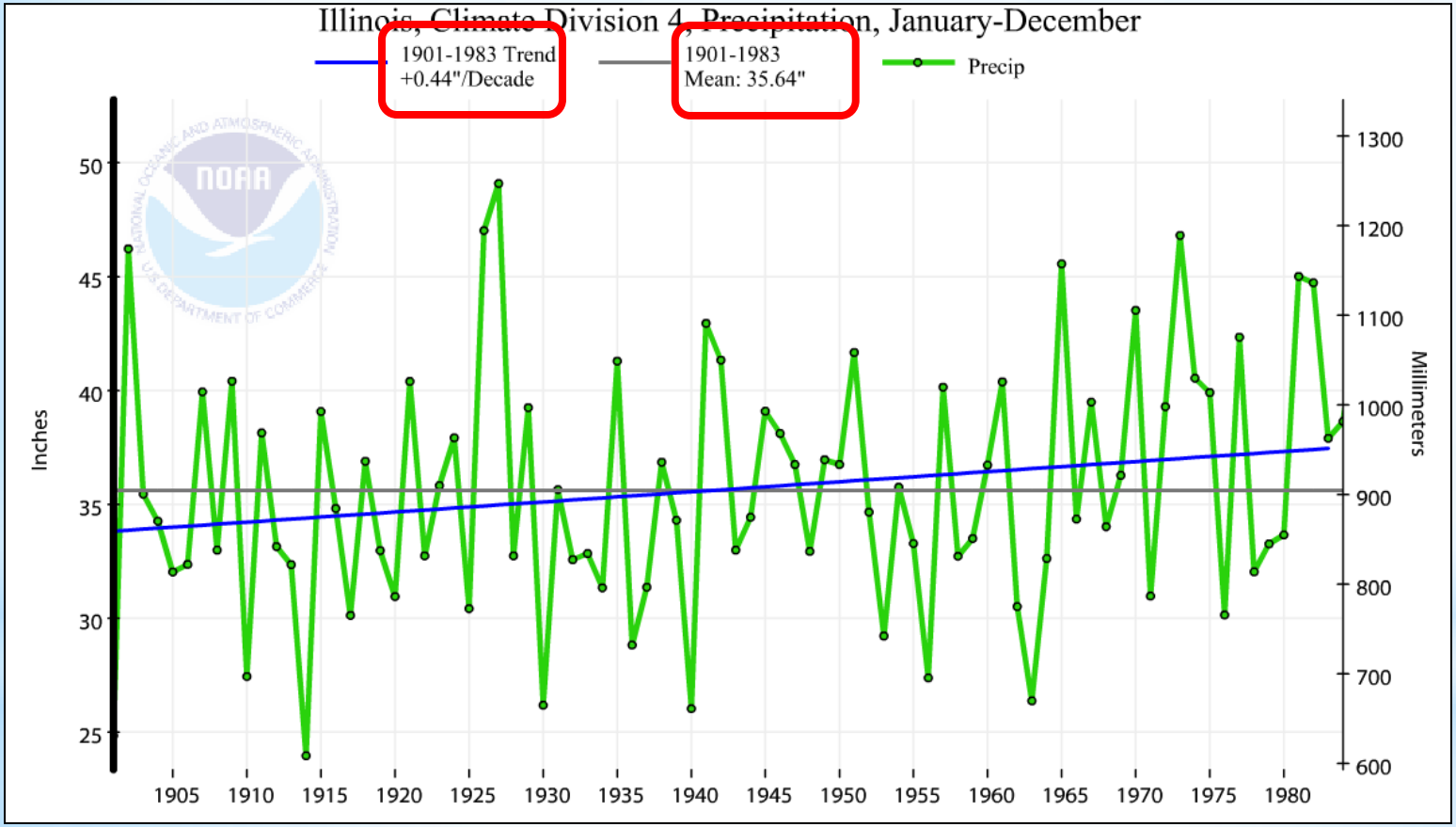
Compute Pre-adjusted Bulletin 70 Data

Utilized regional annual rainfall trend data



* Source: NOAA National Centers for Environmental information, Climate at a Glance: U.S. Time Series, Precipitation, published February 2017, retrieved on February 27, 2017 from http://www.ncdc.noaa.gov/cag/

Precipitation Trend 1901-1983



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Adjusting for Today's Project

	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942	35.64	-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data			0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52

Mean Rainfall

Adjusting for Today's Project

	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942	35.64	-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data		36.35	0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52
			2% Increase							

Adjusting for Today's Project

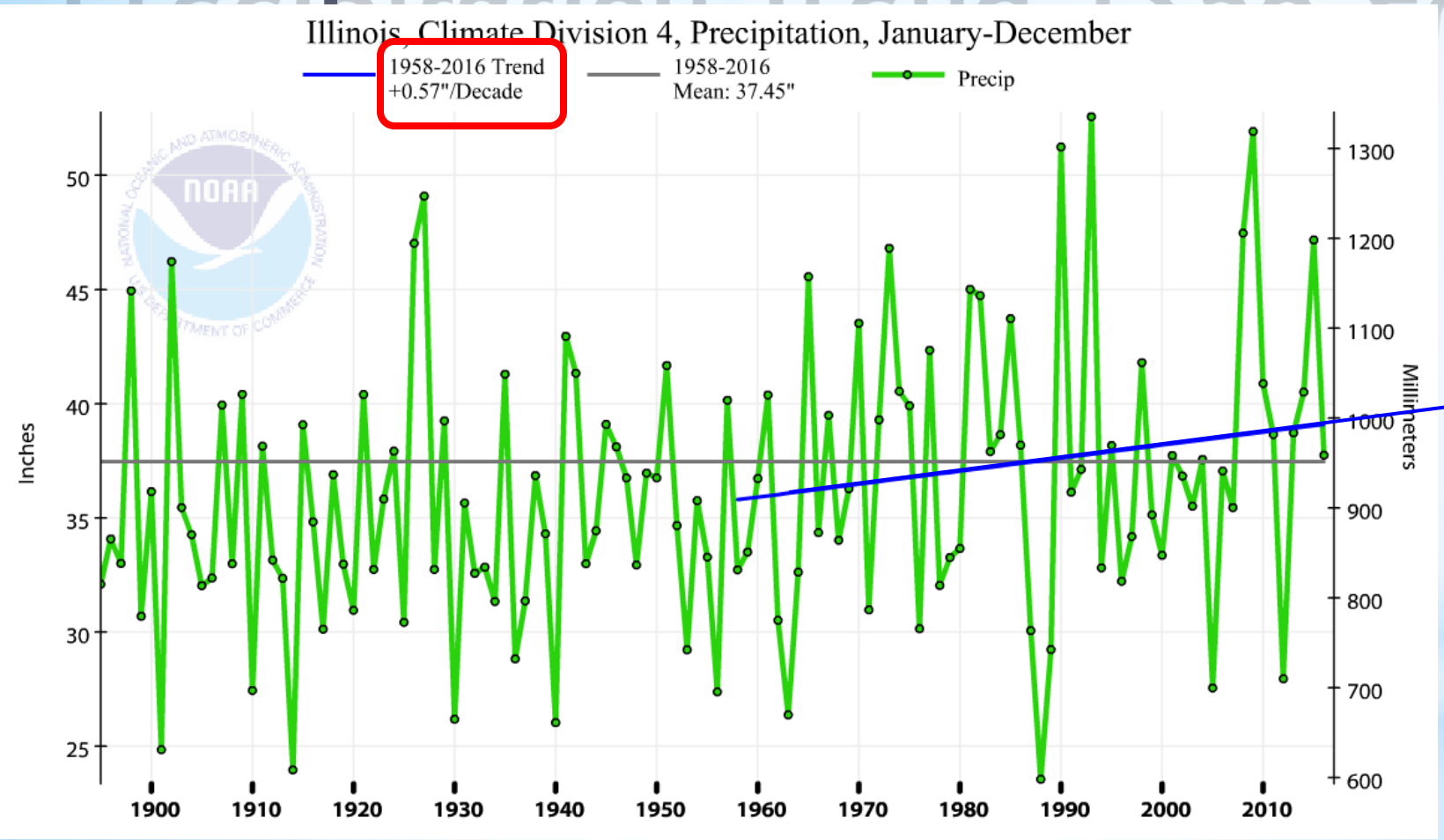
	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942	35.64	-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data	1958	36.35	0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52

0.44"/decade trend

Adjusting for Today's Project

	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942	35.64	-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data	1958	36.35	0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52
Published Date	1989									
Present Day	2017									
50yr design life	2067									
100yr design life	2117									

Precipitation Trend 1958-2016



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Adjusting for Today's Project

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Unadjusted Data	1942	35.64	-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data	1958	36.35	0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52
Published Date	1989	38.11								
Present Day	2017	39.70								
50yr design life	2067	42.55								
100yr design life	2117	45.40								

0.57"/decade trend

Adjusting for Today's Project

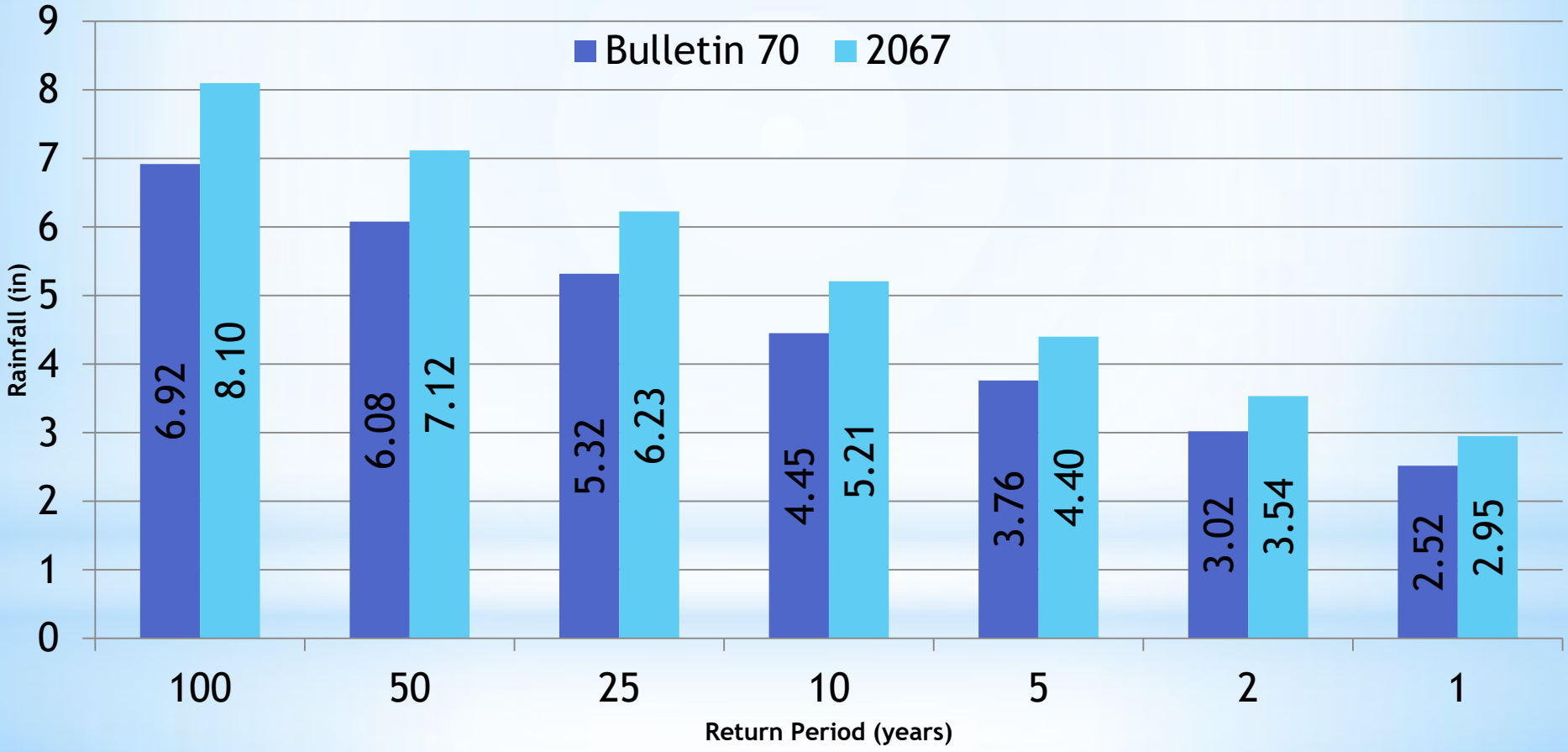
	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942	35.64	-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data	1958	36.35	0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52
Published Date	1989	38.11	4.83%							
Present Day	2017	39.70	9.24%							
50yr design life	2067	42.55	17.10%							
100yr design life	2117	45.40	24.96%							

Adjusting for Today's Project

	Equiv. Year	Annual Rainfall	% inc.	100yr	50yr	25yr	10yr	5yr	2yr	1yr
Unadjusted Data	1942	35.64	-1.96%	6.78	5.96	5.22	4.36	3.69	2.96	2.47
Published data	1958	36.35	0.00%	6.92	6.08	5.32	4.45	3.76	3.02	2.52
Published Date	1989	38.11	4.83%	7.25	6.37	5.58	4.66	3.94	3.17	2.64
Present Day	2017	39.70	9.24%	7.56	6.64	5.81	4.86	4.11	3.30	2.75
50yr design life	2067	42.55	17.10%	8.10	7.12	6.23	5.21	4.40	3.54	2.95
100yr design life	2117	45.40	24.96%	8.64	7.59	6.64	5.56	4.70	3.77	3.15

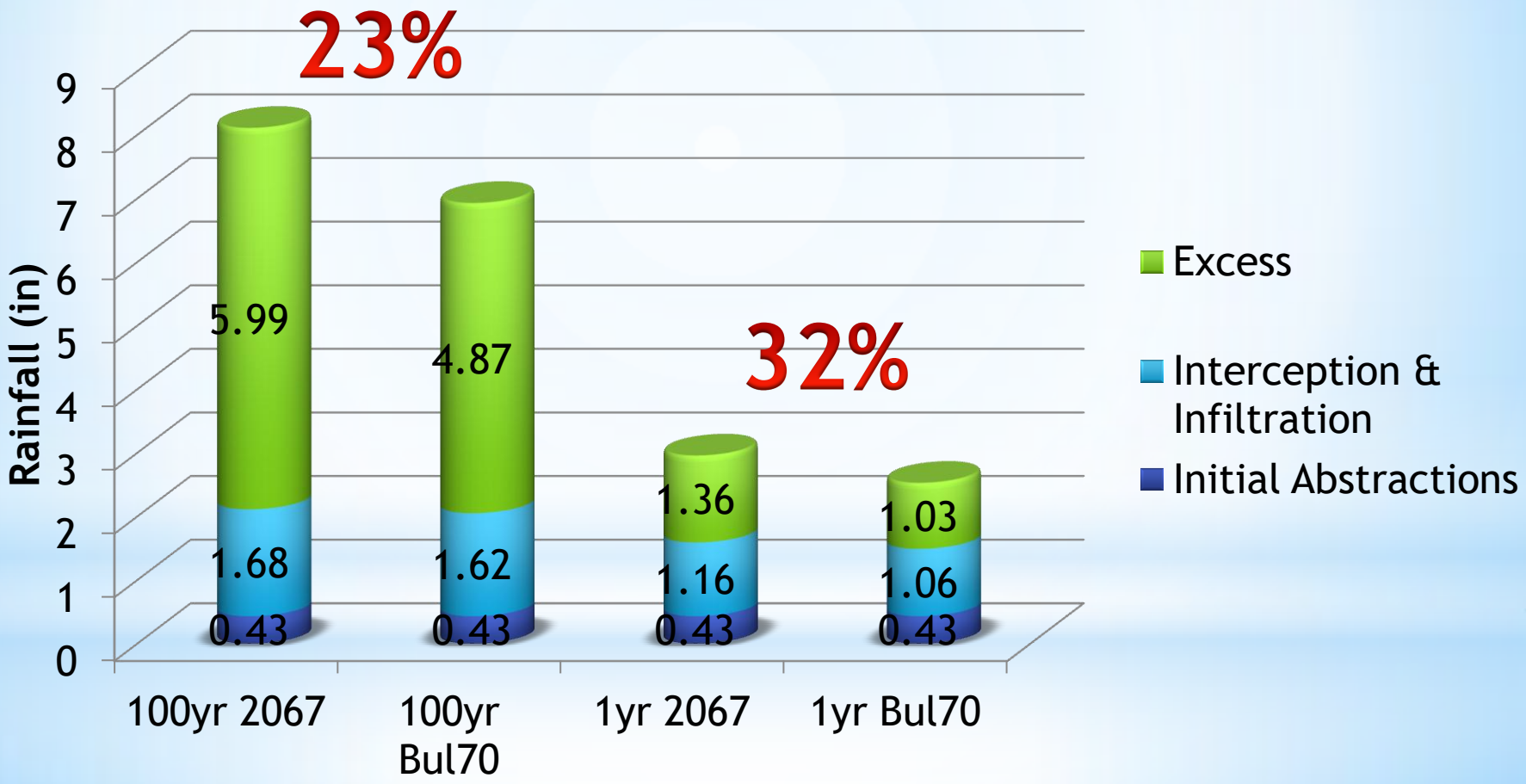
Assumes frequency event changes = total annual rainfall trends

Change Rainfall



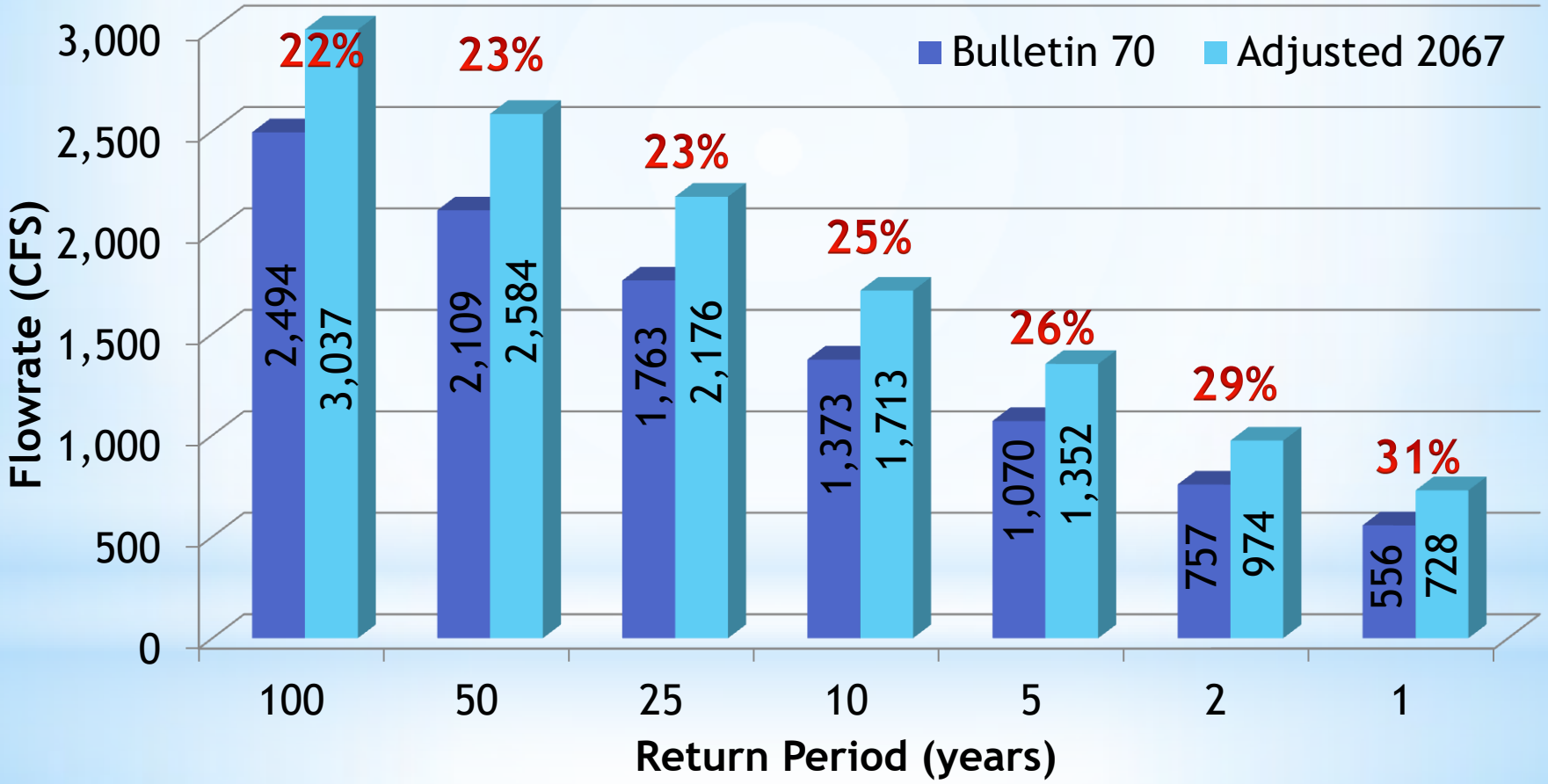
Increase in rainfall = 17.1%

Precipitation losses



*Loss Method – SCS Curve Number
CN = 82.3

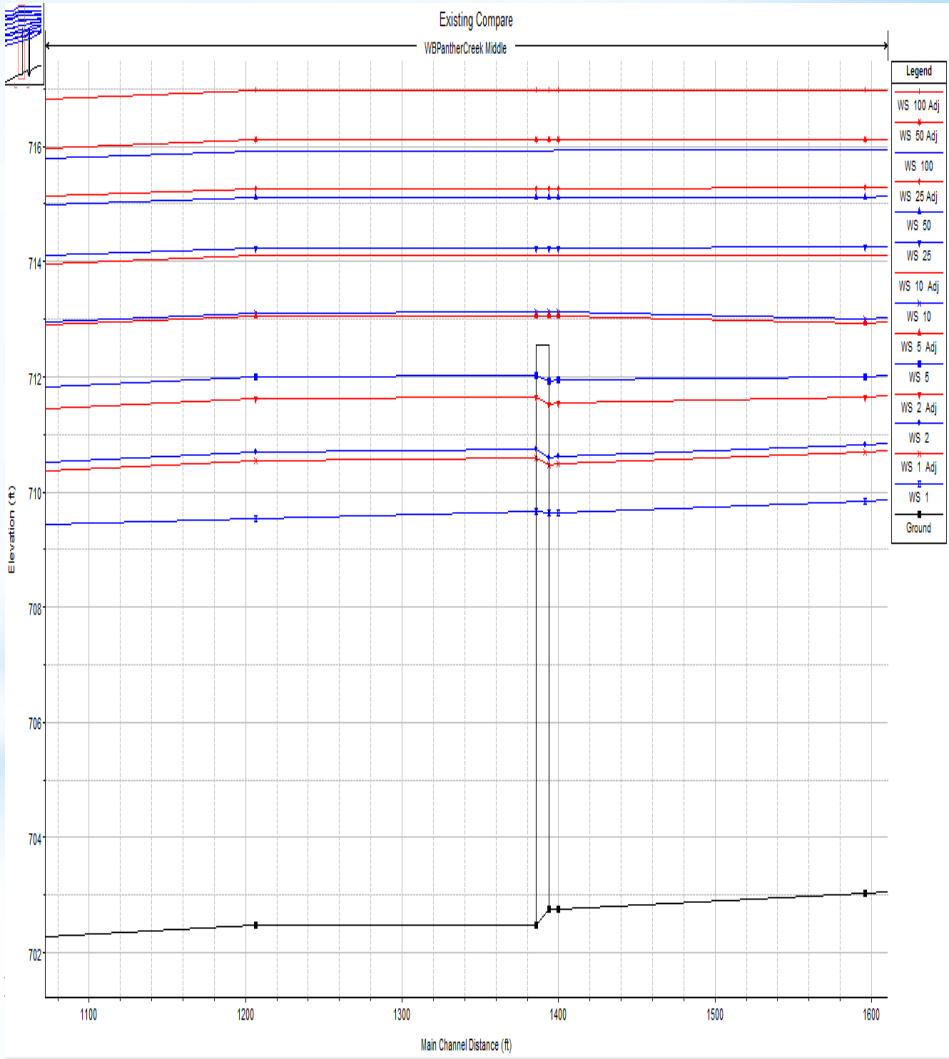
Peak Runoff



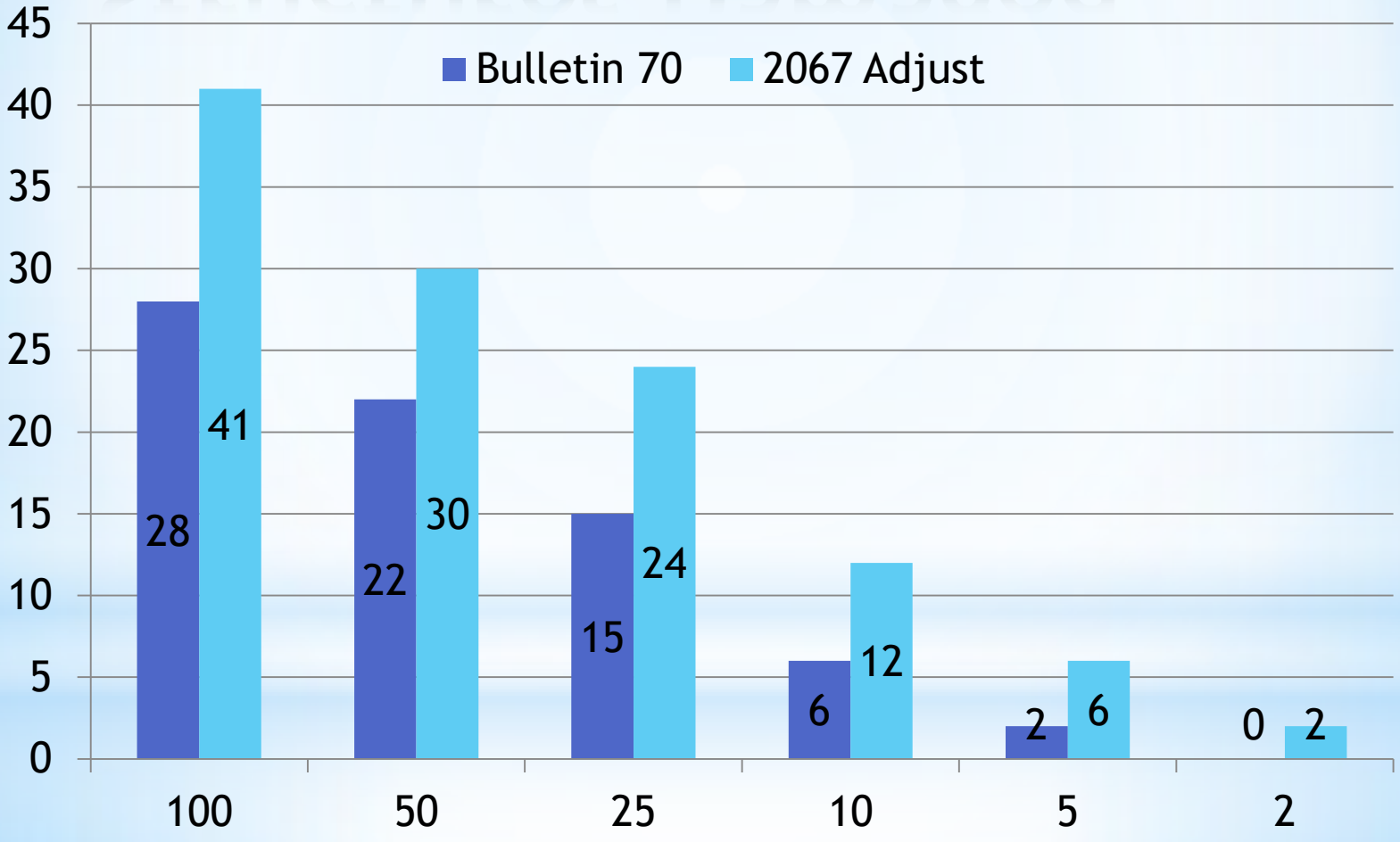
Watershed = 12.33mi^2
*Transform Method – Clark Unit Hydrograph
Tc = 7.42hr, Storage = 5.95hr

Change in WSP

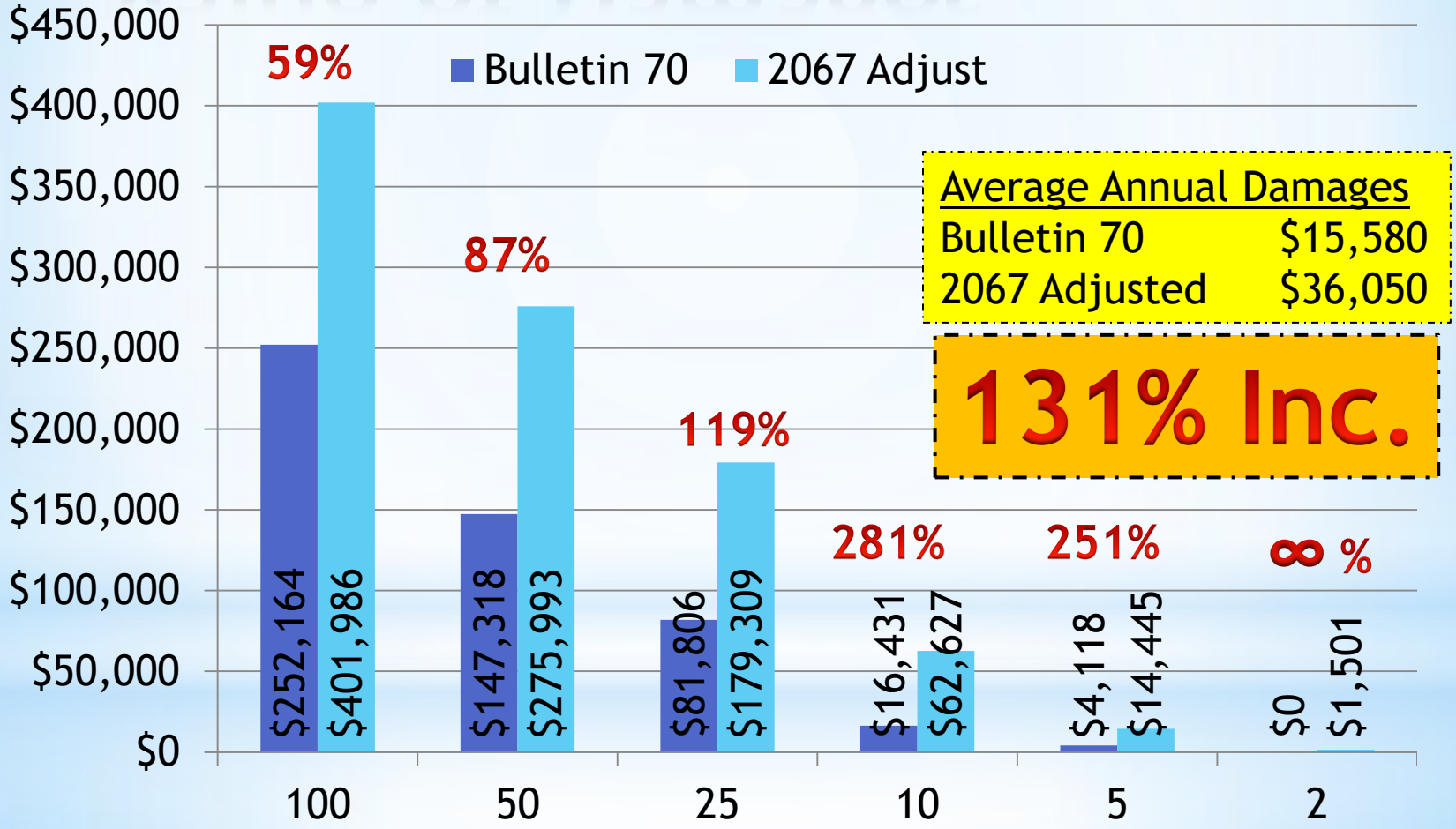
Event	Bul 70	Adj 2065	Diff.
100	715.93	716.97	1.04
50	715.12	716.11	0.99
25	714.24	715.27	1.03
10	713.12	714.10	0.98
5	711.94	713.05	1.11
2	710.61	711.54	0.93
1	709.64	710.48	0.84



Structures Damaged



Value of Damages



HUD / DCEO / IDNR / ISWS Partnership

* 2 Phases of work based on:
  * HUD/DCEO: Funding (Reallocated Hurricane IKE funds)
  * University of Illinois: Illinois State Water Survey: Work
  * IDNR, Office of Water Resources: Project Oversight

* IDNR, Office of Water Resources Goals:
  * Update the design storm rainfall analysis in Bulletin 70 (Huff and Angel, 1989) for Illinois;
  * Preparation of design storm tables commonly used for; Infrastructure design, flood studies, mapping, and regulation;
  * Utilize current technology to estimate future condition (50-yr) events to reflect climate change conditions for resiliency
  * Phase 1 completed by end of 2017
  * Phase 2 completed by end of 2018

Bulletin 70 Update - Phase 1

* Rain gages throughout Illinois and bordering states will be used to prepare extreme rainfall event data.
* Historical rainfall data, ranging from hourly to daily, from the National Centers for Environmental Information (NCEI) (formerly National Climate Data Center/NCDC) will be used
* Cook County Precipitation Network(CCPN) will be considered
* 10 regions defined in Bulletin 70 will be utilized

* Base Report to include
  * 2-, 5-, 10-, 25-, 50-, 100- and 500-year recurrence intervals
  * 1-, 2-, 3-, 6-, 12-, 18-, 24-, 48- and 72-hour rainfall durations

* Revised report to be released Dec 31, 2017

Bulletin 70 Update - Phase 1

* The following checks will be performed upon the rainfall data:

* Exploratory data analysis, e.g. plot the annual maximum series (AMS) data for each gage, trends and outliers.

* Combining two or more stations/missing data

* Determine significant spatial correlations among the gages

* Discordancy and heterogeneity measures from the L-Moments software to select stations for analysis (ask U of I)

* Other tests and analyses, depending on the above steps

Bulletin 70 Update – Phase 2

* Phase 2: Future Conditions
* Scope of work being developed for Phase 2
  * Future rainfall data will be forecasted to 10-year and 100-year frequency for 2050 and 2100;
  * Not a trend analysis – Hindsight look at best performing past prediction models.
* Similar work already being performed in Cook County and for the Des Plaines River watershed

Bulletin 70 Update Phase 1 Timeline

March	Project Start
June	Quality controlled, rainfall data from all gages
July	Data sets selected for statistical frequency analyses
July	Maps comparing trends across different regions
November	Tables for each gage for noted-year recurrence intervals and for various-hour rainfall durations, using the 10 regions defined in Bulletin 70 completed
December	Report in a pdf format for internal and external review
December	Phase 1 Final Report release.

Implementing the Update

* Preparation of design storm tables commonly used for:

    * Infrastructure Design,
    * Flood studies,
    * Mapping, and
    * Regulatory Permit Applications.