The views, opinions and findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation.

INCORPORATING PRECIPITATION TRENDS INTO FLOOD RISK MANAGEMENT STUDIES

USACE Chicago District

Erin Maloney, PE
Planner, Hydraulic Engineer

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Hydraulic Engineer

IAFSM Conference
March 15, 2018
AGENDA

• USACE Policy & Guidance (*Erin*)

• USACE Public Tools (Kristine)

• Application of ISWS precipitation data to economic analysis in Feasibility Studies (*Erin*)
USACE POLICY & GUIDANCE
USACE CLIMATE CHANGE ADAPTATION POLICY, AND CLIMATE ADAPTATION PLAN AND REPORT (2014)

ADAPTATION POLICY STATEMENT

The primary and overarching policy document for USACE is the USACE Climate Projections and Vulnerability Policy Statement, signed by Assistant Secretary of the Army Jo Ellen Darcy in June 2016.

As the Nation’s largest and oldest manager of water resources, the U.S. Army Corps of Engineers (USACE) has long been successfully adapting policies, programs, projects, plans, and operations to prepare for and respond to the impacts of global climate change and variability.

It is the policy of USACE to integrate climate change projections and adaptation planning and policy into all policies, programs, projects, plans, and operations to ensure that USACE projects and projects that interconnect to USACE projects, and actions that are funded by USACE, can be built and maintained with consideration for the impacts of climate change and variability. USACE will continue to develop its knowledge and understanding of climate change and variability, and will strive to ensure that knowledge and understanding is integrated into the evaluation of climate change impacts and into the development of policies, programs, projects, plans, and operations.

USACE recognizes that the impacts of climate change are already being observed and that it is likely that the impacts of climate change will continue to increase over time. Therefore, USACE will continue to develop its knowledge and understanding of climate change impacts and will work to ensure that its policies, programs, projects, plans, and operations are resilient to the impacts of climate change.

http://corpsclimate.us
“It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency’s missions, operations, programs, and projects.”

“… using the best available – and actionable – climate science and climate change information.”

“… it shall be considered at every step in the project life cycle for all USACE projects, both existing and planned, … to reduce vulnerabilities and enhance the resilience of our water-resource infrastructure.”
USACE FEASIBILITY PLANNING PROCESS

“Formulation and evaluation of alternative plans should be based on the most likely conditions expected to exist in the future with and without the plan.”

*Principles and Guidance* - Water Resources Council

Climate Preparedness and Resilience assessments should be focused on steps 2, 3, and 4
Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects (ECB 2016-25)

- Requires consideration of climate change in all current and future studies to reduce vulnerabilities and enhance the resilience of our water resources infrastructure
- Only a qualitative analysis required
  - Consideration of both past (observed) changes in climate trends as well as potential future (projected) changes to relevant hydrologic inputs
  - Can inform the decision process
- Does not prevent the performance of a quantitative analysis in the future
THE ECB 2016-25 ANALYSIS FRAMEWORK

Start Here

Phase I: Relevant Current Climate and Climate Change

- Literature Review: Relevant Current Climate and Climate Change
- Investigate Trends in Annual Maximum Flow Gage Data

Phase II: Projected Changes to Watershed Hydrology and Assessment of Vulnerability to Climate Change

- Investigate Projected Trends in Annual Maximum Flow in Project’s HUC-4 Watershed
- Watershed and HUC-4 Level Vulnerability Assessment

National Climate Assessment and associated Technical Inputs; USACE HUC 2 Climate Change Summaries; other peer-reviewed sources

USACE Climate Hydrology Assessment Tool and USACE Nonstationarity Detection Tool

USACE Watershed Vulnerability Assessment Tool

Write up report, incorporate into risk register as appropriate, and identify special concerns for future analysis

Discussed in this presentation
REGIONAL CLIMATE CHANGE AND HYDROLOGY LITERATURE SYNTHESSES

- USACE had developed 21 regional climate syntheses at the scale of 2-digit USGS Hydrologic Unit Codes (HUC)
- Summarizes observed and projected climate and hydrological patterns cited in reputable peer-reviewed literature
- Summary of USACE business line vulnerabilities

http://www.corpsclimate.us/rccciareport.cfm
REGIONAL CLIMATE CHANGE AND HYDROLOGY LITERATURE SYNTHESSES

**TREND SCALE**
- ▲ Large Increase
- ▼ Small Increase
- ■ No Change
- □ Variable
- ▼ Large Decrease
- ■ Small Decrease
- ◆ No Literature

**LITERATURE CONSENSUS SCALE**
- ● All literature report similar trend
- ★ Majority report similar trends
- ◆ No peer-reviewed literature available for review

(n) = number of relevant literature studies reviewed
USACE PUBLIC TOOLS

Nonstationarity Detection Tool
Climate Hydrology Assessment Tool
Water availability and quality are critical to national security, now and in the future. As part of its water resources management missions and operations, the U.S. Army Corps of Engineers (USACE) has been working together with other federal agencies, academic experts, non-government organizations, and the private sector to translate climate science into actionable science for decision-making.

As part of these efforts, USACE is developing a suite of web-accessible tools to support repeatable analytical results for climate preparedness and resilience planning and engineering design. The sea level change calculator is available here. The calculator is in the process of being revised to add functionality, and will be present in the next several months. We have also developed two tools supporting impacts analysis and design for climate-impacted hydrology, available here.

More tools will be added as they become available. Your comments and feedback are welcome.

www.usace.army.mil/corpsclimate/Public_Tools_Dev_by_USACE.aspx
USACE PUBLIC TOOLS

Nonstationarity Detection Tool
Stationarity, or the assumption that the statistical characteristics of hydrologic time series data are constant through time, enables the use of well-accepted statistical models in water resources planning and design in which future conditions rely primarily on the observed record. However, recent scientific evidence shows that—in some places—and for some impacts relevant to the operations of the U.S. Army Corps of Engineers (USACE)—climate change and human modifications of the water sheds are undermining this fundamental assumption, resulting in nonstationarity.

The Nonstationarity Detection Tool enables the user to apply a series of statistical tests to assess the stationarity of annual instantaneous peak streamflow data series at any United States Geological Survey (USGS) streamflow gage site with more than 30 years of annual instantaneous peak streamflow records through Water Year 2014. The tool aids practitioners in identifying continuous periods of statistically homogenous (stationary) annual instantaneous peak streamflow datasets that can be adopted for further hydrologic analysis. The tool also allows users to conduct monotonic trend analyses on the identified subsets of stationary flow records. The tool facilitates access to USGS annual instantaneous peak streamflow records; does not require the user to have either specialized software or a background in advanced statistical analysis; provides consistent, repeatable analytical results that support peer review processes; and allows for consistent updates over time.

Climate Hydrology Assessment Tool
In releasing Engineering and Construction Bulletin 2014-10, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, USACE took the first step toward developing policy and guidance around projected changes to climate hydrology and how these changes might affect water resources project planning, design, construction, operation, and maintenance.

ECB 2016-25, released on 16 Sept 2016, superseded and updates ECB 2014-10. The qualitative analysis required by this ECB includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs as part of a first-order statistical analysis of the potential impacts to particular hydrologic elements of the study. This analysis can be very useful in considering future without project conditions (FWOP) and the potential direction of climate change. Examples of this type of analysis is provided in Appendix C.

The Climate Hydrology Assessment Tool allows users to easily access both existing and projected climate data to develop repeatable analytical results using consistent information: reducing potential error and increasing the development of information so that it can be used earlier in the decision-making process. It is developed in the development of risk registers. The tool steps through the process of developing information and supplies graphics suitable for use in a report including: trend detection in observed annual maximum daily flow; trend detection in observed annual maximum 3-day flow; climate-modeled annual maximum monthly flow range, and trend detection in annual maximum monthly flow models.
Welcome to the Nonstationarity Detection Tool

This Nonstationarity Detection Tool was developed in conjunction with USACE Engineering Technical Letter (ETL) 1100-2-3, Guidance for Detection of Nonstationarities in Annual Maximum Discharges, to detect nonstationarities in maximum annual flow time series. For this ETL 1100-2-3, engineers will be required to assess the stationarity of all streamflow records analyzed in support of hydrologic analysis carried out for USACE planning and engineering decision-making purposes.

The Nonstationarity Detection Tool enables the user to apply a series of statistical tests to assess the stationarity of annual peak streamflow data series at any United States Geological Survey (USGS) annual instantaneous peak streamflow page site with more than 30 years of flow record through Water Year 2014. The tool is intended to aid practitioners in identifying continuous periods of statistically homogenous (stationary) annual peak streamflow datasets that can be adopted for further hydrologic analysis.

The web tool detects nonstationarities in the historical record to help the user segment the record into flow datasets whose statistical properties can be considered stationary. The tool also allows users to conduct monotonic trend analysis on the resulting subsets of stationary flow records identified. The web tool facilitates direct access to annual maximum streamflow datasets, does not require the user to have specialized software or a background in advanced statistical analysis, provides consistent, repeatable analytical results that support peer review processes, and allows for consistent updates over time.

This functionality is contained within three different sheets:

- Nonstationarity Detector: The Nonstationarity Detector sheet uses a dozen different statistical methods to detect the presence of both abrupt and smooth nonstationarities in the period of record.
- Trend Analysis: The Trend Analysis sheet displays the results from four different statistical methods for trend analysis.
- Method Explorer: Within the Method Explorer sheet, a user can select any of the twelve nonstationarity detection methods to view independently of the other statistical tests.

If you have any questions or comments, please let us know by contacting: corp.support@usace.army.mil
Nonstationarity Detection Tool (NSD) - PROD

We are currently experiencing issues with the Trend Analysis tab. All other tabs in the tool are fully functional. Please contact climatechange@usace.army.mil with any questions.

Nonstationarity Detector | Trend Analysis | Methyl Explorer

Nonstationarities Detected using Maximum Annual Flow/Height:

- Annual Peak Streamflow in CF
- Nonstationarities detected using maximum annual flow/height

This gage has a drainage area of 6,000 square miles.

WARNING: The period of record includes no missing data points. There are potential issues with the gages/pumps detected.

The USGS streamflow gage sites available for assessment within this application include locations where there are discontinuities in USGS peak flow data collected throughout the period of record and gauges with short records. Engineering judgment should be exercised when carrying out analysis where there are significant data gaps.

In general, a minimum of 30 years of continuous streamflow measurements must be available before this application should be used to detect nonstationalities in flow records.

Hatmann - Graphical Representation of Statistical Results

Parameter Selection
- Instantaneous Peak Streamflow
- Stage

Site Selection
- Select a state:
  - ND
- Select a site:
  - 0540000: RED RIVER OF THE NORTH A

Timeframe Selection

Sensitivity Parameters
- Instantaneous parameters are used in the model. Engineering judgment is required as certain parameters are selected.

CETM Methods Turn-on Period
- Default: 20

CETM Methods Sensitivity
- Default: 1.0

NONSTATIONARITY DETECTION TOOL

This page has a drainage area of 26.96 square miles.

The USGS streamflow gauges sites available for assessment within this application include locations where there are discontinuities in USGS peak flow data collection throughout the period of record and gauges with short records. Engineering judgment should be exercised when carrying out analyses where there are significant data gaps.

In general, a minimum of 30 years of continuous streamflow measurements must be available before this application should be used to detect nonstationarity in flow records.

Heatmap - Graphical Representation of Statistical Results

<table>
<thead>
<tr>
<th>Method</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cramer-Von-Mises (CPM)</td>
<td>0.6</td>
</tr>
<tr>
<td>Kolmogorov-Smirnov (K-S)</td>
<td>1,000</td>
</tr>
<tr>
<td>LePage (CPM)</td>
<td></td>
</tr>
<tr>
<td>Energy Divisive Method</td>
<td></td>
</tr>
<tr>
<td>Lombard Willems</td>
<td></td>
</tr>
<tr>
<td>Pettit</td>
<td></td>
</tr>
<tr>
<td>Mann-Whitney (CPM)</td>
<td></td>
</tr>
<tr>
<td>Bayesian</td>
<td></td>
</tr>
<tr>
<td>Likelihood</td>
<td></td>
</tr>
<tr>
<td>Median Likelihood</td>
<td></td>
</tr>
</tbody>
</table>

Parameter Selection
- Instantaneous Peak Streamflow
- Range

Site Selection
- Select a state: IL
- Select a site: 5205000 - WEBB BRANCH DU PAW

Timeline Selection
- 1960: 2065

Sensitivity Parameters
(Sensitivity parameters are described in the manual. Engineering judgment is required if non-default parameters are used.)

CPM Methods: Sensitivity
- Default: 0.6

Bayesian Sensitivity
- Default: 0.9
NONSTATIONARITY DETECTION TOOL

In general, a minimum of 30 years of continuous streamflow measurements must be available before this application should be used to detect nonstationarities in flow records.

Heatmap - Graphical Representation of Statistical Results

Cramer-Von Mises (CPM)
Kolmogorov-Smirnov (CPM)
LePage (CPM)
Energy Divide Method
Lombard Wilcoxon
Puttii
Mann-Whitney (CPM)
Bayesian
Lombard Mood
Mood (CPM)
Smooth Lombard Wilcoxon
Smooth Lombard Mood


Legend - Type of Statistically Significant Change being Detected
- Distribution
- Variance
- Mean
- Smooth

Mean and Variance Between All Nonstationarities Detected

Segment Mean (CFS)
- 600
- 400
- 200

Segment Standard Deviation (CFS)
- 400
- 200
- 0

Segment Variance (CFS Squared)
- 260K
- 160K
- 0K

CPM Methods Sensitivity
(Default: 1.00)

Bayesian Sensitivity
(Default: 0.5)

Energy Divide Method Sensitivity
(Default: 0.5)

Lombard Smooth Methods Sensitivity
(Default: 0.05)

Pettitt Sensitivity
(Default: 0.05)

Please acknowledge the US Army Corps of Engineers for producing this nonstationarity detection tool as part of their progress in climate preparedness and resilience and making it freely available.
How can I interpret all those results?

– Look for **consensus** among tests e.g. multiple tests find changes in mean

– Look for **robustness** across detected changes e.g. changes in mean and variance – multifaceted change

– Assess **magnitude** of change – changes can be statistically significant but of no practical significance
NONSTATIONARITY DETECTION TOOL

Trend in Maximum Annual Flow at WEST BRANCH DU PAGE RIVER NEAR WEST CHICAGO, IL

Monotonic Trend Analysis

Is there a statistically significant trend?
Yes, using the Mann-Kendall Test at the .05 level of significance.
Yes, using the Spearman Rank Order Test at the .05 level of significance.

What type of trend was detected?
Using parametric statistical methods, a positive trend was detected.
Using robust parametric statistical methods (Sen's Slope), a positive trend was detected.

Data updated 01/01/17 4:45:03 PM
NONSTATIONARITY DETECTION TOOL

The U.S. streamflow gage sites available for assessment within this application include locations where there are discontinuities in USGS streamflow data collection throughout the period of record and gages with short records. Engineering judgment should be exercised when carrying out analysis where there are significant data gaps.

In general, a minimum of 30 years of continuous streamflow measurements must be available before this application should be used to detect nonstationarities in those records.

Mean and Variance between Nonstationarities
Detected with Cramer-Von-Mises (CPM)

<table>
<thead>
<tr>
<th>Segment Mean (CPM)</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Segment Standard Deviation (CPM)</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Segment Variance (DFB Squared)</th>
<th>106K</th>
</tr>
</thead>
<tbody>
<tr>
<td>106K</td>
<td></td>
</tr>
<tr>
<td>50K</td>
<td></td>
</tr>
<tr>
<td>6K</td>
<td></td>
</tr>
</tbody>
</table>

The U.S. Army Corps of Engineers is working to reduce or eliminate the negative impact of nonstationarities in streamflow data and to provide engineers with tools to quantify and mitigate the effects of these nonstationarities.
guidance for hydrology used in climate change impact assessments and adaptation planning and design.

Nonstationarity Detection Tool

Stationarity, or the assumption that the statistical characteristics of hydrologic time series data are constant through time, enables the use of well-accepted statistical methods in water resources planning and design in which future conditions rely primarily on the observed record. However, recent scientific evidence shows that—in some places, and for some impacts relevant to the operations of the U.S. Army Corps of Engineers (USACE)—climate change and human modifications of the watersheds are undermining this fundamental assumption, resulting in nonstationarity.

The Detection Tool enables the user to apply a series of statistical tests to assess the stationarity of annual instantaneous peak streamflow data series at any United States Geological Survey (USGS) streamflow gage site with more than 30 years of annual instantaneous peak streamflow records through Water Year 2014. The tool aids practitioners in identifying continuous periods of statistically homogenous (stationary) annual instantaneous peak streamflow datasets that can be adopted for further hydrologic analysis. The tool also allows users to conduct monotonic trend analyses on the identified subsets of stationary flow records. The tool facilitates access to USGS annual instantaneous peak streamflow records; does not require the user to have either specialized software or a background in advanced statistical analysis; provides consistent, repeatable analytical results that support peer review processes; and allows for consistent updates over time. USACE technical guidance on the detection of nonstationarities in annual maximum flows is contained in Engineer Technical Letter 1100-2-3.

The User Manual includes a discussion of the technical concepts incorporated into the Nonstationarity Detection Tool, a description of the user interface, an explanation of how to apply the user interface to execute hydrologic analysis, and a series of examples highlighting how the tool is applied. This user guide does not cover all possible situations one may encounter using the tool. The first step in conducting nonstationarity detection is to carry out data preparation and exploratory data analysis, which are described in detail in Section 3. The Nonstationarity Detection Tool is not a substitute for professional engineering judgment. For more information about the tool, you can read the fact sheet. You can also watch a video (mp4, 541 MB) that explains how to use the tool.

Climate Hydrology Assessment Tool

In releasing Engineering and Construction Bulletin 2014-10, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, USACE took the first step toward developing policy and guidance around projected changes to climate hydrology and how these changes might affect water resources project planning, design, construction, operation and maintenance.

ECB 2016-25, released on 16 Sept 2016, supersedes and updates ECB 2014-10. The qualitative analysis required by this ECB includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs as part of a first-order statistical analysis of the potential impacts to particular hydrologic elements of the study. This analysis can be very useful in considering future without project conditions (FWOP) and the potential direction of climate change. Further details of analysis is provided in Appendix C.

The Climate Hydrology Assessment Tool allows users to easily access both existing and projected climate data to develop reports. It is a tool that supports development of additional information: reducing potential errors and increasing the development of information so that it can be used earlier in the decision-making process, ideally in the development of risk registers. This tool steps users through the process of developing information and supplies graphics suitable for use in a report including: trend detection in observed annual maximum daily flow, trend detection in observed annual maximum 3-day flow, climate-modeled annual maximum monthly flow range, and trend detection in annual maximum monthly flow models.
In releasing the Engineering and Construction Bulletin 2016-25, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, USACE took the first step toward developing policy and guidance around projected changes in climate hydrology and how these changes might affect water resources project planning, design, construction, operation, and maintenance.

The qualitative analysis required by this ECB includes consideration of both observed past changes as well as potential future (projected) changes to relevant hydrologic inputs. A first-order statistical analysis of the potential impacts to particular hydrologic elements of the study can be included as supplemental input to this qualitative assessment, but is not required.

However, this analysis can be very useful in considering future without project conditions (FWOP) and the potential direction of climate change.

The techniques required to obtain the data for the statistical analysis can be cumbersome and the multiple steps required could introduce errors that might adversely impact the results and the interpretations and decisions made based on these results. Because the intent of ECB 2016-25 is to provide information about future conditions useful to decision-makers, we decided to develop a web-accessible tool to allow USACE staff to easily access both existing and projected climate. This allows districts across the country to develop repeatable analytical results using consistent information. In doing so, we reduce potential error and speed the development of information so that it can be used earlier in the decision-making process, ideally in the development of risk registers.

The tool stops users through the process of developing information shown in the figures of Appendix C, and supplies graphics suitable for use in a report:

- Trend detection in observed annual peak instantaneous streamflow. Here the user selects the desired HUC-4 watershed and obtains data for the desired USGS gauge using the pick list or the map. Hovering over a spot on the map provides information on the gage and a link to open the gage data in a separate window. The graphics reproduce Figure C-1 and include a trend line. Hovering over the trend line provides the equation for the line and also an indication of significance.
- Climate-modeled projected annual maximum monthly flow range. This tab provides a graphic of the projected climate-change hydrology for the selected HUC-4 watershed that reproduces Figure C-3. The range of the 95 projections of annual maximum monthly flow is shown in yellow, just as it is in Figure C-3. The mean of the 95 projections of annual maximum monthly flow is shown in blue.
- Trend detection in annual maximum monthly flow models. This tab provides a graphic including the statistical analysis of the mean of the projected annual maximum monthly streamflow projections for the selected HUC-4 watershed, reproducing Figure C-4. Hovering over the trend line provides the equation for the line and also an indication of significance.
CLIMATE HYDROLOGY ASSESSMENT TOOL

1) Choose a HUC-4
0101-St. John
0103-Piscataquis
0103-Kennebec
0104-Merced
0103-Merced Coastal
0106-Sacramento
0107-Merced
0104-Diamond
0104-Crane
0109-Massachusetts/Rhode Island Coastal
0119-Connecticut Coastal
0202-Upper Hudson
0203-Lower Hudson-Lower Richland
0204-Columbia-Mid Atlantic Coastal
0205-Susquehanna
0205-Upper Chesapeake
0207-Potomac
0208-Lower Chesapeake
0201-Chesapeake-Bay
0202-Heritage-Pacific
0303-Cape Fear
0304-Neuse-Dan
0306-Estero-Santee
0306-Ocypetos-Savannah
0307-Alabama-18 Myers
0308-St. Johns
0309-Southern Florida
0319-Panama-City Bay
0311-Susquiene
0313-Ocklawaha
0313-Apalachee
0314-Chiefland-Flintographs-Columbia
0315-Alabama
0316-Holida-Tomahhagee
0317-Quagmires
0318-Pearl
0401-Western Lake Superior
0402-Southern Lake Superior-Lake Superior
0403-Northwestern Lake Michigan
0404-Southern Michigan Lake Michigan
0405-Southeastern Lake Michigan
0406-Northeastern Lake Michigan-Lake Michigan
0407-Northern Lake Huron
0408-Southeastern Lake Huron-Lake Huron
0409-St. Clair-Detroit
0410-Southern Lake Erie

2) Click Map Location or Name to Select Stream gauge

- - - NO GAGE SELECTED OR DATA UNAVAILABLE - - -
Select new gage from list or map above to display trend chart
CLIMATE HYDROLOGY ASSESSMENT TOOL

1) Choose a HUC-4
0712-Uppr Illinois

2) Click Map Location or Name to Select Stream Gage

3) Include Only Years (if Desired)
1757
2016

Annual Peak Instantaneous Streamflow, None Selected
(Hover Over Trend Line For Significance (p) Value)

Analysis: None

- - - NO GAGE SELECTED OR DATA UNAVAILABLE - - -
Select new gage from list or map above to display trend chart
Annual Peak Instantaneous Streamflow, NB CHICAGO RIVER AT ALBANY AVENUE AT CHICAGO, IL
Selected
(Hover Over Trend Line For Significance (p) Value)
Climate Hydrology Assessment Tool v.1.0
Analysis: 3/0/2018 1:05 PM

The p-value is for the linear regression fit drawn; a smaller p-value would indicate greater statistical significance. There is no recommended threshold for statistical significance, but typically 0.05 is used as this is associated with a 5% risk of a Type I error or false
CLIMATE HYDROLOGY ASSESSMENT TOOL

Annual Peak Instantaneous Streamflow, NB CHICAGO RIVER AT ALBANY AVENUE AT CHICAGO, IL
Selected

(Hover Over Trend Line For Significance (p) Value)

Climate Hydrology Assessment Tool v.1.0

Analysis: 3/8/2018 1:05 PM

Value = 54.2927*Water Year + -106935
R-Squared: 0.185102
P-value: 0.0358587

The p-value is for the linear regression fit drawn; a smaller p-value would indicate greater statistical significance. There is no recommended threshold for statistical significance, but typically 0.05 is used as this is associated with a 5% risk of a Type I error or false positive.
CLIMATE HYDROLOGY ASSESSMENT TOOL

Annual Peak Instantaneous Streamflow, NB CHICAGO RIVER AT ALBANY AVENUE AT CHICAGO, IL
Selected

(Hover Over Trend Line For Significance (p) Value)

Climate Hydrology Assessment Tool v.1.0

Analysis: 3/8/2018 1:35 PM

The p-value is for the linear regression line drawn. A smaller p-value would indicate greater statistical significance. There is no recommended threshold for statistical significance, but typically 0.05 is used as this is associated with a 5% risk of a Type I error or false
CLIMATE HYDROLOGY ASSESSMENT TOOL

1) Choose a HUC-4

2) Change Displayed Date Range of Modeled Data (If Desired)

Legend
- Mean of 39 Projections
- Range of Projections
APPLICATION OF ISWS PRECIPITATION DATA TO ECONOMIC ANALYSIS OF PROJECTS IN FEASIBILITY STUDIES
BASIS FOR USING PROJECTED DATA

• Consensus on increased peak precipitation and peak flow rates in future
  o ISWS precipitation frequency analysis provides data to apply to hydrology modeling

• USACE feasibility studies use a 50-year period of analysis to determine economic benefits associated with evaluated projects
  o Flood frequency analysis based on precipitation frequency curves relying on observed data (Bulletin 70, period of record: 1901-1983)
  o Flood frequency does not account for observed or anticipated trends towards increasing precipitation in the future

• Not qualitatively including future precipitation trend projection in our project evaluation could impact plan selection, resiliency/reliability of recommended projects, and the level of residual risks following construction.

• The Chicago District proposes that this risk be managed by quantitatively by incorporating precipitation projections in the future conditions.
PROPOSED METHODOLOGY

* Under Review through USACE Climate Preparedness and Resilience Community of Practice
WHICH SCENARIO??

[Graph showing CO2 concentration (ppmv) over years, with different scenarios represented by lines of different colors and styles.]

- RCP3-PD/2.6
- RCP4.5
- RCP6
- RCP8.5
- B1
- A1B
- A1F1
- A2
ADDRESSING UNCERTAINTY

- Acknowledge Uncertainty Associated with Climate Model Output for Future
- Interpreting Global Climate Model Output
- Hydrologic Model Uncertainty

“REVEALING” UNCERTAINTIES

- Better Understanding, Quantification and Definition of Uncertainty

KEEP CALM IT’S COMING SOON

- Emissions Scenario(s)
- Global Climate Model(s)
- GCM initial conditions
- Downscaling method(s)
- Hydrologic Model Structure(s)
- Hydrologic Model Parameter(s)

Combined Uncertainty
QUESTIONS?