

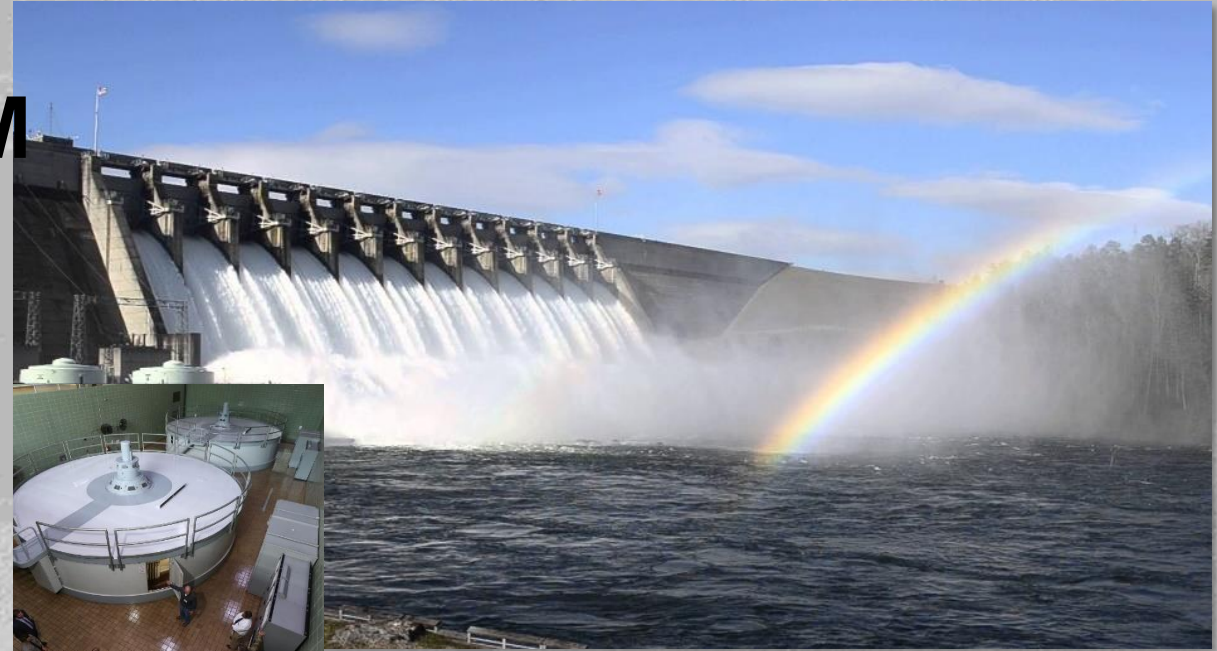
UPDATE ON USACE ACTIVITIES RELATED TO DAM OPERATIONS AND FLOOD SCIENCE

By: Jerry Cotter P.E.

Title: Chief Water Resources, Fort
Worth District

Date: 09 February 2024

Audience: SAME Infrastructure
Conference, Texas



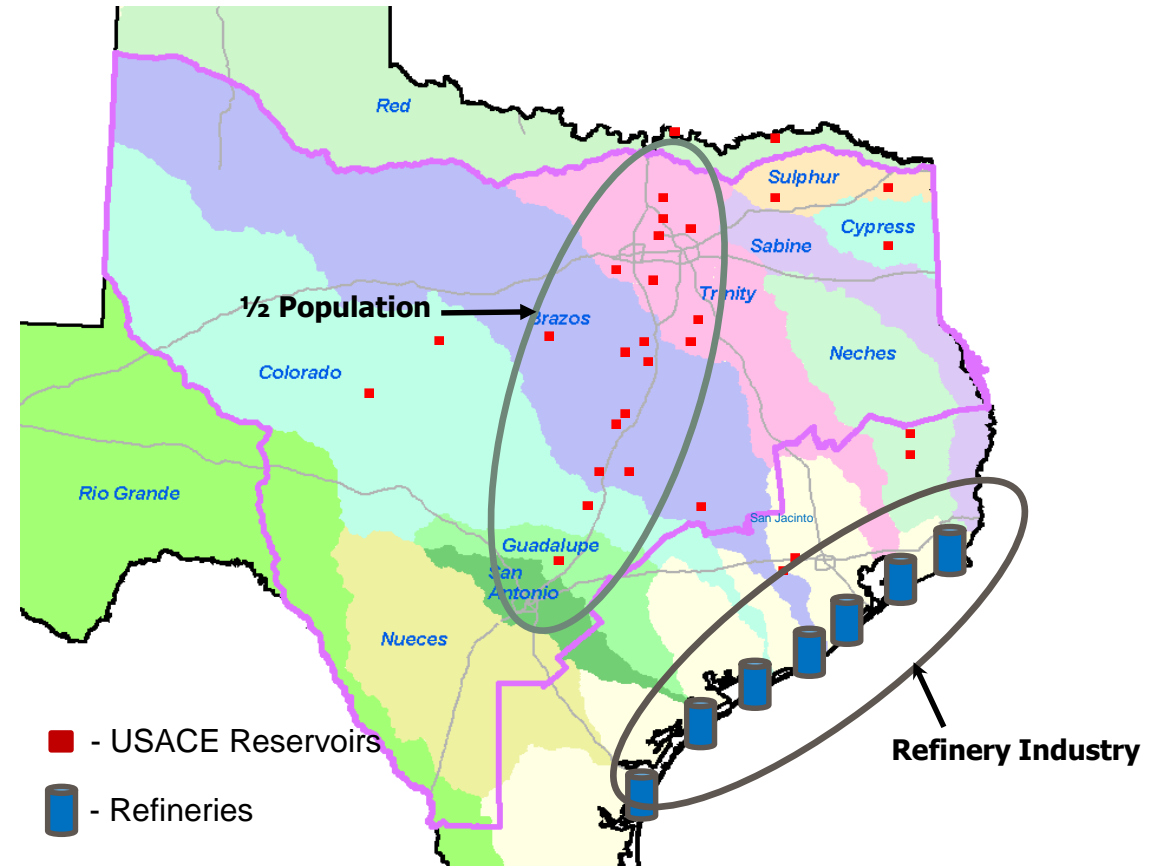
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INCREASING RESILIENCY - STATEWIDE FEDERAL RESERVOIR DEVELOPMENT



- Multi-purpose reservoirs, 32 statewide, \$8B investment
- WS storage 6.5 M ac-ft contracted, 1/3 TX surface water. >50% along I35
- **Flood storage 13.4 M ac-ft, \$150 B benefits**
- Population growth, 1100/day, 30M to >50M 2050
- 1/2 population along I35
- Texas is 2nd in GDP, 3rd in Ag. production
- 32% of refinery capacity
- Significant drought vulnerabilities
- WS deficits 3M ac-ft (current), 7M ac-ft (future)
- \$80B projected cost including 23 new reservoirs
- **What about adaptive management?**
 - Forecast Informed Reservoir Operations (FIRO)
 - Could release patterns be altered to provide increased benefits? (SRP)





INVESTMENTS IN NEW TECHNOLOGIES, TOOLS AND DATA

- Surface Water Gage Network – Critical to dam operations and understanding watersheds
- Doppler Radar and Digital Precipitation Products – Critical to flood sciences and water resource investigations
- Computed Evaporation Tool – Evaporation estimates from pans have significant error and uncertainty
- State of the Art Numerical Modeling Tools – Critical for flood warning, flood mitigation and water availability

SURFACE WATER GAGE NETWORK

Did you know?

- USGS operating partner
 - Shared across federal, state and local governments
 - \$170M national surface water network
 - USACE funds about \$19.2M
- Provides
 - Real-time streamflow and precipitation observations ++
- Highly important for water resources
 - Critical for USACE dam operations
 - Water Supply
 - Flood risk
 - Flood operations and public flood warnings
 - Trends
 - Climate variability and change
 - Forms the basis of any regional or national water resources study

DOPPLER RADAR & DIGITAL PRECIPITATION PRODUCTS

Did you know?

- NWS operating partner
 - Shared across federal, state and local governments
 - USACE initial cost share partner
 - Leverages Cooperative Stream Gage Program
- Provides
 - Real-time precipitation estimates
 - Real-time multi-parameter weather analysis
- Severe weather events
 - Critical for USACE dam operations
 - Critical for NWS flood warnings
 - Critical for NWS weather alerts and warnings
 - Relies on Cooperative Stream Gage Network (calibration)

COMPUTED EVAPORATION FOR TEXAS (TWDB, LCRA & USACE)

- Texas water availability
 - Average annual surface water use is ~ 6.25 MAC
 - Average annual evaporation is ~ 6.1 MAC
 - **Evaporation losses ~ human use**
- Critical component for determination of water availability
- Evaporation pans do not provide ideal evaporation estimates for reservoirs
- How will temperature increase impact evaporation
- Computed evaporation per research with TXA&M and DRI and use of weather observation data
- WEB based application and data base
- Evaluation and testing phase

STATE-OF-THE-ART MODELING TECHNOLOGIES

- Full suite of software applications for reservoir analysis
 - Meteorology (real-time, design storms, shifts)
 - Hydrology (basin response)
 - Reservoir system simulations, period of record analysis (reservoirs)
 - Hydraulics (how deep)
 - Consequences (who gets wet and damages)
 - Probabilistic, Monte Carlo
- Employed across USA and globally
- Purposes:
 - Planning (WAT)
 - Real-time operations (CWMS or RTS)
 - Environmental
- Watershed studies
 - Real-time runoff potential

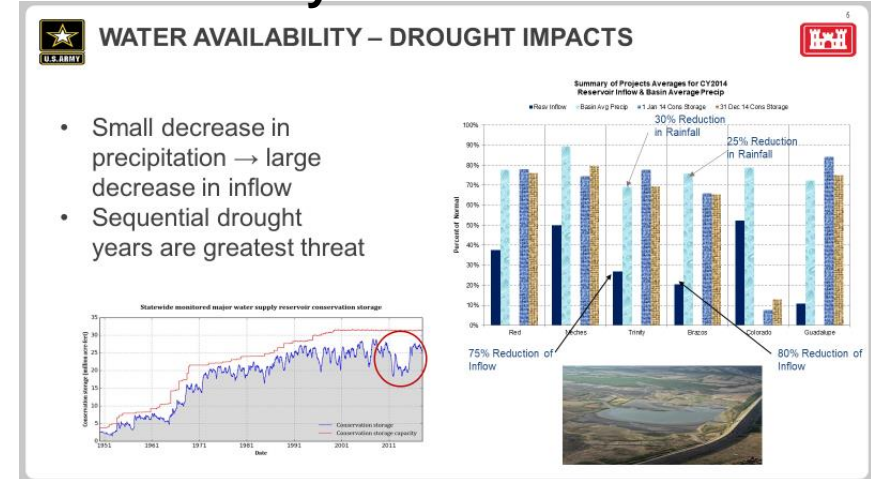
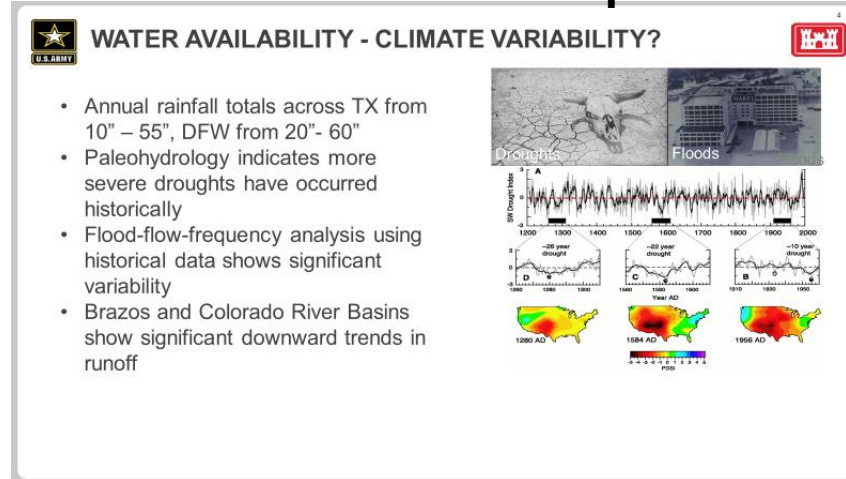


CURRENT AND FUTURE CHALLENGES IN WATER AVAILABILITY

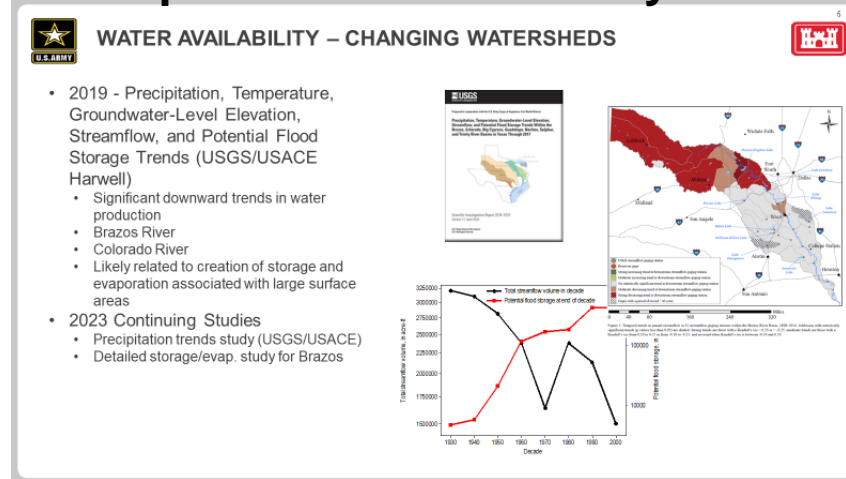


- The region experiences extreme climate variability
 - DFW Precipitation range
 - Max. 62"
 - Min. 18"
 - Normal 36"
- Rainfall-runoff is non-linear with a 30% decrease in precipitation = 75% decrease in runoff
- Sequential drought years most impactful
- Upper Brazos and Colorado Basins producing significantly less runoff
- Population growth, extreme and distributions distributed differently than earlier estimates

Impacts of Climate Variability



Impacts Non-Stationarity in Basin Response and Population Growth



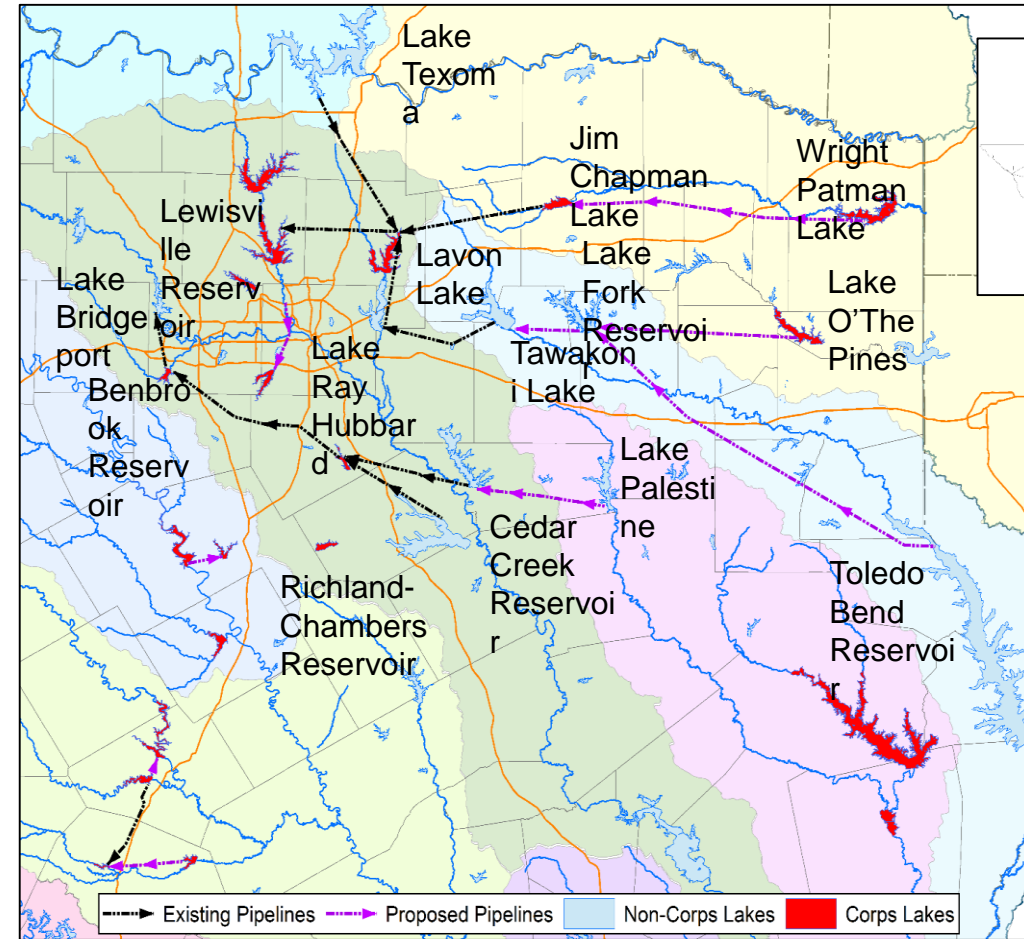


FUTURE CHALLENGES RESPONSE TO INCREASING WATER NEEDS



Water Supply Community

- ~1500 miles of constructed or planned pipelines
- Transport of water to population centers
- Can be seasonal or shortage driven
- New reservoir construction
- Increased conservation

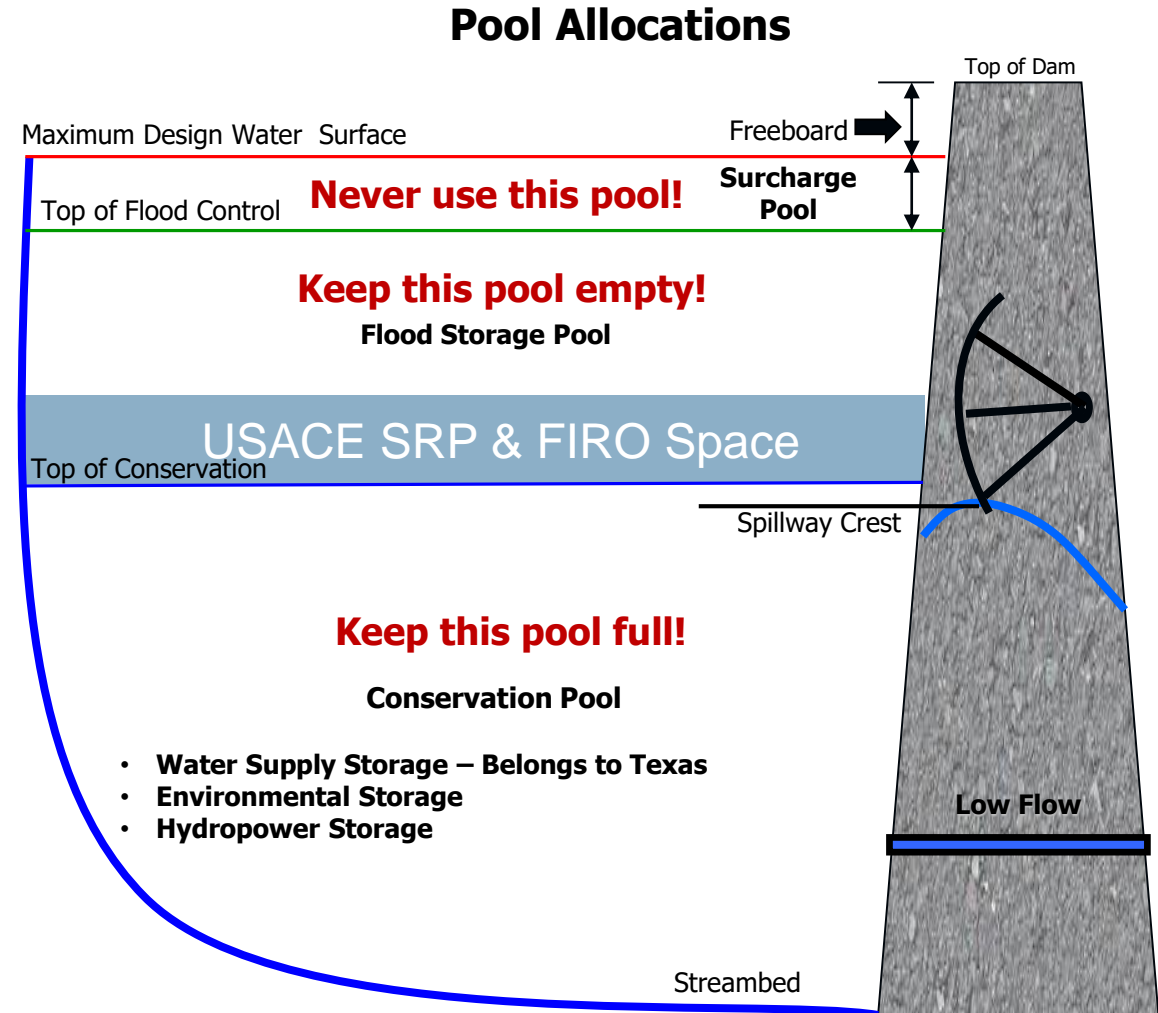




USACE OPERATIONS – WHAT ARE SRP & FIRO OPERATIONS



- Reservoir Operations
 - Follow WCM "Plan of Operation" for reservoir system
 - Store water in conservation pools
 - Temporarily store flood inflow to maintain safe DS conditions
 - Safely release water into DS river reaches
 - **Forecasts are used**
- USACE FIRO (adaptive management)
 - Explores technology driven flexibilities
 - Targets lower 5% - 20% of flood pool
 - Climatology currently supports limited FIRO
 - Requires improvements in sub-seasonal and seasonal forecasts
 - Initially supported thru deviations
 - GOAL: Codified within a WCP
 - Broad national and regional support
 - Identifies the need for greater investments in weather/climate prediction research
- USACE SRP Space (adaptive management)
 - Operational flexibilities for lower 20% of FP
 - Taper program
 - Improving releases in lower portion of the flood pool
 - Enhancing biology
 - Threatened and endangered species
 - Recreation opportunities
 - Goal: Codified within a WCP

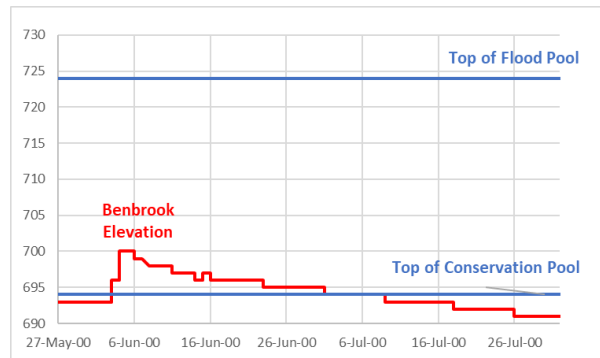
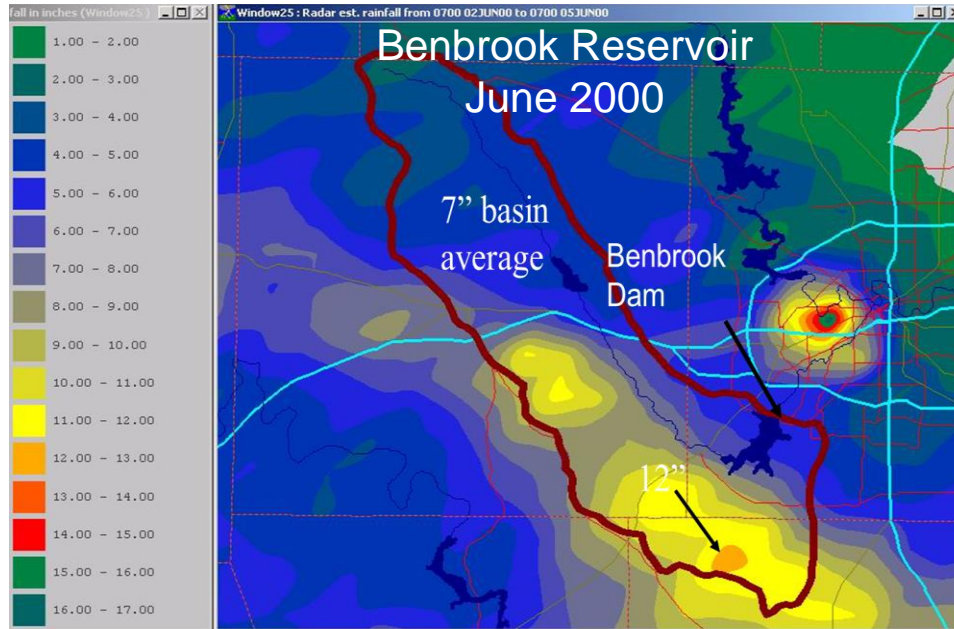




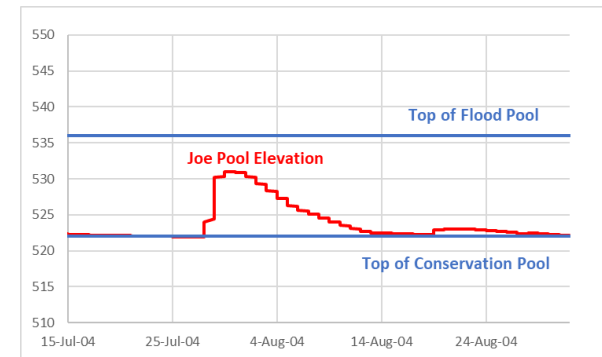
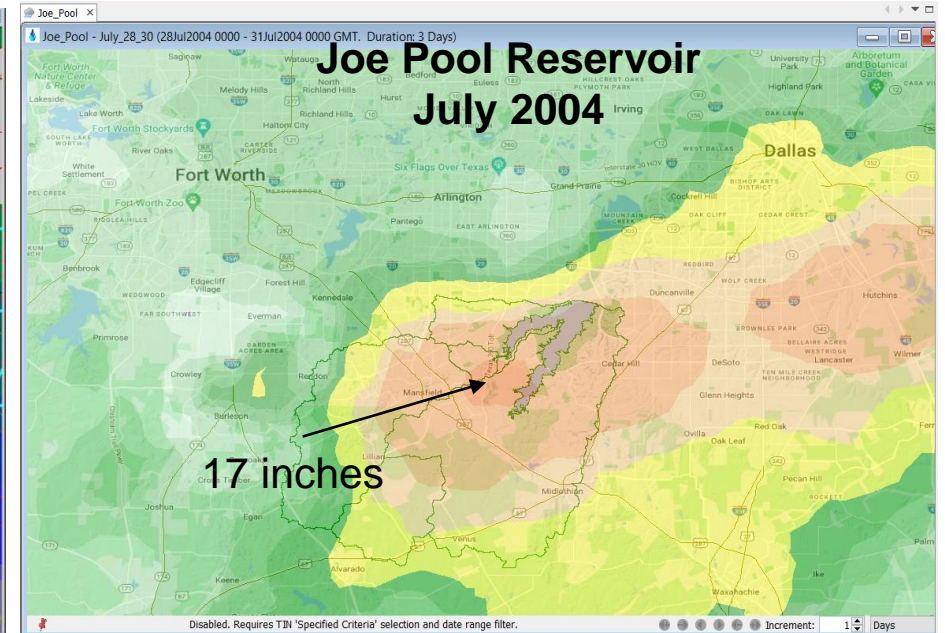
EXTREME EVENTS – SMALLER EVENTS WITH DRY ANTECEDENT CONDITIONS



- Reservoirs are designed to operate thru extreme events
- June 2000 and July 2004 dry WS events suggest:
 - Projects operate through 12" & 17" events
 - 15% storage in Benbrook
 - 50% storage in Joe Pool
 - Ok for FIRO 5% - 20 % retention in flood pool



Benbrook Lake rose 6'



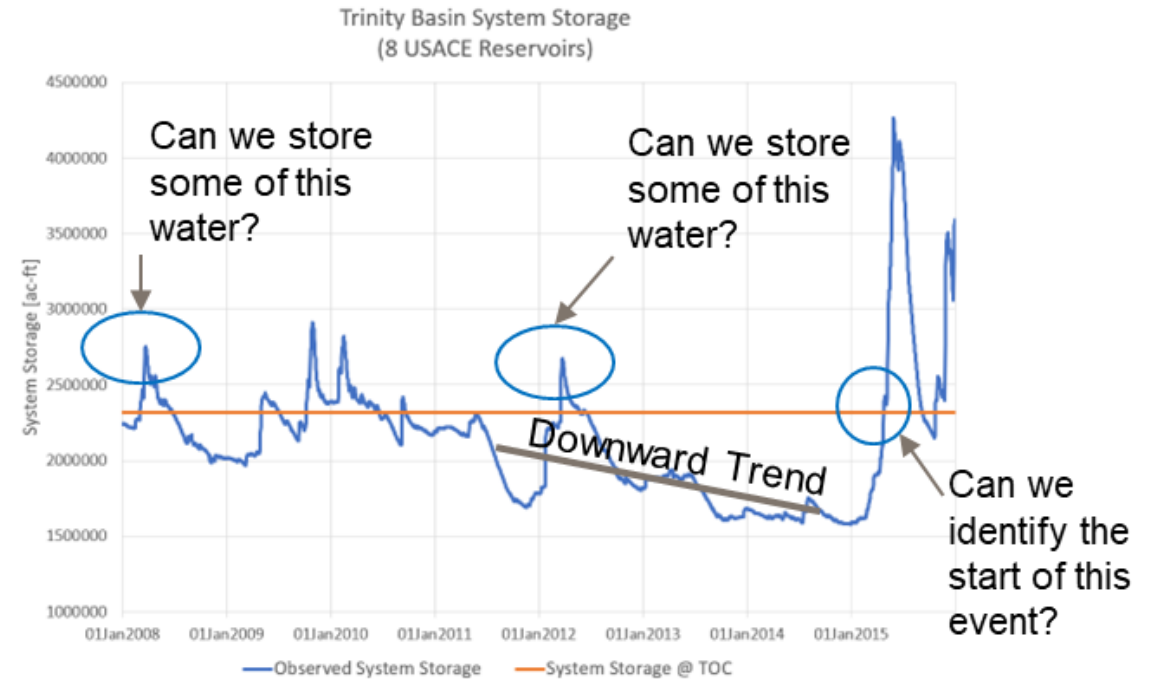
Joe Pool Lake rose 12'



INITIAL FIRO GOALS



- More water available without costly infrastructure investments
- Storing flood water in late spring and early summer (reduced pumping)
- Storing runoff that may occur during sequential drought years
- Current forecast capability may not support any of these FIRO paradigms
- Forecast improvements need to target
 - The end of spring rains
 - Identification of persistent drought
 - Climate shifts from dry to wet and wet to dry





SUSTAINABLE RIVERS PROGRAM OBJECTIVES



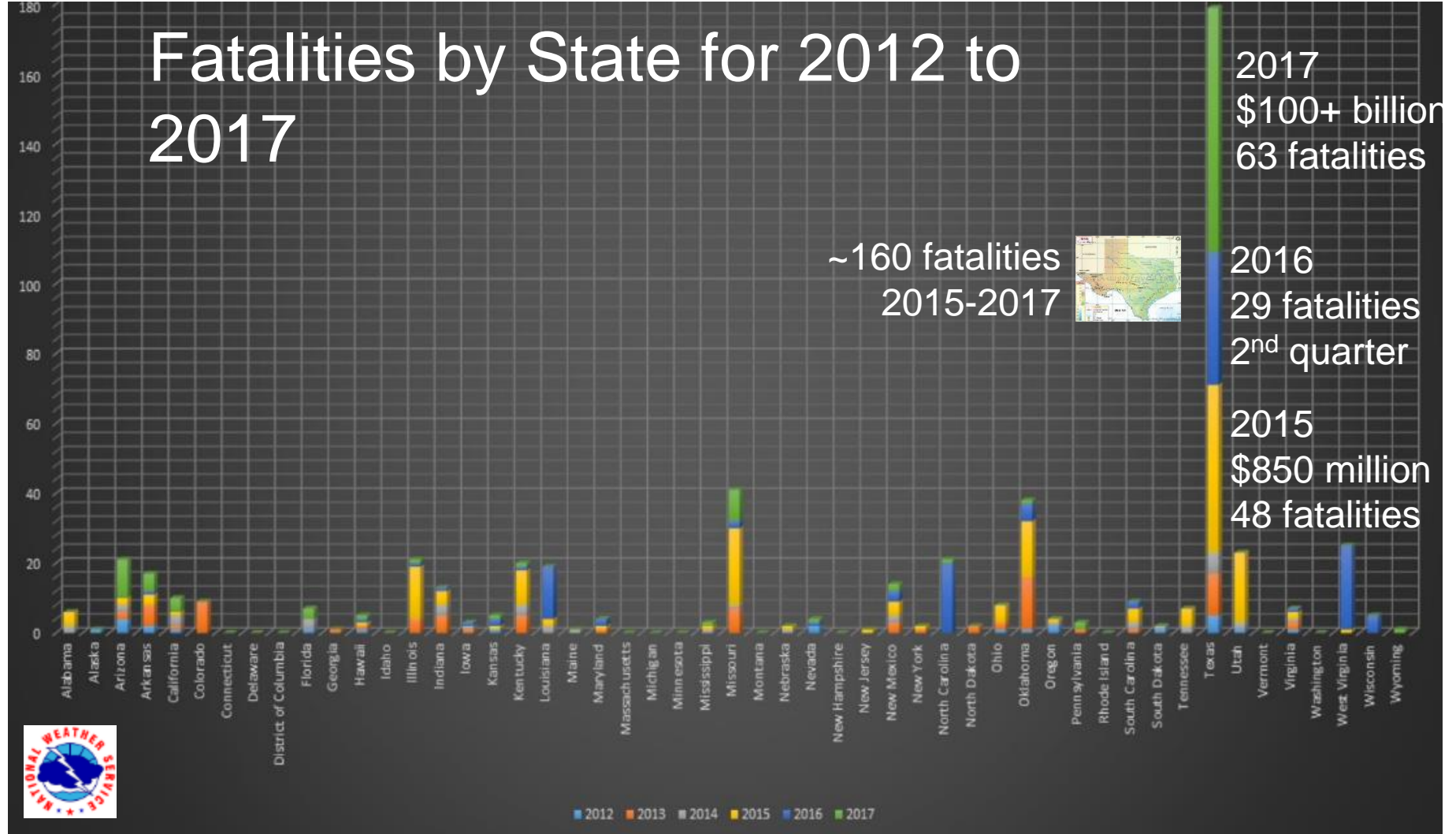
- Build collaboration across competing business lines
- Modify reservoir releases to provide additional benefits
 - Environmental
 - Socioeconomic
 - Cultural
 - Recreational
- Think of the future and identify needs outside of SRP. USACE CAP programs for environmental restoration, fish habitat
- Build partnerships the research community
- Advocacy – we can accomplish SRP but only with your help





FLOODING FATALITIES AND DAMAGES

Texas far outpaces other states in flood related fatalities & flood related damages



(Source: Gregory Waller, Service Coordination Hydrologist, NWS – West Gulf River Forecast Center, <http://www.nws.noaa.gov/om/hazstats.shtml>, 11/18 TFMA)

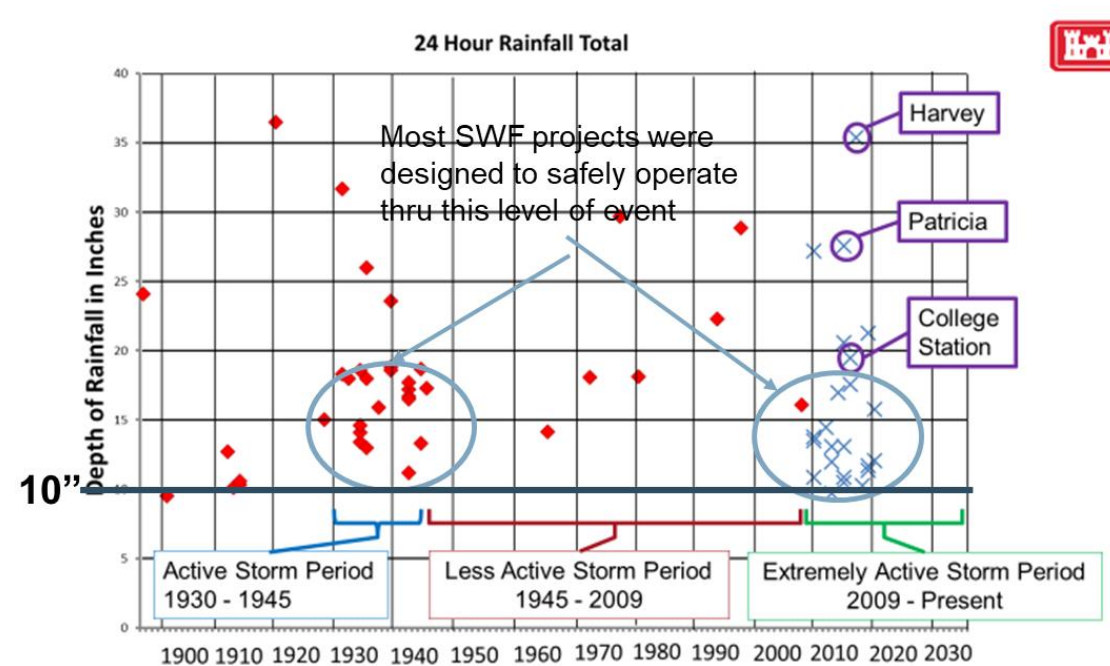


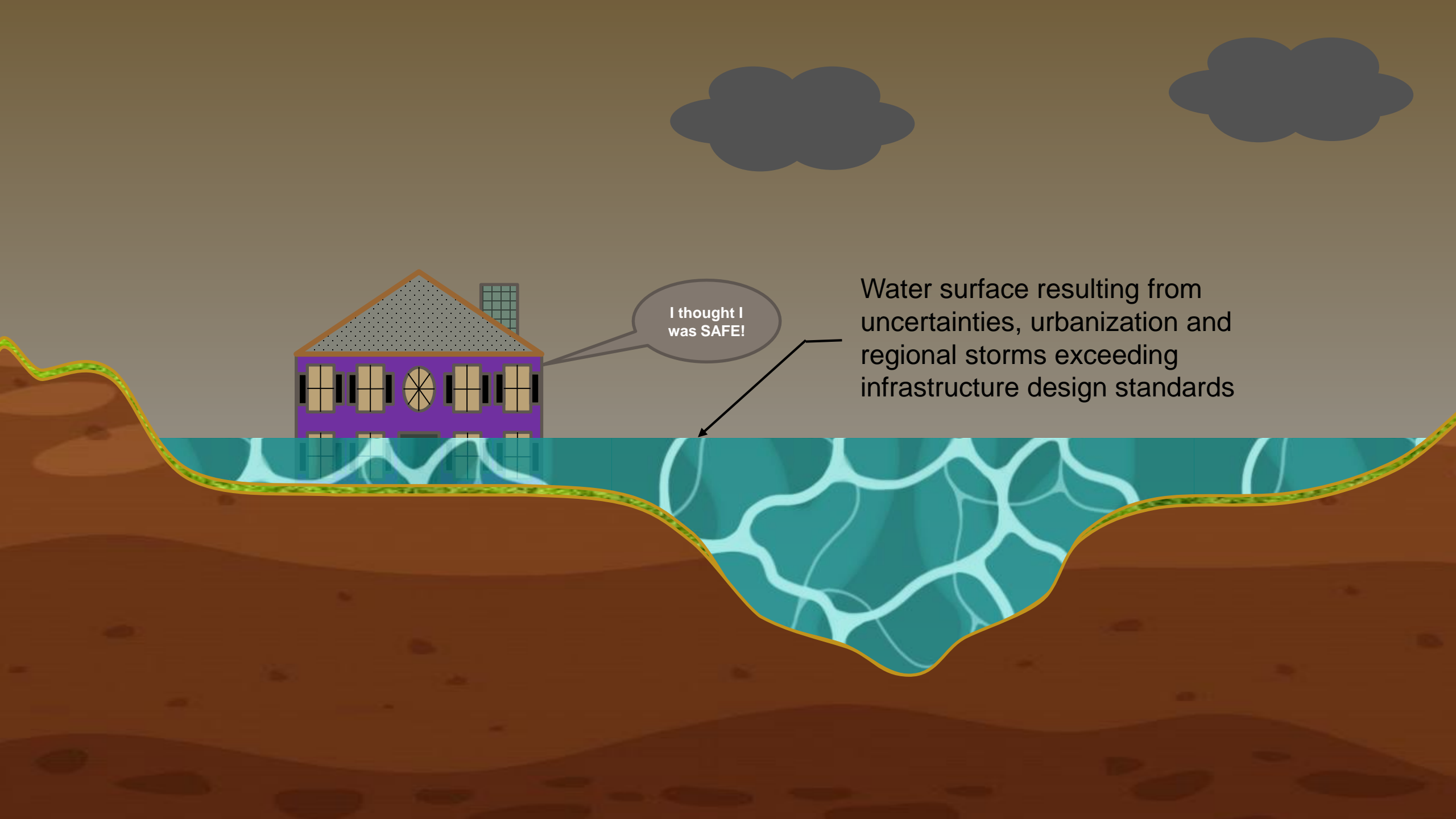
5 Year Tally of Flood Fatalities



FLOODING CYCLES

- Severe flooding events in Texas can occur anytime
- Normally 1-2 events per decade exceed infrastructure design standards
- Severe flooding events in Texas also occur in cycles
- 1930-1945 with over 20 events exceeding infrastructure design standards
- 2009-2020 with over 20 events exceeding infrastructure design standards
- Events can exceed 35" in 24 hours
- Most common are < 20" in 24 hours
- DFW standard is 10" in 24 hours





I thought I was SAFE!

Water surface resulting from uncertainties, urbanization and regional storms exceeding infrastructure design standards



INTERAGENCY FLOOD RISK MANAGEMENT (INFRM)



- Multi-agency collaboration and expertise
- Established 2014
- Integrated Water Resources Science and Services (IWRSS) program
- **Supports Statewide/Regional/Watershed approach**
 - **Incorporates regulation from dams**
 - **Spans community boundaries**
- Leveraging information, programs and resources across agencies
- Actionable data, tools and analysis for communities
- InFRM Academic Council 2017 (IAC)
 - Links researchers and applied scientist/engineers
- www.InFRM.us

InFRM Background & Partners Estimate Your Base Flood Elevation Flood Decision Support Tool Hydrology Assessments Atlas 14

Interagency Flood Risk Management

Collaborating Nationally. Empowering Locally.

Flooding remains the leading cause of natural-disaster loss across the United States. The Interagency Flood Risk Management (InFRM) team brings together Federal Partners with mission areas of hazard mitigation, emergency management, floodplain management, natural resources management or conservation to leverage the policies, resources and programs to determine the needs of communities and define solutions and implement measures to reduce long term flood risk throughout the States of Arkansas, Louisiana, New Mexico, Oklahoma and Texas.

In 2014, the Federal Emergency Management Agency (FEMA) began sponsoring of the InFRM team initiative to allow Federal teams across the States of Texas, Oklahoma, New Mexico, Louisiana and Arkansas to better align and integrate. Currently, the InFRM team is comprised of FEMA, US Army Corps of Engineers, US Geological Survey, and the National Weather Service. No single agency has all the answers, but through a coordinated effort of multiple programs and various perspectives, a cohesive solution can be found. By applying their shared knowledge, the InFRM team can also enhance response and recovery efforts when flood events do occur.

While floods are impossible to prevent completely, and there is no way to guarantee protection of property, loss of life can be greatly reduced when communities have access to good data, practice sound land use, floodplain management and development practices and incorporate warning systems. Local communities can partner with the InFRM team to investigate solutions to reduce their communities flood risk.

Partner Agencies

This effort will be accomplished by an interagency coalition comprised of the Federal Emergency Management Agency, U.S. Army Corps of Engineers, U.S. Geological Survey, and the National Weather Service. These agencies are currently in partnership through the group known as the Interagency Flood Risk Management (InFRM) team and this effort will be undertaken by this group. The InFRM team will reach out to state and local government organizations as well as private industry to aid in moving this monumental effort forward.

Federal Emergency Management Agency (FEMA)	U.S. Army Corps of Engineers (USACE)	U.S. Geological Survey (USGS)	National Weather Service (NWS)
<ul style="list-style-type: none"> Standards Disaster-rebuilding aid through the flood insurance program Mapings products 	<ul style="list-style-type: none"> 2013 USACE CIVMS watershed model development Numerous watershed and planning studies Watershed regulation 	<ul style="list-style-type: none"> Water quantity and quality monitoring and dissemination of reliable, timely data Statistical analysis, modeling, and web application development Impartial, unbiased science 	<ul style="list-style-type: none"> Precipitation estimates Real-time forecasting and precipitation products River forecasting
Region 6 (Southern)	Districts: Fort Worth, Tulsa, Galveston, Albuquerque, Little Rock, Vicksburg	Water Science Centers: Texas, Oklahoma, Arkansas, New Mexico, Louisiana	River Forecast Centers: West Gulf, Arkansas-Red, Beil, Lower Mississippi

Integrated Water Resources Science and Services (IWRSS)

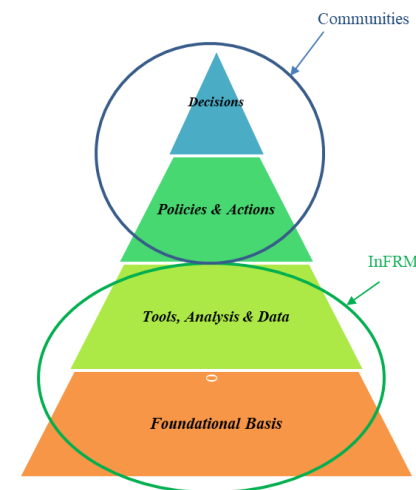
InFRM operates under the umbrella of the Integrated Water Resources Science and Services (IWRSS), a business model for interagency collaboration. IWRSS brings a consortium of United States Federal agencies with complementary water resources missions together to share resources to help solve the nation's water resources issues. In 2011, several Federal agencies came together and issued an Interagency Memorandum of Understanding to create IWRSS. IWRSS's overarching objective is to enable and demonstrate a broad, integrative national water resources information system to serve as a reliable and authoritative means for adaptive water-related planning, preparedness and response activities. The goals are to:

- Integrate information delivery and simplify access to this data.
- Increase accuracy and timeliness of water information.
- Provide timely, cost-effective high resolution water resources information and forecasts.

The members of IWRSS are the same four United States Federal agencies as InFRM: USACE, USGS, NOAA, and FEMA.



InFRM Academic Council



- NOAA Atlas 14 – Provides state-of-the-art precipitation frequency estimates in a spatial viewer
- Texas Storm Study – Informs us in how to formulate design storms using NOAA Atlas 14 data
- Watershed Hydrology Assessments – Determine the 100-yr and other runoff values used to design infrastructure
- BLE and the FDSTB tell us how deep the water will be with the runoff reaches the river

How Much Rain - NOAA Atlas 14 I

- What?**
 - Precipitation frequency estimates for design and operation of infrastructure
- Why?**
 - TP40 and Hydro35 precipitation frequency estimates are out-of-date (1960's and 1970')
 - Significant changes in precipitation frequencies for 1/3 of Texas
- Outcome (2018)**
 - NOAA Atlas 14 estimates represent vastly improved data in terms of both period of record and station density, statistical techniques, and spatial interpolation that accounts for variation in terrain
 - Modernized NOAA Atlas 14 data server
 - Increased spatial resolution

HOW TO APPLY PRECIPITATION - TEXAS STORM STUDY (TSS)

- What?**
 - Study of observed storms across the region
 - InFRM Academic Council (IAC)
- Why?**
 - Rainfall-runoff modeling shows significant sensitivity to storm size, shape, intensity and depth-area functions
 - Flat storms not recommended above 400 mi²
 - Technical guidance on spatial and temporal variation dated (1960s and 1970s)
- Products**
 - Updated region-specific guidance and methodology
 - Formulate elliptical design storms
 - Depth-area-reduction-factors (DARF)
 - Applies NOAA Atlas 14 data
 - Catalog of regional storms with zones

HOW MUCH RUNOFF - WATERSHED HYDROLOGY ASSESSMENTS (WHA)

- What**
 - Determination of 100-year (and other FEMA frequencies) existing & future (land use only) conditions
- Why**
 - Use of historical observations alone carries unacceptable levels of uncertainty
 - Incorporates latest technology and data (NOAA Atlas 14)
 - Consistent watershed approach
 - Used to calibrate BLE data
- Limitations**
 - Detail must be added within communities
 - Uncertainty associated with future precipitation frequency
- Products**
 - Baseline conditions for mitigation/recovery
 - Statewide coverage planned
 - Can be leveraged for other purposes
 - www.InFRM.US

HOW DEEP - RIVER HYDRAULIC MODELS AND DATA

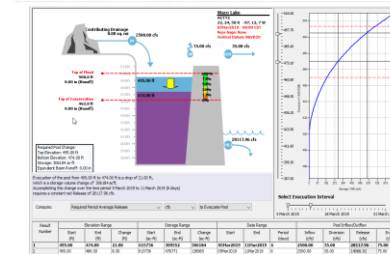
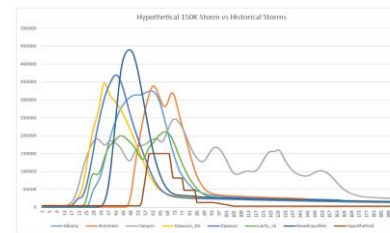
- Flood Decision Support Toolbox (FDST)**
 - Real-time visualization of current flooding conditions
 - What-if scenarios for preparedness planning
- Base Level Engineering**
 - Recovery, mitigation and planning
 - 1D and/or 2D hydraulic models and data based on current LIDAR
 - Shows depth of flooding
 - Allows users to understand their flood risk
 - Point-click-download access to engineering models and Base Level Engineering datasets.
 - Consistent access to flood risk information



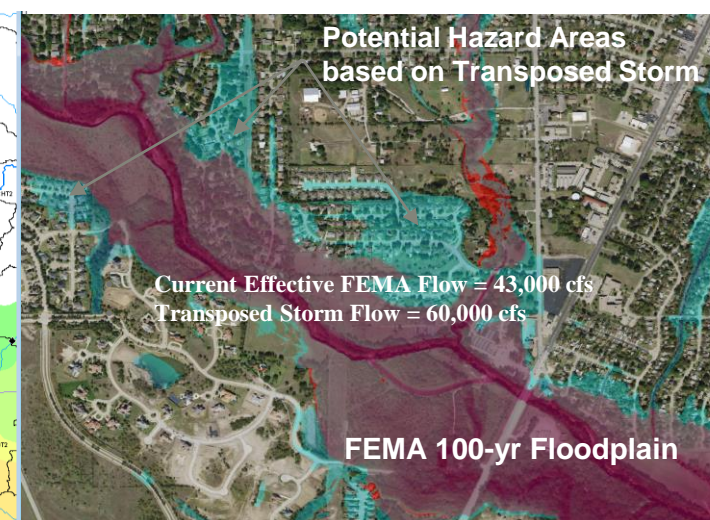
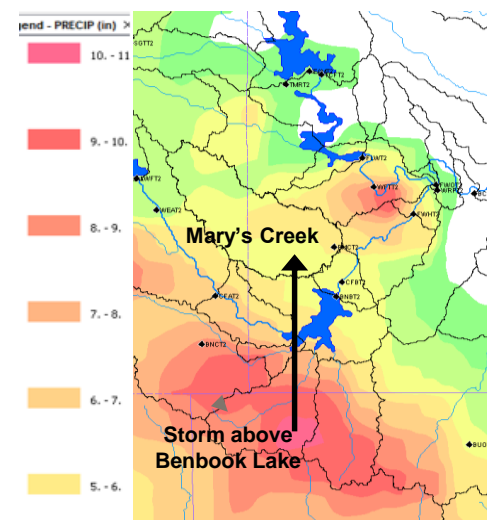
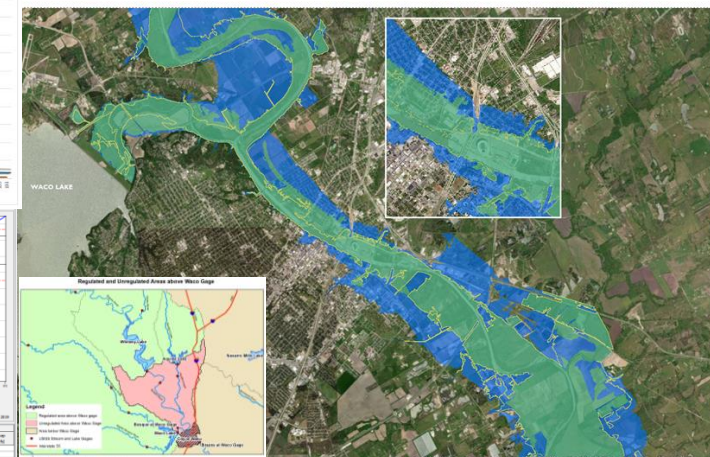
WHAT-IF SCENARIOS - METVUE STORM SHIFT TECHNOLOGY



- Waco, TX
 - **Issue:** Uncertainty and dam operations
 - Shifted range of storms
 - Examined different operational constraints, multiple scenarios
 - **Outcome:** Illustrated full risk envelop
- Mary's Creek, DFW, TX area
 - **Issue:** Uncertainty
 - Shifted 2010 100-year± storm 10 miles
 - **Outcome:** Decreased uncertainty, full risk envelop
- Dallas County, TX
 - **Issue:** Uncertainty & lack of FRM data
 - Shifted range of storms
 - **Outcome:** Decreased uncertainty, full risk envelop



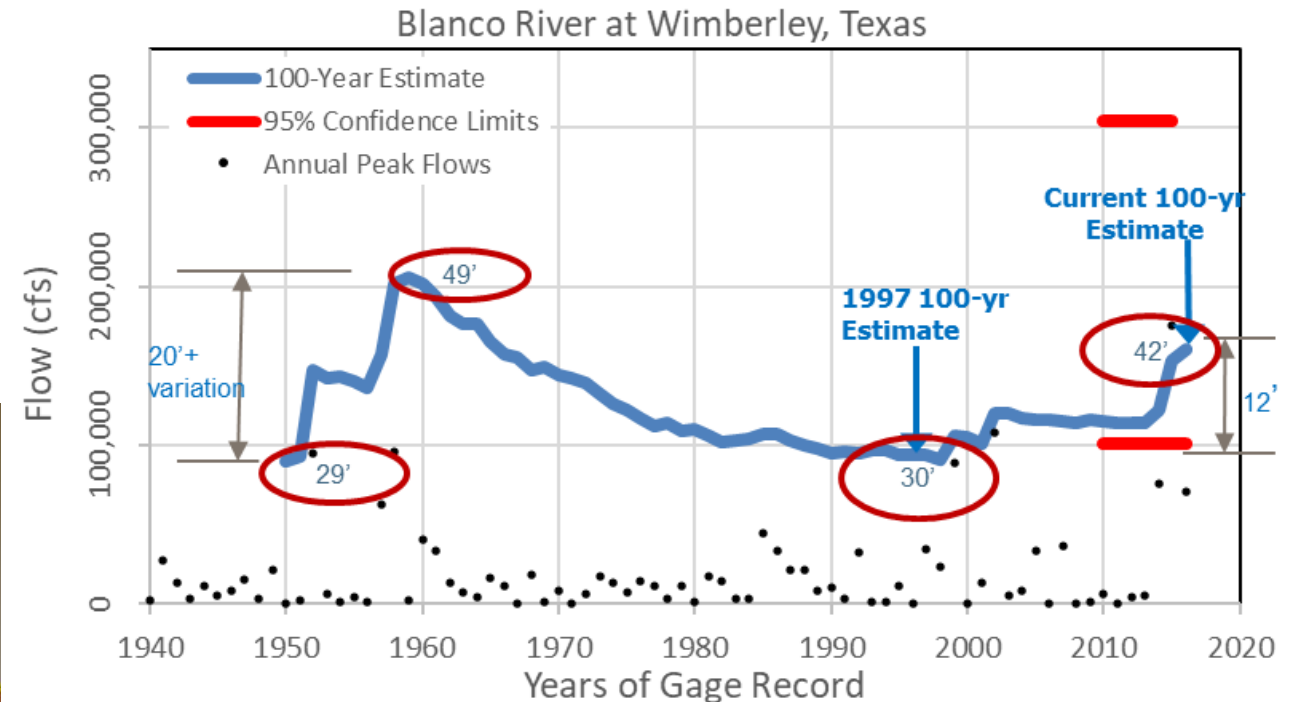
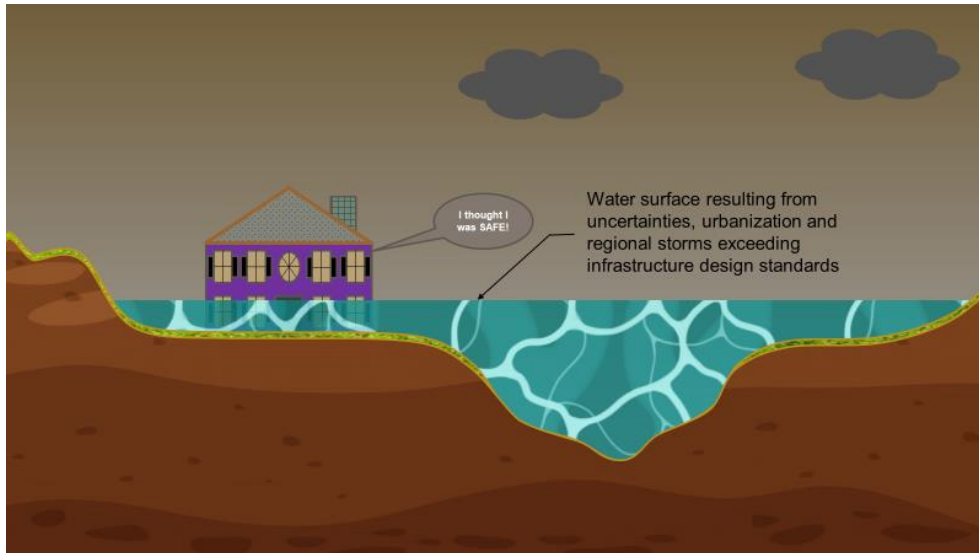
■ Dawson D/S with 500-Year Losses ■ New Braunfels 1998 □ 100-Year Flood This Study





INFRM PRODUCTS ARE IMPORTANT – A CASE STUDY?

- Statistical Hydrology - The most commonly used techniques to estimate flood and rainfall frequencies rely on observations
- Need record length 3-4 times estimated return interval
- Short Observation Periods - On average TX has 50 years of stream record and 70 years of precipitation records
- Significant variability and/or non-stationarity observed in flood flow and rainfall frequency estimates





WHAT HAPPENS WHEN WE DON'T MANAGE FLOOD SCIENCE UNCERTAINTIES?





BRINGING IT ALL TOGETHER - COMMUNITY FLOOD ASSESSMENTS

- InFRM products allow communities to understand the full range of flood risk they face
- Community Flood Assessments
 - Utilize Watershed hydrology Assessments (WHA)
 - Incorporate latest precipitation frequency estimates from NOAA ATLAS 14
 - Formulate NOAA ATLAS precipitation estimates into appropriate design storms
 - Determine runoff for 100-year and other frequency storms
 - Determine runoff from regional storms matching frequency design storms (storm shifting)
 - Determine runoff from nearby storms exceeding infrastructure design standards (storm shifting)
 - Utilize and enhance BLE data
 - Provide the full flood risk envelop for communities
 - Allow communities to make infrastructure adjustments which will enable them to better manage flooding disasters
- Provide a starting point for mitigation designs
- Provide the data and analysis to apply for flood mitigation grants and funding from organizations like TWDB, FEMA, USACE
- Provide the basis for flood warning systems



COMMUNITY FLOOD ASSESSMENT

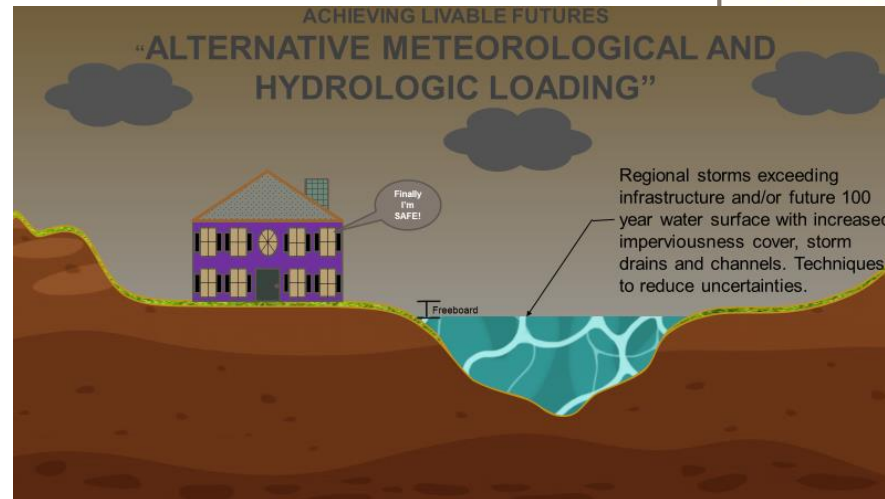
LEVERAGE & ENHANCE AVAILABLE HAZARD INFORMATION TO BETTER UNDERSTAND COMMUNITY FLOOD RISK

COLLABORATIVE & INNOVATIVE FLOOD RISK MANAGEMENT

A Community Flood Assessment (CFA) equips community leaders with accurate, reliable & non-regulatory flood hazard information to empower the decision-making process. It informs hazard mitigation and emergency management action planning and reduces uncertainty related to flood risk.

A CFA is a comprehensive and reliable tool to assist community planning and action, helping promote flood hazard awareness and resiliency

<p>WHA <i>Improved</i> HYDROLOGY</p> <p>Incorporated and tailored latest InFRM Watershed Hydrology Assessment (WHA) to understand how much water https://webapps.usgs.gov/infrm/whav/</p>	<p>BLE <i>Enhanced</i> HYDRAULICS</p> <p>Leveraged and enhanced Base Level Engineering (BLE) hydraulics to assess where water will flow during flooding https://webapps.usgs.gov/infrm/es/BLE/</p>	<p>RAIN <i>Reliable</i> STORM SHIFTING</p> <p>Shifted reliable regional storms to better understand and mitigate true flood risk https://www.usbr.gov/aterahed-management/storm-shifting</p>
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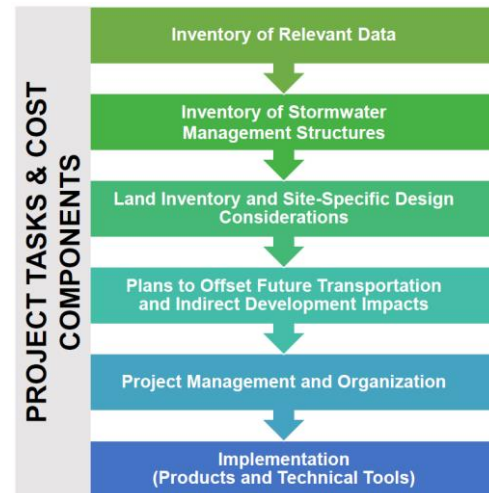
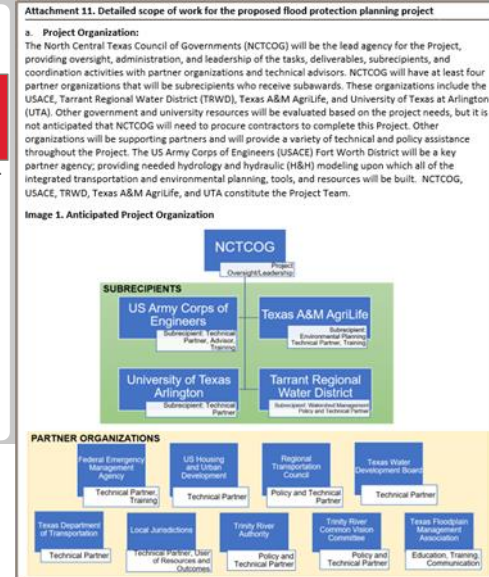
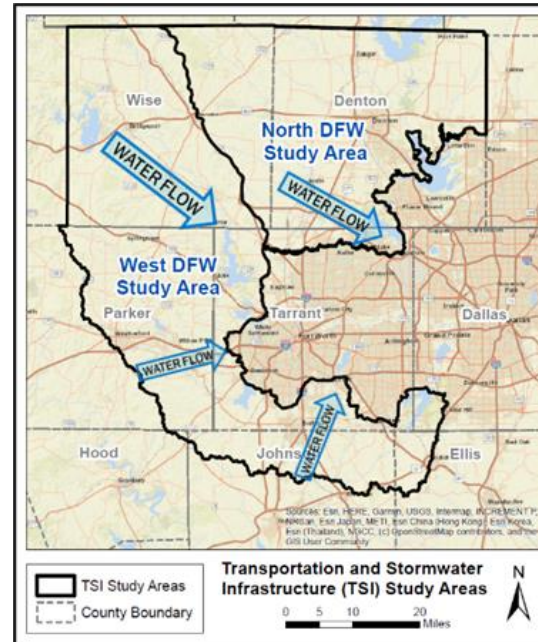
TSI PROJECT SUMMARY



- **Project Organization:** NCTCOG is lead agency for project with subrecipients including (but not limited to) USACE, Tarrant Regional Water District (TRWD), Texas A&M AgriLife, and University of Texas at Arlington (UTA).
- **Purpose:** Minimize overall life cycle costs, **decrease flood risk**, and **reduce impacts** to the natural environment as a result of future population growth in study area.
- **Scope: Proactive vs. Reactive** through integration of regional stormwater management, urban development, transportation, and environmental planning: **a collaborative effort with regional Transportation planners**
- Identify impacts and alleviate risks from severe weather events such as flooding in (and downstream of) rapidly developing study areas 100-yr and alternative hydrologic loading
- Develop a comprehensive and transferrable plan for risk awareness and resiliency
- Utilizes InFRM products
- **Timeline & Budget:** 3-5 years and \$10 million (via NCTCOG, TWDB, transportation & GLO)
- Yes, opportunities for the AE community

PROJECT GOALS AND OUTCOMES

Proactive Planning	Reduce Flooding	Tools/Resources	Local-Scale Innovation	Community Roadmap
<ul style="list-style-type: none"> Reimagine transportation design to integrate stormwater, environmental, and flood reduction benefits Protect current and future infrastructure Develop model for replication 	<ul style="list-style-type: none"> Reduce flooding downstream of rapidly growing upstream communities Increase resiliency to flooding disasters Inform decision-making Implement stormwater infrastructure with transportation infrastructure 	<ul style="list-style-type: none"> Empower communities to adopt higher floodplain management standards Develop GIS based tools and resources 	<ul style="list-style-type: none"> Enhance Trinity River Watershed Hydrology Assessment Enhance existing hydraulic models such as BLE Emergency management modeling tool Optimization study for drainage/flood control structures 	<ul style="list-style-type: none"> Produce planning-level designs for transportation, stormwater detention, and environmental Integrate these layers to identify what needs to be built and achieved benefits Establish ways to fund planned infrastructure

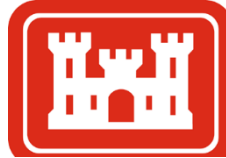




QUESTIONS?



Thank You!
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U.S. Army Corps of Engineers

U.S. Army Corps of Engineers
Fort Worth District (SWF)
819 Taylor Street
Fort Worth, TX 76102

Jerry L. Cotter, P.E.

Chief Water Resources

(817) 886-1549 TEL

(817) 454-1290 CEL

Jerry.L.Cotter@usace.army.mil