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Interagency Flood Risk Management Hydrology Assessments
Basic Technology Concepts

- How often does technology double
  - Pre 1900 ≈ 100 years
  - Post WWII ≈ 25 years
  - TODAY ≈ 1.5 years
  - FUTURE ≈ 12 HOURS

- Inferences
  - If you are an expert today, you may not be tomorrow
  - If you are an expert, your paradigm may be obsolete
  - By the time you create and application, it is obsolete
  - You cannot hold back technology

- Technology can be:
  - Your friend
  - Your nightmare

- Technology can not:
  - Replace experience, wisdom and expertise
  - More data does not mean better data or even good data

- Managing technology will be challenging
Technology Changes
New Technologies In Flood Risk

- Hydrologic network
  - More gages, longer records
- CWMS Modeling (USACE)
- Updated precipitation frequency estimates (Atlas 14)
- New statistical guidance (Bulletin 17C, Interagency)
- Improved precipitation (MetVue) runoff (HMS) and river hydraulics (RAS) modeling techniques (WAT)
- USACE hazard teams (R&D in Meteorology, Hydrology and Hydraulics)
  - Hydrologic hazards
    - Stochastic techniques in hydrology (HEC-WAT)
  - Meteorology hazards
    - HEC-MetVue
  - Levee safety studies
  - Dam safety studies
- Dam operations – watershed regulation
- National Water Center – Tuscaloosa, AL
Hydrologic Network

- Cooperative program – federal, state, local, academia, AE community
- Over 400 Remote Sensing Stations, approximately 2000 Observers
- Basic data for operation of the projects
- Calibration of NWS precipitation estimates
- Model calibrations, real-time forecasting and hydrologic investigations
- Jointly funded with USACE direct expenditures of close to $18 million annually, SWF $1 million annually
- Partnerships
  - USGS, NWS, River Authorities, Counties, Cities
  - Coordination and resource sharing to maximize network benefits
  - USACE-SWF has leveraged partnerships for $700k
- Critical to understanding:
  - Flood risk
  - Non-stationary WS trends
  - Climate
CWMS Implementation

- 200+ USACE watersheds
- $125+ M investment, nationally
- $6 M for Texas
- 6+ year plan
- Supports
  - Dam safety, operations (forecasting), can be leveraged (FEMA)
- 2014
  - Colorado, Neches, Guadalupe, Trinity, San Jacinto (Buffalo Bayou)
- 2016 - Brazos
- 2017 - Red
- MetVue -> HMS-> RiverWare-> RAS-> FIA
NOAA Atlas 14
Precipitation Frequency Estimates

- NOAA - Office of Hydrologic Development – Sanja Perica PhD
- UCAR
  - Technical Paper 40 & 49 (1961 & 1964)
  - USGS/TXDOT (Asquith)
  - 10 volumes completed
  - Improved techniques
  - Additional durations (urban studies, 5-min)
  - Additional frequencies (1000-yr)
  - Aerial reduction factors
  - Increased granularity
    - Denser network
    - Improved spatial interpolation
    - PRISM techniques
  - Longer records
  - Connectivity to USACE software (MetVue)
  - Cost – $1.75 mil
  - $1.0 mil pledged
Rainfall Frequency Data in Texas is limited to TP 40 and 49 (1960s era analysis) which only analyzed precipitation out to a 10-Day Duration.

NOAA Atlas 14 update for Texas is in progress. Hendrix, OK is northwest of Lewisville Dam provides a reasonable estimate of what the NOAA Atlas 14 update may look like in North Texas.
MetVue Real-Time Applications

- Ingest Radar/Forecast Data
- Analyze In-Place or Transpose
  - Ability to rotate storm or maximize
  - Provides a variety of storm options
- Compute Basin Average Rainfall
- Output Data to Hydrology Model
**MetVue PMP/Planning Applications**

- **Analysis of Extreme Storms**
  - Use of radar and point rainfall data
  - Combination of recent and historical storms

- **Transposition to Additional Basins**
  - Provides greater confidence in results
  - Simplifies process for end-users

- **Development of Project Design Storm**
  - Adheres to accepted NWS/WMO standards
  - Incorporates HMR procedures (52, 55A, etc.)

- **Use in PMP/PMF Studies**
  - Ability to conduct studies more efficiently
  - Interconnectivity with Hydrology models

- **Assisting the Planning Process**
Statewide Reservoir Development

Background

- Multi-purpose
  - FDR, WS, hydro, env, rec, navigation
- Critical to the early development of Texas
- Significant federal economic contribution
- Planned/constructed dams 111/32
  - Lake Travis 1942, Cooper 1991
- 8.8 M ac-ft conservation storage
  - 20% - 25% surface water supply
  - BRA, TRWD, Dallas WU, cities, LNVA, GBRA, UCRA, NETMWD (pipelines)
- 15.9 M ac-ft flood storage in 31 federal dams
- Costs (2013)
  - Construction - $8.2 billion
  - Benefits - $76 billion (flood only)
  - B/C ratio – 9+:1
- Annual recreation visits – 22 M
Background

- Congress - National Flood Insurance Act
- FEMA - National Flood Insurance Program (NFIP)
  - Standards
  - Disaster/rebuilding aid funded by land owners through the flood insurance program
  - Mapping products
    - Standards and mapping reflects 1% annual chance
    - Pre 2010 – community basis
    - Post 2010 – watershed basis

- USACE
  - 2013 USACE CWMS watershed model development ($125+ million investment)
  - Numerous watershed and planning studies
  - Watershed regulation

- USGS
  - Stream gage program
  - Statistical hydrology and regional regression
  - Watershed studies

- NWS
  - Precipitation estimates
  - Real-time forecasting and precipitation products
USACE Flood Damage Reduction Projects 1940’s Through 1990’s
Objectives

- Consistent and best estimate of hydrology across entire watersheds
- Utilize various hydrologic analysis techniques
- Examine and account for non-stationary trends
  - Land use changes
  - Climate variability
  - Regulation
- Watershed report
  - 0.2%, 1%, 2%, 4% and 10% exceedance probability events
- Modeling guidelines to facilitate increased granularity
- Interagency partnership
Participating Agencies

- FEMA Region 6 - Sponsor
- U.S. Army Corps of Engineers (USACE)
  - Fort Worth District – Program management
  - Tulsa District
  - Galveston District
  - Albuquerque District
  - Little Rock District
  - Vicksburg District
- U.S. Geological Survey (USGS)
  - Texas
  - Oklahoma
  - Arkansas
  - New Mexico
  - Louisiana
- National Weather Service – River Forecast Centers
  - West Gulf
  - Tulsa
  - Lower Mississippi
Interagency Collaboration

- Project and program management
  - Fort Worth District
    - Funding – receipt and distribution
    - Schedules - oversight
    - Consistency - oversight
    - Resourcing - facilitate

- Technical services
  - Offered first to specific agency offices within who’s footprint the watershed resides
  - Fort Worth will facilitate division of work within that group
  - If insufficient resources are available, work will be offered to other agency offices within FEMA Region 6
  - If insufficient resources are available across all agency offices within FEMA Region 6, work will be resourced through the MMC or contractors
Methodology

- Statistical hydrology
- Rainfall-runoff modeling
  - Existing conditions
  - Future conditions
  - Ultimate development conditions
- Period of record (POR) simulations
  - Regulated
  - Unregulated watershed conditions
- Reservoir studies
- Stochastic methods in hydrology
- Comparison and convergence of methods
Advantages

- Multi-Agency approach
  - Advanced scientific team
  - Leverage knowledge within each agency
  - Strengthens Relationships between Federal Agencies
  - Leverage current and historic flood risk studies
  - Leverage newly developed USACE CWMS models
  - Represents multiple federal agencies working to support FEMA and their flood risk program
  - Complements USACE flood risk programs
- Leverages funding from multiple programs
- Consistent results across watersheds
- Convergence of various hydrologic analysis techniques
- Look at impacts of non-stationary watershed trends on flood risk
- Provides data to address the FFRMS Executive Order
- Tools and models to increase granularity for detailed mapping efforts
Products

- Watershed report
- Results from various hydrologic methods
- Selected results
- Tools, models, techniques and guidelines which can be used to increase granularity
- Comparison to previous flood risk studies within the watershed
First Two Studies for Texas – Guadalupe and Trinity Basins

- First basins selected by FEMA
- Completed CWMS modeling by USACE
- Signed Interagency Agreement Sept 2015
- Multi-year basin-wide hydrology studies
- USACE Fort Worth acting as program lead
- Work performed by team members from USGS Fort Worth, NWS WGRFC, and USACE Fort Worth and ERDC
Guadalupe Basin Hydrology Study

- 24 month schedule
- $500k Budget
- Using existing USACE Guadalupe CWMS HEC-HMS model, RiverWare model, and reservoir studies.
- USGS performing statistical analysis of stream gages
- NWS providing precipitation data
- Equivalent of 1 FTE for 2 years spread across multiple agencies and offices.
Trinity Basin Hydrology Study

- 48 month schedule
- $1M budget
- Using existing USACE Trinity CWMS HEC-HMS model, RiverWare model, and reservoir studies.
- USGS performing statistical analysis of stream gages and some HEC-HMS modeling
- NWS providing precipitation data
- Equivalent of 1 FTE for 4 years spread across multiple agencies and offices.
Why Watershed Scale Hydrology Assessment
Upper Trinity River Dam and Levee Safety Studies

- Flood control system
  - Over $70 billion in damages prevented (60 years)
    - $2-3 billion per year
- Water supply system
  - 6.8 million served
How Much Uncertainty Do You Have with 100 years of Record?

100-yr (1%) Estimate varies from 100,000 to 450,000 cfs with 100 years of Record

Credit: Beth Faber at USACE-HEC
How Much Gage Record Do You Need to Estimate the 100-yr Discharge?

Experiment: 1000 years of data, sampled from LPIII with known parameters

Dashed Yellow Line = Actual 100-yr (1%) Discharge
Solid Yellow Line = Estimate of 100-yr (1%) Discharge based on previous years of record

300 to 400 years of Record before 100-yr Estimate Converges

Credit: Beth Faber at USACE-HEC
Conclusions

- 100 years of Record may not be enough!
- Watershed models and stochastic techniques can help compensate for non-representative samples in the gage record
- Statistical hydrology is still a valuable tool to be used in this effort

![Graph showing discharge vs. return period for Wimberley](chart.png)

- 149,000 cfs 2015 Gage 100-yr, est.
- 126,000 cfs 2013 Gage 100-yr, est.
- 23,000 cfs difference in 100-yr estimate after 1 Flood Event
- 40,000 cfs difference from BFE discharges
Closing

- Our technology centered around flood risk is good CAN BE IMPROVED!
- This effort will leverage the latest technologies
- This effort may result in new technologies for flood risk
- This effort brings more federal tax dollars back to Texas to be spent on flood risk
- Improved life safety
- Decreased property damages
- PLEASE STAY ENGAGED WITH US!
Questions?

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