Hydrology Review *				
*** This document is intended to assist independent quality assurance review engineers in verifying the reasonableness of a hydrologic study for FEMA floodplain mapping. This document covers many common methodologies that are acceptable to FEMA, but does not fully examine all appropriate methodologies and therefore should not be considered a complete guide for acceptable hydrologic practices and approaches. Many of the data required to support a hydrologic analysis are identified, however review engineers may request or require additional data not identified to support the analysis. Furthermore, this document does not intend to make recommendations regarding methodology choice or modeling assumptions, rather this document intends to support the established recommendations by the various modeling and/or methodology developers (i.e., NRCS, USGS, USACE, etc.).**				
MT-2 Case Number or Project Name:				
Stream Name(s):				
Reviewer:				
Review Date:				
	Review Items	**Additional review criteria/explanation (if necessary)**	**Provided/ Additional Data Required/NA**	**Reviewer Comments**
Watershed Information				
1	Have maps of watershed location, sub basins, flood control structures and discharge calculation points been provided?	Maps should include: sub basin delineation, flow paths, topography, topography source information; storm sewers and/or other diversions.		
2	Has a description of the watershed been provided.	A general narrative should include location of watershed, and stream and rainfall gages. The narrative should also discuss the source of the rainfall data used, the topographic data, and the methodology utilized for the study.		
3	If the stream already has effective discharge values, what is the reason for restudying the watershed?	In general, FEMA does not want to update discharge values unless revised hydrology results in 0.5 ft. difference in flood profiles. Common reasons for new hydrology would include: old rainfall data such as TP-40 was used, significant changes in the watershed or land use have occurred, better data can be used to improve hydrology, etc.		
Stream Gage Analysis				
1	Is there a stream gage anywhere on the studied stream?	Stream gage analysis should be completed for gage and non-gage locations on a gaged stream that have between 50-150 percent of the gage drainage area. Gage information that should be included: gage number, drainage area, and period of record.		
2	Is data set appropriate for stream gage analysis?	The length of record, impact of regulatory structures should be considered.		
3	General review of discharge data for errors, missing data, ice jams or other inconsistencies.	Graphing discharge data is recommended to provide a visual check for inconsistencies. Compare calculated discharges to regression equation values and effective discharges.		
4	Has the watershed maintained generally consistent conditions over the period of record or has a trend analysis been considered?	Check for significant changes in land use.		
5	Appropriate methodology/ software for statistical analysis? (annual maximum series, PeakFQ, etc.)	FEMA requires Bulletin 17b methodology unless approved by the region.		
6	Source of general skew coefficient.			
7	Are the dataset and frequency analysis calculations provided and presented clearly?			
8	Have the results of the gage frequency analysis been weighted with regression equation results?	A weighting method is appropriate when the stream gage record is short and is documented in *Estimating Flood-Peak Discharge Magnitudes and Frequencies for Rural Streams in Illinois.*		
Regression Equations				
1	Were regression equations used?			
2	Is watershed appropriate for regression equation analysis?	If the watershed undergone urbanization, are there flood control structures in drainage area?		

3	Documentation of the source of regression equations used and the input variables.	If the most recent USGS 2004 regression equations for Illinois were not used, documentation should include why other regression equations were chosen. Input parameters should fall within appropriate range.		
4	Should urbanization, aerial ratio or other adjustments be considered?	Refer to *Effects of Urbanization on the Magnitude and Frequency of Floods in Northeastern Illinois*		
Rainfall Runoff Model				
1	Why was a rainfall runoff model chosen?	Rainfall runoff models are recommended when a flood hydrograph is required, or when storage is a factor. A rainfall runoff model that is not calibrated should be used with caution.		
2	Was the computer program used to develop the rainfall runoff model approved by FEMA? If not, what program was used and why?	Click for a list of FEMA Approved Hydrologic Models		
3	Is the specific model version documented and approved?			
4	Do all models open without errors or missing files?			
5	Do all models run as submitted?	The results of the proposed model output should be documented in an output file or other format such that the model can be run and verified that the output matches the proposed discharge values.		
6	Are all models and/or plans clearly titled?	Every file provided with the model should be titled with an appropriate description included in the model or in a text file. Files to be used for frequency event determination should be labeled.		
7	Are automation tools used in the developing the rainfall runoff model documented and acceptable?			
8	The model must be submitted with appropriate geo-referenced spatial files must be submitted per FEMA guidelines.	Specifically, spatial files including sub basin and calculation points should be submitted.		
9	Correct rainfall depth used as input to the model?	Nationwide rainfall data is available from NOAA Atlas 14 at http://hdsc.nwq.noaa.gov/hdsc/pfds/ ; and bulletin 70 provides frequency rainfall for Illinois. These are the sources generally approved by IDNR. Appropriate aerial reduction or other adjustments should be documented. In general, the tabular data should be used for flood studies.		
10	Is the rainfall duration appropriate?	The rainfall duration must exceed the time of concentration. Determination and documentation of the critical storm duration is required by IDNR.		
11	Was the appropriate temporal distribution of rainfall used in the model?	Temporal distribution must be documented. Huff's "Time Distribution of Heavy Rainstorms in Illinois" is the standard method used in Illinois. Other sources must be thoroughly detailed.		
12	What methodology was used to determine runoff or rainfall loss volume and how were parameters determined?	Loss rate should vary with frequency of event and must reflect urbanization effects. Refer to *FEMA Guidelines and Specifications: Appendix C* (link below) for detail.		
13	What method is used for runoff transformation and how were parameters determined?	Unit hydrograph (NRCS, Snyder, Clark, Mod Clark, etc.) method or kinematic wave method is used. The impact of urbanization and channel modification must be reflected in time of concentration calculations.		
14	Was an appropriate flow routing method used and how were parameters determined?	Routing method must be able to appropriately analyze hydrograph attenuation and translation. Channel slope, overbank flow, and ability to calibrate the model should be considered.		
15	How was base flow modeled?			

16	Was uncontrolled storage modeled correctly?	Hydrologic routing can be used when the outflow is not dependent on tail water. Hydraulic routing must be used if the outflow from a pond depends on tail water conditions. If rating curve was used in the model, verify the hydraulic computation of the development of the rating curve. Refer to *FEMA Guidelines and Specifications: Appendix C* for detail. If the storage discharge relationship was simulated by the rainfall runoff model, verify the storage elevation area relationship.		
17	Was controlled storage defined and model appropriately?	Normally, storage capacity below the normal pool level for non-flood control reservoirs is not considered. Joint use storage is not acceptable. Exceptions can be found in *FEMA Guidelines and Specifications: Appendix C.*		
18	Were the written commitment to dedication of reservoir storage and the operating plan provided?	Refer to *FEMA Guidelines and Specifications: Appendix C.*		
19	Any input hydrographs, flow diversion, or input rating curves should be well documented.			
20	Was the model calibrated? If so, approximately what frequency event was used for calibration?	If data permits, the model should be calibrated against a flow frequency curve or against known storms in the study area. High-water marks from major storm events should be used for joint calibration of rainfall-runoff and hydraulic models. Refer to *FEMA Guidelines and Specifications: Appendix C.*		
21	Are the model inputs (drainage areas, parameter values, rating curves, etc.) consistent with the submitted drainage area workmap, study narrative, and supporting documentation?	The study narrative is referenced during the compilation of the Flood Insurance Study (FIS) report and should be updated as needed to reflect the approved hydrologic model.		
Proposed Discharge Values				
1	Are the discharge calculation points appropriately located with respect to significant tributaries?			
2	If flows do not increase with drainage area, has documentation been submitted to explain the cause?			
3	Are the discharge estimates reasonable?	Comparison of proposed with effective and regression equation discharge values should be accompanied by a summary of the cause of the increase/decrease. Flows should be compared to values upstream and downstream. If no gage data is available on the studied stream, stream gages on similar watersheds should be utilized as appropriate. Drainage area/discharge should be graphed with 1 standard error indicated.		

Useful Links:
FEMA
USGS Regression Equations
Urbanization Factors