PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO: Technical Policy, TECH-018 **EFFECTIVE DATE:** November 16, 2012
REVISION DATE: **DRAFT 3/6/2020**

POLICY NAME: Acceptable Model Parameterization for Determining Peak Discharges

PURPOSE

The purpose of this technical policy is to standardize the parameterization of hydrologic models for ~~every~~ concentration points of interest within a **contributing-flow** regime. Policy regarding parameterization of hydrologic models within distributary-flow regimes is provided under Technical Policy *TECH-033, Criteria for Two-Dimensional Modeling*.

BACKGROUND

When determining peak discharges, a computer-based hydrologic model or previously-accepted discharge value may be used. Technical Policy *TECH-015, Hydrologic Model Selection for Peak Discharge Determination,* describes which models are acceptable for determining peak discharges. ~~Pima County Hydrology Procedures shall be used for riverine watersheds with an area less than 1 square mile, and it may be used for watersheds up to 10 square miles. HEC-HMS may be applied to riverine watersheds with an area larger than 1 square mile, and is particularly useful for evaluating watersheds that have detention basins or where channel routing or storage is important.~~ This policy describes which parameterization shall be used for submittals to the Pima County Regional Flood Control District (District).

POLICY

A. **Watershed Delineation:** The accuracy of watershed delineation and flow path identification is critical in hydrologic modeling. The watershed delineation shall leverage high-resolution topography that meets or exceeds the United States Geological Survey (USGS) 3-D Elevation Program standards (FEMA, 2018). ~~The District requires the use of 2-foot contour interval (or finer where available) maps, such as the Pima Association of Governments (PAG) contour maps for delineation of basin boundaries and flow paths in all areas other than steep terrain.~~ In areas of steep terrain, or where high-resolution topography ~~2-foot or finer contour interval maps~~ is~~are~~ not available, ~~U.S. Geologic Survey (~~USGS~~)~~ contour maps (7.5 minute series) may be accepted. At the discretion of the District, it may be a requirement that topographic data be sealed by an Arizona registered civil engineer (PE), or land surveyor (RLS).

For watershed delineation within ~~In~~ regulatory sheetflood areas, or areas with potential distributary flow patterns, two-dimensional modeling may be required. Technical Policy *TECH-033, Criterial for Two-Dimensional Modeling* provides the criteria for watershed delineation when performing two-dimensional modeling.

~~, both 2-foot or finer contour interval maps and aerial photos shall be used with a resolution sufficient to determine flow paths and watershed boundaries. If Geo-HMS (COE, 2003) is used, Digital Elevation Models (DEMs) or Digital Terrain Models (DTMs) or DEMs derived from Lidar data from PAG or other reputable vendors, may be used. With the approval of the District, alternative topographic data, such as stereo photography, may be used.~~

~~A.~~B. **Pima County Hydrology Procedures:** Peak-discharge calculations performed using the Pima County Hydrology Procedures shall follow the guidance for parameterization provided in the PC-~~-~~HYRDO~~ydro~~ User Guide (~~Arroyo Engineering, 2007~~District, 2019).

C. **HEC-1 and HEC-HMS:** Peak discharges calculated using HEC-HMS (COE, 2018~~06~~) or HEC-1 (COE, 1998) shall employ the following parameterization:

a. ***Rainfall Loss Method:*** Models shall employ the U.S Soil Conservation Service (SCS) Curve Number method using the Curve Number tables, Vegetation map and Hydrologic Soils Group map associated with the PC-~~-~~HYDRO~~Hydro~~ User Guide (~~Arroyo Engineering~~District, 2019~~07~~), shall be used. The default vegetation cover percent provided in the PC-HYDRO~~ Hydro~~ User Guide (District, 2019~~Arroyo Engineering, 2007~~) shall be used unless additional justification is provided. The Curve Number shall not be adjusted for rainfall intensity or antecedent moisture conditions.

b. ***Time of Concentration Calculation:*** The modified U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (T_c) calculation shall be employed (USDA-NRCS, 1986). The Tc shall be calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow, along the primary flow path.

i. *For sheet flow segment:*

1. Manning's roughness coefficient for sheet flow shall be obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).
2. Maximum slope length for sheet flow shall be 100 feet unless additional justification is provided.
3. The Kinematic wave method shall be used to estimate the travel time for sheet flow.

ii. *For shallow concentrated flow segment:*

1. The travel time for shallow concentrated flow shall be obtained using the velocity determined from Figure 3-1 of Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).

iii. *For channel flow*:

1. Manning's roughness coefficient for channel flow shall be determined using the method described in the District's Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*.
2. HEC-RAS velocity or the Manning's equation may be used to estimate the travel time for channel flow.
3. The discharge for upstream sub-basins shall be 2/3 times the 100-yr discharge value calculated with Regional Regression Equation 13 (Thomas et al., 1997). Sub-basins with channel flow from an upstream basin shall use the 100-yr discharge value calculated with Regional Regression Equation 13.

c. ***Transform:*** The SCS Unit Hydrograph method shall be used.

d. ***Channel Routing:***

i. *Routing in Natural Channels:* Runoff shall be routed using the Modified-Puls method for natural channels with the slope less than 1.5%. It may also be used for steeper channels. A storage discharge table is required if HEC-HMS is used. Such a table can be developed using cross-sections and slopes derived from a Manning normal depth analysis or HEC-RAS (COE, ~~2001~~2016). The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manual. Initial discharge to estimate HEC-RAS velocity for channel flow should be determined using discharge calculated with USGS Regression Equation 13 (Thomas et al., 1997).

ii. *Routing in Constructed Channels and Steep Channel:* The Kinematic Wave Method may be used for constructed channels and natural channels with slopes greater than 1%. Reach length, slope, bottom width and side slope may be obtained using the data utilized for watershed delineation (e.g. 2-foot contour interval contour maps, Digital Elevation Models (DEM) or Digital Terrain Models (DTM). Selection of Manning's n values shall conform to the guidance in Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*. The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manuals.

e. ***Rainfall:*** ~~The NOAA 14 Upper 90% rainfall shall be used as described in the District's~~ Technical Policy *TECH-010, Rainfall Input for Hydrologic Modeling* provides the requirements for rainfall input. A representative point near the centroid of the watershed shall be used.
~~. Point rainfall depth shall be evaluated for a watershed, based on the latitude and longitude of the centroid of the watershed. If appreciable elevation~~

~~change occurs on a watershed, users should use different values for higher and lower elevations.~~

f. ***Rainfall Areal Reduction:*** Areal reduction shall be applied to watersheds larger than 1 square mile. Areal reduction shall be estimated using Hydro-40 (National Weather Service, 1984) for the watershed and event of interest (i.e. same tables as contained in Arizona State Standard [SS10-07]).

g. ***Rainfall Distribution:*** The following rainfall distributions shall be used, with the highest peak discharge selected in order to determine the critical storm (i.e. the storm that produces the highest discharge)~~.~~:

i. ~~**1.**~~ **SCS Type II (3-hr Storm):** The 3-hr distribution shall be used as the local storm. In general, this includes watersheds with a time of concentration (T_c) equal to or less than three hours (Haan et al 1994).

ii. ~~**3.**~~ **SCS Type I (24 hr Storm):** The SCS Type I rainfall (NRCS, 1986) may apply for general storms on watersheds with times of concentration (T_c) greater than three hours.

iii. ~~**City of Tucson**~~**Hypothetical (1-hr Storm)**: The one-hour storm based on the intensity duration frequency data may apply to the smallest watersheds that generate a regulatory discharge, especially within an urban environment.

h. ***Impervious Percentage:*** Impervious cover percentage (Imp. %) shall be determined as follows, unless an alternative is justified:

i. For areas that are already developed, Pima County's most current Land-Use-Land-Cover Image (LULC) should be used~~ to estimate a watershed's percent of impervious (Imp. %) cover~~. Class Fields to be included in the Imp. % shall include "Impervious", "Roads", and "Structures". The Class Field of "Barren/Bedrock" should be evaluated and incorporated into the Imp. % if deemed appropriate.

ii. When upstream undeveloped properties are owned by the federal, state or local jurisdictions, it is assumed to either remain undeveloped or to be developed in such a way that limits post-development peak discharges to no more than pre-development discharges. As such, no additional considerations should be made for future development.

~~i.~~iii. When upstream undeveloped properties are privately owned, it is assumed to be developed to the maximum current zoning density. Modeling shall account for future development within these areas by using the average percent impervious cover from the PC-HYDRO table

D. **Comparison of peak discharge**: Peak discharges shall be compared with the peak discharges obtained from USGS r~~R~~egression e~~E~~quations obtained from **Table 9** of *Methods* *for Estimating Magnitude and Frequency of Floods in Arizona, Developed with Unregulated and Rural Peak-Flow Data through Water Year 2010*, 13 (USGS, 2014Thomas et al., 1997). Eastern Pima County is represented by "Region 5" and western Pima County is represented by "Region and/or the equations (both urban and rural) developed by Eychaner (1984) (See Appendix), and existing regulatory discharge estimates. Appropriate Basin Development Factors (BDFs) shall be used for urban areas. The discharge may also be compared with graphs prepared by Arizona Department of Transportation (ADOT, 1993). 3".

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APPROVED BY:

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Director and Chief Engineer

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Appendix

USGS SIR 2014-5211Regression Equat Table 9ion 13: The current regional regression relationships is Region 3 for western Pima County and Region 5 for eastern Pima Countysouthern Arizona is regression equation 13 from Thomas et al (1994). This method predicts peak discharge in cfs (Qp).

1.) as a function of watershed Area (square miles) only. It has the form:

2.) $$Qp100 = 10^{(5.52 - 2.42 * A^{-0.12})}$$

Table 9. Regional regression equations for predicting the 50–, 20–, 10–, 4–, 2–, 1–, 0.5–, and 0.2–percent annual exceedance probability flows in 5 flood regions of Arizona.

[*DRNAREA*, drainage area in square miles; *PRECIP*, mean annual precipitation in inches; *ELEV*, mean basin elevation in feet]

P–percent annual exceedance probability	Regional regression equations
Flood region 1 (High Elevation) regression equation	
50	$17.4\,(DRNAREA)^{0.655}$
20	$42.1\,(DRNAREA)^{0.625}$
10	$65.5\,(DRNAREA)^{0.613}$
4	$103\,(DRNAREA)^{0.604}$
2	$136\,(DRNAREA)^{0.601}$
1	$173\,(DRNAREA)^{0.599}$
0.5	$215\,(DRNAREA)^{0.599}$
0.2	$279\,(DRNAREA)^{0.599}$
Flood region 2 (Colorado Plateau) regression equation	
50	$53.2\,(DRNAREA)^{0.505}$
20	$142\,(DRNAREA)^{0.476}$
10	$236\,(DRNAREA)^{0.460}$
4	$406\,(DRNAREA)^{0.442}$
2	$573\,(DRNAREA)^{0.431}$
1	$778\,(DRNAREA)^{0.421}$
0.5	$1{,}028\,(DRNAREA)^{0.413}$
0.2	$1{,}429\,(DRNAREA)^{0.403}$
Flood region 3 (Western Basin and Range) regression equation	
50	$2.78\,(DRNAREA)^{0.462}(PRECIP)^{2.229}10^{(-0.351*ELEV/1{,}000)}$
20	$12.8\,(DRNAREA)^{0.474}(PRECIP)^{1.706}10^{(-0.208*ELEV/1{,}000)}$
10	$26.7\,(DRNAREA)^{0.479}(PRECIP)^{1.447}10^{(-0.132*ELEV/1{,}000)}$
4	$89.1\,(DRNAREA)^{0.495}(PRECIP)^{0.839}$
2	$129\,(DRNAREA)^{0.505}(PRECIP)^{0.831}$
1	$183\,(DRNAREA)^{0.516}(PRECIP)^{0.812}$
0.5	$256\,(DRNAREA)^{0.527}(PRECIP)^{0.789}$
0.2	$384\,(DRNAREA)^{0.539}(PRECIP)^{0.758}$

Table 9. Regional regression equations for predicting the 50–, 20–, 10–, 4–, 2–, 1–, 0.5–, and 0.2–percent annual exceedance probability flows in 5 flood regions of Arizona.—Continued

[*DRNAREA*, drainage area in square miles; *PRECIP*, mean annual precipitation in inches; *ELEV*, mean basin elevation in feet]

P–percent annual exceedance probability	Regional regression equations
Flood region 4 (Central Highlands) regression equation	
50	$54.7\,(DRNAREA)^{0.664}$
20	$51.2\,(DRNAREA)^{0.658}(PRECIP)^{0.903}10^{(-0.135*ELEV/1{,}000)}$
10	$43.2\,(DRNAREA)^{0.643}(PRECIP)^{1.204}10^{(-0.150*ELEV/1{,}000)}$
4	$33.6\,(DRNAREA)^{0.624}(PRECIP)^{1.528}10^{(-0.160*ELEV/1{,}000)}$
2	$30.8\,(DRNAREA)^{0.614}(PRECIP)^{1.687}10^{(-0.161*ELEV/1{,}000)}$
1	$30.0\,(DRNAREA)^{0.605}(PRECIP)^{1.805}10^{(-0.161*ELEV/1{,}000)}$
0.5	$30.6\,(DRNAREA)^{0.598}(PRECIP)^{1.893}10^{(-0.161*ELEV/1{,}000)}$
0.2	$33.3\,(DRNAREA)^{0.591}(PRECIP)^{1.976}10^{(-0.160*ELEV/1{,}000)}$
Flood region 5 (Southeastern Basin and Range) regression equation	
50	$10^{(6.363-4.386\,DRNAREA^{-0.060})}$
20	$10^{(5.868-3.506\,DRNAREA^{-0.080})}$
10	$10^{(5.778-3.218\,DRNAREA^{-0.090})}$
4	$10^{(5.757-2.988\,DRNAREA^{-0.100})}$
2	$10^{(5.696-2.795\,DRNAREA^{-0.110})}$
1	$10^{(5.651-2.634\,DRNAREA^{-0.120})}$
0.5	$10^{(5.761-2.638\,DRNAREA^{-0.120})}$
0.2	$10^{(5.750-2.502\,DRNAREA^{-0.130})}$

~~3.) Eychaner 1984 (rural): This is a USGS publication that was prepared in cooperation with the City and County. It presents a series of regression equations that rely on watershed area (sq. miles), main channel slope (%), channel length (miles) and a shape factor to account for the differences in runoff noted between long watersheds and more traditionally-shaped watersheds. The equation for the 100 year peak discharge is:~~

$$Qp_{100} = 10^{(3.044+0.646(\log A)-0.049(\log A)^2+0.729(\log S)-0.367(\log S)^2-0.614(\log S)(LogSh))}$$

~~The shape factor (Sh) is calculated as (channel length)^2/(Area)~~

~~3.) Eychaner 1984 (urban): This equation adjusts Eychaner's rural equation to account for the amount of impervious area, channel lining and channel modification. It is:~~

$$Qp_{100} = 7.7A^{0.15}(13-BDF)^{-0.32}Qp100^{0.82}$$

~~The Basin Development Factor (BDF) is a scoring factor to account for the degree of urbanization. The specific scoring is based on four factors described in pages 10-13 of the~~

manual.The lower, middle and upper portions of a watershed are scored separately and the results are summed. The maximum BDF score is 12, and a score of 0 indicates that the rural equation should be used. (The Qp100 in the equation is the Qp100 calculated using Eychaner's rural method described in section 2 above.)