Appendix A

Analysis of the 90th Percentile Storm in SSCAFCA's Jurisdiction

To define the magnitude of the water quality storm (90th percentile storm) for SSCAFCA's jurisdictional area, regional analysis of the rainfall frequency spectrum was required. Data from a total of five rain gauges was analyzed (see Figure A-1). Data for two gauges was obtained from NOAA's National Centers for Environmental Information or NCEI; the gauge at the Albuquerque airport has an 83-year period of record, the NCEI gauge in Corrales has a 33-year period of record (with approximately 3 years of missing data). MRG stands for Manual Rain Gauge from SSCAFCA's former volunteer rainfall monitoring program. The three MRG's used in this study each have a period of record of nine years.





Data obtained from all five rain gauges represent daily rainfall totals. In the analysis, each day with recorded precipitation was treated as one rainfall event. This assumption may slightly skew the results because it is possible for multiple storms to occur during one day, or for a single storm to last more than 24 hours. Percentiles of total rainfall depths were calculated for all storms with rainfall depths exceeding 0.10 inches. Small storms were excluded from the analysis since they do not produce significant runoff, even from urbanized areas. The 90th percentile storm equals 0.65 inches of rainfall (+/- 8 percent); this is equivalent to the annual 2-hour storm at the centroid of SSCAFCA's jurisdiction.

Appendix B

Appendix B contains two documents:

- Pages B-2 to B-30 includes the hydrology section of the Draft Montoyas Watershed Park Conservation Plan. Findings from this analysis were used in development of SSCAFCA's hydrology guidelines. The document is references as SSCAFCA 2019 in the guideline text.
- Pages B-31 to B-38 contain a technical review of the above document and underlying models by the US Army Corps of Engineers Albuquerque District.

1 Introduction

The Montoyas Arroyo drains a 61 square mile watershed and discharges into the Rio Grande just north of the City of Albuquerque (Figure 1). Approximately 20 percent of the basin is urbanized, predominantly in the lower and central part of the catchment. The rest of the basin is mostly comprised of open space characterized by sandy, erosive soils and semi-desert shrub and grasslands.

The Montoyas Arroyo and its tributaries remain largely in its natural state, except for the last mile, where stormwater is conveyed the Rio Grande in a concrete channel (Harvey Jones Channel). Flow from the Lomitas Negras tributary (Figure 1, blue shading) is diverted to the south in the Dulcelina Curtis Channel and eventually joins the Harvey Jones Channel. The Lomitas Negras Tributary is 6 square miles is size, approximately 10 percent of the overall watershed area.

A regional hydrologic model of the Montoyas watershed was first prepared in 2002 (SSCAFCA, 2002) and updated in 2010 (SSCAFCA, 2011). The present document is a technical addendum that includes the following updates:

- Existing conditions hydrology reflects urbanization as of 2017
- Existing conditions model was calibrated using ten years of measured rainfall/runoff data
- Future conditions hydrology includes best available planning documents and growth projections
- Planned regional facilities were updated based on deficiencies and projected future needs (to be added after initial review)

Hydrologic modeling was used in this study to fulfil a variety of purposes. Primarily, available discharge records for the basin only span a period of approximately twelve years (2007-2018). According to SSCAFCA policy, planning and design of flood control infrastructure is based on runoff from the 100-year storm. Runoff resulting from a storm with a 1-percent chance of occurring in any given year cannot be inferred with confidence based on ten years of data. Moreover, discharge measurements are only available near the outlet of the basin, while flow estimates are needed at various locations throughout the watershed (e.g. road crossings). Finally, it is necessary to anticipate the effects of future urban development in the watershed and plan accordingly for future stormwater management. The following approach was adopted to simulate the rainfall-runoff relationship in the Montoyas watershed:

- Construct a hydrologic model representative of existing (2017) watershed conditions
- Calibrate the model based on available rainfall and discharge data
- Run the calibrated existing conditions model using the 100-year design storm
- Construct a future conditions model based on anticipate future land use and run using the 100year design storm



Figure 1: Overview map of the Montoyas watershed with the extent of urbanized area (red) in 2017.

2 Hydrology

Hydrology of the Montoyas watershed was modeled using HEC-HMS version 4.2.

2.1 Methods and Model Input Parameters

2.1.1 Mapping and Topography

Orthophotography used for this project consists of tiled images which depict color digital aerial photographs acquired in the spring of 2014 during leaf-off conditions. LiDAR-derived elevation data (2-foot contour interval, 2010) was used to delineate watersheds and sub-basins as well as for calculating hydrologic parameters. Both orthophotogarphy and elevation data are part of the Mid-Region Council of Governments (MRCOG) Digital Orthophotography and Elevation Data Project.

2.1.2 Analysis Points

Analysis points were selected for the following locations:

- Tributary confluences with the main stem of the Montoyas Arroyo
- Major existing culverts and road crossings
- Existing and proposed pond locations

2.1.3 Subbasin Delineation

Initial watershed and subbasin boundary delineation was accomplished using *HEC Geo-HMS* software with a digital elevation model (DEM) created from 2010 MRCOG LiDAR data. Basins were modified to accommodate desired analysis points and achieve basins with relatively uniform land use characteristics. All basin boundaries were checked based on 2010 2-ft elevation contours. Questionable boundaries were verified in the field, especially at locations where graded roads influence flow paths, and where a dominant flow path was not immediately obvious from 2-ft contours.

2.1.4 Reach Routing

Routing reaches were delineated and slopes estimated in *Arc-GIS* based on 2010 2-ft contours. Channel reaches were modeled using idealized cross-sections that most closely resembled the natural geometry of the reach (trapezoidal and rectangular). Roughness coefficients (Manning's n-values) were estimated based on orthoimagery and field investigations. In general, the following n-vales were used in the model:

Surface Type	Manning's n-value
Concrete pipe	0.013
Road (asphalt)	0.017
Corrugated metal pipe	0.025
Major arroyo, sandy bed and vertical banks	0.020
Natural channel, moderate to heavy vegetation in channel bed and along banks	0.025 - 0.035

Table 1: Roughness coefficients for routing reaches.

2.1.5 Transmission Losses

In 2016, SSCAFCA conducted a study quantifying transmission losses in the main stem of the Montoyas Arroyo (Schoener, 2016). During flow events, a portion of the runoff infiltrates into the permeable arroyo bed as stormwater travels downstream. Based on the findings from that study, transmission losses in the main stem of the arroyo were simulated in *HEC-HMS* using a constant percolation channel loss rate of 1.5 inches per hour.

2.1.6 Rainfall Loss Methodology

Two loss methodologies were compared in this study: the Curve Number (CN) method (USDA, 1954), and the Initial and Constant Rate loss model (USACE, 1994). Loss parameters were estimated based on 2017 land use conditions in the Montoyas watershed (see Figure 2). Land use was quantified by manual digitization using orthoimagery, and based on GIS data obtained from the City of Rio Rancho.

Special emphasis was placed on impervious coverage: for both loss methods, directly connected impervious areas (DCIA) were specified explicitly for each subbasin rather than including them in a composite loss calculation. A SSCAFCA study on the impacts of urban imperviousness showed that this approach yielded satisfactory result (Schoener, 2017). Major sources of DCIA such as commercial areas and paved roads (Figure 2, red) were digitized manually. A hybrid approach was adopted for residential areas (Figure 2, blue). Residential driveways and five percent of roof areas (the portion of the roof draining onto the driveway) were assumed to be directly connected. Residential roof areas were quantified based on GIS coverage of building footprints maintained by the City of Rio Rancho; an average driveway size of 700 ft² was assumed for each residential lot. Disconnected impervious areas (e.g. 95 percent of roof areas draining onto pervious landscaping) were included in the composite loss calculation for the corresponding subbasin.



Figure 2: Map of the Montoyas watershed and major land use types for existing conditions 2017.

Loss parameters for pervious areas were estimated based on guidance contained in Technical Release 55 (USDA, 1986) and on SSCAFCA's Development Process Manual (SSCAFCA, 2010). Table 2 lists land use types and associated loss parameters.

Land Use Type	Data Source	% DCIA	Pervious CN	Initial Abstraction (in)	Constant Infiltration (in/h)	% of Total Area
Paved roads with curb, residential driveways, other DCIA	CoRR curb coverage, parcels, manual digitization	100	-	-	-	3.5%
Disconnected impervious areas	CoRR building footprints, manual digitization	5	98	1.0	0.0	1.8%
Road ROW	Digitization, buffer around paved roads	0	92	0.3	0.8	1.1%
Unpaved road	CoRR road centerline, buffer applied in GIS	0	82	0.3	0.8	3.0%
Industrial	Manual digitization	0	88	0.3	0.8	0.2%
Graded areas	Manual digitization	0	86	0.3	0.8	0.8%
Sports fields, city parks, landscaping	Manual digitization	0	68 - 80	0.2 – 1.2	0.9	0.5%
Residential yard	CoRR parcels, manual digitization	0	68 - 80	0.2 – 1.2	0.9	6.3%
Open space	GIS	0	68 - 80	0.2 – 1.2	0.9	82.7%

Table 2: Land use categories and associate loss parameters for existing conditions 2017.

Figure 2 illustrates that under existing conditions, a large portion of the Montoyas watershed is undeveloped, with the exception of a network of graded dirt roads. Open space and residential yards account for nearly 90 percent of the basin area (Table 2). Since undeveloped areas likely have a large influence on the runoff response of the watershed, a range of loss parameters was tested for pervious, vegetated areas during model calibration. Parameter ranges are highlighted in blue in Table 2. Please refer to section 2.2 below for a detailed discussion on model calibration.

2.1.7 Transform Methodology

In *HEC-HMS*, the ModClark method was selected to transform excess precipitation into a runoff hydrograph for each subbasin. Times of concentration were estimated in *Arc-GIS* based on the watershed DEM using the methodology outlined in TR-55 (USDA, 1986). Subbasin storage coefficients were estimated as 50 percent of the time of concentration. Transform parameters were adjusted during model calibration.

2.1.8 Stormwater Detention Ponds

The Montoyas watershed model contains a total of 59 ponds and dams that attenuate runoff ranging from less than 1 ac-ft to more than 300 ac-ft in storage volume. Pond parameters and dimensions were collected from corresponding engineering documents and verified in the field where necessary. A comprehensive list of all ponds included in the watershed model is contained in Appendix A. In *HEC-HMS*, pond routing was simulated using rating curves (elevation-storage and storage-discharge curves). Ponds were assumed to be dry at the start of each simulation.

2.1.9 Sediment Bulking

Sediment bulking factors of 18 percent for natural areas and six percent for urbanized areas were added as flow ratios to clearwater discharges in *HEC-HMS* to account for the increase in runoff volume due to suspended sediment in storm flows. Area averaged bulking factors were used for subbasins containing both urbanized and natural areas.

2.2 Model Calibration

Rainfall and runoff data for ten storm events that occurred between October 2008 and August 2014 were available for calibrating the hydrologic model (Table 3).

Storm	Date	Average total rainfall (in) ^a	Duration (h)	Peak flow (ft ³ /s)	Runoff volume (ac-ft)	7-day antecedent rainfall (in) ^b	Antecedent flow
а	10/5/08	1.30 (1.06-1.77)	12	113	14	0.11	Ν
b	10/11/08	1.06 (0.75-1.34)	1	363	71	1.32	Υ
С	8/23/10	1.22 (0.43-2.36)	1	2200	202	0.29	Ν
d	7/26/13	0.59 (0.31-1.34)	3	630	78	0.13	Ν
e	8/4/13	0.71 (0.20-1.50)	3	900	108	0.6	Ν
f	9/13/13	1.46 (0.43-2.01)	12	2030	396	1.24	Ν
g	9/14/13	0.91 (0.55-2.01)	3	858	140	2.21	Υ
h	9/15/13	0.31 (0.08-0.63)	2	851	83	2.21	Y
i	7/3/14	0.94 (0.20-2.01)	2	680	142	0	Ν
j	8/10/14	0.31 (0.12-0.67)	3	69	8	0.22	Ν

^a Average calculated in GIS based on cumulative precipitation grid (range in parentheses)

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^b Average based on available rain gauge data

Precipitation data were obtained from three sources: tipping bucket rain gauges, radar derived rainfall estimates (NOAA, 2017a), and storm total rainfall depths measured by volunteer weather observers. Figure 3 shows a comparison of measured rainfall and IDF curves (NOAA, 2017b) from the location with the highest precipitation record for each storm event. Elements of two storms exceeded the 100-year RI (short dash); portions of four storms fell between the 25- and 50-year RI (solid); one storm (dash-dot) approached the 10-year RI, two storm events fell close to the annual (1-year) storm (dot), and one storm was smaller than the annual storm (long dash). Spatial extent of storms varied considerably; maps of precipitation coverage for each storm event are included on pages 7-11. It is important to note that storm data presented in Figure 3 does not represent basin average rainfall values.

Runoff was measured in the Harvey Jones channel near the watershed outlet using a pressure transducer (Level Troll 500, In-Situ, Fort Collins, CO). Flow depth was recorded in 5-minute intervals and converted to discharge using a theoretical rating curve developed in HEC-RAS.

Incremental (5-minute) point precipitation data were converted to rainfall grids with the inverse distance square weighted average interpolation method using the Gageinterp program. Rain gauge data were augmented with radar derived rainfall estimates (NEXRAD Level-III DTA/172, NOAA, 2017a) for three out of ten storms. Based on the areal extent of each storm, points were selected strategically to fill in gaps in the rain gauge coverage. At each point, radar estimates were converted to 5-minute time series of incremental precipitation and bias-corrected by multiplying each time step with a bias adjustment factor (see Schoener, 2017 for more details).

Four observed storms (see Table 3, storms b, f, g & h) were preceded by substantial rainfall amounts in the 7-day period leading up to the storm. The remainder of the storm events followed a relatively dry period. A recent SSCAFCA study indicates that antecedent moisture in the watershed is an important factor in the generation of runoff and contributes to model uncertainty (Schoener and Stone, 2019). To account for differences in initial conditions, a range of loss parameters was tested both for the curve number and initial and constant rate loss models. The curve number loss model was run for all storms with curve number values ranging from 68 to 80 in increments of one CN for pervious, vegetated areas. For the initial and constant loss rate method, constant loss rates ranging from 0.8-1.5 in/h and initial abstraction values ranging from 0.2-1.2 in were applied to pervious, vegetated areas. Based on an initial set of 16 simulations for each storm event (not reported), it was determined that most of the variability could be accounted for by using a constant loss rate of 0.9 in/h and initial abstraction values between 0.2-1.2 in.



Figure 3: Intensity-duration-frequency curves (grey) and observed calibration storms (black).

Maps for individual storm events along with model results from curve number and initial and constant loss rate models are displayed in Figure 4 through Figure 12. Observed discharge is plotted in red; grey areas show model results for the range of loss parameters considered; black lines represent optimal simulation results along with the corresponding loss parameter.

Optimal simulations for both loss methods yielded acceptable results for most calibration storms. In general, the range of simulated flows was smaller for the curve number method. Based on this analysis, the curve number method was selected as the preferred loss methodology for the Montoyas watershed model.



▲ Tipping Bucket Gauge (5-Minute Data)



Figure 4: Map showing the extent of storm a (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).



▲ Tipping Bucket Gauge (5-Minute Data)



Figure 5: Map showing the extent of storm b (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).





Figure 6: Map showing the extent of storm c (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).



▲ Tipping Bucket Gauge (5-Minute Data)



Figure 7: Map showing the extent of storm d (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).

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Figure 8: Map showing the extent of storm e (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).

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Figure 9: Map showing the extent of storm f (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).



Figure 10: Map showing the extent of storms g (top left) and h (top right), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).





Figure 11: Map showing the extent of storm i (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).





Figure 12: Map showing the extent of storm j (top), and the comparison of observed and simulated hydrographs for the curve number loss method (bottom left) and the initial and constant loss method (bottom right).

2.3 Model Validation

Three runoff-producing storms occurred in the summer of 2018 and were used for model validation (Table 4). Figure 13 shows a comparison of measured precipitation and IDF curves from the location with the most extreme precipitation record for each storm event. Storm k approached the 100-year RI for a 60-minute duration, while storms I and m approached the 10- and 50-year RIs, respectively, for a duration of two hours.

Storm	Date	Average total rainfall (in) ^a	Duration (hr)	Peak flow ^b (ft ³ /s)	Runoff volume ^b (ac-ft)	7 / 14 / 21-day antecedent rainfall (in) ^c	Antecedent flow
k	7/5/18	0.97 (0.22-2.28)	1	166 / 58	49/10	0.00 / 0.00 / 0.26	Ν
I	7/27/18	0.67 (0.11-1.39)	2	- / 452	- / 53	0.51 / 1.09 / 1.86	Y
m	8/22/18	0.75 (0.17-1.39)	2	272 / 701	40 / 102	0.38 / 0.58 / 1.12	Y

^a Average calculated in GIS based on cumulative precipitation grid (range in parentheses)

^b Northern Meadows / Sportsplex Dam

^c Average based on available rain gage data



Figure 13: Intensity-duration-frequency curves (grey) and observed validation storms (black).

Spatial extent of storm coverage varied considerably; maps of precipitation coverage for each storm event are included with Figure 14 through Figure 16. Please note that storm data represented on Figure 13 does not represent basin average rainfall values.

Similar to the calibration period, 5-minute gridded rainfall time series were prepared from gauge and radar data. For the validation storms, a dense network of 23 tipping bucket rain gauges was available for the watershed and surrounding areas. Rain gauge sites and locations where radar data was interpolated are indicated with triangles and circles, respectively, on Figure 14 through Figure 16. Storm k was preceded by two weeks with no measurable precipitation, and below average rainfall for the period of January through June 2018. Storms I and m, on the other hand, followed a period of repeated precipitation events that covered the entire catchment. Although no direct soil moisture measurements were available for the watershed, it appears reasonable to assume that the storms represent end members of a spectrum of soil moisture in the watershed: dry conditions for storm k, and wet conditions for storms I and m. Based on results from model calibration, two model scenarios were run for each storm event: a dry condition simulation (CN=68 for pervious, vegetated areas), and a wet condition run (CN=80). Figure 14 through Figure 16 compare simulated and observed flow for each storm at the new gaging stations in Northern Meadows and at Sportplex Dam. Data from the Harvey Jones channel gauge is not reported here because the other two stations have a higher resolution, especially for low flows.

Storm	Location	Simulated (dry) error	Simulated (wet) error	
Storm	Location	Q _p	V	Q _p	V
k	Northern Meadows	4%	9%	1146%	704%
	Sportsplex Dam	24%	-30%	3103%	3300%
I	Northern Meadows	-	-	-	-
	Sportsplex Dam	-56%	-63%	-25%	-5%
m	Northern Meadows	-61%	-60%	-14%	56%
	Sportsplex Dam	-83%	-80%	6%	29%

Table 5: Peak discharge and runoff volume errors for three validation storms at two gaging stations.

Table 5 compares model error for each scenario based on flow measurements from the Northern Meadows and Sportsplex Dam gauges. The comparison illustrates that dry conditions model predictions closely match measured discharge (within 30%) at both gaging stations for storm k, while the wet conditions model overestimated peak discharge and runoff volume by approximately one order of magnitude. The opposite is true for storms I and m. Dry conditions models underestimated peak discharge and runoff volume by between 56% and 80%. Wet conditions model runs yielded results within 30% of measured flows, with one exception: for the August 22 storm at flow gauge A, the model overestimated runoff volume by 56%.

Model validation illustrates that the model simulates runoff from the Montoyas watershed reasonably well with respect to peak discharge, runoff volume, hydrographs shape and timing if antecedent moisture conditions are accounted for. Pervious area curve numbers (parks, residential yards, landscaping, and open space) of 68 and 80 for dry and wet initial conditions, respectively, are appropriate for this basin.



Figure 14: Comparison of observed (red) and simulated (black) hydrographs at Northern Meadows (top) and Sportsplex Dam (bottom) for dry conditions (left) and wet conditions (right) model runs.



Figure 15: Comparison of observed (red) and simulated (black) hydrographs at Sportsplex Dam for dry conditions (left) and wet conditions (right) model runs.



Figure 16: Comparison of observed (red) and simulated (black) hydrographs at Northern Meadows (top) and Sportsplex Dam (bottom) for dry conditions (left) and wet conditions (right) model runs.

2.4 Land Use – Developed Conditions

Anticipated future land use in the Montoyas watershed (Figure 17) and associated parameters (Table 6) were based on the following assumptions:

- Residential lots in master planned developments and largely developed areas in the lower watershed will develop as platted;
- Areas covered by specific area plans (SAP) will develop as indicated in the planning document, specifically: Boadmoor Drive SAP (CoRR, 2007a), Dos Amigos SAP (CoRR, 2007b), Sierra Vista SAP (CoRR, 2008), Del Norte SAP (CoRR, 2009), Paseo Gateway West SAP (CoRR, 2010a), La Barranca SAP (CoRR, 2010b), Northern Unser SAP (CoRR, 2011);
- The state land tract (see Figure 17) and lots adjacent to the future Paseo-del-Volcan alignment will develop as commercial;
- Approximately 650 acres in the upper watershed predominantly under one ownership will develop as a master planned subdivision and a commercial area (Figure 17);
- 60 percent of remaining residential lots south of the power line easement (see Figure 17, dark purple) will develop as platted, 40 percent will remain undeveloped;
- 15 percent of remaining residential lots north of the power line easement (see Figure 17, light purple) will develop as platted, 85 percent will remain undeveloped;
- Unplatted areas in the upper portion of the watershed will remain open space.

Table 6: Land use categories and associate loss parameters for anticipated future land use.

Land Use Type	Data Source	% DCIA	Pervious CN	Justification
Medium density residential (6du/ac)	Manual digitization	26	84	Non-DCIA is composed of: 32% disconnected impervious (CN=98), 14% road ROW (CN=92), 46% residential yard (CN=74), 8% open space (CN=74); statistics based in CoRR High Range subdivision
Medium density residential (4du/ac)	Manual digitization	21	81	Non-DCIA is composed of: 22% disconnected impervious (CN=98), 10% road ROW (CN=92), 43% residential yard (CN=74), 25% open space (CN=74); statistics based on CoRR Northern Meadows subdivision
Low Density Residential (2du/ac)	Manual digitization	3	77	Non-DCIA is composed of: 8% disconnected impervious (CN=98), 8% unpaved road (CN=82), 84% residential yard (CN=74); statistics based on CoRR Unit 17 typical development
Low Density Residential (1du/ac)	Manual digitization	2	76	Non-DCIA is composed of: 7% disconnected impervious (CN=98), 10% unpaved road (CN=82), 83% residential yard (CN=74); statistics based on Village of Corrales typical development
Residential 60% developed	Sandoval County parcels, manual digitization	1.8	76	Assumes 60% of this area is developed with an average density of 2du/ac; remaining area modeled as open space (CN=74)
Residential 15% developed	Sandoval County parcels, manual digitization	0.5	74	Assumes 15% of this area is developed with an average density of 2du/ac; remaining area modeled as open space (CN=74)
Future commercial	CoRR parcels, manual digitization	85	74	Assumes 85% DCIA, remainder is open space (CN=74)



Figure 17: Map of the Montoyas watershed with anticipated future land uses.

2.5 Design Storm

Point precipitation frequency estimates for the Montoyas watershed were obtained from NOAA Atlas 14 (NOAA, 2017b) and are displayed in Table 7.

Duration	Point precipitation estimate (in)
5 minutes	0.589
15 minutes	1.110
1 hour	1.850
2 hours	2.130
3 hours	2.200
6 hours	2.390
12 hours	2.550
1 day	2.900

 Table 7: Point precipitation frequency estimates and 90% confidence interval for the 100-year recurrence interval in the Montoyas watershed.

The design storm was modeled in HEC-HMS using the built-in frequency storm option with an intensity position of 25 percent (see Figure 18), intensity duration of five minutes, and the depth-area reduction for a catchment area of 61 square miles.



Figure 18: Design storm temporal distribution.

The design storm is used as a planning tool only; temporal and spatial patterns of real-world storm events will likely differ from the design storm, and induce a different watershed response.

2.6 Design Storm Results

Figure 19 shows hydrographs at the outlet of the catchment for existing land use conditions (left) and anticipated future conditions (right) based on the design storm. Black lines in Figure 19 are results from model runs with a curve number of 74 assigned to all open space, landscaping, and residential yards. This represents the best estimate for an curve number representing intermediate moisture conditions based on the calibration and validation analyses described in sections 2.2 and 2.3 above. Grey areas represent model runs with a curve number range of 71-76 for open space, landscaping, and residential yards. This range was selected to provide an uncertainty envelope around the estimated 100-year runoff estimate associated with initial moisture conditions. It was deemed unreasonable to simulate the entire watershed with a wet conditions pervious curve number of 80, as this would imply that catchment soils throughout have high initial moisture conditions and the entire 61 square mile watershed is subsequently impacted by the 100-year storm. Analyses conducted for smaller basins may have to consider higher curve numbers, because the likelihood of successive intense storms increases with decreasing spatial extent.

It is important to note that simulation results only provide a best estimate of the watershed runoff response from the design storm for current and projected future land use conditions. Model results are intended to be used for planning and design of flood control infrastructure, but need to be interpreted with the underlying uncertainty in mind.



Figure 19: Simulated design storm discharge for existing conditions (left) and developed conditions (right).

Based on this analysis, expected peak discharge is approximately 6,900 cfs (range: 4,600 – 9,000 cfs) for existing conditions and 9,900 cfs (range: 7,800 – 11,200 cfs) for developed conditions with existing drainage infrastructure.

3 References

Arc-GIS [Computer Software]. ESRI, Redlands, CA.

CoRR (City of Rio Rancho) (2007a). "Broadmoor Drive Specific Area Plan." Rio Rancho, NM. https://www.rrnm.gov/index.aspx?NID=1543 (accessed Jan. 2017).

CoRR (City of Rio Rancho) (2007b). "Dos Amigos Specific Area Plan." Rio Rancho, NM. https://www.rrnm.gov/index.aspx?NID=1543 (accessed Jan. 2017).

CoRR (City of Rio Rancho) (2008). "Sierra Vista Specific Area Plan." Rio Rancho, NM. https://www.rrnm.gov/index.aspx?NID=1543 (accessed Jan. 2017).

CoRR (City of Rio Rancho) (2009). "Del Norte Specific Area Plan." Rio Rancho, NM. https://www.rrnm.gov/index.aspx?NID=1543 (accessed Jan. 2017).

CoRR (City of Rio Rancho) (2010a). "Paseo Gateway West Specific Area Plan." Rio Rancho, NM. <u>https://www.rrnm.gov/index.aspx?NID=1543</u> (accessed Jan. 2017).

CoRR (City of Rio Rancho) (2010b). "La Barranca Specific Area Plan." Rio Rancho, NM. https://www.rrnm.gov/index.aspx?NID=1543 (accessed Jan. 2017).

CoRR (City of Rio Rancho) (2011). "Northern-Unser Specific Area Plan." Rio Rancho, NM. https://www.rrnm.gov/index.aspx?NID=1543 (accessed Jan. 2017).

Gageinterp [Computer Software]. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

HEC Geo-HMS [Computer Software].]. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

HEC-HMS [Computer Software]. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

HEC-RAS [Computer Software]. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA.

NOAA (National Oceanic and Atmospheric Administration), (2017a). National Centers for Environmental Information, NEXRAD Data Archive. (<u>https://www.ncdc.noaa.gov/nexradinv/index.jsp</u>).

NOAA (National Oceanic and Atmospheric Administration), (2017b). "NOAA atlas 14 point precipitation frequency estimates: NM." (http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nm)

Schoener, G. (2016). "Quantifying Transmission Losses in a New Mexico Ephemeral Stream: A Losing Proposition." J. Hydrol. Eng. 22(3), doi: 10.1061(ASCE)HE.1943-5584.0001473.

Schoener, G. (2017). "Urban Runoff in the US Southwest: Importance of Impervious Surfaces for Small-Storm Hydrology." J. Hydrol. Eng. 23(2), doi: 10.1061/(ASCE)HE.1943-5584.0001610. SSCAFCA (Southern Sandoval County Arroyo Flood Control Authority) (2002). "Montoyas Arroyo Watershed Management Plan." Rio Rancho, NM.

SSCAFCA (Southern Sandoval County Arroyo Flood Control Authority) (2010). "Final Development Process Manual." Rio Rancho, NM.

SSCAFCA (Southern Sandoval County Arroyo Flood Control Authority) (2011). "Montoyas Watershed Park Management Plan Version 2.0." Rio Rancho, NM.

USACE (U.S. Army Corps of Engineers) (1994). "Flood-Runoff Analysis." Manual No. 1110-2-1417, Department of the Army, Washington, DC.

USDA (U.S. Department of Agriculture) (1954). "National Engineering Handbook, Sect. 4, Hydrology." U.S. Govt. Print Office, Washington, D.C.

USDA (U.S. Department of Agriculture) (1986). "Urban hydrology for small watersheds." Natural Resources Conservation Service, Technical Release 55, Washington, D.C.

USACE Albuquerque District – Hydrology and Hydraulics Section Technical Review

Project Title:	SSCAFCA Watershed Management Plan Review
Project Sub-Title/Task:	Assess HEC-HMS assumptions, methods, and results
Authority:	Flood Risk Management Program
Project Manager:	Stephen Scissons, Ch. H&H Section, EC-HH
Reviewing Engineer:	Stephen Brown, EC-HH
Review Date:	April 15, 2019

Project Tasks

- Technical review of existing conditions hydrology reflecting urbanization and drainage infrastructure as of 2017
- Review of existing conditions model calibration based on 13 storm events with measured rainfall and discharge data
- Review of future conditions hydrology based on growth projections
- Provide review comments to SSCAFCA in a brief report
- After SSCAFCA has implemented recommendations, potentially conducted second round of review and provide comments back to SSCAFCA.

Product Reviewed

- DRAFT Montoyas Watershed Management Plan (MOWMP) Technical Addendum (October 2018)
 - File name: MOWMP_TechnicalAddendum_DRAFT_Oct2018.pdf
 - Hydrology report for the Montoyas Arroyo covering updates to the 2010 SSCAFCA HEC-HMS model.
 - o Includes three storms from the summer of 2018, used for model validation.
 - Surface hydrology reflects urbanization as of 2017.
 - HEC-HMS model was calibrated using ten years of measured rainfall/runoff data.
 - Future conditions hydrology includes best available planning documents and growth projections.
 - Planned regional facilities were updated based on deficiencies and projected future needs (to be added after initial review.)

Supplementary Materials

- HEC-HMS models of Montoyas Arroyo
 - Montoyas_CurveNumber uses the curve number loss method with gridded precipitation for calibration/validation.
 - Montoyas_Initial_Const uses the initial and constant loss method with gridded precipitation for calibration/validation.

- Montoyas_Lumped contains existing and future land use scenarios using the curve number method and our 100-year design storm.
- Memo_Storms_July2018_DRAFT.pdf
 - Storms report for July 2018 featuring storm precipitation totals and discharge estimates.
- Parameters.xlsx
 - Excel spreadsheet with loss and transform parameters for the various models.

Review Summary

Primary focus of this review consisted of investigation of assumptions and results presented in the MOWMP draft report. The MOWMP comments summarized in Appendix A. HEC-HMS models were explored to verify certain calibration events.

Parameter estimation and implementation was conducted by SSCAFCA within HEC-HMS guidelines for the available surface and hydrologic data. Calibration to observed events was conducted on historic storm events and validated with precipitation events in 2018.

Delineation of subbasins is of sufficient granularity to capture runoff in urban, rural, and undeveloped regions. Care was taken when defining land use and urbanization variability.

Many stormwater detention ponds are within the study area. A detailed summary of the structures, source of data, and hydraulic parameters is included with the report. Considerable storage is available within these ponds providing clear and sediment attenuation. Care must be taken when routing events that coincident flow estimates are accurately represented as ponds impound and spill.

The USDA Curve Number parameterization falls within accepted guidelines. Appropriate Initial Abstraction and Constant Infiltration values are critical to reaching a viable calibration. Clear guidance should be distributed with the HEC-HMS model for external use. Migrating to an alternative abstraction method may be required if SSCAFCA decides to run continuous, long term HEC-HMS simulations.

Estimating precipitation for calibration and validation has been approached from multiple directions. Ground truthing the radar data with physical collection methods on the surface is currently the most reliable way to adjust for regional radar depth estimation drift. The current methodology provides reasonable rainfall methods given the tools available for analysis. USACE has provided SSCAFCA with a beta distribution of HEC-MetVue to conduct additional interpolation of radar and surface precipitation estimates. The confidence limits of the current HEC-HMS calibration runs may be improved using HEC-MetVue for interpolation, in addition to exploring precipitation trends of storm direction, speed, and intensity.

Full review of hydrologic parameterization and verification of values entered into HEC-HMS was not conducted as part of this investigation. An internal review to ensure model parameters were correctly transferred into HEC-HMS is recommended.

Recommendations

Precipitation

Refinement of radar-based storm totals and rain gage interpolation is possible with a new software package developed by USACE, HEC-MetVue. A copy of the beta release of HEC-MetVue software was provided to SSCAFCA for precipitation analysis in April 2019. MetVue was designed to pre-process precipitation grids for HEC-HMS simulations. A hydrologist can load a subbasin shapefile and a set of precipitation grids into MetVue for automated storm depth totals by subbasin. These storm totals can be tabulated, visualized, animated, and converted to DSS hyetographs. Additional Metvue functionality includes depth-duration curves, surface-based precipitation depth validation and interpolation, and HMR 52 analysis.

Soil abstraction

Initial water content of the watershed and channels drives a considerable amount of uncertainty in final simulated discharges. Estimating the available carrying capacity of the soils is essential for calibration. Running a soil moisture accounting method in HEC-HMS will allow for long term simulations where development sensitivity can modeled. The two methods below may assist with determining antecedent soil capacity via remote sensing. Installation of soil moisture sensors at key locations will provide a valuable observed record of moisture travel time through soil and assist with determining infiltration excess runoff probabilities.

Title: "Estimating growing-season root zone soil moisture from vegetation index-based evapotranspiration fraction and soil properties in the Northwest Mountain region, USA," Pradhan 2019

URL: https://www.tandfonline.com/doi/abs/10.1080/02626667.2019.1593417.

Abstract: A soil-moisture retrieval method is proposed, in the absence of ground-based auxiliary measurements, by deriving the soil-moisture content relationship from the satellite vegetation indexbased evapotranspiration fraction and soil moisture physical properties of a soil type. A temperaturevegetation dryness index threshold value is also proposed to identify water bodies and underlying saturated areas. Verification of the retrieved growing season soil moisture was performed by comparative analysis of soil moisture obtained by observed conventional *in situ* point measurements at the 239-km² Reynolds Creek Experimental Watershed, Idaho, USA (2006–2009), and at the US Climate Reference Network (USCRN) soil-moisture measurement sites in Sundance, Wyoming (2012–2015) and Lewistown, Montana (2014–2015). The proposed method best represented the effective root zone soilmoisture condition, at a depth between 50 and 100 cm, with an overall average R² value of 0.72 and average root mean square error (RMSE) of 0.042. Abstract: SMAP is designed to measure soil moisture over a three-year period, every 2-3 days. This permits changes, around the world, to be observed over time scales ranging from major storms to repeated measurements of changes over the seasons.

Sediment transport

HEC-HMS has robust built-in sediment functions to represent transport based on storm size and intensity. Existing soil analysis from the watershed and channels can be used to parameterize the model. Long term simulations may be run in HEC-HMS to inform O&M planning. Sediment modeling in HEC-HMS should be coupled with HEC-RAS or ERDC-AdH to capture the evolving geomorphology of the channel reaches.

Conclusion

The current and future conditions HEC-HMS have been prepared with sufficient supporting studies to provide a justified representation of the physical system. As with all models, refinement of certain inputs will improve the long term reliability of the simulation.

Additional precipitation analysis will improve runoff estimates by refining storm tracking and intensity. Investigating antecedent soil moisture via remote sensing or surface mounted precipitation gages will provide supplementary antecedent sub surface carrying capacity.

HEC-HMS and HEC-RAS, currently, have robust sediment transport routines incorporated. Use of these tools for event based sediment routing is recommended. HEC-HMS 2DH, with 2D sediment routing, is expected to be released in 2020. The advanced 2D routing is already incorporated into HEC-RAS. Should SSCAFCA choose to implement the 2D features in HMS 2DH, HEC has approved SSCAFCA's use of the beta release when available.

Disclaimer

Full review of hydrologic parameterization and verification of values entered into HEC-HMS was not conducted as part of this investigation. Additional parameterization review is recommended before using the model for design or construction, to ensure model parameters were correctly transferred into HEC-HMS.

Appendix A: MOWMP Technical Addendum DRAFT Comments

The comments below are also summarized along with narrative comments in MOWMP_TechnicalAddendum_DRAFT_Oct2018.SWB-Comments.pdf.

----- Page 1-----

Comment Type: Narrative

Section: Introduction

Consider revising. The variety of purposes is unclear.

1) ? Extent discharge record ?

2) Provide runoff hydrographs from analysis points throughout watershed

3) Future conditions

----- Page 2-----

No Technical Comments. Narrative Comments in PDF.

----- Page 3------

No Comments.

----- Page 4-----

Comment Type: Technical

Recommendation: Antecedent conditions and storm intensity are driving factors for flood runoff.

Recommendation: Incorporate sediment transport functions within HEC-HMS instead of a bulking factors. Bulking the flows is a reasonable way to represent sediment in the system. Modifying the bulking factor based on subbasin soil parameters would be a middle ground between a full sediment model and the current 18% natural and 6% urban bulking factors.

----- Page 5-----

Comment Type: Technical

Recommendation: Remotely sensed or proxy soil moisture data may be helpful for antecedent conditions if sufficient resolution is available. In situ soil moisture measurements will improve antecedent soil moisture estimates and assist with determining precipitation inflection point between infiltration and saturation excess run off regimes.

----- Page 6-----

Comment Type: Narrative

All precipitation maps: The increasing rainfall decreasing is confusing. Although the format is sort of in hyetograph format with increasing depth down. Is the same depth symbology range used in all plots? For example, the same shade of blue is the same depth in each plot.

----- Page 7-----

No Comments.

----- Page 8------

No Comments.

----- Page 9------

No Comments.

----- Page 10------

No Comments.

----- Page 11------

Comment Type: Narrative

2.3 pg 11: Will guidance be included on when to use wet or dry boundary conditions?

----- Page 12-----

No Comments.

----- Page 13------

No Comments.

----- Page 14------

No Comments.

----- Page 15-----

No Technical Comments. Narrative Comments in PDF.

----- Page 16-----

Comment Type: Narrative

2.5 is the depth-area reduction based on NOAA Atlas 2 or TP50. Briefly discuss the spatial rainfall distribution difference between the design storm and a real event.

2.5 Was a single point used or an area average for the NOAA Atlas 14 depth? Including the range of depths for the watershed is helpful for bounding the statistical estimates.

2.6 Including Northern Meadows and Sportsplex Dam peaks will help illustrate the longitudinal change in Q.

----- Page 17-----

No Technical Comments. Narrative Comments in PDF.

----- Page 18------

No Comments.

----- Page 19------

No Comments.

Appendix C

Comparison of Methods for Estimating Design Storm Runoff

The Southern Sandoval County Arroyo Flood Control Authority is the process of updating the drainage guidance manual for the Authority's jurisdictional area. As part of this update, new methodologies for simulating the design storm, losses and unit hydrographs are proposed. Proposed new methods have been vetted using measured rainfall-runoff data (SSCAFCA 2019a). Nevertheless, the question of how results based on proposed methods compare to model results using the previous guidance should be addressed.

Moreover, several recent studies have demonstrated the influence of antecedent soil moisture on runoff, whereby wet soils produce runoff faster and lead to more runoff overall (Schoener and Stone 2019, SSCAFCA 2019b). Urbanized basins comprise a large percentage of impervious surfaces; impervious cover has no "memory" for past storms, the runoff response will be similar regardless of antecedent precipitation. The effect of antecedent soil moisture is therefore most important for undeveloped areas. This raises the question of how off-site basins should be treated. Offsite basins are areas that are not urbanized (developed) at the time of a drainage analysis, but that discharge through the area of interest.

This document contains a comparison of model results using SSCAFCA's existing drainage guidance (SSCAFCA 2010) and the proposed new methods (SSCAFCA 2019a) for two subdivisions in the Rio Rancho area. The intent of this comparison was to assess the impact of changes proposed as part of the new guidance for a realistic development project in SSCAFCA's jurisdictional area. Four different model scenarios were considered:

The **Base Scenario (1)** uses the existing 100-year design storm (see SSCAFCA 2010) with the initial and constant loss method and the Clark Unit Hydrograph. The base scenario assumes developed conditions based on existing platting and zoning for off-site basins in accordance with SSCAFCA's existing drainage guidance.

Scenarios 2-5 use the frequency storm available in HEC-HMS, the curve number loss methodology, and the SCS unit hydrograph. The scenarios differ in their treatment of off-site basins and assumptions about antecedent moisture conditions:

- Scenario 2 assumes undeveloped off-site basins and dry conditions
- Scenario 3 assumes undeveloped off-site basins and wet conditions
- Scenario 4 assumes developed off-site basins based on existing platting and zoning and dry conditions
- Scenario 5 assumes developed off-site basins based on existing platting and zoning and wet conditions

The following relationship between land treatment types (see SSCAFCA 2010) and runoff curve numbers was assumed:

Treatment Type	Initial Abstraction (in)	Constant Infiltration (in/hr)	CN (dry conditions)	CN (wet conditions)
А	0.64	1.67	71	77
В	0.50	1.25	74	80
C	0.35	0.83	78	86
D	0.10	0.04	modeled as	% impervious

Table 1: Land treatment types and associated curve numbers.

Dry conditions curve numbers were calculated based on cumulative losses from the initial and constant method for the 100-year 24-hour design storm from the existing drainage guidance manual (cumulative precipitation = 2.90 inches). Wet conditions curve numbers are based on ongoing SSCAFCA research assessing the impact of soil moisture on runoff curve numbers. Model scenarios were compared for two subdivisions in the Rio Rancho area (Stonegate, and Broadmoor Heights), along with a hypothetical undeveloped basin.

The planned Stonegate subdivision (Hughes, 2014) consists of 0.35 mi² of residential and commercial development (Figure 1, orange) and 0.42 mi² of offsite basins (blue) that drain through the proposed development. Runoff from the combined 0.76 mi² area drains to a regional pond.



Figure 1: Stonegate subdivision overview map.

Off-Site Basins

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For offsite basins, five model scenarios were compared (see Table 2). The base scenario (yellow) based on the existing drainage guidance was compared to model results assuming dry (red, purple) and wet conditions curve numbers (green, blue). Offsite basins were assumed undeveloped (red, green) or developed per existing platting and zoning (purple, blue).

I	able Z:	wodel s	cenarios ar	id param	eters.	

	1	2	3	4	5	
Model Scenario	Base scenario	Off-site basins undeveloped, dry conditions	Off-site basins undeveloped, wet conditions	Off-site basins developed, dry conditions	Off-site basins developed, wet conditions	
Model	AHYMO	HEC-HMS v. 4.3				
Rainfall	DPM distribution	Frequency Storm, 25% Intensity Position				
	Initial and Constant	Curve Number Method				
Loss	10% A	0% Imp	anvious	27% Impervious		
LUSS	33% B	0% imp	ervious	27% impervious		
	30% C	CN - 71	CN - 77	CN - 75	CN - 92	
	27% D	CN - 71	CN = 77	CN = 75	CN - 82	
Transform	AHYMO Unit Hydrograph	SCS Unit Hydrograph				

Figure 2 shows a comparison of peak discharges for all model scenarios for six off-site basins; runoff volumes are compared in Figure 3. Predictably, assuming undeveloped conditions (red, green) lead to substantially lower peak flows and runoff volumes compared to the baseline (yellow) even when wet conditions were assumed (green). Developed conditions with wet soils (blue) yielded higher peak flows and volumes for all off-site basins. Developed dry conditions (purple) lead to the closest match with the baseline model. Please note that the baseline and new models use a different design storm. This comparison is only intended to identify the implications of different land use assumptions as related to the exiting drainage guidance (i.e. the baseline scenario).



Figure 2: Comparison of peak discharges for six off-site basins, Stonegate subdivision.



Figure 3: Comparison of runoff volumes for six off-site basins, Stonegate subdivision.

On-Site Basins

Three scenarios were compared for on-site basins: baseline (yellow), developed with dry soils (purple), and developed with wet soils (blue).



Figure 4: Comparison of peak discharges for 21 on-site basins, Stonegate subdivision.



Figure 5: Comparison of runoff volumes for 21 on-site basins, Stonegate subdivision.

Figure 4 and Figure 5 show comparisons for peak discharges and runoff volumes, respectively, from 21 on-site basins. Again, the dry conditions scenario most closely resembles the baseline model. Peak discharges are runoff volumes are slightly higher than the baseline scenario (on average 11% and 6%, respectively). This is likely due to the treatment of impervious surfaces in the model. Impervious cover (land treatment type D in the baseline model) was treated as "% Impervious" in scenarios 4 and 5. If directly connected and unconnected impervious surfaces were distinguished as outlined in the new drainage guidance, peak flow and volumes would likely be lower.

Pond Results

Table 3 contains model results for the Stonegate subdivision pond. Assuming developed conditions with dry soils (purple) for on-site and off-site basins (purple) led to the closest batch with the baseline scenario.

	1	2	3	4	5
Model scenario	Base scenario	Off-site basins undeveloped, dry conditions	Off-site basins undeveloped, wet conditions	Off-site basins developed, dry conditions	Off-site basins developed, wet conditions
Peak inflow (cfs)	1521	1130	1419	1506	1796
Peak outflow (cfs)	305	279	295	304	311
Peak storage (ac-ft)	35	24	30	34	41

Table 3: Model results for Stonegate Subdivision pond.

The planned Broadmoor Heights subdivision (Caffrey 2019) consists of 0.18 mi² of residential development (Figure 6, orange) and 0.18 mi² of offsite basins (blue) that drain through the proposed development. A portion of the off-site area is already developed. Runoff from the combined 0.36 mi² area drains to a regional pond.



Figure 6: Broadmoor Heights subdivision overview map.

Based on the results from the Stonegate analysis, only scenarios 1 and 4 were compared for the Broadmoor Heights subdivision.



Figure 7 shows a comparison of peak discharges for 13 subbasins for scenario 1 (yellow) and scenario 4 (purple). Figure 8 contains the same comparison for runoff volumes.

Figure 7: Comparison of peak discharges for 13 on-site basins, Broadmoor Heights subdivision.



Figure 8: Comparison of runoff volumes for 13 on-site basins, Broadmoor Heights subdivision.

Peak discharges are within 33 percent of the baseline model (average difference: -2%); Runoff volumes are within 5% of the baseline (average differences: -1%). Model results for the pond at the outlet of the subdivision are shown in Table 4.

	1	4
Model scenario	Base scenario	Off-site basins developed, dry conditions
Peak inflow (cfs)	588	596
Peak outflow (cfs)	335	317
Peak storage (ac-ft)	8	7

Table 4: Model results for Broadmoor Heights Subdivision pond (Cuesta Pond).

Comparison of Model Results for Undeveloped Areas

Table 5 shows a comparison of model results for a hypothetical 1-square mile undeveloped basin for land treatment types A, B and C (yellow) and corresponding dry (orange) and wet (blue) curve numbers. Please not that different design storms were used, since this analysis intends to explore the cumulative impact of the proposed new drainage guidance. The comparison show that dry conditions curve numbers result in similar runoff volumes, but much lower peak discharges. Wet conditions curve numbers yield similar (slightly lower) peak flows, but higher runoff volumes.

Design Storm	SSCAFCA 2010		Frequ	Frequency Storm			Frequ	ency Storn	n
Treatment Type	Peak Discharge (cfs)	Runoff (in)	CN (dry conditions)	Peak Discharge (cfs)	Runoff (in)		CN (wet conditions)	Peak Discharge (cfs)	Runoff (in)
А	568	0.50	71	338	0.70		77	511	1.00
В	789	0.72	74	420	0.85		80	615	1.18
С	1057	1.05	78	545	1.06		86	851	1.58

 Table 5: Comparison of model results for a hypothetical 1-mi² undeveloped basin.

Conclusions

The analysis shows that model scenario 4 (developed, dry conditions) yields results that most closely resemble the existing SSCAFCA drainage guidance. The largest discrepancies exit for undeveloped areas: if dry conditions curve numbers are assumed, resulting peak flows are substantially lower compared to existing methods. For offsite basins that are anticipated to remain undeveloped, sensitivity analysis including wet conditions runoff should be performed.

References

Caffrey A.Q. (2019). "Drainage Master Plan for Broadmoor Heights Subdivision." Bohannan Huston Inc. Albuquerque, New Mexico.

Hughes J.D. (2014). "Stonegate Subdivision Drainage Design Analysis Report Volumes 1 and 2." Mark Goodwin and Associates, Albuquerque, New Mexico.

Schoener, G. and Stone, M.C. (2019). "Impact of Antecedent Soil Moisture on Runoff from a Semiarid Catchment." Journal of Hydrology, 569, 627-636. Doi: 10.1016/j.jhydrol.2018.12.025.

SSCAFCA (Southern Sandoval County Arroyo Flood Control Authority). (2010). "Final Development Process Manual for Southern Sandoval County Arroyo Flood Control Authority and the City of Rio Rancho." Rio Rancho, NM.

SSCAFCA (Southern Sandoval County Arroyo Flood Control Authority). (2019a). "SSCAFCA Hydrology Manual DRAFT." Rio Rancho, NM.

SSCAFCA (Southern Sandoval County Arroyo Flood Control Authority). (2019b). "DRAFT Montoyas Watershed Park Conservation Plan." Rio Rancho, NM.

Guide to Texture by Feel



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Soil Textural Triangle

Summary of review comments and responses, SSCAFCA's Draft Hydrology Manual

No.	Page Reference	Comment	SSCAFCA Response
1	Draft Manual, pg. 6-9	Assumptions for unconnected impervious surfaces – is it reasonable to assume they will remain unconnected (example – if a roof area originally drains onto pervious landscaping, but gutter is later put in and the area now drains onto the road)?	A table listing major sources of urban imperviousness and recommended percentages of DCIA and UIA has been included in the manual (Table 2). Based on comment 1, it is recommended to model 50% of roof areas (i.e. the portion of the roof draining towards the road) as DICA. This value can be adjusted based on site-specific conditions with appropriate justification.
2		Why not use national guidance for the curve number method? Why local guidance necessary?	SSCAFCA's work has shown that local/regional guidance is beneficial because national guidance incudes a wide range of conditions, many of which are not appropriate for use in SSCAFCA's jurisdiction. By providing more site-specific guidance, overall uncertainty of model results can be reduced.
3		Proposed changes are based on measured data. Will procedures be change again when more data becomes available?	SSCAFCA continually strives to improve hydrology methods and will continue to do so in the future; it is therefore possible that guidance and methods will be updated as new information becomes available. Nevertheless, SSCAFCA will not change procedures unless it can be demonstrated that new methods are more accurate.

4	Proposed changes are based only ten years of data and one watershed. Is this representative of the area and of the range of storms, especially large magnitude storms?	 Update guidance is based on a number of studies, including: A paper assessing the impact of different modeling approaches for impervious surfaces in a 0.6 mi² urban basin located in the City of Rio Rancho (Schoener 2017) Rainfall simulator tests carried out on different soils throughout SSCAFCA's jurisdictional area to quantify infiltration and runoff under controlled conditions (see Schoener and Stone 2019) A calibrated hydrologic model of the 1.1 mi² Arroyo 19A watershed on Albuquerque's west side; the entire basin is in its natural state. Hydrologic analysis was based on 20 years of rainfall-runoff data (1992-2013) collected by the U.S Geological Survey (see Schoener and Stone 2019) A detailed hydrologic study of the 61 mi² Montoyas watershed; the underlying model was calibrated and validated using 13 storm events that occurred between 2008 and 2018. Both the model and associated documentation were reviewed by the US Army Corps of Engineers Albuquerque District (see Appendix B) While it would be beneficial to have a longer period of record, several storms in the Montoyas and Arroyo 19A watersheds had large recurrence intervals and thus allow conclusions relating to large magnitude storms. Rainfall simulator test were also designed to mimic cumulative precipitation depths similar to the 100-year 24-hour storm in SSCAFCA's jurisdiction (approximately 3 inches).

5		If expected changes are small, why switch to a new method?	We have demonstrated that the proposed method reduces uncertainty (see Appendix B); it is also easier to use and review.
6	Draft Manual, pg. 6	The largest losses in small storm volumes may actually be attributed to initial abstraction rather than infiltration.	The initial abstraction term includes interception, infiltration during early parts of the storm, and surface depression storage. These mechanisms have been included in the text of the revised manual.
7	Draft Manual, pg. 7	Homogeneity in basin characteristics can include more than just land uses.	Soil texture, subbasin size, basin shape and predominant land slope have been added as additional criteria to evaluate homogeneity.
8	Draft Manual, pg. 7	TR 55 adjustments for impervious across pervious? Weighted Runoff not Weighted Area for rainfall < 3".	Please see response to comment 17 below.
9	Draft Manual, pg. 8	"All DCIA shall be modeled in HEC-HMS as Percent Impervious" - This overstates the runoff from the smallest runoff producing storms by a large margin.	Research conducted by SSCAFCA has demonstrated that this approach works well and does not substantially overestimate runoff from small storms. Please see also response to comment 16 below.

10	Draft Manual, pg. 10	If the probability of the design storm occurring on wet soil is less than 1.0 and we assume wet conditions, what is the probability of the resulting runoff event?	This is a valid question, and one that will require more analysis in the future. The NOAA precipitation statistics currently used to define the design storm are blind to antecedent rainfall. It is therefore not clear what the implicit assumptions regarding soil moisture conditions at the onset of a storm event are. The revised manual contains a brief discussion relating to the impact of antecedent moisture conditions on runoff in general. This is only one source of curve number variability. Other sources include rainfall intensity and duration, cumulative precipitation, and local variations in soil and cover type. The range of CN 70-80 reflects overall variability; specific guidance provided in Tables 3 and 4 can be interpreted as intermediate conditions that are appropriate for most analyses.
11	Draft Manual, pg. 12	Was bulking included in the model calibrations?	Yes, sediment bulking factors were included as flow ratios for each subbasin element.
12	Draft Manual Appendix B, pg. B-8	Why ModClark rather than NRCS Unit Graph?	Gridded rainfall can only be implemented with the ModClark model in HEC-HMS (see also response to comment 29 below). Since it was necessary to use gridded rainfall to account for spatial and temporal dynamics of storms used for model calibration, the ModClark transform was the only viable choice.
13	Draft Manual Appendix B, pg. B-8	Were measured runoff values adjusted for sediment bulking?	No, but sediment bulking was included in the calibration model at the subbasin level (see also response to comment 11 above).
14	Draft Manual Appendix B, pg. B-9	Probability of wet/wet, dry/dry, wet/dry and dry/wet days can be calculated. This is a joint probability issue.	Please see response to comment 10 above.

15	Draft Manual Appendix B, pg. B-28	This is true but what is the joint probability of the 100 yr storm occurring on wet soils?	Please see response to comment 10 above.
16	Draft Manual, pg. 6	Use the split hydrograph method: An approach in dealing with directly connected imperviousness is the "Split Hydrograph" method. In this method, the basin area is split into directly connected impervious and composite, non-directly connected pervious and lawns and landscaped areas, where the impervious area within that portion of the basin sheet flows across pervious areas. This is particularly applicable in single family residential areas where a majority of the roofs drain to back yards, lawn or xeric landscaped areas. Two separate hydrographs are computed for each subbasin using the same Tc with the total area of the two being equal to the total subbasin drainage area. The two hydrograph for the subbasin. The result will be a hydrograph that demonstrates the rapid response of the directly connected impervious areas as well as a more accurate response to small, frequent rainfall events for the purposes of water quality protection BMP design. This approach also accounts for the significant losses that occur as runoff from non-directly connected impervious areas.	SSCAFCA's proposed method uses the split hydrograph approach. A clarifying statement has been added to the draft manual. By specifying directly connected impervious areas (DCIA) as <i>% Impervious</i> in HEC-HMS, the model computes a separate hydrograph for the portion of each subbasin specified as <i>% Impervious</i> . Unconnected impervious areas (UIA) are included in the composite curve number calculation; thus, losses from UIA are accounted for. A SSCAFCA case study ¹ demonstrated that this approach yields reasonable results for small storm events. The approach is also easy to implement in HEC-HMS.

¹ Schoener, G. (2017). "Urban Runoff in the U.S. Southwest: Importance of Impervious Surfaces for Small-Storm Hydrology." J. Hydrol. Eng. 23(2)

			After careful consideration, the area-weighted method
			reasons:
17	Draft Manual, pg. 9	Use of runoff weighted method vs. area weighted method for determination of composite curve numbers	 The differences between the two methods become larger as the difference between curve numbers for individual soil-cover complexes within a subbasin increases. The range of curve numbers recommended in this manual is much narrower compared to national guidance. If subbasins are delineated appropriately (e.g. large open space areas and residential subdivisions are not lumped together in the same subbasin), CN values within subbasins are not expected to differ by more than 10 in most cases. DCIA is modeled as % impervious is HEC-HMS and not included in the composite CN calculation (see also response to comment 16 above). This further reduces the CN discrepancy within a subbasin compared to an approach where impervious areas are assigned a CN=98 and not modeled using the split hydrograph method. The exception to (2) are UIA, which are included in the composite curve number calculation with a CN=98; this approach was developed using the weighted area method and validated based on measured rainfall-runoff data. The runoff-weighted method is more difficult to implement, particularly in subbasins with many soil-cover complexes.

SSCAFCA Hydrology Manual - Appendix E

18	Draft Manual, pg. 6-9	How will DCIA vs. UIA be determined? The noted differences are important, but how will a modeler determine DCIA vs UIA? Some guidance on using areal imagery (Google Earth), land use data (NLCD), or a standard fraction of impervious area as DCIA vs UIA for the region might be beneficial. The appendices discuss how "major sources" of DCIA were "digitized manually", but some specific guidance in the manual would be helpful.	A new paragraph has been added to the manual describing how DCIA and UIA should be delineated, along with a table (Table 2) listing major sources of urban imperviousness and recommended percentages of DCIA and UIA.
19	Draft Manual, pg. 10	Why are dry conditions assumed for planning and design of road drainage and subdivision ponds? Dry conditions produce less flow than wet, as stated in the manual. Are the dry conditions conservative enough for urbanized areas? The manual discusses pretty big CN differences for dry (64) and wet (80) conditions. Wet condition CNs are recommended for natural offsite basins. Some of these inconsistencies between wet vs. dry antecedent soil conditions and urbanized vs. natural land uses could be explained.	When curve numbers are calculated from measured rainfall-runoff data, they vary based on a number of factors including rainfall intensity and duration, cumulative precipitation, soil moisture conditions, and local variations in soil and cover type. In the original draft of the hydrology manual, variability was mainly attributed to antecedent moisture conditions. While soil moisture <u>is</u> an important factor in SSCAFCA's jurisdiction, it is difficult to attribute overall CN variability to the impact of soil moisture alone. Language in the revised manual has been changed to reflect different sources of variability. The range of CN values 70-80 reflects overall variability; specific guidance provided in Tables 3 and 4 can be interpreted as intermediate conditions and are appropriate for most analyses.

20	Draft Manual, pg. 10	Have you consulted Ch. 15 Time of Concentration from the National Engineering Handbook Part 630 Hydrology (2010) related to referencing TR-55 (1986)? It includes everything from TR-55 and a more empirical method for estimating Time of Concentration. TR-55 only includes the "Velocity Method" for TOC while Ch. 15 includes the "Velocity" and "Watershed Lag" Methods. If there is sufficient data, a modeler could compute TOC using both methods and choose the quicker time for a larger flow and more conservative estimate.	The transform section of the manual has been updated, and chapter 15 of the National Engineering handbook has been included as the reference for estimating time of concentration.
21	Draft Manual, pg. 13	Elevation-area and elevation-discharge curves are an option if storage data is not available or unreliable due to changing pond morphology. If storage capacity decreases over time because the pond is filling with sediment, measuring discharges and surface areas at different elevations might be more straight forward and easier to update than computing storage.	The elevation-area-discharge method has been added under the pond routing section.
22	Draft Manual, pg. 4	Storm Area - consider providing more information about the storm-area reduction factor as to its intent and effect on watershed hydrology analysis. One of our engineers attended a HEC Workshop and their advice was not to use area reduction for areas less than 10 sq. mi.	A paragraph discussing depth-area reduction has been added to the revised manual. The threshold of 10 mi ² has been adopted and justified with appropriate references.

23	Draft Manual, pg. 4	Point-Duration-Depth. Instead of stating "Centroid of contributing basin", consider stating the centroid of all contributing basins for clarification. Also consider providing some guidance on size of offsite basins to be used in subdivision level hydrology models. For example, having one basin for all offsite lows could result in lower flows. Modeling a contributing area of 8 sq. mi. might result in a lower cfs per sq. mi. than if the contributing area were broken into smaller size subbasins.	The recommended change has been incorporated in the revised document.
24	Draft Manual, pg. 7	The range of Curve Numbers of open space is quite large - 70 to 80. Consider providing some guidance to provide some granularity to the range. For example, perhaps divide the range to a smaller spacing based on slope and percent ground cover. Could help in justifying the number and make the review process a bit easier.	More detailed guidance for curve number selection based on soil texture and ground cover has been included in the updated manual (see Table 4), along with methods of how texture can be evaluated in the field.

25	Draft Manual, pg. 8	In general a proposed subdivision is mass graded by the developer prior to infrastructure and house construction. It is difficult to cover all cases here. By doing a very quick review of front lots it seems about 20-30% of front lots have grass and the other 70-80% have xeriscape. I think it is best to assume that the xeriscape is put in with impervious plastic. The backlots are a mixture of grass and earth with very few having xeriscape. In general, the backyard of lots are left up to the homeowner to put in landscaping. Perhaps too fine a detail for your model, but I would assume that the back lots would have a lower CN than the front lots and in addition, the slope on the back lots are normally fairly low which also tend to indicate a lower CN. Front lots might best fitunder your Compacted category using the 86. The back lot is difficult, but it might be assigned a CN of 80. It also seems that your guide of using a dry AMC for subdivision would apply only to the "Natural Areas or Landscaping put in bythe developer for trails and in road rights-of-way? I would assume natural areas would then be areas that are untouched by development?	Following this recommendation, more specific guidance on curve number selection has been included in the revised manual (see Tables 3 and 4).
26	Draft Manual, pg. 9	Page 9 of OHM has a curve number of 76 for open space - how is that determined? Explain along with consideration of No. 3 might help.	Additional guidance has been added (see also response to comment 24 above).

27	Draft Manual, pg. 10	Under Antecedent Moisture Conditions - "Dry conditions can be assumed for planning and design of road drainage and subdivision ponds." Does this mean that the hydrologic analysis for a subdivision should assume dry conditions? Farther down you also state that offsite basins that are developed should use dry antecedent moisture conditions.	Additional clarification regarding this issue has been included in the revised manual. See response to comment 19 above for details.
28	Draft Manual, pg. 12	It is my experience that the range of .02025 is too low for sandy bottom arroyos in some situations. You do refer to the Sediment Design Guide. My experience is using the procedure in the Sediment Design Guide will generate a Manning's N number greater than .025. Perhaps increasing the range to 0.035 as an upper limit as shown in Appendix A. In high slope route conditions for example, I have checked to ensure the flow is in the range of critical depth to ensure against high supercritical velocities.	We agree with this comment, this was an error in the draft manual. The range of recommended n-values for sandy bottom arroyos has been increased (n = 0.020 - 0.035).

			The hydrologic model for the Montoyas watershed (see
			Appendix B) was developed using the Modified Clark
			unit hydrograph (UH) method because gridded rainfall
			can only be implemented with this transform in HEC-
			HMS. Since it was necessary to use gridded rainfall to
			account for spatial and temporal dynamics of storms
			used for model calibration, the ModClark transform was
			the only viable choice. SSCAFCA's hydrology guidance
			specifies a different transform, the SCS UH. The main
			reasons for this decision are (1) consistency with the
			curve number method, and (2) for simplicity, since the
29	Draft Manual Appendix B	Calibration performed using modified Clark but	SCS UH only requires estimation of one parameter (lag
			time), while the Modified Clark UH has two parameters
		the new Drainage Hydrology Manual uses SCS for	– time of concentration (T _c) and storage coefficient (R).
		the transform. It would be helpful to provide	Little guidance exists on how to estimate the latter,
		information on how the two relate. For example, providing perhaps a percent difference between	which leads to increased model uncertainty if no
			calibration data is available.
		the peak flow and runoff volume between the	
		two methods.	During development of the Montoyas model, ModClark
			model parameters were calibrated based on measured
			data. A direct comparison with the SCS UH model is
			therefore impossible; lag times cannot be calibrated,
			because the SCS UH can't be used with gridded rainfall.
			Since the UH method only affect the shape of runoff
			hydrographs, runoff volumes are expected be identical
			regardless of which transform is used. Transform
			parameters can have a substantial impact of peak
			discharge. In the absence of calibration data, the simpler
			SCS UH method along with published guidance for
			estimating lag times should be used.

30	Draft Manual Appendix B	In 2.6 Design Storm Results -you have found a best fit for CN of 74 from your calibration. I assume the 74 is only applied when doing watershed modeling? Could it be applied to a subdivision level when assuming dry AMC for "Natural Areas or Landscaping" and back lots?	Please see response to comment 25 above.
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