Interagency Flood Risk Management (InFRM)

Watershed Hydrology Assessment for the Nueces River Basin

Appendix C - Elliptical Frequency Storms in HEC-HMS

March 2025

InFRM
INTERAGENCY FLOOD RISK MANAGEMENT

Table of Contents

1 Elliptical Frequency Storms in HEC-HMS

1.1 INTRODUCTION TO ELLIPTICAL STORMS

Observations of actual storm events show that average precipitation intensity decreases as the area of a storm increases. The uniform rainfall method results (documented in a separate appendix) use the depth-area analysis in HEC-HMS to produce frequency peak flow estimates (Version 4.10; USACE, 2022). The depth-area analysis in HEC-HMS applies the appropriate depth-area reduction factor to the given point rainfall depths based on the drainage area at a given evaluation point, which are derived from the published depth-area reduction factors from Figure 15 of the National Weather Service TP-40 publication (Hershfield, 1961), as shown in the figure below.

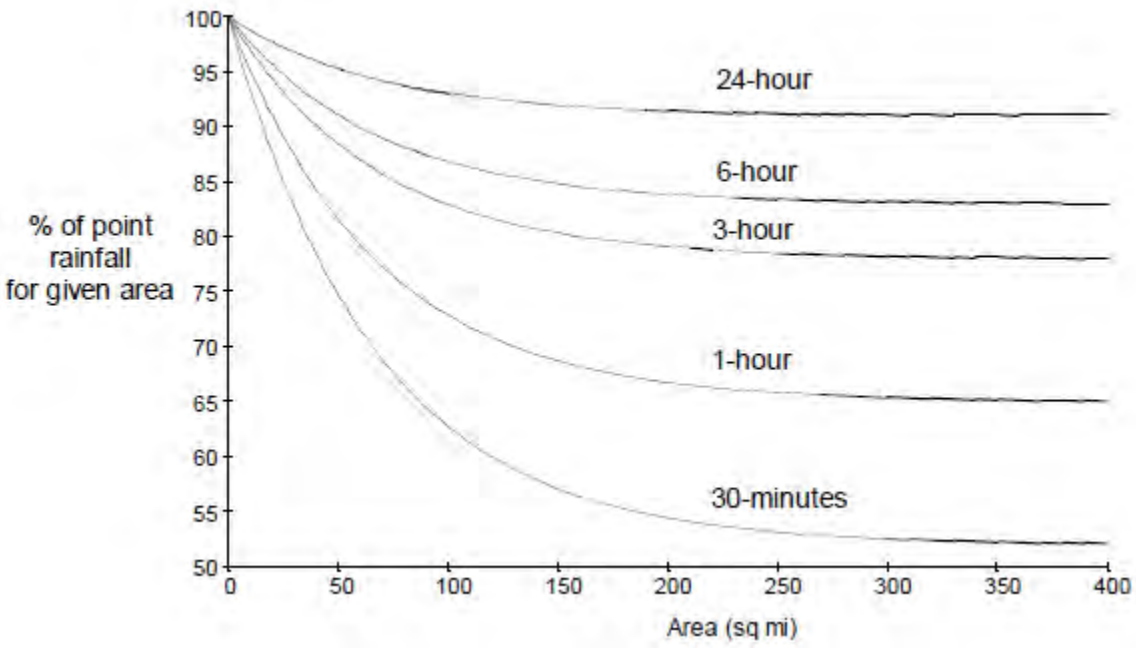

Figure C.1: Published Depth-Area Reduction Curves from TP-40

When evaluating a stream location with a drainage area greater than 400 square miles, the HEC-HMS software issues a warning that the NWS depth-area reduction factors do not support storms beyond 400 square miles, as seen in the figure above. The program will still calculate the peak discharge, but the warning implies that the calculated volume of the storm may be overestimated for larger drainage areas.

Since the Nueces hydrology study involves calculating frequency discharges for points with over 10,000 square miles of drainage area, the InFRM team developed elliptical frequency storms for gage points and junctions with drainage areas greater than 400 square miles. In these elliptical frequency storms, the same point rainfall depths and durations were applied as in the uniform rainfall method, but the spatial distribution of the rainfall varied in an elliptical shaped pattern with higher rainfall amounts in the center of the ellipse and lesser amounts towards the outer fringes.

Elliptical shaped storms have been used in a variety of hypothetical design applications, including the Probable Maximum Precipitation (PMP) storms from Hydrometeorological Report No 52 (HMR 52) (Hansen, 1982). The elliptical frequency storms constructed for this study are similar to those of HMR 52 in that concentric ellipses are used to construct the storm's spatial pattern, and the storm's location is optimized over the watershed by identifying

the storm center location and the angle of its major axis that led to a maximum peak flow at a downstream junction of interest. Figure C.2 shows an example of an elliptical 1% annual exceedance probability (100-yr) storm that was optimized over the watershed above the Nueces River Rockland, TX USGS gage. This particular junction has a contributing drainage area of almost 3,600 square miles.

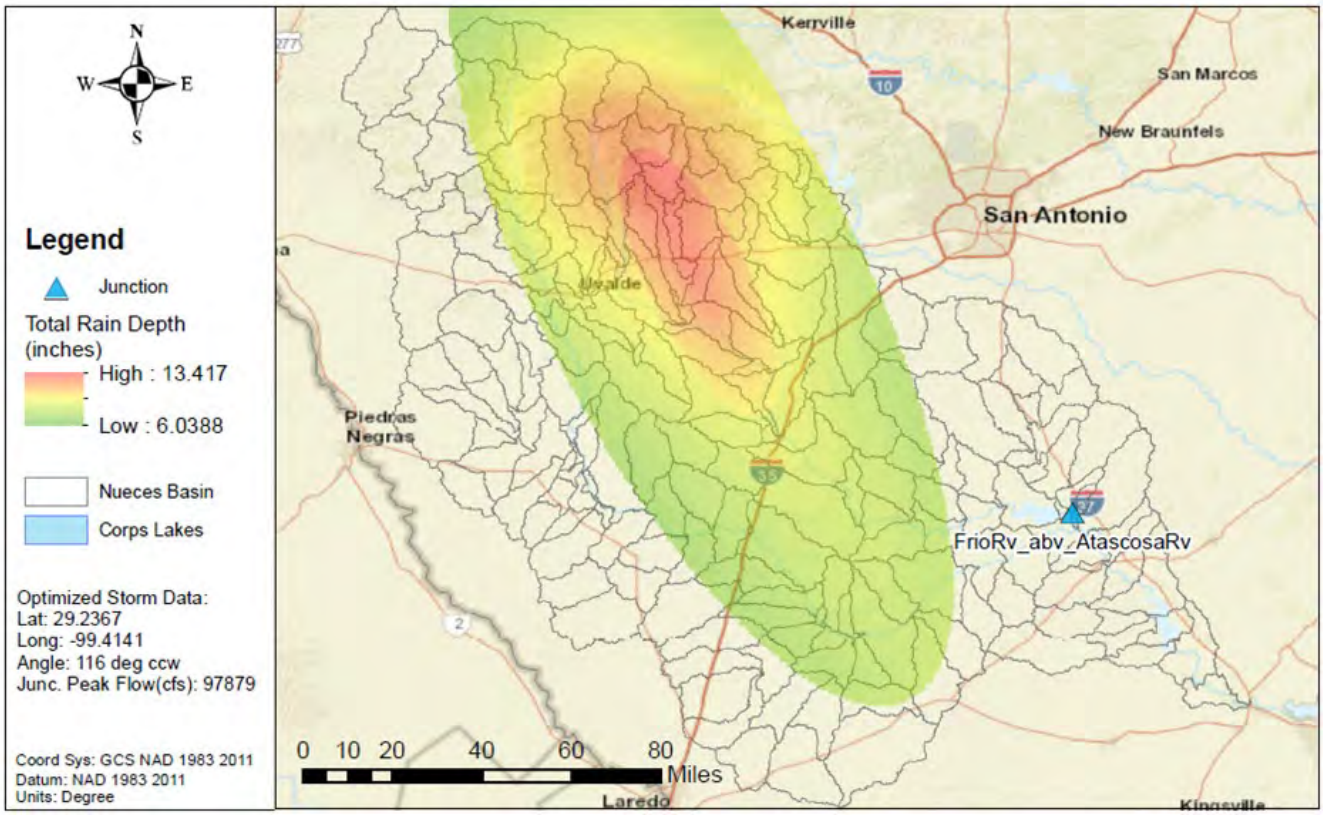

Figure C.2: Example 1% AEP (100-yr) Elliptical Frequency Storm

1.2 ELLIPTICAL STORM PARAMETERS AND METHODOLOGY

The elliptical storm parameters covered below in sections 1.2.1 through 1.2.5 are applicable to the entire Nueces Basin. Unique, optimized elliptical storm configurations were developed for 76 different junction elements within the Nueces HEC-HMS model, 15 of which were USGS stream gage locations.

When comparing the upper reaches of the Nueces Basin with the middle and downstream portions closer to the Gulf of Mexico, the meteorology is noticeably different as demonstrated below in Figure C.3. The meteorological distinctions across the Nueces Riber basin were addressed in the sampling of the point precipitation depths and in the development of the depth-area-reduction curves (covered in depth in sections 1.2.3 and 1.2.4, respectively).

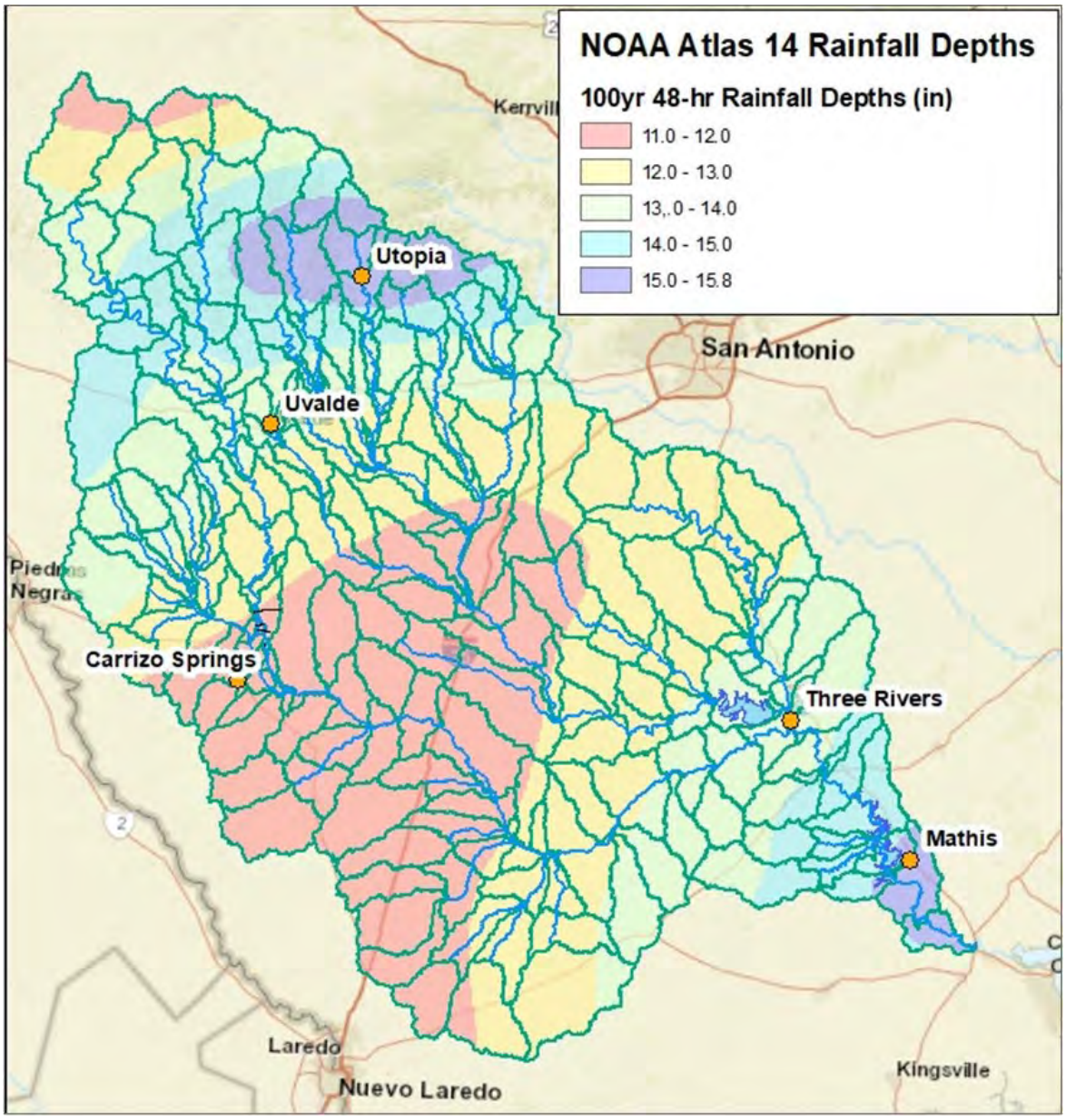

Figure C.3: NOAA Atlas 14 100-yr 48-hr Precipitation Gradient – Nueces Basin

1.2.1 Elliptical Storm Area

This study uses a storm extent of 10,000 square miles. This is due, in part, to historical rainfall studies rarely including data beyond 10,000 square miles (USACE, 1945). However, many of the more recent, historic storm events analyzed in southeast Texas for this study did extend to 10,000 square miles and beyond in coverage. While this storm extent is somewhat arbitrary, testing was done in previous InFRM studies to limit the storm extent to 3,000 square miles or increase it to 20,000 square miles and the resulting peak discharges were only slightly altered. This is likely because the most intense portion of the storm, which drives the peak discharges on the rivers, occurs within the central 1,000 square miles of the storm. Therefore, even though the drainage area of the Nueces River study area is over 17,000 square miles, a 10,000 square mile storm area was adopted as it produced reasonable and realistic results compared to observed storms.

1.2.2 Storm Ellipse Ratio

The HMR-52 study presents the option to design a storm with a major: minor ellipse axis ratio ranging from 2:1 to 3:1. For the final results in the Lower Nueces River basin, a 2.5:1 ellipse was used, as it matched well with the general shape of the Nueces basin. Ellipse ratios of 3:1 and 2:1 were tested in previous InFRM studies, and they showed only nominal differences in regard to optimized storm centerings, storm orientations, and resulting peak flows when compared to the results obtained from using a 2.5:1 ellipse.

1.2.3 Elliptical Storm Rainfall Depths

Elliptical storms were designed for each of the following annual exceedance probabilities (AEP): 1 in 2 years, 1 in 5 years, 1 in 10 years, 1 in 25 years, 1 in 50 years, 1 in 100 years, 1 in 200 years and 1 in 500 years. Point rainfall depths and durations were applied directly from NOAA Atlas 14 Volume 11 which contains depth duration frequency estimates of precipitation for the state of Texas (NOAA, 2018). The point precipitation values that were applied to each elliptical storm were based on the storm's optimized location, not the location of the outlet of interest. It is important to note that out of all the design storm parameters that are discussed here, peak flows were most sensitive to adjustments in the NOAA Atlas 14 point frequency depths.

For the Nueces basin, since the precipitation gradient varies significantly across the basin, all of the precipitation depths that fell under the 10,000 sq mi elliptical storm positioning were queried instead of just the one depth at the storm center. Then all of the queried precipitation depths were reduced based on which of the concentric, DAR ellipses they overlapped with (demonstrated in Figure C-8). In regions where the precipitation depths vary greatly over a short distance, this method performs better since the precipitation gradient is reflected in the makeup of the elliptical storm.

1.2.4 Storm Depth Area Reduction (DAR) Factors

The Texas Storm Study (TSS) was completed during the Nueces InFRM WHA and represented a historic breakthrough in DAR factor research. The project analyzed nearly 20,000 storms and measured the DAR curves for each storm. Through analysis of storms and regional weather patterns, the study developed 3 zones that had similar DAR curve characteristics. From the Texas Storm Study, the appropriate DAR curves zone for the Nueces Basin is the Eastern Zone. See Figure C.4 below.

Note: the Texas Storm Study refers to Depth-Area-Reduction Factors as DARFs but this report will continue to use DAR Curves or DAR factors to be consistent with prior InFRM WHA Studies. There are a few terms used throughout literature on the subject and a few different ways the data can be collected and applied. The Texas Storm Study performed a literature review of the subject and for more information, see the Texas Storm Study on the InFRM Website. https://webapps.usgs.gov/infrm/

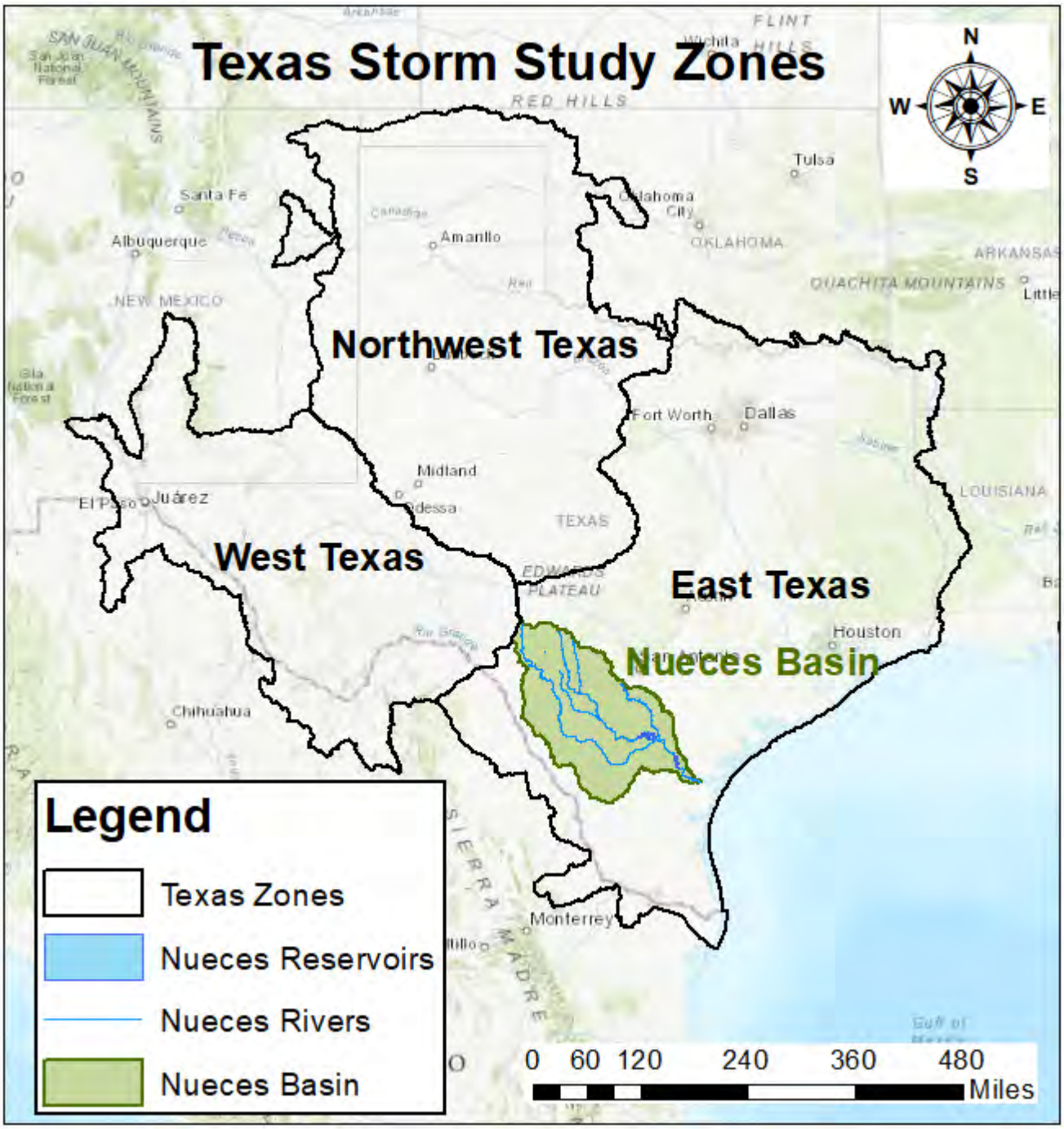

Figure C.4: Texas Storm Study DAR Factor Zones and the Nueces Basin

The Texas Storm Study found a general relationship between Storm Return Period and DAR curves – the more intense the storm, i.e., the longer the return period, the faster the DAR curve reduces at larger areas. The TSS developed DAR curves for 3 ranges of Return Periods, 2-yr to 50-yr, 50-yr, to 200-yr, and greater than 200-yr. For this study, the 2-yr, 5-yr, 10-yr, and 25-yr elliptical storms utilized the '2-yr to 50-yr' DAR curves, the 50-yr, and 100-yr elliptical storms utilized the '50-yr to 200-yr' DAR curves, and the 200-yr to 500-yr elliptical storm utilized the 'greater than 200-yr' DAR curves.

The TSS also developed DAR curves for many storm durations and for areas up to 10,000 square miles. The study provided recommended DAR curves for 1-hr, 2-hr, 3-hr, 6-hr, 12-hr, 24-hr, and 48-hr durations in the East Texas Zone as seen in Figure C.5.

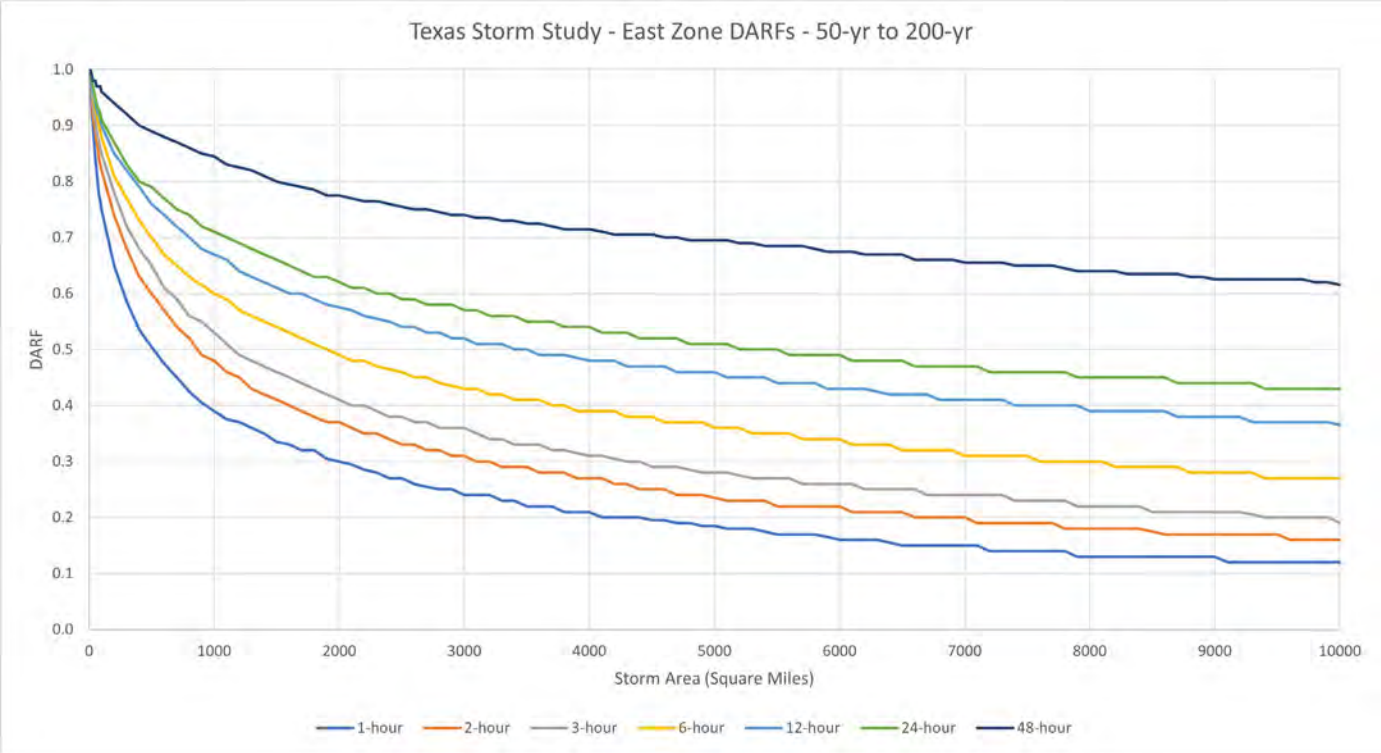

Figure C.5: Texas Storm Study DAR Factors for the East Texas Zone

The InFRM WHA team utilized all 7 duration DAR factors for each elliptical storm, creating a dynamic storm that emulates an intense storm observed in nature. A total of 21 DAR factor relationships were used, all 7 durations for all 3 return period groups.

Table 7.1: East Texas Zone DAR Factors for Return Periods 2-Yr to 50-Yr

East Texas Zone DARFs							
Area (Sq. Mi.)	2-Yr to 50-yr Return Period						
	1-Hr	2-Hr	3-Hr	6-Hr	12-Hr	24-Hr	48-Hr
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	0.98	0.98	0.98	0.99	0.99	0.99	1.00
100	0.81	0.84	0.86	0.88	0.91	0.94	0.96
200	0.73	0.77	0.79	0.83	0.87	0.91	0.94
300	0.67	0.72	0.74	0.79	0.84	0.88	0.92
400	0.63	0.68	0.71	0.76	0.81	0.86	0.90
500	0.60	0.65	0.68	0.74	0.79	0.85	0.89
600	0.57	0.62	0.66	0.72	0.78	0.84	0.88
700	0.54	0.60	0.64	0.70	0.76	0.82	0.87
800	0.52	0.58	0.62	0.68	0.75	0.81	0.87
900	0.50	0.57	0.60	0.67	0.74	0.80	0.86
1,000	0.49	0.55	0.59	0.65	0.73	0.80	0.85
2,000	0.37	0.44	0.48	0.57	0.65	0.73	0.81
3,000	0.31	0.38	0.42	0.51	0.60	0.69	0.78
4,000	0.27	0.34	0.38	0.47	0.57	0.66	0.75
5,000	0.24	0.30	0.35	0.44	0.54	0.64	0.74
6,000	0.22	0.28	0.32	0.41	0.52	0.62	0.72
7,000	0.20	0.26	0.30	0.39	0.50	0.60	0.70
8,000	0.19	0.24	0.28	0.37	0.48	0.59	0.69
9,000	0.18	0.23	0.27	0.36	0.46	0.57	0.68
10,000	0.17	0.22	0.26	0.34	0.45	0.56	0.67

Table 7.2: East Texas Zone DAR Factors for Return Periods 50-Yr to 200-Yr

East Texas Zone DARFs							
Area (Sq. Mi.)	50-Yr to 200-yr Return Period						
	1-Hr	2-Hr	3-Hr	6-Hr	12-Hr	24-Hr	48-Hr
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	0.98	0.98	0.98	0.99	0.99	0.99	1.00
100	0.81	0.82	0.85	0.88	0.90	0.91	0.96
200	0.73	0.74	0.78	0.81	0.85	0.87	0.94
300	0.67	0.68	0.72	0.77	0.82	0.83	0.92
400	0.63	0.63	0.68	0.73	0.79	0.80	0.90
500	0.60	0.60	0.65	0.70	0.76	0.79	0.89
600	0.57	0.57	0.61	0.67	0.74	0.77	0.88
700	0.54	0.54	0.59	0.65	0.72	0.75	0.87
800	0.52	0.52	0.56	0.63	0.70	0.74	0.86
900	0.50	0.49	0.55	0.62	0.68	0.72	0.85
1,000	0.49	0.48	0.53	0.60	0.67	0.71	0.85
2,000	0.37	0.37	0.41	0.49	0.58	0.62	0.78
3,000	0.31	0.31	0.36	0.43	0.52	0.57	0.74
4,000	0.27	0.27	0.31	0.39	0.48	0.54	0.72
5,000	0.24	0.24	0.28	0.36	0.46	0.51	0.70
6,000	0.22	0.22	0.26	0.34	0.43	0.49	0.68
7,000	0.20	0.20	0.24	0.31	0.41	0.47	0.66
8,000	0.19	0.18	0.22	0.30	0.39	0.45	0.64
9,000	0.18	0.17	0.21	0.28	0.38	0.44	0.63
10,000	0.17	0.16	0.19	0.27	0.37	0.43	0.62

Table 7.3: East Texas Zone DAR Factors for Return Periods Greater than 200-Yr

East Texas Zone DARFs							
Area (Sq. Mi.)	Greater than 200-Yr Return Period						
	1-Hr	2-Hr	3-Hr	6-Hr	12-Hr	24-Hr	48-Hr
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	0.97	0.97	0.97	0.98	0.99	0.99	1.00
100	0.72	0.77	0.79	0.85	0.87	0.88	0.95
200	0.60	0.67	0.71	0.77	0.82	0.82	0.93
300	0.54	0.59	0.64	0.72	0.78	0.78	0.91
400	0.51	0.54	0.58	0.68	0.75	0.76	0.89
500	0.46	0.51	0.55	0.66	0.72	0.74	0.88
600	0.42	0.48	0.53	0.63	0.70	0.72	0.87
700	0.39	0.46	0.51	0.61	0.68	0.70	0.86
800	0.38	0.44	0.49	0.59	0.66	0.69	0.85
900	0.36	0.42	0.48	0.57	0.64	0.67	0.84
1,000	0.35	0.41	0.46	0.55	0.63	0.66	0.83
2,000	0.25	0.31	0.35	0.44	0.52	0.58	0.77
3,000	0.21	0.25	0.30	0.38	0.46	0.52	0.74
4,000	0.18	0.21	0.26	0.33	0.41	0.47	0.71
5,000	0.16	0.19	0.23	0.30	0.38	0.43	0.69
6,000	0.15	0.17	0.20	0.27	0.36	0.40	0.66
7,000	0.13	0.16	0.19	0.25	0.33	0.38	0.65
8,000	0.12	0.15	0.17	0.23	0.32	0.36	0.63
9,000	0.11	0.14	0.16	0.22	0.30	0.34	0.61
10,000	0.10	0.13	0.15	0.20	0.29	0.33	0.59

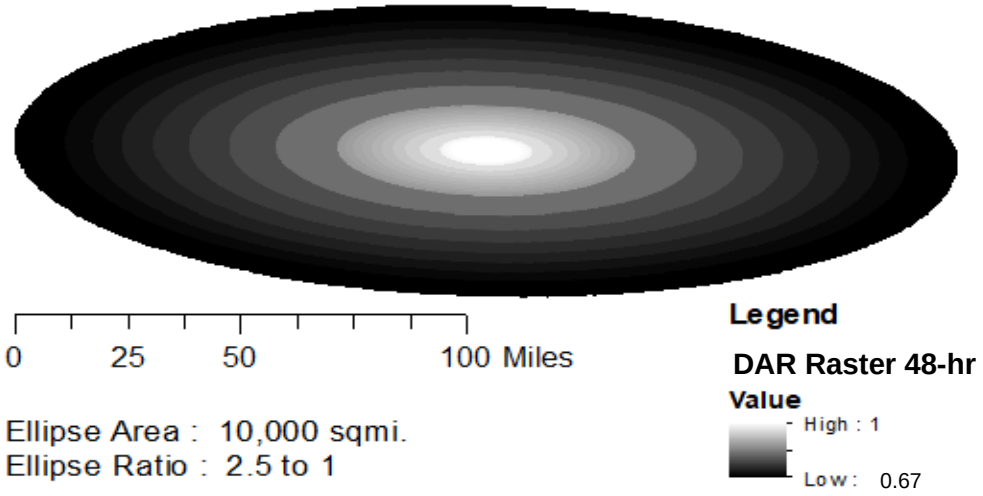

Figure C.6: Adopted Depth-Area-Reduction Rasterized Ellipse for the 48-hr Duration.

1.2.5 Storm Temporal Pattern / Hyetograph

Historically, storms have varied intensities and temporal distributions and many studies have been done to document storm patterns. The six storm temporal distributions that were tested for a previous InFRM study on the Guadalupe Basin are shown in Figure C.7. The Soil Conservation Service (1986) documented different distributions for the United States. Type II is the distribution applicable to Texas; it was included in the testing. Other distributions were also previously tested, including the alternating block Frequency Rainfall temporal distributions from HEC-HMS with the storm centroid occurring at the 25%, 33%, 50%, 67%, and 75% of the total distribution. The HEC-HMS Frequency Rainfall alternating block temporal distributions maintain the appropriate storm intensity for all durations throughout the storm. In other words, the 100 year, 1 hour rainfall depth is maintained within the 100 year, 2 hour rainfall depth and so on all the way through the 100 year, 48 hour rainfall depth. For this Nueces watershed study, a centrally distributed (50%) alternating block temporal distribution was adopted for the final runs.

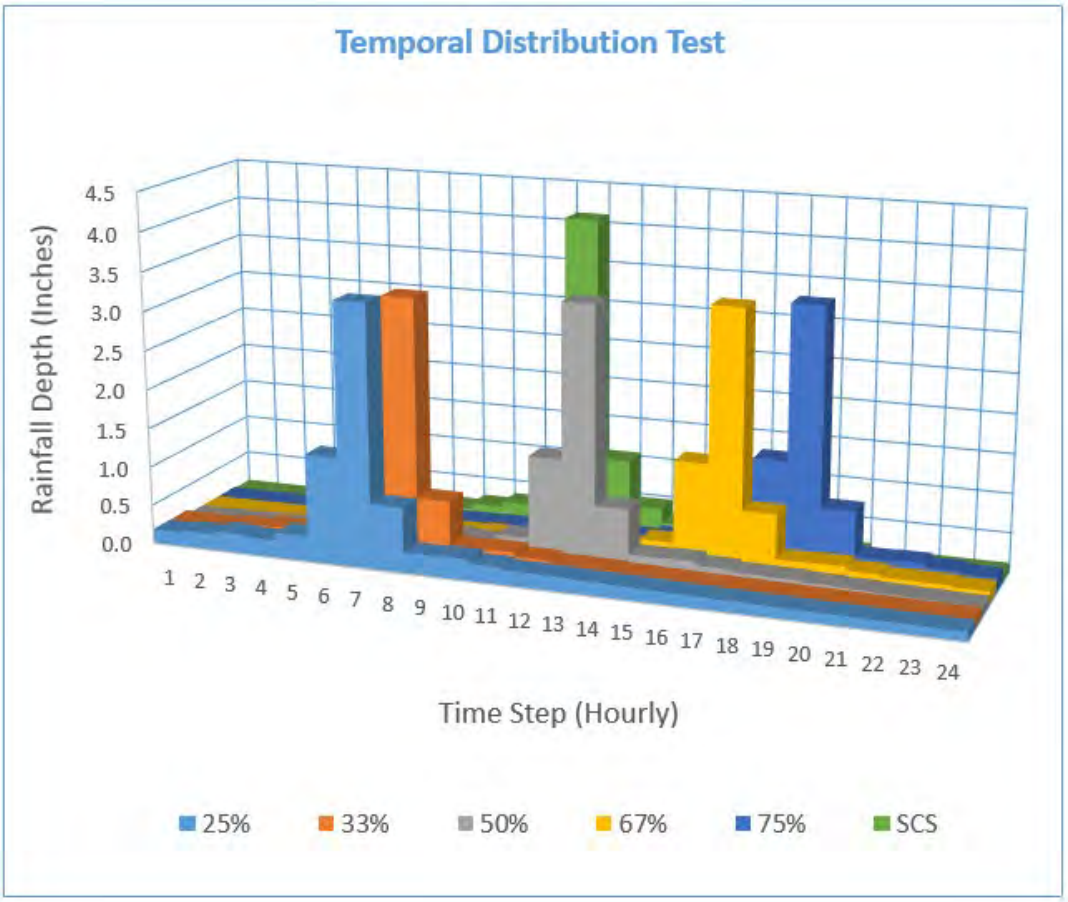

Figure C.7: Previously Tested Storm Temporal Distributions

During the uniform rainfall analysis covered in Appendix B, storm durations ranging from 24 hours to 7 days were tested on the Nueces basin. A duration of 48-hours was ultimately adopted for the uniform rainfall modeling. The 48-hour results yielded slightly higher peak flows when compared to the 24 hour results, but the difference in peak flows tapered off to less than 1% for durations greater than 48-hours. Furthermore, the 48-hour duration also coincides well with the maximum duration of the Texas Storm Study. In order to be consistent with the uniform rain and with the Texas Storm Study, a 48-hour storm duration was adopted for the elliptical storm modeling on the Nueces.

1.2.6 Geospatial Process for Building the Elliptical Storms

For this Nueces InFRM Watershed Hydrology Assessment, a previously developed geospatial method was utilized for creating the rainfall hyetographs that were used as input into the Nueces design storm HEC-HMS model. This new method is built on three principal sources of geospatial data: 1) NOAA Atlas 14 precipitation frequency raster data in asci format for the 1, 2, 3, 6, 12, 24, and 48-hour durations, 2) rasterized DAR ellipses that are built off of the adopted DAR curves for each of these durations, and 3) a HEC-HMS subbasin delineated shapefile. For each unique storm location and orientation within the Nueces basin, the underlying precipitation data is queried and multiplied by the appropriate rasterized DAR ellipse to get the reduced precipitation for each duration (Figure C.8). Then zonal statistics are calculated to determine the average reduced precipitation for each subbasin. Using the subbasin-averaged reduced precipitation for the 1, 2, 3, 6, 12, 24, and 48-hour durations, the alternating block method is used to build rainfall hyetographs for each of the subbasins within the design storm HEC-HMS model. The geospatial algorithm employed builds the storm from the central, maximum intensity duration outwards so that the appropriate storm intensity is maintained throughout the entire storm. For example, the 100 year 1 hour rainfall is maintained within the 100 year 2 hour rainfall and so forth all the way out to 48-hours.

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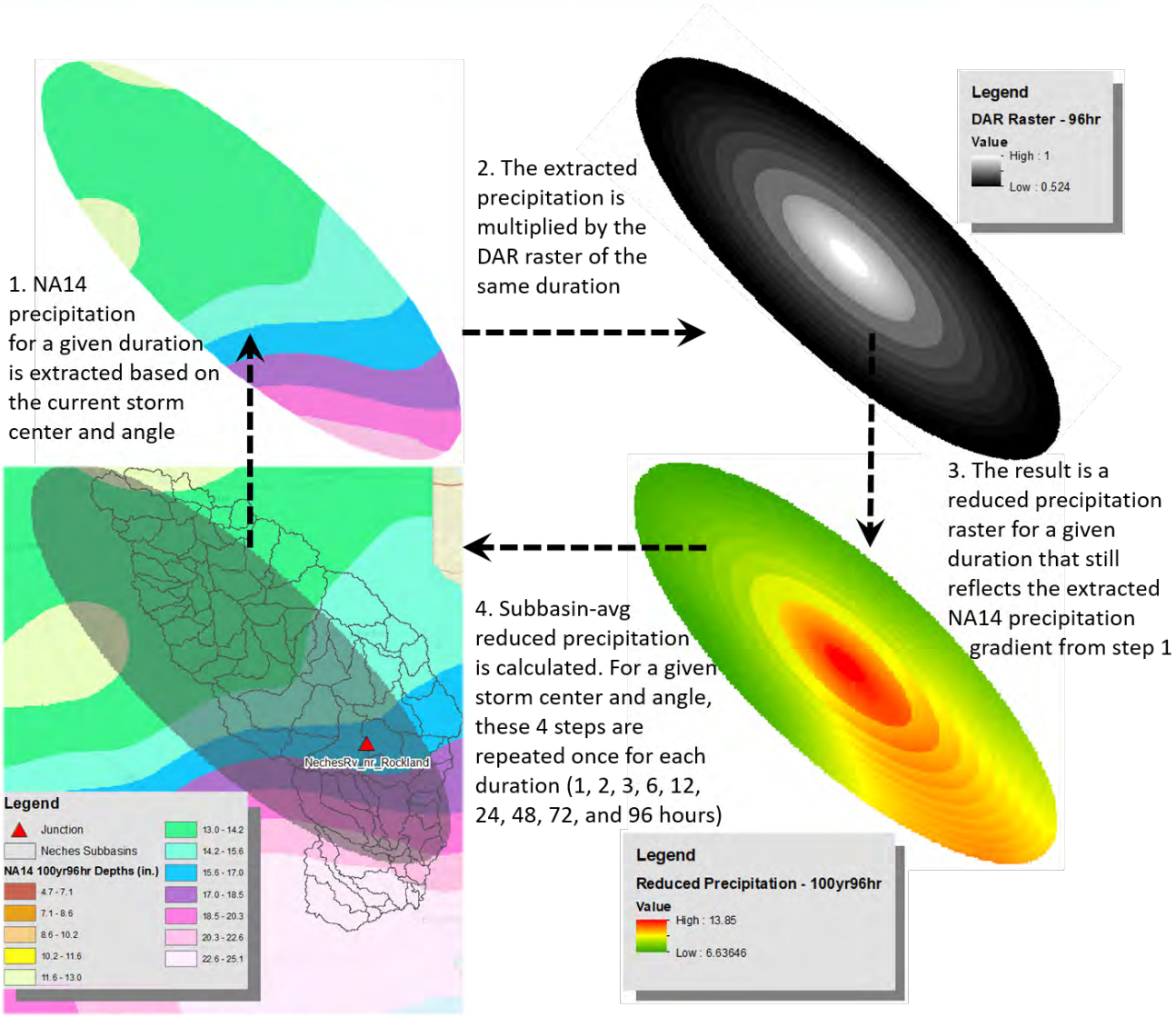

Figure C.8: Geospatial Process for Building Elliptical Design Storms

1.3 OPTIMIZATION OF THE STORM CENTER LOCATION

For the InFRM Watershed Hydrology Assessments, a script was developed by the University of Texas at Arlington that automatically locates optimal centering locations (x and y) and rotations (ɵ) of spatially varied elliptical frequency storms for a list of receiving junctions in an HMS basin model. The script was expected to obtain the combination of the three parameters (x, y, and ɵ) that maximized either peak flow at desired junctions or reservoir pool elevations while achieving the following objectives:

- To complete the task efficiently.
- To allow users to customize the scripts easily based on their needs.
- To generate reasonable results that can be validated manually.
- To outperform the manual grid search method in terms of precision, accuracy and efficiency.
- To function normally on any machine at USACE with the available software and hardware.

The ArcPy Python library, part of Esri's ArcGIS software package, was leveraged for all geospatial operations. The "Optimization Loop" section of Figure C.9 below illustrates the schematic flow of the storm optimization script. The loop consists of two major components: 1) parameter update/optimization and 2) automatic simulation of the HEC-HMS hydrologic model. In each iteration of the optimization process, the rasterized DAR ellipses for each duration are rotated and shifted to align with the updated parameters (x, y, and ϴ) and then are applied to the corresponding NOAA Atlas 14 precipitation rasters to create spatially reduced rainfall for each storm duration. The spatially reduced depths are then allocated into each subbasin as mean areal precipitation (MAP). The subbasin MAP values for each duration are then manipulated using the alternating block method to create a complete time series (covered in section 1.2.5). The time series MAP values, i.e. the hyetographs, are stored in DSS format and transmitted to the HMS model for simulations. After each simulation, the corresponding peak flow value at a desired junction is extracted from the output DSS file. Based on the extracted peak flow value, an optimization algorithm will update the parameters (x, y and ϴ) and then optimization proceeds into the next iteration. After all optimization iterations for a junction are complete, an optimized storm center (x and y) and orientation (ϴ) that leads to a peak flow at a given junction is determined. The optimization process can then be repeated for the next junction of interest.

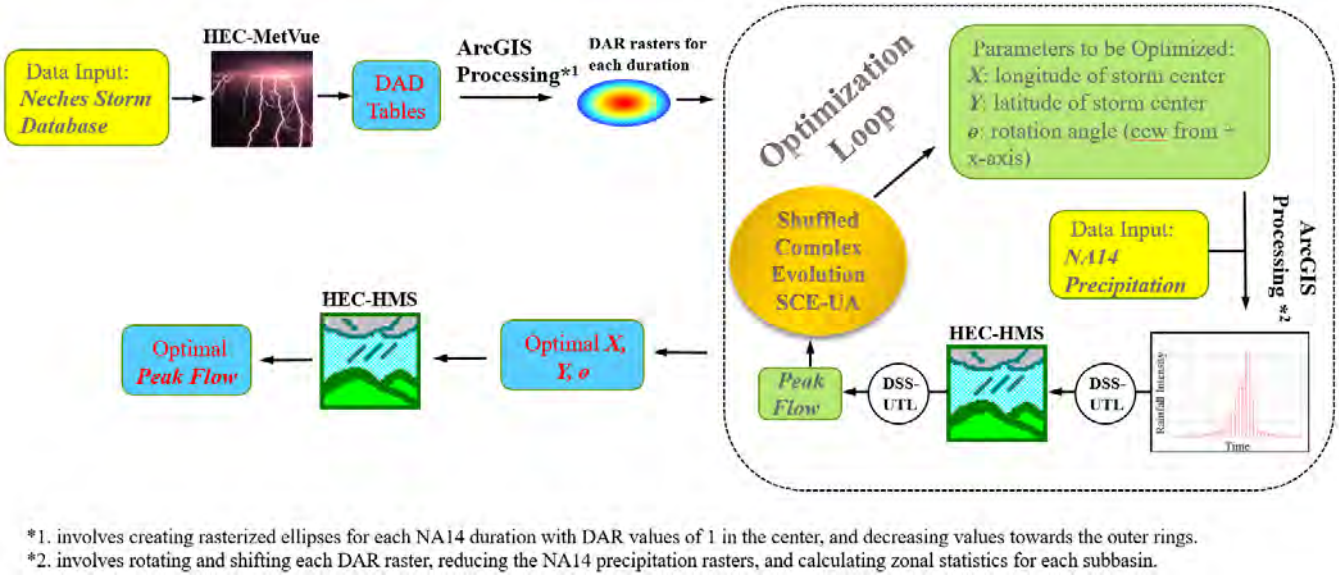

Figure C.9: Schematic Flowchart for the Storm Optimization Script

Originally, the scripts were designed to automate a grid search, where all possible combinations of parameters (i.e. the 'grids') are exhaustively tested and the optimal combination of the three parameters (x, y, and ϴ) can then be obtained. Although the approach of grid search seems straightforward, it does suffer from high computational cost because the computational run time depends on the number of grids, which is further constrained by the range and the interval of each parameter. Given the need of maintaining a certain level of precision or keeping constant intervals of the parameters, the UTA team found that the grid search approach might not be appropriate for this project since the computational run time was excessively lengthy – it increases exponentially with greater drainage area (more possible x and y values).

In order to overcome this issue, the UTA team selected a global optimization (GO) algorithm entitled shuffled complex evolution (SCE) (Duan et al., 1993) - a random sampling approach. Instead of exhausting all possible grids, the random sampling approach tests the objective function around some sampled grids in an iteration while learning about the structure of the objective function for improving the sampling of grids in the next iteration. More details about GO and SCE are included in the following sections.

1.2.1 Global Optimization

The objective of global optimization (GO) is to find the best solution of (possibly nonlinear) models globally, in the (possible or known) presence of multiple local optima. As an example, Figure C.10 shows a 3-D plot of a continuous objective function of two bounded parameters x and y. Suppose the goal is to locate the minimal value globally instead of just locally (Note there are many local minimal values but with only one global minimum value in the chart), a global search in the two-dimensional box region is needed. The theory of GO has been applied to many engineering problems like model calibrations and optimal operations of "black-box" systems. The storm optimization here is essentially a constrained GO problem, where the objective is to seek the combination of storm centering locations and rotations yielding the maximal peak flow within the constraints of the possible parameter values.

The level of difficulty in solving a GO problem depends on several major characteristics of the objective function. First, there may be multiple local minima in the parameter space. As illustrated in Figure C.10, the search of global minimum can be easily "trapped" in the "valleys" of the objective function, depending on the starting point of the search. Second, the objective function in the parameter space may not be smooth or even continuous. In addition, the parameters may exhibit varying degrees of highly nonlinear interaction. In order to deal with these difficulties, the UTA team employed the shuffled complex evolution algorithm (see the following section), which has proven to be effective and efficient for the storm optimization task.

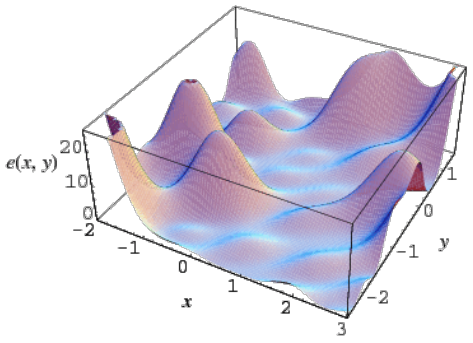

Figure C.10: Example of a Global Optimization Problem

1.2.2 Shuffled Complex Evolution

The shuffled complex evolution works on the basis of four concepts: (1) combination of deterministic and probabilistic approaches; (2) systematic evolution of a complex of grids; (3) competitive evolution; and (4) complex shuffling. The algorithm begins with a randomly selected population of grids from the parameter space. The grids are sorted ascendingly so that the first point represents the smallest value of the objective function and the last point represents the largest. The initial population generated randomly is first partitioned into several complexes. Each complex is allowed to evolve independently to search the parameter space in different dimensions; and each individual grid in a complex has the potential to participate in the process of reproducing new grids. From each complex, some grids are selected to form a sub-complex, where the modified Nelder and Mead Simplex Method (NMSM) (Nelder and Mead, 1965) is applied for global improvement. The grids of higher fitness values have a higher chance of getting selected to generate offspring. The NMSM performs reflection and inside contraction steps to achieve a better fit grid. This new offspring then replaces the grid with the worst performance in the complex. The grids in the evolved complexes are then pooled together and sorted again, shuffled, and finally reassigned to new complexes to enable information sharing. This process is repeated until some convergence criteria are satisfied.

1.4 ELLIPTICAL STORM LOCATIONS

The final optimized storm center locations (x, y) and rotations (θ) for every node of interest in the Nueces watershed are listed in Table C.4. Rotation angles are measured counterclockwise from the positive x-axis. These location and rotation parameters were determined from 100yr frequency optimizations and are assumed to be the same for other frequency events in most cases (2yr – 500yr). Sensitivity testing showed that, in general, optimized locations and orientations did not significantly change between frequency events. Once the optimum storm center location and rotation were determined for each location of interest, the elliptical frequency storms for the standard eight frequency events were constructed using the appropriate NOAA Atlas 14 point rainfall depths.

Table C.4: Optimized Elliptical Storm Center Locations and Rotations for Each Model Junction

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area	Lon	Lat	Theta
West Nueces River above Sycamore Creek	W_NuecesRv_abv_SycamoreCk	535.95	-100.37992	29.834271	91.051
West Nueces River Below Sycamore Creek	W_NuecesRv_blw_SycamoreCk	646.40	-100.33178	29.847607	97.605
West Nueces River near Brackettville (USGS gage 08190500)	W_NuecesRv_nr_Brackettville	693.94	-100.37008	29.800352	98.597
West Nueces River above Live Oak	W_NuecesRv_abv_Live OakCk	767.91	-100.35117	29.785333	96.005
West Nueces River Below Live Oak	W_NuecesRv_blw_Live OakCk	820.22	-100.32679	29.79324	99.079
West Nueces River above Nueces River	W-NuecesRv_abv_NuecesRv	918.29	-100.33602	29.755469	103.881
Nueces River below Pulliam Creek	NuecesRv_blw_PulliamCk	529.82	-99.998139	29.905178	47.714
Nueces River at CR414 at Montell (USGS gage 08189998)	NuecesRv_at_Cr414_at_Montell	659.62	-100.04476	29.902383	73.212
Nueces River below Montell Creek	NuecesRv_blw_MontellCk	679.24	-100.03234	29.850916	62.135
Nueces River at Laguna (USGS gage 08190000)	NuecesRv_at_Laguna	736.17	-100.0307	29.902541	84.266
Nueces River above West Nueces River	NuecesRv_abv_W_NuecesRv	815.94	-100.02983	29.850494	86.599
Nueces River Below West Nueces River	NuecesRv_blw_W_NuecesRv	1734.22	-100.13471	29.767365	42.856
Nueces River below Indian Creek	NuecesRv+IndianCk	1802.06	-100.10409	29.808206	44.217
Nueces River at Highway 90	NuecesRv_at_HWY-90	1838.04	-100.10669	29.793469	36.879
Nueces River near Uvalde (USGS gage 08192000)	NuecesRv_nr_Uvalde	1861.45	-100.14722	29.752449	43.486

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area	Lon	Lat	Theta
Nueces River at Highway 83	NuecesRv_at_HWY-83	1885.45	-100.11305	29.780472	47.435
Nueces River at Highway 57	NuecesRv_at_HWY-57	1981.12	-100.09332	29.709282	96.107
Nueces River at FM 1025 nr Crystal City (USGS gage 08192550)	NuecesRv_at_FM-1025_nr_Cryst	2102.48	-100.07786	29.602548	108.936
Nueces River at The Turkey Creek/Espantosa Slough Split	NuecesRv_TurkeyCk_Split	2122.77	-100.10794	29.608691	115.359
Turkey Creek/Espantosa Slough Diversion	TurkeyCk_Diversion	2122.77	-100.09838	29.632883	112.497
Nueces River Split	NuecesRv_Split_J010	2165.25	-99.745558	28.77756	99.446
Nueces River above Turkey Creek	NuecesRv_abv_TurkeyCk	2165.25	-99.990652	29.376535	111.012
Palo Blanco Creek below Chacon Creek	Palo_BlancoCk_blw_ChaconCk	520.34	-100.15253	28.897615	129.282
Palo Blanco Creek above Picosa Creek	Palo_BlancoCk_abv_PicosaCk	520.34	-100.18835	28.933716	136.411
Palo Blanco Creek below Picosa Creek	Palo_BlancoCk_blw_PicosaCk	744.76	-100.21562	28.87373	100.528
Palo Blanco Creek above Comanche Creek	Palo_BlancoCk_abv_ComancheC	744.76	-100.21667	28.855488	95.157
Palo Blanco Creek Below Comanche Creek	Palo_BlancoCk_blw_ComancheC	822.94	-100.19853	28.837065	95.276
Turkey Creek below Chaparrosa Creek	TurkeyCk_blw_ChaparrosaCk	414.59	-100.05681	29.050424	124.125
Turkey Creek above Picosa Creek	TurkeyCk_abv_PicosaCk	459.10	-100.02259	29.012876	118.979
Turkey Creek below Picosa Creek	TurkeyCk_blw_PicosaCk	1376.61	-100.13842	28.862907	83.385
Turkey Creek at Highway 83 (New USGS gage)	TurkeyCk_at_HWY-83	1554.98	-100.11141	28.806646	103.734
Turkey Creek above Turkey Split	TurkeyCk_abv_Turkey_Split	1563.55	-100.10423	28.817265	96.35
Turkey Creek below Turkey Split	TurkeyCk_blw_Turkey_Split	1568.83	-100.09555	29.401164	94.833
Turkey Creek above Carrizo Creek	TurkeyCk_abv_CarrizoCk	1581.46	-100.11429	29.243369	93.292
Turkey Creek below Carrizo Creek	TurkeyCk_blw_CarrizoCk	1662.70	-100.10871	29.198307	94.805
Turkey Creek above El Barrosa Creek	TurkeyCk_abv_El_BarrosaCk	1687.81	-100.10355	29.133368	93.962
Turkey Creek below El Barrosa Creek	TurkeyCk_blw_El_BarrosaCk	1718.21	-100.11149	29.136126	93.547
Turkey Creek and El Moro Creek	TurkeyCk+El_MoroCk	1836.07	-100.11807	29.086672	93.591
Turkey Creek above Nueces River	TurkeyCk_abv_NuecesRv	1847.03	-100.10919	29.114003	94.968
Nueces River near Asherton (USGS gage 08193000)	NuecesRv_nr_Asherton	4024.67	-100.09322	29.136948	95.176
Nueces River above Arroyo Negro	NuecesRv_abv_Arroyo_Negro	4213.49	-100.08823	29.169757	95.786
Nueces River below Arroyo Negro	NuecesRv_blw_Arroyo_Negro	4333.02	-100.08111	29.113656	96.71
Nueces River above Appurceon Creek	NuecesRv_abv_AppurceonCk	4333.02	-100.08849	29.14405	94.933
Nueces River below Appurceon Creek	NuecesRv_blw_AppurceonCk	4411.17	-100.08693	29.084619	97.074
Nueces River above San Roque Creek	NuecesRv_abv_San_RoqueCk	4488.43	-100.08231	29.072288	95.874
Nueces River below San Roque Creek	NuecesRv_blw_San_RoqueCk	4903.91	-100.06098	29.06561	99.398
Nueces River and Espio Creek	NuecesRv+EspioCk	5084.65	-100.05472	29.06301	100.523
Nueces River at Cotulla (USGS gage 08194000)	NuecesRv_at_Cotulla	5172.43	-100.06719	29.002808	98.814
Nueces River above La Raices Creek	NuecesRv_abv_La_RaicesCk	5366.43	-100.04767	28.971495	100.418
Nueces River below La Raices Creek	NuecesRv_blw_La_RaicesCk	5638.55	-100.05432	29.013892	100.437
Nueces River above Calman Creek	NuecesRv_abv_CalmanCk	5705.26	-100.04455	28.987517	99.777
Nueces River below Calman Creek	NuecesRv_blw_CalmanCk	5890.78	-100.0604	28.989333	101.425
Nueces River above Los Olmos Creek	NuecesRv_abv_Los_OlmosCk	5898.22	-100.03445	28.970549	101.324
Nueces River below Los Olmos Creek	NuecesRv_blw_Los_OlmosCk	6353.75	-99.307032	28.069038	65.575
Nueces River and Sauz Creek	NuecesRv+SauzCk	6419.66	-99.282897	28.10121	65.129
Nueces River above San Casimiro Creek	NuecesRv_abv_San_CasimiroCk	6445.15	-99.33904	28.053946	72.945

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area	Lon	Lat	Theta
San Casimiro Creek near Freer (USGS gage 08194200)	San_CasimiroCk_nr_Freer	467.65	-99.105474	27.667402	163.68
San Casimiro Creek above Nueces River	San_CasimiroCk_abv_NuecesRv	537.34	-99.124402	27.645147	137.112
Nueces River below San Casimiro Creek	NuecesRv_blw_San_CasimiroCk	6982.49	-99.258071	27.95797	95.318
Nueces River above Black Creek	NuecesRv_abv_BlackCk	7007.66	-99.262112	27.94199	95.052
Nueces River below Black Creek	NuecesRv_blw_BlackCk	7431.13	-99.197746	27.921021	112.634
Nueces River above Ygnacio Creek	NuecesRv_abv_YgnacioCk	7611.07	-99.160922	27.94326	123.798
Nueces River below Ygnacio Creek	NuecesRv_blw_YgnacioCk	7754.47	-99.160104	27.937354	120.835
Nueces River above San Jose Creek	NuecesRv_abv_San_JoseCk	7754.47	-99.160868	27.945005	117.35
Nueces River below San Jose Creek	NuecesRv_blw_San_JoseCk	7857.73	-99.162669	27.939462	118.981
Nueces River above Green Branch	NuecesRv_abv_GreenBr	7857.73	-99.146468	27.911956	120.798
Nueces River below Green Branch	NuecesRv_blw_GreenBr	7943.10	-99.150856	27.944951	118.147
Nueces River near Tilden (USGS gage 08194500)	NuecesRv_nr_Tilden	8105.85	-99.154157	27.938817	117.375
Nueces River above Cow Creek	NuecesRv_abv_CowCk	8105.85	-99.135586	27.968502	119.501
Nueces River below Cow Creek	NuecesRv_blw_CowCk	8182.92	-99.144279	27.936433	120.131
Nueces River above Old River	NuecesRv_abv_OldRv	8275.85	-99.151501	27.961328	118.878
Nueces River below Old River	NuecesRv_blw_OldRv	8354.07	-99.148685	27.94378	121.702
Nueces River and White Creek	NuecesRv+WhiteCk	8464.98	-99.132403	27.94323	120.642
Nueces River above Atascosa River	NuecesRv_abv_AtascosaRv	8519.43	-99.137086	27.95977	122.361
Frio River at Concan (USGS gage 08195000)	FrioRv_at_Concan	389.64	-99.771801	29.668322	55.091
Frio River abov Dry Frio River	FrioRv_abv_Dry_FrioRv	441.57	-99.774353	29.622028	52.741
Frio River below Dry Frio River	FrioRv_blw_Dry_FrioRv	628.74	-99.818623	29.617258	52.781
Frio River near Uvalde (USGS gage 08197500)	FrioRv_nr_Uvalde	633.06	-99.780087	29.649408	53.73
Frio River above Blanco Creek	FrioRv_abv_BlancoCk	745.82	-99.806656	29.59962	111.185
Frio River below Blanco Creek	FrioRv_blw_BlancoCk	879.41	-99.78725	29.605181	114.404
Frio River below Sabinal River	FrioRv_blw_SabinalRv	1338.62	-99.730752	29.551379	129.023
Frio River above Elm Creek	FrioRv_abv_ElmCk	1411.00	-99.713183	29.533316	129.682
Frio River below Elm Creek	FrioRv_blw_ElmCk	1499.66	-99.739192	29.55906	128.011
Frio River above Hondo Creek	FrioRv_abv_HondoCk	1514.24	-99.695119	29.509889	128.678
Hondo Creek and Live Oak Creek	HondoCk+Live_OakCk	521.81	-99.172719	29.521278	134.37
Hondo Creek above Seco Creek	HondoCk_abv_SecoCk	666.04	-99.180401	29.520761	125.294
Hondo Creek below Seco Creek	HondoCk_blw_SecoCk	1019.99	-99.219777	29.528286	137.671
Hondo Creek above Frio River	HondoCk_abv_FrioRv	1106.85	-99.237257	29.532367	138.411
Frio River below Hondo Creek	FrioRv_blw_HondoCk	2621.10	-99.348139	29.536389	151.832
Frio River above Leona River	FrioRv_abv_LeonaRv	2675.30	-99.378209	29.529964	148.307
Leona River below Live Oak Creek	LeonaRv_blw_LiveoakCk	460.74	-99.574977	28.930639	139.415
Leona River above Todos Santos Creek	LeonaRv_abv_Todos_SantosCk	585.22	-99.566094	28.939483	144.691
Leona River below Todos Santos Creek	LeonaRv_blw_Todos_SantosCk	660.74	-99.555046	28.935597	145.596
Leona River above Frio River	LeonaRv_abv_FrioRv	670.08	-99.519	28.923102	135.471
Frio River below Leona River	FrioRv_blw_LeonaRv	3345.37	-99.355035	29.506171	170.799
Frio River near Derby (USGS gage 08215500)	FrioRv_nr_Derby	3447.76	-99.368659	29.472884	6.138
Frio River at Highway 85	FrioRv_at_HWY-85	3500.89	-99.428251	29.475836	7.69

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area	Lon	Lat	Theta
Frio River and Ruiz Creek	FrioRv+RuizCk	3653.55	-99.481381	29.444733	128.704
Frio River above Cibolo Creek	FrioRv_abv_CiboloCk	3698.16	-99.483476	29.422281	114.629
Frio River below Cibolo Creek	FrioRv_blw_CiboloCk	4092.91	-99.478202	29.408448	104.517
Frio River above Esperanza Creek	FrioRv_abv_EsperanzaCk	4149.39	-99.454124	29.381616	106.779
Frio River below Esperanza Creek	FrioRv_blw_EsperanzaCk	4248.12	-99.460132	29.360603	112.254
Frio River and Galinda Creek	FrioRv+GalindaCk	4337.72	-99.432691	29.313252	111.347
Frio River above Leoncita Creek	FrioRv_abv_LeoncitaCk	4396.25	-99.422843	29.281683	114.014
Frio River at Tilden (USGS gage 08206600)	FrioRv_at_Tilden	4462.81	-99.419309	29.264179	112.975
Frio River above San Miguel Creek	FrioRv_abv_San_MiguelCk	4519.46	-99.425124	29.28517	112.937
San Miguel Creek below Highway 97	SanMiguelCk_blw_HWY-97	516.77	-98.960927	29.077786	86.613
San Miguel Creek above Lagunillas Creek	SanMiguelCk_abv_LagunillasCk	574.60	-98.962349	29.046874	85.525
San Miguel Creek below Lagunillas Creek	SanMiguelCk_blw_LagunillasCk	741.44	-98.794154	28.797755	152.24
San Miguel Creek near Tilden (USGS gage 08206700)	SanMiguelCk_nr_Tilden	782.15	-98.82906	28.785936	145.817
San Miguel Creek above Frio River	SanMiguelCk_abv_FrioRv	854.80	-98.791324	28.763615	151.158
Frio River below San Miguel Creek	FrioRv_blw_San_MiguelCk	5374.26	-99.408702	29.28252	114.595
Choke Canyon Reservoir Inflow	ChokeCanyon_Inflow	5490.45	-99.421066	29.299061	114.172
Frio River below Choke Canyon Dam	ChokeCanyonRes_OWC_nr_3Rv	5490.45	-99.44436	29.270112	116.593
Frio River above Atascosa River	FrioRv_abv_AtascosaRv	5496.36	-99.414089	29.236739	115.529
Atascosa River at Highway 37	AtascosaRv_at_HWY-37	451.31	-98.573426	29.039461	6.262
Atascosa River near McCoy (USGS gage 08207500)	AtascosaRv_nr_McCoy	510.87	-98.589665	29.025317	17.011
Atascosa River above Borrego Creek	AtascosaRv_abv_BorregoCk	535.96	-98.599188	29.041106	6.638
Borrego Creek and Los Cortes Creek	BorregoCk+Los_CortesCk	142.92	-98.298577	29.027643	135.287
Borrego Creek above Atascosa River	BorregoCk_abv_AtascosaRv	221.19	-98.302856	28.995853	125.703
Atascosa River below Borrego Creek	AtascosaRv_blw_BorregoCk	757.15	-98.501551	29.036967	3.048
Atascosa River above La Parita Creek	AtascosaRv_abv_La_ParitaCK	813.17	-98.522383	29.031561	1.613
Atascosa River below La Parita Creek	AtascosaRv_blw_La_PartaCk	1124.57	-98.507061	29.025384	171.804
Atascosa River at Whitsett (USGS gage 0820800)	AtascosaRv_at_Whitsett	1145.77	-98.526733	29.015057	9.46
Atascosa River above Weedy Creek	AtascosaRv_abv_WeedyCk	1225.28	-98.476071	29.017036	157.067
Atascosa river below Weedy Creek	AtascosaRv_blw_WeedyCk	1364.40	-98.50361	29.027753	163.898
Atascosa River above Frio River	AtascosaRv_abv_FrioRv	1395.61	-98.489892	29.009022	165.862
Atascosa River below Frio River	AtascosaRv_blw_FrioRv	6891.97	-98.340821	28.853472	175.65
Atascosa River above Nueces River	AtascosaRv_abv_NuecesRv	6911.11	-99.333435	29.223602	127.993
Nueces River below Atascosa River	NuecesRv_blw_AltascosaRv	15430.54	-99.258151	28.458183	107.532
Nueces River at Three Rivers (USGS gage 08210000)	NuecesRv_at_Three_Rivers	15430.54	-99.306654	29.117024	116.708
Nueces River and Sulphur Creek	NuecesRv+SulhpurCk	15619.12	-99.20789	28.230758	103.349
Nueces River at Highway 59	NuecesRv_at_HWY-59	15715.07	-98.633936	28.722432	156.963
Nueces River above Spring Creek	NuecesRv_abv_SpringCk	15733.03	-99.243534	28.575217	98.238
Nueces River below Spring Creek	NuecesRv_blw_SpringCk	15833.59	-99.23279	28.415484	105.716
Nueces River and Upper End of Lake Corpus Christi	NuecesRv+UpEnd_LkCorpusChris	15921.68	-99.228619	28.32979	104.282
Nueces River above Lake Corpus Christi	NuecesRv_abv_LkCorpusCh	16076.35	-99.121059	28.262609	111.716

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area	Lon	Lat	Theta
Lake Corpus Christi Inflow	Lk_Corpus_Christi_Inflow	16502.10	-99.326571	28.521758	106.363
Nueces River near Mathis (USGS gage 08211000, Dam Outflow)	NuecesRv_nr_Mathis	16502.10	-99.346254	29.022004	121.265
Nueces at Bluntzer (USGS gage 08211200)	NuecesRv_at_Bluntzer	16617.60	-99.260724	29.025967	112.622
Nueces River at Calallen (USGS gage 08211500)	NuecesRv_at_Calallen	16675.30	-99.304408	29.091755	116.324

1.5 ELLIPTICAL FREQUENCY STORM LOSS RATES

The elliptical frequency storms were then applied to the final HEC-HMS basin model with the same frequency loss rates that were used for the uniform rainfall method which is discussed in Appendix B. In some cases, the 2-yr through 10-yr losses were re-adjusted in order to maintain consistency with the frequent end of the statistical frequency curves at the USGS gages. This final adjustment was performed because of the increased level of confidence in the statistical frequency curve for the 2-yr through 10-yr recurrence intervals. The final 2-yr through 25-yr loss rates used for the elliptical frequency storm events are given in Table C.5. The final 50-yr through 500-yr loss rates are the same as those used for the uniform rainfall method and are shown again in Table C.6.

Table C.5: Final Initial and Constant Losses for the 2-yr through 25-yr Elliptical Frequency Storms

	50% AEP	50% AEP	20% AEP	20% AEP	10% AEP	10% AEP	4% AEP	4% AEP
	2-yr	2-yr	5-yr	5-yr	10-yr	10-yr	25-yr	25-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
NuecesRv_W_S010	2.170	0.226	2.420	0.207	2.078	0.178	1.779	0.148
NuecesRv_W_S011	2.161	0.225	2.411	0.206	2.071	0.177	1.773	0.148
NuecesRv_W_S020	2.200	0.230	2.450	0.210	2.100	0.180	1.800	0.150
NuecesRv_W_S021	2.197	0.230	2.447	0.210	2.097	0.180	1.798	0.150
NuecesRv_W_S022	2.200	0.230	2.450	0.210	2.100	0.180	1.800	0.150
NuecesRv_W_S030	2.400	0.230	2.100	0.180	2.000	0.180	1.800	0.150
NuecesRv_W_S031	2.400	0.230	2.100	0.180	2.000	0.180	1.800	0.150
NuecesRv_W_S032	2.400	0.230	2.100	0.180	2.000	0.180	1.800	0.150
NuecesRv_S011	2.153	0.205	2.653	0.205	2.653	0.205	2.167	0.167
NuecesRv_S010	2.154	0.205	2.654	0.205	2.654	0.205	2.168	0.167
NuecesRv_S012	2.157	0.206	2.657	0.206	2.657	0.206	2.170	0.167
NuecesRv_S020	2.146	0.205	2.646	0.205	2.646	0.205	2.162	0.167
NuecesRv_S030	2.250	0.210	2.750	0.210	2.750	0.210	2.293	0.170
NuecesRv_S041	2.200	0.210	2.700	0.210	2.700	0.210	2.200	0.170
NuecesRv_S040	2.200	0.210	2.700	0.210	2.700	0.210	2.200	0.170
NuecesRv_S050	2.400	0.230	2.100	0.180	2.000	0.180	1.800	0.150
NuecesRv_S061	2.400	0.230	2.100	0.180	2.000	0.180	1.800	0.150
NuecesRv_S060	2.400	0.230	2.100	0.180	2.000	0.180	1.800	0.150
NuecesRv_S070	2.310	0.220	2.027	0.173	1.945	0.174	1.749	0.146
NuecesRv_S071	2.290	0.220	2.009	0.171	1.931	0.173	1.736	0.145
NuecesRv_S080	0.936	0.148	1.023	0.207	1.979	0.297	2.031	0.278
NuecesRv_S081	0.923	0.147	0.997	0.205	1.960	0.295	2.013	0.277
NuecesRv_S082	0.882	0.142	0.919	0.197	1.900	0.287	1.958	0.272
NuecesRv_S083	0.914	0.146	0.980	0.203	1.947	0.293	2.001	0.276
NuecesRv_S084	0.912	0.146	0.977	0.203	1.945	0.293	1.999	0.276
NuecesRv_S090	0.872	0.141	0.899	0.195	1.886	0.285	1.945	0.271
N_ChaconCk_S010	1.636	0.196	2.247	0.254	2.642	0.344	3.486	0.326
N_ChaconCk_S020	1.438	0.187	1.835	0.239	2.137	0.329	2.900	0.317
N_ChaconCk_S021	1.428	0.186	1.815	0.237	2.122	0.327	2.886	0.316
N_ChaconCk_S023	1.456	0.189	1.870	0.242	2.163	0.332	2.924	0.319
N_ChaconCk_S022	1.447	0.188	1.851	0.240	2.149	0.330	2.911	0.318
N_PicosaCk_S010	1.527	0.185	1.898	0.234	2.262	0.324	3.065	0.315
N_PicosaCk_S011	1.777	0.190	2.096	0.244	2.487	0.334	3.318	0.320
N_PicosaCk_S020	1.622	0.192	2.038	0.247	2.380	0.337	3.180	0.322
N_TurkeyCk_S010	1.648	0.196	2.244	0.253	2.646	0.343	3.494	0.326
N_TurkeyCk_S011	1.512	0.196	1.976	0.253	2.244	0.343	2.998	0.326
N_TurkeyCk_S012	1.471	0.191	1.898	0.245	2.185	0.335	2.944	0.321
N_ChapCk_S010	1.501	0.194	1.956	0.251	2.228	0.341	2.984	0.324
N_ChapCk_S011	1.481	0.192	1.918	0.247	2.200	0.337	2.958	0.322
N_TurkeyCk_S020	1.416	0.184	1.791	0.234	2.104	0.324	2.869	0.314

	50% AEP	50% AEP	20% AEP	20% AEP	10% AEP	10% AEP	4% AEP	4% AEP
	2-yr	2-yr	5-yr	5-yr	10-yr	10-yr	25-yr	25-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
N_PicosaCk_S021	1.491	0.193	1.936	0.249	2.213	0.339	2.970	0.323
N_TurkeyCk_S030	1.425	0.186	1.810	0.236	2.118	0.326	2.882	0.316
N_TurkeyCk_S031	1.540	0.199	2.031	0.258	2.285	0.348	3.036	0.329
N_TurkeyCk_S040	1.441	0.187	1.841	0.239	2.141	0.329	2.903	0.317
TurkeyCk_S041	0.933	0.198	1.018	0.257	1.276	0.347	2.028	0.328
N_TurkeyCk_S050	1.440	0.197	2.306	0.256	2.966	0.346	3.550	0.327
N_TurkeyCk_S060	0.946	0.200	1.043	0.259	1.694	0.349	2.045	0.330
N_TurkeyCk_S061	0.901	0.194	0.956	0.251	1.929	0.341	1.984	0.324
N_TurkeyCk_S070	0.903	0.195	0.960	0.251	1.932	0.341	1.987	0.325
N_TurkeyCk_S080	0.874	0.191	0.904	0.245	1.889	0.335	1.948	0.321
N_TurkeyCk_S081	0.956	0.184	0.856	0.233	1.906	0.323	1.997	0.314
N_TurkeyCk_S090	0.851	0.189	0.860	0.241	1.856	0.331	1.917	0.319
NuecesRv_S100	1.080	0.107	1.089	0.109	0.740	0.103	0.052	0.100
NuecesRv_S101	1.150	0.113	1.170	0.119	0.816	0.111	0.210	0.113
NuecesRv_S110	1.020	0.103	1.017	0.102	0.685	0.097	0.102	0.103
NuecesRv_S111	1.120	0.110	1.132	0.113	0.773	0.107	0.183	0.110
N_SanRoqCk_S010	0.998	0.090	1.000	0.093	0.619	0.090	0.041	0.090
N_SanRoqCk_S011	1.039	0.100	1.040	0.096	0.661	0.093	0.086	0.100
N_SanRoqCk_S020	1.040	0.104	1.040	0.103	0.695	0.098	0.111	0.104
N_SanRoqCk_S021	1.040	0.104	1.040	0.103	0.694	0.098	0.110	0.104
NuecesRv_S121	1.290	0.130	1.300	0.130	0.900	0.120	0.200	0.120
NuecesRv_S120	1.290	0.130	1.300	0.130	0.900	0.120	0.200	0.120
NuecesRv_S122	1.330	0.130	1.339	0.130	0.959	0.120	0.200	0.120
NuecesRv_S130	1.785	0.170	2.200	0.200	2.450	0.240	3.060	0.230
N_LaRaicesCk_S010	1.890	0.190	2.400	0.220	2.600	0.260	3.200	0.240
N_LaRaicesCk_S011	1.865	0.185	2.350	0.220	2.560	0.260	3.170	0.240
NuecesRv_S140	1.749	0.163	2.130	0.190	2.390	0.240	3.010	0.220
N_CalmanCk_S010	1.858	0.184	2.340	0.210	2.550	0.260	3.160	0.240
N_CalmanCk_S011	1.743	0.162	2.120	0.190	2.380	0.240	3.000	0.220
NuecesRv_S150	1.717	0.157	2.070	0.190	2.350	0.230	2.970	0.220
N_LosOlmosCk_S012	1.718	0.157	2.070	0.190	2.350	0.230	2.970	0.220
N_LosOlmosCk_S011	1.801	0.173	2.230	0.200	2.470	0.250	3.080	0.230
N_LosOlmosCk_S010	1.874	0.187	2.370	0.220	2.580	0.260	3.180	0.240
N_LosOlmosCk_S020	1.693	0.152	2.020	0.180	2.310	0.230	2.930	0.220
NuecesRv_S151	1.686	0.151	2.010	0.180	2.300	0.230	2.920	0.220
NuecesRv_S160	1.708	0.155	2.050	0.180	2.330	0.230	2.950	0.220
NuecesRv_S161	1.681	0.150	2.000	0.180	2.290	0.230	2.920	0.220
N_SanCasCk_S010	2.266	0.222	2.886	0.237	3.052	0.221	2.728	0.186
N_SanCasCk_S020	1.991	0.204	2.418	0.222	2.459	0.209	2.032	0.177
N_SanCasCk_S021	2.017	0.207	2.439	0.224	2.476	0.211	2.048	0.178

	50% AEP	50% AEP	20% AEP	20% AEP	10% AEP	10% AEP	4% AEP	4% AEP
	2-yr	2-yr	5-yr	5-yr	10-yr	10-yr	25-yr	25-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
N_SanCasCk_S011	2.025	0.208	2.446	0.225	2.481	0.212	2.052	0.179
N_SanCasCk_S030	1.706	0.155	2.050	0.180	2.330	0.230	2.950	0.220
NuecesRv_S170	1.727	0.159	2.090	0.190	2.360	0.230	2.980	0.220
N_BlackCk_S010	1.841	0.178	2.290	0.210	2.520	0.250	3.130	0.230
N_BlackCk_S020	1.796	0.172	2.220	0.200	2.460	0.250	3.070	0.230
N_BlackCk_S021	1.758	0.165	2.150	0.190	2.410	0.240	3.020	0.220
NuecesRv_S180	1.742	0.162	2.120	0.190	2.380	0.240	3.000	0.220
NuecesRv_S185	1.912	0.184	2.370	0.210	2.600	0.260	3.210	0.240
NuecesRv_S190	1.874	0.187	2.370	0.220	2.580	0.260	3.180	0.240
NuecesRv_S200	1.699	0.153	2.030	0.180	2.320	0.230	2.940	0.220
NuecesRv_S210	1.746	0.155	2.070	0.190	2.360	0.230	2.990	0.220
NuecesRv_S220	0.400	0.040	0.600	0.060	1.439	0.144	2.343	0.255
NuecesRv_S221	0.400	0.040	0.600	0.060	1.306	0.130	2.221	0.245
NuecesRv_S222	0.400	0.040	0.600	0.060	1.500	0.150	2.400	0.260
NuecesRv_S230	0.400	0.040	0.600	0.060	1.341	0.133	2.253	0.247
NuecesRv_S231	0.400	0.040	0.600	0.060	1.388	0.138	2.297	0.251
FrioRv_S011	2.164	0.251	2.228	0.243	2.046	0.224	1.550	0.176
FrioRv_S010	2.256	0.253	2.489	0.244	2.424	0.226	2.013	0.177
FrioRv_S020	2.250	0.260	2.300	0.250	2.100	0.230	1.600	0.180
FrioRv_S030	2.300	0.260	1.800	0.210	1.500	0.180	1.300	0.150
FrioRv_D_S010	2.300	0.260	2.600	0.250	2.400	0.240	1.600	0.180
FrioRv_D_S020	2.300	0.260	1.800	0.210	1.500	0.180	1.300	0.150
FrioRv_D_S030	2.200	0.250	1.720	0.202	1.439	0.174	1.244	0.145
FrioRv_S040	2.300	0.260	1.800	0.210	1.500	0.180	1.300	0.150
FrioRv_S051	2.420	0.300	3.320	0.350	4.340	0.350	4.240	0.340
F_BlancoCk_S010	1.920	0.310	2.900	0.360	4.200	0.360	4.300	0.340
F_BlancoCk_S020	1.670	0.295	2.770	0.350	4.100	0.350	4.210	0.330
F_SabinalRv_S010	2.270	0.260	2.985	0.260	3.452	0.250	3.335	0.240
F_SabinalRv_S020	2.149	0.265	2.708	0.256	3.068	0.247	2.870	0.237
F_SabinalRv_S021	2.200	0.260	2.750	0.260	3.100	0.250	2.900	0.240
F_SabinalRv_S030	2.265	0.260	2.071	0.227	1.780	0.200	1.680	0.188
F_SabinalRv_S041	1.740	0.292	2.750	0.350	4.090	0.350	4.200	0.330
F_SabinalRv_S040	2.420	0.307	3.380	0.360	4.380	0.360	4.280	0.340
F_SabinalRv_S050	2.420	0.303	3.340	0.350	4.350	0.360	4.260	0.340
F_SabinalRv_S055	2.420	0.293	3.400	0.350	5.000	0.350	5.250	0.330
FrioRv_Sab_S060	2.420	0.306	3.360	0.360	4.370	0.360	4.270	0.340
FrioRv_S070	2.420	0.306	3.370	0.360	4.370	0.360	4.280	0.340
FrioRv_S071	2.390	0.297	3.290	0.350	4.320	0.350	4.230	0.330
FrioRv_S072	2.420	0.302	3.330	0.350	4.350	0.350	4.250	0.340
F_HondoCk_S010	2.373	0.270	2.742	0.260	2.713	0.250	2.432	0.200

	50% AEP	50% AEP	20% AEP	20% AEP	10% AEP	10% AEP	4% AEP	4% AEP
	2-yr	2-yr	5-yr	5-yr	10-yr	10-yr	25-yr	25-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
F_HondoCk_S020	1.731	0.253	1.743	0.204	1.756	0.195	1.760	0.197
F_HondoCk_S021	2.410	0.299	3.310	0.350	4.330	0.350	4.240	0.330
F_MVerdeCk_S010	1.920	0.310	3.000	0.360	4.200	0.360	4.300	0.340
F_MVerdeCk_S011	1.720	0.302	2.830	0.350	4.150	0.350	4.250	0.340
F_MVerdeCk_S021	1.600	0.288	2.720	0.340	4.060	0.350	4.170	0.330
F_MVerdeCk_S020	1.900	0.296	3.330	0.350	4.380	0.350	4.300	0.330
F_HondoCk_S030	2.330	0.291	3.240	0.340	4.280	0.350	4.190	0.330
F_HondoCk_S031	2.420	0.305	3.360	0.360	4.370	0.360	4.270	0.340
F_SecoCk_S010	2.550	0.310	3.100	0.300	3.000	0.290	2.300	0.220
F_SecoCk_S020	2.284	0.286	2.270	0.267	1.977	0.228	1.779	0.198
F_SecoCk_S021	2.113	0.269	2.127	0.253	1.869	0.216	1.679	0.190
F_SecoCk_S030	2.380	0.290	3.400	0.340	4.560	0.350	4.540	0.330
F_SecoCk_S031	2.400	0.298	3.300	0.350	4.320	0.350	4.230	0.330
F_HondoCk_S040	2.420	0.303	3.340	0.350	4.350	0.360	4.260	0.340
FrioRv_S080	2.420	0.303	3.340	0.350	4.360	0.360	4.260	0.340
F_LeonaRv_S010	1.890	0.250	2.800	0.300	4.200	0.290	5.250	0.290
F_LeonaRv_S011	1.800	0.240	2.720	0.290	3.860	0.290	4.170	0.280
F_LeonaRv_S012	2.000	0.240	2.900	0.290	4.540	0.290	5.130	0.280
F_LeonaRv_S020	1.800	0.240	2.720	0.290	3.860	0.290	4.170	0.280
F_LeonaRv_S021	1.920	0.300	2.900	0.350	4.340	0.350	4.490	0.340
F_LeonaRv_S022	1.910	0.299	2.810	0.350	4.130	0.350	4.240	0.330
F_LeonaRv_S023	1.920	0.307	2.870	0.360	4.180	0.360	4.280	0.340
F_LeonaRv_S030	1.910	0.299	2.810	0.350	4.130	0.350	4.240	0.330
F_LeonaRv_S031	1.920	0.305	2.860	0.360	2.960	0.280	4.270	0.340
F_LeonaRv_S040	1.920	0.304	2.850	0.350	2.950	0.280	4.260	0.340
F_LeonaRv_S041	1.920	0.310	2.900	0.360	2.950	0.280	4.300	0.340
F_LeonaRv_S042	1.920	0.309	2.890	0.360	2.890	0.280	4.290	0.340
FrioRv_S090	2.420	0.309	3.390	0.360	4.390	0.360	4.290	0.340
FrioRv_S100	1.200	0.230	1.250	0.090	1.050	0.070	1.050	0.120
FrioRv_S101	1.200	0.227	1.225	0.090	1.020	0.070	1.032	0.118
FrioRv_S102	1.135	0.213	1.112	0.080	0.900	0.060	0.954	0.112
F_CiboloCk_S010	0.500	0.210	0.250	0.090	0.150	0.070	0.550	0.120
F_CiboloCk_S011	0.500	0.210	0.250	0.090	0.150	0.070	0.550	0.120
F_CiboloCk_S020	0.390	0.194	0.034	0.070	0.034	0.050	0.399	0.107
FrioRv_S110	1.067	0.207	1.056	0.080	0.800	0.060	0.914	0.108
FrioRv_S111	0.947	0.195	0.956	0.070	0.760	0.050	0.844	0.102
FrioRv_S112	0.822	0.182	0.852	0.060	0.650	0.040	0.771	0.096
FrioRv_S113	0.827	0.183	0.856	0.060	0.660	0.040	0.774	0.096
FrioRv_S114	0.851	0.185	0.876	0.060	0.680	0.040	0.788	0.098
FrioRv_S120	0.400	0.040	0.600	0.060	1.180	0.087	3.550	0.233

	50% AEP	50% AEP	20% AEP	20% AEP	10% AEP	10% AEP	4% AEP	4% AEP
	2-yr	2-yr	5-yr	5-yr	10-yr	10-yr	25-yr	25-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
F_SanMigCk_S010	2.034	0.305	2.405	0.298	2.669	0.270	2.580	0.263
F_SanMigCk_S011	2.148	0.317	2.493	0.307	2.730	0.278	2.631	0.268
F_SanMigCk_S020	2.189	0.319	2.575	0.309	2.837	0.279	2.760	0.270
F_SanMigCk_S022	1.840	0.286	2.237	0.282	2.535	0.257	2.452	0.253
F_SanMigCk_S021	2.066	0.309	2.425	0.300	2.678	0.272	2.583	0.264
F_SanMigCk_S023	1.880	0.288	2.330	0.283	2.664	0.258	2.608	0.254
F_SanMigCk_S024	0.400	0.040	0.600	0.060	1.460	0.090	3.890	0.235
ChokeCanyon_S010	0.400	0.040	0.600	0.060	1.120	0.081	3.490	0.228
FrioRv_S130	0.400	0.040	0.600	0.060	3.837	0.313	3.250	0.247
Atascosa_S010	1.795	0.330	2.112	0.300	2.273	0.280	2.512	0.260
Atascosa_S011	1.773	0.330	2.041	0.300	2.166	0.280	2.380	0.260
Atascosa_S020	1.828	0.330	2.224	0.300	2.442	0.280	2.720	0.260
Atascosa_S030	1.686	0.321	1.984	0.292	2.139	0.274	2.365	0.255
Atascosa_S031	1.770	0.330	2.030	0.300	2.150	0.280	2.360	0.260
Atascosa_S040	1.619	0.315	1.904	0.287	2.054	0.270	2.272	0.252
Atascosa_S041	1.444	0.297	1.758	0.273	1.943	0.258	2.170	0.244
Atascosa_S050	1.485	0.300	1.840	0.275	2.053	0.260	2.301	0.245
La_ParitaCk_S010	1.568	0.307	1.935	0.281	2.149	0.265	2.405	0.248
La_ParitaCk_S020	1.566	0.309	1.875	0.283	2.047	0.266	2.274	0.250
La_ParitaCk_S030	1.454	0.298	1.767	0.274	1.950	0.259	2.176	0.244
Atascosa_S060	1.496	0.303	1.802	0.277	1.976	0.262	2.200	0.246
Atascosa_S070	0.400	0.040	0.600	0.060	1.762	0.122	2.688	0.239
Atascosa_S071	0.400	0.040	0.600	0.060	1.767	0.120	2.703	0.237
Atascosa_S080	0.400	0.040	0.600	0.060	1.817	0.131	2.731	0.246
FrioRv_S140	0.400	0.040	0.600	0.060	1.800	0.129	2.716	0.244
NuecesRv_S240	2.730	0.283	2.475	0.237	2.279	0.212	1.992	0.186
NuecesRv_S250	2.946	0.305	2.655	0.256	2.416	0.226	2.119	0.197
NuecesRv_S260	2.901	0.300	2.618	0.252	2.388	0.223	2.092	0.195
NuecesRv_S261	2.942	0.303	2.686	0.254	2.474	0.225	2.193	0.196
NuecesRv_S270	2.915	0.301	2.629	0.253	2.396	0.224	2.100	0.196
NuecesRv_S290	2.844	0.294	2.570	0.247	2.351	0.220	2.059	0.192
N_LagartoCk_S010	2.364	0.306	2.670	0.257	2.427	0.228	2.129	0.198
N_LagartoCk_S020	2.361	0.306	2.668	0.257	2.425	0.227	2.127	0.198
RamirenaCk_S010	2.358	0.306	2.665	0.257	2.424	0.227	2.126	0.198
RamirenaCk_S020	2.331	0.303	2.643	0.254	2.406	0.225	2.110	0.197
CorpusChristi_S010	2.725	0.283	2.471	0.237	2.276	0.212	1.990	0.186
CorpusChristi_S011	2.900	0.300	2.617	0.252	2.387	0.223	2.092	0.195
NuecesRv_S300	2.820	0.284	2.663	0.238	2.358	0.212	2.171	0.187
NuecesRv_S310	2.723	0.282	2.369	0.237	1.924	0.212	1.638	0.186

Table C.6: Final Initial and Constant Losses for the 50-yr through 500-yr Elliptical Frequency Storms

	2% AEP	2% AEP	1% AEP	1% AEP	0.5% AEP	0.5% AEP	0.2% AEP	0.2% AEP
	50-yr	50-yr	100-yr	100-yr	200-yr	200-yr	500-yr	500-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
NuecesRv_W_S010	1.585	0.128	1.391	0.098	1.222	0.087	1.094	0.078
NuecesRv_W_S011	1.580	0.128	1.388	0.098	1.220	0.086	1.092	0.078
NuecesRv_W_S020	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_W_S021	1.598	0.130	1.399	0.100	1.228	0.088	1.099	0.080
NuecesRv_W_S022	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_W_S030	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_W_S031	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_W_S032	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_S011	1.576	0.127	1.386	0.097	1.218	0.086	1.091	0.077
NuecesRv_S010	1.576	0.127	1.386	0.097	1.218	0.086	1.091	0.077
NuecesRv_S012	1.577	0.127	1.387	0.097	1.219	0.086	1.091	0.077
NuecesRv_S020	1.572	0.127	1.384	0.097	1.216	0.085	1.089	0.077
NuecesRv_S030	1.700	0.130	1.500	0.100	1.330	0.089	1.200	0.080
NuecesRv_S041	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_S040	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_S050	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_S061	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_S060	1.600	0.130	1.400	0.100	1.229	0.089	1.100	0.080
NuecesRv_S070	1.562	0.126	1.378	0.096	1.212	0.084	1.085	0.076
NuecesRv_S071	1.553	0.125	1.373	0.095	1.207	0.083	1.082	0.075
NuecesRv_S080	1.586	0.178	1.392	0.148	1.223	0.137	1.095	0.128
NuecesRv_S081	1.573	0.177	1.384	0.147	1.216	0.135	1.089	0.127
NuecesRv_S082	1.532	0.172	1.361	0.142	1.197	0.131	1.074	0.122
NuecesRv_S083	1.564	0.176	1.379	0.146	1.212	0.134	1.086	0.126
NuecesRv_S084	1.562	0.176	1.378	0.146	1.211	0.134	1.085	0.126
NuecesRv_S090	1.522	0.171	1.355	0.141	1.193	0.130	1.070	0.121
N_ChaconCk_S010	3.086	0.226	2.899	0.196	2.732	0.185	2.606	0.176
N_ChaconCk_S020	2.488	0.217	2.336	0.187	2.177	0.176	2.057	0.167
N_ChaconCk_S021	2.478	0.216	2.330	0.186	2.172	0.175	2.053	0.166
N_ChaconCk_S023	2.506	0.219	2.346	0.189	2.185	0.178	2.064	0.169
N_ChaconCk_S022	2.497	0.218	2.340	0.188	2.181	0.177	2.060	0.168
N_PicosaCk_S010	2.677	0.215	2.533	0.185	2.377	0.173	2.259	0.165
N_PicosaCk_S011	2.927	0.220	2.762	0.190	2.601	0.179	2.478	0.170
N_PicosaCk_S020	2.772	0.222	2.601	0.192	2.438	0.181	2.314	0.172
N_TurkeyCk_S010	3.098	0.226	2.914	0.196	2.747	0.184	2.621	0.176
N_TurkeyCk_S011	2.562	0.226	2.378	0.196	2.211	0.184	2.085	0.176

	2% AEP	2% AEP	1% AEP	1% AEP	0.5% AEP	0.5% AEP	0.2% AEP	0.2% AEP
	50-yr	50-yr	100-yr	100-yr	200-yr	200-yr	500-yr	500-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
N_TurkeyCk_S012	2.521	0.221	2.354	0.191	2.192	0.180	2.070	0.171
N_ChapCk_S010	2.551	0.224	2.372	0.194	2.206	0.183	2.081	0.174
N_ChapCk_S011	2.531	0.222	2.360	0.192	2.197	0.181	2.074	0.172
N_TurkeyCk_S020	2.466	0.214	2.322	0.184	2.166	0.173	2.048	0.164
N_PicosaCk_S021	2.541	0.223	2.366	0.193	2.201	0.182	2.077	0.173
N_TurkeyCk_S030	2.475	0.216	2.328	0.186	2.171	0.174	2.052	0.166
N_TurkeyCk_S031	2.590	0.229	2.394	0.199	2.224	0.187	2.096	0.179
N_TurkeyCk_S040	2.491	0.217	2.337	0.187	2.178	0.176	2.058	0.167
TurkeyCk_S041	1.583	0.228	1.390	0.198	1.221	0.187	1.094	0.178
N_TurkeyCk_S050	4.175	0.227	3.985	0.197	3.816	0.186	3.689	0.177
N_TurkeyCk_S060	1.596	0.230	1.398	0.200	1.227	0.188	1.099	0.180
N_TurkeyCk_S061	1.551	0.224	1.372	0.194	1.206	0.183	1.081	0.174
N_TurkeyCk_S070	1.553	0.225	1.373	0.195	1.207	0.183	1.082	0.175
N_TurkeyCk_S080	1.524	0.221	1.356	0.191	1.194	0.180	1.071	0.171
N_TurkeyCk_S081	1.606	0.214	1.464	0.184	1.308	0.173	1.190	0.164
N_TurkeyCk_S090	1.501	0.219	1.343	0.189	1.183	0.177	1.062	0.169
NuecesRv_S100	2.490	0.217	2.337	0.187	2.178	0.176	2.058	0.167
NuecesRv_S101	2.542	0.223	2.367	0.193	2.202	0.182	2.078	0.173
NuecesRv_S110	2.453	0.213	2.315	0.183	2.160	0.172	2.043	0.163
NuecesRv_S111	2.513	0.220	2.350	0.190	2.188	0.179	2.066	0.170
N_SanRoqCk_S010	2.408	0.208	2.289	0.178	2.139	0.166	2.026	0.158
N_SanRoqCk_S011	2.449	0.210	2.324	0.180	2.172	0.168	2.058	0.160
N_SanRoqCk_S020	2.460	0.214	2.319	0.184	2.164	0.172	2.046	0.164
N_SanRoqCk_S021	2.459	0.214	2.319	0.184	2.163	0.172	2.046	0.164
NuecesRv_S121	2.600	0.230	2.400	0.200	2.229	0.189	2.100	0.180
NuecesRv_S120	2.600	0.230	2.400	0.200	2.229	0.189	2.100	0.180
NuecesRv_S122	2.678	0.230	2.478	0.200	2.308	0.189	2.178	0.180
NuecesRv_S130	2.495	0.168	2.340	0.138	2.180	0.127	2.060	0.118
N_LaRaicesCk_S010	2.600	0.180	2.400	0.150	2.229	0.139	2.100	0.130
N_LaRaicesCk_S011	2.575	0.177	2.385	0.147	2.217	0.136	2.090	0.127
NuecesRv_S140	2.459	0.164	2.318	0.134	2.163	0.122	2.046	0.114
N_CalmanCk_S010	2.568	0.176	2.381	0.146	2.214	0.135	2.088	0.126
N_CalmanCk_S011	2.453	0.163	2.315	0.133	2.160	0.122	2.043	0.113
NuecesRv_S150	2.427	0.160	2.300	0.130	2.148	0.119	2.033	0.110
N_LosOlmosCk_S012	2.428	0.160	2.301	0.130	2.149	0.119	2.034	0.110
N_LosOlmosCk_S011	2.511	0.170	2.349	0.140	2.188	0.128	2.066	0.120
N_LosOlmosCk_S010	2.584	0.178	2.391	0.148	2.222	0.137	2.094	0.128
N_LosOlmosCk_S020	2.403	0.157	2.286	0.127	2.137	0.116	2.024	0.107

	2% AEP	2% AEP	1% AEP	1% AEP	0.5% AEP	0.5% AEP	0.2% AEP	0.2% AEP
	50-yr	50-yr	100-yr	100-yr	200-yr	200-yr	500-yr	500-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
NuecesRv_S151	2.396	0.156	2.282	0.126	2.134	0.115	2.021	0.106
NuecesRv_S160	2.418	0.159	2.295	0.129	2.144	0.118	2.030	0.109
NuecesRv_S161	2.391	0.156	2.280	0.126	2.132	0.115	2.020	0.106
N_SanCasCk_S010	2.618	0.166	2.469	0.136	2.312	0.125	2.193	0.116
N_SanCasCk_S020	1.901	0.157	1.785	0.127	1.636	0.116	1.524	0.107
N_SanCasCk_S021	1.912	0.158	1.792	0.128	1.642	0.117	1.528	0.108
N_SanCasCk_S011	1.916	0.159	1.794	0.129	1.643	0.117	1.529	0.109
N_SanCasCk_S030	2.416	0.159	2.294	0.129	2.143	0.117	2.029	0.109
NuecesRv_S170	2.437	0.161	2.306	0.131	2.153	0.120	2.037	0.111
N_BlackCk_S010	2.551	0.173	2.377	0.143	2.213	0.132	2.089	0.123
N_BlackCk_S020	2.506	0.169	2.346	0.139	2.185	0.128	2.064	0.119
N_BlackCk_S021	2.468	0.165	2.324	0.135	2.168	0.123	2.049	0.115
NuecesRv_S180	2.452	0.163	2.315	0.133	2.160	0.122	2.043	0.113
NuecesRv_S185	2.622	0.177	2.435	0.147	2.267	0.135	2.140	0.127
NuecesRv_S190	2.584	0.178	2.391	0.148	2.222	0.137	2.094	0.128
NuecesRv_S200	2.409	0.158	2.290	0.128	2.140	0.117	2.027	0.108
NuecesRv_S210	2.456	0.159	2.333	0.129	2.182	0.118	2.068	0.109
NuecesRv_S220	2.558	0.275	2.376	0.245	2.210	0.234	2.084	0.225
NuecesRv_S221	2.467	0.265	2.323	0.235	2.167	0.223	2.049	0.215
NuecesRv_S222	2.600	0.280	2.400	0.250	2.229	0.239	2.100	0.230
NuecesRv_S230	2.491	0.267	2.337	0.237	2.178	0.226	2.058	0.217
NuecesRv_S231	2.523	0.271	2.356	0.241	2.193	0.230	2.071	0.221
FrioRv_S011	1.063	0.126	0.878	0.096	0.712	0.084	0.586	0.076
FrioRv_S010	1.560	0.127	1.372	0.097	1.204	0.085	1.078	0.077
FrioRv_S020	1.100	0.130	0.900	0.100	0.729	0.089	0.600	0.080
FrioRv_S030	1.100	0.130	0.900	0.100	0.729	0.089	0.600	0.080
FrioRv_D_S010	1.100	0.130	0.900	0.100	0.729	0.089	0.600	0.080
FrioRv_D_S020	1.100	0.130	0.900	0.100	0.729	0.089	0.600	0.080
FrioRv_D_S030	1.058	0.125	0.876	0.095	0.710	0.084	0.584	0.075
FrioRv_S040	1.100	0.130	0.900	0.100	0.729	0.089	0.600	0.080
FrioRv_S051	3.559	0.275	3.376	0.245	3.210	0.234	3.084	0.225
F_BlancoCk_S010	3.600	0.280	3.400	0.250	3.229	0.239	3.100	0.230
F_BlancoCk_S020	3.535	0.272	3.362	0.242	3.199	0.231	3.075	0.222
F_SabinalRv_S010	2.070	0.180	1.870	0.150	1.699	0.139	1.570	0.130
F_SabinalRv_S020	1.578	0.177	1.387	0.147	1.219	0.136	1.092	0.127
F_SabinalRv_S021	1.600	0.180	1.400	0.150	1.229	0.139	1.100	0.130
F_SabinalRv_S030	1.585	0.178	1.391	0.148	1.222	0.137	1.094	0.128
F_SabinalRv_S041	3.524	0.271	3.356	0.241	3.194	0.230	3.071	0.221

	2% AEP	2% AEP	1% AEP	1% AEP	0.5% AEP	0.5% AEP	0.2% AEP	0.2% AEP
	50-yr	50-yr	100-yr	100-yr	200-yr	200-yr	500-yr	500-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
F_SabinalRv_S040	3.588	0.279	3.393	0.249	3.224	0.237	3.096	0.229
F_SabinalRv_S050	3.568	0.276	3.382	0.246	3.214	0.235	3.088	0.226
F_SabinalRv_S055	4.500	0.271	4.500	0.241	4.500	0.230	4.500	0.221
FrioRv_Sab_S060	3.581	0.278	3.389	0.248	3.220	0.236	3.093	0.228
FrioRv_S070	3.582	0.278	3.390	0.248	3.221	0.237	3.093	0.228
FrioRv_S071	3.545	0.274	3.368	0.244	3.203	0.232	3.079	0.224
FrioRv_S072	3.564	0.276	3.379	0.246	3.212	0.234	3.086	0.226
F_HondoCk_S010	2.284	0.180	2.084	0.150	1.913	0.139	1.784	0.130
F_HondoCk_S020	1.570	0.177	1.383	0.147	1.215	0.135	1.089	0.127
F_HondoCk_S021	3.554	0.275	3.373	0.245	3.208	0.233	3.082	0.225
F_MVerdeCk_S010	3.600	0.280	3.400	0.250	3.229	0.239	3.100	0.230
F_MVerdeCk_S011	3.566	0.276	3.380	0.246	3.213	0.235	3.087	0.226
F_MVerdeCk_S021	3.507	0.269	3.346	0.239	3.186	0.228	3.064	0.219
F_MVerdeCk_S020	3.625	0.273	3.450	0.243	3.286	0.232	3.161	0.223
F_HondoCk_S030	3.518	0.271	3.353	0.241	3.191	0.229	3.069	0.221
F_HondoCk_S031	3.579	0.278	3.388	0.248	3.219	0.236	3.092	0.228
F_SecoCk_S010	1.600	0.180	1.400	0.150	1.229	0.139	1.100	0.130
F_SecoCk_S020	1.584	0.178	1.391	0.148	1.222	0.137	1.094	0.128
F_SecoCk_S021	1.510	0.170	1.348	0.140	1.187	0.128	1.065	0.120
F_SecoCk_S030	3.899	0.270	3.736	0.240	3.574	0.229	3.452	0.220
F_SecoCk_S031	3.547	0.274	3.369	0.244	3.204	0.233	3.080	0.224
F_HondoCk_S040	3.569	0.276	3.382	0.246	3.215	0.235	3.088	0.226
FrioRv_S080	3.571	0.277	3.383	0.247	3.216	0.235	3.089	0.227
F_LeonaRv_S010	4.500	0.176	4.500	0.146	4.500	0.135	4.500	0.126
F_LeonaRv_S011	3.004	0.169	2.845	0.139	2.684	0.128	2.563	0.119
F_LeonaRv_S012	4.310	0.169	4.149	0.139	3.988	0.128	3.867	0.119
F_LeonaRv_S020	3.005	0.169	2.845	0.139	2.685	0.128	2.564	0.119
F_LeonaRv_S021	3.822	0.275	3.640	0.245	3.474	0.234	3.349	0.225
F_LeonaRv_S022	3.552	0.274	3.372	0.244	3.207	0.233	3.082	0.224
F_LeonaRv_S023	3.586	0.278	3.392	0.248	3.222	0.237	3.094	0.228
F_LeonaRv_S030	3.552	0.274	3.372	0.244	3.207	0.233	3.082	0.224
F_LeonaRv_S031	3.578	0.277	3.387	0.247	3.219	0.236	3.092	0.227
F_LeonaRv_S040	3.573	0.277	3.385	0.247	3.217	0.236	3.090	0.227
F_LeonaRv_S041	3.600	0.280	3.400	0.250	3.229	0.239	3.100	0.230
F_LeonaRv_S042	3.595	0.279	3.397	0.249	3.227	0.238	3.098	0.229
FrioRv_S090	3.596	0.280	3.398	0.250	3.227	0.238	3.098	0.230
FrioRv_S100	3.600	0.280	3.400	0.250	3.229	0.239	3.100	0.230
FrioRv_S101	3.587	0.278	3.392	0.248	3.223	0.237	3.095	0.228

	2% AEP	2% AEP	1% AEP	1% AEP	0.5% AEP	0.5% AEP	0.2% AEP	0.2% AEP
	50-yr	50-yr	100-yr	100-yr	200-yr	200-yr	500-yr	500-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
FrioRv_S102	3.528	0.272	3.359	0.242	3.196	0.230	3.072	0.222
F_CiboloCk_S010	3.600	0.280	3.400	0.250	3.229	0.239	3.100	0.230
F_CiboloCk_S011	3.600	0.280	3.400	0.250	3.229	0.239	3.100	0.230
F_CiboloCk_S020	3.487	0.267	3.335	0.237	3.177	0.226	3.057	0.217
FrioRv_S110	3.499	0.268	3.342	0.238	3.182	0.227	3.061	0.218
FrioRv_S111	3.447	0.262	3.312	0.232	3.158	0.221	3.041	0.212
FrioRv_S112	3.393	0.256	3.280	0.226	3.132	0.215	3.020	0.206
FrioRv_S113	3.395	0.256	3.282	0.226	3.133	0.215	3.021	0.206
FrioRv_S114	3.406	0.258	3.288	0.228	3.138	0.216	3.025	0.208
FrioRv_S120	3.450	0.263	3.313	0.233	3.159	0.221	3.042	0.213
F_SanMigCk_S010	1.804	0.253	1.631	0.223	1.467	0.211	1.343	0.203
F_SanMigCk_S011	1.836	0.258	1.642	0.228	1.473	0.217	1.345	0.208
F_SanMigCk_S020	1.970	0.260	1.772	0.230	1.602	0.218	1.473	0.210
F_SanMigCk_S022	1.703	0.243	1.565	0.213	1.410	0.202	1.293	0.193
F_SanMigCk_S021	1.800	0.254	1.621	0.224	1.456	0.213	1.331	0.204
F_SanMigCk_S023	1.869	0.244	1.728	0.214	1.573	0.202	1.455	0.194
F_SanMigCk_S024	3.812	0.265	3.667	0.235	3.511	0.223	3.393	0.215
ChokeCanyon_S010	3.410	0.258	3.290	0.228	3.140	0.217	3.027	0.208
FrioRv_S130	3.489	0.267	3.336	0.237	3.177	0.226	3.057	0.217
Atascosa_S010	2.264	0.230	2.064	0.200	1.893	0.189	1.764	0.180
Atascosa_S011	2.121	0.230	1.921	0.200	1.751	0.189	1.621	0.180
Atascosa_S020	2.489	0.230	2.289	0.200	2.118	0.189	1.989	0.180
Atascosa_S030	2.124	0.225	1.941	0.195	1.775	0.184	1.649	0.175
Atascosa_S031	2.100	0.230	1.900	0.200	1.729	0.189	1.600	0.180
Atascosa_S040	2.035	0.222	1.862	0.192	1.699	0.181	1.575	0.172
Atascosa_S041	1.959	0.214	1.818	0.184	1.663	0.172	1.546	0.164
Atascosa_S050	2.096	0.215	1.952	0.185	1.795	0.173	1.677	0.165
La_ParitaCk_S010	2.194	0.218	2.037	0.188	1.877	0.177	1.756	0.168
La_ParitaCk_S020	2.049	0.220	1.887	0.190	1.726	0.178	1.605	0.170
La_ParitaCk_S030	1.963	0.214	1.821	0.184	1.665	0.173	1.547	0.164
Atascosa_S060	1.981	0.216	1.831	0.186	1.674	0.175	1.554	0.166
Atascosa_S070	2.953	0.259	2.829	0.229	2.678	0.218	2.564	0.209
Atascosa_S071	2.976	0.257	2.859	0.227	2.709	0.216	2.596	0.207
Atascosa_S080	2.975	0.266	2.828	0.236	2.671	0.224	2.552	0.216
FrioRv_S140	2.963	0.264	2.821	0.234	2.665	0.223	2.547	0.214
NuecesRv_S240	1.733	0.166	1.582	0.136	1.424	0.125	1.305	0.116
NuecesRv_S250	1.827	0.177	1.637	0.147	1.468	0.136	1.341	0.127
NuecesRv_S260	1.807	0.175	1.625	0.145	1.459	0.134	1.334	0.125

	2% AEP	2% AEP	1% AEP	1% AEP	0.5% AEP	0.5% AEP	0.2% AEP	0.2% AEP
	50-yr	50-yr	100-yr	100-yr	200-yr	200-yr	500-yr	500-yr
Subbasin Name	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)	Initial Deficit (in)	Constant (in/hr)
NuecesRv_S261	1.911	0.176	1.724	0.146	1.556	0.135	1.430	0.126
NuecesRv_S270	1.813	0.176	1.629	0.146	1.462	0.134	1.336	0.126
NuecesRv_S290	1.782	0.172	1.611	0.142	1.448	0.131	1.324	0.122
N_LagartoCk_S010	1.834	0.178	1.641	0.148	1.472	0.137	1.344	0.128
N_LagartoCk_S020	1.833	0.178	1.640	0.148	1.471	0.137	1.344	0.128
RamirenaCk_S010	1.832	0.178	1.640	0.148	1.471	0.137	1.343	0.128
RamirenaCk_S020	1.820	0.177	1.633	0.147	1.465	0.135	1.339	0.127
CorpusChristi_S010	1.731	0.166	1.581	0.136	1.424	0.125	1.304	0.116
CorpusChristi_S011	1.807	0.175	1.625	0.145	1.459	0.134	1.333	0.125
NuecesRv_S300	2.053	0.167	1.902	0.137	1.744	0.125	1.624	0.117
NuecesRv_S310	1.480	0.166	1.331	0.136	1.173	0.125	1.054	0.116

1.6 ELLIPTICAL FREQUENCY STORM RESULTS

The frequency peak flow values were then calculated in HEC-HMS by applying the appropriate, optimized elliptical frequency storms for each junction of interest in the final HEC-HMS basin model. These results will later be compared to the uniform rain results from HEC-HMS along with other methods from this study.

In some cases, one may observe that the simulated peak discharge decreases in the downstream direction. It is not an uncommon phenomenon to see decreasing frequency peak discharges for some river reaches as flood waters spread out into the floodplain and the hydrograph becomes dampened as it moves downstream. This can be due to a combination of peak attenuation due to river routing as well as the difference in timing between the peak of the main stem river versus the runoff from the local tributaries and subbasins.

1.6.1 **Tabular Results**

The final HEC-HMS peak frequency flow results for the locations of interest throughout the watershed model using the NOAA Atlas 14 rainfall depths can be seen below in Table C.7. For the reservoirs, the final HEC-HMS frequency pool elevation and peak outflow results are summarized in Tables C.8 and C.9. The locations of the elliptical storms for these reservoirs were optimized to maximize the reservoir's pool elevation rather than the peak streamflow.

Table C.7: Summary of Discharges (cfs) from the HEC-HMS Elliptical Frequency Storm Method

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area (sq mi)	50% AEP 2-yr	20% AEP 5-yr	10% AEP 10-yr	4% AEP 25-yr	2% AEP 50-yr	1% AEP 100-yr	0.5% AEP 200-yr	0.2% AEP 500-yr
West Nueces River above Sycamore Creek	W_NuecesRv_abv_SycamoreCk	535.95	4582	30159	70085	119293	152438	197744	229144	293108
West Nueces River Below Sycamore Creek	W_NuecesRv_blw_SycamoreCk	646.40	4571	33093	78060	135144	173078	226452	263543	338382
West Nueces River near Brackettville (USGS gage 08190500)	W_NuecesRv_nr_Brackettville	693.94	4312	32485	77030	133549	171638	225642	263575	340224
West Nueces River above Live Oak	W_NuecesRv_abv_Live OakCk	767.91	4025	30720	72726	126050	161982	212831	250160	324554
West Nueces River Below Live Oak	W_NuecesRv_blw_Live OakCk	820.22	4118	31090	73300	126944	162948	214534	253148	329548
West Nueces River above Nueces River	W-NuecesRv_abv_NuecesRv	918.29	3792	28887	68347	118764	152814	203097	242491	317912
Nueces River below Pulliam Creek	NuecesRv_blw_PulliamCk	529.82	11082	37699	78581	149432	195156	246060	275874	341696
Nueces River at CR414 at Montell (USGS gage 08189998)	NuecesRv_at_Cr414_at_Montell	659.62	10187	37632	79950	155421	205724	263543	298397	373892
Nueces River below Montell Creek	NuecesRv_blw_MontellCk	679.24	10058	37314	79565	155037	205668	263979	299280	375610
Nueces River at Laguna (USGS gage 08190000)	NuecesRv_at_Laguna	736.17	9473	36388	78069	152806	203364	261562	298001	376135
Nueces River above West Nueces River	NuecesRv_abv_W_NuecesRv	815.94	9003	34591	74100	144958	193618	249731	286921	364678
Nueces River Below West Nueces River	NuecesRv_blw_W_NuecesRv	1734.22	9817	46827	109895	213868	281953	375738	439651	573210
Nueces River below Indian Creek	NuecesRv+IndianCk	1802.06	9599	44808	104910	204024	269004	359215	421038	550061
Nueces River at Highway 90	NuecesRv_at_HWY-90	1838.04	9070	42072	98844	192614	254165	339761	398483	521010
Nueces River near Uvalde (USGS gage 08192000)	NuecesRv_nr_Uvalde	1861.45	7861	39076	92551	181005	238919	320289	376722	493324
Nueces River at Highway 83	NuecesRv_at_HWY-83	1885.45	5772	27739	67335	134062	177160	239183	282588	371476
Nueces River at Highway 57	NuecesRv_at_HWY-57	1981.12	2497	16979	38254	88239	122522	166496	200030	269221
Nueces River at FM 1025 nr Crystal City (USGS gage 08192550)	NuecesRv_at_FM-1025_nr_Cryst	2102.48	1896	9629	20300	42410	65742	120263	150795	208127
Nueces River at The Turkey Creek/Espantosa Slough Split	NuecesRv_TurkeyCk_Split	2122.77	1100	6714	13614	27904	38917	66016	104987	152829
Turkey Creek/Espantosa Slough Diversion	TurkeyCk_Diversion	2122.77	835	4888	9305	19195	27834	52907	91146	138656
Nueces River Split	NuecesRv_Split_J010	2165.25	2280	3548	3817	5927	8837	11869	14905	19433
Nueces River above Turkey Creek	NuecesRv_abv_TurkeyCk	2165.25	327	1292	2804	5962	7649	9531	10610	11966
Palo Blanco Creek below Chacon Creek	Palo_BlancoCk_blw_ChaconCk	520.34	9468	17389	23255	32912	52124	70405	89805	108132.84
Palo Blanco Creek above Picosa Creek	Palo_BlancoCk_abv_PicosaCk	520.34	7047	13720	18720	27183	44496	63599	84621	121125.83
Palo Blanco Creek below Picosa Creek	Palo_BlancoCk_blw_PicosaCk	744.76	8538	18865	26459	41221	73000	108128	123440	172629
Palo Blanco Creek above Comanche Creek	Palo_BlancoCk_abv_ComancheC	744.76	8110	17904	25150	39095	69395	102890	117099	164042.78
Palo Blanco Creek Below Comanche Creek	Palo_BlancoCk_blw_ComancheC	822.94	9589	21420	30256	46719	83536	124525	130173	182209.88

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area (sq mi)	50% AEP 2-yr	20% AEP 5-yr	10% AEP 10-yr	4% AEP 25-yr	2% AEP 50-yr	1% AEP 100-yr	0.5% AEP 200-yr	0.2% AEP 500-yr
Turkey Creek below Chaparrosa Creek	TurkeyCk_blw_ChaparrosaCk	414.59	9131	16388	23418	37075	66876	99641	126576	172589.5
Turkey Creek above Picosa Creek	TurkeyCk_abv_PicosaCk	459.10	4393	8993	12913	20057	34351	50349	64614	90819
Turkey Creek below Picosa Creek	TurkeyCk_blw_PicosaCk	1376.61	10720	23997	33879	52732	94863	140113	175639	197419
Turkey Creek at Highway 83 (New USGS gage)	TurkeyCk_at_HWY-83	1554.98	7624	14939	20209	31476	59803	92969	119369	143767
Turkey Creek above Turkey Split	TurkeyCk_abv_Turkey_Split	1563.55	6137	13433	19350	31267	58982	91769	117685	141941
Turkey Creek below Turkey Split	TurkeyCk_blw_Turkey_Split	1568.83	3258	10555	15677	27315	45794	77624	122248	202459
Turkey Creek above Carrizo Creek	TurkeyCk_abv_CarrizoCk	1581.46	4211	10790	16401	29023	51348	77754	107049	189279
Turkey Creek below Carrizo Creek	TurkeyCk_blw_CarrizoCk	1662.70	4405	11216	16835	29704	53148	80069	107071	189614
Turkey Creek above El Barrosa Creek	TurkeyCk_abv_El_BarrosaCk	1687.81	4416	9986	15392	27769	51169	78254	102751	177632
Turkey Creek below El Barrosa Creek	TurkeyCk_blw_El_BarrosaCk	1718.21	4436	10022	15471	27918	51516	78669	103501	178515
Turkey Creek and El Moro Creek	TurkeyCk+El_MoroCk	1836.07	4917	10063	15480	28362	53083	80689	104354	178352
Turkey Creek above Nueces River	TurkeyCk_abv_NuecesRv	1847.03	4537	9601	15221	27865	51994	79673	103716	178074
Nueces River near Asherton (USGS gage 08193000)	NuecesRv_nr_Asherton	4024.67	4782	10112	16729	30656	53059	82459	108633	185705
Nueces River above Arroyo Negro	NuecesRv_abv_Arroyo_Negro	4213.49	5072	9962	16557	30320	50085	80886	106707	178866
Nueces River below Arroyo Negro	NuecesRv_blw_Arroyo_Negro	4333.02	5469	10343	16965	30840	51598	82145	107114	179262
Nueces River above Appurceon Creek	NuecesRv_abv_AppurceonCk	4333.02	5067	10128	16751	30505	50243	81141	106371	176740
Nueces River below Appurceon Creek	NuecesRv_blw_AppurceonCk	4411.17	5504	10516	17159	31060	51999	82668	107018	177176
Nueces River above San Roque Creek	NuecesRv_abv_San_RoqueCk	4488.43	5426	10508	17042	30647	50638	81385	105342	171730
Nueces River below San Roque Creek	NuecesRv_blw_San_RoqueCk	4903.91	6376	14198	22771	34041	51073	82027	105602	172809
Nueces River and Espio Creek	NuecesRv+EspioCk	5084.65	6410	14066	22467	33517	50282	81064	104276	169301
Nueces River at Cotulla (USGS gage 08194000)	NuecesRv_at_Cotulla	5172.43	6238	12797	20444	31319	50514	80913	103781	165323
Nueces River above La Raices Creek	NuecesRv_abv_La_RaicesCk	5366.43	6518	12876	20165	30654	48939	78199	100207	157644
Nueces River below La Raices Creek	NuecesRv_blw_La_RaicesCk	5638.55	6399	12697	19946	30652	48615	78033	100323	158194
Nueces River above Calman Creek	NuecesRv_abv_CalmanCk	5705.26	6432	12442	19399	30236	47789	76534	98303	154205
Nueces River below Calman Creek	NuecesRv_blw_CalmanCk	5890.78	6422	12474	19448	30426	48204	76998	98866	154701
Nueces River above Los Olmos Creek	NuecesRv_abv_Los_OlmosCk	5898.22	6730	12989	20061	30292	47835	76355	97875	153247
Nueces River below Los Olmos Creek	NuecesRv_blw_Los_OlmosCk	6353.75	8040	18523	28252	42338	70009	97545	119384	157635
Nueces River and Sauz Creek	NuecesRv+SauzCk	6419.66	7795	18077	27563	41347	68390	95455	117169	155429
Nueces River above San Casimiro Creek	NuecesRv_abv_San_CasimiroCk	6445.15	7250	17125	26251	39536	65410	91565	113194	150755

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area (sq mi)	50% AEP 2-yr	20% AEP 5-yr	10% AEP 10-yr	4% AEP 25-yr	2% AEP 50-yr	1% AEP 100-yr	0.5% AEP 200-yr	0.2% AEP 500-yr
San Casimiro Creek near Freer (USGS gage 08194200)	San_CasimiroCk_nr_Freer	467.65	2591	7818	15916	32312	42865	57261	69929	90799
San Casimiro Creek above Nueces River	San_CasimiroCk_abv_NuecesRv	537.34	2184	6878	14224	29129	38633	51899	63912	83457
Nueces River below San Casimiro Creek	NuecesRv_blw_San_CasimiroCk	6982.49	6899	18406	32891	58396	88594	125183	153121	204133
Nueces River above Black Creek	NuecesRv_abv_BlackCk	7007.66	6773	18041	32087	56864	86383	122162	149762	200105
Nueces River below Black Creek	NuecesRv_blw_BlackCk	7431.13	5976	18689	33503	59668	91787	131351	163212	221346
Nueces River above Ygnacio Creek	NuecesRv_abv_YgnacioCk	7611.07	6326	18564	32037	55401	85573	122411	150655	204993
Nueces River below Ygnacio Creek	NuecesRv_blw_YgnacioCk	7754.47	6160	18440	31994	55503	85706	122661	151095	205604
Nueces River above San Jose Creek	NuecesRv_abv_San_JoseCk	7754.47	6086	18351	31856	55266	85342	122142	150372	204550
Nueces River below San Jose Creek	NuecesRv_blw_San_JoseCk	7857.73	6085	18346	31880	55315	85382	122176	150517	204798
Nueces River above Green Branch	NuecesRv_abv_GreenBr	7857.73	6038	18202	31620	54836	84652	121142	148958	202575
Nueces River below Green Branch	NuecesRv_blw_GreenBr	7943.10	6154	18337	31709	54853	84690	121169	148964	202717
Nueces River near Tilden (USGS gage 08194500)	NuecesRv_nr_Tilden	8105.85	5755	17604	30699	53239	82146	117619	144633	196969
Nueces River above Cow Creek	NuecesRv_abv_CowCk	8105.85	6045	17508	30168	51969	80234	114903	140593	191913
Nueces River below Cow Creek	NuecesRv_blw_CowCk	8182.92	5825	17429	30260	52315	80708	115529	141806	193230
Nueces River above Old River	NuecesRv_abv_OldRv	8275.85	5548	16735	29187	50531	77905	111670	137128	187323
Nueces River below Old River	NuecesRv_blw_OldRv	8354.07	5561	16732	29196	50558	77964	111733	137215	187336
Nueces River and White Creek	NuecesRv+WhiteCk	8464.98	5390	16107	28049	48461	74651	107000	131210	179340
Nueces River above Atascosa River	NuecesRv_abv_AltascosaRv	8519.43	5167	15238	26556	45821	70487	101154	124079	170219
Frio River at Concan (USGS gage 08195000)	FrioRv_at_Concan	389.64	9269	34597	60944	102611	137608	176792	203643	254215
Frio River abov Dry Frio River	FrioRv_abv_Dry_FrioRv	441.57	8042	31344	55521	93931	126187	163493	189825	238710
Frio River below Dry Frio River	FrioRv_blw_Dry_FrioRv	628.74	11038	43437	78945	135767	181951	235781	274043	345112
Frio River near Uvalde (USGS gage 08197500)	FrioRv_nr_Uvalde	633.06	10136	40537	73981	127166	170689	221566	257458	324606
Frio River above Blanco Creek	FrioRv_abv_BlancoCk	745.82	3202	21613	41253	74870	101067	130970	155395	201338
Frio River below Blanco Creek	FrioRv_blw_BlancoCk	879.41	4342	22129	41463	76842	106412	140055	167320	218405
Frio River below Sabinal River	FrioRv_blw_SabinalRv	1338.62	5072	21079	39588	77233	114334	155838	191282	257090
Frio River above Elm Creek	FrioRv_abv_ElmCk	1411.00	2300	14903	25959	52309	80446	113687	144611	201228
Frio River below Elm Creek	FrioRv_blw_ElmCk	1499.66	2196	15068	26369	52761	81211	114818	146185	203904
Frio River above Hondo Creek	FrioRv_abv_HondoCk	1514.24	2206	12798	23527	50194	79618	113494	144292	202036
Hondo Creek and Live Oak Creek	HondoCk+Live_OakCk	521.81	8548	16674	25107	50362	75616	102069	121821	157608

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area (sq mi)	50% AEP 2-yr	20% AEP 5-yr	10% AEP 10-yr	4% AEP 25-yr	2% AEP 50-yr	1% AEP 100-yr	0.5% AEP 200-yr	0.2% AEP 500-yr
Hondo Creek above Seco Creek	HondoCk_abv_SecoCk	666.04	6795	12988	19075	40170	62119	85120	102860	134957
Hondo Creek below Seco Creek	HondoCk_blw_SecoCk	1019.99	7061	17454	29140	57359	84955	116036	138413	181461
Hondo Creek above Frio River	HondoCk_abv_FrioRv	1106.85	6552	16159	26832	53425	79929	109652	131077	172621
Frio River below Hondo Creek	FrioRv_blw_HondoCk	2621.10	6143	21567	36476	79502	121801	173801	212810	282704
Frio River above Leona River	FrioRv_abv_LeonaRv	2675.30	3713	15271	29205	66726	109390	158366	195090	262289
Leona River below Live Oak Creek	LeonaRv_blw_LiveoakCk	460.74	3798	4949	5919	12227	26004	37540	47684	65540
Leona River above Todos Santos Creek	LeonaRv_abv_Todos_SantosCk	585.22	3657	4693	6572	11876	26021	37948	48376	67186
Leona River below Todos Santos Creek	LeonaRv_blw_Todos_SantosCk	660.74	3728	4762	6975	12133	26704	38999	49682	69076
Leona River above Frio River	LeonaRv_abv_FrioRv	670.08	3592	4572	6830	11758	26068	38167	48650	67648
Frio River below Leona River	FrioRv_blw_LeonaRv	3345.37	4541	15689	28645	66087	110072	162174	199771	270376
Frio River near Derby (USGS gage 08215500)	FrioRv_nr_Derby	3447.76	4691	14326	25957	63405	107132	159274	196828	267574
Frio River at Highway 85	FrioRv_at_HWY-85	3500.89	3587	12018	22615	58359	99110	149684	185845	254798
Frio River and Ruiz Creek	FrioRv+RuizCk	3653.55	1941	8650	18226	48136	87636	136769	171972	246178
Frio River above Cibolo Creek	FrioRv_abv_CiboloCk	3698.16	1942	6862	13890	37993	78949	130155	164570	238716
Frio River below Cibolo Creek	FrioRv_blw_CiboloCk	4092.91	2279	11574	19245	40757	80848	134270	169829	246147
Frio River above Esperanza Creek	FrioRv_abv_EsperanzaCk	4149.39	2192	7962	13186	36184	72086	125098	160885	235393
Frio River below Esperanza Creek	FrioRv_blw_EsperanzaCk	4248.12	2498	8502	14061	36305	71740	124538	160363	235180
Frio River and Galinda Creek	FrioRv+GalindaCk	4337.72	2588	8813	13979	33230	64486	115603	151568	225176
Frio River above Leoncita Creek	FrioRv_abv_LeoncitaCk	4396.25	2743	8388	14116	31315	59212	108377	143728	215917
Frio River at Tilden (USGS gage 08206600)	FrioRv_at_Tilden	4462.81	2778	8424	14222	31432	59486	108645	144078	216335
Frio River above San Miguel Creek	FrioRv_abv_San_MiguelCk	4519.46	2713	8339	14074	31371	59252	107583	142835	214796
San Miguel Creek below Highway 97	SanMiguelCk_blw_HWY-97	516.77	2957	7632	13377	25174	35751	46768	58843	90100
San Miguel Creek above Lagunillas Creek	SanMiguelCk_abv_LagunillasCk	574.60	2798	7375	12972	24488	34897	45590	55098	80845
San Miguel Creek below Lagunillas Creek	SanMiguelCk_blw_LagunillasCk	741.44	3357	8724	16569	31906	46153	60375	71451	91766
San Miguel Creek near Tilden (USGS gage 08206700)	SanMiguelCk_nr_Tilden	782.15	3361	8883	15826	30754	44574	58681	69618	90227
San Miguel Creek above Frio River	SanMiguelCk_abv_FrioRv	854.80	7057	11580	16475	30121	43567	58818	70803	92566
Frio River below San Miguel Creek	FrioRv_blw_San_MiguelCk	5374.26	3003	8723	15033	31570	59422	107949	143073	216052
Choke Canyon Reservoir Inflow	ChokeCanyon_Inflow	5490.45	2896	8557	14538	31296	59001	107421	142449	215104
Frio River below Choke Canyon Dam	ChokeCanyonRes_OWC_nr_3Rv	5490.45	1784	8456	14400	29872	53860	97726	130120	177334

Location Description	HEC-HMS Element Name	HEC-HMS Drainage Area (sq mi)	50% AEP 2-yr	20% AEP 5-yr	10% AEP 10-yr	4% AEP 25-yr	2% AEP 50-yr	1% AEP 100-yr	0.5% AEP 200-yr	0.2% AEP 500-yr
Frio River above Atascosa River	FrioRv_abv_AtascosaRv	5496.36	1905	8663	14769	29829	53925	97879	130159	177519
Atascosa River at Highway 37	AtascosaRv_at_HWY-37	451.31	4401	9931	16127	25929	35894	48683	59407	78005
Atascosa River near McCoy (USGS gage 08207500)	AtascosaRv_nr_McCoy	510.87	3915	9191	14934	24735	34352	47774	59026	78260
Atascosa River above Borrego Creek	AtascosaRv_abv_BorregoCk	535.96	3760	8783	14483	23998	33545	46869	58148	78440
Borrego Creek and Los Cortes Creek	BorregoCk+Los_CortesCk	142.92	3780	7327	10551	15809	20971	26996	32265	41337
Borrego Creek above Atascosa River	BorregoCk_abv_AtascosaRv	221.19	3293	6800	10176	16132	22183	29957	36443	48985
Atascosa River below Borrego Creek	AtascosaRv_blw_BorregoCk	757.15	4471	11541	19403	32109	44486	63449	79013	108885
Atascosa River above La Parita Creek	AtascosaRv_abv_La_ParitaCK	813.17	4156	11197	18453	30837	42685	60849	75965	106482
Atascosa River below La Parita Creek	AtascosaRv_blw_La_PartaCk	1124.57	4372	12250	20554	35012	48397	70922	88424	127415
Atascosa River at Whitsett (USGS gage 0820800)	AtascosaRv_at_Whitsett	1145.77	4152	11935	19923	34228	47122	68979	86246	124646
Atascosa River above Weedy Creek	AtascosaRv_abv_WeedyCk	1225.28	4688	11817	19689	33601	46460	67877	84598	122019
Atascosa river below Weedy Creek	AtascosaRv_blw_WeedyCk	1364.40	9860	15386	20025	33930	46879	68748	85822	125236
Atascosa River above Frio River	AtascosaRv_abv_FrioRv	1395.61	9341	13957	19481	33061	45718	67068	83748	122237
Atascosa River below Frio River	AtascosaRv_blw_FrioRv	6891.97	16559	29360	42022	57103	65453	94463	112900	161941
Atascosa River above Nueces River	AtascosaRv_abv_NuecesRv	6911.11	3639	11344	20122	29641	52546	98924	130833	183740
Nueces River below Atascosa River	NuecesRv_blw_AltascosaRv	15430.54	5093	14722	27896	47806	78020	121917	147795	199692
Nueces River at Three Rivers (USGS gage 08210000)	NuecesRv_at_Three_Rivers	15430.54	3761	12093	20109	34223	62547	113979	152914	219522
Nueces River and Sulphur Creek	NuecesRv+SulhpurCk	15619.12	5787	16141	30588	49531	75782	119787	145926	203420
Nueces River at Highway 59	NuecesRv_at_HWY-59	15715.07	23738	41670	52769	65112	71411	104792	126510	183773
Nueces River above Spring Creek	NuecesRv_abv_SpringCk	15733.03	4551	13627	25169	44480	74166	115863	139145	189154
Nueces River below Spring Creek	NuecesRv_blw_SpringCk	15833.59	5351	14982	28216	47410	76650	121772	147943	201840
Nueces River and Upper End of Lake Corpus Christi	NuecesRv+UpEnd_LkCorpusChris	15921.68	5432	15137	28978	48040	75712	120595	147914	203605
Nueces River above Lake Corpus Christi	NuecesRv_abv_LkCorpusCh	16076.35	5717	15856	28090	44020	67432	108607	132459	186821
Lake Corpus Christi Inflow	Lk_Corpus_Christi_Inflow	16502.10	5212	12100	24298	43371	70754	111184	134982	182220
Nueces River near Mathis (USGS gage 08211000, Dam Outflow)	NuecesRv_nr_Mathis	16502.10	3997	11847	19324	31990	56894	101267	137361	203390
Nueces at Bluntzer (USGS gage 08211200)	NuecesRv_at_Bluntzer	16617.60	3640	11317	19184	32474	58326	101951	134807	202356
Nueces River at Calallen (USGS gage 08211500)	NuecesRv_at_Calallen	16675.30	2881	9742	17185	28938	51018	93194	123914	187972

Table C.8: Peak Reservoir Pool Elevations (feet NAVD88) from the HEC-HMS Elliptical Frequency Storms

					Reservoir Elevations (ft NAVD 88)							
					50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Reservoir Name	HEC-HMS Drainage Area (sq mi)	Lon	Lat	Theta	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Corpus_Christi_Dam	5490.45	-99.2672	28.34891	97.818	93.86	93.98	94.14	94.26	94.49	94.99	95.38	96.01
Choke_Canyon_Dam	16502.1	-99.4247	29.26374	115.501	221	221.33	221.55	222.04	222.73	223.87	224.69	227.13

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Table C.9: Reservoir Peak Outflow (cfs) from the HEC-HMS Elliptical Frequency Storms

					Reservoir Peak Outflows (cfs)							
					50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Reservoir Name	HEC-HMS Drainage Area (sq mi)	Lon	Lat	Theta	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Corpus_Christi_Dam	5490.45	-99.2672	28.34891	97.818	4865.1	13154.5	24858.5	43805.1	70146	110881.7	136439.5	185549.3
Choke_Canyon_Dam	16502.1	-99.4247	29.26374	115.501	1820.5	8535.7	14470.3	29971.3	54156.7	98231.1	130616.9	177646.6

1.6.2 **Map Results**

The following ‘a’ figures represent the 100yr 48hr heatmap results for the optimization of each junction of interest in the Elliptical Frequency Storm HEC-HMS model. For each junction of interest, the optimization script ran 300+ times recording the junction flow rate for various storm centerings and orientations. Each of the recorded storm centerings (x,y) and resulting flow rates (z) at the junction of interest were recorded and used to create a rasterized heat map. The red shading represents storm center locations that led to relatively high flow rates at the junction whereas the green shading represents storm center locations that led to relatively low flow rates.

The following ‘b’ figures show the final, total storm depths and optimized storm configurations for each junction. Note that the peak flow values recorded in the ‘a’ figures may differ slightly from the final peak flow values recorded in the ‘b’ figures and in Table C.7 above. These differences are due to some small adjustments to the elliptical storm and HEC-HMS model parameters that occurred during the review process. The ‘b’ figures include the final peak flow values after peer review. The figures in this section are generally organized by major tributary and then by alphabetical order junction name. The figures for the reservoir optimizations are in the last subsection.

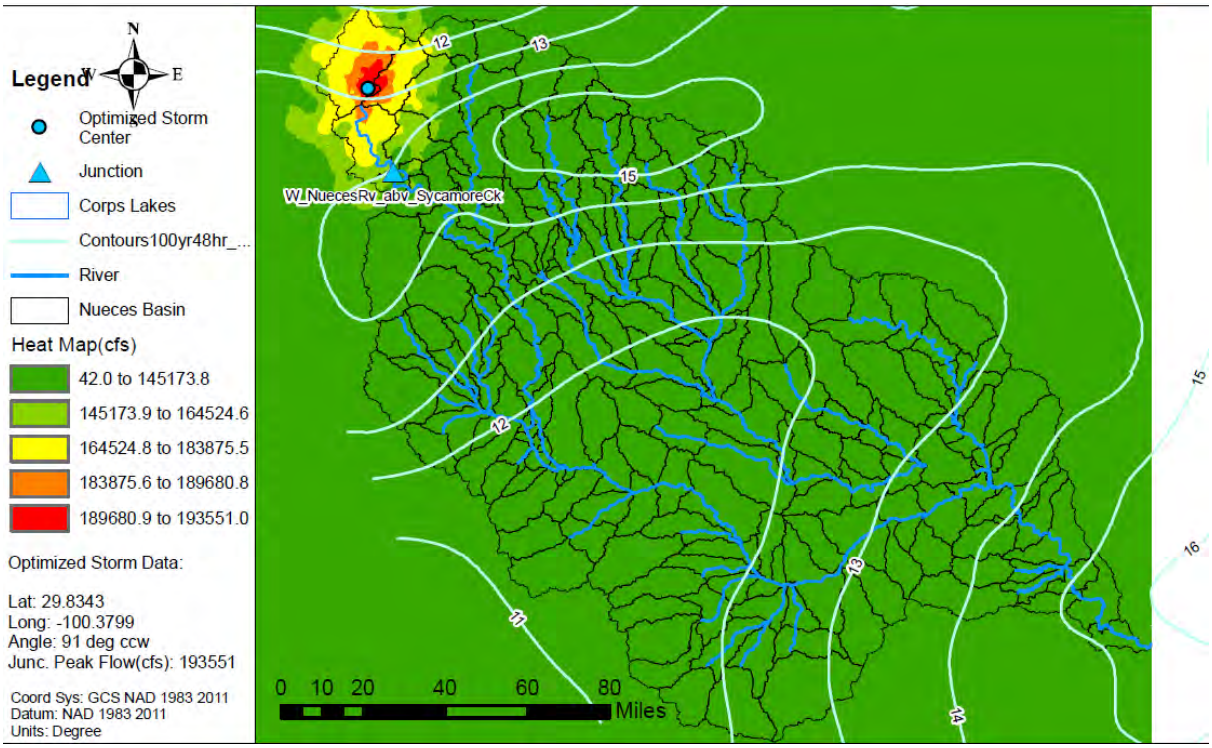

Figure C.11-1a: Elliptical Storm Optimization Heat Map for W_NuecesRv_abv_SycamoreCk

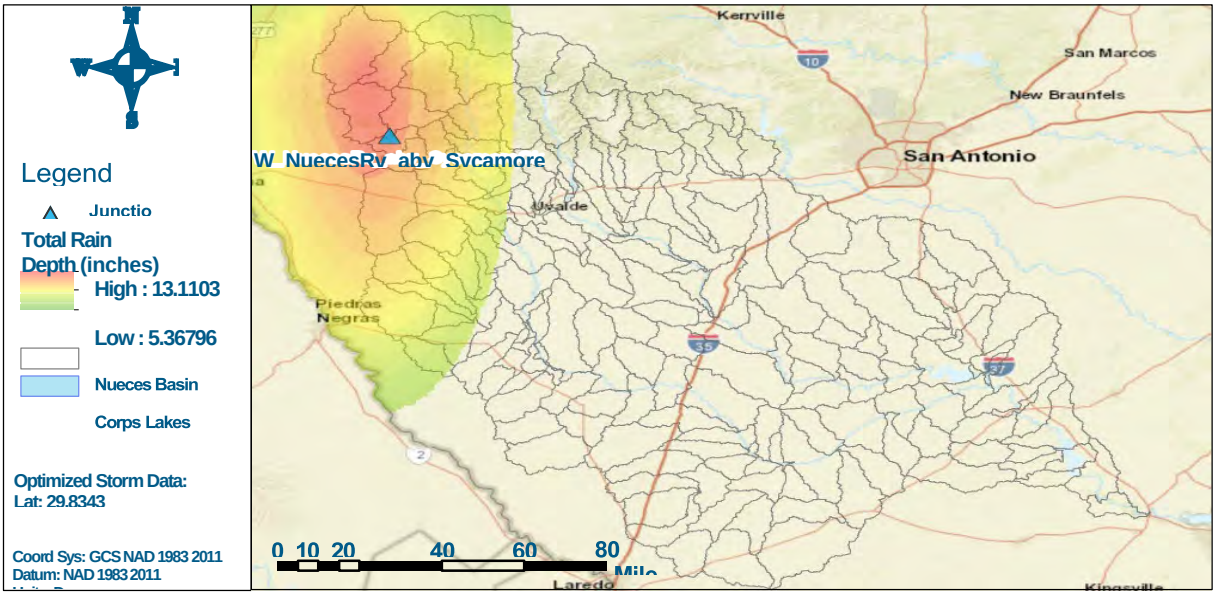

Figure C.11-1b: Elliptical Storm Optimization Heat Map for W_NuecesRv_abv_SycamoreCk

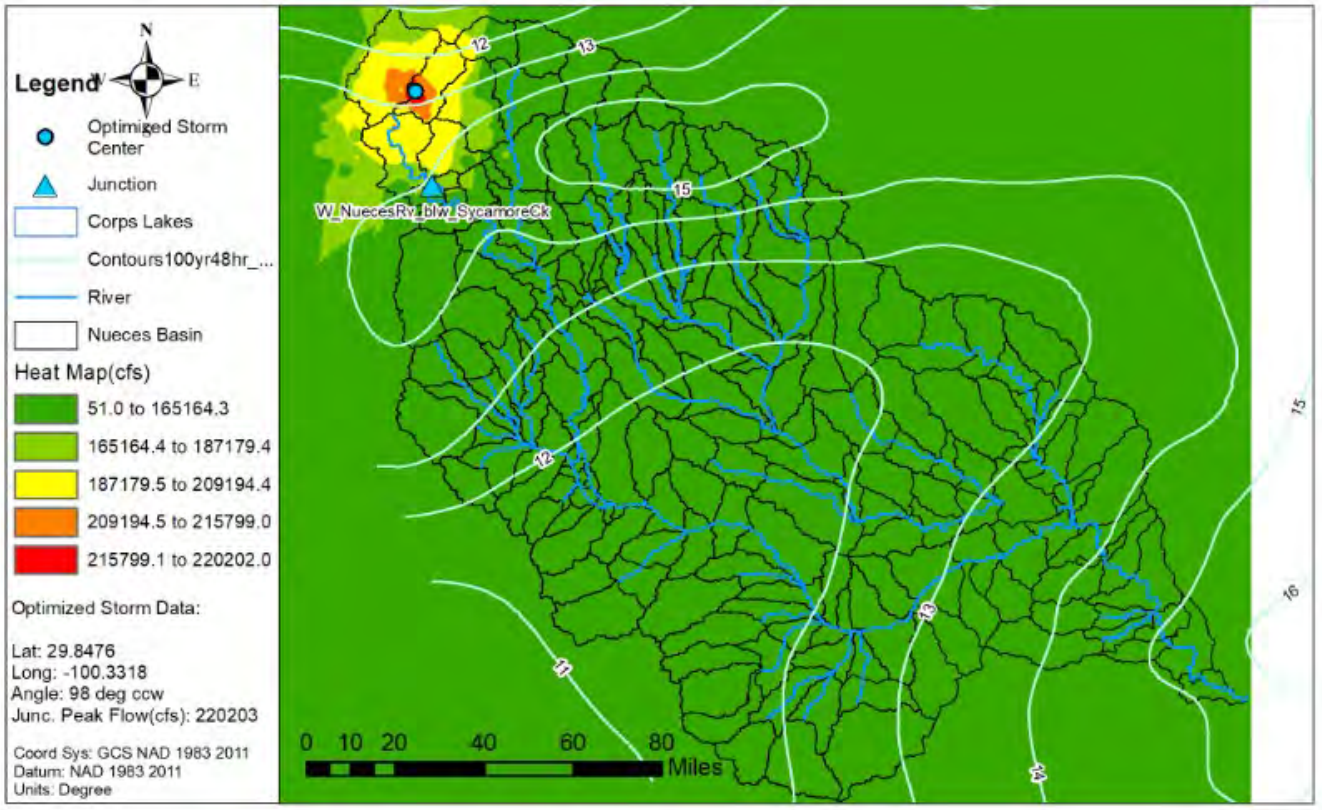

Figure C.11-2a: Elliptical Storm Optimization Heat Map for West Nueces River Below Sycamore Creek

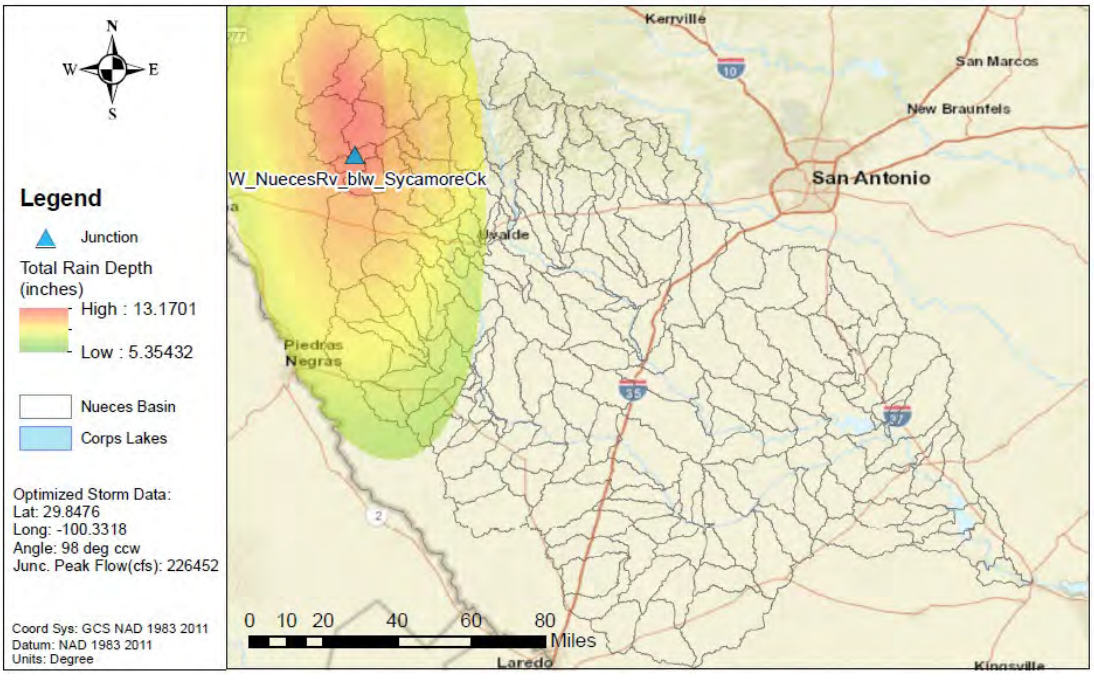

Figure C.11-2ba: Elliptical Storm Optimization Heat Map for West Nueces River Below Sycamore Creek

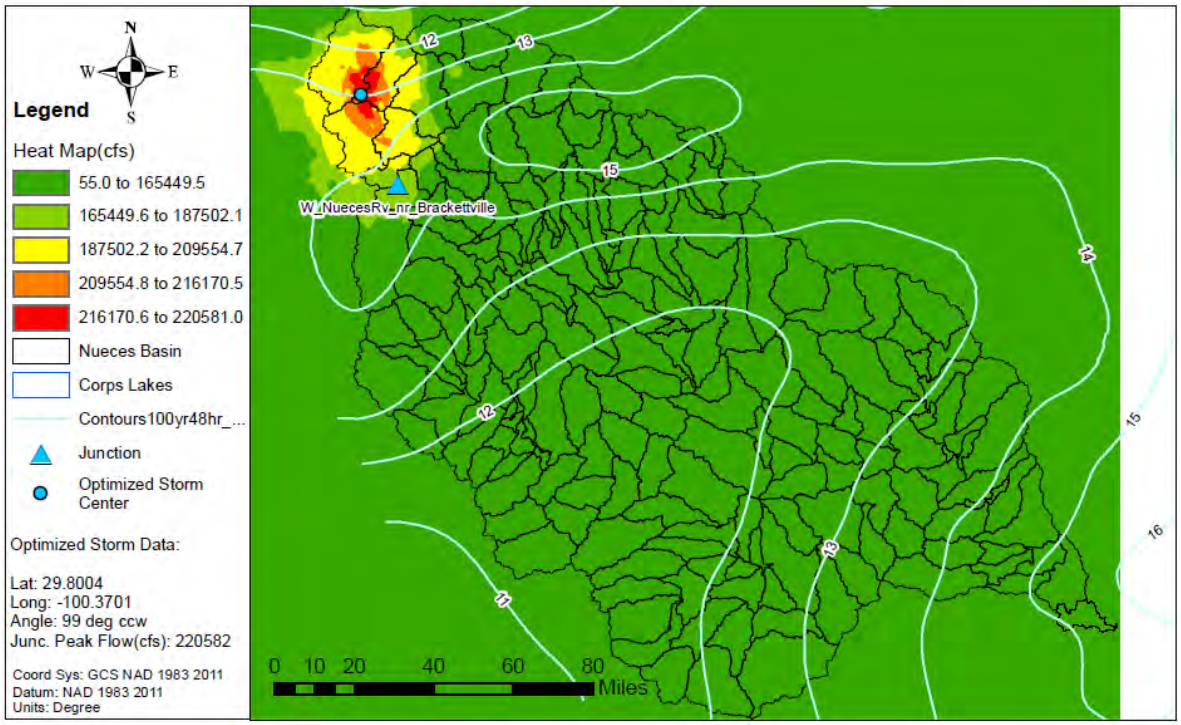

Figure C.11-3a: Elliptical Storm Optimization Heat Map for W_NuecesRv_nr_Brackettville

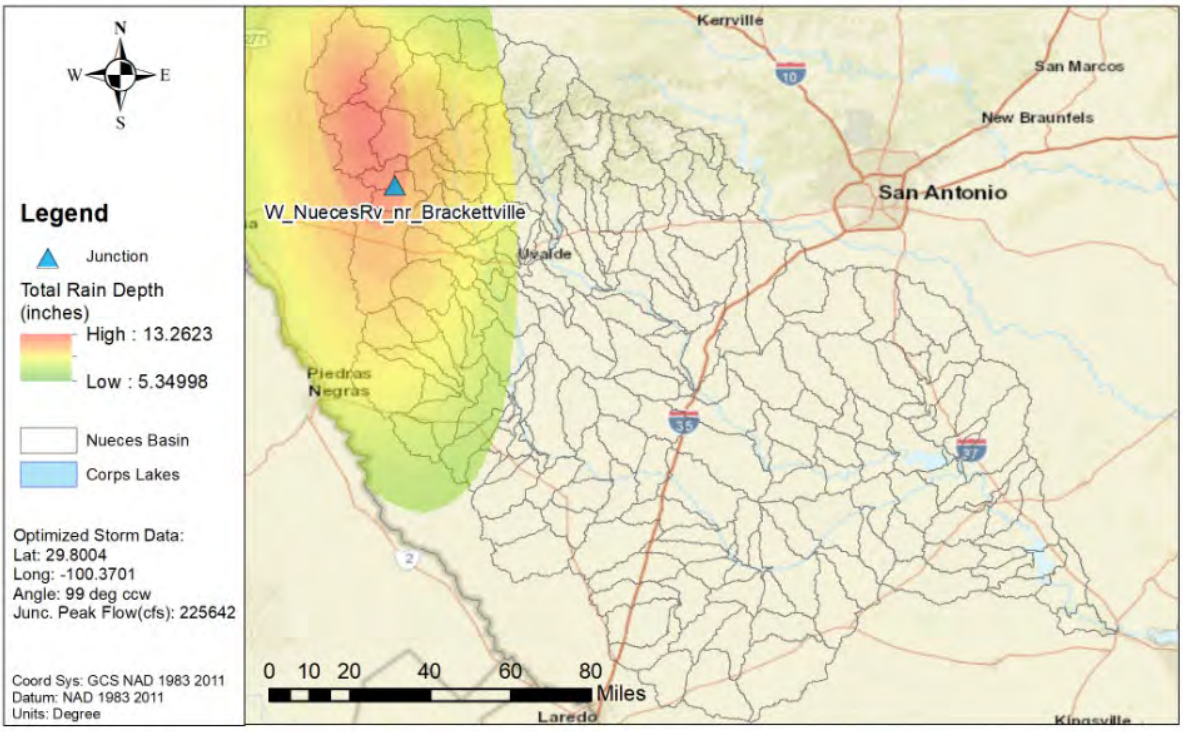

Figure C.11-3b: NA14 1% AEP Elliptical Storm for W_NuecesRv_nr_Brackettville

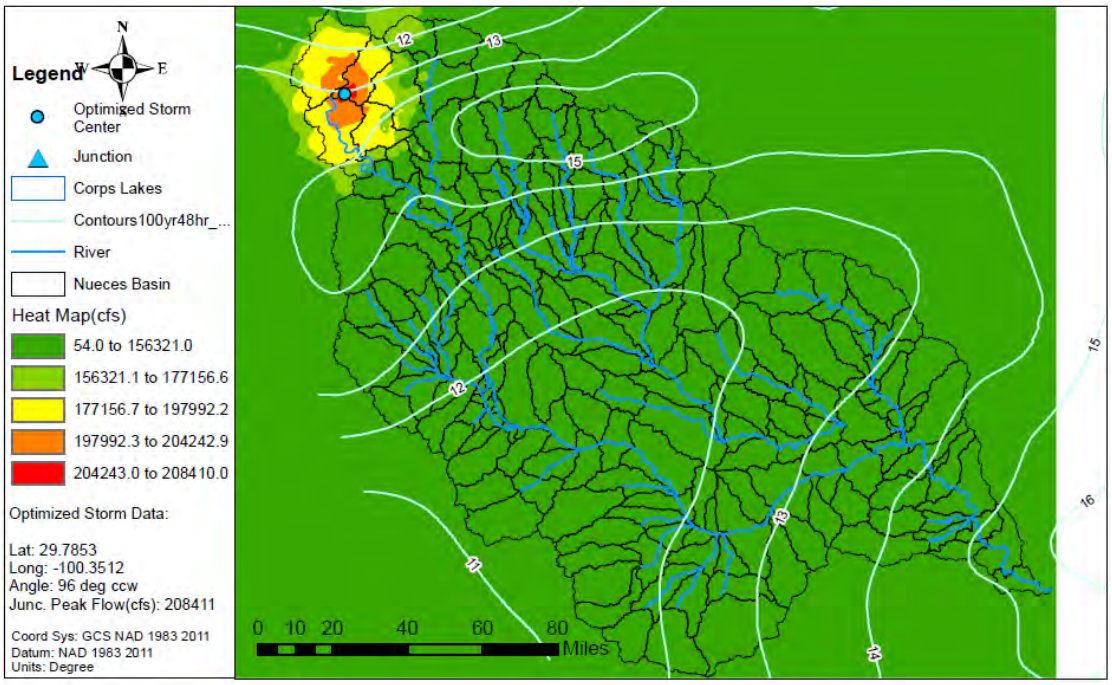

Figure C.11-4a: Elliptical Storm Optimization Heat Map for W_NuecesRv_abv_Live OakCk

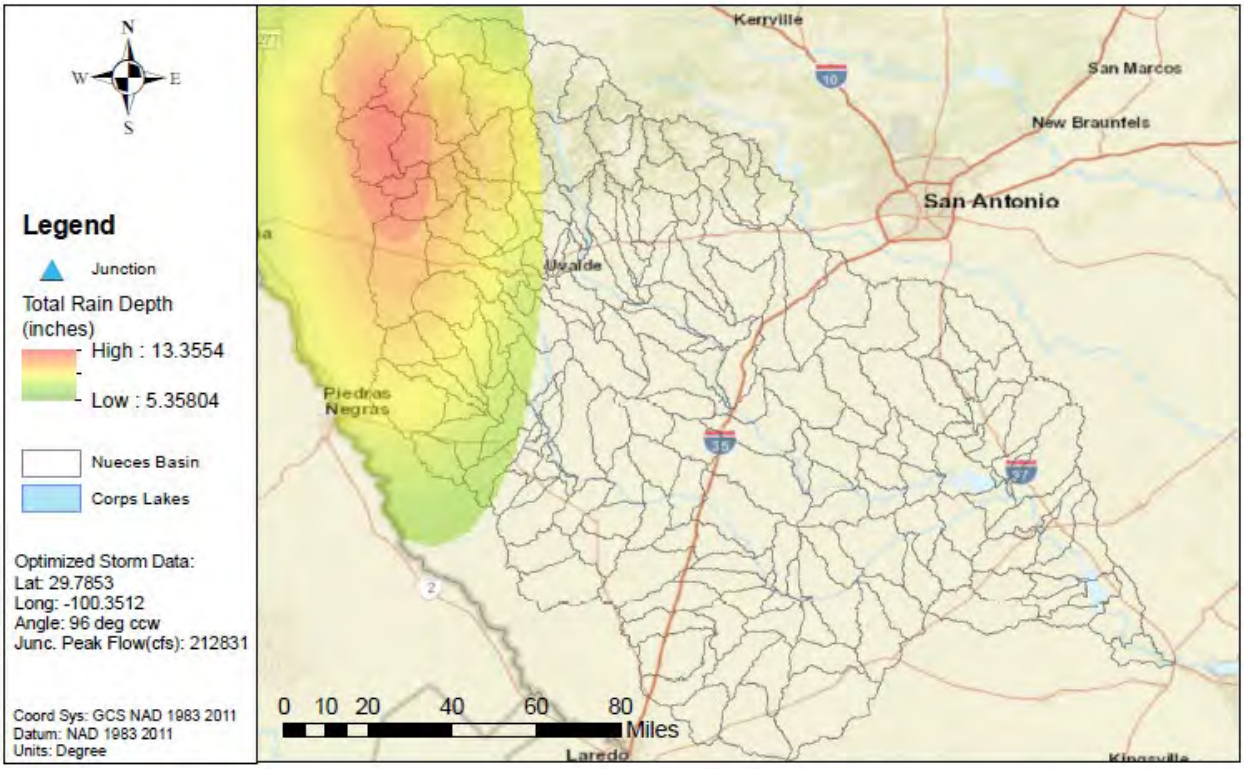

Figure C.11-4b: NA14 1% AEP Elliptical Storm for W_NuecesRv_abv_Live OakCk

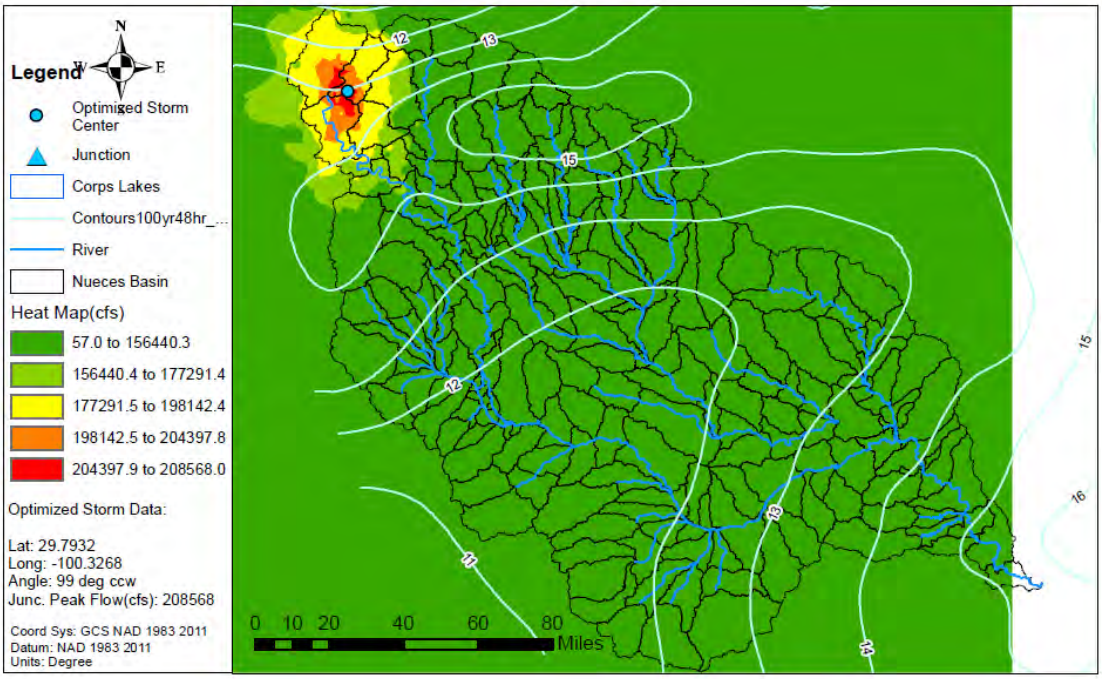

Figure C.11-5a: Elliptical Storm Optimization Heat Map for W_NuecesRv_blw_Live OakCk

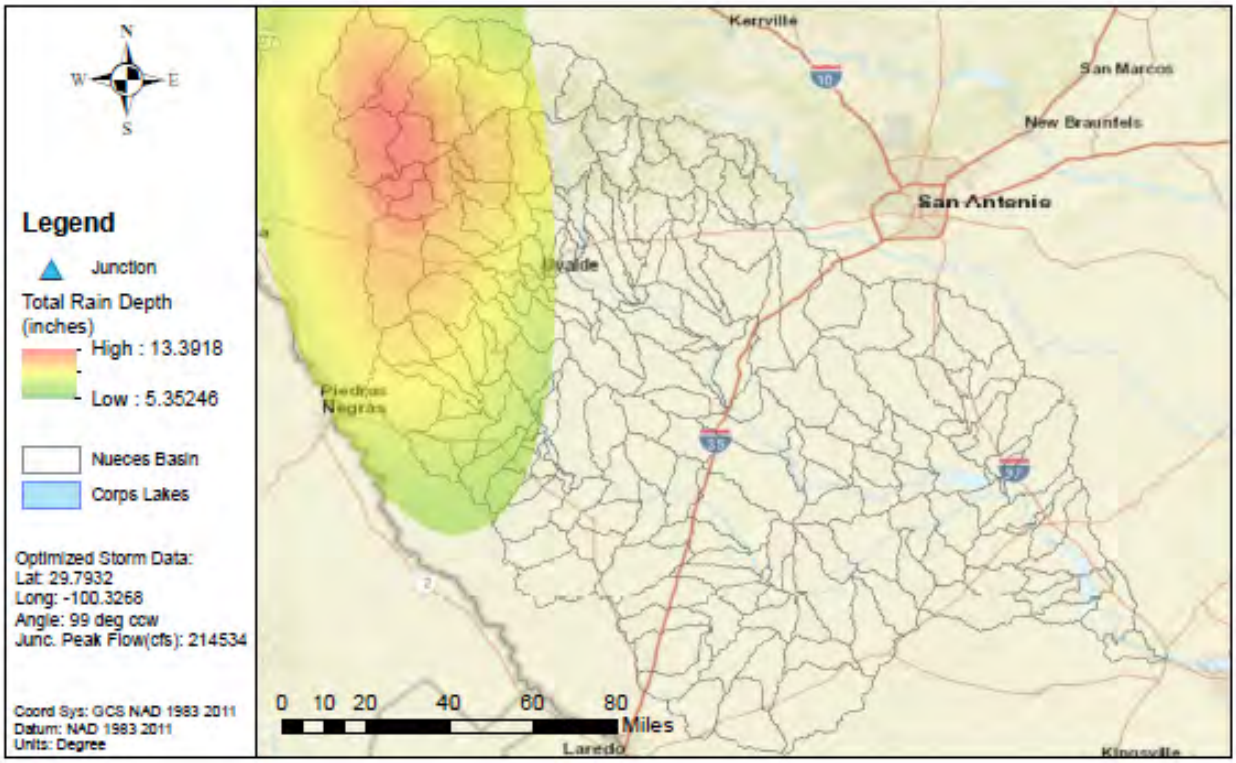

Figure C.11-5b: NA14 1% AEP Elliptical Storm for W_NuecesRv_blw_Live OakCk

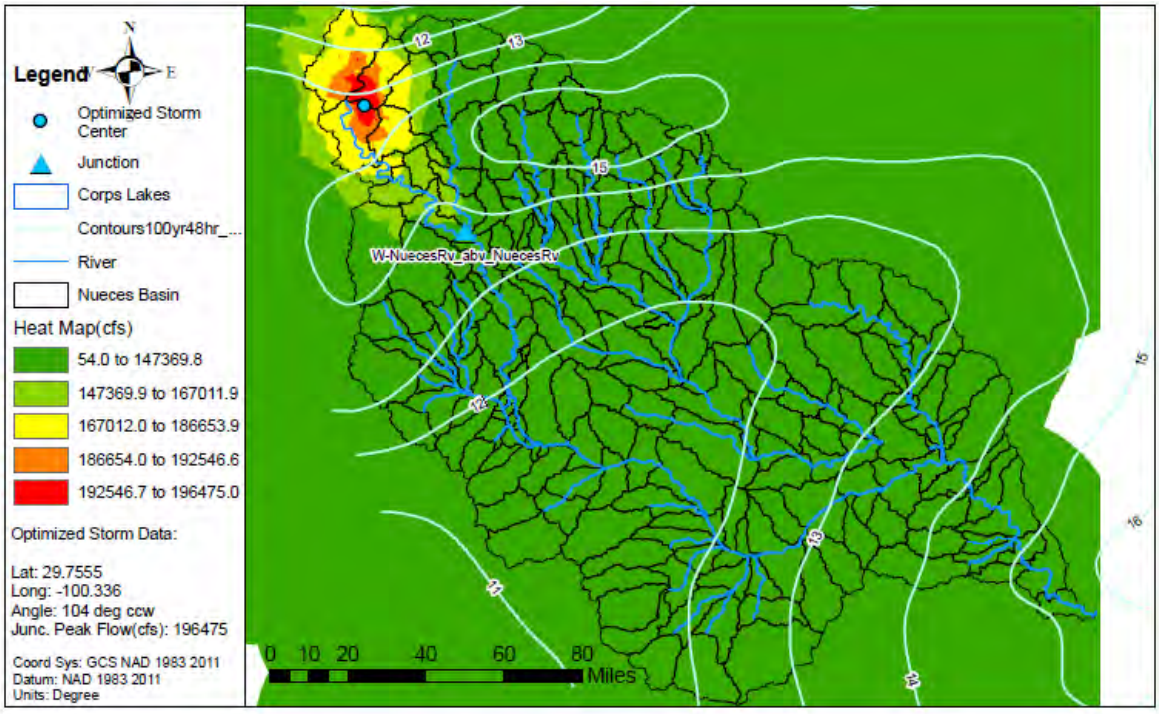

Figure C.11-6a: Elliptical Storm Optimization Heat Map for W-NuecesRv_abv_NuecesRv

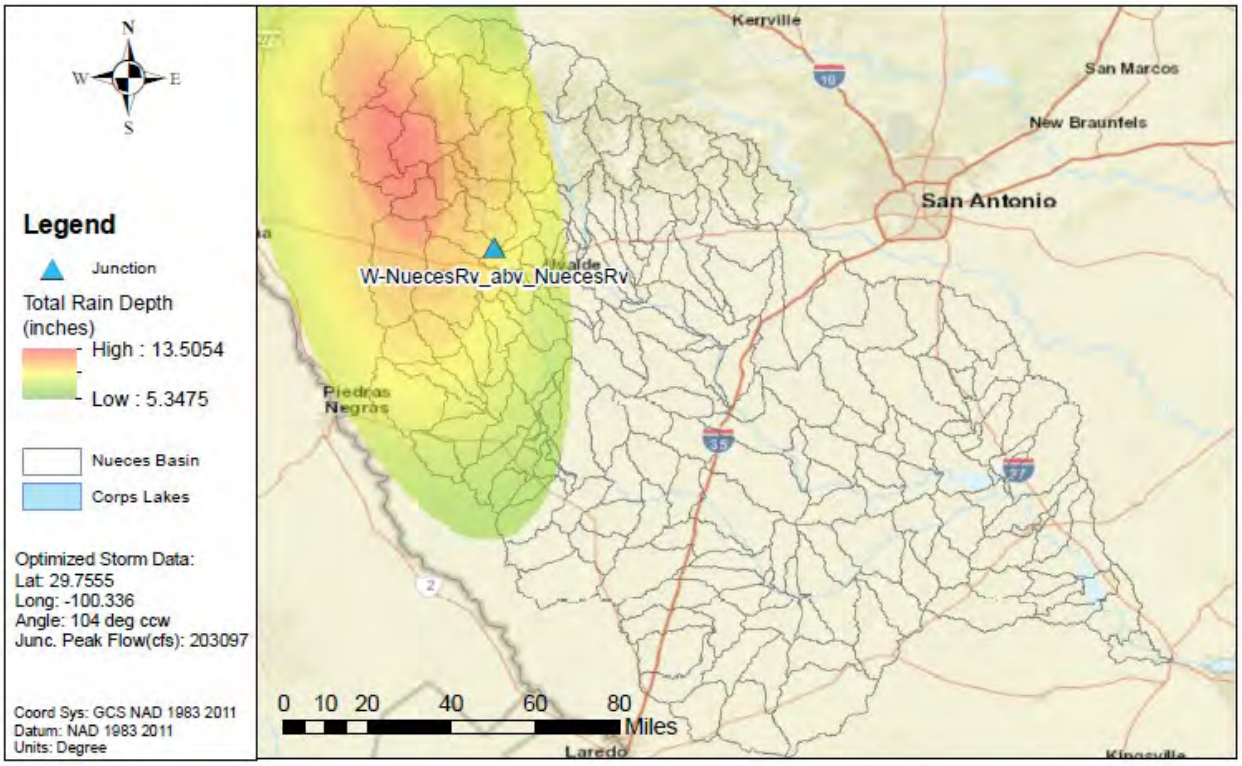

Figure C.11-6b: NA14 1% AEP Elliptical Storm for W-NuecesRv_abv_NuecesRv

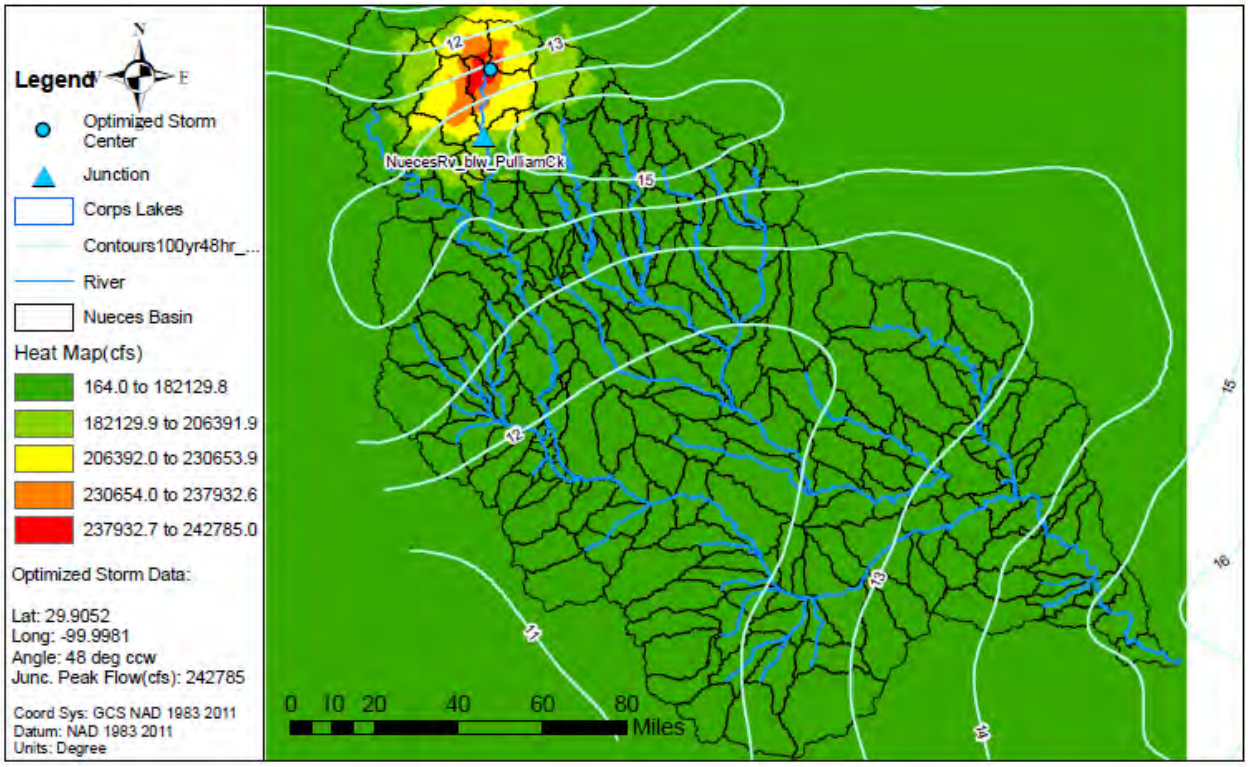

Figure C.11-7a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_PulliamCk

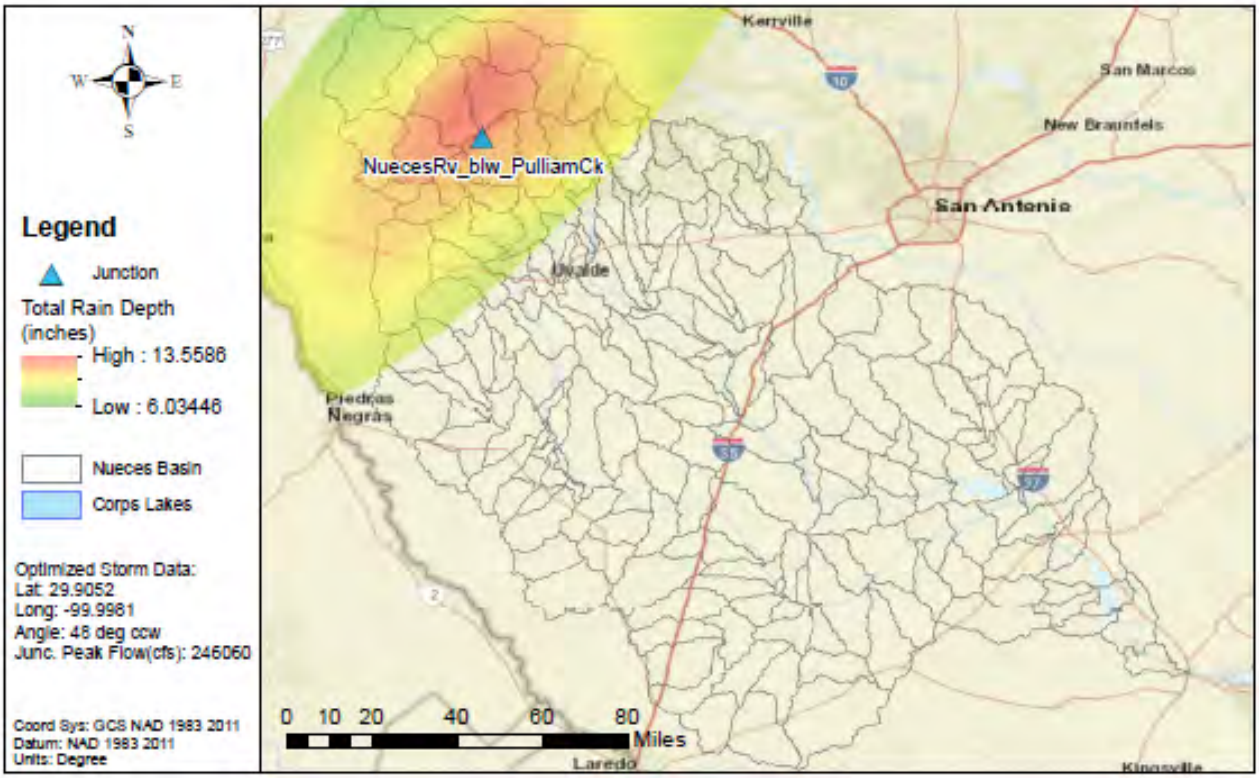

Figure C.11-7b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_PulliamCk

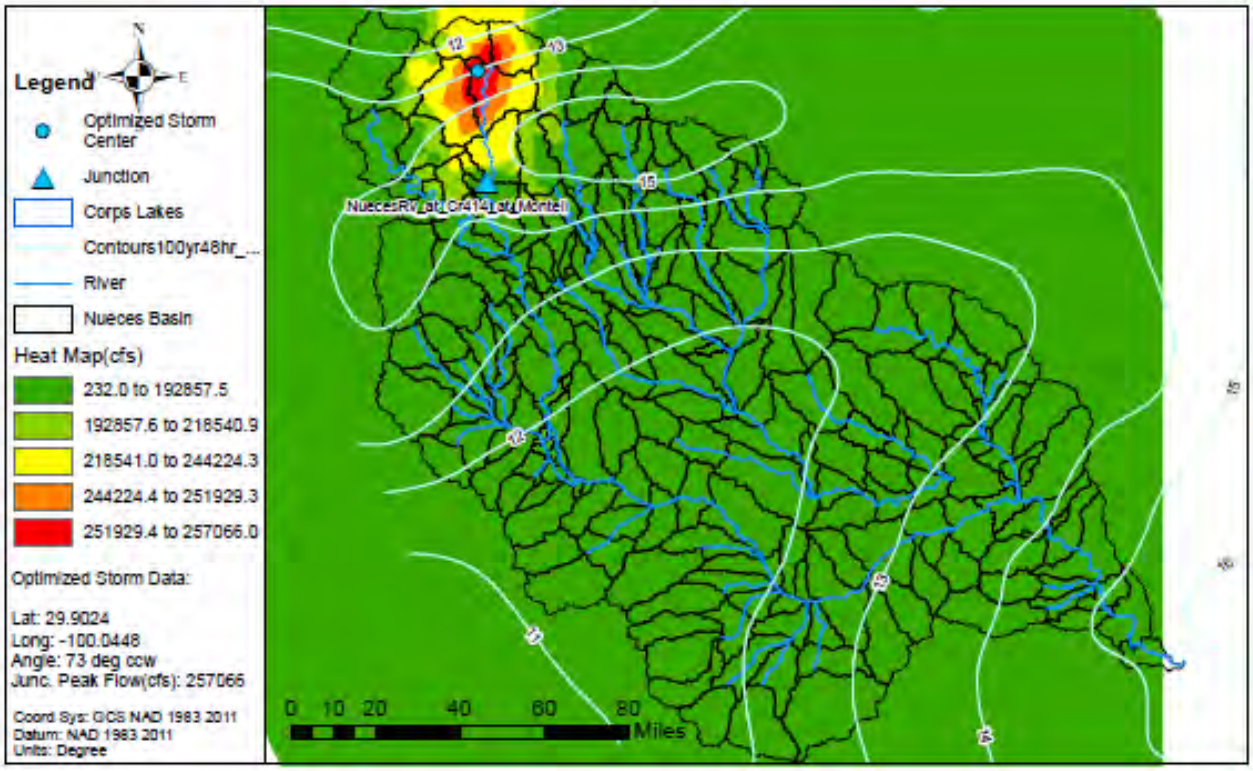

Figure C.11-8a: Elliptical Storm Optimization Heat Map for NuecesRv_at_Cr414_at_Montell

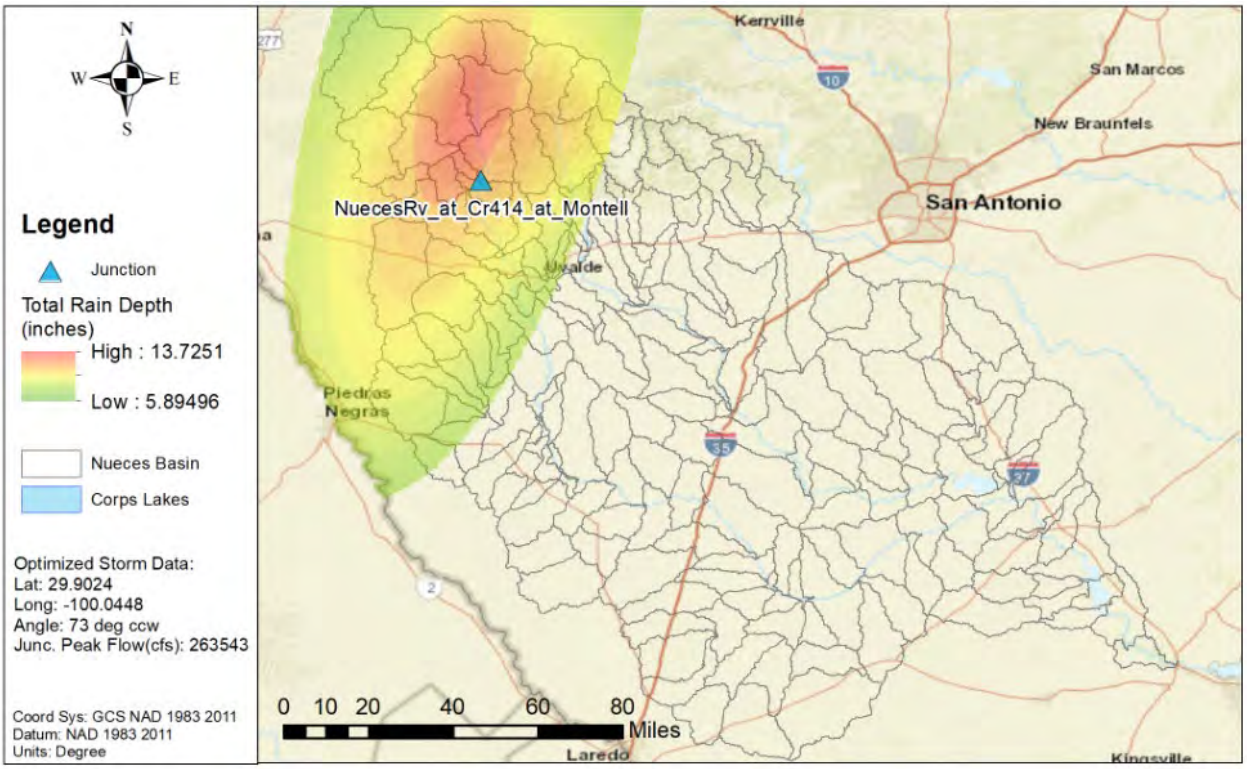

Figure C.11-8b: NA14 1% AEP Elliptical Storm for NuecesRv_at_Cr414_at_Montell

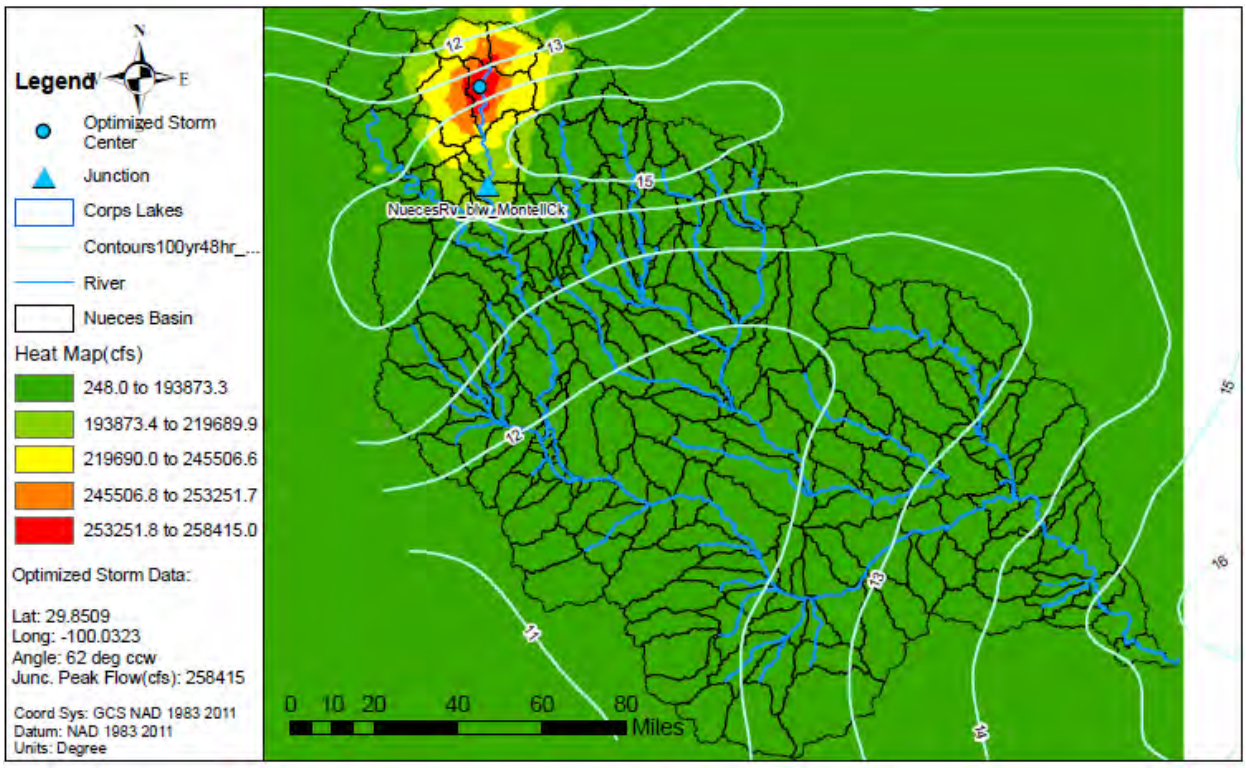

Figure C.11-9a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_MontellCk

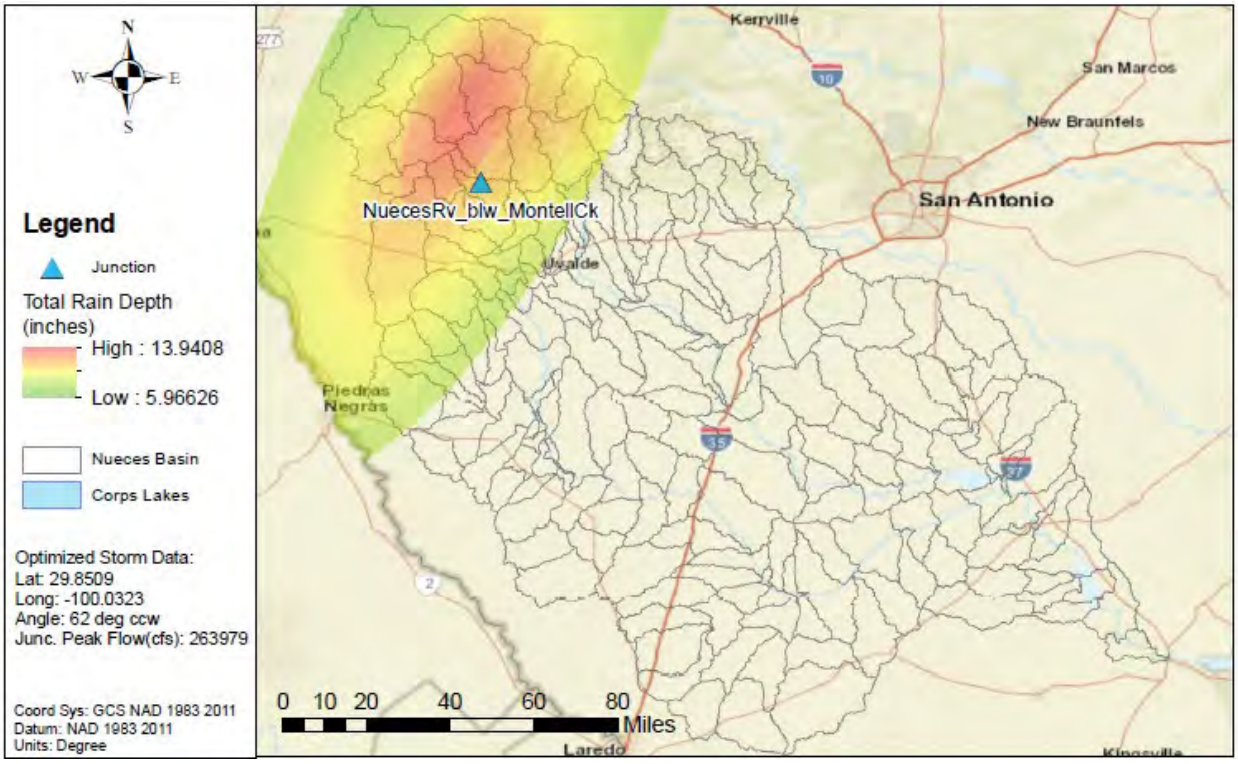

Figure C.11-9b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_MontellCk

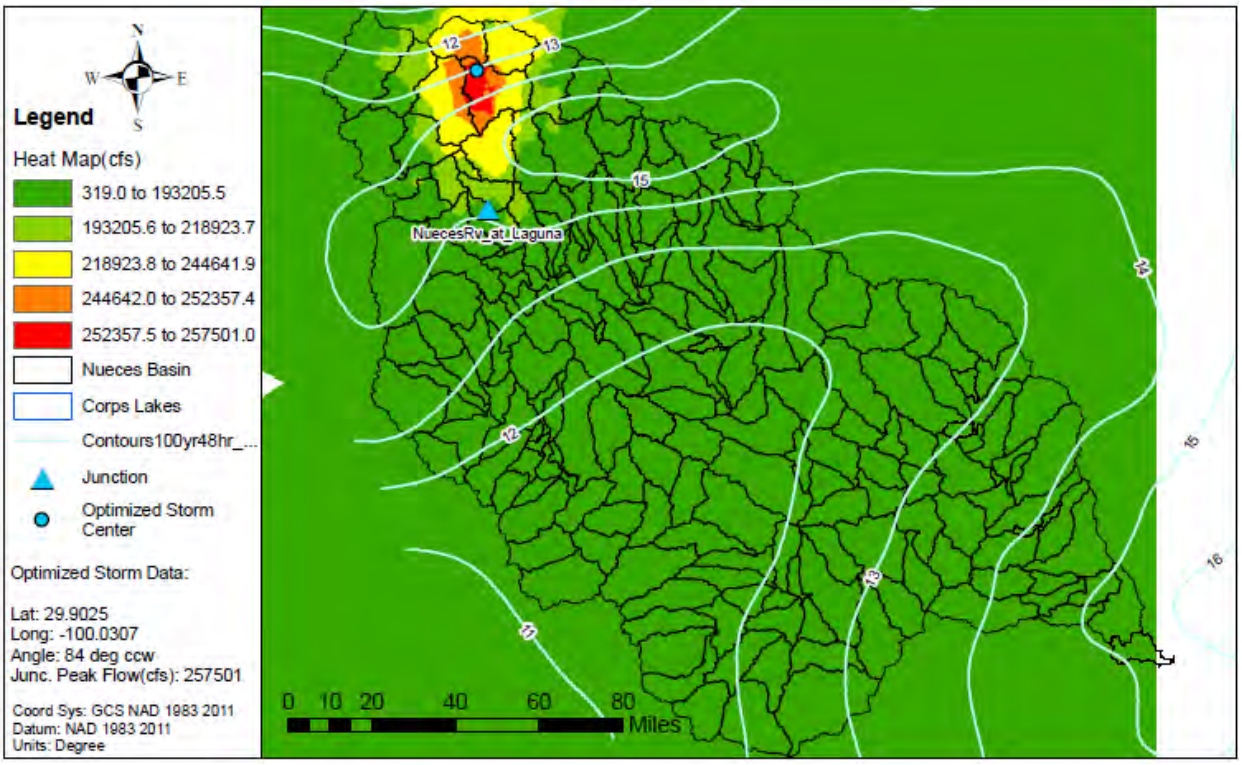

Figure C.11-10a: Elliptical Storm Optimization Heat Map for NuecesRv_at_Laguna

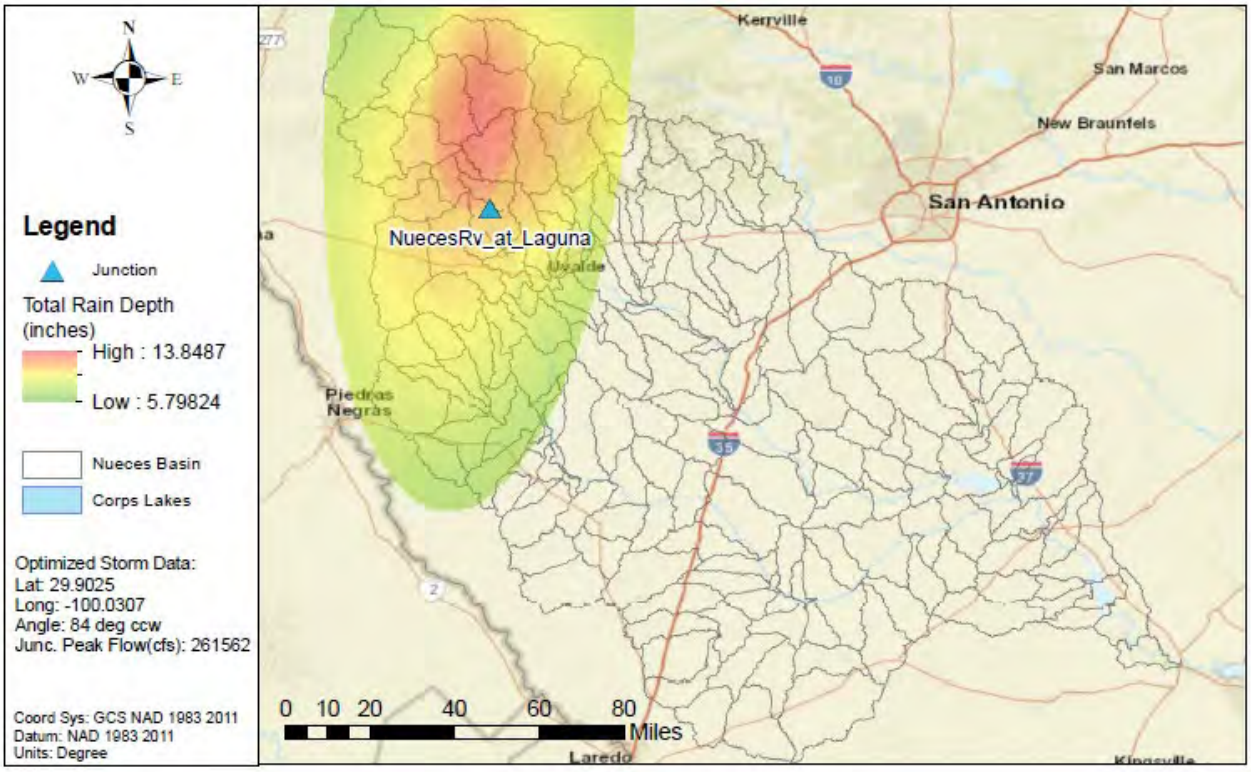

Figure C.11-10b: NA14 1% AEP Elliptical Storm for NuecesRv_at_Laguna

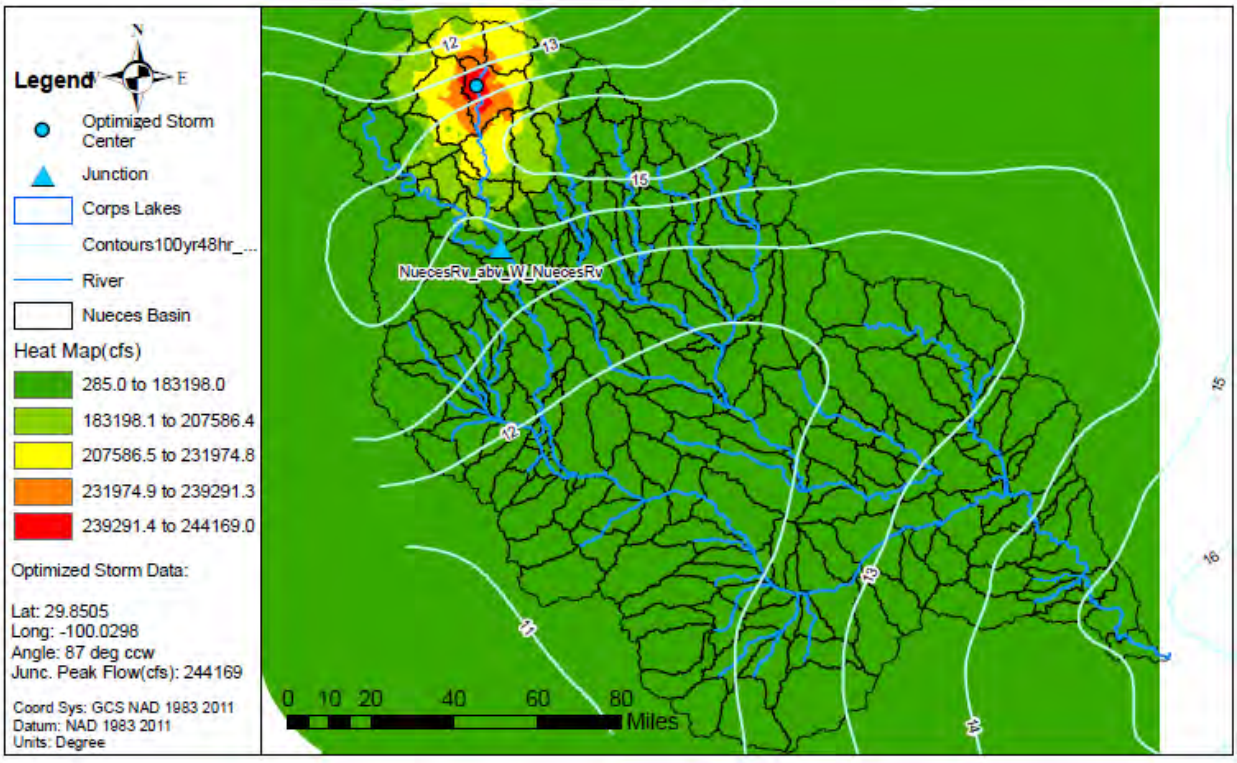

Figure C.11-11a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_W_NuecesRv

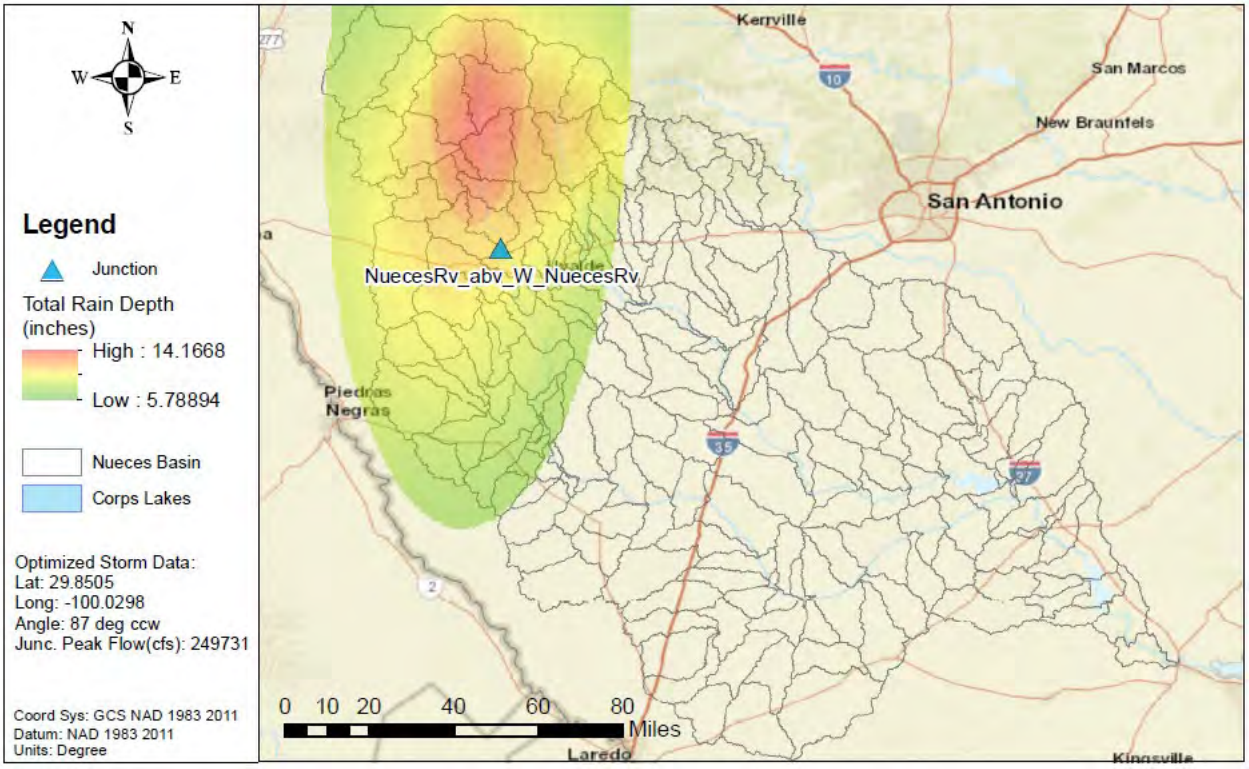

Figure C.11-11b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_W_NuecesRv

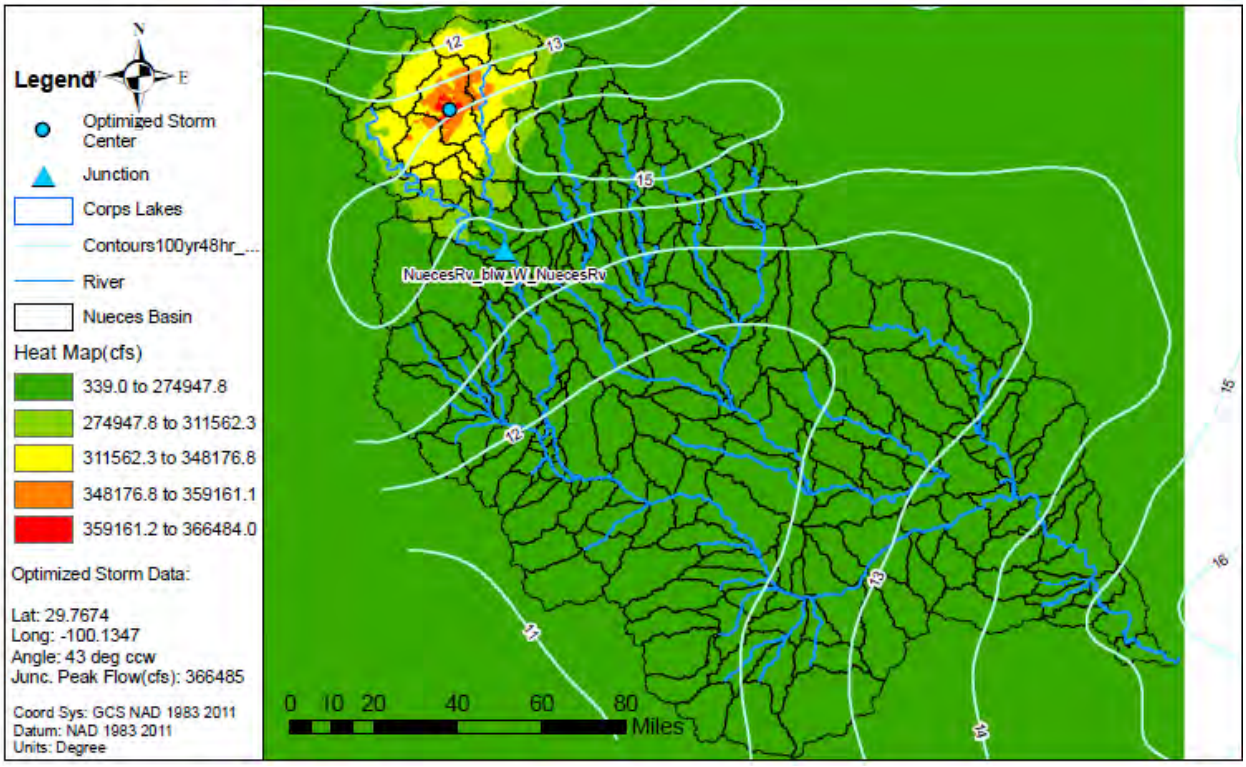

Figure C.11-12a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_W_NuecesRv

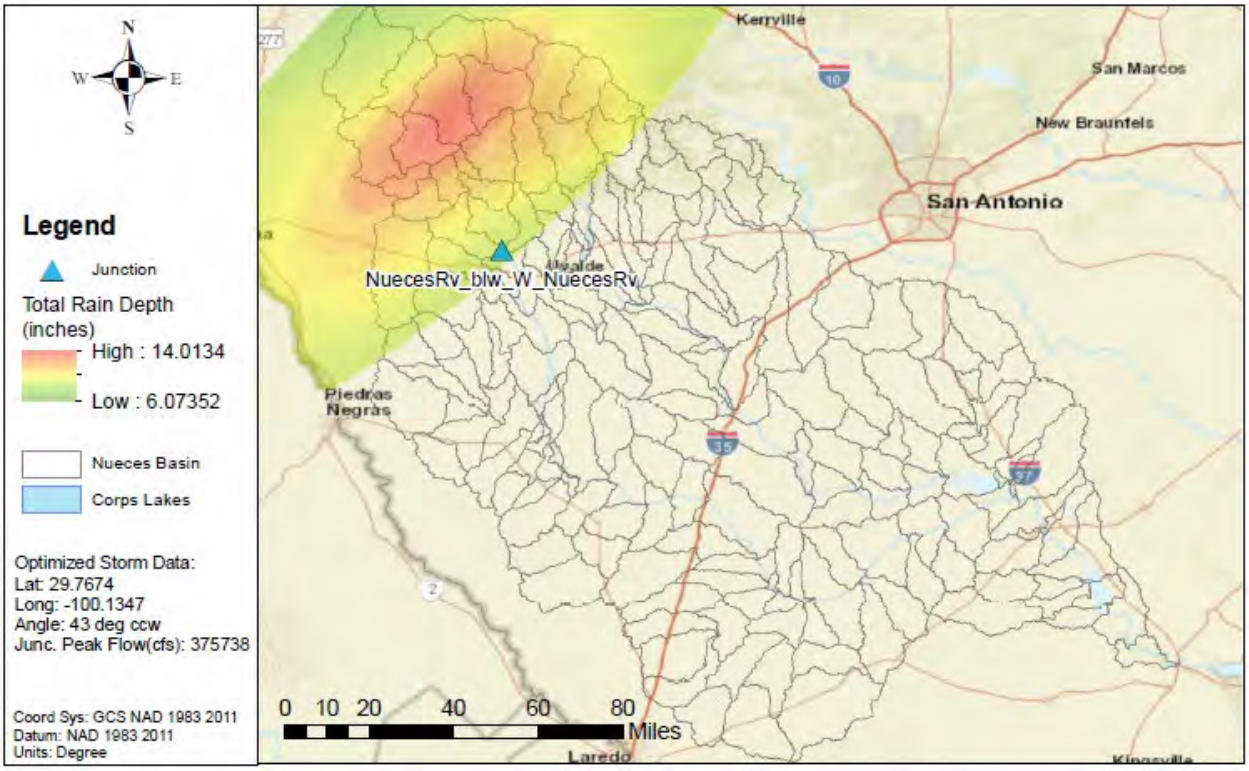

Figure C.11-12b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_W_NuecesRv

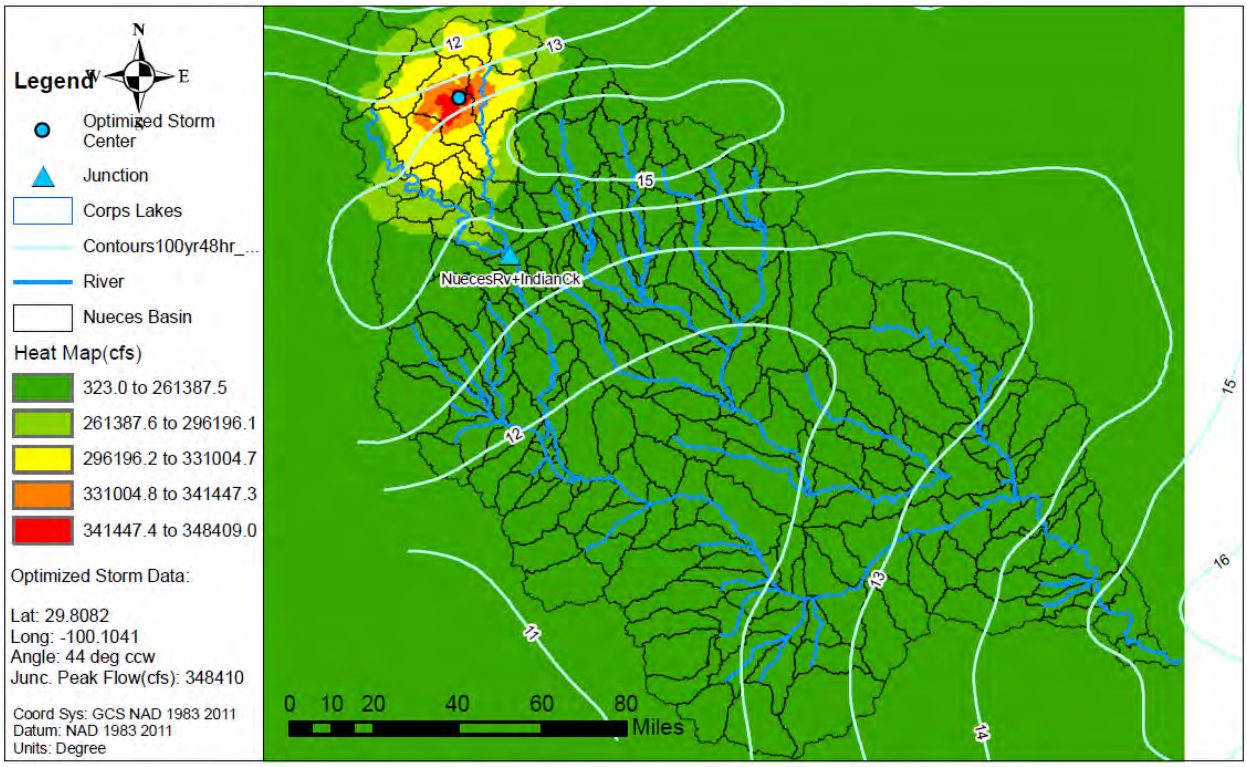

Figure C.11-13a: Elliptical Storm Optimization Heat Map for NuecesRv+IndianCk

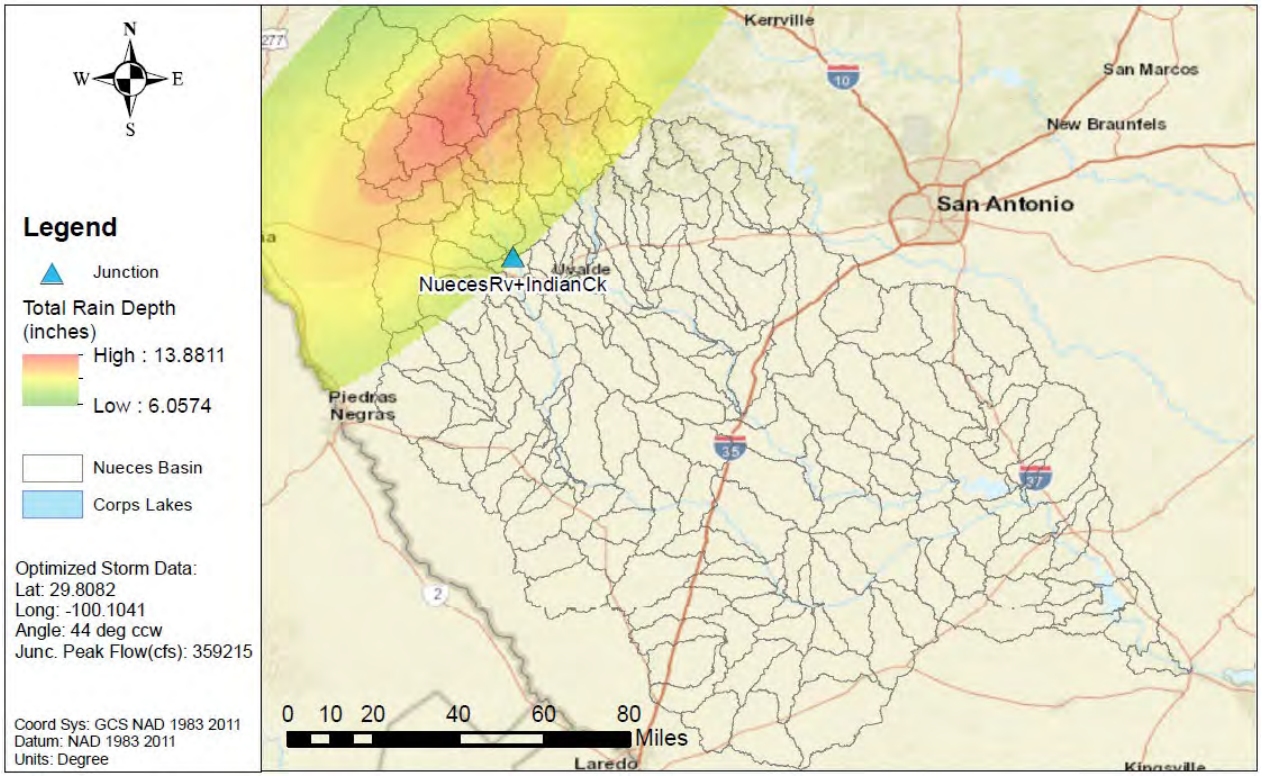

Figure C.11-13b: NA14 1% AEP Elliptical Storm for NuecesRv+IndianCk

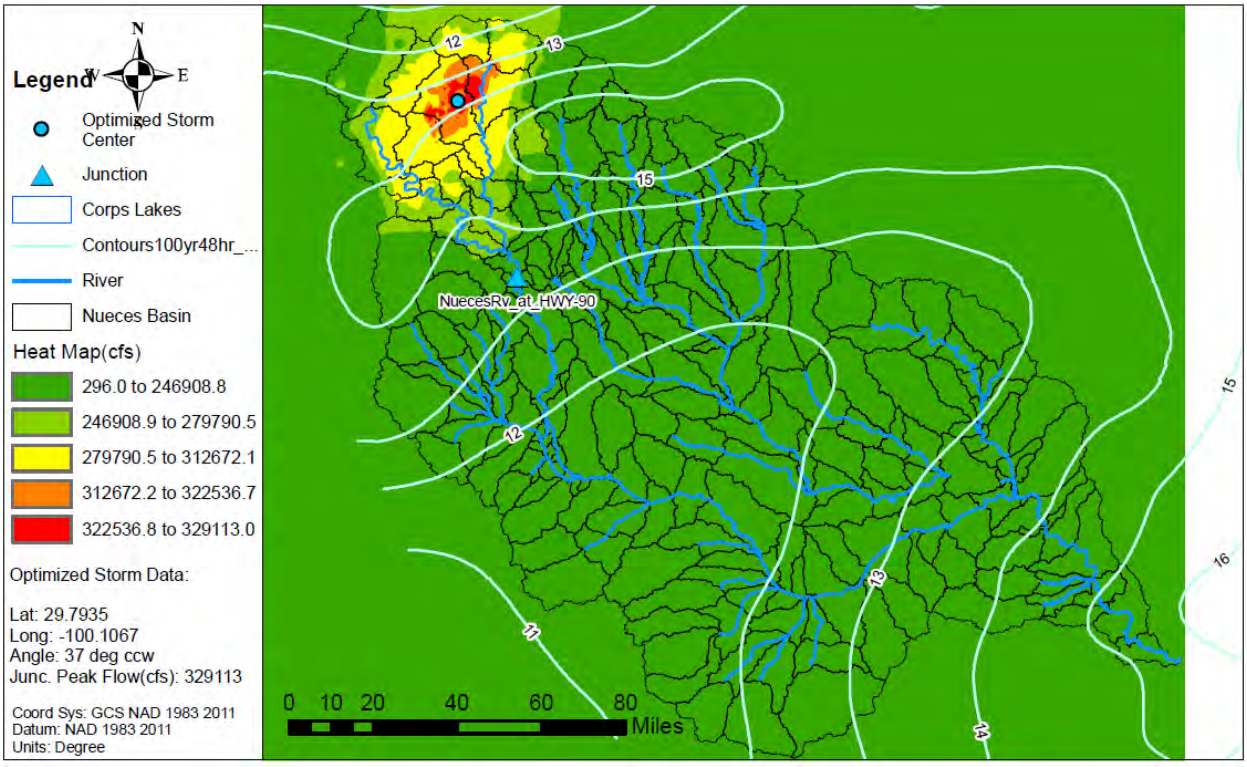

Figure C.11-14a: Elliptical Storm Optimization Heat Map for NuecesRv_at_HWY-90

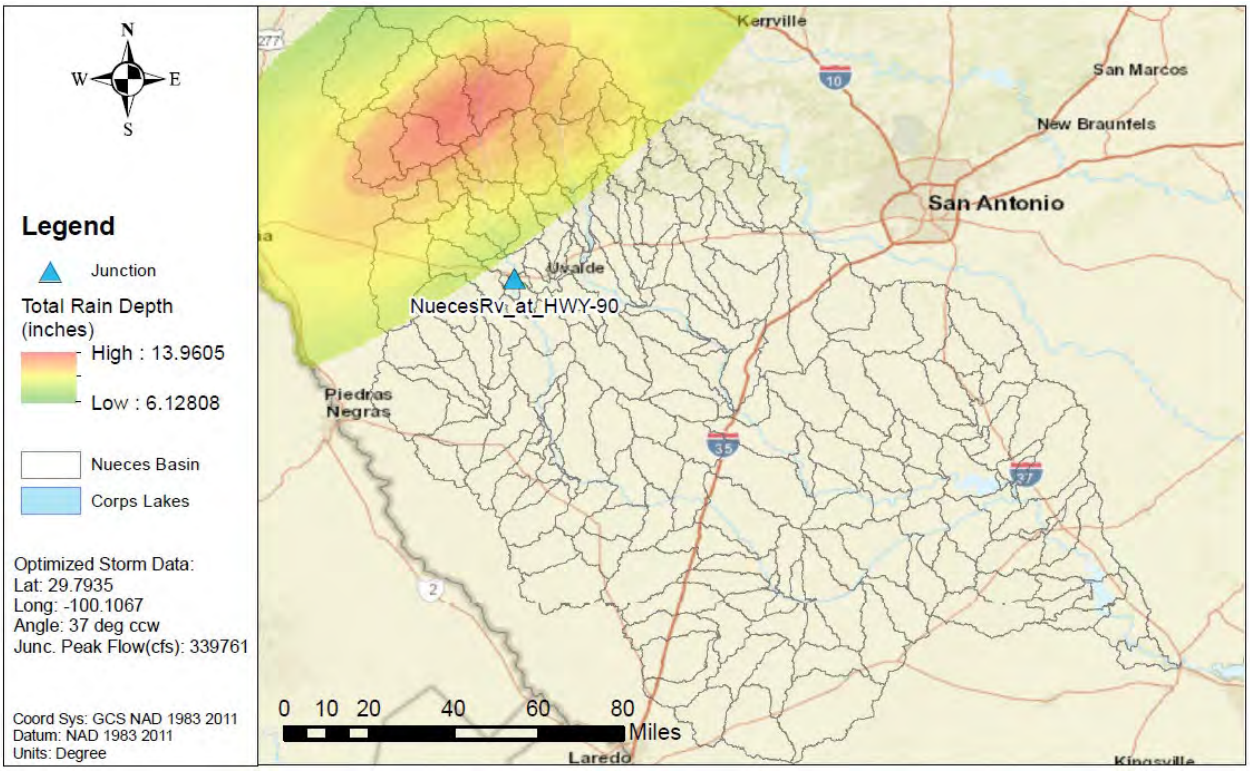

Figure C.11-14b: NA14 1% AEP Elliptical Storm for NuecesRv_at_HWY-90

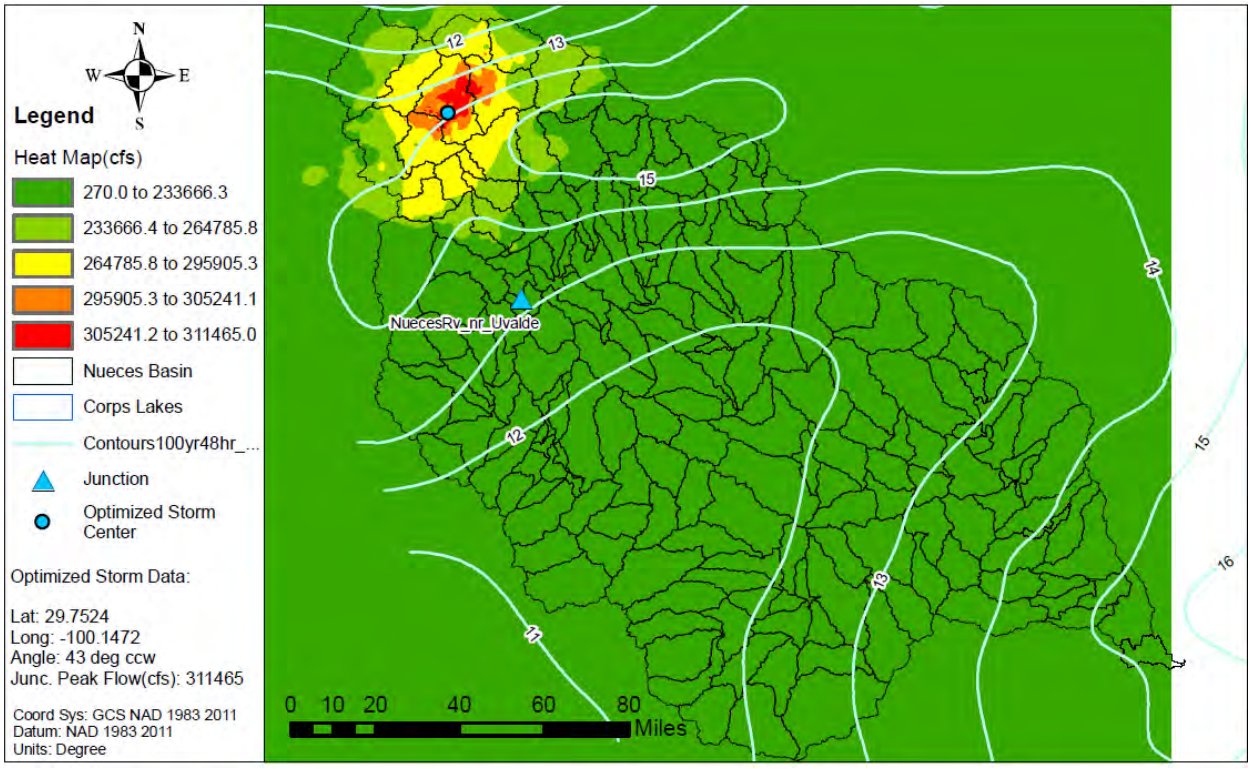

Figure C.11-15a: Elliptical Storm Optimization Heat Map for NuecesRv_nr_Uvalde

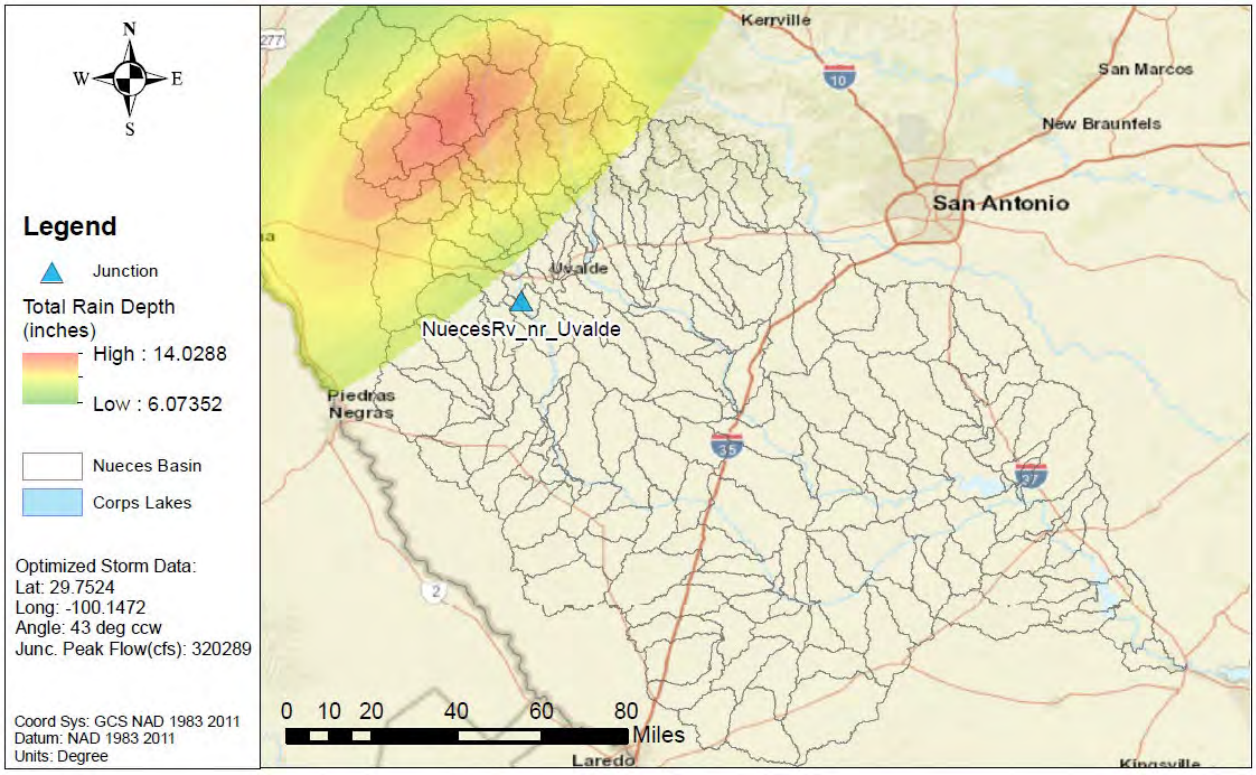

Figure C.11-15b: NA14 1% AEP Elliptical Storm for NuecesRv_nr_Uvalde

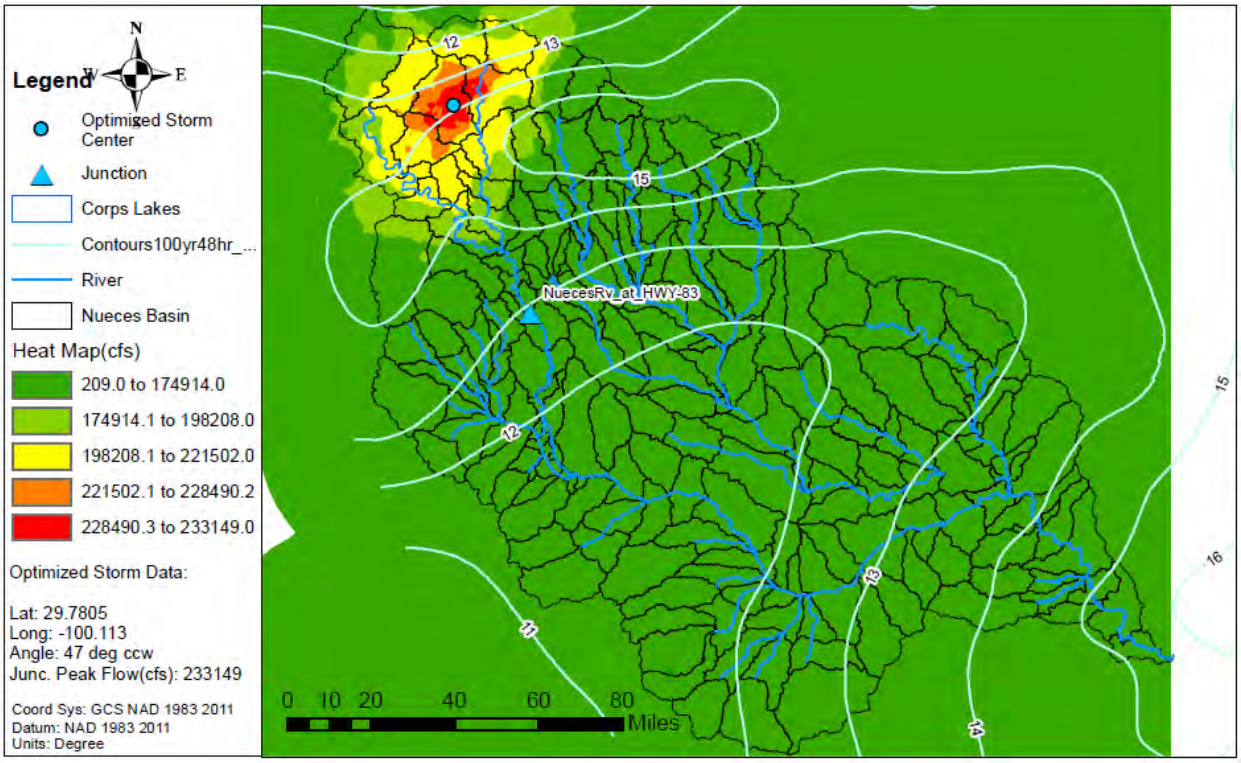

Figure C.11-16a: Elliptical Storm Optimization Heat Map for NuecesRv_at_HWY-83

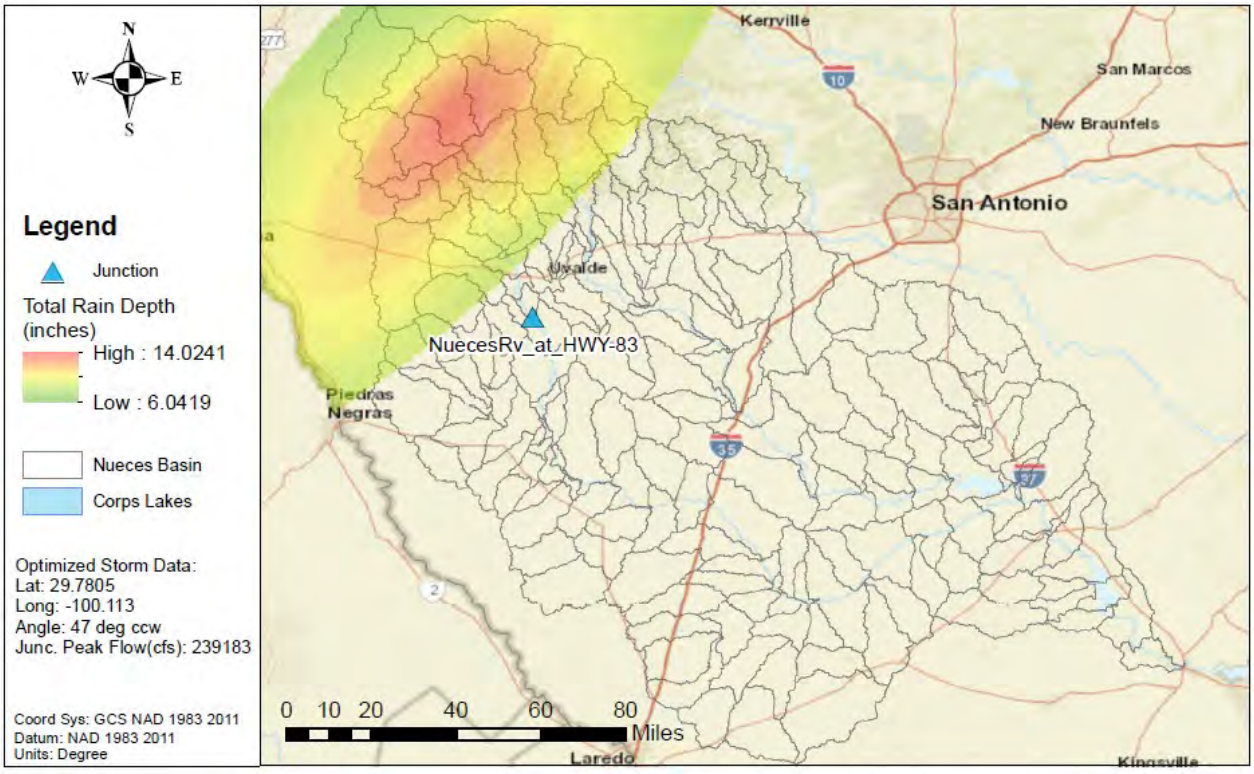

Figure C.11-16b: NA14 1% AEP Elliptical Storm for NuecesRv_at_HWY-83

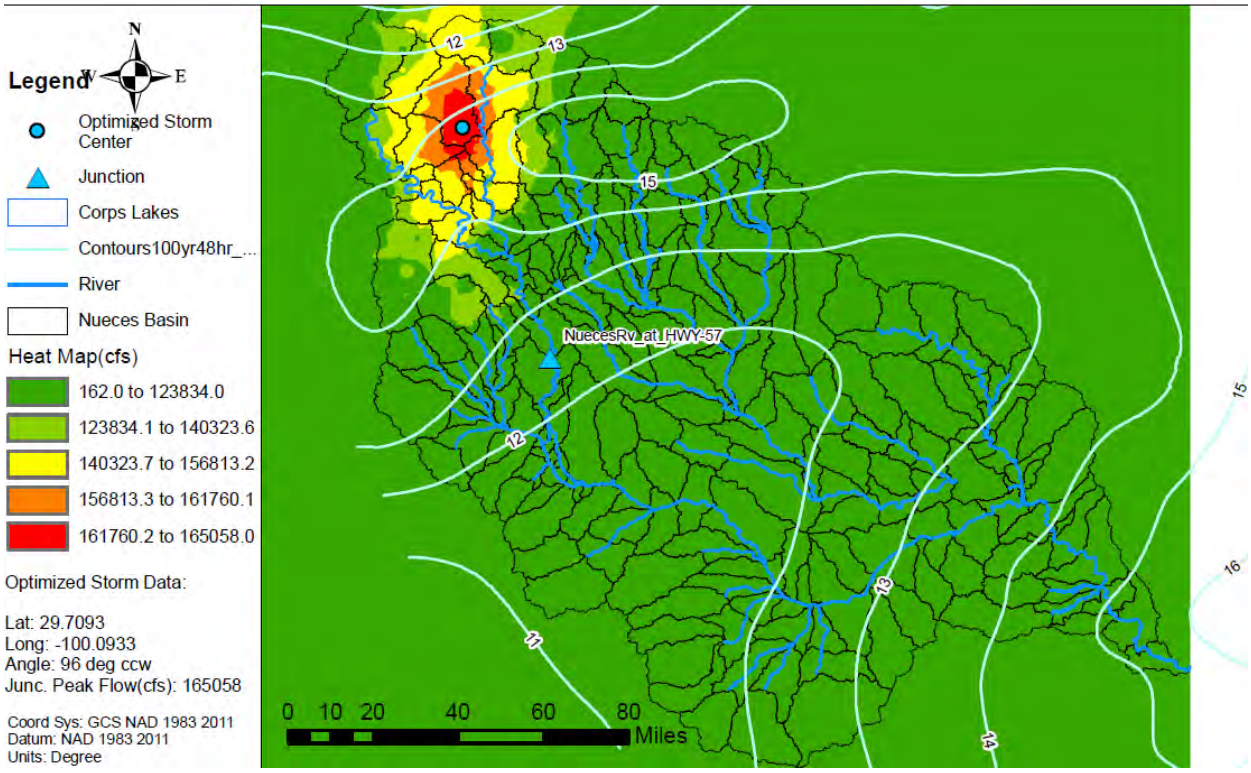

Figure C.11-17a: Elliptical Storm Optimization Heat Map for NuecesRv_at_HWY-57

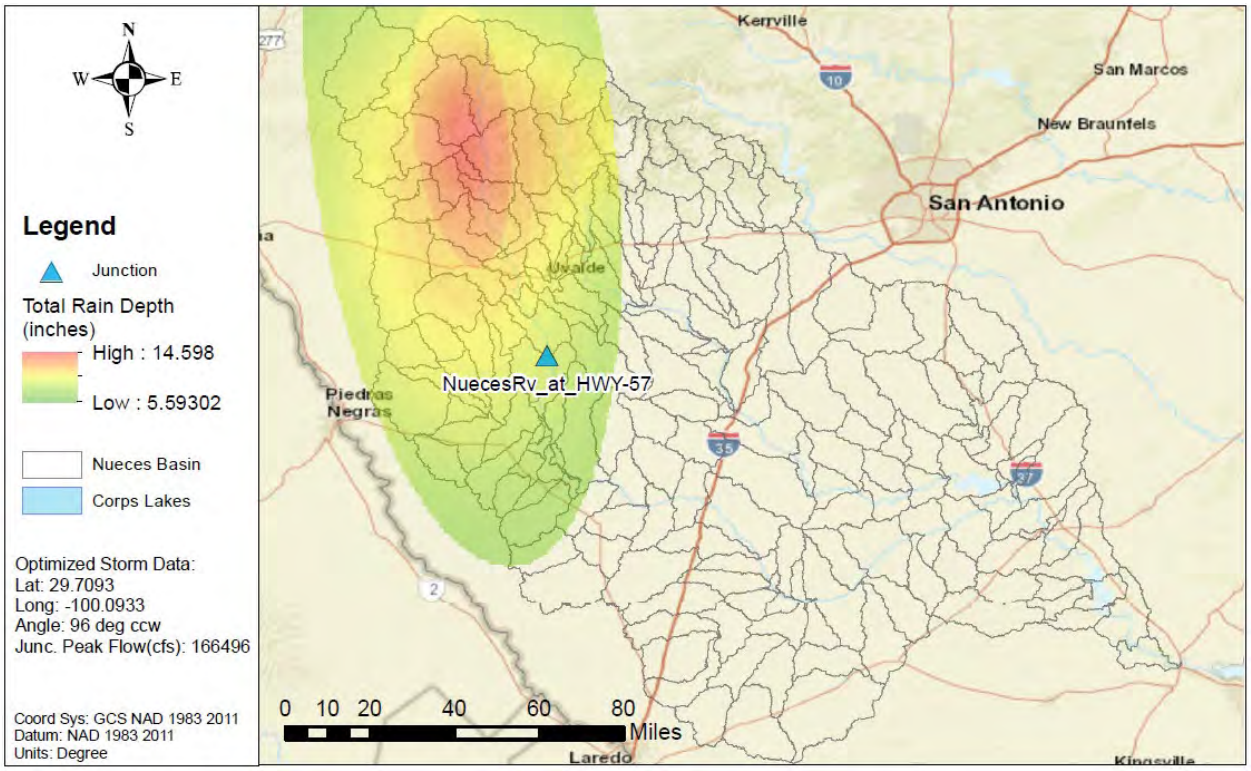

Figure C.11-17b: NA14 1% AEP Elliptical Storm for NuecesRv_at_HWY-57

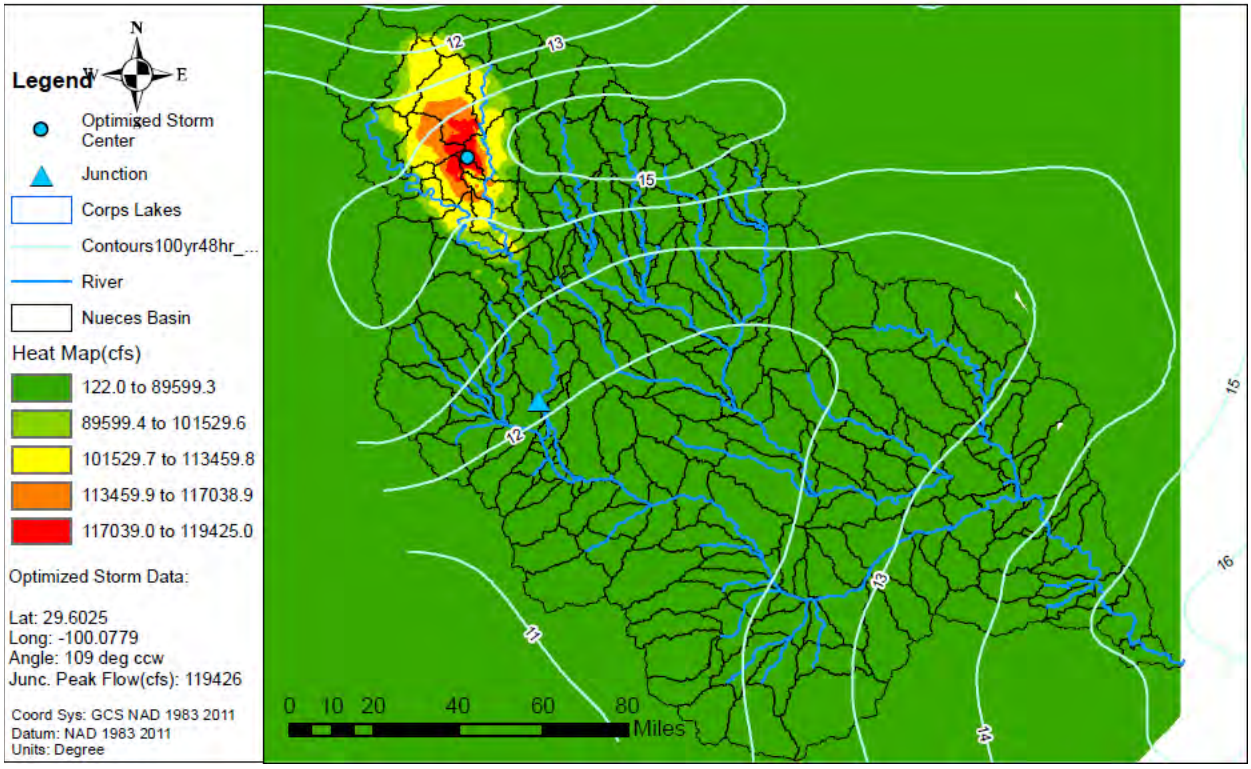

Figure C.11-18a: Elliptical Storm Optimization Heat Map for NuecesRv_at_FM-1025_nr_Cryst

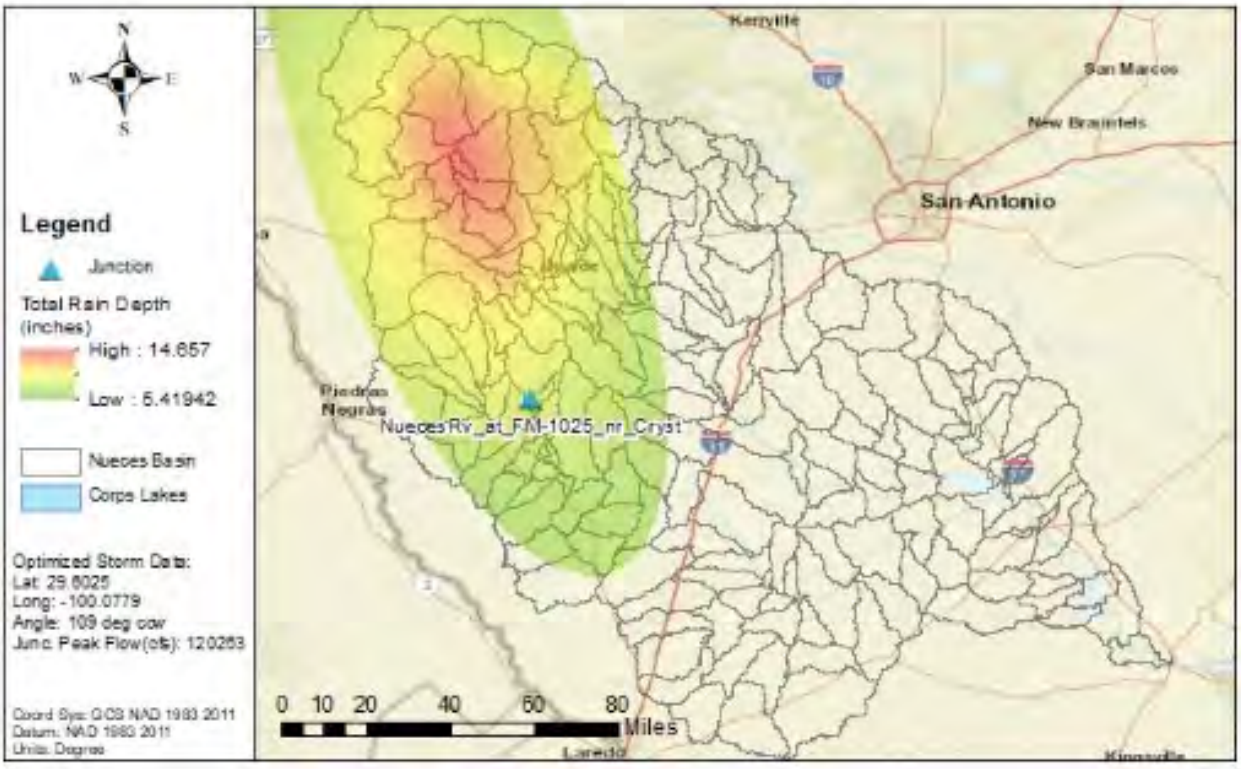

Figure C.11-18b: NA14 1% AEP Elliptical Storm for NuecesRv_at_FM-1025_nr_Cryst

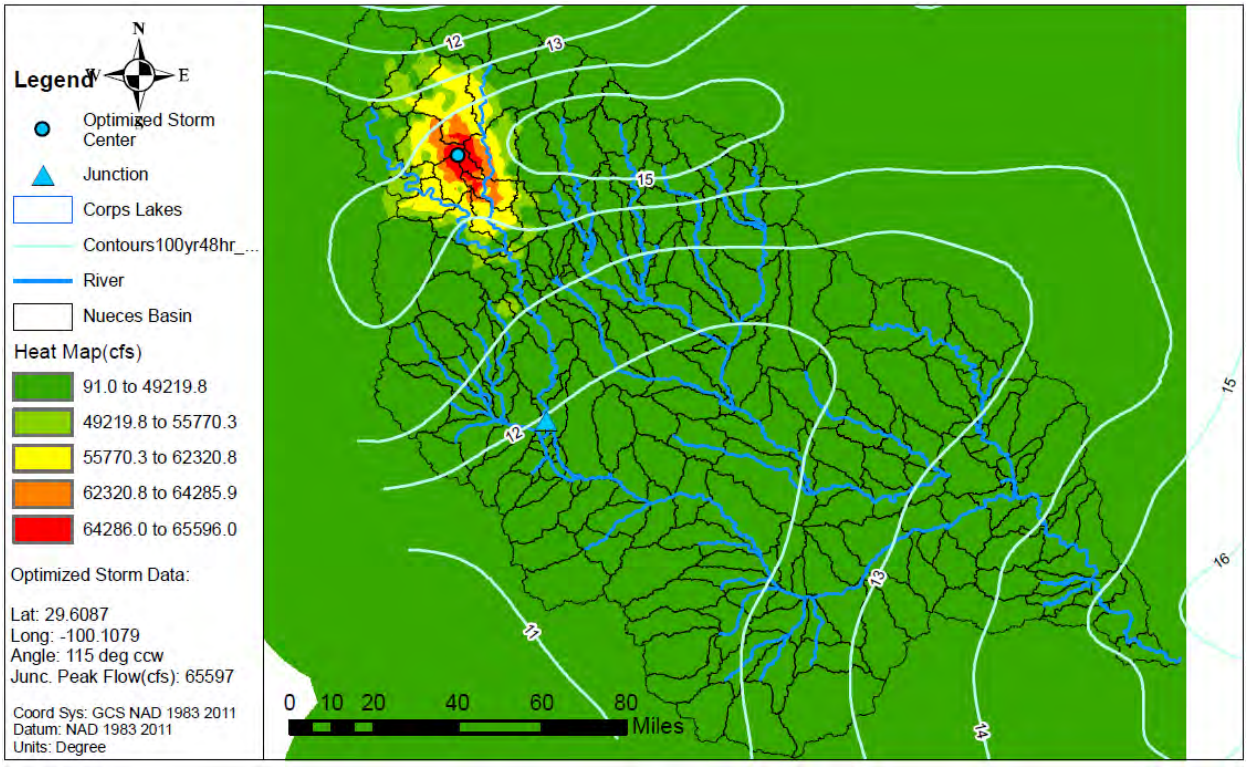

Figure C.11-19a: Elliptical Storm Optimization Heat Map for NuecesRv_TurkeyCk_Split

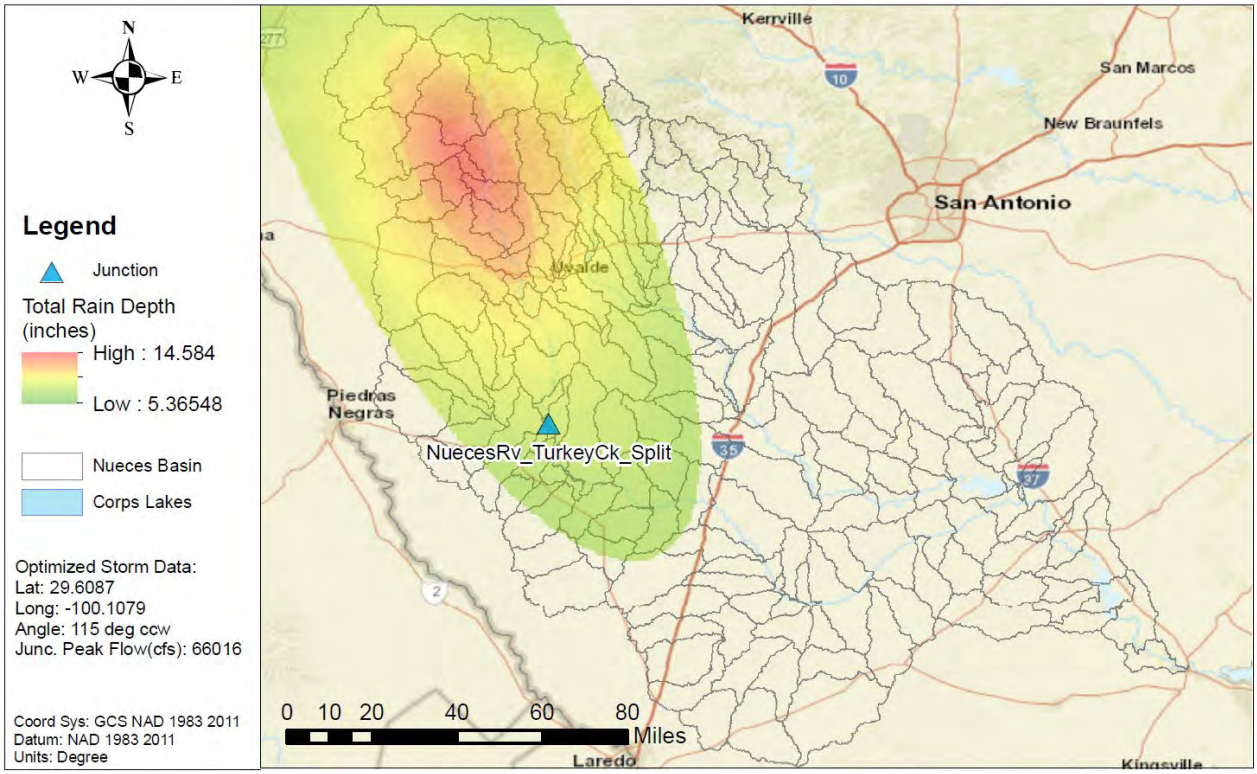

Figure C.11-19b: NA14 1% AEP Elliptical Storm for NuecesRv_TurkeyCk_Split

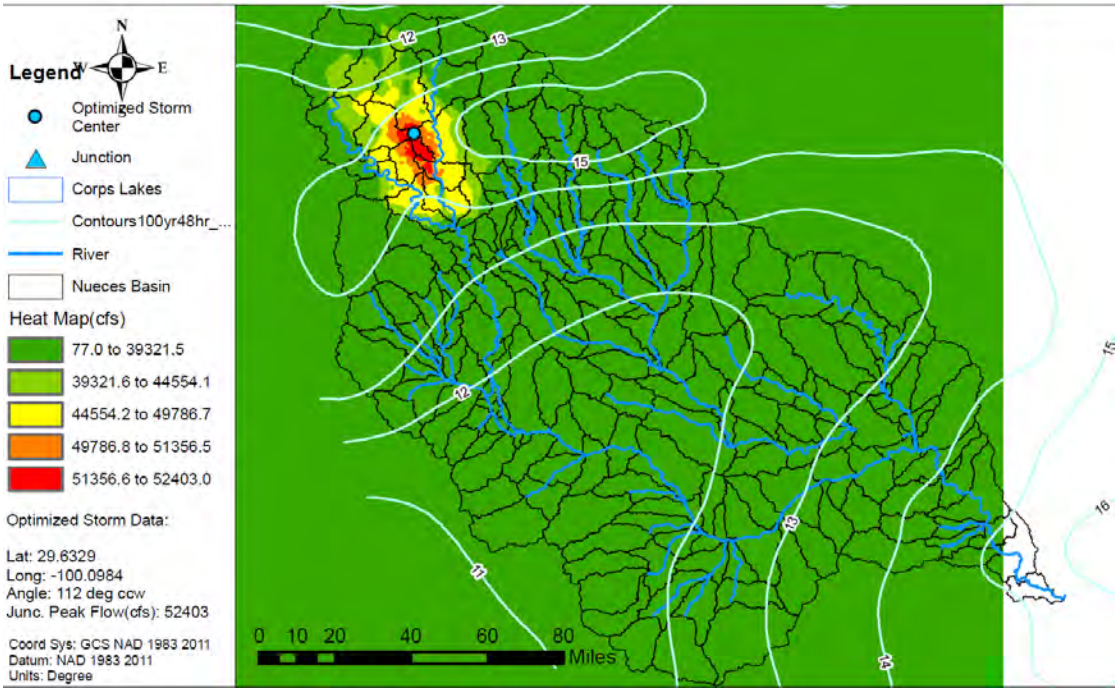

Figure C11-.20a: Elliptical Storm Optimization Heat Map for TurkeyCk_Diversion

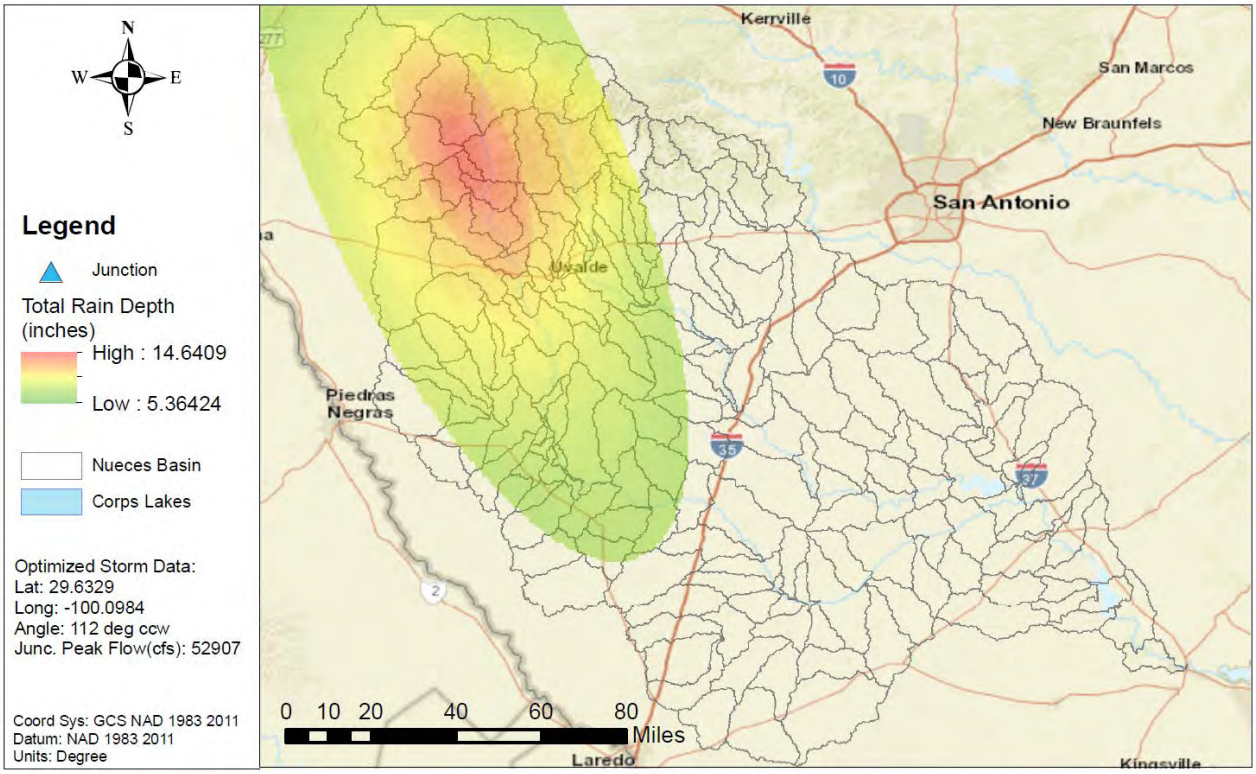

Figure C.11-20b: NA14 1% AEP Elliptical Storm for TurkeyCk_Diversion

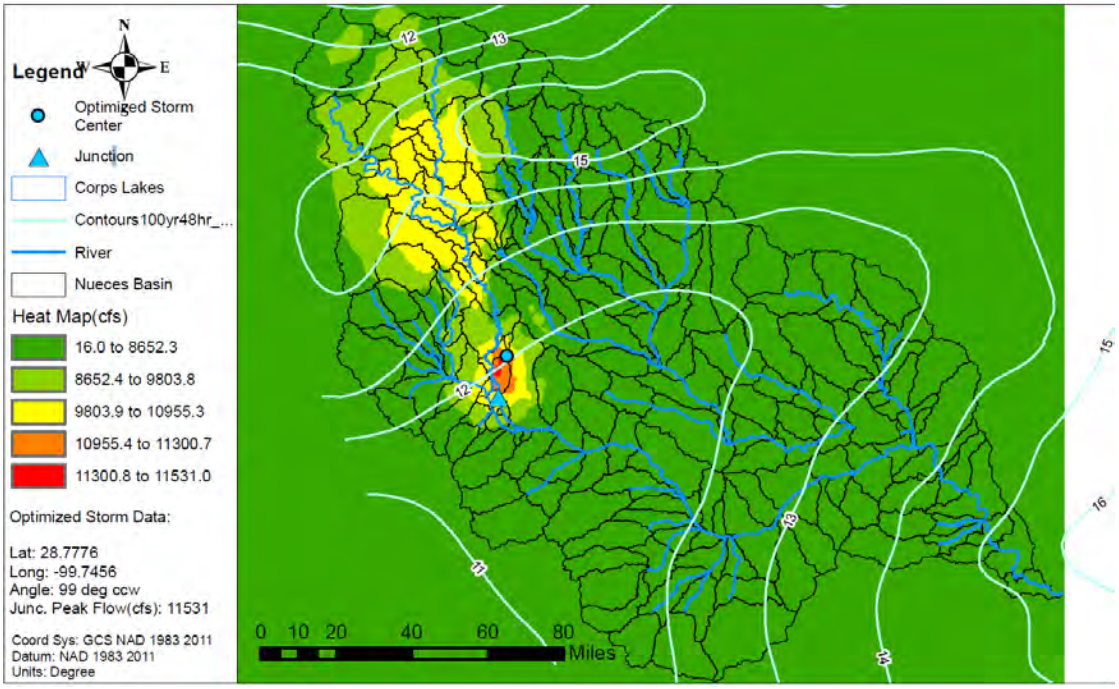

Figure C.11-21a: Elliptical Storm Optimization Heat Map for NuecesRv_Split_J010

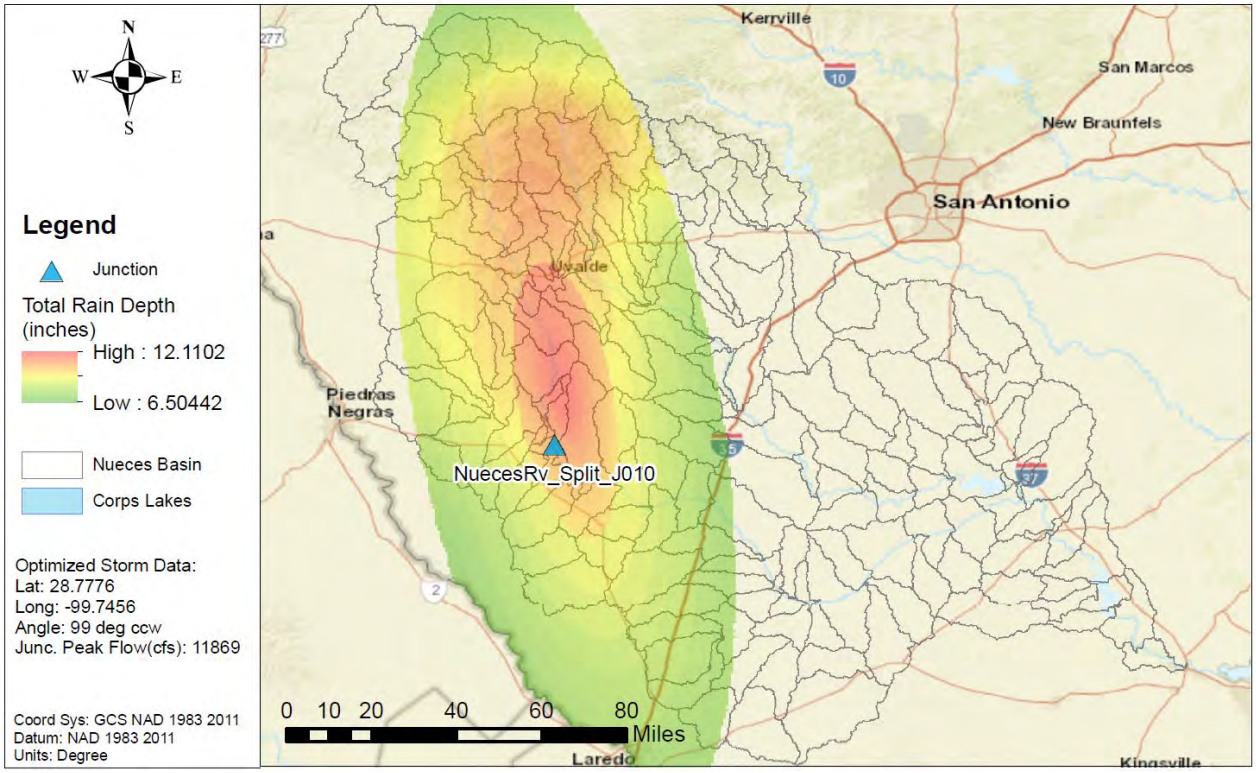

Figure C.11-21b: NA14 1% AEP Elliptical Storm for NuecesRv_Split_J010

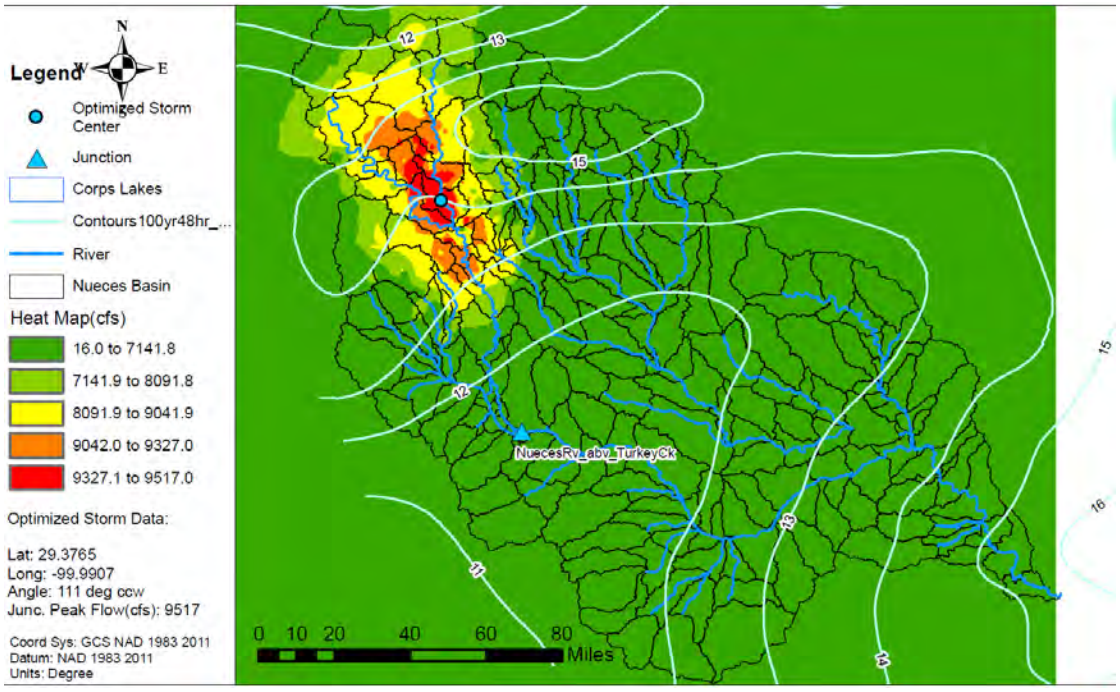

Figure C.11-22a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_TurkeyCk

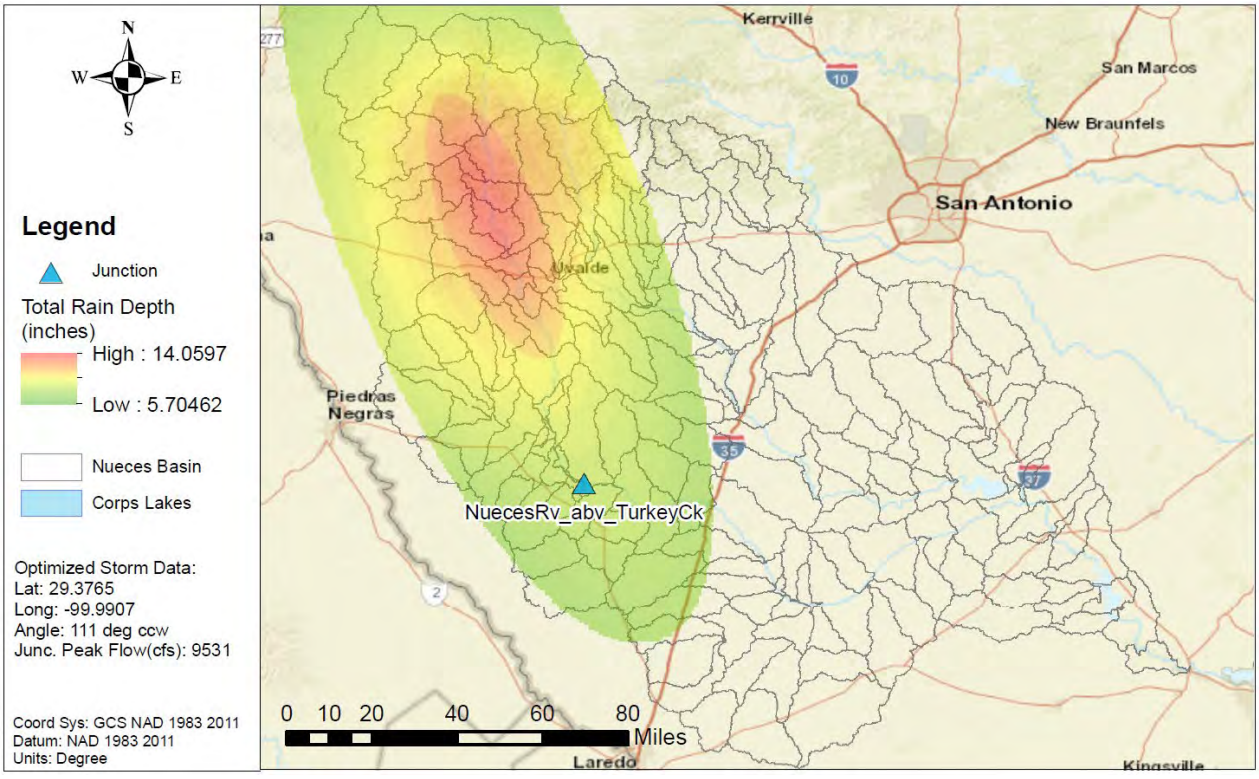

Figure C.11-22b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_TurkeyCk

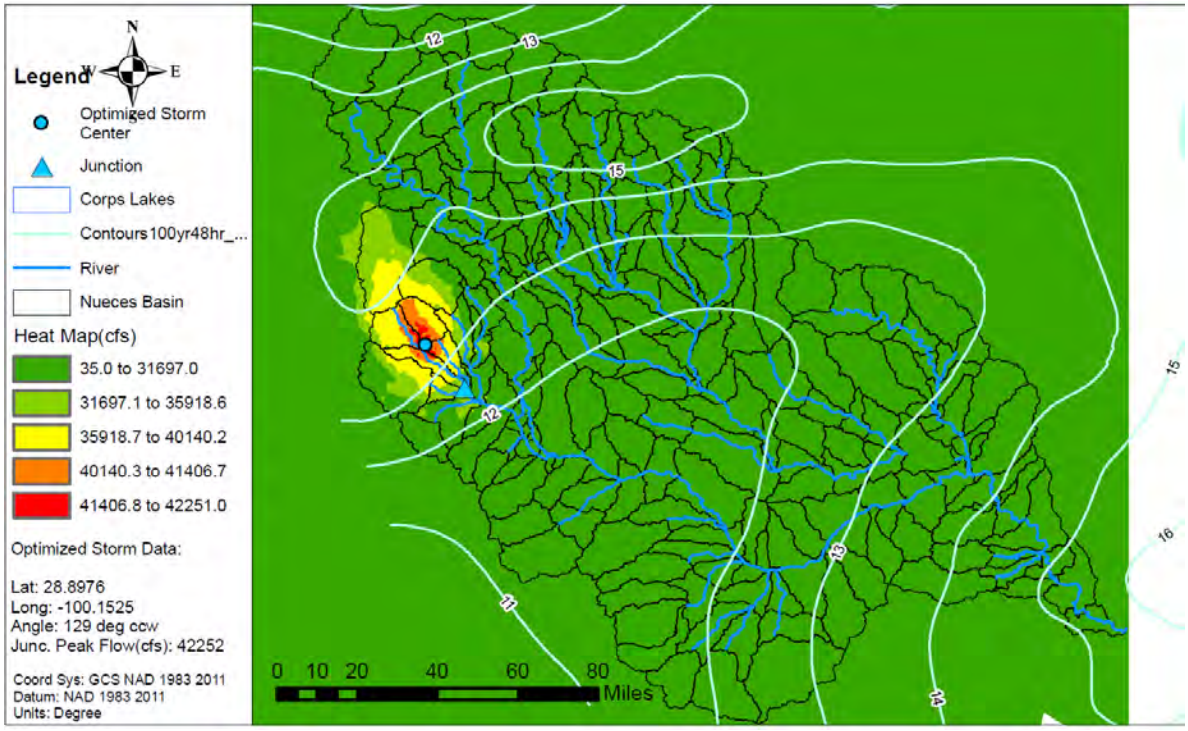

Figure C.11-23a: Elliptical Storm Optimization Heat Map for Palo_BlancoCk_blw_ChaconCk

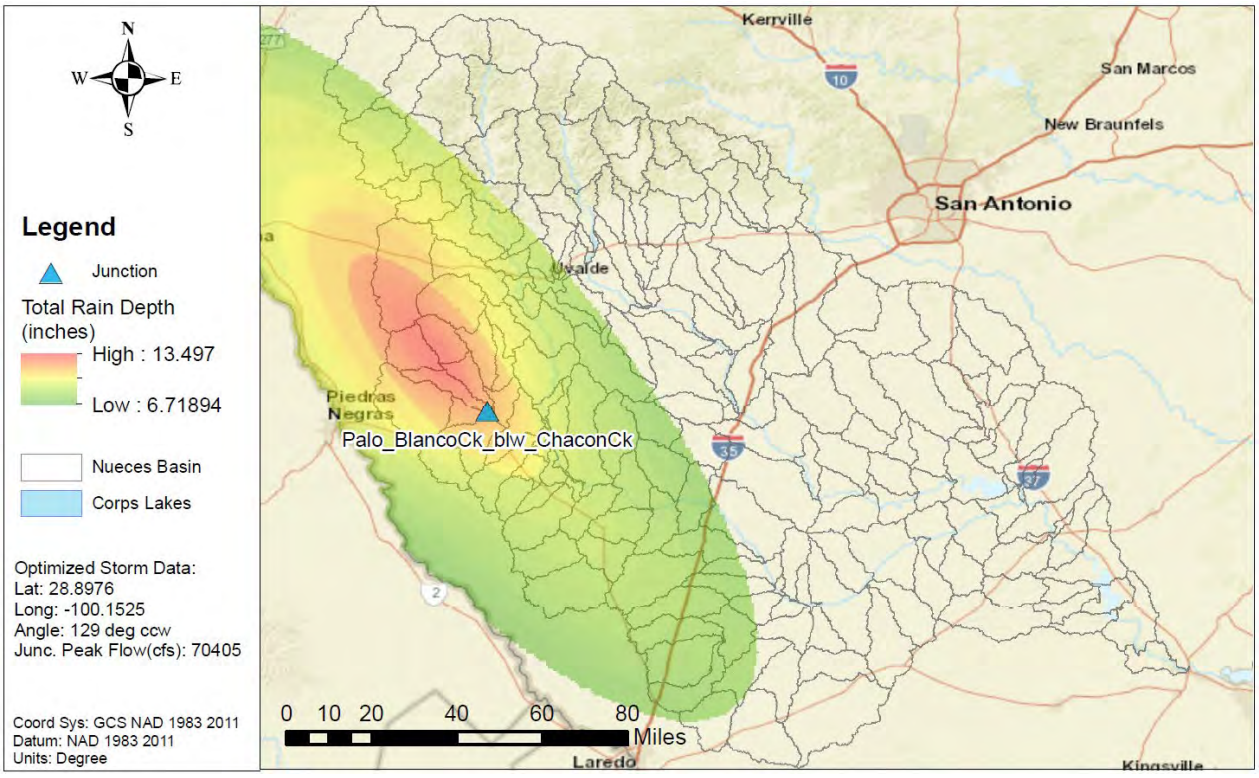

Figure C.11-23b: NA14 1% AEP Elliptical Storm for W_NuecesRv_blw_Live OakCk

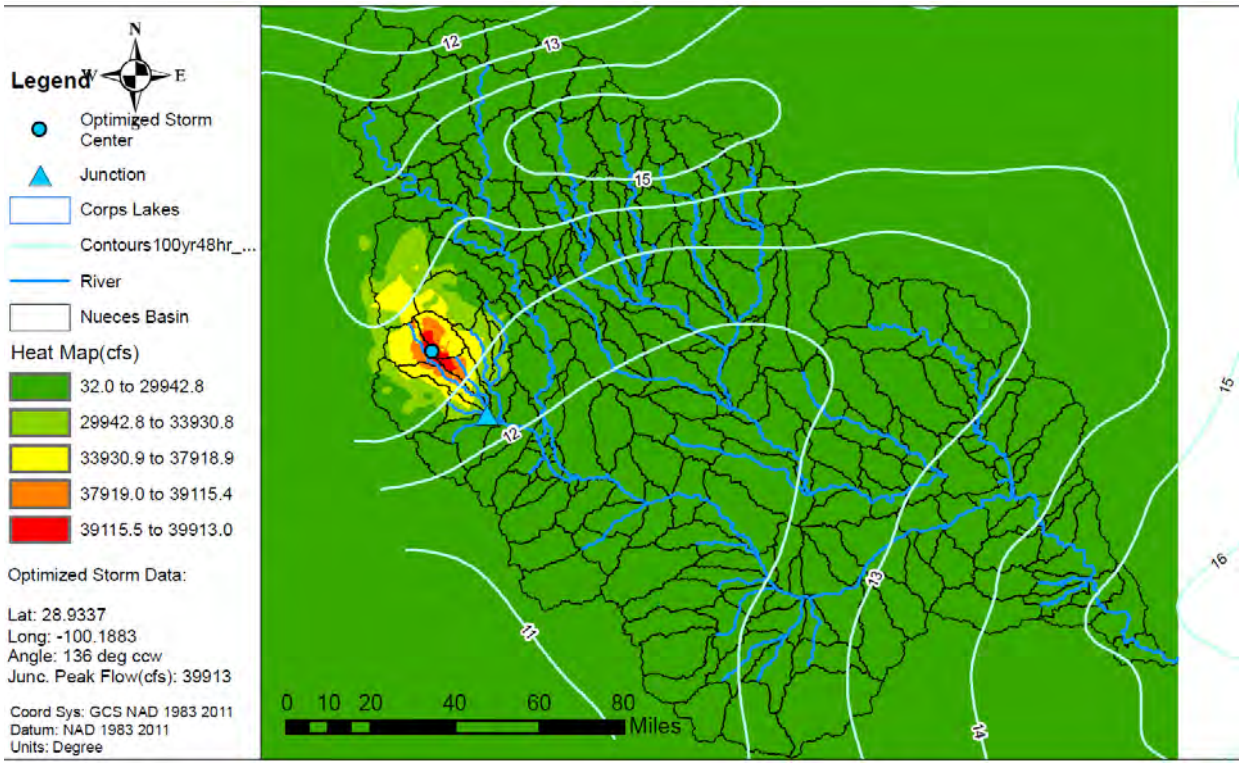

Figure C.11-24a: Elliptical Storm Optimization Heat Map for Palo_BlancoCk_abv_PicosaCk

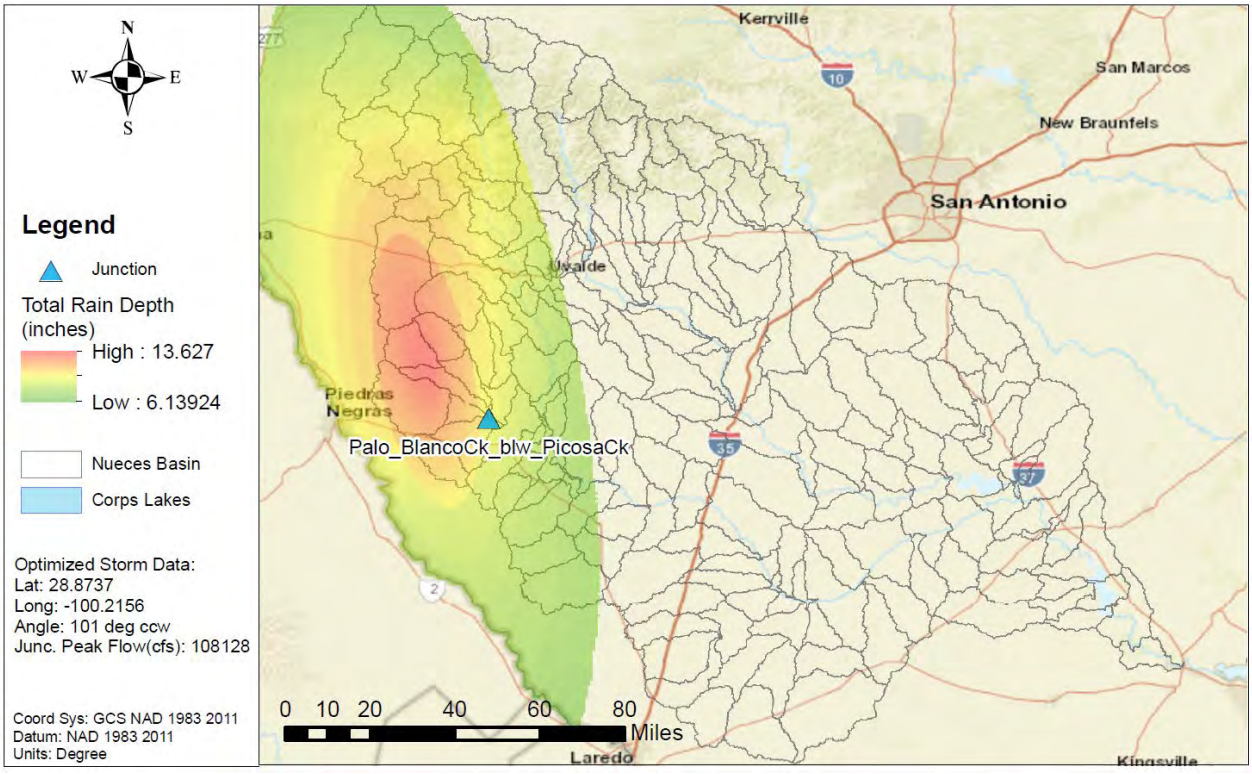

Figure C.11-24b: NA14 1% AEP Elliptical Storm for Palo_BlancoCk_abv_PicosaCk

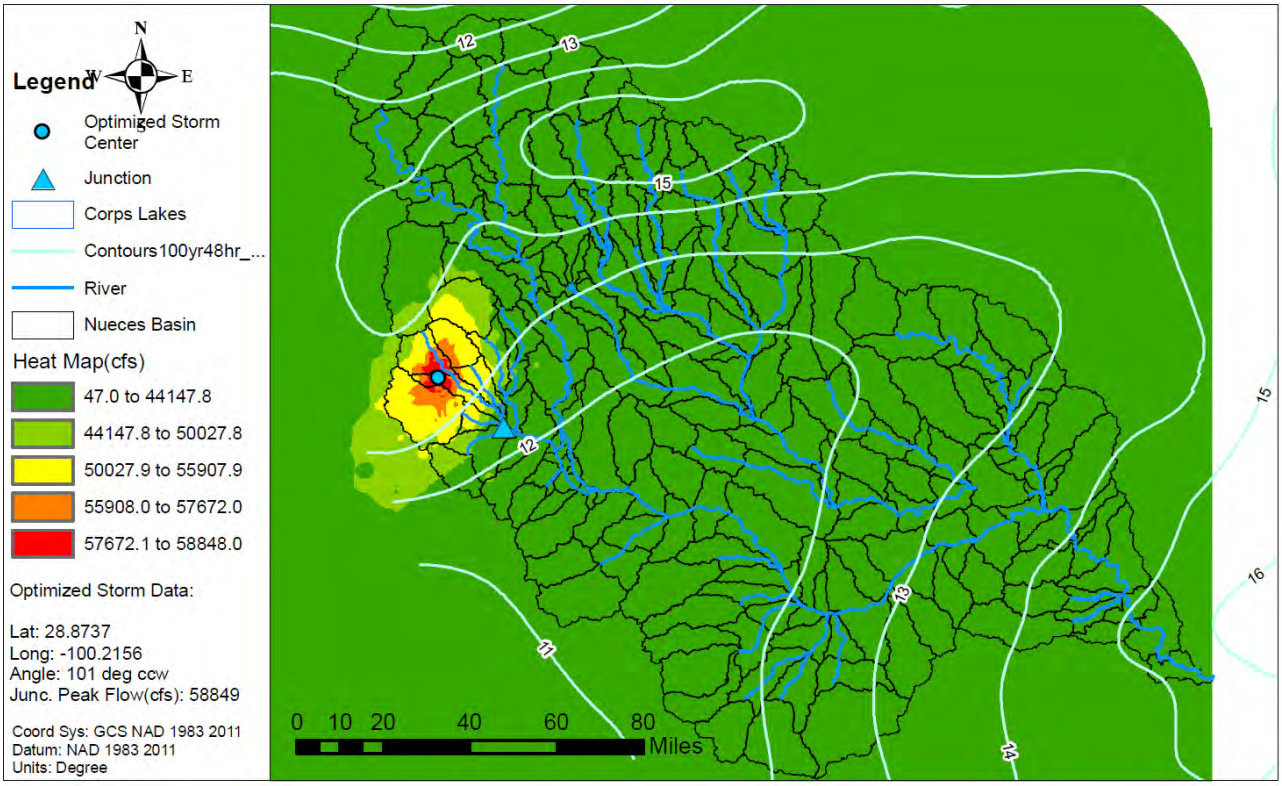

Figure C.11-25a: Elliptical Storm Optimization Heat Map for Palo_BlancoCk_blw_PicosaCk

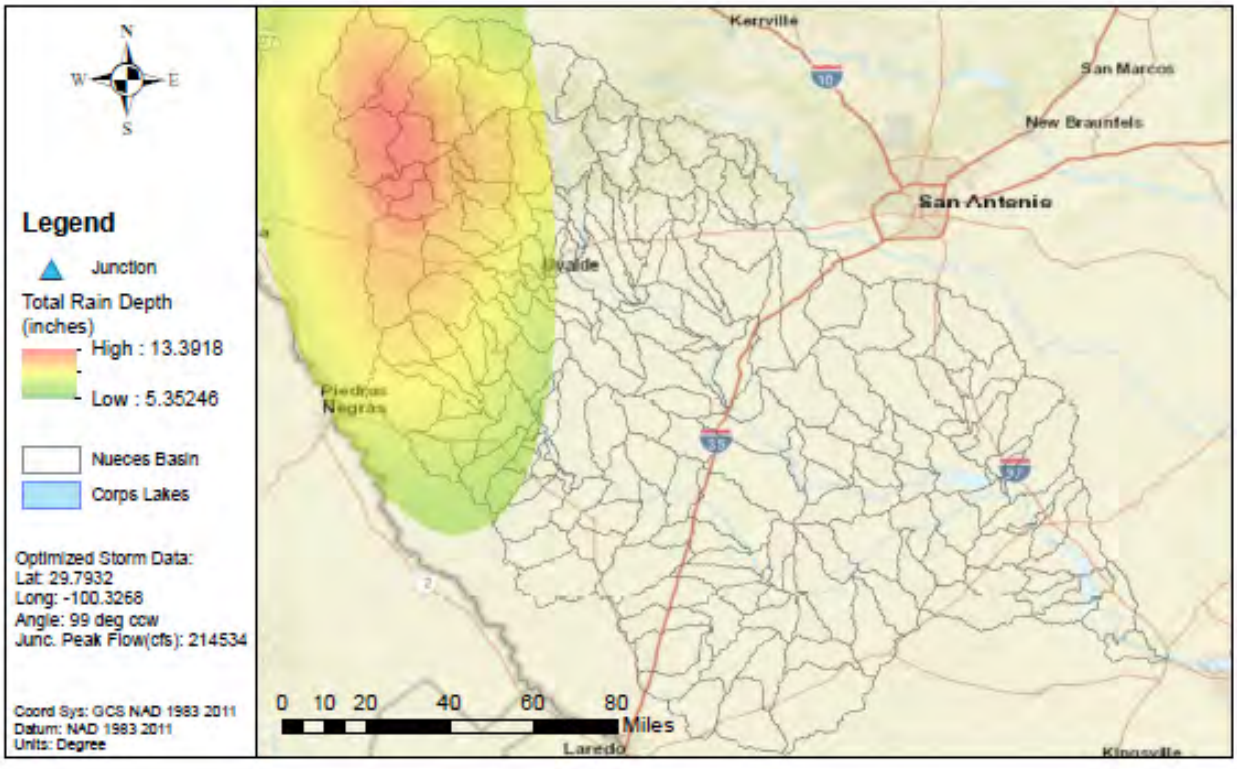

Figure C.11-25b: NA14 1% AEP Elliptical Storm for Palo_BlancoCk_blw_PicosaCk

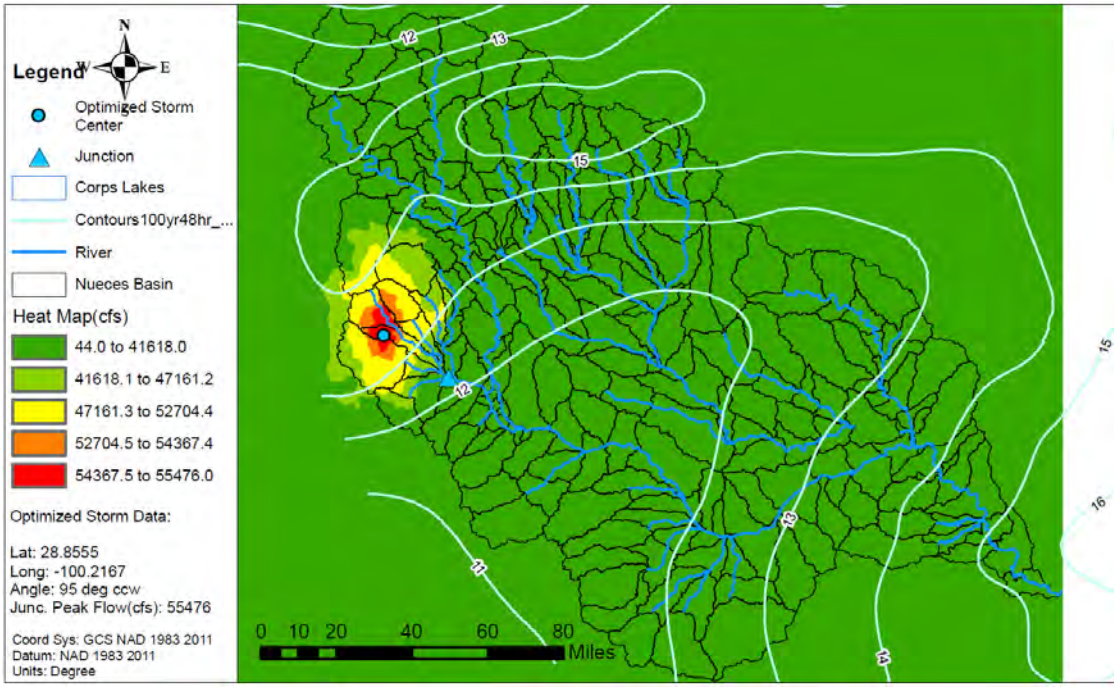

Figure C.11-26a: Elliptical Storm Optimization Heat Map for Palo_BlancoCk_abv_ComancheC

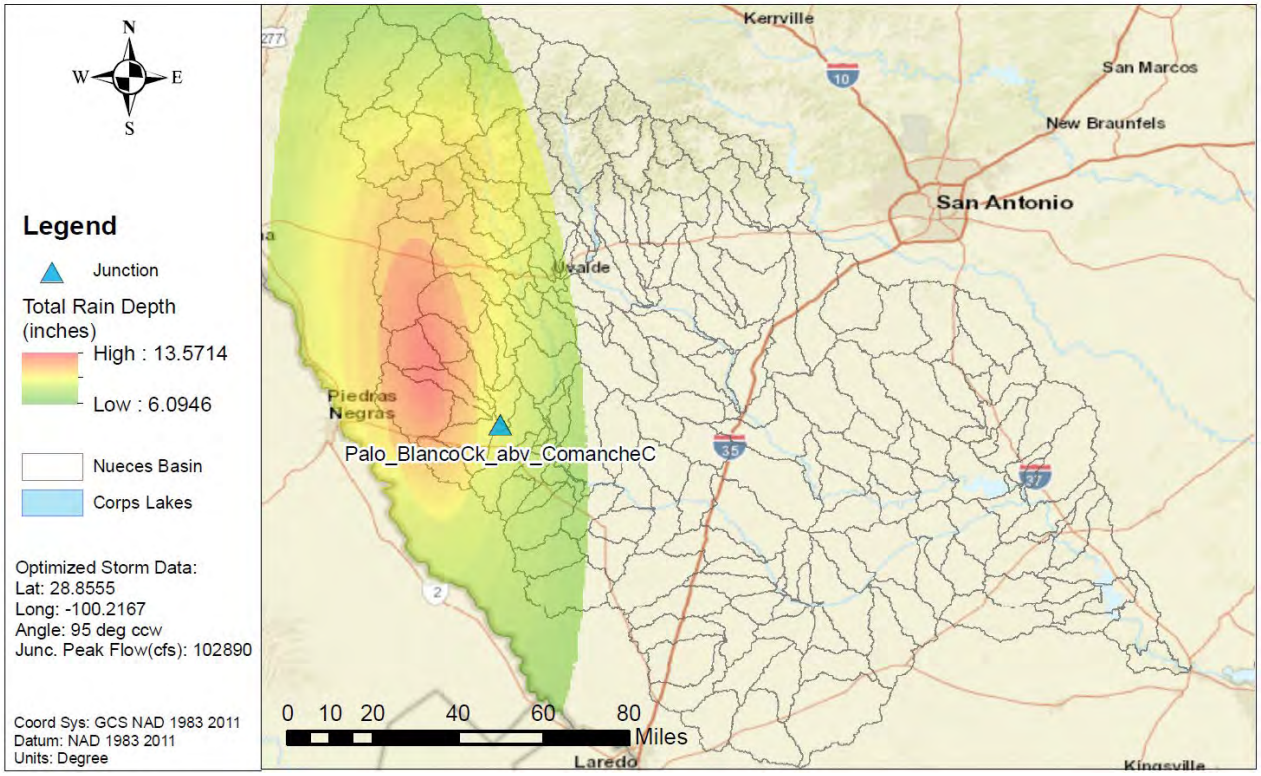

Figure C.11-26b: NA14 1% AEP Elliptical Storm for Palo_BlancoCk_abv_ComancheC

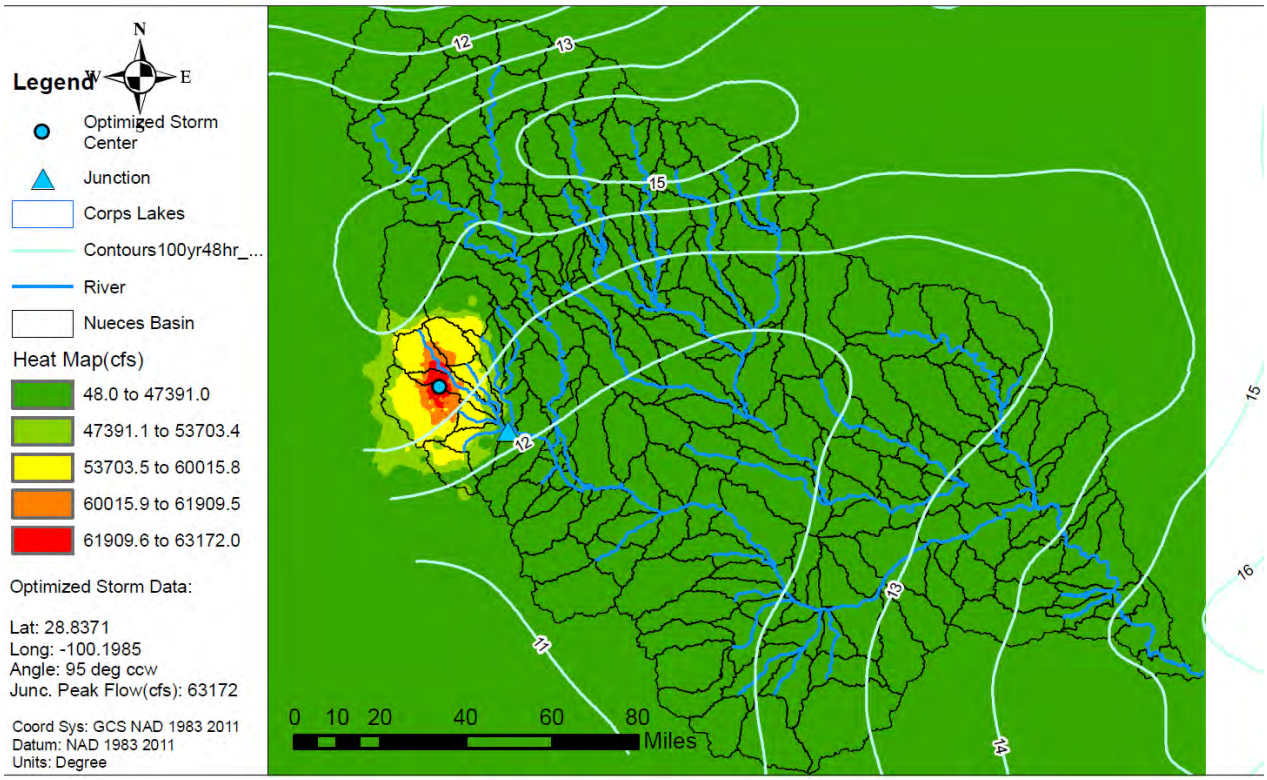

Figure C.11-27a: Elliptical Storm Optimization Heat Map for Palo_BlancoCk_blw_ComancheC

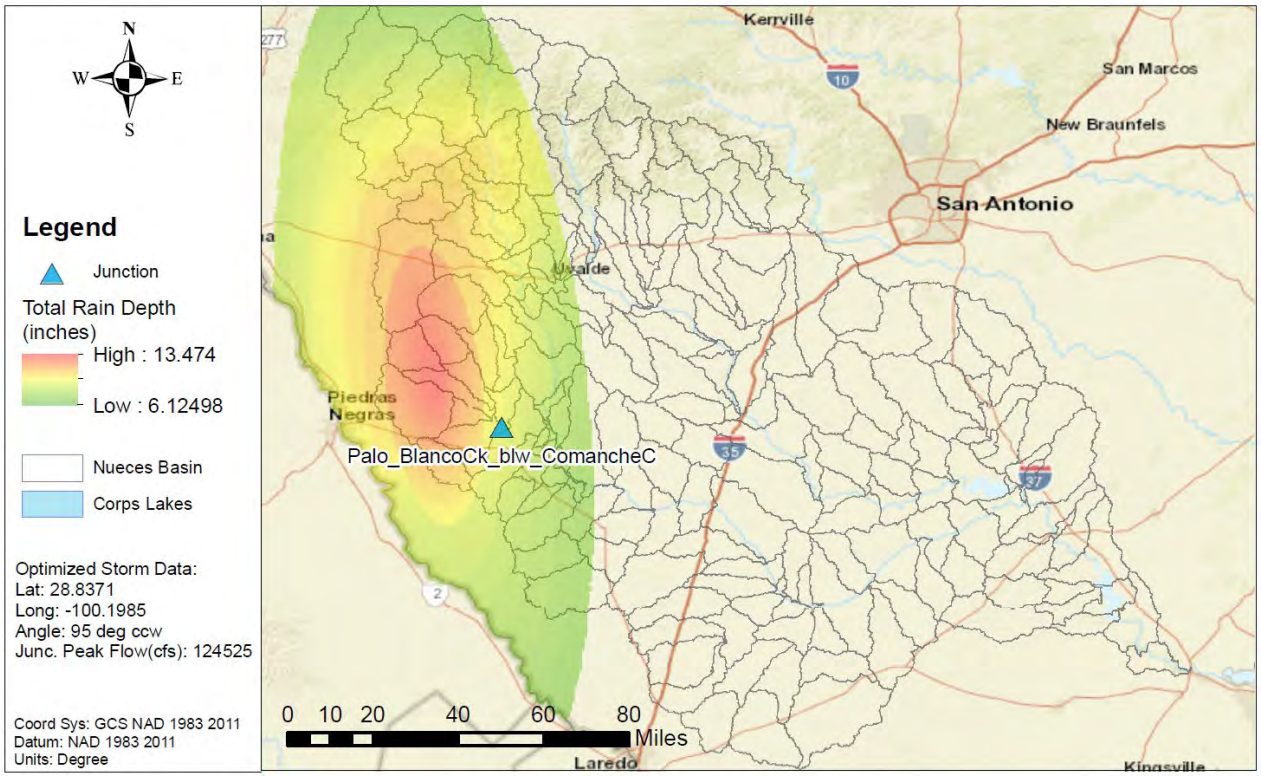

Figure C.11-27b: NA14 1% AEP Elliptical Storm for Palo_BlancoCk_blw_ComancheC

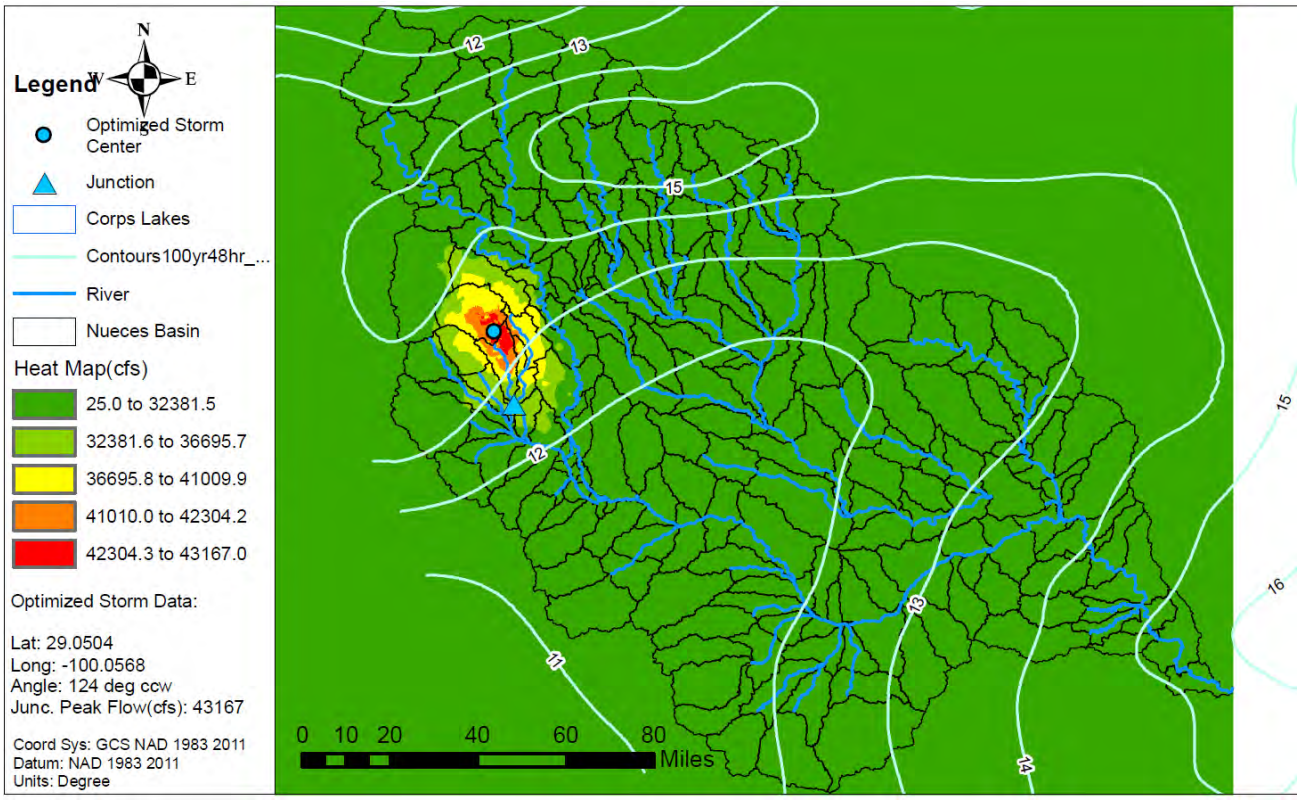

Figure C.11-28a: Elliptical Storm Optimization Heat Map for TurkeyCk_blw_ChaparrosaCk

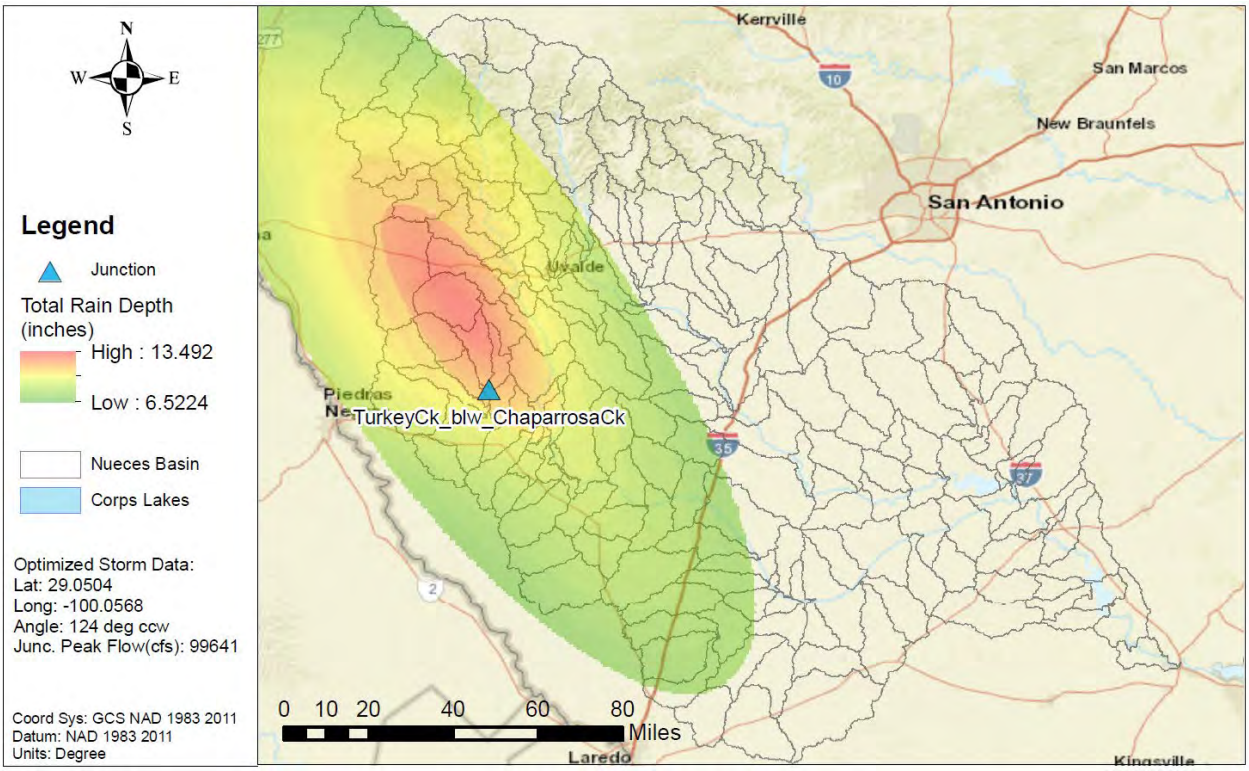

Figure C.11-28b: NA14 1% AEP Elliptical Storm for TurkeyCk_blw_ChaparrosaCk

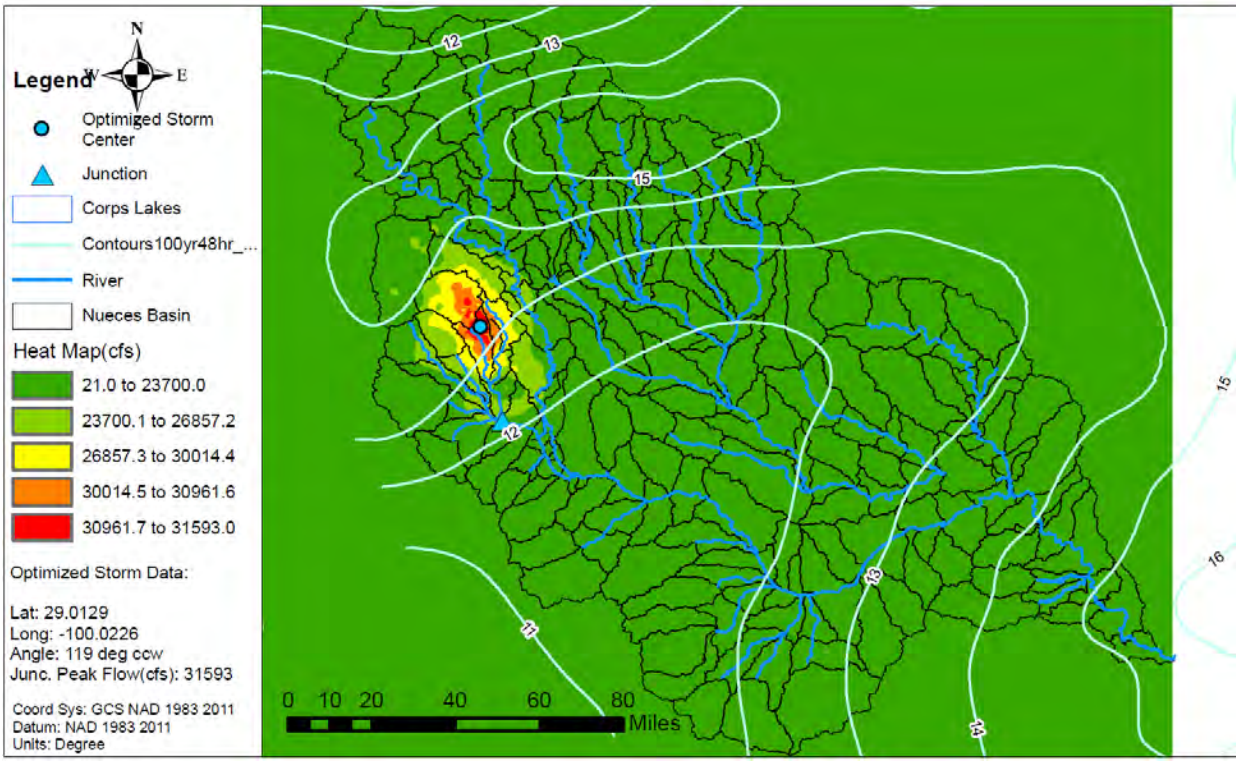

Figure C.11-29a: Elliptical Storm Optimization Heat Map for TurkeyCk_abv_PicosaCk

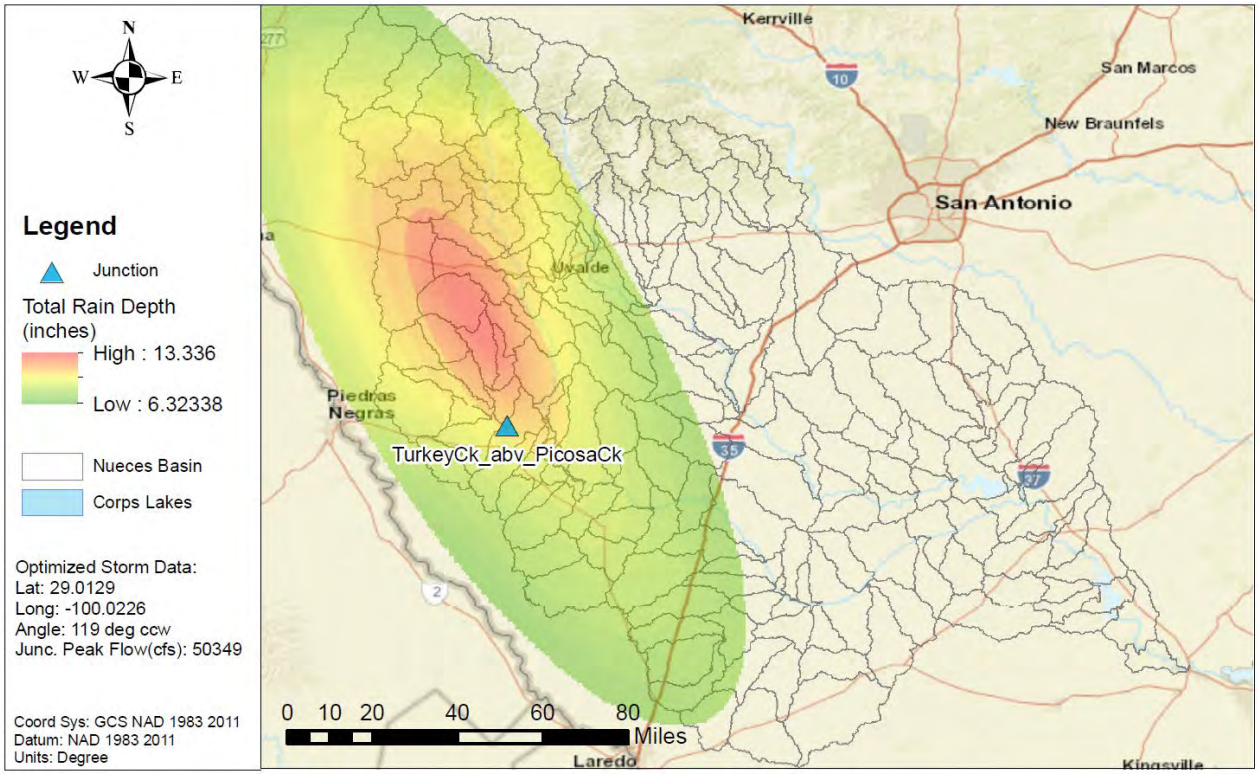

Figure C.11-29b: NA14 1% AEP Elliptical Storm for TurkeyCk_abv_PicosaCk

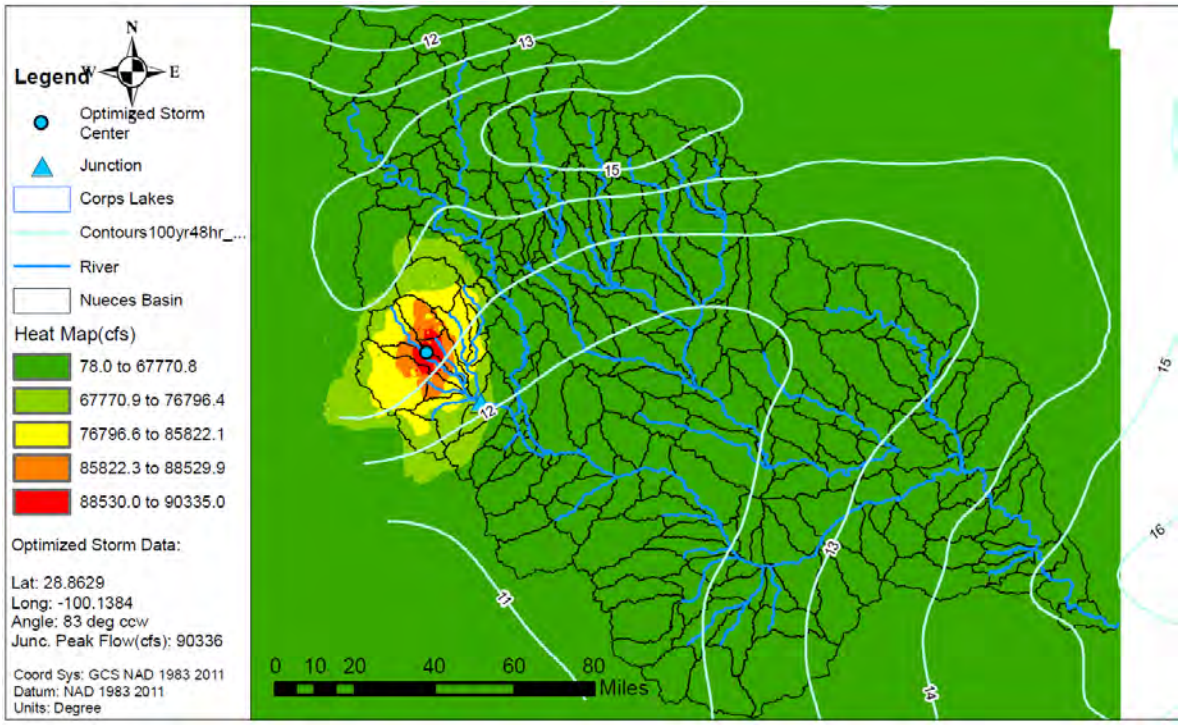

Figure C.11-30a: Elliptical Storm Optimization Heat Map for TurkeyCk_blw_PicosaCk

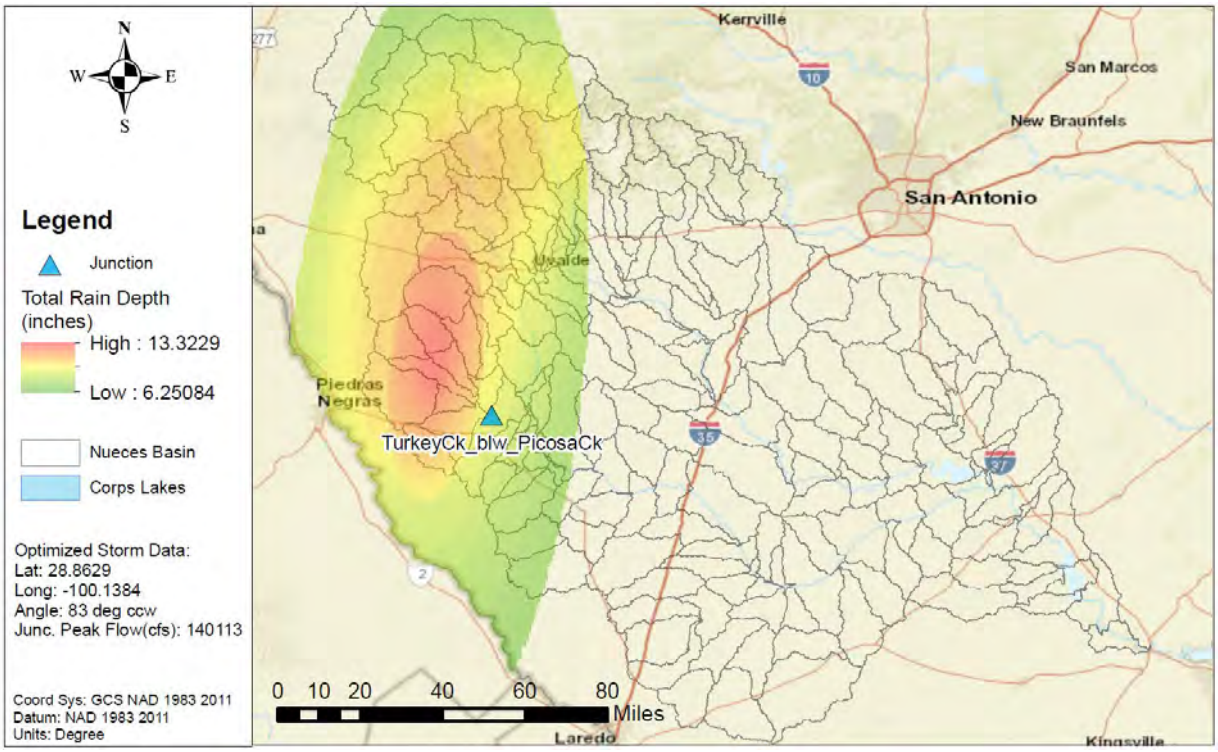

Figure C.11-30b: NA14 1% AEP Elliptical Storm for TurkeyCk_blw_PicosaCk

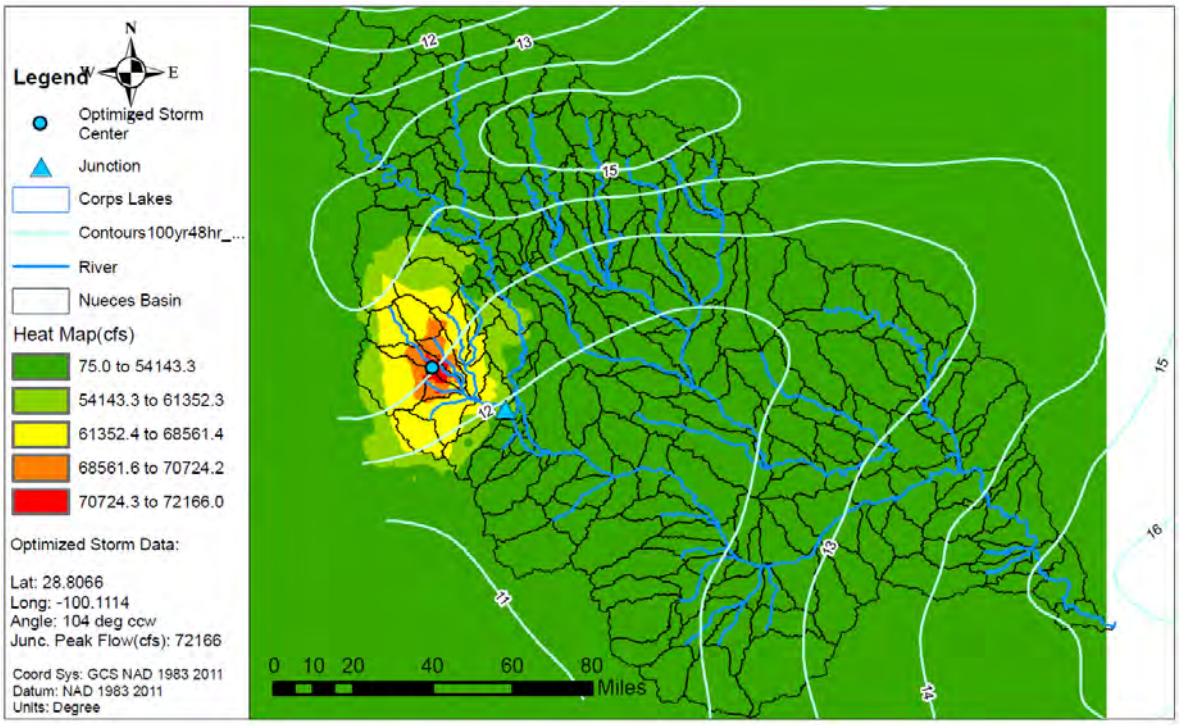

Figure C.11-31a: Elliptical Storm Optimization Heat Map for TurkeyCk_at_HWY-83

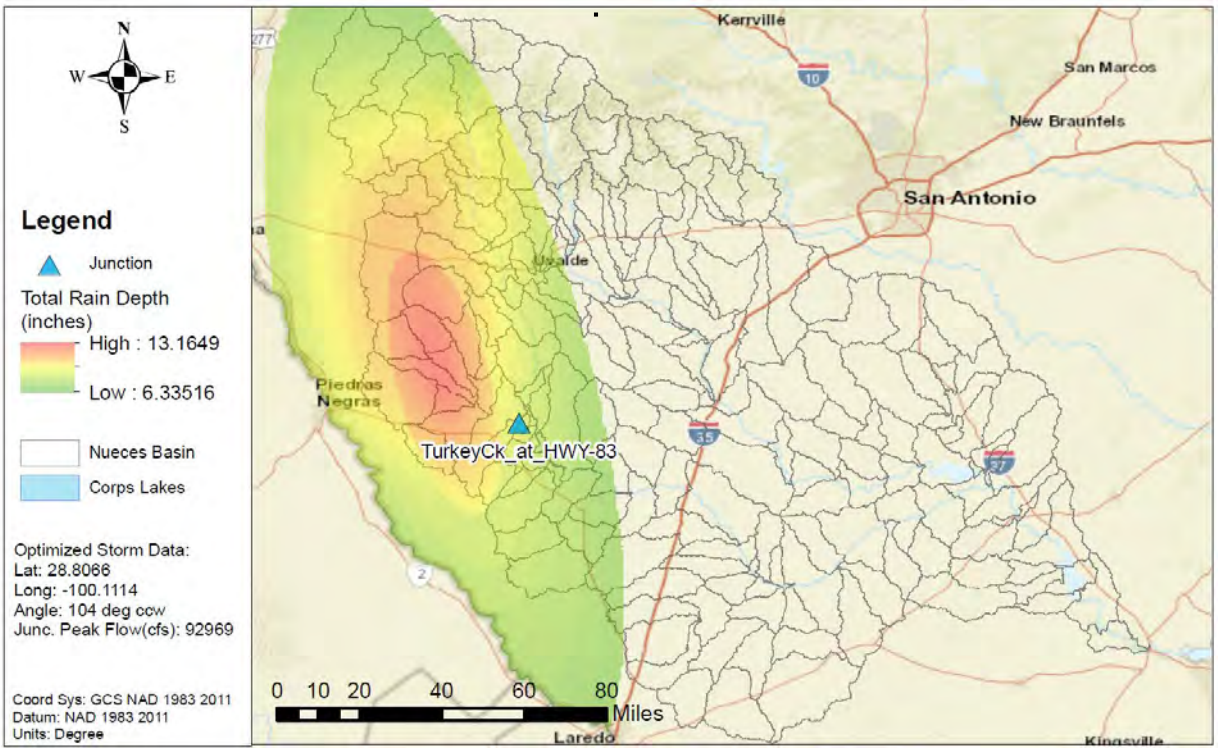

Figure C.11-31b: NA14 1% AEP Elliptical Storm for TurkeyCk_at_HWY-83

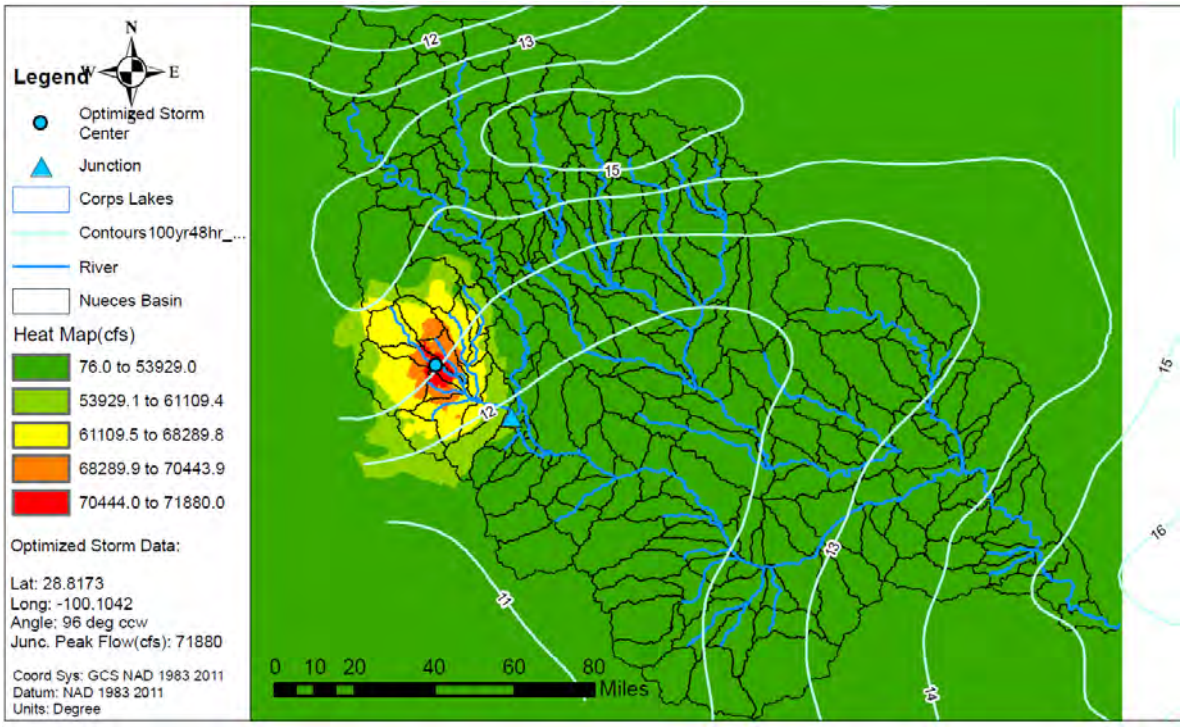

Figure C.11-32a: Elliptical Storm Optimization Heat Map for TurkeyCk_abv_Turkey_Split

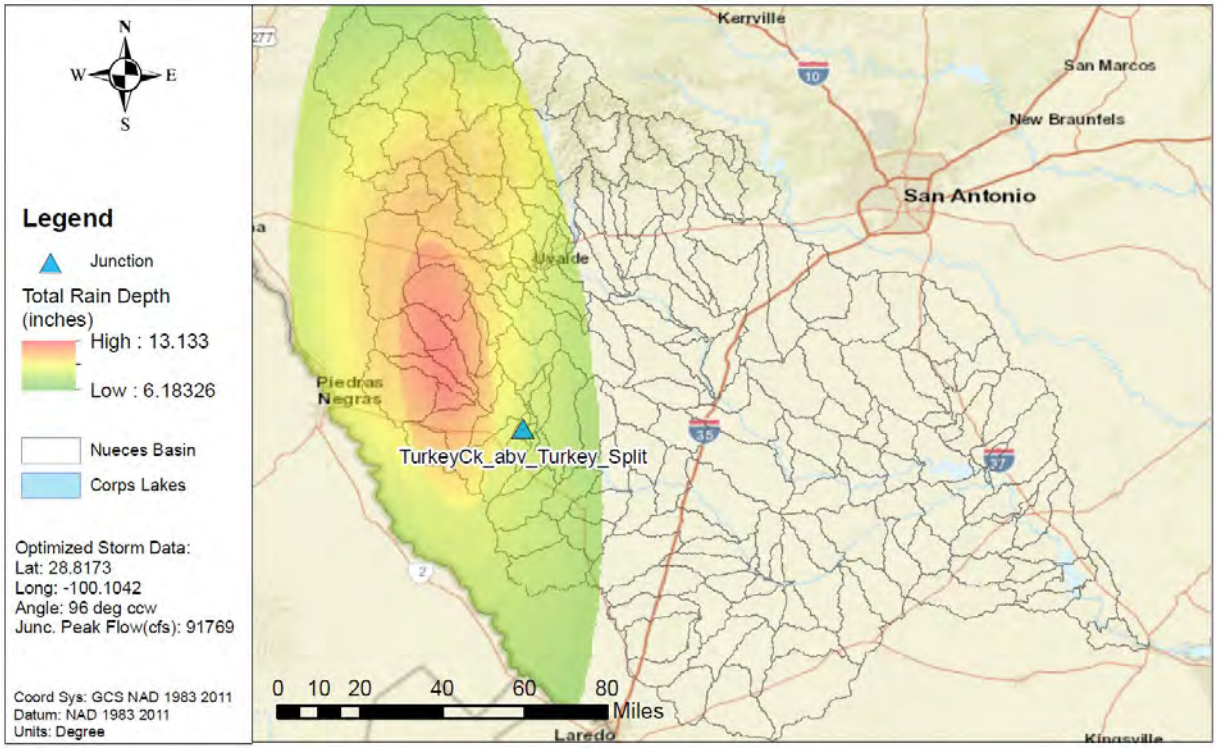

Figure C.11-32b: NA14 1% AEP Elliptical Storm for TurkeyCk_abv_Turkey_Split

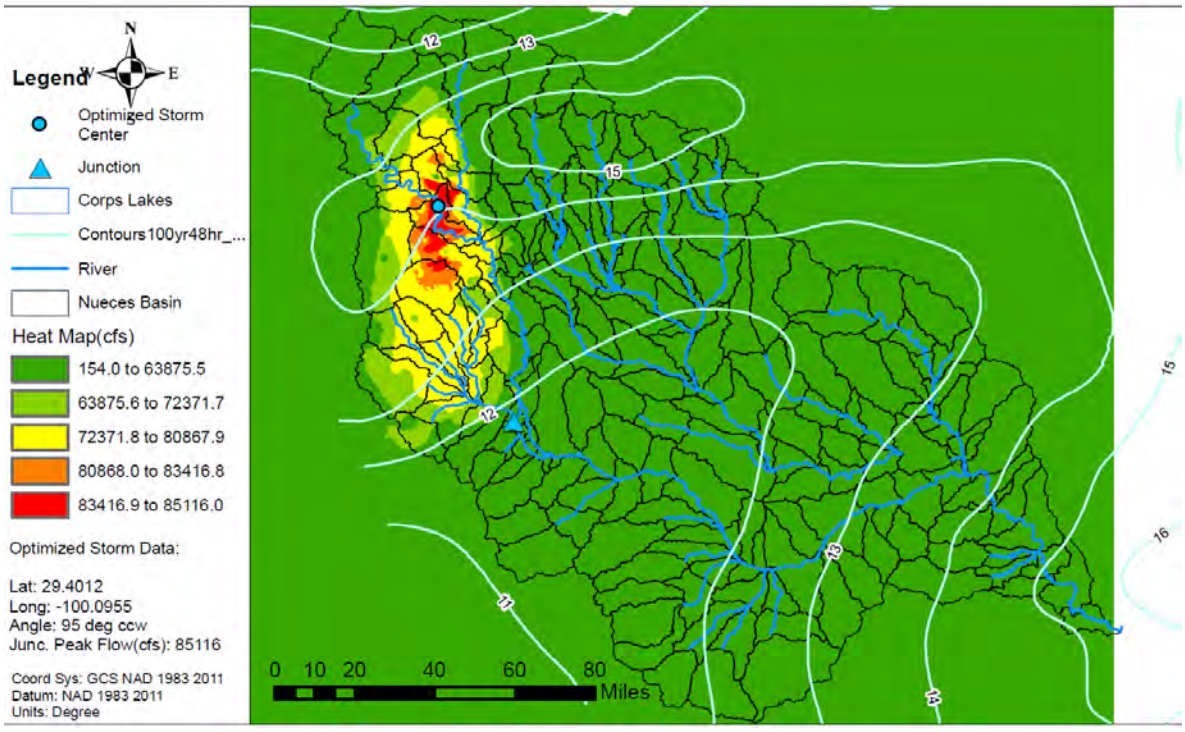

Figure C.11-33a: Elliptical Storm Optimization Heat Map for TurkeyCk_blw_Turkey_Split

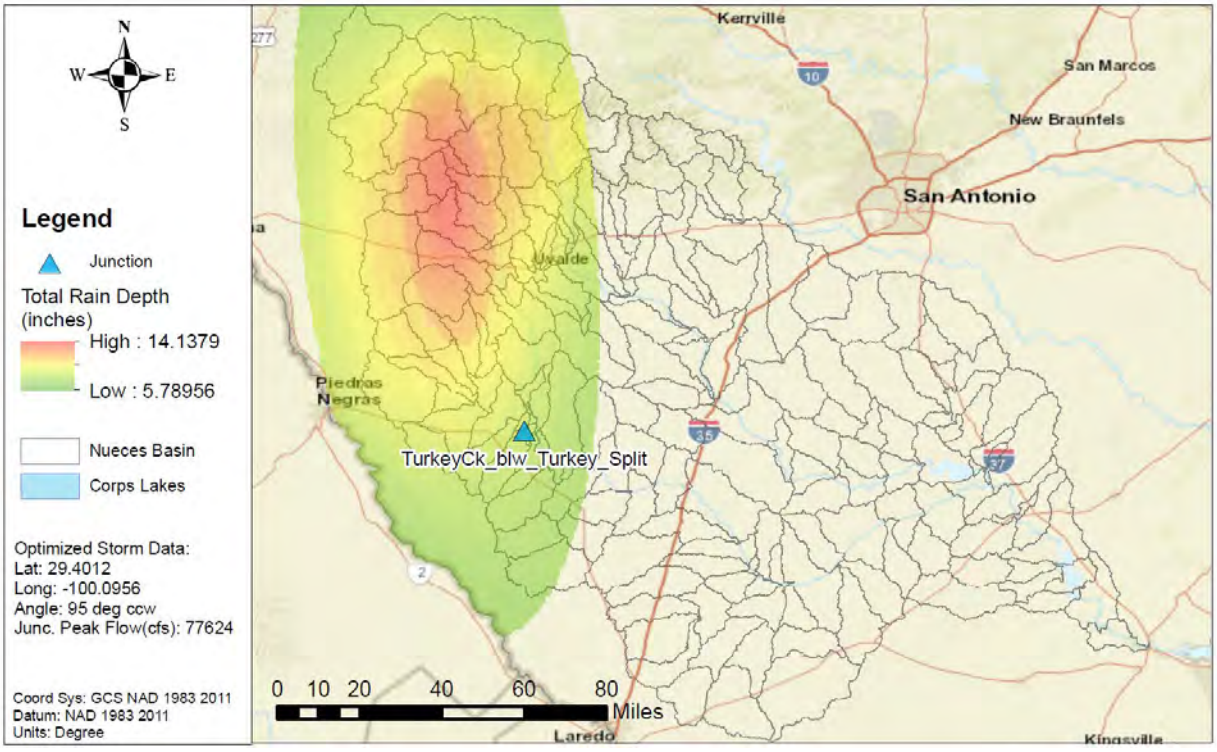

Figure C.11-30b: NA14 1% AEP Elliptical Storm for TurkeyCk_blw_Turkey_Split

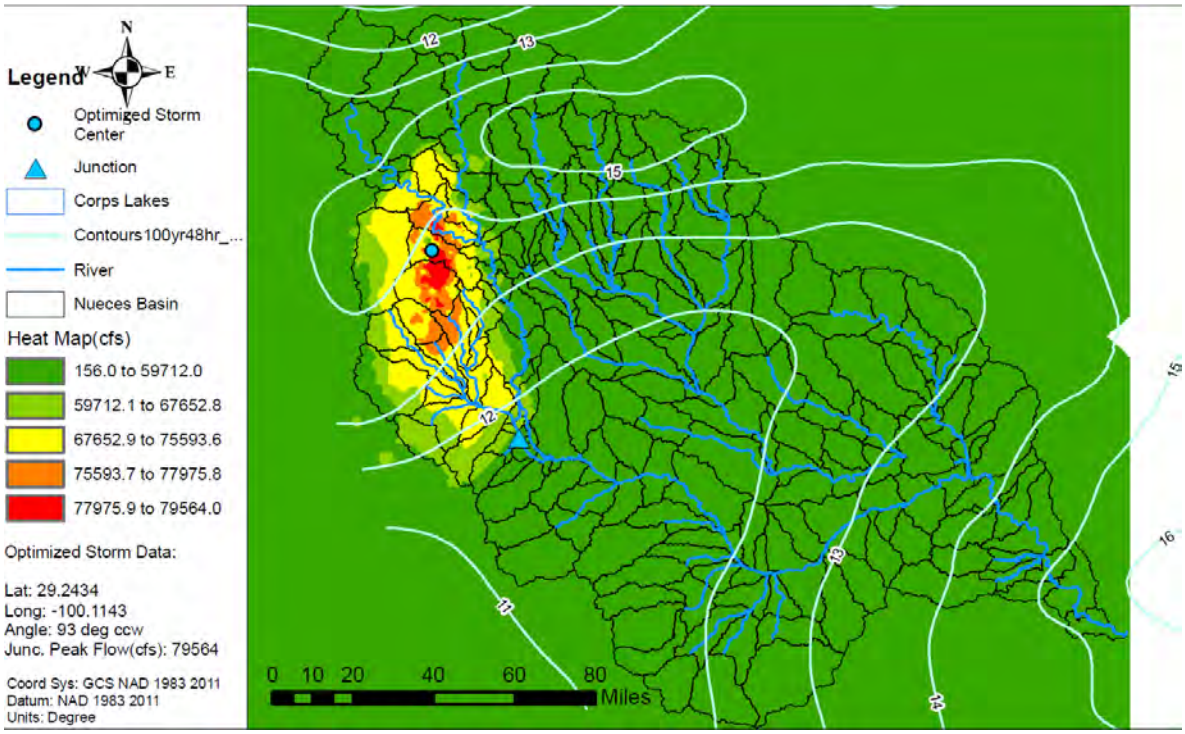

Figure C.11-34a: Elliptical Storm Optimization Heat Map for TurkeyCk_abv_CarrizoCk

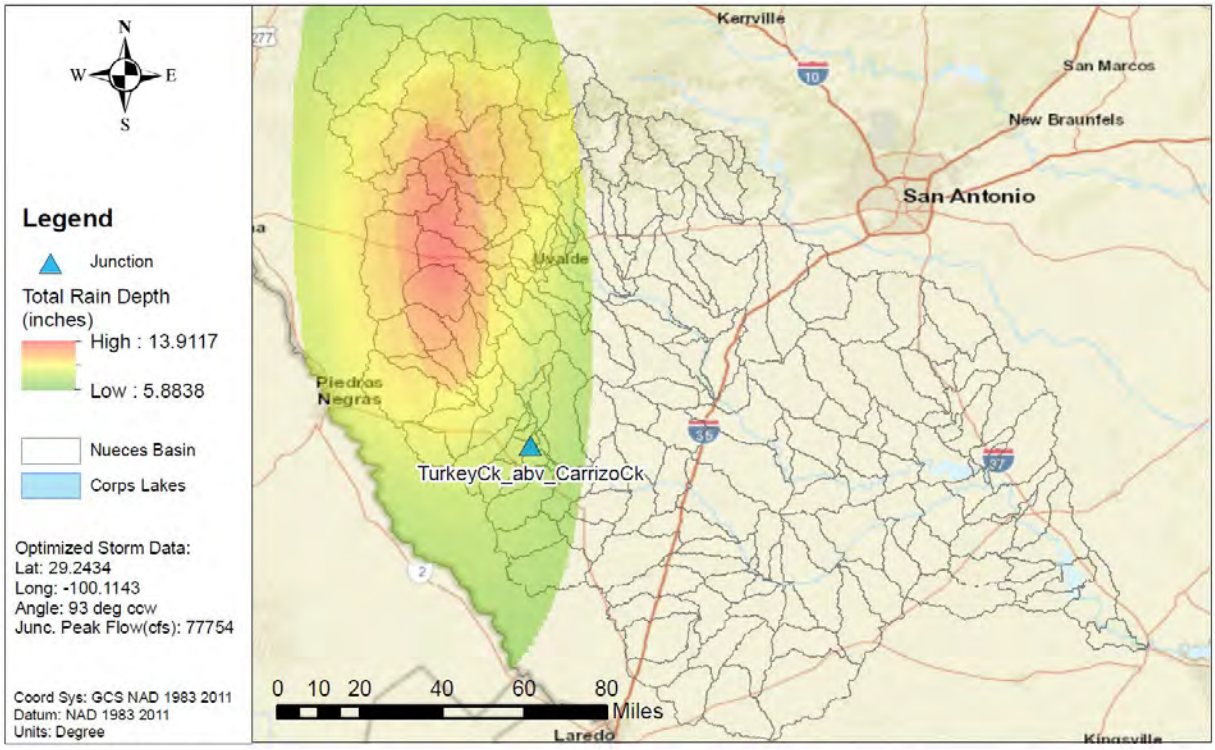

Figure C.11-34b: NA14 1% AEP Elliptical Storm for TurkeyCk_abv_CarrizoCk

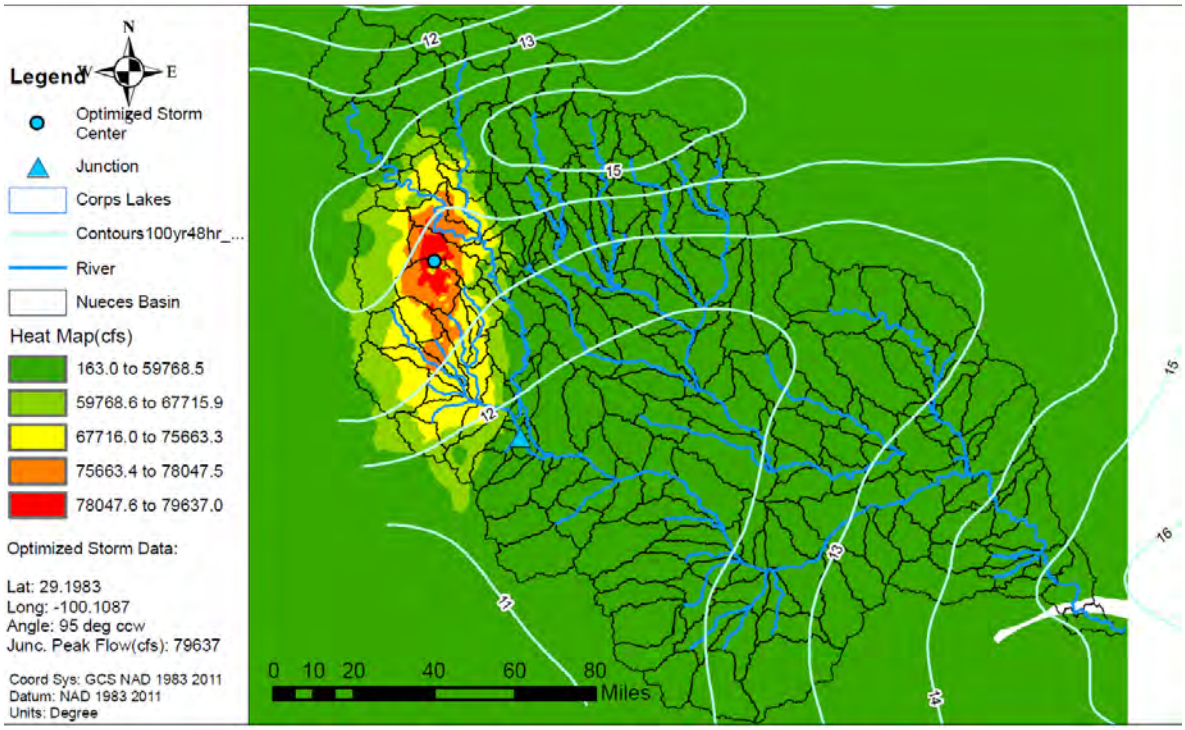

Figure C.11-35a: Elliptical Storm Optimization Heat Map for TurkeyCk_blw_CarrizoCk

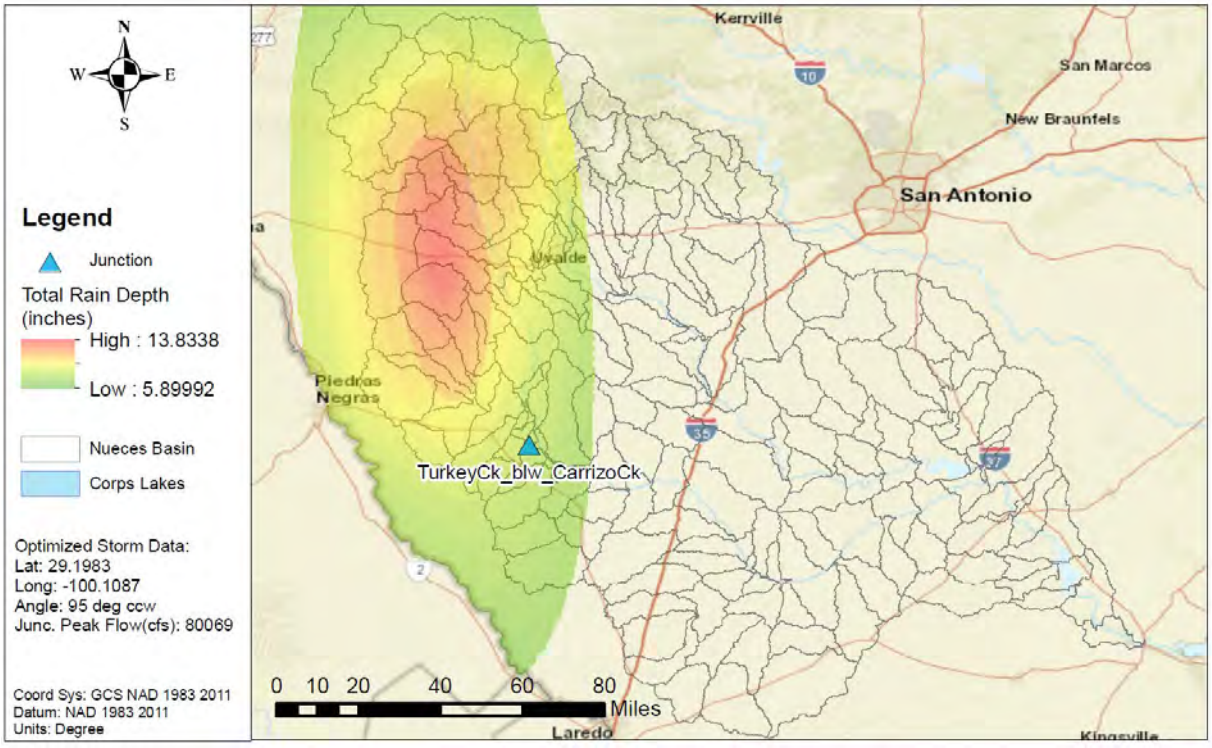

Figure C.11-35b: NA14 1% AEP Elliptical Storm for TurkeyCk_blw_CarrizoCk

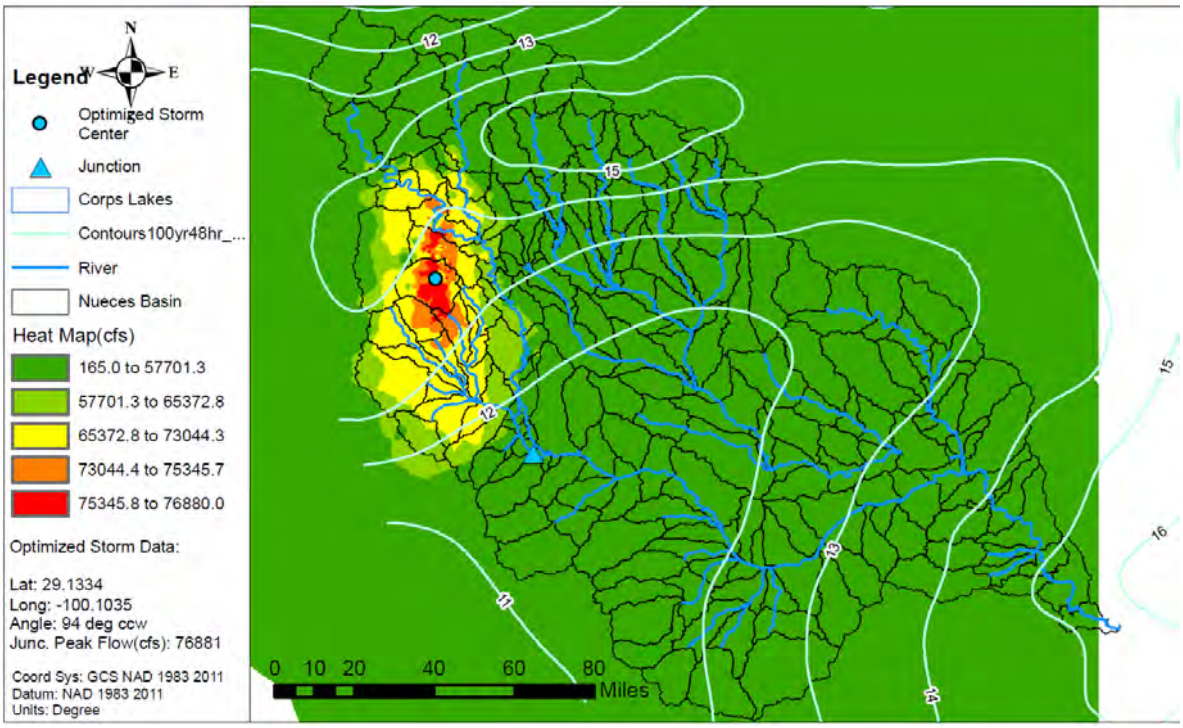

Figure C.11-36a: Elliptical Storm Optimization Heat Map for TurkeyCk_abv_El_BarrosaCk

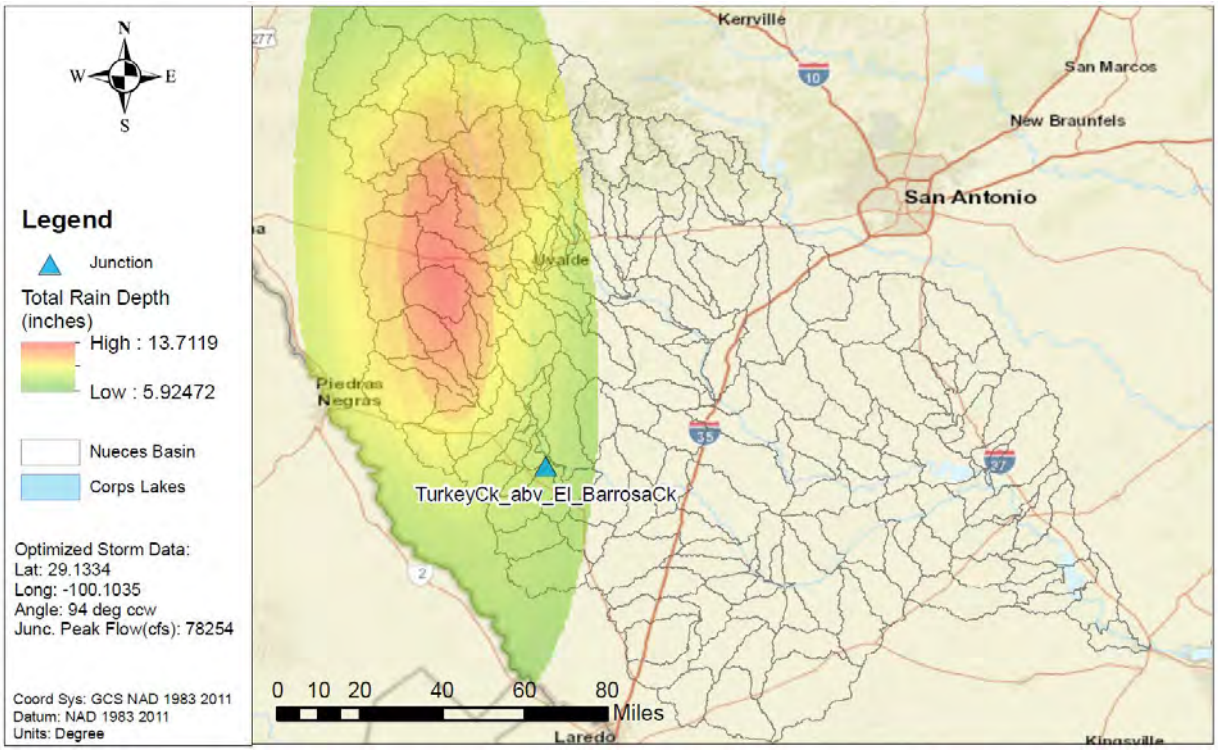

Figure C.11-36b: NA14 1% AEP Elliptical Storm for TurkeyCk_abv_El_BarrosaCk

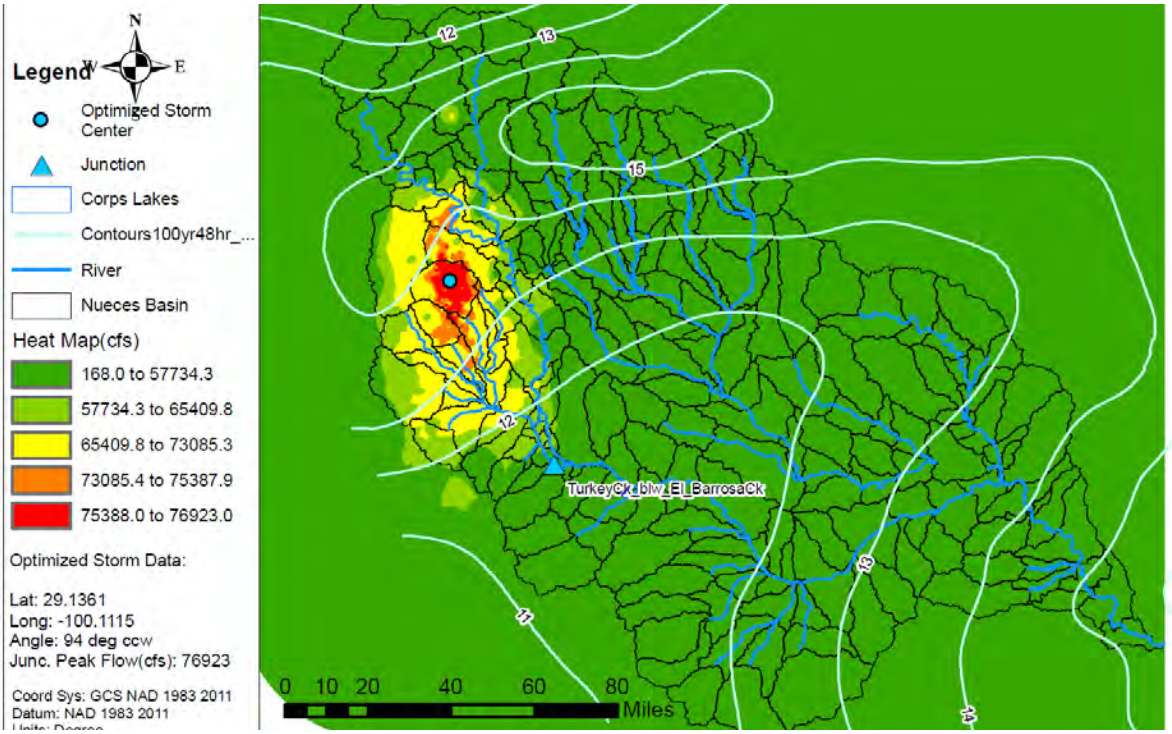

Figure C.11-37a: Elliptical Storm Optimization Heat Map for TurkeyCk_blw_El_BarrosaCk

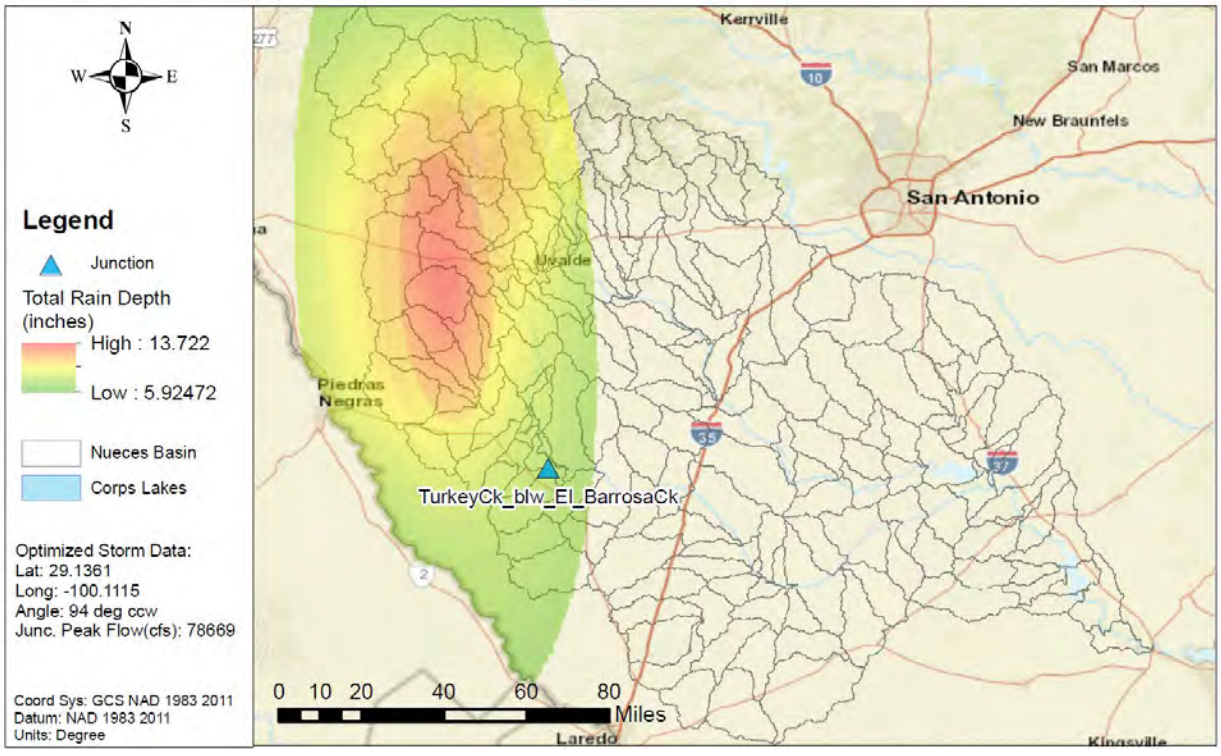

Figure C.11-37b: NA14 1% AEP Elliptical Storm for TurkeyCk_blw_El_BarrosaCk

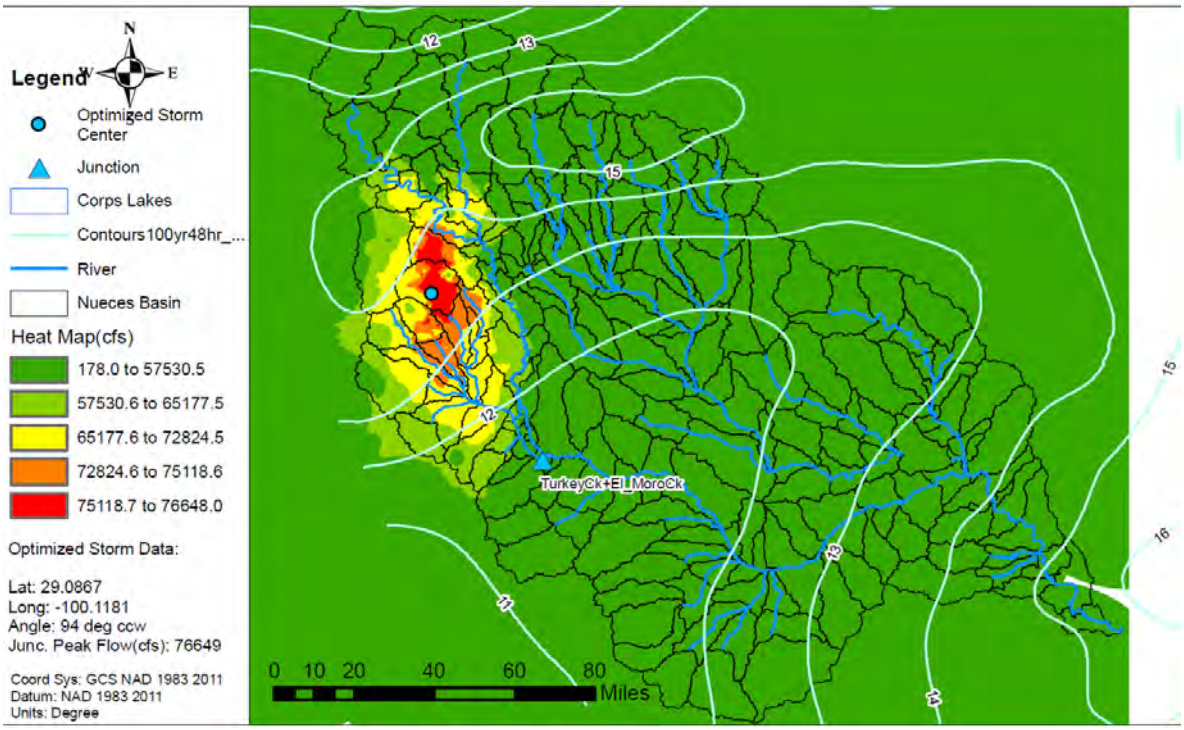

Figure C.11-38a: Elliptical Storm Optimization Heat Map for TurkeyCk+El_MoroCk

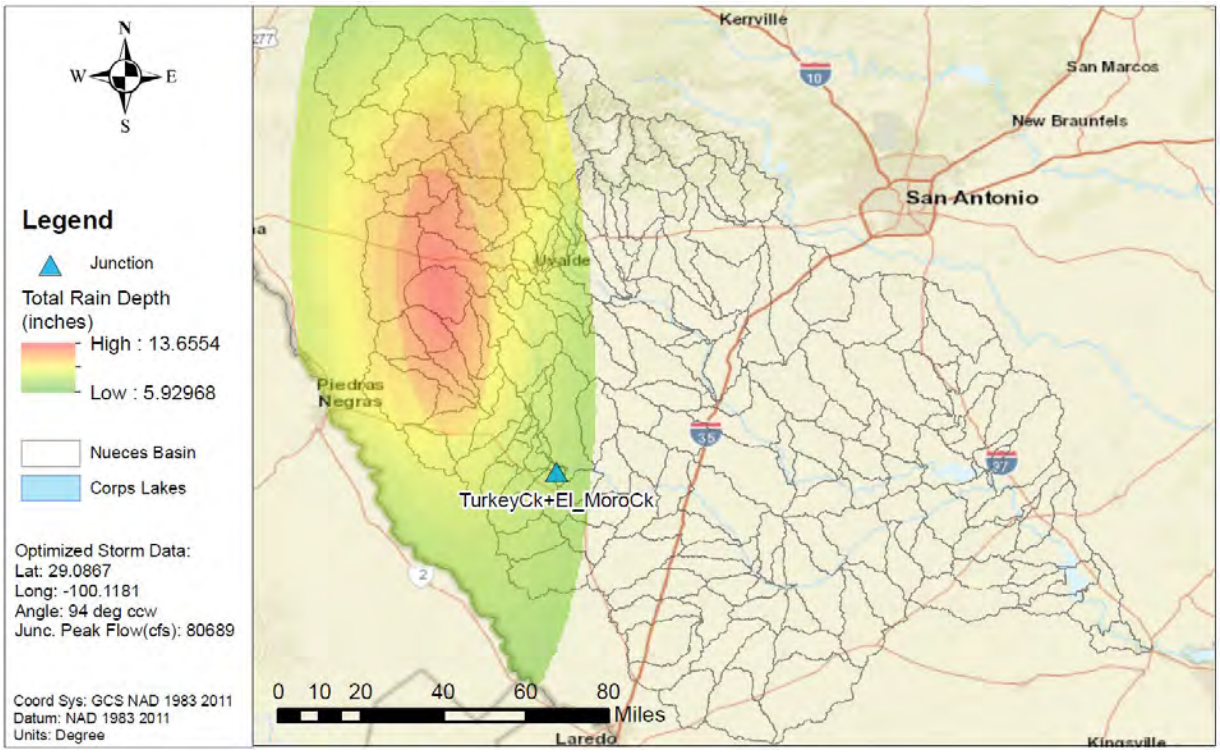

Figure C.11-38b: NA14 1% AEP Elliptical Storm for TurkeyCk+El_MoroCk

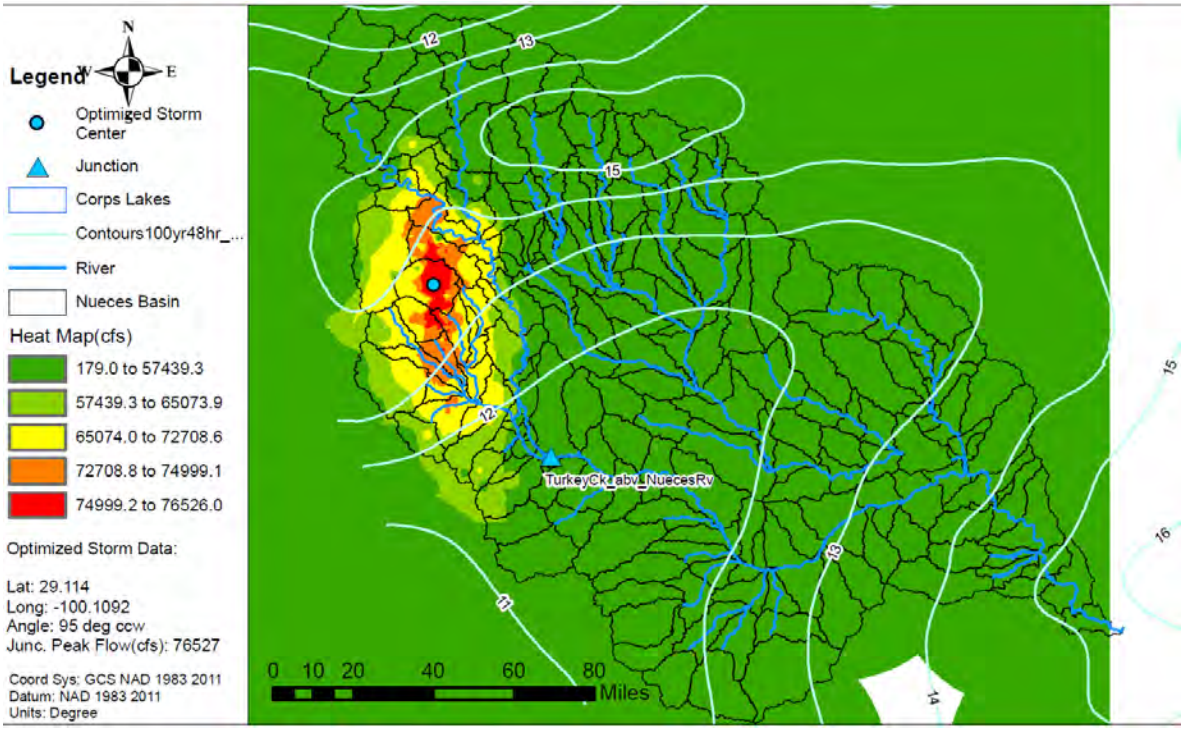

Figure C.11-39a: Elliptical Storm Optimization Heat Map for TurkeyCk_abv_NuecesRv

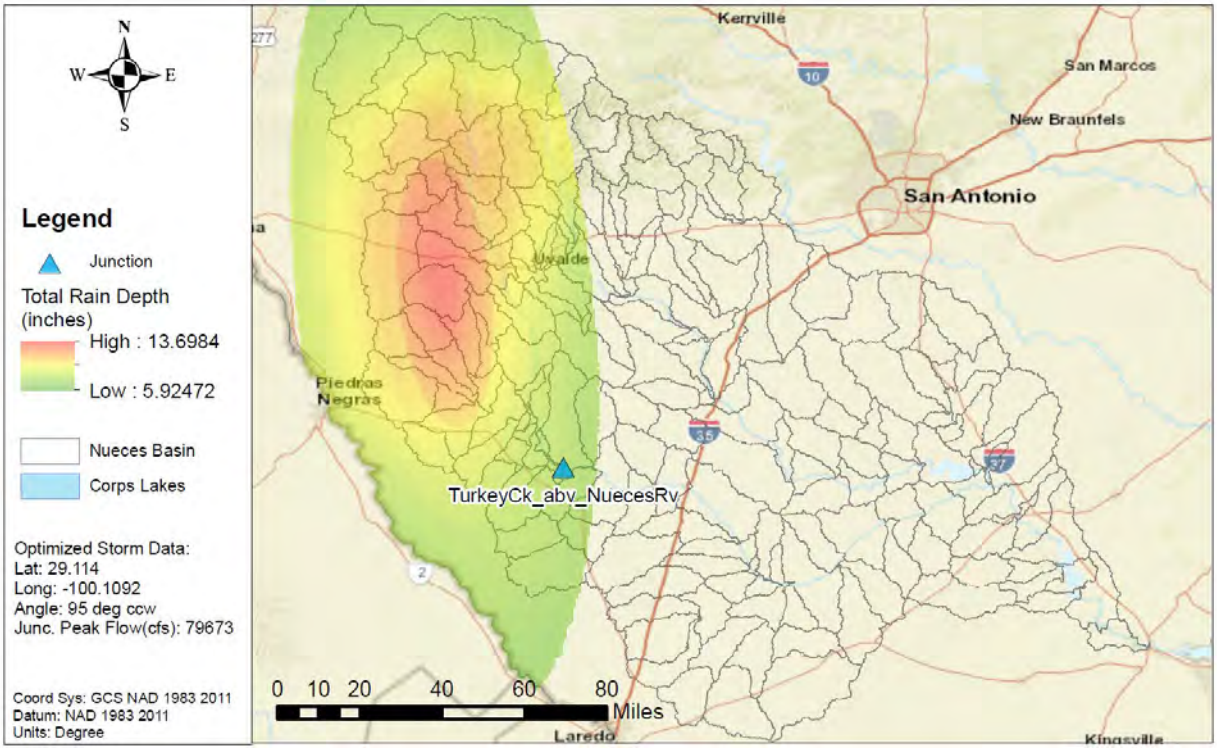

Figure C.11-39b: NA14 1% AEP Elliptical Storm for TurkeyCk_abv_NuecesRv

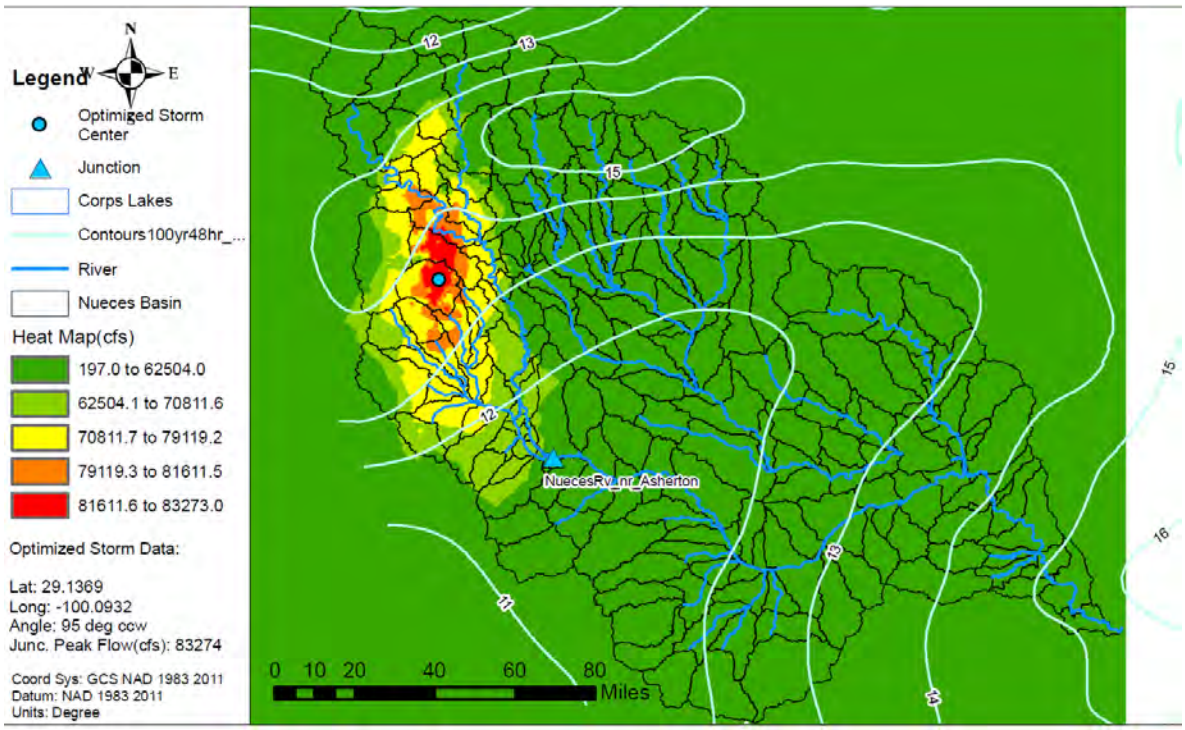

Figure C.11-40a: Elliptical Storm Optimization Heat Map for NuecesRv_nr_Asherton

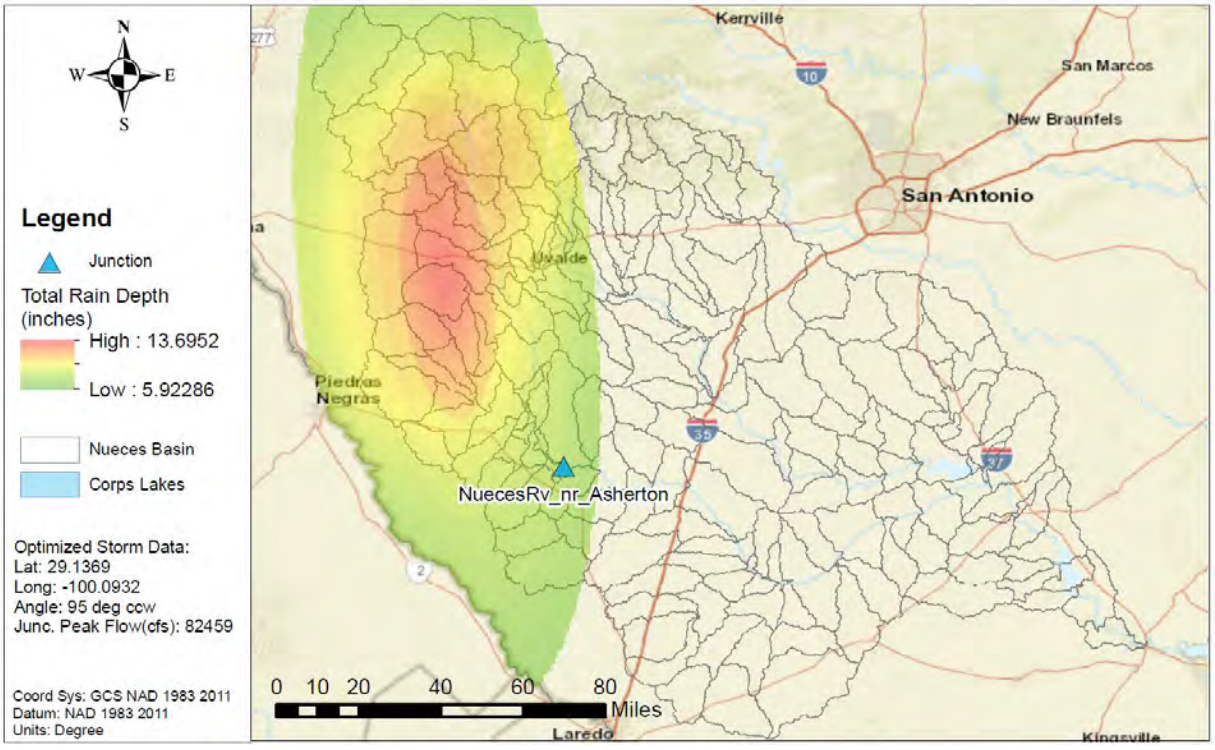

Figure C.11-40b: NA14 1% AEP Elliptical Storm for NuecesRv_nr_Asherton

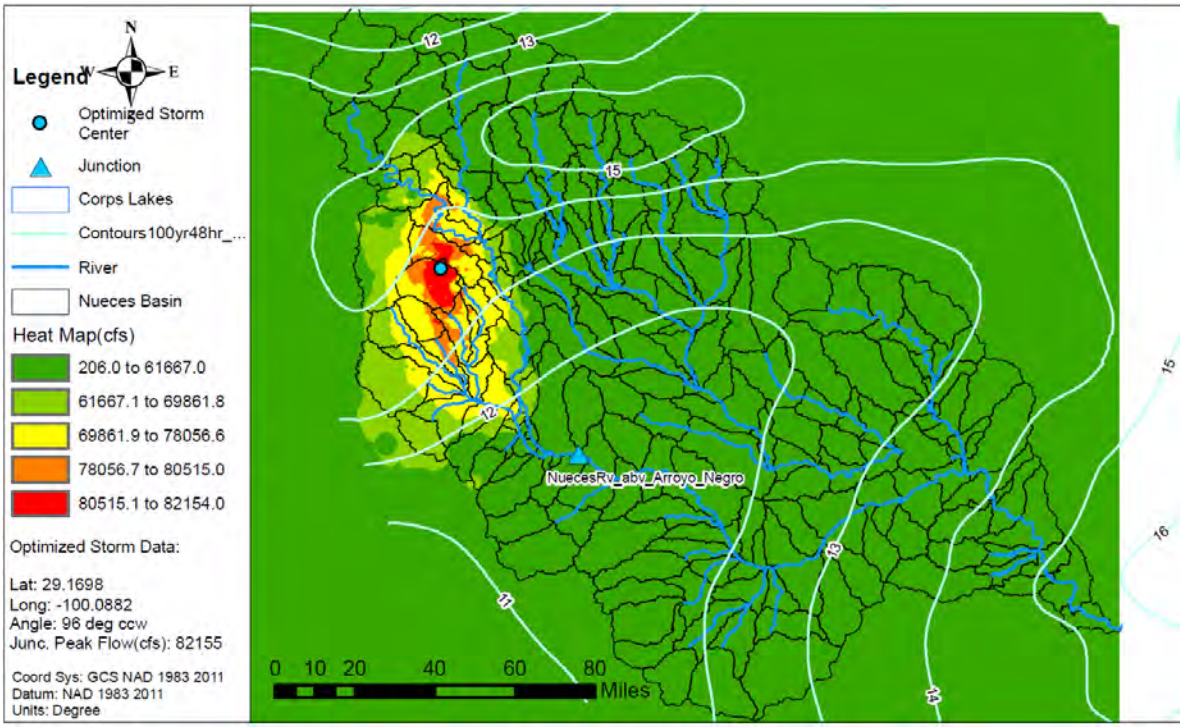

Figure C.11-41a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_Arroyo_Negro

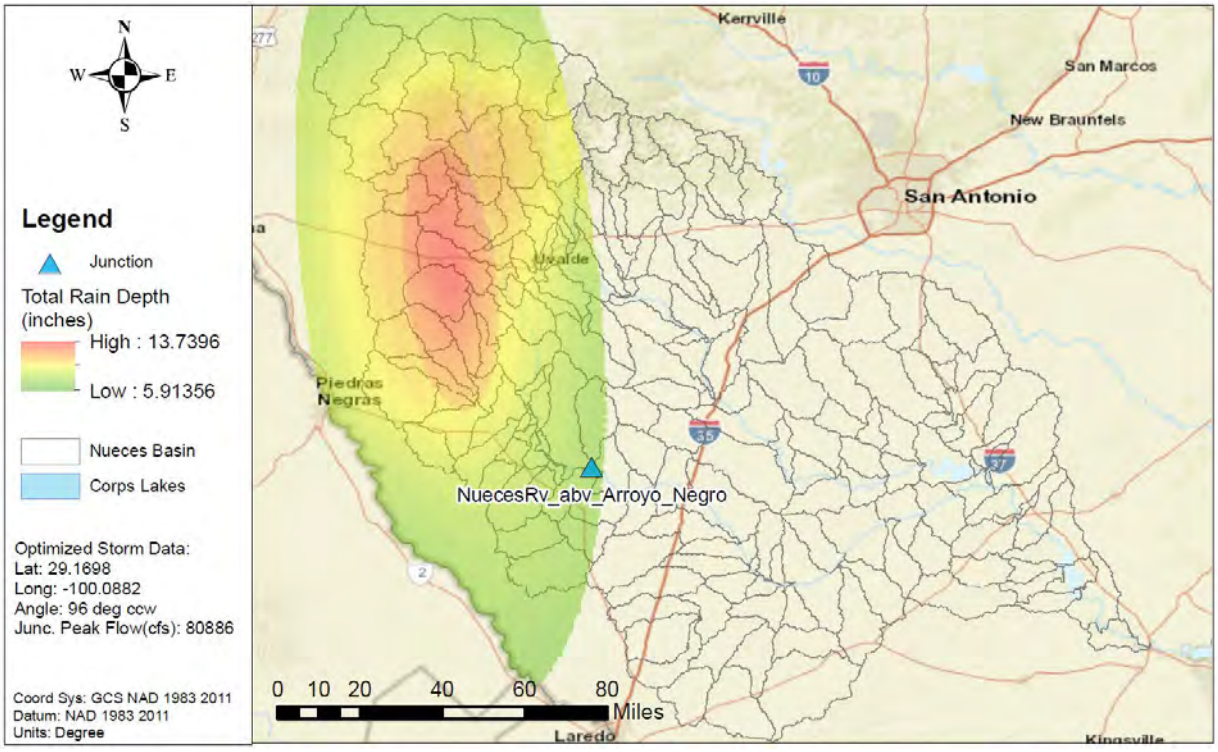

Figure C.11-41b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_Arroyo_Negro

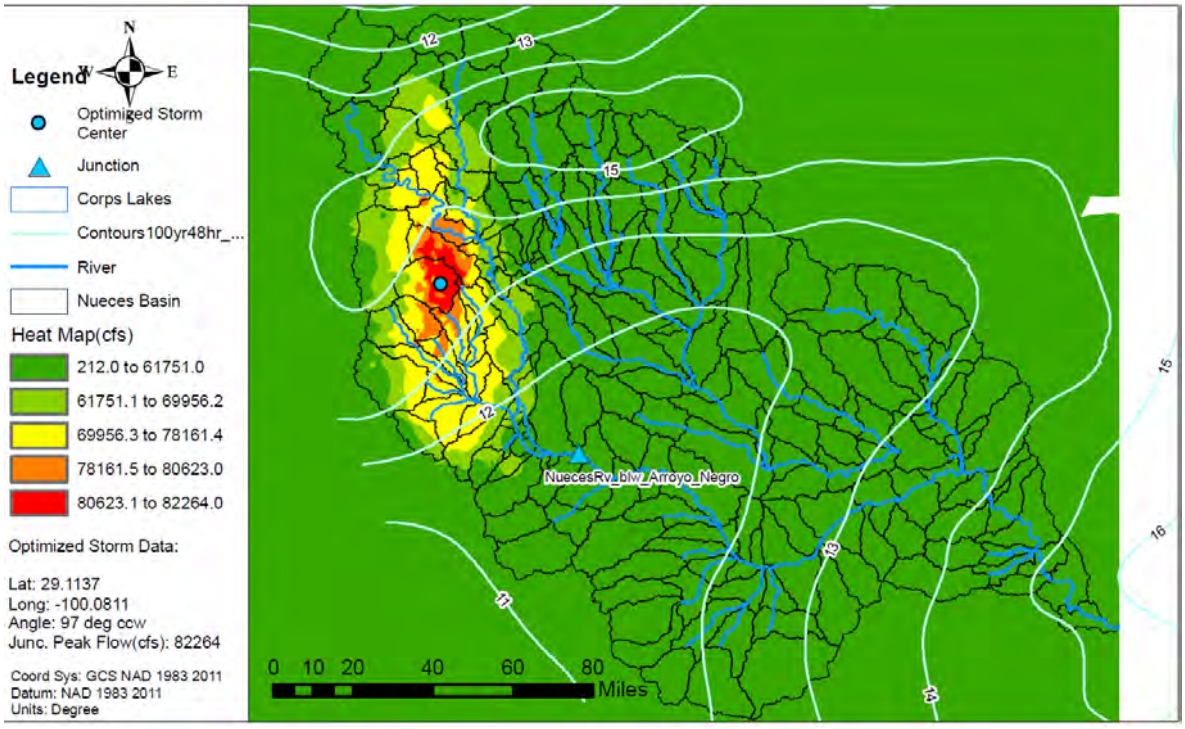

Figure C.11-42a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_Arroyo_Negro

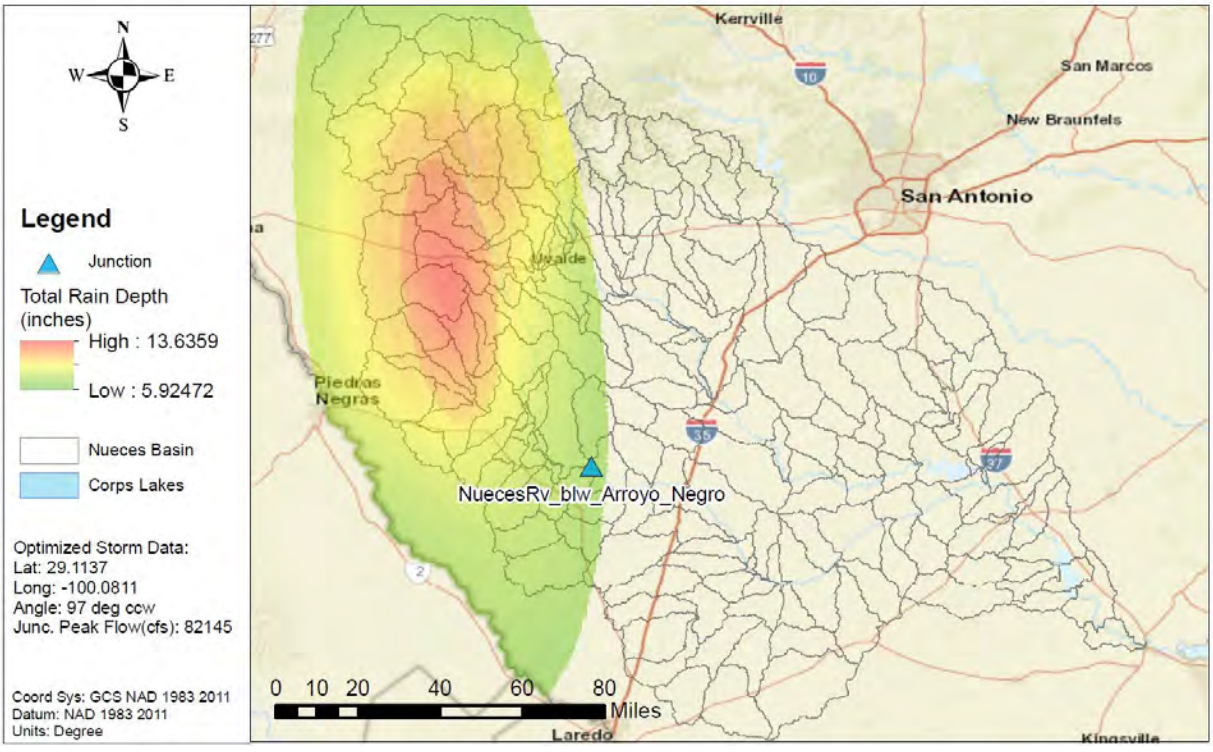

Figure C.11-42b: NA14 1% AEP Elliptical Storm for TurkeyCk_blw_Arroyo_Negro

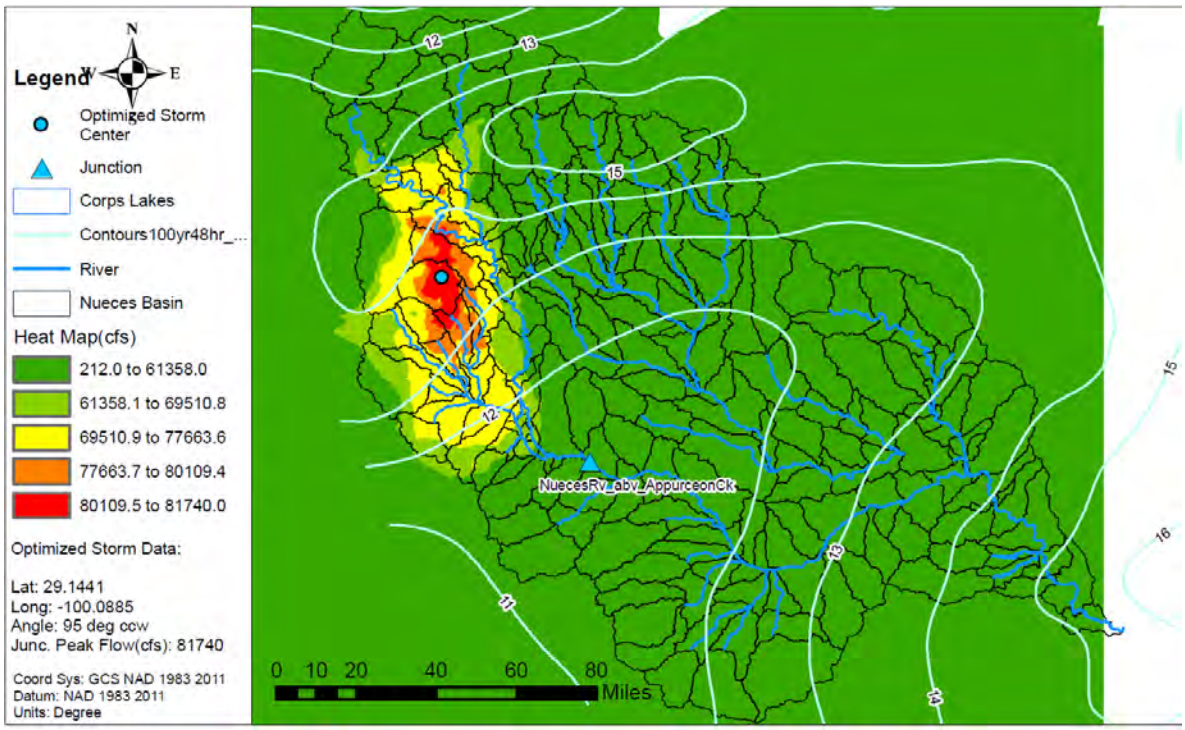

Figure C.11-43a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_AppurceonCk

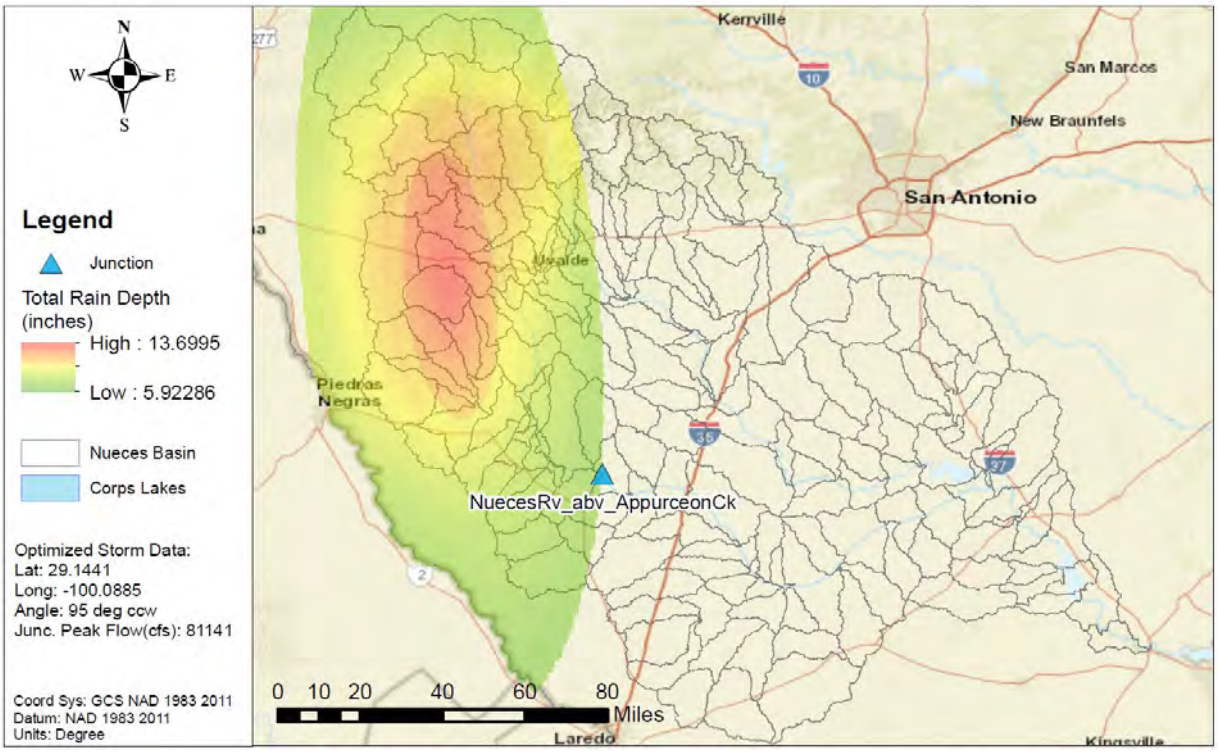

Figure C.11-43b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_AppurceonCk

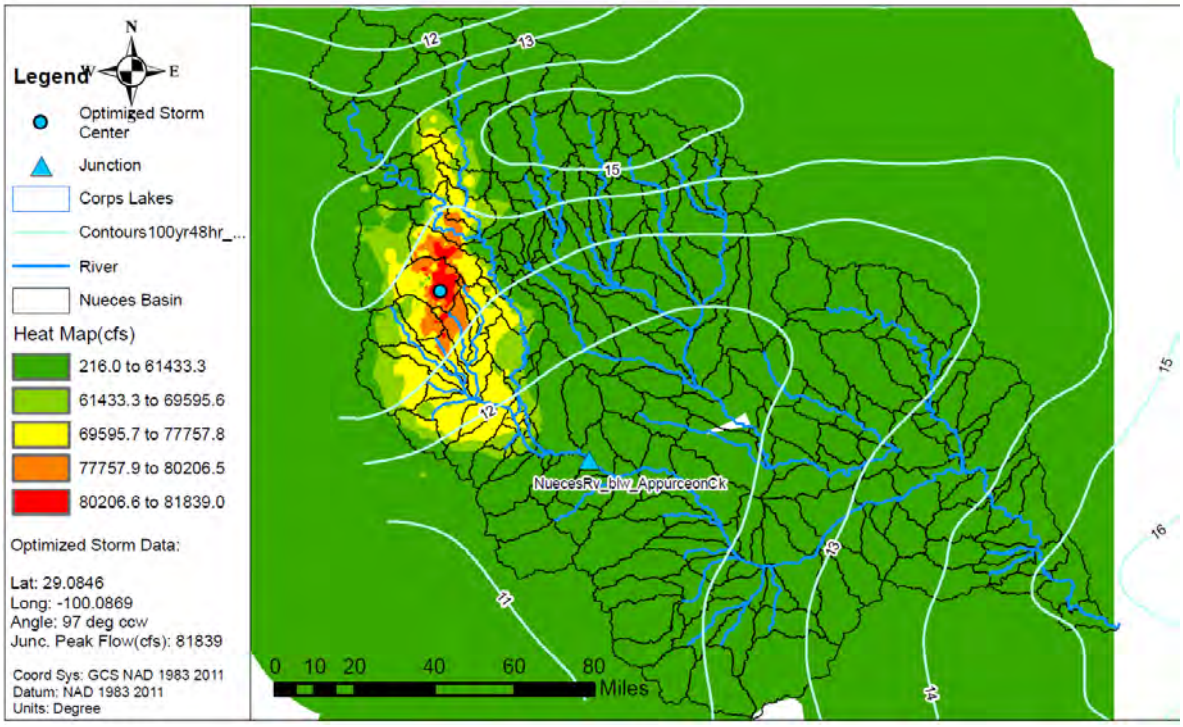

Figure C.11-44a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_AppurceonCk

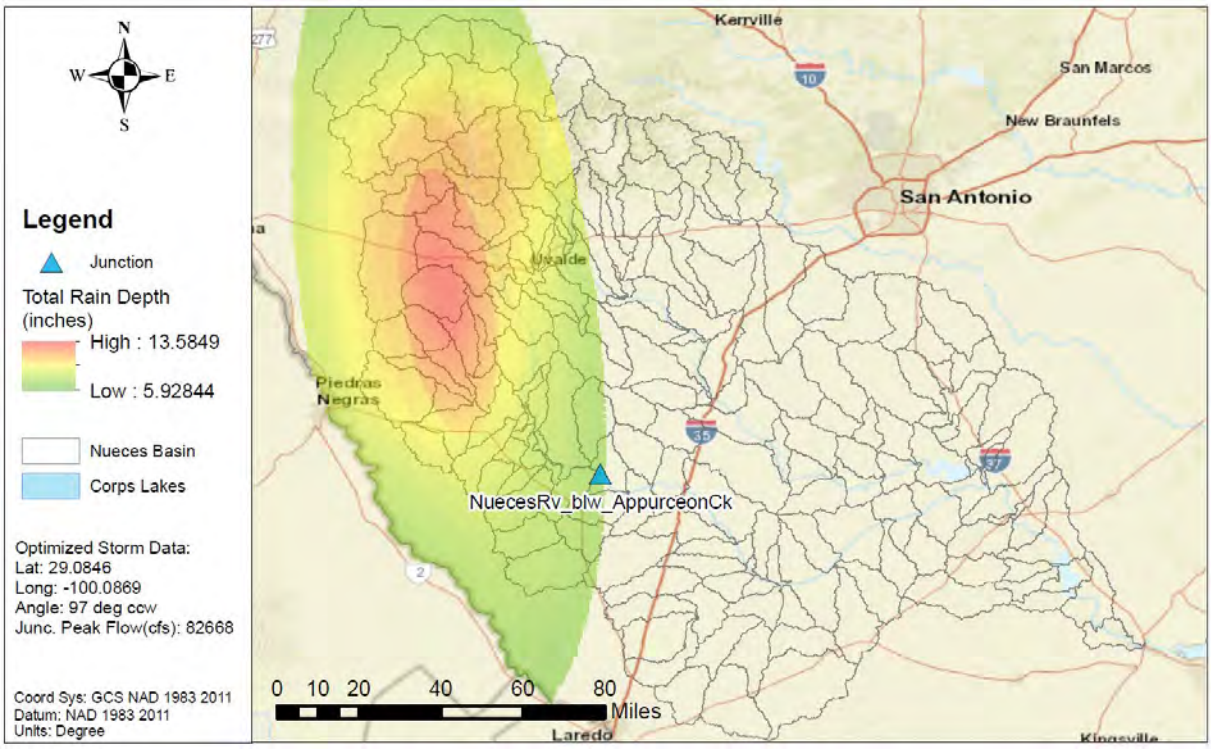

Figure C.11-44b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_AppurceonCk

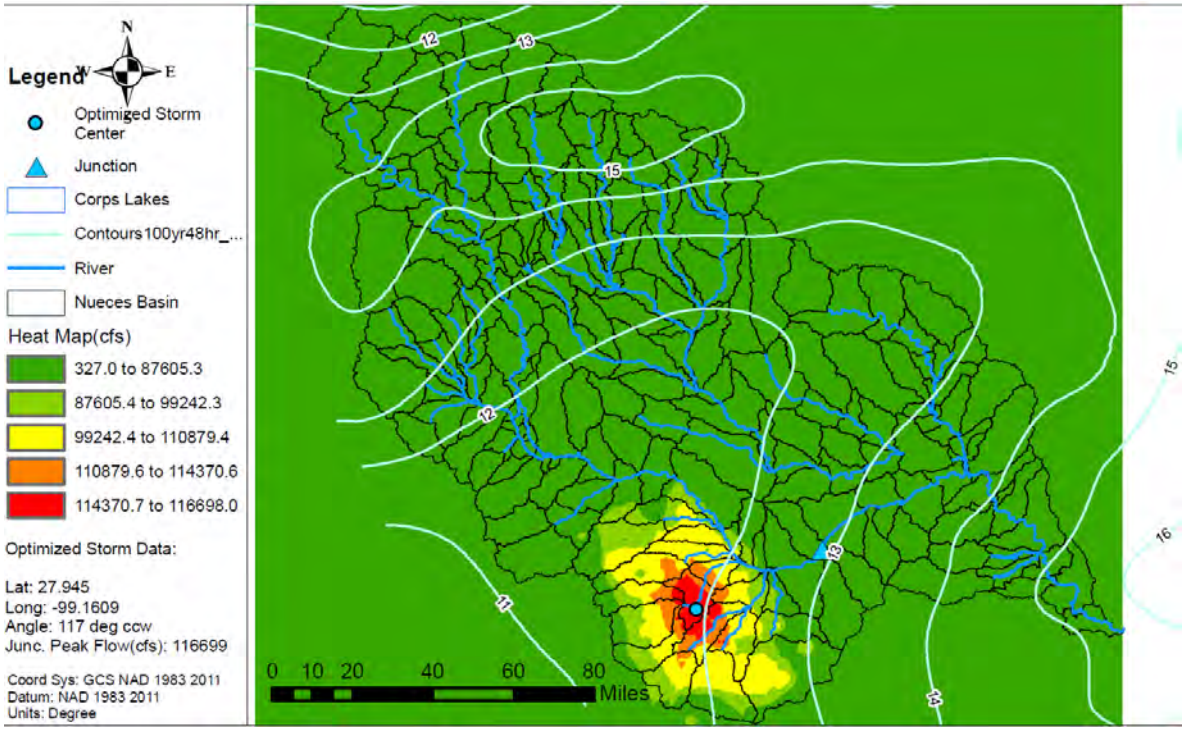

Figure C.11-45a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_San_RoqueCk

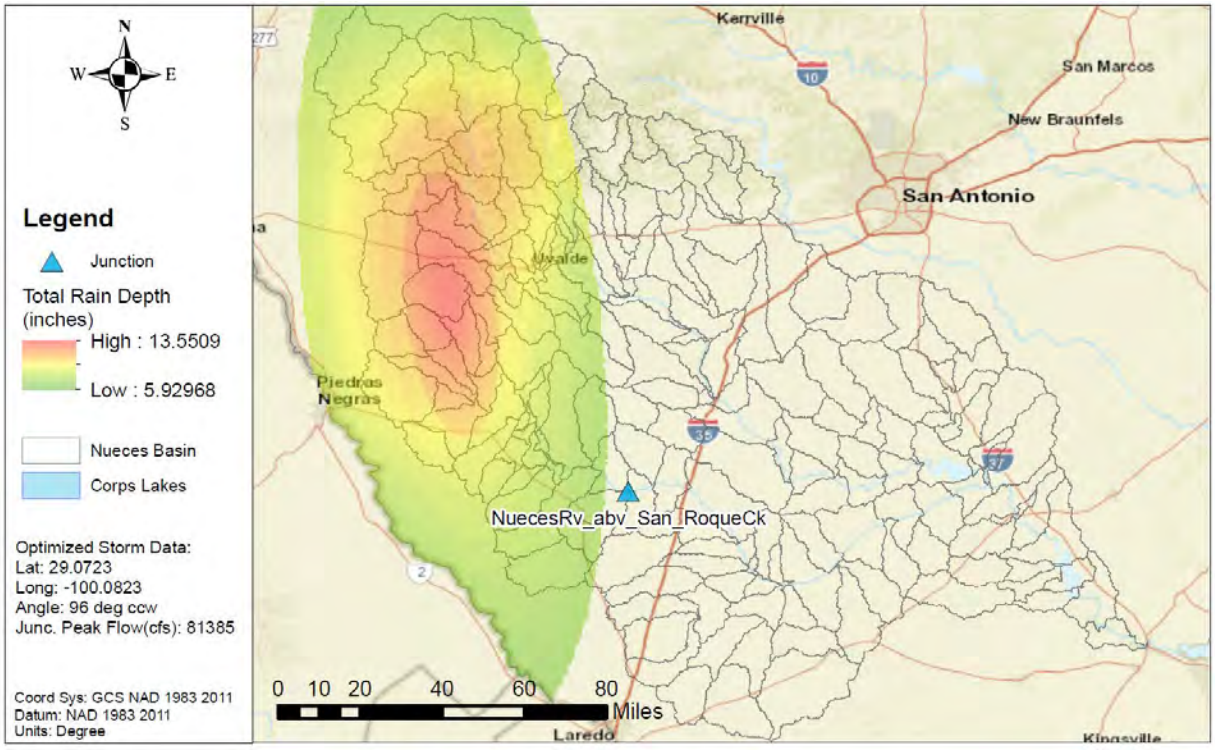

Figure C.11-45b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_San_RoqueCk

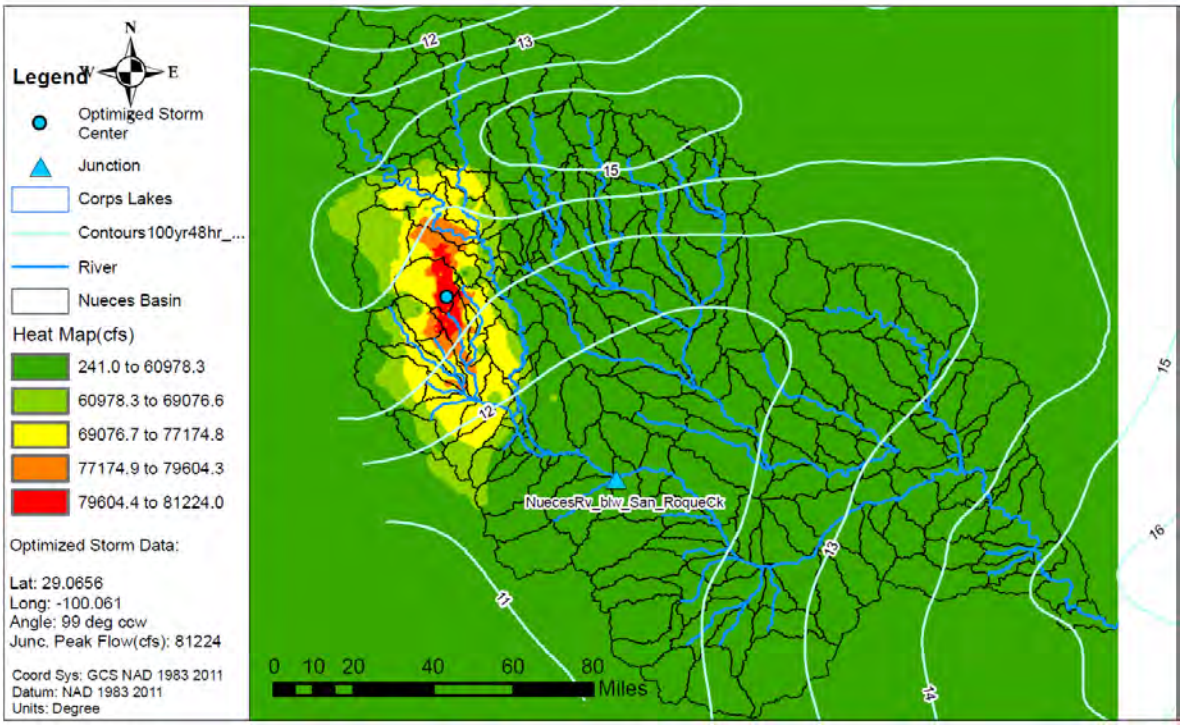

Figure C.11-46a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_San_RoqueCk

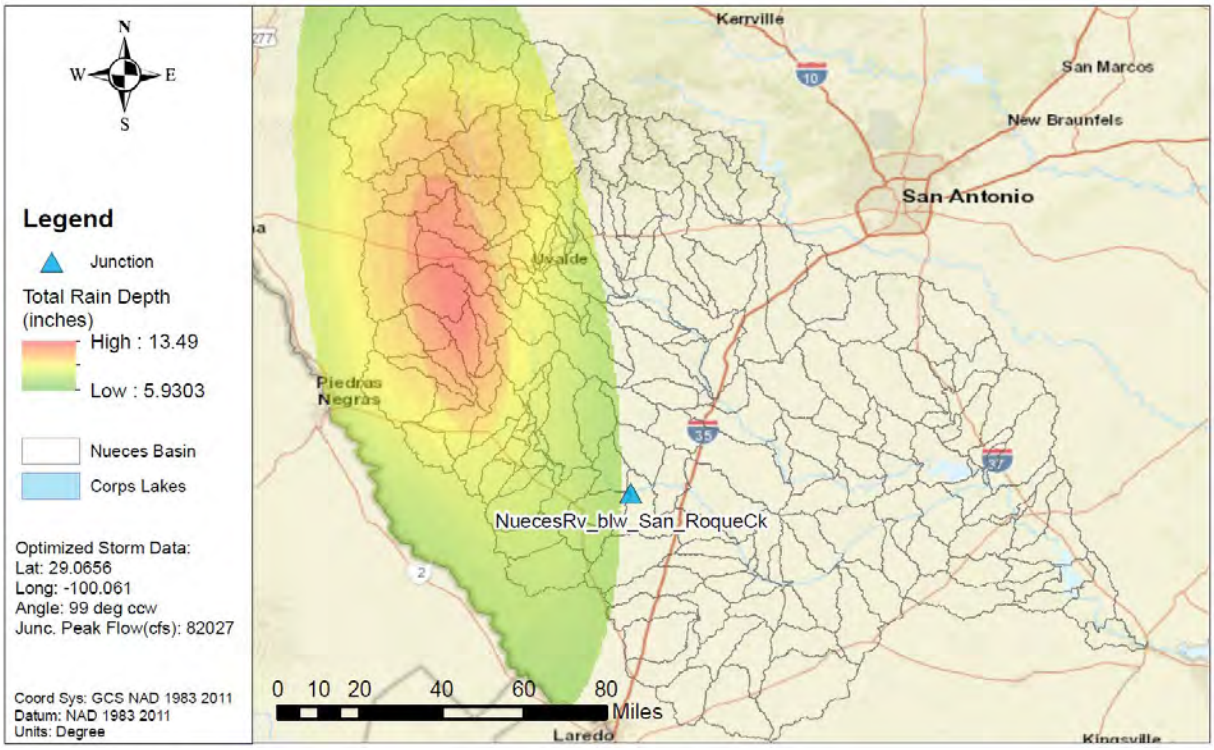

Figure C.11-46b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_San_RoqueCk

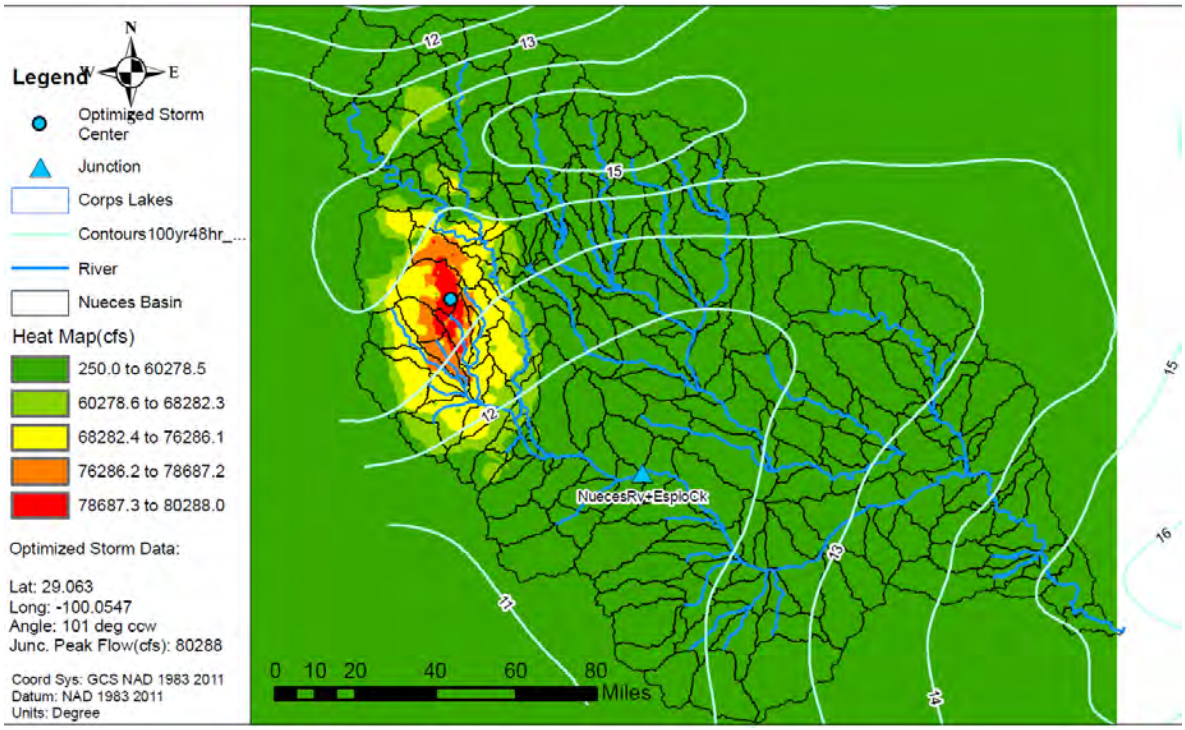

Figure C.11-47a: Elliptical Storm Optimization Heat Map for NuecesRv+EspioCk

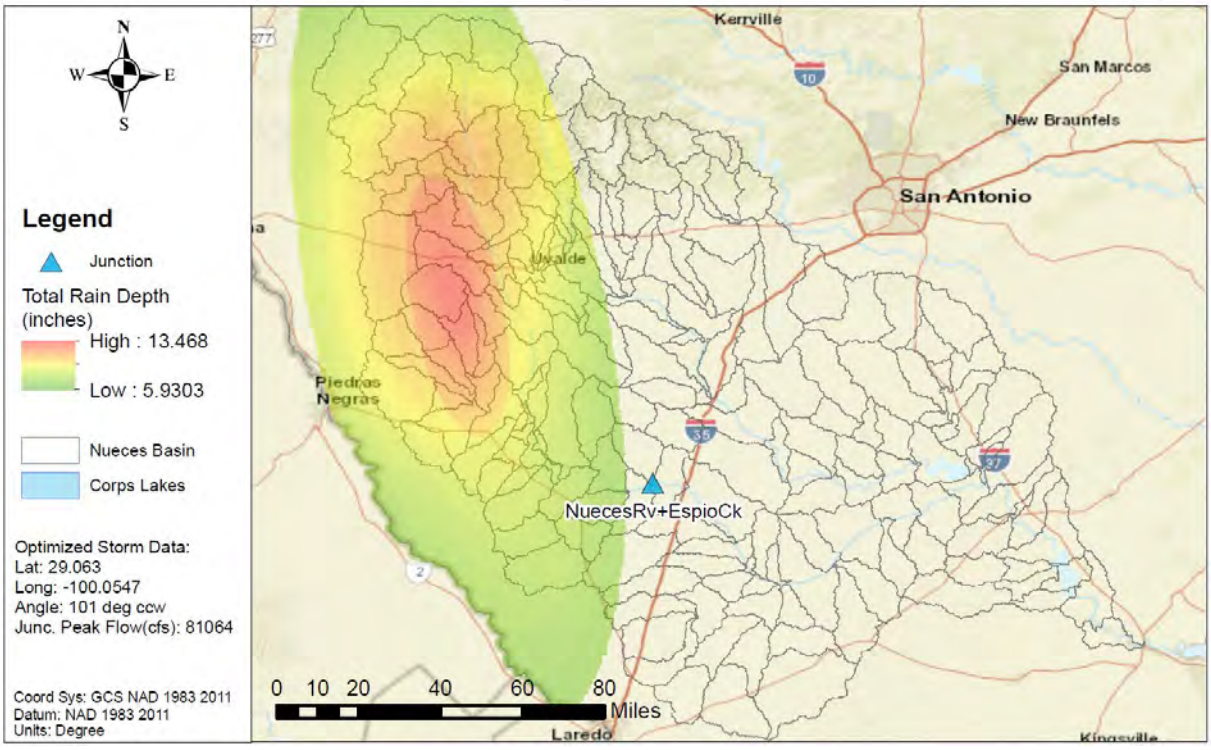

Figure C.11-47b: NA14 1% AEP Elliptical Storm for NuecesRv+EspioCk

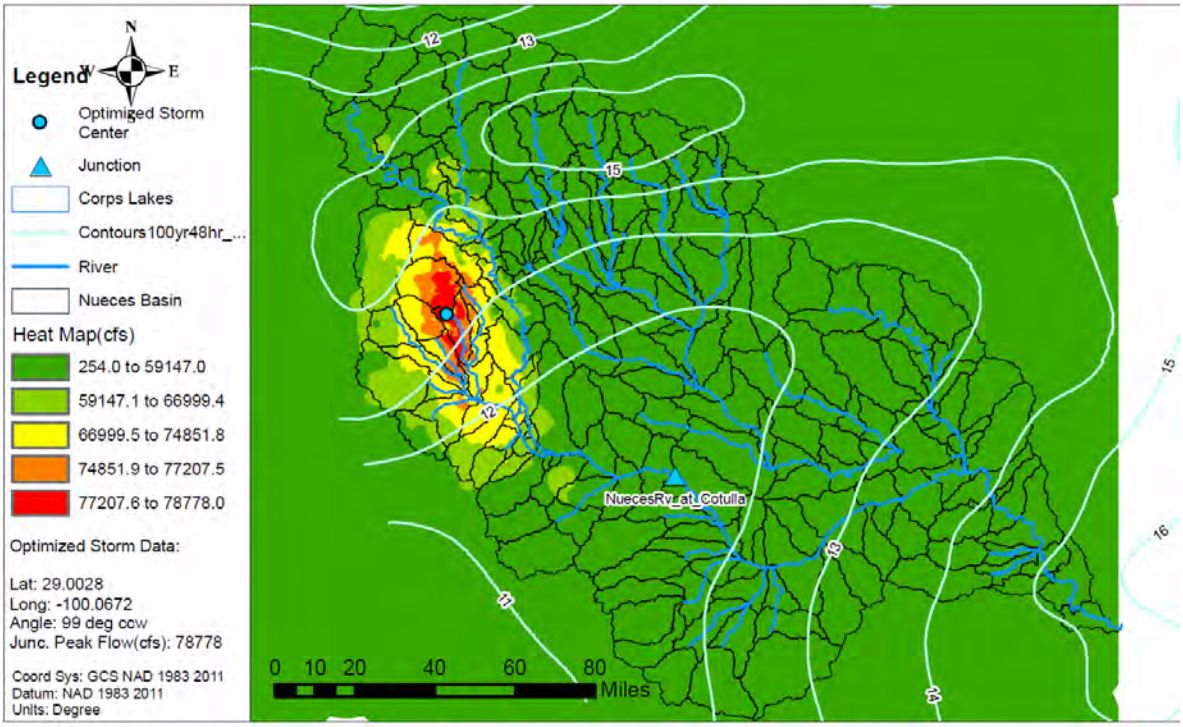

Figure C.11-48a: Elliptical Storm Optimization Heat Map for NuecesRv_at_Cotulla

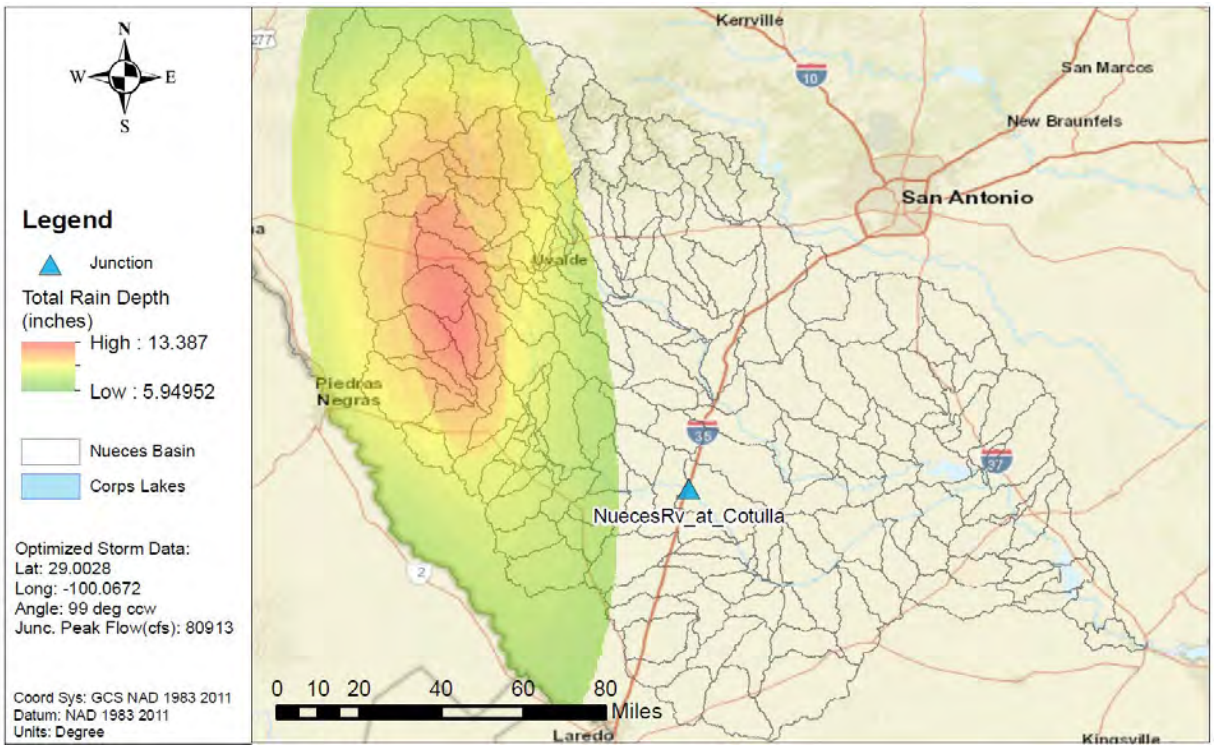

Figure C.11-48b: NA14 1% AEP Elliptical Storm for NuecesRv_at_Cotulla

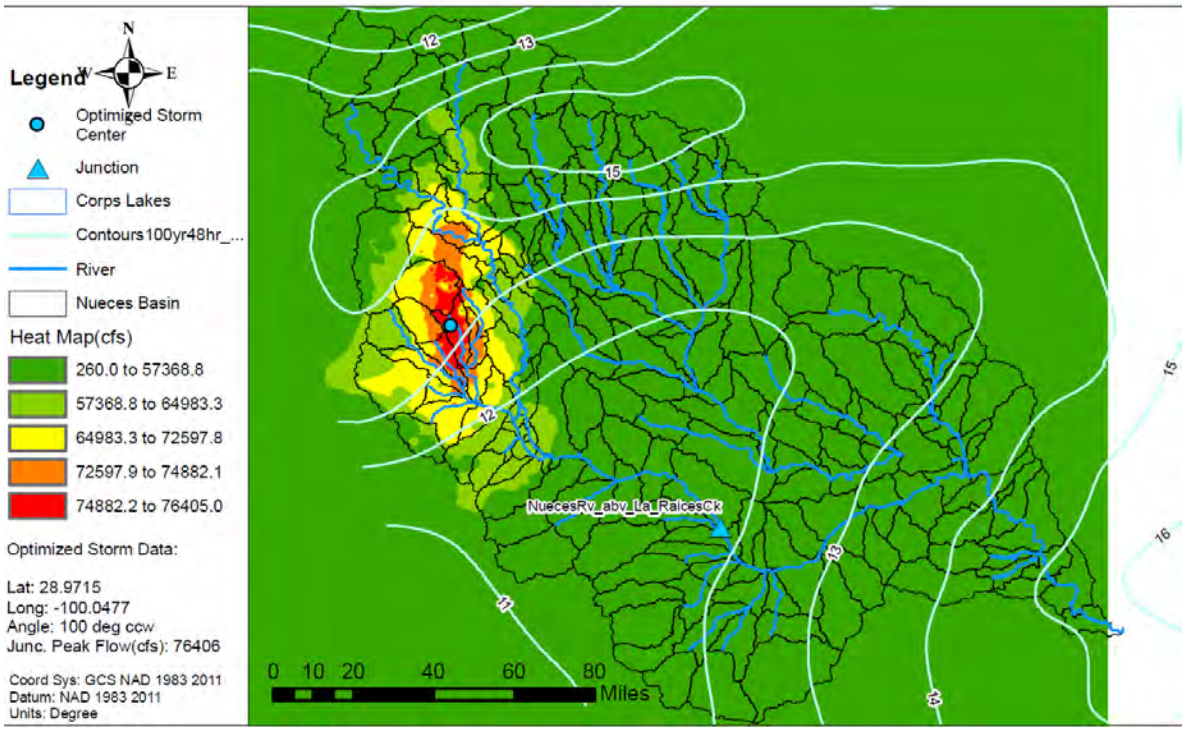

Figure C.11-49a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_La_RaicesCk

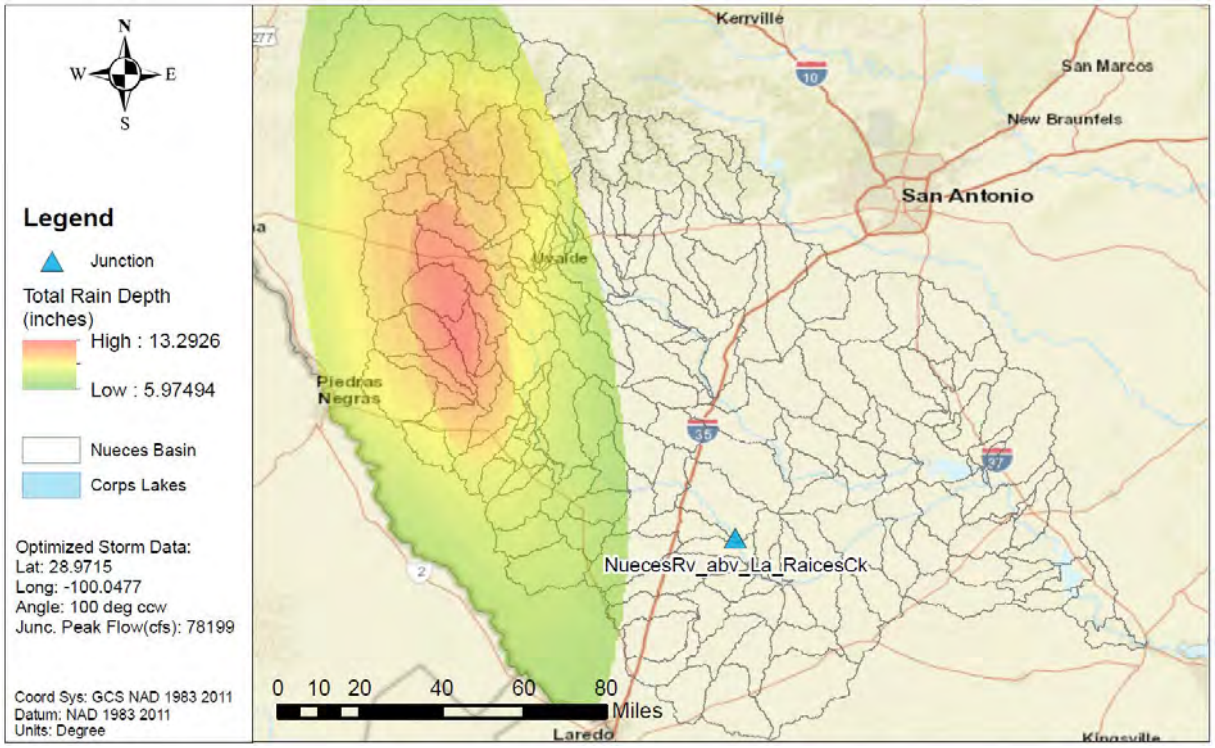

Figure C.11-49b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_La_RaicesCk

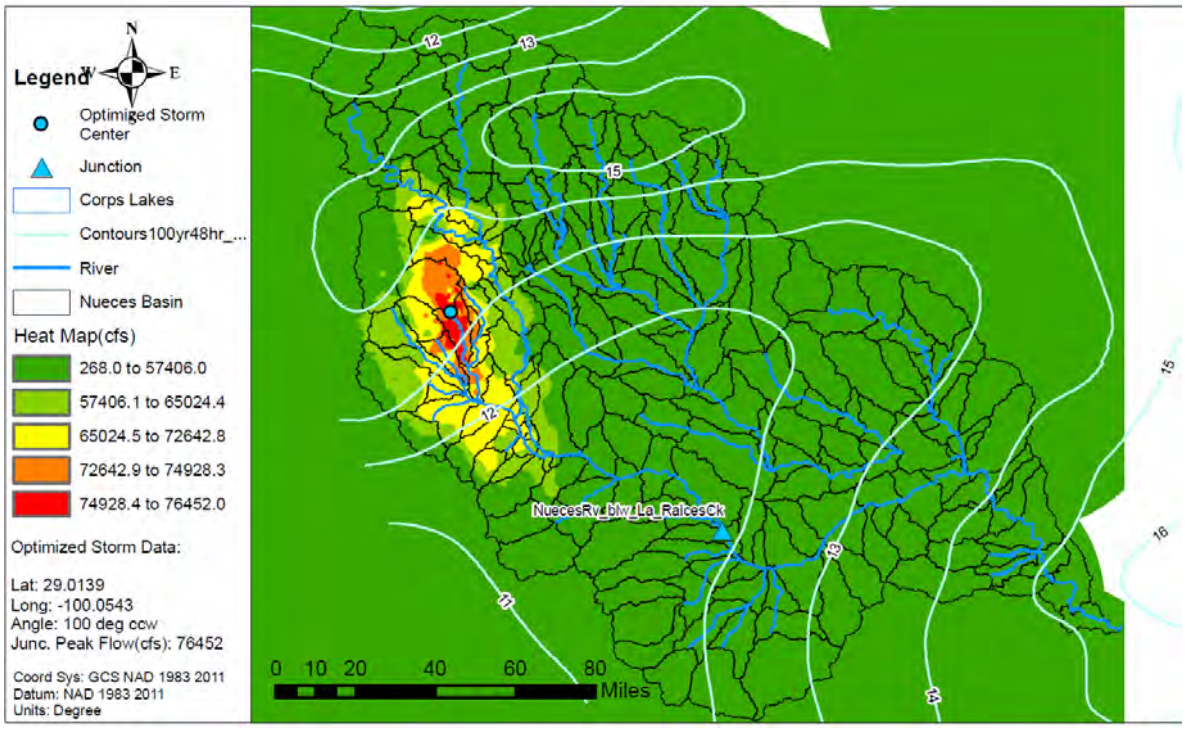

Figure C.11-50a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_La_RaicesCk

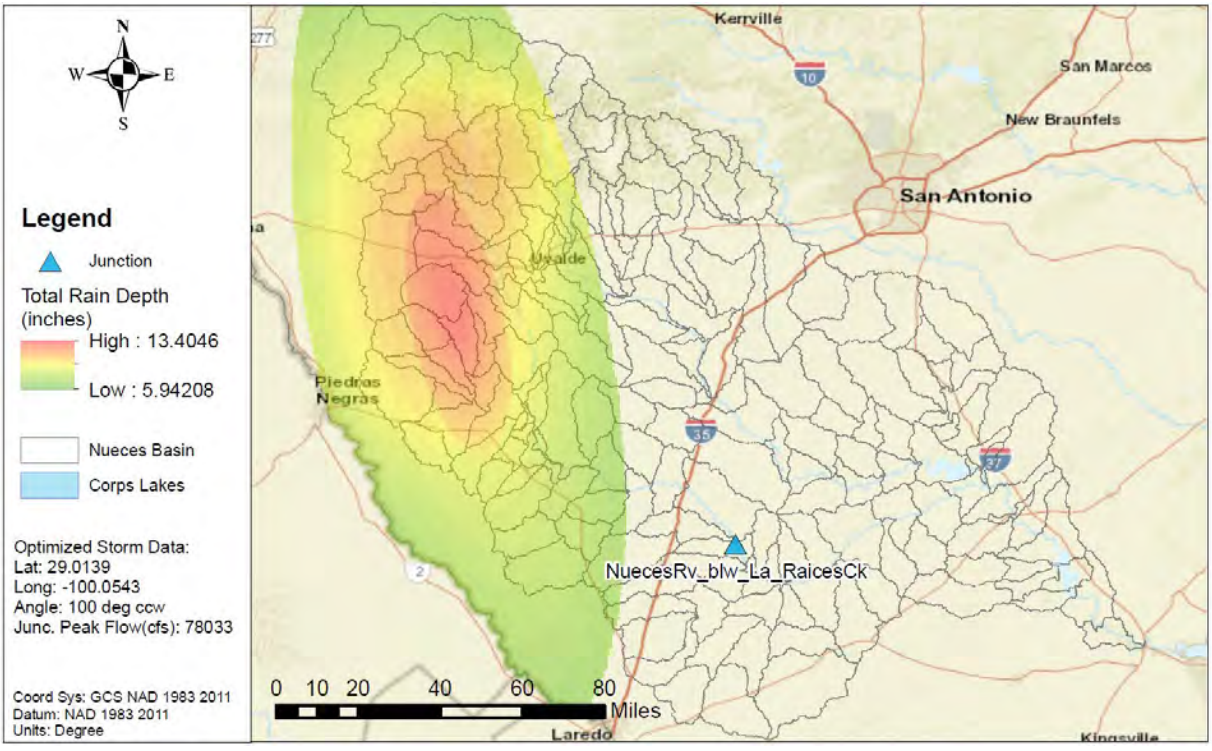

Figure C.11-50b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_La_RaicesCk

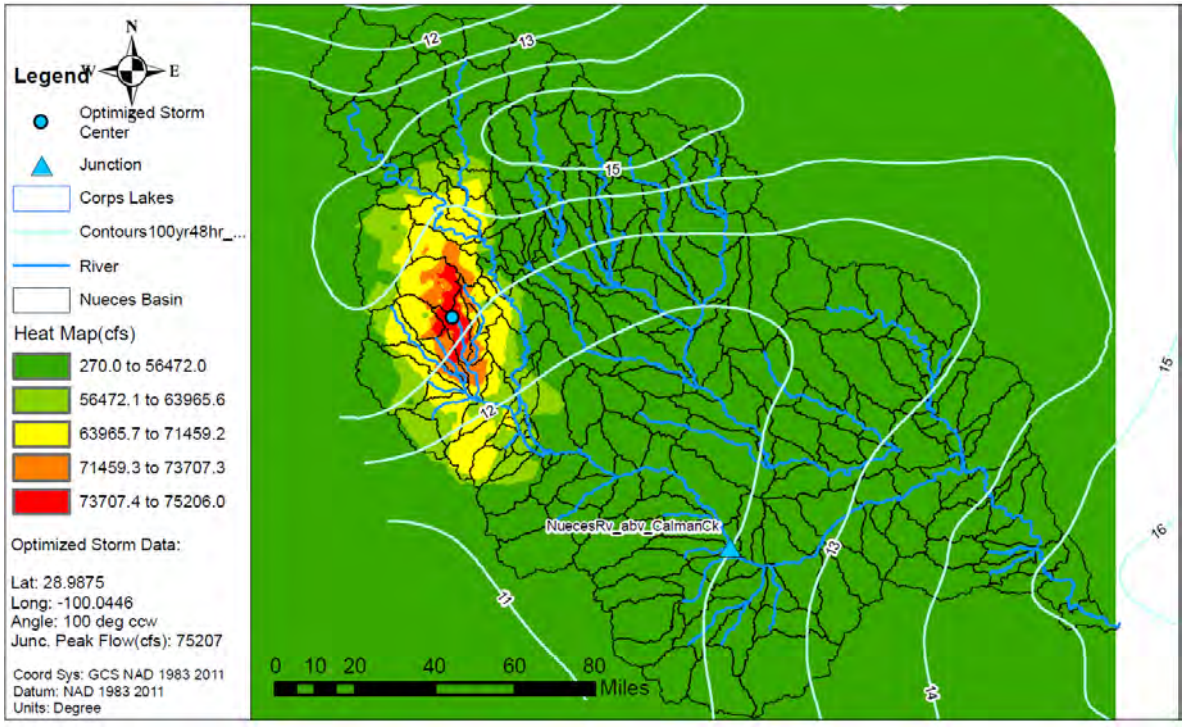

Figure C.11-51a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_CalmanCk

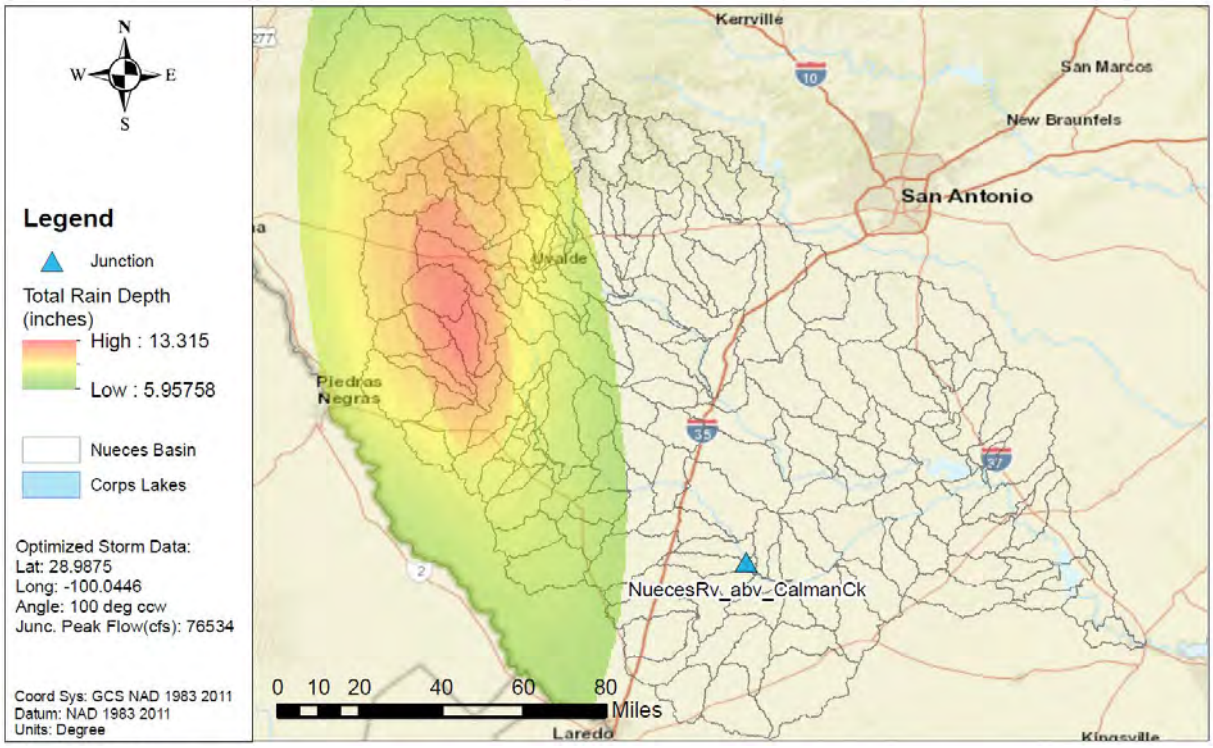

Figure C.11-51b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_CalmanCk

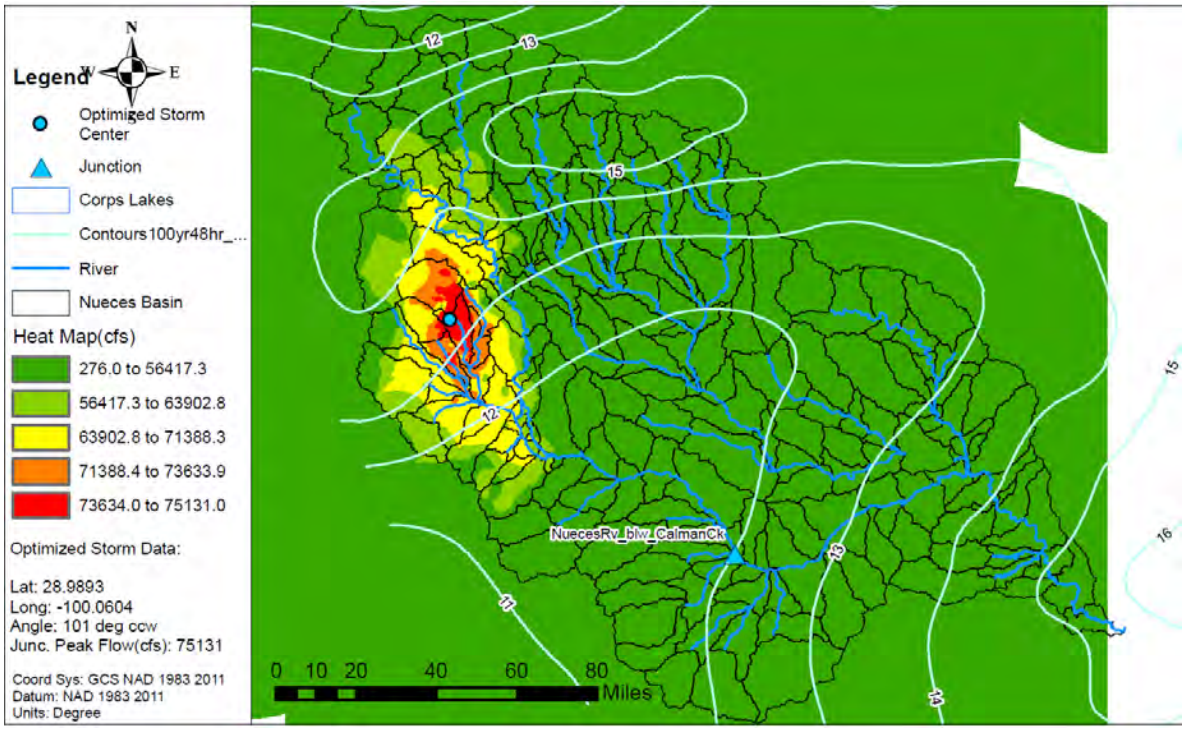

Figure C.11-52a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_CalmanCk

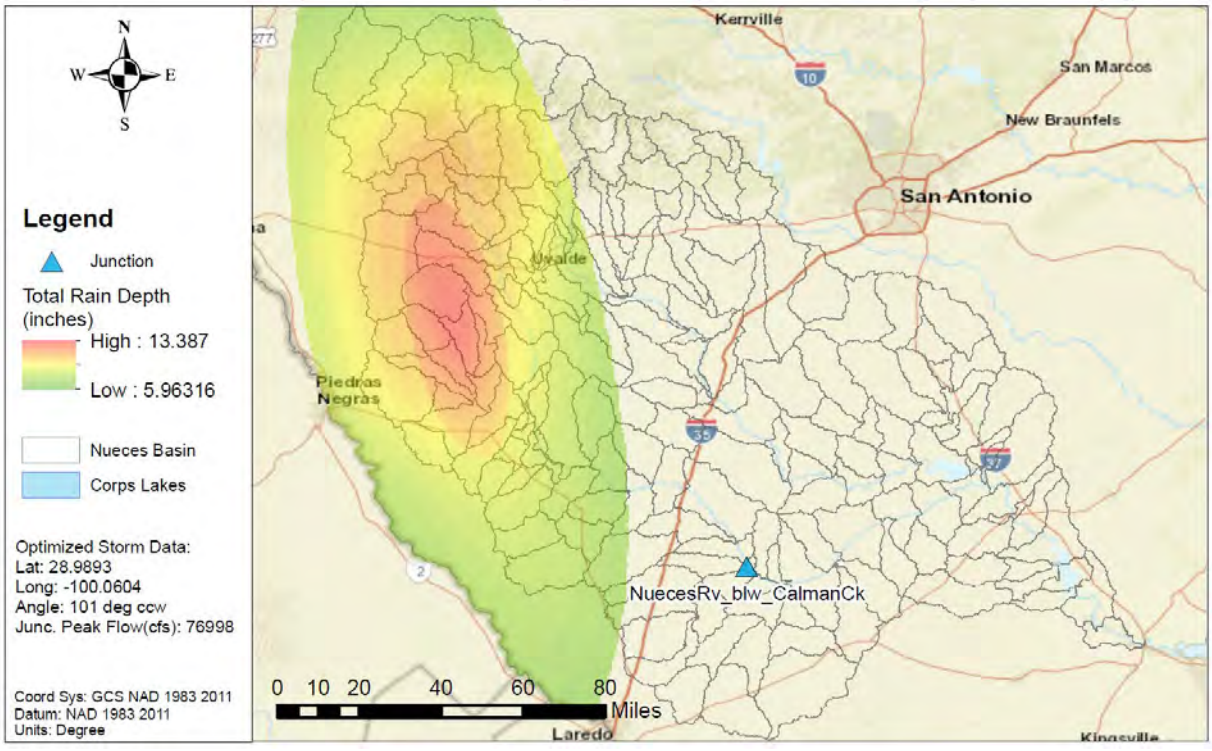

Figure C.11-52b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_CalmanCk

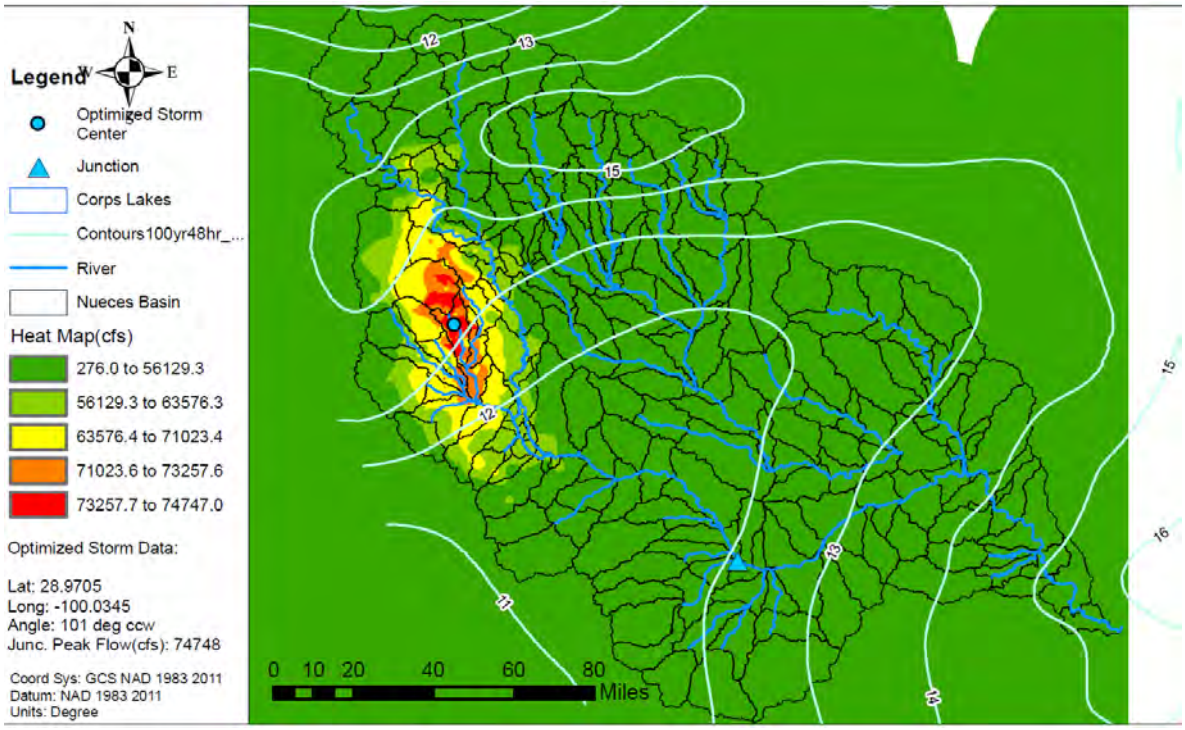

Figure C.11-53a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_Los_OlmosCk

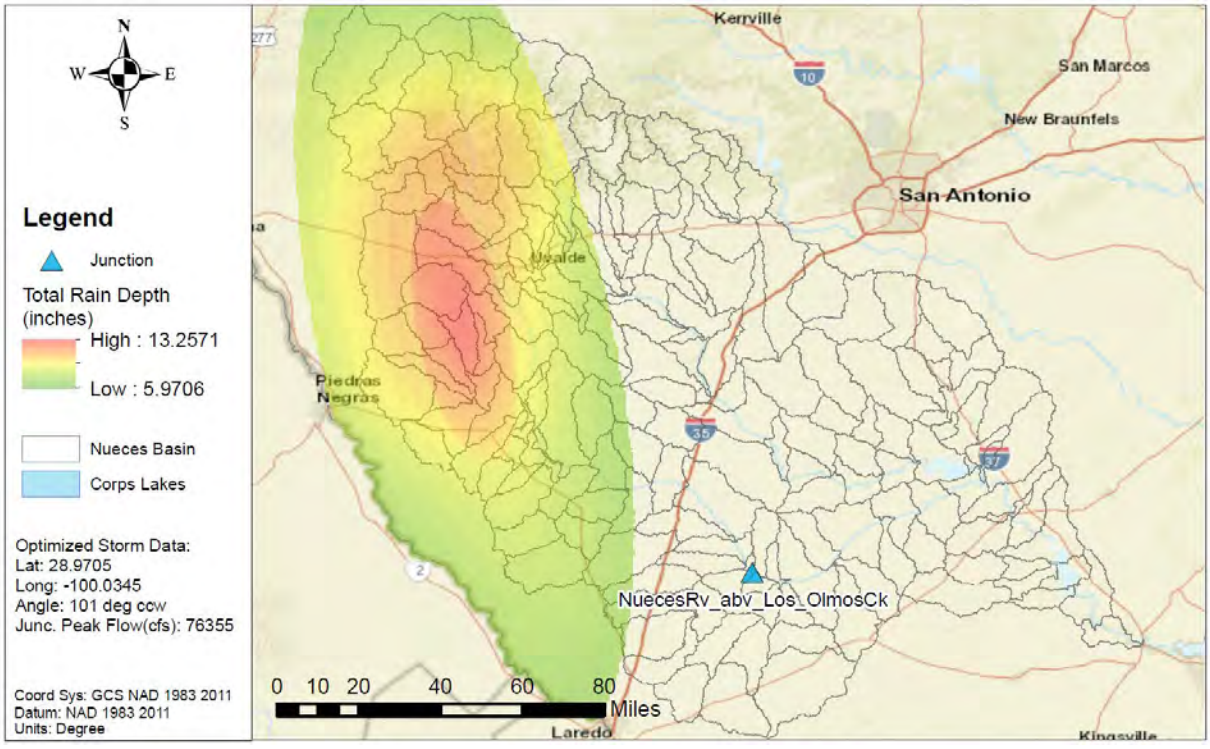

Figure C.11-53b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_Los_OlmosCk

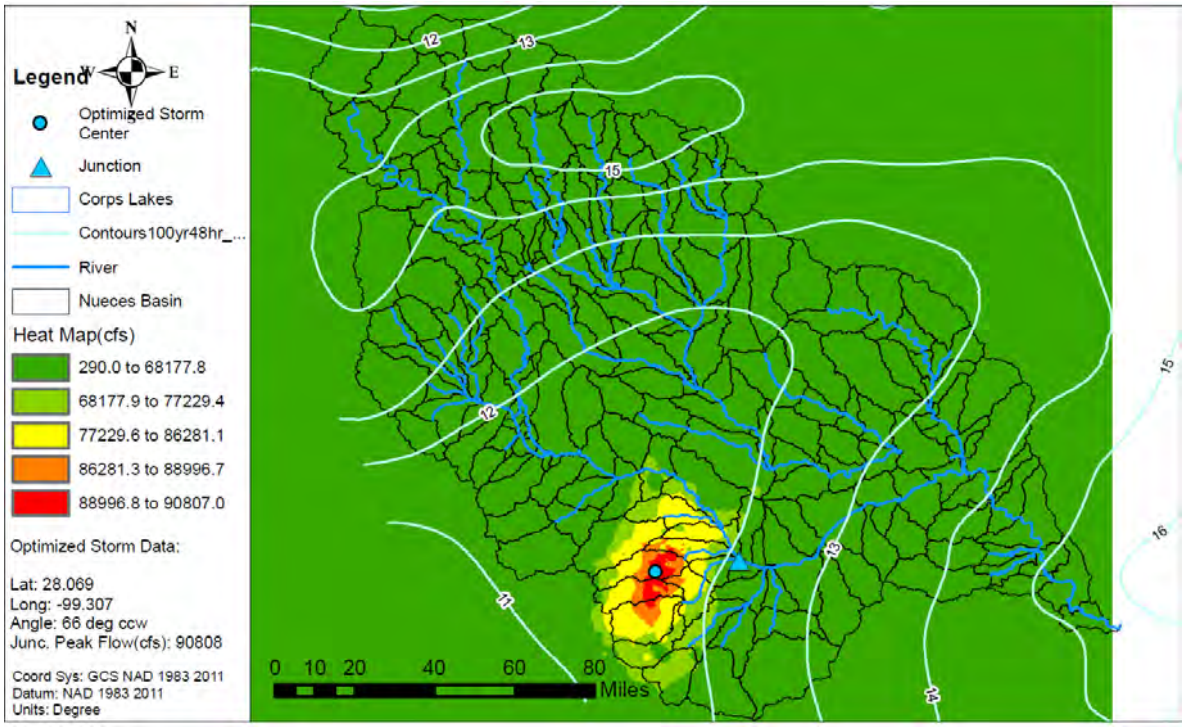

Figure C.11-54a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_Los_OlmosCk

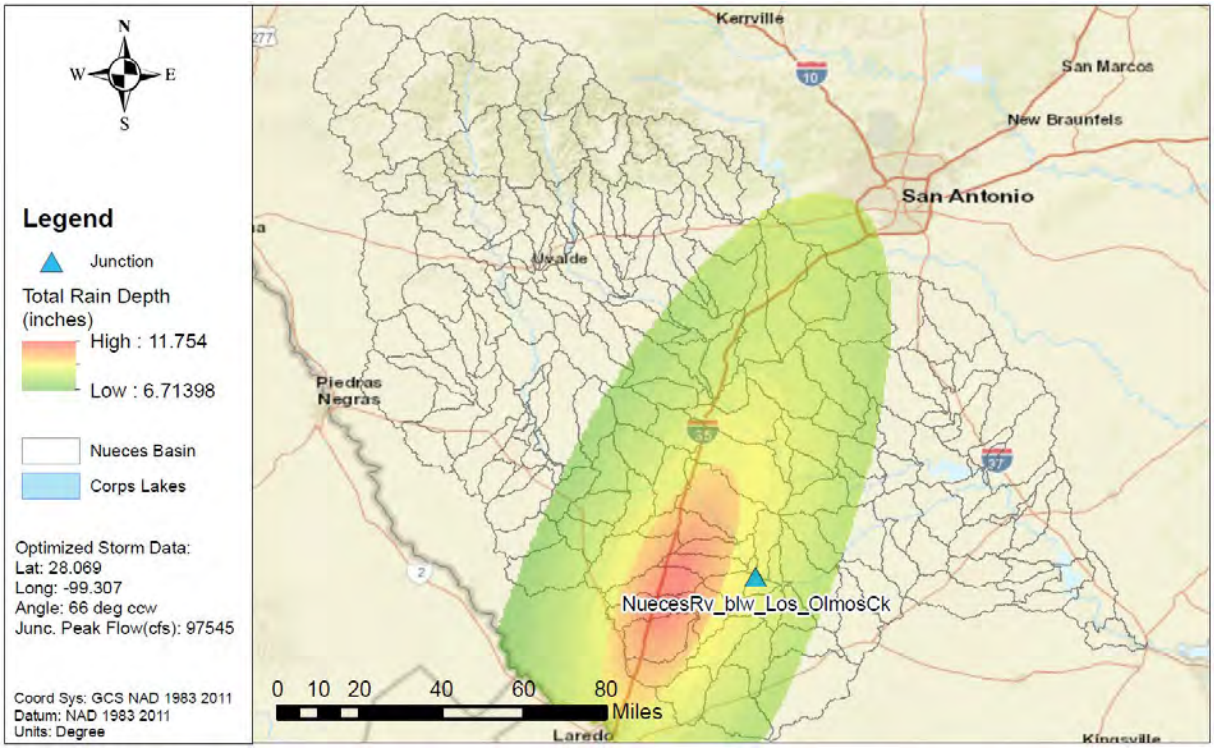

Figure C.11-54b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_Los_OlmosCk

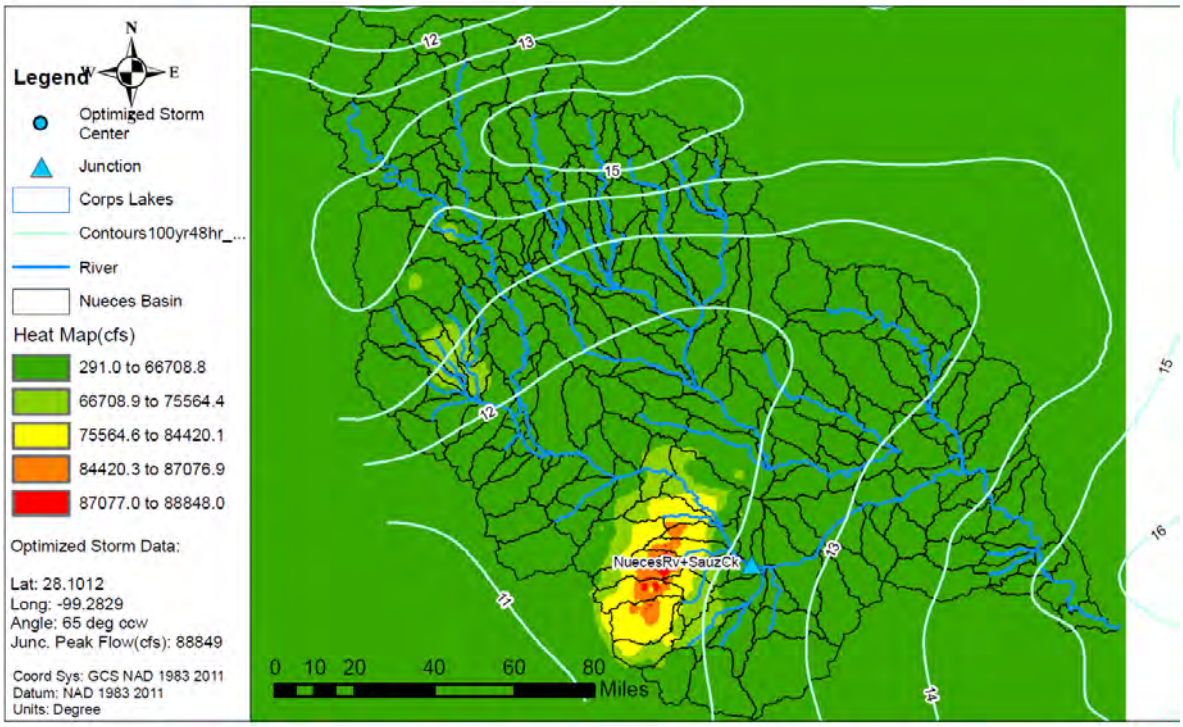

Figure C.11-55a: Elliptical Storm Optimization Heat Map for NuecesRv+SauzCk

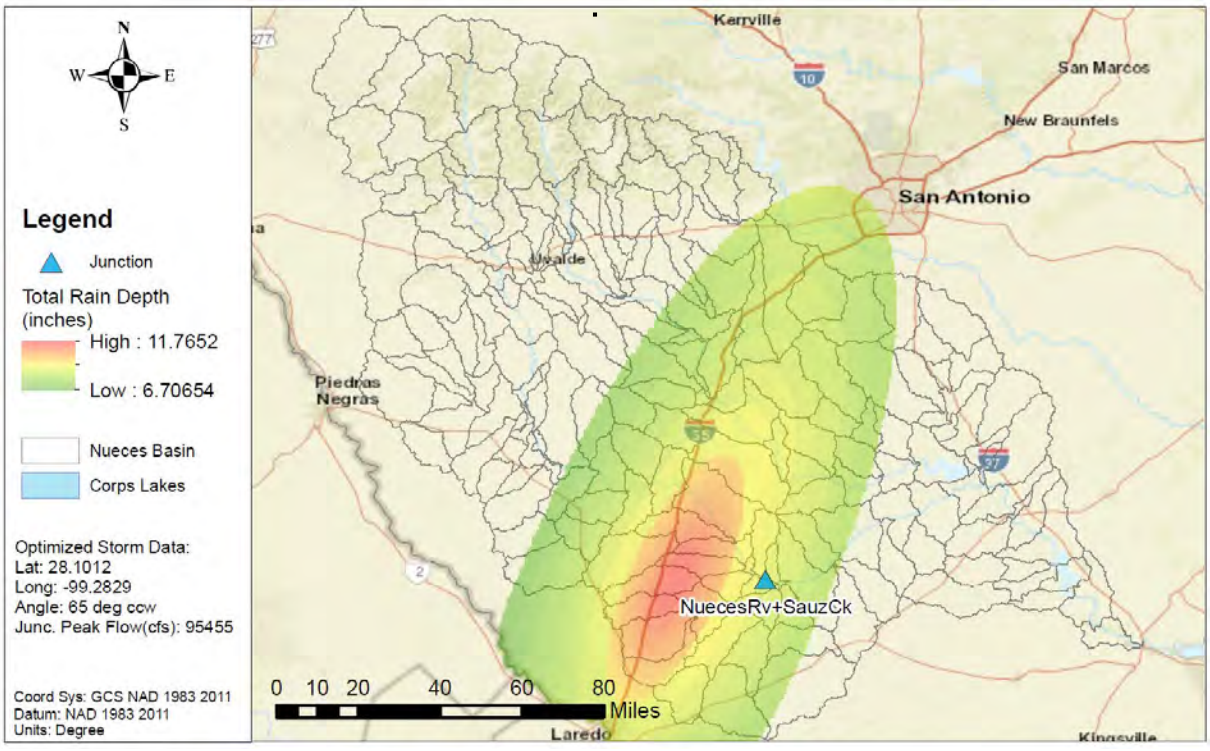

Figure C.11-55b: NA14 1% AEP Elliptical Storm for NuecesRv+SauzCk

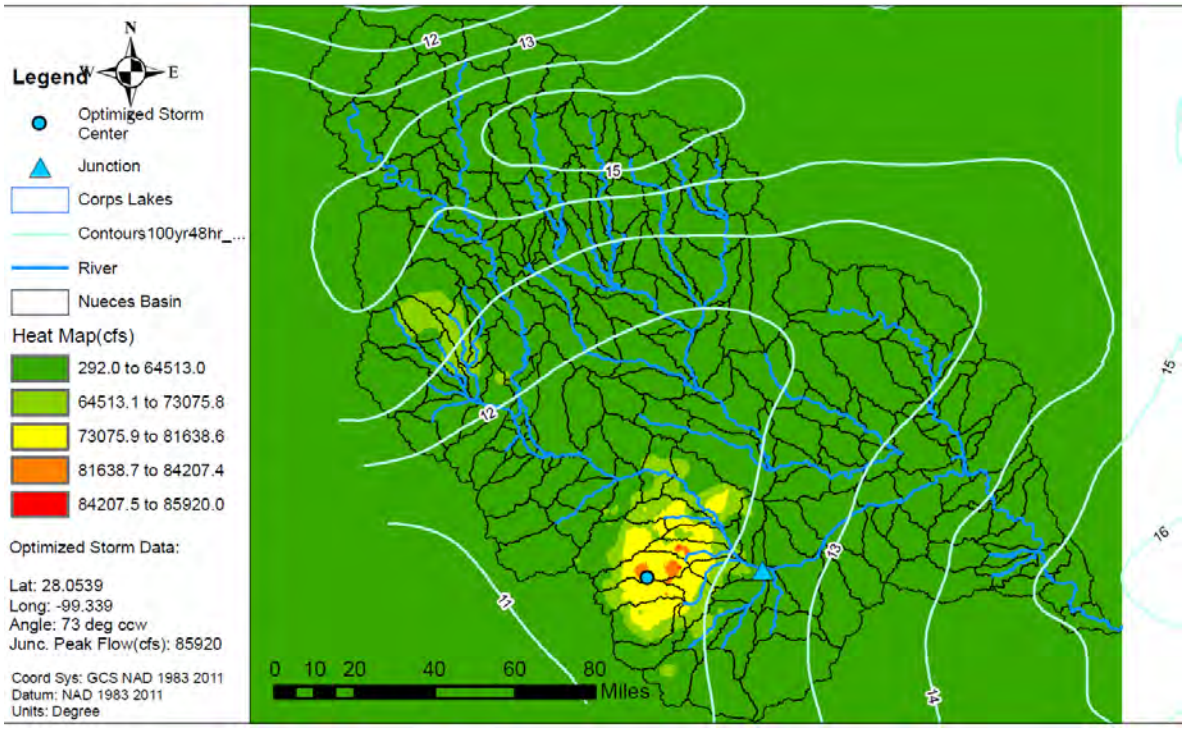

Figure C.11-56a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_San_CasimiroCk

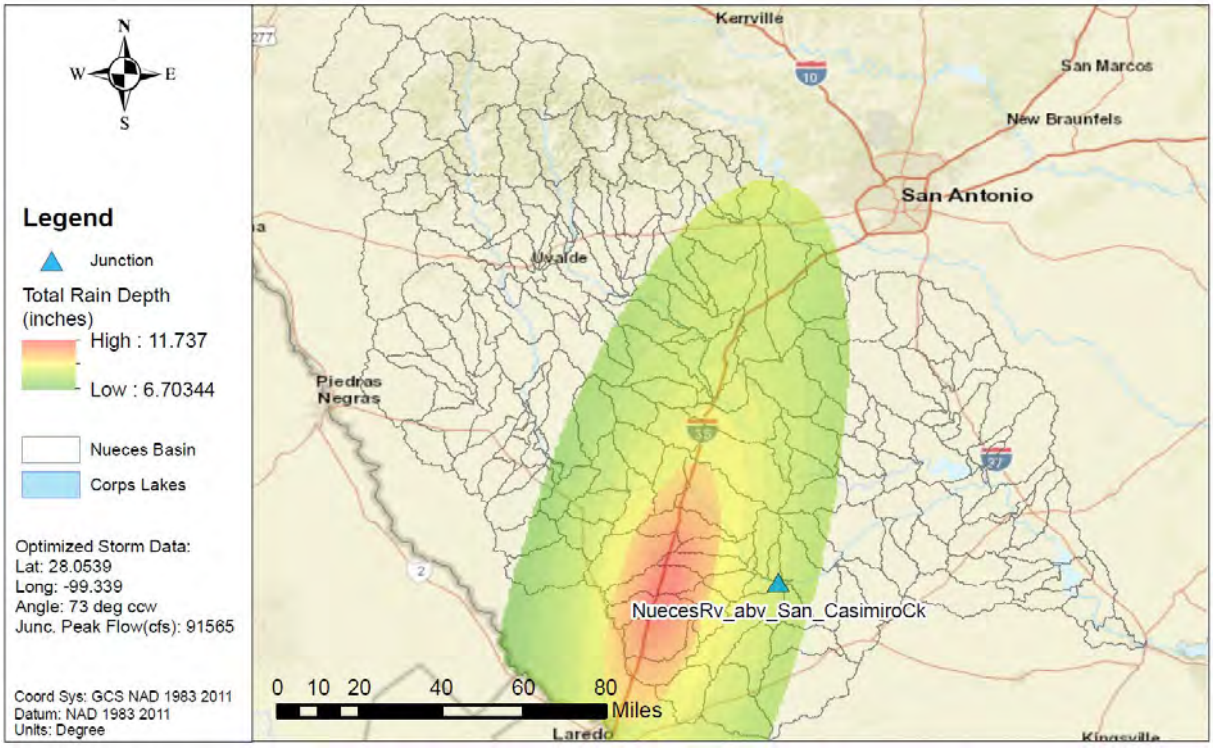

Figure C.11-56b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_San_CasimiroCk

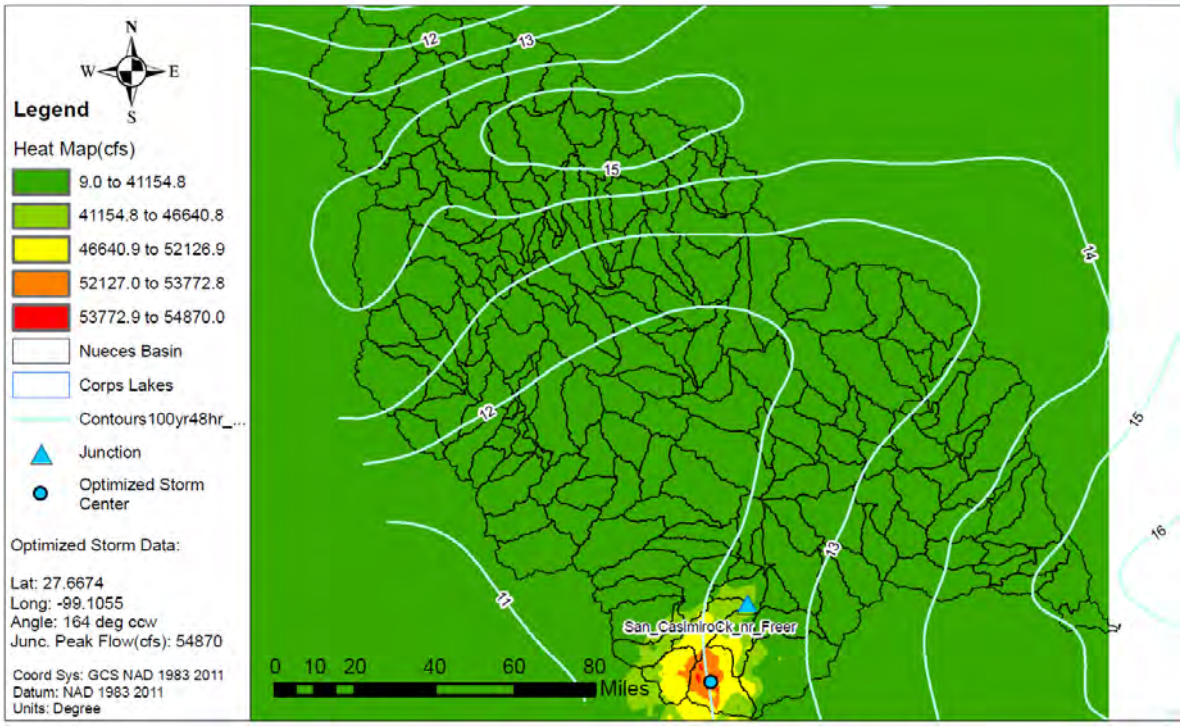

Figure C.11-57a: Elliptical Storm Optimization Heat Map for San_CasimiroCk_nr_Freer

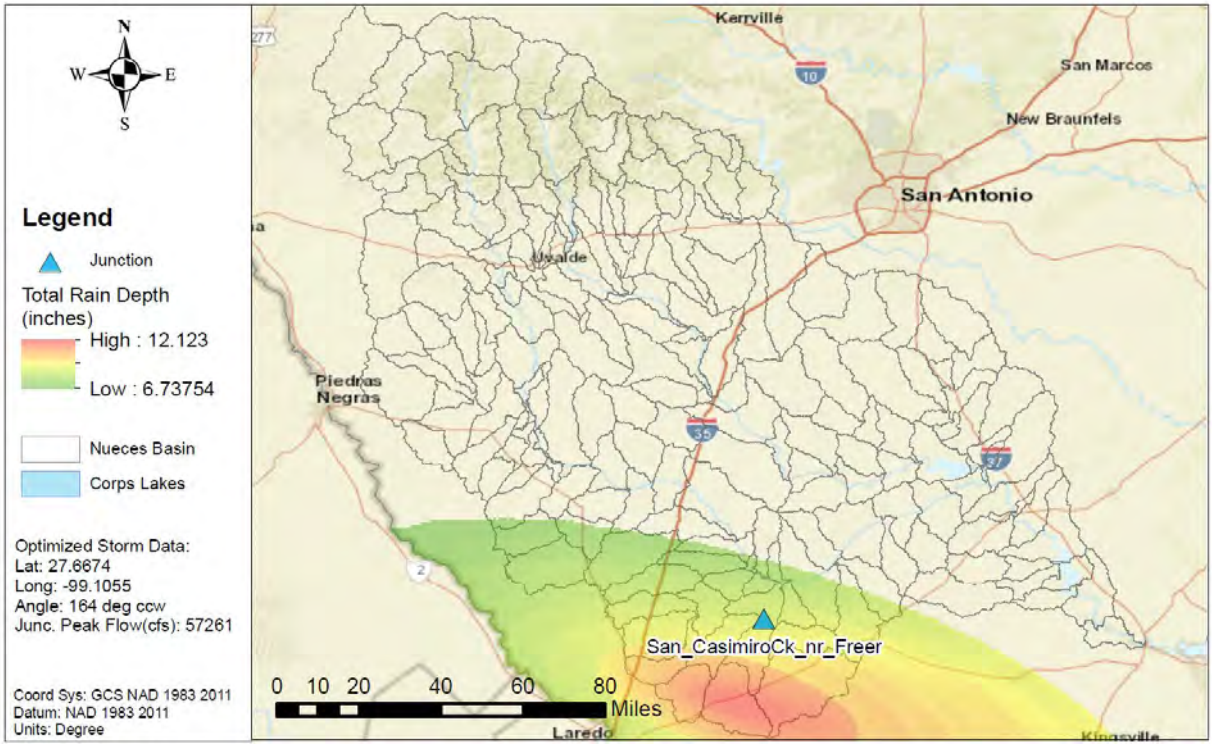

Figure C.11-57b: NA14 1% AEP Elliptical Storm for San_CasimiroCk_nr_Freer

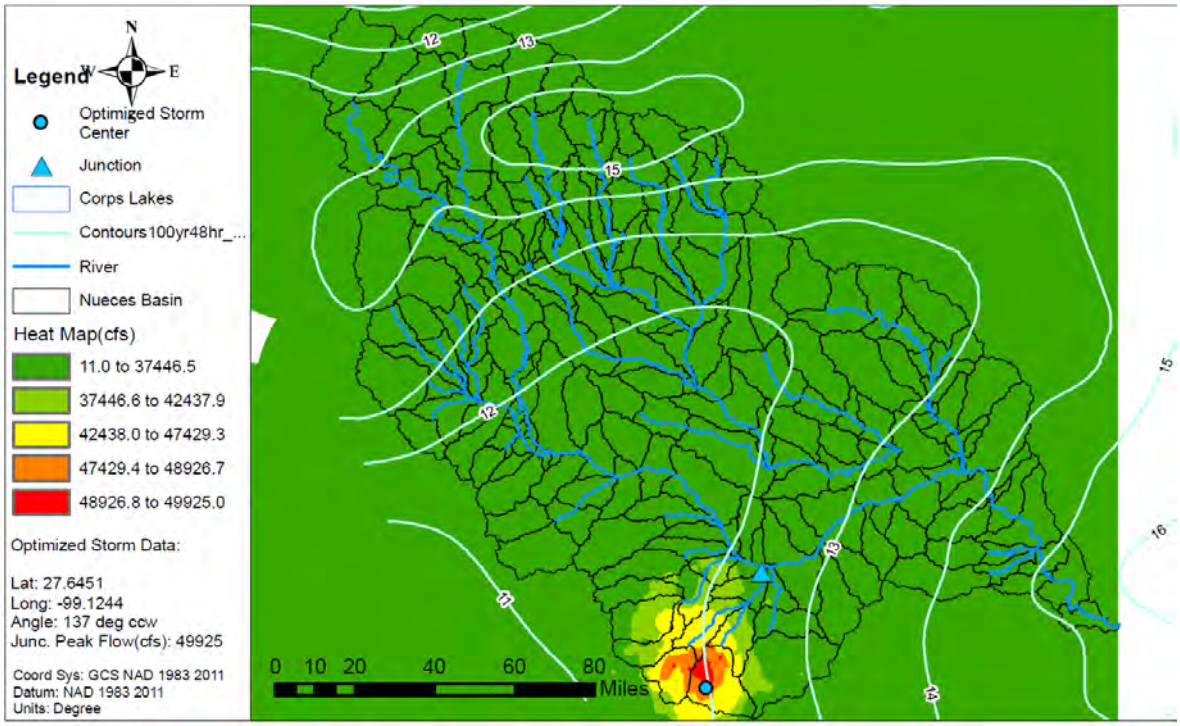

Figure C.11-58a: Elliptical Storm Optimization Heat Map for San_CasimiroCk_abv_NuecesRv

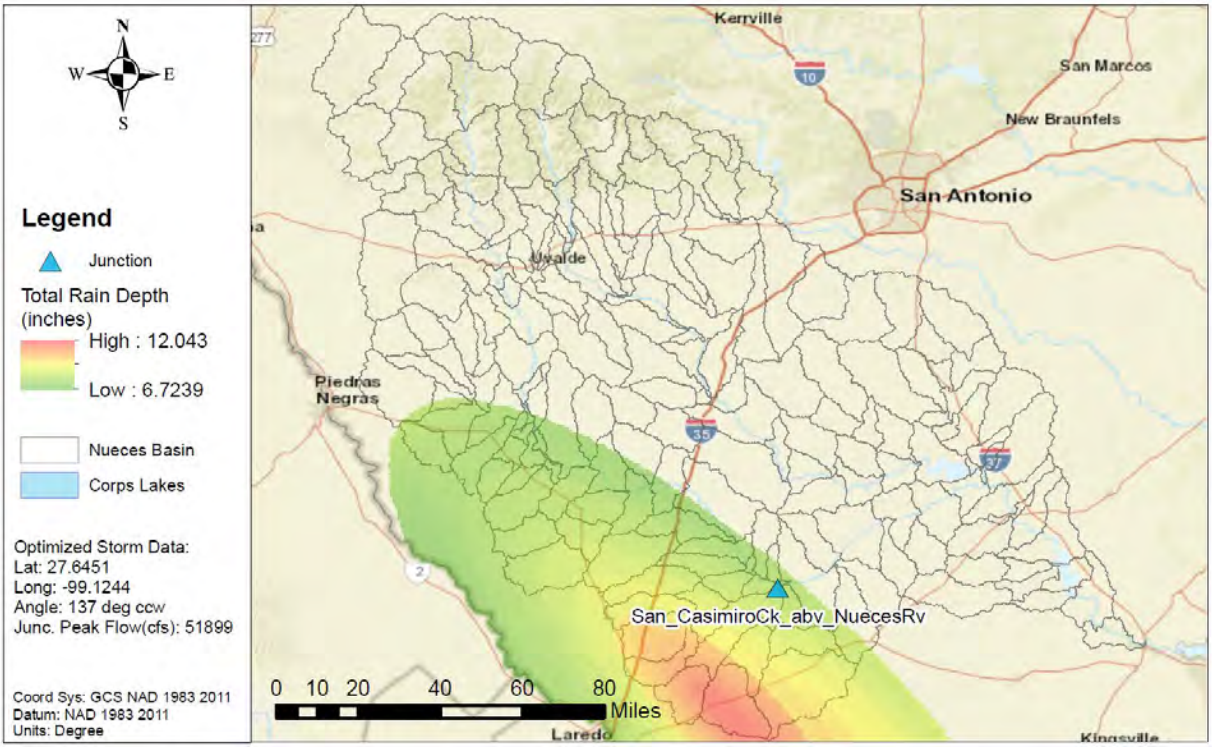

Figure C.11-58b: NA14 1% AEP Elliptical Storm for San_CasimiroCk_abv_NuecesRv

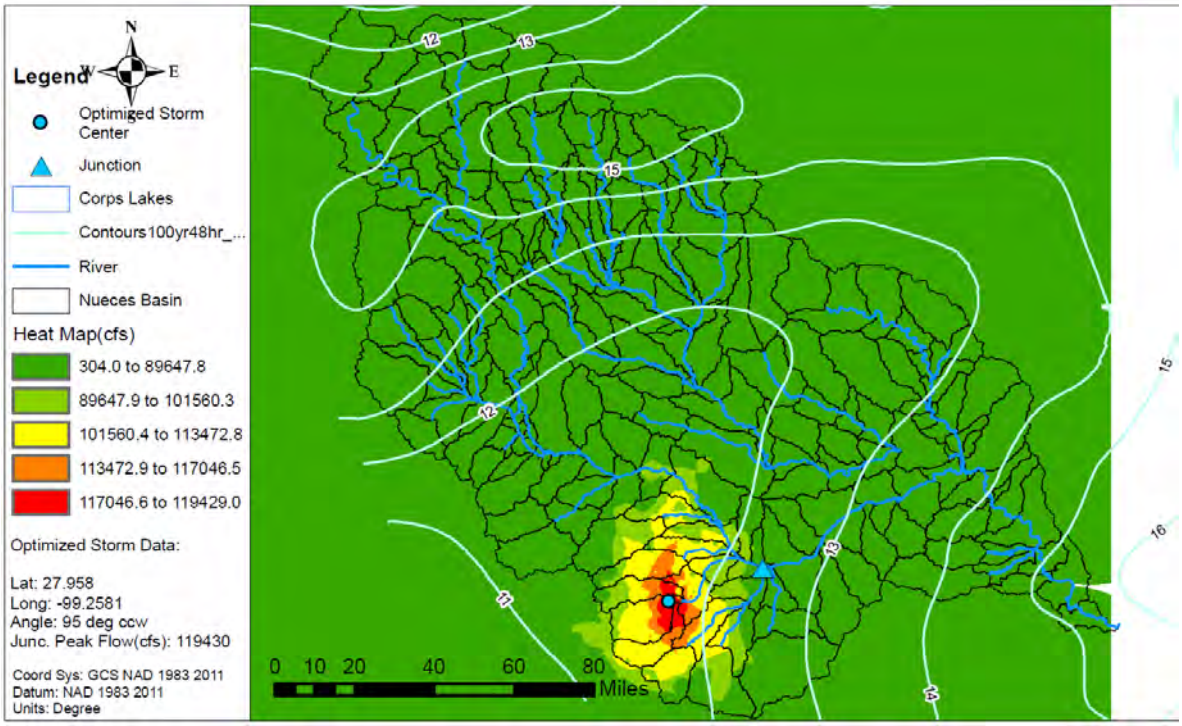

Figure C.11-59a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_San_CasimiroCk

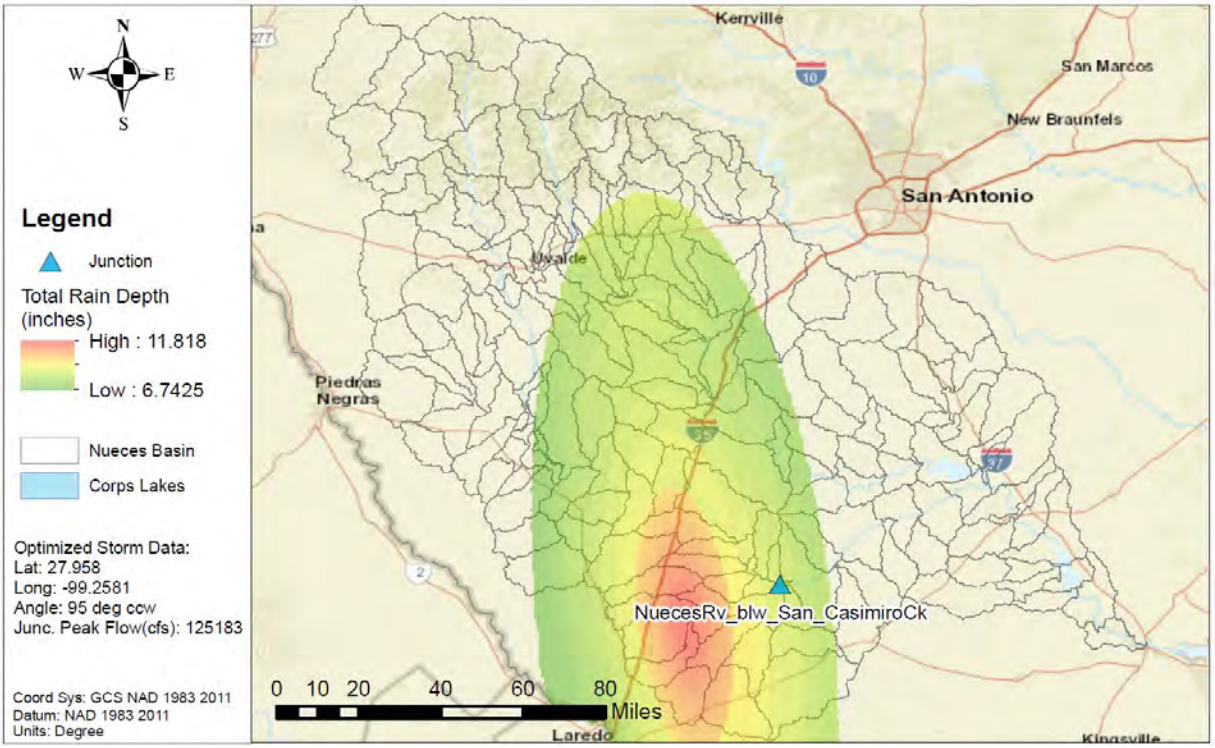

Figure C.11-59b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_San_CasimiroCk

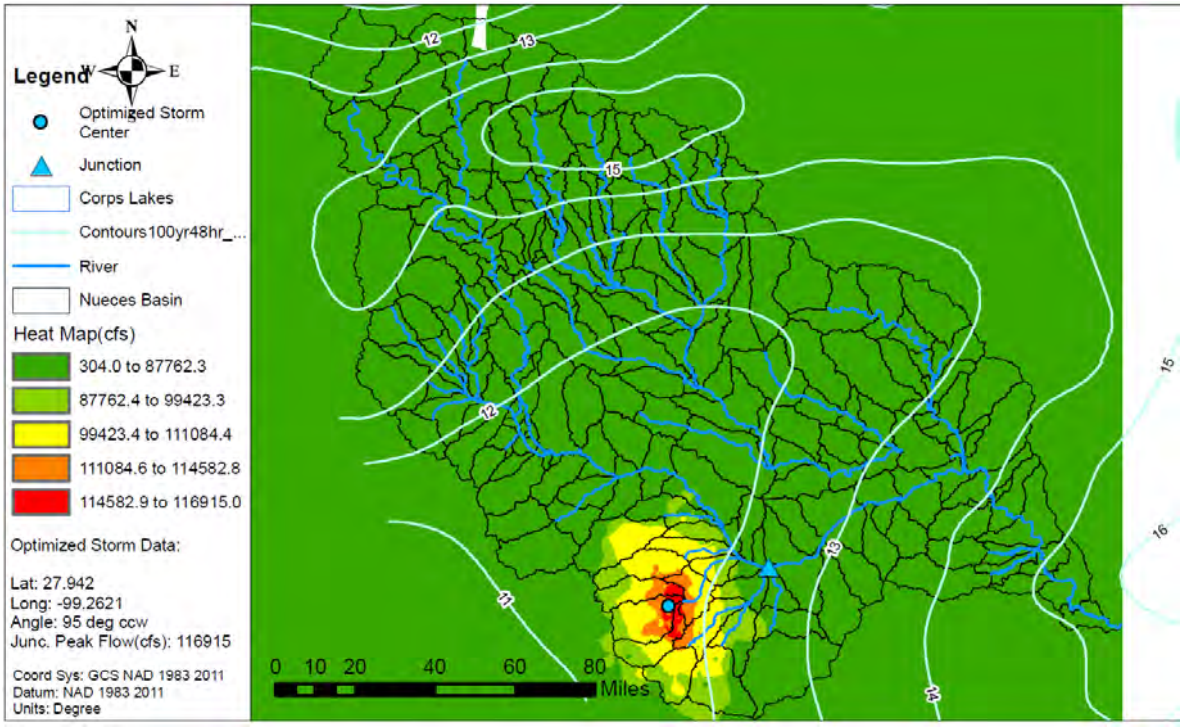

Figure C.11-60a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_BlackCk

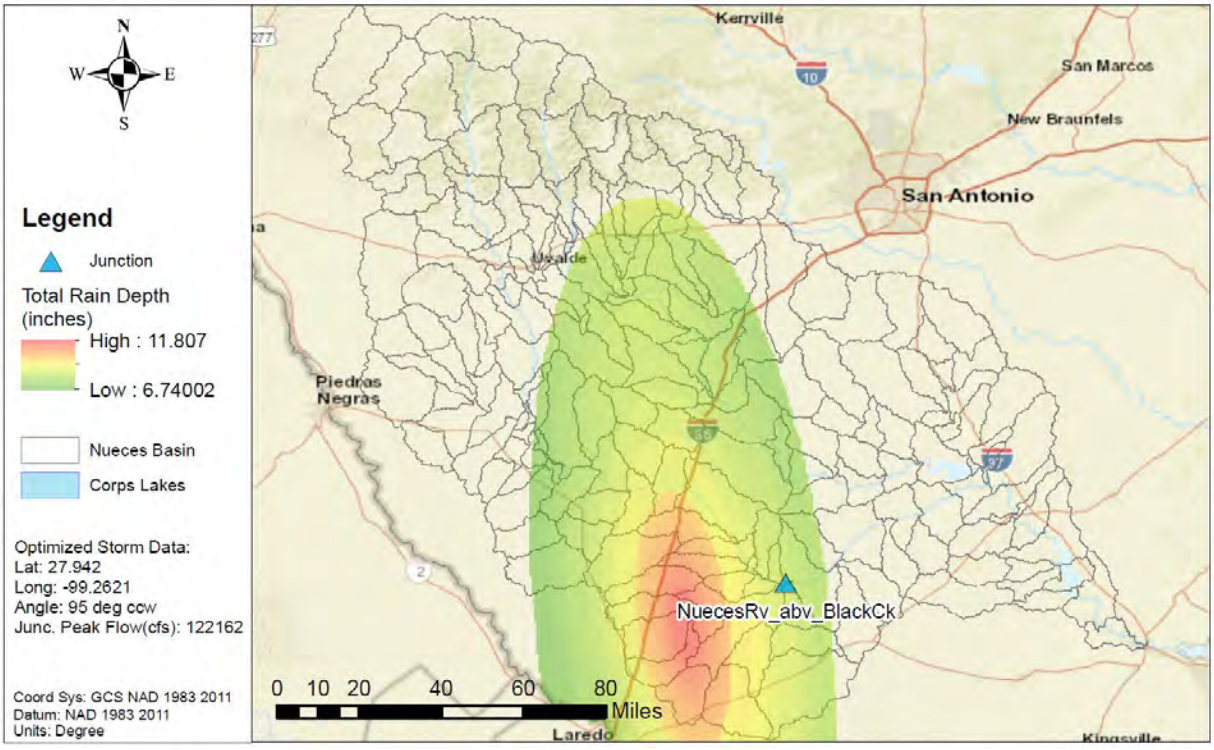

Figure C.11-60b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_BlackCk

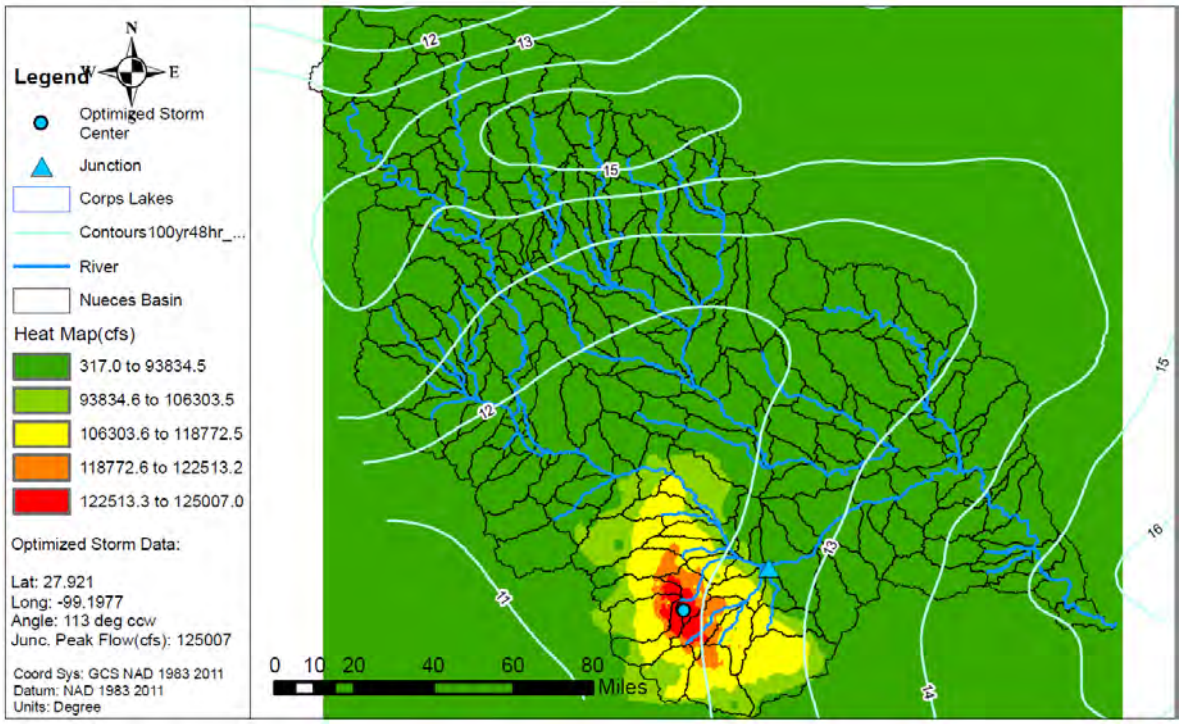

Figure C.11-61a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_BlackCk

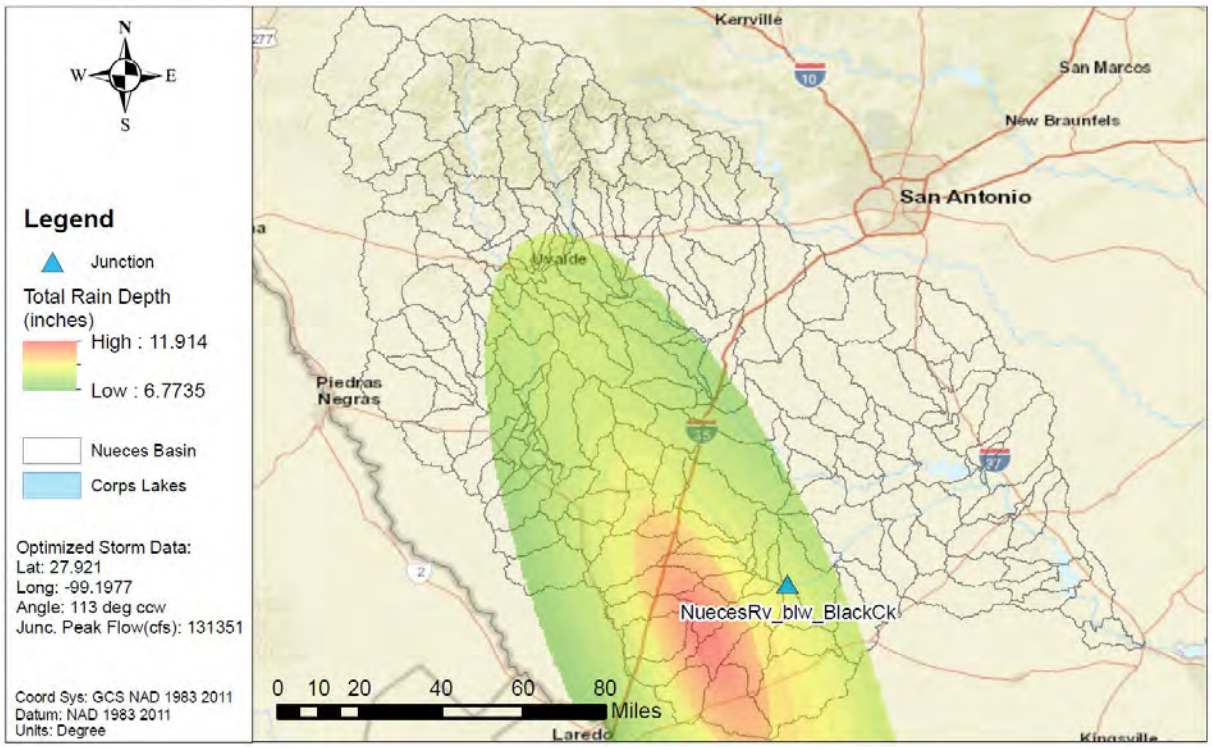

Figure C.11-61b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_BlackCk

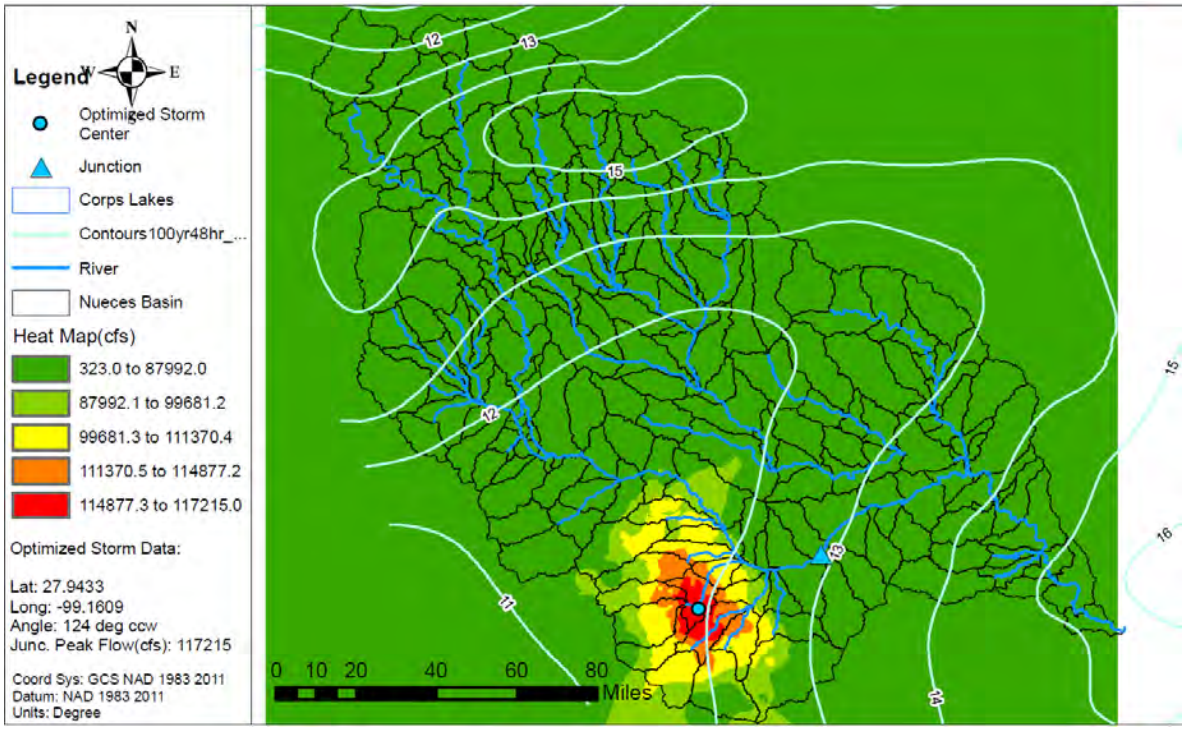

Figure C.11-62a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_YgnacioCk

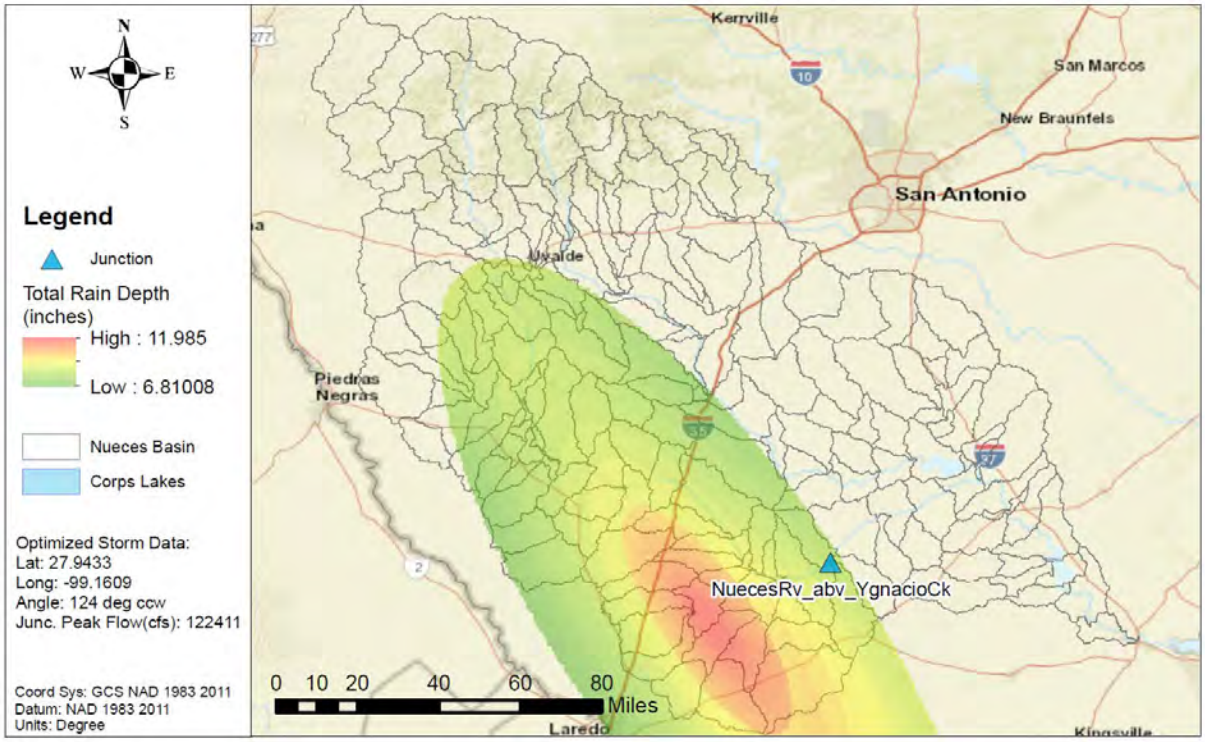

Figure C.11-62b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_YgnacioCk

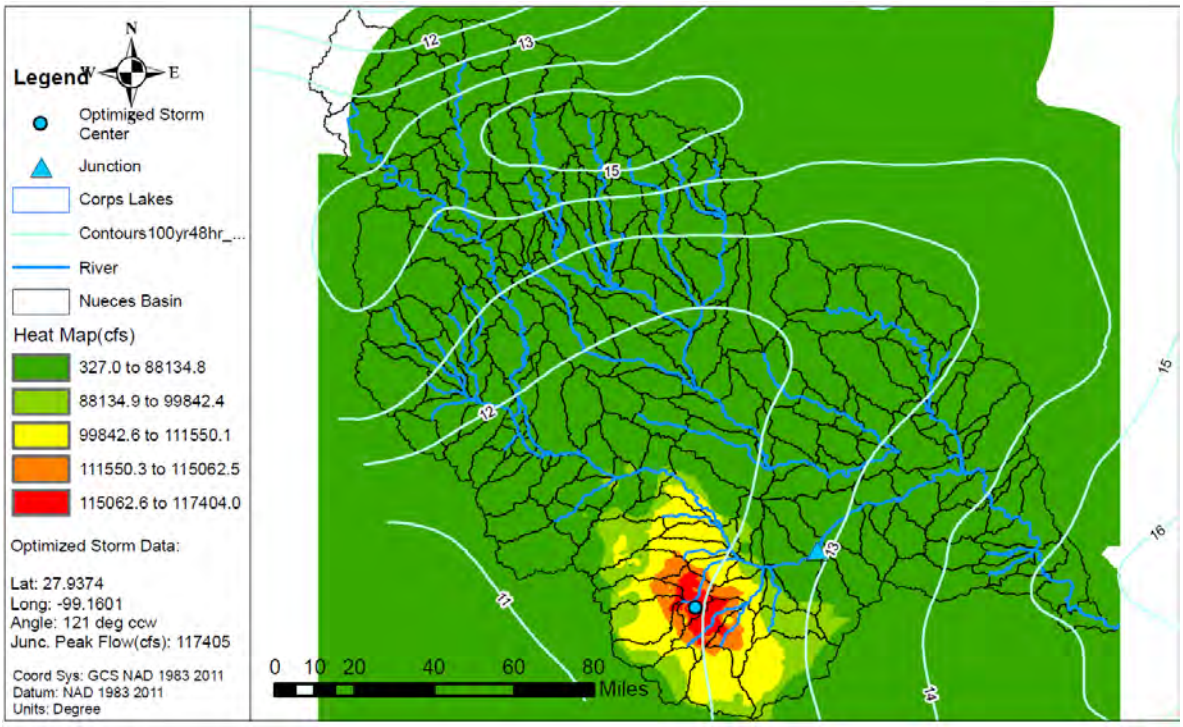

Figure C.11-63a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_YgnacioCk

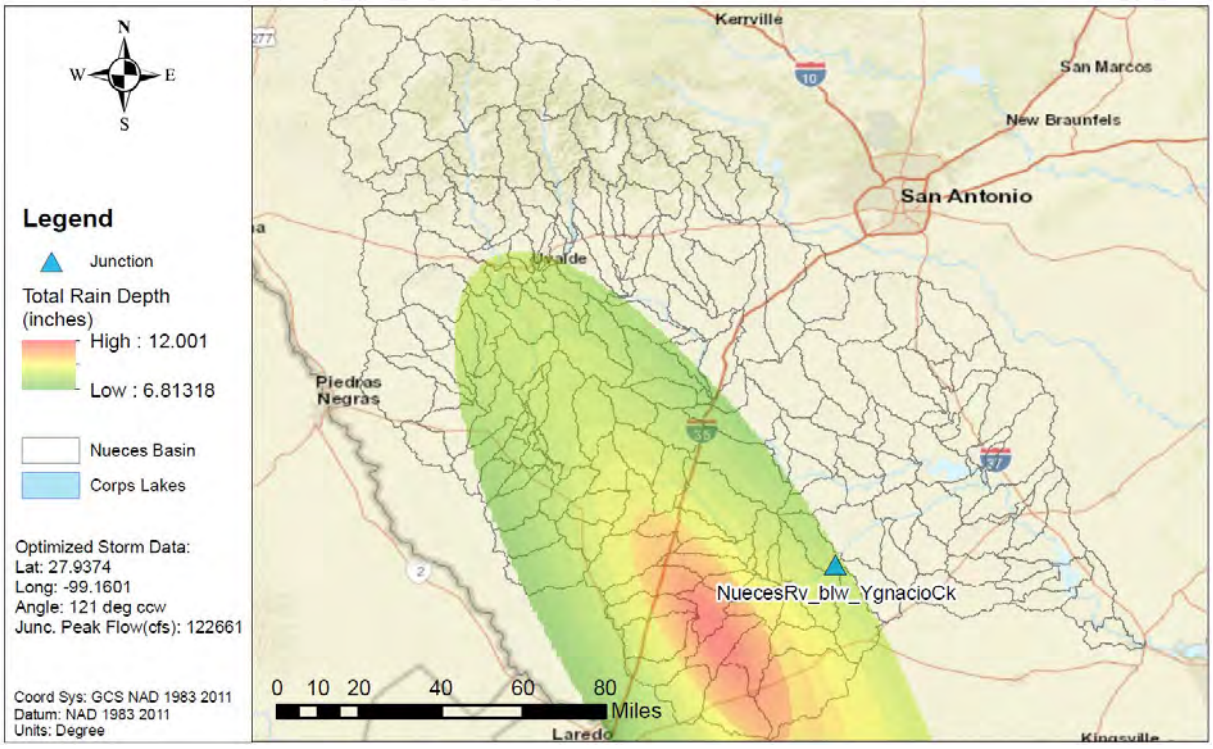

Figure C.11-63b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_YgnacioCk

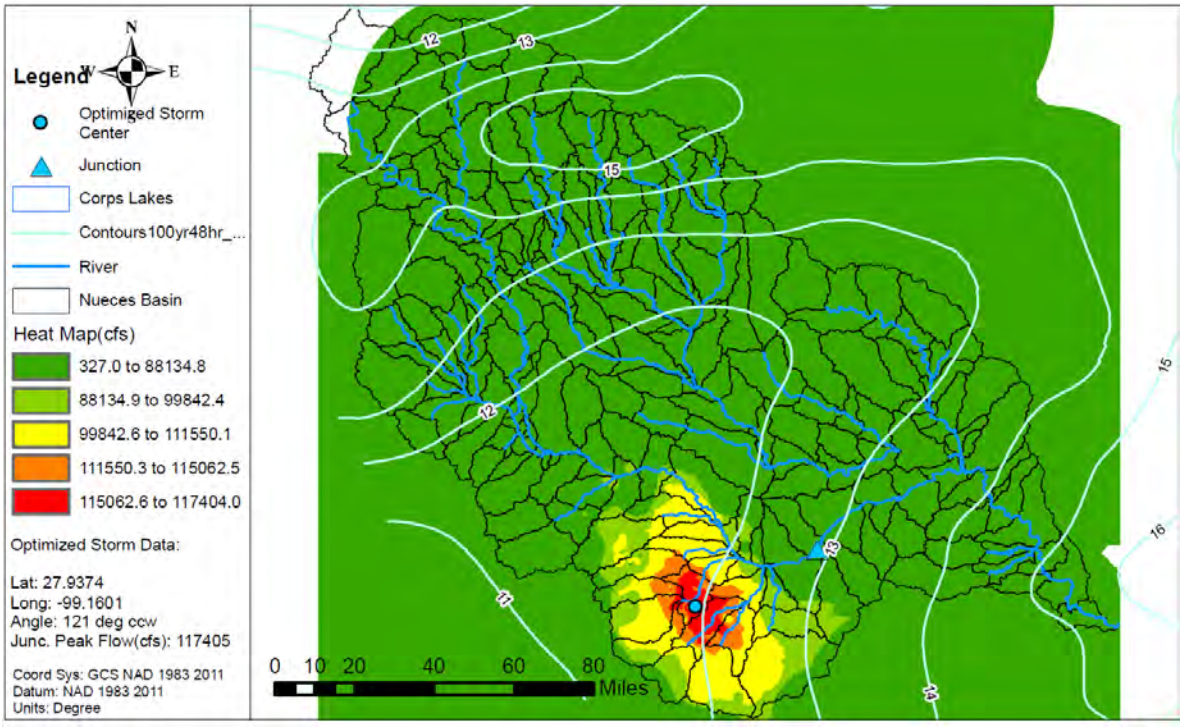

Figure C.11-64a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_San_JoseCk

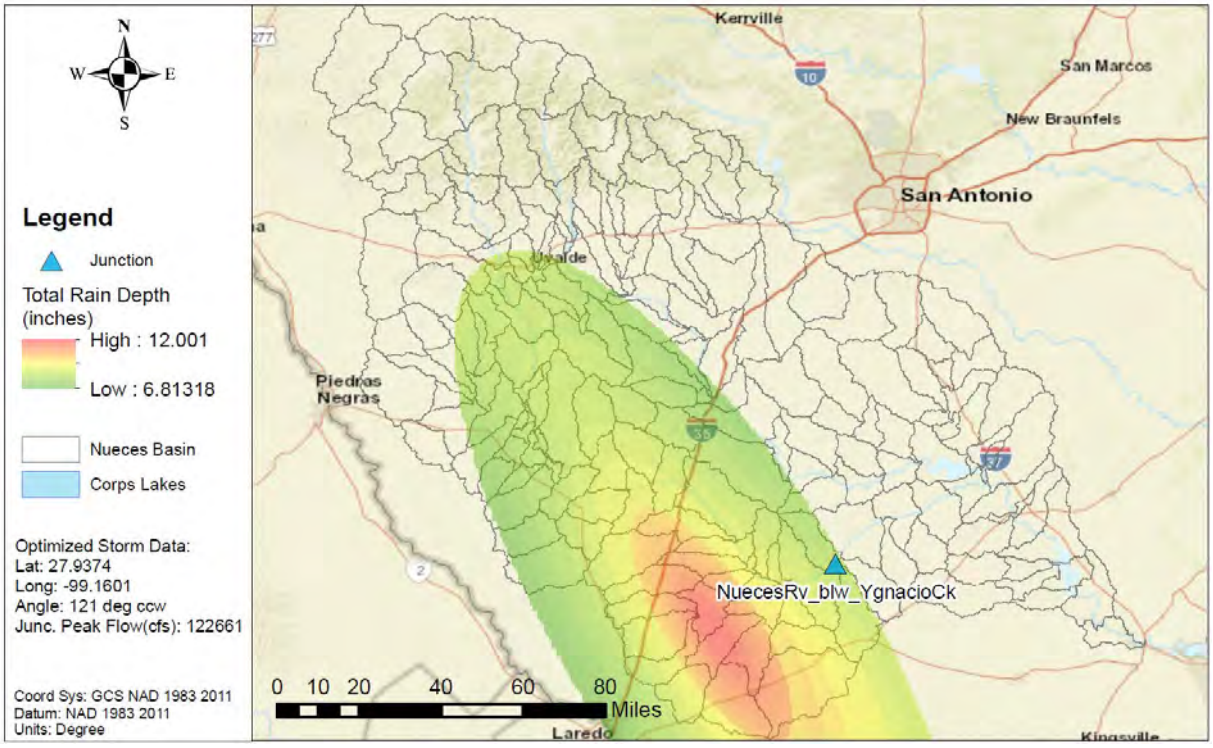

Figure C.11-64b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_YgnacioCk

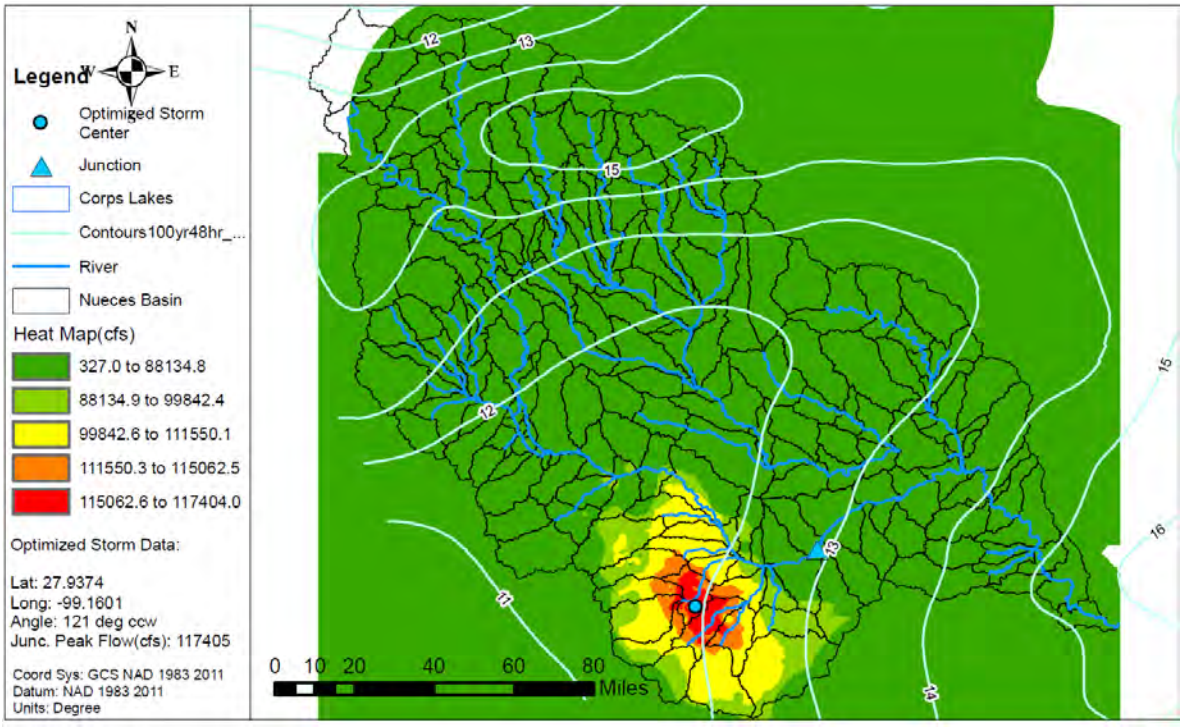

Figure C.11-65a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_San_JoseCk

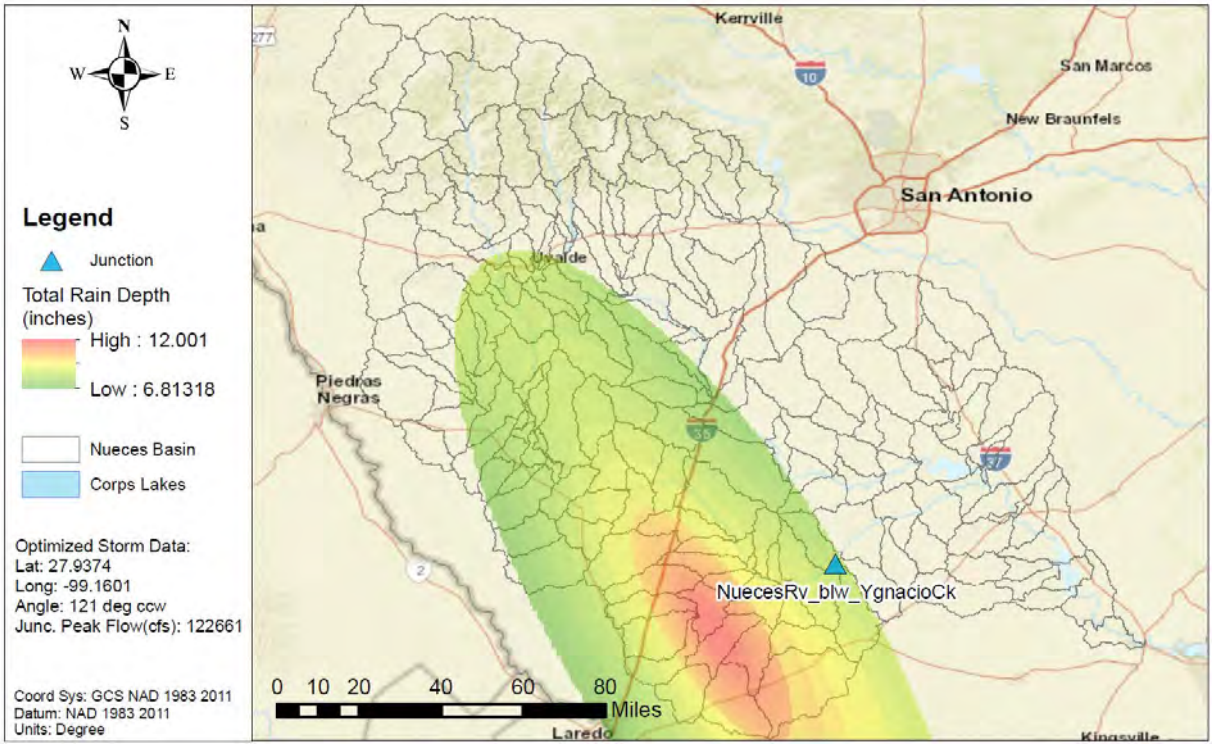

Figure C.11-65b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_San_JoseCk

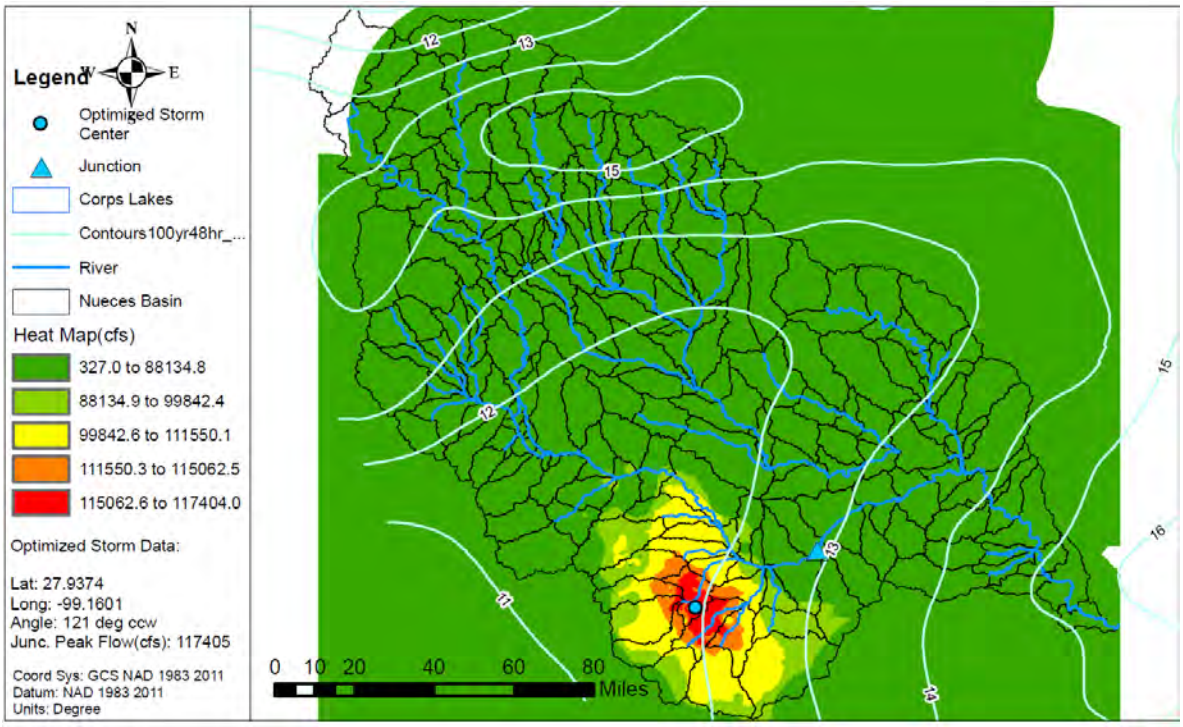

Figure C.11-66a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_GreenBr

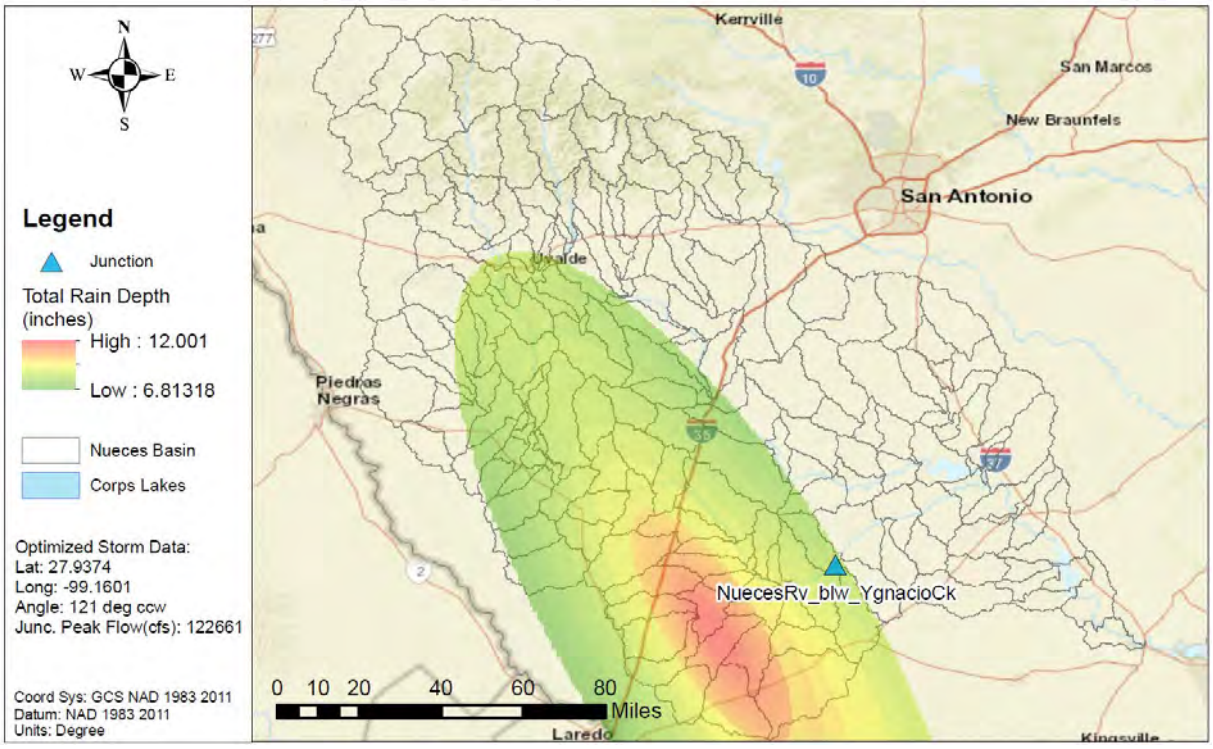

Figure C.11-66b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_YgnacioCk

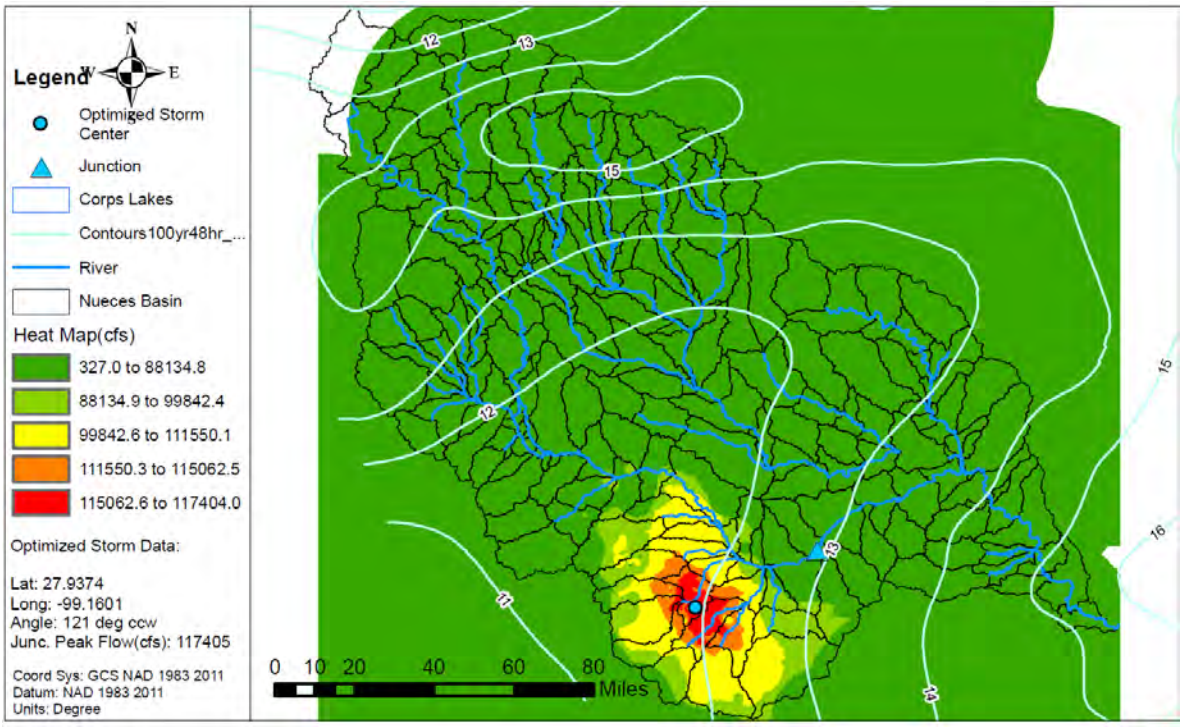

Figure C.11-67a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_GreenBr

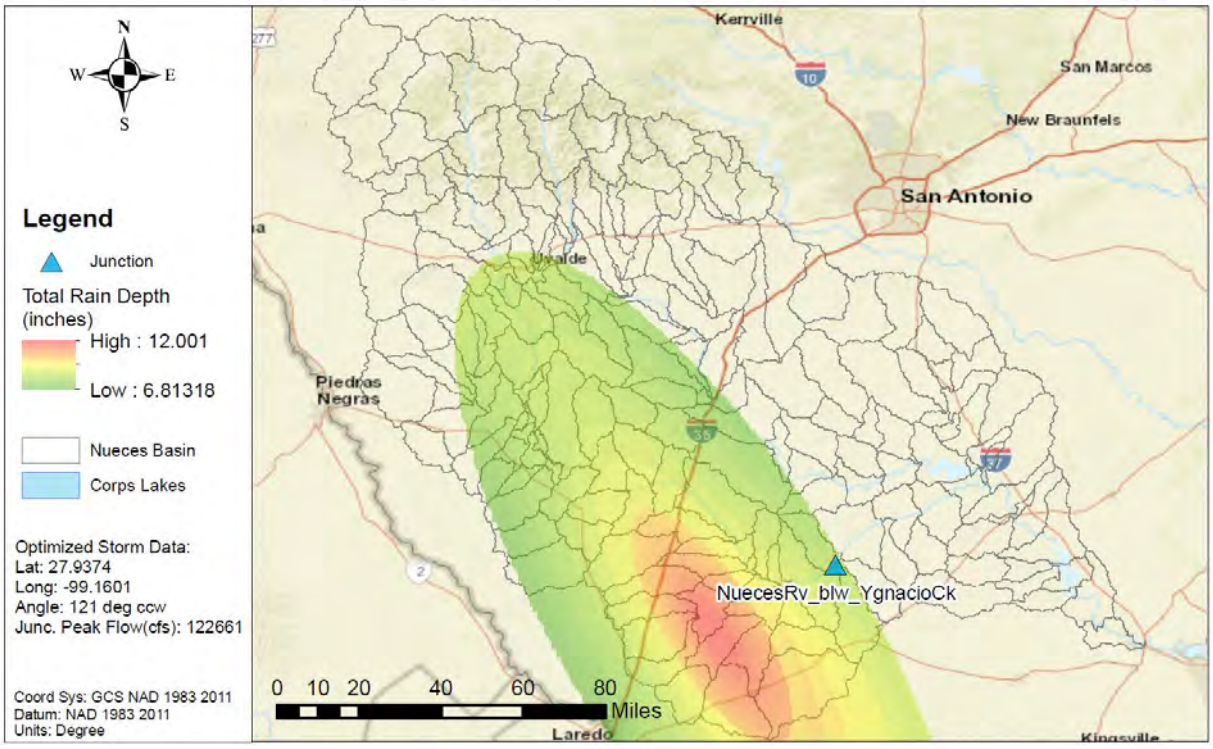

Figure C.11-67b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_YgnacioCk

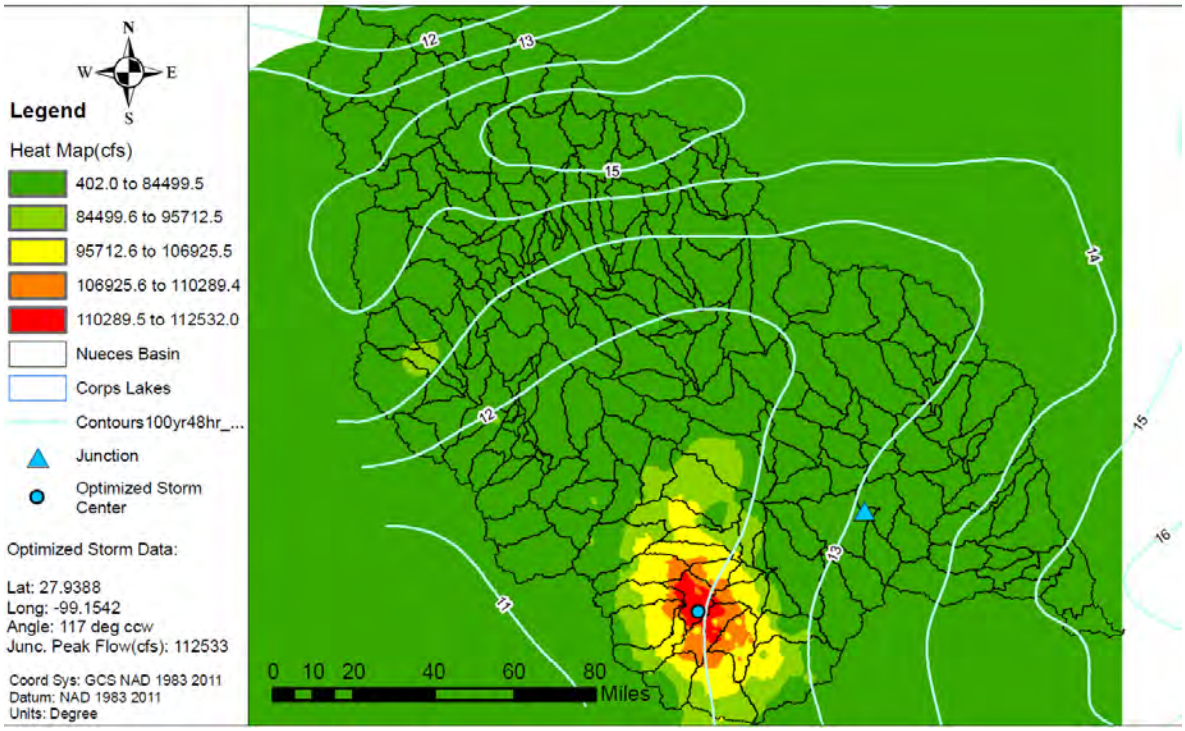

Figure C.11-68a: Elliptical Storm Optimization Heat Map for NuecesRv_nr_Tilden

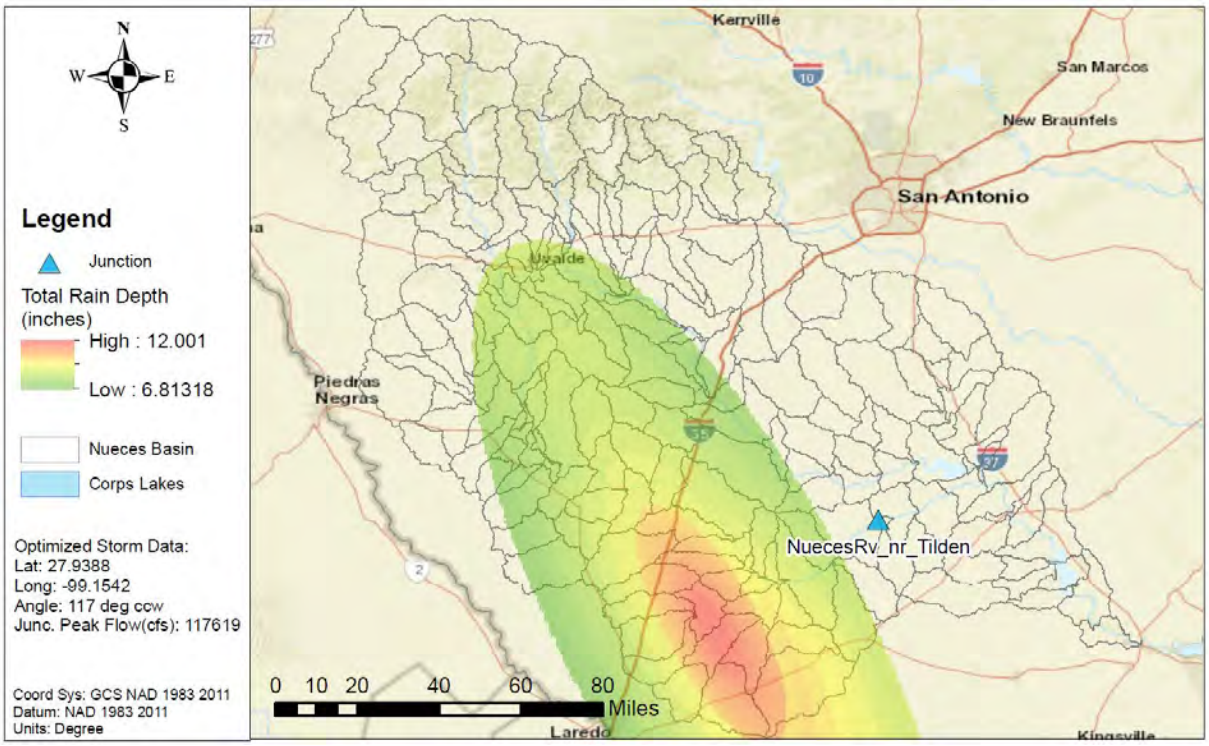

Figure C.11-68b: NA14 1% AEP Elliptical Storm for NuecesRv_nr_Tilden

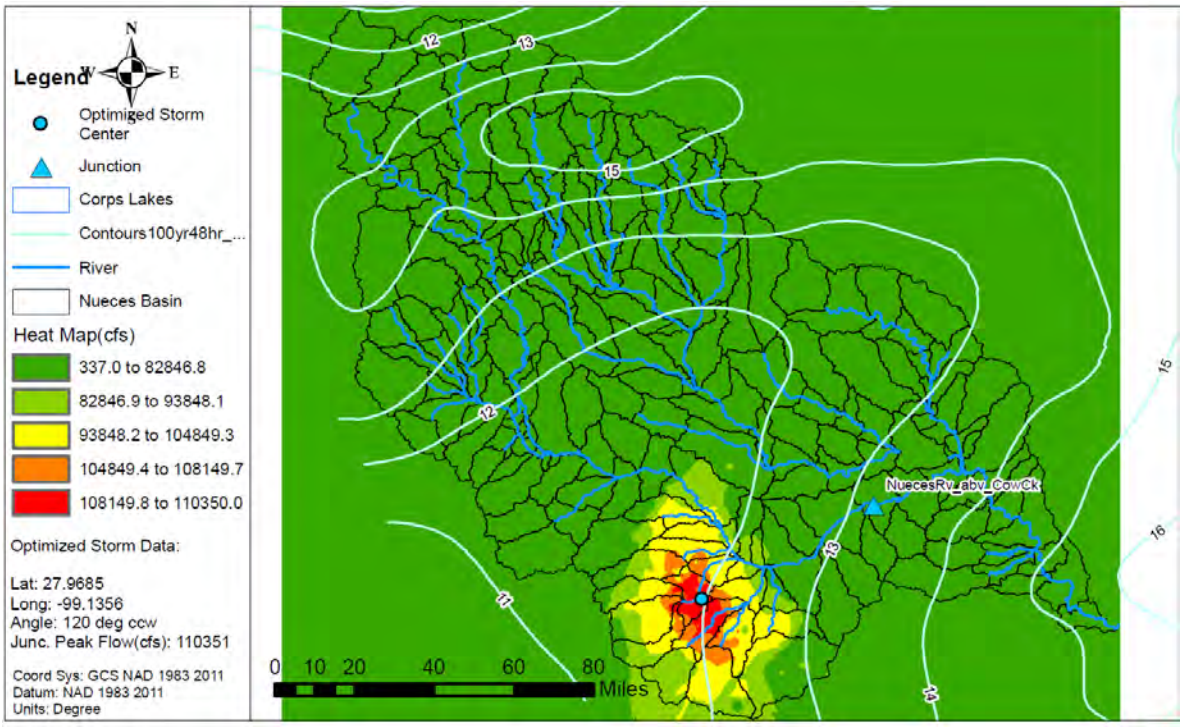

Figure C.11-69a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_CowCk

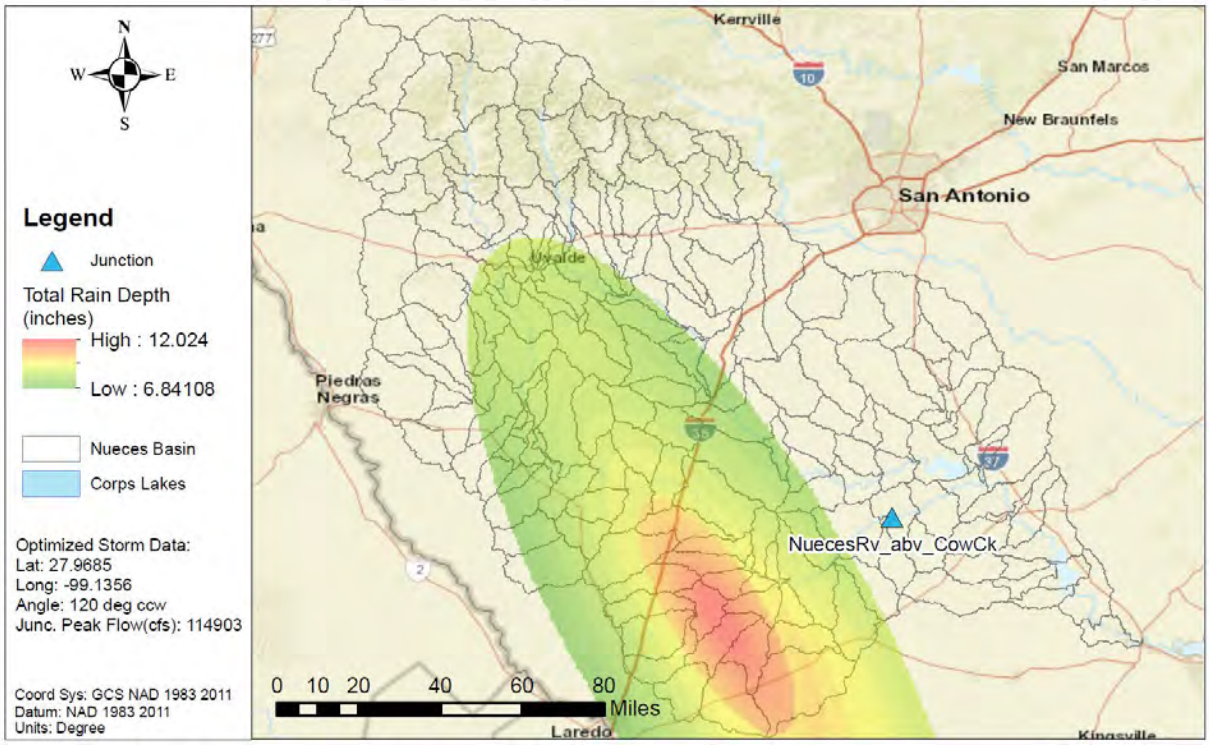

Figure C.11-69b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_CowCk

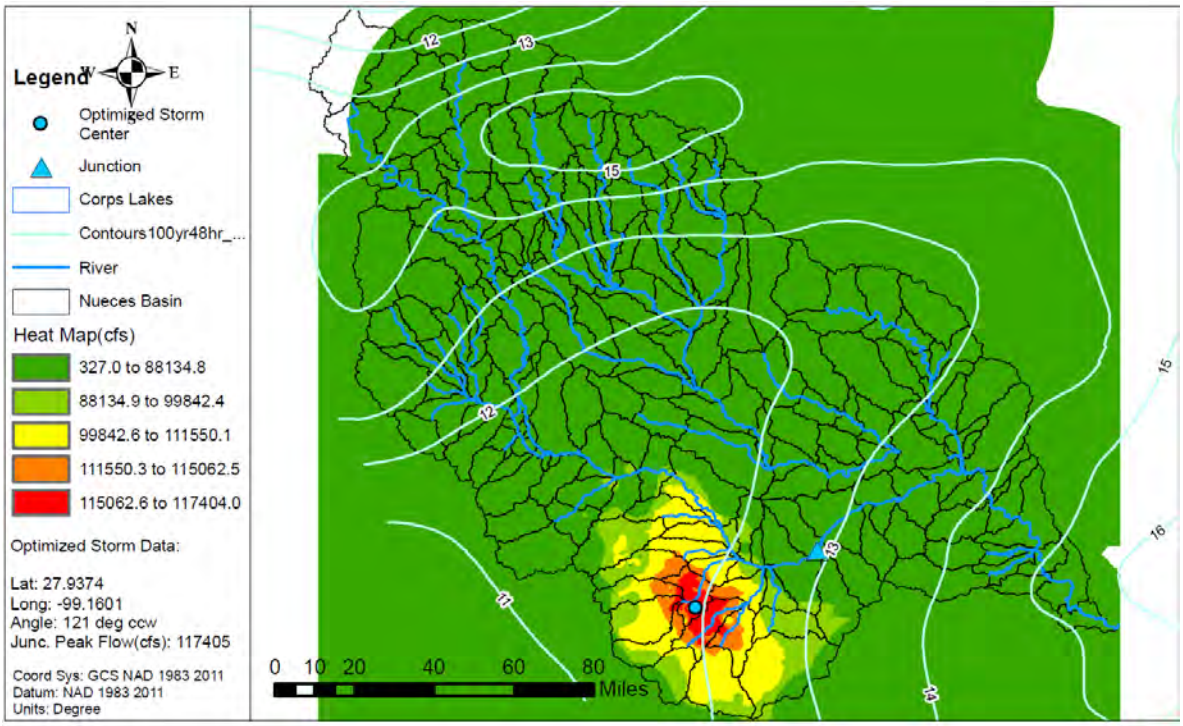

Figure C.11-70a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_CowCk

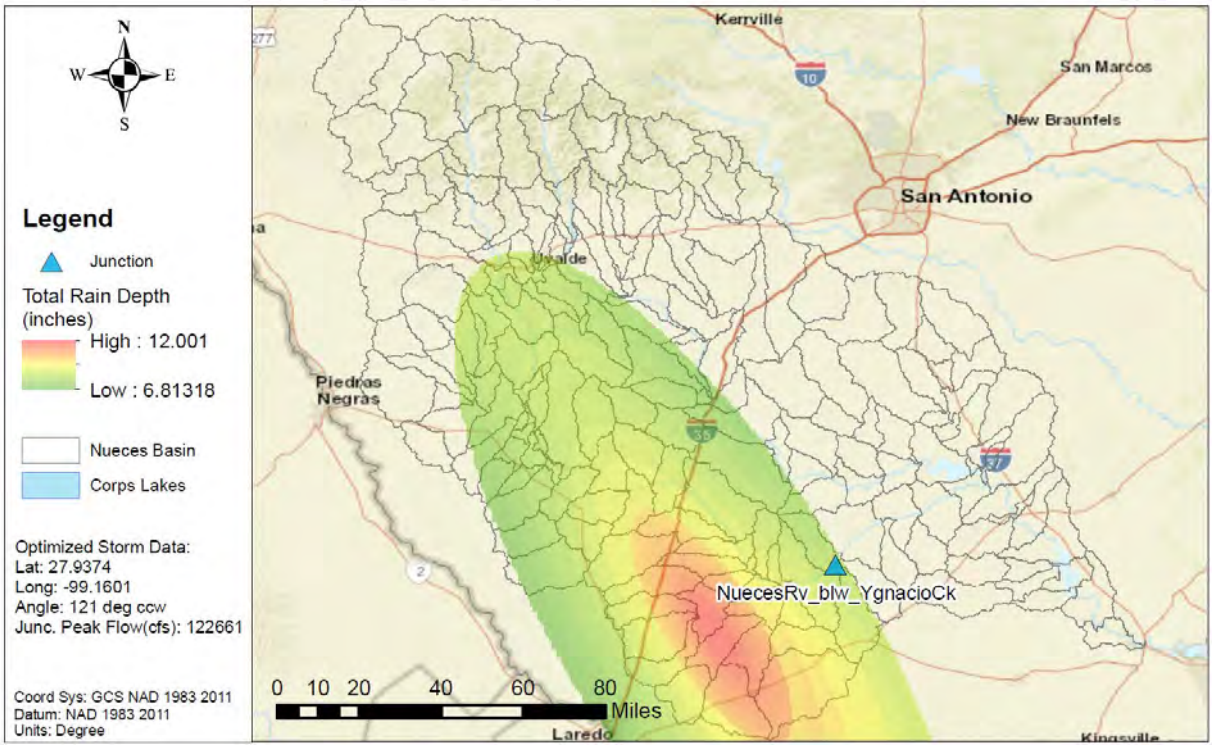

Figure C.11-70b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_YgnacioCk

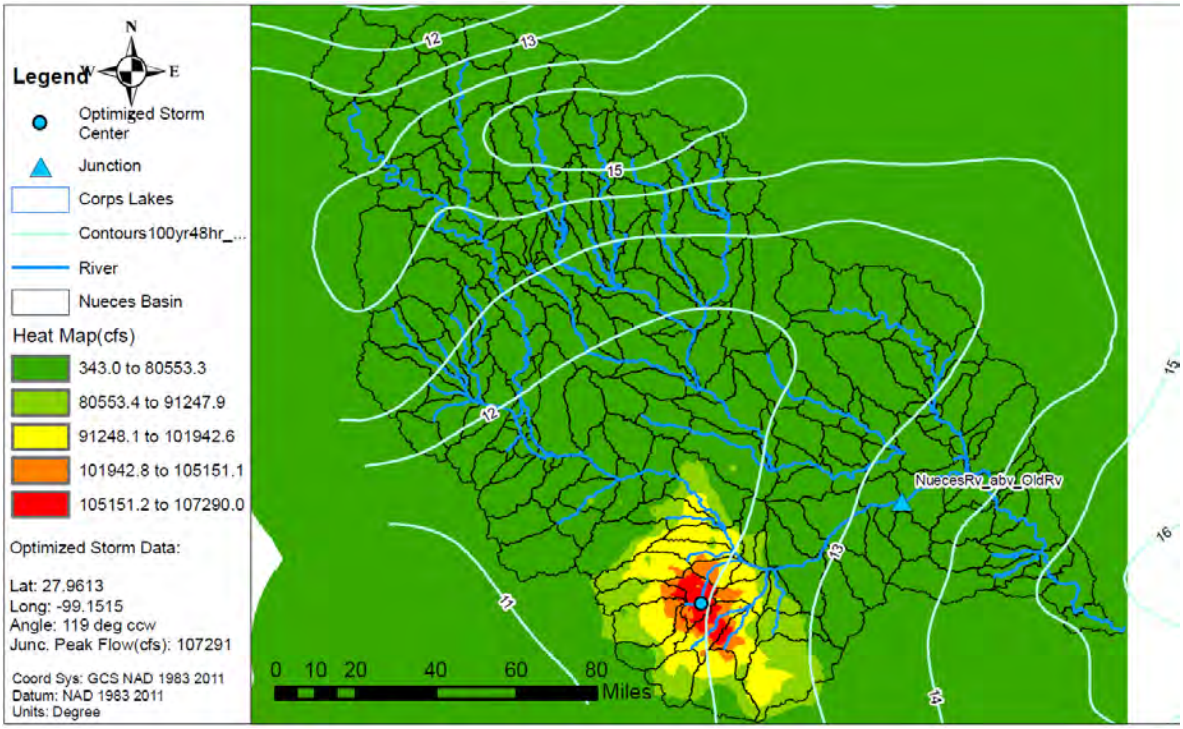

Figure C.11-71a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_OldRv

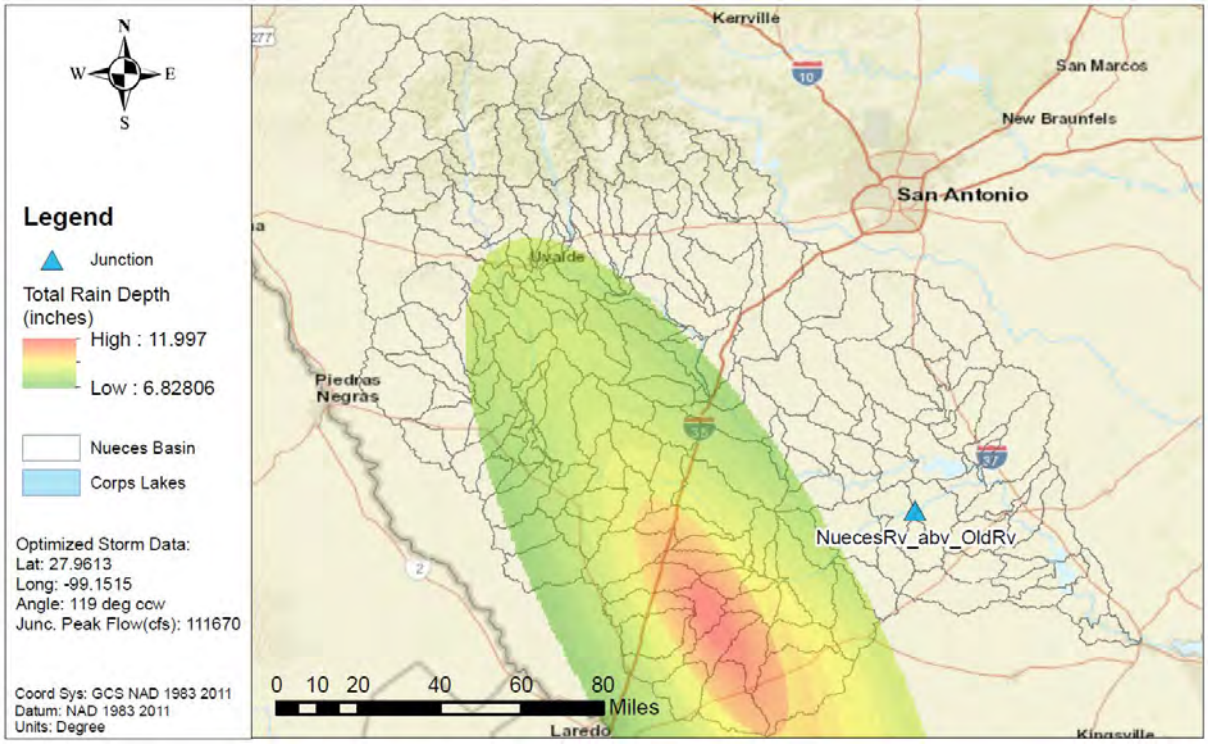

Figure C.11-71b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_OldRv

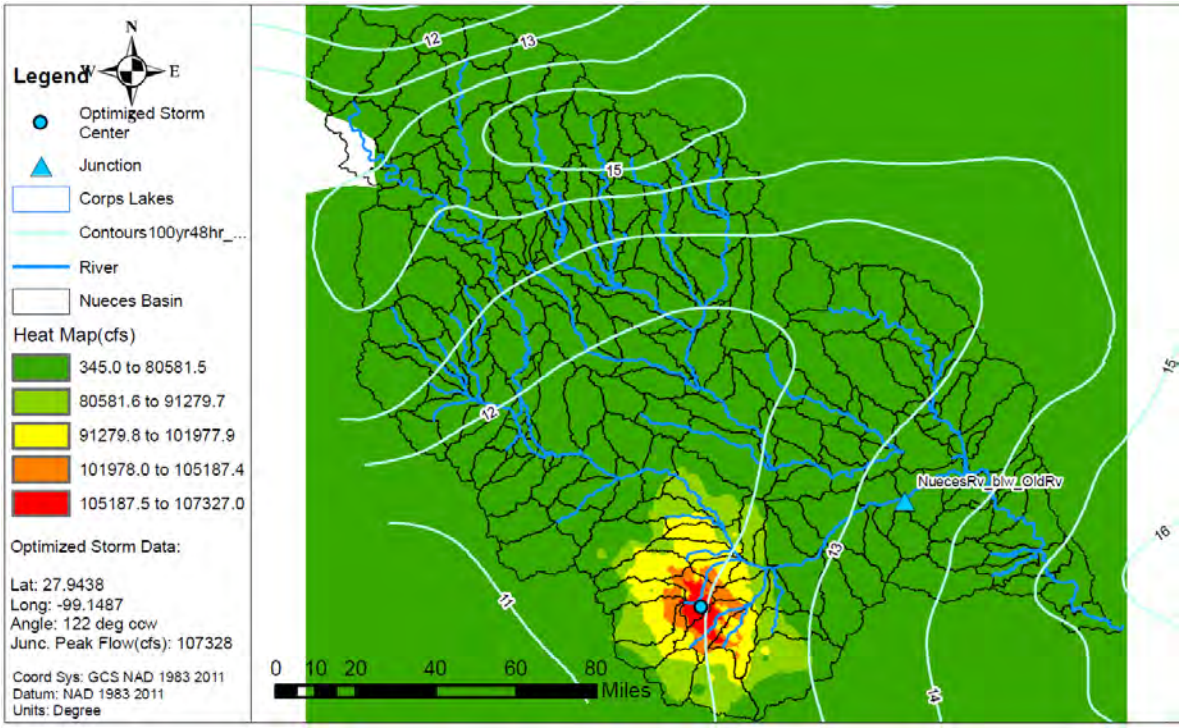

Figure C.11-72a: Elliptical Storm Optimization Heat Map for NuecesRv_blw_OldRv

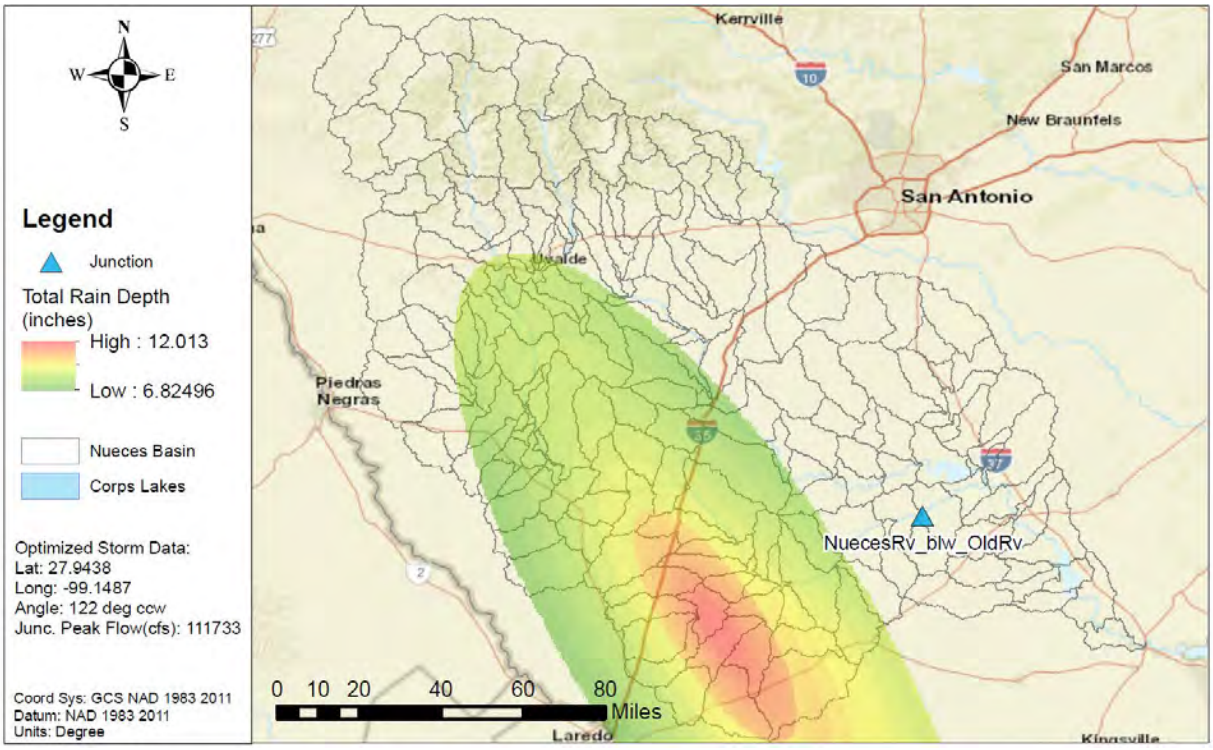

Figure C.11-72b: NA14 1% AEP Elliptical Storm for NuecesRv_blw_OldRv

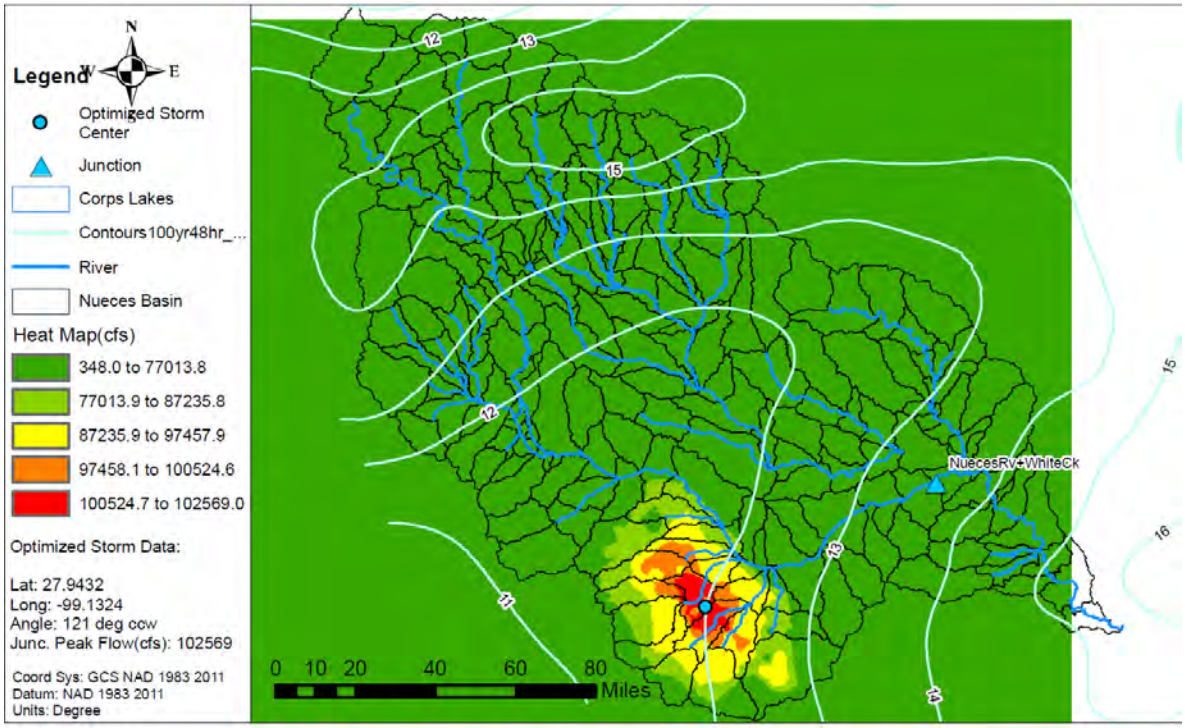

Figure C.11-73a: Elliptical Storm Optimization Heat Map for NuecesRv+WhiteCk

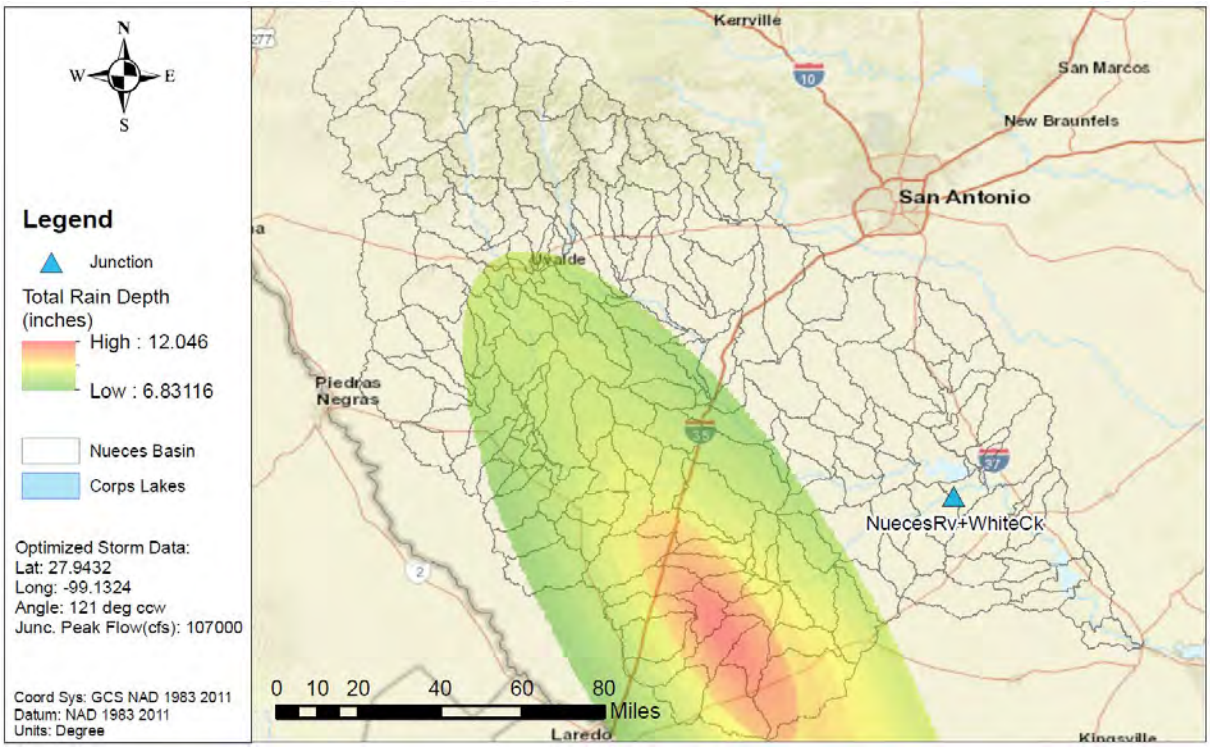

Figure C.11-73b: NA14 1% AEP Elliptical Storm for NuecesRv+WhiteCk

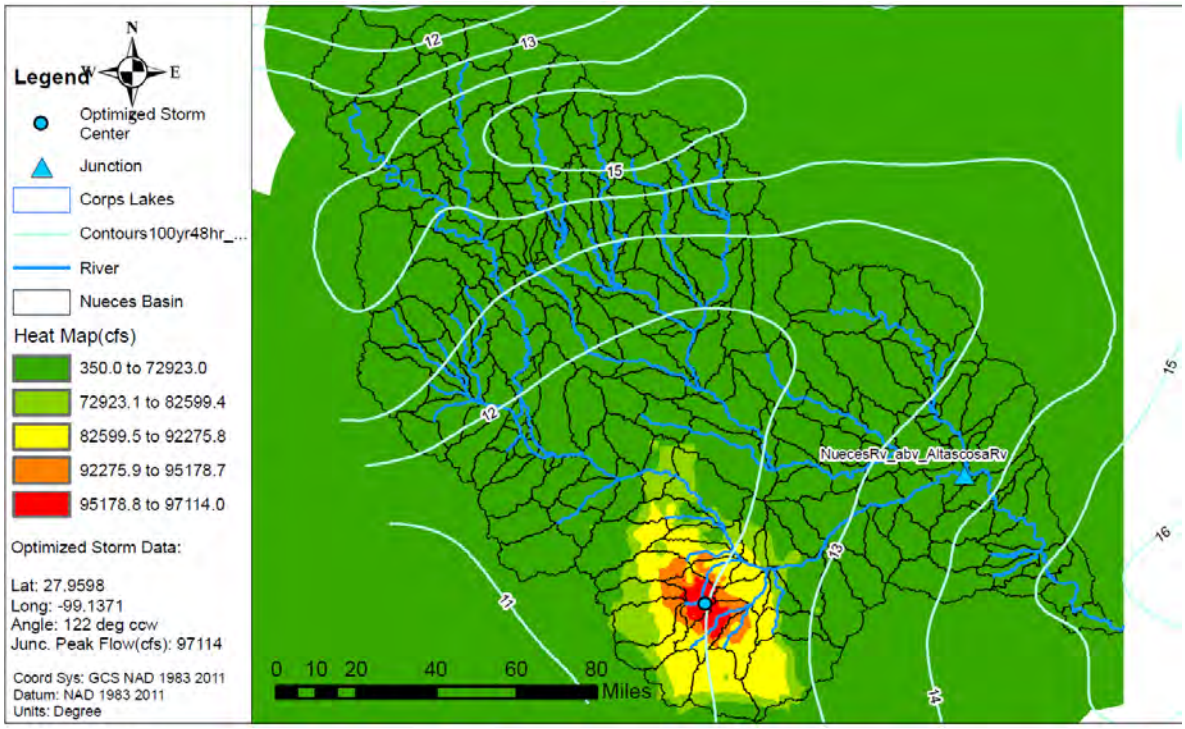

Figure C.11-74a: Elliptical Storm Optimization Heat Map for NuecesRv_abv_AltascosaRv

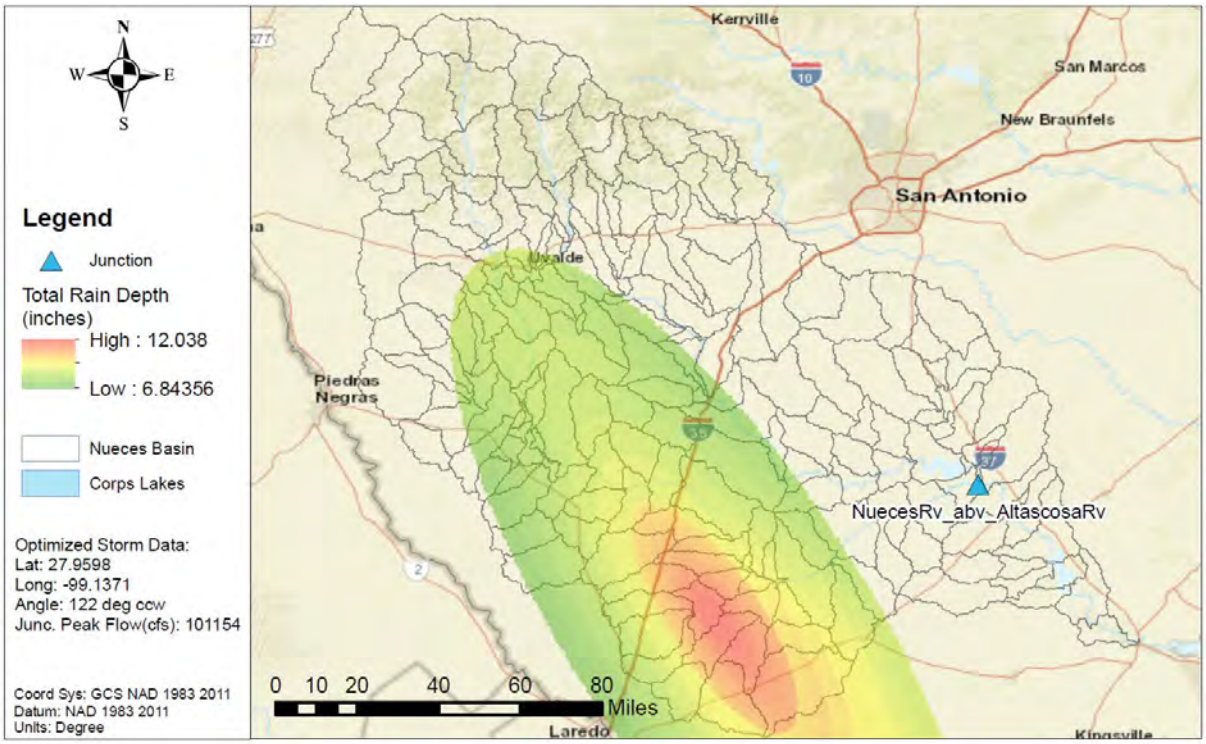

Figure C.11-74b: NA14 1% AEP Elliptical Storm for NuecesRv_abv_AltascosaRv

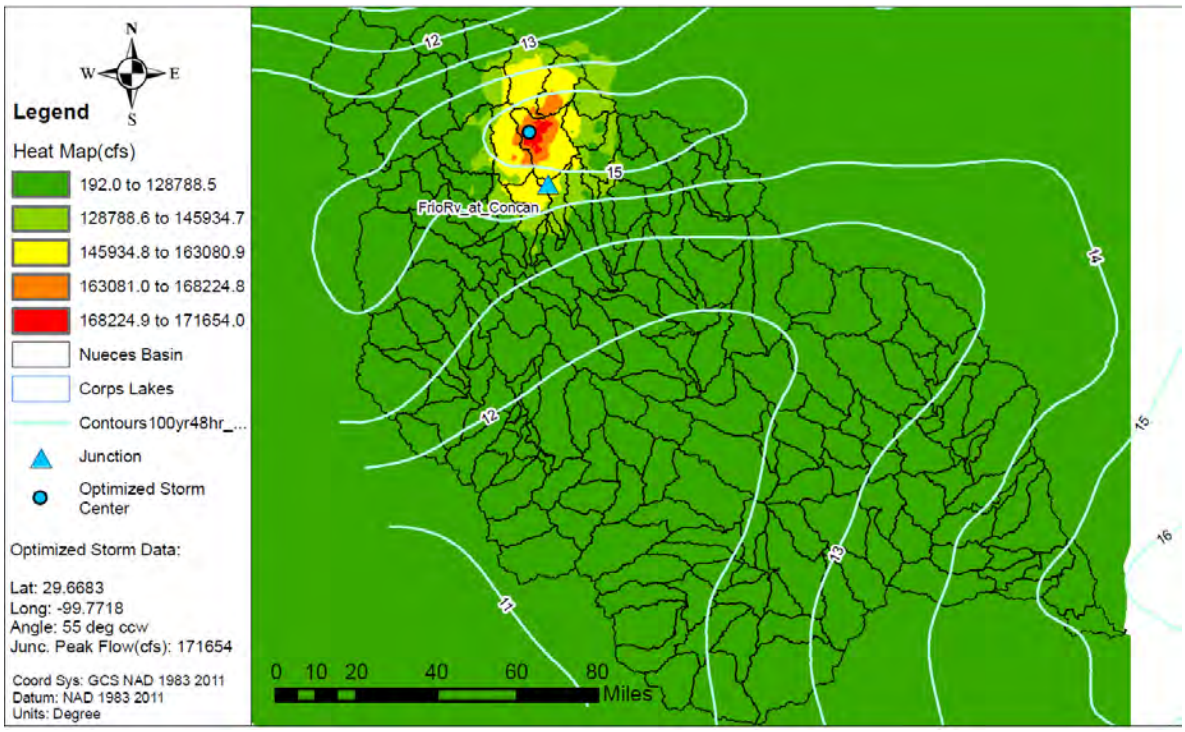

Figure C.11-75a: Elliptical Storm Optimization Heat Map for FrioRv_at_Concan

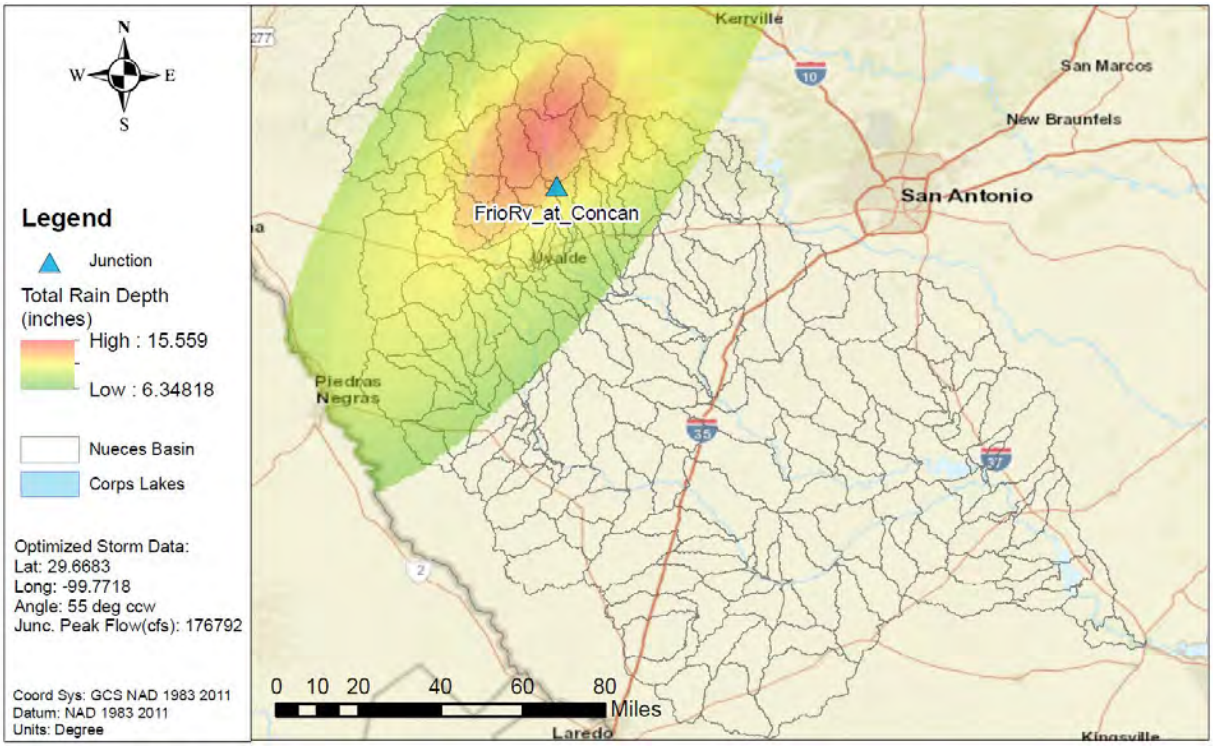

Figure C.11-75b: NA14 1% AEP Elliptical Storm for FrioRv_at_Concan

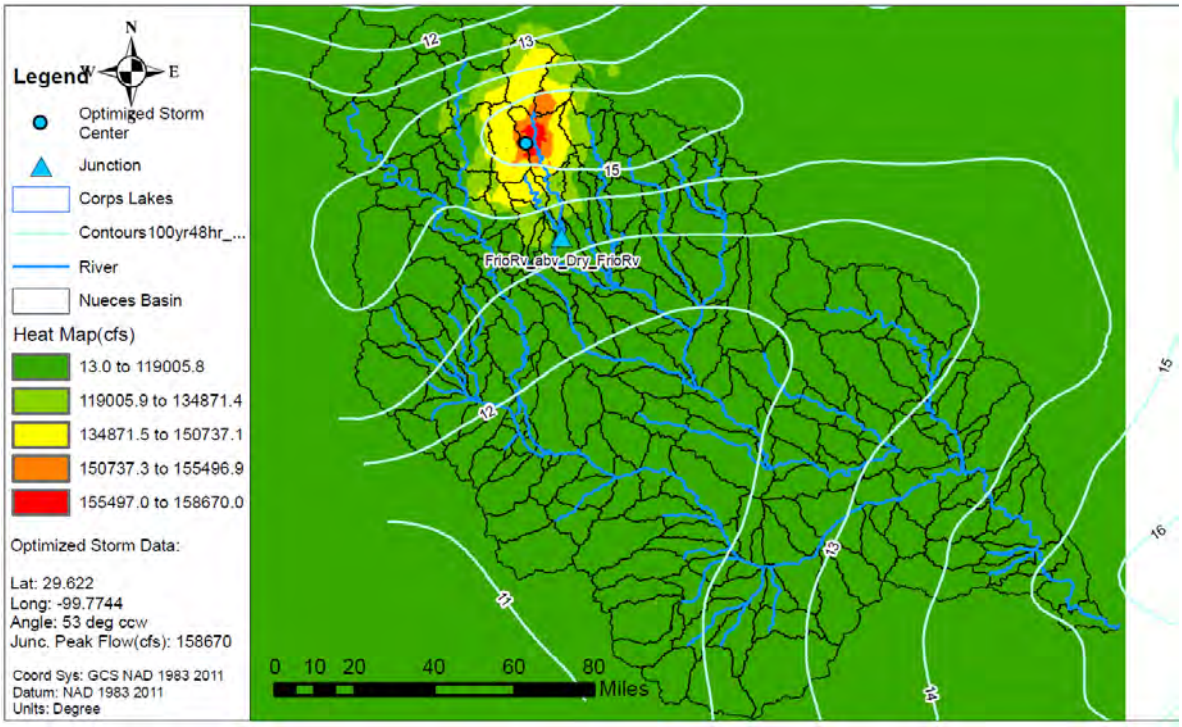

Figure C.11-76a: Elliptical Storm Optimization Heat Map for FrioRv_abv_Dry_FrioRv

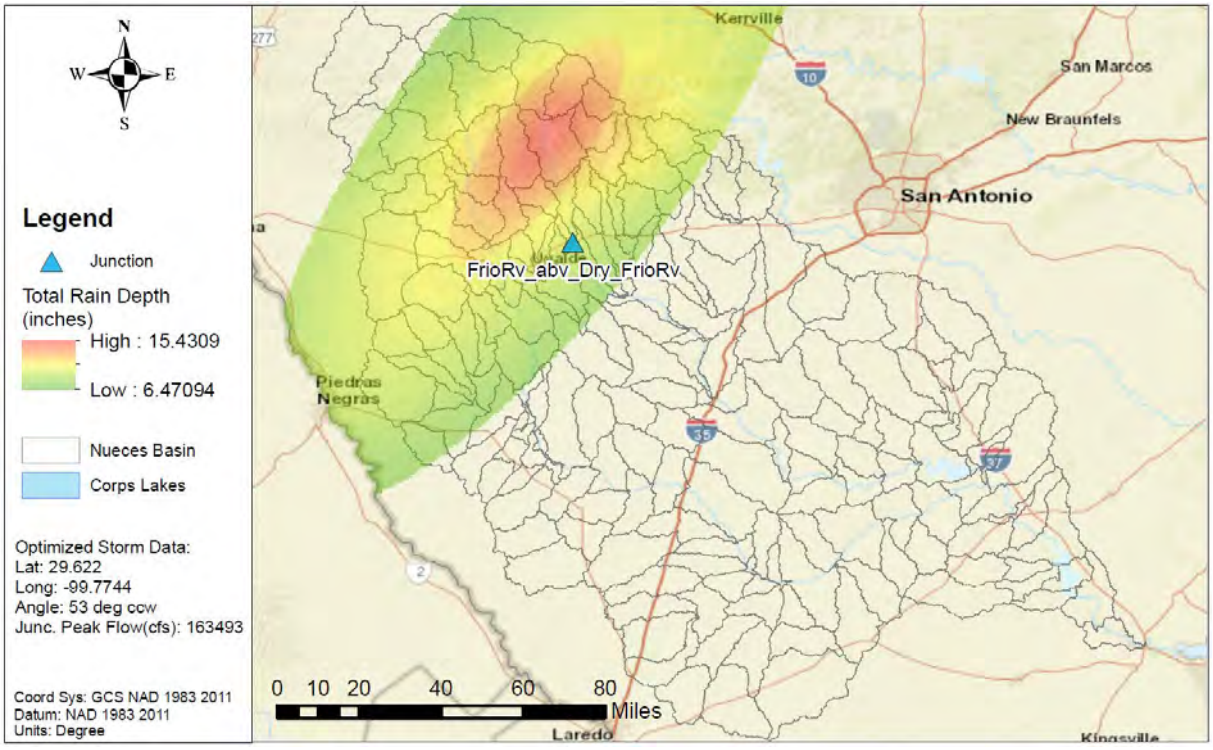

Figure C.11-76b: NA14 1% AEP Elliptical Storm for FrioRv_abv_Dry_FrioRv

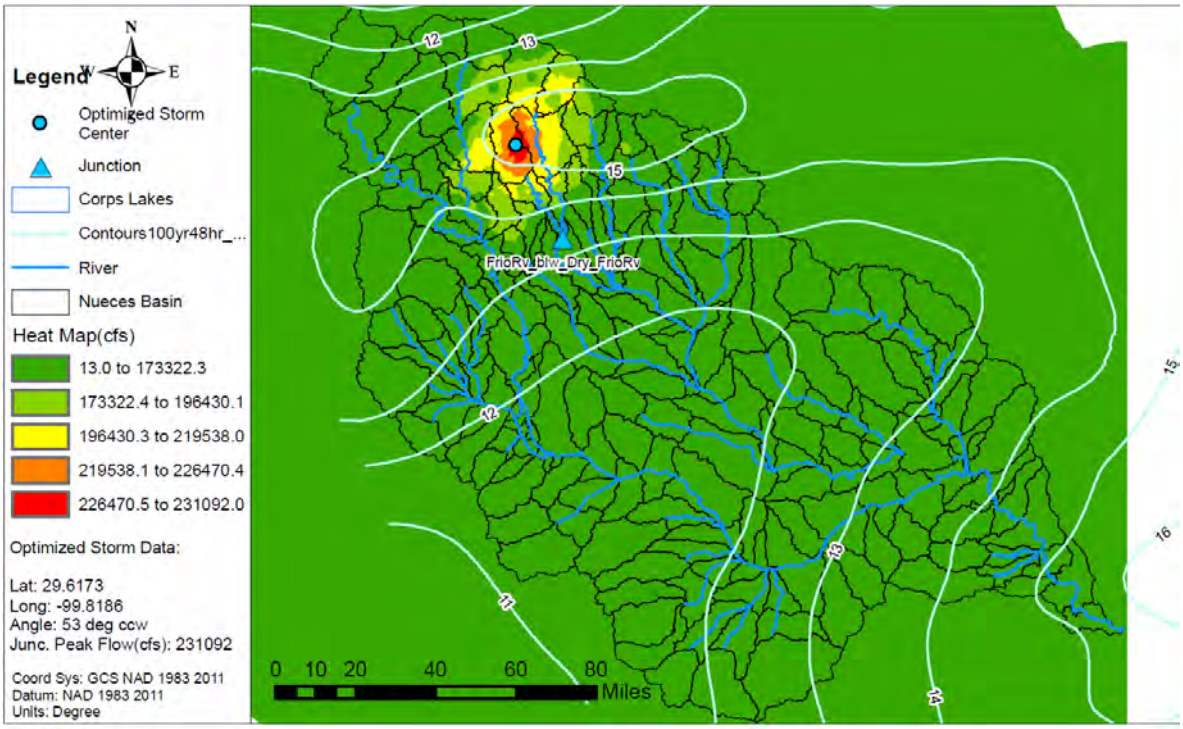

Figure C.11-77a: Elliptical Storm Optimization Heat Map for FrioRv_blw_Dry_FrioRv

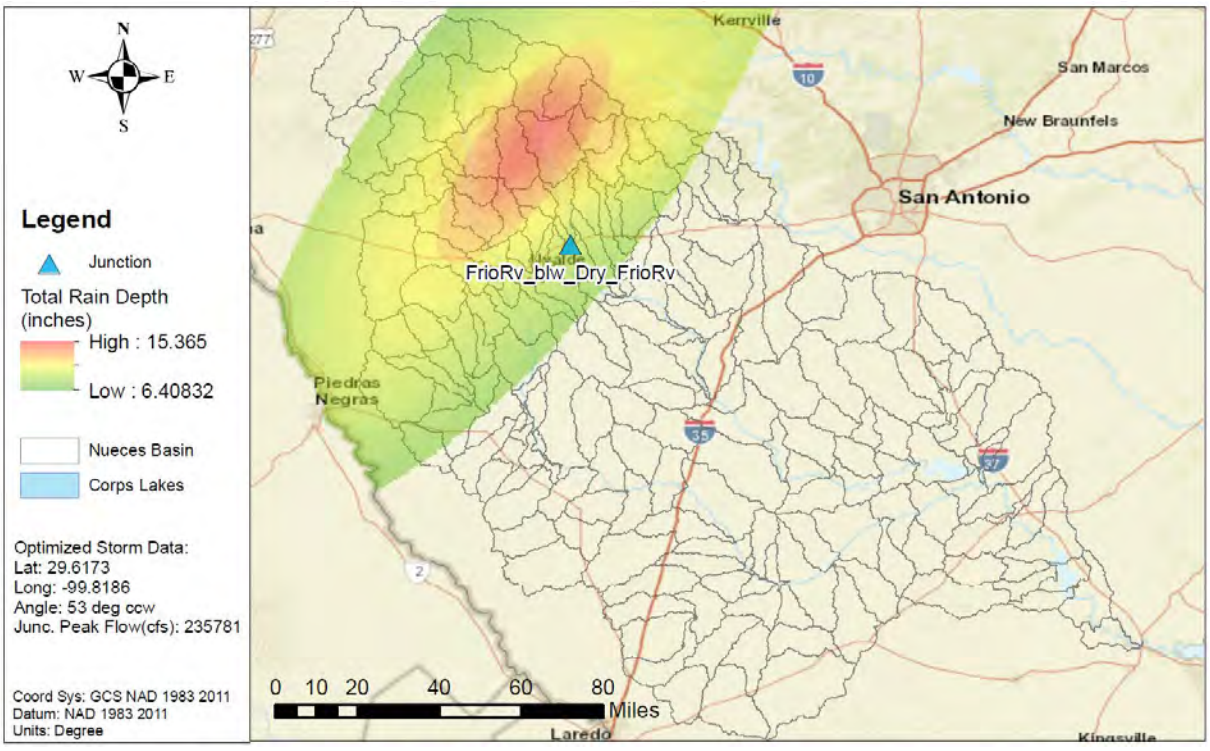

Figure C.11-77b: NA14 1% AEP Elliptical Storm for FrioRv_blw_Dry_FrioRv

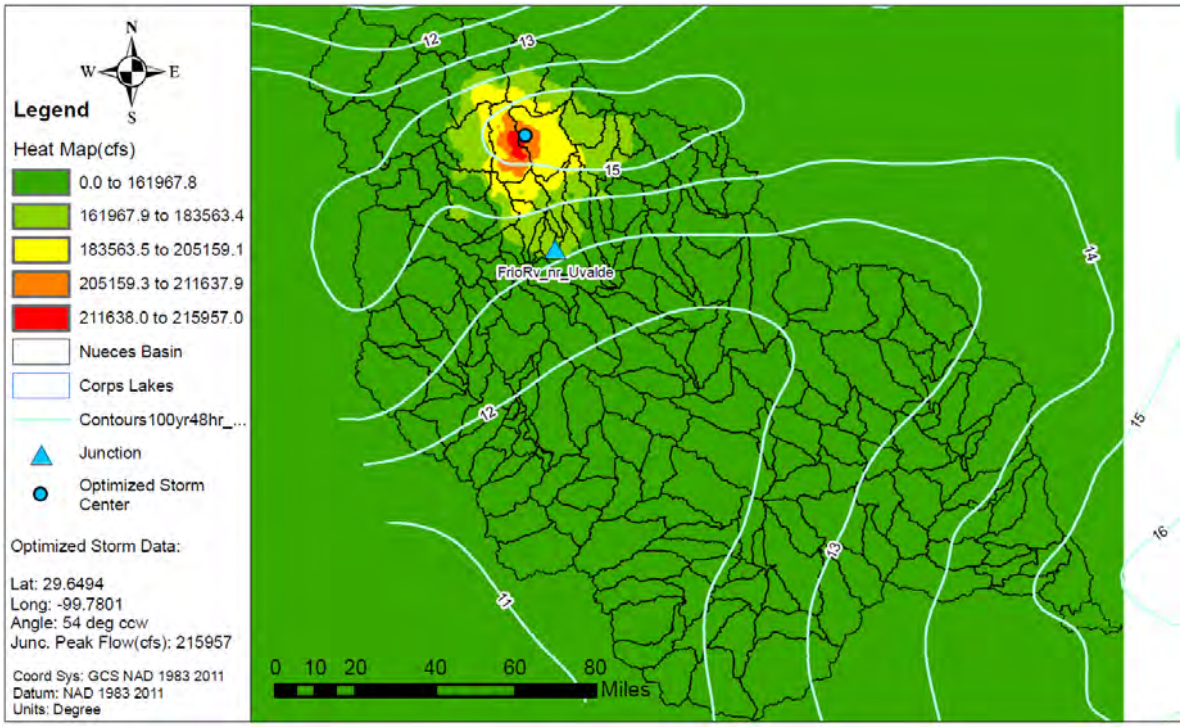

Figure C.11-78a: Elliptical Storm Optimization Heat Map for FrioRv_nr_Uvalde

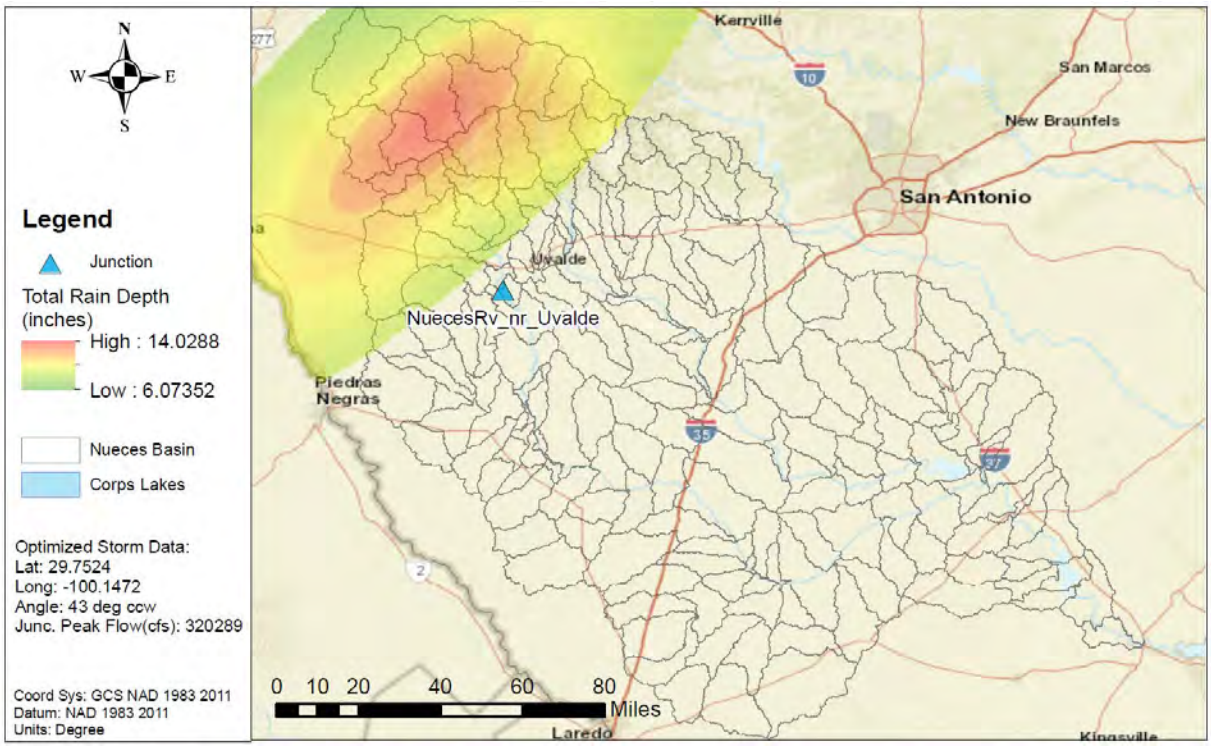

Figure C.11-78b: NA14 1% AEP Elliptical Storm for FrioRv_nr_Uvalde

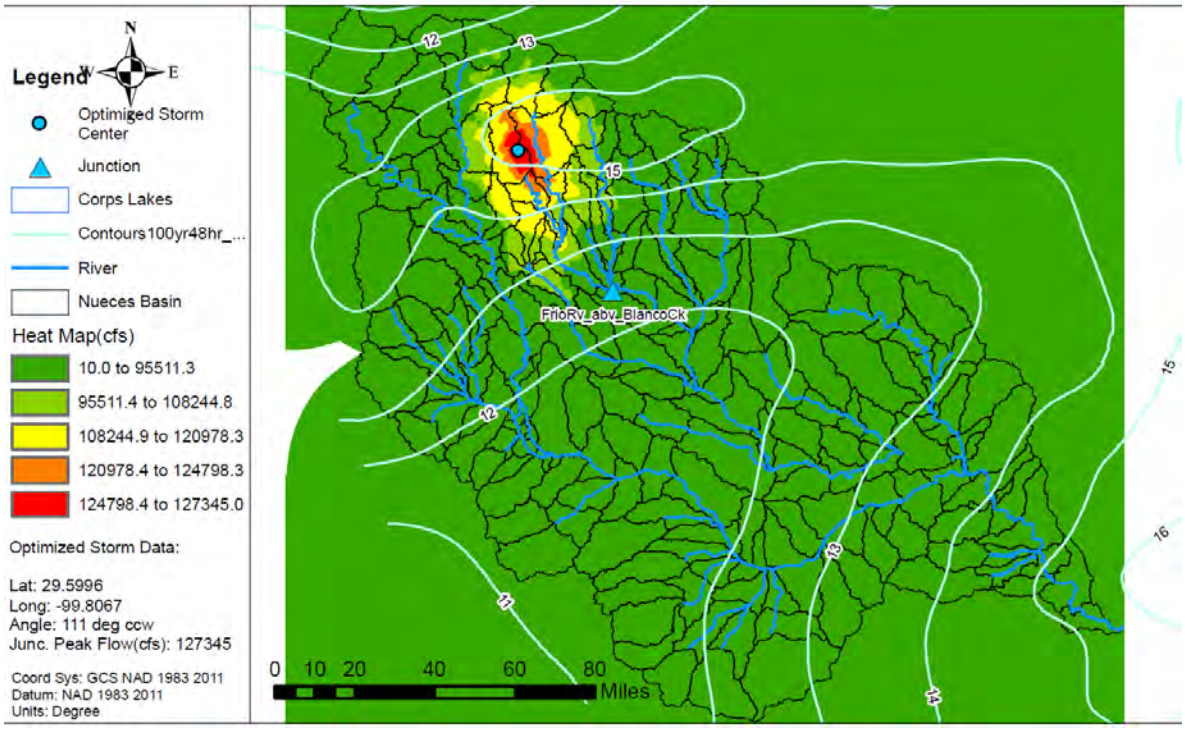

Figure C.11-79a: Elliptical Storm Optimization Heat Map for FrioRv_abv_BlancoCk

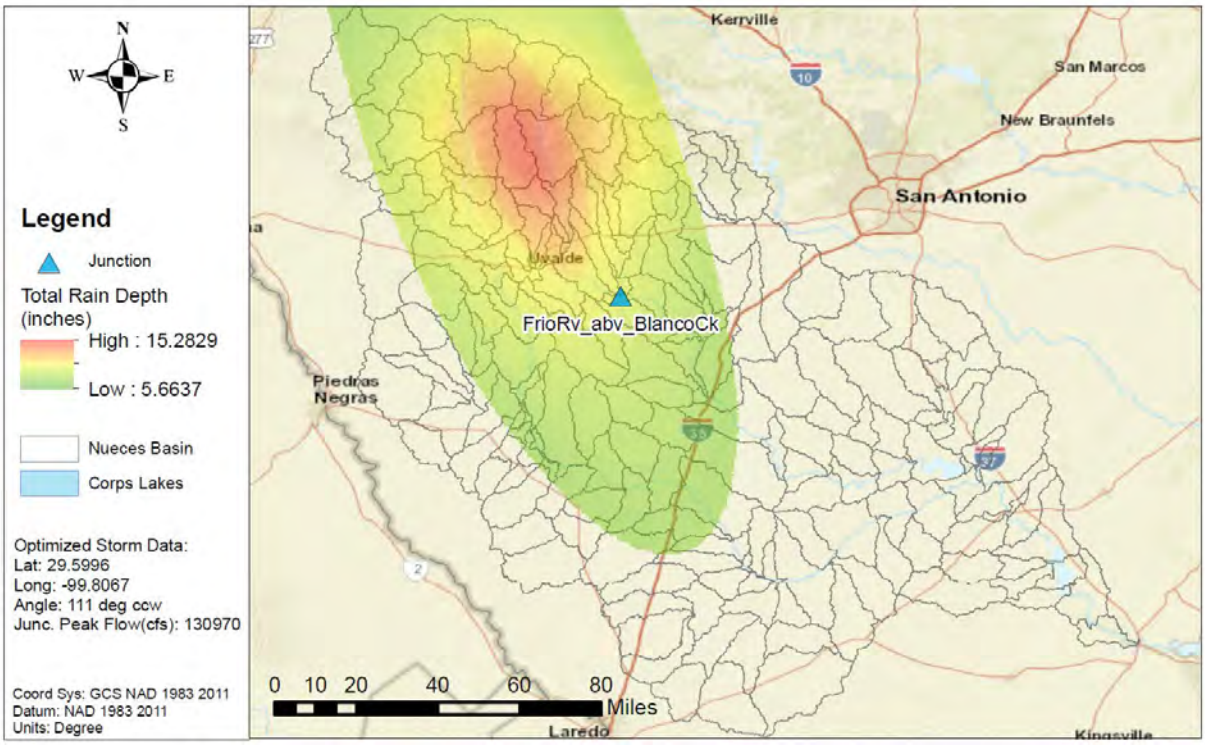

Figure C.11-79b: NA14 1% AEP Elliptical Storm for FrioRv_abv_BlancoCk

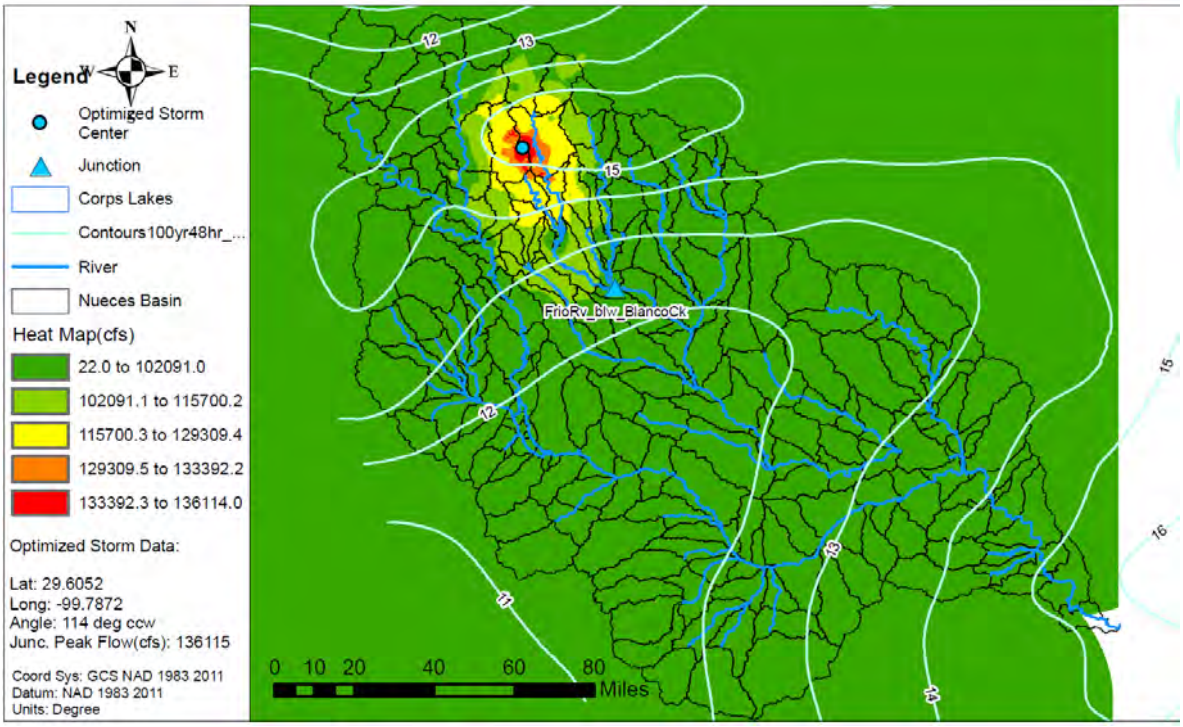

Figure C.11-80a: Elliptical Storm Optimization Heat Map for FrioRv_blw_BlancoCk

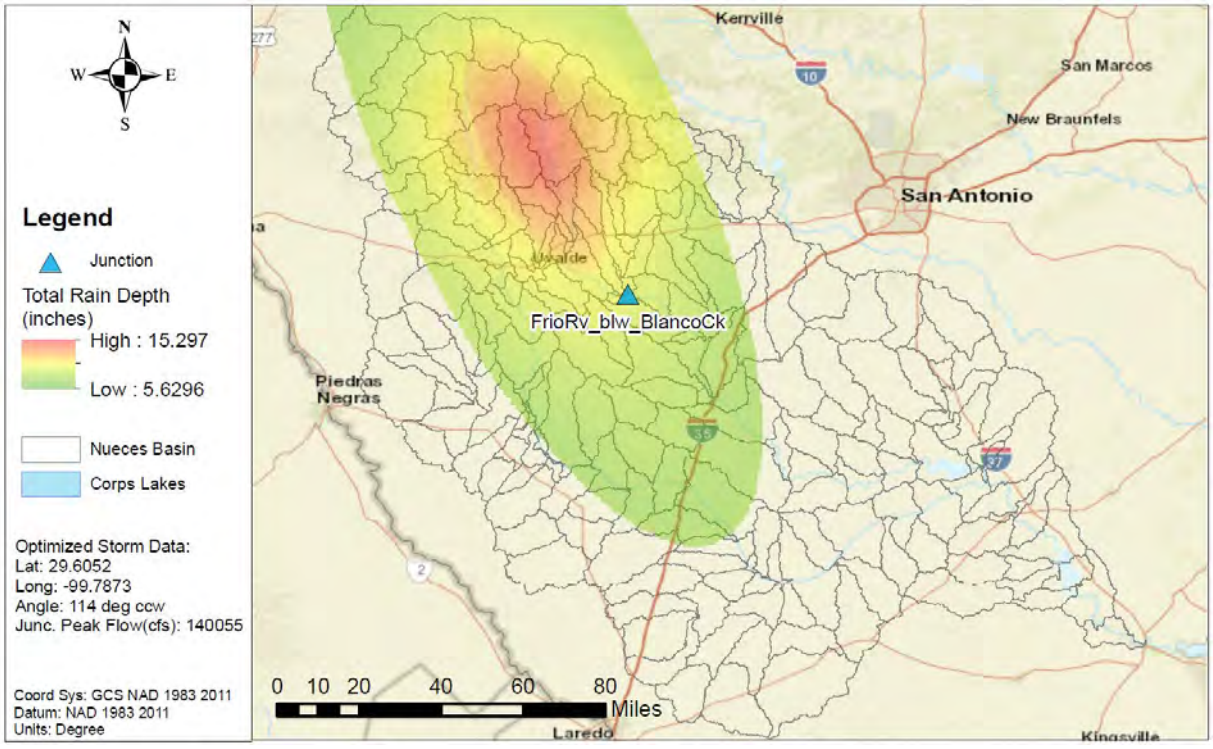

Figure C.11-80b: NA14 1% AEP Elliptical Storm for FrioRv_blw_BlancoCk

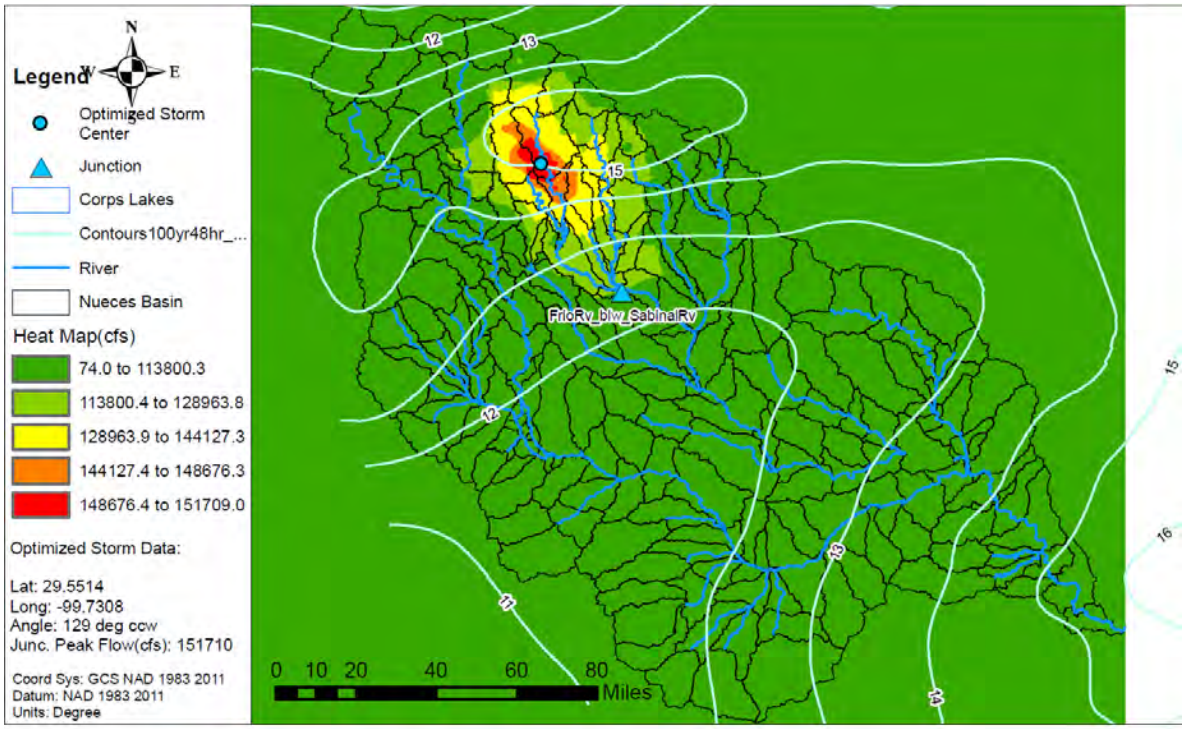

Figure C.11-81a: Elliptical Storm Optimization Heat Map for FrioRv_blw_SabinalRv

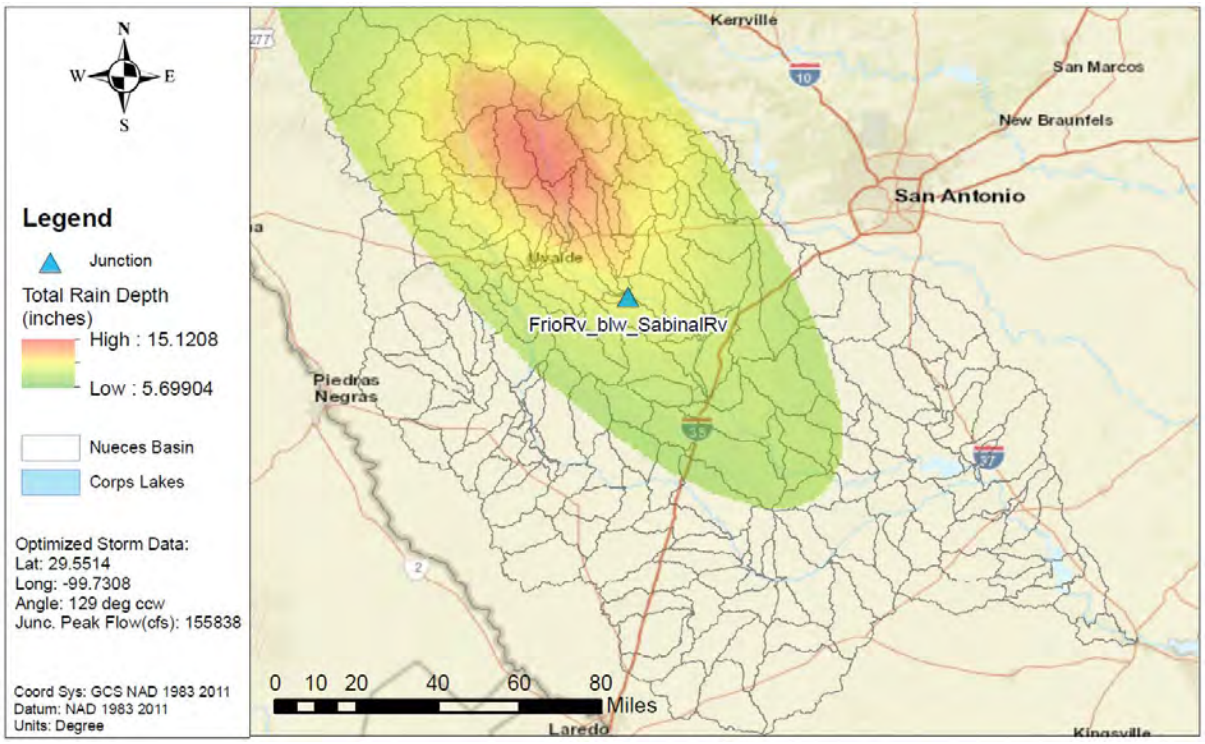

Figure C.11-81b: NA14 1% AEP Elliptical Storm for FrioRv_blw_SabinalRv

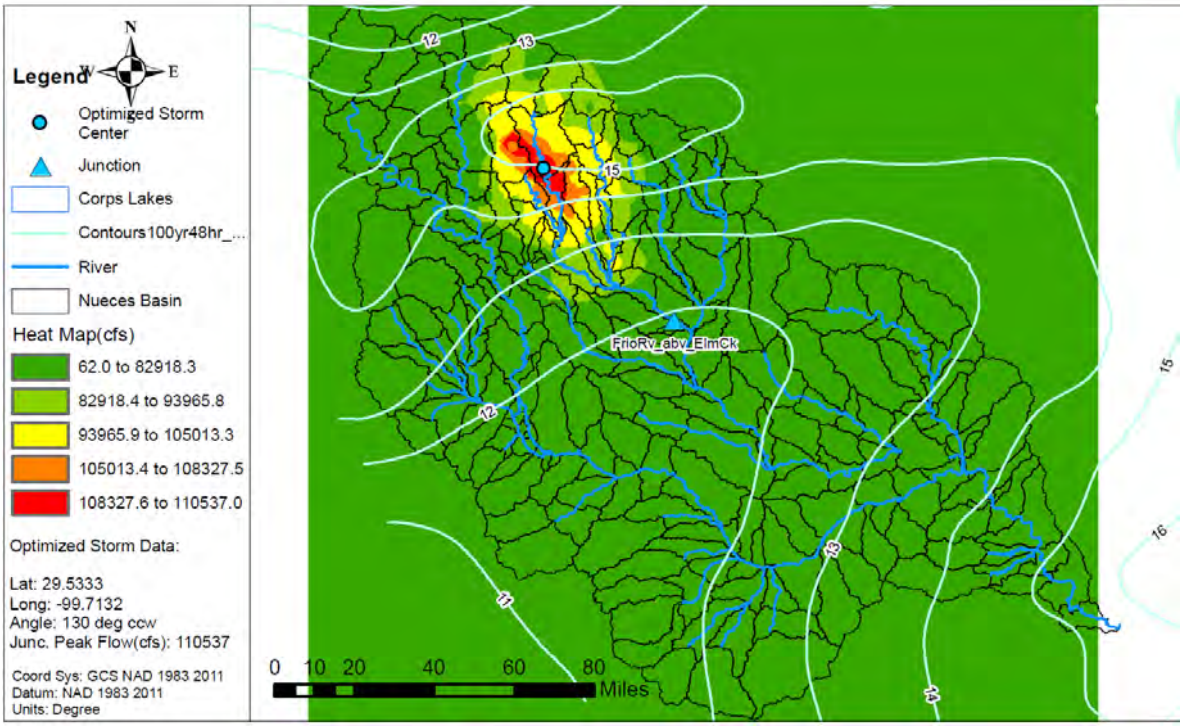

Figure C.11-82a: Elliptical Storm Optimization Heat Map for FrioRv_abv_ElmCk

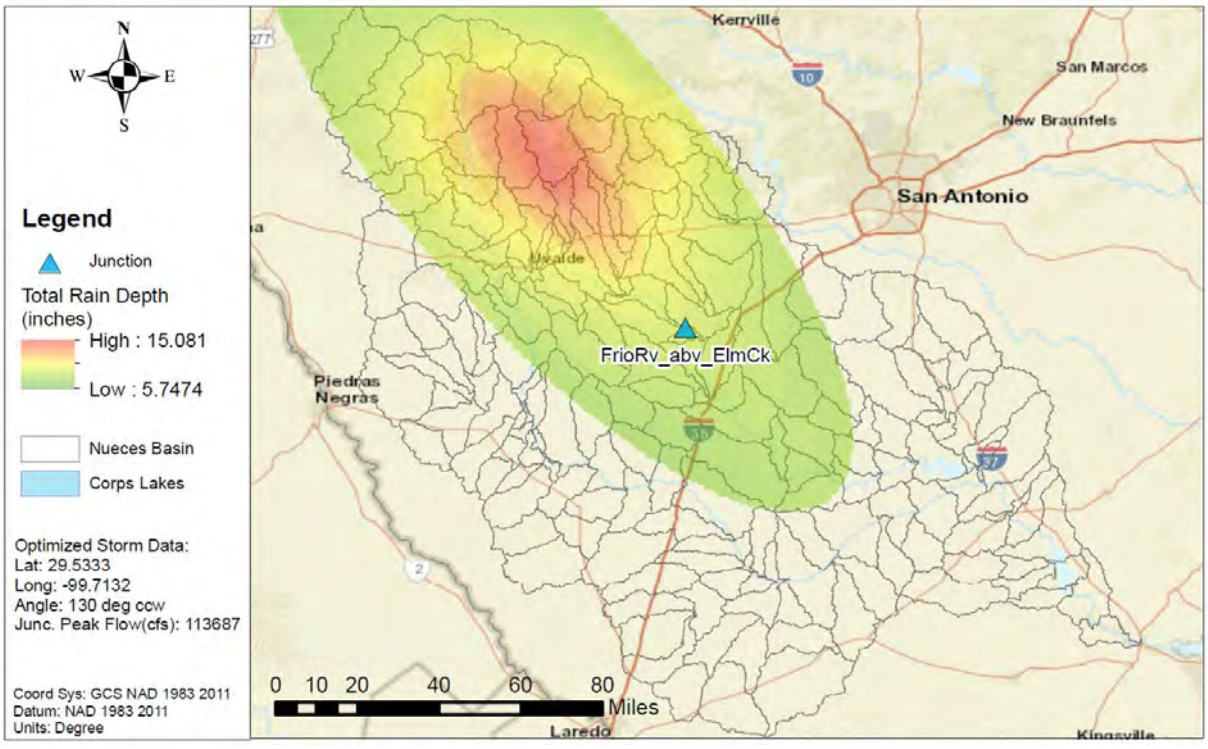

Figure C.11-82b: NA14 1% AEP Elliptical Storm for FrioRv_abv_ElmCk

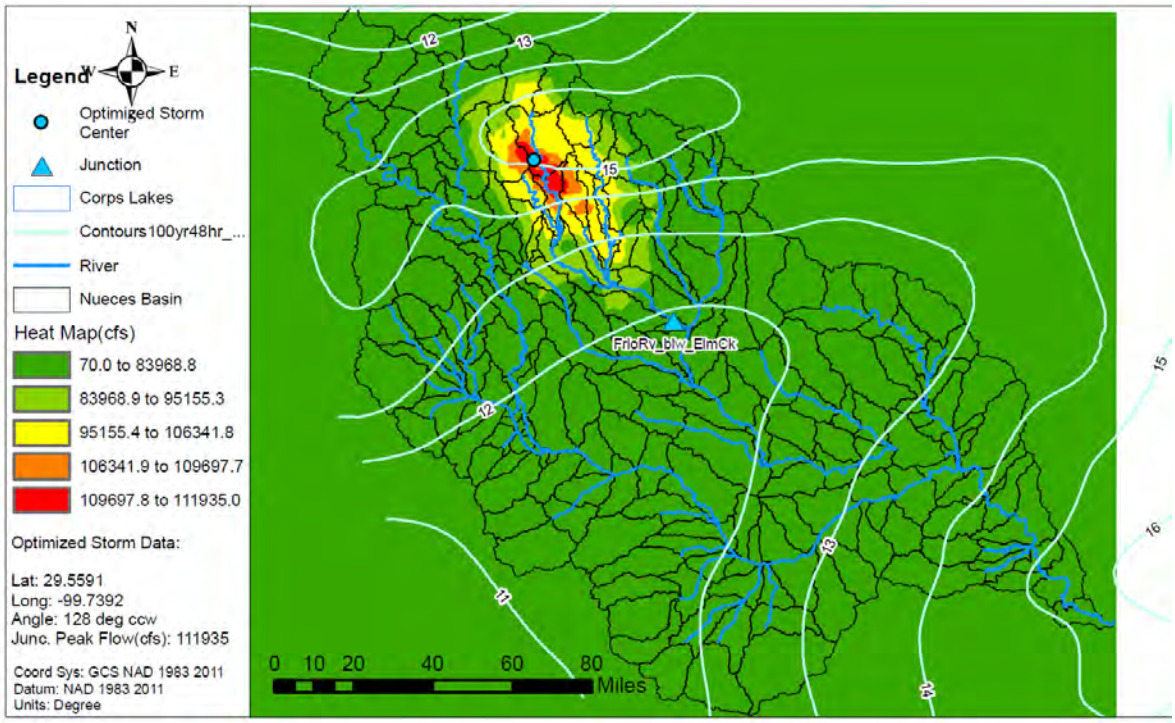

Figure C.11-83a: Elliptical Storm Optimization Heat Map for FrioRv_blw_ElmCk

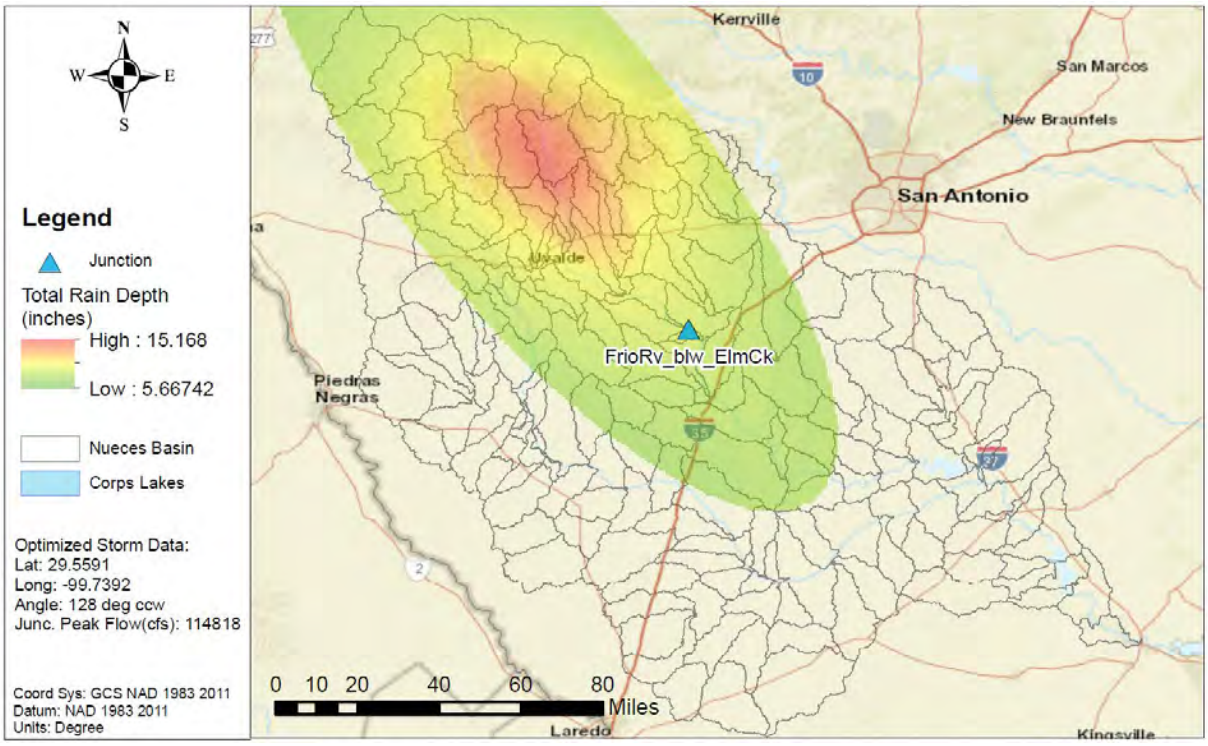

Figure C.11-83b: NA14 1% AEP Elliptical Storm for FrioRv_blw_ElmCk

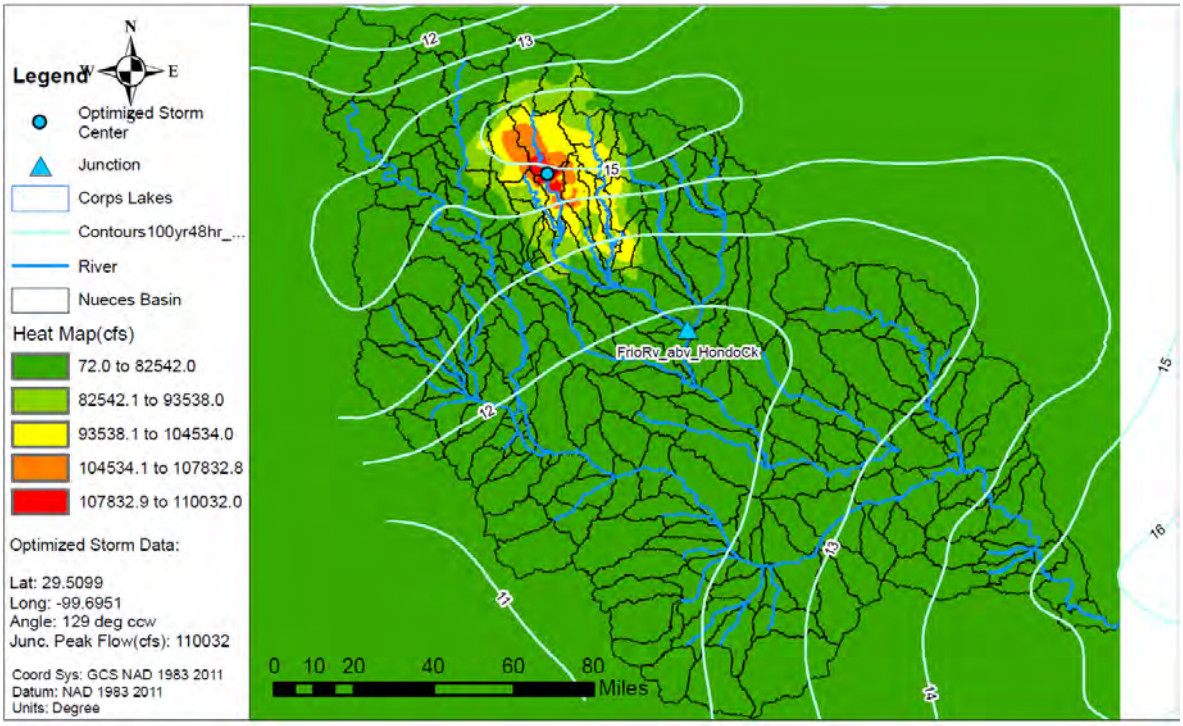

Figure C.11-84a: Elliptical Storm Optimization Heat Map for FrioRv_abv_HondoCk

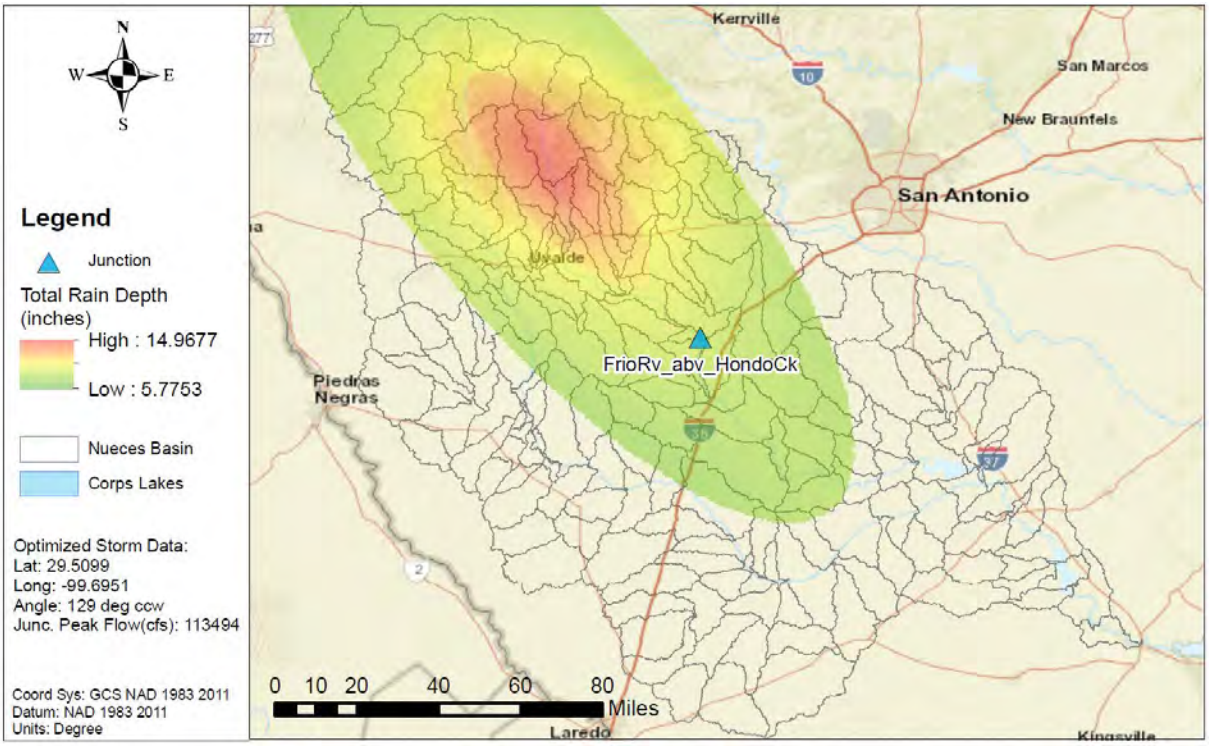

Figure C.11-84b: NA14 1% AEP Elliptical Storm for FrioRv_abv_HondoCk

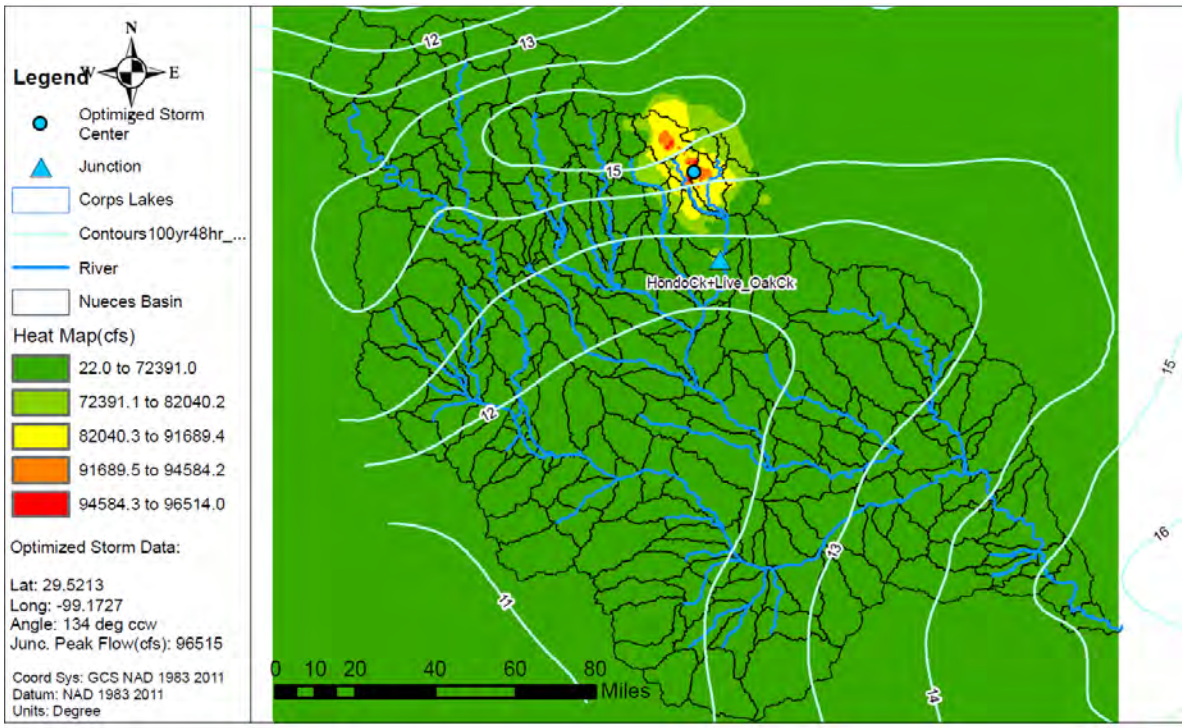

Figure C.11-85a: Elliptical Storm Optimization Heat Map for HondoCk+Live_OakCk

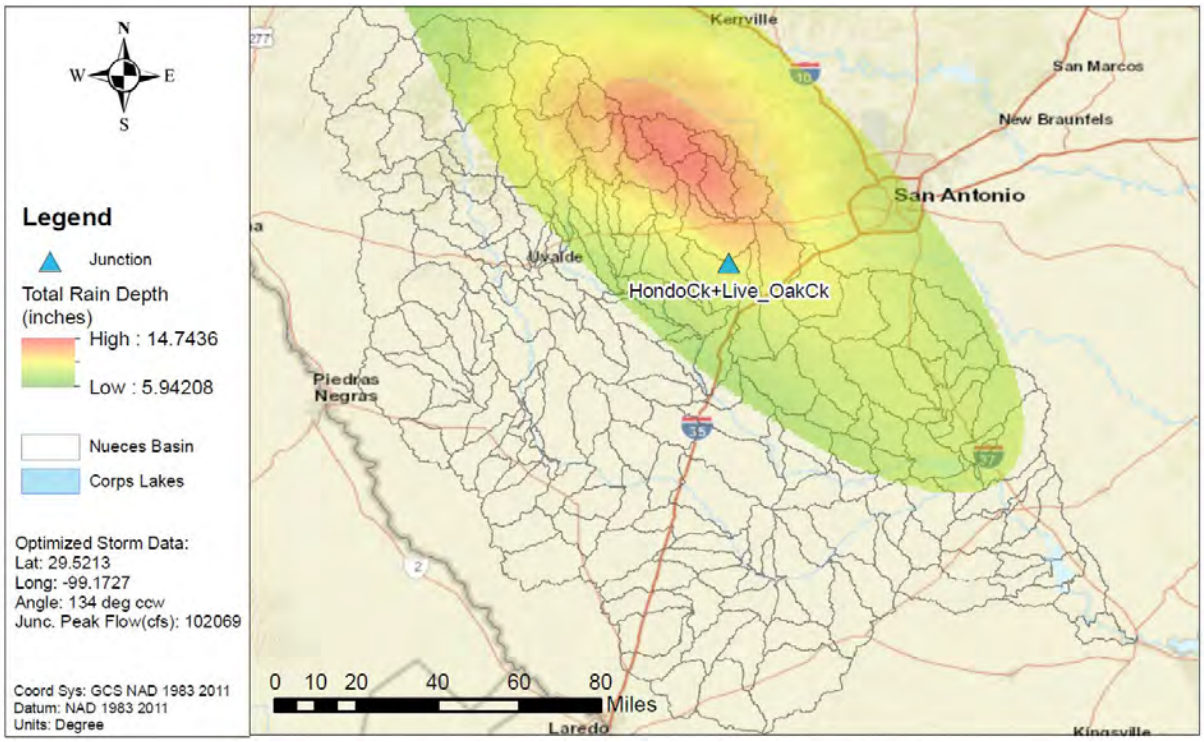

Figure C.11-85b: NA14 1% AEP Elliptical Storm for HondoCk+Live_OakCk

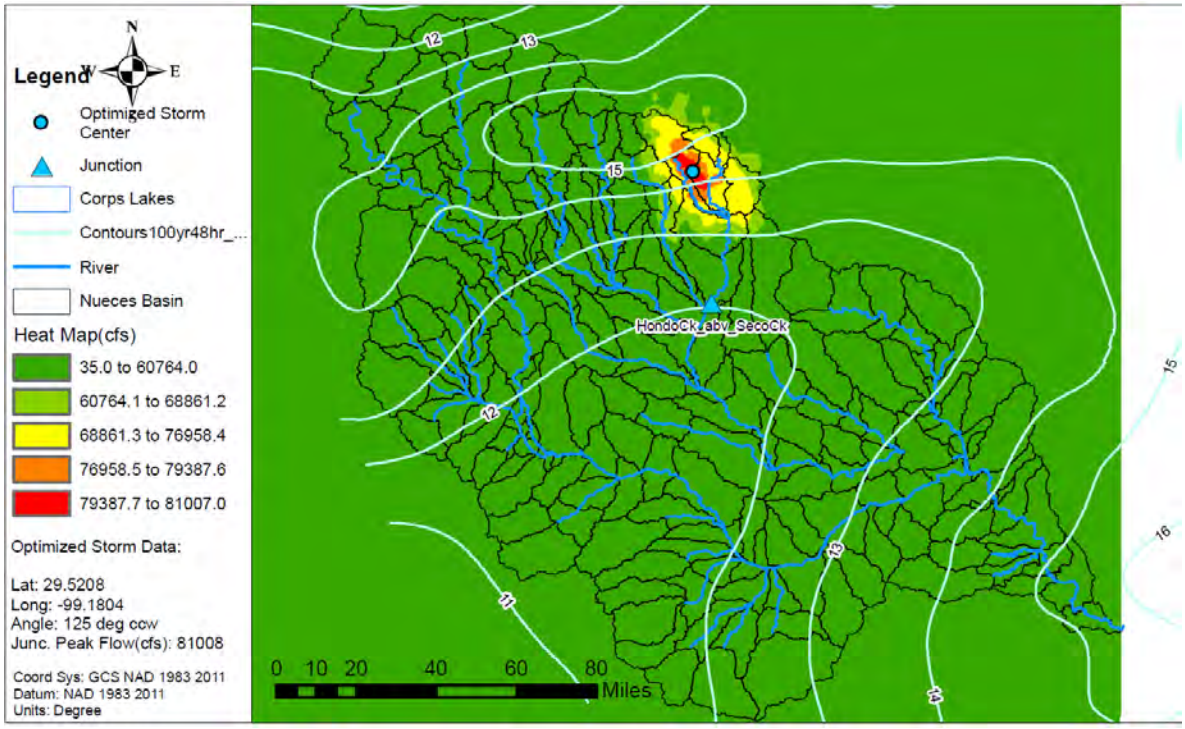

Figure C.11-86a: Elliptical Storm Optimization Heat Map for HondoCk_abv_SecoCk

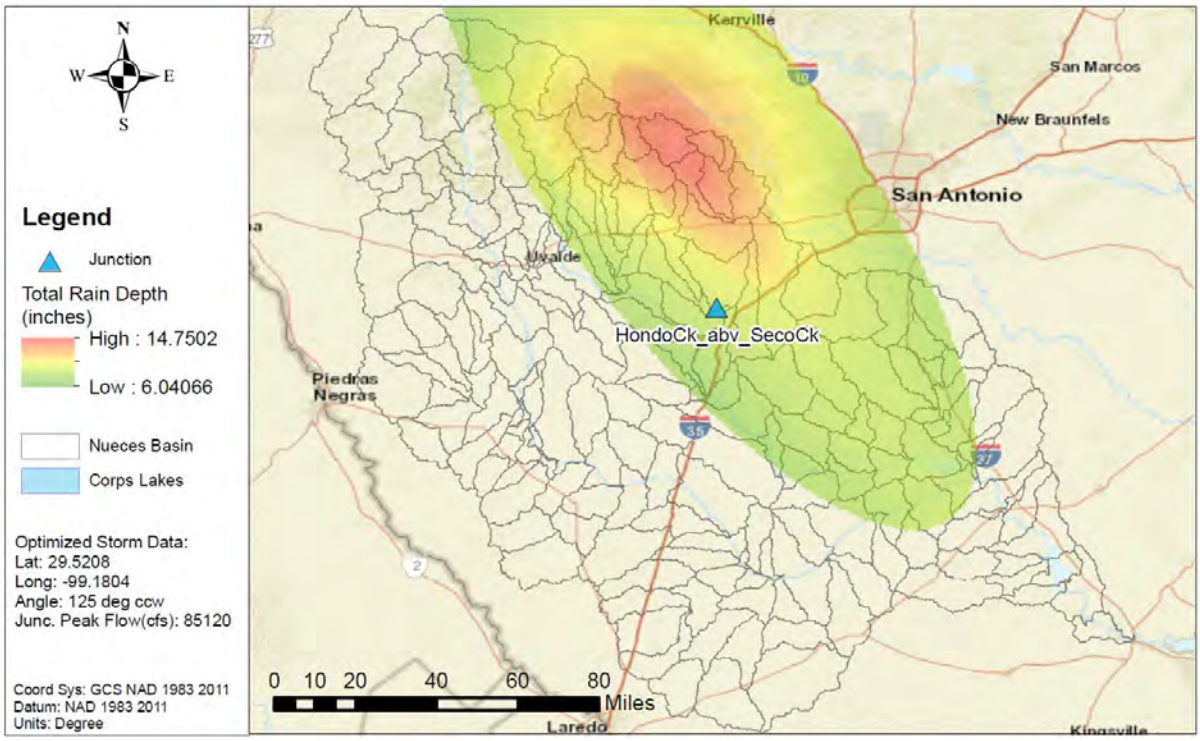

Figure C.11-86b: NA14 1% AEP Elliptical Storm for HondoCk_abv_SecoCk

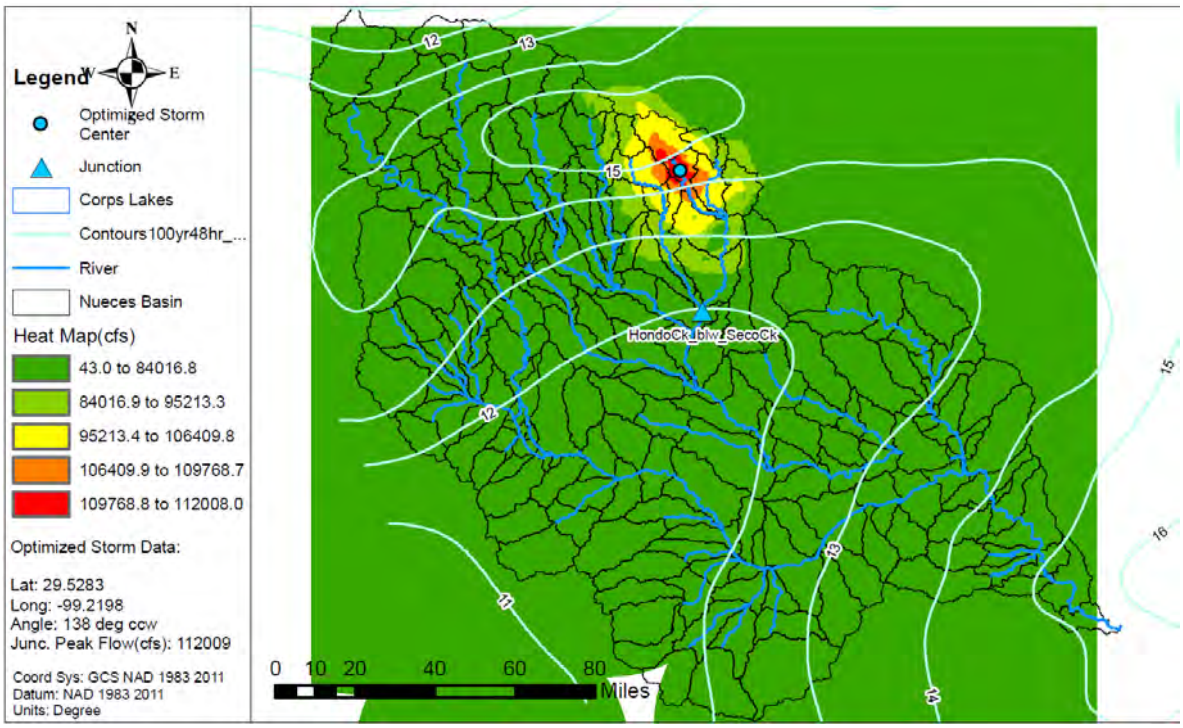

Figure C.11-87a: Elliptical Storm Optimization Heat Map for HondoCk_blw_SecoCk

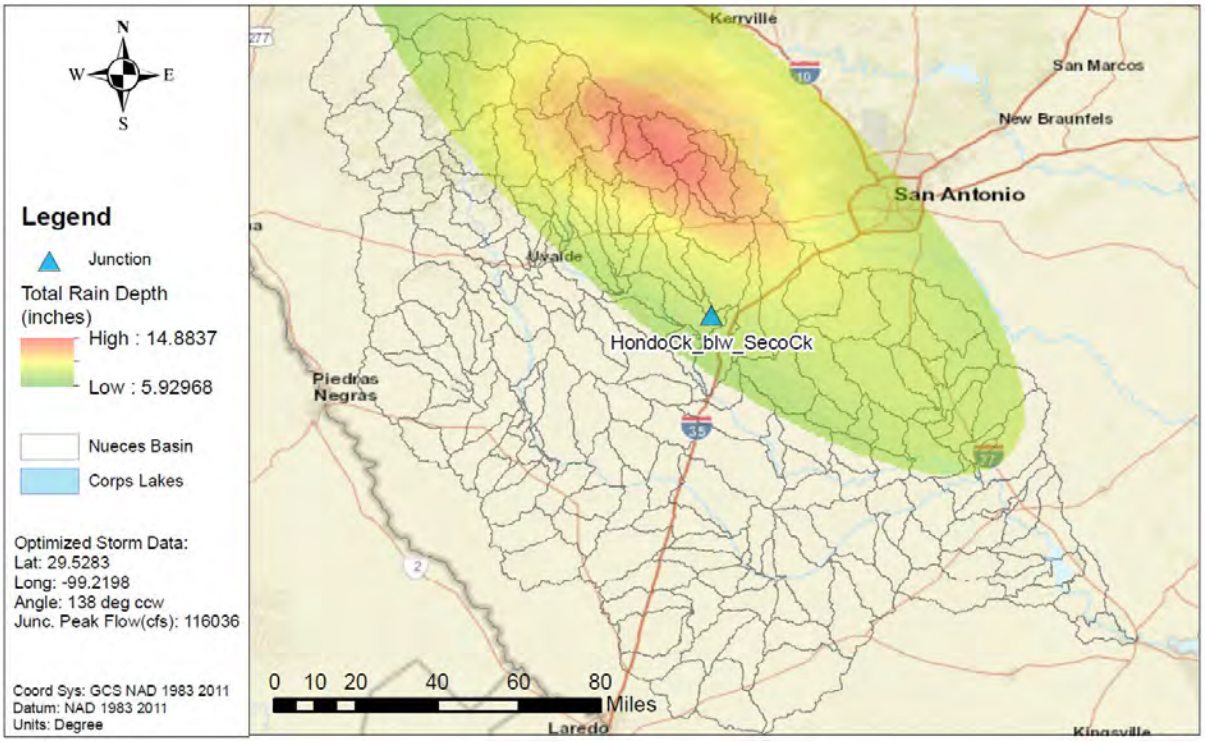

Figure C.11-87b: NA14 1% AEP Elliptical Storm for HondoCk_blw_SecoCk

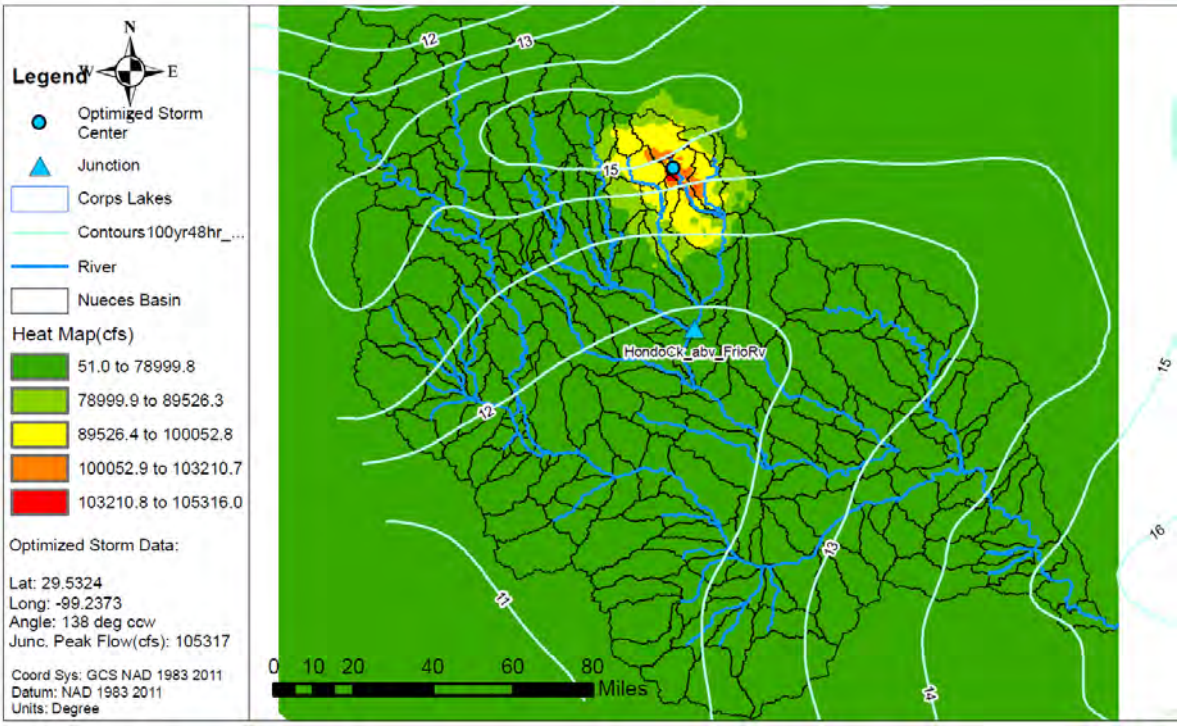

Figure C.11-88a: Elliptical Storm Optimization Heat Map for HondoCk_abv_FrioRv

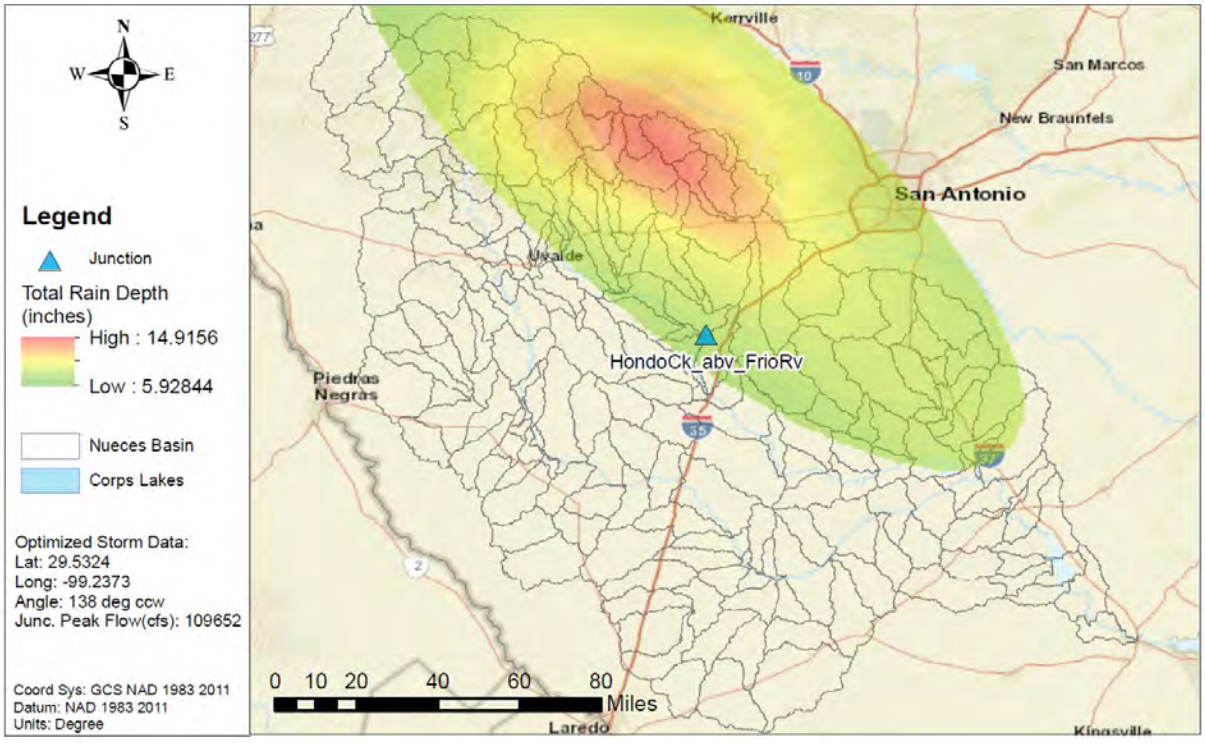

Figure C.11-88b: NA14 1% AEP Elliptical Storm for HondoCk_abv_FrioRv

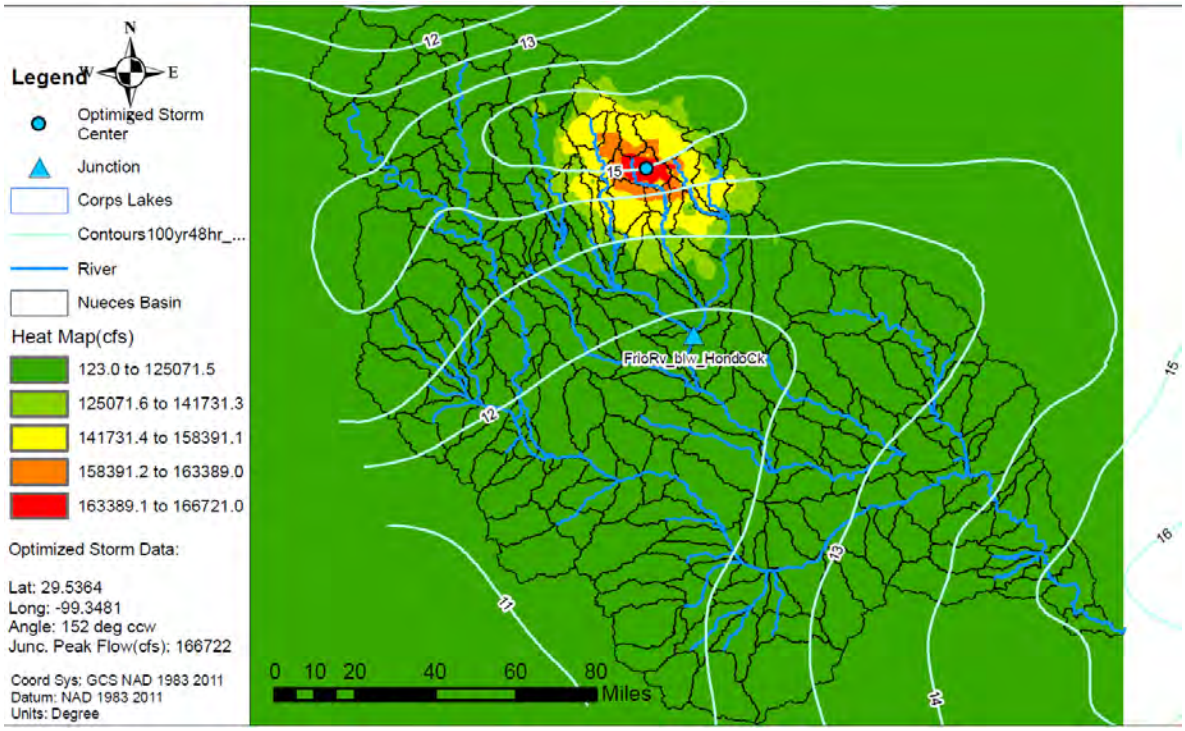

Figure C.11-89a: Elliptical Storm Optimization Heat Map for FrioRv_blw_HondoCk

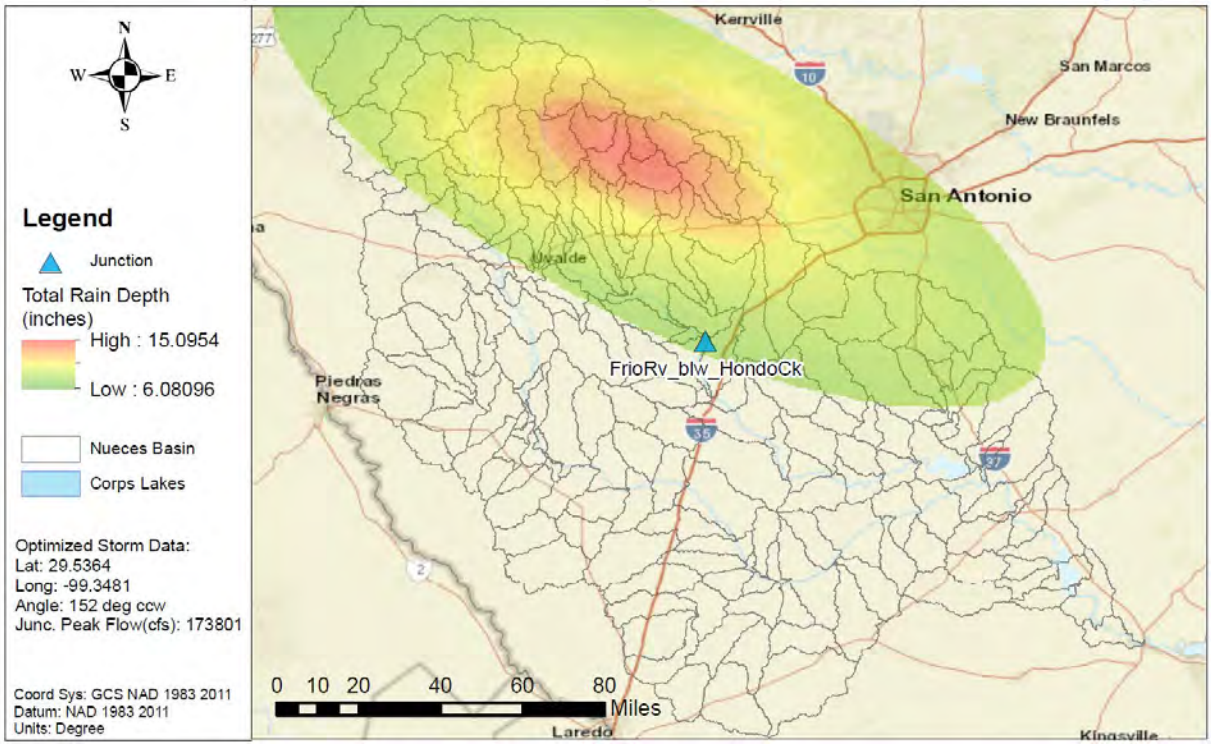

Figure C.11-89b: NA14 1% AEP Elliptical Storm for FrioRv_blw_HondoCk

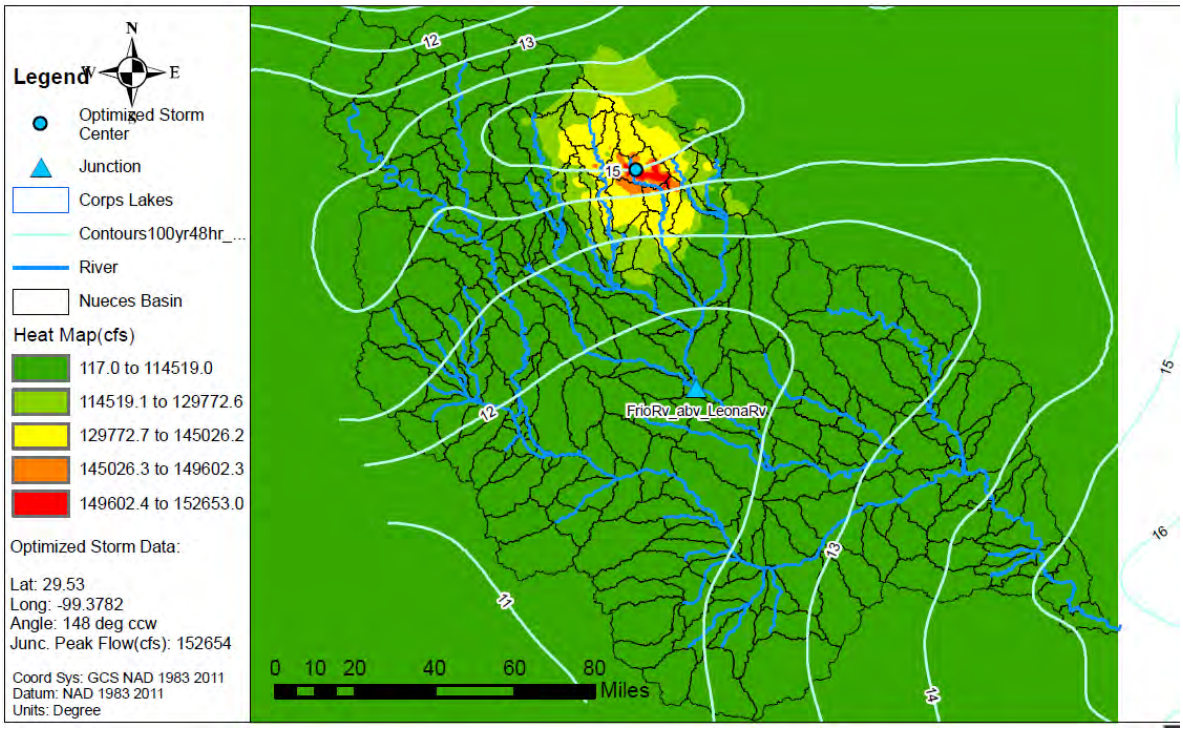

Figure C.11-90a: Elliptical Storm Optimization Heat Map for Frio River above Leona River

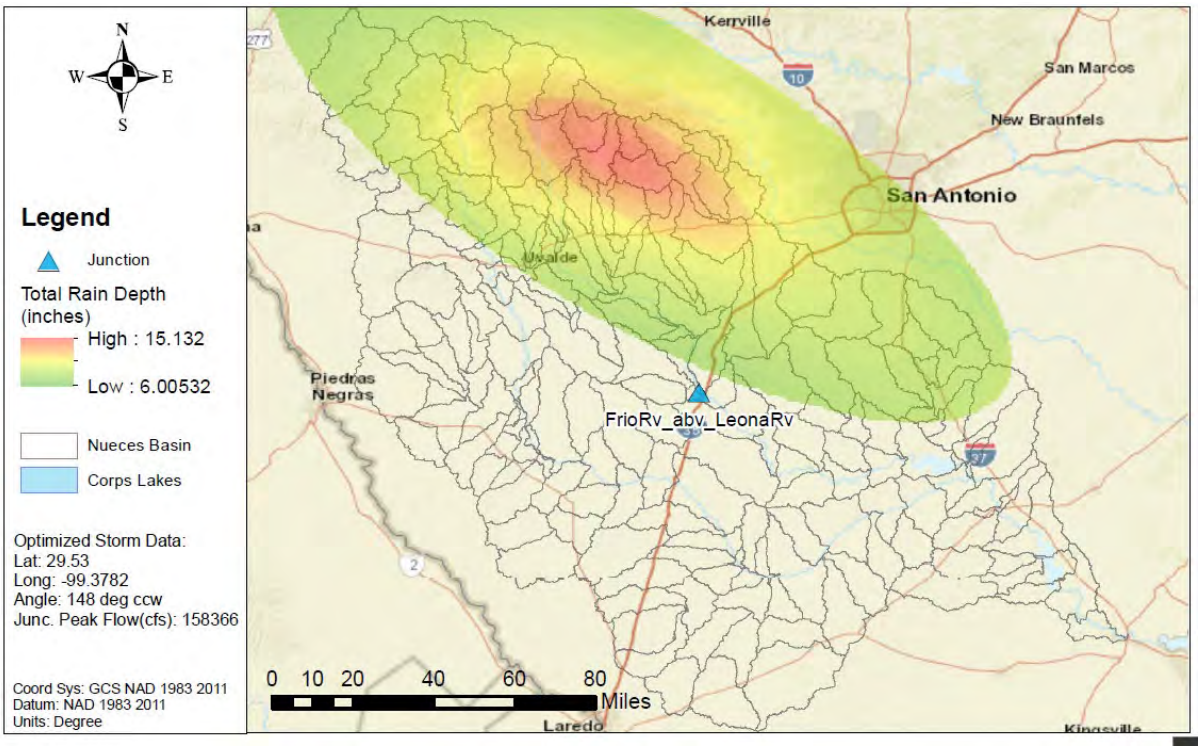

Figure C.11-90b: NA14 1% AEP Elliptical Storm for Frio River above Leona River

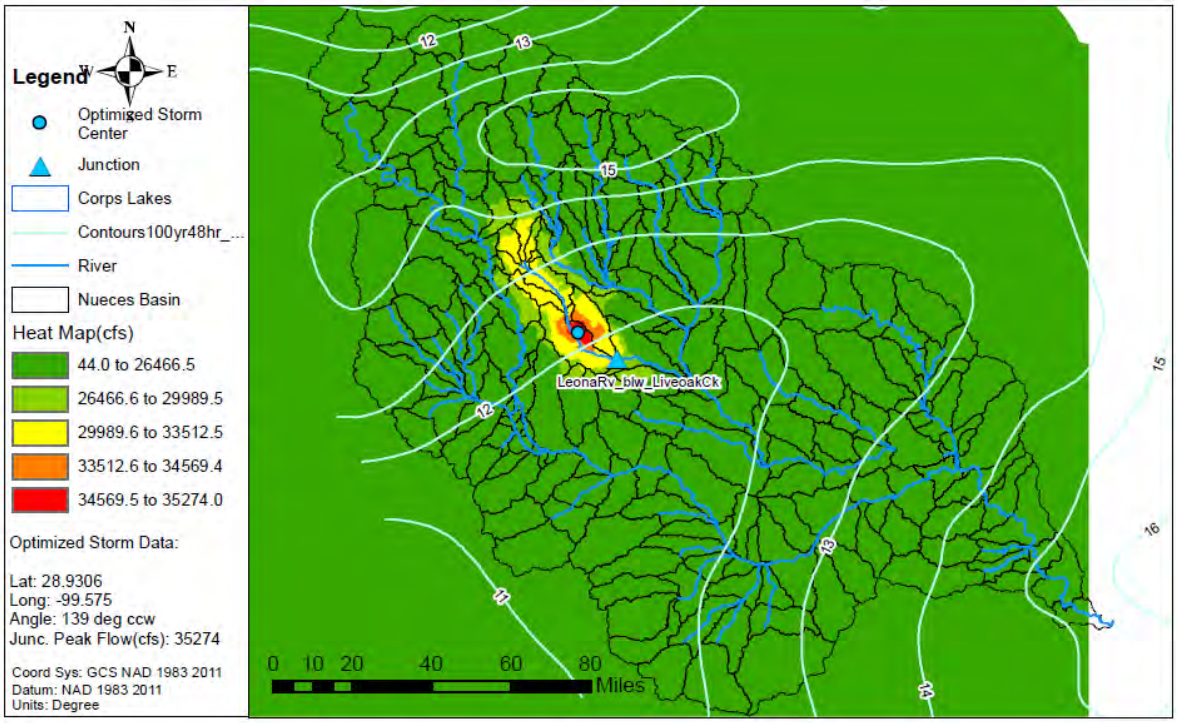

Figure C.11-91a: Elliptical Storm Optimization Heat Map for Leona River below Live Oak Creek

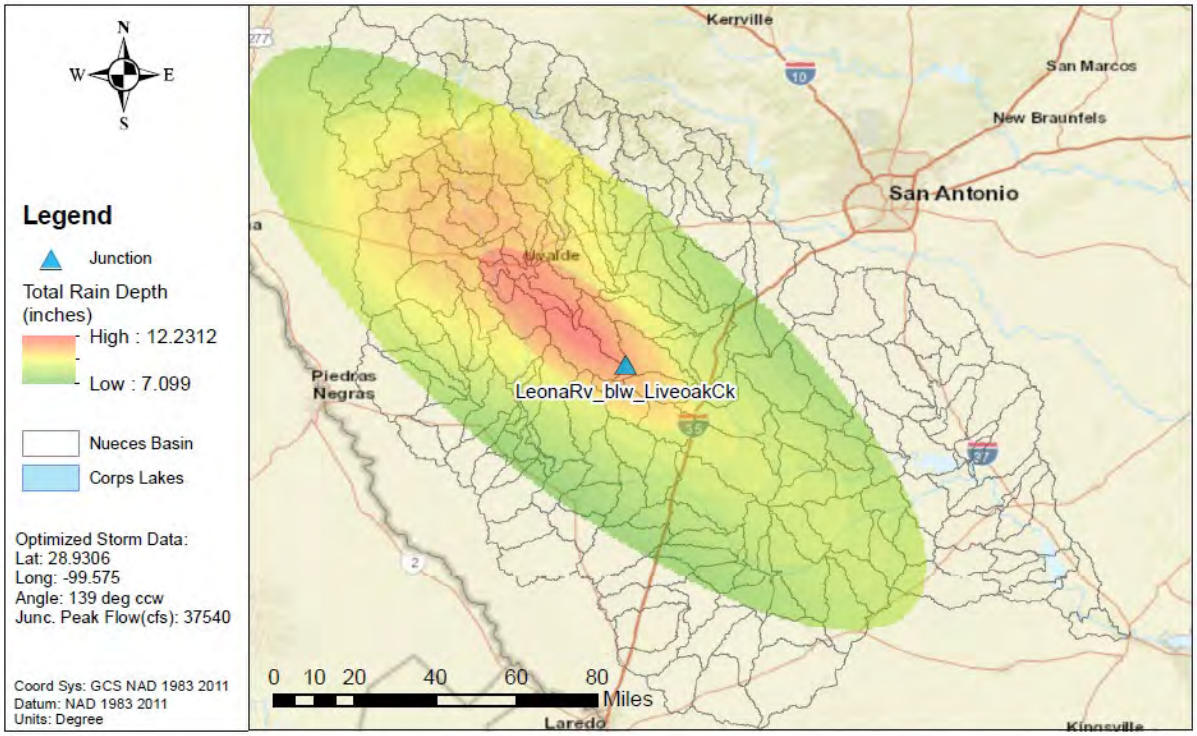

Figure C.11-91b: NA14 1% AEP Elliptical Storm for Leona River below Live Oak Creek

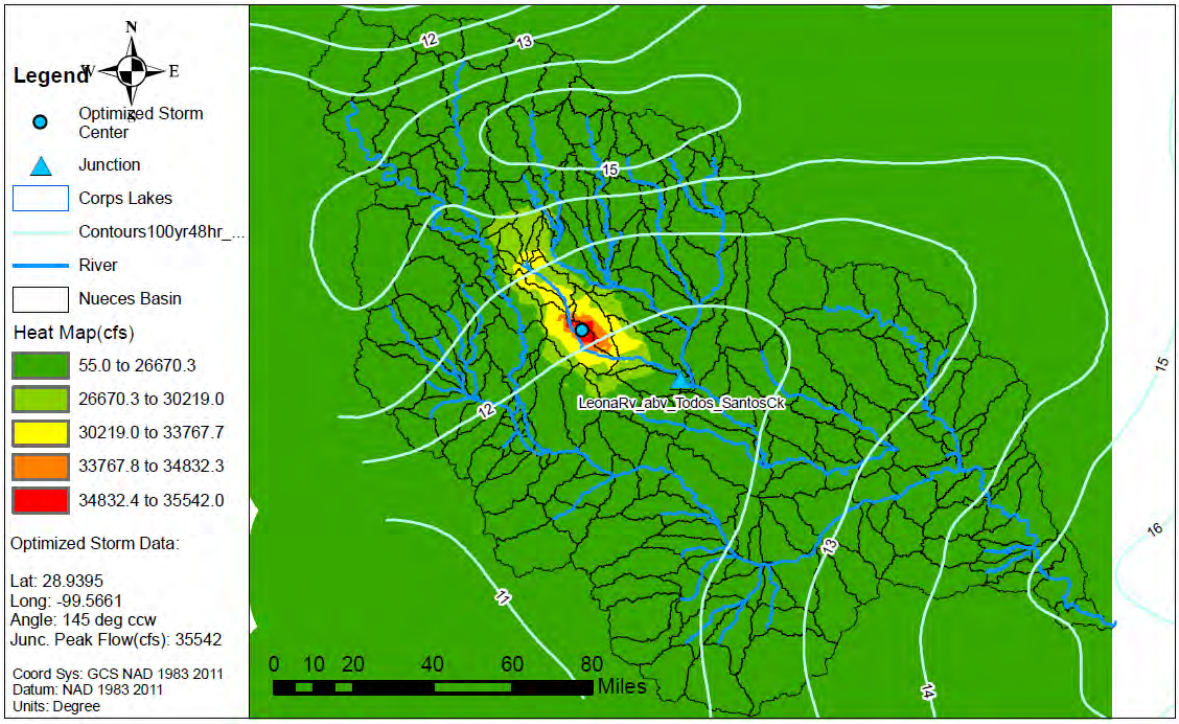

Figure C.11-92a: Elliptical Storm Optimization Heat Map for Leona River above Todos Santos Creek

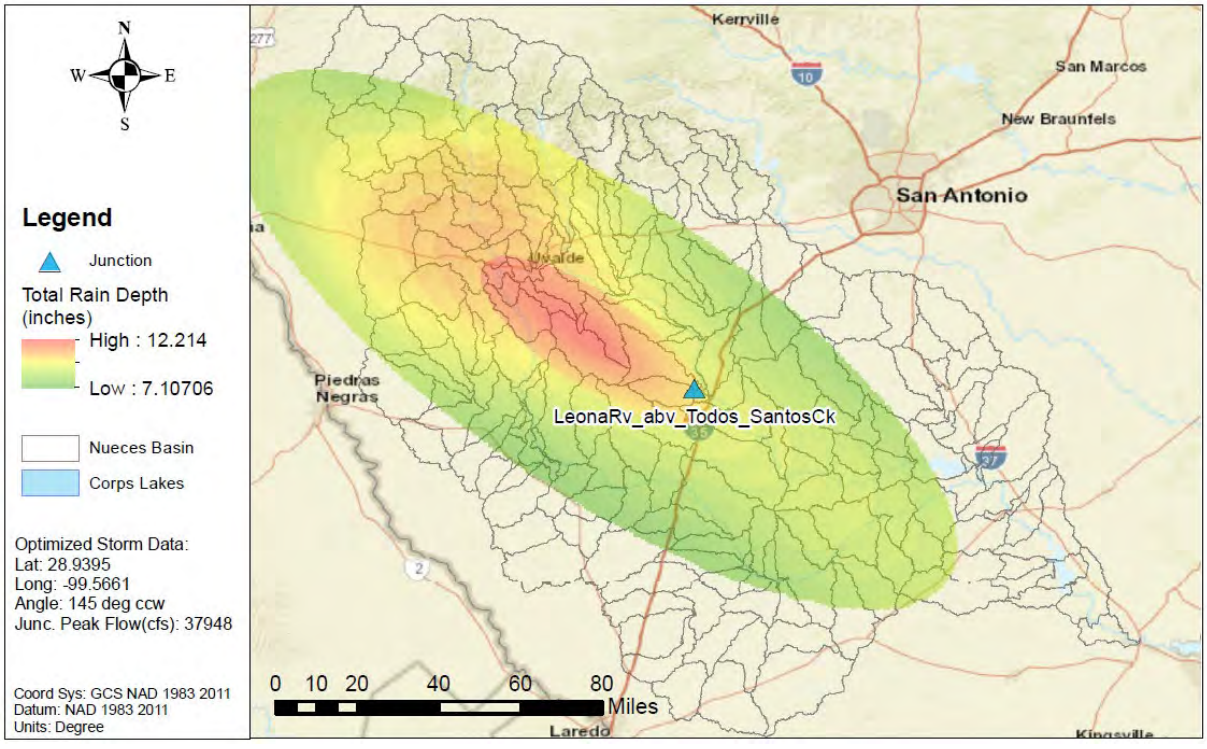

Figure C.11-92b: NA14 1% AEP Elliptical Storm for Leona River above Todos Santos Creek

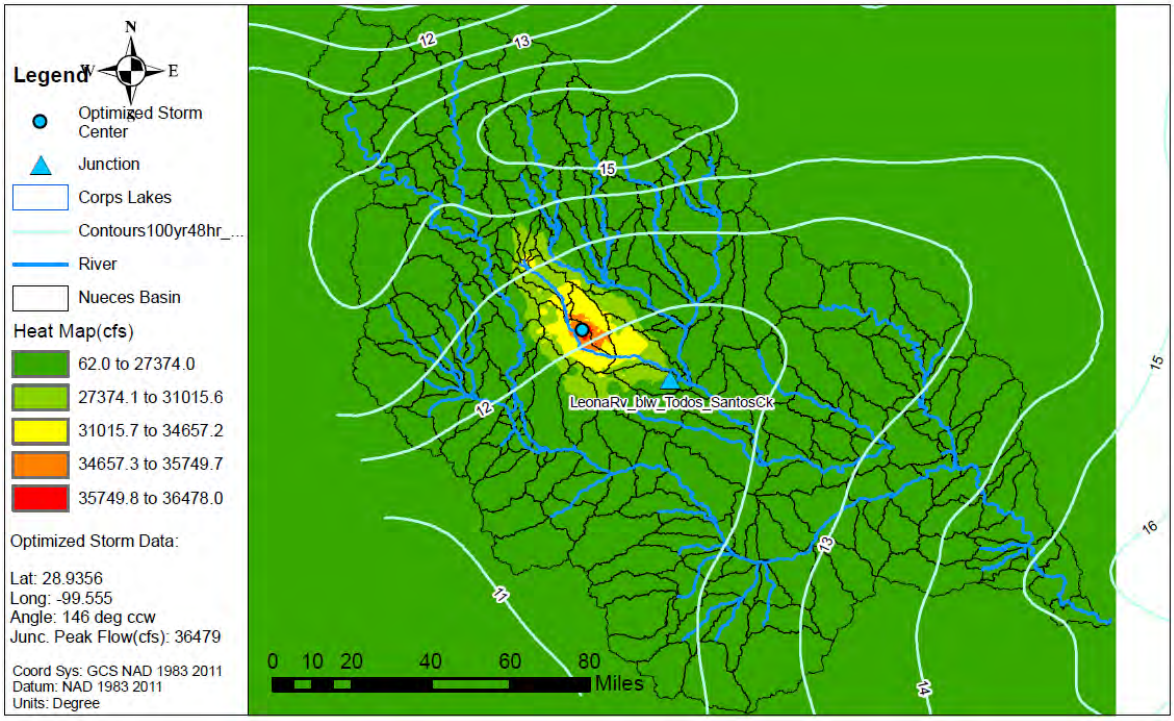

Figure C.11-93a: Elliptical Storm Optimization Heat Map for Leona River below Todos Santos Creek

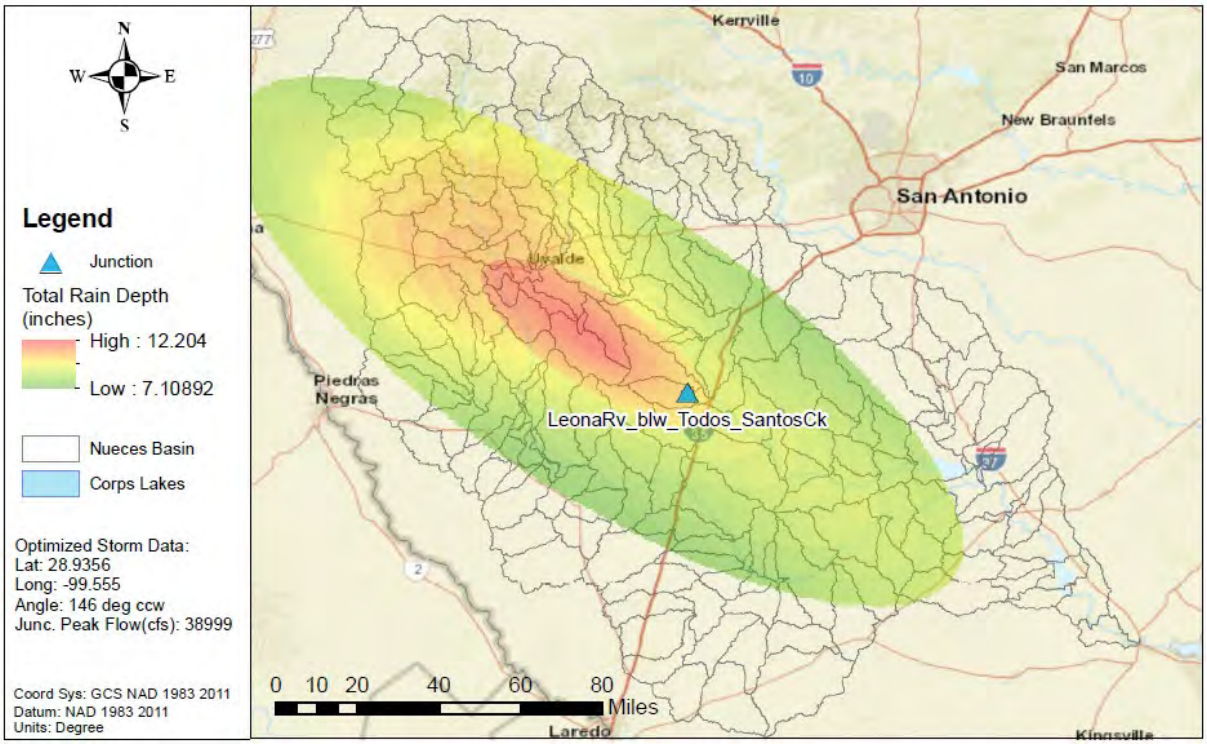

Figure C.11-93b: NA14 1% AEP Elliptical Storm for Leona River below Todos Santos Creek

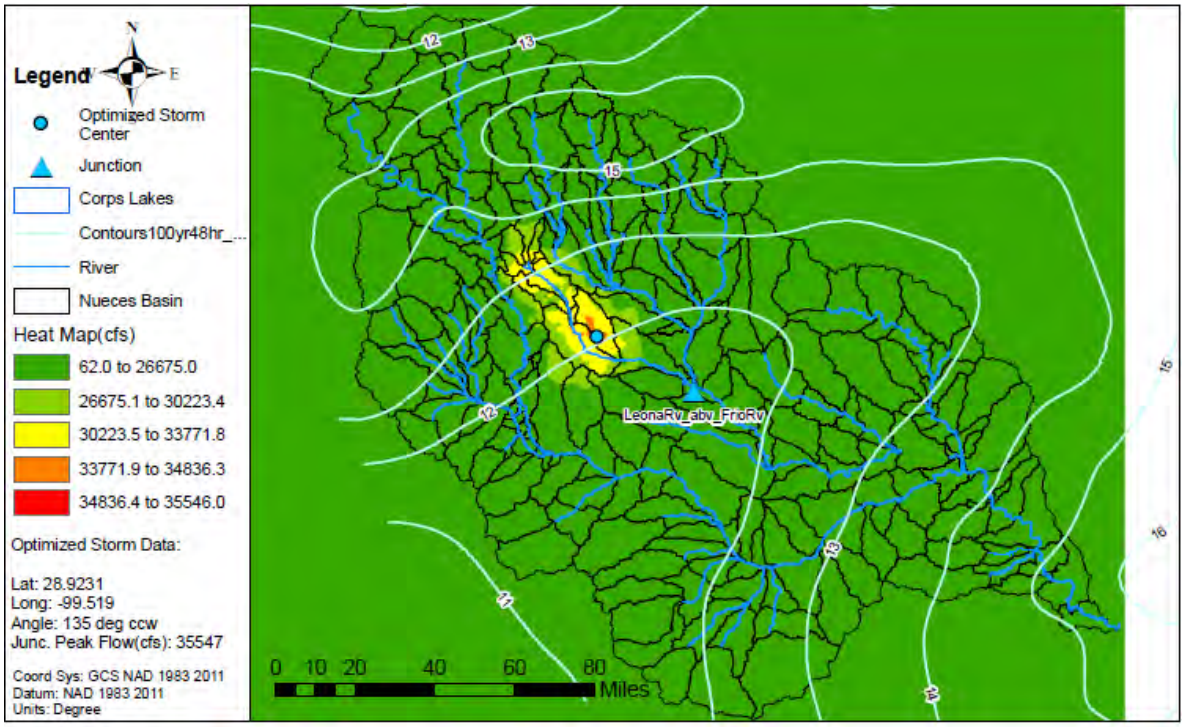

Figure C.11-94a: Elliptical Storm Optimization Heat Map for Leona River above Frio River

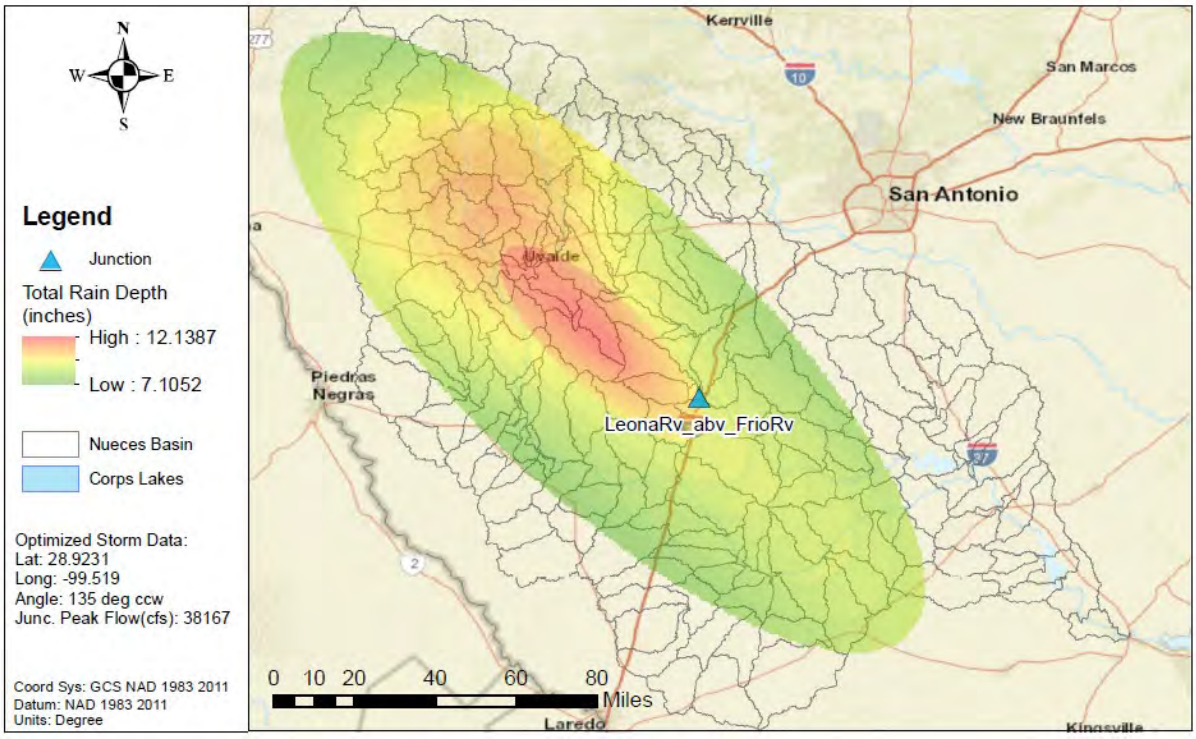

Figure C.11-94b: NA14 1% AEP Elliptical Storm for Leona River above Frio River

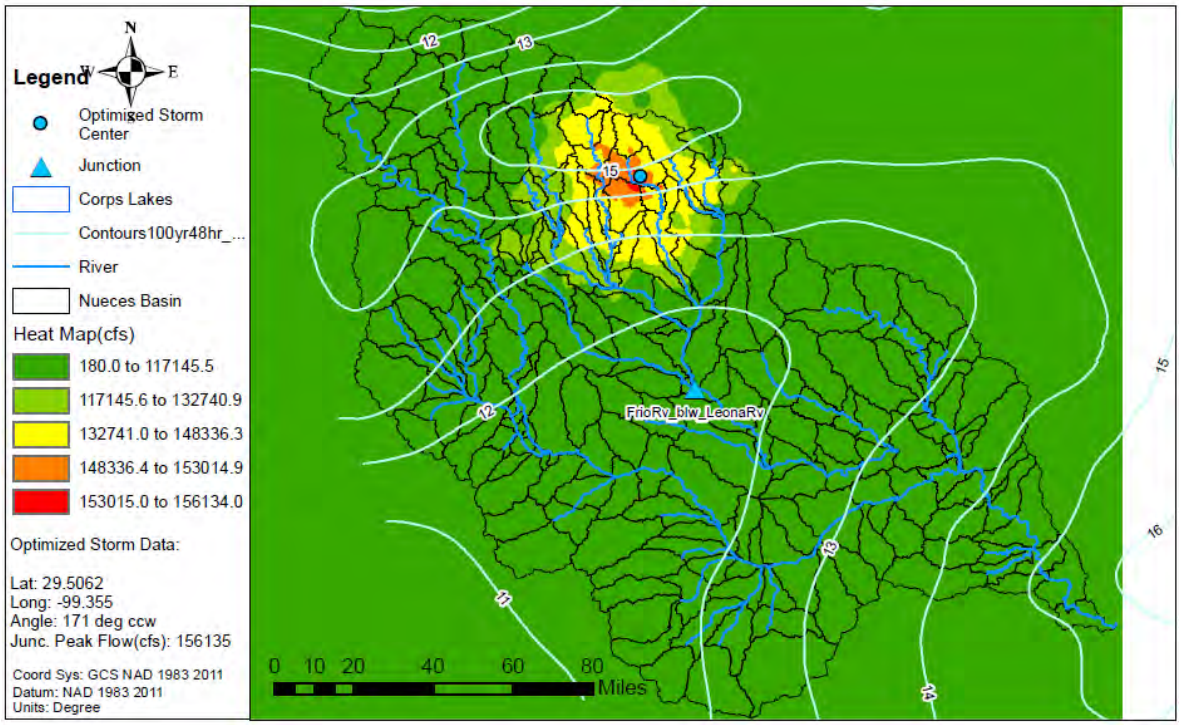

Figure C.11-95a: Elliptical Storm Optimization Heat Map for Frio River below Leona River

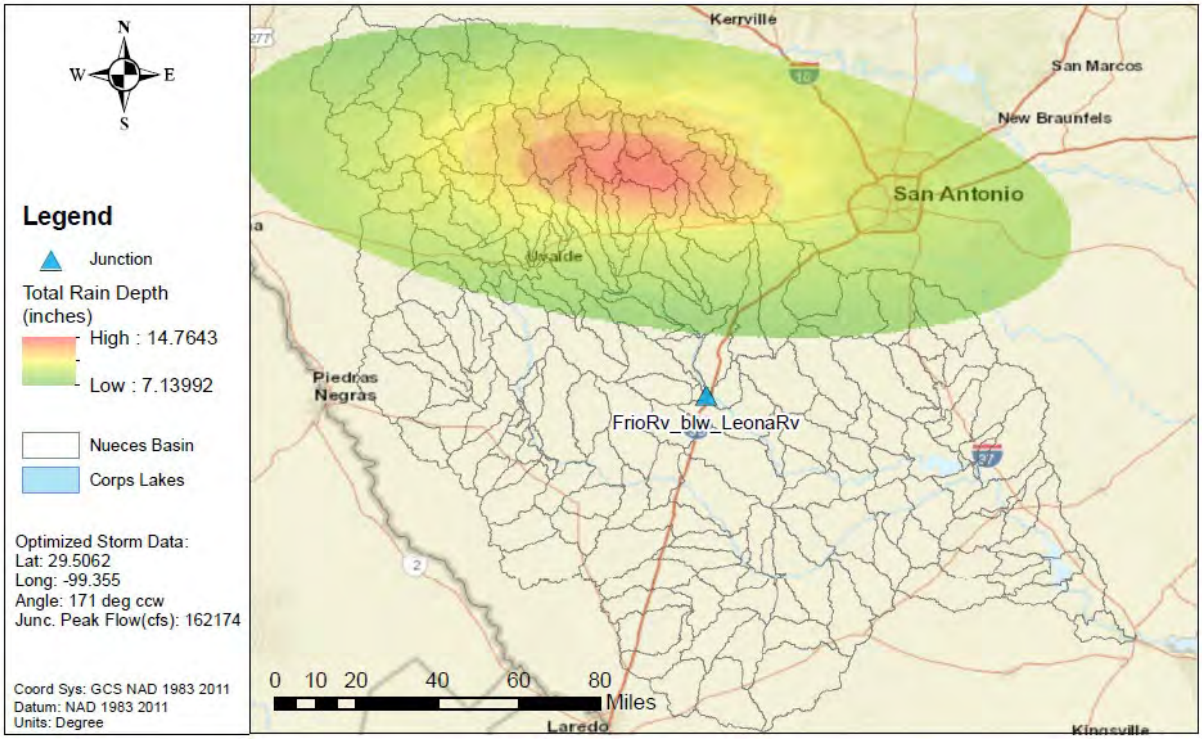

Figure C.11-95b: NA14 1% AEP Elliptical Storm for Frio River below Leona River

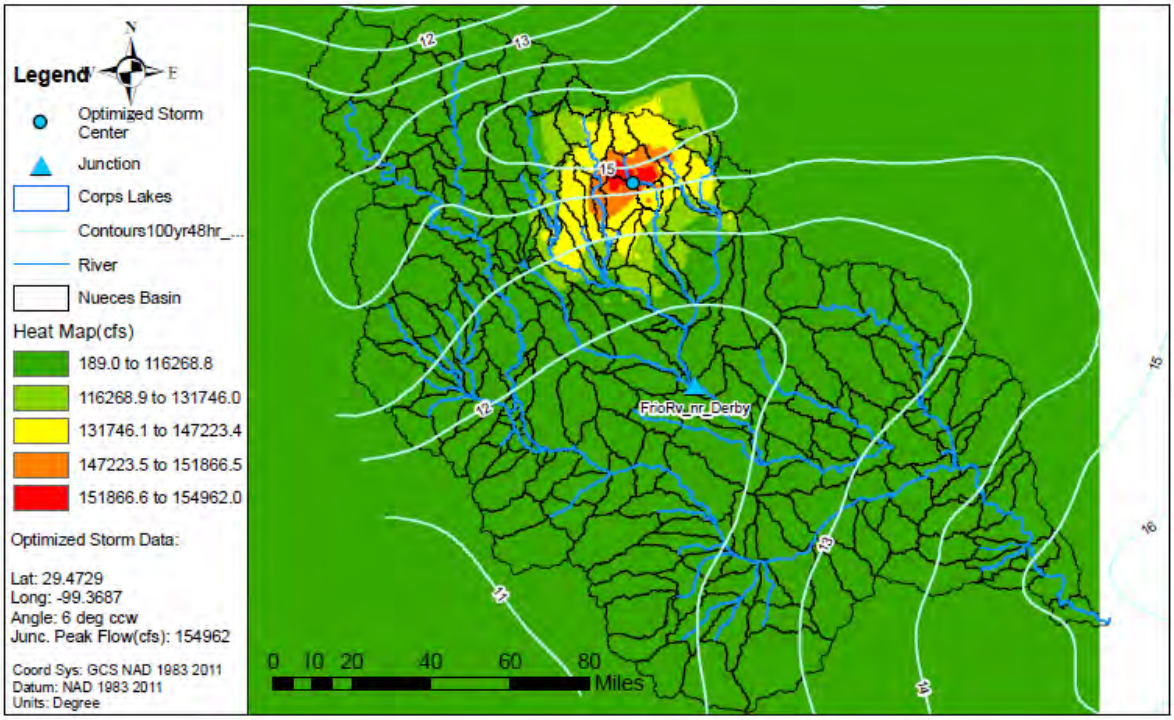

Figure C.11-96a: Elliptical Storm Optimization Heat Map for Frio River near Derby (USGS gage 08215500)

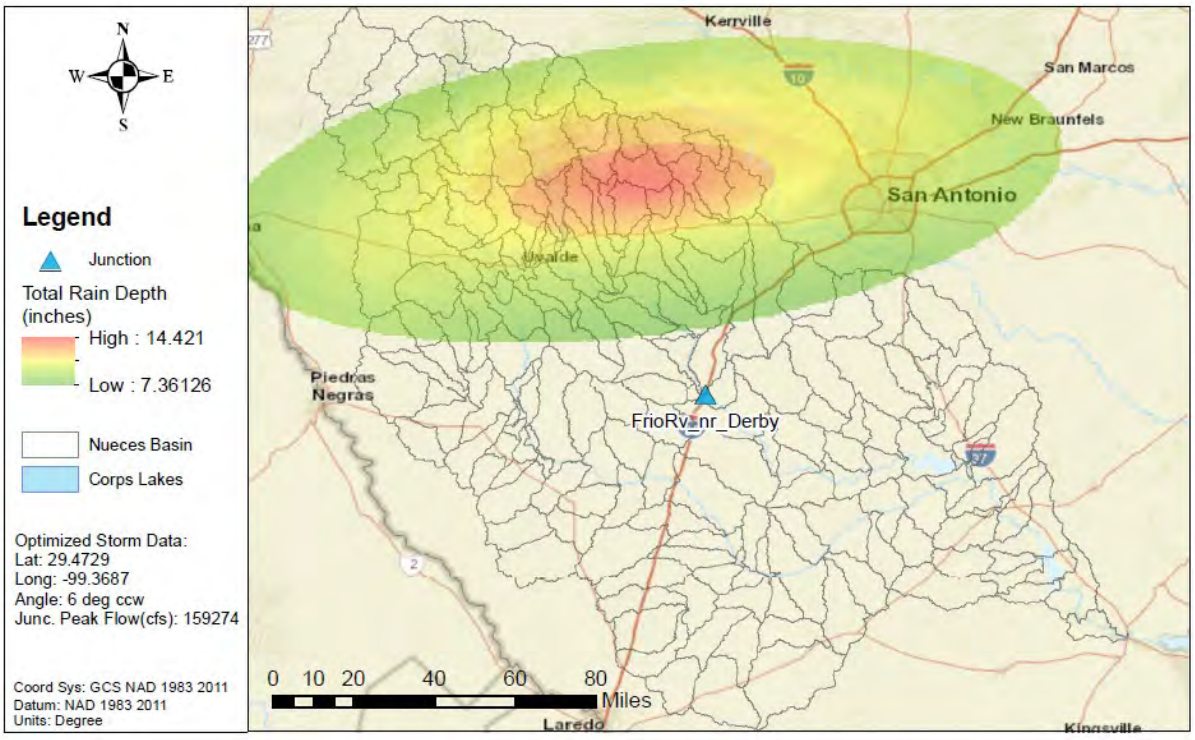

Figure C.11-96b: NA14 1% AEP Elliptical Storm for Frio River near Derby (USGS gage 08215500)

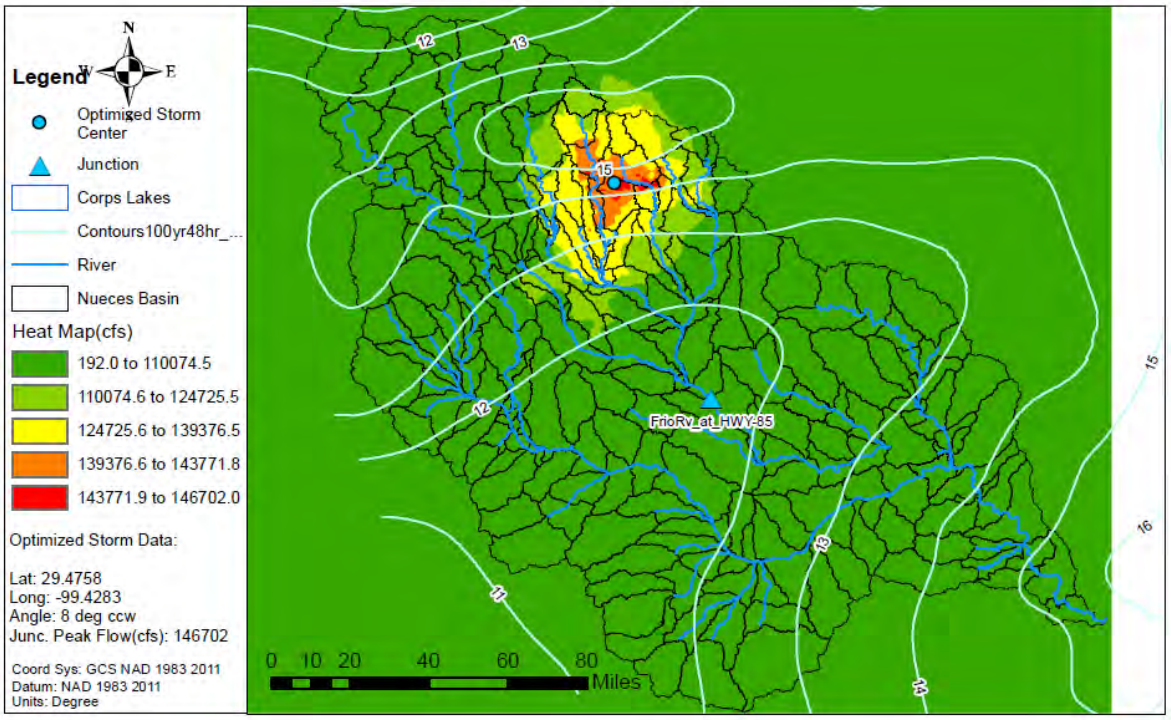

Figure C.11-97a: Elliptical Storm Optimization Heat Map for Frio River at Highway 85

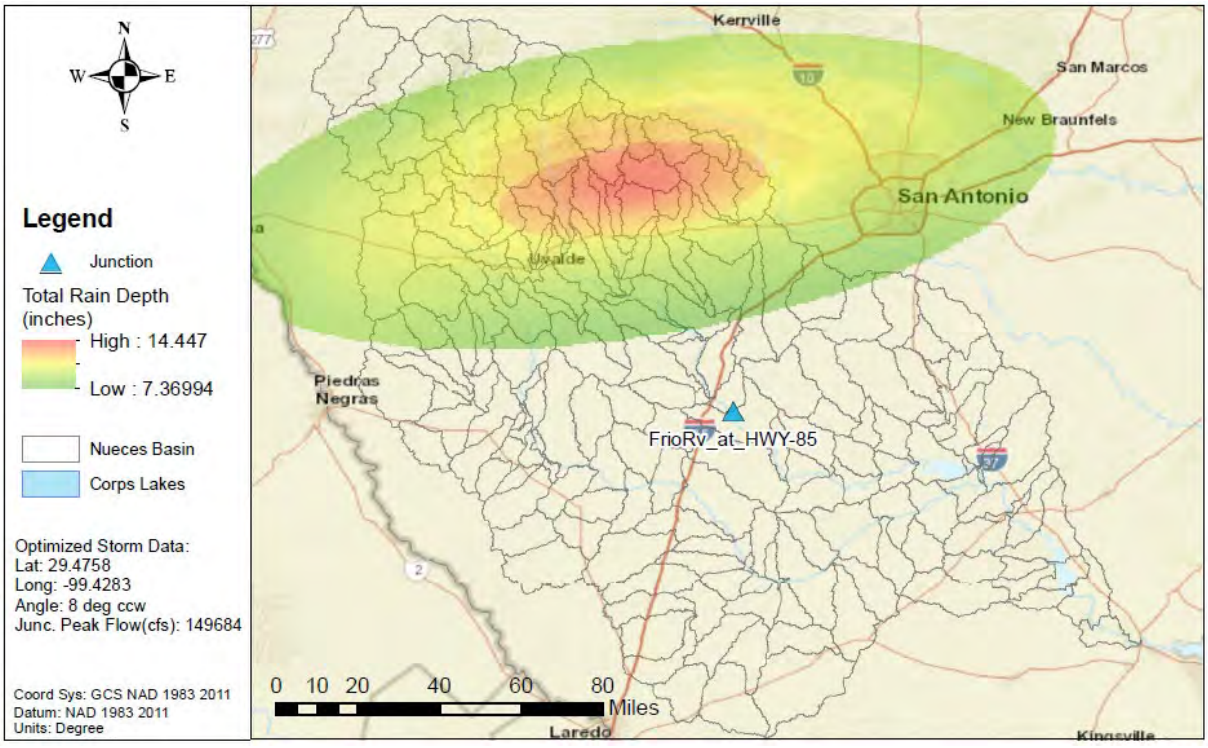

Figure C.11-97b: NA14 1% AEP Elliptical Storm for Frio River at Highway 85

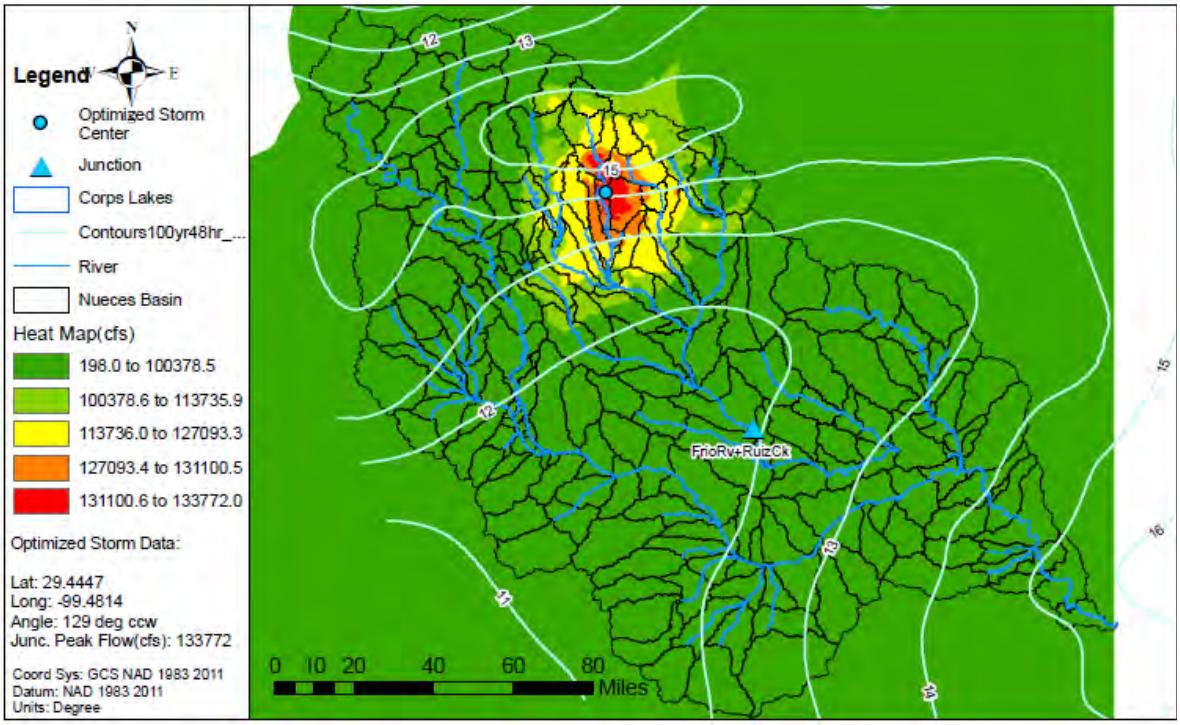

Figure C.11-98a: Elliptical Storm Optimization Heat Map for Frio River and Ruiz Creek

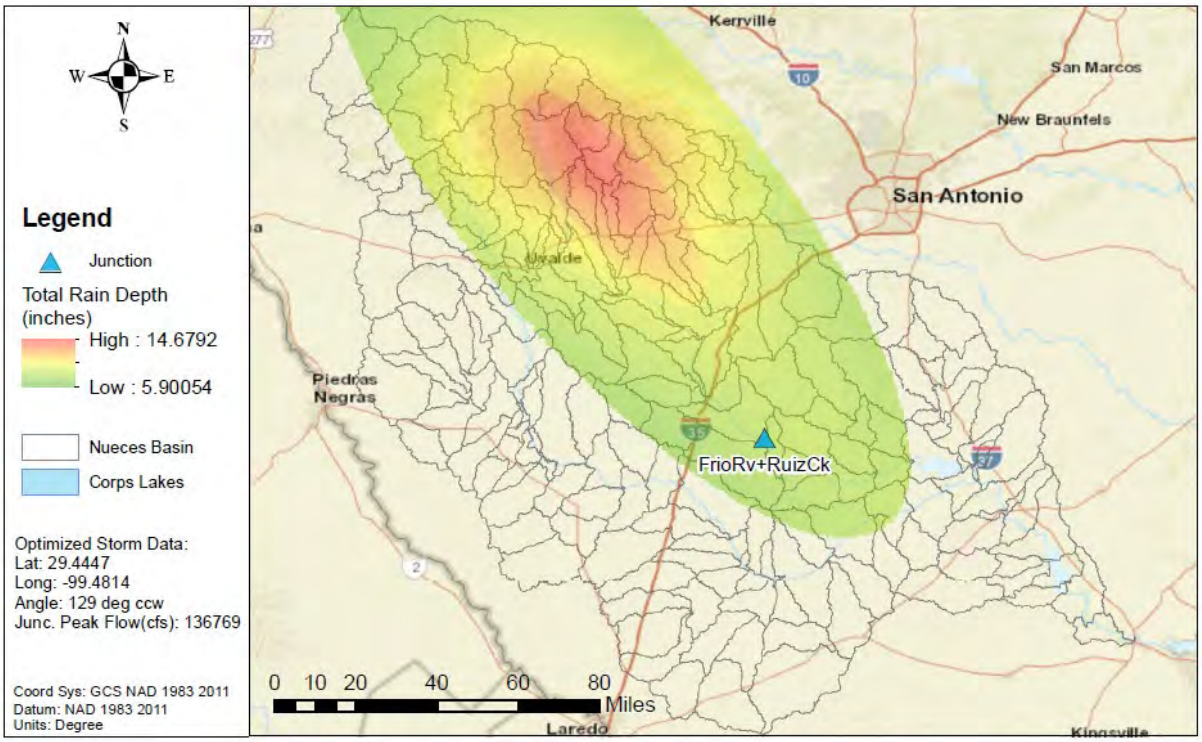

Figure C.11-98b: NA14 1% AEP Elliptical Storm for Frio River and Ruiz Creek

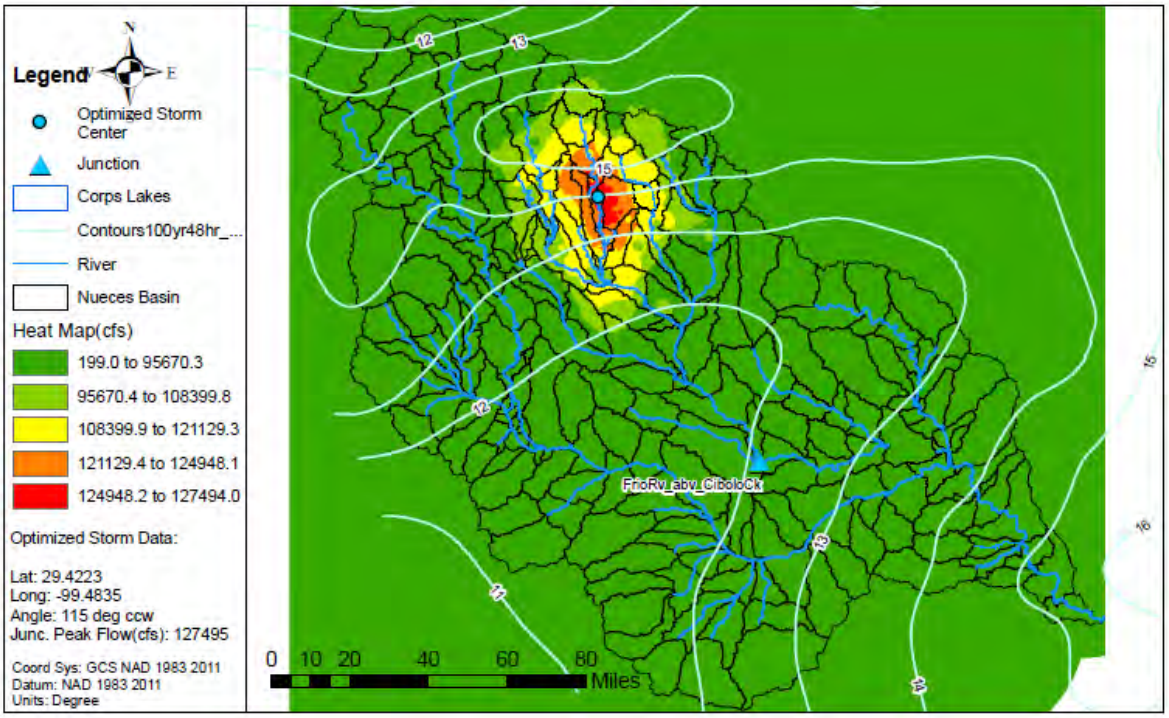

Figure C.11-99a: Elliptical Storm Optimization Heat Map for Frio River above Cibolo Creek

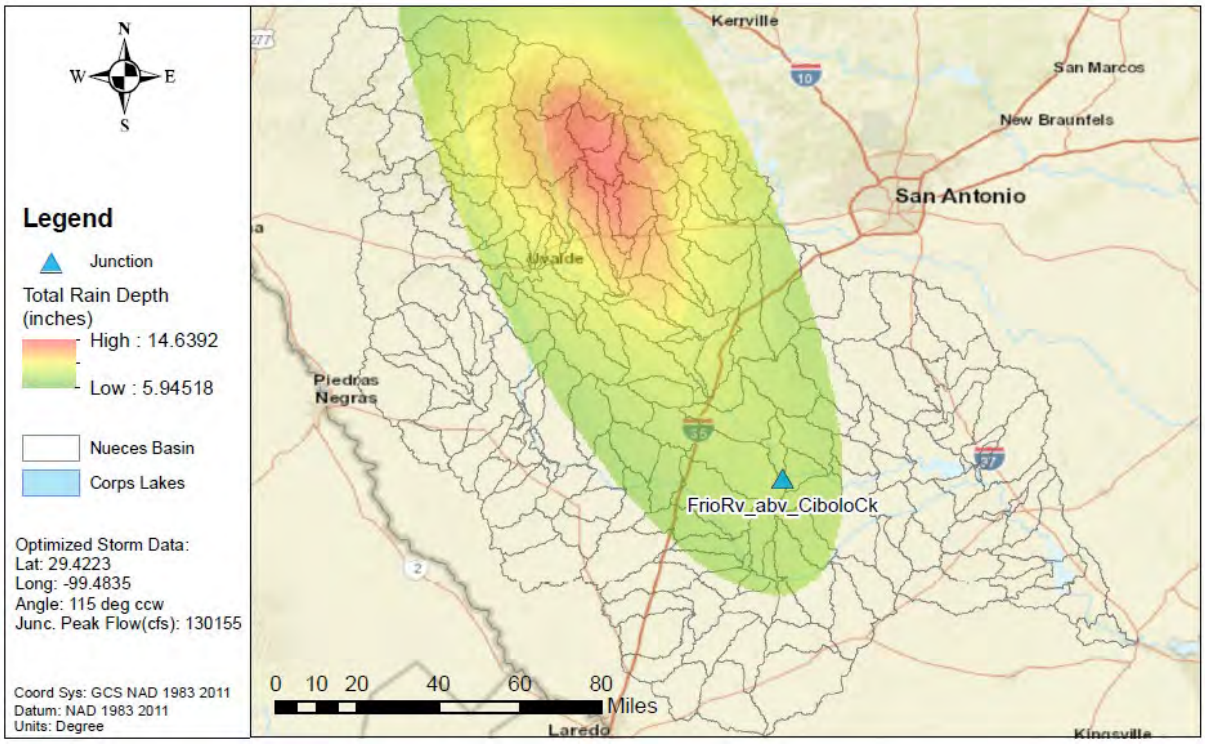

Figure C.11-99b: NA14 1% AEP Elliptical Storm for Frio River above Cibolo Creek

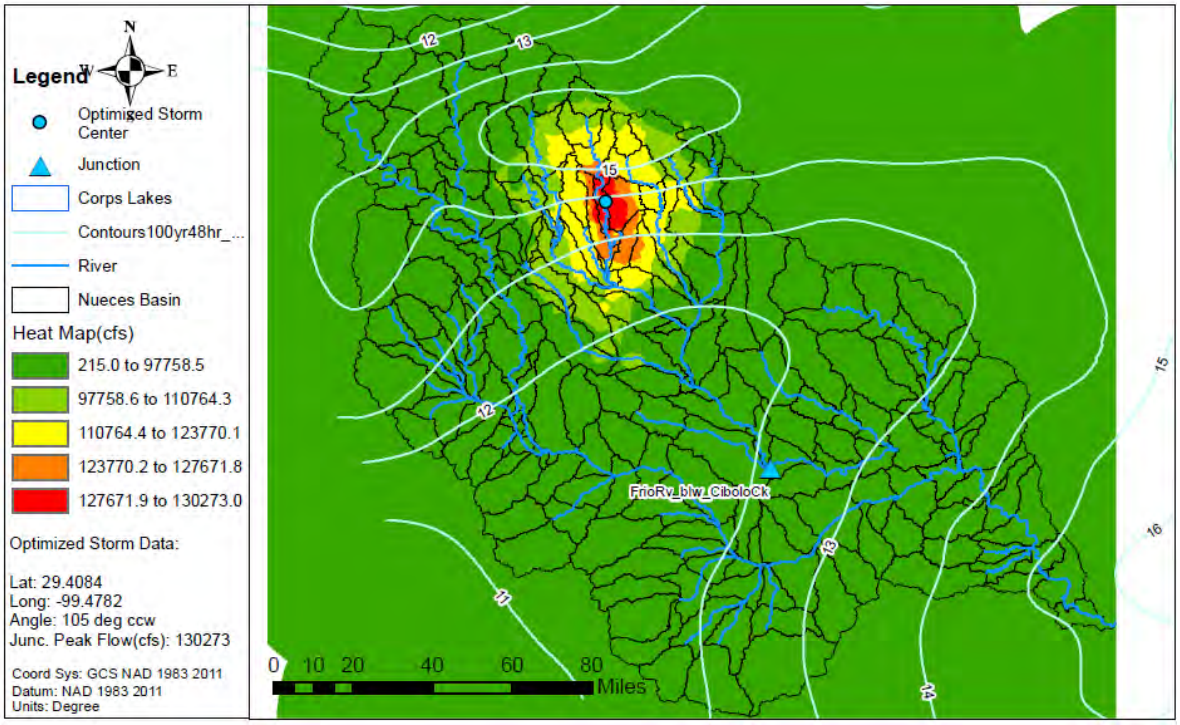

Figure C.11-100a: Elliptical Storm Optimization Heat Map for Frio River below Cibolo Creek

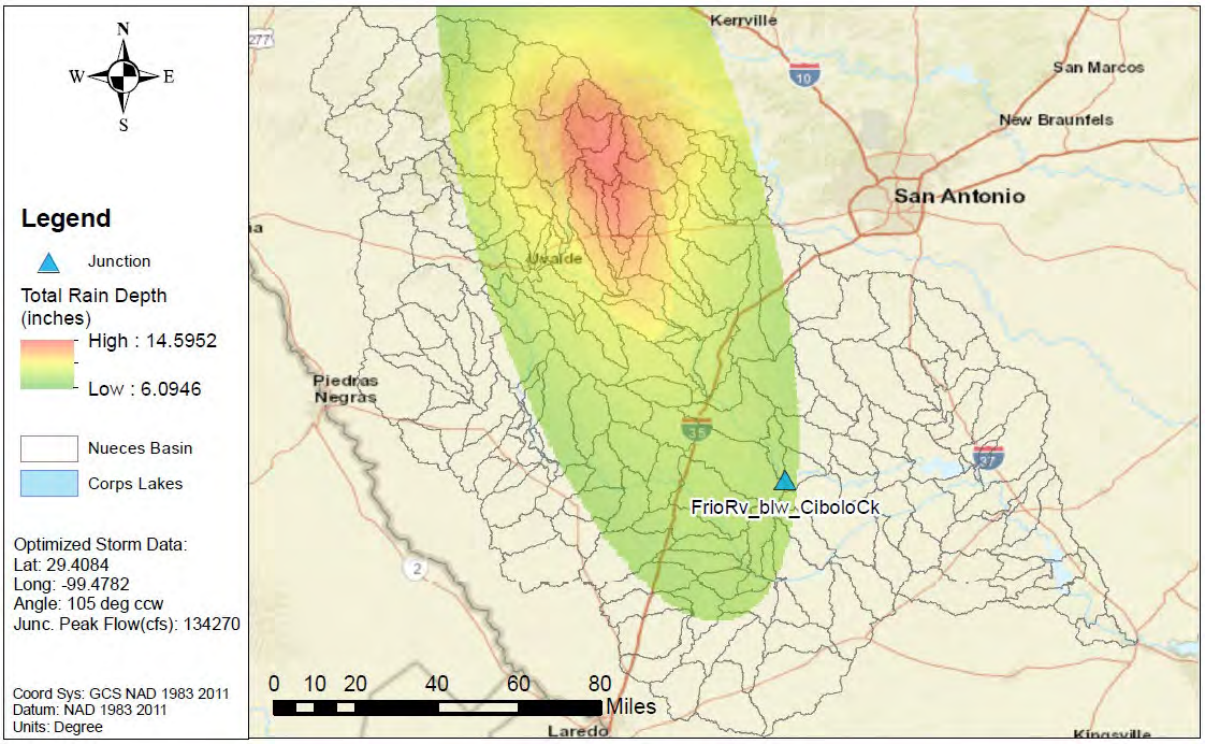

Figure C.11-100b: NA14 1% AEP Elliptical Storm for Frio River below Cibolo Creek

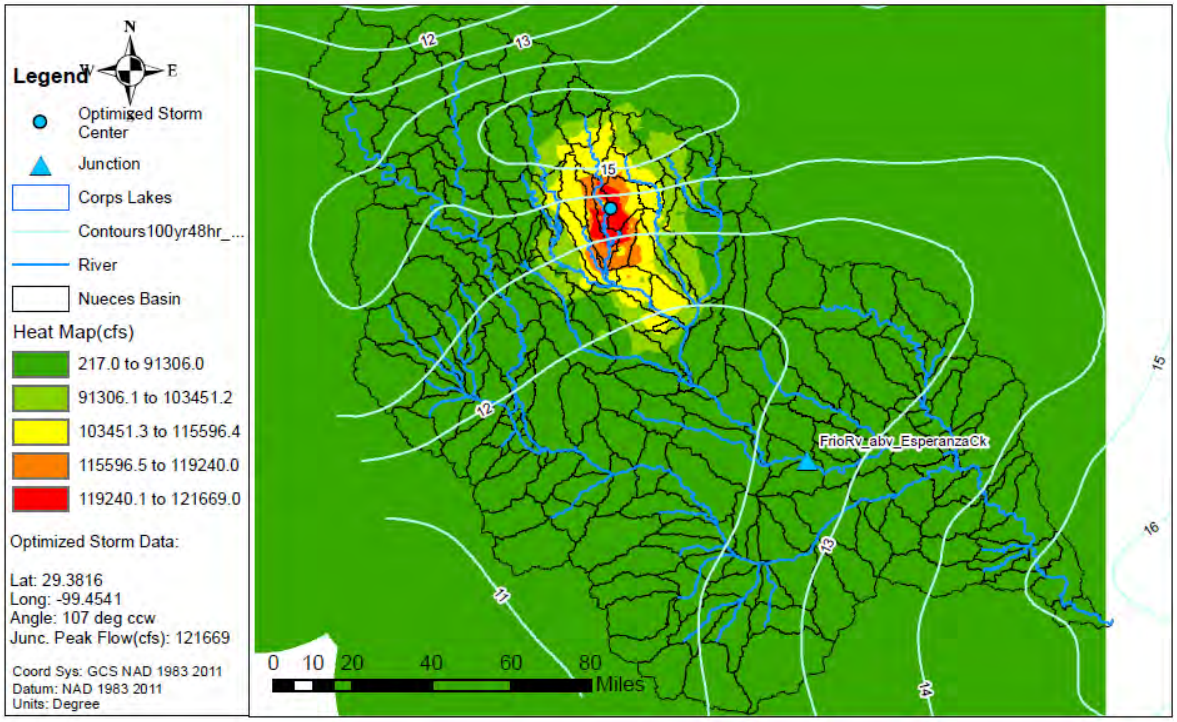

Figure C.11-101a: Elliptical Storm Optimization Heat Map for Frio River above Esperanza Creek

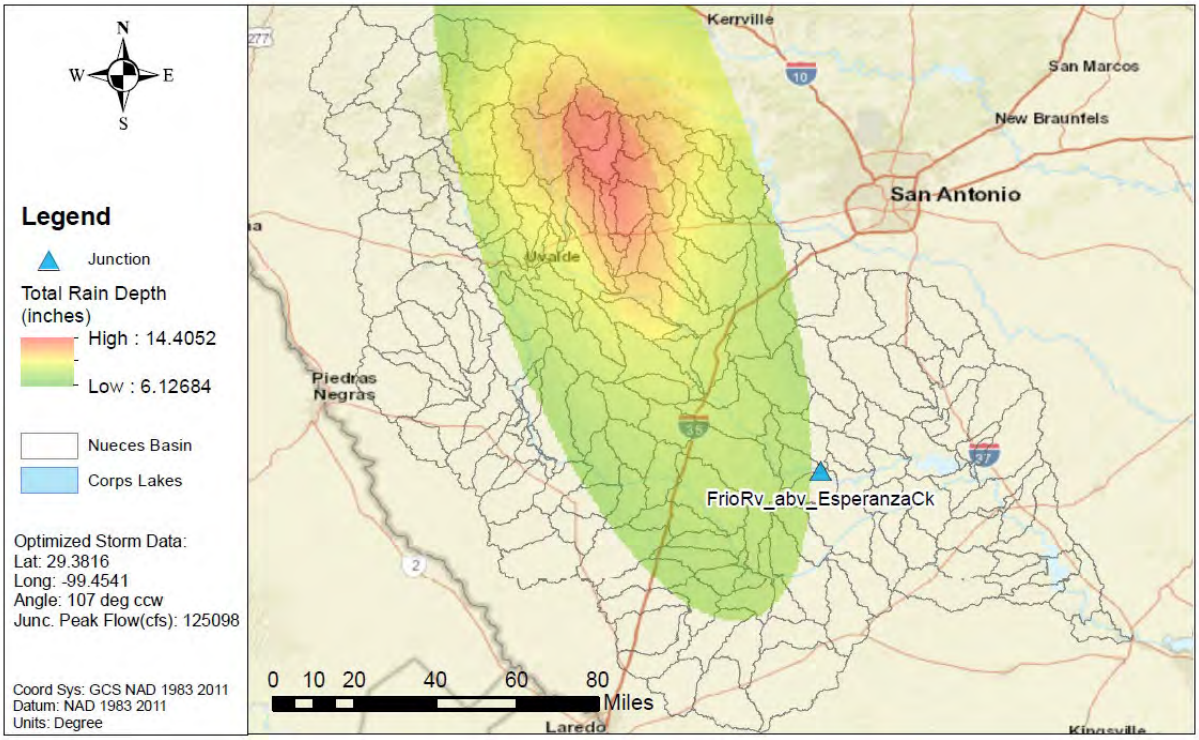

Figure C.11-101b: NA14 1% AEP Elliptical Storm for Frio River above Esperanza Creek

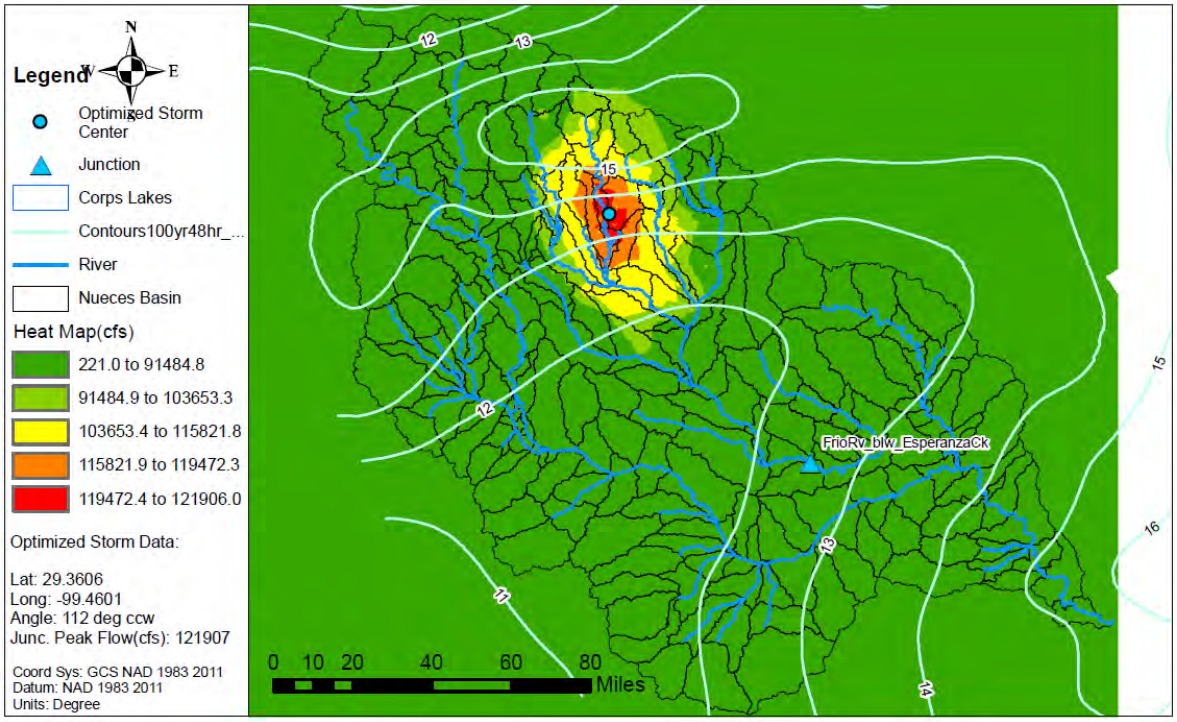

Figure C.11-102a: Elliptical Storm Optimization Heat Map for Frio River below Esperanza Creek

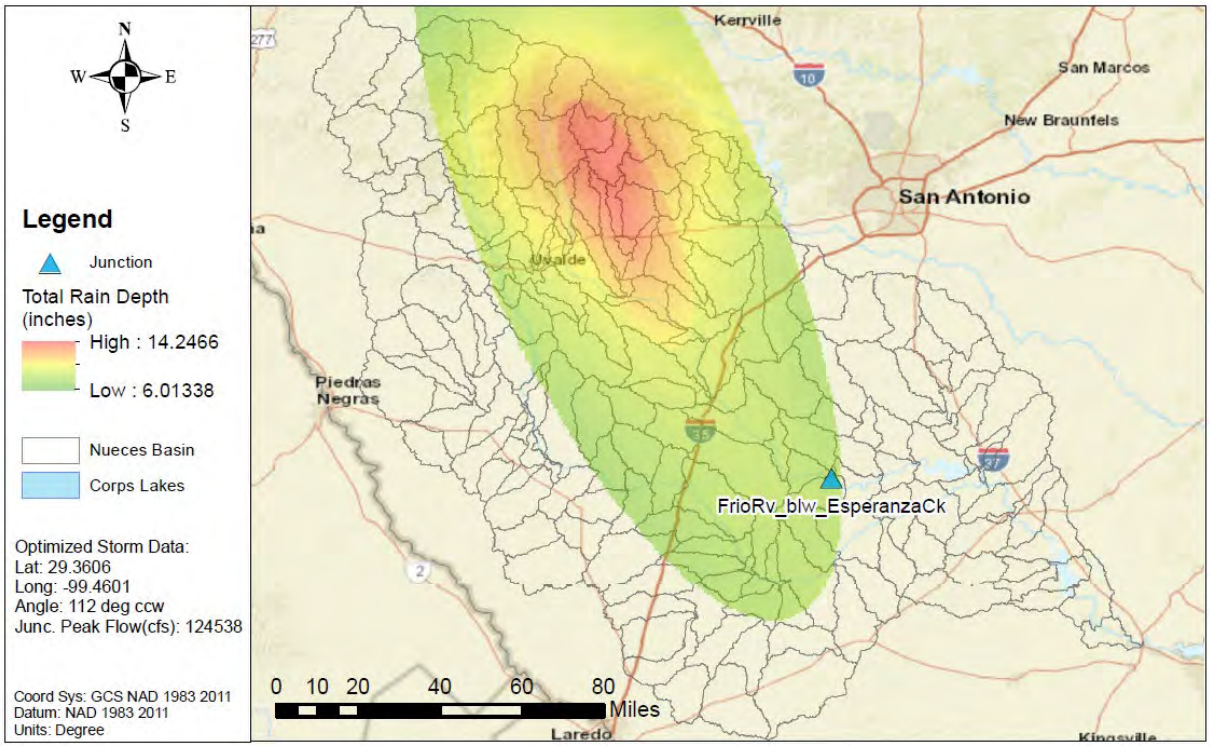

Figure C.11-102b: NA14 1% AEP Elliptical Storm for Frio River below Esperanza Creek

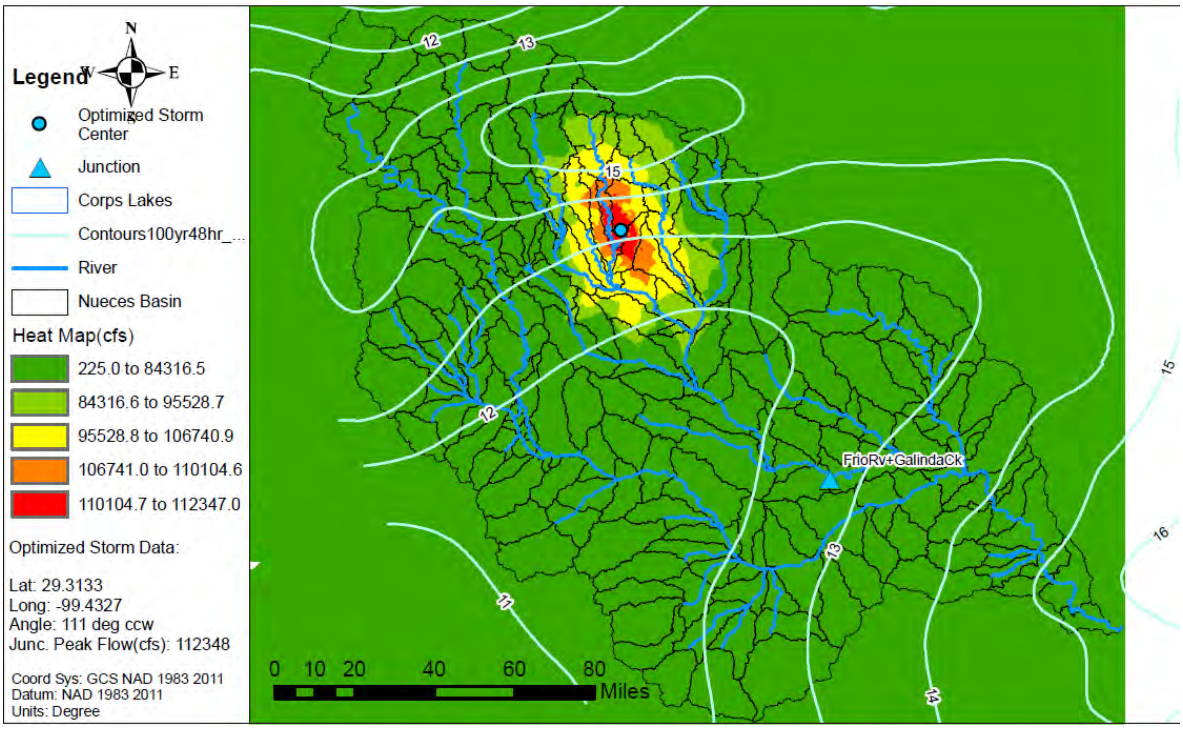

Figure C.11-103a: Elliptical Storm Optimization Heat Map for Frio River and Galinda Creek

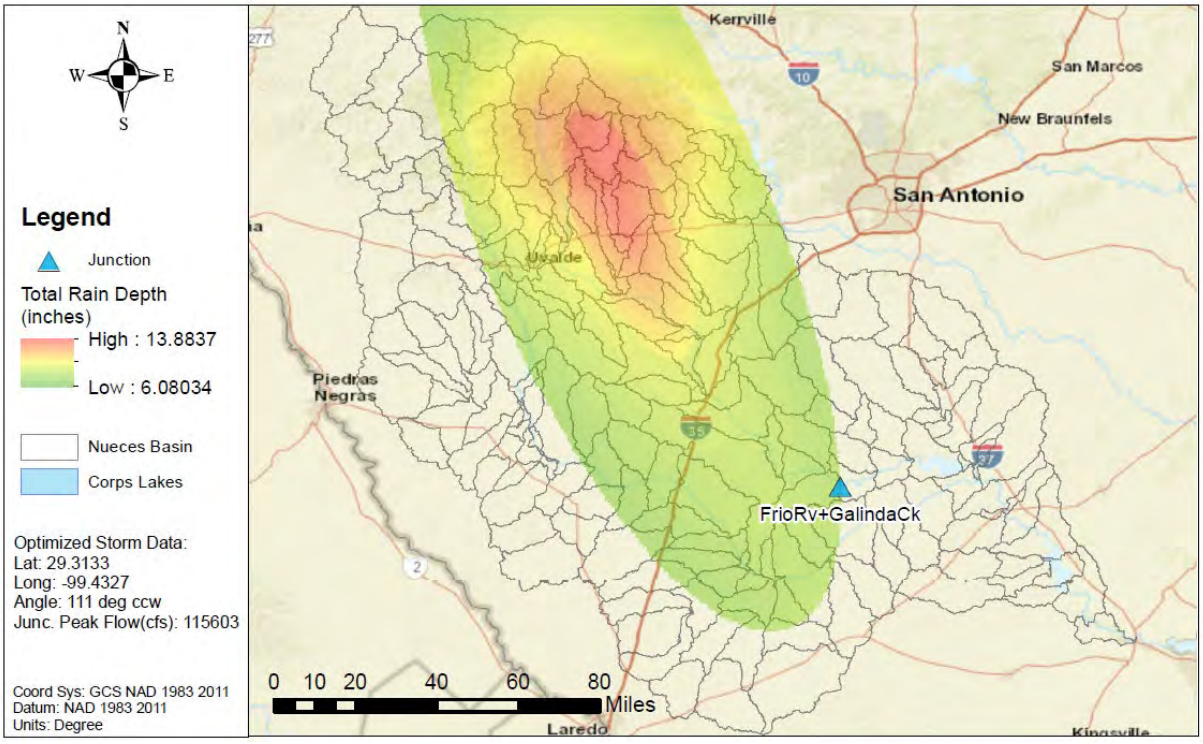

Figure C.11-103b: NA14 1% AEP Elliptical Storm for Frio River and Galinda Creek

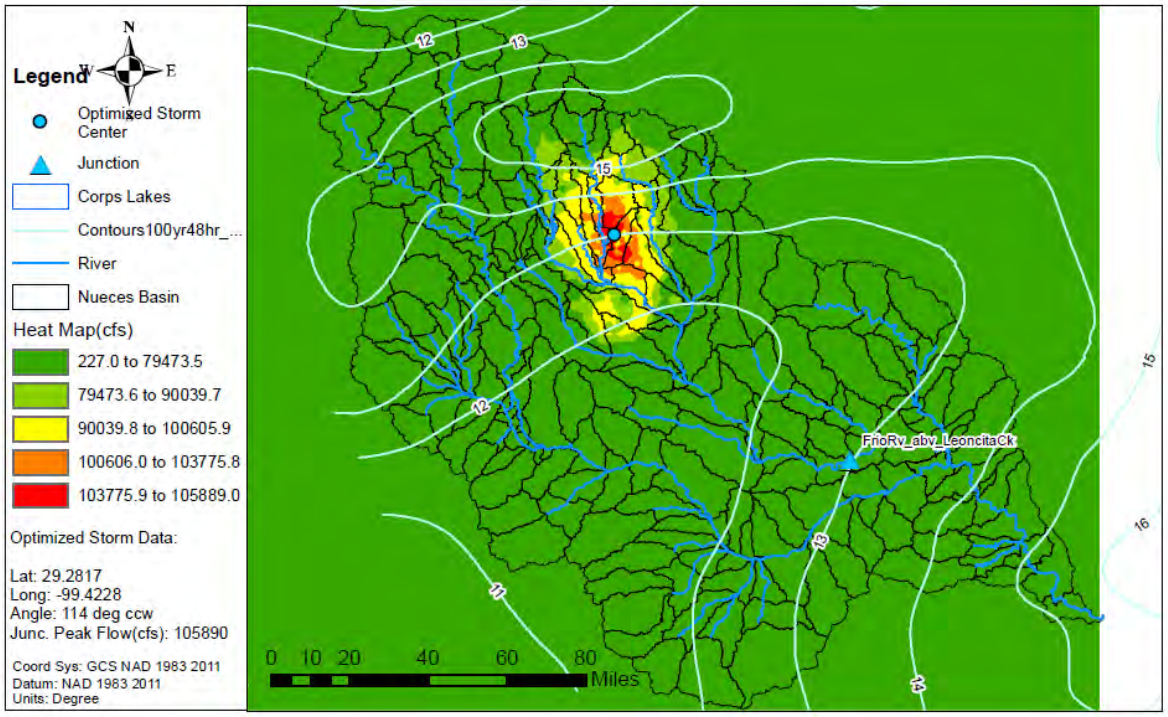

Figure C.11-104a: Elliptical Storm Optimization Heat Map for Frio River above Leoncita Creek

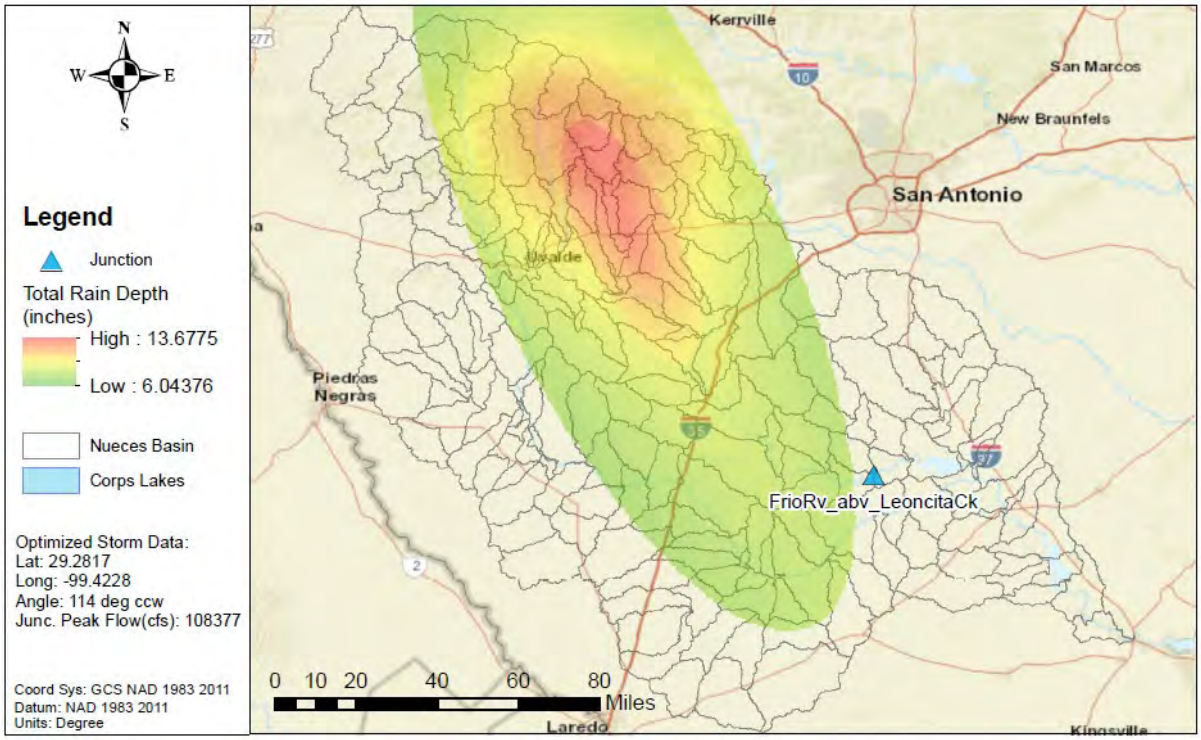

Figure C.11-104b: NA14 1% AEP Elliptical Storm for Frio River above Leoncita Creek

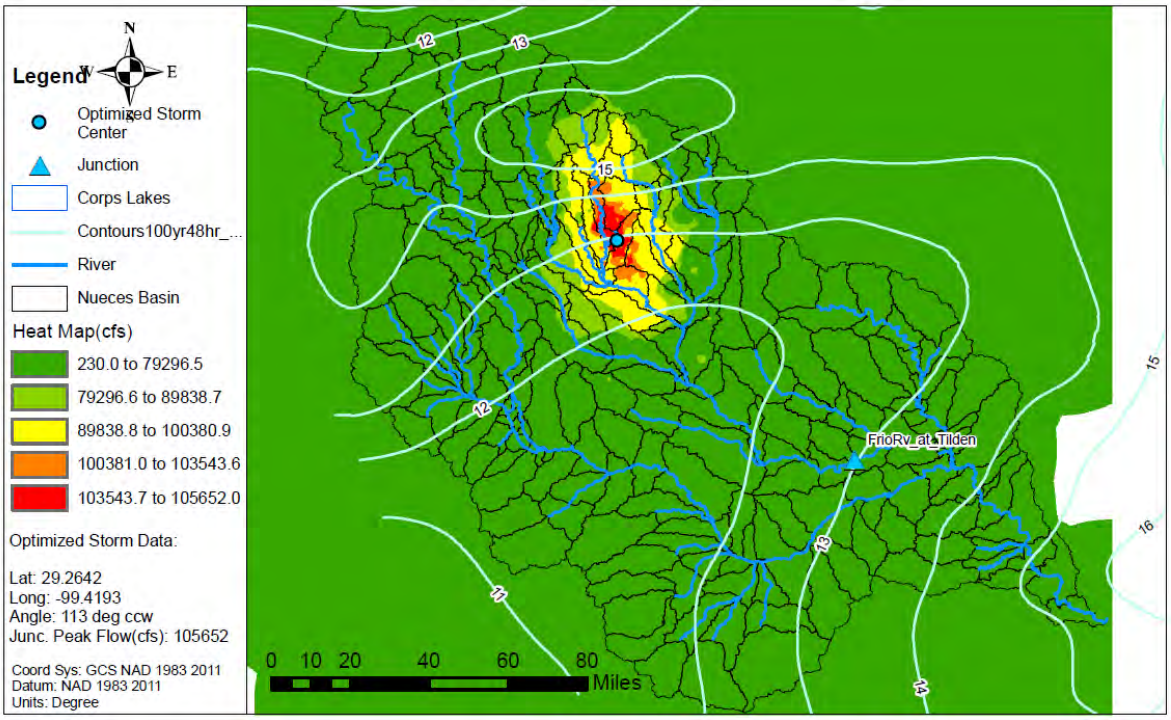

Figure C.11-105a: Elliptical Storm Optimization Heat Map for Frio River at Tilden (USGS gage 08206600)

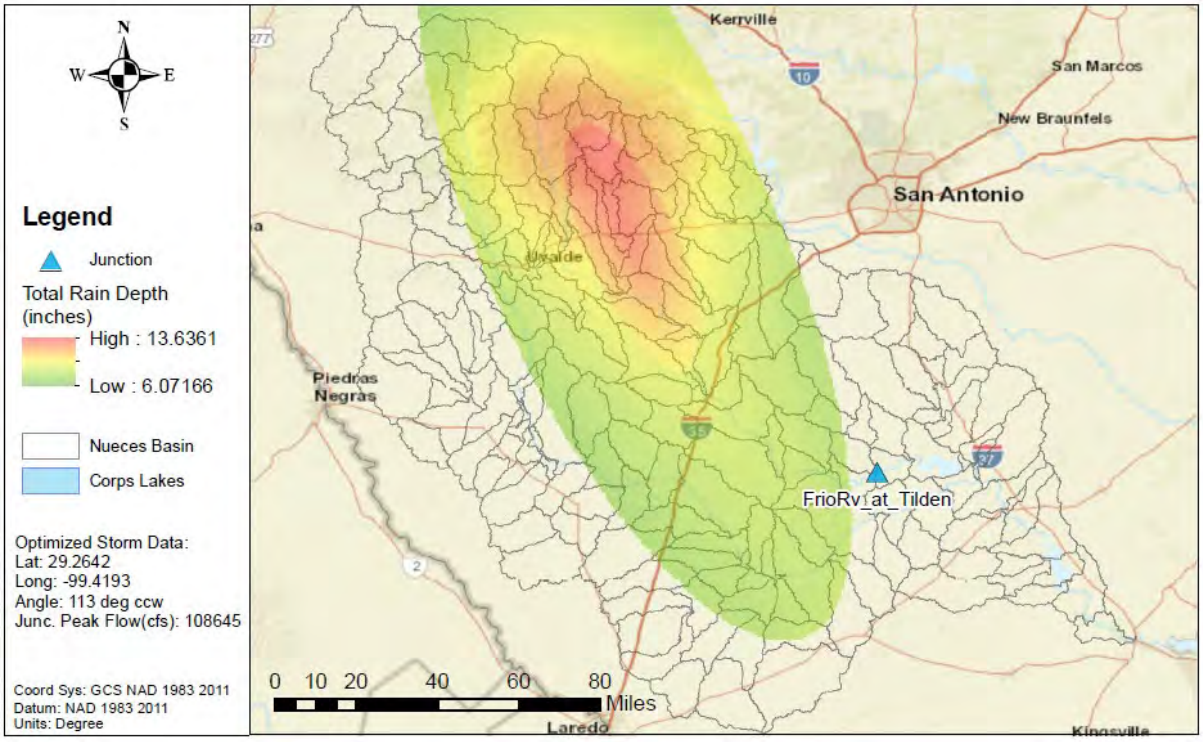

Figure C.11-105b: NA14 1% AEP Elliptical Storm for Frio River at Tilden (USGS gage 08206600)

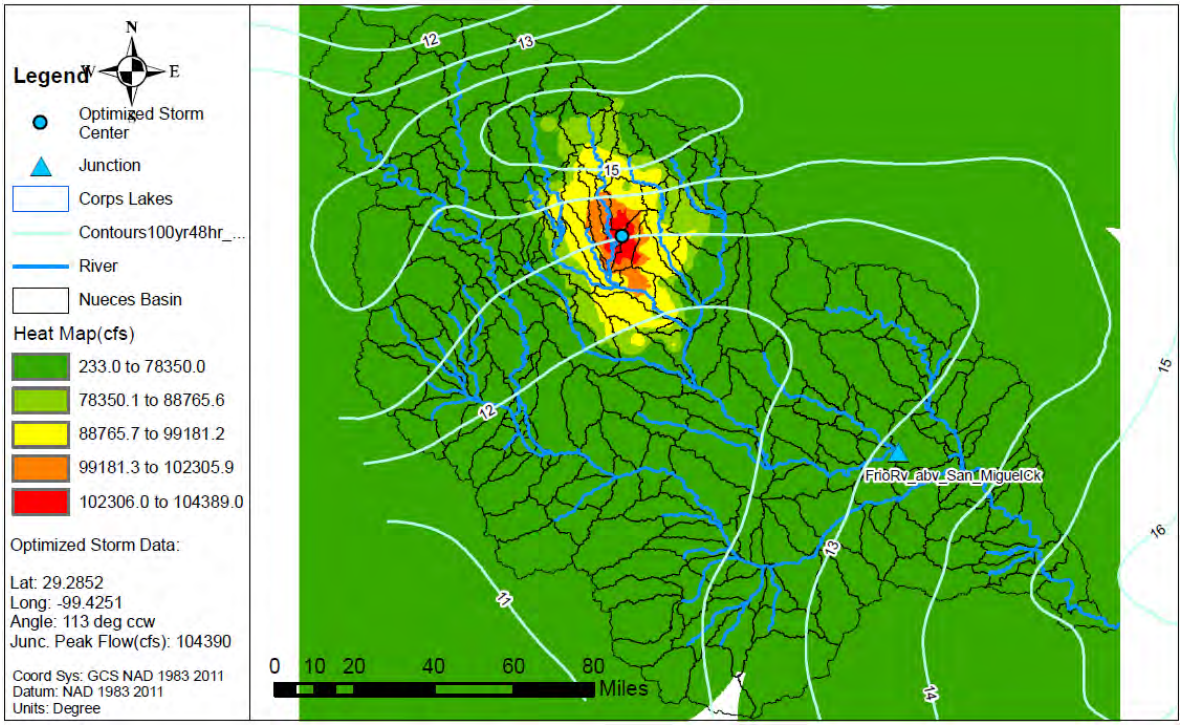

Figure C.11-106a: Elliptical Storm Optimization Heat Map for Frio River above San Miguel Creek

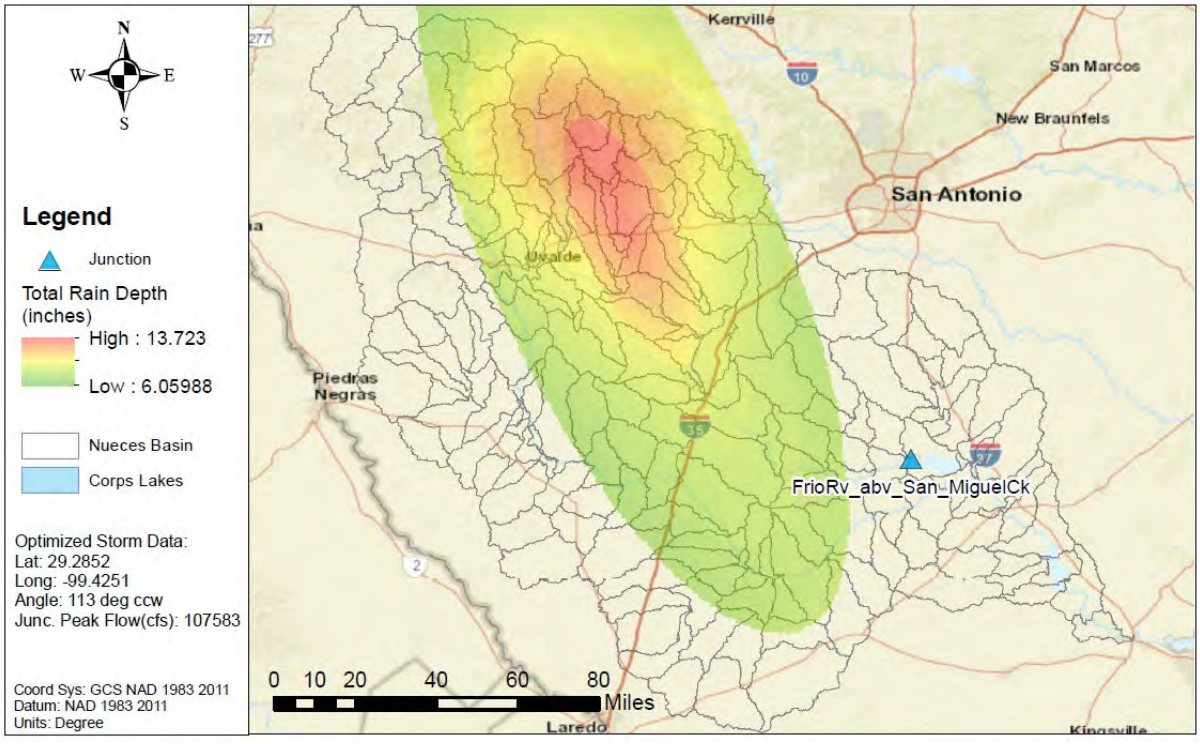

Figure C.11-106b: NA14 1% AEP Elliptical Storm for Frio River above San Miguel Creek

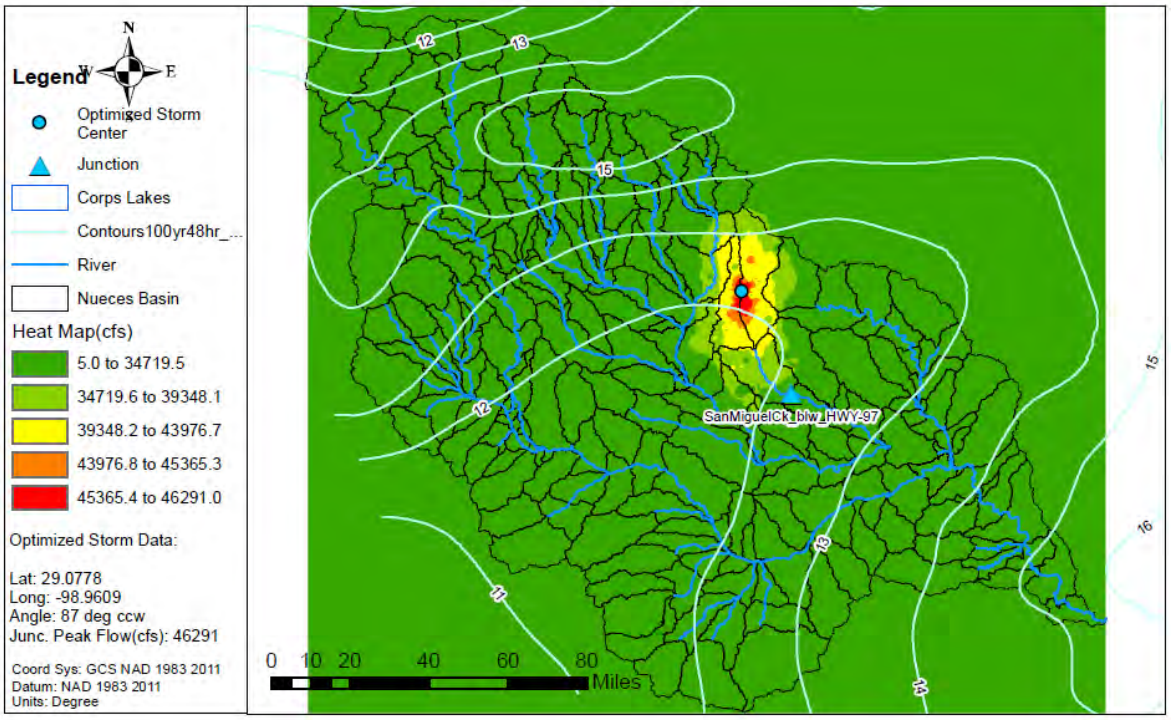

Figure C.11-107a: Elliptical Storm Optimization Heat Map for San Miguel Creek below Highway 97

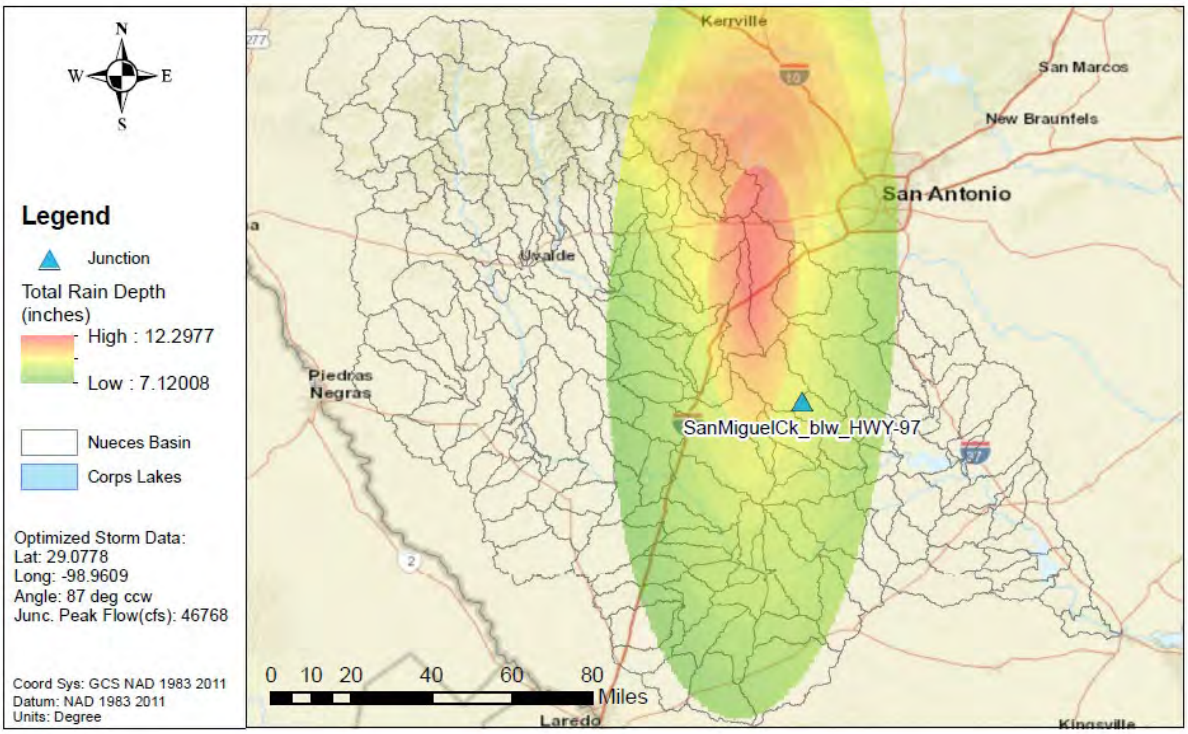

Figure C.11-107b: NA14 1% AEP Elliptical Storm for San Miguel Creek below Highway 97

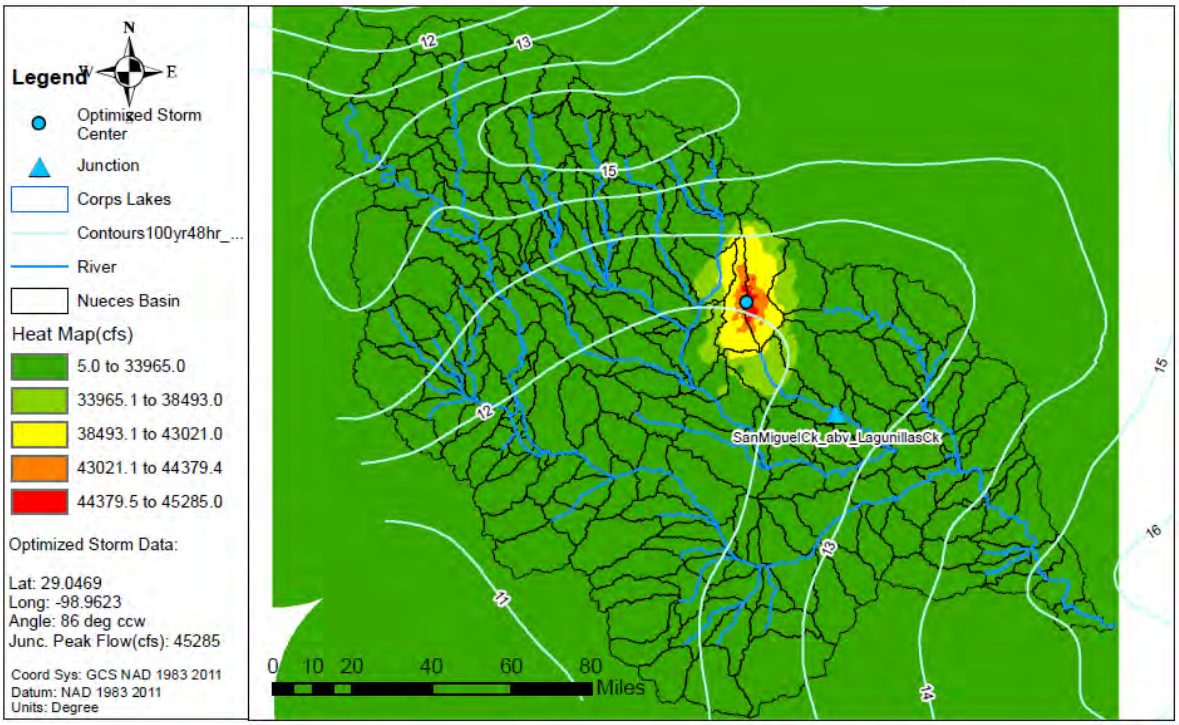

Figure C.11-108a: Elliptical Storm Optimization Heat Map for San Miguel Creek above Lagunillas Creek

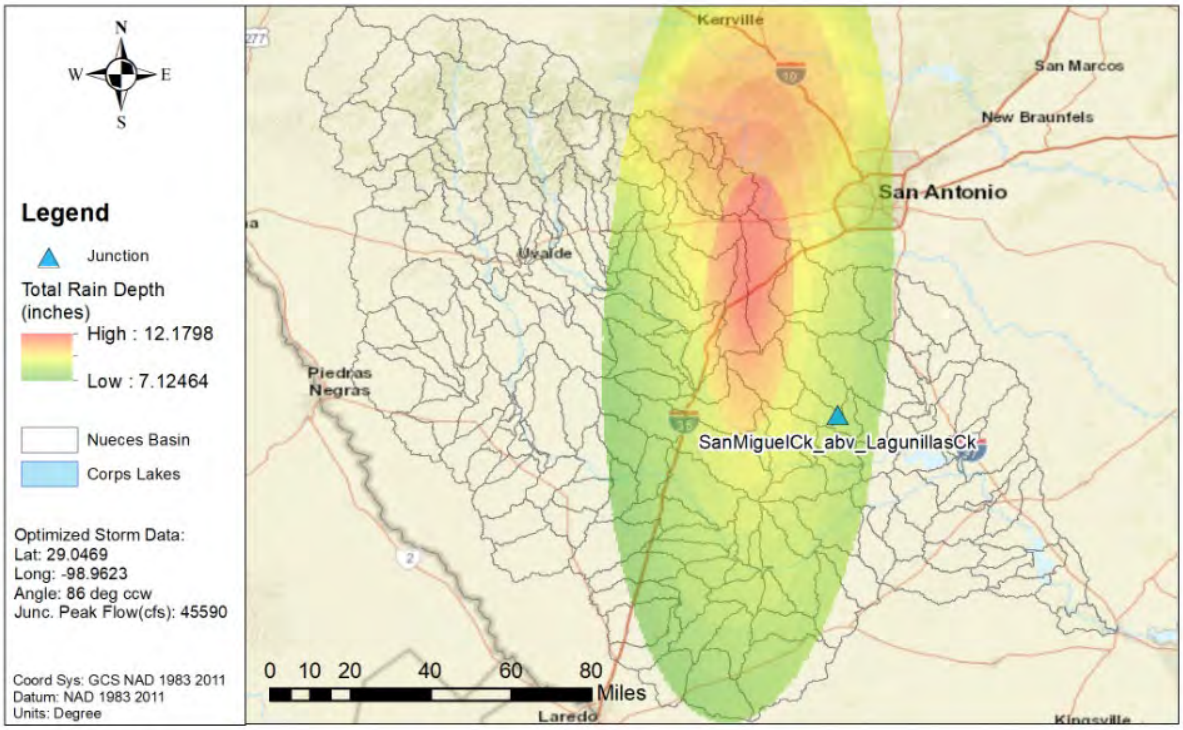

Figure C.11-108b: NA14 1% AEP Elliptical Storm for San Miguel Creek above Lagunillas Creek

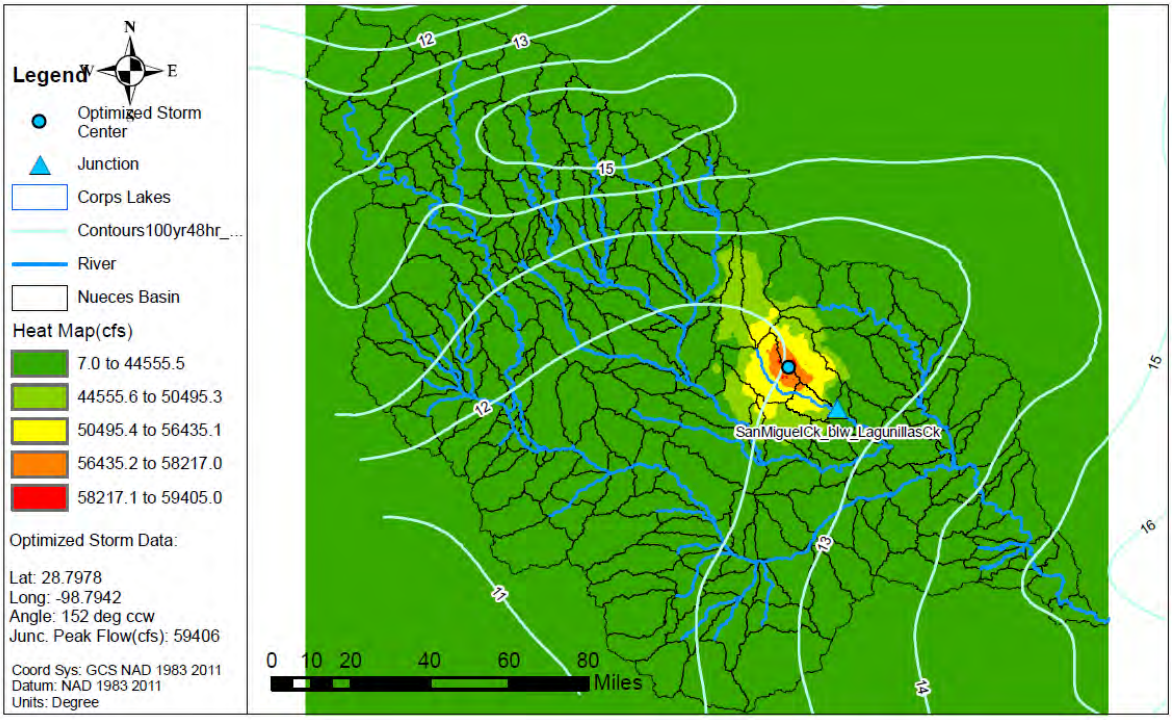

Figure C.11-109a: Elliptical Storm Optimization Heat Map for San Miguel Creek below Lagunillas Creek

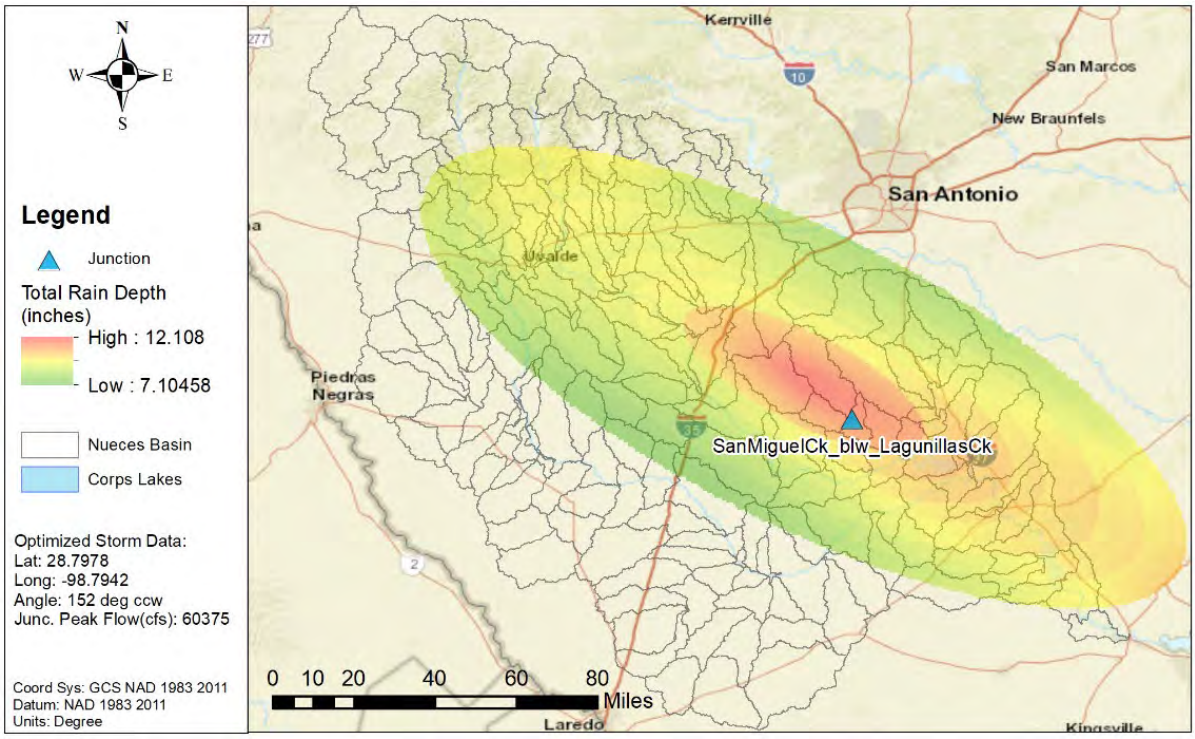

Figure C.11-109b: NA14 1% AEP Elliptical Storm for San Miguel Creek below Lagunillas Creek

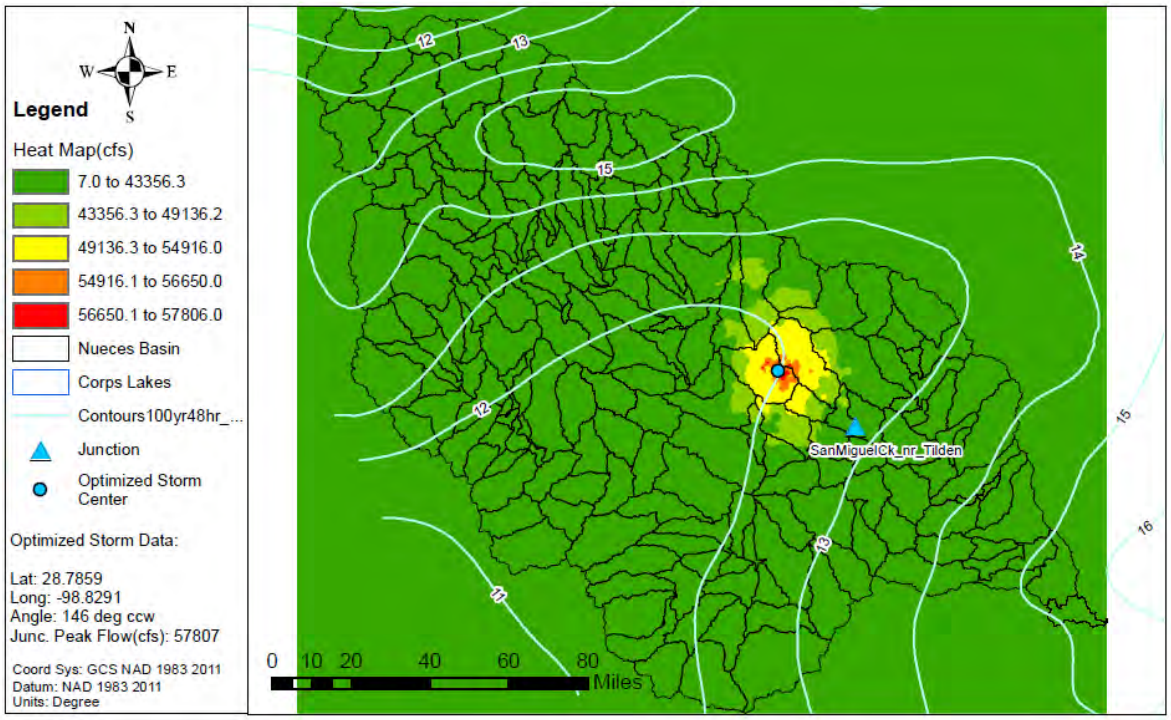

Figure C.11-110a: Elliptical Storm Optimization Heat Map for San Miguel Creek near Tilden (USGS gage 08206700)

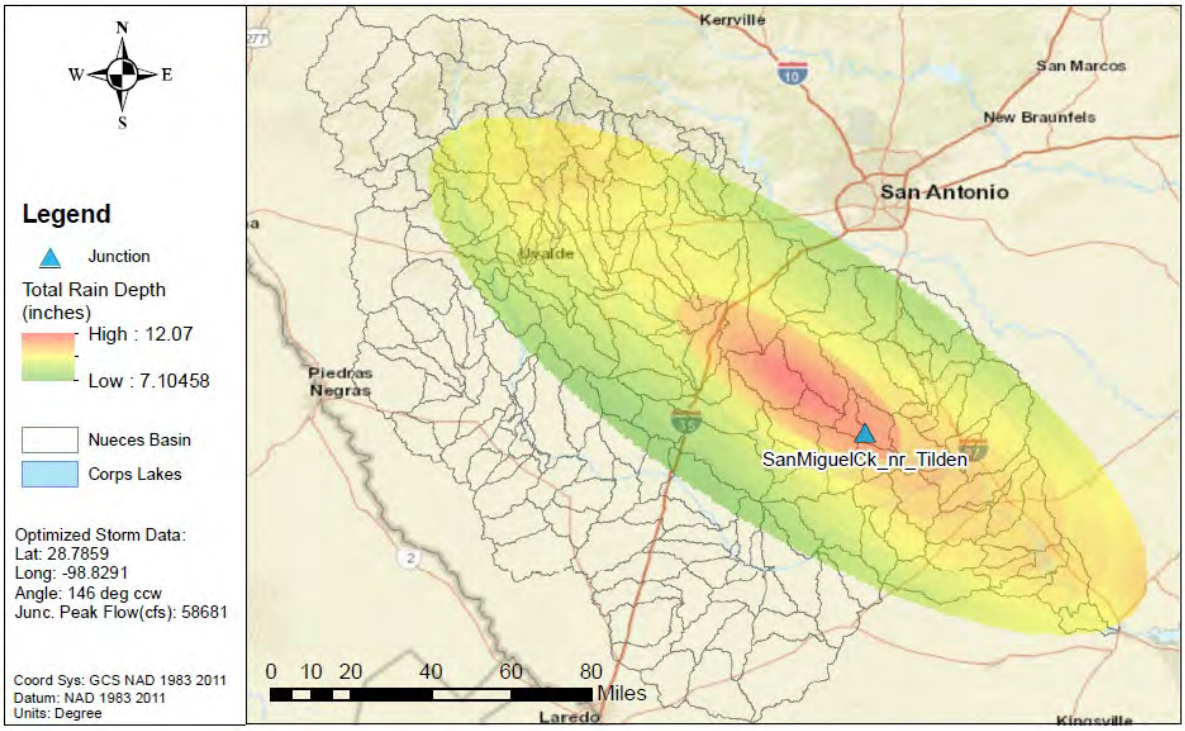

Figure C.11-110b: NA14 1% AEP Elliptical Storm for San Miguel Creek near Tilden (USGS gage 08206700)

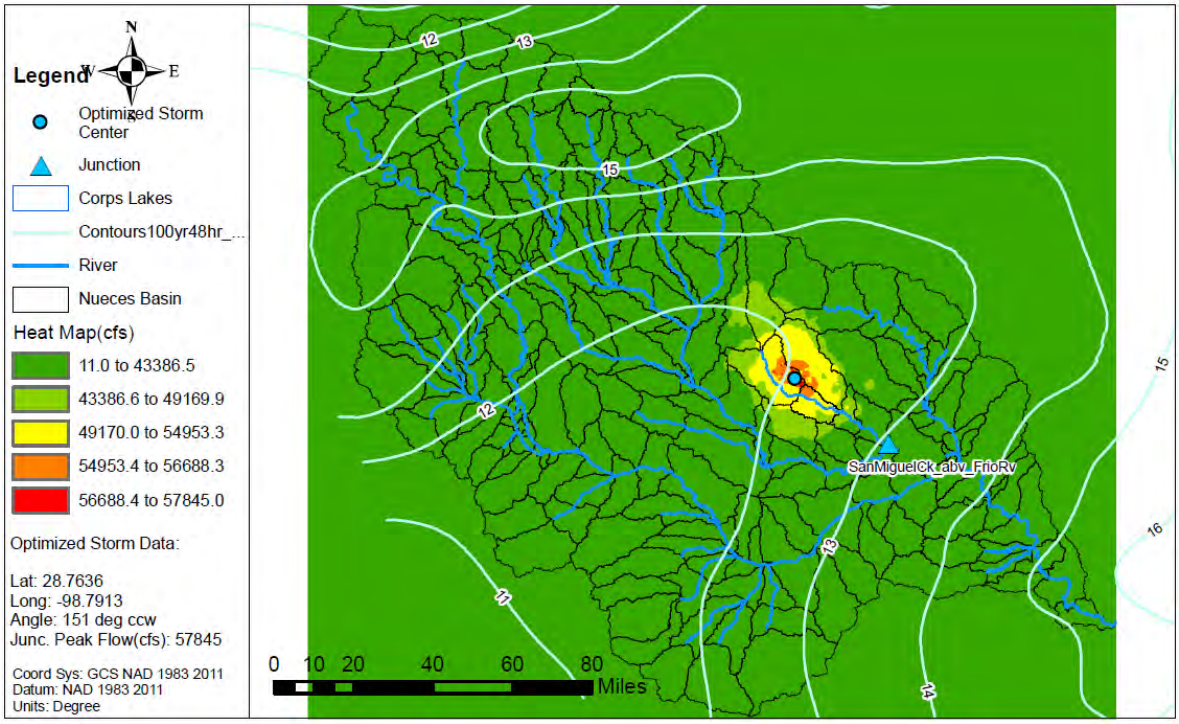

Figure C.11-111a: Elliptical Storm Optimization Heat Map for San Miguel Creek above Frio River

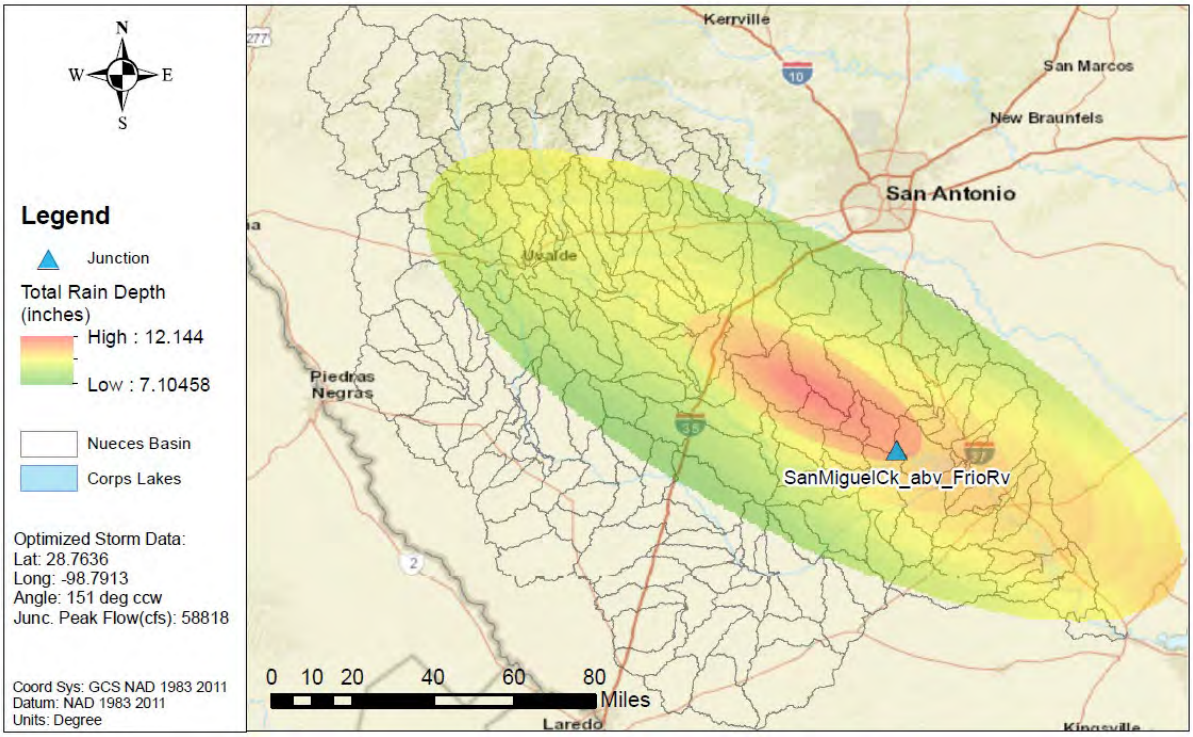

Figure C.11-111b: NA14 1% AEP Elliptical Storm for San Miguel Creek above Frio River

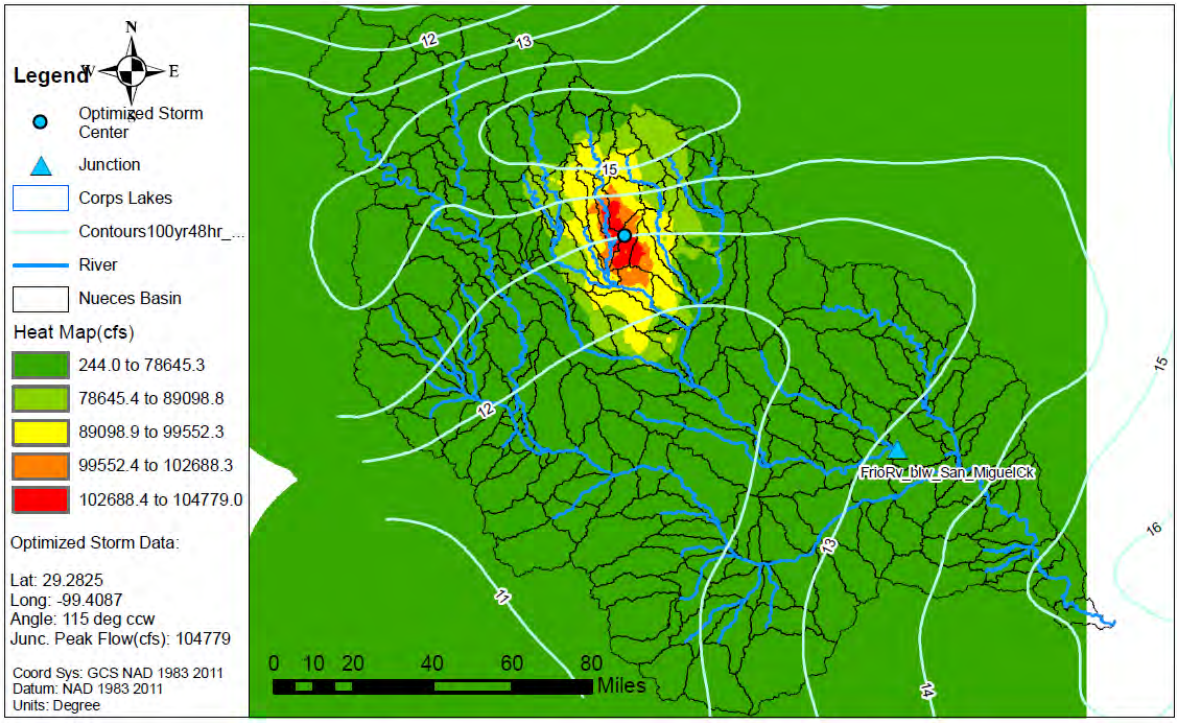

Figure C.11-112a: Elliptical Storm Optimization Heat Map for Frio River below San Miguel Creek

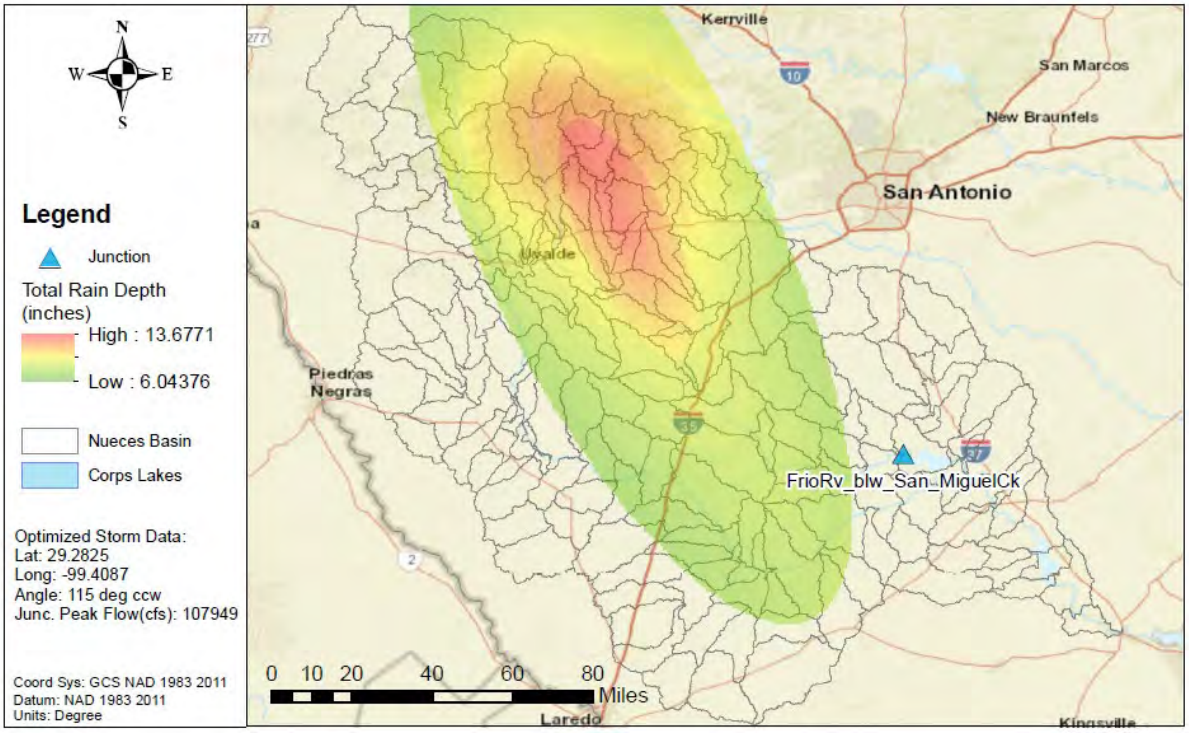

Figure C.11-112b: NA14 1% AEP Elliptical Storm for Frio River below San Miguel Creek

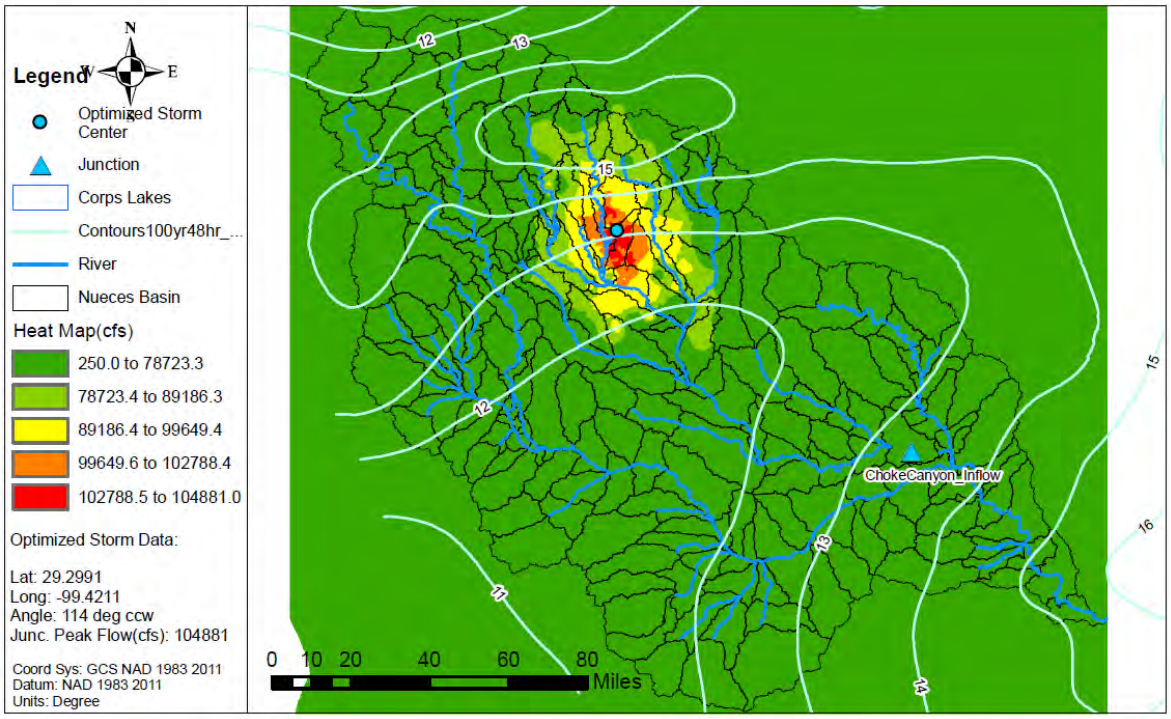

Figure C.11-113a: Elliptical Storm Optimization Heat Map for Choke Canyon Reservoir Inflow

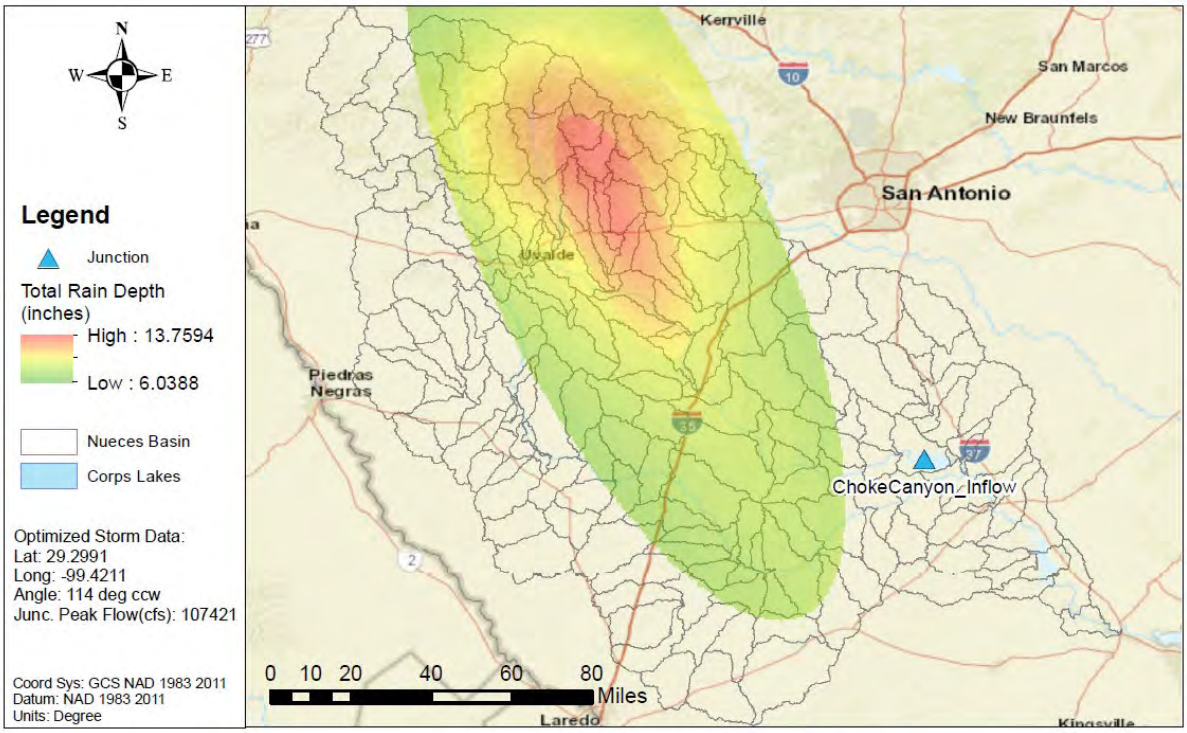

Figure C.11-113b: NA14 1% AEP Elliptical Storm for Choke Canyon Reservoir Inflow

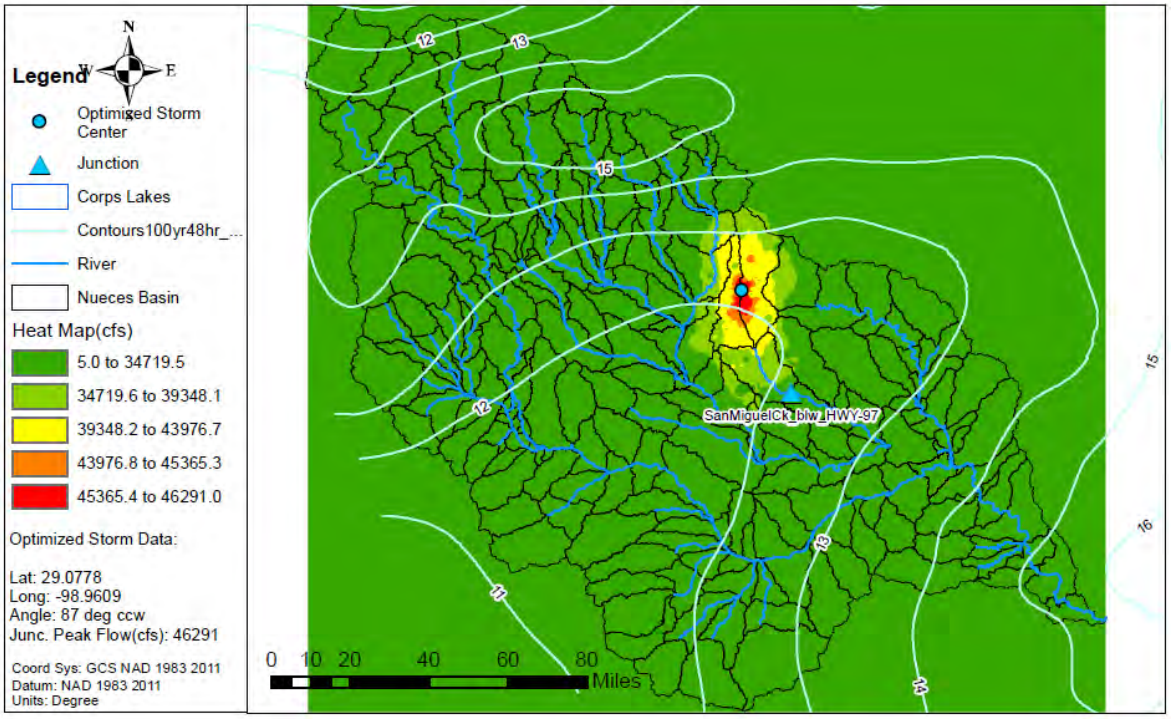

Figure C.11-114a: Elliptical Storm Optimization Heat Map for Frio River below Choke Canyon Dam

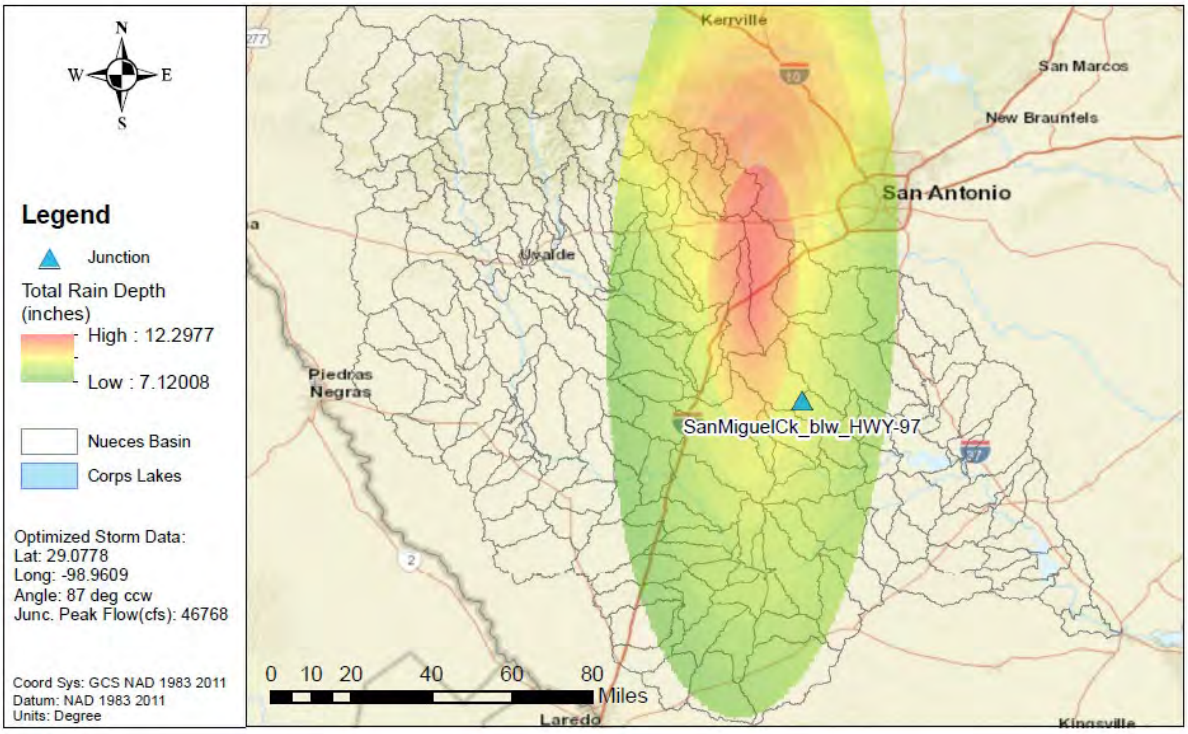

Figure C.11-114b: NA14 1% AEP Elliptical Storm for Frio River below Choke Canyon Dam

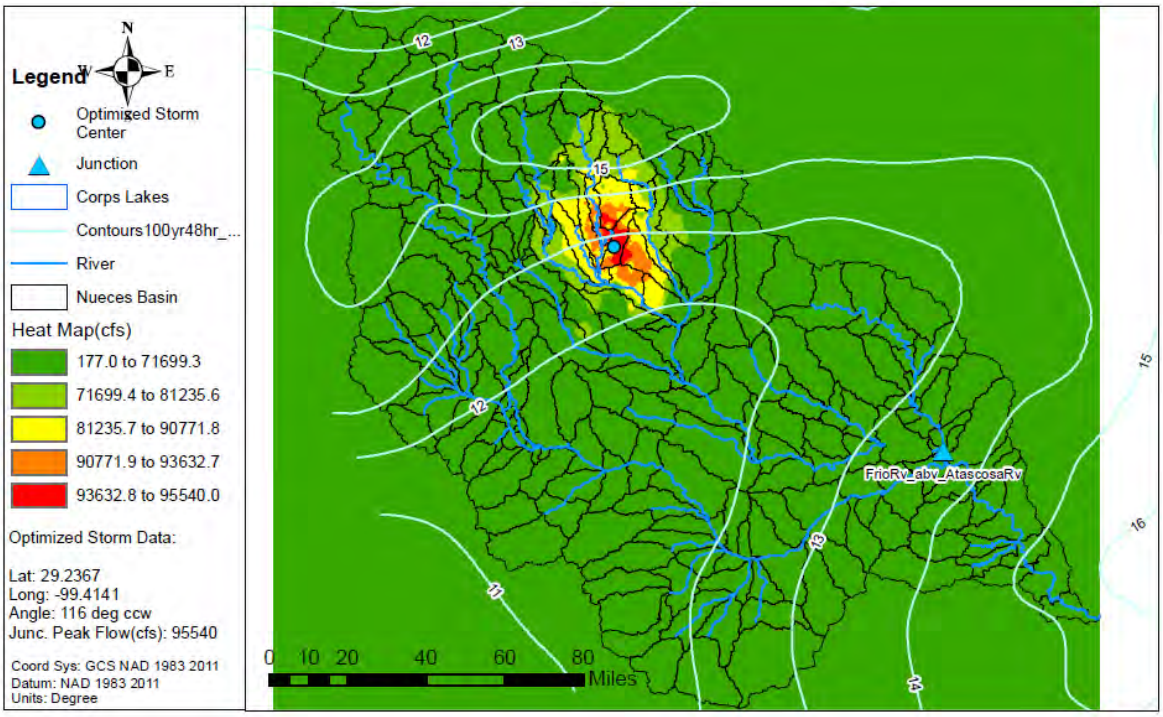

Figure C.11-115a: Elliptical Storm Optimization Heat Map for Frio River above Atascosa River

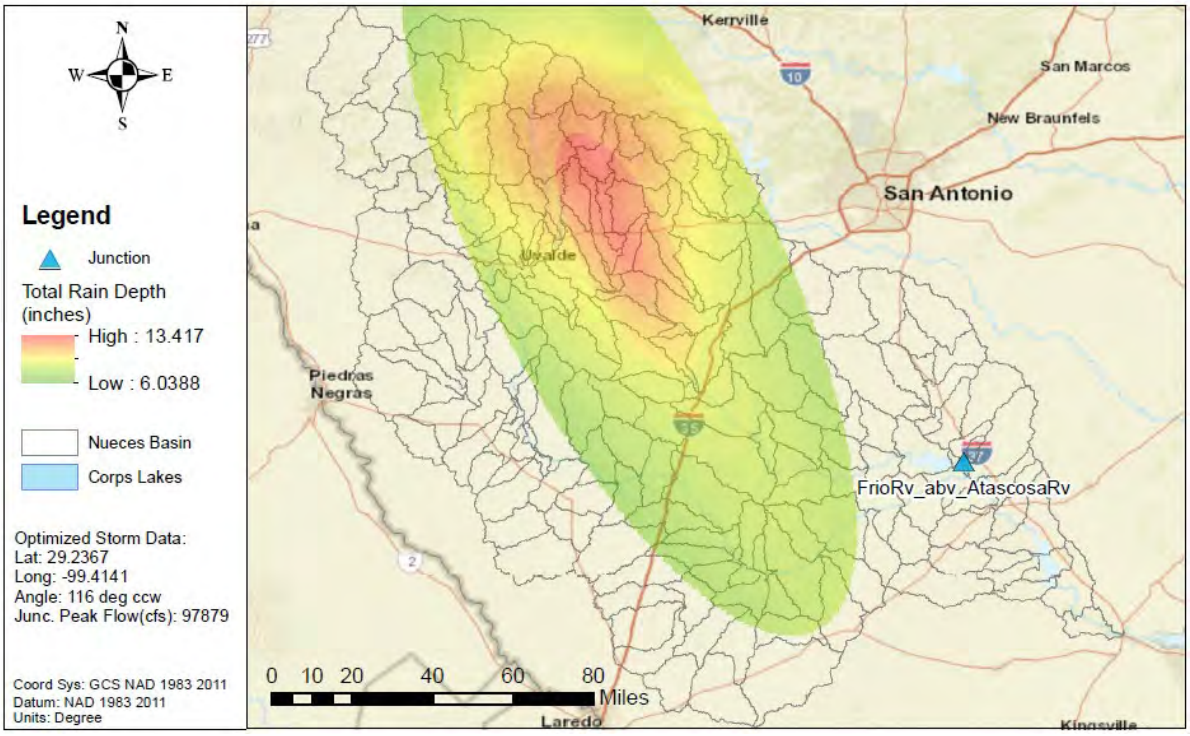

Figure C.11-115b: NA14 1% AEP Elliptical Storm for Frio River above Atascosa River

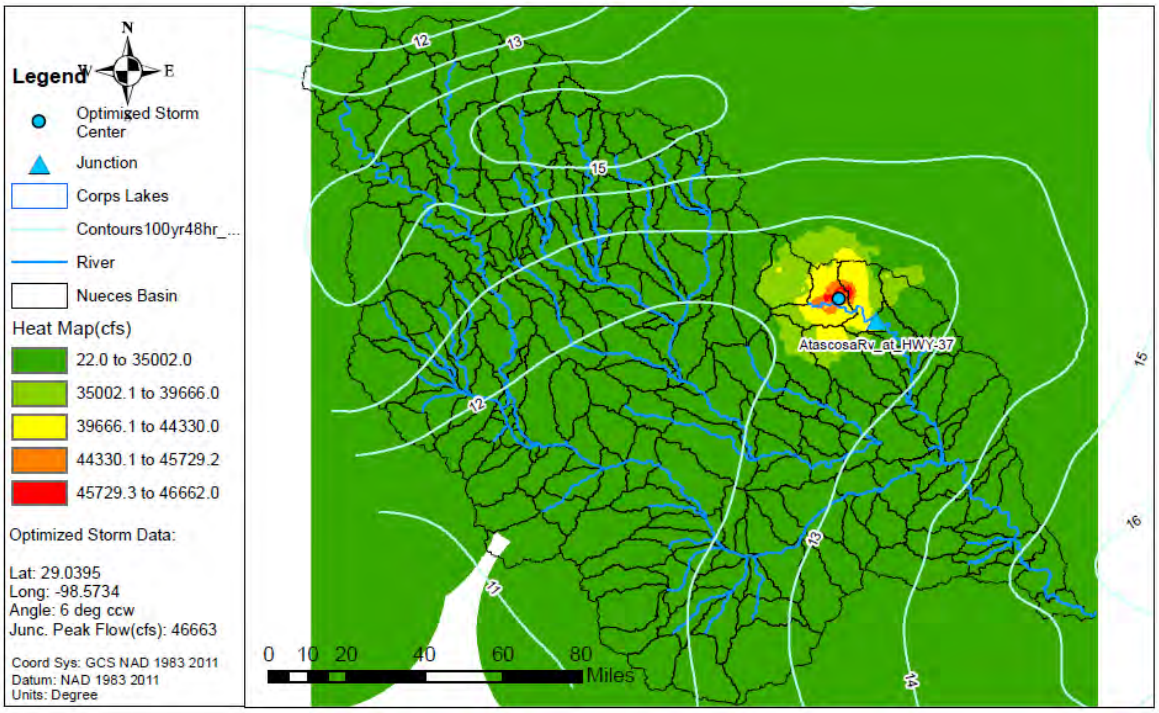

Figure C.11-116a: Elliptical Storm Optimization Heat Map for Atascosa River at Highway 37

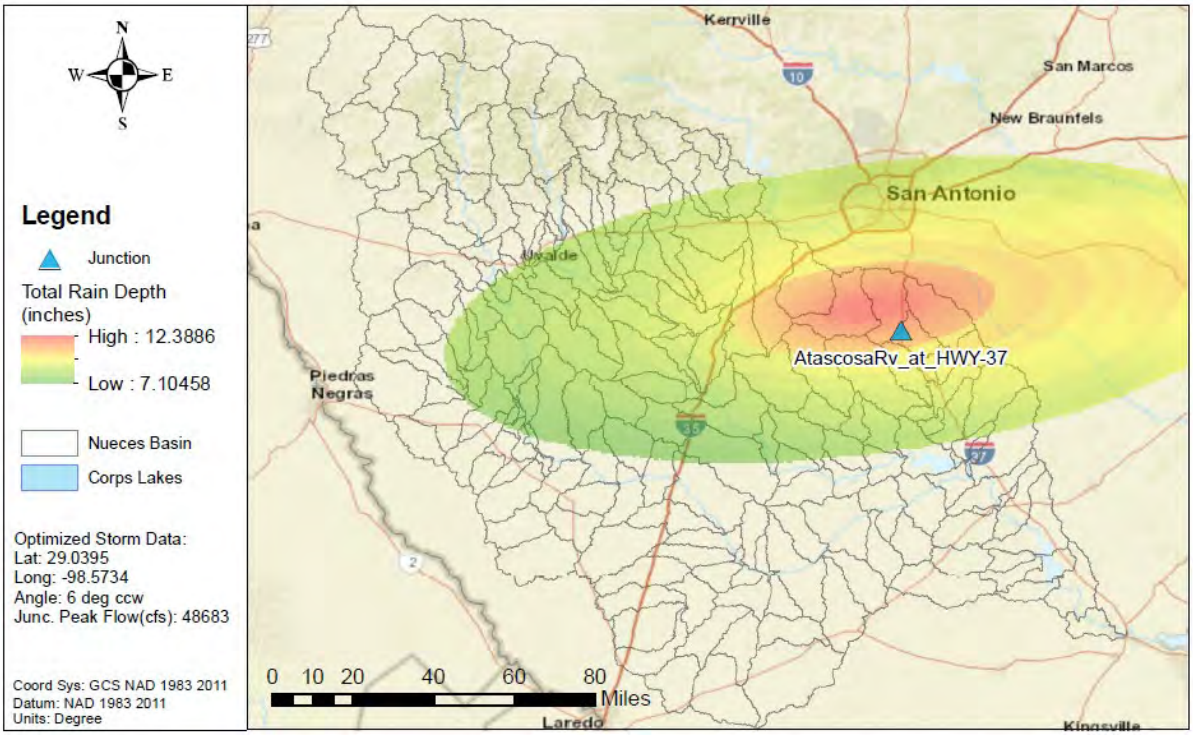

Figure C.11-116b: NA14 1% AEP Elliptical Storm for Atascosa River at Highway 37

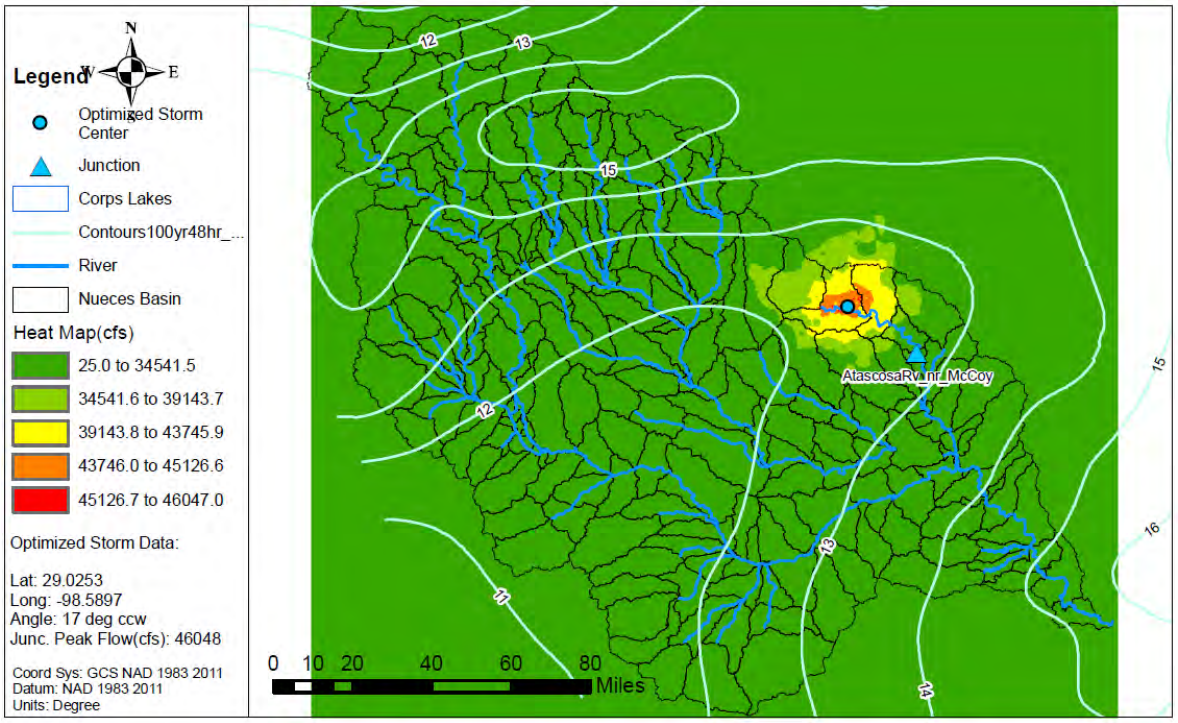

Figure C.11-117a: Elliptical Storm Optimization Heat Map for Atascosa River near McCoy (USGS gage 08207500)

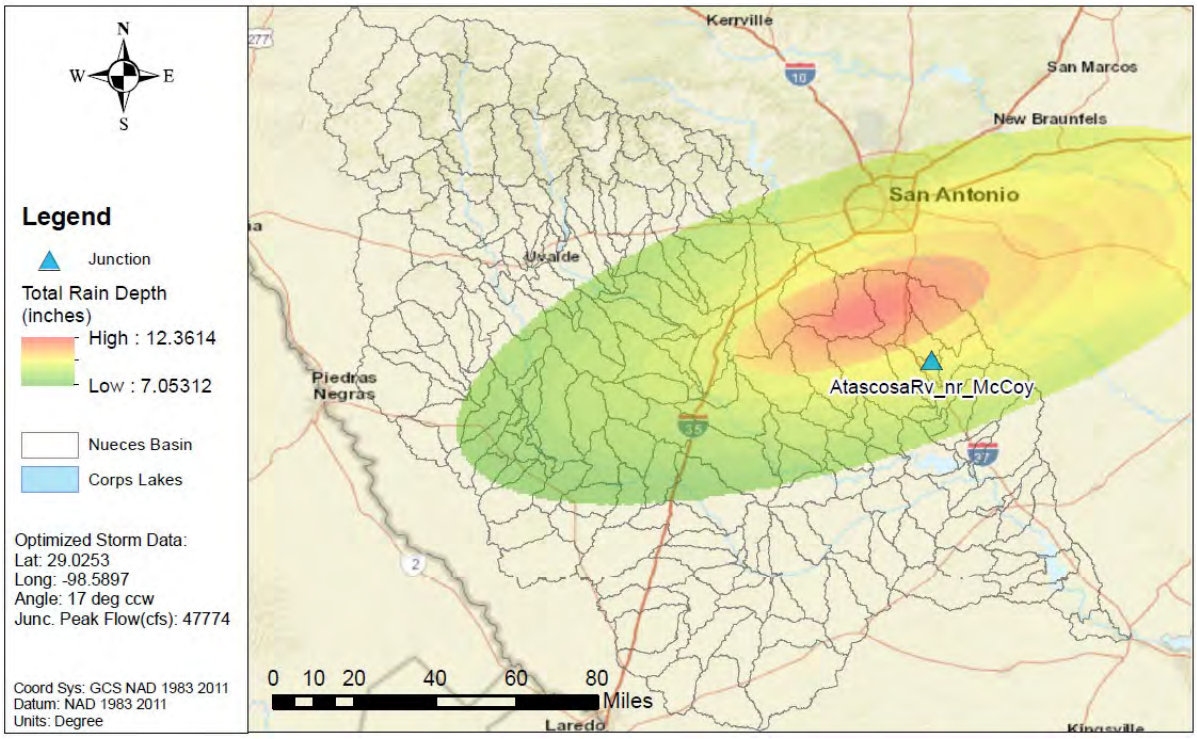

Figure C.11-117b: NA14 1% AEP Elliptical Storm for Atascosa River near McCoy (USGS gage 08207500)

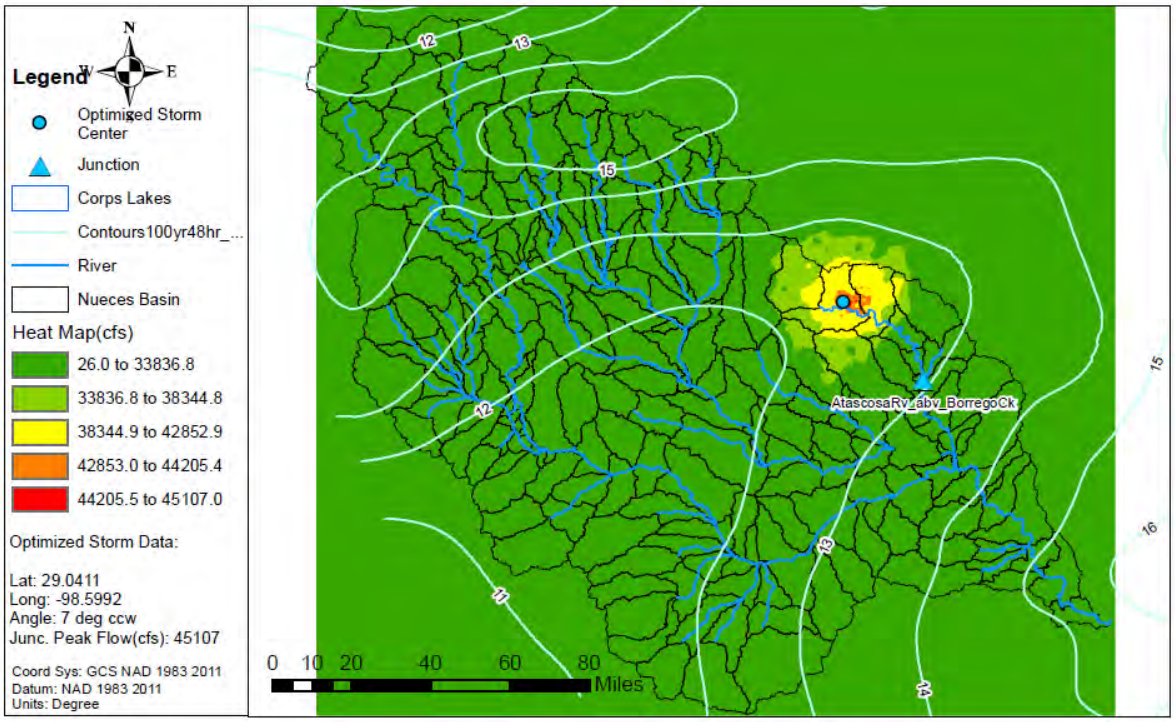

Figure C.11-118a: Elliptical Storm Optimization Heat Map for Atascosa River above Borrego Creek

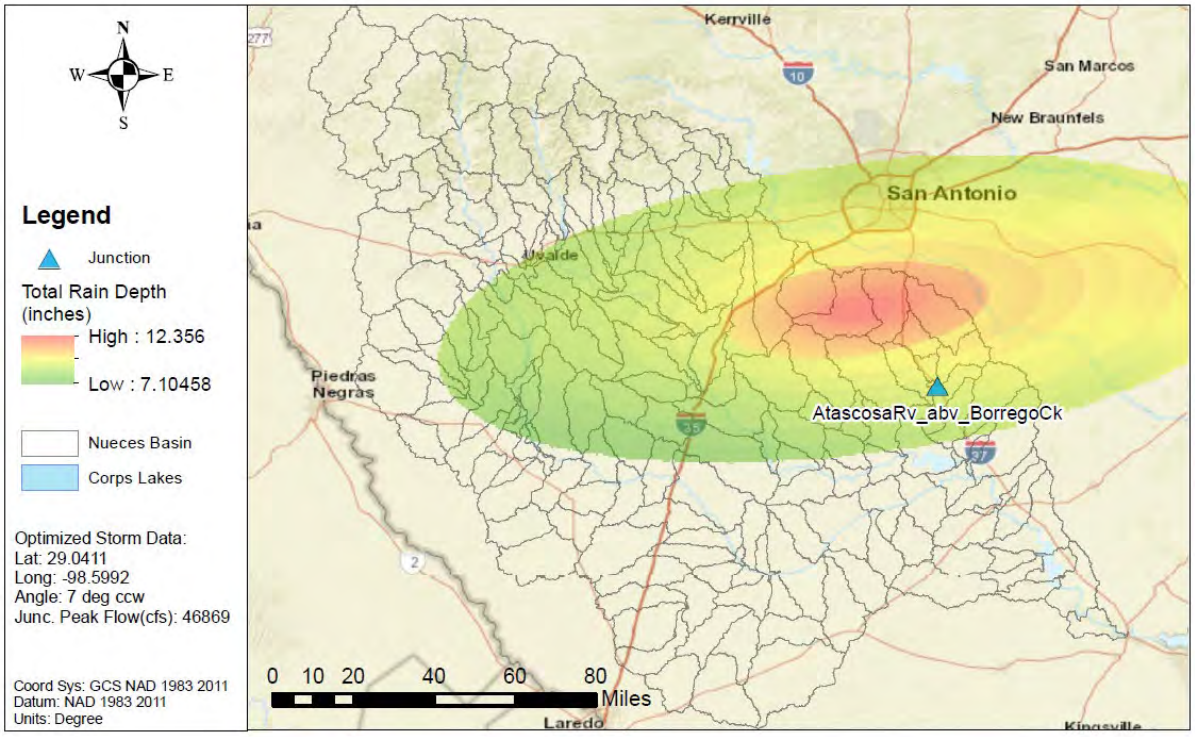

Figure C.11-118b: NA14 1% AEP Elliptical Storm for Atascosa River above Borrego Creek

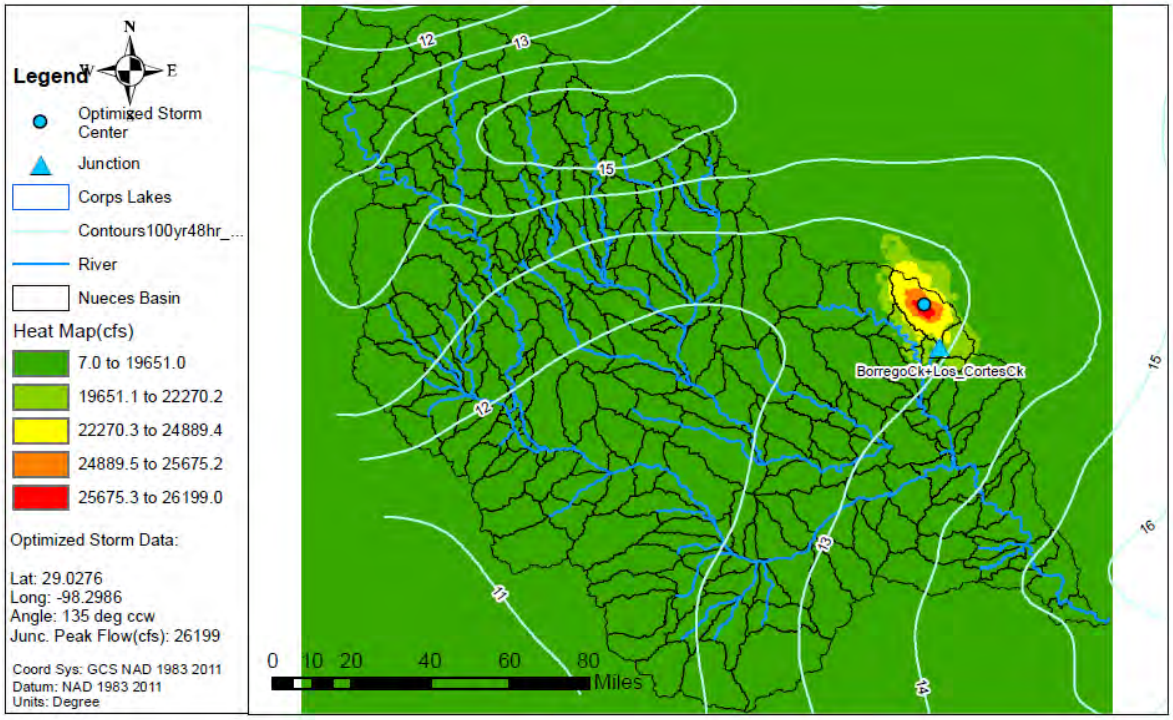

Figure C.11-119a: Elliptical Storm Optimization Heat Map for Borrego Creek and Los Cortes Creek

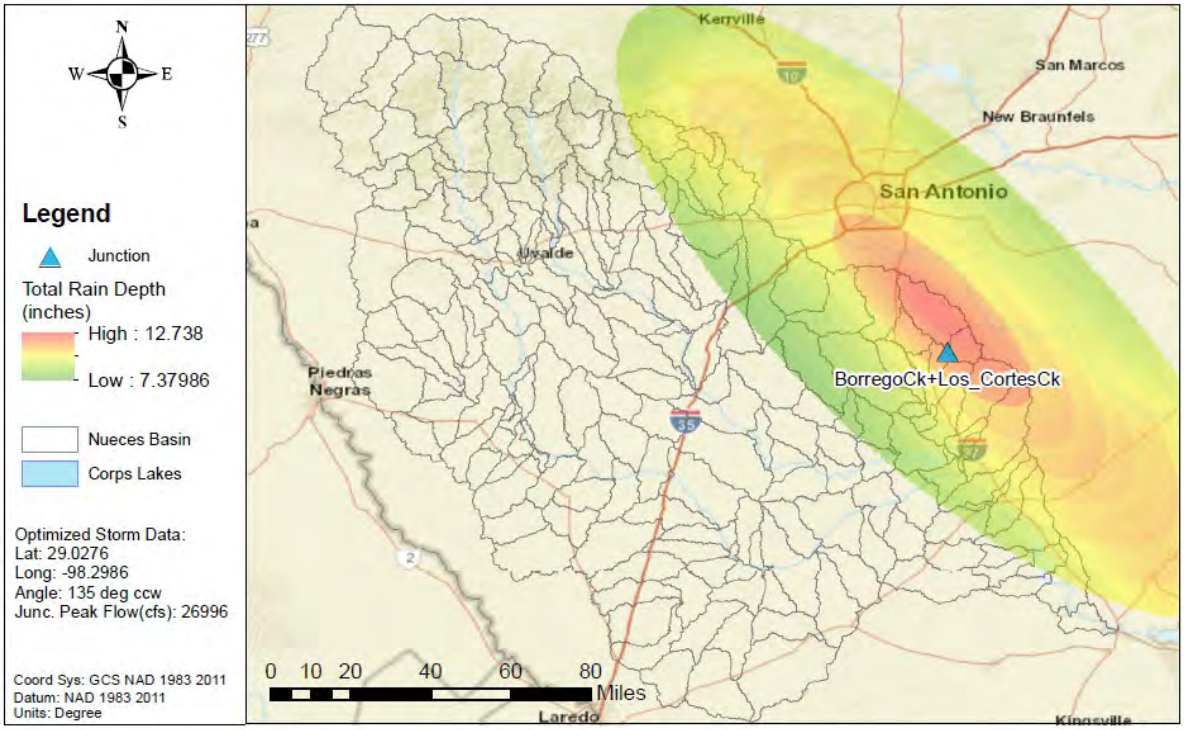

Figure C.11-119b: NA14 1% AEP Elliptical Storm for Borrego Creek and Los Cortes Creek

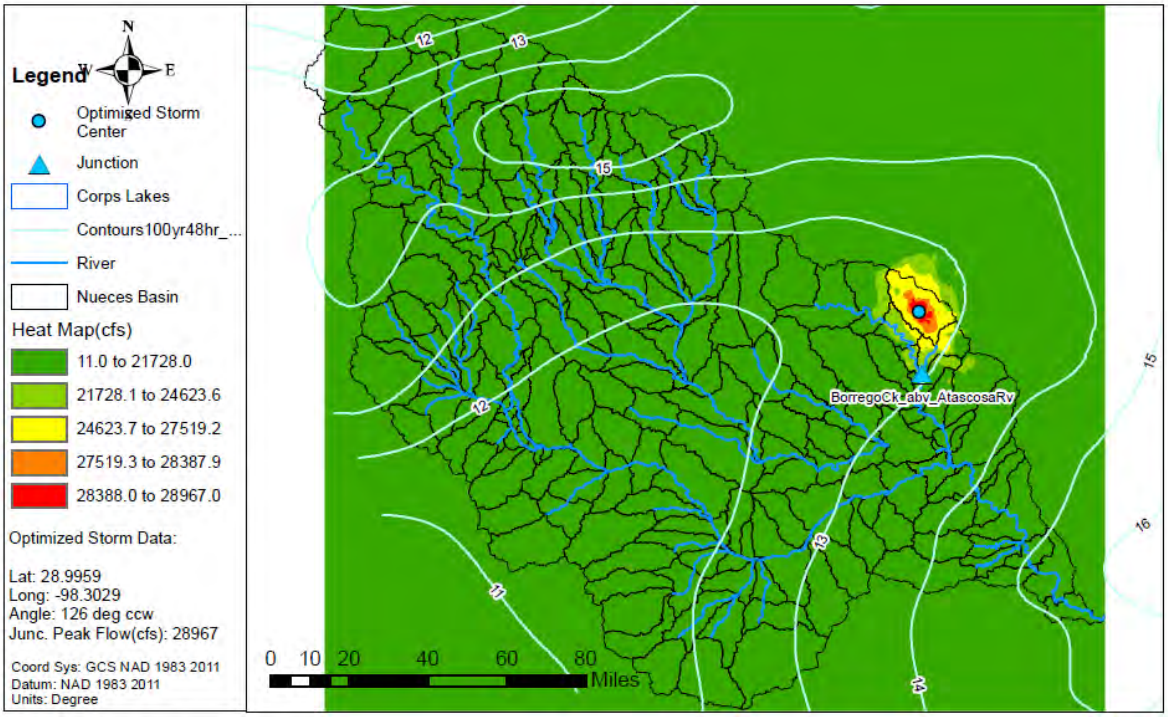

Figure C.11-120a: Elliptical Storm Optimization Heat Map for Borrego Creek above Atascosa River

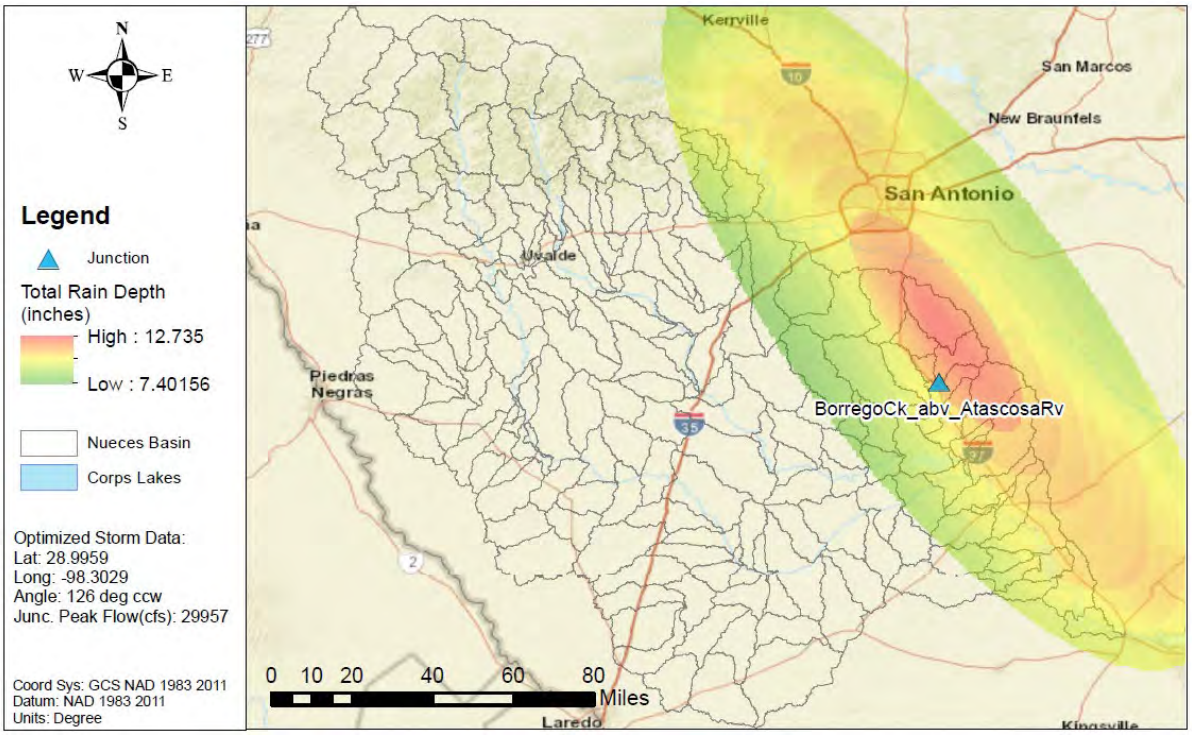

Figure C.11-120b: NA14 1% AEP Elliptical Storm for Borrego Creek above Atascosa River

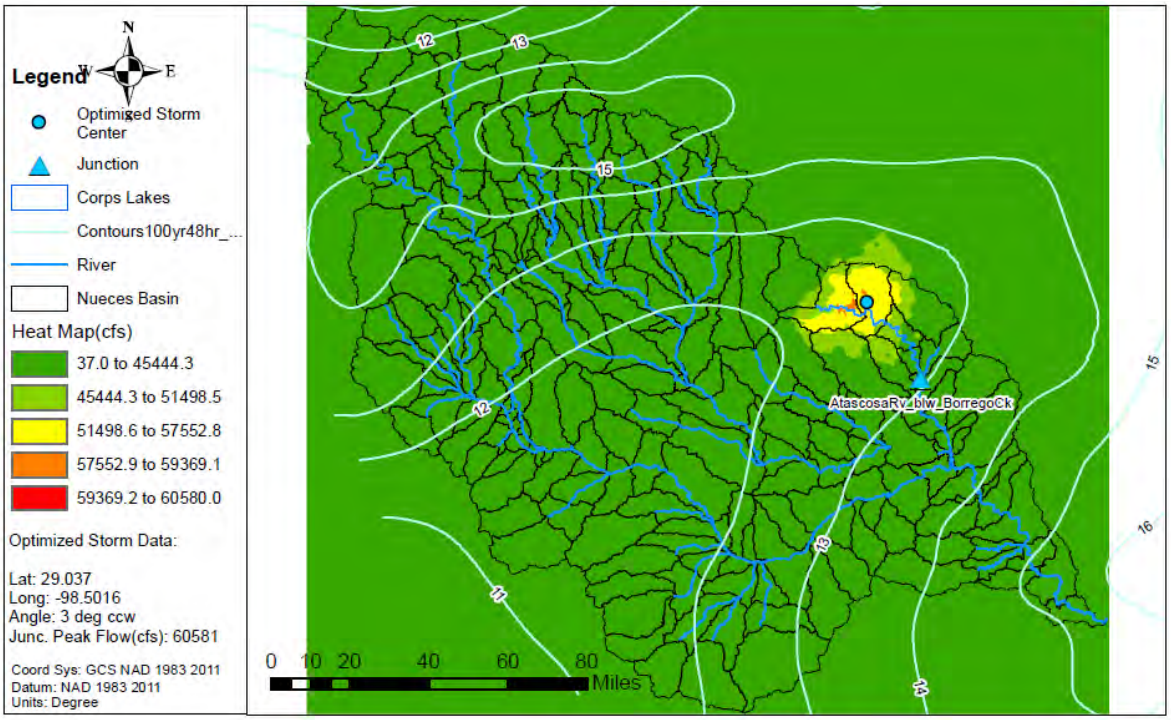

Figure C.11-121a: Elliptical Storm Optimization Heat Map for Atascosa River below Borrego Creek

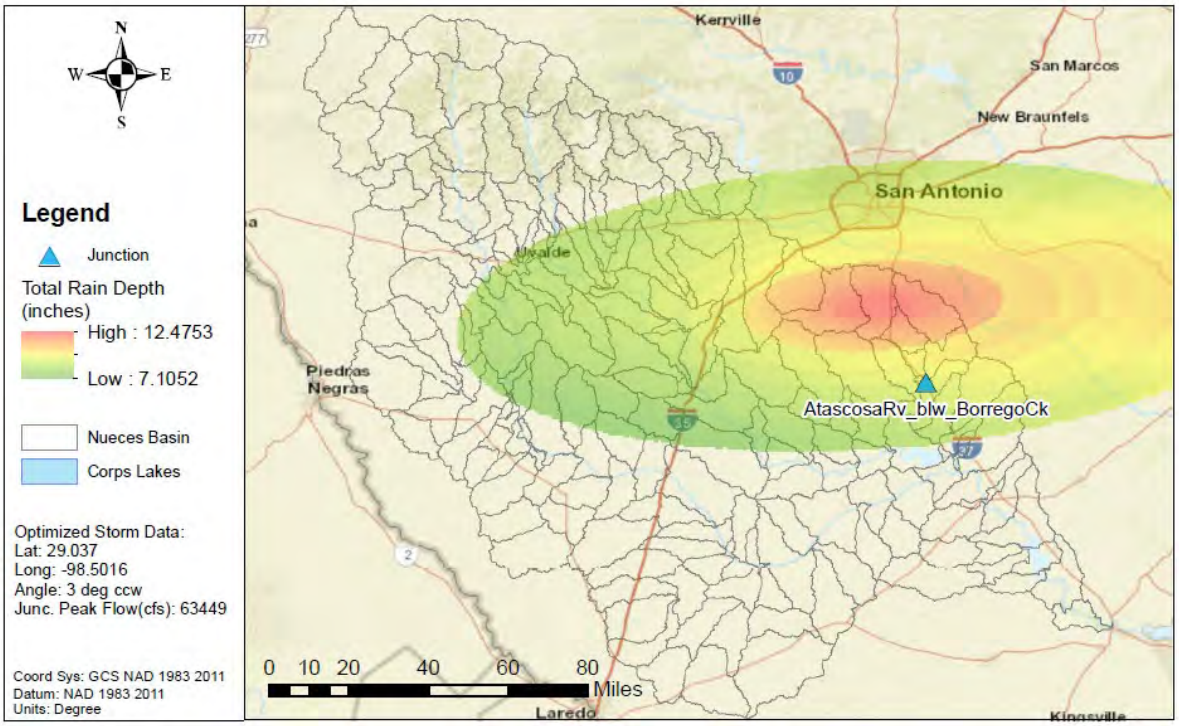

Figure C.11-121b: NA14 1% AEP Elliptical Storm for Atascosa River below Borrego Creek

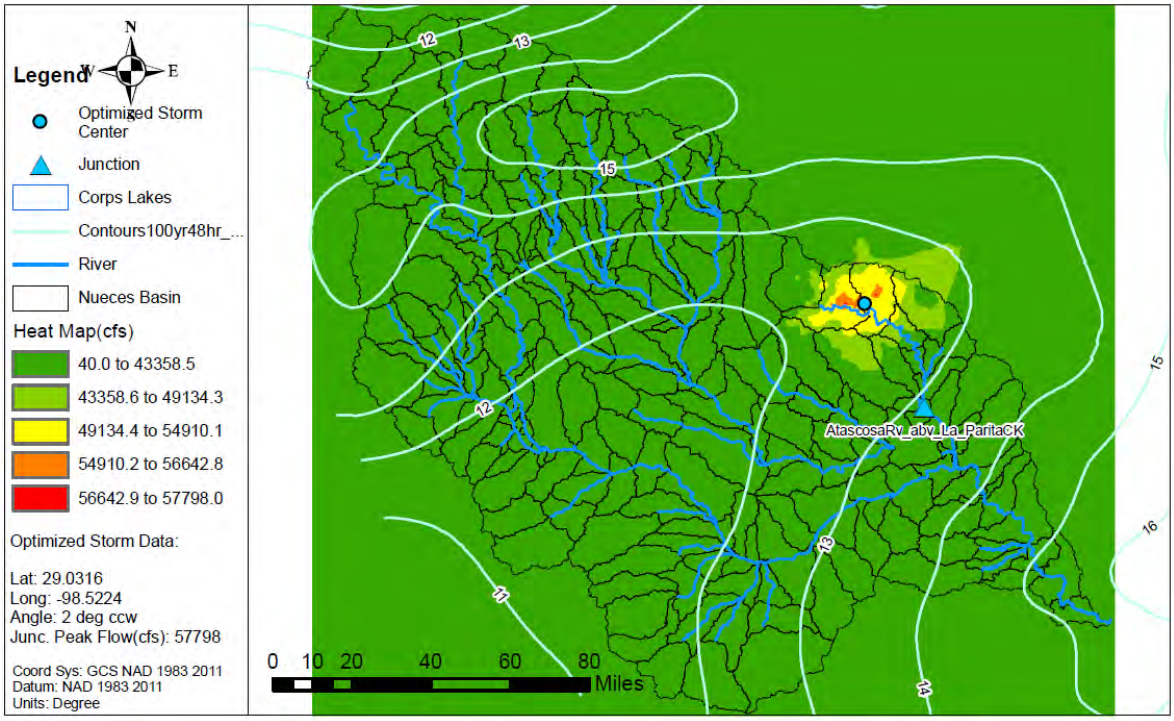

Figure C.11-122a: Elliptical Storm Optimization Heat Map for Atascosa River above La Parita Creek

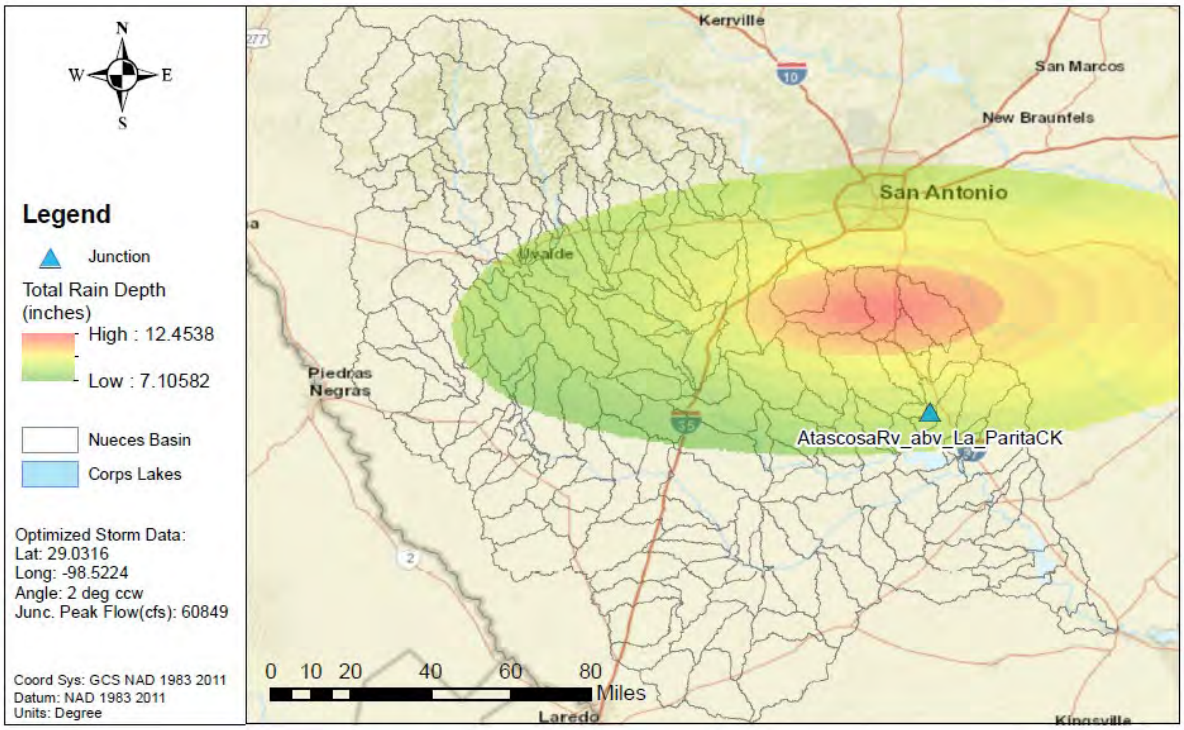

Figure C.11-122b: NA14 1% AEP Elliptical Storm for Atascosa River above La Parita Creek

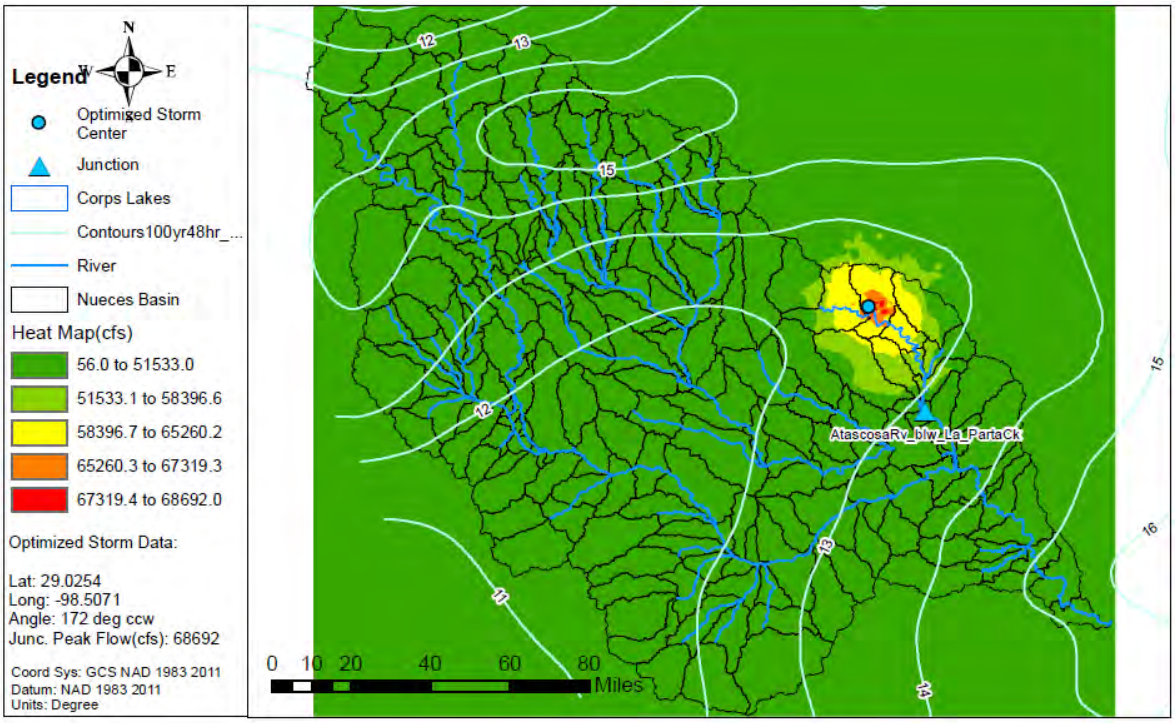

Figure C.11-123a: Elliptical Storm Optimization Heat Map for Atascosa River below La Parita Creek

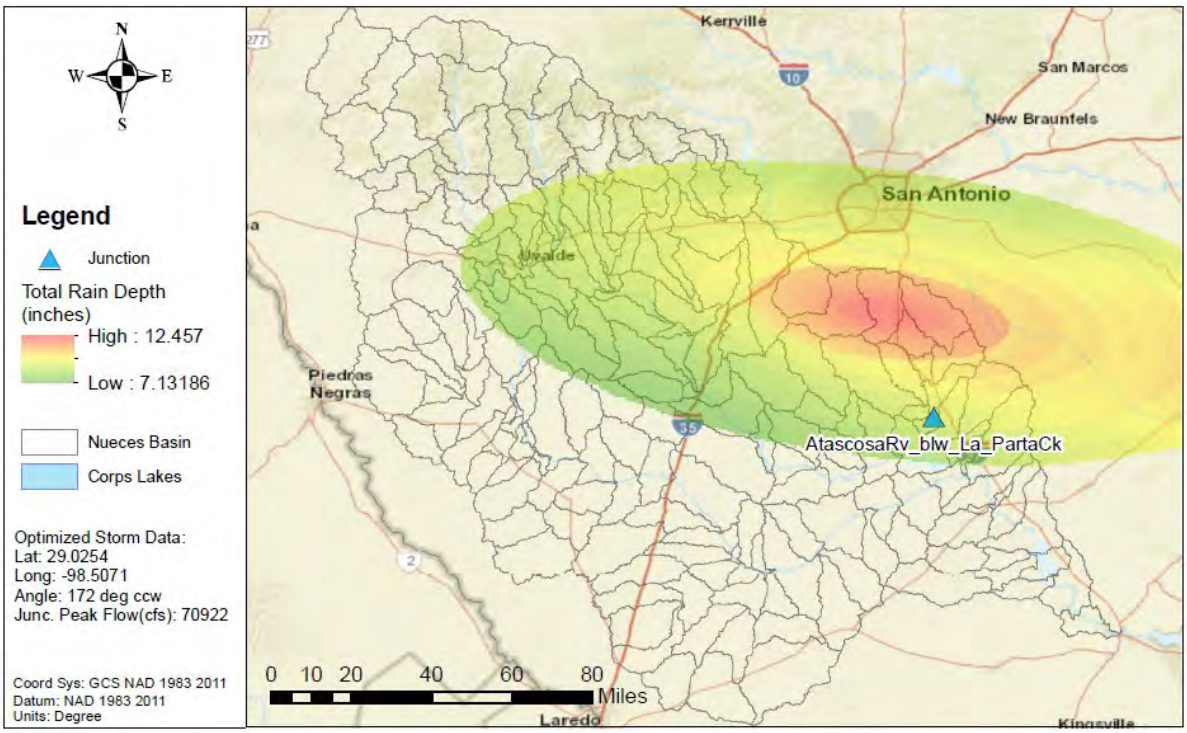

Figure C.11-123b: NA14 1% AEP Elliptical Storm for Atascosa River below La Parita Creek

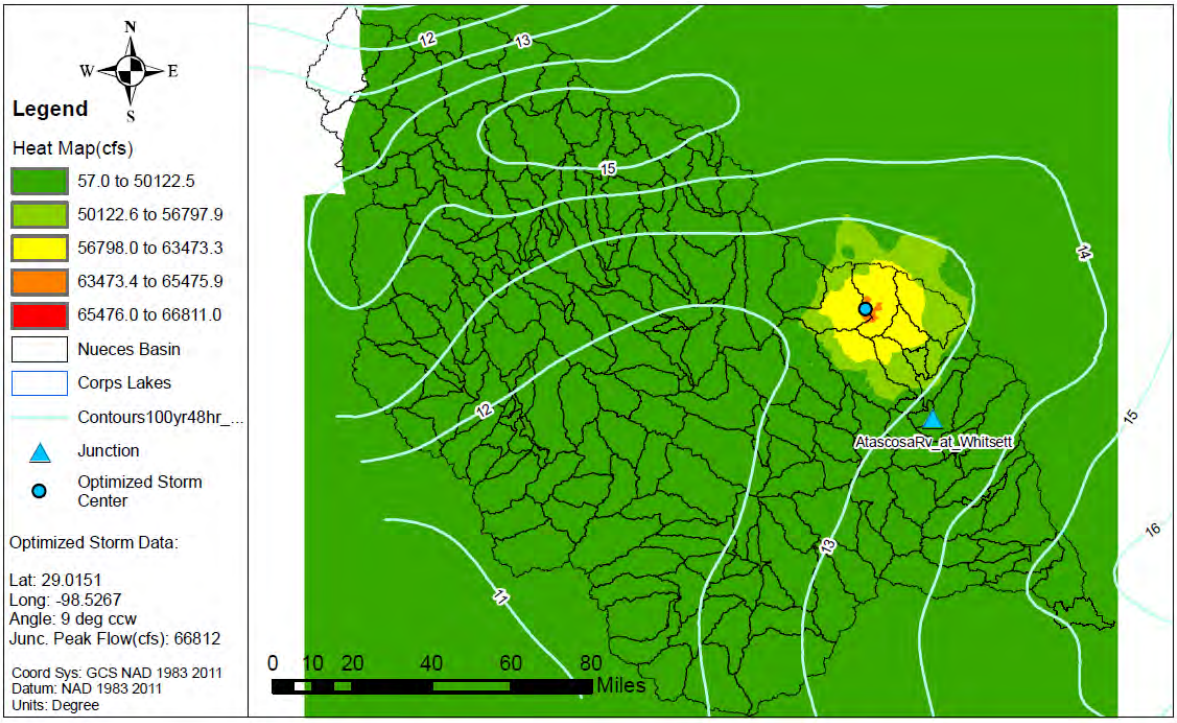

Figure C.11-124a: Elliptical Storm Optimization Heat Map for Atascosa River at Whitsett (USGS gage 0820800)

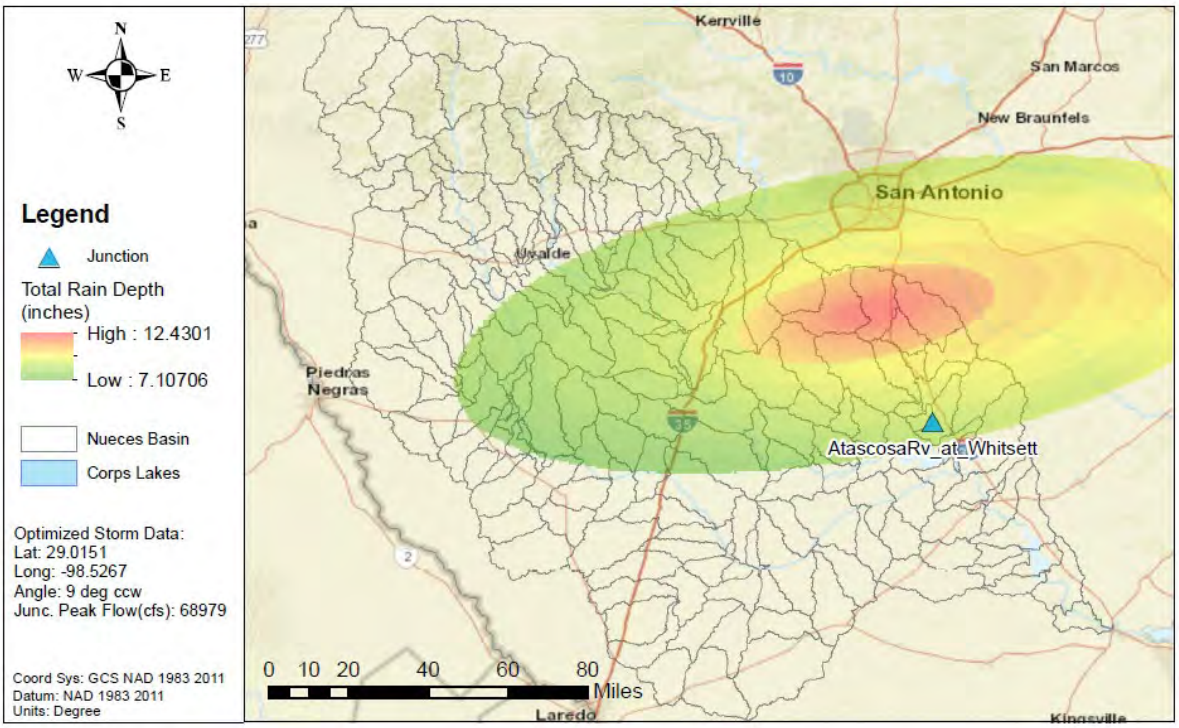

Figure C.11-124b: NA14 1% AEP Elliptical Storm for Atascosa River at Whitsett (USGS gage 0820800)

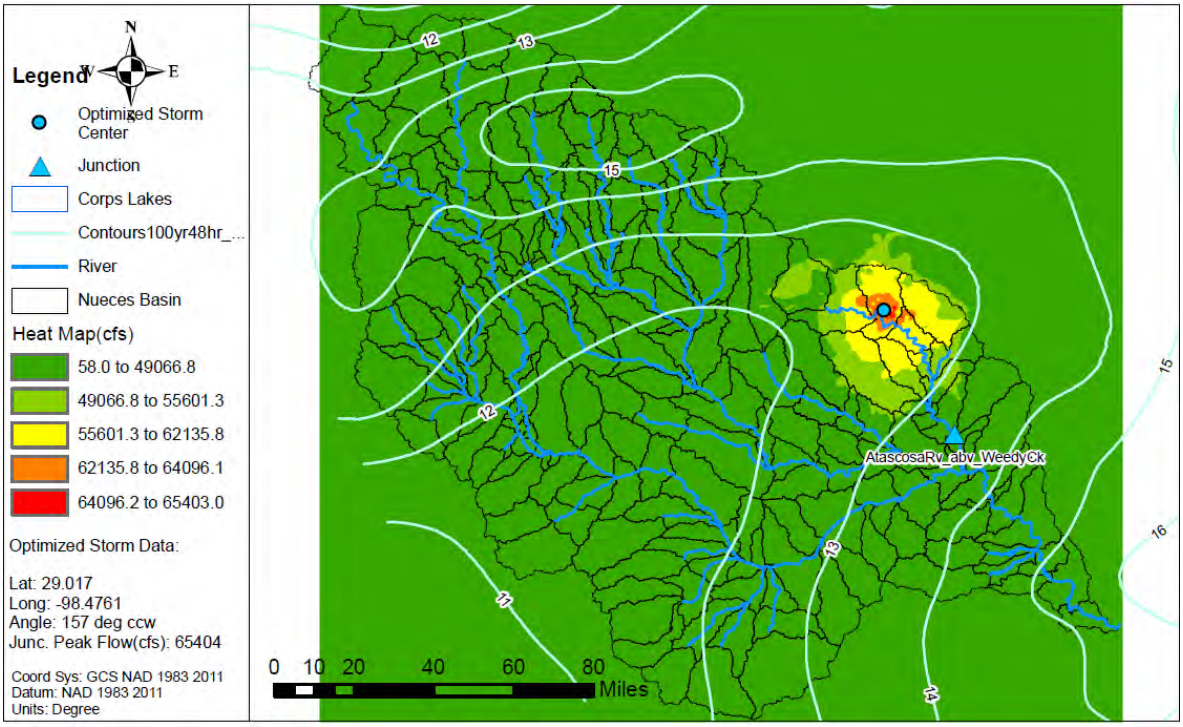

Figure C.11-125a: Elliptical Storm Optimization Heat Map for Atascosa River above Weedy Creek

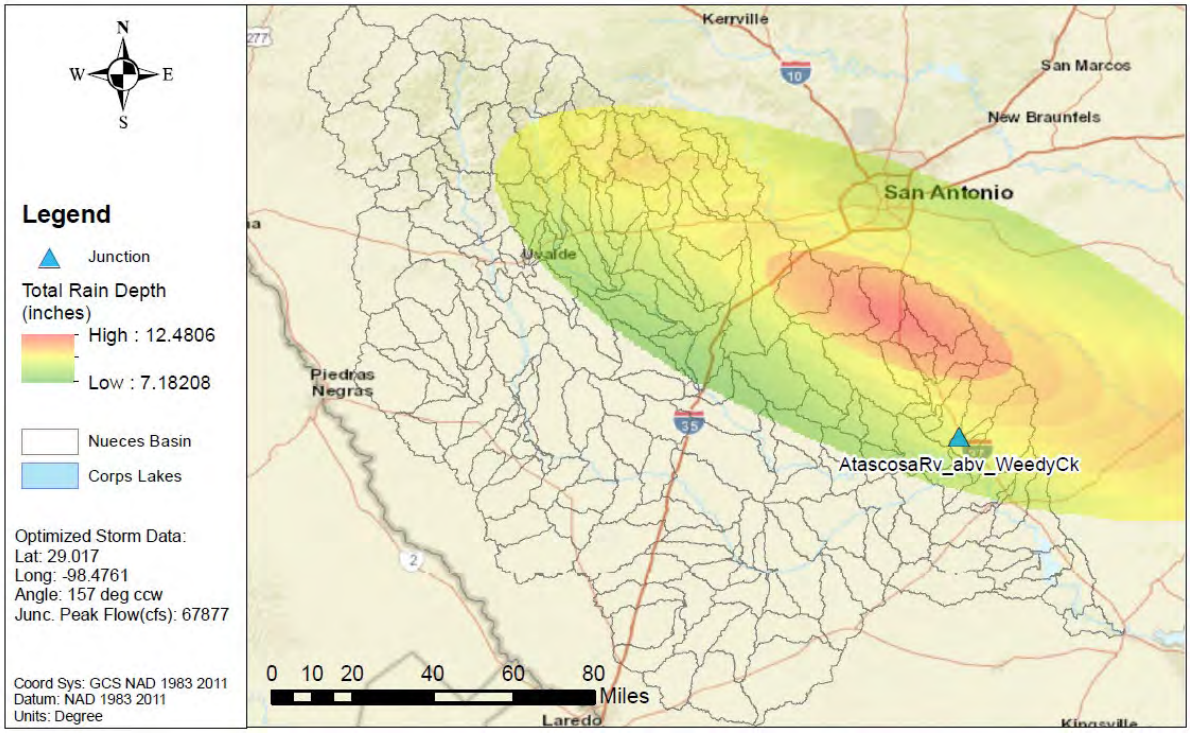

Figure C.11-125b: NA14 1% AEP Elliptical Storm for Atascosa River above Weedy Creek

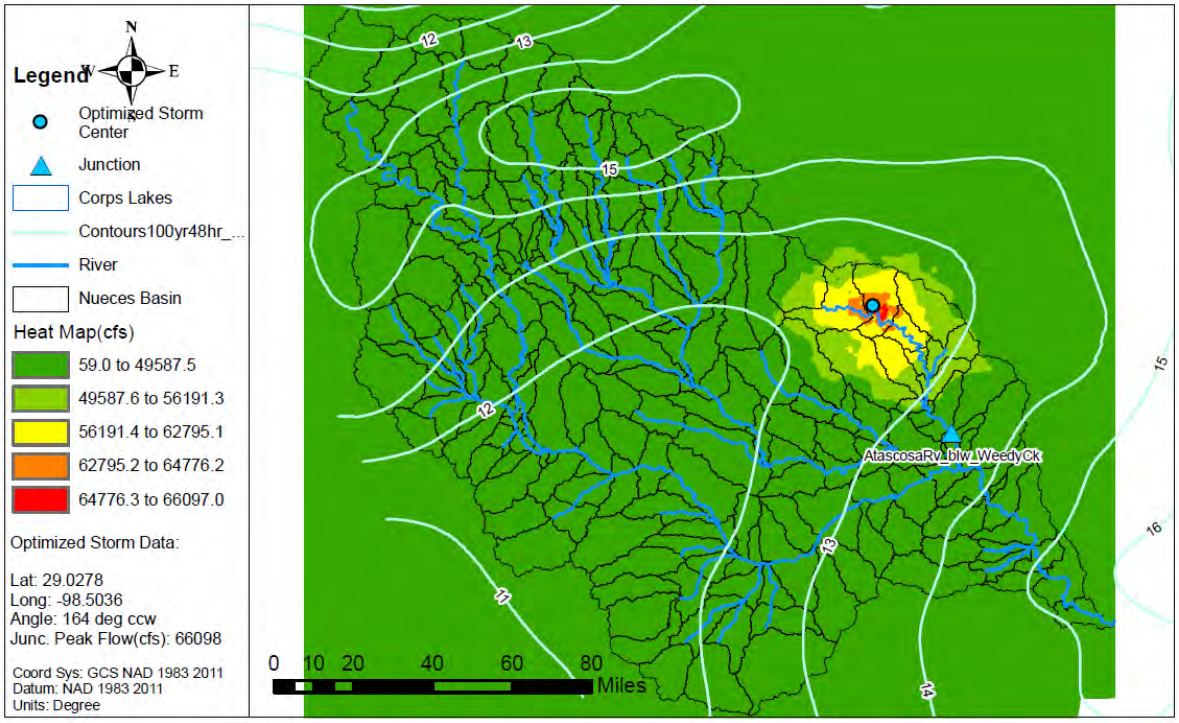

Figure C.11-126a: Elliptical Storm Optimization Heat Map for Atascosa River below Weedy Creek

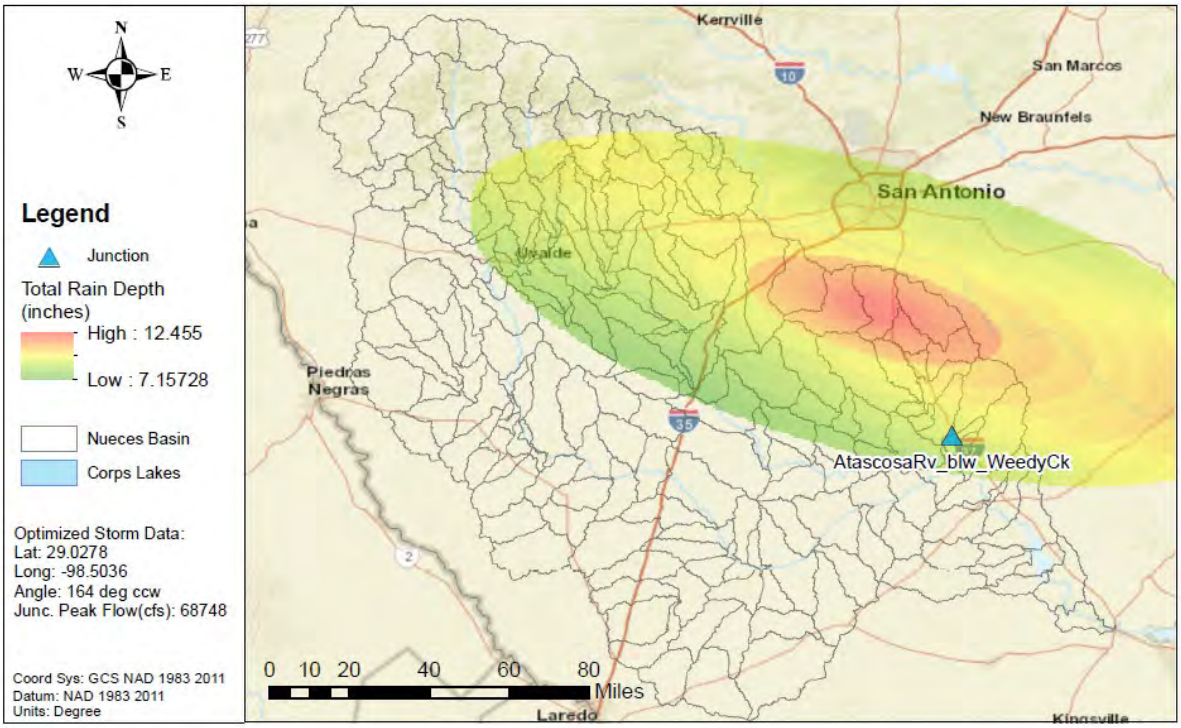

Figure C.11-126b: NA14 1% AEP Elliptical Storm for Atascosa River below Weedy Creek

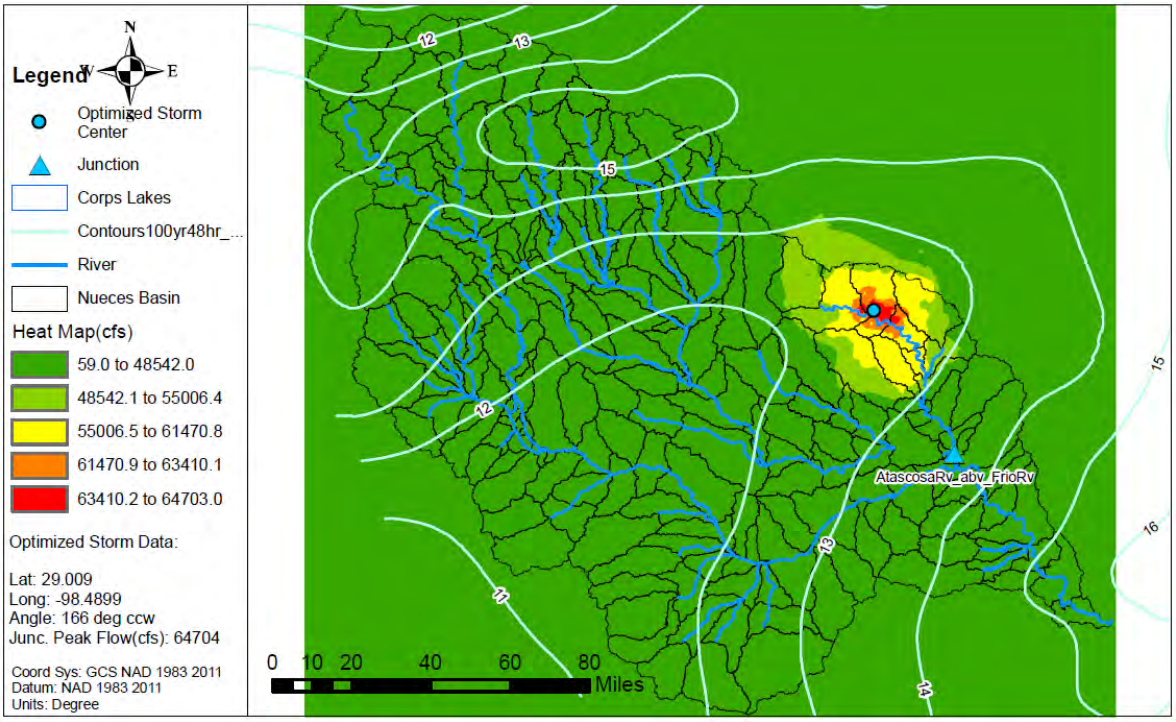

Figure C.11-127a: Elliptical Storm Optimization Heat Map for Atascosa River above Frio River

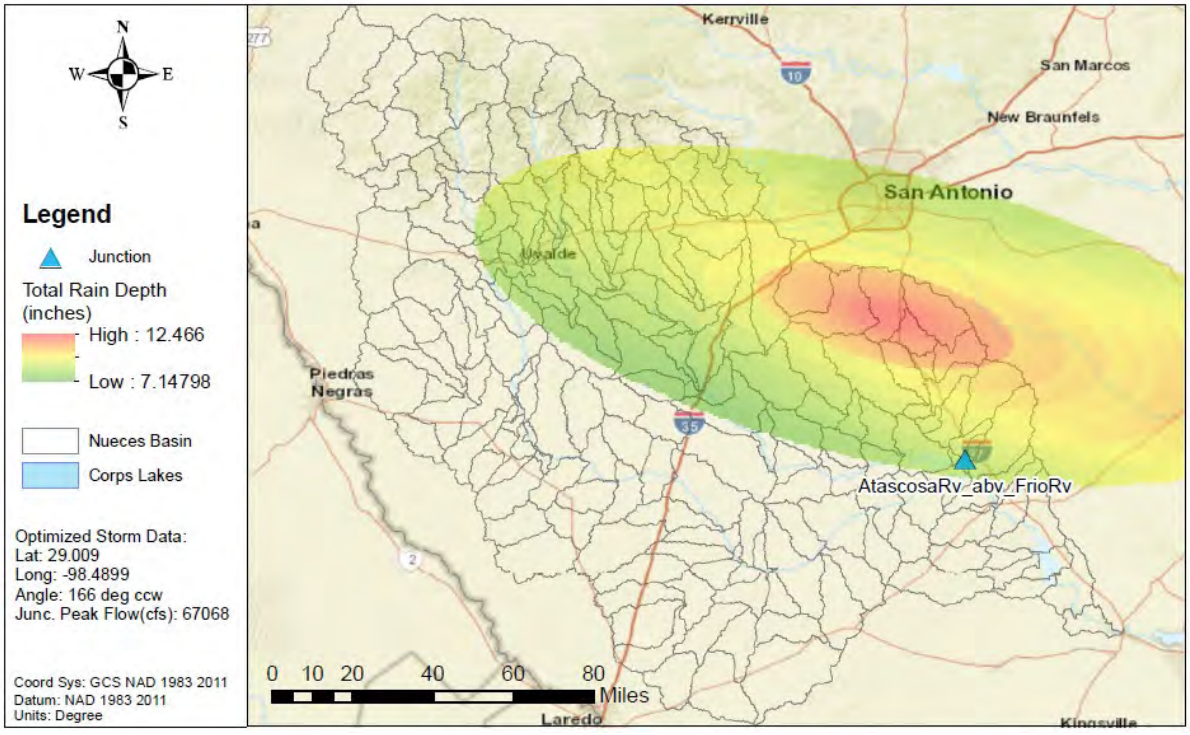

Figure C.11-127b: NA14 1% AEP Elliptical Storm for Atascosa River above Frio River

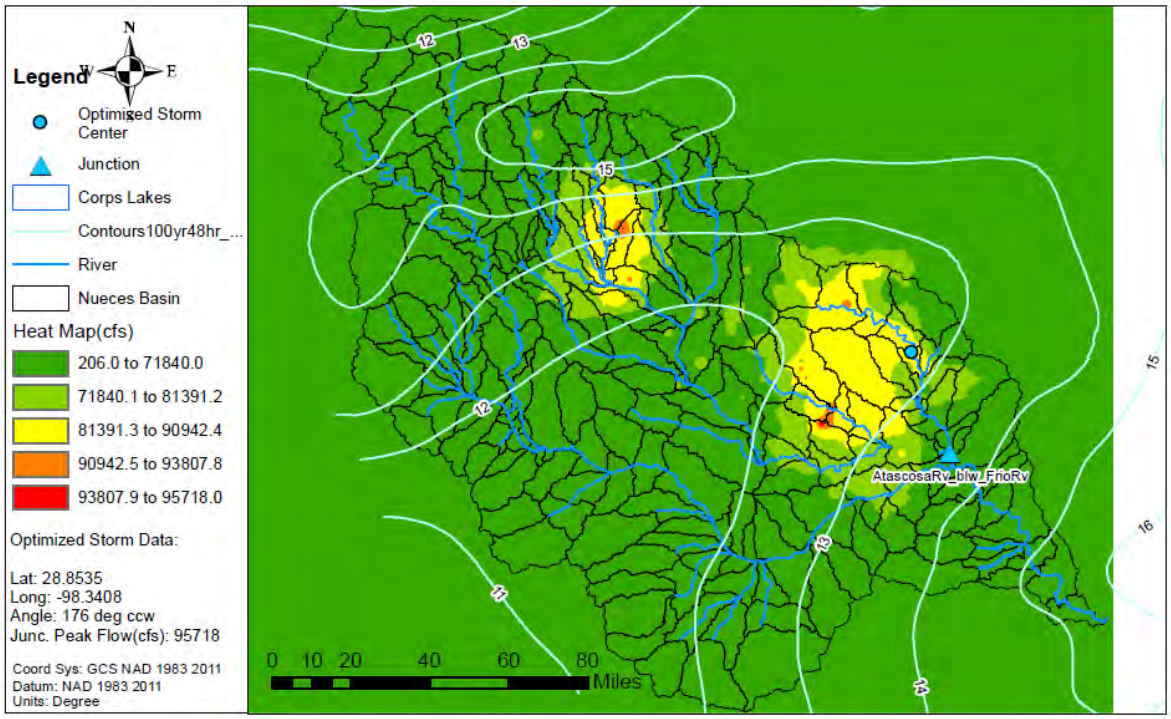

Figure C.11-128a: Elliptical Storm Optimization Heat Map for Atascosa River blw Frio River

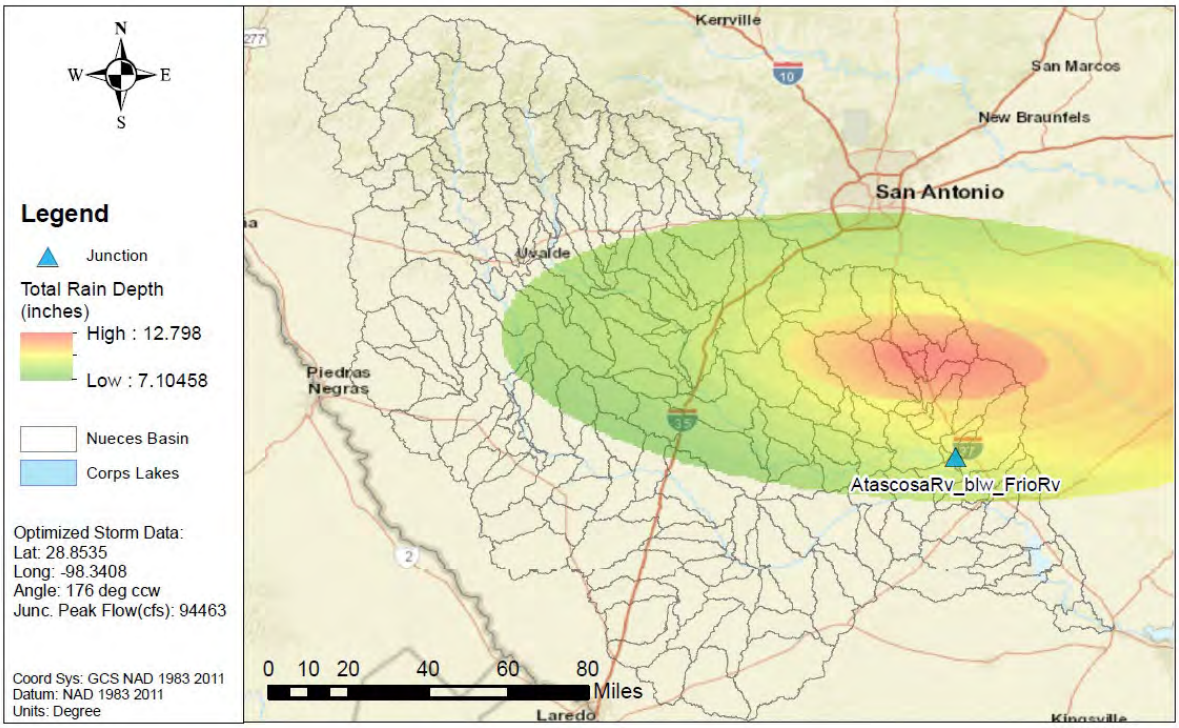

Figure C.11-128b: NA14 1% AEP Elliptical Storm for Atascosa River blw Frio River

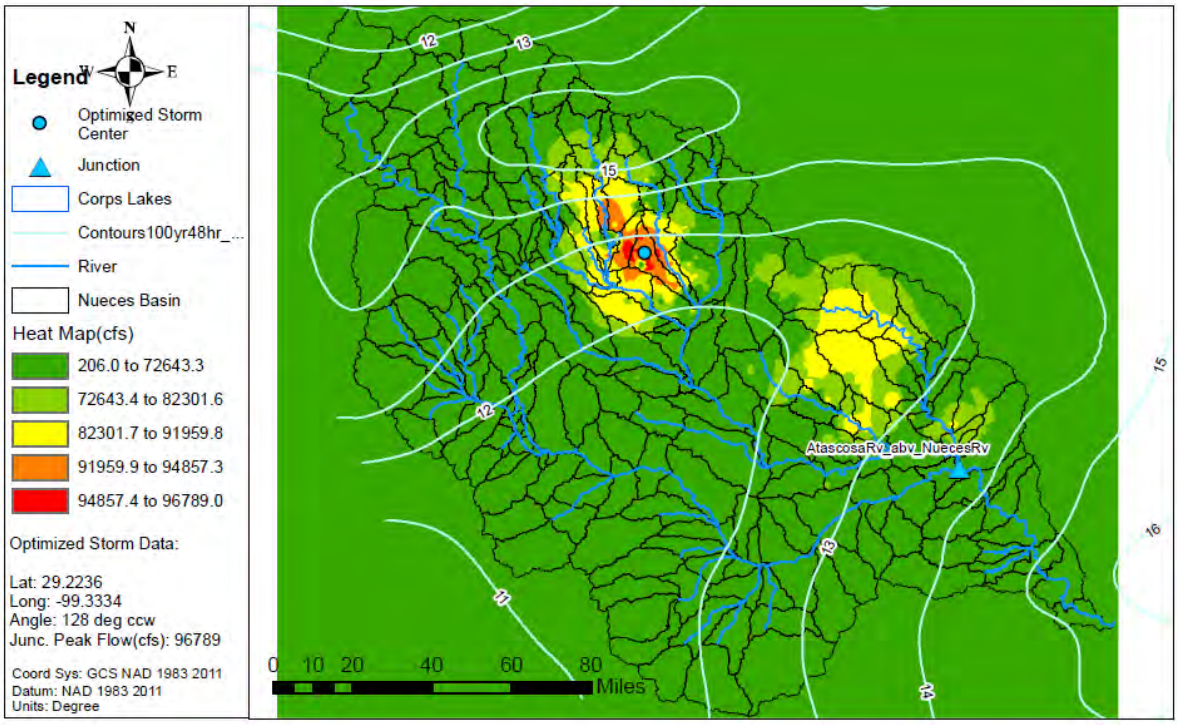

Figure C.11-129a: Elliptical Storm Optimization Heat Map for Atascosa River above Nueces River

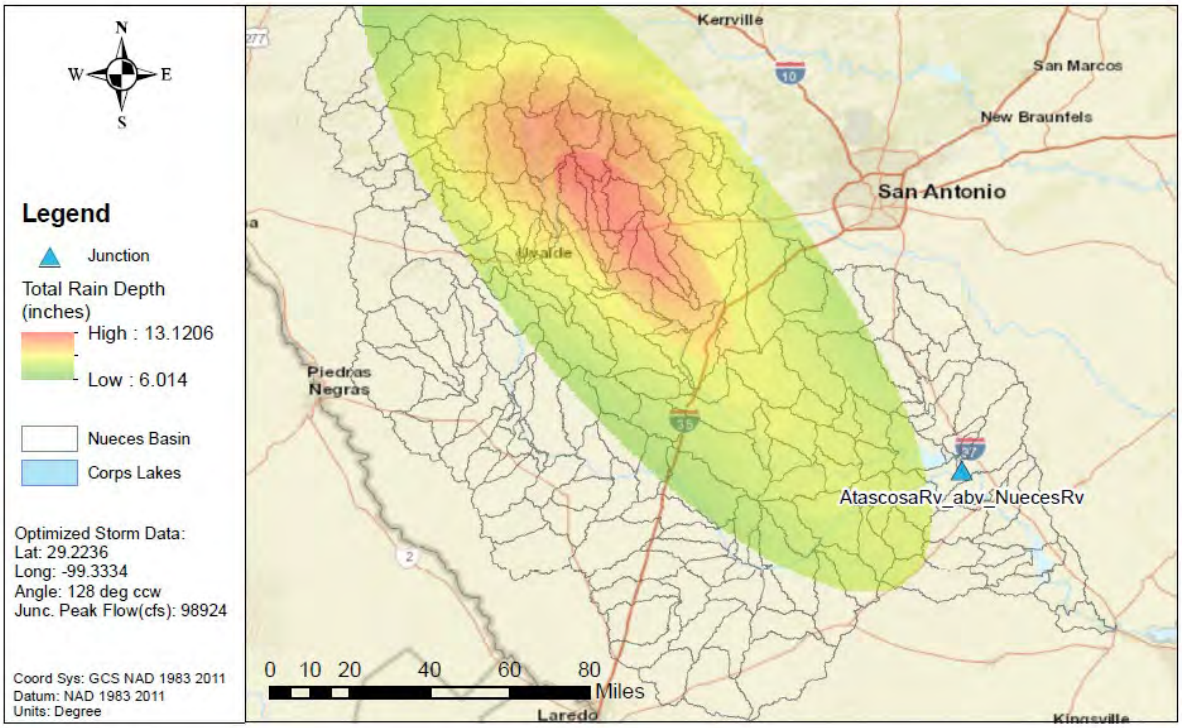

Figure C.11-129b: NA14 1% AEP Elliptical Storm for Atascosa River above Nueces River

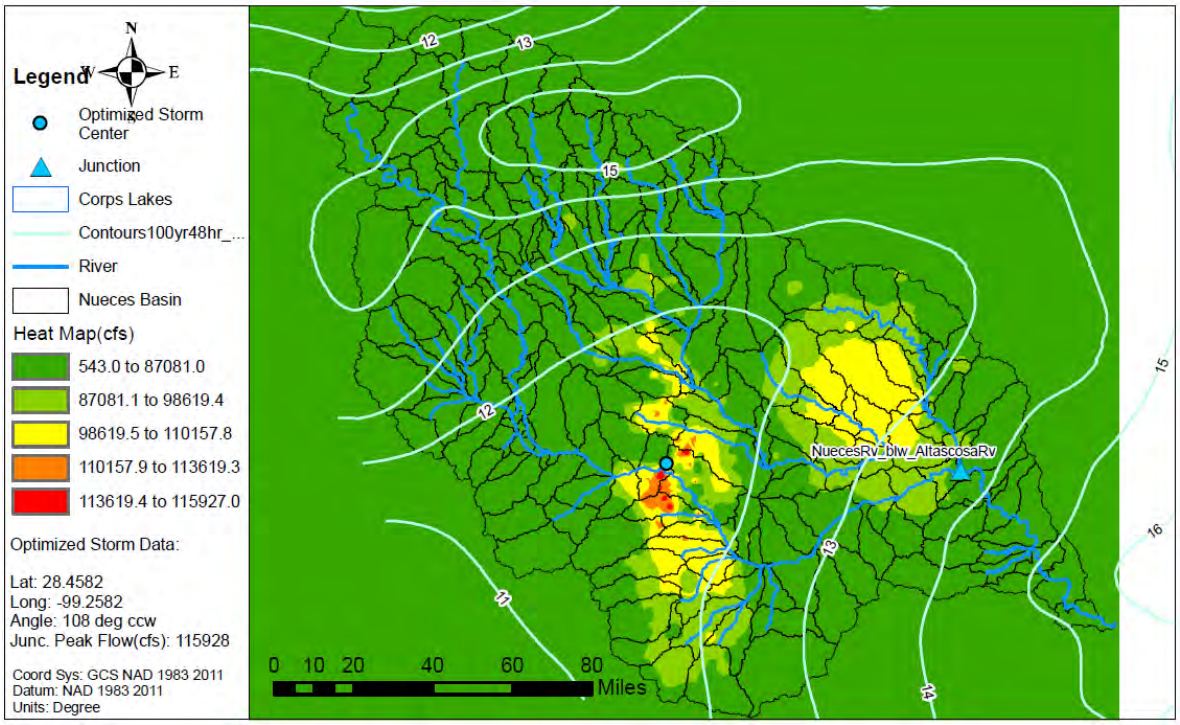

Figure C.11-130a: Elliptical Storm Optimization Heat Map for Nueces River below Atascosa River

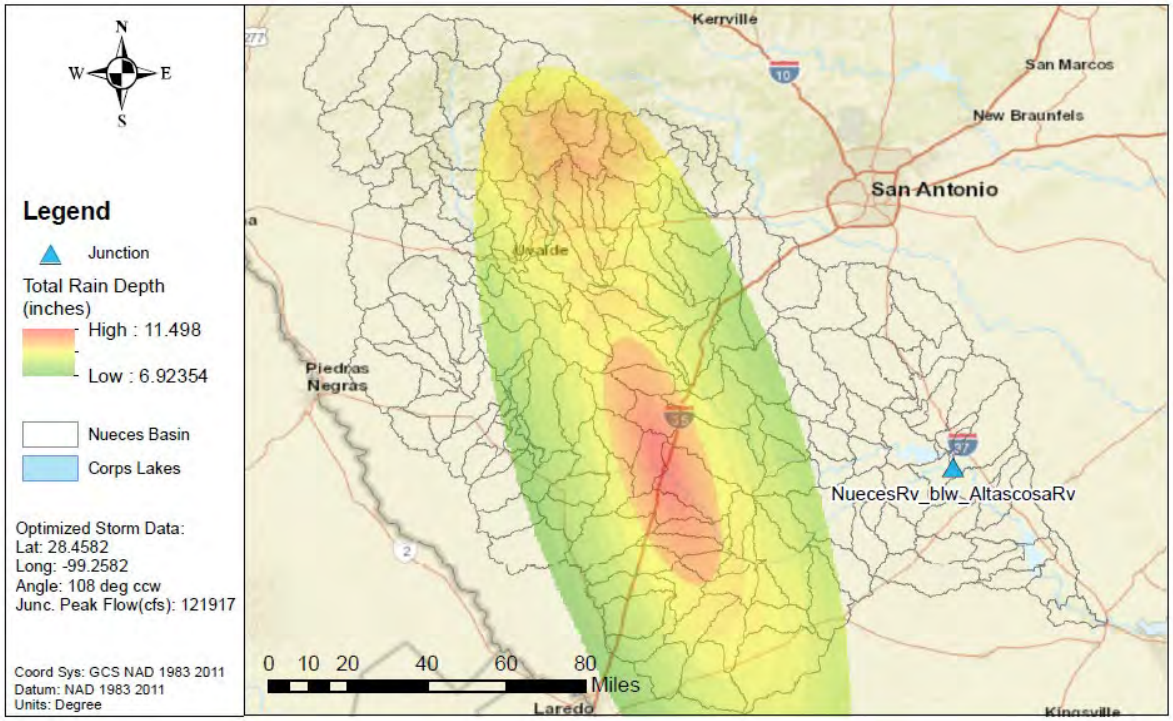

Figure C.11-130b: NA14 1% AEP Elliptical Storm for Nueces River below Atascosa River

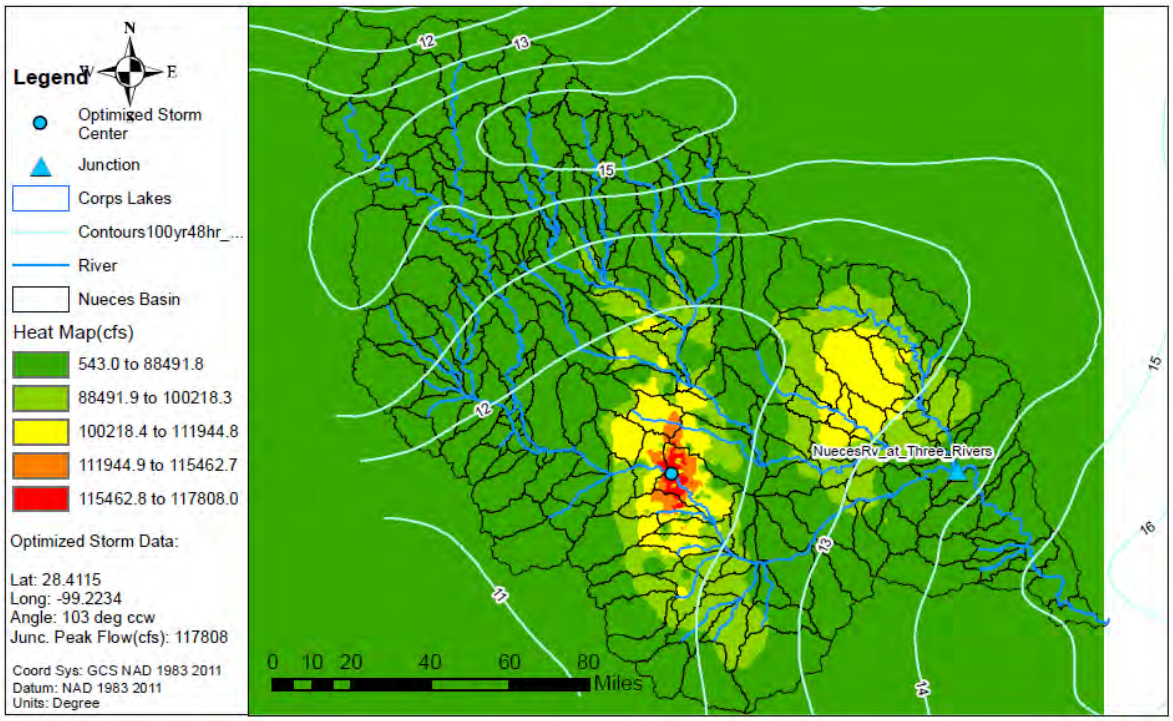

Figure C.11-131a: Elliptical Storm Optimization Heat Map for Nueces River at Three Rivers (USGS gage 08210000)

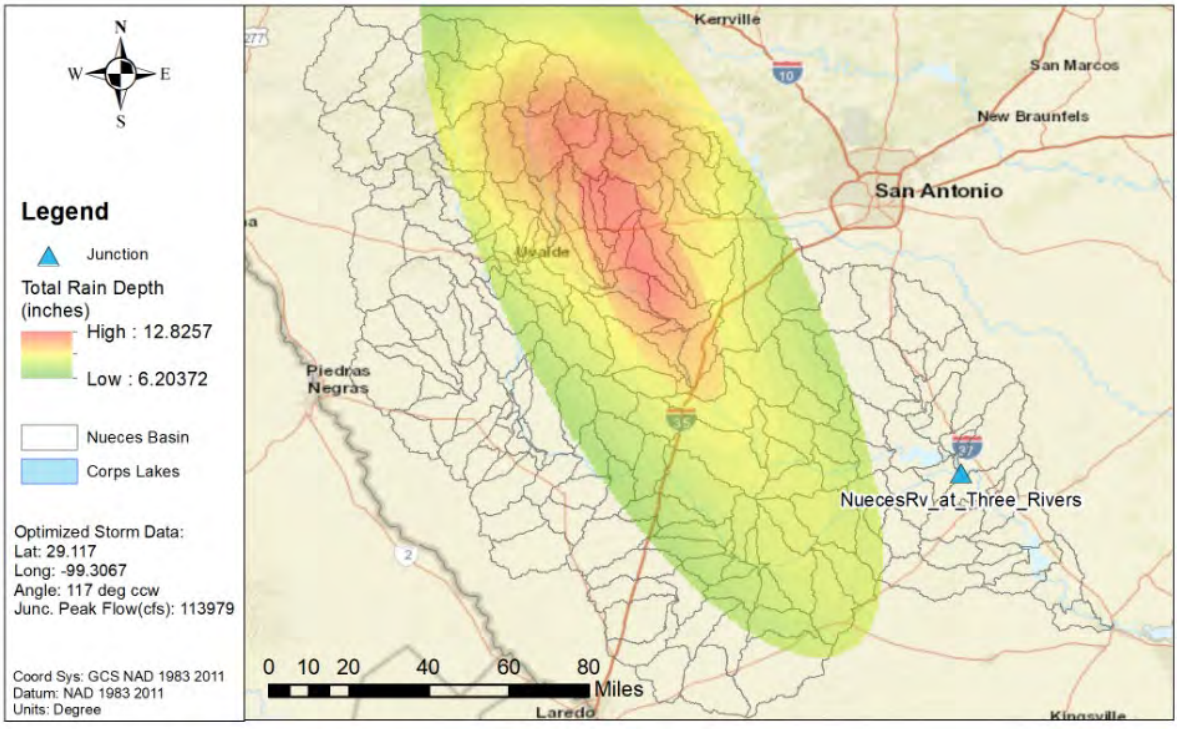

Figure C.11-131b: NA14 1% AEP Elliptical Storm for Nueces River at Three Rivers (USGS gage 08210000)

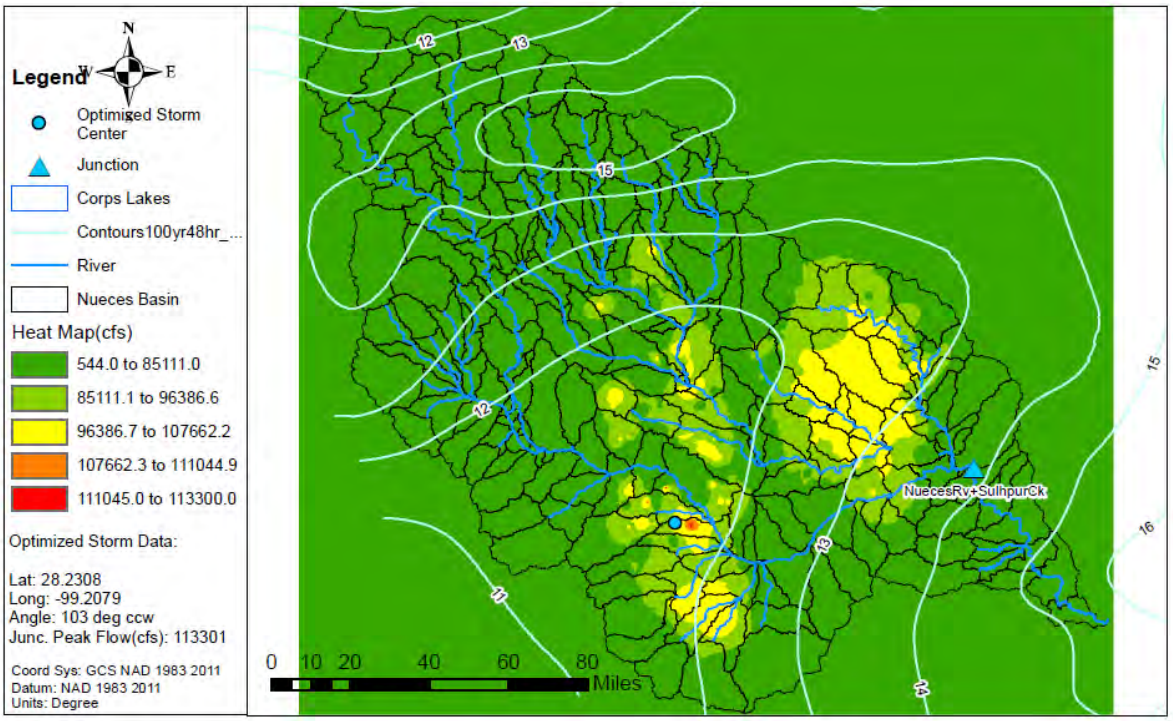

Figure C.11-132a: Elliptical Storm Optimization Heat Map for Nueces River and Sulphur Creek

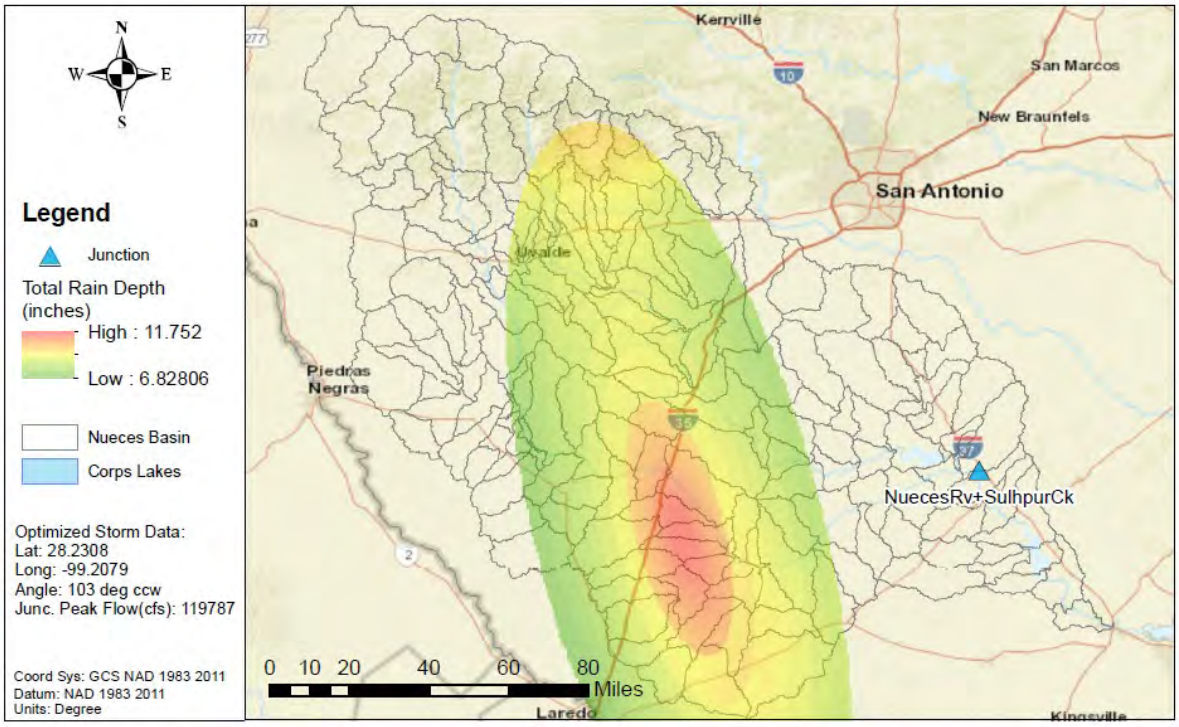

Figure C.11-132b: NA14 1% AEP Elliptical Storm for Nueces River and Sulphur Creek

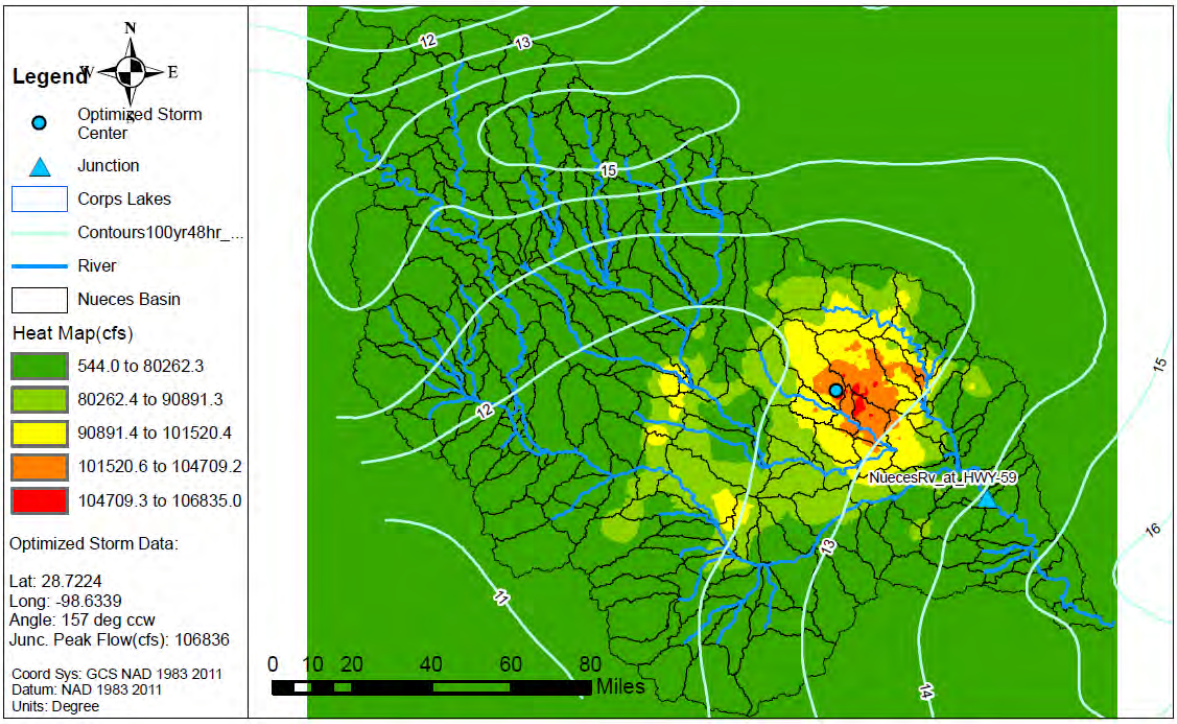

Figure C.11-133a: Elliptical Storm Optimization Heat Map for Nueces River at Highway 59

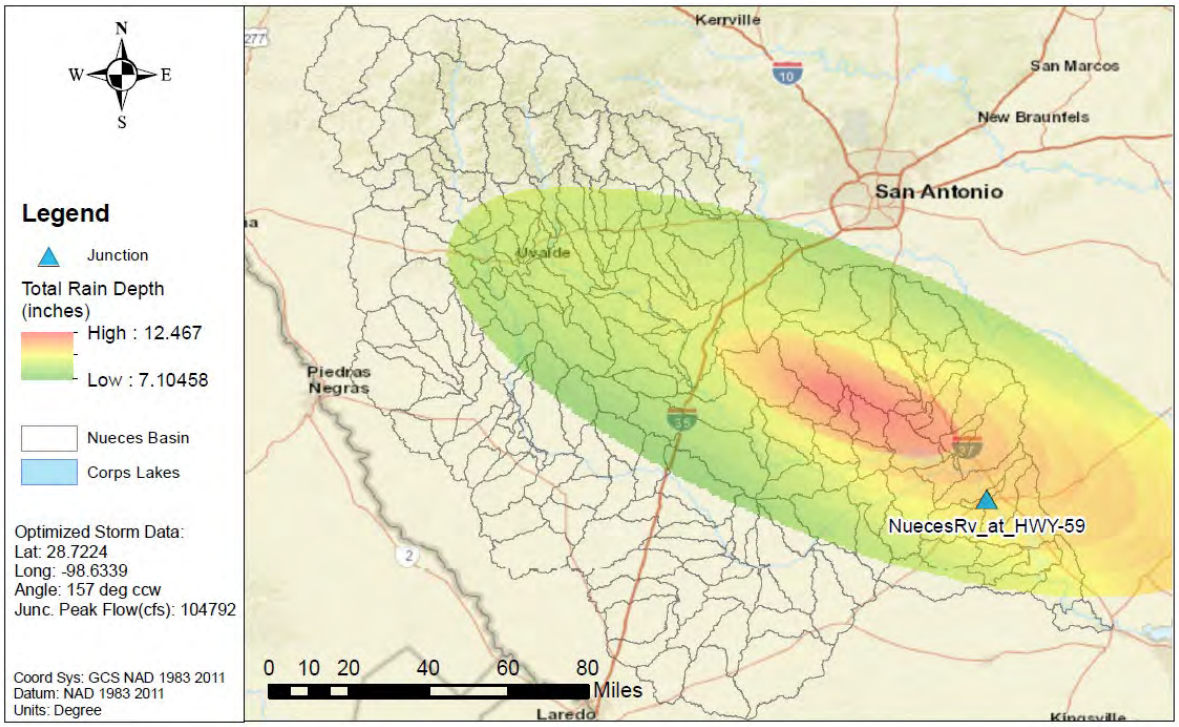

Figure C.11-133b: NA14 1% AEP Elliptical Storm for Nueces River at Highway 59

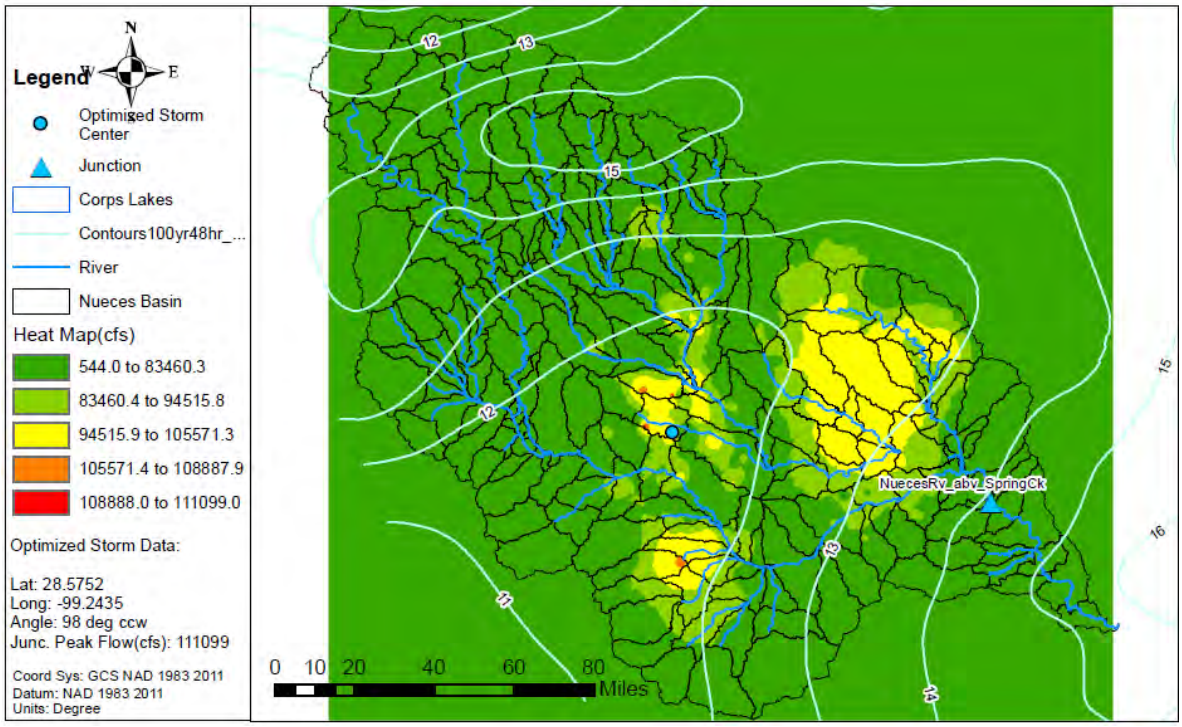

Figure C.11-134a: Elliptical Storm Optimization Heat Map for Nueces River above Spring Creek

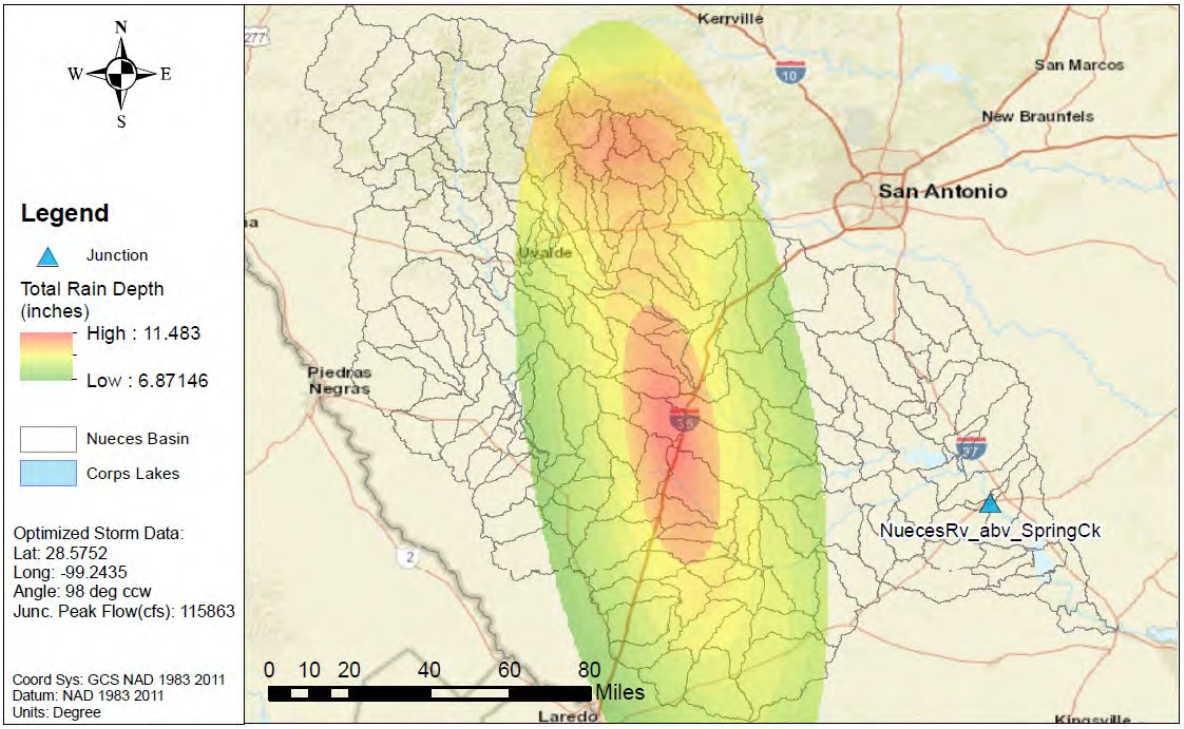

Figure C.11-134b: NA14 1% AEP Elliptical Storm for Nueces River above Spring Creek

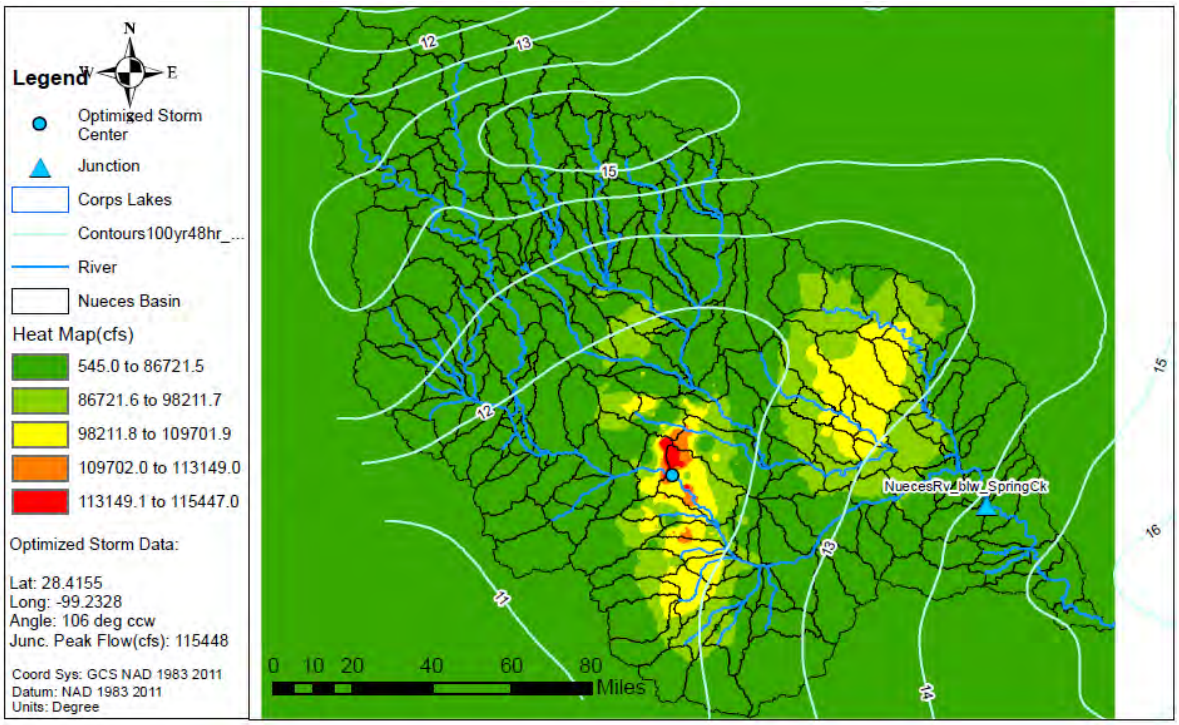

Figure C.11-135a: Elliptical Storm Optimization Heat Map for Nueces River below Spring Creek

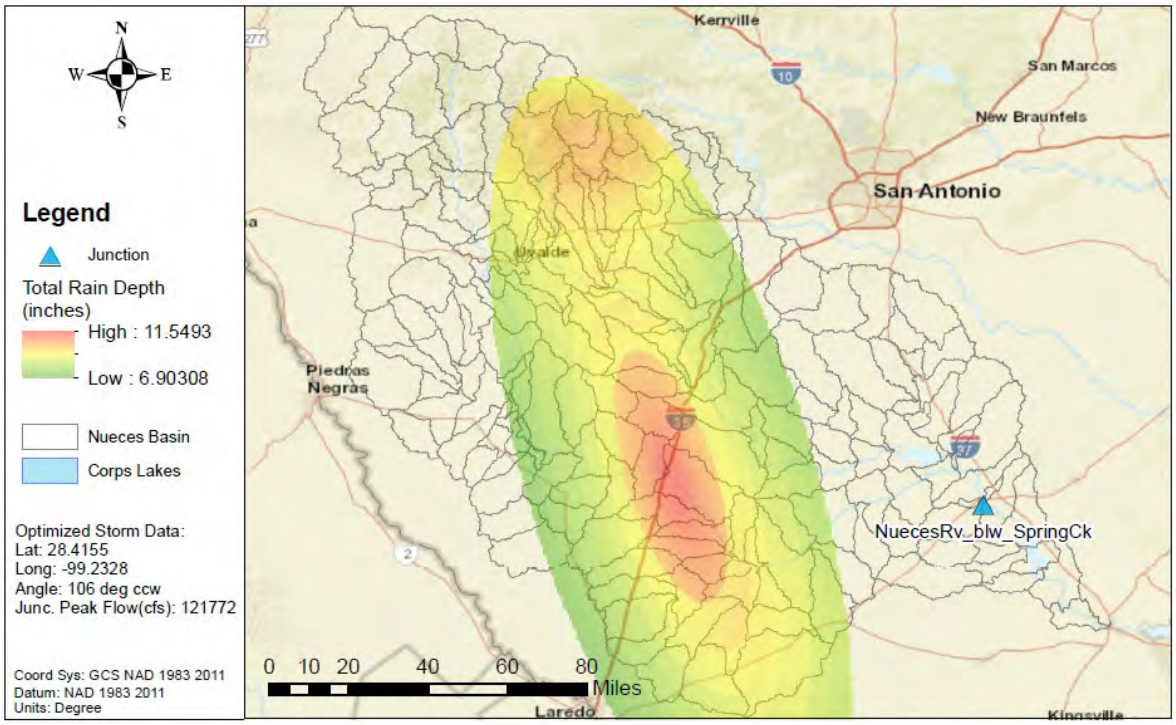

Figure C.11-135b: NA14 1% AEP Elliptical Storm for Nueces River below Spring Creek

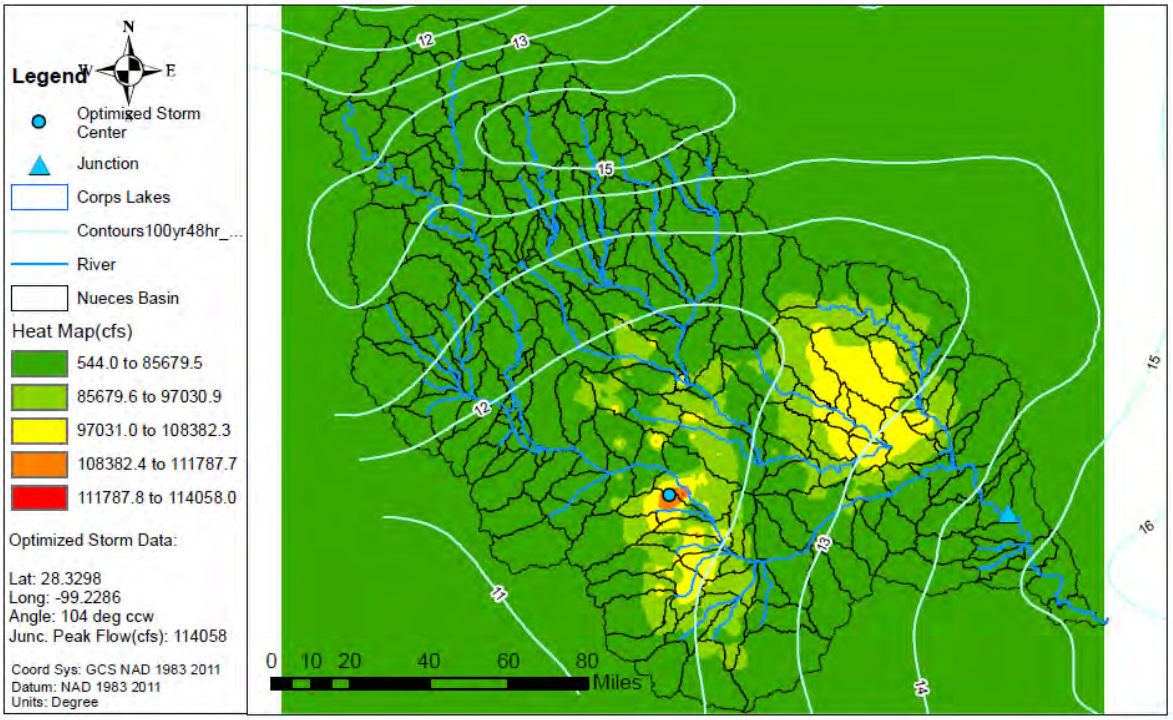

Figure C.11-136a: Elliptical Storm Optimization Heat Map for Nueces River and Upper End of Lake Corpus Christi

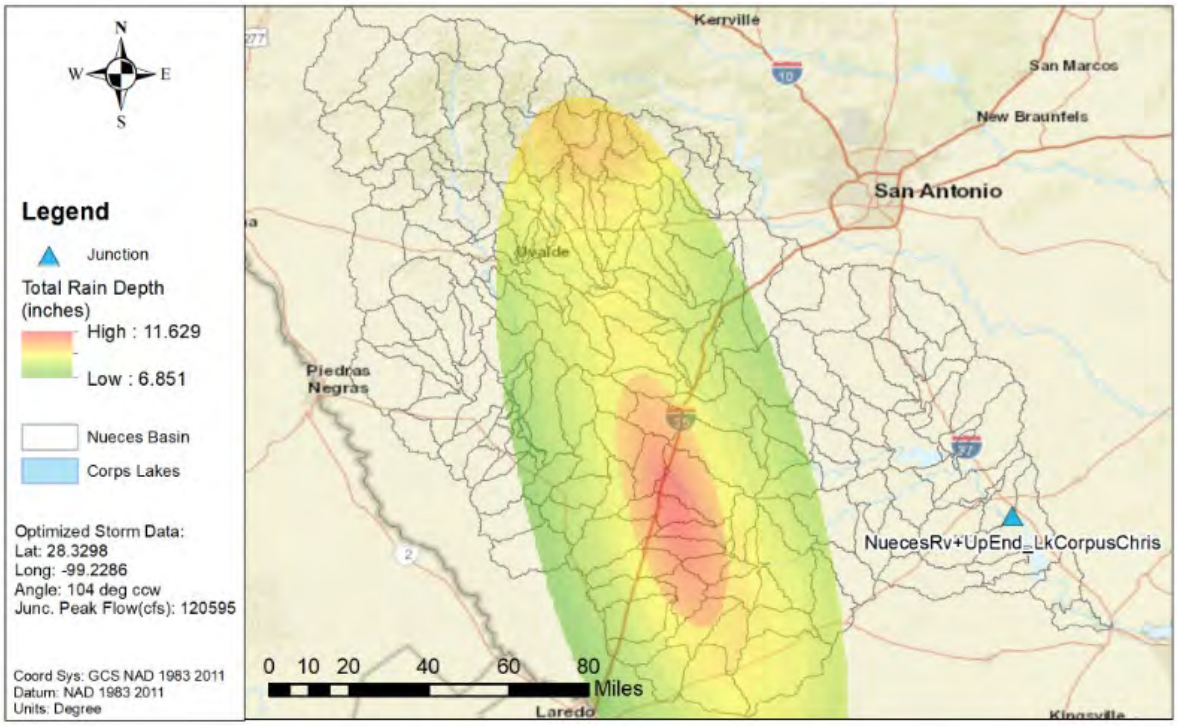

Figure C.11-136b: NA14 1% AEP Elliptical Storm for Nueces River and Upper End of Lake Corpus Christi

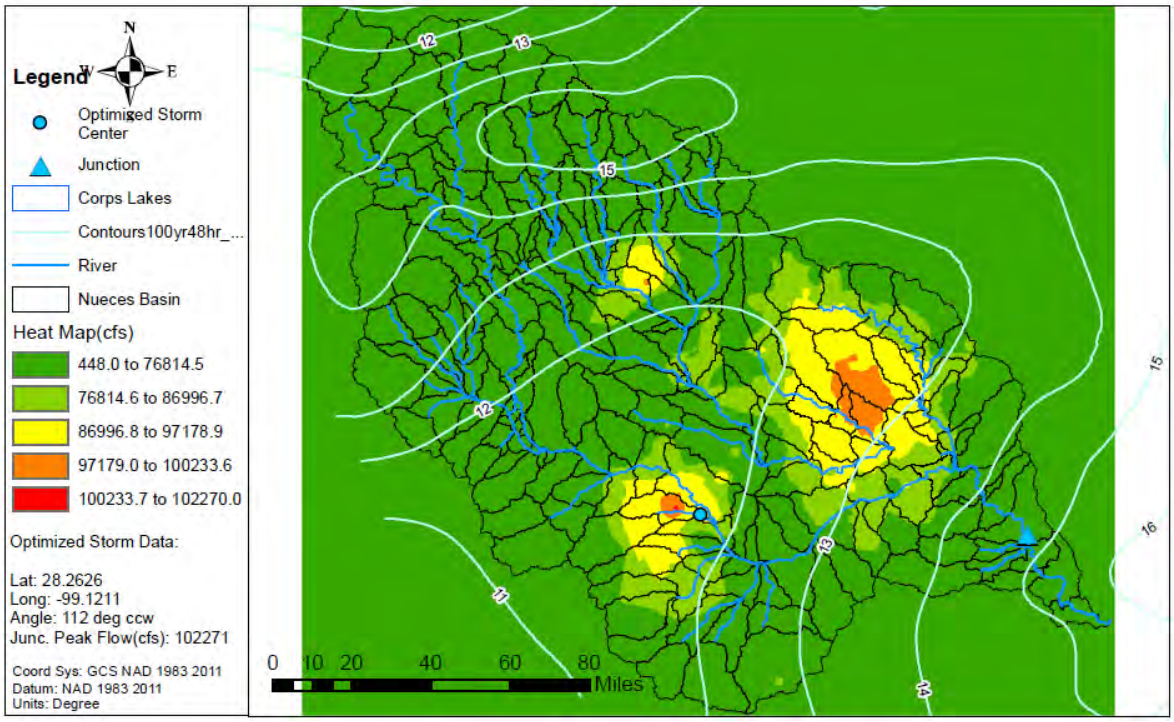

Figure C.11-137a: Elliptical Storm Optimization Heat Map for Nueces River above Lake Corpus Christi

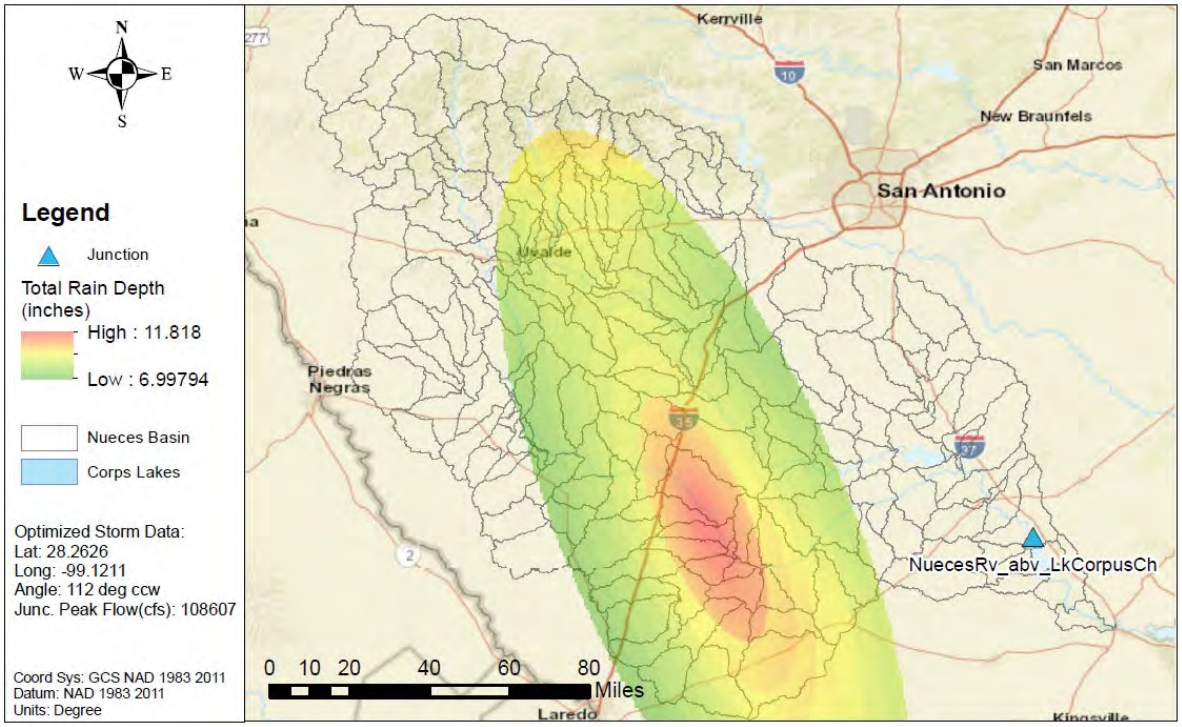

Figure C.11-137b: NA14 1% AEP Elliptical Storm for Nueces River above Lake Corpus Christi

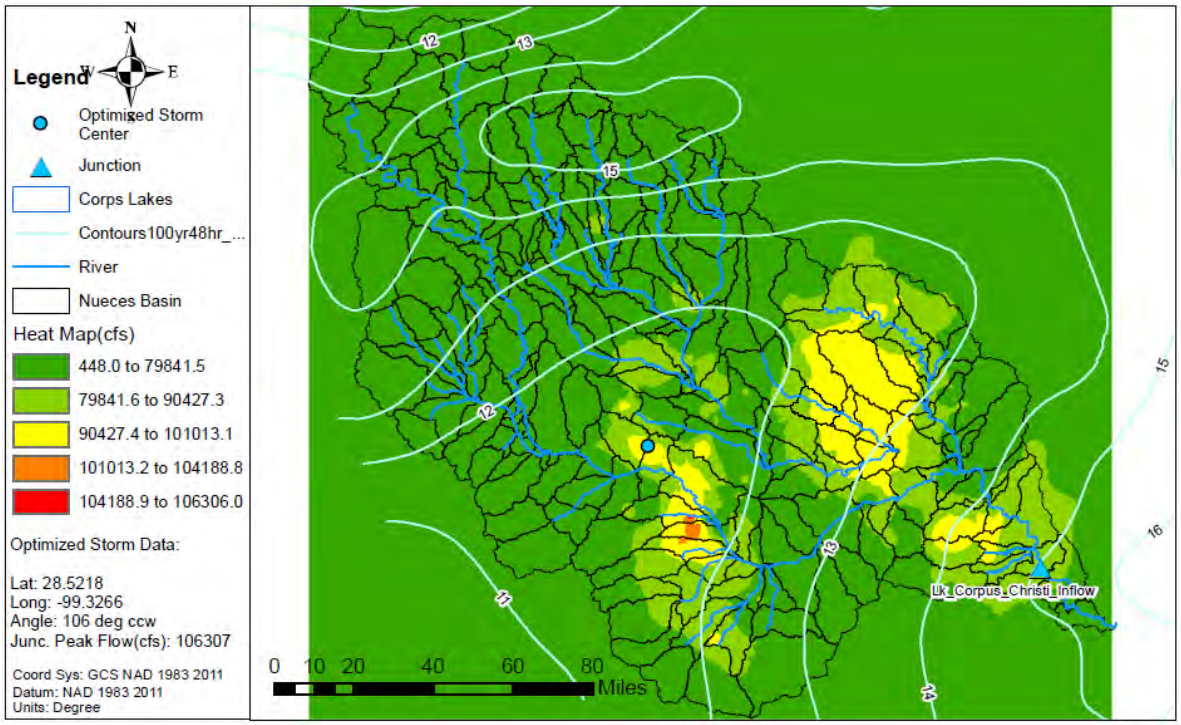

Figure C.11-138a: Elliptical Storm Optimization Heat Map for Lake Corpus Christi Inflow

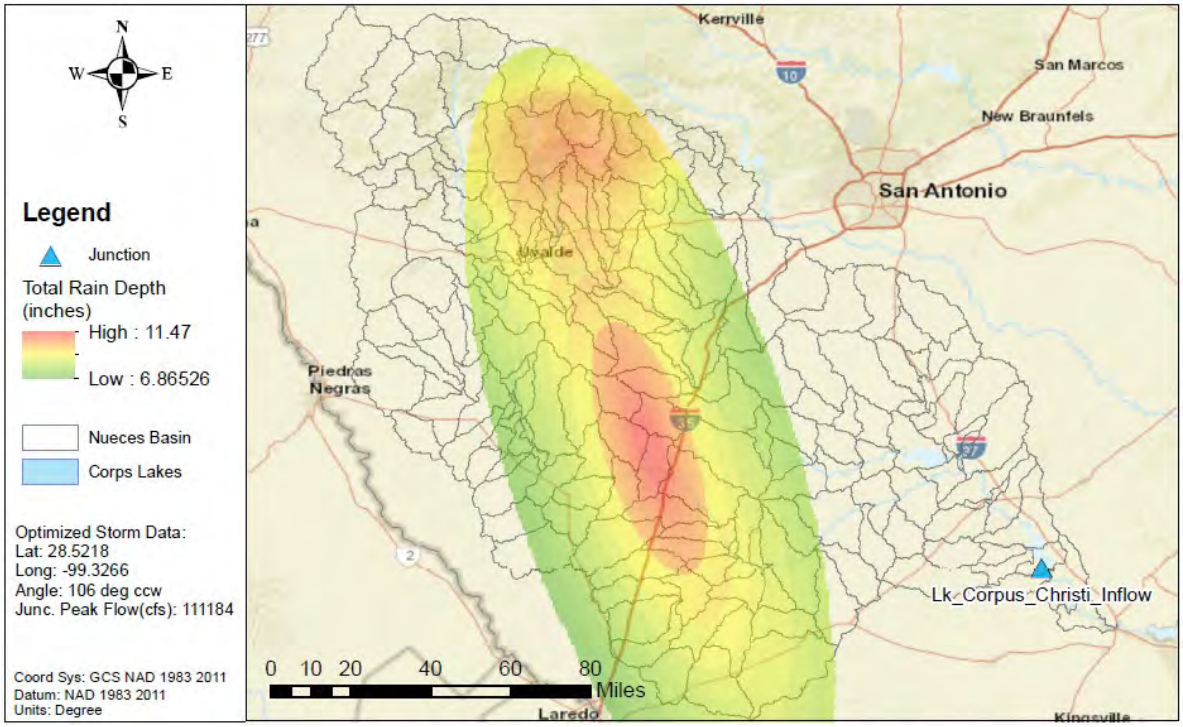

Figure C.11-138b: NA14 1% AEP Elliptical Storm for Lake Corpus Christi Inflow

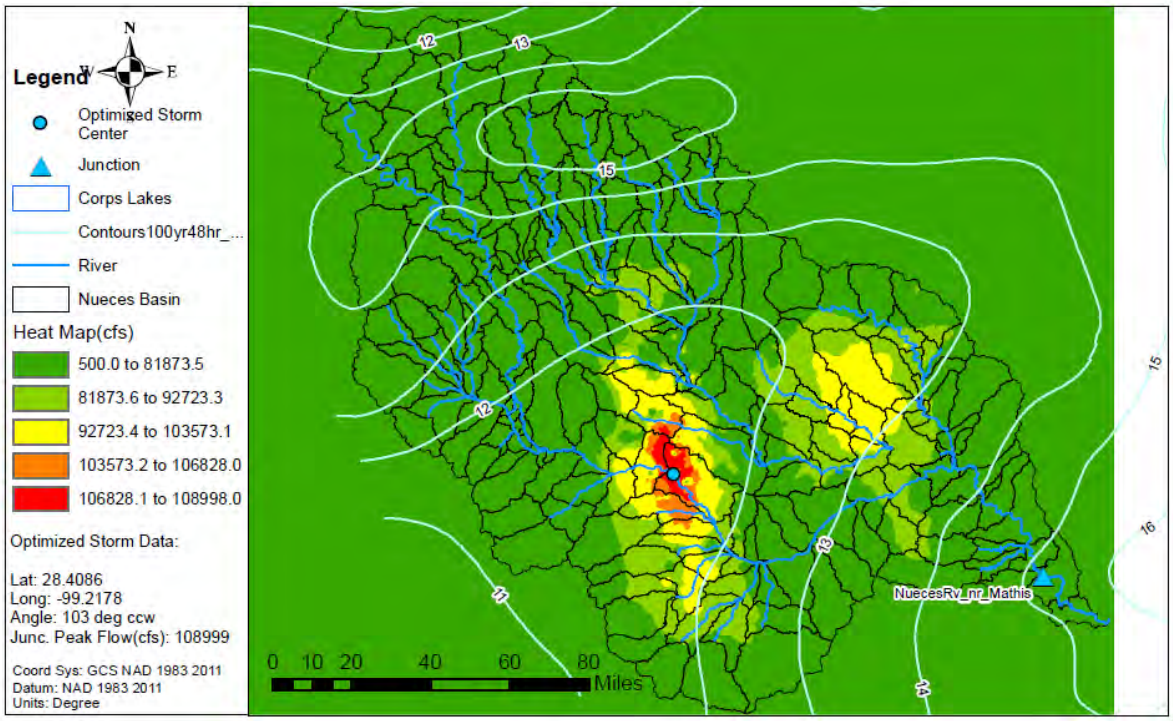

Figure C.11-139a: Elliptical Storm Optimization Heat Map for Nueces River near Mathis (USGS gage 08211000, Dam Outflow)

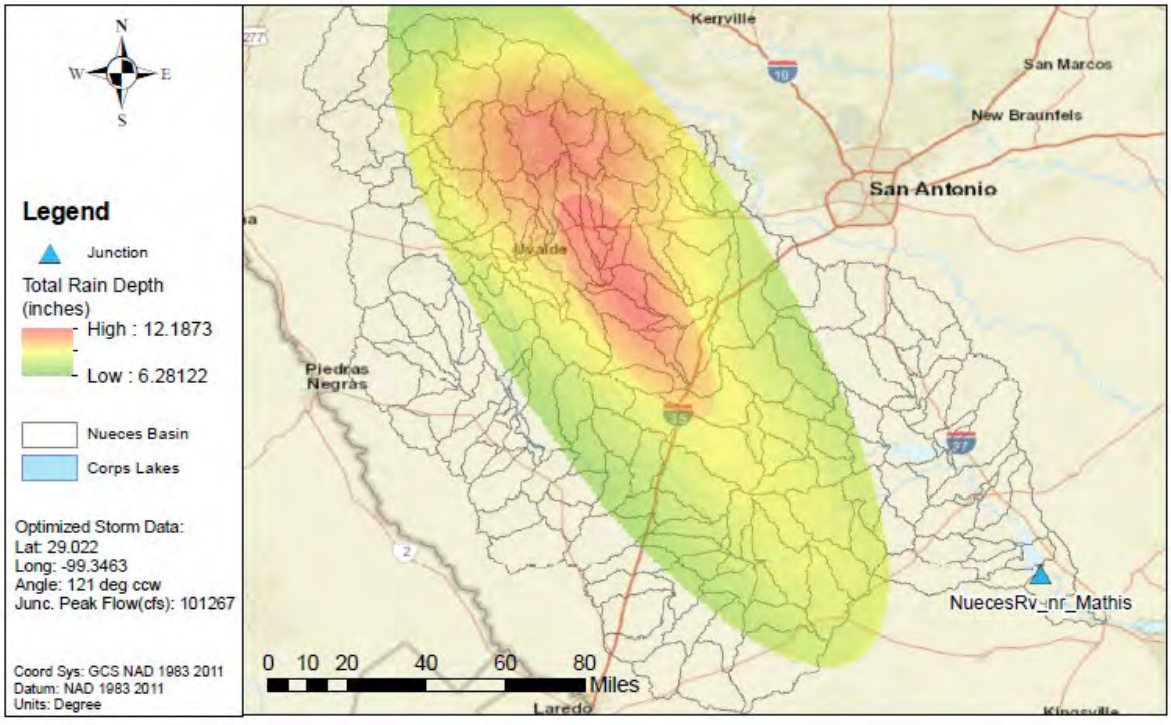

Figure C.11-139b: NA14 1% AEP Elliptical Storm for Nueces River near Mathis (USGS gage 08211000, Dam Outflow)

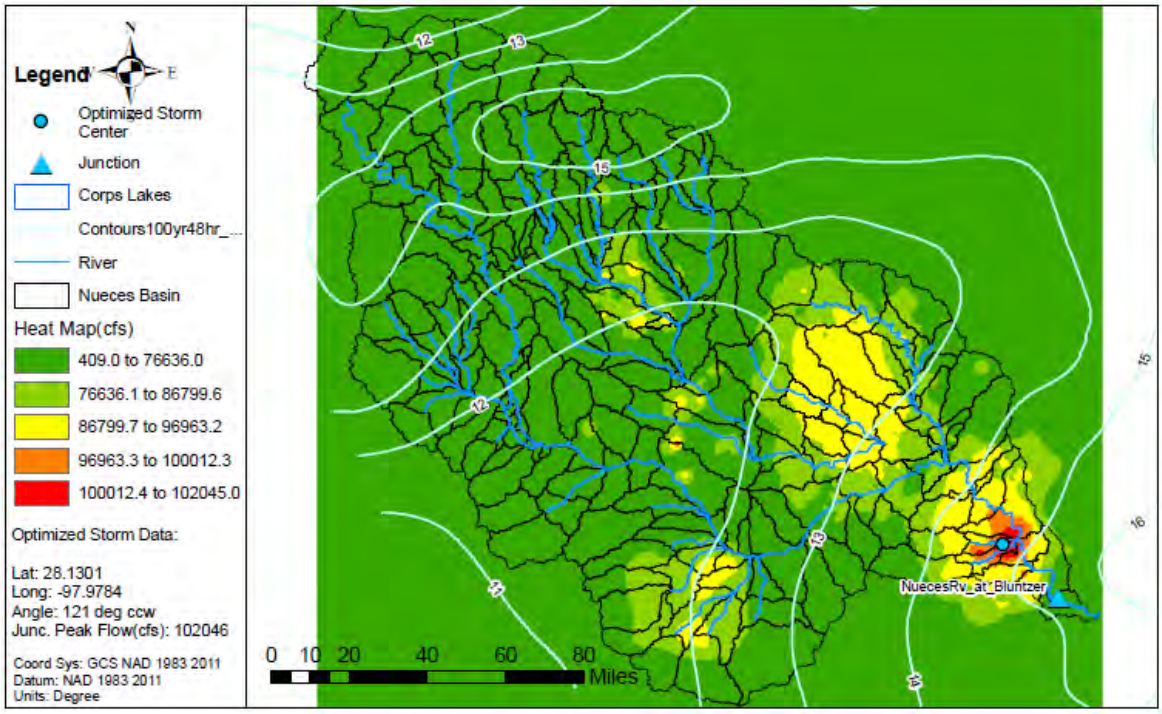

Figure C.11-140a: Elliptical Storm Optimization Heat Map for Nueces at Bluntzer (USGS gage 08211200)

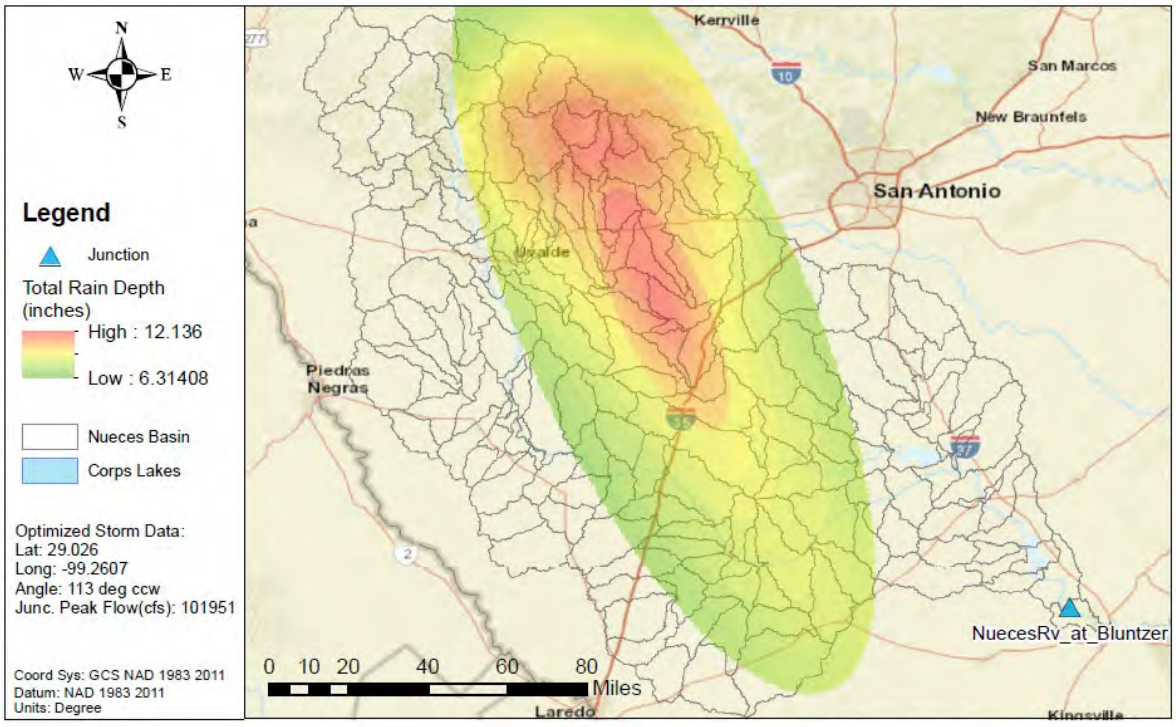

Figure C.11-140b: NA14 1% AEP Elliptical Storm for Nueces at Bluntzer (USGS gage 08211200)

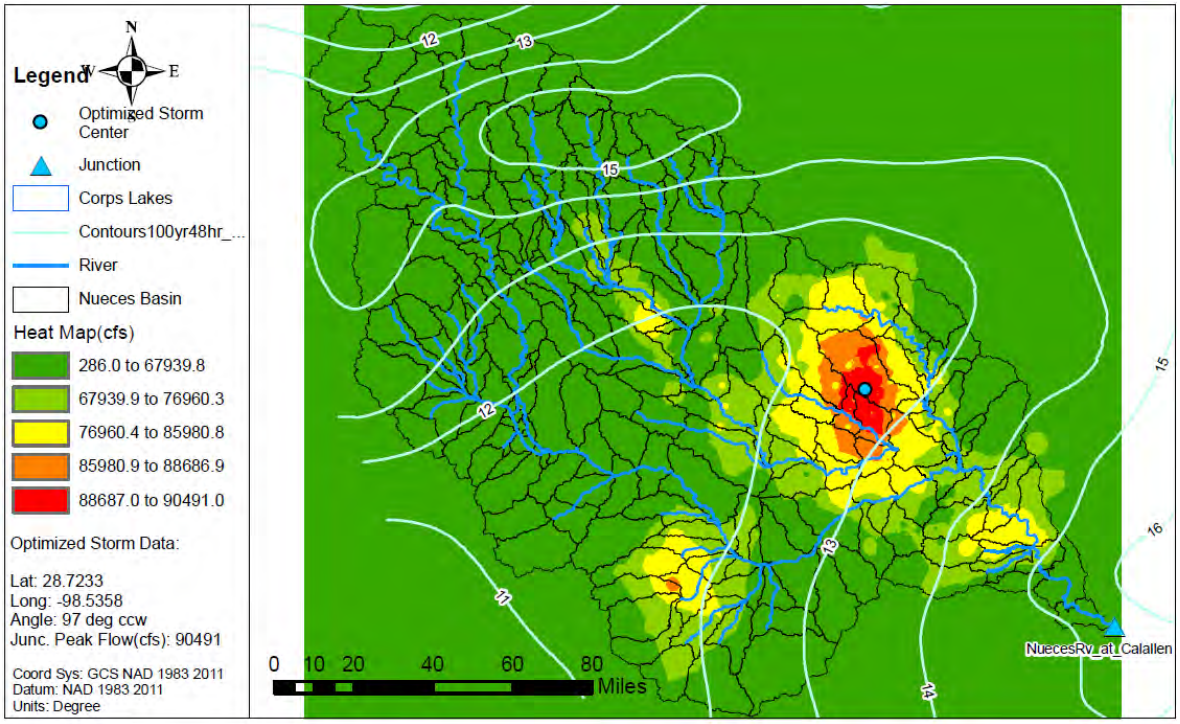

Figure C.11-141a: Elliptical Storm Optimization Heat Map for Nueces River at Calallen (USGS gage 08211500)

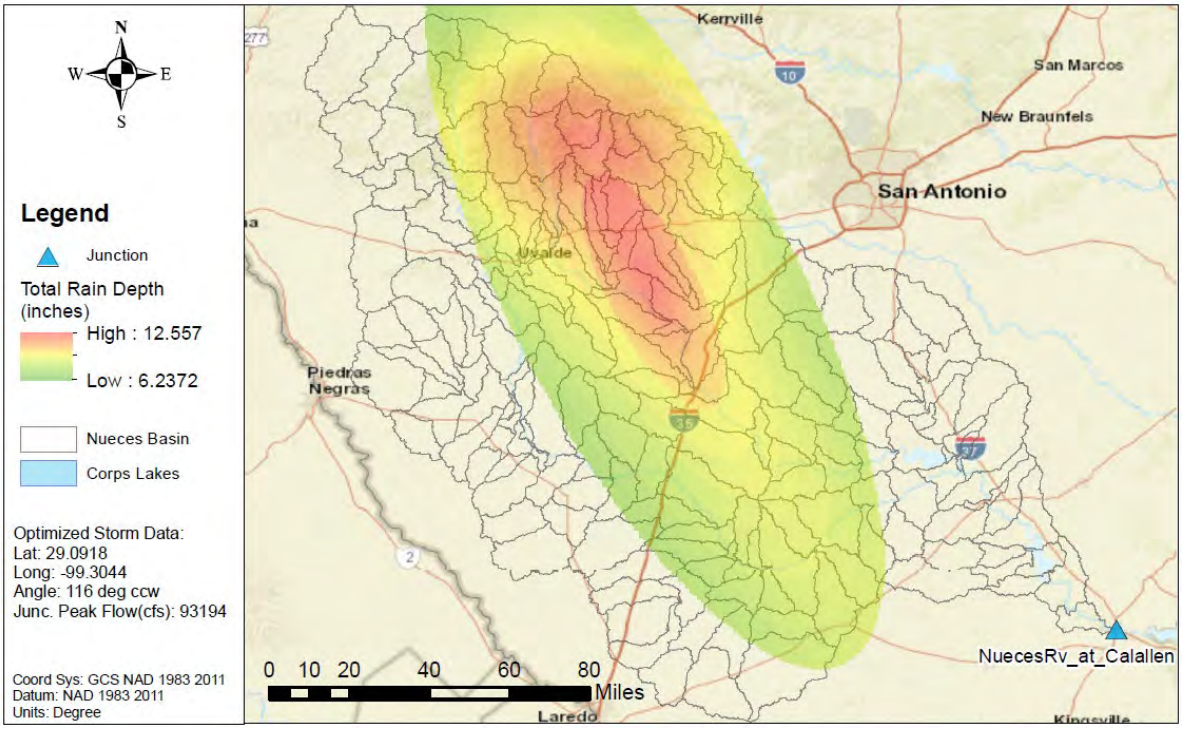

Figure C.11-141b: NA14 1% AEP Elliptical Storm for Nueces River at Calallen (USGS gage 08211500)

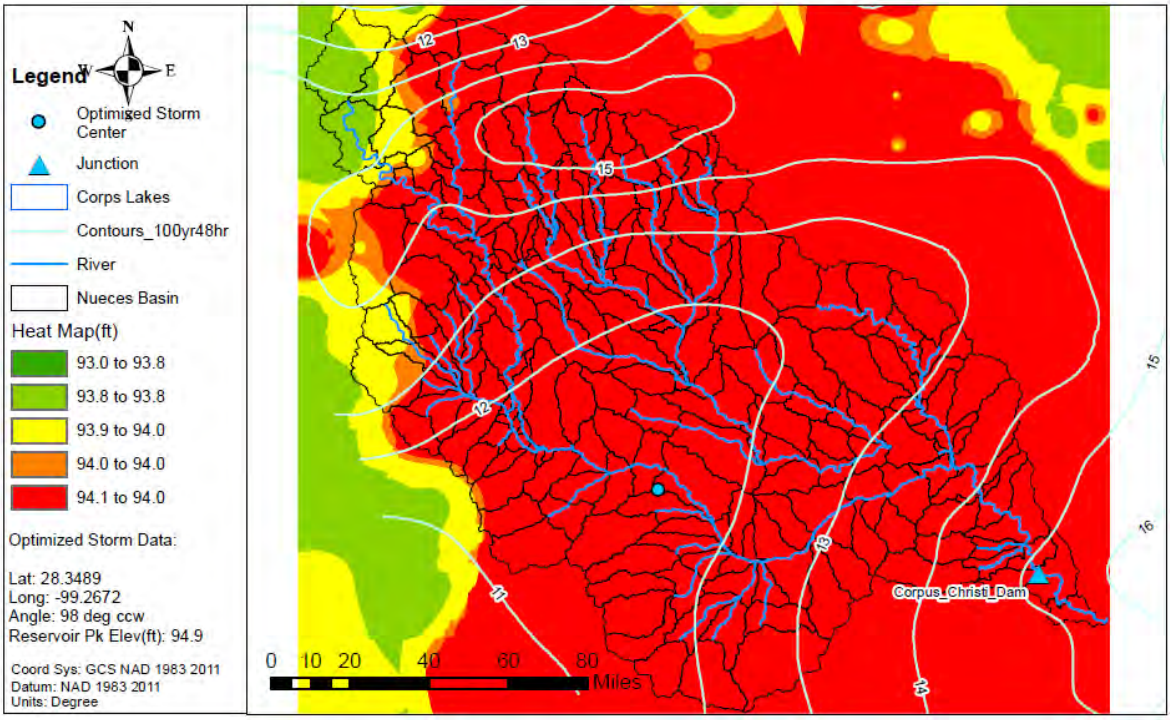

Figure C.11-142a: Elliptical Storm Optimization Heat Map for Corpus_Christi_Dam

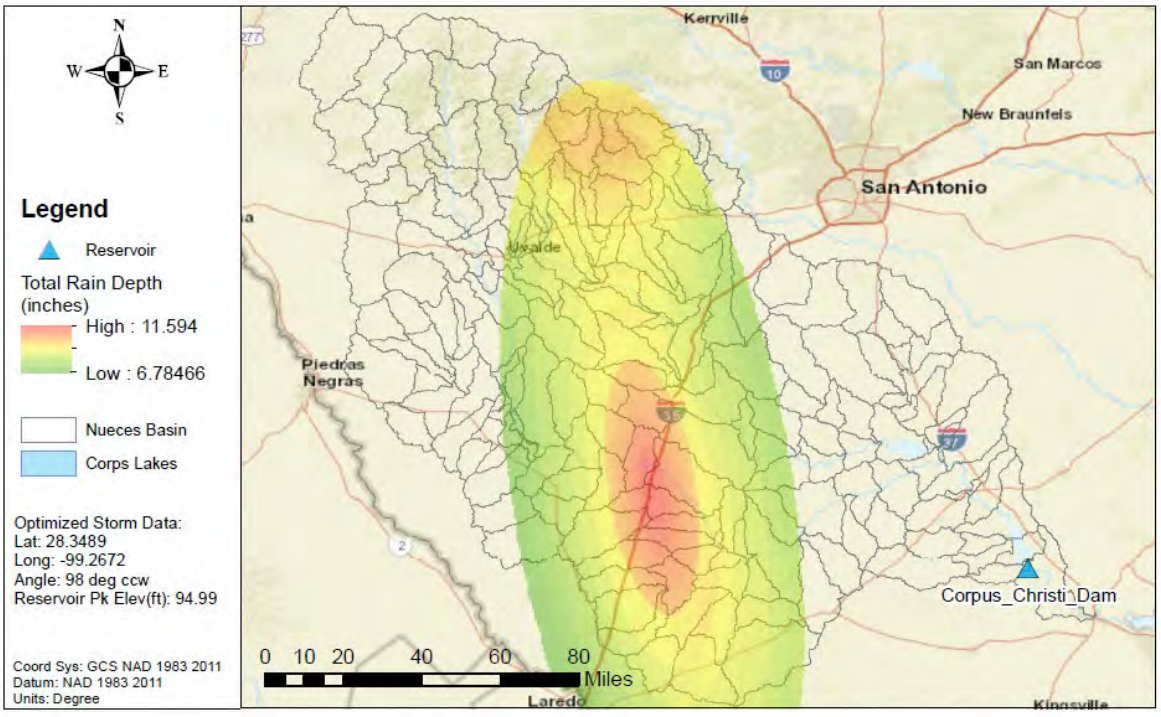

Figure C.11-142b: NA14 1% AEP Elliptical Storm for Corpus_Christi_Dam

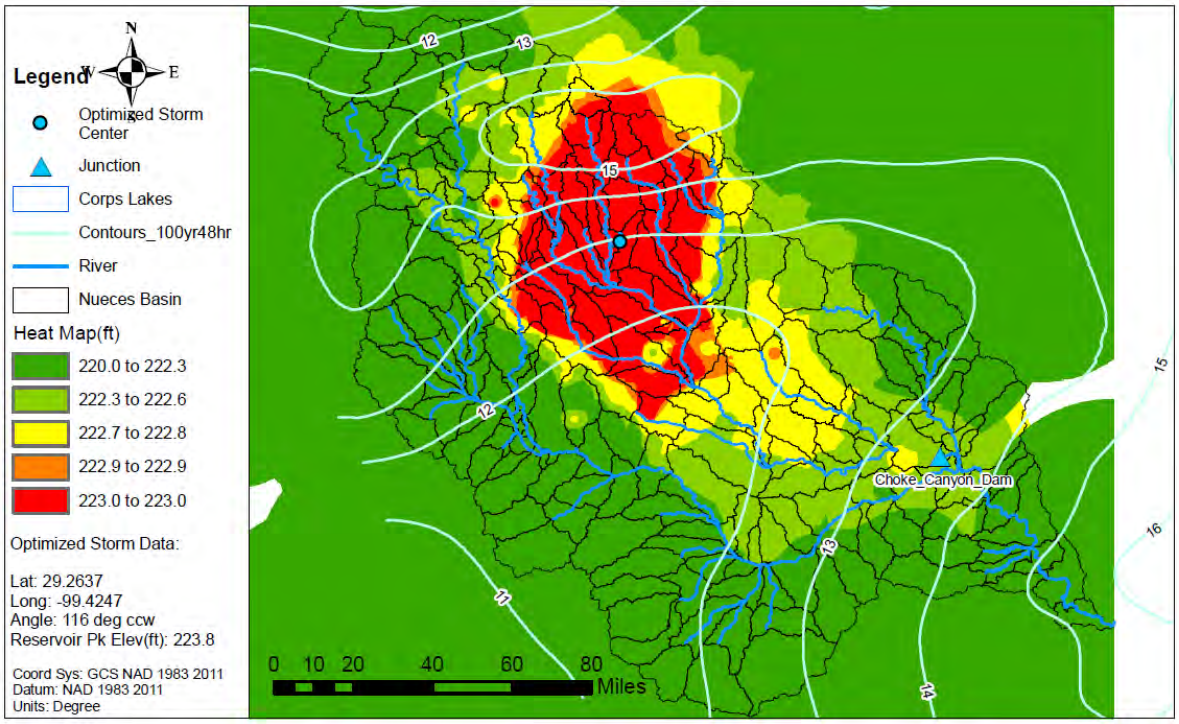

Figure C.11-143a: Elliptical Storm Optimization Heat Map for Choke_Canyon_Dam

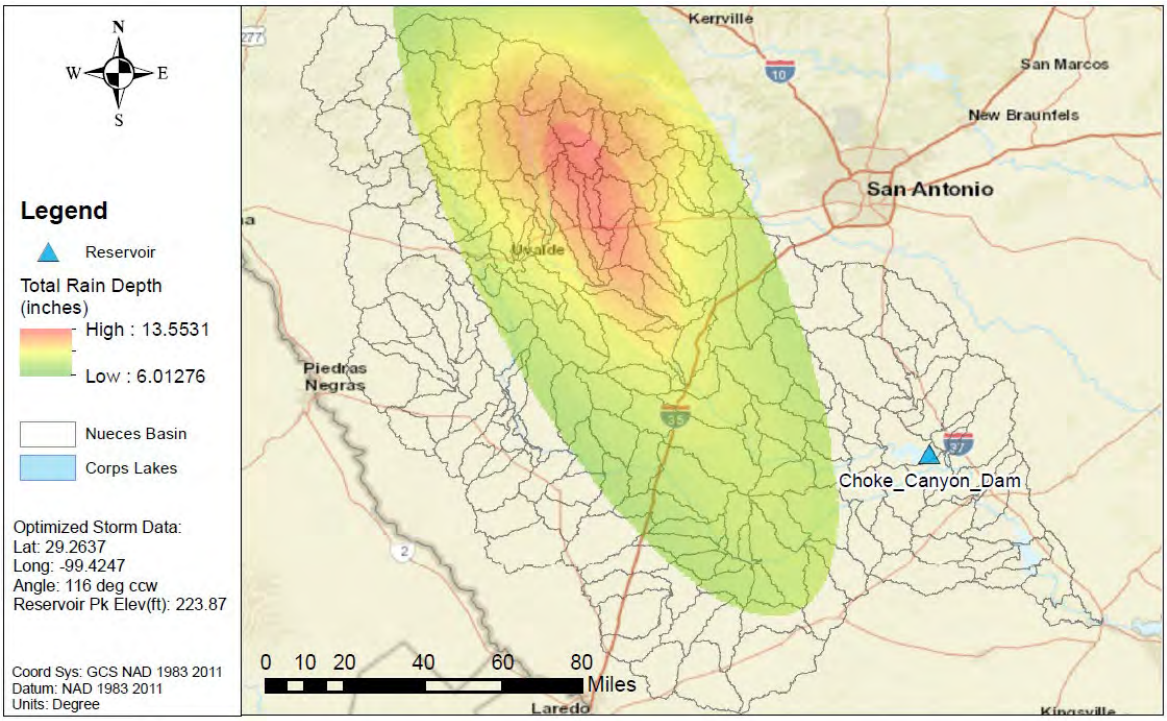

Figure C.11-143b: NA14 1% AEP Elliptical Storm for Choke_Canyon_Dam

1.7 ELLIPTICAL FREQUENCY STORM RESULTS VERSUS DRAINAGE AREA

As a quality check, the peak flow results from the 1% AEP elliptical frequency storms were plotted versus drainage area and outliers were examined, as shown in Figure C.226. This figure shows that the analyzed junctions followed generally expected patterns of increasing peak flow with drainage area, with exceptions for the effects of large reservoirs. The upper Nueces River and the upper junctions on the Frio River have steeper watersheds and have the highest discharge per area on the plot. This behavior is expected due to the steeper slopes and confirmed by historical flood events which can also be seen in the gage records of Appendix A.

Peak discharges on the middle and lower Nueces River main stem have the lowest peak discharges per area. The middle Nueces River has the lowest NOAA Atlas 14 rainfall depths in the Nueces River basin and is affected by channel losses and irrigation withdrawals, while the lower Nueces River is affected by Choke Canyon and Corpus Christi reservoirs.

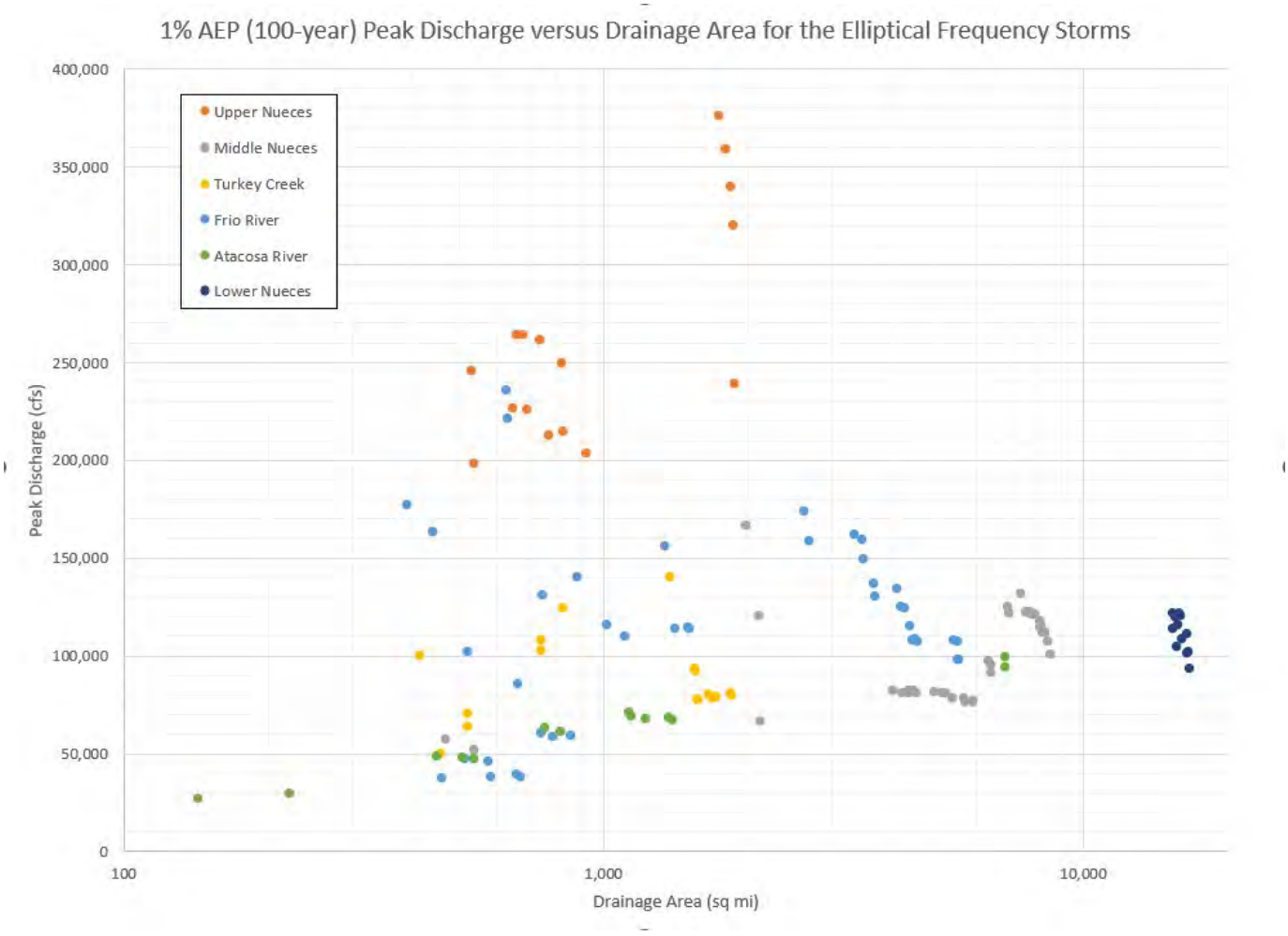

Figure C.226: NA14 1% AEP Elliptical Storm Frequency Results versus Drainage Area

1.8 ELLIPTICAL STORM VERSUS UNIFORM RAIN FREQUENCY RESULTS

As mentioned at the beginning of this appendix, because the published depth-area reduction curves from TP-40 do not extend beyond 400 square miles, the uniform rainfall method may not always be appropriate for larger drainage areas. Therefore, elliptical frequency storms were computed in HEC-HMS as an alternate method to compare to the uniform rain frequency results for larger drainage areas.

Figure C.227 below gives a comparison of the percent difference in the 1% annual chance (100-yr) peak flow estimate from the elliptical storms versus the uniform rainfall method. This percent difference is then plotted versus the drainage area of the point of interest. On this plot, a positive value indicates that the elliptical peak flow was higher than the uniform rain peak flow, and conversely, a negative value indicates that the elliptical peak flow was lower than the uniform rain peak flow.

From this figure, one may observe that the percent difference between the two methods generally increases as drainage area increases, which is as expected. For larger drainage areas encompassing several thousand square miles, the total volume of rainfall being applied to the HEC-HMS model is much less for an elliptical storm than for the uniform rainfall method. For drainage areas less than approximately 500 square miles, the results of the two methods generally stay within 10% of one another. For drainage areas greater than 4,000 square miles, the difference can be more than 50%, as shown in Figure C.227.

This plot also shows that there is a greater difference in the peak flows for the Turkey Creek basin and the Nueces River flow split area than for the rest of the Nueces River basin. This is because the Turkey Creek and upper Nueces headwater watersheds are steep and narrow, but their peak flows quickly attenuate as the streams reach the flat wide floodplains in the middle portions of the basin. As a result, there is a proportionally greater reduction in the peak flow values in these watersheds when comparing elliptical storm to uniform rainfall results.

The lower Nueces River also had a large difference (about a 60% reduction) between the elliptical and uniform rainfall results. This is partially due to the effects of Choke Canyon Reservoir and Lake Corpus Christi. The other reason is that the uniform rainfall method applies an unrealistically large rainfall volume to its 17,000 square mile drainage area by assuming that it is raining on the entire watershed at once. This example illustrates why the elliptical storm method produces more reliable estimates of frequency flows for very large drainage areas.

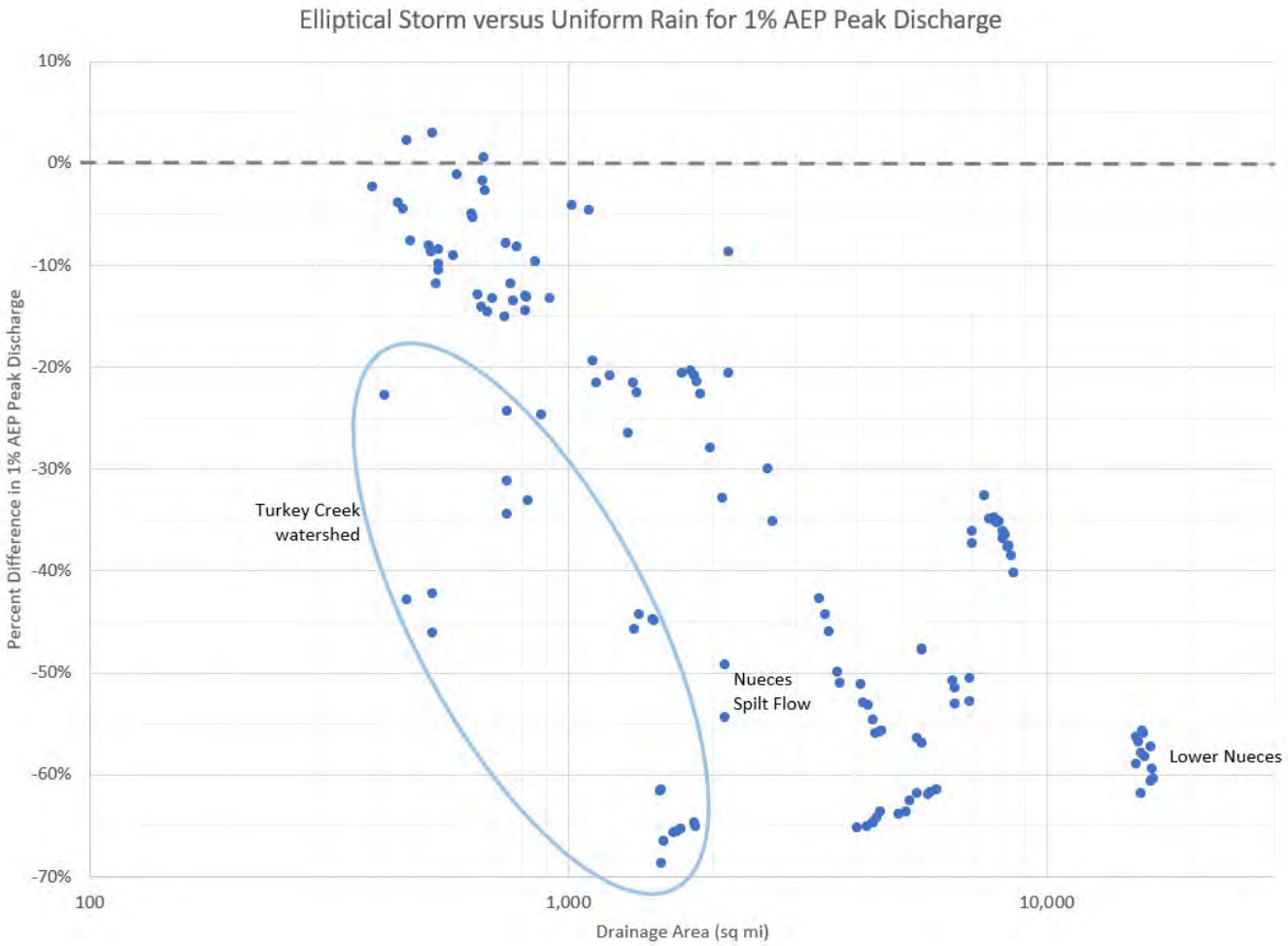

Figure C.227: Percent Difference between Elliptical and Uniform Rain Estimates of the 1% ACE (100-yr) Peak Flow

2 References and Resources

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2.3 DATA SOURCES, GUIDANCE, AND PROCEDURES

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Available from: http://www.esri.com/software/arcgis/arcgisonline/services/map-services

Environmental Systems Research Institute, Inc. (ESRI),

http://www.esri.com/software/arcgis/arcgisonline/map_services.html
ESRI Streetmap2D Image Service - ESRI basemap data, DeLorme basemap layers, Automotive Navigation Data (AND) road data, U.S. Geological Survey (USGS) elevation data, UNEP-WCMC parks and protected areas for the world, Tele Atlas Dynamap® and Multinet® street data for North America and Europe and First American (CoreLogic) parcel data for the United States.
ESRI World Imagery Service - Imagery from NASA, icubed, U.S. Geological Survey (USGS), U.S. Department of Agriculture Farm Services Agency (USDA FSA), GeoEye, and Aerials Express.
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3 Terms of Reference

AEP	Annual Exceedance Probability
ARF	Areal Reduction Factor
cfs	cubic feet per second
CWMS	Corps Water Management System
DAR	Depth Area Reduction
EM	Engineering Manual
EMA	expected moment algorithm
ERDC	Engineering Research & Development Center of USACE
FEMA	Federal Emergency Management Agency
FIS	flood insurance study
GeoHMS	Geospatial Hydrologic Model System extension
GIS	Geographic Information Systems
GO	Global Optimization
HEC	Hydrologic Engineering Center
HMR	Hydrometeorological Report
HMS	Hydrologic Modeling System
InFRM	Interagency Flood Risk Management
MAP	Mean Areal Precipitation
NA14	NOAA Atlas 14
NMSM	Nelder and Mead Simplex Method
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
PFDS	Precipitation Frequency Data Server
PMP	Probable Maximum Precipitation
SCE	Shuffled Complex Evolution
sq mi	square miles
TP40	Technical Paper 40
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey