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Regional Resilience Planning Grants Program Assistance

Craig Wenger, P.E., AICP, CFM, LEED GA

NATIONAL FLOOD INSURANCE PROGRAM
Celebrating 50 Years

ASFPM ANNUAL CONFERENCE
PHOENIX, AZ
June 17-21 2018
Managing Floods Where Mountains Meet the Desert

Priorities

- Holistic Planning
- Total Water Level Understanding
- Vulnerability Assessments Based on Assets

Program

The ***Resilient NJ*** program will provide funding and technical assistance to multi-municipal regions within the nine New Jersey counties most impacted and distressed by Superstorm Sandy, to undertake a comprehensive planning process. This program will help municipalities identify and address their vulnerabilities to increased coastal and riverine flood risk and other climate stressors.

Program

The program will provide grant funding for neighboring communities to develop and implement regional action plans that:

- Assess vulnerability to current and projected flooding, including permanent inundation, chronic and nuisance flooding, riverine and coastal flooding, and coastal storms and storm surge
- Identify locally significant and regionally shared critical assets
- Develop strategic and actionable mitigation actions to reduce flooding risk
- Understand and weigh the costs and benefits of specific actions
- Develop a strategic plan that reduces risk and provides a roadmap for implementation

Why an Enhanced Riverine Analysis?

- CDBG-DR grants to date focused on oceanfront and bayfront communities
- Planning resources for inland communities dealing with riverine flooding are still needed
- Desire to incorporate projected future increases in rainfall and development trends

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Assessment Methodologies

- Method A - NJFHADF
- Method B – River Systems 1D Base Level Engineering (BLE)
- Method C – N.J.A.C. 7:13-3.5 (Method 5)
- Method D – HEC-RAS 2D Rain on Grid

Pilot Study Area
South Branch Rahway River Watershed

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Pilot Study Area

South Branch Rahway River Watershed – Sandy/Irene Impact

Pilot Study Area

South Branch Rahway River Watershed

	Edison	Metuchen	Woodbridge	Rahway
Insurance Policies in Force as of 2015	351	53	592	97
Insurance Claims as of 2015	107	8	494	788

Method A – NJFHADF

Leverage New Jersey Flood Hazard Area Rules

- New Jersey Flood Hazard Area Design Flood = 100-yr Flow Rate plus 25%
- Intended to consider future when developing in/near floodplains
- In areas where models exist, will align studies with eventual permitting that will be required

MATCH TO SHEET 10

FLOOD DELINEATION IN AREAS WHERE TOPOGRAPHY HAS CHANGED ARE BASED ON A REVIEW OF SITE PLANS AND FIELD INSPECTION.

DIKE AND CHANNELIZATION DATA ALONG SOUTH BRANCH, UPSTREAM OF THE GARDEN STATE PARKWAY OBTAINED FROM SITE PLANS FOR PARKWAY INDUSTRIAL CENTER, 1967.

DATA FOR CHANNELIZATION OF PARKWAY BRANCH DOWNSTREAM OF THE GARDEN STATE PARKWAY OBTAINED FROM NJDOT CONSTRUCTION PLANS.

PHOTOGRAMMETRIC MAPPING SUPPLIED BY TOWNSHIP OF WOODBRIDGE: CONTOUR INTERVAL OF 2 FEET. DATE OF FLIGHT 1961

APPROXIMATE SCALE

200 0 200 400 600

LEGEND

STATE FLOOD FRINGE — FLOODWAY — FEDERAL FLOOD FRINGE

NOTES:

1. 1000 FT. GRID BASED ON NEW JERSEY GEODETIC PLANE CO-ORDINATE SYSTEM.
2. VERTICAL DATUM, NATIONAL GEODETIC VERTICAL DATUM (NGVD).
3. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN FLOOD INSURANCE STUDY REPORT.
4. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.

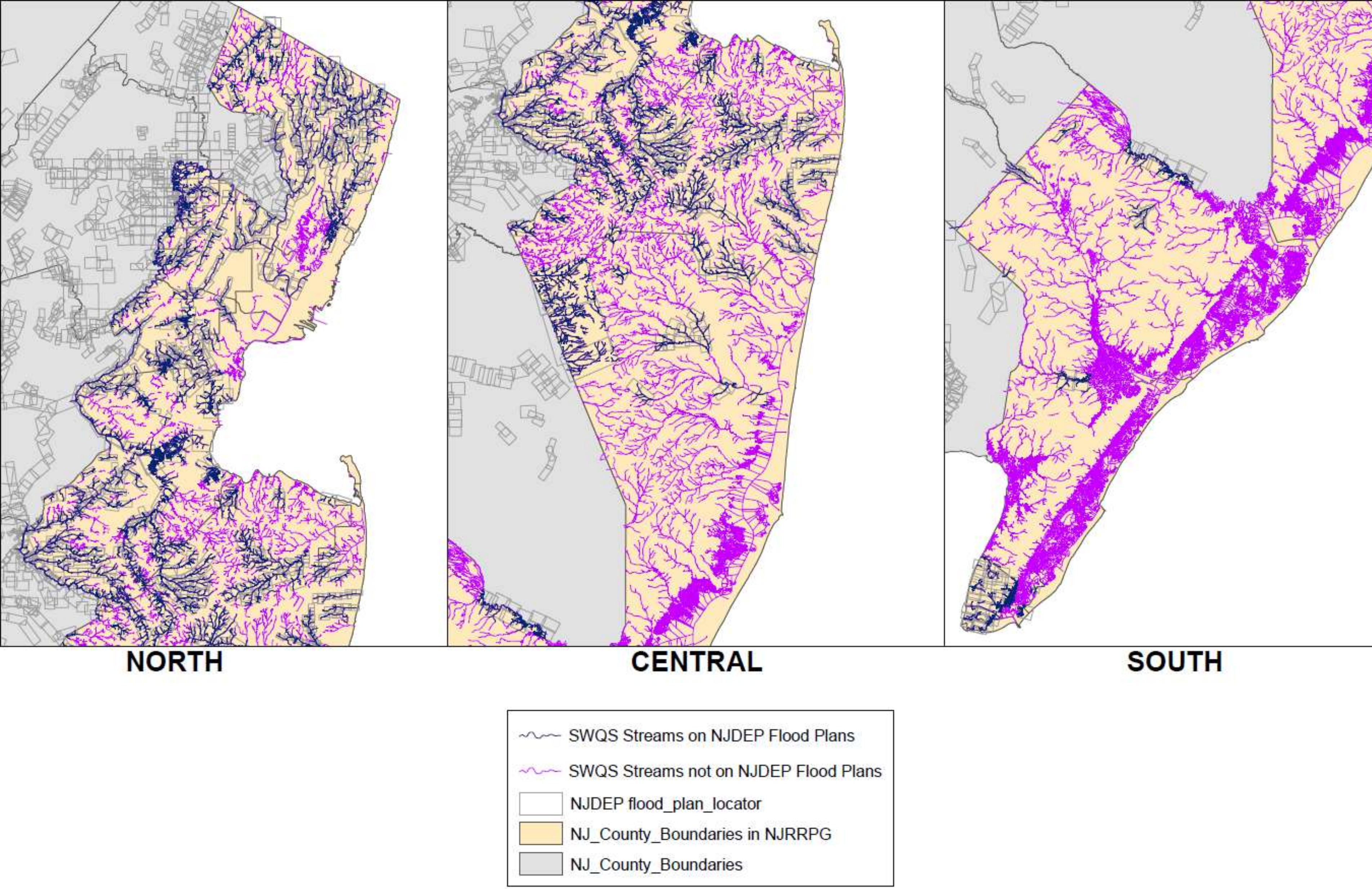
rba
richard p browne associates
professional design & planning consultants
50 gales drive wayne new jersey

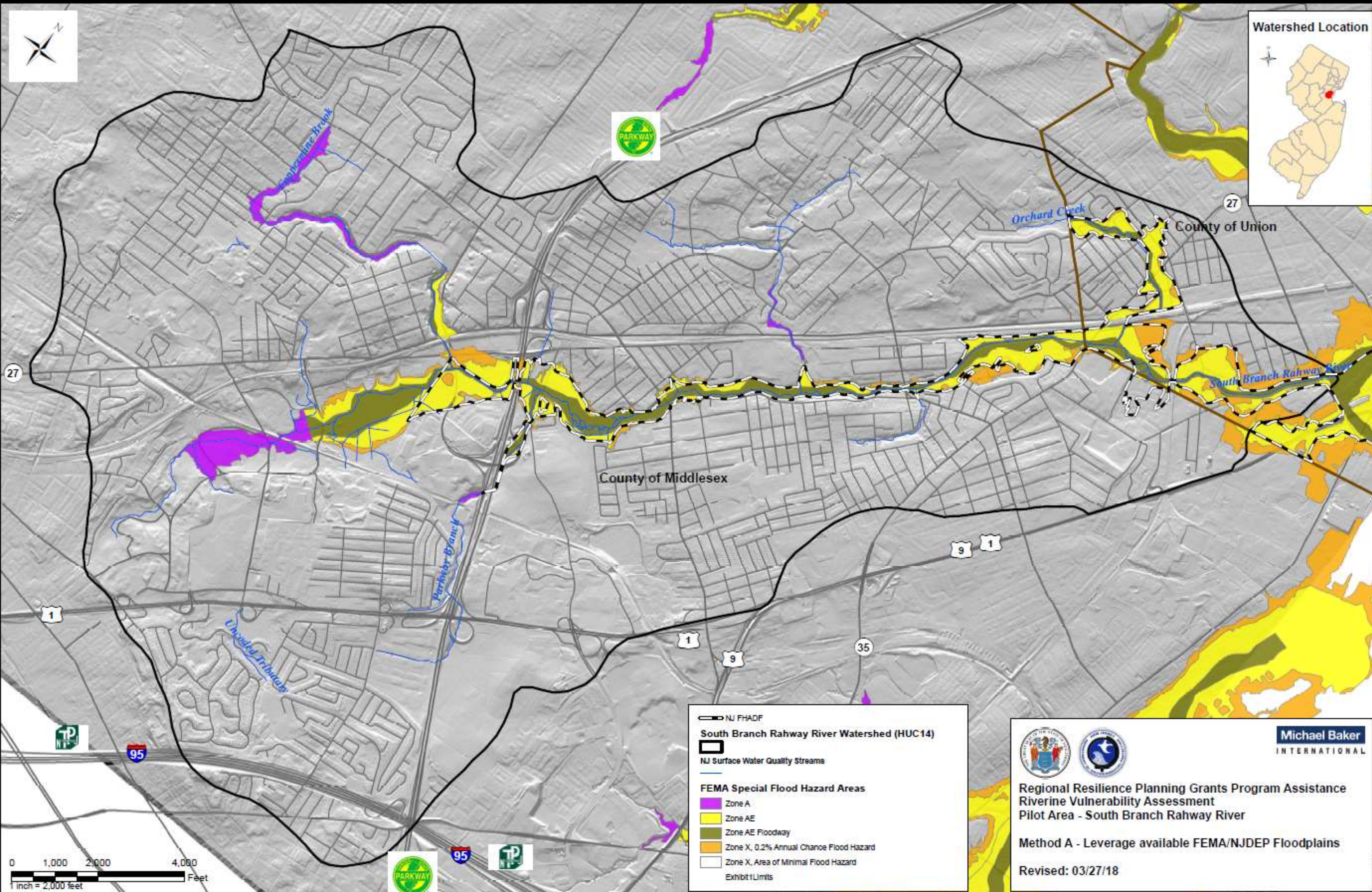
STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES

DELINEATION OF FLOODWAY AND FLOOD HAZARD AREA

PLANS

TOWNSHIP OF WOODBRIDGE, NJ
MIDDLESEX CO


NORTH
CENTRAL
SOUTH
SWQS Streams on NJDEP Flood Plans
SWQS Streams not on NJDEP Flood Plans
NJDEP flood_plan_locator
NJ_County_Boundaries in NJRRPG
NJ_County_Boundaries



Watershed Location
Langewatine Brook
Orchard Creek
County of Union
South Branch Rahway River
County of Middlesex
Parkway Branch
Uncoded Tributary
27
27
9
1
1
1
9
35
95
95
PARKWAY
PARKWAY
NJ FHADF
South Branch Rahway River Watershed (HUC14)
NJ Surface Water Quality Streams
FEMA Special Flood Hazard Areas
Zone A
Zone AE
Zone AE Floodway
Zone X, 0.2% Annual Chance Flood Hazard
Zone X, Area of Minimal Flood Hazard
Exhibit1Limits
0 1,000 2,000 4,000 Feet
1 inch = 2,000 feet
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Regional Resilience Planning Grants Program Assistance
Riverine Vulnerability Assessment
Pilot Area - South Branch Rahway River
Method A - Leverage available FEMA/NJDEP Floodplains
Revised: 03/27/18

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METHOD B –
River Systems 1D BLE

RIVER SYSTEMS

- Model-based approach
- River Systems is a suite of GIS software modules created by MBI to automate different tasks to support flood studies: hydrologic and hydraulic (H&H) engineering, plus database, map, and report production
- The one-dimensional (1D) Base Level Engineering (BLE) module develops highly automated HEC-RAS hydraulic models from terrain, stream centerlines, and minimal user input

Riverine Vulnerability Assessment

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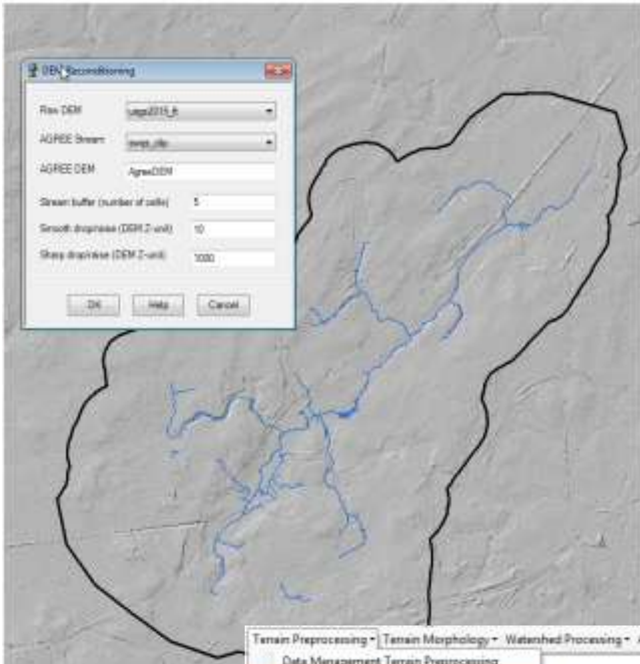
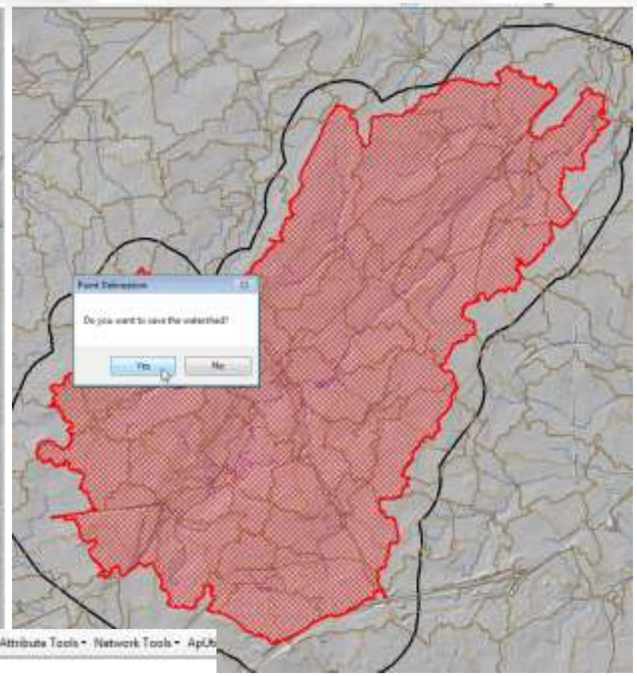
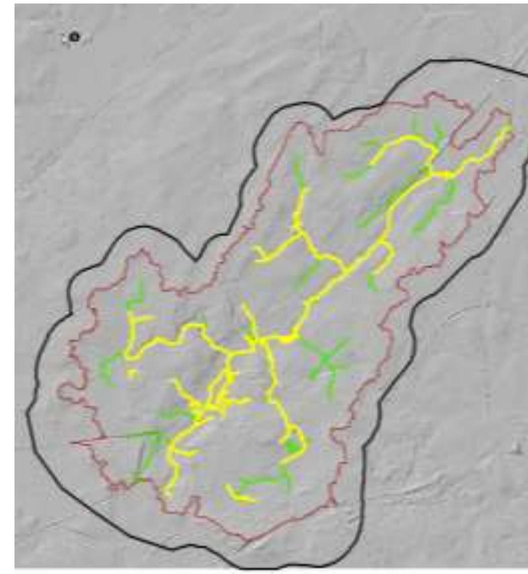
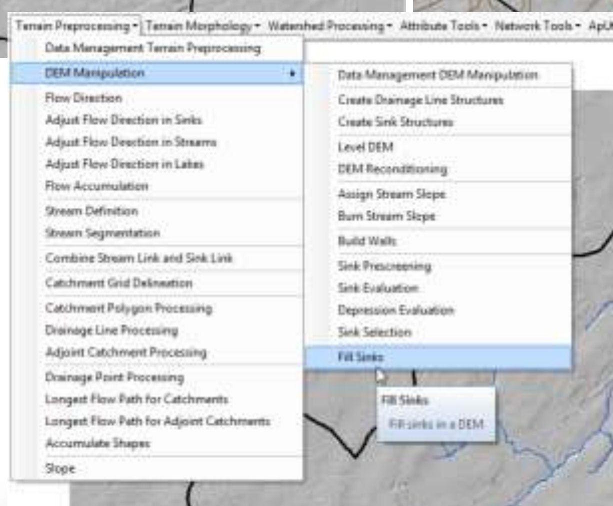
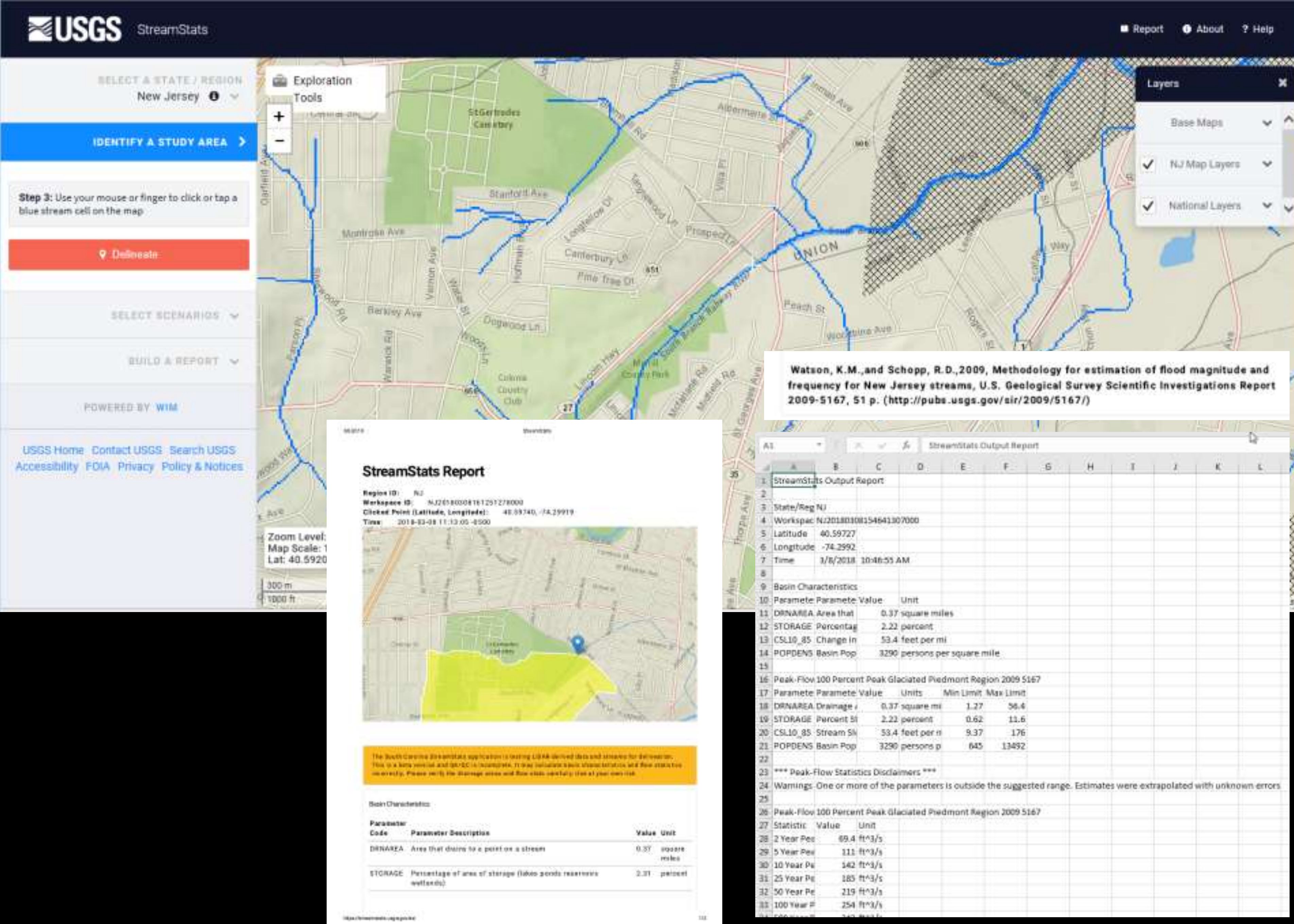
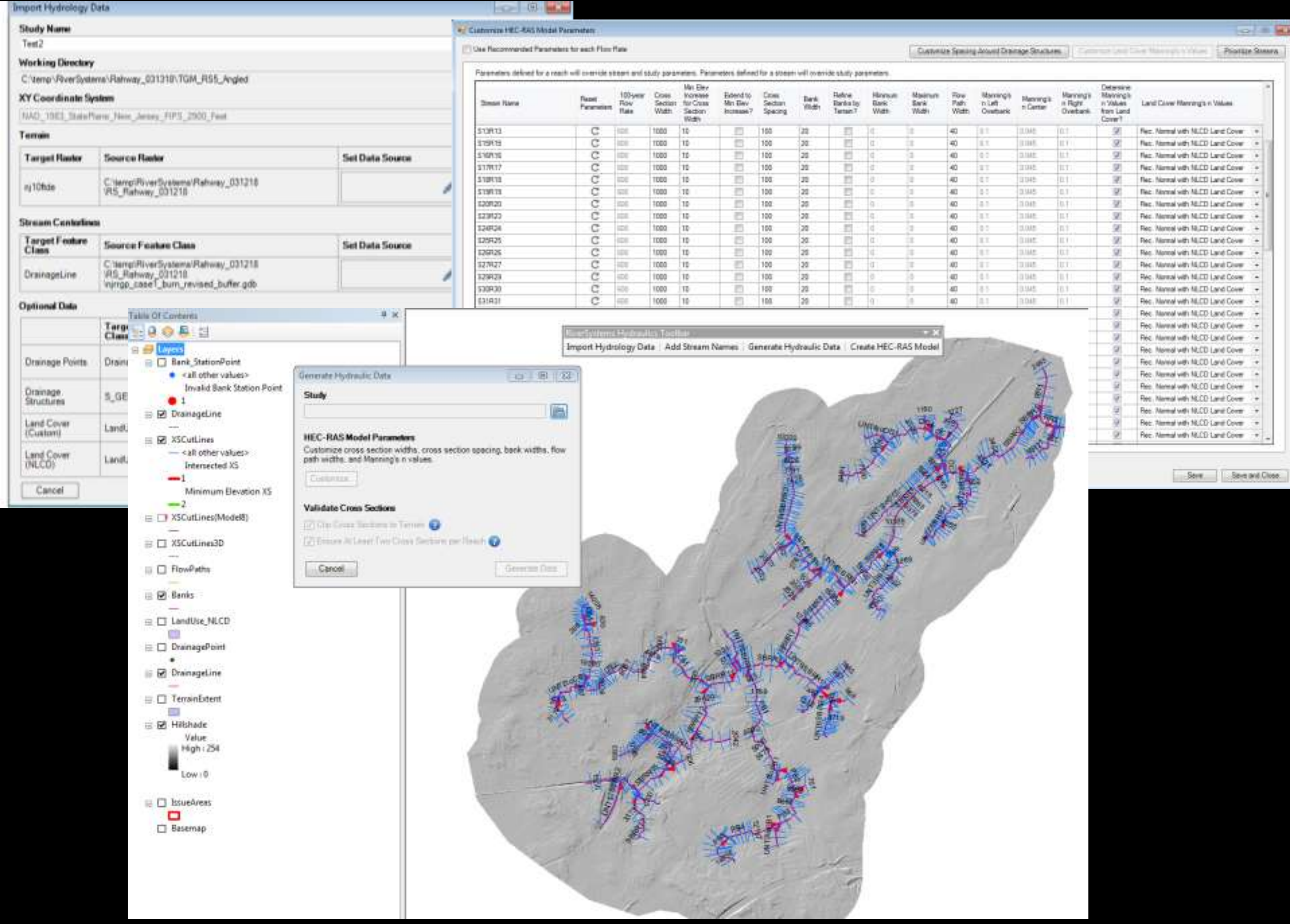









USGS StreamStats
Report
About
Help
SELECT A STATE / REGION
New Jersey
IDENTIFY A STUDY AREA
Step 3: Use your mouse or finger to click or tap a blue stream cell on the map
Delineate
SELECT SCENARIOS
BUILD A REPORT
POWERED BY WIM
USGS Home Contact USGS Search USGS
Accessibility FOIA Privacy Policy & Notices
Exploration Tools
Layers
Base Maps
NJ Map Layers
National Layers
Watson, K.M., and Schopp, R.D., 2009, Methodology for estimation of flood magnitude and frequency for New Jersey streams, U.S. Geological Survey Scientific Investigations Report 2009-5167, 51 p. (http://pubs.usgs.gov/sir/2009/5167/)
StreamStats Report
Basin Characteristics
Parameter Code
Parameter Description
Value
Unit
DRNAREA
Area that drains to a point on a stream
STORAGE
StreamStats Output Report
State/Reg NJ
Latitude 40.59727
Longitude -74.2992
Time 3/8/2018 10:46:55 AM
Basin Characteristics
DRNAREA 0.37 square miles
STORAGE 2.22 percent
CSL10_85 53.4 feet per mi
POPDENS 3290 persons per square mile
Peak-Flow 100 Percent Peak Glaciated Piedmont Region 2009 5167
Min Limit Max Limit
DRNAREA 0.37 square mi 1.27 56.4
STORAGE 2.22 percent 0.62 11.6
CSL10_85 53.4 9.37 176
POPDENS 3290 645 13492
*** Peak-Flow Statistics Disclaimers ***
Warnings One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors
Statistic Value Unit
2 Year Pea 69.4 ft^3/s
5 Year Pea 111 ft^3/s
10 Year Pe 142 ft^3/s
25 Year Pe 185 ft^3/s
50 Year Pe 219 ft^3/s
100 Year P 254 ft^3/s



Import Hydrology Data
Study Name
Test2
Working Directory
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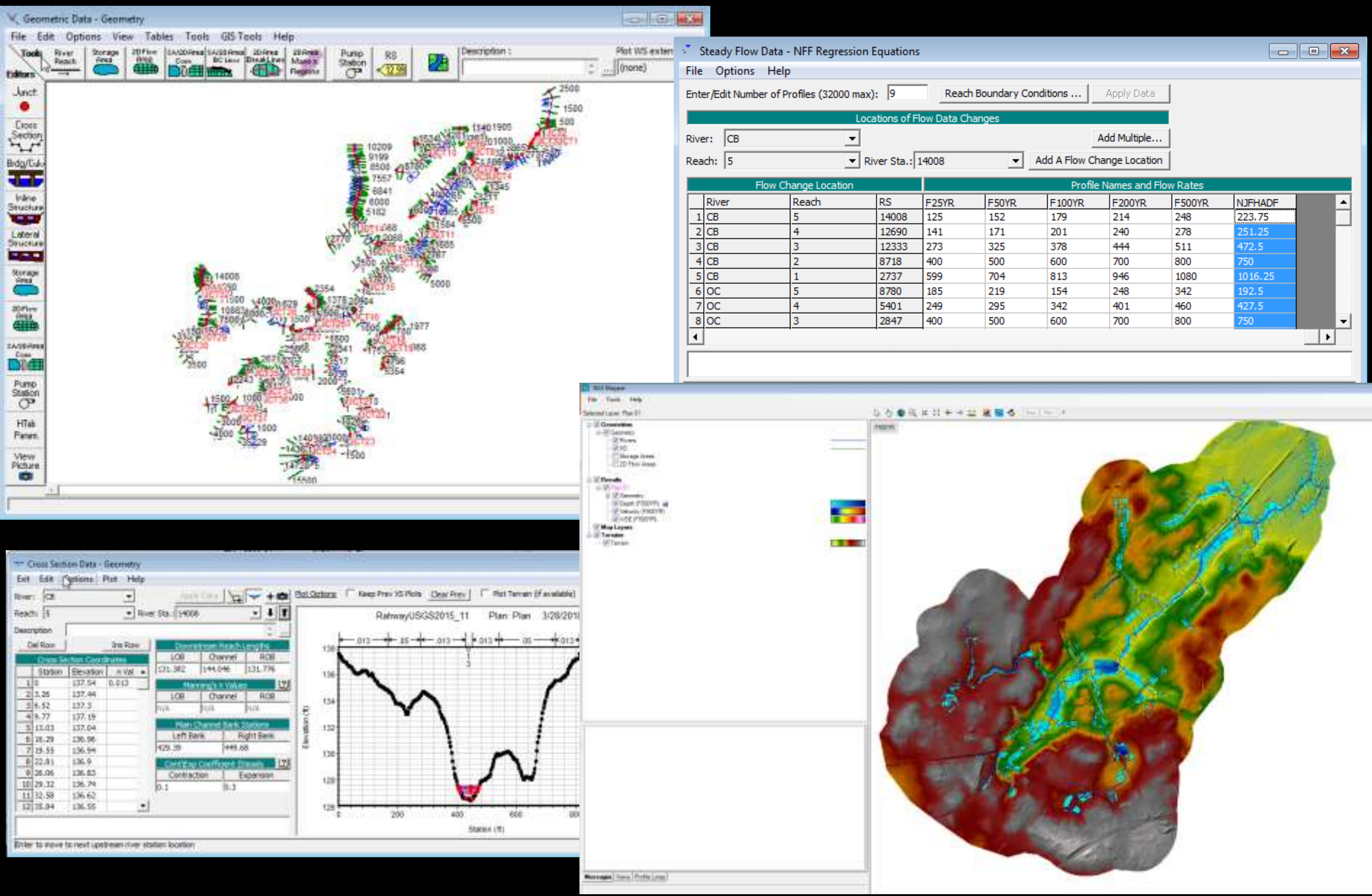
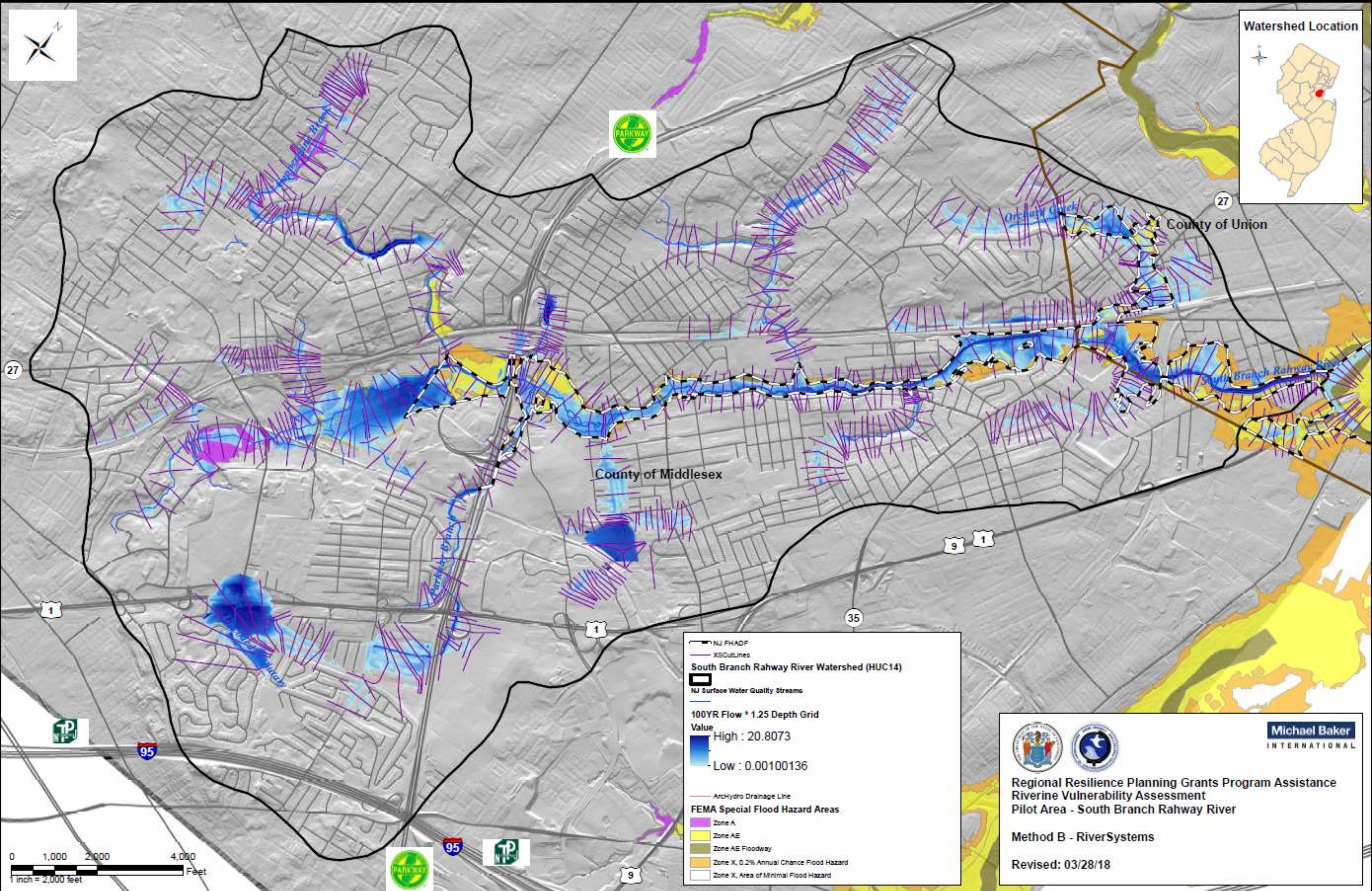
XY Coordinate System
Terrain
Target Raster
Source Raster
Set Data Source
Stream Centerlines
Target Feature Class
Source Feature Class
Set Data Source
DrainageLine
Optional Data
Drainage Points
Drainage Structures
Land Cover (Custom)
Land Cover (NLCD)
Cancel
Customize HEC-RAS Model Parameters
Use Recommended Parameters for each Flow Rate
Customize Spacing Around Drainage Structures
Prioritize Streams
Stream Name
Reset Parameters
100-year Flow Rate
Cross Section Width
Cross Section Spacing
Bank Width
Flow Path Width
Land Cover Manning's n Values
Save
Save and Close
Table Of Contents
Layers
Bank_StationPoint
<all other values>
Invalid Bank Station Point
DrainageLine
XSCutLines
Intersected XS
Minimum Elevation XS
XSCutLines(Model8)
XSCutLines3D
FlowPaths
Banks
LandUse_NLCD
DrainagePoint
DrainageLine
TerrainExtent
Hillshade
Value
High : 254
Low : 0
IssueAreas
Basemap
Generate Hydraulic Data
Study
HEC-RAS Model Parameters
Customize cross section widths, cross section spacing, bank widths, flow path widths, and Manning's n values.
Customize
Validate Cross Sections
Cancel
Generate Data
RiverSystems Hydraulics Toolbar
Import Hydrology Data
Add Stream Names
Generate Hydraulic Data
Create HEC-RAS Model



Geometric Data - Geometry
File Edit Options View Tables Tools GIS Tools Help
Steady Flow Data - NFF Regression Equations
File Options Help
Enter/Edit Number of Profiles (32000 max): 9
Reach Boundary Conditions ...
Apply Data
Locations of Flow Data Changes
River: CB
Add Multiple...
Reach: 5
River Sta.: 14008
Add A Flow Change Location
Flow Change Location
Profile Names and Flow Rates

	River	Reach	RS	F25YR	F50YR	F100YR	F200YR	F500YR	NJFHADF
1	CB	5	14008	125	152	179	214	248	223.75
2	CB	4	12690	141	171	201	240	278	251.25
3	CB	3	12333	273	325	378	444	511	472.5
4	CB	2	8718	400	500	600	700	800	750
5	CB	1	2737	599	704	813	946	1080	1016.25
6	OC	5	8780	185	219	154	248	342	192.5
7	OC	4	5401	249	295	342	401	460	427.5
8	OC	3	2847	400	500	600	700	800	750

Cross Section Data - Geometry
RahwayUSGS2015_11 Plan: Plan
Station (ft)



Watershed Location
27
County of Union
County of Middlesex
Orchard Creek
South Branch Rahway River
27
1
1
9
1
35
95
95
9
PARKWAY
PARKWAY
NJ FHADF
XSCutLines
South Branch Rahway River Watershed (HUC14)
NJ Surface Water Quality Streams
100YR Flow * 1.25 Depth Grid
Value
High : 20.8073
Low : 0.00100136
ArcHydro Drainage Line
FEMA Special Flood Hazard Areas
Zone A
Zone AE
Zone AE Floodway
Zone X, 0.2% Annual Chance Flood Hazard
Zone X, Area of Minimal Flood Hazard
0 1,000 2,000 4,000 Feet
1 inch = 2,000 feet
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Riverine Vulnerability Assessment
Pilot Area - South Branch Rahway River
Method B - RiverSystems
Revised: 03/28/18

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METHOD C –
N.J.A.C. 7:13-3.5 (Method 5)

- GIS Routine based on NJ Flood Hazard Area Control Act Rules
- Generates flood depth grids following Appendix 1 “Approximating the Flood Hazard Area Design Flood Elevation”
- Uses Table 1 inputs (WMA & Drainage Area) to estimate flood depth measured above average streambed

Riverine Vulnerability Assessment

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THIS IS A COURTESY COPY OF THIS RULE. ALL OF THE DEPARTMENT'S RULES ARE COMPILED IN TITLE 7 OF THE NEW JERSEY ADMINISTRATIVE CODE.

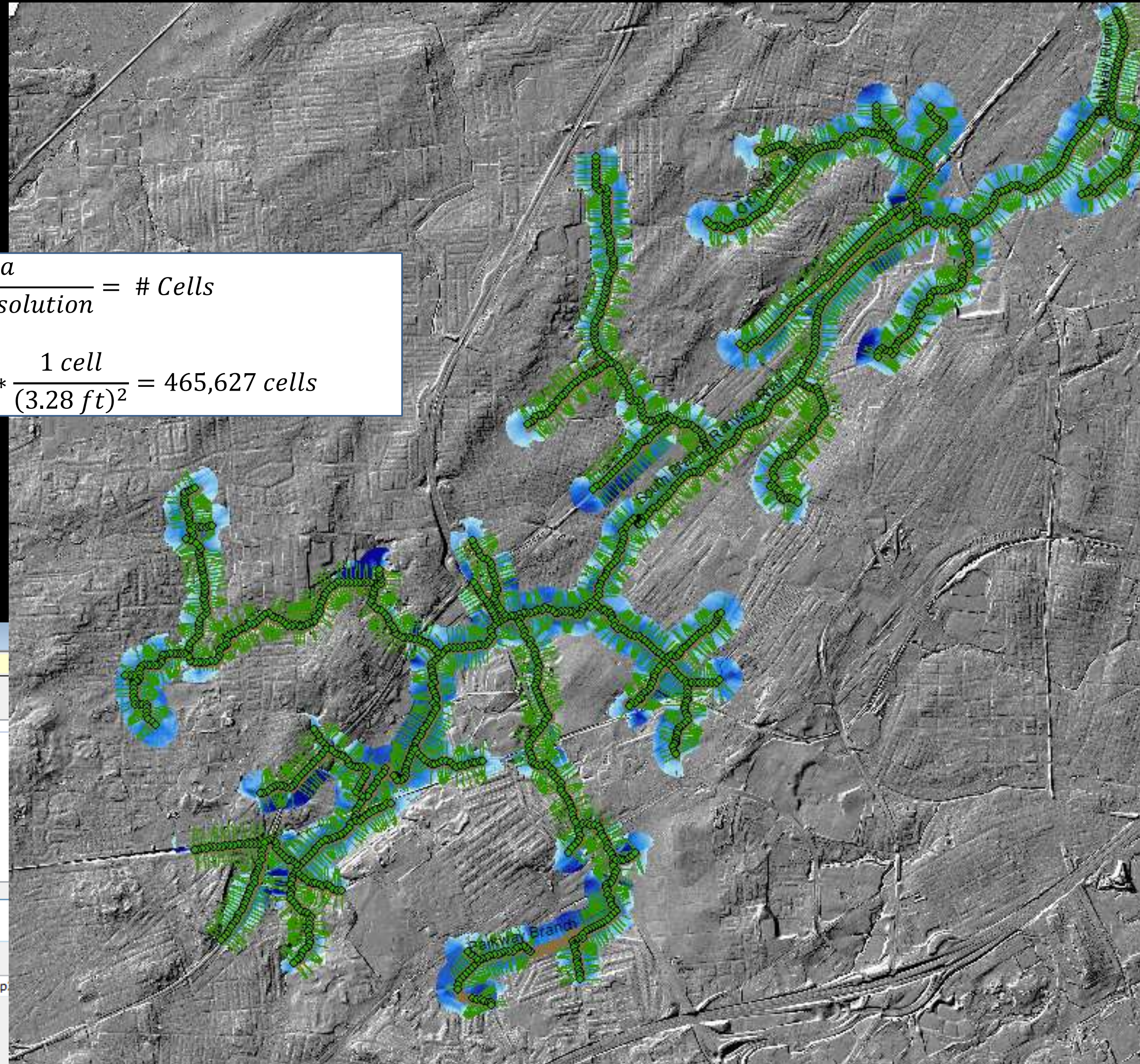
WMA[1]	CONTRIBUTORY DRAINAGE AREA[2] Shaded box indicates area in acres. Unshaded box indicates area in square miles.														
↓	FOR DRAINAGE AREAS UP TO ➡ THE FLOOD DEPTH IS SHOWN ⬇														
1		80	195	495	1.9	4.8	12.1	30.0							
2		80	195	495	1.9	4.8	12.1	30.0							
3			80	150	290	550	1.7	3.2	6.1	11.8	22.6	30.0			
4		70	130	235	430	1.2	2.3	4.1	7.6	13.9	25.4	30.0			
5		95	255	1.0	2.8	7.3	19.2	30.0							
6				85	280	1.4	4.7	15.3	30.0						
7							115	245	510	1.7	3.5	7.4	15.6	30.0	
8			60	115	210	395	1.2	2.2	4.0	7.5	14.1	26.3	30.0		
9		80	130	200	310	485	1.2	1.8	2.9	4.5	7.0	11	17.1	26.7	30.0
10	70	110	165	255	390	605	1.5	2.2	3.4	5.3	8.2	12.6	19.4	30.0	
11		80	145	265	490	1.4	2.6	4.8	8.8	16.1	30.0				
12				115	280	1.1	2.6	6.2	15.0	30.0					
13		85	210	530	2.1	5.1	12.7	30.0							
14		85	210	530	2.1	5.1	12.7	30.0							
15		85	210	530	2.1	5.1	12.7	30.0							
16		85	210	530	2.1	5.1	12.7	30.0							
17		85	210	530	2.1	5.1	12.7	30.0							
18	75	125	205	350	590	1.6	2.6	4.4	7.5	12.6	21.3	30.0			
19	60	115	225	440	1.3	2.6	5.1	9.9	19.2	30.0					
20	60	115	225	440	1.3	2.6	5.1	9.9	19.2	30.0					
DEPTH[3] (feet) ➡	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

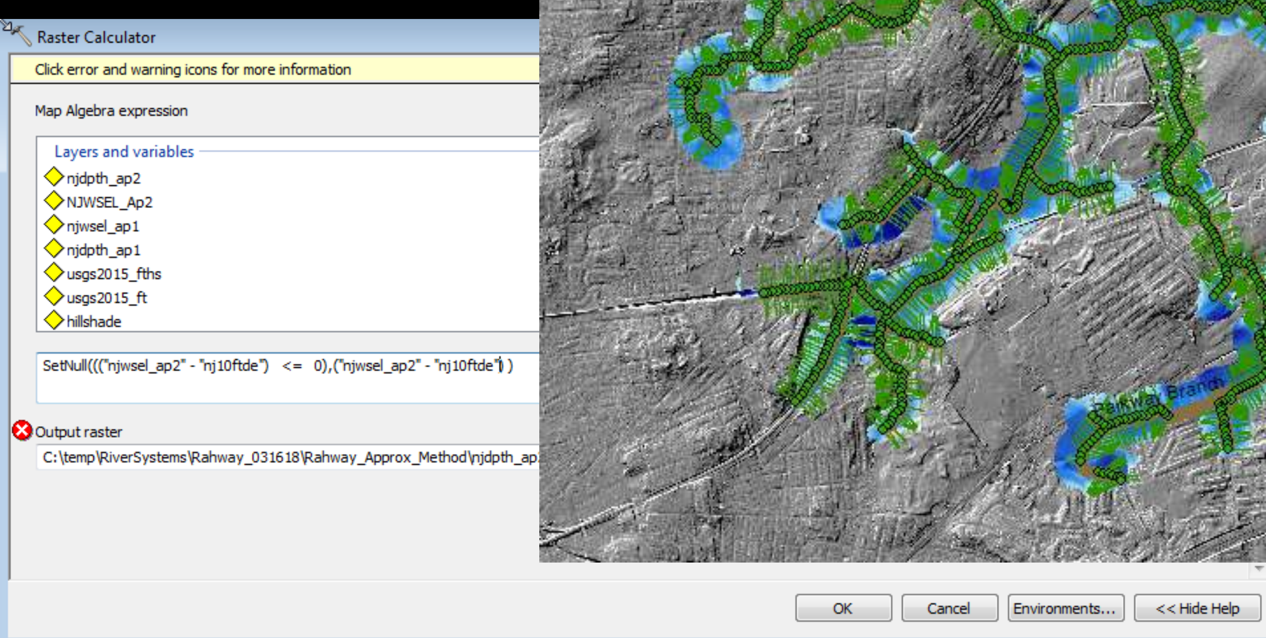
EXAMPLE

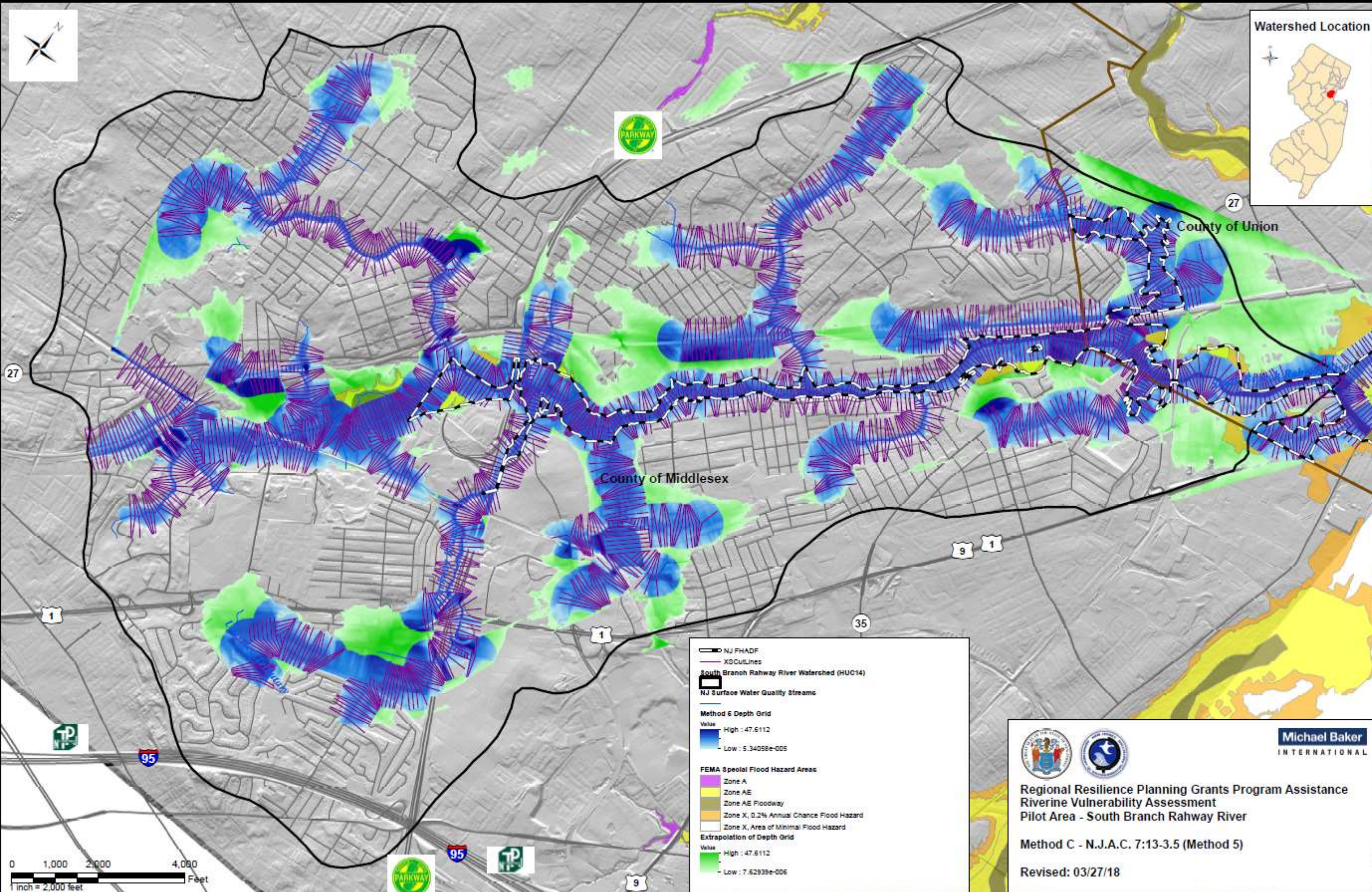
TABLE 1
APPROXIMATE FLOOD DEPTHS ABOVE AVERAGE STREAMBED ELEVATION
(SEE N.J.A.C.-7:13-3.5)

$$\frac{Area}{Raster\ Resolution} = \#\ Cells$$

$$115\ ac * 43560\frac{ft^2}{ac} * \frac{1\ cell}{(3.28\ ft)^2} = 465{,}627\ cells$$







Watershed Location
County of Union
County of Middlesex
PARKWAY
27
35
9
1
95
NJ FHADF
XSCutLines
South Branch Rahway River Watershed (HUC14)
NJ Surface Water Quality Streams
Method 6 Depth Grid
Value
High : 47.6112
Low : 5.34058e-005
FEMA Special Flood Hazard Areas
Zone A
Zone AE
Zone AE Floodway
Zone X, 0.2% Annual Chance Flood Hazard
Zone X, Area of Minimal Flood Hazard
Extrapolation of Depth Grid
Value
High : 47.6112
Low : 7.62939e-006
0 1,000 2,000 4,000
Feet
1 inch = 2,000 feet
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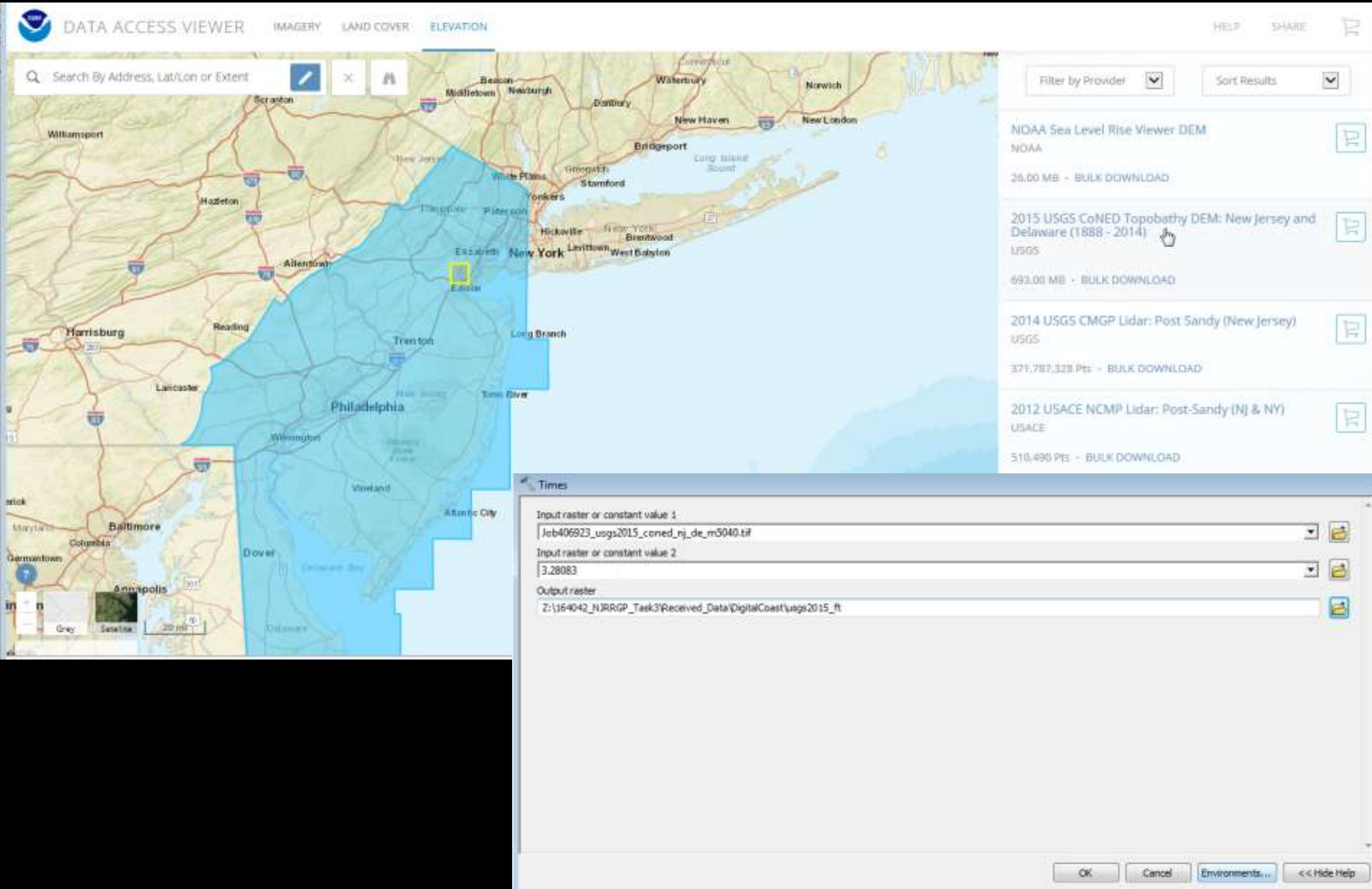
Regional Resilience Planning Grants Program Assistance
Riverine Vulnerability Assessment
Pilot Area - South Branch Rahway River
Method C - N.J.A.C. 7:13-3.5 (Method 5)
Revised: 03/27/18

METHOD D –
HEC-RAS 2D Rain on Grid

- Model-based approach
- Base Level Engineering using two-dimensional (2D) methods aligned with recent FEMA studies in other States
- HEC-RAS hydraulic model primarily from terrain and excess precipitation, with minimal user input
- Doesn’t explicitly account for urban storm management systems, but does have some enhancement options


DATA ACCESS VIEWER
IMAGERY
LAND COVER
ELEVATION
HELP
SHARE
Search By Address, Lat/Lon or Extent
Filter by Provider
Sort Results
NOAA Sea Level Rise Viewer DEM
NOAA
26.00 MB · BULK DOWNLOAD
2015 USGS CoNED Topobathy DEM: New Jersey and Delaware (1888 - 2014)
USGS
693.00 MB · BULK DOWNLOAD
2014 USGS CMGP Lidar: Post Sandy (New Jersey)
USGS
371,787,328 Pts · BULK DOWNLOAD
2012 USACE NCMP Lidar: Post-Sandy (NJ & NY)
USACE
510,490 Pts · BULK DOWNLOAD
Williamsport
Scranton
Hazleton
Allentown
Harrisburg
Reading
Lancaster
Philadelphia
Wilmington
Trenton
Edison
Elizabeth
New York
Paterson
Yonkers
White Plains
Stamford
Bridgeport
New Haven
New London
Norwich
Waterbury
Danbury
Middletown
Newburgh
Beacon
Hicksville
Brentwood
Levittown
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Long Branch
Toms River
Vineland
Atlantic City
Baltimore
Columbia
Germantown
Annapolis
Dover
Grey
Satellite
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Input raster or constant value 2
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Output raster
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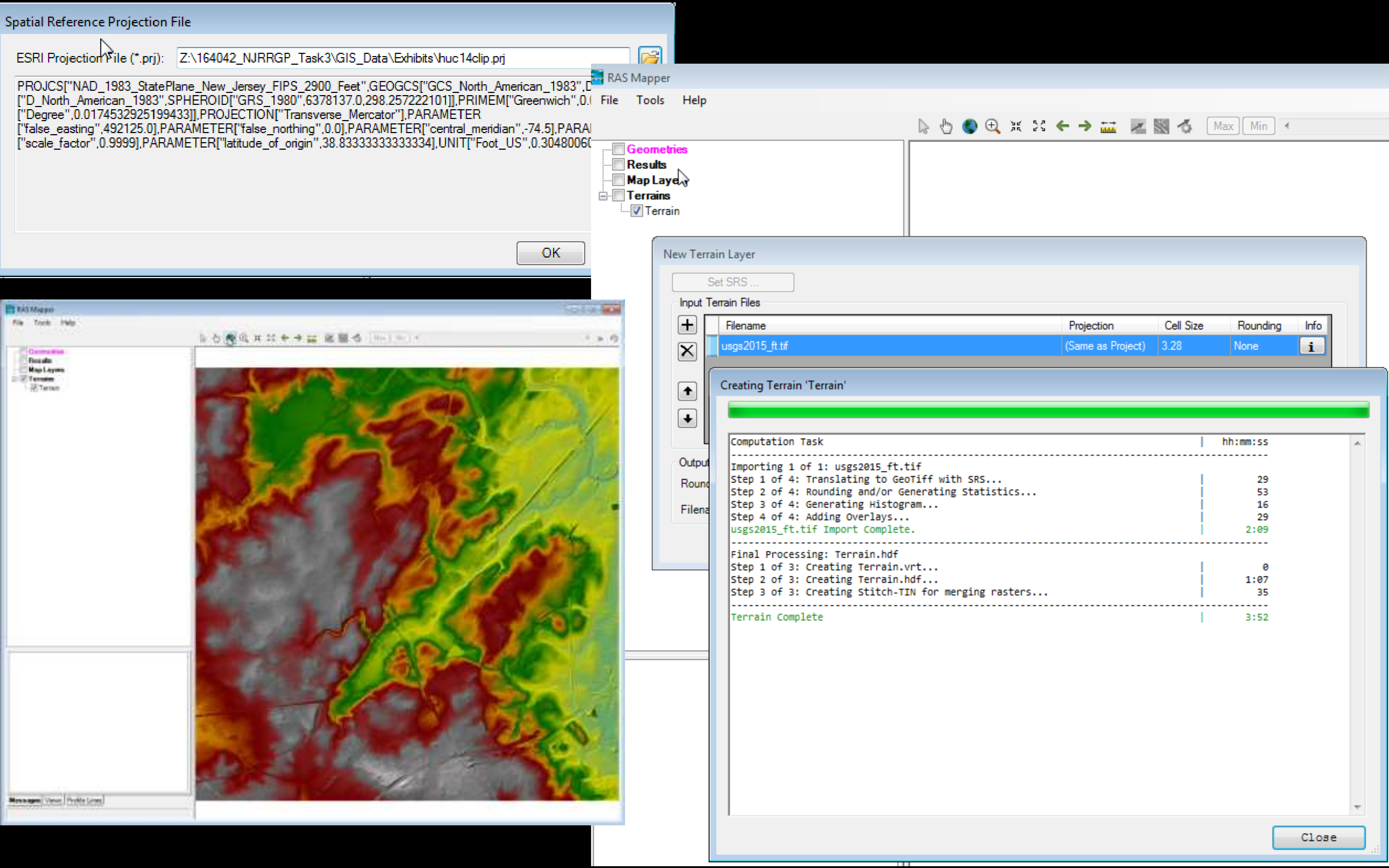
Cancel
Environments...
<< Hide Help


Spatial Reference Projection File
ESRI Projection File (*.prj):
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PROJCS["NAD_1983_StatePlane_New_Jersey_FIPS_2900_Feet",GEOGCS["GCS_North_American_1983",D
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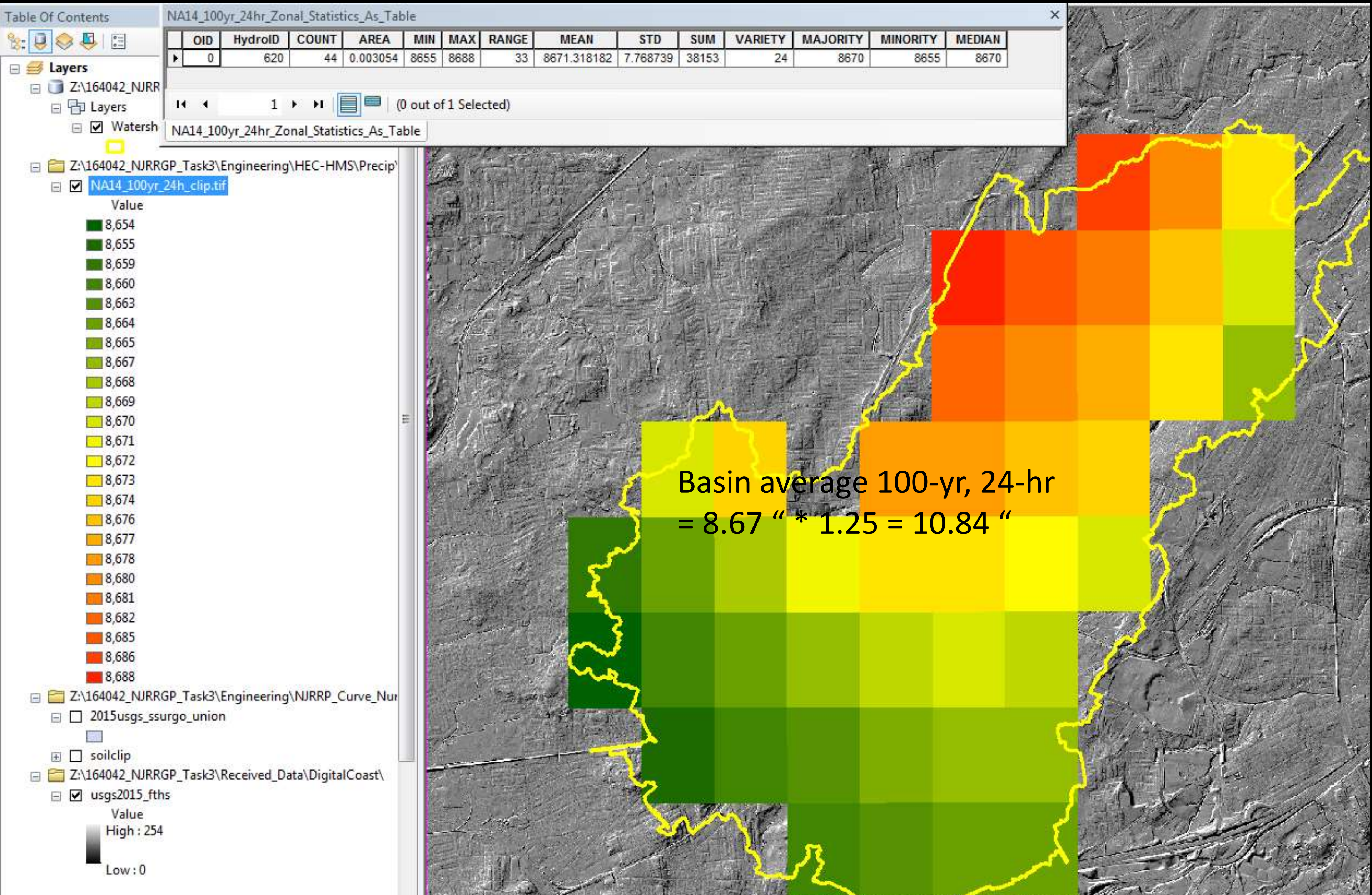
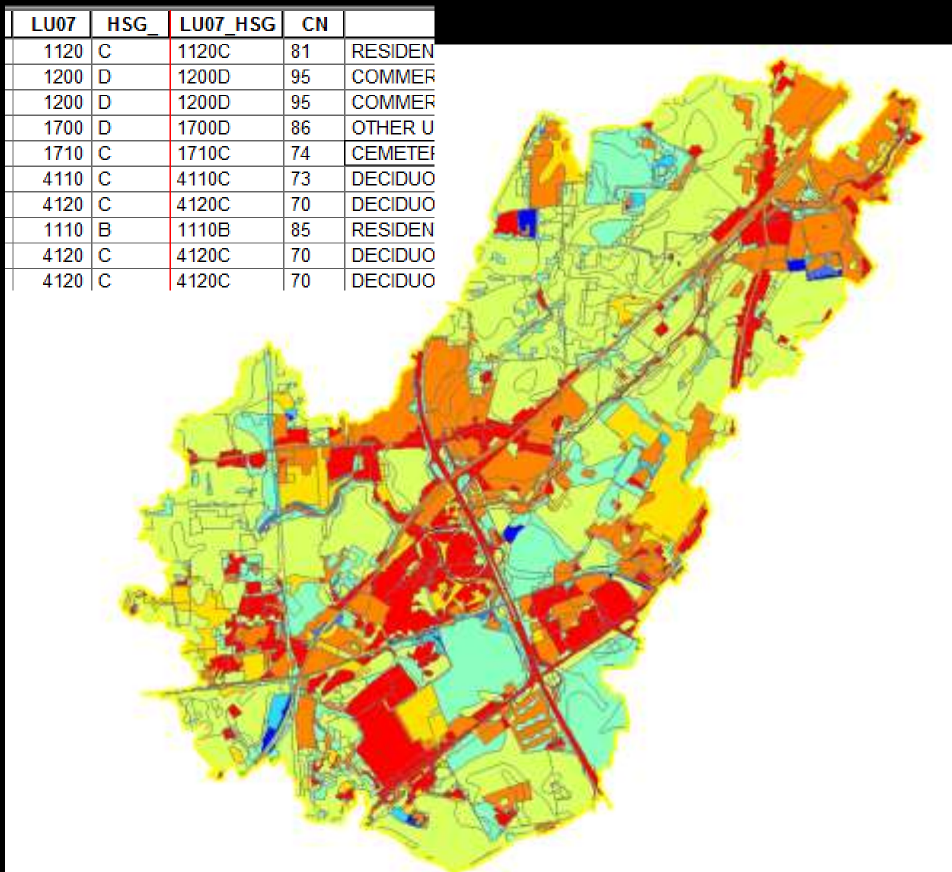
RAS Mapper
File
Tools
Help
Max
Min
Geometries
Results
Map Layers
Terrains
Terrain
New Terrain Layer
Set SRS ...
Input Terrain Files
Filename
Projection
Cell Size
Rounding
Info
usgs2015_ft.tif
(Same as Project)
3.28
None
Outpu
Round
Filena
Creating Terrain 'Terrain'
Computation Task | hh:mm:ss
Importing 1 of 1: usgs2015_ft.tif
Step 1 of 4: Translating to GeoTiff with SRS... | 29
Step 2 of 4: Rounding and/or Generating Statistics... | 53
Step 3 of 4: Generating Histogram... | 16
Step 4 of 4: Adding Overlays... | 29
usgs2015_ft.tif Import Complete. | 2:09
Final Processing: Terrain.hdf
Step 1 of 3: Creating Terrain.vrt... | 0
Step 2 of 3: Creating Terrain.hdf... | 1:07
Step 3 of 3: Creating Stitch-TIN for merging rasters... | 35
Terrain Complete | 3:52
Close



Basin average 100-yr, 24-hr
= 8.67 “ * 1.25 = 10.84 “

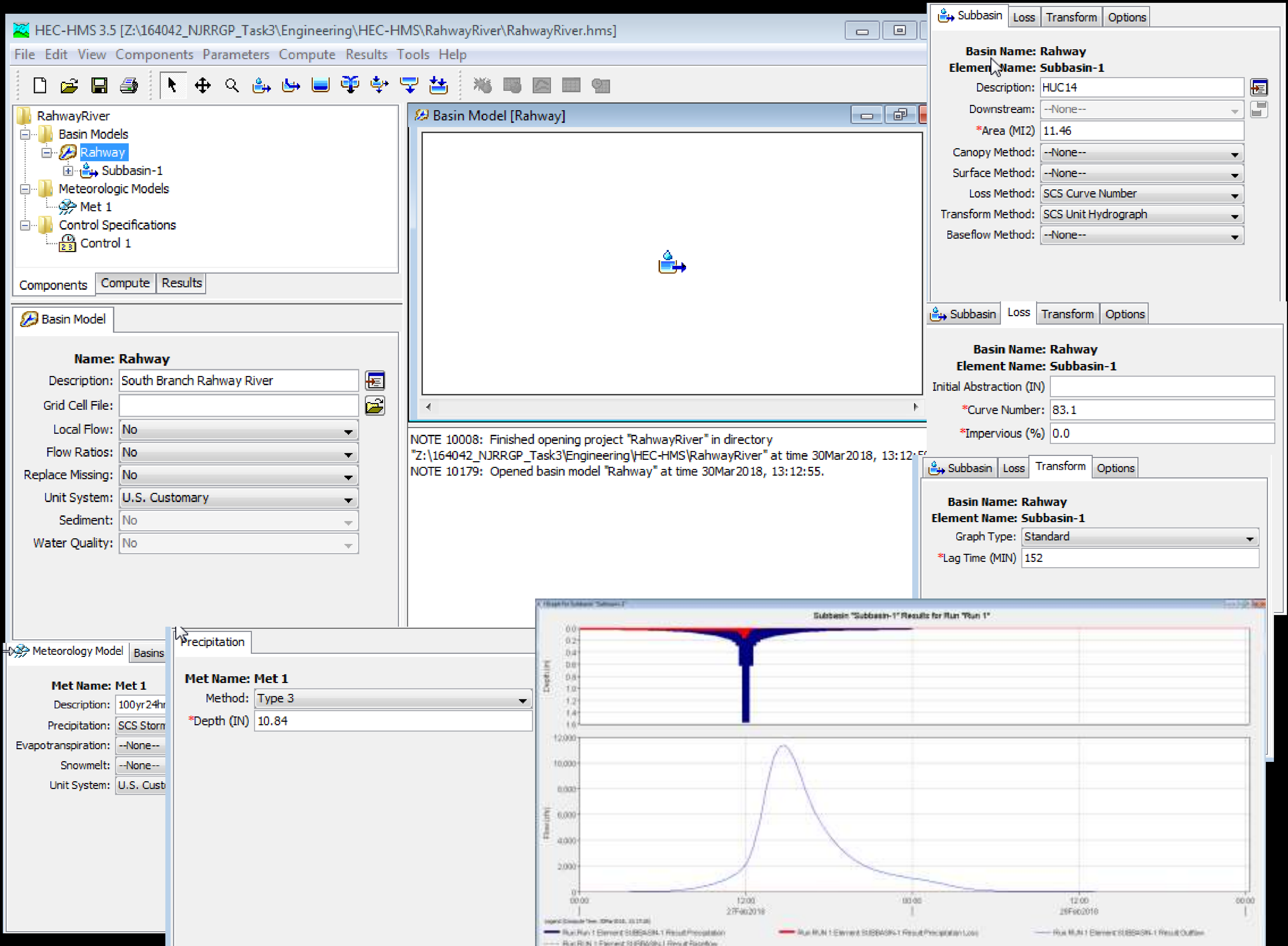
NJ LULC 2012 (rev 2015) -> TR-55 -> CN

				SCS Curve Number				
LU7Code	NJDEP - Anderson_Type	TR-55_Type	TR-55 Avg % Impervious	A	B	C	D	Notes
1110	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	Residential (1/8 acre)	65	77	85	90	92	
1120	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	Residential (1/3 acre)	30	57	72	81	86	
1130	RESIDENTIAL, SINGLE UNIT, LOW DENSITY	Residential (1 acre)	20	51	68	79	84	
1140	RESIDENTIAL, RURAL, SINGLE UNIT	Residential (2 acres)	12	46	65	77	82	
1150	MIXED RESIDENTIAL	Residential (averaged over lot sizes)	32	58	73	82	86	Averaged
1200	COMMERCIAL/SERVICES	Urban districts (commercial and busine	85	89	92	94	95	
1211	MILITARY INSTALLATIONS	Urban districts (commercial and busine	85	89	92	94	95	
1214	NO LONGER MILITARY	Urban districts (commercial and busine	85	89	92	94	95	
1300	INDUSTRIAL	Urban districts (industrial)	72	81	88	91	93	
1400	TRANSPORTATION/COMMUNICATION/UTILITIES	Impervious Areas (Paved, open ditches	75	83	89	92	93	
1410	MAJOR ROADWAY	Impervious Areas (Streets and roads, pa	100	98	98	98	98	
1411	MIXED TRANSPORTATION CORRIDOR OVERLAP AREA	Impervious Areas (Paved, open ditches	75	83	89	92	93	
1419	BRIDGE OVER WATER	Impervious Areas (Paved, open ditches	75	83	89	92	93	
1420	RAILROADS	Impervious Areas (Gravel)	63	76	85	89	91	
1440	AIRPORT FACILITIES	Impervious Areas (Paved, open ditches	75	83	89	92	93	
1461	WETLAND RIGHTS-OF-WAY	Woods (Poor)	0	45	66	77	83	Assumed woodlands wetland with higher runoff
1462	UPLAND RIGHTS-OF-WAY DEVELOPED	Residential (averaged over lot sizes)	32	58	73	82	86	Averaged
1463	UPLAND RIGHTS-OF-WAY UNDEVELOPED	Woods (Fair)	0	36	60	73	79	
1499	STORMWATER BASIN	Open space (good)	0	39	61	74	80	
1500	INDUSTRIAL AND COMMERCIAL COMPLEXES	Urban districts (commercial and busine	85	89	92	94	95	
1600	MIXED URBAN OR BUILT-UP LAND	Residential (averaged over lot sizes)	32	58	73	82	86	Averaged
1700	OTHER URBAN OR BUILT-UP LAND	Residential (averaged over lot sizes)	32	58	73	82	86	Averaged
1710	CEMETERY	Open space (good)	0	39	61	74	80	
1711	CEMETERY ON WETLAND	Open space (poor)	0	68	79	86	89	Assumed cemetary with higher runoff
1741	PHRAGMITES DOMINATE URBAN AREA	Brush (Fair)	0	35	56	70	77	
1750	MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	Open space (fair)	0	49	69	79	84	
1800	RECREATIONAL LAND	Open space (fair)	0	49	69	79	84	
1804	ATHLETIC FIELDS (SCHOOLS)	Open space (good)	0	39	61	74	80	
1810	STADIUM, THEATERS, CULTURAL CENTERS AND ZOOS	Urban districts (commercial and busine	85	89	92	94	95	
1850	MANAGED WETLAND IN BUILT-UP MAINTAINED REC AREA	Open space (fair)	0	49	69	79	84	
2100	CROPLAND AND PASTURELAND	Pasture, grassland, or range (good)		39	61	74	80	
2140	AGRICULTURAL WETLANDS (MODIFIED)	Pasture, grassland, or range (poor)		68	79	86	89	Assumed higher runoff than dry pasture
2150	FORMER AGRICULTURAL WETLAND (BECOMING SHRUBBY, NOT BUILT-UP)	Brush (poor)		48	67	77	83	
2200	ORCHARDS/VINEYARDS/NURSERIES/HORTICULTURAL AREAS	Row Crops (SR Good)		67	78	85	89	



LU07	HSG_	LU07_HSG	CN	
1120	C	1120C	81	RESIDEN
1200	D	1200D	95	COMMER
1200	D	1200D	95	COMMER
1700	D	1700D	86	OTHER U
1710	C	1710C	74	CEMETEI
4110	C	4110C	73	DECIDUO
4120	C	4120C	70	DECIDUO
1110	B	1110B	85	RESIDEN
4120	C	4120C	70	DECIDUO
4120	C	4120C	70	DECIDUO

		EXISTING		FUTURE
	% Total Area	Average CN	% Total Area	Average CN
URBAN (Code 1000)	88%	83.5	90%	83.5
AGRICULTURAL, FOREST & BARREN (Codes 2000,4000 & 7000)	9%	72.3	7%	72.3
WATER/WETLANDS (Codes 5000-6000, 8000)	3%	94.8	3%	94.8
Total	100%	82.9	100%	83.1


HEC-HMS 3.5 [Z:\164042_NJRRGP_Task3\Engineering\HEC-HMS\RahwayRiver\RahwayRiver.hms]
File Edit View Components Parameters Compute Results Tools Help
RahwayRiver
Basin Models
Rahway
Subbasin-1
Meteorologic Models
Met 1
Control Specifications
Control 1
Components Compute Results
Basin Model
Name: Rahway
Description: South Branch Rahway River
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Unit System: U.S. Customary
Sediment: No
Water Quality: No
Basin Model [Rahway]
NOTE 10008: Finished opening project "RahwayRiver" in directory "Z:\164042_NJRRGP_Task3\Engineering\HEC-HMS\RahwayRiver" at time 30Mar2018, 13:12:5
NOTE 10179: Opened basin model "Rahway" at time 30Mar2018, 13:12:55.
Subbasin Loss Transform Options
Basin Name: Rahway
Element Name: Subbasin-1
Description: HUC14
Downstream: --None--
*Area (MI2) 11.46
Canopy Method: --None--
Surface Method: --None--
Loss Method: SCS Curve Number
Transform Method: SCS Unit Hydrograph
Baseflow Method: --None--
Subbasin Loss Transform Options
Basin Name: Rahway
Element Name: Subbasin-1
Initial Abstraction (IN)
*Curve Number: 83.1
*Impervious (%) 0.0
Subbasin Loss Transform Options
Basin Name: Rahway
Element Name: Subbasin-1
Graph Type: Standard
*Lag Time (MIN) 152
Meteorology Model Basins
Met Name: Met 1
Description: 100yr24hr
Precipitation: SCS Storm
Evapotranspiration: --None--
Snowmelt: --None--
Unit System: U.S. Cust
Precipitation
Met Name: Met 1
Method: Type 3
*Depth (IN) 10.84
Subbasin "Subbasin-1" Results for Run "Run 1"

Datums for 8531680, Sandy Hook NJ

Elevations on Station Datum

Station: 8531680, Sandy Hook, NJ
Status: Accepted (Apr 17 2003)
Units: Feet
T.M.: 0
Epoch: 1983-2001
Datum: STND

Datum	Value	Description
MHHW	7.74	Mean Higher-High Water
MHW	7.41	Mean High Water
MTL	5.06	Mean Tide Level
MSL	5.09	Mean Sea Level
DTL	5.12	Mean Diurnal Tide Level
MLW	2.71	Mean Low Water
MLLW	2.51	Mean Lower-Low Water
NAVD88	5.33	North American Vertical Dat

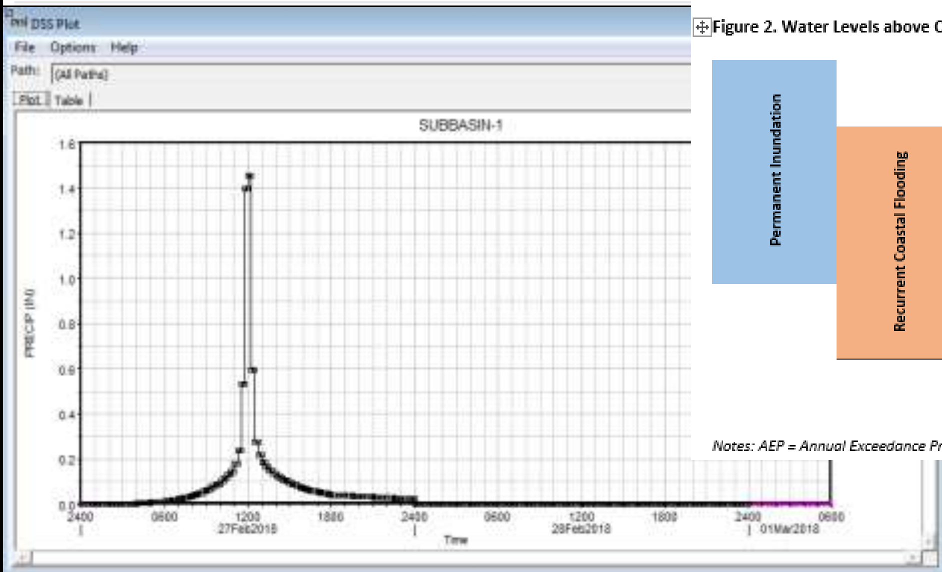


Figure 1. Water Levels above Current MHHW Assessed for Exposure Analyses (Atlantic City, NJ)

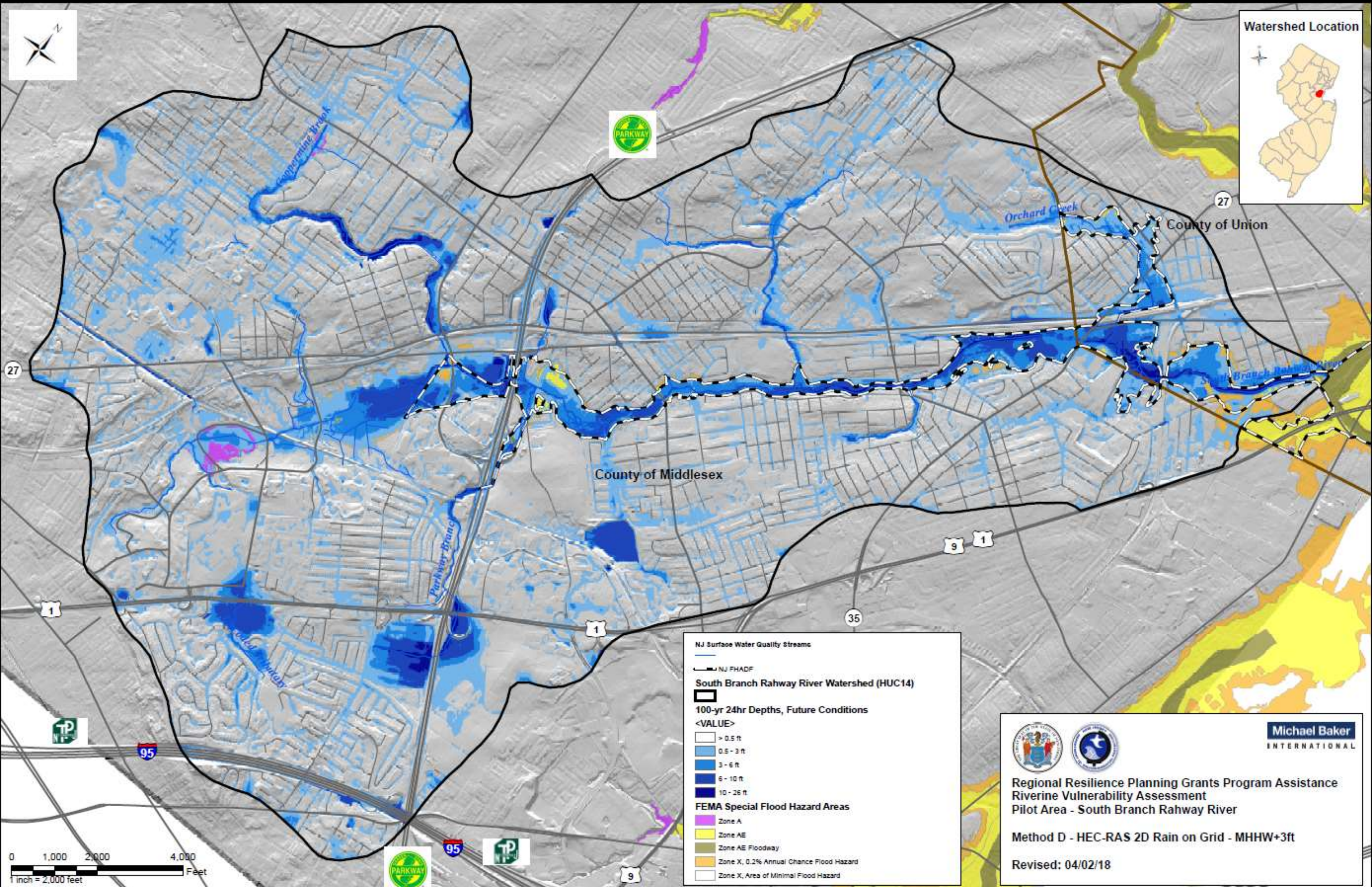
	Water Level	
Permanent Inundation	1 ft.	• Permanent Inundation (MHHW) in 2030 using Central HE/LE Scenarios (0.8 ft.) • Permanent Inundation (MHHW) in 2030 using 1-in-20 Chance HE Scenario (1.1 ft.) • Permanent Inundation (MHHW) in 2050 using Central HE/LE Scenarios (1.4 ft.)
Permanent Inundation	2 ft.	• Current Annual (99% AEP) flood (1.7 ft.) • Permanent Inundation (MHHW) in 2050 using 1-in-20 Chance HE Scenario (2.0 ft.) • Permanent Inundation (MHHW) in 2100 using Central LE Scenario (2.3 ft.)
Permanent Inundation; Recurrent Coastal Flooding	3 ft.	• Annual (99% AEP) flood in 2030 using Central HE/LE Scenarios (2.5 ft.) • Annual (99% AEP) flood in 2030 using a 1-in-20 Chance HE Scenario (2.8 ft.) • Annual (99% AEP) flood in 2050 using Central HE/LE Scenario (3.1 ft.) • Permanent Inundation (MHHW) in 2100 using a Central HE Scenario (3.4 ft.)
Recurrent Coastal Flooding; Extreme Coastal Flooding (Storms)	5 ft.	• Sandy Storm Tide in 2030 using Central HE/LE Scenarios (4.9 ft.) • Sandy Storm Tide in 2030 using 1-in-20 HE Scenario (5.2 ft.) • Current 100-year (1% AEP) Flood (4.9 ft.) • 10-year (10% AEP) flood in 2030 using a 1-in-20 HE Scenario (4.6 ft.) • 10-year (10% AEP) flood in 2050 using Central HE/LE Scenarios (4.9 ft.) • Annual (99% AEP) flood in 2100 using Central HE Scenario (5.1 ft.) • Permanent Inundation (MHHW) in 2100 using a 1-in-20 HE Scenario (5.3 ft.)
Extreme Coastal Flooding (Storms)	9 ft.	• Sandy Storm Tide in 2100 using 1-in-20 HE Scenario (9.4 ft.) • 10-year (10% AEP) flood in 2100 using a 1-in-20 HE Scenario (8.8 ft.)

Notes: AEP = Annual Exceedance Probability, HE = High Emissions, LE = Low Emissions, MHHW = Mean Higher High Water, SLR = Relative Sea Level Rise. All values are with respect to

Figure 2. Water Levels above Current MHHW Assessed for Exposure Analyses (Sandy Hook, NJ)

	Water Level	W
Permanent Inundation	1 ft.	• Permanent Inundation (MHHW) in 2030 using Central HE/LE Scenarios (0.8 ft.) • Permanent Inundation (MHHW) in 2030 using 1-in-20 HE Scenario (1.1 ft.) • Permanent Inundation (MHHW) in 2050 using Central HE/LE Scenarios (1.4 ft.)
Permanent Inundation; Recurrent Coastal Flooding	2 ft.	• Current Annual (99% AEP) flood (1.8 ft.) • Permanent Inundation (MHHW) in 2050 using 1-in-20 HE Scenario (2.0 ft.) • Permanent Inundation (MHHW) in 2100 using Central LE Scenario (2.3 ft.)
Permanent Inundation; Recurrent Coastal Flooding	3 ft.	• Annual (99% AEP) flood in 2030 using Central HE/LE Scenarios (2.6 ft.) • Annual (99% AEP) flood in 2030 using a 1-in-20 HE Scenario (2.9 ft.) • Annual (99% AEP) flood in 2050 using Central HE/LE Scenario (3.2 ft.) • Permanent Inundation (MHHW) in 2100 using a Central HE Scenario (3.4 ft.)
Recurrent Coastal Flooding; Extreme Coastal Flooding (Storms)	7 ft.	• Current 100-year (1% AEP) Flood (6.9 ft.) • Annual (99% AEP) flood in 2100 using a 1-in-20 HE Scenario (7.1 ft.)
Extreme Coastal Flooding (Storms)	12 ft.	• Sandy Storm Tide in 2100 using Central HE Scenario (11.7 ft.) • 100-year (1% AEP) flood in 2100 using 1-in-20 HE Scenario (12.2 ft.)

Notes: AEP = Annual Exceedance Probability, HE = High Emissions, LE = Low Emissions, MHHW = Mean Higher High Water, SLR = Relative Sea Level Rise. All values are with respect to



Watershed Location
Coppermine Brook
Orchard Creek
County of Union
County of Middlesex
South Branch Rahway River
Parkway Branch
27
27
35
9
1
1
1
95
95
9
NJ Surface Water Quality Streams
NJ FHADF
South Branch Rahway River Watershed (HUC14)
100-yr 24hr Depths, Future Conditions
<VALUE>
> 0.5 ft
0.5 - 3 ft
3 - 6 ft
6 - 10 ft
10 - 26 ft
FEMA Special Flood Hazard Areas
Zone A
Zone AE
Zone AE Floodway
Zone X, 0.2% Annual Chance Flood Hazard
Zone X, Area of Minimal Flood Hazard
0 1,000 2,000 4,000 Feet
1 inch = 2,000 feet
Michael Baker INTERNATIONAL
Regional Resilience Planning Grants Program Assistance
Riverine Vulnerability Assessment
Pilot Area - South Branch Rahway River
Method D - HEC-RAS 2D Rain on Grid - MHHW+3ft
Revised: 04/02/18