Research Work Unit 2.3
Flooding Impacts on Wastewater Infrastructure

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NYS RISE
Resiliency Institute for Storms & Emergencies

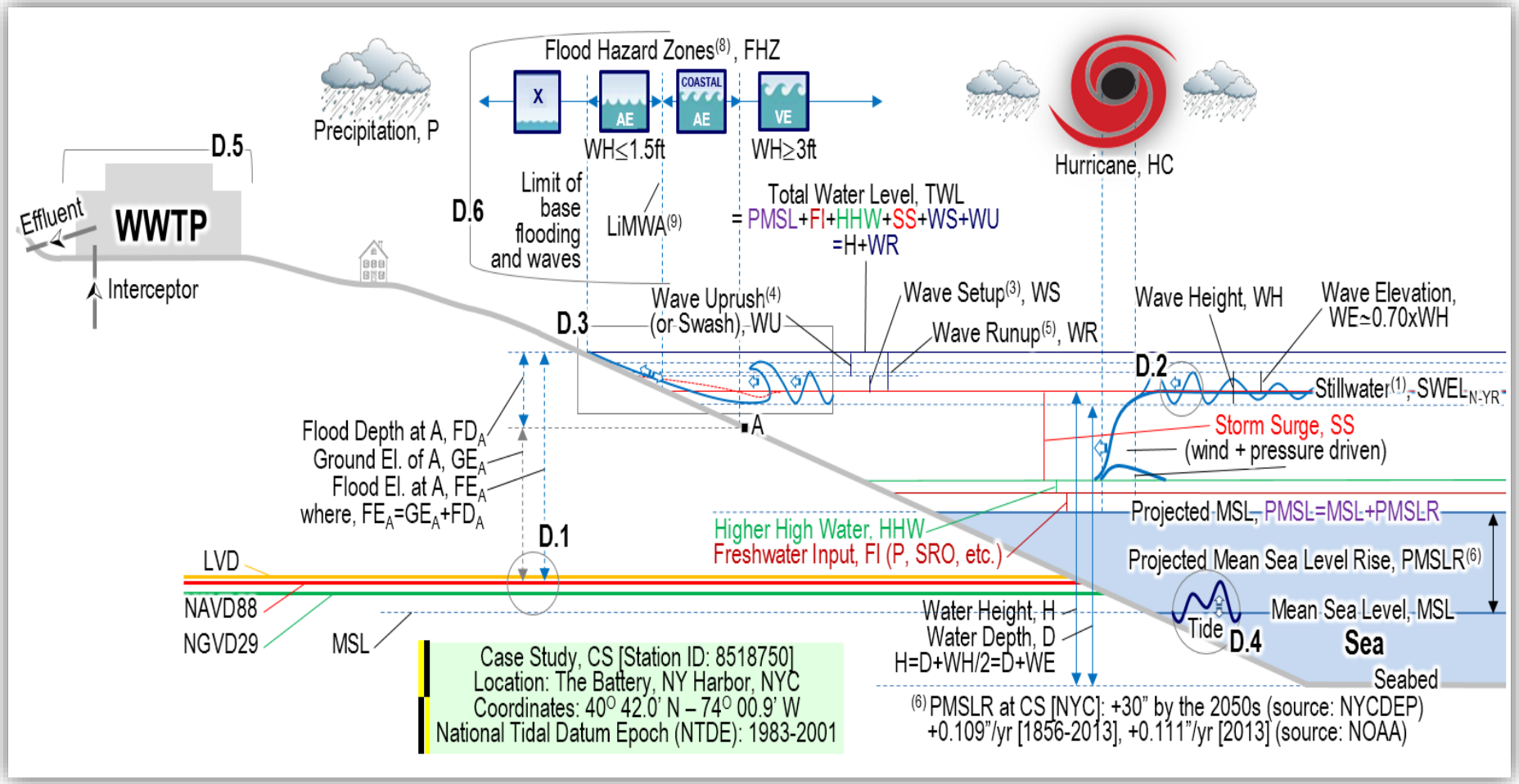
Scope of Work

Inventory, mapping, and performance reviews of sewage treatment plants and pumping stations relative to storm surge levels, characteristics of plant damage, and loss of service at pump stations will be evaluated through a review of publicly available documents and information from government agencies and experts.

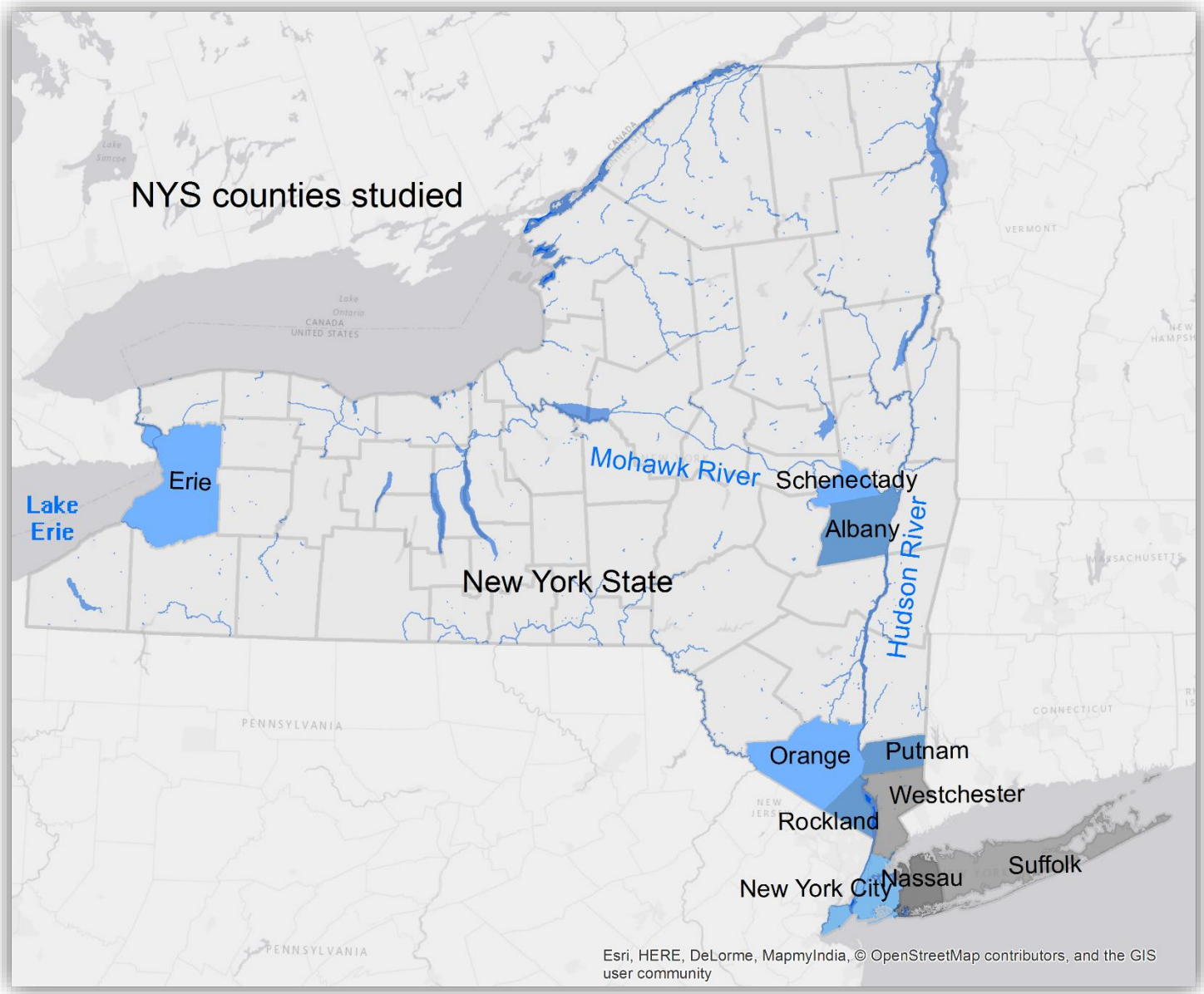
The most vulnerable treatment equipment and conveyance system components will be identified. Measures for plant protection and conveyance system improvements will be evaluated, and ranked on the basis of cost/benefit analysis. Temporal and spatial distributions of wastewater spills and dispersions in past storms.

Working with US-EPA, NYS-EFC, NYS-DOS, NYS-DEC and NYC-DEP to make recommendations on preventing future plant failures and mitigating environmental damages.

Riverine and Coastal Flooding Sketch



NYS COUNTIES STUDIED



Models Used

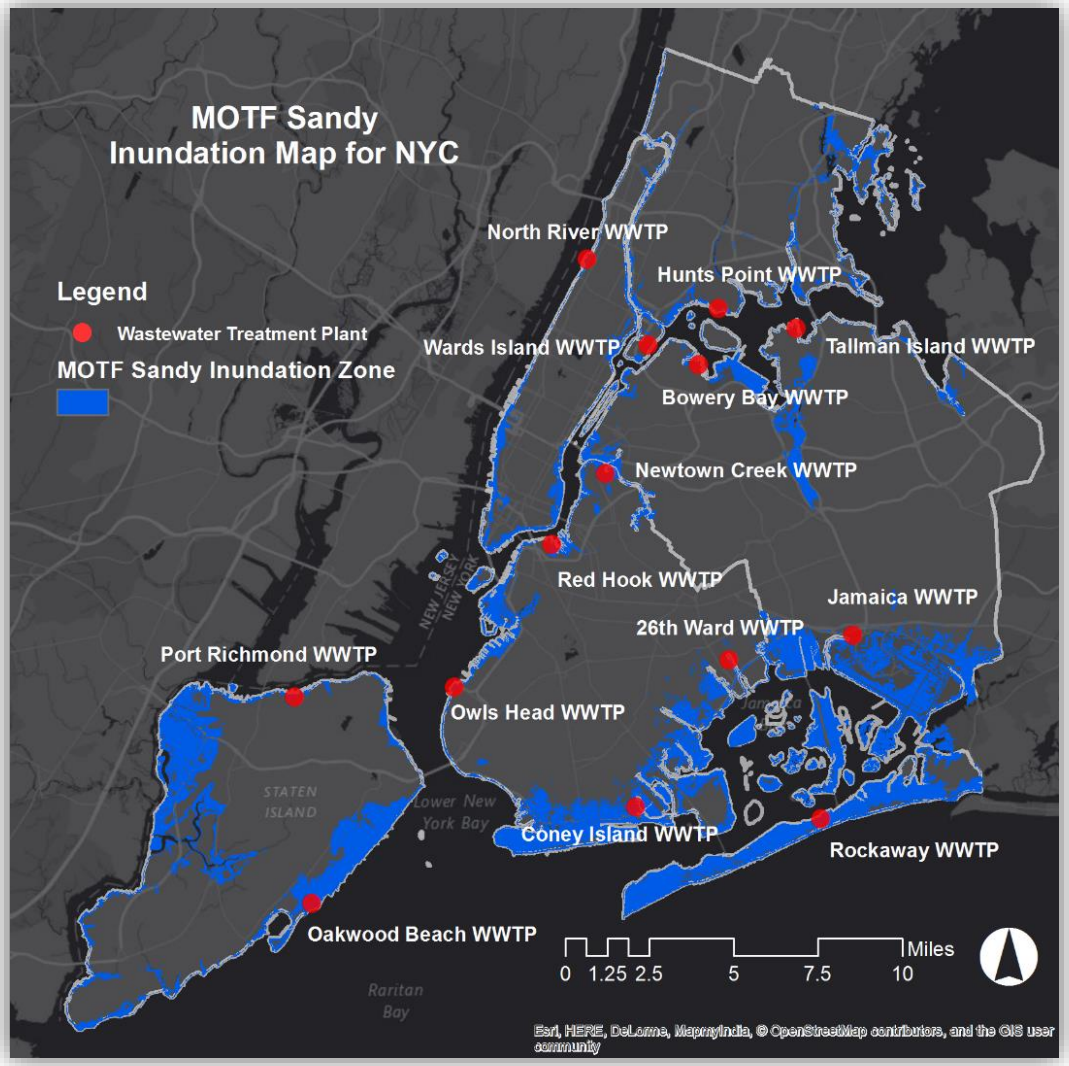
- FEMA MOTF (Federal Emergency Management Agency - Modelling Task Force), a group of modeling and risk analyst experts in support of disaster response operations that provides hazard, modeling and impact assessments information from a variety of information sources through coordination to develop.

- SLOSH (Sea, Lake, and Overland Surges from Hurricanes) is a computerized model developed by the National Weather Service (NWS) to estimate storm surge heights and winds resulting from hurricanes.

- HazUS (Hazards US – Multi-Hazards) is a software developed by FEMA for estimating potential direct/indirect losses from floods, winds and earthquakes. Uses Geographic Information Systems (GIS) technology to graphically depict economic losses, structural damages, etc. for various scenarios

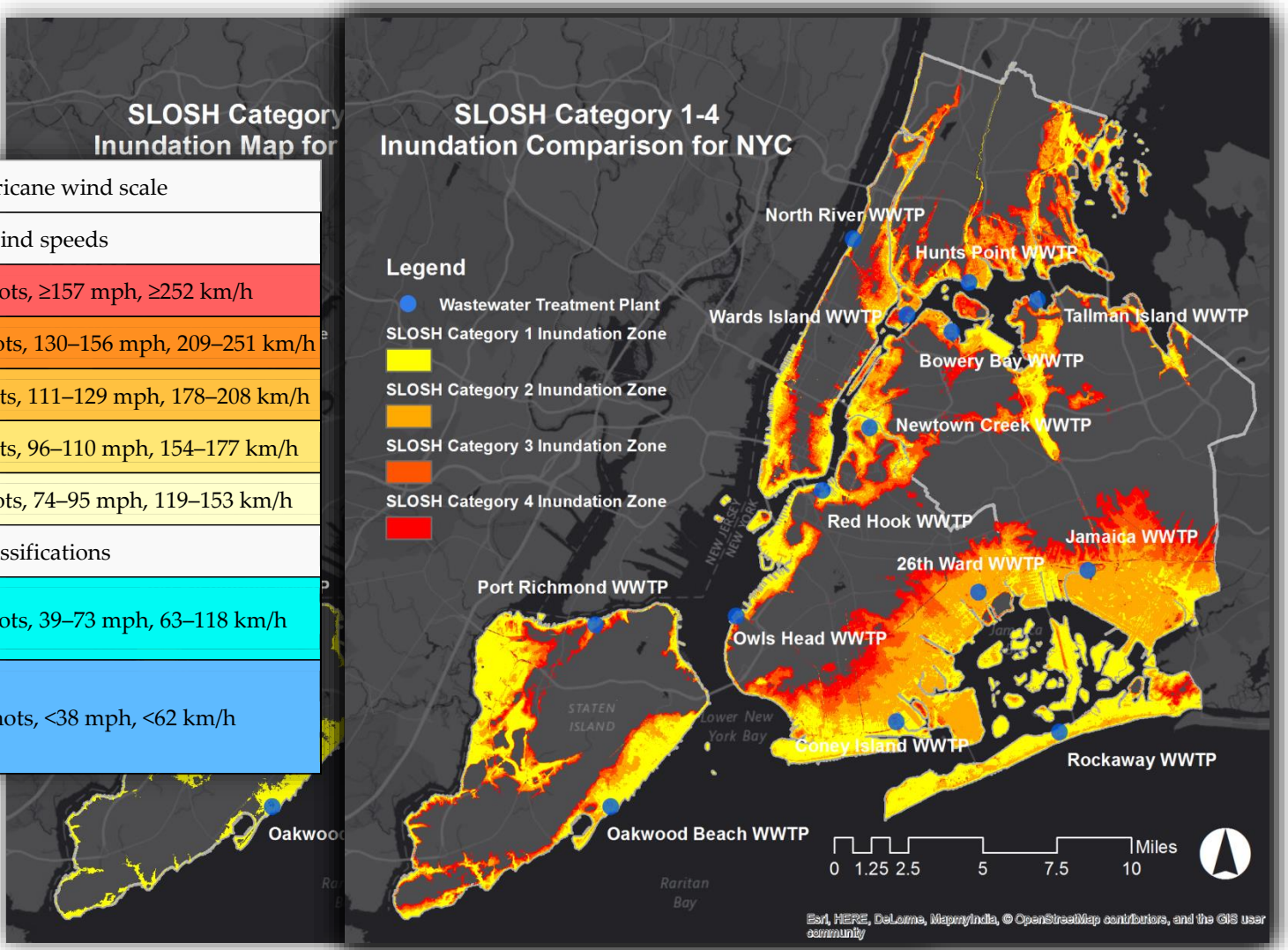
FEMA MOTF OUTPUT NYC

Hurricane Event: Superstorm Sandy
DEM: 1-meter resolution



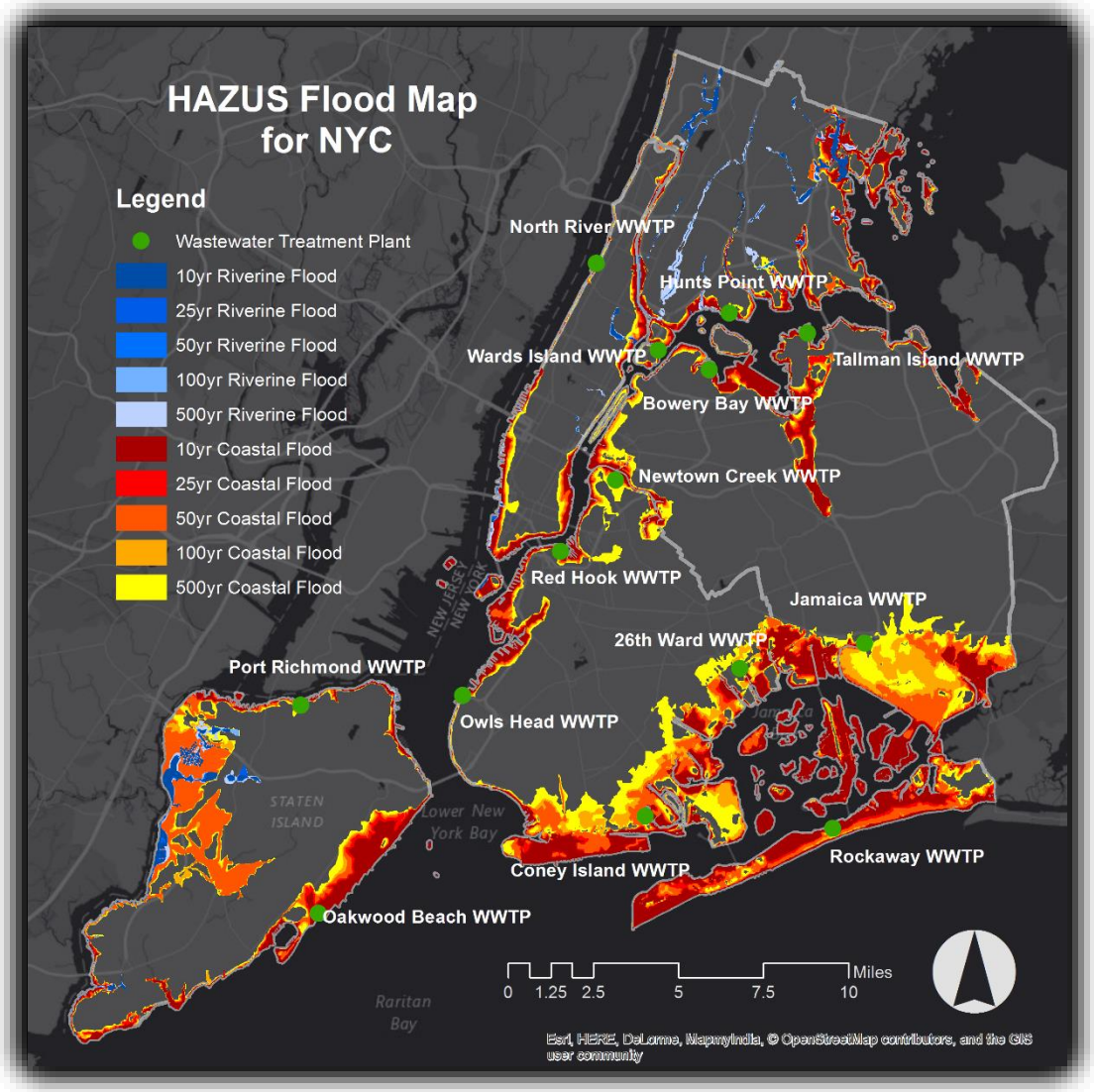
SLOSH Inundation Map of NYC (various categories)

Saffir–Simpson hurricane wind scale	
Category	Wind speeds
Five	≥70 m/s, ≥137 knots, ≥157 mph, ≥252 km/h
Four	58–70 m/s, 113–136 knots, 130–156 mph, 209–251 km/h
Three	50–58 m/s, 96–112 knots, 111–129 mph, 178–208 km/h
Two	43–49 m/s, 83–95 knots, 96–110 mph, 154–177 km/h
One	33–42 m/s, 64–82 knots, 74–95 mph, 119–153 km/h
Additional classifications	
Tropical storm	18–32 m/s, 35–63 knots, 39–73 mph, 63–118 km/h
Tropical depression	<17 m/s, <34 knots, <38 mph, <62 km/h



HazUS Riverine and Coastal Flood Analysis of NYC

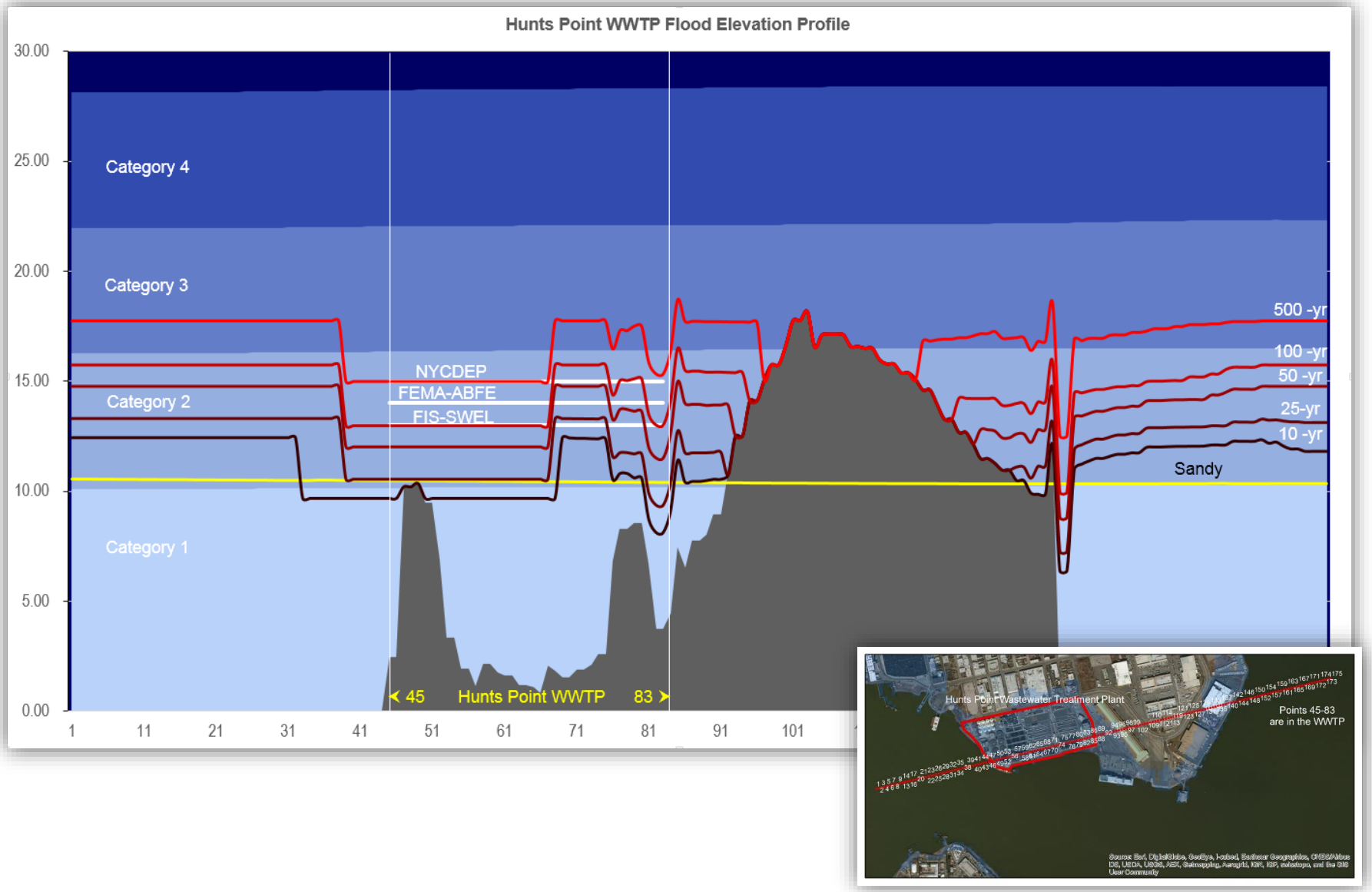
DEM: 1 arc second resolution (~30 meters)
Hazard Type: Riverine and Coastal



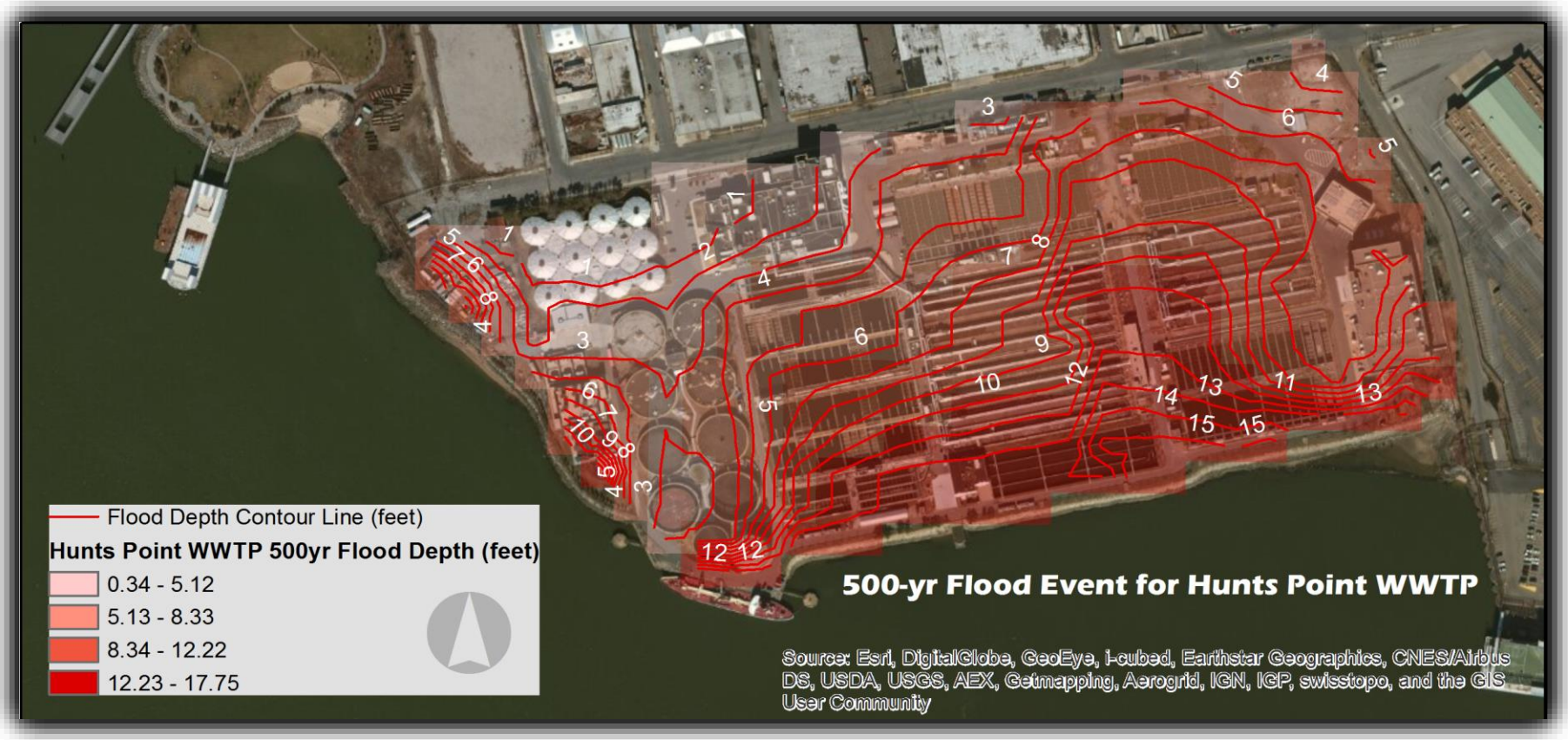
Case Study 1: Hunts Point WWTP

Parameter (Reference Datum)		Hunts Point, Bronx, NYC																											
		FEMA[1]	NYCDEP[2]	WU2.3[3]																									
				FEMA based	MOTF Sandy			*MOTF Damage %*			SLOSH			*SLOSH Damage %*			HazUS-MH Model4												
																	USGS[5a] - Coastal Flooding			USGS - Riverine Flooding[5b]			*Coastal Damage %*[6a]			*Riverine Damage %*[6b]		
					min	mean	max	*min*	*mean*	*max*	min	mean	max	*min*	*mean*	*max*	min	mean	max	min	mean	max	*min*	*mean*	*max*	*min*	*mean*	*max*
A. Current SSA[7] (MHHW)	+		6.873																										
B. MHHW[8] (Local Datum)	+		6.627																										
C. ABFE[9] (Local Datum)	=		13.500	12.492																									
D. ΔE[10] (Local Datum -> NAVD88)	+		1.500	1.508																									
E. 100-YR ABFE[11] (NAVD88)	=	14.000	15.000	14.000																									
F. Stillwater Elevation, SWEL[12] (NAVD 88)	HazUS Input Values																												
$SWEL_{10\text{-}YR}$																	9.610												
$SWEL_{50\text{-}YR}$																	12.020												
$SWEL_{100\text{-}YR}$																	13.010												
$SWEL_{500\text{-}YR}$																	15.120												
G. H_S[13] (NAVD 88)																	2.399												
H. Flood Depth, FE[16] (NAVD 88)	=																												
C1 for SLOSH and $FD_{10\text{-}YR}$ for HazUS	MOTF, SLOSH and HazUS Results				0.000	0.772	17.138				0.000	0.727	20.071				0.029	4.597	12.435	0.137	0.178	0.466							
C2 and $FD_{25\text{-}YR}$											0.000	2.806	26.268				0.072	5.116	13.305	0.160	0.201	0.490							
C3 and $FD_{50\text{-}YR}$											0.000	5.941	31.959				0.005	6.273	14.755	0.197	0.238	0.525							
C4 and $FD_{100\text{-}YR}$											0.000	9.610	38.167				0.062	7.151	15.735	0.222	0.550	0.550							
C5 and $FD_{500\text{-}YR}$											-	-	-				0.341	9.054	17.745	0.055	0.280	0.581							
I. Ground Elevation, GE[15] (NAVD 88)	+																Lowest:	0.000	Average:	6.810	Highest:	16.530							
J. Flood El., FE[16] (NAVD 88) and *Damage %, D%*	=																												
C1, $D\%_{C1}$ for SLOSH & $FE_{10\text{-}YR}$, $D\%_{10\text{-}YR}$ for HazUS	MOTF, SLOSH and HazUS Results				10.405	10.453	10.499	0.000	3.861	40.000	10.123	10.173	10.196	0.000	3.636	40.000	8.132	10.321	12.435	0.137	0.137	0.137	0.000	14.106	40.000	0.000	0.013	0.687
C2, $D\%_{C2}$ and $FE_{25\text{-}YR}$, $D\%_{25\text{-}YR}$											16.297	16.373	16.417	0.000	9.611	40.000	9.380	11.289	13.305	0.179	0.336	0.960	0.000	20.043	40.000	0.000	0.017	0.897
C3, $D\%_{C3}$ and $FE_{50\text{-}YR}$, $D\%_{50\text{-}YR}$											22.005	22.056	22.098	0.000	29.649	40.000	11.496	12.803	14.755	0.197	0.352	0.974	0.000	29.189	40.000	0.000	0.018	0.984
C4, $D\%_{C4}$ and $FE_{100\text{-}YR}$, $D\%_{100\text{-}YR}$											28.209	28.271	28.330	0.000	36.102	40.000	12.980	13.838	15.735	0.222	0.375	0.989	0.000	30.000	40.000	0.000	0.021	1.109
C5, $D\%_{C5}$ and $FE_{500\text{-}YR}$, $D\%_{500\text{-}YR}$											-	-	-	-	-	-	14.990	15.930	17.745	0.417	0.521	1.053	0.000	30.000	40.000	0.000	0.082	2.903
K. $PMSLR_{2050s}$[17] (NAVD 88)	+		2.500	2.500													2.500												
L. 100-yr Critical Flood Elevation[18] (NAVD88)	=		17.500	16.500													15.480	16.338	18.235										
M. Wave Splash[19] (NAVD 88)	+		3.000	3.000													3.000												
N. 100-yr Total Water Level[20] (NAVD88)	=		20.500	19.500													18.480	19.338	21.235										
O. %Δ[21]	%			4.878													9.854	5.669	3.586										

Hunts Point Profile



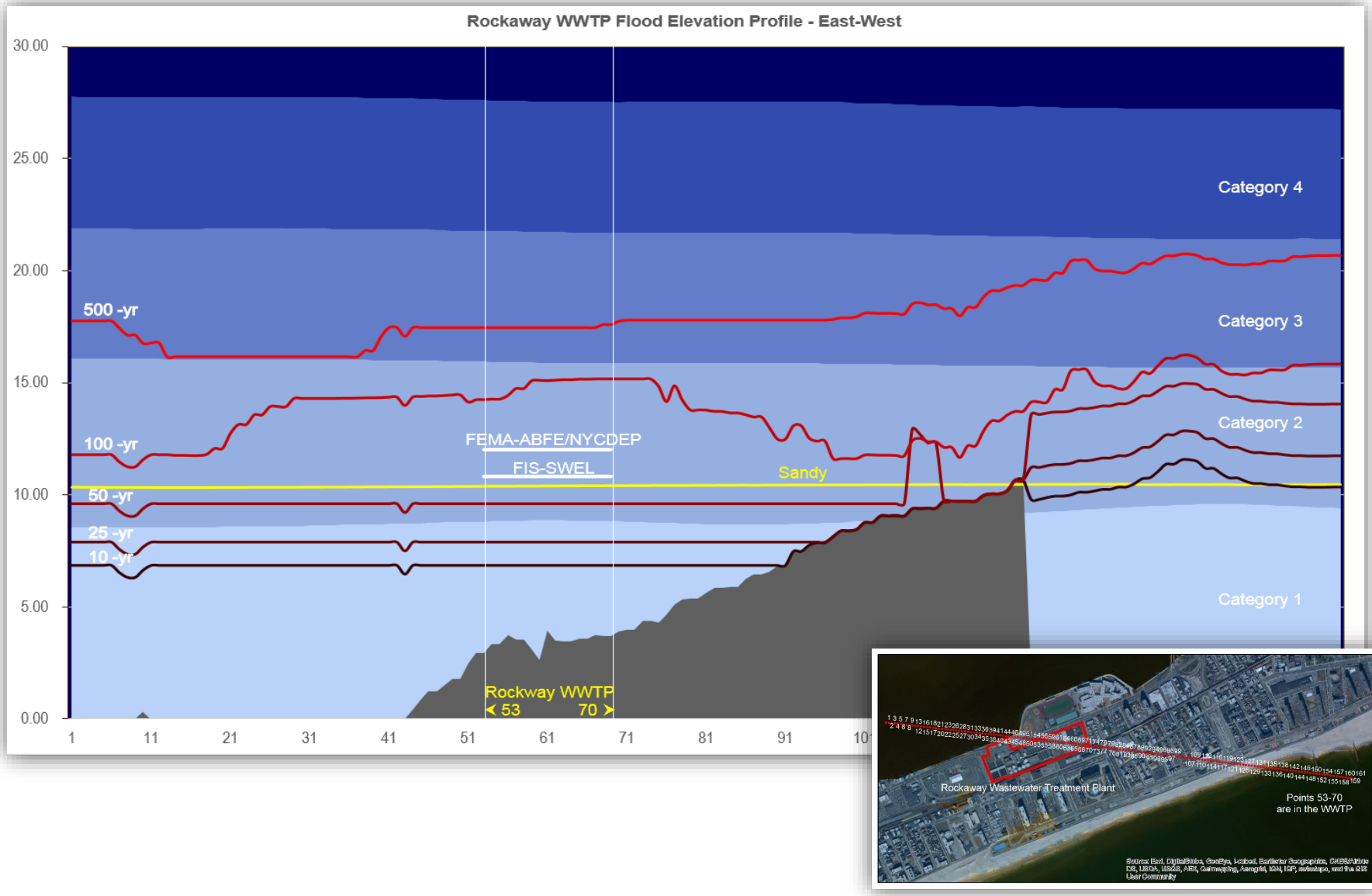
Iso-Flood-Depth curves



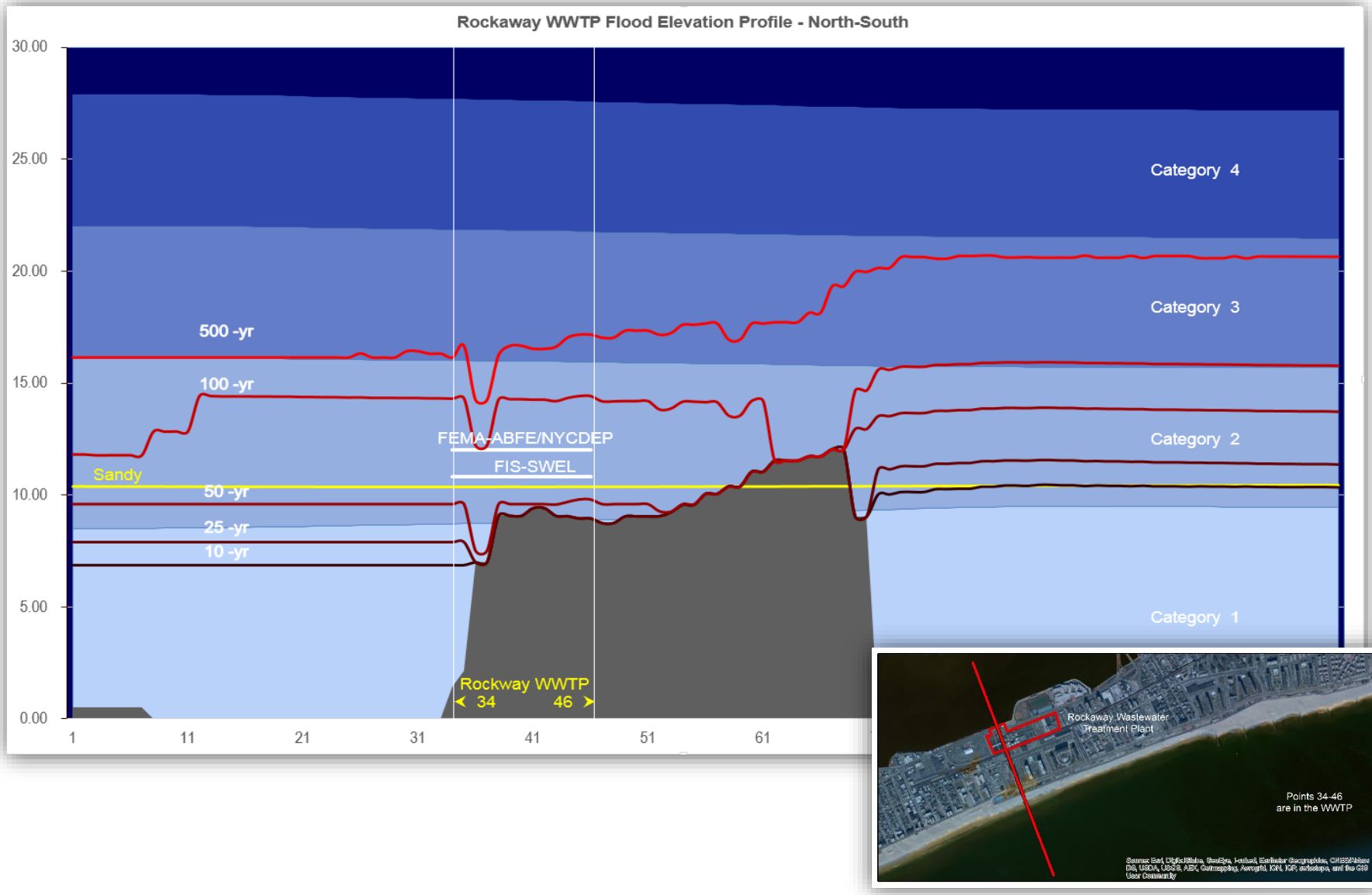
Case Study 2: Rockaway WWTP

Parameter (Reference Datum)		Rockaway, Queens, NYC																								
		FEMA[1]	NYCDEP[2]	WU2.3[3]																						
				FEMA based	MOTF			*MOTF Damage %*			SLOSH			*SLOSH Damage %*			HazUS-MH Model4									
																	USGS[5a] - Coastal Flooding			USGS - Riverine Flooding[5b]			*Coastal Damage %*[6a]			*Riverine Damage %*[6b]		
					min	mean	max	*min*	*mean*	*max*	min	mean	max	*min*	*mean*	*max*	min	mean	max	min	mean	max	*min*	*mean*	*max*	*min*	*mean*	*max*
A. Current SSA[7] (MHHW)	+		9.630																							
B. MHHW[8] (Local Datum)	+		0.770																							
C. ABFE[9] (Local Datum)	=		10.400	10.375																						
D. ΔE[10] (Local Datum -> NAVD88)	+		1.600	1.625																						
E. 100- YR ABFE[11] (NAVD88)	=	**12.000**	**12.000**	**12.000**																						
F. Stillwater Elevation, SWEL[12] (NAVD 88)	HazUS Input Values																6.780									
$SWEL_{10\text{-}YR}$	HazUS Input Values																9.444									
$SWEL_{50\text{-}YR}$	HazUS Input Values																10.820									
$SWEL_{100\text{-}YR}$	HazUS Input Values																14.884									
$SWEL_{500\text{-}YR}$	HazUS Input Values																15.754									
G. H_S[13] (NAVD 88)	HazUS Input Values																									
H. Flood Depth, FD[14] (NAVD 88)	=																									
C1 for SLOSH and $FD_{10\text{-}YR}$ for HazUS	MOTF, SLOSH and HazUS Results				0.000	1.411	14.306				0.000	0.667	12.481				0.006	3.048	6.468	-	-	-				
C2 and $FD_{25\text{-}YR}$	MOTF, SLOSH and HazUS Results										0.000	3.489	19.708				0.443	3.923	7.496	-	-	-				
C3 and $FD_{50\text{-}YR}$	MOTF, SLOSH and HazUS Results										0.000	6.001	25.521				0.177	4.046	9.208	-	-	-				
C4 and $FD_{100\text{-}YR}$	MOTF, SLOSH and HazUS Results										0.000	8.518	31.364				4.818	8.997	13.983	-	-	-				
C5 and $FD_{500\text{-}YR}$	MOTF, SLOSH and HazUS Results										-	-	-				6.932	11.632	17.053	-	-	-				
I. Ground Elevation, GE[15] (NAVD 88)	+																Lowest:	0.000	Average:	5.210	Highest:	9.420				
J. Flood El., FE[16] (NAVD 88) and *Damage %, D%*	=																									
C1, $D\%_{C1}$ for SLOSH & $FE_{10\text{-}YR}$, $D\%_{10\text{-}YR}$ for HazUS	MOTF, SLOSH and HazUS Results				10.336	**10.375**	10.415	*0.000*		*6.234*	8.690	8.819	8.941	*0.000*	*3.336*	*40.000*	4.630	6.670	7.483	-	-	-	*0.000*	*7.954*	*30.000*	*0.000*	*0.000*	*0.000*
C2, $D\%_{C2}$ and $FE_{25\text{-}YR}$, $D\%_{25\text{-}YR}$	MOTF, SLOSH and HazUS Results										15.866	**15.936**	16.011	*0.000*	*13.425*	*40.000*	5.658	7.701	8.511	-	-	-	*0.000*	*9.353*	*30.000*	*0.000*	*0.000*	*0.000*
C3, $D\%_{C3}$ and $FE_{50\text{-}YR}$, $D\%_{50\text{-}YR}$	MOTF, SLOSH and HazUS Results										21.688	21.755	21.839	*0.000*	*30.000*	*40.000*	5.312	9.320	10.223	-	-	-	*0.883*	*17.321*	*32.080*	*0.000*	*0.000*	*0.000*
C4, $D\%_{C4}$ and $FE_{100\text{-}YR}$, $D\%_{100\text{-}YR}$	MOTF, SLOSH and HazUS Results										27.503	27.585	27.689	*0.000*	*30.000*	*40.000*	9.967	**14.268**	15.183	-	-	-	*22.725*	*30.000*	*40.000*	*0.000*	*0.000*	*0.000*
C5, $D\%_{C5}$ and $FE_{500\text{-}YR}$, $D\%_{500\text{-}YR}$	MOTF, SLOSH and HazUS Results										-	-	-	-	-	-	11.855	16.898	17.641	-	-	-	*30.000*	*40.000*	*40.000*	*0.000*	*0.000*	*0.000*
K. $PMSLR_{2050s}$[17] (NAVD 88)	+		2.500	2.500													2.500									
L. 100-yr Critical Flood Elevation[18] (NAVD88)	=		**14.500**	**14.500**													12.467	**16.768**	17.683							
M. Wave Splash[19] (NAVD 88)	+		3.000	3.000													3.000									
N. 100-yr Total Water Level[20] (NAVD88)	=		**17.500**	**17.500**													15.467	**19.768**	20.683							
O. %Δ[21]	%			0.000													11.615	**12.958**	18.187							

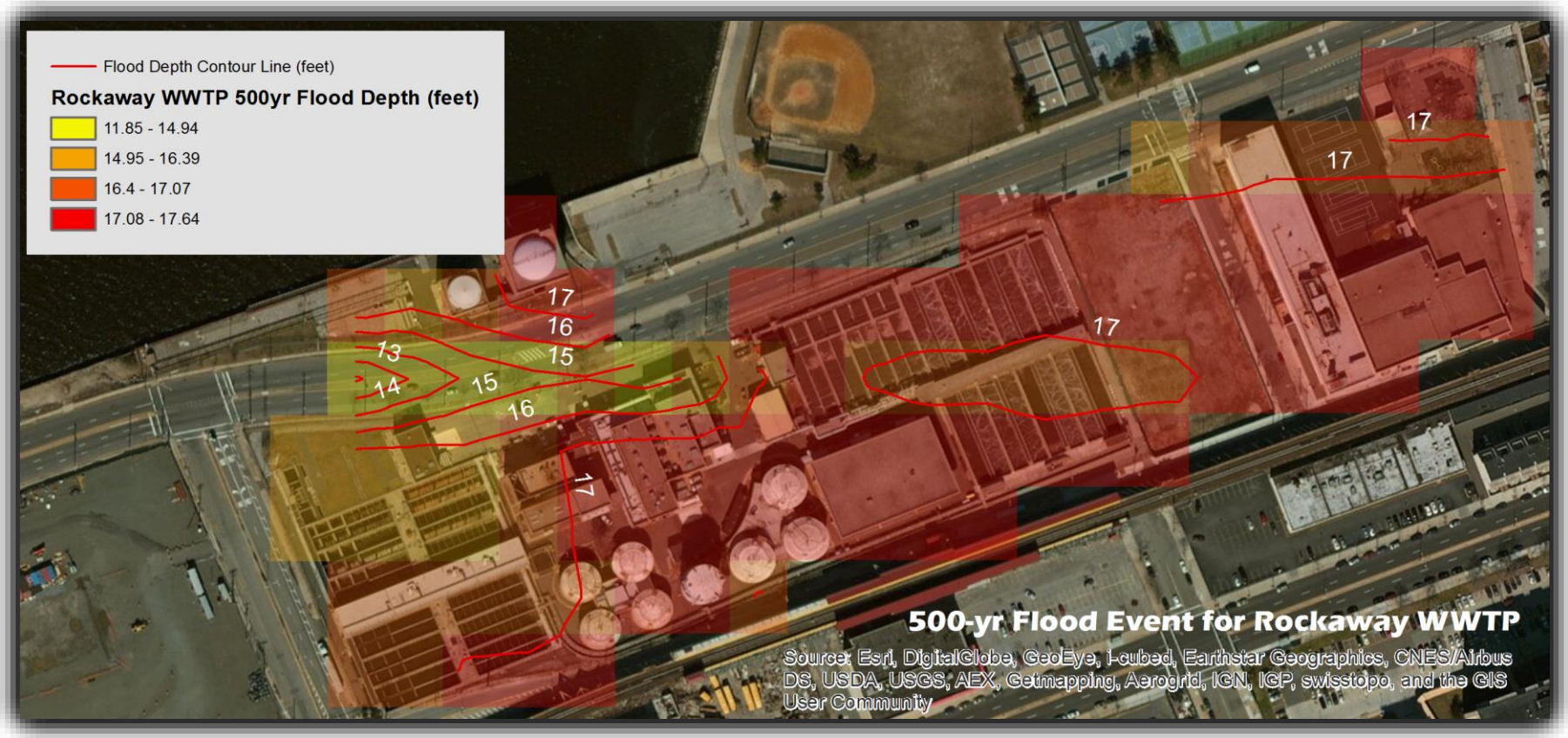
Rockaway WWTP Profile 1



Rockaway WWTP Profile 2

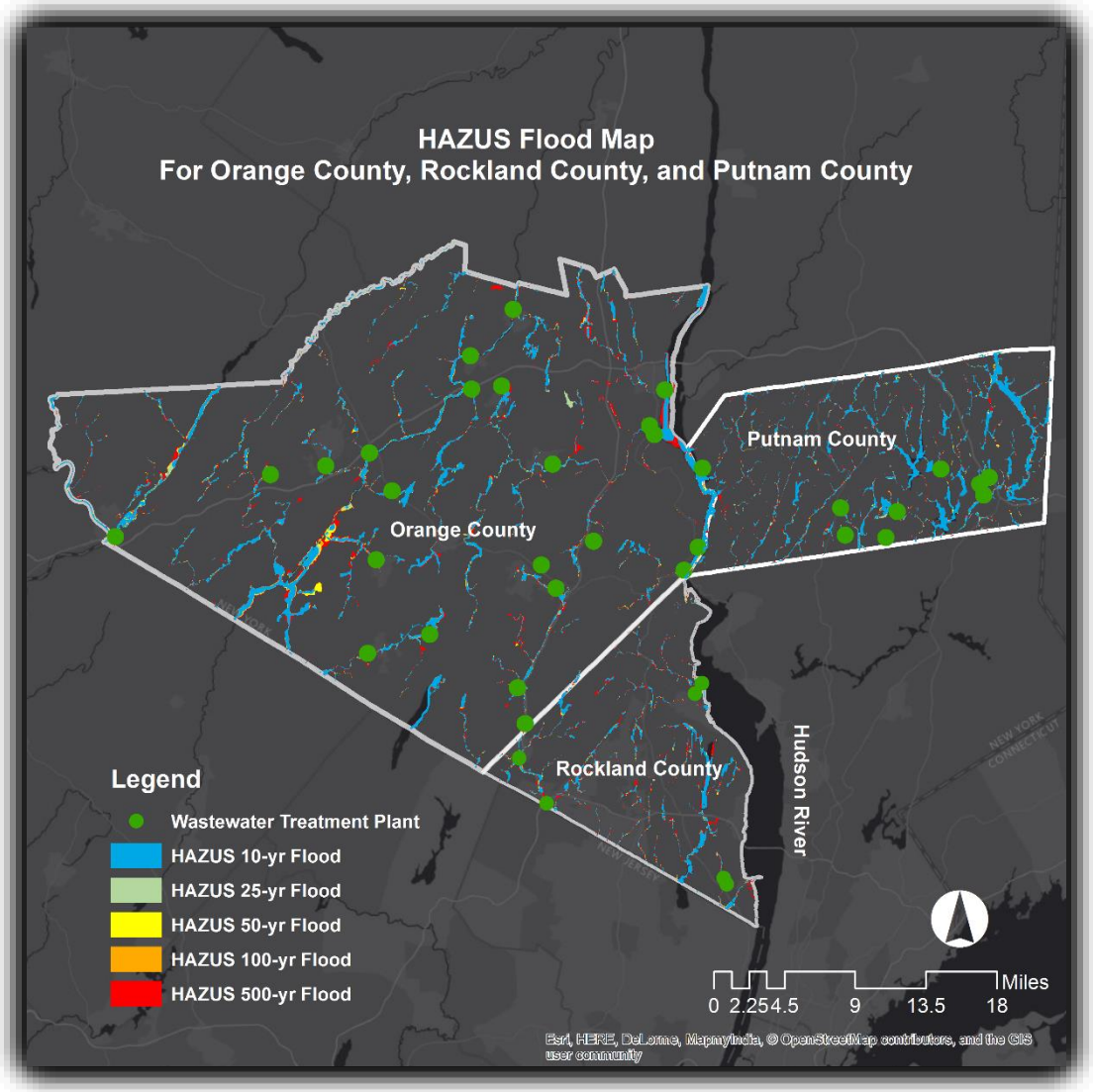


Iso-Flood-Depth curves



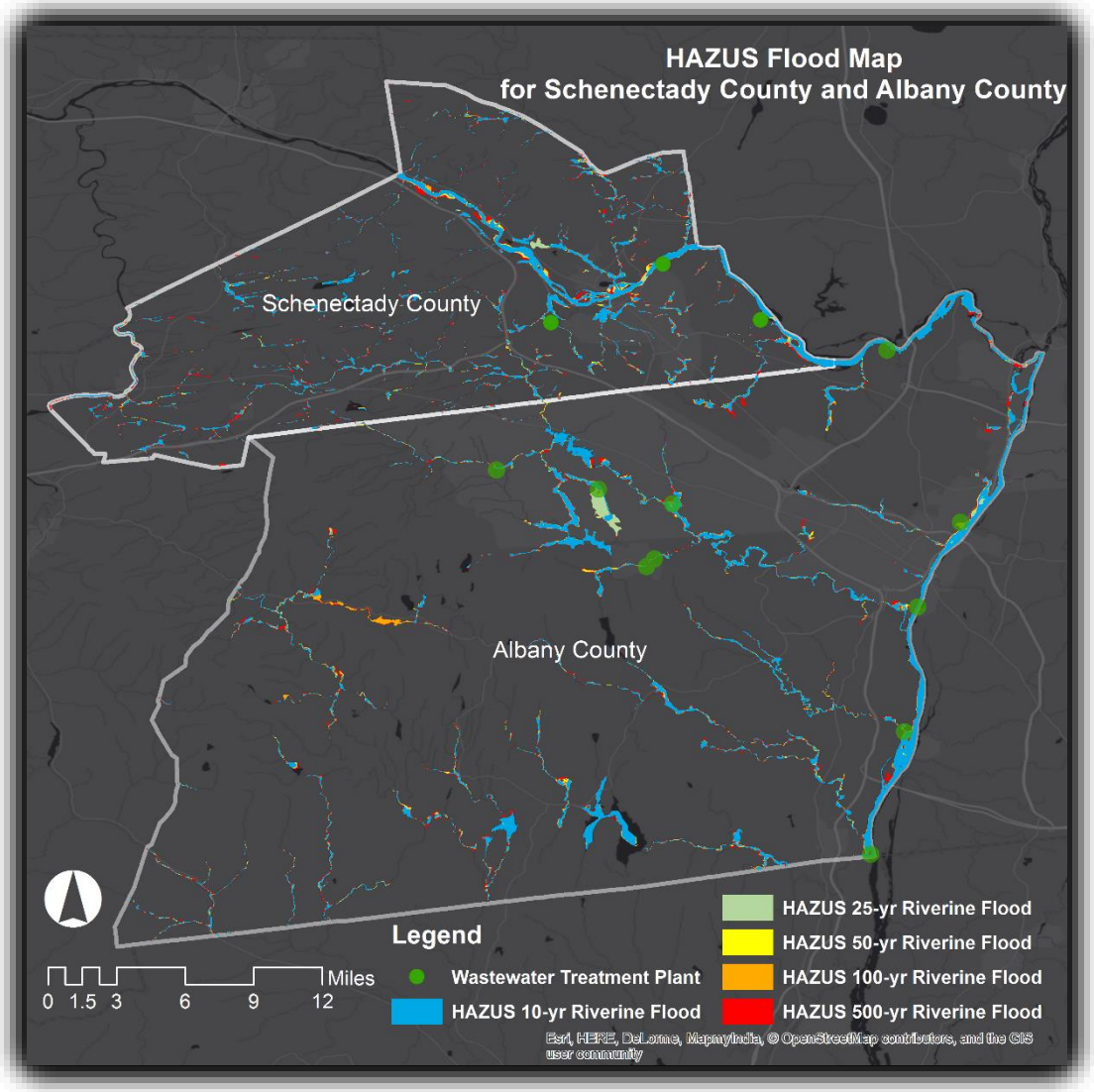
Orange, Putnam and Rockland Counties

DEM: 1 arc second resolution (~30 meters)
Hazard Type: Riverine only



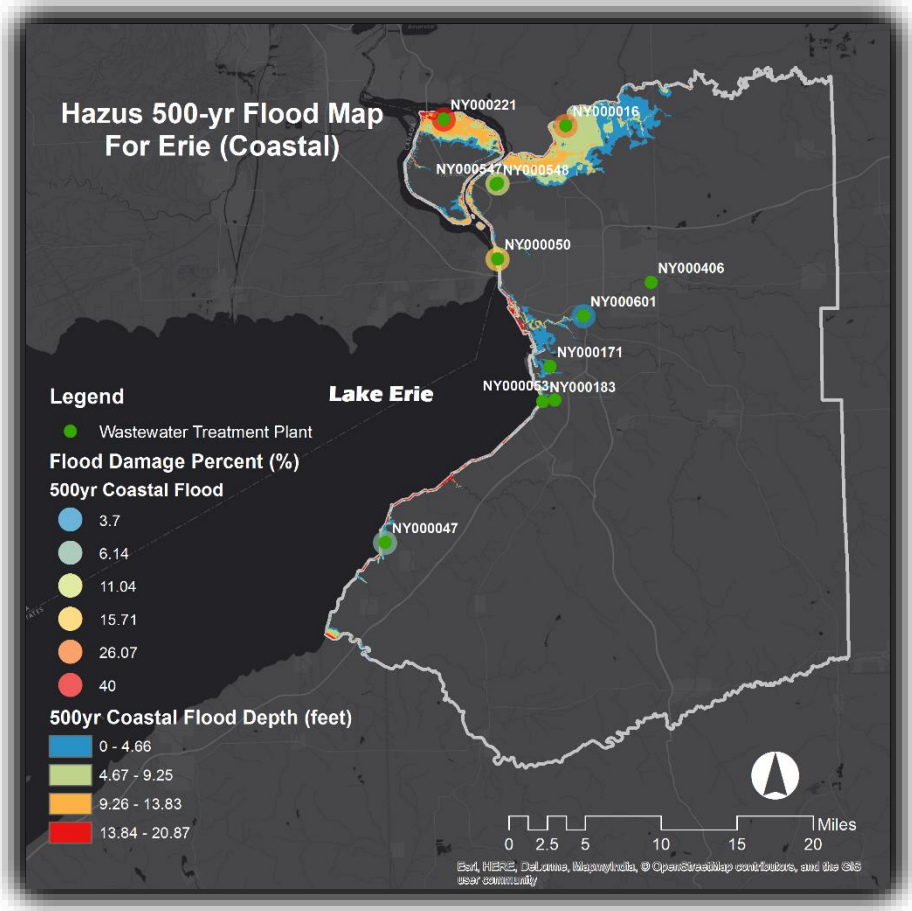
Albany and Schenectady Counties

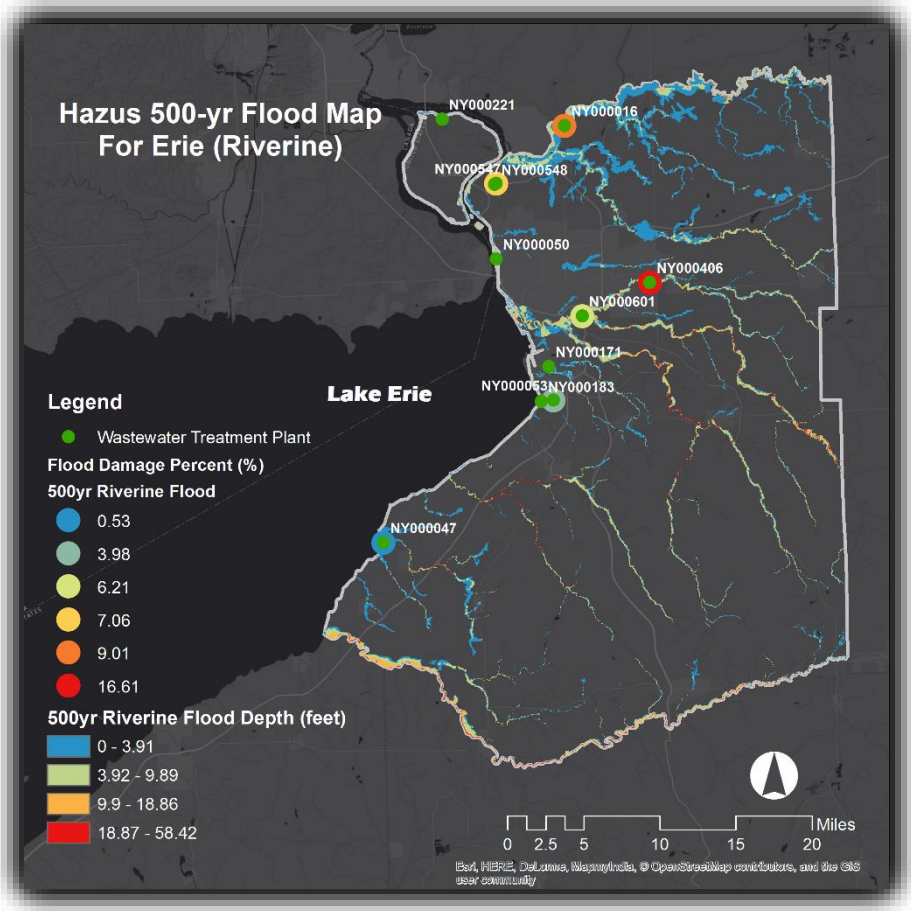
DEM: 1 arc second resolution (~30 meters)
Hazard Type: Riverine only



Erie County

DEM: 1 arc second resolution (~30 meters)
Hazard Type: Coastal and Riverine





References (selected)

- NYC Wastewater Resiliency Plan (Climate Risks Assessment and Adaptation Study), NYC Environmental Protection, October 2013

- HazUS-MH Flood Technical Manual", Department of Homeland Security - Federal Emergency Management Agency Mitigation Division, Washington, D.C

- HAZUS-MH MR4 User Manual", Department of Homeland Security - Federal Emergency Management Agency Mitigation Division, Washington, D.C

- "HazUS-MH Coastal Flood Model FEMA Region IV Standard Operating Procedure", Coastal Flood Hazard and Loss Analysis SOP, August 2012

- "FEMA Modeling Task Force (MOTF) Sandy Impact Analysis." [http://www.arcgis.com/home/item.html]