

## APPENDIX E

### Methodology: Watershed Vulnerability Assessment

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#### **Appendix E.1 – Data Acquisition and Treatment**

The primary data set required for this effort was the 2004 land cover data produced by UCONN (Appendix D). Other important data sets were the USDA NRCS Soil Survey Geographic (SSURGO) Database, USGS elevation and USGS National Hydrography Dataset (NHD), aquifer protection areas and municipal and DEP lands. An abbreviated metadata listing is included as Table E.1-1 to provide additional details.

Using these data sets, additional inputs for the model were created, totaling eight in all. The USGS 10-meter digital elevation model (DEM) was used to produce a percent slope layer for the watershed. The DEM was also used to create a flow accumulation grid. The Flow Accumulation matrix holds values of accumulated flow as the accumulated weight of all cells flowing into each down slope cell in the output raster (ESRI, 2005).

The SSURGO data was used for two input layers into the model: permeability and depth to water table. Both of these parameters are included with the data from NRCS, no additional computations were necessary.

Though ideally a comprehensive layer of protected lands would be available to use as a definitive input, one was not available for this effort. In place of that, several layers were combined and features extracted to produce a preserved lands input layer. The DEP property, municipal property and the DEP aquifer protection areas were merged to produce a single layer then the schools, cemeteries, golf courses, boat ramps, marinas and the Waterford Speed Bowl were removed. The remaining categories of land included preserved open space, State forests, and trust lands, for example. One layer noticeably not obtainable was the surface water protection areas within the watershed.

Multiple ring buffers were created around the water bodies and streams in the NHD at 50 and 100 feet. The final data input that was developed was a forest-water-roads layer. This input provides a distinctive layer of forested areas that are within 200 feet of both roads and water (de la Crétaz *et al.*, 2003).

**Table E.1-1. Watershed Vulnerability Assessment Abbreviated Metadata Listing**

Feature	Data Type	Projection	Date	Source	Comment
Slope	Raster Dataset	Connecticut State Plane, NAD 1983, feet	1999	USGS Eros Data Center	Slope grid calculated from the USGS 10-meter digital elevation model.
Flow accumulation	Raster Dataset	Connecticut State Plane, NAD 1983, feet	1999	USGS Eros Data Center	Flow accumulation calculated from the slope grid.
Soil permeability	Personal Geodatabase Feature Class	Connecticut State Plane, NAD 1983, feet	7/15/2005	USGS NRCS SSURGO	
Soil depth to water table	Personal Geodatabase Feature Class	Connecticut State Plane, NAD 1983, feet	7/15/2005	USGS NRCS SSURGO	
Preserved lands	Personal Geodatabase Feature Class	Connecticut State Plane, NAD 1983, feet	2004 & 1997	CT DEP GIS Data Downloads	DEP Property layer and Municipal and Private Open Space Property layer were merged to produce a single layer. The following categories were removed to produce the protected lands layer: cemeteries, schools and the Waterford Speedbowl.
Forest-water-roads	Personal Geodatabase Feature Class	Connecticut State Plane, NAD 1983, feet	2004 & 2000	UConn, USGS NHD & CT DEP Data Downloads	Forested areas were extracted from the land cover layer. The NHD was buffered at 200' and used to clip the forested layer, producing a layer of forested areas within 200' of water. Finally the roads were buffered at 200' and used to clip the forest/water layer producing forested areas within both 200' of water and roads.
Distance to water	Personal Geodatabase Feature Class	Connecticut State Plane, NAD 1983, feet	2004	USGS NHD	This layer is a multiple ring buffer around water features at distances of 50' and 100'.
Land cover	Personal Geodatabase Feature Class	Connecticut State Plane, NAD 1983, feet	2004	UConn CLEAR	This layer is described in detail in Appendix D.

## Appendix E.2 – Data Model Development

The vulnerability assessment model was developed in the ESRI ArcGIS version 9.1 suite of software. Using the Spatial Analyst extension to the package, a ModelBuilder model was developed from the input layers. The process used within the model was developed by the University of Massachusetts and the U.S. Forest Service Watershed Exchange and Technology Partnership in cooperation with the Massachusetts Department of Conservation and Recreation (de la Crétaz *et al.*, 2003) and only modified due to recent updates in the software and to include additional data inputs that were not used, or only discussed, in the Partnership's methods.

Classifying the data inputs added to the Niantic River Watershed model was specific to the watershed and required some research of soil types, slopes and land covers. Though the detailed process is not summarize here, it is important to outline the rankings of data inputs used. These are listed in Table E.2-1 and described below.

Development restrictions set by the towns listed the gentlest 'no-build' slope at 20%, *i.e.*, the other towns that were reviewed allowed a steeper slope on which development can occur. This gentlest slope was used as the cutoff for the highest priority ranking. Flow accumulation can be a measure of areas of concentrated flow (ESRI, 2005) with high values likely representing overland flow. In this study, flow accumulation is used as an indicator of high erosion potential, possibly due to scour rather than highly erodible soil types. Priority rankings were assigned on the likelihood of accumulation developing into overland flow.

The rankings for soil permeability were assigned using the SSURGO data set from the NRCS. Each soil type is assigned a vertical saturated hydraulic conductivity class, in this case it was important to use the "representative value" from the data set as this is a highly variable characteristic of soils. The vertical, saturated hydraulic conductivity classes from the NRCS Soil Survey Manual along with the Niantic River Watershed priority rankings for each class are listed in Table E.2-2 (USDA NRCS, 1993).

**Table E.2-1. Input Layer Priority Rankings**

Input Layer	Rank			
	3 (High Rank)	2 (Intermediate Rank)	1 (Low Rank)	0 (No Rank)
<b>Slope (%)</b>	>20 - 150	>10 - 20	0 - 10	none
<b>Flow Accumulation</b>	1801 - 676,860	1351 - 1800	0 - 1350	none
<b>Soil Permeability</b>	>100	>1 - 100	>0 - 1	0
<b>Soil Depth to Water Table</b>	D	B, C	A	All others
<b>Preserved Lands</b>	All	none	none	none
<b>Forest-Water-Roads</b>	All	none	none	none
<b>Distance to Water (ft)</b>	0 - 50	>50 - 100	none	>100
<b>Land Cover</b>				
Conservation Priority Index	Deciduous forestland, Plantation, Old field, Deciduous brush/shrubland, Saline marshes, Interior wetlands, Deciduous wooded wetlands	none	none	All others
Restoration Priority Index	Cropland & pastureland, Horse farms	Inactive cropland, Orchards, vineyards, nurseries & horticultural areas	none	All others
Stormwater Management Priority Index	High density residential, Commercial & services, Education institutions, Health institutions, Military installations, Industrial, Power generation, Transportation, communication & utilities, Limited access highways, Railroad facilities, Power facilities, Water treatment facilities, Sewage treatment facilities	Low & medium density residential, Other urban or built-up	Rural residential, Golf courses, Picnic & camping parks, Marinas & boat launches, Community recreation areas, Open areas in parks	All others

**Table E.2-2. Vertical Saturated Hydraulic Conductivity Classes and Priority Rankings**

<b>K<sub>sat</sub> Class (µm/s)</b>	<b>Ranking</b>
Very High (> 100)	3
High (>10 – 100)	2
Moderately High (>1 – 10)	2
Moderately Low (0.1 -1)	1
Low (>0.01 - 0.1)	1
Very Low (< 0.01)	1

The depth to water table rankings ideally would be derived from the distance from the top of the soil to the upper boundary of the moisture layer, which is also in the SSURGO data set. These values were not available in the data for this region of Connecticut. Therefore, the natural drainage classes (USDA NRCS, 1993) were applied to the hydrologic soil groups to rank the soils generally corresponding to appropriate depth to water table values. The “excessively drained” through “very poorly drained” natural drainage classes provide a strong indication of where in the soil profile the free water occurs.

Due to the nature of preserved lands and their direct correspondence to the ability to be used for conservation activities, all currently preserved and trust lands were assigned high rankings for the Conservation Priority Index. These lands were not used in the two remaining priority indices. Similar to preserved lands, the Forest-Water-Roads input has a high ranking for the Conservation Priority Index. These forested areas that are within 200 feet of both roads and water lend support to the idea of creating buffers around water bodies. This is a specialized buffer that identifies the forested areas within a safe distance from both water bodies and roads and ideally would act as a filter for pollutants between the roads and the water.

As mentioned previously, the idea of creating buffers around water bodies allows the surrounding areas to add a safeguard to the surface water. High rankings were applied to the smaller 50-foot buffer and intermediate values to the larger 100-foot buffer. All areas outside of this range were not assigned a ranking. This particular range was defined as it has been deemed appropriate in other coastal studies for the use of nutrient removal (Palone and Todd, 1997).

The land cover data layer was classified for each of the three priority indices using the guidance document developed by the University of Massachusetts (de la Crétaz *et al.*, 2003). Each of the land cover types were assigned to one of the three indices, generally following the idea that undeveloped lands would be placed in the Conservation Priority Index; agricultural lands would be placed in the Restoration Priority Index; and all other developed lands, such as residential, commercial and industrial, would be placed in the Stormwater Management Priority Index. All of the lands in the CPI were assigned high rankings. The agricultural lands that run active animal operations and cropland applying fertilizers and pesticides to the soils were assigned high rankings in the RPI with inactive cropland and cropland applying spray fertilizers and pesticides given intermediate rankings. The SMPI land cover types were assigned rankings based on the use intensity of the development. That is, high density residential, industrial and commercial land cover types were assigned high rankings, while low and medium density residential and other built-up land cover types were assigned intermediate rankings. The low rankings in the SMPI were rural residential areas and managed recreation areas such as golf courses, marinas and community parks.

Each of the input layers held a one-to-one ranking with each other, with the exception of the two derivatives of the soils layer, which were assigned a weight of 0.5. The weighted input layers were overlain and their ranking values added on a cell by cell basis. The model produced three output matrices with each cell containing the calculated sum of the rankings for all input layers.