APPENDIX A

Acronyms and Abbreviations

APPENDIX A

Acronyms and Abbreviations

‰ – parts per thousand

ACOE – US Army Corps of Engineers

AqP – Aquifer & Primary Recharge Protection Zone

AqS – Secondary Recharge Protection Zone

BMP – Best Management Practice

BOD – Biological Oxygen Demand

BWPLR – Bureau of Water Protection and Land Reuse

CAD – Computer-aided Design

CALM – Connecticut Consolidated Assessment and Listing Methodology

CAM – Coastal Boundary Overlay District

CHN – Percent Carbon and Nitrogen

CLEAR – Center for Land Use Education and Research

CN – Curve Number

CNP – Coastal Nonpoint Source Pollution Control Program

ConnDOT – Connecticut Department of Transportation

CPI – Conservation Priority Index

CPUE – Catch per unit effort

CTDEP – Connecticut Department of Environmental Protection

CTDOAG – Connecticut Department of Agriculture

CWP – Center for Watershed Protection

CZARA – Coastal Zone Act Reauthorization Amendments

CT DA/BA – Connecticut Department of Agriculture, Bureau of Agriculture

DEIS – Draft Environmental Impact Statement

DEM – Digital Elevation Model

DNC – Dominion Nuclear Connecticut

DOM – Dissolved Organic Matter

DPW – Department of Public Works

CTDPUC – Connecticut Department of Public Utility Control

E&S – Erosion and Sediment Control

EFC – Environmental Finance Center

EMC – Event Mean Concentration

ERT – Environmental Review Team

ESRI – Environmental Systems Research Institute

FEMA – Federal Emergency Management Agency

FTE – Full Time Employee

GIS – Geographic Information System

HSG – Hydrologic Soil Groups

I/E – Information and Education

IS – Impervious Surface

ISSC – Interstate Shellfish Sanitation Conference

LEDPA – Least Environmentally Damaging Preferred Alternative

MEL – Millstone Environmental Laboratory

MGD – Million gallons per day

MPO – Metropolitan Planning Organization

MS4 – Municipal Separate Storm Sewer System

MSD – Marine Sanitation Device

NAS – National Academy of Sciences

NDA – No Discharge Area

NDZ – No Discharge Zone

NEMO (UCONN) – Nonpoint Education for Municipal Officials

NFWF – National Fish and Wildlife Foundation

NH_4^+ – Ammonium

NHD – National Hydrography Database

NO_2 – Nitrite

NO_3 – Nitrate

NOAA – National Oceanographic and Atmospheric Association

NPDES – National Pollutant Discharge Elimination System

NPS – Nonpoint Source

NSSP – National Shellfishing Sanitation Program

NSSP-MO – National Shellfish Sanitation Program Model Ordinance

OCRM – NOAA's Office of Ocean and Coastal Resource Management

OLISP – Office of Long Island Sound Programs

PAR – Photosynthetically active radiation

PO_4^- – Phosphates

POCD – Plan of Conservation and Development

PRD – Planned Residential Development

RBV – Rivers by Volunteers

RPI – Restoration Priority Index

SAFTEA-LU – The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

SAV – Submerged Aquatic Vegetation

SCCOG – Southeastern Connecticut Council of Governments

SDD – Special Development District

SE – Standard Error

SMPI – Stormwater Management Priority Index

SNET – Southern New England Telephone

SSURGO – Soil Survey Geographic Database

STICS – Spatial Trends in Coastal Socioeconomics

SWMM – Stormwater Management Model

SWMPP – Stormwater Management Program Plan

TKN – Total Kjeldhal Nitrogen

TM – Tidal Marsh

TMDL – Total Maximum Daily Load

TN – Total Nitrogen

TP – Total Phosphorous

TPL – Trust for Public Land

TSS – Total Suspended Solids

UCONN – University of Connecticut

UID – Unidentified

USDA NRCS – US Department of Agriculture, Natural Resources Conservation Service

USDOT – US Department of Transportation

USEPA – US Environmental Protection Agency

USFWS – US Fish and Wildlife Service

USGS – United States Geological Survey

WELSCO – Waterford-East Lyme Shellfish Commission

WQ – Water Quality

WQS – Water Quality Standards

WVA – Watershed Vulnerability Assessment

YOY – Young of the year

APPENDIX B

Terms and Definitions

APPENDIX B

Terms and Definitions

Antidegradation policy – A policy or legal principal stating that activities degrading a waterbody's quality will not be allowed.

Aquatic Life Support – The waterbody provides suitable habitat for protection and propagation of desirable fish, shellfish,and other aquatic organisms.

Designated uses – *See* 'Use Classification"

Indicator bacteria – Some waterborne bacteria, viruses and protozoa can cause human illnesses, ranging from typhoid and dysentery to minor skin diseases. These pathogens may enter waters through a number of routes, including inadequately treated sewage, storm water drains, septic systems, runoff from livestock pens and sewage dumped overboard from recreational boats. Because it is impossible to test waters for every possible disease causing organism, regulatory agencies usually measure fecal coliforms (like *Escherichia coli* or "e. coli") as indicator bacteria (which are found in great numbers in the stomachs of warm blooded animals). The presence of indicator bacteria suggests that the waterbody may be contaminated with untreated sewage and that other, more dangerous organisms may also be present. Bacterial criteria are frequently used to determine if waters are safe for contact recreation or shellfish harvesting.

National Shellfish Sanitation Program (NSSP) – The NSSP requires annual assessments of shellfish growing areas to ensure that the growing areas are properly classified. These 'Shellfishing Area Classifications' are different from the water quality classifications mentioned above and are designated specifically for shellfish growing areas. More information is available from the *Guide for the Control of Molluscan Shellfish 2003*. U. S. Department of Health and Human Services Public Health Service, Food and Drug Administration, Center for Food Safety and Nutrition, Washington D.C. (http://www.cfsan.fda.gov/~ear/nss2-toc.html).

Primary Contact Recreation (Swimming) – People can swim in the waterbody without risk of adverse human health effects (such as catching waterborne diseases from raw sewage contamination).

Shellfish Grow Area Classifications – A shellfish growing area is any area which supports, or could support, the growth and/or propagation of molluscan shellstock (live clams, oysters, mussels and scallops in their shell). All shellfish growing areas are classified in accordance with the Interstate Shellfish Sanitation Conference (ISSC) National Shellfish Sanitation Program Model Ordinance (NSSP-MO). These classifications established to minimize health risks and may restrict the taking and use of shellfish from some areas. No fresh water areas have been classified for the harvesting of shellfish (CT DOAG).

Shellfishing / Shellfish Harvesting – The waterbody supports a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.

Tier – Waters are assigned to one of five tiers for the 303(d) List. **Tier 2** signifies that it has been determined that the impairment is caused by a pollutant stressor (*e.g.*, chemical, clean sediment and/or temperature), a surrogate indicator (*e.g.*, indicator bacteria) or can be attributed to a source that contributes multiple pollutants to a waterbody such that implementing a TMDL for one or more pollutants can be reasonably expected to result in attainment of uses. Where more than one pollutant is associated with the impairment, the waterbody or waterbody segment will remain in this category until TMDLs for all pollutants have been completed and approved by USEPA. Further investigative monitoring, if necessary, will be scheduled to confirm causes. Follow-up monitoring will be scheduled to determine if the standard is attained following TMDL implementation. **Tier 3 –** The waterbody or waterbody segment does not support a use based on biological, or other information, and the cause is unknown. It is uncertain whether the impairment is caused by a pollutant. Additional monitoring will be scheduled to identify the cause of the impairment. If the additional monitoring determines the cause of the impairment to be a pollutant(s), CTDEP will complete a TMDL(s) for the pollutant(s). If the additional monitoring determines the impairment is not caused by a pollutant, the waterbody or waterbody segment will be moved to Tier 5.

TMDL (Total Maximum Daily Load) – "A TMDL is a watershed plan that focuses resources on reducing loads of known pollutants. TMDLs provide the framework to restore impaired waters by establishing the maximum amount of a pollutant that a waterbody can assimilate without adverse impact to aquatic life, recreation, or other public uses. The TMDL is then divided up between all potential sources of that pollutant. TMDLs are often expressed by the mathematical equation:

TMDL = Point Sources + Nonpoint Sources + Background + Margin of Safety.

The end result of the TMDL process is a Water Quality management Plan with quantitative goals to reduce pollutant loadings to the impaired waterbody. TMDLs are implemented under the existing authorities of CT DEP and may include both regulatory and voluntary actions as part of a larger Water Quality Management Plan." CTDEP, 2004b

Use classification – Classifications are assigned to surface and groundwater in all areas of the state. These assignments are based on both the use, or potential use, of such waters as well as on their known., or presumed, quality. Generally, the classification describes the actual activities that the waterbody is expected to support (*e.g.* swimming, fishing, habitat for fish and wildlife). The individual water quality classifications are described in more detail at CTDEP's website: http://dep.state.ct.us/wtr/wq/wqsinfo.htm.

Use Support Category – "In making water quality assessments, each designated use of a waterbody or waterbody segment is assigned a level of support (*e.g*., full support, partial support), which characterizes the degree to which the water is suitable for that use." CTDEP, 2004c.

Water Quality Impairments – Describes the state of pollution of a waterbody with relation to the negative impacts it has on the use of that waterbody.

Water quality standards (WQS) – Standards that set an "overall policy" for management of Connecticut's surface and groundwaters in accordance with the directives provided by Section 22a-426 of the Connecticut General Statutes and Section 303 of the Federal

Clean Water Act. These standards are made up of three components: designated uses, water quality or pollution criteria/thresholds, and a policy of antidegradation.

Water quality or pollution criteria – Criteria or limits on the levels of biological, chemical and physical characteristics of water.

APPENDIX C

SA Criteria from Connecticut Water Quality Standards

APPENDIX C

SA Criteria from Connecticut Water Quality Standards

<u>CLASS SA CRITERIA</u>

Parameter	**Criteria**
Aesthetics	Uniformly excellent.
Dissolved oxygen	Not less than 6.0 mg/L at any time in the nearshore water of Long Island Sound, including harbors, embayments and estuarine tributaries. Not less than 6.0 mg/L at any time in the offshore waters of Long Island Sound, above the seasonal pycnocline and throughout the Sound when no pycnocline is established. Not less than 3.5 mg/L for offshore waters within and below the seasonal pycnocline. Cumulative periods of dissolved oxygen in the 3.5 – 4.8 mg/L range shall not exceed exposure parameters.
Sludge deposits solid refuse-floating solids-oils and grease-scum	None other than of natural origin.
Color	None other than of natural origin.
Suspended and settleable solids	None other than of natural origin.
Silt or sand deposits	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity, dredging activity or the discharge of dredged or fill materials provided all reasonable controls or Best Management Practices are used in such activities and all designated uses are protected and maintained.
Turbidity	None other than of natural origin except as may result from normal agricultural, road maintenance, or construction activity, dredging activity or discharge of dredged or fill materials provided all reasonable controls and Best Management Practices are used to control turbidity and none exceeding levels necessary to protect and maintain all designated uses.
Indicator bacteria	NEXT PAGE
Taste and odor	As naturally occurs.
pH	6.8 – 8.5
Allowable temperature increase	There shall be no changes from natural conditions that would impair any existing or designated uses assigned to this Class and, in no case exceed 83 degrees F, or in any case raise the temperature of the receiving water more than 4 degrees F. During the period including July, August, and September, the temperature of the receiving water shall not be raised more that 1.5 degrees F unless it can be shown that spawning and growth of indigenous organisms will not be significantly affected.
Chemical constituents	None in concentrations or combinations which would be harmful to designated uses. Refer to Standards numbers 10, 11, 12,13, 17, and 19.

WATER QUALITY CRITERIA FOR BACTERIAL INDICATORS OF SANITARY QUALITY
SEE ALSO STANDARDS # 23 AND 25

DESIGNATED USE	CLASS	INDICATOR	CRITERIA
Freshwater			
Drinking Water Supply (1)			
Existing / Proposed	AA	Total coliform	Monthly Moving Average less than 100/100ml Single Sample Maximum 500/100ml
Potential	A	----	--------
Recreation (2)(3)			
Designated Swimming (4)	AA, A, B	*Escherichia coli*	Geometric Mean less than 126/100ml Single Sample Maximum 235/100ml
Non-designated Swimming (5)	AA, A, B	*Escherichia coli*	Geometric Mean less than 126/100ml Single Sample Maximum 410/100ml
All Other Recreational Uses	AA, A, B	*Escherichia coli*	Geometric Mean less than 126/100ml Single Sample Maximum 576/100ml
Saltwater			
Shellfishing			
Direct Consumption	SA	Fecal coliform	Geometric Mean less than 14/100ml 90% of Samples less than 43/100ml
Commercial Harvesting	SB	Fecal coliform	Geometric Mean less than 88/100ml 90% of Samples less than 260/100ml
Recreation			
Designated Swimming (4)	SA, SB	Enterococci	Geometric Mean less than 35/100ml Single Sample Maximum 104/100ml
All Other Recreational Uses	SA, SB	Enterococci	Geometric Mean less than 35/100ml Single Sample Maximum 500/100ml

Table Notes:
(1) Criteria applies only at the drinking water supply intake structure.
(2) Criteria for the protection of recreational uses in Class B waters do not apply when disinfection of sewage treatment plant effluents is not required consistent with Standard 23.
(3) See Standard # 25.
(4) Procedures for monitoring and closure of bathing areas by State and Local Health Authorities are specified in: <u>Guidelines for Monitoring Bathing Waters and Closure Protocol</u>, adopted jointly by the Department of Environmental Protection and the Department of Public Health, May 1989, revised June 1992.
(5) Includes areas otherwise suitable for swimming but which have not been designated by State or Local authorities as bathing areas, waters which support tubing, water skiing, or other recreational activities where full body contact is likely.

Guidelines for Use of Indicator Bacteria Criteria

Water Quality Classifications are reviewed approximately every three years at which time all available water quality monitoring data is considered along with other relevant information. Relevant information includes but is not limited to federal guidance concerning the scientific basis for deriving the criteria and the potential health risks associated with excursions above the criteria, recommended implementation procedures, and the results of sanitary surveys or other investigations into sources of indicator bacteria in the watershed. Public input is also solicited and considered in determining the existing water quality conditions and water quality goals. Nevertheless, the Water Quality Classification may not be an accurate representation of current water quality conditions at any particular site. For this reason, <u>the Water Quality Classification should not be considered as a certification of quality by the State or an approval to engage in certain activities such as swimming or shellfish harvest</u>

APPENDIX D

Methodology: 2004 Land Cover, Build-Out, Impervious Surfaces

APPENDIX D

Methodology: 2004 Land Cover, Build-Out, Impervious Surfaces

The purpose of this component of the project was to develop an updated land cover data set for the watershed using existing information from CLEAR for the years 1985, 1990, 1995 and 2002 and updating them to be current as of 2004. The second component of this task includes the development of a point data layer of possible building centers resulting from hypothetical buildout scenarios. Finally, an analysis to develop a methodology to estimate the increase in impervious surfaces that could occur within the Niantic River Watershed under full buildout conditions was created and implemented.

Appendix D.1 – 2004 Land Cover Development

Updated land cover data were developed for the purpose of conducting a watershed-scale assessment of land cover changes over the past two decades. Using ArcGIS version 9.1 at the ArcView licensing level along with two plug-in tools developed by ET Spatial Technologies, existing land cover data sets were updated to be current as of April 2004. The ET Spatial Technology tools, ET GeoTools and ET GeoWizards, provide enhanced editing functionality and data processing in the ArcView environment. More information about these tools can be found at http://www.ian-ko.com/.

Computer-aided design (CAD) drawings of the edge of forested area was converted to a GIS format for the towns of East Lyme (1995), Montville (approximately 1995) and Waterford (1995). For Salem, this information was digitized from April 2004 aerial photographs. The information for the four towns was conflated to a single data layer and used as a base for the land cover, designating forested and non-forested areas. The forested areas for Montville, Salem and Waterford were modified to reflect changes occurring up through the ConnDOT/CTDEP April 2004 black and white aerial photography and for East Lyme using Southern New England Telephone (SNET) (SBC/AT&T) 2004 color aerial photography.

The aerial photography was used to portion the non-forested polygons into Anderson (1976) Level 1 and Level 2 cover types (Figure C1). Where the Level 3 cover type was easily distinguishable it was defined, though this attribute is incomplete for the data set. A moderate amount of field checking was done during the spring of 2006. The field checks were done by visual aerial survey supplemented by photographs taken during the aerial flights. The final land cover data set has an accuracy determined to be to the level discernable with the SNET and CTDEP/ConnDOT 2004 aerial photography, which was produced with a six-inch pixel resolution.

Appendix D.2 – Buildout Analysis

Scenario360, a software product developed by the Orton Family Foundation that runs as an extension to ArcGIS, was used to perform the buildout analysis. A buildout is an estimate of how much development can occur on buildable land based on current zoning densities. Buildable land can be defined as land that does not have any user-defined constraints and that is not already built to its maximum allowed density. For this analysis, we used the following data sets, many of which underwent some modification to make them suitable for the analysis.

From the municipalities:

- Zoning
- Parcels
- Roads
- Building footprints (except for Salem)
- Proposed Route 11 ROW (provided by East Lyme)

Developed or provided by UCONN

- Interpreted detailed land cover
- 2004 digital B&W 0.8’ resolution orthoimagery
- 2004 digital color 0.5m resolution orthoimagery (did not include Salem)
- Buildings point layer with one point / residential parcel (created by heads-up digitizing using the building footprints and orthoimagery as a guide)
- Water features – lakes, ponds, streams

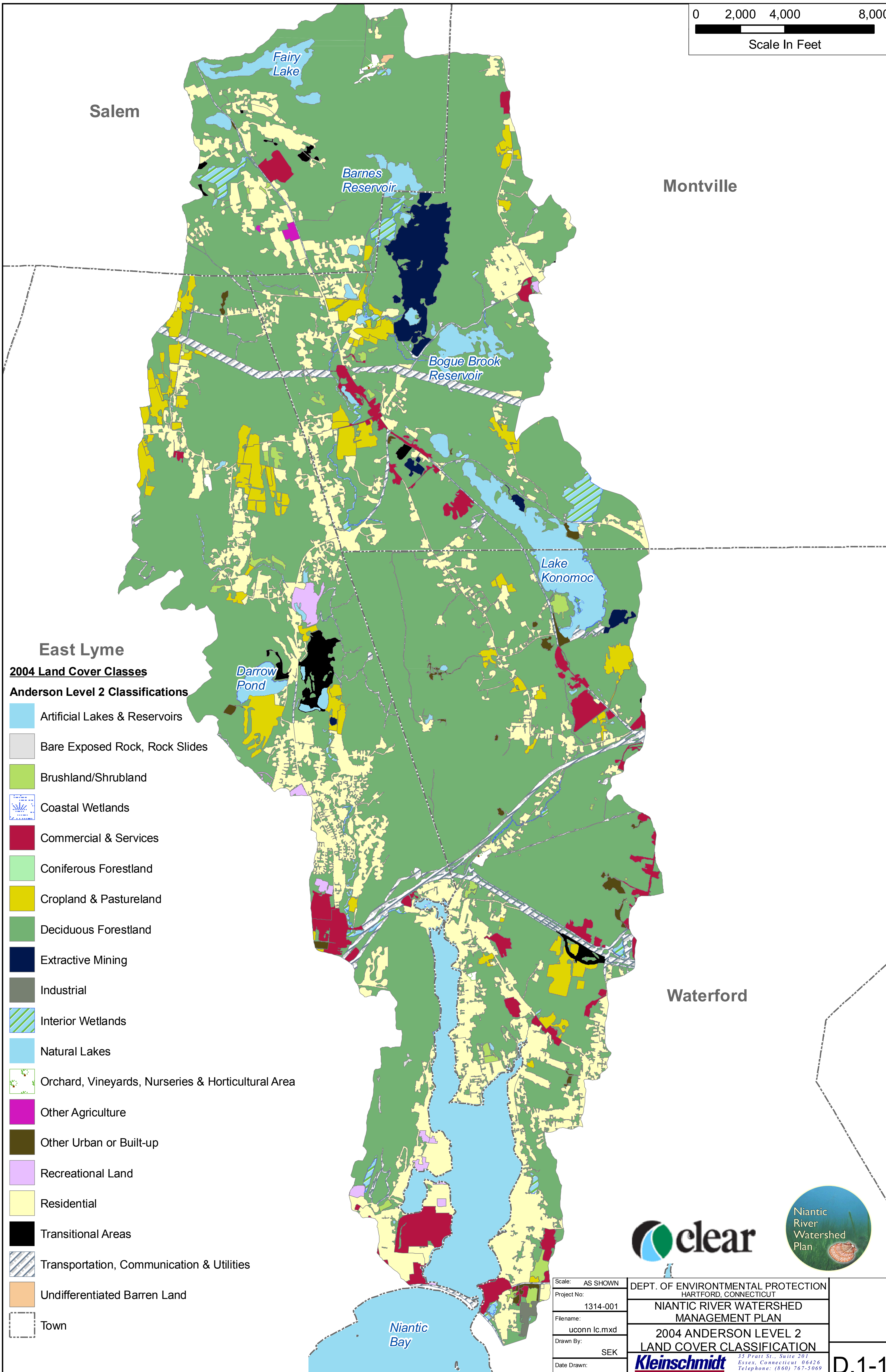
- Wetland soils

The buildout analysis was parcel-zoning based. Zoning designations were used to determine future residential building densities for existing parcels. The analysis also determines the portion of each parcel that is buildable land. The user-defined assumptions for this analysis were:

1. No construction can take place on protected open space;
2. No construction can take place on water bodies, streams, wetlands or within 100' of these resources;
3. No construction can take place on the proposed Route 11 corridor;
4. No construction can take place on parcels already developed unless the parcel exceeds the minimum lot size for the zone it is in;
5. Only one building can be built on flag lots regardless of their size;
6. Only one building can be built on lots without road frontage.

Additionally, based on input from local officials, a number of specific parcels were assigned unique zone classes that were used to define future building densities. For example, in East Lyme there are several special use zones. One is being developed as a high density housing complex and the other as a golf course with homes. The zone designations for these properties were changed from SU (special use) to SU-600 and SU-110 where the numeric portion of the class refers to the number of houses or dwelling units that will be allowed. In other cases where specific numbers of dwelling units will be permitted, the zoning was changed to DU-1, DU-25, *etc.* where DU is dwelling units and the numeric portion of the class is the permitted number of units. A complete list of all general zone designations used in the buildout is included in the Buildout Report in Appendix D4.

After removing the constrained areas described above, the buildout tool of Scenario360 determined the number of existing residential buildings per parcel and then calculated the number of new buildings that could be added, based on the buildable area and permitted zoning densities. For this analysis, a dataset of existing buildings was created so every developed residential parcel had one building point feature. The dataset was based on building footprints provided by the towns and augmented by a visual inspection of the 2004 orthoimagery, used to add residential buildings not included in the town datasets. A spatial buildout was then run that randomly placed “new” residential buildings in the buildable areas. It should be noted that this is **not** a site planning analysis and that the placement of “new” buildings provides a general picture of future development. Absent from the buildout was the creation of new roads.



Land cover classes developed by the University of Connecticut Center for Land Use Education and Research, June 2006.

Appendix D.3 – Impervious Surface Analysis

Results from the buildout analysis were used to estimate additional impervious surface (IS) created as a result of the hypothetical buildout. In residential zones, this is based on the number of "new" residential buildings where each building adds a certain square footage of additional impervious area. A summary of the methods used to generate these estimates can be found in Appendix D.5. The area is based on the following parameters:

- Footprint of house 2,000
- Outbuildings 260
- Associated road 2,636
- Driveway *1,440*
- **Total IS per house 6,336**

For non-residential areas, it was estimated that 55% of the buildable area will be covered with impervious surfaces at buildout. This is based on impervious surface research conducted by William Sleavin (1999) as part of his Master's Thesis research at UCONN where the percent area of impervious surfaces in commercial and industrial zones in Woodbridge and West Hartford, Connecticut was calculated. This was reviewed with town staff in East Lyme, Montville and Waterford and it was agreed that this would be a reasonable estimate for future imperviousness in these zones.

A dataset of non-residential parcels was created from the parcel-zoning. Each non-residential parcel was overlaid on the 2004 orthoimagery and visually inspected. An estimated current percent impervious surface value was added as an attribute to each parcel in the data layer and was used to calculate the current area of impervious surface for the parcel.

To calculate how much additional impervious surface may be built on each non-residential parcel, the buildable area of the parcel was calculated as part of the buildout analysis. If the current percent impervious surface area of the parcel was less than 55%, then additional impervious surfaces could be added to the parcel. The calculation to determine this amount was:

$(IS\%_{BO} - IS\%_{C})$ * Buildable Area (sq. feet) = Additional IS (sq. feet), where

$IS\%_{BO} = 55\%$

$IS\%_{C}$ = current estimated % impervious

Appendix D.4 – Buildout Report

Build-Out Report - BO July 7 2006
Analysis Name: NRW BO 5-30-06
Tuesday, July 11, 2006, 5:44 PM

Report Contents

Report Summary

This report gives details about a single run of the Build-Out Wizard for this scenario.

☑ Numeric Build-Out has been run

☑ Spatial Build-Out has been run

☒ Visual Build-Out has not been run

Numeric Build-Out Settings

Land Use Layer

Layer containing land-use information	General Zoning Designation
Attribute specifying land-use designation	B_O_Zone
Attribute specifying unique identifier of each land-use area	FID

Density Rules

Land-Use Designation	Dwelling Units	Floor Area	Efficiency Factor (%)
?			0
B			0
C			0
CA			0
CB			0
DU-1	1 DU		100
DU-2	2 DU		100
DU-20	20 DU		100
DU-25	25 DU		100
DU-3	3 DU		100
DU-5	5 DU		100
GOV			0
I			0
IMF			0
No Dev			0
OS			0
R10	4 DU per acre		50

R120	0.33 DU per acre		70
R120-L	0.33 DU per acre		50
R160	0.25 DU per acre		70
R20	2 DU per acre		65
R40	1 DU per acre		65
R5	8 DU per acre		90
R80	0.5 DU per acre		70
Residentia			0
RO40/20	1 DU per acre		65
ROW			0
RuA	0.5 DU per acre		70
RuB	0.33 DU per acre		70
SU			100
SU-110	110 DU		100
SU-600	600 DU		100
VR10	4 DU per acre		65
W			0
C-Park			0
Camp Rell			0

Building Information

Land-Use Designation	DU per Building	Area (sq feet)	Floors
?	1	0	1
B	1	0	1
C	1	0	1
CA	1	0	1
CB	1	0	1
DU-1	1	0	1
DU-2	1	0	1
DU-20	1	0	1
DU-25	1	0	1
DU-3	1	0	1
DU-5	1	0	1
GOV	1	0	1
I	1	0	1
IMF	1	0	1
No Dev	1	0	1
OS	1	0	1
R10	1	0	1
R120	1	0	1
R120-L	1	0	1
R160	1	0	1

R20	1	0	1
R40	1	0	1
R5	1	0	1
R80	1	0	1
Residentia	1	0	1
RO40/20	1	0	1
ROW	1	0	1
RuA	1	0	1
RuB	1	0	1
SU	1	0	1
SU-110	1	0	1
SU-600	1	0	1
VR10	1	0	1
W	1	0	1
C-Park	1	0	1
Camp Rell	1	0	1

Constraints to Development

Constraint Layer	Can density be transferred?
Proposed Rt11 Corridor	no
Water Resource Contraints Areas	no

Existing Buildings

Layer containing existing buildings	Value or attribute specifying DU/bldg	Value or attribute speci (sq feet)
Existing residential buildings	1	

Spatial Build-Out Settings

Settings

Land-Use Designation	Minimum Separation Distance (feet)	Layout Pattern	Road or Line Layer
?	0	Random	
B	0	Random	
C	0	Random	
CA	0	Random	
CB	0	Random	
DU-1	0	Random	
DU-2	150	Random	
DU-20	50	Random	
DU-25	50	Random	
DU-3	50	Random	

DU-5	50	Random	
GOV	0	Random	
I	0	Random	
IMF	0	Random	
No Dev	0	Random	
OS	0	Random	
R10	50	Random	
R120	200	Random	
R120-L	200	Random	
R160	200	Random	
R20	50	Random	
R40	150	Random	
R5	50	Random	
R80	200	Random	
Residentia	0	Random	
RO40/20	100	Random	
ROW	0	Random	
RuA	200	Random	
RuB	200	Random	
SU	0	Random	
SU-110	50	Random	
SU-600	50	Random	
VR10	50	Random	
W	0	Random	
C-Park	0	Random	
Camp Rell	0	Random	

Results

Dwelling Unit Quantities

Land-Use Designation	Numeric Build-Out	Spatial Build-Out	Difference	Existing Dwelling
?	0	0	0	
B	0	0	0	
C	0	0	0	
CA	0	0	0	
CB	0	0	0	
DU-1	72	72	0	
DU-2	9	9	0	
DU-20	19	19	0	
DU-25	24	24	0	
DU-3	3	3	0	
DU-5	4	4	0	
GOV	0	0	0	
I	0	0	0	
IMF	0	0	0	
No Dev	0	0	0	

OS	0	0	0	
R10	85	61	24	
R120	199	181	18	
R120-L	52	52	0	
R160	142	136	6	
R20	146	139	7	
R40	507	469	38	
R5	122	120	2	
R80	249	232	17	
Residentia	0	0	0	
RO40/20	25	16	9	
ROW	0	0	0	
RuA	250	237	13	
RuB	92	92	0	
SU	0	0	0	
SU-110	108	108	0	
SU-600	599	599	0	
VR10	13	9	4	
W	0	0	0	
C-Park	0	0	0	
Camp Rell	0	0	0	
Total	**2720**	**2582**	**138**	

Commercial Quantities - Floor Space

Land-Use Designation	Numeric Build-Out Floor Area (sq. feet)	Spatial Build-Out Floor Area (sq. feet)	Difference
?	0	0	0
B	0	0	0
C	0	0	0
CA	0	0	0
CB	0	0	0
DU-1	0	0	0
DU-2	0	0	0
DU-20	0	0	0
DU-25	0	0	0
DU-3	0	0	0
DU-5	0	0	0
GOV	0	0	0
I	0	0	0
IMF	0	0	0
No Dev	0	0	0
OS	0	0	0
R10	0	0	0
R120	0	0	0
R120-L	0	0	0
R160	0	0	0
R20	0	0	0

R40	0	0	0
R5	0	0	0
R80	0	0	0
Residentia	0	0	0
RO40/20	0	0	0
ROW	0	0	0
RuA	0	0	0
RuB	0	0	0
SU	0	0	0
SU-110	0	0	0
SU-600	0	0	0
VR10	0	0	0
W	0	0	0
C-Park	0	0	0
Camp Rell	0	0	0
Total	**0**	**0**	**0**

Commercial Quantities - Buildings

Land-Use Designation	Numeric Build-Out Units	Spatial Build-Out Units	Difference	Existin
?	0	0	0	
B	0	0	0	
C	0	0	0	
CA	0	0	0	
CB	0	0	0	
DU-1	72	72	0	
DU-2	9	9	0	
DU-20	19	19	0	
DU-25	24	24	0	
DU-3	3	3	0	
DU-5	4	4	0	
GOV	0	0	0	
I	0	0	0	
IMF	0	0	0	
No Dev	0	0	0	
OS	0	0	0	
R10	85	61	24	
R120	199	181	18	
R120-L	52	52	0	
R160	142	136	6	
R20	146	139	7	
R40	507	469	38	
R5	122	120	2	
R80	249	232	17	
Residentia	0	0	0	
RO40/20	25	16	9	
ROW	0	0	0	
RuA	250	237	13	

RuB	92	92	0
SU	0	0	0
SU-110	108	108	0
SU-600	599	599	0
VR10	13	9	4
W	0	0	0
C-Park	0	0	0
Camp Rell	0	0	0
Total	**2720**	**2582**	**138**

Buildable Area

Land-Use Designation	Gross Area (sq feet)	Net Buildable Area (sq feet)	Difference (sq fe
?	96422.797	96422.78	0.
B	2243017.1	1332979.939	910037.
C	5951880.161	3921158.355	2030721.
CA	6666787.557	4335110.263	2331677.
CB	61799.748	61799.738	(
DU-1	81233005.752	61230019.559	20002986.
DU-2	8161537.487	6010343.806	2151193.
DU-20	686262.145	532145.099	154117.
DU-25	5978997.309	4258179.986	1720817.
DU-3	1863154.142	1388838.632	474315
DU-5	365070.651	258449.709	106620.
GOV	842461.888	792299.003	50162.
I	49595228.888	29214295.216	20380933.
IMF	6086410.392	3279338.734	2807071.
No Dev	8158712.782	5554621.989	2604090.
OS	110818284.771	57737815.243	53080469.
R10	8991447.481	7398793.906	1592653.
R120	70188279.984	49997883.08	20190396.
R120-L	16253218.605	14161543.187	2091675.
R160	67244020.957	45166119.3	22077901.
R20	23999701.795	19359020.823	4640680.
R40	86763368.074	57762160.131	29001207.
R5	884662.544	884662.566	-0.
R80	73321438.092	42841863.155	30479574.
Residentia	4634674.255	3793406.422	841267.
RO40/20	12926913.768	9967952.579	2958961.
ROW	37850049.999	29171782.301	8678267.
RuA	64803671.631	45332332.765	19471338.
RuB	31933825.348	17419587.666	14514237.
SU	9070012.066	6145740.816	2924271
SU-110	8425517.353	6828567.016	1596950.
SU-600	8380155.39	4457331.582	3922823.
VR10	3608856.23	2741276.632	867579.
W	36704706.828	17551.39	36687155.
C-Park	2582016.614	498356.163	2083660.

Camp Rell		3335776.752	3186546.771	149229.
	Total	**860711347.334**	**547136296.302**	**313575051.**

Exceptions

Land-Use Designation	Number of dwelling units that couldn't be placed because of space constraints	Number of commerical buildings that couldn't be placed because of space constraints	Number of numbe buildings ex
?	0	0	
B	0	0	
C	0	0	
CA	0	0	
CB	0	0	
DU-1	0	0	
DU-2	0	0	
DU-20	0	0	
DU-25	0	0	
DU-3	0	0	
DU-5	0	0	
GOV	0	0	
I	0	0	
IMF	0	0	
No Dev	0	0	
OS	0	0	
R10	24	24	
R120	18	18	
R120-L	0	0	
R160	6	6	
R20	7	7	
R40	38	38	
R5	2	2	
R80	17	17	
Residentia	0	0	
RO40/20	9	9	
ROW	0	0	
RuA	13	13	
RuB	0	0	
SU	0	0	
SU-110	0	0	
SU-600	0	0	
VR10	4	4	
W	0	0	
C-Park	0	0	
Camp Rell	0	0	
Total	**138**	**138**	

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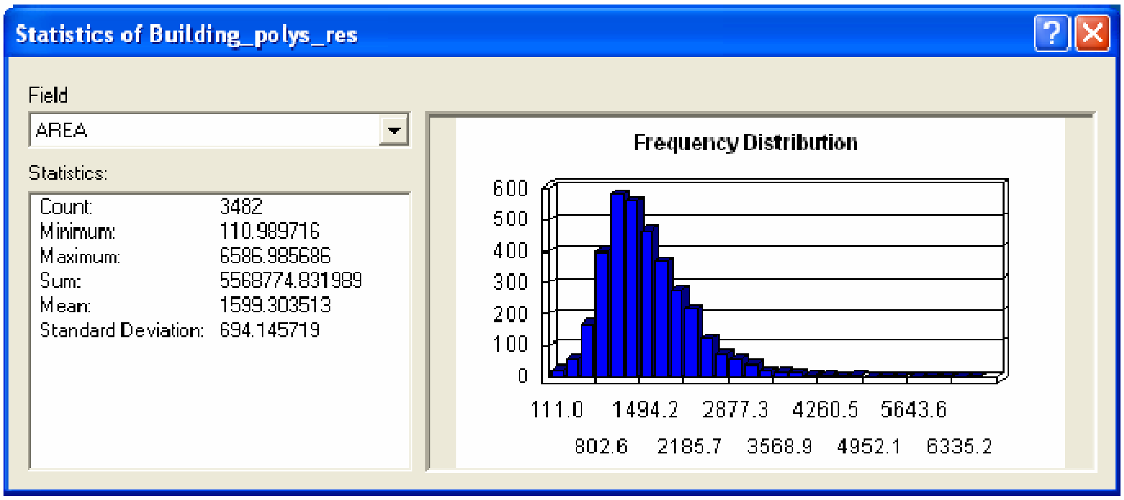
Appendix D.5 – Methods Used to Generate IS Estimates and IS Summary

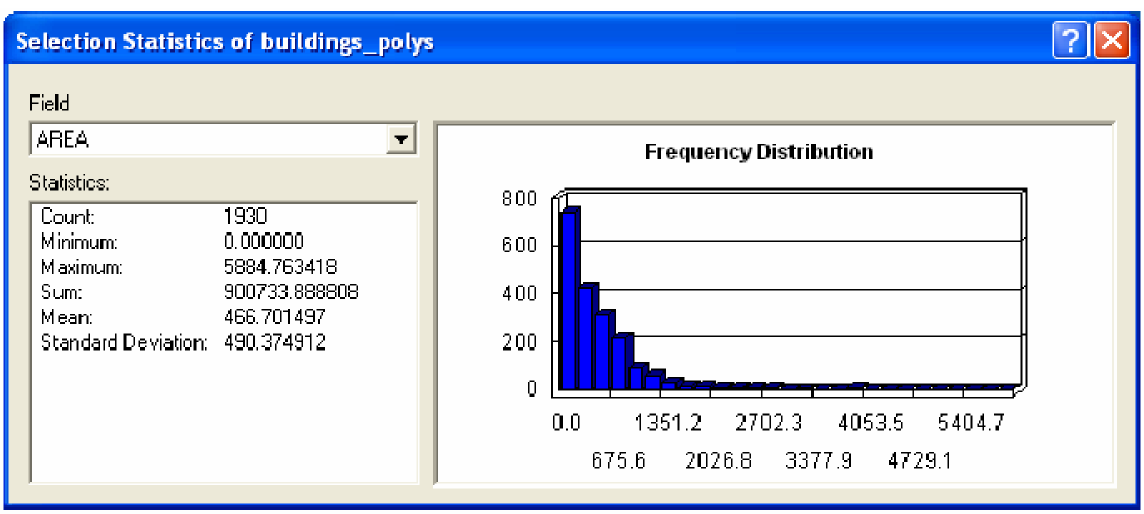
Methods to develop components used in the impervious surface estimates

Statistics for buildings classified as residences in residential Land Cover polygons



From this analysis, the average size of existing houses is ~ 1,600 square feet. For buildout analysis purposes, the average size for new homes was increased to 2,000 square feet since houses today tend to be significantly larger than older homes.

Statistics for outbuildings in residential Land Cover polygons

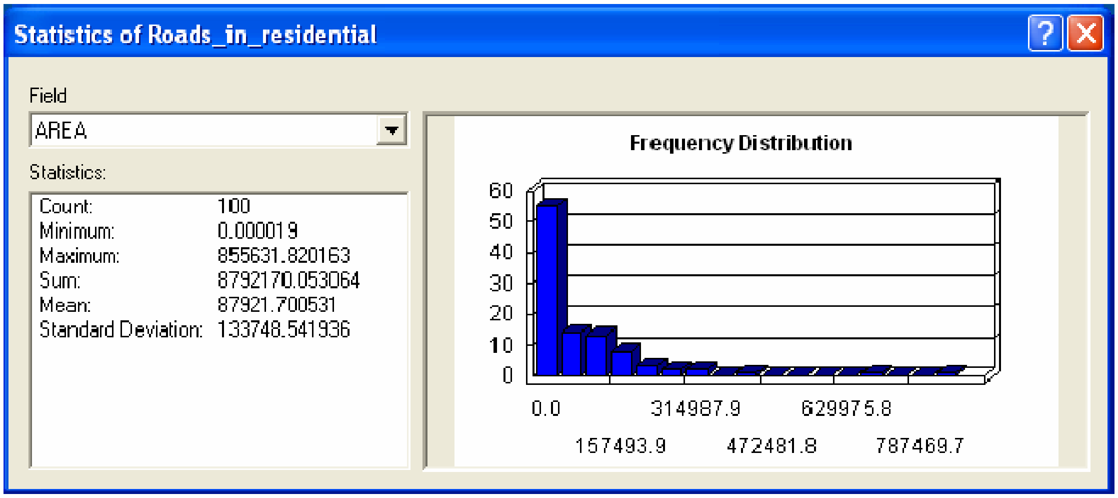


Not all homes have outbuildings. Therefore, an average outbuilding area was calculated as the sum of all outbuildings divided by the number of residential homes.

900,734 / 3,482 = 259 square feet

This average amount, rounded to 260, will be added to all new homes created through the buildout analysis.

Area of road associated with existing residential homes

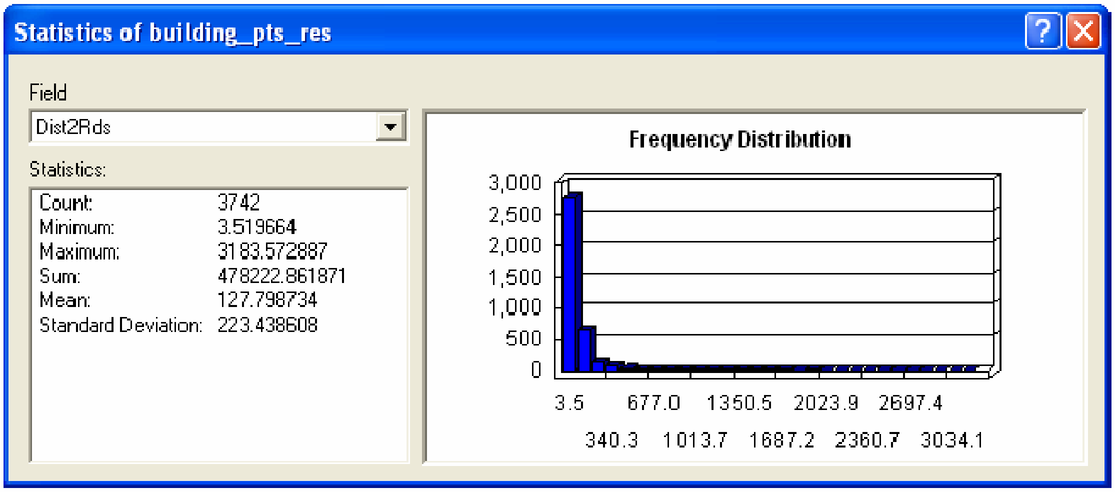


The average square foot area of road associated with each house was calculated by calculating the area of roads in residential land cover polygons (Anderson Level II code = 1100, 1976) and then dividing by the number of houses. Since the buildout analysis does not create new roads, we needed an average road square footage per house value in order to estimate IS from new roads.

8,792,170 / 3,335 = 2,636 square feet

Area of driveways associated with each home

The impervious surface area associated with residential driveways and parking is highly variable and depends on the lot configuration and distance of the house to the road. Planimetric data for the towns in the study area did not include driveways for all residential structures nor were the planimatric data, which were in a CAD format, easily converted to a GIS format. Therefore, CommunityViz was used to calculate the straight-line distance from residential homes to the closest road in the watershed and the average house-to-road distance was determined.



Note: there are more houses in this analysis than in the analysis to calculate average house footprint. This is because no planimetric data exist for Salem and houses in the other towns had been built since the last town GIS data updates. Point locations of existing houses were created based on the 2004 aerial orthoimagery and were included in the driveway calculations.

The area of each driveway is calculated to be the average driveway length (~130') times an average width of 8 feet and a turn/parking area of 400 square feet.

(130 * 8) + 400 = 1,440 square feet

Summary – residential areas

Average square foot areas of impervious surfaces associated with existing houses is calculated as follows:

Footprint of house	1,600
Outbuildings	260
Driveway	1,440
Total IS per house	**3,300**

~ 4,150 houses existed within the watershed based on 2004 orthoimagery.

The area of existing house related IS was calculated as 4,150 houses * 3,300 sq. feet per house = 13,695,000 square feet (~ 314 acres)

Average square foot areas of impervious surfaces associated with new houses is calculated as follows:

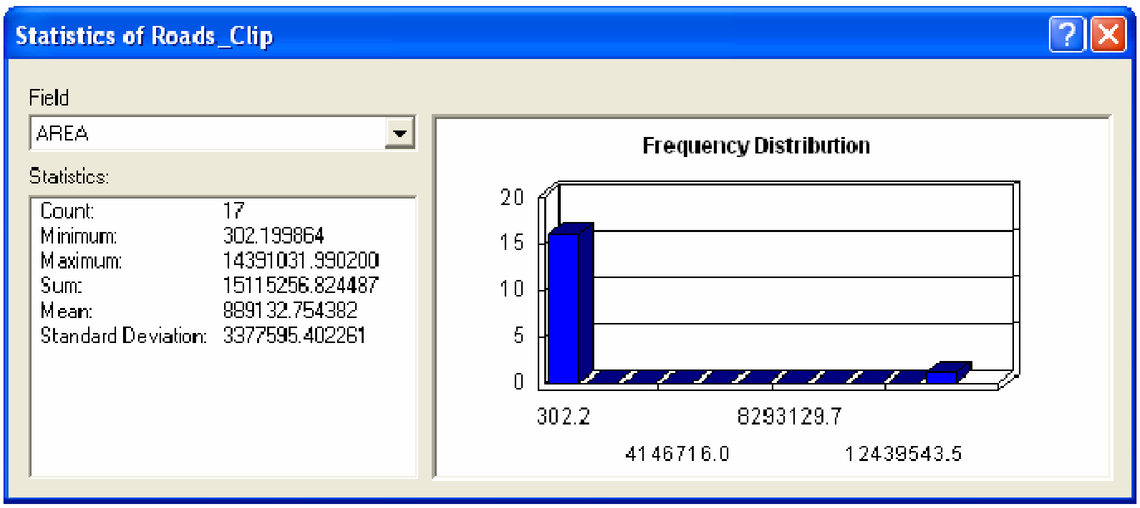
Footprint of house	2,000
Outbuildings	260
Associated road	2,636
Driveway	1,440
Total IS per house	**6,336**

The buildout tool calculated that an additional 2,855 houses could be built under full buildout conditions based on current zoning.

The area of buildout house related IS was calculated as 2,855 houses * 6,336 square feet per house = 18,089,280 square feet (~ 415 acres)

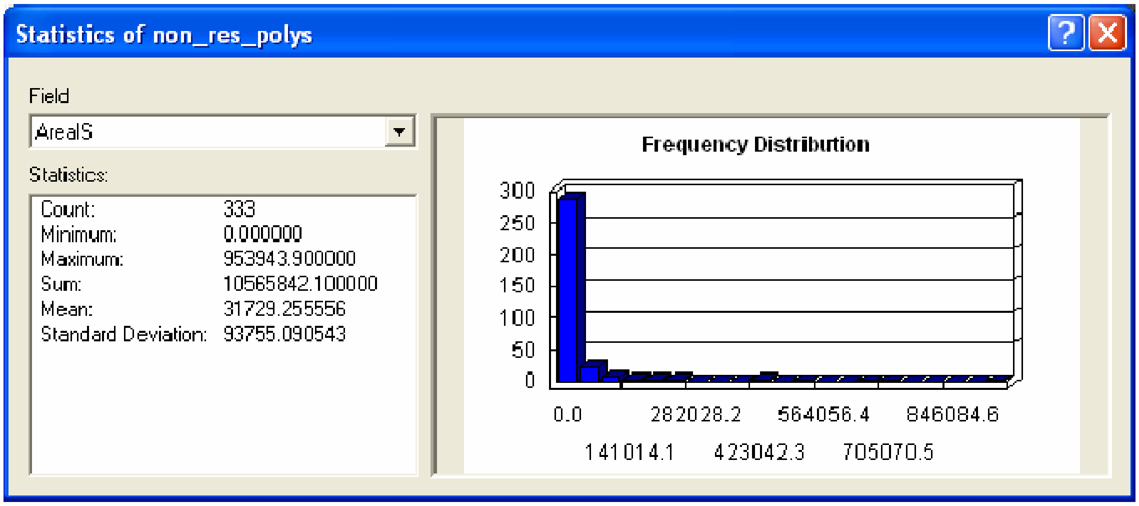
Roads

The area of existing roads in the watershed is 15,115,257 square feet (~ 347 acres). This value was used to calculate existing IS.



Impervious surfaces for non-residential areas

The current percent IS area for parcels with a general zone designation of commercial, industrial, business and government was estimated by visually inspecting parcels overlaid on the 2004 orthoimagery and adding the estimated value to the attribute table. Parcels with structures were assigned a minimum value of 5% to a maximum value of 100%. The area of each parcel was then multiplied by the percent IS to calculate the square footage of IS and statistics were run to calculate the total IS for these parcels.

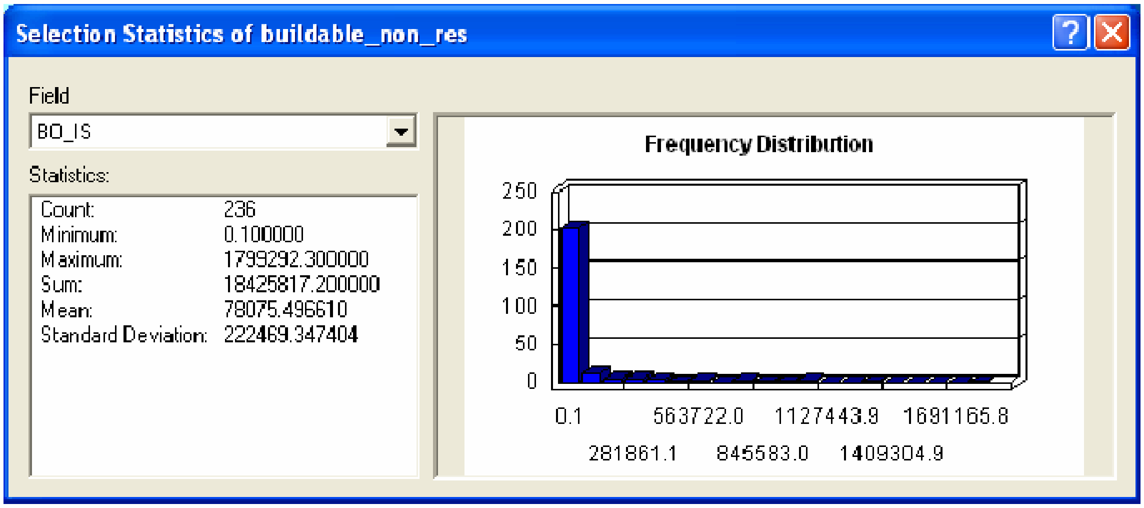


Estimated total existing IS = 10,565,842 square feet (~ 243 acres)

Impervious surfaces for non-residential areas at buildout

To estimate future impervious surface area for parcels zoned for business, commercial, industrial and government uses and for the area of Camp Rell, it was decided that approximately 55% of the buildable land within these zones would be covered with IS at buildout. The total buildable non-residential area was calculated after running the buildout analysis and the constraint areas had been removed. These are the shaded areas in the example screen capture. For each buildable area polygon, an estimate was made of the current percent IS. This is the number shown in each shaded polygon. For all polygons where the current IS percent was less than 55, the following calculation was run:

(55% - current IS %) * buildable area = increase in IS area at buildout



Area of additional IS, in buildable areas at buildout = 18,425,817 square feet (~ 423 acres)

NRW Impervious Surfaces Summary

University of Connecticut

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Report Contents

Analysis Description

This Sceanrio360 analysis was used to summarize impervious surface amounts - current and under buildout conditions - for the local basins.

Scenarios in this Analysis

What is a scenario?

Base Scenario

Report Summary

Report Date/Time: Friday, July 14, 2006 3:28 PM

Assumptions

What is an assumption?

Assumption Info

Assumption	Details
Impervious surface	
Associated road IS	Type: Number Range: 2500 - 3000 Default: 2636 Units:
Driveway	Type: Number Range: 1340 - 2340 Default: 1440 Units:
Existing house footprint	Type: Number Range: 1500 - 2000 Default: 1600 Units:
New house footprint	Type: Number Range: 1800 - 2400 Default: 2000 Units:
	Type: Number

Outbuildings	Range: 260 - 500 Default: 260 Units:

Assumption Descriptions

Assumption	Description
Associated road IS	The estimated square feet of roads that will be constructed to service new residential buildings. This is based on the average area of existing roads relative to existing residential buildings.
Driveway	Estimated average area of driveways associated with existing and future residential buildings.
Existing house footprint	Average building footprint size based on existing planimatric data from Waterford, East Lyme and Montville.
New house footprint	Estimated average building footprint size for future residential construction.
Outbuildings	Average area of outbuildings based on existing planimatric data from Waterford, East Lyme and Montville.

Dynamic Attributes

What is a dynamic attribute?

Attribute Info

Attribute	Details
Basins	
Bldgs_BO	Type: Double Formula: Count ([Layer:Residential buildings - buildout], Where (Intersects ([Attribute:Shape])))
Bldgs_BO_IS	Type: Double Formula: [Attribute:Bldgs_BO] * ([Assumption:Outbuildings] + [Assumption:Driveway] + [Assumption:New house footprint] + [Assumption:Associated road IS])
Bldgs_Existing	Type: Double Formula: Count ([Layer:Residential buildings - existing], Where (Intersects ([Attribute:Shape])))
Bldgs_Existing_IS	Type: Double Formula: [Attribute:Bldgs_Existing] * ([Assumption:Existing house footprint] + [Assumption:Outbuildings] + [Assumption:Driveway])
Percent_IS_BO	Type: Double Formula: ([Attribute:Total_IS_BO] / [Attribute:Shape_Area]) * 100
Percent_IS_existing	Type: Double Formula: [Attribute:Total_Existing_IS] / ([Attribute:Shape_Area]) * 100

Road_IS	Type: Double Formula: OverlapArea ([Layer:Paved roads])
Rt_11_IS	Type: Double Formula: OverlapArea ([Layer:Proposed Route 11])
Total_Existing_IS	Type: Double Formula: [Attribute:Bldgs_Existing_IS] + [Attribute:Road_IS] + [Attribute:Non_Res_IS_Existing]
Total_IS_BO	Type: Double Formula: [Attribute:Bldgs_Existing_IS] + [Attribute:Bldgs_BO_IS] + [Attribute:Road_IS] + [Attribute:Non_Res_IS_Existing] + [Attribute:Non_Res_IS_BO] + [Attribute:Rt_11_IS]

Attribute Descriptions

Attribute	Description
Basins	
Bldgs_BO	The number of residential buildings added at buildout.
Bldgs_BO_IS	The total impervious surface area, in square feet, attributed to new residential buildings in the basin.
Bldgs_Existing	The number of existing residential buildings per basins.
Bldgs_Existing_IS	The total impervious surface area, in square feet, attributed to existing residential buildings (exisitng as of 2004) in the basin.
Percent_IS_BO	Impervious surface as a percent of the basin area at buildout.
Percent_IS_existing	Existing impervious surface as a percent of the basin area.
Road_IS	The impervious surface area of roads, in square feet, based on an "Overlap" function with the roads layer.
Rt_11_IS	Impervious surface area attributed to that portion of proposed route 11 within the basin. Formula Description: the area of the overlap of this feature on the layer RT_11_lanes_Buffer20
Total_Existing_IS	The sum total of impervious surface as of 2004. Formula Description: [Attribute:Bldgs_Existing_IS] + [Attribute:Road_IS] + [Attribute:Non_Res_IS_Existing]
Total_IS_BO	The sum of impervious surface area at buildout. Formula Description: [Attribute:Bldgs_Existing_IS] + [Attribute:Bldgs_BO_IS] + [Attribute:Road_IS] + [Attribute:Non_Res_IS_Existing] + [Attribute:Non_Res_IS_BO] + [Attribute:Rt_11_IS]

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APPENDIX E

Methodology: Watershed Vulnerability Assessment

APPENDIX E

Methodology: Watershed Vulnerability Assessment

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 Geodagtabase Feature Class	Connecticut State Plane, NAD 1983, feet	7/15/2005	USGS NRCS SSURGO	
Soil depth to water table	Personal Geodagtabase Feature Class	Connecticut State Plane, NAD 1983, feet	7/15/2005	USGS NRCS SSURGO	
Preserved lands	Personal Geodagtabase 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 Geodagtabase 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 Geodagtabase 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 Geodagtabase 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)
Slope (%)	>20 - 150	>10 - 20	0 - 10	none
Flow Accumulation	1801 - 676,860	1351 - 1800	0 - 1350	none
Soil Permeability	>100	>1 - 100	>0 - 1	0
Soil Depth to Water Table	D	B, C	A	All others
Preserved Lands	All	none	none	none
Forest-Water-Roads	All	none	none	none
Distance to Water (ft)	0 - 50	>50 - 100	none	>100
Land Cover				
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

K_{sat} Class (μm/s)	Ranking
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.

APPENDIX F

Methodology: Stormwater Modeling (SWMM Model)

APPENDIX F

Methodology: Stormwater Modeling (SWMM Model)

Appendix F.1 – Methodology

Appendix F.1.1 – Pollutant Loading Approach

Pollutant loadings from a watershed are obtained when rainfall actually becomes runoff and is not lost due to infiltration. Runoff passes over yards, forests, parking lots and all other land covers and can 'pick up' pollutants along the flow path. Every type of land cover contributes some degree of pollutants, but the type of pollutant and the concentration will vary. The *first assumption* is how the concentration of pollutants is accounted for within the runoff. Some methods allow for a buildup of pollutant loads over time, followed by a wash-off. The first one-inch (1") of rain after a dry spell will produce a higher pollutant load concentration than the following one inch of rain during the same storm. Analysis using this method requires a detailed study of active land management practices such as potential buildup ratios over time, or street sweeping schedules.

Another method is called the *Event Mean Concentration* (EMC) approach, which uses a constant loading of a pollutant per volume of calculated runoff. This was the approach utilized for the analysis of the Niantic River Watershed. This method allows for even analysis of potential pollutant loadings without biasing loadings from variable methods of street maintenance or pollution enforcement between towns or locations.

Variables for EMCs for the studied land covers were obtained from various published sources and have been referenced. Using these variables is a generalization of loadings from certain land covers and is assumed to be homogenous across the watershed, which may not always be the case. In some instances, published values for certain land covers are not readily available, so the most similar type of cover or land use (*i.e.* animals, excess fertilizers, parking areas, *etc.*) was used to determine the EMC loading rates (Table F.2.1-1).

The following key pollutants were studied within the SWMM model:

- Total Suspended Solids (TSS)
- Total Kjeldahl Nitrogen (TKN)
- Total Nitrogen as NO_2 & NO_3 (TN)
- Total Phosphorous (TP)
- Biological Oxygen Demand (BOD)

Table F.1.1-1. Land Use and Event Mean Concentration Pollutant Loading Rates[1, 2, 3, 4,5]

	Value	TSS (mg/l)	BOD (mg/l)	Total P (mg/l)	NO3-NO2 (mg/l)	TKN (mg/l)
Residential	1100	54.5	11.5	0.26	0.53	1.47
Residential (High Density)	1110	100	36	0.5	0.84	1.49
Residential (Rural)	1140	42	11.5	0.4	0.34	1.48
Commercial & Services	1200	55.5	23	0.32	0.26	1.1
Educational Institutions	1207	67	7.8	0.26	0.56	1.3
Health Institutions	1208	67	7.8	0.26	0.56	1.3
Military Installations	1211	67	7.8	0.26	0.56	1.3
Industrial	1300	60.5	14	0.28	0.3	1
Power Generation	1330	55.5	23	0.32	0.26	1.1
Transportation, Communication & Utilities	1400	1	0.5	0.01	0.4	0.2
Limited Access Highways	1410	50.3	5.6	0.34	0.1	2.72
Railroad Facilities	1420	50	0.5	0.1	0.01	0.1
Power Facilities	1460	1	0.5	0.01	0.4	0.2
Water Treatment Facilities	1470	67	7.8	0.26	0.56	1.3
Sewage Treatment Facilities	1480	60.5	14	0.28	0.3	1
Other Transportation, Communication & Utilities	1490	50	0.5	0.1	0.01	0.1
Other Urban or Built-up	1700	11.1	1.45	0.05	0.25	1
Cemeteries	1710	3	4	0.03	0.4	0.2
Open Areas	1740	3	4	0.03	0.4	0.2
Golf Courses	1801	202	10	1.07	1.02	6.85
Picnic & Camping Parks	1802	3	4	0.03	0.4	0.2
Marina & Boat Launches	1803	60.5	14	0.28	0.3	1
Community Recreation Areas	1804	3	4	0.03	0.4	0.2
Open Areas in Parks	1809	3	4	0.03	0.4	0.2
Cropland & Pastureland	2100	55.3	3.8	0.344	1.6	1.7
Harvested Cropland	2110	107	4	0.562	0.5	1.7
Pastureland	2120	151	5.1	2.14	1.3	3.46
Inactive Cropland	2130	5	0.5	0.01	0.4	0.2
Orchards, Vineyards, Nurseries & Horticultural Areas	2200	16.3	2.55	0.14	0.5	1.25
Nurseries	2230	16.3	2.55	0.14	0.5	1.25
Horse Farm	2430	151	7	2.14	1.3	3.46
Deciduous (>50% Crown Closure)	4120	487	0.1	0.15	0.17	0.61
Plantation	4230	3	4	0.03	0.4	0.2
Old Field (<25% Brush Covered)	4410	1	0.5	0.01	0.4	0.2
Deciduous Brush/Shrubland (>25% Brush with Decid Species >75%)	4420	80	4	0.25	0.1	1.37
Natural Lakes	5200	3.1	1.6	0.11	0.25	1.0
Artificial Lakes & Reservoirs	5300	3.1	1.6	0.11	0.25	1.0
Artificial Lakes	5310	3.1	1.6	0.11	0.25	1.0
Saline Marshes	6110	15	5	0.05	0.25	1.0
Interior Wetlands	6200	10.2	5	0.19	0.6	1.0
Deciduous Wooded Wetlands	6210	487	0.1	0.15	0.17	0.61
Exposed Rock	7220	5	0.05	0.1	0.01	0.1
Extractive Mining	7300	3491	0.1	0.43	0.21	1.08
Stone Quarries	7310	3491	0.1	0.43	0.21	1.08
Sand & Gravel Pits (Borrow Pits)	7320	3491	0.1	0.43	0.21	1.08
Transitional Areas	7500	1453	0.1	0.28	1	5.69
Single Unit Residential Under Construction	7510	1453	0.1	0.28	1	5.69
Transportation/Communication/Utilities Under Construction	7550	1453	0.1	0.28	1	5.69
Undifferentiated Barren Land	7600	11.1	1.45	0.05	0.25	1

[1] Harper (1998)
[2] Schueler (1996)
[3] USEPA (2005d)
[4] Line (2002)
[5] Lin (2004)

Appendix F.1.2 – Model Approach

In order to assemble and analyze the vast collection of data, the USEPA Storm Water Management Model v.5 .008 (SWMM5) was utilized. SWMM "is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each subcatchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps"[20].

This model was used because of the simplicity of data assembly through text file inputs. Data was able to be assembled within a GIS application and exported to text files used as inputs for SWMM. Additionally, the model is extremely flexible when defining land uses and the associated pollutant loads.

Appendix F.1.3 – Hydrologic Analysis

Total pollutant contribution from a subcatchment is dependent on the total volume of runoff over time. SWMM accounts for hydrologic routing and losses over a given subcatchment as a response to precipitation. Figure F.1.3-1 shows the Subcatchments generated for use in this Stormwater Modeling.

The watershed was analyzed hydrologically on a subcatchment by subcatchment basis using the NRCS TR-20 approach[21]. Curve Numbers (CN) for each subcatchment were developed from typical land cover and Hydrologic Soil Grouping (HSG) type. A table of these values (in conjunction with the Anderson Land Use Classification) can be seen in Table F.1.3-1.

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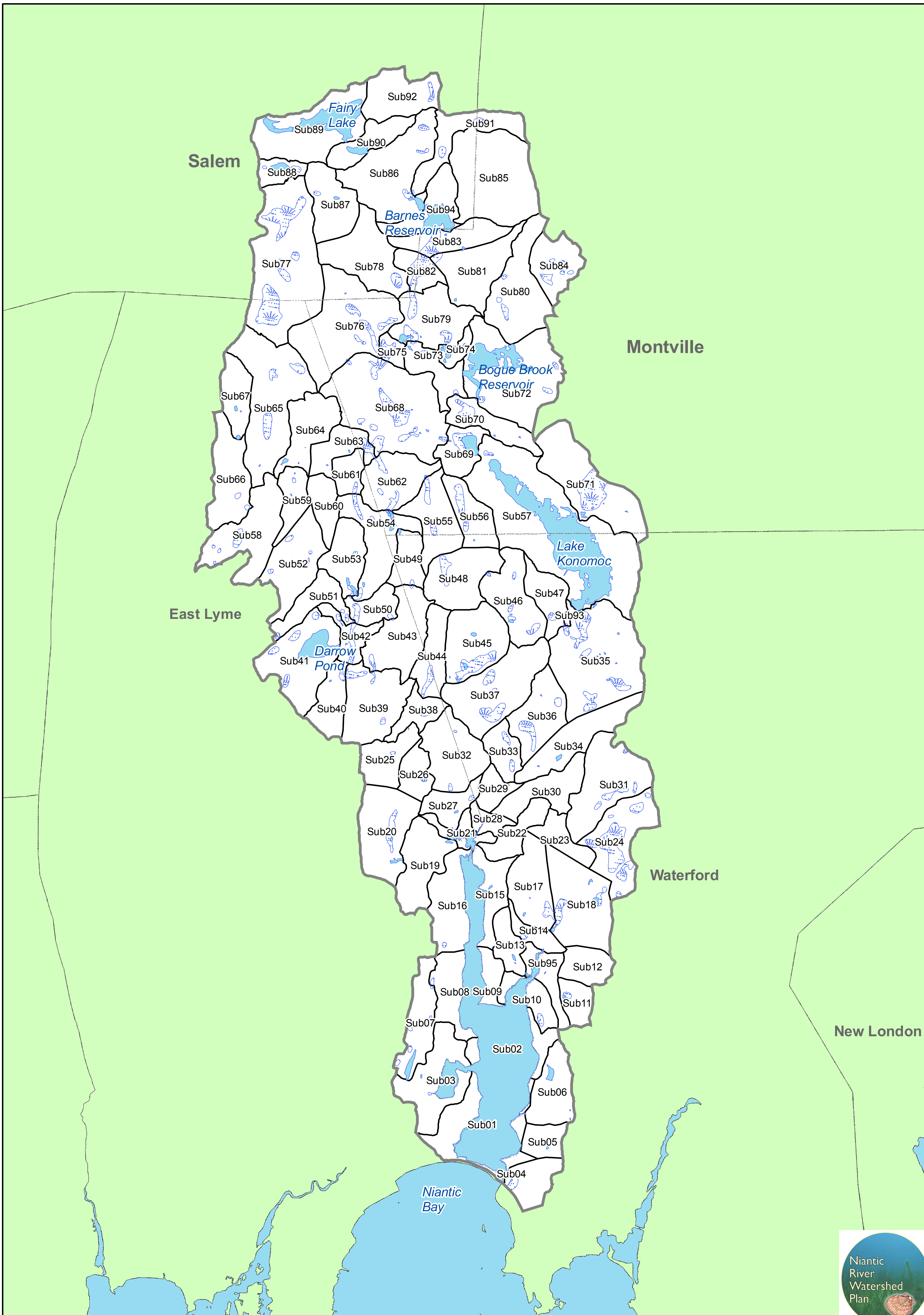
[20] Passage description from the EPA SWMM website: http://www.epa.gov/ednnrmrl/models/swmm/index.htm

[21] http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr20.html



Scale: AS SHOWN	DEPT OF ENVIRONMENTAL PROTECTION HARTFORD, CONNECTICUT
Project No: 1314-001	NIANTIC RIVER WATERSHED MANAGEMENT PLAN
Filename: SWM_Subcatchments.mxd	
Drawn By: SEK	STORMWATER MODELING SUBCATCHMENTS
Date Drawn: 09-07-2006	Kleinschmidt Energy & Water Resource Consultants 35 Pratt Street, Suite 201 Essex, Connecticut 06426 Telephone: (860) 767-5069 Fax: (860) 767-5097 www.KleinschmidtUSA.com

F.1.3-1

Table F.1.3-1. Land Cover / HSG Curve Number (CN) Lookup Table

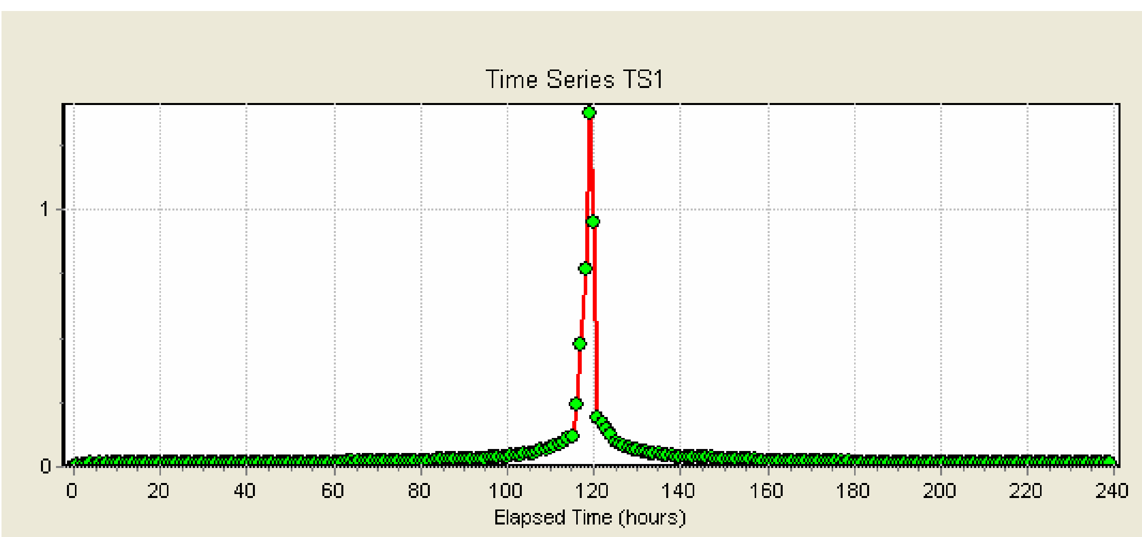
	Value	A	B	C	D
Residential	1100	54	70	80	85
Residential (High Density)	1110	77	85	90	92
Residential (Rural)	1140	51	68	79	84
Commercial & Services	1200	89	92	94	95
Educational Institutions	1207	89	92	94	95
Health Institutions	1208	89	92	94	95
Military Installations	1211	89	92	94	95
Industrial	1300	89	92	94	95
Power Generation	1330	89	92	94	95
Transportation, Communication & Utilities	1400	74	83	88	90
Limited Access Highways	1410	98	98	98	98
Railroad Facilities	1420	76	85	89	91
Power Facilities	1460	30	48	65	73
Water Treatment Facilities	1470	89	92	94	95
Sewage Treatment Facilities	1480	89	92	94	95
Other Transportation, Communication & Utilities	1490	72	82	87	89
Other Urban or Built-up	1700	59	74	82	86
Cemeteries	1710	39	61	74	80
Open Areas	1740	39	61	74	80
Golf Courses	1801	39	61	74	80
Picnic & Camping Parks	1802	39	61	74	80
Marina & Boat Launches	1803	98	98	98	98
Community Recreation Areas	1804	39	61	74	80
Open Areas in Parks	1809	39	61	74	80
Cropland & Pastureland	2100	59	74	82	86
Harvested Cropland	2110	67	78	85	89
Pastureland	2120	39	61	74	80
Inactive Cropland	2130	39	61	74	80
Orchards, Vineyards, Nurseries & Horticultural Areas	2200	32	58	72	79
Nurseries	2230	32	58	72	79
Horse Farm	2430	39	61	74	80
Deciduous (>50% Crown Closure)	4120	30	55	70	77
Plantation	4230	39	61	74	80
Old Field (<25% Brush Covered)	4410	39	61	74	80
Deciduous Brush/Shrubland (>25% Brush with Decid Species >75%)	4420	32	58	72	79
Natural Lakes	5200	100	100	100	100
Artificial Lakes & Reservoirs	5300	100	100	100	100
Artificial Lakes	5310	100	100	100	100
Saline Marshes	6110	57	73	82	86
Interior Wetlands	6200	57	73	82	86
Deciduous Wooded Wetlands	6210	30	55	70	77
Exposed Rock	7220	98	98	98	98
Extractive Mining	7300	77	86	91	94
Stone Quarries	7310	77	86	91	94
Sand & Gravel Pits (Borrow Pits)	7320	77	86	91	94
Transitional Areas	7500	77	86	91	94
Single Unit Residential Under Construction	7510	77	86	91	94
Transportation/Communication/Utilities Under Construction	7550	77	86	91	94
Undifferentiated Barren Land	7600	49	69	79	84

Soils data was obtained from the NRCS that contains a listing of the HSG value. This information was overlaid with the land use data and a curve number for each unique land cover / soil type was developed in each subcatchment. Area weighted averages of the curve numbers were developed for each subcatchment and assigned within SWMM.

The percent impervious area within each subcatchment was also obtained from data by UCONN. Of percent impervious cover polygons were provided and the area averaged value was determined for each subcatchment. This also was an input for the hydrologic analysis within SWMM.

Precipitation data were obtained from a synthetic storm event with a total rainfall of almost 10” within a 24-hour period. Time was lagged significantly on either side of the event to view the rise and recession limb of not only the storm flows but also the pollutant runoff concentrations. A significant storm-event was needed to ensure full contribution from all watersheds with a ‘measurable’ amount of each pollutant for comparison. Each subcatchment across the watershed received an equal distribution of rainfall at the same time. Figure F.1.3-2 shows the precipitation hyetograph for the synthetic event.

Figure F.1.3-2. Modeled Rainfall Hyetograph



The model also required inputs such as total drainage area, average basin slope, and flow path width[22]. Using this assembled information, a hydrologic analysis of each subcatchment was completed. This allowed for the determination of a total volume of runoff from the synthetic storm event for each subcatchment dependent on specific soils and land covers. Similarly, this information is directly associated to the pollutant contributions from each subcatchment.

Appendix F.1.4 – Data Assembly

Subcatchments were created within the Niantic watershed to model hydrologically similar catchments and major contributing streams. In all, 95 subcatchments have been assembled within the watershed averaging at approximately 200 acres each. Data for each of these subcatchments was assembled within a GIS database. For the purposes of this assessment, the following data layers were required:

- Digital Elevation Model (10m DEM)
- 2004 Land Cover Data (developed by UCONN)
- Medium Intensity Soils Data (SSURGO)

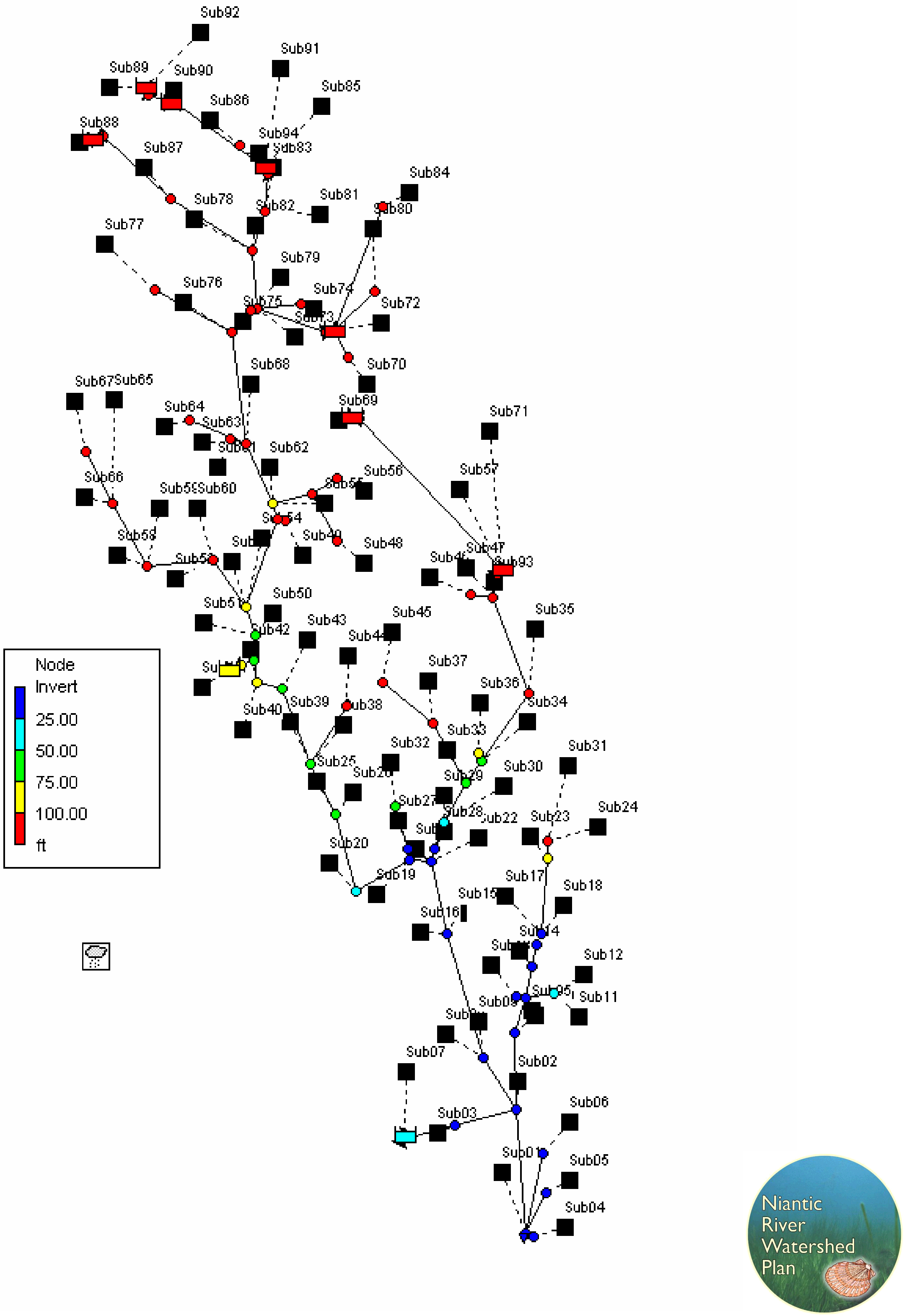
Additional data layers were created and used in conjunction with the base data in order to assemble the model. The following layers were generated:

- Subcatchment Polygons
- Polygon Centroid Points
- Subcatchment Linking Reaches
- Reservoir Outlet Points
- Outfall Point

[22] The routing of flows within SWMM is calculated using the Manning's equation with an average flow width and an average flow depth, rather than a standard Time of Concentration (Tc) routing associated with the NRCS TR-20 method. To calibrate between these two methods, three different subcatchments ranging from 50 to 380 acres were developed to compare results from a HEC-HMS model to similar subcatchments within SWMM5. The closest calibration between these similar subcatchments with respect to peak outflow and contributing volume was obtained from the default width of 500' and slopes averaging 7%. The size of the watershed did not appear to affect the variables / constants used to determine the standard calibration.

A linked network within ArcGIS was developed with reaches connecting all subcatchments and routing the network eventually towards the outfall. The layout of the network in SWMM can be seen in Figure F.2.3-3. The reaches were not designed to determine actual flood routing, but are instead to function as links to determine total pollutant loading. 'Dummy' values were used for the links to determine the routing. Nodes were required to create connection points where multiple subcatchments or reaches are joined. Storage areas allowed for ponding and storage of flows from contributing subcatchments. Functional curves were used to route the flows out of the reservoir, entirely dependent on available head. The outfall node was a steady state elevation node which acts as a sink for incoming flows.

Additional data needed to be interpreted from these inputs, such as the weighted Curve Numbers or the total percent of land covers within each subcatchment.



Scale: AS SHOWN	DEPT OF ENVIRONMENTAL PROTECTION HARTFORD, CONNECTICUT
Project No: 1314-001	NIANTIC RIVER WATERSHED MANAGEMENT PLAN
Filename: Node_Network.mxd	NODE NETWORK DIAGRAM FOR NIANTIC WATERSHED (SWMM5)
Drawn By: SEK	Kleinschmidt Energy & Water Resource Consultants 35 Pratt Street, Suite 201 Essex, Connecticut 06426 Telephone: (860) 767-5069 Fax: (860) 767-5097 www.KleinschmidtUSA.com
Date Drawn: 09-07-2006	

F.1.4-3

This analysis was completed within ArcGIS, where the resulting datasets were exported as text files. SWMM uses a *.inp extension, which is a text input file. Data are organized within this file according to the following categories:

[TITLE]
[OPTIONS]
[RAINGAGES]
[SUBAREAS]
[INFILTRATION]
[JUNCTIONS]
[OUTFALLS]
[CONDUITS]
[XSECTIONS]
[POLLUTANTS]
[LANDUSES]
[COVERAGES]
[LOADINGS]
[WASHOFF]
[TIMESERIES]
[REPORT]
[TAGS]
[COORDINATES]
[VERTICES]
[POLYGONS]
[SYMBOLS]
[BACKDROP]

Each of these categories are assigned specific data either gathered from within ArcGIS or from other data sources. Some of the categories are also automatically established from within SWMM as the model is developed. Results from SWMM5 were exported for each subcatchment back into the GIS database for interpretation and presentation.

Appendix F.1.5 – Pollutant Modeling

The overall goal is to determine the potential changes of pollutant loading from the development of the watershed over time. As described earlier, the EMC were used to determine the loading of certain pollutants from the various land covers. Only the table of pollutants and the associated contributions from land covers were required as inputs into the SWMM model. The percentage of land cover for each subcatchment then determined the ratio of pollutants, with the total loading determined from the total runoff volumes.

Appendix F.2 – Proposed Development Scenario

Appendix F.2.1 – Buildable Lands

In order to determine the potential for pollutant load increases, the area available for potential development must be determined. Several assumptions regarding what may be considered developable had to be made with respect to the current zoning regulations and the current developed land.

Certain lands have been considered un-developable because of either their classification or their proximity to certain land cover types. The following were considered not developable:

- Any waterbodies, and a 50 foot buffer around the waterbodies
- Riparian Wetlands, and a 50 foot buffer around each
- Slopes greater than 30%
- Protected lands by either State or Municipalities (Parks, *etc.*)

In addition, only the land uses in Table F.2.1-1 were considered to be developable. High density developments are not going to be developed further, similarly a cemetery is most likely to remain undeveloped. Land uses in which further development is unlikely were removed, leaving the following table:

Table F.2.1-1. List of Developable Lands and Anderson Classification Values

Land Cover Type - Developable	ALUCV*
Residential (Rural)	1140
Open Areas	1740
Cropland & Pastureland	2100
Harvested Cropland	2110
Pastureland	2120
Inactive Cropland	2130
Orchards, Vineyards, Nurseries & Horticultural Areas	2200
Nurseries	2230
Horse Farm	2430
Deciduous (>50% Crown Closure)	4120
Plantation	4230
Old Field (<25% Brush Covered)	4410
Deciduous Brush/Shrubland (>25% Brush with Decid Species >75%)	4420
Exposed Rock	7220
Extractive Mining	7300
Stone Quarries	7310
Sand & Gravel Pits (Borrow Pits)	7320
Transitional Areas	7500
Undifferentiated Barren Land	7600

*Anderson Land Use Classification Value (1996)

Appendix F.2.2 – Future Developed Lands

For any lands that are considered developable, a prescribed land cover has been created called, 'Developed' land. Any lands that are considered to be developable, had their land cover type changed to *Developed* land from one of the classifications listed in Table F.2.2-1. Developed lands are a combination of existing land covers, typical of currently developed lands, within the watershed. Table F.2.2-1 shows the percentages of various land covers found within 'developed' lands. These ratios were used to prescribe the characteristics of this developed land to be applied across the watershed such pollutant contribution, runoff characteristics and BMP application.

Table F.2.2-1. Percent of Land Uses Comprising Developable Lands

	% of Area
Residential	30
Residential (High Density)	15
Commercial & Services	10
Educational Institutions	2
Health Institutions	2
Industrial	2
Transportation, Communication & Utilities	4
Power Facilities	2
Other Transportation, Communication & Utilities	1
Cemeteries	1
Open Areas	10
Golf Courses	0.5
Community Recreation Areas	0.5
Deciduous (>50% Crown Closure)	15
Old Field (<25% Brush Covered)	5
	100

Appendix F.2.3 – Developed Land Runoff Characteristics

Following the percentages prescribed to the developed land, a revised curve number was developed for use in determining a change in runoff volume. This value is important as the quantity of any pollutant contribution is directly associated to the volume of runoff through the EMC methodology. Table F.2.3-1 displays the various land cover types with the associated HSG grouping and respective curve number.

Table F.2.3-1. Land Cover HSG and Curve Number Values

	Value	A	B	C	D
Residential	1100	54	70	80	85
Residential (High Density)	1110	77	85	90	92
Commercial & Services	1200	89	92	94	95
Educational Institutions	1207	89	92	94	95
Health Institutions	1208	89	92	94	95
Industrial	1300	89	92	94	95
Transportation, Communication & Utilities	1400	74	83	88	90
Power Facilities	1460	30	48	65	73
Other Transportation, Communication & Utilities	1490	72	82	87	89
Cemeteries	1710	39	61	74	80
Open Areas	1740	39	61	74	80
Golf Courses	1801	39	61	74	80
Community Recreation Areas	1804	39	61	74	80
Deciduous (>50% Crown Closure)	4120	30	55	70	77
Old Field (<25% Brush Covered)	4410	39	61	74	80

Using Table F.2.3-1 as a 'lookup' table, the ratios of each land cover create a composite curve number for developed lands for each HSG (Table F.2.3-2).

Table F.2.3-2. Developable Lands Composite Curve Number

		Composite Curve Number			
	% of Area	A	B	C	D
Residential	30	16.2	21	24	25.5
Residential (High Density)	15	11.55	12.75	13.5	13.8
Commercial & Services	10	8.9	9.2	9.4	9.5
Educational Institutions	2	1.78	1.84	1.88	1.9
Health Institutions	2	1.78	1.84	1.88	1.9
Industrial	2	1.78	1.84	1.88	1.9
Transportation, Communication & Utilities	4	2.96	3.32	3.52	3.6
Power Facilities	2	0.6	0.96	1.3	1.46
Other Transportation, Communication & Utilities	1	0.72	0.82	0.87	0.89
Cemeteries	1	0.39	0.61	0.74	0.8
Open Areas	10	3.9	6.1	7.4	8
Golf Courses	0.5	0.195	0.305	0.37	0.4
Community Recreation Areas	0.5	0.195	0.305	0.37	0.4
Deciduous (>50% Crown Closure)	15	4.5	8.25	10.5	11.55
Old Field (<25% Brush Covered)	5	1.95	3.05	3.7	4
	100	**57.4**	**72.2**	**81.3**	**85.6**

Appendix F.2.4 – Developed Land Event Mean Concentration Characteristics

Following a similar methodology of developing a composite curve number for the developed lands, the contribution of various pollutants from each of the land covers was considered. Table F.2.4-1 shows the contributions of pollutants (mg/L) for each of the developed land covers in areas considered developed with a composite total at the bottom. Each EMC has been multiplied by the respective percent of that land cover and summed to provide a single composite value.

Table F.2.4-1. Developable Lands Composite Pollutant Loading Values

	Composite Pollutant Loading (mg/L)				
	TSS	**BOD**	**Total P**	**NO_3-NO_2**	**TKN**
Residential	16.350	3.450	0.078	0.159	0.441
Residential (High Density)	15.000	5.400	0.075	0.126	0.224
Commercial & Services	5.550	2.300	0.032	0.026	0.110
Educational Institutions	1.340	0.156	0.005	0.011	0.026
Health Institutions	1.340	0.156	0.005	0.011	0.026
Industrial	1.210	0.280	0.006	0.006	0.020
Transportation, Communication & Utilities	0.040	0.020	0.000	0.016	0.008
Power Facilities	0.020	0.010	0.000	0.008	0.004
Other Transportation, Communication & Utilities	0.500	0.005	0.001	0.000	0.001
Cemeteries	0.030	0.040	0.000	0.004	0.002
Open Areas	0.300	0.400	0.003	0.040	0.020
Golf Courses	1.010	0.050	0.005	0.005	0.034
Community Recreation Areas	0.015	0.020	0.000	0.002	0.001
Deciduous (>50% Crown Closure)	73.050	0.015	0.023	0.026	0.092
Old Field (<25% Brush Covered)	0.050	0.025	0.001	0.020	0.010
	115.81	**12.33**	**0.23**	**0.46**	**1.02**

Appendix F.2.5 – Best Management Practices Implementation

For the purposes of assessing potential reductions of pollutants through the implementation of BMPs, a reduction of pollutant contributions from each land cover using a typical BMP has been applied. Multiple BMPs, either in parallel or series, may be actually used in practice, but here only a single 'typical' BMP effectiveness for each pollutant has been specified.

Table F.2.5-1 displays a BMP for each land cover type, with the percent removal effectiveness for each pollutant.

Table F.2.5-1. Land Cover Types with Assumed BMP and Percent Effectiveness

		Percent Treatment				
	BMP	**TSS**	**BOD**	**Total P**	**NO_3-NO_2**	**TKN**
Residential	Dry Detention	50%	50%	30%	30%	30%
Residential (High Density)	Grass Lined Swale	30%	0%	8%	8%	8%
Commercial & Services	Dry Detention	50%	50%	30%	30%	30%
Educational Institutions	Extended Detention	60%	0%	15%	15%	15%
Health Institutions	Extended Detention	60%	0%	15%	15%	15%
Industrial	Retention Basin	65%	50%	60%	70%	70%
Transportation, Communication & Utilities	Grass Lined Swale	30%	0%	8%	8%	8%
Power Facilities	Grass Lined Swale	30%	0%	8%	8%	8%
Other Transportation, Communication & Utilities	Grass Lined Swale	30%	0%	8%	8%	8%
Cemeteries	Grass Lined Swale	30%	0%	8%	8%	8%
Open Areas	Grass Buffer Strip	15%	0%	5%	5%	5%
Golf Courses	Wetland Basin	60%	18%	30%	20%	20%
Community Recreation Areas	Extended Detention	60%	0%	15%	15%	15%
Deciduous (>50% Crown Closure)	n/a	0%	0%	0%	0%	0%
Old Field (<25% Brush Covered)	n/a	0%	0%	0%	0%	0%

With these BMP removal efficiencies, a composite pollutant contribution of each type of pollutant for the ‘developed’ land cover was developed as shown in Table F.2.5-2.

Table F.2.5-2. Developable Lands Composite Pollutant Loading with BMP Implementation

	BMP Implementation Developable Loading (mg/L)				
	TSS	**BOD**	**Total P**	**NO_3-NO_2**	**TKN**
Residential	8.175	1.725	0.055	0.111	0.309
Residential (High Density)	10.500	5.400	0.069	0.116	0.206
Commercial & Services	2.775	1.150	0.022	0.018	0.077
Educational Institutions	0.536	0.156	0.004	0.010	0.022
Health Institutions	0.536	0.156	0.004	0.010	0.022
Industrial	0.424	0.140	0.002	0.002	0.006
Transportation, Communication & Utilities	0.028	0.020	0.000	0.015	0.007
Power Facilities	0.014	0.010	0.000	0.007	0.004
Other Transportation, Communication & Utilities	0.350	0.005	0.001	0.000	0.001
Cemeteries	0.021	0.040	0.000	0.004	0.002
Open Areas	0.255	0.400	0.003	0.038	0.019
Golf Courses	0.404	0.041	0.004	0.004	0.027
Community Recreation Areas	0.006	0.020	0.000	0.002	0.001
Deciduous (>50% Crown Closure)	73.050	0.015	0.023	0.026	0.092
Old Field (<25% Brush Covered)	0.050	0.025	0.001	0.020	0.010
	97.12	**9.30**	**0.19**	**0.38**	**0.80**

Appendix F.3 – Discussion

The results appear to provide a decent approximation of increases in the potential pollutant load in various subcatchments, but seem to approximately higher than the expected loadings for certain pollutants. Part of the higher loading than would seem appropriate is from the process of using Event Mean Concentrations, which are a generalization of loadings and do not allow for washoff or ‘first-flush’ conditions. Additionally, there are various features within a watershed that allow for the removal of pollutants. For example, a simple sump in a catch basin can allow for the removal of larger solids, whereas flow that passes through a wetland or is retained behind a culvert may allow for the removal of finer sediments. The model has assumed that once a unit of land has contributed a pollutant to runoff that it remains in the concentration of the runoff.

The model also generalizes the potential land use buildup scenario for the watershed, and does not consider variations of residential density or commercial uses dependent on zoning. The average buildout scenario aims to mimic the existing ‘built-out’ coverages, but does not vary these conditions dependent on current zoning regulations. The effect of adding this into the analysis is not expected to significantly affect the resultant ‘increases’ from the model.

Similarly, there has been a generalization of land covers and not a specific placement of potential large developments, which may be qualified as ‘point-sources’. Future models may incorporate either planned or approved large construction projects to determine the potential impact from such a development on a site specific basis.

Appendix F.4 – Presentation

Results have been prepared for a spatial presentation of calculated loads for all of the target pollutants. For each pollutant, there are four maps showing the following features on a subcatchment level:

- Existing Conditions
- Full Development Conditions without BMP Implementation

- Full Development with BMP Implementation
- Percent Change Loading from Existing to Full Development

Ranges of parameters have been organized to show respective levels of pollutant concentrations expected from EMC runoff. The following is a listing of all the figures associated with this modeling:

Table F.4-1. List of Model Result Figures

	Figure
F-1	BOD_Exist
F-2	BOD_Developed
F-3	BOD_BMP
F-4	BOD_Increase
F-5	TP_Exist
F-6	TP_Developed
F-7	TP_BMP
F-8	TP_Increase
F-9	TSS_Exist
F-10	TSS_Developed
F-11	TSS_BMP
F-12	TSS_Increase
F-13	TN_Exist
F-14	TN_Developed
F-15	TN_BMP
F-16	TN_Increase
F-17	Percent Subcatchment Developable

With respect to the Total Nitrogen, the TKN and the NO_3 / NO_2, contributions have been summed and graphed together as the total nitrogen contribution.

The maps display local features such as major roads, lakes and reservoirs along with all the subcatchment delineations. These maps may be used by planners and developers to locate areas with existing higher loadings and also the largest potential change for increased pollutant loading from development. Also, key pollutants may be studied in a given location, such as phosphorous loading, in areas with sensitive receiving streams or bodies of water.

Appendix F.5 – SWMM Result Figures