APPENDICES

A. **RI Source Water Assessment Program, Methods and Assumptions in ranking public water supply susceptibility** *Summary of the RISWAP assessment method used to evaluate susceptibility to contamination; describes basic susceptibility ranking applied to all supplies and more in-depth assessment conducted for major community supplies.*

B. **Susceptibility Ranking Worksheet** Assessment results using basic RI SWAP ranking applied to all RI public water supplies.

C. **Sampling Data Analysis and Rating** *Summarizes review of water supplier monitoring data for the past five years and assigns rating for risk of contamination; results provide input to the basic SWAP Susceptibility Ranking.*

D. **Public Participation in the Assessment Process** *Sample public notice of assessment developed for each study area; provides overview of assessment approach, volunteer roles in mapping and assessment, list of meetings and typical agendas.*

E. **Existing Condition of Surface and Ground Water Resources** *Table used to organize data collection and public input during the assessment process; this is not a complete summary.*

F. **Current and Future Land Use Estimates** *Summary results of GIS land use analysis with current land use, future build out acreage and percent change.*

G. **Characteristics of Rhode Island Soils** *Itemizes soil features incorporated into assessment; useful reference.*

H. **RIGIS Coverages used in the MANAGE Assessment of Major Community Supplies**

I. **MANAGE Summary Results** *Summary output from MANAGE spreadsheets with land use features, soil characteristics, hydrologic budget and nutrient loading for each study area. Results reported for current land use and other scenarios such as future build out and use of alternative management practices.*

J. **MANAGE GIS-Based Pollution Risk Assessment Method, Watershed / Aquifer Pollution Risk Indicators.** *List and rating key for land use, landscape features and modeled nutrient loading estimates used to evaluate pollution risk. Includes background information on interpreting results.*

K. **Hydrologic and Nutrient Loading Assumptions** *Summary of MANAGE input values and assumptions using average annual values. Includes surface runoff coefficients for nitrogen and phosphorus, nitrogen inputs to groundwater from specific sources, housing occupancy, and other assumptions. Complete technical documentation, MANAGE GIS-Based Pollution Risk Assessment Method - Database Development, Hydrologic Budget and Nutrient Loading, available at* http://www.edc.uri.edu/cewq/manage.html.

APPENDIX A

RI Source Water Assessment Program
Methods and Assumptions in ranking public water supply susceptibility

Prepared by URI Cooperative Extension and RI HEALTH
April 2003

The Rhode Island Source Water Assessment Program assigns a susceptibility rating to each public water supply. The ranking considers potential sources of pollution from land use and identified facilities, as well as the water supply's vulnerability to contaminants based on geology, well type and sampling history. This summary outlines the methods and assumptions made in assigning ranking scores, including evaluating public water supply sampling history using the RI HEALTH public water supply database.

The Rating System

Surface water supplies and groundwater supplies use a slightly different ranking system that accounts for unique features of each resource. In each case, the full watershed or wellhead protection area was evaluated.

The ranking system assigns a rank from low to extreme for each factor. A numeric score from 5 to 25 is also assigned to each rank. Totaling scores for all factors results in a maximum score of 200 for surface water supplies and 210 for groundwater supplies. The final susceptibility rank is assigned as follows: Low 0-49, Medium 50-100, and High > 100.

In general, low threshold limits were set to identify potential threats as an early warning to provide ample opportunities to implement pollution prevention measures as a cost effective way to protect future water quality. Setting low threshold also allows a water supplier to track changes over time as source areas become developed and begin monitoring trends that would otherwise go unnoticed at higher detection levels. For example, review of sampling data for groundwater supplies includes monitoring increases in nitrogen above background levels to detect trends in drinking water supplies and also in nitrogen-sensitive coastal areas that are subject to nutrient enrichment at very low levels far below drinking water standards.

Each groundwater supply and surface waters supply watershed wellhead protection was ranked separately. Large surface water supply watersheds were divided into subwatersheds ranging generally from 500 to 5,000 acres. Each subwatershed was evaluated individually for land use factors but where water from different subwatersheds or even geographically separate watersheds was treated at one location, the same sampling data was used for each.

Where several wells are located within one wellhead area, the same input data for wellhead land use was used for each well. However, sampling data specific to each well was used except where wells within one wellhead area were owned by one water supplier or located so close to one another that all would be susceptible to any contaminate present in one. In this case well sampling data as analyzed as one group to identify maximum levels.

Although each water supply source was ranked separately, where one water supplier managed more than one well or surface water reservoir results were averaged to create an average susceptibility rank for the supplier.

Assessment Factors

Watershed Land use, landscape features, and potential sources of pollution
Information on land use characteristics, soils and identified facilities are derived from the RIGIS database. For major community supplies, 1995 land use maps were reviewed and updated by local volunteers to correct for major changes. Volunteers were also trained to conduct windshield surveys to update locations of potential sources of pollution such as gas stations and manure storage areas.

Aquifer, watershed and reservoir characteristics
For groundwater supplies, well construction was used as one factor in evaluating vulnerability to contamination, with unconfined sand and gravel wells considered at higher risk than bedrock wells. Well construction was identified based on RI HEALTH records.

For surface reservoirs, vulnerability to contamination was based on estimated nutrient enrichment levels using readily available reports, input at local assessment group meetings, and RI Department of Environmental Management data including 305 (b) reports. Where no data on nutrient enrichment level was available, a moderate level was assigned. Factors considered in assigning a high or extreme level in the absence of monitored chlorophyll, clarity or phosphorus levels included: local reports of frequent or severe algal blooms, DEM applications for herbicide application, high (> ½ MCL) levels of disinfection byproducts such as total trihalomethanes, and impaired status for biodiversity.

Determination of compliance with water quality standards was based on the RIDEM 303 (d) impaired waters listing and supporting data.

All determinations of nutrient enrichment status and compliance with water quality standards were made in cooperation with RI DEM Office of Water Resources.

Outflow / Well Water Quality
The RI HEALTH public water supply database was used to evaluate sampling history over the past five years.

The method for evaluating and ranking sampling results is different for surface waters and groundwater to account for unique features of each resource, as follows:

Samples for both reservoir outflows and wellwater were analyzed for history of contaminant detects based on Maximum Contaminant Levels for public health.

Groundwater supplies were also evaluated specifically for bacteria detects. Since most surface water supplies are disinfected, this analysis was not considered necessary for surface waters.

In addition, groundwater supplies were evaluated using nitrogen concentrations as an indicator of wastewater and fertilizer inputs from human activities. In this case low ranking thresholds were set to identify levels above background concentrations rather than identifying contaminant detects based on the Maximum Contaminant Levels for public health. Relatively low concentrations were used to identify trends and areas at higher risk to coastal waters in addition to public health risks.

Data was collected at the source, before treatment; except that distribution samples after treatment were used to evaluate the level of disinfection by products such as total trihalomethanes. Where distribution samples were not available, the available consumer confidence reports were used to determine the maximum level.

For more information contact:
RI HEALTH, Office of Drinking Water Quality 401-222-6867
URI Cooperative Extension, Nonpoint Education for Municipal Officials 401-874-2138

APPENDIX B Susceptibility Ranking Worksheet

Pollution Risk Ranking for Wellhead Protection Areas WORKSHEET																
ROW	RISK INDICATOR	RATING						WESTERLY COMMUNITY WATER SUPPLY WELLHEAD PROTECTION AREAS								
	Note: Input data are based on RIGIS data, HEALTH files and information provided by volunteers and the Town.	LOW	MEDIUM	HIGH	EXTREME	Max Rank	Rating Method	**Bradford WHPA**		**Crandall WHPA**		**Noyes Ave. WHPA**		**Whiterock WHPA**		
		0	5	10	25			**Input**	**Rating**	**Input**	**Rating**	**Input**	**Rating**	**Input**	**Rating**	
	Wellhead Protection Area Land use and landscape features															
1	High intensity land use (HILU) (%) throughout the WHPA	<10%	≥10-25%	≥25-40%	≥40%	25	1. list	0.14	**5**	24%	**5**	62%	**25**	28%	**10**	
2	HILU (%) located on highly permeable soils throughout the WHPA	≤5%	≥5-15%	≥15%-30%	≥30	25	2. list	4%	**0**	3%	**0**	25%	**10**	10%	**5**	
3	**Land Use Risk**					50	3. sum of 1 & 2		**5**		**5**		**35**		**15**	
4	Identified Facilities within inner protective radius (IPR) (400' or 200')	none	Presence of one source	Presence of two or three sources	Presence of more than 5 sources	25	4. List	1	**5**	0	**0**	4	**10**	3	**10**	
5	Identified Facilities Per Acre (x10) throughout WHPA, excluding IPR	< 0.1	< 0.5	< 1.0	>1.0	25	5. List	0.030	**0**	0.050	**0**	0.500	**10**	0.060	**0**	
6	Identified Facilities thoughout WHPA including within inner protective well radius (400' or 200') on highly permeable soils	none	one	two or three	More than three	25	5. List	2	**10**	0	**0**	6	**10**	2	**10**	
7	**Known Pollution Source Risk**					75	7. Sum of 4, 5 & 6		**15**		**0**		**30**		**20**	
8	**WATERSHED LAND USE AND LANDSCAPE FEATURES RISK RATING (Susceptibility)**					125	8. Sum of 3 and 7		**20**		**5**		**65**		**35**	
	Aquifer Characteristics															
9	**AQUIFER TYPE RISK RATING**	bedrock well		sand and gravel well		10	9. List	S/D	**10**	S/D	**10**	S/D	**10**	S/D	**10**	
	Well Water Quality	0	5	10	25											
10	History of contaminant detects (organics, HC, pesticides, metals, radionuclides, etc.) within 5 yrs. (Community and Non-transient non-community sources only.)	none	≤1/2 MCL	>1/2 MCL	Violation	25	10. List	none	**0**	none	**0**	none	**0**	≤1/2 MCL	**5**	
11	Bacteria detection within 5 years.	none	generic coliform detection	fecal; cause identified and corrected	E. coli Positive Violation	25	11. List	none	**0**	none	**0**	none		none	**0**	
12	Nitrogen concentration (5 yr. Maximum)	≤ .5 mg/l	.5 - 2 mg/l	>2 - 5 mg/l	> 5 mg/l	25	12. List	2.8	**10**	0.6	**5**	1.2	**5***	2.8	**10**	
13	**WELL WATER QUALITY RISK RATING (Vulnerability)**					75	13. Sum of 10 - 12.		**10**		**5**				**15**	**Average Rating**
14	**SUMMARY RATING for Wellhead Protection Areas**					**210**	**14. Sum of 8, 9 & 13.**		**40**		**20**		**80**		**60**	**50**
*Because no well data is available, Nitrate levels are assumed to be at least 0.5 mg/L, and assigned a low rating.									Low		Low		Moderate		Moderate	**Moderate**

Rating	Low	Moderate	High
	0-49	50-100	>100

APPENDIX C: Sampling Data Analysis and Rating - *Summarizes review of water supplier monitoring data for the past five years and assigns rating for risk of contamination; results provide input to the basic SWAP Susceptibility Ranking.*

Wells # 1 A, B, D (Whiterock WHPA)

PWSID#	Contaminant	UNITS	MCL	MAX	RANK	RATING
1559512	Barium	ppm	2	0.073	medium	5
Nitrates						
1559512	Nitrate As N	ppm	10	2.5	high	10
Coliform						
1559512	Coliform		5%	0%	low	0
1559512	Fecal Coliform		5%	0%	low	0
1559512	Total Coliform		5%	0%	low	0

* Detects occurred only once in a five-year period and are excluded the well ranking.

Overall Well Rate		
Contaminants	medium	5
Nitrates	high	10
Bacteria	low	0

> No violations of the standards for regulated contaminants (excluding bacteria and nitrates) have been identified. However, there have been detections below levels considered acceptable by US EPA. This indicates the need for continued monitoring.
> Nitrate levels in groundwater are higher than background levels, which may indicate contribution from human activity.
> Bacteria have not been detected.

Wells # 2 A, B, D (Whiterock WHPA)

PWSID#	Contaminant	UNITS	MCL	MAX	Rank	Rating
1559512	Barium	ppm	2	0.047	low	0
1559512	Gross Alpha	pCi/	15	0.562	*	*
1559512	Gross Beta	pCi/	50	1.21	*	*
1559512	Selenium	ppm	0.05	0.005	*	*
Nitrates						
1559512	Nitrate As N	ppm	10	2.8	high	10
Coliform						
1559512	Coliform		5%	0%	low	0
1559512	Fecal Coliform		5%	0%	low	0
1559512	Total Coliform		5%	0%	low	0

* Detects occurred only once in a five-year period and are excluded the well ranking.

Overall Well Rate		
Contaminants	low	0
Nitrates	high	10
Bacteria	low	0

> There has been no detection of regulated contaminants (excluding bacteria and nitrates).
> Nitrate levels in groundwater are higher than background levels, which may indicate contribution from human activity.
> Bacteria have not been detected.

Well #3 (Whiterock WHPA)

PWSID#	CHEMICAL	UNITS	MCL	MAX	Rank	Rating
1559512	Barium	ppm	2	0.017	*	*
Nitrates						
1559512	Nitrate As N	ppm	10	1.2	medium	5
Coliform						
1559512	Coliform:		5%	0%	low	0
1559512	Fecal Coliform		5%	0%	low	0
1559512	Total Coliform		5%	0%	low	0

* Detects occurred only once in a five-year period and are excluded the well ranking.

Overall Well Rate		
Contaminants	low	0
Nitrates	medium	5
Bacteria	low	0

> There has been no detection of regulated contaminants (excluding bacteria and nitrates).
> Nitrate levels in groundwater are somewhat higher than background levels, which may indicate contribution from human activity.
> Bacteria have not been detected.

Bradford Well

PWSID#	Contaminant	UNITS	MCL	MAX	RANK	RATING
Nitrates						
1559512	Nitrate As N	ppm	10	2.8	10	high
Coliform						
1559512	Coliform:		5%	0%	low	0
1559512	Fecal Coliform		5%	0%	low	0

* Detects occurred only once in a five-year period and are excluded the well ranking.

Overall Well Rate		
Contaminants	low	0
Nitrates	high	10
Bacteria	low	0

> There has been no detection of regulated contaminants (excluding bacteria and nitrates).
> Nitrate levels in groundwater are higher than background levels, which may indicate contribution from human activity.
> Bacteria have not been detected.

Crandall Well

PWSID#	Contaminant	UNITS	MCL	MAX	RANK	RATING
1559512	Barium	ppm	2	0.014	medium	*
Nitrates						
1559512	Nitrate As N	ppm	10	1.1	medium	5
Coliform						
1559512	Coliform:		5%	0%	low	0
1559512	Fecal Coliform		5%	0%	low	0
1559512	Total Coliform		5%	0%	low	0

* Detects occurred only once in a five-year period and are excluded the well ranking.

Overall Well Rate		
Contaminants	low	0
Nitrates	medium	5
Bacteria	low	0

> There has been no detection of regulated contaminants (excluding bacteria and nitrates).
> Nitrate levels in groundwater are somewhat higher than background levels, which may indicate contribution from human activity.
> Bacteria have not been detected.

APPENDIX D: Public Participation in the Assessment Process- *Sample public notice of assessment developed for each study area; provides overview of assessment approach, volunteer roles in mapping and assessment, list of meetings and typical agendas.*

Public Participation in the Assessment Process

The RI Source Water Assessment Program was designed to actively involve local officials, water suppliers, and the general public in the assessment process. The attached sample workshop notice outlines this public participation effort. It provides an overview of the assessment approach, describes roles of mapping and assessment volunteers and lists training sessions and meetings, with summary agendas.

Complete documentation of the public participation process is provided at the URI Cooperative Extension web site. This includes a list of workshops held in each study area and complete guide to working with volunteers in source water assessments organized as a how-to manual for others interested in working with volunteers to update pollution source maps.

For more information go to: www.uri.edu/ce/wq/program/html/SWAP2.htm.

SAMPLE
Public notice and public participation process

Rhode Island Department of HEALTH

UNIVERSITY OF RHODE ISLAND

Evaluating pollution risks to Public drinking water supplies

North Kingstown • Exeter • Kent County

RI HEALTH and University of Rhode Island Cooperative Extension in partnership with municipalities and water suppliers

PROJECT DESCRIPTION

RI HEALTH and the University of Rhode Island Cooperative Extension are assessing pollution threats to all public drinking water supplies throughout the State. The focus is on public drinking water supply "source" areas – the wellhead protection area that recharges a well or the watershed that drains to a surface water reservoir. Under the *Source Water Assessment Program* (SWAP) all states are required to conduct these assessments. Rhode Island has adopted a unique approach that involves the active participation of local water suppliers, town officials, and interested citizens.

SCHEDULE

Assessments will be conducted for public water supplies in North Kingstown, Exeter, Jamestown, and Kent County in 2001, beginning in March. Public wells throughout Kent County and southern Rhode Island will also be assessed in 2001.

GOAL

To ensure that public water systems have the ability to provide safe drinking water, now and into the future, the assessments will identify and rank each drinking water source according to its likelihood of becoming contaminated. A more extensive assessment of major water supplies will:

- Identify pollution risks under current land use and predict future threats.
- Evaluate the effectiveness of management options.
- Identify practical steps town officials and residents can take to reduce pollution risks.

Groundwater

Whether pumped from a shallow backyard well or piped from a high-yield public supply, groundwater is a major source of drinking water for many Rhode Islanders.

For residents of North Kingstown and Exeter, groundwater is the *only* source of drinking water.

A recent URI survey found that protecting this vulnerable and precious resource is the number one land use concern of local officials in southern Rhode Island.

SAMPLE Public notice and public participation process

APPROACH

Our assessment method is based on the following:

- Most pollution comes from the way we use and develop land.
- Most land overlying a wellhead recharge area or within a reservoir watershed is privately owned, not protected by a water supplier.
- Rhode Island cities and towns have primary authority to manage land use and minimize associated impacts.
- Effective protection of local water supplies requires local action.

LOCAL ROLE

The assessment is carried out in partnership with water suppliers, town officials, and other local volunteers such as business interests, environmental organizations and interested citizens. Volunteers may choose one or both of the following "jobs". The focus is on the major drinking water supplies but inventory volunteers may choose to work in smaller supply areas.

➢ Inventory volunteers

Update and verify land use within the wellhead protection areas and reservoir watersheds through a windshield survey, using simple maps. All materials and training are provided. This updated information provides a more accurate picture of potential risks to water supplies as a basis for the assessment.

Study area: Volunteer may choose a particular wellhead or watershed area but focus is on the major water supplies.

Time Commitment: 7-10 hours total. This includes one, 2-hour training session, conducting the windshield inventory of assigned areas on your own time (alone or with partner), and one, 1-hour session to report results.

➢ Assessment volunteers

Work closely with URI and HEALTH staff to guide the assessment process.

- Review and provide input on draft products,
- Identify local water quality goals, protection priorities, and land use issues,
- Assist in selecting management options for analysis,
- Develop recommendations for future action.

Study area: In-depth analysis focuses on the major water supplies, with opportunity for review and comment on basic assessments carried out for the smaller supplies throughout each town.

Time Commitment: Three work sessions over a 4-5 month period, scheduled at the convenience of local volunteers.

ASSESSMENT METHOD

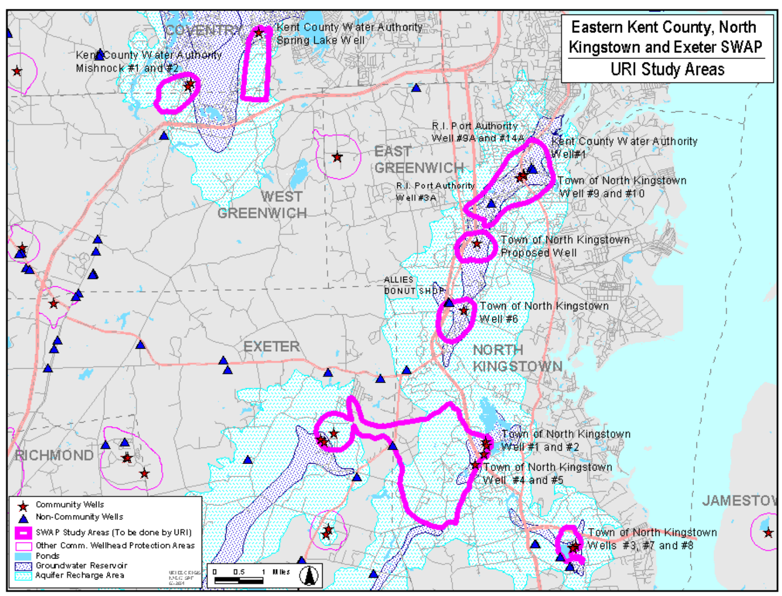
Our approach relies on computer-generated maps known as Geographic Information Systems (GIS) to identify, evaluate, and display pollution risks. This is a screening-level analysis using readily available sources of information, including well head protection inventories, watershed protection plans, and other local data. Using land use and soil information extracted from the GIS database, the method identifies and ranks pollution threats based on:

- Proportion of high intensity land uses where pollutants are most likely to be generated.
- Number of mapped pollution sources, both known and potential sources.
- Soil features and buffers where pollutants are most likely to reach a well or surface waters.

In addition, map analysis of each wellhead and watershed area is used to locate high-risk pollution sources on problem soils. The pollution potential in each wellhead /watershed is then ranked so town officials can compare risks among different areas and direct management actions.

Attention to Major Supplies

For the major community water supplies, URI Cooperative Extension will conduct a more in-depth analysis using the MANAGE risk assessment method. In addition to the assessment information developed for all smaller supplies, this will include:



- Multiple "watershed health indicators" such as percent impervious cover and percent forest,
- Modeled estimates of average annual runoff, groundwater recharge, and nutrient loading as an additional indicator of cumulative impact. We use a standard mass balance method similar to those widely used in comparable applications elsewhere including Cape Cod, Massachusetts and the New Jersey Pine Barrens,
- Future land use impacts envisioned through a "build-out" analysis,
- Comparison of the relative effectiveness of stormwater controls, wastewater management, and reduced fertilizer use in reducing nutrient sources.
- Work with the local volunteer group in developing water supply protection recommendations.

FINAL PRODUCTS

- Updated land use and pollution source mapping in source water areas.
- Pollution source "hot spot" mapping identifying high risk land uses where pollutants are most likely to move into groundwater or surface waters.
- Assessment of cumulative land use impacts using multiple risk factors.
- Future land use "build-out" analysis with population, building units, and septic systems estimates for each major water supply source area.
- Estimated water budget with runoff and nutrient loading (nitrogen and phosphorus) estimates for each major source water area, with relative comparison of current land use, future growth, and management options.
- Summary of assessment results and public presentation to town officials and general public.

BENEFITS

- Focus on source water protection to reduce or avoid treatment costs and improve taste/odor.
- Obtain monitoring waivers for low-susceptibility contaminants.
- Use map products in town planning and routine land development review.
- Incorporate results in water supply management plans, town plans, and wastewater management programs.
- Prioritize water supply protection needs and management actions.
- Direct education, monitoring, inspection, and enforcement to identified problem areas.
- Incorporate findings as technical basis for improved stormwater or wastewater pollution controls.
- Adopt protection measures with support from local officials and citizens involved in the assessment process.
- Receive priority for RIDEM nonpoint /groundwater grants to address identified threats.
- Follow-up assistance from RIDEM in pollution prevention at public facilities and businesses.

CONTACTS

Source Water Assessment Program	***Assessment of Major Supplies***	***To Volunteer***
Clay Commons	Lorraine Joubert & James Lucht	Alyson McCann & Holly Burdett
SWAP Coordinator	URI Cooperative Extension	URI Cooperative Extension
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Project funded by RI HEALTH

Rhode Island Department of HEALTH
UNIVERSITY OF RHODE ISLAND

Evaluating pollution risks to public drinking water supplies
North Kingstown • Exeter • Jamestown • Kent County

Work Sessions with Assessment Volunteers

MEETING 1 **Land Use Issues and Assessment Goals**
April 11, 2001 4-6 PM North Kingstown Library, Wickford, RI

- Introduction to the Source Water Assessment Program.
- Risk assessment approach using MANAGE: overview of data sources, type of analyses, results generated, and final products.
- Role of advisory committee – input needed and expectations for next two sessions.
- Discussion of local water quality goals, water supply management priorities, and information sources for existing conditions.
- Review of land use maps and selection of study area boundaries; directions to update land use and ID pollution problems (where inventory help not available).

MEETING 2 **Pollution Risks - existing and future land use**
May 30, 2001 4-6 PM North Kingstown Library, Wickford, RI

- Review summary of existing conditions and management goals.
- Presentation of preliminary results:
  - Method and assumptions,
  - Land use updates and results of build-out analysis,
  - Watershed indicators for current and future land use,
  - Pollution source "hot spot" mapping,
  - Summary of analysis and discussion.
- Discuss Management practices:
  - Limitations in modeling,
  - Select best management practices to model.

MEETING 3 **Management alternatives and future direction**
June 27, 2001 4-6 PM North Kingstown Library, Wickford, RI

- Brief review of findings for current and future land use.
- Present results of nutrient loading change with management practices.
- Discuss management options and form recommendations.
- Determine next outreach steps: fact sheet format and distribution, presentation of results to public and decision makers, action steps for advisory committee.

Volunteers Conducting the Land Use Inventory

Training Workshop
April 2, 2001 7-9 PM Rocky Hill Grange, East Greenwich, RI

- Introduction to the Source Water Assessment Program.
- Basics about groundwater and wellhead protection areas, watersheds and the hydrologic cycle.
- Review Training Packets to learn how to:
  - Read and work with maps
  - Identify land use changes
  - Identify high risk activities
  - Conduct a "windshield survey"

Conduct Land Use Inventory over One-Month Period
In pairs or teams on own time

- Contact CE staff for assistance or answers to questions at any time.
- Follow-up calls are made by CE staff two weeks after the training workshop to status progress.

Meeting to Collect Land Use Inventory Results
April 30, 2001 6 –7 PM Rocky Hill Grange, East Greenwich, RI

- Briefly review land use inventory maps and data with CE staff.
- Clarify final questions or discrepancies.
- Complete a volunteer evaluation of land use inventory process.

CONTACTS

Source Water Assessment Program	***Assessment of Major Supplies***	***To Volunteer***
Clay Commons	Lorraine Joubert & James Lucht	Alyson McCann & Holly Burdett
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Cooperative Extension provides equal program opportunities without regard to race, age, sex or preference, creed, or disability

Project funded by RI HEALTH

APPENDIX E: Existing Condition of Surface and Ground Water Resources - *Table used to organize data collection and public input during the assessment process; this is not a complete summary.*

Existing condition of surface and ground water resources ...*What do we already know?*			
The Town of Westerly provides public water services to 10,712 customers in Westerly and 2,427 customers in Pawcatuck, CT (1999-2000).			
Water resources	**Water quantity**	**Monitoring data & assessment of actual conditions**	**Pollution sources, concerns and recommended actions**
Source	*System capacity-- present and proposed yields; development constraints*	*Field data available, conditions and trends for source water and associated waterbodies.*	*Includes documented and potential pollution sources, related water quality issues, and Town plan recommendations.*
Bradford Wellhead Protection Area	The two wellfields supply an average 1.3 million gallons a day (mgd), contributing 20% of the town's total supply of 6.02 mgd.	The Pawcatuck River has been placed on the State's 303(d) List of Impaired Waterbodies for unknown toxicity and biodiversity impacts. URI Watershed Watch monitoring data for the Pawcatuck River at Bradford detected levels of fecal coliform and *E. coli* bacteria in exceedance of the State's recreational contact standard (1998). Bradford II well experienced an acute violation for elevated bacterial levels in 2000. The Bradford Aquifer was designated in 1988 as a Sole Source Aquifer by USEPA.	In 1999, the Town of Westerly adopted a Aquifer Protection Overlay District, which covers the Bradford WHPA. This WHPA is largely undeveloped (70%). This area is unsewered. Many of the Onsite Wastewater Disposal Systems in the area are cesspools, predating RIDEM standards. The town's Wastewater Facility Plan recommends the establishment of Wastewater Management Districts to protect groundwater resources. Most of the failing on-site systems in the Bradford Aquifer Recharge area were either repaired or replaced during a community development program.

Water resources	Water quantity	Monitoring data & assessment of actual conditions	Water resources protection priorities
Crandall Wellhead Protection Area	The Town of Westerly withdraws an average 765,487 gallons a day from this wellfield, which provides approximately 12% of overall town supply.	Chapman Pond is on the State's 303(d) List of Impaired Waterbodies for noxious aquatic plants and lead.	In 1999, the Town of Westerly adopted an Aquifer Protection Overlay District, which covers the Crandall WHPA. A large wetlands complex accounts for over 50% of the total land area in the WHPA. The town's Wastewater Facility Plan recommends the establishment of Wastewater Management Districts, as well as sewer extensions in certain areas. The town has purchased 11.3 acres and has obtained protective easements on an additional 35 acres surrounding the well site. Groundwater contamination from leaking underground storage tanks is a concern in this WHPA—there have been two documented incidences of leaking tanks in the last 5 years. Hazardous materials spills are also a concern in this area. There have been 4 documented spills in the last 5 years. There is a potential of chemicals and hazardous materials being transported through the WHPA and Aquifer along Routes 1 and 78. Runoff from highways, in general, can cause water quality degradation. There are two waste disposal sites in the WHPA.

Water resources	Water quantity	Monitoring data & assessment of actual conditions	Water resources protection priorities
Noyes Ave. Wellhead Protection Area	The well has been inactive since 1993.	Monitored nitrate levels are exceeding the SMCL, ranging from 5.1 to 6.9 mg/l. The highest levels of sodium are associated with the Noyes Ave. well, which have consistently exceeded the Health Advisory level of 20 mg/l. The Pawcatuck River has been placed on the State's 303(d) List of Impaired Waterbodies for unknown toxicity and biodiversity impacts.	The majority of the area lies in Stonington, CT. Both Stonington and Westerly have an Aquifer Protection Overlay District to protect the WHPA. Over 60% of land use activity in the WHPA is consider high intensity (commercial, industrial, high density residential, farming). Seventy percent of the WHPA is sewered. Groundwater contamination from leaking underground storage tanks is a concern in this WHPA—there has been one documented incidence of a leaking tank in the last 5 years. There are 18 registered underground fuel tanks in the WHPA. Hazardous materials spills are also a concern in this area. There have been 12 documented spills in the last 5 years. Highway runoff is an ongoing concern, particularly sodium from road salts.

Water resources	Water quantity	Monitoring data & assessment of actual conditions	Water resources protection priorities
Whiterock Wellhead Protection Area	The three wellfields in this WHPA provide approximately 4.1 mgd, accounting for close to 70% of Westerly's supply.	Some of the wells in the Whiterock WHPA have exceeded the SMCL for sodium (20 mg/l) over the last 5 years The Westerly Aquifer was designated a Sole Source Aquifer by USEPA.	Approximately half of the WHPA extends into Stonington, CT. Both Stonington and Westerly have an Aquifer Protection Overlay District to protect the WHPA. Over a quarter of land use activity in the WHPA is consider high intensity (commercial, industrial, high density residential, farming). A large portion of the WHPA protection is sewered in both towns. During dry months, the Pawcatuck River becomes a recharge for the Whiterock wells, which are located within a few hundred feet of the river. Development along the river can become a source of contamination for the wells. Groundwater contamination from leaking underground storage tanks is a concern in this WHPA—there have been two documented incidences of leaking tanks in the last 5 years. There are 4 registered underground fuel tanks in the WHPA. Hazardous materials spills are also a concern in this area. There have been 7 documented spills in the last 5 years. Highway runoff is a concern, particularly sodium from road salts.

DATA SOURCES

Herron, E. and L. Green. 2000. URI Watershed Watch 1997 and 1998 Water Quality Monitoring Results. Kingston, RI: University of Rhode.

Rhode Island Geographic Information System, Department of Administration. Providence, RI.

Town of Westerly, Rhode Island "Water Supply Management Plan Update". March 2001.

APPENDIX F Current and Future Land Use Estimates

Current and Future Land Use Estimates – Westerly study areas

Current	Bradford WHPA		Crandall WHPA		Noyes WHPA		Whiterock WHPA	
LAND USE	Acres	% area	Acres	% area	Acres	% area	Acres	% area
[1] HD Res.(>8 /ac)	0.0	0.0%	15.8	0.8%	60.8	24.8%	91.5	8.4%
[2] MHD Res.(4-7.9/ac)	45.2	6.6%	146.8	7.6%	0.0	0.0%	106.7	9.8%
[3] MD Res.(1-3.9/ac)	69.3	10.1%	43.3	2.2%	0.0	0.0%	145.9	13.3%
[4] MLD Res.(0.5-0.9/ac)	2.3	0.3%	28.9	1.5%	4.4	1.8%	38.0	3.5%
[5] LD Res.(<0.5/ac)	2.5	0.4%	11.1	0.6%	0.0	0.0%	7.4	0.7%
[6] Commercial	0.0	0.0%	132.3	6.9%	38.7	15.8%	21.9	2.0%
[7] Industrial	0.0	0.0%	0.0	0.0%	0.1	0.0%	2.9	0.3%
[8] Roads	0.0	0.0%	36.0	1.9%	0.0	0.0%	9.0	0.8%
[9] Airports	0.0	0.0%	21.8	1.1%	0.0	0.0%	0.0	0.0%
[10] Railroads	0.0	0.0%	0.0	0.0%	4.8	1.9%	0.0	0.0%
[11] Junkyards	0.0	0.0%	22.3	1.2%	0.0	0.0%	0.0	0.0%
[12] Recreation	0.0	0.0%	40.4	2.1%	0.0	0.0%	91.1	8.3%
[13] Institution	1.4	0.2%	0.3	0.0%	0.0	0.0%	14.9	1.4%
[14] Pasture	13.6	2.0%	13.6	0.7%	6.4	2.6%	50.0	4.6%
[15] Cropland	49.7	7.2%	77.6	4.0%	48.2	19.6%	50.0	4.6%
[16] Orchards	0.0	0.0%	0.0	0.0%	0.0	0.0%	8.0	0.7%
[17] Brush	8.2	1.2%	36.0	1.9%	0.0	0.0%	25.4	2.3%
[18] Forest	318.2	46.3%	190.1	9.9%	76.1	31.0%	330.9	30.2%
[19] Barren	21.0	3.1%	11.1	0.6%	0.0	0.0%	18.2	1.7%
[20] Wetland	152.7	22.2%	1,079.0	56.0%	5.9	2.4%	81.6	7.5%
[21] Water	2.9	0.4%	19.2	1.0%	0.2	0.1%	0.7	0.1%
Total (acres)	**687.0**	100%	**1,925.8**	100%	**245.4**	100%	**1,094.1**	100%

Future

LAND USE	Bradford WHPA Acres	Bradford WHPA % area	Crandall WHPA Acres	Crandall WHPA % area	Noyes WHPA Acres	Noyes WHPA % area	Whiterock WHPA Acres	Whiterock WHPA % area
[1] HD Res.(>8 /ac)	0.0	0.0%	15.8	0.8%	60.8	24.6%	91.5	8.2%
[2] MHD Res.(4-7.9/ac)	45.2	6.6%	146.8	7.6%	0.0	0.0%	106.7	9.6%
[3] MD Res.(1-3.9/ac)	95.9	13.9%	87.0	4.5%	40.9	16.6%	240.1	21.6%
[4] MLD Res.(0.5-0.9/ac)	2.3	0.3%	28.9	1.5%	4.4	1.8%	38.1	3.4%
[5] LD Res.(<0.5/ac)	251.3	36.5%	99.3	5.1%	40.5	16.4%	122.1	11.0%
[6] Commercial	0.0	0.0%	142.5	7.4%	38.7	15.6%	56.1	5.1%
[7] Industrial	0.0	0.0%	60.4	3.1%	0.1	0.0%	54.1	4.9%
[8] Roads	0.0	0.0%	36.0	1.9%	0.0	0.0%	9.0	0.8%
[9] Airports	0.0	0.0%	21.8	1.1%	0.0	0.0%	0.0	0.0%
[10] Railroads	0.0	0.0%	0.0	0.0%	4.8	1.9%	0.0	0.0%
[11] Junkyards	0.0	0.0%	22.3	1.2%	0.0	0.0%	0.0	0.0%
[12] Recreation	0.0	0.0%	40.4	2.1%	0.0	0.0%	91.1	8.2%
[13] Institution	1.4	0.2%	0.3	0.0%	0.0	0.0%	14.9	1.3%
[14] Pasture	6.7	1.0%	2.4	0.1%	1.3	0.5%	26.3	2.4%
[15] Cropland	7.9	1.1%	9.6	0.5%	10.8	4.4%	17.5	1.6%
[16] Orchards	0.0	0.0%	0.0	0.0%	0.0	0.0%	1.3	0.1%
[17] Brush	6.0	0.9%	10.2	0.5%	0.0	0.0%	18.2	1.6%
[18] Forest	98.0	14.2%	106.5	5.5%	37.1	15.0%	126.0	11.4%
[19] Barren	18.9	2.7%	0.3	0.0%	0.0	0.0%	0.0	0.0%
[20] Wetland	152.7	22.2%	1,079.0	55.9%	5.9	2.4%	81.5	7.3%
[21] Water	3.0	0.4%	19.2	1.0%	2.0	0.8%	15.3	1.4%
Total (acres)	**689.4**	100%	**1,928.8**	100%	**247.2**	100%	**1,109.7**	100%

Land Use Change

LAND USE	Bradford WHPA Acres	Bradford WHPA % area	Crandall WHPA Acres	Crandall WHPA % area	Noyes WHPA Acres	Noyes WHPA % area	Whiterock WHPA Acres	Whiterock WHPA % area
[1] HD Res.(>8 /ac)	0.0	*	0.0	-0.1%	0.0	-0.7%	0.0	-1.4%
[2] MHD Res.(4-7.9/ac)	(0.0)	-0.4%	(0.0)	-0.2%	0.0	*	0.0	-1.4%
[3] MD Res.(1-3.9/ac)	26.6	38.0%	43.7	100.6%	40.9	***	94.2	62.3%
[4] MLD Res.(0.5-0.9/ac)	0.0	-0.3%	(0.0)	-0.2%	0.0	-0.5%	0.0	-1.3%
[5] LD Res.(<0.5/ac)	248.8	9838.6%	88.1	789.0%	40.5	***	114.7	1530.5%
[6] Commercial	0.0	*	10.2	7.5%	0.0	-0.7%	34.2	152.8%
[7] Industrial	0.0	*	60.4	***	0.0	-0.7%	51.2	1727.0%
[8] Roads	0.0	*	0.0	-0.1%	0.0	*	0.0	-1.4%
[9] Airports	0.0	*	0.0	-0.2%	0.0	*	0.0	*
[10] Railroads	0.0	*	0.0	*	0.0	-0.7%	0.0	*
[11] Junkyards	0.0	*	0.0	-0.2%	0.0	*	0.0	*
[12] Recreation	0.0	*	(0.0)	-0.2%	0.0	*	(0.0)	-1.4%
[13] Institution	0.0	-0.3%	0.0	-0.2%	0.0	*	0.0	-1.4%
[14] Pasture	(6.9)	-50.9%	(11.2)	-82.4%	(5.0)	-79.4%	(23.8)	-48.2%
[15] Cropland	(41.8)	-84.2%	(68.0)	-87.6%	(37.4)	-77.8%	(32.5)	-65.5%
[16] Orchards	0.0	*	0.0	*	0.0	*	(6.6)	-83.4%
[17] Brush	(2.2)	-27.1%	(25.8)	-71.6%	0.0	*	(7.2)	-29.4%
[18] Forest	(220.1)	-69.3%	(83.6)	-44.1%	(39.0)	-51.6%	(204.9)	-62.5%
[19] Barren	(2.1)	-10.4%	(10.9)	-97.6%	0.0	*	(18.2)	-100.0%
[20] Wetland	0.0	-0.3%	0.0	-0.2%	0.0	-0.7%	(0.0)	-1.5%
[21] Water	0.1	2.1%	0.0	-0.1%	1.8	816.0%	14.5	1906.1%
Total (acres)								

APPENDIX G Characteristics of Rhode Island Soils

Characteristics of Rhode Island Soils

SOIL NAME	MAP SYMBOL	Hydrologic Soil Group	Restrictive Soils[1]	Flooding Duration & Depth	Water Table Depth(ft)	High Water Table Duration & Type[2]	Parent Material	Highly Erodible	Hydric/ Drain Class	Groundwater N Removal Potential[5]
Adrian	Aa	A/D**	-------	Long; Nov-May	0 - 1.0[4]	Nov-May, A	Organic	No	VP	High
Agawam	AfA, AfB	B[3]	-------	-------	> 6.0	-------	Outwash	No		
Birchwood	Bc	C	Restrictive	-------	1.5 - 3.5	Nov-April, P	Lodgement Till	No		
Bridgehampton	BhA, BhB, BmA, BmB	B[3]	-------	-------	> 6.0	-------	Outwash	No		
Bridgehampton	BmA, BmB	B	-------	-------	> 6.0	-------	Ablation Till	No		
Bridgehampton/Charlton	BnB*, BnC*, BoC*	B	-------	-------	> 6.1	-------	Ablation Till	No		
Broadbrook	BrA, BrB, BsB	C	Restrictive	-------	> 6.0	-------	Lodge. Till, EM	No		
Canton Charlton	CaC*, CaD*, CB*, CC*, CdA*, CdB*,CdC*,CeC*, ChB*, ChC*, ChD*, CkC*	B	-------	-------	> 6.0	-------	Ablation Till	Yes		
Carlisle	Co	A/D**	-------	Long; Nov-May	0 - 1.0[4]	Sep-Jun, A	Organic	No	VP	High
Deerfield	Dc	B[3]	-------	-------	1.0 - 3.0	Dec-Apr, A	Outwash	No		
Enfield	EfA, EfB	B[3]	-------	-------	> 6.0	-------	Outwash, E.M.	No		
Gloucester	GBC*, GBD*, GhC*, GhD*	(A/B)[3]	-------	-------	> 6.0	-------	Ablation Till	Yes		
Hinckley	HkA, HkC, HkD, HnC*	A[3]	-------	-------	> 6.0	-------	Outwash	Yes		
Ipswich	Ip	D	-------	Very brief; Jan-Dec	1 - 0.0[4]	Jan-Dec, A	Organic	No	VP	High
Lippitt	LgC	C[3]	BEDROCK	-------	> 6.0	-------	Ablation Till	No		
Mansfield	Ma, Mc	D	Restrictive	-------	0 - 0.5	Nov-Jul, A	Lodgement Till	No	VP	
Matunuck	Mk	D	-------	Very brief; Jan-Dec	1 - 0.0[4]	Jan-Dec, A	Organic	No	P, VP	High
Merrimac	MmA, MmB, MU	A[3]	-------	-------	> 6.0	-------	Outwash	No		
Narragansett	NaA, NaB, NbB, NbC, NcC	B	-------	-------	> 6.0	-------	Ablation Till	No		
Newport	NeA, NeB, NeC, NfB, NoC	C	Restrictive	-------	> 6.0	-------	Lodgement Till	Yes		
Newport (Urban Land)	NP	C	Restrictive	-------	>6.0	-------	-------	No		
Ninigret	Nt	B[3]	-------	-------	1.5 - 3.5	Nov-April, A	Outwash	No		

Paxton	PaA, PaB, PbB, PbC, PcC	C	Restrictive	-------	> 6.0	-------	Lodgement Till	No		
Paxton (Urban Land)	PD	C	Restrictive	-------	> 6.0	-------	-------	No		
Pittstown	PmA, PmB, PnB	C	Restrictive	-------	1.5 - 3.0	Nov-April, P	Lodgement Till	No		
Podunk	Pp	B	-------	Brief; Nov - May	1.5 - 3.0	Nov-May, A	Alluvial	No		
Poquonock	PsA, PsB	C	Restrictive	-------	> 6.0	-------	Lodge. Till, S.M	No		
Quonset	QoA, QoC	A[3]	-------	-------	> 6.0	-------	Outwash	No		
Rainbow	RaA, RaB, RbB	C	Restrictive	-------	1.5 - 3.5	Nov-April, P	Lodge. Till, EM	No		
Raypol	Rc	C[3]	-------	-------	0 - 1.0[4]	Nov-May, A	Outwash, E.M.	No	SP, P	High
Ridgebury	Re, Rf*	C	Restrictive	--------	0 - 1.5[4]	Nov-May, P	Lodgement Till	No	SP, P	
Rumney	Ru	C	-------	Brief; Oct - May	0.0 - 1.5	Nov-June, A	Alluvial	No	P	High
Scarboro	Sb	D[3]	-------	-------	0 - 1.0[4]	Nov-Jul, A	Outwash	No	VP	High
Scio	ScA, SdB	B	-------	-------	1.5 - 3.0	Nov-May, A	Ablation Till, E.M.	No		
Stissing	Se, Sf	C	Restrictive	-------	0 - 1.5[4]	Nov-May, P	Lodgement Till	No	SP, P	
Sudbury	Ss	B	-------	-------	1.0 - 3.0	Nov-April, A	Outwash	No		
Sutton	StA, StB, SuB, SvB	B	-------	-------	1.5 - 3.5	Nov-April, A	Ablation Till	No		
Tisbury	Tb	B[3]	-------	-------	1.5 - 3.5	Nov-April, A	Outwash	No		
Walpole	Wa	C	-------	-------	0 - 1.0[4]	Nov-April, A	Outwash	No	SP, P	High
Wapping	WbA, WbB, WcB, WdB	B	-------	-------	1.5 - 3.5	Nov-April, A	Ablation Till, E.M.	No		
Windsor	WgA, WgB	A[3]	-------	-------	> 6.0	-------	Outwash	No		
Woodbridge	WhA, WhB, WoB, WrB	C	Restrictive	-------	1.5 - 3.0	Nov-April, P	Lodgement Till	No		

[1] Restrictive soils have a permeability of <0.2 in/hr at a depth of about 20 to 60 inches.

[2] A=Apparent, P=Perched

[3] Excessive permeabilit in the subsoil may cause ground water pollution from septic system effluent, Permeability rates range from 6-20 in/hr or greater. From Soil Survey of RI Table 19; for septic tank absorption fields.

Hydric Soil Drainage Classes

V-Poorly Drained

SP-Somewhat Poorly Drained

VP-Very Poorly Drained

[4] Designated as Hydric Soils.

[5] Nitrogen removal potential based on URI research indicating high N removal in hydric soils with organic, alluvial, and outwash parent material (Rosenblatt 1999).

*See description of map unit from the Soil Survey of Rhode Island, 1981; for composition and behavior characteristics of the map unit.

** Designated as D for MANAGE

Compiled by Adam Rosenblatt, URI

Source: *Soil Survey of Rhode Island, Dean R. Rector, Soil Conservation Service, 1981.*

Amended by Jim Lucht 10/00

Soil Hydro-Group	Basic Description	Typical Depth to Seasonal High Water Table From ground surface	Water Quality Risks with Developed Land Use	Management implications
A	Sandy, deep water table, high infiltration, low runoff	Greater than 6 feet	• Highest pollutant movement to *groundwater* from septic systems and fertilizers, • Largest increase in runoff with impervious cover, • Greatest loss of groundwater recharge with impervious cover.	• Preserve as recharge areas. • Direct stormwater runoff to these areas to promote infiltration after pretreating to remove sediment and other pollutants. • Consider prohibiting deep wastewater seepage pits (galleys); evaluate need for advanced onsite treatment systems.
B	Most are well-drained, moderate runoff, moderate infiltration	Greater than 6 feet or 1½ to 3½ feet	• High potential for pollutant movement to *groundwater* from septic systems in sandy subsoils, • Moderate increase in runoff and loss of recharge with impervious cover. • May include prime farmland soils.	• Prime soils for building and agriculture. Consider best use to meet town goals and strategies to preserve prime farmland. • Consider prohibiting deep wastewater seepage pits (galleys); evaluate need for advanced onsite treatment systems.
C	Slowly permeable, collection areas for surface water, typically high water table, high runoff	1½ to 3½ feet or 0 to 1½ feet	• High pollutant movement to *surface waters* from septic systems, fertilizers, and land disturbance. • High potential for *hydraulic failure* of septic systems, with surfacing or lateral movement of effluent. • High potential for wet basements, temporary flooding.	• Septic systems may require use of filled leachfields to achieve minimum separation distance to groundwater; consider aesthetic impact of fill and need for advanced treatment. • Stormwater treatment ponds not suitable where water table is less than 2 feet from the ground surface. • Limit filling and regrading required to raise elevation of homes with full basements; consider prohibiting basements in wet soils. • Maintain undisturbed wetland buffers and drainageways. • Prohibit use of subdrains to lower water table; regulate location of subdrains adjacent to isds and their discharge, • Divert runoff from wells and septic systems.
D	Very high water table, often classified as wetlands based on wet (hydric) soils	0 to 1½ feet	• Highest pollutant movement to *surface waters*. • Loss of pollution treatment potential with disturbance of wetland buffers. • Wetland habitat encroachment.	• Avoid impacts to small streams, wetlands, and wetland buffers with development • Treat runoff before discharge to wetlands. • Identify wetland buffers for restoration. • Prohibit use of advanced treatment systems on shallow water tables (less than two feet from ground surface) for new construction.

APPENDIX H

RIGIS coverages used in the MANAGE Assessment of Major Community Supplies
RI Source Water Assessment Program

Original analysis maps are generally produced at the watershed level. In order to create a more useful product, some basic inventory maps were redone at the town level. All maps have major and minor roads differentiated, with annotation on numbered routes- annotation from RIGIS Roads or USGS Topographic Overlay.

GIS Coverages

1. STUDY AREA BOUNDARY OUTLINE (Watershed, subwatershed, wellhead protection area, or aquifer recharge area)

Data Layers	*Description*	*Use*
Watershed boundaries	Surface water drainage basins and sub-basins in RI. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hdb90.html	Study Area boundary outline
Community Wellhead Protection Areas	Areas around public community wells considered critical for the protection of their source water supplies. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hwa97.html	
Non-Community Well Head Protection Areas	Areas around public non-community wells considered critical for the protection of their source water supplies. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hwb97.html	
Aquifer recharge areas	Critical portions of recharge areas for major RI groundwater aquifers suitable as sources for untreated drinking water. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hgg94.html	

2. Land Use

Data Layers	*Description*	*Use*
1995 RIGIS Land Use	1995 Land use / land cover updated using 1988 land use as a base. Coded to Anderson modified level 3 with one half acre minimum polygon resolution. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Landuse/s44llu95.html	Note: Light colored forest to allow writing on map- also emphasizes developed areas. Local volunteers assist with land use updates for each study area

3. Soils

Data Layer	*Description*	*Use*
Soils	1996 USDA/NRCS SSURGO soils delineated with name, type and feature attributes. Replaces 1990 RIGIS soils dataset. For metadata go to:	See below for uses.

	http://www.edc.uri.edu/spfdata/rigisup2002/Soil/risoi96.met	

4. Sewers

Data Layer	*Description*	*Use*
Sewer Lines	Sewer mains and interceptors for public sewer systems - Generally shows only pipes with a diameter of 10 inches or greater. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Utilities/s44usl96.html	Buffered to 750' to estimate service area

5. Community Water Supply Wells

Data Layer	*Description*	*Use*
Community Wells	Public wells serving at least 25 residents or 15 service connections year round. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hwc97.html	Existing water quality impacts
Non-Community Wells	Public wells serving at least 25 persons at least 60 days of the year. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hwn97.html	

6. Public Water Systems

Data Layer	*Description*	*Use*
Water Supply Lines	Water lines for public water systems. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Utilities/s44uwl95.html	Existing water quality impacts

7. Political Boundaries

Data Layer	*Description*	*Use*
Municipalities	RI state and municipal boundaries with city and town attribute codes and annotation. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Boundary/s44btp88.html	Basemap and reference
State of RI	RI state line boundary including coastline. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Boundary/s44bri89.html	

8. Roads

Data Layer	*Description*	*Use*
Roads	All roads in RI including paved , unpaved and track/trail with name attributes and annotation. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Transportation/s44trd98.html	Basemap and reference

9. Water Resources

Data Layers	*Description*	*Use*
Hydro lines	Centerlines for all fresh water rivers and streams including some seasonal streams in RI. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hhl98.html	Location of critical resource areas and existing water quality impacts.

Major Surface Water Bodies	Major freshwater rivers and lakes as polygon features with name annotation and RIDEM water quality attribute designation. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hhm99.html	
Reservoirs	Surface reservoirs used as sources for public drinking water supplies. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hpr94.html	
Narragansett Bay Water Classification	Water zone classifications in Narragansett Bay by the RI CRMC and RIDEM. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hbc94.html	
Shellfishing Closure Areas	Rhode island coastal waters & Narragansett Bay shellfish closure areas. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Nature/s44nsc00.html	
Coastal Water Classification	Near shore water classifications by the RI Coastal Resources Management Council (CRMC) for the south coastal regions of Rhode Island and Block Island Sound. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hcc94.html	
Groundwater Classification	Groundwater quality classifications for major aquifers, public well head areas and other subsurface resources. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hydro/s44hgc93.html	

10. Open Space and Protected Areas

Data Layer	*Description*	*Use*
Audubon Lands	Protected open space lands owned and managed by the Audubon Society of Rhode Island. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Openspace/s44oal95.html	Facilitates comparison of hot spots to resource areas. Shows potential for greenway linkages. Open space was updated with town data in each watershed.
State Conservation and Recreational Openspace 1990	State Conservation, Open Space, and Recreational Program lands as of 1990. For metadata go to: http://www.edc.uri.edu/spfdata/rigisup2002/OpenSpace/scorp90.htm	
Protected Public Lands	Protected open space lands managed by or acquisition supported through the Rhode Island Department of Environmental Management. For metadata go to: http://www.edc.uri.edu/spfdata/rigisup2002/OpenSpace/demopen.htm	
Private Land Trust Holdings	Land owned by The Nature Conservancy or Municipal Land Trusts. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Openspace/s44onc98.html	
Protected Open Space	Protected open space land, the majority of which is not fully developed. Owned or maintained by Rhode Island cities, towns, and non-for-profit conservation groups. For metadata go to: http://www.edc.uri.edu/spfdata/rigisup2002/OpenSpace/protopen.htm	
Rare Species	Estimated habitat and range of rare species and noteworthy natural communities. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Nature/s44nrs97.html	

11. Topography

Data Layer	*Description*	*Use*
USGS 7.5 Minute Topo	TIF image files of USGS 7.5 minute topoquads that encompass	Used as base map for most

Maps	RI. Distributed on USGS Quad basis.	maps in Wickford Harbor Assessment. Provides topography, annotation, and local landmarks.

12. Point Sources of Pollution

Data Layer	*Description*	*Use*
CERCLIS	Point locations of hazardous material sites designated by the U.S. EPA and RIDEM. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hazmat/s44xcc97.html	Determining exact locations of known pollution sources and the proximity to water resources. Additions and revisions made by town and state officials, and volunteers.
RIPDES	Rhode Island point discharge elimination system point locations for all sanitary waste sites where permits have been issued by RIDEM. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hazmat/s44xsp99.html	
LUSTs	Storage tanks and associated piping used for petroleum and certain hazardous substances that have experianced leaks as determined by RIDEM. For metadata go to: http://www.edc.uri.edu/rigis-spf/Metadata/Hazmat/s44xlt99.html	

13. Zoning

Data Layer	*Description*	*Use*
Town Level Zoning	Town blue-print for future development patterns	Buildout analysis

MANAGE – Modified coverages

Surface Water Hot Spots

Data Layer	*Use*
MANAGE modified land use/soil (high intensity land use on seasonal high water table (0-3.5') soils)	Helps identify areas with higher risk for pollutant movement to surface water.

Groundwater Hot Spots

Data Layer	*Use*
MANAGE modified land use/soil (high intensity land use on hydro-group A soils)	Helps identify areas with higher risk for pollutant movement to groundwater.

Buildout Analysis

Data Layer	*Use*
MANAGE modified land use/zoning	Shows patterns of future development coded to the current land use legend for comparison.

APPENDIX J

MANAGE GIS-Based Pollution Risk Assessment Method
Watershed / Aquifer Pollution Risk Indicators

List of Indicators and Rating Key
The following indicators are commonly used in the MANAGE watershed assessment, although not all may be used in each assessment, depending on the characteristics of the study area and type of analysis. Mapping the site-specific location of these features, including overlay mapping to identify potential pollution source "hotspots" is an important aspect of the assessment conducted separately identified characteristics is The mapping analysis, including "hot spot" mapping is conducted separately.

WATERSHED / AQUIFER INDICATOR *Relative Pollution Risk Rating*

	Low	Medium	High	Extreme
1. LAND USE [1]				
Watershed-wide				
High intensity land use	< 10 %	10 – 14 %	15 – 25%	> 25 %
Impervious surface area	< 10 %	10 – 14%	15 – 25%	> 25 %
Forest and Wetland	> 80 %	50 – 80%	20 – 49%	< 20%
Septic systems per acre [4]	< .10	.10 – .23	.24 – .49	.50 – 1.15
Percent sewered land use	Not rated [3]			
Riparian (shoreline)				
Riparian High intensity land use	< 5 %	5 – 9 %	10 – 15 %	> 15 %
Riparian Impervious surface area	< 5 %	5 – 9 %	10 – 15 %	> 15 %
Riparian Forest and Wetland	> 95 %	80 – 95 %	60 – 79 %	< 60 %
Disturbed Riparian Area (inverse of Riparian Forest and Wetland)	< 5 %	5 – 19 %	20 – 40 %	> 40 %
Existing or potential pollution sources				
Mapped pollution sources within study area, within 200' buffer to surface waters and tributaries, or within public well inner protected radius (200' bedrock; 400' gravel well).	Mapped and used in basic SWAP ranking			

2. NATURAL FEATURES [2]	Low	Med – High	Extreme
SOILS- Risk to groundwater			
Very sandy, rapidly permeable	< 10 %	10 – 60 %	> 60 %

SOILS - Risk to surface water and/or shallow groundwater				
Slowly permeable soils			Not rated [3]	
Presence of restrictive layers	< 2%		2 – 10 %	> 10 %
High water table	< 5 %		2 – 20 %	> 20 %
Erosion potential	< 5 %		2 – 20 %	> 20 %
Wetlands with high potential for nitrogen removal (organic sediments in outwash parent material).			Mapped	
3. COMBINED LAND USE/ NATURAL FEATURES		Mapped and also used in basic SWAP rating		
High intensity land use on highly permeable soils	< 5 %	≥ 5 – 15	≥ 15 – 30	≥ 30
High intensity land use on highly permeable soils	none	≥ 5	≥ 5 – 15	≥ 15
High intensity land use within shoreline zone.	NONE	≥ 5	≥ 5 – 15	≥ 15
Erodible soils in vacant, unprotected areas			Mapped	
4. HYDROLOGIC BUDGET and NUTRIENT LOADING ESTIMATES				
Phosphorus to surface runoff [4] (lbs / acre/ year)	< .46	.47 – .68	.69 – .93	> .93
Nitrogen loading to groundwater recharge (lbs / acre/ year) [4]	< 5.4	5.4 – 8	8.1 – 16	> 16
Nitrate-N concentration to groundwater recharge (mg/l) [4]	< 2	2 – 4.9	5 – 7.9	8 –10
Nitrogen to surface runoff (lbs / acre/ year)			Not rated [3]	
Surface water runoff (inches /year)			Not rated [3]	
Infiltration and recharge from rainfall and septic systems (inches /year)			Not rated [3]	

5. OTHER POLLUTION SOURCES and HYDROLOGIC MODIFICATIONS — Not rated, may be mapped. Field inspection needed

"Point sources" - discharges to surface or groundwater, salt storage, underground storage tanks, hazardous waste sites, contaminated sediments, composting sites.

Boat and marina discharges; fuel from 2-stroke engines, wastes from recreational vehicles.

Livestock, manure storage, kennels, large assemblages of birds

Well pumping, water withdrawal from or into a basin; dams

Closed stormwater systems; stream channelization; subsurface drainage of fields, subdivisions, and individual home sites.

6. RECEIVING WATER CHARACTERISTICS

Existing Condition

History of contaminant detects	Trace	< ½ MCL	> ½ MCL	Violation

Existing Condition - Groundwater

Monitored concentration of nitrate (mg/l)	< .5	.5 – 2	> 2 – 5	> 5

Existing Condition – Surface waters

Nutrient enrichment level (based on trophic state index, phosphorus concentration, clarity, frequency and severity of algal blooms; also dissolved oxygen and other factors.

History of contaminant detects

Visual and physical condition (odors, trash)

Invasive vegetation, use of herbicides

Compliance with water quality goal

Eelgrass health extent and condition (coastal waters)

Sensitivity to impact

Flushing time, depth, shoreline configuration (D_L)

Aquifer type- bedrock (low risk) vs. sand and gravel (high risk) (RIDOH, 1999); USGS vulnerability rating (USGS, 1999); potential for lateral flow

Rating Pollution Risks

1 The ratings assigned to the **land use** indicators are approximate thresholds intended to provide a frame of reference for measuring pollution risk. The ratings are based on abundant evidence linking these land use factors to water quality impacts in streams and wetlands (EPA 1996). Documented impacts include changes in stream hydrology, impaired aquatic habitat, and increased pollutant inputs. The relationship between percent impervious cover ratings and resulting impacts to watershed streams is the most well documented. The ratings assigned to the other indicators are loosely based on EPA-recommended indicators, similar research-based ratings used to evaluate habitat impacts to New England wetlands (Ammann, A.P. and A.L. Stone. 1991; Hicks 1997), and best professional judgment. In all cases we assign lower tolerances to risk indicators in shoreline areas, where there is a greater chance for direct pollutant movement into surface waters. Increased travel time from the point where pollutants are generated to discharge to receiving waters generally increases opportunity for pollutant removal through plant uptake, microbial activity, chemical transformations, or physical filtering, even though this may be very limited in sandy soils.

2 Risk ratings for **soil features** are very approximate thresholds indicating increasing risk and need for management. They were selected based on best professional judgment considering the range of characteristics typical of RI soils.

3 Not rated – Results are used to compare relative differences among study areas, between different land use / pollution control scenarios; or compared with forested reference conditions.

4. Rating developed based on percentile ranking (25th = low, 50th moderate, 75th = high, 95th = extreme) of all ranked results of analyses conducted for all major drinking water supplies.

Measuring Indicators

Unless otherwise noted, indicators are calculated as a percent of the study area, using either the full watershed /aquifer study area or just the shoreline area within this zone. The following ratios apply:

$$\text{Study area risks} = \frac{\text{Sum of indicator land use area (acres)}}{\text{Total study area (acres)}}$$

$$\text{Shoreline Risks} = \frac{\text{Sum of indicator land use within 200 ft. of surface waters (acres)}}{\text{Total area of the 200 ft. shoreline buffer (acres)}}$$

For example:

$$\text{High intensity land use} = \frac{\text{Sum of all high intensity land use in the study area (acres)}}{\text{Total study area (acres)}}$$

Understanding Watershed / Aquifer Pollution Risk Indicators

Using multiple indicators to evaluate pollution risk

The MANAGE pollution risk assessment method uses selected characteristics of a watershed or groundwater recharge area to evaluate the degree to which water resources in each study area are susceptible to pollution. Watershed land use and natural features used as "indicators" of watershed health were chosen based on their documented relationship to water quality conditions. Practical considerations factored into the selection, such as availability of data using high-resolution GIS coverages and ease in deriving summary statistics about the indicator from the RIGIS database. The indicators used are best suited to identifying pollution risks in rural and suburban communities characterized by a mix of forest and agriculture, limited village and urban development that may be sewered, and unsewered residential development where groundwater is the primary pathway for water flow and pollutant movement. Given this focus on suburbanizing landscapes the indicators used are well suited to Rhode Island drinking water supply watersheds and aquifers, most of which are subject to intense development pressure. Because of similar soils and land use characteristics the indicators used are generally suitable for the southern New England area provided corresponding GIS coverages are available. The assessment approach is less useful in highly urban areas where surface water flow is controlled more by engineered stormwater drainage systems than soils. In these urban areas more site-specific information on the particular type of high risk uses, stormwater discharge locations and treatment systems, good housekeeping practices at industries and businesses, and age and maintenance of sewer lines all become important variables that are not directly addressed in this screening level assessment.

Although many watershed assessment methods rely heavily on one or two indicators – most commonly percent impervious cover and nutrient loading, the MANAGE approach incorporates a number of watershed characteristics focusing on both land use and natural features. The additional factors used, such as forest cover and riparian buffer continuity, are widely used measures of potential water quality impacts at the watershed scale, and have long been used in evaluating water quality function of both individual wetlands and collective wetland resources within a drainage area (Center for Watershed Protection 2002; Ammann, A. and A. Stone, 1991). As with any watershed assessment method, the effort required to calculate additional indicators must be weighed against the value of the information generated. Where high quality GIS databases for soils and land use are available, such as the RIGIS system, a wide range of indicators may also be readily available for direct use with minimal database development.

Clearly one of the primary advantages of using a variety of different watershed indicators is that the range of data generated can shed light on the type of pollutant or stress most likely to influence water quality. This is especially useful where the link between one watershed characteristic and associated water quality condition is weak. For example, more recent research on the effect of watershed impervious suggests that in relatively undeveloped watersheds with average impervious cover less than 10%, other factors such as forest cover, contiguous shoreline buffers, soils, agriculture, historical land use and a "host of other stressors" can greatly influence water quality in sensitive areas. Consequently watershed managers "should evaluate a range of supplemental watershed variables to measure or predict actual stream quality within these lightly developed watersheds" (Center for Watershed Protection, 2002). Because drinking water supply watersheds often fall under the 10% impervious level, multiple indicators are especially valuable in evaluating these sensitive watersheds.

Using a range of indicators avoids over-reliance on one or two factors, especially where input values and results may be uncertain. Minor map errors and inaccuracies are common to all map databases, but in general the simplest watershed indicators obtained directly from high quality maps – such as percent high intensity land use and percent forest– are the most reliable. Some indicators, such as percent impervious cover, the estimated number of septic systems within a study area, and all future projections, are created by overlaying map coverages in combination with population and housing data, and use of simplifying assumptions. Any of these operations can amplify map errors and introduce uncertainty associated with input values and assumptions. These uncertainties are inherent in any type of modeling and as long as assumptions remain consistent among study areas, the comparative value of the results is unaffected. Using a range of indicators, including reliable land use factors, can help reduce reliance on any one factor while providing a range of supporting data.

When a variety of watershed features are available, key indicators can be selected to focus on pollutants of concern to particular receiving waters. For example, primary factors for evaluating impacts to groundwater aquifers include: nitrogen loading to groundwater– where nitrogen is a both drinking water contaminant and indicator of other dissolved pollutants; and percent high intensity land use in general, and especially commercial and industrial land use where hazardous materials may be used. In contrast, key indicators for fresh surface waters would include impervious cover, percent watershed forest, estimated phosphorus inputs and land use within shoreline buffers.

A brief look at the indicators used clearly show that many of the factors measure similar features. For example, high intensity land use, impervious cover, runoff and nutrient loading all tend to increase as development increases. Results are best used to compare general trends and to focus on few primary pollutants or stressors of concern for particular receiving waters rather than trying to "add up" total risks from a large number of different factors. Where indicators appear to be very similar, basic differences factor into interpreting results and selecting management practices. For example, high intensity land uses encompass both urban land and tilled agriculture while impervious cover measures only urban roads, rooftops and parking. As a result, riparian buffers having both high intensity land use and high impervious cover are likely to be more urbanized and difficult to restore; those with high intensity land use and low impervious are likely to be in agricultural use or in backyards of moderate to large lot house lots where reclaiming natural buffers may be more feasible. For sensitive cold water trout streams, any areas where naturally vegetated shoreline buffers have been lost would provide useful information on extent of impact and potential restoration sites.

Interpreting Results

Assessment results are best used to compare relative differences in risk among study areas or between different land use scenarios. When comparing results for a number of subwatersheds or recharge areas it is useful, but not always possible, to select study areas representing a range of different land use types and densities. Undeveloped study areas with unfragmented forest and naturally vegetated shorelines are particularly valuable as "reference" sites representing natural background conditions. Even lightly developed study areas with good water quality, though not pristine, provide a useful benchmark of low-risk conditions. At the other end of the spectrum, densely developed or disturbed study areas, whose water quality is highly susceptible to impact, represent "high risk" circumstances. In each case reference watersheds provide more realistic benchmarks when monitored water quality data corresponds to estimated risk levels based on mapped features or modeled nutrient loading estimates.

Watershed indicators are useful in evaluating sensitivity of a watershed or aquifer recharge area to changing land use and to different pollution control practices. Typical analyses include the following:

- Comparing differences between current and future land use, where a future "build-out" map is used to calculate indicators representing future land use;

- Evaluating the range of results possible using low and high input values for factors that are difficult to estimate precisely, such as impervious cover or nutrient loading; and

Comparing the relative change in risk among alternative management scenarios. Typical pollution control strategies that can be modeled include: reduced fertilizer application, use of nitrogen-reducing septic systems, and use of stormwater treatment systems designed to remove nitrogen or phosphorus. Alternative land development options and pollution control practices can be modeled for the entire study area, for particular land use types, or for any combination of land use by soil type or location in shoreline buffers.

Ranking Pollution Risks

To make the assessment more useful for management decisions, indicator results are generally ranked along a scale from low to high or extreme risk. These thresholds are general guidelines designed to serve as a frame of reference in interpreting results. They should be considered points along a continuum, not rigid categories with distinct boundaries. These threshold levels are set based on the following factors, as described below.

- Ranking based on literature values. Each indicator is a standard, widely accepted measure of watershed health. In some cases extensive research results are available to document a solid relationship between the presence or extent of watershed features and associated water quality condition. The relationship between percent impervious cover and stream habitat is probably the most well documented, where average watershed impervious levels above 10% are associated with declining stream quality. For other indicators, supporting data linking the extent of the water features to water quality conditions is more limited. Where minimal literature data is available to rank pollution potential, best professional judgment was used to select risk thresholds based on known water quality conditions compared to watershed risk indicators.

- Relative comparison of results using a selected range of study areas. To establish a representative range of values for watershed indicators, assessments were first conducted for a small number of study areas representing extremes in soil types and development levels. Study areas included pristine forests to highly urban watersheds with known water quality impairment. For example, indicator results for pristine areas were set as low risk, while results for the most highly developed watersheds with known water quality impairment were ranked as having an extreme risk of contamination., with a moderate risk ranking assigned to study areas with intermediate indicator levels. Where research data was available to support selection of risk rankings, we used the literature values but adjusted them where necessary to correspond to known low or high risk situations based on actual water quality.

- Percentile ranking of assessment results. When a large, representative database is available, risk thresholds may be set using statistical breakpoints to rank assessment results. Assessment results for 74 major community water supplies and other Rhode Island watersheds and aquifers were compiled using current land use conditions. We ranked results various mapped indicators, including: percentage of forest and wetland in shoreline areas, number of septic systems per acre, nitrogen loading to groundwater, and phosphorus loading to surface runoff. Each indicator was examined individually using results from all 74 study areas. Results were ranked and percentiles (25^{th}, 50^{th}, 75^{th} and 95^{th}) were calculated for each indicator, and a corresponding rank of low, moderate, high and extreme risk was assigned respectively. This method provided an objective ranking based purely on comparative results where literature values on risk thresholds were very weak or unavailable. For example, the risk levels for the number of septic systems per acre and phosphorus loading to surface waters were established this way. Although this method generates an objective ranking, it does not necessarily provide a better relationship to actual water quality unless indicator levels are also correlated with monitored data. Although the assessment areas covered a wide range of rural and urban watersheds, most of the study areas are not highly developed, resulting in more conservative ranking than if the range of rural, suburban and urban watershed were equally distributed.

Setting risk levels

In setting pollution risk levels for the various watershed indicators, risk thresholds are generally set low as an early warning for potentially hazardous conditions before adverse impacts occur. For example, in drinking water supply watersheds the presence of any high intensity land use within 200 feet of surface waters automatically rates a moderate risk to water quality. This is based on the assumption that *any* high-risk land use within this critical buffer zone is a potential threat and should be investigated. This approach is designed to provide early warning of potential threats to high quality waters, including drinking water supplies that may be untreated, coastal waters that are sensitive to low level increases in nitrogen, and unique natural habitats that may also be sensitive to minute increases in sediment, temperature or phosphorus. Identifying risks in early stages also provides time to take pollution prevention actions as the most cost effective approach to protecting local water quality rather than relying on clean up actions after degradation occurs. In general, restoring a polluted water body is much more costly and technically challenging than pollution prevention.

Indicators have also been selected to focus on situations of highest pollution risk and may not detect circumstances where a variety of factors combine to magnify pollution potential. For example, we do not include medium density residential development (1 to 3.9 dwellings per acre) as a high-intensity land use. But development at this density could easily affect water quality depending on site specific features such as soil suitability, proximity to surface waters, level of septic system maintenance, and landscape care practices. Likewise, we assume a high level of protection to wetlands, which may underestimate risks where wetlands are disturbed through DEM approval, by zoning variance, or unpermitted encroachment. For example, only buffers to surface waters and tributaries are evaluated when considering shoreline pollution risks. Wetland buffers are not considered because wetlands themselves provide an extra measure of protection, potentially capturing or transforming pollutants before they reach downstream surface waters. Wetland buffers are often less suitable for development due to high water table and usually don't attract waterfront development pressure. Given these conservative assumptions, any development in wetland buffer zones would obviously result in greater pollution risk beyond our estimates.

When interpreting indicator results we have tried to emphasize major differences while minimizing minor variations that are not likely to represent real differences. Recognizing major differences is equally important where a rating system is used since rating and ranking systems can easily mask or oversimplify results. For instance, when indicator risk levels are near the edge of one risk category, a change in only a few points can shift the rating to the next risk level while greater increases may occur within a category. We have chosen not to evaluate results using statistical measures, partly because doing so may suggest results are actual data points rather than estimates of potential risk. Instead we have relied on professional judgment in making interpretations and hope results stimulate discussion of what is an acceptable level of risk and management actions.

Limitations of GIS-based screening level analysis

The quality of any screening level assessment relying on map databases is only as good as the resolution and accuracy of the coverages available. No amount of sophisticated overlays or data analysis will compensate for map data generated at too small a scale to distinguish between significantly different features. Even up-to-date GIS coverages are primarily screening level, suitable for planning purposes but not site-specific analysis. It is important to keep data limitations in mind when combining planning scale data – for example parcel ownership boundaries can easily be laid over soils types but results are best used to evaluate the area as a whole rather than examining soil features individually on lots, especially when working with lots as small as 5,000 sq. ft. in area. There is also a point when information needed simply may not be obtainable by maps. For example, unless locations where livestock are pastured and fed are mapped and frequently updated, even one or two large animals such as horses and cows could be a pollution risk if they are allowed access to surface waters or wastes are improperly stored. Although fields and pastures adjacent to surface waters or overlying high water table soils can be mapped, local knowledge and field inspection is needed to identify these areas.

APPENDIX K

Westerly Source Water Assessment
Hydrologic and Nutrient Loading Assumptions

HYDROLOGIC BUDGET:

Average Annual Precipitation	45.0	inches
Average Annual Evapotranspiration	18.0	inches

Surface Runoff Nutrient Loading Factors

Surface Runoff Coefficients			**Phosphorus** lb P/acre/year		**Nitrogen** lb N/acre/year		
LAND USE	Low	High	Low	High	Low	High	
[1] HD Res.(>8 /ac)	0.64	0.77	3.6	4.4	11.9	14.3	
[2] MHD Res.(4-7.9/ac)	0.39	0.64	2.2	3.6	7.3	11.9	
[3] MD Res.(1-3.9/ac)	0.23	0.39	1.3	2.2	4.3	7.3	
[4] MLD Res.(0.5-0.9/a	0.16	0.23	0.9	1.3	3.0	4.3	
[5] LD Res.(<0.5/ac)	0.10	0.16	0.6	0.9	1.9	3.0	
[6] Commercial	0.50	0.85	1.0	2.5	2.0	20.0	
[7] Industrial	0.50	0.85	1.0	3.5	2.0	15.0	
[8] Roads	0.70	0.82	1.0	3.5	2.0	20.0	
[9] Airports	0.70	0.82	1.0	3.5	2.0	20.0	
[10] Railroads	0.70	0.82	1.0	3.5	2.0	20.0	
[11] Junkyards	0.70	0.82	1.0	3.5	2.0	20.0	
[12] Recreation	0.10	0.30	0.5	1.5	1.5	4.0	
[13] Institution	0.39	0.64	2.2	3.6	7.3	11.9	
[14] Pasture	0.05	0.25	0.3	1.0	2.0	5.5	
[15] Cropland	0.15	0.50	0.5	4.5	4.0	50.0	
[16] Orchards	0.05	0.25	0.4	2.0	4.0	35.0	
[17] Brush	-	0.10	0.1	0.2	0.9	2.9	
[18] Forest	-	0.10	0.1	0.2	0.9	2.9	
[19] Barren	0.05	0.80	0.1	0.2	0.9	2.9	
[20] Wetland	-	0.10	0.0	0.0	0.0	0.0	Water N =
[21] Water	1.00	1.00	0.3	0.3	8.0	8.0	atmospheric deposition

Calculating the most likely runoff and nutrient loading coefficients

C = LC + (HC - LC)*X
C= most likely export coefficient
LC = low export coefficient for a land use
HC = high export coefficient for a land use
X = 0 for soil type A;
1/3 for soil type B;
2/3 for soil type C;
1 for soil type D.
Calculation of UC and LC for residential uses
is based on Schueler's (1987) Simple Method:
C=0.05+0.9I where I = percent impervious.

Percent impervious from USDA TR55 (1975)

Land Use	% Impervious
RESIDENTIAL	
1/8 acre	65
1/4 acre	38
1/3 acre	30
1/2 acre	25
1 acre	20
2 acre	12
COMMERCIAL	85
INDUSTRIAL	72

Note: *Some of the loading factors are calculated using precipitation and surface runoff coefficients.*

GROUNDWATER NUTRIENT LOADING ASSUMPTIONS:

Septic Systems:

Factors determining septic tank effluent characteristics

	2.4	people/dwelling unit	*Derived from town and/or U.S.census data*
	50	gallons H_2O /person/day	
	2.3	lb P/person/year	
	7.0	lb N/person/year	
Concentration of P	15.1	mg/l	
Concentration of N	46.0	mg/l	

90% of the N in the septic effluent leaches to the groundwater

Estimated Septic System Density in Unsewered Areas

LAND USE	Number of Dwelling Units/Acre	= *number of septic systems/acre*
[1] HD Res.(>8 /ac)	***8.00***	*Low end in each residential category is closest to actual*
[2] MHD Res.(4-7.9/ac)	***3.60***	*count based on comparison with census and/or parcel data*
[3] MD Res.(1-3.9/ac)	***1.00***	*in many study areas. Where a more accurate count is*
[4] MLD Res.(0.5-0.9/ac)	***0.50***	*available the final number of septic systems is adjusted in*
[5] LD Res.(<0.5/ac)	***0.20***	*the main spreadsheet.*
[6] Commercial**	***1.00***	
[7] Industrial**	***1.00***	*** Commercial, Industrial, Institution, and Recreation are*
[12] Recreation **	***0.50***	*assumed to contribute at the same level as MD Res. except*
[13] Institution**	***1.00***	*Recreation is assumed to be in use for 6 months each year.*

Fertilizers:

Lawn Fertilizers

Estimated Lawn Area by Land Use

LAND USE	Fraction of area which is lawn
[1] HD Res.(>8 /ac)	***0.25***
[2] MHD Res.(4-7.9/ac)	***0.35***
[3] MD Res.(1-3.9/ac)	***0.50***
[4] MLD Res.(0.5-0.9/a	***0.35***
[5] LD Res.(<0.5/ac)	***0.25***
[6] Commercial	***0.05***
[7] Industrial	***0.10***
[12] Recreation	***0.70***
[13] Institution	***0.25***

75% of residents and businesses apply fertilizer
at a rate of ***175*** lb N/ac/yr
or 4.0 lb N/1000 sq. ft./yr
6% of the N applied leaches to the groundwater

Agricultural Fertilizers

Agricultural fertilizer applied at a rate of ***215*** lb N/ac/yr
or 4.9 lb N/1000 sq. ft./yr.
30% of the nitrogen applied leaches to the groundwater.

Other:

Pets in Residential Areas

0.41 lb N/person/yr leaches to the groundwater from pet waste.

Unfertilized Pervious Areas

1.2 lb/acre/yr leaches to the groundwater from unfertilized lawns, pastures, forests, and brush areas (background level).

BEST MANAGEMENT PRACTICES (BMP'S)

1. Agricultural Management

Reduces surface runoff volume and nutrient loading to both surface and ground water by **20%**

2. Lawn Management

Assume that **35%** of residents who are currently applying fertilizer will adopt improved lawn care recommendations with education. Improvements will include a reduction in the amount of fertilizer applied t **87.5** lb N/acre/year which is equivalent to 2.0 lb N/1000 sq. ft./year and a reduction in the amount of nitrogen leached to groundwater to **3%**

3. Stormwater Management

Nutrient loads to surface waters will be reduced by:

45% WITH a maintenance program, and

10% WITHOUT a maintenance program.

4. Reducing Imperviousness Through Creative Design

Imperviousness is reduced by **20%** reducing runoff coefficients and nutrient loads accordingly. Otherwise impervious areas are converted to unfertilized pervious areas (e.g., forest, brush or unfertilized lawn).

5. Septic System Alternatives

Denitrification or Advanced Treatment Systems

The fraction of N leached to groundwater from advanced treatment systems is rec **50%**

Improved Septic System Maintenance

Nitrogen and phosphorus delivery to surface waters from malfunctioning systems, primarily from hydraulic failure, is eliminated.

Sewering

Nitrogen and phosphorus delivery to surface water from malfunctioning septic systems is eliminated, and nitrogen delivery to groundwater from all septic systems is eliminated. NOTE: Leakage from sewer lines does occur, and will contribute pollutants to groundwater. These estimates do not account for this leakage. Other factors, such as water diversion outside the watershed, are not considered here, but are important when looking at the overall effects of sewering.

NOTE: The nutrient loading estimates do not consider: Animals other than dogs and cats, wildlife, polluted runoff that may infiltrate groundwater with concentrations higher than natural forested conditions, direct discharges, landfills, and other mapped sources. Consult maps to locate these sites.