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**.

L. Recommendations for groundwater protection and wastewater management

M. Response to public comments at 9/9/02 hearing.

N. GIS Documentation of Parcel-Based Septic system repair analysis - Jamestown Shores and northern area including Plat 4 GIS

O. Comments received on Soil Component of Jamestown RI MANAGE program

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.

IIn 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 cholophyll, 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 for Surface Water Reservoirs

	RISK INDICATOR	RATING SYSTEM					Carr Pond Reservoir		Watson Pond Reservoir	
		LOW	MEDIUM	**HIGH**	**EXTREME**		Results Current land use		Results Current land use	
		0	5	**10**	**25**	Maximum Rating	Input data	**Rating**	Input data	**Rating**
1	High intensity land use (%) throughout the watershed	<10%	>10-15%	>15-25%	>25%	25	5.1%	**0**	12.4%	**5**
2	High intensity land use (%) located on highly impermeable soils throughout the watershed	none	<5%	>5-15%	>15%	25	<5%	**5**	>5-15%	**10**
3	High intensity land use (percent) located within 200' buffer of reservoir and tributaries.	none	<5%	>5-15%	>15%	25	0.0%	**0**	2.5%	**5**
4	Mapped point sources within 200' buffer to reservoir and tributaries	none	-	-	Presence of one or more sources	25	0	**0**	0	**0**
5	Mapped point sources (per 10 acres) throughout watersheds including within 200' buffer to reservoir and tributaries	<0.1/10 acres	<0.5/10 acres	<1/10 acres	>1/10 acres	25	0.005	**0**	0.002	**0**
6	Trophic status (clarity, phosphorus, dissolved oxygen) (A measure of the amount of treatment needed)	oligotrophic (O)	mesotrophic (M)	meso / eutrophic (M/E)	eutrophic (E)	25	meso / eutrophic (M/E)	**10**	meso / eutrophic (M/E)	**10**
7	Compliance with water quality standards. Based on RIDEM 305(d) list March 2003.	Fully supporting (all criteria)	Tributary impaired (minor, not affecting supply)	Tributary impaired (potential to affect supply)	Not fully supporting for drinking water.	25	Fully supporting (all criteria)	**0**	Tributary impaired (potential to affect supply)	**10**
8	History of contaminant detects (organics, HC, pesticides, metals, etc.) within 5 yrs.	none or trace	<1/2 MCL	>1/2 MCL	Violation	25	>1/2 MCL	**10**	>1/2 MCL	**10**
	Total score	0	1 to 35	36 to 70	71 to 200	200	**Total**	**25**	**Total**	**50**
	Rank		0 - 49 LOW	50-100 MODERATE	>100 HIGH			**Low**		**Moderate**

Average for	**38**
Supplier	**LOW**

NOTES:

Factors 1 - 5 address watershed land use and landscape features.

Factors 6 - 8 address reservoir characteristics and sampling history. The history of contaminant detects considers regulated primary contaminants only and does not include parameters that may be associated with the distribution system such as copper or lead.

6. Nutrient enrichment status. Both reservoirs were ranked as moderately nutrient enriched (meso-eutrophic) based on occurance of algal blooms in Carr Pond and impaired status of Jamestown Brook due to high organic matter. Insufficient data was available to determine the level of enrichment.

7. Compliance with water quality criteria. Jamestown Brook upstream of Watson Pond is listed as impaired due to biodiversity impacts and pathogens. Naturally occuring organics and low flow are considered responsible. The water quality status of drinking water supplies is determined by RIDEM and RI HEALTH staff based on review of available data (Personal communication, Connie Carey, RIDEM).

8. History of contaminant detects considers regulated primary contaminants only and does not include parameters that may be associated with the distribution system such as copper or lead. Bacteria have not been detected and no violations of the standards for regulated contaminants have been identified. There have been detections of naturally occuring radioactive particles and Chromium in trace amounts, well within levels considered acceptable by US EPA. In addition, average total trihalomethanes have been detected at greater than half the levels considered acceptable by EPA. This indicates the need for continued montoring and may indicate the need for future management and/or treatment. Because trihalomethanes are sampled from the distribution system where sources are mixed, both reservoirs were ranked as high risk for this parameter.

In general, input data are based on RIGIS data and limited assessment information. Where no data are available for water quality condition (factors 6 and 7) a medium rating is assigned.

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

South Pond

PWSID#	TESTING RESULTS	MCL	Units	Max	Rank	Rating
	Contaminants					
	Total Trihalomethanes**	0.08	ppm	0.0493	high	10
1858419	Nitrate As N	10	ppm	0.6	low	0
1858419	Chromium	0.1	ppm	0.006	*	*
1858419	Gross Beta	50	pCi/l	3.2	*	*
1858419	Residual Chlorine(Field Test)	4	ppm	0	*	*

* Detects occurred only once during the 5 year period and should not be included in the ranking.
** Total Trihalomethane levels taken from the 2001 Consumer Confidence Reports.

▲ No violations of the standards for regulated contaminants (excluding bacteria) have been identified. However, there have been detections greater than half the levels considered acceptable by US EPA. This indicates the need for continued monitoring and may indicate the need for future management and/or treatment.

Overall Rating for SWA		
Contaminants	high	10

North Pond

PWSID#	TESTING RESULTS	MCL	Units	Max	Rank	Rating
	Contaminants					
	Total Trihalomethanes	0.08	ppm	0.0493	high	10
1858419	Nitrate As N	10	ppm	0.7	low	0
1858419	Residual Chlorine(Field Test)	4	ppm	0	low	0
1858419	Cadmium	0.005	ppm	0.0019	*	*
1858419	Chromium	0.1	ppm	0.0006	*	*
1858419	Gross Beta	50	pCi/l	3.2	*	*

* Detects occurred only once during the 5 year period and should not be included in the ranking.
** Total Trihalomethane levels taken from the 2001 Consumer Confidence Reports.

▲ No violations of the standards for regulated contaminants (excluding bacteria) have been identified. However, there have been detections greater than half the levels considered acceptable by US EPA. This indicates the need for continued monitoring and may indicate the need for future management and/or treatment.

Overall Rating for SWA		
Contaminants	high	10

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 .

UNIVERSITY OF RHODE ISLAND

PROJECT SUMMARY

Jamestown Wastewater /Source Water Assessment

Using the MANAGE watershed assessment method
to evaluate pollution risks and management options

University of Rhode Island Cooperative Extension
in partnership with the Town of Jamestown and RI HEALTH

PROJECT DESCRIPTION

The University of Rhode Island Cooperative Extension is conducting a map-based analysis of pollution risks to Jamestown's surface waters and groundwater from onsite wastewater systems and other land use activities. This is a screening-level assessment using computer-generated maps to display and analyze the most serious pollution threats. Conducted in support of the Town's wastewater management program, this study will focus on identifying septic system problems and management options. This study is being combined with an assessment of pollution threats to the Town's public water supply under the RI Source Water Assessment Program.

GOAL

To identify practical steps town officials and residents can take to reduce pollution inputs from onsite wastewater systems and other sources. Our study objectives are to:

- Identify pollution sources to Jamestown surface waters and groundwater using readily available information
- Evaluate pollution risks from onsite wastewater treatment systems and other sources under current land use and predict future threats
- Identify effective wastewater management options and other water supply protection measures.

BACKGROUND

Protecting the quality of public drinking water supplies and private wells is a major concern in the Town of Jamestown. The effect of land use activities on the Island's limited water supplies is of greatest concern in densely developed areas dependent on both onsite wastewater systems and individual wells. Septic systems have been identified as a source of contamination to local groundwater supplies. To protect the current and future quality of the Island's precious water supplies, the town is undertaking development of a local wastewater management program to better manage onsite systems throughout the island.

METHOD

We use a screening-level assessment method known as MANAGE* to identify, evaluate, and display pollution problems. Our approach relies on computer-generated maps and other readily available local sources of information. This first-cut assessment is a type of watershed "health checkup." Similar to a health physical, the assessment describes current conditions, points our problems, and identifies changes that can reduce health risk. We use multiple factors for a broad-based assessment that includes:

- Map analysis of land use, soils, and other watershed features to systematically locate high-risk zones for septic system failure and other probable pollution "hotspots" using the RI Geographic Information System (RIGIS) database.
  - Key land use and soils information summarized as "watershed health indicators" extracted from the RIGIS map database and compiled using a separate spreadsheet.
- Modeled estimates of average annual runoff, groundwater recharge, and nutrient loading as measures of cumulative pollution risk. We use a standard mass balance method similar to those widely used in comparable applications elsewhere including Cape Cod and the New Jersey Pine Barrens.

The analysis will be conducted townwide using current land use maps. We will predict future land use changes and potential new pollution sources through a "build-out" analysis. The relative effectiveness of different wastewater management options in reducing nitrogen inputs will be evaluated using the nutrient loading component of the model. Using the town's parcel database, a more site-specific analysis will be generated for the densely developed Jamestown Shores area. This will include for example, map analysis of DEM septic system repair permits and location of older homes built before adoption of DEM standards. This in-depth study will assist the town to initiate a pilot wastewater management program in this target area.

Results of the watershed assessment will help strengthen the technical foundation of the towns's wastewater management program to: a) identify the level of wastewater treatment needed to protect sensitive water resources, b) establish guidelines for system siting and design based on site-specific constraints and c) evaluate and select the most effective wastewater management options. Assessment results can also support broader town planning and resource management needs. Results can be used for example, to identify data gaps and need for monitoring, focused public education, and implementation of stormwater or wastewater pollution controls.**

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* MANAGE is the Method for Assessment, Nutrient-loading, and Geographic Evaluation of watersheds and aquifers. This screening-level pollution risk assessment method uses computerized maps known as Geographic Information Systems (GIS) to compile, analyze, and display watershed and aquifer information. MANAGE was developed by URI Cooperative Extension for use with Rhode Island communities as a tool for nonpoint pollution education and local management of water resources.

** Other URI activities supporting development of the town wastewater management program include: Technical assistance and design standards on siting and design of enhanced wastewater treatment systems in Jamestown Shores and other critical resources; assistance in conducting townwide education on-site wastewater management to include septic system inspection workshops, and workshops on enhanced treatment systems through the URI Onsite Wastewater Training Center.

TOWN ROLE

The assessment is carried out in partnership with the local advisory group. Committee member input is necessary to:

- Identify local water quality goals, protection priorities, and land use issues in the watershed,
- Verify accuracy of maps used,
- Assist in selecting management options for analysis, and to
- Develop recommendations for future action.

TIME FRAME

Three meetings with the local advisory group are needed, scheduled at the convenience of the Conservation Commission. The first meeting is scheduled for October 16, 2000.

FINAL PRODUCTS

- ArcView mapping of the town, including existing land use, future land use, natural characteristics and pollution problem areas.
- Town-wide "build-out" analysis with population, building units, and septic systems estimates.
- Watershed health "indicators" summarizing key information about land use and soil characteristics under current and future land use scenarios.
- Hydrologic budget and estimated nitrogen and phosphorus inputs from the watershed for each land use/management option evaluated.
- Specialized mapping including DEM ISDS repairs and parcel-based analysis of septic system risks in the Jamestown shores area.
- Brief fact sheet summarizing pollution risks and wastewater management options with supporting technical appendices.
- Presentation to town officials and the public on final results.

CONTACTS

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Jamestown Wastewater / Source Water Assessment
Work Sessions with Local Advisory Committee

University of Rhode Island Cooperative Extension
In partnership with the Town of Jamestown and RI HEALTH

MEETING 1 Land Use Issues and Assessment Goals
October 16, 2000 1 ½ hours
- Assessment goals and relationship to Town wastewater management efforts.
- 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, wastewater management priorities, and information sources for existing conditions.
- Review of land use maps and study area boundaries with directions for updating land use and identifying pollution problems.

MEETING 2 Pollution Risks - existing and future land use
June 7, 2001 2 hours
- 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,
  - 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
Schedule – Four to six weeks following Meeting 2 (2 hours)
- 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.

APPENDIX E

Existing condition of surface and ground water resources ...*What do we already know?*

Updated October 2002

- The supply consists of two reservoirs that capture surface runoff, about (1) percent is natural spring fed and one active bedrock well
- The main service area is the Village area and the Beavertail section of town.
- The JWD services an estimated 2,757 residential customers or 43% of the Town's residential population as well as 65 commercial and 15 governmental service connections.
- The JWD maintains a single cross-connection to the North Kingstown water system (150 gpm). The connection runs along the Old Jamestown Bridge

Water resources	**Water quantity**	**Water resources protection priorities**	**Monitoring data & assessment of actual conditions**	**Pollution sources, concerns and recommended actions**
Source	*System capacity--present and proposed yields; development constraints*	*Identification and status of important landscape features*	*Field data available, conditions and trends*	*Includes documented and potential pollution sources, related water quality issues, and Town plan recommendations.*
Carr Pond Reservoir (North Pond) The watershed sub-basin for the pond is approx. 210 acres, with a water body area of 28 acres	It is the primary public drinking water supply on the island. Net usable water from the reservoir is 51 million gallons Total maximum yield is 225,000 gallons per day. Current demand exceeds the Drought of Record safe daily yield of North Pond.	The Carr Pond basin is part of the larger Jamestown Brook Watershed, which is the town's principal conservation area.	The majority of northern Conanicut Island has very good water quality	The Reservoir Circle development (1/4 mile east of North Pond) served by ISDS, possibly posing some concern Of the 760 acres of land in the Jamestown Brook Watershed, 73% is permanently protected from development. The remaining 113 acres of developable land is zoned RR-200 with a minimum lot size of 4.6 acres The Zoning Ordinance contains a lot merger provision for grandfathered parcels There are no known point sources of pollution. New underground storage tanks are prohibited The Town will continue an aggressive acquisition of fee simple and development rights to all properties located within the Jamestown Brook Watershed. The CILT actively identifies and prioritizes wetland protection measures

Water resources	Drinking water supply	Water quantity	Monitoring data & assessment of actual conditions	Water resources protection priorities
Watson Pond (South Pond) The watershed sub-basin for the pond is 448 acres and a water body area of 7.3 acres	Useable capacity is approx. 8 million gallons Total max. safe daily yield is 100,000 gallons.	A vast wetland encompasses much of the watershed above South Pond	A vast wetland encompasses much of the watershed above South Pond. This increases evaporation and transpiration and reduces the quantity of runoff, especially during dry weather. Jamestown Brook is listed as impaired for aquatic habitat and pathogens under the RIDEM 305(b) list. Low flow is considered a major factor. Disturbances to Jamestown Brook during reconstruction of Rt 138 may contribute to the problem. (Connie Carey, RIDEM, personal communication). South Pond's storage capacity is the limiting factor in its utility to the water supply. The percolating process from North Pond causes the South Pond water to have high quantities of organic matter, iron, acid, and other contaminants, resulting in discoloration and unpleasant tastes and odors. Because of the physical and water quality limitations of South Pond, it should not be considered a reliable source of drinking water. It remains a potential source if the associated problems can be overcome.	Of the 760 acres of land in the watershed, 85% is permanently protected from development. The remaining 113 acres of developable land is zoned RR-200 with a minimum lot size of 4.6 acres.
Jamestown Shores Area	Private wells	Wells running dry and salt water intrusion are already a problem in the area during drought conditions Hydrogeology investigations (Veeger et al) mapped areas of highest risk for salt water intrusion in shoreline areas.	Three sources of ground water contamination were identified in the Jamestown Shores Area: septic-system effluent, fertilizer runoff, and saltwater intrusion (one isolated occurrence of road salt contamination was noted) (Veeger, p. 27) The septic system contamination is not necessarily due to failing septic systems, but rather is due primarily to housing density. (pg.28) The occurrence of coliform, and associated high levels of nitrate in the Jamestown Shores area suggests that the high housing density has resulted in a degradation of ground-water quality due to septic system leachate (pg. 31) More than 10% of the sites sampled in the URI study showed evidence of significant anthropogenic input of nitrate to the ground water, and fully 50% of the sites show some evidence of anthropogenic input (pg.31) Higher nitrate levels in private wells are correlated with lot sizes smaller than 1 acre.	The Town has a new wastewater management ordinance requiring septic system inspections and routine maintenance; the ordinance also encourages all cesspools to be brought into compliance with state and local standards by December 31, 2006 The Town has a lot merger requirement for grandfathered parcels.

Water resources	Drinking water supply	Water quantity	Water resources protection priorities	Monitoring data & assessment of actual conditions
Groundwater supply **Jamestown Wellhead Protection Area (WHPA)** The WHPA is 280 acres in size. Three bedrock wells have been drilled (JR-1, JR-3 and JR-4) a fourth well is in the exploration stage.		Due to the impact that production would have on lowering water level in wetlands, only two of the wells can operate at the same time. To date, only JR-1 has been utilized due to wetlands permitting based on potential for lowering wetland water levels. Water is pumped directly into the intake structure of North Pond where it is mixed with reservoir water.	No contaminant detections.	A Wellhead Protection Management Plan was adopted in 1997 Residential development is subject to a 200,000 square foot development area

APPENDIX F Current and Future Land Use Summary – Jamestown study areas

CURRENT LAND USE	Jamestown Acres	Jamestown % area	Carr Pond Acres	Carr Pond % area	Wellhead Acres	Wellhead % area	Watson Pond Acres	Watson Pond % area	J. Shores Acres	J. Shores % area
Residential Density										
High < 1/8 acre lots	**8**	0.1%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Med High 1/8 - 1/4 ac/du	**214**	3.5%	**11**	5.1%	**15**	5.8%	**0**	0.0%	**60**	8.1%
Medium 1/4 - 1 ac/du	**1,096**	17.7%	**10**	4.7%	**2**	0.7%	**3**	0.7%	**345**	46.4%
Med. Low 1-2 ac/du	**538**	8.7%	**27**	13.0%	**32**	12.1%	**16**	3.5%	**54**	7.2%
Low > 2 ac/du	**222**	3.6%	**5**	2.3%	**9**	3.3%	**13**	2.9%	**5**	0.7%
Commercial	**68**	1.1%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**3**	0.4%
Industrial	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Roads	**74**	1.2%	**0**	0.0%	**11**	4.1%	**18**	4.1%	**14**	1.9%
Airports	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Railroads	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Junkyards	**24**	0.4%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Recreation	**299**	4.8%	**3**	1.5%	**10**	3.7%	**2**	0.5%	**12**	1.6%
Institution	**185**	3.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Pasture	**487**	7.9%	**14**	6.6%	**29**	11.0%	**86**	19.0%	**21**	2.8%
Cropland	**189**	3.1%	**0**	0.0%	**0**	0.0%	**38**	8.4%	**0**	0.0%
Orchards	**1**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**1**	0.1%
Brush	**347**	5.6%	**13**	6.4%	**30**	11.4%	**23**	5.1%	**31**	4.1%
Forest	**1,520**	24.6%	**52**	24.9%	**77**	29.5%	**144**	32.1%	**115**	15.4%
Barren	**33**	0.5%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**2**	0.3%
Wetland	**829**	13.4%	**48**	22.7%	**47**	18.2%	**107**	23.7%	**78**	10.5%
Water	**51**	0.8%	**27**	12.8%	**0**	0.0%	**0**	0.0%	**2**	0.2%
Total (acres)	**6,185**	100%	**210**	100%	**260**	100%	**450**	100%	**743**	100%

FUTURE LAND USE	Jamestown Acres	Jamestown % area	Carr Pond Acres	Carr Pond % area	Wellhead Acres	Wellhead % area	Watson Pond Acres	Watson Pond % area	J. Shores Acres	J. Shores % area
Residential Density										
High < 1/8 acre lots	8.0	0.1%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Med High 1/8 - 1/4 ac/du	214.1	3.5%	10.6	5.1%	15.0	5.2%	0.0	0.0%	120.0	16.1%
Medium 1/4 - 1 ac/du	1,120.6	18.1%	9.9	4.7%	1.9	0.7%	3.0	0.7%	316.0	42.5%
Med. Low 1-2 ac/du	606.7	9.8%	28.3	13.5%	31.5	11.0%	17.7	3.9%	50.0	6.7%
Low > 2 ac/du	986.0	15.9%	44.5	21.2%	67.0	23.3%	112.2	24.9%	63.1	8.5%
Commercial	68.3	1.1%	0.0	0.0%	0.0	0.0%	0.0	0.0%	3.2	0.4%
Industrial	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Roads	74.5	1.2%	0.0	0.0%	10.8	3.7%	18.3	4.1%	14.2	1.9%
Airports	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Railroads	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Junkyards	23.6	0.4%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Recreation	299.0	4.8%	3.2	1.5%	9.1	3.2%	2.3	0.5%	11.9	1.6%
Institution	184.7	3.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Pasture	268.0	4.3%	7.5	3.6%	6.8	2.4%	30.4	6.7%	5.5	0.7%
Cropland	153.1	2.5%	0.0	0.0%	0.0	0.0%	22.9	5.1%	0.0	0.0%
Orchards	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Brush	261.8	4.2%	4.1	2.0%	22.5	7.8%	17.1	3.8%	5.0	0.7%
Forest	1,003.0	16.2%	27.2	12.9%	48.2	16.8%	119.4	26.5%	72.7	9.8%
Barren	33.5	0.5%	0.0	0.0%	0.0	0.0%	0.0	0.0%	2.3	0.3%
Wetland	829.0	13.4%	47.7	22.7%	47.4	16.5%	106.9	23.7%	78.2	10.5%
Water	50.8	0.8%	26.9	12.8%	26.9	9.4%	0.1	0.0%	1.8	0.2%
Total (acres)	**6,184.9**	100%	**209.8**	100%	**287.0**	100%	**450.4**	100%	**744.0**	100%

Land Use Change

Current to Future	Jamestown Acres	Jamestown % area	Carr Pond Acres	Carr Pond % area	Wellhead Acres	Wellhead % area	Watson Pond Acres	Watson Pond % area	J. Shores Acres	J. Shores % area
Res. Density - acres/ dwelling unit (lot size)										
High < 1/8 acre lots	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Med High 1/8 - 1/4 ac/du	**0**	0.0%	**0**	0.0%	**0**	-0.5%	**0**	0.0%	**60**	8.1%
Medium 1/4 - 1 ac/du	**25**	0.4%	**0**	0.0%	**0**	-0.1%	**0**	0.0%	**(29)**	-4.0%
Med. Low 1-2 ac/du	**69**	1.1%	**1**	0.5%	**(0)**	-1.1%	**2**	0.5%	**(4)**	-0.5%
Low > 2 ac/du	**764**	12.3%	**40**	18.9%	**58**	20.0%	**99**	22.0%	**58**	7.8%
Commercial	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Industrial	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Roads	**0**	0.0%	**0**	0.0%	**(0)**	-0.4%	**0**	0.0%	**0**	0.0%
Airports	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Railroads	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Junkyards	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Recreation	**0**	0.0%	**0**	0.0%	**(1)**	-0.6%	**(0)**	0.0%	**0**	0.0%
Institution	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Pasture	**(219)**	-3.5%	**(6)**	-3.0%	**(22)**	-8.7%	**(55)**	-12.3%	**(15)**	-2.1%
Cropland	**(36)**	-0.6%	**0**	0.0%	**0**	0.0%	**(15)**	-3.3%	**0**	0.0%
Orchards	**(1)**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**(1)**	-0.1%
Brush	**(85)**	-1.4%	**(9)**	-4.4%	**(7)**	-3.5%	**(6)**	-1.3%	**(26)**	-3.5%
Forest	**(517)**	-8.4%	**(25)**	-11.9%	**(29)**	-12.7%	**(25)**	-5.6%	**(42)**	-5.7%
Barren	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%	**0**	0.0%
Wetland	**0**	0.0%	**0**	0.0%	**0**	-1.7%	**(0)**	0.0%	**0**	0.0%
Water	**0**	0.0%	**(0)**	0.0%	**27**	9.4%	**0**	0.0%	**0**	0.0%
Total (acres)	**6,185**	100%	**210**	100%	**260**	100%	**450**	100%	**743**	100%

Note: Projections are based on RIGIS land use maps and do not include development on substandard lots of record.

Build out assumptions include the following:
• All permanently protected open space will not be built upon.
• Most privately held open space (Scout Camps, golf courses, rod & gun clubs) will also not be built upon.
• Areas with severe slope (>15%), wetlands, bedrock on surface, and very high water table soils (>1.5') will not be built u
• Wetlands and 150' buffer thereto will not be disturbed.
• Development of remaining unprotected forest, farmland and other vacant land will occur at the density of current zoning

APPENDIX G

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.

[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

Hydric Soil Drainage Classes

V-Poorly Drained

SP-Somewhat Poorly Drained

VP-Very Poorly Drained

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

Compiled by Adam Rosenblatt, URI

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) 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.

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: http://www.edc.uri.edu/spfdata/rigisup2002/Soil/risoi96.met	See below for uses.

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 Layer	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 Maps	TIF image files of USGS 7.5 minute topoquads that encompass RI. Distributed on USGS Quad basis.	Used as base map for most 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.

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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

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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 (25^{th} = low, 50^{th} moderate, 75^{th} = high, 95^{th} = 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:

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

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 leaching, use of nitrogen-reducing septic systems, and stormwater treatment 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

Jamestown Source Water Assessment
Hydrologic and Nutrient Loading Assumptions

HYDROLOGIC BUDGET:

Average Annual Precipitation 40.0 inches
Average Annual Evapotranspiration 18.0 inches

Surface Runoff Nutrient Loading Factors

Surface Runoff Coefficients

LAND USE	Surface Runoff Coefficients Low	High	Phosphorus lb P/acre/year Low	High	Nitrogen lb N/acre/year Low	High	
[1] HD Res.(>8 /ac)	0.64	0.77	3.2	3.9	10.6	12.8	
[2] MHD Res.(4-7.9/ac)	0.39	0.64	2.0	3.2	6.5	10.6	
[3] MD Res.(1-3.9/ac)	0.23	0.39	1.2	2.0	3.8	6.5	
[4] MLD Res.(0.5-0.9/a	0.16	0.23	0.8	1.2	2.7	3.8	
[5] LD Res.(<0.5/ac)	0.10	0.16	0.5	0.8	1.7	2.7	
[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	2.0	3.2	6.5	10.6	
[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

	2.41	people/dwelling unit	*(Based on Jamestown Planning Dept. 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)	***4.00***	*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 to ***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 reduce ***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.

URI Manage Impervious Coefficients

RIGIS Land Use	Updated 2003*	Original USDA 1975
HD Res. 1/8 acre	55	72
MHD Res. ¼ acre	36	50
MD Res 1 acre	14	30
MLD Res 2 acre	11	16
LD Res. < 2 acre	8	8
Commercial	72	72
Industrial	54	72
Roads	72	72
Airports	72	72
Railroads	72	72
Junkyards	72	72
Recreation	10	10
Institution	34	50

*Based on CWP 2002 adjusted to reflect RI parcel characteristics

APPENDIX L

Recommendations for groundwater protection / wastewater management
Jamestown Source Water /Wastewater Needs Assessment
Lorraine Joubert, URI Cooperative Extension
Revised 4/8/02

FINDINGS

Town goals

Protecting the Island drinking water is a primary goal of the Town's comprehensive community plan.

Limited water supply

As an island ecosystem, the Town of Jamestown depends on a limited supply of fresh water drawn from municipal wells interconnected with small surface water reservoirs, and private wells.

All drinking water comes from rain and snow that seeps into the ground, reaching cracks in underlying bedrock.

Groundwater occurs as a thin layer, or lens-shaped mound of fresh water in bedrock fractures. Because it is less dense than seawater, this fresh water "floats" above the surrounding salt water found below and at the island edges. The thickness of the lens with freshwater in bedrock fractures is estimated to be about 500 feet in the center of the Island, thinning to tens of feet at the perimeter of the island. Overpumping wells can result in salt water intrusion, drawing salt water into the freshwater lens. (Veeger etal. 1997)

The Island's bedrock aquifers have limited yield, especially compared to deep sand and gravel aquifers found in other parts of the State.

The public water supply is at maximum capacity and safe yields may be exceeded in summer months. Private wells running dry and salt water intrusion is a problem during drought conditions.

The town has no other drinking water sources directly under its control. Additional off-island water connections are available for emergency supply only, subject to available capacity.

Protecting both the quality and limited amount of this supply is essential to meet the Island's current and future needs with limited growth.

The quality of drinking water is a reflection of land use activities in the watershed or recharge area, the quality of effluent discharged from septic systems, and the amount of recharge available to dilute infiltrating pollutants.

Water quality is directly related to land use activities in surface watersheds and groundwater recharge areas. Because ground and surface waters are connected, contaminants entering one resource can easily pollute the other.

Existing water quality

The quality of public drinking water in Jamestown is generally very good but there are signs of impact from land use activities.

USGS investigations show that groundwater in densely developed areas is contaminated with nitrogen and bacteria from wastewater effluent. Nitrate concentrations above 1 mg/l are a sign that groundwater is receiving animal waste, septic systems, or fertilizers. Elevated nitrogen also indicates the potential presence of other land use pollutants, such as bacteria and organic chemicals. Of 122 wells sampled by

USGS (Veeger etal. 1997) in northern Jamestown, more than 50% had nitrogen concentrations above 1 mg/l. About 9% were in the 5 – 10 mg/l range, indicating significant inputs from land use activities.

DEM has listed Jamestown Brook, which connects the Carr Pond and Watson Pond reservoirs, as not meeting water quality standards due to high bacteria and poor stream habitat.

Water Quality Threats

Pollution risks are concentrated in densely developed areas with substandard lots. Under the RI Department of Health Source Water Assessment, URI Cooperative Extension identified threats in the Jamestown Shores area to include the following:

- Extensive pavement, rooftops, and other impervious cover (21%) reduces recharge, degrades stream habitat, and bypasses natural pollutant removal processes is soils.
- Lost recharge to groundwater from development-related runoff is estimated to be 162 million gallons per year.
- Low forest and wetland cover (26%) minimizes natural pollutant removal function.
- Nitrate loading to groundwater is estimated to be approximately three times higher in the Jamestown Shores area than the Town overall.
- Septic systems are estimated to contribute more than 80% of the nitrogen entering as groundwater recharge.
- Approximately 32% of homes in the Jamestown shores area were built before 1970, have no record of repair, and are likely to be cesspools.
- With future development, pollution risks are expected to remain low in the drinking water supply areas due to large lot zoning, but continue to increase further in the Jamestown Shores area.
- Nutrient loading estimates indicate that future increases in nutrient loading to groundwater can be kept closer to present levels by use of advanced treatment systems for new construction and repairs on substandard lots and by avoiding new development of parcels with severe shallow depth to water table (0 – 1.5 ft.).

Dense, slowly permeability till soils typical of the island are characterized by an underlying restrictive layer or "hardpan" and seasonal high water table. These have severe limitations for development due to the potential for septic system failure, horizontal movement of effluent along restrictive layers, high runoff and wet basements.

Mapped soil information provides only an approximate indication of soil types and associated characteristics for planning purposes and actual water table depth may vary significantly. As a result of the restrictive layer (permeability 0.2 inches per hour) typical of the Island, soils with a mapped water table depth of greater than six feet are not likely to be found; actual seasonal water table is more likely to be 1.5 – 3.5 feet (J. Turrene, Soil Scientist, Natural Resources Conservation Service, Personal communication).

In a recent field study of water table fluctuations in Jamestown, URI researchers (Stolt, et al., 2001) found that dense till soils typical of the Island respond rapidly to rainfall with rising water table depths, resulting in higher water table than expected. At both study sites, soils (Pittstown and Sakonnet series) mapped as having a seasonal high water of 1.5 – 3.0 feet were found to have high water table at or near the surface following rainstorms. As a result, septic systems designed for the lower water table depth will be inundated with groundwater during at least a portion of the year, increasing the risk of effluent movement.

Onsite wastewater treatment technologies are available to provide advanced treatment of nitrogen and /or pathogens on very small lots with limited site disturbance and without fill "mounds" required for conventional systems constructed in high water tables.

Localized flooding with continued development in wet areas has been identified as a concern in densely developed areas.

MANAGEMENT OPTIONS

The authors of the USGS groundwater investigation recommend septic system maintenance, use of advanced treatment systems where needed, and controlling impacts of future development on small lots-of-record. The URI Cooperative Extension assessment also supports focusing pollution controls in areas of dense development where pollutant inputs are likely to be the greatest. In addition, we used the following approaches to develop our recommendations:

- Focus pollutant controls in high risk areas such as areas of dense development, high water tables and shoreline buffers where the potential for pollutant movement is the greatest.
- A high level of protection is needed to restore contaminated wells and protect the Island's highly vulnerable water supply.
- Existing State ISDS standards are minimum standards that do not specifically address the Island uniquely vulnerable conditions.
- A balance of stormwater controls and wastewater management improvements is needed to limit pollution sources while enhancing natural pollutant removal processes.
- Existing State regulations for Stormwater Management do not specifically target runoff volume, nutrients or pathogen reduction.
- Maintaining water quality through pollution prevention is generally more cost effective than restoring degraded waters.

GOALS

Recommendations are designed to achieve the following performance goals:

- Ensure proper septic system operation to avoid inadequate pathogen treatment,
- Maintain groundwater nitrogen at safe concentrations for private wells,
- Control volume of stormwater runoff through on-site infiltration to recharge groundwater supplies, promote natural pollutant removal processes, and dilute wastewater effluent and other contaminants entering groundwater.
- Protect and restore wetland buffers to maintain their water quality function by filtering sediment, other pollutants in surface runoff, and promoting denitrification of shallow groundwater.
- Limit use of advanced treatment systems where necessary and provide for their adequate maintenance.

A, ISLAND-WIDE RECOMMENDATIONS

ISDS siting and performance

Phase out cesspools, beginning in areas of densely developed substandard lots, source water areas, shellfishing areas, and sensitive aquatic habitat.

> *Rationale: More than 32% of homes in Jamestown are estimated to have a cesspool or other substandard system. Cesspools do not treat wastewater, both solids and liquid eventually seep in to the groundwater These outdated systems present the most serious risk to groundwater quality from onsite systems.*

Prohibit galleys. Deep (4 x 4 ft.) leaching chambers or "galleys" provide little opportunity for effluent treatment by natural soil processes due to the depth of discharge (6-10 ft. below the ground surface) to groundwater and small leaching area. In addition, these are unsuitable for slowly permeable soils occurring in Jamestown.

Require all new or repair septic systems to meet the following standards:

- Watertight tank testing
- Access risers (retrofitting functioning tanks recommended)
- Effluent filters
- Tipping distribution box where appropriate for gravity flow leaching systems

Site Evaluation

On marginal sites where the seasonal high water table is 3 ½ feet from the ground surface or less, the site evaluation to determine water table depth and suitability for onsite wastewater treatment shall be conducted by a certified professional soil scientist registered by the American Registry of Certified Professionals in Agronomy, Crops, and Soils, Ltd. (ARCPACS), recognized by the Soil Science Society of Southern New England (SSSSNE) and also holding a RIDEM Class IV Designer License (i.e. Soil Evaluator), OR by a certified professional soil scientist certified as noted above working with a DEM Class IV Designer.

Construction

The site where the septic system leachfield is to be located should be protected from compaction by heavy equipment, vehicles, material storage, and other disturbance by clearly identifying the correct location on the plans and fencing off the area using construction fencing or other physical barriers sufficient to prevent disturbance. The site should be designed to keep heavy traffic from the site following construction, using a permanent fence where there is a potential for cars to drive over or park above the system.

> *Rationale: Protecting the leach field area to maintain infiltration capability is recommended under all circumstances but especially in the silty soils characteristic of Jamestown as these are particularly susceptible to compaction.*

For all new and repair septic systems, stormwater should be diverted from the leaching area and wherever possible, retained on the lot. Increased flow to neighboring properties should be avoided.

Maintenance

For any system requiring a pump or other mechanism, the septic system owner should be required to demonstrate that a maintenance contract is in effect with a contractor qualified to perform routine inspection and maintenance for the type of system installed. The applicant should be required to submit evidence that a maintenance contract is in place annually. Ideally, operating permits would be issued annually as a means to enforce this provision. Maintenance firms would be registered with the town and required to notify the town when a contact is terminated.

Stormwater Management

The following recommendations for stormwater management and public actions are applicable Island-wide, but especially for source water areas (public and private) and areas where unique aquatic habitat, shellfishing, and swimming areas may be affected.

- Establish a goal of 10% impervious cover for new construction, repairs, expansion and redevelopment on individual residential lots and subdivisions in drinking water source areas, and a goal of 20% for substandard lots and noncritical areas served by public water. Reduce impervious cover in commercial and mixed use areas on a case-by-case basis.
- Maintain pre-development runoff rates and volume, avoiding a net increase in off-site runoff.
- Encourage use of nonstructural stormwater controls to maintain pre-development hydrology. Simple techniques include diverting runoff from roofs and other paved surfaces to lawns, naturally vegetated areas, and small depressions, or very shallow impoundments serving as temporary on-lot storage and infiltration sites.
- Avoid regrading that may intercept perched water table and bypass subsurface flow.

- Minimize the amount of pavement and other impervious material covering the site through design, narrow driveways, and use of gravel or permeable pavers rather than asphalt.
- Minimize site disturbance and removal of natural vegetation associated with construction.
- Provide for on-lot storage and of the first 1" rainfall on impervious areas consistent with RI DEM stormwater management guidelines (RIDEM 1980). As a rule of thumb, allow approximately 5-10% of the site for on-lot retention and infiltration of surface runoff. (Prince George's County, 2001; R. Claytor, personal communication).
- Using cisterns to capture roof runoff for lawn and garden watering is recommended.

Municipal and State

- Incorporate impervious limits in town comprehensive plan.
- Establish a town policy to use low-impact stormwater management systems on public properties.
- Plan for stormwater drainage system retrofits with road work or redevelopment. (Focus on retrofitting direct discharges to swimming and shellfishing areas, including areas served by public water.)

B. ADDITIONAL RECOMMENDATIONS FOR PUBLIC DRINKING WATER SOURCE AREAS AND AREAS SERVED BY INDIVIDUAL WELLS

Setbacks to wells

No onsite wastewater treatment systems should be permitted within 400 feet of a public well. If unavoidable, advanced treatment should be required.

- Maintain 100' minimum setback from new or repaired onsite wastewater treatment systems to private drinking water supply wells.
- For repairs, require advanced treatment for pathogen removal where the 100 foot setback cannot be met. Where a septic system repair is located less than 80 feet from a well, no increase in livable area and associated wastewater flow should be allowed.
- No new septic system construction should be permitted within 100 feet of a well except that this distance may be reduced to 80 feet where a pathogen treatment systems is used and all other steps have been taken to reduce flow and minimize pollution risk.
- Consider replacing existing shallow dug wells with sealed drilled wells as needed on a case-by-case basis.

Large systems

- New or repair systems with a maximum daily design flow of 900 gallons per day or larger should be required to provide advanced wastewater treatment. Analysis of groundwater flow paths, mounding analysis, and impact to water quality may be required where there is potential impact to nearby wells or other sensitive receptors.
- Systems discharging high strength wastes such as restaurants should be required to provide adequate pretreatment.

Hazardous materials

Systems serving commercial uses or home businesses and having the potential to discharge toxic materials should have a separate holding tank to accommodate potentially contaminated wastewater. Beauty parlors are one example.

Rationale: Recent studies by the MA Department of Environmental Protection have found this precaution necessary to protect groundwater.

C. HIGH WATER TABLE ZONE A

Depth to seasonal water table 0 – 2 feet
Depth to impervious layer 0 – 4 feet

In this zone the following additional recommendations apply to areas where the water table is estimated to be within 0-2 feet of the ground surface during any part of the year or where an impervious layer is within four (4) feet of the surface.

Prohibit new construction of onsite wastewater treatment systems.

> *Rationale: As noted in the findings sections, Stolt (2001) and others found that water tables in dense till soils in Jamestown quickly responded to rainfall, rising to higher levels than that estimated by the RI Soil Survey, and remained elevated for days following the rain event, especially during the wet season with frequent storms and low evapotranspiration.. Elevated groundwater levels increase the potential for improperly treated effluent to enter saturated soils. Once in the groundwater, there is a greater potential for pathogens to survive and phosphorus to remain mobile, and then move laterally to surface waters or water supply wells (EPA, 2000).*

Require use of advanced onsite wastewater treatment systems for repairs serving existing dwellings.

The type of system should be approved by RIDEM, and meet standards for secondary treatment of total suspended solids (TSS) and biological oxygen demand (BOD), and/or pathogen treatment, and/or nitrogen removal to the levels specified below (definitions). The system type shall be determined on a case by case basis by the system designer based upon the adjacent wetland or water resource. Town staff shall approve the final system selection. Factors considered should include the need to reduce pathogens to drinking water sources, nitrogen loading to sensitive coastal waters, phosphorus inputs to nutrient-sensitive fresh waters, and the need to minimize site disturbance, regrading, stormwater runoff volume, loss of naturally vegetated areas, and visual/aesthetic impacts.

> *Rationale: Using advanced treatment systems for repairs with a shallow pressurized drainfield or bottomless sand filter eliminates the need for extensive filling with a conventional raised "mound" system while providing far better effluent treatment.*

Prohibit expansion of existing uses on substandard lots smaller than 1 acre and dependent on private wells.

Allow limited expansion of existing uses where all other applicable provisions have been met and all steps have been taken to minimize impact.

Allow new construction where the water table is within 18" in noncritical areas where lot impervious cover will not be more than 20%, public water is available, all other requirements have been met, including maintenance of pre-development hydrologic characteristics.

Limit maximum impervious cover for new construction, repairs, expansion and redevelopment on individual lots and subdivisions as follows: **NOTE: Impervious limits apply to Zone B and wetland buffers also. Include in general island section to avoid duplication.**

- 20 percent impervious limit on substandard lots smaller than 1 acre. (Because this maximum level includes all accessory structures it is strongly recommended that the building footprint for the dwelling be kept to 15% or other level below 20% to accommodate future needs).
  Rationale: The existing estimated percent impervious land use is estimated to be about 20% in densely developed areas (Jamestown Shores). Given that future development in this area is limited,

setting a goal to maintain this present level is realistic and would help minimize increased runoff and reduced recharge with future growth.

- 10 percent impervious limit for public drinking water supply watersheds and wellhead protection areas.
  Rationale: Numerous research studies (Arnold & Gibbons 1996; Schueler 1994) show that stream quality is closely correlated with impervious land cover, with levels higher than 8-10% corresponding to reduced stream habitat quality. Maintaining low impervious cover will also help maintain recharge rates to sustain water yields. The estimated impervious cover in source water areas is estimated to be less than 5% for current land use, without significant change with future low-density development. Maintaining 10% is realistic given the existing low levels.

- In each case, portions of the lot that are wetland should be excluded from the calculation. Percent Impervious Area = [Total impervious area (sq.ft. or acres) / Total lot area – wetland area (sq.ft. or acres)] x 100

Prohibit use of subsurface drains to intercept or otherwise lower the water table, especially on substandard lots of record smaller than one acre, except where necessary to ensure adequate function of the wastewater treatment system.

Rationale: Subsurface drains intercept groundwater that otherwise might be available to gradually recharge groundwater. This also creates a discharge that must be handled to avoid contributing to high water tables or nuisance flooding on neighboring properties. On small substandard lots with high water table there are few opportunities to store and infiltrate this discharge on site. Finally, subsurface drains installed in close proximity to the leach field have the potential to intercept and convey wastewater effluent. To minimize this risk, RIDEM specifies a minimum distance from disposal trenches, bed or flow diffusers the drainfield of 25' upgradient and 75' downgradient of the leachfield, with also a 50 feet minimum distance from the point of drainage discharge to any watercourse.

Prohibit installation of basements with either new construction or expansion.

Rationale: The amount of groundwater displacement is minimal (roughly equivalent to one month's wastewater flow from a typical 3-bedroom system, A. Gold, Personal communication). However, waterproofing sealants are not always 100% effective and the more practical problem is that homeowners may be compelled to install subdrains at a later date when sealants fail.

Maintain pre-development hydrologic conditions, with no net increase in runoff rate and volume, using techniques listed under Island-wide stormwater management above.

Where necessary to further minimize potential impacts, establish a building envelope for all site disturbance, construction, stockpile areas and material storage. Delineate the smallest possible area of disturbance need for construction, delineate boundaries on plans, and fence off in the field.

D. HIGH WATER TABLE ZONE B
Depth to seasonal water table 2 – 3.5 feet
Depth to impervious layer 4 – 6 feet

In this zone the following additional recommendations apply where the water table is estimated to be within 2 - 3.5 feet of the ground surface during any part of the year or where an impervious layer is within 4 –6 (4) feet of the surface.

Require use of advanced treatment systems for new system construction, expansion of existing uses, and repairs serving existing dwellings on substandard lots smaller than 1 acre. In other areas, use advanced treatment systems where necessary to reduce site disturbance and provide a higher level of treatment on a case-by-case basis.

Impervious limits specified for Zone A apply.

Avoid use of subsurface drains on substandard lots except where necessary for system function. Avoid installation of basements in these areas to minimize need for subdrains.

E. WETLAND BUFFERS ZONE C

Maintain 150' undisturbed buffer from a septic system leaching system to either a freshwater (or coastal) wetland.

The freshwater wetland edge and presence of "special aquatic sites" such as vernal pools shall be identified by a qualified professional wetland scientist, recognized by the RI Association of Wetland Scientist (RIAWS). Wetland boundaries shall be clearly flagged in the field and corresponding locations identified on the plans. The accuracy of the delineation shall be attested to by and the plans dated and signed by the biologist. Where the wetland boundary or presence of a special aquatic site is in question the applicant shall request a determination from the RI Department of Environmental Management.

New subdivisions shall be designed to preserve undisturbed buffers. Where wetland buffers are located within private lot boundaries, a permanent fence or other bound should be installed to mark the edge of buffer and discourage encroachment. The developer should also be required to notify the homebuyer of any wetland restrictions on the lot.

For pre-existing lots of record in critical areas the following conditions are recommended:

- Limit impervious cover to 10% in critical areas (drinking water supply watersheds, wellhead protection areas, areas of sensitive aquatic habitat and shellfishing areas), excluding wetlands (20% in noncritical areas).
- Where vernal pools or other special aquatic sites have been identified, these will be protected and an undeveloped migration pathway provided to nearby wooded and/or aquatic areas.
- The location of the septic system and associated dwelling has been sited as far from the wetland as practical.
- The project will result in the least site disturbance and vegetation removal as possible.
- In sensitive areas, identify limits of disturbance to include areas to be cleared and/or graded, construction easements, temporary material and equipment storage areas, and temporary stockpiles. These areas should be delineated on plans and fenced off in the field. Adequate protection must be provided to individual trees and groups of trees to avoid construction injury.
- There will be no net increase in off-site runoff volume and runoff is controlled primarily through nonstructural means.
- The applicant has developed an erosion and sediment control plan.
- The buffer is revegetated as soon as practical following disturbance using native, noninvasive species (refer to URI Cooperative Extension 1999. Sustainable Trees and Shrubs, 3rd Edition, East Alumni Avenue, Kingston, RI (401) 874-2900.
- A permanent fence is erected to demarcate the wetland buffer and prevent future encroachment.
- In critical areas, land disturbance will be scheduled to avoid seasonal high water levels from October through April, or as otherwise determined locally.

- Advanced wastewater treatment is recommended to used to reduce pollutant inputs and limit site disturbance. In less critical areas the need for advanced treatment will be based on presence of high water table and the need to limit site disturbance.

Definitions

1. All **water table depths** are measured from the original ground surface. Maps developed from the RI Geographic Information System (RIGIS) are available to show approximate depths to water table at 0-1.5 feet and 1.5 to 3 .5 feet (not 2 feet). Mapping is not available to show water table depths greater than 3.5 feet. These maps are to be used only as a planning tool. Actual measurements must be obtained from on-site data. In the event that critical depths for the various site characteristics overlap, the most restrictive shall apply.
2. **Impervious layer** includes "ledge" and other soils with a percolation rate equal to or slower than 40 minutes per inch.
3. **Restrictive layer** includes "hardpan" and other soils with permeability equal to or less than 0.2 inches/hour.
4. **Impervious cover** includes paved driveways, concrete, rooftops, basketball courts, accessory structures such as sheds, and any other surfaces that restrict water from infiltrating into the ground. Gravel driveways, walkways and patios constructed using permeable pavements are not included as impervious areas. Wetland area present on the lot should be excluded from the total lot area for the purpose of calculating impervious area.

   Percent Impervious Area = [Total impervious area (sq.ft. or acres) / Total lot area – wetland area (sq.ft. or acres)] x 100

Wastewater Treatment Performance standards

The design of advanced onsite wastewater treatment systems must be approved by RIDEM. The technology shall be selected on a case by case basis to meet water resource protection needs, overcome site constraints, and be capable of meeting one or more of the following treatment standards:

> **Nitrogen Removal:** minimum total nitrogen removal of fifty percent and a reduction to less than or equal to 19mg/l total nitrogen, and biochemical oxygen demand and total suspended solids each reduced to less than or equal to 30 mg/l; all as measured at the outlet of the treatment unit prior to discharge to a drainfield.*
>
> **Pathogen treatment**: reduces fecal coliform to less than or equal to 1,000 fecal coliform counts/100ml and reduces biochemical oxygen demand and total suspended solids to less than or equal to 10 mg/l as measured at the outlet of the treatment unit prior to discharge to a drainfield.*
>
> **Secondary treatment for BOD and TSS:** Biochemical oxygen demand and total suspended solids each reduced to less than or equal to 30 mg/l; all as measured at the outlet of the treatment unit prior to discharge to a drainfield, and where an alternative drainfield is used to enhance wastewater treatment capacity using a shallow narrow pressurized drainfield or single pass sand filter as the final polishing and dispersal unit.

*Shallow narrow pressurized drainfields or a single pass sand filter is the recommended dispersal unit for these systems. Where pathogen treatment is critical UV disinfection is appropriate.

APPENDIX M Response to comments from 9/9/02 hearing

Lorraine Joubert, URI Cooperative Extension

Comment #s listed

2. DEM establishes Statewide **Minimum** Standards for sewage **disposal**, not treatment to address local resources. DEM strongly encourages towns to establish site specific standards.

6 and 7. We believe there is a strong technical basis for maintaining 8-10% impervious in water supply areas based on potential impacts to streams. This standard is easily met on a watershed level and exceptions could be made for substandard lots where efforts are made to keep impervious as low as possible. In less critical areas the issues becomes maintaining recharge for groundwater recharge and dilution of effluent where wells are used, inavoiding increased runoff, nuisance flooding, and maintaining natural pollutant removal in soils to protect wells and nearby surface waters.

In Jamestown shores our initial recommendation was to maintain current levels, given that nuisance flooding is already a problem. We estimated 20% based on only the lots in Jamestown shores (Plat 3, 5, 14, 15, and 16). The less developed plat 4 is not included in this or other land use calculations when referring to Jamestown shores.

If the Town agrees maintaining current conditions is a reasonable goal, it would be useful to determine if our estimates are close enough to reality. Depending on the coefficients used for impervious, Jamestown shores could currently be only 12-15 percent impervious (see table following below) Although we took into account typical house/lot sizes for this area a more thorough analysis may be justified.

8. I contacted Dr. Veeger. She agreed to provide the town with a copy of the final but stated this has no new information – final form was requested by DEM.

9.
a) Impervious levels can be easily met in most areas, as shown in following table. Adminstrative review can be used where applicants are proving actions are taken to meet the standard.

Lot Size (sq.ft.)	**Percent Impervious**					
	25%	**20%**	**15%**	**10%**	**8%**	**5%**
5000	1,250	1,000	750	500	400	63
7,200	1,800	1,440	1,080	720	576	90
10,000	2,500	2,000	1,500	1,000	800	200
20,000	5,000	4,000	3,000	2,000	1,600	400
40,000	10,000	8,000	6,000	4,000	3,200	800
80,000	20,000	16,000	12,000	8,000	6,400	1,600
120,000	30,000	24,000	18,000	12,000	9,600	2,400
200,000	50,000	40,000	30,000	20,000	16,000	4,000

As shown above percent impervious limits only become a concern with very small lot sizes. Even a 7,200 sf lot typical of the smallest in Jamestown shores area can accommodate a 36 x 30' house at 15% impervious. Driveway can be permeable materials.

These estimates do not include impervious associated with roads required for new development.

b) Flood control requirements and standards for infiltration should be adjusted based on following.

Stormwater Design Standards for Flooding vs Water Quality vs. Recharge

	Flood control	**Water Quality**	**Recharge**
Center for watershed protection	2, 5, 10, or 25-y ear storms	Treat 90% of the average annual stormwater runoff volume (1"each rainstorm)	Recharge volume required for impervious areas based on soil hydrogroups as follows. MA DEP requirements are similar. Jamestown has mostly C hydrogroup soils. A = .38" B = .25" C = .13" D = .06" This means on an individual lot only 0.13 inches /rainstorm may infiltrate. This is much lower than the 1" volume to be treated and far lower than the flooding volume.
RIDEM	Maintain postdevelopment peak runoff rates for 2 and 25 year storms.	Same 1" rule – remove 80% TSS for first inch of runoff from impervious areas. DEM recognizes this is minimum and higher standard is needed for sensitive or degraded areas.	Encourages maintaining pre-development volume but no standard given. Manual is outdated and being revised to address nonstructural controls and

Recommendations for infiltration

CWP recognizes that most likely communities will need to incorporate stormwater credits such as stream buffer requirements and rooftop disconnection to meet the requirement. Avoid direct recharge from pollution hotspots such as convenience stores and gas stations.

Because infiltrating is so difficult to achieve, especially in slowly permeable high water table areas typical of Jamestown, we strongly favor keeping impervious low to begin with, reducing site disturbance to avoid compacting soil.

Other actions include diverting rooftop runoff to lawns or even rain barrels, build in swales and small bioinfiltration areas to temporarily retain runoff onsite.

Use gravel or permeable pavers for driveways; plastic grids with gravel or grass fill for low use areas, wooden decks and patios where water can infiltrate between boards and underneath, not bricks. Porous pavement not recommended for home use as is high maintenance and some evidence shows clogging is likely eventually. Crushed rock storage below driveways as recommended by R. Pastore is a good idea provided water table is deep enough.

Avoid basements and subdrains on small lots; allow on larger lots where provision is made to keep discharge on site.

Requiring flood control runs counter to these recommendations as it will require extensive site disturbance and basin construction.

If adopted as conditions of approval, applicants meeting these and other recommendations could obtain administrative review and approval.

c) We still stand by our recommendations of 4/8/02. However, minimum water table depths could possibly be reduced to 18" in noncritical areas with public water, where impervious levels and buffers requirements are met. The town may also consider calculating impervious area on the upland portion of the site and excluding at least a portion of the wetland. This, or establishing minimum buildable lot size for a house would avoid building on sites that are almost 100% wetland.

19. Nitrogen estimates
The issue of nitrogen removal in groundwater is currently a subject of much debate in the scientific community. Some researchers such as I. Valiela, whose student compared our mass balance model with others, use a standard (30%) reduction in groundwater nitrogen for sources distant from a receiving water body or well. Art Gold and others have found up to 80% nitrogen removal in wetland sediments but there is great uncertainty about how much N-enriched groundwater is actually flowing through these shallow soils. Because of these uncertainties our model examines nitrogen sources for comparative purposes among study areas and to compare current/future scenarios, without attempting to account for removal. Obviously higher loadings increase pollution risks and over time, groundwater concentration is likely to reflect higher inputs. Nitrogen is also used as an indicator of pathogens and other pollutants in wastewater effluent.

- Because wetland sediments are known to remove nitrogen as well as filter sediment and phosphorus, we strongly recommend maximum protection for wetland buffers to preserve this water quality function.

- Maintaining recharge on individual lots helps ensure subsurface flow paths through wetland treatment zones rather than short-circuiting directly to stormdrains, surface waters and wetlands.

Response to I. Valiela follows

MEMORANDUM

TO: Jennifer Bowen
Ivan Valiela

FROM: Lorraine Joubert, Q. Kellogg, Dr. Arthur J. Gold

DATE: 1/19/01

SUBJECT: Model comparison

Thank you for the opportunity to comment on your draft report "Assessment of models for estimation of land-derived nitrogen loads to shallow estuaries". We are uncomfortable with the basic concept of comparing Manage results to field data – that suggests we were trying to create a validated model. We did not create Manage as a research tool, but as a decision support tool. The groundwater nitrogen loading component of Manage is only one of many risk indices within the model and it is not appropriate to use the groundwater nitrogen loading component independent of the Manage assessment tool as a whole. Any review or comparison of Manage should focus on the GIS "hot spot" mapping approach and the use of multiple risk indices, and not solely on the nitrate loading index. I have included specific comments as highlighted revisions to the document itself. Our major concerns are as follows:

1) Manage is designed as a GIS-based risk assessment tool to assist local decision makers involved in watershed management issues. The heart of Manage is GIS "hot spot" maps that display current locations that have a high risk of water quality degradation and undeveloped areas that could have a high risk of water quality degradation if they are not developed with care. We have included a recent report that illustrate these aspects of Manage.

2) Manage uses a number of risk indices to communicate "cumulative" water quality risks at the watershed or subwatershed scale. These include % impervious cover, nitrogen loading, phosphorus loading, % developed lands within 100 meters of surface waters and high risk land uses. The attached list of watershed indicators includes the various factors that may be considered.

3) Our nitrogen loading component deals strictly with ***sources*** of inputs to surface water runoff and groundwater infiltration. We did not include nitrogen sinks, because we believe that great scientific uncertainty surrounds the fate of nitrate in groundwater. Therefore, we stress that the results are intended for relative comparison among different land use/pollution control options, or for comparison among subwatersheds. In conjunction with the other components of the Manage model, we believe relative results are appropriate for management decisions, especially at a screening level. We have found that local communities rarely have the budget to create a detailed, scientifically valid set of monitoring data and Manage is intended to provide insight into watershed/water quality relationships.

4) We suggest that without high resolution data on groundwater flowpaths through organically enriched, anaerobic soils, a watershed nitrate model will have great uncertainties that are difficult to quantify. Our own research (Groffman and Gold) and the work of Robertson, Devito, and Hill in Ontario has demonstrated that nitrate can behave conservatively for long distances in sandy aquifers and undergo marked transformations over brief distances if appropriate riparian characteristics exist.

5) Because of the uncertainty, spatial variability and large error bars associated with groundwater field data, we have chosen to use the nitrogen loading component of Manage strictly in the context of a decision support tool, rather than as a validated model.

6) We also chose to develop our model as a comparative decision support tool because of our concern for non-uniqueness of watershed models. Given the many significant gaps in our understanding of watershed nitrogen sources, travel paths and transformations, we are concerned that multiple combinations of factors can interact to produce "agreement" with field data. Thus, we have chosen to inform and assist decision makers by providing them with a suite of tools, such as GIS mapping, to help them manage watershed risks to water resources.

Again, thank you for the opportunity to comment. We hope you can add some caveats to your comparisons with the Manage model. Please contact me if you have any questions.

APPENDIX N

GIS Documentation of Parcel-Based Septic system repair analysis
Jamestown Shores and northern area including Plat 4

	Jamestown Shores (Plats 3, 5, 14, 15 & 16)	**Plats 3, 4, 5, 14, 15 & 16** (Graphic Image)
Jamestown Shores Parcel Preliminary Analysis		
Number of Parcels	**1357**	**1484**
Developed Residential (statecode = 01)	**807**	**886**
Single Family (statecode = 01)	**754**	**828**
Multi-family (statecode = 02)	**2**	**3**
Seasonal (statecode = 11)	**51**	**55**
Undeveloped Residential (statecode = 13)	**403**	**427**
Cemeteries (statecode = 70)	**2**	**3**
Municipal (statecode = 78)	**65**	**69**
State (statecode = 80) mostly public-right-of-way along roads	**36**	**36**
Other Improved Land (statecode = 13)	**8**	**8**
Farm, Forest & Open Space (statecode = 33)	**0**	**13**
NOT CODED	**14**	**15**
Jamestown Shores Septic Repair Preliminary Analysis		
Number of recorded septic system repairs	**62**	**71**
Number of recorded pre-1970 residential units	**292**	**332**
Number of recorded pre-1970 septic repairs	**31**	**38**
Number of parcels with high water table soils (HG C 0-3.5’, HG D)	**651**	**743**
Number of **occupied residential** parcels with high water table soils (HG C 0-3.5’, HG D)	**274**	**333**
Number of **pre-1970 occupied residential** parcels with high water table soils (HG C 0-3.5’, HG D)	**117**	**146**
Number of **pre-1970 occupied residential** parcels with high water table soils (HG C 0-3.5’, HG D) **that have a recorded septic system repair**	**12**	**18**

Documentation – Parcels selected for analysis of management options

PLAT	NUMBER OF POTENTIAL UNITS
1	122
2	43
3	71
4	42
5	103
6	84
7	95
8	88
9	87
10	43
11	39
12	91
13	3
14	79
15	66
16	65

BMPs February 18,2002 (based on parcel data)

OPTION #1---No new development on soils with shwt 0 to 1.5
*64 vacant parcels have shwt D soils <= 1.5
*49 vacant parcels have shwt C soils <= 1.5
*Those 113 vacant parcels comprise 47.5 acres.
*In the spreadsheet, I simply subtracted 113 septic systems from future development. I did not convert 47.5 acres of future residential back to forest or brushland.

OPTION #2---Denitrification systems on all residential parcels less than 10,000 Sq.Ft.
* There were 547 parcels(ISDS).
*Enter number in BMP spreadsheet.

OPTION #3---Denitrification systems in Wetland (150 ft) and surface water(200 ft) buffers--includes shore.
*247 residential parcels in buffer.

OPTION #4---Denitrification systems for all new development
*394 new ISDS.

OPTION #5---Denitrification systems for all development

Documentation – Building units per plat
Data source: Town parcel database

PLAT	EXISTING UNITS	VACANT ACREAGE	NUMBER OF POTENTIAL UNITS	POTENTIAL POPULATION INCREASE
1			122	
2			43	
3			71	
4			42	
5			103	
6			84	
7			95	
8			88	
9			87	
10			43	
11			39	
12			91	
13			3	
14			79	
15			66	
16			65	

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1	122
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Documentation – Input data for nutrient loading using alternative management practices February 18,2002 (based on parcel data)

OPTION #1---No new development on soils with shwt 0 to 1.5

*64 vacant parcels have shwt D soils <= 1.5

*49 vacant parcels have shwt C soils <= 1.5

*Those 113 vacant parcels comprise 47.5 acres.

*In the spreadsheet, I simply subtracted 113 septic systems from future development. I did not convert

47.5 acres of future residential back to forest or brushland.

OPTION #2---Denitrification systems on all residential parcels less than 10,000 Sq.Ft.

* There were 547 parcels(ISDS).

*Enter number in BMP spreadsheet.

OPTION #3---Denitrification systems in Wetland (150 ft) and surface water(200 ft) buffers--includes shore.

*247 residential parcels in buffer.

OPTION #4---Denitrification systems for all new development

*394 new ISDS.

OPTION #5---Denitrification systems for all development

*1214 ISDS

APPENDIX O

Friday, November 24, 2000

Subject: Soil Component of Jamestown, RI
MANAGE program (Onsite Wastewater
Needs Assessment).

To: Lorraine Joubert
URI Cooperative Exension

Dear Lorraine:
As a member of the Jamestown Wastewater Management Sub-Committee, I have reviewed the soil map component for the MANAGE program you presented at the October 16, 2000 meeting.

My comments are based on my personal expertise as a soil scientist (specializing in soil survey operations) and via personal communication with Everett Stuart, Assistant State Soil Scientist, with the RI USDA-NRCS office in Warwick RI.

General Comments on the RI soil survey:
The "Soil Survey of Rhode Island" was issued in 1981; field mapping was conducted during the early 1970's. The mapping is published at a scale of 1:15,840 with minimum delineation's approximately 2-3 acres in size. The mapping is order 2 soil survey consisting of consociations (soil series) and complexes of two or more soil and non-soil types. There are currently no plans to update the soil mapping for the Jamestown area. In the 25+ years since the field mapping was performed, the NRCS has greatly improved soil survey maps with the use of better imagery, remote-sensing equipment, extended depth of observation, and improved mapping techniques.

Jamestown Soil
Most of the soil in Jamestown formed in very dense, very slowly permeable (1) dark colored glacial till derived from carboniferous rock. The depth to the dense till typically ranges from 12 to 50 inches. The till is underlain by meta-sedimentary rock of Pennsylvanian age ranging from 0 to approximately 30 feet below the surface. The bedrock is highly fractured and folded. Water moves rapidly along the cracks in the rocks into the bedrock aquifer. The dense till is capped by a wind-blown mantle (solum) of loamy-fine sand to silt loam soil textures (USDA textural class). Minor areas of stratified fluvial material is mapped along some drainage-ways, wetlands, and along beaches.

The slowly permeable dense till causes perched seasonal high watertables particularly on gently-sloping to level, concave landforms. On steeper convex slopes (>8%), water moves laterally along the till interface to lower landforms and the perched watertable is only present for brief periods of time.

Jamestown Soil Map:
The GIS soil map presented at the October wastewater sub-committee meeting groups the individual soil map units into soil hydrologic groups (2) and watertable depths.

Comments on Keys to Features:

Streams and Ponds: I'm not sure of the source of the stream-line, most likely from the USGS. The soil survey does have numerous intermittent streams delineated in the published report that are very important to show the drainage network of the wet areas. I don't think the streams layer is available from the NRCS SSURGO data set for RI, the newer SSURGO soils data does include the drainage layer. Several man-made ponds have been created since the soil mapping was made which do not show on the map. The new land-use map should have these new ponds delineated better. There is a small pond delineated just southwest of Conanicut Park, which is not on the published map (in the old dump). The issue of the streams was mentioned at the meeting.

Areas designated hydrologic group A- Excessively Permeable (pink colored polygons on map): These areas are mapped Windsor and Agawam soils on Jamestown in the published soil survey. Windsor and Agawam soils formed in sandy and gravelly glacial fluvial deposits. While taxonomically, these areas are mapped correctly, they do not fit the concept of hydrologic group A soils due to the very slowly permeable till underlying the soil material. These areas were mapped where the wind-blown (Eolian) mantle was thicker than 36 inches (the soil series control section). Modern soil mapping extends the depth of soil observation to 72 inches and these areas would be re-mapped Poquonock soils with a hydrologic group - C. The impact of rating these soils in the hydroloic group A may cause these areas to show a high potential for ground water contamination when actually the dense till would prevent effluent from infiltrating into the aquifer.

Areas designated hydrologic group B-well drained (white polygons on the map): This unit is used for the town dump in the northern part of the island. Dumps areas are unclassified as far as hydrologic groups due to the variability of the soils. If the dump were capped with a clay liner a hydrologic group C would be more appropriate. If its been capped with permeable soils, the B group is ok to use.

The other areas designated hydrologic group B is areas mapped CeC: Canton & Charlton fine sandy loam, **very rocky** 3-15% slopes in the published survey. Although Canton and Charleton soils are in hydro group B, this unit is mapped in areas where the bedrock is at or near the surface and has up to 10 percent of the unit with exposed bedrock outcrops. Areas of bedrock outcrop are assigned a hydro group rating of D due to the high runoff potential. These areas are extremely important areas for groundwater protection due to the rapid movement of water once it enters the rock via fracture and travels rapidly into the aquifer.

Areas designated hydrologic group C- SHWT > 6 feet (yellow polygons on the map): This unit is used for the "well drained" dense till soils of the Newport and Poquonock soil series. The concept of soil drainage classes was mainly used for agricultural interpretations but is now used to relate seasonal high watertable depths and permeability. The listing of these soils agrees with the tables in the published survey, however, both soils are now recognized as having a perched seasonal high watertable for brief periods after heavy rains at depths ranging from 2.5 to 4 feet below the surface. The unit could still be used for map units NeC and NP (Newport soil on 8-15% slopes and Urbanland complexes).

No Data/Water/Variable: This unit is used for areas of bedrock outcrop and human transported fill soils. Map unit Rk should be changed to hydrologic group D-excessively drained soils (watertable > 6 feet). Areas mapped UD can remain unclassified, hydrologic groups can be assigned by a sit specific basis but is probably not needed due to small acreage's.

(1): Permeability. Soil permeability is the quality of the soil that enables water or air to move through it. Accepted, as a measure of this quality is the rate at which a saturated soil transmits water. That rate is the "saturated hydraulic conductivity" of soil physics. In line with conventional usage in the engineering profession and traditional usage in published soil surveys, this rate of flow, principally downward, continues to be expressed as "permeability". It is expressed in inches per hour. Soils with slow to very slow permeability have rates of 0.06 to less than 0.002 inches/hour.

(2) Hydrologic Groups: A grouping of soils having the same runoff potential under similar storm and cover conditions.

(Submitted by Jim Turrene, professional soil scientist and member, Wastewater Management Commission)