1.2 Summary of Existing Conditions

As a first step in evaluating potential pollution risks in the assessment study areas, this section summarizes existing, readily available information on water quality concerns, pollution sources, and existing management practices (See Appendix D for further information). This overview has several purposes:

- To insure that the assessments build on existing information;
- To highlight the most valuable or vulnerable water resources;
- To provide a basis for refining water supply system management plans, wellhead protection plans and town water resource protection goals and priorities;
- To provide a baseline for reviewing progress in water resource protection efforts and for establishing new
- watershed management strategies.

This summary is drawn from information sources such as water supply system management plans, municipal plans and ordinances, water quality monitoring data, and input from state and municipal officials, water suppliers, and other participants in these assessments. Key features of this water quality status check are summarized below.

Water Quality Goals and Water Resource Protection Strategies

The City of Newport Water Division has a Water Quality Protection Plan as part of its mandated Water Supply System Management Plan. The plan clearly sets forth an analysis of potential sources of contamination within the nine drinking water supply watersheds, and provides detailed recommendations for enhanced protection of its drinking water supplies. Newport Water currently owns and protects perimeter buffers around most of the reservoirs. Continued acquistion of land for conservation and protection purposes is listed as a top priority in the Water Quality Protection Plan.

The protection of drinking water supplies is addressed in each of the five town comprehensive plans. On Aquidneck Island, Middletown is the only town that has adopted a watershed protection overlay district to protect drinking water resources. The ordinance does not, however, restrict the use of underground storage tanks in the watersheds, hence limiting the protection it affords. In 1999, the Aquidneck Island Partnership, representing each of the three municipalities on the Island, conducted a series of workshops entitled *"A Safe, Sustainable Drinking Water Supply"* to promote regional cooperation in the protection of the Island's drinking water resources. The Town of Portsmouth has adopted a 500 foot no-build setback from Lawton Valley Reservoir, St. Mary's Pond and Sisson Pond. Better stormwater management is a concern for all three towns on the Island.

Monitoring Requirements for Public Drinking Water Supplies

Rhode Island Department of Health Testing

Parameter	Testing Requirement
Asbestos	Once every ninth year.
Nitrates	Quarterly for 1 year; reduce to annually.
Nitrites	One sample.
Pesticides/Synthetic Organic Compounds (SOCs)	Quarterly every 3 years; reduced to twice every third year.
Selected Inorganics	Annually.
Unregulated Organics	Quarterly every 3 years.
Volatile Organic Compounds (VOCs)	Quarterly for 1 year; then annually; then reduced to every 3 years.

The Town of Tiverton has adopted a watershed protection overlay district for both Stafford Pond and Nonquit Pond. Tiverton has also recently adopted a wastewater management district in the Stafford Pond watershed, and has bought the 500-acre Weetamoo Woods property in the Nonquit Pond watershed. The Stone Bridge Fire District along with town residents and officials, URI Cooperative Extension, RI DEM and RI Bass Federation created a *Public Education Committee for Stafford Pond*. The group wrote and published *Your Guide to Protecting Stafford Pond* as part of its educational outreach strategy.

2. ASSESSMENT METHOD

This assessment uses a screening-level approach to evaluate pollution risks in water supply watersheds and recharge areas. The focus is on identifying land use and natural features where pollutants are most likely to be generated and move to drinking water supplies. This approach takes advantage of existing information sources, including the extensive computer-mapping database readily available to water supply managers and municipalities through the Rhode Island Geographic Information System (RIGIS). Computer mapping provides the chief tool to identify, analyze, and display potential pollution threats. Assessment results are intended to generate information water suppliers and local officials can use to make land use decisions that reduce pollution risks to water supplies.

This chapter briefly summarizes our approach in assessing the susceptibility of water supply source areas to contamination.. It includes:

- A brief overview of the two-level assessment approach used in RI for small and major supplies,
- Background on the challenges of evaluating water quality impacts from land use in source water areas;
- Description of the assessment approach using watershed features to evaluate pollution risk, with outline of data source,
- Methods and assumptions in creating the land use database for current conditions and future projections; and
- Steps in conducting the assessment, and use of assessment products.

This section is designed to provide an overview of assessment issues and our approach. Complete documention of assumptions and methods are provided in the Appendix to this report.

__MANAGE__ is the __M__ethod for __A__ssessment, __N__utrient-loading, and __G__eographic __E__valuation of watersheds and groundwater recharge areas. This screening-level pollution risk assessment method uses computerized maps known as Geographic Information Systems (GIS) to compile, analyze, and display watershed and recharge area information.

The assessment incorporates a suite of pollution risk factors including:

- *Map analysis locating likely pollution "hot spots."*
- *Land use and landscape features summarized as watershed health "indicators".*
- *Nutrient loading estimates comparing potential pollution sources associated with different land uses.*

This method incorporates a simple mass balance hydrologic spreadsheet but is a collection of assessment techniques rather than a packaged model. MANAGE was developed and is applied by URI Cooperative Extension as a watershed education and decision support tool for use with Rhode Island communities.

For more information go to: http://www.uri.edu/ce/wq/mtp/html/manage.html.

2.1 Two Levels of Assessment

The RI Source Water Assessment program uses a two-tiered assessment strategy developed by RI HEALTH and URI Cooperative Extension in partnership with an advisory Technical Committee. This provides a consistent review process for all water supplies while ensuring a more thorough assessment of the largest and most productive community supplies.

Basic assessment and ranking - all water supplies

All water supplies were assessed and ranked according to their susceptibility to contamination. The assessment considers potential sources of pollution and natural features that promote movement of pollutants, to include, for example: high intensity land use, number of mapped potential pollution sources such as underground storage tanks, location of potential sources by soil type and proximity to the supply, and existing water quality. A simple scoring system assigns a

"Rhode Island's groundwater resources are extremely vulnerable to contamination because of the generally shallow depth to groundwater, aquifer permeability, and the absence of any confining layers. Preventing groundwater pollution must be a priority if the long-term quality of the state's groundwater resources is to be protected.

The focus of state water pollution concerns has shifted from specific discharges or 'point' sources…. Maintaining or restoring state waters requires that non-point sources of pollution be addressed."
RIDEM 2002

numerical value, which categorizes the water supply's overall risk of pollution from low to high. Results of this basic ranking for the source water areas are included in the appendix of this report.

Comprehensive assessment - major community supplies

In addition to the basic mapping and ranking of pollution sources, major community water systems supplying more than 50 million gallons per day also receive a more in-depth assessment using the URI Cooperative Extension MANAGE pollution risk assessment method. This makes more extensive use of computer map databases, in order to evaluate land development patterns and landscape features posing the greatest risk to local water resources. The additional analyses may include any or all of the following:

- Calculation of percent impervious area, percent forest and wetland, land use characteristics in shoreline buffers, and other factors.
- Development of a hydrologic and nutrient loading budget estimating average annual nitrogen inputs to surface runoff and groundwater leaching; phosphorus to surface runoff.
- Forecast of potential threats using a "build out" analysis to evaluate future growth based on zoning.
- Comparison of the relative effectiveness of alternative pollution controls in reducing pollutant inputs using nutrient loading estimates.
- Public involvement in the assessment by field checking and updating land use maps; and reviewing and commenting on draft results.

Both the basic and comprehensive assessment are fully consistent with each other as the basic ranking was developed using elements of the MANAGE method. This technical report includes the combined results of both the basic and in-depth assessment.

2.2 Background on assessing water quality impacts

Pollutants most likely to contaminate drinking water

According to the RI Department of Environmental Management's report to congress on the state's water quality, pollution from routine land use activities is the greatest threat to water quality outside of urban areas (RIDEM 2002). Stormwater runoff, septic systems and erosion are the number one threat to the State's drinking water supplies and other high quality fishable and swimmable waters. Bacteria, nutrients and sediment associated with these sources have adversely affected drinking water reservoirs, inland lakes and ponds, and coastal shell fishing waters. In fact, pollutants from land use activities are the main cause of new shellfish closures (RIDEM 2002).

Land use activities are also the primary threat to groundwater. The most frequently detected contaminants in RI public wells, excluding naturally occurring compounds, are MTBE, a highly soluble gasoline additive, and the widely used chemical solvents such as trichloroethene and tetrachloroethane. According to RIDEM's 2002 report on the state's waters, between 15 and 30 percent of all RI public wells have been found to contain low levels of these volatile organic solvents (VOCs). Petroleum products from leaking underground storage tanks are the leading cause of new groundwater contaminant incidents. Nitrate is also a concern as it is often detected at concentrations far above natural background levels. Annually, almost 90 percent of wells have nitrate concentrations less than 3 mg/l, with only five wells slightly exceeding the 10 mg/l nitrate standard. Because even 3 mg/l is more than 10 times the naturally occurring level, this is a serious concern in coastal areas where shellfishing habitat can be impaired at total nitrogen levels as low as 0.35 mg/l (Howes et.al.1999). This low level is near the natural background concentration of groundwater in undeveloped areas of Rhode Island.

Because most land in a reservoir watershed or overlying a well head protection area is often privately owned and not controlled by the water supplier, source water areas are just as susceptible to land use pollutants unless local watershed protection regulations are adopted and enforced. With Rhode Island's population moving out of urban centers to new homes in outlying suburbs and rural source water areas, the potential for water quality impacts to drinking water supplies is greater than ever.

Threats to lakes and ponds

22% of RI lakes and ponds are not clean enough for healthy aquatic life or swimming due to bacteria, nutrients, low oxygen or metals. The major sources are:

- *Runoff*
- *Septic systems*
- *Agricultural fertilizers*
- *Water withdrawals and other changes in flow.*

RIDEM's assessment of lakes and ponds includes 42 drinking water supply reservoirs. Of these reservoirs, 99 percent are meeting drinking water standards. In most areas, however, this assessment does not include information on upstream tributaries due to lack of data.

RIDEM 2002

Challenges of measuring land use impacts

Field monitoring and modeling are two basic approaches, often used hand-in-hand to evaluate effects of land use activities on water quality. Field monitoring data provides the most solid information to assess water quality conditions and identify pollution sources. However, field studies of even small watersheds is complex and time consuming, especially when compared to traditional sampling of discharge pipes. Pollutants from multiple sources such as over fertilized lawns, storm drains, and septic systems enter streams and groundwater at many locations scattered throughout a watershed, making it difficult to accurately evaluate impacts. In addition, any one sample represents only a snap shot in time. Regular sampling is needed to separate variations due to weather or season and to establish trends.

To complicate matters, mounting evidence points to basic changes in hydrology brought about by development as a root cause of water quality problems. Increased runoff with construction – almost impossible to avoid unless strictly controlled, prevents rainwater from naturally infiltrating into the ground. Water running off the ground surface escapes treatment that would have occurred through slow movement through soil. The combined result is reduced groundwater

"It is generally recognized that protecting the quality of drinking water is cheaper than treating water after it has been contaminated, and more certain than seeking new sources."

RI HEALTH Source Water Assessment Plan, 1999.

recharge and degraded surface water quality. Monitoring is a challenge given the wide range of physical, chemical and biological impacts that are possible. Finally, even where significant resources are devoted to field studies, results are often inconclusive. For example, DEM scientists have conducted extensive field studies of impaired surface waters only to conclude that "in the majority of cases there is not enough data to link the causes of non-support to actual sources of pollution" (RIDEM 2002).

Watershed scale models provide an alternative or supplement to field sampling. Modeling uses information regarding specific features of a study area, such as soil types and water flow patterns, with research data about pollutant interactions. It then makes simplifying assumptions to apply these facts to the whole study area, creating a picture of how a study area functions. Modeling is frequently used to estimate sources of pollutants, especially when sparse or inconclusive field data indicates the amount of pollutant present without leading to a verified source. Modeling is used to extrapolate from known data points to make assumptions about the larger study area, thus gaining a "big picture" perspective needed to evaluate cumulative impacts. And modeling is a valuable tool in testing.

It is important to remember that all models generate results that are only as good as the input values. Results of both simple and sophisticated models are estimates. Complex models may not generate more useful data for management, especially when comparing relative differences is adequate for choosing pollution controls (Center for Watershed Protection 1998). For both simple and complex models alike, great uncertainty surrounds the fate and transport of pollutants in the environment. Because of these data gaps, quantifying a direct response between pollution sources and resulting water quality in a down gradient well or surface reservoir is extremely complex and filled with uncertainty. In the Waquoit Bay watershed in Cape Cod, Massachusetts, for example, researchers modeling watershed nutrient dynamics concluded that even in heavily studied watersheds with an extensive field monitoring database, the relationship between pollution sources and resulting water quality was the most difficult to estimate (Weiskel, 2001). These unknowns currently preclude researchers from setting up a direct relationship between pollution sources in a watershed and resulting impact of those pollutants in receiving waters.

2.3 Approach: Linking landscape features to pollution risks

Given the difficulties in assessing land use impacts through field monitoring and conventional water quality models, the RI Source Water Assessment Program relies on accepted pollution risk factors established by the U.S Environmental Protection Agency (EPA) and other scientific organizations to identify and rate pollution threats (EPA, 1996; Chesapeake Bay Foundation, 2001; Maryland Department of Environmental Protection, 2002; Nolan et.al 1997). Given that water quality is a reflection of the land use activities and physical features of a watershed or recharge area, this approach relates the characteristics of the watershed to potential sources of pollution that may lead to impaired water quality through "cumulative" effects of increased pollutant inputs and hydrologic stresses with increased impervious and surface water runoff. These indices couple high quality spatial data on a suite of landscape features with our current understanding of land use impacts to evaluate and compare risks to water supplies. Our focus is on identification of high risk situations that could lead to impaired water quality and identification of appropriate management options to prevent degradation.

Threats to Groundwater

Ninety percent of Rhode Island groundwater is suitable for drinking but low-level organic contaminants have been found in 15 – 30% of wells tested. The most common contaminants are petroleum products, organic solvents, nitrates and pesticides.

The major sources are:

- *Underground storage tanks*
- *Hazardous and industrial disposal sites*
- *Spills*
- *Landfills*
- *Septic systems*
- *Road salt*
- *Fertilizers and pesticides*

RIDEM 2002

The relationship between watershed characteristics and water quality is grounded on basic, widely accepted concepts about movement of water and pollutants applicable to both surface stormwater flow and leaching to groundwater (Dunne and Leopold, 1978; National Academy of Sciences, 1993). These principles include:

- Most water pollution comes from the way we use and develop land.
- Intensive land use activities are known to generate pollutants through for example, accidental leaks and spills, septic system discharges, fertilizer leaching, or runoff from impervious areas.
- Forest, wetlands, and naturally vegetated shoreline buffers have documented ability to retain, transform, or treat pollutants.
- Natural landscape features such as soil types and shoreline buffers determine water flow and pollutant pathways to surface waters and groundwater.

Land use pollutants are therefore not completely diffuse across a landscape but are associated with recognizable patterns of intense land use in combination with hydrologically active sites, such as areas of high water table and excessively permeable soils, where pollutant movement is more likely given soil type and proximity to receiving waters. Recent findings by the U.S. Geological Survey document the validity of using this approach to assess pollution risk. In an extensive national review comparing water quality of streams and aquifers with watershed characteristics, USGS researchers (Nolan et.al. 1997) concluded that water quality is the result of multiple variables, not pollutant inputs alone. This study demonstrated that a combination of land use and landscape characteristics were highly reliable in identifying settings at greatest risk of contamination.

Using these accepted concepts, areas of high pollution risk can be mapped to provide a rapid, first-cut assessment to screen pollution risks and set a direction for additional analysis or management. The indicators used in this source water assessment are standard measures commonly used in similar watershed analyses to evaluate a waterbody's susceptibility to degradation. These indicators include for example, the factors listed below.

Type of Pollution Risk	Indicators
The presence of likely pollution sources and stressors.	▪ Percent high intensity land use ▪ Percent impervious cover ▪ Estimated average annual runoff and nutrient loading
Landscape features promoting pollutant movement to surface or ground waters.	▪ Location and extent of highly permeable soils ▪ Location and extent of shallow water table networks. ▪ Developed shoreline buffers
Waterbody features that amplify vulnerability to contaminants.	▪ Aquifer type ▪ Reservoir depth and flushing rate ▪ Existing water quality condition.

More detailed information about pollution risk indicators and mass balance modeling methods used in this assessment are provided in the results section of this report, with more extensive information also provided in the appendix.

Data Sources and Outputs

The assessment results are based on five types of information either used or generated by the risk analysis.

- Review of existing water supply management plans, municipal plans and ordinances, state reports, Rhode Island Department of Health water quality monitoring data.
- Local input from municipal officials, water supply representatives and assessment volunteers for important information on existing conditions and concerns.
- Map analysis of land use, soils, known pollution sources and other watershed features to systematically locate probable pollution "hotspots" using the RI Geographic Information System (RIGIS) database. Data derived from the RIGIS database is intended for planning-level analysis only.
- Land use and soils acreages extracted from the RIGIS map database, compiled using a separate spreadsheet and summarized as averages for each study area.
- Modeled estimates of average annual runoff, groundwater recharge, and nutrient loading as measures of cumulative pollution risk. This is a standard mass balance method similar to those widely used in comparable applications elsewhere including Cape Cod and the New Jersey Pine Barrens.

2.4 Database Development

Land use derived from the RIGIS database provides the main source of data for land use. Complete documentation of methods used to create a land use database, and detailed results for each study area, is included in the Appendices. This includes a land use breakdown by soil type for each study area, land use characteristics of shoreline zones, and estimated future land use based on buildout projections.

Land Use Inventory

The land use data for this analysis was derived from the 1995 RIGIS coverage, using twenty-one land use categories consolidated from 32 mapped categories based on similar use, intensity, and pollution risk. Land use maps were updated with major changes and corrections identified by assessment mapping volunteers based on their knowledge of the area and windshield surveys. The number of dwelling units was estimated from the RIGIS residential land use categories. Population was based on 2.4 persons per dwelling unit, unless otherwise determined. The town sewer service district was updated when possible using sewer line information provided by the towns. Without parcel level data on the number of homes actually connected to the sewer line, we assumed homes within 500 feet are reasonably likely to take advantage of public sewers. Based on the land area outside the sewer district, we estimated the number of houses with septic systems per acre based on RIGIS residential land use categories.

Build-out Methods and Assumptions

To estimate future development potential we conducted a build-out analysis for each study area individually. Using town zoning maps as the future land use scenario, we assumed all privately owned and unprotected land would be eventually developed based on the underlying zoning district. We did not estimate a time frame for this growth. In calculating the potential change in future land use acreages we made the following assumptions:

- All permanently protected open space will not be built upon.
- New development density will adhere to current zoning.
- Most privately held open space (Scout Camps, golf courses, rod & gun clubs) will not be developed further.
- Areas with wetlands, bedrock on surface, and very high water table soils (>1.5’) will not be built upon.
- Surface waters and their tributaries will retain undisturbed buffers of 200 feet.

2.5 Assessment Steps

The following steps briefly outline the process used to involve the public and conduct the assessment.

1. ***Organize an assessment group.*** In each study area, RI Health and URI Cooperative Extension worked with the water supplier and municipal officials to coordinate and schedule the assessment, identify key organizations to be involved, and recruit local volunteers to participate in the assessment. *Mapping volunteers* were trained to field check land use maps and inventory potential sources of pollution. A small group of *Assessment volunteers* – primarily town staff and board members –reviewed draft results, provided input on local resource issues, and made suggestions for management controls.

2. ***Create land use and natural resource inventory maps for display and analysis.*** The study area boundaries were selected in cooperation with the water suppler and/or town officials. At a minimum this included the water supply watershed or wellhead protection area but in some cases was expanded to include other areas for future planning purposes. In cooperation with local volunteers, RIGIS land use maps were updated with major land use changes and known or suspected pollution sources. A future land use/zoning map was created using town coverages or digitized from zoning boundaries provided by the town. The basic coverages used in the assessment include land use, soils, sewer lines (buffered to create an area coverage) and surface water buffers (200 feet).

3. ***Briefly summarize existing conditions.*** This is a brief overview, based on available plans, monitoring data, and water quality issues identified by water suppliers, municipal officials and assessment volunteers. In addition, the RI HEALTH public well database was analyzed and results for the past five years were summarized and ranked using the RI Source Water Assessment ranking.

4. ***Identify and rank pollution risks based on current land use.*** Using land use, soils, and other mapped data, the MANAGE model uses a spreadsheet to generate summary statistics, or "indicators" such as percent impervious area. The same spreadsheet calculates a hydrologic budget and nutrient-loading estimate as an additional indicator of pollution risk. Basic land use characteristics, number of potential pollution sources, and monitored data are factored into a pollution risk rating for each source water area.

5. ***Map high-risk pollution "hot-spots" for the whole wellhead protection area or reservoir watershed.*** Mapped hot spots help to target the location of potential pollution sources by combining high intensity land uses that are known pollution sources with soil features where pollution movement is most likely.

6. ***Predict future land use and population change through a "build-out" analysis for each study area.*** This map-based analysis, projects the type and location of growth assuming all unprotected land is eventually developed based on municipal zoning and future land use maps created in step 2.

7. ***Forecast future land use impacts to water resources using the "build-out" analysis.*** Pollution risk indicators and a hydrologic budget/ nutrient loading for future land use are estimated by re-running the spreadsheet analysis (Step 4) using the future land use map.

8. ***Summarize and rank pollution risks.*** The RI Source Water Assessment Ranking was used to summarize and rate pollution risks for each water source, with results averaged as one ranking for suppliers having more than one source of supply. This basic rating is used for all public water supplies in Rhode Island. For major community supplies additional risk factors, such as impervious estimates, nutrient loading and build out results, were also identified and rated.

9. ***Evaluate effectiveness of management options to reduce pollution risk.*** Using the MANAGE spreadsheet, we estimated the relative change in runoff and nutrient loading that could be expected under different pollution control practices. Because this analysis is limited to change in nutrient loading only, a wide range of management options were identified based on accepted current best pollution prevention practices.

10. ***Make results available to water suppliers, local decision makers and the public.*** Final results are summarized as a technical report and a 4-page full color fact sheet. These are available through the RI HEALTH and URI Cooperative Extension web sites. Fact sheets are suitable for direct mail to watershed residents by water suppliers or municipalities. Although it is beyond the scope of the source water assessment program to develop detailed action plans, reports include recommendations focusing on pollution prevention. Map analyses are made available as large-format maps. In cooperation with RI HEALTH, final summary results will be presented to town officials, with presentations scheduled at the convenience of town councils and planning/zoning boards.

Source Water Protection Savings

Rhode Island public water suppliers are estimated to have saved **$2,755,180** in a three-year period through "monitoring waivers" granted by US EPA based on source water protection plans.

Where a supplier has a source water protection plan in place, where certain pesticides and organic chemicals are not used in a source area or state, and where sampling data also confirms the supply is not vulnerable, water suppliers may reduce monitoring. This means money saved can be better spent protecting against actual threats.

Source: Technical and Economic Capacity of States and Public Water Systems to Implement Drinking Water Regulations, Report to Congress, September 1993, as reported by New England Interstate Water Pollution Control Commission, 1996.

Applying Results

In addition to meeting EPA requirements, source water assessments have many practical applications. One key benefit for water suppliers is to support monitoring flexibility. Based assessment results, RI HEALTH may grant monitoring waivers to a supplier for specific contaminants that are not found within the source area. This can amount to savings of several hundred dollars per year for each system that receives waivers. The actual amount depends on the specific testing requirements that may be waived. The state can also use assessment results to require additional monitoring for supplies at risk or to earmark grant money for pollution prevention programs for the systems at highest risk (RI Health 1999).

Assessment results can also provide a basis for future watershed assessment. The GIS map inventory of land use risk factors and mapped pollution sources establish a database that can be used to update watershed protection plans. In source water areas where field monitoring data is limited, assessment results may be used to locate high risk areas for additional field monitoring, to support design of expanded field monitoring, or identify areas where specialized field studies or modeling is warranted.

Because the assessment focuses on potential land use impacts, assessment results have been used to strengthen local land use planning and regulation. The following are, for instance, a few ways RI communities have used assessment results:

- Update town water quality goals and priorities for action. Towns have incorporated assessment findings and recommendations into town comprehensive plans, water supply or wastewater management plans, and other watershed plans.
- Support adoption of wastewater inspection and upgrade ordinances, and develop standards for performance of onsite systems through zoning overlay districts. Information generated on pollution risks and suitability for onsite wastewater treatment has been used to build support for better wastewater management and to determine level of improvement needed.
- Create and distribute public information materials, incorporating assessment results and maps, targeting high risk areas.
- Use map products generated in routine town planning and project review.

Assessment recommendations incorporate current accepted management practices focusing on pollution prevention. Although these were developed with local input, recommendations in this report are not truly town priorities unless incorporated into town plans, capitol improvement budgets, and ordinances. The next step is for local officials to review assessment results in light of current policies and management practices, and develop their own list of protection priorities with implementation plan.