

## CHEPACHET Village Pollution Risk Indicators

The following indicators represent average results for the study area. Map analysis can be used to better target specific locations of greatest pollution risk based on location of pollution sources, soils and proximity to surface waters and wetlands.

WATERSHED / AQUIFER INDICATOR	RELATIVE POLLUTION RISK RATING			
	Low	Medium	High	Extreme
<b>LAND USE - Study Area</b>				
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 <sup>4</sup>	< .10	.10 – .23	.24 – .49	.50 – 1.15
<b>LAND USE - Riparian (shoreline)</b>				
Riparian High intensity land use	< 5 %	5 – 9 %	10 – 15 %	16 %
Riparian Impervious surface area	< 5 %	5 – 9 %	10 – 15 %	> 15 %
Riparian Forest and Wetland	> 95 %	80 – 95 %	60 – 79 %	< 60 %
<b>SOILS - Risk to surface water and/or shallow groundwater <sup>2</sup></b>				
Presence of restrictive layers	< 2%	2 – 10 %		> 10%
High water table (1.5-3.5 ft)	< 5 %	2 – 20 %		> 20 %
<b>COMBINED LAND USE AND NATURAL FEATURES</b>				
High intensity land use on highly permeable (hydrogroup A) soils	< 5 %	≥ 5 – 15	15 – 30	> 30
High intensity land use on seasonal high water table < 3.5 ft.	none	≥ 5	5 – 15	> 15
<b>ESTIMATED RUNOFF AND NUTRIENT LOADING</b>				
Phosphorus to surface runoff <sup>4</sup> (lbs / acre/ year)	< .46	.47 – .68	.69 – .93	> .93
Nitrate-N concentration to groundwater recharge (mg/l) <sup>4</sup>	< 2	2 – 4.9	5 – 7.9	8 – 10
<b>MONITORED WATER QUALITY</b>				
Monitored concentration of nitrate-N in public wells (mg/l)	< .5	.5 – 2	> 2 – 5	> 5

### 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<sup>th</sup> = low, 50<sup>th</sup> moderate, 75<sup>th</sup> = high, 95<sup>th</sup> = extreme) of all ranked results of analyses conducted for all major drinking water supplies.

### Measuring Indicators

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

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

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

*For example:*

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

## 5. OTHER POLLUTION SOURCES and HYDROLOGIC MODIFICATIONS

“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.

### 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

# Understanding Watershed / Aquifer Pollution Risk Indicators

## Using multiple indicators to evaluate pollution risk

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

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

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

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

assumptions remain consistent among study areas, the comparative value of the results is unaffected. Using a range of indicators, including reliable land use factors, can help reduce reliance on any one factor while providing a range of supporting data.

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

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

## **Interpreting Results**

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

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

- Comparing differences between current and future land use, where a future “build-out” map is used to calculate indicators representing future land use;
  - Evaluating the range of results possible using low and high input values for factors that are difficult to estimate precisely, such as impervious cover or nutrient loading; and
- Comparing the relative change in risk among alternative management scenarios. Typical pollution control strategies that can be modeled include: reduced fertilizer application, use of nitrogen-reducing septic systems, and use of stormwater treatment systems designed to remove nitrogen or phosphorus. Alternative land development options and pollution control practices can be modeled for the entire study area, for particular land use types, or for any combination of land use by soil type or location in shoreline buffers.

## Ranking Pollution Risks

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

- Ranking based on literature values. Each indicator is a standard, widely accepted measure of watershed health. In some cases extensive research results are available to document a solid relationship between the presence or extent of watershed features and associated water quality condition. The relationship between percent impervious cover and stream habitat is probably the most well documented, where average watershed impervious levels above 10% are associated with declining stream quality. For other indicators, supporting data linking the extent of the water features to water quality conditions is more limited. Where minimal literature data is available to rank pollution potential, best professional judgment was used to select risk thresholds based on known water quality conditions compared to watershed risk indicators.
- Relative comparison of results using a selected range of study areas. To establish a representative range of values for watershed indicators, assessments were first conducted for a small number of study areas representing extremes in soil types and development levels. Study areas included pristine forests to highly urban watersheds with known water quality impairment. For example, indicator results for pristine areas were set as low risk, while results for the most highly developed watersheds with known water quality impairment were ranked as having an extreme risk of contamination., with a moderate risk ranking assigned to study areas with intermediate indicator levels. Where research data was available to support selection of risk rankings, we used the literature values but adjusted them where necessary to correspond to known low or high risk situations based on actual water quality.
- Percentile ranking of assessment results. When a large, representative database is available, risk thresholds may be set using statistical breakpoints to rank assessment results. Assessment results for 74 major community water supplies and other Rhode Island watersheds and aquifers were compiled using current land use conditions. We ranked results various mapped indicators, including: percentage of forest and wetland in shoreline areas, number of septic systems per acre, nitrogen loading to groundwater, and phosphorus loading to surface runoff. Each indicator was examined individually using results from all 74 study areas. Results were ranked and percentiles (25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup>) 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.