Fact Sheet #6: Functions of Riparian Areas for Groundwater Protection

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[This fact sheet was prepared by Russell Cohen, Rivers Advocate, Riverways Program, Massachusetts Department of Fish and Game. This document is intended for educational purposes only and does not necessarily represent the viewpoint of agencies and commissions having regulatory authority over riparian lands. Date: June 4, 1997.]

How do naturally vegetated riparian areas protect groundwater quantity and quality?

Most groundwater in Massachusetts gets there by way of gravity and the infiltration of surface water through exterior layers of soil and rock. The two major pathways for surface water to enter the ground is (1) precipitation falling on land and percolating through the soil and (2) water in rivers, streams and other water bodies seeping through their sides and bottoms into the adjoining ground. Groundwater can also seep back into surface water, playing a vital role for smaller rivers and streams (discussed further below).

Lands adjacent to rivers and streams (also known as riparian areas) maintained in and/or restored to a naturally vegetated condition are especially effective in enabling precipitation and runoff to infiltrate the soil and pass through to the water table (the "surface" of the groundwater). The uncompacted soil beneath streamside forests, for example, is honeycombed with cavities and passageways created by decaying roots, burrowing animals and fungi, making it a highly porous medium that readily absorbs precipitation. In the meantime, ground cover and organic debris accumulated on the forest floor acts as a barrier to help slow down and deter surface water runoff after rainfall or during snowmelt, thus providing additional time for infiltration to take place.

Furthermore, the streamside forest acts as a living filter to help prevent groundwater contamination by intercepting and absorbing excess nutrients, sediment and other pollutants carried along in runoff before it percolates down to the water table. This is accomplished by several biochemical processes, including the uptake of excess nutrients and heavy metals into living plant tissues and the breakdown of these and other pollutants into less harmful substances by soil bacteria.

How can riparian areas affect the quantity and quality of groundwater as a source of public and private water supply?

A little over half of Massachusetts' communities (185 out of 351 cities and towns), comprising 40% of the state's population, are dependent in whole or in part on groundwater withdrawals as their primary source of drinking water supply. Many of these groundwater wells are sited in riparian areas, to take full advantage of the typically higher water yields found in those locations. For example, areas of stratified drift (deposits of water-bearing sand and gravel that serve as major aquifers) are often found directly underneath rivers and adjacent floodplains and uplands. This means that a significant portion of the "zone of contribution" (the area of land and subsurface from which water in a well originates) for such wells is made up of riparian areas.

This is important from both a groundwater quantity and quality standpoint. Keeping riparian areas naturally vegetated will help maintain high infiltration rates, thereby replenishing the groundwater and recharging the aquifer, which is key to the long-term sustainability of groundwater-based public water supplies and private wells. In the meantime, the naturally vegetated area's cleansing action will help ensure the purity of water entering the aquifer. On the other hand, if riparian lands within a well's zone of contribution are used in a fashion that enables pollutants to get into the groundwater, then there is a significant possibility that some of this polluted groundwater will enter and contaminate the adjoining well.

Why is maintaining high groundwater quantity and quality important for rivers as well as people?

As mentioned previously, groundwater can and often does reemerge as surface water, and groundwater discharge into rivers and streams has a beneficial effect on both the quantity and quality of water in the recipient watercourse. This is particularly true for the smaller headwater streams, where most of their annual flow is attributable to groundwater reentering the surface as natural spring seeps that, in turn, are replenished by rainwater falling onto and infiltrating the soil under vegetated areas. Since water seeps slowly through the soil, the surface water flowing in streams can represent rainwater that fell days, weeks or even months ago. This regular, continuous seepage of groundwater that keeps streams flowing is called "baseflow".

Baseflow is critical to stream life and water quality. Low flow periods are typically the most stressful periods for aquatic organisms, resulting in crowding due to less available habitat, excessive water temperatures in the summer and greater freezing in the winter. Sportfish, fish food animals, and water plants require a stable, continuous flow of water, particularly during dry periods. Groundwater discharge is a major source of streamflow for smaller streams, especially during hot and dry summers, where the discharge both augments the streamflow and mitigates harmful temperature increases. This groundwater discharge is key to maintaining adequate water levels and temperatures in streams to support aquatic life.

The failure to maintain vegetative cover on riparian areas adjacent to smaller brooks and streams is likely to result in a significant loss of groundwater recharge and increase the frequency, duration and severity of low flow conditions. In the smaller streams, where flows are already modest in size, a reduction in baseflow is especially harmful. Small streams deprived of groundwater flow may even dry up completely, a condition that is obviously extremely stressful if not fatal to fish and other aquatic organisms.

Furthermore, as the level of pollutants in groundwater is typically lower than in surface waters, groundwater discharge into rivers and streams helps augment streamflows available to dilute and flush out toxic chemicals and other pollutants. As rain falling on a vegetated streamside buffer readily infiltrates into the underlying groundwater, it will further help to dilute concentrations of pollutants originating in adjacent land uses before they reach the river. Although this has the most visible and dramatic impact on smaller streams, larger rivers benefit as well from the cleaner flow of groundwater-augmented tributaries as well as discharges of groundwater directly into mainstem rivers. As it is the larger rivers that are burdened with pollutants coming from industrial and other wastewater treatment discharges, the addition of cleaner, cooler groundwater gives a significant boost to the mainstem rivers' ability to assimilate pollutants, especially during the drier months.

Last but not least, scientists have recently discovered the hyporheic zone, a biologically active subsurface area associated with riparian areas, whose existence is primarily dependent upon groundwater. The hyporheic zone is that area of the land underneath and bordering the river on both sides where there is a constant interchange of water from the ground to the stream and back again. The hyporhiec zone is important to riverine organisms, especially invertebrates, during periods of disturbance to riverine ecosystems (floods, droughts and so forth). The hyporheic zones have also been identified as intimately associated with fish spawning and rearing areas and are an important source of energy and nutrient transport. The zones can extend from a few centimeters on small streams to include large floodplain aquifers in gravel-bed rivers. The importance of the hyporheic zone and its role in providing refugia (i.e., secure places to retreat to when adjacent habitat has been degraded) in streams is just now being recognized.

What alterations to riparian areas impair their ability to protect groundwater quantity and quality?

The biggest impediment to a riparian area's ability to replenish groundwater is the construction of impervious surfaces such as paved driveways and parking lots and the roofs of buildings that prevent precipitation and runoff from infiltrating slowly into the ground. Other uses of riparian land have lesser but nevertheless significant adverse impacts. Streamside forests disturbed by logging, trampling by livestock, and heavy recreational use by people can destroy the forest floor and severely compact forest soils, drastically reducing their porosity and infiltration rate. Streamside forests cleared for cultivation or grazing are likely to experience a 33-67% reduction in water infiltrating the soil and entering the groundwater than if the forests, with their more porous soils, had been left in place and maintained in a relatively undisturbed condition. Replacing streamside forests with lawns will also result in a reduction in groundwater recharge. There is less biological activity in the soil underlying a mowed lawn than there is in forest soil, so the earth is less tunneled and less water percolates down into the groundwater. This is particularly harmful for riparian areas adjacent to small streams, where, as stated previously, groundwater seeping into streams is a critical source of streamflow, especially during the hotter, drier months.

Ditching, tiling, channelization and similar alterations to riparian areas and river and stream channels intended to increase the efficiency with which precipitation and flood water is collected and conveyed downstream is likely to reduce opportunities for the water to infiltrate into the ground and recharge groundwater levels. Removing streamside vegetation and/or the natural sinuosity of river and stream channels will produce a similar result, as channels bordered by vegetation slow the water down and allow for more groundwater replenishment than if the stream is channelized and the water flows away quickly without having a chance to sink into the adjacent groundwater.

As groundwater levels are frequently found at or just below the surface of many riparian lands, providing little or no vertical buffer, groundwater beneath riparian areas is especially vulnerable to degradation from polluting activities. The list of potentially polluting land uses is quite extensive, ranging from cropland and lawns (which are typically treated periodically with pesticides, herbicides and fertilizers) to heavy metals and automobile fluids accumulating and running off of parking lots. Malfunctioning and even fully operational septic systems that have been sited within riparian areas can contribute to excessive levels of nutrients and even pathogens to the adjacent groundwater.

A major adverse impact of such groundwater pollution is the potential contamination and forced treatment or even closure of public and private water supply wells, which as stated previously, are frequently sited in riverfront areas. For example, without the presence of vegetated riverfront areas to filter and absorb the high levels of nitrate ions that are a standard component of septic system leachate, they can seep into the adjoining groundwater aquifer and can move by subsurface flow to water supply withdrawal points as well as streams. High concentrations of dissolved nitrates in well water can necessitate well closure. Excessive sedimentation resulting from alterations to riparian areas, while not harmful to public health per se, may nevertheless decrease river bottom infiltration and reduce the yield of nearby wells. For other types of pollutants (hazardous wastes, for example), cleaning up groundwater supplies once contaminated is a very expensive, often times impossible, undertaking.

What are some best management practices (BMPs) for riparian areas to maintain and enhance their groundwater prevention function?

Maintaining and/or restoring riparian areas to a naturally vegetated condition is, in general, the best way to ensure maximum infiltration of precipitation, stormwater runoff and flood water into the soil and an influx of uncontaminated water to aquifers and other groundwater resources. The best way to maximize infiltration of runoff discharged into riverfront areas is to site the discharge at the outer edge of the riparian area and disperse it as much as possible through the use of a level lip spreader or other device that converts the runoff into sheet flow. This will maximize the water's beneficial interaction with the streamside forest soil. Keeping riparian lands naturally vegetated will also preclude the vast majority of alterations to riparian areas that could potentially pollute the groundwater.

It should be recognized, however, that naturally vegetated streamside buffers, as effective as they are in filtering out most forms of pollution before they reach the groundwater, may not offer complete protection for some types and/or concentrations of pollutants. For example, untreated runoff from a gas station discharging into a vegetated riparian area may contain pollutants of such a nature and amount that they can not be effectively absorbed by streamside forests alone. Runoff from this and similar activities must undergo pretreatment through a specially designed filtering mechanism before it is allowed to infiltrate into the soil. DEP's recently issued Stormwater Management Policy prohibits infiltration of stormwater from areas with higher pollutant loads without pretreatment. State and local regulatory authorities should be consulted when there is any doubt as to whether it is appropriate to allow runoff from a potentially polluting activity to infiltrate the ground without pretreatment.