



Drinking Water Protection Series

Nitrate Contamination— What is the Cost?

Current Groundwater Conditions

In the “Land of Sky Blue Waters”, groundwater is a highly prized natural resource which quenches the thirst of over 70% of Minnesota’s 5 million residents. Ninety-eight percent of the state’s 1,000 community water supply systems draw from groundwater resources. Only Minneapolis, St. Paul, St. Cloud, Mankato, Moorhead, Duluth, and a handful of smaller communities rely on rivers or lakes for drinking water. High quality ground water is also vital for irrigation and industrial needs, and is essential for recharging lakes, streams, and many wetlands.

While many parts of the state are blessed with excellent groundwater quality, there are potential trouble spots scattered throughout the state. Shallow aquifers underlying sandy soils in central Minnesota, glacial outwash aquifers in the southwest, and the fractured bedrock aquifers in the southeast are highly susceptible to nitrate contamination. *Figure 1* illustrates these general areas. These aquifers are vulnerable to impacts from land use activities such as septic systems, lawns, and agricultural inputs. Wellhead protection teams need to consider whether the well(s) serving their water system are potentially vulnerable when making decisions about preventative actions.

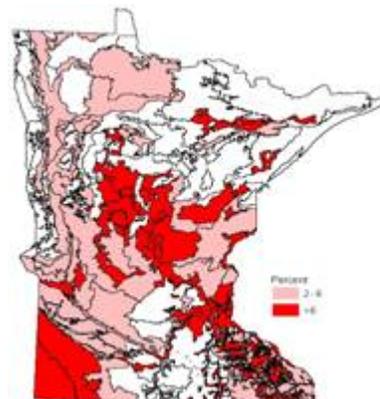


Figure 1. Percentage of wells > 3 mg/L. MDH County Well Index nitrate results summarized by agroecoregion. (Map courtesy of Dr. David Mulla, UM)

Wellhead protection teams should also be aware of the costs of treatment and other corrective actions, when preventative actions have not yet been taken, have not been fully implemented, or when it takes some time for the benefits of corrective actions to be observed. Due to nitrate contamination, a number of public water suppliers have needed to take significant (and often costly) corrective steps to provide safe drinking water.

The purpose of this fact sheet is to describe corrective action choices made by communities and their associated costs. Wellhead teams and water suppliers should consider this information when weighing out the merits and costs of preventative actions. Ideally, wellhead protection teams can act to implement strategies to reduce nitrate inputs before contamination occurs, and avoid the costs associated with treatment or other remedial steps.

Nitrate Reduction and Removal Options

Once contamination occurs, responding to nitrate problems can be complicated and expensive. Water suppliers have used one or more of the following actions; 1) *drilling a new well in a non-vulnerable location*; 2) *blending of existing water supplies*; or 3) *removing nitrates in existing water supplies*. However, it should be noted that these strategies alone do not accomplish the long-term goal of reducing nitrate inputs and do not eliminate the need to continue working to reduce these inputs.

1. **New Well Construction**-- In some cases, a new well may need to be installed in a deeper, uncontaminated aquifer. Construction and pumping costs associated with these new wells can frequently double the water cost to the customer. Drilling a new well can cost a community \$75,000 to \$500,000 depending on depth and size of the well. Deep aquifers contain older water which frequently contains high levels of iron, manganese, sulfur, or other elements. Costs associated with the removal of these elements and sealing contaminated supply wells must also be considered.
2. **Blending**—Water suppliers commonly “blend” water from multiple wells to obtain the desired nitrate level. In some instances, a new high capacity well may need to be installed for dilution purposes.
3. **Treatment**—In situations where high quality water is not available, nitrate removal (treatment) maybe the only feasible option. Nitrate removal systems used by public water suppliers include:
 - ❖ **Reverse Osmosis Process**—Pressure forces water through a semi-permeable membrane leaving behind most contaminants and a portion of the rejected solution. The membranes need to be replaced on a regular basis. Typically, reverse osmosis can reduce nitrates by 85 to 95% but actual removal rates vary depending on the initial water quality, system pressure, and water temperature.

- ❖ **Ion Exchange Process**—An ion exchange system works by passing contaminated water through a resin bead filled tank. The resin is saturated with chloride which chemically trades places with the similarly charged nitrate ion. Eventually the resin needs to be recharged by backwashing with a sodium chloride solution. The presence of sulfates can reduce the efficiency of the nitrate removal.

Case Studies— New Well Construction and Blending

The City of Perham installed a new well in 2002 for blending purposes and to replace two lower producing wells. Construction expenses cost city residents over \$600,000. Perham was one of the first cities in Minnesota to develop and implement a Wellhead Protection Plan. As a result of implementing their wellhead protection strategies, nitrate concentrations are stabilizing in the recharge area. Strategies used by the city can be viewed at: <http://www.mda.state.mn.us/appd/waterperham.pdf>

The City of Hastings has experienced elevated nitrate concentrations in three supply wells. In 2003, a test well was drilled to determine quality of a potential water supply. Initial installation and testing costs exceeded \$20,000. Initial pumping results indicate elevated nitrate concentrations and now the city is seeking proposals for alternative treatment/blending options.

Case Studies— Nitrate Treatment

In response to elevated nitrate levels, five municipal water suppliers in Minnesota have constructed nitrate removal systems. Initial construction costs for these removal systems are expensive, especially for smaller communities. Because each situation is unique, it is extremely difficult to estimate the economic burden due to nitrate problems. Up front construction costs can range from \$350 to \$1000 per resident. Annual operating costs are dependant on nitrate concentrations in raw water, the amount of water treated, filter replacement costs, maintenance costs, and chemicals costs. Annual equipment maintenance can cost \$0.25-\$0.35 per 1000 gallons treated. For comparison purposes, public water suppliers without nitrate contamination can produce finished drinking water for \$0.05-\$0.10 per 1000 gallons.

Minnesota Public Water Supply Systems with Nitrate Removal Systems	Public Water Supply	Pop. Served	Type of System	Year Installed	Nitrate Removal Construction Costs	Construction Cost per Resident	Annual Gallons (Millions)	Cost to produce 1000 gallons*
	Adrian	1,234	Ion Exch	1998	\$601,000	\$ 487	47 m	\$1.32
LPRW**	4,100	RO	1999	\$1,706,650	\$416	461 m (96 m rejected)	\$1.35	
Ellsworth	538	Ion Exch	1994	\$362,000	\$672	17 m	\$5.71	
Edgerton	1,050	Ion Exch	2002	\$368,000	\$350	50 m	\$0.97	
Clear Lake	425	Ion Exch	1995	\$412,390	\$970	17 m	\$4.38	

*Approximate cost to produce 1000 gallons assuming a 20 year amortization of initial costs (without interest expense) plus annual operating costs

**Lincoln-Pipestone Rural Water—Holland Wellfield

Conclusions

A small number of Minnesota communities are responding to nitrate contamination remediation by drilling new wells, blending, or installing nitrate removal systems. However, these choices can be expensive and do not address the immediate problem of nitrates entering the drinking water supply. Based on the additional costs from the communities that have installed nitrate removal, it appears that the treatment costs are four to five times higher than for other water suppliers not impacted by nitrates. Currently we can not estimate the additional costs incurred by communities that are blending or those that have found it necessary to replace wells.

Numerous steps can be taken to reduce nitrate contamination before it enters our drinking water resources. Among these, the development and implementation of Wellhead Protection Plans. Strategies in these plans should prove to be a powerful tool for preventing nitrate contamination of drinking water supplies.

Wellhead teams are encouraged to review the entire series of related fact sheets.

<http://www.mda.state.mn.us/appd/waterprotect.htm>

For more information:

Minnesota Department of Agriculture—www.mda.state.mn.us/appd/waterprotect.htm

Minnesota Department of Health— www.health.state.mn.us/divs/eh/water/index.html

Minnesota Rural Water Association—www.mrwa.com

