Septic Systems and Ground Water Quality

Background

Individual Sewage Treatment Systems (ISTS or septic systems) are used for treatment and disposal of wastewater from individual homes, clusters of homes, isolated communities, industries, or institutional facilities. Currently, over 26 million septic systems recycle at least five billion gallons of effluent daily in the United States (Dix and Nelson, 1998). More than 37 percent of new construction utilizes septic systems to manage waste. In Minnesota, there are approximately 500,000 septic systems. The number of septic systems continues to grow as metropolitan areas expand beyond municipal services and as lakeshore property is developed. For more information on numbers of septic systems and trends in Minnesota, see http://www.bae.umn.edu/~septic/Homeowner/health.html

Septic systems have the potential to impact ground water. Human waste contains high concentrations of microorganisms and many chemicals, including carbon, nitrogen, phosphorus, salts, and trace elements. Septic systems have often been used for disposal of other wastes such as paint, oil, and household cleaners. Chemicals such as dichlorobenzene were often used for odor control. These chemicals are no longer used. For more information on construction and operation of septic systems, see http://www.extension.umn.edu/distribution/naturalresources/components/6583-03.html

GWMAP Studies

GWMAP began a study in St. Cloud in 1997 to examine ground water impacts from different land uses. As part of the monitoring design, three shallow monitoring wells were completed in a vulnerable sand aquifer underlying nonsewered residential areas. Quarterly sampling in 1997 revealed a median concentration of 6.1 mg/L for nitrate, compared to a median concentration of 1.4 mg/L in sewered residential areas and 0.8 mg/L in forested areas. While continuing quarterly sampling in St. Cloud through 2000, we also conducted ground water investigations in several other areas. These included extensive studies in Baxter, Lakeland, and St. Joseph, Minnesota, and limited studies in several communities in the Twin Cities Metropolitan Area. The figure below shows the locations of the studies.

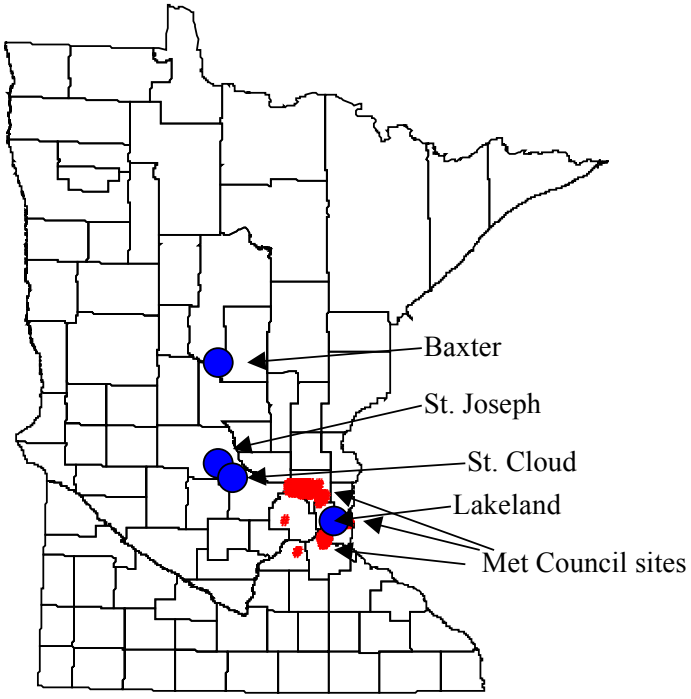

Figure: Locations of septic system studies.

Design

- The studies in Baxter, Lakeland, and St. Joseph, were all conducted in nonsewered communities underlain by coarse textured soils and an unconfined sand aquifer. At each site, we drilled nine to twelve temporary wells that were screened in the upper few feet of the water table. We also collected samples from 24 to 44 private drinking wells completed deeper in each aquifer. Wells were sampled for nitrate, ammonia, Kjeldahl nitrogen, chloride, organic carbon, major ions, some trace elements (Using ICP), and bacteria.
- We used a geoprobe to collect samples from seven septic plumes in Baxter. We drilled approximately ten temporary wells at each site. We sampled for the same parameters as described above, plus VOCs.
- In the Met Council studies, we collected geoprobe samples from four communities and samples from private drinking water wells in twelve communities.
- In the St. Cloud study, we sampled quarterly between 1997 and 2000 for a wide range of inorganic and organic chemicals. These included VOCs, herbicides, and PAHs.

Results

In all study areas, nitrate concentrations in shallow ground water (4.1 to 6.4 mg/L) are higher than under sewered residential (between 1.5 and 2.0 mg/L) or undeveloped (less than 1.0 mg/L) areas. Median concentrations for the different study areas are shown below (at this time, we do not have the Metro area results back).

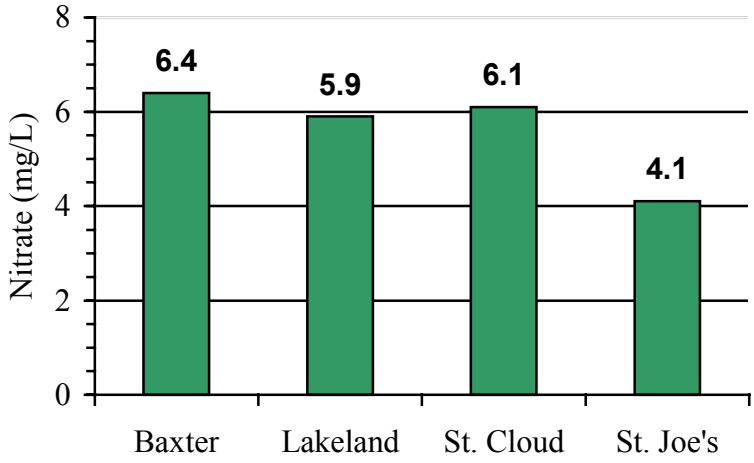

Figure: Median nitrate concentrations in shallow ground water.

Results for the various studies can be found at the following locations:
Baxter: http://www.pca.state.mn.us/water/groundwater/gwmap/septic.pdf
Baxter, St. Joseph, and Lakeland:
http://www.pca.state.mn.us/water/groundwater/gwmap/gwq-unseweredsub.pdf
St. Cloud: http://www.pca.state.mn.us/water/groundwater/gwmap/rpt-landuse-stcloud.pdf
The Met Council study is not complete. Results for private wells can be viewed in the following attached document.

- Summary of Met Council Sites

Concentrations of most other chemicals were lower in nonsewered communities compared to sewered communities. Although we detected VOCs in each of the seven septic tanks we sampled, we only detected VOCs in ground water directly beneath three of the systems and never more than 50 feet down-gradient of a system. High concentrations of phosphorus were often detected directly below the drainfield, but concentrations were within the range of background 30 feet down-gradient of the system. Coliform bacteria were detected in high concentrations directly beneath most systems. Bacteria were generally not detected 30 feet down-gradient of the system. Typical plumes for nitrate, phosphorus, and bacteria are shown in Figures 6, 7, and 8 in the following report:
http://www.pca.state.mn.us/water/groundwater/gwmap/septic.pdf

Our Metro study was designed to examine the effect of factors such as lot size and system age. Results for that study are not available yet. From our other studies, it appears that ground water nitrate concentrations increase for about the first 15 years under a new development that has 1-acre or smaller lots. Concentrations remain steady after about 15 years. Since plumes are relatively predictable in their shape and length, we can estimate the percent of shallow ground water impacted above the drinking water criteria. This is about 20 percent for 1/2-acre lots, 10 percent for 1-acre lots, and so on. We measured an

exceedance rate of 22 percent in areas with 1/2-acre lots. Predicting plume development under a nonsewered community therefore seems reasonable. This would allow use of computer models to predict ground water quality in areas where nonsewered developments occur.

In deeper ground water, we often found nitrate concentrations below the reporting limits. This is because many sand aquifers in Minnesota have denitrifying conditions below about 15 feet. These aquifers are not sensitive to nitrate contamination. There are exceptions, however, as illustrated below. Exceptions occur in areas with fractured bedrock, deep well-connected sand aquifers, and where irrigation pulls shallow water deep into the aquifer.

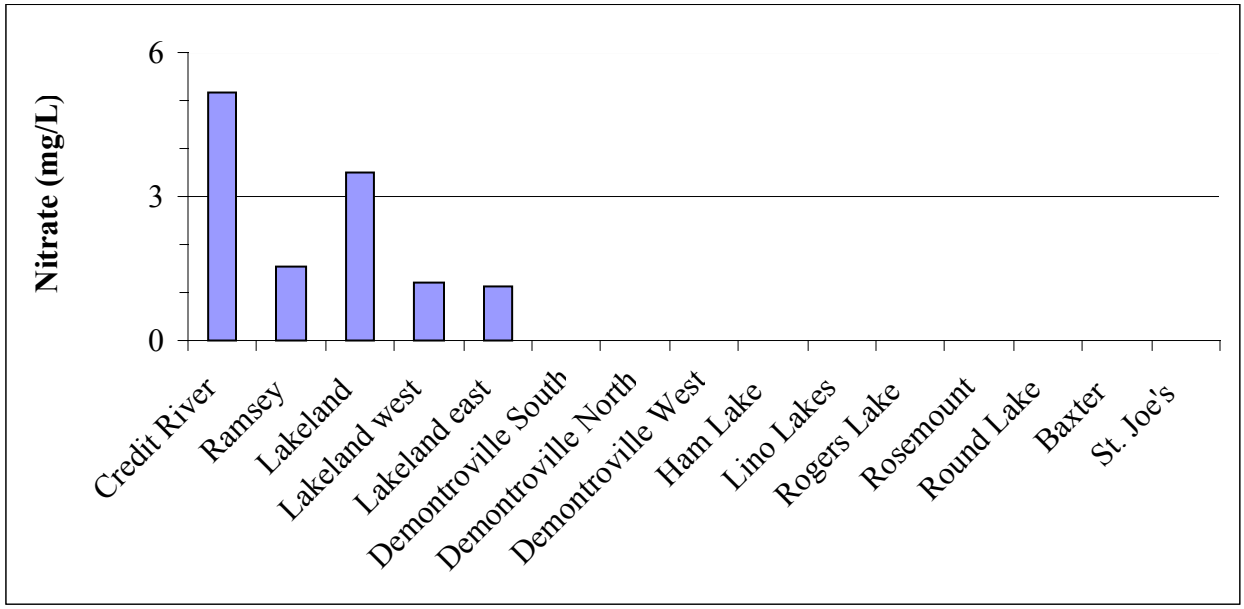

Figure: Nitrate concentrations in private wells screened deep in an aquifer.

Management Options

- Drill private wells deeper when denitrifying conditions exist in an aquifer.
- Use larger lot sizes when deep ground water is vulnerable to contamination.
- Be aware of where septic systems are when siting a well.
- Employ appropriate nitrate setback distances for surface water.
- Maintain septic systems to minimize the risk from pathogens.

Programs, Activities, and other sources of information

- MPCA: The agency is involved in many ISTS efforts. See http://www.pca.state.mn.us/programs/ists/index.html
- Minnesota Rules, see: http://www.revisor.leg.state.mn.us/arule/7080/

- University of Minnesota Extension (outreach and education): http://www3.extension.umn.edu/listing_source.html?topic=3&subcat=110; http://www.extension.umn.edu/distribution/naturalresources/DD6583.html
- Prevention activities/documents: http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/SepticSystemControls.htm
- Example of a County program (Scott): http://www.co.scott.mn.us/EH/ISTS/septic.htm
- Minnesota Lakes Association bibliography: http://www.mnlakesassn.org/Main/Resources/SepticSystems/index.cfm