UNDERSTANDING POLLUTION SOURCES AND PROTECTING WATER QUALITY IN CLEAR LAKE

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Copies provided by the Clear Lake Betterment Association

Executive Summary

- **Water quality affects lake property values**

- **Clear Lake has become a "bedroom community/retirement community"**

- **Clear Lake water quality is declining**

- **Nonpoint source pollution is a problem on the lake**

- **Phosphorus loadings from agricultural production affects water quality**

- **Nitrates and phosphorus are a major cause of algal blooms**

- **Septic tank systems cause nitrate and phosphorus pollution in the lake**

- **Nitrates from septic tank systems can cause health problems**

- **Federal programs to institute best conservation practices help control nonpoint source pollution from farms and ranches**

- **Lake communities are implementing public sewer systems to lower pollution from septic tanks**

Protecting Water Quality

In the original articles of incorporation for the Clear Lake Betterment Association, the purpose of the organization is outlined. The CLBA will "promote good recreation and water safety for Clear Lake…and in connection therewith to also undertake studies for controlling water levels, pollution and environment and to promote good ecology for Clear Lake and surrounding areas…and generally improve the lake and lake shore property for the betterment of all occupants." Understanding pollution sources and protecting water quality in Clear Lake has been a goal of the CLBA since its inception.

Water quality has a big impact on the usefulness of the lake and the value of lake shore property. Protecting Clear Lake water from pollution sources is critical to the use of the lake for recreational purposes and to the quality of life around the lake. High levels of certain nutrients can affect the ability of the lake to propagate fish life. Poor water clarity and algae blooms impact recreation on the lake and the quality of life for lake property owners. Maintaining good water quality is probably the most important factor related to quality of life on the lake and to property values for lake property owners.

A recent study of the lakes in north-central Minnesota shows just how much clear water can enhance the value of lakeshore property. In a study of Stubbs Bay in Minnesota, researchers examined 1,205 residential property sales from 1996 to 2001. They concluded that **water clarity is very significantly related to the price per foot of lakeshore**. Water quality is a measure of how deep you can see into a lake. It can be affected by pollution, erosion and other factors, including the removal of shore vegetation.

Clear Lake Geographical Information

Located: Lake Township and Red Iron Township in Marshall County, SD

Average Lake Depth: 13 feet

Surface Area: 1,087 acres

Watershed Area: 55,000 acres

Shoreline Development: highly developed with approximately 210 lake homes and cabins

River Basin: Big Sioux

Land Uses in the Clear Lake Watershed

26 %	Water and Wetlands
2%	Urban and Housing

1%	Trees
67%	Grass and Hay Lands
4%	Crops

One of the current positive characteristics of the Clear Lake watershed is the fact that about two-thirds of the watershed area is in grass and hay lands. Fertilizer (phosphorus) run-off from grass and hay lands is much smaller than for croplands, since there is less soil erosion on grass land and hay lands. (For example, Big Stone Lake had major pollution problems that had to be addressed because its watershed consists of a lot of crop land.) However, a large number of those hay and grass lands within the Clear Lake watershed could change significantly in the future as Conservation Reserve Program (CRP) land is moved into crop production.

Clear Lake Changes Its Economic and Demographic Face

Many people who have been on the lake for many years have a sense of nostalgia about the lake and "the good old days." The lake has changed from almost a pastoral setting **to having a highly developed shoreline.** Some would like to go back to those old days, but progress is not a genie that you can put back in the bottle. For one thing, the economic and demographic "face" of the lake has changed. There are a lot more people and homes on all parts of the lake.

Over time, Clear Lake has changed from being basically a weekend recreation spot to becoming a bedroom/retirement community. In the 1950s, 1960s, and 1970s the Clear Lake state park was a hotspot for picnics and swimming. Small lake cabins were maintained around the lake as a place for couples with children to enjoy the lake on weekends.

Now, Clear Lake has the characteristics of a residential neighborhood, with lake residents living here the year around. Many of the current permanent homes contain small (one to two persons) households. There are only a limited number of families with young children living on the lake all year.

Included in the permanent households on the lake are working couples that commute from the lake to jobs someplace else. For some families with younger children, the commuting only takes place during the summer months, when school is not in session. There are also now more retirees on Clear Lake. Some of the retirees are couples who have returned "back home" after living in other places. Others were just looking for a "lake place" to enjoy their retirement.

With the transition from predominantly young families visiting the lake on weekends to more couples living on the lake all year, there has been a demographic change. Retirees tend to be older than couples with young children, and they tend to have higher median household incomes. The same would hold true for the working families who commute to work. With higher median household income, a process called "gentrification" has probably occurred, where some long-time residents were displaced by new commuter residents due to rising house prices. But it is interesting to note, despite the prevalence of one-to-two person households, traffic at the lake on weekends rises significantly. Many of the retired couples/worker couples living on the lake maintain larger homes mainly for the use of their grown children and younger grandchildren on weekends.

The current CLBA roster of lake residents shows 209 addresses for homes on the lake. Based on a comparison of the listing's 911 addresses and mailing addresses, it appears that around thirty-two of those homes house full-time residents.

Housing Changes on Clear Lake

When lake residents first built homes or moved buildings to Clear Lake, most cabins were small in size and designed for occasional weekend use during the summer. Besides a couple of farm homes around the lake, there were very few houses built for year-around use. During the drought years in the 1980s, many lake lots changed hands. As the lake regained normal water levels, people started looking for a "place on the lake." Yet the housing norm during the 1980s was still small houses and trailers for many lake lots. Beginning in the late 1990s and early 2000s, housing trends changed dramatically. Large lake homes were built on all sides of the lake. Many of the small cabins and trailers disappeared with new larger homes being built on the bigger lake lots. In recent years, a large area on the northwest side of the lake was developed into a new housing division. Several large, year-around homes have been built in this new part of the lake. During the 2000s, the southeast side of the lake saw several year-round homes being built.

Since 1989, Marshall County has granted 50 building permits for new residential construction. The following table shows that new residential construction has really increased over time.

	Residential Building Permits
1989-1993	2
1994-1998	8
1999-2003	12
2004-2008	28

These housing changes have dramatically changed the demand for utilities around the lake, including electricity, water and sewage disposal. Many of the early cabins had 50-60 amp electrical services with no connection cost for hooking-up to Lake Region Electric service. Now new electrical connections are for 200 amp service, and there is a $300 connection cost. For years, each cabin or lake home had its own well and/or hauled drinking water from town. Now many of the lake homes have BDM Rural Water and a $23 minimum monthly utility charge. There is also a $1,000 connection cost for BDM Rural Water System service. The monthly water rate pays for system maintenance and helps repay the original construction costs.

With the additional shoreline development, new home construction, more lake residents, and increasing "lake days," water clarity is not as good as it was in the "good old days," and algal blooms restrict lake use during parts of the summer. Pollution has become a greater concern for lake residents.

National Efforts to Control Water Pollution

Major national efforts to control water pollution began in 1972 with the creation of the US Environmental Protection Agency and the passage of the Federal Water Pollution Control Act of 1972, which later became known as the Clean Water Act (CWA). Early water pollution control focused on point sources such as industrial and municipal wastewater discharges.

The CWA requires that specific actions be taken and specific reports be submitted by state agencies. Water Quality Standards are created by state agencies for different types of water bodies and water body locations per desired uses. The Clean Water Act (CWA) requires each governing jurisdiction (states, territories, and covered tribal entities) to submit a set of biennial reports on the quality of water in their area. These reports are known as the 303(d), 305(b) and 314 reports, named for their respective CWA provisions, and are submitted to, and approved by, the EPA. These reports are completed by the governing jurisdiction, typically a Department of Environmental Quality or similar state agency, and are available on the web. All US governing jurisdictions, including South Dakota, submit all three reports in a single document called the "Integrated Report."

The 305(b) report National Water Quality Inventory Report to Congress is a general report on water quality, providing overall information about the number of miles of streams and rivers and their aggregate condition. The 314 report has similar information for lakes. The CWA requires states to adopt water quality standards for each of the possible designated uses that they assign to their waters. Should evidence suggest or document that a stream, river or lake has failed to meet the water quality criteria for one or more of its designated beneficial uses, it is placed on the 303(d) list of impaired waters.

Nonpoint Water Pollution

Early water pollution control efforts focused on point sources, because they were readily identified and control technology was readily available. Because of these factors, nonpoint source pollution control and holistic watershed management was deferred.

As the name implies, Nonpoint Source (NPS) pollution results from diffuse sources. The South Dakota categories of (NPS) pollution include agriculture, silviculture, construction runoff, resource extraction/exploration/development, habitat modification, urban runoff and other. (Waste storage/storage tank leaks would be a sub-category of the "other" category.)

Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground and carrying natural and human-made pollutants into water bodies. In terms of pollutant loads, numbers of sources, aerial extent and number of persons contributing, nonpoint source pollution is a much larger and more complex problem than point source water pollution. **The primary parameters of nonpoint source pollution are sediment, nitrogen, phosphorus and bacteria.**

Nonpoint source pollution was first addressed, although in only a minor way, through section 208 of the Clean Water Act during the late 1970s and early 1980s. These control efforts generally failed because funds were for planning only. However, things changed dramatically in the late 1980s. The Clean Water Act of 1987 authorized section 319 which provided for nonpoint source water pollution control strategies and funding for implementation. South Dakota and Delaware were the first states to implement a nonpoint source program.

The SD nonpoint source program, as a component of the Watershed Protection Program, is built on voluntary participation and local leadership. The program is designed to reduce and prevent water pollutant loadings to rivers, lakes, watersheds and ground waters so that water quality standards are met and beneficial uses are supported. Watershed areas are assessed, pollutant sources are identified, necessary reductions are calculated and restoration methods are implemented.

With respect to Clear Lake, efforts are already underway within the Watershed Protection Program to control nonpoint source pollutants, especially those related to agriculture. For example, the Northeast Glacial Lakes Watershed Improvement and Protection Project is currently in place. The project is a cooperative venture between the Day, Marshall and Roberts County Conservation Districts. Grants from federal and state agencies **provide monies for cost share incentive payments to agricultural producers and landowners who implement best conservation practices on their lands.** The best practices are designed to reduce non-point pollution in the 12 watersheds within the three county project areas.

Phosphorus

As previously noted, the primary parameters related to nonpoint source pollution are sediment, nitrogen, phosphorus and bacteria. The factor which probably gets the most attention relative to water quality measurement is phosphorus. Phosphorus is an important nutrient with respect to water quality and greatly influences algae blooms.

Phosphorus is a nutrient that occurs in many forms that are bio-available. It is a main ingredient in many fertilizers used for agriculture as well as on residential and commercial properties, and may become a limiting nutrient in freshwater systems. Phosphorus is most often transported to water bodies via soil erosion, since the various forms of phosphorus tend to be adsorbed to soil particles. Another source of excess phosphorus in lakes is poorly-functioning septic tank systems. Excess amounts of phosphorus in these systems lead to algae blooms and consequently hypoxia. A recent study by the Interlakes Water Quality Committee (for Brant, Herman, Madison and neighboring lakes) reported that **"the high levels of phosphorus entering the lakes are no doubt the cause for the algae bloom that occurs during the summer months."**

Nutrient runoffs (animal waste, fertilizers, sewage) from the land cause a deterioration of water quality. When excessive quantities of nutrients in a lake or other body of water are measured, it is known as eutrophication.

Measuring Water Quality with TSI

The quantities of nitrogen, phosphorus, and other biologically useful nutrients are the primary determinants of a lake's **trophic state index** (TSI). Nutrients such as nitrogen and phosphorus tend to be limiting resources in standing water bodies, so increased concentrations tend to result in increased plant growth, followed by corollary increases in subsequent trophic levels. Consequently, a lake's trophic index may sometimes be used to make a rough estimate of its biological condition. Although the term "trophic index" is commonly applied to lakes, any surface water body may be indexed.

Carlson's Trophic State Index

Carlson's index is one of the more commonly used trophic indices and is the trophic index used by the United States EPA. The *trophic state* is defined as the total weight of biomass in a given water body at the time of measurement. Because this measurement is of public concern, the Carlson index uses the algal biomass as an objective classifier of a lake or other water body's trophic status. According to the US EPA, the Carlson Index should only be used with lakes that have relatively few rooted plants and non-algal turbidity sources.

Because they tend to correlate, three independent variables can be used to calculate the Carlson Index: chlorophyll pigments, total phosphorus and Secchi depth. Of these three, chlorophyll will probably yield the most accurate measures, as it is the most accurate predictor of biomass. Phosphorus may be a more accurate indicator of a water body's summer trophic status than chlorophyll if the measurements are made during the winter. Finally, the Secchi depth is probably the least accurate measure, but also the most affordable and expedient one. Consequently, citizen monitoring programs and other volunteer or large-scale surveys will often use the Secchi depth. By translating the Secchi transparency values to a log base 2 scale, each successive doubling of biomass is represented as a whole integer index number. The Secchi depth, which measures water transparency, indicates the concentration of dissolved and particulate material in the water, which in turn can be used to derive the biomass.

Trophic Classifications

A lake is usually classified as being in one of three possible classes: *oligotrophic*, *mesotrophic* or *eutrophic*. Lakes with extreme trophic indices may also be considered *hyperoligotrophic* or *hypereutrophic*. The table below demonstrates how the index values translate into trophic classes.

The following table shows the relationships between Trophic Index (TI), chlorphyll (Chl), phosphorus (P, both micrograms per litre), Secchi depth (SD, metres), and Trophic Class (after Carlson 1996)

TI	Chl	P	SD	Trophic Class
<30--40	0--2.6	0--12	>8--4	Oligotrophic
40--50	2.6--7.3	12--24	4--2	Mesotrophic
50--70	7.3--56	24--96	2--0.5	Eutrophic
70--100+	56--155+	96--384+	0.5--<0.25	Hypereutrophic

Oligotrophic lakes generally host very little or no aquatic vegetation and are relatively clear, while eutrophic lakes tend to host large quantities of organisms, including algal blooms. Each trophic class supports different types of fish and other organisms as well. If the algal biomass in a lake or other water body reaches too high a concentration (say >.80 TI), massive fish die-offs may occur as decomposing biomass deoxygenates the water.

Both natural and anthropogenic factors can influence a lake or other water body's Trophic Index. A water body situated in a nutrient-rich region with high Net-Primary Productivity may be naturally eutrophic. Nutrients carried into water bodies from nonpoint sources

such as agricultural runoff, residential fertilizers, and sewage will all increase the algal biomass and can easily cause an oligotrophic lake to become hypereutrophic.

Trophic State Management Targets

Often, the desired Trophic Index differs between stakeholders. Water-fowl enthusiasts (e.g. duck hunters) may want a lake to be eutrophic so that it will support a large population of waterfowl. Residents, on the other hand, may want the same lake to be oligotrophic, as this is more pleasant for swimming and boating. Natural Resource agencies are generally responsible for reconciling these conflicting uses and determining what a water body's trophic index should be.

Clear Lake Water Quality

As previously discussed, there are several different factors that impact water quality in Clear Lake. Over the years, water quality on Clear Lake has been tested to determine the impact of pollutants. The lake's water quality remains relatively good. The TSIs have varied from mesotrophic to eutrophic. In recent years, it has ranged widely in the eutrophic category. One of the primary factors for the erratic movement of the TSIs is the amount of pollutants that had been trapped in the lake at the time of the water testing. Basically, the lake acts as a filter for phosphorus and other pollutants that come from the watershed. During years with high run-off, the lake gets "flushed," with nutrients leaving the lake. However, the high run-off also brings in another load of phosphorus and other pollutants. High run-off is most helpful when it removes a lot of nutrients during a hot summer when an algal bloom is taking place.

Since there is wide variability in water quality over time, it is important (for research purposes) to conduct water testing on a consistent basis. SD Department of Environment and Natural Resources (DENR) staff conduct intermittent water quality testing on the state's lakes. They sampled Clear Lake in 1979, 1989, 2001, and 2005. (According to DENR's *The 2008 South Dakota Integrated Report for Surface Water Quality Assessment*, Clear Lake was scheduled for testing in 2008, but no 2008 measurements were found for the lake.) Under different federal funding, the SD Water Resources Institute checked Clear Lake water quality in 1991-1995. In 2006, WRI conducted sampling as part of an undergraduate research project. The CLBA contracted with WRI to conduct studies in 2007, 2008 and 2009.

A WRI report titled *Clear Lake Water Quality 1979-2005* summarized the testing of the lake over the years. "Lakes range from nutrient poor (oligotrophic) to moderately rich

(mesotrophic) to high enriched (eutrophic) to excessively enriched (hyper-eutrophic). Calculating a Trophic State Index (TSI) is a numerical way of describing how productive or enriched a lake may be compared to other lakes. TSIs also provide a way to detect water quality changes that have occurred over the years. Lower TSIs indicate better water quality. Total phosphorus and Secchi disk transparency are commonly used to calculate TSI values." Clear Lake TSIs from 1979 to 2005 are shown in Figure 1 and Figure 2.

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The WRI study goes on to describe what the measurements mean. "What do these graphs tell us about Clear Lake? In the period from 1979, Clear Lake could be described as mesotrophic to eutrophic. Year to year variations in water quality may be due to weather patterns or changes in phosphorus loads from the watershed. Mesotrophic lakes typically respond to relatively small increases or decreases in phosphorus loadings. It appears that Clear Lake water quality is sensitive to changes in phosphorus loadings.

"Water quality in Clear Lake declined somewhat in the period from 1979 to 1992, then improved to a mesotrophic status by 1994. Clear Lake drifted to more eutrophic conditions again by 2005. Apparently weather events or watershed activity had increased phosphorus loadings to the lake. Large snowfalls in 1996-97 probably increased phosphorus loadings to the lake, but no sampling data is available.

"The two most recent years (2001-2005) of sampling data for both phosphorus and Secchi disk transparency show declining water quality. Shoreline development tends to increase phosphorus loadings to lakes and results in declining water quality. Construction and increased seepage from septic tanks are major factors.

"Because of potential future phosphorus loadings, Clear Lake will probably drift to a more eutrophic state." As additional CRP acres in the watershed are converted back to cropland, this farming change will result in additional sources of sedimentation and phosphorus, adding to current levels from lake shore development and septic tanks. The report goes on to describe the impact of additional cropland on water quality if septic tank pollution is not lowered. "When the CRP land in the watershed is returned to production, the combined increases in phosphorus loadings from cropland and shore line development will probably result in **declining water quality in Clear Lake if phosphorus loadings from other sources are not reduced."**

In May, 2009 David German and Dennis Skadsen (Water Resources Institute) provided a preliminary report on their Clear Lake water quality findings for 2006-2008. The Secchi disk transparency readings moved around but were basically in the same category (eutrophic) as the long-term previous report showed. For the same current time period, total phosphorus readings remained in the eutrophic category.

German also reported on ammonia levels in Clear Lake. He noted that the Sept. /Oct. 2007, 2008 ammonia readings on the bottom of the lake were significantly higher than the surface concentrations. Higher readings on the bottom represent the release of ammonia from the sediments. Ammonia is generated as an end product of bacterial decomposition of dead plants and animals. It can support the rapid development of algal blooms if other nutrients are present. In productive lakes, ammonia commonly accumulates in bottom waters in conjunction with the onset of anoxic (dissolved oxygen depleted) conditions, thereby degrading lake water quality. Anoxic conditions can occur naturally and can be created or exacerbated by the oxidation of human-made contaminants such as septic tank discharges.

In addition to the WRI water quality study, the DENR also produces reports on water quality in individual lakes. The Clean Water Act requires states to adopt water quality standards for each of the possible designated uses that they assign to their waters. The DENR has to determine whether or not the lakes meet the criteria for four different assigned beneficial uses. The South Dakota designated uses include wildlife propagation and stock watering; immersion recreation; limited contact recreation; and fish life propagation. (In some cases, the DENR may not assess all four beneficial uses.) Should evidence suggest or document that a stream, river or lake has failed to meet the water quality criteria for one or more of its designated uses, it is placed on the 303(d) list of impaired waters. Once a state has placed a water body on the 303(d) list, it must develop a management plan establishing Total Maximum Daily Loads for the pollutant(s) impairing the use of the water. These TMDLs establish the reductions needed to fully support the designated uses. TMDLs are required by the federal Clean Water Act for water bodies that do not meet WQS. TMDLs are receiving more attention now because of the several recent lawsuits in federal courts.

In South Dakota, TMDLs are set by the Department of Environment and Natural Resources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include any contributions from natural sources and a margin of safety to ensure that the water body can be used for the purposes SD has designated. The calculation must also account for seasonal variation in water quality.

It is important to remember that a goal of every lake association is to protect the lake so that it does not attain the impaired designation and does not require the determination of TMDL levels. **Biologists and ecologists say that once water quality has deteriorated, it**

takes about 10 years of hard work to get back to good water quality. A good example of the work and cost required to reclaim a lake would be the Big Stone Restoration Project which was funded by the Environmental Protection Agency (EPA). Around 1986, Big Stone was classified as a lake with water quality problems. It was given a lake status of hypereutrophic. It had major problems with nonpoint source pollution, including sediment and nutrients. Algae blooms were a major problem. After about 13 years of restoration work, the lake has improved to the eutrophic state.

The DENR uses median TSI levels for Secchi depth and Chlorophyl-a to determine if a lake supports fish propagation. The DENR's *The 2008 South Dakota Integrated Report for Surface Water Quality Assessment* determines whether or not selected lakes met the warmwater permanent fish life propagation beneficial use criteria during 2000-2007. (Clear Lake is compared to other lakes in the warmwater permanent fish propagation group.) The following table from the DENR report shows that Clear Lake water quality fully supports this beneficial use. (In comparison, Roy Lake is in the non-support classification for this beneficial use.)

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Septic Tank Problems

The WRI reports say that septic tank systems are a source of pollutants into lakes. A 2006 article titled *Getting to Know Your Septic Tank* included information from the DENR on septic tank design and maintenance. It says "there are a variety of reasons why a septic tank system may run into problems. **A septic tank is designed to provide a certain number of years of service.** In the case of coated metal tanks, the life expectancy is less than seven years under South Dakota regulations. Concrete and plastic tanks last longer, but will eventually fail due to exposure to hydrogen sulfide produced." When the Pickerel Lake Sewer system was being built, the construction company inspected individual homeowners' "septic tanks" to make sure that they met regulations. A wide variety of "septic tanks" were discovered, ranging from the 50 gallon metal barrel to kitchen appliances to car bodies to approved septic tanks. Not surprisingly, based on their life expectancy, many of the metal "septic tanks" were just pieces of metal and not performing their designated role. In other words, raw sewage was going directly from the house into the soils near the lake.

The engineering firm that is currently working on a section of the Lake Poinsett public sewer project talked about their experience with digging up the old septic tanks and drain fields during a previous phase of construction. The firm indicated that **fifty percent of the old septic tank systems had totally failed and sewage was going directly in the soil** (and the lake)**.**

The 2006 article *Getting to Know Your Septic Tank* went on to talk about another part of septic tank design. "Another aspect of septic tank design is that tank size is based on how many people live in the house and how much of the day they are expected to spend there. The minimum design requires that it be large enough to handle the waste for 3 ½ people." Undersizing the septic tank will result in a tank that needs to be pumped quite frequently. Over-designing the system to handle an occasional increase in use can result in the system not treating the smaller flow. As lake residents are now spending more time in their lake homes, **many of the older "septic tanks" are probably not adequate to handle the increased flow.** Most new plastic septic tanks are around the 1500 to 2000 gallon size to meet the requirements for a normal house.

Another part of the septic tank sewer system can be a source of lake water pollution. Soil conditions are critical to proper dissolution of solids and phosphorus. The septic tank article states that "state law requires a percolation test be conducted when a new septic tank system is installed to make sure that wastewater will percolate through the soil and be taken up by the roots of plants. Over time, the percolation can become less due to adsorption of waste particles on soil, or due to changes in soil alkalinity caused by the

wastewater. When this happens, less wastewater will flow out of the leach field, backing up the septic tank.

A report on the website for New Garden Township in Pennsylvania provides information about septic tank systems. The website says that **"failing septic systems are one of the largest sources of pollution in Pennsylvania."**

The University of Minnesota Extension website also warns about pollution problems with septic tank systems. C. J. Rosen (Extension Soil Scientist) and B. P. Horgan (Extension Turfgrass Specialist) talk about water pollution from nitrates. "**Most problems of Minnesota wells contaminated by nitrates have been traced to animal manure, septic tank sources, or fertilizer spills."** However, over-application of nitrogen fertilizer can also contribute to nitrate pollution, especially on sandy, coarse textured soils. This is because the nitrates not used by the plants can leach through the soil when excessive rainfall occurs.

The Minnesota Department of Natural Resouces has published a report titled *Your Lake, Our Lakes: The Science of Septic Systems.* Paul Radomski and Russ Schultz discuss nitrate and phosphorus pollution from septic tanks. "A septic system consists of a septic tank and a drain field. The septic tank captures solid material and anaerobic bacteria decompose some of the solids. The wastewater that leaves the septic tank, or effluent, contains significant amounts of pathogens, pollutants, and nutrients, such as nitrogen and phosphorus. The drain field, with a system of perforated pipes, distributes the effluent to a large area so that aerobic bacteria can further break down pathogens and the soil can absorb phosphorus and filter the effluent.

"Septic systems that are properly installed and maintained in areas with appropriate soils do meet public health standards. **However, septic systems have limited capabilities and have the potential to pollute groundwater and lakes.**

"Conventional septic systems can be effective at removing phosphorus. Drain field soils usually absorb or mineralize phosphorus. However, **certain soil conditions and close proximity of drain fields to lakes can result in phosphorus pollution.** The Minnesota Pollution Control Agency has found that elevated phosphorus concentrations in groundwater are usually within 50 feet from functioning septic systems. However, some phosphorus plumes have been found to extend 66 feet from drain fields. Other evidence suggests that drain fields should be at least 100 feet from the lake to minimize the risk of phosphorus reaching the lake.

"Phosphorus is another concern because it is usually the limiting nutrient for lake algae. One pound of phosphorus can produce 500 pounds of algae. A household produces about two pounds of phosphorus per person each year, and it is discharged to septic systems.

"Conventional septic systems are relatively ineffective in removing nitrogen. Nitrogen (in the form of nitrate) can flow with groundwater through the soil and end up in well water

or lakes. Nitrate that gets into the lake will increase aquatic plant and algae growth. Nitrate in drinking water increases the risk to infants of methemaglobinemea, or blue baby syndrome."

There have been other studies and articles on health issues related to septic tanks systems and pollution problems. Marylynn V. Yates wrote an article called *Septic Tank Density and Ground-Water Contamination.* (Yates received her Ph.D. in Microbiology from the University of Arizona. She also has an M.S. in Chemistry from New Mexico Institute of Mining and Technology and a B.S. in nursing from the University of Wisconsin-Madison.)

She writes, "As more and more cases of ground-water contamination are reported, the public has become increasingly aware of the importance of preserving the quality of this limited resource, especially in areas totally dependent on ground-water sources. Although most of the attention is focused on pollution by organic chemicals, these compounds are responsible for a relatively small percentage of ground-water-related disease outbreaks. The majority of waterborne disease outbreaks are caused by bacteria and viruses present in domestic sewage. **Septic tanks contribute the largest volume of waste water, 800 billion gallons per year to the subsurface, and are the most frequently reported cause of ground-water contamination associated with disease outbreaks.** The U.S. Environmental Protection Agency has designated areas with septic tank densities of greater than 40 systems per mi^2 (1 system per 16 acres) as regions of potential ground-water contamination. Numerous cases of ground-water contamination have been reported in areas of high septic tank density; lot sizes in these areas range from less than one-quarter acre to three acres. The single most important means of limiting ground-water contamination by septic tanks is to restrict the density of these systems in an area."

Clear Lake Septic Tank Issues

At the 2008 CLBA annual meeting, Dennis Skadsen (Project Coordinator of the Northeast Glacial lakes Watershed Project) said there are **many areas around the lake that are not well suited for septic tank systems, based on soil type.** The four most prominent soil types around Clear Lake are Forman, Fordville, Poinsett and Renshaw. In some places, the soil is basically a clay soil (Forman) that does not allow the wastewater to drain away from the drain field. Those drainage problems generally result in wet or soggy ground around the drain field and/or frequent pumping of the septic tank. Other parts of the lake have sandy soils (Fordville). Sandy soils work great for quick drainage, but sandy soils do not hold the waste particles in the soil. Instead, those waste particles move directly into the lake. Frequently, lake residents in those sandy areas proudly claim their 30 year old septic tanks systems have "worked perfectly" ever since installation. But it is easy to figure out what is happening to the sewage in Fordville soils. The Poinsett soil type is better suited for the location of septic tank systems than the Forman and Fordville soil types. However, Renshaw soil is the best soil type for septic tank systems.

There are some people around the lake who have no idea where their septic tank or drain field is located. They just assume that because they don't have plugged toilets or need to pump their "septic tanks," everything is okay. What they may not realize or do not want to admit is that solid wastes are going directly into the soil and the lake.

In May 2009, Dave German and Dennis Skadsen (Water Resources Institute) discussed a concern about water quality near the Clear Lake shoreline. (Most water quality tests are conducted in the middle of the lake.) German maintains that the presence of aquatic macrophytes (basically weeds, grasses, etc.) near the shoreline is another indicator of excess nutrients due to septic tank problems.

The presence of large numbers of aquatic midges (blind mosquitos, non-biting mosquitos) during recent springs might also be an indicator of polluted waters near the Clear Lake shoreline. Many residents believe the swarms of spring-time insects are mayflies, but they are actually midges. May flies would be a more welcome pest since they are an indicator of clean water, while midges are known to hatch from polluted waters.

In 2006, David German conducted a study of macroinvertebrates for three lakes in northeastern South Dakota, including Clear Lake. (His report is titled *Development of an Optimal Macroinvertebtate Bioassessment Index for Prairie Lake in Northeastern South Dakota*.) Since they are good indicators of localized conditions, macroinvertebrates provide insight into the health of a lake. German summarized his findings for the three lakes. "Statistical and metric analysis showed that Enemy Swim was placed in a mesotrophic status (50.24) during the sampling period. It was also found to contain the least pollution tolerant families and the highest Ephemoptera and Trichoptera (ET) family diversity. Clear Lake was found to be in the eutrophic status (59.68) based on Phoshorus TSI values. Clear Lake fell between Enemy Swim Lake and Lake Minnewasta in the ASPT Biotic Index Value and ET Diversity values. Lake Minnewasta was found to be hyper-eutrophic and also had the most pollution tolerant invertebrate communities and the least ET Diversity." In non-scientific terms, Enemy Swim Lake was in the best shape, based on the number of invertebrate families present and their built-up tolerance to pollution. Lake Minnewasta was showing the greatest effects of pollution. Clear Lake was in between the other two lakes.

Public Sewer Solutions to Septic Tank Pollution

A SDSU Cooperative Extension Service circular titled *Wastewater Treatment Systems for Rural Homes and Cabins* discusses septic tank issues around lakes. The SDSU information states that "lake cabin wastewater treatment is a special concern because groundwater is shallow and flow is always towards the lake. Soils around lakes generally are sandy and

ground-water flow is relatively fast. For this reason, many highly-developed lakeshore communities have installed sanitary districts to deal with inadequately located, sized, and/or failing on-site systems built in the past. If a new cabin is high enough and far enough away from the lake's established high water mark, a gravity system can be installed. However a better choice for a new installation is a lift station to pump effluent uphill away from the lake to a safe disposal area.

"If you are remodeling a seasonal cabin for year-around use, consider installing a new on-site system designed for higher waste-water flows. Alternatives include increasing soil treatment field size, adding a lift station to an adequately-sized treatment field away from body waters, or installing a 'collector' system with a group of neighbors and sharing the reduced installation costs."

One of the ways that communities address pollution problems related to septic tank systems has been to build and operate public sewer systems. Municipal (city and town) sewer systems have been around for many years. All except the smallest cities in South Dakota have implemented public sewer systems. Since large and medium-sized city residences have a high density of homes, it is quite cost-effective to build and maintain public sewer systems in most cities. Some years ago, the state legislature recognized that lake communities and housing developments outside city limits also needed to address the pollution issues related to septic tanks systems and allowed those types of communities to form governmental entities called special districts, including sanitary districts. Some lake communities have had sanitary districts operating for years, but the process is more difficult than for cities because of the lower housing density around lakes. Some of the early sanitary districts benefitted from significant federal grants. In recent years, a scarcity of grant funds has made it more difficult to fund sewage projects around lakes. In 2007 the state legislature attempted to make regional sewer systems a reality for more rural parts of the state when they passed legislation which gave counties the authority to acquire, construct, maintain, and operate sewer utility systems. It appears that the SD legislature has recognized the pollution problems related to septic tanks systems and has tried to address the issue in a non-regulatory manner.

Although lake community sewer districts are difficult to fund, they are basically the only way for some communities to address pollution issues related to septic tank systems. According to the Secretary of State website, there are **31 active sanitary districts in the state.** (Lake communities and housing developments are included, but municipal sewer systems are not.) Not surprisingly, a significant portion of them are lake sanitary districts, including Brant Lake, Lake Cochrane, Lake Hendricks, Lake Herman, Lake Kampeska, Lake Madison, Lake Poinsett, Pickerel Lake, Richmond Lake, McCook Lake, and Wall Lake. Although Enemy Swim has had an (inactive) sewer district for years, they recently received DENR stimulus funding for a public sewer district for part of the lake. All of these lakes

have one common factor; they have a significant number of residents with year-around homes. **It is probably only a matter of time before all highly-developed lake communities form sewage districts and implement closed public sewer systems.** The cost of these public sewer systems is financed through a monthly sewer rate, which pays for the system maintenance costs and helps repay the construction costs. Some sewer districts also charge a connection cost to help offset construction costs.

Pickerel Lake's Solution of Septic Tank Problems

The Pickerel Lake sewage district is the public sewer system nearest to Clear Lake. The Pickerel Lake Sanitary District was incorporated by the Day County Commissioners in 1993. After passing resolutions pertaining to financing of the sewer project, the sanitary district opened bids on February 15, 1997, for the construction of Phase I of the project. Dahme Construction Company submitted the low bid, but because the sanitary district was unsure of its own finances, the meeting was adjourned until March 29, 1997. When the meeting was reconvened on March 29, a resolution was adopted, awarding the construction of Phase I to Dahme, based upon its low bid of approximately $1,194,000. Two of the three trustees of sanitary district voted in favor of the resolution. Construction on the project commenced two days later.

Pickerel Lake residents were required to sign up and pay a connect fee. All residents had to hook up in a set number of days. Pickerel Lake residents paid a connect fee of $1000 if they signed up within 90 days and $1500 after the 90 day time deadline passed. Pickerel Lake has a totally closed sewer system: part gravity flow and part pressure. Significant changes in terrain forced the use of lift stations in some areas. The total project cost was $2.5 million. They got $600,000 in two grants and $1,560,000 in two loans. The initial hook-up fees brought in around $300,000.

In 2007, the U.S. Environmental Protection Agency presented a Performance and Innovation in the State Revolving Fund Creating Environmental Success (PISCES) Award to the Pickerel Lake Sanitary District, Grenville, S.D., for constructing a new wastewater collection and treatment system. The award information identifies why Pickerel Lake decided to implement a public sewer system and why the Pickerel Lake Sanitary District got the award. The EPA website notes, "This EPA award recognizes the innovative use of South Dakota's Clean Water State Revolving Fund program funds to improve water quality for the 950 permanent and seasonal residents of the Pickerel Lake area.

"The Pickerel Lake Sanitary District constructed a small collection system and an artificial wetland treatment system when it was determined that the residents' **on-site, individual septic systems around the lake were failing**. The South Dakota Department of

Environment and Natural Resources concluded that the on-site systems were likely contributors to the presence of fecal bacteria levels in the lake.

"The district was awarded two Clean Water State Revolving Fund low interest loans totaling more than $1.5 million and two state grants totaling $600,000 to help finance the project that replaced the individual septic tanks with the new water treatment system."

Legislative Solutions for Clear Lake Septic Tank Problems

During the 2008 legislation session, Clear Lake residents encouraged state legislators to introduce a bill requiring the inspection of individual septic tank sewage systems before lake property could be sold. Because of concerns about passage of any bill requiring an additional inspection before the sale, the legislation was changed to "an Act to require the disclosure of known contamination of waterways on property condition disclosure statements." Even after the changes, the bill still did not pass because of objections from the real estate industry.

In 2009, a few Clear Lake residents again discussed legislation to address pollution problems associated with inadequate septic tank sewage systems on the lake. Legislation to require state inspection of new septic tank sewage systems was discussed. The idea would be to require a state inspection similar to the electrical inspections required by state law when new buildings are constructed. The septic tank system inspection would occur during construction and would be funded by a fee paid by the homeowner. However, the residents ran out of time getting the concept adequately formulated and supported in time to introduce legislation.

"Collection" System Solutions for Clear Lake Septic Tank Problems

The history of concern about Clear Lake septic tank problems goes back for many years. A 1977 report on northeastern SD lakes includes a recommendation that a sewer district be formed and a public sewer system be built around Clear Lake.

Although a public sewer district was not incorporated for the entire lake based on the 1977 recommendation, individual homeowners have tried to solve the septic tank pollution problems around the lake. In the 1990s, a group of Clear Lake homeowners along the north shore recognized a problem in their area and decided to solve it.

After many years of low water levels, high water in the mid-1990s intensified the problem related to septic tank pollution. The average water level of Clear Lake for the years 1967-

1985 was 1,820 feet above sea level, which was almost 4 feet below the "Ordinary High Water Mark" of Clear Lake at 1,823.7 feet above sea level. As the level of the lake began to rise in the mid-1990s, cabin owners on the north shore of Clear Lake at Schlekeway Drive began to notice the water in the slough north of their cabins had a sewage smell as the water in the slough reached the same level as the lake.

The higher level of the lake and higher underground water table was causing the septic tank drain fields and septic drain mounds to "leach" gray water into the water table that was the same level as Clear Lake.

Cabin owners were concerned about the quality of the water in Clear Lake and in 1996 formed the North Schlekeway Drive Environmental Association (NSDEA), a non-profit corporation filed in the State of South Dakota. Cabin owners contributed $100 to help pay the cost of organization and to contract with Holton Engineering, Inc. of Sisseton, SD, to begin plans for a gray water sanitation collection system.

In 1997, Holton Engineering conducted a Preliminary Evaluation of information from each cabin owner on cabin use, water use, type of septic tank, etc., that was used to design a collector sewage system. The engineering firm also did land surveying, system design, platting and filing of the plat with governmental agencies.

NSDEA purchased 2 acres of land on the hill about ¼ mile north of the lake along SD Highway 10. The land was purchased from Celia Schlekeway, and Holton Engineering designed a leach field with four dosing beds for the gray water collected from each cabin member of NSDEA. All of the gray water from the cabins would be pumped to these four beds. The solids remaining in the cabin septic tank would be pumped annually at the expense of the cabin owner.

The design plan required cabin owners to install new septic tanks to be pressure tested prior to hook-up to the new system. Some of the old septic tanks were simple metal barrel type containers; some were cracked and leaching in place. The new septic tanks for all the cabins were connected directly to a 6-inch line that drains the gray water to a manhole containing two submersible pumps. Each of the two pumps is connected to a 2-inch line, and the gray water is pumped the ¼ mile uphill to the dosing beds. Each pump feeds to two of the four dosing beds on an alternating basis.

The application for the "gray water sanitation collection system" was approved by the State of South Dakota in June of 1998. Construction work began on August 17, 1998, by Ted's Trenching, Inc., of Britton, SD., and was finished that fall.

The cabin owner members of NSDEA felt the importance of cleaning up the lake for future generations. The approved design system has worked well for the past 11 years. Total cost

of the land, testing, engineering design, and construction was $49,625.38. The cost per cabin owner was about $3,450, plus the cost of the new septic tank.

In recent years, lake home owners have tried to solve the septic tank problems for the entire lake. Clear Lake residents have made two attempts to incorporate a sewage district on the lake as a first step in determining whether or not a public sewer system is a practical solution to pollution problems on the lake. In 2007, a vote on a sewer district was defeated by two votes. In another vote in 2008, the sewer incorporation vote lost by nine votes. One of the biggest concerns expressed by lake residents was the issue of cost. There was a lot of speculation about actual cost for a public sewer system, although the vote was just on forming the sewage district and not whether or not a system would be constructed. That decision would be made by the members of the sewage district. The sewage district could be dissolved if the trustees decided a sewer system should not be built.

Future Water Quality Work

The CLBA Board is trying to address the cost issue this year. The CLBA Board has received funding for a small community planning grant. The grant (and other funds) will be used to fund a pre-engineering study of the requirements and costs of a public sewer system. The results of the study will be reported around the end of the year. Hopefully the pre-engineering study will provide information which will help residents make an informed decision on how they want to proceed. It is difficult to believe that there are any lake residents who do not want to improve the lake's water quality and who would not support a cost-effective system that achieves that goal.

Even though lake residents have not supported the formation of a sewer district, the pollution problems around the lake still exist. The CLBA board will continue looking at sources of pollution and taking steps to keep Clear Lake water quality at the highest level possible, as the CLBA charter describes.