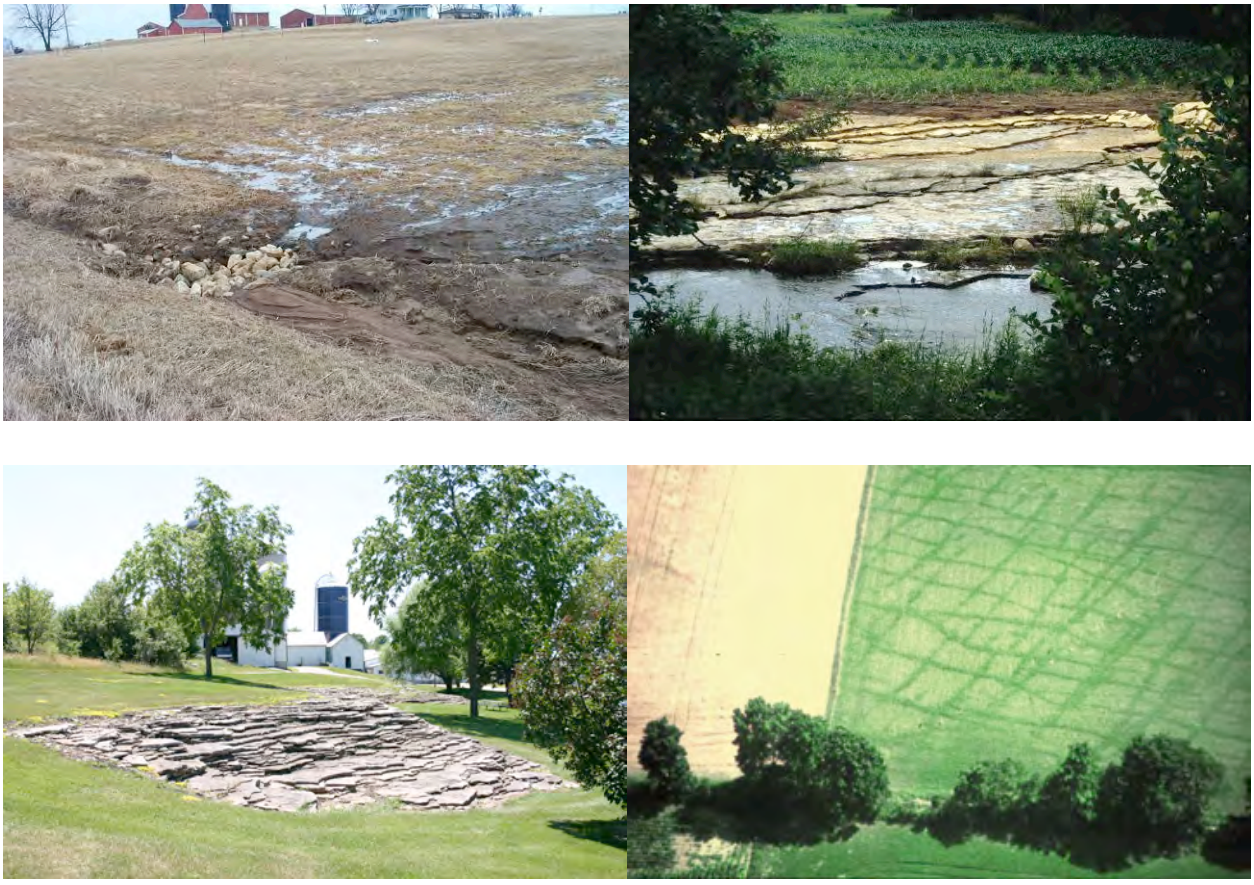
G3836

Final Report of the Northeast Wisconsin Karst Task Force



February 9, 2007

Edited By: Kevin Erb and Ron Stieglitz

Northeast Wisconsin Karst Task Force
Final Report
Table of Contents

Figures and Tables:

Cover Photos: *Field runoff (and manure) entering a sinkhole in a road ditch that the farmer has filled in with field stone. Shallow bedrock in a cornfield along a Bower Creek tributary (Brown County), showing how field runoff can enter not only surface water, but groundwater as well. Exposed bedrock near a farmstead in Brown County. Air photo showing fracture traces in an alfalfa field. Photos courtesy of WDNR, UW-Extension, John Luczaj (UW-Green Bay) and the Calumet County LCD.*

Northeast Wisconsin Karst Task Force
EXECUTIVE SUMMARY
February 9, 2007

Northeastern Wisconsin has experienced groundwater quality problems for many years. Both anecdotal and documented reports of water well contamination abound in the region. Voluntary homeowner well testing programs and sponsored research projects have indicated that a significant proportion of the water supply wells were contaminated at sometime during the year. For example, a voluntary program in Calumet County indicated that from 4.6% to 47% of the wells tested contained *E.Coli* or were unsafe for either bacteria or nitrate respectively. Recent incidents of spring manure runoff and well contamination further highlighted the problem and focused the public's attention.

In order to have a unified approach throughout the region, the UW Extension and County Conservationists in Brown, Calumet, Door, Kewaunee, and Manitowoc Counties convened a task force to consider the existing scientific data and make recommendations on how to address the problem. The Task Force included representatives of county and state agencies, the University System, and the private sector. A complete list of members can be found in the body of this report.

The goals of the task force were to:

1. Determine where our impact on the karst aquifer begins.
2. Evaluate the best methods to reduce the impact of agriculture on groundwater quality.
3. Prioritize the implementation of available technologies to prevent future problems.
4. Identify gaps in our knowledge base.

Task force members quickly focused on agricultural issues and agreed that because of the aquifer type, overlying soils and land use practices it would be impossible to prevent every instance of contamination but that landowners can take significant steps to reduce the potential for animal and human waste, and other materials from entering the groundwater. It also became clear that the physical environment cannot be characterized, understood, or protected by merely locating and dealing with karst features at the surface. Rather, the controlling factor is the underlying fractured carbonate bedrock. The task force relied on the best existing scientific data or understanding available to make its recommendations. The members also unanimously concluded that a uniform approach to regulation and enforcement across the entire carbonate bedrock region of northeastern Wisconsin is critical to the development of a stable and effective framework for environmental protection.

The recommendations fall into the following six categories:

1. *Establishment by the legislature of a Carbonate Bedrock Management Zone similar to the existing Atrazine Prohibition Zones defined in ATCP 30.* This will create a framework for multi-county cooperation and local efforts, rather than a piecemeal approach to aquifer protection.

2. *Cooperation among federal, state and local agencies and units of government responsible for the regulation of agricultural and other types of waste to ensure uniformity of state codes based on current scientific understanding.* Current state codes have a variety of setbacks and separation distances for similar types of wastes, and vary significantly based on whether the generator has a WPDES permit. A uniform, science-based approach is needed.

3. *The adoption of a Contamination Vulnerability Ranking for the Northeastern Wisconsin Carbonate Bedrock Region.* Subcommittees were formed to consider available Best Management Practices and to define Karst Vulnerability. A coordinating subcommittee combined those reports and developed the Vulnerability Ranking presented in the table below that was accepted by the task force.

Level of protection required	Criterion	Relative vulnerability to contamination
1	Less than 5 feet (60 inches) to carbonate bedrock, *and/or* closed depressions or any drainage areas that contribute water to sinkholes/bedrock openings.	Extreme
2	5-15 feet to carbonate bedrock	High
3	>15-50 feet to carbonate bedrock	Significant
4	Greater than 50 feet to carbonate bedrock	Moderate

Specific recommendations detailed in the body of this report for practices and limitations in the following three groups are based on this scale:

- ∞ Land Application of Waste in Shallow Carbonate Bedrock Areas
- ∞ Waste Storage and Polluted Runoff from Concentrated Waste Sources in Shallow Carbonate Bedrock Areas
- ∞ Karst Features (Sink Holes and Bedrock Openings)

4. *Implementation of a set of simple pro-active steps and management practices developed and endorsed by farmers and professional service providers that would reduce incidents of contamination to the aquifer.* A set of farmer-developed initiatives that have been incorporated into #5.

5. *Implementation of a broad array of basic low-cost actions and practices that can be initiated without modification of existing or enactment of new statutes or codes.* These include simple practices such as a visual well inspection, winter spreading plans, landowner identification of karst features, and enhanced citizen awareness that can be implemented immediately by farmers and rural homeowners at minimal cost.

6. *Implementation of enhanced longer-range actions and practices that require investment or action at the town or county level*. Actions range from improved training of farmers and professional service providers to better data management, and regular sharing of information among government agencies and departments. Examples include a multi-county database of well information, improved bacteria and nitrate testing programs, uniform town-level ordinances and enforcement, and interactive web-based data management and sharing.

Any approach to reducing the impact of agriculture on the aquifer must include a strong emphasis on education and voluntary adoption, as well as regulation when necessary.

We recognize that other wastes such as those from industry and septic tanks also pose threats to groundwater quality. It is the position of the task force that separate groups of knowledgeable people should be formed to deal specifically with those issues.

The task force also recognizes that some of the existing technical standards and specifications are not adequate to protect groundwater and that additional research and requirements are needed. Improved understanding is needed of the physical factors such as groundwater flow in fractured rock, infiltration pathways through soils, and weather influences. Additional research on innovative manure handling and processing technologies, crop rotation and management practices, and the application of advanced subsurface investigation techniques will contribute to more specific and effective resource protection while continuing productive agriculture in the region.

Northeast Wisconsin Karst Task Force
FINAL REPORT

Background: Contamination of the shallow fractured bedrock aquifer in several Northeast Wisconsin counties (Brown, Calumet, Door, Kewaunee and Manitowoc) is not a new environmental problem; local residents have noticed color and odor changes in well water for decades. Contaminants, including coliform bacteria, *E.Coli* and nitrate are becoming more and more of an issue across a five-county area (Appendix 1). Yet despite decades of educational efforts and millions of dollars spent helping municipalities, farmers and rural homeowners address the issue, the number of contaminated wells **and the severity of the contamination** continues to rise.

The snowmelt and rains of each spring have been the precursor to several clusters of contaminated wells in the area, including:

- Morrison, Brown County, Feb-March 2006—86 wells tested unsafe for Coliform and/or *E.Coli.*
- Franklin, Manitowoc County, 2005—Manure enters karst aquifer in multiple documented events; 10 wells bacterially unsafe, 6 positive for *E.Coli.*
- Luxemburg, Kewaunee County, 2004—Manure runoff enters karst aquifer; wells contaminated, children hospitalized.
- More than 30% of wells in certain towns in Calumet, Brown and Kewaunee Counties exceed the nitrate standard of 10 ppm.

A significant portion of Northeast Wisconsin has been mapped as very susceptible to groundwater contamination (Figures 1–4). The problem is not limited to just small areas. Since 2002, over 1000 well owners have tested their well water through Calumet County's voluntary sampling program. Results for 2002–2005 documented that:

- 35% of the samples have come back positive for coliform bacteria.
- 4.6% have come back positive for *E.Coli.*
- 25% have come back above the health standard of 10 ppm for nitrate.
- 28% have come back with elevated levels of nitrate (2-10 ppm).
- 47% have come back unsafe for either bacteria or nitrate.
- 12% have come back unsafe for both bacteria and nitrate.

A statewide survey in 1994 (Warzecha et al.) showed coliform in 23.3% of wells, *E.Coli* in 2.5% and 6.5% of wells exceeding 10 ppm nitrate.

One of the common factors in almost all of these incidents is the Silurian bedrock, a sequence of fractured dolomitic limestone (dolostone) units that extends from the tip of Door County south-southwest through northeast Wisconsin. Key features of this geologic feature include a northwest to southeast dip or slope, complex fracturing, and anisotropic flow (groundwater has different flow rates and directions throughout the aquifer). In general, extensive weathering is absent, and bedrock collapses and caves are rare. There are several areas in the state with similar concerns; however, this report addresses only carbonate bedrock areas.

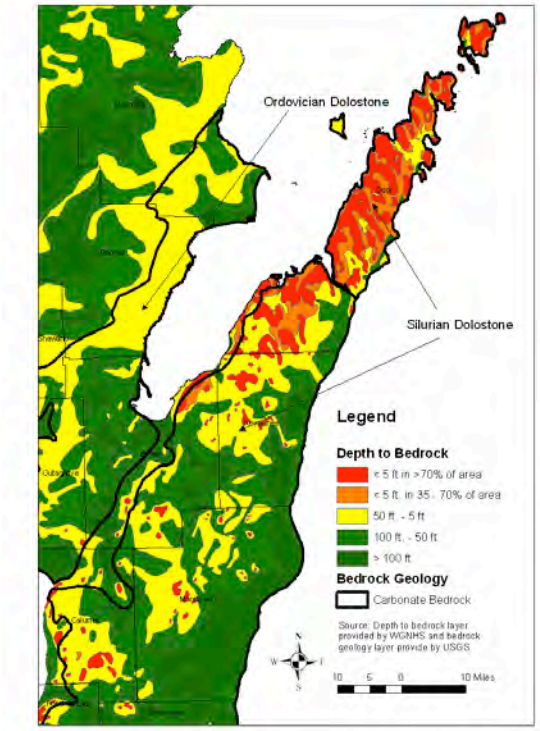


Figure 1: Map showing estimated depth to bedrock and dolostone region of northeast Wisconsin. (DeVito et al, 2006)

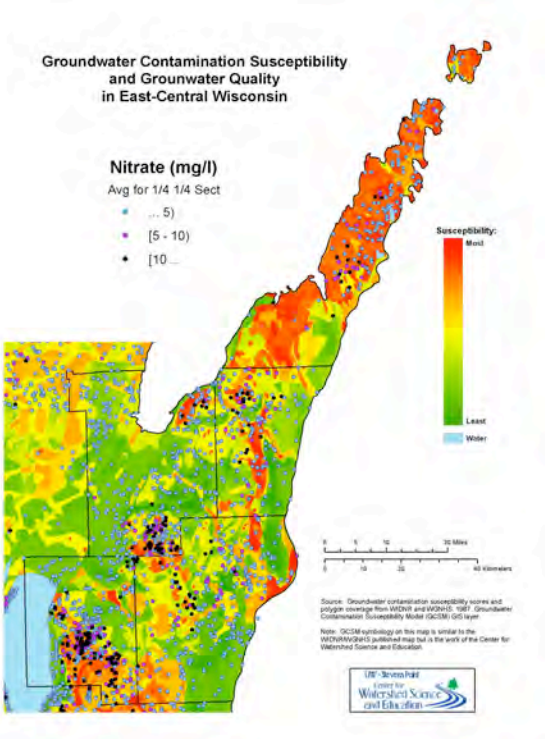


Figure 2: Map showing average nitrate concentrations in well water samples.

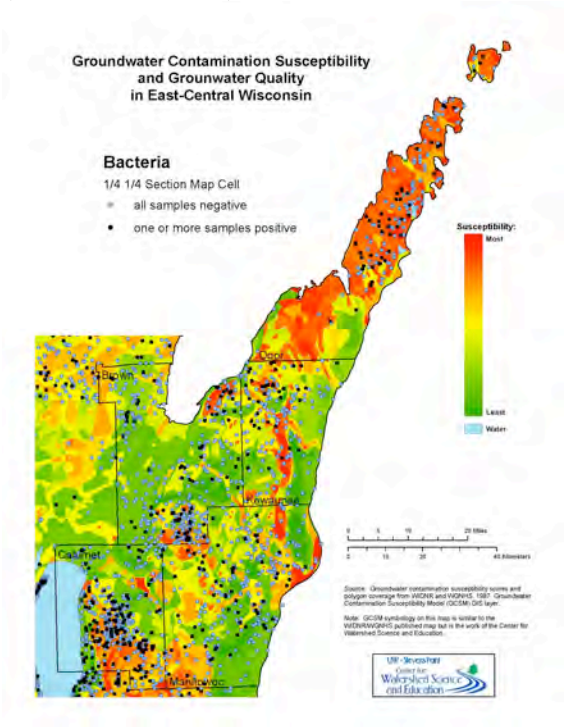


Figure 3: Map showing locations of wells testing positive for bacteria

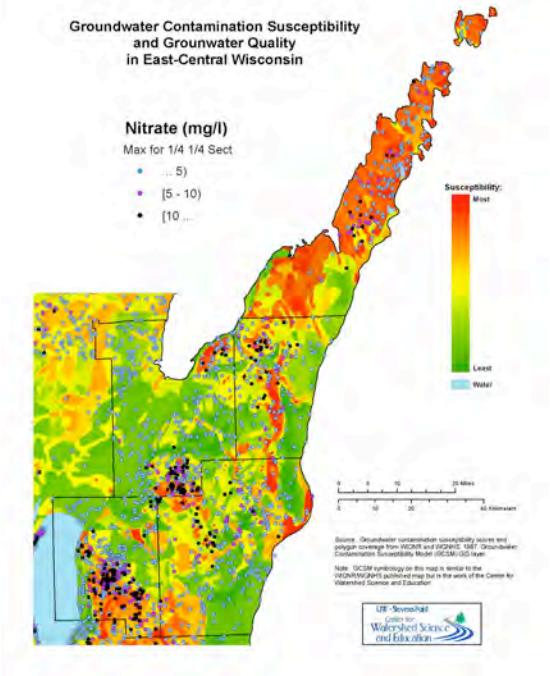


Figure 4: Map showing MAXIMUM nitrate detects in well water samples

County Land and Water/Soil and Water Conservation and County Health Departments, DNR drinking water specialists, and others have long struggled with how to deal with groundwater quality issues; however, it became clear in the spring of 2006 that further action was needed to protect the aquifer. It quickly became apparent that hard science that supports which Best Management Practices (BMPs) are most effective at protecting the aquifer is somewhat lacking. Making the situation more confusing, state codes and statutes used by the DNR to regulate landspreading of different byproducts (manure, industrial, septage) differ in the required depth of soil to groundwater (0.8 ft to 3 ft), bedrock (0.8 to 5 ft), surface water setbacks (50 to 1,000 ft) and well setbacks (0 to 250 ft for private wells, 0 to 1,000 ft for municipal). The codes also vary in the requirements for storage structures for these wastes (see Appendix 2).

Local units of government have cooperated with state and federal programs to advance the protection of groundwater. County conservation departments have provided education and technical assistance to farmers with the support of UW Extension and others. State and federal cost-sharing has been a valuable resource in changing farm practices. Where necessary, local governments have supplemented these efforts with ordinances to secure compliance, nutrient management and other farm standards. There are challenges in adopting local ordinances. For example, authorities to adopt new manure management ordinances are complex (there is limited authority under current state law to implement additional restrictions on manure and waste application), and should be carefully evaluated with the help of experts such as attorneys. Any future actions to implement new approaches will need to fit within this framework. As discovered in 2006, a town ordinance banning land application of manure may result in farmers without storage transporting manure to neighboring towns and applying it in areas with higher risk than the original target field.

In light of these issues, UW-Extension and the County Conservationists in Brown, Calumet, Door, Kewaunee and Manitowoc Counties created a the Northeast Wisconsin Karst Task Force to examine the existing scientific data and make recommendations on the next steps to address the problem.

Task Force Membership

Task Force members were selected from a variety of technical and scientific backgrounds, professional experience, and practical working knowledge of the aquifer and land application issues in Northeast Wisconsin. Several other individuals provided key leadership and information. They are included after the Task Force membership list.

Task Force Members, credentials

- Bill Hafs, County Conservationist, Brown County LCD
- Bill Schuster, County Conservationist, Door County SWCD
- Bob Barnum, Drinking Water Leader, Wisconsin DNR
- Colleen Luppnow, Independent Agronomist, Certified Crop Advisor
- Dave Bougie, Animal Waste Specialist, Wisconsin DNR
- Dave Gruett, Professional Manure Applicator, Gruett's, Inc
- George Kraft, PhD, Groundwater Specialist, UW – Stevens Point

- ∞ Jim Hunt, District Conservationist, USDA-NRCS
- ∞ Jim VandenBrook, Groundwater Specialist, WI DATCP
- ∞ John Luczaj, PhD, Assistant Professor, Geology, UW – Green Bay
- ∞ Ken Bradbury, PhD, Hydrogeologist, WGNHS
- ∞ Kevin / Lisa Collins, Farmer, Collins Dairy
- ∞ Kevin Erb (Facilitator),UW Extension, Certified Crop Advisor
- ∞ Kevin Fermanich, PhD, Professor, Soils, UW – Green Bay
- ∞ Maureen Muldoon, PhD, Professor, Geology, UW Oshkosh
- ∞ Randy Virlee, Farmer, Virlee Farms
- ∞ Ron Stieglitz, PhD, Emeritus Professor, Geology, UW – Green Bay
- ∞ Tom Van De Yacht, Professional Well Driller, Bill Van De Yacht Well Drilling

Significant Contributors

- ∞ Amy Callis, Groundwater Educator, Calumet County LCD
- ∞ Calvin Alexander, Jr., Geologist, University of Minnesota
- ∞ Jeff Green, Hydrogeologist, Minnesota DNR
- ∞ Eugene McLeod, County Conservationist, Calumet County LCD
- ∞ Steven Shimek, STS Consulting, Green Bay

Task Force Goals

The Task Force convened in April of 2006 and was charged with these goals:

1. Determine where our impact on the karst aquifer begins.

2. Evaluate the best methods to reduce the impact of agriculture on groundwater quality.

3. Prioritize the implementation of available technologies to prevent future problems.

4. Identify gaps in our knowledge base.

Guiding Assumptions of the Task Force

The Task Force met seven times between April and November 2006. Several decisions made by the Task Force impacted their recommendations, including the following.

- ∞ Given the rapid interconnection between surface waters and ground waters in these areas, prevention of all surface contamination of groundwater is a physical impossibility; however, landowners can take action to greatly reduce the potential for animal waste, human waste and other contaminants from entering the aquifer.

- ∞ A karst feature should not be defined by a circle around a sinkhole or bedrock outcrop. These indicate that carbonate bedrock is near the surface, and may be a potential direct

conduit, but may or may not be the primary contamination route. Dozens of smaller sinkholes, conduits or features may be covered by soil and not visible. For the implementation of management practices, we should look at the presence of known features, and determine the likelihood of additional ones, and implement on a larger area. These should be designed as "Karst Landscape Units."

- The recommendations are based on a combination of scientific knowledge and professional judgment. Where good research is available, that information was used. Where it is not or where it does not apply directly to the types of landscape found locally, a hybrid approach was used.

- The recommendations from this Task Force are focused primarily on agricultural issues. Management of septage, industrial waste, and on-site sewage treatment inspections are regulated by state code, and are beyond this Task Force's scope, but in some areas could be a significant part of the overall contamination problem.

- A piecemeal approach where different local units of government impose restrictions not based on science and best professional judgment can lead to overloading of wastes in areas without restrictions or can have unintended negative environmental consequences (for example, prohibiting manure
- spreading on frozen ground without guidance for temporary manure storage on farm). A uniform approach across the entire carbonate bedrock region will provide a stable framework for environmental protection.

Task Force Recommendations

The final recommendations of the task force are broken down into six sub categories. These recommendations are the consensus of the task force as a whole, and are not presented in a priority order. As with any scientific or technical consensus document, the final report will not reflect 100% agreement of all participating parties. We agree, however, that these recommendations are a giant step in the right direction.

 # 1: Creation of a Carbonate Bedrock Management Zone

There are a number of sensitive areas in the state with unique groundwater resource concerns. These include the Central Sands, the fractured Pre-Cambrian bedrock in the north, and the Silurian dolostones. Each of these has unique aspects that make a statewide management approach problematic, even counter-productive.

The Task Force recommends that the legislature establish a Carbonate Bedrock Management Zone program similar to the existing Atrazine Prohibitions Zones as defined in ATCP 30. The exact boundaries of the zone should be determined at the local level, based on the hydrogeology of the aquifer, and at a minimum include the five counties participating in this effort.

 # 2: Unification of state and local codes

As noted previously, there are significant differences in the setbacks and prohibitions found in state codes and federal standards (WI NRCS 590) for different land applications for manure, and even more variation when non-agricultural wastes are considered (see Appendix 2). The Task Force recommends that the responsible state agencies examine the scientific data, if any, behind these recommendations and work towards a more uniform set of protections (regulations). This will require legislative action.

Key to this recommendation is that the same parcel of land may be approved by DNR for whey application, but restricted by a county LCD/SWCD (under ATCP 50/NR 151/WI NRCS 590) for manure application. In cases where land is suitable and approved for multiple waste applications, a single individual or entity should be responsible for determining the rates allowed, taking into consideration both nutrient loading (from all sources) and hydrology. A list of sites approved by various agencies for non-manured wastes should be provided to the local LCD/SWCD on a regular basis.

These findings need to be worked into the existing framework of local, regional and county agencies, and changes to any rules or ordinances should rely on the technical advice of experts in the field. Agencies on all levels should work together to maximize aquifer protection and minimize contradictions in recommendations.

 # 3: Carbonate Aquifer Protection Strategies – Long Term

Midway through the Task Force deliberations, the group formed two subcommittees—one to look at Best Management Practices and a second to define Karst Vulnerability. The subcommittees presented their reports in September, and a coordinating subcommittee was formed to combine the reports and presented them to the Task Force. Not every member of the task force agreed with the final recommendations as outlined in this particular section, however a strong majority felt they should be included.

The Task Force approved the final subcommittee report with the understanding that these steps would enhance aquifer protection in a perfect science-based world. These recommendations are what counties, state agencies and the legislature must work towards in the future. We strongly encourage individual farmers and landowners to implement them voluntarily.

Final Report of the Long Term Strategies Subcommittee
Approved at the November 12, 2006 Karst Task Force meeting

The working group was charged with combining recommendations presented by the Karst Vulnerability and Best Management subcommittees at the September 12, 2006 meeting of the Northeast Wisconsin Karst Technical Advisory Committee.

The ground rules followed were:

1. The BMPs and vulnerability ranking recommendations were to be merged to form one recommendation.

2. We consider only scientific data in making our recommendation and not politics, practicality or economics.

3. We could modify the original BMPs and vulnerability rankings in our recommendation.

The second ground rule was interpreted to include professional experience and knowledge of karst landscape systems in addition to scientific studies as a basis for making recommendations. The recommendations are made in the context of an "ideal world" in which we answer the following question based on our current understanding and knowledge of how karst landscape systems work: *What practices and restrictions should be implemented to protect the quality of groundwater resources in areas with shallow carbonate bedrock?* It is possible that in the future some of the specific recommendations may need to be more restrictive to protect groundwater while others could be made less restrictive as new information, knowledge and technology is acquired.

The recommendations are limited to practices and restrictions relative to agricultural land applications of nutrients and animal waste and animal waste management and storage. That is the subcommittee's field of expertise and knowledge. Other land uses may impact groundwater, but there are more qualified people to develop recommendations for those uses.

The recommendations are primarily intended to minimize groundwater contamination from pathogens and "brown water" and secondarily intended to minimize groundwater contamination from nitrate.

The vulnerability subcommittee proposed the following vulnerability ranking for NE Wisconsin (Table 1). Levels of protection fall on an arbitrary scale, with level 1 requiring the most protection. Most of our recommendations are based on these categories.

Table 1: Level of protection recommended based on vulnerability ranking and site specific criteria. Criteria are site specific, and multiple criteria may occur in the same agricultural field.

Level of protection required	**Criteria**	**Relative vulnerability to contamination**
1*	Less than 5 feet (60 inches) to carbonate bedrock, *and/or* closed depressions or any drainage areas that contribute water to sinkholes/bedrock openings	Extreme
2	5-15 feet to carbonate bedrock	High
3	>15-50 feet to carbonate bedrock	Significant
4	Greater than 50 feet to carbonate bedrock	Moderate

* Level 1 requires the most protection.

LAND APPLICATIONS OF WASTE IN SHALLOW CARBONATE BEDROCK AREAS:

1. Frozen or snow-covered ground and saturated soils

There is a high probability of groundwater contamination when manure is applied to frozen or snow-covered ground or saturated soils in Criteria 1, 2 and 3 in Table 1.

RECOMMENDATIONS:

Hazard	Limitation	Exception/comments
Frozen, snow-covered, saturated soils	No applications of manure in Criteria 1, 2, and 3 areas.	None

2. Soil Depth Restrictions

There is a high probability of groundwater contamination when manure is applied to soils in Criteria 1.

RECOMMENDATIONS:

#	Hazard	Limitation	Exception/comments
1	Land with less than 3 feet of soil to bedrock	No applications of manure.	None
2	Soils 3 to 5 feet to bedrock	Maximum application rates should be 3,000 gal/acre per application (or solid waste ton/ac equivalent) with a maximum application rate of 6,000 gal/yr.	None
3	Soils 3 to 5 feet to bedrock	Shallow incorporation (<10 inches) of all wastes immediately after application. No deep injection of wastes.	None
4	Areas with >5 to 50 feet of soil to carbonate bedrock (Categories 2 and 3)	Incorporation of all wastes immediately after application.	None

3. Setbacks and Land Draining to Sinkholes, Closed Depressions or Bedrock Openings (includes losing streams on carbonate bedrock)

a. There is a high probability of groundwater contamination when manure is applied to land areas within closed depressions and within drainage areas that contribute runoff to sinkholes or bedrock openings (Criteria 1).

b. Land areas near channels and concentrated flow paths that deliver runoff to closed depressions, sinkholes and bedrock openings are the most critical to the quality of runoff water.

c. No runoff or concentrated flow of liquid wastes.

RECOMMENDATIONS:

#	Hazard/Sensitive Feature	Limitation	Exceptions/comments
1	Sinkholes, bedrock openings, surface inlets, and areas of focused infiltration within closed depressions	No applications of wastes within 100 feet.	None
2	Delivery system * to sinkholes, bedrock openings, surface inlets, and areas of focused infiltration within closed depressions.	No application of wastes within 100 feet.	None
3	Closed depressions, regardless of soil depth.	Incorporation of all wastes immediately after application.	None

* Delivery system is a defined channel or concentrated flow path.

4. Requirements for Persons Who Plan or Conduct Applications of Animal Wastes in Shallow Carbonate Bedrock (<50 ft) Areas

RECOMMENDATIONS:

Hazard/Sensitive Feature	Limitation	Exceptions/ comments
Areas with less than 50 feet of soil to carbonate bedrock (Categories 1, 2 and 3)	Require field investigations to identify and map closed depressions, sinkholes, bedrock openings, bedrock outcrops, surface inlets, and areas of focused infiltration within closed depressions and drainage areas to these features (Figure 5) during nutrient management planning	None
	Require a spill response plan for waste storage, transport, and applications.	None
	Require training on karst topography, spill response planning, and field identification of the above sensitive features.	None

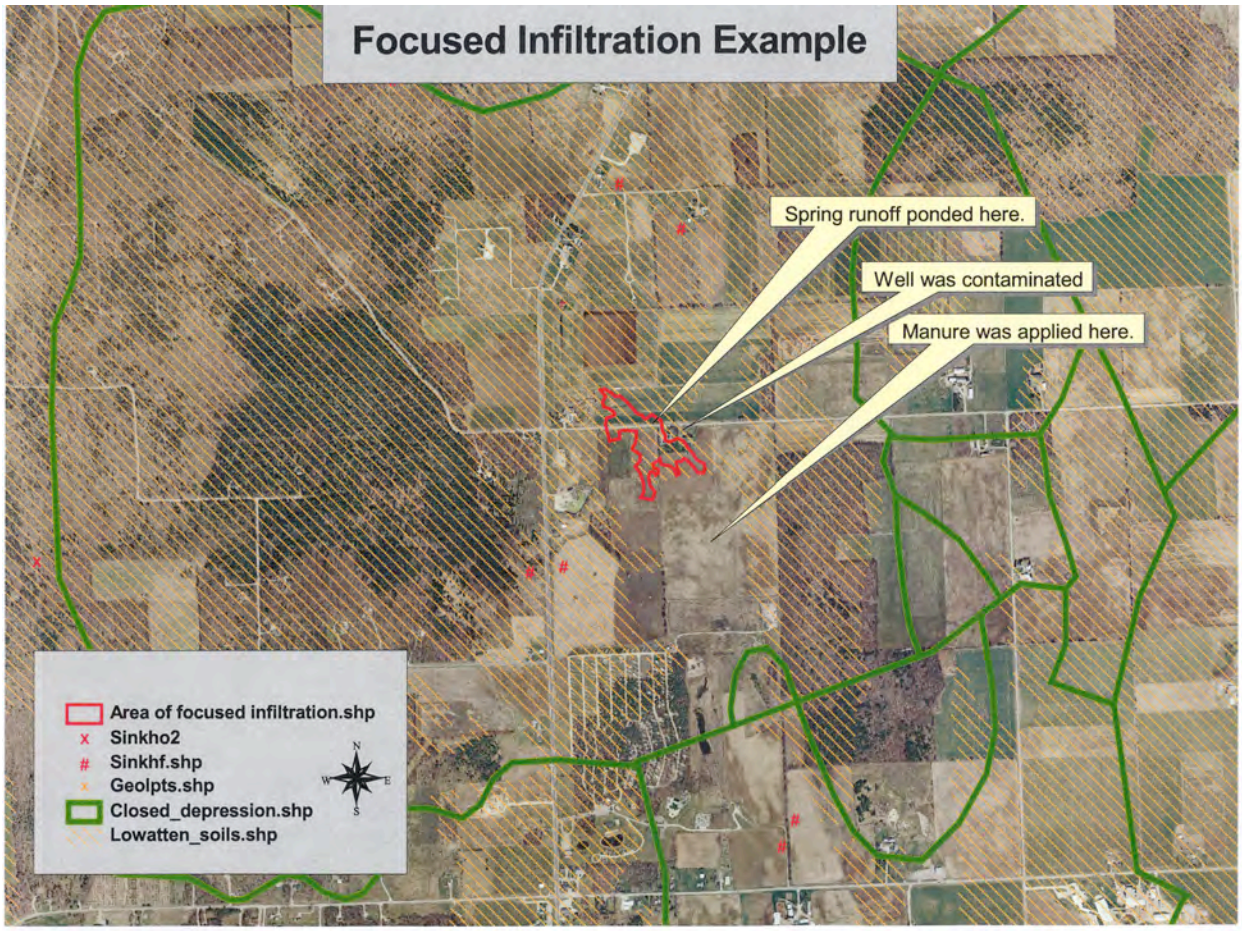


Figure 5: Map showing several closed depressions (outlined in Green) in Door County. During spring runoff, snowmelt (and field runoff) accumulates in the low area outlined in red (note no identified sinkhole in the low area). Within a few days of the ponding, manure was reported in a neighboring well. The field where manure was applied was not marked as restricted for manure application due to shallow soils, but the area where runoff ponded was restricted. The shaded area on the map (lowatten_soils.shp layer) are low attenuation soils or those mapped as high hazard (WI NRCS 590 Tech Note) where both winter spreading is prohibited and incorporation required. The delivery systems to the area of focused infiltration were determined by 2-foot contours, orthophoto imagery and a field inspection. This map is for example purposes and should not be used for actual regulation or management. Map courtesy Door County SWCD.

WASTE STORAGE AND POLLUTED RUNOFF FROM CONCENTRATED WASTE SOURCES IN SHALLOW CARBONATE BEDROCK AREAS:

1. Temporary, Unconfined Stacks of Manure and Derivatives

a. Areas with Criteria 1 and 2 vulnerability rankings have extreme or high susceptibility to groundwater contamination and therefore would meet the definition of a Water Quality Management Area (WQMA) under NR151.

b. NR 151 states: "A livestock operation shall have no unconfined manure pile in a water quality management area."

c. Table 9 of USDA-NRCS Technical Standard 313, Animal Waste Storage Facility defines setback distances, waste consistency, stack size, stacking period and frequency, and conservation BMPs for unconfined manure pile sites.

RECOMMENDATIONS:

#	Hazard/Sensitive Feature	Limitation	Exceptions/comments
1	Soil less than 15 ft to bedrock (Criteria 1 & 2 areas)	No unconfined manure piles*	None
2	Sinkholes, bedrock openings, surface inlets, and areas of focused infiltration within closed depressions.	No unconfined manure piles within 1,000 feet.	None
3	Delivery system to sinkholes, bedrock openings, surface inlets, and areas of focused infiltration within closed depressions.	No unconfined manure piles within 1,000 feet.	None
4	>15-50 feet of soil	No delivery of runoff from unconfined manure piles to the hazards/sensitive area features in the above 3 rows. Unconfined manure piles in Criteria 3 areas must meet the most protective criteria set forth in Table 9, NRCS Technical Standard 313 (12/05) for 16 – 32 % solids waste consistency under the categories of size and stacking period, hydrologic soil groups, and surface separation distance.	None

* As defined in NR 151, an unconfined manure pile is a quantity of manure that is at least 175 cubic feet in volume and that covers the ground surface to a depth of at least 2 inches and is not confined within a manure storage facility, livestock housing facility or barnyard runoff control facility or covered or contained in a manner that prevents storm water access and direct runoff to surface water or leaching of pollutants to groundwater.

2. Waste and Feed Storage Facilities

There is a significant risk of soil subsidence in areas with sinkholes, other karst features, and shallow soils over carbonate bedrock that could lead to groundwater contamination from waste or feed storage facilities.

RECOMMENDATIONS:

#	Hazard/Sensitive Feature	Limitation	Exceptions/comments
1	Areas with less than 50 feet of soil to carbonate bedrock (Categories 1, 2 & 3)	No earthen-lined manure impoundments in Criteria 1, 2 and 3 areas.	None
2	Areas with less than 50 feet of soil to carbonate bedrock (Categories 1, 2 & 3)	Waste storage facilities built before a certain date* are to be inspected and certified by a qualified person. If not certified they must be properly abandoned, upgraded, or inspected annually or when emptied for structural integrity by a qualified person.	None
		Animal waste storage facility capacity of at least 9 months of waste generated.	None
3	Sinkholes, bedrock openings, surface inlets, and areas of focused infiltration within closed depressions in areas 50 feet or more of soil over carbonate bedrock (Criteria 4)	No manure or feed storage facilities within 400 ft.	None

* Certain date: Decision left up to local jurisdiction

Outside Animal Lots

Direct infiltration and runoff from outside animal lots is a significant contributor to groundwater contamination in areas with sinkholes, other karst features and shallow soils.

RECOMMENDATIONS:

Hazard/Sensitive Feature	Limitation	Exceptions/comments
Outside animal lots, feed lots, and milking facilities in areas with less than 15 feet of soil over carbonate bedrock (Categories 1 and 2)	No discharge of **untreated** waste from outside animal lots and feedlots or **untreated** milkhouse wastewater.	Treatment is operationally defined (see below)

The required BMPs to adequately treat waste generated from outside animal lots will be dependent on soil depth, number and type of animals, density of animals, etc. Appropriated treatment may range from low density/duration grazing to complete confinement and collection of waste and runoff from outside animal lots. Other examples of treatment BMPs include: wastewater treatment strips, diversions, heavy use area protection, roof runoff structures, prescribed grazing, etc.

KARST FEATURES (SINKHOLES, BEDROCK OPENINGS)

Dumping waste materials or directing polluted runoff and tile discharge water to these features will cause groundwater contamination.

RECOMMENDATIONS:

Hazard/Sensitive Feature	Limitation	Exceptions/comments
Sinkholes and bedrock openings at the land surface	No dumping of waste materials into these features.	None
	No drain tile outlets in these features.*	None
	No diverting or directing of surface runoff to these features.	None
	Presume that waste material or polluted runoff entering these features is reaching groundwater and is a source of groundwater contamination (for regulation purposes).*	None
	Establish and maintain a permanent vegetative buffer around these features that is at least 100 feet wide.	None

* Under current state law, tile drainage systems entering sinkholes are considered injection wells and therefore illegal.

The approved report included several additional recommendations, all of which have been included elsewhere in this document.

4: Carbonate Aquifer Protection Strategies – Field Implementation

A fourth subcommittee (Agricultural Field Implementation) formed independently during the Task Force deliberations. This group met with about two dozen farmers, crop consultants and professional manure applicators. Its goal was to develop a set of simple, easy to implement management practices for livestock and cash grain farmers that would reduce the risk of aquifer contamination. The subcommittee's report was presented and accepted at the November Task Force meeting.

The farmers and agricultural professionals who developed these steps strongly encourage farmers to voluntarily adapt the recommendations. For the purposes of this report, many of their recommendations have been included in the Basic Recommendations below, and are so noted with an asterisk (*). The full version of the report is found in Appendix 3.

 # 5: Carbonate Aquifer Protection Strategies – Basic Recommendations

The members of the Taskforce considered an array of actions and management practices that can be implemented by farmers, professional service contractors, rural non-farm landowners, and county and town governments. A common element of these activities is that they have limited economic impact and require no action by a local body of government.

Most of the recommendations are not new concepts and many are already being applied and followed on a scattered basis throughout Northeastern Wisconsin. Significant progress can be made in groundwater protection with a wider and more consistent application of these practices and a greater appreciation of the value and effectiveness of these rather simple actions. Not all are totally without cost. Plugging a well has a direct out-of-pocket cost, while setbacks and buffer strips reduce crop acreage. However, over time, these steps will reduce the number of threats and incidents that require remediation. The key to progress is increased awareness of environmental and land use factors that affect groundwater in the region fostered by citizen education. The cost of inaction can also directly impact rural residents, as the need to drill a new well (because the current one is not compliant with existing code) can decrease the resale value of a rural residence (just like a home with an old, multi-layer roof). If a new well is needed, a portion of the cost is often passed along to the new owner in the form of an increased sale price, but only if the market allows.

We encourage farmers and rural landowners to immediately implement the recommendations outlined below.

- Identify and map areas of shallow bedrock and obvious karst interface features on a field-by-field basis. *
- Provide detailed information to manure haulers before and during application and provide the same information to subsequent owners and operators. *
- Inspect fields for soil cracks, and plan pre-tillage prior to surface applications.*
- Adjust manure and fertilizer application rates to crops requirements, soil tests, existing soil moisture conditions, and when possible, to weather forecasts. Avoid manure applications when conditions pose the greatest risk.*
- Split manure applications to reduce the risk of runoff and downward movement.*
- Time manure application to crop nitrogen uptake (for summer alfalfa, no more than 2 weeks prior to seeding).*
- Spread manure according to a nutrient management plan and/or winter manure spreading plan.

- Avoid mechanical manure applications within a 250 foot radius of a private residence water supply well and within 1,000 foot radius of a well that is part of a municipal or community water system or a non-transient, non-community well that serves a captive population (rural school). Nitrogen fertilizer applications with these same areas shall be limited to soil test recommendations and made in accordance with the Wisconsin NRCS 590 nutrient management standard.
- Designate a centralized authority in each county (LCD/SWCD) to receive copies of all karst information and begin the process of designating local Karst Landscape Units, with input from local stakeholders and technical specialists.
- Temporary manure storage sites should be reviewed by technical experts and based on the provisions of the NRCS Waste Storage 313 Technical Standard.
- Report all karst-related features on the State Karst Feature Reporting Form (Appendix 5).
- Avoid manure application on areas with shallow bedrock and identified features.
- Implement buffers and setbacks.
- Require visual well inspections by property owners on a regular basis (quarterly preferred).
- Test wells for nitrate and bacteria at least annually during the runoff season or when changes are detected or suspected.
- Identify and properly abandon unused/non-compliant wells.
- Install back flow prevention devices on all new and reconditioned wells or when a major change is made to the water system.
- Educate rural homeowners on the risks of a non-compliant well and the value of correcting problems, bringing it up to code, or a drilling a new well.
- Continue to aggressively educate citizens on the threats to groundwater and the best management practices to protect the resource. This includes any or all of the following:
  —County and agency web sites.
  —Hard copies of information: pamphlets, fact sheets, reports.
  —Workshops, seminars or field days.
  —Meeting with property owners and decision makers.

Items marked with an asterisk (*) are directly from the Field Implementation subcommittee.

 # 6: Carbonate Aquifer Protection Strategies – Enhanced Recommendations

The Task Force also discussed other actions or management practices that can be used to monitor quality and prevent groundwater contamination. The items recommended in this section will directly or indirectly affect groundwater quality and are viewed as important steps needed to ensure best use of the environment. The recommendations include improved training of farmers and professional manure haulers, better data management, and regular sharing of information among agencies and government departments.

The Task Force recognized that a great amount of information pertaining to water quality has been and continues to be collected from multiple sources throughout the region. Collation, maintenance, analysis, evaluation, and sharing of those data, however, are not uniform or consistent. Strengthening of the systems and relations involved with the collection and use of pertinent data will contribute significantly to protection of the groundwater in Northeastern Wisconsin. First, improvements will reduce the direct threats to the resource through better management and land use practices. In addition, early detection of leaks and spills as well as the selection and application of appropriate responses and solutions to those incidents will be enhanced. Recognition of common human or environmental elements in different locations will assist all stakeholders to report and deal with problems effectively and in a timely manner.

The recommendations in this section require government action at some level and/or funding to be put in place. They are viewed as critical elements of a program to bring organization and focus to groundwater protection efforts in the region.

- Mapping and designations of Karst Landscape Units. Uniform procedures need to be developed for determining these units and use across the region. As noted in Green et al., creating mapping resources that denote the potential for hidden interface features is critical to reduce potential contamination.
- Regular, scheduled training for farmers on identification and management of karst interface features.
  —Implement the module that already exists in UWEX Farmer Nutrient Management Education Curriculum (2006 edition) when farmers are trained on nutrient management.
  —Expanded farmer education for those producers not involved in the above training.
  —Implement the State Manure Task Force Recommendations on farmer training. (http://www.manuretaskforce.wi.gov/)
- Training for professional manure haulers on identification and management of karst interface features.
  —UWEX and the Professional Nutrient Applicators Association must incorporate a karst module into their Level 2 training program.
  —The State Manure Task Force Recommendations included applicator training. (http://www.manuretaskforce.wi.gov/)
- Create a unified, readily accessible, multi-county database of well information. This will assist agency personnel to more accurately identify areas of concern and to prioritize efforts accordingly.
  —Individual well testing data are currently in a variety of locations, including the state well database, county health departments, and LCD/SWCDs which are not easily searchable to determine trends or the extent of the problem.
  —The DNR should expand their data systems to allow for easier access to initial baseline well testing results.

—Track well test data obtain each time property is sold. (Kalamazoo County, Michigan's health department already has a prototype and posts address-specific information at: http://www.kalcounty.com/eh/groundwater-concerns.htm#Partial). Their version, however, only contains data sent through a public lab, and bacterial samples only when taken by agency staff.

—Initiate a local program to precisely map older (pre-1988) WDNR unique well id numbers. (Many pre-1980 well logs show only a "Rural Route 1" for a street address). Provide decals to homeowners to post in the electrical circuit breaker box that serves the well.

—Identify wells that are early indicators of problems (first in a neighborhood to show problems each spring), and consider a more rigorous testing schedule.

- Develop a mandatory program for regular inspection of wells by a professional well driller every 3-5 years. Inspection would include the well cap, casing integrity, surface slope and grade, impacts of new construction or grading, and ensure placement of Unique Well ID number.
- Locate all existing wells by GPS.
- Require installation of backflow prevention devices on existing farm water systems as allowed by state code.
- Establish programs in county health departments to offer both bacteria and nitrate testing.
- Prepare depth to bedrock maps at the town level using well logs and other available data. Provide resources to county agencies or WGNHS to complete this effort.
- Reduce water use in manure systems to create more solid manure.
- Support efforts to identify, test, and implement innovative methods to collect and process manure and their potential effects on the aquifer.
- Incorporate Karst feature and drainage tile mapping into the local requirements for ATCP 51 (Livestock Siting)
- Establish uniform ordinances and enforcement at the town level.
- The Standards and Oversight Council (SOC) should reconvene a technical committee to review the Manure Storage Standard and consider enhancing manure storage requirements in carbonate bedrock areas.
- Create a Niagara Escarpment and Carbonate Bedrock Center on the UW-Green Bay campus to serve as a clearinghouse for collection and sharing of data and information from the region and beyond.
- Create a web-based, interactive resource that landowners and waste applicators can use to determine if karst features have been found in close proximity to their existing operations or proposed new operations. Such a resource would have locally designated Karst Landscape Units, as well as data reported to the state on the Interagency Karst Reporting Form. An online mapping example from Iowa can be found at http://www.iowadnr.com/afo/maps_instruct.html, and from Minnesota at http://www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html. Key to including any feature on the online system is independent field verification of each feature listed by a trained individual.

Non-Manure Wastes

We recognize that the storage, management, disposal, and application of other wastes (industrial, septage, sludge, etc) in areas with shallow carbonate bedrock also contribute to groundwater contamination. We recommend that a committee of people with expertise and knowledge of these other types of waste be formed to develop practices and restrictions for these waste products.

We also recognize that septic systems may contribute to groundwater contamination in areas with shallow carbonate bedrock and that wells may provide direct conduits for polluted runoff and wastes to enter groundwater. We recommend that separate committees with knowledgeable people be formed to develop practices and restrictions for such systems.

Needed Research

We recognize that there are concerns with the siting of certain types of animal waste storage facilities in areas of shallow carbonate bedrock. Existing technical standards and specifications may not be adequate to fully protect groundwater. We recommend that additional research be conducted on the following concerns and that additional recommendations/requirements be developed as needed to meet the following objectives.

- To better understand the characteristics and land-applied fate of manure derivatives from compost, digester and incineration facilities. These products may pose less of a groundwater quality risk than untreated manure and application may be permissible in higher vulnerability areas.

    - To evaluate crop rotations and identify which crops, management practices, soils, and other conditions are most likely to contribute to acute and chronic nitrate pollution of the carbonate aquifer.

    - To evaluate potential methods to conduct a bedrock surface analysis in a less invasive/destructive manner than boring or excavating at sites of both existing and proposed manure storage facilities.

    - To determine the most efficient way to inventory the shallow soils in the field. Examine current and theoretical methods, including, but not limited to: hand probing, cone penetometer+GPS, ground conductivity, etc.

    - To develop greater understanding of groundwater flow in the carbonate formations that can be used to contain and remediate contamination situations.

    - To asses the impacts of fall applied and incorporated manure versus waiting until spring.

    - To determine if soil cracking and macropore formation can be predicted with current models and used to guide the timing of manure application.

- To investigate if weather forecasts can be used to fine-tune the timing of manure applications.

- To establish the impacts of polymers and other additives on manure product leaching.

References

Alliance for a Clean Rural Environment. No Date. Sinkhole Management Protects Groundwater. Kansas City, Mo. 3 pp.

Bradbury, K.R. and M.A. Muldoon, 1991. *Hydrogeology and Groundwater Monitoring of Fractured Dolomite in the Upper Door Priority Watershed, Door County, Wisconsin*. Grant Report to the Wisconsin Water Resources Center, Madison, Wisconsin.

Bradbury, K.R., M. Blanchard, and M.A. Muldoon. 1988. Hydrology and Groundwater Geochemistry in Fractured Dolomite, Northeastern Wisconsin. In: *Conference Proceedings, International Conference on Fluid Flow in Fractured Rocks*, Center for Hydrogeology, Georgia State University, Atlanta. pp. 23-27.

Bradbury, K. R. (2003). A circuitous path: Protecting groundwater in Wisconsin. *Geotimes*, April 2003. URL: http://www.agiweb.org/geotimes/apr03/feature_wisconsin.html.

Devito, J., A. Pierce, N. Reckinger, and T. Valenta. 2006. *Groundwater Quality and Management in Northeast Wisconsin Areas with Shallow Aquifers: A follow up report to the 2006 Northeast Wisconsin Karst Task Force*, University of Wisconsin-Green Bay, pp.1-48.

Green, J.A., Wm. J Marken, E.C. Alexander, and S.C. Alexander. 2002. Karst Unit Mapping Using Geographic Information System Technology, Mower County, Minnesota. In: *Environmental Geology*, Vol. 42. pp. 457-461.

Hart, D. 2007. A geologic and geophysical investigation of a liquid manure transport through the valdose zone: Poster Session, Wisconsin AWRA Section meeting, March 2007.

Iowa DNR, 2006, *Animal Feeding Operations Siting Atlas*, http://csbweb.igsb.uiowa.edu/imsgate/maps/afo_siting_atlas.asp.

Johnson, S.B. and R.D. Stieglitz. 1990. Karst features of a glaciated dolomite peninsula, Door County, Wisconsin. *Geomorphology*, V. 4, pp. 437-454.

Minnesota Pollution Control Agency. 2000. *Liquid Manure Storage in the Karst Region*. Recommendation of the Technical Workgroup to the Minnesota Senate and House Agricultural Committees, 16 pp. http://www.pca.state.mn.us/hot/legislature/reports/2001/karst.pdf

Minnesota Pollution Control Agency. 2001. Karst Workgroup Recommendations. Legislative Fact Sheet, 2 pp.
http://www.pca.state.mn.us/hot/legislature/factsheets/karst01.pdf

Minnesota Pollution Control Agency, 2005. *Siting Manure Storage Areas in Minnesota's Karst Region: State Requirements*. Water Quality/Feedlots #8.13, 7 pp.
http://www.pca.state.mn.us/publications/wq-f8-13.pdf

Minnesota Pollution Control Agency. No date. Applying Manure in Sensitive Areas: State Requirements and Recommended Practices to Protect Water Quality. 11 pp. http://www.pca.state.mn.us/publications/feedlots-manureapplication.pdf

Mississippi Karst Resource Planning Committee. No date. *Southwest Illinois Sinkhole Plain: Best Management Practices Manual*, 25 pp.

Quinlan, J.F. 1987. How often should samples be taken at relevant locations for reliable monitoring of pollutants from agricultural, waste disposal or spill sites in a karst area? A first approximation. In: B.F. Beck and W.L. Wilson (eds.) *Karst Hydro-geology: Engineering and Environmental Applications. Proceedings of the Second Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst*, Orlando, Florida, pp. 277-286.

St. Ores, J., E.C. Alexander Jr, and C.F. Halsey, 1982. *Groundwater Pollution Prevention in Southwest Minnesota's Karst Region*. University of Minnesota, Agricultural Extension Service, Bulletin 465.

Stieglitz, R.D. and S.B. Johnson, 1986. Mapping and Inventorying of Geologic Features in the Upper Door Priority Watershed. Technical Report for Door County, Wisconsin, University of Wisconsin-Green Bay, 44 pp.

Stieglitz, R.D. and T.J. Dueppen, 1994. *Mapping and Inventorying of Geologic Features in the Sturgeon Bay - Red River Priority Watershed*. Technical Report to Door, Brown and Kewaunee Counties, University of Wisconsin-Green Bay, 85 pp.

Stieglitz, R.D. and T.J. Dueppen, 1995. *Mapping and Inventorying of Geologic Features in the Branch River Priority Watershed*. Technical Report to Brown and Manitowoc Counties, University of Wisconsin-Green Bay, 64 pp.

United States Department of Agriculture—Natural Resources Conservation Service (USDA-NRCS), Technical Standards and Technical Notes:

- 342 Critical Area Planting
- 351 Well Decommissioning
- 360 Closure of Waste Impoundment
- 362 Diversion
- 551 Heavy Use Protection Area
- 558 Roof Runoff Structure
- 590 Nutrient Management (1999)
- 590 Nutrient Management (2002)
- 590 Nutrient Management (2005)
- 606 Subsurface Drain
- 620 Underground Outlet
- 629 Waste Treatment
- 634 Manure Transfer
- 635 Wastewater Treatment Strip

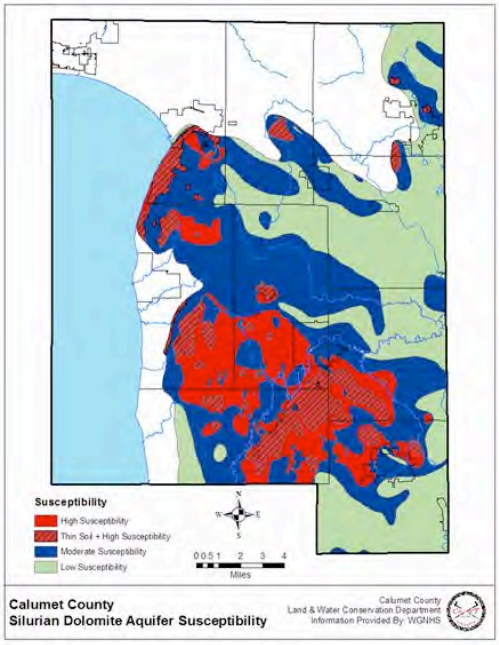
- 725 Sinkhole Treatment
- Tech Note 1, Nutrient Management (1999)
- Tech Note 1, Nutrient Management (2002)
- Tech Note 1, Nutrient Management (2005)

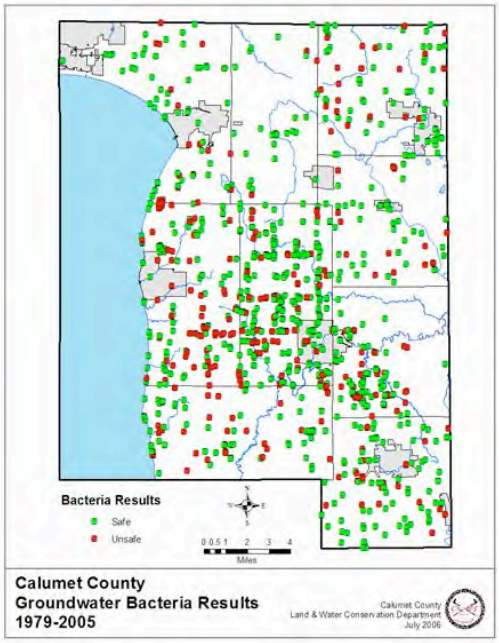
Warzecha C., R. Gerhardt, and S. Kluender. Wisconsin Private Well Water Quality Survey. Wisconsin Department of Health and Social Services, Department of Natural Resources and State Laboratory of Hygiene; 1995. pp. ii.

Wisconsin Department of Natural Resources, 2004. *Answers to Your Questions on Well Abandonment. Bureau of Drinking Water and Groundwater*, PUB-016, 8 pp.

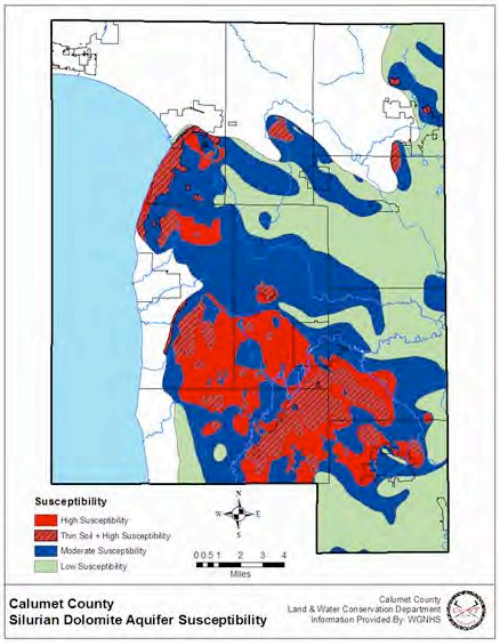
Appendix 1: County Data documenting the problem

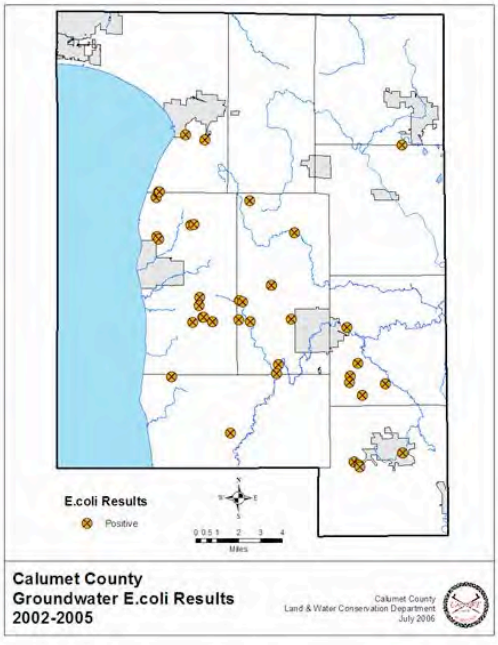
Calumet County Bacteria Results & Aquifer Susceptibility



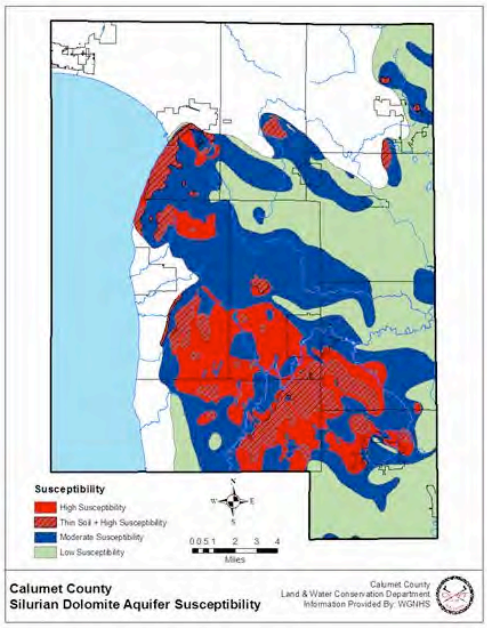


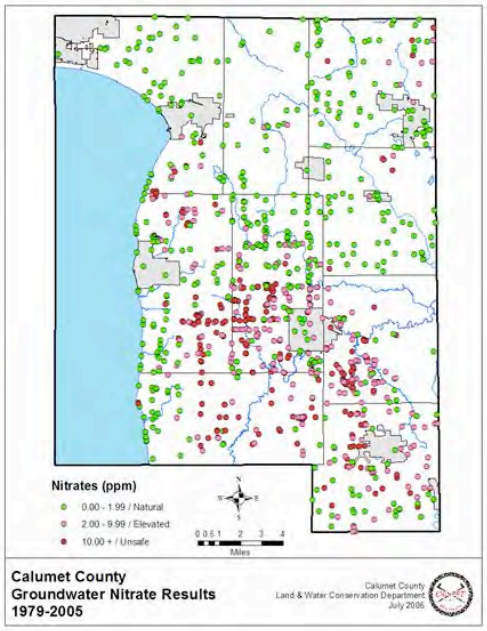
Calumet County E.coli Results & Aquifer Susceptibility



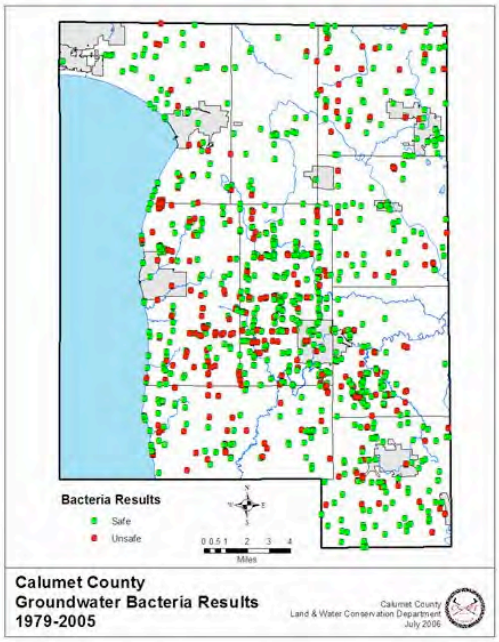


Calumet County Nitrate Results & Aquifer Susceptibility

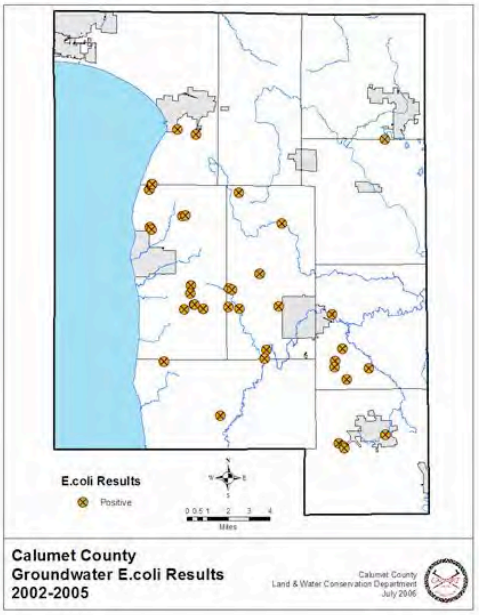




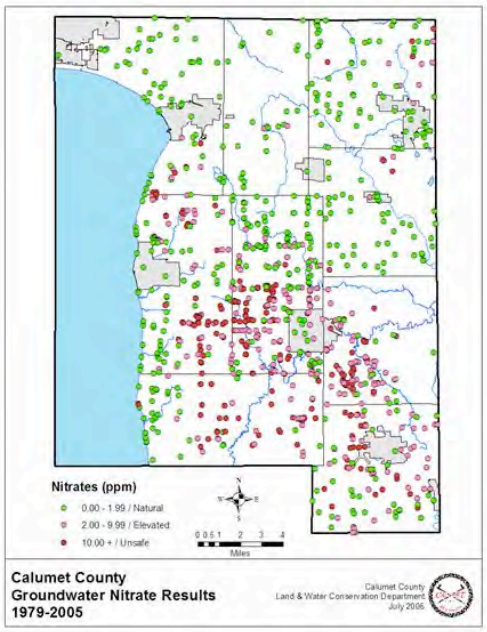
Calumet County Bacteria Results & Shallow/Light Soils



Calumet County E.coli Results & Shallow/Light Soils



Calumet County Nitrate Results & Shallow/Light Soils



Scope of Problem – Kewaunee County
Andy Wallander, County Conservationist

Since August of 2004 the Kewaunee County Land & Water Conservation Department, along with assistance from the local chapter of the Groundwater Guardians and the UW-Stevens Point Center for Watershed Science and Education, have held semi-annual, voluntary well-testing programs for owners of rural private wells within Kewaunee County.

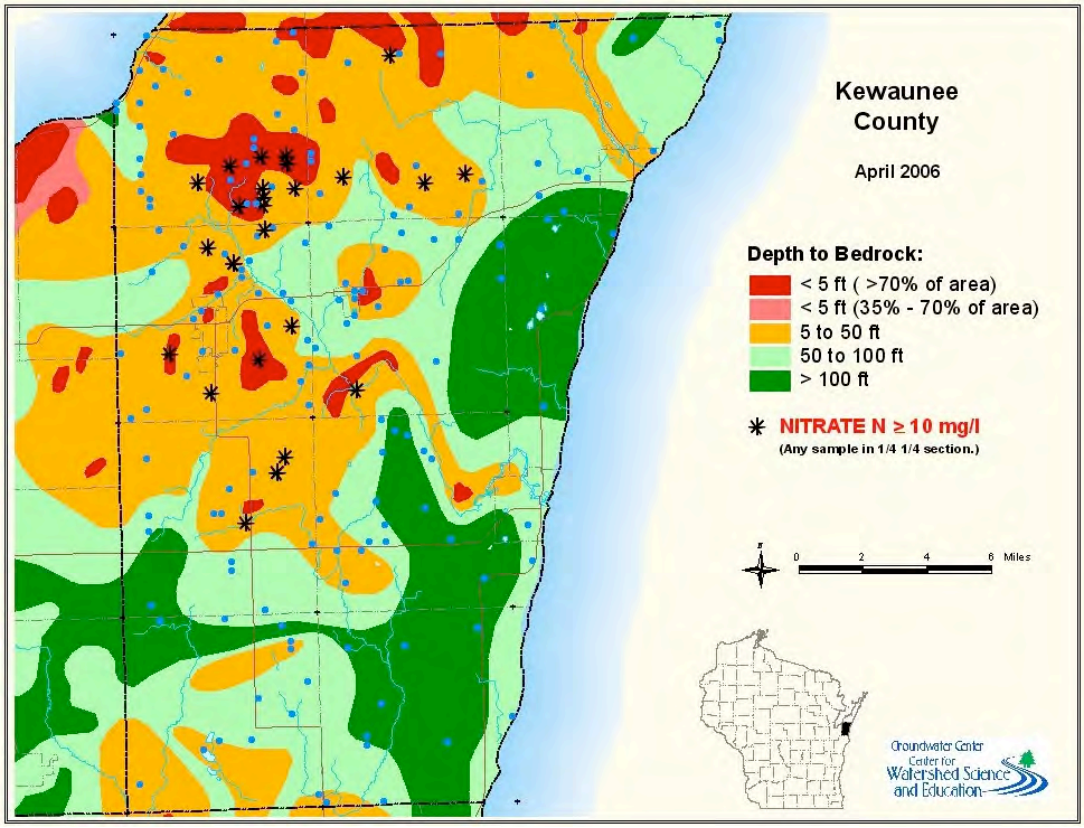
To date, of the 173 well tests completed:

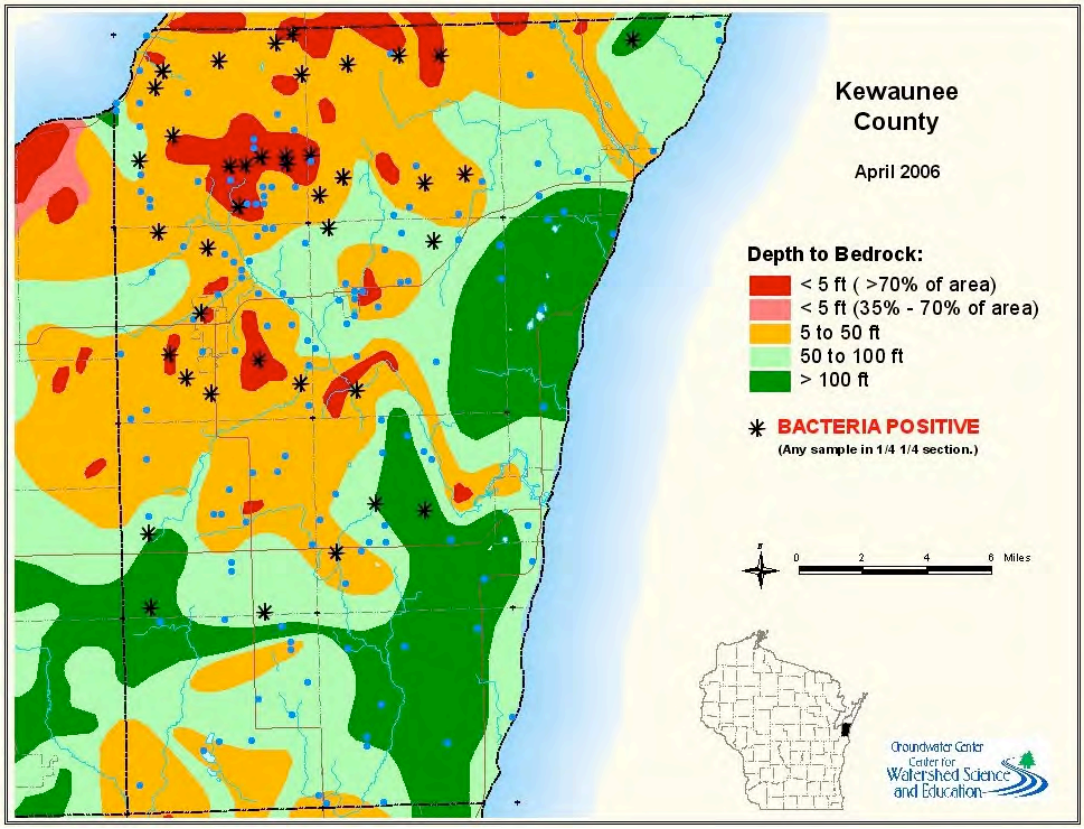
- ✓ **18%** have come back as bacteriologically unsafe for human consumption
- ✓ **18%** have come back with nitrate-nitrogen levels above the human health standard of 10 ppm (parts per million)
- ✓ **35%** have come back with varying nitrate-nitrogen levels of below 10 ppm but still above natural background levels (an indication of various sources of groundwater contamination caused by local land use practices)
- ✓ **40%** of well test participants reported observed groundwater quality problems resulting from color, taste, odor or health effects

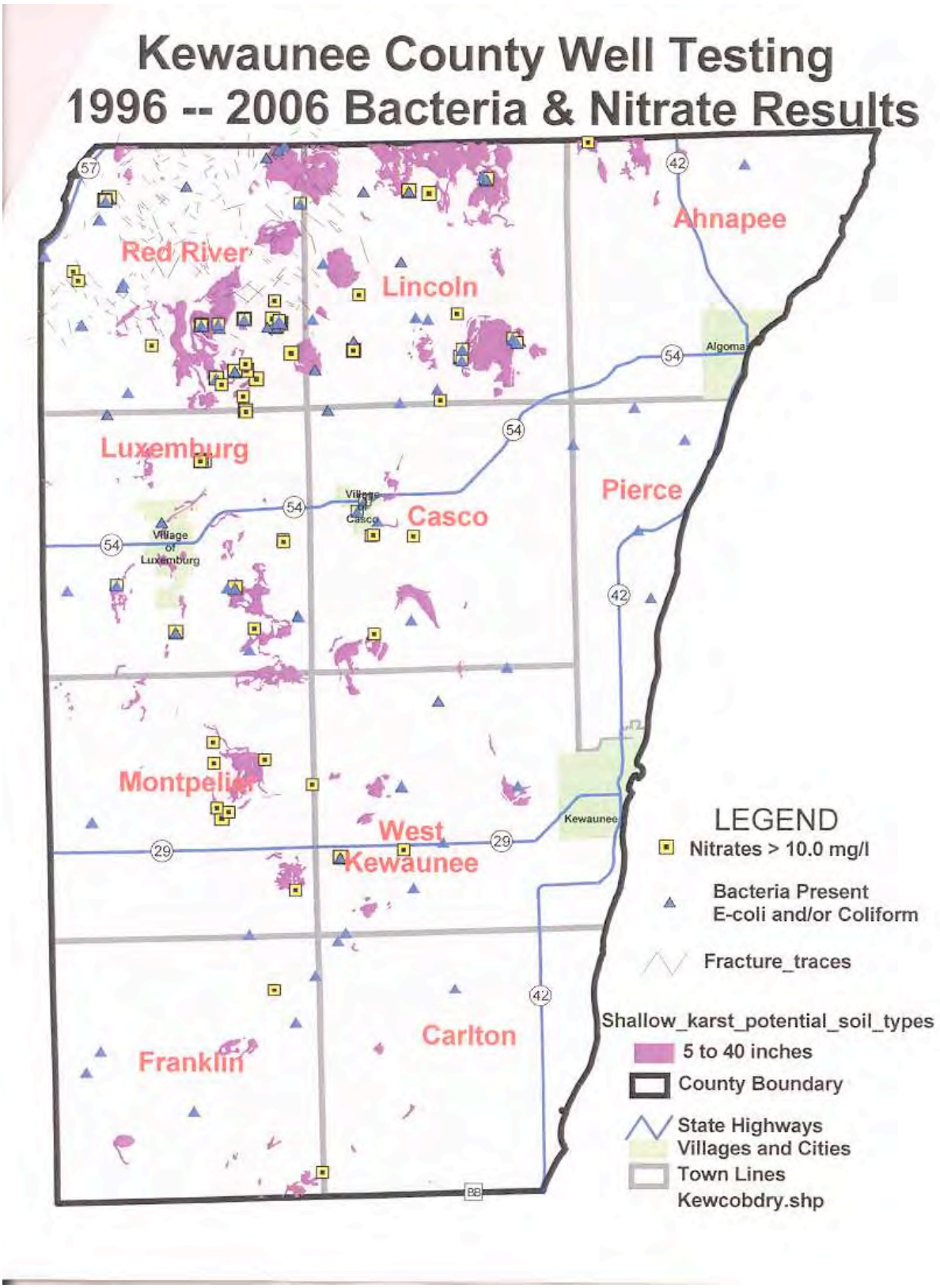
---

The Kewaunee County Public Health Department provides free well water test kits for bacteria and nitrates to families having their first pregnancy. Since 1996, 258 well have been tested through this program. **Approximately 30%** of these tests came back as unsafe for human consumption either due to presence of bacteria, or nitrates above the human health standard of 10 ppm.

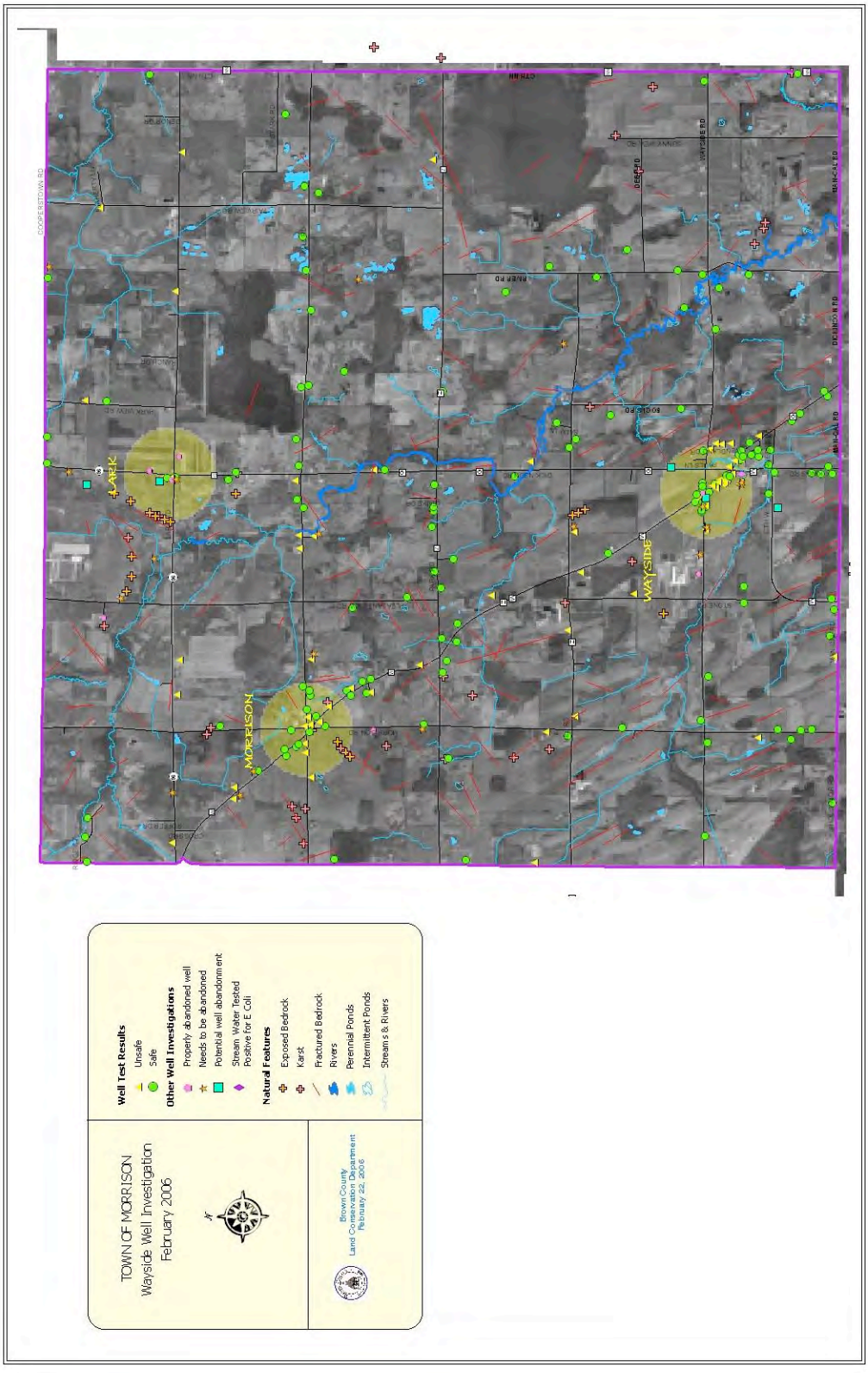
Kewaunee County LWCD well testing program results – Nitrate and Bacteria






Kewaunee County Well Testing
1996 -- 2006 Bacteria & Nitrate Results
Red River
Lincoln
Ahnapee
Luxemburg
Pierce
Casco
Montpelier
West Kewaunee
Carlton
Franklin
Algoma
Kewaunee
Village of Luxemburg
Village of Casco
LEGEND
Nitrates > 10.0 mg/l
Bacteria Present
E-coli and/or Coliform
Fracture_traces
Shallow_karst_potential_soil_types
5 to 40 inches
County Boundary
State Highways
Villages and Cities
Town Lines
Kewcobdry.shp

Brown County – Morrison Township 2006 karst feature and well testing inventory.



Appendix 2: Comparison of Setbacks and Codes

Prepared by Steve Shimek, STS Consultants, Green Bay (additional info from Sue Porter, DATCP, Kevin Erb, UWEX)

Wisconsin DNR and DATCP rules related to spreading of different kinds of materials on land are separated into two categories: 1) land application and 2) land treatment. Land application means spraying or spreading onto the land surface, injecting or incorporating into the soil the following: manure, process wastewater or biosolids. Land application rules are more restrictive for human waste (biosolids) than for animal waste. Materials that are land applied are considered a resource for conditioning the soil or fertilizing crops and vegetation. Animal waste land application rules generally refer to Natural Resources Conservation Service (NRCS) guidance 590, dated September 2005, which in turn references University of Wisconsin Extension (UWEX) publication A2809, "Soil Test Recommendations for Field, Vegetable, and Fruit Crops".

Land treatment (and disposal) practices are defined as systems that utilize the physical chemical and biological abilities of the soil to decompose pollutants in wastes. Land treatment rules require groundwater monitoring and are exempt from NRCS 590. Wastes are applied according to crop nitrogen needs. Because the rules are complex, I have not summarized them in one table.

Land Application

NR 204: Domestic Sludge Management

A WPDES permit is required for use and disposal of sludge generated by any domestic wastewater treatment facility. The sludge is analyzed for specific parameters and each land application site is evaluated for crop agronomic needs based on nitrogen. Bulk sludge may only be applied to sites that meet the following groundwater and drinking water protections:

Criteria	Surface	Incorporation	Injection
Depth to Bedrock	3 ft.	3 ft.	3 ft.
Depth to High Groundwater	3 ft.	3 ft.	3 ft.
Distance to Wells			
Community or School Wells	1000 ft.	1000 ft.	1000 ft.
Private Potable, OTM, Non-community wells	250 ft.	250 ft.	250 ft.
Soil Permeability Range (in/hr)	0.2 – 6.0	0 – 6.0	0 – 6.0

NR 113: Servicing septic or holding tanks, pumping chambers, grease interceptors, seepage beds, seepage pits, seepage trenches, privies or portable restrooms.

A WPDES permit is required for use and disposal of these wastes. Wastes must be land applied, according to crop nitrogen needs, subject to site approval by the DNR. Wastewater can be applied to sites that meet the following groundwater and drinking water protections:

Criteria	Spreading	Incorporation	Injection
Minimum depth from bedrock and groundwater	3 ft.	3 ft.	3 ft.
Minimum distance to community well	1000 ft.	1000 ft.	1000 ft.
Minimum distance to other well	250 ft.	250 ft.	250 ft.
Minimum distance to sinkhole	200 ft.	150 ft.	100 ft.
Soil Permeability Range (in/hr)	0.2 - 6.0 w/ 3ft. soil		

NR 243: Animal Feeding Operations

A WPDES permit is required for animal feeding operations of 1000 animal units or more. The permit covers manure and process wastewater. Because NR 243 references NRCS 590, nutrients are applied to crop phosphorus need (NRCS 590, September 2005). Manure or process wastewater may not cause the fecal contamination of water in a well. Wastewater and manure can be applied as follows:

Criteria	Separation
Depth to groundwater and/bedrock	> = 24 inches
Separation distance to direct conduit to groundwater	100 feet
Separation to private well (NR 812)	100 feet
Separation to community well (NR 811)	1000 feet
Separation to bedrock on frozen or snow covered soil	60 inches
During snow melt	Not allowed

NR 151: Runoff Management subchapter II – Agricultural Performance Standards and Prohibitions
This subchapter sets performance standards for agricultural facilities, operations and practices. ATCP 50 sets technical standards for practices used to meet the performance standards in this subchapter. ATCP 50 references NRCS 590 dated September, 2005 which specifies that nutrients will be applied to crop needs as determined by UWEX publication A2809. The standard is described below. All farms are subject to requirements in NR 151. No permit is required, although if cost sharing is provided under ATCP 50, performance and technical standards in NR 151 and ATCP 50 must be met. Unconfined manure piles are prohibited in water quality management areas. A water quality management area is defined as a "Site that is susceptible to groundwater contamination under s. 281.16(1)(g), Statues, means any one of the following:

- An area within 250 feet of a private well.
- An area within 1000 feet of a municipal well.
- An area within 300 feet upslope or 100 feet downslope of karst features.
- A channel with a cross-sectional area equal to or greater than 3 square feet that flows to a karst feature.
- An area where the soil depth to groundwater or bedrock is less than 2 feet
- An area where the soil does not exhibit one of the following soil characteristics:
- At least a 2-foot soil layer with 40% fines or greater above groundwater and bedrock.
- At least a 3-foot soil layer with 20% fines or greater above groundwater and bedrock.
- At least a 5-foot soil layer with 10% fines or greater above groundwater and bedrock."

ATCP 50: Soil and Water Resource Management Program
This rule sets technical standards for t state cost-shared practices including nutrient management standards. Nutrient management practices must comply with NRCS 590 dated September, 2005.

ATCP 51: Livestock Facility Siting

This chapter applies to local approvals of new or expanded livestock facilities with 500 animal units or more and new or expanded livestock facilities approved under local zoning ordinance before July 19, 2003. New or substantially altered livestock structures must be separated from exiting wells by the distances required in chapters NR 811 and NR 812 Wis. Adm. Code. Land application of waste from a livestock facility approved under this chapter shall comply with NRCS nutrient management technical standard 590 dated September 2005.

NR 812: Well Construction and Pump Installation
This chapter applies to all wells except monitoring wells (NR 141) and Community wells (NR 811) and includes all high capacity wells and private wells as defined in NR 812. Separation distances for various structures that may be included under ATCP 51 include but are not limited to:

Structure	Separation
Liquid Waste Disposal System	250 feet
Manure Stack	250 feet
Temporary Manure Stack	150 feet
Manure Storage Structure	250 feet

NR 811: Requirements fro the Operation and Design of Community Water Systems
This chapter governs the construction of community water systems serving 7 or more homes, 10 or more duplexes, 10 or more mobile homes, 10 or more condominiums, or 10 or more apartments. Unless a hydrogeologic investigation indicates lesser separation distances would provide adequate protection of a well from contamination, the minimum separation distances provided will be (NR 811.16 (4) (d) 5.) one thousand feet between a wells and land application of municipal, commercial or industrial waste, …Manure stacks or storage structure and septic tanks or soil adsorption units receiving 8,000 gallons per day or more.

NRCS Standard 590: Nutrient Management (dated September, 2005):
This standard is codified by reference into NR 151, NR 243, ATCP 50 and ATCP 51. It establishes acceptable criteria and documentation requirements for a plan that addresses the application and budgeting of nutrients for plan production. The criteria are intended to minimize nutrient entry into groundwater while maintaining and improving the physical chemical and biological condition of the soil. The standard applies to all fields where plant nutrient sources and soil amendments are applied during the course of a rotation. It is consistent with UWEX publication A2809 which has recommendations for nitrogen application rates are based on crop yield, crop quality, and economic return. The amount of nitrogen applied is based on cost. The relationship between the recommended nitrogen application rates and groundwater nitrate concentration is unknown. Additional nutrient application prohibitions include:

Feature	Prohibition
Non-farmed wetland, sinkhole, non-metallic mine or well	No application
Within 50 feet of a potable drinking water well	No mechanical manure application
Areas contributing runoff within 200 feet upslope of direct conduits to groundwater such as a well, sinkhole, fractured bedrock at the surface, tile inlet, or non metallic mine	Nutrients must be effectively incorporated within 72 hours
Frozen or snow covered soils in locally identified areas delineated in the conservation plan as contributing nutrients to direct conduits to groundwater as a result of runoff	No application when incorporation is not possible.

To minimize nitrogen leaching to groundwater on high permeability soils or soils with less than 20 inches to bedrock or soils with less than 12 inches to apparent water table or within 1000 feet of a municipal well, there are specific management practices that must be followed. These practices include:

Where sources of N are applied:

- ∞ No fall commercial N applications except for establishment of fall-seeded crops. Commercial N application rates, where allowed, shall not exceed 30 pounds of available N per acre.
- ∞ On irrigated fields, including irrigated manure, apply one of the following management strategies: 1) A split or delayed N application to apply a majority of crop N requirement after crop establishment. 2) Utilize a nitrification inhibitor with ammonium forms of N.

When manure is applied in late summer or fall to meet the fertility needs of next year's crop and soil temperatures are greater than 50º F, apply one of the following options:

- ∞ Use a nitrification inhibitor with liquid manure and limit N rate to 120 pounds available N per acre.
- ∞ Delay applications until after September 15 and limit available N rate to 90 pounds per acre.
- ∞ Apply to fields with perennial crops or fall-seeded crops. N application shall not exceed 120 pounds available N per acre or the crop N requirement, whichever is less.

When manure is applied in the fall and soil temperatures are 50º F or less, limit available N from manure application to 120 pounds per acre or the crop N requirement, whichever is less.
(Note: The restrictions in B. 2. and 3. do not apply to spring manure applications prior to planting. The balance of the crop N requirements may be applied the following spring or summer).
Where P enrichment of groundwater is identified as a conservation planning concern, implement practices to reduce delivery of P to groundwater.

Land Treatment and Disposal
Land treatment and disposal practices are defined as systems that utilize the physical, chemical and biological abilities of the soil to decompose pollutants in wastes and wastewater. The wastes are applied for the benefit of vegetative cover.

NR 110, Sewerage Systems
WPDES permits are issued for land disposal of sewage. A site evaluation must be done and sewage can be applied based on the following criteria:

Criteria	Separation distance (ft.)
Private water supply wells	250
Public water supply wells	1000
Absorption ponds	
Separation between pond bottom and highest anticipated groundwater	5
Separation between pond bottom and bedrock	10
Spray irrigation systems	
Separation to bedrock	5
Separation to highest anticipated groundwater	5
Ridge and Furrow systems	
Separation to highest anticipated groundwater	5
Separation to bedrock	5
Overland flow systems	
Separation to bedrock	5
Separation to seasonally high groundwater	5

Groundwater level monitoring is required for these systems under NR 206. Groundwater quality monitoring may be required quarterly. Wastes are applied to nitrogen needs for the cover crop.

NR 206, Land Disposal of Municipal and Domestic Wastewater.
This chapter establishes effluent limitation and monitoring requirements for systems permitted under NR 110.

NR 214, Land Treatment of Industrial Liquid Wastes, By-product Solids and Sludge.
Establishes design and construction criteria for all land treatment systems that receive industrial wastes under the WPDES permit process. Application of wastes is limited by the nitrogen needs of the cover crops. Groundwater quality is monitored. Waste can be applied after a site evaluation has shown the following criteria are met;

Criteria	Separation distance (ft.)
Community public water supply wells	1000
Other potable drinking water well	250
Absorption ponds	
Separation between pond bottom and groundwater	5
Separation between pond bottom and bedrock	5
Spray irrigation systems	
Separation to bedrock	5
Separation to groundwater	5
Ridge and Furrow systems	
Separation to groundwater	5
Separation to bedrock	5
Overland flow systems	
Separation to bedrock	5
Separation to groundwater	5

Summary

Rules that regulate land application of human waste generally require 3 feet of separation to groundwater and/or bedrock, 1000 feet of separation between application sites and community wells and 250 feet between non-community wells. Application rates are based on nitrogen use by crops.

Rules that regulate land application of animal waste have 2 or less feet of separation to groundwater and/or bedrock and also rely on NRCS 590 for nutrient application rates and a minimal separation from potable wells and other direct conduits to groundwater. ATCP 51 which regulates CAFO siting is an exception in that the location of structures is protective of private and community wells.

Rules that regulate land treatment of sewage, wastewater, and industrial wastes are most protective of groundwater. In general these wastes cannot be spread where depth to groundwater and bedrock is less than 5 feet and separation from community wells is less than 1000 feet and private wells is less than250 feet.

Appendix 3: Farmer Committee Brochure

Who to Contact if Manure Spills or Run-off Event Occurs:

Wisconsin DNR (24 hour) Spill Reporting Hotline:

1-800-943-0003

Manitowoc County Soil & Water: 1-920-683-4183

Kewaunee County Soil & Water: 1-920-

Door County Soil & Water: 1-920-

Calumet County Soil & Water: 1-920-

Brown County Soil & Water: 1-920-

Manitowoc County Emergency Management: 1-920-683-4207

Kewaunee County Emergency Mgmt: 1-920-

Door County Emergency Mgmt: 1-920-

Calumet County Emergency Mgmt: 1-920-

Brown County Emergency Mgmt: 1-920-

Marine Warden 1-920-

Conservation Warden1-920-

Prepared by: Kevin & Lisa Collins Colleen & Jeff Loppnow

Agriculture & Karst Features

Teamwork for a Safe Environment

What's On Your Land?

- Surface Water (Streams, Rivers Lakes, Ponds,Channels)
- Wells (Existing, Abandoned and Neighboring)
- Waterways & Ditches (including road ditches)
- Tile inlets, Broken tile lines
- Sinkholes
- Springs
- Bedrock Surfacing or Shallow bedrock

Are You AND Your Custom Haulers AWARE of the Locations of these Features on the Properties Being Hauled ?

Use Caution when Applying Manure near Risky Sites

As Farmers Lets Be Pro-Active

- ★ Develop a written spreading plan prior to hauling.
- ★ Identify Risk Factors on a field by field basis.
- ★ Communicate Plan with Custom Haulers Prior to & During Process
- ★ Changing soil conditions warrant different application practices
- ★ Inspect fields for cracked soils, plan to pre-till prior to application
- ★ If soil is wet; back down planned amount to reduce chance of off-site movement (Remember while we can't control the amount of precipitation added to the soils, we can control the amount of moisture added from a manure application.)
- ★ Manure application rates should be linked to what the next crop will utilize & Soil tests will allow. Make more frequent lower rates of application rather than a single heavy one
- ★ Maintaining a low phosphorus diet can reduce phosphorus levels in manure which can ultimately reduce the acreage needed for spreading
- ★ Manure applied prior to summer seeding should not be applied > 2 weeks prior to reduce chance of leaching or volatilization of converted nitrogen forms.

Storage & Containment Issues:

- ★ Do you have enough capacity for storage to eliminate hauling during critical times?
- ★ Identify & properly handle where milkhouse waste is going
- ★ Maintain proper area per animal for Pastures or exercise lots to maintain vegetative cover & prevent run-off.
- ★ Be alert of areas with thin soil over bedrock as surface water can flow into groundwater with little or no filtration.
- ★ Daily Hauling on approved sites.

Preventing Manure Run-off from Field:

- ➡ Immediately Incorporate manure behind application.
- ➡ Work a border around entire field and around risky areas prior to hauling
- ➡ Frozen, snow-covered ground, shortly preceding snowmelt has been identified as the most critical, environmentally risky, time of the year for manure applications.
- ➡ Contain or Divert Run-off from risky sites through use of berms, basins, or use of mechanical means.
- ➡ Evaluate a situation that caused run-off, to prevent a future occurrence.

Preventing Spills & Run-off from Facilities:

- ➡ Monitor manure level in facility to prevent topping over.
- ➡ Consider a back-up plan (neighboring manure storage, neighboring cash-crop acreage available, Identify area for temporary in-field manure storage, in accordance with 313 standard)
- ➡ Uncontained Manure Stacks in proper locations
- ➡ Identify & Prevent non-manure nutrient movements (feed storage, barnyard runoff, animal composting, etc.)
- ➡ Inspect facilities for leaks or other damage
- ➡ Maintain equipment

AN ACCIDENTAL SPILL IS NOT ILLEGAL. FAILURE TO REPORT IT IS.

Appendix 4: Manitowoc Field Assessment Sheets

AWO FIELD FEATURE RESTRICTION CHECKLIST

FIELD NUMBER _____

- □ Streams, ditches, lakes, ponds and setbacks
- □ Concentrated Flow areas (small waterways, ditches, concentrated flow is evident, flowing springs)
- □ Wells in use
- □ Wells not used
- □ Tile Surface inlets (pipes, French, blind, gravel, rock, curtain, blowouts)
- □ Sink holes (rock holes, swallets, fractures open to surface)
- □ Exposed Bedrock
- □ Shallow Bedrock (<20 in to bedrock)
- □ Gravel pits/quarries
- □ Shallow water table (<12 in to apparent water table) identified via soil survey.
- □ Excessively permeable Soil
- □ Slope restrictions (>6% slope)
- □ Other areas restricted
- □ Soil Erosion Management Plan is Current?

FIELD NUMBER _____

- □ Streams, ditches, lakes, ponds and setbacks
- □ Concentrated Flow areas (small waterways, ditches, concentrated flow is evident, flowing springs)
- □ Wells in use
- □ Wells not used
- □ Tile Surface inlets (pipes, French, blind, gravel, rock, curtain, blowouts)
- □ Sink holes (rock holes, swallets, fractures open to surface)
- □ Exposed Bedrock
- □ Shallow Bedrock (<20 in to bedrock)
- □ Gravel pits/quarries
- □ Shallow water table (<12 in to apparent water table) identified via soil survey.
- □ Excessively permeable Soil
- □ Slope restrictions (>6% slope)
- □ Other areas restricted
- □ Soil Erosion Management Plan is Current?

Signature of evaluator_____ Date _____

F:/AWO/Application Material/AWO Field Feature Form
February 2003

APPENDIX 5: State Karst Inventory Form

WISCONSIN INTERAGENCY KARST FEATURE REPORTING FORM 2000-1

This form is used to report the locations of "karst" features such as caves, sinkholes, enlarged fractures, disappearing streams or other surface drainage, and springs. Old/abandoned mine shafts are also included.

Please mail or FAX completed form to:
Karst Information File
WISCONSIN GEOLOGICAL & NATURAL HISTORY SURVEY
3817 MINERAL POINT RD
MADISON WI 53705-5100 fax: (608) 262-8086 phone: (608) 262-1705

WGNHS use only:
Form Received Date: _____
Database Entry Date: _____

THESE THREE SECTIONS MUST BE COMPLETED

(circle one) Gov
County:_____ T. ____N R.____E or W ____¼ of _____¼ of Sec.____ Lot:_____

Fire #/Street Address:_____

City/Town/Village:_____ Zip Code: _____

Topographic Quad/Map Name:_____

Landscape Area *(✓ all that apply)*
☐ rural ☐ industrial
☐ urban ☐ highway
☐ other *(describe)*

Reporter Name (Last, First):_____ Reporter Phone:_____

Employer/Occupation:_____ Reporter Email:_____

Field Observation Date:_____ Reporting Date:_____

Property Owner Name:_____

Property Owner Address:_____ Owner Phone:_____

Feature Arrangement *(✓ all that apply)*
☐ isolated features
☐ cluster of features

total # of features = _____

Feature Type *(✓ all that apply)*
☐ sinkhole
☐ enlarged fracture
☐ cave
☐ spring
☐ mine
☐ other *(describe)*

Concern *(✓ all that apply)*
☐ soil loss/erosion
☐ water quality
☐ collapse/safety
☐ endangered species
☐ flooding
☐ other *(describe)*

Karst Classification* *(enter one from list on back of this form)*:_____

Shape *(✓ one)*
☐ circular
☐ elongate
☐ linear
☐ other *(describe)*

Size *(enter all that apply & circle unit)*
length:_____ feet / meter
width:_____ feet / meter
depth:_____ feet / meter
diameter:_____ feet / meter

Feature orientation *(compass)*: _____
Is feature open? ☐Y ☐N
Is feature filled? ☐Y ☐N
fill material:_____

Evidence of surface drainage into feature? ☐Y ☐N
Feature may receive polluted drainage? ☐Y ☐N

Drainage Area Size in Acres *(✓ one)*
☐ < 1 ☐ 1 - 10 ☐ > 10

Nearby Land Use & Estimated Distance *(✓ all that apply, then enter distance & measurement unit)*

☐ high capacity well - municipal:_____	☐ house:_____	☐ landfill:_____
☐ high capacity well - agricultural:_____	☐ building:_____	☐ dam:_____
☐ high capacity well - industrial:_____	☐ septic field:_____	☐ farm field:_____
☐ high capacity well - other:_____	☐ quarry:_____	☐ parking lot:_____
☐ gasoline service station:_____	☐ gravel pit:_____	☐ livestock pen:_____
☐ animal waste lagoon:_____	☐ potable well:_____	☐ irrigation ditch:_____
☐ sanitary plant lagoon:_____	☐ salt storage shed:_____	☐ cemetery:_____
☐ storm water detention pond:_____	☐ highway/street pavement:_____	
☐ chemical storage:_____	☐ other (describe):_____	

WISCONSIN INTERAGENCY KARST FEATURE REPORTING FORM 2000-1

This form is used to report the locations of "karst" features such as caves, sinkholes, enlarged fractures, disappearing streams or other surface drainage, and springs. Old/abandoned mine shafts are also included.

Feature mapped as … *(✓ one)*
☐ point ☐ line ☐ area

X-coordinate *(e.g., Long., Easting)*

Y-coordinates *(e.g., Lat., Northing)*

Referencing System:_____
(e.g., WTM, Lat/Long, State Plane, UTM, county system)

Datum (or Spheroid for Lat/Long):_____
(e.g., datums = NAD91, NAD27; spheroids = WGS84, GRS80)

(see note* below)

* ***Attach another sheet or a diskette with an ASCII file of coordinates or ArcView shapefile, if more than four x-y coordinates are collected for the karst feature(s) described on this form.***

Comments:_____

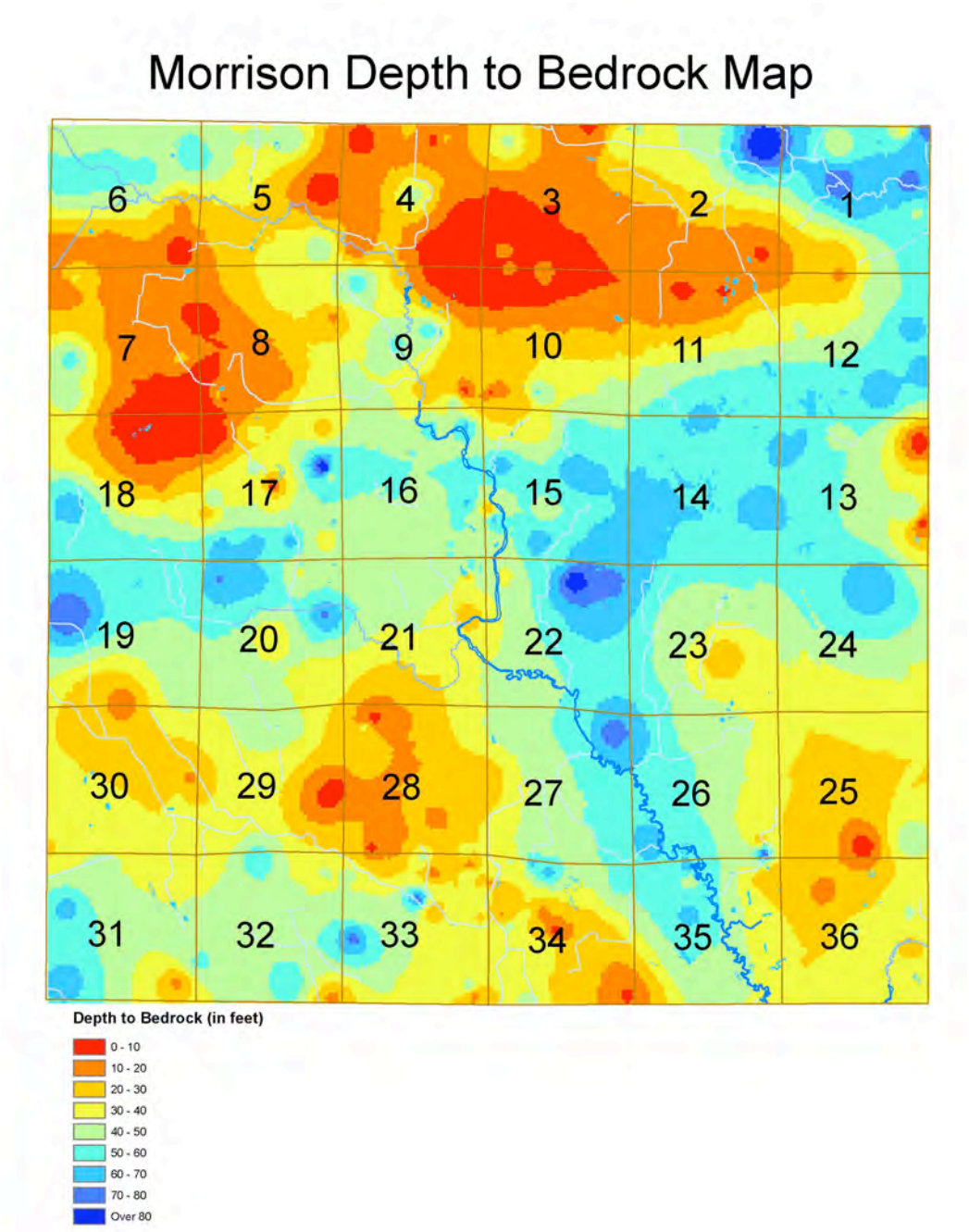
Feature Drawing: *Plan view sketch should include: nearby landmarks (e.g., roads, fences, buildings), approximate scale, north arrow, cross-section (if appropriate). Attach photos or other reference maps as needed.*

Karst Classification List:

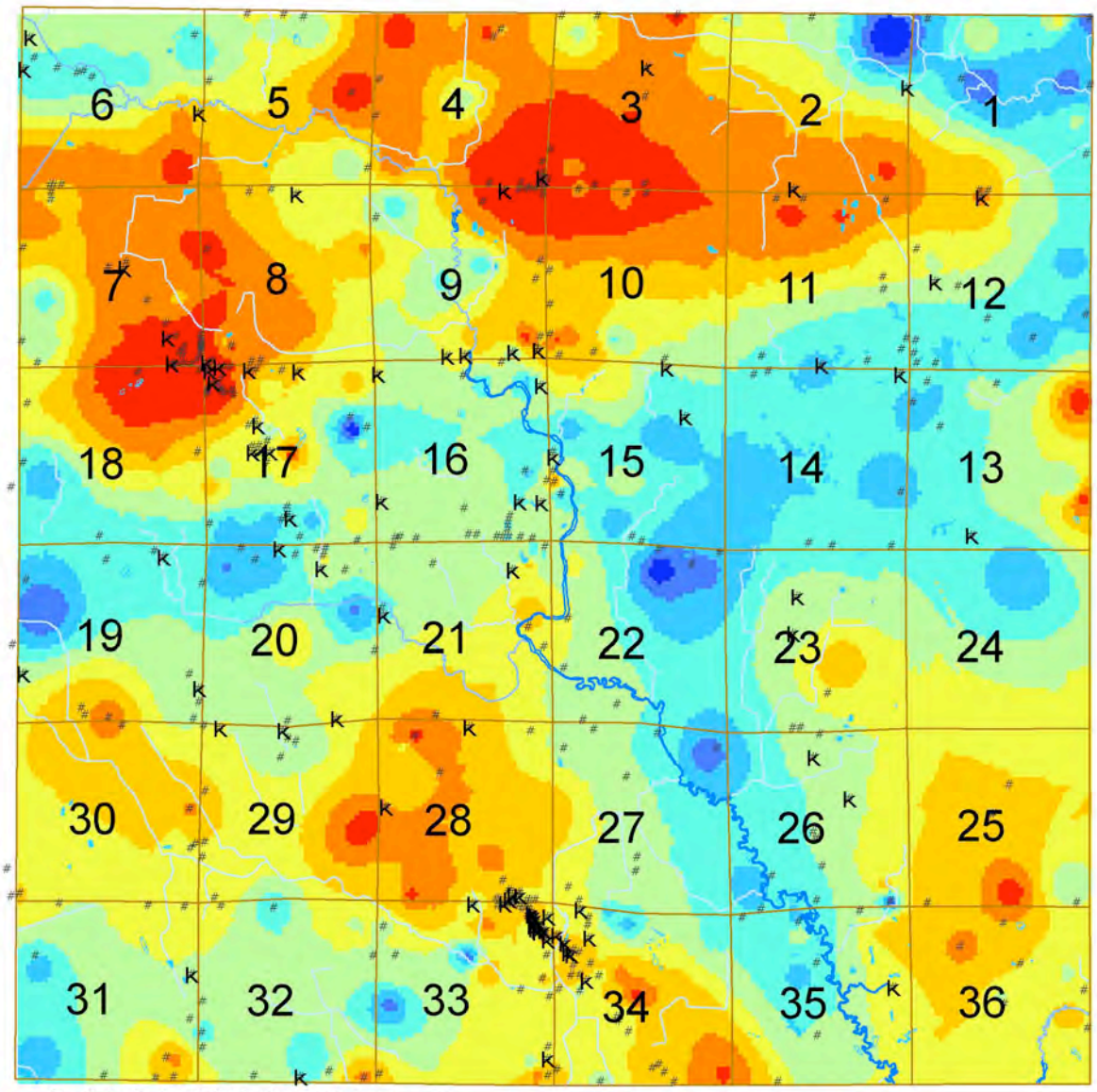
Sinkhole: a topographic depression (unless filled) in which bedrock is dissolved or collapsed. Sinkholes may be open, covered, buried, or partially filled with soil, field stones, vegetation, weathered bedrock, water or other micellaneous debris. Sinkholes are usually circular, funnel-shaped, or elongated. Sinkhole dimensions vary by region. Wisconsin sinkholes generally range between 20 to 30 feet in diameter and 4 to 10 feet deep, although some can be wider and/or deeper.
Enlarged Fracture: solution enlarged or widened bedrock fracture that usually narrows with depth.
Pavement: extensive bare areas of exposed bedrock surfaces with many enlarged fractures or sinkhole features.
Fracture Trace: linear feature, including stream segment, vegetative trend and soil tonal alignment.
Spring/Seep: intermittent or permanent seepage of water from ground surface or bedrock outcrop or karst area.
Cave: natural cavity, large enough to be entered, which is connected to subsurface passages in bedrock.
Karst Pond: closed depression in a karst area containing standing water.
Swallet: a place where surface or storm water drainage disappears underground.
Karst Fen: marsh formed by plants overgrowing a karst lake or seepage area.
Mine Feature: a man-made shaft, tunnel, cave, hole, or other feature created for mining purposes.

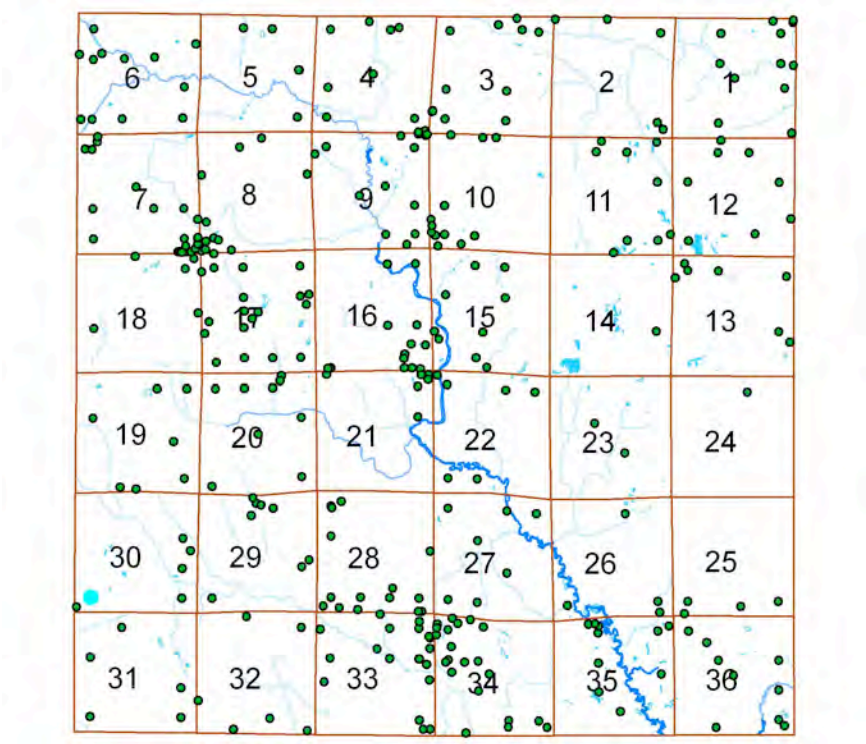
Appendix 6: Morrison Mapping Project

With funding from a variety of agencies (county, state) and stakeholder groups, Brown County LCD hired two summer interns (Brandon Cramer and Stacy Frisk) to conduct a karst inventory in Morrison township. In addition to the inventory, the students used DNR and WGNHS well logs to create a detailed depth to bedrock map of the township, overlaying well testing data to create the maps in this appendix. These are examples of the type of enhanced information that can be used to help make land use decisions

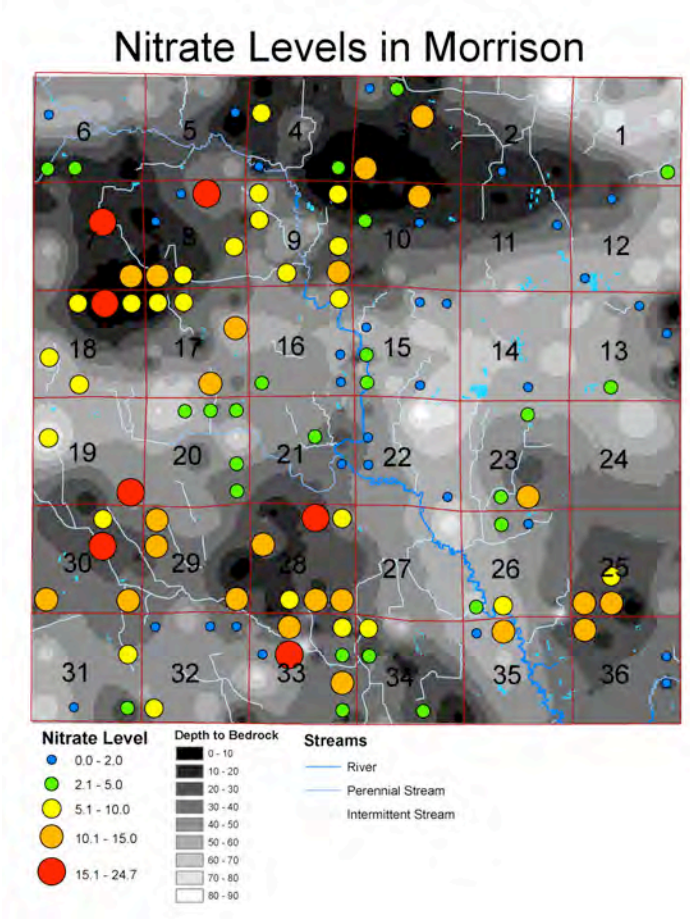


Morrison Wells Tested 2006: Bacteria

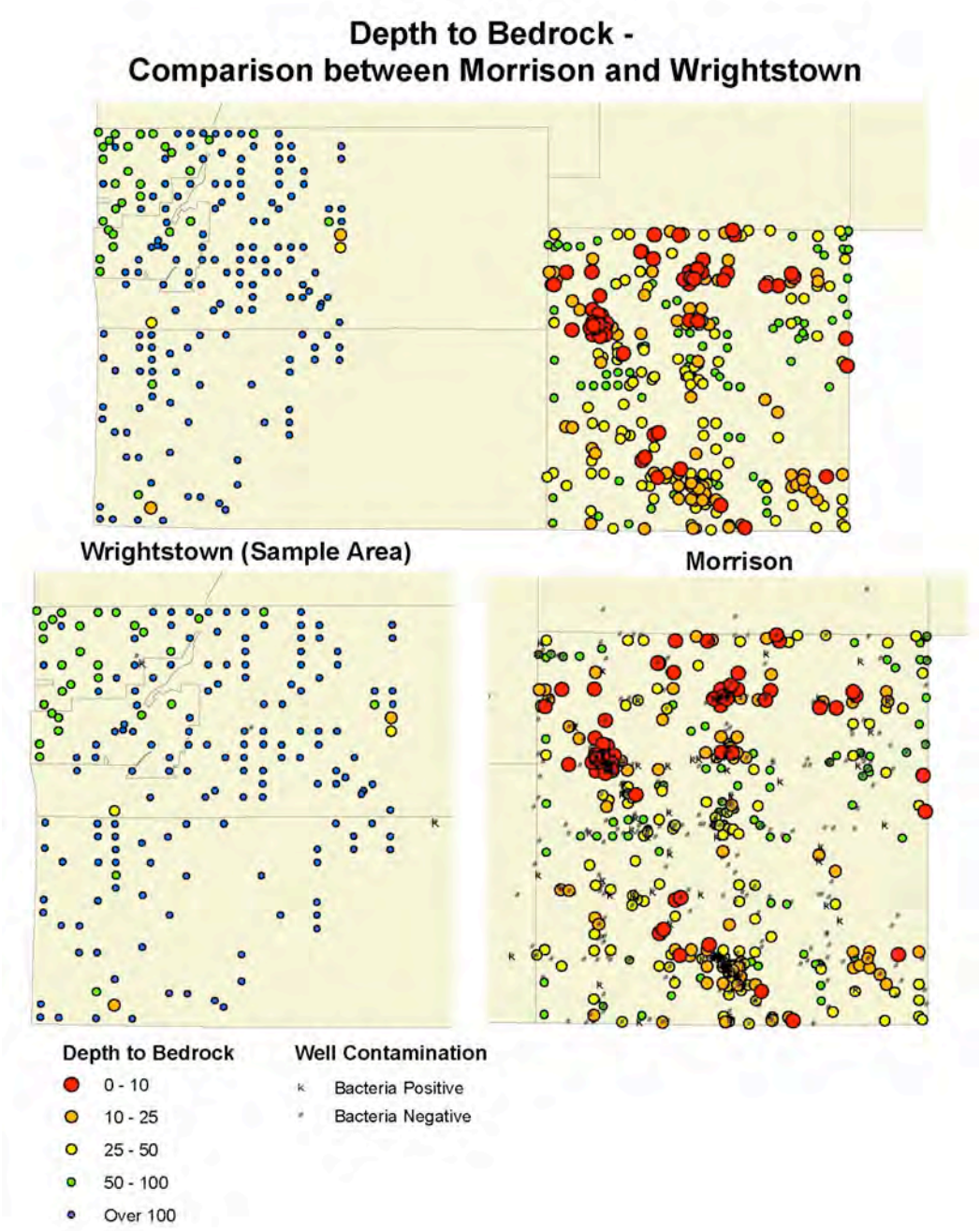




Well density used to generate depth to bedrock map. It should be noted that mappers were only able to locate ~70% of the wells for which records existed, as exact locations for pre-1980 well logs were not able to be determined in all cases.



The interns also mapped out the highest nitrate concentration found from the 2006 sampling (mapped to the quarter quarter section).



In addition to Morrison, the students also mapped a 38 square mile area near Wrightstown (west of Morrison - see top map for location comparison). The lower maps show bacterial contamination overlaid on depth to bedrock (Wrightstown well data from 1990-1994, Morrison 2006).

Issued in furtherance of Cooperative Extension, work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, University of Wisconsin–Extension. The University of Wisconsin-Extension, Cooperative Extension provides equal opportunities in employment and programming, including Title IX and Americans with Disabilities (ADA) requirements. If you need this information in an alternative format, contact the Office of Equal Opportunity and Diversity Programs or call Cooperative Extension Publishing at 608-262-2655.

To see more publications visit our web site at **http://learningstore.uwex.edu** or call toll–free: 1-877-WIS-PUBS (947-7827).

Final Report of the Northeast Wisconsin Karst Task Force (G3836)

I/08/2007