Wisconsin Groundwater Coordinating Council

REPORT TO THE LEGISLATURE

August 29, 2006

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Department of Commerce - **Berni Mattsson**
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State of Wisconsin \ GROUNDWATER COORDINATING COUNCIL

Jim Doyle, Governor

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August, 2006

To: The Citizens of Wisconsin
The Honorable Governor Jim Doyle
Senate Committee on Environment and Natural Resources
Assembly Committee on Natural Resources
Secretary Frank Busalacchi - Department of Transportation
Secretary Mary Burke - Department of Commerce
Secretary Rod Nilsestuen- Department of Agriculture, Trade & Consumer Protection
Secretary Helene Nelson - Department of Health and Family Services
Secretary Scott Hassett - Department of Natural Resources
President Kevin P. Reilly - University of Wisconsin System
State Geologist James Robertson - Geological and Natural History Survey

The Groundwater Coordinating Council (GCC) is pleased to release its 2006 Report to the Legislature. The GCC was formed in 1984 to help state agencies coordinate non-regulatory activities and exchange information on groundwater. For the past 22 years, the GCC has served as a model for interagency coordination and cooperation among state agencies, the Governor, local and federal government, and the university. It is one of the few groups in the nation to effectively coordinate groundwater activities in its state from an advisory position.

This report summarizes GCC and agency activities related to groundwater protection and management in FY 06 (July 1, 2005 to June 30, 2006) and provides an overview of the condition of the groundwater resource. See the *Executive Summary* for highlights and the GCC's recommendations in *Future Directions for Groundwater Protection*. The full report will be made available online.

Highlights of the State's groundwater protection activities this past year include:

- The first year of implementation of the new groundwater legislation 2003 Wisconsin Act 310. The Groundwater Advisory Committee continued to meet regularly and made significant progress on groundwater management areas and other issues. DNR secured funding, hired staff and took several steps to implement the new law.
- Key groundwater information and education publications were revised including *Groundwater: Wisconsin's Buried Treasure* a Natural Resources Magazine insert, and the *Groundwater Study Guide,* a popular DNR publication for teachers. Additionally, agency and UW staff supported teacher workshops, a groundwater festival for students, Farm Technology Days, county groundwater programs and other educational outreach opportunities.
- The UW Water Resources Library put online many UW and DNR monitoring and research final reports. The reports are included in the widely accessible UW Ecology and Natural Resources Digital Collection *http://digital.library.wisc.edu/1711.dl/EcoNatRes.Groundwater*.

We hope you will find this report to be a useful reference in protecting Wisconsin's valuable groundwater resource.

Sincerely,

Todd Ambs, Chair
Groundwater Coordinating Council

EXECUTIVE SUMMARY

This is the Executive Summary of the annual Report to the Legislature by the Groundwater Coordinating Council (GCC) as required by s. 15.347, Wisconsin Statutes. The report describes the condition and management of the groundwater resource and summarizes the GCC's activities for fiscal year (FY) 2006. The full report along with several appendices can be accessed online.

In 1984, the Legislature enacted 1983 Wisconsin Act 410 to improve the management of the state's groundwater. The GCC is directed by s. 160.50, Wis. Stats., to "serve as a means of increasing the efficiency and facilitating the effective functioning of state agencies in activities related to groundwater management. The Groundwater Coordinating Council shall advise and assist state agencies in the coordination of non-regulatory programs and the exchange of information related to groundwater, including, but not limited to, agency budgets for groundwater programs, groundwater monitoring, data management, public information and education, laboratory analysis and facilities, research activities and the appropriation and allocation of state funds for research."

Membership of the GCC includes the Secretaries of the Departments of Natural Resources (DNR); Commerce; Agriculture, Trade and Consumer Protection (DATCP); Health and Family Services (DHFS); Transportation (DOT); the President of the University of Wisconsin System (UWS); the State Geologist; and a representative of the Governor. Agency designees are listed on the inside of the front cover. More information about the GCC and its activities can be found on the GCC web pages.

Highlights from each of the major parts of the Report are summarized below.

GROUNDWATER COORDINATION

The GCC, its Subcommittees, and member agencies worked together to address groundwater management issues and coordinate groundwater activities in FY 06. Examples include:

1. *Implementation of the Groundwater Protection Act, 2003 Wisconsin Act 310.* The Groundwater Advisory Committee (GAC), required by Act 310, met regularly throughout 2006 and made significant progress on groundwater management area and other issues. The GCC and its subcommittees shared technical information and advice with the GAC.

2. *The fourth annual Groundwater Festival was held in Manitowoc on April 27, 2006.* The event was organized by staff at the Center for Watershed Science and Education (CWSE), Groundwater Guardians, and local land conservation departments. Volunteers from many state agencies, local colleges and high schools helped lead hands-on groundwater activities to over 600 5th and 6th graders from Brown, Calumet, Kewaunee, Manitowoc and Door counties.

3. *Groundwater: Wisconsin's Buried Treasure* and the *Groundwater Study Guide,* both very popular DNR publications, were revised, printed and distributed in FY 06. Other informational or educational publications that were recently updated to include new information were *Arsenic in Drinking Water, Nitrate in Drinking Water, Iron Bacteria Problems in Wells,* and *Karst: Avoid that Sinking Feeling.*

4. *For the sixth year in a row, three groundwater workshops for teachers were taught jointly by staff from the DNR, WGNHS and CWSE at UW Stevens Point.* The workshop leaders instructed teachers on using a groundwater sand tank model and provided additional resources to incorporate groundwater concepts into their classroom. Teachers from 21 different schools attended the workshops and received a free model for their school. With funding from an EPA grant, 141 groundwater models have been given to schools since 2001.

5. *The GCC and the UWS Groundwater Research Advisory Council (GRAC) continued coordination of the annual solicitation for groundwater research and monitoring proposals among state agencies*. The GCC approved the FY 07 solicitation for groundwater research and monitoring proposals, which was sent out in September 2005 (see *Appendix D*). A total of 12 project proposals were received. A comprehensive review process resulted in the selection of 10 new projects for funding for FY 07, five by UWS and five by the DNR. The GCC unanimously approved the proposed UWS groundwater research plan as required by s. 160.50(1m), Wis. Stats. The FY 07 groundwater monitoring and research projects are listed by funding agency in Table 2, including projects that were carried over from FY 06.

SUMMARY OF AGENCY GROUNDWATER ACTIVITIES

State agencies and the University of Wisconsin System addressed a number of issues related to groundwater protection and management and implementation of Chapter 160, *Wis. Stats.* in FY 06:

1. *Groundwater Protection Act Implementation* – The Groundwater Protection Act (2003 Act 310) expanded DNR's authority to consider environmental impacts on critical surface water resources when considering approval of high-capacity well applications. Notification and fees for all new wells, and annual water use reporting for high capacity wells are also now required. Further provisions include designation of two Groundwater Management Areas to address regional groundwater quantity issues and the creation of a Groundwater Advisory Committee to recommend management approaches in these areas and evaluate the need for further statutory changes. In FY 06 DNR secured funding for and hired five staff to implement the new law. FY 06 accomplishments include:
   - Implementation of an automated Internet well construction notification and fee collection system as well as an internal DNR approval application tracking system.
   - Assessment of the availability of data and evaluation tools needed for evaluating potential significant adverse impacts of high-capacity wells on protected surface waters.
   - Coordination of three inventory, monitoring, and research projects on springs and one project measuring baseflows on small protected streams.
   - Support for the Groundwater Advisory Committee (GAC) and Subcommittee meetings. The GAC meetings occurred every two months.

2. *Continued Remediation and Redevelopment of Contaminated Properties*
   - The DNR approved 512 cleanups of contaminated properties raising the total of approved cleanups (excluding spills and abandoned container responses) to more than 13,700. More than 95 percent of the cleanups undertaken by responsible parties proceeded without enforcement.
   - DNR awarded 50 Site Assessment Grants totaling approximately $1.7 million to 33 communities across the state. The grants will provide funds for site assessments and investigations, the demolition buildings or structures and the removal of tanks, drums and other abandoned containers.
   - To protect human health and the environment the DNR used $3.5 million in State Environmental Fund dollars to initiate or continue environmental cleanup actions at over 60 sites where groundwater contamination is known or suspected and the responsible party is unknown, unable or unwilling to conduct environmental restoration.
   - The DNR, in a Wisconsin's Urban Reinvestment Initiative partnership with the city of Milwaukee and the 30th Street Industrial Corridor Corporation, initiated work on redevelopment of this economically and environmentally distressed area of the state. A focus area was selected and within it 14 Phase I Environmental Site Assessments have been completed. Sampling has taken place on two properties for completion of Phase II reports.

3. *Nutrient management plans* - DATCP, through its land and water resource management program, provides funding, primarily to counties to assist in the protection of water resources through farmer adoption of nutrient management planning. In FY 06 approximately $90,000 was provided to develop tools for nutrient

management plans on farms to maximize profitability and to minimize excessive runoff of nutrients to surface and groundwater. Additionally, $520,000 was budgeted and allocated in FY 06 to provide cost-sharing to write nutrient management plans. Staff also worked to train farmers, consultants, and local agencies on the principles of sound nutrient management and how to comply with performance standards.

4. *New wellhead protection plans*. In FY 06, 11 communities received DNR approval of required WHP plans (for new wells) and 22 communities submitted voluntary plans to the DNR. In addition, WRWA completed Source Water Protection Plans for 3 geographic areas (with multiple public water systems). There are now nearly 300 communities who have a WHP plan for at least one of their wells.

5. *Groundwater project reports online* - The UW Water Resources Library disseminates the results of more than 120 groundwater research projects funded since 1989 by UWS, DNR, DATCP and the Department of Commerce through its Web site devoted to the Wisconsin Groundwater Research and Monitoring Program at *http://www.wri.wisc.edu/wgrmp/wgrmp.htm*. During the past year, the Water Resources Library partnered with UW Libraries' Digital Collections Center to digitize and put online most WRI and selected DNR final project reports. The WRI Groundwater Research and Monitoring Program Web site now links to the full-text reports, which are included in the University of Wisconsin Ecology and Natural Resources Digital Collection at *http://digital.library.wisc.edu/1711.dl/EcoNatRes.Groundwater*. Inclusion in the UW Ecology and Natural Resources online collection should make a wider audience aware of this important groundwater research.

CONDITION OF THE GROUNDWATER RESOURCE

Major groundwater quality and quantity concerns in Wisconsin include:

1. *Volatile Organic Compounds (VOCs):* Sources of VOCs in Wisconsin's groundwater include landfills, underground storage tanks, and hazardous substance spills. Thousands of wells have been sampled for VOCs. Fifty-nine different VOCs have been found in Wisconsin groundwater. Trichloroethylene is the VOC found most often in Wisconsin's groundwater.

2. *Pesticides*: Pesticide contamination in groundwater results from field applications, pesticide spills, misuse, or improper storage and disposal. The most commonly detected pesticides in Wisconsin groundwater are: metabolites of alachlor (Lasso) and metolachlor (Dual); atrazine and its metabolites; metribuzin (Sencor); and a metabolite of cyanazine (Bladex). DATCP databases show that about 40% of private wells tested have atrazine detections, while about 1% have atrazine over the groundwater enforcement standard of 3 µg/L. A recent DATCP survey of 336 private drinking water supplies showed that 38% of wells contain a detectable level of a herbicide or herbicide metabolite.

3. *Nitrate*: Nitrate-nitrogen is the most common contaminant found in Wisconsin's groundwater. Nitrate can enter groundwater and surface water from a variety of sources including farm fields, animal feedlots, septic tanks, urban storm water, and decaying vegetation. Concentrations of nitrate in private water supplies frequently exceed the state drinking water standard of 10 mg/L. In 2005, DNR aggregated and analyzed data from three extensive statewide groundwater databases. This combined dataset from DNR's Groundwater Retrieval Network (GRN) database, the Center for Watershed Science and Education database and DATCP's groundwater database, includes only the most recent nitrate result for each sampled private well. Out of the 48,818 samples, 5686 (11.6 %) equaled or exceeded the 10 mg/L standard. Further analysis of this data continued throughout FY 06 and will continue in FY 07.

4. *Microbial agents*: Microbiological contamination often occurs in areas where the depth to groundwater or the depth of soil cover is shallow, or in areas of fractured bedrock. Microbial agents include bacteria, viruses, and parasites. These agents can cause acute illness and result in life-threatening conditions for some population groups. In one assessment, approximately 23% of private well water samples statewide tested positive for total coliform bacteria, an indicator species of other biological agents. Approximately 3% tested positive for *E. coli*,

an indicator of water borne disease that originates in the mammalian intestinal tract. Viruses are increasingly becoming a concern as new analytical techniques have detected viral material in private wells and public water supplies.

5. *Radionuclides*: Naturally-occurring radionuclides, including uranium, radium, and radon are becoming an increasing concern for groundwater quality, particularly in the Cambro-Ordovician aquifer system in eastern Wisconsin. The water produced from this aquifer often contains combined radium activities in excess of 5 pCi/L, in some cases in excess of 30 pCi/L. Approximatly 60 public water systems exceed the drinking water standard of 15 pCi/L for gross alpha activity. New federal standards are causing many communities to search for alternative water supplies.

6. *Arsenic*: Naturally occurring arsenic has been detected in wells throughout Wisconsin. DNR historic data show that 3,830 public wells and 3,013 private wells have detectable levels of arsenic. About 10% of these wells exceed the new Federal drinking water standard of 10 µg/L. The highest concentration of arsenic detected in a private well in Wisconsin is 15,000 µg/L. Arsenic has been detected in well water samples in every county in Wisconsin. However, the problem is especially prevalent in northeastern Wisconsin where increased water use has likely mobilized arsenic into the groundwater. The State continues to proactively address arsenic concerns through well drilling advisories, health studies, well testing campaigns, and studies aimed at improving geological understanding and developing practical treatment technologies.

7. *Groundwater quantity*. Despite a general abundance of groundwater in Wisconsin, there is a concern about the overall availability of good quality groundwater for municipal, industrial, agricultural, and domestic use and for adequate baseflow to our lakes, streams, and wetlands. Groundwater use grew from 570 to 804 million gallons per day (Mgal/d) from 1985 to 2000. Groundwater quantity problems have occurred both naturally and from human activities, and often affect groundwater quality. Regional effects of groundwater withdrawals are well documented in the Lower Fox River Valley, southeastern Wisconsin, and Dane County. Localized effects of groundwater pumping on trout streams, springs, and wetlands have been noted throughout the state. Groundwater quantity legislation enacted in 2004 was the first step towards managing groundwater quantity on a comprehensive basis. The DNR began to implement the provisions of the new law in FY 06.

BENEFITS OF MONITORING AND RESEARCH PROJECTS

The GCC provides consistency and coordination among state agencies in funding groundwater monitoring and research to meet state agency needs. Approximately $13.3 million has been spent by DNR, UWS, DATCP, and Commerce through FY 06 on 336 different projects dealing with groundwater or related topics. While the application of the results is wide and difficult to document, this report describes topic areas where the results of state-funded groundwater research and monitoring projects have been successfully applied to groundwater problems in Wisconsin. These areas include:

- Pharmaceuticals and personal care products
- The Atrazine Rule
- Groundwater monitoring at solid waste disposal sites
- Arsenic monitoring and research in Northeastern Wisconsin
- Groundwater movement in fractured dolomite
- Developing new tools for groundwater protection
- Prevention and remediation of groundwater contamination
- Detection and monitoring of microbiological contaminants
- Groundwater drawdown
- Comprehensive planning
- Microbiological groundwater monitoring
- Rain garden design & evaluation
- Methylmercury formed in groundwater
- Estrogenic endocrine disruptors in groundwater

FUTURE DIRECTIONS FOR GROUNDWATER PROTECTION

The GCC recommends the following priorities for future groundwater protection and management:

1. **Restore adequate funding for groundwater monitoring and research**: State budget cuts have limited the number and scope of groundwater research and monitoring projects that were funded in the recent years (see Table 3 in Chapter 2). Cuts continue to hamper the State's ability to address critical groundwater monitoring and research needs in the future. Most of these research and monitoring needs are targeted at identifying strategies to prevent subsurface problems and their costly remediation and thus result in a net savings for the State. The GCC encourages its member agencies and the Legislature to restore adequate resources for groundwater monitoring and research and to seek partnerships to leverage additional funds.

2. **Acute and chronic impacts to groundwater from manure management:** Groundwater contamination resulting from manure disposal has been an increasing problem in recent years for private well owners. A statewide assessment is needed to understand the scope and magnitude of the problem. Mechanisms, pathways, and timing of movement into groundwater, the influence of landscape settings and climatic factors, the applicability of new analytical tools and methods of vulnerability assessment and best management practices (BMPs) and the threat of associated contaminants (bacteria, nitrates, pharmaceuticals, viruses, other pathogens, etc. all need to be understood better to address the problem.

3. **Address groundwater quantity management issues at both statewide and regional levels:** Groundwater quantity issues came to the forefront of public discussion in FY 04, with the development and passage of landmark groundwater quantity legislation, 2003 Wisconsin Act 310. This legislation has the potential to address needs identified by two recent forums, the 2001 Groundwater Summit and the 2003 Waters of Wisconsin Initiative. Common themes included the need for a statewide management plan for water quantity, water conservation, high capacity well reform, reevaluation of water pricing structures and regional approaches to water quantity issues. The GCC will continue to serve as a resource for addressing scientific and technical questions related to groundwater quantity and facilitate further dialogue among all parties on potential approaches and solutions.

4. **Support implementation of a Statewide Groundwater Monitoring Strategy:** Chapter 160 of the Wisconsin Statutes requires the DNR to work with other agencies and GCC to develop and operate a system for monitoring and sampling groundwater to determine whether harmful substances are present. In 2004, several agencies worked together to develop a Statewide Groundwater Monitoring Strategy to guide agency monitoring efforts for the next ten years to address both groundwater quality and quantity needs. This strategy recognizes the importance of long-term data collection to be able to make informed decisions based on science. The GCC encourages agencies, the university, and federal and local partners to implement the various components of the strategy and to seek funding to support its implementation.

5. **Coordinate and facilitate consistent messages on groundwater related issues:** The public has benefited from the consistent educational messages that have been endorsed by the GCC. In FY 05, the Subcommittee launched a "Groundwater Information Network" with non-governmental organizations to further its mission of promoting consistent messages regarding groundwater protection and building a groundwater constituency. The GCC will continue to use this network and other means to promote water stewardship and awareness of water quantity issues, find innovative ways to encourage testing of private water supplies, and provide materials for local communities to support comprehensive planning activities.

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Chapter 1 -- INTRODUCTION

PURPOSE OF THE REPORT

The Groundwater Coordinating Council (GCC) is required by s. 15.347, Wis. Stats., to prepare a report which "summarizes the operations and activities of the council..., describes the state of the groundwater resource and its management and sets forth the recommendations of the council. The annual report shall include a description of the current groundwater quality of the state, an assessment of groundwater management programs, information on the implementation of ch. 160, Wis. Stats., and a list and description of current and anticipated groundwater problems." This report is due each August. The purpose of this report is to fulfill this requirement for fiscal year 2006 (FY 06).

The activities of the Council and its subcommittees, including coordination of groundwater monitoring and research programs, are described in the chapter titled *Groundwater Coordination*. The chapter *Summary of Agency Groundwater Activities* describes groundwater management programs and implementation of ch. 160, Wis. Stats., by the individual state agencies in FY 06. *Condition of the Groundwater Resource* provides an assessment of Wisconsin's groundwater quality and quantity, as well as current and anticipated groundwater problems. The *Benefits from Monitoring and Research Projects* chapter describes how research and monitoring findings are used to better manage groundwater resources in Wisconsin. The recommendations of the Council are contained in *Future Directions for Groundwater Protection*.

SUMMARY OF WISCONSIN'S GROUNDWATER LEGISLATION

1983 Wisconsin Act 410, Wisconsin's Comprehensive Groundwater Protection Act

Wisconsin has a long history of groundwater protection. The first major milestone in this effort was adoption and implementation of 1983 Wisconsin Act 410, Wisconsin's Comprehensive Groundwater Protection Act, which was signed into law on May 4, 1984. The law expanded Wisconsin's legal, organizational, and financial capacity for controlling groundwater pollution. 1983 Wisconsin Act 410 created Chapter 160, Wisconsin Statutes, which serves as the backbone of Wisconsin's program. Chapter 160 provides a multi-agency comprehensive regulatory approach, using two-tiered numerical standards, based on the premise that all groundwater aquifers in Wisconsin are entitled to equal protection. There are a number of major components to Wisconsin's groundwater quality protection program:

1) Standards. Under chapter 160, Wis. Stats., the Department of Natural Resources (DNR) must establish state groundwater quality standards based on recommendations from the Department of Health and Family Services (DHFS). Standard setting is a continuing process based on a priority list of substances detected in groundwater or having a high possibility of being detected, established by the DNR in conjunction with other state agencies. The state groundwater standards are contained in chapter NR 140, Wisconsin Administrative Code. For each substance there is an enforcement standard (ES) which determines when a violation has occurred and a preventive action limit (PAL) which is set at a percentage of the ES. The PAL serves as a trigger for possible remedial action.

2) Regulatory Programs. Once groundwater quality standards are established, all state agencies must manage their regulatory programs to comply. Each state regulatory agency must promulgate rules to assure that the groundwater standards are met and to require appropriate

responses when the standards are not met. The state regulatory agencies are the DNR (solid and hazardous waste, industrial and municipal wastewater, remediation and redevelopment, wetlands and water supply); the Department of Commerce (private sewage systems, petroleum product storage tanks and petroleum environmental clean-up fund); the Department of Agriculture, Trade and Consumer Protection (DATCP) (pesticide use and storage and fertilizer storage); and the Department of Transportation (DOT) (salt storage).

3) Aquifer Classification. One of the most important features of Wisconsin's groundwater law is an item that was omitted. When Wisconsin was debating the groundwater protection legislation, the U. S. Environmental Protection Agency (EPA) tried to develop a nationwide groundwater approach. A keystone of EPA's proposal was aquifer classification - a scheme whereby each aquifer would be classified according to its potential use, value or vulnerability, and then would be protected to that classification level. This entails "writing off" certain aquifers as industrial aquifers not entitled to protection and never again usable for human water supply. Wisconsin said "no" to aquifer classification. The philosophical underpinning of Wisconsin's groundwater law is the belief that all groundwater in Wisconsin must be protected equally to assure that it can be used for people to drink today and in the future.

4) Monitoring and Data Management. At the time the groundwater legislation was created, there was concern that Wisconsin needed a groundwater monitoring program to determine whether the groundwater standards were being met. Therefore, a groundwater monitoring program was created under s. 160.27, Wis. Stats. Money from the Groundwater Account of the Environmental Fund has been used for problem-assessment monitoring, regulatory monitoring, at-risk monitoring, and management-practice monitoring, as well as establishment of a data management system for collection and management of the groundwater data.

5) Research. Although all state agencies must comply with the groundwater standards, the processes by which groundwater becomes contaminated, the technology for cleanup, the mechanisms to prevent contamination, and the environmental and health effects of the contamination are often not well understood. In addition, the basic data on geology, soils, and groundwater hydrology is often not available. The UWS and the state agencies have recognized that additional efforts in these research areas are badly needed. The Governor and the Legislature included a new groundwater research appropriation for the UWS beginning with the 1989-1991 biennial budget. Since 1992, the UWS, DATCP, DNR and Commerce have participated in a joint solicitation for groundwater-related research and monitoring proposals.

6) Coordination. In establishing the groundwater law, the Legislature recognized that management of the state's groundwater resources was a responsibility divided among a number of state agencies. Therefore, the GCC was created to advise and assist state agencies in the coordination of non-regulatory programs and the exchange of information related to groundwater. The Council has been meeting since 1984.

7) Local Groundwater Management. The Groundwater Protection Act clarified the powers and responsibilities of local governments to protect groundwater in partnership and consistent with state law.

    a. Zoning authority for cities, villages, towns and counties was expanded to "encourage the protection of groundwater."

b. Counties can adopt ordinances regulating disposal of septage on land (consistent with DNR requirements); cities, villages, or towns may do so, if the county does not.

c. Counties can regulate (under DNR supervision) well construction and pump installation for certain private wells.

d. Property assessors must consider the time and expense of repairing or replacing a contaminated well or water supply when assessing the market value of real property; they must consider the "environmental impairment" of the property value due to the presence of a solid or hazardous waste disposal facility.

Wisconsin's Groundwater Protection Act, 2003 Wisconsin Act 310

After several years of discussion on groundwater quantity issues in the state, Governor Doyle issued a challenge to legislators on Earth Day 2003 to have groundwater quantity legislation for him to sign on Earth Day 2004. Senator Neal Kedzie and Rep. DuWayne Johnsrud took up this challenge and convened a group of stakeholders to draft legislation. In March of 2004, a bill was passed in both houses with only one dissenting vote.

On Earth Day, April 22, 2004, Governor Doyle signed a new groundwater protection law, 2003 Wisconsin Act 310, that expands the State's authority to consider environmental impacts of high capacity wells and institutes a framework for addressing water quantity issues in rapidly growing areas of the state.[1] This legislation recognizes the link between surface water and groundwater, and that all wells have an impact on groundwater quality and quantity. The law applies many principles of adaptive management, allowing for changes in the regulation of high capacity wells as relevant information becomes available or groundwater conditions change.

Major components of the legislation include:

1) *Tracking well construction and water use.* As of May 1st, 2005, well owners are required to obtain approval of a high capacity well (pumping more than 100,000 gallons per day) by the DNR prior to construction, pay a fee of $500, and submit an annual pumping report to DNR. For any new well that is not a high capacity well, the owner must notify DNR of the well location prior to construction and pay a fee of $50. The fees directly support the administration of this Act, including tracking well construction, review of high capacity well applications, and collection of groundwater data. In addition, fees will support increased inspections and enforcement of well construction activities, helping to ensure a safe drinking water supply. The law requires all high capacity well owners to report water use on an annual basis, including ones with existing approvals. Previously, only municipal water supply wells were required to submit pumping reports, along with some high capacity wells that required reporting as part of their approval. The collection of this information will assist in evaluating proposed new wells, monitoring approval conditions, identifying trends, calibrating groundwater flow models, and improving water use estimates, all contributing to better understanding and management of groundwater resources.

2*) Expanded regulation of high capacity wells.* The Act requires DNR to undertake an environmental review (under ch. NR 150, Wis. Adm. Code), for the following proposed high capacity wells:

1 More details can be found at the Wisconsin State Legislature website:
Text of Act 310: *http://www.legis.state.wi.us/2003/data/acts/03Act310.pdf*
Legislative Council memo: *http://www.legis.state.wi.us/lc/act_memo/2003/act310-ab926.pdf*

- Wells located in a “groundwater protection area” (an area within 1,200 feet of an Outstanding or Exceptional Resource Water or any Class I, II, or III trout stream).
- Wells that may have a significant environmental impact on a spring with a flow of at least one cubic foot per second for at least 80% of the time.
- Wells where more than 95% of the amount of water withdrawn will be lost from the basin.

In these cases, DNR may deny or limit an approval to assure that these wells do not cause significant environmental impact. There are also protections and exceptions for public water utility wells. For example, the DNR must weigh the public health and safety benefits of a proposed well in a groundwater protection area or near a spring if it is to be used for a public water supply. In these cases, the DNR must balance the well’s environmental impact and its public health and safety benefits. Some of the criteria that might be used for this "balance test" include provisions for water conservation, appropriate use (drinking water vs. lawn watering or car washing), and long range water supply planning. The DNR must also ensure that a public utility's water supply is not impaired by another high capacity well, maintaining a long-standing requirement from previous statutes.

3) *Designation of groundwater management areas.* The Act directs the DNR to establish two groundwater management areas in Southeastern Wisconsin and the Lower Fox River Valley. These areas will include Waukesha and Brown Counties, and surrounding cities, villages and towns where the water level of the deep sandstone aquifer has been drawn down more than 150 feet since pre-development. In the Lower Fox River Valley, this could include portions of Outagamie and Calumet Counties, while in Southeastern Wisconsin it could include Kenosha, Racine, Milwaukee, and Ozaukee Counties, and portions of Washington and Walworth Counties. The intention of the groundwater management area is to encourage a coordinated management strategy among the state, local government units, regional planning commissions, and public and private users of groundwater to address problems caused by over-pumping of the deep aquifer, including increased levels of radium, arsenic and salinity. The DNR will assist local government units and regional planning commissions in those areas as they undertake research and planning related to groundwater management.

4) *Creation of a Groundwater Advisory Committee.* The Act establishes a Groundwater Advisory Committee. The Committee is to make recommendations regarding:

- the regulation of wells in groundwater protection areas, that have a water loss of 95 percent or more, or that have a significant environmental impact on a spring;
- the definition of springs;
- adaptive management approaches;
- the potential for the use of general permits; and
- factors to be considered in determining whether a high capacity well causes significant environmental impact.

The Act also directs the Groundwater Advisory Committee (GAC) to recommend legislation that addresses the management of groundwater within groundwater management areas and any other areas of the state where a coordinated strategy is needed. The Committee may identify other parts of the state that should be designated as groundwater management areas, and will recommend how and when this designation may be removed. The Committee is to issue reports to the legislature no later than December 31, 2006 regarding groundwater management areas, and December 31, 2007 regarding its review of the implementation of the new regulations. If the committee fails to submit these reports, the DNR may adopt rules to address management of groundwater in the groundwater management areas.

In the Spring of 2005, GAC members were appointed by the Governor and Legislature to represent municipal, environmental, agricultural and industrial interests. The Groundwater Advisory Committee has met every two months from April 2005 through June 2006 and has made significant progress on groundwater management area issues. The DNR received appropriations and positions to begin implementing the new legislation in the 2005-2007 biennial budget and hired five staff to implement the new law in FY 06. The GCC will track progress of the implementation and provide assistance on education, research, monitoring, planning, and data management needs related to the new legislation.

Chapter 2 -- GROUNDWATER COORDINATION

The Groundwater Coordinating Council (GCC) is directed by s. 160.50, Wis. Stats., to "advise and assist state agencies in the coordination of non-regulatory programs and the exchange of information related to groundwater, including, but not limited to, agency budgets for groundwater programs, groundwater monitoring, data management, public information and education, laboratory analysis and facilities, research activities and the appropriation and allocation of state funds for research." To assist in this work, the GCC is authorized to create subcommittees on "the subjects within the scope of its general duties…and other subjects deemed appropriate by the Council." Additionally, the GCC is directed to "advise the Secretary of Administration on the allocation of funds appropriated to the Board of Regents of the University of Wisconsin under s. 20.285(1)(a) for groundwater research."

The purpose of this chapter is to describe the activities of the Council and its Subcommittees during FY 06, as well as the coordination of the Wisconsin Groundwater Research and Monitoring Program. Through these activities, the GCC continues to play an important role in ensuring agency coordination, increasing efficiency and facilitating the effective functioning of state agencies in activities related to groundwater protection and management. Ultimately groundwater is better protected, which protects public health and preserves Wisconsin's natural resources for future generations.

GROUNDWATER COORDINATING COUNCIL

The GCC consists of the heads of all state agencies with some responsibility for groundwater management plus a Governor's representative. The agency heads have appointed high-level administrators with groundwater responsibilities to sit on the Council. The state agencies include the DNR, Commerce, DHFS, DATCP, DOT, WGNHS, and the UW System. The GCC has created four subcommittees to assist in its work. The subcommittees are composed of approximately 60 people including members of the GCC, employees of state and federal agencies, university researchers and educators, representatives of counties and municipalities and public members. Through FY 05, the DNR has had one permanent position with half of its responsibilities related to coordination of the GCC. In FY 06, due to budget cutbacks there was less GCC support than in previous years.

The GCC took an active role in many groundwater issues and activities during FY 06, several of which are highlighted and summarized here.

Addressing Long-Term Groundwater Management Needs

In October 2001, the GCC facilitated an event called "Wisconsin's Groundwater Summit." The Summit brought together a broad spectrum of groundwater users and stakeholders to discuss issues facing groundwater protection and management and develop solutions to better protect Wisconsin's groundwater. Representatives from over 50 organizations attended the meeting. These included environmental, conservation, and agricultural groups, industrial users, water utilities, local and tribal government, planning agencies, state and federal agencies, and university researchers and educators. Findings and recommendations from the Summit are contained in the document *Sharing Our Buried Treasure: A Summary of the 2001 Groundwater Summit*.

Summit participants identified 9 "Key Themes" to guide groundwater management activities over the next decade:

1) Clarifying "Whose Water is it?"
2) Recognizing the Connections Between Groundwater and Surface Water
3) Evaluating and Managing Threats to Groundwater Quality
4) Linking Land Use Planning and Groundwater Protection
5) Developing a Comprehensive Approach to Groundwater Quantity
6) Addressing Water Use and Conservation Issues
7) Exploring Options for Regionalization of Water Management
8) Building a Groundwater Constituency through Public Education and Involvement
9) Collecting Long-Term Groundwater Data to Address Long-term Problems

During the past year, the GCC and its Subcommittees continued to address strategies suggested by these Key Themes. The Education Subcommittee continued to make linkages to a broader base of people involved in groundwater education (*Key Theme 8).* Members of the Monitoring and Data Management Subcommittee began implementing a long term groundwater monitoring strategy (*Key Theme 9).* Several research priorities identified at the Summit were incorporated into agency research and monitoring priorities that yielded projects funded for FY07 *(Key Themes 2, 3 and 9).*

There have been a number of collaborative efforts to promote groundwater protection in the comprehensive planning process by local governments (*Key Theme 4*). In 2002, representatives from three GCC Subcommittees prepared and distributed three Comprehensive Planning and Groundwater Fact Sheets to promote inclusion of groundwater information in comprehensive plans. The fact sheets were reviewed and updated in 2005. Through the Wisconsin groundwater research and monitoring program, two projects have been funded to address how to make groundwater information available to local governments for use in comprehensive plans.

The historic groundwater quantity law signed by Governor Doyle on Earth Day 2004 (see *Introduction* and groundwater quantity discussion in *Condition of the Resource* chapter) addressed several key themes of the Groundwater Summit. The law recognizes that groundwater quantity issues need a more comprehensive approach (*Key Theme 5).* For the first time, impacts of groundwater withdrawals on surface waters were acknowledged in statutory language *(Key Theme 2).* Provisions requiring reporting of water use for high capacity wells *(Key Theme 6)* and the creation of Groundwater Management Areas *(Key Theme 7*) also reflect a more comprehensive approach.

The GCC was an active participant in the process that led to the creation of the groundwater quantity law through the creation of a Quantity Subcommittee and discussions at its quarterly meetings. Many subcommittee members and agency representatives contributed data, research findings, maps, modeling scenarios, and technical expertise to help answer questions and ensure that the legislation was based on sound scientific principles. The GCC has continued to play a role in the implementation of the legislation, through its research and monitoring oversight, as well as making technical information and expertise available to the Department of Natural Resources and the Groundwater Advisory Committee created by the legislation.

Implementing a Statewide Groundwater Monitoring Strategy

In FY 06 initial stages of the statewide groundwater monitoring strategy were implemented with the help of representatives from the DNR, DATCP, USGS, WGNHS, and UW Stevens Point. The

objective of the new monitoring strategy is to coordinate groundwater monitoring between all state agencies that regulate groundwater to assess groundwater quality and quantity in the state.

Over the next ten years, components of the strategy will be integrated into DNR's overall water monitoring plan. Other agencies will also continue to make improvements in their monitoring efforts based on the comprehensive strategy. The components of the strategy may change over time according to needs of the different agencies.

Information and Outreach Activities

Groundwater: Wisconsin's Buried Treasure and the *Groundwater Study Guide,* both very popular DNR publications, were revised, printed and distributed in FY 06. Other informational or educational publications that were recently updated to include new information were *Arsenic in Drinking Water, Nitrate in Drinking Water, Iron Bacteria Problems in Wells,* and *Karst: Avoid that Sinking Feeling.*

For the sixth year in a row, three groundwater workshops for teachers were taught jointly by staff from the DNR, WGNHS and the Center for Watershed Science and Education (CWSE) at UW Stevens Point. The workshop leaders instructed teachers on using a groundwater sand tank model and provided additional resources to incorporate groundwater concepts into their classroom. Teachers from 21 different schools attended the workshops and received a free model for their school. With funding from an EPA grant, 141 groundwater models have been given to schools since 2001.

Drinking Water Education programs continue to offer communities across Wisconsin the opportunity to have private wells tested and attend a program to learn more about their community's groundwater quality. In 2005, nearly 2,000 private well owners in 11 different counties took part in this educational opportunity.

This year, the fourth annual Groundwater Festival was held in Manitowoc on April 27, 2006. The event was organized by staff at CWSE, Groundwater Guardians, and local land conservation departments. Volunteers from many state agencies, local colleges and high schools helped lead hands-on groundwater activities to over 600 5th and 6th graders from Brown, Calumet, Kewaunee, Manitowoc and Door counties.

Attendants of this year's Farm Technology Days had an opportunity to have their private well water tested for nitrate and receive additional information regarding drinking water and groundwater quality. Over 200 individuals had water tested and hundreds more stopped by to have their questions answered by CWSE staff.

Coordination of Groundwater Research and Monitoring Program

The GCC, the UW System, and the Groundwater Research Advisory Council (GRAC) continued coordination of the annual solicitation for groundwater research and monitoring proposals among state agencies, as specified in a November 2002 Memorandum of Understanding (MOU). (Details are found in the section on *Wisconsin's Groundwater Research and Monitoring Program*). The GCC approved the FY 06 Solicitation for Proposals in August of 2004 (see *Appendix D*). In January 2005, members of 2 GCC Subcommittees reviewed the proposals that were submitted and made their recommendations to the agencies and GRAC. The GCC unanimously approved the proposed UWS groundwater research plan as required by s. 160.50(1m), Wis. Stats., at its February meeting and a letter was sent to the UW System president and the Department of

Administration to this effect.

Through these coordination activities, the GCC helps create efficiencies in the proposal submittal process and help ensure that taxpayer dollars are directed at the most pressing needs for groundwater information.

Other Coordination Activities

The GCC continued to promote communication, coordination and cooperation between the state agencies through its quarterly meetings. The meeting minutes are included in Appendix B. In addition to the activities listed above, the GCC received briefings and heard presentations on:

- Subcommittee activities (see below)
- 2006 GCC Report to the Legislature
- UWS FY 07 groundwater research plan, including optimization of Water Research Center funding
- FY 07 joint solicitation for groundwater proposals
- Annex 2001 update
- Springs research progress report
- Groundwater Advisory Committee progress
- Using Groundwater Models to Assess Flow to Wells in Residential Subdivisions
- Manure Management Task Force Recommendations and Implementation Strategy
- Groundwater Modeling Effort for Village of Eagle
- Agency updates

SUBCOMMITTEE SUMMARIES

The GCC is directed to "serve as a means of increasing the efficiency and facilitating the effective functioning of state agencies in activities related to groundwater management." The Subcommittees of the GCC carry out this charge by regularly bringing together staff from over 15 different agencies, institutions and organizations to communicate and work together on a variety of research, monitoring and data management, planning and mapping, educational and local government issues.

In FY 05, the GCC approved a reorganization of the GCC Subcommittees to more effectively meet current needs. The functions and members of the Planning and Mapping Subcommittee were merged with the Local Government Subcommittee and Monitoring and Data Management Subcommittee. The Planning and Mapping Subcommittee no longer exists. In addition, the Monitoring and Data Management Subcommittee was maintained as one Subcommittee, but the tasks will be divided between two workgroups. With the enactment of the groundwater quantity legislation, the need for the Groundwater Quantity Subcommittee no longer exists so it has been dissolved. See further details on the Subcommittee restructuring below.

In addition, numerous contacts and informal conversations are generated both at meetings and through email communications among Subcommittee members, leading to better communication across agency lines on a variety of issues. These activities are related to participation of agency staff on GCC Subcommittees and create efficiencies and provide intangible benefits to Wisconsin's taxpayers.

Research Subcommittee

The purpose of the Research Subcommittee is to assist the GCC in establishing priorities for groundwater research and monitoring activities and to review proposals submitted through the Wisconsin Groundwater Research and Monitoring Program. The subcommittee met with the Monitoring and Data Management Subcommittee in January 2006 to review proposals that were submitted in response to the FY 07 solicitation. Subcommittee members made recommendations that were used by the UWS in deciding which groundwater-related proposals to fund for FY 07. The projects to be funded in FY 07 are listed in Table 2.

To address the need for more dissemination of research and monitoring findings, and to ensure that future proposals address pressing state needs, the subcommittee chose to address groundwater research and monitoring needs related to manure management at a special topic meeting to be held in early FY 07. This meeting and other similar future meetings will help efficiently focus limited research and monitoring funds on high priority project areas, maximizing use of state dollars.

Monitoring & Data Management Subcommittee

The goal of the Monitoring & Data Management Subcommittee (MDMS) is to coordinate groundwater monitoring and data management activities of state agencies to maximize value and efficiency. Subcommittee members continued to work collectively, individually, and in small groups on GCC activities or action items targeted by the subcommittee. Several key issues were addressed in FY 06. The Groundwater Monitoring strategy drafted in 2004 was further revised and incorporated into the DNR's Water Division strategy. Several subcommittee members were involved in helping the DNR's Groundwater Section draft a "Condition of the Resource Report" on nitrate.

Subcommittee members evaluated and discussed the 12 proposals received in this year's solicitation at their annual meeting with the Research Subcommittee. Subcommittee members made recommendations that were used by the UWS in deciding which groundwater-related proposals to fund for FY 07.

The subcommittee continued to be a forum for information exchange to prevent duplication of efforts and increase the utility of monitoring data. In FY 06 the MDMS met regularly to update one another on their agencies' activities. This year's topics included: DNR implementation of groundwater quantity legislation; a WGNHS water use study; changes to DNR UW, and DATCP groundwater monitoring databases; and new digital products from WGNHS.

Education Subcommittee

The Education Subcommittee's mission is to review public information and education materials, coordinate educational messages among agencies, and serve as a forum to identify groundwater education needs, ideas and concerns in Wisconsin. At each meeting, representatives share information about current agency activities related to groundwater and discuss current and future ideas for informational needs and educational activities.

The subcommittee met a total of four times during FY 06. During that time, the members of the subcommittee were involved in a number of collaborative efforts related to groundwater education; some of which are included in the Information and Outreach Activities section of this

report. Members also provided inputs into revisions of popular groundwater publications such as the *Groundwater Study Guide* and *Groundwater: Wisconsin's Buried Treasure* publications. The Subcommittee commented on a proposed arsenic well test result website to provide information to homeowners on results of private well testing for arsenic. Representatives from some of the organizations on the Groundwater Information Network were brought in to discuss relevant groundwater education work that they are involved in.

During the next year the subcommittee will continue to identify and respond to educational needs on emerging groundwater issues in the state.

Local Government and Planning Subcommittee

The Local Government Subcommittee was formed in 1993 to promote communication between local governments and the state government regarding groundwater issues. At its February 2004 meeting, the GCC combined the Local Government Subcommittee with the planning function of the former Planning and Mapping Subcommittee to create the Local Government and Planning Subcommittee (LGPS). Both Subcommittees have been addressing planning issues for some time, so it made sense to combine these two subcommittees.

The LGPS met April 25, 2006 in Madison. The Subcommittee heard an update on the effort by the UW Stevens Point Center for Land Use Education (CLUE) and the U. S. Geological Survey to develop a website for groundwater information for use in comprehensive plans and provided input on a questionnaire to be sent out by CLUE. The Subcommittee also got a status report on implementation of the 2004 groundwater quantity law and learned about Annex 2001 to the Great Lakes Charter and its implications for Wisconsin. The Subcommittee discussed including more local government representation and addressing issues of interest to local governments that might lead to recommendations to the GCC. The LGPS will continue to follow the comprehensive planning and groundwater quantity law implementation initiatives.

WISCONSIN'S GROUNDWATER RESEARCH AND MONITORING PROGRAM

The GCC provides consistency and coordination among state agencies in funding groundwater monitoring and research to meet state agency needs. Approximately $13.3 million has been spent through FY 06 on 336 different projects dealing with groundwater or related topics (see *Appendix C* for a complete listing). The four programs, collectively called the Wisconsin Groundwater Research and Monitoring Program, have different sources of money and purposes, which are summarized as follows: include:

1. DNR Management Practice Monitoring – Except for FY 05, the DNR has had at least $125,000 available each year since FY 86 to support groundwater monitoring studies evaluating existing design and/or management practices associated with potential sources of groundwater contamination. The intent of these studies is to identify appropriate management practices to reduce the impacts of potential sources of contamination. The money comes from the Groundwater Account of the Environmental Fund (which is funded by various fees). Additional funds have been available in some years through various Federal and State sources, enabling the DNR to fund additional projects. Through FY 06, the DNR has spent approximately $6 million on 182 monitoring projects. Several of these projects have been co-funded with DATCP, Commerce and/or UWS.

2. UWS Groundwater Research - The UWS, through its UW-Madison Water Resources Institute (WRI), has received funding since FY 90 for groundwater research. Projects

may be of a fundamental or applied nature on any aspect of groundwater research in the natural sciences, engineering, social sciences or law. Through FY 06, the UWS has spent $5 million on 138 groundwater research projects. Several projects have been co-funded with DNR, Commerce and/or DATCP and eleven were co-funded with WRI through the US Geological Survey.

3. DATCP Pesticide Research - Since 1989, DATCP has had up to $135,000 available annually to fund research on pesticide issues of regulatory importance. The money comes from fees paid by pesticide manufacturers to sell their products in Wisconsin. Starting in FY 03, these funds have not been available for new research. Through FY 06, DATCP has spent about $1.8 million on 42 pesticide projects. Several of these projects have been co-funded with DNR and/or UWS.

4. Department of Commerce Private Onsite Wastewater Treatment System (POWTS) Research – Due to budget shortfalls, Commerce has not been able to fund research projects since FY02. Through FY 06, DILHR/Commerce has spent approximately $600,000 on eight projects. Two projects were co-funded with DNR and UWS.

Solicitation and Selection of Proposals

The UWS, DNR, DATCP, and Commerce annually participate in a joint solicitation for research and monitoring proposals dealing with groundwater, pesticides and/or onsite wastewater treatment systems.

In 1988, the GCC requested that the UWS create a Groundwater Research Advisory Council (GRAC) to establish a long-range groundwater research plan and develop a groundwater research decision item narrative (DIN) for inclusion in the University's biennial budget. The GRAC consists of university, state agency, and public representatives. During the summer of 1990, the GRAC and GCC developed and endorsed a plan to coordinate the solicitation of projects for funding in FY 92 and subsequent years. The joint solicitation provides for only one submittal of project proposals, rather than four as had been the case. The intent of the joint solicitation is to determine the most appropriate funding source for a particular project.

Statutory language requires that there be agreement between the UWS and the GCC on the use of the UWS research funds before the funds can be released by the Department of Administration (s. 160.50(1m), Wis. Stats). To expedite this agreement, a Memorandum of Understanding (MOU) was signed in 1989 and 1991 by representatives of the GCC, the GRAC, and the UWS on use of the UWS groundwater research funds. This MOU was reviewed and updated in November 2002. The MOU spells out the procedures for establishing priorities and selection of projects for funding of UW groundwater research. The MOU recognizes that the GCC has a substantive role in establishing research priorities and an advisory role in project selection to minimize overlap and duplication.

FY 06 Proposal Solicitation. The Solicitation for Proposals (SFP) for FY 06 was distributed in September 2004. A total of 29 project proposals were submitted in response to the SFP. To assist in the review process, a joint meeting of the Monitoring & Data Management and Research Subcommittees of the GCC was held in January 2005 to review and rank the projects that were submitted for funding. As a result of the subcommittee meeting, the GRAC meeting in March, and review of the proposals by agency staff, 16 new projects were selected for funding in FY 06, by the DNR and UWS. Four on-going projects were carried over into FY 06. A total of 20 projects were funded through the joint solicitation at a cost of approximately $525,956 (see Table

1).

FY 07 Proposal Solicitation. The SFP was distributed in September 2005 for funding in FY 07. The SFP package (see *Appendix D*) contained a listing of the monitoring and research priorities for each of the agencies, as determined by agency staff, the GRAC, and members of the GCC Monitoring & Data Management and Research Subcommittees. The deadline for proposals was November 14, 2005.

The entire submission and review process was conducted online through a secure web site administered by the WRI. Investigators could upload and modify contact information, proposal narratives, and budget information at any time up to the deadline. Reviewers were able to simply log on to the site to review proposals at their convenience. A total of 12 proposals were submitted, requesting a total of $643,311 in funding. A minimum of 3 external peer reviews was solicited for each proposal from experts within the field. GCC Subcommittee members and agency staff also reviewed the proposals and met in January to rank the proposals. In addition, the GRAC met in February to select projects to recommend to the GCC for UWS funding.

A total of eight new projects were selected for funding; five by DNR and three by UWS. Including projects continued from FY 06, the DNR will fund 11 projects and the UWS will fund eight projects in FY 07 at a total cost of $574,122. DATCP and Commerce will not be funding new projects in FY 07. With the assistance of Federal (USGS) dollars leveraged through the Water Resources Institute, all of the continuing UWS projects that began in FY 05 will be funded through FY 07. The projects to be funded in FY 07 are listed in Table 2.

State budget shortfalls have limited the number of new projects that were selected for funding during recent years. Commerce has been unable to fund new projects since 2001, DATCP since 2003. The UWS budget was cut by 10% in FY 04 and again in FY 05. DNR's state groundwater funding for projects has been cut significantly since FY 02 (see Table 3) but has recovered somewhat because of the addition of Federal Wellhead Protection and State Act 310 Groundwater Quantity funds to State Groundwater Management Practice Monitoring funds.

Continued cuts will hamper the State's ability to address critical groundwater monitoring and research needs in the future. Research and monitoring can be extremely cost-effective in that once a problem is established in the subsurface it is much more time, labor, and cost intensive to remediate than to use prevention strategies. Without adequate funding for research and monitoring we don't know what the best prevention strategies are. The GCC will continue to encourage its member agencies to maintain adequate resources for groundwater monitoring and research and to seek partnerships to leverage additional funds.

Coordination with Other Research Programs

The GCC attempts to compile information about other groundwater research programs within Wisconsin. For example, many groundwater-related research projects are funded through the Wisconsin Fertilizer Research Council (*http://www.soils.wisc.edu/frc/*). Staff from the GCC also work with the Research Committee of the Wisconsin Water Association (WWA), the state affiliate of the American Water Works Association (AWWA).

Also, the GCC is actively involved in efforts to use state funded research projects to leverage Federal funds, through the USGS, EPA, and the Centers for Disease Control (CDC). Proposals submitted to Wisconsin's Groundwater Research and Monitoring Program are occasionally forwarded to these federal partners, or re-worked to meet the specific needs of the funding source.

Distributing Project Results

Final reports are required for each project funded through Wisconsin's Groundwater Research and Monitoring Program. Reports from UWS funded projects are kept in the Water Resources Library. DATCP, Commerce, and DNR funded reports are kept on file with the respective agencies, but many are provided to the Water Resources Library for public distribution as well. All project investigators must submit a 2-page Project Summary upon completion of the final report. These summaries are made available on the WRI web site (*http://www.wri.wisc.edu/wgrmp/wgrmp.htm*). Over 130 summaries are currently provided. Summaries from older reports are printed in *Wisconsin Groundwater Research and Monitoring Project Summaries* (DNR PUBL-WR-423-95 and DNR PUBL-WR-205-90) both of which are available from the Water Resources Library or the DNR.

Previously, only summaries of the funded projects were available online. During the past year, the Water Resources Library partnered with UW Libraries' Digital Collections Center to digitize and put online most WRI and selected DNR final project reports. The WRI Groundwater Research and Monitoring Program Web site now links to the full-text reports, which are included in the University of Wisconsin Ecology and Natural Resources Digital Collection at *http://digital.library.wisc.edu/1711.dl/EcoNatRes.Groundwater*. Inclusion in the UW Ecology and Natural Resources online collection should make a wider audience aware of this important groundwater research.

Projects funded through Wisconsin's Groundwater Research and Monitoring Program have provided valuable information regarding the Wisconsin's groundwater resources, helped evaluate existing regulatory programs, increased the knowledge of the movement of contaminants in the subsurface, and developed new methods for groundwater evaluation and protection. Chapter 6, *Benefits from Monitoring and Research Projects*, highlights some of these projects and illustrates how agencies have used the project results to improve the management of the state's groundwater resources.

Table 1: Groundwater Research and Monitoring Projects Funded in FY 06

Agency	*Title*	*Author(s)*	*Affiliation*	*FY 06 Budget*
DNR				
	Mechanisms of Groundwater Flow across Aquitards	David Hart, Kenneth Bradbury, Daniel Feinstein and Basil Yikoff	WGNHS, USGS & UW-Madison	$37,615
	Centralizing Access to Groundwater Information for Use in Comprehensive Planning	Lynn Markham, Chin-Chun Tang and Charles Dunning	UW-Stevens Point & USGS	$22,884
	A Survey of Baseflow for Groundwater Protection Areas Western Fox-Wolf Watershed	G. Kraft	UW-Stevens Point	$35,438
	Groundwater Mounding and Contaminant Transport Beneath Stormwater Infiltration Basins	Anita Thompson	UW-Madison	$34,840
	Mapping and Characterization of Springs in Brown and Calumet Counties	Kevin Fermanich Ron Stieglitz and Michael Zorn	UW-Green Bay	$13,800

Identification and characterization of springs in west-central Wisconsin	Katherine Grote	UW-Eau Claire	$21,686
Evaluating drinking-well vulnerability to viruses	Randall Hunt and Mark Borchardt	USGS, Marshfield Clinic	$36,485
Disinfection of Enteric Viruses in Wisconsin Municipal Groundwater Systems	Gregory Harrington, Mark Borchardt and Irene Xagoraraki	UW-Madison, Marshfield Clinic	$31,615
+Assessing the Ecological Status and Vulnerability of Springs in Wisconsin	David Zaber, Susan Swanson, Kenneth Bradbury & Dave Hart	UW-Extension, Beloit College	$12,000

The total cost for all projects funded by DNR through the FY 06 solicitation for proposals was $246,363. There were no continuing projects to be funded by the DNR in FY 06.

Agency	*Title*	*Author(s)*	*Affiliation*	*FY 06 Budget*
UWS				
	*Mercury Speciation along a Groundwater Flowpath	D. Armstrong and C. Babiarz	UW-Madison	$25,595
	*Occurrence of Estrogenic Endocrine Disruptors in Groundwater	W. Sonzogni, J. Hemming, M. Barman and S. Geis	WSLH	$0#
	*Monitoring Environmental Effects at an Established Phytoremediation Site	W. DeVita and M. Dawson	UW-Stevens Point	$17,890
	*Foundry Slag for Treating Arsenic in Ground Water and Drinking Water	C. Benson and D. Blowes	UW-Madison	$0#
	Transient Functioning of a Groundwater Wetland Complex, Allequash Basin, Wisconsin	M. Anderson	UW-Madison	$23,633
	Measuring and Modeling Macroporous Soil Water And Solute Flux Below the Root Zone of a Plano Silt-Loam Soil	B. Lowery, J. Norman & B. Lepore	UW-Madison	$31,121
	Evaluation of On-site Wastewater Treatment as a Source of Antibiotic Resistance Genes in Groundwater	K. McMahon	UW-Madison	$39,190
	Arsenic Species (III,V) Distribution in Wisconsin's Groundwaters: Field Measurements and Prediction Using Multivariate Analysis of Geochemical Data	M. Shafer, K. Ellickson and J. Schauer	UW-Madison	$28,026
	Validation of Transport of VOCs from Composite Liners	T. Edil & C. Benson	UW-Madison	$25,821
	Nitrate and Pesticide Penetration into a Northern Mississippi Valley Loess Hills Aquifer	G. Kraft and B. Browne	UW-Stevens Point	$30,562
	Climate Signals in Groundwater and Surface Water System: Spectral Analysis of Hydrologic Processes	H. Bravo	UW-Milwaukee	$33,717
	+Assessing the Ecological Status and Vulnerability of Springs in Wisconsin	David Zaber, Susan Swanson, Kenneth Bradbury, Dave Hart	UW-Extension, Beloit College	$24,038

The total cost for all new projects funded by the UWS in 06 was $236,108. The total cost for all projects funded by the UWS in FY 06 is $279,593 (including fringe benefits and 6% administration costs and excluding USGS co-funding).

funded by USGS base funding of WRI
+ denotes joint funding between the DNR and UWS
* denotes continuing project from FY 05

Table 2: Groundwater Research and Monitoring Projects to be funded in FY 07

Agency	*Title*	*Author(s)*	*Affiliation*	*Cost*
DNR				
	* Mapping and Characterization of Springs in Brown ar Calumet Counties (extension from FY 06)	Kevin Fermanich, Ron Stieglitz and Michael Zorn	UW-Green Bay	$4,000
	* Centralizing Access to Groundwater Information for Use in Comprehensive Planning	Lynn Markham, Charles Dunning Gregory	UW-Stevens Point& USGS	$23,349
	* Disinfection of Enteric Viruses in Wisconsin Municipa Groundwater Systems	Harrington, Mark Borchardt and	UW-Madison, Marshfield Clinic	$13,385
	* Evaluating drinking-well vulnerability to viruses	Randall Hunt and Mark Borchardt	USGS, Marshfield Clinic	$32,485
	* A Survey of Baseflow for Groundwater Protection Areas of the Western Fox-Wolf Watershed	G. Kraft	UW-Stevens Point	$29,138
	* Groundwater Mounding and Contaminant Transport Beneath Stormwater Infiltration Basins	Anita Thompson Pedersen,	UW-Madison	$31,859
	Use of Human and Bovine Adenovirus for Fecal Source Tracking	McMahon, Kluender		$41,262
	Mineral transformation and release of arsenic to solution under the oxidizing conditions of well disinfection	Gotkowitz, Roden, Schreiber, Shelobolina		$32,137
	Groundwater recharge through a thick sequence of fine-grained sediment in the Fox River Valley, east-central Wisconsin	Hooyer, Hart, Bradbury, Mickelson		$37,997
	Precambrian Basement Surface Estimation using Coupled 3D Modeling of Gravity and Aeromagnetic Data in Fond du Lac County and Southeastern, Wisconsin	Skalbeck		$14,601
	Knowledge Development for Groundwater Withdrawal Management around the Little Plover River	Clancy and Kraft		$55,093

The total cost for all projects funded by DNR through the FY 07 solicitation for proposals is $321,242.

Table 2 (cont.): Groundwater Research and Monitoring Projects to be funded in FY 07

Agency	*Title*	*Author(s)*	*Affiliation*	*Cost*
UWS	*Arsenic Species (III,V) Distribution in Wisconsin Groundwaters: Field Measurements and Prediction Using Multivariate Analysis of Geochemical Data	Shafer, Ellickson, Schauer	UW-MSN	$28,666
	*Validation of Transport of VOCs from Composite Liners	Edil, Benson, Carlson	UW-MSN	$34,868
	* Nitrate and Pesticide Penetration into a Northern Mississippi Valley Loess Hills Aquifer	Kraft, Browne	UW-STP	$31,784
	*Climate signals in groundwater and surface water system: Spectral analysis of hydrologic processes	Bravo	UW-MKE	$35,195
	*Transient functioning of a groundwater wetland complex, Allequash basin, Wisconsin	Anderson	UW-MSN	$32,772
	* Assessing the Ecological Status and Vulnerability of Springs in Wisconsin (Madison Share, Beloit on USGS 104B)	Zaber, Swanson, Bradbury, Hart	UW-MSN	$14,143
	*Measuring and Modeling Macroporous Soil Water and Solute Flux Below the Root Zone of a Plano Silt-Loam Soil (on USGS 104B)	Lowery, Norman, Lepore	UW-MSN	$0
	Enhanced Reductive Dechlorination of Chlorinated Aliphatic Hydrocarbons: Molecular and Biochemical Analyses	W. Hickey and F. Payne	UW-MSN with USGS	$35,670
	Application of LSQR to Calibration of a Regional MODFLOW Model: Trout Lake Basin, Wisconsin	M.P. Anderson and H. Zhang	UW-MSN with USGS	$32,927
	Multi-Parameter, Remote Groundwater Monitoring with Referencing Using Crossed Optical Fiber Fluorescent Sensor Arrays	P. Geissinger	UW-MKE	$6,855

The total cost for all projects to be funded by the UWS through the FY 07 joint solicitation for proposals is $252,880.

The total cost for all projects to be funded by DNR and UWS in FY 07 is $574,122.

* denotes continuing project from FY 06

Table 3: Groundwater Research and Monitoring Projects Funded from FY 1999 through FY 2006

Fiscal Year	Total		DNR		UWS		DATCP		Commerce	
	#	$	#	$	#	$	#	$	#	$
New projects										
1999	**16**	**438,689**	5	186,766	8	160,333	4	91,590	0	0
2000	**14**	**327,338**	6	115,321	9	196,266	1	15,751	0	0
2001	**19**	**[1]578,895**	8	276,090	7	165,924	4	78,881	1	58,000
2002	**21**	**626,068**	9	281,259	10	252,619	3	92,190	0	0
2003	**7**	**180,621**	2	17,864	6	162,757	0	0	0	0
2004	**13**	**347,835**	4	124,495	9	251,423	0	0	0	0
2005	**8**	**130,502**	0	0	8	130,502	0	0	0	0
2006	**18**	**482,471**	9	246,363	9	236,108	0	0	0	0
Continuing Projects										
1999	**8**	**237,900**	3	102,360	5	121,647	1	13,893	0	0
2000	**11**	**321,171**	5	186,221	4	87,000	2	47,950	0	0
2001	**8**	**179,441**	2	60,623	7	[2]118,818	0	0	0	0
2002	**11**	**234,913**	5	155,026	4	[2]37,077	3	42,810	0	0
2003	**13**	**311,237**	4	110,198	7	[2]121,039	3	80,000	0	0
2004	**3**	**15,170**	0	0	3	[2]15,170	0	0	0	0
2005	**9**	**256, 280**	3	92,580	6	[2]163,700	0	0	0	0
2006	**4**	**43,485**	0	0	4	43,485	0	0	0	0
All Projects										
1999	**24**	**676,589**	**8**	**289,126**	**13**	**281,980**	**5**	**105,483**	**0**	**0**
2000	**25**	**648,509**	**11**	**301,542**	**13**	**283,266**	**3**	**63,701**	**0**	**0**
2001	**27**	**758,336**	**10**	**336,713**	**14**	**284,742**	**4**	**78,881**	**1**	**58,000**
2002	**32**	**860,981**	**14**	**436,285**	**14**	**289,696**	**6**	**135,000**	**0**	**0**
2003	**20**	**491,858**	**6**	**128,062**	**13**	**283,796**	**3**	**80,000**	**0**	**0**
2004	**16**	**391,088**	**4**	**124,495**	**12**	**266,593**	**0**	**0**	**0**	**0**
2005	**17**	**386,782**	**3**	**92,580**	**14**	**294,202**	**0**	**0**	**0**	**0**
2006	**22**	**525,956**	**9**	**246,363**	**13**	**279,593**	**0**	**0**	**0**	**0**

[1]2001 DNR figures do not include 71K from Federal 106 funds applied toward FY02 projects
[2]2001-2006 UWS figures do not include matching USGS funds (approximately 46K per year)

Chapter 3 -- SUMMARY OF AGENCY GROUNDWATER ACTIVITIES

DEPARTMENT OF NATURAL RESOURCES

The Department of Natural Resources (DNR) has statutory authority as the central unit of state government to protect, maintain and improve the quality and management of the waters of the state, ground and surface, public and private (s. 281.11 Wis. Stats.). The DNR establishes the groundwater quality standards for the state under authority of ch. 160, Wis. Stats. DNR regulatory activities to protect groundwater are the responsibility of four programs:

Drinking Water and Groundwater (DG) – Regulates public water systems, private drinking water supply wells, well abandonment and high capacity wells. DG is responsible for adoption and implementation of groundwater standards contained in ch. NR 140, Wis. Adm. Code, and works closely with other programs and agencies to implement Chapter 160, Wis. Stats., including groundwater monitoring, database management, and staffing the Groundwater Coordinating Council. The new provisions under 2003 Wisconsin Act 310 are also being implemented by DG. The program also coordinates the state's Wellhead Protection and Source Water Protection programs.

Waste and Materials Management (WMM) – Regulates and monitors groundwater at proposed, active, and inactive solid waste facilities and landfills. WMM reviews investigations of groundwater contamination and implementation of remedial actions at active solid waste facilities and landfills. WMM also maintains a Groundwater and Environmental Monitoring System (GEMS) database of groundwater quality data from over 600 solid waste facilities and landfills and uses reports from GEMS to evaluate whether sites are impacting groundwater quality.

Remediation and Redevelopment (RR) – Oversees response actions at spills, hazardous substance release sites, abandoned containers, drycleaners, brownfields (including the Site Assessment Grant program), “high priority” leaking underground storage tanks, closed wastewater and solid waste facilities, hazardous waste corrective action and generator closures, and sediment cleanup actions. A significant amount of the RR's work relates to groundwater contamination.

Watershed Management (WT) – Regulates the discharge of municipal and industrial wastewater, by-product solids and sludge disposal from wastewater treatment systems and wastewater land treatment/disposal systems. WT also issues permits for discharges associated with clean-up sites regulated by WT for the RR program. WT also has primary responsibility for regulating stormwater and agricultural runoff as well as managing waste from large animal feeding operations.

The Department made significant strides in protecting groundwater in FY06

1. *Revised the Groundwater Study Guide materials* - Groundwater Section staff worked with other staff from the DNR, the Department of Public Instruction (DPI) and other agencies on revisions to the Groundwater Study Guide booklet and activity sheets. These are important components of the Groundwater Study Guide packet that the DNR has distributed to teachers for over 15 years. The revised booklet, activity sheets and new folders for the packet materials were published in early 2006, replacing 1990 versions.

The 2006 versions of these documents have been added to the DNR Environmental Education for Kids (EEK!) website and the groundwater education website.

2. *Provided Groundwater workshops for teachers* - For the sixth year in a row, DNR staff worked with the Wisconsin Geological and Natural History Survey and Center for Watershed Science and Education to sponsor three groundwater workshops for teachers in January 2005. Teachers from 21 school districts were given training in the use the groundwater sand tank model and given models to take back to their schools. The intent is to provide information for teachers to educate students – and their parents – on the importance of groundwater protection.

3. *Implemented the Groundwater Protection Act* – In May of 2004, the statutes regarding high capacity wells were expanded to give the DNR the authority to consider environmental impacts of wells in order to protect critical surface water resources. Other changes include notification and collection of fees for all new wells and requirements for reporting water use on an annual basis for all high capacity wells. Further provisions in the Groundwater Protection Act include designation of two Groundwater Management Areas to address regional groundwater issues and the creation of a Groundwater Advisory Committee to recommend management approaches in these areas and further statutory changes. In FY 06 DNR hired staff to implement the new law. Progress was made on the following components of the new law:
   - Implementation of an automated Internet well construction notification and fee collection system as well as an approval application tracking system.
   - Assessing the availability of data and evaluation tools needed for evaluating potential significant adverse impacts of high-capacity wells on sensitive surface waters.
   - Management and coordination of three research and monitoring projects on springs and one on small stream flow monitoring.
   - Staffed the first year of Groundwater Advisory Committee (GAC) and Subcommittee meetings. The GAC meetings occurred every two months.

4. *Implemented the Groundwater Monitoring Strategy* - In FY 06, DNR staff began implementation of the statewide groundwater monitoring strategy with representatives from the DATCP, USGS, WGNHS, and UW Stevens Point. The objective of the strategy is to coordinate groundwater monitoring between all state agencies that regulate groundwater to assess groundwater quality and quantity in the state. Over the next ten years, components of the strategy will be integrated into DNR's overall water monitoring plan.

5. *Approved 512 Cleanups of Contaminated Properties*- That number raised the total of approved cleanups (excluding spills and abandoned container responses) to more than 13,700. Program staff also:
   - helped 95 percent or more of the cleanups undertaken by responsible parties proceed without enforcement.
   - responded to nearly 100 requests for detailed, fee-based technical reviews.
   - worked with hundreds of inactive responsible parties resuming site investigation and cleanup activities.

6. *Provided Assistance Through Start-up Site Assessment Grants For Brownfields* - In FY 06, the RR Program awarded 50 Site Assessment Grants totaling approximately $1.7 million to 33 communities across the state. Small grants up to $30,000 make up 42 of the awards, while eight are large grants between $30,000 and $100,000. Local governments have also pledged more than $1.1 million in additional funds for the projects, well beyond the 20 percent match required through the application process.

   The grants will provide funds for environmental activities on 94 acres of land. Activities include 69 site assessments and investigations, the demolition of 50 buildings or structures and the removal of 120 tanks, drums and other abandoned containers. Since 2000, 307 grants have been awarded to 150 communities around the state for work on 944 acres of land.

7. *Helped Prevent and Control Toxic Spills* - The RR Program partnered with state and local emergency responders at more than 500 hazardous substance spills and provided outreach and education to facilities and responders statewide to help prevent spills.

8. *Provided State-Funded Response at Orphan Site* - When a responsible party is unknown, unable or unwilling to conduct environmental restoration, the RR Program protects human health and the environment with a state-funded cleanup. In 2006, the Program spent $3.5 million in Environmental Fund dollars to initiate or continue environmental cleanup actions at approximately 62 locations where groundwater contamination is known or suspected. The Program also recovered over $550,000 in state expenses that had been used to address contamination, where responsible parties would not proceed with investigation or cleanup.

9. *Initiated Work on Brownfield Grant for 30th St. Corridor Work in Milwaukee* – Capitalizing on $400,000 in grants obtained in FY 05 ,The DNR, in partnership with the city of Milwaukee and the 30th Street Industrial Corridor Corporation, selected a focus area as the priority location for conducting site assessments. Fourteen Phase I Environmental Site Assessment reports have been completed. Sampling has taken place on two properties for the completion of Phase II reports. The partnership participants are working with EPA and the Department of Health and Family Services to leverage additional studies and resources to encourage brownfields redevelopment.

10. *Provided Accessible and In-Depth Public Information* – Remediation and Redevelopment staff continued to improve one of the nation's most comprehensive web sites on environmental contamination, investigation, cleanup, liability, redevelopment and financial aid, averaging over 100,000 web hits per month. The RR Program also maintains records on thousands of active investigations and cleanups of contaminated properties in an Internet-accessible format. In addition, Program staff attended more than 100 meetings with local officials to provide assistance on cleanup and redevelopment of contaminated properties.

11. *Approved New Wellhead Protection Plans*. In FY 06, 11 communities received DNR approval of required WHP plans (for new wells) and 22 communities submitted voluntary plans to the DNR. In addition, WRWA completed Source Water Protection Plans for 3 geographic areas (with multiple public water systems) in FY 06. There are now nearly 300 communities who have a WHP plan for at least one of their wells.

More information about the groundwater programs and activities of the DNR is detailed in the following pages.

Drinking Water and Groundwater Program

Groundwater standards. Chapter 160, Wis. Stats., requires the DNR to develop numerical groundwater quality standards, consisting of enforcement standards and preventive action limits, for substances detected in, or having a reasonable probability of entering, the groundwater resources of the state. Chapter NR 140, Wis. Adm. Code, establishes these groundwater standards and creates a framework for their implementation. There are currently groundwater quality standards for 122 substances of public health concern, 8 substances of public welfare concern and 15 indicator parameter substances in ch. NR 140.

DG maintains a table listing NR 140 groundwater quality standards, NR 809 state drinking water standards, and established health advisory levels (HALs) for substances in water. This table of regulatory standards and advisory levels provides a useful source of information to members of the public concerned about the safety of their drinking water and also is a valuable resource for DNR staff involved with groundwater contamination and remediation cases. Links in this table allow users to obtain additional toxicological and health related information on many of the substances listed.

DG staff work closely with the RR program to identify policy issues, develop guidance, and provide training regarding the implementation of chs. NR 720, 722, 724 and 726 dealing with soil cleanup standards, selecting and implementing remedial actions, and case closures. DG staff also provide advice and assistance on site investigations, soil and groundwater remediation, and general case closure decisions. This coordination is critical in obtaining statewide consistency on how the DNR evaluates, addresses and closes soil and groundwater contamination sites.

DG staff work with Runoff Management staff to ensure that new performance standards for stormwater infiltration (NR 151) comply with groundwater standards specified in NR 140. DG participated on a team writing stormwater management guidance for developers, land use planners and government agencies to help assure that stormwater practices meet performance standards while preserving groundwater quality.

Revisions to NR 140 groundwater quality standards have been adopted by the Natural Resources Board. These revisions include revised NR 140 groundwater quality standards for butylate, dacthal and naphthalene, and new NR 140 groundwater quality standards for molybdenum and alachlor ethane sulfonic acid (alachlor-ESA), a breakdown product of the herbicide alachlor. The proposed revisions to NR 140 adopted by the Natural Resources Board are currently being reviewed by State Legislative Committees.

Groundwater Protection Act Implementation. The DNR is authorized under statute to regulate wells on each property where the combined capacity of all wells on the property, pumped or flowing, is greater than about 70 gallons per minute (100,000 gallons per day over a 30-day period). Such wells are defined as high capacity wells. Prior to 2004, when the operation of a high capacity well was anticipated to have an adverse impact on the quality or quantity of water available to a public utility well, the DNR was obligated to deny approval or to limit operation of the high capacity well so that their operation does not adversely impact a public utility well. In May of 2004, the statutes regarding high capacity wells were expanded through Wisconsin Act 310 to give the DNR the authority to consider environmental impacts of wells in order to protect

critical surface water resources. Specifically, the DNR is mandated to complete an environmental review under ch. NR 150, Wis. Adm. Code, for the following proposed high capacity wells:

- Wells located within 1,200 feet of an outstanding or exceptional resource water or a trout stream (i.e. Groundwater Protection Areas)
- Wells that may have a significant environmental impact on a high volume spring
- Wells where more than 95% of the water will be lost from the basin

In these cases, DNR may allow, deny or limit an approval to assure that these wells do not cause significant environmental impact.

Other statutory changes created by Act 310 include a new fee to be collected along with the application for approval and requirements for reporting water use on an annual basis for new and existing high capacity wells. Beginning May 1, 2005, the DNR required notification for all water supply wells prior to construction. A fee of $500 is required for all new high capacity wells and $50 for private wells.

In FY 06 the DNR hired five groundwater quantity staff to implement the new programs created by the law. Staff are handling workload associated with high-capacity well registration, fees, application review, data management, and inspections; and providing support to the Groundwater Advisory Committee (GAC), which has met every two months since April 2005.

The GAC has been addressing on a wide range of groundwater quantity issues and potential solutions including:

- Designation of Groundwater Management Areas and required water supply planning for water users in areas with water quantity problems;
- Data collection, research, and monitoring needed for evaluation of high-capacity well applications in Groundwater Protection Areas including tracking the progress of four springs projects.
- Other states' high capacity well application processes

Well construction and abandonment. DG sets and enforces minimum standards for well construction, pump installation and well abandonment through ch. NR 812, Wis. Adm. Code. The standards are intended not only to provide health protection but also to protect groundwater. DG also licenses and educates well drillers under ch. NR 146, Wis. Adm. Code, so that they are qualified to construct wells in a way that won't contaminate groundwater. Drillers submit reports to the DNR describing the construction of each well drilled. Field staff in the program conduct surveillance and inspections to enforce the minimum well construction standards.

Representatives of the Private Water Supply Program worked with the Wisconsin Water Well Association and members of the Wisconsin legislature to draft revisions to ch. 280, Wis. Stats. that should result in increased protection of groundwater (as well as increased public health protection.) The changes will go into effect in June, 2008. The significant changes include:

- Well abandonment must be performed by a licensed well driller or pump installer, or someone employed by a licensed well driller or pump installer—homeowners may not abandon their own wells. There is an exemption for wells under the authority of municipal abandonment ordinances.

- Well and pressure system inspections conducted as part of real estate transactions must be done by an individually-licensed well driller or pump installer (not an employee of a licensed person.) Inspection details will be specified in department rules and will require a diligent search for any wells that need to be abandoned.

- Drill rig operators must register with the department and will be required to complete additional training and/or testing requirements prior to becoming eligible to receive a well driller license. Each rig must have a licensed well driller or registered rig operator present onsite to supervise during all drilling activities.

- The department will have authority to issue citations for some violations that don't rise to the level of referral to the Department of Justice, e.g., work done without a license; work on substantially noncomplying existing pump installations (pits, short-cased wells); improper well abandonment; or repeated failure to collect water samples and/or submit well construction reports.

DG continues to promote electronic management of well construction and other information through its website at and through semiannual releases of a Water Well Data CD.

The Private Water Supply program continued its surveillance, investigation, and referral of well drilling and pump installation violators to the Department of Justice for prosecution. Violations have included falsification of water samples, failing to grout, and short casing wells. Falsification of water samples involves collecting a water sample from a known safe source and claiming it was collected from the newly constructed well. Failure to grout or failure to properly grout is a threat to groundwater because the empty space around the well casing pipe provides an easy conduit for contamination to enter the groundwater and contaminate lower aquifers. Short casing well involves installing less than the code minimum amount of casing, and then reporting and billing for casing that was not installed.

Another activity involved the designation and enforcement of special well construction requirements in areas where arsenic is known to exist. These requirements, if not followed, could allow naturally occurring arsenic to enter groundwater at higher levels. The DNR has designated a special casing area that covers all of Outagamie and Winnebago Counties. In these areas wells must be constructed to avoid the arsenic rich St. Peter and Prairie du Chien formations. Wells can be constructed to draw water from the overlying Galena/Platteville dolomite or they must be cased and grouted into the Cambrian sandstone. The Department is working with the WGNHS to update and refine the geologic mapping and improve the accuracy of the special casing requirement depths.

Groundwater monitoring well requirements, as specified under NR 141, are administered by DG staff. Activities include consultation on well construction with Remediation and Redevelopment, Waste Management & Materials, Watershed Management and Department of Commerce staff, consultants and drillers. Random inspections of environmental drilling operations provide an opportunity for DNR hydrogeologists to update drillers and consultants about NR 141 requirements and enhance compliance with the code. Review of new technologies and their application also continue to be a priority.

Aquifer Storage & Recovery (ASR) pilot testing. Aquifer storage and recovery (ASR) is a water supply management technique involving the injection of water into an underground aquifer for storage and later recovery. The technique has been proposed in Wisconsin to address the problem of peak seasonal water supply demand. A water utility may not have the storage reservoir volume or water treatment plant capacity to provide enough water to users during summer high, "peak", water demand periods. Using ASR a utility might store "surplus water", water treated during periods of "low" demand, underground for later recovery during peak demand periods.

ASR has been proposed as a lower cost alternative to address peak seasonal water demand, than construction of additional "above ground" water storage structures, or upgrading to increase existing water treatment facility capacity.

Rules have been established by the DNR to regulate the use of ASR technology in Wisconsin. These regulations, in ch. NR 811, Wis. Adm. Code, limit use of ASR to municipal water systems and require that any water, placed underground for ASR storage, meet state drinking water (ch. 809, Wis. Adm. Code) and groundwater quality (ch. NR 140, Wis. Adm. Code) standards. Chapter NR 811 also requires that water recovered from ASR storage meet drinking water standards prior to being placed in a municipal water distribution system and that operation of an ASR system not cause exceedances of state NR 140 groundwater quality standards in the aquifer used for ASR water storage. Before "long term" operational approval of an ASR system is granted in Wisconsin, pilot testing of the system is required.

To date, two municipalities in Wisconsin, Oak Creek and Green Bay, have conducted ASR pilot tests. Both pilots have tested the viability of storing treated Lake Michigan surface water in the Ordovician - Cambrian carbonate/sandstone aquifer ("deep sandstone aquifer") system. Both tests were designed to inject and recover ASR water through a single test site ASR well, and both pilot tests have included monitoring to assess ASR impacts on ambient groundwater quality.

Both ASR pilot tests conducted to date have resulted in trace elements, from aquifer matrix material, being mobilized in groundwater to levels above state groundwater quality standards. This appears to have been caused by the injection of highly oxidized, "reactive" Lake Michigan surface water into the relatively reduced redox environment of the deep sandstone aquifer system. It also appears that some trihalomethane (THM) disinfection byproducts present in the disinfected Lake Michigan surface water, and also generated in the aquifer during ASR storage, are not degrading as readily as originally suggested. Because the proposed operation of the ASR systems pilot tested results in some of the stored ASR water remaining in the aquifer after each ASR pumpout cycle is completed, there is the potential for THM disinfection byproducts to accumulate over time in the aquifer used for ASR storage. The increasing accumulation of THM disinfection byproducts in an ASR storage zone over time is likely to result in exceedances of state groundwater quality standards for these substances at the ASR system compliance boundary.

Green Bay decided after the second smaller injection to abandon further plans to test ASR. Significant levels of arsenic and other contaminants were mobilized from aquifer bedrock during the Green Bay pilot test ASR storage periods. Additionally, the city's need for increased water storage changed. Communities surrounding the city that initially considered purchasing drinking water from Green Bay decided to purchase their water from Manitowoc instead.

Pilot testing of ASR at Oak Creek has shown that the technology may be viable, although, manganese appears to have been mobilized from aquifer bedrock during the ASR pilot test and levels of this substance in groundwater have increased. Oak Creek has been issued a conditional approval to use ASR, as pilot tested, provided that geochemical monitoring indicates that mobilized substances do not exceed state groundwater quality enforcement standards.

Public water systems. DG oversees monitoring and operation of public water systems through ch. NR 809 (Safe Drinking Water), Wis. Adm. Code, to ensure all public water systems are safe to drink and use. Working in cooperation with owners and operators of water systems DG ensures that samples are collected and analyses completed to determine if the water meets federal Safe Drinking Water Act (SDWA) standards. Also, through ch. NR 811 (Requirements for the Operation and Design of Community Water Systems), DG regulates the general operation, design

and construction of community water systems. DG also works to educate water system owners and operators concerning proper operation and maintenance of water systems to ensure safe drinking water for Wisconsin consumers.

DG developed and continues to maintain data about Wisconsin's drinking water and groundwater quality through the Drinking Water System database. The Drinking Water System is an important tool used to efficiently enforce SDWA regulations for public water systems. It contains the monitoring and reporting requirements for each public water system and their drinking water sampling results. It also includes violations for any missing requirements and exceedances of the maximum contaminant levels (MCLs).

This fiscal year, DG has been working with private laboratories to allow electronic submission of data to continuously improve the process in which water quality sampling results are received. Additionally, DG has been working on implementing new federal rules and updates to existing rules dealing with arsenic and disinfection byproducts.

Wellhead protection. The DNR is the lead state agency for developing and implementing the Wisconsin Wellhead Protection (WHP) Program. The specific goal of Wisconsin's program is to achieve groundwater pollution prevention in public water supply wellhead areas (area contributing groundwater recharge to a well) consistent with the state's overall goal of groundwater protection. A WHP plan is required for new municipal wells and must be approved by the DNR before the new well can be used. A WHP plan is voluntary for any public water supply well approved prior to May 1, 1992; the DNR promotes and encourages but does not require wellhead protection planning for these older wells.

The DNR coordinates a statewide public information effort aimed at encouraging water utilities to protect their water supplies from potential sources of contamination through wellhead protection planning. Wellhead protection staff responded to over 30 requests for information during FY 06. Staff answered questions, sent publications, reviewed draft plans and ordinances and visited communities to assist in their WHP efforts. The DNR has prepared a video and several publications to assist communities in their wellhead protection efforts. The DNR also works with the Wisconsin Rural Water Association in providing assistance to local water utilities. Information is shared with local communities through a spring and fall wellhead protection newsletter. The DNR also maintains a web page with a variety of relevant information. In addition, the DNR has developed a tracking system for both wellhead protection activities in the DNR's Drinking Water System database. The DNR uses this information to report annually to EPA on WHP progress.

Other highlights include:

- *New wellhead protection plans*. In FY 06, 33 communities received DNR approval of required WHP plans (for new wells) or submitted voluntary plans to the DNR. (There were 11 communities with approved plans and 22 communities with voluntary plans.) In addition, WRWA completed Source Water Protection Plans for 3 geographic areas (with multiple public water systems) in FY 06. There are now nearly 300 communities who have a WHP plan for at least one of their wells.

- *Teacher training*. For the sixth year in a row, DNR staff worked with the Groundwater Center at the Center for Watershed Science and Education (CWSE) and the Wisconsin Geological and Natural History Survey (WGNHS) to sponsor three groundwater workshops for teachers

in January. Forty-two teachers from 21 schools took part in the workshops held in Madison, Green Bay and Spooner and were able to take a free groundwater model back to their school. Besides learning how to use the groundwater model, the teachers received groundwater resources to incorporate groundwater concepts into their classroom. The intent of the workshops is to provide information for teachers to educate students – and their parents – on the importance of protecting groundwater in their own communities. With funding from an EPA grant, 141 groundwater models have been given to schools since 2001.

- *Hosting meeting of EPA Region 5 states groundwater managers.* Wisconsin hosted the annual meeting of groundwater program managers for the EPA Region 5 states in September. Representatives from USEPA Headquarters and Region 5 joined managers from the 6 Region 5 states in Madison to talk about wellhead and source water protection and other issues of common interest.

- *CRP in wellhead protection areas*. The DNR worked with the federal Farm Service Agency to identify cropland in wellhead protection areas. Farmers that use cropland in wellhead protection areas could be eligible for cost-sharing and annual rental payments as part of the federal Conservation Reserve Program (CRP). The CRP program is designed to protect the environment by taking agricultural cropland out of production and installing conservation practices.

Groundwater Information and Education. In FY 06 DG staff, with help from other state agencies, revised three widely used groundwater publications. *Groundwater: Wisconsin's Buried Treasure***,** a popular DNR publication has been updated. The glossy 32-page color publication has a new look with updated photos and graphics. Information on Wisconsin aquifers, the water cycle and groundwater protection programs has been updated. New sections added include: How a well works, Groundwater quantity, and the Great Lakes Charter. To see the web version visit: *www.wnrmag.com/supps/2006/apr06/intro.htm*.

The *Groundwater Study Guide* booklet and activity sheets were recently revised and replace versions last updated in 1990. DNR, Department of Public Instruction (DPI) and other agency staff worked cooperatively on revisions to the Study Guide booklet and activity sheets, important components of the packet that the DNR has distributed to teachers for over 15 years. The booklet contains 13 groundwater exercises for students in grades 6-9 plus introductory information, a glossary, other groundwater activity ideas, groundwater education resource list and DPI Wisconsin Model Academic Standards; activity sheets correspond to the exercises. The 2006 version of these 2 documents has been added to the DNR Environmental Education for Kids (EEK!) website and the groundwater education website.

Recently the arsenic standard for drinking water was officially lowered by the EPA from 50 µg/L to 10 µg/L. The *Arsenic in Drinking Water* brochure was updated to reflect the most current information and recommendations regarding arsenic in Wisconsin's groundwater. This will be helpful to those who seek reliable sources of information to help them understand whether their water supply is safe. The brochure is found online.

Groundwater monitoring and research. Chapter 160 of the Wisconsin Statues requires the DNR to work with other agencies and the Groundwater Coordinating Council (GCC), to develop and operate a system for monitoring and sampling groundwater to determine whether harmful substances are present (s. 160.27, Wis. Stats.). The DNR has also supported groundwater monitoring studies evaluating existing design and/or management practices associated with

potential sources of groundwater contamination. The intent of these studies is to reduce the impacts of potential sources of contamination by changing the way land activities that may impact groundwater are conducted. See Chapter Two for more information on the DNR's monitoring studies .

During FY 06, $246,363 was spent on nine projects. Five new projects were selected for funding in FY 07. More details on the DNR's groundwater monitoring and research activities can be found online.

Final reports received by the DNR in FY 06 include:

Bahr, J., Gittings Trethewey, H., 2005 Development of a groundwater flow model for the Mukwonago River watershed, southeastern Wisconsin

Bradbury, K., Bahr, J.M., and Wilcox, J.D. 2005 Monitoring and predictive modeling of subdivision impacts on groundwater in Wisconsin

Final reports and 2-page research summaries are available for most projects from the Water Resources Institute website: *http://wri.wisc.edu/wgrmp/wgrmp.htm*.

In FY 06, DG staff worked with representatives from the DATCP, USGS, WGNHS, and UW Stevens Point on refining and implementing a new statewide groundwater monitoring strategy. The objective of the strategy is to coordinate groundwater monitoring between all agencies that assess groundwater quality and quantity in the state. The statewide groundwater monitoring strategy will help DNR meet the prerequisites of the Clean Water Act Section 106(e)(1) as described in the EPA's "Elements of a State Water Monitoring and Assessment Programs" guidance document. Specific goals include:

- Documenting status and trends in groundwater quality, quantity and use;
- Improving of understanding of groundwater systems and groundwater/surface water interactions; and
- Communicating groundwater information to citizens, policy makers and resource managers.

Over the next ten years, components of the strategy will be integrated into DNR's overall water monitoring plan. Other agencies will also continue to make improvements in their monitoring efforts based on the comprehensive strategy. The components of the strategy may change over time according to needs of the different agencies. The requirements of Chapter 160, Wis. Stats., will continue to be met under the strategy.

Groundwater data management. Groundwater data from the DNR's consolidated Groundwater Retrieval Network (GRN) system is available online. GRN accesses groundwater data from three database systems in the Waste Management and Drinking Water and Groundwater programs including information on approximately 300,000 wells. These wells represent public and private water supply wells, piezometers, monitoring wells, non-potable wells, and groundwater extraction wells. In FY 06, DG staff continued to improve the locational data associated with GRN's wells.

The DNR continued to make progress on several other groundwater-related data initiatives in FY 06. DG continued to improve its public water supply well data and coordinated efforts with the RR, WMM, and WT programs to improve the DNR's data on significant potential sources of contamination that may threaten these wells. Additionally the WGNHS and DNR continue to

improve their searchable index of scanned images of more than 350,000 well construction reports (see WGNHS section) for SWAP and other program uses. Work continued to refine and update the Source Water Assessment Mapping Application which is a Geographic Information System that maps locations of public wells, their source water areas, and potential contaminant sources in a format consistent with vulnerability assessment program, WHP, and other DNR needs. Another application, the Assessment Form, uses the mapped potential contaminant sources along with well construction, monitoring, and geologic information to help DNR staff determine susceptibility of public wells to contamination. These applications are at the leading edge of DNR's efforts in integrating spatial and tabular data toward the goal of public health protection.

Waste and Materials Management Program

The Bureau of Waste and Materials Management (WMM) implements the DNR's Groundwater Standards Program in several ways during the life of a landfill. Whenever staff review an applicant's "Feasibility Report," which proposes to site a landfill in a particular location, they review baseline data submitted by the applicant to determine whether exemptions and alternative concentration limits are needed for the public health and welfare parameters listed under NR 140. In addition, the reviewers establish preventive action limits for indicator parameters based on calculations submitted by the applicant. During the active life of a landfill and after closure, staff evaluate groundwater conditions at the landfill site to determine compliance with NR 140 Standards. Should conditions warrant, staff require groundwater investigation reports that include proposals for further evaluations and recommendations for remediation at landfills that exceed groundwater standards. Staff review results of site investigations triggered by the exceedances of groundwater standards and evaluate the effectiveness of remedial actions at active solid waste facilities and at closed landfills by comparing results to groundwater standards over time.

WMM only accepts electronic submittal (via diskette or CD) of environmental monitoring data from landfill owners, labs and consultants. As of January 2006, WMM provides facilities and the public access to the environmental monitoring data contained in its Groundwater and Environmental Monitoring System (GEMS) database. In the future, we hope to provide a web interface, possibly using the Department's Data Portal and/or Web Access Management System, to allow facilities to upload environmental monitoring data into GEMS, if funding is available to do the necessary programming.

WMM has been concerned that staff might not be aware of some old, closed landfills that may be impacting groundwater. Program staff used several reports from the Groundwater and Environmental Monitoring System to do a rough screening of old, closed town, city and village landfills with monitoring wells. In July 2003 we sent the screening reports, identifying landfills that need further attention to each of the regions for follow-up evaluations. Program staff have since reviewed most of the identified sites. A more in depth screening of all closed landfills is planned by the end of 2006.

Between July 2000 and July 2001 WMM studied 31 landfills that accept municipal solid waste, to try to determine whether VOC contamination in groundwater at these landfills is increasing, decreasing or remaining stable. We chose sites with 10 years of data and summarized the trends over this period of time. One purpose of this study was to determine whether natural attenuation is occurring in groundwater near leaking landfills. The study showed that natural attenuation processes were occurring at most of the landfills as evidenced by the large number of stable or decreasing concentration trends. However, the concentrations took longer to stabilize and stabilized at higher levels than at other types of VOC contamination sites described in the literature.

WMM and the UW Stevens Point received funding from July 1999 to July 2001 to evaluate the effectiveness of chemical oxygen demand (COD) as an indicator parameter at landfills. One reason for evaluating COD is that mercury waste is generated when COD is analyzed in the laboratory. The DNR's overall goal is to reduce the amount of mercury that gets into the environment so eliminating COD sampling at the 400+ landfills that currently sample for it would help us meet that goal. Findings from the first year of the study indicated that there was potential to eliminate COD monitoring at some types of landfills. The second year of the study evaluated possible alternatives to sampling for COD. Dissolved organic carbon (DOC) appears to be an acceptable alternative in certain circumstances. WMM staff have incorporated the recommendations of this study into code changes that went into effect in February 2006.

WMM received funding for the period October 2002 to October 2003 to study groundwater quality at solid waste landfills to determine whether they are a source of pesticide contamination. We sampled 11 sites the spring and summer of 2003 and summarized the findings in a 2005 GEMS Newsletter article. Groundwater samples were analyzed for 14 common Wisconsin pesticides using immunoassays and additional GC/MS methods. Preliminary findings indicated that leaking landfills may be contributing alachlor, aldicarb, atrazine and 2,4-D to groundwater. The study researchers believed a follow-up study was needed to provide more evidence to help make concrete recommendations about which pesticides to sample for. However, staff and funding are not currently available for this.

Remediation and Redevelopment Program

The Bureau for Remediation and Redevelopment (RR) has primary responsibility for implementing and aiding cleanups under the Spill Law, the Environmental Repair Law, federal programs (Superfund, Hazardous Waste Corrective Action, Leaking Underground Storage Tanks(LUST), Brownfields), the Land Recycling Law and State Brownfield Initiatives, the Drycleaner Environmental Response Fund and at closed landfills. The RR program provides technical assistance, helps to clarify legal liability, provides financial assistance primarily to local governmental units and provides technical project oversight of cleanup projects.

All cleanups are conducted according to the NR 700 rule series, Wis. Adm. Code, Investigation and Remediation of Environmental Contamination, and NR 140, Groundwater Quality. The majority of cleanups are done by persons responsible under the laws, or persons or groups involved in the redevelopment of potentially contaminated properties. Program staff provide technical assistance on cleanups conducted by consultants at the direction of responsible parties. In addition, RR staff contract and direct consultants on state-funded cleanups.

Cleanup of groundwater contamination. The program used $5.7 million in Environmental Fund dollars to initiate or continue environmental cleanup actions at over 60 locations where groundwater contamination is known or suspected. The Environmental Fund is used when contamination is significant but private parties do not undertake the cleanup because no one has legal responsibility for the contamination, the person(s) legally responsible do not have the financial ability to proceed, or the responsible person simply refuses to proceed. Private contractors conduct these cleanups with oversight by DNR staff. The program spends an average of over $5 million per year from the fund to address contamination at new and continuing project sites. Whenever feasible, the RR program and legal staff attempt to recover costs from responsible persons after the cleanups are undertaken.

Investigation, cleanup and redevelopment of brownfields. Brownfields are abandoned, idle or underused industrial or commercial facilities or sites whose expansion or development is adversely affected by actual or perceived environmental contamination. The RR program coordinates several efforts to encourage local governments and private businesses to cleanup and redevelop brownfield properties. At many brownfields sites, the release of hazardous substances threaten groundwater quality.

One of the financial assistance programs implemented by the DNR is the Brownfields Site Assessment Grant (SAG) program. The SAG program benefits groundwater by serving as a funding source for (1) the removal of potential sources of groundwater contamination, and (2) site investigations to determine whether groundwater and soil are contaminated, including the determination of the extent and degree of contamination.

This program provides grants to local governmental units to conduct environmental site assessments and other eligible activities at contaminated properties. Eligible activities include site assessment and investigation, demolition, asbestos abatement, removal of petroleum and hazardous substance storage tanks and removal of abandoned containers. Although the SAG program does not fund remediation activities, it funds preliminary activities to determine whether remediation is necessary. Sites are eligible for funding only if the persons responsible for the contamination are unknown, cannot be located, or cannot pay for the activities for which grant funding is requested.

In FY 06, DNR awarded 50 Site Assessment Grants totaling approximately $1.7 million to 33 communities across the state. Small grants up to $30,000 make up 42 of the awards, while eight are large grants between $30,000 and $100,000. Local governments have also pledged more than $1.1 million in additional funds for the projects, well beyond the 20 percent match required through the application process.

The grants will provide funds for environmental activities on 94 acres of land. Activities include 69 site assessments and investigations, the demolition of 50 buildings or structures and the removal of 120 tanks, drums and other abandoned containers. Since 2000, 307 grants have been awarded to 150 communities around the state for work on 944 acres of land.

The RR program also provides redevelopment assistance at brownfield sites with groundwater contamination. Program staff assist local governments and private businesses with the cleanup and redevelopment of brownfields by providing technical assistance. In many cases, these properties have groundwater contamination, or soil contamination that poses a threat to groundwater.

The RR program also provides a number of different assurance, comfort or general liability clarification letters related to properties with groundwater contamination. Collectively, these letters facilitate the reuse and development of properties. The RR program provided 103 redevelopment assistant reviews – which can include liability clarification letters, off-site exemption letters, cleanup agreements for tax delinquent properties, etc. – at brownfield properties throughout the state in FY 06.

The RR program also continues to provide technical assistance and assist parties with voluntary investigations and cleanups of Brownfield properties through the Voluntary Party Liability Exemption (VPLE) process. Many sites that follow the VPLE process have contaminated groundwater.

After a person has conducted an environmental investigation of the property, and cleaned up soil and groundwater contamination, the DNR will issue a "Certificate of Completion" which provides a release from future liability for any contamination that occurred on the property prior to issuance of the certificate. In FY 06, DNR issued a Certificate of Completion at nine properties for completed cleanups and 13 new sites began the voluntary cleanup process.

Drycleaner Environmental Response Fund (DERF) Program. The DERF program reimburses drycleaner owners and operators for eligible costs associated with the cleanup of soil and groundwater at sites contaminated by dry-cleaning solvents. Fees paid by the dry-cleaning industry provide program funding. Environmental cleanups at dry cleaner sites are conducted following the NR 700 rule series. To date, there are more than 130 sites in the program, at various stages of investigation and cleanup. The program is implemented through ch. NR 169, Wis. Adm. Code.

Site closure rules for petroleum contaminated sites. Under the Petroleum Environmental Cleanup Fund Award (PECFA) Program, NR 746 – and its Department of Commerce counterpart, Comm 46 – was promulgated in February 2001. The bulk of NR 746 establishes risk and closure criteria to determine whether petroleum contaminated sites can be closed using natural attenuation as a final remedy for groundwater contamination. The rule also defines which petroleum-contaminated sites DNR and Department of Commerce have authority to administer; summarizes site investigation requirements, and delineates other administrative requirements such as when remediation and remediation funding is terminated, tracking and transfer of sites, staff training and dispute resolution.

The rule provides that sites with contamination in low permeability (clay) materials can close after a site investigation if all risk criteria are met and the groundwater contamination is stable or receding. For contamination in permeable materials, sites must meet all risk criteria and demonstrate through monitoring that groundwater contaminants are declining. Sites requesting closure with groundwater contamination above NR 140 enforcement standards are placed on the GIS Registry of Closed Remediation Sites.

NR 726 provides closure requirements for all other sites.

Tracking System and GIS Applications. The program's main database on the status of sites undergoing investigation and/or cleanup is the Bureau of Remediation and Redevelopment Tracking System (BRRTS). In 2000, the program created *BRRTS on the Web*, making the DNR's main database for contaminated properties accessible via the Internet.

In 2001, revisions to NR 726, 716, 749, and 811/812 implemented a Geographic Information System (GIS) Registry of Closed Remediation Sites to replace the requirement to record groundwater use restrictions at the County Register of Deeds Office. In 2002, additional rule revisions required the inclusion of sites with residual soil contamination on the GIS Registry. The GIS Registry currently includes locational information on sites closed with residual groundwater contamination above the NR 140 enforcement standards and sites closed with soil contamination above NR 720 soil standards, as well as site specific information pertaining to where the contamination is on the property in question and at what concentration it was found at the time the closure decision was made. In 2006, new legislation in WI Act 418 replaced the use of deed restrictions for certain sites with residual soil contamination with conditions of closure and placement on the GIS Registry.

Inclusion on the GIS Registry on the Internet provides a means of notifying future owners or users of the property of the existence of soil and/or groundwater contamination, as well as any responsibilities of the property owner (or occupant in some cases) to comply with any conditions of closure. The site specific information is attached to each site by a link to a .pdf. The GIS Registry can be accessed on the Internet.

The GIS Registry is to be used with well construction requirements for private wells, and with a setback distance for new municipal wells. Beginning in July 2004, the DNR made the GIS Registry information available to well drillers through a Well Construction CD that is updated twice a year. Before drilling, well drillers are asked to consult the CD to determine if a well is proposed for a property listed on the Registry. If the proposed well is located on a closed remediation site, then the driller must contact regional Drinking Water and Groundwater staff prior to any well construction activities to determine if additional casing or other construction techniques may be required.

In 2005, an additional GIS application was made available, called the RR Sites Map. This application shows the locations of the majority of sites available on BRRTS (open and closed), or provides an address for those sites for which geolocational coordinates have not yet been obtained. The RR Sites Map can also be accessed on the Internet.

The GIS applications are linked to *BRRTS on the Web* and are all useful for locating potential contamination sites when evaluating new municipal well placement or for property transactions. These databases make site specific information on open and closed remediation sites much more available and accessible to the public and specific interested groups, particularly those wanting to install or replace a potable well on an affected property, as well as those buying properties. Sites regulated by the Departments of Commerce and Agriculture, Trade and Consumer Protection are also included in *BRRTS on the Web, the GIS Registry and RR Sites Map.*

The RR Program continues to make improvements to both BRRTS and the GIS applications. The existing GIS applications are intended to be converted to ESRI's software product, ARCIMS, so that the programming and other maintenance tasks can be accomplished more quickly and at a lower cost. In addition to the ongoing efforts, work continues on quality assurance and quality control (QA/QC) of existing data.

Watershed Management

The Bureau of Watershed Management (WT) is responsible for statewide implementation of DNR's groundwater standards primarily through the issuance of discharge permits to facilities, operations and activities that discharge treated wastewater and residuals to groundwater. Field staff that work on integrated basin teams carry out compliance and enforcement activities using policies, codes and guidelines developed by the WT program. Integrated basin planning carried out in the field under guidelines developed by WT assess and evaluate groundwater (and surface water) and provide general and specific recommendations for the protection and enhancement of the basin's groundwater.

Wastewater discharges. WT issues Wisconsin Pollutant Discharge Elimination System (WPDES) permits to all communities, industrial facilities, and large privately owned wastewater systems which discharge treated domestic or industrial wastewater to groundwater through land treatment/ disposal systems. These systems are primarily spray irrigation, seepage cell, subsurface absorption systems, and ridge & furrow treatment systems. WPDES permits issued to these

facilities contain groundwater monitoring and data submittal requirements that are used to evaluate facility compliance with ch. NR 140, Wis. Adm. Code, groundwater quality standards. Groundwater monitoring systems at existing facilities are evaluated and upgraded as necessary at permit re-issuance.

WT maintains a database, designated the System for Wastewater Applications, Monitoring, and Permits (SWAMP), for holders of specific WPDES and general permits. This database system stores facility specific information such as address, contacts, location, permit requirements, monitoring results, and violations of permit requirements for private and municipal wastewater treatment facilities. The system contains current information on groundwater, wastewater, and biosolids treatment/management. Historical sampling data from groundwater monitoring wells is available through the system and current sample results are added on a monthly basis. Sampling results and site loading information are also available for land application of municipal biosolids, septage and industrial sludge, by-product solids and wastewater.

WT continues to assist unsewered communities, served by failing or inadequate individual on-site treatment systems in their efforts to construct centralized wastewater treatment facilities.

In 2000, the Department of Commerce and DNR completed revision of an interagency memorandum of understanding after Commerce issued rules for private onsite wastewater treatment systems under ch. Comm 83, Wis. Adm. Code. The DNR completed refined procedures, guidance, and rules for the review and permitting of large private onsite wastewater treatment systems (POWTS). In general, large POWTS are defined as those with a capacity of greater than 12,000 gallons per day (gpd). The DNR started issuing permits to large POWTS in early 2000. On February 1, 2005 WT issued a general permit to regulate the operation of these types of systems in a more streamlined manner.

Septage and sludge management. WT implements the regulations in chapters NR 113, NR 204 and NR 214, Wis. Adm. Code. NR 113 relates to septage management and NR 204 governs the treatment quality, use, and disposition of municipal wastewater treatment plant sludge. NR 113 and NR 204 incorporate federal septage and sludge standards. WT regulates the land application of industrial sludge, liquid wastes and by-product solids through NR 214. Chapters NR 113, NR 204 and NR 214 contain treatment quality standards and land application site requirements and restrictions that are designed to prevent runoff to surface water or leaching of nutrients and pollutants to groundwater.

WT continues to implement a new statewide computer system that records and monitors treatment and disposal of municipal sludge, septage, and industrial land applied wastes. This system includes an inventory and a history of all sites used for land application. Wisconsin became the fourth state delegated authority by EPA to implement municipal sludge regulations, through its delegated NPDES (WPDES) permit program, in July of 2000.

Wisconsin Act 347 became effective April 29, 2006 and provides incentives for more wastewater treatment plants to accept and treat septage. This is accomplished through the offer of a zero percent Clean Water Fund loan for the planning, construction of receiving facilities, and additional capacity provided for septage. Facilities whom are upgrading capacity by more than 20% must evaluate septage generation and available disposal options in their planning area during facility planning. Although they are not mandated to provide such capacity they are offered the zero percent loan if they do so. Structures are provided by which Publicly Owned Treatment Works establish costs for receipt of septage and a process is laid out for dispute resolution when such costs are questioned. Land application also remains a viable option when appropriate and

the Act provides explicit pre-emptive authority to the state by disallowing restrictive local ordinances if they are not identical to state regulations.

Agricultural runoff. Chapter NR 243 Wis. Adm. Code covers the permitting requirements for livestock operations and currently contains provisions to protect surface water and groundwater in Wisconsin. DNR has proposed changes to ch. NR 243, Wis. Adm. Code to address revisions to federal rules that govern the operation and permitting of large concentrated animal feeding operations (CAFO) that were promulgated in April 2003. The proposed revisions to NR 243 improve groundwater protection from CAFOs by increasing setback requirements from community and non-community wells and karst features; and further restrict winter application of manure in areas with shallow soils over bedrock and groundwater. The Natural Resources Board adopted the proposed revisions to NR 243 in May 2005 and the rules are now before the state legislature for review. The rules are expected to be finalized in fall of 2006.

Under this existing rule, there are currently 146 WPDES permits issued for livestock operations (85% dairy; 8% poultry; 7% swine & beef). In addition, there are 5 large-scale livestock operations seeking permits for the first time. Regional and central office staff have successfully maintained the permit backlog at less than 15%. The trend of growing numbers of permit applications for operations with 1,000 or more animal units is expected to continue. In early 2005, a number of livestock operations (some not regulated as larger systems) had discharges that adversely impacted surface water and non-community wells. DNR investigated these incidents, initiated enforcement actions, and is evaluated the effectiveness of programs and procedures that are designed to protect water resources. The proposed revisions to NR 243 (see above) contain elements that are intended to help avoid discharges from permitted operations seen in 2005.

Storm water. Final revisions to Chapter NR 216, Wis. Adm. Code were promulgated on August 1, 2004. The revisions were completed primarily to comply with federal storm water regulations that took effect on March 10, 2003. The revisions to NR 243 requires nearly 200 municipal separate storm sewer systems to obtain permit coverage and also requires construction sites down to one acre of land disturbance to have permit coverage to control erosion during construction. Permit holders will also are required to install post-construction practices to limit pollutant discharge after construction is completed (storm water management). The DNR has developed performance standards (i.e. 80% sediment control, infiltration, peak flow, buffer requirements, etc.) that became effective in 2002. Many of these standards will be implemented through storm water permits, especially for new development.

Nutrient management plans: One of the performance standards included as part of the Nonpoint Redesign Initiative was a nutrient management standard, NRCS Standard 590. Under the rules, the performance standard itself became effective January 1, 2005 for high priority areas in the State (source water areas, impaired waters and outstanding/exceptional resource waters). The standard will become effective for the remainder of the state in 2008. On an ongoing basis, federal, state and local agencies are working to build the necessary resources and expertise to implement NRCS Standard 590. As an example, the Department of Agriculture, Trade and Consumer Protection (DATCP) cooperatively revised the technical standard to achieve DNR's performance standards. Although the implementation of the performance standards is limited by the amount of cost share that is available to participants, NRCS has provided extensive support of nutrient standards implementation through the EQIP cost share program.

For more information, visit the following website (http://dnr.wi.gov/) or contact Todd Ambs at 608-264-6278 (Todd.Ambs@dnr.state.wi.us) or Mike Lemcke at 608-266-2104 (Michael.Lemcke@dnr.state.wi.us), DNR, P O Box 7921, Madison, WI 53707-7921.

DEPARTMENT OF AGRICULTURE, TRADE AND CONSUMER PROTECTION

Protecting Wisconsin's groundwater is a priority for the Department of Agriculture, Trade and Consumer Protection (DATCP). DATCP's major activities in this area include management of pesticides and nutrients, research, and funding of local soil and water resource management projects.

In compliance with the Wisconsin Groundwater Law (1983 Wisconsin Act 410), DATCP manages pesticides and pesticide practices to assure that established groundwater standards for contaminants are not exceeded. This may include prohibition of certain activities including pesticide use. The agency also manages practices to "minimize" groundwater contamination to the extent "technically and economically feasible." DATCP regulates storage, handling, use, and disposal of pesticides, and the storage of bulk quantities of fertilizer. DATCP has authority to develop a statewide nutrient management program through section 92.05 Wis. Stats. The program includes compliance, outreach, and incentive components.

Enforcement standards have been established in Wisconsin for many known and potential groundwater contaminants, including over 30 pesticides. Standards for additional pesticides have been proposed. DATCP applies these standards and the Groundwater Law when addressing nonpoint and point sources of pesticide contamination in groundwater.

Nonpoint Source Activities

Pesticides. DATCP's primary effort related to nonpoint contamination (i.e., due to general use) of groundwater from pesticides continues to involve the herbicide atrazine. In response to concerns about atrazine contamination, DATCP amended administrative rule ch. ATCP 30 in 1992 to manage the use of atrazine in an effort to reduce or eliminate the potential for further groundwater impacts. Rule revisions have been made annually in response to additional detections of atrazine in groundwater. A set of 102 maps of new or existing prohibition areas is available from the Environmental Quality Section covering 1.2 million acres that have been incorporated into the rule. Information suggests that atrazine use has declined from peak levels in the late 1980's and is now holding roughly constant. The decline in use may have been a result of the atrazine management rule and concern about groundwater contamination.

Nutrients. DATCP, through its land and water resource management program, provides funding primarily to counties to assist in the protection of water resources through farmer adoption of nutrient management planning. A portion of this funding is dedicated to the development and implementation of improved nutrient and pesticide management practices. In FY 06 approximately $90,000 was provided to develop tools for nutrient management plans on farms to maximize profitability and to minimize excessive runoff of nutrients to surface and groundwater. $520,000 was budgeted and allocated in FY 06 to provide cost-sharing to write nutrient management plans. In 2005 the total reported acres with nutrient management plans was 772,661 acres. Additionally, staff worked to train farmers, consultants, and local agencies on the principles of sound nutrient management and how to comply with performance standards.

Point Source Activities

Previous work by DATCP identified pesticide and fertilizer operations as possible point sources of groundwater contamination. Past problems included improper disposal of unwanted agricultural chemicals, lack of containment for spills, out-dated product handling methods, and poor understanding by workers in the industry of how small actions when continued over time

lead to large problems. DATCP has worked to address these problems through point source prevention. In cases where environmental degradation has already occurred, DATCP oversees environmental cleanup of contaminated soil and groundwater.

Point source prevention for agrichemicals includes Agricultural Clean Sweep, enforcement of product containment rules and handling regulations, and education beyond the rule requirements through the Environmental Partners program. Point source cleanup activities are performed under the Agricultural Chemical Cleanup Program (ACCP), which provides technical oversight and reimbursement to offset much of the costs for investigation and cleanup.

Since 1990, the Agricultural Clean Sweep program has helped farmers dispose of unwanted pesticides, farm chemicals, and empty pesticide containers. Beginning in 1996, the program extended collection services to small agricultural businesses. In 2004 DATCP began operating and managing the state's household hazardous waste program. Approximately $731,500 was made available during 2005 for both agricultural and household programs and more than 600,000 pounds of waste were collected.

DATCP's rules for minimizing environmental damage from agrichemical storage and handling were put in place in 1988. Fourteen local DATCP specialists work with facilities across the state to keep them in compliance with the ATCP rules designed to protect the environment. DATCP staff also educate facility managers and employees about how routine practices may affect the environment.

The Environmental Partners program works to reduce the amount of agrichemicals that escape into the environment. 2005 was the fifth year for this program. Participation in the program is voluntary with the agrichemical industry and Department working together to identify the problems and brainstorm ideas to reduce pollution. The ideas used to solve problems at each facility are shared so that everyone can learn and benefit from the program.

In August 1993, section 94.73 of the Wis. Stats. was created and established the Agricultural Chemical Cleanup Program (ACCP) to address point sources of contamination. The ACCP reimburses responsible parties for cleanup costs related to pesticide and fertilizer contamination at facilities and in nearby wells. The program may also handle point source contamination on farms. To date, more than 390 cases involving soil and/or groundwater remediation related to spills, misuse, and improper storage or mixing and loading have been initiated at pesticide and fertilizer facilities and on farms.

The ACCP also funds DATCP oversight of pesticide and fertilizer cleanup activities. Program staff respond to and investigate pesticide and fertilizer contaminated sites throughout the state. Investigations at these sites are prioritized based on suspected contamination levels, with the higher levels investigated first. Investigations include discussions with facility staff or farmers to determine the most likely locations of contamination at the site. Other oversight activities include, but are not limited to, sample collection, laboratory analysis, and financial auditing.

Groundwater Sampling Surveys

DATCP conducts a number of annual surveys to investigate the occurrence of pesticides in groundwater resulting from nonpoint sources. Results of these surveys are provided in the "Pesticides" section under *Condition of the Resource - Groundwater Quality*.

Research Funding

Pesticide Research - Due to budget constraints, DATCP did not have funding for new pesticide research projects in FY06.

Nutrient Research - DATCP funds fertilizer research at approximately $130,000 per year.

Groundwater Data Management

DATCP maintains two groundwater sample databases: the Drinking Water Well System and the Monitoring Well System. The Drinking Water Well System contains contact and location information, well characteristics, and pesticide and nitrate sample results for private and public drinking water wells. The Monitoring Well System contains similar information for monitoring wells, and also tracks specific pesticide use history, soils, crop history, well construction, and precipitation and irrigation at monitored sites. These data represent samples analyzed by DATCP, Wisconsin State Lab of Hygiene (WSLH), and other public and private laboratories. DATCP's Drinking Water Well System currently contains information for over 38,000 wells and nearly 240,000 pesticide and nitrate-N results.

DATCP uses geographic information system (GIS) tools to analyze groundwater data and prepare maps for public hearings, DATCP board meetings, presentations, and other uses. DATCP prepares and maintains ArcInfo and ArcView data layers of well locations, atrazine concentrations, atrazine prohibition areas, and other pesticide and nitrate-N data. These GIS layers and associated database information are used to generate maps of statewide pesticide and nitrate-N detections in wells, as well as maps for chapter ATCP 30, Wis. Adm. Code (Pesticide Product Restrictions). For example, see the map of "Private Wells Tested for Atrazine in Wisconsin" in Chapter 4, *Condition of the Groundwater Resource*. Other GIS analyses involve identifying groundwater wells that may be impacted by point sources of pesticide and nitrate-N contamination. DATCP also uses global positioning system (GPS) receivers to locate and map wells and other features, such as agrichemical facilities and spill sites, that may affect groundwater quality.

For further information, visit the following web site (http://www.datcp.state.wi.us) or contact Kathy Pielsticker, DATCP, 2811 Agriculture Drive, PO Box 8911, Madison, Wisconsin, 53708-8911; phone: 608-224-4567; e-mail:kathy.pielsticker@datcp.state.wi.us.

DEPARTMENT OF COMMERCE

Two of the seven Divisions of the Department of Commerce regulate activities, protect or remediate Wisconsin’s groundwater resources.

Within the Division of Safety and Buildings, two programs have the responsibility of safeguarding public health and the waters of the State. Graywater reuse and stormwater is regulated by the Plumbing Program (Admin. Code Comm 82) and private onsite wastewater treatment systems by the Private Onsite Wastewater Treatment Systems Program (Admin. Code Comm 83).

Within the Division of Environmental and Regulatory Services (ERS), two bureaus regulate petroleum tanks and petroleum cleanups: The Bureau of Petroleum Products and Tanks regulates flammable and combustible liquids and hazardous substance liquids (Admin. Code Comm 10).

The Bureau of PECFA reimburses owners and operators of leaking petroleum storage tanks (Admin Code Comm 47) and has regulatory jurisdiction of petroleum sites determined to be a low or medium risk to the environment (Admin Code Comm 46).

Plumbing – Reuse, Stormwater and Private Onsite Wastewater Treatment Systems (POWTS)

In addition to public health and safety, the water supply and quality issues facing Wisconsin are a focus of the General Plumbing and POWTS programs in the Department of Commerce.

General Plumbing – Reuse and Stormwater Use. The Department plumbing code includes standards for reuse of gray water and stormwater. Currently, with revised stormwater rules, plumbing will be integrally involved with the design and installation of storm systems complying with NR 151.

Private Onsite Wastewater Treatment Systems (POWTS). The Department continues to communicate with the Department of Natural Resources regarding mutual issues such as large onsite sewage systems, mixed wastewater treatment systems and Underground Injection Control (UIC) regulations. The Department has increased its communication with the USEPA Region 5 office regarding POWTS related matters. Department staff continue to participate in an effort to develop a national model code related to onsite sewage systems.

Petroleum Product and Hazardous Substance Storage Tanks

The ERS Division continues to maintain regulatory oversight of aboveground and underground petroleum and CERCLA hazardous substance storage tanks in the Comm 10 administrative code. Underground storage tank regulations include the Federal EPA Underground Storage Tank (UST) requirements, as well as heating fuels, tanks supplying stationary combustion engines such as emergency generators, and other tanks storing regulated liquid products. Comm 10 is progressing with the Phase II revision to address technical requirements associated with current day concerns, trends and technology.

Since 1991 the database inventory of petroleum product tanks regulated under Comm 10 has increased from 143,681 to 206,695 USTs as previously unregistered tanks have become registered. In 1991 the database included 68,056 tanks classified as federally regulated with 51,088 of those tanks in use. As of June 19, 2006 the database reflects 80,319 federally regulated tanks with only 12,402 tanks in use and 254 in temporary-out-of-service status. In order to maintain a federally regulated tank in use, the tank must have a valid "permit-to-operate." Permit renewal administrative review includes compliance assessment of the owner's financial responsibility. Federally regulated and large fuel oil USTs are subject to periodic inspections involve verification of leak detection, spill and overfill protection, and record keeping.

Program tank permit initiatives have resulted in approximately 92% of the tanks required to have financial responsibility being in compliance with the rule. The remaining tanks will not be permitted and will be shut-down if financial responsibility coverage is not verified. The closure of federally regulated tanks will continue, but at a slower pace than experienced over the past few years. Closure of out-of-service residential heating fuel tanks is continuing as realtors and lenders recognize the potential problems and liability.

The closure of underground storage tanks is being supplanted by private fueling moving to retail fueling and some operators moving storage tanks to above ground. Residential heating fuel has

not been significantly impacted, as the closures are generally associated with the conversion to natural gas or liquid propane gas (LPG).

Proactive educational outreach efforts and annual inspections by the Department and its agents have resulted in a high level of regulatory compliance, and a reduction of system failures and environmental contamination. The ongoing regulatory challenges are owner operational compliance with leak detection. Wisconsin's progress and regulatory oversight continues to reflect very favorably with the US EPA.

Petroleum Environmental Cleanup Fund Act (PECFA)

Since 1989, the PECFA program has reimbursed approximately $1.45 billion to petroleum storage tank system owners for costs associated with the investigation and remediation of petroleum contaminated sites. The program, in addition to auditing owner invoices and authorizing payments, performs technical reviews of site investigations, evaluates the feasibility of remedial options, conducts a competitive public bid process for scopes of work, and makes decisions regarding closures for the majority of the State's leaking underground storage tank (LUST) sites.

The petroleum inspection fee supports PECFA's spending authority. The spending authority was $40.4 million in FY06 and is $37.6 million for FY07. In FY05, the PECFA program reimbursed $47.2 million to 1284 claimants. In FY06, the PECFA program reimbursed $21.3 million to 825 claimants. Currently, costs claimed per month are at or below the monthly spending authority and the program provides reimbursement within approximately three to four months of receiving the claim.

The previous budget bill eliminated the PECFA bonding authority and reduced the Petroleum Inspection Fee by one cent as of 5/1/06. The proceeds from the sale of revenue bonds were used to pay down the backlog of audited claims awaiting payment. The total current outstanding debt is $752 Thousand.

In addition to administering the PECFA fund, the Department of Commerce PECFA Bureau has the administrative authority for low and medium risk petroleum contaminated sites (which includes both soil and groundwater sites). The Bureau closes approximately 200 sites per year.

Data Management

Commerce is continuing its data integration information technology (IT) initiative. With regard to groundwater protection, Commerce maintains databases of underground petroleum storage tank systems and properties with petroleum contamination either in the past or currently. This year, the PECFA Bureau has introduced web reporting to the environmental consulting industry. Environmental consultants will provide data regarding groundwater and soil contaminant levels via the Internet. The data is directly entered into the Department's database and is available immediately to staff for review. The database also stores information on activities associated with on-site sewage system design, installation and maintenance. The Department continues to participate in discussions with county code administrators, service providers and other interested parties relative to reporting and recording of inspection, maintenance and servicing events for onsite sewage systems. Governmental units continue to enhance their maintenance reporting abilities. More are expected to follow in the future as the department begins implementation of POWTS program related provisions contained in 2005 Wisconsin Act 347.

For more information, visit the following web site or contact Berni Mattsson, ERS Division Administrator, P. O. Box 7839, Madison, Wisconsin 53707-7839, phone: 608-266-9403, fax: 608-267-1381; e-mail bmattson@commerce.state.wi.us.

DEPARTMENT OF TRANSPORTATION

The Department of Transportation (DOT) regulates the storage of highway salt (ss. 85.17 and 85.18, Wis. Stats.) to protect the waters of the state from harm due to contamination by dissolved chloride. DOT is also responsible for potable well sampling at 29 rest areas and 73 waysides. Other DOT groundwater related activities include: road salt research; hazardous material and waste investigation or remediation; wetland compensation and research; and storm water management and research. Various divisions and sections in DOT are responsible for these activities:

- Salt Use and Storage - Bureau of Highway Operations
- Salt Research - Bureau of Highway Construction (Geotechnical Section)
- Hazardous Materials (petroleum) - Environmental Services Section
- Hazardous Waste - Environmental Services Section
- Wetlands - Environmental Services Section
- Erosion Control and Storm Water Management - Environmental Services Section
- Rest Area Potable Well Sampling - Bureau of Highway Operations

Salt Storage

Highway salt is stored statewide by suppliers, counties, cities, villages, and private companies. Annual inspections occur and reports are provided for salt storage sites to insure that storage practices are in accordance with ch. Trans 277, Wis. Adm. Code (Highway Salt Storage Requirements). The intent of the Code is to help prevent entry of highway salts into waters of the state from storage facilities. All salt must be covered and stored on an impermeable base. The base for stockpiles is required to function as a holding basin and to prevent runoff. The covers must consist of impermeable materials or structures to prevent contact with precipitation. State funded facilities are being added to the DOT salt storage program to provide greater capacity of indoor storage. This will improve groundwater protection and create greater flexibility for scheduling salt purchase at optimal prices.

The DOT annually updates salt storage facility records into a database and assists the DNR source water protection program in locating salt storage facilities for GIS mapping applications. There are currently 1,219 salt storage sites listed in the database and 2,320 sub-sites. Each county keeps detailed inventories of salt which are updated monthly. Facility inventories, inspections, repairs and improvements are included in the database.

Salt Use

The DOT Bureau of Highway Operations produces the Annual Winter Maintenance Report describing statewide salt use based on weekly reports from each county. Current policy in the State Highway Maintenance Manual restricts the spreading of deicer salts to a maximum of 400 pounds per lane mile per initial application, and 300 pounds per lane mile for subsequent applications. Electronic controls for salt spreader trucks are continually tested to record and verify application rates and coverage effectiveness. Other technology is used on county highway patrol trucks to keep salt on pavement surfaces (e.g., zero-velocity spreaders, ground speed

controllers, and onboard liquid pre-wetting units). Additional efforts to minimize and conserve salt applications include the use of in-situ weather monitoring system. Pavement temperature sensors recorded at 62 locations along major highway routes are used to determine application methods. Annual training for snowplowing and salt spreading techniques is provided for county snowplow operators.

Salt Monitoring and Research

Since 1970, DOT has investigated potential road salt impacts on the environment adjacent to highways. Early investigations (1970s to early 80s) were focused on evaluating road salt impacts to surface water runoff, vegetation, and soils. In the last several years DOT has conducted limited investigations evaluating road salt impacts to groundwater. Approximately 20 sites throughout the state have been studied. In general, 1 or 2 shallow monitoring wells at each site were monitored quarterly for a period of 5 years. The monitoring consists of analyzing soil, water, or vegetation samples for calcium, sodium, chloride, and electrical conductivity. Approximately 5 sites are currently monitored, and new sites are added periodically. Results from the studies are discussed in 5 separate DOT progress reports entitled: Investigation of Road Salt Content of Soil, Water and Vegetation Adjacent to Highways in Wisconsin (1972, 1975, 1979, 1989 and 1996).

For more information, visit the following web site (http://www.dot.state.wi.us) or contact Mr. Dan Scudder, Chief, Environmental Services Section, Room 451, P. O. Box 7965, Madison, Wisconsin 53707-7965; phone: 608-267-3615, or e-mail dan.scudder@dot.state.wi.us.

DEPARTMENT OF HEALTH AND FAMILY SERVICES

Chapter 160, Wis. Stats., directs the Department of Health and Family Services (DHFS) to recommend health-based enforcement standards for substances found in groundwater and specifies the protocol for developing the recommended standards. Recommended standards are sent to the DNR and are submitted through the rule-making process as amendments to ch. NR 140, Wis. Adm. Code. DHFS staff serve as a primary resource for information about the health risks posed by drinking water contaminants, and are charged with investigating suspected cases of water-borne illness. Toxicologists, public health educators, and epidemiologists employed in the Department's Division of Public Health present this information to the public at meetings and conferences, and provide direct assistance to Wisconsin families via home visits, letters to well owners, and telephone consultations. DHFS staff review correspondence sent to well owners by DNR representatives. The agency frequently provides supplemental advice to owners of wells that are highly contaminated with volatile substances such as benzene and vinyl chloride, especially in cases where the contaminants may pose concerns from inhalation of indoor air. Follow-up letters sent by DHFS explain the health effects of specific contaminants and suggest strategies for reducing exposure until a safe water supply can be established. DHFS staff are called upon to review the toxicity of constituents of well construction and rehabilitation products to ensure that products approved for use in Wisconsin can be used safely without risk of chemical overexposure. DHFS prepares and distributes a wide variety of informational materials on groundwater and drinking water issues related to human health.

Summary of Agency Activities in FY 06

In December of 2005, DHFS sponsored a conference in Madison for local health department staff and others interested in environmental health hazards. The program included several

presentations on local health responses to chemical and bacteriological groundwater contamination events, and on the application of GIS technology to the management of groundwater quality.

Over the past four years, DHFS has worked on developing environmental public health tracking (EPHT) modules for childhood cancer, multiple sclerosis (MS) and amyotrophic lateral sclerosis (ALS) to create data systems that link information on relevant hazards, exposures and health outcomes. In support of this initiative, DHFS is working with DNR to access groundwater and drinking water data to create exposure profiles and generate environmental hypotheses about the etiology of these conditions. As part of this cooperative agreement, DHFS has identified and developed environmental public health indicators of priority drinking water contaminants such as total trihalomethanes (TTHMs) and arsenic in community water supplies, and county-level indicators of nitrate contamination of private wells. Additional county level indicators describing the proportion of the total population served by private or public wells, and surface or groundwater drinking water sources have also been developed. All indicators serve as tools to assist in developing future targeted environmental health analyses. Other partners in this initiative include DATCP, the Wisconsin State Laboratory of Hygiene, and the UW's Division of Information Technology (DoIT) and School of Medicine and Public Health.

Throughout 2005 and 2006, DHFS oversaw the implementation of multiple environmental public health projects relating to groundwater-related issues. DHFS staff developed a screening level tool that uses a hazard risk score to estimate where the potential for exposure to agricultural pesticides in groundwater is greatest. The algorithm integrates datasets from DNR and DATCP to characterize the potential for exposure at various geopolitical boundaries. DHFS also worked with DATCP to use previous survey sampling results to explore the relationship between nitrates and pesticides in private wells. The analysis showed a clear trend towards a higher proportion of pesticide detections as the concentration of nitrate-N increases in wells; however, the strength and magnitude of the relationship varied by agricultural regions. This suggests that the relationship is also dependent upon variations in agricultural practices, crop production, geology and soil type.

In 2006, DHFS has also been integral in national CDC-supported initiatives to explore the utility and feasibility of incorporating consistent and comparable drinking water contaminant measures onto a national environmental public health tracking (EPHT) network. DHFS staff co-chair the drinking water workgroup of the State Environmental Health Indicators Collaborative (SEHIC), in which state Safe Drinking Water Information Systems (SDWIS) data have been evaluated for development of state level public health indicators. Through SEHIC, DHFS established partnerships with the U.S. Geological Survey (USGS) to map and explore geological predicators of groundwater contamination in the state. DHFS has also been an active participant in a national Drinking Water Exposure Methods Workgroup, which has sought to improve methods of estimating community-level contaminant exposures based on monitoring data and water distribution system parameters. The workgroup developed an online tool to survey water utilities and wrote guidance to identify relevant drinking water data and critical data gaps for estimating exposures and using existing data resources in public health assessments.

For more information, visit http://dhfs.wisconsin.gov/eh/Water/, or contact Henry Anderson (608-266-1253; anderha@dhfs.state.wi.us), Lynda Knobeloch (608-266-0923; knobelm@dhfs.state.wi.us) or Mark Werner (608-266-7480; wernema@dhfs.state.wi.us), 1 W. Wilson St., Rm. 150, Madison, Wisconsin, 53702.

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

The Wisconsin Geological and Natural History Survey (WGNHS), University of Wisconsin-Extension, performs basic and applied groundwater research and provides technical assistance, maps, and other information and education to aid in the management of Wisconsin's groundwater resources. The WGNHS groundwater program is complemented by the geology and soils programs, which provide maps and research-based information essential to the understanding of groundwater recharge, occurrence, quality, and movement.

Highlights of the WGNHS groundwater activities for FY 06 include the following:

Groundwater-level monitoring network

Wisconsin's statewide groundwater-level monitoring network has been operated jointly with the U.S. Geological Survey (USGS) since 1946. Currently, the network consists of approximately 140 wells in 66 counties. The groundwater-level monitoring network provides a consistent, long-term record of fluctuations in water levels in deep and shallow aquifers. Such information is critical for accurate analyses of the effects of high-capacity wells pumping, the response of groundwater levels to droughts, and the effects of land-use changes on groundwater systems. The WGNHS will continue to supply the information to public and private clients and aid in data interpretation. For available data see http://wi.water.usgs.gov/public/gw/.

County groundwater studies.

Geologic and groundwater studies at the county scale continue to be an important part of WGNHS programs. During 2005 the Survey initiated or carried out geologic and/or groundwater studies in the following counties: Dane, Calumet, Fond du Lac, Iowa, Outagamie, Pierce, St Croix, Sauk, Washington, Waukesha, and Winnebago. Many of these studies will generate or have generated water-table maps. For a current list of available county-scale water-table maps see http://www.uwex.edu/wgnhs/watertable1.htm.

Regional groundwater studies

Regional geologic and groundwater studies usually span multiple counties. During FY 06 the WGNHS was involved in several regional projects, including the following:

a. Geologic and hydrogeologic analyses in southeastern Wisconsin. The WGNHS conducted regional groundwater modeling in the SEWRPC (Southeastern Wisconsin Regional Planning Commission) region, spanning seven counties in SE Wisconsin. (see http://www.uwex.edu/wgnhs/gw_se_wisc.htm and http://water.usgs.gov/pubs/fs/fs-116-03/)

b. Development of well-drilling guidelines for the Lower Fox River Valley. This effort assisted the DNR in developing casing guidelines to reduce potential arsenic contamination in private wells. See http://www.dnr.state.wi.us/org/water/dwg/arsenic/casingrequire.htm

c. Geologic mapping and groundwater investigations. With funding from the federal STATEMAP program and additional funding from the UW Groundwater Research Advisory Council (GRAC), WGNHS scientists are preparing new geologic maps and acquiring new groundwater data for Iowa, Pierce, Polk, and St Croix Counties.

Groundwater Research Activities

The WGNHS carries out specific groundwater research projects focused on understanding topics important to groundwater use and management in Wisconsin and elsewhere. Active projects during FY05 include the following:

a. *Methods of investigating aquitards.* Aquitards, low-permeability geologic materials such as clay or shale, are critical resources for protecting water-supply wells from contamination, yet are often difficult to characterize. In late 2005 the WGNHS completed a project funded by the American Water Works Association Research Foundation (AWWARF) for evaluation of the properties of aquitards. See http://www.awwarf.org/research/topicsandprojects/execSum/2780.aspx

b. *Arsenic in groundwater.* The WGNHS is continuing research on the source(s) and geochemical characteristics of arsenic contamination in water-supply wells in northeastern and southeastern Wisconsin.

c. *Groundwater recharge.* Groundwater recharge is critical to maintaining the supply of Wisconsin's groundwater, but mapping and quantifying recharge areas and rates can be a difficult process. In cooperation with UW-Madison, the WGNHS has developed a computerized technique for rapidly delineating recharge areas for use in regional groundwater models. Currently, the WGNHS is incorporating the recharge delineation methodology into new projects and is cooperating with the USGS in using it in other areas of Wisconsin.

d. *Fluid flow in fractured rocks.* Fractured rocks (limestone, dolomite and crystalline rocks) underlie much of Wisconsin and form important aquifers over large parts of the state. Groundwater in carbonate rocks can move through fractures and solution features. Groundwater velocities in such rocks can be unusually high, and the rocks usually have very low ability to attenuate contaminants. Work by the WGNHS on carbonate aquifers in eastern Wisconsin suggests that detailed stratigraphic analysis, coupled with geophysical and hydrogeologic data, may help predict the hydraulic properties of these complex and vulnerable aquifers.

   Karst features, including a variety of sinkholes, cavities, and solution openings, commonly are found in carbonate rock (limestone and dolomite). In recent years there has been increased concern about the hazards and effects of karst features in many parts of Wisconsin, but little published information has been available. The WGNHS is serving as a clearinghouse for karst information, and has begun assembling a karst database for the state: http://www.uwex.edu/wgnhs/karst.htm.

e. *Investigation of unsewered rural subdivisions*. Population growth and urban expansion in many areas has resulted in residential development on formerly agricultural land, but there have been few studies of the impacts of such developments on groundwater quality. To document the effects of this land-use conversion on groundwater quality, the WGNHS initiated a monitoring program to collect water-quality data before, during, and after construction of a new, unsewered subdivision located on agricultural land several miles outside of Madison, Wisconsin. See http://www.uwex.edu/wgnhs/pdfs/staffpdf/WilcoxBradburyetal2005.pdf

f. *Groundwater use*. This project began in FY 05 and focuses on determining the cause of exponential growth in groundwater pumping that has occurred in Waukesha County over

the last several decades, and compare this to changes in groundwater pumping that have occurred in a predominantly rural area (Sauk County). This study, funded by the USGS and the Water Resources Institute, will also evaluate methods for tracking groundwater pumping in Wisconsin.

g. *Hydrogeology/geochemistry in southeast Wisconsin.* A major issue facing water managers and users in eastern Wisconsin is a high, and in certain wells, increasing concentration of TDS and radioactivity in the deep sandstone aquifer. WGNHS scientists are working with USGS and UW-Milwaukee personnel to investigate these issues in Waukesha County. See http://www.wri.wisc.edu/Project-Grundl.html.

h. *Springs in Wisconsin.* During FY07 the WGNHS will also contribute to the understanding of springs in Wisconsin by providing office space, records, and other assistance to an employee of the Wisconsin Wildlife Federation who is developing a statewide springs inventory. This work is an outgrowth of the 2003 Groundwater Quantity Legislation and seeks to determine the numbers and types of springs that would be protected under that legislation.

Groundwater data management

During FY 06 the WGNHS continued to collect geologic and groundwater data and provide this data to a variety of users. Significant efforts include the following:

a. *WiscLith database*. The Survey has developed and distributed a digital database, called *wisc*LITH, that contains lithologic and stratigraphic descriptions of geologic samples collected from across the state. This database was updated during 2004. Current work efforts aim to improve the quantity of data for areas of the state where there are active geologic and hydrogeologic projects, and to improve quality control and consistency of information in the state-wide database. See http://www.uwex.edu/wgnhs/wisclith.htm

b. *Well construction reports.* The WGNHS serves as the repository for 1936–1995 Well Constructor's Reports, one- to two-page reports that are usually submitted to the DNR by a well driller within a few months of a well's completion. The database and scanned images are now available to state agencies, consulting firms, and private well owners on CD-ROM. See http://www.uwex.edu/wgnhs/wcrs.htm

c. *Tillpro Database*. TILLPRO is primarily a database of grain-size analyses performed on unlithified sediment samples collected from Wisconsin and analyzed in the Quaternary Laboratory at the Department of Geology and Geophysics, University of Wisconsin-Madison. During 2004 the WGNHS released this database for public distribution on CD-ROM. See http://www.uwex.edu/wgnhs/wisclith.htm

d. *New core and sample repository.* During 2004 the WGNHS acquired space for storage of geologic records, core samples, and other materials in Mt Horeb, Wisconsin. See http://www.uwex.edu/wgnhs/core.pdf

Groundwater education

WGNHS groundwater education programs for the general public are usually coordinated with the UW-Extension network of county-based faculty, the DNR, the Central Wisconsin Groundwater Center, or the UW-Extension Environmental Resources Center. The WGNHS also produces and serves as a distributor of many groundwater educational publications and visual aids. In FY 06

WGNHS staff members plan to participate in groundwater educational meetings in counties where county mapping and/or other hydrogeologic studies are in progress. Arsenic in groundwater and the potential groundwater implications of proposed quarries, gravel pits, and high-capacity wells have been popular topics recently and probably will continue to provide educational opportunities in FY 07. Geologic and hydrogeologic field trips for DNR water staff and new DNR employees have been held in the past and will continue in FY 07.

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For more information, contact Ken Bradbury, Wisconsin Geological and Natural History Survey, 3817 Mineral Point Road, Madison, Wisconsin, 53705-5100; phone: 608-263-7389; email: krbradbu@wisc.edu; Web site: http://www.uwex.edu/wgnhs/.

UNIVERSITY OF WISCONSIN SYSTEM

The University of Wisconsin System (UWS) has research, teaching and outreach responsibilities. These three missions are integrated through cooperation and joint appointments of teaching, research and Extension personnel who work on groundwater issues. UWS staff members work with state and federal agencies and other partners to solve groundwater resource issues. Citizen outreach is accomplished through use of publications, news media, public meetings, teleconferences, and water testing and satellite programs. Activities of several specific programs follow.

The UW Water Resources Institute (WRI)

The UW Water Resources Institute (WRI) is one of 54 water resources institutes located at Land Grant universities across the nation. It promotes research, training, and information dissemination focused on the nation's water resources problems.

Research. The WRI research portfolio includes interdisciplinary projects in four broad areas: groundwater, surface water, groundwater-surface water interactions, and drinking water. Groundwater is a top priority and an area of particular strength at the WRI. Key areas of emphasis

in FY 06 included identifying contamination of groundwater by pharmaceuticals and other endocrine disrupting compounds in groundwater, addressing groundwater resources in Wisconsin's Smart Growth planning, and developing treatment processes for pesticides and arsenic.

During FY 06, the WRI directed a wide-ranging program of priority groundwater research consisting of 12 projects. These included short- and long-term studies both applied and fundamental in nature. They provide a balanced program of laboratory, field, and computer-modeling studies and applications aimed at preserving or improving groundwater quality. Groundwater problems investigated during the past year include:

- Applying a screening technique to test for the presence of endocrine disrupting compounds in groundwater;
- Assessing the use of slag from steel processing for treatment of arsenic in groundwater;
- Determination of the role of hyporheic zones (layers of sediment beneath or adjacent to a stream) in the production and transport of methylmercury;
- Determination of the influence of trees on groundwater pesticide remediation;
- Testing the use of "rain gardens" for receiving runoff and recharging local aquifers;
- A better understanding of groundwater flow through a fen-stream complex in northern Wisconsin;
- Determining the processes affecting water infiltration through the uppermost soil levels;
- An investigation of the links between antibiotics leaching from onsite wastewater treatment systems and antibiotic resistance of microbes in groundwater;
- A study of speciation of arsenic in groundwater arsenic and its relationship to geochemical characteristics of the surrounding sedimentary deposits;
- Determination of permeability of volatile organic compounds through composite liners in landfills;
- Better understanding the ecological importance and determining indicators of springs in Wisconsin;
- Understanding how pesticides and fertilizers penetrate soils and enter subsurface aquifers in the unglaciated region of Wisconsin; and,
- Understanding how groundwater responds to climatic fluctations in the upper Midwest.

These 12 funded projects provided training in several disciplines for post-doctoral research associates, graduate student research assistants and undergraduate students at UW-Madison, UW-Milwaukee, UW-Stevens Point, UW-Extension and UW-Parkside.

The UWS selected eight new groundwater research projects from this year's Solicitation for Proposals for support during FY 07 (July 1, 2006–June 30, 2007) (see Table 2). Four projects, selected from the previous year's solicitation, will receive continuation support during FY 06. The new projects are based at UW-Madison and UW-Milwaukee.

Teaching. Institutions within the UWS continue to offer undergraduate- and graduate-level courses and programs focusing on diverse issues regarding groundwater resources. Additionally, several campuses offer for-credit, field-oriented water curriculum courses for middle and high school teachers during summer sessions. The WRI views education as an important component of its total program and recognizes the importance of K-12 education as a fundamental component of its outreach and training effort. The WRI distributes two publications—*Local Watershed Problem Studies-Elementary Activities* and *Local Watershed Problem Studies-Middle and High School Curricula Guide*—upon request. These two guides assist educators in the development

and dissemination of curricula concerning soil and water resources. In addition, the UW-Madison Water Resources Library has purchased a number of other guides with innovative approaches to teaching water-related science in K-12 classes.

Grants administration**.** WRI staff members developed a Web site that enables online proposal submission and review of the FY 07 Joint Solicitation of Groundwater and Related Research and Monitoring Proposals. The site allows investigators to submit proposals one section at a time, as they are completed, rather than waiting until the entire proposal document is finished. Having proposals in electronic format also makes the proposal peer-review process more convenient. Reviewers can log on to the site and review proposals at their convenience. Review packets for the GRAC funding meeting are generated directly from this Web-based database.

Water Resources Publications

In February 2006, WRI and the UW-Madison Department of Civil & Environmental Engineering published "Design Guidelines for Stormwater Bioretention Facilities" by Dustin Atchison, Ken Potter and Linda Severson. This manual provides design guidelines and a numerical model (RECARGA) that can be used for creating bioretention facilities for small-scale stormwater management that promotes infiltration of storm water in order to reduce its volume, improve its quality and increase groundwater recharge. A basic bioretention facility is commonly referred to as a rain garden. It is a landscaped garden in a shallow depression that receives storm water from nearby impervious surfaces.

UW Water Resources Library Outreach Activities

During the past year, the UW Water Resources Library maintained its involvement in outreach while continuing to serve university system faculty, staff and students. A highlight of the past year was the launch of a new library outreach Web site, **Wisconsin's Water Library for Kids** (*aqua.wisc.edu/waterlibrary/kids*). From Dr. Seuss to a simple explanation of the water cycle, "Wisconsin's Water Library for Kids" features children's books with aquatic themes that have won awards or appeared on best books lists. Most books are for preschool through second grade children, although there are also materials for older kids. Besides fiction and nonfiction books, the Web site also has ideas and resources for story hours. Users can browse recommended reading lists by topic (frogs, fish and fishing, Great Lakes, water pollution, etc.) and age group. Any adult Wisconsin resident can check out books online and pick them up at their local public library. Library staff involved three students from the UW School of Library and Information Studies in the development of the site. Tina Yao, the ASC Art Director, used pictures from the Water Library's Allied Drive Story Hour series to design the site.

Library staff also continued to be involved in the "Allied Drive Story Hours" doing a story hour in July 2005 based on picture books about frogs. Allied Drive is a neighborhood of Madison, Wisconsin which is pocket of poverty and crime. The "Allied Drive Story Hours" began during the summer 2004 when the Water Resources Library launched the first of a series of story hour programs. The project has since become a partnership between six other specialized campus libraries, the UW-Madison School of Library and Information Studies, and the Madison School and Community Recreation Safe Haven Childcare Program. The library's July story hour received television coverage.

Web Sites

WRI maintains several other Web sites in addition to the site for the Eight International Conference on Mercury as a Global Pollutant described above. The **UW Water Resources Institute Web Site** (*wri.wisc.edu*) introduces users to the Wisconsin program and includes a variety of information for those interested in water-related issues and research. During the past

year, the following sections were updated: project listing, groundwater research database, funding opportunities and conference information.

The **ASC Publications Store** (*www.aqua.wisc.edu/publications*) features publications from both the Water Resources and Sea Grant Institutes. During the reporting period, the publication described above, "Design Guidelines for Stormwater Bioretention Facilities" was added to the online store.

The **Wisconsin Water Policy Inventory** (*www.aqua.wisc.edu/waterpolicy*) is a web-based tool for researching the state's major policies pertaining to water. This project enables Wisconsinites to browse state policies by category or to search using keywords.

Library Web Sites

In addition to the new **Wisconsin's Water Library for Kids** described above, the Water Resources Library maintains several Web sites, all of which were updated during the past year. The **Water Resources Library Web Site** (*wri.wisc.edu/library*) introduces UW-Madison faculty, staff and students to the library services tailored to them. Two of the most popular pages on that site are "Guide to Finding a Water-Related Job" (*wri.wisc.edu/library/finding_jobsall.html*) and "Guide to Finding Water-Related Information" (*library.wisc.edu/guides/WaterResources/index.htm*).

Wisconsin's Water Library (*aqua.wisc.edu/waterlibrary*) continues to make the books and other materials of the Water Resources Library available to any Wisconsin resident. During the past year, staff updated the entire site and added several special features or annotated reading lists on popular topics, including "Great Lakes Ships and Shipping", "Did you know? Learn more about Wisconsin Waters and the Great Lakes", and "Aquaculture, A Resource Guide". The most popular pages on the Water Library are "Wisconsin Water Facts" (*aqua.wisc.edu/waterlibrary/facts.asp*), "Native Americans and the Environment" (*aqua.wisc.edu/waterlibrary/nativeamericans.asp*) and "Environmentally-friendly Lawn and Garden Care" (*aqua.wisc.edu/waterlibrary/lawn.asp*).

The popularity of the library Web sites continues to grow. From August 2003 to April 2006, the number of visits per day to the Water Library Web site has grown from 45 to about 300. The average user likes what he sees and spends about 10 minutes on the site. Our library sites (Wisconsin's Water Library + Water Resources Library + our material on the UW-Madison Libraries site) currently receive over 500 unique visits per day.

UW System Publications Resulting from Wisconsin Groundwater Research and Monitoring Program Projects in FY06

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Dussaillant, A. R.; Wu, C., and Potter, K.W. Richards equation model of a rain garden, Journal of Hydrologic Engineering, ASCE, 9(3), 219-225, 2004.

Eaton, T.T., and Bradbury, K.R. 2005. What happens when the confined Cambrian Ordovician aquifer in Southeastern Wisconsin begins to be dewatered? Water Resources Institute, University of Wisconsin, Madison. 19p.

Gu, C., and Karthikeyan, K.G., Interaction of tetracycline with aluminum and iron hydrous oxides., Environ. Sci. Technol., 39,2660-2667, 2005.

Gu, C.; and Karthikeyan, K.G. Sorption of the antimicrobial ciprofloxacin to aluminum and iron hydrous oxides. Environ. Sci. Technol. (in review – submitted June 2005).

Lowry, C.S., M.P. Anderson, R.J. Hunt. 2006. Modeling groundwater flow and heat transport within a fen/stream complex. MODFLOW and More 2006: Managing ground water systems, IGWMC, Golden, CO.

Masbruch, M.D., Hunt, R.J., and Anderson, M. P. 2005. Investigation of Three Flowpaths of Different Lengths, Allequash Basin, Vilas County, Wisconsin (*abstract).* Wisconsin's Waters: A Confluence of Perspectives: Delavan, WI, Wisconsin Section of the American Water Resources Association, p. 44.

Masbruch, M.D., Hunt, R.J., and Anderson, M. P. 2005. Delineation of Flow Paths and Processes Affecting Chemical Variability, Allequash Basin, Wisconsin (abstract). Geological Society of America Abstracts with Programs, Annual Meeting, Salt Lake City, Utah, October 2005.

Masbruch, M.D., 2005, Delineation of Source Areas and Characterization of Chemical Variability using Isotopes and Major Ion Chemistry, Allequash Basin, Wisconsin, MS Thesis, Department of Geology and Geophysics: Madison, WI, University of Wisconsin - Madison, 131 pp.

Olstadt, J., J.J. Schauer, J. Standridge, and S. Kluender. A Comparison of Ten US EPA Approved Total Coliform/E. *coli* Tests. Submitted to Journal of Water and Health.

Root, T.L. Arsenic in groundwater in southeastern Wisconsin: sources of arsenic and mechanisms of arsenic mobilization. Ph.D. thesis, University of Wisconsin-Madison, Department of Geology and Geophysics, expected spring 2005.

Root, T.L.; Bahr, J.M., and Gotkowitz, M.B. Controls on arsenic in groundwater in southeastern Wisconsin, in: Vlassopoulos, D.; Benning, L.; Meng, X., and O'Day, P., Advances in Arsenic Research, American Chemical Society Symposium Series, in press, 2005.

Skalbeck, J.D. 2004. Coupled modeling of gravity and aeromagnetic data for analysis of the Waukesha Fault, southeastern Wisconsin. Water Resources Institute, University of Wisconsin, Madison. 17 p.

Stoor, R.W., J.P. Hurley, C.L. Babiarz and D.E. Armstrong. 2006. Subsurface Sources of Methylmercury to Lake Superior from a Wetland-Forested Watershed. In Press. Science of the Total Environment.

For more information, visit http://www.wri.wisc.edu/ or contact Dr. Anders W. Andren, Director, UW-Madison Water Resources Institute, 1975 Willow Drive, Madison, WI 53706;

phone (608) 262-0905, fax (608) 263-2063, or email awandren@seagrant.wisc.edu.

UW-Extension's Central Wisconsin Groundwater Center

The Central Wisconsin Groundwater Center provides groundwater education and technical assistance to the citizens and governments of Wisconsin. Assistance includes answering citizen questions, helping communities with wellhead protection planning, describing the extent and causes of groundwater nonpoint pollution in Wisconsin, assessing drinking water quality, and working on groundwater policy. The center is part of the Center for Watershed Science and Education, an office of UW-Extension Cooperative Extension Service and the UW-Stevens Point College of Natural Resources, and frequently works through county Extension faculty in program delivery. More information can be found online at *http://www.uwsp.edu/cnr/gndwater/*.

Drinking Water Programs. In 2005, the Center assisted over 2,600 households in having their water tested in conjunction with county Extension offices and the Watershed Center's Water and Environmental Analysis Laboratory. Of these, 11% exceeded drinking water standards for nitrate-nitrogen. Seventeen percent of samples were unsafe because of coliform bacteria. Eleven Drinking Water Education Programs helped over 1,000 well users in seven counties to understand potential remedies for these problems and the relationship of land use practices to groundwater quality.

Water quality database. The Groundwater Center maintains a database of private well testing data from the Water and Environmental Analysis Regional Laboratory at UW-Stevens Point, and Drinking Water Education Programs conducted through the Center. There are currently over 400,000 individual test results for approximately 60,000 samples covering the state. Chemistry data includes pH, conductivity, alkalinity, total hardness, nitrate-nitrogen, chloride, saturation index, and coliform bacteria. In 1998, a new sampling program for iron, sodium, potassium, copper, lead, calcium, magnesium, manganese, zinc, and triazine was also initiated. Arsenic and sulfate were added late in 1999. The database primarily covers the period 1985 to the present. The database is PC-based and can be easily queried to be a significant source of information for local communities and groundwater managers. Forty-four counties are represented by 100 or more samples in the databases and 27 counties are represented by 500 or more samples.

Policy. The Center continues to play pivotal roles in a number of state groundwater issues. Working with partners in the private and public sectors on groundwater quantity policy and law has been a continuing priority for the Center. Center staff serves on the Technical Advisory Group of the Groundwater Advisory Council as well as the Northeast Wisconsin Karst and Manure Management Task Force.

Partnerships. Center staff works with agencies and private organizations, including the Wisconsin Agricultural Stewardship Initiative, Wisconsin Potato and Vegetable Growers Association Nonpoint Pollution subgroup, DATCP Atrazine Technical Advisory Committee, and Extension Nutrient Management Self-Directed Team. The Center continues to work closely with a number of Land Conservation Departments, Groundwater Guardian groups, and many local watershed based groups.

Other UW-Extension Water Programs

UW Environmental Resources Center (ERC). The UW Environmental Resources Center (ERC) develops and coordinates a number of national youth water education initiatives related to

groundwater. The ERC provides national coordination for two youth water education programs, *Educating Young People about Water* (EYPAW) and *Give Water a Hand* (GWAH).

EYPAW offers four guides and a water curricula database to provide assistance for developing a community-based, youth water education program. The EYPAW Web site, http://www.uwex.edu/erc/eypaw, provides access to a database of more than 190 water-related curricula that may be searched by grade level or water topic.

Goals of the GWAH curriculum are to protect and improve local water quality by encouraging youth to investigate local issues, and to plan and complete a service project. Youth then address a problem they identify with the assistance of a local natural resource expert. Program materials may be downloaded from the *Give Water a Hand* Web site, http://www.uwex.edu/erc/gwah.

Other ERC youth water education initiatives include:

- *Agua Pura* – a leader institute planning manual and guide for Latino water education
- *Evaluating USGS Water Education Resources* – an assessment of USGS materials to assist with USGS education program development decisions
- *Source Water Education* – a gap analyses of youth water curricula for source water education and riparian education resources.
- *Water Action Volunteers (WAV)* – a program for both kids and adults who want to learn about and improve the quality of Wisconsin's waterways through projects and hands-on activities.

Work continues on new water education initiatives including a national youth riparian curriculum, and the National Extension Water Outreach Education project to develop and promote best education practices for water education and to improve access to education resources and strategies. Find links to these programs on the ERC Web site at http://www.uwex.edu/erc.

UWS Farm and Home Environmental Management Program. The UWS Farm and Home Environmental Management Program, originally Farm*A*Syst and Home*A*Syst, enable and motivate urban and rural landowners, managers and residents to assess environmental and health risks and to take voluntary actions to prevent pollution. Projects focus on everything from long-term investments in structural design and siting to daily management practices.

The Wisconsin Dairy Environmental Management Systems (EMS) project, completed in 2005, collaborated with commodity and farm organizations, environmental organizations, government agencies and the private sector to test and evaluate the potential of EMS on Wisconsin dairies. Farmers engaged with EMS report improved profitability and a sense of greater control over environmental and health impacts, even in the face of rising regulatory scrutiny and greater international competition. The project work has also enhanced the statewide Green Tier program, which relies on EMS in regulating industries.

A grant from the North Central Region Sustainable Agriculture, Research and Education Program (NCR-SARE) is supporting research on six different regulatory and eco-label approaches to managing the environmental impacts of Midwestern dairy farming. Research involves identifying specific environmental goals of different programs and how they might be complemented with an Environmental Management System to strengthen farm sustainability. Methods include document analysis of various programs, including certified organic and NRCS program requirements, complemented by six farm case studies. Results will include

recommendations toward improving the policy and implementation of a range of environmental agricultural policies.

The Wisconsin Healthy Homes Project, a subset of Home*A*Syst, is contributing to a revision of the UWEX publication *Rent Smart.* Additional state Healthy Homes work will develop a pollution prevention resource website for Wisconsin citizens and Extension professionals.

The Farm & Home Program also concluded a two-year study of the use of Integrated Pest Management by professional landscapers in the Lake Monona Watershed. Data from this research was shared with community collaborators and used to develop a prototype outreach and education strategy to promote the use of IPM.
Visit: *http://www.uwex.edu/farmandhome/monona*.

Additional information is available at *http://www.uwex.edu/farmandhome/*.

Multi-Agency Land and Water Education Grant Program (MALWEG). UW-Extension coordinates the Multi-Agency Land and Water Education Grant Program (MALWEG), which has funded 134 groundwater-focused education projects since its inception in 1997. These projects have resulted in awards of over $1.8 million in educational assistance funds to county-based conservation professionals in Wisconsin who in turn deliver research-based best management practices and expertise into the hands of farmers on an individual basis.

MALWEG partners, such as US Department of Agriculture Cooperative State Research, Education and Extension Service and Natural Resource Conservation Service, UW-Extension, Wisconsin DNR, the Basin Education Program and Discovery Farms, have contributed funding and time to this milestone effort. The counties have also matched a considerable amount of resources to reach more than 1,400 farmers since 1997. More information can be found at *http://clean-water.uwex.edu/malweg/*.

Basin Education Initiative. The UWS cooperates on community-focused educational programs with other state agencies involved with water resources and natural resource issues. Since 1998, UW-Extension had worked in partnership with the DNR, USDA-NRCS, and local organizations and agencies to provide water and related natural resources education within the state's 22 major river basins. Fifteen Basin Educators work collaboratively at the local level and access state-level support for educational material development and program evaluation. The Basin Education Initiative works to support local conservation professionals such as county Extension agents, Land Conservation Department staff, and NRCS staff. The educational programs address a broad range of groundwater-related topics, including drinking water, threats to groundwater quality, impacts of land-use changes and land management decisions on groundwater quantity, information about localized groundwater problems such as karst geology, and a variety of other water quality issues. More information can be found at *http://basineducation.uwex.edu*.

UW Nutrient and Pest Management (NPM) program. In 1990 a broad coalition of agricultural organizations, environmentalists, and the University sought funding for a water quality program for farmers and the agricultural community. Over the past fourteen years, the NPM outreach program has conducted on-farm demonstrations and education throughout Wisconsin to address groundwater and surface water contamination from agriculture and the profitability of recommended practices.

A major portion of the program's focus has been nutrient management – the careful, profitable use of fertilizers and animal manures in crop production. NPM recently revised and distributed

the *Nutrient Management Farmer Education Curriculum* that includes a discussion of nitrates in groundwater. The curriculum has been taught throughout the state to hundreds of producers. NPM also coordinates training workshops for Nutrient Management Planners that teach agricultural and conservation professionals how to write nutrient management plans. To prevent pesticide contamination of groundwater resulting from field applications, the program delivered integrated pest management education and coordinated Wisconsin extension's WeedSoft development and delivery. WeedSoft is a computer program that helps growers makes cost effective, environmentally sound weed management decisions. One module includes leaching ratings to assist growers in herbicide selection.

NPM continues to work with Wisconsin farmers to ensure they are not over-applying nitrogen and other inputs so as to minimize potential losses to groundwater. The NPM field staff completed on-farm demonstrations, manure spreader calibration, and taught many farmers how to write and update their nutrient management plans. More information on these efforts and many publications are available at the NPM web site (*http://ipcm.wisc.edu*).

For more information on UW Extension programs related to groundwater, contact Ken Genskow, UW Environmental Resources Center, 1545 Observatory Drive, WI 53706-1289, phone (608) 262-0020, fax (608) 262-2031, or email kgenskow@wisc.edu; or George Kraft, Center for Watershed Science and Education, College of Natural Resources, UW-Stevens Point, Stevens Point, WI 54481; phone (715) 346-4270; email: gndwater@uwsp.edu.

Wisconsin State Laboratory of Hygiene

General program description. At the Wisconsin State Laboratory of Hygiene (WSLH), a great deal of effort is focused on identifying and monitoring chemical and microbial contaminants in groundwater through routine testing, emergency response, education and outreach, and specialized research. The activities related to groundwater span several departments at WSLH and, collectively, their efforts make up the WSLH Drinking Water Quality Program. The mission of the WSLH Drinking Water Quality Program is to protect the health of drinking water consumers by providing analytical expertise, research and educational services to the scientific and regulatory communities.

The chemical and microbial groundwater contaminants routinely tested for include all contaminants regulated by the federal Safe Drinking Water Act as well as many emerging contaminants that appear on the USEPA Contaminant Candidate List. Examples include: fecal indicators (total coliform, *E. coli,* coliphage), *Helicobacter pylori, E. coli* O157:H7, *Salmonella*, waterborne viruses, parasites (*Cryptosporidium*, *Giardia*, and microsporidia), radioactivity, inorganic compounds (mercury, nitrate, arsenic) and organic compounds (atrazine, PCBs, PBDEs).

Another important focus of the WSLH Drinking Water Quality Program is emergency response to incidences involving groundwater. For example, WSLH works with DHFS and DNR to investigate outbreaks of illnesses of unknown (possibly food or water) origin. Staff provides background information on the outbreaks for local public health officials, local media, and the general public. WSLH also responds to spills and incidents and supports state agencies in remediation and emergency clean-up activities. Most recently, WSLH has focused its efforts on enhancing and expanding terrorism response programs.

WSLH also provides educational and outreach activities related to groundwater and drinking water including: instructional consultations for well owners and well drillers; on-site training of municipal water supply operators; and tours for a variety of international, educational, regulatory, and other governmental groups. Staff has developed an interactive study guide dealing with safety, sampling, and chemistry for drinking water operators and publications related to drinking water. Staff attends and presents papers at a variety of conferences and symposia and publishes research finding in professional journals.

Summary of groundwater-related activities in FY 2006.
Two research projects funded by the UW System through the GCC's Groundwater Research and Monitoring Program in FY 05 were continued in FY 06:

Occurrence of Estrogenic Endocrine Disruptors in Groundwater. Jocelyn Hemming, PhD, Wisconsin State Laboratory of Hygiene.

A comparison of USEPA approved enzyme-based total coliform/E. coli tests for microbiological groundwater monitoring and laboratory consultation. Jeremy Olstadt, Wisconsin State Laboratory of Hygiene.

Research projects that were on-going or completed in FY 06 include:
Evaluation of Gross Alpha and Uranium Measurements for MCL Compliance. Michael F. Arndt, PhD, Wisconsin State Laboratory of Hygiene (funded by the American Water Works Association).

Assessment of endocrine disrupting chemical in water reclamation systems Jocelyn Hemming, PhD, Wisconsin State Laboratory of Hygiene (funded by the Water Environment Research Foundation).

Comparison of pesticide home water testing kits with certified analytical laboratory results. John Strauss, Wisconsin State Laboratory of Hygiene (funded by DNR).

For more information, visit the following website (http://www.slh.wisc.edu/) or contact William Sonzogni, Wisconsin State Laboratory of Hygiene, 2601 Agriculture Drive, Madison, WI 53703, phone (608) 224-6200, or email sonzogni@facstaff.wisc.edu.

FEDERAL AGENCY PARTNERS

U.S. Geological Survey: Water Resources Discipline - Wisconsin Water Science Center

The mission of the U.S. Geological Survey-Water Resources Discipline is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States. This mission is accomplished, in large part, through cooperation with other Federal, State and local agencies, by:

- Collecting on a systematic basis data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.

- Conducting analytical and interpretive water-resource appraisals describing the occurrence,

availability, and physical, chemical, and biological characteristics of surface water and ground water.

- Conducting supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress.

- Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.

- Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and groundwater.

- Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to international agencies on behalf of the U.S. Department of State.

The Wisconsin Water Science Center is currently conducting cooperative projects that have a significant groundwater component with the DNR, WGNHS, Southeast Wisconsin Regional Planning Commission (SEWRPC), the Menominee, Stockbridge-Munsee, Ho-Chunk, and Lac Court Oreilles Tribes of Wisconsin, and the numerous county and city governments. In addition, several projects are funded by Federal agencies: EPA-Region 5, National Park Service, and USGS. Recent and current projects that have a significant groundwater component are listed below.

Cooperatively funded projects with state and local agencies:

1. Collection of data from the Wisconsin groundwater observation-well network.
2. Compilation of data for the Wisconsin water-use data file.
3. Investigation of the hydrology of southeastern Wisconsin and development of a Regional Water Supply Plan.
4. Quantification of the impacts of urbanization on infiltration in the Black Earth Creek watershed.
5. Evaluation of the effectiveness of Wisconsin closure protocols for petroleum contaminated sites.
6. Simulation of groundwater/surface-water systems in Pierce, St. Croix, and Polk Counties.
7. Evaluation of drinking water vulnerability.
8. Simulation of the effects of the Shell Lake water diversion, Washburn County, on the shallow groundwater – lake system.
9. Centralization of access to Wisconsin ground water data to encourage the consideration of ground water in all elements of comprehensive planning by communities and the state

Projects funded primarily by Federal agencies:

1. Availability and use of fresh water in the United States: Lake Michigan Pilot Study (USGS funded) http://water.usgs.gov/ogw/gwrp/activities/wateravail_pilot.html.
2. Hydrologic and biogeochemical budgets in temperate lakes and their watersheds, northern Wisconsin (USGS funded) http://infotrek.er.usgs.gov/doc/webb/index.html.

3. Western Lake Michigan Drainages National Water-Quality Assessment (USGS funded) *http://wi.water.usgs.gov/nawqa/index.html.*
4. Prediction of groundwater susceptibility to contaminants to protect the St. Croix National Scenic Riverway (National Park Service and USGS funded)
5. Spatial and temporal shallow groundwater recharge rates in Wisconsin (USGS funded).

The USGS contributed two significant accomplishments to help protect Wisconsin's groundwater in FY 06:

- In cooperation with the National Park Service a screening model was developed for simulating regional ground-water flow in the St. Croix River Basin. The screening model and associated hydrologic databases have provided a better understanding of the regional ground-water-flow system and its relation to stream drainage in the basin. Simulations using the calibrated screening model show ground-water-contributing areas for selected stream reaches, very useful for water-resource managers concerned with protection of fisheries and other resources. Model simulations also identify areas of the basin where ground-water travel time from the water table to streams and wells is relatively short (less than 50 years). This screening model is now being used as the framework for a ground-water flow modeling effort being undertaken by the USGS in cooperation with St. Croix, Pierce, and Polk Counties. A USGS report of the recently completed St. Croix River Basin study can be found at *http://pubs.usgs.gov/sir/2005/5283/*

- In cooperation with DNR and Marshfield Clinic a study was undertaken to investigate the susceptibility of La Crosse municipal wells to enteric virus contamination from surface Water contributions The primary objective of the study was to monitor the municipal drinking water wells of La Crosse for human gastrointestinal viruses and relate the amount of Mississippi River water infiltrating the wells to the frequency of virus detection. A secondary objective was to relate microbial indicators of water sanitary quality with the occurrence of gastrointestinal viruses. Study results indicate there are frequent occurrences of viral RNA in the La Crosse drinking water wells included in this study, some of which are attributable to surface water infiltration and the rest must be derived from another unidentified fecal source. To ascertain the public health significance of these findings it would be necessary to conduct an epidemiological study relating virus occurrence to a defined health endpoint. It is likely given the chlorination dose at each wellhead and residence time within the system that any viruses present in the groundwater are inactivated before ingestion. However, evaluations of the effectiveness of the present disinfection system were outside the scope of this research. This study was funded by grants from the Wisconsin Department of Natural Resources and funding provided by the U.S. Geological Survey Water Resources Cooperative Program. A final report containing more detailed information on this project is available for loan at the Water Resources Institute Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069

For more information please contact Charles Dunning USGS, 8505 Research Way, Middleton, Wisconsin, 53562-3581 (608-821-3827), cdunning@usgs.gov, Randy Hunt (608-821-3847), rjhunt@usgs.gov or visit the Wisconsin Water Science Center web page (http://wi.water.usgs.gov).

USDA Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) is a federal agency within the US Department of Agriculture. The NRCS, formerly the Soil Conservation Service, works with private landowners to promote conservation of natural resources. In Federal fiscal year 2005 (Oct. 1, 2004 to Sept. 30, 2005), NRCS planned over 587,000 acres of conservation systems and applied over 522,000 acres in Wisconsin in cooperation with county Land Conservation Departments.

The agency protects groundwater by providing technical assistance to landowners through the following ongoing conservation practices and programs:

- *Nutrient management*: management of the amount, form, placement and timing of nutrients applied to the soil so that the amount applied is only what is needed to produce optimum crop yield. This reduces the potential for applied nutrients to pollute surface and groundwater. Last year 1616 farmers implemented nutrient management plans totaling 151,400 acres through the Environmental Quality Incentives Program in Wisconsin.
- *Pest management*: utilization of environmentally sensitive prevention, avoidance, monitoring and suppression strategies to manage weeds, insects, diseases, animals and other organisms that directly or indirectly cause damage or annoyance. This enhances quantity and quality of commodities. It also minimizes negative impacts of pest control on soil resources, water resources, air resources, plant resources, animal resources and/or humans. Last year pest management was implimented on 11,300 acres
- *Animal waste storage*: proper waste storage siting and design is imperative to protect groundwater from contamination by nutrients in animal waste. Last year 80 animal manure storage structures were planned and 46 were installed.
- *Comprehensive Nutrient Management Plan (CNMP):* a conservation system unique to livestock farms. It is a grouping of conservation practices and management activities to insure both production and resource protection goals. It addresses soil erosion, manure, and organic by-product impact on surface and groundwater quality. CNMP components include nutrient management based on phosphorus or nitrogen, manure and wastewater handling and storage, adequate erosion control of cropland, and proper record keeping. CNMPs entail a thorough review of the farmstead, ensuring that manure and wastewater are properly stored and handled, stormwater remains clean or is captured, and drinking water wells are properly protected. It may also include feed management to reduce phosphorus in manure and other manure use alternatives such as biofuel production and composting. Last year, CNMPs were written for 163 farms and implemented on 57 farms.
- *Managed grazing:* Pastureland is divided into small paddocks and intensively grazed for 1 or 2 days and then rested for 25-35 days. About 330 prescribed grazing plans were written covering 27,000 acres. Prescribed grazing was applied to 24,000 acres. Some crop fields converted to managed grazing had 10 times less groundwater nitrate levels.
- *Wetland Reserve Program*: restores wetlands through permanent or 30-year easements or 10-year contracts. Last year about 3,000 acres of wetlands were restored, bringing the total acres in WRP to over 42,800.
- *Environmental Quality Incentives Program*: provides cost sharing for conservation practices on agricultural land. Statewide priorities include groundwater protection practices such as well decommissioning and nutrient and pesticide management and prescribed grazing. In 2005 a total of 1439 contracts for $16.4 million were signed. About 408000 acres of conservation systems were planned.

- *Well decommissioning*: proper decommissioning is essential to prevent contaminants from entering groundwater through abandoned wells, which are direct conduits to the groundwater. NRCS planned 88 well decommissionings, and completed 44.
- *Conservation Reserve Program/Conservation Reserve Enhancement Program*: participants establish permanent vegetative cover on agricultural lands in return for guaranteed rental payments.
- *Dam rehabilitation pilot projects*: From the 1950s to 1980s, through the Watershed Flood Prevention Act (PL566), NRCS built 87 small flood control dams in Wisconsin that reduced flooding and improved groundwater infiltration. Since 2000, NRCS has planned or completed the rehabilitation of 13 deteriorating dams in seven western counties as part of a four state pilot project. These accomplishments resulted in obligating of $4.5 million in federal rehabilitation funds. In an average year, these projects reduce flood damages on crops, roads, and communities by an estimated $2 million.
- *Conservation Security Program*: In 2004, Wisconsin was one of the pilot states to launch the new CSP, a program to reward good land stewardship and provide incentives to farmers to increase and enhance their conservation practices. In 2004, 212 CSP contracts were signed with farmers in the lower Chippewa and Kishwaukee watersheds. In 2005, an additional 282 CSP contracts were signed with farmers in four watersheds (the Lower Chippewa, Kishwaukee, the Duck-Pensaukee, and the Crawfish). The average payment per farm was $7,000. Good erosion control, water quality protection and improving soil quality are prerequisites for the program.

The agency also provides leadership in the following:

- *Standards Oversight Council – an Interagency Committee to revise and maintain Conservation Practice Standards*. Practice Standards benefit the public by helping to protect groundwater. For example NRCS Practice Standard Code 590 – Nutrient Management was revised in 2005. This revision enhances groundwater protection by promoting better nutrient management and minimizing agricultural nonpoint source pollution of surface and groundwater resources. Several new standards were developed in 2005 for manure storage, handling and management.

To find out more information about NRCS, go to the home page at http://www.wi.nrcs.usda.gov, contact Renae Anderson at 608-662-4422 ext. 227, or Jim Kaap at 608-662-4422 ext. 266.

Chapter 4 -- CONDITION OF THE GROUNDWATER RESOURCE

The Groundwater Coordinating Council (GCC) is directed by s. 15.347(13)(g), Wis. Stats., to submit an annual report which "…describes the state of the groundwater resource…" and to "…include a description of the current groundwater quality of the state…and a list and description of current and anticipated groundwater problems."

The purpose of this chapter is to describe the state [condition] of the groundwater resource, provide an assessment of groundwater quality and quantity issues, as well as describe current and anticipated groundwater problems. In general, groundwater is plentiful and of high quality in Wisconsin, but concern is growing about its limits and the existence of persistent and emerging threats. In addition, there is growing recognition of the interdependence of groundwater and surface water resources, as well as the influence of groundwater quantity on water quality. Further recommendations of the Council are listed in Chapter 6, *Future Directions for Groundwater Protection*.

GROUNDWATER QUALITY

As part of 1983 Wisconsin Act 410, the Groundwater Account of the Environmental Fund was created to support groundwater monitoring by state agencies to determine the extent of groundwater contamination in Wisconsin and identify the sources of contamination. Groundwater monitoring has found that the primary contaminants of concern are volatile organic compounds (VOCs), pesticides and nitrate. Increased attention is also being given to several "emerging threats," including naturally occurring radioactivity, arsenic, and microbial agents (bacteria, viruses, and parasites). Each is discussed below.

Volatile Organic Compounds

VOCs are a group of common industrial and household chemicals that evaporate, or volatilize, when exposed to air. Examples of VOCs include gasoline and industrial solvents, paints, paint thinners, drain cleaners, air fresheners, and household products (such as spot and stain removers). Short-term exposure to high concentrations of many VOCs can cause nausea, dizziness, tremors or other health problems. Some VOCs are suspected of causing cancer upon long-term exposure. Sources of VOCs in Wisconsin's groundwater include landfills, underground storage tanks (USTs), and hazardous substance spills.

Thousands of wells have been sampled for VOCs. Fifty-nine different VOCs have been found in Wisconsin groundwater, though only 34 of those have associated health standards. Trichloroethylene is the VOC found most often in Wisconsin's groundwater. **Figure 4.1** shows the location of drinking water wells with past ES and PAL exceedances based on data from 6,399 unique wells recorded in the GRN database.

Wisconsin has 72 active, licensed solid waste landfills, all of which are required to monitor groundwater. In addition, the DNR currently tracks about 20,000 leaking underground storage tanks (LUSTs) and about 4,000 waste disposal facilities. Many of these sites have been identified as sources of VOCs. Facilities include gas stations, bulk petroleum and pipeline facilities, plating, dry cleaning, industrial facilities, and abandoned non-approved unlicensed landfills.

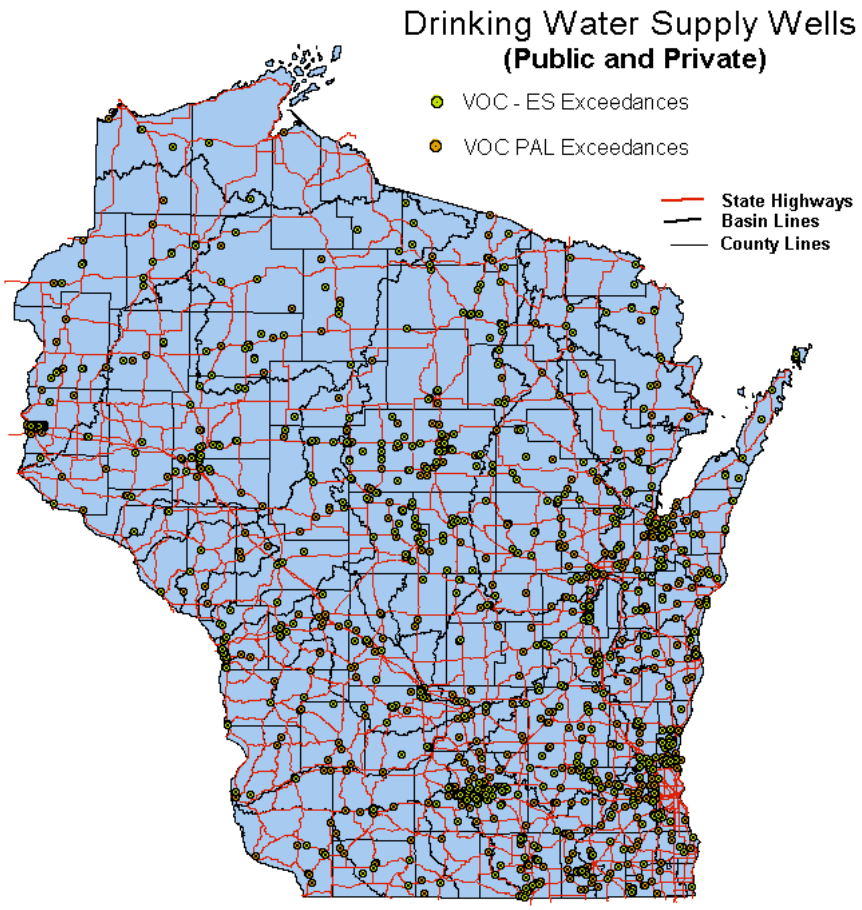

Figure 4.1 Volatile Organic Compounds (VOCs) past enforcement standard (ES) and preventive action limit (PAL) exceedances for public and private drinking water supply wells. Source DNR

Landfills. Two studies conducted over four years revealed that VOCs were significant contributors to groundwater contamination at Wisconsin landfills (DNR 1988, 1989). Out of a total of 45 unlined municipal and industrial landfills tested, 27 (60%) had VOC contamination in groundwater. All of these landfills are currently closed. Of 26 unlined municipal solid waste landfills tested, VOCs contaminated groundwater at 21 (81%). No VOCs were confirmed present at any of the six engineered (liner and leachate collection) landfills included in the studies. While 20 different VOCs were detected overall, 1,1 – Dichloroethane was the most commonly occurring VOC at all of the solid waste landfills.

In a follow-up VOC study conducted from July 1992 through July 1994, the DNR reviewed historical data and sampled groundwater at 11 closed, unlined landfills and at six lined landfills. VOC levels had decreased after closure at all but two of the unlined landfills, though at many sites VOC levels did not show continued improvement. Also, the level of contamination, while below initial concentrations, remained high at many closed sites. No VOC contamination attributable to leachate migration was found at any of the six lined landfills investigated.

Over the past few years increasing numbers of residential developments have been located close to old, closed landfills. In 1998 and 1999 the DHFS sampled private wells down-gradient of 17 small, closed landfills in Ozaukee County. Eight of the private wells had VOC results above

maximum contaminant levels. The results of this sampling showed that there may be more landfills with serious problems that have not yet been identified.

The DNR Bureaus of Waste Management, Remediation and Redevelopment, and Drinking Water and Groundwater in cooperation with the DHFS, responded to this issue in early 1999 by evaluating 16 old, closed landfills – at least three from each of the five DNR regions across the state. Private wells around each of the landfills were sampled in 1999 and significant levels of contamination found. Of the 113 wells that were tested, 31 had detects of VOCs. Fourteen of the homes had levels exceeding drinking water standards and have been given health advisories not to drink their water.

Underground storage tanks. Wisconsin requires underground storage tanks with a capacity of 60 gallons or greater to be registered with the Department of Commerce. Since 1991, this registration program has identified over 175,000 underground storage tanks with over 80,000 federally regulated tanks with only about 12,500 tanks in use. A federally regulated tank is any tank, excluding exempt tanks, that is over 110 gallons in size, has at least 10 percent of its volume underground, and is used to store a regulated substance. Wisconsin regulates USTs down to 60 gallon capacity. Exempt tanks include: farm or residential tanks of 1,100 gallons or less; tanks storing heating oil for consumptive use on the premises where stored; septic tanks; and storage tanks situated on or above the floor of underground areas, such as basements and cellars.

Hazardous waste. Hazardous waste treatment storage and disposal facilities are another VOC source. The DNR Bureau for Remediation and Redevelopment is investigating or remediating contamination at about 30 sites. Approximately 140 sites statewide are subject to corrective action authorities. However, only a small percentage will follow the corrective action process because of minimal contamination at the site or jurisdiction under other regulatory authorities. Generators improperly managing hazardous waste are another source of VOC contamination. All new generator remediation cases statewide and many existing actions are to be addressed in accordance with the NR 700 Wis. Adm. Code series.

Hazardous Substance Spills. The Hazardous Substance Spill Law, ch. NR 292.11 Wis. Stats., requires immediate notification when hazardous substances are discharged, as well as taking actions necessary to restore the environment to the extent practicable. Approximately 800 discharges are reported annually to the DNR, and of those, approximately 65% are petroleum related, with another 15% being agrichemicals.

The NR 700 Wis. Adm. Code series, specifically ch. NR 706, contains the requirements for notification when a discharge or spill occurs. Chapter NR 708 contains requirements for taking immediate and/or interim actions when releases occur. Groundwater monitoring is performed when necessary to delineate the extent of contamination. The spills program develops outreach materials to help reduce the number and magnitude of spills and provide guidance for responding to spills. Topics addressed include spills from home fuel oil tanks, responses to illegal methamphetamine labs, and mercury spills, all of which can lead to significant environmental impacts, if not properly addressed.

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DNR, 1989. VOC Contamination at Selected Landfills – Sampling Results and Policy Implications. Wisconsin Department of Natural Resources, Bureau of Solid and Hazardous Waste, June 1989.

Pesticides

Pesticide contamination in groundwater results from field applications, pesticide spills, misuse, or improper storage and disposal. Serious concerns about pesticide contamination in Wisconsin were first raised in 1980 when aldicarb, a pesticide used on potatoes, was detected in groundwater near Stevens Point. The DNR, DATCP, and other agencies responded to these concerns by implementing monitoring programs and conducting groundwater surveys.

The DNR and DATCP expanded their sampling programs in 1983 to include analysis of pesticides commonly used in Wisconsin. The most commonly detected pesticides in Wisconsin groundwater are:

- Metabolites of alachlor (Lasso), metolachlor (Dual) and acetochlor (Harness)
- Atrazine and its metabolites
- Metribuzin (Sencor)
- A metabolite of Cyanazine (Bladex). Cyanazine is no longer manufactured.

Federal and state groundwater quality standards for many of these compounds have also been adopted. To date, standards for over 30 pesticides are included in ch. NR 140, Wis. Adm. Code.

Atrazine, a herbicide used on corn, is one of the pesticides most often found in private drinking water wells in Wisconsin. There are significant health concerns for humans and wildlife associated with atrazine. Recent studies have found that male frogs develop both male and female sex organs when exposed to concentrations of atrazine at $1/30^{th}$ of the current drinking water standard (Hayes et. al. 2002 and Hayes et. Al. 2003)

The first systematic well sampling program to characterize atrazine contamination on a statewide basis was the 1988 DATCP Grade A Dairy Farm Well Water Quality Survey. This state-funded well survey estimated that atrazine was present in 12% of the Grade A Dairy Farm Wells in the State. Since that initial study, DATCP has collected data from many private and monitoring wells in the state as part of statewide surveys and focused monitoring projects (summarized below).

In July 2005, DATCP produced a map showing locations of private drinking water wells tested for atrazine in the state (**Figure 4.2**). The DATCP pesticide database contains test results from nearly 16,000 wells tested with the immunoassay screen for atrazine and over 7000 wells tested by the full gas chromatograph method. The immunoassay screen results show that about 40% of private wells tested have atrazine detections, while about 1% of wells contain atrazine over the groundwater enforcement standard of 3 µg/L. The 7000 wells tested by full gas chromatograph show detectable levels of atrazine 25% of the time and are over the enforcement standard in about 5% of the wells. The enforcement standard for atrazine includes parent atrazine and three of its breakdown products (metabolites).

Some pesticides, like atrazine, get into groundwater mostly through general use, while others are only found in groundwater if they have been spilled or mishandled. A combination of factors is most likely responsible for the widespread atrazine contamination shown on this map:

- Atrazine has been the most widely used herbicide in Wisconsin for more than 30 years because it is effective and inexpensive

- Atrazine was commonly used at much higher rates and applied more often before DATCP's Atrazine rule (ch. ATCP30, Wis. Adm. Code) began in 1991
- Atrazine sinks (leaches) through the soil into groundwater faster than many other herbicides

Triazine screen. In 1991, the Wisconsin State Laboratory of Hygiene (WSLH) began a public testing program using an immunoassay screening test for triazine-based compounds, such as atrazine. The triazine immunoassay screen uses specific antibodies designed to selectively bind to target compounds that are present at low concentrations. While there is no enforcement standard (ES) for the triazine screen, comparing the triazine results to the ES and preventive action limit (PAL) for atrazine provides a reference point for the severity of contamination. In a recent survey of DNR groundwater databases, more than 14,000 triazine screen results have been recorded. Forty-two percent of the samples had a detection for a triazine compound; 13% exceeded the PAL for atrazine of 0.3 µg/L; and 1.6% exceeded the ES for atrazine of 3.0 µg/L.

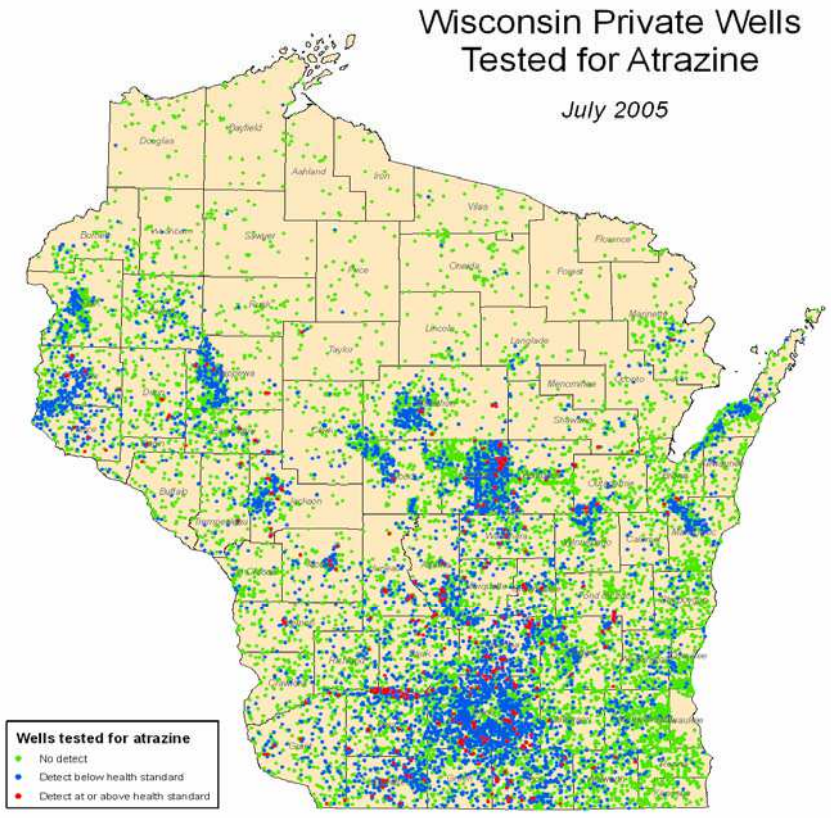

Figure 4.2 Private wells tested for atrazine in Wisconsin as of July 2005. Source: DATCP

One problem with the triazine screen is that it does not detect all the atrazine metabolites and therefore underestimates the total atrazine concentration. The WSLH advises homeowners that

the triazine screen results should be used for initial screening purposes only. Higher triazine detects often receive a follow-up gas chromatography test. In 2002, the DNR funded a study with the WSLH to evaluate a new immunoassay test for the metabolite diamino atrazine. Results were delivered in late 2003 and it appears that a combination of new and existing tests can improve analytical accuracy greatly.

Chloroacetanilide herbicide metabolites are increasingly being detected in Wisconsin groundwater. In a study completed in 2000, 27 monitoring wells, 22 private drinking water wells, and 23 municipal wells in Wisconsin were sampled for alachlor, metolachlor, acetochlor, and their ethane sulfonic acid (ESA) and oxanillic acid (OA) metabolites. Wells were selected based on previous detections of pesticides or proximity to agricultural fields. Alachlor, metolachlor, and acetochlor are chloroacetanilide herbicides that are commonly used on corn and other crops in Wisconsin. With the exception of alachlor ESA, no historical data exists for these metabolites in Wisconsin groundwater because laboratory methods were not previously available. Over 80 percent of the monitoring wells and drinking water wells included in the survey contained the ESA and OA metabolites of alachlor and metolachlor. The metabolites of acetochlor showed a lower frequency of detection. Metabolite concentrations ranged from near the level of detection to 42 µg/L. Monitoring wells and private drinking water wells showed higher detection frequencies and concentrations than the deeper municipal wells, but the municipal wells did show significant impacts. Fifty-two percent of the municipal wells had at least one detection. No municipal well had pesticide levels that exceeded an enforcement standard.

Beginning in October 2000 and ending in May 2001, DATCP collected 336 samples from private drinking water supplies to determine the statewide impact of pesticides on groundwater resources (DATCP 2002). DATCP analyzed the samples for commonly used herbicides including the chloroacetanilide herbicides and their metabolites. This study also was compared to previous surveys to attempt to understand trends in groundwater quality over time. A total of seven common herbicides, ten metabolites and nitrate were included in the latest survey. Highlights from this overall study show:

- The proportion of wells that contain a detectable level of a herbicide or herbicide metabolite is 37.7%.
- Alachlor ESA and metolachlor ESA are the most commonly detected herbicide compounds with proportion estimates of 27.8 and 25.2%, respectively.
- A statistically significant decline in parent atrazine concentrations between 1994 and 2001.
- However, a decline in total chlorinated residues of atrazine was not apparent.

The following are other DATCP pesticide related studies conducted recently or as part of ongoing research.

Exceedance Survey. In 1995, DATCP completed a re-sampling of 122 Wisconsin wells that previously exceeded a pesticide enforcement standard. Most of the wells in the survey had exceeded standards for atrazine. Most were also within an atrazine prohibition area. Of wells exceeding standards for atrazine, 84% had declined in concentration and 16% had increased. About 50% of well owners continued to use their contaminated well and about 25% had installed new wells at an average cost of $6,300. This well survey has been repeated annually through 2005, with samples collected from 150 different wells at least once during this time period. As of 2005, atrazine levels have gone down in 82% of the wells, up in 15%, and stayed about the same in 3%. Eighteen wells remain above the enforcement standard.

Pesticide and Groundwater Impacts Study. In 1985, DATCP began a 2-year study funded by the Wisconsin DNR to evaluate the potential impact of agriculture on groundwater quality. The

study focused on areas of the state with high groundwater contamination potential. In 2005, this study entered its 20th program year. In 2005 samples from monitoring wells near 15 agricultural fields were sampled. A total of ten compounds were detected in groundwater. Three of these (nitrate, alachlor ESA and atrazine + metabolites) were found at levels above an existing water quality standard. Other compounds detected include alachlor, acetochlor ESA, metribuzin, metolachlor and its ESA and OA metabolites, and cyanazine amide.

Monitoring Reuse of Atrazine in Prohibition Areas - In FY 98 through FY 05, DATCP monitored the limited reuse of the herbicide atrazine in selected areas where atrazine use has been prohibited. DATCP gathered the data to see if renewed atrazine use at current restricted use rates will cause groundwater contamination. DATCP monitored groundwater quarterly at 17 fields, 10-40 acres in size, for 5 to 7 years. Although a final determination of the project's findings has not yet been made 1998 through 2005 summary data showed that all of the sites that followed study protocols exceeded the ES for atrazine at some point during the study. The nitrate enforcement standard was exceeded at 100% of these sites over the same sampling period.

References cited:

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Nitrate

Two Wisconsin state agencies, the DNR and DATCP, both agree that nitrate is the most widespread groundwater contaminant in Wisconsin and is increasing in extent and severity. Nitrate (NO3-N) is a water-soluble molecule made up of nitrogen and oxygen that forms when ammonia or other nitrogen rich sources combine with oxygenated water. Nitrate occurs naturally in water but only at very low levels of less than 1 milligram per liter (mg/L), higher levels indicate a source of contamination. Common sources of nitrate contamination include fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris.

Since 80% of nitrate inputs into groundwater originate from manure spreading, agricultural fertilizers, and legume cropping systems (Shaw, 1994), it makes sense that nitrate contaminated wells are found to be more prevalent in agricultural districts. Studies have repeatedly shown that predominantly agricultural counties in southern and west-central parts of Wisconsin have a higher percentage of wells exceeding the 10 mg/L federal and state nitrate enforcement standard (ES).

In a 1994 study, WGNHS and DHFS estimated that 9 to 14% of private water wells in Wisconsin exceed the nitrate standard. A 1997 DATCP study showed exceedance rates of 17 to 26% for wells in agricultural districts. In 2005, DNR aggregated and analyzed data from three extensive

statewide groundwater databases as part of a "Condition of the Resource" paper focused on the contamination of nitrate in Wisconsin groundwater. This combined dataset from DNR's Groundwater Retrieval Network (GRN) database (25,894 samples), the Center for Watershed Science and Education database (21,525 samples) and DATCP's groundwater database (1,399 samples), includes only the most recent nitrate result for each sampled private well. Out of the 48,818 samples, 5686 (11.6 %) equaled or exceeded the ES of 10 mg/L. As seen in **Figure 4.3**, the percent of wells exceeding the ES varies across the state. Calumet, Columbia, Dane, La

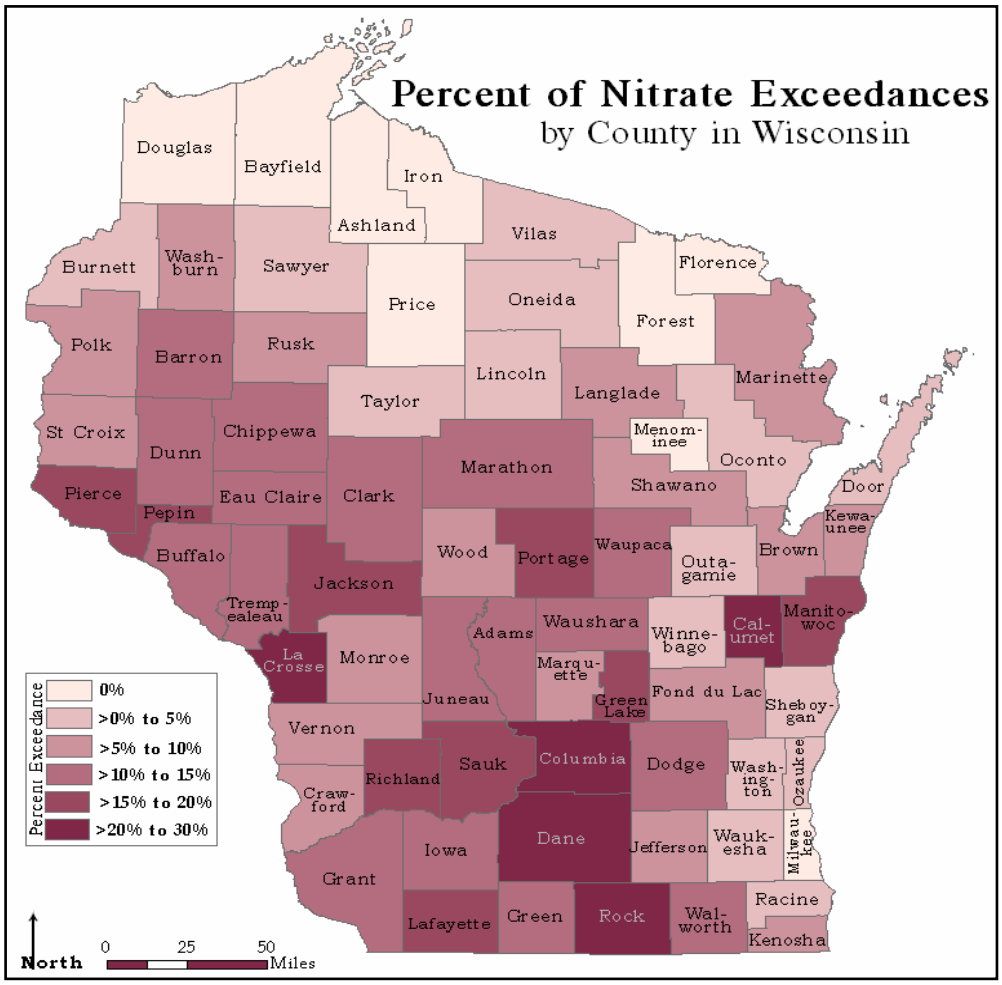

Figure 4.3 - Percentage of nitrate samples from private wells exceeding 10mg/L by county. Date sources: DNR, Center for Watershed Science and Education, and DATCP groundwater databases.

Crosse and Rock counties all show the highest percent exceedances with 20% to 30% of the samples from private wells exceeding the 10 mg/L ES.

Human health concerns are the primary reason high levels of nitrate in drinking water are of concern. Nitrate can cause a condition called methemoglobenemia or "blue-baby syndrome" in infants under six months of age. Nitrate in drinking water used to make baby formula is converted to nitrite in the child's stomach, the nitrite then changes hemoglobin in blood (that part of the blood that carries oxygen to the body) to methemoglobin which deprives the infant of

oxygen and in extreme cases can cause death. The Wisconsin DHFS has investigated several cases of suspected blue-baby syndrome and associated at least two with nitrate contaminated drinking water. These two non-fatal cases were reported in Columbia County (July 1998) and Grant County (April 1999). The Grant County case required an emergency MedFlight to a regional medical center and 17 day hospitalization to stabilize the 3 week old infant (Knobeloch, 2000).

When nitrate converts to nitrite in the human body it can then convert into a carcinogen called N-nitroso compounds (NOC's). NOC's are some of the strongest know carcinogens and have been found to induce cancer in a variety of organs. As a result, additional human health concerns linked to nitrate contaminated drinking water include; increased risk of: non-Hodgkin's lymphoma (Ward et al., 1996); gastric cancer (Xu et al., 1992; Yang et al., 1998); and bladder and ovarian cancer in older women (Weyer et al., 2001). There is also growing evidence of a correlation between nitrate and diabetes in children (Parslow et al., 1997; Moltchanova et al., 2004).

Because of these health concerns, city and village water supplies that exceed the 10 mg/L ES are required to mitigate the problem. Common solutions include drilling of a new non-contaminated well or the removal of excess nitrate through water treatment processes. Currently 25 (up from just 14 in 1999) of Wisconsin's public drinking water systems have exceeded the nitrate ES and have collectively spent over $24 million on remedies.

The 10 mg/L ES is also advised for privately owned wells that supply drinking water; however, the individual owners carry the responsibility of making sure their wells are tested. Private wells should be tested for nitrate at the time of installation and at least every five years during their use. Testing is also recommended for wells used by pregnant women and is essential for wells that serve infants less than 6 months of age. Owners of nitrate-contaminated water supplies have few mitigation options. They do not qualify for well-compensation funding unless the nitrate level in their well exceeds 40 mg/L and is used for farm stock. In order to establish a safe water supply, they may opt to replace an existing well with a deeper, better cased well or to connect to a nearby public water supply. Alternatively, they may choose to install a water treatment system or to use bottled water. A study published by DHFS examined this issue (Schubert et al., 1999). Their survey of 1500 families found that few took any action to reduce nitrate exposure. Of those who did, most purchased bottled water for use by an infant or pregnant woman.

With nitrate contamination increasing in extent and severity, it makes sense to reduce the amount of nitrate inputs into Wisconsin groundwater. Current proposed changes to state rules that could decrease groundwater nitrate contamination (at least near existing wells) include:

NR243 – Would lower the levels of nitrogen associated with manure and process wastewater from reaching groundwater by reducing improperly designed manure storage facilities and excessive or improper application of manure and process wastewater on cropped fields. This proposed rule applies to large Concentrated Animal Feeding Operations, 1000 animal units and larger. There are about 150 of these permitted operations currently.

ATCP51 – With its emphasis on water quality protection, this new livestock siting standard would afford protection to areas susceptible to groundwater pollution. Required standards would prevent runoff from entering sinkholes, ensure that existing storage structures do not leak, and require application of manure according to plan that minimizes risks to groundwater. It would impose standards that will reduce water pollution risks including the potential for well contamination. This adopted rule applies

to new and expanding farms, typically over 500 animal units and would apply to about 70 farms annually.

ATCP50 – This rule applies to all farms and includes the requirement of all farms in Wisconsin to implement nutrient management plans by 2008. Similar to NR243 and ATCP51 it would require farms to use UW recommendations for nutrients including nitrogen. As mentioned in the introduction, current over-application of nitrogen sources to farm fields likely accounts for most of the nitrate loading to groundwater in the state. Application to UW recommendations will reduce nitrate loading and improve groundwater quality.

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Microbial agents

The United States produces some of the cleanest drinking water in the world and yet there are still reports of waterborne disease outbreaks. These outbreaks are produced by microbial agents including bacteria, viruses and parasites. These agents can cause acute and chronic illnesses and

result in life-threatening conditions for individuals with weakened immune systems. Of the approximately 20 outbreaks reported nationally per year, more than half are related to groundwater consumption (Lee, et al. 2002). Many waterborne outbreaks are not reported or detected.

In one statewide assessment a decade ago, approximately 23% of private well water samples statewide tested positive for total coliform bacteria, an indicator species of other biological agents (Warzecha et al 1995). Approximately 3% of private well water samples tested positive for *E. coli*, an indicator of water borne disease that originates in the mammalian intestinal tract.

Some parts of the state are particularly vulnerable to microbial contamination. Microbiological contamination often occurs in areas where the depth to groundwater or depth of soil cover is shallow or in areas of fractured bedrock. In these areas, there is little natural attenuation potential. Door County is one such location where bedrock is fractured and wells are often shallow.

In a recent survey of 25 private wells in Door County, 18 had detections of total coliform in at least one monthly sample over a 1-year period (Braatz, 2004). 40% had detections of a fecal indicator (*E. coli* or enterococci). Significant seasonal trends were also apparent, with higher percentages of wells with fecal indicators in the summer months. There was also a waterborne illness outbreak at a Door County restaurant in December 2004 (Wisconsin DNR).

Researchers at the Marshfield Clinic Research Foundation have investigated the association of pathogenic viruses and bacteria in private wells with incidences of infectious diarrhea and indicators of well water contamination (Borchardt et al. 2003b). In general, infectious diarrhea was not associated with drinking from private wells, nor was it associated with drinking from wells positive for total coliform. However, wells positive for enterococci were associated with children having diarrhea of unknown etiology, which was likely caused by Norwalk-like viruses. Results from a subsequent study of 50 private wells throughout the state indicate that 8% of private wells may be subject to virus contamination (Borchardt et al. 2003a). Wells positive for viruses were not consistent seasonally, nor were they associated with commonly used indicators of microbial contamination such as total coliform or fecal enterococci. These studies suggest that increased monitoring and detection methods for viruses are needed to assess the risk of drinking water with potential microbial contamination.

In another recently completed study in collaboration with the US Geological Survey, Marshfield researchers found that 50% of water samples collected from four La Crosse municipal wells were positive for enteric viruses, including enteroviruses, rotavirus, hepatitis A virus, and Norwalk-like virus (Borchardt et al. 2004). As with the private well study, there was no correspondence to common indicators of sanitary quality, nor was there a consistent seasonal trend. More surprising, viruses were common even in those wells without any Mississippi River water infiltration, suggesting other fecal sources were contaminating the wells. The most likely source is leaking sanitary sewers. The study did not address whether the viruses are inactivated through disinfection processes, or result in illness in the community.

The DNR recommends that private well owners test for microbial water quality annually or when there is a change in taste, color, or odor of the water. Public drinking water systems that disinfect their water supplies are required to sample, on a quarterly basis, for bacteria from the raw water (before treatment) in each well. These raw water samples are representative of the source from which the wells draw groundwater. The DNR has recently begun tracking total coliform detects in the raw water samples through its Drinking Water System database. The number of public

water systems and locations where groundwater samples are collected quarterly for microbial analysis, along with the number of total coliform positive (TCP) samples for the period July 1, 2004 through June 30, 2005 are listed in the following table.

System type	# systems w/ Raw Req.	# locations w/ Raw Req.	# Raw TCP samples	# sys w/ Raw TCP
Municipal (MC)	475	1350	204	60 (12.6%)
Other-than-municipal (OTM)	64	100	9	6 (9.4%)
Non-transient, non-community (NN)	38	59	6	3 (7.9%)
Transient non-community (TN)	39	40	9	5 (12.8%)

Most wells belonging to the group of transient non-community systems (TN), such as restaurants and convenience stores, sample for bacteria on an annual basis. These systems have very small distribution systems and are similar to private water systems in that their water samples represent the groundwater source. There are approximately 9500 active TN systems in Wisconsin.

Data from the Environmental Protection Agency (EPA) shows that the highest percentage of microbial unsafe water is found in small water systems, like TNs, serving less than 500 people (Peterson 2001). The mobility of transient people consuming water at small water systems and general lack of knowledge of illness symptoms hinder waterborne illness outbreak identification.

Nationally, the Center for Disease Control continues to track and identify failures in water systems that lead to illness outbreaks. Because of the increasing evidence for widespread occurrence of microbial contaminants, additional monitoring requirements for vulnerable public water systems are on the horizon. The Environmental Protection Agency (EPA) is developing a strategy, known as the "Groundwater Rule," which would modify Safe Drinking Water Act requirements to increase detection of fecal contamination in groundwater and reduce the occurrence of illness from microbial pathogens. The Groundwater Rule will include 5 preventative strategies that prior EPA drinking water legislation did not adequately address.

The first strategy includes sanitary surveys of public systems to identify deficiencies. The second strategy is a hydrogeologic sensitivity assessment of each public system to identify wells sensitive to fecal contamination. The third strategy is source water monitoring. Currently, the Safe Drinking Water Act focuses on sampling for microbial indicators in the distribution system. Fourth, the law will require corrective action for non-complying features found in the water system and eliminating fecal contamination with treatment or providing an alternative permanent source of water. The fifth strategy of the law is monitoring requirements to ensure that treatment equipment is maintained.

Wisconsin already conducts inspections and requires correction of non-complying features. Therefore, the major changes resulting from the proposed EPA law will be additional monitoring of source water for sensitive systems and installation of approved treatment devices or a new water source the wells found to contain fecal contamination.

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Arsenic

The DNR became aware of naturally occurring arsenic in groundwater and water supply wells in the early 1990's. Initial investigations found that in NE Wisconsin about 3.5% of wells tested were greater than the then current standard of 50 µg/L. The highest well tested at 15,000 µg/L. The DNR issued an advisory for the area which recommended drilling and casing 80 feet beyond the top of the St Peter sandstone where the main arsenic bearing zone was determined to be. This proved to be over 85% successful in bringing arsenic concentrations to below 50 µg/L. Over the years the department has continued to work with drillers to improve construction techniques to minimize arsenic in potable wells.

Arsenic is released from aquifer materials by several mechanisms. The primary mechanism in NE Wisconsin is oxidative breakdown of sulfide minerals. This is caused both by well construction techniques and by local and regional drawdown caused by increasing water use. When this happens, other metals which are also in the sulfides are also released, often times in concentrations that may pose health risks. These metals include nickel, cobalt, cadmium, chromium, lead and iron. A different release mechanism is predominant in SE Wisconsin and along glacial moraines in Northern Wisconsin. In these areas arsenic is bound to iron oxides in the aquifer material and is released due to reduction reactions. When iron oxide is reduced the arsenic is freed into groundwater.

With a new federal standard on the horizon the department coordinated with DHFS and local health departments to sample private wells in several towns in Outagamie and Winnebago

Counties. Over 3900 wells were sampled between 2000 and 2002. Results were delivered to the homeowners at public information meetings. Results indicated that overall about 20% of the wells had concentrations over the new standard of 10 µg/L (the same as the earlier sampling). In some areas, over 40% of the wells exceeded 10 µg/L. One key area was the high density development in the Town of Algoma - just west of Oshkosh. The department made this the first special well casing depth area (SWCDA) in 2002. Three other smaller areas followed soon after.

Between 2002 and 2004 the DNR required more stringent specifications within four small areas where arsenic contamination problems were severe. But it was realized that if SWCDAs were established in this manner, it would result in a 'hodge-podge' of small areas, scattered over a two-county region. So it was decided to seek a more comprehensive regional approach.

The goal was to produce maps delineating low arsenic zones and provide well drillers with guidelines for constructing wells in those aquifers. DNR and WGNHS staff used approximately 14000 wells over a 12 county area to provide a regional context. In the problem area in Outagamie and Winnebago counties over 6000 well constructor reports (WCR) were interpreted to contour problem areas between the top of the St Peter sandstone and top of the Cambrian formations. Maps were then produced giving the maximum depth of a shallow well option or the minimum depth of casing to reach the Cambrian sandstone aquifer. Information on the specifics of the requirements can be found under special casing areas.

Based on the success of the SWCDA and the high levels of wells the DNR moved forward with expanding the SWCDAs to cover the entire counties. Working with the WGNHS and well drillers from the area, detailed maps of casing depths were generated. (See more under interagency coordination) The maps and construction requirements can be seen online.

The project has been a good example of interagency cooperation. Initial work with DHFS and local health departments and town boards effectively define the problem and raised awareness. . Research supported by the joint solicitation helped define the extent and mechanisms of release. DNR and Commerce worked jointly with water treatment companies on developing treatment systems for arsenic removal. Well drillers assisted in identifying drilling methods that reduce arsenic.

Since the realization of the problem in the early 1990's much research has been focused on the arsenic problems. Sixteen studies through the joint solicitation have explored arsenic related topics from detection to geologic controls to well construction and treatment. (See appendix C and "Arsenic Monitoring and Research in Northeastern Wisconsin" in chapter 5). Arsenic concentrations greater than 10 µg/L have been documented in 51 counties. The studies have helped develop real working solutions in the SWCDA. Much has been learned from these studies but much remains to be learned.

Current research is focused on release mechanisms, triggers and reaction kinetics that effect well finishing and rehabilitation operations. The other focus is defining the problem in other areas of the state. For example recently 4 wells in Pierce County had arsenic ranging from 5-59 µg/L. Other metals were also elevated. Lead was as high as 927 µg/L, zinc to 21,000 and nickel and manganese were over 1700 µg/L. With the assistance of WGNHS staff who were mapping the area, a new well was drilled, logged with geophysical equipment and tested. The logging will help with understanding the structure and distribution of arsenic bearing minerals in that part of

the state. Already what was learned there has helped with the design of a new municipal well for Turtle Lake.

The DNR, DHFS, Commerce and others continue to work on the arsenic problems around the state. Arsenic has been found in groundwater in every county in the state. DHFS has shown health outcome effects in two separate studies. In addition there are 2 known cases of confirmed arsenic poisoning from drinking water. (In both cases neurological damage was moderate to severe.) Current arsenic work includes:

- Refinement of the geology in the Outagamie and Winnebago county area and updating casing requirements,
- DHFS and DNR sampling of transient non community wells
- DHFS and DNR targeting of wells for sampling in the southern and SW potions of the state
- Commerce and DNR evaluating and pilot testing arsenic treatment systems for public and private systems that do not have an alternative aquifer option.
- DNR and local governments are working with several Blue Cross / Blue Shield grants for a healthier Wisconsin to explore impediments to private wells sampling and promote well sampling programs
- DNR efforts to improve well construction for schools and community wells
- DHFS, DNR and the WGNHS are working together to gather information from drillers and pump installers on areas with high iron and corrosive water, which may be indications of an arsenic problem. Sampling of these areas is being lead by DHFS.
- A new study funded through the joint solicitation will begin in July 2006 involving researchers from Wisconsin and West Virginia. WGNHS and the DNR are working to add new data to the geologic model for the SWCDA and refine the mapping project.
- Educational outreach to the well drillers continues.

More information related to arsenic can be found on the DNR Arsenic Web Page.

Naturally-Occurring Radionuclides

Naturally-occurring radionuclides, including uranium, radium, and radon are becoming an increasing concern for groundwater quality, particularly in the Cambro-Ordovician aquifer system in eastern Wisconsin. The water produced from this aquifer often contains combined radium activities in excess of 5 pCi/L (picocuries/liter) and in some cases in excess of 30 pCi/L. Nearly 60 public water systems exceed the drinking water standard of 15 pCi/L for gross alpha activity (**Figure 4.4**). The DNR is enforcing the radionuclide standard adopted into NR 809. The DNR has signed consent orders with 42 community water systems that will bring them into compliance with drinking water standards for radium and gross alpha by December of 2006.

Previous studies have shown that radium concentrations in excess of 5 pCi/L can not be explained solely by the presence of parent isotopes in the aquifer solids. It is possible that high radium concentrations in Cambro-Ordovician water originate from downward flow of recharge water through the Maquoketa Shale. Indeed, high radium activity occurs in the Cambro-Ordovician in a band roughly coincident with the Maquoketa subcrop pattern (Grundl, 2001). This pattern extends across the entire eastern portion of the state from Brown County in the north to Racine County in the south. Radium activities have remained relatively constant from the middle 1970s to the present. High gross alpha activity also occurs in a band roughly coincident with the Maquoketa subcrop pattern extending along the entire eastern portion of the state.

The Maquoketa outcrop pattern forms the demarcation between unconfined conditions in the underlying Cambro-Ordovician aquifer to the west and confined conditions to the east. Strong downward gradients exist across the Maquoketa and flow across the unit is maximal near the outcrop where total thickness is at a minimum. This strong downward gradient is very recent and is caused by heavy pumpage of the Cambro-Ordovician in urban areas.

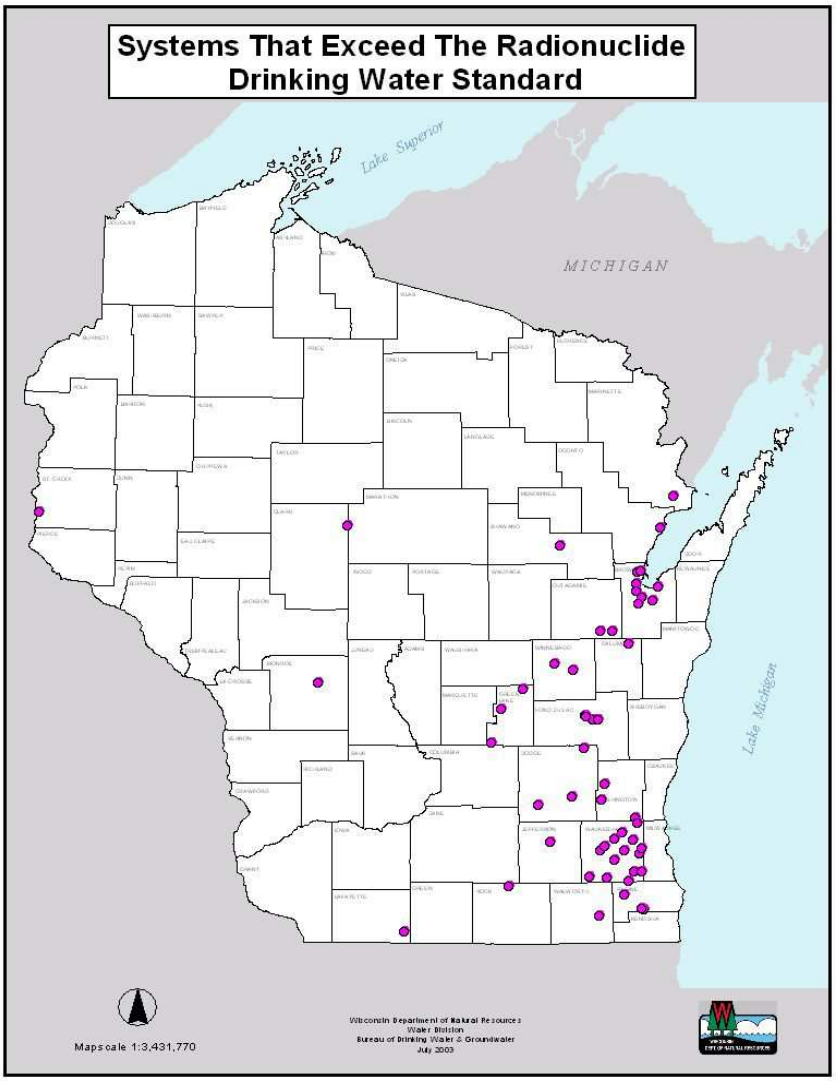

Figure 4.4 Public water systems that exceed 15 pCi/L for gross alpha activity as of July 2003. Source: DNR

The actual cause for high radium and gross alpha activities in the Cambro-Ordovician is undoubtedly a combination of multiple, sometimes subtle, processes that may differ from location to location. Determining which process(es) control the release of solid- phase radioactivity in the Cambro-Ordovician into the groundwater will require a more thorough understanding of the system. Because the source of this radium is not fully understood, basic questions as to how best to manage this increasingly important source of drinking water may be difficult to answer.

Two additional studies were funded by the DNR to address concerns about radioactive compounds in groundwater. In 2000 and 2001, DNR staff collected samples from about 100 community and nontransient noncommunity public water wells. The WSLH analyzed each sample for several alpha-emitting radiochemicals (total Uranium (U-238, U-234, U-235), total Thorium (Th-228, Th-230, Th-232), Radium 226, and Polonium 210) in an attempt to identify and quantify the relative contribution of each chemical to the total gross alpha activity in the samples (Arndt and West, 2004).

Results indicate that radium and its progeny (uranium is a major contributor in relatively few systems, 2 or 3) is the major contributor to high gross alpha activities. Small quantities of polonium and thorium have also been detected but they do not appear to be major contributors to the total gross alpha activity in public water system wells. Another important finding was that total gross alpha measurements are an overestimate of the activities of all of the alpha emitters. The WSLH has developed models to account for the discrepancy between the total gross alpha activity and measurements of individual radionuclides.

In addition, the study showed that the gross alpha activity depends appreciably on the radionuclide used as the calibration standard, the time between sample collection and sample preparation, the time between sample preparation and sample analysis, and whether a radiochemical or a gravimetric method is used to determine the total uranium activity. This is important since according to EPA regulations an adjusted gross alpha activity exceeding 15 pCi/L is considered to be a gross alpha violation. Using the model, it is shown that for some water samples the value obtained for the adjusted gross alpha activity can range from being well within compliance to being well out of compliance. Thus the use of the model developed in this work should be of assistance in helping a water utility with a gross alpha violation determine the reason for the violation, and, therefore, how to correct it.

A second study "Factors Affecting the Determination of Radon in Groundwater" will help determine the impact of expected new EPA standards for radon in drinking water. Staff from the DNR will sample about 340 noncommunity, nontransient and other than municipal water systems per year. To date, approximately 250 samples have been collected from nontransient, noncommunity wells. Preliminary results tend to support findings from earlier community water system monitoring which indicated that approximately 50% of the public water systems monitored in Wisconsin exceed the proposed radon standard of 300 pCi/L. As of July 2006, EPA has not finalized the drinking water standard for radon. – since Wisconsin has a radon air program, the standard will likely be set at 3,000 pCi/L.

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Summaries of the gross alpha and radon studies are available on the WSLH web site at *http://www.slh.wisc.edu/radiochem/research.html*.

GROUNDWATER QUANTITY

Despite a general abundance of groundwater in Wisconsin, there is a growing concern about the overall availability of good quality groundwater for municipal, industrial, agricultural, and domestic use and for adequate baseflow to our lakes, streams, and wetlands. In a 1997 report titled “Status of Groundwater Quantity in Wisconsin," the GCC concluded that a coordinated effort is needed to determine appropriate management options for addressing groundwater withdrawals, to prioritize information needs, and to implement information and education programs (DNR 1997). The report also called for funding additional data collection and research to address groundwater quantity management issues. Though funding has been scarce some progress on these objectives has been made.

Water Use
As part of the National Water-Use Information Program, the U.S. Geological Survey (USGS) stores water-use data in standardized format for different categories of water use. Information about amounts of water withdrawn, sources of water, how the water was used, and how much water was returned, is available to those involved in establishing water-resource policy and to those managing water resources. In 1978, the USGS entered into a cooperative program with the Wisconsin DNR to inventory water use in Wisconsin. Since that time, five reports have been periodically published summarizing water use in Wisconsin.

Groundwater use statewide grew from 570 to 804 million gallons per day (Mgal/d) from 1985 to 2000 (Ellefson and others, 2002). The majority of groundwater use in 2000 is used for public water supplies (330 Mgal/d), which is primarily for domestic use, but also supplies water for some industrial and commercial purposes. Agriculture and irrigation uses are a close second (295 Mgal/d). The remainder provides water for self-supplied domestic, commercial and industrial uses.

Regional Drawdowns
The effects of groundwater withdrawals are well documented on a regional scale in the Lower Fox River Valley, southeastern Wisconsin, and Dane County. There are substantial declines in groundwater levels in these three areas (**Figure 4.5**). The best-documented regional water quantity problem is in the Southeast part of the State. A recent study by the University of Wisconsin Extension - Wisconsin Geological and Natural History Survey and the U.S. Geological Survey shows that in the last 60 years groundwater withdrawals throughout southeastern Wisconsin, Illinois and Michigan were substantial enough to slow and reverse groundwater flow in some areas (Feinstein and others, 2004). In the region between Milwaukee and Waukesha County, simulations using groundwater models show that pumping water from the deep Sandstone Aquifer has begun to alter groundwater flow patterns extending to Lake Michigan, the Illinois border and western Waukesha County. Indeed, about 7.5 percent of the groundwater that used to flow toward Lake Michigan never reaches the coast; it’s drawn into wells. Most of that water eventually reaches Lake Michigan through storm sewers and as treated wastewater, “but the location, timing and quality of the return flow is different than what it was under natural conditions,” the USGS report concludes.

Quantity and Quality
An example of how regional drawdown can bring about quality concerns is seen in Southeastern Wisconsin where many communities that use deep wells now have a problem with naturally occurring radionuclides present deeper in the Sandstone Aquifer. Wells in the Sandstone Aquifer have drawn water levels down hundreds of feet and in recent years the concentrations of radionuclides and other elements have increased in many of these wells. There appear to be

correlations between large drawdowns and radionuclide concentrations, but the scientific relationships between the two are not yet completely understood. This is a very serious problem as radionuclides are carcinogenic and very costly to remove. Several communities facing a December 2006 deadline for reducing the level of a specific radionuclide, radium, in their drinking water are being forced to look for alternative sources. However, the most available alternative of drilling wells into the shallow aquifer is problematic in that it may impact surface waters or other shallow wells. In addition, shallow wells are more vulnerable than deeper wells to contamination from near-surface sources. Fortunately several communities voluntarily went beyond what state law requires to protect surface waters and other water users in siting their wells and managing their water use.

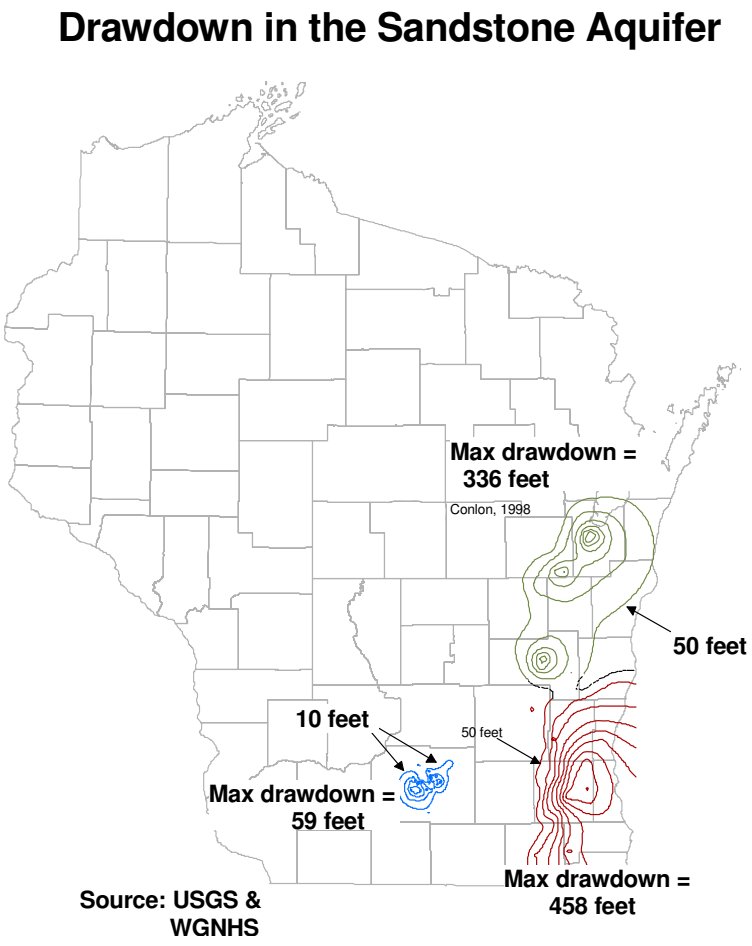

Figure 4.5 Simulated drawdown in the Sandstone Aquifer as of 1998-2000. Contour intervals represent levels of equal hydraulic head and are 50 feet in eastern Wisconsin and 10 feet in Dane County. Sources: USGS and WGNHS

Another example that illustrates the potential that regional drawdown has to cause groundwater quality problems is in the Lower Fox River Valley where detections of arsenic in private well water have increased in recent years (also described above in the Groundwater Quality Section of this Chapter). Investigations in the affected area indicate that most of the arsenic is coming from a

highly mineralized zone at the top of the St. Peter Sandstone. It appears that pumping in the Lower Fox River Valley has lowered water levels in the bedrock aquifer to such an extent that the mineralized zone is exposed to the atmosphere and becomes oxidized, releasing arsenic. Some of the arsenic concentrations found in groundwater have been quite high, with 20% of private wells sampled over the new standard of 10 µg/L.

Alternative Sources

Other developments have also highlighted the importance of groundwater quantity. Two communities, Green Bay and Oak Creek, have proposed aquifer storage and recovery (ASR) as a method for addressing water shortages. ASR involves injecting treated water into the aquifer during times of less water use and pumping that water out when water demand is high, typically during the summer. Both communities worked with DNR to conduct pilot studies to determine if this is feasible in Wisconsin. In Green Bay it was determined that ASR, as pilot tested, was not feasible. Significant levels of arsenic and other contaminants were mobilized from aquifer bedrock during the Green Bay pilot test ASR storage periods. In addition, the plan to utilize ASR for water storage at Green Bay changed. Communities surrounding the city that initially considered purchasing drinking water from Green Bay decided to purchase their water from Manitowoc instead. Pilot testing of ASR at Oak Creek has shown that the technology may be viable, although, manganese appears to have been mobilized from aquifer bedrock during the ASR pilot test and levels of this substance in groundwater have increased. Oak Creek has been issued a conditional approval to use ASR, as pilot tested, provided that mobilized substances do not exceed state groundwater quality enforcement standards.

For some communities tapping Lakes Superior and Michigan is a potential solution to quantity problems. But, for other communities, there are bottlenecks. The Council of Great Lakes Governors which consists of Governors from the eight states and premiers from the two Canadian provinces bordering the Great Lakes has taken the lead in protecting the Great Lakes. The Council signed a Great Lakes Charter in 1985 a voluntary agreement setting guidelines and principles for managing Great Lakes water. A key provision of the Charter aimed to regulate large water withdrawals and diversions from metropolitan centers bordering the lakes. The Council also coordinates the authority granted to the Governors under the U.S. Federal Water Resources Development Act (WRDA) of 1986. This Act requires the Governors' unanimous approval on any proposed out-of-basin diversion or export of water from the Great Lakes Basin. To update the regional water management system and ensure that the Great Lakes are protected, the Governors and Premiers signed the Great Lakes Charter Annex in 2001. The Annex includes proposed provisions clarifying how, where and when water can be removed or diverted from the lakes or from groundwater that feeds them. In general it is difficult to receive permission from Great Lakes charter members to divert lake water outside of the basin which extends only some tens of miles from the Lakes in some areas.

On December 13, 2005 the Annex Implementing Agreements were signed by the Great Lakes Governors and Premiers. Once enacted, the signed agreements will provide the necessary framework to help the States and Provinces to protect the Great Lakes Basin. The agreements include a ban on new diversions of water outside the Basin with limited exceptions, were approved. This agreement to manage water quantity in the Great Lakes basin is the first multi-jurisdictional agreement of this magnitude in the world. All 10 governments have agreed to collectively manage water usage according to the shared goals expressed in this agreement. Now the agreement must be approved by the eight state Legislatures and Congress before it can become law.

Surface Water Impacts

Localized effects from groundwater withdrawals are not as well documented as the regional effects. Cases exist around the state where wells, springs, and wetlands have gone dry; lake levels have dropped; and streamflow has been reduced. In 2000, Perrier (Nestle Waters North America) proposed installing one or more wells in the Big Springs area in southeastern Adams County to pump groundwater to be bottled and sold as spring water. Many local residents opposed the Perrier proposal because of concern about potential impacts to the spring. The DNR issued an approval with conditions to protect the aquifer. The proposal highlighted the issue that, for high capacity wells, the DNR only had authority to deny a high capacity well application if it determined that the new well would interfere with a municipal water supply well.

Solutions

The outcome of several years of work on groundwater pumping policy was 2003 Act 310. The authors of the Act touted it as a "good first step", but recognized that further efforts would be needed to adequately manage groundwater resources in Wisconsin. Specifically, the Act:

- Designated "Groundwater Management Areas" (GMAs) in the northeast and southeast where large drawdowns exist in the deep sandstone aquifer. In the GMAs, plans will be written and implemented to help manage groundwater resources in a sustainable manner.

- Regulates new high capacity wells in Groundwater Protection Areas (GPAs) within 1,200 feet of outstanding or exceptional resource waters, or any class I, II, or III trout stream.

- Regulates new wells that may have a significant environmental impact on springs with a flow of at least one cubic foot per second for at least 80% of the time.

- Creates systems for fees and groundwater pumping data management.

- Created a Groundwater Advisory Committee with members appointed by the legislature and governor to provide guidance as to implementing the present law and making recommendations for future legislative efforts.

Gaps exist in Act 310. These include

- No protections from groundwater pumping exist for 99% of lakes, 92% of stream miles, most springs, and all wetlands.

- The 1200 foot buffer provided by GPAs to trout streams and exceptional and outstanding resource waters is not necessarily sufficient to protect these resources from harm.

Still in play is the work of the Groundwater Advisory Committee. Its report to the Legislature may address these and other gaps. The Groundwater Advisory Committee has until the end of 2006 to make recommendations on GMA issues and until the end of 2007 to make recommendations on GPA issues.

Chapter 5 -- BENEFITS FROM MONITORING AND RESEARCH PROJECTS

The State of Wisconsin has funded over 330 groundwater-related monitoring and research projects since enactment of Wisconsin's comprehensive groundwater protection legislation (1983 Wisconsin Act 410) in 1984 (see *Appendix C*). Those agencies that have funded projects are the DNR, DATCP, DILHR/Commerce, and the UW System.

This chapter highlights some of the areas that have been the focus of research and monitoring projects and illustrates how agencies have used the project results to improve the management of the state's groundwater resources. Many projects have contributed to our understanding of subsurface hydrology, surface water and groundwater interactions, and geology. Some have helped to evaluate existing regulatory programs and determine if there is a need for additional regulations. Numerous studies have increased the knowledge of the movement of contaminants in the subsurface. Others have developed new methods for groundwater evaluation and protection.

Citations refer to the projects listed in the table in *Appendix C*.

PHARMACEUTICALS AND PERSONAL CARE PRODUCTS IN GROUNDWATER

Pharmaceuticals and personal care products (PCPs) are a large group of substances present in human generated waste streams that potentially could contaminant groundwater resources. Pharmaceuticals such as antibiotics, birth control pills and various prescription medicines may be present in wastewater effluents. PCPs, including shampoos, detergents and "over the counter" medications, are found in both treated wastewater discharges and the municipal solid waste stream. Some pharmaceutical/PCP compounds may act as endocrine disruptors, adversely affecting the behavior of natural hormones in humans and other animals. New analytical methods, allowing detection of very small quantities of a substance, have helped improve investigations into the occurrence of pharmaceuticals and PCPs in the environment.

Discharges of treated wastewater through land treatment systems, leachate leaking from solid waste landfills, and agricultural/municipal biosolids landspreading activities can potentially contaminate groundwater aquifers. The mobility and fate of discharged/released substances in the subsurface is a function of a variety of factors such as adsorption properties and biodegradability of the substance, and the amount and properties of the soil material through which the substance is passing. Recent studies in other states, assessing the occurrence of pharmaceuticals and PCPs, have shown the presence of these substances in groundwater at sites where treated wastewater is used to recharge groundwater.

In Wisconsin, research has been done evaluating the occurrence, and movement in the subsurface, of pharmaceuticals and PCPs. A 2003 University of Wisconsin (UW) study, conducted by K.G. Karthikeyan and William F. Bleam, investigated the presence of antibiotics in treated wastewater effluents, and their potential fate in the subsurface. Two antibiotics, tetracycline and sulfamethoxazole, were found in all of the wastewater effluents tested for the study. A variety of other antibiotics were also detected in the tested wastewaters. Tetracycline and sulfamethoxazole were found to be present in groundwater monitoring wells located directly adjacent to some of the

study land treatment system discharge areas.

A second UW study, conducted by Joel Pedersen and K.G. Karthikeyan, has investigated the soil adsorption properties of common antibiotics. This study found that under the right soil conditions some antibiotics, such as the sulfonamide antibiotics, have the potential to be fairly mobile in the subsurface.

Several other pharmaceuticals/PCP studies are currently in progress. A study of the use of a screening assay to evaluate the occurrence of estrogenic endocrine disruptors in groundwater is currently being conducted by the WSLH. This study is to include testing of both high capacity water supply wells located in close proximity to surface waters (where wastewater effluent is being discharged), and water supply wells in the vicinity of home on-site wastewater treatment system discharges to groundwater. A Dane County research project, assessing groundwater impacts from on-site wastewater treatment system discharge, is also currently underway. This project will include an assessment of pharmaceuticals and PCPs in both soil water and groundwater impacted by on-site system discharges in an unsewered subdivision.

The Department has begun to use the results of these recent pharmaceutical and PCP research studies to evaluate whether current state groundwater protection regulations are adequate to address potential adverse impacts that might result from the discharge of these substances. Studies comparing the levels of pharmaceutical and PCP substances in wastewater influent with those present in treatment system effluents will be useful in assessing the removal effectiveness of currently approved wastewater treatment processes. Research into the behavior of pharmaceutical and PCP substances in soil and groundwater is helping the Department develop effective monitoring strategies. Studies evaluating new sampling techniques and analytical methods help assure that the Department is utilizing the best available tools to assess the occurrence of these substances in the environment.

THE ATRAZINE RULE

The development of the Atrazine Rule (ATCP 30, Wis. Adm. Code) illustrates how the benefits of state-funded research and monitoring can build on one another. In the mid-1980s the corn herbicide atrazine was first detected in monitoring wells and private drinking water wells in Wisconsin. The first systematic well sampling program to characterize atrazine contamination on a statewide basis was the 1988 DATCP Grade A Dairy Farm Well Water Quality Survey (LeMasters, 1989). This state-funded well survey estimated that atrazine was present in 12% of the Grade A Dairy Farm Wells in the State.

This study left unanswered many questions regarding the sources, groundwater susceptibility, and the presence of pesticides other than atrazine. Without better information on these and other questions, it was challenging for DATCP, the agency charged with groundwater protection related to agricultural chemicals, to develop a plan of action. It was obvious that a concerted information gathering program was needed. Over the next several years, before and during the development of the DATCP atrazine rule, the Wisconsin Groundwater and Pesticide Research Program played an essential role in providing the needed information. Research and monitoring were conducted on several topics that played a direct role in the evolution of the atrazine rule.

The state research and monitoring program funded several key projects to better understand the sources of atrazine contamination. When atrazine was first found in groundwater, an argument had been made that this was the result of point sources such as spills and mishandling. One of the most important findings that allowed DATCP to begin developing the atrazine rule was that

normal agricultural applications of atrazine could lead to groundwater contamination. The DATCP groundwater monitoring project for pesticides (Postle, 1986-96) used monitoring wells located next to agricultural fields to study groundwater contamination by atrazine and other pesticides. This study showed that atrazine from field use on sandy soils could cause contamination, often above the 3 µg/L ES. The UW Water Resources Center conducted a detailed hydrogeologic study (Chesters, 1990-91) at a farm in Dane County and showed conclusively that atrazine contamination could result from both field applications and mixing/loading practices. With the knowledge that nonpoint contamination of groundwater by atrazine was indeed occurring, DATCP could develop ways to reduce this contamination.

State-funded research was essential in showing that atrazine contamination did not follow simplistic notions of groundwater contamination susceptibility. One of the most important findings was that the Central Sands and the Lower Wisconsin River Valley (LWRV), two areas that appear similar in soils and agricultural practices, had significantly different susceptibility to contamination. These differences were pointed out in several research projects conducted by the UW Soil Science Department (Daniel, 1991; Lowery, 1991; McSweeney, 1991; Lowery, 1992-3). This information had a direct influence on the atrazine rule in that there is now a use prohibition in the LWRV and managed use in the Central Sands.

Another key finding related to the susceptibility of groundwater to atrazine contamination was that many of the areas with high frequency of detections had medium textured (loamy) soils. It had previously been thought that these areas were less susceptible to leaching and groundwater contamination than areas with sandy soils. State-funded research and monitoring efforts, however, showed that the intensity of atrazine use, in addition to soil and geologic conditions, played an important role in the contamination. This finding helped to explain why many areas in south central Wisconsin, with medium textured soil and high corn production, had many wells contaminated with atrazine. This knowledge allowed DATCP to adopt management strategies for reducing atrazine contamination in these areas.

When atrazine was first discovered in Wisconsin's groundwater in the mid-1980s, DATCP was interested in managing its use based on predictive modeling of contamination processes. Modeling activities funded by the state research program, however, indicated that the behavior of atrazine and other contaminants in the environment was complex and could not be reliably predicted by modeling. In response to this finding, DATCP adopted a more empirical approach to identifying management areas. Actual well results were plotted on maps and, together with an analysis of soils and geology, management areas were delineated.

When monitoring and rule making efforts for atrazine first started, parent atrazine was the only compound that was considered. As more research was conducted, however, it was discovered that three metabolites (breakdown products) of atrazine were present in groundwater and were of health concern (Chesters, 1990-91; LeMasters, 1990; Cowell, 1990; Cates, 1991). State-funded sampling programs showed that due to the presence of atrazine metabolites, the groundwater problems were more serious than previously considered. This knowledge allowed DNR to strengthen the groundwater standard for atrazine in 1992 and allowed DATCP to strengthen the atrazine rule in 1993 and extend required use reductions to the entire state.

It is interesting to try to envision how DATCP's atrazine rule would look if it did not have the benefit of the intensive research and monitoring efforts. It is safe to say that it would not have been developed on as good an understanding of the behavior of atrazine in the environment or the geographic patterns of contamination. It is possible that without the intensive monitoring efforts, the full extent of the problem would not have been discovered and atrazine use would not have

been reduced. On the other hand, it is possible that with inadequate knowledge a "broad brush" approach would have been taken. This could have resulted in unfair regulations that were not tailored to the different geographic areas of the state.

Two important aspects of environmental regulation that promote its acceptance are that it is based on science and that it is fair. Good research is necessary to achieve these two characteristics. The Atrazine Rule has experienced a relatively high degree of acceptance due to the effort that was put into its development.

GROUNDWATER MONITORING AT SOLID WASTE DISPOSAL SITES

The DNR's Waste and Materials Management (WMM) program received project funding ten times from 1985 to 2003 through the joint solicitation process. These projects have benefited the program in many ways, primarily impacting regulations and monitoring practices.

The first two studies (Friedman, 1985-87; Battista, 1988-89) revealed for the first time that groundwater around many Wisconsin landfills was contaminated by VOCs. The studies also showed that VOC contamination of groundwater was more common at unlined municipal solid waste landfills than at other types of landfills. A follow-up VOC study (Connelly 1993-94) showed that VOC levels have decreased at most of the unlined landfills, though at many of the sites VOC levels do not show continued decline. There was no VOC contamination definitely attributable to leachate migration at any of the older, engineered landfills that confirmed that these sites are performing as WMM program staff had hoped. The results of the three VOC studies have been used to establish requirements for VOC sampling at new and existing landfills. These studies have also indicated that inorganic compounds could be useful in predicting VOC contamination at landfills. Therefore, until recent EPA rules required VOC monitoring, the WMM program allowed sites to sample for inorganic parameters as part of routine monitoring and not sample VOCs until inorganics were elevated. The VOC studies provided valuable data that was used to convince EPA to reduce the number of VOCs required for monitoring at municipal solid waste landfills in Wisconsin. This reduction in monitoring (the use of inorganics and the reduced number of VOCs when they are required) allowed landfill owners considerable cost savings while maintaining equivalent environmental protection. Additionally, the VOC data was used to require responsible parties to define the degree and extent of contamination and remediate groundwater contamination at their landfills.

Research on methods of assessing groundwater quality data and data quality control completed in the third VOC study has been helpful to WMM program staff and consultants in interpreting groundwater quality data from landfills and other facilities. This study also showed the need to require laboratories to report data between the limit of detection and the limit of quantitation.

An assessment of Wisconsin's Groundwater Monitoring Plan program (Pugh, 1992) for active non-approved landfills provided the documentation of a set procedure for selecting monitoring sites. This information has been useful in recent meetings with municipalities held to convince municipalities that they have not been singled out for further evaluation of groundwater contamination and to demonstrate that the process used for selecting landfills for monitoring is objective.

Three studies from 1991 to 1994 on the potential groundwater impacts at deer pits, yard waste sites, and construction and demolition landfills (Pugh, 1992-3; Pugh, 1994) were conducted because little or no data existed on the potential impact to groundwater from these sites. Research has provided the information necessary to revise rules and establish policy regarding monitoring

and siting of construction and demolition (C/D) landfills, deer pits, and yard waste sites in Wisconsin. The groundwater study of deer pits showed that impacts were minimal and helped the WMM program to decide not to require liners and to loosen some construction and reporting requirements. Similarly, the yard waste site study showed only minor groundwater impacts, which led the WMM program to encourage active management of these sites rather than stiffen regulations. The study of construction and demolition landfills showed some groundwater impacts at large sites but little or no impacts at smaller sites. These findings led to new regulations (effective June 1996) allowing lined intermediate size C/D landfills, which can provide the economic benefits of a large site without the potential negative impacts of very large sites. Based on the research, the regulations were written to require groundwater monitoring of inorganic parameters at small size C/D landfills but only require VOC sampling when establishing background. Since these studies have been conducted, many states and the EPA have contacted the WMM program about the information collected.

Another study undertaken by the WMM program (Connelly, 1994) was a comparison of groundwater sampling methods for collecting metals samples at monitoring wells. The study was in response to EPA's October 1991 ban on field filtering of groundwater samples that became effective in October 1994. The WMM program opposed this ban because many Wisconsin monitoring wells produce very turbid water which can lead to false positive results for metals if samples are not filtered. Additionally, the new EPA-recommended procedure, low-flow pumping, requires a significant amount of additional equipment. The study showed that the low-flow pumping method was appropriate in many circumstances but could not be used to sample slowly recovering wells. The results showed that turbidity was the best indicator that a well has been sufficiently purged. The results of the investigation are being used to revise groundwater sampling procedures required by the WMM program. Additionally, the study helped establish Wisconsin as one of two leading states playing a major role in advising EPA on revisions to their groundwater sampling requirements at municipal solid waste landfills.

A follow up study by the WMM program (Svavarsson, 1995) compared low flow pumping and bailing for VOC groundwater sampling at landfills. The study indicated that, in contrast to what some were claiming, there was very little difference in the results when using the two different methods. These findings were incorporated into the new groundwater sampling code and allowed the use of either method for sampling VOCs. This reduced the cost that landfill owners would otherwise have had to bear to purchase and operate low flow pumping equipment.

A joint project between the Bureau and UW Stevens Point evaluated the effectiveness of chemical oxygen demand (COD) as an indicator parameter at landfills (Connelly and Stephens, 2000). One reason for evaluating COD is that mercury waste is generated when COD is analyzed in the laboratory. The DNR's overall goal was to reduce amount of mercury that gets into the environment. Eliminating COD sampling at the 400+ landfills that currently sample for it would help the agency meet that goal. Findings from the first year of the study indicated that there are potential to eliminate COD monitoring at some types of landfills. The second year of the study evaluated possible alternatives to sampling for COD. Dissolved organic carbon (DOC) appears to be an acceptable alternative in certain circumstances. WMM staff have incorporated the recommendations of this study into code changes that went into effect in February 2006.

Between July 2000 and July 2001 the Bureau studied 31 landfills accepting municipal solid waste, to try to determine whether VOC contamination in groundwater at these landfills is increasing, decreasing or remaining stable (Connelly 2001). Investigators chose sites with 10 years of data and summarized the trends over this period of time. One purpose of this study was to determine whether natural attenuation is occurring in groundwater near leaking landfills. The

study showed that natural attenuation processes were occurring at most of the landfills as evidenced by the large number of stable or decreasing concentration trends. However, the concentrations took longer to stabilize and stabilized at higher levels than at other types of VOC contamination sites described in the literature.

WMM received funding for the period October 2002 to October 2003 to study groundwater quality at solid waste landfills to determine whether they are a source of pesticide contamination. We sampled 11 sites the spring and summer of 2003 and summarized the findings in a 2005 GEMS Newsletter article. Groundwater samples were analyzed for 14 common Wisconsin pesticides using immunoassays and additional GC/MS methods. Preliminary findings indicated that leaking landfills may be contributing alachlor, aldicarb, atrazine and 2,4-D to groundwater. The study researchers believed a follow-up study was needed to provide more evidence to help make concrete recommendations about which pesticides to sample for. However, staff and funding are not currently available for this.

ARSENIC MONITORING AND RESEARCH IN NORTHEASTERN WISCONSIN

Wisconsin is also a leader in groundwater monitoring for naturally occurring compounds. Two projects in the DNR Lake Michigan District (Stoll, 1992; 1994) identified the existence of lead and arsenic contamination in groundwater. Homeowners were alerted through direct mailings, public meetings and mass media news releases. Over 72,000 people were unaware of their exposure to the substances in their drinking water. In one case, the sources of metals in these drinking water supplies were given priority for removal (Door County Lead Arsenate Mixing Sites).

The DNR coordinated with the DHFS to conduct health surveys on individuals consuming locally contaminated water supplies and made appropriate health recommendations. Local County Health Departments in affected areas are also actively monitoring groundwater quality and are providing assistance to homeowners. In 2001 and 2002, DHFS staff received additional funding to conduct a follow-up investigation on the relationship between exposure to inorganic arsenic in water and health outcomes (Knobeloch 2001). As part of this research effort, local health departments, DNR staff, town clerks and others have conducted well sampling campaigns in townships in the affected counties.

2233 households submitted samples and returned health surveys, providing health and exposure information for 6669 individuals. Approximately 20% of the water supplies contained arsenic levels above 10 µg/L. Slightly more than 10% of the families consumed water that had an arsenic level greater than 20 µg/L. People over the age of 50 were more likely to report a diagnosis of skin cancer if they had consumed water that had an arsenic concentration greater than 5 µg/L for 10 years or more. Cigarette use was also associated with higher skin cancer rates: residents who both smoked and consumed arsenic-contaminated water reported the highest skin cancer prevalence rate. No association was seen between exposure to arsenic-contaminated water and the incidence of other types of cancer. However, findings from this study were consistent with previously reported associations between arsenic exposure and the prevalence of adult onset diabetes and cardiovascular disease.

As part of this study, DHFS conducted a survey of households in selected areas of northeastern Wisconsin affected by arsenic in groundwater. The goal of this survey was to assess residents' understanding of their laboratory results, learn what actions people have taken in response to their results, and to identify barriers to increased participation in well sampling campaigns. The survey revealed that more than 80% of those who perceived their well water to be unsafe had taken

action to reduce their exposure to arsenic, usually by installing a treatment system or by drinking bottled water. Among those who had not sampled their wells for arsenic, confidence in the safety of their well and lack of information about how to have their water tested were the most commonly cited reasons. Many of those who had not had their wells tested had reported that they had only recently moved into their homes or into the area.

Studies conducted by DNR of the extent of the arsenic contaminated area led to the establishment of an "Arsenic Advisory Area" (AAA) in the early 1990s. This area includes the strip of land five miles either side of the bedrock subcrop of the St. Peter Sandstone, extending in a northeasterly trend, from a location just southwest of Oshkosh, to a location just west of Green Bay. For this area, DNR developed special well construction specifications, more stringent than the minimum Private Well Code requirements. DNR guidance recommends the installation of 80 feet of casing through the sandstone contact for drinking water wells in the AAA. These specifications were recommended, but not required, for new wells constructed within the "Arsenic Advisory Area". The specifications, when followed, will increase the likelihood of installing a well free of arsenic. A special well casing depth area (SWCDA) has been established for the Town of Algoma in Winnebago County. In this area, all wells must be drilled with mud/wash rotary methods with a 10-inch upper enlarged drillhole, Bradenhead grout methods and cased to the Cambrian sandstone aquifer.

In 2002 the WGNHS completed field experiments in the Fox River Valley that evaluated mechanisms of arsenic release to groundwater from domestic wells completed in the St. Peter sandstone aquifer, including studies of arsenic exposure to residents in the area and the effects of well chlorination on arsenic levels (Gotkowitz 2001). Findings support the hypothesis that high levels of arsenic in groundwater occur where mineralization is oxidized in well boreholes. However, two distinct geochemical mechanisms appear to contribute low to moderate arsenic concentrations to well water in this aquifer. 1) Oxidation of sulfide minerals may release arsenic to groundwater in confined portions of the aquifer; oxidation may have occurred at some time in the geologic past, or current levels of oxygen dissolved in the groundwater may be sufficient to permit slow oxidation to occur. 2) Reductive dissolution of arsenic-bearing iron oxides also seems to contribute low to moderate levels of arsenic to groundwater when the geochemical environment becomes sufficiently reducing. This occurs under typical domestic water use patterns, because increasing groundwater residence time in wells correlates to the onset of strongly reducing conditions and higher arsenic concentrations. The well borehole is a microbiologically active environment, and biogeochemical reactions likely contribute to the observed increase in arsenic concentrations. Reducing the volume of well bore storage relative to water use may help to limit arsenic concentrations in well water. Results of this study were presented to DNR Drinking Water and Groundwater Program staff and used by the DNR to develop well construction guidelines for the Towns of Algoma and Omro.

Several other ongoing projects addressing arsenic issues include a study refining analytical methods for detection of arsenic compounds (Aldstadt 2001), a study of the role of chlorination in releasing arsenic (Sonzogni 2002), three projects investigating treatment methodologies for both private and public water supplies (Anderson 2001, Park 2002, McGinley 2002), and a project investigating the occurrence of arsenic in southeastern Wisconsin aquifers (Bahr and Gotkowitz 2003). These studies will help provide needed information about the occurrence, health risks, and remediation of arsenic in drinking water supplies. Results will be made available as final reports are completed.

GROUNDWATER MOVEMENT IN FRACTURED DOLOMITE

Door County has been the site of five research projects by the WGNHS to develop a framework for studying the complex groundwater flow regime in fractured rock found in many parts of the state. The first project (Bradbury, 1986-90) started as a nonpoint source watershed project investigating the hydrogeology and groundwater geochemistry in the shallow fractured dolomite aquifer in Door County. Groundwater quality was found to vary widely over time with bacteriological contamination common. The second study (Bradbury, 1992) showed that modeling results obtained from a discrete fracture model varied considerably from results produced by a continuum model for groundwater movement. The discrete fracture model estimated capture zones, groundwater flow paths, and groundwater travel times by using mathematical representations of fractures digitized from aerial photos. The third study (Bradbury, 1993-94) used a tracer for characterization of groundwater movement and contaminant transport. It revealed that hydraulic conductivity can vary widely in the same well depending on what depth interval is tested.

A fourth study applied the discrete fracture flow model above to wellhead protection at the City of Sturgeon Bay (Bradbury 1996). Municipal wells at Sturgeon Bay draw groundwater from a series of horizontal fracture planes in Door County's dolomite aquifer, and delineating wellhead protection areas in such environments is extremely challenging. This complex project has relied upon hydrogeologic information and analytical tools developed through the three research projects described above which targeted processes and models for groundwater movement in fractured rocks. Without the knowledge and experience gained through these previous projects the Sturgeon Bay Wellhead Protection Project could not have been accomplished.

During 1999, Bradbury and others began a follow-up project to attempt to verify the results of the Sturgeon Bay wellhead protection project using natural groundwater tracers (Bradbury 2000). This research measured the natural seasonal variations in temperature, electrical conductivity, and oxygen and hydrogen isotopes of groundwater and precipitation in order to verify the sources and velocities of groundwater moving toward Sturgeon Bay's wells. The use of such tracers is attractive because they are naturally present in the environment. The geochemical and isotopic data are consistent with conceptual and numerical groundwater models near Sturgeon Bay. Both the field study and the numerical model show that the dolomite aquifer responds very rapidly to precipitation events. Advective transport simulations using particle tracking produce concentration breakthrough curves consistent with field results.

DEVELOPING NEW TOOLS FOR GROUNDWATER PROTECTION

Applications of a wide variety of tools for gathering and working with hydrogeologic and groundwater quality data have been funded. Projects involving Geographic Information Systems (GIS) and sophisticated groundwater modeling applications have been funded in the many areas of the state. The funding agencies hope to continue to develop improved methodologies to make groundwater quality, quantity and contaminant source data more readily available.

Previous support of county-wide groundwater inventory studies and of modeling methodologies (Potter, 1992-93; Anderson, 1997) has given WGNHS and USGS personnel the hydrogeologic databases and analytical tools needed for the construction of regional groundwater models such as the recently completed Dane County groundwater model. This computer model, which covers all of Dane County, simulates current and future groundwater conditions and is being used to evaluate how current and future groundwater pumping affects regional water levels and also how

groundwater use affects shallow lakes, streams, and wetlands. In addition, this model has been used to delineate groundwater capture zones for all municipal wells in Dane County (Bradbury 1996).

The Dane County model, which provides a modern hydrogeologic framework for groundwater movement in Dane County, has stimulated a number of significant research projects by other investigators (Mickelson 1994-95; Bradbury et al., 2000). These investigators are using the model as a starting point for more detailed flow models of specific problems or areas of the county. One of the most significant of these is the award of a multi-year USEPA STAR grant to a team of DNR, UW-Madison, USGS, and WGNHS investigators who are investigating the water-resources impact of different land-use strategies on Madison's urban fringe. This research will support several graduate students and is will provide an integrated assessment of the hydrological, ecological, and institutional impacts of urbanization and land-use change. This research is focused on the Pheasant Branch watershed just west of Madison. Other research projects are investigating the sources of groundwater supplying important springs in the Nine Springs and Token Creek watersheds, with the goal of determining how nearby development and groundwater use could affect the springs.

The Dane County model has now become a prototype for regional groundwater models in other parts of Wisconsin. In 2003, the WGNHS, USGS, and SEWRPC finalized a cooperative project to develop a similar model for the entire seven-county SEWRPC area of southeast Wisconsin. Other modeling projects are taking place in Sauk, Rock, and La Crosse Counties. Such models are critical tools in the planning process, and allow water managers to evaluate the impacts of various future water management and land use alternatives in order to make well-informed land-use decisions.

PREVENTION AND REMEDIATION OF GROUNDWATER CONTAMINATION

The State of Wisconsin (through the UWS Water Resources Institute) has supported many research projects emphasizing new technologies for prevention or remediation of groundwater contamination. Final reports and studies in progress provide information or products that will be important for future efforts aimed at controlling or attenuating groundwater contamination in Wisconsin. The findings cover a wide range of technologies including:

- New and enhanced physicochemical or biological methods to renovate waters contaminated by pesticides and volatile organic carbon compounds (Collins, 1997-2002), (Li, 2000), (Benson and Eykholt, 2000), (Benson, 1997-2000), (Hoopes, 1997-99), (Park, 1997-98), (Bahr, 1996-98), (Hickey, 1994-96), (Anderson, 1994-95), (Chesters and Harkin, 1991), (Harris and Hickey, 1991-92);
- Enhancements in the ability to control, monitor, and predict the movement of landfill and mine waste contaminants to groundwater (Edil and Benson, 2000), (Edil 1997), (Benson, 1995-96), (Edil and Park, 1992-93);
- Improvements in the predictability of pump-and-treat remediation applications to contaminated aquifers (Bahr, 1994-95);
- Innovative agricultural practices designed to reduce groundwater contamination by pesticides and nitrate (DeVita and Dawson, 2001-04), (Norman, 2000-03), (Bundy, 1993-94, 1997-98), (Shinners, 1995-96), (Newenhouse, 1995), (Harrison, 1992-93), (Bahr, 1991-92); and
- Development of new technologies for evaluating the integrity of water supply well and exploration borehole seals (Edil, 1996, 1998-99), (Edil and Benson, 1997-98).

DETECTION AND MONITORING OF MICROBIOLOGICAL CONTAMINANTS

The GCC has solicited research projects during the last several years that attempt to improve understanding of microbiological aspects of groundwater contamination.

Several projects have focused on developing new techniques for detecting, quantifying, and monitoring microorganisms in groundwater and soils. Researchers at the UW-Madison Soil Science Department, developed a rapid molecular method using the polymerase chain reaction (PCR) to assay soils for the presence of specific sewage-borne pathogens (Hickey 1997). PCR-based methods eliminate the need to culture organisms for detection, and remedy shortcomings of traditional techniques by allowing rapid, sensitive, and specific identification of the pathogens of concern rather than indicator organisms. The PCR protocol Hickey developed was designed to detect DNA originating from *Escherichia coli,* which is one of the major species of bacteria associated with human waste. With this method he could distinguish *E. coli* DNA from that of its closest relative, *Shigella*. The method allowed the detection of DNA equivalent to about 20 cells. Currently, he is testing the PCR method for tracking of *E. coli* in the environment.

Because they have the capacity to co-metabolize a wide variety of organic chemicals, including halogenated compounds, methanotrophic bacteria have significant potential for bioremediation. The UW-Milwaukee Department of Biological Sciences has developed methods for quantification of methanotrophs in groundwater (Collins 1997, 1999). These methods, that include competitive PCR and direct PCR, provide approaches to monitoring bioremediation and natural attenuation. In addition, this work has provided the basis of another study that applied direct PCR to the detection of pathogens in groundwater (Collins 2001).

A recently completed study by the Wisconsin State Laboratory of Hygiene (WSLH) investigated storage and handling requirements for water samples submitted for coliform and *E. coli* analysis (Sonzogni and others, 2002). Currently the USEPA has no guidelines for sample holding times and shipping temperatures for drinking water samples submitted for *E. coli* testing. The study provided evidence to expand the allowable storage time of water samples submitted for *E. coli* analysis beyond the current eight hour limit as well as supporting a single preservation protocol for both surface waters and drinking water samples. A change to a maximum holding time of chilled samples for up to 30 hours could easily be supported by the data presented in this study. The data also called into question the current practice of allowing up to 48 hours for submitting drinking water samples with no attempt to cool them. A reduction in the time period to 30 hours, or a requirement to ship the samples at less than 10 degrees C, could be supported by the data.

Another recent WSLH study developed a culture method for detecting *Helicobacter pylori* from a heterogeneous microbial population in water, and then use this method to establish a data base for its occurrence in Wisconsin groundwater (Sonzogni and others 2002). Prior to this study, there were no reliable methods for detecting viable *H. pylori* in environmental samples (water, manure, vegetables, etc.). *H. pylori* is recognized by the World Health Organization to be the primary cause of peptic ulcers, chronic gastritis and stomach cancer. About 50% of the U.S. population are thought to be symptomatic or asymptomatic carriers, even though the source of human infection is not well understood. The efforts of this study resulted in the development of a high quality plating media for selecting viable *H. pylori* from mixed microbial populations. Samples from over 400 private wells were *H. pylori*-absent, including wells used by infected residents. These results suggest that the route of *H. pylori* to humans in Wisconsin probably does not involve private well water.

The Marshfield Clinic Research Foundation has investigated the association of pathogenic viruses and bacteria in private wells with incidences of infectious diarrhea and indicators of well water contamination (Borchardt 1997, 1999). In general, infectious diarrhea was not associated with drinking from private wells, nor was it associated with drinking from wells positive for total coliform. However, wells positive for enterococci were associated with children having diarrhea of unknown etiology, which was likely caused by Norwalk-like viruses. Final results indicate that the incidence of virus contamination in private wells may affect 4-12% of private wells. Of concern to drinking water regulators is the seasonal variability of the virus occurrences and lack of correspondence between viral presence and common microbial indicators.

In another recently completed study with the US Geological Survey, Marshfield researchers found that 50% of water samples collected from four La Crosse municipal wells were positive for enteric viruses, including enteroviruses, rotavirus, hepatitis A virus, and Norwalk-like virus (Hunt and Borchardt, 2002). As with the private well study, there was no correspondence to common indicators of sanitary quality. More surprising, there was no relationship between presence of surface water in the well water samples as determined by isotope analysis and virus occurrence. These findings suggest that viruses may be more common than expected in drinking water samples, although they do not indicate whether the viruses are viable, are inactivated through disinfection processes, or result in illness in the community. Research into the link between virus occurrence and human health is needed to answer these questions.

GROUNDWATER DRAWDOWNS

Large-scale withdrawals of groundwater are adversely affecting the environment, economy and public health in large areas of Wisconsin. These drawdowns can cause the water level in wells, streams and wetlands to drop or cause them to dry up entirely. Drawdowns can also cause the levels of arsenic, radium (the precursor to radon) and salinity in drinking water to increase.

State-supported research is using groundwater information and groundwater flow models developed at a regional scale and adapting it for use at the local level. In Washington County, researchers are working with the city of Richfield to develop a protocol for quantifying its groundwater budget (Cherkauer, 2003). That information will be coupled with projected changes in land use and pumping demand to define the effects of several development scenarios on the community's water supply. Once developed, this protocol will enable other communities to decide how to best protect vital groundwater recharge areas, local streams, lakes and wetlands.

Another project is investigating the sources of high salinity and radium in the deep sandstone aquifer that supplies water to residents of eastern Wisconsin (Grundl and Bradbury, 2003). This project is examining in detail the chemistry of the groundwater and the rock formations of this complex aquifer and determining whether high pumping rates are raising salinity and radium levels. This will help city planners and water utility directors better understand the relationship between well operations and water quality in this region, and evaluate effects of urban growth on water supplies.

Regional studies have identified central Waukesha County as an area where continued deep groundwater pumping might be causing the deep aquifers to become unconfined as water levels fall. A 2004 project installed one deep piezometer near Pewaukee for use as a monitoring point to document water-level declines. In 2006 the WGNHS will complete a study to help understand the vertical movement of groundwater through the regional Maquoketa aquitard, with emphasis on the possible effects of cross-connecting wells and fractures.

Other State-supported research is investigating the viability of aquifer storage and recovery (ASR) for Wisconsin, where excess water is stored in aquifers when demand is low and withdrawn for use when demand increases (Anderson, 2003). Computer models of groundwater flow and transport in ASR systems are being developed for two representative groundwater systems in Wisconsin. A better understanding of pumping rates, storage times and other factors that affect recovery efficiency of ASR systems will help guide future decision-making about using these systems in Wisconsin.

COMPREHENSIVE PLANNING

The State of Wisconsin has required Wisconsin towns, cities, villages and counties to develop comprehensive plans by 2010 in order to undertake common land use activities such as zoning and land division regulation. Communities that rely on ground water as their sole source of water need to assess the magnitude and limits of their water source as part of their comprehensive development plan, but most have little expertise in quantifying and protecting their water supply. A two-year project funded by the University of Wisconsin Water Resources Institute (WRI) partnered with such a community (Richfield, Wis.) to determine what kinds of groundwater supply information was most relevant and usable for land use planning from a community's perspective. This study determined that the most important information needed by such a community is a good basic understanding of the geology, sources, sinks and water balance of its aquifer system so that residents and community leaders know where their water comes from. Interaction with users at all levels is also crucial to developing the awareness needed to create a long-term land use plan and supporting laws to ensure a sustainable water supply under foreseeable future conditions. The next step is to share this model with other communities to help them plan how best to actively manage and protect the recharge areas that supply their water.

A related WRI project evaluated whether Wisconsin communities are addressing groundwater in their comprehensive plans, and what tools would make them more likely to do so. This project providing multiple presentations to local and state groups involved in groundwater planning; a webpage of study results; articles in a Center for Land Use Education newsletter distributed to more than 160 community planners and educators; a presentation to about 100 people at the 2005 conference of the American Water Resources Association-Wisconsin Section; and publication of an article in a national journal (Comprehensive Planning in Wisconsin: Are Communities Planning to Protect Their Groundwater Water Resources IMPACT 7(6):19-21).

MICROBIOLOGICAL GROUNDWATER MONITORING

Protecting groundwater from microbial contamination is a top public health priority. The United States and Canada experience significant levels of gastrointestinal disease from drinking water, more than 70 percent of which is associated with contaminated well water. A UW Water Resources Institute project examined the strengths and weaknesses of 10 enzyme-based tests approved by the U.S. Environmental Protection Agency for detecting total coliform and E. coli in drinking water. The results suggest these tests differ significantly in their ability to detect/enumerate total coliforms and E. coli and to suppress false positive results from Aeromonas, a non-coliform organism. The most significant of these findings was the inability of some test method/sample matrix combinations to even detect E. coli in high concentrations.

RAIN GARDEN DESIGN & EVALUATION

One product resulting from recently completed Wisconsin WRI research is a user-friendly computer model that can be used in the design and evaluation of rain gardens and bioretention

facilities. This model is now recommended by the Wisconsin Department of Resources (DNR) for use in meeting its new stormwater infiltration regulations and is available free of charge on the DNR website. A manual based on related WRI-funded research, Design Guidelines for Stormwater Bioretention Facilities, has been accepted for publication next spring by the University of Wisconsin Aquatic Sciences Center.

METHYLMERCURY FORMED IN GROUNDWATER

A WRI study conducted at the Allequash Creek watershed in northern Wisconsin determined that anoxic zones in shallow groundwater are an important site of methylmercury formation. This information will advance our understanding of mercury transport and methylation in groundwater and watershed response to mitigation of mercury inputs.

ESTROGENIC ENDOCRINE DISRUPTORS IN GROUNDWATER

A WRI-funded analysis of multiple groundwater samples from high capacity wells at five Wisconsin municipalities showed no estrogenic endocrine disruptor activity, leading the investigators to conclude that no infiltration of these contaminants from surface water into nearby groundwater is occurring. Also, analysis of multiple samples of septic influent, effluents, monitoring wells and soil water indicate septic systems using the biomicrobic aerobic and sand filtration system provided cleaner effluent than mound systems.

Chapter 6 -- DIRECTIONS FOR FUTURE GROUNDWATER PROTECTION

The Groundwater Coordinating Council (GCC) is directed by statute to include in its annual report a "list and description of current and anticipated groundwater problems" and to "set forth the recommendations of the Council" (s. 15.347(13)(g), Wis. Stats.). The purpose of this Chapter is to call attention to statewide priorities in the area of research, monitoring, policy, planning, and coordination related to groundwater and to provide direction to the GCC and its Subcommittees. In addition, this Chapter sets forth the Council's recommendations for future groundwater protection and management needs to state agencies, the Governor, the Legislature, and the citizens of Wisconsin.

PRIORITY RESEARCH & MONITORING NEEDS/ISSUES

- **Restore adequate funding for groundwater monitoring and research**: State budget cuts have limited the amount of groundwater research and monitoring projects that were funded in recent years (see Table 3 in Chapter 2). DNR's state funding for projects has been cut since FY 02 and has been forced to use more Federal dollars with high overhead costs. Although relatively new Wellhead Protection and Groundwater Quantity funding has offset some of these DNR cuts the new funding is earmarked towards a limited scope of work. The UWS budget was cut by 10% in FY 04 and FY 05. DATCP and Commerce have been unable to fund any new projects in the last three fiscal years. Continued cuts will hamper the State's ability to address critical groundwater monitoring and research needs in the future. Research and monitoring are necessary to identify cost-effective prevention strategies. These strategies are needed to prevent problems from being established in the subsurface that are much more time-, labor-, and cost-intensive to remediate than to prevent in the first place. Without adequate funding for research and monitoring we don't know what the best prevention strategies are. The GCC encourages its member agencies and the Legislature to restore adequate resources for groundwater monitoring and research and to seek partnerships to leverage additional funds.

- **Acute and chronic impacts to groundwater from manure management:** Groundwater contamination resulting from manure disposal has been an increasing problem in recent years for private well owners. A statewide assessment is needed to understand the scope and magnitude of the problem. Mechanisms, pathways, and timing of movement into groundwater, the influence of landscape settings and climatic factors, the applicability of new analytical tools and methods of vulnerability assessment and best management practices (BMPs) and the threat of associated contaminants (bacteria, nitrates, pharmaceuticals, viruses, other pathogens, etc all need to be understood better to address the problem.

- **Investigate adverse impacts from groundwater withdrawals:** Recent headlines about lakes and streams drying up, long term water supplies in the Fox River Valley, and severe drawdowns in southeastern Wisconsin have generated many questions about the effects of groundwater withdrawals on surface waters and long-term groundwater availability. There is a need to further quantify hydrographic relationships between surface and groundwater, as well as to develop tools to evaluate the impacts of withdrawals on surface waters. The GCC should continue to encourage research efforts that will provide information useful in

addressing this issue.

- **Investigate extent and causes of naturally occurring substances in groundwater:** Continued problems of elevated arsenic, low pH, and other water quality problems in domestic wells exist over large areas of northeast Wisconsin. Additionally elevated sulfate, total dissolved solids (TDS), and radium have been found in some new deep municipal wells in the Lower Fox River Valley, making the wells difficult to use. In some other existing deep wells as far south as Milwaukee, the TDS have been steadily increasing over the years. These sulfate and TDS levels pose a problem for local water managers, and the origin of the dissolved solids is not completely understood. The State needs more information about the extent and causes of these problems in order to give advice to homeowners, municipalities, and well drilling contractors. The GCC should continue to encourage research efforts that will provide information useful in addressing these issues.

- **Evaluate occurrence of recently discovered groundwater contaminants:** Recent research conducted in Europe and the U.S. indicates that traces of pharmaceuticals (including antibiotics and hormones) and pesticide breakdown products are common contaminants found in groundwater and surface water. In addition, studies have found evidence of viruses and other microbial agents in both municipal water supplies and domestic wells. Research is needed to determine whether these substances pose a threat to Wisconsin's groundwater resource, and also to human health.

- **Research land use management and its impact on the groundwater resource:** Additional research is needed on the effect of various land uses (e.g. urbanization and agriculture) on groundwater quality and quantity. For example, recently enacted stormwater infiltration rules help reduce runoff in urban areas, but the effects on groundwater quality are largely unknown. Similarly, agricultural nonpoint source rules require nutrient management plans that protect surface water quality, but may also improve groundwater quality. Projects must be managed in such a way as to maximize their relevance to state land use problems. This issue crosses agency lines and promises to be an important issue for years to come.

- **Identify potential groundwater quality issues associated with innovative water management tools.** Aquifer Storage and Recovery (ASR) and Enhanced Aquifer Recharge are two techniques that are being explored in Wisconsin and other parts of the world to address long-term water supply needs in water-limited areas. These tools may help communities meet water demands during peak use periods or help mitigate adverse effects of long-term water withdrawals. However, the long-term effects on water quality and aquifer geochemistry are relatively unknown, especially in areas with existing water quality issues (e.g. arsenic and radium). Research is needed on a variety of levels in order to evaluate whether these tools are appropriate for Wisconsin.

PRIORITY POLICY & PLANNING NEEDS/ISSUES

- **Address groundwater quantity management issues at both statewide and regional levels:** Groundwater quantity issues came to the forefront of public discussion in FY 04, with the development and passage of landmark groundwater quantity legislation, 2003 Wisconsin Act 310. In FY 05 and FY 06 the DNR began to implement the new law and the Groundwater Advisory Committee began to address specific policy issues related to groundwater management planning. There is a clear need for proactive regional groundwater

planning in areas of concern, where development/population growth pressures intersect limited groundwater resources. The GCC will continue to serve as a resource for addressing scientific and technical questions related to groundwater quantity and facilitate further dialogue among all parties on potential approaches and solutions.

- **Provide resources to local governments for Smart Growth/Comprehensive Planning activities**. Recent legislation has required local units of government to develop a comprehensive plan by 2010 in order to undertake land use activities. This plan must address nine elements, including natural and agricultural resources, housing, utilities, and land use. This planning process presents a unique opportunity to address and implement groundwater protection at the local level. Through the Local Government and Planning Subcommittee, the GCC will seek ways to assist local communities in their planning efforts to encourage groundwater protection.

- **Find solutions to groundwater nonpoint pollution problems**: A 2002 DATCP report indicates that 37.7% of wells contain a detectable level of at least one herbicide or herbicide metabolite and 11.1% of Wisconsin's wells still contain detectable atrazine residues. In addition, 14% exceed the nitrate standard. These rates are substantially higher in agricultural areas. More work is needed to determine how far Wisconsin groundwater will deteriorate without a substantial change in farming practices, and what practices will sustain both agriculture and groundwater quality. The GCC will support the agencies and the UWS in obtaining information pertinent to the human health implications of consuming nitrate and pesticide contaminated groundwater and the effect of discharge of this groundwater on surface waters and their ecosystems.

PRIORITY COORDINATION NEEDS/ISSUES

- **Support implementation of a Statewide Groundwater Monitoring Strategy:** Chapter 160 of the Wisconsin Statutes requires the DNR to work with other agencies and the GCC to develop and operate a system for monitoring and sampling groundwater to determine whether harmful substances are present (s. 160.27, Wis. Stats.). In FY 04, several agencies worked together to develop a Statewide Groundwater Monitoring Strategy to guide agency monitoring efforts for the next ten years. In FY 06 the strategy was incorporated into the DNR Water Monitoring Strategy. The GCC encourages agencies, the university, and federal and local partners to implement the various components of the strategy and to seek funding to support its implementation.

- **Coordinate and facilitate consistent messages on groundwater related issues:** The public has benefited from the consistent educational messages that have been endorsed by the GCC. Through the Education Subcommittee, the GCC will continue to provide its leadership and assistance to state agencies that provide educational materials to the public. In FY 05, the Subcommittee launched a "Groundwater Information Network" with non-governmental organizations to further its mission of promoting consistent messages regarding groundwater protection and building a groundwater constituency. The GCC will continue to use this network and other means to promote water stewardship and awareness of water quantity issues, find innovative ways to encourage testing of private water supplies, and provide materials for local communities to support comprehensive planning activities.

- **Promote consistency between the agencies on data management issues:** Through the

DNR's groundwater data system (GRN) and the GCC's Directory of Groundwater Databases, state and local government agencies now have more convenient access to groundwater data. This effort must be maintained by continuing to identify data needs and ways to make data easily accessible. Data consistency must be promoted by use of common geographical locators and minimum data elements for use in a GIS environment. In 2002 the GCC's Monitoring and Data Management Subcommittee produced *Recommended Minimum Data Elements for Groundwater Databases* to guide groundwater database architects towards multi-user-friendly data element choices. The GCC will continue to provide leadership and communication on data management through its subcommittees. This continued effort displays the GCC's commitment to management of the resource through sound scientific methods.

- **Ensure access to findings of groundwater research and monitoring projects:** More than 120 summaries of groundwater-related monitoring and research projects funded through the Wisconsin Groundwater Research and Monitoring Program are now available online. The WRI Water Resources Library digitized and put online the full text of most WRI and selected DNR project final reports. To maintain and enhance this resource it will be important to add new summaries and reports as they become available, create a more visually appealing set of front-end pages for the site, and publicize the web site location and content more widely. Another WRI initiative is the development of topical fact sheets to summarize research and monitoring findings relative to important groundwater issues in the state. The GCC supports development of these fact sheets and resources and will continue to promote ways to translate sound science into effective groundwater management strategies.

Appendix A :

Statutory Language Relating to the Groundwater Coordinating Council

Chapter 15, Wis. Stats., "Structure of the Executive Branch"

15.347 (13) Groundwater Coordinating Council.

(a) *Creation*. There is created a groundwater coordinating council, attached to the department of natural resources under s. 15.03. The council shall perform the functions specified under s. 160.50.

(b) *Members.* The groundwater coordinating council shall consist of the following members:
1. The secretary of natural resources.
2. The secretary of commerce.
3. The secretary of agriculture, trade and consumer protection.
4. The secretary of health and family services.
5. The secretary of transportation.
6. The president of the University of Wisconsin System.
7. The state geologist.
8. One person to represent the governor.

(c) *Designees*. Under par. (b), agency heads may appoint designees to serve on the council, if the designee is an employe or appointive officer of the agency who has sufficient authority to deploy agency resources and directly influence agency decision making.

(d) *Terms*. Members appointed under par. (b) 8 shall be appointed to 4-year terms.

(e) *Staff*. The state agencies with membership on the council and its subcommittees shall provide adequate staff to conduct the functions of the council.

(f) *Meetings*. The council shall meet at least twice each year and may meet at other times on the call of 3 of its members. Section 15.09 (3) does not apply to meetings of the council.

(g) *Annual report*. In August of each year, the council shall submit to the head of each agency with membership on the council, the governor and the chief clerk of each house of the legislature, for distribution to the appropriate standing committees under s. 13.172 (3), a report which summarizes the operations and activities of the council during the fiscal year concluded on the preceding June 30, describes the state of the groundwater resource and its management and sets forth the recommendations of the council. The annual report shall include a description of the current groundwater quality in the state, an assessment of groundwater management programs, information on the implementation of ch. 160 and a list and description of current and anticipated groundwater problems. In each annual report, the council shall include the dissents of any council member to the activities and recommendations of the council.

Chapter 160, Wis. Stats., "Groundwater Protection Standards"

160.27 Substances in groundwater; monitoring.

(1) The department [of natural resources], with the advice and cooperation of other agencies *and the groundwater coordinating council*, shall develop and operate a system for monitoring and sampling groundwater to determine whether substances identified under s. 160.05 (1) are in the groundwater or whether preventive action limits or enforcement standards are attained or exceeded at points of standards application.

160.50 Groundwater coordinating council.

(1) GENERAL FUNCTIONS. The groundwater coordinating council shall serve as a means of increasing the efficiency and facilitating the effective functioning of state agencies in activities related to groundwater management. The groundwater coordinating council shall advise and assist state agencies in the coordination of nonregulatory programs and the exchange of information related to groundwater, including, but not limited to, agency budgets for groundwater programs, groundwater monitoring, data management, public information and education, laboratory analysis and facilities, research activities and the appropriation and allocation of state funds for research.

(1m)FUNDING FOR GROUNDWATER RESEARCH**.** The groundwater coordinating council shall advise the secretary of administration on the allocation of funds appropriated to the board of regents of the University of Wisconsin System under s. 20.285 (1) (a) for groundwater research.

(2) SUBCOMMITTEES. The groundwater coordinating council may create subcommittees to assist in its work. The subcommittee members may include members of the council, employes of the agencies with members on the council, employes of other state agencies, representatives of counties and municipalities and public members. The council shall consider the need for subcommittees on the subjects within the scope of its general duties under sub. (1) and other subjects deemed appropriate by the council.

(3) REPORT. The groundwater coordinating council shall review the provisions of 1983 Wisconsin Act 410 and report to the chief clerk of each house of the legislature, for distribution to the legislature under s. 13.172 (2), concerning the implementation of the act by January 1, 1989.

Chapter 281.34, Wis. Stats., "Groundwater Withdrawals"

(10) Research and monitoring. To aid in the administration of this section the department [of natural resources] shall, *with the advice of the groundwater coordinating council*, conduct monitoring and research related to all of the following:

(a) Interaction of groundwater and surface water.

(b) Characterization of groundwater resources.

(c) Strategies for managing water.

APPENDIX B: MEETING MINUTES

WISCONSIN GROUNDWATER COORDINATING COUNCIL
DRAFT MEETING MINUTES – AUGUST 12, 2005
WISCONSIN DEPARTMENT OF NATURAL RESOURCES
FITCHBURG SERVICE CENTER

Members Present: Todd Ambs (DNR), Eric Scott for Berni Mattsson (Commerce), Jamie Robertson (WGNHS), Mark Werner for Henry Anderson (DHFS), Kathy Pielsticker (DATCP) and George Kraft (Governor's Representative).

Others Present: Mike Lemcke, Shaili Pfeiffer and Dave Lindorff (DNR), Steve Born (UW Madison), Randy Zogbaum (DATCP), and Ed Morse (WRWA).

The meeting began at 10:00 AM.

1. **General business** – Introductions were made. George Kraft from the UW Stevens Point Center for Watershed Science and Education was welcomed as the new Governor's Representative. Minutes were approved from the May 13, 2005 GCC meeting.

2. **Manure Management Task Force -** Steve Born summarized the effort to date by the Task Force of which he and Senator Ruud are the co-chairs. The Task Force is a joint effort by DNR and DATCP, made up of externals, staffed by both agencies. The Task Force is to provide recommendations to the two agency Secretaries, that will reduce manure runoff to protect surface & groundwater, by December, 2005. During their first meeting they worked on establishing the problem statement and what it means. The next Manure Task force meeting is scheduled for August 24, 2005.

3. **Groundwater Advisory Committee (GAC) Update –** Todd Ambs indicated that the GAC had their 3rd meeting on August 5th. They are trying to address difficult questions including what is a significant drawdown in the Groundwater Management Areas. The GAC established two technical advisory committees. The technical advisory committees will be working on technical issues and providing information to the GAC. The GAC is required by Statute to give two reports to the Legislature, one at the end of 2006 and the other at the end of 2007. Steve Born suggested key issues include a springs inventory, definition of significant impact, how is the new law working, and how to implement the Groundwater Management Area concept.

4. **Education Subcommittee report** - Randy Zogbaum summarized the last Education Subcommittee meeting held July 6, 2005. The subcommittee spent a fair amount of time talking about how to proceed with Tim Asplund no longer available to help with the agenda, minutes, and general organization. The Subcommittee decided to continue to meet on a quarterly basis. Members will take turns taking minutes for a year at a time. Dave Lindorff talked about the planned revision of the Groundwater Study Guide booklet and invited comments on the draft. Dave will continue to share drafts with the Subcommittee and hopes to have it ready for reprinting this fall.

   Jamie Robertson asked that the DNR hire a replacement for Tim Asplund who had coordinated GCC activities. Todd Ambs indicated that there would be 5 new positions in the Bureau of Drinking Water and Groundwater to implement the groundwater quantity law; he implied the DNR would find a way to handle Tim's GCC responsibilities. George Kraft said a new focus for the Education Subcommittee should be groundwater quality or quantity and that the GCC members need to reinvest in their subcommittees.

5. **GCC Report to the Legislature for 2005** – Dave Lindorff invited comments from the Council regarding the latest draft of the Report to the Legislature which must be submitted to the Legislature by the end of August, 2005. Jamie Robertson suggested that, under Future Priorities, the report

recommend that research funds be restored rather than maintained. Todd and Jamie talked about the importance of our groundwater monitoring strategy. They talked about the need for adequate resources to do research/science and that there should be an ongoing monitoring program to collect sufficient data to make informed decisions. Groundwater monitoring should be both quality and quantity. We should look for other sources for getting monitoring done, including citizen monitoring. The GCC approved the Report. Dave asked folks to get any other comments to him by the 19th; then he'll finalize it and send to the Legislature.

6. **Agency Updates** –

   DHFS – Mark Werner reported that Sherry Johnson is the new Division of Public Health Administrator.

   Commerce - Eric Scott indicated that a PECFA reimbursement package has been developed which will be effective Jan. 1, 2006.

   Governor's Representative - George Kraft handed out a PowerPoint presentation of the Little Plover River and talked about the discovery of a dry streambed August 9th.

   DNR - Mike Lemcke reported that the proposed groundwater standard for alachlor ESA will go the DNR Board meeting in September for final adoption.

   WGNHS - Jamie Robertson indicated that the Wisconsin Wildlife Federation hired an employee, placed them at WGNHS, to work on a springs inventory.

   DATCP - Kathy Pielsticker reported that DATCP 50 goes to the Agriculture Board in September. She also mentioned the Manure Management Task Force. Laurie Bowman has been hired as the new Ag Chem Section Chief.

   DNR - Todd Ambs said that there are 27 public meetings in July and August on topics from shoreland zoning and the NR 243 to Annex 2001 revisions.

7. **The meeting adjourned at 12:10 PM.** The next meeting will be November 11, 2005, 10:00 - 1:00 PM, at WisDOT, 4802 Sheboygan Avenue.

Respectfully submitted,

Mike Lemcke, Chief
Groundwater Section
Department of Natural Resources

WISCONSIN GROUNDWATER COORDINATING COUNCIL
MEETING MINUTES – NOVEMBER 11, 2005
WISCONSIN DEPARTMENT OF TRANSPORTATION
4802 SHEBOYGAN AVENUE FACILITY

Members Present: Mike Lemcke for Todd Ambs (DNR), Eric Scott for Berni Mattsson (Commerce), Jamie Robertson (WGNHS), Rob Thiboldeaux for Henry Anderson (DHFS), Kathy Pielsticker (DATCP), Dan Scudder (DOT), Fran Garb (UW-System), and George Kraft (Governor's Representative).

Others Present: Jeff Helmuth (DNR), Jim Hurley (Water Resources Center), Paula Allen (DATCP), Bob Pearson (DOT), and Ed Morse (WRWA).

The meeting began at 10:00 AM.

1. **General business** – Introductions were made. Minutes were approved from the August 12, 2005 GCC meeting.

2. **Education Subcommittee report** – Paula Allen summarized the last Education Subcommittee meeting held October 5, 2005. The subcommittee discussed what to do now that their chair has moved to the private sector. Kevin Masarik agreed to assume the responsibilities of organizing the meetings and serving as its main contact point. Paula Allen agreed to attend the GCC meetings. The group then discussed the update which is in progress to the Groundwater Study Guide that was released in 1990 and provides a resource for K-12 teachers. Dave Lindorff is leading this effort . Other topics of discussion were: Arsenic Well Test Result Web Development; Great Lakes Forever Campaign; Groundwater Model Teacher Workshops; and the upcoming Groundwater Festival. The 4th annual Groundwater Festival will be held in Manitowoc County on April 27th, 2006.

3. **Monitoring and Data Management Subcommittee Report** – Jeff Helmuth reported out on the October 12th, 2005 subcommittee meeting. The subcommittee set a tentative meeting schedule for 2006. The monitoring workgroup will meet in January for proposal review, the subcommittee as a whole will meet in March, the data management and mapping workgroup will meet in June, and the monitoring workgroup will meet in September. The subcommittee went on to discuss the status of the Nitrate and Groundwater: A Condition of the Resource Paper that the DNR is preparing and made suggestions for topics for the next paper of the series. The group then reviewed information related to the drying up of a stretch of the Little Plover River. Madeline Gotkowitz then presented on Groundwater use and Sustainability project which is being completed by WGNHS and USGS. Other updates included the implementation of Act 310, the USGS 2005 Water Use report, and the FY07 Joint Solicitation.

4. **Annex 2001 update** – Mike Lemcke reported that the group working on the Annex comments is about to complete their task. If all goes well there will be general acceptance of the revision and it will be adopted in early December. After that point it will still need to be legislatively adopted by each of the states it pertains to and the appropriate Canadian provinces.

5. **Groundwater Advisory Committee (GAC) Update –** Mike Lemcke indicated that the GAC continues to hold meetings and have begun to put together outlines and draft work pieces which they are sharing electronically with the other GAC members. The group continues to make progress but they are hopeful that greater strides will be made after DNR is able hire positions which will assist supporting the GAC. As a reminder, the GAC is required by Statute to give two reports to the Legislature, one at the end of 2006 and the other at the end of 2007.

6. **FY 07 Proposal Optimization and Status** – Jim Hurley reviewed that each year at this time the GCC reviews a strategy put forth by the Water Resources Center which if the GCC approves then the system will be able to optimize USGS 104b funding dollars. Currently the Water Resources Center is funding

8 new projects and 7 continuing projects. To optimize the total dollars for the next funding year there would need to be a motion for the Water Resources Center to fund appropriate second year projects. After much discussion Dr. Kraft moved that "The GCC endorse the University of Wisconsin Water Resources Institute's inclusion of two projects funded through the FY2006 Joint Solicitation for Groundwater Research and Monitoring in their USGS 104(B) base institute funding submission for FY2006. Based on sufficient progress, the second year of two multiple-year projects will be selected for inclusion in the 104(B) submission." Fran Garb seconded the motion. After discussion the motion was passed unanimously.

Jim noted that this year's joint solicitation is not using the electronic entry/submission process. The process now will require project investigators to submit by attaching the relevant information. This change is necessitated by web restructuring that is occurring. However, the web review mode will still be functional for this year.

Jim also floated an idea of moving the joint solicitation to a two year cycle due to decreasing funds from all parties involved. The GCC members believed that this idea could use further discussion at a later meeting. However, initial feelings were that if we shifted cycles it could have some negative consequences.

7. **Springs – Work in Progress** – Jeff Helmuth noted that on October 4th the second springs workshop was held with all of the Springs project investigators. Many springs issues were discussed and project updates were given. Jeff plans to have meetings or conference calls approximately quarterly to assure communication on issues such as establishing common data elements, consistent field measurement techniques and use of historic information, etc.

   As reported, it's been interesting to see the wide range of results so far. We will soon have field data on springs in seven counties (Dane, St. Croix., Brown, Calumet, La Crosse, Iowa and Waukesha). Then it may be possible to begin to extrapolate results statewide and try to reassess whether our original estimate (10,000-18,000 springs statewide with about 100 flowing at 1 cfs or greater) was accurate. The project results should also help us set up protocols for doing a statewide inventory and provide information useful in considering revisions to the definition of a spring.

   The two PIs from the UW/DNR funded ecological classification project, Sue Swanson and Dave Zaber, invited Abe Springer and Larry Stevens of the U of Arizona to the springs workshop. Springer and Stevens have developed a spring classification system based on the physical, biological, and socio-cultural characteristics of typical spring systems. Swanson and Zaber intend to adapt the Springer/Stevens system to make assessments of the ecological status of typical spring systems in Wisconsin. This will be the first step in assessing vulnerability to pumping because it will provide baseline conditions to which changes can be compared.

   At the workshop Stevens described the highly complex ecosystems that rely on springs and noted that the most vulnerable of these are not those dependent on high-flow springs which are rare in the southwest where they have done most of their work. Instead it is the lower flow systems, sometimes those with just a trickle of flow, that support the most fragile ecosystems. This raises the question of whether the current definition of a spring will enable us to protect all the springs that should be protected. If our goal is to protect sensitive ecosystems then we may need to use more than a flow threshold to define the ones to be protected. Swanson and Zaber's ecological classification system may help us to do that.

8. **Agency Updates** –

   Commerce - Eric Scott indicated that Comm 47 has also been changed with regards to PECFA reimbursements and it will go into effect April 1, 2006.

   DNR - Mike Lemcke reported that the proposed NR 140 groundwater standard package was unanimously approved by the DNR Board. This package includes a proposed standard for alachlor-ESA. Positions are being announced for many positions in the agency due in part to a Water

Division restructuring and from 5 new positions from the Groundwater Quantity law. He also noted that the agency has begun its IT Server consolidation with DOA.
WGNHS - Jamie Robertson indicated that the Wildlife Federation staff, placed at WGNHS, is working out well in cooperatively inventorying springs. The Groundwater Use and Sustainability project in Sauk and Waukesha Counties is also looking promising. Jamie also noted that, for the record, a full time replacement for GCC staff is essential in keeping the GCC fully functional.
DATCP - Kathy Pielsticker reported that Lori Bowman is the new Director for the Bureau of Agrichemical Management. She also noted that due to staff contingent and placement there have been agreements established to utilize hydrogeologists across Bureaus. A revised phosphorus standard has been established in ATCP 50. The Manure Management Task Force will host its final meeting in January and bring to the Departments its recommendations.
Water Resources Center – Jim Hurley noted that Anders has taken over as chair of the 54 National Water Resources Institutes.
DHFS – Robert Thiboldeaux commented that they are involved in some chlorinated solvent site monitoring and also in the vapor intrusion issue. Additionally, much effort is still being spent on the health effects and outreach related to naturally occurring Arsenic.
DOT – Dan Scudder reported that they are still pursuing a means to convert their 1,800 foot Milwaukee well to a long-term groundwater monitoring well.

9. **2006 Meeting Dates –** The committee decided that the 2006 meetings should be in the following months and with the following hosts. Mike Lemcke will get specific dates established (now noted below). The meetings will all begin at 10 am.

February 24	Water Resources Center Hosting
May 12	WGNHS Hosting
August 11	DATCP Hosting
November 10	DOT Hosting

10. **The meeting adjourned at 12:20 PM.** The next meeting will be February 24, 2006, 10:00 - 1:00 PM, University of Wisconsin – Aquatic Sciences Center, Goodnight Hall, 1975 Willow Drive.

Respectfully submitted,

Mike Lemcke, Chief
Groundwater Section
Department of Natural Resources

WISCONSIN GROUNDWATER COORDINATING COUNCIL
MEETING MINUTES – FEBRUARY 24TH, 2006
UNIVERSITY OF WISCONSIN – AQUATIC SCIENCES CENTER
GOODNIGHT HALL 1975 WILLOW DRIVE

Members Present: Mike Lemcke for Todd Ambs (DNR), Eric Scott for Berni Mattsson (Commerce), Madeline Gotkowitz for Jamie Robertson (WGNHS), Henry Anderson (DHFS), Bruce Rheineck for Kathy Pielsticker (DATCP), and Fran Garb (UW-System).

Others Present: Dave Lindorff (DNR), Anders Andren & Jim Hurley (Water Resources Center).

The meeting began at 10:00 AM.

1. **General business** – Introductions were made. Minutes were approved from the November 11th, 2005 GCC meeting.

2. **Education Subcommittee report** – David Lindorff summarized the last Education Subcommittee meeting held January 12th, 2006. Progress on the update to the Groundwater Study Guide has been substantial and it should be printed in the next several months. Kevin Masarik noted that a Blue Cross Blue Shield grant application was submitted to the Medical College of Wisconsin. If funded the grant would support the development of an arsenic partnership to evaluate strategies for communicating arsenic messages and raise awareness across the state. Paula Allen noted that DATCP was working on a data layer for old orchard sites that used arsenic. Dorie Turpin noted that the Arsenic in Drinking Water tri-fold will be revised and printed soon. It was noted that the 4th annual Groundwater Festival will be held in Manitowoc County on April 27th, 2006. Kevin asked for help updating the UWEX publication entitled "Improving your Drinking Water Quality. The next Subcommittee meeting will be held on April 12th, 2006.

3. **Research Subcommittee Report** – Mike Lemcke reported that the subcommittee met on January 24th, 2006 and reviewed the 12 project submittals. Because of the low number of proposals it is likely that many of them will be funded this year. DNR committed to continue working with GRAC to optimize their funding options. The low number of submittals was attributed to the lack of funding identified in the solicitation. It is hoped that the submittal number will once again go up next year.

4. **Groundwater Research Advisory Council (GRAC)** – Jim Hurley presented the priority ranking list of new projects for funding for UW System funds with Fiscal year 2007 funds. The ranking list was developed by the Groundwater Research and Advisory Council (GRAC), who met the previous week in Madison. The final decision on specific projects to be funded was not known because WDNR had not received final guidance on availability of its funds, nor had UW-Madison issued guidance on tuition remission. Hurley asked the GCC to consider that the prioritized list of projects "is consistent with priorities established by GCC, and that the GCC and the UW System will jointly submit a request to the Secretary of DOA for approval to expend or encumber groundwater research funds pursuant to Section 20.285(1)(a)." Motion by Garb, seconded by Anderson, passed unanimously.

   Hurley and Andren also relayed the results of discussions held by GRAC regarding a conflict of interest policy for members who meet to decide on project funding. At GRAC's February meeting, a motion unanimously passed that: 1) prohibits Principal Investigators or Co-Principal Investigators on proposals under consideration from serving on the GRAC research review panel that year; and, 2) Prohibits a GRAC member directly affiliated with an applicant of a proposal from participating in discussions of that specific proposal at the research review meeting. GCC supported GRAC in this policy.

5. **Groundwater Advisory Committee (GAC) Update –** Mike Lemcke indicated that the GAC continues to hold meetings and have made great strides in working on issues related to Groundwater

Management Areas (GMAs). However, work on Groundwater Protection Areas (GPAs) has only just begun. The DNR has begun to fill the positions associated with the Groundwater Quantity legislation. As the positions are filled the new staff will provide support to the Groundwater Advisory Committee.

6. **Using Groundwater Models to Assess Flow to Wells in Residential Subdivisions** – Madeline Gotkowitz

   The study compared results from two independent modeling projects to assess the capture zones of residential wells. In the first case, they calibrated a three-dimensional, subdivision-scale model using detailed, site-specific hydrogeologic data to simulate groundwater flow near Sun Prairie, Wisconsin. In the second case, they refined a two-dimensional, regional-scale flow model of northwestern Sauk County. These models demonstrate that a relatively simple assessment of hydrogeologic conditions can yield practical guidelines for well construction at a specific development. In each case, a community well that serves the entire subdivision would have a larger capture zone, but that capture zone may be more easily protected by controlling land-use activities.

7. **Agency Updates** –
   Commerce - Eric Scott indicated that Comm 47 effective date will be May 1, 2006. Comm 47 deals with PECFA reimbursements.
   DNR - Mike Lemcke reported that the proposed NR 140 groundwater standard package was sent back to the DNR by the Assembly's Committee on Natural Resources. The Committee asked the Department to consider modifications to the rule related to groundwater quality standards and request the department commence a scientific review panel.
   DATCP - Kathy Pielsticker reported that the Manure Management Task Force has wrapped up its meetings. Kathy suggests that the manure topic be placed on a future agenda.
   Water Resources Center – Anders noted that Seagrant is up for potential cuts.

8. **Adjourn –** The meeting adjourned at 12:30 pm. The next meeting will be April 28th, 2006 and will be hosted by the Wisconsin Geological & Natural History Survey. Their facility is located at 3817 Mineral Point Road in Madison.

Respectfully submitted,

Mike Lemcke, Chief
Groundwater Section
Department of Natural Resources

WISCONSIN GROUNDWATER COORDINATING COUNCIL
MEETING MINUTES – APRIL 28TH, 2006
WISCONSIN GEOLOGICAL & NATURAL HISTORY SURVEY
3817 MINERAL POINT ROAD

Members Present: Todd Ambs (DNR), Jamie Robertson (WGNHS), Henry Anderson (DHFS), Kathy Pielsticker (DATCP), and Fran Garb (UW-System).

Others Present: Mike Lemcke & Dave Lindorff (DNR), Ken Bradbury (WGNHS), Lori Bowman & James Vanden Brook (DATCP), and Ed Morse (WRWA)

The meeting began at 10:00 AM.

1. **General business** – Introductions were made. Minutes were approved from the February 24, 2006 GCC meeting.

2. **Education Subcommittee report** – David Lindorff summarized the April 12, 2006 subcommittee meeting minutes which had been sent out earlier. The Subcommittee spent considerable time with Lori Severtson (affiliated with the UW Department of Nursing) who is developing an arsenic well test result website. The Subcommittee discussed the options for location of the website and how best to characterize the authority of the information on the website. No consensus was reached. She plans to talk to the GCC later this year for their input. GCC members emphasized the importance of making sure consistent messages are being given with respect to arsenic test results and that there be agreement on what those messages are. The Subcommittee had also learned that a group of state agency representatives received a planning grant from the Medical College of Wisconsin to develop a plan to bring together traditional and non-traditional partners to address community outreach efforts related to arsenic.

   The Subcommittee also discussed the recent manure spill in Brown County which contaminated several private wells. This resulted in legislation, Senate Bill 646, which allows the DNR to create "areas of special eligibility" in which homeowners with wells contaminated by bacteria could be eligible for the well compensation program if certain criteria are met. At the Subcommittee meeting, Dave handed out the newly updated Groundwater: Wisconsin's Buried Treasure publication and the Groundwater Study Guide booklet and activity sheets. Dave handed out copies of the Groundwater Study Guide folders to GCC members.

3. **Local Government and Planning Subcommittee** – Dave Lindorff distributed draft minutes of the Local Government and Planning Subcommittee (LGPS) meeting held April 25, 2006. Lynn Markham of the UW Stevens Point Center for Land Use Education had summarized her efforts to make groundwater information available to communities which are developing comprehensive plans. She's completed a review of groundwater information in existing plans and is now focused on identifying websites where groundwater information is available. She requested input from the Subcommittee on a questionnaire she'll be sending out soon.

   At the Subcommittee meeting, Barb Hennings and Larry Lynch from the DNR Bureau of Drinking Water and Groundwater provided an update on the status of groundwater quantity law implementation. Shaili Pfeiffer of the DNR Office of the Great Lakes summarized the implications of Annex 2001.

   The Subcommittee discussed the purpose of the LGPS and expressed an interest in being able to talk about issues and make recommendations to the GCC as appropriate. Dave will follow through on this. GCC members talked about some of the groundwater quantity and conservation efforts currently going on or being considered. The Local Government and Planning Subcommittee may have a role in some of these activities.

4. **Manure Management Task Force's Recommendations and Implementation Strategy** – Jim Vanden Brook. A Manure Management Task Force was convened by DNR and DATCP to address water quality problems from manure-related runoff events. From July 2004 to June 2005, fifty two events were documented. 80% were related to dairy operations, 74% were related to land-spreading of manure, 84% of the land spreading problems were on frozen soil, and 60% of the land spreading problems were associated with liquid manure. Fish-kills, well contaminations, and discharges to water bodies occurred. The task force recommended a number of actions which the agencies have agreed to initiate.

   Kathy Pielsticker proposed that the GCC should consider coordinating research on manure management issues related to groundwater impacts, including priority setting, data sharing, and interpretation. She suggested that DATCP staff could develop a proposal for consideration by the council before their next meeting in August and that the proposal could be on the August agenda. There was consensus on the suggestion.

5. **Groundwater Model for the Village of Eagle** – Ken Bradbury reported that the WGNHS, with support from SEWRPC and the Village and Town of Eagle, has constructed a focused groundwater flow model to help evaluate the impacts of two new shallow municipal wells recently installed by the Village of Eagle. This is a good example of the type of water-resources conflict that we will probably see increasing as municipalities in southeastern Wisconsin replace deep wells with shallow wells to avoid water quality and drawdown issues with the deep aquifer.

   Conclusions/Questions from the modeling are:

   1)The new municipal wells installed by the Village of Eagle will impact nearby water-table levels and cause a small decrease in groundwater discharge to the Mukwonago River and associated lakes and wetlands.
   2)Drawdowns of 1 foot might occur up to 1.5 mile from the wells. These drawdowns are within the range of background water-level fluctuations.
   3)The return of water through onsite septic systems tends to mitigate the quantity impacts. What effect this has on water quality remains unclear.
   4)Reductions in discharge to the watershed are on the order of 1-3 percent. Are these reductions significant?
   5)Understanding of the impacts of the new wells will require long-term monitoring and ecological studies.

6. **Agency Updates** –

   UW - Fran Garb noted that there is a lot of monitoring done by UW students and that the information is valuable and should be incorporated into our knowledge base.
   DNR – Todd Ambs noted that NR 243 (Animal Waste Management) will be taken to the DNR's Board in May. The Groundwater Advisory Council is working on the Groundwater Management Area (GMA) Concept looking to prepare for future groundwater problems. Annex 2001 now needs to be ratified by the Legislatures in each of the Great Lake States, by Congress, and by Provincial Governments. A "Symposium on Demand Side Management Strategies for Water Utilities" will be held in Sheboygan on May 23, 2006. The symposium will be focusing on developing a menu of options for the demand side of the water conservation equation. Many excellent speakers will be presenting from across the United States.
   DATCP - Kathy Pielsticker reported that ATCP 32 (Fertilizer Bulk Storage) and ATCP 33 (Pesticide Bulk Storage) are proposed to be combined. DATCP staff will be taking the final rule to the DATCP's Board for adoption in June. They are also considering if another atrazine prohibition area needs to be made/or expanded in ATCP 30 (Pesticide Use Restrictions) rule.
   WGNHS – Jamie noted that WGNHS is becoming more visible within UW-Extension for all of the hard work that they have been accomplishing.

7. **Adjourn –** The meeting adjourned at 12:30 pm. The next meeting date needs to be changed. An email soliciting dates in August will be sent out shortly. The meeting will be hosted by the

Department of Agriculture, Trade and Consumer Protection. Their facility is located at 2811 Agriculture Drive in Madison.

Respectfully submitted,

Mike Lemcke, Chief
Groundwater Section
Department of Natural Resources

Appendix C : WI Groundwater Research & Monitoring Projects 1986-2006

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
1986				
Hydrogeological Investigation of VOC Contaminated Private Wells Near Hudson, Wisconsin	Anklam	1986	DNR	31b
Treatment of Cheese Processing Wastewater by Ridge and Furrow Disposal - Nitrogen Transformations	Boyle	1986	DNR	23
A Case Study of Nitrogen Transformations at a Rapid Infiltration System Used for the Disposal of Food Processing Wastewater	Boyle, Hoopes	1986	DNR	17b
Volatile Organic Compounds in Small Community Wastewater Disposal Systems Using Soil Absorption	Boyle, Sonzogni	1986	DNR	5
Investigation of Hydrogeology and Groundwater Geochemistry in the Shallow Fractured Dolomite Aquifer in Door County, Wisconsin	Bradbury	1986-90	DNR	12
Hydrogeology of the Wisconsin River Valley in Marathon County, Wisconsin	Bradbury	1986	DNR	22
The Prediction of Nitrate Contamination Potential Using Known Hydrogeologic Properties	Cherkauer	1986-87	DNR	10
The Effect of Construction, Installation and Development Techniques on the performance of Monitoring Wells in Fine-Grained Glacial Tills	Cherkauer, Palmer	1986	DNR	16
Volatile Organic Compounds in Groundwater and Leachate at Wisconsin Landfills	Friedman	1985-87	DNR	4a
Barron County Nitrate Study	Hanson	1986-87	DNR	37
Field Investigation of Groundwater Impacts from Absorption Pond Systems Used for Wastewater Disposal	Hoopes	1985-86	DNR	17a
A Simple Stochastic Model Predicting Conservative Mass Transport Through the Unsaturated Zone into Groundwater	Hoopes	1986	DNR	1
The Use of Groundwater Models to Predict Groundwater Mounding Beneath Proposed Groundwater Gradient Control Systems for Sanitary Landfill Designs	Hoopes	1986	DNR	6
Evaluation Techniques for Groundwater Transport Models	Hoopes	1986	DNR	7
The Occurrence of Volatile Organic Compounds in Wastewater, Sludges and Groundwater at Selected Wastewater Treatment Plants in Wisconsin	Hunger	1985-90	DNR	18

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Groundwater Quality Monitoring - Long Term Effects of Intensive Farming and Sprinkler Irrigation on Groundwater Quality	Kammerer	1986	DNR	15
Fate of Aldicarb Residues in A Groundwater Basin near Plover, Wisconsin	Kraft	1986-87	DNR	3
Monitoring of Volatile Organic Compounds in Tomah, Wisconsin	Krohn	1986, 1989	DNR	31a
Fate and Mobility of Radium-226 in Municipal Wastewater Sludge Following Agricultural Landspreading	Portle	1986	DNR	19
Groundwater Monitoring for Pesticides	Postle	1986-97	DNR	2
Graphical and Statistical Methods to Assess the Effect of Landfills on Groundwater Quality	Potter	1986-87	DNR	14a
Groundwater Quality and Laundromat Wastewater: Summit Lake, Wisconsin	Saltes	1986-88	DNR	29
Filtration Preservation Study of Groundwater Samples	Sauer	1984	DNR	21a
West Bend Road Salt Use and Storage Study	Sucht	1986-91	DNR	8
Environmental Investigation of the City of Two Rivers Landfills, Manitowoc County, Wisconsin	Van Biersel	1986-87	DNR	24
Volatile Organic Compound Contamination of Private Water Supplies Adjacent to Abandoned Landfills in Marathon County	Wittkopf	1986-89	DNR	41
1987				
Plover Area Nitrate Study	Bailey	1987-88	DNR	48
Characterization of Groundwater Impacts at an Above Ground Petroleum Storage Terminal	Becker, Ham	1987	DNR	43
Research and Data Analysis of Groundwater Contamination from Municipal Rapid Infiltration Land Disposal Systems	Boyle, Hoopes, Potter	1987-88	DNR	56
Downward Movement of Water Below Barnyard Grass Filter Strips - Case Studies	Bubenzer, Converse	1987-89	DNR	39
1987 Volatile Organic Compound Testing Project in Rock County, Wisconsin	Holman	1987	DNR	40
Flambeau Paper Sulfite Lagoon Site Contamination Study	Lantz	1987	DNR	30

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Groundwater Survey of Bacterial Contamination Near Rapid Infiltration Wastewater Treatment System	Norenberg, Standridge	1987	DNR	21b
Investigation of Large Scale Subsurface Soil Absorption Systems	Peerenboom	1987	DNR	42
Hydrogeologic Investigation and Groundwater Quality Assessment (Havenswood Landfill)	Singh	1987	DNR	28
Nitrate Contamination in West-Central Wisconsin with Emphasis on Mill Run First Edition Subdivision	Tinker	1987-90	DNR	11
Lead Migration from Contaminated Sites - Door County, Wisconsin	Wiersma, Stieglitz	1987-88	DNR	13
1988				
A Ground Penetrating Radar Study of Water Table Elevation in a Portion of Wisconsin's Central Sand Plain	Anderson (Mary), Bentley	1988	DNR	50
VOC Contamination at Selected Wisconsin Landfills - Sampling Results and Policy Implications	Battista	1988-89	DNR	4b
Assessment of Geologic Controls on Groundwater Flow and Distribution in Precambrian Bedrock, Central Wisconsin, Using Remote Sensing and Geophysical	Brown, Davidson Jr.	1988	DNR	49
Digital Simulation of Solute Transport to Green Bay and Lake Michigan by Groundwater from Door County, Wisconsin	Cherkauer	1988-91	DNR	57
Degradation of Atrazine, Alachlor, Metolachlor in Soils and Aquifer Materials	Chesters	1988-90	DNR	52
Radionuclides in Drinking Water of North central Wisconsin	Dobbins, Fitzgerald	1988-89	DNR	54
Sealing Characteristics of Sodium Bentonite Slurries for Water Wells	Edil	1988	DNR	34
Mutagenic Effects of Selected Toxicants Found in Wisconsin's Groundwater	Meisner, Belluck	1988-89	DNR	38
Mineralogical and Geophysical Monitoring Naturally Occurring Radioactive Elements in Selected Wisconsin Aquifers	Morsky, Taylor	1988	DNR	51
Evaluation of the Effect of Stormwater Disposal on Groundwater	Nienke, Shaw	1988-89	DNR	53
Methods for Determining Compliance with Groundwater Quality Regulations at Waste Disposal Facilities	Potter	1988-89	DNR	14b

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Analytical Determination of Atrazine Alachlor and Their Selected Degradation Products in Contaminated Groundwater: Implication for Wisconsin Groundwater	Sonzogni	1988-89	DNR	47
Lead Contamination Study of Door County	Stoll	1988	DNR	44
Freedman Creek Hydrogeologic Baseline Report	Wilson	1988-89	DNR	45
1989				
Effect of Soil Type on Atrazine and Alachlor Movement Through Unsaturated Zone	Daniel	1989	DATCP/ DNR	62
Effects of Volatile Organic Compounds on Clay Landfill Liner Performance	Edil, Berthouex, Park, Sandstrom	1989	DNR	61
Grade A Dairy Farm Water Well Quality Survey	LeMasters, Doyle	1989	DNR	58
Groundwater Quality Investigation of Selected Townships in Jefferson County, Wisconsin	Madison	1989	DNR	60
Designs for Wellhead Protection in Central Wisconsin	Osborne, Sorenson, Knaak, Mechenich	1989	DNR	63
Pesticide Migration Study	Shaw	1989-90	DNR	55
Optimum Manure Application Rate - Corn Fertility Management and Nitrate Leaching to Groundwater in Sandy Soils	Shaw	1989-90	DNR	71
Subdivision Impacts on Groundwater Quality	Shaw, Ameson, VanRyswyk	1989	DNR	67
Demo of Low Input Strategies for Potato/Vegetable Production in Irrigated Sands	Shaw, Curwen, Kraft, Osborne	1989-90	DNR	59
1990				
A Field Evaluation of Drainage Ditches as Barriers to Contaminant Migration	Bahr, Chambers	1990-91	DNR	75
Incorporation of County Groundwater Inventory Data into the DNR Groundwater Information Network (GIN)	Bohn	1990	DNR	68
Atrazine Contamination of Groundwater in Dane County, Wisconsin	Bradbury, McGrath	1990-91	DATCP/ DNR	64
Sources and Extent of Atrazine Contamination of Groundwater at a Grade A Dairy Farm in Dane County, Wisconsin	Chesters, Levy	1990-91	DATCP/ UWS/DNR	65
Follow Up to the Grade A Dairy Farm Well Water Quality Survey	Cowell, LeMasters	1990	DATCP/ DNR	70

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Report on Bacteriological Water Quality Monitoring of Door County Variance and Special Casing Approval Wells	Hutchinson	1990-91	DNR	72
DNR and DATCP Rural Well Survey	LeMasters	1990	DATCP/ DNR	69
Variation in Hydraulic Conductivity in Sandy Glacial Till: Site Variation Versus Methodology	Mickelson, Bradbury, Rayne	1990-92	DNR/UWS	74
Analytical Determination of Pesticide Metabolites and Carrier Chemicals in Wisconsin Wells	Sonzogni, Eldan, Lawrence	1990	DNR	77
Nitrogen Isotope Monitoring at Unsewered Subdivisions	Tinker	1990	DNR	76
Volatile Organic Chemical Attenuation in Unsaturated Soil Above and Below an Onsite Wastewater Infiltration System	Tyler, Peterson, Sauer	1990-91	DNR/UWS	73
1991				
Integrated Decision Support for Wellhead Protection	Adams, Bensen	1991	UWS	
Role of Mobile Colloids in the Transport of Chemical Contaminants in Groundwaters	Armstrong, Shafer	1991-93	UWS	
On-site Nitrogen Removal Systems Research Demonstration Project: Phase I	Ayres & Assoc.	1991	DILHR	
Evaluation of Potential Phytotoxicity and Crop Residues when Using Sprayer Rinsate as a Portion of the Diluent in Pesticide Spray Mixtures	Binning	1991	DATCP	
To Expand Groundwater Sampling in the Lower Wisconsin River Valley	Cates, Madison, Postle	1991	DNR	78
Renovation of Pesticide Contaminated Rinse Waters	Chesters, Harkin	1991	UWS	
In-situ Removal of Fe, Mn, and Ra from Groundwater	Christensen, Cherkauer	1991	UWS	
Reactions of Chlorohydrocarbons on Clay Surfaces	Fripiat	1991	UWS	
The Biological Impact of Landfill Leachate on Nearby Surface Waters	Geis, Sonzogni, Standridge	1991	DNR	83
Chemical Transport Across a Sediment-Water Interface	Green	1991-92	UWS	
Adsorptive Behavior of Atrazine and Alachlor in Organic-Poor Sediments	Grundl	1991	UWS	
Effect of Complex Mixtures of Leachate on the Transport of Pollutants in Groundwater	Grundl, Cherkauer	1991-92	UWS	

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Bioremediation of Herbicide-Contaminated Soil and Water	Harris, Armstrong	1991	UWS	
Near-Source Transport of Contaminants in Heterogeneous Media	Hoopes	1991-92	UWS	
Design of a Small Scale Transportable Mixing/Loading System	Kammel	1991	DATCP	
Municipal Wastewater Project	Kopecky	1991	DNR	85
Dependence of Aldicarb Residue Degradation Rates on Groundwater Chemistry in the Wisconsin Central Sands	Kraft, Helmke	1991-92	DNR	84
Using Ground Penetrating Radar to Predict Preferential Solute Movement and Improve Contaminant Monitoring in Sandy Soils	Kung, Madison	1991	UWS	
Nitrate Movement Through the Unsaturated Zone of a Sandy Soil in the Lower Wisconsin River Valley	Lowery, Kussow	1991-93	UWS	
Effect of Soil Type, Selected BMPs, and Tillage on Atrazine and Alachlor Movement Through the Unsaturated Zone	Lowery, McSweeny	1991	DATCP/ DNR	66
A Study of the Response of Nitrate and Pesticide Concentrations to Agricultural BMPs in Sandy Corn Fields	Madison, Cates	1991-94	DNR	81
Facility Plan Amendment for Wastewater Collection for Green Lake Sanitary District, Green Lake, WI	McMahon & Assoc.	1991	DILHR	
Contamination Attenuation Indices for Sandy Soils: Tools for Information Transfer	McSweeney, Madison	1991	UWS	
Tracking Contaminant Pathways in Groundwater Using a Geologically Based Computer Code for Outwash	Mickelson, Anderson	1991-92	UWS	
A Tracer Technique for Measuring Regional Groundwater Velocities from a Single Borehole	Monkmeyer	1991	UWS	
The Economic Effects of Groundwater Contamination on Real Estate	Page	1991	UWS	
Prediction of Organic Chemical Leachate Concentrations from Soil Samples	Park	1991	UWS	
Crop Rotations Effects on Leaching Potential and Groundwater Quality	Posner, Bubenzer, Madison	1991-92	DNR	80
Barnyard Management Practices: Effect on Movement of Nitrogen Through Soils and Impact on Groundwater Quality	Shaw	1991-92	DNR	9

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
A Comparative Study of Nitrate-N Loading to Groundwater from Mound, In Ground Pressure and at Grade Septic Systems	Shaw, Turyk	1991-92	DNR	82
Waupaca County Groundwater Project: Towns of St. Lawrence and Little Wolf	Wilson, Blonde	1991	DNR	79a
1992				
Effects of Transient Cross-Stratification Flow on Contaminant Dispersion	Bahr	1992-93	UWS	
Geographical Information System for Subsurface Characterization	Bosscher, Adams	1992-93	UWS	
Distribution of Radionuclides in Wisconsin Groundwater	Bradbury, Mudrey	1992	DNR	91
Evaluation of NURE Hydrogeochemical Groundwater Data for Use in Wisconsin Groundwater Studies	Bradbury, Mudrey, Shrawder	1992	DNR	90
Preliminary Comparison of a Discrete Fracture Model with a Continuum Model for Groundwater Movement in Fractured Dolomite	Bradbury, Muldoon	1992	DNR	89
GIS Mapping of Groundwater Contaminant Sources, Quality and Contamination Susceptibility for Door County	Carlson, Stoll, Hronek	1992-93	DNR	93
Distribution, Transport and Fate of Major Herbicides and Their Metabolites	Chesters	1992-93	UWS/DATCP	
Dane County Atrazine/Land Management Project	Conners, Bohn, Madison, Muldoon, Richardson	1992	DATCP/ DNR	99
Use of Tire Chips to Attenuate VOCs	Edil, Park	1992-93	UWS	
Municipal Wastewater Absorption Pond Renovation for Enhanced Nitrogen Removal	Gilbert	1992-93	DNR	97
Living Mulch Systems for Nitrate Trapping in Vegetable Production	Harrison	1992-93	UWS	
Remediation of Soils Contaminated by Leaking Underground Storage Tanks by Vapor Extraction and In-situ Biostimulation	Hickey, Jacobsen, Bubenzer	1992-93	DNR	96
Herbicide and Nitrate Movement in a Sandy Soil in the Lower Wisconsin River Valley	Lowery, McSweeney	1992-93	UWS/DATCP	
Spatial Attributes of the Soil-Landscape-Groundwater System of the Lower Wisconsin River Valley	McSweeney, Madison, Attig, Bohn, Falk	1992-93	DNR	88

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Nitrogen Removal from Domestic Wastewater in Unsewered Areas	Otis, Converse	1992-96	DILHR	
New Approaches to Measuring Biologic Effects of Groundwater Contaminants	Porter	1992	UWS	
Estimating the Spatial Distribution of Groundwater Recharge Rates Using Hydrologic, Hydrogeologic and Geochemical Methods	Potter	1992-93	UWS/DATCP	
Investigation of Potential Groundwater Impacts at Demolition Landfills and Deer Pits	Pugh, Connelly	1992-93	DNR	98a
Assessment of Wisconsin's Groundwater Monitoring Plan Program for Active Non-Approved Landfills (1985-1990)	Pugh, Gear	1992	DNR	92
Evaluation of Denitrification Systems for Improving Groundwater from On-Site Waste Disposal Systems	Shaw	1992-93	DNR	95a
Arsenic as a Naturally Elevated Parameter in Water Supply Wells in Eastern Winnebago and Outagamie Counties	Stoll	1992	DNR	87
Waupaca County: Towns of Lebanon and Scandinavia	Wilson, Blonde	1992	DNR	79b
1993				
Urban Stormwater Infiltration: Assessment and Enhancement of Pollutant Removal	Armstrong	1993-94	DNR	102
Trace Metal Transport Affected by Groundwater Stream Interactions	Bahr	1993-94	UWS	
Tracer Study for Characterization of Groundwater Movement and Contaminant Transport in Fractured Dolomite	Bradbury, Muldoon	1993-94	DNR	101
Evaluation of Five Groundwater Susceptibility Assessments in Dane County, Wisconsin	Bridson, Bohn	1993-94	DNR	100
Management of Sweet Corn Processing Wastes to Protect Groundwater Quality	Bundy	1993-94	UWS	
Impact of Tunnel Dewatering on Surface Water Bodies in Milwaukee County	Cherkauer	1993-94	UWS	
A Further Study of Organics at Wisconsin Municipal Solid Waste Landfills	Connelly	1993-94	DNR	104
Ultrasonic Verification Technique for Evaluating Well Seals	Edil	1993-94	UWS	
Long-Term Transformation and Fate of Nitrogen with Mound Type Soil Absorption Systems for Septic Tank Effluent	Harkin	1993-94	DNR	103

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Field Evaluation of Near Source Transport of Contaminants in Heterogeneous Media	Hoopes	1993-94	UWS	
Variability of Hydraulic Conductivity in Supraglacial Sediments	Mickelson	1993-94	UWS	
The Impact of Atrazine Management Areas Designation on Weed Control Strategies in Wisconsin Corn Production	Nowak	1993	DATCP	
1994				
Photocatalytic degradation of volatile organic carbon	Anderson (Marc)	1994-95	UWS	94REM2B2
Improved design of pump and treat systems for heterogeneous aquifers	Bahr	1994-95	UWS	94REM3B2
Herbicide contamination of soil and groundwater at a mixing and loading site	Chesters	1994-95	UWS/ DATCP	94PES2B2
An Investigation of Field-Filtering and Low-Flow Pumping When Sampling for Metals	Connelly	1994	DNR	106
Mineral phase sorption of selected agrichemicals to Wisconsin Soils	Grundl	1994-95	UWS	94PES1B2
Stratigraphy, sedimentology, and porosity distribution of the Silurian rocks of the Door Peninsula, Wisconsin	Harris	1994-95	UWS	94HGE2B2
Using 'PREDICT' to reduce herbicide usage and improve groundwater quality	Harvey	1994-95	UWS	94PES6B2
Comparative evaluation of biostimulation approaches for enhancing in situ TCE degradation in contaminated aquifers	Hickey	1994-95	UWS	94REM6B2
Leaching Potential of Imazethapyr and Nicosulfuron in Sparta Sand	Lowery	1994	DATCP	
Cover Crops to Limit Herbicide Use on Sweet Corn	Newenhouse	1994	DATCP	
Groundwater Hydrogeology of an Agricultural Watershed	Potter	1994-95	DATCP/ DNR	109
Investigation of Potential Groundwater Impacts at Yard Waste Sites	Pugh, Connelly	1994	DNR	98b
Optimization of Two Recirculating Sand Filters for Nitrogen and Organic Chemical Removal from Domestic Wastewater	Shaw	1994	DNR	95b
Factors Affecting the Determination of Radon in Groundwater	Sonzogni	1994	DNR	111

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Integrated Computerized Mapping of Point Source Contaminants and Physical Environmental Characteristics to Protect and Manage Groundwater Quality	Stoll	1994	DNR	105
The Further Incidence of Native Arsenic in Eastern Wisconsin Water Supply Wells; Marinette, Oconto, Shawano and Brown Counties	Stoll	1994	DNR	110
Groundwater Survey of Alachlor and ESA its Polar Metabolite in Southern Wisconsin	Vanden Brook, Postle	1994	DATCP/ DNR	112
The Use of Peat as an Absorptive Medium	Wiersma, Stieglitz	1994	DATCP	
1995				
Evaluating the Effectiveness of Landfill Liners	Benson	1995-96	UWS	
Tracer Study for Characterization of Groundwater Movement and Contaminant Transport in Fractured Dolomite	Bradbury	1995-96	UWS	
Application of a Discrete Fracture Flow Model for Wellhead Protection at Sturgeon Bay, Wisconsin	Bradbury, Muldoon	1995-96	DNR	113
Direct and Residual Effects of Land-applied Sweet Corn Processing Wastes on Nitrate Loss to Groundwater	Bundy	1995-96	DNR	120
Integration of Hydraulics and Geology into a Hydrostratigraphic Model for the Paleozoic Aquifer of Eastern Dane County, Wisconsin	Cherkauer	1995	UWS	
A Comparison of Low Flow Pumping and Bailing for VOC Sampling	Connelly	1995	DNR	114
A Low-Input Crop Management Plan for Wisconsin Fresh-Market Vegetable Growers	Delahaut	1995	DATCP	
Use of Heavy Nitrogen to Study Nitrate Flux from Septic Systems	Harkin	1995-96	UWS/Comm	
Agrichemical Impacts to Groundwater Under Irrigated Vegetables in the Central Sand Plain	Kraft	1995-96	DNR	116
Vertical and Horizontal Variability of Hydrogeologic Properties in Glaciated Landscapes	Mickelson	1995	DNR	119
Synergistic Effects of Endocrine Disrupters in Drinking Water	Porter	1995-96	UWS	
Development and Demonstration of an Accurate Manure Spreading System to Protect Water Quality, Improve Waste Management and Farm Profitability	Shinners	1995-96	UWS	

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Geologic Constraints on Arsenic in Groundwater with Applications to Groundwater Modeling	Simo	1995	UWS	
Characterization of E. Coli and Total Coliform Organisms Isolated from Wisconsin Groundwater and Reassessment of their Public Health Significance	Sonzogni	1995	DNR	117
Evaluation of Enzyme-linked Immunosorbent Assay for Herbicide Analysis of Wisconsin Soil in Comparison to Gas Chromatography	Sonzogni	1995	UWS	
An Evaluation of Long-term Trends and a Mineralogical Interpretation of Naturally Occurring Metals Contamination and Acidification of the	Weissbach	1995-96	DNR	115
Collection of Hydraulic and Geologic Data to Improve the Quality of the Wisconsin Groundwater Monitoring Network	Zaporozec	1995-96	DNR	118
1996				
Bioremediation of Hydrocarbons Influenced by Air Sparging: A Multi-model Approach to Assess Contaminant Mass Removal	Bahr	1996	UWS	
Delineation of Capture Zones for Municipal Wells in Dane County, Wisconsin	Bradbury	1996	DNR	121
Responses of Biological Toxicity Tests to Mixtures of Pesticides and Metabolites	Chesters	1996-97	UWS	
Evaluation of Well Seals Using an Ultrasonic Probe	Edil	1996	UWS	
Iron-based Abiotic Destruction of Chlorinated Solvents and Pesticides in Groundwater	Eykholt	1996	DATCP	
Biostimulation of Trichloroethylene Degradation in Contaminated Aquifers	Hickey	1996	UWS	
Optimum Management of Ground-water Resources in the Lower Fox River Valley	Krohelski	1996-97	DNR	122
Variability of Nitrate Loading and Determination of Monitoring Frequency for a Shallow Sandy Aquifer, Arena, Wisconsin	Madison	1996-97	DNR	123
Characterization of the Role of Evapotranspiration on Groundwater Movement and Solute Chemistry in Groundwater-fed Wetlands	Potter	1996-97	UWS	
Ground-water Recharge and Contamination in Wisconsin's Driftless Area	Potter	1996	DATCP	

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Land Use Effects on Groundwater and Streamwater Quality in the Little Plover River Watershed	Shaw	1996-97	DATCP	
Stratigraphic Controls on the Mobilization and Transport of Naturally Occurring Arsenic in Groundwater: Implication for Wellhead Protection in	Simo	1996	UWS	
Evaluation of Shallow-soil Absorption Fields Associated with Advanced On-site Disposal System	Stieglitz	1996-97	DNR/UWS Comm	125
GIS as a Tool to Prioritize Environmental Releases, Integrate their Management, and Alleviate their Public Threat	Stoll	1996-97	DNR	126
The Use of Azimuthal Resistivity & Self Potential Measurements to Delineate Groundwater Flow Direction in Fractured Media	Taylor	1996	UWS	
An Integrated Approach to the Management of Insects in Sweet Corn Grown for Fresh Market	Wedberg	1996-97	DATCP	
1997				
Improved Estimation of Groundwater Recharge Rates	Anderson (Mary)	1997	UWS	
Hydrogeochemical and Microbiological Studies for Enhanced Ground Water Bioremediation	Bahr	1997-98	UWS	
In situ Air Sparging: Air Plume Characterization and Removal Effectiveness	Benson	1997-98	UWS	
Groundwater Protection by Application of Modern Portfolio Theory to Microbiotesting Strategies	Blondin	1997	UWS	
Holding Tank Effluent and Fecal-Contaminated Groundwater: Sources of Infectious Diarrhea in Central Wisconsin?	Borchardt	1997-98	Comm	
Development of a Variable Rate Nitrogen Application Approach for Corn	Bundy	1997-98	UWS	
Groundwater Bioremediation: Monitoring with MMO Probes	Collins	1997-98	UWS	
Experimental Verification of Models Used to Evaluate Landfill Liner Effectiveness	Edil	1997	UWS	

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Stratigraphy, sedimentology, and Porosity Distribution of the Silurian Aquifer of Ozaukee County, Wisconsin	Harris	1997	UWS	
Molecular Techniques for Detection and Identification of Sewage-Borne Human Pathogens in Soils	Hickey	1997-98	Comm	
Nitrate-Contaminated Drinking Water Followback Study	Kanarek	1997	DNR	131
Fate of Nicosulfuron in Sparta Sand	Lowery	1997	DATCP	
Treatment of Groundwater Contaminated with Chlorinated Aliphatics Using a Silicone Tubing Supported Methanotrophic Biofilm Reactor	Park	1997-98	UWS	
Evaluation of the Use of DUMPSTAT to Detect the Impact of Landfills on Groundwater Quality	Potter	1997	DNR	130
Stratigraphic Controls on Distribution of Hydraulic Conductivity in Carbonate Aquifers	Simo	1997-98	DNR	129
Improved Detection Limits for Ground Water Monitoring	Sonzogni	1997	DNR/UWS	128
Determining Compatibility Between Herbicide Release and Habitat for Karner Blue Butterfly in Red Pine Plantations	Sucoff	1997	DATCP	
A Study of Well Construction Guidance for Arsenic Contamination in Northeast Wisconsin	Weissbach	1997-98	DNR	127
1998				
Assessment of Impacts on Groundwater/Lake and Wetland Systems	Anderson (Mary)	1998	UWS	
Groundwater-Surface Water Interactions in the Nine Springs Watershed	Bahr	1998-99	DNR	137
Evaluation of the Confining Properties of the Maquoketa Formation in the SEWRPC Region of Southeastern Wisconsin	Bradbury	1998	DNR	138
Watershed-Scale Nitrate Contamination and Chloroflurocarbon Ages in the Little Plover Basin: A Study at the Groundwater/Surface Water Interface	Browne	1998-99	UWS	
Determining Ground-Water Recharge Rates in Southern Washington County	Cherkauer	1998-99	UWS	
Characterization of the Hydrostratigraphy of the Deep Sandstone Aquifer in Southeastern Wisconsin	Eaton	1998-99	DNR	134

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Further Evaluation of Well Seals Using an Ultrasonic Probe	Edil	1998	DNR	136
Evaluation of Exploration Borehole Seals Using Time Domain Reflectometry (TDR)	Edil	1998-99	UWS	
Fate of Metolachlor, Alachlor, and Nitrate in Granular Iron/Soil/Water Systems,	Eykholt, Davenport, Wonsettler	1998	DATCP	
Investigation of Air Sparging: Numerical Modeling, Laboratory Verification and Design Guidelines	Hoopes	1998-99	UWS	
The Direct Effect of Agricultural Chemicals on Wisconsin's Declining and Endangered Amphibians	Karasov	1998-99	UWS/DATCP	
Relationships Between Water Quality in Stream Base Flow and Private Wells and Land use in the Tomorrow/Waupaca River Watershed	Shaw	1998-99	DNR	132
Impact of Ginseng Production on Groundwater Quality,	Shaw, De Vita	1998	DATCP	
Northeast Region Public Water Supply Location Utilizing Geographic Information Systems and Global Positioning Systems	Stoll	1998	DNR	133
Effects of Fosamine, Picloram, and Triclopyr on Reducing Aspen in Prairie Bush Clover Habitat,	West	1998	DATCP	
Evaluation of Geology and Hydraulic Performance of Wisconsin Ground-Water Monitoring Wells	Zaporozec	1998	DNR	135
1999				
On-line SFE/GC for Improved Detection of Trace Organic Pollutants in Ground Water Monitoring	Armstrong	1999	UWS/DATCP	
A Rational Design Approach for Permeable Reactive Walls	Benson	1999-2000	UWS	
Viral Contamination of Household Wells Near Disposal Sites for Human Excreta	Borchardt, Sonzogni	1999-2000	DNR	144
Groundwater Flow and Heat Transport in Wetlands: Transient Simulations and Frequency-Domain Analysis	Bravo	1999-2000	UWS	
Monitoring: Evaluation of the Abundance, Diversity, and Activity of Methanotroph Populations in Groundwater	Collins	1999-2000	UWS	

Title	Principal Investigator(s)	Years Funded	Funding Agency	Project # (if assigned)
Mechanical Controls on Fracture Development in Carbonate Aquifers: Implications for Groundwater Flow Systems	Cooke	1999-2000	DNR	142
Acute and Chronic Toxicity of Nitrate to Brook Trout (Salvelinus fontinalis)	Crunkilton	1999-2000	DNR	140
Maquoketa Shale as Radium Source to the Cambro-Ordovician Aquifer System	Grundl	1999-2000	DNR	141
Sedimentology, Stratigraphy, and Porosity-Conductivity Relations of the Silurian Aquifer of Ozaukee County, Wisconsin	Harris	1999-2000	UWS	
Analysis of Microbiological and Geochemical Processes Controlling Biodegradation of Aromatic Hydrocarbons in Anaerobic Aquifers	Hickey	1999-2000	DNR	143
Assessing and Reducing Leaching of Agricultural Chemicals on Silt Loam Soils under Different Farming Systems	Kung	1999-2000	DATCP	
Using Geographic Information Systems and Soil Landscape Models to Predict Critical Sites for Nonpoint Source Pollution	Lowery	1999-2000	DATCP	
Water and Land Use: Interpretation of Existing Data to Foster Constructive Public Dialogue and Policy Formulation	Read	1999	UWS	
Natural Attenuation of Fuel and Related Groundwater Contaminants - A Measurement Method	Sonzogni	1999	UWS	
Fate of the Herbicides Atrazine, Cyanazine, and Alachlor and Selected Metabolites	Stoltenberg	1999	DATCP	
Hydraulic Conductivity and Specific Storage of Maquoketa Shale	Wang	1999	UWS	
2000				
A groundwater model for the Central Sands of Wisconsin: Assessing the environmental and economic impacts of Irrigated agriculture	Anderson (Martha), Bland, Kraft	2000	DATCP/ DNR	146
Remediating groundwater using reactive walls containing waste foundry sands	Benson, Eykholt	2000-01	DNR/UWS	147
Field verification of capture zones for municipal wells at Sturgeon Bay, Wisconsin	Bradbury, Rayne, Muldoon	2000	DNR	148
Refinement of two methods for estimation of groundwater recharge rates	Bradbury, Anderson, Potter	2000	DNR	150

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Causes of historical changes in ground-water recharge rates in southeastern Wisconsin	Cherkauer	2000-01	UWS	
Evaluating options for changing groundwater and leachate monitoring requirements for landfills to reduce mercury used by laboratories	Connelly, Stephens, Shaw	2000-01	DNR	151
Compatibility of containment systems with mine waste liquids	Edil, Benson	2000-01	UWS	
Time domain electromagnetic induction survey of eastern Waukesha County and selected locations	Jansen, Taylor	2000	UWS	
Admicelle-catalyzed reductive dechlorination of PCE by zero valent iron	Li	2000-01	UWS	
Development of neural network models for predicting nitrate concentration in well water	Lin, Shaw	2000-01	UWS	
Field monitoring of drainage and nitrate leaching from managed and unmanaged ecosystems	Norman, Brye	2000-01	UWS	
Macropore flow: A means for enhancing groundwater recharge or a potential source of groundwater contamination	Potter, Bosscher	2000-01	UWS	
Hydraulic Conductivity and Specific Storage of Maquoketa Shale	Wang	2000	UWS	
Improvement of Wisconsin groundwater monitoring network	Zaporozec	2000	DNR	149
2001				
Development of analytical methods for comprehensive chemical and physical speciation of arsenicals in groundwater	Aldstadt	2001-02	DNR	154
Removal of As(III) and As(V) in Contaminated Groundwater with Thin-Film Microporous Oxide Adsorbents	Anderson (Marc)	2001-02	UWS	
The Spatial and Temporal Variability of Groundwater Recharge	Anderson (Mary), Potter	2001	UWS	
Importance of Groundwater in Production and Transport of Methyl Mercury in Lake Superior Tributaries	Armstrong	2001-02	UWS	
A study of microbiological testing of well water quality in Door County and incidence of illness in humans	Braatz	2001	DNR	159
A Basin-Scale Denitrification Budget for a Nitrate Contaminated Wisconsin Aquifer: A Study at the Groundwater/Surface Water Interface	Browne, Kraft	2001-02	UWS	

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New approaches to the assessment of microbes in groundwater: application to monitoring bioremediation and detection of pathogens	Collins	2001-02	DNR	155
VOC trend analysis of WI solid waste landfill monitoring data: A preliminary analysis of the natural attenuation process	Connelly	2001-02	DNR	153
Evaluation of pathogen and nitrogen movement beneath on-site systems receiving domestic effluent from single pass sand filters	Converse	2001	Comm	
Effectiveness of phytoremediation and hydrogeologic response at an agricultural chemical facility in Bancroft, WI	DeVita, Dawson	2001-02	DATCP	
Effect of Clean and Polluted Groundwater on Daphnia Reproduction and Development	Dodson	2001-02	UWS	
Verification and characterization of a fracture network within the Maquoketa shale confining unit, SE Wisconsin	Eaton	2001	DNR	157
Groundwater Modeling: Semi-Analytical Approaches for Heterogeneity and Reaction Networks	Eykholt	2001	UWS	
Geologic and geochemical controls on arsenic in groundwater in northeastern Wisconsin	Gotkowitz	2001-02	DNR	152
Screening of agricultural and lawn care pesticides for developmental toxicity using the mouse embryo assay	Greenlee	2001	DATCP	
Public health impacts of arsenic contaminated drinking water	Knobeloch	2001-02	DNR	158
Pesticide and nitrate leaching in soils receiving manure	Lowery, Arriaga, Stoltenberg	2001	DATCP	
An analysis of arsenic replacement wells to determine validity of current DNR well construction guidance	O'Connor	2001-02	DNR	156
Remediation of Soil and Groundwater Using Effectively and Ineffectively Nodulated Alfalfa	Turyk, Shaw	2001-02	UWS/DATCP	
2002				
Groundwater-lake interaction: Response to climate change Vilas County, Wisconsin	Anderson (Mary)	2002	UWS	02-GSI-1
Impacts of privately-sewered subdivisions on groundwater quality in Dane County, WI	Bradbury	2002-3	UWS	02-OSW-1
Chloroacetanilide and atrazine residue penetration and accumulation in two Wisconsin groundwater basins	DeVita, McGinley, Kraft	2002-3	DATCP	

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Effect of clean and polluted groundwater on reproduction and development of Daphnia	Dodson	2002	UWS	02-BEP-1
Monitoring contaminant flux from a stormwater infiltration facility to groundwater	Dunning, Bannerman	2002-3	DNR	168
Removal of heavy metals and radionuclides from soils using cationic surfactant flushing	Evans, Li	2002-3	UWS	02-REM-3
Impacts of land use and groundwater flow on the temperature of WI trout streams	Gaffield, Wang	2002-3	UWS	02-GSI-3
Delineation of high salinity conditions in the Cambro-Ordovician aquifer of eastern Wisconsin	Grundl, Taylor	2002	DNR	170
Investigation of changing hydrologic conditions of the Coon Creek watershed in the driftless area of Wisconsin	Hunt	2002	UWS	02-GSI-2
Susceptibility of La Crosse municipal wells to enteric virus contamination from surface water contributions	Hunt, Borchardt	2002	DNR	165
Occurrence of antibiotics in wastewater effluents and their mobility in soils. A case study for Wisconsin	Karthikeyan, Bleam	2002-3	DATCP/ DNR	169
Nitrate loading history, fate, and origin for two WI groundwater basins	Kraft	2002-3	DNR	171
Monitoring and Scaling of Water Quality in the Tomorrow-Waupaca Watershed	Lin, Browne	2002-3	UWS	02-SAM-1
Co-occurrence and removal of arsenic and iron in groundwater	McGinley	2002-3	UWS	02-REM-2
Agrochemical leaching from sub-optimal, optimal, and excessive manure-N fertilization of corn agroecosystems	Norman, Brye	2002-3	DATCP	
Removal of arsenic in groundwater using novel mesoporous sorbent	Park	2002-3	UWS	02-REM-5
Field evaluation of raingardens as a method for enhancing groundwater recharge	Potter	2002-3	UWS	02-BMP-1
Importance of disinfection on arsenic release from wells	Sonzogni, Bowman Standridge, Clary	2002-3	DNR	172
Preservation and survival of E. coli in well water samples submitted for routine analyses	Sonzogni, Standridge, Bussen	2002	DNR	173
Development of a culture method for detection of Helicobacter pylori in groundwater	Sonzogni, Standridge, Degnan	2002	DNR	167
Time domain electromagnetic induction survey of the sandstone aquifer in the Lake Winnebago area	Taylor, Jansen	2002	DNR	173

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2003				
Photocatalytic Adsorption Media and Processes for Enhanced Removal of Arsenic from Groundwaters	Anderson (Marc)	2003	UWS	03-WSP-02
Role of the Hyporheic Zone in Methylmercury Production and Transport to Lake Superior	Armstrong, Babiarz	2003-4	UWS	03-CTP-02
Arsenic Contamination in Southeast Wisconsin: Sources of Arsenic and Mechanisms of Arsenic Release	Bahr, Gotkowitz	2003-4	DNR/UWS	174/03-HDG-01
Monitoring the Effectiveness of Phytoremediation and Hydrogeologic Response at an Agricultural Chemical Facility	DeVita, Dawson	2003-4	UWS	03-REM-06
F Test for Natural Attenuation in Groundwater: Application on Benzene	Evangelista, Pelayo	2003	UWS	03-REM-08
Determination of Aquitard and Crystalline Bedrock Depth Using Time Domain Electromagnetics	Hart, Alumbaugh	2003	UWS	03-HDG-03
An Experimental and Mathematical Study of the Alpha-Particle Activity of Wisconsin Ground Waters with High Gross Alpha	Sonzogni, Arndt, West	2003	DNR	176
Evaluation of Enzyme Linked Immunosorbent Assay for Analysis of Di Amino Atrazine in Wisconsin Groundwater in Comparison to Chromatography	Strauss, Sonzogni	2003	DNR	175
2004				
Field and Laboratory Validation of Photoactivated Adsorption for Removal of Arsenic in Groundwaters	Anderson (Marc)	2004	DNR	179
An Assessment of Aquifer Storage Recovery for Selected Generic Hydrogeologic Settings in Wisconsin	Anderson (Mary)	2004	UWS	04-HDG-01
Development of a groundwater flow model for the Mukwonago River watershed, southeastern Wisconsin	Bahr	2004-5	DNR	180
Monitoring and predictive modeling of subdivision impacts on groundwater in Wisconsin	Bradbury, Bahr	2004-5	DNR	178
Providing communities with the groundwater information needed for comprehensive planning.	Cherkauer	2004-5	UWS	04-WSP-01
What happens when the confined Cambrian-Ordovician aquifer in SE Wisconsin is "dewatered"?	Eaton	2004	UWS	04-HDG-02
Evaluation of Contamination of Groundwater Around Landfills	Edil, Benson, Connelly	2004-5	UWS	04-CTP-04

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A Combined Hydrogeologic/Geochemical Investigation of Groundwater Conditions in the Waukesha County area, WI	Grundl, Bradbury, Feinstein, Hart	2004-5	UWS	04-WSP-02
Fate Of Representative Fluoroquinolone, Macrolide, Sulfonamide And Tetracycline Antibiotics In Subsurface Environments	Karthikeyan, Pedersen	2004-5	UWS	04-CTP-02
Groundwater Pollutant Transfer and Export in Northern Mississippi Loess Hills Watersheds	Kraft, Browne	2004-5	DNR	181
Combination of Surfactant Solubilization with Permanganate Oxidation for Groundwater Remediation	Li	2004-5	UWS	04-REM-04
Design and Evaluation of Rain Gardens for Enhancement of Groundwater Recharge	Potter	2004-5	UWS	04-BMP-01
Coupled Modeling of Gravity and Aeromagnetic Data For Analysis of the Waukesha Fault, Southeastern Wisconsin	Skalbeck	2004	UWS	04-HDG-03
2005				
Mercury Speciation along a Groundwater Flowpath	Armstrong, Babiarz	2005-6	UWS	05-CTP-01
Delineation of Flow Paths, Capture Zones and Source Areas, Allequash Basin, Vilas County, Wisconsin	Mary Anderson	2005	UWS	05-HDG-01
A Comparison of USEPA Approved Enzyme-based Total Coliform/E.coli Tests for Microbiological Groundwater Monitoring and Laboratory Consultation	Schauer, Olstadt, Standridge, Kluender	2005	UWS	05-SAM-01
Occurrence of Estrogenic Endocrine Disruptors in Groundwater	Sonzogni, Hemming, Barman, Geis	2005-6	UWS	05-BEP-01
Development of Tools to Address Groundwater in Comprehensive Planning	Markham, Dunning, Tang	2005	UWS	05-BMP-01
Hydrostratigraphy of west-central Wisconsin: A new approach to Groundwater Management	LePain, Bradbury	2005	UWS	05-HDG-02
Monitoring Environmental Effects at an Established Phytoremediation Site	DeVita, Dawson	2005-6	UWS	05-REM-01
Foundry Slag for Treating Arsenic in Groundwater and Drinking Water	Benson, Blowes	2005-6	UWS	05-REM-02
2006				
Title	**Principal Investigator(s)**	**Years Funded**	**Funding Agency**	**Project # (if assigned)**
Mechanisms of Groundwater Flow across	Hart, Bradbury	2006	DNR	191

Aquitards	Feinstein and Yikoff			
Centralizing Access to Groundwater Information for Use in Comprehensive Planning	Markham, Tang, Dunning	2006-2007	DNR	190
A Survey of Baseflow for Groundwater Protection Areas Western Fox-Wolf Watershed	Kraft	2006-07	DNR	186
Groundwater Mounding and Contaminant Transport Beneath Stormwater Infiltration Basins	Thompson	2006-07	DNR	189
Mapping and Characterization of Springs in Brown and Calumet Counties	Fermanich Stieglitz Zorn	2006	DNR	183
Identification and characterization of springs in west-central Wisconsin	Grote	2006	DNR	184
Evaluating drinking-well vulnerability to viruses	Hunt, Borchardt	2006-07	DNR	187
Disinfection of Enteric Viruses in Wisconsin Municipal Groundwater Systems	Harrington, Borchardt, Xagoraraki	2006-07	DNR	188
Assessing the Ecological Status and Vulnerability of Springs in Wisconsin	Zaber, Swanson, Bradbury, Hart	2006-07	DNR/ UWS	185/06-GSI-09
Transient Functioning of a Groundwater Wetland Complex, Allequash Basin, Wisconsin	Anderson	2006-07	UWS	06-WLA-01
Measuring and Modeling Macroporous Soil Water And Solute Flux Below the Root Zone of a Plano Silt-Loam Soil	Lowery, Norman, Lepore	2006-07	UWS	06-CTP-05
Evaluation of On-site Wastewater Treatment as a Source of Antibiotic Resistance Genes in Groundwater	McMahon	2006	UWS	06-SAM-02
Arsenic Species (III,V) Distribution in Wisconsin's Groundwaters: Field Measurements and Prediction Using Multivariate Analysis of Geochemical Data	Shafer, Ellickson, Schauer	2006-07	UWS	06-CTP-03
Validation of Transport of VOCs from Composite Liners	Edil, Benson	2006-07	UWS	06-CTP-06
Nitrate and Pesticide Penetration into a Northern Mississippi Valley Loess Hills Aquifer	Kraft, Browne	2006-07	UWS	06-CTP-07
Climate Signals in Groundwater and Surface Water System: Spectral Analysis of Hydrologic Processes	Bravo	2006-07	UWS	06-GSI-10