State of Wisconsin Joint Solicitation of Groundwater and Related Research/Monitoring Proposals for Fiscal Year 2004

Proposal Number: **04-GSI-02**

Title: Development of a groundwater flow model for the Mukwonago River watershed, southeastern Wisconsin

Investigator(s): Bahr, Jean, UW Madison, Geology & Geophysics

Abstract: Wetlands of the Mukwonago River watershed have been the target of conservation efforts for almost two decades. Recent suburban development has spawned a rapidly expanding commuter population and increasing demands for public water supplies, with several new high capacity wells proposed within the last year. There is a critical need to evaluate potential effects of increased pumping and reduced recharge in order to protect the springs and wetlands of this watershed. The proposed project addresses the WDNR's high priority "emerging issue"; of groundwater withdrawals and connections to surface waters. The overall objective of the proposed project is to improve understanding of hydrogeologic controls on groundwater discharge to springs and wetlands in the watershed in order to allow assessment of current and potential future impacts of groundwater withdrawals and suburban development. The primary product of the research will be a numerical model of groundwater flow. The model will be developed by a telescopic mesh refinement process and calibrated using records of water levels and synoptic stream flow measurements. The project will also provide opportunities to 1) test a conceptual model of spring localization near buried bedrock valleys, 2) assess the usefulness of a regional scale model as the basis for development of local scale models, and 3) evaluate the combined use of water levels and geochemical signatures to constrain spring water sources. Users of the findings will include concerned parties in the watershed including The Nature Conservancy and local planners.

Work Location: Madison and SE Wisconsin

Target Agencies: WDNR, UWS, DATCP, Commerce

Year 1 Budget (2003-04): $26,180

Year 2 Budget (2004-05): $17,444

BUDGET: JULY 1, 2003 - JUNE 30, 2004

04-GSI-02

Salaries, Wages and Fringe Benefits

Investigator(s)	% Effort	Mos.	Salary Amount	Fringe Rate	Fringe Amount	Salary and Fringe $
Bahr, Jean	10.00%	0.00	0	0.00%	0	0
Project Personnel	**# Supported**					
Post-Doctoral	0	0.00	0	0.00%	0	0
Graduate Student	1	6.00	17,772	15.60%	2,772	20,544
Undergraduate Student	0	0.00	0	0.00%	0	0
Limited-Term Employee	0	0.00	0	0.00%	0	0
Clerical	0	0.00	0	0.00%	0	0
Technical Staff	0	0.00	0	0.00%	0	0
Other:	0	0.00	0	0.00%	0	0
Total Salaries, Wages and Fringe Benefits			**$17,772**		**$2,772**	**$20,544**

Supplies and Publications Costs

Office	photocopying etc	100
Laboratory	Sr isotope analysis supplies	1,500
Field	multilevel sampler materials ($200), colorimetric test kits, electrodes, etc. ($1500), filtering and sampling supplies ($300).	2,000
Computer	Dept of G&G user fee	276
Publications Costs		0
Total Supplies and Publications Costs		**$3,876**

Travel	# of People	Amount
Transportation	1	360
Meals	0	0
Lodging	0	0
Other travel costs	0	0

Justification/Details:

Fuel costs for approximately 24 trips at $15/trip to field site near Mukwonago WI

Total Travel **$360**

Other Costs

Major cations and anions (10 samples at approx $140/sample)- $1400

Total Other Costs **$1,400**

TOTAL FIRST-YEAR BUDGET $26,180

BUDGET: JULY 1, 2004 - JUNE 30, 2005

04-GSI-02

Salaries, Wages and Fringe Benefits

Investigator(s)	% Effort	Mos.	Salary Amount	Fringe Rate	Fringe Amount	Salary and Fringe $
Bahr, Jean	10.00%	0.00	0	0.00%	0	0
Project Personnel	**# Supported**					
Post-Doctoral	0	0.00	0	0.00%	0	0
Graduate Student	1	4.00	12,322	16.20%	1,996	14,318
Undergraduate Student	0	0.00	0	0.00%	0	0
Limited-Term Employee	0	0.00	0	0.00%	0	0
Clerical	0	0.00	0	0.00%	0	0
Technical Staff	0	0.00	0	0.00%	0	0
Other:	0	0.00	0	0.00%	0	0
Total Salaries, Wages and Fringe Benefits			**$12,322**		**$1,996**	**$14,318**

Supplies and Publications Costs

Office	photocopying etc	100
Laboratory	Sr isotope analsyses	500
Field	colorimetric test kits (500), filtering and sampling supplies ($100)	600
Computer	Dept of G&G user fee($270), 1 license for Groundwater Vistas software ($1000)	1,276
Publications Costs	report preparation and printing	500
Total Supplies and Publications Costs		**$2,976**

Travel

Travel	# of People	Amount
Transportation	1	150
Meals	0	0
Lodging	0	0
Other travel costs	0	0

Justification/Details:
Fuel costs for approximately 10 trips to field site near Mukwonago WI

Total Travel **$150**

Other Costs

Total Other Costs **$0**

TOTAL SECOND-YEAR BUDGET $17,444

Project Title

Development of a groundwater flow model for the Mukwonago River watershed, southeastern Wisconsin

Project Investigator

Jean M. Bahr, Professor, Department of Geology and Geophysics, University of Wisconsin – Madison

Project Summary

Specific problem addressed

The Mukwonago River watershed, located about 35 miles southeast of Milwaukee, has been identified as an "outstanding water resource" by the Wisconsin Department of Natural Resources (WDNR) and has been the target of conservation efforts by The Nature Conservancy (TNC) and others for almost two decades. Recent suburban development has spawned a rapidly expanding commuter population and increasing demands for public water supplies, with several new high capacity wells proposed within the last year. There is a critical need to evaluate potential effects of increased pumping and reduced recharge in order to protect the springs and wetlands of this watershed.

Contributions of findings to problem solution and understanding

The proposed project will provide the necessary tool for evaluating pumping and urbanization impacts in the form of a numerical groundwater flow model. The model will be developed through telescopic mesh refinement of an existing regional scale model and will be calibrated using records of water levels and synoptic stream flow measurements. The proposed project directly addresses questions related to groundwater withdrawals and connections to surface waters, which have been identified by the WDNR as one of its high priority "emerging issues" for groundwater monitoring and research. Specifically, the project will 1) include monitoring of surface and groundwater flow to constrain hydrologic connections and pathways, 2) provide a means of quantifying the groundwater budget of the watershed, 3) and provide a tool for assessing impacts of withdrawals on public water supplies and surface water features.

Project objectives

The overall objective of the proposed project is to improve understanding of hydrogeologic controls on groundwater discharge to springs and wetlands in the Mukwonago River watershed in order to allow assessment of current and potential future impacts of groundwater withdrawals and suburban development. This will be accomplished through field studies and development of a numerical groundwater flow model. The project will also provide opportunities to 1) test and refine a conceptual model of spring localization along the edge of preglacial, buried bedrock valleys, 2) assess the usefulness of a regional scale model as the basis for developing more detailed models of areas of particular concern, and 3) evaluate the combined use of water level records and groundwater geochemical and isotopic signatures in constraining sources of water to springs and wetlands.

Project approach

The project will involve compilation and interpretation of existing data including well logs, water level records, and water chemistry data; field measurements of water levels, streamflow, and chemical indicator parameters; sampling for major ion and Sr isotope analyses; development and calibration of a telescoped model informed by existing data and new measurements; and use of the model to identify sources of water to springs and wetlands and to assess effects of current and potential future development. The field work and modeling will be conducted by a graduate student working with, and under the supervision of, the PI. The project will be conducted in cooperation with staff of TNC, who are providing access to field sites and are serving as liaisons with interested parties in the Mukwonago River watershed.

Users of findings

The improved understanding of the hydrogeologic system will be of use to a wide variety of concerned parties in the watershed including conservation organizations, local planners, and water utilities. Project results will be disseminated to interested parties in the watershed through public presentations and distribution of the project report. Training in the use of the model to simulate additional scenarios beyond those assessed during the project period will be provided to TNC staff and to other interested users with appropriate technical backgrounds.

Proposal Narrative

Objectives

The overall objective of the proposed project is to improve understanding of hydrogeologic controls on groundwater discharge to springs and wetlands in the Mukwonago River watershed in order to allow assessment of current and potential future impacts of groundwater withdrawals and suburban development. The primary product of the research will be a numerical model of groundwater flow, which will be developed through telescopic mesh refinement of an existing regional scale model. The model will be calibrated using records of water levels and synoptic stream flow measurements. The resulting model will provide a tool that can assist conservation organizations and local planning agencies in guiding land use and water resource planning to meet population needs while addressing biodiversity concerns. The project will also provide opportunities to 1) test and refine a conceptual model of spring localization along the edges of preglacial, buried bedrock valleys, 2) assess the usefulness of a regional scale model as the basis for developing more detailed models of areas of particular concern, and 3) evaluate the combined use of water level records and groundwater geochemical and isotopic signatures in constraining sources of water to springs and wetlands.

Background

The Mukwonago River watershed. The Mukwonago River watershed (see Figure 1), located about 35 miles southeast of Milwaukee, has been identified as an "outstanding water resource" by the Wisconsin Department of Natural Resources (WDNR). It is one of the last remaining areas of the Prairie-Forest Border ecoregion with an intact fish population (of 50 species) as well as 12 species of mussels. It contains a complex of largely intact wetlands ranging from bogs to calcareous fens, as well as globally endangered oak openings. The watershed has been a target of conservation efforts for almost two decades. The Nature Conservancy (TNC) acquired land for its Lulu Lake Preserve in 1986 and now owns 438 acres within the watershed. An additional 1,450 acres are currently protected by private owners and the WDNR State Natural Areas Program.

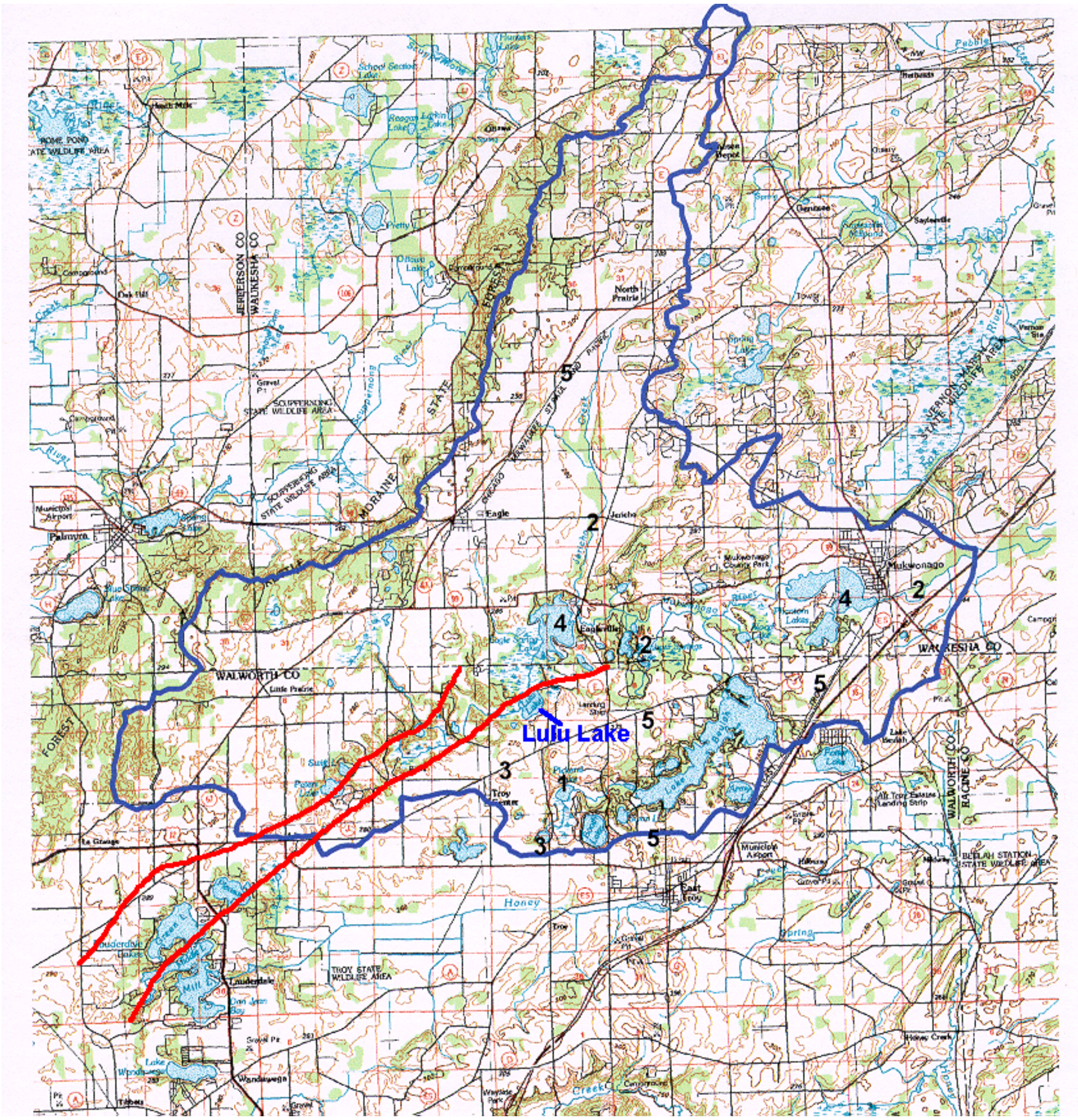

Figure 1 – The Mukwonago River watershed is outlined in blue. The approximate location of the northwest side of the buried Troy Valley near Lulu Lake is outlined in red (after bedrock contours in Borman, 1976).

Although agriculture remains the dominant land use in the watershed today, only 3% of the current residents are farmers. Suburban development has spawned a rapidly expanding commuter population and increasing demands for public water supplies. Several new high capacity wells have been proposed recently (Scott Thompson, TNC, personal communication), including one located less than a mile from the spring and wetland complex at the headwaters of the Mukwonago River. Recognizing that maintaining spring discharge and water levels in wetland is essential to preserving the integrity of these aquatic habitats, the TNC and others involved in conservation within the watershed see a critical need to evaluate potential effects of increased pumping and decreased recharge that may accompany continued suburban development. The proposed project will provide such a tool in the form of a numerical groundwater flow model.

Sources of water to springs. Previous studies of groundwater in the watershed include the county scale reports of Gonthier (1975) and Borman (1976) and an MS thesis (Krueger 1996) focused on local scale flow patterns and geochemistry in a wetland near Lulu Lake. A preliminary evaluation of available data (TNC 2002), led to a conceptual model of springflow and diffuse discharge to wetlands supported by shallow groundwater flow through glacial deposits, with minimal contributions from (or even groundwater loss to) shallow and deeper bedrock aquifers. An alternative conceptual model, suggested by recent studies of springflow in the Dane County, WI (Swanson 2001, Bahr and Parent 2001, Anderson 2002) is that high volume springs may be supported by discharge from preferential flow zones in the shallow bedrock, with the location of springs controlled by the intersection of these preferential flow zones with the steep wall of a buried bedrock valley. These studies, each of which involved development and calibration of a telescoped flow model, demonstrated that inclusion of stratigraphically controlled high permeability zones is necessary in order to provide a good match between simulated and measured baseflow is springfed streams.

A preglacial bedrock valley, the Troy Valley, exists within the Mukwanago watershed and extends northeast towards Waukesha (Batten and Conlon 1993). As shown in Figure 1, the northwest side of this valley underlies many of the springs and wetlands upstream of Lulu Lake. The southeast side of the valley is near another set of wetlands, springs and lakes along the southern margin of the watershed. The bedrock that was exposed in this valley, which is now buried by glacial outwash, includes some of the Cambrian sandstones that make up the bedrock valley walls in Dane County as well as the Ordovician carbonates and, in some areas where they have not been removed by erosion, the Ordovician Maquoketa Shale and Silurian age carbonates. The proposed project will, thus, provide a broader test of a conceptual model of buried bedrock valley controls on spring locations in glaciated terrains.

Telescoped models of groundwater flow. Numerical models of groundwater flow for several watersheds in Dane County have been developed in recent years by the PI and her graduate students (Domber 2000; Bahr and Parent; 2001; Swanson 2001; Anderson, 2002). Each of these models employs the USGS code MODFLOW (McDonald and Harbaugh 1998), a well documented finite-difference code that is widely used for simulation of groundwater flow. Each of these models was derived from a county scale model developed by the USGS and the Wisconsin Geologic and Natural History Survey (WGNHS) (Krohelski et al. 2000) using the telescopic mesh refinement tools available in Groundwater Vistas software (available from Environmental Simulations Inc.), a pre- and post- processing code that facilitates creating MODFLOW data sets and analyzing output from MODFLOW simulations. The telescopic mesh refinement process allocates boundary conditions to a local inset model that initially takes its layers and distribution of hydraulic parameters directly from the regional scale model. Further refinement of the telescoped model can involve increasing the number of layers, altering nodal spacing within layers, and modifying hydraulic parameters and boundaries such as recharge arrays and locations of streams or wells. Refinement and calibration of telescoped models from the Dane County model demonstrated the importance of 1) including more layers to account for significant variations in hydraulic conductivity and vertical anisotropy among bedrock hydrostratigraphic units, 2) addition of stream and drain nodes to represent surface water features that were ignored in the county scale model, 3) using both head and flow measurements as calibration targets, and 4) refining recharge arrays to improve the match between simulated and measured streamflow.

The WGNHS and USGS have recently developed a regional scale flow model for the Southeastern Wisconsin Regional Planning Commission (SEWRPC). This regional scale model includes the Mukwonago River watershed and adjacent areas.

Geochemical signatures as constraints on source waters. Major ion and isotopic signatures of groundwater discharging to springs and wetlands can provide a powerful tool with which to identify aquifer systems through which the groundwater has traveled prior to discharge. Evaluating these signatures in a meaningful way, however, may require more than simply identifying the major ion facies. For example, in the case of springs and groundwater samples collected in the Nine Springs watershed

(Swanson et al. 2001), all samples were of a calcium-magnesium bicarbonate type. In this case, a two-way cluster analysis technique revealed that the samples could be distinguished on the basis of relatively subtle differences in average chloride, nitrate and sodium concentrations and the degree of temporal variability in concentrations of these solutes. Three sample groups were identified and attributed to water that had flowed primarily a) through unlithified deposits, b) through shallow bedrock, or c) along longer flow paths, possibly through deeper bedrock.

A previous study that included sampling of shallow groundwater from wetlands and uplands within the Lulu Lake Preserve (Krueger 1996) concluded that major ion facies were similar across the site and that vegetation variations could not be attributed to variations in groundwater chemistry. However, a more detailed analysis of existing data using statistical tools such as those employed in the Nine Springs watershed and an examination of spring geochemistry over a larger portion of the Mukwonago River watershed may reveal more subtle signatures that can be used to identify contributing aquifers.

An isotopic tool that may be particularly useful in the Mukwonago River watershed is strontium (Sr) isotope ratios. A recent study of a spring complex in Dane County by Hunt and Steuer (2000) demonstrated the use of these isotopic signatures to distinguish between spring recharge areas underlain by Ordovician carbonates and those in which the uppermost bedrock is Cambrian sandstone. Within the Mukwonago River watershed, the uppermost bedrock consists of Silurian dolomite in the east and Ordovician carbonates in the west. Cambrian and Ordovician sandstone units underlie the Ordovician carbonates. Water-rock interactions should yield distinctive Sr signatures as a function of differences in Sr isotopic compositions in these bedrock units. Groundwater interactions with glacial deposits covering the bedrock and filling the Troy Valley may also yield a distinct Sr isotope composition in groundwater that has not flowed through bedrock.

Relationship to other initiatives in the Mukwonago River watershed. The proposed project is designed to contribute directly to ongoing initiatives by TNC to assess and monitor the hydrologic and ecologic integrity of the watershed as well as to develop conservation strategies and partnerships with local landowners, lake management districts, state agencies such as the WDNR, municipal and county planners and others. This project will be coordinated with TNC in order to provide timely availability of results to the many interested parties in the watershed.

Project Plan:

The project will involve compilation and interpretation of existing data including well logs, water level records, and water chemistry data; field measurements of water levels, streamflow, and chemical indicator parameters; sampling for major ion and Sr isotope analyses; development and calibration of a telescoped model informed by existing data and new measurements; and use of the model to identify sources of water to springs and wetlands and to assess effects of current and potential future development. The schedule for collection of field data will provide approximately 1.5 years of water level and streamflow records and approximately one year of data on geochemical indicators prior to final calibration of the flow model. While this may not be sufficient to capture effects of long term climate fluctuations or increased groundwater pumping, it should provide a representative record with which to assess the expected magnitudes of seasonal variations. The monitoring network established during the project will be maintained through the entire duration of the project and made available to TNC or others for continued monitoring of water levels and stream flow after the end of the project period. Additional monitoring following calibration of the groundwater flow model will provide data with which users can test and further refine the model if necessary.

A graduate student working under the supervision of the PI will be responsible for field and modeling aspects of the project. The project will be conducted in cooperation with staff of TNC, who are providing access to field sites and are serving as liaisons with interested parties in the Mukwonago watershed. Access to the regional scale SEWRPC model will be available through staff at the USGS and WGNHS (K. Bradbury, personal communication). An outline of tasks to be conducted over the course of the two-year project is provided below.

A. Fall 02 and Spring 03 (preceding the proposed funding period) – compilation of existing data; development of preliminary hydrostratigraphic model based on existing well logs; installation of shallow, hand augered monitoring points; water level monitoring; synoptic stream flow sampling;

possible monitoring of well and streamflow response during testing of new high capacity well

B. Summer 03 – continued monitoring of water levels and streamflow; installation of multilevel samplers; field monitoring of multilevels and springs; identification of sites for collection of samples for major ion and Sr isotope analysis; collection of samples for major ion analysis; preliminary work on telescopic mesh refinement of the SERPC model.
C. Fall 03 – continued monitoring of water levels, streamflow, and field chemical parameters; collection and analysis of first set of Sr isotope samples; continued model development.
D. Spring 03 – continued field monitoring, additional Sr isotope sampling and analysis, preliminary calibration of numerical model.
E. Summer 04 – continued field monitoring; final set of Sr isotope samples; refinement and final calibration of numerical model.
F. Fall 04 – continued water level and stream flow monitoring; use of calibrated model to identify contributing areas for springs and existing high capacity wells; simulation of potential effects of increased groundwater withdrawals and reduced recharge
G. Spring 05 – preparation of final report and MS thesis; technology transfer to staff of conservation organizations, local planners and others.

Methods:

Water level monitoring. Water level records are available for the period 1995 to present from a former domestic supply well near Lulu Lake that has been converted to a USGS groundwater monitoring point (http://waterdata.usgs.gov/wi/nwis/gwlevels/?site_no=425006088271501). Records from this well show annual fluctuations of approximately 1 ft. Several shallow wells were installed during the fall of 2002 by hand augering at the Lulu Lake Preserve and on private land near the headwaters of the Mukwonago River. In addition, a stilling well was installed in the Mukwonago River within the preserve in order to provide a point for measurement of stream stage. Additional shallow wells will be installed in the spring of 2003. The shallow wells installed to date have been instrumented with "Waterlogger" pressure transducers for continuous recording. A sample of these water level records is shown in Figure 2 below.

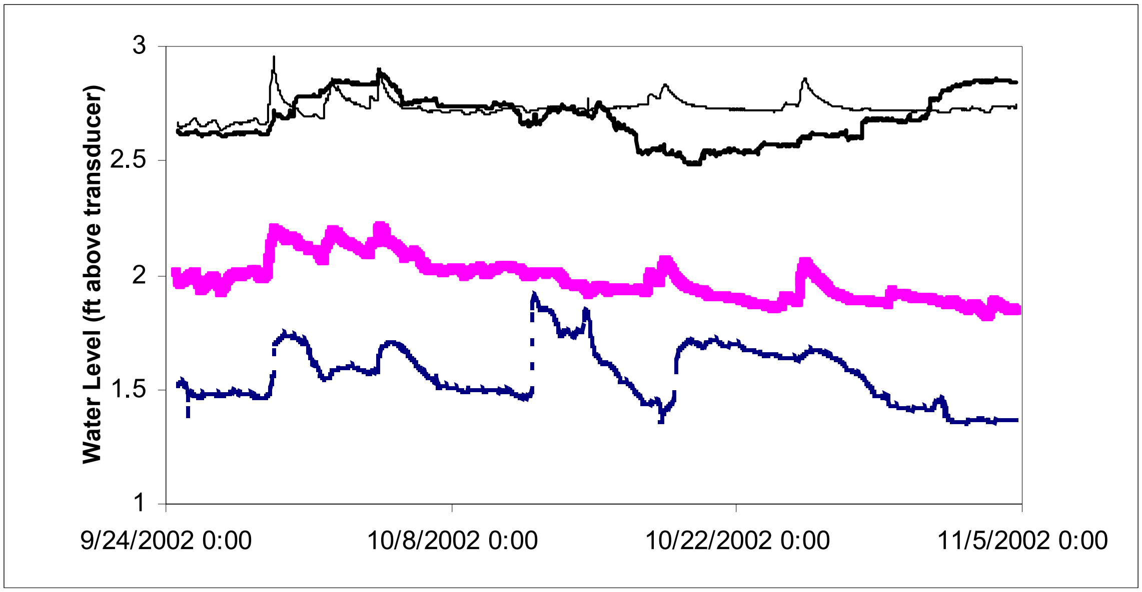

Figure 2 – Water level records from transducers at the Lulu Lake Preserve. The upper two lines are from a nested pair of wells. The shallower well shows a peaked response to rainfall events while the deeper well shows a delayed response and increases in water level that appear to be unrelated to rainfall events. The middle record is from a second shallow well. The lower line is a record of variations in stream stage of the Mukwonago River. It shows water level increases that correspond to rainfall events as well as stage increases that may be associated with releases from spring ponds or removal of beaver dams.

Synoptic stream flow measurements. Stream flow measurements will be made using mini current (pygmy) meters available in the hydrogeology lab of the Department of Geology and Geophysics. Repeated sets of synoptic measurements will be made during baseflow conditions at approximately 5 stations upstream of Lulu Lake. Additional measurements will be made under a range of flow conditions near the stilling well on the Lulu Lake preserve in order to develop a rating curve to use with stage records at that site.

Field chemical monitoring. Samples for field monitoring of indicator parameters will be collected from the stream, springs, shallow wells and miniature multilevel samplers (Stites and Chambers 1991) installed as part of this project, and selected private wells. Electrodes and colorimetric kits (primarily from Chemetrics Inc.) will be used to monitor spatial and temporal variations in temperature, electrical conductance, pH, alkalinity, dissolved oxygen, nitrate, phosphate, and chloride. Results of this monitoring will be evaluated using cluster analysis and other techniques in an attempt to identify water groups associated with distinct flow paths through the glacial and bedrock aquifers.

Sampling and analysis for major ions and Sr isotopes. Approximately 10 existing wells will be selected for sampling and analysis of both major ions and Sr isotopes to establish end member concentrations of water within the glacial deposits and bedrock aquifers. It is anticipated that these will be domestic supply wells in the watershed. Samples will be collected from a cold-water tap upstream of any in-line treatment systems. Temperature, pH, electrical conductance, alkalinity, and dissolved oxygen will be measured in the field using electrode and colorimetric techniques. Samples will be filtered to 0.4 µm and preserved according to requirements of the analytical laboratories. Major ions will be analyzed at a state certified laboratory. Sr analyses will be performed in the Radiogenic Isotope Laboratory of the UW Dept. of Geology and Geophysics under the supervision of Professor Clark Johnson. Following identification of end member Sr isotopic signatures, 20-30 additional samples for Sr isotope analyses will be collected from springs and wells in the watershed.

Numerical model development. Development of a telescoped model for the Mukwonago River watershed as part of the proposed project will be accomplished using the same modeling tools and calibration strategies that were employed in the previous telescoped models of watersheds in Dane County (see discussion in Background section).

Relevance to Groundwater and Related Problems:

The proposed project directly addresses questions related to groundwater withdrawals and connections to surface waters, which have been identified by the DNR as one of its high priority "emerging issues" for groundwater monitoring and research. Specifically, the project will 1) include monitoring of surface and groundwater flow to constrain hydrologic connections and pathways, 2) provide a means of quantifying the groundwater budget of the watershed, 3) and provide a tool for assessing impacts of withdrawals on public water supplies and surface water features.

References Cited:

Anderson, K., 2002. Hydrogeologic controls on flow to Frederick Springs in the Pheasant Branch Watershed, Middleton, Wisconsin, MS thesis in Geology, UW Madison

Bahr, J. and L. Parent, 2001. An improved hydrogeologic model for the Token Creek watershed, Final report to WDNR

Batten, W. G. and T. D. Conlon, 1993. Hydrogeology of glacial deposits in a preglacial bedrock valley, Waukesha County, Wisconsin, USGS Water-Resources Investigations Report 92-4077

Borman, R. G. 1976. Ground-Water Resources and Geology of Walworth County, Wisconsin, WGNHS Circular 34

Domber, S., 2000. An improved hydrogeologic model for groundwater flow in the Token Creek watershed, MS thesis in Geology, UW Madison.

Gonthier, J. B., 1975. Ground-Water Resources and Geology of Waukesha County, Wisconsin, WGNHS Circular 29.

Hunt, R. J. and J. J. Steuer, 2000. Simulation of the recharge area for Frederick Springs, Dane County, Wisconsin, USGS Water-Resources Investigations Report 00-4172

Kreuger, E. A., 1996. The hydrogeology and phosphorus status of two calcareous fens separated by a monotypic sedge meadow, M.S. thesis in Geosciences, UW Milwaukee

Krohelski, J. T., K. R. Bradbury, R. J. Hunt, and S. K. Swanson, 2000. Numerical simulation of groundwater flow in Dane County, Wisconsin. WGNHS Bulletin 98.

McDonald, M.G. and A. W. Harbaugh, 1998. A modular three-dimensional finite-difference ground-water flow model: USGS Techniques of Water Resources Investigations, Book 6, Chapter A1

Stites, W. and L W. Chambers, 1991. A method for installing miniature multilevel sampling wells. Ground Water 29(3): 430-432.

Swanson, S. K, 2001. Hydrogeologic controls on spring flow near Madison, Wisconsin, PhD thesis in Geology, UW Madison

Swanson, S. K., J. M. Bahr, M. T. Schwar and K.W. Potter, Two-way cluster analysis of geochemical data to constrain spring source waters, 2001. Chem. Geol. 179:73-91

TNC, 2002. Wetlands of the Mukwonago River Watershed, A conceptual hydrogeologic model, integrity assessment and management plan.

Training Support/Information Dissemination Plan:

The proposed project will provide training for a graduate student, Hilary Gittings, who plans to pursue a double degree in Geology (Hydrogeology) and Water Resources Management. This work will form the basis for her M.S. thesis in Geology. Additional training will be provided to other graduate students through data collection activities conducted in conjunction with the course Geology 929, Field Applications in Hydrogeology. Project results will be disseminated to interested parties in the watershed through public presentations and distribution of the project report. Training in the use of the model to simulate additional scenarios beyond those assessed during the project period will be provided to TNC staff and to other interested users with appropriate technical backgrounds. One license to Groundwater Vistas, the software package that will be used in developing the model, is included in the funding request to provide TNC staff with full access to the final model. The monitoring network established as part of the project will be available to TNC for continued use in conjunction with their ongoing integrity assessment and management activities.

Curriculum Vitae of Principal Investigators

JEAN MARIE BAHR (10% time commitment, no salary requested)

VITAE

Professor, Department of Geology and Geophysics, Gaylord Nelson Institute for Environmental Studies, and Geological Engineering Program
University of Wisconsin - Madison
1215 W. Dayton St., Madison WI 53706
Ph: (608) 262-5513; Fax: (608) 262-0693
Internet: jmbahr@geology.wisc.edu

FORMAL EDUCATION

1976 B.A. Geology and Geophysics, Yale University
1985 M.S. Applied Earth Sciences (Hydrogeology), Stanford University
1987 Ph.D. Applied Earth Sciences (Hydrogeology), Stanford University

POSITIONS HELD

1976-1980 Geologist, Wahler Associates, Palo Alto, CA
1980-1985 Research Assistant and Teaching Assistant, Stanford University
1982-1983 Hydrogeologist (part-time), GTC Geologic Testing Consultants Ltd., Ottawa, Canada
1984-1986 Hydrologist (part-time) Water Resources Division, U.S.G.S., Menlo Park CA
1987-1993 Assistant Professor, Dept. of Geology and Geophysics, UW-Madison
1993-1998 Associate Professor, Dept. of Geology and Geophysics, UW-Madison
1996 Member Ocean Drilling Program Leg 169 Shipboard Scientific Party
1998 - Professor, Dept. of Geology and Geophysics, UW-Madison
1995-1999 Chair, Water Resources Management Program, Institute for Environmental Studies, UW-Madison

RESEARCH INTERESTS

Interactions between physical and biogeochemical processes in groundwater; effects of heterogeneity on solute transport; groundwater-surface water interactions; paleohydrogeology

HONORS AND AWARDS

1976 B.A. granted magna cum laude, distinction in Geology and Geophysics
1976 Yale College Samuel Lewis Penfield Prize mineralogy)
1976 Hammer Award (Yale Dept. of Geology and Geophysics)
1991 Editors Citation for Excellence in Refereeing - Water Resources Research
1996 Elected Fellow Geological Society of America
2003 GSA Hydrogeology Division Birdsall-Dreiss Distinguished Lecturer

PROFESSIONAL SOCIETY MEMBERSHIPS

Sigma Xi
American Geophysical Union
Association of Engineering Geologists
Association of Geoscientists for International Development
Association of Women Geoscientists
Assoc. of Ground Water Scientists & Engineers
American Water Resources Association
Geological Society of America

OTHER PROFESSIONAL ACTIVITIES

National Research Council Committee on Restoration of the Greater Everglades Ecosystem (1999- ; chair 2001-)
NSF Hydrological Sciences Panel (1996-99)
Member NRC/NAS Panel on Fluid Infiltration in Fractured Media (1998-99)
Chair, GSA Hydrogeology Division (2000-01)
Associate Editor, Water Resources Research (1996-2000)
Books Editor, Ground Water (1998-1999)
Editorial Board, Geotimes (1995-1998; chair 1997)
Editorial Board, ODP Leg 156 Scientific Results Volume (1995-97)
National Research Council Board on Radioactive Waste Management (1992-97)
Editorial Board, Ground Water (1993-95)
Sedimentary and Geochemical Processes Panel of Joint Oceanographic Institutions for Deep Earth Sampling (1992-94)

SELECTED PUBLICATIONS

Moline, G. R. and J. M. Bahr, 1995. Estimating spatial distributions of heterogeneous subsurface characteristics by regionalized classification of electrofacies, Mathematical Geology, v. 27, no. 1, pp. 3-22.

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Keating, E. H. and J. M. Bahr, 1998. Using reactive solutes to constrain groundwater flow models at a site in northern Wisconsin, Water Resources Research, v. 34, no. 12, pp. 3561-3571.

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Current or Pending Support

Current:

Alternative urbanization scenarios for an agricultural watershed: Design criteria, social constraints, and effects of groundwater and surface water systems (J. Bahr co-investigator with K. Potter, R. Lathrop, and 6 others), $886,105, EPA Water and Watersheds Program, 3/00-2/03.

Arsenic contamination in southeastern Wisconsin: Sources of arsenic and mechanisms of arsenic release [J. Bahr and M. Gotkowitz (WGNHS) co-PIs], $69,903, WNDR and UWS, 7/02-6/04.

Pending:
Monitoring and predictive modeling of subdivision impacts on groundwater in Wisconsin (J. Bahr co-PI with K. Bradbury) submitted to Joint Solicitation