Symposium Purpose

The Second Annual Groundwater Symposium is sponsored by the Pennsylvania Department of Environ-mental Protection, bureaus of Watershed Management and Water Supply and Wastewater Management.

Its purpose is to bring together federal, state and local groundwater scientists and managers to exchange information and ideas about effective groundwater protection programs and studies.

The goal is to promote the protection and prudent use of Pennsylvania's groundwater resources.

Groundwater Symposium 2001

Clarion Hotel and Convention Center
Wednesday May 2, 2001

AGENDA

8:00-9:30	Sign In		
8:45-8:50	**Grand Ballroom**	Welcome - **Stuart Reese**, DEP Bureau of Watershed Management	
8:50-9:10	Opening Remarks - **Lawrence Tropea, Jr.** DEP Deputy Secretary for Water Management		
9:10-9:30	Keynote Speaker - **The Honorable Carole Rubley** Pa. House of Representatives		
9:30-10:00	Plenary Session	**Bruce Lindsey**, USGS; Relation of hydrogeologic framework to groundwater residence time and nitrogen transport in a fractured bedrock aquifer in the East Mahantango Creek Basin, Pennsylvania	
10:00-10:20	**Windsor Ballroom**	**Break**	
10:20-11:00	**Carlisle/Penn Room**	**Franklin/Cumber-land Room**	**Grand Ballroom**
	Angelika Forndran and **Melissa Faga**, Spotts, Stevens & McCoy; How municipal authorities are using GIS as a tool for ground-water protection	**Mike Moore**, DCNR Bureau of Topographic and Geologic Survey; Arsenic in groundwater in Northwestern Pennsylvania; two case studies	**Stuart Gansell**, DEP; State water plan issues and developments
11:05-11:45	**Joel Jordan** and **Judy Muehl**, Pa. Rural Water Association; Programs on wellhead and source water protection	**Curtis Schreffler**, USGS; A study of the effect of land application of treated sewage effluent, New Garden Township spray irrigation site, Chester County, Pa.	**John Owsiany**, Consol Energy and **Burt Waite**, Moody and Associates; Coal Mining in Low Cover Areas of the Enlow Fork Stream Valley in Southwestern Pa.
11:45-12:45	**Windsor Ballroom**	**Lunch**	

12:45-1:25	**Grand Ballroom**	Plenary Sessions	**Mark Ralston**, Converse Consultants; Identification of hydrogeologic environments of the Upper Penns Creek watershed; case history of the development of tools for watershed management under the DEP Growing Greener Program	
1:25-2:00			**Bob Day-Lewis**, DEP Southeastern Regional Office Environmental Cleanup Program; MTBE contamination cases in Southeastern Pennsylvania	
2:00-2:20	**Windsor Ballroom**		**Break**	
2:20-2:50	**Carlisle/Penn Room**		**Franklin/ Cumberland Room**	**Grand Ballroom**
	Dayne Crowley, Harding ESE; Groundwater and surface water relationships in an allvial aquifer with respect to the potential effects of dredging		**John Charlton**, Carus Chemical Company; Treatment for bacteria contaminated wells	**Dennis Risser**, USGS; Recent Improvements to the USGS Observation Well Network and Groundwater Database
2:55-3:25	**Jeff Chaplin** and **Chuck Cravotta**, USGS; Abatement of abandoned mine drainage requires characterization of interaction between surface water and underground mine water		**Tammy Zimmerman** and **Bruce Lindsey**, USGS; Bacteria and viruses in ground-water; relation between well construction practices and occurrence of bacteria	**Barry Evans**, Penn State University, ERRI; A Streamlined GIS-Based Approach to Source Water Assessments for Small Water Systems
3:30-4:00	**Joe Schueck**, DEP; Investigating Stream Loss into Underground Mines Using Geophysical Techniques		**Michael Arnold**, Pa. DEP and **Greg Hafer**, Concurrent Technologies; Ground Water 2000; A Pennsylvania DEP e-commerce initiative	**Gary Fleeger**, Pa. Geologic Survey; 101 formations the hydrogeologic characteristics of the ridge and valley province

Abstracts and Speaker Contact Information

(In alphabetical order of main speaker)

Michael Arnold and Greg Hafer

Pennsylvania Department of Environmental Protection
Bureau of Land Recycling and Waste Management and Concurrent Technologies Corporation (respectively)
Ground Water 2000: A Pennsylvania DEP E-Commerce Initiative

Groundwater 2000 is an initiative of the DEP to convert the process for submitting, storing, managing and retrieving groundwater data from Pennsylvania's municipal landfills to electronic commerce.

The objectives for this project are to:

- Make it easier for landfills, laboratories and consultants to submit data;
- Drive the data to be more accurate before it's submitted;
- Make it faster and easier for DEP staff to receive and review the data;
- Provide built-in tools to alert staff of major data changes or potential problems;
- Integrate groundwater data with geo-spatial software to provide graphic views of groundwater conditions; and
- Provide easier public access to appropriate records and information.

This project is a partnership effort between landfill owners/operators, environmental consultants, DEP field staff, academia and DEP consultants and contractors.

Initial efforts started in 1999 with a single landfill Pilot Project and a needs assessment, which involved DEP staff and the regulated community. Conceptual design, commercial software evaluation and an "as-is" business process study were completed in 2000. These initial efforts identified the need for "standards" in several key areas.

The project is moving forward through the system design stage and a six-landfill initial implementation for collecting digital data, drawings and photos.

As one of DEP's initial e-Government initiatives, Groundwater 2000 has helped the Department to focus on infrastructure needs to support broad based electronic commerce deployment in Pennsylvania.

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Michael Arnold has more than 30 years of experience in environmental science, technology and management. He has developed a broad knowledge of environmental issues through his association with water quality and waste management programs. Currently serving as the manager of Emerging Technologies for DEP's Office of Air, Recycling and Radiation Protection, Michael is involved with the deployment of environmental technology both in Pennsylvania and at the national level.

Greg Hafer is employed as an electronic commerce consultant for Concurrent Technologies Corp. He serves as a project manager on Groundwater 2000 at DEP, assisting Michael Arnold with development and implementation. Greg brings more than 20 years of communication and project management experience to the Groundwater 2000 project. Previously, he has worked on a broad range of conventional and electronic communication programs, including the development of corporate Inter- and Intranet applications.

Jeffrey J. Chaplin III and Charles A. Cravotta

U.S. Geological Survey (USGS)

Abatement of Abandoned Mine Drainage Requires Characterization of Interaction Between Surface Water and Underground Mine Water

More than 100 years of underground and surface mining of anthracite have contaminated water in the Nanticoke Creek Basin, Luzerne County. Extensive areas of spoil and refuse from mining operations have not been reclaimed, and the abandoned underground workings are flooded and collapsed in places. Surface water from headwater streams that crosses mined areas infiltrates and becomes contaminated with acidity, iron, and sulfate.

From April 1999 to March 2000, the influence of abandoned mines on water quantity and chemistry in Nanticoke Creek and its tributary Leuder Creek was investigated. During most of the study, both streams lost all flow in the vicinity of the coal outcrop along the boundary of the mined area. However, on Feb. 29, 2000, after heavy rainfall and snow melt, streamflow in Nanticoke and Leuder Creeks was maintained or increased along upper reaches that had lost water or were dry earlier in the study. Nevertheless, along an intermediate reach where Nanticoke Creek flowed through a refuse bank across the channel, more than 80 percent of the streamflow was lost. Water quality downstream of the refuse bank was degraded compared to upstream; specific conductance increased from 270 to 430 μS/cm, and pH decreased from 6.1 to 3.6. In contrast, Leuder Creek gained flow along its entire reach. From the headwaters to the mouth of Leuder Creek, specific conductance increased from 40 to 200 μS/cm, and pH decreased from 6.5 to 4.7; most water quality changes were in the lower reach. Interflow from Nanticoke Creek or upwelling water from the mine pool probably degraded Leuder Creek along its lower reach.

Recently, interest has grown for abating water losses and passively treating contaminated water in the Nanticoke Creek Basin. Constructed wetlands currently treat a portion of flow that discharges from the Askam Borehole, but efforts have not been made to prevent stream leakage to the mines or to prevent contact of surface water with mine refuse. Episodes of acidic water flowing in normally dry reaches of Nanticoke and Leuder Creeks are poorly characterized because they are short lived and difficult to predict. Streambed sealing or passive treatment that is implemented without knowledge of such episodes may fail to be effective during ephemeral high-flow conditions. Additional data on the frequency, quantity and chemistry of streamflow over the complete range of flow conditions and the effects of abandoned mines on these variables are needed to characterize the interaction between surface water and underground mine water. The improved characterization can be used to evaluate and implement appropriate remediation.

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Jeffrey J. Chaplin is a hydrologist with the USGS, Water Resources Division, in New Cumberland, Pa. He received a Bachelor's in Plant Biology from Ohio University and a Master's in Water Resources Management from the University of Wisconsin – Madison. His work in Pennsylvania has ranged from studying abandoned mine drainage to monitoring created wetland and riparian systems. Current project responsibilities include characterization of mine discharge chemistry and stream water loss to underground mines, monitoring of created wetland and riparian systems, and determining the effects of dam removal on water quality and channel morphology.

John Charlton

Carus Chemical Co.

Microbiological Contaminants and Groundwater

This presentation focuses on bacterial contamination of groundwater wells used for potable water. Many wells in the United States are contaminated with bacteria, and cleaning these wells with traditional methods, bleach and acid, are typically ineffective. Alternative methods can be used to effectively clean and disinfect wells, and the results typically last for several years, not just several months.

Well-cleaning procedures, which specifically differ from traditional surge block methods using acids and bleaches and produce excellent results bacteria reduced/coliform free water after cleaning - will be discussed.

The choice of well-cleaning chemicals used in well-cleaning can determine the performance of the cleaning. We will look at how and why these materials perform as they do. Chemicals to be investigated include acids, bleaches, phosphates, polymers and others. Water chemistry conditions literally dictate how well bleach performs as a disinfectant. How and why these chemistry conditions work will be presented.

A review of bacterial growth conditions/requirements and how chemical choice affects bacterial responses will be presented. Carbon, nitrogen and phosphorus ratios, bacterial requirements for these, and the presence of these elements found in water wells will also be presented. Case studies, observed data, research papers/projects and a demonstration will be presented to show positive results achieved in water system and well cleaning projects where bacteria have been an unsolvable problem.

With the upcoming implementation of the Groundwater Rule by United States Environmental Protection Agency, water wells are now coming under much scrutiny, and this presentation will provide tools and insight as to how to proceed in determining if a well needs cleaning and how to clean it effectively.

This presentation was developed for the water system operator and does not require a strong background in chemistry or microbiology. Data to be presented and handouts will be available. Key points and the most valuable material can be presented to meet time constraints.

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John Charlton holds a Bachelor's degree in Chemistry from University of Wisconsin and has worked in water treatment for seven years. He began with The Kjell Corp. in 1994, which was purchased by Carus Chemical Co. in 1998. He is currently a technical specialist with Carus.

His work has focused on corrosion control, lead source research and overall water quality treatment. His current focus is researching the effects of phosphates on the microbiology found in water systems and wells. Much of his work now focuses on working with and teaching well and pump service companies how to effectively treat wells that are contaminated and cannot be easily disinfected. Some of this work was presented at American Water Works Aassociations's Water Quality Technology Conference in 1999 and 2000.

Dayne Crowley

Harding ESE, A Mactec Co.

Groundwater and Surface Water Relationships in an Alluvial Aquifer with Respect to the Potential Effects of Dredging

Dredging of sand and gravel from the lower Allegheny River has occurred throughout the last 100 years. During this time period, the sand and gravel aquifer adjacent to the river has been developed as a major source of water for many municipalities and industries. Following the occurrence of high temperatures in surface water during the drought of 1998, unusually high temperatures were reported in groundwater from an industrial production well located along the bank of the Allegheny River. Because dredging had recently occurred in the river adjacent to this site, it was believed that dredging may have enhanced the hydraulic connection between the river and the aquifer, and thereby caused the reported change in groundwater conditions.

Because future dredging is planned for areas that include the capture zones of municipal well fields, a study was completed to determine whether any changes in groundwater quality could be detected that may be related to dredging. The study evaluated the interaction between the groundwater and surface water flow systems and assessed potential impacts from dredging. Data were collected for a period of five months prior to dredging, then for five months during dredging, and for one month following the completion of dredging. The study included continuous logging of water levels, temperature and specific conductance and sampling for major cations and anions. The data were compared for the different time periods to determine whether any changes had occurred that were attributable to dredging sand and gravel from the river.

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Dayne M. Crowley is an associate hydrogeologist for Harding ESE in Pittsburgh. Mr. Crowley has worked as a hydrogeologist in the environmental field since 1983. He worked with USGS in Pittsburgh as a hydrologist technician on several county-wide groundwater resources investigations, including projects in Washington and Warren Counties. Mr. Crowley has worked with environmental consulting firms in the Pittsburgh area since 1986, where he has specialized in groundwater and surface water investigation projects. Mr. Crowley earned his Bachelor of Science degree in Geology from Waynesburg College and is

a masters degree candidate in Hydrogeology at West Virginia University. Mr. Crowley is a Registered Professional Geologist in Pennsylvania, South Carolina and Arkansas.

Bob Day-Lewis

Pennsylvania Department of Environmental Protection
Southeastern Regional Office, Environmental Cleanup Program
MTBE Contamination Cases in Southeastern Pennsylvania

DEP's Southeast Region is comprised of Bucks, Chester, Delaware, Montgomery and Philadelphia Counties. The U.S. Census Bureau's 2000 Census, reports the eighteen and older population in the five counties to be 2.9 million. Helping to transport the populace, according to 1999 Pennsylvania Department of Transportation figures, are approximately 2.4 million registered vehicles, 1.9 million of which are passenger cars. To supply these vehicles with fuel, the region contains 2,332 registered facilities, each having at least one currently active underground storage tank (UST). The total number of currently active gasoline UST's in the region is 4,176. According to the United States Environmental Protection Agency's Office of Underground Storage Tanks (OUST) semi-annual activity report, Pennsylvania contains 28,842 active tanks, and has reported 12,131 confirmed releases. DEP reports that approximately 1,100 releases occur from underground storage tanks in the Commonwealth annually. Payments and commitments made by the Underground Storage Tank Indemnification Fund on behalf of owners in the Southeast Region (696 claims) exceed $50 million dollars since its inception.

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Robert E. Day-Lewis is a hydrogeologist supervisor of the Special Projects Section of the Environmental Cleanup Program responsible for supervision and direction of a staff of fourteen technical specialists including hydrogeologists, soil scientists and environmental chemists. He has worked 22 years as a hydrogeologist in the area of groundwater contamination, site assessments and characterizations, remedial actions and site restoration. He is responsible for the oversight of remedial activities performed under the authority of the Storage Tank and Spill Prevention Act; the Hazardous Sites Cleanup Act; the Land Recycling and Environmental Remediation Standards Act; and the Clean Streams Law of Pennsylvania.

Barry M. Evans
Environmental Resources Research Institute, The Pennsylvania State University
A Streamlined Gis-Based Approach To Source Water Assessments For Small Systems

A streamlined GIS-based approach is currently being developed for DEP to support source water assessments for small community water supply systems in the state. This approach is based on the use of a customized ArcView software application that includes a number of specialized analysis functions and updated statewide GIS data sets. The application also includes an interface to TWODAN, a two-dimensional flow model, that is used to define capture zones around community water supply wells. Input data for the model is automatically created using information contained within specially-attributed GIS map files as well as region-specific default information. This default information is based on "conceptual models" recently developed by DEP that characterize varying hydrogeologic conditions for different basins, aquifers and physiographic regions around the state. Once capture zones are defined for any given water supply well, other functions are used to identify and quantify vulnerability to existing "threats" such as agricultural land and waste disposal sites.

In addition to the groundwater-oriented assessment tool described above, an existing application previously developed by Penn State for use in watershed studies being conducted by DEP's Bureau of Watershed Conservation will be adapted for use in the source water assessment application. This application, called AVGWLF, provides a link between the GWLF (Generalized Watershed Loading Function) watershed simulation model and ArcView GIS software. This application is presently used to estimate nitrogen, phosphorus and sediment loads within a watershed, and relies upon the use of existing and specially-created statewide data sets. This AVGWLF tool, when used in conjunction with previously-digitized boundaries of "contributing areas" associated with surface water intakes, will allow for an evaluation of threats to surface water supplies as well.

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Barry Evans is a Ph.D. candidate in Soil Science at Penn State University. He received his Master's in Environmental Pollution Control from Penn State in 1978, and his Bachelor's in Natural Resources from the Ohio State University in 1975.

Mr. Evans is a Senior Research Assistant within the Office for Remote Sensing of Earth Resources (ORSER), a research unit affiliated with the Environmental Resources Research Institute at Penn State University. At ORSER, he is primarily responsible for managing GIS projects funded by a variety of governmental and institutional sponsors. One of his primary ongoing activities involves managing a multi-year contract to provide GIS services to DEP. Mr. Evans' specific areas of expertise include project management, GIS mapping and analysis, watershed/water quality modeling, airphoto interpretation, digital remote sensing and environmental impact assessment.

Prior to ORSER, Mr. Evans was President of Geo Decisions, Inc., a GIS consulting firm located in State College, Centre County, and was responsible for overall GIS project management in addition to his corporate administrative duties. Previously, Mr. Evans was Director of Remote Sensing Applications at Resource Technologies Corporation (RTC) in State College.

Mr. Evans has authored dozens of remote sensing and GIS-oriented publications and technical reports dealing with air photo acquisition, air pollution damage to vegetation, septic system performance, waste disposal siting, wetland evaluation, groundwater management, surface mine operations, nonpoint source assessment, hydrologic modeling and spatial decision support systems. He is a member of the American Society of Photogrammetry and Remote Sensing, Soil and Water Conservation Society, Water Environment Federation and American Water Resources Association.

Gary Fleeger

Pa. Department of Conservation and Natural Resources (DCNR)
Bureau of Topographic and Geologic Survey
101 Formations: the Hydrogeologic Characteristics of the Ridge and Valley Province

The PaGS (Pennsylvania Geological Survey) is continuing a project to statistically analyze various hydrogeologic and groundwater chemistry parameters of the stratigraphic units on the 1980 state geologic map. The project has been divided into three parts based on physiographic provinces. The U.S. Geological Survey has completed volume 1 (Atlantic Coastal Plain, Piedmont, Blue Ridge and New England Provinces) and will publish it as a Water-Resources Investigation Report. PaGS is currently completing volume 2 (Ridge and Valley Province). This will be available as a Microsoft Access database, and as ArcView attribute tables to accompany the digital state geologic map. Volume 3

will cover the Appalachian Plateaus and Central Lowlands Provinces, and will be formatted similar to volume 2.

The raw dataset for the statistical analysis is drawn from PaGWIS (Pennsylvania Groundwater Information System). PaGWIS includes data from water well records primarily included in: 1) the PaGS water well inventory of records submitted by licensed water well drillers in Pennsylvania since 1966, 2) the USGS GWSI (Groundwater Site Inventory), 3) DEP's public water supply database, 4) Pennsylvania Department of Agriculture, and 5) the USGS QWDATA database. Data from more than 14,000 field-located wells in the Ridge and Valley Province from the GWSI, DEP, DOA and QWDATA sources were used in the statistical calculations.

The data set was first subdivided by physiographic section, then under each section, by stratigraphic unit. The dataset was further stratified according to the topographic position as well as whether the well was constructed for domestic or high demand applications. Statistics were then calculated for the well depth, casing length, specific capacity, SWL (static water level) and yield. WBZ (water-bearing zone) data were categorized using all of the above categories, except water use, before their density was analyzed using a moving-average technique. A variety of water chemistry parameters includes specific information related to changing detection limits, MCLs and SMCLs over time.

The categories of analysis will allow the user to make a plethora of comparisons of various units, physiographic sections, topographic positions, etc. in various combinations as required by the user's specific need. Combining the resulting hydrologic statistics with the lithologic attributes in an Access database will enable geologists, planners, regulators, consultants, and legal eagles to create customized attribute tables for various types of GIS analyses, be it the generation of a classic geologic map, or a map depicting the relationship of well yield to bedrock lithology. The PaGS will also use the data to guide future water resource projects.

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Gary Fleeger received his Bachelor's in Geology from Bucknell University, and an Master's in Geology from the University of Illinois at Urbana-Champaign in 1980. Prior to his current position as a hydrogeologist with the Pennsylvania Geological Survey, he was a

hydrogeologist with the Pennsylvania Bureau of Mining and Reclamation, and a geologist with the Pennsylvania Bureau of Oil and Gas Management. Employers previous to the Commonwealth include the Colorado Department of Health, the oil and gas industry in Colorado and the Illinois State Geological Survey.

Angelika Forndran and Melissa A. Faga

Spotts, Stevens and McCoy Inc.
How Municipal Authorities Are Using GIS as a Tool for Groundwater Protection

This presentation will provide an overview of how GIS is being used by municipal authorities to protect groundwater resources in Pennsylvania. The following topics will be covered:

- Review existing environmental databases available through local, county, state and federal government programs that can be used for groundwater protection.
- Identify and evaluate GIS analysis methods for evaluating groundwater sources and protection of groundwater.
- Site example of using GIS for groundwater protection: Wellhead Protection Area Delineation and Protection Program using GIS for Telford Borough Authority.

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Melissa Faga is the GIS Manager and Watershed Coordinator for Spotts, Stevens and McCoy Inc., a consulting, planning and engineering firm, in Reading. Ms. Faga has more than nine years experience applying GIS and information technology to water resource and environmental projects. In particular, Ms. Faga has specialized in the application of GIS to source water protection and watershed assessments. Currently, she is the project manager for a DEP source water assessment contract that will assess the quality of surface waters and their vulnerability for 127 community water systems across the state. She holds a bachelor's in Geology from West Chester University and a master's in Geological and Environmental Science from Stanford University.

Stuart Gansell
Pennsylvania DEP
Bureau of Watershed Conservation
State Water Plan Issues and Developments

The final subbasin report in Pennsylvania's most recent State Water Plan was completed in 1983. It was the culmination of a 15-year effort that began with five years of data collection and development of planning procedures and criteria followed by nearly ten years of data analysis, public participation, planning and, finally, publication of nineteen subbasin reports.

That plan was comprehensive in nature, and examined water resources problems and potential solutions in the areas of: water supply and consumption; flood damage; recreation and scenic rivers; water quality; and navigation. The births of several of our existing water resources management programs were either coincident with or a result of the development of the State Water Plan. Examples of such programs include the Stormwater Management, Floodplain Management and Scenic Rivers Programs.

The plan culminated in an unsuccessful attempt in the early 1980s to pass comprehensive water resources legislation that would have provided statutory authority to manage water withdrawals and use. That attempt was followed by several subsequent, and equally unsuccessful, attempts during the 1990s. These past efforts to pass legislation generally met with broad agreement that Pennsylvania needs to collect good water resources data and needs to maintain a comprehensive State Water Plan, but there was little agreement about the need for management authority over water withdrawals and use.

DEP, for most of the past 20 years, continued to maintain up-to-date water withdrawal and use information, until staff reductions in the mid-1990s reduced our ability in this area. Our Water Use Data System, which included not only historical and current water use information, but also included 50-year water use projections in most categories of use, declined rapidly from a national showpiece to an "also-ran." Although staffing has recently been replaced, we are playing a difficult game of "catch up."

Once again, there is strong interest, both within DEP and within the General Assembly, to pursue comprehensive water resources management legislation. Growing water resources problems related to droughts, interference between water users, stormwater management, removal of unsafe or no-longer-useful dams and both groundwater and stream flow protection, among others, have spurred numerous piecemeal legislative attempts in the past few years. In concert with the findings of Gov. Tom Ridge's 21st Century Environment Commission's,

as well as others, many now recognize the need to address our water resource problems comprehensively.

DEP has organized a series of public meetings across the Commonwealth to present a vivid description of the varied problems we are facing and to solicit public input on a range of key questions directed toward developing a comprehensive legislative proposal. An update on the progress of those meetings, which are planned for April, May and June, as well as DEP's plans, will be discussed in this presentation.

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Stuart Gansell is DEP's Director of the Bureau of Watershed Management. He is responsible for a number of DEP's watershed resource management and water quality protection programs. Mr. Gansell has been with DEP for more than 29 years and has served in a variety of capacities in both a regional and central office environment. He received his bachelor's degree in Civil Engineering from Lafayette College and a master's in Public Administration from Pennsylvania State University. He is a registered professional engineer, a registered land surveyor and is a certified operator of wastewater and drinking water treatment facilities.

Joel Jordan and Judy Muehl

Pa. Rural Water Association

Programs on Wellhead and Source Water Protection

What motivates a water supplier to develop a source water protection Plan? Why do some source water protection programs fail to become sustainable?

Part I - Development of the Plan

In Pennsylvania, approximately 10 percent of community water suppliers have developed a Source Water (Wellhead or Watershed) Protection Plan. Some Plans are comprehensive and extremely effective, while other have not advanced beyond assessment of the risks. What are the basic elements necessary for the development of a comprehensive Plan?

Part II - Implementation of the Program

PRWA has been conducting on-site evaluations of all local Source Water Protection Programs. These evaluations have shed some light on the reasons why some programs succeed and others fail. What are the key

elements for implementing an effective and sustainable local Program? What are the pitfalls to avoid?

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Judy Muehl is the National Rural Water Association (NRWA) Groundwater Specialist employed by the Pennsylvania Rural Water Association (PRWA). Judy was a Borough Manager in Erie County before she started to work for NRWA as Field Representative in Ohio and Pennsylvania. After three years as a National Field Representative, Judy was hired by PRWA as a Groundwater Technician. For five years she worked with community water systems developing wellhead protection plans, presenting workshop and seminars across the state on Groundwater Protection and initiated the state water supply protection sign and took it through the approval process up to the Federal Highways Commission. She also obtained a Kellogg Grant to complete six pilot projects along Interstate highways where the sign was erected to notify motorists they are traveling through a sensitive area of recharge for water supplies. In 1991, Judy was asked to develop a new program for PRWA known as the Water 2000 Program. She traveled to impoverished areas of the state that had been impacted by mining and developed feasibility studies to bring water into the areas. In 1998, Judy was asked to become the State Coordinator for the Pa. Senior Environment Corps. The program is a state funded program that teaches senior citizens to monitor surface water sources. In 1999, Judy resigned her position and was offered the Groundwater Position at PRWA again, where she is now involved with over 20 systems in developing wellhead protection plans.

Bruce D. Lindsey, William C. Burton, William J. Gburek, L. Neil Plummer and Johnkarl Bohlke

USGS

Relation of Hydrogeologic Framework to Groundwater Residence Time and Nitrogen Transport in a Fractured Bedrock Aquifer in the East Mahantango Creek Basin, Pennsylvania

The influence of groundwater on surface-water quality is being studied in the Chesapeake Bay watershed in order to assist resource managers in anticipating the potential lag time between implementation of land-management practices and the corresponding response of nonpoint source contaminants in baseflow discharge to streams. Controls on ground-water residence time include aquifer properties such as hydraulic conductivity and porosity, the hydraulic gradient, and the hydrogeologic

framework. Fracture and bedding orientation is an important part of the hydrogeologic framework and has the potential to affect groundwater residence time in a systematic fashion, depending on whether the water is moving parallel or counter to the dominant fracture orientation.

A study of groundwater residence time and delivery of nutrients is being conducted in a USDA-ARS upland experimental watershed in east-central Pennsylvania, where fracture orientation may be a dominant control on groundwater flow patterns. Analysis of the local fracture geometry has shown that the most abundant fracture set consists of east-striking, north-dipping bedding-plane partings. Piezometer nests that are oriented perpendicular to the strike of the partings were installed in two transects across a stream. Therefore, in order to reach the stream from the north side of the transects, groundwater moves opposite the dip direction, whereas it moves parallel to the dip direction on the south side of the transects.

Several approaches were used to analyze the flow regime at two sites in the watershed where the two piezometer nests were installed. Flow nets generated using water-level data revealed only minor differences in the flow field between the two sides of the transects. However, apparent groundwater ages interpreted from environmental tracer data, including chlorofluorocarbons (CFC's) and tritium/helium-3, show that the ages are significantly older on the north side of the transects than on the south side. The ages on the north side of the transects ranged from 7 to 50 years, whereas ages on the south side of the transects ranged from 5 to 16 years. A groundwater flow model (MODFLOW), constructed to estimate travel times in this watershed, indicated rapid groundwater travel times in the range of several months to a few years. The new information on groundwater ages and hydrogeologic framework is being used to update and rerun the model to determine if model-predicted ages more closely resemble the tracer ages when the new information is included. Water-chemistry data, including dissolved-gas concentrations, show that denitrification is more advanced on the sides of the transects having older water. Information on nitrate concentrations, dissolved oxygen, excess nitrogen gas (indicating denitrification) and age indicators supports the hypothesis that groundwater movement is strongly influenced by the orientation of bedding planes in the aquifer. The study of residence time is a joint effort by the USGS and the U.S. Department of Agriculture, Agricultural Research Service, and builds on numerous previous hydrologic studies in this watershed.

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Michael Moore

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Arsenic in Groundwater in Northwestern Pennsylvania: Two Case Studies

Case Study 1: Understanding the Occurrence and Fate of High Concentrations of Total Dissolved Arsenic in the Groundwater at Presque Isle State Park Erie County, Pennsylvania

Groundwater sampling conducted in conjunction with an investigation of the groundwater system at Presque Isle State Park led to the discovery of a systemic elevation in the concentration of total dissolved arsenic. Concentrations as high as 299 ug/l were measured and sample results suggest that virtually all groundwater, 18 feet or more, below the water table, exceeds the 50 ug/l drinking-water standard set by the EPA. Although this study was not designed to collect information specific to understanding the elevated arsenic concentrations, the comprehensive nature of the investigation did provide some insight into the geochemistry of the groundwater system. Results of the water analyses indicate that total dissolved arsenic concentration correlates with both the depth of sample collection and the total dissolved iron concentrations. Most likely arsenic moves into solution from adsorption sites as iron oxides in the sediment are dissolved. The reducing conditions under which this occurs is confirmed by a decrease in sulfate concentration with depth. This information is used to propose a model for the fate and transport of arsenic in the groundwater system of the peninsula.

Case Study 2: Politics, Human Nature, and the Discovery of Arsenic in the Groundwater at a Housing Development in Warren County, Pennsylvania

During the summer of 1987, routine groundwater sampling at a domestic supply well, conducted in conjunction with a countywide resource evaluation, indicated total dissolved arsenic concentrations above EPA's 50ug/l standard. The discovery well was located in the middle of a 61-

home development – each house with its own supply well. Sampling for arsenic and barium (which also exceeded the EPA standard in the discovery well) was quickly offered to all homeowners in the development.

Despite everyone's best efforts to do the right thing, we soon learned valuable lessons regarding human nature, politics and the "science" of setting standards for groundwater quality. Following the public meeting where we presented the results of our sampling, instead of acknowledging our efforts to protect their health, residents blamed us for destroying the value of their real estate. After our departure, the citizens' organization formed to deal with the issue, spent as much time attempting to discredit our results as they did on the extension of the public water system that ultimately solved their water problems.

Data will be presented that confirms that water from 16 of 59 wells tested, exceeded the 50 ug/l standard for total dissolved arsenic in drinking water. Meager well construction data, supplemented with anecdotal information from homeowners is used to formulate a couple of working hypotheses regarding the arsenic geochemistry. Newspaper coverage will be used to lead the discussion of the socio-political aspects of this case.

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Michael E. Moore graduated from Penn State in 1975. Mike worked as a consultant, focusing most of his time on the bituminous coal industry in Pennsylvania, Maryland and West Virginia. Overseeing a staff of geologists, mining engineers and mineral economists, he gained a wealth of experience in all aspects of the mining business. After five years of consulting work, he accepted a position at the first of two mining companies he would work for over the next couple of years. The collapse of Pennsylvania's bituminous coal industry during the recession of the early 1980s forced him back into consulting for several years. Since 1986, he has been employed at the Pennsylvania Geological Survey where he has been chief of the Hydrogeology Section since 1991.

John A. Owsiany and Burt A. Waite

Consol Energy and Moody and Associates (respectively)

Evaluation of Groundwater and Surface Water Impacts from Longwall Coal Mining in Low Cover Areas of the Enlow Fork Stream Valley in Southwestern Pennsylvania.

The effect of longwall mining on streams and shallow aquifers has been the subject of numerous research studies for more than twenty years. As a result of these studies it has become common to consider an overburden thickness of 400 feet as the lower limit at which longwall mining methods may be used with little or no effect on hydrologic systems. A research study was conducted to document the response on a large high order stream and ground water aquifers system to shallow cover undermining by longwall methods in the bituminous coalfield of southwestern Pennsylvania. The field site is located in the narrow Enlow Fork stream valley where the overburden, composed primarily of limestone and sandstone units interbedded with shales and siltstones, ranges in thickness from 340 to 285 feet above the main bench of the Pittsburgh coal seam. Streamflow monitoring and monitor well measurements at multiple locations in the Enlow Fork valley indicate that no significant loss zones or catastrophic water table lowering resulted from undermining the stream or the adjacent valley bottom area. Additionally, hydrographs for shallow near stream wells exhibit fluctuations related to natural seasonal variations which are nearly identical to those observed in a non-undermined control well in the same watershed.

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Burt A. Waite is senior geologist with Moody and Associates Inc. in Meadville, Pa. He received a bachelor's degree in geology from the College of William and Mary in 1969 and a master's degree in geology from the University of Vermont in 1971. Mr. Waite has been employed as a consulting geologist with Moody and Associates, Inc. in Meadville, Pa. since 1974 and currently directs the environmental consulting division of that firm. Mr. Waite has worked with coal mine hydrology issues in Pennsylvania and other eastern and mid-west states since the late 1970s and is currently a member of the DEP's Citizens Advisory Council and the DEP's Mining and Reclamation Advisory Board.

Mark Ralston

Converse Consultants

Identification of Hydrogeologic Environments of the Upper Penns Creek Watershed; Case History of the Development of Tools for Watershed Management Under the DEP Growing Greener Program.

The Penns Valley Conservation Association (PVCA) was awarded a Growing Greener Grant in April 2000 for an Integrated Watershed Assessment (IWA) of the upper Penns Creek Watershed in central Pennsylvania. A primary goal of the watershed project is to involve local citizens, students, local government, industry, the farming community and other stakeholders in the assessment process, and to provide informative tools for local decision-making and for educational purposes.

One aspect of the Penns Creek watershed assessment is the compilation of existing information on the geology and hydrogeology of the watershed. An interpretive aspect of the assessment project is the identification of hydrogeologic environments, which are land areas within which groundwater flow system behavior is similar. The "hydrogeologic environment" concept is similar in some respects to the classification and rating approach of the DRASTIC[1] system to classify aquifer vulnerability, although the use of hydrogeologic environment information can extend beyond aquifer vulnerability issues to include water resource utilization, wellhead protection, land use management, educational and other aspects of groundwater management.

[1] Aller, L., Bennett, T., Lehr, J.H., Petty, R., and Hackett, G., 1987, DRASTIC: A standardized system for evaluating groundwater pollution potential using hydrogeologic settings: Robert S. Kerr Environmental Research Laboratory, E.P.A. Report EPA/600/2-87/ 035, 622 p.

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Dennis Risser

USGS

Recent Improvements to the USGS Observation-Well Network and Groundwater Database

Improvements in both the observation-well network and groundwater database will provide new capabilities for the use of groundwater data collected by the USGS in Pennsylvania. The statewide network of groundwater observation wells is being upgraded, and public access to groundwater data is being improved through a new USGS website.

In cooperation with the DEP, USGS currently operates a statewide observation-well network of 50 wells to record the long-term trends of groundwater levels in areas unaffected by groundwater withdrawals. Records from the network have been collected since 1931 for drought monitoring. This year, 17 new wells will be added to the observation-well network and satellite telemetry will be installed at all sites. These additions will result in an observation well in each of Pennsylvania's 67 counties providing real-time information on water levels via USGS web sites: http://water.usgs.gov/pa/nwis/current/?type=gw and http://pa.water.usgs.gov/pa_duration.html.

USGS stores water data from approximately 1.5 million sites around the country in a system of distributed computers called the National Water Information System (NWIS). Data stored in the NWIS network include site information, time-series (flow, stage, precipitation, chemical), peak-flow, groundwater and water quality data. Recently, access to water information in NWIS was improved for the public with an easy to use, geographically seamless web-based interface called NWISWeb. Information is updated from the NWIS sites throughout Pennsylvania on a regularly scheduled basis; real-time data from the groundwater observation wells and about 200 stream gages are transmitted to NWISWeb several times a day. NWISWeb provides several output options: graphs, data tables and site maps.

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Curtis Schreffler

USGS

A Study of the Effect of Land Application of Treated Sewage Effluent, New Garden Township Spray Irrigation Site, Chester County, Pennsylvania

An increasing number of communities in Pennsylvania are implementing land-treatment systems to dispose of treated sewage effluent. Disposal of treated effluent by spraying onto the land surface, unlike instream discharge, recharges the groundwater system and does not directly degrade stream water quality. Seasonal differences in application, evapotranspiration and nutrient uptake rates may result in seasonal differences in recharge and nutrient loading to the groundwater system. Knowing these seasonal differences and the processes that cause them will result in faster system permitting and better management of spray application sites.

USGS, in cooperation with the DEP, Chester County and New Garden Township is currently conducting a limited study on the effects of secondary treated sewage effluent sprayed on the land surface at the New Garden Township Spray Irrigation Site. The New Garden Township site lies west of Kennett Square Borough in Chester County just north of Baltimore Pike (U.S. Business Route 1). The site covers approximately 54 acres.

The objectives of this study are: (1) to determine the percentage of applied effluent that recharges the groundwater system and the percentage that is lost to evapotranspiration using a monthly water-budget approach, (2) to characterize the effect of land treatment on groundwater and surface water quality, and (3) to determine the fate and transport of nitrogen as it moves from effluent into soil, soil water, groundwater, crops and the atmosphere using an annual nitrogen budget approach.

Intensive data collection began in April 1999 and system operation started June 1999. Data collection includes groundwater levels from shallow and deep aquifers, groundwater quality samples, streamflow, stream water quality, pond levels, pond water quality, percent soil moisture, meteorological parameters, wet and dry atmospheric deposition, effluent water quality samples, soil water quality samples and plant tissue samples. Groundwater level and quality data, streamflow and pond quality data, soil moisture and meteorological data will be presented and preliminary results will be addressed.

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Curtis Schreffler has been working for the USGS in Pennsylvania for over 13 years. He has a bachelor's in Petroleum and Natural Gas Engineering from the Pennsylvania State University. His career started in north central Pennsylvania where the work mainly focused on surfacewater data collection. After college graduation, he transferred to the Pittsburgh Subdistrict Office where he assisted in a groundwater assessment of the unconsolidated glacial deposit aquifers of Erie County. He is currently working in the Malvern Project office where he has conducted a groundwater assessment of the fractured rock aquifers of northern Bucks County. He conducted a hydrogeologic investigation of a Superfund site in northeastern Bucks County. He wrote a water-use analysis program for the Neshaminy Creek Basin in southeastern Pennsylvania. He determined the drought-trigger warning and emergency groundwater levels for the Chester County drought monitoring network and described the low flow characteristics of Chester County streams. He has completed a hydrogeologic assessment of groundwater quantity and quality in the vicinity of the Philadelphia Naval Shipyard and Naval Base. He is currently completing a numerical groundwater-flow model of the coastal plain deposits in the south Philadelphia area and assessing the effects of secondary treated sprayed wastewater on a small watershed in Chester County.

Joseph Schueck

DEP Bureau of Abandoned Mine Reclamation

Investigating Stream Loss into Underground Mines Using Geophysical Techniques

Many stream segments in the Appalachian coalfields are underlain by underground mine workings. Bedrock fractures, either natural or mining-induced, provide a direct connection between the stream and mine workings and allow stream flow to enter the underground mine workings. Stream losses into deep mines can be significant. In the majority of the cases where stream loss into an underground mine occurs, the water ends up being degraded within the deep mine and ultimately discharges to the surface as AMD. The ability to locate and seal stream loss zones not only eliminates the need to provide treatment for large quantities of water, but also restores the ability of affected streams to maintain a healthy ecosystem. In some cases, the stream loss zones are visually evident. Loss zones can also be located by taking stream flow measurements at frequent intervals along a stretch of stream. This process is slow and somewhat labor intensive. On the other hand, geophysical techniques can be used to rapidly and accurately locate fracture zones that provide the connection between the stream and the underground mine. Two techniques, VLF and EM, are recommended to be used in combination to locate the loss zones.

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Tammy Zimmerman and **Bruce Lindsey**
USGS
Bacteria and Viruses in Groundwater; Relation Between Well Construction Practices and Occurrence of Bacteria

Groundwater is an important source of household supply in the Pennsylvania. Close to a million private wells in the state provide the source of water for about two and a half million people. A study in the Lower Susqehanna River basin showed that, in that area, approximately 40 percent of the households depend on groundwater from private wells for water supply. That study was conducted as part of the National Water Quality Assessment (NAWQA) Program and analyzed water samples collected from 146 household-supply wells in the Lower Susquehanna River Basin for fecal-indicator organisms including total coliform, fecal coliform, *Escherichia coli* (*E. coli)* and fecal streptococcus. Bacteria were not detected in water samples from 31 of the 146 wells sampled. Of the 146 wells sampled, 70 percent tested positive for total coliforms, 25 percent tested positive for fecal coliforms and 65 percent tested positive for fecal streptococcus. *E. coli* testing was not conducted during 1993. Waters from approximately 30 percent of the 88 wells sampled tested positive for *E. coli*. The NAWQA study found the bacteriological quality of groundwater was related to land use and physiographic province. Differences in bacteria concentrations among bedrock types were only statistically significant for *E. coli*. Bacteria concentrations were not related to well characteristics such as total well depth or casing length, although further study was recommended. Other factors may exist, besides land use and physiographic province, that could affect bacteria concentrations. These factors include whether or not (1) the septic system is functioning, (2) manure has been applied to nearby fields, or (3) the well has been protected from surface contamination by grout and a sanitary seal. Hydrogeologic structures, such as sinkholes and fractures in the bedrock, transport the water rapidly from the land surface to the well and could affect bacteria concentrations. The large number of wells that were not grouted made it difficult to determine if bacterial contamination was a result of aquifer contamination or well characteristics. Further studies have been conducted since the NAWQA studies to determine the affect of well construction practices, and to determine the relationship between indicator bacteria and pathogens.

One follow-up study on a subset of the Lower Susquehanna NAWQA wells showed that the *E. coli* detected were not virulent strains. Another study was conducted to determine if there is a relation between well-construction practices and occurrence of total coliform and *E. coli* bacteria in groundwater from private, household-supply wells. Although some counties and municipalities in Pennsylvania regulate the well-construction practices and bacteriological testing of water from these private supplies, in most parts of the state, drilling and testing of private on-lot wells are unregulated. Wells completed with a grouted annular

space between casing and bedrock (“sanitary wells”) were compared to wells that were completed without any grout (“nonsanitary wells”) in areas underlain by carbonate and noncarbonate bedrock in predominantly agricultural land-use areas. Wells in Chester and Montgomery counties and in South Middleton Township were chosen as the sanitary wells since well-construction regulations are currently in place in those areas. The regulations require that wells be completed with annular grout which provides a database of wells with known construction practice. Wells in areas other than Chester and Montgomery county or South Middleton Township were also termed sanitary if it was verified with the well driller that grout was installed along the entire length of casing. These sanitary wells were compared to nonsanitary (or typical) Pennsylvania private, on-lot wells constructed as open-holes completed in bedrock with minimal surface casing, little or no annular grout seal, and a loose-fitting well cap. Waters from an equal number of sanitary and nonsanitary wells was analyzed in areas underlain by carbonate and noncarbonate bedrock for a total of 80 wells. Total coliform bacteria were found in waters from about 60 percent of the wells sampled. *E. coli* bacteria were found in approximately 20 percent of the samples where total coliform was detected. Spiders, earwigs or other insects were observed under the well cap and inside the top of the casing in most of the wells. Loose-fitting well caps are common - even in the counties and municipalities that have well-construction regulations. Sanitary, surface-seal well caps are not required and are rarely used in Pennsylvania.

Another study was conducted to determine if viruses or other pathogens are present in aquifers used for water supply. This study focused on non-community supply wells. This population of wells closely resembles the characteristics of the wells sampled for the NAWQA study, but also serves the public and is subject to testing and regulation by the Pa. Department of Environmental Protection. The primary areas of focus for the project were the carbonate and crystalline aquifers in the state, based on population density and aquifer vulnerability. A smaller number of samples were collected in the siliciclastic and unconsolidated aquifers, as a reconnaissance effort. Samples were collected at 25 wells in each of the primary areas and five wells in each of the reconnaissance areas. Samples were analyzed for viruses and *helicobacter pylori*, as well as indicator organisms such as *clostridium perfringens*, coliphage, *enterococcus*, total coliform and *E. coli*.

The results to date show total coliform in 42 percent of the wells sampled, *E. coli* in 12 percent of the wells sampled, *Clostridium perfringens* in 15 percent of the wells sampled, *enterococcus* in 13 percent of the wells sampled, coliphage in eight percent of the wells sampled, *helicobacter pylori* in 12 percent of the wells sampled and culturable viruses in eight percent of the wells sampled. All of the water collected was prior to treatment systems, and most of the water supplies had treatment systems that would adequately treat for microorganisms.

Several of the water supplies, however, had pathogens detected, but did not have a treatment system in place. This was due to the fact that the previous routine sampling for total coliform and E. coli had been negative. Addition analysis of this data will be conducted to determine the factors affecting the occurrence of bacteria and viruses in these wells.

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