Center for Water Resources Research
Annual Technical Report
FY 2003

Introduction

A computerized source water assessment tool is being developed that uses digital elevation model (DEM) information and other geographical information system (GIS) databases to assist drinking water watershed managers in assessing the susceptibility of surface water supplies to pollution from current and future activities in the watershed. The major components of the tool and the approach to its development are described in detail in the annual report for FY 2003. This report will provide a summary description of the tool, describe current efforts to incorporate groundwater source protection modeling, and describe the development of an on-site wastewater system inventory database.

The source water protection assessment tool described here is being designed to use scientific information and professional experience in the pollution susceptibility assessment process while minimizing the need for new data collection by the user.

Research Program

Source Water Protection Assessment Tools Development

Basic Information

Title:	Source Water Protection Assessment Tools Development
Project Number:	2003UT29B
Start Date:	3/1/1999
End Date:	2/28/2004
Funding Source:	104B
Congressional District:	UT 1
Research Category:	Water Quality
Focus Category:	Water Supply, Hydrology, Models
Descriptors:	Drinking Water, Source Water, Pollution Sources, Watershed Management
Principal Investigators:	Darwin L. Sorensen, R. Ryan Dupont, Donald T. Jensen, Mariush Kemblowski, Nancy Mesner, Ronald C. Sims, David K. Stevens, David Gavin Tarboton, Gilberto E. Urroz

Publication

1. Gogate, S.V. (2004). "Groundwater modeling for a source water protection tool." MS Thesis, Civil and Environmental Engineering, College of Engineering, Utah State University, Logan, UT.
2. Tarboton, D.G., Gogate, S.V., Kemblowski, M., Shu, Q., Wahlstrom, E., Sorensen, D.L., Stevens, D.K. (2004). Terrain Analysis for Water Quality Modeling. In: Presentation at AWRA 2004 Specialty Conference Geographic Information Systems and Water Resources III, Nashville, TN, May 19.

Research Project Synopses

Title:	**Source Water Protection Assessment Tools Development**
Project Number:	2003UT29B
Start Date:	03/99
End Date:	02/04
Funding Source:	104B
Congressional District:	UT 1
Research Category:	Water Quality
Focus Category:	Water Supply
Descriptors:	Drinking water, source water, pollution sources, watershed management
Primary PI:	Darwin L. Sorensen
Other PIs	David G. Tarboton, Mariush Kemblowski, David K. Stevens, Gilberto E. Urroz, Donald T. Jensen, R. Ryan Dupont, Nancy Mesner, and Ronald C. Sims
Project Class:	Research

Introduction

Source water protection assessments provide information about potential contamination risks to drinking water supplies in a watershed. They may be done initially to characterize the drinking water contamination risks in the watershed. They may also be done to inform planners about the potential impacts of development and changes in watershed activities. This information may be used by watershed managers to rank risks and to prioritize activities that will protect the drinking water supplies. Protective measures may be expensive. Land use restrictions to protect water quality can extensively alter the potential for development of private property and diminish property values. These potential impacts of management make it very important that source water assessments correctly identify potential risks and present a scientifically credible evaluation of the magnitude of the risk so that the monetary and social costs of protective management can be minimized. Simultaneously, management activities must effectively protect public health. It is vital that sound scientific principles are used to direct the assessment approach and that arbitrariness is avoided. It is also important that the assessment be completed in a timely way and that the costs of the assessment are reasonable. To control costs, available information should be used and the need to collect new data should be minimized. Assessment tools are needed that will help watershed managers appropriately apply the scientific principles of pollutant transport while maximizing the use of available information.

A computerized source water assessment tool has been developed to assist drinking water watershed managers in assessing the susceptibility of drinking water supplies to pollution from current and future activities in the watershed. The tool provides visualization of the locations of potential pollution sources and pathways that pollutants may follow. Principally, it provides exploratory modeling to assess pollution susceptibility so that detailed analysis can be prioritized. The tool development has focused on providing assistance with the pollutant source inventory process, on modeling surface runoff and stream flow processes, on ground water flow and on the fate and transport of pollutants related to these processes. The surface water pollutant transport model is called the Utah Pollutant Transport Model (UPTraM). The details of the development of the pollution source inventory portion of the tool and UPTraM were described in the FY 2000 and FY 2001 annual reports. Moncur (2002) also described the development of the source inventory system, UPTraM, and the associated graphical interface for the assessment tool. Gogate (2004) described ground water modeling components of the tool.

The Source Inventory and Other Data

The source water protection assessment tool includes a potential pollution source inventory database and a pollutant chemical properties database. A database of information for model operations (e.g., digital elevation models (DEM), river reaches, land use, etc.) is also provided. A graphical user's interface (GUI) and models to simulate the transport and fate of water-borne pollutants form the core of the tool. Figure 1 illustrates the relationship of the major components of the assessment tool. The tool provides assistance in finding the appropriate data for the potential source inventory and transport modeling.

The watershed inventory is a user input database of the current and/or future potential contamination sources within the watershed. A quick-reference database of chemical properties, including toxicity information, is provided to help the user identify and prioritize potential pollution sources The chemical properties within the quick-reference database are physical and chemical properties for EPA's National Primary Drinking Water Regulation listed compounds (USEPA 2003).

Ranges of loading rates for total and fecal coliforms and nitrogen and phosphorus are also available in the database. Geographical information system (GIS) land use coverages that delineate urban and agricultural land use practices may be used with loading rate data to evaluate pathogen risk, as indicated by coliforms, from urban runoff, animal feeding operations, and pastures. Potential nutrient inputs to reservoirs may be estimated using the nutrient loading data. Land use coverages may be available from state natural resource management or environmental protection agencies or the National Land Cover Dataset (NLCD) (http://edcwww.cr.usgs.gov/programs/lccp/nationallandcover.html). In Utah, land use data for much of the state is maintained by the Department of Natural Resources, Division of Water Resources.

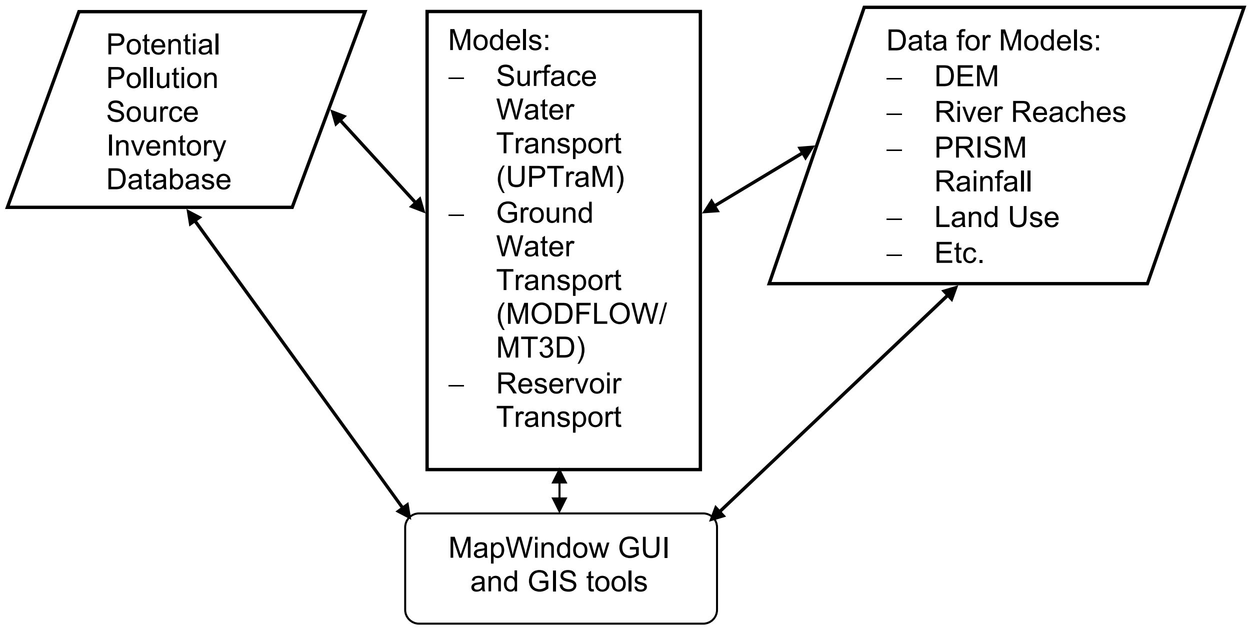


Figure 1. Source Water Assessment Tool schematic.

The Graphical User's Interface (GUI)

The GUI for the tool facilitates the operations of the databases and the various models that make up the tool. The current, fully functional components of the GUI support the databases, the surface water transport model, and the ground water models. The components of the surface water protection assessment tool are: (1) the main GIS graphical interface, (2) the GIS coverage project builder, (3) the potential contaminant source (PCS) inventory data management utility, (4) the transportation accident data form, and (5) the pollutant transport and degradation/volatilization analysis model, UPTraM.

Figure 2 shows the source water protection assessment tool MapWindow graphical interface for surface water transport. The GIS coverages shown in Figure 2 are a grid DEM, an animal feeding operation inventory shape file, an above ground tank inventory shape file, and a contents panel on the left but are not active watershed boundary shape file (green). Other GIS datasets that are included in the table of in contents panel on the left but are not active this display are the annual average precipitation grid, a major roads shape file, an EPA level 3 river reach shape file, and several accident scenario shape files.

The program guides the user to input the required GIS data sets for use in UPTraM. The data sets that must be input are: a grid DEM, a precipitation grid, a river reaches shape file, a watershed boundary shape file, and a land use grid. The land use grid needs to be condensed into the five general land use groups to be used by the tool, namely (1) water, (2) urban, (3) pasture, (4) non-pasture agriculture, and (5) rangeland/forest areas. The user selects the GIS coverage

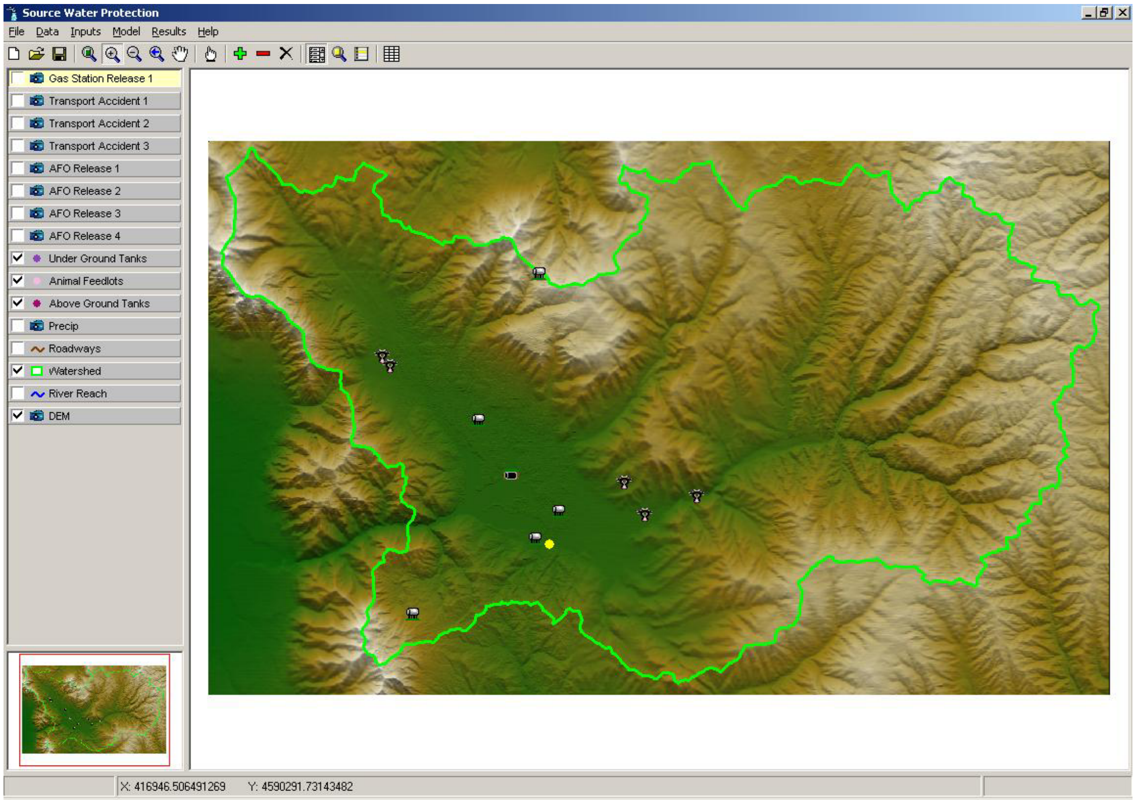


Figure 2. The MapWindow graphical interface for surface water transport.

that is going to be input and the program prompts the user with another form that allows the user to browse the computer hard drive for the desired information. The inventory requires the user to input PCSs for geographical placement within the watershed and associated chemical property information from the quick-reference database. There are eight different PCS types that can be inventoried. These different PCS types are:

1. Above ground tanks
2. Underground tanks
3. Animal feeding operations
4. Transportation accidents
5. Landfills
6. Superfund sites
7. Chemical Companies
8. Hazardous waste sites.

The Surface Water Transport Model, UPTraM

The surface water transport model is a risk-ranking assessment tool that models source water protection scenarios without using arbitrary protection zones. The tool has been created using a GIS framework. The user has the option of incorporating fate processes such as volatilization of organic pollutants and dieoff of fecal indicator bacteria into transport simulations.

The development of GIS and DEMs has provided an unprecedented opportunity to describe the pathways of water movement in a watershed. Visualization of the locations of PCSs relative to stream locations and topography within a watershed along with the possible route or routes of pollutant transport provides watershed managers with insight that can help in the risk ranking process and in selecting or designing pollution control mechanisms. GISs provide an elegant mechanism for displaying this kind of information as well as facilitating models for routing water and associated pollutants through the watershed to the drinking water treatment plant.

DEM databases for the United States provide data that allows the extraction of drainage networks from the DEMs (Band 1986; O'Callaghan and Mark 1984). Topographic structure, watershed delineations, and overland flow paths derived from DEMs can be transferred to a vector-based GIS for further analysis. Garbrecht and Martz (1997) (Garbrecht and Martz 1997) have developed a procedure for assigning flow direction over flat surfaces in raster DEMs. TOPMODEL (Beven et al. 1995; Beven and Kirkby 1979) used DEM topographical information in the simulation of runoff from natural watersheds and from agricultural watersheds with tile drain systems (Kim et al. 1999)

Tarboton (1997) developed a procedure for the representation of flow direction and calculation of upslope areas using rectangular grid DEMs. Rather than representing flow in one of the eight possible directions from a grid cell to an adjacent or diagonal neighbor (D8) this procedure represents flow direction as a vector along the direction of the steepest downward slope on eight triangular facets centered at each grid cell. An infinite number of flow directions, represented as an angle between 0 and 2π are possible, so this procedure is named D∞. Flow from a grid cell is shared between the two, downslope grid cells closest to the vector flow angle based on angle proportioning. Drainage area is accumulated using this model that has two flow paths from each grid cell based on the angle proportions. This procedure has been included in the Terrain Analysis using Digital Elevation Models (TauDEM) software (Tarboton 2000; Tarboton 2002) that is used as a basis for the surface water protection assessment tool developed here. Overland flow and the transport of contaminants simulated in the assessment tool are routed using the D∞ surface flow model. Much of the information necessary to support water routing simulation including DEMs <http://mcmcweb.er.usgs.gov/status/dem_stat.html>, stream shape files, and precipitation data (SCAS and OCS 2002) are readily available through the internet for nearly all of the United States.

In UPTraM, the contaminant concentration in water leaving the contaminated area is the saturation concentration for soluble contaminants. Coliform concentrations leaving contaminated areas are the high, medium, or low (e.g., 10^9, 10^6, 10^3/100 mL) export concentration for a given land use that is selected by the user. The contaminants that move with surface water may be subject to reduction due to various processes, such as die off (in the case of coliforms) or volatilization (in the case of chemical spills). We have incorporated the capability to model first order decay in UPTraM to represent these processes.

A concentration limited accumulation function is then used to evaluate the contaminant concentration downslope from the source. Flow is written

$$q(x,y)=a[r_s] \qquad (1)$$

Over the substance supply area, concentration is at the threshold C_{sol}.
If i(x, y) = 1

$$C(x,y) = C_{sol} \qquad (2)$$
$$L(x,y) = C_{sol}\, q(x,y)$$

Where L(x,y) denotes the load being carried by the flow (per unit width). At remaining locations the load is determined by accumulation of this Load L with decay

$$L(x,y) = \sum_{\text{k contributing neighbors}} p_k d(x_k, y_k) L(x_k, y_k) \qquad (3)$$

Concentration is determined by

$$C(x,y) = L(x,y)/q(x,y) \qquad (4)$$

The denominator in (4) includes the base flow for stream locations, but includes only surface flow for off-stream locations.

The Ground Water Transport Model

Ground water is the source of water for most drinking water systems in the western United States so having a ground water model available in the assessment tool is important. The ground water-modeling component consists of a ground water quantity model and a ground water quality model. The ground water quantity model may be used to simulate ground water movement in an aquifer. The ground water quality model requires the output of the ground water quantity model. The ground water quality model simulates pollutant movement in the ground water system. Output from the quality model is provided in a GIS data format.

Figure 3 shows the major components of the ground water modeling part of the source water assessment tool. The ground water quantity-modeling component is MODFLOW-96 and the pollutant transport component MT3D. The US Geological Survey developed MODFLOW and MT3D. These models are public domain software, and are widely accepted in ground water hydrology and engineering practice. MODFLOW is a modular, three dimensional, finite difference model that is used to generate a flow field that is then used with the ground water transport model MT3D. The major inputs required for running MODFLOW are:

- Model grid size and aquifer's thickness
- Model area soil hydraulic conductivity
- Recharge to aquifers (area and point source)
- Ground water boundary conditions
- Rivers stages and river cell location (when the river package is used)

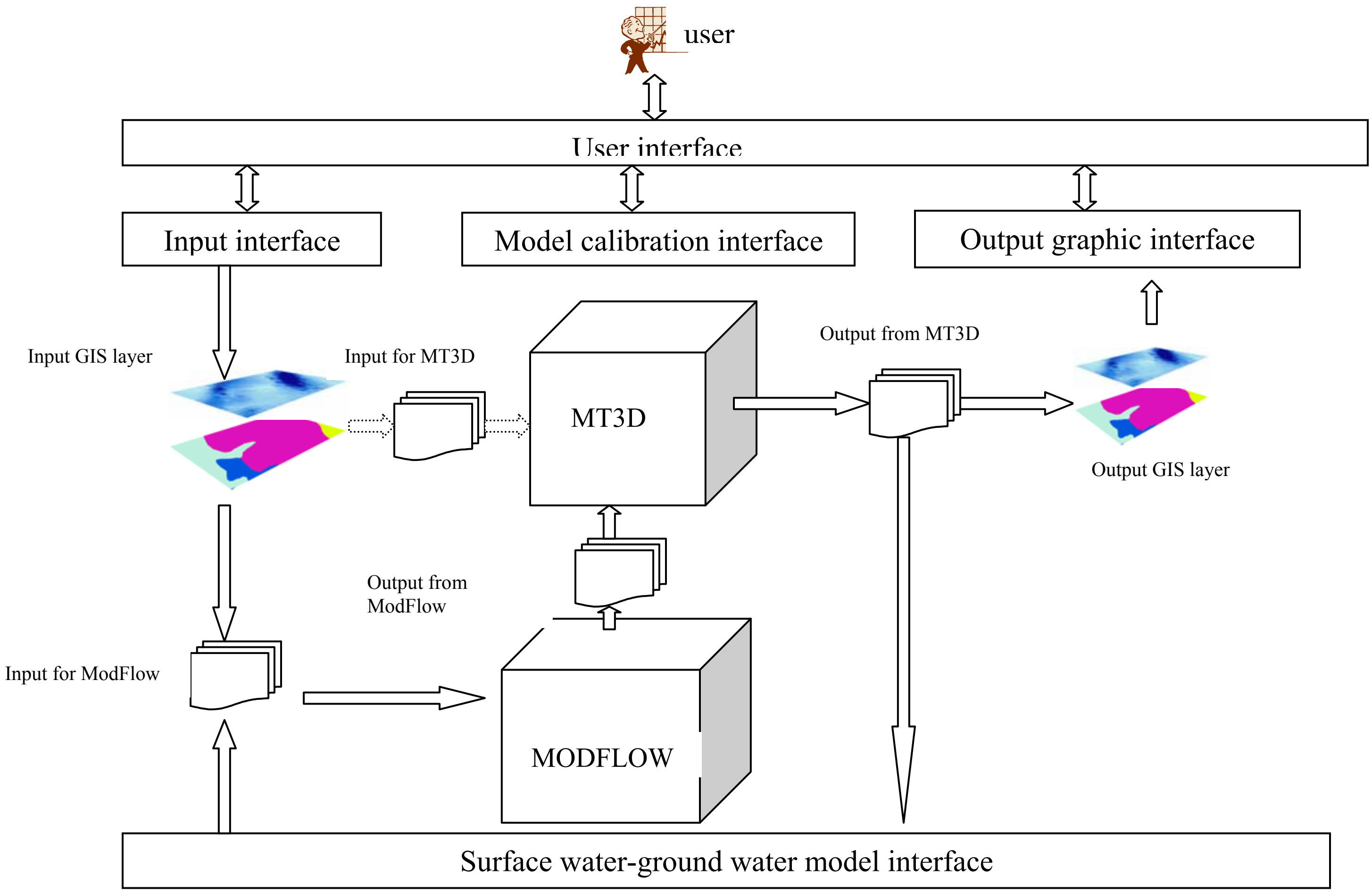


Figure 3. Schematic structure of the ground water modeling component

The major outputs from MODFLOW are the predicted ground water elevation or head for each grid cell in the model along with a water budget (mass balance) for each grid cell. These two outputs can be used as inputs to run MT3D. MT3D takes into account the affect of advection, diffusion, dispersion, reaction and retardation on pollutant transport. The major input data to MT3D are:

- Ground water head and water mass budget generated by MODFLOW
- Model grid size and aquifers thickness
- Effective soil porosity at each model cell
- Advection numerical solver parameters
- Soil dispersion and diffusion effect parameter (longitudinal dispersivity, horizontal/ transverse dispersivity, vertical dispersivity and diffusion coefficient)
- Pollutant loading source location, type and rate

The MODFLOW data input form is shown in Figure 4. Inputs such as contaminant loading rates and pollutant chemical properties are stored in the input interface and may be entered into MT3D from there. Input files for MODFLOW are generated automatically through the GUI.

Assumptions made to reduce the amount of data required for running the groundwater model are: steady state flow; a single layered, unconfined aquifer; major surface water bodies interact with the ground water; all model cells derive equal or uniform recharge which is equal to some proportion of annual average precipitation; values of hydraulic conductivity are based on values in the professional literature; and the depth to bedrock or other aquitard is known to the user.

Boundary conditions describe how the system being modeled interacts with the world. External boundary conditions define the perimeter of the model domain within which the differential equations are solved. In the assessment tool, head-dependant and flux-dependant, external boundary conditions are used. A mask file stores the physical and hydrologic boundary conditions. The tool provides a “polycharacterization” module that allows the user to establish

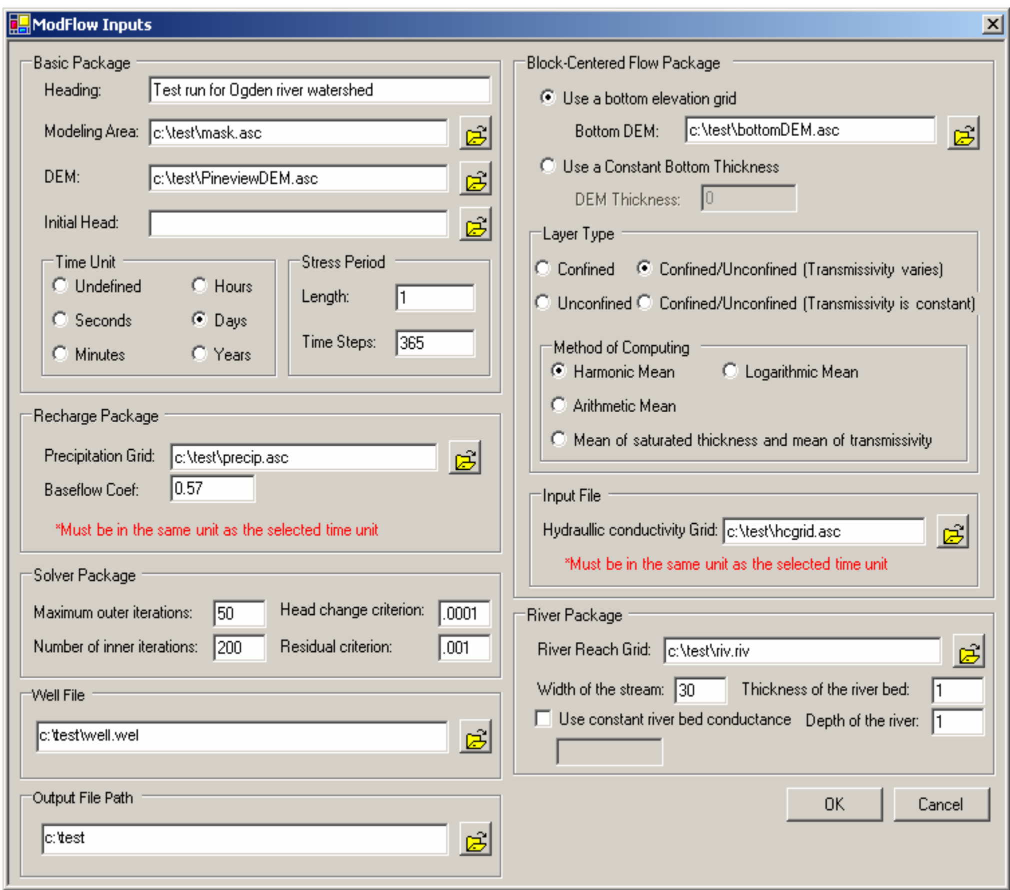


Figure 4. MODFLOW data input form.

the physical boundaries of the modeling domain using multiple mouse clicks on a map displayed in the GUI. Constant head boundaries include areas beneath perennial streams, lakes and reservoirs. No-flow boundaries include rock formations, clay layers, and all of the cells outside the modeling domain boundaries. The flux of water into the modeling domain is accounted for by accumulating the flow on the boundary cells through virtual injection wells on those cells. Ground water flow is assumed to be some fraction of the surface runoff. Surface runoff is calculated using the TauDEM D8 method (Tarboton 2000). A "make grid" function will generate the boundary condition mask file or an externally generated mask file can be imported.

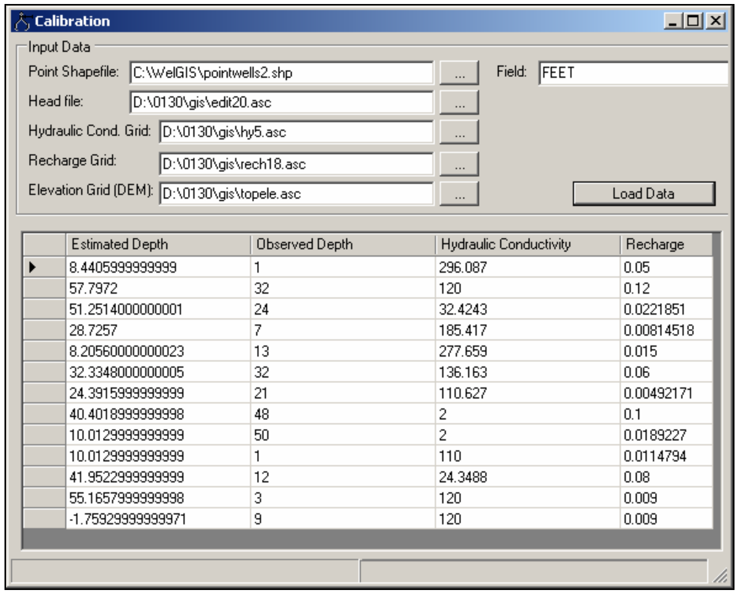
The MODFLOW river package is used to model the effect of streams on ground water hydrology. When the ground water table is above the bottom of the stream, the stream will gain water and contaminants from ground water. When the water table is below the bottom of the stream water will be lost. Only streams with perennial flow were considered during model development. Stream bed conductance was estimated by assuming the same hydraulic conductivity for the bed as the soil surrounding the stream. The thickness of the stream bed must also be estimated.

The MODFLOW well package is used to simulate the effects of real, ground water withdrawl wells and imaginary boundary wells. The locations and pumping rate data for actual wells need to be obtained. State water resources management agencies often compile these kinds of data. The GUI for the tool provides a wizard to help incorporate well data into the model.

Recharge is estimated as a fraction of the annual average precipitation. The fraction is the same as the baseflow fraction. Baseflow is estimated using hydrograph separation and the baseflow coefficient is used to multiply the precipitation grid to get the recharge grid.

MODFLOW calibration is accomplished by inverse modeling, i.e., obtaining the most suitable values for the input parameters to match the simulated outputs with field observations. Obviously, more than one combination of parameters will give the same output (Beven and Freer 2001). A calibration aid is provided in the user interface (Figure 5). A shapefile of observed groundwater elevation can be imported in the calibration interface and can be compared with the estimated groundwater elevation. Corresponding values of recharge and hydraulic conductivity are shown in a table. By examining the difference between the observed and the estimated groundwater elevation, values of hydraulic conductivity and recharge can be altered using a grid editing tool. For comparing the observed and simulated baseflow a utility to visualize baseflow at any point in the streams is provided in the tool. Using this tool a river cell can be selected and a cumulative baseflow value at that point is given in a graphical format.

MT3D is a three dimensional, block centered contaminant transport model developed by the USGS (Zheng and Wang 1999) and is widely used to simulate pollutant transport in ground water. Only dissolved phase contaminant transport can be modeled using MT3D. It has a modular structure and the contaminant transport can be modeled using various processes such as advection, dispersion, reaction and retardation. Contaminant loading can be specified as mass loading rate or concentration at any source in the modeling area. Mass balance equations are solved for each cell and a contaminant concentration is reported at the end of the stress period.



Calibration

Input Data

Point Shapefile: C:\WelGIS\pointwells2.shp ... Field: FEET

Head file: D:\0130\gis\edit20.asc ...

Hydraulic Cond. Grid: D:\0130\gis\hy5.asc ...

Recharge Grid: D:\0130\gis\rech18.asc ...

Elevation Grid (DEM): D:\0130\gis\topele.asc ... Load Data

Estimated Depth	Observed Depth	Hydraulic Conductivity	Recharge
8.4405999999999	1	296.087	0.05
57.7972	32	120	0.12
51.2514000000001	24	32.4243	0.0221851
28.7257	7	185.417	0.00814518
8.20560000000023	13	277.659	0.015
32.3348000000005	32	136.163	0.06
24.3915999999999	21	110.627	0.00492171
40.4018999999998	48	2	0.1
10.0129999999999	50	2	0.0189227
10.0129999999999	1	110	0.0114794
41.9522999999999	12	24.3488	0.08
55.1657999999998	3	120	0.009
-1.75929999999971	9	120	0.009

Figure 5. MODFLOW calibration aid form.

The major data file needed by MT3D is the contaminant source. Area sources (cropland, pasture) and point sources (septic tanks, leaking underground storage tanks) can be modeled. Area source location data can be generated from land use GIS data. Land use GIS data should be converted to an ASCII grid file. This is done manually using ArcInfo tools. Point sources can be manually added into MT3D data file directly. The user is required to provide all the loading rates and source types for all sources.

Soil dispersivity values in 3 dimensions are needed. These values are estimated based on soil type in the watershed area. Initially, a single value may be used for an entire watershed.

Groundwater Surface Water Interaction

There is a constant interaction between the groundwater aquifer and surface water bodies. Perennial streams interact with groundwater by either gaining or losing water. A simplified depiction is given in Figure 6 where:

$Q_{t,}$ = Total Discharge out of the cell
C_t = Concentration of contaminant coming out of the cell
Q_{ri} = Surface runoff (flow) coming into the stream cell
C_{ri} = Contaminant concentration in surface runoff
Q_s = Flow in the stream
C_s = Contaminant concentration in the stream
Q_{bi} = Baseflow coming into the stream cell
C_{bi} = Contaminant concentration in the groundwater (Baseflow)

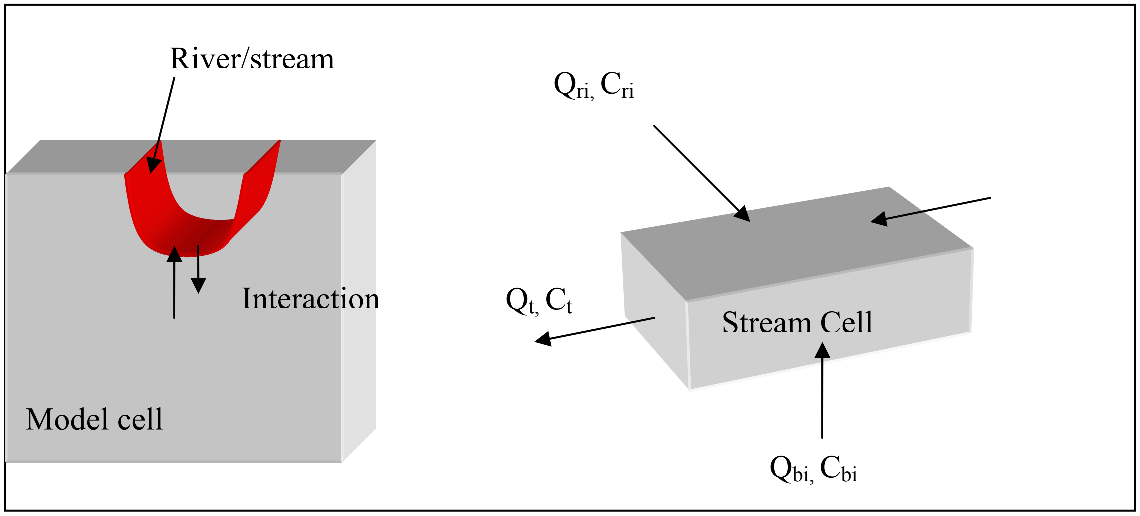


Figure 6. Groundwater surface water interactions.

The baseflow coming into the river cell from the groundwater is obtained from a budget file. If the value is positive, it means the stream cell is gaining water from the groundwater and if the value is negative it means the stream is losing water to the aquifer. The concentration C_b at the stream cell is obtained from the concentration grid produced by MT3D. Only in the case where the stream is gaining water from the aquifer is considered. Losing streams are not considered as the pollution in the aquifer caused by leaking streams is assumed to be insignificant. The stream flow, Qs, and the surface runoff, Qr, can be obtained from the surface water quality model UPTraM. For the case of groundwater polluting a stream, the concentration of contaminant in the stream and in surface runoff is set equal to zero. A case when these concentrations are not zero can also be considered. Considering mass balance we get

$$Q_t = Q_s + Q_{ri} + Q_{bi} \quad (5)$$
$$Q_tC_t = QsCs + Q_{ri,}C_{ri} + Q_{bi}C_b \quad (6)$$

Equations 5 and 6 are solved to calculate the contaminant concentration in the stream resulting from surface runoff and groundwater discharge.

The worst case scenario is assumed when there is no precipitation and hence no overland flow, i.e., the flow in the streams is contributed only by baseflow. The mass flow rate into the streams due to the contaminated groundwater is given by Q_bC_b. Various river cells derive baseflow and hence contamination. Mass of contaminants at any river cell is obtained by accumulating the mass loading into all the river cells that are upstream. Figure 7 shows a tool to calculate the mass loading rate of contaminants into a stream cell.

Conclusions

The ease of obtaining GIS data combined with the development of a computational procedure for representing flow direction and calculating upslope areas using DEMs (Tarboton 1997) has opened the opportunity for simulating pollutant transport in watersheds in a new way. This approach is realistic, scientifically credible, and requires relatively little data. Simplifying assumptions about chemical pollutant loading into storm water and pollutant fate processes allows the use of chemical property data from the literature to estimate contaminant concentrations at a point of extraction for drinking water for drinking water use. Similarly, estimated coliform loading and die-away rates allow the estimation of coliform concentrations from possible sources in a watershed. This approach facilitates delineation and ranking of zones of potential contamination based on the risk that possible contamination sources within those zones present to a drinking water treatment and distribution system. The source water assessment planning tool helps managers to determine if other methods of analysis or additional system monitoring are needed to increase confidence in determining a possible contaminant source's threat to source water quality.

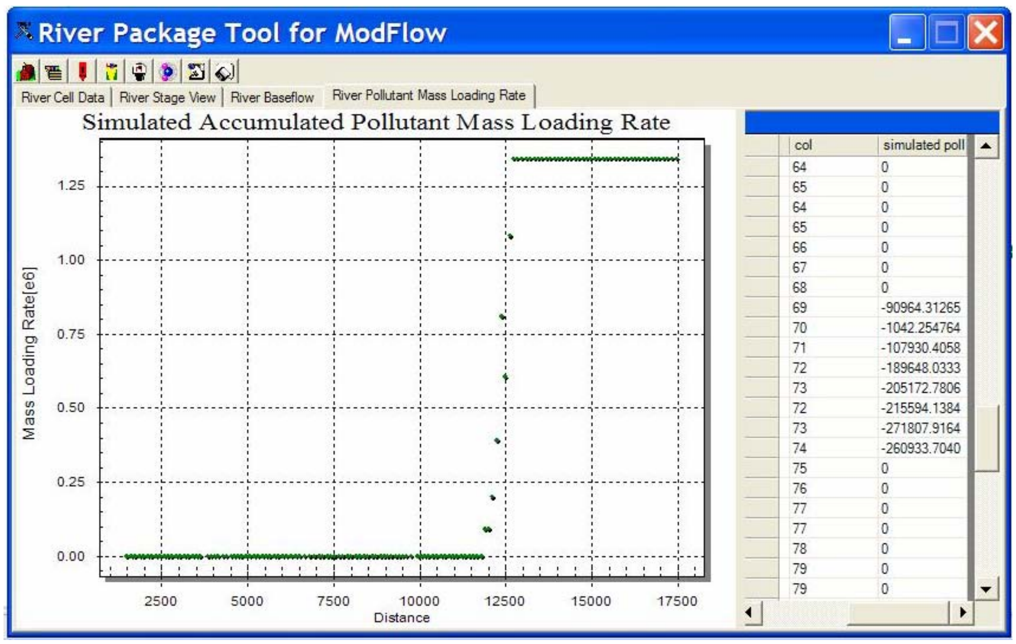


Figure 7. Mass loading rate into a river cell.

Literature Cited

Band, L. E. (1986). "Topographic partition of watersheds with digital elevation models." *Water Resour. Res.*, 22(1), 15-24.

Beven, K., and Freer, J. (2001). "Equifinality, data assimilation, and uncertainty estimation in mechanistic modeling of complex environmental systems using the GLUE methodology." *J. Hydrol.*, 249(1-4), 11-29.

Beven, K., Lamb, R., Quinn, P., Romanowicz, R., and Freer, J. (1995). "TOPMODEL." Models of Watershed Hydrology, V. P. Singh, ed., Highlands Ranch, CO., 627-668.

Beven, K. J., and Kirkby, M. J. (1979). "A physically based variable contributing area model of basin hydrology." *Hydrol. Sci. Bull.*, 24(1), 43-69.

Garbrecht, J., and Martz, L. W. (1997). "The assignment of drainage direction over flat surfaces in raster digital elevation models." J. Hydrol., 193, 204-213.

Gogate, S. V. (2004). "Groundwater modeling for a source water protection tool," MS Thesis, Utah State University, Logan, UT.

Kim, S., Delleur, J. W., Mitchell, J. K., Engel, B. E., and Walker, S. E. (1999). "Simulation of runoff in agricultural watersheds with tile drains using an extended TOPMODEL." Trans. ASAE, 42(3), 639-650.

Moncur, K. D. (2002). "Synthesis of a risk-based management tool for the prediction of source water protection concerns," MS Thesis, Utah State University, Logan, UT.

O'Callaghan, J. F., and Mark, D. M. (1984). "The extraction of drainage networks from digital elevation data." CVGIP Graphical Models Image Process, 28, 328-344.

SCAS and OCS. (2002). "Climate mapping with PRISM. <http://www.ocs.orst.edu/prism/prism_new.html>." Spatial Climate Analysis Service and the Oregon Climate Service, Oregon State University, Corvalis, OR.

Tarboton, D. G. (1997). "A new method for the determination of flow directions and upslope areas in grid digital elevation models." Water Resour. Res., 33(2), 309-319.

Tarboton, D. G. (2000). "Terrain analysis using digital elevation models (TauDEM)." Utah Water Research Laboratory, Utah State University, Logan, UT.

Tarboton, D. G. (2002). "TauDEM, a suite of programs for the analysis of digital elevation data. <http://www.engineering.usu.edu/cee/faculty/dtarb/>." Utah Water Research Laboratory, Utah State University, Logan, UT.

USEPA. (2003). "National primary drinking water standards < http://www.epa.gov/safewater/consumer/mcl.pdf>" EPA 816-F-03-013. US Environmental Protection Agency, Washington, DC.

Zheng, C., and Wang, P. P. (1999). "A modular three-dimensional multispecies transport model for simulation of advection, dispersion, and chemical reactions of contaminants in groundwater systems: documentation and user's guide." US Army Corps of Engineers, Washington, DC.

Information Transfer Program

The Source Water Protection project described under the Research Project section of this report is an integrated research and information transfer project that was planned, developed, and implemned with the collaboration of UCWRR and the relevant State of Utah water agencies.

Information Transfer Plan

Basic Information

Title:	Information Transfer Plan
Project Number:	2003UT5B
Start Date:	3/1/2003
End Date:	2/29/2004
Funding Source:	104B
Congressional District:	UT1
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	Public Education, Education Transfer
Principal Investigators:	Mac McKee, R. Ivonne Harris, Tamara Peterson, Jan Urroz

Publication

1. Smith, G.G. 2003. Substitute Teacher Handbook (Elementary VI Edition). International Office for Water Education, Utah Water Research Laboratory, Utah State University, Logan, UT.
2. Smith, G.G. 2003. Powell States and Columbia Water Education Calendar. International Office for Water Education, Utah Water Research Laboratory, Utah State University, Logan, UT.
3. Sorensen, D.L., K.D. Moncur, D.G. Tarboton, M. Kemblowski. S. Quiang, and S. Gogate. 2003. A Surface Water Protection Assessment Tool that Uses Digital Elevation Models. American Water Works Association, Source Water Protection Symposium, Albuquerque, NM, January 19-22.

Center for Water Resources Research

Annual Technical Report

The Source Water Protection project described under the Research Project section of this report is an integrated research and information transfer project that was planned, developed, and implemented with the collaboration of the Utah Center for Water Resources Research (UCWRR) and the relevant State of Utah water agencies. Please refer to the Research Project section of this Annual Report for specific information transfer activities related to the Source Water Protection project supported by the USGS Section 104 funds.

In FY 04, the Utah Water Research Laboratory (UWRL) expended a total of more than $9 million in water research support. USGS Section 104 funds administered through the UCWRR accounted for about one percent of this total. These funds were used for research addressing source water protection (SWP) problems, and outreach, information dissemination, and strategic planning and water resources and environmental quality issues in the State of Utah.

USGS Section 104 funds were used specifically to address the Utah Source Water Protection Plans (SWPP) during FY 2003-2004 at the request for assistance from the Utah Department of Environmental Quality (UDEQ), Divisions of Water Quality and Drinking Water. Risks to Utah's source water include both point and non-point sources of pollution. Several UCWRR faculty members are involved from the Colleges of Engineering, Agriculture, and Natural Resources. In partnership with the UDEQ and the Divisions of Water Quality and Drinking Water, the UCWRR is developing specific information systems in important watersheds in Utah. The UCWRR has formed a partnership with the UDEQ and its Divisions of Water Quality and Drinking Water to assess non-point source pollution as part of the SWPP. As part of this partnership, the UCWRR is developing specific information and a database concerning the location and status of on-site wastewater treatment systems in important watersheds in Utah. SWPPs are especially important during periods of lower than normal precipitation that have been characteristic of the past two fiscal years.

Approximately 4,000 on-site wastewater treatment systems are currently installed annually in Utah. The UCWRR and UWRL faculty have teamed with local health departments and the Utah Department of Environmental Quality to address issues including establishing criteria, testing, and monitoring for decentralized systems. Passage of Utah House Bill 14 (#B-14) for the Utah On-Site Wastewater Treatment Training Center during the 2000 session of the Utah Legislature provided a mechanism to generate funds for training and technology transfer regarding siting, design, installation, maintenance, and monitoring of on-site wastewater treatment systems for local health departments, designers, installers, developers, and state regulators. Air quality issues along the Wasatch Mountains in Utah (Wasatch Front) have been identified by the Governor of Utah as a current and future concern as a result of projected increases in automobile traffic. To address these concerns, the UCWRR appointed a faculty member (Dr. Randal Martin) during this fiscal year to work with the State of Utah DEQ Air Quality Board in the evaluation and assessment of air quality problems and in developing alternatives to meet air quality standards. New federal source water protection plan requirements require river basinwide characterization, assessment, and reevaluation with regard to risks of contamination of source water from near and far sources. Both point and non-point sources need to be identified.

Information Transfer

Information Transfer and Outreach within the UCWRR are forms of scholarship that were stimulated, supported, and rewarded in FY 04. Outreach activities through the UCWRR, the UWRL, and Utah State University (USU) have had an impact on the technical and economic development of the State of Utah. As part of the UCWRR outreach activities supported by USGS 104 funds, there continues to be a vigorous dialogue and experimentation with regard to efficiency and effectiveness of outreach activities of the UCWRR. Faculty are engaged in regular meetings with State of Utah water resources agencies, including the Department of Environmental Quality (DEQ), the Department of Natural Resources (DNR), and the State Engineer's Office to provide assistance in source water protection, on-site training, non-point source pollution management, technology transfer, and development of source water protection plans (SWPPs) within the context of water-related issues in Utah.

UCWRR staff, through the facilities at the UWRL, provide short courses both on- and off-site within the State of Utah, regionally, and globally. Generally offered from one- to five-days duration, short courses are tailored to meet the needs of the requestor. A partial list of short courses, field training, and involvement of UCWRR staff is given below.

"Design, Inspection, and Maintenance of Conventional Systems." Utah On-Site Wastewater Treatment Training Program, Logan, Utah, April 10, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

"Design, Inspection, and Maintenance of Conventional Systems." Utah On-Site Wastewater Treatment Training Program, Cedar City, Utah, May 1, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

"Design, Inspection, and Maintenance of Alternative Systems." Utah On-Site Wastewater Treatment Training Program, Logan, Utah, May 13-14, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

"Design, Inspection, and Maintenance of Conventional Systems." Utah On-Site Wastewater Treatment Training Program, Vernal, Utah, September 11, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

"Design, Inspection, and Maintenance of Conventional Systems." Utah On-Site Wastewater Treatment Training Program, Tooele, Utah, October 2, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

"Design, Inspection, and Maintenance of Alternative Systems." Utah On-Site Wastewater Treatment Training Program, Logan, Utah, November 11-12, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

“Design, Inspection, and Maintenance of Alternative Systems (Recertification).” Utah On-Site Wastewater Treatment Training Program, Logan, Utah, September 18, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

“Design, Inspection, and Maintenance of Alternative Systems (Recertification).” Utah On-Site Wastewater Treatment Training Program, Logan, Utah, October 14, 2003. Judith L. Sims, Peg Cashell, and Richard Jex.

“EPA Basins Training Course.” Utah State University, Logan, Utah, March 3-7, 2003. David K. Stevens and Bethany Neilson.

“Event Trees in Dam Safety Risk Assessment.” Three-day Workshop for Waterways Experiment Station, US Army Corps of Engineers, Vicksburg, Mississippi. June 2003, David S. Bowles and Loren R. Anderson.

“Physical Habitat Simulation and Habitat Time Series (PHABSIM-Windows).” Bellingham, Washington, March 2003. Thomas Hardy.

“Physical Habitat Simulation and Habitat Time Series (PHABSIM-Windows).” Utah State University, Logan, Utah, May 2003. Thomas Hardy.

“Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, Logan, Utah, April 8-9, 2003. Judith L. Sims and Peg Cashell.

“Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, Cedar City, Utah, April 29-30, 2003. Judith L. Sims and Peg Cashell.

“Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, Vernal, Utah, September 9-10, 2003. Judith L. Sims and Peg Cashell.

“Soil Evaluation and Percolation Testing.” Utah On-Site Wastewater Treatment Training Program, Tooele, Utah, September 30 – October 1, 2003. Judith L. Sims and Peg Cashell.

“Specialty Short Course on the Modular Modeling System (MMS).” Utah State University, Logan, Utah, June 2003. Luis Bastidas.

Principal Outreach Publications

Principal outreach items include the Comprehensive Water Education Grades K-6 manual (several thousand copies of the manual have been distributed throughout the country, and distribution is now being planned in the United Kingdom and Australia), newsletters addressing the on-site wastewater issues (Utah WaTCH), and a Mineral Lease Report to the Utah Office of the Legislative Fiscal Analyst. The UWRL’s International Office for Water Education (IOWE) produced and distributed a regional water education calendar to elementary schools in Arizona, California, Colorado, Nevada, New Mexico, Wyoming, Alaska, Hawaii, Idaho, Montana, Oregon, and Washington. The calendar featured the winning posters from the K-6 poster contests conducted in seven Colorado River and Columbia River states. It also included lessons, questions with answers, and facts about water. The UWRL prepared and distributed two water education manuals for 4th grade elementary school teachers and students. The UCWRR, through the UWRL, provides outreach materials related to public service, information dissemination, technology transfer, and short courses. These are provided for the benefit of Utah state agencies, elected officials, Utah citizens, and the nation. Additional outreach is available through the UWRL web site at: http://www.engineering.usu.edu/uwrl/. An on-line journal, the "Utah Water Journal," is a collaboration between USU and state, local, and private organizations involved in stewardship issues that include managing and protecting Utah's water quality and quantity. The Utah Water Journal is available on-line at: http://www.engineering.usu.edu/uwrl/uwj.

Technical publications in FY 03-04 that were partially supported by the cooperative program described in this report are listed below. Other publications from the Utah Water Research Laboratory appear regularly as technically-reviewed project reports, professional journal articles, other publications and presentations, theses and dissertation papers presented at conferences and meetings, and project completion reports to other funding agencies.

Smith, G. G. 2003. Substitute Teacher Handbook (Elementary VI Edition). International Office for Water Education, Utah Water Research Laboratory, Utah State University, Logan, UT.

Smith, G.G. 2003. Powell States and Columbia Water Education Calendar. International Office for Water Education, Utah Water Research Laboratory, Utah State University, Logan, UT.

Sorensen, D. L., K. D. Moncur, D. G. Tarboton, M. Kemblowski. S. Quiang, and S. Gogate. 2003. A Surface Water Protection Assessment Tool that Uses Digital Elevation Models. American Water Works Association, Source Water Protection Symposium, Albuquerque, NM, January 19-22.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	6	0	0	0	6
Masters	2	1	0	0	3
Ph.D.	1	1	0	0	2
Post-Doc.	0	0	0	0	0
Total	9	2	0	0	11

Notable Awards and Achievements

The UCWRR achieved one of the highest annual total resource income of its history, approximately $9 million, through contract and grant awards and through federal, state, and private funding.

Tirusew Asefa, Abedalrizq Khalil, and Karl Neiman, graduate students working at the UWRL, won 1st, 2nd, and 3rd places, respectively, in the 2003 Annual Student Paper Competition sponsored by the Utah Chapter of the American Water Resources Association. The final round of competition was held at the Utah Water Research Laboratory on May 9, 2003. Total cash awards for these winning papers amounted to $900.

Dr. Mac McKee was elected President of the Universities Council on Water Resources.

UCWRR faculty continue to serve on state and local advisory panels, including the Utah Drinking Water Board (Dr. Laurie McNeill), Utah Water Quality Board (Dr. Ronald C. Sims), the Utah Solid and Hazardous Waste Board (Dr. William J. Doucette), the Lake Powell Technical Advisory Committee (Dr. Darwin L. Sorensen), the Salt Lake County Solid Waste Management Council (Dr. R. Ryan Dupont), and the Utah On-Site Wastewater Association (Dr. Ronald C. Sims, Ms. Judith L. Sims, Dr. Darwin L. Sorensen).

Dr. Thomas B. Hardy, Professor, was appointed as a member of the Committee to Review the Basis for Instream Flow Standards for Rivers in Texas. This appointment comes from the National Academy of Sciences.

Ms. Judith L. Sims, Research Associate Professor, received a Non-Point Source Water Quality Award for her work with the Utah On-Site Wastewater Treatment Training Program to improve treatment and water quality protection practices. This award is given by the Utah Non-Point Task Force.

Publications from Prior Projects