#60 Copy 4 Volume 1 of 1

4.STPUD
Local Groundwater Assistance Grant
Appli
2002

OCT 2 4 2002

South Tahoe
Public Utility District

Robert G. Baer, Genera Manger

1275 Meadow Crest Drive South Lake Tahoe CA 96150
530 544-6474 530 541-0614

October 22, 2002

Ralph Svetich
California Department of Water Resources,
Division of Planning and Local Assistance
1416 Ninth Street, Room 338,
Sacramento, CA 95814

RE: Local Groundwater Assistance Grant Application For The Development of Groundwater Resources in the Presence of Contaminant Plumes, South Lake Tahoe, California.

Dear Mr. Svetich:

The South Tahoe Public Utility District is pleased to provide your Department, one original and five (5) copies of the subject local groundwater assistance grant application. A 3.5-inch diskette containing the electronic files of the text and accompanying figures in Microsoft-Word compatible format is also enclosed. Please note that the completed Local Groundwater Assistance Grant Application Cover Sheet is incorporated into the grant application as Attachment B. A schedule and budget for the proposed project are included as Attachments C and D, respectively.

We appreciate the opportunity to submit the enclosed proposal for your Departments review and consideration. The grant application was developed in collaboration with Dr. Graham Fogg, University of California - Davis, the lead investigator for our proposed project. As the principal point of contact for the local agency requesting funding, please direct any questions or requests for additional documentation to my attention.

Sincerely,

Ivo Bergsohn, R.G., C.HG
Hydro-Geologist

cc: R. Hydrick
B. Baer
G. Fogg, UC-Davis

4.58.L078

4.58.L078

South Tahoe
Public Utility District

1275 Meadow Crest Drive South Lake Tahoe CA 96150
530 544-6474 530 541-0614

November 12, 2002

Ralph Svetich
California Department of Water Resources,
Division of Planning and Local Assistance
1416 Ninth Street, Room 338,
Sacramento, CA 95814

RE: Local Groundwater Assistance Grant Authorizing Resolution No. 2748-02

Dear Mr. Svetich:

Attached is a copy of the authorizing resolution adopted on November 7th, 2002, by the South Tahoe Public Utility District Board of Directors. Please include this resolution as part of our recently submitted "Local Groundwater Assistance Grant Application For The Development of Groundwater Resources in the Presence of Contaminant Plumes, South Lake Tahoe, California."

Please feel free to give me a call at extension 204 or e-mail me at ibergsohn@stpud.dst.ca.us, should you require any additional information regarding our application.

Sincerely,

Ivo Bergsohn, R.G., C.HG
Hydro-Geologist

cc: R. Hydrick
B. Baer
G. Fogg, UC-Davis

RESOLUTION NO. 2748-02

A RESOLUTION OF THE BOARD OF DIRECTORS OF SOUTH TAHOE PUBLIC UTILITY DISTRICT ACCEPTANCE OF A GRANT AND EXECUTION OF AGREEMENT WITH THE CALIFORNIA DEPARTMENT OF WATER RESOURCES TO RECEIVE A GRANT FOR THE DEVELOPMENT OF GROUNDWATER RESOURCES IN THE PRESENCE OF CONTAMINANT PLUMES IN SOUTH LAKE TAHOE

BE IT RESOLVED, by the Board of Directors of the South Tahoe Public Utility District, County of El Dorado, State of California, as follows:

That the application shall be made by the South Tahoe Public Utility District (District) to the California Department of Water Resources to obtain a grant pursuant to the Local Groundwater Management Assistance Act of 2000 (Water Code Section 10795 et seq.), and to enter into an agreement to receive a grant for the Development of Groundwater Resources in the Presence of Contaminant Plumes, South Lake Tahoe, California.

The General Manager of the District is hereby authorized and directed to prepare the necessary data, make investigations, execute, and file such application. The General Manager is further authorized to accept the grant and execute an agreement with the California Department of Water Resources.

PASSED AND ADOPTED at a duly held Regular Meeting of the Board of Directors of the South Tahoe Public Utility District on the 7th day of November 2002 by the following votes:

AYES: Directors Jones, Wallace, Schafer, Mosbacher

NOES: None

ABSENT: Director Becker

Duane Wallace

Duane Wallace, Board President
South Tahoe Public Utility District

ATTEST: Kathy Sharp

Kathy Sharp, Clerk of the Board and Ex-Officio
Secretary of the Board of Directors

LOCAL GROUNDWATER ASSISTANCE GRANT APPLICATION FOR THE DEVELOPMENT OF GROUNDWATER RESOURCES IN THE PRESENCE OF CONTAMINANT PLUMES, SOUTH LAKE TAHOE, CALIFORNIA

Prepared For:

California Department of Water Resources
Division of Planning and Local Assistance
P.O. Box 942836
Sacramento, CA
94236-0001

Prepared By:

South Tahoe Public Utility District
1275 Meadow Crest Drive
South Lake Tahoe, CA 96150

LOCAL GROUNDWATER ASSISTANCE GRANT APPLICATION FOR THE DEVELOPMENT OF GROUNDWATER RESOURCES IN THE PRESENCE OF CONTAMINANT PLUMES, SOUTH LAKE TAHOE, CALIFORNIA

1. GROUNDWATER MANAGEMENT PLAN (GMP)

1.1. Adopted Plan (GMP)

In August 1998, the South Tahoe Public Utility District (STPUD) began developing a Groundwater Management Plan (the Plan) pursuant to the Groundwater Management Act (California Water Code sections 10750, et seq.). This plan was developed in response to the contamination of STPUD drinking water supply wells and groundwater resources by man-made contaminants, notwithstanding efforts to prevent such contamination. The purpose of this plan is to regulate, manage, conserve and protect the groundwater resources available to the STPUD so that the groundwater remains a viable potable water resource.

The Plan was developed over a more than eighteen month period by STPUD staff and STPUD counsel, in conjunction with a Stakeholders Advisory Group (SAG) consisting of leading staff members of the California Regional Water Quality Control Board - Lahontan Region (RWQCB - Lahontan), the El Dorado County Environmental Management Department - Tahoe Division (EDCEMD - Tahoe), the Tahoe Regional Planning Agency, the City of South Lake Tahoe (CSLT) and the Tahoe Resource Conservation District (TRCD). A local business rate payer and at large STPUD rate payer also participated in the SAG. This plan was completed and added as Division 7, Sections 7.1 through 7.13 to the Administrative Code on December 21, 2000. A copy of the Plan is provided in Attachment A.

1.2. Stakeholders

The Plan was developed in close consultation with the SAG. This included conducting eleven SAG meetings over a nearly two-year period in order to develop the Plan. This involvement shows that the SAG believed that the Plan was necessary and worth pursuing. The final Plan went through numerous working draft copies, which were revised in accordance with SAG comments. In addition, final drafts of the Plan were also presented during three public hearings. Comments from these hearings were addressed and, where appropriate, also incorporated into the Plan. Therefore, it is believed that the final Plan, in itself, represents a statement of support and the consensus of the SAG and other interested parties.

1.3. Accomplishments

In an effort to regulate, manage, conserve and protect groundwater resources, the STPUD has succeeded in completing the following actions.

The STPUD has delineated the zones of contribution (ZOCs) surrounding all STPUD drinking water sources to identify and prioritize the management of its available groundwater resources. Within each ZOC, the STPUD has identified the locations of all active underground storage tank (UST) facilities and has identified the number of existing and recommended additional monitoring wells that would be required to fully implement the groundwater-monitoring program described in the Plan. Cost estimates have been developed and funding allocated from STPUD budgets for implementation of the monitoring program.

In order to monitor and protect groundwater resources, the STPUD has either installed or requested that responsible parties install several sentinel wells within the ZOCs of three of its drinking water wells. These sentinel wells are regularly sampled to monitor the potential movement of identified MtBE groundwater contaminant plumes toward STPUD drinking water wells and are used to assist the STPUD in managing pumping rates for these potentially impacted drinking water wells.

To protect the groundwater resource, the STPUD participates along with RWQCB-Lahontan and EDCEMD-Tahoe staff in monthly inter-agency meetings to evaluate and discuss the progress of contaminant investigation and remediation projects, which potentially affect STPUD drinking water sources. These meetings have been successful in developing better communication and have led to cooperative efforts between these agencies toward managing groundwater contaminant problems within the STPUD service area.

The STPUD has been significantly impacted by MtBE groundwater contamination. In response to this contamination, the STPUD has retained the services of outside consultants to perform engineering evaluations of varying water source alternatives. The STPUD pursued litigation against identified responsible parties. As part of the litigation effort, expert witnesses have developed detailed groundwater models to evaluate the potential movement and impact of MtBE contaminants on STPUD groundwater resources in selected areas. The STPUD has also been conducting on-going water resource investigations to identify potential new groundwater sources. As part of these investigations the STPUD has directed the performance of geophysical gravity surveys and data interpretation, exploration drilling and well testing programs. Information gathered from outside engineering, expert witness and STPUD investigations are being used to develop and enhance the current understanding of regional groundwater flow systems and the character of drinking water aquifers used by the STPUD. This information will be critical to fulfill the purpose of the Plan in an efficient and rational manner.

In August 2002, the STPUD reached a final settlement in it's MtBE litigation lawsuit. Total settlements in this case were more than $69 million. This settlement is being used to cover damages (including existing wellhead treatment) and legal costs incurred through August 2002, projected net costs for capital and operations and maintenance for future wellhead treatment and pending legal costs. It is estimated that the total settlements in excess of costs are on the order of roughly $371,000. Given the inherent uncertainties associated with wellhead treatment costs (projected over a 30-year life cycle), the realization of this excess is not assured.

1.4. Implementation

The development of the Plan, the accomplishments achieved by the STPUD since the adoption of the Plan, and the expenditure and allocation of STPUD funds shows the strong commitment by the STPUD toward the regulation, management, conservation and protection of it's available groundwater resources.

To date, the STPUD has expended significant staff time and funds toward the development and implementation of the Plan. The development of the Plan is estimated to have cost nearly $185,000. To date, the installation and monitoring of sentinel wells has cost roughly $90,000. Direct water resource investigations have cost an additional $340,000 with roughly $270,000 allocated for additional geophysical exploration and test well drilling next year.

2. PUBLIC OUTREACH

As indicated in Section 1.2 of this grant application, the STPUD facilitated eleven SAG meetings over a nearly two-year period and three public hearings during the development of the Plan. As a public agency, the STPUD is committed to sharing information with our customers to foster and maintain a well-informed community.

Public education and community relations are an important component of the Plan. The STPUD will provide information regarding the use and development of groundwater resources and the susceptibility of those resources to contamination. In the past, these services have been provided predominantly through public presentations. Groundwater resource information developed through this grant will also be presented in public forums and through informational items.

3. PROJECT WORK PLAN

3.1 Objectives

The proposed project involves a three-dimensional analysis of groundwater flow, heat transport and contaminant transport in the South Lake Tahoe area. These analyses will be accomplished through construction of hydro-geologic data bases and numerical modeling and have the following objectives:

A) Determine optimal strategies for supply well pumping in the presence of MtBE and natural contaminants.
B) Determine potential third party impacts on private well owners from optimized well pumping schemes.

C) Develop an appropriate groundwater quality monitoring program based on groundwater flow and contaminant transport pathways elucidated through the characterization and modeling.

D) Identify mechanisms of recharge, regions of enhanced natural groundwater inflow, and potential sites for groundwater development.

E) Use advanced graphical animations and model results as a public education tool to provide awareness of the susceptibility of community drinking water resources to contamination by illustrating the nature of groundwater and subsurface contaminant flow.

3.2 Need

The STPUD produces, on average, approximately 2,200 million gallons (6,750 acre-feet) of potable water per year, to meet the drinking water needs of the City of South Lake Tahoe and the neighboring communities of Angora Highlands, Tahoe Paradise and Meyers, California. Combined, these communities represent a population varying from between 25,000 to more than 65,000 residents and visitors to the South Tahoe area. The sole source of drinking water in the area is groundwater. To meet it's needs the STPUD operates and maintains 31 drinking water wells and has more than 13,000 commercial and residential connections. In order to help manage it's drinking water resource, the STPUD is seeking to develop a numerical model that can be used to simulate the groundwater system and the hydraulic and contaminant-mass transport effects on that system from the operation of its wells.

MtBE has had a severe impact on the groundwater resources of the STPUD. Numerous MtBE groundwater contaminant plumes have been identified and are typically associated with releases from gasoline retail petroleum facilities situated within the STPUD service area. It is estimated that these plumes may have contaminated as much as 400 million gallons of groundwater within the water table aquifer. Where detailed three-dimensional analyses of MtBE contaminant fate and transport has been performed, it has been determined that these contaminant plumes have the potential to affect groundwater quality in the water table aquifer for decades to come.

Many of the STPUD drinking water wells either produce directly or are in hydraulic connection with the water table aquifer. Vulnerability well pumping tests have shown that some of the deeper wells produce groundwater from multi-layered semi-confined aquifer systems which also have limited hydraulic connection with the overlying water table aquifer. Therefore, many of the STPUD wells are believed to be susceptible to this shallow groundwater contamination.

To date, the STPUD has either removed from service or reduced the production of thirteen (13) of its drinking water wells as a result of MtBE groundwater contamination. This has led to an estimated loss of more than twenty percent of its nominal capacity to produce drinking water. This groundwater contamination has had a significant impact on the capability of the STPUD water supply system to meet both current operation and emergency (fire flows) water system demands. The STPUD is solely reliant on groundwater to meet its drinking water needs. Recent evaluation shows that, after considering MtBE impacts, the STPUD well supply is nearly one million gallons below estimated total maximum day demand and nearly nine million gallons below estimated peak hourly demand. The proposed Arsenic Rule may exacerbate these problems by making additional wells unusable without future treatment.

3.3 Location and Geographic Scope

This investigation will focus on the Tahoe Paradise Study Area (Figure 1) to create the understanding and methods necessary to develop and manage groundwater in the presence of anthropogenic and natural contaminants. This particular area is key to development of additional groundwater resources in the South Tahoe Groundwater Basin and will facilitate similar analyses in other portions of the basin as well as other groundwater basins in California.

Sediments in the southern Tahoe Basin were deposited by glacial, fluvial, and lacustrine processes (Hyne et al, 1972). During the Pleistocene, huge valley glaciers moved down the canyons, scouring away loose rock and building great piles of glacial debris. Fluvial processes have operated to re-work and redistribute sediments between episodes of glacial activity and fluctuating lake levels, resulting in a complex, heterogeneous aquifer system.

In the Tahoe Paradise area, valley fill consists of Quaternary deposits, including areas of moraines, alluvium, and lake beds (Burnett, 1971). These valleys are bounded by mountain fronts of exposed glacially-scoured granitic bedrock. This bedrock is part of the granitic Sierra Nevada batholith, which also underlies the valley fill areas.

3.4 Methodology and Background

The continuing use of groundwater to supply the needs of the Tahoe Paradise area under the looming threat of MtBE and other contaminants poses numerous challenges. For example, how can STPUD minimize susceptibility of production wells to contamination? Can current remediation efforts prevent MtBE migration to the Bakersfield Well and to other wells? Where should STPUD locate new production wells to reduce the likelihood of adverse impacts from potential sources of contamination? Such questions can only be answered in the context of a three dimensional analysis of contaminant transport.

Proposed numerical model development will include (1) extension of the STPUD regional-scale numerical model of groundwater flow in South Lake Tahoe to include the Tahoe Paradise Study Area (Figure 1), and (2) constructing a highly-refined, sub-regional scale groundwater flow and contaminant transport model within the Tahoe Paradise Study Area. The regional-scale model will be used, for example, to (1) obtain boundary conditions for the proposed sub-regional scale flow model, (2) investigate well-interference effects from existing and proposed production wells in the Tahoe Paradise Basin, and (3) importantly, evaluate potential impacts of aquifer development in the Tahoe Paradise area on the rest of southern Lake Tahoe.

Upgrades to the regional-scale model will rely on archival data and ongoing data collection by STPUD. However, at present there is little information on contributions of mountain-front and aerial recharge in the Tahoe Paradise area. To supplement existing data, STPUD and UCD co-investigators propose (1) a field program to monitor subsurface temperature profiles (2) heat-flow analysis to delineate relative contributions of aerial and mountain-front recharge and to constrain or minimize uncertainty in modeled groundwater flow paths and (3) isotope analysis to supplement the heat-flow analysis.

The proposed numerical model of flow and contaminant transport in Tahoe Paradise Basin will be fully three-dimensional and include an unusually high degree of resolution, possibly more than two million cells, to define preferential paths for contaminants to flow to production wells. The transport model will be calibrated to observed MtBE contaminant behavior in the Tahoe Paradise area. The proposed approach has been used successfully in the adjacent South-Y area of South Tahoe to evaluate efficacy of MtBE remediation efforts and forecast MtBE mass arrival to production wells.

Application of the high-resolution transport model will begin with hypothesis testing to answer questions crucial to effective management of the basin. For example, can changing supply well pumping schedules minimize vulnerability to contamination while satisfying demand? How long can the Bakersfield Well continue to operate in the presence of existing contaminant plumes and with ongoing remediation efforts? With the knowledge from this first phase in hand, the next phase will involve the building and testing of feasible management alternatives to achieve the management objectives outlined in this proposal. Background and methodology are described in more detail in the following sections.

3.4.1 Contaminant Transport Analysis

At present, little is known about sources of groundwater recharge or about the distribution of various sediments in the Tahoe Paradise area. Aquifer recharge sources and heterogeneity of hydrostratigraphic units significantly influence migration of subsurface contaminants. Contaminant migration is directly affected by the rate at which groundwater is supplied to the system, and the sources of this recharge (e.g. overlying soil infiltration vs. mountain front recharge). Within the basin-fill sediments, networks of sands and gravels provide pathways in which dissolved contaminants flow with groundwater supplied by this recharge. As they are being advected with moving groundwater, contaminants will diffuse into adjacent low permeability clays and silts, where they can be sequestered for years to decades. Sequestered contaminants slowly bleeding back into adjacent flowing channels can hamper remediation efforts and act as long-term sources to production wells [*LaBolle and Fogg*, 2001].

Standard analyses of subsurface transport generally lack resolution of geologic material structure to simulate the processes described above. To accurately account for the processes affecting contaminant transport, analyses should consider the complex geometry of subsurface materials and their associated hydraulic and transport properties, while honoring lithologic data [*NRC*, 1994]. Only recently have the methods and computing power been available to conduct such analyses.

UCD co-investigators propose to use subsurface characterization methods together with TPROGS [*Carle et al.*, 1998] software recently developed at University of California, Davis, (UCD) to construct realistic models of geologic variability from interpretive and quantitative analyses of the Tahoe Paradise geologic systems based on commonly available subsurface log data. Importantly, these (transition-probability based) geostatistical methods take into account the complex heterogeneity that controls contaminant transport and fate.

The resulting computational grids can contain millions of cells requiring innovative methods to simulate flow and transport. An enhanced version of groundwater flow code MODFLOW [*McDonald and Harbaugh, 1988*] and an advanced random walk simulation code RWHet developed at UCD [*LaBolle et al.*, 2000] will be used to efficiently simulate contaminant transport. Examples of this approach include simulation of well interference effects [*Carle, et al.*, 1998], isotopic studies of mean groundwater age [*Weissmann et al.*, 2000 and *Tompson et al.*, 1998], and more recently, predictions for MTBE migration in the South-Y area of South Lake Tahoe (see Figure 1), north of the Tahoe Paradise Basin [*LaBolle and Fogg*, 2001, unpublished results]. The South-Y area model has been validated against extraction well data on extracted MtBE mass through time and on the arrival of MtBE mass to production wells.

3.4.2 Analysis of Regional Groundwater Flow

Boundary conditions, including groundwater inflow and elevations, for the Tahoe Paradise area will be developed from a regional groundwater model of the South Tahoe Groundwater Basin. STPUD currently has such a model of groundwater flow in adjoining areas to the north of Tahoe Paradise, but this model does not include the Tahoe Paradise area. The proposed work will extend this model into the Tahoe Paradise area and refine its vertical discretization. The regional-scale model will also be used, for example, to evaluate potential impacts of aquifer development in the Tahoe Paradise area and on the rest of the South Lake Tahoe region. Extending the regional scale model will require improved knowledge of groundwater recharge rates in the Tahoe Paradise area.

3.4.3 Improving Definition of Groundwater Flow Fields: Thermal and Isotopic Investigations

The use of borehole temperature profiles to estimate groundwater recharge and discharge rates began in the 1960's (Bredehoeft and Papadopulos, 1965). Subsurface movement of heat is analogous to that of solute. Heat is conducted down a temperature gradient, similar to solute diffusion down a concentration gradient. Like solute mass, heat energy is conserved, and is advected with moving groundwater. Groundwater advection of heat energy in the subsurface helps determine subsurface temperature fields, which can be probed at accessible sites such as boreholes. Since the advent of low cost access to high processing power in the 1980's, complex 2-D and 3-D interactions of heat and groundwater flow have been investigated for numerous areal and regional-scale aquifer systems. Many of these investigations have been directed successfully toward a more accurate depiction of the groundwater flow field (Beck et al, 1989, Deming, 1993, Reiter, 1999). Additionally, shallow subsurface temperature measurements have been used to estimate groundwater recharge and discharge rates (Tabbagh et al, 1999).

As part of ongoing studies at UCD's EPA Center for Ecological Health Research, our UCD co-investigators have had excellent success in application of thermal information to elucidating groundwater flow and to constraining groundwater models. The Tahoe basin is proving to be an especially good location for this approach because previous studies have measured regional heat flow rates from deep intervals and because the substantial topographic relief produces significant variations in shallow groundwater temperature. Temperature of recharge waters decreases substantially with increasing elevation, and subsurface vertical temperature gradients are highly sensitive to recharge rates.

The method depends on accurate field measurements of groundwater temperature gradients. Recent improvements in temperature probe technology have enabled quick, easy, inexpensive measurement of temperature profiles at high resolution. Robust low-cost temperature logging devices have recently become available for long-term monitoring of shallow subsurface temperatures.

The USGS investigated stream recharge of an aquifer near Carson City, by means of thermocouples deployed within and below a stream, to log the arrival of thermal pulses advected with recharging streamwater (Ronan et al, 1998). These initial investigations have been expanded in ongoing stream surface and subsurface temperature monitoring studies within the South Tahoe Basin by the USGS. UCD co-investigators have measured temperature profiles in USGS monitoring wells near Clear Creek, located in Carson City. Results for vertical groundwater flow rate, as inferred using the temperature data alone (to be published), precisely match the vertical groundwater flow based on hydraulic parameters measured by the USGS.

Reconnaissance subsurface temperature measurements performed by the UCD co-investigators in the South Tahoe Basin during summer 2001 show a large contrast in subsurface temperatures (~ 4 C) from well-to-well, and a large contrast in temperature profile shapes between wells. Such large differences in groundwater temperature are not unexpected in mountainous areas. These differences reflect significant contrasts in shallow subsurface and recharge temperatures, and in groundwater flow patterns.

A warm springs named Meyers Warm Springs has been documented near Meyers. Additionally, UCD co-investigators have measured a temperature gradient in the STPUD Henderson Well (located in Christmas Valley) that is substantially larger than a normal conductive gradient, indicating the presence of substantial groundwater upwelling from depth. Such thermal waters demonstrate the presence of deep groundwater flow, and warrant further investigation of subsurface thermal energy flow, as it relates to recharge of aquifers at depth, and recharge from bounding mountain fronts.

To supplement geologic and hydrologic data provided by STPUD and available from other sources, subsurface temperatures will be measured. These measurements provide independent constraints on models of groundwater flow. That is, if the simulated groundwater flow field is incorrect, the simulated groundwater temperature field will typically not match field measurements, thereby indicating where and how the flow model needs to be improved or calibrated. Moreover, measured temperature gradients can give strong indications of magnitude and direction of groundwater flow. Temperature profiles in wells and boreholes will be measured using a recently available temperature probe (Chandra and Associates, Vancouver, B.C.) with millidegree resolution and stability. Shallow subsurface temperatures in selected wells and soil sites will be logged over extended periods (as much as 1-2 years) using robust low-cost temperature logging devices (Stowaway Tidbits, Onset Corp.). Temperature measurements are simple to perform upon identification of accessible wells and/or suitable soil sites. GIS layer data (e.g. vegetative cover, elevation, slope, aspect, albedo) will be used for areal interpolation of our point measurements of shallow subsurface temperature. Supplemental data on Tahoe Paradise area surface temperatures may be extractable from satellite coverages in IR bands.

Temperature data will be used to help define the thermal energy flow characteristics of the subsurface in the greater Tahoe Paradise area. The departure of the observed thermal energy flow field from a purely conductive thermal flow field provides a measure of the influence of groundwater on thermal energy flow. In this way, subsurface temperature measurements constrain possible patterns and magnitudes of groundwater flow. Because of the complex nonlinear coupling between groundwater flow and subsurface heat flow, numerical approaches are needed to resolve the results of their mutual interaction. The USGS has developed public domain software (SUTRA) to accomplish this (Voss, 1984), downloadable free of charge from the USGS website.

Groundwater flow in the Tahoe Paradise area will be modelled on the basis of: (1) available pertinent geologic and hydrologic data, but *without* thermal data (2) available pertinent geologic, hydrologic, and thermal data. Model results will be compared to assess the degree of improvement in definition of groundwater flow and recharge rates and mechanisms achieved by including the thermal data in the groundwater flow model.

The addition of thermal data provides independent constraints on the groundwater flow field, and we anticipate that this will yield a more accurate representation of actual groundwater flow in the Tahoe Paradise area. We anticipate that temperature data will be especially valuable in helping to better delineate recharge source areas and rates, including water table recharge and mountain front recharge. Knowledge of subsurface temperature fields also can help to define the depth to which substantial groundwater flow occurs, and whether substantial groundwater flow occurs at depths below the bottom of wells and boreholes probed.

The use of the stable isotopes ^{2}H and ^{18}O to help define recharge source areas and groundwater flow paths is well established in groundwater investigations (Fritz and Fontes, 1980). A wide range in stable isotope levels in groundwaters at different depths and locations has been documented for the South Tahoe Basin area (e.g. Woodling, 1987, Thodal,1997). This range in measured stable isotope levels in part reflects inter-storm and inter-annual differences in isotope levels in precipitation, and differences in isotope fractionation at different locations and elevations. Although the use of isotope data alone is unlikely to yield groundwater recharge source areas and flow paths, in combination with thermal analysis the isotope data should help to further resolve groundwater flow paths and recharge areas. Additionally, Lake Tahoe is greatly enriched in ^{2}H and ^{18}O relative to groundwaters in the Tahoe Basin, due to evaporative concentration. Thus stable isotope measurements in wells near the lake can provide strong indications of groundwater recharge from the lake.

Estimates of recharge will be used in groundwater flow and contaminant transport analyses in the Tahoe Paradise Basin. The South-Y Case Study illustrates an example of such an analysis in a comparable geologic setting.

3.4.4 South-Y Case Study

The South-Y Study was conducted to assess time scales on which MtBE contamination would remain in groundwater under various conditions. The analysis demonstrates the proposed methods and highlights the need to conduct comparable analyses in the Tahoe Paradise Basin. The approach included assembling existing driller's logs, geophysical logs, and other measurement data in the South-Y Area. Interpretive analysis of the geologic systems and quantitative analysis of the available data were used in the transition-probability based geostatistical approach [*Carle, et al.*, 1998] to construct numerous equaly-probable, plausible geologic models of the study area using the TPROGS software. The resulting geologic models (Figure 2), resolved to a scale of 40 ft x 40 ft x 1 ft in east, west and vertical directions, contained more than two million cells to represent the complex geometry of subsurface materials while honoring available lithologic data. Geologic models were used to inform groundwater flow and contaminant transport analyses on the spatial variability of hydraulic and transport properties.

Groundwater flow was simulated with an enhanced version of MODFLOW capable of handling the more than two million cells. Contaminant transport analyses were conducted with the RWHet transport code developed at UCD. RWHet is based on the random-walk method and is specifically designed to facilitate simulation of contaminant transport on immense computational grids.

Figure 3 shows predictions for the arrival of MtBE contamination to production wells of the South-Y area from releases at the USA Gas and South-Y Shell Stations. MtBE contamination eventually arrives to all water supply wells in the region by 2021. Results of this analysis illustrate the importance of location, timing and magnitude of pumping on the migration of MTBE contamination to production wells. The success of this application in the adjacent South-Y area demonstrates the feasibility applying these methods in Tahoe Paradise Basin to provide a framework for optimizing well placement and operational strategies.

3.4.5 Scientific Merit

The proposed project will (1) improve understanding of the hydrogeology of South Lake Tahoe, (2) exploit the coupling of heat flow to groundwater flow, in order to constrain groundwater flow and better delineate recharge sources and rates, and (3) mark the first extensive use of highly-resolved simulations of flow and transport to support groundwater planning and management decisions. Importantly, this project provides a scientific basis for making decisions that will affect the availability of groundwater to meet needs of the Tahoe Paradise Basin now and into the future. Important lessons will be learned about creative management of pumping rates and patterns so as to prevent incursions of bad water quality in the short (~10 yr) and long (>20 yr) terms.

3.5 Project Tasks, Schedule and Budget

Figure 4 is an organization chart for this project. The proposed project would be conducted by Post-Graduate Researchers, Dr. Eric Labolle and Jim Trask, under the direct supervision of Dr. Graham Fogg, Professor of Hydrology at the University of California-Davis, as principal investigator. Mr. Ivo Bergsohn, Hydro-Geologist, is a California Certified Hydro-Geologist and Registered Geologist and would be the principal point of contact for the Department of Water Resources. Mr. Bergsohn will be working with the UCD investigation team and overseeing the performance of this project for the STPUD.

A detailed project task list and accompanying schedule are provided in Attachment C. It is estimated that the project will have require approximately 22 months, commencing immediately following execution of a grant agreement in July 2003 and ending by May 1, 2005.

A proposed budget for this work is estimated at approximately $210,802 and is provided as Attachment D.

3.6 Deliverables

Deliverables include the following:

1. Quarterly process reports summarizing progress.
2. Archived data include groundwater heads, MtBE concentrations, temperature, and lithologic logs.
3. Upgraded (Agra) regional model of South Lake Tahoe, extended into the Tahoe Paradise area.
4. Detailed groundwater flow and contaminant transport model of a region within the Tahoe Paradise Study Area.
5. Final report detailing methodology and results.

3.7 Public Outreach

The STPUD will facilitate two public workshops to present the findings of the hydro-geologic characterization and groundwater flow and transport analyses for the Tahoe Paradise area. One of these workshops will be incorporated into a regular meeting of the STPUD Board of Directors in the City of South Lake Tahoe. A second workshop shall be presented at a regular meeting of the Meyers Community Roundtable in Meyers, California. A slide presentation with accompanying handouts will be developed for these presentations and will be used to enhance public awareness of the importance of groundwater protection in the South Tahoe area. These materials may also be made available for electronic access through the STPUD web site.

4 AUTHORIZING RESOLUTION

After the proposal due date, an authorizing resolution to enter into a grant agreement with the California Department of Water Resources will be presented at the next scheduled regular meeting of the Board of Directors on November 7, 2002. A fully executed copy of this resolution will be sent under separate cover within ten (10) business days following the Board meeting date.

REFERENCES

Burnett, John L. 1971. Geology of the Lake Tahoe Basin. *California Geology* 24:119-127.

Carle, S. F., E. M. LaBolle, G. S. Weissmann, D. Van Brocklin and G. E. Fogg. 1998. Conditional simulation of hydrofacies architecture: A transition probability/Markov approach. In: G. S. Fraser and J. M. Davis (eds.), *Hydrogeologic Models of Sedimentary Aquifers*, Concepts in Hydrogeology and Environmental Geology No. 1, SEPM (Society for Sedimentary Geology) Special Publication, p. 147-170.

Fritz, P., and Fontes, J. Ch., 1980. Handbook of Environmental Isotope Geochemistry, vol. 1, Elsevier, 1980.

Hyne, N.J., P. Chelminski, J.E. Court, D. Gorsline, and C.R. Goldman, Quaternary History of Lake Tahoe, California-Nevada, Geol. Soc. Am. Bull., 83, 1435-1448, 1972.

LaBolle, .E. M., J. Quastel, G. E. Fogg and J. Gravner. 2000. Diffusion processes in composite porous media and their numerical integration by random walks: Generalized stochastic differential equations with discontinuous coefficients. Water Resources Research 36(3): 651-662.

McDonald, M.G., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Techniques of Water-Resources Investigations, book 6, chap. A1, 586 p.

National Research Council (NRC), Alternative for Ground Water Cleanup, National Academy Press, Washington, D.C., 1994.

Thodal, Carl E., 1997. Hydrogeology of Lake Tahoe Basin, California and Nevada, and Results of a Ground-Water Quality Monitoring Network, Water Years 1990-92. U.S. Geological Survey Water-Resources Investigations Report 97-4072.

Tompson, A.F.B., S.F. Carle, N.D. Rosenberg, and R.M. Maxwell, 1999, Analysis of groundwater migration from artificial recharge in a large urban aquifer: A simulation perspective, *Water Resources Research*, 35(10),2981-2998.

Voss, C.I., 1984, A finite-element simulation model for saturated-unsaturated, fluid-density-dependent ground-water flow with energy transport or chemically-reactive single-species solute transport: U.S. Geological Survey Water-Resources Investigations Report 84-4369, 409 p.

Weissmann, G.S., LaBolle, E.M., and Fogg, G.E., 2000, Modeling environmental tracer-based groundwater ages in heterogeneous aquifers. In, Bentley, L.R., Sykes, J.F., Brebbia, C.A., Gray, W.G., and Pinder, G.F. (eds.), Computational Methods in Water Resources, Volume 2: Computational Methods, Surface Water Systems and Hydrology, Proceedings of the XIII International Conference on Computational Methods in Water Resources, Calgary, Alberta, Canada, June 25-29, 2000, A.A.Balkema, Rotterdam, p. 805-811.

Woodling, John K., 1987. A Hydrologic Investigation of Ground Water-Lake Interaction in the Southern Tahoe Basin. Thesis, Earth Sciences and Resources, UC Davis.

FIGURES

1. Map of study area

2. High-resolution transition probability geostatistical simulation of hydrofacies distribution in the South-Y area.

3. Maximum concentration of MtBE in year 2021 due to releases at the USA Gas and South-Y Shell stations as predicted by high-resolution flow and transport model of South-Y area.

4. Organization Chart

ATTACHMENTS

A. Groundwater Management Plan

B. Local Groundwater Assistance Grant Application Cover Sheet (Attachment A)

C. Proposed Project Schedule and Accompanying Project Task List

D. Proposed Budget Worksheet

FIGURES

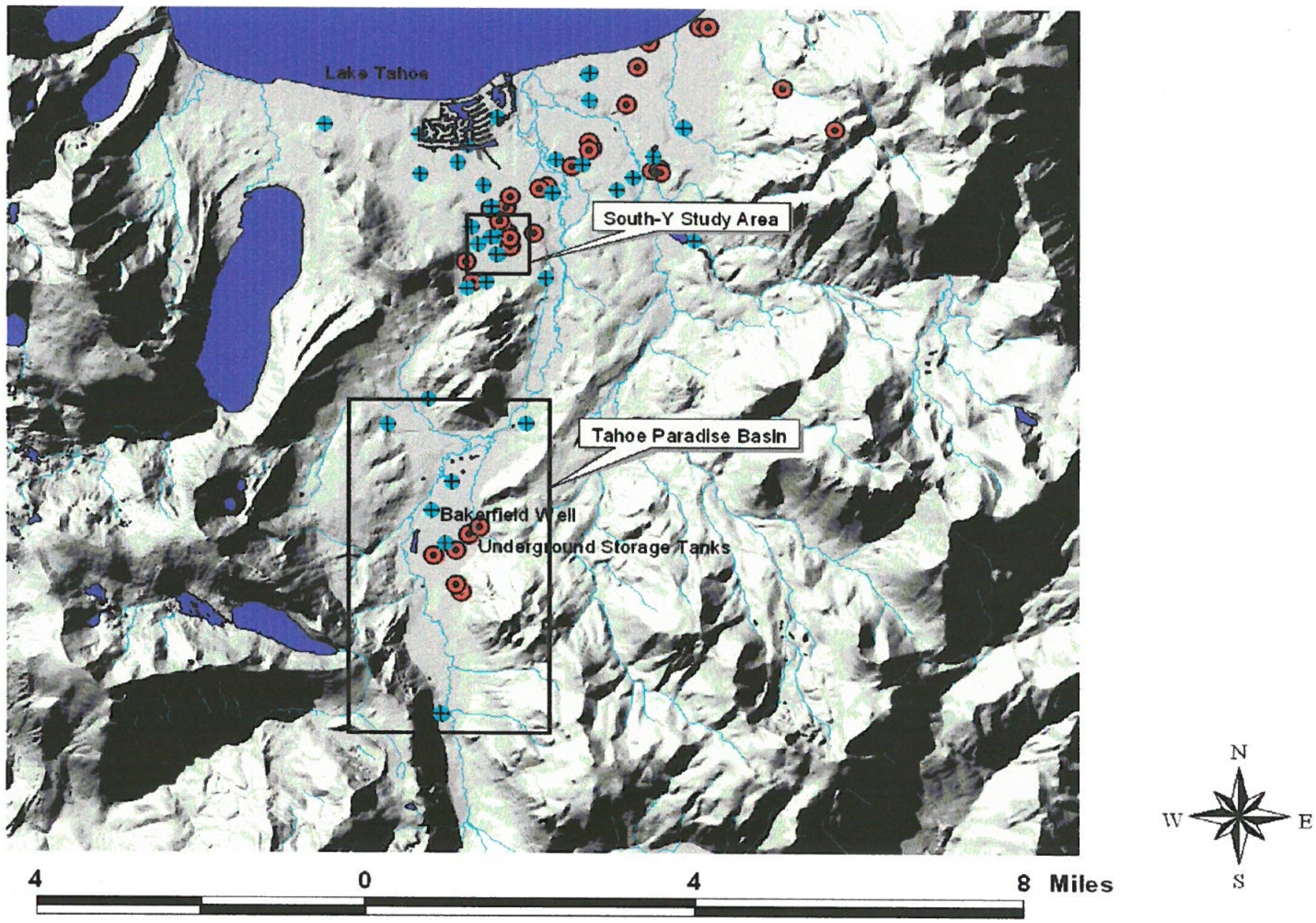

Figure 1. Map of study area.

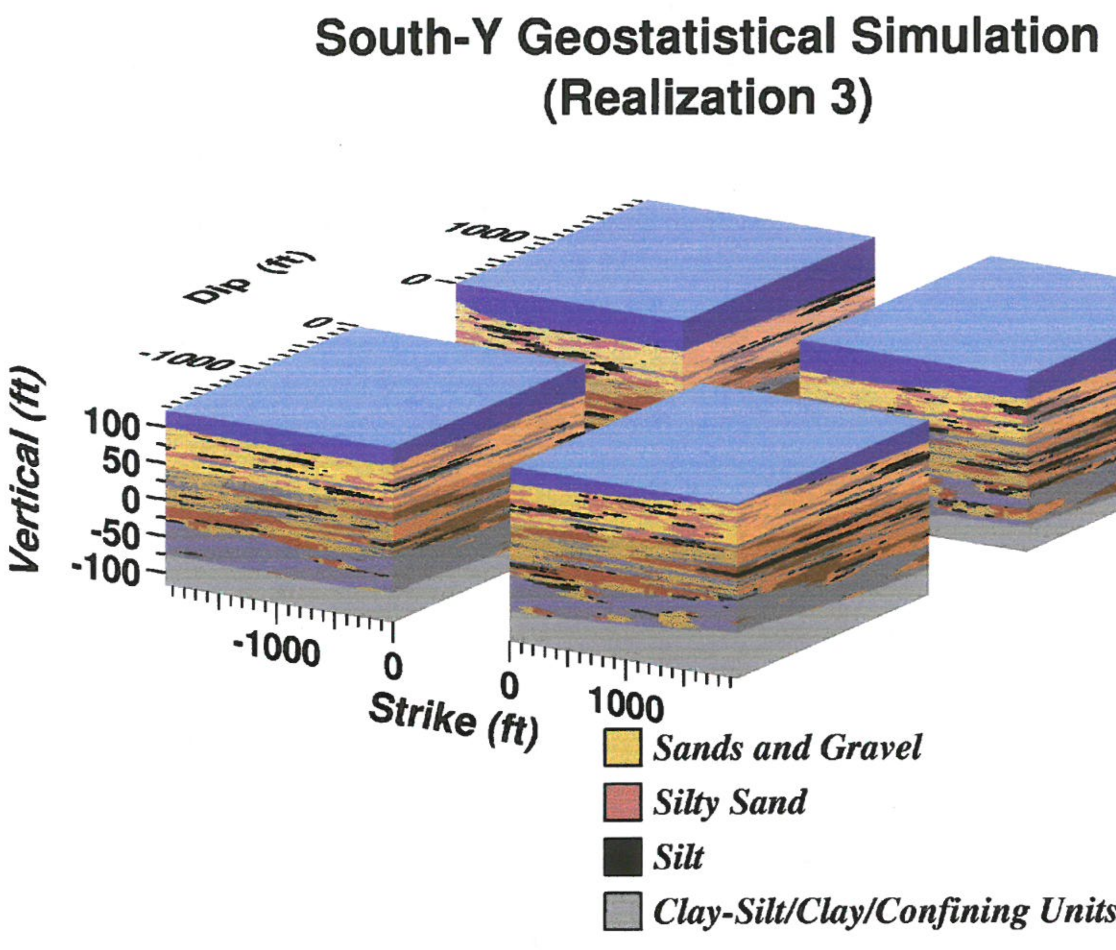

Figure 2. High-resolution transition probability geostatistical simulation of hydrofacies distribution in the South-Y area.

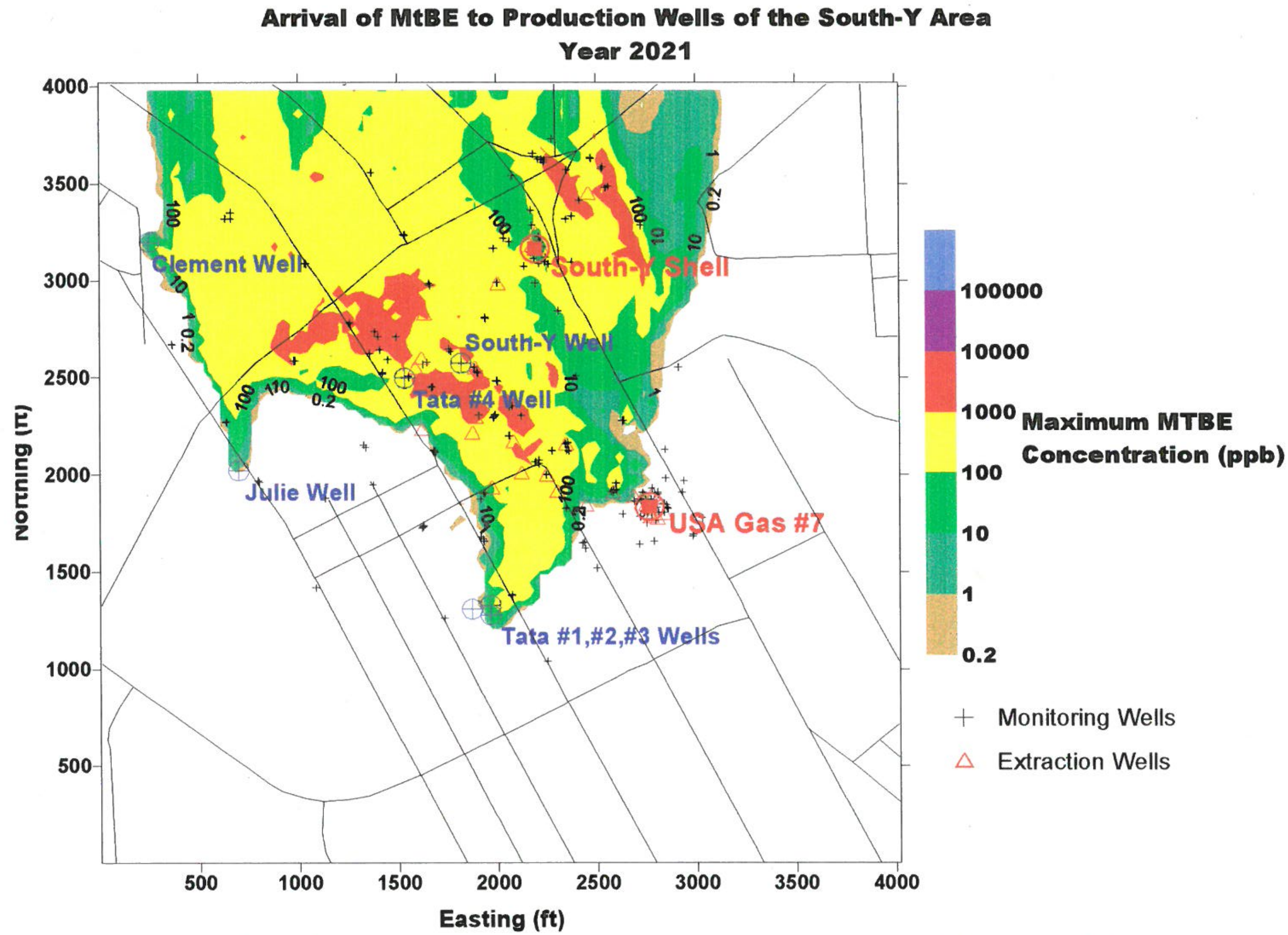

Figure 3. Maximum concentration of MtBE in year 2021 due to releases at the USA Gas and South-Y Shell stations as predicted by high-resolution flow and transport model of South-Y area.

Figure 4. ORGANIZATION CHART

Local Groundwater Assistance Grant
Groundwater Model For The Tahoe Paradise Area,
South Lake Tahoe, CA

FUNDING AGENCY

California Department of Water Resources
Division of Planning and Local Assistance
Carl Hague/Chief Hydro-Geologist
916.651.9649
chague@water.ca.gov

LOCAL AGENCY

South Tahoe Public Utility District
Ivo Bergsohn, R.G., C.HG./Hydro-Geologist
530.544.6474 x 204
ivob@stpud.dst.ca.us

PRINCIPAL INVESTIGATOR

University of California - Davis
Land, Air and Water Resources
Dr. Graham Fogg/Professor of Hydrology
530.752.6810
gefogg@ucdavis.edu

INVESTIGATORS

- Dr. Eric LaBolle/Post-Graduate Researcher
  530.752. 5185
  emlabolle@ucdavis.edu
- Jim Trask/Post-Graduate Researcher
  530.756.3244
  jctrask@ucdavis.edu

SOUTH TAHOE
Sewer · 1950 · Water
PUBLIC UTILITY DISTRICT