SUBSURFACE MONITORING

WORKSHOP REPORT


Facilitated by:
National Water Research Institute

On behalf of
British Petroleum
and Santa Clara Valley Water District

June 14-16, 2004

Hilton Costa Mesa
Costa Mesa, California

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FOREWORD

Since 1992, the National Water Research Institute has used the Nominal Group Technique (NGT) process as a means to identify, prioritize, and develop approaches that address critical water issues. This report, as with other NGT reports cited in Appendix D, documents the results achieved by 22 experts during a two-day workshop to provide answers to the workshop question: *What improvements to subsurface monitoring are needed to properly evaluate the fate and transport of petroleum and fuel oxygenate contaminates?*

The workshop was organized because the professionals engaged with subsurface monitoring activities were concerned that current methodologies and strategies were inadequate. By taking lessons learned from experiences throughout the nation, including the California MTBE Research Partnership, it was anticipated that participants would provide more robust and wide-ranging answers to the workshop question.

This report offers the results of the participants who identified 67 issues, consolidated them into 17 overarching themes, and then ranked the issues. Participants were assigned to one of the seven working groups and asked to synthesize all of the individual issues into a refined proposal prospectus or working group report.

It is anticipated that the results will assist responsible parties in improving current monitoring strategies, as well as to offer insights into planning monitoring programs that will take into consideration new technologies that can provide cost-effective means to protect drinking-water resources.

The success of any activity is due in great part to the participants. However, others provided the energy and vision to create the workshop. The Planning Committee and the "back-room crew" are singled out for congratulations for providing the glue to make the event work. In particular, special thanks are extended to Cris Tulloch and Jim Crowley (Santa Clara Valley Water District); Kyle Christie, Ravi Kolhatkar, Vic Kremesec, and Chris Winsor (British Petroleum); Brian Brady, Workshop Secretary; Patricia Linsky, Editor; Tammy Russo, Workshop Coordinator; Barbara Close, Graphics; Raymon Thomas, Graphics Assistant; and Teresa Taylor, Photographer.

Ronald B. Linsky
Executive Director
National Water Research Institute

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GROUP PHOTOGRAPH OF PARTICIPANTS

Back Row: Yue Rong, Amanda Hayes (Word Processor), Eric Nichols, Thomas Mohr, Todd Ririe, Andrew Barnes, Vic Kremesec, Ravi Kolhatkar, Jim Crowley, Thomas Young

Middle Row: Dennis England, ElJahOna Harris (Word Processor), Matt Small, Gary Robbins, Kevin Graves, Fred Stanin, Ken Williams, Thomas McHugh, Donna Drogos, Murray Einarson

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PART 1

WORKING GROUP REPORTS


QUALITY OBJECTIVES AND DATA
MANAGEMENT REQUIREMENTS
SHOULD
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V. KREMESEC
Working Group
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PRIORITY 1

Subsurface Monitoring Plans, Including Goals, Data Quality Objectives, and Data Management Requirements, Should Be Based on the Site Conceptual Model (SCM)

WORKING GROUP MEMBERS:

Crowley, Dorn, and Kermesec

Rationale:

A large portion of monitoring that is conducted across the United States is ineffective and does not add value to the information dataset that exists for contaminated sites. Human resources and funds are often wasted by adopting standard monitoring and monitoring routines with monitoring well networks that are most often monitored quarterly and that are often not be properly positioned and may be redundant. At many of these sites, there is no SCM, and wells are monitored just because they exist, regardless of whether they will provide useful scientific data.

The SCM should be developed based upon the characterization of the site and is needed prior to implementation of any long-term monitoring strategy. It is not okay to just install monitoring wells based on a two-dimensional cartoon picture of the site. The SCM has to include a proper understanding of site conditions, hydrogeology, geochemistry, groundwater flow patterns, source issues, mass flux, chemicals of concern, onsite and offsite receptors, pathways, risk criteria, and residual contaminant monitoring and have consensus from all stakeholders.

Following the SCM development, a consensus decision is needed to determine what is necessary at the site in terms of remedial efforts and long-term monitoring. The goals and objectives of the monitoring program should be defined in terms of remedial strategy, remediation timeline, and long-term monitoring plan. Data quality objectives are then set that identify chemicals of concern, geochemical changes, laboratory analyses, detection limits, and monitoring frequency. Data quality objectives should be specific for the situation and complexity of the site (e.g., expanding plume, mass flux, system performance analysis, natural attenuation, etc.).

Approach:

Site monitoring and sampling plans should be based upon SCMs and data quality objectives that are consensus based. Although guidance and training are available for developing SCMs and sampling and monitoring plans, the state of the practice tends to be “cookie-cutter” and not based on site conditions and needs.

To promote the effective use of SCMs and data quality objectives, an approach will require that basic changes be made to fit with methods that regulators, consultants, and responsible parties use to develop and gain approval of sampling and monitoring plans. Changes could include the following:

- *Legislative.* Amending California Health and Safety Code, Chapter 6.7, to split site characterization and monitoring requirements, requiring SCM and data quality objective development at the beginning of the corrective action process.

- *Administrative*. Rewriting corrective action regulations by deleting quarterly reporting requirements, requiring geochemistry data, and changing Underground Storage Tank Cleanup Fund reimbursement requirements to include not being reimbursed unless there is an approved SCM and data quality objective.

- *Policy*. Revisiting the State Water Resources Control Board policy 92-49, Investigation and Cleanup, and 88-63 Sources of Drinking water to include these concepts.

- *Training and education*. Separating out the technical issues from the policy issues and focusing on success stories, with pertinent examples of lesson learned.

- *Incentives*. There needs to be incentives for consultants and regulators to change the state of current practices and implement the approaches advocated here.

The approaches should be advocated by a group comprising regulators, consultants, and responsible parties at both the national and state levels. Examples of the organizations include: Partners in risk-based corrective action (RBCA) Implementation (PIRI); the Remediation Technologies Development Forum, etc. Willing participants may include the American Petroleum Industry (API), major oil companies, consulting firms, and state and local regulators.

Potential Conflicts:

- Entrenched attitude among state, regional, and local regulators: Small administrative changes are viewed as major policy changes, when in reality regulators have a lot of discretion and influence. For example, the California Underground Storage Tank Cleanup Fund could administratively determine that no reimbursement payments will be issued to sites that do not have a defined SCM and data quality objectives.

- Entrenched attitude of consultants: There are no incentives to change the status quo; they are making money on quarterly monitoring regardless of the usefulness of the data. The State cleanup funds are often paying for what may be unnecessary work.

- Standard and prescribed sample and monitoring plans minimize certain types of risk for consultants, responsible parties, lawyers, and regulators.

- Passive remedial techniques can be considered conflicting with current water codes and policies.

- Changes in monitoring techniques could be considered a costly burden to responsible parties and regulators.

Time Line:

- *Legislative:* At least six months, generally up to a year.

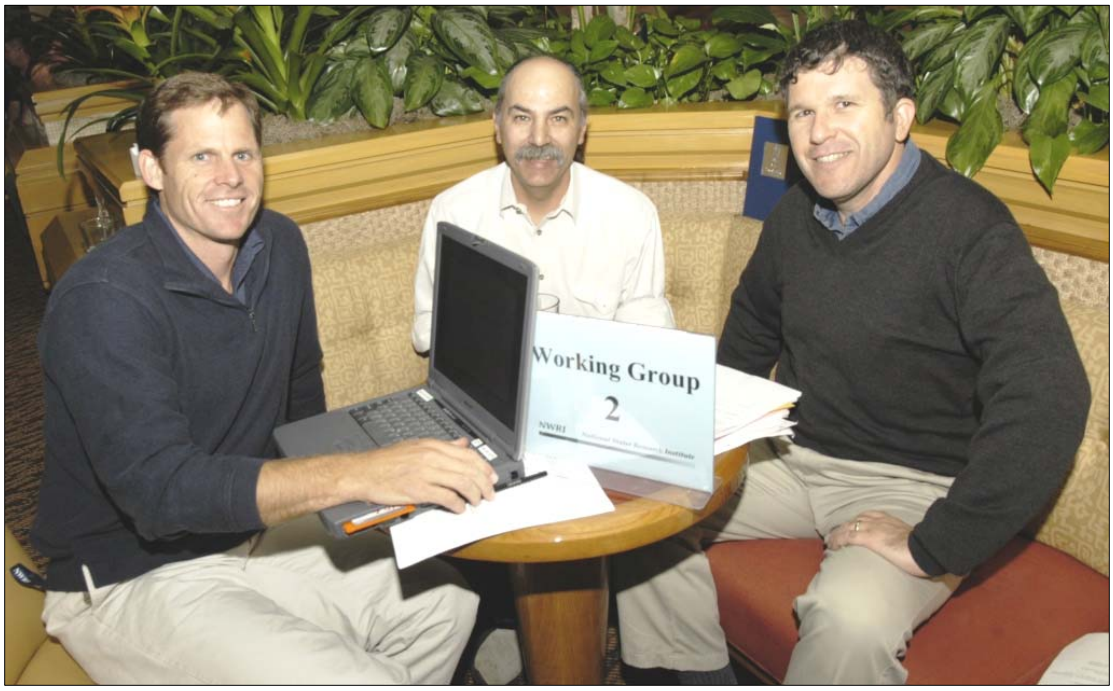
- *Administrative:* Could take years because of procedural requirements.

- *Policy:* Could be quick, but generally takes many years, if at all, due to entrenched attitudes.

- *Training and education:* Up to one year.

Budget:

Approximately: $150,000 to $250,000.


Working Group
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PRIORITY 2

The Level of Effort Expended to Monitor Occurrence and Remediation of Petroleum, Oxygenate, and Other Contaminant Releases in Groundwater Should Be Commensurate with the Degree to Which the Groundwater Resource Is Threatened

WORKING GROUP MEMBERS:

Barnes, Mohr, and Williams

Rationale:

There are limited funds available for resource protection. Presently, there is a need to prioritize resources to maximize protection of susceptible receptors. Policies should combine current knowledge of present and future groundwater use to focus environmental restoration activities and encourage cost minimization by reserving active remediation and higher data density to sites inside a sensitive buffer zone.

The current system of site characterization and monitoring is a reactive process that is triggered by the identification of a release and generally applies the same level of effort to all sites, without consideration of the location of the site with respect to water-supply wells. A programmatic reorientation is required to make monitoring and response actions proportional to risk.

We need to drastically reduce the allocation of resources to cleanups where little or no appreciable resource protection benefit can be demonstrated. An appropriate level of resource protection includes protecting human health and the environment, water-supply infrastructure, and financial resources.

A robust cleanup prioritization framework will assure end-users of the water that unavoidable releases will be responded to in a manner that will prevent impacts to the drinking water system, and that the response will be commensurate to the context of the release that occurred.

Approach:

Integrate zones of contribution to supply wells into GeoTracker to allow regulators to prioritize cases and identify appropriate levels of monitoring based on the location of the release and relative risks posed to the groundwater resource.

This approach will produce a multi-tier response with requirements for monitoring and remediation corresponding to the level of risk – varying from monitored natural attenuation outside the conservatively established capture zone of the supply well, to a proactive preventive monitoring and response with contingency plans for fuel facilities located in the highest risk portions of the capture zone. Integration of wellhead protection zones into the regulations of release sites will extend to land-use planning decisions on siting future facilities whose operations have the potential to contaminate groundwater. Re-evaluation and possible relocation of potentially contaminating activities and land uses likely to contaminate groundwater in the highest risk areas may be included in this approach. An example of a program that includes this approach, in part, is the City of Portland Municipal Water Authority.

Based on capture zone and zone of contribution information supplied by the Water Purveyor/District to the California Department of Health Services, release sites will be categorized based on their potential threat to groundwater within those capture zones, and monitoring and response activities will be conducted in a manner scaled to the estimated risk. Regulators will have online access to capture zones in the geographic information system (GIS) through GeoTracker. GeoTracker will be modified to accommodate polygon features, such as plumes and wellhead buffer zones. Stakeholders will have input to establishing the buffer zones, and water utilities will provide operational data to permit determination of capture zones. Regulators will provide sufficient data to the responsible parties' consultants to allow development of a scope of work, or the consultants will be given direct access to the data on GeoTracker.

The spatial density and temporal frequency of monitoring can be adjusted according to where the release site lies with respect to the identified capture zones. Regionally protective measures, such as the Regional Water Quality Control Board's (RWQCB) Basin Plans, would still apply as default standards, and some monitoring will be necessary wherever a release has occurred. The prioritization scheme may permit investigation of some releases without installation of permanent monitoring wells in low risk areas but may also require frequent preemptive sampling of permanent monitoring wells at facilities sited in high-risk areas where groundwater flow rates are high.

Site specific SCMs will be integrated into the regional conceptual model, such as articulated in the water purveyor's *Groundwater Management Plan.*

Upward migrating vapors, which may pose a risk to humans living or working over release sites, will be evaluated upon confirmation of a release at any site, regardless of the location.

Potential Conflicts:

Presently, standing requirements have not produced uniformly reliable delineation of wellhead protection zones. The default application of the Department of Health Services-Drinking Water Source Area Protection (DHS-DWSAP) modified fixed radius capture zone may fall short of a useful estimation of threats to wells.

Water utilities may be compelled to refine their estimated capture zone base; however, for security and economic reasons, utilities may not be inclined too provide their data. Property value diminution may also be a factor deterring utilities and municipalities from furnishing data for this effort.

Supply wells that have been impacted should be outfitted with wellhead treatment and pumping should be continued to prevent further downgradient impacts (e.g., lateral and vertical), unless it can be demonstrated that shutting down the well will not cause further spread or downward migration of a plume.

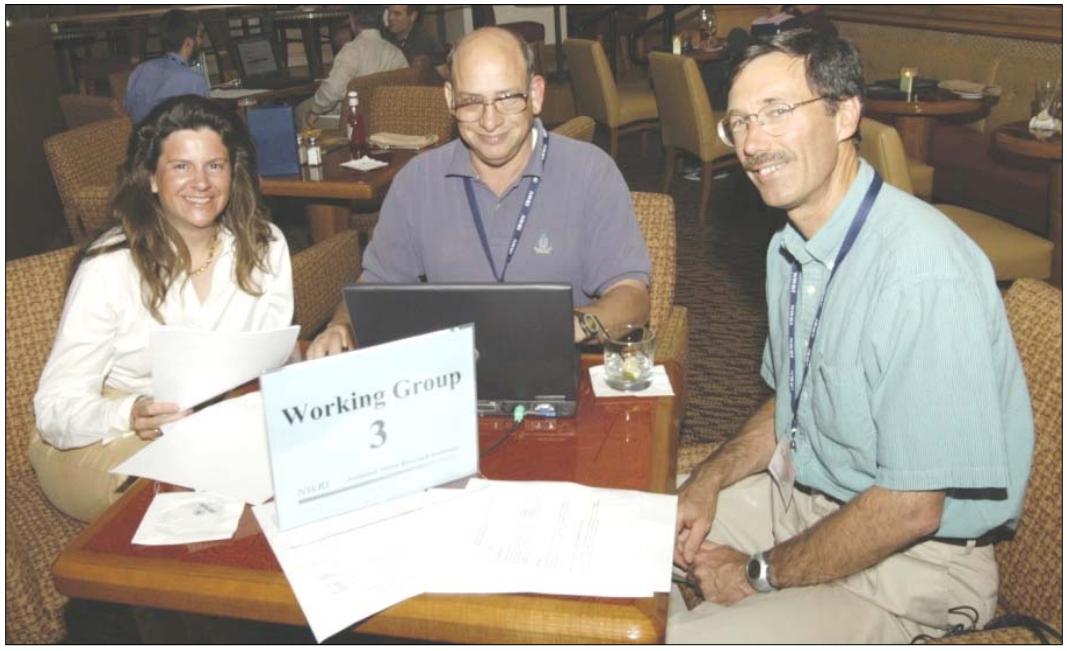
Timeline:

By capitalizing on the existing DHS-DWSAP program, this programmatic shift could occur relatively quickly (i.e., within 18 months).

Budget:

Given the existing GeoTracker structure and the availability of DHS-DWSAP data, this represents an additional phase of GeoTracker development that require additional funding to incorporate the additional data set. Through automation and scripting, much of the work for this phase can be completed by GIS professionals and proofed by hydrogeologists and water-utility stakeholders. Approximately 5 people years would be sufficient to complete the first pass at this effort. Thereafter, capture zones can be revisited to improve the accuracy of estimated zones of contribution and to review of present and past potential or known contaminating activities.

The anticipated results of this reprioritization would be smaller or timelier response actions at release sites and the increased use of natural attenuation programs at release sites residing in currently underutilized portions of the basin.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PRIORITY 3

Implementation of Three-Dimensional Site Characterization

WORKING GROUP MEMBERS:

Drogos, Ririe, and Robbins

Rationale:

Problems with Traditional Approach:

- Averaging effects lead to misleading plume delineation.
- No assessment of vertical flow.
- Poor delineation of vertical heterogeneities (water quality and physical parameters).
- Poor well location based on biased data obtained in successive phases.
- Failure to recognize that the problem is three dimensional in nature.
- Vertical spreading of contamination in wells.
- Bad data leads to bad decisions.

Three-Dimensional Assessment Permits:

- Improved data for modeling efforts.
- Estimate mass flux.
- Properly evaluate site risk.
- Quantifying attenuation processes:
  - fluxes of oxygen in the vadose zone for assessing natural attenuation
  - fluxes of vapors in the vadose zone
- Assessing flow and contaminant conditions in time.

- Use of multilevel sensors (MLS) for assessing how pumping wells influence the vertical and horizontal distribution of contamination.

- Focused remediation efforts on high mass flux zones.

- Improved source term definition, including seasonal variations.

Approach:

- *Site Conceptual Model (SCM)*. Develop an initial SCM of release scenario to guide site characterization.

- *Determine site hydrogeology*. Continuous core borings above and below water table (i.e., investigate entrapped product – submerged nonaqueous phase liquid [NAPL]) and collect depth-discrete samples.

- *Transects*. Install transects perpendicular to groundwater flow direction.

- *Install Multilevel Monitoring Systems to*: (1) Use available tools - direct push, temporary and permanent sampling systems; (2) perform K measurements, water quality sampling, measure vertical gradients; (3) use a phased approach - install temporary multilevel systems to determine concentration distribution in space and flow direction before permanent transect is installed; (4) develop methods for determining optimal screen length and depth interval; and (5) collect depth-discrete groundwater samples.

- *Mass Flux*. Perform mass flux calculations using depth-discrete sampling data collected from transects.

- *Retrofit traditional monitoring wells*: Convert to a multilevel monitoring system capable of depth-discrete measurements; eliminate ambient vertical flow.

- *Regulatory Approach*. Issue regulatory directives specifying new and innovative investigative methods.

- *Demonstration Sites – Success Stories*. (1) Evaluate whether detailed site investigations will improve decision making and remediation as well as reduce costs; (2) conduct comparison studies – how do multilevel sampling systems improve site characterization? – (3) create a climate to foster innovation, such as offering training classes using real site data to develop scopes of work and demonstrating application for real sites.

Potential Conflicts:

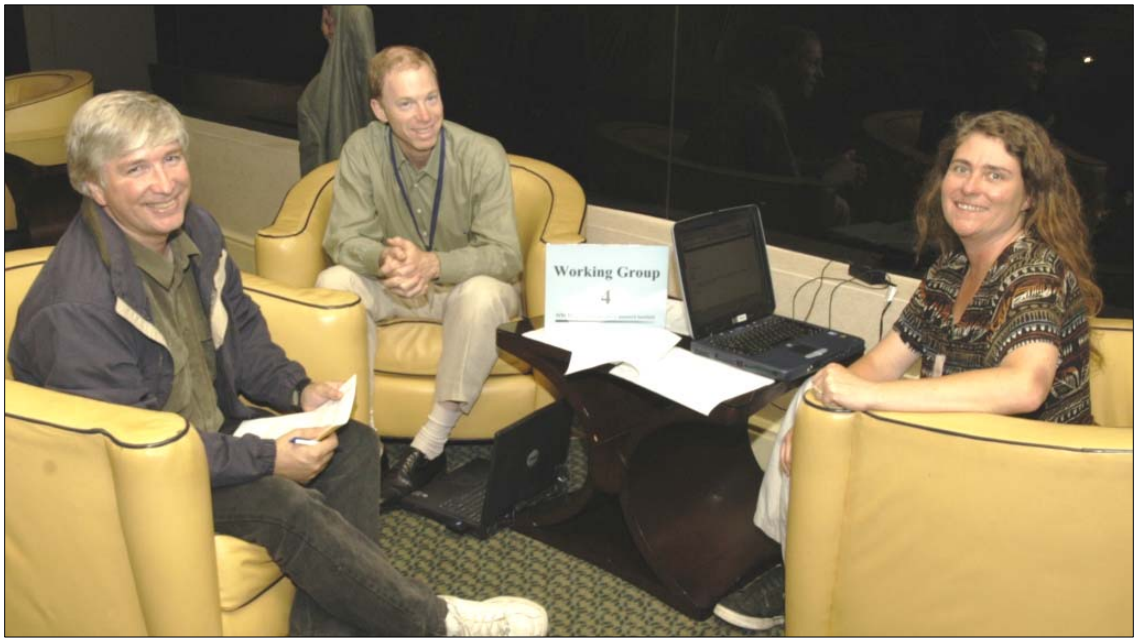
- How is the data to be used? Not just about collecting more data but the purpose.
- Monitoring once provides an understanding of the system; it is not necessary to monitor every point.
- Fears are that costs will rise and regulators will be buried in data.
- Miss product floating on water table.
- Dry MLS because water table has fallen.
- Problems in sampling in low K environments.
- Higher up front costs versus lower long-term savings.

Timeline:

3 years.

Budget:

Training:		$300,000
Case study review compilation:		25,000
Comparison:		175,000
Mass Flux Assessment:		200,000
	Total	$700,000


Working Group
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PRIORITY 4

Improve Characterization to Better Understand Fate and Transport in the Heterogeneous Subsurface

WORKING GROUP MEMBERS:

Graves, Tulloch, and Young

Rationale:

Proper site characterization is important because it drives regulatory decisions that affect investigation and cleanup costs and could potentially affect public health and safety. Subsurface heterogeneity (e.g., in flow fields, retardation factors, or initial NAPL distributions) is handled badly or ignored in developing most SCMs. It is now well documented that point-to-point variability in many fate and transport-related parameters (e.g., groundwater velocities, adsorption equilibriums and rates, biodegradation rates) can span multiple orders of magnitude at a site, and preferential transport of a plume through high or low reactivity zones will dramatically affect when (or whether) it reaches receptors. Failure to appropriately consider such factors will result in poor monitoring network design, both spatially and temporally, and may consequently result in risk estimates that are seriously in error, misallocation of cleanup resources, and adverse impacts to receptors.

Approach:

Although further research is necessary to refine our understanding of the physical processes that occur in the subsurface, we believe that a body of knowledge exists that is not currently being used by many practicing professionals in the industry. Therefore, we have chosen to focus on training for regulators, consultants, and responsible parties as the preferred project to increase the quality of subsurface investigations.

Training should emphasize the need for valid science-based investigations to ensure that the current state of the practice improves. In addition to training, incentives are needed to encourage regulators to complete training programs; approaches could include continuing education units or certificate programs. Training curriculum for dealing with heterogeneities could include, at a minimum, the following:

Lithologic Characterization

- Several continuous cored soil borings for lithologic characterization.

- Cone penetrometers (CPT) for the majority of the lithologic characterization. CPT is an expedited rapid assessment tool. CPT data must be validated and calibrated against the continuous core soil borings.

- E-logs.

Chemical Distribution Characterization

- Depth-discrete soil samples for chemical analysis with an emphasis on collecting soil samples at changes in lithology.

- Depth-discrete groundwater samples for chemical and geochemical analyses. Evaluating changes in distribution of chemical and geochemical characteristics can demonstrate and identify changes in heterogeneity and transport mechanisms.

- Passive diffusion samplers can be used to identify chemical distribution in wells if multiple bags are used, if there is horizontal flow, and if vertical flow is not present in the well.

Physical Tools

Once the lithologic heterogeneity is relatively well understood, appropriately screened wells are installed across specific hydrographic units. Pump tests conducted in these wells can confirm or deny assumptions in the SCM regarding hydraulic connection between the hydrographic units.

Mass Flux

Historically, sites have been regulated based upon the concentration of contaminants detected in groundwater samples at the site. It is now recognized that even relatively high concentrations of contaminants may not be leaving the source area with sufficient mass flux to negatively impact a drinking-water well or other receptor. Mass flux of contaminants can be estimated using several techniques and is a useful tool when determining the risk a site may pose to receptors. The investigator should be careful to sample dissolved concentrations using transects perpendicular to flow and outside of the "smear zone." Passive diffusion samplers may aid in this investigation.

Experimental Assessment of Heterogeneity

In many risk assessments, contaminant transport and transformation processes are characterized by a single value of a retardation coefficient that encompasses all sorption reactions and a first-order decay coefficient that is intended to capture all biotic and abiotic transformation processes. If impact to a receptor can be reasonably anticipated from a release, revising these first-order assumptions may be cost effective. At sites where semivolatile constituents are responsible for a significant fraction of the risk, sorption reactivity of subsurface samples (e.g., discrete samples from a continuous core) should be experimentally characterized. Measurements of sorption capacity, desorption rates, and any competition among multiple contaminants would be included. Biodegradation microcosm studies should be performed on core subsamples to assess the variability in the rate and extent of intrinsic biological transformation. Tracer studies may also be performed to experimentally assess transport pathways in cases where receptor impacts are deemed most likely.

Potential Conflicts:

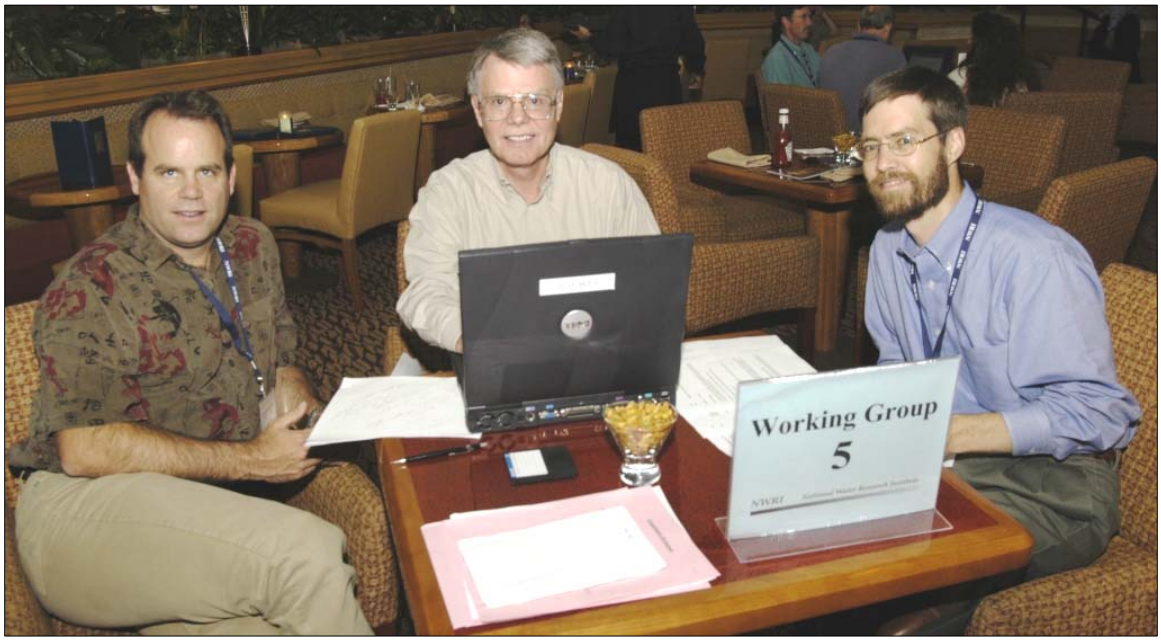
Different groups of stakeholders, and individuals within those groups, often have differing perspectives on issues. There will likely be resistance to changing existing practices if those changes affect the cost or timing of projects, funding and staffing at agencies, the level of control of projects, or other sensitive issues. Spending additional money to repeat work already completed with outdated techniques will also likely elicit resistance from some stakeholders.

Time Line:

Training programs already exist through government agencies, industry groups, conferences, and universities. Several months to one year of advance notice is normally required to secure a place at these programs. We believe that at least one seminar could be prepared and delivered within six months through a governmental agency with others to follow at conferences within one year.

Budget:

Our proposal is to conduct this training within California using existing resources within the SWRCB budget. Training outside of California will require additional resources, which would be determined based on the magnitude of the training that is envisioned or undertaken.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PRIORITY 5

Validation of Site Investigation and Monitoring Methods

WORKING GROUP MEMBERS:

Einarson, England, and McHugh

Rationale:

Methods used to validate site investigations and monitoring data may be flawed, resulting in misleading and inappropriate conclusions. New and existing methods need validation to demonstrate that they provide accurate data. At a minimum, technology validation eases the way to regulatory acceptance of the methods in question.

Regulatory requirements stating that only technologies that have undergone a rigorous validation/verification program can be used for environmental assessments and/or remediation should result in a more effective and less-expensive environmental restoration.

Approach:

- Validation needs to be based on a sound experimental design. The design should be peer reviewed and approved by an outside committee of technical experts.
- Validation results need to be peer reviewed.
- Use of the technology needs to be demonstrated to regulators and consultants.

Potential Conflicts:

The developer of proprietary technology has a vested interest in the outcome of the validation. Consequently, it is important that the validation program be performed, or at least overseen, by a committee of technical experts that have no financial interest in the technology being evaluated.

Time Line:

As soon as possible:

- Experimental design: 6 months.
- Validation program: 1 year.
- Report preparation and peer review: 6 months.
- Publication of validation program: 3 months.

Budget:

$50,000 to $500,000.

PRIORITY 6

Promote Better Decision Making by More Effective Communication and Interpretation of Data

WORKING GROUP MEMBERS:

Lapine, Nichols, and Small

Rationale:

Site characterization techniques continue to evolve, and many modern methods result in large quantities of highly technical information that practitioners and regulators may be challenged to manage, interpret, and communicate. Examples include rapid high-resolution reconnaissance data, depth-discrete sampling data, and non-chemicals of concern geochemical data. Therefore, it is important that the SCM, characterization goals, characterization data, and remedial performance metrics are communicated in clear, easy-to-understand ways that allow rapid assimilation and interpretation by all stakeholders to better promote informed decision making.

Without an upfront agreement between stakeholders on the site, data collection, a characterization approach, and remedial goals can be a waste of time, money, and investigative resources. Effective communication, participation, and input by technical and non-technical stakeholders can increase the effectiveness of site characterization and the durability of resulting remedial decisions.

Some site characterization technologies can dramatically increase the density of monitoring points – vertically, horizontally, and temporally. This can create a virtual avalanche of data. However, regulators may already have trouble reviewing the quantity of data currently being submitted. Therefore, it is key to communicate monitoring data in a way that allows rapid assimilation and interpretation for decision making. If resources are expended to collect data, the data should be used in the decision-making process. A clear and concise presentation of data and data interpretation allows more stakeholders to understand the issues and participate in decisions.

One example of technical information is inorganic geochemical data. Many practitioners and regulators are challenged to interpret of this type of data. Users who are accustomed to comparing chemical concentrations with fixed regulatory limits often find it difficult to interpret data whose value more often lies in its spatial patterns and its relationship with other data, rather than in the absolute concentration at any given location.

It is important to appropriately communicate uncertainty in the data, interpretations of the data, and predictions based on the data. For example, predicting future contaminant concentrations in a water-supply well requires estimation of groundwater flow and contaminant transport

parameters. Subsurface complexities, such as physical and chemical heterogeneities, contribute significant uncertainty in the reliability and accuracy of such estimates. These uncertainties may be more effectively represented via presentation of a range of input parameters resulting in a range of transport scenarios communicated via graphical summaries and other visualization techniques.

Remedial measures must be monitored to evaluate progress toward remedial goals. Defining appropriate metrics for remedy performance can help to ensure that remedial progress is appropriately evaluated. An example of a poor metric would be deployment of a biostimulation remedy in a well and subsequently measuring performance only in that same well. Monitoring data should allow cause-and-effect relationships to be demonstrated and should target the entire region of the affected aquifer. Inadequate performance data can mislead stakeholders into concluding that remedial efforts are effective, when the opposite may be actually be true.

Approach:

Solutions to resolving this issue involve actively encouraging and facilitating state-of-the-art techniques. Some examples include:

- Promoting more effective use, communication, and validation of the SCM.
- Promoting site characterization strategies, such as the interactive, real-time Triad approach.
- Developing better tools and guidance for data management and interpretation.
- Developing examples of effective data presentation and visualization techniques for communicating complex data sets to technical and non-technical audiences.
- Educating users to become more skilled in interpreting multiple data sets (e.g., organic and inorganic chemical data, hydraulic data, and geologic data).
- Developing approaches for communicating data uncertainty, natural data variability, and the range of possible data interpretations.
- Encouraging data evaluators to develop, honestly communicate, and test multiple working hypotheses that may explain the observed spatial and temporal patterns in the data.

To address improved communication of data, we recommend the creation of a guidance document outlining techniques and approaches for effective communication and interpretation of data. This document would discuss of state-of-the-art techniques for effectively communicating technical data to all stakeholders. A time line and budget for creation of this document are presented below. The audience for this document would mainly be technical professionals in the consulting and regulatory arenas.

Improving the quality of technical interpretations of data sets, while an important component of this issue, is beyond the scope of this document. Some sources for this additional training include:

- Continuing professional competency requirements currently imposed by many states.
- Increasing awareness of and compliance with applicable industry standards for data evaluation and interpretation.
- Training provided by vendors of data management and visualization tools.
- Training provided by professional societies and industry groups.

Potential Conflicts:

Implementation of these approaches may require additional training on the part of professionals involved in the interpretation and representation of data. Available tools should be presented in an impartial manner. The guidance document should be created by a knowledgeable group of individuals without financial interest in a particular product or solution.

Time Line:

This guidance document should be made available as soon as possible. However, a general timeline would include (time from start of project):

- Contractor selection, Month 3.
- Review of state-of-the-art practices for data communication, interpretation, and visualization, Month 6.
- First draft, Month 9.
- Review and comment on first draft, Month 10.
- Trial evaluations with users and stakeholders, Month 11.
- Revisions and final draft, Month 14.
- Comments on final draft, Month 15.
- Publication of final guidance document, Month 18.

Budget:

Salaries and Wages:	$200,000
Materials and Supplies:	50,000
Travel:	15,000
Equipment:	10,000
Total:	$275,000

PRIORITY 7

Selection of Target Parameters to Evaluate Petroleum and Fuel Oxygenate Contaminants in Groundwater

WORKING GROUP MEMBERS:

Kolhatkar, Rong, Stanin, and Zemo

Rationale:

Data collected as part of a groundwater monitoring program is the basis for all subsequent interpretations and decisions. Therefore, the target parameters selected for the family of data should be identified and determined to be sufficient to support such interpretations and decisions.

Examples of target parameters would be benzene, toluene, ethylbenzene, xylenes (*o-, m-, p-* xylene*)* (BTEX), methyl-tert-butyl-ether (MTBE), polycyclic aromatic hydrocarbons (PAH), isotopes, tracers, inorganics, electronic acceptors and metabolic byproducts, and chemicals related to non-petroleum-related sources. Thus, the parameters need go beyond the traditional analytes.

Approach:

The approach to select target parameters is logical and linear:

- Existing regulatory protocols, both federal and state, will be identified and reviewed.
- Relevant peer-reviewed journal articles will be reviewed.
- Selected federal and state regulators and industry and academic researchers will be identified and interviewed.

- Categories of parameters, and corresponding member target parameters, will be identified. An initial working list of categories is as follows:
  - parameters used for protection of beneficial uses (i.e., regulated chemicals and other fuel constituents) to define extent of impact
  - parameters used for source identification
  - parameters used for assessment of fate and transport
  - parameters that are potential constituents of future concerns (a.k.a. emerging contaminants) – parameters that may be used as fuel additives and presently unregulated parameters that may be regulated in the future

- A parameter selection methodology will be developed. This will incorporate the concept that interim monitoring results should drive selection of target parameters as an iterative process.

- Future research needs will be identified, .which may include laboratory work and standardization of analytical protocols for potential constituents of future concerns.

Potential Conflicts:

Issues to overcome for this project to provide benefits to end users are identified below with a strategy to resolve the potential conflict.

- *Potential Conflict:* Costs of analyzing for parameters. *Resolution Method:* Benefits for including specific parameters will be identified.

- *Potential Conflict:* Parameters not practical or easily implemented. *Resolution Method:* Advocacy, education, and training.

- *Potential Conflict:* Lack of regulatory acceptance. *Resolution Method.* Advocacy, education, training, and lobbying.

Time Line:

The following time line of 14 months is based on milestones and is expressed as incremental time frames to achieve each successive milestone:

- Research of protocols and articles, and interviews of regulators and researchers (3 months).

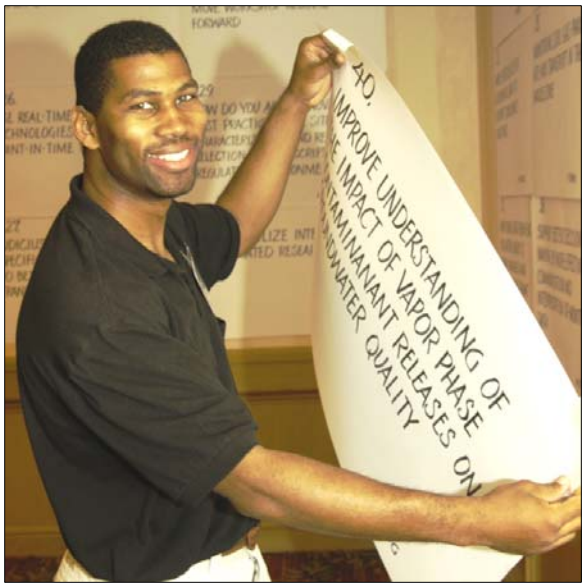
- Category identification and parameter selection (2 months).

- Interim report (1 month).

- Client review of interim report (1 month).
- Parameter selection methodology (3 months).
- Future research needs identification (1 month).
- Draft report (1 month).
- Review of draft report by client (1 month).
- Final report (1 month).

Budget:

Total budget estimate to complete the work described herein is $100,000. This estimate will be refined and presented with supporting details with the full project proposal.


40.
IMPROVE UNDERSTANDING OF
THE IMPACT OF VAPOR PHASE
CONTAMINANANT RELEASES ON
GROUNDWATER QUALITY


2.
ADD OR INCREASE ANALYSIS
OF TRHs IN SUBSURFACE
MONITORING
3.
CEASE THE INSTALLATION OF


C. TULLOCH
18.
SITE-SPECIFIC EXPERIMENTAL

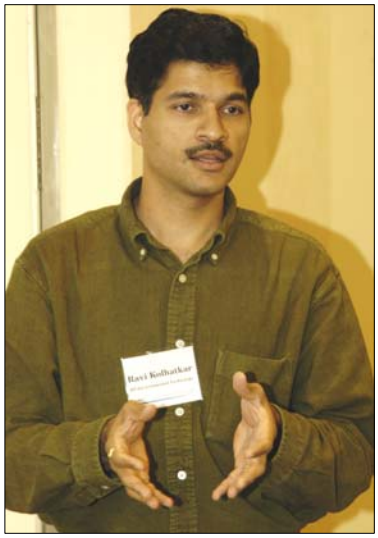
PART 2

NGT WORKSHOP

Gary Baldwin

Eric Nichols

Yue Rong



Ravi Kolhatkar

PRIORITY 1

Subsurface Monitoring Plans, Including the Goals, Objectives and Management Requirements Should Be Based on the Site Conceptual Model

Originators:

Kremesec on behalf of himself, Crowley, Dorn, Kolhatkar, McHugh, Nichols, Robbins, Rong, Small, and Zemo

The following issues were consolidated under the above title:

Title: **Decide the Purpose of Monitoring and the Frequency and Accuracy Required**

Originator: Kremesec

Issue Description:

Monitoring can be used for an expanding plume, mass flux programs, stable plumes, system performance analysis, natural organization monitoring, etc. How do we build consensus with regulators and communities on the purpose and frequency of monitoring plans? These are often prescribed in regulations or guidance. How do we decide on the accuracy needed since monitoring date is inherently "dirty" (factor of 2, generally at best)?

Importance:

Human resources and funds are often wasted by adopting a standard quarterly sampling routine. Need to define time goals of sampling and develop a sampling plan accordingly. Many regulators do allow alternative sampling plans, but many do not, and industry often does not pursue them.

How Do You Propose Meeting or Complying with This Issue?

I would like a strong statement from the workshop, if everyone agrees that sampling plans should be developed to support the purpose of the sampling.

Title: **The Site-Specific Conceptual Model Should Dictate the Design of the Monitoring Network/Programs of the Future**

Originator: Crowley

Issue Description:

Too often, monitoring of soil and groundwater quality is conducted without proper understanding of site conditions, hydrogeology, and groundwater flow patterns. An understanding of the SCM is needed prior to implementation of any long-term monitoring strategy. It is not okay to just install monitoring wells based on a two-dimensional cartoon picture of the site.

Importance:

A large portion of monitoring occurring at LUST sites is ineffective and does not add value to the information dataset that exists. We have a large array of tools and techniques that can generate better data for making site investigation and cleanup decisions.

How Do You Propose Meeting or Complying with This Issue?

The state cleanup fund can be used to ensure that the SCM is required and is the basis for the design of the monitoring program. The current system of monitoring should change (i.e., phase-in over time), so that costs for work that do not meet a minimum standard will not be reimbursed. Current regulatory programs need to be restructured.

Title: **Identify Site-Specific Goals and Objectives for Subsurface Monitoring**

Originator: Crowley

Issue Description:

Why are we monitoring the subsurface in the way that we have been? Have we learned lessons? Are we still making the same mistakes? How can more intelligence be introduced into the decision process for investigation and long-term monitoring? These two issues are different.

Importance:

Our business and field needs to change. The ideas discussed in this workshop must be brought into the mainstream and become the basis for development of new subsurface and environmental monitoring systems.

How Do You Propose Meeting or Complying with This Issue?

- Consistent guidelines on how to develop site-specific questions and monitoring objectives.
- Techniques to link data back to goals and objectives.

Title: **Appropriate Subsurface Monitoring to Determine Optimization of Remediation Systems**

Originator: Dorn

Issue Description:

Remediation, once implemented, is not normally evaluated to determine if the system is operating at its maximum capability.

Importance:

Remediation systems not operating effectively cost money and do not improve the environment.

How Do You Propose Meeting or Complying with This Issue?

Require system optimization evaluations at specific time intervals after startup.

Title: **Analysis of Groundwater Geochemistry Data to Make More Efficient Remedial Decisions**

Originator: Kolhatkar

Issue Description:

- Most sites we deal with are anaerobic, so it would make sense to consider other electron acceptors (e.g., nitrate and sulfate) to enhance naturally occurring biological processes.
- Help Mother Nature, not fight her.

Importance:

- Most remedial approaches focus on adding oxygen, which is inherently inefficient in anaerobic plumes.
- A large number of sites are open mainly due to localized hotspots; if they can be efficiently remediated using anaerobic bioremediation approaches, there could be huge savings.

How Do You Propose Meeting or Complying with This Issue?

- Literature is replete with laboratory and pilot studies demonstrating effectiveness of enhanced anaerobic bioremediation (with addition of nitrate and sulfate).
- Educate data users to interpret groundwater geochemical data.

Title: **Identify Consequences of Inadequate Monitoring and Benefits of Additional Monitoring**

Originator: McHugh

Issue Description:

Without question, many petroleum release sites are poorly characterized, limiting our understanding of contaminant fate and transport at these sites. However, the adverse consequences of this limited understanding have not been well defined. Conversely, the benefits provided by a better understanding of fate and transport are also not well defined.

The consequences on missing data and the benefits of additional data should be defined in terms of the relevant endpoints for the site:

- Predicting impacts to receptors.
- Remediating sites to achieve applicable site standards.

Importance:

More site data will increase our understanding of contaminant fate and transport. However, if this improved understanding does not allow us to better achieve the objectives for the site, then this increased understanding does not actually provide a defined benefit. Conversely, if the lack of understanding does not prevent us from achieving the site objectives, then a better understanding is not actually required.

How Do You Propose Meeting or Complying with This Issue?

Unknown

Title: **More Effective Use of Inorganic Geochemical Data to Interpret Subsurface Conditions**

Originator: Nichols

Issue Description:

The transport and fate of petroleum hydrocarbons and fuel oxygenates are highly dependent on redox poise and electron acceptor availability within the subsurface. Many practitioners and regulators are challenged in the interpretation of this type of data. Users who are accustomed to comparing chemical concentrations with "bright line" regulatory limits often find it difficult to interpret data whose value more often lies in its spatial patterns and its relationship with other data, rather than in the absolute concentration at any given location.

Importance:

Careful collection and analysis of geochemical data can help assess the potential for biodegradation; can explain observed patterns in concentration of fuel hydrocarbons and oxygenates; and can help confirm whether monitoring locations are appropriately located (e.g., in the likely path of the plume or outside the path of the plume).

How Do You Propose Meeting or Complying with This Issue?

- Develop better tools and guidance. Educate users to become more skilled in interpreting multiple data sets (e.g., organic and inorganic chemical data, hydraulic data, and geologic data).

- Encourage data evaluators to develop, honestly communicate, and test multiple working hypotheses that may explain the observed spatial and temporal patterns in the data.

Title: **Need to Develop Methods for Cost-Effective, Four-Dimensional Monitoring of Contamination, Flow, and Degradation Processes in Fractured Crystalline Rock**

Originator: Robbins

Issue Description:

In New England and elsewhere, once gasoline contamination has occurred in fractured crystalline rock, detailed site characterization efforts are either crude or cost prohibitive. Limitations in understanding fracture flow and processes that may attenuate contamination make remediation difficult or ineffective.

Importance:

Resolving this issue can help reduce, if not eliminate, contaminant conditions in bedrock, especially bedrock impacted by LNAPL migration into fractures.

How Do You Propose Meeting or Complying with This Issue?

I recommend performance of research on the use of tracers, groundwater age dating, downhole geophysical methods, and methods that stress water-quality conditions to help improve our understanding of contaminant migration in bedrock.

Title: **Understanding Data from an Analytical Chemistry Perspective**

Originator: Rong

Issue Description:

It seems that the analytical laboratory is a separate industry from monitoring groundwater. Actually, it is not.

Importance:

Necessary for data interpretation.

How Do You Propose Meeting or Complying with This Issue?

Provide education and seminar training.

Title: **Subsurface Monitoring Must Include Time Considerations and Requirements**

Originator: Small

Issue Description:

- The design and location of monitoring points and/or monitoring systems often do not include a quantitative analysis of travel time.
- The design and monitoring of a remedial system often do not include a quantitative evaluation and prediction of cleanup times.
- There is often no evaluation of how long it might take for a monitoring point to indicate changes in the subsurface environment when placing that monitoring point.

Importance:

- Contaminant travel and arrival times are key considerations in evaluating the risks associated with contaminant fate and transport.
- Cleanup time frames can dramatically influence resource requirements.
- Imposing time frames can help to decrease cleanup time frames.

How Do You Propose Meeting or Complying with This Issue?

- Design and locate subsurface monitoring systems in time as well as in space. This must be done with recognition of the uncertainties associated with calculating groundwater velocities tempered with knowledge of site history.
- Incorporate time limits into regulatory orders and decisions.
- Incorporate time limits into cleanup contracting and funding.

Title: **Separate the Functions of Site Characterization and Monitoring**

Originator: Zemo

Issue Description:

The functions of site characterization and monitoring are often confused.

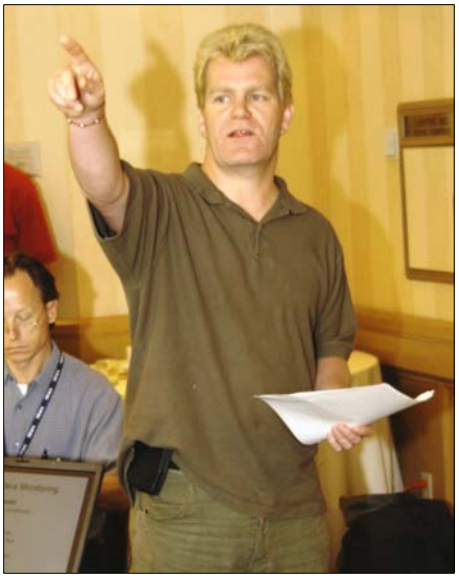
Importance:

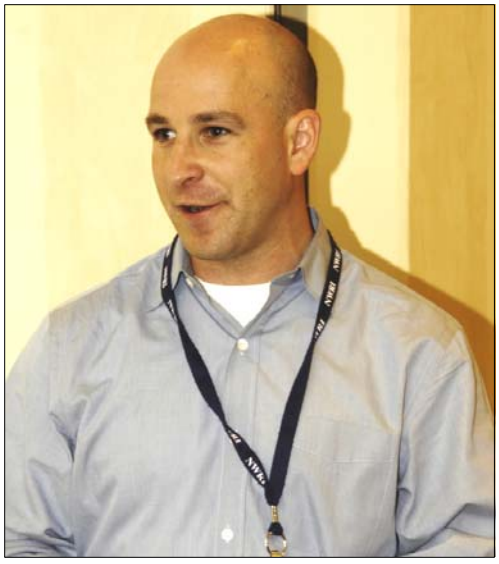
Resources expended on detailed site characterization provide our best understanding of what small-scale site conditions are and provide the basis for designing a monitoring network. Resources expended for long-term monitoring should be focused on generating time-series "representative" data to evaluate risk to receptors.

How Do You Propose Meeting or Complying with This Issue?

Resources could be separated overtly; semantics are important. Encourage relatively dense data density and sophisticated evaluation during characterization, and then agree to where the permanent monitoring wells should be placed (in four-dimensions), based on monitoring risk to receptor.


LUSTOP
Thomas Mohr





PRIORITY 2

The Level of Effort to Monitor Sites Should Correspond to the Magnitude of the Estimated Threat

Originators:

Mohr on behalf of himself, Barnes, Crowley, Drogos, Lapine, and Williams

The following issues were consolidated under the above title:

Title: **The Level of Effort to Monitor Sites Should Correspond to the Magnitude of the Estimated Threat**

Originator: Mohr

Issue Description:

Monitoring costs may sometimes grow to levels that exceed the expected benefit where existing or potential future beneficial uses are not impacted or imminently threatened. Conversely, large impacts that do directly impact or threaten beneficial uses of groundwater may not be sufficiently monitored because the funds and efforts expended are not in step with the magnitude of the threat.

Importance:

Funds used for groundwater contamination investigation and cleanup are limited regardless of its origin. As a society, we cannot bear the cost of redundant or ineffective monitoring programs. The use of funds allocated for monitoring the occurrence and remediation of groundwater contamination should be optimized, so that the most problematic releases are monitored with sufficient detail to provide the resolution needed for effective remediation.

How Do You Propose Meeting or Complying with This Issue?

Where possible, apply a decision support system based on verifiable risks to receptors where cases are determined to be low threat. Monitoring requirements can be relaxed by adjusting monitoring frequency and spatial distribution of monitoring points.

Title: **Estimating Production Well Capture Zone with Site-Specific Data**

Originator: Barnes

Issue Description:

Additional monitoring of well field hydraulics is needed to better understand the three-dimensional flow of groundwater to production wells. The use of monitoring wells or piezometers should be considered to evaluate the hydraulic influence of production wells on aquifers susceptible to groundwater contamination.

Importance:

Understanding the capture zone of, and flow to, a production well will facilitate evaluating the potential risks to the well and can lead to better land-use practices.

How Do You Propose Meeting or Complying with This Issue?

Coordinate with DHS-DWSAP programs or other state agency equivalents mandated by the Clean Water Act.

Title: **Every Site with a UST System Should Be Characterized and the Hazardous Materials Management Plan (HMMP) Should Address Whether the Monitoring System Is Effective to Protect Receptors**

Originator: Crowley

Issue Description:

In California, public water wells are required to perform a vulnerability assessment to identify potentially contaminating activities. Every site with a UST system should be characterized so that the level of threat can be evaluated in the event of a release. The strategy for monitoring any release that occurs should be identified. This site characterization study is especially necessary

for new facilities prior to the permit for the facility being issued. Depending on the threat posed, additional system construction, containment, and monitoring may be required by the permit agency.

Importance:

Helps prevent future problems and allows understanding of the threat posed by the UST facility to water resources in the event of a leak.

How Do You Propose Meeting or Complying with This Issue?

Legislation is needed to require this characterization at new sites, as well as existing ones. This should be a requirement of the facility operating permit and incorporated into HMMP.

Title: **Consider the Effect That a Decision to Stop Pumping a Contaminated Water Supply Well Will Have on a Contaminant Plume**

Originator: Drogos

Issue Description:

Decisions to stop pumping a contaminated water-supply well can allow the plume to move further downgradient, potentially impacting other downgradient water supply wells. Also, ambient vertical flow that may occur in the well once pumping stops can cause contamination to migrate to different aquifers.

Importance:

- Ensure that decisions made to protect one receptor do not cause contamination to other receptors or spread contamination to other aquifers.
- Manage impacted supply wells with the knowledge that the decisions made can have significant repercussions.

How Do You Propose Meeting or Complying with This Issue?

Establish decision-making criteria at fuel release sites that specifically consider the management of water supply wells that are currently impacted or may become impacted in the future.

Title: **Potential Completion of Receptor Exposure Pathways Should Drive All Aspects of Site Characterization and Remedy Selection**

Originator: Lapine

Issue Description:

- Need to prioritize resources.
- Prioritize the protection of human health and the environment; do not leave out of the process.
- Establish the goal of characterization – to understand subsurface conditions enough to quantify risk to receptors and formulate means of protection.

Importance:

We need to acknowledge inherent uncertainties and allocate resources to control them on the basis of risk and not specifically on the management of uncertainty for its own sake.

How Do You Propose Meeting or Complying with This Issue?

Ensure site goals are well defined to protect human health and the environment.

Title: **Temper Policies to Identify "Threatening" Types of Sites (Geographically Based) and Demand Cost Minimization at Other "Less-Threatening" Types of Sites**

Originator: Williams

Issue Description:

- Policies should combine current knowledge of groundwater use to focus environmental restoration activities and encourage cost minimization by reserving active remediation and higher data density to sites inside a sensitive buffer zone.

- Within the well captive zone, an increased standard for tank system construction, monitoring, and response times would be required.

- Outside the well captive zone, normal standards of tank system construction, monitoring, and remedial response times would suffice.

Importance:

- "Near" receptor, response times are critical.

- Costs should be commensurate with threat potential.

- Known cost-effective approaches should be encouraged.

- Regulators should not be ignorant or unresponsive to costs of policies and specific requirements.

- With response times minimized, response actions are minimized.

How Do You Propose Meeting or Complying with This Issue?

Water producers would have to supply capture zone maps identifying UST sites (existing and/or potential) to determine which of these sites deserve increased levels of protection.

PRIORITY 3

Need for Three-Dimensional Site Characterization and Containment Assessment

Originators:

Robbins on behalf of himself, Barnes, Drogos, Einarson, Graves, Nichols, Ririe, Stanin, and Tulloch

The following issues were consolidated under the above title:

Title: **Need for Three-Dimensional Site Characterization and Contaminant Assessment**

Originator: Robbins

Issue Description:

Current site characterization and monitoring efforts rely on monitoring-well data for site characterization and contaminant assessment. Wells typically have screens that are 10 feet in length or longer. Data collected from wells are inherently qualitative because of vertical depth weighted averaging (e.g., head, K, or concentration). Furthermore, efforts to purge and sample wells are problematic. Bailing produces complex recharge and concentration averaging conditions because of variations in water levels achieved during purging. Low-flow sampling may be insufficient to purge the transitional water quality in sand packs. Even in the ideal case, low-flow sampling produces K and depth weighted concentration averaging, and depth weighted K values (i.e., concentrations and K values are a function of the geology in the vicinity of the well). Furthermore, the concentration of contaminants in wells in influenced by vertical-flow conditions.

Importance:

The conditions described above make the use of well data problematic to quantitatively evaluate the fate and transport of petroleum and fuel oxygenate contaminants to determine natural or enhanced biodegradation rates, estimate risks, and use contaminants data for model calibration.

How Do You Propose Meeting or Complying with This Issue?

Installing multilevel samplers for K testing and water-quality sampling should be required instead of wells (with perhaps the exception of locating free product). The tools already are available for cost-effective installations using direct push methods. I suggest more comparison studies be performed to demonstrate to the regulatory community how assessments are enhanced by using multilevel samplers (e.g., Navy and Army Site Characterization and Analysis Penetrometer System, Geoprobe, Solinst, etc.).

Title: **How Does One Determine an Appropriate Vertical Discritization for Estimating Contaminant Mass Flux?**

Originator: Barnes

Issue Description:

Evaluating the potential vulnerability of a production well to dissolved-phase contamination involves many aspects of hydrogeologic assessment. One particular means of assessment that has gained increasing interest is estimating mass flux through the aquifer. There are multiple methods described for estimating mass flux, one being the use of monitoring well transects. A key element in the use of well transects is determining the appropriate vertical discritization of contaminant concentration.

Importance:

To date, screen lengths for monitoring wells are governed by nonsite-specific regulatory guidance and conventional practice. Currently, there is no guidance for optimizing monitoring well screen length for mass flux estimation.

How Do You Propose Meeting or Complying with This Issue?

Develop a programmatic approach that identifies site-specific criteria used for estimating monitoring well screen length. The criteria to be considered fall into categories including, but not limited to, technical issues, cost, and resource availability.

Title: **Cease Installation of Traditional Monitoring Well Networks and Require Transect(s) of Depth-Discrete Monitoring Points to Assess Fuel Release Impacts**

Originator: Drogos

Issue Description:

- Actually implement the new and innovative investigation techniques and technologies described in the numerous guidance documents developed to address oxygenate contamination.

- Eliminate the disconnect between available, proven, and innovative science and the traditional scope of work currently requested by regulators and proposed by consultants.

Importance:

Traditional subsurface investigation techniques and long-screen monitoring well networks do not provide data sufficient to evaluate and make decisions about fuel-release sites.

- Long-screen monitoring wells allow blending and dilution of contaminants yielding a composite groundwater sample that is not representative of the actual subsurface contaminant distribution.

- Traditional monitoring networks do not have the spatial density of monitoring points and consequently miss contamination.

- Source-area sampling stops at the water table missing submerged NAPL source areas.

How Do You Propose Meeting or Complying with This Issue?

- Issue regulatory directives specifying new and innovative investigative techniques and methods.

- Provide training classes that include case studies of fuel-leak site data and scopes of work using innovative characterization and monitoring technologies.

Title: **Take a Minimalist Approach to Groundwater Monitoring; Initially Install a Single Transect of Closely Spaced, Multilevel Monitoring Wells Downgradient from the Smear Zone**

Originator: Einarson

Issue Description:

Spatially distributed "shotgun" arrays of data points are appropriate for contouring surfaces such as dipping beds, water table elevations, etc. However, they are not good for depicting dissolved plumes for the following reasons:

- Dissolved plumes are spatially complex and vertically stratified.
- Spatial variations in plumes are often due to temporal fluctuations in the source term.
- Sparse networks of monitoring wells are very sensitive to the location of the plumes.

A single monitoring transect oriented perpendicular to the groundwater flow direction offers several advantages:

- Is less sensitive to lateral fluctuations in the plume location.
- Shows contaminant distribution more accurately (important for remediation and risk assessment).
- Facilitates estimates of contaminant mass flux and therefore significance of release.
- Shows seasonal and longer-term trends in the sources term if transect is monitored over time.

Importance:

Data from a single transect of closely spaced, multilevel wells allows more accurate definition of the dissolved plume; provides an initial estimate of the significance of the release (i.e., based on the calculated mass flux); and provides more accurate data for designing remediation systems, if remediation is, in fact, needed.

How Do You Propose Meeting or Complying with This Issue?

Need some good showcase sites where benefits of this approach are shown.

Title: **Develop and Advertise Success Stories**

Originator: Einarson

Issue Description:

We know better ways to characterized fuel release sites. But, there is a reluctance to adopt these new approaches at most sites. Current approaches and technologies are "entrenched" due to history ("we've always done it this way"), unclear goals, false economies (e.g., short-term rather than long-term savings), lack of training, outdated guidance documents, poor transfer of knowledge from academic research to practitioners, and even economic disincentives to clean up sites (e.g., state funds)

Importance:

Help is needed to promote better site characterization.

How Do You Propose Meeting or Complying with This Issue?

- Develop and advertise success stories:
  - accelerated site character/SCM
  - monitoring transects
  - flux-based framework
  - streamline reporting
  - bottom line is money saved

- Showcase success stories in technical publications, trade journals (e.g., Lust Line), websites, USEPA and State guidance documents, National Ground Water Association and API training courses, etc.

- Highlight how better site characterization and monitoring can save money in both the short and long term.

Title: **Use Real-time Monitoring Technologies Rather Than Point-in-Time Technologies**

Originator: Graves

Issue Description:

Current practice looks at the subsurface every three months.

Importance:

Real-time continuous data would allow a better understanding of the subsurface and increase the ability to make better decisions.

How Do You Propose Meeting or Complying with This Issue?

Fund a pilot test for real-time monitoring.

Title: **Develop Methods to Adapt Existing Monitoring Wells for Multilevel Sampling That Also Eliminates Vertical Flow**

Originator: Graves

Issue Description:

Current well-monitoring design homogenizes samples, averaging them over the length of the screen. Current designs also allow for ambient flow to occur in wells.

Importance:

Bad data leads to bad decisions.

How Do You Propose Meeting or Complying with This Issue?

Create a climate where innovation is fostered and encouraged.

Title: **Expanded Use of Mass Discharge (Mass Flux) Estimates**

Originator: Nichols

Issue Description:

Point estimates of concentration, by themselves, are a poor metric for assessing threat to water resources and receptors. Combining discrete chemical and hydraulic data to estimate resulting total mass discharge at specific locations within a groundwater plume provides a more useful metric for assessing threat or risk.

Importance:

Application of flow continuity and mass continuity principles promotes development of more rigorous SCMs, more effective evaluation and demonstration of natural attenuation, and better-informed remedy decisions.

How Do You Propose Meeting or Complying with This Issue?

Develop better tools and guidance, especially guidance on minimum data requirements, range of uncertainties, and appropriate consideration of these uncertainties in decision making.

Title: **Acquisition of Vertical Profile Data from Existing Groundwater Monitoring Wells**

Originator: Ririe

Issue Description:

Groundwater data from hydrocarbon-impacted sites is usually collected on a quarterly basis from monitoring wells that are screened over a long interval to accommodate fluctuations in groundwater elevation over time. Thus, the data collected represent a composite sample from the

screened interval. What is lost in this process is the ability to evaluate the spatial distribution of vertical changes in water chemistry associated with the area being evaluated. At many sites, adding oxygen through the vadose zone has a significant impact on the degradation of dissolved hydrocarbons in the upper portions of the groundwater. Documenting this process is not possible with current standard monitoring programs, and thus collecting proper data for plume stability and attenuation parameters is compromised. Plume geometries and evaluations of natural attenuation time frames are not being accurately documented.

How Do You Propose Meeting or Complying with This Issue?

There are several approaches that can be used to address the issue of acquiring vertical profile data in aquifers. For new wells, the options include installing multi-screen intervals in the same well and geoprobe-installed well points. For existing wells, there is the option of acquiring groundwater data from multiple depths by simply introducing a small collection device, such as a stainless steel point with perforations attached to tygon tubing. The sample is then collected into a syringe at the other end of the tubing. The point is lowered into the well, where samples are collected at the top of the water table, then at other appropriate depths within the well screened interval. This technique is appropriate for aquifers with a relatively homogenous geology and relatively high flow rates. However, even if these conditions are not met, there is still the possibility that vertical changes in the aquifer can be documented using this approach.

Title: **Monitoring Networks Should Allow for Assessment at a Variety of Scales and Levels of Bias**

Originator: Stanin

Issue Description:

Monitoring network designs too often are one-dimensional. For example, monitoring points tend to be located from only a biased point of view, or all monitoring points tend to be constructed in the same way, regardless of the purpose of the monitoring point.

Importance:

We think we know where we should be looking, but this is not necessarily true. Also, we think that extremely depth-discrete sampling provides better data, but it is only different data collected at a different scale. How are the data to be used?

How Do You Propose Meeting or Complying with This Issue?

The recommended approach is to define monitoring arrays based on three approaches:

- Spatial grid.
- Random grid.
- Biased grid.

Title: **Use Transects and SCM to Better Understand the Nature of Groundwater Flow**

Originator: Tulloch

Issue Description:

Investigation should begin with continuous cored borings and depth-discrete sampling. Once the direction of groundwater flow and basic geology are understood, transects perpendicular and parallel to groundwater flow should be employed when possible. These transects will better detect and define contamination that may otherwise have gone unseen. Site investigation must be able to answer the following fundamental questions as a part of the SCM:

- What is the real direction of groundwater flow and what causes the flow patterns?
- Does interpreted direction of groundwater flow make sense with the chemical pattern seen from groundwater sampling?
- Are stratigraphic units under a site hydraulically isolated, connected, or leaky?
- How much does the geology affect the transport of the petroleum hydrocarbons?
- How does well construction (given anisotropies and heterogeneities) affect interpretations?
- Are other sources or timing of releases considered, distinguishable, and understood?

Importance:

More emphasis and resources on transect-based investigations and the SCM will lead to savings in investigation, monitoring, and cleanup costs.

How Do You Propose Meeting or Complying with This Issue?

Regulators and consultants should convince responsible parties that initial planning and detailed investigation will ultimately lead to less confusion and quicker decision making and may lead to reduced costs and achieving case closure sooner.

PRIORITY 4

Improve Subsurface Characterization to Better Understand Heterogeneous Subsurface Conditions and Fate and Transport within Different Hydrographic Units

Originators:

Tulloch on behalf of herself, Graves, Robbins, Young, and Zemo

The following issues were consolidated under the above title:

Title: **Improve Subsurface Characterization to Better Understand Heterogeneous Subsurface Conditions and Fate and Transport within Different Hydrographic Units**

Originator: Tulloch

Issue Description:

Environmental monitoring networks, monitoring wells, need to be designed to ensure that continuous and similar hydrographic units are screened across the same unit, regardless of thickness. This is particularly important in two areas that are necessary for proper remediation and risk reduction:

- Ensuring adequate understanding of groundwater gradient and flow.
- Understanding the horizontal and vertical flow of contaminants.

Importance:

Too many site investigations have monitoring wells with screens over several hydrographic units – because the investigator has not adequately characterized the site and believe that the units are interconnected, when they are not. Careful characterization of the site lithology should include continuous core sampling, aquifer testing, and laboratory analysis for all contaminants of concern, so that proper remediation and risk management decisions can be made.

How Do You Propose Meeting or Complying with This Issue?

The education of regulators, the regulated community, and environmental consultants of the importance of the proper understanding of the subsurface fate and transport of contaminants is paramount to properly evaluating and quantifying risk to protect human health and water resources for the future, and investigation and proper site closure.

Title: **Use Continuous Spatial Investigation Techniques Rather Than Point-in-Space Techniques**

Originator: Graves

Issue Description:

Point-in-space techniques (point samples) only give snapshots of the subsurface, rather than a continuous picture; should use CPT, continuous core, E-logs, etc.

Importance:

Point-in-space misleads decision makers.

How Do You Propose Meeting or Complying with This Issue?

Establish better work plans and regulatory directives.

Title: **Application of Tracers for Determining Contaminant Sources**

Originator: Robbins

Issue Description:

Often when contamination is found, there may be more than one possible contamination source. I suggest the use of tracers to help identify sources of contamination. This would require developing techniques for tracer injection or input, and tracer monitoring.

Importance:

Determine responsible party.

How Do You Propose Meeting or Complying with This Issue?

Conduct tracer studies at UST sites.

Title: **Site-Specific Experimental Characterization of Fate and Transport Processes and Associated Heterogeneity**

Originator: Young

Issue Description:

- Few (or no) experimental measurements of key fate and transport parameters are made at most release sites.
- Rates and equilibriums of key transport controlling processes vary by orders of magnitude, sometimes between points on one site.
- Key processes to consider include sorption and biodegradation. "Non-ideal" sorption processes, including desorption resistance, sorption nonlinearity, and competitive sorption, are now documented. Biodegradation rates depend strongly on organism type, population density, and local availability of growth factors.

Importance:

- Risk to groundwater posed by a release of a given magnitude is critically dependent upon subsequent fate and transport processes, yet many of these processes are not directly measured at most sites.
- In an adaptive monitoring framework, the determination of where, when, and how frequently to monitor depend on the plume's exposure to varied fate and transport processes.
- Subsurface heterogeneity is handled badly or ignored in most fate and transport modeling, while we know that retention in fine-grained material is an important cause of tailing, for example.

How Do You Propose Meeting or Complying with This Issue?

- Develop guidance and standard procedures for experimental assessment of fate and transport processes on a site-specific basis.

- Through modeling and experiment, assess the impact of varying degrees of heterogeneity in fate and transport model parameters on predicted groundwater impacts.

Title: **Samples for Mass Flux/Fate and Transport Should Be Collected Downgradient of Smear Zones**

Originator: Zemo

Issue Description:

There is interference in many data sets by non-dissolved components, and it is not recognized by data users. Sheens are sometimes sampled, and discrete constituents are at concentrations exceeding their effective solubility for fresh or weathered product.

Importance:

The concentrations are not representative of dissolved phase and provide erroneous inputs to calculations/models.

How Do You Propose Meeting or Complying with This Issue?

Either sample immediately downgradient of the smear (source) zone or use alternative sampling methods, such as passive diffusion samplers, within the smear zone.

PRIORITY 5

Validation of Low-Cost Investigation and Monitoring Techniques

Originators:

McHugh on behalf of himself, Einarson, England, and Robbins

The following issues were consolidated under the above title:

Title: **Validation of Low-Cost Site Investigation and Monitoring Methods**

Originator: McHugh

Issue Description:

A number of low-cost site investigation and monitoring methods have been developed in recent years. However, many of these methods are not widely applied at corrective-action sites due to a lack of adequate validation or regulatory acceptance.

Examples of new investigation and monitoring technologies include:

- Small-diameter monitoring wells installed using direct push technology.
- Passive diffusion samples.
- Adsorbent samplers.

Both validation and technology transfer programs are needed to ensure that effective new technologies are adopted and accepted.

Importance:

Investigation and remediation of petroleum and fuel oxygenate sites have been slowed by limited funds available from responsible parties and state insurance funds. Use of lower-cost site investigation and monitoring methods will allow for better characterization of these sites without increasing total investigation costs.

How Do You Propose Meeting or Complying with This Issue?

Validation and technology transfer can be facilitated by existing national stakeholder groups that address multiple issues, such as the Interstate Technology Regulatory Council, or specially formed advocacy groups, such as PIRI, for the promotion of risk assessment.

Title: **Focus on Collecting More Accurate Raw Data, Not Just Better Data from Flawed Monitoring Devices (e.g., Conventional Long-Screened Monitoring Wells)**

Originator: Einarson

Issue Description:

- "You cannot make a silk purse out of a sow's ear."
- There is a need to focus on what is in an aquifer and not in a well. A lot of attention is recently placed on collecting depth-discrete data from existing wells (e.g., passive diffusion bag samplers, vertical profilers, bomb samples, pressurized bailers, etc.).
- That may be a great way of finding out what is in a monitoring well but may provide little information about what is in the aquifer. This is due to the ambient vertical flow (and attendant redistribution of contaminants) in conventional monitoring wells (e.g., one study recorded ambient vertical flow in 70 percent of the wells tested).
- Do not judge the accuracy of new devices by comparing the results to wells that we know have strong biases.

Importance:

Sound decisions cannot be made on inaccurate data.

How Do You Propose Meeting or Complying with This Issue?

- Test devices in a controlled environment, with a goal of defining what is in the aquifer, not in a monitoring well. The complexity of contaminant distribution at real sites makes field tests of new technologies generally inconclusive.

- Suggest testing devices in a more controlled environment (e.g., field laboratories like those that exist at Oregon Graduate Institute or Canadian Forces Base Borden).

Title: **Groundwater Sample Collection Consistency**

Originator: England

Issue Description:

Lack of consistency in collection of groundwater samples:

- Some with purge; some with no purge.

- Some purge with vacuum trucks; some with bailers, some with electric, downhole pumps; some with peristaltic pumps.

Have studies been done of how these compare? What is more reliable?

Importance:

How do we compare results from different collection methods at same or nearby sites?

How Do You Propose Meeting or Complying with This Issue?

Need standardization or study to show that results are equivalent.

Title: **Use of Time Series Geophysical Methods for Monitoring**

Originator: Robbins

Issue Description:

Geophysical methods offer a means not only to improve our understanding of subsurface geological conditions but also to evaluate changes in water quality conditions through time series sampling. Given the relation of hydrocarbon contamination with other water-quality parameters, such as total dissolved solids and geophysical methods (e.g., resistivity, electrophoretic mobility), these methods provide a means to spatially extend data, monitor the effectiveness of remediation, and assess conditions that may influence contaminant migration direction and rate.

Importance:

Provide more information for interpreting contaminant conditions and remediation.

How Do You Propose Meeting or Complying with This Issue?

Perform geophysical surveys at sites and correlate with site data.

PRIORITY 6

Support Better Decision Making by More Effective Communication and Interpretation of Monitoring Data

Originators:

Small on behalf of himself, England, Nichols, Stanin, and Tulloch

The following issues were consolidated under the above title:

Title: **Support Better Decision Making by More Effective Communication and Interpretation of Monitoring Data**

Originator: Small

Issue Description:

Many participants here today are proposing to dramatically increase the density of monitoring points – vertically, horizontally, and temporally. This will create an avalanche of data. However, regulators are already having trouble reviewing the quantity of data currently being submitted. Therefore, it is key to communicate monitoring data in a way that allows rapid assimilation and interpretation for decision making.

Importance:

- If we are going to spend resources to collect data, it should be used in the decision-making process.

- A clear, concise presentation of data and data interpretation allows more stakeholders to understand the issues and participate in decisions.

How Do You Propose Meeting or Complying with This Issue?

- Present a graphical representation and summary of data, including a clear indication of areas with uncertainty or no data.
- Include a clear, concise, decision-based written interpretation of data in reports.
- Encourage stakeholders to work together to create meaningful ways for communicating and interpreting data.
- Collect data to support specific decisions or questions.
- Ensure that the data is of sufficient quality to communicate.

Title: **Minimize Institutional Constraints**

Originator: England

Issue Description:

- *Oil Companies*: The oil companies are in business to make profits. One way to improve profits is to cut costs. With respect to environmental issues, the result is that consultants are squeezed to provide services at the lowest costs possible, while still surviving. The oil companies are also concerned about controlling short-term cash flow. In some cases, it is preferable to continue paying a routine quarterly monitoring and reporting cost than to aggressively investigate a release and bring it to closure.
- *Consultants*: Consultants are also in business to make profits. In order to perform the necessary services at a low cost, consultants have to resort to using junior staff as much as possible to produce cookie-cutter work plans and carry out site investigations unimaginably. There is little site-specific planning and evaluation of data, because the consultant cannot afford to use senior staff necessary to do this effectively. Also, it is rare to use data from nearby sites, even though this may significantly improve the understanding of groundwater conditions.

  A lack of standardization in certain field practices also makes it difficult to evaluate data. For example, some groundwater samples are collected after purging the wells; some are collected without purging. Purging is sometimes used with a vacuum truck (not allowed by some counties), sometimes with a bailer, sometimes with an electric Grundofs pump, sometimes with another pump. This creates confusion in evaluating data.

- *Regulators*: Some regulatory agencies are overloaded; some have people who are not specially trained in the field. There is a lack of consistency in how sites are managed by the agencies. It seems that often agency staff will approve an action if it has the appearance of making progress, even if little or no true progress is made toward understanding and remedying a release.

Importance:

Meaningful investigations and data interpretation are required to define and resolve the issues. This issue is of greatest importance to high-priority sites.

How Do You Propose Meeting or Complying with This Issue?

This is the hard part. It depends on getting top-level people together from the oil company's environmental management, consultants, and regulators to establish a protocol for dealing with high-priority sites. Oil companies have to provide budgets for the properly qualified people to address the important technical issues.

Title: **More Effective Use of Inorganic Geochemical Data to Interpret Subsurface Conditions**

Originator: Nichols

Issue Description:

The transport and fate of petroleum hydrocarbons and fuel oxygenates are highly dependent on redox poise and electron acceptor availability within the subsurface. Many practitioners and regulators are challenged in the interpretation of this type of data. Users who are accustomed to comparing chemical concentrations with "bright line" regulatory limits often find it difficult to interpret data whose value more often lies in its spatial patterns and its relationship with other data, rather than in the absolute concentration at any given location.

Importance:

Careful collection and analysis of geochemical data can help assess the potential for biodegradation; can explain observed patterns in concentration of fuel hydrocarbons and oxygenates; and can help confirm whether monitoring locations are appropriately located (e.g., in the likely path of the plume or outside the path of the plume).

How Do You Propose Meeting or Complying with This Issue?

- Develop better tools and guidance. Educate users to become more skilled in interpreting multiple data sets (e.g., organic and inorganic chemical data, hydraulic data, and geologic data).

- Encourage data evaluators to develop, honestly communicate, and test multiple working hypotheses that may explain the observed spatial and temporal patterns in the data.

Title: **Protecting Drinking-Water Wells by Incorporating Expressions of Uncertainty in the Prediction of Timing and Magnitude of Impacts**

Originator: Stanin

Issue Description:

Innovative methods for predicting a future contaminant concentration in a pumping water-supply well include estimates of contaminant mass discharge at one or more portions of the impacted aquifers. These estimates require knowledge of:

- The three-dimensional extent of the pumping well's capture zone and its pumping rate/history.

- The three-dimensional magnitude and extent of the contaminant plume.

- The physical parameters of the aquifer.

Subsurface complexities, such as physical and chemical heterogeneities, increase the level of uncertainty in the reliability and accuracy of current measurement techniques for the mass discharge metric. Ways to address these uncertainties need to be investigated (i.e., expressing the prediction in terms of uncertainty and/or improving measurement methods of the mass discharge metric).

Importance:

The prediction of the timing and ultimate magnitude of a contaminant impacting a water-supply well will affect risk management and abatement strategies. The choices of such strategies will vary in costs (e.g., to the responsible parties, water purveyor, and consumer), public acceptability, and technical practicability. Thus, realistic forecasting, incorporating uncertainties inherent in required measurement methods, will improve response actions.

How Do You Propose Meeting or Complying with This Issue?

- Review the current mass discharge estimation methods:
  - characterization along transects
  - integral pumping tests
  - borehole flux meters

- Identify components of each that have inherent uncertainties.

- Quantify levels of uncertainties and their potential synergistic effects.

- Develop methods for incorporating the uncertainties into the predictions (including methods of communication).

Title: **Discriminate Metrics of Performance Monitoring from Metrics of Success**

Originator: Stanin

Issue Description:

The performance of a remedial measure and the measurement of that performance by monitoring are too often used as measures of success. An extreme example includes insertion of an oxygen release compound sock in a monitoring well, where performance is good in lowering a fuel contaminant concentration in a well but is not successful in remediating an aquifer.

Importance:

The importance lies in the performance data misleading stakeholders into believing that remedial efforts are actually resulting in cleanup to typical low requirements, such as drinking-water standards. This can also be used as rationale to waste money on impractical clean-up efforts. Technical impracticality is an underutilized strategy.

How Do You Propose Meeting or Complying with This Issue?

- Identify all metrics used or possible for all classes of remedial technologies.

- Identify those appropriate for integration into a measurement of success (e.g., mass discharge metrics versus point-measurement metrics).

Title: **Employ an Approach Similar to the USEPA Triad Investigation at Sites Where Stakeholders Identify the Goals and Approach of Expedited Site Assessment**

Originator: Tulloch

Issue Description:

The Triad approach involves agreement of goals of investigation and cleanup needs and employs an evergreen workplan. Site investigation begins with qualitative field investigation tools, such as soil gas surveys, membrane interface probes and CPT to characterize source area conditions and lithologic conditions. This data is used to update the SCM and plan for further investigation. Using this approach captures subsurface data which is relayed to the decision makers on a daily basis and enables the investigator to alter the investigation plan in real time to meet the agreed upon goals of site characterization.

Importance:

Expedited site assessment conducted without upfront agreement of the site investigation approach and goals between stakeholders can result in a waste of money and investigation resources. The Triad approach ensures an agreed upon approach so that proper remediation and risk management decisions can be made.

How Do You Propose Meeting or Complying with This Issue?

USEPA to provide increased training and education of the Triad approach and document field successes.

PRIORITY 7

Select Target Constituents to Properly Evaluate Petroleum and Fuel Oxygenate Contaminants in Groundwater

Originators:

Stanin on behalf of himself, Dorn, Kolhatkar, Mohr, Nichols, Robbins, and Zemo

The following issues were consolidated under the above title:

Title: **Select Proper Target Constituents to Properly Evaluate Petroleum and Fuel Oxygenate Contaminants in Groundwater**

Originator: Stanin

Issue Description:

The target constituents for overall fate and transport assessment should be able to address at least four potential concerns:

- To protect drinking water supplies.
- To provide information on potential sources.
- To provide information on fate and transport.
- To provide information on potential future contaminants of concern.

A constituent may exist in more than one of these categories.

Importance:

Compliance with this issue will provide a more complete, holistic assessment of the major known and potential concerns that will lead to better decision making.

How Do You Propose Meeting or Complying with This Issue?

Investigate all four concerns by identifying all possible constituents corresponding to each concern for major fuel types.

Title: **Add or Increase Analysis of PAHs in Subsurface Monitoring**

Originator: Dorn

Issue Description:

In the future, the environmental community will need to consider human health impacts and water resource impacts from pollution sources containing PAHs. The impacts, or potential impacts, are unknown until measured. The current state of most investigations does not include PAH analysis; therefore, case closures will be delayed without full analyses of the risks.

Importance:

Closures can be questioned, and possibly reopened, by the public or regulators if the risk associated with PAHs is not addressed.

How Do You Propose Meeting or Complying with This Issue?

Regulators must require that the analyses of all constituents of concern are addressed in all phases of an investigation.

Title: **Judicious Use of Compound-Specific Isotope Analysis (CSIA) to Better Understand Biotransformation of MTBE and TBA**

Originator: Kolhatkar

Issue Description:

- Recent studies have demonstrated the use of CSIA of MTBE as a cost-effective indicator of MTBE biotransformation.
- However, the knowledge base remains fairly limited (few academia and some regulatory agencies).

Importance:

- Natural attenuation demonstration of MTBE and tertiary-butyl alcohol (TBA) biodegradation in groundwater is critical to rely on monitored natural attenuation as a site remedy (or devise biological enhancements).
- A number of sites can be closed if it is recognized that the natural biotransformation of MTBE is more widespread than perceived.

How Do You Propose Meeting or Complying with This Issue?

- Advocacy for wider regulatory acceptance of CSIA as a Tier-III indicator parameter for MTBE (and TBA).
- API and USEPA-Office of Research and Development have ongoing projects to describe use of CSIA and data interpretation.

Title: **Include at Least One Scan for Chlorinated Aliphatics**

Originator: Mohr

Issue Description:

Fuel leaks often occur at sites where automotive maintenance was performed. Also, checking for highly volatile organic compounds (HVOCs) may reveal solvents from nearby solvent release sites.

Importance:

The overall goal of regulations driving monitoring for investigation and cleanup is groundwater protection. Where funds are expended toward this goal, the potential impacts of multiple contaminants should be investigated by analyzing for a broader analytical suite at least once.

How Do You Propose Meeting or Complying with This Issue?

- Encourage full reporting of GC-MS results, including HVOCs and tentatively identified compounds.
- Discourage limiting reports to BTEX/oxygenate results when a longer list of analytes can be produced at no additional cost.

Title: **More Effective Use of Inorganic Geochemical Data to Interpret Subsurface Conditions**

Originator: Nichols

Issue Description:

The transport and fate of petroleum hydrocarbons and fuel oxygenates are highly dependent on redox poise and electron acceptor availability within the subsurface. Many practitioners and regulators are challenged in the interpretation of this type of data. Users who are accustomed to comparing chemical concentrations with "bright line" regulatory limits often find it difficult to

interpret data whose value more often lies in its spatial patterns and its relationship with other data, rather than in the absolute concentration at any given location.

Importance:

Careful collection and analysis of geochemical data can help assess the potential for biodegradation; can explain observed patterns in concentration of fuel hydrocarbons and oxygenates; and can help confirm whether monitoring locations are appropriately located (e.g., in the likely path of the plume or outside the path of the plume).

How Do You Propose Meeting or Complying with This Issue?

- Develop better tools and guidance. Educate users to become more skilled in interpreting multiple data sets (e.g., organic and inorganic chemical data, hydraulic data, and geologic data).

- Encourage data evaluators to develop, honestly communicate, and test multiple working hypotheses that may explain the observed spatial and temporal patterns in the data.

Title: **Application of Tracers for Determining Contaminant Sources**

Originator: Robbins

Issue Description:

Often when contamination is found, there may be more than one possible contamination source. I suggest the use of tracers to help identify sources of contamination. This would require developing techniques for tracer injection or input, and tracer monitoring.

Importance:

Determine responsible party.

How Do You Propose Meeting or Complying with This Issue?

Conduct tracer studies at UST sites.

Title: **Develop a Comprehensive Constituent-Specific Analyte List for Fuel/Oxygenate Releases and Do Not Require Total Petroleum Hydrocarbons (TPH) Analyses**

Originator: Zemo

Issue Description:

High-quality, constituent-specific GC-MS data is the best tool we have to assess dissolved concentrations. TPH is vastly inferior in both accuracy and precision and requires sophisticated interpretation.

Importance:

TPH adds virtually no significant value to decision making about impact or risk and conversely can waste resources.

How Do You Propose Meeting or Complying with This Issue?

- Summarize available research on dissolved phase constituents from various crudes and products, including biodegradation byproducts that are of concern.

- Summarize available target analyte lists from states.

PRIORITY 8

Need a National Research Strategy and Program for Subsurface Monitoring, Investigation, and Cleanup of Contaminated Sites

Originators:

Crowley on behalf of himself, McHugh, and Drogos

The following issues were consolidated under the above title:

Title: **Need National Research Strategy and Program for Subsurface Monitoring, Investigation, and Cleanup of Contaminated Sites**

Originator: Crowley

Issue Description:

Research needs to be coordinated and national/state research priorities need to be identified so we can best leverage research funds to answer public health, water resources, cost effectiveness, and new technology issues.

Importance:

This will help us to agree on what our research issues are and the priority for addressing these issues. Coordination and increased knowledge will help us all avoid redundant research and develop synergies on key issues. Benefits would be monumental at all levels.

How Do You Propose Meeting or Complying with This Issue?

- Establish a new program/forum for coordinating research at the national level. Effective public outreach efforts tied to issue development and priority setting should involve all stakeholders. This process and program should be visible to all.

- Set up a website to allow people to become involved and participate in meetings.

- Need legislation.

Title: **Better Use Intensively Investigated Research Sites**

Originator: McHugh

Issue Description:

The basic fate and transport processes that control the movement of constituents are the same at all sites. The understanding gained from intensive investigation of research sites should be applied to corrective-action sites in order to minimize the amount of site-specific information needed to fully understand fate and transport.

For example, the impact of subsurface heterogeneity on contaminant fate and transport may not need to be evaluated at every corrective-action site. By obtaining a better general understanding to how the three-dimensional distribution of contaminants impacts fate and transport, we may be able to effectively manage corrective-action sites without obtaining a site-specific understanding of the three-dimensional distribution at each specific site.

Importance:

The generation of site data is very expensive. Many questions about contaminant fate and transport can be answered with a reasonable degree of certainty by using knowledge gained from other sites. By better using knowledge gained from research sites, site-specific data collection efforts can be better focused to answer site-specific questions.

How Do You Propose Meeting or Complying with This Issue?

Regulators and industry should fund the intensive investigation of research sites in order to improve our understanding of fate and transport processes likely to be broadly applicable to corrective-action sites. Research results must be communicated to the regulators and consultants so that lessons can be applied to corrective-action sites.

Title: **Perform a "Post Mortem" of the 1998 California Report to the Governor Where Widespread MTBE Impacts to California Water Supply Wells Were Predicted**

Originator: Drogos

Issue Description:

The above referenced report predicted that there would be many more impacts to water supply wells in California today than have been detected so far. What is the reason for this discrepancy?

Importance:

Performing a critical review of the Governor's report will allow us to make more accurate predictions of future impacts to water supply wells in the future. Estimates of potential future impacts of TBA on water-supply wells are beginning to be made, so lessons learned from this post mortem would assist in better predicting risks to supply units posed by TBA and other contaminants.

How Do You Propose Meeting or Complying with This Issue?

Bring in a team of experts consisting of professors and researchers from multiple institutions to perform the review.


Kevin Graves

PRIORITY 9

Federal, State, and Local Government Programs/Agencies Need Radical Restructuring; Legislative Changes Are Needed to Improve Programs

Originators:

Crowley on behalf of himself and Lapine

The following issues were consolidated under the above title:

Title: **Federal, State, and Local Government Programs/Agencies Need Radical Restructuring; Legislative Changes Are Needed to Improve Programs**

Originator: Crowley

Issue Description:

Major inefficiencies exist in current regulatory programs. Regulatory staff that are well trained and experts in their fields can properly guide the regulated community through the regulatory process, thus saving all of us and our community much needed dollars. Our regulatory programs need to evolve to address the concerns of all stakeholders.

Importance:

We need to take a step back and look at what we are doing as a society. Although our environmental programs are good, these can be improved, and cost savings can be significant. Industry, government, and environmental organizations can come together to address all our interests and costs effectively.

How Do You Propose Meeting or Complying with This Issue?

We need a multistakeholder "Think Tank" that is supported by the public and that can develop consensus on improvements and changes needed in federal, state, and local programs, as well as the overall regulatory process. Government regulators and consultants invested in the current status quo should not be allowed to hijack our ability to change.

Title: **How Do You Apply Innovative Best Practices for Site Characterization and Remedy Selection in a Prescriptive Regulatory Environment?**

Originator: Lapine

Issue Description:

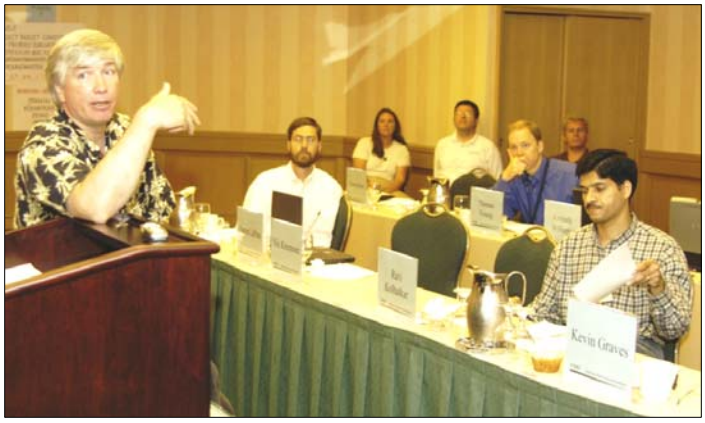
The rate of regulatory promulgation cannot keep up with the rate of scientific discovery.

Importance:

The policies need to be challenged to apply good innovative science.

How Do You Propose Meeting or Complying with This Issue?

It is necessary to insert flexibility into regulations, both federally and locally, to allow for innovation.



PRIORITY 10

Develop and Advertise Success Stories

Originators:

Einarson on behalf of himself and Graves

The following issues were consolidated under the above title:

Title: **Develop and Advertise Success Stories**

Originator: Einarson

Issue Description:

We know better ways to characterized fuel release sites. But, there is a reluctance to adopt these new approaches at most sites. Current approaches and technologies are "entrenched" due to history ("we've always done it this way"), unclear goals, false economies (e.g., short-term rather than long-term savings), lack of training, outdated guidance documents, poor transfer of knowledge from academic research to practitioners, and even economic disincentives to clean up sites (e.g., state funds)

Importance:

Help is needed to promote better site characterization.

How Do You Propose Meeting or Complying with This Issue?

- Develop and advertise success stories:
  - accelerated site character/SCM
  - monitoring transects
  - flux-based framework
  - streamline reporting
  - bottom line is money saved

- Showcase success stories in technical publications, trade journals (e.g., Lust Line), websites, USEPA and State guidance documents, National Ground Water Association and API training courses, etc.

- Highlight how better site characterization and monitoring can save money in both the short and long term.

Title: **Provide More and Better Continuing Education for Stakeholders (Required for Geologists and Engineers)**

Originator: Graves

Issue Description:

Different parties to environmental decisions often have different understandings of fate and transport principles as well as different understandings of the range of policy interpretation available.

Importance:

- Environmental decisions involve high costs.

- Environmental activities should have the least detrimental effect on society as possible.

How Do You Propose Meeting or Complying with This Issue?

Organizations should provide training on various topics available to a wide range of participants.

PRIORITY 11

Assess the Total Risk of Exposure to Multiple Contaminants by Multiple Pathways

Originators:

Mohr on behalf of himself, Rong, and Young

The following issues were consolidated under the above title:

Title: **Assess the Total Risk of Exposure to Multiple Contaminants by Multiplying Pathways**

Originator: Mohr

Issue Description:

The synergistic toxic effects of multiple contaminants are unknown but may be more than additives. Where no toxic effects can be produced from the whole suite of contaminants or the most mobile fraction, the benefits of remediation may be minimal. However, multicontaminant cell line testing may show toxicity where risk analysis of single contaminants did not. Knowledge of the total risk can guide better decisions on the degree of monitoring and remediation needed to protect resources.

Importance:

- Current approaches are susceptible to overestimating risk leading to unnecessary expense.
- Current approaches may also underestimate risk where toxicity of multiple contaminants is greater than the sum of individual contaminants.

How Do You Propose Meeting or Complying with This Issue?

This approach is in the research realm. Research needs to be completed in order to better understand the total toxicity of multiple contaminants at the concentration expected in the most sensitive potential receptors (e.g., a private well). Research must also include the total exposure of consumers by all routes, including ambient air.

Title: **Monitoring Soil Gas Phase Fate and Transport in the Vadose Zone**

Originator: Rong

Issue Description:

A question has been brought to light by the indoor air intrusion issues.

Importance:

In cases where there is no standard protocol for soil gas sampling, people use soil gas sampling, model prediction, soil gas flux chambers, ambient air samples, etc.

How Do You Propose Meeting or Complying with This Issue?

Develop a protocol for soil gas sampling.

Title: **Improved Understanding of the Impact of Vapor-Phase Contaminant Releases of Groundwater Quality**

Originator: Young

Issue Description:

- Recent studies have documented that vapor releases of motor vehicle fuels from USTs are widespread (approximately 60 percent of sites) and, in some instances, produce high leak rates.

- Limited modeling efforts have attempted to assess the groundwater quality impacts of these releases, which span a wide range of sizes.

Importance:

- Vapor-phase releases far outnumbered liquid-phase releases in a stratified random sample of California UST systems.

- Several vapor-phase releases exceeded USEPA standards for a minimum-detectable release (0.1 gallons/hour), some by more than an order of magnitude.

- Our ability to predict the groundwater impacts of such releases is limited, especially since coupled vadose/saturated zone models are not well developed.

How Do You Propose Meeting or Complying with This Issue?

- Conduct experimental field studies of vapor-phase release impacts on groundwater using appropriate partitioning tracer compounds.

- Improve coupled vadose/saturated zone fate and transport models. Validate the models using data collected in field studies.

PRIORITY 12

Monitor from the Perspective of the Receptor

Originators:

Mohr on behalf of himself and Stanin

The following issues were consolidated under the above title:

Title: **Monitor from the Perspective of the Receptor**

Originator: Mohr

Issue Description:

Where multiple contaminant releases threaten a single receptor (e.g., an existing supply well), the level of effort needed to characterize, monitor, and remediate a new case can be weighed against existing damage. Contrasting the severity of multiple impacts allows more judicious decisions for monitoring requirements and may allow identification of synergies in remedial strategies. Similarly, if a release is within the zone of contribution to a well already contaminated by other pollutants, the evaluation framework may shift to allow more flexible decisions.

Importance:

If a new petroleum/oxygenate is found upgradient of a more problematic solvent plume, funds expended to remediate the petroleum/oxygenate plume may show little benefit. Managing multiple impacts within a wellhead protection zone together permits regulators and water purveyors to develop remedial strategies that look beyond the single release case as the basic unit of regulatory scrutiny.

How Do You Propose Meeting or Complying with This Issue?

Presently, responsible parties must perform searches for drinking-water wells and vertical conduits. These searches could be expanded to include other known or potential contaminant releases that may threaten beneficial uses. Knowledge of all potential or known threats can help devise an appropriate monitoring regimen. This approach should also seek to address the synergistic toxic effects of multiple contaminants in commingled plumes.

Title: **Protecting Drinking-Water Wells by Incorporating Expressions of Uncertainty in the Prediction of Timing and Magnitude of Impacts**

Originator: Stanin

Issue Description:

Innovative methods for predicting a future contaminant concentration in a pumping water-supply well include estimates of contaminant mass discharge at one or more portions of the impacted aquifers. These estimates require knowledge of:

- The three-dimensional extent of the pumping well's capture zone and its pumping rate/history.
- The three-dimensional magnitude and extent of the contaminant plume.
- The physical parameters of the aquifer.

Subsurface complexities, such as physical and chemical heterogeneities, increase the level of uncertainty in the reliability and accuracy of current measurement techniques for the mass discharge metric. Ways to address these uncertainties need to be investigated (i.e., expressing the prediction in terms of uncertainty and/or improving measurement methods of the mass discharge metric).

Importance:

The prediction of the timing and ultimate magnitude of a contaminant impacting a water-supply well will affect risk management and abatement strategies. The choices of such strategies will vary in costs (e.g., to the responsible parties, water purveyor, and consumer), public acceptability, and technical practicability. Thus, realistic forecasting, incorporating uncertainties inherent in required measurement methods, will improve response actions.

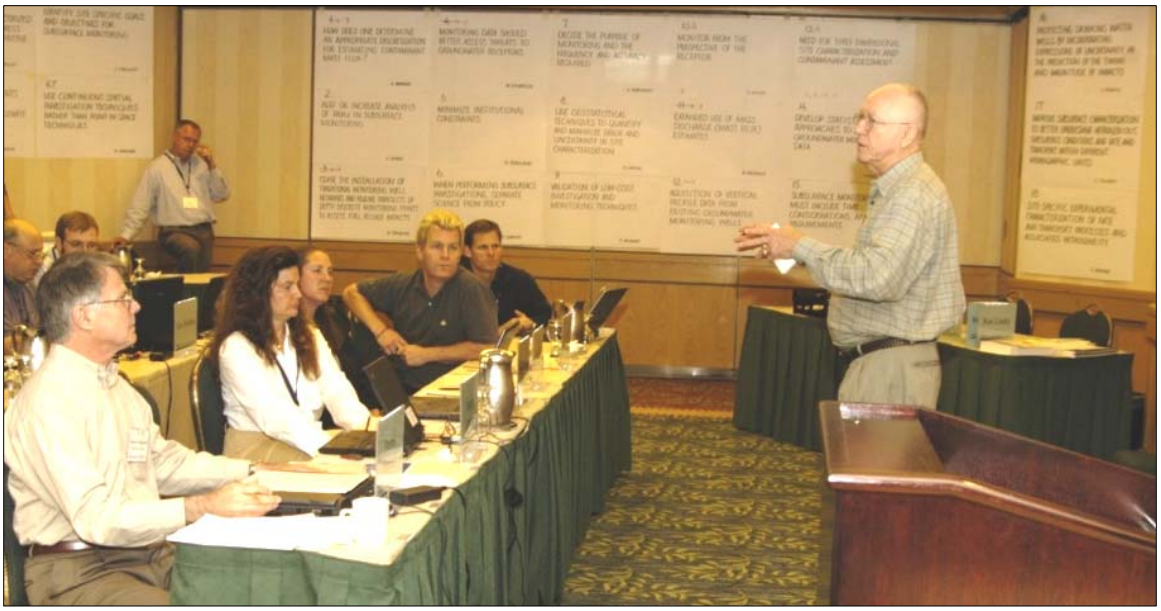
How Do You Propose Meeting or Complying with This Issue?

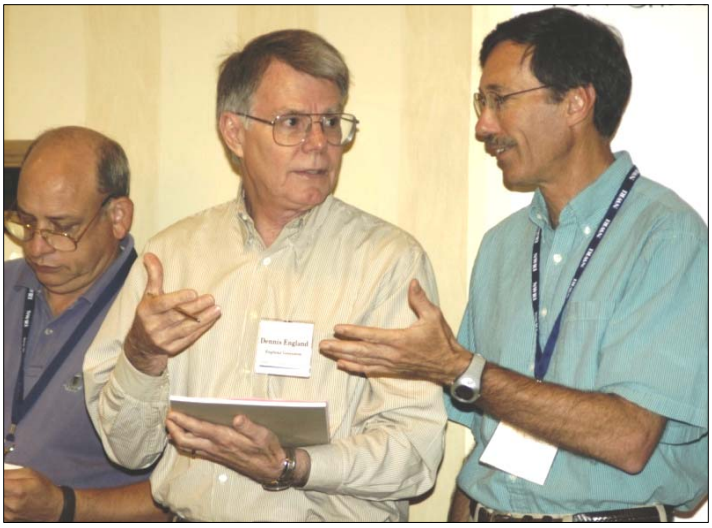
- Review the current mass discharge estimation methods:
  - characterization along transects
  - integral pumping tests
  - borehole flux meters

- Identify components of each that have inherent uncertainties.

- Quantify levels of uncertainties and their potential synergistic effects.

- Develop methods for incorporating the uncertainties into the predictions (including methods of communication).




Dennis England


MOHR
BARNES
WILLIAMS
MCHUGH
EINARSON
ENGLAND

PRIORITY 13

Make Monitoring Data from Regulatory Agencies Easily Accessible in Electronic Format for Use in Characterization of Nearby Sites

Originators:

England on behalf of himself, Mohr, and Ririe

The following issues were consolidated under the above title:

Title: **Use Monitoring Data from Nearby Sites**

Originator: England

Issue Description:

Site characterization is often based only on site-specific data. In many cases, there are nearby sites with groundwater data that are not used.

Importance:

Gives a better understanding of the local conditions and groundwater flow rate and direction.

How Do You Propose Meeting or Complying with This Issue?

Make use of monitoring data from nearby sites.

Title: **Include at Least One Scan for Chlorinated Aliphatics**

Originator: Mohr

Issue Description:

Fuel leaks often occur at sites where automotive maintenance was performed. Also, checking for highly volatile organic compounds (HVOCs) may reveal solvents from nearby solvent release sites.

Importance:

The overall goal of regulations driving monitoring for investigation and cleanup is groundwater protection. Where funds are expended toward this goal, the potential impacts of multiple contaminants should be investigated by analyzing for a broader analytical suite at least once.

How Do You Propose Meeting or Complying with This Issue?

- Encourage full reporting of GC-MS results, including HVOCs and tentatively identified compounds.
- Discourage limiting reports to BTEX/oxygenate results when a longer list of analytes can be produced at no additional cost.

Title: **Monitoring Data from Each Agency Is Readily Available in an Easily Accessible Format**

Originator: Ririe

Issue Description:

In order to accurately determine the current aquifer conditions and to predict the fate and transport of contaminants, it is necessary to have proper data. Currently, it is not easy to acquire data from nearby sites in order to properly evaluate area-wide conditions.

Importance:

Having all data available in an easily accessible form is important in order to prioritize monetary and human resources.

How Do You Propose Meeting or Complying with This Issue?

All data are generated in electronic form but rarely is there available any electronic database available for any specific area. Require each agency to prepare an electronic database of all their groundwater monitoring data.

PRIORITY 14

Statistics for Data Analysis in Site Characterization

Originators:

Lapine on behalf of himself and Rong

The following issues were consolidated under the above title:

Title: **Use Geostatistical Techniques to Quantify and Minimize Error and Uncertainty in Site Characterization**

Originator: Lapine

Issue Description:

Too often during the investigation phase of a project, insufficient time and effort are focused on answering three questions paramount to good decision making:

- How many samples should we take?
- Where do we collect them?
- How confident are we that we know how much is there?

Importance:

You have to know the problem to evaluate it. Geostatistical techniques, such as the kriging suite, provide a mechanism to quantify and assess how well a site is characterized by acknowledging that a correlation exists between samples.

How Do You Propose Meeting or Complying with This Issue?

Use kriging methods to optimize monitoring networks and quantify errors inherent in the monitoring network to benefit the overall decision-making process.

Title: **Develop Statistical Approaches to Evaluate Groundwater Monitoring Data**

Originator: Rong

Issue Description:

Many sites have a long history of monitoring data that have not really been evaluated in terms of trend or characteristics of the sites.

Importance:

- Use data effectively.
- Make data worthwhile.

How Do You Propose Meeting or Complying with This Issue?

- Compile statistical methods and evaluate the applications of these methods.
- Develop guidelines.

PRIORITY 15

Separate Science from Policy When Performing Subsurface Investigations

Originators:

Graves on behalf of himself and Kremesec

The following issues were consolidated under the above title:

Title: **Separate Science from Policy When Performing Subsurface Investigations**

Originator: Graves

Issue Description:

The fate and transport of contaminants is driven by the physical principles of the world. Often, a political or social agenda clouds the interpretation of data.

Importance:

Advocates for a particular point of view often try to manipulate scientific data to conform to their point of view. Decisions then become biased and do not reflect physical reality.

How Do You Propose Meeting or Complying with This Issue?

We should all be willing to say, "The emperor has no clothes."

Title: **Identify Policies, Goal Setting, and Technical Issues to Move Workshop Results Forward**

Originator: Kremesec

Issue Description:

An important question is, "How do we make use of the results of this workshop?"

Importance:

Technical and policy changes will likely be put forward by the workshop. These need to be separated so results and ideas can be targeted to the appropriate individuals in government, consulting firms, and industry.

How Do You Propose Meeting or Complying with This Issue?

Develop appropriate messages.

PRIORITY 16

Use Thousands of Small, Private Wells as a Statewide Monitoring Network to Assess Regional Groundwater Quality

Originator:

Drogos

Issue Description:

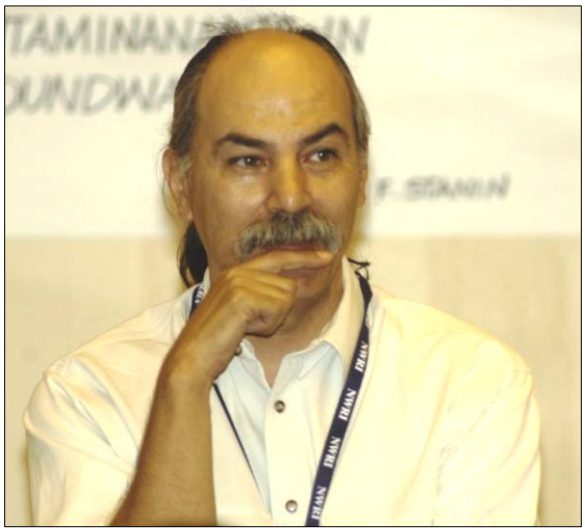
- Collect groundwater data in areas where little data is currently available by monitoring and sampling small domestic and irrigation wells.
- Identify previously unknown contamination; potential to provide an early warning of groundwater contamination.
- Measure regional depth to water; monitor seasonal fluctuations in depth to water; develop regional groundwater contours.

Importance:

In some areas of the groundwater basin, there is little data available (e.g., water quality, depth to water, gradient, etc.) from water providers. A wealth of readily available monitoring points is potentially available to provide groundwater data.

How Do You Propose Meeting or Complying with This Issue?

- Require registration of private water-supply wells.
- Establish a program to maintain and analyze the collected data.




Fred Stanin
Dennis

PRIORITY 17

Point of Compliance Should Be Outside the Natural Attenuation Zone

Originators:

Williams on behalf of himself and Small

The following issues were consolidated under the above title:

Title: **Points of Compliance Should Be Outside the Natural Attenuation Zone**

Originator: Williams

Issue Description:

If we are able to be cost effective, use a growing body of evidence in support of natural attenuation processes in lieu of active remediation.

Importance:

The tendency is to minimize needless groundwater remediation; however, with a large "reaction" zone and longer time frame, natural processes can be allowed to develop.

How Do You Propose Meeting or Complying with This Issue?

Property line remediation.

Title: **Should We Use Non-Detect Wells to Define Plume Boundaries or Points of Compliance?**

Originator: Small

Issue Description:

How many non-detect samples are collected each quarter in this country? How much information do we obtain from this data? What is this data telling us?

Importance:

A lot of resources are being spent to collect non-detect samples. There is little or no evaluation of what these non-detect data are telling us. For example, we typically do not know if we would "expect" to see an impact in these wells within a given time frame. We often do not know if these monitoring points are located in a manner to support decision making. For example, we do not know if these wells are located in a contaminant flow path.

How Do You Propose Meeting or Complying with This Issue?

- Use attenuation and concentration trend data to define plume boundaries and points of compliance.
- Use non-detect wells more as sentry wells to detect unexpected contaminant immigration.
- Ensure that non-detect wells are placed spatially and temporally to actually detect contaminant migration within a reasonable or given time frame.

STRENGTH OF FEELING ANALYSIS

The Strength of Feeling Analysis is a method that gives a quantitative sense – expressed as a percentage of the degree of agreement, or disagreement, among the participants regarding the importance of each identified issue.

Table 1 is organized according to the priority ranking by all 22 participants of the 17 major issues on which they voted. Also shown are the rankings and relative levels of agreement among the four categories of participants: consultants, regulators, utilities, and industry.

TABLE 1 STRENGTH OF FEELING

Rank	Title	Overall (22)*	Consultants (10)	Regulators (5)	Utilities (4)	Industry (3)
1.	Subsurface Monitoring Plans, Including the Goals, Objectives and Management Requirements Should Be Based on the Site Conceptual Model	71.8%	77.0%	72.0%	55.0%	76.7%
2.	The Level of Effort to Monitor Sites Should Correspond to the Magnitude of the Estimated Threat	70.5%	68.0%	78.0%	62.5%	76.7%
3.	Need for Three-Dimensional Site Characterization and Containment Assessment	51.4%	55.0%	34.0%	72.5%	40.0%
4.	Improve Subsurface Characterization to Better Understand Heterogeneous Subsurface Conditions and Fate and Transport within Different Hydrographic Units	50.0%	51.0%	52.0%	47.5%	46.7%
5.	Validation of Low-Cost Investigation and Monitoring Techniques	45.9%	55.0%	38.0%	35.0%	43.3%
6.	Support Better Decision Making by More Effective Communication and Interpretation of Monitoring Data	35.9%	35.0%	36.0%	45.0%	26.7%
7.	Select Target Constituents to Properly Evaluate Petroleum and Fuel Oxygenate Contaminants in Groundwater	33.6%	37.0%	38.0%	15.0%	40.0%
8.	Need a National Research Strategy and Program for Subsurface Monitoring, Investigation, and Cleanup of Contaminated Sites	29.5%	33.0%	8.0%	52.5%	23.3%
9.	Federal, State, and Local Government Programs/Agencies Need Radical Restructuring; Legislative Changes Are Needed to Improve Programs	25.9%	30.0%	18.0%	35.0%	13.3%
10.	Develop and Advertise Success Stories	23.6%	20.0%	24.0%	17.5%	43.3%

*Number of participants in each category

Rank	Title	Overall (22)*	Consultants (10)	Regulators (5)	Utilities (4)	Industry (3)
11.	Assess the Total Risk of Exposure to Multiple Contaminants by Multiple Pathways	20.0%	21.0%	30.0%	17.5%	3.3%
12.	Monitor from the Perspective of the Receptor	18.2%	20.0%	12.0%	17.5%	23.3%
13.	Make Monitoring Data from Regulatory Agencies Easily Accessible in Electronic Format for Use in Characterization of Nearby Sites	16.8%	17.0%	12.0%	12.5%	30.0%
14.	Statistics for Data Analysis in Site Characterization	16.4%	17.0%	22.0%	10.0%	3.3%
15.	Separate Science from Policy When Performing Subsurface Investigations	15.5%	2.0%	42.0%	7.5%	26.7%
16.	Use Thousands of Small, Private Wells as a Statewide Monitoring Network to Assess Regional Groundwater Quality	14.5%	6.0%	14.0%	47.5%	0.0%
17.	Point of Compliance Should Be Outside the Natural Attenuation Zone	10.5%	6.0%	20.0%	0.0%	23.3%

*Number of participants in each category

APPENDICES

A P P E N D I X A

ACRONYMS

API	American Petroleum Institute
BTEX	benzene, toluene, ethylbenzene, xylenes (*o-, m-, p-* xylene)
CERCLA	Comprehensive Environmental Resource and Compensation Liability Act
CPT	cone penetrometer
CSIA	compound specific isotope analysis
DHS–DWSAP	Department of Health Services–Drinking Water Source Area Protection
GC-MS	gas chromatography- mass spectrometry
GIS	geographic information system
HMMP	Hazardous Materials Management Plan
HVOC	highly volatile organic compounds
K	constant
LNAPL	light nonaqueous phase liquid
MLS	multilevel sensors
MNA	monitored natural attenuation
MTBE	methyl-tert-butyl-ether
NAPL	nonaqueous phase liquid
PAH	polycyclic aromatic hydrocarbons
PDB	passive diffusion bags
PIRI	Partners in RBCA Implementation
RBCA	Risk-Based Corrective Action
RWQCB	Regional Water Quality Control Board
SCM	site conceptual model
TBA	tertiary-butyl alcohol
TPH	total petroleum hydrocarbons
USEPA	United States Environmental Protection Agency
UST	underground storage tank

APPENDIX B

WORKING GROUPS' VISUAL PRESENTATIONS

Subsurface monitoring plans, including goals, data quality objectives, and data management requirements should be based on the site conceptual model.

By
Kremesec, Dorn, Crowley

Subsurface Monitoring
"State of the Practice Sucks" **Zemo 2004**

- A lot of "pointless" monitoring is performed
- Traditional Monitoring Wells expensive and networks ineffective for plume monitoring.
- Little use of Site Conceptual Model despite training.
- Confusion between Characterization vs Monitoring Strategy.
- Objectives of monitoring and data quality not defined.

Subsurface Monitoring

Site Conceptual Model
- Understanding of site conditions
- Hydrogeology
- Geochemistry
- Groundwater flow patterns
- Source issues and mass flux
- Chemicals of concern
- On-site and offsite receptors
- Pathways and risk criteria
- Cleanup Objectives
- Residual Risk Management

SubSurface Monitoring

Goals and Objectives of Monitoring Program
- Consensus based
- Support CAP, Interim Remediation, Fate and Transport Questions, Groundwater flow
- (Uncertainty related to SCM)

Data Quality Objectives Consistent with
- Long term Monitoring Program
- SCM
- CAP
- Timelines

Subsurface Monitoring

APPROACH
- Legislative changes – H &S Code Chapter 6.7, split site characterization and monitoring requirements, requiring site conceptual model and data quality objective development at the beginning of the corrective action process.

Subsurface Monitoring

- **Administrative changes**
  - Rewrite Corrective Action regulations, deleting quarterly reporting requirements, requiring geochemistry data.
  - UST Cleanup Fund Reimbursement changed to include not being reimbursed unless there is an approved site conceptual model with clearly defined and agreed upon data quality objectives.

Subsurface Monitoring

- **Policy Changes**
  - Revisit 92-49 Investigation and Cleanup
  - Revisit 88-63 Sources of Drinking Water

Subsurface Monitoring

- **Training and Education**
  - Technical Issues
  - Policy Issues
  - Success stories and lessons learned

  Lots of training in CA, why hasn't it worked?

Subsurface Monitoring

Potential Conflicts

- Entrenched attitudes
- Sense of hopelessness
- Minimization of risk
- Resources-Public/Private

Subsurface Monitoring

- **Timeline**

  -Up to two years
  (if at all)

Subsurface Monitoring

- Budget

  -For all approaches estimated range of $150,000 to $250,000

  -Does not include donated resources

Subsurface Monitoring

- TO BE CONTINUED – we all agree that the Status Quo needs to change.

All Change is Good Change!

WORKING GROUP NO. 2 REPORT

PROJECT PROSPECTUS

Multi-stakeholder Approach To Risk-based Prioritization Of Resource Allocation To Site Characterization And Monitoring

Rationale

- The current system of site characterization and monitoring is a reactive process that is triggered by the identification of a release, and generally applies the same level of effort to all sites regardless of available data and the potential threat or risk to receptors.
- This process can lead to the misallocation of resources (human, institutional and financial) and in some cases inappropriate response actions by stakeholders that can exacerbate impacts.

Rationale

- A new process that dovetails with existing programs optimizes the use of stakeholder data and prioritizes existing and future sites based on the potential threat or risk to receptors. This process allocates resources commensurate with the level of potential threat/risk.

Approach

- Sites categorized relative to potential threat to production wells
- Monitoring and response activities will be conducted in a manner commensurate with the perceived risk.
- This approach will produce a multi-tier response with monitoring requirements corresponding to the level of risk – varying from monitored natural attenuation to a proactive preventive monitoring and response program with contingency plans.

Approach

- The threat/risk assessment will integrate the site conceptual model with the regional conceptual model. Specific data considerations include:
  - Production well capture zone
  - Production well construction
  - Production well hydraulics
  - Local and regional hydrogeology
  - Contaminant travel time
  - DWSAP database
  - GeoTracker database

Potential Conflicts

- Water purveyor providing a useful capture zone analysis.
- Concerns over writing-off areas outside existing capture zones.
- Property values diminution.

Timeline

- Capitalizing on efforts of existing DWSAP program programmatic shift could occur relatively quickly – within 18 months

Budget

- Funding required to support addition of 5 PY within the GeoTracker program.
- Implementation of this program is intended to reallocate existing resources, and not increase the overall cost of site characterization and monitoring.

IMPLEMENTATION OF 3D SITE CHARACTERIZATION

Work Group 3

Gary Robbins
Todd Ririe
Donna Drogos

RATIONALE

- Problems with traditional approach:
  - Averaging effects lead to misleading plume delineation;
  - No assessment of vertical flow;
  - Poor delineation of vertical heterogeneities(water quality and physical parameters);
  - Poor well location based on biased data obtained in successive phases;
  - Fails to recognize that problem is 3D in nature;
  - Vertical spreading of contamination in wells.
  - Bad data leads to bad decisions

RATIONALE CONT.

- Three-dimensional assessment permits:
  - Improved data for modeling efforts;
  - Estimate mass flux;
  - Properly evaluate site risk;
  - Quantifying attenuation processes;
    - Fluxes of oxygen in vadose zone for assessing natural attenuation;
    - Fluxes of vapors in the vadose zone;
  - Assessing flow and contaminant conditions in time;
  - Use of MLS for assessing how pumping wells influence the vertical and horizontal distribution of contamination;
  - Focused remediation efforts on high mass flux zones;
  - Improved source term definition, including seasonal variations;

APPROACH

- Site Conceptual Model (SCM)
  - Develop an initial SCM of release scenario to guide site characterization
- Determine site hydrogeology
  - Continuous core borings above and below water table (investigate entrapped product—submerged NAPL) and collect depth discrete samples
- Transects
  - Install transects perpendicular to groundwater flow direction

APPROACH CONT.

- Install Multilevel Monitoring Systems to
  - Utilize available tools - direct push, temporary and permanent sampling systems
  - Perform K measurements, water quality sampling, measure vertical gradients
  - Utilize a phased approach - install temporary multilevel systems to determine concentration distribution in space and flow direction before permanent transect installed
  - Develop methods for determining optimal screen length and depth interval
  - Collect depth discrete groundwater samples

APPROACH CONT.

- Mass Flux
  - Perform mass flux calculations utilizing depth discrete sampling data collected from transects
    - Retrofit traditional MWs
    - Convert to multilevel monitoring system capable of depth discrete measurements
    - Eliminate ambient vertical flow
    - Regulatory Approach
    - Issue regulatory directives specifying new and innovative investigation methods

APPROACH CONT.

- Demonstration Sites – Success Stories
- Evaluate whether detailed site investigations improve decision making, remediation and reduce costs.
- Comparison studies - how do multilevel sampling systems improve site characterization
- Create a climate to foster innovation

- Provide training classes using real site data to develop scopes of work, demonstrating application for real sites

POTENTIAL CONFLICTS

- How is data to be used. Not just about collecting more data but the purpose.
- Monitoing once understand system, don't need to monitor every point.
- Fear costs will be raises, and fear of regulators that they will be buried in data.
- Miss product floating on water table
- Dry MLS because water table has fallen
- Problems in sampling in low K environments
- Higher up front costs vs lower long terms savings

TIMELINE

- 3 Years

BUDGET

- **Training: $300,000**
- **Case study review compilation: $25,000**
- **Comparison: $175,000**
- **Mass Flux Assessment: $200,000**

Improving Subsurface Characterization to Better Understand Fate and Transport in the Heterogeneous Subsurface

Chris Tulloch
Tom Young
Kevin Graves

Rationale

- Site Characterization is important because:
  - Drives regulatory decisions
  - Affects cleanup costs
  - Affects impacts on receptors

Approach

- Training of stakeholders to utilize the most recent information
  - Lithology
  - 3D Chemical distribution
  - Geophysics and pump tests
  - Mass Flux
  - Measurement of physical/chemical/biological properties of soil

Potential Conflicts

- Change is difficult
  - Increased costs
  - Extending timeframes for projects
  - Repeating work already completed that used outdated technology

Time line

- Existing training programs already exist
  - Government agencies
  - Industry groups
  - Conferences
  - Universities
- Usually need several months to one year notice
- At least one class will be held within 6 mon

Budget

- Use existing resources

Group 6

Promote Better Decision Making by More Effective Communication and Interpretation of Data

Matt Small
Eric Nichols
Aaron LaPine

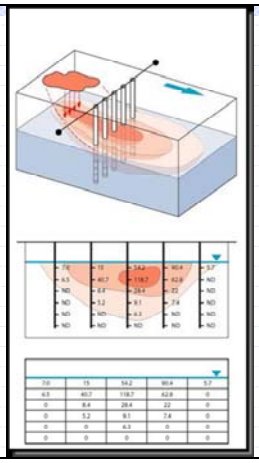
Rationale:

- Practitioners and regulators are challenged to manage, interpret, and communicate large quantities of highly technical information
- Data needs to be communicated in clear, easy-to-understand ways that allow rapid assimilation and interpretation by all stakeholders to better promote informed decision-making
- Data collection conducted without upfront agreement between stakeholders on the site characterization approach and remedial goals can waste time, money, and investigation resources
- Effective communication, participation, and input by technical and non-technical stakeholders can increase the effectiveness of site characterization and the durability of resulting remedial decisions

Example #1

- Some site characterization technologies can dramatically increase the density of monitoring points – vertically, horizontally, and temporally, resulting in an avalanche of data
- It is key to communicate monitoring data in a way that allows rapid assimilation and interpretation for decision making
- Clear, concise presentation of data and data interpretation allows more stakeholders to understand the issues and participate in decisions

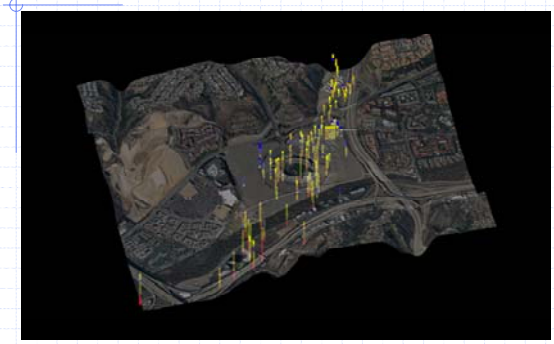
Example: Presenting Technical Information to Multiple Stakeholders



Example #2

- Many practitioners and regulators are challenged to interpret inorganic geochemical data
- Users who are accustomed to comparing chemical concentrations with fixed regulatory limits often find it difficult to interpret data whose value more often lies in its spatial patterns and its relationship with other data, rather than in the absolute concentration at any given location
- Spatial patterns and the subsequent relationships can be effectively communicated visually

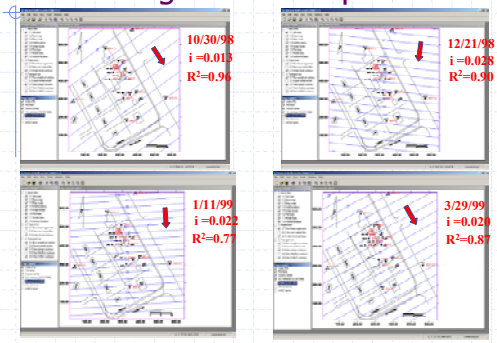
Example: Spatial Patterns and Relationships



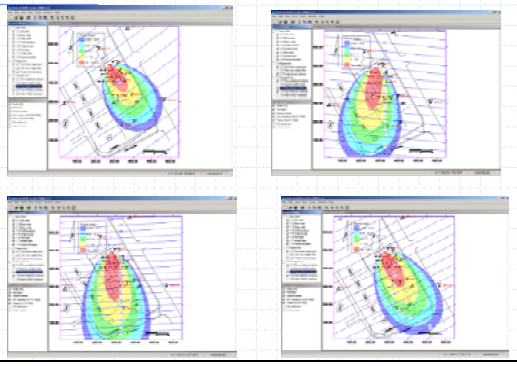
Example #3

- Predicting future contaminant concentrations in a water supply well requires estimation of groundwater flow and contaminant transport parameters, resulting in levels of uncertainty within the results
- These uncertainties may be more effectively represented via presentation of a range of input parameters resulting in a range of transport scenarios communicated via graphical summaries, and other visualization techniques

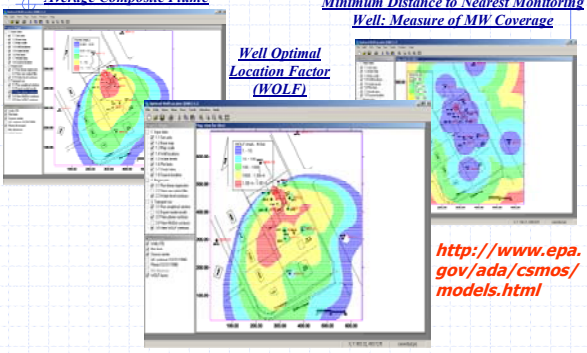
Example: Uncertainty and Monitoring Network Optimization



Example: Uncertainty and Monitoring Network Optimization



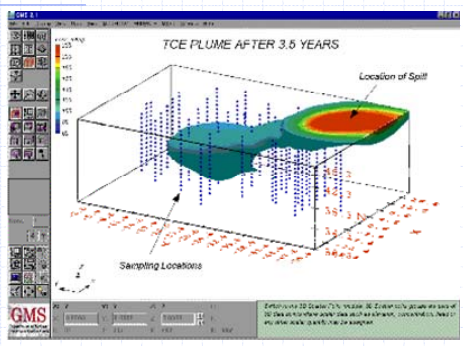
Example: Uncertainty and Monitoring Network Optimization



Example #4

- Inadequate communication and selection of performance data can mislead stakeholders into concluding that remedial efforts are effective, when the opposite may be actually be true
- Defining and communicating appropriate metrics for remedy performance can help to ensure that remedial progress is appropriately evaluated
- Monitoring data should allow cause-and-effect relationships to be demonstrated, and should target the entire region of affected aquifer

Example: Data Presentation and Communication



Approach:

- Actively encouraging and facilitating state-of-the-art techniques for data communication and interpretation:
  - Promoting more effective use, communication, and validation of the site conceptual model
  - Promoting site characterization strategies such as the interactive, real-time Triad approach
  - Developing better tools and guidance for data management and interpretation
  - Developing examples of effective data presentation and visualization techniques for communicating complex data sets to technical and non-technical audiences
  - Educating users to become more skilled in interpreting multiple data sets (e.g., organic and inorganic chemical data, hydraulic data, and geologic data)
  - Developing approaches for communicating data uncertainty, natural data variability, and the range of possible data interpretations
  - Encouraging data evaluators to develop, honestly communicate, and test multiple working hypotheses that may explain the observed spatial and temporal patterns in the data

Approach:

- Improved communication
  - Creation of a guidance document outlining techniques and approaches for effective communication and interpretation of data
- Improving the quality of technical interpretations of data sets, (important but beyond the scope of this document):
  - Continuing professional competency requirements currently imposed by many states.
  - Increased awareness of and compliance with applicable industry standards for data evaluation and interpretation.
  - Training provided by vendors of data management and visualization tools.
  - Training provided by professional societies and industry groups

Potential Conflicts:

- Implementation may require additional training for professionals involved in the interpretation and representation of data
- Available tools should be presented in an impartial manner
- The guidance document should be created by a knowledgeable group of individuals without financial interest in a particular product or solution

Time Line:

- Contractor selection, month 3 (following initiation)
- Review of state-of-the-art practices for data communication, interpretation, and visualization, month 6
- First draft, month 9
- Review and comment on first draft, month 10
- Trial evaluations with users and stakeholders, month 11
- Revisions and final draft, month 14
- Comments on final draft, month 15
- Publication of final guidance document, month 18

Budget:

- Salaries and Wages: $200,000
- Materials and Supplies: $50,000
- Travel: $15,000
- Equipment: $10,000

Total - $275,000

Thanks for Your Attention

Project Prospectus Working Group No. 7

Fred Stanin
Ravi Kolhatkar, Ph.D.
Dawn Zemo
Yue Rong, Ph.D.

NWRI
Subsurface Monitoring Strategies Workshop
June 14-16, 2004

Title

Selection of Target Parameters to Evaluate Petroleum and Fuel Oxygenate Contaminants in Groundwater

Rationale

- Data collected as part of a groundwater monitoring program are the basis for all subsequent interpretations and decisions.
- Therefore, the target parameters selected for the family of data should be identified and determined to be sufficient to support such interpretations and decisions.

Examples of Target Parameters

- BTEX, MTBE, PAHs, etc.
- Isotopes
- Tracers
- Inorganics
- Electronic acceptors and metabolic byproducts
- Non-petroleum related sources

Approach

- Existing regulatory protocols, both federal and state, will be identified and reviewed.
- Relevant peer-reviewed journal articles will be reviewed.
- Selected federal and state regulators, and industry and academic researchers, will be identified and interviewed.

Approach (Cont.)

- Categories of parameters, and corresponding member target parameters, will be identified. An initial working list of categories is as follows:
  - Parameters used for protection of beneficial uses (i.e., regulated chemicals) and to define extent of impact
  - Parameters used for source identification.
  - Parameters used for assessment of fate and transport.
  - Parameters that are “potential constituents of future concern.”

Approach (Cont.)

- Parameter selection procedures will be developed.
- Future research needs will be identified, which may include laboratory work (e.g., standardization of analytical protocols for "PCOFCs".

Potential Conflicts

- Costs of analyzing for parameters.
- Parameters not practicable or easily implementable.
- Lack of regulatory acceptance.
- Benefits for including specific parameters will be identified.
- Advocacy, education, and training.
- Advocacy, education, training, and lobbying.

Timeline

Milestone	Incremental Time Requirement
Research	3 months
Category identification / parameter selection	2 months
Interim report	1 month
Client review	1 month
Parameter selection methodology	3 months
Research identification	1 month
Draft report	1 month
Client review	1 month
Final report	1 month
Total	*14 months*

Budget

- $100,000
- Full project proposal will present supporting details.

APPENDIX C

BIOGRAPHICAL SKETCHES AND CONTACT LISTS

Andrew J. Barnes, R.G.

Andrew Barnes has been an environmental consultant for more than 15 years. During that time, he has developed a practice in groundwater resources that includes the characterization and restoration of impacted groundwater, as well as the development of drinking-water resources. His experience in the field of contaminant hydrogeology has focused on fuel hydrocarbons, fuel oxygenates, and chlorinated hydrocarbon impacts, including NAPL and dissolved-phase impacts, as well as the implementation of emerging technologies for subsurface characterization. He has worked on Federal Superfund projects and in a variety of capacities, including field geologist, project manager, project director, principal investigator, and consultant. Barnes received a B.A. in Geology from the University of California, Santa Barbara, and is a Registered Geologist in the State of California.

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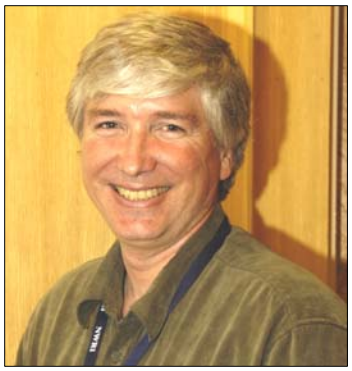

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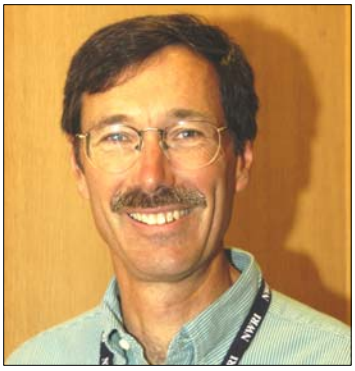

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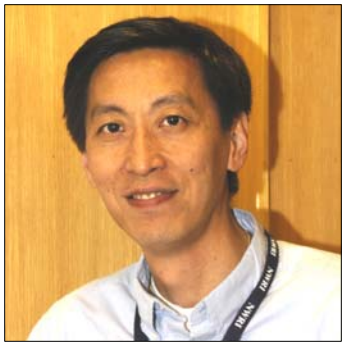

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A P P E N D I X D

PREVIOUS NGT WORKSHOPS CONDUCTED BY NWRI

Water Reuse Economics Framework Report. Report of a workshop sponsored by NWRI in cooperation with Stratus Consulting Inc. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA May 10-12, 2004. 123p.

Value of Water Roundtable Report. Report of a roundtable sponsored by NWRI in cooperation with American Water Works Association Research Foundation. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, September 23-25, 2003. 160p.

CALFED-Bay Delta Drinking Water Quality. Report of a workshop sponsored by NWRI in cooperation with CALFED Bay-Delta Drinking Water Quality Program and USEPA Region IX. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, July 29-31, 2003. 239p.

Water Reuse Planning for the State of Washington. Report of a workshop sponsored by NWRI in cooperation with Washington State Department of Ecology. DoubleTree Hotel Seattle Airport, Seattle, WA, May 30-June 1, 2003. 221p.

Seawater Desalination: Opportunities and Challenges. Report of a workshop sponsored by NWRI in cooperation with Metropolitan Water District of Southern California and Member Agencies. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, March 28-30, 2003. 213p.

Decision Support System. Report of a workshop sponsored by NWRI in cooperation with Tellus Institute. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, February 4-6, 2003. 161p.

Water Quality and Resource Management Issues. Report of a workshop sponsored by NWRI in cooperation with Lawrence Livermore National Laboratory and University of California. Wente Vineyards, Livermore, CA, January 28-30, 2003. 252p.

Life Cycle Environmental Impacts Associated with Different Fuel Options. Report of a workshop sponsored by NWRI in cooperation with Clarkson University, Lawrence Livermore National Laboratory, and USEPA – Office of Research and Development. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, February 15-17, 2002. 202p.

Issues in Methanol Research. Report of a workshop sponsored by NWRI in cooperation with the American Methanol Institute. Hilton Hotel, Costa Mesa, CA, October 5-7, 2001. 173p.

Chino Basin Organics Management. Report of a workshop sponsored by NWRI in cooperation with the Inland Empire Utilities Agency, and the Southern California Alliance of Publicly Owned Treatment Plants. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, April 18-20, 2001. NWRI Report No. NWRI-01-03, 205p.

Desalination Research & Development. Report of a workshop sponsored by NWRI in cooperation with the United States Bureau of Reclamation. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, January 19-21, 2001. 185p.

Knowledge Management. Report of a workshop sponsored by NWRI. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA January 5-7, 2001. 169p.

Oxygenate Contamination. Report of a workshop sponsored by NWRI in cooperation with the United States Bureau of Reclamation. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, September 15-17, 2001: 258p.

Utility Leadership. Report of a workshop sponsored by NWRI in cooperation with Malcolm Pirnie, Inc., the University of Southern California, and the University of South Florida. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, October 24-26, 1999: 154p.

Non-potable Water Recycling. Report of a workshop sponsored by NWRI in cooperation with Irvine Ranch Water District and the Orange County Water District. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, May 23-25, 1999: 174p.

Conjunctive Use Water Management Program. Report of a workshop jointly sponsored by NWRI, Association of Ground Water Agencies, and the Metropolitan Water District of Southern California. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, May 27-29, 1998: 157p.

Barriers to Providing Safe Drinking Water Through Small Systems. Report of a workshop jointly sponsored by NWRI, Pan American Health Organization, and NSF International/WHO Collaborative Center. Pan American Health Organization Headquarters, Washington, D.C., May 13-15, 1998: English report: 175p., Spanish report: 188p. (Bound in a single volume.)

Barriers to Harvesting Stormwater. Report of a workshop jointly sponsored by NWRI, Los Angeles County Department of Public Works, County of Orange Public Facilities & Resources Department, Southern California Coastal Water Project, and the American Oceans Campaign. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, September 22-24, 1997: 159p.

Groundwater Disinfection Regulations Benefits Conference. Report of a conference sponsored by NWRI. Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, Irvine, CA, March 17, 1997: 75p.

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