

U.S. EPA TECHNICAL SUPPORT PROJECT TECHNICAL SESSION SUMMARY

June 3-6, 2002
The Magnolia Hotel
Denver, Colorado



Technical Support Project

U.S. EPA TECHNICAL SUPPORT PROJECT CO-CHAIRS

Engineering Forum:

Camille Hueni, Region 6 • Chet Janowski, Region 1 • Neil Thompson, Region 6

Ground-Water Forum:

Vince Malott, Region 6 • Bernie Zavala, Region 10

Federal Facilities Forum:

Steve Hirsh, Region 3 • Craig Thomas, Region 5 • Chris Villarreal, Region 6

TABLE OF CONTENTS

JUNE 3, 2002: GROUND WATER TO INDOOR AIR SESSION	1
Welcome and Introduction	
Forum Co-Chairs	1
Ground Water to Indoor Air: Introductory Comments	
Ray Cody, U.S. EPA Region 1, and Helen Dawson, U.S. EPA Region 8	1
Redfield Rifle Scopes: A Case History	
Edgar Ethington, Colorado Department of Public Health and Environment	2
Colorado Department of Transportation MTL Indoor Air Site	
Terry Bennett, Colorado Department of Public Health and Environment	2
Background and Development of National Guidance for Evaluating Subsurface Vapor Intrusion	
Henry Schuver, U.S. EPA Office of Solid Waste	3
Vapor Intrusion Modeling: Theory and Implications	
Robbie Ettinger Shell Global Solutions (U.S.) Inc.	5
Reliability of Screening Level Approaches for Assessing the Vapor Intrusion Pathway	
Helen Dawson, U.S. EPA Region 8	6
Sub-Slab Air Permeability Testing and Air Sampling Using TO-17	
Dominic DiGuilio, U.S. EPA Office of Research and Development—Subsurface Protection and Remediation Division	8
Raymark Industries: A Superfund Indoor Air Case Study	
Ray Cody, U.S. EPA Region 1	8
Assessing Risks from Indoor Air	
Susan Griffin, U.S. EPA Region 8	10
Ground-Water Contamination to Indoor Air	
Kathy Baylor, U.S. EPA, Region 9 RCRA Corrective Action Office	10
ITRC Indoor Air Proposal	
Randy Carlson, Kansas Department of Health and Environment	12
 JUNE 4, 2002: PERCHLORATE TRAINING SESSION	 13
 JUNE 5, 2002: MINING WASTE WORKSHOP	 14
Welcome and Introduction	
Robert E. Roberts, Regional Administrator, U.S. EPA Region 8	14
Hardrock Mining: EPA’s Roles	
Carol Russell, U.S. EPA Region 8	14
ORD Technical Support for Mining Sites	
David Reisman, Director, Office of Research and Development, Engineering Technical Support Center	15
Anaerobic Bioreactor Technologies	
Tim Pickett, Applied Biosciences	15
Passive Mine Drainage Treatment	
Jim Gusek, Knight Piésold and Co.	16
Mary Murphy Mine Case Study	
Mike Wireman, U.S. EPA Region 8	17
Pit Lakes Overview	
Jim Jonas, Camp Dresser & McKee	18
Hardrock Mining 2002 Workshop	
Jim Dunn, U.S. EPA Region 8, Hazardous Substance Technical Liaison	19

Leadville Superfund Case Study
Mike Holmes, U.S. EPA Region 8 19

Summitville Water Treatment Case Study
Karen Taylor, Camp Dresser & McKee 20

Mining Waste Field Trip 20

JUNE 6, 2002: JOINT TSP/ITRC SESSION 23

ITRC DNAPL Team: Mission and Past Activities
Eric Hausamann and Jim Harrington, New York State Department of Environmental
Conservation 23

ITRC DNAPL Team: Existing and Future Activities
Jim Harrington, New York State Department of Environmental Conservation 23

TSP Activities Relating to DNAPLs
Rich Steimle, U.S. EPA, Technology Innovation Office 24

Update from the U.S. EPA Ground Water Technical Support Center
Dave Burden, U.S. EPA, Office of Research and Development—Subsurface Protection and
Remediation Division 24

ITRC Characterization Subgroup and Strategies for Characterizing DNAPL Characterization
Michael B. Smith, Vermont Department of Environmental Conservation 25

ITRC Thermal Subgroup 25

Case Summary: Electrical Resistance Heating
Jennifer Sutter, Oregon Department of Environmental Quality 26

Rocky Mountain Arsenal Hex Pit
Eric Hausamann, New York State Department of Environmental Conservation 27

ITRC Surfactant Subgroup
Ana Vargas, Arizona Dept. of Environmental Quality, and Hans Meinardus, Intera, Inc. ... 28

PARTICIPANTS LIST 30

JUNE 3, 2002: GROUND WATER TO INDOOR AIR SESSION

Welcome and Introduction

Forum Co-Chairs

Vince Malott (Region 6), co-chair of the Ground Water Forum, welcomed participants to the Spring 2002 meeting of U.S. EPA's Technical Support Project (TSP). Vince introduced the co-chairs of the Engineering Forum, Federal Facilities Forum, and the Ground Water Forum. Vince noted that Wanda Taunton, the Director of Region 8's Solid and Hazardous Waste Program, was unable to attend the morning's sessions, but wished to welcome participants to Denver and Region 8.

Ground Water to Indoor Air: Introductory Comments

Ray Cody, U.S. EPA Region 1, and Helen Dawson, U.S. EPA Region 8

Indoor air has recently emerged as a hot topic at EPA spurred, in part, by high profile cases involving contaminated residential properties. A series of articles in the Denver Post were instrumental in highlighting the importance of indoor air issues as they relate to human health and the environment. The articles were critical of EPA, the state agencies, and the Johnson-Ettinger (J-E) model, claiming that regulatory responsiveness was lackadaisical, at best. Among the newspapers allegations were that the J-E model underestimates risk, that EPA dismisses threats based solely on ground-water data, and that some regulators are changing risk levels to avoid cleanup. While these articles consistently use sensationalism to get their point across, there is some veracity to the notion that regulators and scientists have much to learn about indoor air's health effects and pathways.

Ray mentioned three reasons why the indoor air pathway has only recently emerged to the extent and degree that it has:

- Historically, EPA was focused on source removal.
- The technical and economic difficulties associated with remediation or control of dissolved-phase contamination coupled with the elapsed time since many of these releases occurred has naturally resulted in the expansion of these plumes—often beyond site boundaries.
- A “management paradigm” has only recently emerged to largely replace the “cleanup to pristine conditions” paradigm.

Indoor air problems may reflect a new environmental paradigm that is emerging. This paradigm suggests that low-level contamination resulting from multi-media sources is ubiquitously distributed throughout the environment. This paradigm challenges state-of-the-art sampling and analytical techniques and remediation processes. In addition, a host of new chemicals (e.g., steroids and antibiotics) about which we have little or no information has been detected at low concentrations in U.S. waterways—to what extent should we be concerned about these chemicals?

The Government Performance and Result Act (GPRA) has had an impact on traditional Agency decision making in that it places more reliance on policy and “regulation by memo.” Because the *Draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway* is not law, regulators must be careful not to rely upon it as such. The burden is on the regulator to understand the issue of indoor air so that site-specific decision making is reasonable, appropriate, and technically defensible.

According to Ray, the J-E model is a good screening-level model, but it is chronically misapplied. He urged caution in relying only upon the model when making decisions about risk and cleanup levels at a site. Mitigating or complicating factors should always be identified when dealing with site-specific information. And the project manager should always confirm the risk and correlate the risk to the

contaminant source. The upcoming 1,1-DCE toxicity change will not likely affect the need for characterization, but will likely affect actionable risk. The Office of Research and Development (ORD), Region 1, and Region 8 are currently working with Henry Schuver (OSWER) to gather more information about indoor air pathways, risk levels, and cleanup tools.

To view Ray Cody's presentation materials for details, click here.

To view Helen Dawson's presentation materials for details, click here.

Redfield Rifle Scopes: A Case History

Edgar Ethington, Colorado Department of Public Health and Environment (CDPHE)

Edgar Ethington presented an overview of the impacts of contaminated ground water on indoor air at the Redfield Rifle Scope facility in Denver, Colorado. The Redfield site encompasses about 11 acres and a building where rifle scopes and binoculars were manufactured between 1967 and 1998.

In 1994, an environmental investigation was completed on the Redfield site in connection with the potential sale of the property. This investigation revealed the presence of chemicals in the ground water at the site. Further investigation tied these materials, in part, to a former degreaser that was used in the manufacturing facility to remove oil and grease from manufactured parts. In January 1998, samples taken from ground-water monitoring wells near the northeast corner of the Redfield property indicated that ground water containing cleaning solvents might be moving off the Redfield site into the surrounding neighborhood. An investigation into the extent of contamination that began in February 1998 is ongoing and includes ground-water monitoring wells and indoor air testing in homes near the Redfield property.

Since Denver Water supplies residential water to the Cook Park and Virginia Village neighborhoods, there is no danger to the residential domestic drinking water. The only way someone could be exposed to the chemicals in the ground water is by breathing vapors that move from the ground water, through the soil, into the basements or lower levels of homes. These vapors could collect inside a house or building. Several chemicals have been found in the ground water at the Redfield property, including DCE, TCE, TCA, PCE, VC, MeCl₂, and benzene. The primary chemical of concern for indoor air is 1,1-DCE, which can impact buildings even when the apparent ground-water concentration is below the MCL.

CDPHE is using Summa[®] canisters along with EPA Method TO-15 to conduct air sampling at the site. Early findings related ground water contamination to indoor air readings, but these correlations were not reliable on a house-specific basis. As of May 1, 2002, 690 residences had been tested and 354 mitigation systems had been installed. Radon abatement systems have been used for mitigation and have been effective at reducing levels of contaminants. Results have demonstrated that modeling is not as reliable as sampling and analysis. Correlation with soil gas was inconclusive. In conclusion, VOC ground-water plumes can result in measurable impacts to indoor air. Site assessments can and should always address the indoor air pathway.

To view Edgar Ethington's presentation materials for details, click here.

Colorado Department of Transportation MTL Indoor Air Site

Terry Bennett, Colorado Department of Public Health and Environment

Terry Bennett described the impact of a volatile organics plume (primarily TCE) emanating from the Colorado Department of Transportation (CDOT) MTL site on the indoor air of downgradient residences. The site is just one mile away from the Redfield Rifle Scopes site, and the two plumes

commingle, in part. A tremendous number of indoor air samples have been collected for the site, which has brought the indoor air issue into the national limelight.

The MTL plume resulted from releases of waste solvents from storage tanks installed in the 1970s. Ground water is found at depths ranging from 8 to 10 feet bgs to 30 feet bgs across the site, which is underlain by the fractured bedrock of the Denver Formation. Concentrations of volatile chemicals in indoor air correlate very well with the plume (0.95 correlation coefficient), primarily because there are no background sources of the chemicals. Pre-remedial concentrations of DCE in indoor air were as high as $100 \mu\text{g}/\text{m}^3$.

A pump and treat system was constructed to treat the plume at the source, and an offsite remediation system was installed to treat the distal end of the plume by injecting methane, oxygen, and nutrients into hydrofractured wells to augment aerobic bioremediation. Indoor air remediation systems were installed single-family dwellings, apartment buildings, and town homes in the vicinity of the plume.

Soil vapor studies were conducted at the site to determine the extent of soil vapor contamination. The studies also revealed a poor correlation between soil vapor and indoor air concentrations, indicating that several impacted homes would have been overlooked based on soil vapor data alone.

If the long-term cleanup goal of 1×10^{-6} (set in the Corrective Measures Plan) for the indoor air chemicals of concern (DCE and TCE) is enforced, then CDOT will be required to clean up to this level or background, whichever is higher. As a result, a controlled, site-specific study of background levels of chemicals was conducted using three data sets. Mean background concentrations of benzene, chloroform, and PCE were found to exceed their respective 1×10^{-6} risk-based concentrations. However, the mean background concentrations of DCE and TCE did not.

In conclusion, Terry indicated that a “lines of evidence approach” was used to evaluate the indoor air data at the CDOT site to determine whether indoor air chemicals were coming from the plume. The best line of evidence was the spatial relationship of the indoor air contamination to the plume.

To view Terry Bennett’s presentation materials for details, click here.

Background and Development of National Guidance for Evaluating Subsurface Vapor Intrusion

Henry Schuver, U.S. EPA Office of Solid Waste

Henry Schuver discussed the events that led to a decision by the Office of Solid Waste (OSW) to develop the *Draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway* (dated October 23, 2001). The guidance is tied to the Interim Final Environmental Indicator (EI) Guidance (dated February 5, 1999), which describes how OSW measures program progress. Question 3 of the EI guidance asks if there are any complete exposure pathways for seven media; indoor air is one of the media.

The purpose of the draft vapor intrusion guidance is to determine whether or not a site can be eliminated from further consideration (i.e., no complete pathway exists) or when it is necessary to proceed further with an investigation. The premise is to use measurements taken *outside* a building, which are easier to obtain, to predict what will be *inside* the building. If indoor problems are possible, then the site goes to a higher level of examination and the indoor air is sampled.

There are three tiers of screening: primary (Questions 1, 2, and 3), secondary (Questions 4 and 5), and site-specific (Question 6).

- Question 1: Are volatile organics that can pose a risk present?
- Question 2: Are buildings nearby?
- Question 3: Are immediate actions necessary or appropriate?
- Question 4: Do media concentrations exceed generic criteria with $\alpha = 0.01$?
- Question 5: Do media concentrations exceed scenario-specific criteria? A table of default values and α values is provided in the guidance to aid in this determination using the Johnson/Ettinger (J/E) model. The only site-specific data allowed is depth to ground water and type of soil.
- Question 6: Do media concentrations exceed media-specific criteria developed specifically for this site? (This requires using the J/E model with site-specific parameters.)

If this series of questions confirms there is a problem at the site, then a seventh question is asked: Will performance or pathway monitoring data be collected? Performance monitoring is conducted to determine the effectiveness of engineering controls. Pathway monitoring is done when a vapor front is expected, but has not arrived at the time of the assessment.

OSW is considering edits to the draft guidance. For instance, there are exclusions applied to Questions 4 and 5 that will push sites directly to Question 6. OSW is debating whether or not to treat ground water and soil gas differently in Question 5. In addition under Question 6, the guidance would recommend direct sampling rather than using site-specific modeling.

Major issues still remain to be decided with respect to the guidance:

- The risk tables in the guidance are based on theoretical levels, which yield maximum ground-water concentrations for some chemicals that are less than MCLs or less than normally achievable detection limits. This may mean that adequate site characterization data will be sparse for these chemicals. There is not much evidence that ground-water plumes with chemical concentrations less than MCLs are causing problems, but the possibility exists. OSW, however, does not think that there is sufficient reason to recharacterize a site's ground-water contamination to measure these low concentrations. Since screening is done to identify worst sites first, they prefer to use existing ground-water data and leave the tables with their MCLG-like values. They do not think the MCLG-like values are incorrect, and perhaps these sites can be revisited later on when the science and instrumentation is better.
- There are numerous background sources of volatile organic chemicals in a building's ambient air. These include numerous stationary and mobile outdoor sources, indoor consumer product sources, and hobby and maintenance (painting, lawn mower) sources. In addition, there are potential human exposures at work, from pumping gasoline, visiting clothing stores, etc. How do you calculate the risk of the additional exposure from soil gas? The background only technically comes into play when the indoor air is sampled so it is better to make decisions based on soil gas measurements outside the house. CERCLA's policy on background levels is to use the whole dose in the risk assessment and *do not* screen out background.
- It is well documented that petroleum products biodegrade, but in a specific setting there might not be sufficient information to predict the biodegradation rate. There is very poor correlation between ground water contaminated with petroleum products and indoor air quality, but this is not true for chlorinated chemicals. There are several proposals on this issue. One is to remove petroleum products from the guidance entirely. Another is to use a mass flux or risk-based corrective action approach. Henry indicated that he does not think these will work.

OSW met with Occupational Safety and Health Administration (OSHA) risk assessors to discuss environmental versus workplace exposure numbers. The OSHA staff presented data to show that their

risk numbers were not protective and should not be used. This raises the issue of which numbers can be used for non-residential structures.

To view Henry Schuver's presentation materials for details, click here.

Vapor Intrusion Modeling: Theory and Implications

Robbie Ettinger Shell Global Solutions (U.S.) Inc.

Robbie Ettinger discussed common issues and questions regarding the Johnson/Ettinger (J/E) model including the development of the model, underlying assumptions, key parameters, and the adequacy of models. Robbie believes that models are very useful aids in site characterization and remediation, but are not ends in themselves. He suggested that it may be better to estimate the risk associated with vapor intrusion to indoor air by modeling soil gas and ground-water concentrations, rather than sampling indoor air itself because of the confounding problems associated with background chemical concentrations.

The conceptual model for the indoor air pathway suggests ground-water contaminants partition into the soil gas, which migrates through diffusion up through the subsurface where it vents either to the open air or into a building structure. Advective transport beneath a building will also influence the vapor intrusion pathway. There are a number of assumptions in the J/E model that should be compared with site-specific conditions before it is used. The model has an attenuation factor ("") that is equal to the concentration of a contaminant in the indoor air divided by the concentration in the soil gas (" = $C_{\text{Bldg}}/C_{\text{SG}}$). The *smaller* the attenuation factor, the *lower* the risk.

There are a large number of parameters included in the expression for the attenuation factor. When using the model, focus on key parameters such as the effective diffusion coefficient, building ventilation, soil gas convection rate, and biodegradation. Robbie discussed the derivation of these parameters and the sensitivity of the input values. He also discussed the underlying mathematical equations for deriving these parameters and the effect some of the input values may have on the end result.

Robbie presented a case study in which he compared the calculated attenuation factors from a large data set provided by the Colorado Department of Transportation Materials Testing Laboratory Site, to the modeled attenuation factor using the same data. The attenuation factors for this case study were similar: 4 E-05 for the 90th percentile for measured data, versus 8.4 E-05 by model.

In summary:

- Ensure that site conditions match conceptual model assumptions before using model results.
- It may be necessary to use some combination of data collection and modeling.
- Ensure the data quality when evaluating the adequacy of a model.
- Indoor air sampling is a direct measurement; however confounding factors are not easy to address.
- Although there are a large number of input parameters for the model, the attenuation factor is not sensitive to many.
- When modeling, ensure that input parameters are reasonable and match site conditions.

Questions and Answers

Question: Based on today's presentation soil gas surveys seem to have a lot of scatter and are difficult to interpret. Can you recommend better ways to perform soil gas surveys?

Answer: I agree that better soil gas surveys can be performed and a soil gas survey protocol is needed. Many soil gas surveys are poorly designed and executed, for example concentrations are measured at wells or headspace samples. Hence the bad data. Heterogeneity at the site is a significant factor in obtaining good results.

Question: Isn't biodegradation rate a fairly sophisticated calculation?

Answer: There are resources available that can be used to estimate the biodegradation rates of petroleum hydrocarbons under various circumstances and this is well understood. The site-specific data required may make calculations impractical for doing at the local gasoline station. However, for larger releases calculating the biodegradation rate may be cost effective.

Question: The constraints you placed on the case study data eliminated low level ground-water concentrations. Yet there are sites where low level contamination does cause indoor air problems. Using the higher numbers, aren't you biasing the study so that there will be fairly close correlation between the calculated factors and the model factors?

Answer: The calculation does focus on the higher values. I have not run the lower numbers to see if their inclusion would make a difference.

Comment: Especially in the early years of the project, the lower concentration data had many quality problems, so there is justification in not using them for this comparison.

Question: We assume that the capillary fringe is saturated, but under negative pressure. You don't seem to be using the same definition.

Answer: Our definition of the capillary zone is that it is mostly saturated (80-90 percent) and under negative pressure. We do not assume 100 percent saturation.

Question: Does the model assume that the capillary fringe is clean?

Answer: The model assumes that the capillary fringe is in equilibrium with the vapor phase, so it is not necessarily clean. There will be contamination in the capillary fringe, but it will be less than in the saturated zone.

Comment: The version of the J/E model used by EPA in the guidance assumes a source in the saturated zone and none in the capillary zone or unsaturated zone. Robbie's model assumes a concentration gradient through the capillary zone and a second concentration gradient through the unsaturated zone.

Question: What data would you advise a project manager to collect to better refine the model?

Answer: I would not recommend collecting data about the building itself. Focus on collecting data to better evaluate the effective diffusion coefficient. If you are performing a soil gas survey, include parameters to evaluate biodegradation.

Reliability of Screening Level Approaches for Assessing the Vapor Intrusion Pathway Helen Dawson, U.S. EPA Region 8

Helen Dawson summarized her work on evaluating the reliability of screening level approaches for assessing the vapor intrusion pathway. Helen assembled a database of measured attenuation factors, encompassing 15 sites (residential structures only) and 15 VOCs, and compared them to the attenuation factors modeled for given sites and chemical concentrations. Measured attenuation factors are site-specific, depending on conditions such as building construction, site geology and hydrogeology, and the chemicals present. There is a wide range of values in the database—from less than 10 to 10^{-7} —with higher ranges for BTEX than chlorinated hydrocarbons (CHC). She acknowledged that the QA/QC of some of the data may be questionable.

The attenuation factor is the ratio of the concentration of a chemical in indoor air, to the concentration of the chemical in the source vapor. The concentration in the source vapor can be estimated by multiplying the Henry's constant for the chemical by the concentration in the ground water. Helen graphed data showing the soil gas concentrations estimated from the Henry's constants for PCE and TCE to be comparable to, or higher than, the measured soil gas concentrations, which indicates the calculation is conservative.

Background sources, such as car exhaust and household cleaning products, may also contribute to indoor air concentrations. Indoor air concentrations that exceed sub-slab concentrations may indicate background sources. Post remediation data can also be used to identify sources.

The influence of soil type (silts and clays versus sands) on attenuation factor data was not conclusive. Also, the influence of ground-water depth was not conclusive because there are instances where residences above relatively deep ground water sources exhibit high indoor air concentrations and attenuation factors. In addition, a graph of CHC source vapor concentrations versus the indoor air concentrations measured for basements, crawlspaces, and slabs on grade, showed that slabs on grade exhibited the lowest attenuation factors. Helen qualified the observation by mentioning the slab data were all measured at one site. She further showed that sub-slab measurements, or concentrations measured directly beneath the slab on grade, exhibited a fairly good correlation to indoor air concentrations.

Helen's approach to the reliability assessment of the data was to evaluate the number of false negatives and false positives using: 1) empirical, screening-level attenuation factors; 2) J/E model-derived attenuation factors as a function of soil type and depth to water; and 3) J/E model, site-specific attenuation factors. (These approaches relate to questions 4, 5, and 6 of the *Draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway*, respectively.) For the empirical, screening-level attenuation factor assessment, the data revealed that attenuation factors of 1/100 and 1/1,000 yielded no false negatives in 37 residences (with indoor air concentrations that exceed target concentrations, no indoor sources, a risk factor of 10^{-5} , and a hazard index of 1). An empirical attenuation factor of 1/10,000, however, yielded 6 false negatives; thus, it is not conservative enough. Helen recommended an attenuation factor of 1/1,000.

Based on data from a paper by Johnson and Ettinger, when the J/E model is calibrated with site-specific data, the resulting estimated attenuation factor better correlates with measured attenuation factors—within a range of +/- one order of magnitude. Therefore, a safety factor of at least 10x is needed to use the estimate as a regulatory tool.

Questions and Answers

Question: I am concerned that the mean background concentration for TCE ($5.4 \mu\text{g}/\text{m}^3$) used in this analysis is about an order of magnitude higher than what I observe in the field.

Answer: That's a good point. I plan to change the background values to see if the curves for benzene and TCE change.

Question: If the answer to question 5 in the draft supplemental guidance is "no," should question 6 (using the J/E model calibrated with site-specific data) be eliminated?

Answer: Question 6 and modeling probably shouldn't be discarded. Modeling may help predict when/if a problem may occur.

To view Helen Dawson's presentation materials for details, [click here](#).

Sub-Slab Air Permeability Testing and Air Sampling Using TO-17

Dominic DiGuilio, U.S. EPA Office of Research and Development—Subsurface Protection and Remediation Division

The focus of Dominic DiGuilio's presentation was sub-slab air permeability testing and air sampling using Method TO-17 from *Compendium of Methods for Determination of Toxic Organic Compounds in Ambient Air*. He began, however, by summarizing why sub-slab samples are important in the analysis of indoor air problems. He noted that EPA's Office of Research and Development (ORD) is concerned that questions 4 and 5 of the *Draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway* may not be conservative enough to protect human health. Therefore, ORD is proposing that confirmatory sampling be performed in addition to calculating λ and using the J/E model.

For the boundary conditions $C_g(0)=0$ and $C_g(Z_{(source)})=C_{g(source)}$ and $\lambda=C_{g(indoor)}/C_{g(sub-slab)}$, the attenuation factor (λ) can be shown to equal λ times the depth of the sub-slab divided by the distance to the source. If λ equals 0.1 and the sub-slab is 5 feet deep, then the distance to the source must be 50 feet or greater in order to have a sufficiently conservative λ of 0.01, as specified in question 4 of the draft guidance. There are several factors that affect the appropriateness of $\lambda=0.01$ in the subsurface, including uncertainties in plume delineation, lateral vapor transport, and the presence of layered soils and discontinuous layers of low permeability.

Dominic also pointed out potential problems with the use of the J/E model in question 5 of the guidance. Models are more appropriately used to predict the potential for future exposures, not current exposures. The model cannot simulate first-order transport processes in deep or non-homogeneous systems. Dominic also sees a danger of "creative" model application or use of the model instead of data to ensure a finding of an incomplete pathway. He indicated that sub-slab testing allows more definitive assessment of vapor intrusion, collection of sub-slab depressurization design information, and immediate mitigation if required.

Next, Dominic explained the design and installation of soil vapor sample probes and calculation of purge volume for the sample hole and modeling to determine the affected radius of sampling. The analysis of the sample is performed by Method TO-17, which has several advantages including, rigorous QA/QC requirements, commercially available thermal desorption units and a large selection of sorbents, small size and weight of the sorbent and equipment, and the possibility of moisture management by dry purging and sample splitting prior to injection into the gas chromatograph. He summarized the sorbent tube design and conditioning, the selection of sorbents and potential for mixed use, breakthrough volumes, QA requirements, and back pressure.

Dominic also explained the equipment for steady-state, single-interval air permeability testing and noted that it takes about 20 seconds to run the test. The results must be corrected for frictional head loss through the tube. The output includes the air flow rate, the change in pressure in the water, the estimated pressure in the well, and lower and upper estimates of permeability. Simulated and observed pressures for steady-state, multiple interval air permeability testing were shown to have a very good correlation coefficient.

To view Dom DiGuilio's presentation materials for details, click here.

Raymark Industries: A Superfund Indoor Air Case Study

Ray Cody, U.S. EPA Region 1

Ray Cody presented a case study of a ground water to indoor air contamination investigation at the Raymark Industries Superfund Site in Stratford, CT. A dissolved-phase plume of chlorinated organic

solvents, their degradation products, and BTEX has moved into a downgradient residential area containing 235 homes. The subsurface consists of a complex sequence of glacial outwash with some shallow fill areas and peat. The overburden is approximately 100 feet thick, and the bedrock surface is very uneven. The depth to ground water averages 7 to 15 feet bgs.

Because there were very few wells in the residential area upon which to base decisions, the Region decided to conduct a soil gas survey to better define the plume location and to identify homes in which to test. In January 2001, a shallow soil gas survey, consisting of 235 sample locations around the foundations of 130 buildings, was conducted. The samples were collected using a slide-bar-driven soil probe, personal sample pump, and Tedlar™ bags or a Summa® canister. The samples were analyzed by GC/MS, trace atmospheric gas analyzer (a MS/MS), and a MicroGas Sampler (O₂, N₂, CO₂), using an Emergency Response Team mobile laboratory.

The survey results indicated nine buildings should be tested for indoor air problems, although one owner denied access. Four of the remaining eight buildings had indoor air concentrations that required the installation of mitigation systems. However, the MicroGas Sampler results indicated higher than expected levels of oxygen in the soil gas samples. This indicated that ambient air diluted the soil gas, thus the results would underestimate actual contaminant concentrations.

A second soil gas survey with ground-water contaminant profiling was undertaken in January 2002. Six Geoprobe rigs equipped with ground-water and soil vapor sampling capabilities sampled 60 locations. The regional mobile laboratory was brought onsite to analyze water samples for temperature, specific conductivity, redox, pH, dissolved oxygen, and turbidity, and soil vapor samples for VOCs. Ground-water samples and the indoor air samples were sent offsite for analysis.

Preliminary data indicate that 19 of the 60 sampling locations have soil gas concentrations above the threshold levels that are a trigger for indoor sampling. Indoor sampling of 15 of the 19 buildings indicates that three of them will require mitigation measures.

Questions and Answers

Question: Was the ground frozen at the time?

Answer: This could have been a problem, but does not appear to have been in this case.

Question: Were the slam bar holes grouted up?

Answer: No.

Question: Do you have any idea of the effects of the extensive surface cover (asphalt streets, sidewalks etc) on the soil gas results?

Answer: We have not been able to determine if there was any effect on the concentrations due to surface cover.

Question: For the homes that have had mitigation systems installed in them, what are the ground-water concentrations?

Answer: There is little ground-water data in the neighborhood and the results of the second survey data are not in.

Question: Soils gas sensitivities are 30 to 300 times less sensitive than indoor air techniques. Is it protective to use soil gas measurements alone?

Answer: The sensitivities were sufficiently low to allow comparisons with the Connecticut Standards.

Question: Were the mitigation systems installed in the homes after one sampling or were these double checked?

Answer: They were installed based on the one sample.

To view Ray Cody's presentation materials for details, click here.

Assessing Risks from Indoor Air

Susan Griffin, U.S. EPA Region 8

Susan Griffin summarized issues associated with assessing risk from indoor air exposure. The risk assessment must include the contaminant concentration in the indoor air at the point of exposure, in addition to other variables such as contact rate, exposure frequency/duration, body, and exposure averaging time. These variables are used to estimate a reasonable maximum exposure level, which is the highest exposure that is reasonably expected to occur from the exposure pathway. Exposure assumptions should always be site-specific and should include land uses, receptors, and complete exposure pathways.

Different EPA guidance documents seem to provide different equations for estimating risk. For example, the equation found in the Risk Assessment Guidance for Superfund (RAGS) is different from that found in the Soil Screening Level (SSL) Guidance. However, the equations are actually the same except that the SSL Guidance uses default values for a number of the variables used in the RAGS equation and combines them into one term. Hence, the SSL equation is far more generic than RAGS. Susan advised the audience to be sure to understand the root of the equations before using them.

The toxicity values for TCE and 1,1-DCE are currently under review. The old provisional toxicity value for TCE was $1.7E-06$ Fg/m³. The new values, which are not final, range from $5.7E-06$ to $1.1E-04$ Fg/m³. Susan does not recommend using the new values until they are finalized. In addition, 1,1-DCE will no longer be classified as a carcinogen.

In concluding, Susan emphasized that published toxicity value tables are generally suitable for screening purposes, but final risk determinations must use site-specific exposure pathways and site-specific chemical data.

Questions and Answers

Question: If see screening level data are above acceptable levels, as given in published tables, do you advise that no action should be taken?

Answer: The toxicity values in the tables are not necessarily appropriate; you need to know what assumptions went into generating them. Data showing chemical concentrations above the screening levels indicate that the site should be further investigated, not that a mitigation action should be initiated.

To view Susan Griffin's presentation materials for details, click here.

Ground-Water Contamination to Indoor Air

Kathy Baylor, U.S. EPA, Region 9 RCRA Corrective Action Office

Kathy Baylor summarized Region 9's investigation of a TCE plume's effect on indoor air at a nearby housing development. A GTE Government Systems facility operated on the site between 1952 and 1993, contaminating the ground water with TCE and 1,1,1-TCA. In the early 1990s, the facility buildings were razed, and in 1995, the site was redeveloped for residential use. The houses on the 60-

acre property were typical slab-on-grade construction that included a plastic sheet over a gravel vent. At closing, the residents received forms that informed them that there was a TCE plume in the subsurface.

The subsurface at the site consists of interbedded silts and clays with sand and gravel. Ground water is present at approximately 20 feet bgs. A pump and treat system is being used for containment of the plume.

Region 9 investigated seven homes above the primary area of contamination and two reference homes. Two ambient air samples were collected in two backyards. Sampling was conducted during the spring and fall. Indoor air samples were collected over a 24-hour period with 6-liter Summa[®] canisters. The samples were analyzed for TCE, DCE, and vinyl chloride by GC/MS using a TO-15 analysis with selected ion mode as developed by the CDPHE. This method allows you to zero in on a select number of VOCs and provides better quality data than general scan methods such as 8260. Results indicated that the houses were generally below the 10^{-6} cancer risk level, with the exception of one house that consistently had 10^{-5} risk levels, despite the in-place gas barrier.

The Summa canisters were set at the height of a 3-year-old child. In order to ensure they operated for the full 24-hours, the flow rate was set to leave a final negative pressure of 4 inches of mercury. Rough calculations using the Nazaroff-Little and J/E models indicated that the models may not be conservative. The indoor air TCE concentrations were consistent with ground water and soil gas data, and there did not appear to be any interference with household chemicals. Kathy noted that the work presented is not an endorsement of the J/E model. The model likely works at this site because of the new construction and vapor barriers installed. These features are not likely to be present at most sites. Therefore, the model should be ground-truthed if it is to be used.

Questions and Answers

Question: What action level did you use?

Answer: We used 1.1 Fg/m^3 , which is associated with a 1 E-06 risk level.

Question: Is there a competent aquitard?

Answer: No. The interbedded materials were discontinuous.

To view Kathy Baylor's presentation materials for details, click here.

ITRC Indoor Air Proposal

Randy Carlson, Kansas Department of Health and Environment

Randy Carlson gave a general presentation on the makeup, role, and functions of the Interstate Technology Regulatory Council (ITRC). He then spoke on a proposal submitted by the Kansas Department of Health and Environment to the ITRC to develop an indoor air investigation, characterization, and remediation guidance document. The goals of the guidance are to address concerns that the indoor air pathway has been overlooked and to be a "one-stop shop" for information on all aspects of the contaminated soil/ground water to indoor air problem.

The proposed activities for completing the document would take place over a two-year period. In the first year, a workgroup will be formed and the guidance written. Following publication of the guidance, the ITRC will offer classroom and Internet training. The classroom training courses generally last two to three days and the Internet sessions are generally two to three hours long.

The proposal is one of a number that have been submitted to the ITRC, and it is not known at this time whether it will be chosen for implementation. If it is chosen, work should begin in fiscal year 2003. The lead for this project is Rob Weber, Kansas Department of Health and Environment, (785)296-8801, rweber@kdhe.state.ks.us.

Questions and Answers

Question: How should EPA be involved?

Answer: The workgroups are composed of volunteers. To become a member, you (and your office) would have to agree to commit 10 percent of your time to the project.

To view Randy Carlson's presentation materials for details, click here.

JUNE 4, 2002: PERCHLORATE TRAINING SESSION

The Technical Support Project sponsored training on issues associated with perchlorate contamination in the environment. This training consisted of the following presentations:

- *Introduction*, Chris Villarreal, U.S. EPA Region 6
- *The Nature of Perchlorate (General Background Information) and the National Occurrence of Perchlorate*, Kevin Mayer, U.S. EPA Region 9
- *Perchlorate Toxicity Assessment (Human Health)*, Annie Jarabek, U.S. EPA Office of Research and Development, National Center for Environmental Assessment
- *Perchlorate in the Environment—Ecological Considerations*, Philip Smith, Texas Tech University
- Question and Answer Session
- *Perchlorate Treatment Technologies*, Wayne Praskins, U.S. EPA Region 9
- *Perchlorate Analytical Detection Methods*, David Munch, U.S. EPA Office of Water, Office of Ground Water and Drinking Water, Technical Support Center
- *Current Regulatory Aspects of Perchlorate*, David Huber, U.S. EPA Office of Water, Office of Ground Water and Drinking Water, Standards and Risk Management Division
- Question and Answer Session

The training session was broadcast live on the Internet with close to 500 people participating remotely, in addition to 80 participants onsite. Remote participants were able to listen to the presentations through phone line connections and audio streaming, and view slides online as they were discussed. They were also able to submit questions through their PC or phone line.

The audio archive and slides for the perchlorate training can be accessed at:

http://www.clu-in.org/studio/perchlorate_060402/ .

JUNE 5, 2002: MINING WASTE WORKSHOP

Welcome and Introduction

Robert E. Roberts, Regional Administrator, U.S. EPA Region 8

Jim Dunn (Region 8 HSTL) introduced Robert E. Roberts, the Regional Administrator for Region 8. Before his appointment by Administrator Whitman, Mr. Roberts served for seven years as Executive Director of the Environmental Council of States (ECOS). From 1990 to 1995, Mr. Roberts was Secretary of the South Dakota Department of Environment and Natural Resources.

Mr. Roberts welcomed participants to Denver and Region 8. He remarked that the TSP meeting will focus on a number of issues that are of great significance to both Region 8 and the entire country, including mining waste and indoor air contamination. The characterization and remediation of hardrock mining waste is one of the greatest concerns in Region 8. The mining industry fell upon hard times in the past century, and many mine owners and operators went out of business overnight, leaving behind a legacy of environmental contamination. According to some estimates, there are nearly 500,000 mining sites in Region 8, many of which are abandoned. Many states are beginning to inventory these sites, which is an important first step in addressing the mine waste problem. With so many sites, it is difficult to identify, characterize, and clean up these environmental liabilities without a well-funded, coordinated effort.

Mr. Roberts is pleased that the TSP is meeting with the Interstate Technology Regulatory Council (ITRC). His experiences with the ITRC while he was at ECOS were positive. Together, EPA and ITRC can facilitate the dissemination and acceptance of new technologies in multiple jurisdictions.

Hardrock Mining: EPA's Roles

Carol Russell, U.S. EPA Region 8

Carol Russell (Region 8) presented a general overview of hardrock mining and its associated wastes. Nevada, Arizona, and Utah are the largest toxic polluting states due to their extensive mining operations. Carol noted that every American uses minerals, metals, and fuels (averaging over 3.5 million pounds per person) over the course of their lifetime. Metals released during surface and underground mining, as well as mineral processing and smelting, however, can be harmful to humans health and the environment. These metals and minerals can be released into ground and surface water, soil and sediments, and the air.

EPA has a regulatory arsenal of laws that can address each of these pathways, including the Clean Water Act, Clean Air Act, CERCLA, and Federal Agency 106 removal authority. In addition, the new brownfields bill, along with state programs, address mining waste mitigation. While these laws may aid in the regulation of remediation activities, more money and resources must be devoted to mining waste research needs. Among the most pressing needs are sampling and monitoring technologies, pollution prevention strategies and modeling (including acid drainage prediction and water routing), more cost-effective water treatment options, and more funding. Carol indicated that standardized data collection management is essential to addressing all of these needs.

Carol concluded with a brief overview of the mining waste problem in the Animas River watershed southwest of Denver. More than 2,000 mines are located in the watershed. The Animas River stakeholder group did not want Superfund designation for their site because they feared the stigma would lessen their property values. Following community meetings, the stakeholders backed the cleanup plan, which included using Federal Agency 106 removal actions, Clean Water Act NPDES/NPS actions, and voluntary actions.

Questions and Answers:

Question: How are conventional surface water sampling methods failing you?

Answer: Colloidal material often fouls the filters, sometimes resulting in 100-fold variations in concentrations from the same sample. In addition, the laboratory's holding time for sulfate samples is 28 days, which is too long for practical purposes.

To view Carol Russell's presentation materials for details, click here.

ORD Technical Support for Mining Sites

David Reisman, Director, Office of Research and Development Engineering Technical Support Center

David Reisman indicated that technical support for mining issues can be obtained through him at the Engineering Technical Support Center (Cincinnati, OH), through Dave Burden at the Ground Water Technical Support Center (Ada, OK), and through Dave Jewett at the Center for Subsurface Modeling Support (Ada, OK). The Superfund Innovative Technology Evaluation (SITE) Program and Mine Waste Technology Program are also involved.

The Engineering Technical Support Center has provided technical support at 26 mine sites in the past four years, including the Luttrell Repository, which is owned by EPA. Dave explained that the issue of reclamation versus remediation is particularly important because the definitions of the two approaches are not the same for different agencies. Other mining issues at a site can include chemical, physical, biological, metallurgical, radiological, cultural, political, and economical. Mining sites are typically difficult to address because often source control cannot be attained. There is typically too much acidic surface water and ground water requiring treatment, and power is not available at many sites. Also, there can be numerous and scattered piles of tailings, chat, and waste rocks. Pits and pit lakes can be present, and there can be a noticeable lack of flora and fauna.

Dave reviewed issues and progress at several mining sites across the country noting a site remediation involving anaerobic bioreactor, a pipeline to keep water away from wastes, and a reverse osmosis treatment plant. He concluded by thanking and acknowledging the people involved in addressing mining waste issues, including Ed Bates (NRMRL-Cincinnati), Trish Erickson (NRMRL-Cincinnati), Jim Dunn (Region 8 HSTL), and the Region 8 and 9 RPMs and OSCs.

To view David Reisman's presentation materials for details, click here.

Anaerobic Bioreactor Technologies

Tim Pickett, Applied Biosciences

Tim Pickett highlighted Applied Biosciences' biological selenium removal process (BSeR™), which was validated under a six-month EPA Mine Waste Technology Demonstration Program. Anaerobic bioreactors are used in pump and treat systems to remove metals from contaminated ground water. Their benefits include high removal efficiencies, low operating costs, and removal of difficult contaminants such as arsenic, nitrate, and selenium. Selenium is a metal associated with deposits of gold, silver, copper, etc. It can become concentrated in the food chain and at low mg/L levels, cause decreased survival rates, deformity, cancer, and death. Tim explained that anaerobic bioreactors can be as effective or more effective than other technologies (e.g., reverse osmosis and ion exchange) in reaching discharge standards, yet they are cheaper.

Tim summarized the biotreatment requirements for BSeR™ and showed an example microbial evaluation from bench-scale testing. The results showed reductions in selenium to at or near the

detection limit. The demonstration of BSeR™ was conducted on a selenium plume site that used to have wetlands, but the water was diverted. The test was run for 180 days and was able to reduce selenium levels in the influent (about 300 gpm with about 2 mg/L selenium) to less than the 2 µg/L detection limit. An economic analysis of the six technologies tested showed BSeR™ costs to be the lowest. Nutrient costs were about \$0.55/1,000 gallons of water treated, but this cost could be lower.

Tim also summarized the results of anaerobic biotreatment results for systems operating at the Wharf Mine in South Dakota and the Zortman/Landusky Gold Mine in Montana. He concluded by saying that pump and treat bioreactors are cost-effective solutions for the removal of inorganics with simple bioreactor designs, low O&M costs, and high removal efficiencies.

Questions and Answers

Question: Are they batch reactors?

Answer: No, they are continuous reactors.

Question: What kind of support media was used?

Answer: Activated carbon.

Question: Can the system treat larger volumes successfully?

Answer: The system is scalable, so a larger flow can be treated with a larger system.

To view Tim Pickett's presentation materials for details, click here.

Passive Mine Drainage Treatment

Jim Gusek, Knight Piésold and Co.

Jim Gusek explained principles of passive treatment systems for metals-contaminated mine drainage. Passive systems use common geochemical reactions that are typically assisted by microbes or plants. They do not require the addition of chemical reagents, power, or the short-term exchange of process media. Furthermore, passive systems can function without human intervention for long periods of time.

The control of the operating pH to remove metals through precipitation can be difficult, especially if more than one metal is being treated, due to differences in metal hydroxide solubility. Jim summarized the chemical reactions behind the precipitation of metals. He noted that sulfide and carbonate precipitation by sulfate reducing bacteria and hydroxide and oxide precipitation by T.B.-F.O. are major passive treatment approaches for removing metals. There are a number of components that can be placed in a passive system, but only one process is emphasized in each cell. Mirroring typical wetland ecosystems, passive systems may include reactions that occur in the oxidizing zone, and reactions that occur in the reducing zone.

Jim provided examples of full-scale passive treatment systems, noting that there are hundreds of full-scale systems at coal and metal mines worldwide. These systems represent a wide range of operating conditions and metals and non-metals (CN^- , SO_4^{2-} , NO_3^- , NH_3 , BOD, and P) treated. Flow rates range up to 1,200 gpm. Jim explained key passive treatment issues, such as required treatment area (can be large depending on water chemistry), system longevity (decades), residuals and residual disposal, performance, and costs (can be half the cost of active treatment for identical chemistry). He explained the number of advantages of passive treatment, and possible reasons why some passive treatment systems have not worked as designed.

To view Jim Gusek's presentation materials for details, click here.

Mary Murphy Mine Case Study

Mike Wireman, U.S. EPA Region 8

Mike Wireman described the research conducted at the Mary Murphy Mine Site located in southern Colorado. The Mary Murphy Mine has been an applied research site for 12 years. The objectives at the site are to: 1) advance the conceptual understanding of the hydrology and geochemistry of hardrock mine sites, especially relating to metals loading in streams, 2) develop characterization tools; 3) develop source control techniques; and 4) technology transfer. Mike's presentation focused on three of the tools used to determine mass loading, ground-water flow pathways, and the pathways for water entering the mine works.

Mary Murphy Mine is located atop Chrysolite Mountain in a quartz monzonite batholith. The fractures and faults of the batholith trend north and northeast, and ground-water flow is primarily within these preferential pathways. Chalk Creek, the primary receptor for metals from the mine, is located about 2 miles from and 2,200 feet below the top of the mountain.

Over the years, a lot of water chemistry data have been collected from the mine and from Chalk Creek. The results of flow-weighted mass loading at the site revealed that approximately 50 kg of zinc enters Chalk Creek daily, and 40% of the metals loading cannot be attributed to surface water sources. Therefore, ground water must contribute to the mass loading. The first tool used to determine mass loading was stream tracing, which is a very accurate stream flow measurement tool that allows discrete inflows to be pinpointed. To conduct stream tracing, NaBr or NaCl is injected upstream for 24 hours at a constant concentration. Then downstream concentrations and travel times are measured to determine the location of inflows. Detailed sampling of the zinc-rich inflows further bracket the sources and determined loading. Based on the results, most of the loading to the creek was found to occur between 80 and 300 meters downstream. A 10-foot wide fracture zone entering Chalk Creek was found to deliver about 10% of the zinc load

The second tool used at the site was ground-water tracing, which involved the injections of the fluorescent dyes, eosin and rhodamine, to find ground-water pathways. The rhodamine was injected into a collapsed stope visible at the ground surface. The dye showed up in the Lady Murphy Adit at the 1,100-foot level in just 2 or 3 days then exited the adit into the creek. The rhodamine was not found much elsewhere. A helicopter was lowered to the top of the mountain to drill the borehole for the eosin injection. The driller attempted to intercept a buried stope with the borehole, but did not. The eosin dye was detected in three wells, which are screened in different intervals, in the valley bottom two miles from the injection point. It took five weeks for the dye to reach all of the wells, indicating high ground-water velocities. An interesting finding was that bulk of the dye was not found in the northern direction of fracture strike. Instead, it flowed to the northwest in the shortest path to the creek. Furthermore, the dye wasn't detected in the mine workings.

The third tool was an isotopic study to determine the path of water flow from precipitation and runoff into the mine. Both oxygen-18 and deuterium levels were measured for all the inflows on a daily or weekly basis during the runoff period. The ratios of oxygen-18/oxygen-16 and deuterium/hydrogen were examined to determine whether the source of the water was snowmelt (snowmelt is more depleted in O-18 and deuterium than rain or ground water). In addition to isotopic data, water quality data from all the inflows were collected. The results showed that zinc concentrations were highest in periods of high inflows, rather than low inflows as would be expected. Initially, the north vein contributed most of the inflow, but with time, the south vein contributed more. The highest concentrations of zinc come the north vein, which contributes 70-80% of the zinc. Inflow to the north vein was found to be dominated by snow melt. The snowmelt likely penetrates an old chute full of ore or waste piles high in pyrite. This finding is good from a remedy point of view, since the snowmelt inflow can be controlled. Water from

the south vein is dominated by ground-water flow and contains less zinc. Additional isotopic testing with sulfur-35 confirmed these findings.

The conceptual model developed for the Mary Murphy Mine show that three flow systems exist:

- the regolith, which is highly chemically and physically weathered, but only has water in it for about six weeks per year during the snowmelt
- bedrock fractures, although gravity, not strike, is determining fracture flow to the creek
- slopes, tailings, and mine workings, which serve as hydraulic sinks, but are not significant in terms of zinc loading.

Additional research is planned at the mine.

Pit Lakes Overview

Jim Jonas, Camp Dresser & McKee

Jim Jonas explained that a pit lake develops from an open pit that was dewatered during mining, but has since filled with ground water and surface water once mining ceased and the pumps were turned off. Pit lakes are a problem because sulfide minerals can become oxidized during dewatering, and once the water table rebounds, metal sulfate salts and acidity are flushed into the pit lake. The cycling of oxidized and reduced iron through water-rock interactions also lead to poor water quality. Furthermore, the lakes become even more concentrated with dissolved metals as water evaporates. Pit lakes are classified according to climate (terminal and flow-through) and mineralogy (acidic and circum-neutral).

Pit lake problems can be managed by:

Backfilling with reactive wastes, either below the water or below the water with a clean fill cap. Or clean fill can be placed below the water table and reactive waste placed above.

Induced stratification by pumping saline water into the lake with fresh water diverted to the surface. The water stratifies due to the density difference, but the stratification is susceptible to turnover if the gradient isn't strong enough.

Accelerated filling after mining ceases to divert a large volume of clean water to the pit, which keeps the ground water from flushing large quantities of metal salts. The runoff must be diverted to keep the salts on the surface from being flushed into the lake.

Neutralization by adding a material with a high neutralizing capacity to the lake to raise the pH and precipitate the metals. Trace metals may be difficult to remove if neutralization is completed after filling.

Eutrophication by adding large amounts of organic matter to the lake during or after filling it. The organic matter stimulates biological activity (e.g., sulfate-reducing bacteria).

Jim concluded his presentation with case studies of the treatment of the East Pit Lake, Island Copper Pit Lake, and Berkeley Pit Lake.

To view Jim Jonas's presentation materials for details, click here.

Hardrock Mining 2002 Workshop

Jim Dunn, U.S. EPA Region 8, Hazardous Substance Technical Liaison

Jim Dunn (Region 8) gave an overview of *Hardrock Mining 2002*, a workshop that was held May 7-9 in Westminster, Colorado. The workshop, which was sponsored by EPA's Office of Research and Development (ORD), was attended by over 450 professionals. The purpose of the workshop was to examine and discuss current and future environmental issues related to hardrock mining operations and waste, with an emphasis on technology verification and case studies. The goals of the workshop were to provide a forum for the exchange of scientific information, enhance the legacy of remediation and cleanup, and contribute to the sustainability of the U.S. mining industry. The workshop steering committee was composed of a diverse group of experts from numerous organizations and agencies, including EPA, USGS, DOE, the Universities of Nevada and Montana, and the Barrick Mining Company.

During the workshop's plenary sessions, numerous issues were discussed, including the effects of mining on indigenous peoples, micro- and macroeconomic limits to cleanup, and the capabilities of the Rocky Mountain Hazardous Substance Research Center. The 60 presentations that were given over the course of the three-day workshop covered a wide variety of topics, including pit lakes, ecological monitoring, and community involvement. There was also a poster session with 38 displays. The workshop provided an excellent opportunity for networking. The proceedings will be available on CD-ROM in January 2003.

To view Jim Dunn's presentation materials for details, [click here](#).

Leadville Superfund Case Study

Mike Holmes, U.S. EPA Region 8

Mike Holmes summarized the approach to cleanup at the Leadville Superfund site, including EPA's work with the community to develop an approach that would meet cleanup goals, while meeting the town's goal of promoting tourism. The Leadville mining area became a Superfund site in 1983. It is approximately 16 square miles with about 1,200 waste rock piles—most of which are acid producing. The mines were operated by Asarco and Resurrection, which is a division of Newmont. During World War II the U.S. Government operated one of the mills at the site and is a PRP. The final settlement splits the costs of remediation into thirds.

There are two large tunnels that drain the site: the Yak tunnel and the Leadville tunnel. The Yak tunnel is about four miles long and produces between 350 and 600 gallons of pH 4 water per minute. The water discharges into the Arkansas River. The first two miles downstream from the discharge point are devoid of aquatic life. The first step in the cleanup was to rehabilitate the Yak tunnel so a bulkhead could be built to control the flow of water. Once the flow was regulated, it could be directed through a wastewater treatment plant.

An AVIRIS (airborne visible infrared imaging spectrometer) overflight of the area allowed the waste rock piles to be prioritized by identifying the pyrite-containing rock. The initial approach was to consolidate and cap the piles. However, this approach met with considerable opposition from the local community, which wanted to keep the landscape for "atmosphere" so the town could better promote itself as a tourist attraction. After some study, it was decided that working directly on the piles should be avoided, if possible. Work was concentrated instead on managing the water flow into and out of the piles. This was done with a system of concrete conduits (painted with tar to prevent corrosion from the acid water). The water is directed to a treatment area before discharge.

During the 1950s, the Leadville mining area was also the home of the largest lead smelter in the world. This operation created large piles of slag. The town allows any slag fragments over 3/8 inches in diameter to be used in construction. However, they have placed controls on fragments smaller than 3/8 inches in diameter for fear they may be crushed and used as road “sand” during the winter. Crushing the slag produces respirable particulate and hence becomes a breathing hazard.

Work is still ongoing to capture and treat some acid waters. Also as part of the hazard mitigation, and in keeping with the community’s desire for mining town ambience, they have shored and repaired some of the old mine head frames rather than tear them down.

Summitville Water Treatment Case Study

Karen Taylor, Camp Dresser & McKee

Karen Taylor noted that Summitville has been the location of gold mining since the 1870s. The operations were primarily strip mining with the gold extracted by a cyanide leach procedure. When Summitville came to EPA’s attention, releases from the cyanide leach pad were occurring. In addition, the Summitville Dam Impoundment (SDI), which dams wastewater, was in danger of eminent failure and there had been a fish kill. The site was placed on the NPL in 1994.

Currently all surface water runoff and ground-water seeps are collected and stored in the SDI. This water, which has a pH ranging from 2.7 to 3.8 and a high manganese, zinc, iron, and copper content, is pumped from the SDI to a wastewater treatment plant. The plant is operated between April and October. Plant operators have noticed that the water tends to stratify, with water nearer the bottom of the impoundment being richer in metal salts.

The treatment plant process is a modified high-density lime precipitation system that uses bulk lime as feed. Because of its abrasiveness, the lime feed is handled by an eductor system, rather than as a slurry. The lime is injected into the reactor tanks and mixed with the influent water; the tanks are maintained at a pH of 9. The whole system operates by gravity flow, and the influent flows out of the reactor tanks to a 60-foot diameter thickener tank located outside the main treatment building. Various ionic polymers are used at the end of the process to help with coagulation, and the polymers are changed as the chemistry of the influent water changes. To obtain a thicker sludge and to minimize its volume, part of the sludge is recycled through the beginning of the process. The clarified water overflows the thickener tank and passes through a weir where it discharges to a surface water. Excess sludge is put through a filter press and disposed of onsite. The plant is currently treating about 1,000 gallons per minute, which is the high end of its capacity.

To view Karen Taylor’s presentation materials for details, click here.

Mining Waste Field Trip

The three TSP forums took a field trip, led by Ron Abel and Mary Scott of the Colorado Department of Health and Environment, to the Clear Creek/Central City Superfund Site located approximately 30 miles west of Denver. The first stop on the trip was in Idaho Springs where forum members toured the Argo Tunnel treatment plant and the Clear Creek Watershed Forum exhibit at the Idaho Springs Visitors Center. The second stop was in the town of Black Hawk to observe a demonstration of the BASX Systems’ CERAMX™ microfiltration technology to treat acid mine drainage in the North Fork of Clear Creek.

Clear Creek Watershed Forum exhibit: The Clear Creek Watershed Forum exhibit gave an overview of the history of mining in the watershed and highlighted successful cleanup stories. Historically, the 400-square mile Clear Creek Watershed was used for gold and silver mining, agriculture, and industry. Today, the watershed provides drinking water for 350,000 people in the Denver area and recreational activities for residents and visitors. EPA has improved its relationship with the watershed communities over the past 15 years by addressing the needs of the communities and dealing with sites on a watershed basis.

There are more than 1,300 orphan mine sites in the Clear Creek Watershed. Orphan mine sites cannot be regulated under current laws (e.g., Superfund) and have no identifiable responsible parties that can be located or that have the means to clean up the site. The McClelland Mine and Mill Site was one of EPA's first orphan site projects. A mining company not responsible for the contamination chose to clean up the site as a public relations gesture. They sealed and covered the tailings with soil and built an access road and boat launch.

The Black Eagle Mill Tailings Site was one of the most significant Superfund actions to occur in the Clear Creek Watershed. The tailing piles were graded and covered with soil and vegetation. The site owner, who was originally against the cleanup, is now proud of the cleanup actions taken. Cleanup at the Minnesota Mine Tailings Site involved diverting drainage around the tailings and covering them with soil and grass.

Argo Tunnel Treatment Facility: The Argo Tunnel extends 4.2 miles into the mountain and drains much of the Central City gold mining district, which has been called "the richest square mile on earth." The tunnel was built in 1893 by British investors for transportation and drainage. The tunnel has not been used for mining since the 1940s after a surge event killed four people. However, water containing large amounts of heavy metals and with a pH of 2.8 continues to drain from the tunnel at an average rate of 250 gpm. (The rate at the time of the tour was considerably lower due to persistent drought conditions in Colorado.) The Argo Tunnel and four other tunnels in the watershed were placed on the National Priorities List in 1982 and 1983. Today, the entire watershed is on the NPL.

Because drainage water from the Argo Tunnel posed a threat to the aquatic life in Clear Creek, a treatment facility was constructed in 1996-97. The treatment facility has the capacity to handle 700 gpm. Water from the tunnel flows into two equalization basins that hold up to 130,000 gallons each. In case a surge occurs, water can be stored in one basin while the treatment train runs from the other. A pipe that returns water to be retreated also discharges to the basin. The pH of this water is often high enough to cause the precipitation of some metals in the drainage water. This causes a maintenance problem due to sludge buildup.

Water from the equalization basins flows through an adit via gravity flow into two rapid-mix tanks inside the building. The water is mixed with a 50% sodium hydroxide (NaOH) solution to raise the pH to 9.9, which causes metal precipitates to form. The water flows from the tanks to a dike unit where dry anionic polymer is added to cause flocculation. The water passes through baffles containing tubes 2 inches in diameter, 2 inches long, and set at angles. As water passes through, particles get trapped in the angles between the tubes. The water subsequently is clarified in a filter made of anthracite and sand, which must be back washed every third day. The pH is then lowered using carbon dioxide gas, and the clean water discharged over a V-notch weir into Clear Creek.

The liquid sludge, which contains about 3% solids, is put in a batch filter press at about 100 psi to dewater the sludge to about 15% solids. The sludge undergoes the Toxicity Characteristic Leaching Procedure before it is sent to a hazardous waste landfill. The facility removes about 1,200 pounds of dissolved metals (including manganese, copper, zinc, iron, and aluminum) per day. To date, 9 tons of

sludge have been disposed. The State has evaluated three locations within the watershed to build a sludge and tailings repository.

O&M costs at the facility are approximately \$1 million per year, 90% of which is paid by EPA and 10% by the State. Approximately one-third of costs are for NaOH, one-third are for sludge disposal, and one-third are for labor. Seven full-time operators staff the facility, which is operated around the clock. However, some processes will soon be automated. Automation of the facility would save about 10% in operating costs.

Microfiltration Demonstration: The Gregory Incline adit discharges acid mine drainage from the surrounding hills into North Fork at approximately 100 to 150 gpm. The North Fork is the most heavily impacted portion of the Clear Creek watershed with high concentrations of copper, iron, manganese, and zinc. Wayne Brothers, Jerry Carlson, and Matt Hayes of BASX Systems demonstrated the use of the CERAMX™ microfiltration system, coupled with NaOH and electrocoagulation pretreatment, to treat the metals-contaminated water of the North Fork.

EPA's Mine Waste Technology Program Activity III, Project 36, was implemented in three phases. The first phase, a bench-scale test, began in October 2001. Surface water was collected to test several pretreatment options in the laboratory. NaOH and electrocoagulation (using a direct current to oxidize the metals) techniques were found to work the best to precipitate the metals. The second phase was to run the filtration system with each pretreatment option for 72 hours. Approximately 4,500 gallons were treated with each method. In the NaOH test, the pH of the surface water was raised to 10.1. Compressed air was passed through the water to oxidize the iron and manganese, increasing the formation of their precipitates. In the electrocoagulation test, an electrical current induced oxidation and reduction reactions that caused the formation of both oxide and hydroxide precipitates. The pH in this test was maintained at 6.5.

The pretreated wastewater was pumped through the pores of a ceramic membrane. Water was recirculated through the membrane at an 8:1 ratio, which allowed the shearing force to keep solids off the membrane surface. The ceramic membrane was described as durable and easy to clean. The systems must be back-pulsed every 90 seconds to avoid clogging. The membrane is cleaned with caustic soda and bleach followed by water and sulfuric acid rinses.

Every metal in the NaOH-treated water was reduced to below detection limits, except for iron and manganese. However, both the iron and manganese concentrations were well below discharge standards. The results of electrocoagulation showed iron, manganese, nickel, and zinc above the detection limit, and manganese and zinc above their respective discharge levels. The precipitates formed by the NaOH method were in the 5 to 10 μm range. Tests showed that a diaphragm press is needed to dewater the sludge.

The third phase of the project is to design a portable, skid-mounted, 300 gpm treatment facility to treat the water of the North Fork.

JUNE 6, 2002: JOINT TSP/ITRC SESSION

ITRC DNAPL Team: Mission and Past Activities

Eric Hausamann and Jim Harrington, New York State Department of Environmental Conservation (NYSDEC)

Eric Hausamann (NYSDEC), ITRC DNAPL Team Leader, welcomed participants to the TSP/ITRC joint session and introduced the other members of the ITRC DNAPL workgroup. The mission of the DNAPL workgroup is to educate regulators and decision-makers about the “DNAPL challenge” while highlighting the potential benefits of DNAPL mass removal. The DNAPL challenge includes devising ways to detect and remediate DNAPL sources. Currently, the workgroup encourages use of the Triad Approach to site characterization with an integrated or phased remedial strategy.

The DNAPL workgroup was formed in 1999 and currently has 50 active members. To date, the workgroup has produced technology and regulatory overview documents, over 20 cases studies, and is in the process of drafting three additional guidance and training documents.

DNAPLs are a problem because they migrate downward into soil and ground water, are difficult to detect, and are hard to eliminate or clean up. There are many ways that DNAPL can be contained or removed from the environment, including natural attenuation, source containment (e.g., pump and treat, bio-barriers, permeable reactive barriers, slurry walls), and source reduction (e.g., thermal, chemical, or biological treatment within the source). In situ thermal source reduction technologies include steam enhanced extraction, electrical resistance heating, and thermal conduction. In situ chemical flushing technologies include cosolvent flooding and surfactant enhanced aquifer remediation (SEAR). In situ enhanced desorption and bioremediation and in situ chemical oxidation are also means of source reduction.

According to its guiding principles, the DNAPL team encourages:

- adequate site characterization
- source mass reduction
- removal of free-phase DNAPL
- remediation of residual DNAPL to the point where the rate of attenuation exceeds mass flux
- no routine technical impracticability waivers for DNAPL sites
- the inclusion of remediation of DNAPL source in the presumptive response strategy for ground water

Source reduction shortens the remedial time frame, eliminates long-term O&M costs and restrictions on future use, and is consistent with regulatory goals.

To view Jim and Eric’s presentation materials for details, click here.

ITRC DNAPL Team: Existing and Future Activities

Jim Harrington, New York State Department of Environmental Conservation

ITRC is currently gathering empirical data on technology’s ability to remove mass, ground-water monitoring data, and lessons learned at sites throughout the country. The DNAPL workgroup is interested in collaborating with other federal agencies, including EPA, to leverage resources and share data and ideas. This collaboration will also allow the states to express their viewpoints to federal regulators. EPA’s Technology Innovation Office is co-publishing with ITRC *Guidelines for Characterizing DNAPL Contamination*, which is currently in draft form. In addition, ITRC is working

with EPA, USACE, and the Air Force Center for Environmental Excellence (AFCEE) on an engineering manual.

In 2003, ITRC will be publishing three new guidance documents dealing with characterization strategies, thermal remediation, and surfactant flooding. These documents should be ready for internal review this fall. ITRC is also planning to conduct Internet training courses next summer.

For more information on the ITRC, visit their website at www.itrcweb.org.

To view Jim Harrington's presentation materials for details, click here.

TSP Activities Relating to DNAPLs

Rich Steimle, U.S. EPA, Technology Innovation Office (TIO)

Rich Steimle gave an overview of the history of the TSP and its current and planned activities relating to DNAPLs. The TSP was formed over 15 years ago to facilitate technology transfer between Headquarters, EPA technical experts at the laboratories, and Regional scientists, RPMs, and field staff. Before TSP, there was little communication among these groups, limiting their ability to effectively use the latest technology to characterize and remediate sites.

The TSP consists of three forums: the Ground Water Forum, the Engineering Forum, and the Federal Facilities Forum. The three forums meet twice a year and hold monthly teleconferences. In the past few years, state representatives have participated in the forums, thanks to a cooperative agreement between EPA and the National Ground Water Association. The agreement expired in February 2002, but a new agreement with the ITRC will allow state representatives to continue to collaborate with the TSP.

The DNAPL debate will not be resolved until adequate field data is produced and analyzed. EPA plans to track sites where there has been source removal in an effort to compile empirical data on its effectiveness. The data that is collected must be high quality and consistent so that results at different sites can be compared. Rich said that he hopes the collaboration between EPA and ITRC is strengthened in the coming years. He referred everyone to the numerous resources that are available on TIO's Clu-In website (www.cluin.org).

Neil Thompson (Region 10), co-chair of the Engineering Forum, briefly discussed plans for the Spring 2003 TSP meeting, which will focus on DNAPLs. The meeting will be held in Seattle next April and will likely include a field trip to the Wycoff Superfund site. ITRC members will be invited to attend.

Comments

Comment: The quality of data on the effectiveness of source reduction is inadequate. We need to move beyond passive field reporting and must design our own parameters that will help answer the necessary questions. A protocol or checklist should be developed, and we should comment on this checklist.

Comment: We need a common format in preparing case studies so that they all answer the same questions. Case studies rely on anecdotal evidence and rarely contain standardized empirical data that can be compared among different sites.

Comment: It is critical to transfer the source reduction data to an electronic database so that it can be analyzed and shared remotely.

Update from the U.S. EPA Ground Water Technical Support Center

Dave Burden, U.S. EPA, Office of Research and Development—Subsurface Protection and Remediation Division (SPRD)

Dave Burden indicated that Lynn Wood (SPRD-Ada) is part of a team of 13 international experts performing a critical review of DNAPL remediation research. The team, which is co-chaired by Suresh Raoul and Mike Cavanaugh, held its first meeting in Dallas in October. Their main objectives are to produce a summary of remediation technologies, examine the benefits of partial source removal, catalog key metrics, identify research needs, and perform a cost benefit analysis on new technologies. A draft of their report is due on July 1, and a final report is targeted for September 30. Lynn is also looking at the relationship of cosolvent flushing and bioremediation at the Sages Dry Cleaner Site and has a proposal to the Strategic Environmental Research & Development Program (SERDP) on the benefits of mass reduction. Eva Davis (SPRD-Ada) is looking at the influence of temperature on degradation processes at the Wycoff Superfund Site and Loring Air Force Base.

Comments

Comment: We should have a mechanism in place that allows for cross-agency review of drafts before they are released.

ITRC Characterization Subgroup and Strategies for Characterizing DNAPL Characterization

Michael B. Smith, Vermont Department of Environmental Conservation

Michael Smith indicated that the ITRC's Site Characterization Subgroup is made up of state regulators, technology vendors, consultants, and Linda Fiedler of EPA's Technology Innovation Office. The subgroup is writing a document entitled *Strategies for Characterizing DNAPL Contamination*. The document will address characterization of DNAPL sites such that adequate information is collected so the site can be properly remediated. Suggested strategies will include the use of dynamic/flexible work plans and innovative and multiple site characterization techniques coupled with real-time analytical data to improve results of characterizing sites contaminated with DNAPLs. The purpose of the document will be to promote and publicize the use of these strategies, not to reiterate the physics of DNAPL flow.

Michael discussed the outline of the document, which will include an overview of the DNAPL problem, site characterization issues, site characterization strategies, data collection techniques and intrusive site investigation methods, and regulatory issues. The appendices will include an innovative DNAPL characterization and monitoring tools matrix, case studies, and product list. The document is already available for external review, and comments are due by July 2002. The final document is expected to be ready in December 2002, and Internet training will be provided in spring/summer 2003.

To view Michael Smith's presentation materials for details, click here.

ITRC Thermal Subgroup

Eric Hausamann, New York State Department of Environmental Conservation

DNAPLs are difficult to remediate once they reach a residual state or when they are in low permeability soil matrices. Thermal processes can penetrate low-permeability strata and enhance the recovery of DNAPLs by manipulating their physical properties.

The ITRC Thermal Subgroup is preparing the document, *Regulatory Guidance for In Situ Thermal Remediation of DNAPL Source Zones*. The guidance is structured in a question and answer format and is not a technical "how-to." The intended audience is regulators and decision makers. The guidance is the companion to a more technical engineering manual being developed by the U.S. Army Corps of

Engineers, U.S. EPA, and the Air Force Center for Environmental Excellence. It is organized into seven sections:

- Introduction
- Technology Description
- Characterization and Modeling
- Design and Implementation
- Performance Monitoring
- Regulatory Concerns/Acceptance
- Stakeholder/Public Involvement

The guidance will have the following case summaries:

Electrical Resistance Heating

- Cape Canaveral LC-34
- ICN Pharmaceuticals
- Confidential (Skokie, IL)
- Charleston Naval Complex

Steam Enhanced Extraction

- Cape Canaveral LC-34
- Savannah River Site A/M Area
- Visalia Pole Yard

Thermal Conduction Heating

- Rocky Mountain Arsenal Hex Pit
- Confidential site (Portland, IN)

The guidance is scheduled for external review in August/September 2002 with a final version expected in December 2002. In conjunction with the issuance of the guidance, the subgroup will sponsor Internet training in the spring/summer of 2003.

To view Eric Hausamann’s presentation materials for details, click here.

Case Summary: Electrical Resistance Heating

Jennifer Sutter, Oregon Department of Environmental Quality

Jennifer Sutter presented a case study on electrical resistance heating at the ICN Pharmaceuticals, Inc. site located in Portland, OR. The site is a former clinical laboratory that operated between 1960 and 1980. Site geology consists of 60 feet of fluvial and lacustrine overbank deposits (hydraulic conductivity 2-5 E-05 cm/s) overlying a gravel aquifer that is approximately 175-feet thick. There is a 100-foot thick confining unit that separates the gravel aquifer from a sandstone aquifer below. The primary chemicals of concern at the site are chlorinated solvents, benzene, and toluene. Depth to ground water is approximately 8 feet, and the source zone is a 120-foot by 80-foot oblong area centered around a former dry well. DNAPLs are believed to exist in the overbank deposits only. However, a dissolved phase plume has penetrated to the gravel aquifer. Source characterization was done by direct push technology and more than 50 monitoring wells onsite.

Six Phase Heating™ was the technology chosen for the remediation. The strategy was to create a hot floor beneath the contamination to prevent vertical migration and hot walls around it to prevent lateral migration. It was subsequently determined that it would not be practical to create the hot walls considering the need to heat in hexagonal arrays and the inefficiency of heating a narrow segment of soil. The initial system had 60 electrodes, 53 vapor extraction points, 13 pressure monitoring points, and a 950-kW transformer. This was later expanded to include 13 additional electrodes and 67 electrode

vents. A modified SVE system was used to recover contaminants in multiple phases (steam/vapors/liquids) and separate them into liquid and vapor streams for treatment and discharge.

The electrodes (6-foot long angle iron) were placed in boreholes at approximately 20-30 feet bgs, 30-40 feet bgs, and 40-50 feet bgs and surrounded by metal filings to provide contact with the soil. The “hot floor” was effectively created; however, lateral contaminant migration outside the treatment area did occur. This was thought to result from the presence of low permeability layers and lack of heating in the shallow zones, causing contaminant movement by steam and vapors produced as the ground water was heated from below. This problem was addressed by the installation of deep vents screened at 25 to 35 feet bgs, which provided a pathway for steam/vapor movement into the vapor extraction system.

Performance sampling was difficult because the monitoring wells contained boiling water and steam. This problem was resolved by installing permanent tubing into the wells and allowing them to be sampled from 20 feet away.

Also, even though CPVC inserts had been inserted into the PVC monitoring wells, this material deformed as a result of heating and may have failed at the joints due to the prolonged heating. Approximately 96 gallons of VOCs were recovered, and observed concentrations were reduced by up to four orders of magnitude in the DNAPL zone. It is thought that much of the reduction resulted from enhanced biodegradation of the chlorinated solvents. VOC levels in the treated zone indicate that DNAPL is no longer present and concentrations are below MCLs over much of the area.

Lessons learned:

- Performance monitoring for this technology may require sampling very hot water with the potential for pressurized steam release.
- PVC/CPVC wells and bentonite seals will fail if they are within the heating zone. Suggest using stainless steel wells with cement grout for future work.
- There was lateral movement of superheated water and steam out of the treatment zone. Steam can be vented from within the saturated zone during heating.
- There will be large pressure gradients created, and vents/collection systems should be designed to handle them.

To view Jennifer Sutter’s presentation materials for details, click here.

Rocky Mountain Arsenal Hex Pit

Eric Hausamann, New York State Department of Environmental Conservation

Eric Hausamann presented a thermal conductance case study for the Rocky Mountain Arsenal Hex Pit located near Commerce City, CO. Rocky Mountain Arsenal is a 27-square-mile site. Shell Oil Co. manufactured pesticides in the South Plants complex from 1952 to 1982. Residues from the production of hexachloropentadiene were placed in the “hex” pit. The source zone is approximately 10 feet deep, and the waste volume is estimated to be about 3,000 cubic yards. The waste itself can be visually identified as an amber-colored oily substance that turns black when oxidized.

Thermal conductance was chosen for a Superfund Innovative Technology Evaluation (SITE) Program demonstration. The waste could probably have been excavated with a backhoe more cheaply, but this was deemed a good site to try this technology out on this type of waste. A bench-scale treatability study indicated thermal conductance would be effective for this waste, and no pilot test was performed. The basis of the technology is to heat the target materials above their boiling points and extract them as gases. 266 wells were installed to a depth of 12 feet. One quarter of the wells performed both heating

and extraction functions, while the remainder were solely for heating. The heating elements reached 1,600EF, while the soil and the materials in it were expected to reach 617EF.

The thermal conductance system operated for about two weeks before being shut down for evaluation. The high temperatures and the highly chlorinated wastes produced a large amount of hydrochloric acid in both liquid and vapor phase, and the hot acid attacked all the metal parts such as the wells, above ground piping, etc. Also, rather than boiling off in the subsurface, much of the waste rose and boiled at the surface of the thermal wells creating a safety hazard and making capture less than optimal.

Lessons learned:

- Stainless steel is not immune to failure in thermal systems.
- A pilot-scale test may have revealed the problem.
- Need to thoroughly understand the chemistry before designing the system.
- If highly chlorinated pesticides are to be treated with this process, a different material may be necessary for the piping and wells.

To view Eric Hausamann's presentation materials for details, click here.

ITRC Surfactant Subgroup

Ana Vargas, Arizona Department of Environmental Quality, and Hans Meinardus, Intera, Inc.

Ana Vargas indicated that the ITRC Surfactant Subgroup is preparing a document entitled *Regulatory Guidance for Surfactant/Cosolvent Flushing of DNAPL Source Zones*. The document is not a technical "how-to" but rather is directed at regulators and decision makers. It is organized into seven sections:

- Introduction
- Technology Description
- Pre-Design Characterization (site)
- System Operation Considerations
- Process Monitoring
- Regulatory Concerns/Acceptance
- Stakeholder/Public Involvement

The guidance will contain three surfactant case summaries (Hill Air Force Base, Marine Corps Base, Camp Lejeune, and McClellan Air Force Base) and one cosolvent flushing case summary (Sages Dry Cleaners). The subgroup hopes to have a draft ready for external review in August or September 2002 with a final version in early 2003. In conjunction with the issuance of the guidance, they will sponsor Internet training in the spring/summer of 2003.

Hans Meinardus gave a presentation on a full-scale implementation of Surfactant Enhanced Aquifer Remediation (SEAR) at Hill Air Force Base, Ogden, UT. Before getting into site specifics, he emphasized the need for adequate source characterization and suggested that SEAR performance assessments at various sites in different settings are available in the literature. Before deciding on using SEAR or other surfactant flushing techniques, one should study these assessments to see if any lessons learned apply to the site under consideration.

At Hill Air Force Base's Operable Unit-2, approximately 60,000 gallons of spent solvents were deposited in two unlined trenches. Investigations in the mid-1980s revealed mobile-phase DNAPL contamination in this area. The initial RI located two pools of DNAPL, so an extraction system was installed. The free phase was pumped out, but this left a large amount of residual DNAPL (held in place by capillary pressure). In 1996-1997, three demonstrations (surfactant flood, surfactant foam flood, and steam flood) were conducted on 20-foot square areas. In characterizing these areas for the

demonstrations, it became apparent that the DNAPL was located in a paleochannel, and there was a good chance that there were more than two pools. The USAF implemented a flexible field investigation program that began with a ground-penetrating radar survey to map the paleochannel. The mapping was followed by cone penetrometer test soundings and soil grain size and contaminant analyses. With this information, a new monitoring well system was put in place.

The best way to remove free-phase DNAPL is to pump it directly, and approximately 1,200 gallons were removed this way. The surfactant-enhanced flood was accomplished over a 110-foot-long area by placing a line of injection wells down the center of the channel and a line of extraction wells along each side. A study was conducted of the interaction of the surfactant mixture with the soil materials to maximize mobility control (i.e., experiment with the surfactant mix to increase the efficiency of the sweep by decreasing such things as viscosity). During the SEAR, a gas chromatograph was connected directly to the injection and extraction wells to ensure the process met specifications and to monitor the progress of the flood. The removal took 45 days and recovered about 436 gallons of residual DNAPL. They estimated the recovery efficiency at 84-92%.

Lessons learned:

- Establish trust and open communication with all stakeholders.
- Success depends upon application of a multi-disciplinary team.
- Use a quantitative approach and let science/technology drive the process.
- Define the expectations and performance goals and how these will be measured.

Questions and Answers

Question: You mentioned that you can't expect to clean up a site with one technology. However, many consulting firms are specialists in one technology only. Do you see a way to get them to diversify?

Answer: There are multiple contractors working on the cleanup at Hill AFB. You will generally have a prime contractor, and you should insist they bring subcontractors on board with the appropriate experience.

To view Ms. Vargas's and Mr. Meinardus's presentation materials for details, including a detailed description of the Hill Air Force Base treatment train, [click here.](#)

PARTICIPANTS LIST SPRING 2002 TSP MEETING

David Abshire
U.S. EPA, Region 6
Mailcode: 6SF-AP
1445 Ross Ave.
Dallas, TX 75202
Phone: (214) 665-7188
abshire.charles@epa.gov

Robert Alvey
U.S. EPA, Region 2
290 Broadway
New York, NY 10007-1866
Phone: (212) 637-3258
Fax: (212) 637-4360
alvey.robert@epa.gov

Keith Arnold
EMS, Inc.
8601 Georgia Ave., Suite 500
Silver Spring, MD 20910
Phone: (301) 589-5318
Fax: (301) 589-8487
keith.arnold@emsus.com

Harold Ball
U.S. EPA, Region 9
Mailcode: SFD-8B
75 Hawthorne St.
San Francisco, CA 94105
Phone: (415) 744-2309
Fax: (415) 744-1916
ball.harold@epa.gov

Jim Barksdale
U.S. EPA, Region 4
Mailcode: 4WD-FFB
61 Forsyth St., SW
Atlanta, GA 30303-8960
Phone: (404) 562-8537
Fax: (404) 562-8518
barksdale.james@epa.gov

Gary Baughman
Colorado Dept. of Public Health
& Environment
4300 Cherry Creek Dr., South
Denver, CO 80246

Phone: (303) 692-3338
Fax: (303) 759-5355
gary.baughman@state.co.us

Kathy Baylor
U.S. EPA, Region 9
Mailcode: WST-5
75 Hawthorne St.
San Francisco, CA 94105
Phone: (415) 972-3271
baylor.katherine@epa.gov

Terry Bennett
Colorado Dept. of Public Health
and Environment
4300 Cherry Creek Dr., South
Denver, CO 80246-1530

Bob Benson
U.S. EPA, Region 8
Mailcode: 8P-W-MS
999 18th St., Suite 300
Denver, CO 80202-2466
Phone: (303) 312-6130
Fax: benson.bob@epa.gov

Tim Blume
U.S. Army Environmental
Center Western Regional Office
721 19th St.
Denver, CO 80202
Phone: (303) 844-0985
Fax: (303) 884-0951
tblume@rma.army.mil

Jon Bornholm
U.S. EPA, Region 4
Mailcode: 4WD-NSMB
61 Forsyth St., SW
Atlanta, GA 30303-8960
Phone: (404) 562-8820
Fax: (404) 462-8788
bornholm.jon@epa.gov

Sandra Bourgeois
U.S. EPA, Region 8
Mailcode: EPR-F
999 18th St., Suite 300
Denver, CO 80202-2466
Phone: (303) 312-6666
bourgeois.sandra@epa.gov

Linda Bowling
Solid and Hazardous Waste
Program
Mailcode: 8P-HW
999 18th St., Suite 300
Denver, CO 80202
Phone: (303) 312-6400
bowling.linda@epa.gov

Jerry Breed
Wyoming Dept. of
Environmental Quality
122 W. 25th St.
Herchler Blvd. 4-W
Cheyenne, WY 82009
Phone: (307) 777-7752
jbreed@state.wy.us

Randy Breeden
U.S. EPA, Region 8
Mailcode: P-HW
999 18th St., Suite 500
Denver, CO 80202-2466
Phone: (303) 312-6522
breeden.randy@epa.gov

John Brennan
BASX Systems
2649 East Mulberry St.
Fort Collins, CO 80524
Phone: (800) 722-2269 (x 103)
John.Brennan@BASX.com

Ken Brown

U.S. EPA/NERL-CRD
P.O. Box 93478
Las Vegas, NV 89193-3478
Phone: (702) 798-2270
Fax: (702) 798-3146
brown.ken@epa.gov

Dave Burden

U.S. EPA, Robert S. Kerr
Environmental Research Center
P.O. Box 1198
Ada, OK 74820
Phone: (580) 436-8606
Fax: (580) 436-8614
burden.david@epa.gov

Darcy Campbell

U.S. EPA, Region 8
Mailcode: 8EPR-EP
999 18th St., Suite 500
Denver, CO 80202
Phone: (303) 312-6709
Campbell.darcy@epa.gov

Judy Canova

South Carolina Dept. of Health
and Environmental Control
2600 Bull St.
Columbia, SC 29201
Phone: (803) 896-4046
Fax: (803) 896-4292
canovajl@dhec.state.sc.us

Randy Carlson

Kansas Dept. of Health and
Environment
1000 S.W. Jackson
Topeka, KS 66612
Phone: (785) 296-1682
Fax: (785) 296-4823
rcarlson@kdhe.state.ks.us

Meghan Cassidy

U.S. EPA, Region 1
Mailcode: HBT
1 Congress St.
Boston, MA 02114-2023
Phone: (617) 918-1387
Fax: (617) 918-1294
cassidy.meghan@epa.gov

Ray Cody

U.S. EPA, Region 1
Mailcode: HBT
1 Congress St., Suite 1100
Boston, MA 02114-2023
Phone: (617) 918-1366
Fax: (617) 918-1291
cody.ray@epa.gov

Kathy Davies

U.S. EPA, Region 3
Mailcode: 3HS41
1650 Arch St.
Philadelphia, PA 19103
Phone: (215) 814-3315
Fax: (215) 814-3015
davies.kathy@epa.gov

Helen Dawson

U.S. EPA, Region 8
Mailcode: 8EPR-PS
999 18th St., Suite 500
Denver, CO 80202-2466
Phone: (303) 312-7841
Fax: (303) 312-6065
dawson.helen@epa.gov

Dom DiGiulio

U.S. EPA, R.S. Kerr
Environmental Research
Laboratory
P.O. Box 1198
Ada, OK 74821-1198
Phone: (580) 436-8605
digiulio.dominic@epa.gov

Diane Dopkin

EMS, Inc.
8601 Georgia Ave., Suite 500
Silver Spring, MD 20910
Phone: (301) 589-5318
Fax: (301) 589-8487
diane.dopkin@emsus.com

Dave Drake

U.S. EPA, Region 7
Mailcode: SUPR/FFSE
901 N. 5th St.
Kansas City, KS 66101
Phone: (913) 551-7626
Fax: (913) 551-7063

drake.dave@epa.gov

Stacie Driscoll

U.S. EPA, Region 3
Mailcode: 3HS513
1650 Arch St.
Philadelphia, PA 19103-2029
Phone: (215) 814-3368
Fax: (215) 814-3051
driscoll.stacie@epa.gov

Jim Dunn

U.S. EPA/Region 8/STL
Mailcode: 8EPR-PS
999 18th St.
Denver, CO 80202
Phone: (303) 312-6573
Fax: (303) 312-6897
dunn.james@epa.gov

Thomas Early

Oak Ridge National Laboratory
Phone: (865) 576-2103
earlyto@ornl.gov

Edgar Ethington

Colorado Dept. of Public Health
and Environment
Hazardous Materials & Waste
Management Division
4300 Cherry Creek Dr., South
Denver, CO 80246-1530
Phone: (303) 692-3438
Fax: (303) 759-5355
edgar.ethington@state.co.us

Robbie Ettinger

Shell Global Solutions, Inc.
P.O. Box 1380
Houston, TX 77251
Phone: (281) 544-7540
Fax: (281) 544-8727
robert.ettinger@shell.com

René Fuentes

U.S. EPA, Region 10
Mailcode: OEA-095
1200 Sixth Ave.
Seattle, WA 98101
Phone: (206) 553-1599
Fax: (206) 553-0119
fuentes.rene@epa.gov

Susan Gawarecki

Oak Ridge Reservation Local
Oversight Committee
102 Robertsville Rd., Suite B
Oak Ridge, TN 37830
Phone: (865) 483-1333
Fax: (865) 482-6572
loc@inx.net

Lisa Gebler

EMS, Inc.
8601 Georgia Ave., Suite 500
Silver Spring, MD 20910
Phone: (301) 589-5318
Fax: (301) 589-8487
lisa.gebler@emsus.com

Michael Gill

U.S. EPA, Region 9
Mailcode: SFD-8B
75 Hawthorne St.
San Francisco, CA 94105
Phone: (415) 972-3054
Fax: (415) 947-3518
gill.michael@epa.gov

Susan Griffin

U.S. EPA, Region 8
Mailcode: EPR-TA
999 18th St., Suite 500
Denver, CO 80202
Phone: (303) 312-6651
griffin.susan@epa.gov

Jim Gusek

Knight Piésold & Co.
1050 17th St., Suite 500
Denver, CO 80265
Phone: (303) 629-5934 (x 282)
Fax: (303) 629-8789
jgusek@knightpiesold.com

George Hall

ITRC Program Advisor
4217 W. 91st
Tulsa, OK 74132-3739
Phone: (918) 446-7288
Fax: (918) 446-9232
TechnologyConsultant@prodigy.net

Jim Harrington

New York State Dept. of
Environmental Conservation
625 Broadway, 12th Floor
Albany, NY 12233-7012
Phone: (518) 402-9755
Fax: (518) 402-9722
jbharrin@gw.dec.state.ny.us

Eric Hausamann

New York State Dept. of
Environmental Conservation
50 Wolf Rd., Rm. 268
Albany, NY 12233-7010
Phone: (518) 457-0327
Fax: (518) 457-9639
eghausam@gw.dec.state.ny.us

Mark Henry

Michigan Dept. of
Environmental Quality
Environmental Resources
Division
P.O. Box 30426
Lansing, MI 48909-7926
Phone: (517) 335-3390
Fax: (517) 335-4887
Henryma@state.mi.us

Jerry Hill

SSEB/ITRC Southern States
Energy Bd
Norcross, GA
Phone: (770) 242-7712
hill@sseb.org

Steve Hirsh

U.S. EPA, Region 3
Mailcode: 3HS13
1650 Arch St.
Philadelphia, PA 19103-2029
Phone: (215) 814-3352

Fax: (215) 814-3051
hirsh.steven@epa.gov

Mike Holmes

U.S. EPA, Region 8
Mailcode: OC-PAI
999 18th St., Suite 500
Denver, CO 80202-2466
Phone: (301) 312-6607
holme.michael@epa.gov

David Huber

U.S. EPA/Office of Ground
Water and Drinking Water
Standards & Risk Management
Division
Mailcode: 4607M
1201 Constitution Ave.
Washington, DC 20004
Phone: (202) 564-4878
Fax: (202) 564-3760
huber.david@epa.gov

Camille Hueni

U.S. EPA, Region 6
Mailcode: 6SF-AP
1445 Ross Ave., 12th Floor
Dallas, TX 75202-2733
Phone: (214) 665-2231
Fax: (214) 665-6660
hueni.camille@epa.gov

David Ingle

U.S. Department of Energy
7887 Bryan Dairy Rd., Suite 260
Largo, Florida 33777
Phone: (727) 541-8943
Fax: (727) 549-1121
D.S.Ingle@worldnet.att.net

Ruth Izraeli

U.S. EPA, Region 2
290 Broadway, 24th Floor
New York, NY 10007-1866
Phone: (212) 637-3784
Fax: (212) 637-3889
izraeli.ruth@epa.gov

Annie Jarabek

U.S. EPA/NCEA-10
Mailcode: B-243-01

Research Triangle Park, NC
27711
Phone: (919) 541-4847
Fax: (919) 541-1818
jarabek.annie@epa.gov

Dave Jenkins
U.S. EPA, Region 4
Mailcode: OTS
61 Forsyth St.
Atlanta, GA 30303-8960
Phone: (404) 562-8462
Fax: (404) 562-9964
jenkins.dave@epa.gov

Dave Jewett
U.S. EPA, R.S. Kerr
Environmental Research Lab
P.O. Box 1198
Ada, OK 74821-1198
Phone: (580) 436-8560
jewett.david@epa.gov

Jeff Johnson
U.S. EPA, Region 7
901 N. 5th St.
Kansas City, KS 66101
Phone: (913) 551-7849
Fax: (913) 551-9849
johnson.jeff@epa.gov

Jim Jonas
Camp Dresser & McKee
1331 17th St., Suite 1050
Denver, CO 80202
Phone: (720) 264-1146
Fax: (303) 295-1895
jonasjp@cdm.com

Gene Keepper
U. S. EPA, Region 6
Mailcode: 6EN-HX
1445 Ross Ave., Suite 900
Dallas, TX 75202-2733
Phone: (214) 665-2280
Fax: (214) 665-7264
keepper.gene@epa.gov

Steve Kinser
U.S. EPA, Region 7
901 N. 5th St.

Kansas City, KS 66101
Phone: (913) 551-7728
Fax: (913) 551-9728
kinser.steven@epa.gov

Brian Lewis
California Dept. of Toxic
Substances Control
Mailcode: R1-2
8800 Cal Center Dr.
Sacramento, CA 95826-3268
Phone: (916) 255-6532
Fax: (916) 255-3596
blewis@dtsc.ca.gov

Don Macalady
Colorado School of Mines
Dept. of Chem./ Geochemistry
312A Coolbaugh Hall
Golden, CO 80401
Phone: (303) 273-3996
Fax: (303) 273-3629
dmacalad@mines.edu

Kelly Madalinski
U.S. EPA/TIO
Mailcode: 5102G
1200 Pennsylvania Ave., NW
Washington, DC 20460
Phone: (703) 603-9901
Fax: (703) 603-9135
madalinski.kelly@epa.gov

Vince Malott
U.S. EPA, Region 6
Mailcode: 6SF-AP
1445 Ross Ave.
Dallas, TX 75202
Phone: (214) 665-8313
Fax: (214) 665-6660
malott.vincent@epa.gov

Scott Marquess
U.S. EPA, Region 7
Mailcode: FFSESUPR
901 N. 5th St.
Kansas City, KS 66101
Phone: (913) 551-7131
Fax: (913) 551-7063
marquess.scott@epa.gov

Kevin Mayer
U.S. EPA, Region 9
Mailcode: SFD-7-2
75 Hawthorne St.
San Francisco, CA 94105
Phone: (415) 972-3176
mayer.kevin@epa.gov

Ed Mead
U.S. Army Corps of Engineers
Mailcode: CENWO-HX-G
12565 West Center Rd.
Omaha, NE 68144
Phone: (402) 697-2576
Fax: (402) 697-2595
s.ed.mead@usace.army.mil

Hans Meinardus
INTERA, Inc.
9111 A Research Blvd.
Austin, TX 78758
Phone: (512) 425-2040
Fax: (512) 427-2099
hmeinardus@intera.com

Mark Mercer
U.S. EPA
Mailcode: 5303W
1200 Pennsylvania Ave., NW
Washington, DC 20460
Phone: (703) 308-8652
Mercer.Mark@epa.gov

Nancy Morlock
U.S. EPA, Region 8
Mailcode: 8P-HW
999 18th St., Suite 300
Denver, CO 80202-2466
Phone: (303) 312-6421
Fax: (303) 312-6044
morlock.nancy@epa.gov

Dave Munch

U.S. EPA/OGWDW
26 W. Martin Luther King Dr.
Cincinnati, OH 45268
Phone: (513) 569-7843
Fax: (513) 569-7191
munch.dave@epa.gov

Rich Muza

U.S. EPA, Region 8
Mailcode: 8 EPR.EP
999 18th St., Suite 300
Denver, CO 80202
Phone: (303) 312-6595
Fax: (303) 312-6071
muza.richard@epa.gov

Bill Myers

EMS, inc.
8601 Georgia Ave., Suite 500
Silver Spring, MD 20910
Phone: (301) 589-5318
Fax: (301) 589-8487
bmyers@emsus.com

Wendy O'Brien

U.S. EPA, Region 8
Mailcode: 8 EPR-PS
999 18th St., Suite 300
Denver, CO 80202
Phone: (303) 312-6712
obrien.wendy@epa.gov

Tim Pickett

Applied Biosciences
P.O. Box 520518
Salt Lake City, UT 84152
Phone: (801) 485-4988
Fax: (801) 485-4987
tpickett@bioprocess.com

Wayne Praskins

U.S. EPA, Region 9
Mailcode: SFD-7-3
75 Hawthorne St.
San Francisco, CA 94105
Phone: (415) 972-3181
praskins.wayne@epa.gov

Steve Price

Camp Dresser and McKee Inc.
1331 17th St.
Denver, CA 80202
Phone: 303-383-2433
prices@cdm.com

David Reisman

U.S. EPA/NRMRL
Mailcode: MS-489
26 West Martin Luther King Dr.
Cincinnati, OH 45268
Phone: (513) 569-7588
Fax: (513) 569-7676
reisman.david@epa.gov

Marta Richards

U.S. EPA/ORD/LRPCD/SMSB
Mailcode: MS-489
26 W. Martin Luther King
Cincinnati, OH 45268
Phone: (513) 569-7692
Fax: (513) 569-7676
richards.marta@epa.gov

Bill Rothenmeyer

U.S. EPA, Region 8
Mailcode: 8P2-HW
999 18th St.
Denver, CO 80202-2466
Phone: (303) 312-6045
Fax: (303) 312-6064
rothenmeyer.william@epa.gov

Bill Ruddiman

Arizona Dept. of Environmental
Quality
Mailcode: M0701C
3033 N. Central
Phoenix, AZ 85012
Phone: (602) 207-4414
Fax: (602) 202-2346
ruddiman.william@ev.state.az.us

Bill Ruoff

URS
5315 S. Telluride Cf.
Aurora, CO 80015
Phone: (303) 680-2612
Fax: (303) 694-3946
Ruoff_William@urs.com

Carol Russell

U.S. EPA, Region 8
Mailcode: 8 EPR-EP
999 18th St., Suite 300
Denver, CO 80202
Phone: (303) 312-6310
Fax: (303) 312-6897
russell.carol@epa.gov

Gary Schafer

U.S. EPA, Region 5
Mailcode: SRF-5J
77 W. Jackson Blvd.
Chicago, IL 60604
Phone: (312) 353-8827
Fax: (312) 353-8426
schafer.gary@epa.gov

Larry Schmaltz

A2L Technologies
10220 Harney Rd., NE
Thonotosassa, FL 33592
Phone: (813) 248-8558
Fax: (813) 248-8656
LarryS@A2LTechnologies.com

Bernard Schorle

U.S. EPA, Region 5
Mailcode: SR-6J
77 W. Jackson Blvd.
Chicago, IL 60604
Phone: (312) 886-4746
schorle.bernard@epa.gov

Henry Schuver

U.S. EPA
Mailcode: 5303W
1200 Pennsylvania Ave., NW
Washington, DC 20460
Phone: (703) 308-8656
Fax: (703) 308-8638
schuver.henry@epa.gov

Charles Shackelford
Colorado State University
Dept. of Civil Engineering
Fort Collins, CO 80523-1372
Phone: (970) 491-5051
Fax: (970) 491-3584
shackel@engr.colostate.edu

Philip Smith
Texas Tech University, The
Institute of Environmental and
Human Health
P.O. Box 41163
Lubbock, TX 79409-1163
Phone: (806) 885-0316
Fax: (806) 885-4577
phil.smith@ttu.edu

Michael Smith
Vermont Dept. of
Environmental Conservation
Waste Management Division
West Building
103 S. Main St.
Waterbury, VT 05671-0404
Phone: (802) 241-3879
mikes@dec.anr.state.vt.us

Rich Steimle
U.S. EPA, TIO
Mailcode: 5102G
1200 Pennsylvania Ave., NW
Washington, DC 20460
Phone: (703) 603-7195
Fax: (703) 603-9115
steimle.richard@epa.gov

Robert Stites
U.S. EPA, Region 8
Mailcode: 8EPR-F
999 18th St., Suite 300
Denver, CO 80202
Phone: (303) 312-6658
Fax: (303) 312-6067
stites.rob@epa.gov

Jennifer Sutter
Oregon Dept. of Environmental
Quality
2020 SW 4th Ave., Suite 400
Portland, OR 97201

Phone: (503) 229-6148
Fax: (503) 229-6899
sutter.jennifer@deq.state.or.us

Karen Taylor
Camp Dresser & McKee
1331 17th St., Suite 1050
Denver, CO 80202
Phone: (720) 264-1106
Fax: (303) 295-1895
TaylorKs@cdm.com

Craig Thomas
U.S. EPA, Region 5
Mailcode: SRF-5J
77 W. Jackson Blvd.
Chicago, IL 60604
Phone: (312) 886-5907
Fax: (312) 353-8426
thomas.craig@epa.gov

Neil Thompson
U.S. EPA, Region 10
Mailcode: ECL-113
1200 Sixth Ave.
Seattle, WA 98101
Phone: (206) 553-7177
Fax: (206) 553-0124
thompson.neil@epa.gov

Luanne Vanderpool
U.S. EPA, Region 5
Mailcode: SR-6J
77 W. Jackson Blvd.
Chicago, IL 60604
Phone: (312) 353-9296
Fax: (312) 886-4071
vanderpool.luanne@epa.gov

Ana Vargas
Arizona Dept. of Environmental
Quality
3033 N Central Ave.
Phoenix, AZ 85012
Phone: (602) 207-4178
Fax: (602) 207-4236
vargas.ana@ev.state.az.us

Chris Villarreal
U.S. EPA, Region 6
Mailcode: 6SF-AP
1445 Ross Ave., Suite 1200
Dallas, TX 75202-2733
Phone: (214) 665-6758
Fax: (214) 665-6660
villarreal.chris@epa.gov

Brad Wahlquist
Applied Biosciences
P.O. Box 520518
Salt Lake City, UT 84152
Phone: (800) 280-7852
Fax: (801) 485-4987
bwahlquist@bioprocess.com

Robert Weld
Virginia Dept. of Environmental
Quality
Federal Facilities Restoration
Program
629 E. Main St.
Richmond, VA 23219
Phone: (804) 698-4227
Fax: (804) 698-4383
rjweld@deq.state.va.us

Julie WestHoff
Hoag Environmental Systems
5639 W. 82nd St.
Prairie Village, KS 66203
Phone: (913) 381-3737
Fax: (913) 381-8778
jwesthoff@mindspring.com

Steve Wharton
U.S. EPA, Region 8
Mailcode: 8P.HW
808 18th St., Suite 300
Denver, CO 80202
Phone: (303) 312-6935
wharton.steve@epa.gov

Steve White

U.S. Army Corps of Engineers
12565 W. Center Rd.
Omaha, NE 68144
Phone: 402-697-2660
Fax: 402-697-2613
stephen.j.white@usace.army.mil

Richard Willey

U.S. EPA, Region 1
Mailcode: HBS
1 Congress St., Suite 1100
Boston, MA 02114-2023
Phone: (617) 918-1266
Fax: (617) 918-1291
willey.dick@epa.gov

Kevin Willis

U.S. EPA, Region 2
Mailcode:
ERRD/NYRB/ENYRS
290 Broadway
New York, NY 10007-1866
Phone: (212) 637-4252
Fax: (212) 637-3966
willis.kevin@epa.gov

Mike Wireman

U.S. EPA, Region 8
999 18th St., Suite 500
Denver, CO 80202
Phone: (303) 312-6719
wireman.mike@epa.gov

Sandra Woods

Colorado State University
Dept. of Civil Engineering
Fort Collins, CO 80523
Phone: (970) 491-5049
Fax: (970) 491-7763
sandra.woods@colostate.edu

Mary Wu

U.S. EPA, Region 8
Mailcode: 8P-HW
999 18th St., Suite 300
Denver, CO 80202
Phone: (303) 312-6789
Fax: (303) 312-6064
wu.mary@epa.gov

Laura Yeh

Naval Facilities Engineering
Service Center
1100 23rd Ave.
Port Hueneme, CA 93043
Phone: (805) 982-1660
Fax: (805) 982-4304
yehsl@nfesc.navy.mil

Mary Yelken

WGA/ITRC

Ruben Zamarripa

Missouri Department of Natural
Resources
1738 E. Elm St.
Jefferson City, MO 65101
Phone: (573) 751-7757
Fax: (573) 526-5268
nrzamar@mail.dnr.state.mo.us

Bernie Zavala

U.S. EPA, Region 10
Mailcode: OEA-095
1200 Sixth Ave.
Seattle, WA 98101
Phone: (206) 553-1562
Fax: (206) 553-0119
zavala.bernie@epa.gov