California State Senate Bill 1764 Advisory Committee

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Date: MAY 3 1996

John P. Caffrey
Chairman, SWRCB
901 P Street, P.O. Box 100
Sacramento, CA 95812-0100

Subject: Transmittal of the California Senate Bill 1764 Advisory Committee Recommendations Report to the State Water Resources Control Board

Dear Mr. Caffrey:

Enclosed is the California Senate Bill 1764 Advisory Committee's Recommendations Report. The Report is submitted to the State Water Resources Control Board (SWRCB) pursuant to the requirements of Section 25299.38 of the California Health and Safety Code. The Report presents our conclusions and recommendations to the SWRCB regarding California's Underground Storage Tank (UST) Regulatory Program. The Report contains 1) majority conclusions, recommendations, and discussions that were ratified by committee votes, 2) minority conclusions, recommendations, and discussion, and 3) a minority report section.

We hope that our recommendations will lead to meaningful improvements in the UST Regulatory Program, and we thank the SWRCB in advance for their thoughtful consideration of our report.

Respectfully,

The California Senate Bill 1764 Advisory Committee

Enclosure

c: James Giannopoulos
Interested Parties

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Senate Bill 1764 Advisory Committee Recommendations Report Regarding California's Underground Storage Tank Program

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Submitted to the California State Water Resources Control Board

May 31, 1996

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SENATE BILL 1764 ADVISORY COMMITTEE REPORT
EXECUTIVE SUMMARY

This is the Executive Summary of the Senate Bill 1764 Advisory Committee's Recommendations Report. The report presents conclusions and recommendations of the SB 1764 Advisory Committee to the SWRCB regarding the Underground Storage Tank Regulatory Program. The SB 1764 Advisory Committee was appointed by the SWRCB pursuant to SB 1764, which was signed into law by Governor Pete Wilson and became effective January 1, 1995. SB 1764 specifically requires the Advisory Committee to "recommend to the Board any changes which it believes are necessary to ensure that cleanup standards are both technologically feasible and necessary to ensure the protection of human health and safety and the environment."

The SB 1764 Advisory Committee is comprised of the following appointed members: George Apostolakis, Ph.D., Massachusetts Institute of Technology; Michael Collins, Ph.D., University of California, Los Angeles; Robert Carrington Crouch, Ph.D., University of California, Santa Barbara; John Farr, Ph.D., P.E., ICF Kaiser Engineers; Graham Fogg, Ph.D., University of California, Davis; Martin Reinhard, Ph.D., Stanford University; and Kate Scow, Ph.D., University of California, Davis. Dr. Farr served as chair.

Following the Executive Summary is the main body of the committee's report, containing the full conclusions, recommendations, and supporting discussions that were ratified by committee votes. Also included in the report are some minority conclusions, recommendations, and discussions, and a minority report filed by Dr. Robert Carrington Crouch.

Summary versions of the Committee's conclusions and recommendations are as follows:

1. THE USE OF RISK ASSESSMENT

Conclusion:

The current corrective action process is not implemented in a consistent manner, is wasteful of resources, and is controversial.

Recommendation:

A framework for formulating corrective actions should be developed that uses the concepts and tools of risk-based decision making.

2. SITE CLOSURE CRITERIA

Conclusion

Site closure criteria, based on defined levels of acceptable risk, do not exist for LUFT sites in California. Correcting this deficiency will greatly improve California's UST program.

Recommendation

The State should issue clear written guidance on what levels of risk are acceptable for various receptors of interest, or if necessary, procedures for determining contaminant concentrations which yield acceptable levels of protection.

3. RISK CLASSIFICATION

Conclusion

The SWRCB has tended to treat all LUFT sites as though they pose equal threats. This has caused a misallocation of remediation resources. Too many resources have been allocated to "lower risk" sites and too few resources have, therefore, been allocated to "higher risk" sites.

Recommendation

Guidance should be provided on how LUFT sites should be classified based on the threat they present. This can be achieved by adopting a risk-based decision-making framework.

4. INSIGNIFICANT RISK SITES

Conclusion

LUFT sites bear a stigma that makes them difficult to sell even when they pose an insignificant threat. This prevents the sites being conveyed to their highest and best uses.

Recommendation

Make it a matter of public record that a LUFT site contains residual hydrocarbons, but that insignificant-risk sites pose no foreseeable threat to human health, safety, the environment, or beneficial water use.

5. SIGNIFICANT RISK SITES

Conclusion

Some LUFT sites pose a significant risk to human health, safety, the environment, and/or beneficial water uses.

Recommendation

These sites should be actively remediated at the least possible cost to meet risk-based remediation goals. The estimated degree of residual risk should be made a matter of public record.

6. INTRINSIC BIOREMEDIATION

Conclusion

Intrinsic bioremediation of certain LUFT contaminants appears to be occurring at many LUFT sites. If the effectiveness of intrinsic bioremediation can be established at a given site, this process should be considered as a viable treatment alternative.

Recommendations

a) Analytical and hydrogeological protocols should be established to determine whether intrinsic bioremediation is sufficient to contain and remove existing contamination within a reasonable time frame.
b) The SWRCB should issue written guidance regarding how the "reasonable" time frame for intrinsic bioremediation is to be determined.
c) Evidence of intrinsic bioremediation may be used to lower the priority ranking of a LUFT site for cleanup with respect to the contaminants being biodegraded.
d) Monitoring of the contaminant plume should be conducted during the process of intrinsic bioremediation to ensure that contamination does not spread beyond acceptable boundaries.
e) The SWRCB should verify the LLNL report conclusions and collect and evaluate data for LUFT contaminants not considered in the LLNL report.

7. SOURCES OF DRINKING WATER RESOLUTION

Conclusion

The prevailing interpretations of SWRCB Resolution 88-63 have resulted in protection of essentially all groundwater to MCL's, even in areas where it is unsuitable as a source of drinking water.

Recommendation

The SWRCB should issue interpretive clarification of SWRCB Resolution 88-63 to clearly define what type of groundwater systems comprise California's sources of drinking water, and what level of protection is reasonable for those sources.

8. BENEFICIAL USE DESIGNATIONS AND WATER QUALITY OBJECTIVES

Conclusions

The beneficial water use designations and Basin Plan water-quality objectives are often overly restrictive, compelling virtually all groundwater remediation in California to MCLs for drinking water, even in cases where groundwater is non-potable due to natural causes or commonly accepted human practices. The beneficial-use designations and water-quality objectives do not adequately address certain requirements of Porter-Cologne (Water Code sec. 13241).

Recommendations

a) The beneficial use designations and Basin Plan water-quality objectives should be revised as necessary to address all requirements of Porter-Cologne so that groundwater systems unsuitable as sources of drinking water are not designated "MUN".
b) The State should consider classifying groundwater systems for beneficial use suitability on a sub-regional scale.
c) It would be worthwhile for the SWRCB to recognize the benefits of subsurface treatment zones for highly degradable chemicals, such as petroleum hydrocarbons, in its public review/revision of Resolution 92-49.

9. CONSIDERATION OF ECONOMIC FACTORS

Conclusion

The UST Program has failed to adequately recognize that management of water resources should be conducted in full consideration of the benefits and costs associated with management decisions.

Recommendation

The UST Program's decision making should be made in full consideration of economic factors. Remediation requirements should be necessary to protect human health, safety, and the environment, or economically justifiable.

10. MTBE AND OTHER FUEL OXYGENATES

Conclusion

The relatively recent use of fuel oxygenates that are recalcitrant to biodegradation (primarily MTBE) has created the potential for contamination of much larger volumes of groundwater than when such additives were not used. MTBE has been added in significant quantities to fuels in California only within the last five to ten years, and previous evaluations of LUFT impacts on groundwater, including the LLNL studies, have not accounted for this relatively new threat.

Recommendation

LUFT site characterization should include data on recalcitrant fuel additives such as MTBE in soil and groundwater; and when a recalcitrant fuel additive is present, the risks to human health, the environment, and water resources should be considered greater than if it were not present. Working with USEPA or other appropriate agencies, the SWRCB should evaluate the risks posed by MTBE and other fuel additives as compared to benzene.

11. INDEPENDENT REVIEW PANELS

Conclusion

The existing appeals process regarding regulatory decisions can be lengthy, and some aggrieved parties are reluctant to file appeals due to the fear of alienating regulators.

Recommendation

The SWRCB should consider creating an alternate avenue for appeals using a network of independent, regional LUFT technical review panels manned by qualified environmental experts to help resolve disputes based on technical arguments.

12. ADEQUATE SOURCE REMOVAL

Conclusion

What constitutes adequate "source removal" is often ambiguous.

Recommendation

What determines adequate source removal should be determined site-specifically using a risk-based decision-making approach.

13. ANALYTICAL AND SAMPLING CONSIDERATIONS

Conclusion

Current sampling and analyses protocols are inadequate to assess intrinsic bioremediation potential and predict the evolution of dissolved fuel hydrocarbon and additive plumes. Chemical species that would aid in interpretation of whether intrinsic bioremediation is occurring are not currently monitored. Additionally, most groundwater monitoring designs at LUFT sites have provided inadequate data regarding downward chemical transport to greater depths.

Recommendation

The SWRCB should develop guidelines for LUFT sites regarding the type of data required, and how such data are to be collected, to assess if:

a) a LUFT plume is growing in concentration and size;
b) intrinsic bioremediation is occurring;
c) there is significant potential for downward migration or preferential flow of contaminants along highly permeable pathways that result in significant offsite impacts;
d) there are potential impacts to laterally or vertically adjacent receptors and water resources.

14. NEED FOR SKILLED PRACTITIONERS

Conclusion

The large number of LUFT sites has outrun the number of qualified personnel available to properly handle them.

Recommendation

The SWRCB should initiate training and recruitment programs to remedy this deficiency. Contracting-out for expert advice should also be considered an option to improve regulatory decision making.

15. NEED FOR DETAILED WRITTEN GUIDANCE

Conclusion

There is a need for detailed written guidance on how LUFT sites should be investigated, remediated, monitored and closed.

Recommendation

Cal/EPA should create a task force to develop such written guidance.

16. SOIL CLEANUP STANDARDS

Conclusion

Default regulatory standards for soil cleanup at LUFT sites are not scientifically supportable, particularly those based on TPH concentrations in soil.

Recommendation

Soil cleanup "standards" should be developed site-specifically as outlined in the adopted risk-based decision-making approach, and should be determined for chemicals of concern (not TPH).

LLNL HISTORICAL CASE ANALYSIS REPORT

Conclusion

The LLNL Historical Case Analysis Report adds significantly to the growing body of evidence that average benzene plume dimensions tend to be smaller than if the benzene were not biodegrading significantly at many sites. The LLNL and SWRCB staff should be congratulated for this major effort in data reduction and analysis. Estimates of plume dimensions in the LLNL report are highly approximate, however, and should not be used directly as general screening criteria in risk-based decision making.

Recommendation

The LLNL Historical Case Analysis Report findings should be used to provide a scientific foundation for consideration of intrinsic bioremediation as a viable clean-up alternative where appropriate. Also, the SWRCB should direct LLNL to thoroughly demonstrate the efficacy of methods used in estimating plume dimensions so that readers can more fully ascertain the meaning of the results. Following this necessary demonstration, some of the report statistics may be useful in development of screening-level criteria for risk-based decision-making.

LLNL RECOMMENDATIONS REPORT

Conclusion

The LLNL Recommendations Report provides a cogent, generally realistic review of the regulatory framework and cleanup processes currently applied to LUFT sites in California; however, parts of the report unrealistically minimize the magnitude of the LUFT problem.

California Senate Bill 1764 Advisory Committee Recommendations Report to the State Water Resources Control Board Regarding the Underground Storage Tank Regulatory Program, May 1996

INTRODUCTION

This report is hereby submitted to the California State Water Resources Control Board (SWRCB) pursuant to the requirements of section 25299.38 of the California Health and Safety Code. Section 25299.38 was a product of California Senate Bill 1764 (SB 1764), authored by Senator Thompson. The report presents conclusions and recommendations of the SB 1764 Advisory Committee to the SWRCB regarding the Underground Storage Tank Regulatory Program. The SB 1764 Advisory Committee was appointed by the SWRCB pursuant to SB 1764, which was signed into law by Governor Pete Wilson and became effective January 1, 1995. SB 1764 required the SWRCB to "convene an advisory committee consisting of distinguished chemists, biologists, health professionals, geologists, engineers, and other appropriate professionals" to advise the Board on matters pertaining to the Underground Storage Tank Regulatory Program (UST Program). The Board appointed the SB 1764 Advisory Committee members on January 19, 1995 and convened the first Committee meeting on February 3, 1995 in Sacramento.

SB 1764 specifically requires the Advisory Committee to "recommend to the Board any changes which it believes are necessary to ensure that cleanup standards are both technologically feasible and necessary to ensure the protection of human health and safety and the environment." SB 1764 further states the Committee's recommendations are to be made following a mandated comprehensive review by the Advisory Committee of the following:

1. "groundwater monitoring requirements, remediation techniques, and methodologies;

2. criteria for determining that remediation has been satisfactorily completed;

3 the cleanup standards which responsible parties conducting corrective action pursuant to this article are required to meet; and

4. the policies, guidelines, and methods which are used to establish those standards".

SB 1764 was passed into law to address growing concern and criticism of California's UST Program. Critics have argued that the implementation of the UST Program has resulted in wasteful application of resources at sites that pose little risk to human health, safety, the environment, and beneficial uses of water. Concern has focused on the Program's lack of consistent, site-specific risk-based decision making and reliance on narrow and inconsistent interpretations of existing SWRCB policies for water-quality control.

In the face of such criticism, the SB 1764 Advisory Committee wishes to recognize the environmental protection and restoration benefits of California's UST Program over the past decade. The UST Program has been a positive force, driving improvements in fuel storage and handling equipment, procedures, and maintenance that have dramatically reduced fuel tank leaks, and tank overfill and spills. Under the UST Program, investigation and remediation methods and technology for leaking underground fuel tanks

(LUFT) sites have evolved over the past decade to the point where investigation and remediation of LUFT sites is practical and efficient when directed by skilled professionals.

Although the UST Program has benefited California in many respects, many of the regulatory requirements have come to be seen as onerous. The parties held responsible for site investigations and remediation, environmental consultants, and regulators now agree that the existing UST Program requires change to better allocate economic resources and improve environmental protection and restoration. Our current recognition of the need for regulatory reform, and our state of knowledge on how to better implement the UST Program is, of course, a direct benefit of lessons learned over the past decade of UST Program implementation.

One of the general problems of the UST Program is that regulators have tended to treat, a priori, all petroleum leak sites as major problems that require extensive investigation, remediation, and monitoring. The existing UST Program, which derives much of its authority and guidance from general water-quality control policies of the SWRCB, does not adequately recognize the wide range of site-specific risk to human health, safety, the environment, and beneficial uses of the waters of the State posed by individual LUFT sites, which varies from no-risk to significant risk. While the regulatory requirements for investigation and remediation of LUFT sites are, in many cases, necessary to ensure the protection of human health, safety, the environment, and beneficial water uses, the regulatory requirements often result in little to no risk reduction at considerable expense. This is a misallocation of economic resources, and regulatory program changes appear to be necessary in order for California to better allocate its resources, including both land and water resources.

The SB 1764 Advisory Committee is comprised of the following appointed members:

George Apostolakis, Ph.D., Massachusetts Institute of Technology; Expertise in Risk Assessment
Michael Collins, Ph.D., University of California, Los Angeles; Expertise in Public Health
Robert Carrington Crouch, Ph.D., University of California, Santa Barbara; Expertise in Economics
John M. Farr, Ph.D., P.E., ICF Kaiser Engineers; Expertise in Hydrology, Environmental Modeling, and Remediation Engineering
Graham Fogg, Ph.D., University of California, Davis; Expertise in Hydrogeology
Martin Reinhard, Ph.D., Stanford University; Expertise in Environmental Chemistry
Kate Scow, Ph.D., University of California, Davis; Expertise in Soil Microbial Ecology

The Committee is chaired by Dr. Farr. The Committee held a total of 8 public meetings at the SWRCB First Floor Hearing Room at 901 P Street, Sacramento, and also conducted 15 noticed and open conference calls. Presentations were made to the Committee by regulatory staff of the State Underground Storage Tank Program (James Giannopoulos, Kevin Graves, Jon Marshack, John Richards, and Luis Rivera), the State Air Resources Board (Carole Scibienski), Lawrence Livermore National Laboratory (Dave Rice), The Environmental Resource Council (Roland Brust), the Western States Petroleum Association (WSPA, John Gustafson), the U.S. Air Force Center for Environmental Excellence (AFCEE, Patrick Haas) and by John Farr.

A large volume of written materials was reviewed by the Committee (see reference list), including more than 56 White Papers submitted to the Committee in response to a call for White Papers on the UST Program issued by the SB 1764 Advisory Committee May 24, 1995. The Committee believes the White Papers are a valuable resource in identifying important issues and ways to improve the existing regulatory program.

It is important to note that the SB 1764 mandate for the Advisory Committee differs from portions of the long-standing water quality control policies of the SWRCB. While SB 1764 requires the Committee to recommend changes necessary to ensure that UST Program "cleanup standards are necessary to protect human health, safety, and the environment," California's Water Code and SWRCB Policies focus on the protection of beneficial uses of the waters of the State. In making its recommendations, the Committee has chosen to retain the inclusion of beneficial water use protection as a necessary and worthwhile goal of the UST Program. Because of the inconsistent interpretations of the existing water quality control policies, discussion is provided by the Committee on the nature and extent of beneficial water use protection that should be considered adequate.

The conclusions and recommendations of the Advisory Committee are as follows:

1. THE USE OF RISK ASSESSMENT

Conclusion

The current corrective action process is not implemented in a consistent manner, is wasteful of resources, and is controversial.

Recommendation

The committee recommends that a framework for formulating corrective actions be developed that uses the concepts and tools of risk assessment (in its broader sense) to the maximum extent possible. The committee acknowledges that risk assessment cannot be the sole basis for selecting corrective actions and recommends that the framework clearly delineate its limitations and how such limitations are accounted for in the decision-making process. The American Society of Testing and Materials (ASTM) standard for Risk-Based Corrective Action, ASTM E-1739-95 (RBCA), as well as the experience of states that have already adopted risk-based programs, are good starting points for developing this framework.

Discussion

Selecting the appropriate corrective actions for underground leaking fuel tanks is a very complex problem that involves several stakeholders with different objectives. Defining rationality for such problems has eluded the scientific community even at the theoretical level. In practice, the best that we can hope for is a process that is acceptable to the stakeholders, that uses the best available science, and that efficiently applies the available resources to attain maximum benefit to the people of the State. Risk assessment has the potential for contributing to this process by making the selection of corrective actions transparent and focusing the expenditure of effort and resources where the return is the highest.

The term "risk assessment" means different things in different industries. In environmental restoration, it usually means the derivation of quantitative estimates of risks to human health (i.e., the probability of adverse health effects) or to environmental receptors. In other industries it is used in a broader sense, i.e., only the probabilities of undesirable events resulting from a specific hazard are evaluated. These undesirable events include, but are not limited to, health effects. Thus, in the nuclear power industry, where risk assessment is called probabilistic risk (or safety) assessment (PRA or PSA), these events include reactor core damage; in the chemical process industry, where it is known as quantitative risk assessment (QRA), undesirable events include specific releases of chemicals; finally, in the nuclear waste management industry, where it is known as performance assessment (PA), undesirable events include releases of radionuclides from repositories at specific locations and at specific times in the future.

A very important result of these studies, indeed some people argue that it is the most important result, is a list of "dominant" hazard or exposure scenarios, that is, a list of the most likely pathways through which the hazard may cause the undesirable events. Developing this list requires the utilization of data and models. The dominant exposure scenarios are a few in number (while the risk assessment itself may deal with a large number of possible scenarios) and can serve as the basis for risk management. Typically, these scenarios involve events whose analysis requires diverse scientific disciplines, such as physics, chemistry, structural analysis, reliability theory, and toxicology. The study of these scenarios helps the risk assessors and managers focus their attention on what information is needed from these disciplines, from the system itself, and why.

It is this broad usage of risk assessment that the Committee has in mind in its recommendation. The undesirable events in this case will be defined for the various receptors of interest, such as humans and biota. Basing remedial actions on the set of most likely scenarios (and their timing) that may lead to undesirable effects on the receptors will go a long way toward injecting rationality into the process and guiding sound, defensible decision making. However, problems still remain and they stem largely from the uncertainties that are usually associated with the identification of these scenarios and the evaluation of the likelihood of their occurrence. Significant sources of uncertainty include the common lack of adequate data and the lack of full process representation in the relatively simple subsurface chemical transport models commonly applied to LUFT site analysis.

It is important to realize that these uncertainties are related to our understanding of the relevant phenomena and that they are present regardless of whether one performs a risk assessment. Risk assessment focuses our attention on the uncertainties; it does not create them. Even in the presence of large uncertainties, the risk scenarios are still valuable, because we can now ask questions such as, "what data do we need to collect to increase our confidence in the validity of these scenarios?" In other words, the scenarios can be the basis for the evaluation of the significance of events and processes that have not been included in the risk assessment. This qualitative evaluation can expand on the risk results and point to corrective actions that supplement those suggested by the risk assessment. This is why we recommend that risk assessment not be the sole basis for remedial action decisions.

The uncertainties and the requirement of a qualitative evaluation of the risk assessment results create a conflict between the need to retain flexibility and complete the best possible technical evaluation of a given site and the need to produce prescriptive guidance that promotes rapid decision making and consistency. A good example of an effort to deal with this conflict is the ASTM Standard E 1739-95 (RBCA), which could serve as a good starting point for the type of decision-making framework that the Committee believes would serve California well. The tiered approach and the Tier-1 look-up tables are an attempt to strike a reasonable balance between flexibility and prescriptive guidance. Tier-1 look-up tables are easily generated for various known parameter values or estimates applicable to given site conditions. It is here that the model uncertainties that we have referred to enter the picture; while we recognize that more work is needed in this area, we believe that a review of actual implementations of RBCA will provide valuable insights into the kinds of issues that arise in practice and how often practitioners have found RBCA existing written guidance to be satisfactory.

Finally, we note that risk assessment can only identify what is important; it does not tell us what should be done to reduce the major sources of risk or how site closure can be achieved. For these reasons, it is important to develop performance or acceptance criteria, that is, a set of requirements that must be satisfied before site closure is granted. The policy decisions required to clearly define such criteria and the acceptable methods for demonstrating compliance will be a challenging, yet a necessary task.

2. SITE CLOSURE CRITERIA

Conclusion

Defined levels of acceptable risk that can guide risk-based decision making for California's LUFT sites have not been agreed upon or adopted by the State. The critical question of "How clean is clean?" is not adequately addressed under existing UST Program directives, and guidance on how this critical question should be answered in a defensible manner is sorely needed. Recognizing the limitations of fixed numerical standards for acceptable chemical concentrations in soil, water, and air, there is an urgent need for the adoption of clear written guidance on what levels of risk to potential receptors are acceptable, as well as what methods should be used to evaluate potential receptor exposures. Within a risk-based decision-making framework, such guidance would provide the basis to determine the primary site closure criteria: site-specific, media-specific chemical concentrations that pose acceptable levels of risk.

Recommendation

The State should issue clear written guidance on acceptable criteria for closure of LUFT sites. It is presumed that in order to institute a risk-based approach, such criteria should be predicated on determining acceptable levels of risk that would be applicable to all sites. This guidance could potentially be in the form of acceptable levels of risk, or procedures for determining combinations of chemical concentrations allowable in groundwater and/or soils predicated on risk. In the latter case, written guidance should be provided on the risk analysis methods and/or assumptions necessary to make the extrapolations from acceptable levels of risk to chemical concentrations with particular attention to the relevant uncertainties. Because fixed numerical standards independent of risk are not based on complete pathways to receptors, they should only be used as part of a conservative screening stage in the lowest tier of a multi-tiered risk-based decision-making approach. A clear and precise process is needed to determine remedial objectives and to support closure decisions that are based on the risks associated with the site.

Discussion

The Committee believes that the State should not rely solely on fixed numerical cleanup goals or closure criteria in terms of acceptable chemical concentrations in soil and water, because these numbers should depend on site-specific and media-specific factors and on the risk-based approach that has been recommended (Recommendation 1). Thus, it is appropriate for the State to issue guidance regarding the levels of acceptable risk for chemical exposures. However, it is possible that acceptable contaminant concentrations can substitute for actual risk values for certain sites. This may be necessitated by the large uncertainties that are associated with estimating risk values for some sites or by the significance that the State assigns to some intermediate points in the risk pathway, such as groundwater and the protection of its beneficial uses.

The existing water quality-objectives (generally MCLs) are intended to protect beneficial water uses to acceptable levels of risk. However, because they apply to virtually all waters of the state (not just potential exposure points), they contribute little to the definition of acceptable levels of risk, and their application by state and local regulators can be viewed as arbitrary. In addition, the water-quality objectives do not directly address certain exposure pathways of concern, such as those associated with the inhalation of hydrocarbon vapors in indoor air, and MCLs do not exist for many chemicals of concern that may affect the beneficial uses of water. Thus, the existing water-quality objectives are not uniformly risk based, and, therefore, should not be used as closure criteria in their present form (see Recommendation No. 8). There is a need for guidance on what levels of risk should be considered acceptable as a starting point for risk-based decision making. Using recommended risk assessment methods, observed or simulated chemical concentrations at potential exposure points (e.g., through the screened sections of existing or probable future water-supply wells) could then be compared to acceptable exposure-point concentrations or risk levels to determine what degree of site remediation, if any, is required.

To expedite the process of site evaluation, fixed levels of acceptable risk may be stated in terms of media-specific chemical concentrations or standards at the lowest tier of risk analysis (assuming a tiered, risk-based approach is adopted). At higher tiers, target levels of acceptable risk serve as the starting point for the risk analysis and decision making. However, the State may decide to determine the procedure for transforming a health risk value into a contaminant concentration because the risk assessment process may require a large number of assumptions and great uncertainty. Rather than having the various parties debate the merits of different risk assessment methods, the State should provide guidance for the procedures used to extrapolate to site-specific, media-specific contaminant concentrations.

For the higher tiers of analysis applied to sites with greater potential remediation costs, the risks posed by chemicals of concern for both existing and probable future pathways should be evaluated through realistic consideration of the chemical transport distance horizontally and vertically between LUFT contaminant source(s) and the screened depth intervals of existing and probable future water-supply wells. This has been done sporadically in many cases, but regulators have often required that the range of potentially complete exposure pathways evaluated must include unrealistic hypothetical exposure scenarios involving direct human ingestion of very shallow groundwater (e.g., through wells with screened depths less that 25 ft bgs, which are not legally permitted), ingestion of groundwater that is nonpotable due to natural causes or widely accepted practices of man, and ingestion of groundwater contained within low-permeability sediments that yield insufficient quantities of water to possibly serve as a water supply. The SWRCB should discourage the enforcement of such unsupportable and economically counterproductive regulatory requirements.

The State should define a level of acceptable risk that is consistent with other environmental exposures. To begin this difficult task, the SWRCB could consider holding hearings and possibly soliciting white papers regarding what levels of estimated risk should be deemed acceptable by the State for LUFT sites. The SWRCB should consider comparative risks that the State currently deems acceptable due to other sources of pollution and for other media (such as risks due to the impact of automobile emissions on ambient air, or acceptable estimated cancer risks as defined in the Safe Drinking Water and Toxic Enforcement Act of 1986, Proposition 65, California Health and Safety Code Section 25249.5 et. Seq.) compared to the fuel leak impacts on soil and groundwater media that are of primary concern at LUFT sites. Similarly, acceptable levels of risk from all other causes should be considered.

3. RISK CLASSIFICATION

Conclusion

UST Program regulators have tended to treat all LUFT sites as though they pose similar, nearly always significant threats to human health, safety, the environment, and beneficial water uses. This has caused misallocation of remediation resources. UST Program regulators, responsible parties, and environmental consultants have been devoting relatively too much effort to lower risk LUFT sites and relatively too little effort to higher risk LUFT sites and other non-LUFT water-quality threats in California.

Recommendation

The SWRCB should provide definitive guidance on how LUFT sites should be classified based on the risk they pose to human health, safety, the environment, and beneficial water uses. This can be achieved by adopting a risk-based decision making framework for consistent application to all LUFT sites in California.

Discussion

Some LUFT sites in California pose de minimis or insignificant risks to human health, safety, the environment, and the beneficial uses of water, while some sites pose significant risks. To aid in decision making and resource allocation, it would be useful to classify LUFT sites based on the risks they pose. Initial classification could be divided between insignificant risk sites and significant risk sites. Risk classification can be achieved by applying a risk-based decision making framework to LUFT sites in California. Minimal resources for investigation and remediation should be allocated to the insignificant risk sites, while the vast majority of the resources should be allocated to the significant risk sites. This low key approach to insignificant risk sites will allow more resources to be allocated to significant risk sites where tangible benefits will accrue to society through site remediation. Investigation and monitoring at significant risk sites should be thorough enough to define the risks and provide adequate support to risk-based decisions regarding the nature and extent of required remediation. In significant risk cases, actively engineered containment and remediation technologies should be considered to reduce risks in a timely manner. Risk reduction should be achieved using the most cost-effective means, not necessarily through the application of best-available technology (BAT).

4. INSIGNIFICANT-RISK SITES

Conclusion

LUFT sites bear a stigma that makes them difficult to sell even when they pose "insignificant risk" (i.e., within "acceptable levels," as discussed above in Recommendations 1 and 2) to human health, safety, the environment, and beneficial water uses. This imposes hardship on the responsible party (RP), and prevents the sites from being conveyed to their best and highest uses. California would benefit from regulatory changes to reduce the stigma associated with LUFT sites. An accepted determination that a site poses insignificant risk to human health, safety, the environment, and beneficial water uses should be deemed a determination that it is safe to develop and use the property, recognizing that in some cases the risk analysis may indicate the need for certain land-use restrictions to maintain the state of insignificant risk.

Recommendation

Make it a matter of "public record" (by a legally appropriate technique) that a LUFT site contains residual petroleum hydrocarbons in the subsurface, but that insignificant-risk sites pose no foreseeable risk to human health, safety, the environment, and beneficial water uses. The term "public record" as used here is not intended to imply the need for recording with the property title deed or related instruments that run with the land. It is merely intended to mean that the information should be readily available to the public, including parties interested in land transactions. The State should strive to convince the public and financial institutions that such properties pose no foreseeable risk to continued or future land use (with certain land-use restrictions in some cases). If deemed advantageous by the property owner, monitoring could be conducted to determine the progress of intrinsic bioremediation.. The public record should be corrected when monitoring shows that residual petroleum hydrocarbons have been removed from the property.

Discussion

Many RPs realize significant property devaluation when their land is affected by petroleum fuel releases and designated as a LUFT site. This is reasonable to a certain degree because a contaminated property is inherently less valuable than an uncontaminated one. However, being designated a LUFT site often makes a piece of property not only less valuable, but also unsalable and uncollateralisable. This is due to the reluctance of financial institutions to become involved with LUFT-designated properties. This is especially unreasonable with respect to insignificant risk sites, and it prevents such sites from being conveyed to their highest and best uses. The Committee believes that the SWRCB should urge cleanup oversight agencies to close insignificant risk cases, and that closure letters should clearly state that the site poses no significant risks. Such closure letters may not restore full value to LUFT contaminated properties, but such letters would help restore property salability.

5. SIGNIFICANT-RISK SITES

Conclusion

For sites that appear to pose significant risks (i.e., exceeding acceptable levels), remedial actions are often selected in a somewhat arbitrary manner, depending on the personal preferences of the regulators or responsible parties. In some cases, this seems to be in response to locally established norms or expectations based on perceived effectiveness of certain types of remedial actions. In some cases, this is described as a requirement for application of "best available technology" (BAT), which may not be the least-cost way to reach defined remedial action objectives.

Recommendation

For sites that pose a significant threat to human health, safety, the environment, or beneficial water uses, the risks should be reduced to acceptable levels using the most cost-effective technology, not necessarily by adopting BAT. The application of BAT should only be required in cases where the necessary risk reduction cannot be achieved by other (perhaps less costly) means.

In cases where the risks cannot be reduced to acceptable levels within a reasonable time frame, the estimated degree of risk should be made a matter of "public record," as defined above in

Recommendation No. 4. The record should then be amended when monitoring shows the risk has been adequately reduced.

Discussion

The vast majority of remediation resources should be concentrated on significant risk sites. In such cases, benefits will accrue to society through site remediation. Again, though, those benefits should be captured using the most cost-effective means of achieving the accepted risk-based remediation goals, not necessarily with BAT. Investigation and monitoring at significant risk sites should be thorough enough to: 1) fully define the risks posed by chemicals at the site and support risk-based decision making regarding remediation requirements; 2) ensure that implemented remediation progresses at an acceptable rate and chemically-affected groundwater remains under control; and, 3) demonstrate that remediation is complete and risks have been reduced to acceptable levels.

6. INTRINSIC BIOREMEDIATION

Conclusions

Intrinsic bioremediation, defined here as the innate capability of indigenous microbial communities to biodegrade or transform pollutants into benign products without human intervention, appears to be occurring at many LUFT sites. Certain active remediation technologies, such as groundwater pump-and-treat, are not always effective at reaching MCLs within a reasonable time frame and may be costly (National Research Council, 1994, Alternatives for Ground Water Cleanup, National Academy Press, Washington, D.C.). In addition, active remediation efforts may pose additional health risks and have adverse effects on the environment. Thus, if the effectiveness of intrinsic bioremediation can be established at a given site, this process should be considered a viable treatment alternative.

Recommendations

a) Analytical and hydrogeological protocols should be established to permit support or rejection of site-specific hypotheses that intrinsic bioremediation is sufficient to contain and remove existing contamination within a reasonable time frame (see also Recommendation No. 12).
b) The SWRCB should issue written guidance regarding how the "reasonable" time frame for intrinsic bioremediation is to be determined.
c) Evidence of intrinsic bioremediation of LUFT contaminants may be used to lower the priority ranking of a LUFT site for cleanup.
d) Sufficient monitoring of the contaminant plume should be conducted during the process of intrinsic bioremediation to ensure that contamination does not spread beyond acceptable boundaries.
e) The SWRCB should verify the LLNL Report conclusions regarding intrinsic bioremediation of petroleum hydrocarbons with data from additional LUFT sites, and collect and evaluate data for more recalcitrant LUFT contaminants (e.g., MTBE).

Discussion

Biodegradation is defined as the biological conversion of a substrate into carbon dioxide and methane; biotransformation is defined as the transformation of a substrate into some other product which may or may not be of concern from a human health or environmental risk perspective. Though benzene, toluene, ethyl benzene, and xylenes (BTEX) are often the contaminants of primary concern to human health at

LUFT sites, other compounds such as fuel additives must be considered if present. Our knowledge about the biodegradation of specific LUFT contaminants varies by chemical, with more data available for BTEX and aliphatics than other fuel components. There is lack of information for fuel additives such as MTBE and ethyl tert-butyl ether (ETBE), some of which appear to be relatively recalcitrant to biodegradation. It should be recognized that the biodegradation of organic pollutants is an area of active research and the concept of intrinsic bioremediation as a treatment alternative is a relatively new one. Thus, new scientific findings will continue to modify our understanding of the efficacy of intrinsic bioremediation. Below, we discuss some of the issues associated with the biodegradation of BTEX compounds.

Biodegradation of BTEX compounds occurs under favorable geochemical conditions. The biodegradation or biotransformation potential of BTEX compounds has been demonstrated under both aerobic and anaerobic (ferric iron-reducing, nitrate-reducing, sulfate-reducing and methanogenic) geochemical conditions. The anaerobic biotransformation is not expressed at all sites under all conditions for all BTEX compounds. The extent to which intrinsic anaerobic bioremediation can be used to remediate sites is subject to current research.

Intrinsic bioremediation depends not only on the type and concentration of contaminants and potential electron acceptors, but also on the site hydrogeochemistry and the microbial community present. Conditions for intrinsic bioremediation appear especially favorable at sites where the groundwater flow is sufficient to supply the contaminated zone with sufficient electron acceptors and remove potentially inhibiting products. Factors known to inhibit biotransformation include toxicity due to high concentrations of TPH, and accumulation of metabolic end products such as sulfide. Hydrogeochemical conditions conducive to intrinsic bioremediation include the presence of carbonates to buffer pH changes, high concentrations of or access to oxygen and other electron acceptors, and presence of nutrients.

Generally, intrinsic bioremediation is far slower than active remediation processes. Human-caused contamination of groundwater by petroleum has occurred primarily within the past century and thus there is limited long-term data (e.g., on the order of decades) on the persistence of groundwater plumes. There are data indicating that petroleum plumes under conditions of intrinsic bioremediation can persist on the order of decades. There are several reasons for the long-term persistence of petroleum plumes. Rates of biodegradation vary across a contaminant plume; activity is likely to be highest on the fringes of the plume, where mixing with aerobic water occurs, and lower where anaerobic processes predominate. Sorption or other surface interactions between contaminants and the aquifer solids may substantially reduce the bioavailability and biodegradation rates of LUFT contaminants. Also, the contaminant removal rate is insignificant relative to the total mass of contaminants. Thus it is important to recognize that the short-term, and perhaps long-term, outcome of intrinsic bioremediation may not be a reduction of plume size. Instead, intrinsic bioremediation may result in a containment of the plume within a fixed boundary where biodegradation rates are equal to the rate at which the petroleum constituents are released from residual material (remaining after source removal) into the groundwater plume.

Some potentially negative impacts of intrinsic bioremediation should be recognized. These may include formation of: 1. methane, which may create fire or explosive hazards in structures, and 2. sulfides and reduced iron species, which may degrade water quality downgradient of the LUFT site. Nondegradable organic residues of petroleum biodegradation, e.g., tar-like substances, may also be residual products of bioremediation.

Intrinsic bioremediation is distinctly different from a no-action alternative. Evidence that intrinsic bioremediation is occurring at acceptable rates is necessary before decisions can be made regarding the viability of this process as a treatment alternative. Monitoring information that can be used to demonstrate the effectiveness of biodegradation is discussed in various publications (e.g., National Research Council, 1993; Wiedemeier, T. 1995). Briefly, this information can include: I) monitoring data of concentration changes in LUFT contaminants, potential electron acceptors, and products of metabolism, and ii) use of analytical and/or numerical models to evaluate site data and simulate changes in time and space in the LUFT contamination profile. These are discussed more thoroughly under "Analytical and Sampling Considerations."

If evidence of intrinsic bioremediation is established, judgment must be made as to whether intrinsic bioremediation will be sufficient to achieve removal or containment within a "reasonable" length of time. A reasonable length of time must be defined by the State and thus the SWRCB should issue written guidance regarding how the reasonable time frame is to be determined.

The SWRCB should verify the LLNL Report conclusions regarding intrinsic bioremediation with data from additional LUFT sites, as well as collect and evaluate data for other LUFT contaminants. Close attention should be paid to sites where plume lengths are longer than expected in order to identify the conditions under which intrinsic bioremediation is likely to fail as a treatment alternative. The SWRCB should identify types of hydrogeological conditions where intrinsic bioremediation is not successful at containing LUFT contaminant plumes. Special consideration will be needed at sites that have high levels of residual contamination of their soils, sites with recalcitrant fuel additives such as MTBE, sites with geological material that are conducive to rapid movement of plumes, or sites with considerable spatial heterogeneity.

7. SOURCES OF DRINKING WATER RESOLUTION

Conclusions

The prevailing interpretations of SWRCB Resolution 88-63 have resulted in protection of essentially all groundwater in the State to drinking-water standards (MCLs), even in areas where the groundwater is unsuitable to serve as a source of drinking water due to natural causes and/or commonly accepted human practices. The provisions to exempt certain groundwater systems from consideration as sources of drinking water that are contained in Resolution 88-63 have not been generally used due to a prevalent and narrow legal interpretation that such exemptions should only be granted through Basin Plan amendment(s). The Basin Plan amendment process is an impractical means for granting site-specific drinking-water source exemptions, and practical means for such exemptions are critically needed to avoid wasteful site remediation in cases where the groundwater is clearly not suitable as a source of drinking water.

Recommendations

The SWRCB should issue interpretive clarification of SWRCB Resolution 88-63 (Sources of Drinking Water Policy) to more clearly define what type of groundwater systems comprise California's sources of drinking water, and what level of protection is reasonable for those sources. It would be particularly useful for the SWRCB to clarify that only existing and probable/anticipated future beneficial uses need to be protected. For example, very shallow groundwater that is non-potable due to natural causes and/or commonly permitted activities such as sanitary sewer operations, and which is unlikely to impact water quality in deeper water-supply aquifers, should not be designated as municipal and domestic supply (MUN).

The SWRCB should also make the necessary policy changes so that the beneficial use protection exemptions in Resolution 88-63 would be made available on a site-specific basis, given adequate documentation that a given body of affected water is unsuitable for the officially designated beneficial uses of water in the site vicinity due to natural causes and/or commonly accepted human practices. The authority to grant site-specific exemptions to the regionally designated beneficial use water-quality objectives should be given to the executive directors of each RWQCB. When such exemptions are granted, appropriate points of compliance (e.g., where water-quality standards such as MCLs might logically be enforced) may need to be defined to protect nearby sources or potential sources of drinking water, for example, within a drinking-water aquifer in a deeper groundwater zone than the exempted zone.

Beneficial use suitability determinations (designations) and beneficial use protection exemptions for a given water body or portion thereof should be based on not only the existing water quality and water production capacity, but also the potential sustainability of minimum water quality and quantity criteria, considering the potential for salt-water intrusion or other water-quality impacts that would be created by the potential water-supply development (e.g., groundwater on the saline side of salt-water intrusion barriers should be generally exempted from MUN beneficial use designation).

Discussion

With the recognition that certain types of water contaminants, such as certain petroleum hydrocarbons, are highly degradable, it becomes apparent that the protection of beneficial water uses does not necessarily need to include the protection of nearly all waters of the State to drinking water standards. There have been disputes regarding the overly uniform regional beneficial water use designations and water-quality objectives, and the appropriateness of granting of site-specific exemptions to MUN beneficial use and MCL water-quality objectives pursuant to the exemption provisions in Resolution 88-63. Further disputes may be avoided, and the UST Program could be improved if the SWRCB implements the above recommendations.

8. BENEFICIAL USE DESIGNATIONS AND WATER QUALITY OBJECTIVES

Conclusion

The beneficial water use designations and water quality objectives currently established in the water quality control plans (basin plans) of the various Regional Water Quality Control Boards (RWQCBs) in California are too inflexible, and are often overly restrictive (i.e., unnecessary to ensure the protection of human health, safety, the environment, and existing and probable future beneficial uses of the waters of the State). The vast majority of California's groundwater systems are officially designated for the beneficial uses of MUN. The existing, largely uniform regional beneficial use designations ignore the fact that not all groundwater systems are suitable for MUN beneficial use. Little or no effort has been made to map, classify, or categorize California's groundwater systems in terms of beneficial use suitability on a sub-regional scale.

The basin-plan water-quality objectives compel virtually all groundwater remediation in California to MCLs for drinking water, regardless of background or ambient water quality, even in cases where the groundwater is non-potable due to natural causes or commonly accepted human practices. The water-quality objectives in the basin plans are based on the regional beneficial use designations and current interpretations of SWRCB Resolutions 68-16 and 88-63, but do not adequately reflect the requirements of Porter-Cologne (Water Code sec. 13241).

Recommendation

The beneficial use designations and water quality objectives in the Regional Water Quality Control Board (RWQCB) Basin Plans should be carefully examined and revised as necessary to address the requirements of Porter-Cologne, retaining justifiable beneficial use protection for existing and probable future water-supply aquifers[1] and adjacent water-bearing zones that may pose a water-quality threat to said water-supply aquifers. The State should examine the possibility of categorizing or classifying groundwater systems for beneficial use suitability on sub-regional scale.

California's land and water resources should be managed in recognition of their many competing uses, and the benefits of waste treatment/assimilation should be acknowledged. In particular, the significant treatment/assimilation capacity of the subsurface for certain petroleum hydrocarbons should be accounted for in the decision-making process for LUFT sites. It would be worthwhile for the SWRCB to recognize the capabilities and limitations of subsurface treatment zones at LUFT sites for highly degradable chemicals, such as certain petroleum hydrocarbons, in its public review/revision of Resolution 92-49. Under a treatment-zone policy, given appropriate site conditions and adequate monitoring, regional or sub-regional water-quality objectives could be suspended for a reasonable period of time within approved treatment zones until the necessary waste treatment has been completed.

Discussion

California's existing beneficial water use designations and water quality objectives attempt to further certain interpretations of the intent of the 1968 "Anti-degradation Policy" (SWRCB Resolution 68-16) and the 1988 "Sources of Drinking Water Policy (SWRCB Resolution 88-63), but seem to conflict with the Porter-Cologne Water Quality Control Act, Chapter 1 (commencing with Section 13000, Division 7 of the California Water Code), which requires "that activities and factors which may affect the quality of the waters of the State shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible." Section 13241 of the Water Code specifically requires that each Water Quality Control Plan must consider the following factors:

(a) Past, present, and probable future beneficial uses of water.

(b) Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.

(c) Water quality conditions that could reasonably be achieved through coordinated control of all factors that affect water quality in the area.

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[1] The term "water-supply aquifer" is defined here to be a water-saturated subsurface flow zone capable of storing and transmitting water in sufficient quantities and of sufficient quality to support beneficial uses.

(d) Economic considerations

(e) The need for developing housing within the region, and

(f) The need to develop and use recycled water.

It appears from the adoption of drinking-water MCLs as water quality objectives for virtually all the waters of the State in the RWQCB's Basin Plans (with the additional requirements of compliance with the SWRCB Resolution 68-16) that the RWQCBs have not fully considered all the factors listed above, as required by Porter-Cologne. The protection of nearly all waters of the State to drinking-water standards or lower levels (virtually everywhere at all times and to unreasonably local scales) can not be justified in full consideration of all the factors listed above.

Formally recognizing the significance of petroleum hydrocarbon biodegradation in the subsurface would pave the way toward better decision making regarding LUFT sites. The designation of subsurface treatment zones (active or passive), where the general water-quality objectives of a water body could be exceeded for a limited time under controlled and monitored conditions, is a worthwhile concept that could be implemented through the current revision process for SWRCB Resolution 92-49. Treatment zones should be distinguished from containment zones, which might be appropriate for poorly degradable contaminants, such as recalcitrant fuel additives. Appropriate points of compliance could be used to ensure treatment zones remain controlled, and water-quality objectives continue to be met outside the treatment zones. The treatment-zone concept is analogous to the "zones of initial dilution" and "mixing zones" currently used in the management of surface-water quality in California. The potential economic benefits to be gained by this approach justify its use in place of the existing approach of protecting nearly all waters of the State to at least drinking-water standards at all times.

9. CONSIDERATION OF ECONOMIC FACTORS

Conclusion

Remedial actions at LUFT sites have generally been conducted in an attempt to reduce perceived threats to human health, safety, and the environment, or to protect and restore economically important beneficial uses of California's water resources. The latter is most often cited as the reason for regulatory requirements to investigate and remediate LUFT sites. The UST Program, however, has failed to adequately recognize that management of water resources should be conducted in full consideration of the benefits and costs associated with management decisions. To protect and restore beneficial uses of California's water resources is a highly worthwhile task, but the implementation of this task should be "consistent with the maximum benefit to the people of the State," as mentioned in SWRCB Resolution 68-16 and called for in Porter-Cologne. The consideration of economic factors in the decision-making process would improve the UST Program.

Recommendation

The appropriate level of water-quality protection and the degree of required LUFT site restoration should be governed by a balanced consideration of economic factors, along with the need to protect human health, safety, the environment, and existing and probable future uses of the waters of the State. In cases where the risks to human health, safety, and the environment are insignificant, the costs of contamination can be valued from an economic perspective, for example as the quantifiable costs of water treatment to restore usable sources of drinking water to potable quality (although some sites may also pose inhalation or safety risks due to land-surface emissions of volatile organic chemicals, and other sites may pose environmental risks). When water quality is threatened or impaired, the costs of well-head treatment of affected or potentially affected sources of water should be compared to the costs of more invasive remediation methods, and regulatory requirements for remediation should be necessary to eliminate significant risks to human health, safety, or the environment, or justifiable on economic grounds to protect existing and probable future beneficial water uses.

Discussion

Water-quality control based on economic considerations is particularly justified in cases where there are insignificant risks to human health, safety, and the environment. At many regulated sites, there is little risk of drinking-water exposure to toxic chemicals because of well-head treatment and/or institutional controls that prevent the chronic consumption of contaminated water. This is particularly true when considering potential drinking-water exposures to petroleum hydrocarbons in groundwater, given that the taste and odor thresholds for the dissolved fractions of petroleum products in water are generally lower than the drinking-water standards for the chemicals of concern in the petroleum products (Marshack, 1995).

10. MTBE AND OTHER FUEL OXYGENATES

Conclusions

MTBE is a major additive to gasoline in California, and it is much more mobile and resistant to biodegradation in groundwater than petroleum hydrocarbons such as BTEX. Effects of LUFTs on groundwater quality have been potentially underestimated because of the lack of monitoring for recalcitrant fuel additives such as MTBE. Recent nationwide surveys of shallow groundwater quality by the USGS National Water Quality Assessment Program (Squillace et al., 1995) reveal MTBE to be the second most frequently encountered VOC in urban land-use settings. Much of the MTBE detected by Squillace et al. (1995) appears to have originated from LUFTs. Many of the monitoring wells used by Squillace et al. (1995) may have been in the immediate vicinity of LUFT sites; therefore the lateral extent of MTBE from LUFT sites remains unclear. Although only used for less than 5-10 years in most cases and not extensively monitored, evidence shows that MTBE has already impacted a substantial volume of shallow groundwater in urban areas studied by Squillace et al. (1995). Insufficient data exist on soil and groundwater contamination from recalcitrant fuel additives (primarily MTBE) in California to assess fully the likely range of groundwater impacts from LUFT sources, as was done for benzene in the LLNL study.

Recommendations

LUFT site characterization should include data on the concentrations of MTBE in soil and groundwater. If other fuel oxygenates besides or in addition to MTBE were or are present in the fuel stored at a site, and if these oxygenates have the potential to be at least as mobile as the BTEX compounds (e.g., ETBE), they too should be monitored. A recommended maximum contaminant level for MTBE and other fuel oxygenates in drinking water should be established so that soil and groundwater clean-up levels can be more easily determined within the risk-based decision-making framework. The State should determine how long MTBE as well as other fuel oxygenates have been used in California, so that links between historical use and groundwater quality can be better ascertained. Fuel leak sites where such additives were or are present in the leaked fuel (i.e., more recent leak sites) must be more carefully evaluated for potential risks within a risk-based decision-making framework, using more stringent screening-level criteria than might be appropriate for older fuel leak sites, where such additives are absent. The State of California should also evaluate the data from a more general (statewide) perspective over time to assess the likely range of groundwater impacts (i.e., the spatial extent of dissolved plumes, chemical concentrations, and plume size stability over time). This will allow practical guidance to be issued regarding these additives.

Discussion

Key chemical parameters used to characterize LUFT sites are concentrations of total petroleum hydrocarbons (TPH) and/or the BTEX compounds. The advantage of TPH as a monitoring parameter is that it supposedly represents a single quantifiable overall measurement of all the compounds found in various fuels. A disadvantage of TPH as an indicator of environmental fuel contamination is that TPH may not be specific to fuel leaks and may occur in sewage or natural deposits or other environmental occurrences. BTEX is considered an indicator of the toxic constituents within the TPH profile because these four compounds are considered the primary determinants of human risk among the petroleum hydrocarbons. Evidence from the LLNL LUFT Historical Case Analysis study together with others (see Recommendation No. 6) strongly indicates that the most mobile of the BTEX compounds, benzene, is highly prone to attenuation by sorption and biodegradation. The localized, point-source nature of LUFT plumes together with the strong tendency for benzene to biodegrade make natural groundwater remediation schemes (i.e., schemes relying on sorption, biodegradation, and dispersion processes) feasible for cleanup of BTEX in many cases. Importantly though, MTBE is much more mobile and persistent than benzene (Squillace et al., 1995; Davidson, 1995), with a much lower tendency to sorb onto soil/sediment particles and much greater resistance to biodegradation.

The toxicity of MTBE and its major metabolite tertiary butyl alcohol (TBA) are currently under investigation. The U.S. EPA has been discussing the use of a drinking water standard for MTBE of 200 ug/liter if MTBE is determined to be a non-carcinogen, and 20 ug/liter if MTBE is determined to be a carcinogen. Whether MTBE is a human carcinogen is currently being debated and has not been determined at this time. However, depending upon the environmental levels of this contaminant, MTBE may contribute significantly to the risk associated with LUFTs whether it is a carcinogen or not. Thus, BTEX compounds may not be the only significant contributors to the risk associated with LUFT sites. In addition to MTBE, chemicals such as ethanol, for which a large amount of toxicology data exists, or ETBE and TAME (tertiary amylmethyl ether) which have less toxicology data than MTBE, may be used as fuel oxygenates. Data should be collected regarding the fate and transport of all fuel oxygenates known to be present in LUFT fuel.

Squillace et al (1995) summarized progress in a nationwide survey of MTBE occurrence in groundwater as part of the USGSs NAWQA program (National Water Quality Assessment). They found 27 percent of the shallow Urban Land-Use (ULU) wells and springs to have more than 0.2 ug/L MTBE The reasons for such widespread detection of MTBE are not known with adequate certainty, and further investigation is needed. Nevertheless, the following mechanisms are probably both active: (1) widespread wet deposition of atmospheric MTBE because of its high volatility and solubility, and (2) lateral migration of MTBE away from LUFT sites. The data of Squillace et al. (1995) on occurrence of MTBE in groundwater of urban areas suggests that impacts of MTBE from LUFTs on shallow groundwater quality are already significant.

Although the potential lateral and vertical extent of MTBE plumes will be substantially greater than BTEX plumes, it appears that most of the LUFT sites being currently evaluated in California were not used for fuel storage during the current era of high MTBE usage. Consequently, MTBE is probably not a significant risk at a majority of the currently identified LUFT sites. It is therefore paramount that the State determine the usage history of MTBE as well as other fuel oxygenates in California. (Much of that determination has already been performed by the Regulatory Programs Branch of the State Water Resources Control Board.) In most cases, sites with LUFTs that leaked or spilled recalcitrant fuel additives (RFAs) such as MTBE should be viewed as having potentially higher risks than sites where no RFAs are present.

11. INDEPENDENT REVIEW PANELS FOR LUFT SITE ISSUES RESOLUTION

Conclusion

LUFT site RPs and their consultants often feel that regulatory decisions are not technically defensible, and the existing avenues for appeal require the RP to move up the chain of authority within the UST Program regulatory agencies. The existing appeals process can be lengthy, and many RPs and consultants are generally reluctant to file appeals due to fears of alienating regulators by going "over their heads."

Recommendation

The SWRCB should consider creating a network of independent, regional LUFT technical review panels comprised of qualified environmental experts. The panels could review submitted appeals, and render judgments regarding the appropriate course of action for each case.

Discussion

The creation of a network of independent LUFT site review panels would offer a valuable alternative to the existing appeals process that involves only the regulatory agencies. Regional review panels comprised of qualified environmental experts could be charged with the task of resolving decision-making disputes based on technical evaluation of site-specific issues. Following the adoption of a risk-based decision making process for LUFT sites in California, the primary charge of the review panels could be to determine what course of action is most supportable by the adopted process. The intended emphasis of such review panels should be to resolve defined technical issues, which will no doubt arise during the implementation of a scientifically supportable risk-based decision making approach.

12. ADEQUATE SOURCE REMOVAL

Conclusion

There is a critical lack of definition for what degree of petroleum contamination constitutes significant threat(s) to human health, safety, the environment, and beneficial water uses. Agreement on the methods to answer this central question consistently on a case-by-case basis will go a long way toward "fixing" the UST Program in California. In particular, the question of how much "source removal" is adequate requires careful site-specific, risk-based analysis.

Recommendation

The determination of what constitutes adequate source removal should be determined site-specifically, based on a risk-based corrective-action approach, to achieve adequate protection for human health, safety, the environment, and beneficial water uses. The evaluation of potential risk should be based on a scientific assessment of whether chemicals of potential concern in the source are mobile enough to be transported to potential receptor exposure points. The degree of source removal required should be sufficient to effectively remove the risks posed by the source.

Discussion

Although the Committee agrees that in most cases, floating product should be removed to at least the point of residual saturation, the decision to remove floating product should be made on a site-specific basis depending on the risk posed by the product and the benefits, in terms of risk reduction, that may be provided by the product recovery. With scientifically sound risk-based decision making implemented consistently throughout the State, site-specific analyses would call for product recovery at many sites, but for some sites, it may not.

It should be recognized that conventional floating product recovery is technically difficult and costly; and it is generally very ineffective. Under fairly ideal conditions, such recovery can only be expected to remove roughly 25-35% of the separate-phase petroleum product that has spread out on the water table. (The source area product in the shallower vadose zone is generally not recoverable through conventional liquid product recovery methods.) Conventional floating product recovery is roughly analogous to letting the excess liquid drip from an excessively wet sponge, without squeezing the sponge. Because of the poor effectiveness of conventional floating product recovery operations, additional remedial actions would be required at most sites to eliminate significant threats to human health, safety, the environment, or beneficial water uses. For example, enhanced methods of multiphase fluid extraction and SVE/bioventing can be applied to effect significant risk reduction at sites where risks are present (U.S. EPA, 1994). However, site-specific risk analysis may show that floating product poses no significant risks to human health, safety, the environment, or beneficial water uses. Although such cases may be rare, the adopted risk-based decision-making framework should be flexible enough to allow a no-action alternative to be considered for such sites.

13. ANALYTICAL AND SAMPLING CONSIDERATIONS

Conclusions

There is strong evidence that intrinsic biodegradation and sorption are effective in limiting the spread of petroleum contaminants at many, though not all, LUFT sites. Consequently, groundwater monitoring at many sites not involving MTBE or other recalcitrant fuel additives can be focused on a more specific set of objectives aimed at identifying whether passive remediation will be inadequate.

2. The length of contaminant plumes at LUFT sites is not, in itself, sufficient information to evaluate the efficacy of intrinsic bioremediation. Current sampling and analyses protocols typically used to characterize LUFT sites are inadequate to assess intrinsic bioremediation potential and predict the evolution of dissolved fuel hydrocarbon and additive plumes. From the typical data describing contaminant behavior at LUFT sites, it is generally not possible to draw firm conclusions regarding the rates of intrinsic biotransformation of fuel hydrocarbon and additives.

3. The suite of chemical species that are typically analyzed to characterize the geochemistry at LUFT sites has been limited to benzene, toluene, ethylbenzene, xylene isomers (BTEX) and total petroleum hydrocarbons (TPH). Other reactants, most notably the electron acceptors oxygen, nitrate, ferric iron and sulfate, and respective products such as ferrous iron, sulfide, methane, and organic metabolites have not been commonly measured. In addition, fuel additives, such as MTBE, are not routinely analyzed.

4. Most groundwater monitoring designs at LUFT sites have not provided adequate data regarding downward chemical transport to greater depths where intrinsic bioremediation may be less effective.

Recommendation

The SWRCB should develop guidelines for LUFT sites regarding the type of data required, and how such data are to be collected, to assess if: a) a LUFT plume is growing in concentration and size; b) intrinsic bioremediation is occurring; c) there is significant potential for downward migration of contaminants or preferential flow along highly permeable pathways that result in significant off-site impacts; d) there are potential impacts to laterally or vertically adjacent receptors and water resources.

Discussion

Given the complexity of the subsurface, the small numbers of groundwater monitoring wells typically used for LUFT site evaluation, and the tendency not to monitor at depths significantly below the water table, undetected transport of contaminants beyond the estimated 'plume' boundaries may have occurred at some LUFT sites. Because such transport is likely to occur due to downward flow through confining beds, contaminants may experience reduced rates of biodegradation in these more anaerobic environments. Nevertheless, the fact that impacts of petroleum contaminants such as BTEX on the quality of water produced by water-supply wells has been small may be attributed to: (1) the limited areal extent of contaminant sources at typical LUFT sites; (2) biodegradation; (3) sorption; (4) dispersion; and, (5) the slow vertical groundwater velocities in confining beds. A summary of processes affecting transport of fuel hydrocarbons can be found in Rice et al. (1995). A brief overview of the subsurface processes determining the transport and fate of LUFT contaminants is given below, for physical and biological processes. Also discussed in this section are analytical considerations for field monitoring and measurement of these factors as they relate to LUFT sites.

Physical processes

Physical processes governing transport of contaminants dissolved in groundwater are advection (bulk groundwater movement) and dispersion (mixing). Above the water table, in the vadose zone, transport of fuel hydrocarbons also depends on multiphase flow processes involving complex interplay between water, free-phase liquid hydrocarbon, and the gas phase. Separate-phase hydrocarbon is usually entrapped below the water table, especially when the water-table elevation fluctuates. When most of the mobile hydrocarbon product floating on the water table is removed, potential for off-site or deeper aquifer impacts depends primarily on transport of contaminants that dissolve into groundwater from the residual hydrocarbon liquid. A rudimentary perspective for groundwater monitoring is provided by the following discussion of advection and dispersion.

Advection is the bulk movement of solutes along water flow paths in groundwater. Rates of groundwater flow in granular porous media (e.g., alluvial soils and sediments) are commonly on the order of cm/yr to ~102 m/yr, depending on hydraulic conductivity (K) of the soils and sediments and driving forces maintained by hydrologic boundary conditions, including pumping from wells. K is highly variable spatially, typically ranging over 4 to 6 orders of magnitude. Most commonly a majority of sedimentary materials have lower K's than the mean, and a very small percentage of the materials have the highest K's. Good interconnection of the very high K materials can create relatively high groundwater velocities along local avenues that are easily missed if site characterization is based on only a few boreholes.

Importantly, if a LUFT site consists of laterally extensive, relatively low-K soil/sediment (confining bed) at and below the water table, and if this material is underlain by laterally extensive, relatively high-K material, then direction of groundwater flow will be essentially vertical in the upper layer and horizontal in the lower layer. The contrast in K values of a factor of 100 is sufficient to create this scenario. Thus, if a site consists of a fine, silty sand to a depth of 50 ft below the water table, and an underlying coarse sand or gravel having lower hydraulic potential, one can anticipate direction of groundwater flow will be downward to 50 ft below the water table. Such a scenario is of particular concern for LUFT sites, because it would potentially place dissolved BTEX chemicals in an anaerobic environment in which biodegradation would less active. It is also possible that flow would be upward at such a site, in which case plume containment might actually be easier. Experience shows, however, that direction of vertical flow in groundwater is most commonly downward. Vertical downward flow in alluvial aquifers that sustain water supplies is accelerated by pumping from water-supply wells.

Dispersion is the spreading of a solute due to mixing caused by (1) local variations in groundwater velocity, and (2) molecular diffusion. Dispersion can effect substantial dilution of a solute plume but can also cause the plume to spread over a larger area than if only advective transport were occurring. Dispersion is caused mainly by heterogeneity at all scales (mm to km), and dispersion parameters (dispersivity) are very difficult to measure. Nevertheless, conservative dispersion parameters can be commonly assumed for the sake of analysis. Because of dispersion, it is physically possible for solutes from a point source to be diluted to concentrations below detection levels at some distance downstream from the source. Such dispersive attenuation to non-detect levels is most probable when the source has been eliminated.

Intrinsic bioremediation

There are several approaches to demonstrate that intrinsic biotransformation contributes to containment or remediation of contaminant plumes. These approaches include monitoring of chemical parameters which provide information on one or more of the following:

1) Consumption of hydrocarbon contaminants; 2) Consumption of electron acceptors, such as oxygen, nitrate, and sulfate; 3) Formation of metabolic end products, such as carbon dioxide, sulfide and/or methane; and 4) Formation of characteristic biochemical markers, such as benzoic acid and/or succinic acid derivatives.

A list of geochemical parameters that can help demonstrate the existence of intrinsic bioremediation are given in Table 2.1 of Wiedemeier, et al. (1995). Parameters should include resident chemical constituents that behave as conservative tracers, such as chloride, bromide and, potentially, MTBE.

Estimating the effectiveness of these processes may be accomplished by measuring the temporal and spatial distribution of the reactants, products and/or intermediates in the field. The scope of the field investigation should be appropriate considering the scale of the plume and potential threat of the contamination. Attenuation is then evaluated by analyzing the longitudinal concentration profiles and temporal concentration histories using appropriate modeling tools that consider the local hydrologic conditions. MTBE may serve as a useful internal (nearly conservative) tracer for LUFT sites, for example, to help calibrate the advective and dispersive transport terms in models used to analyze the site data, and to help estimate biodegradation rates for the petroleum hydrocarbons present.

14. URGENT NEED FOR SKILLED PRACTITIONERS

Conclusion

Many of the consultants and state regulators investigating LUFT sites are highly qualified; however, the great number of LUFT cases has outrun the number of available qualified personnel. Consequently, the LUFT site characterization and evaluation process suffers from a lack of both consulting and regulatory practitioners who are knowledgeable about risk assessment methods and the subsurface hydrologic processes that often control the risks posed by LUFT sites.

Recommendation

The State should initiate a training program for regulators, responsible parties, and consultants who are involved in LUFT site investigation, remediation, monitoring, and closure. Specifically, training should be provided on the risk-based decision-making approach adopted by the State. Although such training through short courses and university extension courses will help, it will not create overnight a labor force that is capable of routinely and efficiently assessing risks and making sound management decisions for moderately complex LUFT sites. Therefore, the SWRCB, RWQCBs, and LOPs should additionally consider the establishment of hiring objectives aimed at placing enough qualified subsurface hydrologists, risk assessors, and other technical specialists on their staffs to evaluate subsurface transport mechanisms at Tier 2 and 3 sites with state-of-the-art knowledge and tools and to serve as in-house technical consultants/mentors for their regulatory colleagues.

Discussion

The foundation of any risk-based approach is an understanding of the potential subsurface pathways between contaminant sources and receptors and the relative risks posed by these various pathways. The lack of such understanding leads to regulatory enforcement that is either too strict or too lax.

The above recommendation derives from the fact that nothing that the State can do with respect to LUFT oversight, remediation, or containment can substitute for well qualified, properly trained personnel. Such persons represent the focal point of any State-mandated strategy. The best guard against mismanagement and inappropriate remediation of LUFT sites is to have well qualified and properly trained personnel.

A potential advantage of providing a State program for the training of personnel involved in the management of LUFT sites is that common training for the personnel should lead to some degree of uniformity in site management (e.g., using a State-adopted risk-based decision-making approach). It has been stated that there is too much variation in LUFT cleanup requirements for closure from one region of the State to another. A common training process would hopefully minimize the variability between regions. However, it is recognized that some of the variability in site management may be inherent in the environmental differences between the different regions of the state. Thus, Northern California and Southern California may differ with respect to aquifer depth, geologic conditions, soil types, and many other variables that may impact management decisions for LUFT sites in these two different regions. However, if the personnel involved in the regulation and management of these diverse areas have a common pedagogical paradigm, it will foster uniformity in the process used to determine closure requirements.

The committee has received many complaints from both the industry and regulators that the lack of qualified practitioners is a problem. Our recommendation for increased use of risk assessment will increase the demand for skilled practitioners. As stated above, risk assessment involves a number of disciplines. Scientists trained in one discipline do not necessarily understand the elements of another that may be very relevant to the evaluation of potential exposure pathways, and there is an almost universal lack of appreciation of what uncertainty is and how it should be handled. The Committee's recommended risk-based approach will require a considerable amount of judgment both in the performance of risk assessment and in the selection of corrective actions. It is very important that the analysts involved, from both the regulatory and the industry side, appreciate the merits and limitations of the risk-based decision-making framework, especially the need for informed judgments, so that unnecessary conflicts will be avoided. This can be achieved through a rigorous program of education and training, as well as other means, e.g., state certification.

15. NEED FOR DETAILED WRITTEN GUIDANCE

Conclusion

There is an urgent need for detailed written guidance for regulators and the regulated community regarding how LUFT sites should be investigated, remediated, monitored, and closed. The guidance document(s) need to be adopted for consistent application throughout the State of California.

Recommendation

Cal/EPA should create a task force, including representation by U.S. EPA to develop new written LUFT guidance for California. The completed guidance should be adopted for consistent application throughout the State of California. The written guidance should describe the risk-based decision-making framework to be applied case by case to support decisions regarding the nature and extent of required site investigations, and the approach to data interpretation and decision making regarding the determination of appropriate cleanup goals, the selection and application of appropriate remedial measures, and the criteria for site closure. Care should be taken that the resulting LUFT guidance remain flexible and not overly prescriptive.

Discussion

The ASTM Standard Guide for Risk-Based Corrective Action at Petroleum Release Sites (ASTM RBCA Standard E 1739-95) and the many documents that have been written to support the implementation of RBCA programs in other states should be considered a good starting place for the development of written LUFT guidance for California. Whenever appropriate, the guidance should require that performance-based standards be met, rather than requiring that prescribed methods be employed (e.g., for field or laboratory site investigation methods, or site remediation methods).

16. SOIL CLEANUP STANDARDS

Conclusion

Although uniform, consistently applied cleanup standards do not officially exist for petroleum contaminated soil in California. LUFT sites are most commonly cleaned up to either "non-detect" or to an arbitrary level of 10 to 1000 mg/kg TPH in soil. Soil cleanup to these levels is required in many cases where the site evidence indicates underlying groundwater quality is unaffected by the soil contamination, where the natural quality of underlying groundwater is unfit for use as a drinking-water source, or where there are no pathways for health-risk exposure. The use of the above range of TPH cleanup "standards" represents a misapplication of the LUFT Manual screening Table 2-1, and requirements to remediate soil to such "standards" are often not necessary to protect human health, safety, the environment, and beneficial water uses. LUFT regulators and the regulated community lack sufficient guidance on scientifically defensible methods to determine appropriate site-specific soil cleanup goals sufficient to protect the quality of the waters of the State.

Recommendations

Soil cleanup "standards" need to remain flexible, considering the widely varying site conditions, and should generally be developed site specifically, as outlined in the adopted risk-based corrective-action guidance.

2. Soil cleanup "standards" should be determined for chemicals of concern.

COMMENTS ON THE HISTORICAL CASE ANALYSES REPORT AND THE RECOMMENDATIONS REPORT OF LAWRENCE LIVERMORE NATIONAL LABORATORY

General Comments:

The LLNL Historical Case Analyses Report adds significantly to the growing body of evidence that migration of benzene in groundwater beneath a majority of LUFT sites in unconsolidated sedimentary materials of California has been substantially controlled by the natural attenuation processes of biodegradation, sorption, and dispersion. Average plume dimensions are smaller than would be expected if the contaminant were not subject to biodegradation. It was an excellent idea to use historical LUFT site data in this fashion, and the SWRCB staff and the LLNL research team should be congratulated for their efforts.

The LLNL Recommendations Report provides a cogent, generally realistic review of the regulatory framework and cleanup processes currently applied to California's LUFT sites. Most of the findings, conclusions, and recommendations in this report are well-supported by observations and will be constructive in revision of the LUFT regulatory framework. As outlined in the comments that follow, however, the Committee believes that parts of the report unrealistically minimize the magnitude of the LUFT problem.

This Committee believes that caution must be used when interpreting data and analyses in the LLNL Historical Case Analyses and the LLNL Recommendations Reports. Realizing that potential threats of LUFT sites to human health and the environment were commonly overestimated in the past, the Committee is concerned that undisciplined interpretation of the above reports might lead to an equally unwise shift in perceptions: a tendency to underestimate potential threats of LUFT sites. The potential for such a shift is especially real in light of the relatively recent emergence of new LUFT contaminants of concern, that is, recalcitrant fuel additives such as MTBE. Accordingly, the comments listed below are aimed primarily at fostering a balanced interpretation of the LLNL reports.

Comment A: Accuracy of methods used to estimate plume lengths in the LLNL Historical Case Analyses Report is not adequately documented and discussed in the report. Consequently, it is difficult for the reader to ascertain the accuracy of the resulting plume length estimates. The estimated 90th percentile plume length estimates of 306 feet using the exponential model and 261 feet using the error function model should be considered highly approximate, and in any case, 90th percentile estimates should not be used as screening criteria in risk-base decision making.

Recommendation: The committee recommends that accuracy of the methods used by LLNL to estimate plume dimensions be better documented by presenting the results of statistical goodness-of-fit tests of the plume model fits. In addition, model validation could be pursued by fitting the spatial plume distribution models to exceptionally well-defined plumes using various subsets of the available data (e.g., using data from subsets of only 6 monitoring wells out of perhaps 20 available wells) and comparing the resulting model fits to the complete set of field data. This should be done for a variety of plume geometries and sampling scenarios so that reliability of the models and any tendencies to overestimate or underestimate plume dimensions can be ascertained quantitatively by users of the LLNL study results.

Comment B: The LLNL Historical Case Analyses Report does not adequately point out potential for vertically downward migration of benzene in light of (1) potential for vertical groundwater flow at some LUFT sites and (2) lack of monitoring wells at depths significantly below the water table at such sites.

While the Committee does not believe that vertical migration of benzene or other LUFT contaminants would always represent significant threats, it believes that the potential for such migration should be considered in any comprehensive, risk-based corrective action approach.

Discussion: As detailed in many groundwater hydrology textbooks and demonstrated in many field studies, given two layers of soil or sediment differing in permeability by a factor of at least 100, groundwater will flow essentially vertically (or normal to bedding) in the lower permeability layer and horizontally in the other layer. At some sites (particularly in cases with significant groundwater pumping at depth), there is potential for LUFT dissolved contaminants to migrate downward to more anoxic environments that are less conducive to biodegradation. It is therefore possible for vertically downward transport of LUFT contaminants to extend to distances beyond conventional monitoring locations. The tendency to only monitor very shallow groundwater quality at LUFT sites increases the likelihood that such contaminant transport might go undetected. By the same token, the relatively small number of water supply wells that have been contaminated by benzene suggests that impacts from the downward migration of this highly degradable compound have not been widespread. Nevertheless, two-dimensional LUFT site plume characterizations that rely solely on data from a single horizontal plane are clearly incomplete. Given the lack of other than horizontal-plane data, we see little else the LLNL study team could have done; however, readers of the LLNL reports should be mindful of this limitation, particularly when dealing with RFAs.

Recommendation: LUFT site investigations should evaluate potential for vertical contaminant migration. The Committee understands that drilling of deeper monitoring wells has been avoided because of concerns about contaminating deeper zones in the process of drilling. Importantly, one does not necessarily need to drill through the existing shallow plume to evaluate potential for vertical migration. Two safer alternatives to this approach are, (1) use existing regional data on geology and water levels to evaluate whether potential for vertical downward flow exists, and (2) drill the deeper wells outside the perimeter of the existing shallow plume. The probability of causing significant deeper contamination due to drilling of the deeper wells is minimal unless annular seals in the wells are not properly designed and constructed.

Comment C: Because the LLNL Recommendations Report does not address any compounds other than benzene (e.g., MTBE, other fuel additives, TBA), some of the Report's conclusions and recommendations may not apply directly to fuel release sites involving the release of these other compounds. Please refer to our Recommendation No. 10, which addresses MTBE in particular.

Comment D: The finding in the LLNL Recommendations Report, that the total volume of groundwater impacted by LUFT plumes greater than 1 part per billion benzene was approximately 0.0005% of California's total groundwater basin storage capacity is a specious argument, potentially misleading some readers into concluding that the LUFT problem is trivial. Moreover, this argument is not needed to justify the conclusions and recommendations in the report.

Discussion: Because California's total groundwater basin storage capacity is vast (1.3 billion acre-feet; 4.2×10^{14} gallons), any groundwater contamination process, even from non-point sources, can be construed as impacting only a small fraction of the total. Indeed, the vast majority of our groundwater is still clean. Because, however, groundwater resources are replenished very slowly (most groundwater in storage in California is 100s to 1,000s of years old) and tend to recover from contamination impacts very slowly, the present quality of groundwater may not be sustainable in many basins if various point- and nonpoint-sources of persistent contaminants are allowed to exert their cumulative impacts over a period of decades or centuries.

The main thesis of the LLNL Recommendations Report is that natural processes have limited migration of benzene and that this should be recognized in LUFT site regulation and clean-up. The Committee agrees with this thesis, but feels that this groundwater volume argument is misleading and not necessary to support the conclusions and recommendations of the LLNL report.

Comment E: Although the Committee concurs with the main part of LLNL's Conclusion 5.2, the estimated $1 million/acre-foot groundwater cleanup cost presented in the conclusion is unreasonably high. It appears to the Committee that the presented cost estimate was made without due consideration for the local-scale long-term yield of groundwater systems at LUFT sites. The conceptual model used by the LLNL LUFT Team to value groundwater considers California's groundwater systems to be static, without consideration of the dynamic groundwater flow that exists in nearly all usable groundwater resources. The remediation cost estimate presented in LLNL's Conclusion 5.2 was made based on a snapshot assessment of the volume of resident groundwater contained within a typical LUFT plume of petroleum hydrocarbons dissolved in groundwater. In Section 4.5.3 of the LLNL Recommendations Report, a remediation cost per acre-foot of groundwater is estimated to be $637,000, based on average remediation costs ($450,000) for an average plume volume that includes 0.7 acre-feet at any given time. (Note that the origin of the 0.7 acre-foot plume volume estimate is unclear, but it can be described roughly for example by a rectangular subsurface box 200 ft long, 85 ft wide, and 5 ft thick, with a porosity of 0.36.)

The Committee believes that the value of water-supply aquifers or portions thereof should generally be based on the continuous, renewable nature of the resource. Appropriate conceptual models for use in assessing the value of groundwater resources and thus the remediation cost per volume of potentially producible groundwater should include the long-term, continuous-use potential of the resource if it were not contaminated. When groundwater is contaminated by a UST fuel leak and no active remediation is implemented, the resource use will be locally impaired for decades in most cases, even when a spatially stable (controlled) plume exists. Thus, the volume of groundwater that cannot be developed or used without treatment in the vicinity of the groundwater plume, due to the potential for a water well to pull contaminated water into the well, should include the volume of groundwater that the system could yield over (typically) several decades.

As an example of how a dynamic, flow-through conceptual model could be used to assess the average cost of groundwater remediation per volume of producible groundwater, consider a typical LUFT site groundwater plume 200-ft long, 85 ft wide, and 15 ft thick. With an average groundwater flux of 82 ft/yr (natural-gradient flux value from ASTM RBCA Tier 1 Example Look-up Table 2X.1) and an estimated passive/intrinsic cleanup time of 25 years, the calculated amount of flow-through water impacted by the LUFT contamination amounts to 60 acre-feet. This is an estimate of the foregone groundwater resource volume during the assumed passive remediation period for a potential water user who wants to use the groundwater available in the plume vicinity, assuming that the screened interval of the user's groundwater extraction well(s) could be located within or immediately downgradient of the dissolved fuel hydrocarbon plume. With a total remediation cost of $450,000, the remediation cost per acre-foot of producible groundwater is $7,500. Even with this more supportable estimate of the remediation cost per volume of groundwater, the Committee concurs with the general conclusion that remediation costs may not be justifiable in some cases, especially if the water under consideration is not currently in use and it is not likely to be used in the future.

Comment F: Choice of words in the lead conclusion 5.1 of the LLNL Recommendations Report that Fuel hydrocarbons have limited impacts on human health, the environment, or California's groundwater resources (p. EX-2) is misleading and can easily be misinterpreted to mean that the LUFT problem is trivial. A more accurate statement, paraphrased elsewhere in the report, would be: Benzene from fuel hydrocarbons have impacted human health, the environment, and California's groundwater resources substantially less than had been anticipated in the 1970s and 1980s when most of the LUFT sites were discovered.

Comment G: The LLNL Recommendations Report states that well construction standards, intended to isolate shallow groundwater contamination from deeper aquifers tapped by the wells, have effectively lessened impacts on groundwater resources. While this may be true, it should be emphasized that the protection offered by well construction standards is only temporary if the shallow contaminants are not degrading fast enough. As discussed elsewhere in this report, rates of benzene degradation can vary widely, and fuel oxygenates such as MTBE are highly resistant to degradation. Specifically, if the contaminant does not degrade rapidly enough, given enough time and certain hydrogeologic conditions, deeper contamination may occur via vertical transport.

Comment H: The LLNL Recommendations Report consistently sends the message that intrinsic bioremediation (biodegradation at rates sufficient to effect remediation) of FHCs can be expected to occur, without warning the reader sufficiently that it will **not always** occur, especially for RFAs. The report lacks adequate qualifiers for generalizations of this nature, and repeatedly cites statistics on plume lengths in 90% of the cases without devoting sufficient attention to meaning of data from the remaining 10% of cases. 10% or 20% of the some 20,000 LUFT sites in California still constitutes an enormous problem. As discussed briefly in this report, one can anticipate situations in which bioremediation is hampered by geochemical conditions and/or downward transport of LUFT contaminants to deeper, more anaerobic groundwater zones. The Report's conclusions and recommendations should be viewed as applicable to many (perhaps most) LUFT sites, but only after site-specific evaluations have been performed (e.g., to demonstrate occurrence of intrinsic bioremediation) according to a properly implemented risk-based decision-making approach.

Comment I: The SB 1764 Advisory Committee strongly endorses the LLNL Recommendations Report recommendation for California to adopt a RBCA decision-making framework; however, many details remain to be worked out regarding how the new risk-based decision-making approach will be implemented throughout California.

Comment J: The Report implicitly assumes that groundwater pump and treat is <u>the</u> engineered active remediation technique [for LUFT sites] as compared to intrinsic passive bioremediation and that remediation to MCLs is technically infeasible in every case. On the contrary, many sites have been successfully remediated to MCLs (many by SVE/bioventing or means other than groundwater pump and treat). Admittedly, groundwater pump and treat is still occasionally practiced in California despite its ineffectiveness. The correction of this situation will hopefully be aided by the U.S. EPA Document "How to Evaluate Alternative Cleanup Technologies for UST Sites" (EPA/510-B-94-003), which describes a dozen remediation technologies that are vastly more efficient than groundwater pump and treat.

Comment K: The LLNL Recommendations Report implies that it is worthwhile and necessary to remove floating product from all LUFT sites (including de minimis risk sites). Although the Committee agrees that in most cases, floating product should be removed to <u>at least</u> the point of residual saturation, the decision to remove floating product should be made on a site-specific basis depending on the risk posed by the product and the benefits, in terms of risk reduction, that may be provided by the product removal (see SB 1764 Advisory Committee Recommendation No. 12).

Comment L: The Committee agrees that passive bioremediation should be considered a feasible alternative for many LUFT sites (LLNL Recommendations Report's Conclusion 5.4). However, the Committee disagrees with the statement that by using passive bioremediation, groundwater quality is "restored in approximately the same time period as can be expected using actively engineered cleanups." The Committee believes instead that by using state-of-the-art methods and technology, groundwater cleanup rates can be greatly accelerated over the typically observed rates under passive/intrinsic bioremediation. The effectiveness of technologies such as SVE/bioventing and air sparging/bio-sparging, and the enhancement of passive bioremediation through the addition of slow release oxygen compounds to petroleum-affected groundwater have been demonstrated at many LUFT sites.

Comment M: The Committee agrees with the majority of LLNL's Conclusion 5.7, except for the fourth paragraph. The risk-based decision-making approach should be applied consistently to all cases, regardless of the depth to groundwater. The decision to excavate contaminated soils should not be made without first performing at least a screening level (e.g., Tier 1) assessment.

Comment N: The Committee suggests that LLNL's Recommendation 6.1 be modified to read "Utilize passive bioremediation as a remediation alternative whenever appropriate." What is appropriate should be guided by the risk-based corrective action process applied on a case-by-case basis, including cost-effectiveness evaluations of the feasible remediation alternatives. The first bullet item in Recommendation 6.1 should be revised to read "Minimize costs to effectively remediate LUFT sites within a reasonable time frame." In some cases, the most cost effective means will be passive bioremediation; in other cases, "actively engineered" measures will be most cost effective at meeting the cleanup goals indicated by the risk-based corrective action approach. The second bullet in Recommendation 6.1 should be revised to read "close cases after **sufficient** source removal." Definition for what is sufficient source removal should be decided on site-specifically using the risk-based corrective action approach. With these suggested changes, the Committee concurs with Recommendation 6.1.

Comment O: The Committee concurs with LLNL Recommendation 6.3, although the critical term "threat" once again requires definition, which the Committee believes a properly implemented risk-based corrective action approach can provide on a case-by-case basis.

Comment P: The Committee concurs with LLNL's Recommendations 6.2, 6.4, and 6.5 without comment.

MINORITY OPINIONS

M1. COMMENTS ON THE SWRCB EXECUTIVE DIRECTOR'S LETTER OF DECEMBER 8, 1995 - by John M. Farr

The effort of the SWRCB to rapidly respond to the LLNL Recommendations Report by issuing the SWRCB Executive Director's letter of December 8, 1995 (signed by Walt Pettit) should be commended. The significant regulatory response to the letter suggests that the SWRCB possesses the necessary power to rapidly effect significant change in the administration of the UST Program in California. While the Executive Director's letter and the LLNL Recommendations Report have already resulted in substantially altered attitudes and subjective judgments on the part of many regulators throughout the State, lasting regulatory reform must be supported by more detailed written policy and guidance. If sufficient detail is provided in written policy and guidance, there will be less need for management control (e.g., as provided through the Executive Director's letter), and the attitudes and subjective judgments of individual regulators will have less influence on the decision-making process for LUFT sites in California. This will lead to more consistent and technically defensible decisions within the UST Program.

Although it is recognized that the Executive Director's letter was only intended to serve as interim guidance for the UST Program, the following comments may help guide the development of long-term guidance. The example criteria in the Executive Director's letter, on how to characterize "low-risk groundwater" cases ("shallow groundwater with maximum depth to water less than 50 feet and no drinking water wells screened in the shallow groundwater zone within 250 feet of the leak") are too simplistic, and not sufficiently conservative for use in screening-level assessments of the potential risks posed by LUFT sites. This is particularly important because neither the LLNL Report nor the Executive Director's letter accounted for the significant issue of MTBE in the environment. Even in the absence of MTBE, however, the example criteria given in the Executive Director's letter are not conservative enough for use in screening-level (e.g., Tier 1) risk assessments.

There are many sites with benzene plume lengths greatly exceeding 250 feet horizontally, and the potential for vertical contaminant migration to impair beneficial uses in water-supply aquifers is not adequately guarded against by simply requiring that the "maximum depth to water [be] less than 50 feet." Considering the high migration potential of recalcitrant fuel additives such as MTBE, groundwater contaminant plumes may grow to many thousands of feet in length at sites where the leaked fuel contains such additives, and screening-level criteria to roughly assess the risks posed by LUFT sites must account for this.

Extreme care must be exercised when issuing abbreviated guidance on LUFT site decision making. Abbreviated guidance should be kept very general, with no specific numerical criteria or examples given. Quantitatively specific guidance should be provided in detailed written form for consistent and defensible site-specific application.

M2. ANTI-DEGRADATION POLICY - by John M. Farr

Conclusion

SWRCB Resolution 68-16 (Anti-degradation Policy) serves as a cornerstone policy for water-quality control by state and local regulators in California. The terse and somewhat vague language of this now dated policy (1968), has been widely interpreted to indicate that any water-quality changes from "background" conditions (e.g., due to LUFTs) represent unacceptable water-quality impacts that must be mitigated. Res. 68-16 is the most commonly cited policy in support of regulatory orders to conduct site remediation to restore background, "non-detect," or drinking-water quality. As stated elsewhere in this report, such remedial action objectives are often not economically justifiable, and they are often not necessary to protect human health, safety, the environment, or beneficial water uses. Resolution 68-16 has never been publicly reviewed or revised since it adoption, as required by the California Water Code (sec. 13143).

Recommendation

The SWRCB should consider publicly reviewing Resolution 68-16 for possible revision and/or for interpretive clarification as it specifically addresses groundwater protection and restoration. It would be particularly useful to clarify that water-quality protection and restoration should be consistent with the maximum benefit to the people of the State, and not simply involve the protection and restoration of all waters of the State to background quality, non-detect levels, or drinking-water quality at all times. The State should also consider clarifying that water-quality "degradation" should only be deemed significant in terms of how existing or probable future beneficial uses are or may be affected. For example, water should not be considered "degraded" relative to its suitability for MUN designated beneficial use simply because of increased constituent concentrations, when such increased concentrations result in de minimis risk (e.g., no significant health risk associated with long-term consumption) and the water meets the State's standards of quality for drinking water, including secondary aesthetic standards.

Discussion

SWRCB Resolution 68-16 is a policy for water-quality control adopted with the authority granted to the SWRCB by section 13140 of the State Water Code. Resolution 68-16 serves as one of the critical policies relied upon by the SWRCB for demonstration of consistency with the anti-degradation requirements of the federal Clean Water Act. The SWRCB currently holds the delegation of this federal program for surface waters. At the time of its adoption (1968), the policy did not specifically contemplate or attempt to address the complex technical issues involved in groundwater contamination and remediation.

The State Legislature, recognizing the dynamic and complex nature of water-quality issues directed that "State policy for water quality control shall be periodically reviewed and may be revised" (Water Code section 13143). I have found no evidence that Res. 68-16 has ever been publicly reviewed or revised. In light of the numerous complex and technical issues relating to wise groundwater quality management, I strongly recommend that the SWRCB consider publicly reviewing Resolution 68-16 for possible revision and/or for interpretive clarification as it specifically addresses issues of groundwater contamination.

I wish to clarify that this recommendation is <u>not</u> intended to reduce the necessary water-quality protections provided by the SWRCB's anti-degradation policy. Rather, this recommendation is intended to improve the policy by expressing the anti-degradation requirements more precisely and accounting for our current state of knowledge.

To develop a balanced interpretation of California's Anti-degradation Policy (Resolution 68-16) and understand why prevailing interpretations of the policy may not reflect its original intent, a historical perspective on the nature of water quality control policies, water quality criteria, and analytical chemistry capabilities existing at the time Resolution 68-16 was adopted (1968) is useful. In light of such a historical perspective, it can be seen how the wording of Resolution 68-16 has led to existing interpretations that restrict California's water-quality control programs in their ability to fully adapt to the major changes in water-quality control issues, water-quality criteria, and analytical chemistry capabilities that have occurred over the nearly 3 decades since Resolution 68-16 was adopted.

Resolution 68-16 was adopted primarily to address requirements of the Federal Water Pollution Control Act of 1965, during a time of rapidly increasing regulation of waste disposal and/or discharge to the waters of the State of California. Water pollution in the United States had recently become an issue of great concern, and regulators were gaining authority to control waste discharges to surface water and groundwater. Public interest and regulatory activity was focused on controlling point discharges of waste to surface water bodies. The Federal Water Pollution Control Act of 1965 required states to establish water quality standards (fixed numerical concentration standards for known constituents of concern) <u>and</u> general anti-degradation policies designed to protect against water quality degradation that might not be adequately controlled by more specific water quality standards that had been or would be established.

California's anti-degradation policy (Resolution 68-16) states that "whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies." This policy statement contains a provision allowing limited water-quality degradation when it is in the best interest of the people of the State. Such language was used in the anti-degradation policies of most western states in the late 1960s, with the explanation that the highly undeveloped nature of the west may justify some water-quality degradation in the interest of economic development based on the use of land and water resources.

When interpreting the language quoted above, it is also important to recognize that the "quality" of water must be judged in terms of its intended use or uses, and that "water quality" is not simply the numerical inverse of the chemical constituent concentrations found in the water. Water quality is a <u>qualitative</u> term indicating a water's degree of suitability for a given use or uses. To illustrate that lower chemical concentrations do not always result in increased water quality, recognize that plants and animals (including people) benefit from the dissolved solids found in all water. People often pay a premium for bottled mineral water containing increased concentrations of dissolved solids. Another example involves the suitability of water with elevated concentrations of nitrogen compounds for crop irrigation. Water with elevated nitrogen concentrations would be entirely suitable, indeed of high quality, for use in irrigation, while it would be considered of inferior quality for drinking-water supplies.

Thus, the common notion that any increase in detectable chemical concentrations in water represents degradation of that water's <u>quality</u> (a common interpretation of Resolution 68-16) is fallacious. The sheer folly of this widely held notion becomes clear in consideration of the ongoing progress in lowering the analytical limits of detection for various chemicals in water. At some point, ever-lower detectable concentrations of even the most toxic chemicals become insignificant, and water quality control policies should acknowledge this fact. Unfortunately, the terse language of Resolution 68-16 does not address this, and it leaves too much room for widely differing interpretations of what constitutes adequate protection for California's water resources.

To better understand Resolution 68-16, it is useful to consider two relevant water quality documents that existed at the time the Resolution was adopted. The State of California published the second edition of "Water Quality Criteria" in 1963 (J.E. McKee and H.W. Wolf, State Water Quality Control Board Pub. 3-A, Sacramento), which has been widely used throughout the world as a guide in assessing and managing water quality. At the time Resolution 68-16 was adopted in California, the National Technical Advisory Committee to the Secretary of the Interior published an updated "Water Quality Criteria" ("the Green Book", 1968, U.S. Government Printing Office, Wash., D.C.). These documents presented criteria for a host of water quality characteristics and constituents according to their estimated effects on domestic water supplies, industrial water supplies, agricultural irrigation waters, fish and other aquatic life, shellfish culture, and swimming and other recreational uses. These documents represented the best available information in the existing literature combined with the professional judgments of recognized water quality experts of the day.

The U.S. Green Book differed from California's previous (McKee and Wolf, 1963) document in that more prescriptive, fixed numerical water quality criteria were specified in the Green Book, in keeping with the then new federal policies that forced a transition in California's water quality control policies. The flexible water quality criteria ranges of McKee and Wolf gave way to fixed numerical water quality standards (termed "objectives") for most constituents of concern, as specified in California's Regional Water Quality Control Plans (Basin Plans) of today. During this policy transition, McKee and Wolf's recognition that case-specific evaluations of appropriate water quality standards were required in light of the many competing uses of the State's water seems to have been effectively forgotten in California's existing regulatory policy.

Notably, in many cases, water quality criteria of the late 1960s were set to levels at or approaching the analytical detection limits of the day. Many numerical water quality concentration standards have been lowered over the years, yet the gaps between today's standards and the analytical limits of detection have increased significantly since Resolution 68-16 was adopted. In 1968, to guard against the possibility that the fixed water quality objectives of any particular time might not be conservative enough to adequately protect human health and the environment, and to protect the waters of the State from concentration increases of constituents for which there are no set standards, the Anti-degradation Policy (Resolution 68-16) was adopted. The general need for such water quality protection is acknowledged, but the limitations of Resolution 68-16 and its failure to be unambiguously interpreted and adapt to changing times must be recognized.

In most cases, municipal and domestic water supply is the most quality-sensitive use of groundwater, and in such cases, water quality objectives should not be set below the levels thought to represent de minimis health risk, or below the prevailing drinking water standards, including secondary aesthetic standards of taste and odor. For constituents of concern for which no drinking water standards exist, protective levels would need to be set on a case-specific basis using methods of risk assessment.

In some cases (e.g., surface waters), other beneficial uses such as fisheries may be the most quality-sensitive use of water, and water quality objectives would need to be fully protective of this beneficial use. In no case, however, should water quality objectives be adopted that require a higher water quality standard than that sufficient to protect human health, safety, the environment, and the existing and probable future beneficial uses of the water in question.

M3. UST CLEANUP FUND REQUIREMENTS - by John M. Farr

Conclusion

The California UST Cleanup Fund (Cleanup Fund) exerts a controlling influence on the investigation and remediation of most LUFT sites. While the Cleanup Fund has used its controlling position to curb obviously unnecessary expenditures for site investigation and remediation, the Fund typically has not encouraged adequate site data analyses or focused feasibility studies to compare and select the most cost-effective remedial action(s), given the site constraints.

Recommendation

The Cleanup Fund should require that the adopted risk-based decision-making approach be applied to determine appropriate remediation goals, and that whenever multiple feasible alternatives for site remediation exist, a focused feasibility study of these alternatives be conducted to support selection of the most cost-effective remedial action(s) to meet the risk-based remediation goals, given the site constraints. The Cleanup Fund should also encourage the use of thorough, cost-effective (not least cost) site data collection and interpretation in the interest of minimizing overall costs associated with LUFT site investigations and cleanup.

Discussion

A significant portion of the investigation and remediation costs for many LUFT sites are now being reimbursed by the Cleanup Fund. Because of the Fund's power to control expenditures, it is in a position of significant regulatory authority. This position of authority can be leveraged to compel the use of more cost-effective investigations and remedial actions for LUFT sites seeking cost recovery from the Cleanup Fund. The lowest-cost services (e.g., environmental consulting services performed at the lowest hourly rates) do not generally result in cost-effective site investigations and/or remediation. To the contrary, the more thoughtful interpretation, analysis, and decision making of more qualified workers generally reduces the life-cycle costs of LUFT site investigation and remediation, even though more skilled workers command higher hourly rates.

Although the UST Regulations, Article 11 requires a simple cost analysis feasibility study and the implementation of "the most cost-effective corrective action," LUFT site regulators and Cleanup Fund staff have not been routinely enforcing this requirement. Consistent enforcement of this requirement would improve the decision making for LUFT sites in California. The Cleanup Fund should also help ensure that the adopted risk-based decision-making approach is properly applied to determine appropriate site-specific cleanup goals.

California Senate Bill 1764 Advisory Committee

Minority Report

by

Robert Carrington-Crouch
Professor of Economics
University of California, Santa Barbara

Executive Summary of Minority Report Recommendations

It is absolutely essential when the Board makes policy to always bear in mind that *a receptor can only be a living thing (people or biota), everything else is a pathway.*

2 It is the Board's duty to protect all living things (people and biota) from exposure to contaminated groundwater at the least possible cost.

3 The Board should classify LUFT sites according to the risk they pose.

4. Insignificant risk sites should be cleaned up by passive bioremediation.

5. Sites that pose a significant risk should be actively remediated at the least possible cost.

6. Sites that involve fuel oxygenates should be automatically classified as significant risk sites until more is known about the threat these additives pose, if any.

7. Monitoring at low risk groundwater sites should be restricted to establishing plume stability; monitoring at significant risk sites should be done to confirm the effectiveness of the chosen active remediation technology. In both cases, the *minimum* amount of monitoring to achieve these goals should be undertaken.

8 The Board should initiate training and recruitment programs to increase the number of personnel qualified to handle LUFT sites. The Board should also identify a series of LUFT demonstration sites to act as training grounds and test-beds, and to confirm the cost-effectiveness of risk-based corrective actions.

Minority Report *

by

Robert Carrington-Crouch
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Introduction

In July, 1994, the California State Water Resources Control Board (SWRCB, "the Board") decided to re-evaluate its Leaking Underground Fuel Tank (LUFT) cleanup procedures because the prevailing corrective action process was not being implemented in a consistent manner, was wasteful of resources, and was becoming increasingly controversial.

To support this effort, the Board's Underground Storage Tank (UST) Program contracted with the Lawrence Livermore National Laboratory (LLNL) and experts from four campuses of the University of California to review the existing LUFT decision-making process and submit recommendations for its improvement.

The LLNL/UC LUFT team consisted of seven persons with impeccable scientific credentials. Several have international reputations. (I was present at the induction of one of them into the Russian Academy of Sciences in 1994.) The Board can have complete confidence in the team's judgement.

On January 19th, 1995, I was appointed to what has become known as the "SB 1764 Committee". SB 1764 required the Board to "convene an advisory committee ... of distinguished chemists, biologists, health professionals, geologists, engineers, and other appropriate professionals" to advise the Board on matters pertaining to the UST program. I was the economist appointed to the SB 1764 Committee.

Our committee held eight public meetings and more than fifteen public conference calls. We reviewed voluminous quantities of written materials and were briefed by everyone who had an interest in the UST program - including the LLNL/UC LUFT team. We also had the benefit of receiving two reports from that team:

(i) "Recommendations to Improve the Cleanup Process for California's LUFTs", LLNL, October, 1995; and
(ii) "The LLNL Historical Case Analyses Report", LLNL, 1995.

I found the LLNL/UC LUFT team's briefings and its Reports to be invaluable. They offer persuasive and credible evidence that the LUFT "problem" has heretofore been overestimated, and that, consequently, a re-evaluation of the LUFT program was in order.

Mr. Walter Pettit's Letter, 12/8/95

With the LLNL/UC LUFT team's Reports in hand, Mr. Walter Pettit, the Board's Executive Director, recommended what can only be described as a sea-change in the perspective and approach that should be taken toward cleaning up LUFTS.

* In preparing this Minority Report, I have drawn liberally on those parts of the Majority Report with which I agree.

In a letter dated December 8, 1995, and addressed to all regional water board chairpersons, all regional water board executive officers, and all local oversight program agency directors, he observed that the LLNL/UC LUFT team Reports indicated that "the impacts to the environment from leaking USTs were not as severe as once thought." He also went on to note that the Reports present a convincing argument "that passive bioremediation should be considered as the primary remediation tool in most cases once the fuel leak source has been removed."

In the light of the LLNL/LUFT team Reports, Mr. Pettit further recommended that local "cleanup oversight agencies should proceed aggressively to close low risk soil only cases" and for sites "affecting low risk groundwater ... that active remediation be replaced with monitoring to determine if the fuel leak plume is stable. Obviously, good judgement is required in all of these decisions. However, that judgement should now include knowledge provided by the LLNL report."

In concluding, Mr. Pettit wrote that "What I propose ... represents a major departure from how we have viewed the threat from leaking USTs." The Board's Chair, and the Regional Board Chairs, were unanimous in support of the new perspective and approach to the cleanup process that Mr. Pettit recommended. (Mr. Pettit's letter is attached to this Minority Report as Appendix I.)

The SB 1764 Advisory Committee's Response to Mr. Pettit's Letter

As mentioned in the Introduction, the SB 1764 Committee was appointed to advise the Board on matters pertaining to the UST regulatory program.

Notwithstanding this charge, on April 16, 1996, a majority of the SB 1764 Committee voted to exclude all reference to Mr. Pettit's letter from the Report the Committee was preparing. I found this decision to be incomprehensible. Mr. Pettit's letter signaled the most important change in the UST regulatory program since its inception, but a committee appointed to evaluate that program voted to ignore it. I am an economist, not an ostrich, so my conscience dictates that I submit the following Minority Report - which does make reference to Mr. Pettit's letter.

MINORITY REPORT

1. What is a Receptor?

The evidence I digested while on the SB 1764 Committee can be divided into two classes. Evidence which defined a receptor as a living thing; and evidence which defined a receptor as dirt, groundwater, wells, persons, ..., you name it. Those who presented the former type of evidence usually derived policy inferences that were correct; those who presented the latter type of evidence *always* drew policy inferences that were wrong.

Only living things (i.e., people and biota) can be logically defined as a receptor. Soil and groundwater can *never* be defined as receptors. These are *pathways*. Soil and groundwater are inanimate. They feel no pain and it is impossible to "harm" them. Every Philosophy 101 student knows it is grossly anthropomorphic to assert the contrary. Do you think a molecule of H_2O feels better or worse when a molecule of Jack Daniels nestles in alongside it? The question is absurd on the face of it, isn't it? Equally, a water molecule doesn't feel better or worse when a benzene molecule nestles up alongside it, either. So, it is absolutely essential when the Board makes policy to always bear in mind that *a receptor can only be a living thing, everything else is a pathway.*

2. The Board's Goal

Given that a receptor can only be a living thing, the Board's goal, or objective function, becomes obvious. The Board's duty is to protect the people of California and its biota from exposure to contaminated groundwater at the least possible cost.

The LLNL/UC LUFT team presented overwhelming evidence that the vast majority of LUFT sites do not, and never will, threaten people or biota. Intrinsic bioremediation should be relied upon to clean up these sites. They should be monitored minimally to confirm that intrinsic bioremediation is occurring.

Many low risk sites have been actively remediated in the past (usually by "pump and treat"). This was a mistake. The Board's duty is to deliver clean water, not to inventory clean water. Let me expand.

(i) At a LUFT site that is never going to threaten people or biota, it is pointless to make good the quality of the groundwater except by intrinsic bioremediaton. The only gain from active remediation would be the knowledge that the water was cleaned up quicker than nature would have cleaned it up; a trivial benefit obtained at enormous cost.

(ii) At a LUFT site that will only threaten people or biota at some time in the future (often many years), it is not wise to make good the quality of the groundwater now when the water will only be used many years in the future. There are several reasons for this. (a) First, technological progress will make cleanup in the future cheaper than cleaning up now. (b) Second, if you clean it up now it could become re-contaminated in the future and the first cleanup would be pure waste. (c) Third, consider a site that it will take $500,000 to clean up now, but the contamination from that site is only going to threaten a receptor ten years from now. As stated, if the site is cleaned up now and the clean water is inventoried for ten years, the cost will be $500,000. But consider the alternative. Clean up the site ten years from now when receptors are about to be impacted. Assuming an 8% discount rate, this cleanup can be achieved for a mere $230,00 current dollars (because $230,000 will accumulate to $500,000 in ten years time at 8%).

If this example is at all typical, this change in approach ("don't inventory clean water, deliver clean water, ..., just in time") effectively doubles the Board's cleanup capability without asking for so much as a single additional penny from the UST Cleanup Trust Fund. The practice of cleaning up now to protect a receptor from being harmed ten years from now is equivalent to buying a house now but not moving in for ten years. (The arguments presented here are not affected by inflation. In an inflationary environment the future cleanup cost increases, but so does the discount rate -- and in proportion. So, the cost in current dollars remains the same.)

These considerations make it almost certain that the default case for groundwater cleanup will be at point of use (or "well-head treatment").

3. Risk Classification

In the past, the Board has tended to treat all LUFTs as though they posed equal threats. This caused a misallocation of remediation resources. Too many resources were allocated to "low risk" sites, and too few resources were allocated to "higher risk" sites. LUFT sites should be classified according to the threat they present to a *receptor*.

Mr. Pettit was obviously right when he suggested that cleanup oversight agencies should aggressively close low risk soil only cases, and that active remediation be replaced with monitoring to determine if the fuel leak plume is stable at low risk sites where groundwater is impacted. It is absolutely essential to get low risk cases off the table so that the Board and its advisors can get on with the business of making good decisions incorporating judgments that factor in risk. May I add that lots of elaborate, expensive, and time-consuming fate and transport modeling is *not* necessary to decide what is, and what is not, a low risk site. The principles enunciated in Mr. Pettit's letter, based as they are, on the evidence presented by the LLNL/UC LUFT team in its Reports, are perfectly adequate to the task. There is absolutely no need whatsoever to have 25,000 "fate and transport models" massaged into shape at the taxpayer's cost, and the modeler's benefit, to prove that, yes, Mr. Pettit was right 90% of the time -- *exactly* as the LLNL/UC LUFT team predicted.

4. Insignificant Risk Sites

The pernicious legal doctrine of "joint, several, strict, and retroactive liability" imparts a stigma to LUFT sites that makes them difficult to sell even when they pose an insignificant threat. A standard of strict liability means that a firm that generated contamination would be liable, without a need to show that the toxic contamination was due to negligence. Joint and several liability means that a firm found even *partially* responsible could be held liable for up to 100 percent of all costs incurred in remediating a site regardless of that firm's proportional contribution to the damage. Retroactive liability means that current and previous owners can face cleanup costs for practices that occurred years before and that may well have been legal at the time. These wicked principles prevent sites being conveyed to their highest and best uses and have made thousands of homeowners and business persons needlessly miserable.

Intrinsic bioremediation should be relied on to clean up these sites. The length of time a low risk site takes to clean itself up is of little or no consequence. It does not matter whether a low risk site cleans itself up tomorrow or ten years from now since, by definition, low risk sites present no threat to anyone or anything. (This view is 180 degrees opposite to that expressed in Comments L and N of Section 17 of the Majority Report.) The Board should simply make it a matter of public record that such sites may contain residual hydrocarbons but that these insignificant risk sites pose no foreseeable threat to human health, safety, the environment, and current, or future, beneficial water use.

5. Significant Risk Sites

A small minority of LUFT sites do pose a significant risk to human health, safety, and the environment. This is where the Board should concentrate its remediation resources. These sites should be remediated at the least possible cost before they impact a receptor. (Not, note, necessarily actively remediated now; but before they impact a receptor.) The Board should consider modifying the existing regulatory framework to allow consideration of risk-based cleanup goals higher than non-detect, background, or MCLs. If it does, the estimated degree of residual risk should be made a matter of public record.

6. Passive Bioremediation

Actively remediating low risk sites where there is, by definition, no threat to human health, safety, an ecosystem, or beneficial water use, now or in he future, does more harm than good. This is because no threat is avoided and positive environmental harm is done by generating the energy necessary to do the active remediation - which has almost invariably been "pump and treat". (Here the water regulators are working at cross-purposes with the air regulators. However, see the next section where the situation is reversed.)

At these low risk sites, passive bioremediation is the optimal remediation alternative. Once the fuel leak source has been removed at low risk sites, active remediation should be completely eschewed. Instead, the site should be monitored (at the least possible cost) to confirm plume stability and that passive bioremediation is doing its job.

7. MTBE and Other Fuel Oxygenates

Well after the LLNL/UC LUFT team accepted its charge to suggest ways to improve the cleanup process, problems associated with MTBE and other fuel oxygenates at some LUFT sites emerged. The possible threat, if any, that these oxygenates may imply for persons and ecosystems has not yet been established. However, in light of this uncertainty, the Board should be conservative and err on the side of safety. All sites where fuel oxygenates are detected should be classified as "significant risk sites" (until the threat, if any, that these fuel oxygenates generate has been established).

(Parenthetically, may I observe that we have a governmental "left-hand/right-hand" problem with MTBE. Air quality regulators never considered the consequences of MTBE getting into water, even though MTBE may have the potential to create water quality problems. If we knew two years ago what we know now, would we be using MTBE? Should we continue to use it? Air and water quality regulators should speak to each other. See previous section.)

8. Monitoring

Monitoring at low risk groundwater sites should only be done to confirm plume stability. Monitoring at significant risk sites should be done to confirm the effectiveness of the chosen active remediation technology. In both cases, the minimum amount of monitoring to achieve those goals is all that is required. All monitoring should be done with extreme care. Poorly executed monitoring can open up new pathways for contaminants to spread - only making a bad situation worse.

9. Need for Skilled Practitioners and Demonstration Sites

Since the large number of LUFT sites has outrun the number of qualified personnel available to handle them, the Board should initiate training and recruitment programs to remedy this deficiency. In conjunction with these programs, the Board should also identify a series of LUFT demonstration sites to act as training grounds for the implementation of risk-based corrective action, to act as test-beds for new technologies and procedures, and to confirm the cost-effectiveness of risk-based corrective action.

10. Final Observations

The majority *purports* to critique the two LLNL/UC LUFT team Reports in Section 17 of the Majority Report.

(i) Comment E in Section 17 is wrong from beginning to end, with trivial exceptions, in both its physics and its economics.

(ii) Comment L in Section 17 says "state-of-the-art methods and technology" (read, "expensive" methods and technologies) can accelerate cleanup rates. No doubt. However, the rate of cleanup is of little or no consequence at low risk sites as long as passive remediation is doing its job. (See section 4, *supra.*)

(iii) Comment N in Section 17 contains the same flawed logic. There is no reason to increase spending "to remediate LUFT sites within a reasonable time frame" when it is a low risk site. As observed before, the rate of cleanup is of little or no consequence at low risk sites as long as passive remediation is doing its job.

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WHITE PAPERS SUBMITTED TO THE SB 1764 ADVISORY COMMITTEE

1. Anderson Consulting Group (John Baker)
   Inability to Close UST Sites Due to Over-Restrictive Cleanup Standards

2 Arco Products Company (Ralph J. Moran)
   Consistency, Reasonableness of Requirements

3. Borsuk, Mark, Attorney at Law (Mark Borsuk)
   Abolish the UST Program

4. Central Valley Regional Board Staff
   •**Recommendations for Consistent Analysis and Evaluation of Sampling at Fuel Leak Sites** (Karen Clementsen)

   •**Use of Leachability, Fractionation, and Chromatograms in Total Petroleum Hydrocarbon (TPH) Analysis** (Jon B. Marshack, Gordon Lee Boggs)

5. City of Bakersfield (Howard Wines)
   Water Quality Control Plans for Each Basin Should Contain UST Standards

6. City of Vernon (Lewis J. Pozzebon)
   Corrective Action Is Difficult for Responsible Parties to Implement for Two Main Reasons

7. Department of Toxic Substances Control (Barton P. Simmons)
   How Can the Cost of UST Testing Be Reduced While Still Providing Data of Acceptable Quality?

8. Environmental Resource Council (Roland Brust)
Cleanup Standards Have Not Been Based on Science or Common Sense

9. Geomatrix (Dawn Zemo)
Recommended Analytical Requirements for Petroleum Sites

10. Horizon Environmental Inc. (Gary Barker)
Develop Methodology for Determining Cleanup Levels for Consistent Use Statewide

Lawrence Livermore National Laboratory (Dave Rice, Dr, William Kastenberg, Brendan Dooher, Dr. Lorne Everett, Steven Cullen, Dr. Miguel Marino, and Randy Grose)

The LUFT Manual Is Inconsistently Implemented

Local Agency Staff May Be Untrained to Deal with Cleanup Issues

California Groundwater Is Not Actively Managed

Financial Incentives Do Not Exist to Compel Closure

12. Orange County (Karen Hodel and Seth Daugherty)
Delineation of Nonaqueous Phase Liquid (NAPL)

Use of Risk Assessment (Risk-based Corrective Action)

Vertical Delineation of Dissolved Phase Plumes from Hydrocarbon Fuels less Dense than Water (LNAPL)

The Need for Contaminant Removal

Classification of Ground Water Basins

13. Pacific Environmental Group, Inc. (Erin Garner)
Inconsistent Content Requirements for Corrective Action Plans

Inability of the State to Pass Modified Version of Resolution 92-49

Premature Enforcement Action

14. QEM (Penny Silzer)
Lack of Policy and Guidance for Setting Groundwater Cleanup Goals above Background

15. San Francisco Bay Regional Board Staff
Sources of Drinking Water (Kevin Graves)

Let's Implement ASTM Risk- Based Corrective Action (Kevin Graves)

Misinformation Regarding Resource Protection (Kevin Graves)

LUST Data Management (Kevin Graves)

Integrating Resource Protective Standards and Risk-based Standards into California's LUFT Cleanup Program (Ravi Arulanantham and Stephen Morse)

Using Net Benefit Analysis to Manage Risk and Value of Groundwater Resources (Ravi Arulanantham, Stephen Morse, Douglas Charlton)

Tier 1 Standards for LUFT Sites Adjacent to Surface Waters (Diane Mims)

Groundwater to Surface Water Concerns (John West)

State and Local Luft Computer Tracking Efficiency (John West)

Prioritizing TPH Plume Sites (Brad Job)

Managing Low Concentration TPH Plumes Based on Total Chemical Oxygen Demand (Brad Job)

Looking to the Future with Our State and Local LUFT Computer Database's (John West)

16. Santa Clara Valley Water District

    Off-site Migration of Contamination (Jim Crowley)

    Procedures for Determining Whether an Unauthorized Release has Occurred from a UST Based on Results of Sample Analyses Does Not Exist (Christine Tulloch, Jim Crowley)

17. Shell Oil Products (Gustafson, Boschetto, Fossati, Richter, Kirk, and Claudio)
    Regulators Require Large Amounts of Site Monitoring Data that are not Necessary for Making Management Decisions

    Active Remediation is Required Irrespective of Cost, Time or Potential Exposure Considerations

    Application of Remediation is not Based on Balancing Costs Versus the Benefits from These Technologies

    Land Transactions are Hindered for Sites with a "Contaminated" Stigma

    The Current System Does Not Manage the Restoration of Contaminated Groundwater in a Way that Insures the Maximum Benefit to the People of the State

    TPH Alone Is Not a Meaningful Indicator of Risk from Hydrocarbon Contamination

    The Existing Regulatory Infrastructure Does Not Allow for Cost Effective, Efficient Environmental Project Arrangement Nor Does it Support Risk Management Decision-Making

    The Burden of Proof is in the Responsible Party to Show that an Action Requested by an Agency Is Not Appropriate

18. State Water Board Staff (Charles Nesmith)
    Establish Reasonable Statewide Numerical Cleanup Standards for Soil and Ground Water

19. Thomas and Associates (Thomas Stoflet)
    UST Regulatory Process

20. TRI-S (Joe Odencrantz)
    Uncertainty in Site Specific Assessment

21. Ultramar
    Regulatory Requirements Are Without Cost Vs. Benefit, and Are Based on Local Guidelines in Place of the Environmental Law (Randall K. Stephenson)

    The Basic Framework of California's UST Program is Flawed (Glenn R. Dembroff)

The "Non-degradation Policy" is in Conflict with the Porter-Cologne Water Quality Control Act (Water Code) (Terrence A. Fox)

The Cleanup Standards are Arbitrary and Capacious and Do Not Reflect the True Threat to Human Health and the Environment (Kenneth R. Earnest)

22. Unocal (David J. Camolle)
    Lack of Guidance for Groundwater Monitoring Requirements

23. Yim, Okun & Watson - Attorneys at Law (Randall A. Yim)
    Purpose of Resource Protection Standards; Need for Tiered Decision Making

24. Western States Petroleum Association (WSPA) (Jeff Sickenger)
    WSPA Recommendations and Concurrence with Other White Papers Recommendations