PUBLICATIONS & PRESENTATIONS

Excerpt 1: Innovative Ship Yard Wastewater Collection and Treatment System

Proceedings of the National Shipbuilders Research Program, Environmental Technologies Conference, Ketchikan, Alaska. Roberts, Eric and G. Erickson, M Davis and R. Tabachow.

Ship yard operational expansions along with stricter regulatory requirements can trigger significant environmental actions adding significantly to project costs. In an increasingly restrictive regulatory environment, facility growth can prompt reconsideration of facility-wide wastewater management practices and whether they can meet the new demands. These reconsiderations often determine that that ship yard wastewater management improvements are necessary. However, when innovative improvements are made which increase wastewater handling capacity and treatment efficiency while simultaneously reducing operating costs, such environmental improvements make good business sense.

When a ship yard in Alaska began planning to expand its operations to include additional dry dock and land-based maintenance capacity, the ship yard realized its wastewater management practices would need to be improved to cost effectively meet current regulatory standards. The ship yard was adding a second floating dry dock and an upland berth pad to service ships and other vessels up to 450 feet long and 100 feet wide. As part of this expansion to the existing 10,000-ton floating dry dock operations, the ship yard needed to design and build a wastewater collection and treatment system to capture and treat metals and petroleum contaminated wastewater run-off from several sources including primarily the dry docks decking and berthing surfaces contaminated with ship hull wash water, and wash water and impacted storm water from the upland berth pad.

The authors reviewed the facility operations, constraints, and goals to identify and evaluate various collection approaches and treatment technologies. Comparing the advantages and disadvantages of leading treatment technologies, the authors identified an innovative and cost effective wastewater collection and treatment system that promised to meet the increased regulatory requirements while providing operational flexibility and minimizing operational costs. Unique challenges of the design included 25-foot tidal swings; seasonal adverse weather conditions; facility congestion / limited space; elevated and variable wastewater concentrations of copper, zinc, lead and oil & grease; widely ranging wastewater flows; and strict ocean discharge permit constraints. The authors met these challenges by designing the ~14,000 gallon per day treatment system to be situated on a floating barge to limit the space used on the facility grounds. The floating treatment system barge was designed with large integral holding tanks to provide operational flexibility and buffer variable influent flow. The treatment system design incorporated fully automated operation, removing up to 96 mg/l copper, 87 mg/L zinc, and 0.9 ml/L lead (up to 99% removal efficiency for copper, zinc, and lead); and 10 mg/L total oil and grease (TOG) (up to 50% removal efficiency for TOG) using electro-coagulation for primary wastewater treatment prior to ocean discharge. This system provided the additional treatment capacity and efficiency required by the expanding facility operations and stricter regulatory requirements while minimizing capital and O&M costs.

Excerpt 2: Common Factors in In-Situ Remediation Failures

Proceedings of the Tenth International In-Situ and On-Site Bioremediation Symposium, Baltimore, MD. Tabachow, Ross and R.M. Lowe and E. Roberts.

In-situ remediation is often prescribed for a variety of circumstances and site environmental settings to address petroleum spills. Once implemented, these remediation programs frequently proceed under automated and repetitive O&M and

reporting processes for years with little critical review of performance. Years can go by incurring significant expenditures before the question is asked whether or not the system is working effectively. Remedial financiers and stake holders are often surprised and troubled to learn that a remedial program that has been underway for years has not been working effectively that the remedial program should have been preceded by more aggressive source removal, that the program requires significant additional investment to augment with other technologies, and / or shockingly, that the program underway does not even have the capacity to complete the cleanup requiring a complete change in remedial approach. The authors provide third-party review services to remedial financiers and have had to deliver this unfortunate conclusion all too often.

The authors examine over 40 cases of petroleum remediation program failure and identified four key common factors to which the failures can be attributed: inadequate site characterization / site conceptual model development, poor feasibility pilot testing, inadequate remedial alternatives analysis / technology selection, or design / implementation problems. The remedial program failures studied include groundwater pump-and-treat, dual phase extraction, air sparging, oxygen amendment, *in-situ* chemical oxidation, soil vapor extraction, bioremediation, and bioaugmentation. For each failed remedy, the entire remedial approach was reevaluated including a re-examination of the site characterization data, conceptual contaminant model, and actual operating parameters measured during the active remediation. In each case, the remedial system failures were unfortunately discovered many years after implementation because of complacency brought by the automated routine and because early performance reviews were not completed to catch and address problems. Four case studies highlighting each of the four key common factors to which the failures can be attributed will be presented.

This approach addressed the basic question, “Why did the remediation system fail?” For this analysis, failed *in-situ* remediation programs were generally considered to

be those where: (a) there was limited appreciable change in dissolved contaminant concentrations after years of remediation; (b) the presence of source material continued to be suspected in the remedial focus area despite years of remediation; (c) the amount of contaminant mass recovered or destroyed by the remediation is insignificant relative to the mass remaining in the subsurface; and/or (d) the dissolved-phase contaminant reduction rates during remediation are comparable to the rates of natural attenuation preceding remedial program implementation. With the "lessons-learned" identified in this paper in mind, remediation practitioners and stakeholders may be more mindful of potential shortcomings in pre-remediation site activities and the need to complete early and regular independent remedial performance reviews so they may be better equipped to avoid prolonged and costly *in-situ* remediation program failures.

Excerpt 3: Observed Contaminant Half-Lives - Will Natural Attenuation Achieve the Goal?

Proceedings of the Tenth International In-Situ and On-Site Bioremediation Symposium, Baltimore, MD. Roberts, Eric and R. M. Lowe, B. Roberts, and R.Tabachow.

After a release and initial spill response, stakeholders often ask how long the groundwater contamination is likely to persist before acceptable levels are reached. This is important to stakeholders because the rate of contaminant attenuation is often a key factor in considering whether and how to actively remediate a spill site. All too often, there is a rush to judgment that a remedial system must be installed / operated and hundreds of thousands of dollars are spent only to learn years later that natural attenuation would have accomplished the same goal for a fraction of the cost. Forecasting contaminant degradation rates allows for a better negotiating position with the environmental regulators and can influence the stakeholders' environmental liability, cash flow projections, asset valuation, and help avoid disruptions to normal facility operations. However, without many months or years of analytical data,

it can be challenging to confidently estimate contaminant attenuation rates in the early stages of site investigation.

The literature suggests that attenuation rates for two common drivers of petroleum remediation, MTBE and benzene, are generally within a certain range assuming that the immediate spill area has been addressed (e.g., emergency response and immediate product recovery have occurred). Analyzing monitoring data together with published studies of MTBE and benzene attenuation rates is one way to bring more confidence to an early assessment of site contaminant trends for improved remedial decisions that can be more readily sanctioned by regulatory authorities.

The authors assembled and evaluated groundwater data from 34 petroleum release sites in the eastern US to derive MTBE and benzene half-life values assuming first order decay. The study examined years of actual groundwater monitoring data from each of 114 MTBE containing wells and 61 benzene containing wells. The data were also evaluated based on whether the wells were screened within unconsolidated overburden or bedrock. All the wells are situated outside of source material and the plumes were considered stable or contracting. Overall, the authors found measured half-lives were generally consistent with published ranges. Inclusive of all benzene containing wells (bedrock and overburden), the mean benzene half-life in groundwater was 1.6 years with a median of 1.1 years while the mean MTBE half-life in groundwater was 1.3 years with a median of 0.86 years. For bedrock wells, benzene and MTBE half-life means were slightly lower than the overall average. For overburden wells, the half-life means were slightly higher than the overall average. For over 80% of the MTBE contaminated wells, half-lives were calculated between 0.25 and 3.5 years (10% were higher and 10% were lower than this range). Similarly, for approximately 80% of the benzene impacted wells, half-lives were calculated between 0.25 and 3 years. These data along with other half-life data in the literature can help environmental practitioners and stakeholders make better and earlier forecasts of spill

implications based on only limited site information so more informed and cost effective decisions can be made in evaluating environmental response / remedial cleanup options.

Excerpt 4: Microbial Consortium Shifts Induced by Oxygen Amendment at Multiple MTBE and Benzene Sites

Proceedings of the Sixth International Conference, Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA. Roberts, E. and G. Davis, D. McElroy, F. Markert, and R. Tabachow.

A previous study of in-situ stable isotope labeled probes applied at five different MTBE and benzene contaminated sites confirmed that the indigenous microbial communities at these sites actively metabolized the contaminants under both natural and oxygen-enhanced conditions. While the rate of microbial degradation of the contaminants was shown to increase significantly under the oxygen-amended conditions, the particular microorganisms responding to the oxygen amendment could not be discerned from the gross categories of microbial community structures initially quantified using phospholipid fatty acids (PLFA) analysis. In this study, the authors examined the existing PLFA dataset in more detail to specifically identify shifts within the microbial populations, assess which microbial populations responded to the oxygen amendment at each site, and explore trends within the microbial consortium from site to site. Several consistent consortium shifts were observed in response to oxygen-enhanced conditions. The consistency of consortium shifts in response to the oxygen-enhanced conditions suggests these shifts could be used as a cost effective indicator of enhanced biodegradation performance. At each of the five sites, Bio-Trap® samplers containing isotopically-labeled substrates were suspended and incubated in site monitoring wells for 30 days under a range of target dissolved oxygen (DO) concentrations (ambient, 6 ppm, and 12 ppm). The Bio-Trap samplers were amended with 13C-labeled MTBE or

13C-labeled benzene on beads which act as the sampling matrix. Retrieved Bio-Trap samplers were analyzed for PLFA to provide viable biomass and metabolic activity data. Broad phylogenic groups of microbes have different fatty acid profiles, making it possible to distinguish among them, and six major structural groups were initially identified at each of the sites. Detailed examination of the PLFA analysis completed under this study found that signature Proteobacterial biomarkers were observed to shift in relative abundance with oxygen amendment. Furthermore, the biomarkers that increased were shown to be the main uptake sources of the 13C-labeled substrate, indicating that the shift in biomarkers was due to an increased proportion of microorganisms that were degrading the 13C-labeled substrate. This pattern was observed at all five sites, suggesting that measurement of relative abundance of these Proteobacterial biomarkers could provide a useful tool for monitoring the microbial consortium during remediation. The authors believe standard PLFA analysis without 13C-labeled substrate could be a cost effective tool to monitor the relative proportions of these key biomarkers as indicators of ongoing enhanced biodegradation. Only if the relative proportions of these biomarkers were observed to revert to background or other proportions would more costly analyses using 13C-labeled substrate be needed to determine whether DO amendments were no longer effectively stimulating bioremediation at the site.

Excerpt 5: The Unmet Challenges of Performance-Based Contracting – Are Hybrid Contracts the Answer?

Proceedings of the Sixth International Conference, Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA. Tabachow, R. and G. Back, F. Markert, and E. Roberts.

The number of environmental cleanups and related environmental services provided through competitive bidding and negotiated contracting continues to grow. “Pay-for-

performance" is an increasingly popular contracting mechanism as it offers the promise of shifting remedy failure risk to the successful bidder while promoting innovation and offering increased reward potential to consultants and contractors. While popular, the authors have observed after successfully bidding out over 50 environmental remediation projects that strict pay-for-performance contracting was seldom optimal or feasible for competitive bidding. Moreover, hybrid contracts containing to differing degrees, performance, fixed-price, unit cost and / or time-and-materials elements rather than one strict form of contract pricing were observed to generate the most successful competitive bids and most desirable project implementation. Patterns emerged that signaled when pay-for-performance or other types of contracting were feasible and appropriate. Key factors affecting the contracting approach included: project phase; complexity of the problem (e.g., contamination, geology / hydrogeology); uncertainties in existing characterization work; regulatory requirements; level of insurance coverage; third-party impacts; and availability and size of service providers. The ~50 bid projects include sites with: first time / new releases; incomplete characterizations; complete characterizations without remedies, identified remedies that have not been implemented; remedies that have been partially implemented; remedies that have failed; and remedies that have succeeded but site closure has yet to be made. Contracting mechanisms used for these projects include time-and-materials not-to-exceed, pay-for-performance, fixed-price, unit cost, phased contracting, and hybrid contracts. Main conclusions from this analysis were: (1) appropriately devised competitive bidding significantly reduced project cost while quality was maintained or improved; (2) hybrid contracting emerged as the most frequently employed format due to the difficulty of implementing pay-for-performance or other strict single-payment forms of contracting; and (3) hybrid contracting appears to result in an equitable disbursement of risk while facilitating cost efficiency and timely project completion.

Excerpt 6: Multi-site Application of Molecular Biological Tool Reveals Variable MTBE and Benzene Biodegradation Potential

Proceedings of the Ninth International In-Situ and On-Site Bioremediation Symposium, Baltimore, MD. Tabachow, R., R. Breakwell, F. Markert, J. Ozog, Jr., W. Peyton, E. Raes and E. Roberts.

An innovative molecular biological tool was applied at five different MTBE and benzene contaminated sites to determine natural and dissolved oxygen-enhanced biodegradation potential. The results revealed significant differences in MTBE and benzene biodegradation potential between the sites. While conventional groundwater parameters such as dissolved oxygen (DO) and oxygen reduction potential (ORP) provide useful indications of aerobic biodegradation potential, the molecular biological tool used in this study definitively confirmed the occurrence, significance, and relative rates of biodegradation. At each of the five sites, Bio-Trap® samplers containing isotopically-labeled MTBE or benzene were suspended and incubated in site monitoring wells for one month under a range of target DO concentrations (ambient, 6 ppm, and 12 ppm). Retrieved traps were analyzed via GC/MS and for phospholipid fatty acids (PLFA) to confirm in-situ biodegradation of the stable isotope labeled MTBE and benzene, estimate the relative biodegradation rates under varying oxygenated conditions, and provide information regarding viable biomass and metabolic activity. Results showed naturally occurring microorganisms at the majority of the sites were actively metabolizing benzene and MTBE. Through DO amendment alone, biodegradation of MTBE and benzene was significantly enhanced with benzene degradation rates reaching more than two to three times higher with increased DO concentrations.

Excerpt 7: Stable Isotope-Labeled MTBE & Benzene in In-Situ Biotraps Reveal Biodegradation Rates

Proceedings of the Fifth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA. Roberts, E., G. Davis, M. Lowe, J.Ozog, E. Raes, K. Sublette, J. Harris, Z. Zhong, and R. Tabachow

The authors conducted an in-situ biofeasibility study at a petroleum contaminated site in Pennsylvania that focused on determining whether MTBE was naturally biodegrading and if increased dissolved oxygen levels alone would stimulate increased rates of MTBE and benzene biodegradation. A series of stable isotope-labeled tracer bio-trap samplers exposed to the different levels of dissolved oxygen (ambient, 6ppm and 12ppm) were suspended and maintained in a site monitoring well for 30 days. The traps were be preloaded with a “heavy” (13C labeled) MTBE and benzene on medium designed to minimize leaching. Following incubation, the retrieved traps were analyzed for phospholipids fatty acids (PLFA) to confirm the in-situ biodegradation of the stable isotope labeled MTBE and benzene and to provide information on viable biomass, community structure and metabolic activity. The traps were also analyzed by GC/MS to determine the percent loss of stable isotope labeled MTBE and benzene so that relative biodegradation rates for the three levels of dissolved oxygen could be estimated. Results of the study appear to confirm that MTBE and benzene are naturally being biodegraded under ambient (unaltered) site conditions. PLFAs measured in the retrieved traps contained the stable isotope in concentrations typically observed during biodegradation of the labeled MTBE and benzene compounds. The results indicate benzene and MTBE can be biodegraded simultaneously and that biodegradation rates can be significantly increased by increasing dissolved oxygen concentrations in groundwater. The information and conclusions derived from this study are expected to have a significant bearing on the outcome of the remedial alternatives evaluation for the cleanup of this site. The in-situ biofeasibility approach used in this study appears to be

a cost effective and accurate means of determining the capacity of indigenous microorganisms to degrade recalcitrant compounds and evaluating alternative means (e.g., varying levels of increased dissolved oxygen) of stimulating microorganisms and enhancing biodegradation rates.

Excerpt 8: The Forensics of MTBE "Spikes" in Groundwater Investigations

Proceedings of the Eighth International In-Situ and On-Site Bioremediation Symposium, Baltimore, MD. Back, G, E. Roberts and G. Schmidt.

MTBE contamination in groundwater often drives remedial activities at gasoline spill sites. Over time, the environmental investigations have gained greater understanding of how the physical and chemical characteristics of MTBE complicate data interpretation and the allocation of remediation responsibility. A most troublesome phenomenon is the often observed "spiking" of dissolved MTBE concentrations in groundwater at previously contaminated sites. These usually short-duration, one or more order-of-magnitude changes in MTBE concentration may indicate a "new" release or may only represent a temporary redistribution of MTBE mass prompted by changes in hydrogeological conditions. The challenge is how to distinguish between these two possibilities and avoid the consequences of an incorrect interpretation in a liability apportionment. The authors present an evaluation approach, which includes the use of environmental forensic approaches, to critically examine the phenomenon of MTBE "spike(s)" occurring at previously contaminated sites and which relies on evaluating multiple lines of evidence (regulatory, operational, and technical). Available information is examined to discern whether there is corroborating evidence of a "new" release (e.g., concomitant increases of other compounds in the petroleum assemblage, if expected, or increases in remediation system mass recovery) and whether alternative triggers of a concentration "spike" can be ruled out. The authors reveal the significance and

limitations of the regulatory compliance record, the UST system testing records, and the importance of understanding other site activities (e.g., changes in remediation system) and natural phenomenon (e.g., changes in groundwater elevations) at the time of the "spike(s)." The need to evaluate other possible alternative causes for MTBE "spike(s)," such as changes in groundwater movement, contaminant slugs from older releases, off-site sources, unusual precipitation events, site improvement activities, leaks from water lines or sewers, remedial system operational changes, consistency in sampling and analytical methods, and field sampling QA/QC is stressed. The strengths and limitations of various forensic techniques applied as possible additional lines of evidence are discussed. This evaluation approach is applied to two different MTBE "spike" case studies. In one case study, the various lines of evidence explored suggest a "new" release may have occurred; in the other outwardly similar case study, the evidence was not consistent with a "new" release. Both case studies demonstrate that several possible causes of an MTBE concentration "spike" must be evaluated. These case studies also demonstrate the relative strengths and important limitations of various different age dating forensic techniques applied to gasoline releases.

Excerpt 9: Remediation Strategy for Paint Plant with 1,1,1-TCA in a Dual Aquifer System

Proceedings of the Eighth International In-Situ and On-Site Bioremediation Symposium, June 2005. Roberts, E, C. Nguyen, J. Aichroth and ML Capichioni.

The authors developed and implemented a cleanup / closure strategy involving both active remediation and natural attenuation to address 1,1,1-TCA contaminated groundwater in a dual aquifer system beneath a major paint manufacturing plant in Baltimore, Maryland. Positive regulator-owner/operator team participation and a joint understanding of technological limitations led to the derivation of mutually agreeable

risk-based cleanup goals which then set the stage for identifying and implementing an effective goal-oriented solution. The cleanup approach accounts for the urban site setting close in proximity to the Chesapeake Bay, and the challenging set of site and regulatory complexities including, site-specific risks, commingled solvents, contamination beneath the manufacturing building footprint, and significant impacts to both shallow heterogeneous alluvium overburden and deeper fractured bedrock aquifer systems. TCA in the source area and in alluvium groundwater was actively remediated between 1997 and 2004 using a multi-phase extraction system, which accommodated the unusually high natural levels of ferrous iron. A rigorous monitoring program was simultaneously instituted to demonstrate the dissolved TCA plume in bedrock fractures was not expanding and was naturally attenuating abiotically and through biologically mediated reductive dechlorination. When in early 2004 it appeared the cleanup goals had been achieved, the remediation system was idled and post remediation monitoring was initiated to verify that the attainment levels and conditions could be sustained. The groundwater monitoring data show a significant contraction of the 1,1,1-TCA plume and almost 10-fold reduction of the mean (95% UCL) 1,1,1-TCA concentration in alluvium groundwater following remediation. Concomitant reductions of toluene and other VOCs commingled in the alluvium groundwater were also observed. Extensive bedrock groundwater VOC and general chemistry monitoring data show steady or decreasing 1,1,1-TCA concentrations in bedrock and “text book” indications of both abiotic and biological reductive dechlorination processes occurring without any significant daughter product accumulation. Post remediation system idling rebound sampling data appear to confirm the cleanup goal attainment levels can be sustained.

Excerpt 10: Active Remediation's Toll on the Environment

Proceedings of the Eighth International In-Situ and On-Site Bioremediation Symposium. Bauer, N., E. Roberts and R. Lanza.

The decision to implement an active versus a more passive remedial approach is often based on local perceived risks, technical feasibility, and economics. While the authors acknowledge the key importance of balancing these factors and proactively addressing excessive site-specific risks, we find the more global impacts of installing and operating an active remediation system are normally ignored in the cost-benefit equation. This paper presents a compelling case for conducting a more thorough evaluation of environmental costs versus benefit of active remediation approaches before remedial solutions are selected and implemented. We suggest that many active remediation system being operated today result in less readily quantified environmental damages not normally considered when evaluating the use of active versus passive remedial approaches and that these damages may outweigh the achieved reductions in local risks. The authors identify environmentally destructive impacts associated with active remediation systems important for industry, regulators and policy-makers consideration when evaluating alternative more passive remediation approaches. Active remediation systems often involve high-horsepower energy intensive equipment operating 24 hours a day contributing to power plant emissions of carbon dioxide, mercury and ozone producing NOx and SOx compounds. The authors note regulatory emission threshold allowances enable systems to be designed to transfer VOCs from the subsurface (where the potential for human exposure may be limited) to the atmosphere (where human exposure in dilute for is likely), emitting literally tons of VOCs to the atmosphere each year. VOCs are often introduced to surface waters from active remediation systems because of treatment efficiency limitations discharge permit allowances. The operation and maintenance of active remediation system often involves frequent (e.g., weekly) site visits by technicians driving low fuel economy / high emission vehicles (trucks). Active remediation systems often generate sludges and other wastes, the disposal of which consumes additional resources and landfill capacity. Even the manufacturing and subsequent disposal of the equipment components uses finite environmental resources. Rarely, if ever, are the full environmental impacts of

installing and operating an active remediation system considered in the environmental cost-benefit equation. This paper assesses damages typical active remediation systems can inflict on the environment. A semi-quantitative assessment of potential carbon dioxide, and ozone production, natural resource (fuel) consumption, and VOC impacts to the atmosphere and surface waters is made to show why these less tangible costs are important to consider when evaluating active and passive alternative remedial approaches.

Excerpt 11: In-Situ Chemical Oxidation Limited by Site Conditions - A Case Study

Proceedings of the Second International Conference on the Remediation of Chlorinated and Recalcitrant Compounds. Roberts, E., and Bauer, N.

In-situ chemical oxidation (CO) technology applications have emerged as promising means of addressing a wide range of contamination scenarios involving organic compounds. However, with increased use of the technology, several limitations and potential risks are beginning to emerge, some of which are illustrated in this detailed review of a CO field-scale case study. This paper presents a case study selected, implemented, and completed by the authors where the effectiveness of the CO technology is determined through follow-up field monitoring of a dissolved chlorinated solvent plume at a former electroplating and manufacturing plant. Compared to mean concentrations prior to injection, TCE concentrations 20 weeks after injection remained unchanged in 9 wells, decreased in 3 wells, and increased in 2 (downgradient) wells. The measured paper describes why the TCE concentrations appear to indicate that the remedy failed to treat the residual source, and provides a brief overview of this emerging trend at multiple sites.

Excerpt 12: Indigenous Inorganic Constituents and RCRA Closures in Virginia

Proceedings of the Ninth Annual Environment Virginia Symposium, Virginia Military Institute. Roberts, E. and Wendt, S.

Closure of RCRA hazardous waste management units can be costly and time consuming due to the strict protocols to meet detailed federal regulations. This is particularly true if the hazardous waste stream contained inorganic chemical constituents that also naturally occur in native soils near or beneath the hazardous waste unit. The detection of one or more closure plan chemical constituents of concern in the soil at a RCRA site can trigger the need to perform costly additional sampling, laboratory analyses, and comparative statistical evaluations to differentiate between indigenous chemicals and those originating from the waste management activities. This paper researches the literature on levels of naturally occurring inorganic constituents in soil relative to corresponding generic USEPA risk-based concentrations to identify which particular chemical(s) may pose this problem and the greatest risk of project level of effort escalation. The authors also describe how this information could be extremely beneficial to parties developing and implementing RCRA closure plans.

Excerpt 13: Vacuum Vapor Extraction, Design and Application, a Monograph Series

WASTECH and the American Academy of Environmental Engineers. Holbrook, T, Bass, D, Boersma, P, Diguilio, D, Eisenbeis, J, Hutzler, N and Roberts, E.

Vapor Extraction and Air Sparging, Design & Application, a text book monograph co-authored by Eric Roberts, P.E., P.G., and covering the design, applications, and implementation of vapor extraction, bioventing and air sparging has recently been

published by the American Academy of Environmental Engineers (copyright 1998). The book provides technical guidance developed by senior technical experts and project managers for use by practicing professionals to apply their own judgment on whether and how to use innovative technologies under project-specific circumstances confronted. The monograph is also intended to inform regulatory agency personnel and the public about the conditions under which the technologies are potentially applicable.

Excerpt 14: Selection of Practical Remedial Approaches

Proceedings of the Twenty-ninth Mid-Atlantic Industrial and Hazardous Waste Conference, Virginia Polytechnic Institute. Roberts, E. and Wendt, S.

This paper describes a common sense approach to identifying the best site-specific remedial alternatives for contaminated industrial or commercial properties, and the importance of considering both the technical and the real-world aspects in selecting appropriate clean-up technologies to address environmental impacts.

Excerpt 15: Are In-situ Approaches the Answer to Remediation?

Virginia's Environment Magazine, Vol. 4, No. 2. Wendt, S. and Roberts, E.

This article provides an overview of the multiple benefits of using *in-situ* remedial approaches over more traditional technologies to address contamination problems at industrial and commercial facilities. The inherent value of integrated *in-situ* technologies is covered, with multiple examples being offered where such approaches can benefit owners, operators, buyers and sellers of operating and idle facilities.

Excerpt 16: Selecting Practical Remedial Approaches - A Two-Part Article

Virginia's Environment Magazine. Wendt, S. and Roberts, E.

This two-part article focuses on how to conduct a remedial alternatives analysis with emphasis on the critical regulatory, technical, and economic factors relevant to site- and business-specific criteria. This technical paper defines and describes the key elements of a remedial alternatives analysis used to identify the best business solution for a contaminate site. Business factors to be considered included present value cost for full implementation (i.e., capital and O&M costs), cost distribution over time, current and future plant operations, public perception, liability, cost recovery, and owner equity in property. In the second part of this article, the authors review a case study for a Fortune 500 company that operates its most profitable plant immediately over shallow and deep aquifers contaminated with solvents significantly above levels of regulatory concern. The article continues by describing how the remedial alternative analysis methodology was applied to successfully identify the most appropriate combination of technologies and regulatory strategy to meet the client's environmental and business needs.