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Insights from Battelle's Ninth International Conference on Remediation of Chlorinated and Recalcitrant Compounds

As a constant struggle in remediation, clean closure is a high—usually impossible—bar for sites, particularly complex remediation sites, to clear. Contributing factors include the inability of available technologies to perfectly clean up all contamination, the difficulty of sufficiently characterizing sites (or knowing what sufficient is), and the presence of endpoints that require difficult, if not unreachable, goals for closure.

Without alternative cleanup endpoints, site owners find themselves cycling through technologies, searching for a solution that cleans to the molecular level. Even if a site finally achieves closure, the book is never really closed. Regulations for any of ~1,800 typical remediation-targeted compounds, particularly emerging compounds such as methyl-t-butyl ether (MTBE) in the early 2000s, and more recently 1,4-dioxane, perfluorinated compounds, and certain metals such as beryllium and hexavalent chromium, can derail established programs. Emerging compounds often require closed sites to reopen, or active sites to retool existing remedies.

The biennial Battelle Conference on Remediation of Chlorinated and Recalcitrant Compounds brings together scientists, engineers, regulators, and other environmental professionals to discuss these and other challenges and advancements in the field of remediation. In this paper we discuss four trends we are seeing in the industry and were also highlighted at this year's conference, held May 19-22, 2014, in Monterey, CA.

1. ADVANCED SKILLS ARE NEEDED TO NEGOTIATE RISK-BASED END POINTS.

Early Battelle Chlorinated conferences focused on the introduction and development of new environmental technologies, underlining the hope that remedial solutions would be clearer through these technology developments. Over time, new themes have emerged; in particular, sharing knowledge about the realistic capabilities and limitations of technologies as part of a holistic site strategy, as well as how to apply these technologies in managing business risk.

This shift speaks to the need for site owners, regulators and the consulting community to be willing to - and develop the capability to - negotiate risk-based end points. A recent National Research Council (NRC) study underscores this shift. The study concludes that complex sites are not likely to achieve regulatory goals for clean closure, requiring consideration of alternative closure strategies and remedial approaches.

These alternatives to clean closure allow site owners to exit the endless "do loop" (remediate, measure, remediate again with a different, more aggressive technology, repeat), while still achieving end points that protect the public. This trend raises the importance of technical communication, facilitation and the ability to negotiate – not all strong suits for the typical practicing professional.

As one potential solution, risk-based end points will support faster completion of the regulatory process and more predictable future costs. Where to set the bar, in comparison to regulator-preferred goals of clean closure at any particular site, however, will be a matter of negotiation. These negotiations will require an advanced set of skills—the marriage of technical knowledge with business and emotional intelligence. To succeed, project teams must build capabilities in nontraditional "soft" areas—such as risk communication, active listening and collaboration—so they can present and articulate the protective nature of closure alternatives as value propositions that work for both the regulated and the regulators.

2. THERE IS MORE KNOWLEDGE-SHARING ABOUT TECHNOLOGY CAPABILITIES AND LIMITATIONS.

Case studies from technical field applications presented at the conference illustrate there is more information about the reported capabilities of advanced technologies than in the past. Complementing the understanding of technology capabilities are developments in high-resolution methods to quantify contaminant migration.

Part of the industry's challenge is to sift through the multitude of "successes" claimed for various technologies. An increasing number of top practitioners, scientists and regulators are embracing the premise that new goals, or end points, should be based on the measurement of contaminant movement (flux) and risk to receptors—not (as is often true today) on the suspicion of their presence or the ability to detect compounds at minute concentrations.

Technologies are now available to improve the precision of characterization, define transport pathways and identify specific smaller areas that can be used to reduce the footprint of large, complex sites and contain contamination through appropriate management practices. One case study showed how high-resolution characterization provided a refined understanding of contaminant transport, focusing the remedial action to a smaller footprint and measuring results by demonstrating contaminant immobility. The field is moving toward these alternative methodologies, and topics presented at the 2014 Battelle Chlorinated Conference highlighted advances in characterization methods, tools and techniques that will help the industry reach outcomes that are protective, without being prescriptive.

As precision is gained, the focal points of remediation will tighten. Consider a river with an infinite number of bays, wetlands and tributaries. Under the new paradigm, remediation efforts might focus on contributions that affect the primary flow of the river rather than measure the potential contamination of every wetland, harbor, and tributary along its course. This level of precision and

An Innovative, Sustainable Approach to Pump & Treat/MCLs

At the conference Scott Zachary of Haley & Aldrich presented on the real-world application of alternative cleanup standards using a complex site in Arizona as an example. Many sites impacted with recalcitrant chemicals have completed assessment and feasibility studies and implemented groundwater remedies over the past 30 years under the jurisdiction of federal, state, and local regulatory agencies. To close a site, regulators require remediation teams to achieve published regulatory cleanup values such as Maximum Contaminant Levels (MCLs).

The State of Arizona recognized the taxpayer cost and time implications of using conventional MCL-based remedial goals. In collaboration with EPA, local agencies, community members, and Haley & Aldrich, the State of Arizona developed an alternative resource-focused, protective, cost-effective, and sustainable statute under its Water Quality Assurance Revolving Fund (WQARF). This approach focuses on protecting human health primarily through groundwater management—as opposed to conventional groundwater restoration "throughout the plume."

Instead of the unreachable standard of complete restoration to MCLs, Arizona is taking a "restoration, replacement, or otherwise provide for" approach. A feasibility study is used to evaluate the most reasonable and practicable groundwater approach. Options include traditional tactics such as hydraulic control as well as measures such as wellhead treatment.

To date, Arizona's innovative approach has been successfully applied to a handful of large, complex plumes, saving tens of millions of dollars, ensuring public safety, and providing a more sustainable model for other agencies to consider.

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Development of Background Indoor Air Concentrations for Commercial Buildings and Schools

At the conference Rich Rago of Haley & Aldrich presented the results of a background indoor air quality study, which identified that hydrocarbons and chlorinated solvents are commonly identified in indoor air background data. The study will prove to be extremely valuable to owners, regulators, and practitioners in evaluating complex vapor intrusion data. State and federal regulatory agencies provide guidance for assessing the vapor intrusion pathway at contaminated sites. Regulatory indoor air background values currently used were derived from residential indoor air background studies, or from nonresidential studies using data up to 20 years old. These older studies may not be appropriate for evaluation of indoor air quality in current nonresidential settings.

Haley & Aldrich and Alpha Analytical implemented a new indoor air background study for office buildings, commercial buildings, and schools. Phase I included sampling from 10 office buildings and 10 schools during March 2013. Phase II of the study is ongoing and includes sampling of over 30 additional office buildings, commercial buildings, and schools. To date, samples have been collected in California, Arizona, New York, New Jersey, and four New England states.

Results indicate that many compounds that are carefully scrutinized in vapor intrusion investigations were also commonly identified in indoor air background of office buildings and schools. For example, tetrachloroethylene was detected in 85% of office samples and 60% of school samples at concentrations up to 9 µg/m3. Benzene was detected in 85% of office samples and 100% of school samples at concentrations up to 24.8 µg/m3. Trichloroethylene was detected in office samples at concentrations up to 115 µg/m3. These background levels for indoor air in non-residential settings exceed several residential and commercial thresholds.

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how results are analyzed and communicated are slowly reshaping the regulatory philosophies applied to the practice of environmental remediation.

3. MONITORING REQUIREMENTS FOR VAPOR INTRUSION SHOULD BE DATA-DRIVEN.

Considerable effort is often expended to monitor indoor air when there is a potential for the migration of vapor contaminants from soil or groundwater. During this process, at times the unsafe assumption is made that any indoor air contaminants identified are directly related to the presence of contaminated media in the subsurface. Such monitoring presents a considerable burden to sites that may have hundreds of thousands of feet of space, especially where there are groundwater plumes that have little or no potential to impact indoor air quality.

The road ahead will be a long and spirited journey to tease out relationships between indoor air and subsurface contamination and to find consensus on acceptable inhalation levels of chemicals still commercially available to the general public. There is also disagreement on the necessity of burdensome long-term monitoring to evaluate potential exposures. Site owners and other stakeholders need to determine how to shrink the monitoring footprint in a way that protects human health but is also realistic and data-driven.

4. NEW APPROACHES ARE HELPING SHAPE THE REGULATORY RESPONSE TO EMERGING COMPOUNDS.

More sensitive detection tools are leading us to recognize far more contaminants in the environment. We can now detect compounds at very low levels, as well as resolve the "signature" of what was once thought to be a single compound and recognize two distinct substances. Evaluation comes next, followed by debates regarding which contaminants are hazardous enough to require regulation to protect the public.

Regulation of emerging compounds often triggers the reopening of the site regulatory process. Once guidance is developed and a compound is measured at a site, action is required—even though that guidance was not available at project startup. What a site should do, however, is often unclear because the compound's characteristics, treatment approaches and consequences are not yet well documented. With over 1,800 compounds under study, the impact to established programs from emerging compounds will be significant.

Many presentations and discussions at the conference centered on methods to accelerate the assessment process, generate data-driven risk communication to prevent over-reaction, and quickly understand the implications of an emerging compound for existing programs. At any given site, in other words, what are the fate and transport

implications and the potential to treat? At what cost? To what end point? Site knowledge, deep technology expertise and effective communication of respected advocates can be applied to shape the regulatory environment.

> The EPA recently updated a series of technical fact sheets addressing contaminants of concern that present unique issues and challenges at contaminated federal facility sites. Each contaminant-specific fact sheet briefly summarizes the compound's physical and chemical properties, its environmental and health impacts, related federal and state guidelines, and applicable detection and treatment methods. Contaminants addressed by these fact sheets include: 1,2,3-trichloropropane (TCP); 1,4-dioxane; 2,4,6-trinitrotoluene (TNT); dinitrotoluene (DNT); hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); N-nitroso-dimethylamine (NDMA); perchlorate; polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs); tungsten; nanomaterials; and perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA)

CONCLUSION:

Nine Battelle Conferences on Remediation of Chlorinated and Recalcitrant Compounds over 16 years have explored tools, techniques and project management practices for the remediation of recalcitrant compounds. As the practice area has matured, the focus has shifted from remediation methods (i.e., technology) to remediation approaches (i.e., management of technology). This is a subtle but important shift that requires deep technical understanding of technologies but also advanced skills in collaboration and technical communication.

As we collectively learn more about risk, precision characterization, and the capabilities of treatment methods, we apply that knowledge to gain regulatory acceptance of alternatives that are equally protective but economically sustainable. This work, and the discussion about communication and management techniques, stakeholder facilitation and reaching common ground, is transforming the practice itself.

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