# Technology Innovation News Survey

***Entries for June 16-30, 2022***

## Market/Commercialization Information

### RISK ASSESSMENT AND TECHNICAL ANALYSIS SUPPORT
Contract Opportunities at SAM.gov, Solicitation 68HERH22R0066, 2022
U.S. Environmental Protection Agency, Headquarters Acquisition Division, Washington, DC

This is a sources sought notice for marketing purposes only under NAICS code 541620. EPA seeks to identify parties having an interest in and the resources to support the Office of Land and Emergency Management (OLEM), Office of Resource Conservation and Recovery (ORCR), in providing risk assessment and technical analysis support. The resultant contract would support ORCR and its mission to encourage land-based practices that help ensure economic and environmental sustainability, safe materials/waste management, and ongoing waste reduction in accordance with the Performance Work Statement (PWS). Both large and small business firms may provide a response to this notice. There is no solicitation available at this time. Capability statements are due by 4:30 PM EDT on August 12, 2022. https://sam.gov/opp/d14efbb7bd5d4e8b80bdbe18a6a49cdb/view

### R7 ORONOGO-DUENWEG MINING BELT - OPERABLE UNIT 1 REMEDIAL ACTION, SOUTHWEST MISSOURI
Contract Opportunities at SAM.gov, Solicitation 68HE0722R0036, 2022
U.S. Environmental Protection Agency, Region 7 Contracting Office, Lenexa, KS

This is a total small business set-aside under NAICS code 562910. EPA Region 7, requires remediation of mine waste (surficial mine waste areas, contaminated soil, and contaminated intermittent stream sediment) located in multiple areas of Operable Unit 01 (OU1) of the Oronogo -Duenweg Mining Belt (ODMB) Superfund site located in southwest Missouri. The work required covers a broad range of activities including obtaining property access, excavating mine waste, backfilling, implementing erosion controls, revegetation, and implementing repairs at properties remediated under previous contracts. The Contractor must also fill and install proper plugs in mine shafts identified by EPA. The work being conducted under this PWS is part of a Remedial Action (RA) conducted under the authority of 42 U.S. Code § 9606, CERCLA. As such, it is not necessary for the Contractor to apply for permits or pay permitting fees. However, the Contractor must identify and comply with the substantive technical requirements of applicable and relevant permits and must coordinate with the permitting agency prior to beginning work in each area and provide the permitting agency with the required information. The award will be an Indefinite-Delivery/Indefinite Quantity contract with fixed-unit prices consisting of a base period and four 12-month option periods. Offers are due by 4:30 PM CDT on August 26, 2022.
https://sam.gov/opp/ef11812a15044cf6bee7bdb2426f2707/view

### R7 VIENNA WELLS OU1 & OU2 REMEDIAL ACTION, LENEXA, KS
Contract Opportunities at SAM.gov, Solicitation 68HE0722R0035, 2022
U.S. Environmental Protection Agency, Region 7 Contracting Office, Lenexa, KS

This is a women-owned small business program set-aside under NAICS code 562910. EPA Agency Region 7 Contracting office is seeking qualified women-owned firms to complete remedial action at the Vienna Wells Superfund Site (Site), located in Vienna, Maries County, Missouri.The Site consists of three contaminated public drinking water wells and the source area, a former hat factory. The facility consists of two adjoining buildings. The main building has been mostly demolished down to the concrete foundation, with remaining sections of steel framing and rotting overhang roofing on the south central and northwest edges of the building. The secondary building runs north and south and remains intact. The Site is separated into two Operable Units (OU). OU01 Soil addresses contaminated soil at or near the site property, and OU02 Groundwater addresses contaminated groundwater resulting from operations at the hat factory. The performace period is expected to begin in March 2023 and last three years. Offers are due on August 12, by 4:30 PM EDT. https://sam.gov/opp/2072e25ee5d6491596471f201c606315/view

## Cleanup News

### REMEDIATION OF A TRICHLOROFLUOROMETHANE GROUNDWATER PLUME USING PLUMESTOP® LIQUID ACTIVATED CARBON™
Thompson, R. | 29th Annual David S. Snipes/Clemson Hydrogeology Symposium, 21 October, Clemson, SC, 28 minutes, 2021

Geochemical and microbial data were collected, and Environmental Molecular Diagnostics (EMDs) methodologies were used to develop a remedial design at a foam manufacturing site in North Carolina. Investigation activities identified VOCs and CVOCs, including trichlorofluoromethane (Freon 11), methylene chloride, PCE, TCE, and 1,4-dioxane in groundwater. Groundwater samples were analyzed for geochemical parameters, and a DNA method was used to develop the microbial profile. An investigation and injection pilot study were conducted to collect data for full-scale groundwater treatment and to validate the performance of contaminant sorption and bioremediation by stimulating rapid, biologically-mediated VOC and CVOC destruction in groundwater. This was accomplished through in-situ injection of PlumeStop and Hydrogen Release Compound (HRC®) through an array of direct push injection points in the shallow aquifer. A conceptual site model provided a clearer understanding of the groundwater transport mechanisms and the location of contaminant mass reaching the treatment areas. This allowed for the proper PlumeStop dosing and placement. By evaluating the microbial profile, it was possible to determine the types of active microbes and gene functions associated with biodegradation of the target constituents. When combined with field parameters and geochemical analysis, compelling evidence was established for aerobic co-metabolic bioremediation of groundwater constituents, including 1,4-dioxane. https://clemson.app.box.com/s/dmck2528clod6q7gevrxfiyg0qq5b6v1/file/906261912385

### CONSTRUCTING THE NATION'S LARGEST ION EXCHANGE PFAS WATER TREATMENT PLANT
Hakes, K. | | Northeast Conference on The Science of PFAS: Public Health & The Environment, 5-6 April, Marlborough, MA, 23 slides, 2022

Several dozen wells in Orange County were temporarily taken out of service to meet California's advisory Response Levels for PFAS in drinking water. The Orange County Water District (OCWD) initiated a robust response to address PFAS, including designing and constructing treatment facilities for local water agencies to restore the impacted drinking water supply. OCWD, the Yorba Linda Water District, and several companies worked closely together to construct the nation's largest ion exchange PFAS water treatment plant. The treatment plant will treat up to 25 million gals of water a day. The webinar provides an overview of the project from early collaboration through construction, start-up, and operation, including lessons learned and key factors that led to its success.
https://whova.com/xems/whova_backend/get_event_s3_file_api/?event_id=sopc_202003&file_url=https://d1keuthy5s86c8.cloudfront.net/static/ems/upload/files/1651185683_shodp_Craw_ocwd_ylwd_pfas_treatment_plant_webinar_presentation
*See presentation on YouTube from the OCWD:* https://www.youtube.com/watch?v=Cied_FeZnTo
*See the YLWD's website for more information:* https://www.ylwd.com/services/your-water/water-quality/pfas-and-pfoa/

### FIRST TO FIELD MASS MIXING IN-SITU STABILIZATION/SOLIDIFICATION REMEDIATION IN UNCHARTED WATERS OF KENDALL BAY
Meric, D., C. Robb, and P. Hutson. | Remediation Technologies Symposium East, 1-3 June, Niagara Falls, Ontario, 22 slides, 2022

Sediments within Kendall Bay are impacted with PAHs, total recoverable hydrocarbons, and BTEX by former MGP operations. In-situ stabilization/solidification (ISS) was selected as the remedial approach to address impacted sediments while minimizing impacts to adjacent residential areas. A multi-stage laboratory treatability study evaluated a range of cementitious reagent dosages, grout modifiers, and enhancers to achieve performance criteria. Following the treatability study, a two-phase pilot study was implemented to assess the constructability, construction approach, and field verify remedy effectiveness. A tiered validation plan was developed using multiple lines of evidence to allow pass/fail determination within 2 to 7 days from field mixing. Additional design elements consisted of quantitatively establishing a soft sediment buffer zone to mitigate excess surface water ingress to the mixing zone and associated methods to reduce mixing energy. Full-scale ISS remediation was completed in November 2020. The project is the first field implementation of ISS remediation of subaqueous sediments using mass mixing techniques. The project also demonstrated that ISS could be successfully implemented in subaqueous sediments using innovative sediment remediation technology. https://esaa.org/wp-content/uploads/2022/06/RTE22Meric.pdf

## Demonstrations / Feasibility Studies

### PILOT FIELD EVALUATION AND LABORATORY DEVELOPMENT OF CONTROLLED RELEASE TECHNOLOGIES FOR GROUNDWATER REMEDIATION
RELEASE TECHNOLOGIES FOR GROUNDWATER REMEDIATION
Carpenter, A., J. Darcy, D. Meyer, J. Haselow, M. Haselow, and W. Storm.
29th Annual David S. Snipes/Clemson Hydrogeology Symposium, 21 October, Clemson, SC, 22 minutes, 2021

Lab and pilot field deployment of RemRx™ Controlled Release Polymer (CRP) permanganate and persulfate formulations designed to mitigate contaminant rebounding were conducted at two sites. The first site is a PCE-impacted municipal site where injection-based ISCO was not permitted due to issues with daylighting. CRP Permanganate pellets were packed into slotted canisters and suspended in existing monitoring wells. Permanganate release was sustained for >1 yr after deployment and created a radius of influence between 1-7 ft in the tight clay area. At the second site, CRPs were deployed following the excavation of impacted soil at a former gas station where elevated BTEX levels in groundwater remained after UST removal. A >90% decrease in BTEX concentrations was observed in the CRP placement area. Persulfate levels remained elevated up to 1 year after deployment and were measured up to 30 ft down gradient, indicating the CRPs achieved sustained release, and release mechanisms effectively treated downgradient areas. Sulfate and an increase in oxidation-reduction potentials were detected >30 ft downgradient of CRP placement, indicating that decreases in contaminant concentration can be attributed to persulfate oxidation. Site considerations to guide future deployments of CRP. The presentation also discusses preliminary lab studies demonstrating the use of the controlled release matrices to harness the oxidative potential of percarbonate. Considerations for using RemRx CRP percarbonate for pilot field testing are also presented. https://clemson.app.box.com/s/dmck2528clod6q7gevrxfiyg0qq5b6v1/file/906258525159

### A NOVEL FORMULATION OF REAGENTS FOR IN-SITU REMEDIATION OF A COMINGLED PLUME OF METALS AND CHLORINATED SOLVENTS IN SAPROLITE AND BEDROCK AQUIFERS
Golaski, S., J. Foster, B. Hardin, P. Hicks, D. Leigh, and A. Seech.
29th Annual David S. Snipes/Clemson Hydrogeology Symposium, 21 October, Clemson, SC, 23 minutes, 2021

A bench-scale study was conducted to assess the efficacy of multiple formulations of MetaFix®, GeoForm™ ER, SDC-9™ bioaugmentation culture, and Flow-K™ to treat groundwater contaminated with PCE, TCE, cadmium, nickel, and zinc at a former metal plating facility in South Carolina. Concentrations as high as 4,900 ug/L PCE, 9,000 ug/L TCE, 130 ug/L cadmium, 2,700 ug/L nickel, and 6,900 ug/L zinc were measured. The mix of contaminants, naturally low pH of the aquifer (~4.5-5.5), and hydrogeology presented substantial remediation challenges. Based on bench testing, a blend of MetaFix I-3 (0.25% w/w), GeoForm ER (0.25% w/w), potassium bicarbonate (0.1% w/w), and SDC-9 were selected to conduct a field pilot test. The materials were emplaced at 7-depth intervals in one temporary boring using pneumatic fracturing. Performance monitoring included pH, conductivity, dissolved oxygen, oxidation-reduction potential (ORP) measurements, and VOC analyses of cadmium, nickel, and zinc. Some effects were evident 2 months after injection, with increases in pH and conductivity and decreases in dissolved oxygen, ORP, PCE, cadmium, and zinc. Five months after injection, PCE, cadmium, and nickel were below their respective MCLs. The concentration of TCE decreased by >50%, and cDCE decreased after an initial increase due to sequential dechlorination. VC has not been detected, suggesting abiotic/biogeochemical degradation of the cDCE. Full-scale implementation is planned. https://clemson.app.box.com/s/dmck2528clod6q7gevrxfiyg0qq5b6v1/file/906263992879

### CLEANUP CHLORINATED ETHENE-POLLUTED GROUNDWATER USING AN INNOVATIVE IMMOBILIZED CLOSTRIDIUM BUTYRICUM COLUMN SCHEME: A PILOT-SCALE STUDY
Lo, K.-H., C.-W. Lu, C.-C. Chien, Y.-T. Sheu, W.-H. Lin, S.-C. Chen, and C.-M. Kao.
Journal of Environmental Management 311:114836(2022)

An immobilized Clostridium butyricum (ICB) column scheme was applied to assess the efficacy of ICB in treating *cis*-DCE-polluted groundwater and characterize microbial community changes after ICB application. Three remediation wells and two monitor wells were installed within the *cis*-DCE plume. Remediation wells consisted of a 1.2-m PVC column filled with ICB beads and supplied with 20 L of slow polycolloid-releasing substrate (SPRS) for hydrogen production enhancement and primary carbon supply, respectively. Groundwater samples were analyzed for *cis*-DCE and its degradation byproducts, microbial diversity, reductive dehalogenase, and geochemical indicators. *Cis*-DCE concentrations significantly decreased within the ICB and SPRS influence zone. Following ICB injection in a well, ~98.4% of *cis*-DCE removal (initial concentration = 1.46 mg/L) was observed with ethene production after 56 days of system operation. Up to 0.72 mg/L of hydrogen was observed in remediation wells after 14 days of ICB and SPRS, corresponding with the increased population of *Dehalococcoides* spp. (*Dhc*). Results of metagenomics analyses showed an increase in (*Bacteroides*, (*Citrobacter*, and (*Desulfovibrio* populations, which significantly contributed to the reductive dechlorination of (*cis*-DCE. Applying ICB may effectively result in increased populations of (*Dhc* and RDase genes, corresponding with improved dechlorination of cis-DCE and VC. ICB and SPRS may be applied as a potential in situ remedial option to enhance the anaerobic dechlorination efficiency of chlorinated ethenes.

## Research

### NATURALLY AND BIOLOGICALLY-MEDIATED ABIOTIC TRANSFORMATION OF TCE IN LOW PERMEABILITY FORMATIONS
Wang, H., D. Freedman, and R. Yu. | 29th Annual David S. Snipes/Clemson Hydrogeology Symposium, 21 October, Clemson, SC, 15 minutes, 2021

A study was conducted to develop a protocol combining multiple lines of evidence and different tools to predict and evaluate chlorinated ethene transformation within fractured bedrock under intrinsic or enhanced conditions. Results allowed the measurement of biotic and abiotic degradation rates under the influence of matrix diffusion. Three DoD sites were selected for intact core microcosm studies using groundwater and core samples to construct the microcosms, designed to mimic in situ conditions in fractured bedrock aquifers. TCE and/or $^{14}$C-TCE were infused into the rock, along with bromide and resazurin. One end of the core simulated groundwater flow over a fracture surface. Treatments included live and unamended, live and lactate-amended, live, and lactate + sulfate amended and killed controls. Weekly, 2 mL of groundwater within the fracture zone of the microcosms was displaced with groundwater without TCE or bromide to simulate the flow of uncontaminated water over the contaminated rock matrix. Displaced groundwater was analyzed for VOCs, organic acids, and anions. Those amended with $^{14}$C-TCE were tested for $^{14}$C-labeled $CO_2$ and soluble products. Evaluation of δ13C was carried out every 3-4 months to assess degradation based on enrichment. Microcosms were operated for ~17 months for Site 1, 15 months for Site 2, and 9 months for Site 3. At the end of incubation, the microcosms were sacrificed for analysis of various parameters in sections of rock from the top, middle, and bottom. For all sites, the addition of lactate created low redox conditions and stimulated sulfate reduction, which facilitated the abiotic formation of acetylene + ethene + ethane and $^{14}$C-product accumulation. Geochemical modeling and geophysical analyses were consistent with the presence of iron minerals associated with the abiotic transformation of chlorinated ethenes.
https://clemson.app.box.com/s/dmck2528clod6q7gevrxfiyg0qq5b6v1/file/906258251977
*See SERDP project for more information:* https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Persistent-Contamination/ER-2622

### ENHANCED IN SITU SOLIDIFICATION AND STABILIZATION (ISS) BLENDS: IMPACTS OF ADDING SODIUM PERSULFATE, AND WATER CONTENT
Smith, B. | REMTECH 2021: The Remediation Technologies Symposium, Banff, AB, Canada, 13-15 October, 25 slides, 2021

Studies were conducted to evaluate the impact of different binder and sodium persulfate ratios on treating the same soil matrix by combining in situ chemical oxidation with in situ stabilization and solidification. Binders tested include Type I/II Portland cement (PC) and a blend of the same PC with blast furnace slag (BFS). These blends were varied to assess the benefit of varied binder, sodium persulfate, and moisture content on key geotechnical characteristics, including compressive strength over time, hydraulic conductivity, and volume of displaced soil (bulking) during the soil mixing application. Results showed that binder content and blend ratios can significantly impact key geotechnical design parameters. PC only and PC/BFS blends solidified at different rates, with PC-only reactors achieving a higher unconfined compressive strength (UCS) in early time points. The PC/ BFS resulted in greater UCS after 28 days. Water content had a deleterious impact on UCS, but minimal to no impact on the hydraulic conductivity. Adding low levels of sodium persulfate to the binders resulted in higher UCS than binder only and in a lower overall volume to achieve the same UCS as binder-only blends.
***Slides:*** https://esaa.org/wp-content/uploads/2021/10/RT21-BSmith.pdf
***Longer abstract:*** https://esaa.org/wp-content/uploads/2021/10/RT2021-program-Abstracts-61.pdf

### BE ALERT FOR VAPOR INTRUSION OF 1,4-DIOXANE FROM CONTAMINATED GROUNDWATER
Lin, N., L. Zhong, C. Godwin, and S. Batterman.
Science of The Total Environment 825:153713(2022)

A performance evaluation was conducted on a sensitive analytical method that uses passive sampling, automated thermal desorption, and gas chromatography/mass spectroscopy to quantify airborne 1,4-dioxane. Preliminary field measurements above a 1,4-dioxane groundwater plume were initiated. The method can also measure numerous other VOCs simultaneously. A low detection limit (0.067 $\mu g/m^3$) can quantify concentrations below health-based guidelines. The performance evaluation suggests limits to sampling times in high-humidity environments and other means to ensure good performance. The scenario analyses demonstrated potential impacts from shallow plumes, especially in flooded basements, and the need to monitor vapor intrusion of 1-4 dioxane during the flood season.

### ASSESSING LONG-TERM PERFORMANCE OF STABILIZED ZN-CONTAMINATED DREDGED SEDIMENT SLURRY TREATED WITH THE PHDVPSS METHOD
Mastoi, A.K., R. Bhanbhro, X. Chen, T.A. Fatah, and A. Mehroz.
Environmental Science and Pollution Research 29:19262-19272(2022)

Experimental work investigated the long-term efficacy of solidification/stabilization (SS) of dredged contaminated sediments (DCS) treated with a new method that uses a prefabricated horizontal drain (PHD) assisted by vacuum pressure (VP) as well as SS and is abbreviated as PHDVPSS. The DCS were treated using Portland cement (VP-PC) as a binder in the PHDVPSS method at different Zn concentration levels and compared to the cement-based SS method (SS-PC). A series of experimental tests such as unconfined compressive strength, toxicity characteristics leaching procedure, X-ray diffraction, and scanning electron microscopy in conjunction with energy-dispersive spectroscopy were performed to assess the long-term strength, leaching, and microstructural characteristics of high-water-content DCS. Results showed that the PHDVPSS method may be viable for treating high-water-content DCS at different Zn concentration levels with low cement content.

### APPLICATION OF SOLID PHASE EXTRACTION (SPE) MEDIA RODS TO ASSESS DEGREE OF NAPL ENCAPSULATION IN IN SITU DEPOSITED NAPL SEDIMENTS
Johnson, J.A., I. Mamonkina, C.E. Ruiz, D. Blue, and P.R. Schroeder.
Soil and Sediment Contamination: An International Journal 6: 756-769(2022)

This article describes a semi-quantitative method to measure the degree of encapsulation within in situ deposited NAPL (IDN) sediment using the fluorescence response from rods coated with solid phase extraction (SPE) media. The Direct Analysis in Real Time (DART®) technology was applied to measure the amount of contact between the SPE material coated on a vertical rod, and the PAHs contained in the NAPL found in the surrounding IDN sediment. Results show the magnitude of the fluorescence response correlates with the degree of encapsulation. For the single NAPL and various sediment combinations, fully (or nearly fully)-encapsulated IDN sediments produced a DART response below 15% reference emitter (%RE), whereas partially encapsulated IDN sediments produced a DART response that was generally above 30%RE and as high as several thousand %RE. This difference in fluorescence response enables DART technology to be applied as a line of evidence to determine the degree of NAPL encapsulation in an IDN sediment in field screening programs. https://www.tandfonline.com/doi/epub/10.1080/15320383.2021.2005533?needAccess=true

**TCH REMOVES PFAS FROM SOIL - BUT WHERE DOES IT GO? REMOVAL AND FATE OF PFAS DURING THERMAL SOIL REMEDIATION**
Eriksen, S. and A.S. Kruger. I AquaConSoil 2021, 15-17 June, virtual, abstract only, 2021

Thermal remediation of soil containing 195 mg/kg mixed PFAS compounds was tested at lab-scale by heating 200 g samples to 250-500°C for 8 days. Soil samples, condensate, and volatiles collected on sorbent tube were analyzed for total organic fluorine, total extractable organic fluorine, total fluorine, and 30 PFAS with and without TOP assay. Volatile PFAS compounds and decomposition products were analyzed by mass spectrometry. Heat treatment simulating thermal conductive heating remediation reduced PFAS concentrations by 99.998% at 350°C or higher. Soil treated at 350°C contained traces of PFOS (6-13 µg/kg), but all other PFAS compounds were below the detection limit of 5 µg/kg. The total organic fluorine concentration of the soil was reduced by 100 mg/kg, corresponding to the removal of all PFAS compounds. This indicated that the fluorinated material was removed from the soil rather than converted into other fluorine compounds not analyzed for. PFAS compounds recovered in condensates and sorbent tubes were short-chain PFCA precursors and accounted for 0.5% of the original PFAS content of the contaminated soil samples. The absence of PFSAs and longer chain PFCAs indicated that the remaining PFAS were thermally decomposed. Mass spectrometry of outgassing vapors identified PFBA and PFPA precursors and numerous perfluorinated degradation products using the SRI-MS technique. Results suggest thermal conductive heating is a viable solution to remediate PFAS-impacted soil.

## General News

**A REVIEW OF EXIT STRATEGIES AND SITE CLOSEOUT CHALLENGES AT NAVY CLEANUP SITES**
Zimmerman, C. and D. Nair. NAVFAC Technical Report TR-NAVFAC-EXWC-SH-2211, 29 pp, 2022

This report identifies specific milestones along the path to site closeout (SC) and an array of approaches available to develop exit strategies that support response complete (RC) and/or SC. Three Navy case studies are provided as examples of sites that have implemented successful exit strategies that resulted in SC.
https://exwc.navfac.navy.mil/Portals/88/Documents/EXWC/Restoration/er_pdfs/t2-tools/A%20REVIEW%20OF%20EXIT%20STRATEGIES%20AND%20SITE%20CLOSEOUT%20CHALLENGES%20AT%20NAVY%20CLEANUP%20SITES%20FINAL%2028

**DEVELOPMENT OF PER AND POLYFLUOROALKYL SUBSTANCES ECOLOGICAL RISK-BASED SCREENING LEVELS**
Zodrow, J.M., M. Frenchmeyer, K. Dally, E. Osborn, P. Anderson, and C. Divine.
Environmental Toxicology and Chemistry 40(3): 921-936(2021)

Risk-based screening levels (RBSLs) were developed to evaluate the potential for toxicity associated with ecological receptor exposure to PFAS. Wildlife RBSLs were developed using surrogate receptors representative of threatened and endangered species with different habitat types, feeding guilds, and trophic levels. Published uptake and toxicity data were combined with receptor exposure factors to derive RBSLs for terrestrial and aquatic wildlife for several PFAS, including PFNA, PFOS, PFOA, PFHxA, PFBS, and PFBA. Uptake information for surrogate PFAS was considered to calculate RBSLs for PFAS with toxicity data and insufficient bioaccumulation data to develop an RBSL. Both no-observed-adverse-effect level (NOAEL)- and lowest-observed-adverse effect level-based wildlife RBSLs were calculated to allow for a range of risk estimates appropriate to individual threatened and endangered species and populations of non-listed wildlife receptors, respectively. Recommended water quality RBSLs protective of aquatic life were developed for 23 PFAS based on published literature reviews, peer-reviewed aquatic toxicity studies, and the Great Lakes Initiative methodology. For wildlife receptors, NOAEL RBSLs ranged from 0.013 to 340 mg/kg for soil, 0.0014 to 370 mg/kg for sediment, and 0.000075 to 1600 mg/L for surface water. Chronic RBSLs ranged from 0.00022 to 3.4 mg/L for aquatic life. The no-observed-effect concentration screening levels ranged from 0.084 to 642 mg/kg and 1 to 50 mg/kg for terrestrial plants and soil invertebrates, respectively.

**THERMALLY ENHANCED BIOREMEDIATION: A REVIEW OF THE FUNDAMENTALS AND APPLICATIONS IN SOIL AND GROUNDWATER REMEDIATION**
QingWang, Q., S. Guo, M. Ali, X/ Song, Z. Tang, Z. Zhang, M. Zhang, and Y. Luo.
Journal of Hazardous Materials 433:128749(2022)

This article reviews the fundamentals of thermally enhanced bioremediation (TEB), including its applications in soil and groundwater remediation; temperature effects on the bioremediation of contaminants; thermal effects on the physical, chemical, and biological characteristics of soil; and the corresponding changes of contaminants bioavailability and microbial metabolic activities. Temperature increases within a suitable range can proliferate enzyme enrichment, extracellular polysaccharides, and biosurfactants production and further enhance bioremediation. The review also systematically evaluates TEB applications by utilizing traditional in situ heating technologies and renewable energy (e.g., stored aquifer thermal energy and solar energy). TEB has been applied as a biological polishing technology post thermal treatment, which can be a cost-effective method to address contaminant rebound in groundwater remediation. Future research perspectives to further improve the basic understanding and applications of TEB for the remediation of contaminated soil and groundwater are presented.

**DEVELOPING INNOVATIVE TREATMENT TECHNOLOGIES FOR PFAS-CONTAINING WASTES**
Berg, C., B. Crone, B. Gullett, M. Higuchi, M.J. Krause, P.M. Lemieux, T. Martin, E.P. Shields, E. Struble, E. Thoma, and A. Whitehill.
Journal of the Air & Waste Management Association 72(6):540-555(2022)

EPA's Office of Research and Development (ORD) commissioned the PFAS Innovative Treatment Team (PITT) to provide new perspectives on treatment and disposal of high-priority PFAS-containing wastes and complement its ongoing research efforts addressing PFAS contamination. During its six-month tenure, the team was charged with identifying and developing promising solutions to destroy PFAS. The PITT examined emerging technologies for PFAS waste treatment and selected four technologies for further investigation: mechanochemical treatment, electrochemical oxidation, gasification and pyrolysis, and supercritical water oxidation. This paper examines the four novel, non-combustion technologies or applications to treat PFAS wastes. The technologies are introduced along with their current state of development and areas for further development. This information will be useful for developers, policymakers, and facility managers facing increasing issues with disposal of PFAS wastes. https://ndep.nv.gov/uploads/documents/Berg_etal_21.pdf