COLLABORATION CONCEPTS

SRP R2RA INTERAGENCY WORKGROUP

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CONCEPTS FOR COLLABORATION SUMMARY TABLES

Section 1: Analytic Methods		
SRP Project Focus	**Relevance to EPA and ATSDR**	**Aspects and Issues to be Explored**
1. Field-portable Systems for Detection at Low Levels of Contaminants including Mixtures	Developing bioassays and biomarkers as rapid, cost-effective analytic methods for a growing range of analytes including dioxin-like compounds, endocrine disruptors, PBDEs, and triclosan	• In 2007, similar assays for dioxin-like compounds were approved for inclusion in the EPA test methods manual SW-846. • These tools are well accepted in Europe and could be very useful to EPA. • Applicable to mixtures and high-volume chemicals • Ready for field use • Reasons for EPA reluctance need to be addressed.
2. Optimizing Sampling and Statistical Analysis for Hazardous Waste Site Assessment	Developing statistical, analysis, and software tools to improve accuracy and reliability of site and exposure assessment with a focus on lead and arsenic	• Goal of reducing uncertainty and sampling costs • Relating soil concentrations to biomarkers at Tar Creek Superfund (SF) site; also at Coeur d'Alene SF site • Creating software for site assessments • Ready for field use? • Are EPA/ATSDR amenable to working with Harvard on this project?

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Section 2: Biomarkers of Exposure/Effect		
SRP Project Focus	**Relevance to EPA and ATSDR**	**Aspects and Issues to Be Explored**
3. Biomarkers of Susceptibility to Environmentally-Induced Diseases	Using genetic analysis to identify biomarkers of exposure and susceptibility to organophosphate (OP) pesticide toxicity in humans and in a developmental mouse model	• Addresses biomarkers of exposure that could be useful information for advancing risk assessment • Work with OP pesticide mixtures might inform and advance risk assessment • No SF sites listed. Could this information be used for SF site application?
4. Epidemiology of Developmental Windows, Metal Mixtures, and Neurodevelopment	Investigating neurodevelop-mental effects of exposure to arsenic, lead, and manganese mixtures	• Focuses on metal mixtures, synergistic toxicity, and children's health • Includes cohorts from the Tar Creek, OK site, and from Bangladesh and Mexico • Would this work be helpful in dealing with complex mega-sites? • Is EPA amenable to working on this project?
5. Plasma Biomarkers for Parkinsonism in Welders	Identifying biomarkers of effect and susceptibility for manganese in welders and in patient populations	• Uses a model approach that could possibly be developed for other exposure/effects endpoints • Could this be applicable to EPA risk assessment and ATSDR health assessment?

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Section 3: Remediation Enhancement		
SRP Project Focus	**Relevance to EPA and ATSDR**	**Aspects and Issues to be Explored**
6. Evaluation of Mass-Transfer and Mass-Flux Dynamics of Chlorinated Solvents to Improve Groundwater Treatment	Analyzing pump-and-treat and soil vapor extraction data to assess mass flux and improve performance of chlorinated solvent remediation of groundwater	• Technology from previous grant favored by EPA Region 1 • Resulted in 95% cost reductions ($6.5M savings) at DOE Hanford site • Seven Arizona SF sites listed • Are cost savings transferable to other sites?
7. Application of Enhanced Mitigation Methods for Groundwater Arsenic at U.S. Superfund Sites	Accelerating pump and treat remediation via increased arsenic mobilization from sediments using oxalic acid; also investigating magnetite for arsenic immobilization	• Stated that arsenic release from aquifer solids increased from 5% to 85% with oxalic acid treatment • Applied at three SF sites • Have comparative benefits been quantified/monetized? • Is the Dover, NH site an adequate alternative to Vineland?
8. Revaluation of Arsenic Fate in Contained Waste Sites to Prevent Groundwater Contamination	Developing engineered approaches using biogeochemical mineral retention processes to prevent arsenic release from solid waste	• Broad potential application to arsenic-bearing landfills • Includes ion-exchange technology for point-of-use devices • Consider RCRA and drinking water stakeholders. • How would a site be selected for application?

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Section 4: Phyto-, Bio-, and Green Remediation		
SRP Project Focus	**Relevance to EPA and ATSDR**	**Aspects and Issues to be Explored**
9. Phytoremediation to Degrade Airborne PCB Congeners from Soil and Groundwater Sources	Phytoremediation and bioremediation of airborne PCBs using switchgrass and poplar trees Includes studies on mechanisms of PCB metabolism in plants, and field work at a dredge site	• Site-specific application – East Chicago, IN near two schools • Reductive chlorination of PCBs in planted soils • Would EPA OW or the USACE be the appropriate agency? • Is this a significant remediation approach to reducing PCBs in soil and water? • Ready for site application?
10. Phytostabilization of Mine Tailings in the Southwestern United States: Plant-Soil-Microbe Interactions and Metal Speciation Dynamics	Field testing cost-effective phytostabilization of mine tailings dust containing lead and arsenic	• Positive field results suggest reduced amount of soil cover needed, thereby reducing costs. • Five SF sites in Arizona and Mexico • Results are being incorporated into the Iron King/Humboldt Smelter Site Feasibility Study by Region 9 EPA. • Is this research ready for application at other sites? Any limitations?
11. Beyond Parent Compound Disappearance in the Bioremediation of PAH-Contaminated Soil	Identifying genetic determinants in microorganisms and conditions of bioremediation of PAHs in soil to minimize generation of toxic PAH metabolites from soil microorganisms	• Applicable to former manufactured gas plant sites, which are a major category of concern • Four SF sites • Ready for implementation at sites? Can the reactor effect be scaled up for an entire site?
12. Green Remediation by Solar Energy Conversion into Electrolysis in Groundwater	Using scrap iron and solar energy to utilize electrolysis approaches for remediation of phthalates and chlorinated solvents trapped as NAPLs in karstic aquifers	• Green remediation would likely be of great interest to EPA. • No SF sites listed. Is this ready for site application? • Is this technology too complex for practical application with EPA resources and verification requirements?

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Section 5: Advancing Risk Assessment and Individual Susceptibility		
SRP Project Focus	**Relevance to EPA and ATSDR**	**Aspects and Issues to be Explored**
13. Determinants of Individual Variability in Arsenic Cytotoxicity	Using genome-wide scans to identify markers of individual susceptibility to toxic effects of arsenic exposure	• Scientific basis for applying a risk range in risk assessments and remediation decisions • Advances the knowledge of individual variability in toxic responses • Can the data be used to predict variations in susceptibility in humans?
14. Genetic Epidemiology of Neurodevelopmental Metal Toxicity	Identifying single nucleotide polymorphisms (SNPs) as biomarkers that are associated with variability in response to prenatal lead or manganese exposure on fetal growth	• Biomarkers of individual genetic susceptibility in response to exposure may inform risk assessments. • A large-scale, three-cohort coordinated study of genetic susceptibility to metal toxicity with insight into mechanisms of toxicity; includes Tar Creek cohort • Will this work have application for advancing quantitative risk assessment?
15. Genomic and Genetic Analysis of Liver and Kidney Toxicity of Trichloroethylene	Identifying potential biomarkers linked to genetic differences in metabolism and/or response following TCE and PCE exposure in a mouse model	• An example of SRP research being used in an IRIS update • Genetically based inter-individual differences in susceptibility to PCE and TCE in a mouse model • Studies inform human risk assessment with regard to TCE/PCE toxicity mechanisms and response differences • Is work applicable to other contaminants of interest to EPA and ATSDR?
16. Epidemiology, Biomarkers, and Exposure Assessment of Metals	Using genome-wide scans for genetic analysis of biomarkers of effect for mercury and arsenic exposure during development in a cohort study	• A rare molecular epidemiologic investigation of early life exposure to mercury and arsenic • Cohort study investigating the effects on birth outcomes of arsenic exposure regarding host and lifestyle factors on susceptibility • Eighteen SF sites listed; how many have ongoing fieldwork relative to susceptibility?

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Section 6: R01 Projects		
SRP Project Focus	**Relevance to EPA and ATSDR**	**Aspects and Issues to be Explored**
17. In Situ Sampling Tool for Assessing Bioavailability and Toxicity of Sediments	Novel strategy for bioavailability determination of sediment-borne contaminants using a new sampling tool	• Used to track effectiveness of two remediation approaches • Improving bioavailability assessments at low contaminant concentrations • Undergoing field studies • Testing sediments from Lake Apopka, Florida Superfund site
18. Remediation Effectiveness for Mining Sites: Hysteresis and Metal Mixtures Effect	Developing a sampler for use in water/sediment systems to facilitate assessment of bioavailable concentrations of metals	•Sampler being tested at the Central City/Clear Creek Superfund site •Sampling a metal-contaminated stream before, during, and after installation of a treatment system intended to decrease concentrations of metals •Modeling toxicity of metal mixtures in aquatic species
19. Development of Stable Isotope Based Methods to Predict Bioavailability of Hydrophobic Organic Contaminants in Sediments	Focus is to produce a range of rigorously tested methods that may be easily adopted for *ex situ* or *in situ* monitoring to evaluate the effectiveness of sediment remediation operations and predict changes in human exposure potential	•Applying methods for *ex situ* and *in situ* measurement of bioavailability of DDTs and PCBs •Working at the Palos Verdes Shelf Superfund site off the coast of Los Angeles that has undergone pilot remediation trials
20. Combining Bioavailability Assays with Modeling to Predict PCBs in Fish After Remediation	Refining sampling methods and bio-uptake measurements, and incorporating into mathematical modeling of PCB fate and bio-uptake in fish	•Uses advanced fluorescence microscopy, IR microspectroscopy, and sectioning techniques in passive sampling •Evaluating bioavailable PCBs in sediments amended with activated carbon sorbents in through laboratory mesocosm studies
21. A Real-Time Antibody-Based Field Assay to Predict Containment Bioavailability in Sediments	Evaluating, refining, and validating an automated, quantitative sensor for near real time measurement of PAHs in sediment-associated water	• Monoclonal antibody-based biosensor is to be applied at Elizabeth River, Norfolk, Virginia • Assessing effectiveness of strategies to reduce PAH tissue burdens in shellfish

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Section 7: SBIR Projects		
SRP Project Focus	**Relevance to EPA and ATSDR**	**Aspects and Issues to be Explored**
22. Enhanced Endophyte: Poplar System for Remediation of Organic Contaminants	Improved phytoremediation of TCE by poplars inoculated with endophytes that persists under field conditions; biomass from the inoculated poplars can be used as a biofuel feedstock	• Poplar trees are used to remove TCE from contaminated soils and shallow groundwater • New method reduces toxic effects of TCE on the poplars • Enhancing phytoremediation capability of poplar trees • Field testing the modified poplars
23. Field Deployable Vapor Intrusion Monitor	Developing and field testing a miniature cartridge-based sample collection method that pre-concentrates VOCs with high selectivity	• Incorporates advances in solid phase extraction, novel selective coatings for optical detection, needs minimal user expertise • Phase I successfully demonstrated the method's feasibility by sampling and detecting VOCs at low parts per billion levels. • Phase II is characterizing the device's performance at a hazardous waste site
24. Development of a High Performance Bioprocess for Eliminating 1,4-Dioxane in Water	New cost-effective water treatment technology for 1,4-dioxane with wide applicability to a range of water sources	• Currently limited options for water treatment technologies for 1,4-dioxane, and existing ones are cost prohibitive • Phase II work is based on successful Phase I technology development • Planning analysis of cost-effectiveness ("technoeconomic analysis") • Ready for testing at a contaminated site

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EXECUTIVE SUMMARY

In light of the R2RA Workgroup progress on the existing collaborative projects, SRP will be able to present candidate projects that have the potential to enhance productive collaboration between SRP researchers and EPA and ATSDR partners for their mutual benefit and to better solve environmental public health problems. Drawing from the full SRP grant portfolio, we applied an objective screening process to search the portfolio for projects using the SRP search tool, the SRP Research Briefs, and an NIEHS database of grant information. This draft document contains information about SRP research projects that hold potential for R2RA collaborative projects. These candidate projects will need to be further reviewed by the R2RA Workgroup in order to select and prioritize projects. This list is intended to facilitate decision-making; other projects not listed here that have potential could be added on request.

We then developed additional criteria to screen those research projects further. Those additional criteria included:

- Did the project indicate any time or cost comparative advantages to the current science/ technologies used?
- Has the research has been field tested, and were results positive or incorporated? Is it ready for broader application?
- Does the researcher appear to be interested in working with EPA, ATSDR, or the state and local governments?
- Does the research appear to consider how it could be applied at hazardous waste sites or other programmatic application?
- Does the research appear to have potential to be integrated into site-specific risk or health assessment work?
- Does the project have the potential for EPA and ATSDR to give feedback to scientists to help guide and/or support research by offering information about research needs or access to samples?

We screened down from an initial list of over 100 potential candidates in early rounds of selection to this final list of seventeen candidates using these criteria. We also grouped them into categories to assist in the review and screening process. We recommend that one further step be taken before the final selection of new R2RA candidates is made. That step is to contact grantees to evaluate their availability and interest in participating in this effort as well as the current state of their research and their readiness for collaboration with SRP stakeholders.

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PROJECTS DETAILS

SECTION 1: ANALYTIC METHODS

Section 1: Analytic Methods			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
1. Development and Application of Integrated *in vitro* and Cell-based Assays	Mike Denison, Isaac Pessah University of California San Diego	Detection system, bioassay, high-throughput screening, high-volume chemicals	• In 2007, similar assays for dioxin-like compounds were approved for inclusion in the EPA test methods manual SW-846. • Applicable to mixtures and high-volume chemicals • These tools are well- accepted in Europe and could be very useful to EPA. • Ready for field use • Reasons for EPA reluctance need to be addressed.
2. Optimizing Sampling and Statistical Analysis for Hazardous Waste Site Assessment	Brent Coull, Peter Toscas Harvard University School of Public Health	Sampling, biomarkers, spatial modeling	• Goal of reducing uncertainty and sampling costs • Relating soil concentrations to biomarkers at Tar Creek SF (SF) site; also at Coeur d'Alene SF site • Are the benefits of the technology significantly superior to conventional methods? • Ready for field use? • EPA amenable to working with Harvard?

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1) DEVELOPMENT AND APPLICATION OF INTEGRATED *IN VITRO* AND CELL-BASED ASSAYS

P42ES004699
UNIVERSITY OF CALIFORNIA – DAVIS (DENISON, PESSAH)

Rationale for selecting: This project is developing bioassay and biomarkers for applications to chemical detection and screening. Their work is also revealing fundamental mechanisms of toxicity as they search for bioassays to detect contaminants. This work expands on Mike Denison's work with the XDS-CALUX® bioassay system for detecting dioxin-like chemicals, and is actively expanding the number of contaminants that can be detected in environmental and biological samples. They are focusing on creating on-site portable assay systems for a large number of analytes.

- Possible applications, given their growing list of analytes, are expanding.
- Applicable to high-throughput screening and mixtures

Additional information needed:

- Have these assays been used at SF sites?
- Are there assays poised to be applicable to risk assessment?

Background information:

Grant Specific Aims: "…These systems will be integrated…to develop screens to examine and monitor environmental and high volume chemicals, mixtures, and *in vitro* to *in vivo* extrapolations."

2012 Progress Report: "The team's continued improvement in the sensitivity of the CALUX bioassays, increased validation data from screening results, increased diversity in the matrices and materials examined and the diversity in available bioassays, is greatly expanding the group's bioassay capabilities and also leading to greater acceptance of these bioassays. In fact, the estrogen receptor CALUX bioassay (referred to as the BG1Luc-ER-TA assay) was recently officially adopted by the international Organization for Economic Cooperation and Development (OECD) in OECD test guidelines TG455 and TG457 and the assay now may be used for official regulatory purposes in the 34 member countries, including the US. The U.S. EPA agreed to include the BG1Luc-ER-TA assay as an accepted method in its endocrine disruptor screening program."

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2) OPTIMIZING SAMPLING AND STATISTICAL ANALYSIS FOR HAZARDOUS WASTE SITE ASSESSMENT

P42ES016454
HARVARD UNIVERSITY SCHOOL OF PUBLIC HEALTH (COULL, TOSCAS)

Rationale for selecting:

- Applies statistical tools to combine bulk and biomarker sampling results
- "…using a spatial model-based approach, with the goal of reducing uncertainty and sampling costs"
- Creating software tools for the site-assessment community
- SF sites include Tar Creek, OK and Coeur d'Alene, OK.
- This project is one of three Harvard projects at Tar Creek in this report (Projects 2, 5, and 15); consider combining with other projects for ease in establishing a collaborative effort with EPA/ATSDR.

Additional information needed:

- Is this research ready for site application?
- Can these statistical tools be best developed in concert with EPA staff in OSRTI?
- What is new about this research on a question that has been around for a long time?
- Is EPA amenable to working with Harvard University on this?

Background information:

Project Summary: "The objective of this project is to provide statistical design and analysis tools to improve the accuracy and reliability of site and exposure assessment for SF hazardous waste sites. The approach is based on statistical modeling, along with optimal design considerations that maximize prediction accuracy while minimizing cost and accounting for practical considerations. Building on the basic spatial kriging model, the spatial model-based approach to design and analysis is compared to existing design-based approaches that do not account for spatial correlation. Researchers are extending these to complicated real-world settings, including the use of previous targeted samples and non-detect, proxy and composite samples, which may allow a reduction in sampling costs. At the megasite scale, researchers are relating soil concentrations to biomarker levels in the Tar Creek SF site, and developing spatial measurement error models for relating environmental concentrations to exposure as measured by biomarkers, thus accounting for incomplete environmental sampling. Researchers are also clarifying under what circumstances a spatial model-based approach provides real benefits in practice, reducing cost and uncertainty. To make spatial-model based methods accessible to the site-assessment community, researchers are developing software tools for use by Environmental Protection Agency (EPA) and site professionals."

SECTION 2: BIOMARKERS OF EXPOSURE/EFFECT

Section 2: Biomarkers of Exposure/Effect			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
3. Biomarkers of Susceptibility to Environmentally Induced Diseases	Clement Furlong University of Washington	Biomarkers of exposure and susceptibility; PON genes; neurodegeneration	• Addresses biomarkers of exposure that could be useful information for advancing risk assessment • Work with OP pesticide mixtures might inform and advance risk assessment • No SF sites listed. Could this information be used for SF site application?
4. Epidemiology of Developmental Windows, Metal Mixtures, and Neurodevelopment	David Bellinger, David Christiani Harvard University School of Public Health	Mixtures, children, arsenic, manganese, lead, neurodevelopment	• Focuses on metal mixtures, synergistic toxicity, and children's health • Includes cohorts from the Tar Creek, OK site, and from Bangladesh and Mexico • Would this work be helpful in dealing with complex mega-sites? • Is EPA amenable to working on this project?
5. Plasma Biomarkers for Parkinsonism in Welders	Jing Zhang University of Washington	Biomarkers of effect, metals, occupational exposure, neurodegeneration, medical diagnosis	• Uses a model approach that could be developed for other exposure/effects endpoints • Could this work be applicable to EPA risk assessment and ATSDR health assessment?

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3) BIOMARKERS OF SUSCEPTIBILITY TO ENVIRONMENTALLY-INDUCED DISEASES

P42ES004696
UNIVERSITY OF WASHINGTON (FURLONG)

Rationale for selecting for R2RA: This lab is focusing on developing biomarkers of exposure and susceptibility to organophosphate (OP) pesticides. Their work centers on the paraoxonase family of genes (PON1, PON2, and PONS). "PON1 status was found to be altered in male Parkinson's patients compared with male control subjects. The proposed studies aim to increase our knowledge of PON1, PON2 and PONS functions in determining susceptibility to environmentally-induced neurotoxicity and neurodegenerative diseases."

- Addresses biomarkers of exposure that could contribute to advancement of ATSDR health assessments or EPA risk assessments
- Work with OP pesticides mixtures references might advance risk assessment
- Deals with a real world issue – Washington State Farm workers – testing required by the State
- Creative with use of "humanized mice"

Additional information needed:

- How are the results being used? No SF sites are listed for the project. Could this be applied by EPA SF or ATSDR?
- Could SRP explore with EPA Pesticides Program if this is applicable to their work?

Background information:

From the grant abstract and specific aims: "We will expand our preliminary epidemiological studies on the relationship of PON1 status and susceptibility to OP toxicity in this cohort of Washington State agricultural workers … The quantification of OP-adducted biomarker proteins will provide an integrated index of exposure and PON1 status. This aim will also use mass spectrometry of human blood components to examine candidate biomarkers of exposure to the aircraft engine lubricant tricresyl phosphate."

"Characterize PON1 status as a biomarker of OP sensitivity during gestation using a knockout/transgenic mouse model of the human PON1 polymorphism. We will examine the effect of PON1 status on OP exposure during prenatal development using a PON1 humanized mouse model."

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4) EPIDEMIOLOGY OF DEVELOPMENTAL WINDOWS, METAL MIXTURES, AND NEURODEVELOPMENT

P42ES016454
HARVARD UNIVERSITY SCHOOL OF PUBLIC HEALTH (BELLINGER, CHRISTIANI)

Rationale for selecting:

- Metal mixtures, children's health, and mining sites are of great interest to EPA and ATSDR
- Refers to Tar Creek, OK site (as well as Bangladesh and Mexico City)
- This project is one of three Harvard projects at Tar Creek in this report (Projects 2, 5, and 15); consider combining with other projects for ease in establishing a collaborative effort with EPA/ATSDR.

Additional information needed:

- Is this research ready for site application for use as biomarkers of exposure?
- Is the EPA open to collaboration at Tar Creek?

Background information:

Grant Specific Aims: "…This project will study three cohorts of children, one in Bangladesh (where exposures are extremely high), one in Mexico City, where exposures are higher than in the U.S. but lower than in Bangladesh, and one at a U.S. SF site - Tar Creek Oklahoma, where exposures are representative of other SF sites contaminated by metals. Investigators in our program already longitudinally follow two of the cohorts (Tar Creek and Mexico) in which we are studying the effects of arsenic (As), manganese (Mn) and lead (Pb) on neurodevelopment. By adding a 3rd cohort with a similar design to those studies, we will, in this proposal, increase sample size to allow testing of 2-way and even 3 way interactions among these metals …Our Program is uniquely positioned to place mixtures research directly into the context of the EPA SF remediation and risk assessment program. As such, we can serve as a model for future programs dedicated to multidisciplinary chemical mixtures research in human populations. Exposure of children to environmental metals can lead to neurodevelopmental toxicity. While previous work has focused extensively on Pb, exposure to other environmental metals may also have neurotoxic effects. Recent research suggests that exposure to As and Mn in children is associated with lower IQ scores. …This situation is particularly critical for populations living near SF sites, particularly large "mega-sites," as the majority of mega-sites have multiple contaminants …To date, mixtures research on CNS effects has relied mostly on *in vitro* and occasionally *in vivo* models. Studies directly addressing mixed exposures in human populations are exceedingly rare, due in part to their complexity. In summary, the goal of this SBRP is to investigate the relationship between commonly encountered metal mixtures and neurodevelopmental outcome."

5) PLASMA BIOMARKERS FOR PARKINSONISM IN WELDERS

P42ES004696
UNIVERSITY OF WASHINGTON (ZHANG)

Rationale for selecting:

- If this work on plasma markers could be expanded to endpoints other than metal exposure, it might be applicable to a wide range of contaminants and be useful for ATSDR and EPA in determining exposure.

Additional information needed:

- When might results be applicable to risk assessment?

Background information:

Grant specific aims: "Clinically, differential diagnosis between parkinsonism (PS) in welders exposed to a mixture of metals, including manganese, and iPD is difficult, even in the best hands. Additionally, it remains to be investigated whether exposure to low levels of manganese or related metals contributes to the development of iPD. …Thus, biochemical markers unique to various PS in welders, particularly those useful in a routine clinical setting, are pressingly needed for differential diagnosis of underlying etiology of various PS. Also, biomarkers unique to PS progression and/or the population at risk for developing PS will be incredibly important not only for welders but also for the welding or related industries, given the enormous medical legal implications. Finally, the unique biomarkers will also be important to understanding common pathophysiology of parkinsonian disorders in order to design targeted neuroprotective and/or 'neuropreventative' therapies."

2011 Progress Report: "… To date, the researchers have measured the critically important PD proteins, α-synuclein and DJ-1, in whole blood obtained from welders both asymptomatic and symptomatic of PS. They have also compared these welder groups to non-welding controls and patients with idiopathic Parkinson's disease (iPD)… In addition to continuing work on DJ-1 isoforms as candidate biomarkers of PS, the researchers will expand their studies to include potential inflammatory biomarkers of the syndrome. They have completed general profiling experiments of these markers in blood plasma of patients with iPD, identifying several promising candidates to apply to the occupational welding cohort."

SECTION 3: REMEDIATION ENHANCEMENT

Section 3: Remediation Enhancement			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
6. Mass-Transfer and Mass-Flux Dynamics of Chlorinated Solvents in Heterogeneous Systems	Mark Brusseau University of Arizona	Site characterization, field scale, measuring mass discharge, groundwater, vapor intrusion	• Technology from previous grant favored by EPA Region 1 • Resulted in 95% cost reductions ($6.5M savings) at DOE Hanford site • Seven Arizona SF sites listed • Are cost savings substantiated?
7. Application of Enhanced Mitigation Methods for Groundwater Arsenic at U.S. Superfund Sites	Steven Chillrud Columbia University	Arsenic, pump and treat, cost savings, groundwater	• Accelerating pump and treat arsenic remediation using oxalic acid • Stated that arsenic release from aquifer solids increased from 5% to 85% with treatment • Applied at three SF sites • Have comparative benefits been quantified/monetized? • Is the Dover, NH site an adequate alternative to Vineland?
8. Role of Mineral Genesis, Dissolution, and Sorption on Arsenic Fate in Contained Waste Sites	Wendell Ela John Chorover James Farrell James A. Field A. Eduardo Saez University of Arizona	Arsenic, groundwater, drinking water, landfills	• Engineered biological and biogeochemical approaches to prevent arsenic release from solid waste • Broad potential application to arsenic bearing landfills • Includes ion-exchange technology for point-of-use devices • Consider RCRA and drinking water stakeholders • How would a site be selected for application?

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6) MASS-TRANSFER AND MASS-FLUX DYNAMICS OF CHLORINATED SOLVENTS IN HETEROGENOUS SYSTEMS

P42ES004940
UNIVERSITY OR ARIZONA (BRUSSEAU)

Rationale for selecting:

- Technology from previous grant funding period said technology to be favored by EPA Region I
- Technology resulted in 95% cost reductions ($6.5M savings) at DOES Hanford site
- New technology in current funding period at field testing level
- Seven Arizona SF sites are listed with this project

Additional information needed

- Are cost savings substantiated?
- How does EPA Region I favor this technology?
- Is the current work ready for application in the field?

2012 Progress Report: "**…** The research team is developing methods to measure mass discharge at the field scale, and applying these methods at hazardous waste field sites. One example is research being conducted at the TIAA site in Tucson, AZ, wherein researchers have performed an in-depth analysis of the long-term performance of remediation efforts at the site, and their impact on reductions in mass discharge and risk…The group has also tested an approach they have developed that uses enhanced analysis of historic pump-and-treat and soil-vapor-extraction operations data to improve the performance and closure assessments for remediation… In collaboration with scientists from Pacific Northwest National Laboratory, the research team has developed an integrated risk-based approach for assessing SVE operations. This approach involves characterizing contaminant mass discharge associated with the vadose-zone source, and its impact on groundwater or vapor intrusion, and incorporates evaluation of all exposure pathways, as mediated by transport and contaminant attenuation processes. The approach was recently applied at the Department of Energy's Hanford site in Washington. "This recent investment of $500,000 led to an effective strategy for remediation at one location that provides a cost savings of $6.35 million" (EM Technology News Flash, Nov. 29, 2012. U.S. Department of Energy, Office of Environmental Management)."

7) APPLICATION OF ENHANCED MITIGATION METHODS FOR GROUNDWATER ARSENIC AT U.S. SUPERFUND SITES

P42ES010349
COLUMBIA UNIVERSITY (CHILLRUD)

Rationale for selecting:

- Has been applied at SF sites – 3 listed – Dover Landfill, VT; Winthrop Landfill, ME; and Vineland, NJ
- Use of oxalic acid and magnetite to accelerate pump and treat remediation
- "…remediation by *in situ* immobilization might provide cheaper and more effective strategies for some portions of the site."
- "…potentially showing a way to greatly improve the efficiency of the P&T methodology currently in use at Vineland as well as other sites."

Additional information needed:

- Have the comparative benefits been quantified/ monetized?
- Time frames – refers to "… As immobilization with magnetite will be carried out in 4-5 years"?
- What would be the ramifications of no longer being involved at the Vineland site – is the Dover, NH site an adequate alternative site?

Background information:

Grant Specific Aims: "Our prior work has shown that injection of oxalic acid can enhance mobilization of As from sediments at the Vineland SF site (at laboratory to pilot field scales), potentially showing a way to greatly improve the efficiency of the P&T methodology currently in use at Vineland as well as at other sites. In this renewal application, our overall aim is to partner with site managers (EPA/USACE/NJDEP) interested in the development and application of this approach to remediate As at the site. .."

Research Brief (January 2011): "Laboratory column experiments using arsenic-contaminated aquifer solids (~80 ppm arsenic) from Vineland suggest that oxalic acid can be effective at significantly increasing arsenic mobility. Compared to 5% release when flushing with groundwater alone, >85% of the arsenic was removed from the aquifer solids with a 10 mM oxalic acid treatment. More importantly, extrapolations using these data suggest that chemical treatments could lower the Vineland SF Site cleanup time-scale from ~600 years with ambient groundwater alone to ~4 years with 10 mM oxalic acid, based on the cleanup goal of lowering the arsenic on the aquifer solids to less than 20 mg/kg."

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8) ROLE OF MINERAL GENESIS, DISSOLUTION, AND SORPTION ON ARSENIC FATE IN CONTAINED WASTE SITES

P42ES004940
UNIVERSITY OF ARIZONA (ELA, CHOROVER, FARRELL, FIELD, SAEZ)

Rationale for selecting:

- The research has broad potential application to arsenic-bearing landfills.
- Cost savings were quantified.
- Consider RCRA and drinking water stakeholders.

Additional information needed:

- Is the research ready for field application?
- How would we select a site for application?

Background information:

Project Summary: "…to develop engineered intervention approaches that utilize biological and biogeochemical mineral retention processes to minimize arsenic release from solid wastes."

Progress Report: "…A second part of Aim 3 is to develop treatment technologies focused on the use of ion exchange fibers for removing arsenic from potable water in point-of-use (POU) devices. …The mass transfer zone for Fiban A5 was less than 100 bed volumes, whereas it was on the order of 10,000 bed volumes for the commercial media. The extremely rapid mass transfer kinetics makes the sorbent particularly attractive for POU applications. Initial economics analysis indicates the amended PAN ion exchange material is approximately an order of magnitude less expensive than the commercial ion exchange materials for arsenic adsorption. …This advancement, particularly when coupled with the disposal simulation columns showing generation of another arsenic mineral, realgar, show mineralization of arsenic may provide an environmentally friendly, stable means of sequestering arsenic [in] oxygen depleted environments. In addition, the very high fast rate of adsorption of arsenic onto iron amended exchange fibers in oxygen rich environments demonstrates an, small-scale (e.g., single user) means of removing arsenic from water. This is of particular interest as a low tech, inexpensive, simple, point of use treatment device."

"…[These] Aim 4 results show that the release of arsenic and lead from mine tailings into simulated lung and gastric fluids can reach the tens to hundreds of ppm range suggesting that dust inhaled or ingested from these tailings may create a significant health hazard. The results are preliminary, but clearly indicate that further investigations are warranted."

SECTION 4: PHYTO-, BIO-, AND GREEN REMEDIATION

Section 4: Phyto-, Bio-, and Green Remediation			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
9. Phytoremediation to Degrade Airborne PCB Congeners from Soil and Groundwater Sources	John Schnoor Timothy Mattes Hans-Joaquin Lehmler University of Iowa	PCBs, site application, phyto-remediation, bioremediation, soil, water, air	• Site-specific application – East Chicago, IN near two schools • Would EPA OW or the USACE be the appropriate agency? • Is this a significant remediation approach to reducing PCBs in soil and water? • Ready for site application?
10. Phytostabilization of Mine Tailings in the Southwestern United States: Plant-Soil-Microbe Interactions and Metal Speciation Dynamics	Raina Maier John Chorover University of Arizona	Site application, mine tailings, metals, lead, arsenic, dust	• Positive field results suggest reduced amount of soil cover needed, thereby reducing cost • Five SF sites • Results are being incorporated into the Iron King/Humboldt Smelter Site Feasibility Study by Region 9 EPA. • Is this research ready for application at other sites?
11. Beyond Parent Compound Disappearance in the Bioremediation of PAH-Contaminated Soil	Mike Aitken University of North Carolina Chapel Hill	PAHs, bioremediation, toxic metabolites, PAH-metabolizing bacteria	• Applicable to former manufactured gas plant sites, which are a major category of concern • Four SF sites are associated with the project • Ready for implementation at sites?
12. Green Remediation by Solar Energy Conversion into Electrolysis in Groundwater	Akram Alshawabkeh Northeastern University	Groundwater, karstic aquifers, phthalates, chlorinated solvents, NAPLs, green remediation, solar panels	• Using scrap iron and solar energy • Green remediation likely of great interest to EPA • No SF sites listed • Is this ready for site application?

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9) PHYTOREMEDIATION TO DEGRADE AIRBORNE PCB CONGENERS FROM SOIL AND GROUNDWATER SOURCES

P42ES013661
UNIVERSITY OF IOWA (SCHNOOR, MATTES, LEHMLER)

Rationale for selecting:

- Addresses phytoremediation and bioremediation of airborne PCBs
- Has site-specific application – East Chicago, IN near two schools

Additional information needed:

- Are air-borne PCBs viewed as a health threat at SF sites?
- Would EPA OW or the USACE be the appropriate agency to apply this research?
- Is the research ready for site application?
- Is this a significant remediation approach to reducing PCBs in soil and water?
- Are they getting only lower-chlorinated, more volatile forms of PCBs that are of lower toxicity? Or are they pulling up the heavier ones into the plants?

Background information:

2012 Progress Report: "The goal of this project is to provide engineering research (non-biomedical) to determine whether plants can be used for the *in situ* bioremediation of PCB congeners from airborne sources... Phytoremediation represents a cost-effective method to intervene and decrease airborne PCB-exposure of nearby populations in the vicinity of PCB-contaminated sites. "

"…Soil microcosms planted with switchgrass and poplar plants showed that PCB congeners 52, 77, and 153 are reductively dechlorinated by rhizosphere micro organisms at a significantly higher rate than unplanted controls. A large fraction of the mass of PCB biodegraded (90-110%) was recovered as dechlorinated PCB-products, allowing transformation pathways to be elucidated. "

"… During the past year, they have added to these results by developing a novel analytical method and with the discovery PCB-sulfate metabolites in poplar. In addition, they found that LB400-bacteria in the root zone are specifically capable of degrading PCB metabolites hydroxylated on the non-chlorinated ring. These findings allow phytoremediation to be used with greater confidence and efficacy for interventions at SF sites contaminated by low-level PCBs. Contaminated commercial garden soils were successfully dechlorinated by switchgrass and poplar."

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10) PHYTOSTABILIZATION OF MINE TAILINGS IN THE SOUTHWESTERN UNITED STATES: PLANT-SOIL-MICROBE INTERACTIONS AND METAL SPECIATION DYNAMICS

P42ES004940
UNIVERSITY OF ARIZONA (MAIER, CHOROVER)

Rationale for selecting:

- Research was applied at King Mine/Humboldt Smelter site in Region 9
- Five SF sites associated with the project in Arizona and Sonora, Mexico

Additional information needed:

- Have the results been positive?
- Is this research ready for application at other sites?

Background information:

Grant Specific Aims: "… Phytostabilization is a remediation technology that results in the vegetation of mine tailings with sufficient coverage to reduce wind and water erosion. It seeks to accumulate metals in the root zone, rather than to extract them into above-ground biomass, so as to prevent metals from entering the food chain. …The overall goal of this renewal project is to determine how plant-microbe-metal interactions affect the short- and long-term requirements for, and mechanisms of, revegetation of mine tailings and to identify the biological and physico-chemical markers that indicate successful remediation. … Specific objectives include: Objective 1 Translation of phytostabilization technology from the greenhouse to the field. … Objective 2 Determine if a multi-variate, spatial analysis of initial bio-physico-chemical characteristics of mine tailings can serve as a useful predictor of phytostabilization success… Objective 3: Evaluate the progress toward development of a "healthy" soil as a function of time following revegetation of mine tailings."

2012 Progress Report: "…The Phase 1 field trial results (after three years) indicate that greenhouse results were successfully translated to the field in terms of the amount of compost required for plant establishment and in terms of the success of specific plant species. Plants are showing healthy growth in both the 15 and 20% compost treatments and it appears that the 10% compost treatment is performing better than expected. These results are being incorporated into the IKHSS site Fe asibility Study by Region 9 EPA. One implication of this work is that a 6 to 12 inch soil cover (or more) may not be necessary to establish plants on mine tailings (in this study, seeds were put directly into compost-amended tailings). The challenges of such soil covers are high cost and lack of availability of suitable amounts of soil locally."

11) BEYOND PARENT COMPOUND DISAPPEARANCE IN THE BIOREMEDIATION OF PAH-CONTAMINATED SOIL

P42ES005948
UNIVERSITY OF NORTH CAROLINA CHAPEL HILL (AITKEN)

Rationale for selecting: The work stems from Aitken's finding that PAH-contaminated soil from a former manufactured-gas plant site that was treated with *in situ* bioremediation was more genotoxic that untreated soil, with microorganisms playing a role in generating toxic metabolites.

- The research is applicable to former manufactured gas plant sites, which are a major category of concern.
- Four SF sites are associated with the project (two manufactured gas plant sites in North Carolina, Ciba-Giegy Corporation site in Alabama, and Reilly Tar & Chemical Corporation in Minnesota)

Additional information needed:

- Is this research technology ready for implementation at sites?

Background information:

Grant Specific Aims: "…We aim to identify the genetic determinants of PAH substrate ranges as a "bottom-up" approach to understanding the fate of PAHs and the potential for toxic metabolite accumulation in complex systems. We also propose a "top-down" approach to understanding toxicity in soil by studying the factors that can lead to toxicity, whether such toxicity is transient, and methods of overcoming toxicity. Both approaches will be undertaken in a remediation context with a field-contaminated soil, with an overall goal of informing field applications of bioremediation."

2012 Progress Report: "…There are two significant findings from the work conducted in 2012. First, the researchers' analyses of the PAH-degrading bacterial community in the bioreactor are providing an emerging picture that the predominant PAH-degrading bacteria in the bioreactor are not the same as those identified in the untreated soil. … The second significant finding is that, although bioremediation conditions can increase the genotoxicity of contaminated soil, the constituents responsible for genotoxicity may be less bioavailable after bioremediation. This finding has implications for the overall risk of contaminated soil before and after bioremediation."

12) GREEN REMEDIATION BY SOLAR ENERGY CONVERSION INTO ELECTROLYSIS IN GROUNDWATER

P42ES017198
NORTHEASTERN UNIVERSITY (ALSHAWABKEH)

Rationale for selecting:

- Green Remediation would likely be of great interest to EPA.
- "The project will assess power requirement and engineer a strategy that utilizes solar panels for field implementation."

Additional information needed:

- Is this ready for site application? No SF sites are listed.
- Is the use of solar panels the only green remediation facet, or are there other green aspects that would interest EPA?

Background information:

Grant Specific Aims: …"Karstic aquifers, which in geologic settings are predominated by dissolution of soluble rock such as limestone and dolomite, present dynamic pathways for exposure to phthalates and chlorinated solvents due to presence of fissures, sinkholes, underground streams, and caverns. Karstic aquifers are considered vulnerable to pollution because of lack of the filtration effect that is typically produced in alluvial aquifers. The dynamics of the solubility, flow, and exposure to phthalates and chlorinated solvents through karstic groundwater is complicated by their presence as trapped non-aqueous phase liquids (NAPLs) and their possible interactions. Innovative and affordable intervention methods are required to confront and prevent exposure to these contaminants under dynamic flow conditions. Zero valent iron (ZVI) is one of the most commonly used materials for treatment of contaminated groundwater. However, transformation by ZVI follows a single electrode redox system and requires the use iron fillings as micro/nano-sized particles, which results in uncontrolled reactivity and potential for passivation. Effective manipulation of groundwater chemical redox conditions by controlled reactivity of ZVI can lead to effective and sustainable, remediation strategies. The reactivity of iron can be controlled by using a two-electrode system that is controlled by application of low-level electric currents. In this case, cast or scrap iron can be used as rods or sheets in an electrolytic reactor. Our long-term goal is to engineer a "green" *in situ* remediation process that is based on controlled manipulation of groundwater redox through the combined use of solar energy and cast or scrap iron electrolysis. The process is considered green because it uses low-cost natural resources (solar energy and iron) without adverse impacts on the environment. "

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SECTION 5: ADVANCING RISK ASSESSMENT AND INDIVIDUAL SUSCEPTIBILITY

A sound scientific basis for applying individual variability in response to chemical insults is lacking in the SF risk assessment process. To compensate, EPA often adds an arbitrary safety factor to a perceived greater risk that might be based on limited data, or the Agency programs may require the application of the lower end of a protective risk range in making site remedial decisions. The advancement of risk assessment for environmental chemicals requires a greater understanding of individual toxic responses at the genetic level. The following SRP projects are seeking to determine the variability in individual response by studying various toxic endpoints in a range of research models and approaches.

More importantly, this work also incorporates SRP genomic research into the risk assessment process. This direction could lead to research-driven improvements in risk assessment. Identifying individual susceptibility markers could also be applied to mixtures to tease out specific effects and site-specific assessments of risk.

This R2RA research area could be viewed as a longer-tem application of the R2RA concept of enhancing risk assessment. This R2RA collaboration effort would potentially best be pursued as part of an ongoing series of R2RA-promoted discussions via conference calls, webinars, and meetings at scientific symposia.

We recommend soliciting an R2RA sub-group of SRP researchers (listed below) and committed ATSDR and EPA scientists involved in the Toxicological Profile, IRIS, health assessment, and risk assessment processes. The purpose of the discussions would be to work together to vet how the SRP cutting-edge research on individual variability could be meaningfully integrated into risk decision-making. These discussions could result in identifying where such research is sufficiently developed, and the decision-making uncertainty significant enough to be needed by environmental/public health practitioners. These discussions have the potential to develop into a longer-term, two-way effort to get feedback from EPA and ATSDR program scientists regarding how research can best achieve public health improvements. The results would also be published to promote further scientific advances in the future.

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Section 5: Advancing Risk Assessment and Individual Susceptibility			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
13. Determinants of Individual Variability in Arsenic Cytotoxicity	Walter Klimecki University of Arizona	Arsenic, susceptibility, genome-wide screening	• Scientific basis for applying a risk range in risk assessments and remediation decisions • Advances the knowledge of individual variability in toxic responses • Can responses in the LBL cell line be used to predict variations in susceptibility in humans?
14. Genetic Epidemiology of Neurodevelop-mental Metal Toxicity	David Christiani Harvard University School of Public Health	Manganese, lead, neuro-development, genome-wide screening, genetic analysis, biomarkers of effect	• A large-scale, three-cohort coordinated study of genetic susceptibility to metal toxicity with insight into mechanisms of toxicity; includes Tar Creek cohort • Biomarkers of individual variability in response to exposure may inform quantitative risk assessments. • Is this work applicable to advancing quantitative risk assessment?
15. Genomic and Genetic Analysis of Liver and Kidney Toxicity of Trichloroethylene	Ivan Rusyn University of North Carolina Chapel Hill	TCE, PCE, susceptibility,	• An example of SRP research being used in an IRIS update • Identifying biomarkers and inter-individual differences in susceptibility to PCE and TCE directly applicable to quantitative risk assessment • Is the work applicable to other contaminants of interest to EPA/ATSDR?
16. Epidemiology, Biomarkers, and Exposure Assessment of Metals	Margaret Karagas Dartmouth University	Arsenic, mercury, development, genome-wide screening, genetic analysis, biomarkers of effect	• A rare molecular epidemiologic investigation of early life exposure to mercury and arsenic • Could the genetic markers for susceptibility have application to other metals and contaminants? • Eighteen SF sites; how many have ongoing work on susceptibility?

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13) DETERMINANTS OF INDIVIDUAL VARIABILITY IN ARSENIC CYTOTOXICITY

P42ES004940)
UNIVERSITY OF ARIZONA (KLIMECKI)

Rationale for selecting: An aim of this research is to characterize the arsenic-responsive genome-wide expression patterns in a series of lymphoblastoid cell lines representing phenotypic extremes of susceptibility in arsenic-induced cytotoxicity. The research group has published their work on the identification of arsenic-induced damage to cellular proteins as a target of arsenic cytotoxicity. They are conducting groundbreaking work that identifies autophagy (a normal physiological process of cell degeneration) as an arsenic-induced response that identifies cellular proteins as primary targets of arsenic damage. The researchers believe that these findings, in the context of individual susceptibility to arsenite cytotoxicity, will reduce uncertainty in toxicological risk assessment relative to individual variability.

- This work could advance the knowledge of individual variability in toxic responses to arsenic and could perhaps be applied to other contaminants to begin the process of determining the range of variability in the population to exposure to a given contaminant.
- This would provide a more scientific basis for applying a risk range in risk assessments and remediation decisions for use by OSWER and the regions.
- This work might also be relevant to IRIS and ATSDR Tox Profiles.

Additional information needed:

- Will this work determine the variation in individual susceptibility to arsenite cytotoxicity?
- Will the findings be applicable to quantitative risk assessment?
- Are the findings in the LBL model on phenotypic extremes of susceptibility to arsenic toxicity relevant for human variations in response?

Background information:

Grant specific aims: "This proposal is aimed at identifying gene expression patterns that underlie individual differences in arsenic susceptibility and at understanding the influence of arsenic exposure level and urinary MMA on those gene expression patterns, to begin to develop an understanding of the interrelationship between important disease risk factors in arsenic-exposed humans."

2012 Progress Report: "Over the past year, the research laboratory has made great strides in addressing these questions. The group's recent publication demonstrated at both the mRNA level and the protein level that arsenite exposure in LCL engages a protective response known as the unfolded protein response (UPR)."

14) GENETIC EPIDEMIOLOGY OF NEURODEVELOPMENTAL METAL TOXICITY

P42ES016454
HARVARD UNIVERSITY SCHOOL OF PUBLIC HEALTH (CHRISTIANI)

Rationale for selecting: In this project, researchers are assessing data from three longitudinal cohort studies on metal exposure and neurodevelopment. It represents a rare large-scale coordinated study of genetic susceptibility to metal toxicity that seeks to provide biological insight into the mechanism by which metals produce toxicity. In the U.S. cohort (Tar Creek, OK) over 700 mother-infant pairs have been enrolled. Researchers are identifying genetic variants that modify neurodevelopmental effects following prenatal metal exposure. They are currently conducting genome-wide scans to identify single nucleotide polymorphisms (SNPs) that alter the response to prenatal manganese or lead exposure on fetal growth. They have found SNPs that may help predict an individual's susceptibility to environmental factors. This work may contribute to a developing body of data that documents individual variability in toxic response to a number of environmental contaminants.

- Studying three cohorts for occurrence of metal exposure and neurodevelopmental toxicity, including the Tar Creek cohort.
- Identifying genetic markers for susceptibility and could have application to a range of metals and perhaps other contaminants.
- Results could advance the application of scientific data in risk assessment and be used by OSWER, RAF, and IRIS.
- This project is one of three Harvard projects at Tar Creek in this report (Projects 2, 5, and 15); consider combining with other projects for ease in establishing a collaborative effort with EPA/ATSDR.

Additional information needed:

- Are there any data that at this point could inform risk assessment?
- Such population data may be useful at such mega sites where EPA will be involved for years to come. Would results be applicable to other lead contaminated sites?

Background information:

Project Summary: "Using a genome-wide approach, researchers discover susceptibility variants in a discovery phase, and then validate their findings in an independent sample of children while controlling for multiple comparisons....Furthermore, researchers are integrating with Dr. Quan Lu (Genetic Mechanisms of Metal Neurotoxicity) to determine other biological pathways relevant to metal toxicity using state of the art siRNA technology to identify genes/pathways which promote/inhibit metal toxicity. This project represents perhaps the first large scale coordinated study of genetic susceptibility to metal toxicity and provides biological insight into the mechanisms by which metals produce toxicity."

15) GENOMIC AND GENETIC ANALYSIS OF LIVER AND KIDNEY TOXICITY OF TRICHLOROETHYLENE

P42ES005948
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL (RUSYN)

Rationale for selecting: This project uses a panel of inbred mouse strains to investigate the relationship between inter-stain differences in TCE metabolism and kidney toxicity. The differences in metabolism provide a mechanistic basis for inter-strain differences in TCE organ-specific toxicity. The researchers aim to establish toxicokinetic and toxicodynamic genomic data in a mouse strain model useful for determining inter-individual variability. These studies also seek to identify potential biomarkers linked to genetic differences in toxicant metabolism and/or response. The results of this work will inform some of the human health assessment-relevant analyses regarding inter-individual differences in susceptibility to PCE and TCE directly applicable to quantitative risk assessment.

- This work could provide greater knowledge of the range of toxic responses to a given exposure level of contaminants, in this case, TCE, toward understanding inter-individual susceptibility.
- This project is an example of SRP research being used in IRIS update.

Additional information needed:

- Does past use of data from this project in EPA's IRIS file indicate a working relationship with EPA for developing research data useful for informing EPA and ATSDR's toxicity assessments?
- Are data from the inbred mouse model showing inter-strain differences indicative of individual human variability in organ-specific toxicity to TCE?

Background information:

2012 Progress Report: "This project is highly relevant to the overall goals of the SRP because it: (i) represents interdisciplinary (toxicology, genetics, biostatistics, pharmacokinetic modeling) research aimed at elucidating the genetic basis of dose-response and susceptibility; (ii) is concerned with a hazardous agent (and its metabolites) frequently found at SF sites; (iii) uses state-of-the-art technologies; (iv) develops new models and analysis tools for systems biology approaches; (v) identifies potential biomarkers linked to genetic differences in toxicant metabolism and/or response; and (vi) generates knowledge directly applicable to quantitative risk assessment. ... Over the last two years, the EPA released the toxicological profiles and human health assessment information on TCE and PERC through its Integrated Risk Information System (IRIS), a critical source of mechanistic and quantitative data for SF and other hazardous waste sites. The work conducted by our project in previous funding cycle has been used in these documents for both mode of action analysis and species comparisons of TCE metabolism. Work that is performed now is addressing several critical gaps that remain."

16) EPIDEMIOLOGY, BIOMARKERS, AND EXPOSURE ASSESSMENT OF METALS

P42ES007373
DARTMOUTH UNIVERSITY (KARAGAS)

Rationale for selecting: A major component of the study is a prospective pregnancy cohort study in humans with 1,000 mother-infant pairs that will investigate the effects of arsenic and other exposures on birth outcomes and whether lifestyle or host factors influence susceptibility to these factors. The researchers will focus their efforts on determining the optimal ways to measure exposures during pregnancy. They seek to leverage the generated data and samples to conduct collaborative studies of early biologic response markers that may be indicative of genetic susceptibility of disease and risk of adverse birth outcomes. This study represents a rare molecular epidemiologic investigation of early life exposure to mercury and arsenic. The goal is to inform risk assessment and management of toxic metal exposure in the United States.

- This project addresses prenatal arsenic and mercury exposure and individual variation in effects. EPA's IRIS, Air Program, OSWER, and RAF as well as ATSDR are interested in early-life exposures to environmental chemicals.
- Developing biomarkers as a tool for exposure assessment
- Over eighteen SF sites in New Hampshire, and the Elizabeth Mine site in Vermont
- Goal is to inform science-based risk assessment
- Discuss with EPA and ATSDR the possible implications for IRIS, Toxicological Profiles, and children's health.

Additional information needed:

- Does the data collected so far provide enough information to inform risk assessments?
- Will the cohort data on genetic susceptibility show individual variations in the toxic response to levels of arsenic exposure?

Background information:
Project Summary: "The goal is to provide the very best science that can be used for more effective science-based risk assessments, for predicting the specific patho-physiological consequences of arsenic and mercury exposure, for assessing gene-environment, agent-agent, and other complex environmental interactions, for assessing specifically sensitive sub-populations at elevated risk, and for developing effective interventions for these exposed populations."

2012 Progress Report: "The project remains committed to outreach to the community, and to translation to policy makers and regulators in the U.S. and globally."

SECTION 6: R01 REMEDIATION PROJECTS

Section 6: R01 Remediation Projects			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
17. In Situ Sampling Tool for Assessing Bioavailability and Toxicity of Sediments	Rolf Halden, Arizona State University Nancy Denslow, University of Florida	p,p'-DDE, dieldrin, fipronil, triclosan, triclocarban, bioavailability	• Improving bioavailability assessments at low contaminant concentrations • Undergoing field studies • Testing sediments from Lake Apopka, Florida Superfund site
18. Remediation Effectiveness for Mining Sites: Hysteresis and Metal Mixtures Effect	James Ranville, Colorado School of Mines Jim Shine, Harvard University	Metal mixtures, water, sediments, sampling device, bioavailability	•Developing a sampler for use in water/sediment systems to facilitate assessment of bioavailable concentrations of metals •Sampler being tested at the Central City/Clear Creek Superfund site •Modeling toxicity of metal mixtures in aquatic species
19. Development of Stable Isotope Based Methods to Predict Bioavailability of Hydrophobic Organic Contaminants in Sediments	Jay Gan University of California, Riverside	DDT, PCBs, PAHs, dioxins, bioavailability, bioaccessibility, sediments, exposures via fish consumption	•Applying methods for *ex situ* and *in situ* measurement of bioavailability of DDTs and PCBs •Working at the Palos Verdes Shelf Superfund site off the coast of Los Angeles that has undergone pilot remediation trials
20. Combining Bioavailability Assays with Modeling to Predict PCBs in Fish After Remediation	Upal Ghosh University of Maryland, Baltimore County	PCBs, bio-uptake in fish, bioavailability, sampling methods, PCB fate and bioaccumulation modeling	Uses advanced fluorescence microscopy, IR microspectroscopy, and sectioning techniques to measure the diffusion of organic molecules in commonly used passive sampler materials

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Section 6: R01 Remediation Projects (continued)			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
21. A Real-Time Antibody-Based Field Assay to Predict Containment Bioavailability in Sediments	Michael Unger, Steve Kaattari, and Wolfgang Vogelbein Virginia Institute of Marine Science	PAHs, bioaccumulation, biosensor, field assay, sediment-associated water	• Monoclonal antibody-based biosensor is to be applied at Elizabeth River, Norfolk, Virginia • Assessing effectiveness of strategies to reduce PAH tissue burdens in shellfish

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17) IN SITU SAMPLING TOOL FOR ASSESSING BIOAVAILABILITY AND TOXICITY OF SEDIMENTS

R01ES20889
UNIVERSITY OF FLORIDA (HALDEN AND DENSLOW)

Rationale for selecting:

- New device allows simultaneous determination of contaminant levels in bulk water and pore water at hitherto unattainably low method detection limits (MDLs)
- Undergoing field studies
- Testing sediments from Lake Apopka, Florida Superfund site

Follow up questions that need to be addressed with SRP and the grantee:

- How does the time and cost for testing compare to existing technologies?

Project Summary: "This project introduces a novel strategy for bioavailability determination of sediment-borne contaminants featuring a wide range of chemical structures, properties, and physical-chemical behaviors. …The *in situ* sampling/bioavailability determination (IS2B) tool is a novel, patent-pending device enabling simultaneous determination of contaminant levels in bulk water and pore water at hitherto unattainably low method detection limits (MDLs). …the IS2B tool provides ultra-low MDLs for a broad spectrum of contaminants, ranging from fully water-soluble to highly sorptive. This functionality distinguishes the device from presently available passive sampling strategies.

…Laboratory and field studies are being conducted with contaminated sediments from Lake Apopka, home to one of Florida's various Superfund sites. To illustrate the breadth of IS2B applicability, this research concentrates on two traditional and three emerging sediment contaminants (p,p';-DDE and dieldrin versus fipronil, triclosan, and triclocarban).

…Biological responses to contaminant exposure is also being measured in fish using DNA microarray analysis to evaluate effects that may not be predicted solely based on body burden of parent compounds. Mathematical relationships between pollutant concentrations in bulk water, pore water, worms, and fish are being formulated from theory and lab data, and applied to IS2B-derived data to predict risk and track the effectiveness of two remediation approaches (granular activated carbon [GAC] amendment and deep tilling of contaminated sediment)."

18) REMEDIATION EFFECTIVENESS FOR MINING SITES: HYSTERESIS AND METAL MIXTURES EFFECT

R01ES20917
COLORADO SCHOOL OF MINES (RANVILLE)

Rationale for selecting:

- Developing a sampler for use in water/sediment systems to facilitate assessment of bioavailable concentrations of metals
- Sampler being tested at the Central City/Clear Creek Superfund site
- Modeling toxicity of metal mixtures in aquatic species
- Researchers have been reaching out to local stakeholders and EPA scientists.

Follow up questions that need to be addressed with SRP and the grantee

- Does the new device reduce costs of bioavailability assessments?

Project Summary: "…Dr. James Ranville's long-term objective is to … improve the ability to measure, understand, and predict bioavailability and toxicity of metal mixtures arising from environmental contamination. Dr. Ranville will address three specific aims in this research.

First, he is solving a major challenge in analytical measurement of metal bioavailability by developing the "gellyfish" sampler to obtain free metal concentrations in water/sediment systems. Experiments are being performed both in the laboratory and in field deployments of the sampler at the Central City/Clear Creek Superfund site.

Second, he is further developing a model of the toxicity of metal mixtures to individual species of aquatic organisms based on a mixed-metal, multi-site biotic ligand model (MMMS BLM).

…The third objective is to integrate the procedures and information gained from the first two objectives with measurements of more complex effects of metal mixtures on aquatic communities exposed to mixtures in stream microcosms set up in the laboratory.

Dr. Ranville is also conducting a "natural experiment" in a metal-contaminated stream and examining responses before, during, and after installation of a treatment system that will decrease concentrations of the metals…."

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19) DEVELOPMENT OF STABLE ISOTOPE BASED METHODS TO PREDICT BIOAVAILABILITY OF HYDROPHOBIC ORGANIC CONTAMINANTS IN SEDIMENTS

R01ES20921
UNIVERSITY OF CALIFORNIA RIVERSIDE (GAN)

Rationale for selecting:

- Applying methods for *ex situ* and *in situ* measurement of bioavailability of DDTs and PCBs
- Working at the Palos Verdes Shelf Superfund site off the coast of Los Angeles that has undergone pilot remediation trials

Follow up questions that need to be addressed with SRP and the grantee

- Is this method ready for testing at other sites?

Project Summary: "… In particular, bioavailability is a key to better assessing human exposure to hydrophobic organic contaminants (HOCs) such as DDT, PCBs, PAHs and dioxins through consumption of fish from contaminated areas. However, current methods for determining sediment HOC bioavailability suffer from method-specific limitations. Partial extraction techniques to estimate bioaccessibility are invariably influenced by types of extractants and extraction conditions selected. Passive samplers, including solid phase microextraction (SPME), must be used under equilibrium conditions that may take months to reach.

In this project, Dr. Jay Gan is exploiting the wide availability of stable isotope labeled HOC compounds and GC-MS systems in two novel applications aiming to greatly improve the efficiency and accuracy of bioavailability measurement. The first approach uses the concept of isotope exchange (or dilution), similar to what has been done for trace elements, to derive the exchangeable concentration as an approximation of bioaccessible concentration. …In the second approach, Dr. Gan is incorporating stable isotope labeled HOCs with SPME by using the labeled HOCs as performance reference compounds so that SPME may be used under non-equilibrium conditions with short sampling time. The isotope exchange approach may be applied to *ex situ* assessment while the stable isotope-SPME method may be used for both *ex situ* and *in situ* measurements.

Dr. Gan is carrying out systematic studies … and then applying the methods for *ex situ* and *in situ* measurement of bioavailability of DDTs and PCBs at the Palos Verdes Shelf Superfund site off the coast of Los Angeles that has undergone pilot remediation trials and is scheduled for sand capping in 2012. At the end of this project, Dr. Gan expects to produce a range of rigorously tested methods that may be easily adopted for *ex situ* or *in situ* monitoring of sediment remediation sites to evaluate the effectiveness of remediation operations and predict changes in human exposure potential."

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20) COMBINING BIOAVAILABILITY ASSAYS WITH MODELING TO PREDICT PCBS IN FISH AFTER REMEDIATION

R01ES20941
UNIVERSITY OF MARYLAND – BALTIMORE COUNTY (GHOSH)

Rationale for selecting:

- Refining sampling methods and bio-uptake measurements, and incorporating into mathematical modeling of PCB fate and bio-uptake in fish
- Uses advanced fluorescence microscopy, IR microspectroscopy, and sectioning techniques to measure the diffusion of organic molecules in commonly used passive sampler materials

Follow up questions that need to be addressed with SRP and the grantee

- How does the new methodology compare to existing methodology in regards to field deployability and cost?

Project Summary: "Ecological and human health impacts of bioaccumulative contaminants like PCBs are primarily manifested through accumulation of the toxic compounds in higher trophic level organisms like fish that are consumed by humans and top predators in the ecosystem. However, changes in fish are slow to manifest as a consequence of a remedial action and often one has to wait for several years to see such change. To make timely assessments of remediation progress, one alternative is to perform appropriate measurements that indicate changes in key pathways of exposure to fish. …This proposed research project will refine sampling methods to assess PCB uptake pathways and work with practitioners to incorporate such measures into PCB fate and bio-uptake models to assess changes in fish concentration over time, and validate the approach through controlled laboratory exposure studies and measurements in the field. The three primary aims of this project are:

1. **Develop the fundamental basis of passive sampling.** This research uses advanced fluorescence microscopy, IR microspectroscopy, and sectioning techniques to directly measure the diffusion of organic molecules in commonly used passive sampler materials…

2. **Use passive sampling to measure bioavailability processes and uptake in fish.** Ghosh is evaluating how sediments amended with activated carbon sorbents in the field impact PCB bio-uptake in two types of fish through controlled laboratory mesocosm studies and compare with uptake in passive sampling devices developed under Aim 1.

3. **Incorporate passive sampling inputs to PCB fate and bioaccumulation model.** A mathematical model is under development and will be used to interpret results from: 1) the mesocosm exposure experiments, and 2) field observations from a PCB-impacted river site to explore the effect of activated carbon treatments on PCB accumulation in fish. Of particular interest is improving the accuracy of model predictions of the benefits of *in situ* treatment with activated carbon aimed at reducing pore water concentrations and contaminant bioavailability.

21) A REAL-TIME ANTIBODY-BASED FIELD ASSAY TO PREDICT CONTAINMENT BIOAVAILABILITY IN SEDIMENTS

R01ES20949
VIRGINIA INSTITUTE OF MARINE SCIENCE (UNGER, KAATTARI, VOGELBEIN)

Rationale for selecting:

- Monoclonal antibody-based biosensor is to be applied at Elizabeth River, Norfolk, Virginia
- Assessing effectiveness of strategies to reduce PAH tissue burdens in shellfish
- Field testing underway
- Two sites were selected as control sites and four sites were selected based on known PAH contamination issues including the Atlantic Wood Industries Superfund site that is undergoing remediation. Two of the sites are currently under review by EPA for potential Superfund listing in the future.
- Remediation managers have been involved for site selection and sampling station placement.

Follow up questions that need to be addressed with SRP and the grantee

- Are there any cost-related benefits to using the new biosensor?

Project Summary: "Dr. Unger's research uses newly developed biosensor technology to rapidly predict how polycyclic aromatic hydrocarbons (PAH) accumulate in seafood exposed to contaminated sediments. Hydrophobic contaminants such as PAH readily accumulate in shellfish, where they pose a significant human health risk when consumed. …However, temporal variability and heterogeneity of natural habitats make it difficult to reliably predict bioaccumulation for risk assessments from measured sediment concentrations. Ultimately, site-specific measurements are vital to accurately predict contaminant bioavailability and to evaluate the effectiveness of sediment remediation efforts.

Recent advances in biosensor technology now allow near real-time measurement of contaminants at sub part per billion concentrations. Dr. Unger is evaluating, refining, and validating an automated, quantitative, monoclonal antibody-based sensor to measure PAH in sediment-associated water. He is also validating the biosensor as a predictor of PAH tissue burdens in shellfish, an important route for PAH exposure to humans from contaminated sediments. This is being accomplished through controlled laboratory dosing of oysters. The biosensor will be then be applied in the highly contaminated Elizabeth River, Norfolk, Virginia to assess the effectiveness of ongoing remediation strategies being employed to reduce the human health risks associated with PAH exposure through the food web."

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SECTION 7: SBIR REMEDIATION PROJECTS

Section 4: Phyto-, Bio-, and Green Remediation			
SRP Project Name	**Investigator/School**	**Keywords**	**Comments/Questions**
22. Enhanced Endophyte: Poplar System for Remediation of Organic Contaminants	Michaeld Blaylock, Mark Elless Edenspace Systems Corporation	TCE, phytoremediation, bioremediation, poplar trees	• Modifying poplars with endophytes to enhance the phytoremediation capability of poplar trees • Field testing the modified poplars • Potential to produce biofuel feedstock
23. Field Deployable Vapor Intrusion Monitor	Bikas Vaidya Lynntech, Inc.	VOCs, selective sampling device, vapor intrusion, portable spectrometers	• Developed a miniature cartridge-based sample collection method that pre-concentrates VOCs with high selectivity • Incorporates advances in solid phase extraction, novel selective coatings for optical detection, needs minimal user expertise • Phase I successfully demonstrated the method's feasibility by sampling and detecting VOCs at low parts per billion levels. • Phase II is characterizing the device's performance at a hazardous waste site
24. Development of a High Performance Bioprocess for Eliminating 1,4-Dioxane in Water	Joseph Salanitro Microvi Biotechnologies	1,4-dioxane, drinking water, water treatment, cost analysis	• Currently limited options for water treatment technologies for 1,4-dioxane, and existing ones are cost prohibitive • Phase II work is based on successful Phase I technology development • Planning analysis of cost-effectiveness ("technoeconomic analysis") • Ready for testing at a contaminated site

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22) ENHANCED ENDOPHYTE: POPLAR SYSTEM FOR REMEDIATION OF ORGANIC CONTAMINANTS

R43ES20099
EDENSPACE SYSTEMS CORPORATION (BLAYLOCK, ELLESS)

Rationale for selecting:

- Modifying poplars to enhance the phytoremediation capability of poplar trees
- Field testing the modified poplars
- Poplars developed in this project has potential to produce biofuels

Follow up questions that need to be addressed with SRP and the grantee

- Is the modified poplar phytoremediation method ready for testing at other sites?

Project Summary: "Edenspace Systems Corporation, in collaboration with Dr. Sharon Doty's research group at the University of Washington (UW), is developing a novel phytoremediation technology to address environmental contamination by organic pollutants. Phytoremediation with poplar trees has been utilized for over a decade to extract contaminants such as trichloroethylene (TCE) from contaminated soils and shallow groundwater. The high rate of transpiration in poplar allows the trees to remove water-soluble contaminants such as TCE from the environment. TCE, however, is toxic to poplar, reducing growth, and is readily volatilized through evapotranspiration to precipitate in another location.

Through the use of endophytic fungi and bacteria that associate with poplar and are capable of metabolizing TCE, Edenspace and UW are developing an innovative plant-based remediation system that will degrade the organic contaminant *in planta*, reducing both the toxicity to the plant and the amount released aerially through transpiration while also enabling the microbes to act on subsurface contamination through the tree's deep (>5m) root system. A single mature tree is expected to process over one hundred liters of water per day.

In Phase I of this project the researchers are: 1) Demonstrating improved degradation of TCE by the poplar inoculated with endophytes compared to un-inoculated… 2) Demonstrating the endophytes that provide phytoremediation benefits persist in the inoculated poplar under field conditions. …3) Demonstrating the biomass from the inoculated poplar used for phytoremediation can be used as a biofuel feedstock as efficiently as poplar biomass grown in clean soil."

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23) FIELD DEPLOYABLE VAPOR INTRUSION MONITOR

R44ES21625
LYNNTECH, INC. (VAIDYA)

Rationale for selecting:

- Developed a miniature cartridge-based sample collection method that pre-concentrates VOCs with high selectivity
- Incorporates advances in solid phase extraction, novel selective coatings for optical detection, needs minimal user expertise
- Phase I successfully demonstrated the method's feasibility by sampling and detecting VOCs at low parts per billion levels.
- Phase II is characterizing the device's performance at a hazardous waste site.

Follow up questions that need to be addressed with SRP and the grantee

- Is this technology cost-effective in comparison to existing technologies?

Project Summary: "…This project concerns development of a miniature cartridge-based sample collection method that pre-concentrates VOCs with high selectivity. The approach incorporates advances in solid phase extraction, exploits novel selective coatings for optical detection, needs minimal user expertise, and operates without reagents, solvents or carrier gas. The sample collection method is being integrated with existing portable spectrometers, thereby providing a means to unambiguously identify VOCs at low concentrations in a highly portable format. Devices with exactly these characteristics are needed by regulators but are not available commercially.

The Phase I study successfully demonstrated the method's feasibility by sampling and detecting chlorinated VOCs (chlorinated aliphatic hydrocarbons) at low parts per billion levels. …As part of the Phase II study, Lynntech, Inc. is better understanding the capabilities of key components used for selective sampling and addressing methods needed for assembly of a functional device. Lynntech, Inc. is also characterizing the device's performance at a hazardous waste site."

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24) DEVELOPMENT OF A HIGH PERFORMANCE BIOPROCESS FOR ELIMINATING 1,4-DIOXANE IN WATER

R44ES022123
MICROVI BIOTECHNOLOGIES (SALANITRO)

Rationale for selecting:

- Dangerous levels of 1,4-dioxane in water being found across the U.S.
- Current water technologies cost prohibitive and limited options
- Phase II work is based on successful Phase I technology development
- Planning analysis of cost-effectiveness ("technoeconomic analysis")
- Ready for testing at a contaminated site

Follow up questions that need to be addressed with SRP and the grantee

- At what scale has the technology been successfully tested?
- At what site is it planned to be tested?

Abstract
"…There are only two current routes of eliminating 1,4-dioxane in water: UV or hydrogen peroxide coupled with ozone oxidation (i.e. advanced oxidation), and biological degradation. The energy and chemical costs of UV and chemical oxidation processes are often prohibitively high. There is also a significant risk of producing harmful by-products (such as carcinogenic bromate) and these technologies have limited applicability in certain circumstances such as high levels of inorganic salts.

…In Phase I, a technology was designed and tested for 1,4-dioxane degradation that does not require pre-induction and can be applied using a new high performance bioprocess. The prototype developed in the Phase I work will be scaled and piloted at an actual contaminated site. The pilot will seek to establish performance and operational parameters of the new technology, evaluate long-term and sustainable operation, and address parameters informing a technoeconomic analysis. The major outcome of this Phase II effort will be the demonstration and full characterization of a first-of-its-kind high performance bioprocess for eliminating 1,4-dioxane in water resources.

The technology's intended value proposition includes simple operation, rapid and effective degradation, wide applicability to a range of water sources, reliable performance, and lower overall costs compared to existing methods, especially chemical oxidation. Most importantly, the Phase II funding will provide a valuable tool for protecting and remediating drinking water supplies, thus safeguarding public and safety, and environmental sustainability for generations to come. "

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METHODOLOGY

The goal of this analysis was to screen the SRP research portfolio to identify SRP-funded research projects that have greatest potential for applicability to the R2RA Workgroup. We searched: 1) the SaRPS Grant Coding Database that lists grants that were active in FY2012, and 2) all SRP Research Briefs dating back to 1997. We reviewed the initial list of possible candidate research projects and identified those SRP grants most relevant to R2RA.

Searching Grants

The SaRPS Grant Coding Database is a new NIEHS resource that contains detailed information about all DERT-funded grants including experimental design, exposure agents, exposure parameters, research subjects, and environmental science approaches.

We generated a Quick Find Report in Excel that contained all coded information as well as the abstracts and specific aims from all DERT-funded grants in the database. Using this report, we searched for candidate SRP grants using filters within Excel to find potential grants that contained relevant key words in the specific aims. We chose to search the specific aims because this text contains the most detailed description of the research project. Search terms are described in Table 1.

Table 1: Text search terms and Max QDA color-coding for review[1]

Contaminants	Arsenic, lead, PCBs, mixture
Media	Soil, drinking water, groundwater, water
Tools	Technology, sampling, biomarkers, risk, risk assessment, engineer, bioavailability, nanotechnology
Traits	Blood, Tribal, Indian, environmental justice, human
Remediation	Remediation, *in situ*, site, Superfund, phytoremediation, bioremediation, field testing, field studies
Cost Savings	Cost, saving, $, efficient, translation, implementation, faster, months, years

[1]**Note:** Terms listed in the table are base words, and the search included possible stem words from the base words. For example, "remediation" included "remedial and remediate."

Searching Research Briefs

We used the same key words to search through all Research Briefs, dating back to 1997, first using the SRP search tool using key terms to find candidates, and then using a full report of all SRP Research Briefs for further analysis. The SRP Research Briefs are published to a dynamic, database-driven website; the full text of each article is stored in an Oracle database. We retrieved the full text of each research brief and some additional descriptive information, such as the publication date and associated projects.

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Color-coding Text for Review

For all potential grants and Research Briefs, we ran project description text through a qualitative data analysis program called MaxQDA (VERBI GmbH; Berlin, Germany). This program enables color-coding of selected keywords in the text to increase efficiency of text review. The colors of the column headings in Table 2 are the colors used to highlight related terms in the text. Highlighting key terms greatly increases the efficiency of reviewer scanning of the text, allowing rapid assessment of key parameters without a need to read every word of text. We then reviewed the color-coded reports and selected "Recommended Projects" and "Potential Projects." Given that all search results generated **>400 pages of text**, this step was crucial to making this process thorough and efficient.

Criteria

We used the following criteria when assessing projects as possible R2RA candidates:

- Did the project indicate any time or cost comparative advantages to the current science/ technologies used?
- Is there an indication that the research has been field-tested, results were positive or incorporated, and is ready for broader application?
- Does the researcher appear to be interested in working with EPA, ATSDR, or the state and local government offices?
- Does the research appear to have considered how it could be applied at hazardous waste sites or other programmatic application?
- Does the research appear to have potential to be integrated into site-specific risk or health assessment work?

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