Project Number & Title
3.61 - Contaminated Sites

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Project Period
October 1, 2015 (from FY16) to September 30, 2019 (through FY 19)

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Project Summary

SHC Project 3.61 emphasizes research and technical support activities and products to characterize and clean up contaminated sites. This project supports the Agency by providing the scientific foundation and technical knowledge for those who engage in Office of Land and Emergency Management (OLEM)-specific site cleanups and community engagement. Technical support activities will focus on assistance the Office of Research and Development (ORD) provides to OLEM and the Regions in order to characterize and clean up contaminated sites. Technology transfer products will be developed to support remedial project managers and other site management personnel, who then engage communities through the specified procedures. Research activities will address how contamination, from single or multiple sources, can be effectively characterized and optimally remediated to protect community public health and their resources and beneficial uses, and for revitalization and reuse of these sites. Results from this research will provide new and improved methods for characterizing and remediating contaminated ground water, vapors, soils, and sediments to improve community public health and their resources and facilitate revitalization. Research will also address community water supply issues, including environmental justice concerns; providing tools to determine the temporal and spatial impacts of contaminated sites on community public health, including impacts to community drinking water quality and quantity from contaminated ground water, soils, and sediments, and the revitalization and reuse of these sites. A more holistic assessment of community water supplies, one that combines elements of the environment, society, and economy, can be completed by linking predictive tools to mapping-assessments, aquifer vulnerability assessments, water well locations, and economic analyses. This effort will build on previous contaminated sites research and will involve the assessment of metrics for remediation, restoration, and revitalization, in a context of potential spatial and temporal changes due to various factors including climate change.

Project Description

Problem and Decision Context

Contaminated groundwater is found at 80% of Superfund sites and clean up can take decades to complete. Clean up of contaminated sites is part of EPA's Fiscal Year 2014-2018 Strategic Plan Goal 3: "Cleaning Up Communities and Advancing Sustainable Development"[1]. Because of the reliance on aquifers for drinking water, the Superfund program seeks to prevent human exposure to contaminants and to try to ensure that ground water quality meets federal and state drinking water standards[2]. As the need for drinking water increases due to population increase, exacerbated by potential cycles of weather extremes due to climate change,

[1] Fiscal Year 2014-2018 EPA Strategic Plan, April 10, 2014, United States Environmental Protection Agency, Washington, DC. Goal 3: Cleaning Up Communities and Advancing Sustainable Development. Clean up communities, advance sustainable development, and protect disproportionately impacted low-income and minority communities. Prevent releases of harmful substances and clean up and restore contaminated areas. Objective 3.3: Restore Land. Prepare for and respond to accidental or intentional releases of contaminants and clean up and restore polluted sites for reuse.

[2] http://www.epa.gov/superfund/health/conmedia/gwdocs/brochure.htm.

contaminated ground water may directly impact people drinking from private wells, limit water supply in some locations, or it may constrain community choices of water supply. Subsurface contamination can be the source of volatile contaminants that enter residences or businesses, also known as vapor intrusion. People may then be subject to inhalation exposure to hazardous pollutants. Discharge of contaminated ground water to surface water bodies may increase contaminant loadings to sediments and to surface water. Superfund sites with contaminated sediments present a risk to surface water and can be a factor in the degradation of beneficial uses through human and ecosystem impairments (for example, fish-consumption advisories). A few contaminated sediment sites are mega-sites where the sediment remedy cost may exceed $50 million[3]. In some cases, ground water/surface water interactions are the mechanism for contaminating surface waters from contaminated sediments. The Federal Brownfields Revitalization Act[4], signed in 2002, was enacted to promote clean up and revitalization of Brownfields. Brownfields are often multimedia challenges with ground water, surface water, soil, and sediment issues.

Health and ecosystem impacts from contaminated ground water, vapor intrusion, and contaminated soils and sediments continue to be reported by the news media. Recently publicized impacts from contaminated sites include negative health impacts from drinking private well water, restrictions on use of ground water for community supplies, vapor intrusion-caused abandonment of office space and legal action over exposure to school children, and contaminated sediments as a cause of fish consumption advisories.

Because of the potential impacts to human health and the environment, the high cost of remediation, the need to support brownfields revitalization, and the impact to community water supplies, this Contaminated Sites research project includes multiple components that 1) provide technical support; 2) conduct research on characterization, remediation and site management; and 3) conduct research on spatial and temporal impacts on community water supplies. Products from these first two areas facilitate Superfund site decision makers through site-specific technical support; and generalized research on hazardous waste site characterization, remediation and site management. The results of this work also supports decision makers at RCRA sites, Brownfields sites, and Great Lakes National Program Office delisting activities with technical products that address assessment and remediation that might be necessary for restoration and revitalization. Products from the third focus area facilitate community decisions on water supplies with respect to Brownfields and Environmental Justice concerns.

Outputs

The Contaminated Sites project is designed to produce products that contribute to five SHC outputs.

[3] http://www.epa.gov/superfund/health/conmedia/sediment/index.htm

[4]Small Business Liability Relief and Brownfields Revitalization Act, 115 STAT. 2356.

- 3.61.1 Lessons learned from ORD's Technical Support to Superfund and other contaminated sites
- 3.61.2 Incremental report on lessons learned from ORD's Technical Support to Superfund and other contaminated sites
- 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- 3.61.4 Strategies for integrated management of contaminated sites
- 3.61.5 Tools for evaluating temporal and spatial impacts of contaminated sites on public health and the environment, for use in site remediation, restoration and revitalization decisions

Focus Areas

With assistance from the SHC National Program Team, the Contaminated Sites Project Team coordinated with designated staff from OLEM in order to better understand the priorities and needs of this key SHC customer. OLEM staff were engaged through a variety of methods (the SHC Communique, meetings with writing team members, conference calls, and opportunities to review and comment on draft documents). This process of engagement has allowed a greater amount of customer input into the planning process and allowed the project team to better align research and technical assistance activities and key products with customer priorities. Project research and technical support activities are described in the following three focus areas:

1) Technical Support for Contaminated Sites
2) Research on Site Characterization, Remediation, and Management, and
3) Research on Temporal and Spatial Impacts of Contaminated Ground Water - Site Reuse and Revitalization

The exchange of information and ideas between OLEM and the Contaminated Sites Project Team will continue through the project charter development phase. Engagement will also continue throughout the life of the project in order to discuss ongoing research and technical support activities, vet new research and assistance ideas and needs, and adjust to changes in customer priorities to the extent possible.

Focus Area 1: Technical Support for Contaminated Sites

- Clean ups at Superfund sites are complex processes that involve environmental transport phenomena, remedial decisions, technology implementation, community engagement, remedy review, and redevelopment decision-making. Individual EPA site managers do not usually have expertise in all of these areas and ORD provides support in this area to OLEM and the Regions through five technical support centers: Ground Water, Engineering, Monitoring and Site Characterization, Superfund/Human Health and Ecological Risk Assessment Technical Support Centers[5]. ORD

[5] http://www.epa.gov/superfund/health/research.htm. Briefly, the Ground Water Technical Support Center provides support on issues regarding subsurface contaminant fluxes to other media (e.g., surface water or air), and

technical assistance can be requested by EPA remedial site managers in any Region as well as program office staff. Center Directors review requests and identify ORD scientists and engineers with knowledge and expertise commensurate with the requests. These technical support centers provide a valuable link between research and contaminated site problems. Knowledge obtained through these activities provides the basis for designing research projects and likewise research provides improved approaches for characterization and remediation of contaminated sites. For example, one priority research area that has been identified by OLEM is mining site remediation. Mining contaminated sites vary greatly in both extent and types of contamination present. ORD's Engineering and Ground Water Technical Support Centers have a long history of working with Regional scientists and staff to address issues related to contaminated mining sites and mining-influenced waters (acid-rock drainage and waters laden with large concentrations of metals and metalloids).

One of the OLEM's primary priorities for the Contaminated Sites project, one that OLEM wants to maintain, is the continued technical support provided by ORD scientists and technical staff to Regional and Program Office staff at Superfund sites across the Nation. Key technical support products will contribute to Outputs 3.61.1 and 3.61.2, which describe technical support activities and compile information on "lessons learned" from this work. These "lessons" capture experience from working on specific sites for site managers and also provide blueprints for future research. In addition, the technical support program greatly enhances state-of-the-science technology transfer between ORD, OLEM, and Regions, providing scientific and technical approaches, methods, technologies, and strategies that are an essential component to cleaning up contaminated sites efficiently and effectively. This technical assistance is highly valued by the EPA Regions and OLEM and it will remain a key component of the Contaminated Sites Project. Other key products related to the technical support component of the Contaminated Sites Project are aligned with OLEM priorities, such as the development of tools and technologies to characterize and clean-up Superfund, RCRA, Great Lakes National Program Office Areas of Concern, and Brownfields sites, including site reuse and revitalization.

The products for Focus Area 1 include:

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ecosystem restoration. The Engineering Technical Support Center offers short- and long-term assistance to Superfund and RCRA Corrective Action staff. Assistance focuses on treatment technologies and engineering approaches to site management at any phase from problem identification through remedial action. The Monitoring and Site Characterization Technical Support Center supports Superfund and RCRA staff with on- and off-site monitoring and site characterization issues. The Human Health and Ecological Risk Assessment Technical Support Centers provide technical information and address scientific questions of concern or interest on topics relevant to ecological risk assessment at hazardous waste sites. When on-site work is required, the TSCs mobilize specialized teams of field scientists equipped with portable or deployable instruments to aid the Regions with screening and site characterization. Expertise is available for support throughout the various stages of evaluation of a site (from planning and design to analysis and data interpretation). The Engineering, Ground Water, and Monitoring and Site Characterization TSCs are supported through SHC Research Program and the Human health and Ecological Risk Assessment TSCs are supported via the HHRA Research Program.

- Technical support center annual reports: annual reports from the various technical support centers describing assistance activities provided to site managers across the nation.
- Lessons learned: information on lessons learned compiled from technical support activities, capturing site-specific experiences to share with other project managers and providing blueprints for future research.
- Technical support issue papers: issue papers focusing on site characterization or site remediation technologies and strategies (as is current practice, issue paper topics will be coordinated with EPA's Ground water, Engineering, and Federal Facilities Forums, who will provide guidance and input into their development).
- A Decision Support System to Guide the Use of Geophysical Characterization and Monitoring Technologies for Environmental Investigations: reports and web site to advance the effective adoption of geophysical technologies for the management of contaminated sites.

Focus Area 2: Research on Site Characterization, Remediation, and Management - Research in this focus area will advance the science and engineering needed for proper assessment, remediation, and reuse of contaminated sites. In some areas, technical knowledge gaps are addressed by developing our understanding of site characterization, remediation, and site management. In other areas, new approaches build upon prior ORD work, such as the impacts of diffusion from fine-grained sediments at in-situ chemical oxidation sites. This research will support site redevelopment and reuse. Technical issues at many sites can be complex, even at the stage of redevelopment. Characterization, remediation and site management activities continue to play a role when the transition is made to a Brownfields redevelopment or a Great Lakes Area of Concern delisting and restoration which may be a part of a broader community revitalization effort.

OLEM priorities for ground water research include: improving the application and interpretation of high resolution ground water characterization technologies (such as modeling and geophysical tools); conducting research on site characterization and mitigation involving ground water contamination via back diffusion; and developing and evaluating improvements in ground water treatment delivery and extraction technologies and strategies. This focus area targets contaminated ground water research activities that produce important products to address these priorities. EPA publications and papers in scientific and technical journals will be major products of this focus area. In addition to manuscripts for scientific and technical journals, technology transfer products (reports, manuals, tools, models, etc. will be developed that provide the detail necessary to put these products to work, cleaning up our contaminated sites. Several reports and publications are proposed for contaminated ground water research activities; such as, geophysical assessment of monitored natural attenuation; flux-based site management; impacts of multiple treatment technologies; back-diffusion of contaminants from fine-grained materials to conductive aquifers; dense non-aqueous phase liquid source zone and plume response; uncertainty in pump-and-treat and monitored natural attenuation; and related modeling approaches.

Research on ground water will include the application and interpretation of high resolution groundwater characterization technologies and methodologies. ORD, in collaboration with OLEM and the Regions will develop an issue paper on analysis of existing commercially available approaches for high resolution ground water characterization and interpretation to assist Regions.

ORD modeling work will be incorporated with advanced source term characterization to better understand contaminant behavior which can contribute to better site management. ORD will also conduct research on site characterization and mitigation involving plume persistence due to back diffusion[6]. Back diffusion continues to present challenges for the effectiveness of treatment systems and the ability to develop effective exit strategies for site cleanups. Better understanding the diffusion issues as well as developing technologies and high resolution approaches to characterizing sites is essential for effective and protective cleanup of Superfund sites.

Ground water research will continue to develop and evaluate improvements in groundwater treatment delivery and extraction technologies and strategies. As improved source zone and groundwater treatment is contingent on the ability to deliver treatment amendments and extract contamination from the subsurface, this research will support the development of needed data on the effectiveness of available delivery and extraction systems and ways to improve their effectiveness. Ground water research also focuses on improving treatment technologies and strategies to clean up contaminated subsurface environments. Even though many technologies have been developed to help clean up contaminated ground water, more research is needed in order to improve the efficacy and cost-effectiveness of these technologies, as well as provide new, novel combined treatment technology alternatives. ORD is building collaborations with other organizations, such as the U.S. Departments of Defense and Energy, and the Chinese Ministry of Science and Technology, to improve and optimize remediation technologies for contaminated soils and ground water and to better understand remediation and its impacts on bioavailability/bioaccumulation in soils polluted by heavy metals or PAHs.

The development of an environmental leaching assessment framework for organic pollutants also is a priority for the OLEM. A leaching assessment framework has been developed for inorganic pollutants, the Leaching Environmental Assessment Framework, but a similar framework approach has not been developed for organic contaminants. OLEM and ORD need to further discuss this effort

OLEM priorities for contaminated sediments research include: improving our understanding of linkages between contaminant concentrations in sediment and fish tissue concentrations; improving analytical technology for the evaluation of hydrophobic organic contaminants and

[6] Back diffusion is the process where contaminants contained in low permeability aquifer materials diffuse into otherwise remediated aquifers.

metals in soil and sediment; and evaluating the effectiveness of contaminated sediment remediation alternatives and their associated impacts. ORD research on sediments will focus on developing methods and approaches to characterize sources, evaluate remediation technologies, evaluations of remediation and restoration activities, and metrics to measure revitalization and redevelopment efforts. These approaches include techniques such as: deriving sediment interstitial water remediation goals to protect benthic organisms from toxicity, and how interstitial water measurement can be integrated into the prediction of residues in fish. Additionally, research will continue on the use of passive sampling for measuring interstitial water concentrations for contaminants at contaminated sediment sites to help standardize passive sampling techniques and develop rapid evaluation techniques for sediment contaminants. This work will improve the analytical technology for the evaluation of hydrophobic organic contaminants and metals in sediment and in sediment pore water and serve in the development of guidance to apply this new data within the site characterization and remedy effectiveness assessment process. Regarding remedy effectiveness of sediments, ORD will work with OLEM and the Great Lakes National Program Office to evaluate the effectiveness of various remediation processes. As an example, evaluating monitored natural recovery, enhanced monitored natural recovery, amendments, capping, and dredging to meet Remedial Action Objectives at Superfund sites and Great Lakes National Program Office Area of Concern sites, and to evaluate the efficacy of remedy and restoration activities. ORD will work with OLEM, the Regions, and the Great Lakes National Program Office in developing a potential inter-agency effort to better understand the linkages between sediment and fish tissue concentrations of PCBs, PAHs, dioxins, Me-Hg and Hg, and metals.

Additional discussions between ORD and Program Offices, including the possibility of a technical workshop that includes academia, may help elucidate linkages between pollutant concentrations in sediments/pore waters and those in fish tissue. Case studies from place-based research sites and other contaminated sediments sites will demonstrate methods and approaches for characterizing sources of contamination to aquatic sediments sites from point, non-point, groundwater, and upstream sources. Additionally, these case studies will provide long term monitoring methods and protocols to characterize restoration following remediation activities in a watershed to support sustainable use of resources and to assess remediation to restoration to revitalization (R2R2R).

ORD is designing its vapor intrusion research activities to address OLEM requests for information on the use of external remedial controls to reduce vapor intrusion and decrease the need for in-structure intrusive sample collection or in-building remediation systems. Research on vapor intrusion will also include a literature review on the influence of building parameters on vapor intrusion (for example, the role of building physics in indoor air concentration, and the influence of building efficiency on vapor intrusion). Addressing this priority also will allow scientists to describe the defining characteristics of vapor intrusion problems to guide site assessments and model development. Further collaborative efforts between ORD and OLEM and the Regions will include assessment of tools to understand worst case exposure conditions to be able to provide answers quickly and efficiently. Other ORD research and technical support activities will address OLEM priorities on developing short-

duration screening methods; improving subsurface characterization, including sub-slab sampling, to quantify contaminant concentrations in soil gas; and ensuring health protection from vapor intrusion is based on accurate predictions. ORD and OLEM representatives are discussing research activities related to assessing and mitigating vapor intrusion in large buildings and the role of soil vapor extraction. Ongoing discussions with OLEM will help to better focus ORD vapor intrusion research activities to ensure that they address the highest OLEM priorities.

Note that future reductions in contaminated sediment and vapor intrusion research will likely accompany any future reductions in FTE for this research area.

Products in this focus area contribute to outputs 3.61.3 and 3.61.4. These proposed products address several of the OLEM's priorities for ground water (site characterization and remediation), sediments (site characterization and remediation, and bioavailability), and vapor intrusion (assessment and remediation efficacy). The work supports management of Superfund, RCRA, and Great Lakes National Program Office Area of Concern sites and additional work which may be needed for Brownfields revitalization.

The products for Focus Area 2 include:

- Flux-based site management: report on aspects of fluxed-based site management (selection of monitoring points, uncertainty in complex aquifers, application) and economic analysis at a contaminated case study site.
- Strategies for managing risk due to back diffusion: report summarizing research on predicting DNAPL source zone and plume response using site measured flux-based characteristics and recommending guidance on the source zone characterizations, with the goal of demonstrating effective field-scale approaches based on flux measurements that can be coupled with appropriate predictive models to better link characterization, prediction, and decision making.
- Analytical models for three-dimensional contaminant transport in aquifers characterized by low- and high-permeability zones: tool for predicting contaminant distribution at contaminated sites characterized by preferential pathways (high-permeability layers) interacting with surrounding, low-permeability zones.
- Long-Term Performance Monitoring of Emulsified Zerovalent Iron for Source Zone Treatment of Chlorinated Solvents at a Superfund site: report summarizing a six-year study of source zone treatment of dense non-aqueous liquid phase contaminants at a Superfund site using emulsified zerovalent iron and contributing to EPA/China Ministry of Science and Technology (CMOST) Project 2 (Remediation for contaminated soil and groundwater).
- Geophysical methods to characterize and monitor groundwater-surface water interactions: publications on the state of practice for conventional and novel geophysical methods to assess the groundwater-surface water exchange process.
- Natural attenuation and co-contaminant behavior of Arsenic and Selenium: report addressing transport and fate of arsenic and selenium and their management through natural attenuation remedies.

- Predicting the mobilization of arsenic in reducing environments: publication describing a methodology for predicting the potential for metals mobilization in reducing environments.
- Framework for evaluating the leaching potential of organic constituents: framework approach to assess organic pollutant leaching (depending on ongoing discussions between OLEM and ORD, and results of fact-finding workshop).
- Guidance to assess remedy effectiveness at contaminated sediment sites: a weight of evidence assessment guidance using chemical, biological, and physical lines of evidence will be reported following a large scale sediment remediation project.
- Methods for testing freshwater sediment toxicity and bioaccumulation: EPA publication of revised sediment toxicity and bioaccumulation testing methodologies that will result in better testing data and better test performance.
- Guidance on conducting an assessment to identify and characterize legacy and on-going sources to contaminated sediment sites: technical report documenting the use of a weight of evidence approach (chemical, biological, and physical) to identify and characterize legacy and ongoing sources to contaminated sediments.
- Short-duration screening methods for worse case vapor intrusion identification: new information on whether or not a high (or the highest) VOC concentrations can be obtained with minimal disturbances to the home owners.
- Analytical solution for soil vapor extraction subject to diffusion in a water table aquifer: SERDP-leveraged modeling study that couples the soil-vapor extraction process with lateral diffusion in the underlying ground water.
- Soil vapor extraction to prevent vapor intrusion: information on whether soil vapor extraction systems effectively work to not only remediate the site but to prevent/limit vapor intrusion into homes/buildings within the radius of influence of the system.
- Vapor Intrusion monitoring and mitigation in large buildings: taking knowledge gained in homes/residences and scaling it up to apply to large buildings to determine if same practices are applicable and as effective.

Focus Area 3: Research on Temporal and Spatial Impacts of Contaminated Ground Water - Site Reuse and Revitalization - With population increases and increased frequency of extreme weather events due to climate change, there are stresses on aquifer-based water supplies, and the impacts of contaminated sites may constrain community decisions on water supplies. At the decision-making level environmental considerations (Focus Areas One and Two) are augmented by social and economic factors. In Focus Area Three, the temporal and spatial changes in ground water, vapor intrusion and contaminated sediments are coupled with social and economic factors related to community water supplies addressing Environmental Justice concerns and Brownfields needs.

Ground water modeling approaches for both detailed and screening of impacts of contaminated sites are proposed, as are mapping-based evaluation of locations and impacts to private drinking water wells in the context of aquifer vulnerability. These efforts address the environmental pillar of sustainability. This research includes a proposed product that focuses on the economic valuation of various water supply alternatives. This economic valuation of

water supply alternatives will be applied to select communities (that is, demonstration projects) as determined by project stakeholders. Combining all of these research components into a demonstration project incorporates the social and economic pillars of sustainability.

The research products in this focus area will contribute to output 3.61.5 by combining knowledge and tools generated to assess community decisions on water supply. These include understanding aquifer vulnerability and private water well use; contaminant plume transport and its impact on public and private water supply wells; and social and economic factors which influence water use and water valuation.

Products - Focus Area 3:

- Spatial Assessment of Contaminated Groundwater at Hazardous Waste Sites Near Vulnerable Drinking Water Supplies: using existing spatial data on the location of hazardous waste sites and toxic release sites, and current information on public drinking water supplies to produce GIS layers which can be incorporated into existing spatial decision support tools
- Economic evaluation of water supply alternatives, including an evaluation report addressing impacts of contaminated ground water on choices for community water supplies (still under discussion with customer)

Nature of the Work

Technical support activities use FTEs for evaluation of site-specific documents and on-site field activities; extramural funds are used to augment in-house expertise in specific areas. ORD and contract personnel will provide support for field work and sample analyses for individual sites. Contaminated site research is divided among laboratory studies, field studies, model development and application, mapping, and economic analysis. The fundamental knowledge of contaminant behavior is developed from laboratory and field studies, and an emphasis is placed on these activities. Field and laboratory studies can also be expensive given their use of supplies and equipment, and the need to staff sites where research and data collection are occurring; hence more of the expense/extramural resources are devoted to these areas. Field research efforts are leveraged with ongoing characterization and remediation site activities. Modeling consumes less physical materials, but requires labor hours, which we obtain mainly through ORD researchers. Mapping and economic analysis, similarly, require mostly ORD personnel.

Collaboration

Collaboration within SHC: Decision-making for Superfund cleanups and other remediation, restoration, and revitalization activities is closely related and in some cases integrated with Project 1.61. Contaminant fate and transport research and technical support, as well as other remediation, restoration, and revitalization activities, provide foundations for work in Project

2.62 (Community Public Health and Well-Being). Work on contaminated sites includes impacts to vulnerable populations (Project 2.63 Assessing Environmental Health Disparities in Vulnerable groups) as they may be more severely affected than others. Private well mapping, field data evaluation and modeling, and GIS evaluation of impacts contributes to objectives of: EnviroAtlas: A Geospatial Analysis Tool (Project 1.62); Community Public Health and Well-Being (bioavailability and C-FERST, 2.62); and Environmental Releases of Oil and Fuels (3.62). Development of ground water indices supports Project 2.64 (Indicators, Indices and Report on the Environment). Ground water transport and contaminated sediments research provides inputs to Project 2.61 for characterizing linkages between Ecosystem Good and Services (FEGS) and public health. Ground water modeling at contaminated sites supports similar needs in Project 3.62 (Environmental Releases of Oil and Fuels). Sediment and ground water restoration research supports Remediation to Restoration to Revitalization (R2R2R) work in Projects 2.61 and 2.63. Tools developed to assess transport and transformation of contaminants provide building blocks for sustainability assessments in Systems-Based Assessment Methods for Community Sustainability research (Project 4.61).

Collaboration with other ORD National Programs: Research on drinking water resources meshes with the SSWR research areas on Watershed Sustainability, Green Infrastructure, and Water Systems. Research on community ground water impacts is applicable to ACE interests on climate change.

Collaboration within EPA: EPA's OLEM and Regions, the Great Lakes National Program Office (Great Lakes Legacy Act and Great Lakes Restoration Initiative), and the EPA's Ground Water, Engineering, and Federal Facilities Forums are anticipated collaborators on contaminated site related research. Additionally, OW is interested in the research related to ground water and potential water quality impacts from contaminated sites. Lastly, this research supports the Office of Sustainable Communities, Children's Health, and Environmental Justice.

External Collaboration: Existing and future external research collaboration will be with other federal agencies (DOD, DOE, NOAA, USFW, USGS); tribal and state regulatory authorities; the Federal Facilities Forum of the Environmental Council of the States; the Federal Remediation Technologies Roundtable; the Interstate Technology Regulatory Commission; the Strategic Environmental Research and Development Program /Environmental Security Technology Certification Program (SERDP/ESTCP); and academic institutions.

International Collaboration: The collaborative research proposed in the work plan to the ORD-Chinese Ministry of Science and Technology Memorandum of Understanding has a strong relationship with SHC Project 3.61 - Contaminated Sites. This relationship is strongest related to Focus Area 2 research (research on site characterization, remediation, and management). ORD and Chinese scientists will work collaboratively to advance the science and engineering needed for proper assessment, remediation, and reuse of contaminated sites.

Key Project Resources

Key Equipment:

Field sampling equipment (drilling rigs and hydraulic push units, geophysical tools, GPS systems, flux meters, specialized remedial treatment equipment, mobile laboratory, pumps, boats, coring platforms, mobile laboratories, water quality monitoring equipment) and analytical laboratories/laboratory equipment (gas chromatographs, mass spectrometers, flame ionization detectors, electron capture detectors, general water quality parameter equipment, scanning electron microscope, high pressure liquid chromatographs, inductively coupled plasma mass spectrometer).

Key Expertise:

All key expertise required of SHC Project 3.61 are anticipated to be available in-house (ORD) or through one of our anticipated research collaborators.

Assumptions/Constraints

Much of the research and technical support is predicated on the assumption that access to suitable sites and data remain available. For our areas of historic focus, no problems are anticipated. For Focus Area Three, the work is extended to communities: selection and participation from appropriate communities is critical to success and will be coordinated with the Regions, States and communities.

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SHC Project 3.61 - Contaminated Sites - Tasks

SHC 3.61.1	Task 1 – Technical Support
SHC 3.61.2	Task 2 – Contaminated Ground Water Research
SHC 3.61.3	Task 3 – Contaminated Sediment Research
SHC 3.61.4	Task 4 – Vapor Intrusion Research
SHC 3.61.5	Task 5 – Tools for Evaluating Spatio-Temporal Impacts of Contaminated Sites on the Environment

Task 1 – Technical Support

Project Title: SHC 3.61 - Contaminated Sites
Task Title: SHC 3.61.1 - Technical Support Centers
Task Lead: John McKernan, NRMRL

Task Start Date: October 1, 2016 (FY 16)
Task End Date: September 30, 2019 (FY 19)

Task Description:
There are five active Technical Support Centers (TSC) operated by the Office of Research and Development (ORD). All are co-funded by the Office of Land and Emergency Management (OLEM) and ORD, and supported by EPA Regions and Offices. Each TSC is dedicated to serving the EPA and its clients by supplying high-quality, quick-response technical support services when the scope of work is beyond what is available to the Regions, Offices, or states. Technical Support Centers through the TSP (such as the Engineering Technical Support Center [ETSC]**,** Groundwater Technical Support Center [GWTSC] and Site Characterization and Monitoring Technical Support Center [SCMTSC]) are intended to provide technical support to EPA Programs, Regions, Remedial Project Managers (RPMs) and On-Scene Coordinators (OSCs). The TSC**s** also conduct Superfund-related research. This research includes innovative and novel ideas to solve emergent or on-going Superfund related issues (e.g., conducting site investigation or cleanup activities after a natural disaster, or remediating persistent organic pollutants from groundwater and soil). The results of the research is published in either peer reviewed journals or as EPA numbered documents, depending on the audience.

Research Approach:
ETSC's goal is to provide scientific and engineering knowledge and expertise in soil, sediment, and mine remediation technology to Regional staff for risk management decisions. GWTSC's goal is to provide technical support for restoration of contaminated ground water, and also for restoration of impacted ecosystems, under GWERD's mandate (i.e., as the Ground Water and Ecosystems Restoration Division). SCMTSC's goal is to provide site characterization assistance to waste program project managers by supporting the use of state-of-the-science methods and technologies for identifying contaminants, determining levels and concentrations, and identifying their geographic extent. The TSCs provide site-specific assistance and technical support to EPA Regions and program offices by leveraging their network of EPA/ORD scientists and programs, contracts, and expertise from other federal agencies, to collaboratively deliver the latest methods, approaches and technologies needed to investigate, remediate, and manage risk at contaminated sites. It is within the scope of the Centers to develop and evaluate innovative methods, and collaborate on National-level disaster events.

Task Dependencies:
Availability to ORD FTE, timely FY funding availability, and access to technical assistance vehicles.

Task Quality Assurance and Data Management Needs:

- Is there an existing IRP/ QAPP(s) that applies to this Task? If so, identify IRP/QAPP. If new IRP/QAPPs are required, provide the status. **No QAPP for the overall task. May have technical support request specific QAPPs, when necessary.**

- Will this Task involve large amounts of data that need a data management plan? If yes, explain. **No QAPP for the overall task. May have technical support request specific QAPPs, when necessary.**

Task Outputs/Products:

Summary:

1) Output Title: SHC Technical Support Centers - Lessons Learned document (Q4-Each FY starting with 2015)
2) Product Title: Engineering Technical Support Center - Annual Report (Q4 of following FY)
3) Product Title: Ground Water Technical Support Center - Annual Report (Q4 of following FY)
4) Product Title: Site Characterization and Monitoring Technical Support Center - Annual Report (Q4 of following FY)
5) Product Title: A watershed-scale model for simulating the transport of suspended and dissolved particulate matter in receiving water bodies (Q4-2015)
6) Product Title: Technical Support Center Issue Papers (IPs) (Q4-2016)
7) Product Title: Collaborative products and product development with the TSP Forums (Q4-2016)
8) Product Title: ProUCL – Statistical Software for developing support numbers to advance Site Remediation (Q4-2016)
9) Product Title: Evaluating relationships between total dissolved solids (TDS) and total suspended solids (TSS) in a mining-influenced watershed (Q4-2016)
10) Product Title: Development of an ORD Technical Support Center SharePoint Site (Q4-2016)
11) Product Title: A Decision Support System to Guide the Use of Geophysical Characterization and Monitoring Technologies for Environmental Investigations (Q4-2019)

Detailed description of output (1) and proposed products (10):
Output Title: **SHC Technical Support Centers - Lessons Learned document**

- Product Contact (email): John McKernan (mckernan.john@epa.gov)
- Product's Delivery Date: Q3/Q4 of following FY
- Product Description: Annual Lessons Learned document for the 3 SHC Technical Support Centers
- Product's Contribution to Output: Is Lessons Learned output for 3.61
- Product's Timeline (with milestones): Q4 of FY
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM /OSRTI; All 10 EPA Regions

- Does this Product contribute to a Product under another Task? If so, identify other Task. Unknown

Product Title: **Engineering Technical Support Center - Annual Report**

- Product Contact (email): John McKernan (mckernan.john@epa.gov)
- Product's Delivery Date: Q4 of following FY
- Product Description: Annual Report for Engineering Technical Support Center
- Product's Contribution to Output: Is part of annual summary of Lessons Learned output for 3.61
- Product's Timeline (with milestones): Q4 of following FY
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; All 10 EPA Regions
- Does this Product contribute to a Product under another Task? If so, identify other Task. Is part of annual summary of Lessons Learned output for 3.61

Product Title: **Ground Water Technical Support Center - Annual Report**
Product Contact (email): David Burden (burden.david@epa.gov)

- Product's Delivery Date: Q4 of following FY
- Product Description: Annual Report for Ground Water Technical Support Center
- Product's Contribution to Output: Is part of annual summary of Lessons Learned output for 3.61
- Product's Timeline (with milestones): Q4 of following FY
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; All 10 EPA Regions
- Does this Product contribute to a Product under another Task? If so, identify other Task. Is part of annual summary of Lessons Learned output for 3.61

Product Title: **Site Characterization and Monitoring Technical Support Center - Annual Report**

- Product Contact (email): Felicia Barnett (barnett.felicia@epa.gov)
- Product's Delivery Date: Q4 of following FY
- Product Description: Annual Report for Site Characterization and Monitoring Technical Support Center
- Product's Contribution to Output: Is part of annual summary of Lessons Learned output for 3.61
- Product's Timeline (with milestones): Q4 of following FY
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; All 10 EPA Regions
- Does this Product contribute to a Product under another Task? If so, identify other Task. Is part of annual summary of Lessons Learned output for 3.61

Product Title: **A watershed-scale model for simulating the transport of suspended and dissolved particulate matter in receiving water bodies**

- Product Contact (email): Brian Dyson (dyson.Brian@epa.gov)

- Product Delivery Date: Q4-2015
- Product Description: The Tri-State Mining District (TSMD), located in Missouri, Kansas, and Oklahoma, has been a hub of lead, zinc, cadmium and other metal mining activities for decades. Transport of debris and waste from these mining activities by runoff has led to listing Spring River (and a number of other minor waterways) as impaired surface water. This study aims to create a processed-based watershed model to analyze flow and water quality in the TSMD. It is believed that this type of model is more cost effective than monitoring alone, as constant water quality monitoring is resource intensive and difficult to implement in large watersheds. However, modeling without appropriate calibration and validation may lead to highly uncertain predictions of the fate and transport of the TSMD wastes.

  This study used daily hydrologic and available water quality data to develop a SWAT (Soil and Water Assessment Tool) model to help assess metal contamination in the Spring River Watershed, which is approximately 2,377 km^2 in area. Two USGS gages, located at Spring River and Shoal Creek, were selected to develop the SWAT model for baseflow, surface flow, and metals on yearly and monthly basis over the time period of 2008 to 2010. Sensitivity analysis was performed on parameters governing processes for surface water, sub-surface water and basin responses. Results of the SWAT model currently being developed will provide 'goodness of fit' for base flow and surface flow. In the out years, it is planned to validate and calibrate the SWAT model developed, and examine the fate and transport of mining-related heavy metals in the watershed.
- Product's Contribution to Output: Can be part of the annual summary of Lessons Learned output for 3.61 if it impacts Region 6 and 7.
- Product's Timeline (with milestones): Q4-2015
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; EPA Regions 6 and 7
-
- QAPP ID: QAPP #: L18752-QP-1-1 approved: March 27 2013
- Does this Product contribute to a Product under another Task? If so, identify other Task. May be part of annual summary of Lessons Learned output for 3.61

Product Title: **Technical Support Center Issue Papers (IPs)**

- Product Contact (email): EIPs - John McKernan (mckernan.john@epa.gov), GWIPs – David Burden (burden.david@epa.gov), SCMIPs – Felicia Barnett (Barnett.felicia@epa.gov)
- Product Delivery Date: Q4-2016 (2 issue papers)
- Product Description: Issue papers (IPs) are created by the Engineering, Ground Water and Site Characterization and Monitoring Technical Support Centers. Annual Report for Site Characterization and Monitoring Technical Support Center. IPs are created based on Office, Regional or TSP Forum interest in particular topic areas. Examples of potential IPs for 2016 include:
  A. Vapor Intrusion Pathway Screening for Soil Excavation Remedies;
  B. Passive Samplers for Investigations of Air Quality - Method Description, Implementation, and Comparison to Alternative Sampling Methods;

C. Biotransformation Pathways of Dimethylarsinic (Cacodylic) Acid in the Environment; or
D. Application of Advanced Stratigraphic Concepts to Contaminated Groundwater Sites: A Practical Guide to Environmental Sequence Stratigraphy and Facies Models;
E. Leak, Purge, and Gas Permeability Testing to Support Soil Gas Sampling.

- Product's Contribution to Output: Is part of annual summary of Lessons Learned output for 3.61
- Product's Timeline (with milestones): Q4-2016 (2 IPs)
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; All 10 EPA Regions
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- Does this Product contribute to a Product under another Task? If so, identify other Task. Is part of annual summary of Lessons Learned output for 3.61.

Product Title: **Collaborative products and product development with the TSP Forums**

- Product Contact (email): John McKernan (mckernan.john@epa.gov)
- Product Delivery Date: Q4-2016 (1 issue paper)
- Product Description: Technical Support Project (TSP) Forum Issue papers (IPs) are created by the Engineering, Federal Facilities, Groundwater, Human Health and other TSP Forums. These Forum IPs are created based on Office, Regional and external stakeholder interest in particular topic areas. Examples of potential IPs for 2016 include:
  A. Defining a framework for ecosystem services assessment at a site level. The goals of this paper would be to better identify BMPs to mitigate impacts on services during remedy construction and operations, as well as during the restoration phase;
  B. Engineering approaches to remediating perfluorinated compounds (PFCs);
  C. Lessons learned on adaptive site management during RD/RA.
- Product's Contribution to Output: Is part of annual summary of Lessons Learned output for 3.61
- Product's Timeline (with milestones): Q4-2016 (1 IP)
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; All 10 EPA Regions
- Does this Product contribute to a Product under another Task? If so, identify other Task. Is part of annual summary of Lessons Learned output for 3.61.1.

Product Title: **ProUCL – Statistical Software for developing support numbers to advance Site Remediation**

- Product Contact (email): Felicia Barnett (barnett.felicia@epa.gov)
- Product's Delivery Date: Q4-2016

- Product Description: The latest version, ProUCL 5.0, which updated the program from Windows XP to Windows 8 was made available in September of 2013. A minor update to clarify some the new programing is scheduled for the end of FY15.
- Product's Contribution to Output: Product is statistical package available to Regional clients. May have citable impacts noted in the Output planned for 2015 (available in Q4-2016) for 3.61
- Product's Timeline (with milestones): Q4-2016
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; All 10 EPA Regions
- Does this Product contribute to a Product under another Task? If so, identify other Task. May have citable impacts to be mentioned in 2015 Lessons Learned output for 3.61 (available Q4-2016)

Product Title: **Evaluating relationships between total dissolved solids (TDS) and total suspended solids (TSS) in a mining-influenced watershed**

- Product Contact (email): Barbara Butler (butler.barbara@epa.gov)
- Product's Delivery Date: Q4- 2016
- Product Description: A research need in the Regions is understanding better how different water quality parameters are interrelated, especially with respect to practices intended to remedy one or more potential (when being discussed for active mining sites) contaminants and how that might influence other potential contaminants. For abandoned or otherwise inactive mining sites, this understanding becomes important with respect to remediation of existing contamination and is of interest to Regional Offices as well as OLEM and OW. A prior technical support request involved assessing the validity of using a TSS/TDS ratio to predict whether a BMP to treat TSS would provide a predictable and reliable parallel reduction in TDS. Literature on this topic is scarce; therefore, this product expands on this question to examine the validity of this approach, using secondary-data from a mining-influenced watershed. This product is intended to be a source for guidance on how TDS and TSS may interact and relate to one another and how closely a ratio would predict TDS based on known TSS values.
- Product's Contribution to Output: Output 3.61.1 (Lessons learned from ORD's Technical Support to Superfund and other contaminated sites)
- Product's Timeline (with milestones): Q4-2016
- Product's intended user/customer/audience: EPA Offices and Regions; State and Local Governments; NGOs; Academia; Public
- Does this Product contribute to a Product under another Task? If so, identify other Task. No, although knowledge gained will benefit several program areas.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. A product-specific QAPP will be developed and approved through the product lead's laboratory and division.
- Will an independent data management plan be needed for this product? Y/N? If yes, briefly describe a timeline for developing the data management plan. Yes, discussion of data management will be included in the QAPP.

Product Title: **Development of an ORD Technical Support Center SharePoint Site**

- Product Contact (email): John McKernan (mckernan.john@epa.gov)
- Product's Delivery Date: Q4-2017
- Product Description: The Engineering Technical Support Center, with support from the ORD MI for SHC, is developing a Technical Support Center SharePoint Site. This site will house collaborative workspaces for clients (RPM, OSC and Office staff), useful links to Superfund, RCRA and Brownfields resources, and the web form to request assistance from the 3 ORD Technical Support Centers in the SHC RAP. The goal of this SharePoint site is to provide '1-stop shopping' for clients to obtain technical support and information pertaining to contaminated sites. It would be possible for a client to utilize the sharepoint site and its listing of superfund technical support requests as a searchable database to discover and identify best practices/lessons learned to facilitate and transfer application of solutions used at one site to another site.
- Product's Contribution to Output: Product is targeted to Regional and EPA Office clients. May have citable impacts noted in the Output planned for 2017 (available in Q4-2017) for 3.61
- Product's Timeline (with milestones): Technical Objectives divided into three Stages:
  1) Develop SharePoint site, and begin pilot phase of implementation (Q2-2016);
  2) Demonstrate SharePoint as a tool for clients and management for contaminated sites (Q4-2016);
  3) Implement final, full version of SharePoint site on the EPA intranet for clients to access (Q4-2017).
- Product's intended user/customer/audience: OLEM, STLs, Superfund RPMS, RCRA Project Managers, SHC NPD; OLEM/OSRTI; All 10 EPA Regions
- Does this Product contribute to a Product under another Task? If so, identify other Task. May have citable impacts to be mentioned in 2017 Lessons Learned output for 3.61 (available Q4-2017)

Task 2 – Contaminated Ground Water Research

Project Title: SHC 3.61 - Contaminated Sites
Task Title: 3.61.2 - Contaminated Ground Water Research
Task Leads: Michael Brooks, NRMRL

Task Start Date: October 1, 2016 (FY 16)
Task End Date: September 30, 2019 (FY 19)

TASK DESCRIPTION
The focus of project SHC 3.61 is research and technical support to characterize and remediate contaminated sites. This project supports the Agency by providing the scientific foundation for,

and advancing the technical knowledge needed by those engaged in contaminated site restoration, and it is aligned with EPA's Fiscal Year 2014-2018 Strategic Plan Goal 3: "Cleaning Up Communities and Advancing Sustainable Development". In particular, the EPA's Office of Land and Emergency Management (OLEM) is viewed as a primary client for this project given its mission to provide policy, guidance, and direction for the Agency's emergency response and waste programs (including the Superfund program). Regional offices however are ultimately responsible for ensuring compliance and restoration at specific sites. Therefore, products developed within this project will not only support program managers, but also remedial project managers and other site management personnel, who then engage communities to protect public health and natural resources, and restore contaminated sites for beneficial reuse.

Contaminated ground water is found at 80% of Superfund sites and clean up can take decades to complete. Because of the reliance on aquifers for drinking water, the Superfund program seeks to ensure that ground water quality meets federal and state drinking water standards, and therefore prevent human exposure to contaminants. Contaminated ground water may directly impact and limit both public and private water supplies, and this impact may grow more severe in the future as the need for drinking water increases due to population increase, exacerbated by potential cycles of weather extremes due to climate change. Contaminated ground water may also impact other routes of exposure, with linkages to inhalation exposure due to vapor intrusion, and linkages to surface water bodies due to ground water-surface water interactions. Consequently, Task 2 within Project SHC 3.61 is devoted to Ground water Contaminant Research[7].

ORD researchers have expertise in ground water contaminant research and are engaged in research activities that fall within this Task topic. Areas of research activity include geophysics for site characterization, fate and transport of inorganic contaminants, permeable reactive barriers for inorganic treatment, flux-based site management at DNAPL impacted sites, in-situ chemical oxidation, emulsified zero-valent iron treatment, and organic contaminant modeling for site management purposes. The latter activity has also included research investigating back diffusion. As part of ORD's research planning process for FY16 through FY19, OLEM was asked for their priorities on contaminated site research. The following six areas were noted and included by ORD in the contaminated ground water task:

- Improve the application and interpretation of high resolution ground water characterization technologies (such as modeling and geophysical tools);
- Conduct research on site characterization and mitigation involving ground water contamination via back diffusion;
- Ground water permeable reactive barriers (PRB) long-term performance studies, life cycle analysis;

[7] The other tasks within Project SHC 3.61 are: Technical Support (Task 1), Contaminated Sediments (Task 3), Vapor Intrusion (Task 4), and Temporal and Spatial Impacts of Contaminated Ground Water on Site Reuse/Revitalization and Environmental Justice (Task 5).

- Research on co-metabolic bioremediation for dilute solvent plumes;
- Develop and evaluate improvements in ground water treatment delivery and extraction technologies and strategies;
- Mining Site Remediation - Develop technologies to treat mining influenced water (MIW); and
- Develop Leaching Environmental Assessment Framework for organic contaminants.

Consequently, an attempt was made to align research expertise and current research activities with these priority areas, and an emphasis has been placed on contaminated ground water research activities that produce important products to address these priorities. Alignment of specific ORD research expertise and activities with OLEM research priorities are noted in the following section. However, the following qualifications are noted regarding the extent to which OLEM priorities have been met by the proposed research in this plan. First, the OLEM priorities listed above are not exclusively addressed in this Task; and, for example, the first OLEM priority related to high-resolution ground water characterization will also be addressed using an issue paper to be completed under Task 1 of Project SHC 3.61. Second, in some cases OLEM's priorities could not be addressed due to staffing constraints. For example, in the case of co-metabolic bioremediation for dilute solvent plumes, ORD does not currently have research investigators available who specialize in that topic. Third, in other cases, staffing and budget constraints limit the extent to which priorities can be addressed. For example, ORD research activities described below may not fully address OLEM priorities related to PRBs and ground water treatment delivery and extraction technologies because of the focus given to other topics such as back diffusion, mining site remediation, and leaching environmental assessment framework for organic contaminants. In these cases, focus area selections were made to best align priorities with current staff resources. Finally, future opportunities will be used to the extent possible to address OLEM priorities in ways not currently addressed in this plan.

RESEARCH APPROACH

ORD conducts applied research on contaminated ground water by addressing knowledge gaps that have been identified, or that are anticipated, related to the characterization and restoration of contaminated ground water resources. Often, the observations and experiences of practicing professionals (e.g., regulators, consultants, etc.) identify and highlight these knowledge gaps where additional research is needed. The research is accomplished through a wide variety of approaches, including laboratory studies, field studies, model development and application, mapping, and economic analysis. Knowledge of contaminant behavior is developed from laboratory and field studies. Mathematical models are developed and tested against empirical data obtained from lab and field studies for validation. Further refinement of ideas and concepts are made by practicing professionals as the research is communicated and used in practice. Collectively, knowledge gained from these activities serves as a basis for developing decision-support tools and frameworks. Products proposed in this Task encompass one or more of all these research approaches depending on the state of the issue being addressed. Specific details about the research approach used for each product can be found in the Product Information Sheets. However, a general discussion of the research approaches being used

within this Task is summarized below.

Research in this Task can be organized in one of several ways (e.g., characterization versus remediation; or organic versus inorganic contamination). However, research discussed below has been organized according to research activities.

Inorganic Ground Water Contaminants. Research on inorganic ground water contaminants will focus on three aspects. First, a review will be completed of the long-term performance of the East Helena PRB for the treatment of arsenic in ground water. This study will report on contaminant behavior at this PRB using data collected over 10 years, and the approach involves ground water analysis, core collection and analysis, and geochemical modeling. The results of this study are highly significant because they represent the longest available performance record of a PRB for treating arsenic in ground water. Second, there have been examples of arsenic (and other metals) being mobilized after the application of technologies that promote a reduction of ground water redox potential to drive contaminant degradation. Thus, mobilization of inorganic contaminants is a potential unintended secondary water quality impact of in-situ reduction technologies. This research will develop tools that could be used to predict, at a given site, whether there is a potential vulnerability for mobilization of metals. Finally, the third focus area under this activity is an analysis of the co-contaminant behavior of arsenic and selenium in ground water. This study will explore the geochemical controls on the mobilization and attenuation of these inorganic contaminants at the East Helena Superfund site. Geochemical gradients drive contrasting transport and fate behavior of arsenic and selenium. An understanding of their co-contaminant behavior is necessary to select appropriate and effective remediation technologies for these contaminants. This research activity relates to and supports the OLEM research priority of mining site remediation.

Geophysics for Ground Water Characterization. Misapplication of geophysical techniques can be attributed to a widespread lack of understanding about the efficacy, sensitivity, and resolution that reasonably can be expected from geophysics under conditions that vary substantially between sites. Regulators, project managers, and geophysical practitioners lack tools to predict the reliability of a geophysical method in a given application. Therefore, the overall goal of this work is to advance the educated and effective adoption of geophysical technology for management of contaminated ground water. To achieve this goal, it is proposed to develop, demonstrate, and disseminate a Geophysical Toolbox Decision Support System (GTDSS) aimed at both geophysics users and end users (regulators or site professionals). This idea has three technical objectives: 1) provide a decision support system with pre-modeling capabilities to enable selection of appropriate and effective geophysical methods to use at a site, given project goals and site conditions; 2) demonstrate application of the tool for management of contaminated ground water at select sites; and 3) transfer this online tool and technology to site professionals and regulators through software documentation, online dissemination, and training courses. This research relates to OLEM's research priority on the application and interpretation of high resolution ground water characterization technologies and methodologies.

Flux Based Site Management. Another ORD research activity relevant to the topic of high resolution ground water characterization technologies and methodologies is flux-based site management (FBSM), which entails the characterization of contaminant flux and mass discharge, as well as ground water flux (i.e., ground water velocity) across control planes normal to the longitudinal axis of the plume. Two products are proposed under the research activity of FBSM. The first product will summarize research that has been completed under a collaborative research project funded by the Strategic Environmental Research and Development Program (SERDP) to investigate effective field-scale approaches based on flux measurements that can be coupled with appropriate predictive models to better link characterization, prediction, and decision making. This product will include research on the uncertainty of mass flux measurements and provide assistance in method selection. The second proposed product will summarize research to modify a current technology for high-resolution sampling (i.e., passive flux meter) so that the required laboratory based analysis of the technology can be replaced with a more rapid and less expensive field-based analysis. A related effort will be research to better understand dissolution as a function of NAPL wetting conditions. The rate of non-aqueous phase liquid (NAPL) dissolution often governs the clean-up time for subsurface hazardous waste sites. Most formulations for estimating this rate are empirical and assume that the NAPL is the non-wetting fluid. However, field evidence suggests that some waste sites might be organic-wet. Thus, formulations that assume the NAPL is non-wetting may be inappropriate for estimating the rates of NAPL dissolution. An analytical solution under simplified conditions will be explored to provide a theoretical prediction of the rate of dissolution in situations where the NAPL is the wetting phase.

Back Diffusion. Back diffusion may impair the effectiveness of treatment systems and therefore hinder the development of effective exit strategies for site cleanups. A better understanding of the role that diffusion plays in plume persistence is essential for effective and protective cleanup of Superfund sites. ORD will conduct research on plume persistence due to back diffusion, and focus on the following aspects in particular. The first focus is to investigate the functionality between flux across a downgradient control plane as a function of upgradient diffusional processes as well as the mass discharge characteristics from the original contaminant source. The impact of degradation processes in both the high and low permeability zones will also be explored. Building on this, the second focus will be a three-dimensional back diffusion mathematical model, and a group of analytical solutions will be derived based on specific initial and boundary conditions as well as various source functions. The model solution will be a useful tool in assessing contaminant attenuation processes, and therefore aid in site management. A third focus will be on field-based research, and will quantify the specific technical issue of contaminant rebound stemming from back diffusion at an actual ISCO site. A final report is proposed that will build on all three earlier focus areas, and this product will review remedial strategies that can be used to manage sites with contaminant plume persistence due to back diffusion. This effort relates to OLEM's priority to conduct research on site characterization and mitigation involving contaminant plume persistence due to back diffusion.

In Situ Chemical Oxidation. Three products are proposed related to contaminant ground water

treatment using in-situ chemical oxidation (ISCO). The first product is a critical analysis of ISCO design factors used in estimating the delivery of oxidant volume/dosage; the second product addresses aquifer characteristics (in particular permeability) following ISCO permanganate treatment at a contaminated case study site; and the third product evaluates the influence of ISCO on VOC rebound (back diffusion). These research topics are being developed to quantify specific technical issues as they relate to an actual ISCO site. A critical assessment of results will be contrasted with other ISCO sites reported in the scientific literature. This research is aligned with OLEM's priority to develop and evaluate improvements in ground water treatment delivery and extraction technologies and strategies.

Emulsified Zerovalent Iron. Work will be conducted to summarize a six-year study of source zone treatment of dense non-aqueous phase liquid contaminants at a Superfund site using emulsified zerovalent iron. This work will include soil core analysis from the field site to evaluate mineralogical and chemical changes of injected nanoscale zerovalent iron over the six year period. The information is needed for predicting fate and transport of the iron used for remediation and for optimizing the materials that could be potentially used for future remediation work. Work on this product will also be supported through a collaboration with the China Ministry of Science and Technology to improve and optimize remediation technologies for contaminated ground water. This research also relates to OLEM's priority to develop and evaluate improvements in ground water treatment delivery and extraction technologies and strategies.

Organic Constituent Leaching Methodologies. Understanding the ability of organic contaminants to be leached from waste material and transported into ground water is an issue impacting all communities. The development of an environmental leaching assessment framework for organic pollutants is a priority for OLEM. A leaching assessment framework has been developed for inorganic pollutants, the Leaching Environmental Assessment Framework (LEAF). The development of a similar framework, one to assess the ability of semi-volatile and non-volatile organic contaminants to leach from waste materials, is being evaluated by OLEM and ORD. The focus of this research activity is to evaluate leaching assessment methodologies and approaches that are currently available and to determine what would be necessary to develop a leaching assessment framework for organic contaminants.

TASK DEPENDENCIES

Task level dependencies have not been identified. Some products have dependencies on other products within this Task, and those dependencies have been identified in the Product Information Sheets.

TASK QUALITY ASSURANCE and DATA MANAGMENT NEEDS

1. Is there an existing IRP/ QAPP(s) that applies to this Task? If so, identify IRP/QAPP. If new IRP/QAPPs are required, provide the status. The task of ground water contaminant research includes a variety of elements that do not lend themselves to management under one or more task-level QAPPs. Moreover, the level of detail required in a QAPP is

best addressed on a product level basis. Therefore, QAPP information is addressed individually for each product.

2. Will this Task involve large amounts of data that need a data management plan? If yes, explain. The need for data management plans is addressed at the product level, and a task-level data management plan will not be completed.

TASK PRODUCTS

A total of 14 products are proposed under this task, and product information sheets developed for each product are provided in Appendix A. A summary of these products is provided in Table 1. EPA publications and papers in scientific and technical journals will be major products of this Task. Moreover, the product of the geophysics research will be a decision support software package (Geophysical Toolbox Decision Support System).

Table 1. Summary of Proposed Products in the FY16 to FY19 Planning Cycle

	Product Name	ORD Research Activity	Proposed Product Type	Proposed Delivery Date	OSWER Priorities						
					HRT&Ms	BD	PRB's	CoBio	IGD&E	MSR	OL
1	Flux-based site management summary report	FBSM	R	FY17	●						
2	A High Resolution Passive Flux Meter Approach Based on Colorimetric Responses	FBSM	A, R, or F	FY18	●						
3	Modeling NAPL dissolution from pendular rings in idealized porous media	FBSM	A	FY18					●		
4	Strategies for managing risk due to back diffusion	Back Diffusion	R, F, or I	FY19		●					
5	A critical analysis of ISCO design factors used in estimating the delivery of oxidant volume/dosage	ISCO	R or A	FY16					●		
6	Aquifer characteristics following ISCO permanganate treatment at a contaminated case study site	ISCO	R or A	FY17					●		
7	Influences of ISCO on VOC rebound (back diffusion)	ISCO	R, A, or W	FY18		●			●		
8	Natural attenuation and co-contaminant behavior of arsenic and selenium	Inorganics	A	FY17					●	●	
9	Predicting the mobilization of arsenic in reducing environments	Inorganics	A	FY19				●	●	●	
10	Long-term performance of permeable reactive barriers for treating contaminated groundwater	PRBs	A	FY18			●			●	
11	Long-Term Performance Monitoring of Emulsified Zerovalent Iron for Source Zone Treatment of Chlorinated Solvents at a Superfund site	Emulsified ZVI	R	FY19					●		
12	A decision support system to guide the use of geophysical characteization and monitoring technologies for environmental investigations: geophysical tool decision support system (GTDSS)	Geophysics	S	FY18	●						
13	Geophysical methods to characteize and monitor groundwater-surface water interactions	Geophysics	A	FY19	●						
14	Draft framework for evaluating leaching potential of semi-volatile and non-volatile organic contaminants	Organics Leaching	R	FY19							●

Product Key

A = Peer-Reviewed Journal Article

R = EPA Report

I = EPA Issue Paper

W = Workshop or Webinar

F = EPA Fact Sheet
S = Software package

OLEM Priority Key
HRT&Ms - High Resolution ground water characterization technologies and methodologies
BD - Research on characterization & mitigation of contaminant back/matrix diffusion
PRB's - Ground water PRB long-term performance studies, life cycle analysis
CoBio - Research on co-metabolic bioremediation for dilute solvent plumes
IGD&E - Improve ground water Rx delivery and extraction technologies and strategies
MSR - Mining Site Remediation - Develop technologies to treat mining influenced water (MIW)
OL – Organics Leaching – Develop Leaching Environmental Assessment Framework for semi-volatile and non-volatile organic contaminants

APPENDIX A
Product Information Sheets
RAP Project SHC 3.61 - Contaminated Sites
Task 2: Ground Water Contaminant Research

Product Title: **Flux-based site management summary report**

- Product Contact (email): Michael C. Brooks (brooks.michael@epa.gov)
- Product's Delivery Date: Q4 FY17
- Product Description: This report will summarize research that has been completed under a SERDP-funded collaborative research project between EPA, the University of Florida, and Purdue University titled Predicting DNAPL source zone and plume response using site measured flux-based characteristics and recommended guidance on the source zone characterizations. The goal of the project is to demonstrate effective field-scale approaches based on flux measurements that can be coupled with appropriate predictive models to better link characterization, prediction, and decision making. This research relates to OSRTI's priority of improved application and interpretation of high resolution ground water characterization technologies and methodologies by developing methods to use and interpret high resolution data for site management purposes.
- Product's Contribution to Output: This product contributes to Outputs 3.61.3 and 3.61.4
- Product's Timeline (with milestones): (1) Q1 FY16 Field-based research complete, (2) Q4 FY16 Complete milestone journal article on mass flux uncertainty and method selection analysis, (3) Q4 FY16 Submit final product for review, (4) Q4 FY17 Complete final product.
- Product's intended user/customer/audience: Federal and state regulators, and consultants engaged in ground water contaminated site management.
- Does this Product contribute to a Product under another Task? No.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. QAPP ID No.: G-13131, G-18759, and G-19624
- Will an independent data management plan be needed for this product? Y/N? No.

Product Title: **A High Resolution Passive Flux Meter Approach Based on Colorimetric Responses**

- Product Contact (email): Michael C. Brooks (brooks.michael@epa.gov)
- Product's Delivery Date: Q4 FY18
- Product Description: The purpose of this research is to modify a current technology for high-resolution sampling (passive flux meter) so that the required laboratory based analysis of the technology can be replaced with a more rapid and less expensive field-based analysis. This activity is a collaborative effort with the University of Florida, and is a SERDP funded project. This effort relates to OSRTI's priority to improve application and interpretation of high resolution ground water characterization technologies and methodologies. The

anticipated product will be an EPA report, research brief, or issue paper; or a peer-reviewed journal article.

- Product's Contribution to Output: This product contributes to Outputs 3.61.3 and 3.61.4
- Product's Timeline (with milestones): (1) Q1 FY16 Continue research (2) Q1 FY18 Submit document for internal and external reviews, (3) Q4 FY18 Complete clearance process for final product.
- Product's intended user/customer/audience: Federal and state regulators, and consultants engaged in ground water contaminated site management.
- Does this Product contribute to a Product under another Task? No.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. A new QAPP will be written for this product, and it will be completed prior to the end of Q1 FY16.
- Will an independent data management plan be needed for this product? Y/N? No.

Product Title: **Strategies for managing risk due to back diffusion**

- Product Contact (email): Michael C. Brooks (brooks.michael@epa.gov)
- Product's Delivery Date: Q4 FY19
- Product Description: This research effort will review characteristics of and remedial strategies that can be used to manage sites with contaminant plume persistence due to back diffusion. This effort will include research activities to investigate the functionality between flux across a downgradient control plane as a function of upgradient diffusional processes as well as mass discharge characteristics from the contaminant source zone. Moreover, a three-dimensional mathematical model that describes flow and transport of contaminant from a NAPL source zone in a horizontal aquifer with simultaneous diffusion into a clay formation will be developed. This effort relates to OSRTI's priority to conduct research on site characterization and mitigation involving contaminant plume persistence due to back diffusion. The anticipated final product will be an EPA report, research brief, or issue paper.
- Product's Contribution to Output: This product contributes to Outputs 3.61.3 and 3.61.4
- Product's Timeline (with milestones): (1) Q1 FY16 Continue data analysis associated with previous back diffusion experiments, (2) Q1 FY17 Submit milestone manuscript for internal and external reviews, (3) Q4 FY17 Complete milestone manuscript on the impact of back diffusion on down-gradient mass discharge, (4) Q1 FY17 Begin review of remedial and management strategies associated with plume persistence due to back diffusion, (5) Q4 FY18 Complete milestone manuscript on three-dimensional analytical models of back diffusion, (6) Q1 FY19 Submit final product for internal and external reviews, (7) Q4 FY19 Complete clearance process for final product.
- Product's intended user/customer/audience: Federal and state regulators, and consultants engaged in ground water contaminated site management.
- Does this Product contribute to a Product under another Task? No.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. QAPP ID No.: G-19255 will be revised to cover this effort in Q1 FY 17.

- Will an independent data management plan be needed for this product? Y/N? No.
  - Other Resource Needs: None

Product Title: **Modeling NAPL dissolution from pendular rings in idealized porous media**

- Product Contact (email): Junqi Huang (huang.Junqi@epa.gov)
- Product's Delivery Date: Q4 FY18
- Product Description: The rate of NAPL dissolution often governs the clean-up time for subsurface hazardous waste sites. Most formulations for estimating this rate are empirical and assume that the NAPL is the non-wetting fluid. However, field evidence suggests that some waste sites might be organic-wet. Thus, formulations that assume the NAPL is non-wetting may be inappropriate for estimating the rates of NAPL dissolution. An exact solution to the Young-Laplace equation assuming a hexagonal close packing of uniform solid spheres provides a theoretical prediction for non-aqueous phase liquid (NAPL) interfacial area, and, in turn, the rate of dissolution in situations where the NAPL is the wetting phase. In this model, the NAPL is assumed to reside as pendular rings around the contact points between the spheres, which, when coupled with Fick's law for diffusion, enables the prediction of a theoretical dissolution rate.
- Product's Contribution to Output: 3.61.3, Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization.
- Product's Timeline (with milestones): FY16 begin to develop technical model; FY17 complete model and draft manuscript; FY18 complete technical paper.
- Product's intended user/customer/audience: Contaminated site managers.
- Does this Product contribute to a Product under another Task? If so, identify other Task? No.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. TASK NO./QA ID NO.: 25237 / G-14798
- Will an independent data management plan be needed for this product? Y/N? If yes, briefly describe a timeline for developing the data management plan. No.

Product Title: **Critical Assessment of Oxidant Volume Design and post-ISCO CVOC Rebound and Changes in Aquifer Permeability**.

- Product Contact (email): Scott Huling (huling.scott@epa.gov)
- Product's Delivery Date: FY 16 - FY 18
- Product Description: These research topics are being developed to quantify specific technical issues as they relate to an actual ISCO site. A critical assessment of results will be contrasted with other ISCO sites reported in the scientific literature. Design methods and details will be provided to specifically address oxidant volume design, CVOC rebound, and changes in permeability.
- Product's Contribution to Output: The proposed work will contribute to the following outputs - 3.61.1 Lessons learned from ORD's Technical Support to Superfund and other contaminated sites (the ISCO site is a technical support Superfund site); 3.61.3 Methods for

characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization; and 3.61.4 Strategies for integrated management of contaminated sites.

- Product's Timeline: (FY 16) EPA Report or journal article involving a critical analysis of ISCO design factors used in estimating the delivery of oxidant volume/dosage; (FY 17) EPA report or journal article on aquifer characteristics following ISCO permanganate treatment at a contaminated case study site; (FY 18) EPA report, journal article, or workshop on evaluating and addressing the influence of ISCO on VOC rebound (back diffusion).
- Product's intended user/customer/audience : OLEM, Regional office personnel, tribes and states, environmental consultants
- Does this Product contribute to a Product under another Task? No.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs: An existing QAPP will be revised to address additional measurements to be conducted in this project.
- Will an independent data management plan be needed for this product? No.

- **Other Discussion.** The two activity level descriptions described in the previous project level summary have been combined into one activity level description.
  - Title: Critical Assessment of post-ISCO CVOC Rebound, Changes in Aquifer Permeability, and Oxidant Volume Design.
  - Product: (1) EPA Report or journal article involving a critical analysis of ISCO design factors used in estimating the delivery of oxidant volume/dosage (FY 16); (2) EPA report or journal article on aquifer characteristics following ISCO permanganate treatment at a contaminated case study site (FY 17); (3) EPA report, journal article, or workshop on evaluating and addressing the influence of ISCO on VOC rebound (back diffusion) (FY 18).
  - Output: The proposed work will contribute to the following outputs - 3.61.1 Lessons learned from ORD's Technical Support to Superfund and other contaminated sites (the ISCO site is a technical support Superfund site); 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization; and 3.61.4 Strategies for integrated management of contaminated sites.
  - End Users: OLEM, Regional office personnel, tribes and states, environmental consultants.

Product Title**: Long-Term Performance Monitoring of Emulsified Zerovalent Iron for Source Zone Treatment of Chlorinated Solvents at a Superfund site**

- Product Contact (email): Chunming Su (su.chunming@epa.gov)
- Product's Delivery Date: FY 2019

- Product Description: An EPA report to summarize a six-year study of source zone treatment of dense non-aqueous liquid phase contaminants at a Superfund site using emulsified zerovalent iron.
- Product's Contribution to Output: This product will contribute to SHC 3.61.3 output (Methods for characterizing and remediating contaminated ground water, vapors, and sediments impacted from singly- and multiply-contaminated sites to improve community public health and their resources and facilitate revitalization). This product will also contribute to the output of the EPA/China Ministry of Science and Technology Project 2 (Remediation for contaminated soil and ground water).
- Product Timeline (with milestones): (1) Milestone: An invited book chapter entitled "Use of Additives in Bioremediation of Contaminated Ground water and Soil" will be prepared/published for the book (titled Bioremediation to be published by InTech) by September 2016; (2) Milestone: An invited book chapter tentatively entitled "Emulsified zerovalent iron for ground water remediation" will be prepared/published for the book (titled Applying Nanotechnology for Environmental Sustainability to be published by IGI Global) by September 2017; (3) Final Product: EPA report due September 2019.*

* Research activity aligns with SHC 3.61.2, but funding to support this activity is reduced for FY16 (based on FY16 Pres Bud estimates). Delivery of products and milestones may be delayed.

- Product's intended user/customer/audience: OLEM, Regions, States, industry
- Does this Product contribute to a Product under another Task? If so, identify other Task. No
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. An existing QAPP titled "Treatment of Source Zone Chlorinated Solvents Using Emulsified Zerovalent Iron and Fate and Transport of Nanomaterials in the Subsurface" (TASK NO./QA ID NO.: Task 21224/G-10056) will be revised at the start of the activity in FY16.
- Will an independent data management plan be needed for this product? Y/N? If yes, briefly describe a timeline for developing the data management plan. No.

Product Title: **A Decision Support System to Guide the Use of Geophysical Characterization and Monitoring Technologies for Environmental Investigations: Geophysical Tool Decision Support System (GTDSS)**

- Product Contact (email): **Dale Werkema** (werkema.d@epa.gov)
- Product's Delivery Date: Final Product Sept FY19.*

* Research activity aligns with SHC 3.61.2, but funding to support this activity is currently unavailable. Products and milestones may not be produced; delivery will be delayed, at best.

- Intermediate milestones as follows:
  - December 2015: A proof-of-concept GTDSS milestone for 2D resistivity pre-modeling available on-line
  - 4th quarter FY17: Functioning GTDSS with a suite of up to 17 geophysical methods (funding dependent). As methods become developed and tested they will be uploaded and live on-line for download, thereby providing intermittent milestones prior to 4th quarter FY17
  - 4th quarter FY18: Report on field demonstration and evaluation of GTDSS (milestone)

- 2nd quarter FY19: webinar training; on-site training (milestone)
- 4th quarter FY19 – Final product = downloadable software including pdf manual and instructions, webinar training, on-site training

- Product Description: State-of-the-research geophysical technology has enormous potential to improve site characterization and monitoring in support of the management of contaminated ground water and general conceptual site model development; however, state-of-the-practice geophysics has shown mixed results. Indeed, the geophysical community has gained an unfortunate (but sometimes deserved) reputation for over-selling capabilities or over-interpreting results. These problems can be attributed to a widespread lack of understanding—among practitioners and end-users alike—about the efficacy, sensitivity, and resolution that reasonably can be expected from geophysics under conditions that vary substantially between sites. Regulators, project managers, and geophysical practitioners lack tools to predict the reliability of a geophysical method to provide answers to salient questions, e.g., can the method detect DNAPL pools? Monitor amendment emplacement? Verify or monitor biodegradation? Identify discrete fractures? Map permeability?

  The ability of a particular geophysical method to answer such questions depends critically on site-specific conditions, such as lithology (and related physical properties such as clay content), depth to bedrock, depth to water table, fluid conductivity, cultural interference, well design, etc.; thus, new tools are needed to guide the selection and use of geophysical technology at contaminated sites. These tools should enable computational "gut checks" as to the likelihood that a method will produce the answers or information sought, and they should be accessible to site professionals with little prior knowledge of geophysics.

  The overall goal of this work is to advance the educated and effective adoption of geophysical technology for management of contaminated sites or for conceptual site model development. Toward this end, this product will develop, demonstrate, and disseminate a Geophysical Toolbox Decision Support System (GTDSS) aimed at geophysics users and end users (regulators or site professionals). This idea has three technical objectives:
  - Provide a decision support system with pre-modeling capabilities to enable selection of appropriate and effective geophysical methods to use at a site, given project goals and site conditions;
  - Demonstrate application of the tool for management of contaminated ground water at select sites;
  - Transfer this online tool and technology to site professionals and regulators through online dissemination, software documentation, webinars/cyber-seminars, and/or hands-on training courses

    Overall, the GTDSS is a very sophisticated web-downloadable geophysical pre-modeling tool that has applicability to a wide range of environmental issues and needs.
- Product's Contribution to Output: The GTDSS would contribute to the following 3.61 outputs with a focus area under Technical Support For Contaminated Sites
  - 3.61.3: Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization

- 3.61.4: Strategies for integrated management of contaminated sites
- 3.61.5: Tools for evaluating temporal and spatial impacts of contaminated sites on public health and the environment, for use in site remediation, restoration and revitalization decisions

- Product's Timeline (with milestones): See Product's Delivery Date above and resource needs below.
- Product's intended user/customer/audience: All EPA RPMs, State environmental regulators and enforcement, DoE, DoD, tribal governments.
- Does this Product contribute to a Product under another Task? Yes. From Focus Area 1: "Assessment on the application of geophysical methods to contaminated sites: reports and web site update reviewing the successes and failures of using geophysical methods to map and monitor contamination and remediation."
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. This products falls under existing Environmental Geophysics QAPP
- Will an independent data management plan be needed for this product? Y/N? No

Product Title: **Geophysical methods to characterize and monitor ground water-surface water interactions.**

- Product Contact (email): Dale Werkema (werkema.d@epa.gov)
- Product's Delivery Date: Final product 4th quarter FY19. Intermediate milestones as follows:
  - FY16-Q4: Milestone: Review paper or report on the state of the practice for conventional and novel geophysical methods for assessing ground water/surface-water (GW/SW) exchange processes
  - FY17-Q4: Conference papers and (or) abstracts as interim milestones for (a) demonstration experiments utilizing novel geophysical methods (e.g., ionic tracer and/or active heating) to assess GW/SW exchange processes and (b) analytical software under development
  - FY18-Q4: Publication of one or more journal articles on the case study and conference papers and (or) abstracts as interim milestones for the analytical software and GW/SW decision support system under development
  - FY19-Q4: Final product: publication of the analytical software and release of the GW/SW decision support system as a module of the overall Geophysical Toolbox Decision Support System, which is a product in SHC 3.61 Focus Area 1: Technical Support.
- Product Description: The geophysical characterization and detection of ground water – surface water (GW/SW) interactions involves non-invasive, or very minimally invasive, surficial mapping of geophysical properties caused by, or effected by, this dynamic hydrogeological interface. The detection of temperature and electrical gradients between the ground water and surface water enables rapid large area coverage of these interactions, can guide the placement of remediation or capture systems before surface water bodies are impacted, can guide well placements, and monitor temporal variations as fluids move between this interface. The identification and monitoring of GW/SW interaction zones serves many of the Program Office needs where the understanding of subsurface processes

(e.g., fate and transport and remediation effectiveness) is paramount to meeting their specific objectives. Additionally, understanding this zone is important for understanding climate change impacts and critical to understanding streambed nitrogen cycling, which has an impact on greenhouse gas emissions.
This task will include: (a) analytical software to assess GW/SW interaction from hydrogeophysical data (e.g., temperature and electrical resistivity); (b) decision-support system software to support selection of geophysical methods and design of surveys for effective application to GW/SW problems; and (c) publications on the methods/tools developed and a case-study demonstration.

- Product's Contribution to Output: This product and milestones per fiscal year described herein support components of each of the five outputs for SHC 3.61. Understanding GW/SW interactions as part of conceptual site model development, contaminant fate and transport investigations, and remediation monitoring all have applications and relevance to the following 3.61 outputs:
  - 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
  - 3.61.4 Strategies for integrated management of contaminated sites
  - 3.61.5 Tools for evaluating temporal and spatial impacts of contaminated sites on public health and the environment, for use in site remediation, restoration and revitalization decisions
  - Furthermore, the culminating product from this research in the 4th quarter of FY19, is a module for the Geophysical Tool Decision Support Systems (GTDSS), which is a product within 3.61 Technical Support and directly relates to the technical support Outputs within 3.61.
- Product's Timeline (with milestones): See Product's Delivery Date above and resource needs below.
- Product's intended user/customer/audience: This product and sub-products are intended to be utilized by RPMs, Program Office, stakeholders, state environmental officials, tribal governments, and the general scientific public. Understanding the tools available and best practices for GW/SW investigations has broad utility as previously discussed, as well as contaminated sediments, climate change, and mine waste and drainage, for example.
- Does this Product contribute to a Product under another Task? If so, identify other Task. Yes, as detailed above, this product contributes to Task 1 in SHC 3.61. It also contributes to other geophysical research related to long-term landfill performance within SHC 3.63, which will also cross benefit from this GW/SW product. Finally, geophysical research within SSWR 5.02B – Green Infrastructure ground water impacts has cross theme application and utility.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. This research falls under the existing Environmental Geophysics QAPP.
- Will an independent data management plan be needed for this product? Y/N? If yes, briefly describe a timeline for developing the data management plan. No.

Product Title: **Natural Attenuation and Co-contaminant Behavior of Arsenic and Selenium**

- Product Contact (email): Rick Wilkin (wilkin.rick@epa.gov)
- Product's Delivery Date: FY17/FY19
- Product Description: Peer-reviewed journal article describing the co-contaminant behavior of arsenic and selenium. This research will provide an analysis of the co-contaminant behavior of arsenic and selenium in ground water. This study will explore the geochemical controls on the mobilization and attenuation of these inorganic contaminants at the East Helena Superfund site. Geochemical gradients drive contrasting transport and fate behavior of arsenic and selenium. An understanding of their co-contaminant behavior is necessary to select appropriate and effective remediation technologies for these contaminants. This research is highly significant because it begins to look holistically at the co-contaminant behavior of inorganics, rather than examining the behavior of a particular element by itself, as is traditionally done.
- Product's Contribution to Output: This product contributes to Outputs 3.61.3
- Product's Timeline (with milestones): A QAPP is already prepared and approved for this research. The peer-reviewed journal article will be completed by FY17. A factsheet will be prepared to accompany the journal article in FY19 – the factsheet will have the purpose of condensing the key findings of the research and will be useful to EPA clients (e.g., Regional Offices and Program Offices, as well as contractors in the field of ground water remediation). Fieldwork will be conducted on an annual or more frequent basis. The fieldwork will involve ground water sampling and analysis; including X-ray absorption spectroscopy studies at Argonne National Laboratory.
- Product's intended user/customer/audience: EPA clients (regional offices, program offices), contractors in the field of ground water remediation, researchers.
- Does this Product contribute to a Product under another Task? No, but it does relate to another product in this task.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. QAPP ID No.: G-10108
- Will an independent data management plan be needed for this product? Y/N? No.

Product Title: **Predicting the Mobilization of Arsenic in Reducing Environments**

- Product Contact (email): Rick Wilkin (wilkin.rick@epa.gov)
- Product's Delivery Date: FY19
- Product Description: Peer-reviewed journal article(s) describing a methodology for predicting the potential for metals mobilization in reducing environments. In-situ reductive technologies are used to treat chlorinated solvent compounds in ground water and mobilization of inorganics is a potential secondary water quality impact. The research outputs will describe sample collection needs, analysis (total metals; sequential extractions; speciation); modeling; and potential application on samples from one or more field sites.
- Product's Contribution to Output: This product contributes to Output 3.61.3 – "Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization". In-situ redox manipulation is sometimes used

to treat organic compounds at hazardous waste sites. Secondary mobilization of arsenic, in particular, but other metals as well, has been reported in some instances. Whether or not secondary mobilization will occur is a site-specific question. Tools are needed to predict whether this could be an issue at a given site.

- Product's Timeline (with milestones): A QAPP will be prepared for this research. A factsheet will be prepared to accompany the journal article – the factsheet will have the purpose of condensing the key findings of the research and will be useful to EPA clients (e.g., Regional Offices and Program Offices, as well as contractors in the field of ground water remediation). Fieldwork will be conducted if a suitable site is identified.
- Product's intended user/customer/audience: EPA clients (regional offices, program offices), contractors in the field of ground water remediation, researchers.
- Does this Product contribute to a Product under another Task? No, but it does relate to other products in this task.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. A QAPP will be prepared in FY16, if funding for this project is allocated.
- Will an independent data management plan be needed for this product? Y/N? No.

Product Title: **Long-term Performance of Permeable Reactive Barriers for Treating Contaminated Ground Water**

- Product Contact (email): Rick Wilkin (wilkin.rick@epa.gov)
- Product's Delivery Date: FY18/FY19
- Product Description: This research will provide a review of the long-term performance of the East Helena Permeable Reactive Barrier (PRB) for the treatment of arsenic in ground water. This study will report on contaminant behavior at this PRB using data collected over 10 years. The results of this study are highly significant because they represent the longest available performance record of a PRB for treating arsenic in ground water. Peer-reviewed journal article(s) is planned for FY18 describing the >10 year performance of a granular iron permeable reactive barrier for the treatment of arsenic in ground water, with a fact sheet in FY19. This contribution will follow-up on previously published work and will describe the geochemical and hydraulic performance of a PRB that was installed at the East Helena Superfund Site in Montana (EPA Region 8).
- Product's Contribution to Output: This product contributes to Output 3.61.3 – "Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization". The PRB technology is commonly used at hazardous waste sites to remediate contaminated ground water. Decision makers need information about how these systems function over extended periods of time. ORD/GWERD research is unique internationally in providing long-term datasets and evaluation hydraulic and geochemical processes important in PRB systems.
- Product's Timeline (with milestones): A QAPP is already prepared and approved for this research. The peer-reviewed journal article will be completed by FY18. A factsheet will be prepared to accompany the journal article in FY19 – the factsheet will have the purpose of

condensing the key findings of the research and will be useful to EPA clients (e.g., Regional Offices and Program Offices, as well as contractors in the field of ground water remediation). Fieldwork will be conducted on an annual or more frequent basis. The fieldwork will involve ground water sampling and analysis and hydrologic assessments.

- Product's intended user/customer/audience: EPA clients (regional offices, program offices), contractors in the field of ground water remediation, researchers.
- Does this Product contribute to a Product under another Task? No.
- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. QLOG ID: G-10108 and G-10110.
- Will an independent data management plan be needed for this product? Y/N? No.

Product Title: **Draft framework for evaluating leaching potential of semi-volatile and non-volatile organic contaminants**

- Product Contact (email): Susan Thorneloe (thorneloe.susan@epa.gov)
- Product's Delivery Date: FY19 (proposed)
- Product Description: A draft framework approach and draft guidance for methods to evaluate the leaching potential of semi-volatile and non-volatile organic contaminants (SVOCs and NVOCs) will be developed.
- Product's Contribution to Output: Final product providing the draft framework/approach and guidance on evaluating the leaching potential of SVOCs and NVOCs for OLEM.
- Product's Timeline (with milestones):
  - Milestone: Focused workshop on the feasibility of developing a SVOC and NVOC leaching framework – assist OLEM with focused workshop on the feasibility of developing an organics leaching framework (proposed delivery date: FY16)
  - Milestone: Draft methodologies for assessing leaching potential of SVOCs and NVOCs for EPA's Hazardous Water Test Methods (SW 846) – development of methods based on internal and external input received from the organics leaching workshop and future discussions (proposed delivery date: FY18). Note: more than one method may be likely given factors that influence organic constituent leaching. Decisions on feasibility, made following focused workshop (previous milestone), will determine best path forward. Moving forward with a draft method also depends on funding availability.
  - Milestone: Validation of individual test methods for leaching of SVOCs and NVOCs. Multi-laboratory studies to validate methodologies would follow development of draft methods (tentative delivery date: FY18-FY19).
  - Product: Draft framework approach and draft guidance for methods to evaluate the leaching potential of SVOCs and NVOCs (proposed delivery date: FY19).
  - Future Work: Possible integration of organic leaching methods into data management-visualization tool, How To Guide, and other implementation support for methods (proposed delivery date: FY19 and beyond).
- Product's intended user/customer/audience: Framework and guidance document are an OLEM priority (multiple program offices within OLEM: OSRTI, ORCR); Regions, States and Tribes, other federal collaborators; Other users: Regulated community; public.
- Does this Product contribute to a Product under another Task? No.

- Identify existing QAPPs under which the product will be developed, or briefly describe a timeline for developing new QAPPs. QAPPS may need to be developed for draft guidance document development product; will need QAM input on how to proceed.
- Will an independent data management plan be needed for this product? Y/N? No.
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Task 3 – Contaminated Sediments Research

Project Title: SHC 3.61 - Contaminated Sites
Task Title: 3.61.3 - Contaminated Sediments Research
Task Leads: Lawrence Burkhard, NHEERL

Task Start Date: October 1, 2015 (FY 16)
Task End Date: September 30, 2019 (FY 19)

TASK DESCRIPTION
The research performed in the Contaminated Sediment Task addresses OLEM's priority research needs for contaminated sediment sites:

1) *Passive Sampling:* Improving analytical technology for the evaluation of hydrophobic organic contaminants and metals in sediment and in sediment interstitial water, and developing guidance on how to apply the resulting measurements within the Superfund process,
2) *Bioaccumulation:* Improving our understanding of linkages between contaminant concentrations in sediment and fish tissue concentrations, and
3) *Remedy Effectiveness:* Evaluating the effectiveness of contaminated sediment remediation alternatives and their associated impacts in meeting Remedial Action Objectives at Superfund sites.

The research performed in the Contaminated Sediment Task addresses the Great Lakes National Program Office (Region 5) priority needs for contaminated sediments sites within Areas of Concern (AOCs):

1) *Remedy Effectiveness:* Evaluating the effectiveness of contaminated sediment remediation alternatives and their associated impacts (a need shared with OLEM, see #3 above) in support of the Great Lakes Legacy Act and Great Lakes Restoration Initiative,
2) *Source Identification:* Developing methods, metrics, and approaches to identity, track, and apportion contaminant sources at Great Lakes Legacy Act sediment sites, and
3) *Restoration Effectiveness:* Developing long-term assessment methods, metrics, and guidance to characterize, monitor, and maintain habitat restoration following remediation and restoration activities at AOC sediment sites.

An additional need by OLEM and GLNPO is:

1) *Toxicity:* Revision and subsequent release of the 3rd edition of EPA's *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates.*

Efforts within this task fold into the process of Remediation to Restoration to Revitalization (R2R2R) being promoted by GLNPO for their Great Lakes Legacy Act sediment sites within their AOC Program. The research performed on remedy and restoration effectiveness will be coordinated with SHC Project 2.61: Community-Based Ecosystem Goods & Service, Task 5: Coordinated Case Studies, Subtask 5C: Ecosystem Services For Great Lakes Communities in order to bring to fruition an overall process and guidance for the R2R2R process.

RESEARCH APPROACH

1) *Passive Sampling:*

OWSER/OSRTI (Superfund) and GNLPO needs tools and methodologies for (1) measuring and incorporating chemical bioavailability into site assessments and (2) for more effectively monitoring remedy performance and ecosystem restoration. Passive sampling techniques are the ideal tool for meeting both of these needs. This research will lead to the development of passive sampling tools, methodologies and applications for use at the Superfund and GLNPO programs' contaminated sediment sites. Further, passive samplers are likely to make these measurements faster, cheaper and better than conventional tools. Specifically, this effort will involve an assessment of the predictive relationships between passive sampler accumulation and bioaccumulation by aquatic organisms of contaminants of concern (CoCs) at contaminated sediment sites. The first component of this effort will focus on the relationships between passive sampler accumulation and organismal bioaccumulation involving direct exposure to contaminated water columns and sediments at Superfund sites. For example, this part of the assessment will compare the predictive strength of the relationship between bioaccumulation by both field and laboratory deployed mussels and polychaetes, commonly used for research and regulatory biomonitoring, and uptake by co-deployed passive samplers (e.g., polyethylene, polyoxymethylene, polydimethylsiloxane). In the second component of this effort, passive sampler uptake will be compared to bioaccumulation by organisms not necessarily co-deployed with the passive samplers. Specifically, this analysis will determine the efficacy of passive sampling data for predicting bioaccumulation by fish and shellfish. To make these estimates, bioaccumulation models will be used to link passive sampler estimates of bioavailable concentrations to bioaccumulation by organisms exposed to CoCs at contaminated sediment sites via numerous routes including diet. Both components of this effort will provide the Superfund program with information for determining the capability of passive sampler information for predicting bioaccumulation by biomonitoring organisms (e.g., polychaetes, mussels) as well as organisms potentially consumed by humans (e.g., fish and shellfish). These data are critical when conventional biomonitoring and bioaccumulation data are not available or cannot be collected.

The effort will also continue to evaluate the most appropriate passive sampling approaches to apply at contaminated sediment sites. Specifically, research will focus on performing comparisons of different types of passive samplers and related techniques (e.g., methodologies for analyzing passive sampler equilibrium data) in order to provide the Superfund and GLNPO programs with the best available recommendations for using passive sampling for making scientifically-informed decisions at their sites around the country.

2) B*ioaccumulation:*

At most contaminated sediment sites with contaminated sediments, remedial options are evaluated for their effectiveness in reducing risks, and these evaluations, most often, involve the forecasting of contaminant residues in fish spanning 5 to 50 years forwards in time post-remedy completion. Uncertainties in these forecasts can arise, in part, from the correctness of the bioaccumulation models themselves. We will assemble a group of aquatic food web bioaccumulation modeling experts with knowledge and experience of the inner workings of these models, e.g., respiration, growth, and dietary uptake submodels, and those with experience forecasting chemical residues for 5 to 50 year time windows. This group would look into and define the gaps and limitations of existing models, and make recommendations on what should or should not be done to improve such models. The focus of the group would not be on screening chemicals for bioaccumulation potential, but rather on making real life predictions at contaminated sediment sites for basing remedial decisions upon for lowering risks at the site.

At contaminated sediment sites, biota-sediment accumulation factors (BSAFs) often decline with increasing concentration in the sediment, and this behavior is contrary to the expected behavior of BSAFs. Potential causes of this behavior include artifacts rising from conditions in the sediment bioaccumulation tests used to measure the BSAFs and bioavailability of the chemical in the sediments. We will perform research on the sediment testing conditions in conjunction with measurements of chemical bioavailability to determine the cause(s) of this behavior.

3) *Source Identification, Remedy Effectiveness & Restoration Effectiveness:*

Contaminated sediments sites are generally difficult to remediate and restore due to multiple sources (historic and ongoing), complex spatial and geographic features, historic and ongoing shipping, recreational, and industrial uses, sensitive ecosystems, high urban use, and mixtures of COCs. A primary tenet of remediation and restoration of a contaminated site is to identify and manage contaminant sources. In complex systems such as contaminated sediments in ports, harbors, rivers, and lakes, the identification of significant on-going or historic sources is difficult. ORD is developing approaches to distinguish historic sources of contamination from potentially significant on-going sources using methods and approaches that rely on chemical, biological, and physical lines of evidence. The methods and tools includes passive sampling, invertebrate and fish sentinel species with the foodweb, sediment traps, forensic chemistry, etc. These approaches evaluate the COCs at the appropriate spatial and temporal scale for identify, tracking, and apportioning sources. ORD will work with OLEM and GLNPO to select sites were methods or approaches can be developed, validated, and formalized into technical guidance to identify, track, and apportion sources of COCs to sediment sites.

Remediation of the contaminated sediment sites are being conducted or overseen by EPA in programs such as OLEM's RCRA and Superfund programs and the GLNPO's Great Lakes Legacy Act (GLLA) and Great Lakes Restoration Initiative (GLRI). To support these programs, ORD is conducting research to identify methods, metrics, and approaches to assess the effectiveness of remediation projects for their ability to meet remedy objectives, such as delisting of Beneficial Use Impairments (BUIs) within AOCs or meeting Remedial Action Objectives (RAOs)

at Superfund sites. These methods and metrics can be remedy specific in some instances [e.g. measuring scour potential for monitored natural recovery (MNR)] or not remedy specific (e.g. reduction in sentinel species in the food web). Generally the approach being developed is based on a weight of evidence from chemical, biological, and physical lines of evidence. Metrics along these lines of evidence are being developed, evaluated, and tech transferred to site managers. The methods and metrics are further being developed into guidance for developing Remedy Effectiveness Assessments (REAs) for remediation projects and for delisting of BUIs. The metrics will also be used to assign and assess ecosystem services and their functions under task 2.61. ORD will work with OLEM and GLNPO to identify contaminated sediments sites at various stages of remediation to allow for both pre- and post-remedy assessments for a variety of remediation strategies (MNR, capping, dredging, in-situ treatment, etc).

Restoration of a contaminated sediment sites can be through projects designed specifically to restore a habitat or a function on the ecosystem, or through betterment provided during remediation activities. GLNPO has identified a need for developing and validating methods and metrics to assess the effectiveness of restoration. Assessment would include a weight of evidence using chemical, biological, and physical lines of evidence to develop an appropriate baseline and designing a long term assessment plan to characterize the effectiveness of restoration activities with an AOC. Like remedy effectiveness, the methods and metrics developed to assess restoration effectiveness will also be used for designating and/or assessing ecosystem services and their functions under task 2.61.

4) *Toxicity:*

EPA's freshwater sediment toxicity and bioaccumulation testing manual was published in 2000. Recent research and numerous in-house reviews of results from testing facilities have indicated that current freshwater sediment toxicity test methods have weaknesses that can lead to artifacts and misinterpretation. Refinements are needed to eliminate these problems and provide site risk assessments with data that can be more confidently identify sediments posing risk to benthic invertebrates. Our research efforts will refine and improve toxicity test methodologies so that their results better reflect risks to benthic invertebrates, eliminate confounding factors, and improve overall performance/success rate of the tests. These improvements and refinements will be incorporated into a forthcoming 3rd edition of EPA's freshwater sediment toxicity and bioaccumulation testing manual.

TASK CONSTRAINTS

In this task, much of the research can only be done on field sites where remedial and restoration activities are planned, under way, and/or completed. For example, demonstrations of remedy effectiveness tools require field data prior to the remedial action and after remedy completion in order to validate such methods. As a result, ORD is dependent upon and needs to work in close cooperation with Superfund and GLNPO at their sediment sites in order to conduct the research in this task. This close cooperation translates into ORD following the time schedules of remediation and/or restoration activities of Superfund and GLNPO, and not those set by ORD's planners and researchers. Further, at Superfund sites, performing research can be especially difficult because approval from the PRP's (potentially responsible parties) is required

in order for ORD to be present at the site.

Given these constraints, some research efforts may or may not be performed in a timely manner and/or be performed at all.

TASK DEPENDENCIES

Remedial activities are done by Superfund and GLNPO, and not by ORD. Research on remedy effectiveness often involves detailed sampling prior to and post remedial activities. Leveraging of ORD's resources (FTEs, and intramural and extramural funding) with the activities at Superfund and GLNPO sites is essential for successful research on remedy and restoration effectiveness. Without the leveraging of ORD's resources, generating useful and validated tools and methodologies for contaminated sites remedial activities is almost impossible.

TASK QUALITY ASSURANCE AND DATA MANAGEMENT NEEDS

- QAPPs exist at the Division level of ORD's Laboratories. There will not be one master QAPP for the Task given the number of individual efforts, their locations, and vastly different scopes and outputs.
- This Task will NOT involve large amounts of data that need a data management plan.

TASK PRODUCTS

Product Title: **Evaluation and application of passive sampling to estimate bioavailable concentrations of contaminants in sediments and the water column**

- Product Contact (email): Robert Burgess (burgess.robert@epa.gov)
- Product's Delivery Date: September 31, 2016
- Product Description: This technical report will investigate the use of passive samplers as surrogates for organisms exposed directly to hydrophobic organic contaminants at contaminated sites. Organisms being evaluated are commonly used as biomonitoring and sediment toxicity testing species including polychaetes, oligochaetes, and bivalves. This product will provide OLEM/OSRTI (Superfund), Regions, States, Tribes, and other users with an assessment of the merits of using passive samplers as surrogates for organisms in some circumstances.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? No

Product Title: **Weight of evidence for baseline characterization for assessing remedy effectiveness at a contaminated sediment site**

- Product Contact (email): Marc Mills (mills.marc @epa.gov)
- Product's Delivery Date: September 31, 2016
- Product Description: At contaminated sediments sites, pre-remedy site characterization must be conducted prior to remediation and restoration activities. Using a weight of evidence with chemical, biological, and physical lines of evidence, this report will detail standard and innovative metrics for baseline characterization of a contaminated sediment site.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: GLNPO (Region 5), OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? Yes, the FY17 Remedy Effectiveness Assessment deliverable.

Product Title: **A guidance document to assess remedy effectiveness at contaminated sediment sites**

- Product Contact (email): Marc Mills (mills.marc @epa.gov)
- Product's Delivery Date: September 31, 2016
- Product Description: At a contaminated sediment site, a weight of evidence assessment guidance using chemical, biological, and physical lines of evidence will be reported following a large scale sediment remediation project. The guidance provides a framework for selecting appropriate metrics along chemical, biological, and physical lines of evidence to assess the effectiveness of the remediation on a contaminated sediment site.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: GLNPO (Region 5), OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? No

Product Title: **Evaluation of existing food chain models and research needs for lowering uncertainties associated with their forecasts**

- Product Contact: Lawrence Burkhard (burkhard.lawrence@epa.gov)
- Product's Delivery Date: September 31, 2017
- Product Description: At Superfund sites with contaminated sediments, residues in fish are forecasted for time periods ranging from 5 to 50 years after remedy completion, and current forecasts have fairly large uncertainties. This report will evaluate and describe

improvements (if any) that need to be done in order to lower uncertainties with forecasts from food web models.

- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: OLEM/OSRTI (Superfund)
- Does this Product contribute to a Product under another Task? No.

Product Title: **3rd edition of EPA's freshwater sediment toxicity and bioaccumulation testing manual.**

- Product Contact (email): David Mount (mount.dave@epa.gov)
- Product's Delivery Date: September 31, 2017
- Product Description: This EPA 600 series document provides updates and improvements for EPA's freshwater sediment testing methods. The updates will result in better testing data as well as better test performance by laboratories performing these tests.
- Product's Contribution to Output: 3.61.3: Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: OLEM/OSRTI (Superfund), Regions, States, Tribes, testing laboratories, US-ACE, Non-USA regulatory groups
- Does this Product contribute to a Product under another Task? No

Product Title: **A report on the remedy effectiveness assessment using a weight of evidence at a contaminated sediment site**

- Product Contact (email): Marc Mills (mills.marc @epa.gov)
- Product's Delivery Date: September 31, 2017
- Product Description: At a contaminated sediment site, a weight of evidence assessment using chemical, biological, and physical lines of evidence will be reported following a large-scale sediment remediation project. This retrospective assessment report evaluates the standard and innovative methods and metrics to assess the effectiveness of the remediation on a contaminated sediment site.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: GLNPO (Region 5), OLEM/OSRTI (Superfund), Regions, States, Tribes

- Does this Product contribute to a Product under another Task? No

Product Title: **Manuscript on multiple lines of biological evidence for assessing remedy effectiveness in Ottawa River, OH USA**

- Product Contact (email): James Lazorchek (lazorchak.jim@epa.gov)
- Product's Delivery Date: September 31, 2017
- Product Description: This manuscript summarizes a case study performed on the Ottawa River, OH USA that evaluated the use of multiple lines of biological evidence for assessing remedy effectiveness at a contaminated sediment site.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: GLNPO (Region 5), OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? No

Product Title: **Innovative metrics for identifying and characterization for legacy and on-going sources to contaminated sediment sites**

- Product Contact (email): Marc Mills (mills.marc @epa.gov)
- Product's Delivery Date: September 31, 2017
- Product Description: At contaminated sediments sites, identifying and characterizing legacy and ongoing sources are critical first steps in remediating and restoring contaminated sediments sites. Using a weight of evidence with chemical, biological, and physical lines of evidence, a peer reviewed manuscript demonstrating innovative metrics to characterization and allocation of sources to contaminated sediment sites.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: GLNPO (Region 5), OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? No

Product Title: **Efficacy of passive sampler-based interstitial water measurements to improve predictions of contaminant concentrations in fish and shellfish**

- Product Contact (email): Robert Burgess (burgess.robert@epa.gov)
- Product's Delivery Date: September 31, 2018
- Product Description: This technical report will investigate the efficacy of passive samplers in combination with bioaccumulation modelling as tools to predict bioaccumulation of hydrophobic organic contaminants at contaminated sites.

Organisms being evaluated are fish and shellfish that may be consumed by human receptors. Gobas-type bioaccumulation models will be considered. This product will provide OLEM/OSRTI (Superfund), Regions, States, Tribes, and other users with an assessment of the merits of using passive samplers as tools, along with bioaccumulation models, for predicting bioaccumulation of hydrophobic organic contaminants in some circumstances.

- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? No

Product Title: **Weight of evidence for assessing remedy effectiveness at a contaminated sediment site**

- Product Contact (email): Marc Mills (mills.marc @epa.gov)
- Product's Delivery Date: September 31, 2018
- Product Description: At a contaminated sediment site, a weight of evidence assessment using chemical, biological, and physical lines of evidence will be reported following a large scale sediment remediation project. This retrospective assessment report evaluates the standard and innovative methods and metrics to assess the effectiveness of the remediation on a contaminated sediment site.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: GLNPO (Region 5), OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? No

Product Title: **Determination of processes causing the apparent increase in bioaccumulation as concentrations in sediments decrease**

- Product Contact: Lawrence Burkhard (burkhard.lawrence@epa.gov)
- Product's Delivery Date: September 31, 2019
- Product Description: A technical report on resolving the unsettling question of "Why do BSAFs (biota-sediment accumulation factors) decline at some sites?" will be provided. Current sediment theory suggests that the BSAF should be constant. BSAFs are used in designing and evaluating remedy alternatives, and the causes of this behavior, if real, need to be factored into Superfund's decision process.

- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: OLEM/OSRTI (Superfund)
- Does this Product contribute to a Product under another Task? No.

Product Title: **A guidance to conduct an assessment to identify and characterize legacy and on-going sources to contaminated sediment sites**

- Product Contact (email): Marc Mills (mills.marc @epa.gov)
- Product's Delivery Date: September 31, 2019
- Product Description: At contaminated sediments sites, identifying and characterizing legacy and ongoing sources are critical first steps in remediating and restoring contaminated sediments sites. A technical support report will document the use of a weight of evidence approach with chemical, biological, and physical lines of evidence to identify and characterize legacy and ongoing sources to contaminated sediments.
- Product's Contribution to Output: 3.61.3 Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization
- Product's Timeline (with milestones):
- Product's intended user/customer/audience: GLNPO (Region 5), OLEM/OSRTI (Superfund), Regions, States, Tribes
- Does this Product contribute to a Product under another Task? No

Task 4 – Vapor Intrusion Research

Project Title: SHC 3.61 - Contaminated Sites
Task Title: 3.61.4 - Vapor Intrusion Research
Task Lead: Brian Schumacher, NERL

Task Start Date: October 1, 2015 (FY 16)
Task End Date: September 30, 2019 (FY 19)

TASK DESCRIPTION

Vapor intrusion (VI) into residences and other occupied buildings is a potential problem at many contaminated sites as soil and ground water contaminants may volatilize and be transported to the soil surface. There is a possibility that the contaminant vapor may present long-term health risks. Vapor intrusion issues are typically divided into two classes of contaminants, namely, volatile organic compounds (VOCs) and radon. VOC contamination is

predominantly the result of anthropogenic releases into the environment and includes both the chlorinated solvent and petroleum hydrocarbon class of compounds. The most prevalent chlorinated solvents found are tetrachloroethene (a.k.a. perchloroethene) and trichloroethene while benzene, toluene, ethylbenzene, and the xylenes most commonly represent the released petroleum hydrocarbons.

Ongoing research is being conducted examine the distribution and movement of VOCs from a ground water source through the soil to the open surface or subslab and into a residence/building. Efforts to date have examined: different sample collection techniques; the influence of tubing type used to collect soil gas samples; the time necessary to reach dynamic concentrational equilibrium after sampling well installation has been completed; equilibration testing of the fan method to induce vapor intrusion; the effectiveness of a mitigation system to reduce, or eliminate, vapor intrusion of both VOCs and radon; and the possibility to predict when to sample for "maximum" vapor concentrations by using simple, inexpensive, and rapid measurement devices.

RESEARCH APPROACH

A three-pronged approach is being taken to address the issue of vapor intrusion. The three prongs include: (1) examination of the factors influencing the distribution and movement of vapors outside of the building; (2) determination of vapor intrusion pathways, sampling techniques, sampling timing, and distribution of vapors spatially and temporally within the building; and (3) investigation of means to mitigate or prevent vapor intrusion from occurring into the building. Research studies have and are being conducted to fill knowledge gaps, as identified by ORD and OLEM, in each of the three prongs.

TASK CONSTRAINTS

There are no scientific constraints associated with this task other than finding a residence or building with known vapor intrusion to conduct each of the research efforts. Logistical constraints are present as the residence or building is generally outside of the local area of the researchers and; hence, must be travelled to or have a contractor available to collect samples or maintain equipment. No technical constraints have been identified.

TASK DEPENDENCIES

Fiscal funding is required for field sampling and some analyses during intense sampling periods.

TASL QUALITY ASSURANCE AND DATE MANAGEMENT NEEDS

- Past research efforts have been performed under numerous individual QAPPs developed expressly for the study being conducted.
- Current research is being performed under the approved QAPP entitled, "Simple, Efficient and Rapid Methods to Determine the Potential for Vapor Intrusion into the Home"; QATS identifier: QA-ESD-151

- For each research effort leading to the final output, a new QAPP will be prepared to address the specifics of that study. The QAPP(s) for FY15/FY16 will be initiated after contract award. Estimated time frame is June 2015
- No data management plan will be required until new requirement is finalized. At that point, a data management plan will be necessary and will be created

TASK PRODUCTS

Product Title: **The Effect of Equilibration Time and Tubing Material on Soil Gas Measurements**

- Product Contact (email): John Zimmerman (zimmerman.johnh@epa.gov)
- Product's Delivery Date: est. June 1, 2015 submission to journal
- Product Description: journal article providing basic information related to time after monitoring well established
- Product's Contribution to Output: one piece for outdoor soil gas sampling
- Product's Timeline (with milestones) est. June 1 submission to journal; August 1 return with comments from journal; Sept 1 publication
- Product's intended user/customer/audience Program Offices, Regions, VI community, general public
- Does this Product contribute to a Product under another Task? No.

Product Title: **The Evaluation of Long Term Passive Sampler Performance for the Determination of Vapor Intrusion into Homes**

- Product Contact (email): Brian Schumacher (schumacher.brian@epa.gov)
- Product's Delivery Date: est. June 21, 2015 submission to journal
- Product Description: journal article providing basic information on the effectiveness of using passive sorbers to monitor VI events/exposure in a residence
- Product's Contribution to Output: one piece determining indoor air methodologies
- Product's Timeline (with milestones) est. June 21 submission to journal; August 21 return with comments from journal; Sept 21 publication
- Product's intended user/customer/audience Program Offices, Regions, VI community, general public
- Does this Product contribute to a Product under another Task? No.

Product Title: **Comparison of temporary and permanent subslab probes for VOC determinations**

- Product Contact (email): John Zimmerman (zimmerman.johnh@epa.gov)
- Product's Delivery Date: est. July 15, 2015 submission to journal
- Product Description: journal article providing basic information on the effectiveness of temporary subslab port construction technique on maintaining integrity of subslab soil gas concentrations
- Product's Contribution to Output: one piece determining potential vapor build-up, and subsequent intrusion, under slabs of residences

- Product's Timeline (with milestones) est. June 30 submission to journal; August 30 return with comments from journal; Sept 30 publication
- Product's intended user/customer/audience Program Offices, Regions, VI community, general public
- Does this Product contribute to a Product under another Task? No.

Product Title: **Short-duration screening methods for worse case vapor intrusion identification**
- Product Contact (email): Brian Schumacher (schumacher.brian@epa.gov)
- Product's Delivery Date: est. March 1, 2016 submission to journal
- Product Description: journal article providing new information on whether or not a high (or the highest) VOC concentrations can be obtained with minimal disturbances to the home owners from recently conducted research
- Product's Contribution to Output: one piece contributing to when to sample to capture vapor intrusion events and if mitigation is necessary
- Product's Timeline (with milestones) est. March 1, 2016 submission to journal; May 1, 2016 return with comments from journal; June 1, 2016 publication
- Product's intended user/customer/audience Program Offices, Regions, VI community, general public
- Does this Product contribute to a Product under another Task? No.

Product Title: **Efficacy and cost-effectiveness of commercially available air treatment units for reducing concentrations of chlorinated solvent vapors in indoor air purifiers as short-term mitigating systems**
- Product Contact (email): John Zimmerman (zimmerman.johnh@epa.gov)
- Product's Delivery Date: est. July 1, 2016 submission to journal
- Product Description: journal article providing basic information on whether commercially available air filters are efficient enough to use to mitigate indoor air on a temporary basis
- Product's Contribution to Output: one piece contributing to mitigation needs and mechanics if necessary
- Product's Timeline (with milestones) est. July 1, 2016 submission to journal; August 1, 2016 return with comments from journal; October 1, 2016 publication
- Product's intended user/customer/audience Program Offices, Regions, VI community, general public
- Does this Product contribute to a Product under another Task? No.

Product Title: **Analytical solution for soil vapor extraction subject to diffusion in water table aquifer**
- Product Contact (email): Junqi Huang (huang.junqi@epa.gov)
- Product's Delivery Date: 10/1/2016.
- Product Description: A new analytical model is proposed to be developed to describe soil vapor extraction process. The model simultaneously simulates contaminant transport in vadose zone and water table aquifer. The link condition between vadose and water table zones is proposed base on the mass flux conservation principle. The analytical solutions will

be evaluated with the numerical Laplace transform algorithm. The analytical solutions will be derived. The model solutions can be used to simulate concentration change in the soil vapor extraction well and concentration distribution in vadose zone and water table aquifer. The mass flux through water table maybe conveniently calculated using the analytical solution formula. The total contaminant mass could be evaluated based on the observation breakthrough in soil vapor extraction well. The solution can be used as a tool to assess the efficiency of soil vapor extraction in water table aquifer system.

- Product's Contribution to Output: Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization.
- Product's Timeline (with milestones): 10/1/2016, submit technical paper; 3/1/2017, return with comments from journal; 2/15/2018 publication.
- Product's intended user/customer/audience: contaminated site managers.
- Does this Product contribute to a Product under another Task? No.

Product Title: **Soil vapor extraction to prevent vapor intrusion**

- Product Contact (email): Brian Schumacher (schumacher.brian@epa.gov)
- Product's Delivery Date: est. March 1, 2017 submission to journal
- Product Description: journal article providing basic information on whether soil vapor extraction systems effectively work to not only remediate the site but to prevent/limit vapor intrusion into homes/buildings within the radius of influence of the system
- Product's Contribution to Output: one piece contributing to mitigation needs and prevention of vapor intrusion thereby eliminating need for home owner expenses
- Product's Timeline (with milestones) est. March 1, 2017 submission to journal; May 1, 2017 return with comments from journal; June 1, 2017 publication
- Product's intended user/customer/audience Program Offices, Regions, VI community, general public
- Does this Product contribute to a Product under another Task? No.

Product Title: **Vapor Intrusion monitoring and mitigation in large buildings**

- Product Contact (email): Brian Schumacher (schumacher.brian@epa.gov)
- Product's Delivery Date: est. June 15, 2018 submission to journal
- Product Description: journal article taken knowledge gained in homes/residences and scaling it up to apply to large buildings to determine if same practices are applicable and as effective. If not effective, to identify what would need to be changed to effectively monitor vapor intrusion in these larger structures
- Product's Contribution to Output: one piece jumping from residential to "industrial" buildings
- Product's Timeline (with milestones) est. June 15, 2018 submission to journal; August 15, 2018 return with comments from journal; September 15, 2018 publication
- Product's intended user/customer/audience Program Offices, Regions, VI community, general public

- Does this Product contribute to a Product under another Task? No.

Product Title: **Analytical solutions for transport of volatile organic compound in vadose zone incorporating mass exchange through water table**

- Product Contact (email): Junqi Huang (huang.junqi@epa.gov)
- Product's Delivery Date: 10/1/2018.
- Product Description: A group of innovative analytical solution for the equation system describing transport of volatile organic compound in the vadose zone incorporating mass exchange through water table is proposed to be developed. The model investigates different transport mechanisms appear in subsurface domains. In the vadose, the model simulates diffusion, mass transfer and first order decay of volatile organic compound. In the saturated zone, the model simulates convection, dispersion, rate-limited adsorption and first order decay of dissolved volatile organic compound. Mass transfer among gas, residual water and solid phase is described with rate-limited kinetics. The link conditions on water table are proposed base on the mass conservation principle and Henry's law formulating the solubility of organic volatile compound. In addition, the model considers the effect of the atmospheric boundary layer above the ground surface on the transport. The initial distribution of contaminant in specific area and time dependent source functions are involved. The distribution and breakthrough of the contaminant concentration may be evaluated with the analytical formula. The mass flux through water table and ground surface can be calculated as well. The solutions can be used to assess the vapor intrusion risk.
- Product's Contribution to Output: 3.61.3, Methods for characterizing and remediating contaminated ground water, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization.
- Product's Timeline (with milestones): 10/1/2017, submit technical paper; 2/15/2018 return with comments from journal; 6/15/ 2018 publication.
- Product's intended user/customer/audience: contaminated site managers.
- Does this Product contribute to a Product under another Task? No.

Task 5 – Tools for Evaluating Spatio-Temporal Impacts of Contaminated Sites on the Environment

Project Title: SHC 3.61 - Contaminated Sites
Task Title: 3.61.5 - Tools for Evaluating Spatio-Temporal Impacts of Contaminated Sites on the Environment
Task Lead: David Burden, NRMRL

Task Start Date: October 1, 2015 (FY16)
Task End Date: September 30, 2019 (FY19)

TASK DESCRIPTION

The purpose of this task is produce applied research products that will focus on the temporal and spatial changes in groundwater, vapor intrusion and/or contaminated sediments coupled with social and economic factors related to community water supplies addressing Superfund, Brownfields, and/or Environmental Justice concerns. One of the most challenging aspects of site remediation is the selection of a suitable contaminated site management strategy that incorporates both technical and economical feasibilities of available alternatives that include social variables and site reuse considerations. Research is needed to develop a knowledge base and decision tools to assess and predict temporal and spatial changes in aquifer based water supplies related to community water supplies. It is the intention of ORD to focus its efforts on the development of models and/or decision support tools which are both spatially and temporally based.

RESEARCH APPROACH

Over 80 percent of the most serious hazardous waste sites in the U.S. have adversely impacted the quality of nearby groundwater. Just as the groundwater cleanup process is complex, so are the issues behind the methods and techniques used to determine the best approach for each site. Groundwater accounts for more than 95 percent of the nation's available freshwater resources, and is the drinking water source for half the people in the United States. Many households, towns, cities, farms, and industries use groundwater every day, or depend on lakes and rivers that receive part of their water supplies from groundwater. Groundwater wells near Superfund sites supply public and private drinking water wells, irrigation, and other agricultural needs, and commercial and industrial businesses. There is no single way to characterize communities that are located near hazardous waste sites, but a recent EPA study found that approximately 49 million people live within 3 miles of Superfund sites or proposed NPL sites.

For the past several decades Geographic Information Systems (GIS) has been under continuous development and more recently coupling this technology with decision support systems (DSS). The application of DSS have become widely used and have become integral elements of information technology applications in a wide variety of domains. These computer hardware and software tools are primarily used to integrate and manage multifaceted and varying sets of data within a geographic framework for mapping and modeling. A readily available suite of GIS-based analytical and modeling tools help scientists, engineers, planners, and policy makers make better determinations and decisions about the environment. Moreover, spatial decision support systems (SDSS) are systems that combine analytical tools with functions available in GIS as well as models for evaluating various options. GIS lacks the necessary modeling capabilities, whereas DSS do not support spatial data analysis and cartographic display functions. The development of SDSS has evolved to utilize components from both DSS and GIS. SDSS are designed and implemented to address the class of semi-structured problems with advanced analytical tools that help people explore a problem, learn about it, and use the information gained to arrive at improved decisions. SDSS are designed to solve ill-structured problems, they have user interfaces, they have the flexibility to combine models and data, and they can provide an interactive and recursive problem-solving environment. While GIS are able to allow

spatial exploration of data, they usually do not have sufficient flexibility for interactive and recursive problem solving. SDSS approaches for both detailed and screening impacts of contaminated sites are needed, as are mapping-based evaluation of locations and impacts to private drinking water wells in the context of aquifer vulnerability.

TASK CONSTRAINTS
There are no scientific constraints for the tasks being proposed and outlined below.

TASK DEPENDENCIES
Fiscal funding is required for development of computer based models and spatial decision support tools.

TASK QUALITY ASSURANCE AND DATE MANAGEMENT NEEDS
Is there an existing IRP/ QAPP(s) that applies to this Task? No

Will this Task involve large amounts of data that need a data management plan?
New data will not be collected but existing published data sets from EPA and other federal agencies will be utilized. A data management plan may be required for some tasks.

TASK PRODUCTS

Product Title: **GIS-Mapping and Statistical Analyses to Identify Communities and Populations Disproportionately Impacted by Climate Change-Vulnerable Contaminated Sites, and Key Factors**

- Product Contact: Valarie Zartarian and Jianping Xue (zartarian.valerie@epa.gov; xue.jianping@epa.gov)
- Product's Delivery Date: FY17 Q3
- Product Description: Accepted journal article providing GIS maps and statistical analyses to identify communities and populations disproportionately impacted by climate-vulnerable contaminated sites, and key factors (e.g., social, geographic).
- Product's Contribution to Output: Contributes to output 2.63.4
- Product's Timeline (with milestones):
  - Q1 FY16: ISES Conference presentation "GIS-Mapping and Statistical Analyses to Identify Communities and Populations Disproportionately Impacted by Climate Change-Vulnerable Superfund Sites, and Key Factors"
  - Q4 FY16: submitted journal article for Q3 FY17 product
  - Q1 FY17: ISES Conference presentation "GIS-Mapping and Statistical Analyses to Identify Communities and Populations Disproportionately Impacted by Climate-Change Vulnerable RCRA and Brownfields Sites, and Key Factors"

  * Requested funding to support this activity will be reduced for FY16 (based on FY16 Pres Bud estimates). Delivery of products and milestones may be delayed.
- Product's intended user/customer/audience: OLEM, Regions, Communities, Tribes, OEJ, Exposure Science Community, other SHC partners.

- Does this Product contribute to a Product under another Task? Yes – 3.61 Task 5; other Tasks in 2.63; other SHC project tasks (e.g., 2.62).

Product Title: **Spatial Assessment of Contaminated Groundwater at Hazardous Waste Sites Near Vulnerable Drinking Water Supplies**

- Product Contact (email): David Burden (burden.david@epa.gov)
- Product Delivery Date: September 30, 2018
- Product Description: Using existing spatial data on the location of hazardous waste sites and toxic release sites, and current information on public drinking water supplies, produce GIS layers which could be incorporated into existing spatial decision support tools such as EnviroAtlas, EnviroMapper, and/or MyEnvironment. The research will focus on conducting a GIS-based statistical analysis and/or develop a vulnerability index for the most vulnerable public drinking water sources in proximity of hazardous waste sites with groundwater contamination. For public drinking water supplies the focus will be on producing data layers of public and private wells utilized for drinking water, irrigation, and other agricultural needs, and commercial and industrial businesses.
- Product's Contribution to Output: Methods for characterizing and remediating contaminated groundwater sites impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization.
  Product's Timeline (with milestones): TBD. Requested funding to support this activity will be reduced for FY16. Delivery of products and milestones will be in flux.
- Product's intended user/customer/audience: OLEM, OBLR, OEJ,EPA Regions, Cities, Communities, Tribes
- Does this Product contribute to a Product under another Task? No

Product Title: **Exposure Assessment Case Study of a Community Disproportionately Impacted by Climate-Vulnerable Contaminated Sites**

- Product Contact (email): Jianping Xue and Valarie Zartarian (xue.jianping@epa.gov; zartarian.valerie@epa.gov)
- Product's Delivery Date: FY19 Q4
- Product Description: Accepted journal article on exposure assessment of communities and populations disproportionately impacted by climate-vulnerable contaminated sites, based on GIS mapping, statistical analyses, and case study collaborations.
- Product's Contribution to Output: Contributes to output 2.63.4
- Product's Timeline (with milestones):
  - Q4 FY16 Selection of a collaborative case study
  - Product 1 – FY17 journal article will inform this case study
  - Q1 FY18 – conference presentation
  - Q4 FY18 – submitted journal article

  *Requested funding to support this activity will be reduced for FY16. Delivery of products and milestones may be delayed.
- Product's intended user/customer/audience: OLEM, Regions, Communities, Tribes, OEJ, Exposure Science Community.

- Does this Product contribute to a Product under another Task? Yes – 3.61 Task 5; other Tasks in 2.63; other SHC project tasks (e.g., 2.62).

Product Title: **Graphic User Interface for Using Analytical Model Simulating Transport of Volatile Organic Compounds in Vadose Zone Incorporating Mass Exchange Through Water Table**

- Product Contact (email): Junqi Huang (huang.junqi@epa.gov)
- Product Delivery Date: September 30, 2019
- Product Description: Develop a graphic user interface for using a group of analytical solution simulating transport of volatile organic compound in the vadose zone incorporating mass exchange through water table. The analytical model takes into account different transport mechanisms appear in subsurface domains. In the vadose, the model simulates diffusion, mass transfer and first order decay of volatile organic compound. In the saturated zone, the model simulates convection, dispersion, rate-limited adsorption and first order decay of dissolved volatile organic compound. Mass transfer among gas, residual water and solid phase is described with rate-limited kinetics. The link conditions on water table are proposed base on the mass conservation principle and Henry's law formulating the solubility of organic volatile compound. The initial distribution of contaminant in specific area and time dependent source functions are involved. The distribution and breakthrough of the contaminant concentration may be evaluated with the analytical formula. The mass flux through water table and ground surface can be calculated as well. The solutions can be used to assess the vapor intrusion risk. The tool will help for evaluating temporal and spatial impacts of volatile organic contaminants on the subsurface environment.
- *Product's Contribution to Output:* Methods for characterizing and remediating contaminated groundwater, vapor, and sediment sites, impacted with single or multiple contaminants, to improve community public health and their resources and facilitate revitalization.
- Product's Timeline (with milestones): 10/1/2016, develop soil vapor intrusion model; 10/1/2017, develop the Graphic User Interface; 10/1/2018, Verification of the model and the simulator; 10/1/2019, submit technical paper and software delivering.
  Note: Requested funding to support this activity will be reduced for FY16 (based on FY16 Pres Bud estimates). Delivery of products and milestones will be delayed.
- Product's intended user/customer/audience: Contaminated site managers
- Does this Product contribute to a Product under another Task? If so, identify other Task.
  Yes. The product contributes to SHC 3.61 - Contaminated Sites, task: Analytical solutions for transport of volatile organic compound in vadose zone incorporating mass exchange through water table.