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2019 Annual Report
Office of Research and Development
Technical Support Centers

Office of Research and Development

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List of Acronyms

ACS	American Chemical Society
ADEC	Alaska Department of Environmental Conservation
AOP	advanced oxidation process
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
CCA	comfort cooling appliance
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
COPC	chemical of potential concern
CRA	commercial refrigeration appliance
CVOC	chlorinated volatile organic compound
DAPL	dense aqueous phase liquid
DEQ	Department of Environmental Quality
DNA	deoxyribonucleic acid
DNAPL	dense non-aqueous phase liquid
EDX	energy dispersive X-ray spectroscopy
EE/CA	Engineering Evaluation/Cost Analysis
EMI	electromagnetic induction
EPA	U.S. Environmental Protection Agency
ERAF	Ecological Risk Assessment Forum
ERASC	Ecological Risk Assessment Support Center
ERH	electrical resistance heating
ERT	electrical resistivity tomography
ETSC	Engineering Technical Support Center
FLIR	forward looking infra-red
FO-DTS	fiber optic distributed temperature sensing
FS	feasibility study
FSWT	Fairfax Street Wood Treaters
FTIR	Fourier-transform infrared spectroscopy
FY	Fiscal Year
GWTSC	Ground Water Technical Support Center
HAB	harmful algal bloom
HCFC	hydrochlorofluorocarbon

List of Acronyms (Continued)

HVSR	horizontal-to-vertical spectral ratio
ICP	inductively coupled plasma
IPRU	industrial process refrigeration unit
ISCO	in situ chemical oxidation
ITD	Idaho Transportation Department
IVBA	in vitro bioaccessibility assay
JBER	Joint Base Elmendorf-Richardson
LC	liquid chromatography
LSFR	Little Saint Francis River
MDEQ	Mississippi Department of Environmental Quality
MS	mass spectroscopy
NARPM	National Association of Remedial Project Managers
NDEP	Nevada Division of Environmental Protection
NEHA	National Environmental Health Association
NJDEP	New Jersey Department of Environmental Protection
NJDOH	New Jersey Department of Health
NOD	natural oxidant demand
NPL	National Priorities List
OLEM	Office of Land and Emergency Management
ORD	Office of Research and Development
OSC	On-Scene Coordinator
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCA	principal component analysis
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
PRB	permeable reactive barrier
PRP	potentially responsible party
PWS	Performance Work Statement
qPCR	quantitative polymerase chain reaction
RARE	Regional Applied Research Effort
RARPM	Regional Association of Remedial Project Managers

List of Acronyms (Continued)

RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI	remedial investigation
ROD	Record of Decision
RPM	Remedial Project Manager
RSTIP	Regional State Technology Innovation Project
RTP	Research Triangle Park
RU	refrigeration unit
SCMTSC	Site Characterization and Monitoring Technical Support Center
SEE	steam enhanced extraction
SEM	scanning electron microscopy
STAR	Self-Sustaining Treatment for Active Remediation
STL	Superfund and Technology Liaison
STLR	Superfund Technology Liaison Research
STSC	Superfund Health Risk Technical Support Center
TCE	trichloroethylene
TCH	thermal conductive heating
TSC	Technical Support Center
TSP	Technical Support Project
USGS	United States Geological Survey

Disclaimer

This document has been reviewed in accordance with U.S. Environmental Protection Agency (EPA) policy, subjected to review by the Office of Research and Development (ORD), and approved for publication. Approval does not signify that the contents reflect the views of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Acknowledgments

The TSCs would like to recognize our interdisciplinary team of ORD scientists, engineers, and contractors for their significant contributions toward solving the complex issues faced in EPA's environmental cleanup efforts. We would like to extend a special thanks to our Superfund and Technology Liaisons for providing a vital link to identifying EPA Regional needs. We truly appreciate our dedicated EPA employees who provide document reviews, respond to technical requests, and apply technical insights to ensure the client's needs are met. We are grateful for the opportunity to deliver effective solutions to our clients in the Office of Science Advisor, Policy and Engagement; Office of Land and Emergency Management; and the EPA Regions - Superfund and RCRA Remedial Project Managers, Regional Risk Assessors, Regional geologists/hydrogeologists, On-Scene Coordinators, and their management. Thank you for the patronage and support. We welcome the opportunity to work in a collaborative manner across many scientific and engineering disciplines to protect human health and the environment.

This report was prepared by Wendy Condit and Amy Dindal with Battelle Memorial Institute (BMI), under subcontract to Pegasus Technical Services, Inc (Raghuraman Venkatapathy). John McKernan and Diana Bless coordinated and provided oversight for report preparation. We appreciate the constructive reviews provided by Steven Acree, Diana Cutt, Greg Davis, and Kelsey Bufford.

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Abstract

Sharing the latest state-of-the-science and integrating technological advances helps to foster success in the cleanup of hazardous waste sites. This information also helps to inform and improve the decision-making process at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), Resource Conservation and Recovery Act (RCRA), and Brownfield sites. The EPA Office of Research and Development's (ORD) Technical Support Centers (TSCs) support the agency in addressing challenges at contaminated sites through direct and rapid access to technical expertise.

The TSCs actively collaborate to address issues that arise at the EPA's most complex and high-priority cleanup sites. Our combined efforts help to accelerate the use of scientific knowledge and innovative technologies for practical application in the field. Continuous feedback from the field on the remaining cleanup challenges faced by EPA Regional staff also provides ORD with input to further prioritize research efforts.

In Fiscal Year (FY) 2019, ORD's five TSCs recorded 144 technical support activities, giving assistance to 99 Superfund and RCRA sites and responding to requests from all 10 EPA Regions. This report highlights the accomplishments of ORD's TSCs in FY 2019.

1. Introduction

Sharing the latest state-of-the-science and integrating technological advances helps to foster success in the cleanup of hazardous waste sites. This information also helps to inform and improve the decision-making process at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), Resource Conservation and Recovery Act (RCRA), and Brownfield sites. The EPA Office of Research and Development's (ORD) Technical Support Centers (TSCs) support the agency in addressing challenges at contaminated sites through direct and rapid access to technical expertise.

The ORD TSCs were established in 1987 under the Technical Support Project (TSP) to assist EPA Regions, Program Offices, and State Agencies in site characterization, monitoring, and remediation efforts.[1] The TSP was formed by an agreement among EPA's ORD, the Office of Land and Emergency Management (OLEM), and the EPA Regional Offices. The TSP consists of a network of EPA Regional Forums, the OLEM Environmental Response Team, and five ORD TSCs. The five TSCs are hosted within EPA ORD to facilitate the transfer of research results to the field. The TSP network also encourages sharing of ORD research and Regional best practices within EPA.

The TSCs, in coordination with Superfund and Technology Liaisons (STLs) in each Region, actively collaborate to address issues that arise at the EPA's most complex and high-priority cleanup sites. Our combined efforts help to accelerate the use of scientific knowledge and innovative technologies for practical application in the field. Continuous feedback from the field on the remaining cleanup challenges faced by the Regions also provides ORD with input to further prioritize research efforts. As summarized in Table 1-1, each of the five TSCs contributes to the overall TSP mission based upon their technical focus and support capabilities.

Table 1-1. EPA TSCs Offer Focused Technical Expertise and Support Capabilities

	Ecological Risk Assessment Support Center (ERASC): Provides technical information and addresses scientific questions related to ecological risk assessments. Also evaluates and publishes on emerging issues and develops state-of-the science responses for ecological risk assessments.
	Engineering Technical Support Center (ETSC): Provides site-specific assistance on engineering and treatment issues during any phase of a site cleanup. Offers guidance for incorporating technology-based data needs in studies, designs, and operational phases. Publishes on characterization and remediation technologies for contaminated soil, sediment, and mine sites.
	Ground Water Technical Support Center (GWTSC): Provides support on issues related to groundwater contamination, cross-media transfer (e.g., movement from the groundwater to surface water or air), and ecosystem restoration. Publishes on characterization and remediation technologies for contaminated groundwater.
	Site Characterization and Monitoring Technical Support Center (SCMTSC): Provides support for the use of cutting-edge methods and technologies for identifying the nature and extent of contamination. Expertise is available from planning to design and for data analysis and interpretation, including statistical analyses. Publishes on innovative site characterization methods and tools.
	Superfund Health Risk Technical Support Center (STSC): Provides scientific technical support on issues related to human health risk assessments, including interpretation of guidance and assessments and evaluation of toxicity values from EPA or other Agencies, that allow for the development of more accurate quantitative estimates of risk.

[1] http://nepis.epa.gov/Adobe/PDF/10002SXI.pdf

2. Impact of Our Work

The TSCs serve as a valuable resource to EPA's management and scientific staff that support the Superfund, RCRA, and Brownfields Programs. The TSCs actively support cleanup at sites by delivering expertise on the latest methods, approaches, and technologies.

STLs work with Remedial Project Managers (RPMs) and other EPA Regional staff nationwide to identify the specialized expertise needed to address their site challenges. Clients include EPA Superfund RPMs, risk assessors, hydrogeologists, On-Scene Coordinators (OSCs), and RCRA corrective action staff; authorized contractors; state scientists; and others. The STLs are aligned with each EPA Region and readily provide linkages to the appropriate TSC to address site-specific issues. EPA Headquarters and EPA Program Offices also submit direct requests for technical support to the TSC Directors. Each TSC is also accessible via phone, web sites, and e-mail for more information (see Section 5).

In Fiscal Year (FY) 2019, ORD's five TSCs recorded 144 technical support activities, giving assistance to 99 Superfund and RCRA sites and responding to requests from all 10 EPA Regions (see Figure 2-1). The requests spanned 35 states and territories with the most requests for contaminated sites in Missouri (15), California (14), Nebraska (10), New York (10), and New Jersey (7).

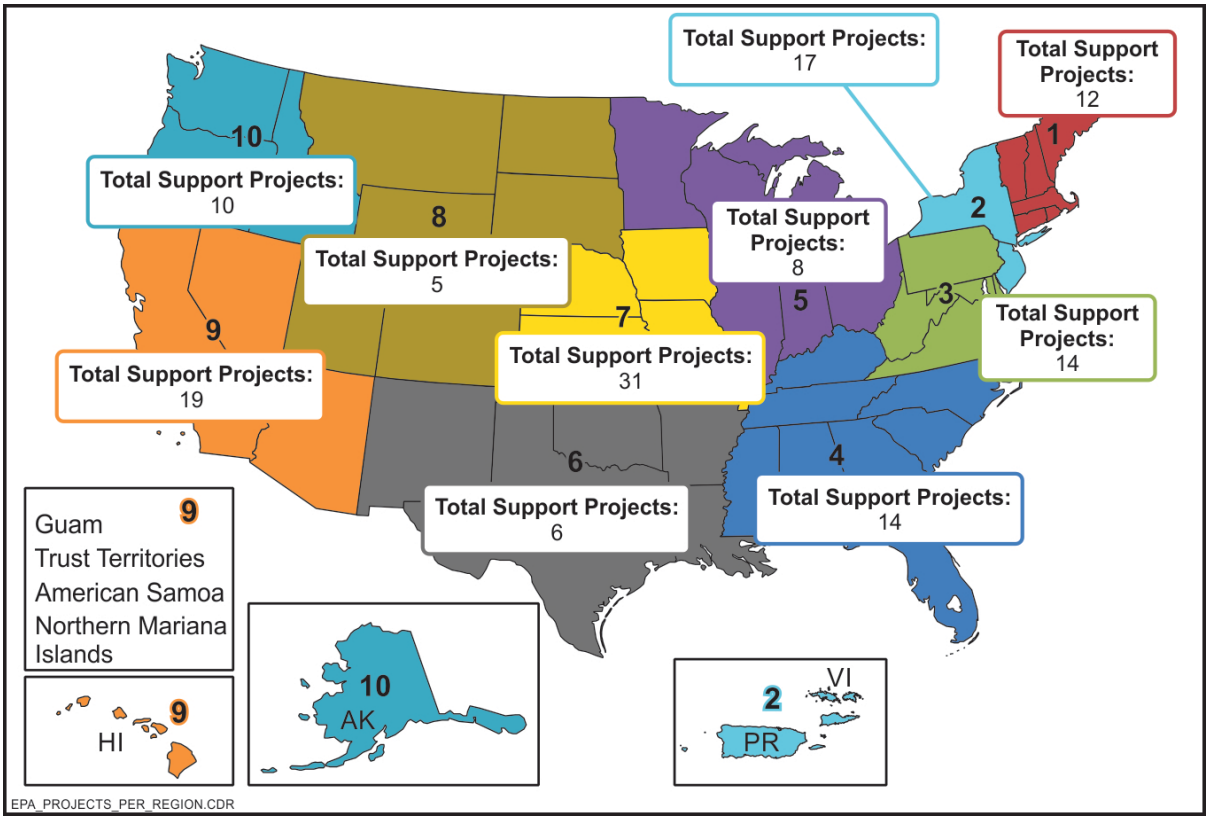

Figure 2-1. TSC Technical Support Spans all EPA Regions in FY 2019

In addition, there were eight support activities designed to address EPA Program Office needs and/or cross-regional challenges. Examples of cross-regional issues addressed include vapor intrusion research, evaluation of remediation technology trends, geochemical evaluations of background metals concentrations, climate change issues for ecological risk assessments, greener cleanup metrics, along with the selection of toxicity values and surrogates for several chemicals.

In FY 2019, four of the 99 Superfund sites supported were on the EPA Administrator's Emphasis List of Superfund sites targeted for immediate and intense action (see Table 2-1).[2] These consultations helped to optimize remedy selection, evaluate pilot testing efforts, and deploy innovative site characterization techniques and sensor networks. The TSCs also provided support for a site on the Superfund Task Force's List of Superfund Redevelopment Opportunity Sites (see Table 2-1).[3] For this site, the TSCs provided geophysical and hydrogeological expertise to assist in site characterization during an emergency response effort.

Table 2-1. TSC Support to Superfund Emphasis and Redevelopment Opportunity Sites

Superfund Emphasis List	
#1	**Olin Chemical [EPA Region 1, Massachusetts]:** Conducted a technical review to optimize recovery of a dense liquid pooled on top of bedrock. Researched potential causes for the failure of the extraction pilot test and provided an alternative design that involves a short-screened extraction well to improve contaminant recovery from the subsurface. Consulted on the design and installation of the new extraction well to improve the pilot-scale remedy performance. The new well design was also expected to yield more consistent physical/chemical characteristics for wastewater treatment.
#2	**L.A. Clark & Son [EPA Region 3, Virginia]:** Provided technical assistance to evaluate both ex situ and in situ treatment technologies for minimizing dense non-aqueous phase liquid (DNAPL) migration, including in situ thermal heating. Reviewed a potentially responsible party (PRP)-prepared Supplemental DNAPL Investigation Plan. Reviewed the site's human health risk assessment. Recommended suitable data to use in transport estimates related to long-term groundwater levels, river gauge, and precipitation data.
#3	**Bonita Peak Mining District [EPA Region 8, Colorado]:** Assisted with strategic visioning to assess technology options for site characterization and remediation, achievable end states, watershed approaches, and adaptive management strategies. Provided support for the application of innovative techniques such as isotopic analysis to better understand groundwater flow paths, contaminant transport, and surface water/groundwater interactions. Supported low-flow groundwater sampling and sensor deployment for temperature and conductivity profiling in mine-impacted surface water.
#4	**Quendall Terminals [EPA Region 10, Washington]:** Reviewed the data and conclusions from a pilot study report of an innovative in situ smoldering combustion technology. Provided comments on the determination of the radius of influence of the combustion process and the propagation rates, which would drive the cost of the full-scale remedy.*
Superfund Redevelopment Opportunity Sites	
#5	**Bunker Hill [EPA Region 10, Idaho]:** Provided geophysical expertise to assess a slurry wall surrounding an impoundment area and to determine the root causes of nearby turbid river discharges and erosion damage. Assessed groundwater-river interactions and changes in hydrogeology.

Note: *Quendall Terminals Site is on both the Superfund Emphasis and Redevelopment Opportunity Site Lists.

The TSCs provided a wide range of technical services across all EPA Regions in FY 2019 (see Table 2-2). As shown in Figure 2-2, TSC requests in FY 2019 were primarily related to document reviews (48%), technical advice (31%), and human health risk assessment (8%). The types of documents reviewed spanned all project phases and included remedial investigation (RI) work plans, sampling data trends, modeling reports, feasibility studies (FS), treatability studies, remedial designs, monitoring plans, and more. Several types of contaminants were addressed in the technical support requests, with lead and metals being the most prominent followed by DNAPL, trichloroethylene (TCE), and per- and polyfluoroalkyl substances (PFAS).

[2] https://www.epa.gov/superfund/administrators-emphasis-list
[3] https://www.epa.gov/superfund-redevelopment-initiative/superfund-redevelopment-opportunity-sites

Table 2-2. Variety of Technical Support Services across EPA Regions

Support Type	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	M	Total
Document Review	7	7	11	7	5	3	8	1	16	3	1	69
Engineering/Prototype Testing	1			1	1						1	4
Ecological Risk Assessment							2			1	2	5
Groundwater Monitoring						1						1
Human Health Risk Assessment	1	6		1			1				2	11
Plume Delineation					1		1	2				4
Research/Technical Transfer	2						1			2		5
Technical Advice	1	4	3	5	1	2	18	2	3	4	2	45

Note: M = Multi-Regional or Program Office Need

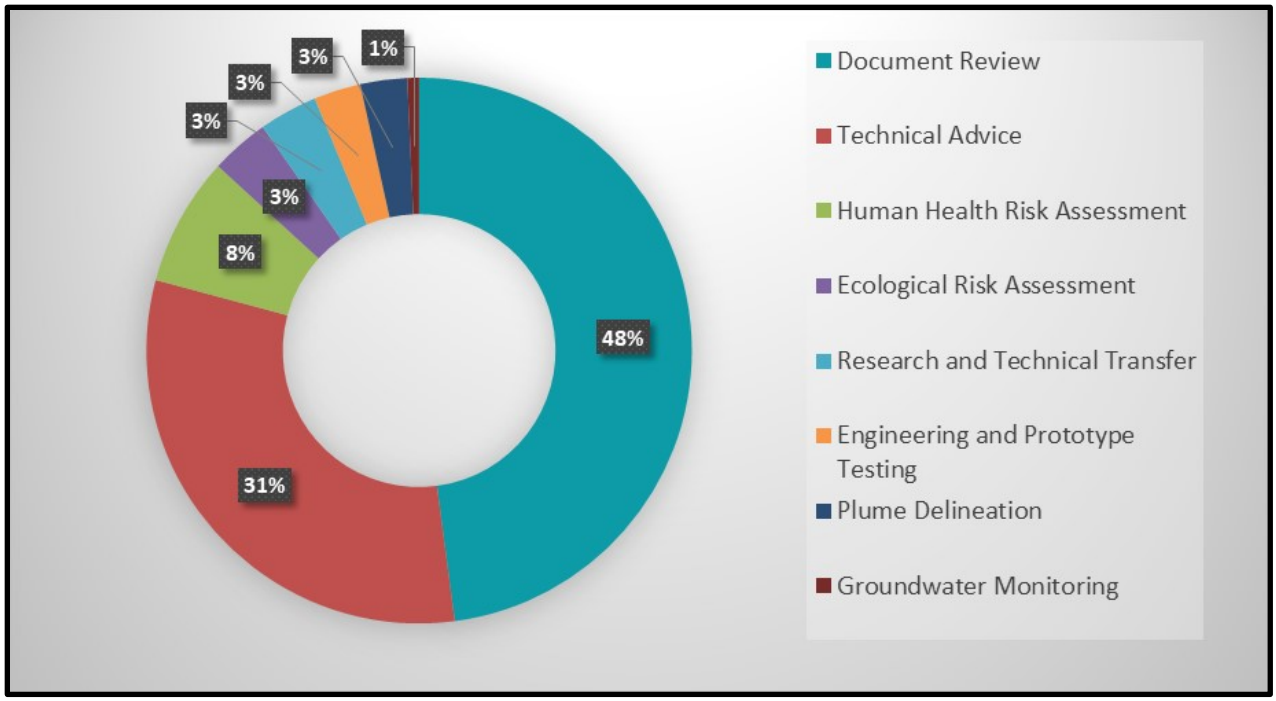

Figure 2-2. Technical Support Services by Type in FY 2019

3. Challenges Addressed

There are complexities in site characteristics, contaminant types, and potentially exposed populations that can lead to challenges in defining acceptable restoration endpoints and the technical approaches required to achieve desired endpoints. These factors may call for the use of specialized techniques or innovative technologies to assess, characterize or remediate the site. In FY 2019, TSCs have helped to overcome major site challenges as summarized in Table 3-1. The technical support examples summarized in this section are a selected sample of those undertaken by the ORD TSCs in FY 2019.

Our approach starts by forming a team of EPA scientists, engineers, and external technical experts (as needed) with interdisciplinary backgrounds and knowledge to bring effective solutions to "real world" problems. The team also looks for opportunities to accelerate the application of research results and scientific knowledge into the field to optimize each project. Several of the TSC's support efforts in FY 2019 have already generated substantial results as highlighted in Sections 3.1 to 3.7 below. These results include optimized site sampling strategies, increased remediation effectiveness, cost optimization, and improved cleanup timeframes. For each site challenge listed in Table 3-1, key projects are described to demonstrate successful outcomes from the TSC's FY 2019 technical support efforts.

Table 3-1. TSCs Provide Technical Expertise to Address Key Cleanup Site Challenges

Section	Description
3.1	**Characterizing Complex Mine and Landfill Sites** • Geophysical Investigation at the Bunker Hill Superfund Site (R10) • Profiling Mine-Impacted Surface Water at the Bonita Peak Mining District Superfund Site (R8) • Geophysical Assessment of a Proposed Landfill Site to Serve Madison County Mines (R7)
3.2	**Selecting, Designing and Optimizing Remedial Technologies** • Optimized Contaminant Recovery at the Olin Chemical Superfund Site (R1) • Thermal Remediation Evaluation at the L.A. Clark and Son Superfund Site (R3) • In Situ Smoldering Combustion Evaluation at the Quendall Terminals Superfund Site (R10) • In Situ Remediation of Arsenic-Impacted Groundwater at the Vineland Chemical Company Superfund Site (R2)
3.3	**Modeling Fate, Transport and Exposures** • Evaluation of Metals Transport to the Weber Reservoir from the Anaconda Copper Mine (R9) • Ambient Exposure Model to Simulate Potential Releases of Mercury during Various Fire Scenarios for the Vo-Toys Site (R2)
3.4	**Assessing and Treating Emerging and Persistent Contaminants** • PFAS Sampling Strategies for Joint Base Elmendorf-Richardson (R10) • Chemical Oxidation Treatability Studies for the 57th and Broadway Superfund Site (R7)
3.5	**Analyzing Statistical Trends** • Using Statistical Methods to Develop a Sampling Plan for Kroger Refrigeration Units (R5) • Monitoring for Algal Blooms and Occurrence of Toxic Algae (R7)
3.6	**Preventing Adverse Ecological Impacts** • Separating Anthropogenic Metals Contamination from Background (All Regions) • Developing a Tool to Assess the Bioavailability of Metals in Soils (All Regions) • Refined Ecological Risk Assessment for the Fairfax Street Wood Treaters Superfund Site (R4)
3.7	**Preventing Adverse Human Health Impacts** • Evaluation of Suitability of Chemical Surrogates at the Hercules Inc. Site (R4) • Evaluation of a Screening Level Toxicity Value for Naphthalene at the Quanta Resources Superfund Site (R2)

3.1 Characterizing Complex Mine and Landfill Sites

The revitalization of mine-impacted sites is a major focus of EPA cleanup efforts. Many of the largest and most complex Superfund sites are related to historic mining operations. Cleanup costs are estimated to be as high as $54 billion for the approximately 500,000 abandoned hardrock mines located in the U.S.[4] As part of our FY 2019 efforts, the TSCs have applied innovative geophysical and hydrological tools to help solve site characterization challenges at mine-related sites. Three case studies are presented where innovative tools were applied for investigating erosion issues, understanding mine-related sources with high resolution sensor networks, and identifying a suitable landfill location for mine-related wastes.

Geophysical Investigation at Bunker Hill Superfund Site

Site: Bunker Hill Mining and Metallurgical Complex Superfund Site
Location: Region 10, Idaho and Washington
Challenge: Apply geophysical and hydrogeologic tools to assess potential impact of river-aquifer interactions on remedy performance
Center Support: ETSC and SCMTSC

The Bunker Hill Superfund Site is located in northern Idaho and eastern Washington. The site is one of EPA's largest and most complex Superfund sites that spans 1,500 square miles and 166 river miles. Mining operations began in 1883 and continue today. Historical mining and milling methods disposed of tailings in rivers and streams and spread contaminants throughout the floodplain of the South Fork of the Coeur d'Alene River. Contamination also resulted from smelter operations that yielded large waste piles, waste rock, and past air emissions. Soil, sediment, groundwater, and surface water were contaminated with heavy metals including lead at levels that pose serious risks to human health and wildlife. The Lower Basin of the Coeur d'Alene River contains more than 18,000 acres of waterfowl habitat that have been adversely impacted. The concentration of lead in sediments is so elevated at some locations that the loss of bird life has occurred due to acute lead toxicity with as little as two weeks of exposure. The Bunker Hill Superfund Site was added to the National Priorities List (NPL) in 1983.

The 2002 Record of Decision (ROD) for the site included a groundwater collection system, along with upgrades to the Central Treatment Plant (see Figure 3-1). In September 2018, the contractor installed an underground hydraulic barrier in this location to control contaminated groundwater migration from the Central Impoundment Area to the Coeur d'Alene River. In December 2018, the contractor began to observe increased turbidity in the river. In February 2019, observations were reported of settlement in Interstate-90 north of the barrier wall and adjacent to the river where seeps were observed. EPA mobilized an OSC and Emergency Response contractors to address the settlement and erosion damage. All efforts were conducted in cooperation with the Idaho Department of Environmental Quality (Idaho DEQ) and the Idaho Transportation Department (ITD).

Figure 3-1. Bunker Hill Central Treatment Plant Location (Source: EPA)

[4] https://naturalresources.house.gov/download/abandoned-mines

The Region 10 STL, with the assistance of the ETSC and the SCMTSC, assembled a team of ORD scientists to support Region 10 with evaluating the groundwater-surface water hydraulics at the site. ORD assisted with hydrologic analysis of groundwater and surface water interactions and geophysical analysis to characterize the subsurface stratigraphy. The expertise provided by ORD on groundwater-surface water interactions was critical in assisting Region 10 in the identification of potential root causes for the changes in the hydrogeology. The technical feedback was used to incorporate new procedures within the site monitoring plan to better assess potential changes in aquifer-river dynamics that could influence performance of the installed groundwater remedy.

Profiling Mine Impacted Surface Water at the Bonita Peak Mining District Superfund Site

Site: Bonita Peak Mining District Superfund Site
Location: Region 8, Colorado
Challenge: Provide water quality measurements with higher spatial resolution to improve remediation
Center Support: SCMTSC

The Bonita Peak Mining District consists of 48 historic mines or mining-related sources where ongoing releases of metal-laden water and sediments are occurring within the Upper Animas Watershed in San Juan County, Colorado. These historic mining operations contaminated soil, groundwater, and surface water with heavy metals. The site was added to the NPL in 2006. The site-wide RI is ongoing and mining-related sources were identified where contaminant migration could be quickly addressed through interim remedial actions. In May 2019, the EPA released the Interim ROD documenting remedial actions to be taken at 23 source areas across the district over the next 3 to 5 years. These actions are intended to stabilize source areas and reduce contaminant loading from erosion of mine waste into nearby streams.

As part of an EPA Region 8 Regional State Technology Innovation Project (RSTIP), the SCMTSC, assisted by the Region 8 STL, deployed a dense network of sensors to continuously provide accurate water quality measurements with high spatial resolution to improve the remedial actions. Field work consisted of a site reconnaissance effort in August 2019 and deployment of fiber optic distributed temperature sensing (FO-DTS) and a high-density network of temperature and conductivity loggers in September 2019.

During the reconnaissance effort in August 2019, the project team evaluated several kilometers of Upper Cement Creek and the West Fork of the Animas River within the Bonita Peak Mining District. These critical stream sections include discharge zones where metals loading from seeps and shallow groundwater is suspected of impacting the surface water. The project team used thermal imaging with a forward looking infra-red (FLIR) camera to identify temperature anomalies indicative of locations where surface or shallow seeps may be contributing to surface stream flow. Along stream sections of interest, the team collected resistivity and magnetic susceptibility measurement lines along and adjacent to each stream bank with a GEM-2 instrument (see Figure 3-2). These results provided information on the shallow geology and groundwater

Figure 3-2. Stream Geophysical Survey Deployment (Source: EPA)

flow. The team also assessed the feasibility of sensor deployment in the extreme high alpine, high energy stream environments. Potential challenges to instrument deployment included limited site access due to log jams/debris, waterfalls, avalanche activity, and/or snow-covered sections.

The project team returned to the site in September 2019 with the United States Geological Survey (USGS) to conduct FO-DTS surveys and install a high-density network of in-stream loggers for temperature, conductivity, and pH. The FO-DTS surveys collected temperature measurements every 15 minutes, every 25 cm along approximately 3 km of cable for several days in both Upper Cement Creek and the West Fork of the Animas River. USGS provided data interpretation for temperature variance and anomalies to identify up to 20 likely seep or shallow groundwater spring contributions along each drainage. Geophysical surveys, thermal imaging, and FO-DTS results were provided to EPA Region 8 in December 2019 to support remedial action decisions. Technology deployment best practices will be shared in future technology transfer efforts planned for FY 2020.

Geophysical Assessment of a Proposed Landfill Site to Serve Madison County Mines

Site: Madison County Mines Superfund Site
Location: Region 7, Missouri
Challenge: Evaluate the suitability of a proposed landfill site for disposing dredged sediments
Center Support: ETSC

Mining operations at the Madison County Mines site in Missouri occurred from the 1700s to the mid-1900s. Erosion from 13 major tailings and other mining waste deposit areas resulted in heavy metals contamination (primarily lead) of soils, sediments, surface water, and groundwater. In addition, residential properties were impacted by mine wastes historically used in foundations, driveways, and fill. The site was added to the NPL in 2003. Over 813 residential properties have had yard soils remediated to acceptable levels, while remediation of contaminated materials is ongoing throughout the Operable Units (OUs) associated with the Superfund site.

The Little Saint Francis River (LSFR) Watershed is the seventh Operable Unit (OU7) designated for investigation and potential cleanup and restoration in Madison County. The LSFR Watershed includes all surface water, floodplain soil, overbank deposits, and sediments in the Fredericktown City Lake and other streams that are not specifically addressed under other OU cleanups. The RI is underway, with supplemental sampling to continue into 2020. Dredging and disposal of contaminated sediments is anticipated as one of the remedial actions.

Region 7 requested support through the ETSC to evaluate the suitability of city-owned land for disposal and long-term containment of dredged sediments. The property for the proposed landfill site was located in Fredericktown, Missouri. The ETSC collaborated with the USGS to conduct site investigations to assess the depth to competent bedrock, physical characteristics of the overlying unconsolidated soils, and the extent of connection between the underlying aquifer and the adjacent Fredericktown City Lake.

A range of geophysical and hydrological tools were applied to map out site characteristics within the approximate 50-acre parcel of the proposed landfill site. The geophysical tools included electromagnetic induction (EMI), electrical resistivity tomography (ERT) (see Figure 3-3), horizontal-to-vertical spectral ratio (HVSR) passive seismic, and shear-wave refraction. These tools were used to characterize the unconsolidated soils and depth to bedrock at the proposed disposal site. In addition, the groundwater-surface water interface associated with the nearby lake shoreline was studied using nested piezometers, water-based electromagnetic surveys, and FLIR imagery.

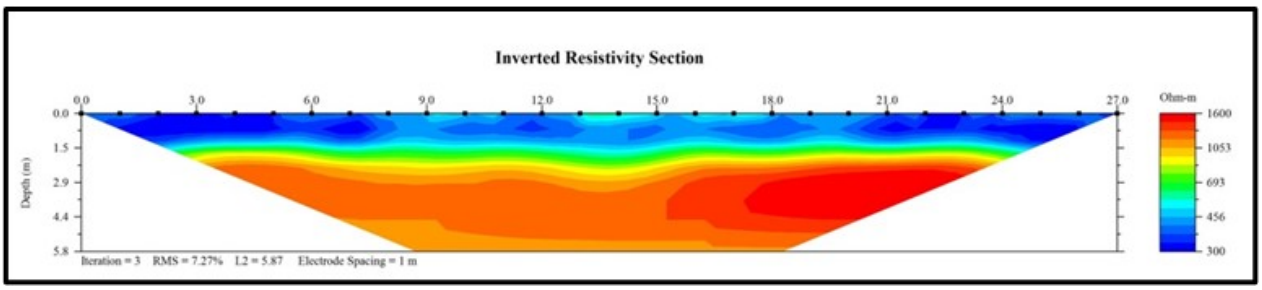

Figure 3-3. ERT Profile Shows Bedrock Contact at Approximately 1.5 Meters (Source: EPA)

The results of these investigations will inform the Region's decision on possible use of this property as a final repository for mine waste soil and dredged sediment. The results were also presented at a 2019 Geophysics Symposium and used as a case study for training Region 7 RPMs to illustrate the capabilities and limitations of the geophysical techniques for site investigations.

3.2 Selecting, Designing and Optimizing Remedial Technologies

As remedial technologies evolve and change over time, so does the overall strategy for site cleanup. Through our combined expertise, the TSCs provide up-to-date knowledge on the latest technologies for soil, sediment, and groundwater remediation. Independent evaluations are paramount to improve remedial strategies and ensure remedial goals are achieved. The TSC's consultations for four Superfund sites in FY 2019 highlighted below relate to optimizing contaminant recovery and supporting the selection of successful remedial strategies.

Optimized Contaminant Recovery at the Olin Chemical Superfund Site

Site: Olin Chemical Superfund Site
Location: Region 1, Massachusetts
Challenge: Address need for improved recovery of a dense liquid pooled on top of bedrock.
Center Support: GWTSC

Olin Chemical, located in Wilmington, Massachusetts, made specialty chemicals for the rubber and plastics industry until its closure in 1986. Historic waste disposal practices resulted in both on-site and off-site groundwater contamination. This ultimately led to the closure of nearby municipal drinking water supply wells in 2002 to 2003. The site was added to the NPL in April 2006.

Figure 3-4. Storage Tank for Recovered Liquids (Source: EPA)

Liquid wastes were disposed of in unlined pits and migrated vertically to the bedrock surface. These liquid wastes contained fluids with densities greater than water, forming a brine layer in bedrock depressions. This type of contamination is referred to as dense aqueous phase liquid (DAPL).[5] The DAPL serves as a long-term source of n-nitrosodimethylamine (NDMA) and other contaminants to impacted groundwater. Recovery efforts are underway (Figure 3-4).

[5] https://semspub.epa.gov/src/document/HQ/199603

In FY 2019, the GWTSC reviewed documents to determine the root cause of the failure of a pilot test to extract adequate amounts of DAPL from the subsurface. Based on a review of the data, it was established that shear-produced turbulence was disturbing the DAPL layer and adversely mixing the groundwater and DAPL layers during pumping from the extraction well. The immediate decline in conductivity observed in nearby monitoring locations supported this observation and provided a viable explanation as to why the pilot test failed to remove adequate quantities of DAPL.

GWTSC experts then provided an alternative design involving a short-screened extraction well to improve DAPL recovery. The objective of the alternative well design was to allow multiple wells to operate simultaneously, minimize disturbance of the DAPL, and to achieve a uniform decline in the DAPL pool. The new extraction well design accomplished this by maximizing the distance between the DAPL intake of the extraction well and the "interface" between the DAPL and the overlying groundwater. GWTSC helped to define the specific well construction details related to the well screen length, sand pack, and well installation depth. This new well design was also expected to yield more consistent physical and chemical characteristics for the DAPL wastewater stream as required to test the proposed wastewater treatment train.

Thermal Remediation Evaluation at the L.A. Clark and Son Superfund Site

Site: L.A. Clark and Son Superfund Site
Location: Region 3, Virginia
Challenge: Evaluate ex situ and in situ treatment methods for minimizing DNAPL migration, including in situ thermal heating technology options
Center Support: GWTSC

The L.A. Clark and Son site is located near Fredericksburg, Virginia. Wood preservation operations occurred at the site from 1937 to 1988. Railroad ties, telephone poles, and fence posts were preserved with creosote at the wood treatment plant located on the North Terrace (see Figure 3-5). EPA identified polycyclic aromatic hydrocarbons (PAHs) and benzene as the contaminants of concern in surface soil and sediment at the site. The site was added to the NPL in 1986.

In FY 2019, GWTSC provided a technical review of the technologies evaluated in both the Engineering Evaluation/Cost Analysis (EE/CA) and the RI/FS for the L.A. Clark Superfund Site. The focus of the review was on the list of available technology options and the applicability of thermal technologies for the North and South "Terraces" and the "Floodplain," which were evaluated separately (see Figure 3-5).

The North Terrace appears to be heavily contaminated as a result of serving as the location of the processing area while the plant was in operation. The presence of DNAPL in wells demonstrated that there is mobile DNAPL in this area. Likewise, significant mobile DNAPL was present in parts of the South Terrace. These Terrace areas were determined by GWTSC to be amenable to thermal remediation. The soil stratigraphy is likely more amenable to thermal conductive heating (TCH) or electrical resistance heating (ERH) than steam enhanced extraction (SEE).

Data in the RI/FS show that there is substantial DNAPL contamination in the Floodplains and directly adjacent to Massaponax Creek. Without remediation in this area, the creosote contamination will persist well into the future. However, it was determined that the amount of water in this area would make it difficult to apply thermal remediation. Smoldering combustion and passive recovery wells were also found to have limitations for application in the Floodplains.

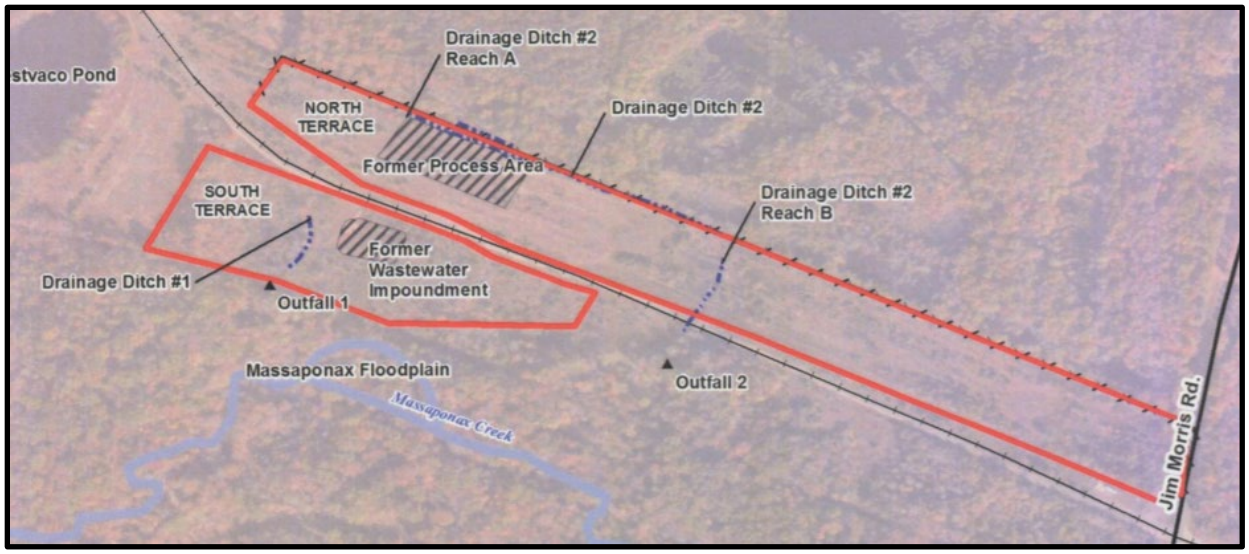

Figure 3-5. Site Map Showing the Terrace Areas and Floodplain (Source: EPA)

In Situ Smoldering Combustion Evaluation at the Quendall Terminals Superfund Site

Site: Quendall Terminals Superfund Site
Location: Region 10, Washington
Challenge: Review pilot study results for an in situ smoldering combustion technology
Center Support: GWTSC

The Quendall Terminals Superfund Site is located along the shore of Lake Washington. Creosote was manufactured at the site from 1916 through 1969. Coal tars were distilled on site and then transported to a nearby company for use in wood-treating operations. Between 1969 and 1983, the site was used to store crude oil, waste oil, and diesel. From 1975 to 2009, it was used as a log-sorting and storage yard. Quendall Terminals was contaminated by releases of coal tars and distillate products from these historic operations. Soil in the uplands and sediments on the lake bottom are both contaminated. The site was added to the NPL in 2006.

GWTSC reviewed the data and conclusions from a pilot study report of an innovative in situ smoldering combustion technology. Figure 3-6 shows the Self-Sustaining Treatment for Active Remediation (STAR) process. GWTSC's subject matter experts provided comments on the determination of the radius of influence of the combustion process and the propagation rates, which would drive the cost of the full-scale remedy.

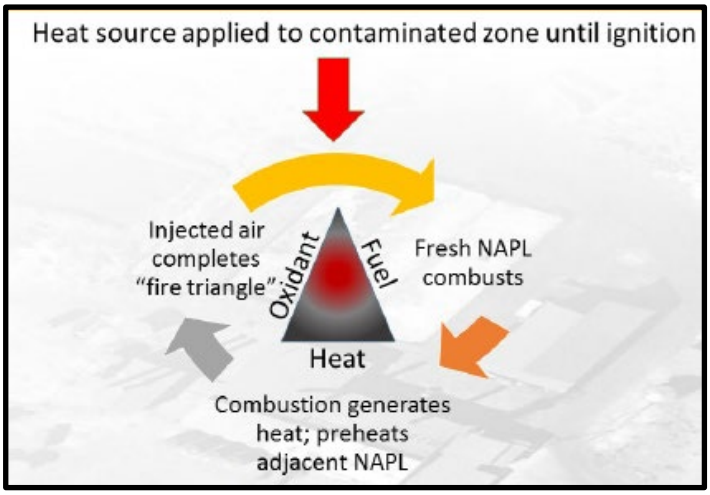

Figure 3-6. STAR Technology Process (Source: EPA)

Recommendations were made to provide all of the data collected during the pilot study in the final report. This included temperature data graphs, pictures of the soil cores from the pilot study area, as well as the additional cores that were

obtained for characterization purposes, soil gas concentration data, and any other data collected. It was recommended that the modeling be made available for peer review and that post-treatment conditions be further evaluated such as the leachability of the remaining PAHs after STAR to further understand the extent of treatment.

In Situ Remediation of Arsenic-Impacted Groundwater at the Vineland Chemical Superfund Site

Site: Vineland Chemical Company Superfund Site
Location: Region 2, New Jersey
Challenge: Evaluate geochemical controls on arsenic plume migration to support optimization of the remediation system
Center Support: GWTSC

The Vineland Chemical Company operated from 1949 to 1994 and produced arsenical herbicides and fungicides. The company stored byproduct arsenic salts in open piles, lagoons, and chicken coops. As a result, arsenic contamination has impacted groundwater, surface water, sediment, and soil across the site. EPA constructed a pump and treat system in 2000 to address the contaminated groundwater.

An optimization study, conducted in 2010, recommended that a sustainable in situ remedial approach for the arsenic-impacted groundwater be evaluated. The U.S. Army Corps of Engineers conducted bench-scale tests and single well field tests demonstrating that in situ air sparging had the potential to address the groundwater by immobilizing the arsenic. Region 2 engaged the GWTSC to further evaluate this approach.

As shown in Figure 3-7, the GWTSC assisted in evaluating the key processes controlling the arsenic immobilization through specialized testing of aquifer sediment. The techniques employed included Fourier-transform infrared spectroscopy (FITR), scanning electron microscopy (SEM), energy dispersive X-ray spectrometry (EDX), and metals analysis using microwave digestion, targeted chemical extractions, and arsenic speciation using liquid chromatography-inductively coupled plasma-mass spectrometry (LC-ICP-MS).

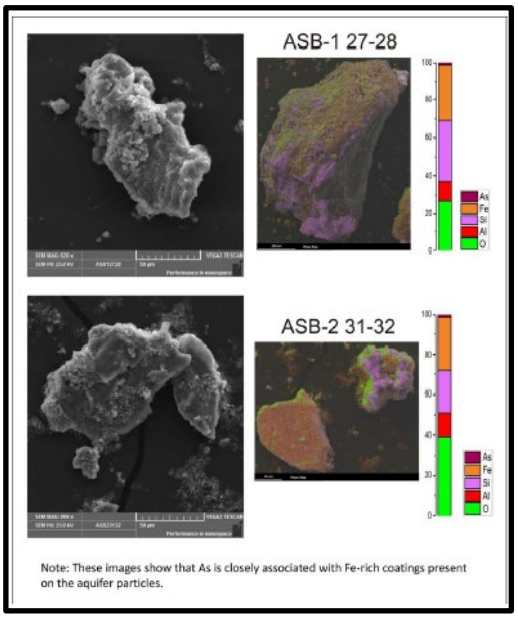

Figure 3-7. SEM Images and EDX Maps of Particles in Soil Samples (Source: EPA)

Characterization studies conducted by ORD provided oxidation-state information for arsenic and iron and helped to reveal a mechanistic understanding of arsenic uptake by the aquifer solids. Results from this work can be used to optimize the design and operation of the full-scale system and provide guidance for the design of air sparge systems at sites with similar conditions. The collaborative work was supplemented with ORD Superfund Technology Liaison Research (STLR) funding and the results are published in an EPA report.[6]

[6] Investigation of a Sustainable Approach to In-situ Remediation of Arsenic Impacted Groundwater

3.3 Modeling Fate, Transport and Exposures

Models are an important part of our toolbox used to understand the fate and transport of contaminants and to determine if completed pathways exist for exposure. TSC expertise has allowed for the development and application of models to determine the sources of contamination and to assess impacts to the surrounding communities. Two examples are provided of FY 2019 TSC support to better understand site impacts through modeling fate, transport, and exposures.

Evaluation of Metals Transport to the Weber Reservoir from the Anaconda Copper Mine

Site: Anaconda Copper Mine
Location: Region 9, Nevada
Challenge: Determine the probable cause of elevated metals concentrations in the Weber Reservoir
Center Support: SCMTSC

The former Anaconda Copper Mine Site, located in western Nevada, is an abandoned open pit copper mine and processing facility (see Figure 3-8). The majority of the copper mining, milling, and processing operations occurred from 1952 to 1978. The property was then used for the secondary milling and processing of ores from 1978 to 2000 under various owners. The last owner went bankrupt in 1997 and the site was subsequently abandoned in 2000. The potential risks include fugitive dust, contaminated groundwater, and contaminated on-site surface water that could impact human health or wildlife. Metals and sulfate are the predominant mine-related contaminants. Uranium is also the driver for mine-impacted groundwater. The site is not on the NPL and cleanup of the Anaconda Copper Mine site was transferred to the Nevada Division of Environmental Protection (NDEP) Abandoned Mine Land Program in 2018. However, EPA remains involved to assist NDEP in the cleanup efforts and to further assess the impact to Tribal lands where NDEP does not have jurisdiction.

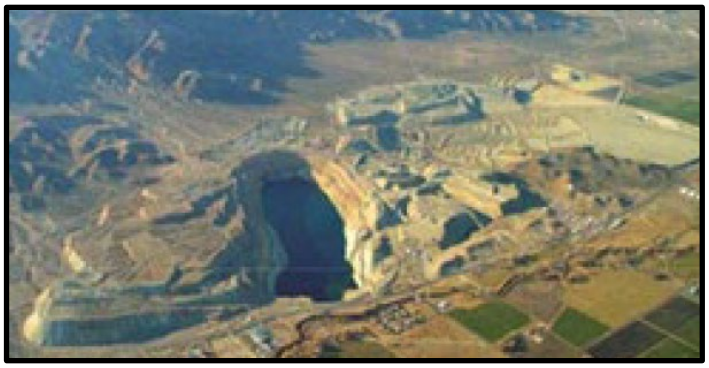

Figure 3-8. Anaconda Copper Mine (Source: EPA)

There was uncertainty at this site associated with delineating the extent of mine-related contamination given both naturally-occurring and anthropogenic sources of metals, uranium, and sulfate. Therefore, establishing background concentrations was critical to understanding the extent of mine-related impacts. SCMTSC provided a review of the site documents and historical background information to determine whether or not there is a probability that chemical transport from the mine may be the cause of elevated metals concentrations in the nearby Weber Reservoir. Based on the review, it was noted that high metal concentrations observed in the sediment at Weber Reservoir have been elevated but stable over time and concentrations increased only slightly during the operation of the mine. The higher metal concentrations in the sediment of the reservoir were determined to be caused by the natural and effective trapping and scavenging of dissolved and particulate metals from the water reaching the Weber Reservoir.

Ambient Exposure Model to Simulate Potential Releases of Mercury during Various Fire Scenarios for the Vo-Toys Site

Site: Vo-Toys
Location: Region 2, New Jersey
Challenge: Determine the potential ambient exposure to mercury from uncontrolled fire events
Center Support: ETSC and SCMTSC

In Harrison, New Jersey, an industrial complex known as the Vo-Toys site spans a city block. The complex was used to manufacture incandescent lightbulbs from 1902 to 1918, radio vacuum tubes from 1918 to 1976, and pet products from 1977 to 2014. In 2015, developers began to redevelop the site into residential units. However, during the re-development, the three buildings on the site were found to be contaminated with significant quantities of mercury, including beaded and pooled mercury in building materials. Mercury vapor in the air inside the buildings was elevated making the interior space unusable. Mercury is a toxic metal that can threaten human health and the environment when released, particularly in the vapor phase. Mercury adversely affects the central nervous system and can have serious consequences depending on concentration and duration of exposure. In 2018, the New Jersey Department of Environmental Protection (NJDEP) requested EPA to assist in the cleanup of the site through the removal of the buildings and the associated mercury contamination. Because the buildings are unoccupied, the biggest risk posed by the mercury in the buildings was through a catastrophic release to the surrounding community during a fire.

Given the presence of mercury contamination at the facility, an uncontrolled potential fire at the facility could adversely impact infrastructure and create potential health hazards to those working in the facility, emergency first responders, and residents in the nearby community. EPA Region 2 worked with the ETSC and SCMTSC to determine what risk the facility posed to the community, especially in the case of a fire. ETSC worked with the Region 2 OSC to collect data to allow for the prediction of the amount of mercury in the buildings at the site. SCMTSC then used these data to create air dispersion fate and transport models for many different fire scenarios (see Figure 3-9).

Figure 3-9. Modeling Performed to Assess Risk of Mercury Exposure due to Fire at Vo-Toys Site (Source: Battelle)

As a result of the modeling work, EPA Region 2 was able to provide education to first responders about environmental and health dangers the site may pose in the case of a fire, train the first responders how to best protect themselves from these risks, and aid in the creation of an evacuation plan for the surrounding community in the case of a fire. The modeling also supported EPA's determination of threat that the site posed to the community and paved the way for a removal action that will include demolition and removal of the buildings.

3.4 Assessing and Treating Emerging and Persistent Contaminants

ORD scientists are leading the way in terms of understanding the state-of-the-science for emerging contaminants and for sharing best practices for their sampling and treatment. Superfund RPMs and others are counting on TSC expertise to help them to address these new challenges faced at a growing number of sites. In FY 2019, TSCs supported multiple projects related to emerging and persistent contaminants. Two examples projects are highlighted below for PFAS sampling and 1,4-dioxane treatment.

PFAS Sampling Strategies for Joint Base Elmendorf-Richardson, Alaska

Site: Joint Base Elmendorf-Richardson
Location: Region 10, Alaska
Challenge: Support PFAS split sampling efforts and analytical method selection
Center Support: ETSC

Joint Base Elmendorf-Richardson (JBER) covers about 86,000 acres in Anchorage, Alaska. Beginning in the mid-1940s, operations at the base generated hazardous and non-hazardous wastes from industrial and airfield operations, fire training, and fuels management. Site activities contaminated soil and groundwater with hazardous chemicals and pollutants, including PFAS compounds. The U.S. Air Force is the lead agency for environmental cleanup in coordination with EPA and the Alaska Department of Environmental Conservation (ADEC).

Figure 3-10. PFAS Sample Collection at JBER, Alaska (Source: EPA)

The ETSC provided technical assistance from ORD scientists to support PFAS site characterization at JBER in collaboration with EPA Region 10 and Region 5 (see Figure 3-10). ORD previously provided a review of an Air Force work plan to collect groundwater and soil samples for PFAS analysis. ORD scientists took samples following the collection of groundwater samples by an Air Force contractor and EPA separately collected wastewater and creek samples.

> *"EPA's collaboration with the ADEC and the Air Force on PFAS sampling and analytical methods is key to ensuring valid, defensible data are collected on these emerging contaminants that are being found in soil, groundwater and drinking water in Alaska and elsewhere across the country."*
>
> **Former ADEC Commissioner Larry Hartig**

EPA Region 5 scientists analyzed split samples to evaluate the American Society for Testing and Materials (ASTM) analytical PFAS methods (ASTM 7968-14 and ASTM 7979-15, a preliminary version of SW-846 Method 8327). This sampling effort provided an opportunity to apply the ASTM methods to additional environmental matrices. In addition to the common PFAS analytes, samples were analyzed for PFAS precursors and transformation products. The analytical methods produced accurate and precise data for most analytes. Many groundwater

locations were found to contain perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), as well as other PFAS compounds.

A data summary was provided to EPA Region 10, along with recommendations for future monitoring protocols. The lessons learned and future recommendations for PFAS site characterization efforts were also presented at the National Association of Remedial Project Managers (NARPM) Training Program held August 2019 in Chicago, Illinois.

Chemical Oxidation Treatability Studies for the 57th and North Broadway Superfund Site

Site: 57th and North Broadway Superfund Site
Location: Region 7, Kansas
Challenge: Evaluate project plans for a bench-scale chemical oxidation treatability study
Center Support: GWTSC

The 57th and North Broadway Superfund site is located near Wichita, Kansas and consists of an area where drinking water supply wells were contaminated by chlorinated volatile organic compounds (CVOCs) and 1,4-dioxane. Approximately 50 private wells and two public water supply well fields (serving over 10,000 people) were impacted. Institutional controls and alternate public water supplies were established in the 1990s, while the source zone was addressed. The site was added to the NPL in 1992. Source excavation, along with in situ chemical oxidation (ISCO) is planned as part of the site remedy (Figure 3-11).

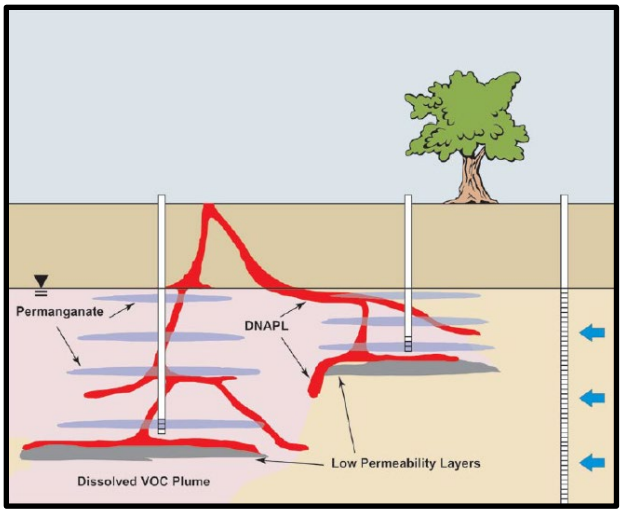

Figure 3-11. Schematic of Oxidant Injection into the Subsurface (Source: EPA)

The GWTSC provided a technical review of documents related to implementation of the site remedy. The review included the Project Plan and the Performance Work Statement (PWS) for the Remedial Design. Specifically, input was requested as to whether bench-scale treatability studies should be conducted prior to field deployment. The bench-scale treatability studies were focused on: 1) ISCO effectiveness for the removal of CVOCs, 1,4-dioxane, and possibly petroleum hydrocarbon in soil and 2) advanced oxidation processes (AOPs) associated with the treatment of 1,4-dioxane.

Bench-scale ISCO treatability studies were recommended. This should include testing various oxidants (e.g., persulfate and permanganate) to determine the optimal oxidant selection. Although source area excavation is planned, uncertainty exists regarding the petroleum residuals that will remain and the natural oxidant demand (NOD). Petroleum residuals in the targeted ISCO zone will serve as an oxidant sink. A high NOD at the site would suggest that greater oxidant loading would be required to achieve the treatment objectives. This would translate directly into greater oxidant requirements, which would impact the effectiveness of the remedy, the schedule, the cost, and the oxidant residuals. It was recommended that the bench-scale tests be conducted prior to pilot-scale or field-scale deployment. The results were expected to further gauge the feasibility of the remedy and provide useful full-scale design information.

3.5 Analyzing Statistical Trends

Statistical approaches and tools help to inform decision-making for sampling and cleanup strategies. The TSCs provide unparalleled expertise in the development and application of statistical methods for environmental data. Two examples are provided here where TSC applied statistical tools to develop defensible sampling approaches for diverse environmental issues including air emissions and toxic algae.

Using Statistical Methods to Develop a Sampling Plan for Kroger Refrigeration Units

Site: Kroger Refrigeration Units
Location: Region 5
Challenge: Optimize sampling strategy to determine leak rates from refrigeration units
Center Support: SCMTSC

Under the Clean Air Act, leak rate equipment standards are set for comfort cooling appliances (CCAs), commercial refrigeration appliances (CRAs), and industrial process refrigeration units (IPRUs) that contain more than 50 pounds of certain refrigerants. These refrigerants include chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs), which are ozone-depleting chemicals that can have adverse impacts upon release to the atmosphere. In August 2018, EPA issued a Clean Air Act Section 114 request for information to Kroger Company. The response was received in 2019 and indicated that Kroger operates 2,624 CCAs, 6,400 CRAs, and 21 IPRUs at 1,733 facilities in 36 states and the District of Columbia. Figure 3-12 shows the RU locations by EPA Region.

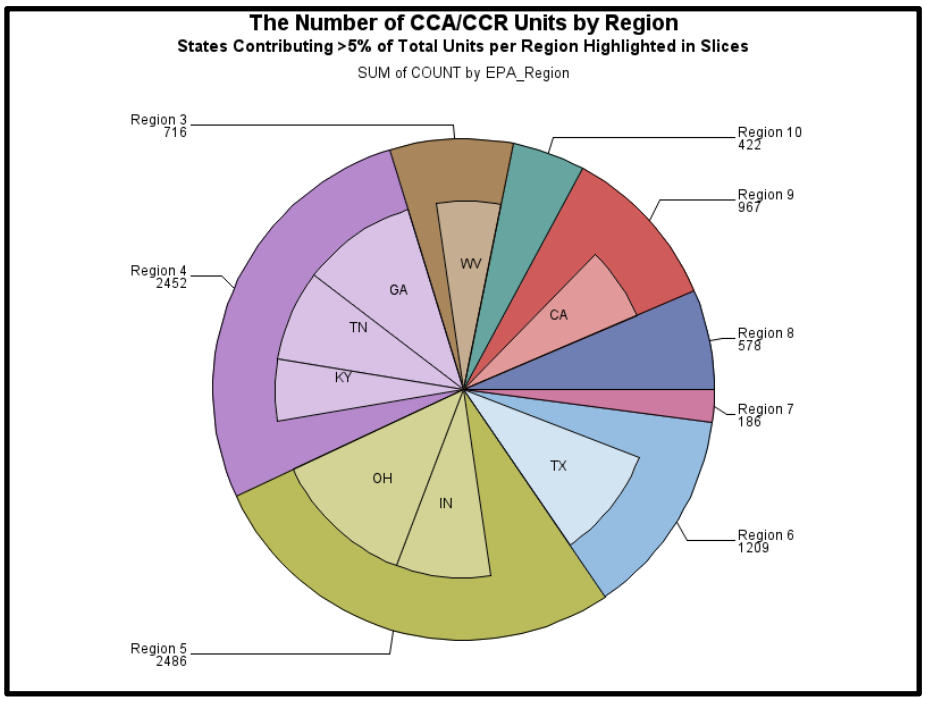

Figure 3-12. Number of RUs by Region (Source: EPA)

Region 5 decided to issue a second request for information regarding repairs and refrigerant additions for the 21 IPRUs and will use that information to determine the IPRUs' compliance with the equipment standard. If collecting and analyzing the information from 9,024 appliances was not burdensome, the Region would request information for all of the remaining units to determine compliance. However, it was determined that the amount of responsive information would be burdensome for Kroger to collect and for EPA to analyze. Therefore, Region 5 requested support in developing a representative sampling plan for leak detection at Kroger-operated refrigeration units (RUs) using CFCs or HCFCs.

The Kroger stores had between one and 30 appliances with refrigerant capacities that ranged from 51 to 4,200 pounds (average of 240 pounds of refrigerant). There were several unknowns related to the distribution of appliance sizes and the distribution of CRAs and CCAs at each store. EPA Region 5 required a representative sampling plan that would demonstrate violations at a representative rate for all 9,024 appliances including a determination of the number of stores or appliances that should sampled.

To address these requirements, the SCMTSC developed a SAS code based on the specified criteria. From the resulting analysis, SCMTSC recommended a cluster sampling methodology with a statistically derived optimum sample size and provided a scoping plan with recommended sample numbers. The sampling design reflected a population survey to establish a 95% level of confidence that the clusters were in compliance. The SAS code was formulated so that it could be modified should the Region wish to increase the sample size.

Monitoring for Algal Blooms and Occurrence of Toxic Algae

Site: Midwestern Lakes Impacted by Toxic Algae
Location: Region 7
Challenge: Support statistical review and correlations for bacterial and cyanobacterial data
Center Support: SCMTSC

Excessive nutrient runoff into lakes can result in harmful algal blooms (HABs). The HABs can in turn produce cyanotoxins, which are detrimental to human health and the safety of drinking water. Under a Regional Applied Research Effort (RARE) project, Region 7 worked to develop a strategy and methodology for monitoring HABs from five Midwestern lake and reservoir locations (Figure 3-13). SCMTSC provided statistical evaluation of the data collected.

Figure 3-13. Five Midwestern Lakes Sampled for Water Quality Parameters that Influenced HABs (Source: Iowa Department of Natural Resources Nine Eagles State Park)

The RARE project plan was developed to define the cyanobacterial and environmental parameters to be collected and the statistical analyses to be performed. This included measured biological and environmental parameters, their quality assurances, correlations, multivariate stepwise regressions, and principal component analysis (PCA) for five lakes and their associated watersheds. The statistical review focused on the presence/absence of specific genetic markers for cyanobacterial toxins in the lakes. Innovative methods were applied for biological measurements including next generation deoxyribonucleic acid (DNA) sequencing, quantitative polymerase chain reaction (qPCR) data, and PhyloChip microarrays.

The study allowed for the exploration of statistical correlations between the presence of toxic cyanobacteria, cyanotoxin, and various environmental parameters. This helped to establish patterns and associations within chemical, water quality, and cyanobacterial data and to identify the major factors influencing the presence of cyanobacterial blooms in lakes. The statistical analyses conducted by SCMTSC helped to refine data interpretation and will be used for future publication of the study results.

3.6 Preventing Adverse Ecological Impacts

The state-of-the-science for ecological risk assessment continues to evolve. TSC experts provide an in-depth understanding of the chemical constituents most likely to drive ecological risks and how to incorporate key concepts related to background, bioaccumulation, and bioavailability into the assessment of ecological impacts. Support is provided to EPA Regional staff for optimizing sampling strategies and for refining ecological risk calculations. For FY 2019, three projects are highlighted below related to TSC support to ecological risk assessments.

Separating Anthropogenic Metals Contamination from Background

Site: All Metals-Impacted Sites
Location: All Regions
Challenge: Evaluate geochemical association plots for their effectiveness in separating anthropogenic metals contamination from background
Center Support: ERASC

Meaningful estimates of background contaminant levels are a critical component of site assessments. A request was submitted by the Ecological Risk Assessment Forum (ERAF) to ERASC relating to the issue of background soil chemical demarcation at metals contaminated sites.

Specifically, the request pertained to the validity of an empirical methodology (geochemical association plots) that utilizes covariation between chemical concentrations and concentrations of major soil elemental constituents (i.e., reference metals) to identify samples that deviate from "natural" variation. Consequently, a comprehensive investigation of this methodology was conducted and assumes assessments are conducted with chemical and reference metal data collected from reference sites (i.e., background data) and site-related locations.

In part 1 of the review, chemical/reference metal associations among uncontaminated soils of contrasting mineralogy and chemical/physical composition were tested to help determine the extent of compatible background data sets. Chemical/reference metal associations were shown to vary significantly among background data sets. Thus, geochemical association plots are a useful screening tool for environmental site assessments, but ubiquitous application of generic background data sets could result in erroneous conclusions. It was determined that additional methodologies are needed as objective lines of evidence to conclude that a chemical occurs as site-related contamination.

In part 2 of the review, ERASC proposed a novel application to environmental site assessments: a multivariate methodology utilizing discriminant analysis with clustered chemical concentrations to: 1) identify distinct signatures, or contrasting chemical concentrations within site samples and 2) determine, in relative order of magnitude, chemicals related to site contamination.

Summary Report

Separating Anthropogenic Metals Contamination from Background: A Critical Review of Geochemical Evaluations and Proposal of Alternative Methodology (December 2019).

"*The authors obviously did a lot of work here… their logic and approach are clear.*"

From Deputy Branch Chief,
EPA Emergency Response Team

Developing a Tool to Understand and Assess the Bioavailability of Contaminants in Soils

Site: All Metals-Impacted Sites
Location: All Regions
Challenge: Characterize soils for potential to sequester metal contaminants and mitigate their bioavailability
Center Support: ERASC

Summary Report

Terrestrial Metals Bioavailability: A Literature-Derived Classification Procedure for Ecological Risk Assessment (In Press)

A request was submitted by the ERAF to ERASC relating to the issue of terrestrial metals bioavailability. The ERAF specifically requested a product that characterizes typical aerobic soils in terms of their potential to sequester common divalent cationic metal contaminants and mitigate their bioavailability to soil-dwelling biota. An extensive literature search and corresponding meta-analysis of the empirical data was recommended and performed. The result is a validated classification procedure, or quantitative tool, that broadly characterizes typical aerobic soils in terms of their potential to sequester common divalent cationic metal contaminants and mitigate their bioavailability to soil-dwelling biota. It is proposed to augment other ecological risk assessment approaches and risk-based remediation of metals contaminated soils.

Refined Ecological Risk Assessment for the Fairfax Street Wood Treaters Superfund Site

Site: Fairfax Street Wood Treaters Superfund Site
Location: Region 4, Florida
Challenge: Analyze sediment for arsenic bioavailability to refine the ecological risk calculations
Center Support: SCMTSC

Fairfax Street Wood Treaters (FSWT) Superfund Site is a 12-acre property located near a dense residential area in Jacksonville, Florida. Wood treating operations were carried out from 1980 to 2010 using the preservative chromated copper arsenate on utility poles, pilings, and other lumber products (see Figure 3-14). The operations resulted in arsenic, chromium, and copper contamination of soil, water, and sediment. The impacts also include contaminated stormwater runoff from the site onto surrounding properties including a parking lot retention pond and Moncrief Creek. In August 2010, the Florida Department of Environmental Protection requested the EPA's assistance in mitigating the release of hazardous substances to the environment. The site was added to the NPL in 2012.

Figure 3-14. FSWT Superfund Site Before, During and After Remedial Action (Source: EPA)

Region 4 is working with the SCMTSC to perform sediment toxicity testing to complete the ecological risk assessment for the site. Under a RARE project, the Region is also working with the STL, the EPA Gulf Ecology Laboratory, the EPA Research Triangle Park (RTP) Laboratory, and the EPA Cincinnati Laboratory to further study the site using innovative techniques. The purpose of the RARE research is to determine whether EPA Method 1340 (developed for soils) may be leveraged to analyze sediments for arsenic bioavailability. The research also aims to develop a rapid, cost-effective microbial-based assay of arsenic bioavailability in sediments.

Field sampling was conducted in July 2019 to collect data as follows:

- Fish testing and sediment toxicity testing;
- Analysis of sediment samples using: 1) an in vitro bioaccessiblity assay (IVBA) as outlined in EPA Method 1340, 2) arsenic speciation, 3) invertebrate toxicity testing, and 4) total metals;
- Fish tissue testing for arsenic bioaccumulation; and
- Microbiological assays being developed in this research (samples included sediment samples, invertebrates, and intestines from fish).

Samples and specimens were collected (Figure 3-15) and sent to an ORD contractor for toxicity testing, the EPA RTP Laboratory for IVBA, the EPA Cincinnati Laboratory for arsenic speciation, the EPA Gulf Breeze Laboratory for developing the microbiological assays, and the Region 4 Laboratory Services and Applied Science Division for fish tissue and metals analysis. Laboratory analysis and toxicity tests were completed in FY 2019 and final reports will be issued in FY 2020. The toxicity results will be used to finalize the site Ecological Risk Assessment and determine if remediation will be required in Moncrief Creek for completion of the on-going remedial action.

Figure 3-15. Sample Collection at the FSWT Superfund Site (Source: EPA)

3.7 Preventing Adverse Human Health Impacts

Addressing the unique contaminants and range of potential human health effects at Superfund sites requires site-specific estimates of current and possible future risks to the community at multiple stages in the Superfund process, from baseline planning through remedial review. Support is provided by the STSC to evaluate and review toxicity values and assessments. Two examples are provided below of FY 2019 STSC support that allowed the Regions to better characterize the potential human health risk of chemical exposures.

Evaluation of Suitability of Chemical Surrogates at the Hercules, Inc. Site

Site: Hercules, Inc.
Location: Region 4, Mississippi
Challenge: Determine suitability of chemical surrogates for five chemicals
Center Support: STSC

Traditional risk assessment practices rely on adequate and comprehensive toxicity studies, primarily in animals, for evaluation of potential human health hazards associated with chemical exposures. However, many chemicals of interest do not meet the data requirements for conventional characterization of hazard and risk metrics. Consequently, these data-poor chemicals that do not have associated toxicity values are not considered in the calculation of a hazard index, and do not inform cleanup levels.

To address this data gap, a framework was designed to apply a categorical approach for quantitative human health risk assessment.[7] This innovative approach relies on information to identify potential analogue chemicals across three categories including structural, metabolic, and toxicity-like similarity to determine the suitability of proposed surrogates for the data-poor target chemicals. In FY 2019, the STSC evaluated the suitability of analogue chemicals proposed as surrogates to support cleanup efforts at several Superfund and RCRA sites including the Hercules, Inc. site.

Environmental cleanup work is ongoing at the former Hercules manufacturing plant in Hattiesburg, Mississippi. The facility is located on approximately 200 acres of land. From 1923 to 2009, manufacturing operations consisted of working with rosins, papers chemicals, and an agricultural insecticide. The work is being conducted by the Mississippi Department of Environmental Quality (MDEQ) under the direction of EPA following RCRA requirements.

EPA Region 4 contacted the STSC to evaluate surrogate suitability for five chemicals found at the site as follows:

- 1,3-dichlorobenzene,
- 3-methylpheno/4-methylphenol mixture,
- phenanthrene,
- propionitrile, and
- *o,o,o*-triethyl phosphorothionate.

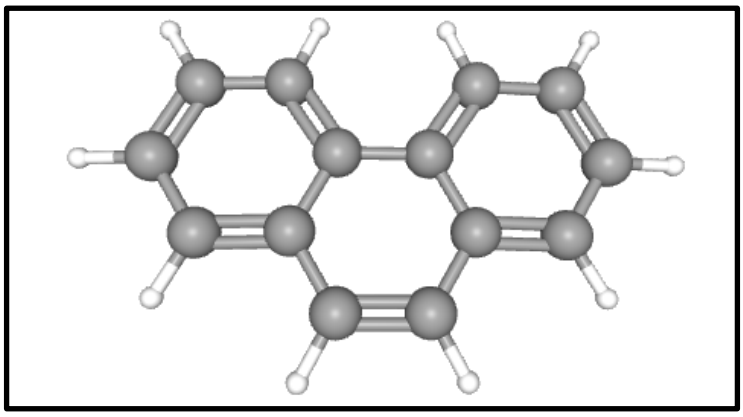

Figure 3-16. Structure of Phenanthrene (Source: National Institute of Health)

This information was requested to fill gaps in the available screening levels for data-poor chemicals being evaluated during the identification of chemicals of potential concern (COPCs), which will be carried through to the human health risk assessment.

For these five chemicals, the STSC developed a weight-of-evidence justification for each, which was informed by chemical similarity and expert knowledge of the bay-region theory of PAHs to ensure that the proposed surrogate chemicals were health protective.

[7] https://hero.epa.gov/hero/index.cfm?action=search.view&reference_id=1239453

Evaluation of Screening Level Toxicity Value for Naphthalene at Quanta Resources Superfund Site

Site: Quanta Resources Superfund Site
Location: Region 2, New Jersey
Challenge: Evaluate health-based screening value for exposure to naphthalene
Center Support: STSC

The Quanta Resources Corporation site in New Jersey started operations in the 1800s where various companies manufactured coal tar, paving, and roofing materials over time. Quanta Resources operated an oil processing facility at the site from 1974 to 1981, when the NJDEP closed the facility. Impacted media include soil, groundwater, as well as surface water and sediments in the nearby river. The main contaminants being remediated are coal tar and arsenic. The site was placed on the NPL in 2002.

As part of the remedial actions, an air monitoring program is conducted to address odors, dust prevention, and incorporate best practices to meet site-specific health-based residential air screening levels. The air monitoring network includes both on-site and perimeter monitoring, along with air monitors at residential properties adjacent to the site (see Figure 3-17). Air samples are also collected for off-site laboratory analysis. The laboratory results are compared with risk screening levels and used to evaluate and adjust emission control activities, if necessary, and to assess potential human health risks.

Figure 3-17. Air Sampling Locations During Remediation Activities (Source: EPA)

During remediation activities, community members complained of odors and asked the New Jersey Department of Health (NJDOH) for an assessment to determine if exposures to the odors in the ambient air around the site were a threat to human health.

In FY 2019, Region 2 requested support in evaluating an Agency for Toxic Substances and Disease Registry (ATSDR) and NJDOH health-based screening value for short-term (acute) exposures to naphthalene in ambient air along the fence line, developed for use at the Quanta sites. The STSC evaluated the derivation of an acute exposure guideline for naphthalene developed in a Letter Health Consultation for the site by ATSDR and NJDOH. In addition, the STSC evaluated comments provided by the PRP to Region 2 on the Letter Health Consultation. The responses from the STSC provided an evaluation of the underlying scientific and technical judgments used to evaluate the public health consultation and refuted arguments by the PRP.

4. Technology Transfer

TSCs share the results of their work in a variety of formats to ensure successful outreach. Each year, the ORD scientists affiliated with the TSCs and the STLs participate in meetings and publish reports and articles on significant developments. These products may take the form of reports, issue papers, peer-reviewed journal articles, conference presentations, posters, webinars, web pages, models, and more. In FY 2019, 58 scientific communication products related to ORD TSC work were published in collaboration with various researchers. Figure 4-1 shows the distribution of TSC's outreach products published for public release in FY 2019. Select outreach products are highlighted below in Table 4-1 by product type.

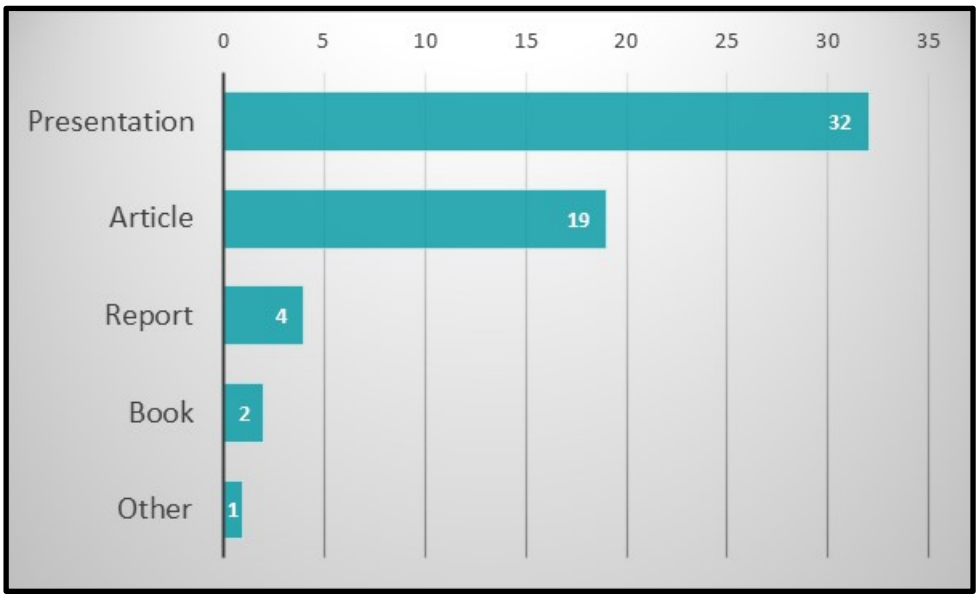

Figure 4-1. TSC-Related Outreach Products by Type for FY 2019

Table 4-1. Select TSC Outreach Products for FY 2019

Presentations and Posters:

- Al-Abed, S. et al. Adsorption of Metals from Mining-Impacted Water onto Biochar from Different Sources. 258th American Chemical Society (ACS) Meeting, San Diego, California, August 25-29, 2019.
- Bless, D. et al. In-Situ Stabilization of PFAS Contaminated Soils at Two Superfund Sites. National Environmental Health Association (NEHA) 2019 Annual Educational Conference and Exhibition, Nashville, Tennessee, July 9-12, 2019.
- Day-Lewis, F. et al. Using Temperature Measurements to Map and Quantify Flow across the Sediment/Water Interface. 2019 Sediments Conference, New Orleans, Louisiana, February 11-14, 2019.
- Halstead, S. et al. JBER: Sampling and Analysis. 26th National Association of Remedial Project Managers (NARPM) Training Program, Chicago, Illinois, August 26-30, 2019.
- Johnson, C. et al. Geophysical Assessment of a Proposed Landfill Site in Fredericktown, Missouri. Symposium on the Applications of Geophysics to Environmental and Engineering Problems, Portland, Oregon, March 17-21, 2019.
- Werkema, D. et al. ORD ESTC: Case Study of Madison County Mines. Region 7 Regional Association of Remedial Project Managers (RARPM), Lenexa, Kansas, June 18-19, 2019.

Table 4-1. Select TSC Outreach Products for 2019 (Continued)

	Webinars: • Lynch, K. and J. McKernan. ORD's Contaminated Sites Research and Technical Support Program. EPA Tools and Resources Webinar Series, Washington D.C., December 17, 2018. • Marks, C. and C. Acheson. Chlorinated Solvent Bioremediation: Fundamentals and Practical Application for Remedial Project Managers. CLU-IN Webinar, Ada, Oklahoma, November 14, 2018. • McKernan, J., D. Powell, and H. Henry. EPA/ORD Perspectives -Technology Assessment and Evaluation Opportunities. National Institute of Health Superfund Research Program Webinar Series, January 15, 2019.
	Articles: • Baek, S. et al. 2019. "Antibacterial Effects of Graphene- and Carbon-Nanotube-Based Nanohybrids on Escherichia Coli: Implications for Treating Multidrug-Resistant Bacteria" in Journal of Environmental Management. • Bradham, K. et al. 2018. "Long-Term in Situ Reduction in Soil Lead Bioavailability Measured in a Mouse Model" in Environmental Science & Technology. • Li, T. et al. 2019. "A Disposable Acetylcholine Esterase Sensor for As(III) Determination in Groundwater Matrix based on 4-Acetoxyphenol Hydrolysis" in Analytical Methods. • Rue, K. et al. 2018. "Abiotic Hydroxylamine Nitrification Involving Manganese- and Iron-Bearing Minerals" in Science of the Total Environment. • Stanley, D. and R. Wilkin. 2019. "Solution Equilibria of Uranyl Minerals: Role of the Common Groundwater Ions Calcium and Carbonate." Journal of Hazardous Materials. • Wilkin, R. et al. 2019. "Geochemical and Isotope Study of Trichloroethene Degradation in a Zero-Valent Iron Permeable Reactive Barrier: A Twenty-Two-Year Performance Evaluation" in Environmental Science & Technology.
	Reports: • North, T., L. Sehayek, R. Wilkin, D. Cutt, N. Klaber, and H. Young. Investigation of a Sustainable Approach to In-situ Remediation of Arsenic Impacted Groundwater. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-19/102, 2019. • Rahman, K., Mohamed M. Hantush, A. Hall, and J. McKernan. Watershed Hydrologic and Contaminated Sediment Transport Modeling in the Tri-State Mining District. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-18/247, 2019. • U.S. EPA. Summary Report. Separating Anthropogenic Metals Contamination from Background: A Critical Review of Geochemical Evaluations and Proposal of Alternative Methodology. U.S. Environmental Protection Agency, Ecological Risk Assessment Support Center, Cincinnati, Ohio, EPA/600/R-19/196, 2019.
	Books: • Chapter coauthored by C. Marks titled: "Anaerobic Hydrocarbon-degrading Deltaproteobacteria" in Taxonomy, Genomics, and Ecophysiology of Hydrocarbon-degrading Microorganisms. • Chapter coauthored by C. Su titled: "Application of Nano Zerovalent Iron for Water Treatment and Soil Remediation: Emerging Nanohybrid Approach and Environmental Implications" in Iron Nanomaterials for Water and Soil Treatment.
	Other Products: • Web Page: Enviro Wiki page by R. Wilkin on Permeable Reactive Barriers

5. Conclusions

The technical support requests and responses summarized in this report are a selected sample of those undertaken by the ORD TSCs in FY 2019. Several of these investigations have generated substantial results, while others are working toward that end. The highlighted support efforts provide insight into the unique role that the ORD TSCs play as a bridge between environmental restoration efforts and innovative research in ORD. Through their interdisciplinary staff, the TSCs bring creative thinking to life by applying innovative research in real-world scenarios. In addition to the site-specific solutions delivered, these innovations have the potential to produce long-lasting dividends, improved environmental conditions, and, ultimately, provide for safer and healthier communities. More information can be obtained through the EPA Web site, TSC Directors, and STLs from each EPA Region (see Table 5-1).

Table 5-1. Contacts for Obtaining Technical Support through the TSCs

Web Sites	EPA TSCs Main Page https://www.epa.gov/land-research/epas-technical-support-centers ERASC https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=154348 ETSC https://www.epa.gov/land-research/engineering-technical-support-center-etsc GWTSC https://www.epa.gov/water-research/ground-water-technical-support-center-gwtsc SCMTSC https://www.epa.gov/land-research/site-characterization-and-monitoring-technical-support-center-scmtsc STSC https://www.epa.gov/land-research/epas-technical-support-centers
TSC Contacts	ERASC Point of Contact: Michael Kravitz, kravitz.michael@epa.gov ETSC Point of Contact: Felicia Barnett (Acting), barnett.felicia@epa.gov GWTSC Point of Contact: Randall Ross, ross.randall@epa.gov SCMTSC Point of Contact: Felicia Barnett, barnett.felicia@epa.gov STSC Point of Contact: Dahnish Shams, shams.dahnish@epa.gov
STL Contacts	Region 1 Point of Contact: Diana Cutt (Acting), cutt.diana@epa.gov Region 2 Point of Contact: Diana Cutt, cutt.diana@epa.gov Region 3 Point of Contact: Jonathan Essoka, essoka.jonathan@epa.gov Region 4 Point of Contact: Felicia Barnett, barnett.felicia@epa.gov Region 5 Point of Contact: Stephen Dyment (Acting), dyment.stephen@epa.gov Region 6 Point of Contact: Terry Burton, burton.terry@epa.gov Region 7 Point of Contact: Robert Weber, weber.robert@epa.gov Region 8 Point of Contact: Stephen Dyment, dyment.stephen@epa.gov Region 9 Point of Contact: Anna-Marie Cook, cook.anna-marie@epa.gov Region 10 Point of Contact: Kira Lynch, lynch.kira@epa.gov

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