EPA
United States
Environmental Protection
Agency

Draft as of March 28, 2022

Sustainable and Healthy Communities

STRATEGIC RESEARCH ACTION PLAN
FISCAL YEARS 2023-2026

Office of Research and Development
Sustainable and Healthy Communities Research Program

Sustainable and Healthy Communities (SHC)

STRATEGIC RESEARCH ACTION PLAN

Fiscal Years 2023–2026

(Draft as of March 28, 2022)

Table of Contents

List of Acronyms

ACE	Air, Climate and Energy Research Program
AOC	Area of Concern
ASTHO	Association of State and Territorial Health Officials
ASTSWMO	Association of State and Territorial Solid Waste Management Officials
BU	Beneficial Use
BUILD	Brownfields Utilization, Investment and Local Development Act
C&D	Construction and Demolition
CBRP	Community Based Participatory Research
CECs	Contaminants of Emerging Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIC	Contaminants of Immediate Concern
CIEC	Chemicals of Immediate and Emerging Concern
CISA	Climate Informed Science Analysis
COPCs	Constituents of Potential Concern
CSS	Chemical Safety for Sustainability Research Program
DBPs	Disinfection by-products
DoD	U.S. Department of Defense
DoE	U.S. Department of Energy
EEIO	Environmentally-Extended Input-Output Model
EJ	Environmental Justice
EO	Executive Order
EtO	Ethylene Oxide
EPA	U.S. Environmental Protection Agency
FY	Fiscal Year
GHG	Greenhouse Gases
GIS	Geographic Information System
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
GLRI	Great Lakes Restoration Initiative

HERA	Health and Environmental Risk Assessment Research Program
HS	Homeland Security
LCA	Life Cycle Assessment
LEAF	Leaching Environmental Assessment Framework
LUST	Leaking Underground Storage Tanks
MIW	Mining-influenced Water
NEPA	National Environmental Policy Act
NPL	Superfund National Priority List
OCHP	EPA's Office of Children's Health Protection
OCR	EPA's Office of Community Revitalization
OEJ	EPA's Office of Environmental Justice
OLEM	EPA's Office Land and Emergency Management
OP	EPA's Office of Policy
ORCR	EPA's Office of Resource Conservation and Recovery
ORD	EPA's Office of Research and Development
OSC	On-Scene Coordinator
OW	EPA's Office of Water
Pb	Elemental heavy metal – lead
PFAS	Per- and poly-fluoroalkyl substances
PRST	Program, Regional, State and Tribal
R2R2R	Remediation to Restoration to Revitalization
RA	Research Area
RACT	Research Area Coordination Teams
RCRA	Resource Conservation and Recovery Act
RESES	Regional Sustainability and Environmental Sciences Research Program
ROE	EPA's Report on the Environment
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act
SDR	Solutions-driven Research
SHC	Sustainable and Healthy Communities Research Program

SMM	Sustainable Materials Management
SSWR	Safe and Sustainable Water Resources Research Program
STPC	Science and Technology Policy Council
StRAP	Strategic Research Action Plan
SWDA	Solid Waste Disposal Act
TSCA	The Toxic Substances Control Act
TSP	Superfund Technical Support Project
USEEIO	U.S. Environmentally-Extended Input-Output Model
USGS	U.S. Geological Survey
UST	Underground Storage Tanks
VI	Vapor intrusion
WARM	Waste Reduction Model

Definitions

Office of Research and Development (ORD): Scientific research arm of EPA that conducts leading-edge research to inform Agency decisions and support partner needs, including state, tribal, and community partners.

National Research Program (NRP): ORD's overall research effort is organized around six integrated and transdisciplinary national programs and closely aligned with the Agency's strategic goals and cross-Agency strategies. ORD is a matrixed organization with research direction coming from its six NRPs, each being guided by a Strategic Research Action Plan that identifies the most pressing environmental and public health research needs with input from many internal and external partners and stakeholders.

Strategic Research Action Plan (StRAP): A description of the overarching direction of ORD's research in a specified timeframe and under a specific research program. Each of ORD's NRPs is guided by a StRAP to structure and coordinate research activities. A StRAP includes a description of identified environmental and public health challenges, research priorities, and ORD's approach to meeting the challenges.

Topic: Overarching research focus under a NRP that encompasses Research Areas, Outputs, and Products.

Research Area: Science area or body of research and expertise assembled to address partner needs in the protection of human health and the environment. It encompasses problem statements, which are delineated through Outputs. Research Areas are nested under Topics and are composed of Outputs, which are composed of Products.

Output: A statement of the results to be achieved in pursuing a Research Area problem statement. It is not a tangible deliverable but encompasses Products that are deliverables. They are designed and developed to address specific partner needs that draw on the scientific knowledge and expertise represented in research areas. An Output can be expressed in many ways, such as an intended intermediate outcome, a purpose, aim, goal, or target. Outputs are composed of Products and nested within Research Areas, which are nested within Topics.

Product: A tangible scientific or technical deliverable. It addresses the research needs of ORD and ORD's partners. Products are nested within Outputs, which are nested within Research Areas, which are nested within Topics.

Partner: An EPA program office, EPA region, representative of a state, or a representative of a Tribe—often referred to as PRST.

Program, Regional, State, and Tribal (PRST) needs: A description of research needs related to human health and the environment as identified by EPA program offices, EPA regional offices, states, and/or Tribes.

Executive Summary

ORD's Sustainable and Healthy Communities (SHC) National Research Program (NRP) conducts research to support EPA's mission to protect human health and the environment through research activities under three topics: 1) Advancing Remediation and Restoration of Contaminated Sites, 2) Materials Management and Beneficial Reuse of Waste, and 3) Integrated Systems Approaches to Building Healthy and Resilient Communities. This SHC Strategic Research Action Plan (StRAP) was developed through a series of partner engagement activities on relevant key topics to address Agency and partner needs, and feasibility of the proposed work. Across the SHC program, the full range of available data from public health, environmental and social sciences, toxicology, engineering, and ecosystems research is integrated to support Agency priorities and empower communities to make scientifically informed decisions.

SHC researchers develop, evaluate, and apply methods and approaches to anticipate and address the scientific needs of our partners and to inform cross-cutting priorities, including cumulative impacts, environmental justice, and climate change as well as community resilience, children's environmental health, and contaminants of immediate and emerging concern. SHC collaborates with communities to develop and translate our science to inform their environmental decisions. Work with communities looks ahead to generate the best available science to avoid unintended consequences and improve access to clean air, water and land for increased health and well-being where people live, learn, work, and play.

Introduction

EPA's Sustainable and Healthy Communities (SHC) National Research Program (NRP) conducts research to support EPA's mission to protect human health and the environment. Specifically, SHC research is designed to support partner priorities related to advancing remediation and restoration of contaminated sites, materials management and beneficial reuse of waste, and integrated systems approaches to building healthy and resilient communities. SHC research helps to empower communities to make scientifically informed decisions.

To assist the Agency in meeting its goals and objectives, the SHC Research Program developed this Strategic Research Action Plan (StRAP) for fiscal years 2023–2026 (FY23-26). The SHC StRAP is one of six of the following research plans for each of the NRPs in EPA's Office of Research and Development (ORD):

- Air, Climate, and Energy (ACE)
- Chemical Safety for Sustainability (CSS)
- Health and Environmental Risk Assessment (HERA)
- Homeland Security (HS)
- Safe and Sustainable Water Resources (SSWR)
- Sustainable and Healthy Communities (SHC)

The StRAPs outline four-year research strategies to deliver the research necessary to support EPA's overall mission to protect human health and the environment. The StRAPs are designed to guide an ambitious research portfolio that delivers the science and engineering solutions the Agency needs to meet its goals now and into the future. They also inform our partners and the public of the program's strategic direction over the next four years. The SHC StRAP FY23-26 builds upon the previous StRAP FY19-22, and where appropriate, continues research efforts to address longer-term strategic research objectives that can bridge between the four-year research planning cycles.

The strategic directions and Research Areas (RAs) identified in each StRAP serve as planning guides for ORD's research Centers to design specific research products to address the needs of EPA program and regional offices, states, Tribes, and external partners. Partner engagement is an essential part of the StRAP development process to identify research needs to be addressed.

Solutions-Driven Research

ORD is committed to producing research results that address real-world problems, inform implementation of environmental regulations, and help EPA partners make timely decisions based on sound science. This commitment includes exploring ways to improve research processes through the application of a solutions-driven research (SDR) framework. SDR is a specific research approach that emphasizes partner engagement and integration of tasks to develop research that is directly along the path to a solution or decision. Solutions-driven research emphasizes the following:

- Planned partner engagement throughout the research process, starting with problem formulation and informing all elements of research planning, implementation, dissemination, and evaluation.
- A focus on solutions-oriented research Outputs identified in collaboration with partners.

- Coordination, communication, and collaboration both among ORD researchers and between researchers and partners to develop integrated research that multiplies value to partners.
- Cooperation with partners to apply research results to develop solutions that are feasible, appropriate, meaningful, and effective.

ORD is applying principles of solutions-driven research broadly across its six NRPs. ORD will also monitor how we engage with our partners and how we design and conduct our research to ensure that it informs solutions for our partners' most pressing environmental problems. By doing this, we are engaging in translational science, which will continually improve and increase the value of our research for our partners. Our emphasis on translating science is exemplified by the Outputs listed in this StRAP—they provide solutions to problems identified by our partners.

Solutions Driven Research (SDR) Project in the SHC Research Program

Blue Carbon and Coastal Resilience: This SDR project is a collaborative effort across EPA's ORD, Office of Water, Region 3, and Chesapeake Bay Program Office, as well as coastal communities in the Chesapeake Bay region. It aims to restore, conserve, and monitor wetlands, tidal marshes, and sea grasses to help mitigate climate change by promoting long-term carbon sequestration and to empower communities with knowledge and tools to build resilience to future flooding, storm surge, coastline erosion, and habitat degradation.

Program Vision

The SHC research program takes a systems approach to integrate the full range of available data from public health, physical, natural, and social sciences, toxicology, engineering, and ecosystems research to support communities. SHC researchers are leaders in environmental science disciplines, working with and for communities to improve access to clean air, water and land for increased health and well-being where people live, learn, work, and play. SHC works with partners to develop and translate our research to support their environmental decision-making, and to look ahead to use the best available science to inform their choices in order to avoid unintended consequences. SHC research supports and empowers communities to make science-based decisions to improve public and environmental health through

(1) application of technologies and methods to expedite remediation and restoration of contaminated sites;

(2) enhanced approaches to materials management practices, including the beneficial reuse or redirection of waste materials to advance waste management toward a circular economy; and

(3) increased understanding of linkages between the total environment (built, natural, and social) and public and ecosystem health to support communities that are revitalizing former contaminated sites, addressing cumulative impacts (including both chemical and nonchemical stressors), and pursuing climate resilience and environmental justice (EJ) goals.

SHC's strategic direction for the next four years is grounded in the statutes that provide EPA the authority or guidance to conduct research to support the cleanup and revitalization of contaminated sites and the communities impacted by these sites. These include but are not limited to the following:

- **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) also known as the Superfund and the Superfund Amendments and Reauthorization Act of 1986 (SARA).** CERCLA specifies that a research program should be established within the EPA to enhance Agency health protective activities related to contaminated sites. SARA authorizes research to fuel the development of innovative treatment technologies.
- **Brownfields Revitalization Act and the Brownfields Utilization, Investment and Local Development (BUILD) Act.** The term "Brownfield site" refers to real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.
- **Resource Conservation and Recovery Act (RCRA).** RCRA is our Nation's primary law governing the disposal of solid and hazardous waste. Congress passed RCRA on October 21, 1976, to address the increasing problems the Nation faced from our growing volume of municipal and industrial waste.
- **Underground Storage Tanks (UST).** Legislation concerning underground storage tanks (UST) is part of the Solid Waste Disposal Act (SWDA), titled the Underground Storage Tank Compliance Act of 2005.
- **Great Lakes Legacy Act (GLLA) and Great Lakes Restoration Initiative (GLRI).** GLLA was authorized in 2002 and reauthorized in 2008 to clean up sediments and former industrial sites that are impediments to community revitalization throughout the Great Lakes region. GLRI aims to restore the beneficial uses of local ecosystems. The GLRI Action Plans have sponsored research to facilitate the delisting of beneficial-use impairments.

In addition to these statutes, cleaning up sediment, soil, and groundwater at contaminated sites (Superfund NPL, RCRA Corrective Action, Brownfield, and other hazardous waste sites) will also improve surface water quality under the **Clean Water Act**. Remediating contaminated groundwater in aquifers that are a source of drinking water is responsive to the **Safe Drinking Water Act**. SHC research on ecosystem services, contaminated sites, and groundwater also informs decisions relevant to the **Clean Air Act**, **Clean Water Act**, **Safe Drinking Water Act**, and SHC research on ecosystem services, cumulative impacts, and EJ is relevant to the **National Environmental Policy Act**.

Strategic Direction

Relationship to EPA and ORD Strategic Plans

The FY 2023-2026 EPA Strategic Plan is designed to implement the Administrator's priorities for the next four years. This Strategic Plan identifies four cross-cutting strategies and seven strategic goals with related objectives, describing how the Agency will work toward its mission to protect human health and the environment.

ORD will develop its own Strategic Plan to respond to and build upon the FY 2023-2026 EPA Strategic Plan. ORD's Strategic Plan will align with the StRAPs for ORD's six research programs, which outline specific research activities that address objectives of the Agency's Strategic Plan.

SHC integrates efforts with other research programs across ORD, with EPA program and regional office partners, and with external partners to provide a research portfolio aligned around the Agency's strategic goals and cross-cutting strategies in the Strategic Plan. Cross-Agency Strategy 1, **Ensure Scientific Integrity and Science-Based Decision Making**, guides ORD's research program in supporting Agency partners in meeting their programmatic goals. SHC will assist all of EPA's program and regional offices, as well as states and Tribes in addressing the current Administrator's priorities related to EJ, cumulative impacts, and climate change.

The SHC StRAP is oriented primarily towards all three objectives under EPA's Goal 6 to **Safeguard and Revitalize Communities**. Research conducted by SHC will provide science-based methods and evidence to achieve this goal. SHC will assist EPA's Office of Land and Emergency Management (OLEM) in reaching their strategic goals related to "restoring land to safe and productive use to improve communities and protect public health." This includes addressing existing contamination as well as reducing waste and preventing pollution. For example, SHC will develop and translate the research that is needed for OLEM to implement the 2021 National Recycling Strategy, particularly related to understanding plastic and food wastes using a circular economy approach. Further, SHC research on critical minerals is designed to inform Agency initiatives in support of Executive Orders (E.O. 13953 and E.O. 14017) on addressing America's supply chain and the threat to the domestic supply chain from reliance on critical minerals from foreign adversaries. The Program will also continue to collaborate with the Great Lakes National Program Office (GLNPO) to advance the remediation to restoration to revitalization (R2R2R) paradigm and examine potential links between human health and ecosystem services.

Under the EPA Strategic plan, SHC also supports Objective 1.2: **Accelerate Resilience and Adaptation to Climate Change Impacts** and Objective 2.2: **Embed Environmental Justice and Civil Rights into EPA's Programs, Policies, and Activities**, which both relate to the recent Executive Orders on EJ and Climate Change. SHC will develop research to support EPA's Office of Policy's (OP) Office of Community Revitalization (OCR) in its community revitalization and resiliency goals, OP's Office of Environmental Justice (OEJ) in its efforts to advance cumulative impact assessment and support overburdened and underserved communities, and the Office of Children's Health Protection (OCHP) in its goals to consider the health and well-being of children at all lifestages, which is captured in Cross-Agency Strategy 2: **Consider the Health of Children at All Lifestages and Other Vulnerable Populations**. SHC will measure its progress over the next four years by increasing the percentage of research products that meet partner needs.

Changes from FY 19-22 StRAP

The FY 23-26 SHC StRAP will continue guiding innovative, cost-effective solutions to meet current, emerging, and long-term contaminated site clean-up and sustainable materials management challenges. This includes technical support for program and regional partners and communities as well as exploratory research that may lead to future sustainable solutions. In addition, this strategic plan will continue to emphasize healthy and resilient communities.

Increased focus will be given to Administration priorities, such as working with communities to identify solutions to address cumulative impacts and EJ concerns, including those dealing with impacts from climate change. Other areas of increased emphasis include critical minerals and recycling research, including plastics.

There is also a concerted effort across the national research programs to coordinate our portfolios related to the six cross-cutting research priorities, which are discussed in more detail in Appendix 4.

Partner Engagement

Development of ORD's StRAPs has been informed by ongoing and extensive engagement with EPA program and regional offices and external (non-EPA) partners. ORD's partner engagement during strategic research planning ensures a collaborative, transparent, and highly coordinated research portfolio that delivers the data and information that Agency program and regional offices need, and provides resources that help states, Tribes, local communities, and other partners. ORD relies on partner engagement as an essential component throughout the research cycle and especially during problem formulation to identify partner research needs and develop the research Outputs outlined in the StRAPs.

The SHC Research Program engages partners at different levels and stages throughout the research cycle to identify and discuss their research needs. Building from engagement during StRAP FY19-22 planning and implementation, engagement methods for the SHC StRAP FY23-26 included the following:

- Recurring dialogues and meetings with EPA program and regional offices.
- Listening sessions with external partners, including state, tribal, and local partners.
- Workshops with ORD staff and EPA program and regional offices.
- Participation in EPA state and tribal organization meetings (e.g., Environmental Council of the States, Tribal Science Council, Association of State and Territorial Health Officials (ASTHO), the Association of State and Territorial Solid Waste Management Officials (ASTSWMO), the Tribal Waste Response Assistance Program, and the Tribal Superfund Working Group).

The SHC Research Program will continue to engage with our EPA partners and state, tribal, and local organizations as we implement the research program outlined in the StRAP, support our research products after they are delivered, and evaluate the usefulness and effectiveness of our research in helping solve environmental and public health problems.

Research Topics and Research Areas

Maintaining support for priorities identified in the SHC FY19-22 StRAP, this StRAP includes a three topic and 11 research area structure focused on cleaning up contaminated sites, waste and materials management, and healthy and resilient communities. Emphasis across and within these research areas has shifted to accommodate new Administration and Agency priorities, such as those codified through President Biden's Executive Orders on EJ, climate change, and critical minerals. SHC focus in these areas will expand capacity to address Administration priorities as well as support EPA's contributions under the Bipartisan Infrastructure Law. SHC will also provide support for EPA's *National Recycling Strategy* released in 2021, as well as a series of related, targeted strategies and goals to support circular economies. SHC will continue to support per- and polyfluoroalkyl substances (PFAS); lead ; plastics,

including microplastics; food wastes; cumulative impacts; and community science. SHC's topics and research areas are summarized below, as well as high-level representative priorities received from program, regional, state, and tribal partners that inform the research that will be completed under this StRAP. An overview of some of the priority needs are mapped to the Outputs under each research area. More detail on the Outputs can be found in Appendices 1 and 3.

Topic 1: Advancing Remediation and Restoration of Contaminated Sites

The objective of this topic is four-fold: 1) to provide cost-efficient, rapid, and effective technical support and innovative methods (e.g., cumulative impact assessment, future use and potential community benefits analyses, health impact assessments, and ecosystem services assessments) for site characterization, cleanup, and redevelopment, especially for complex site-specific issues; 2) to contribute to EPA program guidance and other technical support to manage contaminated groundwater (present at 85% of National Priorities List sites), sediments, soils, leaking underground storage tanks, and mine waste; 3) to provide science-based approaches so that EPA partners, states, and Tribes can better engage in effective clean-up and restoration and reduce the burden on nearby communities, particularly those that are overburdened and under-resourced; and 4) to provide research to advance the clean-ups of PFAS, lead, and other contaminants of immediate and emerging concern. Research and development under this topic will provide data and tools to support EPA partners, states, Tribes, and local delegated programs regarding the following Research Areas.

Research Area 1: Technical Support

OLEM, ORD, and the EPA regions established the Superfund Technical Support Project (TSP) in 1987 to provide technical assistance to decision-makers including regional Remedial Project Managers (RPMs) and On-Scene Coordinators (OSCs). Through technical support centers, SHC will assist EPA partners, federal land management agencies, states, Tribes, and local delegated programs with short-term, specific requests for expert consultation regarding identification, optimization, and evaluation of waste and waste-site characterization, assessment, remediation, monitoring, or reuse.

SHC will provide scientific and engineering expertise at contaminated sites by applying the latest methods, approaches, and technologies for assessing, characterizing, remediating, site redevelopment/reuse, and managing risks. SHC will provide solutions for complex contamination scenarios and promote robust, transparent science (Output SHC.1.1).

Research Area 2: Site Characterization and Remediation

This research area provides state-of-the-science methods, models, tools, and technologies that OLEM uses in programmatic guidance, and that EPA decision-makers use in the site cleanup process. Research in this area will be used to support site characterization, remedial investigations, feasibility studies, and cleanup effectiveness at contaminated sites, including sampling and monitoring strategies, determination of the nature and extent of contamination, identification of remedial action objectives, screening of potential technologies for treatment and containment, and evaluating site reuse potential. SHC will conduct remediation and restoration research to assist EPA partners, states, Tribes, and local delegated programs, addressing CERCLA sites (including Brownfields), RCRA facilities, and Great Lakes Areas of Concern.

The research will provide science-based solutions to the most challenging technical issues identified by our partners at large-scale, complex sites. These include how to 1) more efficiently characterize and remediate contaminated soils and sediments at Superfund and RCRA corrective action sites (Output SHC.2.1); 2) develop and evaluate remediation alternatives to contaminated groundwater at Superfund and mine waste sites (Outputs SHC.2.2, SHC.2.3, SHC.2.4); 3) evaluate source control technologies at mine waste sites (Output SHC.2.5); and 4) investigate remediation, recovery, and reuse of critical minerals from contaminated sites (Output SHC.2.6).

Research Area 3: Solvent Vapor Intrusion

Vapor intrusion (VI) is the migration of vapor-forming chemicals from a subsurface source into an overlying building or structure via any opening or conduit. Industrial chemicals (e.g., volatile organic chlorinated solvents) released into the subsurface may form hazardous vapors that migrate through the vadose zone and eventually enter buildings through openings and conduits such as cracks, seams, foundations, sump pits, utility vaults, floor drains, and sewer lines. These vapors could pose threats to indoor air quality and cause health risks. Research Area 3 is focused on effective, cost-conscious, reliable, and documentable means to identify, monitor, and control VI to 1) reduce exposures; 2) reduce contaminant sources; and 3) define sampling strategies that address when, where, and how to sample.

To assist partners, research should determine ways to increase community participation to improve equity of exposure reduction and speed the cleanups at VI sites in communities with EJ concerns (Output SHC.3.2). Getting assistance from social science experts and developing community and citizen science programs for these sites could improve outcomes. Protocols and guidance for the investigation of VI at sites contaminated with per- and polyfluoroalkyl substances (PFAS) need to be developed, and the physical and chemical properties of PFAS chemicals that impact VI need to be studied (Output SHC.3.1). This information could allow modeling of the fate and transport of PFAS in groundwater and evaluation for VI. SHC partners also need data analysis and decision support tools for identifying and ideally, predicting a reasonable worst-case VI condition on a site- and building-specific basis. These tools, needed for both solvent and PFAS VI, could inform VI assessments, interpretation and risk management decision-making, and monitoring (Output SHC.3.3). Information on the volatility of PFAS compounds and their ability to enter a building by VI and models for the distribution within structures would assist program partners to develop protocols for investigating and monitoring sites contaminated with PFAS (SHC.3.3).

Research Area 4: Leaking Underground Storage Tanks

An underground storage tank (UST) is a tank and any underground piping connected to the tank that has at least 10 percent of its combined volume underground. Corrosion in USTs can cause leaks that release hazardous materials into soil and contaminate groundwater. Faulty installation or inadequate operating and maintenance procedures also can cause USTs to release their contents into the environment. Research Area 4 will assist partners in assessing the degradation of USTs, which will help to identify vulnerable tanks before leaks occur. Tools to track and monitor the status of existing and abandoned USTs will reduce the impact of leaking underground storage tanks (LUSTs) on communities.

To assist partners, SHC will develop tools and provide technical support for both the prevention and cleanup of leaks in USTs (Output SHC.4.1). This research will assist in identifying vulnerabilities from UST sites, provide information on preventing corrosion, and develop GIS tools. Support will be provided to evaluate new technologies and the effectiveness of technologies in use in specific environments.

Assistance is also needed to improve understanding of the fate and toxicity of evolving petroleum fuels and their breakdown products (SHC.4.1). Solutions are needed in preparing for extreme weather events through assistance with triaging sites, response, and recovery. How to identify, respond to, and mitigate UST-related impacts on communities with EJ concerns from extreme weather events will be a focus of the research as well (Output SHC.4.2).

Research Area 5: Chemicals of Emerging and Immediate Concern

As contaminants gain attention from researchers, policy makers, and the public, they may be considered or referred to as contaminants of emerging concern (CECs). Contaminants of immediate concern (CIC), meanwhile, include legacy contaminants (e.g., lead) that have proven human health and/or environmental impacts that require continued focus. These contaminants may be previously unknown or unregulated, or alternatively become subject to more attention as science becomes more refined in areas such as occurrence, fate, and risk to humans and ecosystems. The bulk of the activities in the research area is currently focused on PFAS and lead to advance clean-ups of these contaminants to protect vulnerable groups, especially children. However, the methodologies and approaches developed here will also apply to other known and unknown chemicals of emerging and immediate concern (CEIC).

Identifying U.S. communities with the highest risk of childhood lead exposure is a priority for EPA and a goal of interagency lead collaboration efforts (Output SHC.5.1). Identifying and mapping areas with highest children's exposures and blood lead levels across the Nation will help to target and prioritize lead exposure risk reduction, prevention, and mitigation efforts. Data are also needed to determine key drivers of blood lead levels from multimedia exposures to enhance and apply multimedia exposure modeling for regulatory determinations and for use in calculating cleanup levels at Superfund and other contaminated sites (Output SHC.5.2). Data from these efforts will help to inform SHC and HERA collaborative efforts to better assess and model lead levels in communities.

SHC will develop methods to evaluate wastes, soils, and sediments and investigate PFAS fate and transport in the environment to support the need of EPA partners, states, Tribes, and local communities to identify and characterize PFAS concentrations and distributions at contaminated sites and solid waste sites (Output SHC.5.3). Additionally, SHC will identify locations and contributors to high potential human PFAS exposure by evaluating multimedia PFAS sources and pathways for human exposure, including children (Output SHC.5.5). SHC will also investigate approaches, methodologies, and technologies to treat, remove, destroy, and dispose of PFAS in environmental matrices (Output SHC.5.4).

Topic 2: Materials Management and Beneficial Reuse of Waste

The objective of this topic is an integrated approach to materials management, with the goal of increased sustainability through reducing waste and supporting more circular economies. Sustainable Materials Management (SMM) considers full life cycles of materials, through estimating and analyzing materials flows; evaluating ways to reduce waste and recycle materials, such as food waste; sustainable funding of waste management; and developing tools and strategies to help states, Tribes, and communities make sustainable decisions. A circular economy, as defined in the Save Our Seas 2.0 Act, refers to an economy that uses a systems-focused approach and involves industrial processes and economic activities that are restorative or regenerative by design, enable resources used in such processes and activities to maintain their highest value for as long as possible, and aim for the elimination of waste through the superior design of materials, products, and systems (including business

models). It is a change to the model in which resources are mined, are made into products, and then become waste. A circular economy reduces materials use, redesigns materials and products to be less resource-intensive, and recaptures 'waste' as a resource to manufacture new materials and products. SHC investigates landfills to evaluate their performance; effects of landfill moisture, temperature, and contents such as food wastes and plastics; and long-term landfill impacts on human health and the environment, especially in the context of disproportionately affected communities and changing climates. SHC also examines waste recovery and safe beneficial use of materials, since many existing materials, whether hazardous or non-hazardous and intended for some form of disposal, containment, or treatment, could potentially be reused, recycled, or reprocessed into other resources.

Research Area 6: Landfill Management

Landfilling remains a prominent method of waste management. SHC will explore the diverse funding methods for waste management that are developing across the United States. This will help states and local governments understand how to restructure their funding and financial incentives in ways not tied to increased generation of landfill waste. There is still a need to evaluate landfill performance and its long-term impact on human health and the environment. Over the past four years, SHC has worked with our partners on guidance for assessing whether post-closure care should be extended at hazardous and nonhazardous waste sites, along with better understanding of performance issues in landfills. Through continued research, SHC will collaborate to develop and advance tools, processes, and methods to improve management of wastes in municipal and hazardous waste landfills. It will also evaluate the impact of climate change on landfills and will interact with the ACE Research Program to investigate landfill emissions' impact on climate change, thus using a multimedia approach to understand total environmental releases. Droughts, wildfires, and other extreme weather events projected to be exacerbated by climate change influence landfill releases to air, land, and water, which could disproportionately impact overburdened and under-resourced communities.

SHC will develop methodologies to improve assessment of risks associated with ending post-closure care after 30 years (Output SHC.6.1). SHC will develop recommendations to improve bioreactor processes so liquid additions and landfill temperatures can be optimized (Output SHC.6.2). SHC will also investigate anticipated climate change effects on landfill waste decomposition and containment, as well as corresponding potential disproportionate impacts on nearby overburdened and under-resourced communities (Output SHC.6.3).

Research Area 7: Material Flow and Life Cycle Analysis

Resource conservation under RCRA focuses on reducing material use at the source and recovering and reusing valuable materials from waste streams. This research area is designed to support the minimization of waste generation with a focus on applying input-output materials and economic models and databases to assess the life-cycles of materials. EPA describes sustainable materials management in its report, Sustainable Materials Management: The Road Ahead, as fulfilling human needs and encouraging societal advancement while using fewer materials, reducing toxics, reducing greenhouse gases, and recovering more of the materials used. EPA has also embraced a circular economy approach in its Strategy Series on Building a Circular Economy for All; the Agency has set two ambitious goals associated with that approach and may set several more. SHC will support partners by developing, advancing, and applying input-output materials and economic models and databases to establish baselines and measure progress towards these goals; as well as assessing the life-cycles of materials to

minimize waste generation (including the priority areas of plastics and food wastes), reducing environmental impacts, and increasing circularity.

SHC will build models and update and expand the U.S. Environmentally-Extended Input-Output (USEEIO) model to support life cycle inventories, goal measurement, and methodologies of EPA, its partners, states, Tribes, and local delegated programs (Output SHC.7.1). To provide national estimates of waste generation, management, and leakage for states and communities' materials management planning, SHC will develop data, methods, and an innovative modeling framework (Output SHC.7.2). SHC will address food waste research needs by evaluating potential contaminants in compost and digestate and identifying opportunities for food waste reduction by applying a life cycle/systems approach to analyze paths of food waste generation, treatment, and disposal. SHC will use this research to develop decision-support tools for identifying promising solutions to prevent food waste (Output SHC.7.3). Across this research area, SHC will engage and empower communities around key issues or challenges related to materials management. To this end, SHC will conduct research to identify and develop suitable metrics and indicators for community-scale measurement and modeling and employ social science concepts for actionable and implementable solutions (Output SHC.7.4).

Research Area 8: Waste Recovery and Beneficial Use of Materials

Similar to Research Area 7, this research area is designed to support resource conservation under RCRA; however, the focus is on using engineering approaches to recover specific materials for beneficial reuses, and to chemically test the safety of the new uses. Many existing materials considered as waste for disposal could potentially be reused, recycled, or reprocessed to reduce the extraction and consumption of natural resources, decrease waste generation, and reduce the volume of materials disposed into hazardous and non-hazardous landfills. SHC will develop innovative waste recovery and reuse tools and processes to maximize the beneficial uses and reuses of wastes, including plastics, and to evaluate the safety of the resulting products.

To enhance the recovery of construction and demolition (C&D) materials, SHC will identify methods, technologies, and cost-effective practices to develop decision support resources and tools. These will assist C&D materials sorting, segregation, reuse, and recycling (Outputs SHC.8.1 and SHC.8.2). SHC will develop, test, and demonstrate methodology and optimization tools for specific waste materials (e.g., plastics, mining and mill waste, forest fire biochar, critical minerals from batteries) to be beneficially reused in infrastructures, technologies, and revitalization of environmentally impacted natural resources and communities (Output SHC.8.4). To elucidate potential leaching from materials beneficially reused, land-disposed, or remediated, SHC will develop, demonstrate, validate, and publish analytical methods that enable more accurate and precise source terms of partitioning (Output SHC.8.3).

Topic 3: Integrated Systems Approach to Building Healthy and Resilient Communities

The objectives of this topic are to recognize and address the impacts of contamination, remediation, and redevelopment on the revitalization of a community. This topic will address cumulative impacts of stressors and exposures, especially in overburdened and under-resourced communities. The goal of the research is to increase community resilience by reducing potential risks, promoting health, and revitalizing communities, and to increase research translation to benefit communities. The research will

identify links between desirable community outcomes and health-promoting features of the built and natural environments. It will seek to advance the science of cumulative impact analysis for EPA and community decision-making and provide solutions to foster community resilience. SHC will develop indicators for tracking progress nationally and regionally and interpret trends to understand the changes that occur. Research and development under this topic will provide data and tools to support Agency and delegated programs, such as Superfund, Brownfields, Great Lakes Restoration Initiative, civil rights, enforcement, and permitting.

Research Area 9: Benefits from Remediation, Restoration, and Revitalization

There are numerous ways the environment benefits individuals and society. The purpose of this research area is to continue to build the causal connections between the environment and human health and wellbeing. The *Remediation to Restoration to Revitalization* (R2R2R) paradigm used by the Great Lakes National Program Office recognizes that remediation and restoration contribute to community revitalization. SHC embraces this paradigm. Considering community revitalization goals up front can improve the focus and outcomes of remediation and restoration activities in Great Lakes Areas of Concern and other cleanup programs. To maximize the R2R2R benefits for all individuals, communities need solutions that consider the needs and capacity of diverse groups within communities, including those historically disadvantaged and disproportionately affected by environmental harms. Emphasis on science communication and translation is paramount to success in community-oriented research. Thus, this research area emphasizes working with communities, and recognizing and supporting their capacity to incorporate science into decision-making, especially for communities with EJ concerns.

Approaches for assessing the effectiveness of restoration efforts have only recently been developed. Temporal and spatial variability in existing restoration metrics is poorly characterized and difficult to implement for short-term and longer-term assessments of ecological recovery and associated beneficial uses. The resilience of socio-ecological systems to environmental changes, such as extreme weather events, is also poorly characterized and needs further research. Such research will develop and refine methods and data for managers to better project future restoration effectiveness or assess the effectiveness of previous restoration actions (Output SHC.9.1). These redevelopment and revitalization processes are opportunities to improve community health and wellbeing and address disproportional burdens and injustices. Socio-economic valuations of community benefits are needed to better compare the costs of remediation and restoration to the benefits of redevelopment and revitalization. SHC will develop spatially explicit metrics and methods to enable decision-makers to demonstrate linkages between remediation/restoration and socio-economic benefits from redevelopment/revitalization that can inform efforts such as Justice40 and the Infrastructure Investments and Jobs Act (Output SHC.9.2).

There are gaps in our understanding of the connections between ecosystem condition and human health and well-being, and what environmental interventions may yield positive impacts. To fill these data gaps, SHC will continue to work with program and regional offices to collect, analyze, and publicly release human health and environmental data through online applications which can be used to help inform public health and environmental decisions. SHC will develop translational research approaches to integrate community priorities, redevelopment goals, and human health and well-being impacts more fully into remediation and restoration decisions (Output SHC.9.3). Community-based approaches, including health impact assessment, will be employed for assessing the cumulative impacts of ecosystem remediation and restoration on community redevelopment and revitalization (SHC.9.3).

Research Area 10: Cumulative Impacts and Community Resilience

This Research Area seeks to address the cumulative impacts and risks from contamination, climate (e.g., natural disasters and extreme events), and other stressors on the environment and the health of vulnerable groups, such as children, the elderly, and pregnant women. To support overburdened and underserved communities with EJ concerns, SHC will identify critical information to improve local planning; community, state, and federal permitting; and rulemaking and enforcement. The focus is on improving environmental equity, benefits, and resilience for both individuals and communities from the adverse effects of climate change and exposure to both chemical and non-chemical stressors from the built, natural, and social environments.

Partners have identified the need to characterize determinants of local environmental health risks; assess disparities, cumulative impacts, and community resilience; and develop and implement cumulative impact assessments and resilience and recovery plans. Research here will include identifying community assets and vulnerabilities (Output SHC.10.1). Further, it will address partner needs to quantify the cumulative impacts of chemical exposures, lifestage vulnerability, and stressors from the built and degraded natural environments on existing background burdens of vulnerable groups (Output SHC.10.2). Climate change is an added stressor on communities, especially those already burdened. Resilience is the capacity of a social-ecological system to cope with a natural hazard event or disturbance, responding in ways that maintain its essential structure and function, while also maintaining the capacity for adaptation and transformation. SHC research will help stakeholders prepare for natural hazards, identify beneficial actions, anticipate and respond to events, and evaluate the effectiveness of their actions (Output SHC.10.3). The goal is for communities to be more resilient when adverse events occur, and to experience greater health and well-being in the long term.

Effectively targeting interventions and resources to serve the most overburdened communities requires an understanding of how environmental exposures interact with factors, such as aspects of the built environment, access to or degradation of valued ecosystem services, and the social determinants that contribute most to disproportionate impacts. Research is needed on how community capacity plays a role in local decision-making and affects environmental and health outcomes, and how EPA research, tools, and programs can strengthen community capacity (Output SHC.10.4).

Research Area 11: Measuring Outcomes through the Report on the Environment

The Report on the Environment (ROE) is a compilation of the environmental indicators that help to answer critical questions about current trends in human exposure and health, and ecological conditions. Indicators are the simple measures that track the state of the environment and human health over time, based primarily on measurements of physical or biological conditions within a clearly defined geographic area. Indicators help to measure outcomes of environmental protection and allow for the evaluation of trends that provide a nationwide view of progress toward EPA's mission of providing clean and safe air, water, and land. Under Research Area 11, the ROE will be maintained to ensure it is kept up-to-date and that new indicators are developed to meet Agency needs (Outputs SHC.11.1 and SHC.11.2).

To ensure that ROE indicators are addressing questions of most relevance to the EPA mission, the EPA Science and Technology Policy Council (STPC) will be consulted as an advisory committee regarding any updates to the ROE and on the development of new indicators. New indicators will be identified in consultation with EPA scientists and specialists, other federal and state agencies, academic experts, and non-government organizations. Understanding the cause of an observed environmental or human

health indicator trend is important to effectively evaluate performance or actions. The ROE, like many of its underlying data sources and other EPA geospatial tools (e.g., EnviroAtlas, EJ Screen), provides numerous opportunities for further investigating and understanding relevant features and trends in indicators. In collaboration with program offices and regions, SHC will implement ROE Extensions including those related to the Regions 2 and 3 Regional Sustainability and Environmental Sciences Research Program (RESES) ROE development process (Output SHC.11.3).

Implementing the Strategic Research Action Plan

In collaboration with EPA program, regional, state, and tribal partners, ORD scientists and engineers design specific research products responsive to the Outputs outlined in the StRAPs. During the implementation of the previous FY19-22 StRAPs, ORD piloted a successful process in which Research Area Coordination Teams (RACTs), made up of ORD scientists and engineers, EPA program and regional staff, and state members, collaborated to determine the individual research products responding to each Output. ORD is continuing this process for the FY23-26 StRAPs.

Each Output in the StRAPs is reviewed by a RACT, which develops goals and objectives for the Output and establishes criteria for the work needed to accomplish it. ORD researchers propose research products, which the RACT reviews and refines to ensure products will meet the goals and objectives of the Output and reflect the timing and specific needs of EPA program and regional, state, and tribal partners. RACT members serve as liaisons to their programs or organizations, which ensures that ORD's partners are able to provide input into the proposed research products. Products developed to address the Outputs may take the form of assessments, reports, tools, methods, journal articles, or other deliverables.

Throughout implementation of the StRAPs, ORD's researchers develop and deliver products. Research to deliver StRAP products is implemented by staff scientists and engineers at research laboratories and facilities in twelve locations across the country, which collectively comprise ORD's four Centers and four Offices. EPA staff are joined in this endeavor by a network of collaborators and partners within and external to EPA. In addition to the extensive intramural research program outlined in the StRAPs, ORD's research portfolio includes extramural research programs that complement or add special focus areas to the overarching program.

Cross-Cutting Research Priorities

For priorities that cut across their programs, ORD's six NRPs will work together to integrate efforts, provide a research portfolio aligned around the Agency's goals, and assist all of EPA's program and regional offices, as well as states and Tribes. Where appropriate, the NRPs will combine efforts to conduct research that advances the science and informs public and ecosystem health decisions and community efforts on the following cross-cutting priorities (Appendix 4):

- Environmental Justice
- Climate Change
- Cumulative Impacts
- Community Resiliency
- Children's Environmental Health

- Contaminants of Immediate and Emerging Concern

EPA program and regional offices and external (non-EPA) partners and stakeholders will also be engaged for these integrated efforts. Long-term, innovative, and multi-disciplinary research is needed to make progress on these complex issues to support a sustainable pathway towards equitable distribution of social, economic, health, and environmental benefits.

Appendix 1: Summary of Proposed Outputs Mapped to Program, Regional, State, and Tribal (PRST) Needs

The following table lists the proposed SHC Research Program Outputs organized by topic and research area and mapped to PRST needs. It should be noted that the Outputs might change as new scientific findings emerge and are also contingent on budget appropriations. See Appendix 2 for more detailed descriptions of the PRST needs and Appendix 3 for detailed descriptions of Outputs.

Research Area	Output	PRST Need(s)
Topic 1: Contaminated Sites		
SHC.1 Advancing Remediation and Restoration of Contaminated Sites	SHC.1.1 Superfund Technical Support to the Program Offices, Regions, federal agencies, States, and Tribes to Characterize, Remediate, and Manage Contaminated Sites	• Technical Support • Contaminated Sites • Contaminants of Immediate and Emerging Concern
SHC.2 Site Characterization and Remediation	SHC.2.1 Methods, Tools, and Guidance on Remediation Options	• Contaminated Sites • Contaminants of Immediate and Emerging Concern
	SHC.2.2 Methods and Approaches to Improve Groundwater Characterization and Heterogeneous Contaminant Sites	• Contaminated Sites • Linking Remediation and Restoration to Community Revitalization
	SHC.2.3 Remediation Approaches and Technologies for Subsurface Contamination	• Contaminated sites • Linking Remediation and Restoration to Community Revitalization
	SHC.2.4 In Situ Treatment for Mining-Influenced Waters	• Mining Research • Contaminated Sites
	SHC.2.5 Innovative Technologies to Eliminate or Control Mining Wastes as Sources of Water Contamination	• Mining Research • Contaminated Sites • Environmental Justice

Research Area	Output	PRST Need(s)
Topic 1: Contaminated Sites		
SHC.2 Site Characterization and Remediation	SHC.2.6 Technologies and Approaches for Recovery, Remediation, and Reuse of Critical Minerals from Contaminated Sites	• Critical Minerals • Mining Research • Linking Remediation and Restoration to Community Revitalization
SHC.3 Solvent Vapor Intrusion	SHC.3.1 Method Development and Testing for Vapor Phase PFAS	• Vapor Intrusion • Contaminated Sites • Contaminants of Immediate (PFAS, Pb) and Emerging Concern
	SHC.3.2 Soil Gas Safe Communities	• Vapor Intrusion • Contaminated Sites • Environmental Justice
	SHC.3.3 Vapor Intrusion in Buildings	• Vapor Intrusion • Contaminated Sites • Contaminants of Immediate (PFAS, Pb) and Emerging Concern
SHC.4 Leaking Underground Storage Tanks	SHC.4.1 Underground Storage Tanks Site Management: Models, Metrics, and Spatial Tools	• Leaking Underground Storage Tanks
	SHC.4.2 Underground Storage Tanks Site Management: Extreme Weather Events and Environmental Justice	• Leaking Underground Storage Tanks • Climate Change • Environmental Justice • Cumulative Impacts
SHC.5 Chemicals of Emerging and Immediate Concern	SHC.5.1 Collaborative Science-Based Approaches and Results to Identify High Potential Lead (Pb) Exposure Locations in the U.S. and Key Drivers at those Locations	• Contaminated Sites • Contaminants of Immediate (PFAS, Pb) and Emerging Concern • Children's Environmental Health
	SHC.5.2 Methods and Data on Key Drivers of Blood Lead Levels in Children	• Contaminated Sites • Contaminants of Immediate (PFAS, Pb) and Emerging Concern • Children's Environmental Health
	SHC.5.3 Identification and Characterization of PFAS sites and sources	• Contaminated Sites • Contaminants of Immediate (PFAS, Pb) and Emerging Concern

Research Area	Output	PRST Need(s)
Topic 1: Contaminated Sites		
SHC.5 Chemicals of Emerging and Immediate Concern	SHC.5.4 Remediation and Treatment to Manage PFAS in the Environment	• Contaminated Sites • Contaminants of Immediate (PFAS, Pb) and Emerging Concern • Waste and Materials Management
	SHC.5.5 Methodology for Estimating PFAS Multimedia Human Exposure to Identify Locations of High Potential Exposure	• Contaminated Sites • Contaminants of Immediate (PFAS, Pb) and Emerging Concern • Cumulative Impacts
Topic 2: Materials Management and Beneficial Reuse of Waste		
SHC.6 Landfill Management	SHC.6.1 Evaluate RCRA Sites Approaching the 30-Year Post-Closure Period	• Landfill Management
	SHC.6.2 Heat and Liquids Management at Landfills	• Landfill Management
	SHC.6.3 Environmental Justice and Climate Change Implications of Waste	• Landfill Management • Climate Change • Community Capacity • Community Resilience • Environmental Justice
SHC.7 Material Flow and Life Cycle Analysis	SHC.7.1 USEEIO Economy-Wide Life Cycle Models	• Life Cycle Assessment • Waste and Materials Management • Beneficial Reuse
	SHC.7.2 Data and Methods to Advance EPA's Waste Measurements Program	• Waste and Materials Management • Community Capacity • Community Resilience • Beneficial Reuse
	SHC.7.3 Opportunities for Food Waste Reduction	• Life Cycle Assessment • Waste and Materials Management • Community Capacity • Community Resilience
	SHC.7.4 Tools and Methods to Empower Community-Based Decisions	• Community Capacity • Community Resilience • Beneficial Reuse • Waste and Materials Management • Environmental Justice

Research Area	Output	PRST Need(s)
Topic 2: Materials Management and Beneficial Reuse of Waste		
SHC.8 Waste Recovery and Beneficial Use of Materials	SHC.8.1 Enhance the Recovery and Increase Reutilization of Construction and Demolition Materials	• Waste and Materials Management • Beneficial Reuse • Community Capacity • Community Resilience
	SHC.8.2 Methods and Technologies to Increase Reutilization of Construction and Demolition Materials	• *Merged with SHC.8.1*
	SHC.8.3 Potential Leaching from Beneficial Use, Land Disposal, and Remediation	• Waste and Materials Management • Beneficial Reuse
	SHC.8.4 Optimization Tools and Methods to Beneficially Reuse Waste Products and Materials	• Waste and Materials Management • Beneficial Reuse • Community Resilience
Topic 3: Integrated Systems Approach to Building Healthy and Resilient Communities		
SHC.9 Benefits from Remediation, Restoration, and Revitalization	SHC.9.1 Methods and Measures for Characterization Restoration Effectiveness	• Linking Remediation and Restoration to Community Revitalization • Climate Change • Site Redevelopment/Reuse • Ecosystems Services • Translational Science
	SHC.9.2 Contribution of Site Remediation and Restoration to Revitalizing Communities and Improving Well-Being	• Socio-economic Valuations of Community Benefits • Linking Remediation and Restoration to Community Revitalization • Assessment of eco-health interventions and community impacts • Ecosystems Services • Climate Change • Community Resilience • Environmental Justice • Community Capacity • Cumulative Impacts

Research Area	Output	PRST Need(s)
Topic 3: Integrated Systems Approach to Building Healthy and Resilient Communities		
SHC.9 Benefits from Remediation, Restoration, and Revitalization	SHC.9.3 Increasing Environmental Benefits and Community Involvement	• Socio-economic Valuations of Community Benefits • Linking Remediation and Restoration to Community Revitalization • Assessment of eco-health interventions and community impacts • Community Capacity
SHC.10 Cumulative Impacts and Community Resilience	SHC.10.1 Develop, Map and Analyze Assets and Vulnerabilities to support Cumulative Impact Assessments for Vulnerable and Disadvantaged Communities	• Asset and Vulnerability Mapping • Environmental Justice • Cumulative Impacts
	SHC.10.2 Characterize interrelationships between chemical and non-chemical stressors and their impacts on disproportionately impacted and overburdened communities to support cumulative impact and risk assessments	• Cumulative Impacts • Children's Environmental Health • Environmental Justice
	SHC.10.3 Characterize and quantify the cumulative impacts of climate change related stressors with social, natural, and built environment assets and vulnerabilities to support community decision making for resilience	• Assessment of eco-health interventions and community impacts • Cumulative Impacts • Community Resilience • Climate Change • Environmental Justice
	SHC.10.4 Advance methods for supporting community capacity to address cumulative impacts in communities with environmental justice concerns	• Community Capacity • Environmental Justice

Research Area	Output	PRST Need(s)
Topic 3: Integrated Systems Approach to Building Healthy and Resilient Communities		
SHC.11 Measuring Outcomes Through the Report on the Environment	SHC.11.1 The Report on the Environment (ROE)	• Environmental and Human Health Indicators • Environmental Justice • Climate Change
	SHC.11.2 New Nationwide Indicators	• New Indicators on Emerging Issues and Agency Priorities
	SHC.11.3 Identify and Implement ROE Extensions	• Analysis of Environmental and Human Health Trends

Appendix 2: Descriptions of Program, Regional, State, and Tribal (PRST) Needs

The following describe, in more detail, the PRST needs summarized in the body of the SHC Research Program StRAP for each Research Area and as listed in Appendix 1.

- **Analysis of Environmental and Human Health Trends:** To accomplish its mission, EPA must pay close attention to trends in the condition of the Nation's air, water, and land, and to the associated trends in human exposure and health and ecological condition. Reliable indicators and analysis of trends within the United States provide EPA and the public the ability to assess whether the Agency is succeeding in its overall mission to protect human health and the environment.
- **Assessment of Eco-Health Interventions and Community Impacts:** There are gaps in our understanding of the connections between ecosystem condition and human health and well-being and what environmental interventions may yield positive impacts. Research needs in this area relate to the development of methodologies for incorporating the cumulative impacts of environmental burdens and lack of services into an explicit health analysis. Solutions-driven research approaches are needed to integrate community priorities, redevelopment goals, and human health and well-being impacts more fully into remediation and restoration decisions, such that outcomes of community revitalization efforts are more beneficial.
- **Asset and Vulnerability Mapping:** EPA recognizes the need to protect and revitalize communities, take action to advance environmental justice (EJ), and address the climate crisis. To support these priorities, EPA must have a data-driven, scientifically sound foundation on which to analyze changes in cumulative impacts for communities, including those with EJ concerns. Methods are needed to assess built, natural, social, and economic assets and vulnerabilities in order to develop strategies that reduce or prevent exposures, avoid or manage hazards, realize benefits, speed up recovery, and increase overall resilience to chemical and nonchemical stressors.
- **Beneficial Reuse:** Reuse of wastes and other materials is a strategy that facilitates sustainability through supporting a circular economy. After products reach the end of their usefulness, some or all of the materials that comprise them can be recycled in the manufacture of similar products or reprocessed for use in other products or applications. Such a strategy both reduces the need to obtain virgin materials for manufacturing new products and decreases the accumulation of discarded, previously used materials that can be harmful to the environment and human health.
- **Children's Environmental Health:** EPA's Policy on Children's Health commits to explicitly consider early life exposures and lifelong health in all human health decisions. There is a need for research to evaluate and consider children's environmental health information and data during development, including topics such as soil and dust ingestion rates and asthma.
- **Climate Change:** Understanding and addressing climate change impacts to human health and the environment is an Agency priority and spans national research programs. There is a need to continue assessments of the ecological and human health effects of contaminant exposures from climate change and extreme events and their impact on communities, contaminated sites, and

facilities. These assessments will inform regulatory and permitting decisions, as well as climate policy efforts, and support further climate change impact assessments.

- **Community Capacity:** EPA recognizes the need to increase the accessibility and usability of EPA tools and resources so that communities and Tribes can apply them to address environmental problems. There is also a need to better understand how community capacity plays a role in local decision making to affect environmental and health outcomes. Addressing these two needs will help EPA better support community-driven solutions to cumulative impacts for disadvantaged communities and those with EJ concerns.
- **Community Resilience:** There is a need to develop and implement methods to increase the sustained ability of a community to respond to, withstand, and recover from adverse situations while also maintaining the ability to adapt and transform in the face of these hazards. Understanding of a community's assets and vulnerabilities and having tools to assist with resilience planning and recovery and mitigation planning will help communities enhance their resilience. A particular need is consideration of EJ and distributional justice to build resilience of an entire community. SHC aims to increase community resilience by reducing potential risks and promoting efforts to improve community health and revitalization.
- **Contaminants of Immediate (PFAS, lead) and Emerging Concern (CIECs):** Contaminants of immediate (e.g., PFAS, lead) and emerging concern include chemical substances that may cause ecological or human health impacts and are either long-term or new contaminants of increased priority. When CIECs are discovered in environmental media, the appropriate methods for detection, treatment, disposal, and remediation, as well as exposure and toxicological information required to inform decision making are often lacking. lead is of particular interest, as is the class of PFAS chemicals, including individual, categories, and mixtures of PFAS, that are frequently being detected in a variety of environmental media.
- **Contaminated Sites:** Research in this area is primarily focused on developing, validating, and demonstrating alternatives and tools to evaluate and manage risks from contaminants and sources to ultimately protect ecological and human health including accumulation in the food chain. The contaminant matrixes are surface water, subsurface contamination in groundwater, fractured rock, sediments, soils, dust, air, and mined sites and materials.
- **Critical Minerals:** Research from contaminated sites focuses on improving the recovery, remediation and reuse of identified minerals and rare earth elements in support of EO 14017, and EPA's Federal partners and stakeholders (DOD, DOE, DOI/USGS). These materials exist in treated, untreated and stockpiled sources at contaminated sites and may have a high value for the current economy and present a potential benefit to communities with EJ concerns.
- **Cumulative Impacts:** Addressing cumulative impacts, specifically the impact of chemical and nonchemical stressors on environmental degradation and health effects, is an Agency priority. There is a need to advance and evaluate cumulative impact assessment approaches and models. Understanding how multiple stressors from the total environment interact with health effects from chemical stressor exposures is of particular importance. There is also a need to develop effective interventions and resources targeted toward the most overburdened communities and Tribes, and consider how communities, the environment and health outcomes respond to climate change and the resulting changes in environmental conditions.

- **Ecosystems Services:** The natural environment and healthy ecosystems provide several benefits to human health and well-being. Ecosystem services assessments will focus on strengthening the link between ecosystem services and human well-being benefits, on the quantification of health impacts and their translation to socio-economic benefits and policy decisions.
- **Environmental and Human Health Indicators:** EPA recognizes the need to further develop and maintain environmental and human health indicators on status and trends that are scientifically sound to support Agency decision making and to communicate to the public. Indicators need to reflect new priorities and emerging issues—such as cumulative impacts and EJ—and observed indicator trends should inform Agency priorities and actions.
- **Environmental Justice (EJ):** EPA is committed to addressing environmental and health inequalities in vulnerable populations and communities. There is a need to better understand how health disparities can arise from unequal environmental conditions, and from inequitable social and economic conditions, to help support decision-making and empower overburdened and under-served communities to take action.
- **Landfill Management:** A significant area of waste management is landfilling of waste, the oldest and most common form of waste disposal. Attention will be paid to various aspects of landfill management and the internal (including liquid content and temperature) and external (including climate change impacts) conditions that can impact performance and effectiveness, potentially leading to environmental and human health impacts. Further needs include research on how landfill management can adapt to ensure effective and efficient operation given changing conditions. Specific research examples include impacts/risks of melting permafrost on unlined landfills in Alaskan Native tribal lands (and subsequent hazardous and human waste fate and transport, human health risk, and ecological risk). Landfills are not only vulnerable to climate change impacts, they are also a significant source of GHGs—the 3rd largest contributor to climate change—which also requires better understanding to manage and mitigate these emissions.
- **Leaking Underground Storage Tanks:** Leaking underground storage tanks are a major concern for the Nation. Research and support to regulators is needed for both prevention of leaks and cleanup of contaminated zones. Specific needs are to assist in prevention of tank corrosion and understand the fate and toxicity of leaked petroleum fuels, especially with new additives and their breakdown products. Understanding the impact of extreme weather events, assisting in planning for these events, responding to impacted sites, and recovering leaked materials is critical. This research will be especially impactful to communities with EJ concerns.
- **Life Cycle Assessment:** An important analytical tool for sustainable materials management is life cycle assessment (LCA), an evaluation of the environmental impacts of products and services over their entire lifespan, applied to the consumption of goods and services. SHC is expanding life cycle-based SMM tools for OLEM's Office of Resource Conservation and Recovery (ORCR) and integrating them with the United States Environmentally-Extended Input-Output (USEEIO) Model. The objective of this family of modeling tools is to provide a faster, easier, and less costly way to incorporate streamlined life cycle information into decisions for prioritizing materials and engaging in strategic, system-level dialogue and actions with stakeholders.
- **Linking Remediation and Restoration to Community Revitalization:** EPA, partner agencies and communities recognize the benefits between remediation, restoration, and revitalization. There is a

need to continue to evaluate remediation effectiveness and develop methodologies to evaluate restoration effectiveness. Further, it is critical to assess how these activities contribute to revitalization of adjacent communities, and how community input into the remediation and restoration processes can improve project outcomes and overall benefits for the community. Approaches are needed to assess the distribution of public access to beneficial natural resources. Research should support the needs of project managers to link the environmental condition of restored sites to short and long-term measures of human health and well-being and for state and federal programs to understand how investments to clean up and redevelop contaminated sites will benefit their communities.

- **Mining Research:** There is a need for research to evaluate and identify innovative characterization, cleanup, and reuse approaches to reduce costs, waste quantities, and energy usage in mining site cleanups. A primary need is to evaluate innovative technologies for treating mining-influenced waters, especially passive and semi-passive treatments. Characterization and treatment of pollution sources— whether in-ground, stockpiled, or tailings—to reduce their impact and the number of mine influenced waters that require long-term treatment are substantial community needs. An additional consideration is the reuse of treated water to address water shortage needs in the western United States.
- **New Indicators on Emerging Issues and Agency Priorities:** Dynamic tracking capabilities for new indicators are needed to better answer pressing or emerging issues and identify changing or new priorities.
- **Restoration Effectiveness:** EPA, partner agencies, states, and the private sector invest heavily in restoration activities relevant to contaminated sites, such as within the Great Lakes Areas of Concern (AOCs). Approaches for assessing the effectiveness of restoration efforts have only recently been developed. Assistance is needed to conduct site specific climate informed science analysis (CISA) assessments and evaluation of how well various options for adaptation measures improve remedy protectiveness over a range of future scenarios.
- **Socio-economic Valuations of Community Benefits:** Research is needed to better weigh the costs of remediation, restoration, and health and environmental impacts against the benefits of environmental improvement, site redevelopment, and community revitalization. The validity and integrity of EJ analysis and considerations in the NEPA process need to be strengthened by more comprehensive economic impact analyses, including positive and negative impacts on the benefits people receive from nature. Further research is necessary to develop spatially explicit metrics, methods, and tools to enable decision-makers to demonstrate linkages between remediation/restoration and the value of community benefits from redevelopment/revitalization that can inform efforts such as Justice40.
- **Technical Support Centers:** Deliver expertise on the latest methods, approaches, and technologies to characterize, remediate, and manage risk at contaminated sites (CERCLA, RCRA, TSCA, and Brownfield sites are most common). Provide solutions as an honest broker using published peer-reviewed science and engineering.
- **Translational Science:** Research should focus on providing solutions to problems identified by partners. The products of the research (e.g., journal articles, reports, tools, databases, etc.) should be conveyed in such a way so they can be readily used by partners to solve their problems.

- **Vapor Intrusion:** Research in the area of vapor intrusion is designed to address a wide variety of needs. These include the development of protocols and guidance for the investigation and monitoring of sites contaminated with emerging compounds with a current focus on PFAS, along with the study of the physical and chemical properties of PFAS chemicals to inform modeling of the fate and transport of PFAS in groundwater and evaluation for vapor intrusion. Finally, development of tools (e.g., data analysis and decision support tools) for identifying (and ideally, predicting a few weeks in advance of mobilization) a reasonable worst case vapor intrusion condition on a site- and building-specific basis will be developed to assist with risk management decisions.
- **Waste and Materials Management:** Sustainable waste and materials management research will provide ways to reuse, reprocess or reclaim desired materials, derive energy from wastes, produce less waste and better manage unavoidable waste to conserve natural resources, reduce human health and environmental impacts, and reduce disposal costs. The overarching goal is to move towards a circular economy.

Appendix 3: Output Descriptions

The following describe, in more detail, the Sustainable and Healthy Communities (SHC) Research Program Outputs listed in Appendix 1. Outputs are planned under each Topic and respective Research Area (RA). It should be noted that the Outputs might change as new scientific findings emerge and are also contingent on budget appropriations.

Topic 1: Contaminated Sites

RA SHC.1: Technical Support

Output SHC.1.1: Superfund Technical Support to the Program Offices, Regions, Federal Agencies, States and Tribes to Characterize, Remediate, and Manage Contaminated Sites
ORD will provide and conduct technical assistance at Superfund contaminated sites for decision makers in EPA's program and regional offices. States and Tribes working through the regions can request assistance. These decision makers include remedial project managers, corrective action staff, and on-scene coordinators. ORD will deliver expertise on the latest methods, approaches, and technologies to characterize, remediate, and manage risk at contaminated sites. In addition, ORD will provide an annual report and quarterly updates, develop issue papers, and co-sponsor workshops, webinars or state-of-the-science informational sessions for partners and stakeholders to ensure knowledge dissemination to the decision makers.

RA SHC.2: Site Characterization and Remediation

Output SHC.2.1: Methods, Tools, and Guidance on Remediation Options
SHC will evaluate, develop, validate, and demonstrate remediation alternatives and tools to reduce risk, better assess sources and exposure at contaminated sites, and connect them quantitatively to ecological and human health consequences. Potential products include 1) optimized sampling methods for contaminants of concern; 2) methods and guidance for assessing contaminant bioavailability using passive sampling; 3) advancements in assessment tools for forecasting residues in fish, shellfish, and wildlife; 4) improvements for addressing temporal and spatial variability associated with contaminant exposure; 5) bench, laboratory and field demonstration studies to validate existing and newly developed assessment measures and tools; and 6) filling of key data gaps on contaminants of concern at contaminated sites, including reduced detection limits for priority contaminants.

Output SHC.2.2: Methods and Approaches to Improve Groundwater Characterization and Remediation at Heterogeneous Contaminated Sites.
Development of geochemical, geophysical, and modeling tools to support site characterization and the design of timely and cost-efficient groundwater remediation. This can include optimizing existing tools and designing new tools and approaches to define conceptual models at heterogeneous contaminant sites. Research may be based on numerical modeling simulations, laboratory experimentation, or field-based research.

Output SHC.2.3: Remediation Approaches and Technologies for Subsurface Contamination
SHC will conduct research on priority groundwater remediation topics using laboratory experiments, computer models, or field-based research. Priority research topics include remediation of organic or

inorganic contaminants in complex environments, such as fractured rock; improvement in the effectiveness of amendment delivery and contaminant extraction systems; management of large dilute plumes based on naturally occurring biotic or abiotic degradation; and long-term performance evaluations for remedial treatments, especially permeable reactive barriers. Collectively, this research will improve the selection, implementation, and operation of remediation systems at groundwater contaminated sites.

Output SHC.2.4: In Situ Treatment for Mining-Influenced Waters

This Output will provide information focused on remediation challenges for MIW, as well as technical support and outreach on current, state-of-the-art passive and active treatment technologies. SHC will evaluate innovative technologies for treating MIW (especially in-situ treatment of groundwater) using field-based studies and share results from these technology pilots with all interested stakeholders.

Output SHC.2.5: Innovative Technologies to Eliminate or Control Mining Wastes as Sources of Water Contamination

This Output will develop and evaluate innovative technologies for source control. It will provide an understanding of current technologies for coating or altering the geochemical characteristics of mining waste materials or mined surfaces (e.g., tailings, waste rock, underground tunnels) to minimize or eliminate generation of MIW, accompanied by technical support to evaluate use of these technologies at Superfund sites. Additionally, this Output will explore characterization options that may improve targeting sources to control. SHC will conduct field pilot testing of innovative source control technologies with the EPA regional offices and share findings with all stakeholders.

Output SHC.2.6: Technologies and Approaches for Recovery, Remediation, and Reuse of Critical Minerals from Contaminated Sites

SHC will conduct research and provide technical support regarding the current needs of OLEM, Regions, federal agencies, states, and Tribes to address the recovery, remediation, and reuse of critical minerals from contaminated sites. These minerals may exist in treated, untreated and stockpiled material or in mine-influenced waters (e.g., drainage from underground workings or open pit waters) at Superfund sites and may have significant value. The research would be coordinated with other federal agencies who are working to advance critical minerals recovery from mine waste under E.O. 14017 on America's Supply Chain and lead to the development of innovative, cost-effective methods to capture critical minerals while reducing their impacts to human health and the environment.

RA SHC.3: Solvent Vapor Intrusion

Output SHC.3.1: Method Development and Testing for Vapor Phase PFAS

There are multiple research needs to improve guidance and methodologies related to vapor intrusion. One need is how to sample for vapor phase PFAS in indoor air, soil gas, subslab gas, and sewer gas where the sewer gas may be entering a residence or building via conduit flow. Additionally, PFAS physical and chemical properties are needed to allow for the improvement of exposure assessments and to better understand their fate and transport in the environment. Research under this Output will focus on development and testing of methods for collecting and identifying vapor phase PFAS. The results will be shared with program and regional partners to inform risk estimates and modeling of PFAS.

Output: SHC.3.2: Soil Gas Safe Communities

The academic literature (e.g., Little & Pennell, 2017) makes a strong case that the technical-science-only approach to vapor intrusion perpetuates injustice, particularly in communities with EJ concerns, and slows the 'completion' of the cleanup response. Research is needed to field test for method development applying simple and easy to use methods following an indicators, tracers, and surrogates style approach in new communities. This research needs to include social scientists. Communities in pilot VI cases can test whether this approach can reduce injustice and speed the cessation of exposures and related community concerns and stress. Research will be conducted in conjunction with ORCR, which will have the authority to designate soil gas safe communities. Ultimately, this Output will assist ORCR and communities in reduction of exposure due to vapor intrusion.

Output: SHC.3.3: Vapor Intrusion in Buildings

There is no unified-coherent theory or consensus about the causes of temporal and spatial variability in vapor concentrations in indoor air. Some areas of concern include (a) vapor intrusion arising from soil gas intrusion versus conduit (preferential pathway) gas intrusion, and their relative importance in various geological and geographic settings; (b) differential pressure field monitoring alone, and how much of that monitoring is adequate to assure human health protection in buildings that are undergoing vapor intrusion mitigation using active depressurization; and (c) whether or not the vapors sorb onto building surfaces and into building materials once they have entered the structure, which could be a major concern when mitigation is being undertaken due to delayed release from the sorbed materials. This Output will provide the information and data needed to help partners with planning, scoping, and scheduling of vapor intrusion assessments, and interpretation and risk management decisions; and inform when periodic monitoring is needed if initial assessment results are not conclusive.

RA SHC.4: Leaking Underground Storage Tanks

Output SHC.4.1: Underground Storage Tanks Site Management: Models, Metrics, and Spatial Tools

ORD will develop tools and technical support to assist the Regional Offices, states, Tribes, and territories to support decision making in both the prevention and cleanup areas of the UST program. This research will assist in identifying vulnerabilities from UST sites, from preventing corrosion to developing GIS tools and analyses to support decision-making on sites and program management. ORD and OLEM will work with the regions, states, and Tribes in developing training on these tools and approaches to assist in prevention and site cleanups.

Output SHC.4.2: Underground Storage Tanks Site Management: Extreme Weather Events and Environmental Justice

Extreme weather events are placing an increasing burden on the infrastructure of USTs within the U.S. and are heightening the risk of releases. USTs are a critical part of the supply chain to provide essential fuel supplies needed to respond and recover from disasters. SHC research will help emergency managers to understand vulnerable and critical areas of the supply chain to reduce post-storm bottlenecks. Extreme weather events also increase the risk of fuel leaks from USTs, which can impact drinking water supplies. This research will directly inform solutions for addressing extreme weather events, from preparing for events to assisting in triaging sites, response, and recovery; EJ is an integral part of this research as well.

RA SHC.5: Chemicals of Emerging and Immediate Concern

Output SHC.5.1: Collaborative Science-Based Approaches and Results to Identify High Potential Lead Exposure Locations in the U.S. and Key Drivers at those Locations

This Output will produce collaborative science-based approaches and apply results to identify high potential lead exposure locations in the U.S. and key drivers (i.e., indicators and sources) at those locations. Collaborative engagement with EPA regional and program offices, state and federal partners, and others to obtain data and evaluate locations identified will be critical to this Output. Results will include geospatial data for visualizing high potential lead exposure locations and data analyses to inform EPA and stakeholders. This Output responds to the Agency's priority for identifying U.S. communities with the highest risk of childhood lead exposure. Identifying locations with highest potential for children's exposures and blood lead levels will assist with targeting and prioritization for lead exposure risk reduction, prevention, and mitigation efforts.

Output SHC.5.2: Methods and Data on Key Drivers of Blood Lead Levels in Children

SHC plans to provide distributional (location specific) estimates of lead in soil, dust, drinking water, and food and will develop methods to estimate bioaccessibility of lead from soil and dust under different soil chemistry and biological conditions. SHC will explore the best methodologies and approaches to obtain field data for soil and dust ingestion rates as a function of lifestage, geographic factors, socioeconomic factors, and factors in the built environment. In conjunction with work in HERA, SHC will 1) develop innovative methods for evaluating exposure factors and 2) assess impacts of risk management or mitigation actions on lead exposure risk or blood lead levels. These data will inform HERA research to predict blood lead levels. The research also ties to SSWR's Water Treatment and Infrastructure Topic.

Output SHC.5.3: Identification and Characterization of PFAS Sites and Sources

This Output will synthesize the state of the science for PFAS sampling and analysis, and for identifying and characterizing sources of PFAS related to contaminated soils and sediments, grounwater, landfills, leachate, industrial facilities, and air (jointly with SSWR, ACE, and CSS). SHC will develop, evaluate, and review sampling and analysis methods and identify and characterize PFAS in groundwater, surface waters, soils/sediment, plants, and wildlife from sources that include contaminated sites, industrial facilities, landfills, industrial wastes, and fire training/emergency response activities. This work will include technical support directly and through the ORD Technical Support Centers, for requests received from region, state, municipal, and tribal partners.

Output SHC.5.4: Remediation and Treatment to Manage PFAS in the Environment

This Output will advance the state of the science regarding the management, control, treatment, destruction, and removal of PFAS in groundwater, soils, aquifer materials, sediments, wastes, wastewaters, and landfill leachates. One of the main goals of this Output is to provide data to reduce key uncertainties related to the destruction and disposal of PFAS and PFAS-containing materials through thermal treatment and landfilling, respectively—research needs identified in EPA's 2020 Interim Guidance on the Destruction and Disposal of PFAS and Materials Containing PFAS. Research conducted under this Output will inform future updates of the interim guidance, which are currently scheduled for 2023 and 2026. Another goal under this Output is to promote innovation in evaluating and managing PFAS-containing materials (e.g., consumer and industrial waste, contaminated environmental media, treatment residuals) through the identification of transformation residuals, effective management practices, and technical methods. Treatment, destruction, control and removal systems and

technologies will be evaluated for performance and cost. Fate and transport are common themes between site characterization and remediation and a necessary area of research. Overlap between Outputs 3 and 4 is to be expected and will be leveraged.

Output SHC.5.5: Methodology for Estimating PFAS Multimedia Human Exposure to Identify Locations of High Potential Exposure

This Output will generate and synthesize information to understand the relative contributions of sources and pathways of human exposure; variation of human exposure by location, demographics, and consumer practices; and vulnerability of populations to high-level exposure. Human exposure data will be curated from the literature, aggregated from national sources, generated in the laboratory from available house dust and serum specimens, and collected by supplementing cohort studies. These data will be used to estimate human exposures, understand how PFAS contribute to the cumulative burden of pollution in communities with EJ concerns, and prioritize additional data collection to support actions that mitigate and prevent risks.

Topic 2: Materials Management and Beneficial Reuse of Waste

RA SHC.6: Landfill Management

Output SHC.6.1: Evaluate RCRA Sites Approaching the 30-Year Post Closure Period

SHC will evaluate RCRA Subtitle D sites approaching the end of the 30-year post-closure period and provide methodology for the determination of impacts of ending post-closure care to minimize environmental risks as sites enter periods of minimum oversight and maintenance. These methods will inform guidance for state, tribal, and local regulatory officials responsible for oversight of RCRA sites.

Output SHC.6.2: Heat and Liquid Management at Landfills

SHC will gather data to optimize liquids addition parameters and develop, with OLEM, recommendations for improved bioreactor processes such as leachate collection, gas collection and control wells. SHC will also collaborate with EPA regional offices, states, and industry to gather and analyze data from landfill sites with elevated temperatures to evaluate the nature and causes of these changes. This analysis includes waste incompatibility, density, pressure, overburden height, degradation dynamics, and management strategies for these facets of operation.

Output SHC.6.3: Environmental Justice and Climate Change Implication of Waste

This Output will focus on waste decomposition, EJ issues, and other climate related issues. It provides opportunities to conduct targeted studies on landfill rehabilitation and more. We envision including climate effects on landfills such as the impact/risk of melting permafrost on unlined landfills in Alaskan native tribal lands (and subsequent hazardous and human waste fate and transport, human health risk, and ecological risk). There may be other types of communities/case studies disproportionately impacted by climate effects to landfill risk from leachate or other transport pathways that are not necessarily air emissions.

RA SHC.7: Material Flow and Life Cycle Analysis

Output SHC.7.1: USEEIO Economy-Wide Life Cycle Models

Enhancements to the current USEEIO model are critically needed to address gaps and needs expressed by EPA program offices, states, and other users. The existing national and state models will be updated

and expanded to improve sector resolution, geographic coverage, and improve the underlying economic, environmental, and indicator data. Expansions of the traditional EEIO model form will be developed including waste input-output, process-based-input-output hybrid models and mixed-unit input-output models to track materials and wastes and assess their related impacts throughout the economy. The model will be customized and applied to fully or partially support applications including, but not limited to, an ORCR materials dashboard, the WARM tool, SMM Prioritization tools, the Recycling Economic Information report, the EPA Recycling Strategy and Strategy Series on Building a Circular Economy for All, consumption-based GHG inventories for states, community sustainability web pages integrating USEEIO, and the EPA climate and materials management report.

Output SHC.7.2: Data and Methods to Advance EPA's Waste Measurements Program

EPA provides national estimates of waste generation and management to assist states and communities with materials management planning. There is a need for a next-generation modeling framework to produce these estimates using a variety of approaches and data sources, including state-based measurement and economic input-output modeling. This Output includes activities to support the development of this modeling framework in a way that maintains transparency, consistency, and reproducibility. This work will be complimentary to research in Output SHC.SHC.7.1 and will readily integrate with the USEEIO material tracking model being developed there.

Output SHC.7.3: Opportunities for Food Waste Reduction

SHC will collaborate with OLEM/ORCR, EPA's regional offices, states and communities, and the food industry to understand from a life cycle or systems perspective the generation and disposal of food waste. This work will include an understanding of the state of the science in food waste generation and treatment, an analysis of treatment technologies, an analysis of potential contaminants in compost and digestate, development of decision-support tools for use by food waste generators and waste handlers, and identification of promising solutions to preventing food waste. Research will be used to inform public- and private-sector decision-making, develop prevention or mitigation strategies for contaminants, and provide research-supported solutions to federal, state, and local governments, communities, food businesses, and others on how to successfully prevent food waste.

Output SHC.7.4: Tools and Methods to Empower Community-Based Decisions

While EPA develops methods and data to support materials management decisions across the U.S., there is a need to engage with communities to better understand how to translate this support into actionable and implementable strategies for specific needs. Activities in this Output will focus on projects that engage communities around key issues or challenges related to materials management. The projects can include consideration of community-scale measurement/modeling needs, identification of suitable metrics and indicators, and the use of social science concepts to implement policy and affect changes in community mentalities and behaviors.

RA SHC.8: Waste Recovery and Beneficial Use of Materials

Output SHC.8.1: Enhance the Recovery and Increase Reutilization of Construction and Demolition Materials

SHC will develop methods and tools and review and apply technologies to facilitate the use, reuse, and recycling of C&D materials. Although a significant amount of C&D is recovered already, the amount that remains is large, therefore any improvements to recovery and reutilization will reduce health and

environmental impacts. It will also enhance secondary materials markets and reduce barriers for material recovery. Research activities will be designed to quantify the reuse and recycling of C&D materials, develop and enhance existing tools and resources to inform segregation and storage decisions to enhance recovery, and develop and apply best and cost-effective practices to foster recovery and reuse of building materials from deconstruction and demolition activities.

Output SHC.8.2: Methods and Technologies to Increase Reutilization of Construction and Demolition Materials

Merged with Output SHC.8.1.

Output SHC.8.3: Potential Leaching from Beneficial Use, Land Disposal, and Remediation

SHC will continue support to OLEM's RCRA and CERCLA programs through research to develop, demonstrate, validate, and publish analytical methods that predict more accurate and precise source term of partitioning of Constituents of Potential Concern (COPCs) between air, land, and water. The Leaching Environmental Assessment Framework (LEAF) provides a standardized procedure to evaluate different waste matrices and environmental conditions so that results across treatment technologies, end of life processes such as land disposal, and beneficial use of industrial by-products can be compared in developing more effective policy decisions for waste management. Use of LEAF ensures that changing environmental conditions be considered in evaluating leaching of COPCs for a range of waste and materials, waste treatment options, proposed beneficial use of industrial by-products, and other waste streams.

Output SHC.8.4: Optimization Tools and Methods to Beneficially Reuse Waste Products and Materials

SHC will develop, test, and demonstrate methodology and optimization tools for beneficially reuse of waste materials in infrastructure, technologies, environmentally damaged natural resources, and revitalization of communities. As Beneficial Use (BU) applications replace virgin/conventional materials with materials typically thought of as wastes, the substitution ratios that will result in the minimal amount of environmental, economic, and social impacts are not yet completely understood and evaluated. This Output may include re-evaluating BU of materials and waste previously evaluated for environmental impact (e.g., foundry sands, coal combustion residue, slag) and emerging waste materials (e.g., plastics, mining waste, forest fire biochar, critical minerals from batteries, and other industrial materials). This research will produce scientifically tested tools and methods that can be used to enhance beneficial use policies and practices, and potentially feed into the needs of EO 14017.

Topic 3: Integrated Systems Approach to Building Healthy and Resilient Communities

RA SHC.9: Benefits from Remediation, Restoration, and Revitalization

Output SHC.9.1: Methods and Measures for Characterizing Restoration Effectiveness

SHC will evaluate both short-term and long-term effectiveness of linked remediation and ecological restoration actions, including potential threats from extreme weather events. SHC will consider acute and chronic climate change effects in developing metrics and measures of restoration success. Working with other research programs, SHC will also explore potential work with geographically located partners

(e.g., Great Lakes National Program Office, Chesapeake Bay region) to refine existing or develop new approaches that can be used to assess restoration effectiveness and to measure changes in ecological condition and associated beneficial uses, considering the distribution of those benefits among populations. The development of spatial distributions of ecosystem service supply and use in biophysical terms will also allow assessment of EJ deficits and climate change effects while providing methods, metrics, and measures for populating natural capital ecosystem service accounts.

Output: SHC.9.2: Contribution of Site Remediation and Restoration to Revitalizing Communities and Improving Well-being

The goal of this Output is to identify new metrics and approaches to better promote community health and revitalization through site remediation and ecological restoration. With a focus on the benefits side of cumulative impacts, this research addresses the contribution that improvements in environmental quality and ecological condition make to human health and well-being and community revitalization. Research will focus on linking ecosystem services to human well-being benefits and on the quantification of health impacts and their translation to socio-economic benefits. Development of approaches for evaluating the distributions of ecosystem services will allow for the identification of inequalities in the provision of nature's benefits to inform future policy decisions. SHC will develop metrics and indices of community revitalization that integrate ecological, socio-cultural, human health, and economic factors. SHC will assess longer-term resilience of social and economic benefits to climate-related stressors This work will further the translation and applications of ecosystem services tools and approaches in support of community-based restoration and revitalization-related decision making and other decision contexts such as brownfield redevelopment.

Output SHC.9.3: Increasing Health and Environmental Benefits and Community Involvement

There are gaps in our understanding of the connections between ecosystem condition and human health and well-being and what community and environmental interventions may yield positive impacts. Solutions-driven research approaches are needed to integrate community priorities, redevelopment goals, and human health and well-being impacts more fully into remediation and restoration decisions, such that outcomes of community revitalization efforts are more beneficial, and those benefits are equitably distributed. To maximize the public benefits from site cleanup, restoration, redevelopment, and revitalization efforts to all individuals we need solutions that consider the needs and capacities of diverse groups within communities. These groups should include those historically discriminated against and disproportionately affected by environmental harms. Working with partners and communities, evaluation and measurement of the impacts of EPA and ORD efforts on building community capacity across various types of communities and decision contexts can help to inform these gaps. SHC will explore the use of community-based approaches, such as social and health impact assessment, in concert with population-based epidemiologic approaches, to inform community work that will be used to assess the cumulative impacts of applied ecosystem-related interventions on community public health benefits. Community engagement and co-development of solutions-driven research products will help refine our understanding of community capacity and research translation to appropriately engage with communities, including building capacity in communities with environmental-related health interventions.

RA SHC.10: Cumulative Impacts and Community Resilience

Output SHC.10.1: Develop, Map and Analyze Assets and Vulnerabilities to support Cumulative Impact Assessments for Vulnerable and Disadvantaged Communities

SHC will develop methods and provide data and tools derived from existing and emerging data sources (e.g., remote sensing, GIS, monitoring, surveys, health outcomes, etc.), to help partners and stakeholders understand their current and changing socio-ecological and physical conditions (i.e., assets and vulnerabilities) to inform their decisions about equity, climate change, food systems, cumulative impacts, resilience, and other issues. SHC will explore and implement ways to apply and expand EnviroAtlas and other tools for targeted, solutions-driven, local decision-making using the finest resolution possible and practical. For example, partners will help identify high priority assets and vulnerabilities to be quantified and mapped related to their programmatic and regional needs; and new, higher resolution data layers will be added to the EnviroAtlas to assist with targeted, local decision making. Mapping assets and vulnerabilities is responsive to EPA Strategic Goals 1, 2, 4, 5, & 6. Resources and training will be developed and provided to help decision-makers use the tools. Materials will also be developed to support educational programs and other relevant activities.

Output SHC.10.2: Characterize Interrelationships Between Chemical and Non-Chemical Stressors and Their Impacts on Disproportionately Impacted and Overburdened Communities to Support Cumulative Impact and Risk Assessments

SHC will collaborate with EPA partners to enhance our capabilities to identify environmental disparities to enable EPA, states, Tribes, and communities to incorporate disproportionate impacts into cumulative impact assessments, exposure and risk assessments, and epidemiological investigations. SHC will develop and use information, methods, approaches, and tools within a Total Environment framework to understand how selected chemical and non-chemical stressors affect health, welfare, and well-being outcomes for vulnerable groups and disproportionately impacted and overburdened communities. This includes 1) understanding the myriad chemical and non-chemical stressors found in the total environment (built, natural, social), including changing climatic conditions; 2) identifying linkages between built and natural environmental conditions, social determinants of health, and adverse impacts on health and well-being; 3) identifying environmental disparities to enable EPA, states, Tribes, and communities to incorporate considerations of disproportionately-impacted groups into cumulative impact, exposure, and risk assessments and epidemiological investigations; and 4) developing and applying multiple methods and lines of evidence to assess cumulative impacts. Work in this Output will inform and be informed by other Outputs in RAs 9 and 10.

Output SHC.10.3: Characterize and Quantify the Cumulative Impacts of Climate Change Related Stressors with Social, Natural, and Built Environment Assets and Vulnerabilities to Support Community Decision Making for Resilience.

To support local, state, tribal, and regional resilience and other planning, SHC will identify critical information and develop approaches for communities to 1) assess their current social, natural, and built environment assets and vulnerabilities to hazards and/or unintended releases of toxic chemicals from contaminated sites and facilities; 2) examine how anticipated changes in climate-related stressors interact with other social, natural and built environment stressors, and can lead to cascading shocks to communities; and 3) evaluate community preparedness and methods to increase resilience or improve resilience planning. The focus is on communities that may be disproportionately impacted due to a

changing climate or proximity to contaminated sites and most vulnerable socio-demographically. Identifying expected impacts will require using forecasts of future changes in weather and climate that lead to chronic conditions and hazardous events. Products in the Output will consider realized and potential impacts on communities of a changing climate and other stressors through changes to the natural, built, and social environments; improve understanding of the links between ecological and social resilience; improve assessment of the systemic benefits to communities of natural buffers to climate hazards; develop methods for climate-smart adaptation that will support resilience to natural hazards and community health and well-being; and produce recommendations for how to use and apply data and tools to estimate and manage impacts and increase resilience.

Output SHC.10.4: Advance Methods for Supporting Community Capacity to Address Cumulative Impacts in Communities with Environmental Justice Concerns

This Output will create actionable information and resources for EPA programs, regions, and researchers to design and implement scientific support, technical assistance, and decision support tools that strengthen the capacity of overburdened communities with EJ concerns to address cumulative impacts. This includes research that 1) investigates the nature of cumulative impacts in particular places through quantitative, qualitative or mixed-method approaches and uses translational approaches designed to strengthen capacity in the most overburdened and under-resourced communities; 2) develops research approaches, products and ancillary activities that strengthen community capacity to address cumulative impacts (this may include evaluating and revising existing tools and approaches or developing new ones)—examples include community-based participatory research (CBPR), community and citizen science, transdisciplinary research, co-production, communication, training, and technical assistance or support activities including use of decision support tools; 3) explores relationships between capacity and desirable outcomes, such as improved resilience, recovery, and revitalization, especially to develop methods for assessing 'baseline' capacity and recommending capacity strengthening strategies; and 4) maps out existing EPA program and regional activities that strengthen capacity and assesses strengths and gaps in order to enhance effectiveness and improve connections with other EPA research and activities.

RA SHC.11: Measuring Outcomes through the Report on the Environment

Output SHC.11.1: The Report on the Environment (ROE) Program Data, Infrastructure, and Communication

ORD, through SHC, will continue to manage the Report on the Environment, the Agency's authoritative source on the status and trends of nationwide environmental indicators. Maintenance of the ROE includes updating each indicator as new data become available, revising the web site to adhere to EPA web standards, and providing overall quality control of the curated data. The current management plan will be updated on an as-needed basis to describe how the ROE program will continue to meet partners' needs. The plan defines the goals, scope, and outlook for the ROE program and website. The plan also includes a communication blueprint and will explore additional outreach opportunities informed by other Agency efforts (e.g., EnviroAtlas). As the ROE's Steering Committee, the Science and Technology Policy Council (STPC) will provide advice on implementation of the management plan, including coordination with the Agency's implementation of the Evidence Act.

Output SHC.11.2: New Nationwide Indicators

SHC will continue to engage with the STPC and technical workgroup members to prioritize and develop new nationwide indicators and indicators of national importance. Proposed indicators will be vetted with the STPC and included in the ROE following standard protocols (e.g., utility to Agency partners and stakeholders, plan for indicator maintenance and updating, peer review).

Output SHC.11.3: Identify and Implement ROE Extensions

In response to STPC direction, SHC will identify and implement several ROE Extensions. These Extensions include 1) build out trends analyses and their interpretations, 2) explore relevance of the ROE concept for regional application by evaluating the transferability of the Region 2 and 3 RESES ROE development process, 3) use the cross-media pilot to develop a roadmap for additional cross-media issues, and 4) explore EJ and tribal concerns using ROE indicators and other data sources. SHC will continue to collaborate on these Extensions with program offices and regions through technical workgroups. New priorities arising from the technical workgroups will be vetted through the STPC.

Appendix 4: Cross-Cutting Research Priorities

Working together on Agency priorities that cut across the six National Research Programs (NRPs), ORD will integrate efforts, provide a research portfolio aligned around the Agency's goals, and assist all of EPA's program and regional offices as well as states and Tribes. Where appropriate, the NRPs will combine efforts on the following cross-cutting priorities to conduct research that advances the science and informs public and ecosystem health decisions and community efforts. Although research efforts have been highlighted for each of these cross-cutting priorities, this does not mean that the research efforts only support that priority; the efforts may cut across priorities.

NRPs: Air, Climate, and Energy (ACE); Chemical Safety for Sustainability (CSS); Health and Environmental Risk Assessment (HERA); Homeland Security (HS); Sustainable and Healthy Communities (SHC); and Safe and Sustainable Water Resources (SSWR). The Strategic Research Action Plans for the NRPs are available on ORD's website at epa.gov/research/strategic-research-action-plans-2023-2026.

Environmental Justice

ORD's NRPs will integrate research efforts to identify, characterize, and solve environmental problems where they are most acute, in and with communities that are most at risk and least resilient. Research will strengthen the scientific foundation for actions at the Agency, state, tribal, local, and community levels to address environmental and health inequalities in vulnerable populations and communities with environmental justice and equity concerns. Coordinating research efforts will lead to a better understanding of how health disparities can arise from unequal environmental conditions, including impacts from climate change and exposures to pollution, and inequitable social and economic conditions. By working across NRPs, and through partner engagement, information, tools, and other resources will be developed that help support decision-making and empower overburdened and under-served communities to take action for revitalization.

Integrated Efforts Across National Research Programs	
ACE	Understand inequities in air pollution exposures and impacts, and impacts of climate change, accounting for social, cultural, and economic determinants that can lead to disproportionate exposures and impacts. Develop science to support effective interventions to reduce air pollution exposures and impacts, and adaptation and resilience measures to address climate impacts, including excessive heat (urban heat islands), flooding, and wildfires.
CSS	Investigate factors relevant to exposures for populations experiencing disproportionate adverse impacts from chemical exposures.
HERA	Expand the identification and consideration of information on susceptibility and differential risk in assessments, advance the evaluation of chemical mixtures and improve cumulative risk assessment practices to better characterize and assess health disparities.
HS	Assess and address community needs and vulnerabilities to ensure equitable incident management during disaster response and recovery by analyzing the community-specific cumulative impacts and the social implications of environmental cleanup; and by identifying potential interventions.
SHC	Identify risks and impacts to vulnerable communities and groups and improve the ability of communities to address cumulative impacts from contamination, climate (e.g., natural disasters and extreme events), and other stressors on health and the environment.
SSWR	Help provide clean and adequate drinking water and tools for stormwater management and urban heat island mitigation.

Climate Change

Understanding and addressing climate change impacts to human health and the environment is a critical component of ORD's research. To be effective, climate change research must be scientifically broad and systems-based. Where appropriate, the NRPs will integrate efforts to avoid duplicative efforts, fill critical gaps, and provide results that reflect the multiplicity of impacts and needs associated with climate change. Each NRP recognizes the critical need for continued communication with ORD partners to ensure that we are taking advantage of opportunities for collaboration, integration, and understanding.

Integrated Efforts Across National Research Programs	
ACE	Better understand and characterize air pollution and climate change and their individual and interrelated impacts on ecosystems and public health and identify and evaluate approaches to reduce the impacts of climate change through mitigation of climate forcing emissions, adaptation strategies, and building resilience in communities and ecosystems. Model energy, emissions, and environmental impacts of transformations in the nation's energy, transportation, and building sectors, and identify approaches to increase equitable benefits of those transformations.
CSS	Explore the use of newer analysis methods for identifying chemical contamination in environmental media after large catastrophic environmental events, such as wildland fires.
HERA	Continue development of assessments of air pollutants to inform climate policy efforts and leverage expertise, approaches, tools, and technologies in support of further climate change impact assessments.
HS	Enhance capabilities and develop new information and tools to maximize relevance and support for response and recovery from natural disasters related to climate change.
SHC	Integrated systems-approach research applicable to challenges that communities, including those with contaminated sites, face in preparing for and recovering from the impacts of natural disasters and climate change, ensuring that approaches are beneficial and equitable for the communities at risk.
SSWR	Improve resiliency of water resources and infrastructure to mitigate impacts related to climate change, including coastal acidification and hypoxia, harmful algal blooms, wildland fires, drought and water availability, stormwater flooding and combined sewer overflows, and urban heat islands.

Cumulative Impacts

Addressing the cumulative impacts of exposure to multiple chemical and non-chemical stressors is necessary for EPA to fulfill its mission to protect human health and the environment with the best available science. Cumulative Impacts refers to the total burden—positive, neutral, or negative—from chemical and non-chemical stressors and their interactions that affect the health, well-being, and quality of life of an individual, community, or population at a given point in time or over a period of time. It is the combination of these effects and any resulting environmental degradation or health effects that are the focus of ORD's cumulative impacts research. The NRPs will integrate efforts to improve understanding of cumulative impacts and develop and apply the necessary models, methods, and tools to conduct real-world assessments of cumulative impacts that result in both adverse and beneficial health and environmental effects. With this information, internal and external partners can

make informed, scientifically credible decisions to protect and promote individual, community, and environmental health.

Integrated Efforts Across National Research Programs	
ACE	Develop measurement methods and approaches to characterize ambient air quality and deposition, and human and ecosystem exposures to chemical (including criteria pollutants and air toxics) and non-chemical (including built environment, social, and climate-related) stressors, and health impacts from exposure to the combination of chemical and non-chemical stressors
CSS	Development and application of new approach methodologies to rapidly generate exposure and hazard information for chemicals, chemical mixtures, and emerging materials and technologies (including safer alternatives).
HERA	Research to advance the evaluation of chemical mixtures and improve cumulative risk assessment practices to better characterize and assess health disparities in communities with environmental justice and equity concerns.
HS	Through a focus on resilience equity, ensure that information and tools include the multitude of stressors impacting a community when used to support incident response. Research will recognize that resilience to an incident is directly impacted by the cumulative impacts of the incident and other stressors affecting a community.
SHC	Address the risks and impacts to improve the ability of communities to address cumulative impacts from contamination, climate, and other chemical and nonchemical stressors on health and the environment.
SSWR	Support human health ambient water quality criteria for chemical mixtures through research using bioassays and risk management, and assessment for exposure to groups of regulated and unregulated disinfection byproducts (DBPs) and opportunistic pathogens.

Community Resiliency

It is critical that communities have the knowledge and resources needed to prepare for and recover from adverse situations, such as natural disasters, contamination incidents, and failing infrastructure. Through combined research efforts, the NRPs will provide information and resources that support and empower communities to make science-based decisions to withstand, respond to, and recover from adverse situations.

Integrated Efforts Across National Research Programs	
ACE	Improve evaluations of climate change adaptation and mitigation measures and community resiliency to extreme events in a changing climate, such as wildfire, floods, heat waves, and drought—especially for vulnerable and disadvantaged communities experiencing environmental injustice.
CSS	Efforts relevant to chemical safety evaluations will be leveraged with other NRP activities.
HERA	Continue to expand the portfolio of assessment products to improve understanding of potential human health and environmental impacts of contamination incidents.
HS	Generate resources and tools for environmental cleanup, risk communication, outreach, building relationships, and community engagement to improve equitable community resilience for environmental contamination incidents and other disasters.
SHC	Increase resilience by reducing potential risks, promoting health, and revitalizing communities.
SSWR	Support coastal resilience by advancing monitoring, mapping, and remote sensing and by the economic valuation of coastal resources. Improve the performance, integrity, and resilience of water treatment and distribution systems through research on water infrastructure and water quality models.

Children's Environmental Health

From EPA's 2021 Policy on Children's Health, "children's environmental health refers to the effect of environmental exposure during early life: from conception, infancy, early childhood and through adolescence until 21 years of age." Environmental exposures that impact health can occur before conception, and during pregnancy, infancy, childhood, and adolescence; and include long-term effects on health, development, and risk of disease across lifestages. Much of ORD's research is relevant to communities, including susceptible and vulnerable populations. Where appropriate, the NRPs will combine efforts to conduct research that will inform public health decisions, advance our scientific understanding of early-life susceptibility to environmental stressors, and inform community efforts that create sustainable and healthy environments protective of all lifestages.

Integrated Efforts Across National Research Programs	
ACE	Explore air pollution and climate health impacts within different lifestages and populations, including overburdened groups. Assess vulnerabilities to air pollution for those with chronic illnesses and sequelae from respiratory viruses. Research social determinants of health, and air pollution impacts resulting from different exposure time-activity patterns.
CSS	Research will build the scientific foundation to predict adverse outcomes resulting from chemical exposures in various biological contexts, including early life-stage susceptibility.
HERA	Continue to evaluate health effects, over the course of a lifetime, from environmental exposure to stressors during early life (i.e., from conception to early adulthood) to inform decision-making and advance research on methods to properly characterize risks to children.
HS	Improve and develop decision-support tools and cleanup capabilities to make children less vulnerable during response to, and recovery from, contamination incidents.
SHC	Address the risks and impacts to vulnerable communities and lifestages, including underserved/overburdened communities, and improve the ability of communities to address cumulative impacts from contamination, such as site clean-ups of per- and polyfluoroalkyl substances (PFAS) and lead; climate, such as natural disasters and extreme events; and other stressors on health and the environment.
SSWR	Evaluate health effects and toxicity related to algal toxins and expanded research that will explore exposure risks for lead, DBPs, and—through quantitative microbial risk assessment models—for high priority opportunistic pathogens in drinking water (e.g., *Mycobacterium*, *Pseudomonas*, *Naegleria fowleri*).

Contaminants of Immediate and Emerging Concern

Contaminants of immediate and emerging concern (CIECs) include chemical substances that may cause ecological or human health impacts and are either new or existing contaminants of increased priority. The NRPs will work with EPA partners in the program and regional offices, along with input from Agency leadership, to identify the highest priority contaminants (broadly defined to include chemical, biological, and other

categories as appropriate), including those of immediate concern, such as PFAS and lead, that warrant further research attention.

Integrated Efforts Across National Research Programs	
ACE	Develop and evaluate measurement methods and approaches to characterize sources of air pollutants and climate forcing pollutants, such as measurement of emissions of criteria pollutant precursors and air toxics, including emerging concerns, such PFAS and EtO.
CSS	Continue to develop new approach methods for CIECs with a focus on applying these, as appropriate, for prioritization, screening, and risk assessment for decision making.
HERA	Continue and expand the portfolio of assessment products, as well as advance risk assessment models and tools, to better characterize potential human health and environmental impacts of new and existing contaminants.
HS	Predict the movement of chemical, biological, and radiological contaminants in the environment resulting from environmental contamination events and develop tools and methods for effective characterization, decontamination, and waste management.
SHC	Advance site clean-ups of PFAS and lead to protect vulnerable groups, especially children.
SSWR	Research on PFAS, including innovative drinking water and wastewater treatments, support for future drinking water regulations, the development of aquatic life criteria, management in water resources, and evaluation of land-applied biosolids; contaminants of emerging concern (CECs), lead, opportunistic pathogens, and DBPs in drinking water; cyanobacterial metabolites other than microcystin (e.g., anatoxin, saxitoxin, and nodularin); microplastics in sediments and surface water; and CECs (non-PFAS) in wastewater treatment systems and biosolids.