



Health and Environmental Risk Assessment

Strategic Research Action Plan Fiscal Years 2023-2026



Health and Environmental Risk Assessment (HERA)

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Foreword

A little more than 50 years ago, at a time when thick, visible soot obscured the sunrise and the threat of toxic industrial legacies undermined community health and development, the American people looked to a newly formed federal entity—the Environmental Protection Agency (EPA)—to lead a path forward.

In the ensuing decades, a remarkable success story has unfolded in improving our air, water, and land. These achievements have been built on a legacy of scientific research to better understand the links between people, our environment, and public health. EPA’s Office of Research and Development (ORD) continues to be a world leader in this research.



Today, I am pleased to share with you the next chapter in EPA’s commitment to delivering the research needed to meet the existing and emerging environmental challenges of today: ORD’s Strategic Research Action Plans (StRAPs) for fiscal years 2023 to 2026. There are six StRAPs, one for each of ORD’s highly coordinated and transdisciplinary National Research Programs (NRPs), which align with the Agency’s strategic goals: 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); and Sustainable and Healthy Communities (SHC).

Each StRAP is focused to harness the expertise of ORD’s leading-edge researchers in their respective disciplines. We identified six cross-cutting priorities—environmental justice, climate change, cumulative impacts, community resilience, children’s environmental health, and contaminants of immediate and emerging concern—for close coordination throughout research planning and implementation. The StRAPs also anticipate emerging issues and identify research that will build the foundation needed to address those issues into the future.

The StRAP development process was informed by active engagement to gather input from a diversity of both internal and external Agency partners and stakeholders. These include Agency program and regional offices, Tribes, state agencies, public health and environmental organizations, nongovernmental organizations and associations, and the scientific community. Each of the StRAPs benefited from independent peer review provided by EPA’s external Board of Scientific Counselors.

By working collaboratively and embracing partnerships from across a wide spectrum of environmental and public health professionals, our strategic research plans identify our most pressing public health and environmental challenges and outline concrete plans that will deliver accessible and relevant science to inform effective decisions regarding those challenges.

The StRAPs renew our commitment to upholding the highest levels of scientific integrity as we continue to provide the critical, high quality, and credible science the Agency and our partners rely on to make science-based decisions to protect public health and the environment.

Together, we are ushering in a new generation of environmental research that is poised to lay the groundwork for another 50 years of achievement, and beyond.

A handwritten signature in black ink, appearing to read 'H. Christopher Frey'.

H. Christopher Frey, Ph.D.
Assistant Administrator for Research and Development

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List of Acronyms

ACE	Air, Climate, and Energy
ADME	Absorption, Distribution, Metabolism, and Excretion
APIs	Application Program Interface
AOP	Adverse Outcome Pathway
ATSDR	Agency for Toxic Substances and Disease Registry
CAL EPA	California Environmental Protection Agency
CIECS	Contaminants of Immediate and Emerging Concern
CSS	Chemical Safety for Sustainability
DBP	Disinfection Byproducts
EFH	Exposure Factors Handbook
EMT	Emerging Materials and Technologies
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
EtO	Ethylene Oxide
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HERA	Health and Environmental Risk Assessment
HSRP	Homeland Security Research Program
HTTK	High-throughput Toxicokinetic
ISA	Independent Science Assessment
NAAQS	National Ambient Air Quality Standards
NAM	New Approach Methods
NCA4	National Climate Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRP	National Research Program
OAR	EPA Office of Air and Radiation
OCSP	EPA Office of Chemical Safety and Pollution Prevention
OLEM	EPA Office of Land and Emergency Management
ORD	EPA Office of Research and Development
OW	EPA Office of Water

Pb	Lead
PFAS	Per- and Polyfluoroalkyl Substances
PBPK	Physiologically-Based Pharmacokinetic Model
PRST	Program, Regional, State and/or Tribal
QA	Quality Assurance
RA	Research Area
RACT	Research Area Coordination Team
RCRA	Resource Conservation and Recovery Act
SBIR	Small Business Innovation Research
SDR	Solutions-Driven Research
SHC	Sustainable and Healthy Communities
SLTT	State, Local, Territorial, and Tribal
SSWR	Safe and Sustainable Water Resources
STAR	Science to Achieve Results
StRAP	Strategic Research Action Plan
TCSA	Toxic Substances Control Act
TK	Toxicokinetic
TSC	Technical Support Centers
UVCB	Unknown or Variable Composition
WHO	World Health Organization

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 comprise a group of related Outputs, which comprise of a group of related 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 comprise a group of related Products and are 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 – with whom we directly engage during the research planning process. As EPA implements our research, we seek partnerships with these groups, as well as local governments and communities, NGOs, associations, and other stakeholders, as appropriate, so our research is applicable to and informed by real use cases.

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

The Environmental Protection Agency's (EPA) Health and Environmental Risk Assessment (HERA) National Research Program (NRP) develops a portfolio of fit-for-purpose human health or environmental assessment products and assessment-related research to meet EPA's wide-ranging statutory and regulatory needs. More specifically, the program identifies, evaluates, and integrates existing and emerging information from diverse scientific disciplines to characterize human or environmental hazards, including both qualitative and quantitative stressor/response relationships. Maintaining and advancing the efficiency, transparency, and scientific rigor of HERA assessment products and associated risk assessment decision making throughout the Agency requires innovative assessment research and tool development. HERA advances the science and practice of assessment through methods development, case studies, models, and tools that are tethered to assessment needs.

HERA will continue as a leader in innovating and applying systematic review methods, including evidence integration and mapping. The program will continue to focus on research that builds user confidence in the full range of available data in risk assessment, including integration of new approach methods (NAMs) and data into workflows. Areas of new or increasing emphasis will incorporate research relevant to children's environmental health, equity and environmental justice, climate change, and cumulative risk. The HERA program will ensure health and environmental assessment products and translational support are appropriately tailored to decision or application contexts. HERA's strategic direction culminates in a program structured to facilitate efficient construction and production of high-quality, transparent, state-of-the-science assessment research that maximizes resources to address priority statutory, regulatory, and programmatic needs.

Introduction

Every day, EPA's programs and regions, states, Tribes, and external partners must make decisions to ensure that human health and the environment continue to be protected from the known or potential adverse effects of exposure to environmental stressors. These decisions span a large regulatory and non-regulatory landscape and require different degrees of information to characterize qualitative and quantitative toxicity information and develop health-protective toxicity values to support air, water, and land management programs; evaluate ecological effects and characterize ecosystem responses and impacts of exposure to one or more environmental stressors, such as chemicals, land change, disease, and invasive species; characterize potential human health and environmental impacts during emergent situations; and interpret and integrate different lines of evidence to support decisions.

EPA's HERA National Research Program (NRP) is designed to develop and apply state-of-the-science research to characterize the impacts on human and ecological systems, whether they result from exposure to single, complex, or multiple physical, chemical, or biological stressors. In doing so, HERA provides key components of the scientific foundation for risk assessments to inform decisions aimed at protecting human health and the environment.

To assist the Agency in meeting its goals and objectives, the HERA NRP developed this Strategic Research Action Plan (StRAP) for fiscal years 2023–2026 (FY23-26). The HERA StRAP is one of six of the following research plans for each of the NRPs¹ 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 programs' strategic direction over the next four years. The HERA 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.

¹ The FYs 2023-2026 StRAPs for all six of ORD's NRPs are available on EPA's website: epa.gov/research/strategic-research-action-plans-fiscal-years-2023-2026.

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.

Program Vision

The HERA Research Program vision is to innovate and advance the science and practice of health and environmental risk assessment by developing a portfolio of fit-for-purpose assessment products and assessment research that meets the needs and priorities of EPA programs and regions, states, Tribes, and external stakeholders.

EPA's national program offices, including the Office of Land and Emergency Management (OLEM), Office of Water (OW), Office of Air and Radiation (OAR), Office of Chemical Safety and Pollution Prevention (OCSPP), as well as EPA's regional offices, have statutory authorities and mandates that require a large landscape of risk assessment and risk management activities. HERA strives to develop and apply state-of-the-science research to characterize the impacts on human (including sensitive populations and lifestages) and ecological systems, whether they result from exposure to single, complex, or multiple physical, chemical, or biological stressors, to serve as the scientific foundation to inform and improve EPA's risk assessment decisions.

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.

HERA 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 with the Agency's strategic goals and cross-cutting strategies in the Strategic Plan. HERA's research will support three of the Cross-Agency Strategies, including **Ensure Scientific Integrity and Science-Based Decision-Making** (Strategy 1), **Consider the Health of Children at All Life Stages and Other Vulnerable Populations** (Strategy 2), and **Strengthen Tribal, State, and Local Partnerships and Enhance Engagement** (Strategy 4). The HERA StRAP will also support EPA's Goals to **Ensure Safety of Chemicals for People and the Environment** (Goal 7), **Ensure Clean and Healthy Air for All Communities** (Goal 4), and **Ensure Clean and Safe Water for All Communities** (Goal 5). In addition, HERA research will support Goal 1, to **Tackle the Climate Crisis**; and Goal 2, to **Take Decisive Action to Advance Environmental Justice and Civil Rights**.

Changes from FY19-FY22 StRAP

HERA is integrating areas of new or increasing emphasis with the incorporation of research relevant to children's environmental health, as well as increasing focus on research to expand the identification and consideration of information on susceptibility in assessments, advance the evaluation of chemical mixtures, and improve cumulative risk assessment practices to better characterize and assess health disparities in state and Tribal communities with environmental justice and equity concerns. Further, HERA will leverage its assessment expertise, approaches, tools, and technologies to support climate change impact assessments.

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 HERA 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 HERA 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).

The HERA 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

Topic 1: Science Assessments and Translation

The *Science Assessments and Translation* research topic showcases HERA's focus on the science and practice of assessment development and support. HERA has increased emphasis on identifying a range of EPA decision-making contexts—including consideration of susceptible populations and lifestages—to support the required priorities of EPA program and regional offices and is tailoring the scope of its products to meet demands. HERA will remain responsive to regulatory drivers and timelines by implementing a portfolio of assessment products that optimize the application of the best available science and technology. There will also be increased emphasis on providing scientific and technical support across the lifecycle of a decision and from development to application of the assessment products.

Research Area 1: Science Assessment Development

The *Science Assessment Development* Research Area is focused on producing high quality, transparent, consistent, and scientifically defensible assessment products to meet EPA's diverse statutory and policy needs. This research area comprises the portfolio of assessment products developed under well-established product lines (e.g., Integrated Science Assessments², Integrated Risk Information System³, and Provisional Peer-Reviewed Toxicity Value⁴ assessments) yet maintains the agility to produce other fit-for-purpose assessment products as prioritized by the Agency. Conceptually, assessment development comprises the same set of steps regardless of scientific discipline and varying evidence streams, including scoping and problem formulation, identification of evidence, study evaluation and data extraction (summarizing study methods and results), analysis, evidence integration, and presentation of conclusions. HERA assessment products will be tailored through targeted engagement with partners to a specific decision or application context.

² More information can be found at epa.gov/isa.

³ More information can be found at epa.gov/iris.

⁴ More information can be found at epa.gov/pprtv.

Outputs under the *Science Assessment Development* Research Area are important to decision-making in EPA program offices and regions, state and local agencies, and Tribes as they provide pollutant-specific science assessments and toxicity values (HERA.1.1 and 1.2). Decisions by these partners span a large regulatory and non-regulatory landscape and may include screening and prioritization of chemicals for monitoring or cleanup, including chemicals of immediate and emerging concern; and considerations for establishing, retaining, and revising national pollutant standards, such as the National Ambient Air Quality Standards. Assessments developed will characterize the impacts on human (including sensitive/vulnerable populations and across lifestages) and ecological systems, whether they result from exposure to single, complex, or multiple physical, chemical, or biological stressors (Outputs HERA.1.1, 1.2, 1.3). This includes assessments that address the need to understand aggregate climate damages to EPA-critical endpoints (HERA.1.3).

Research Area 2: Science Assessment Translation

EPA and its partners and stakeholders request, on an as-needed basis, technical support and consultation from ORD. These requests cover a wide variety of topics, including those related to human health and environmental risk assessment, plus issues encountered in emergent, crisis-level situations. HERA exposure, human health, and environmental assessors serve as an Agency resource and respond to requests based on HERA assessment product applications or to support other Agency assessment decisions. The *Science Assessment Translation* Research Area includes the range of tailored support activities, products, and applications developed to address the requests received from EPA program and regional offices, states, and Tribes for technical support and consultations. The science assessment translation and support provided within this research area are integral for linking scientific research and assessments from HERA to Agency decisions, facilitating the application of best practices to science assessments, and serving as a dynamic conduit between assessment application and research.

Outputs in this research area cover the technical support and consultation provided by HERA on topics related to human health and environmental risk assessment to support the EPA program and regional offices, states, and Tribes in applying HERA research products to their decision needs and implementing HERA techniques and tools in their decision-making (HERA.2.2), including requests through the ORD Superfund Technical Support Centers (TSCs) (HERA.2.1). This support includes responding to the critical need for training in risk assessment, tool literacy and standard operating procedures/templates for assessment development within the Agency (e.g., EPA program and regional offices), as well as for outreach to external partners (e.g., CalEPA, ATSDR, EFSA) via easy-to-access modules (HERA.2.3). HERA collaborates with other ORD NRPs (e.g., CSS), EPA partners, and the EPA Risk Assessment Forum to coordinate training on key concepts and procedures for risk assessment. Training modules and outreach enhance communication regarding assessments and approaches, cultivating acceptance by stakeholders, providing transparency, and increasing understanding and engagement.

Topic 2: Advancing the Science and Practice of Risk Assessment

Continuing to deliver transparent, consistent, and scientifically defensible assessment products requires innovations in approaches and applications. Research under the *Advancing the Science and Practice of Risk Assessment* topic addresses gaps observed in the assessment activities undertaken in response to specific needs under Topic 1, as well as needs from the EPA risk assessment community. Refinements and updates to current approaches and new assessment science will be anchored in assessment

development and are expected to improve the accuracy, efficiency, flexibility, and utility of applications across the large landscape of assessment activities. These research advancements, when illustrated and applied within assessments, will provide new information and demonstrate approaches to the scientific community for consideration by a variety of users. These actions all implement the vision of increasing transparency and reducing uncertainty in assessment science and accelerating the pace of assessment development.

Research Area 3: Emerging and Innovative Assessment Methodologies

To address the assessment needs of EPA partners and stakeholders, technological and scientific advances in data-driven approaches can increase confidence in assessment conclusions, accelerate the pace of assessment development, and ensure transparency in assessments that characterize the potential human health and environmental hazards associated with exposure to single or multiple stressors across lifestages. The *Emerging and Innovative Assessment Methodologies* Research Area aims to incorporate new and innovative methodologies in predictive toxicology, rapid evidence evaluation, systematic review, cumulative risk and mixtures approaches, and toxicokinetic and dose-response modeling across a landscape of decision contexts and assessment products covered by HERA.

The Outputs in this research area aim to develop, evaluate, and advance the practical implementation of emerging technologies and data streams, clearly articulating the scope, advantages, and limitations in the application of these approaches in risk assessment. In addition to ensuring HERA science assessments are meeting the needs of EPA program offices and regions, state and local agencies, and Tribes, Outputs will address the need for building greater confidence in the application of NAMs in HERA assessment products (HERA.3.1); advancing methods for considering cumulative impacts and mixtures (HERA.3.2); reducing uncertainty in predicting internal dose from chemical exposure in assessments (HERA.3.3); increasing the efficiency in systematic review practices (HERA.3.4); advancing methods in dose-response modeling, toxicity value derivation, and benefits analysis (HERA.3.5); and ensuring the Exposure Factors Handbook conveys current recommendations (HERA.3.6). Outputs in this research area will also contribute to Administration priorities of addressing environmental justice concerns (HERA.3.2) and considering children's environmental health (HERA.3.6). Innovative research under these Outputs is intended to be complementary to research planned in the CSS program and may involve collaborative research efforts between scientists within the HERA and CSS programs. For example, HERA research may build upon data and science generated in CSS to develop HERA assessment solutions.

Research Area 4: Essential Assessment and Infrastructure Tools

Developing rigorous scientific assessments and related models and tools in a timely and transparent manner has been and continues to be a critical objective of the HERA program. This portfolio of diverse and multi-disciplinary assessment products requires the use of software and database tools to provide necessary infrastructure and facilitate efficient and transparent assessment development according to systematic review methodologies. Research under the *Essential Assessment and Infrastructure Tools* Research Area will enable the maintenance and development of new and existing tools, models, and databases used in the assessment development process and to maintain interoperability between HERA tools and tools from other EPA programs/offices or assessment producers. These efforts will ensure that HERA scientific assessments and other Agency decisions that rely upon these models and tools continue

to be relevant, timely, transparent, and ultimately, deliver scientifically sound conclusions to support defensible decision-making for Agency policies and regulations.

Outputs under this research area support assessment development at each conceptual step, including identification and screening of literature/evidence, study quality evaluation, data extraction, synthesis, evidence integration, quantitative modeling, and presentation of conclusions. The research will advance tools and databases to increase efficiency and transparency in assessment development and systematic review practices (Output HERA.4.1), ensuring interoperability of tools within assessment workflows. Outputs will also provide important validation and evaluation for models used to simulate levels of lead in body compartments following exposure (HERA.4.2). The Outputs will expand the portfolio of research addressing contaminants of immediate and emerging concern and consideration of children's environmental health (HERA.4.2).

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 compose 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 HERA Research Program Outputs organized by topic 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 the Outputs.

Research Area	Output	Needs Topics
Topic 1: Science Assessments and Translation		
HERA.1 Science Assessment Development	HERA.1.1 Portfolio of interim assessment products to support decision-making	<ul style="list-style-type: none"> • Pollutant-specific science assessments and toxicity values • Integrated Science Assessments to support the Ambient Air Quality Standards • Address environmental justice concerns • Contaminants of immediate and emerging concern • Consider children’s environmental health • Cumulative impacts and mixtures • Support harmonization of risk assessment approaches across EPA
	HERA.1.2 Portfolio of final assessment products to support decision-making	
	HERA.1.3 Series of assessments evaluating combined health and ecological impacts of climate change for informing quantitative estimation of hazard	
HERA.2 Science Assessment Translation	HERA.2.1 Technical support to EPA regions through the Superfund Health Risk Technical Support Center and Ecological Risk Assessment Support Center	<ul style="list-style-type: none"> • Technical science and risk assessment support to Superfund
	HERA.2.2 Deliver technical support to address program, regional, public health or environmental professional decision needs and assessment challenges	<ul style="list-style-type: none"> • Ad hoc technical support for assessment requests
	HERA.2.3 Training program on advances in risk assessment and systematic review	<ul style="list-style-type: none"> • Risk assessment science and tools training

Research Area	Output	Needs Topics
Topic 2: Advancing the Science and Practice of Risk Assessment		
HERA.3 Emerging and Innovative Assessment Methodologies	HERA.3.1 Build confidence in the application of new approach methods (NAMs) and data in human health risk assessment	<ul style="list-style-type: none"> • Building confidence in NAMs
	HERA.3.2 Advance the application and evaluation of cumulative risk assessment methodologies, including assessment of chemical mixtures	<ul style="list-style-type: none"> • Cumulative impacts and mixtures • Addressing environmental justice concerns
	HERA.3.3 Improved methods for dosimetry extrapolation and the related uncertainty characterization in human health risk assessment	<ul style="list-style-type: none"> • Reduce uncertainty in predicting internal dose from chemical exposure in assessments • PBPK model for route-to-route extrapolation of PFAS
	HERA.3.4 Advance systematic review and related evidence assessment methods, including evidence integration	<ul style="list-style-type: none"> • Increase efficiency in systematic review practices • Support harmonization of risk assessment approaches across EPA
	HERA.3.5 Advance dose-response modeling and toxicity value derivation methods and implementation with application in risk assessment	<ul style="list-style-type: none"> • Methodological advancements in dose-response modeling • Benefits analysis for noncancer health endpoints
	HERA.3.6 Expand and update Exposure Factors Handbook	<ul style="list-style-type: none"> • Update and advance Exposure Factors Handbook chapters • Assess Tribal exposure pathways to support Tribal communities • Consider children’s environmental health
HERA.4 Essential Assessment and Infrastructure Tools	HERA.4.1 Innovate, develop, and maintain a suite of essential software and support tools for risk and hazard assessment	<ul style="list-style-type: none"> • Assessment development efficiency and transparency • Increase efficiency in systematic review practices • Support harmonization of risk assessment approaches across EPA
	HERA.4.2 Advance biokinetic models for lead, including children	<ul style="list-style-type: none"> • Lead model validation • Contaminants of immediate and emerging concern • Consider children’s environmental health

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 HERA Research Program StRAP for each Research Area and as listed in Appendix 1.

- **Pollutant-specific science assessments and toxicity values:** EPA and its partners and diverse stakeholders must make decisions to ensure that human health and the environment are protected from known or potential adverse effects of exposure to environmental stressors, including environmental justice considerations, so that everyone enjoys the same degree of protection. Such decisions span a large regulatory and non-regulatory landscape and require different degrees of information: developing health-protective toxicity values (at various durations) to support air, water, and waste management programs; evaluating ecological effects and characterizing responses and impacts of exposure to one or more environmental stressors such as chemicals, land change, disease, and invasive species; characterizing potential human health and environmental impacts during emergent situations; characterizing human health effects to inform risk management options in the wake of natural or man-made disasters; screening and prioritization of chemicals for monitoring at Superfund sites and in the air, water, soil, and sediment; characterizing increased susceptibility of early life exposures; and evaluating health and environmental effects data to derive benchmark estimates.
- **Integrated Science Assessments to support the Ambient Air Quality Standards:** Interpreting and integrating different lines of evidence to support decisions to establish, retain, or revise national pollutant standards.
- **Addressing environmental justice concerns:** EPA is committed to addressing environmental and health inequalities in vulnerable populations and communities. There is a need to better understand how health disparities that arise from unequal environmental conditions, and inequitable social and economic conditions, affect chemical stressor responses in order to help support decision-making and empower overburdened and under-served communities to take action.
- **Expand climate change research:** Understanding and addressing climate change impacts to human health and the environment is an Agency priority. There is a need to continue the development of assessments of air pollutants to inform climate policy efforts and leverage assessment expertise, approaches, tools, and technologies in support of further climate change impact assessments across the larger landscape of hazards associated with climate change.
- **Contaminants of immediate (PFAS, lead) and emerging concern (CIECs):** Substances (e.g., PFAS, lead) that may cause ecological or human health impacts and are either long-term or new contaminants of increased priority. When immediate and emerging contaminants are detected in environmental media, the hazard and risk information required to inform decision-making is often lacking. PFAS chemicals as a class are of particular focus, as PFAS chemicals, including mixtures of PFAS, are frequently being detected in a variety of environmental media.
- **Consider children's environmental health:** EPA offices are to consistently and explicitly consider early life exposures and lifelong health in all human health decisions. There is a need for

assessments to evaluate and consider children’s environmental health information and data during development.

- **Support harmonization of risk assessment approaches across EPA:** ORD is committed to continuing to work with EPA program and regional offices, especially those that also produce assessments (e.g., OW, OCSPP), and with the EPA Risk Assessment Forum (RAF) to promote Agency-wide consensus on difficult and controversial risk assessment issues, ensuring that EPA offices continue to work together to harmonize methods and practices and contributing to Agency risk assessment guidelines.
- **Technical science and risk assessment support to Superfund:** Access ORD technical expertise for technical support through Superfund Technical Support Centers, specifically related to human health and ecological risk assessment.
- **Ad hoc technical support for assessment requests:** Access to expertise in the application of assessment science beyond the development of traditional assessment products in HERA. This includes providing support for assessments led by other EPA offices including the Office of Water’s (OW) Health Effects Support Documents and Office of Pollution Prevention and Toxics’ (OPPT) risk evaluations and new chemical risk assessments.
- **Risk assessment science and tools training:** Critical need for training in risk assessment, tool literacy and standard operating procedures/templates for assessment development within the Agency, as well as for outreach to collaborators via easy-to-access modules.
- **Building confidence in new approach methods (NAMs):** EPA programs and regions are often tasked with addressing potential hazard(s) to human health and the environment associated with exposure to environmental chemicals. For many chemicals of interest under different program/regional office purviews, formal risk assessment is challenging due to lack of relevant human epidemiological or experimental animal study data. Consistent with EPA’s [NAMS workplan](#), which outlines goals for reducing the use of animal testing while continuing to protect human health and the environment, research is required to evaluate, apply, and build appropriate confidence in the application of information and data from NAMs in human health risk assessment. NAMs are defined as any technology, methodology, approach, or combination that can provide information on chemical hazard and risk assessment to avoid the use of animal testing.
- **Assessing Tribal exposure pathways to support Tribal communities:** Tribes need a framework and tools to address Tribal lifeways in risk assessments, including historical lifeways; Tribes need research to identify suitable Tribal health indicators and incorporate Tribal lifeways assessments and restoration.
- **Cumulative impacts and mixtures:** Addressing cumulative impacts, specifically those of chemical and nonchemical stressors on environmental degradation and health effects, is an Agency priority. There is a need to advance and evaluate both cumulative and mixtures risk assessment approaches and models. In particular, there is a need to understand how multiple stressors affect health effects from chemical exposures.
- **Reduce uncertainty in predicting internal dose from chemical exposure in assessments:** Need for reducing and better characterizing uncertainty in extrapolation between species or across routes or scenarios in assessments.

- **PBPK model for route-to-route extrapolation:** There is currently insufficient information to develop inhalation toxicity values for PFAS, limiting the ability to address associated human health risks from inhalation of PFAS. Need to develop models and methods for route-to-route extrapolation for estimating inhalation effects of PFAS from oral exposure PFAS information.
- **Benefits analysis for noncancer health endpoints:** Evaluate health endpoints that can be quantified and monetized in the benefits analyses for risk management rules.
- **Increase efficiency in systematic review practices:** Systematic review approaches are being embraced across the Agency to enhance transparency of human health and ecological risk assessment activities. There is a need to develop more automated systematic review methods that are scientifically sound and can be operationalized in a reasonably consistent manner across assessment products.
- **Methodological advancements in dose-response modeling:** Continue to resolve issues and complications in dose-response modeling.
- **Update and advance Exposure Factors Handbook chapters:** The [Exposure Factors Handbook](#) is critical for Agency risk assessments and needs to be maintained and updated to ensure the evidence and recommendations are current and easily accessible.
- **Assessment development efficiency and transparency:** Assessments developed by HERA support regulations and policies required of EPA by several mandates (e.g., Clean Air Act; Clean Water Act; Safe Drinking Water Act; Toxic Substances Control Act; Comprehensive Environmental Response, Compensation, and Liability Act; Resource Conservation and Recovery Act) that are led by numerous program offices (Office of Air and Radiation, Office of Water, Office of Land and Emergency Management, Office of Chemical Safety and Pollution Prevention, etc.). Software tools and database applications have served as important infrastructure to facilitate efficient and transparent assessments that are relied upon by a wide range of stakeholders.
- **Lead model validation:** It is essential to demonstrate the value of model predictions used in support of regulatory decisions. Research to better characterize and reduce uncertainties in use of lead exposure and biokinetic models (e.g., the Integrated Exposure Uptake Biokinetic Model and All Ages Lead Model) are needed; for example, evaluation and/or validation at the not to exceed level of 3.5 µg/dl.

Appendix 3: Output Descriptions

The following describe, in more detail, the HERA 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: Science Assessments and Translation

RA HERA.1: Science Assessment Development

Output HERA.1.1: Portfolio of Interim Assessment Products to Support Decision-Making

HERA's science assessment development processes are highly coordinated with Agency program and regional offices to ensure assessment products are designed to support statutory or policy needs, are tailored to the specific decision or application context, and reflect the best available science and technology. Delivery of timely interim assessment products, such as scoping and problem formulation materials and draft assessments, ensures that HERA is engaged with the user community around the on-going assessment products. It also provides EPA and its partners and external stakeholders with solutions-focused and transparent deliverables that allow for continued engagement to shape the nature of the product and the context for its application, facilitating adaptive implementation and course correction as needed. Products under this Output may include Integrated Review Plans for NAAQS, IRIS Assessment Plans, Systematic Review Protocols, Evidence Maps, and External Review Drafts.

Output HERA.1.2: Portfolio of Final Assessment Products to Support Decision-Making

HERA's final assessment products efficiently support a range of decisions, such as informing national standards, clean-up levels at local sites, and setting advisory levels. This collection of fit-for-purpose and timely assessment products provides the integrated scientific evidence needed to characterize effects and potential impacts to the environment and human health across all lifestages. This Output provides high-quality, transparent, state-of-the-science, peer-reviewed assessment products (e.g., final Integrated Science Assessments [ISAs to inform the NAAQS], IRIS assessments, PPRTV assessments, etc.).

Output HERA.1.3: Series of Assessments Evaluating Combined Health and Ecological Impacts of Climate Change for Informing Quantitative Estimation of Hazard

Climate change introduces additional stresses and disruptions into the people-environment nexus, and starkly highlights the social determinants of public health, posing substantial and additional challenges for protecting human health and the environment. Multiple frameworks exist for evaluating climate change impacts to ecological and eco-health endpoints, but none focus specifically on quantitative estimates of EPA-critical endpoints. A series of assessments will be produced in high-priority areas of climate damage and partner need, such as waste sites, water quality and infrastructure, air quality, and energy, and that focus on effects that cut across human health and ecological endpoints. Assessments under this Output would additionally serve as critical technical inputs to the National Climate Assessment (NCA) process.

RA HERA.2: Science Assessment Translation

Output HERA.2.1: Technical Support to EPA Regions Through the Superfund Health Risk Technical Support Center and Ecological Risk Assessment Support Center

HERA will continue to provide technical assistance and support in the area of human health and ecological risk assessment for EPA's program offices and regions related to issues of concern at Superfund, Resource Conservation and Recovery Act (RCRA), and Brownfield sites. HERA manages two of the five ORD Technical Support Centers (TSCs) [i.e., Superfund Health Risk Technical Support Center (STSC) and Ecological Risk Assessment Support Center (ERASC)], dedicated to supplying high-quality, quick-response technical support services when the scope of work is beyond what is available to the regions, program offices, states, and Tribes.

Output HERA.2.2: Technical Support to Address Program, Regional, Public Health or Environmental Professional Decision Needs and Assessment Challenges

Application of assessment science beyond the development of traditional assessment products in HERA requires expert and technical consultation, techniques, and use of materials or resources (i.e., tools) ready to address program office, regional, public health, or environmental professional decision-making needs and assessment challenges. This work may be ad hoc and may require implementing responsive strategies and workflows, possibly under high-pressure time demands or under long-term timeframes. This work may also include translating and communicating existing HERA assessment products for public health or environmental protection professionals in need of decision-making support.

Output HERA.2.3: Training Program on Advances in Risk Assessment and Systematic Review

There is a continuing, critical need to develop and provide training in basic and advanced risk assessment concepts and practices, tool literacy, and standard operating procedures/templates for assessment development. The audiences for training include both new and experienced Agency staff (e.g., EPA program, regional offices, and within ORD), collaborators (e.g., Cal-EPA, ATSDR, EFSA), and community partners. Broadly accessible training modules developed on key risk assessment concepts and procedures and on the basic use of systematic review tools being used within HERA enhance communication by assuring all parties have common understanding of how HERA risk assessments are developed and implemented.

Topic 2: Advancing the Science and Practice of Risk Assessment

RA HERA.3: Emerging and Innovative Assessment Methodologies

Output HERA.3.1: Build Confidence in the Application of New Approach Methods (NAMs) and Data in Human Health Risk Assessment

EPA programs and regions are often tasked with addressing potential hazards to human health and the environment associated with exposure to environmental chemicals where formal risk assessment is challenging due to lack of relevant human epidemiological or experimental animal study data. The utility and availability of new approach methods (NAMs) could be leveraged to inform hazard and dose-response assessment, directly supporting decision-maker needs, particularly for data-poor chemicals. Additionally, NAMs can be used as integrative and mechanistic information to address physicochemical, toxicokinetic, and toxicodynamic data gaps for chemicals with variable gradations of existent/available in

vivo data for evaluation via traditional risk assessment practices. This Output encompasses the research required to evaluate, apply, and build appropriate confidence in the application of information and data from NAMs in HERA human health risk assessment. This Output involves coordination and collaborative research efforts between scientists within the HERA and CSS National Research Programs in the integration of NAMs in human health risk assessment to support assessment product development and delivery, and technical support efforts conducted within the HERA Program to meet the chemical assessment needs of partners and stakeholders.

Output HERA.3.2: Advance the Application and Evaluation of Cumulative Risk Assessment Methodologies, Including Assessment of Chemical Mixtures

Cumulative impacts refer to the accumulation or total burden of health-degrading conditions or circumstances in a community at a given point in time or over a period of time. A necessary element of consideration in cumulative impacts assessment, cumulative risk assessment and chemical mixtures risk assessment is the evaluation of combined impacts of multiple chemical stressors. This Output focuses on the evaluation and advancement of cumulative and chemical mixtures risk assessment approaches and models through case studies and publications. Specific focus will be placed on evaluating and developing chemical mixtures methods and developing methods to estimate health risks following exposures to disparate stressors (e.g., chemical and physical agents, chemicals and biological agents, and chemical agents and psychosocial stressors) and/or buffers.

Output HERA.3.3: Improved Methods for Dosimetry Extrapolation and the Related Uncertainty Characterization in Human Health Risk Assessment

Dosimetry models are an important component of evaluating hazard and risk by predicting the internal dose, meaning the concentration or amount of a chemical or other agent in a target tissue or location, the blood, or the whole body from an external chemical exposure—often across species or for different exposure routes or scenarios within a species. This Output focuses on the evaluation of dosimetry models for potential use, implementation of models in currently available software, performing quality assurance (QA) evaluations of those models, and integration of dosimetry analyses and uncertainty estimation into risk calculations. Also, as work on modeling of quantitative adverse-outcome-pathways progresses, dosimetry models that predict corresponding dose metrics, such as binding to specific molecules, will need to be developed and evaluated. This Output involves coordination and collaborative research efforts between scientists within the HERA and CSS National Research Programs.

Output HERA.3.4: Advance Systematic Review and Related Evidence Assessment Methods, Including Evidence Integration

Systematic review approaches are being embraced across the Agency to improve the defensibility of human health and ecological assessment products, making them transparent, accessible, and easily updated representations of the best available science for informing EPA decisions. Keeping the information supporting assessments updated with the latest relevant research is time-consuming, labor-intensive, and therefore a particular challenge in chemical assessments where a rapid compilation of new information and/or update to existing information is needed in a pre-decisional, regulatory context. The goal of this Output is to use computationally intelligent methods to reduce this ongoing and manual effort. This Output aims to address and advance some of the existing developments in areas of systematic review methodologies by continuing development on and applying emergent methods (e.g., text mining, text analytics, natural language processing, and machine learning) to human health and environmental

assessments. Building from previous work, this Output further facilitates coordination with other offices (e.g., OPPT) and consistent application of systematic review methods across the Agency.

Output HERA.3.5: Advance Dose-Response Modeling and Toxicity Value Derivation Methods and Implementation with Application in Risk Assessment

Dose-response modeling is a critical step in a human health risk assessment where toxicological and epidemiologic data are modeled to derive toxicity values. While existing methods improve upon older methods, many unresolved issues and complications remain that require targeted research to address. This Output includes methodological advancements in dose-response modeling to augment the modeling capabilities of HERA assessments and other dose-response assessments within and outside of EPA (e.g., OW, OCSPP, WHO, state/Tribal partners, academia, and industry). In addition, this Output includes advancements in the probabilistic and statistical methods for deriving risk-specific doses, including updating empirical data used in estimating probability distributions. Research under this Output also represents critical expansion of current capabilities in the use of probabilistic approaches for addressing uncertainty when deriving noncancer toxicity values. These research products will result in dose-response methods that are more precise, robust, and meet varied partner needs.

Output HERA.3.6: Expand and Update Exposure Factors Handbook Chapters

Exposure factors are factors related to human behavior and characteristics that help determine an individual's exposure to an agent. The [Exposure Factors Handbook](#) (EFH) is intended for use by exposure and risk assessors both within and outside EPA as a reference tool and primary source of exposure factor information. It may be used by scientists, economists, and others as a source of EPA recommendations on data and numeric estimates for behavioral and physiological characteristics needed to estimate exposure to environmental agents. Since 2017, the EFH has released individually updated chapters as new information becomes available and EPA priorities dictate. This Output will continue to ensure the EFH is presenting up-to-date information and recommendations and applying systematic review principles in review of the evidence.

RA HERA.4: Essential Assessment and Infrastructure Tools

Output HERA.4.1: Innovate, Develop, and Maintain a Suite of Essential Software and Support Tools for Risk and Hazard Assessment

The development of science assessments that are rigorous, timely, and transparent requires infrastructure, including software tools and databases, that facilitate systematic review methodologies. As systematic review is further adapted and implemented across the portfolio of products, maintaining existing infrastructure and continuing development as new assessment needs emerge will be critical. Tools in the context of this Output relate to each step in the assessment development and include web applications, data visualization dashboards, web services, Application Program Interface (APIs), and software packages written in Python, R, or other data-science programming languages. This infrastructure, consisting of tools and databases and their interoperability, will contribute to more seamless assessment workflows and yield greater efficiency and consistency in delivering assessments to partners and stakeholders.

Output HERA.4.2: Advance Exposure and Biokinetic Models for Lead, Including Children

EPA Offices and Regions rely upon ORD models to simulate levels of lead (Pb) in body compartments (e.g., blood) that are expected to occur in children and adults following exposure, for the purpose of risk

assessment and decision-making. To appropriately apply existing Pb models, it is essential to demonstrate the usefulness of model predictions as decision-making scenarios shift to lower Pb exposures. This Output will take into account new data sources on exposure factors (e.g., soil-dust ingestion rates, dietary intake, bioavailability etc.), Pb concentrations in exposure media (e.g., water, soil, dust, food, air), and human biokinetics.

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 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).

Cross-Cutting Priorities:



Environmental Justice



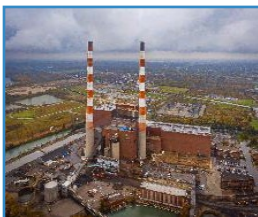
Community Resiliency



Climate Change



Children’s Environmental Health



Cumulative Impacts



Contaminants of Immediate and Emerging Concern

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

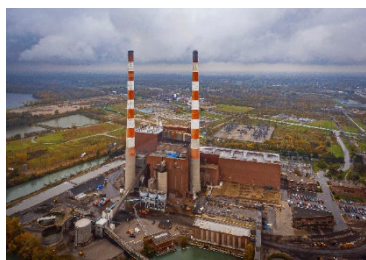


Understanding and addressing climate change impacts to human health and the environment is a critical component of ORD’s research. To be effective, climate change research must be scientifically broad and systems-based. Where appropriate, the NRPs will integrate efforts to avoid duplicative efforts, 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 is defined as the totality of exposures to combinations of chemical and non-chemical stressors and their effects on health, well-being, and quality of life outcomes.

It is the combination of these exposures and effects and any resulting outcomes 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, well-being, and quality of life 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 EPA and communities to address cumulative impacts from contamination, climate, and other chemical and non-chemical stressors on health, well-being, and quality of life.
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 lifestage 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	Help provide clean and adequate drinking water, 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., <i>Mycobacterium</i> , <i>Pseudomonas</i> , <i>Naegleria fowleri</i>).

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 (ethylene oxide).
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; CIECs, 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 CIECs (non-PFAS) in wastewater treatment systems and biosolids.