BOSC
BOARD OF SCIENTIFIC COUNSELORS

July 6, 2022

H. Christopher Frey, Ph.D.
Assistant Administrator, Office of Research and Development
U.S. Environmental Protection Agency

Dear Dr. Frey:

On behalf of the Board of Scientific Counselors (BOSC), I am pleased to provide you a review report addressing charge questions posed by the Office of Research and Development's (ORD) six National Research Programs.

The BOSC was reconstituted in 2022 with an Executive Committee, two subcommittees, and six workgroups aligned with each of the National Research Programs. This report represents the cumulative effort of the workgroups and the Executive Committee.

We anticipate that this report will assist ORD in evaluating the strength and relevance of these six research programs and aid in guiding further course adjustments to each program. We will be happy to provide any additional information concerning the review or answers to any questions you may have, and we look forward to working with you in the future on these programs.

Sincerely,

Paul Gilman, Ph.D.
Chair, BOSC

Lucinda Johnson, Ph.D.
Vice Chair, BOSC

Cc: Bruce Rodan, Associate Director for Science

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Tom Tracy, Designated Federal Officer

June 10, 2022

Federal Advisory Committee for the U.S. Environmental Protection Agency's Office of Research and Development

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BOARD OF SCIENTIFIC COUNSELORS

REPORT OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY BOARD OF SCIENTIFIC COUNSELORS AIR, CLIMATE, AND ENERGY WORKGROUP

RESPONSES TO CHARGE QUESTIONS

BOSC Air, Climate, and Energy StRAP Workgroup

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LIST OF ACRONYMS

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TOF	Total organic fluoride
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VCPs	Volatile chemical products
VOCs	Volatile organic compounds

INTRODUCTION

To protect human health and the environment, the U.S. Environmental Protection Agency (EPA) and its Federal, state, and other government partners and stakeholders must make critical decisions about the risks of exposures to environmental stressors. The primary focus of EPA's Office of Research and Development (ORD) is to provide the strong scientific and technical foundation the Agency relies on to fulfill its statutory obligations and help Agency, state, and other partners address their most pressing environmental and related public health challenges. The EPA has designed the Air, Climate, and Energy (ACE) program to develop and apply state-of-the-science research to characterize impacts on human and ecological systems – whether they result from exposure to single, complex, or multiple physical, chemical, or biological stressors – to support and improve EPA's risk assessment decisions. It is one of the Agency's six, highly integrated national research programs. The other five are Health and Environmental Risk Assessment (HERA), Chemical Safety for Sustainability (CSS), Homeland Security Research Program (HSRP), Safe and Sustainable Water Resources (SSWR), and Sustainable and Healthy Communities (SHC).

ORD prepares Strategic Research Action Plans (StRAPs) to guide its research planning over the ensuing 4 years, and beyond. The StRAPs are designed to guide an ambitious research agenda that delivers the science and engineering solutions the Agency needs to meet its goals now and into the future, while also cultivating an efficient, innovative, and responsive research enterprise. Currently, ORD is seeking input from the Board of Scientific Counselors (BOSC) on the draft 2023–2026 StRAP documents and proposed research strategies. The emphasis is on advancing ORD research that can successfully address the needs identified by EPA programs and regions, and states and tribes. This review by the BOSC ACE Workgroup is focused on strategic directions and proposed research priorities described in the draft ACE StRAP. Future BOSC reviews will address research activities and outcomes over the course of the StRAP implementation.

BACKGROUND

The overarching goal of the ACE National Research Program is to examine the interplay between air pollution, climate change, and the dynamic energy sector to develop innovative and sustainable solutions for improving air quality and taking action on climate change. The subject of this review is restricted to the 2023-2026 ACE StRAP.

CHARGE QUESTIONS AND CONTEXT

The ACE Workgroup was charged with two questions as follows:

> Q.1: Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 timeframe
>
> Q.2: With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Charge Question 1

> Q.1: Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 timeframe

Narrative

ACE Workgroup applauds ORD for its proposed work and investments in research methods as described in the draft StRAP. Air, climate, and energy issues range across wide scales in space (e.g., indoor to regional to global) and time (e.g., acute to chronic health effects), which demand innovative tools and multidisciplinary approaches that consider technological, social, cultural, behavioral, life stage, and economic factors. ORD has proposed an ambitious and balanced research portfolio with investments in new tools (e.g., low-cost sensors, satellite products) and scientific investigations on criteria pollutants, toxic air pollutants (e.g., PFAS, EtO), and emerging issues (e.g., wildland fire impacts, transformation of the Nation's energy and transportation systems). The StRAP matches the Administration's priorities of addressing the increasing risks posed by climate change and the disproportionate environmental burdens faced by low-income communities and communities of color. The Workgroup identified the following strengths of ORD's ACE program: developing new research methods, addressing critical emerging environmental needs, and investing in staff expertise. The Workgroup also provides suggestions and recommendations for ACE program leadership consideration.

ORD continues to be the Nation's key leader on air pollution research and played a significant role in developing the science-based approaches behind the large number of lives saved, health effects avoided, and economic benefits from progress on ambient air quality since the Clean Air Act in 1970. While the Workgroup strongly supports the reinsertion of climate change research in the ACE StRAP, the current Plan should better articulate ORD's unique role in the areas of climate change and energy, which are led by other Federal agencies in contrast to EPA's leading role on air pollution. The program, regional, state, and tribal (PRST) needs in these areas are much broader than what ORD can accomplish within its responsibilities, expertise, and available resources as part of the U.S. Global Change Research Program and toward the transformation of the Nation's energy and transportation systems. The ACE StRAP needs to more clearly identify the unique role of the ACE program in the areas of climate change and energy.

Strengths

- The ACE StRAP provides a logical flow of ideas structured by a well-conceived conceptual overview. Dividing the StRAP into Topic 1 (understanding climate change and air pollution impacts) and Topic 2 (responding to those impacts and preparing for the future) provides a sound structure with a clear, cohesive story to follow that is also able to encompass the wide breadth of research topics in ORD's portfolio.
- The StRAP provides a summary of how the proposed research outputs map to PSRT needs in Appendix 1, which are more fully described in Appendix 2. The PSRT needs come from regulatory drivers, Executive Orders, and listening sessions to determine stakeholder needs.

- The StRAP incorporates recommendations from past BOSC reviews such as improved accessibility and usability of products, attention to cumulative impacts, partner engagement throughout the research process, increased emphasis on chemical precursors to both ozone and $PM_{2.5}$, air toxics research, and more focus on research translation for stakeholders.

- Environmental justice is well embedded in the StRAP. For example, there is explicit mention of the need to ensure that costs and benefits of the clean energy transition are equitably distributed, with a focus on the environmental and public health issues associated with emerging energy systems (e.g., electrified end uses, renewables). The reference to citizen science and use of low-cost air quality sensors will facilitate more community involvement and augment regulatory networks with finer-scale data for scientists and non-scientists. The StRAP also reflects EPA's emphasis on more outreach and involvement of tribal entities.

- The StRAP recognizes the importance of framing air pollution and climate impacts on human and ecosystem health and incorporating community feedback to address these challenges. Examples include impacts to ecosystems from wildfires, floods, droughts, and changes in mean and extreme weather patterns, including impacts to ecosystems important to tribal culture and sustenance.

- The StRAP emphasizes multiple stressors – both chemical (e.g., criteria pollutants, air toxics) and non-chemical (e.g., extreme temperatures, noise, social factors) – that are needed for comprehensive cumulative health impact assessments. For example, the StRAP includes research on interactions between air pollution and climate change-related stressors (e.g., heat, aeroallergens) that affect human health.

- EPA will expand the capabilities of its air quality modeling systems used by many Federal and state/local/tribal regulatory permitting and toxics programs to address climate change and environmental justice priorities. Examples include improving the capabilities of the photochemical modeling system CMAQ for understanding wildfire smoke impacts and enabling linkages to global climate models and expanding the AERMOD dispersion modeling system to include improved representation of buildings, roadway barriers (e.g., sound walls), and NO_2 chemistry.

- The StRAP will assess interventions for compound and cascading disasters, which is an important area of research as the greatest health impacts are likely to be seen in these types of events.

Suggestions

1. The Workgroup suggests that ORD flesh out the climate change and energy components to match the robustness of the air quality component. For climate change, the StRAP focuses on its impact on extreme events (fire, floods), but less so on its other impacts (e.g., vector ecology, allergens, drinking water and food systems) and what these impacts mean for health and ecosystems. For energy, none of the two topics and nine research areas covered in the StRAP (Table 1) explicitly mention energy yet all feature air quality and climate change. In addition, the detailed research questions and outputs focus on air pollution with little mention of climate impacts or interventions. An important example of this is ACE.7 (Empowering Communities and Individuals to Improve Public and Ecosystem Health) which, while noting that local communities want information on how they can respond to air pollution and the changing climate, only includes outputs on air pollution (Appendix 1). The Workgroup suggests that ORD consider how to both translate knowledge *to* and incorporate knowledge *from* communities on the interventions that can be used to respond to

climate stressors, such as heat, drought, and flooding. In some cases, these will be the same as those used for air pollution (e.g., ACE.7.6 Community and Individual Strategies for Green Spaces and the Built Environment to Reduce Exposures to Air Pollution).

2. The Workgroup suggests that one possible area to integrate climate and energy with air quality is the sections on indoor environments. There is a justified emphasis on indoor air pollutants and obtaining a better understanding of individual- and population-level exposures through modeling of time-activity patterns and consideration of indoor environments (ACE.3). This may be an area where energy systems (e.g., indoor heating, cooling) could be better integrated. Indoor thermal environments are relevant to heat-health effects of populations—particularly environmental justice and other low-resource communities—but much of the current research on health effects does not account for indoor temperatures. A better characterization of the indoor thermal environment is needed. Consideration of energy justice (e.g., access to air conditioning and the broader system-wide impacts to energy systems) would also be important in this context and can be integrated with Output ACE.9.3. Indoor air quality and thermal comfort challenges will confront the United States and other countries as they seek to adapt to and mitigate climate change. Research will be needed on the implications of such factors as increased energy efficiency, building tightness, changing indoor source profiles, provision of healthy levels of fresh air while controlling temperature, humidity, and ambient pollution penetration (e.g., wildland fire smoke), and emerging and recurrent airborne pathogens such as COVID-19.

3. The Workgroup suggests that the StRAP encompass research on agricultural-related methane and nitrogen emissions because of their climate and ecosystem impacts, perhaps through collaboration with the Department of Agriculture. Landfill methane emissions are another under-studied area. Research in California indicates that individual super-emitting sources are found in the dairy/livestock and waste sectors and represent a disproportionally high fraction of methane emissions that could be targeted for mitigation. Progress in these areas could help facilitate the Global Methane Pledge (30% reduction by 2030) by the current Administration, as the agricultural and waste sectors are each responsible for approximately one-third of the Nation's methane emissions.

4. The Workgroup suggests prioritizing research devoted to near-term or immediate 'solutions' to reducing air pollutants or adaptation/resilience plans. This research is needed by communities now, given that many communities (particularly environmental justice communities) are already experiencing climate change impacts.

5. The Workgroup suggests that within the scope of research on compound and cascading disasters, EPA also consider the co-occurrence of natural and technological disasters (e.g., heat waves and power outages) as well as the interaction of natural disasters with legacy pollution (e.g., catastrophic flooding releasing fugitive contaminants from wastes sites, power outages interfering with the operation of pollution control devices) as these types of compound events are particularly concerning, especially for environmental justice communities.

6. The Workgroup suggests that Appendix 2 be strengthened by providing a high-level timeline of specific PRST needs that are anticipated within this 4-year period, such as NAAQS reviews, SIP deadlines (that may drive the modeling and analysis needed by states and tribes for developing their plans and regional EPA offices for reviewing them), and the Administration's climate change and

environmental justice targets. This should be based on the listening sessions with PRST partners and ORD's and ACE's research role and expertise.

7. The Workgroup suggests that a high-level description of EPA-sponsored extramural research be provided in the StRAP to give a more complete picture of the research program. The extramural research programs (e.g., existing STAR and ACE Center grants, Health Effects Institute support) address important environmental topics (e.g., health effects from low-concentration exposures, cumulative impacts of multiple-pollutants, organic carbon) that complement ACE intramural efforts undertaken by ORD staff.

Recommendations

The Workgroup offers the following recommendation:

> Describe the unique role of the ACE program in the Nation's collective climate change and energy research enterprise and identify the subset of PRST needs the program plans to address in these areas in coordination with the major research efforts by other Federal agencies and non- governmental entities

Charge Question 2

> Q.2. With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Narrative

As demonstrated by the ACE StRAP, EPA ORD has established itself as the leading Federal authority on research at the intersection of air pollution, climate change, and environmental and human health. The ACE StRAP lays out a comprehensive and thoughtful research agenda that takes into account both legacy (mostly air quality) and emerging (both air quality and climate) risks in the context of the changing climate and energy system challenges confronting the nation. The document as written has many strengths, as noted both here and in response to Charge Question 1. Recognizing the constraints that EPA faces in addressing the full range of these enormous and complex challenges, we offer several suggestions and two recommendations for areas that EPA should consider in further refining this excellent research plan to better address emerging public health and environmental challenges. Among the many strengths of the ACE StRAP, we highlight the valuable input from consultation with program, regional, state, and tribal partners; integration of environmental justice concerns throughout the document; emphasis on environmental health literacy; and emphasis on emerging needs and approaches. These latter include emerging challenges related to chemical and cumulative exposure/risk, systems and solutions-oriented thinking, and the importance of emerging technologies like low-cost sensors and remote sensing. We also suggest several ways in which the document could be further strengthened.

While climate plays a more prominent role in this StRAP than in recent ones, some aspects of ACE's climate change research could be further integrated. For example, there could be greater emphasis on the complex interactions among climate extremes, infrastructure failures, ecosystem changes, and human and environmental risks. There could be greater consideration of strategies to reduce the impacts of extreme heat in a warming climate, including indoor cooling, and opportunities to improve predictive modelling of extreme events such as heat waves that could lead to cutting-edge early warning systems and plans at appropriate geographical scales. Also, both climate change and the energy transition will have profound impacts on indoor environmental quality and health, with important EJ dimensions. The key role of ecosystems both as targets and indicators of climate impacts, as well as mediators of human risks, could be further developed. Finally, we raise two issues to the level of recommendations, the first focusing on the science of complex system interactions, and the second on the importance of forward-thinking research on unintended consequences from climate adaptation and mitigation solutions, especially on low-income communities and communities of color.

Strengths

- There is appropriate consideration given to program, regional, state, and tribal (PRST) needs related to monetized estimates of the health impacts of climate change, particularly for storms, flooding, agriculture, and heat (e.g., in ACE.6.2). Such assessment of the economic valuation of climate change impacts will be highly valuable in informing needed policies at multiple levels.
- There is a good level of integration of cross-cutting priorities for EJ and community resilience in the context of climate and air quality adaptation and mitigation. The document highlights the opportunity offered by the ongoing energy transition to address long-standing inequities in air pollution, climate exposures, and health risks.
- We appreciate the emphasis on environmental health literacy (sharing and understanding knowledge and data) and not just providing data/information.
- Several forward-looking approaches are incorporated, including a greater emphasis on multipollutant, systematic, and solutions-oriented approaches. For example, the StRAP recognizes the importance of taking a multi-pollutant, cumulative risk perspective in addressing local air quality problems for environmental justice communities, something EJ groups have been talking about for years. There is also a greater emphasis on a systems approach in the planning process, which should help early identification of emerging issues. The solutions orientation is also welcome given that we understand many of the exposure-risk relationships (especially for criteria pollutants) and are now in a better position to take action at the local and regional levels to reduce exposures.
- The strong emphasis on partner engagement in planning and implementation will help capture emerging challenges facing partners across diverse geographies, communities, and economic situations.
- With the success of the Clean Air Act in improving air quality (as measured by individual criteria pollutants at regulatory monitors), attention is now shifting to understanding multipollutant risks at "hotspots" that fall mostly "under the radar" of the regulatory monitoring system. The StRAP appropriately recognizes the need for new research approaches to address this challenge using emerging technologies such as low-cost sensors, remote sensing, and high-resolution modeling.

Suggestions

1. There could be greater emphasis on extreme heat and cooling options in adapting to climate warming. There are also opportunities around improved predictive modelling of extreme events such as heat waves that could lead to cutting-edge early warning systems and plans for states and tribes.
2. While indoor air quality is an area of historical strength in EPA's research program, IAQ (or more broadly indoor environmental quality – taking into account temperature and humidity) will undergo unprecedented changes in the face of climate, energy, and air quality transitions, and the additional challenges presented by emerging viral pathogens. This calls for new types of integrated research that ensures equitable access to healthy indoor environments.
3. While ecosystem impacts from air pollution are discussed, there could be greater emphasis on research designed to better inform EPA's setting of NAAQS secondary standards. In addition, research is needed to address how climate drivers will impact ecosystem services of interest to EPA's mission (e.g., water quality and air quality benefits, natural hazards protection provided by natural ecosystems). These ecosystems (e.g., coastal wetlands, coral reefs, urban green spaces and trees, watersheds) face risks from climate change, particularly around compound and indirect effects (e.g., impacts of drought, wildfires, and invasive species combined) and identification of tipping points (where ecosystems shift over to a novel state, with consequences for ecosystem services) is an important emerging area of research. In many cases, impacts on human health can occur downstream of these ecosystem impacts.
4. Given the need for carbon sequestration and negative carbon technologies, what are the health, food productivity, and other impacts (negative and positive) on communities?
5. Is there a role for EPA in geoengineering research (e.g., solar radiation modification) being conducted by other agencies?
6. Many states and tribes have established their own policies that impact air quality both indoors and out. Recent examples include municipal gas bans, oil and gas rulemakings, identifying and mitigating super-emitters, and changing building codes. Scientific and technical outputs from ACE can help inform partner thinking in these contexts.
7. In addition to increased floods and droughts impacting food supplies, other climate change factors (e.g., excessive heat) and ambient air quality (e.g., tropospheric ozone) impact crop yield. In addition, the growing of rice – the food that feeds most of the world – emits methane second only to beef production in the agricultural sector. ORD could work with USDA to study how climate change and ambient air quality, alone and in combination, impact crop yield, store carbon, and/or emit greenhouse gases.
8. Beyond solutions-driven research, consider investing resources in convergence research as defined by the National Science Foundation.
9. Enhance the ability and opportunity for real-time data collection and reporting of air toxics and the potential inclusion of low-cost sensors to measure these pollutants.
10. It was good to see the mention of renewables and other energy technologies, but the StRAP should explicitly call out the environmental/health impacts of low-carbon fuels (e.g., green/blue/grey hydrogen, ammonia, synthetic hydrocarbons) as an emerging topic, including the air quality and climate impacts of their production and use.

11. While the importance of air pollution health risks from wildland fires is emphasized, one topic seems missing: the question of the relative potency of wildfire PM vs. anthropogenic PM, which will be highly relevant in revisions to, and assessing compliance with, the NAAQS, particularly the short-term standard.

Recommendations

The Workgroup offers the following recommendations:

1. In studying and analyzing extreme events, where appropriate, include the complex interactions among climate extremes, cascading disasters, infrastructure failures, air quality, ecosystem changes, and environmental and human health effects across the ACE spectrum, as well as from cross-cutting perspectives including environmental justice, synergistic solutions, and emergent risks.

2. Develop, or participate in the development of, scientific guidance documents and tools that help partners identify and measure impacts on human health and the environment associated with maladaptation (often unintended consequences) as defined by the IPCC Sixth Assessment Report, which can not only harm but perpetuate social inequities.

    a. [For reference, the Working Group II contribution to the IPCC Sixth Assessment Report – Climate Change 2022: Impacts, Adaptation and Vulnerability uses the term "maladaptation" defined as follows (emphasis added): "Maladaptive actions (Maladaptation) Actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas (GHG) emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. *Most often, maladaptation is an unintended consequence." (IPCC, 2022)*]

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CHEMICAL SAFETY FOR SUSTAINABILITY WORKGROUP

RESPONSES TO CHARGE QUESTIONS

BOSC Chemical Safety for Sustainability StRAP Workgroup

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BACKGROUND

The overarching goal of the CSS National Research Program is to lead the development of innovative scientific methods and tools to reduce risks associated with exposure to chemicals in commerce, consumer products, food, and the environment. The subject of this review is restricted to the 2023-2026 CSS StRAP.

CHARGE QUESTIONS AND CONTEXT

The CSS Workgroup was charged with two questions as follows:

> Q.1: Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 time frame.
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> Q.2: With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Charge Question 1

> Q.1. Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 time frame.

Narrative

The FY2023-2026 CSS StRAP highlights the Program's valuable ongoing work as a global leader in chemical assessment. The document outlines methods, data, information, and tools being developed by ORD for use by EPA partners (i.e., EPA offices and regions, states, and tribes) to enable informed decisions about chemicals — including emerging contaminants — that involve potential risks to human and ecological health. The StRAP identifies and incorporates EPA's new crosscutting priorities (i.e., climate change, environmental justice, potential for early life-stage, susceptibility, mixtures, real-world exposures, and contaminants of immediate and emerging concern).

Many of the previous recommendations from the BOSC have been incorporated into the current CSS program portfolio, including improvements in describing relationships of the CSS research to other ORD and EPA programs, EPA partners' engagement, and mapping research areas to specific research outputs. The BOSC appreciates the increased effort put forward to ascertain and describe the needs of EPA programs and regions, states, and environmental justice and indigenous communities and to link these needs to CSS research areas. We encourage EPA to continue implementing the program as presented in the StRAP, taking into consideration the suggestions and recommendations specified below.

Strengths

- The StRAP reflects responses to past Workgroup comments with its improved overall clarity (e.g., definitions of key terms), emphasis on links between each output and partner needs, and descriptions of the practical utility of outputs.
- The CSS program continues to develop, advance, and apply novel predictive technologies for the assessment and management of chemical risks. CSS presentations to the BOSC Workgroup demonstrated that the methods, data, information, and tools currently provided to EPA partners (i.e., EPA program offices and regions, states, and tribes) and other stakeholders contribute to informed decisions about chemicals that pose potential risks to human and ecological health.
- The CSS program continues to use the RACTs (Research Area Coordination Team) to help identify and develop products that are responsive to partner and stakeholder needs and to support the iterative process of integrating feedback into product development. Effectively deployed RACTs are an especially notable strength.
- In addition to the RACTs, the CSS program engages broadly with different partners throughout the research cycle to identify and discuss products and outputs that are responsive to the needs of partners and other stakeholders. Engagement methods have included participation in dialogues and meetings, listening sessions, and workshops. This ongoing dedication to engaging with EPA partners is critical to ensure that research products are used effectively to deal with relevant environmental and public health challenges.

Suggestions

1. Drawing on CSS' global leadership in transforming chemical safety evaluation methods, the Workgroup suggests that EPA expand the StRAP description of EPA's relevant global activities in such venues as OECD and the Accelerating the Pace of Chemical Risk Assessment collaboration and delineate in the StRAP the EPA's outputs associated with these activities.

2. The Workgroup suggests that EPA integrate the fully designed ORD OCSPP Collaborative Research Program to Support New Chemical Reviews into the StRAP.

3. To better anticipate and meet the evolving needs of their partners, the Workgroup suggests CSS establish and implement (or describe in the StRAP if one already exists) a workable outreach and engagement process with other parts of the Agency (e.g., EPA Tribal Program Managers: https://www.epa.gov/tribal/epa-tribal-program-managers; HERA, etc.).

4. CSS continues to serve as a leader for developing innovative science, providing scientific expertise, and leading collaborations in numerous areas relevant to chemical safety assessment. With such a large scope of research, the need to juggle many partner needs, and the bold cross-cutting goals for all ORD programs, CSS would benefit from a clear process and criteria for prioritizing the numerous issues and activities with which it is tasked. A description of this process and criteria would strengthen the StRAP.

5. The pilot of the RACTs from the previous FY19-22 StRAP was successful and continues in this iteration of the StRAP. To promote a better understanding of the role and function of the RACTs, the Workgroup suggests adding an appendix to the StRAP with additional detail about how RACTs function. The appendix could describe the membership, processes, and engagement throughout the full cycle of product development, deployment, and evaluation. The Workgroup further suggests that RACT members should not only be involved in the review of individual Outputs and research products, but also contribute to modifications that might eliminate barriers to their uptake among CSS program partners.

6. Given the cross-cutting research theme of environmental justice, the Workgroup suggests that the StRAP indicate how elements related to environmental disparities (e.g., susceptibility and non-chemical stressors such as biological, physical, social and behavioral stressors) influence development of research tools. The StRAP could describe how the elements are integrated into the work of various research programs (CSS and HERA, in particular) to assure that products; are useful to communities most affected by these issues.

Recommendations

The CSS Workgroup offers the following recommendations:

1. **The CSS StRAP should clearly convey how the various outputs and activities are aligned and how they leverage and amplify each other in service of the StRAP objectives.** While the StRAP currently describes research areas and outputs, and generally provides a clear strategic plan and structure, it would benefit from details and selected examples of relationships between research areas and their outputs that amplify and leverage activities in service of CSS objectives. For example, the StRAP could be improved by describing how various outputs collectively contribute to the Office of Chemical Safety and Pollution Prevention's goal of transitioning away from animal testing of chemicals under the Toxic Substances Control Act and pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act.
2. **The CSS should describe in the StRAP the process or framework used to evaluate product uptake and use by its partners and stakeholders in and outside of the RACTs.** Such a process or framework is critical for documenting the effectiveness of the CSS program and whether its outputs are meeting partner, and where applicable, stakeholder needs.

Charge Question 2

Q.2. With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Narrative

The FY2023-2026 CSS StRAP provides a helpful description of the Program's approach to, and results from, its consultations with partners to identify public health and environmental challenges meriting research. CSS is now organized around three broad topic areas (Chemical Evaluation, Complex Systems Science, and Knowledge Delivery and Solutions-Driven Translation to Support Chemical Safety Decision Making) and integrates specific cross-cutting priority areas of climate change, environmental justice, early lifestage susceptibility, cumulative impacts, and contaminants of immediate and emerging concern. Notably, the newly prioritized research areas of climate change and environmental justice are now viewed as integral to the program and woven through all aspects of program activity, as opposed to standalone areas. These topic areas and cross-cutting considerations address a range of priority partner needs as well as those of the Agency, which positions CSS to address key issues at the forefront of environmental health. The consultations with partners are vital to ensure that CSS takes into consideration partner needs, including emerging or additional public health and/or environmental challenges.

This charge question asks whether there are other public health or environmental challenges beyond those currently being addressed by CSS that merit investment of CSS resources. Each Workgroup member could no doubt list many important challenges, but they might not necessarily be the most important ones for CSS's partners. For this reason, a more useful question is whether CSS has a systematic, efficient and effective horizon scanning process in place to help the program identify and prioritize emerging and additional public health and environmental challenges?

Strengths

- The StRAP describes how CSS has made significant efforts to understand and address the research needs of its partners.
- The StRAP clearly and effectively communicates the manner in which the CSS has incorporated the newer priority areas. This illustrates the ability of the program to effectively integrate new and emerging issues into its research areas.
- The CSS research areas integrate cutting edge science at the forefront of discovery that will contribute significantly to public health protection. This includes developing and establishing scientific confidence in computational, high-throughput screening assays and other *in vitro* NAMs, developing and establishing scientific confidence in AOPs, and developing and applying exposure and dosimetry prediction modelling methods for new and existing chemicals as well as chemical mixtures in the environment.
- While it is not referenced in the CSS StRAP, ORD led a global horizon scanning exercise in 2017 to solicit questions about the challenges in realizing the full potential of the AOP framework in supporting research and regulatory decisions (LaLone et al. 2017)[1].

[1] LaLone CA, Ankley GT, Belanger SE, Embry MR, Hodges G, Knapen D, Munn S, Perkins EJ, Rudd MA, Villeneuve DL, Whelan M, Willett C, Zhang X, Hecker M. Advancing the adverse outcome pathway framework-An international horizon scanning approach. Environ Toxicol Chem. 2017 Jun;36(6):1411-1421. doi: 10.1002/etc.3805. PMID: 28543973; PMCID: PMC6156781.

Suggestion

1. CSS should recognize that its partners and external stakeholders are likely uniquely positioned to provide input on certain emerging or additional public health and environmental challenges, and should include partner and stakeholder engagement as part of CSS' horizon scanning process. As such, the StRAP should outline a formal process by which to solicit input and feedback on research focus areas and new and emerging issues from relevant partners and stakeholders to ensure that input is received in an efficient manner and utilized to inform CSS activities to identify, prioritize and, as appropriate, take action within its research program on new and emerging issues. Partner and stakeholder feedback and engagement activities should be an integral component of research planning.

Recommendation

The CSS Workgroup offers the following recommendation:

> **CSS should articulate its approach to, and mechanisms for, horizon scanning to identify and prioritize and to act upon, as appropriate, new, emerging, and additional public health and environmental challenges.** An effective horizon scanning process is a critical component of organization strategic planning because lead times for developing new capabilities or adapting existing capabilities to emerging issues can be long. Ad hoc or episodic planning is not an effective alternative to an active horizon scanning process. This should include how CSS leverages the efforts and resources of its partners, how input is obtained from stakeholders, how emerging issues are evaluated (effectiveness in meeting partner needs, alignment with current activities, feasibility, etc.), prioritized (e.g., cost, feasibility, opportunity, mission need) and selected for action. Research investment decisions, will, by necessity, require EPA ORD and CSS to consider how strategic plan activities are subsequently adjusted (e.g., additional resources are obtained, or selected on-going activities are deprioritized) to accommodate new higher priority activities.

BOSC
BOARD OF SCIENTIFIC COUNSELORS

REPORT OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY BOARD OF SCIENTIFIC COUNSELORS HEALTH AND ENVIRONMENTAL RISK ASSESSMENT WORKGROUP

RESPONSES TO CHARGE QUESTIONS

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June 10, 2022

Federal Advisory Committee for the U.S. Environmental Protection Agency's Office of Research and Development

CONTENTS

LIST OF ACRONYMS

ACE	Air, Climate, and Energy
ARS	Agricultural Research Service
BOSC	Board of Scientific Counselors
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CMAQ	Community Multiscale Air Quality Modeling System
COMET	City-based Optimization Model for Energy Technologies
COVID-19	Coronavirus Disease 2019
CPHEA	U.S. EPA Center for Public Health and Environmental Assessment
CSS	Chemical Safety for Sustainability
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Policy Integrated Climate
EtO	Ethylene oxide
EV	Electric vehicle
FEM	Federal Equivalent Model
FRM	Federal Reference Model
GCAM-USA	Global Change Analysis Model
GHG	Greenhouse gas
GLIMPSE	GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator
GWP	Global warming potential
HERA	Health and Environmental Risk Assessment
HFCs	Hydrofluorocarbons
HS	Homeland Security
IAs	Interagency agreements
ICLUS	U.S. EPA Integrated Climate and Land-Use Scenarios project
IDF	Intensity, duration, and frequency
IPCC	Intergovernmental Panel on Climate Change
LASSO	U.S. EPA Locating and Selecting Scenarios Online tool
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NGEM	Next Generation Emission Monitoring
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
ORD	U.S. EPA Office of Research and Development
OTAQ	U.S. EPA Office of Transportation and Air Quality
PFAS	Per- and Polyfluoroalkyl substances
$PM_{2.5}$	Particulate matter less than 2.5 microns in diameter
PNNL	Pacific Northwest National Laboratory
RFS	Renewable Fuel Standard
SOAs	Secondary organic aerosols

SHC	Sustainable and Healthy Communities
SSWR	Safe and Sustainable Water Resources
StRAP	Strategic Research Action Plan
TOF	Total organic fluoride
USDA	U.S. Department of Agriculture
VCPs	Volatile chemical products
VOCs	Volatile organic compounds

INTRODUCTION

To protect human health and the environment, the U.S. Environmental Protection Agency (EPA) and its Federal, state, and other government partners and stakeholders must make critical decisions about the risks of exposures to environmental stressors. The primary focus of EPA's Office of Research and Development (ORD) is to provide the strong scientific and technical foundation the Agency relies on to fulfill its statutory obligations and help Agency, state, and other partners address their most pressing environmental and related public health challenges. The EPA has designed the Health and Environmental Risk Assessment (HERA) program to develop and apply state-of-the-science research to characterize impacts on human and ecological systems – whether they result from exposure to single, complex, or multiple physical, chemical, or biological stressors – to support and improve EPA's risk assessment decisions. It is one of the Agency's six, highly integrated national research programs. The other five are Chemical Safety for Sustainability (CSS), Air and Energy (AE), Homeland Security Research Program (HSRP), Safe and Sustainable Water Resources (SSWR), and Sustainable and Healthy Communities (SHC).

ORD prepares Strategic Research Action Plans (StRAPs) to guide its research planning over the ensuing 4 years, and beyond. The StRAPs are designed to guide an ambitious research agenda that delivers the science and engineering solutions the Agency needs to meet its goals now and into the future, while also cultivating an efficient, innovative, and responsive research enterprise. Currently, ORD is seeking input from the Board of Scientific Counselors (BOSC) on the draft 2023–2026 StRAP documents and proposed research strategies. The emphasis is on advancing ORD research that can successfully address the needs identified by EPA programs and regions, and states and tribes. This review by the BOSC HERA Workgroup is focused on strategic directions and proposed research priorities described in the draft HERA StRAP. Future BOSC reviews will address research activities and outcomes over the course of the StRAP implementation.

BACKGROUND

The overarching goal of the HERA National Research Program is to lead the development of innovative scientific methods and tools to reduce risks associated with exposure to chemicals in commerce, consumer products, food, and the environment. The Health and Environmental Risk Assessment (HERA) Program at EPA is focused on advancing the understanding of the effects that exposure to pollutants have on key biological, chemical, and physical processes that affect human health. The subject of this review is restricted to the 2023-2026 HERA StRAP.

CHARGE QUESTIONS AND CONTEXT

The HERA Workgroup was charged with two questions as follows:

> Q.1: Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023–2026-timeframe.

Q.2: With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Charge Question 1

Q.1: Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023–2026-timeframe.

Narrative

The HERA (Health and Environmental Risk Assessment) National Research Program of the U.S. Environmental Protection Agency Office of Research and Development (EPA ORD) devotes attention to both human and ecological/ecosystem health. This is a positive for this program and seems to differ from the draft StRAP for some of the other National Research Programs. More specifically, some other StRAPs focus attention primarily on human health, while the overarching goal for the EPA is protection of both human and ecological receptors.

It should also be noted that HERA, and the other five EPA ORD National Research Programs did a great job during the planning process for drafting the respective StRAPs of including, via meetings, listening sessions, etc., multiple partners outside of EPA regional offices, especially states across the 10 regions and federally recognized tribes. Moreover, HERA has made connections to other National Research Programs, explicitly with CSS, and indirectly (via a priori needs as shown during FFY 2019-2022) with ACE, HS, SHC, and SSWA. HERA appropriately supports EPA ORD entities (centers and laboratories) and other EPA offices nationwide. Overall, BOSC members want to ensure EPA ORD Programs and Centers are not siloed from one another relative to each organization's Research Areas and Outputs. Interactions and synergisms across ORD Programs and Centers need to be better elaborated upon and documented.

In addition, there is a common feature in the eyes of BOSC members that the HERA draft StRAP Research Areas and Outputs are currently described at a macro-level, and more specificity and detail are desired so that work (products or deliverables) is tied to actual Research Areas and Outputs. For example, EPA states they will address environmental justice concerns, which is a broad statement without specifics. In this example, EPA should consider including the incorporation of factors that affect health inequities including social stressors (e.g., pre-existing conditions, poverty, food insecurity, racism/discrimination, workplace factors).

BOSC members reviewing the current HERA StRAP also agreed that the new assessment methods (NAMs) recommendation for chemicals is vague and should provide specifics about what is intended to improve confidence in NAMs, including how HERA will integrate EPA's other priorities, including children's health and environmental justice within the overall StRAP. EPA ORD staff involved in HERA should also consider adding more text and detail about how they will continue to improve methods to ensure they are applying the best available science (Research Area 2) for evidence evaluation.

Strengths

- HERA appropriately provides attention and prioritization to both human and ecological/ecosystem health. This differs, in a positive way, from the draft StRAP for some of the other National Programs.
- HERA and the other five National Research Programs have done a good job during the planning process for drafting the StRAP of including via meetings, listening sessions, etc., multiple partners outside of EPA regional offices, especially in states across the ten regions and federally recognized tribes.
- We appreciate HERA connections to other National Research Programs, explicitly CSS and indirectly (e.g., via a priori needs during FFY 2019-2022) with ACE, HS, SHC and SSWA. However, more specificity relative to these connections is needed so that work (products or deliverables) is tied to actual RAs and Outputs.

Suggestions

1. HERA could better map the various federal executive orders (E.O.) discussed with the BOSC, as to how they are directly and indirectly relevant to EPA ORD research within the revised/final HERA StRAP. The BOSC suggests and encourages adding more detail and specificity within the descriptions of HERA Research Areas and Outputs (e.g., cumulative assessment, climate change/extreme weather events, environmental justice, and evidence-based decision-making). It is clear HERA intends to connect to the EPA StRAP's seven goals and 1st and 2nd cross-cutting themes, and ORD StRAP's cross-cutting research priorities for the six NRPs.

    a. For example, with respect to climate change, could we have more details about Outputs by EPA for the National Climate Assessment (with other agencies involved), given the current Administration's rejoined "2015 Paris Agreement"?

2. HERA should promote continued use of best practices for communications about use of Outputs. This is particularly relevant to systematic reviews (noted in multiple HERA RAs and Outputs) as well as continuing and ongoing work with NAMs and other Outputs. In general, BOSC members feel there is a lack of detail on Outputs in the draft StRAP, given that many products/deliverables are not listed or described with sufficient detail or specificity.

3. Similarly, BOSC members appreciate some repetition across the StRAP, but do suggest more specificity within the final StRAP research areas and output descriptions (e.g., some specific examples of work continuing from FFY 2019-2022 (besides lead/Pb2+ and PFAS) as well as for new work in FFY 2023-2026. There are explicit connections made between HERA and CSS in the draft FFY 2023-2026 StRAP (see pp.22-23 at Topic #2, RA #3, Output #3.1), which builds on the work BOSC reviewed and commented on in the final FFY 2019-2022 StRAP. This includes work with NAMs for testing new chemicals for toxicity, etc. However, there can be more text, specificity, and description about NAMs in terms of new outcomes and endpoints.

4. There are potential collaboration opportunities in new National Research Program work not only with CSS and SHC, but also with ACE and SSWA. Collaborative and coordinated efforts could include specific modern understandable tools (data-based, creating visual products) for cumulative assessment regarding ambient or outdoor air pollution from various point and non-point (area and mobile) sources in urban/suburban areas (small and large) with lower-income, minority populations, and in rural areas with tribes, sensitive ecosystems, and surface water resources critical to local water supplies for drinking and agricultural irrigation.

5. For HERA 2.3 Science Assessment Translation:

    a. Systematic reviews methods are continually evolving to incorporate the best available science and approaches and EPA should include a focus on methods for improvement and refinement. This should incorporate the National Academy of Sciences recent recommendations for further methods development, as well as evaluations of heterogeneity in risks. This would include expanding types of systematic review – in particular, methods for rapid reviews that can be responsive to immediate needs.

6. For HERA Topic #2, RA #3, Output #3.5:

    a. A broader category title for this RA and Output should be considered.

    b. Methods and implementation for dose-response modeling for non-cancer health effects (proposed name change).

    c. There are methods already developed by authoritative and regulatory bodies (e.g., WHO, OECD, USEPA) that have been applied for estimating noncancer health risks, and the need for dissemination of these tools is critical for the agency to be able to better account for the full range of potential health risks from chemical and other ambient/environmental exposures. EPA ORD should include a component in HERA similar to the systematic review methods, stated as "Training modules and outreach enhance communication regarding assessments and approaches, cultivating acceptance by stakeholders, providing transparency, and increasing understanding and engagement." In addition, EPA ORD should consider improving the basis of the distribution of variability due to factors and including children.

7. For HERA.3.5, Re: 'benefits analysis for noncancer health endpoints'...

    a. This text is somewhat vague and could consider adding the following specific suggestion.

    b. EPA ORD staff across national research programs should consider leveraging internal EPA resources (e.g., National Center for Environmental Economics in the EPA Office of Policy) and over the long-term work with HERA to consider specific work products to inform approaches to developing monetary values for important and relevant health endpoints. This could overlap with children and environmental justice community concerns, for example exploring age-related susceptibility to environmental stressors and better estimates for asthma etc. In addition, existing approaches, methods and models developed by authoritative and regulatory bodies (e.g., WHO, OECD, USEPA) for estimating non-cancer health risks should be applied in EPA risk evaluations to improve the basis for evidence-based decision making and account for a broad range of potential health risks. Finally, EPA should consider using the term ''risk- specific dose' instead of 'reference value' which would clarify that EPA is developing risk estimates for noncancer health effects. This language and approach have also been recommended by the National Academy of Sciences.

8. For HERA.3.2. Re: Advance the application and evaluation of cumulative risk assessment methodologies, including assessment of chemical mixtures...:

    a. BOSC members noted how under this recommendation EPA indicates that they will address environmental justice concerns. This statement needs more specificity and should convey the EPA intent to incorporate factors that may affect health inequities including social stressors (e.g., pre-existing conditions, poverty, food insecurity, racism/discrimination, workplace factors).

b. Thus, we suggest, EPA ORD - in HERA and other national research programs - should prioritize development of smaller area risk assessment tools (e.g., environmental justice concerns within an urban area or specific zip code areas or census tracts), such as within EPA's EJSCREEN and adding community relevant sub-county level estimation of exposures and risks within EPA's user friendly BenMAP-CE model.

Recommendations

The Workgroup offers the following recommendations:

1. Risk assessment tools useful to decisionmakers and the public should continue to be developed and applied, particularly to improve evidence-based decision making and to address health risks, including quantifying noncancer health risks, which are directly applicable to exposure and risk assessment in environmental justice communities, including children across age groups and developmental stages.

2. EPA ORD HERA staff should:
    - Incorporate factors that influence health inequities including non-chemical and social stressors and
    - Specify how potential health-related susceptibilities will be evaluated and applied in new assessment methods (NAMs) for chemicals.

Charge Question 2

Q.2. With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Narrative

HERA (Health and Environmental Risk Assessment) National Research Program of the U.S. Environmental Protection Agency Office of Research and Development (EPA ORD) has already identified PFAS (large group of persistent organic chemicals) and lead (Pb2+), the latter found in water from older mains and service lines as well as older homes (interior and/or exterior paint contaminating chips and dust on surfaces) as current areas of focus. The BOSC members discussed two key things requesting clarification. One, this seems to be a yes or no question versus a brainstorming question. Two, some emerging public health issues related to climate change and extreme weather events, including infectious diseases and underlying changes to human susceptibility and vulnerability due to SARS-CoV-2 (COVID-19), really cross multiple national research programs. In other words, HERA may work in a lead or supporting role with other U.S. EPA National Research Program areas (e.g., CSS, ACE, SHC).

HERA (e.g., Research Area #4) can invest in improved tools for identifying chemical and non-chemical stressors, which should be evaluated for potential health concern, including enhancement of computational toxicology/cheminformatics/machine learning tools that can be used to investigate hazard and exposure potential for chemicals with little empirical data that could pose a concern relative to human or ecological health effects.

Children's environmental health continues to be a priority, and the current EPA ORD HERA StRAP lacks specifics around how this focal area will be addressed within the different Research Areas and Outputs and associated work products or deliverables. For example, a specific work product could focus on how to address potential susceptibility in different subpopulations for various toxicological endpoints, using new assessment methods (NAMs) for chemicals. These results may then be compared with available

existing toxicological data to determine whether there is coherence or divergence in the respective data/approaches.

Strengths

- The draft HERA StRAP for 2023-2026 builds upon the final HERA StRAP for 2019-2022, including continuation of important work on PFAS, lead (Pb2+), and NAMs.
- The draft HERA StRAP reflects the current Administration's priorities noted by EPA ORD and EPA OSAPE staff reflecting increased emphasis on environmental justice, population health equity, children's environmental health, other susceptible, vulnerable sub-populations (e.g., lower-income communities and communities of color), federally recognized tribes, and cumulative impacts/cumulative exposure-response assessments.

Suggestions

1. We suggest HERA should develop more specific working relationships, including enhanced communications and collaborations, with relevant NIH institutes (e.g., NIESH, NIAID, NICHD) in addition to the NTP (National Toxicology Program) that have similar/focused work (e.g., health inequities, chemical exposures, children's health). BOSC members have acknowledged that some historical initiatives were discontinued due to cancellation of funding for the (now closed) National Children's Study, Children's Environmental Health EPA/NIH-funded Research Centers, etc.

   1a. *Please note from the prior review of the 2019-2022 StRAP review process by the BOSC: BOSC SHC recommended, for 2019-2022, increasing EPA ORD involvement in NIH/OSHA SBIR/STTR Phase I and II extramural grant mechanism to complement intramural ORD research for HERA and other NRPs/RAs.*

2. With respect to increasing connections between HERA and ACE, we suggest more research is needed pertaining to the six main criteria air pollutants subject to regulation as well as chemical toxicants adsorbed/attached to particulate matter (across size fractions). This could potentially yield important insight on other characteristics of particulate matter (across size fractions), including information by source sectors and/or composition. Focused research could also include chemical pollutant mixtures and chemical-physical agent co-exposures as well as chemical and non-chemical agent co-exposures. Given the experience in 2020-2022 of SARS-CoV-2 (COVID-19), HERA could consider potential interactions by mixtures of particulate matter (across size fractions) with aerosolized viruses for inhalation exposures.

These next two suggestions pertain to environmental data used with toxicology and epidemiology data for assessments conducted by EPA ORD HERA staff and other NRP staff (ACE, etc.). For maximum clarity, we cited three components of the HERA StRAP and one specific component of the ACE StRAP.

- Re: Topic #1, RA #1, Outputs #1.1, 1.2 in HERA
- Re: Topic #2, RA #3 and #4, Outputs #3.2, 3.4, 3.5, 3.6 and 4.1 in HERA
- Re: Topic #1, RA #1-#5 as well as Topic #2, RA#7 in ACE

3. With respect to increasing connections between HERA and ACE, EPA ORD should emphasize improvement of air toxics modeling, with a focus on improving the emissions inventory. Additionally, more research is needed on air toxics related to oil and natural gas development (extraction, use, and emissions) in terms of both human and ecological exposure and exposure/dose-response assessments.

4. With respect to ecological health/ecosystems, HERA could more fully explore the impacts of the oil and gas extraction process, beyond current (ongoing and new) work on measured water quality parameters and the treatment of wastewater contaminated with pollutants/chemicals resulting from the fracking process. Methods used in this work could help address environmental justice concerns (human and ecological health in rural areas). For example, EPA ORD HERA staff, and other EPA ORD staff in other NRPs could examine sentinel and indicator species in surface waters. To date, methane as a greenhouse gas, emitted directly or from unintentional leaks, and potential outdoor- to-indoor air pollutants and fire/life safety risks, has received more attention than fracking wastewater issues. In summary, we suggest EPA ORD staff and other national research programs in collaboration with HERA staff and others within EPA, can better inform future energy policy and climate action health and environment benefits analyses with research (models and tools) and regulatory impact analyses, respectively. For example, directly compare the emissions and environmental and human health impacts among the various fossil fuel combustion and alternative energy options. These include, for illustrative examples, research on differences in:

    - Particulate matter emission characteristics by source-sector;
    - Impacts on surface water resources used as sources of drinking water and agricultural irrigation;
    - Impacts on land use related to agriculture, erosion control, green spaces (e.g., parks, recreation, etc.) and cultural protection/preservation, including tribal lands.

5. HERA Topic #2, RA #3, Output 3.5: We suggest EPA ORD should both move to implement improvements to existing methods for human health and environmental or ecosystem health science assessments as well as use multiple existing data sources and methods to move to implementation/dissemination to help contribute to evidence-based decision making in support of the Executive Orders (E.O.) by past and current Administrations. This includes efforts pertaining to chemical and non-chemical stressors, NAMs, children's health, and environmental justice, e.g., use the Social Vulnerability Index or SVI, to identify and help lower-income communities and communities of color.

6. HERA Topic #2, RA #3, Output 3.1: 'Build confidence in the application of NAMs and data in human health risk assessment': We suggest some further clarifying details could be presented by EPA ORD in the HERA StRAP. What are the various NAMs approaches that EPA is presently using to evaluate chemicals and children's potential susceptibility? This would include model systems that capture response from developmental exposures and how this response may differ from adult/mature organisms. Also, we suggest EPA ORD HERA improve and clarify details of, and examples for, definitions on non-chemical social stressors in cumulative assessments. The plan should include social vulnerabilities that have been used by other agencies, e.g., U.S. Centers for Disease Control and Prevention's Social Vulnerability Index. Also, given the experience in 2020-2022 of SARS-CoV-2 (COVID-19), HERA can incorporate verified changes in human susceptibility and vulnerability.

    6a. *Note*: The Social Vulnerability Index uses 15 metrics to create an index: Below poverty; unemployed; income; no high school diploma; age 65 or older; age 17 or younger; older than age 5 with disability; single parent households; minority; speaks English "less than well"; multiunit structures; mobile homes; crowding; no vehicle; group quarters.

    6b. Reference: https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

7. We suggest HERA evaluate other small-scale spatial data layers that could be developed for local communities to improve exposure-response assessments (e.g., in geographic information systems). This has both environmental justice and children's environmental health relevance.

7a. The U.S. EPA CHPAC report/letter related to recent reform of the Toxic Substances Control Act (TSCA), in 2020-2021, focused on prenatal to adolescent time periods. For a copy of this letter/report and its appendices, see: https://www.epa.gov/children/chpac-2021-letters-chemical-prioritization-and-data-needs-protect-childrens-health-under. [In reference here, pp. 41-43 of the letter/PDF online show maps of chemical discharges (from use of data from U.S. EPA EPCRA TRI, etc.) and community-level social vulnerability.]

Recommendations

The Workgroup offers the following recommendations:

1. EPA ORD staff and other national research programs, in collaboration with HERA and others within EPA, should expand and improve inputs, including data sets and models, to allow better quantification of the health and environmental benefits in research and regulatory impact analyses of competing future energy, climate action, and environmental policies.
2. EPA ORD staff across national research programs working with HERA should use existing approaches, methods, and models for human health and environmental or ecosystem assessments to substantially contribute to evidence-based decision-making that supports implementation of Executive Orders.

BOSC

BOARD OF SCIENTIFIC COUNSELORS

REPORT OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY BOARD OF SCIENTIFIC COUNSELORS HOMELAND SECURITY WORKGROUP

RESPONSES TO CHARGE QUESTIONS

BOSC Homeland Security StRAP Workgroup

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June 10, 2022

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LIST OF ACRONYMS

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CO	Carbon monoxide
CO_2	Carbon dioxide
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COMET	City-based Optimization Model for Energy Technologies
COVID-19	Coronavirus Disease 2019
CPHEA	U.S. EPA Center for Public Health and Environmental Assessment
CSS	Chemical Safety for Sustainability
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Policy Integrated Climate
EtO	Ethylene oxide
EV	Electric vehicle
FEM	Federal Equivalent Model
FRM	Federal Reference Model
GCAM-USA	Global Change Analysis Model
GHG	Greenhouse gas
GLIMPSE	GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator
GWP	Global warming potential
HERA	Health and Environmental Risk Assessment
HFCs	Hydrofluorocarbons
HS	Homeland Security
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IDF	Intensity, duration, and frequency
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LASSO	U.S. EPA Locating and Selecting Scenarios Online tool
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NGEM	Next Generation Emission Monitoring
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
ORD	U.S. EPA Office of Research and Development
OTAQ	U.S. EPA Office of Transportation and Air Quality
PFAS	Per- and Polyfluoroalkyl substances
$PM_{2.5}$	Particulate matter less than 2.5 microns in diameter
PNNL	Pacific Northwest National Laboratory
RFS	Renewable Fuel Standard
SOAs	Secondary organic aerosols

SHC	Sustainable and Healthy Communities
SSWR	Safe and Sustainable Water Resources
StRAP	Strategic Research Action Plan
TOF	Total organic fluoride
USDA	U.S. Department of Agriculture
VCPs	Volatile chemical products
VOCs	Volatile organic compounds

INTRODUCTION

To protect human health and the environment, the U.S. Environmental Protection Agency (EPA) and its Federal, state, and other government partners and stakeholders must make critical decisions about the risks of exposures to environmental stressors. The primary focus of EPA's Office of Research and Development (ORD) is to provide the strong scientific and technical foundation the Agency relies on to fulfill its statutory obligations and help Agency, state, and other partners address their most pressing environmental and related public health challenges. The EPA has designed the Homeland Security (HS) program to develop and apply state-of-the-science research to characterize impacts on human and ecological systems – whether they result from exposure to single, complex, or multiple physical, chemical, or biological stressors – to support and improve EPA's risk assessment decisions. It is one of the Agency's six, highly integrated national research programs. The other five are Health and Environmental Risk Assessment (HERA), Air, Climate, and Energy (ACE), Chemical Safety for Sustainability (CSS), Safe and Sustainable Water Resources (SSWR), and Sustainable and Healthy Communities (SHC).

ORD prepares Strategic Research Action Plans (StRAPs) to guide its research planning over the ensuing 4 years, and beyond. The StRAPs are designed to guide an ambitious research agenda that delivers the science and engineering solutions the Agency needs to meet its goals now and into the future, while also cultivating an efficient, innovative, and responsive research enterprise. Currently, ORD is seeking input from the Board of Scientific Counselors (BOSC) on the draft 2023–2026 StRAP documents and proposed research strategies. The emphasis is on advancing ORD research that can successfully address the needs identified by EPA programs and regions, and states and tribes. This review by the BOSC HS Workgroup is focused on strategic directions and proposed research priorities described in the draft HS StRAP. Future BOSC reviews will address research activities and outcomes over the course of the StRAP implementation.

BACKGROUND

The overarching goal of the HS National Research Program is to lead the development of innovative scientific methods and tools to reduce risks associated with exposure to chemicals in commerce, consumer products, food, and the environment. The subject of this review is restricted to the 2023-2026 HS StRAP.

CHARGE QUESTIONS AND CONTEXT

The HS Workgroup was charged with two questions as follows:

> Q.1: Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 time frame.
>
> Q.2: With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Charge Question 1

> Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 time frame.

Narrative

The Homeland Security Research Program (HS) undertakes scientific research that delivers timely information and tools to federal, state, tribal, and local decisionmakers and stakeholders as they endeavor to strengthen community resilience – on an equitable basis – to catastrophes involving environmental contamination that endanger public health and welfare.

Three interrelated topics comprise the HS research portfolio: contaminant characterization and risk assessment, environmental clean-up and infrastructure remediation, and community engagement and systems-based tools supporting equity in resilience to extreme events.

To ensure that its science translates into interventions that are relevant, feasible, and effective in real-world settings, HS applies Solutions-Driven Research (SDR) principles. The SDR approach involves among other things, engaging in ongoing dialogue with partners across the entire research process life cycle and coordinating/collaborating with other ORD researchers.

HS has an experienced and scientifically diverse staff which has allowed them to develop a wide variety of products over a number of years on a limited budget. The products consist of sampling and analytical methods, remediation procedures, databases, modeling, and software applications. Recent work aims to integrate legacy and new products in the Remediation Data Repository (RADAR), a web-based portal that is accessible to states, tribes, local communities, other partners, and other users.

Strengths

- Exhibiting strong core technical programming, in which more social science is being integrated, as is attention to environmental justice issues.
- Maintaining a clear scheme for solutions-oriented research that ably integrates top-down (e.g, Administration, Agency) and bottom-up (e.g., state/local partners, practitioner associations) direction/feedback. Agency and Administration communications, for instance, include executive orders and memos (e.g., OMB/OSTP high-level priority memos) and interagency reports to address government priorities such as confronting the climate crisis, advancing racial equity and support for underserved communities, and restoring trust in government for scientific integrity. In response, the HS has integrated community level (state/local partners, practitioner associations, etc.) feedback to evolve and elevate a new research area (communities, resilience, and remediation) to rapidly assess and address community-based needs related to the climate crisis and associated environmental justice concerns.
- Using multiple methods to engage partners in the development of the HS StRAP FY23-26, including recurring exchanges 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; and participation in EPA state and tribal organizations meetings (e.g., Tribal Science Council).

- Manifesting a genuine and mature systems-level understanding of the interface between technical and social arenas. For instance, HS sees emergency mitigation, characterization, environmental cleanup, operations management, waste management *and* community engagement as linked activities. The program demonstrates a mature vision of environmental contamination management as something *done with* the community, rather than something *done to* the community. Moreover, a HS social scientist assumed a leadership position in the chemical incident workgroup, ensuring true integration and avoiding a siloing of physical and social sciences.

Suggestions

1. **Increase opportunities to engage/ partners/stakeholders (especially the utilities), discern their views, address practical needs, and market HS resources.**

   1a. **Establish and strengthen collaborations and communication efforts with professional societies and associations that have mission alignment** (e.g., American Council of Independent Laboratories, Association of Public Health Laboratories, Water Environment Federation, and American Water Works Association): The StRAP demonstrates HS's efforts to connect with internal EPA partners and state/local partners, but gaps remain. For instance, "Area 4: Water Systems Incident Response Support" largely targets the water and wastewater utilities, yet critical infrastructure stakeholders are unmentioned in the proposed StRAP's "Partner Engagement" section (although called out in the oral presentation); presumably these relationships are left to EPA's Office of Water to handle. In previous StRAP reviews, the BOSC has questioned this disconnect between HS and the utilities.

   1b. **Obtain customer comments and satisfaction data to guide current/new project developments:** e.g., develop and deploy online questionnaires among RADAR end-users to gather their feedback; host workshops on HS's products at professional conferences to solicit feedback, identify emerging needs, and improve market awareness.

   1c. **Develop a recruitment strategy to hire researcher(s) with expertise in utilities' concerns, needs, operations, and culture.** This would enhance the focus of HS's utility-directed programs and ability to liaise with utilities and their associated professional organizations, e.g., Water Environment Federation. Credentialed candidates can be found at water/wastewater engineering services firms and university graduate schools.

   1d. **Assist local utilities in anticipating adverse situations**: Develop inventory of potential contamination that may result from a natural disaster, e.g., flood, hurricane, tornado, etc.

2. **Improve the fidelity of HS products to the real-world social conditions in which mitigation and remediation decision-making and activities will take place.**

   2a. **Incorporate socioeconomic and demographic data in remediation simulations**: Recognition exists that sufficient/objective data and evidence-informed decision making are principal foundations for achieving equity in emergency mitigation, characterization, environmental cleanup, operations management, and waste management. A deficit, for instance, in the

COVID-19 response has been the often-missing data concerning racial/ethnic disparities in pandemic impacts and in access to medical resources (e.g., COVID-19 vaccination).

2b. **Ensure community engagement work accounts for heterogeneity and conflict:** As the HS StRAP notes, responders need to navigate community power dynamics and stakeholder conflicts that affect environmental cleanup. This point cannot be stressed too much. The notion of "community" often assumes homogeneity and social cohesiveness. In addition to racial/ethnic groupings, researchers should be attuned to other forms of internal differentiation (e.g., gender, age, employer/employee) that affect expressed concerns.

3. Augment work in the area of contaminant characterization.

3a. **Consider development of rapid characterization methods.**

3b. **Develop capabilities to address persistence, movement, and related phenomena** to understand exposure risk and inform mitigation and remediation decisions – include potential degradation products that may pose a risk to public health.

3c. **Develop rapid testing methods to determine contaminants and extent of contamination:** Research will continue, but be scaled down, on online contamination detectors, transitioning to a focus on pilot-scale detection capability and management of sensor data in Federal Risk and Authorization Management Program (FedRAMP) approved clouds.

Recommendations

The Workgroup offers the following recommendations:

1. **Develop a flow diagram for contacts, analyses, reporting, remediation, and waste management in response to an incident** – streamline process. This flow diagram should be developed in partnership with the interagency (i.e., across federal agencies and departments), and nationwide, in tandem with relevant local, state, and university stakeholders. The processes of remediation and response require absolute coordination across the federal, state, and local governments and jurisdictional authorities. Partnerships will be essential to successfully meet the mission. If EPA does not feel supported to pursue these issues in the interagency, then the agency should advocate with OSTP, OMB, and EPA leadership to create the needed partnership mechanisms in the NSTC and other policy bodies so the long-term, sustained funding is available for these programs.
2. **Test, and perhaps refactor, products listed in RADAR** to ensure that they run properly on cellular enabled devices like iPads and Android tablets with mobile browsers. These have become extremely common in so many utility operations, with even the smallest (under 2000 connections) systems adopting them. In the case of a natural disaster, decontamination event, or etc., it is far more likely that Utility personnel will have their phone or tablet with them in the field, where they would need to use the software products.

Charge Question 2

With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Narrative

Sixty percent of new pathogens are estimated to come from animals. Loss of biodiversity brought by habitat destruction and global warming is increasing the emergence of diseases that spread from animals to people, including coronaviruses and other respiratory illnesses from bats and birds, and diseases transmitted by insects, such as West Nile encephalitis. In the past, human infections were repressed by our planet's sub-climates and spatial buffers between people and the wild.

In 2019 nearly 5 million deaths were linked to antimicrobial infections, which could increase to 10 million deaths per year by 2050 unless corrective measures are taken. Eighty per cent of the world's wastewater is untreated, and many treatment plants in developed countries cannot remove dangerous pathogens. This creates conditions for breeding antimicrobial resistant infections that might trigger a pandemic. Many diseases are climate-sensitive, suggesting a potential increase in the spread of bacterial, viral, parasitic, fungal, and vector-borne diseases.

Ukraine's Ministry of Environmental Protection and Natural Resources recorded at least 1,200 environmental disasters in the first 2+ months of Russia's invasion, creating health risks that will last long after war ends. Chemicals released in warfare have numerous pathways to humans via soil and surface water contamination. Atmospheric soot, sulfur, and aldehyde have respiratory and cardiovascular consequences. Munitions containing highly toxic phosphorus used by the Russians can burn in the air for hours. The Russian occupation at Chernobyl disturbed the ground and started fires that may have widely spread radioactive particles.

Sources

- https://www.propublica.org/article/climate-infectious-diseases
- https://www.unep.org/news-and-stories/story/how-drug-resistant-pathogens-water-could-spark-another-pandemic
- https://www.rollingstone.com/culture/culture-news/ukraine-russia-war-climate-destruction-crime-1347742/

Strengths

- Demonstrated skills and flexibility to quickly assemble and deploy resources for unforeseen events, e.g., responses to anthrax, Ebola, and COVID-19
- HS research supports the development of overall community resilience, that is, an ability to withstand/adapt to any hazard, even unforeseen or emergent threats. HS is undertaking research that can enhance community resilience to CBRN incidents and other disasters, including developing decision support tools and resources for state/local partners to use in disaster preparedness, response, and recovery, and generating resources, tools, and trainings

for risk communication, outreach, building relationships, and community engagement. By working on ways to strengthen decision-making and to inform/involve affected communities, HS continues to build upon comprehensive, all-hazards emergency management capabilities.

- Identified needs and potential outputs to address them.
- Identified need to determine fate and transport of contaminants

Suggestions

1. **Attend/adapt to all-hazards landscape as seen in the Russian-Ukrainian conflict** – revisit the current tools for nuclear, radiological, chemical, and biological hazards to ensure that they are up to the task of incident management, e.g., lab capacity to handle wide area characterization and waste stream management, cybersecurity as new capabilities emerge.
2. **Improve capabilities in radiochemical methods, resources, training, and workforce to enhance mitigation and remediation**: Despite the expertise noted in the HS StRAP, the need for maintaining and improving upon existing capabilities is widely recognized. EPA also has responsibilities, but less specific experience, in remediating CBRN contamination intentionally released over wide areas—including indoor and outdoor areas and impacting critical infrastructures and water systems. Given the breadth and magnitude of potential scenarios, these releases pose a significant challenge with long-standing consequences. HS activities on this topic aim to fill the most critical scientific gaps in the capabilities of EPA's response community so that, when needed, EPA can make and support the most informed mitigation and remediation decisions.
3. **Develop process to identify non-target contaminants.** Place greater focus on non-targeted compounds – even if they are not regulated contaminants, they may present the potential for adverse public health impacts.
4. **Develop strategies to assess and evaluate long-term impact of contamination events,** e.g., 6 months, 1-year, 2-years, decade.
5. **Develop methods to rapidly assess efficacy of disinfection/neutralization procedures.** HS should continue the great work coordinating across the agency as well as other agencies and academia generating data to support these methods and processes.
6. **Evaluate learning and participation opportunities related to climate-driven spread of diseases and the environmental impacts of war**. Many diseases have a sensitivity to climate; evolving environmental conditions and temperature changes may lead to an increase in the spread of bacterial, viral, parasitic, fungal, and vector-borne diseases. War must be included among the extreme events that the HS considers alongside natural disasters, pathogens that cause communicable diseases, covert release of chemicals, oil spills and other technological accidents, and agricultural incidents with animal and crop diseases.
7. **Better characterize exposure risk to the public:** Maintain data on emerging contaminants and associated risks to prioritize research investment.

8. **Consider the growing cannabis industry**: What are the implications for environmental and public health?

Recommendations

The Workgroup offers the following recommendations:

1. **Develop full scale exercises** to test preparedness tools, capability, and capacity, and to strengthen in advance of an incident relationships across agencies, sectors, etc. – relationships that can be quickly and effectively mobilized in an emergency.
2. **Establish specific and dedicated research capabilities and work with agencies like CISA.gov to prepare minimum cybersecurity standards for the water and wastewater industries**. While it is extremely positive to see how cybersecurity posture and maturity in the water and wastewater space are discussed more often than in recent years, it continues to be one of the areas that needs more research to drive policy.

BOSC
BOARD OF SCIENTIFIC COUNSELORS

REPORT OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY BOARD OF SCIENTIFIC COUNSELORS SUSTAINABLE AND HEALTHY COMMUNITIES WORKGROUP

RESPONSES TO CHARGE QUESTIONS

BOSC Sustainable and Healthy Communities StRAP Workgroup

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June 10, 2022

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Narrative

The 2023-2026 StRAP is a great stride towards fulfilling EPA's renewed focus on climate change and environmental justice, which are critical for sustainable and healthy communities. The Sustainable and Healthy Communities (SHC) Workgroup of EPA's Board of Scientific Counselors commends EPA ORD's emphasis on these issues as well as the translational aspects of research, including the need for technical assistance and consulting with Tribes as well as States, Territories, and EPA Regions, and to understand their research needs. We offer several suggestions that could improve clarity, including clarifying definitions, broadening partnerships, the scope of technical assistance, priorities, and relationships to other programs. We also offer a number of substantive suggestions, including ideas to improve evaluation and the integration of cross-cutting concerns and executive orders/memoranda (particularly those related to tribal consultation). We recommend that EPA ORD SHC develop a specific method for integrating cross-cutting concerns, considering whether and how they apply to each Research Area.

Strengths

- **Themes:** We appreciate the emphasis on themes that were missing from the previous StRAP, including the community lens, equity, climate change impacts, resilience, and environmental justice—themes that align with those in the 2022-2026 EPA Strategic Plan.[2] There is increasing recognition of the impact of the climate crisis on communities, and how it impacts the SHC research topics.
- **Technical Assistance**: The StRAP shows that EPA ORD SHC is aware of the need for technical assistance to support their research.
- **Tribal Consultation:** Overall, EPA is increasing consultation with tribes in its research plans and other areas.
- **Appendix 2**: Appendix 2 (Descriptions of Program, Regional, State, and Tribal (PRST) Needs) is quite clear and useful and should improve collaboration between ORD and these partners.

Suggestions

1. **Clear definitions**: The StRAP should define certain terms or consistently use the same term to avoid confusion (e.g., community science vs. citizen science; community revitalization; resilience; and community mentalities).

2 See https://www.epa.gov/system/files/documents/2022-03/fy-2022-2026-epa-strategic-plan-overview.pdf.

2. **Partners:** EPA ORD may want to consider broadening the definition of Partners to include local communities. On page vi, the current definition of "Partners" is "An EPA program office, EPA region, representative of a state, or a representative of a tribe—often referred to as PRST." Local communities are missing from this definition, despite the fact that many issues of importance to SHC emerge at the community level (e.g., community resilience and environmental justice), and the importance of communities is emphasized throughout the StRAP.[1]

3. **Technical assistance**: Some sections (e.g., SHC Topic 1, Research Area 1) refer to technical support as research objectives, and it is not clear if the intent is to conduct research on technical assistance, or merely to provide it. EPA may want to clarify how the technical support relates to the research, e.g., is it assisting states with translating research outcomes?

4. **Priorities**: EPA ORD SHC may want to clarify which topics and research areas are priorities, if that is possible, or whether all research areas are receiving equal emphasis. If some research areas will take priority over others, topics and research areas in the StRAP could be arranged in the order of importance.

5. **Relationship to other programs**: EPA ORD may want to clarify the relationship between SHC and other programs. For example, Research Area 5, horizon scanning for chemicals of emerging concern, or other threats, could take place in most ORD programs. Is SHC collaborating with other programs for this research area?

6. **Appendix 1 structure**: Appendix 1 may need to be restructured somewhat to avoid confusion, particularly in terms of the presentation of "PRST Needs." For example, PRSTs do not *need* "contaminated sites." The "PRST Needs" column might be better titled as "PRST Concerns," or the wording in the column could be changed to action items such as "clean up contaminated sites," or "reduce exposures to contaminants associated with contaminated sites", etc. It may also make sense to reorder the appendices such that the current Appendix 1 relating outputs to needs is placed after the appendices outlining the outputs and the PRST Needs.

7. **Evaluation**: Evaluation can be an area of research that ORD takes on (e.g., evaluating the efficacy of technical assistance); it can also be a "quality control" component of the StRAP that evaluates the achievement of the StRAP Outcomes. We offer suggestions on both aspects:

    7a. *Research to evaluate*: EPA ORD is already carrying out research to determine the effectiveness of potential interventions (e.g., remediation of contaminated groundwater at Superfund and mine waste sites through Outputs SHC.2.2, SHC.2.3, SHC.2.4 and technologies to address LUST under Research Area 4). EPA ORD may want to consider evaluating social science aspects such as whether an intervention to increase community engagement is building community capacity. ORD does this to some extent through Output SHC.10.3 (evaluating the effectiveness of actions to prepare for resilience and climate change), but there may be a need for a more robust

[3] For example, the Executive Summary of the StRAP says, "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." The Partner Engagement section on p. 6 refers to "Listening sessions with external partners, including state, tribal, and local partners."

evaluation that operationalizes resilience and community capacity. Evaluation of natural experiments and circumstances beyond the control of EPA and communities may inform the efficacy of environmentally-relevant interventions. For example, given the long time required from listing to cleanup of Superfund sites, ORD could explore how the Superfund process can increase community capacity.

7b. *Evaluation of StRAP execution*: The StRAP indicates that: "SHC will measure its progress over the next four years by increasing the percentage of research products that meet partner needs" (p. 5). But it is unclear how this will be assessed. For example, is there baseline data on "the percentage of research products that meet partner needs"? The StRAP could include a plan for evaluating whether the proposed outputs are achieved as intended and whether they are having the desired results.

8. Environmental Justice (EJ) and Cross-Cutting Areas:

8a. *Method for analysis*: Certain research areas (e.g., SHC Research Areas 2.5, 3.2, 4.2, 6.3, 9.2, 10, 11) have much greater emphasis on environmental justice (EJ) than others. Because EJ is a cross-cutting issue, EPA ORD SHC should carefully consider whether and how it may apply to each research area. For some areas such as lead exposure, LUSTs, and chemical of emerging and immediate concern, the distributional EJ connection is obvious. For other research areas, EJ may be applicable but in less obvious ways, particularly where EJ concerns relate to procedural issues (e.g., lack of community voice in government decision-making), yet EJ is not mentioned. For example, EJ should be integral to "SHC.5 Chemicals of Emerging and Immediate Concern," including Outputs SHC.5.1-SHC.5.4, as well as "SHC.9.3 Increasing Environmental Benefits and Community Involvement." EJ (and all cross-cutting themes) should be integral to "SHC.11.2 New Nationwide Indicators" and "SHC.11.3 Identify and Implement ROE Extensions." There is a need for a methodology to systematically consider EJ concerns that are present or may be present in the future for each research area. The same applies to the other cross-cutting concerns, including Climate Change, Cumulative Impacts, Community Resiliency, Children's Environmental Health, and Contaminants of Immediate and Emerging Concern.

8b. *Conceptual grounding and operationalizing*: There is a need for clarity as to how EPA ORD SHC conceptualizes EJ (e.g., process or procedural issues vs. outcomes and distributive issues).

Beyond just focusing on outcomes, the StRAP should address the multiple dimensions of EJ, including recognition, interactional, procedural, distributional, and even intergenerational (with the focus on children's health). Further, the StRAP should "operationalize" each of these EJ concepts so that they can be measured.

9. Report on the Environment: For Research Area 11, the Report on the Environment is designed to track the state of the environment and human health over time, but it is largely based on measurements of physical or biological conditions within a clearly defined geographic area rather than social indicators. EPA ORD should consider including indicators of the social environment, such as factors related to environmental justice and community resilience. If these two terms are better defined and operationalized, as recommended above, this may facilitate measurement.

10. EPA-Wide Strategic Plan: While the SHC StRAP shares many of the themes found in the FY 2022-2026 EPA Strategic Plan, it is not clear how the SHC StRAP Outcomes are harmonized with the Long-Term Performance Goals in the Strategic Plan. For example, the Long-Term Strategic Plan sets the

following Goal that has no corollary in the StRAP: "Goal 2: Environmental Justice > Obj. 2.1: Increase by 40% the number of Office of Research and Development activities related to environmental justice that involve or are applicable to Tribes, states, territories, local governments, and communities." Just as Appendix 1 in the StRAP maps outputs to PRST Needs, it may be useful to map outputs to objectives in the Long-Term Strategic Plan.

11. **Executive Orders**: The May 4, 2022 BOSC Review included a helpful presentation on recent Executive Orders and Presidential Memoranda. The StRAP specifically discusses some executive orders, but not others. EPA ORD SHC should consider specifically addressing compliance with Executive Order 13990 and the related Memorandum to restore public confidence in science, as this ties to the efficacy of ORD's research.

12. **Tribal engagement**: We specifically call attention to the Presidential Memorandum on Tribal Consultation and Strengthening Nation-to-Nation Relationships. The StRAP should explain how EPA is meaningful increasing engagement with tribes, particularly given connectivity challenges. For example, only 64 tribes out of 579 involved in a recent virtual consultation. Many tribes are dissatisfied with phone and video calls and request face-to-face consultation. EPA should have a system for planning to visit as many tribes as possible, and identify a process on how to select which or how many tribes to engage with.

13. **Typographical Issues**:
    13a. p. 9: "CECs" to "CEC"

    13b. p. 14: "program" to "programs"

    13c. p. 40: Under "Community Resiliency" there is text that should be deleted.

Recommendations

The Workgroup offers the following recommendation:

Evaluation and Integration of Cross-Cutting Concerns: We recommend that EPA ORD SHC have a systematic method (e.g., a flowchart with questions for analysis) to examine the applicability of each cross-cutting concern to outcomes in each research area, and integrate these concerns into the research design and outputs where applicable.

Charge Question 2

With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Narrative

The Sustainable and Healthy Communities (SHC) Workgroup of EPA's Board of Scientific Counselors appreciates EPA ORD's focus on emerging challenges that may affect not only ORD's future research but also the focus of the entire EPA. PFAS is an example of an issue that caught the nation off guard, although EPA is now poised to address it. It is important for EPA to rapidly adapt its response to chemical public health hazards like these, while also anticipating response to a broad range of future threats to the environment and public health (including social and mental-wellbeing). We offer suggestions on emerging threats to consider, not only in the context of chemicals, but also in the larger realm of public health and supply chains. We recommend that ORD increase focus on non-chemical stressors and develop a specific method for identifying emerging concerns and solutions.

Strengths

- **Framing**: "Solutions-driven research" (p. 2) is a great way to frame research and demonstrates ORD's commitment to addressing real-world problems, including emerging concerns.
- **PFAS**: It is encouraging to see the focus on PFAS in EPA ORD SHC Research Area 5. At this time the research focus is general enough that there is room to identify more specific outputs as additional concerns emerge.
- **Circular Economy**: There is a growing research program on the ways EPA's regulatory and technical assistance programs support national and state circular economies.

Suggestions

1. **Increasingly regulated chemicals**: EPA ORD may want to track regulatory changes that restrict the use of chemicals, as these chemicals may be emerging threats. For example, on May 5, 2022, EPA's regulatory branch announced a proposed rule that would require comprehensive reporting on asbestos, including information pertaining to asbestos-containing articles and impurities. There is a similar trend with formaldehyde regulation.

2. **Carbon mitigation**: There is an increasing effort to mitigate greenhouse gases through mechanisms such as carbon capture and storage. EPA ORD may want to evaluate the efficacy of these emerging technologies (for example, consider the efficacy of carbon storage and potential leaking).

3. **Equitable, Local, Low Carbon, and Resilient (ELLCR) Supply Chains**: International conflict has elevated the importance of resilient supply chains. There is a need to ensure more equitable, local, low carbon, and resilient (ELLCR) supply chains by increasing the use of domestic recycled materials. These ELLCR supply chains also help US manufacturers reduce their Scope 3 (value chain) GHG emissions. For example, the company GM estimates its Scope 3 emissions to be 50 million metric tons of carbon dioxide. EPA ORD should explore the utility of input-output models to demonstrate the state-level GHG reduction benefits of ELLCR supply chains in addition to the equity and economic co-benefits. Also, as noted during the BOSC Review held October 28 and 29, 2021 on life cycle analysis and reuse of construction and demolition debris (e.g., local, lower carbon), there is a risk that contaminants (e.g. PFAS in food packaging material) can enter waste streams and impede reuse. Through Research Areas 7 and 8, EPA ORD SHC could consider ways to address such contaminants in the context of waste recovery and supply chain resilience.

4. **Non-Chemical Issues**: There are many issues of emerging concern not related to chemicals that EPA may want to consider, ranging from non-chemical stressors like algal blooms to community trauma and loss of social capital related to contamination and disasters. EPA ORD SHC could consider renaming SHC Research Area 5 as "Issues of Emerging and Immediate Concern." The following are examples of non-chemical issues:

   4a. *Public trust*: As we noted in Charge Question 1 in regard to Executive Order 13990 and the related Presidential Memorandum, the loss of public trust is an emerging and immediate concern to public health (e.g., vaccination reluctance) as well as the efficacy ORD's research.

   4b. *Vulnerability*: There is a need to have a better understanding of vulnerability and how it can increase risk to disease and disasters. For example, there is recognition of factors such as age that can increase vulnerability, but less recognition of factors like stress, climate change, and cumulative effects that can increase vulnerability, along with buffers that can mitigate risk.

   4c. *Environmental justice*: EPA ORD should consider the potential for interventions that improve particular environments and infrastructures—including those in EJ communities—to create emergent environmental justice issues through subsequent processes of "green gentrification."

5. **Collaboration**: As we noted in Charge Question 1 in regard to relationships between SHC and other programs, some of the issues of emerging concern may be addressed by other programs in addition to SHC. For example, algal blooms may be addressed by EPA's water quality division. SHC may want to have a system to coordinate with other ORD program and divisions beyond ORD that may be addressing similar challenges.

6. **Methodology for Horizon-Scanning**: There is a need for methods to strategically and objectively identify what the next emerging concerns will be in each research area. This may involve the establishment of a committee of experts that follows the Delphi method to forecast concerns. EPA ORD may want to incorporate the establishment of a front-end methodology within SHC Research Area 5. For example, if the aim is to detect harmful levels of chemicals entering a system, a method could be to look at sales of chemicals (rather than just measure what appears in wastewater). Just as there are emerging threats, there are emerging technologies that are positive. EPA ORD may want to include methods for identifying upcoming innovations (e.g., technologies to remove PFAS). Thus, EPA ORD should explain how it is planning and budgeting to address emerging threats and innovations within each of the SHC Research Areas. At a minimum, highlight for each Research Areas where or how Horizon Research is expected, as some portion of the research budget.

Recommendations

The Workgroup offers the following recommendations:

1. **Non-Chemical Issues**: We recommend that EPA ORD SHC broaden the scope of Research Area 5 to include a broader range of stressors to public health and the environment, including threats to environmental justice and social factors that increase vulnerability.
2. **Methodology for Horizon-Scanning**: We recommend that EPA ORD SHC establish a more systematic approach for horizon-scanning to consider shorter as well as longer-term emerging threats for each research area, along with beneficial technologies. This method should involve coordination with other EPA divisions that may be addressing similar challenges.

BOSC
BOARD OF SCIENTIFIC COUNSELORS

REPORT OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY BOARD OF SCIENTIFIC COUNSELORS SAFE AND SUSTAINABLE WATER RESOURCES WORKGROUP

RESPONSES TO CHARGE QUESTIONS

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CONTENTS

LIST OF ACRONYMS

ACE	Air, Climate, and Energy
ARS	Agricultural Research Service
BOSC	Board of Scientific Counselors
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CMAQ	Community Multiscale Air Quality Modeling System
COMET	City-based Optimization Model for Energy Technologies
COVID-19	Coronavirus Disease 2019
CPHEA	U.S. EPA Center for Public Health and Environmental Assessment
CSS	Chemical Safety for Sustainability
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Policy Integrated Climate
EtO	Ethylene oxide
EV	Electric vehicle
FEM	Federal Equivalent Model
FRM	Federal Reference Model
GCAM-USA	Global Change Analysis Model
GHG	Greenhouse gas
GLIMPSE	GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator
GWP	Global warming potential
HERA	Health and Environmental Risk Assessment
HFCs	Hydrofluorocarbons
HS	Homeland Security
IAs	Interagency agreements
ICLUS	U.S. EPA Integrated Climate and Land-Use Scenarios project
IDF	Intensity, duration, and frequency
IPCC	Intergovernmental Panel on Climate Change
LASSO	U.S. EPA Locating and Selecting Scenarios Online tool
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NGEM	Next Generation Emission Monitoring
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
ORD	U.S. EPA Office of Research and Development
OTAQ	U.S. EPA Office of Transportation and Air Quality
PFAS	Per- and Polyfluoroalkyl substances
$PM_{2.5}$	Particulate matter less than 2.5 microns in diameter
PNNL	Pacific Northwest National Laboratory
RFS	Renewable Fuel Standard
SOAs	Secondary organic aerosols

SHC	Sustainable and Healthy Communities	SSWR	Safe and Sustainable Water Resources
		StRAP	Strategic Research Action Plan
TOF	Total organic fluoride	VCPs	Volatile chemical products
USDA	U.S. Department of Agriculture	VOCs	Volatile organic compounds

INTRODUCTION

To protect human health and the environment, the U.S. Environmental Protection Agency (EPA) and its Federal, state, and other government partners and stakeholders must make critical decisions about the risks of exposures to environmental stressors. The primary focus of EPA's Office of Research and Development (ORD) is to provide the strong scientific and technical foundation the Agency relies on to fulfill its statutory obligations and help Agency, state, and other partners address their most pressing environmental and related public health challenges. The EPA has designed the Safe and Sustainable Water Resources (SSWR) program to develop and apply state-of-the-science research to characterize impacts on human and ecological systems – whether they result from exposure to single, complex, or multiple physical, chemical, or biological stressors – to support and improve EPA's risk assessment decisions. It is one of the Agency's six, highly integrated national research programs. The other five are Health and Environmental Risk Assessment (HERA), Air and Energy (AE), Homeland Security Research Program (HSRP), Chemical Safety for Sustainability (CSS), and Sustainable and Healthy Communities (SHC).

ORD prepares Strategic Research Action Plans (StRAPs) to guide its research planning over the ensuing 4 years, and beyond. The StRAPs are designed to guide an ambitious research agenda that delivers the science and engineering solutions the Agency needs to meet its goals now and into the future, while also cultivating an efficient, innovative, and responsive research enterprise. Currently, ORD is seeking input from the Board of Scientific Counselors (BOSC) on the draft 2023–2026 StRAP documents and proposed research strategies. The emphasis is on advancing ORD research that can successfully address the needs identified by EPA programs and regions, and states and tribes. This review by the BOSC SSWR Workgroup is focused on strategic directions and proposed research priorities described in the draft SSWR StRAP. Future BOSC reviews will address research activities and outcomes over the course of the StRAP implementation.

BACKGROUND

The overarching goal of the SSWR National Research Program is to provide the science and innovative technologies that the Agency and the nation need to maintain drinking water resources and systems, as well as to protect the chemical, physical and biological integrity of the nation's waters. The subject of this review is restricted to the 2023-2026 SSWR StRAP.

CHARGE QUESTIONS AND CONTEXT

The SSWR Workgroup was charged with two questions as follows:

> Q.1: Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 time frame.
>
> Q.2: With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Charge Question 1

Given the vision and strategic direction provided in the StRAP and the research objectives articulated through the Topics, Research Areas, and Outputs, please comment on the extent to which the StRAP provides a clear strategic plan and a coherent structure toward making progress in the 2023-2026 time frame.

Narrative

The SSWR StRAP is a well-conceived document that appropriately describes the highest priority issues for EPA and their stakeholders. The plan provides a mechanism for developing nationally-consistent tools for assessing ecological status, setting goals, and monitoring progress.

While the BOSC generally supports the StRAP, four concerns were raised. The first is that the document provides little sense for how the program has evolved. The structure of the document is the same as the last StRAP, with much of the text repeated in this version. As such, it is difficult to discern where ORD has succeeded and where research has stalled. Communicating progress, and anticipated next steps that build on that progress, will help clarify your vision and direction to the audience outside of EPA that looks to the StRAP to examine potential partnership opportunities.

The second is that the StRAP focuses too much on short-term needs and not enough on looking at the future. While we complement ORD for paying attention to client needs, the process of gathering input in that way naturally gravitates towards addressing immediate pressures. As such, the StRAP fails to adequately address a number of emerging issues. ORD should develop an enhanced strategy for identifying and prioritizing emerging research opportunities and issues of concern. We expand upon this further with specific examples of forward-looking research ORD should consider in our response to Charge Question 2.

The third is that ORD told us verbally that much of the document is responding to administration priorities regarding climate change and environmental justice, but the document does not highlight those areas particularly well. ORD has responsibility for assessing how climate change will affect water quality management or how local management actions can exacerbate or lessen such effects. The StRAP has material sprinkled throughout the document, but it is difficult to locate and be seen as a comprehensive plan. Appendix 4 provides context for how the SSWR plan fits into a larger ORD set of efforts, but this section needs restructuring to provide a comprehensive climate change research vision. The document also needs greater clarity regarding how ORD will partner with other agencies on these topics, as these priorities transcend EPA and there is much potential for both duplication and opportunities for collaborative synergy. Below we provide a recommendation that the ORD develop a comprehensive strategic plan for its climate change research programs that is well-integrated within the ORD, the Agency and is contextualized within the activities of other Federal agencies.

The fourth concern is the document is uneven in its coverage, with some topical areas describing a well-conceived vision, while other sections only illustrating individual research projects. ORD's research seems to include three topic areas: 1) Developing tools for assessing condition, including determination of thresholds for what constitutes impairment; 2) Examination of sources, fate and transport to determine causality factors, and 3) Engineering or other solutions to lessen the effect of each stressor. ORD does not have the resources to address all these topics for each stressor type and they may need to focus on a

subset initially, such as developing assessment methods. However, the StRAP would be improved by providing a more holistic vision of where the research is headed, stating a rationale as to why EPA is limiting themselves to a subset of topics in this particular three-year window, and what steps they anticipate taking beyond, after completing that work.

Strengths

- The StRAP provides a comprehensive examination of important challenges facing our country in providing safe water for both human consumption and ecosystem needs. It contains guidance on scientific, technological, and translational efforts required to respond to these challenges. It communicates how these efforts will support EPA's mission and its various Congressional mandates, providing a clear path forward for addressing the EPA's priority research objectives.

- The StRAP presents a comprehensive program to address research at multiple spatial scales, recognizing that ecosystems operate differently under a range of climatological and landscape conditions. This is a positive attribute as it recognizes the need to account for these geographical differences technologies that EPA adopts. It is also a negative attribute, as it requires large investment to thoroughly research a topic, limiting the number of topics in which ORD can invest.

- The plan addresses the needs of many of its stakeholders, which ORD did a good job of querying while developing their plan. Moreover, the focus on delivering tools directly to stakeholders is appropriately highlighted.

- The StRAP provides a clear vision of the technical activities needed to advance the proposed research. Of particular value is emphasis on expanded analytical methodologies, continued environmental monitoring, and enhanced modeling capabilities.

Suggestions

1. **Add a section describing what was accomplished during implementation of the previous StRAP and how the research vision has evolved.** There is a section titled "Changes from FY 19-22 StRAP", but that material comes across as a disjointed list. We hope for a more comprehensive presentation that illustrates: 1) major successes ORD has had and advances they are expecting in the next phase of research, 2) work that is being sunsetted as having been accomplished, 3) new challenges that ORD is taking on, and 4) reason or context for setting particular priorities.

2. **Expand sections to better reflect a strategy, rather than a list of projects.** The document should convey a multi-year strategy for each of the research topics, not just the specific research that is being conducted in this particular year. When ORD is only tackling a subset of the multi-year vision at this time, the StRAP should provide rationale, such as limited resources or the need to address portions of the research sequentially.

3. **Consider refining the structure of the document.** The charge question specifically asks about appropriateness of the StRAP structure, to which we respond that we found the document's organization confusing. The first section (Watersheds) is place-based, the second (HABs/nutrients) is stressor-based and the third is action-based. Many other stressors are detailed in the watersheds section, such as toxins, pathogens, microplastics, so it was unclear why nutrients/HABs is broken out as its own chapter. During the conversations, we were informed that the breakout was because HABs is a high priority issue for EPA. If that is so, the document should identify the relative prioritization among stressors and explain why HABs is

important enough to EPA that there is a need for it to have its own section.

3a. There are a number of alternative structures that could be used, one of which is to create a chapter for each stressor, as was done for nutrients/HABs. This would allow the reader to see the larger strategy for each. Another would be to organize around types of research activity, such as: 1) Developing tools for assessing condition, including determination of thresholds for what constitutes impairment; 2) Examination of sources, fate and transport to determine causality factors, and 3) Engineering or other solutions to lessen the effect of each stressor.

3b. Refining the document structure is not the BOSC's biggest priority, as we are more focused on the research to be conducted than we are about the communication vehicle. However, we feel obliged to provide this suggestion as it was specifically asked as part of the charge question. The BOSC realizes that a major restructuring at this late date is challenging and we suggest restructuring be considered when developing the next StRAP.

4. **Various granular suggestions.** Beyond these high-level comments on the document, the BOSC also provides several more granular suggestions regarding technical details within various sections of the document:

4a. **HABs:** HABs is a topic that is covered by a number of different agencies and the StRAP document would benefit from an explanation of EPA's niche in this crowded research space. The EPAs HABs research focuses on toxicity to humans, pets, livestock, and aquatic dependent wildlife. The BOSC would like greater emphasis of ecosystem effects from HABs, such as to food webs and biodiversity. We would also like greater emphasis on predicting "vulnerability" to blooms, including machine learning approaches that examine collections of drivers. ORD should also identify how their research on HABs is integrated with their climate change research (e.g., temperature, drought, flooding).

4b. **Water infrastructure:** Increased emphasis is suggested on improved resilience from natural disasters and climate change. Also, water reuse should be expanded to include alternative water sources (stormwater and produced water from oil/gas) and from decentralized systems.

4c. **Quantify performance of stormwater management infrastructure:** Consider life cycle performance of green and grey infrastructure, especially in vulnerable communities.

4d. **Emerging contaminants beyond PFAS**: While there is an immediate need for work on PFAS, the BOSC would like to see a more strategic approach for how ORD will address the wide range of emerging contaminants (hormones, antibiotic resistant genes, pharmaceuticals, micro- and nanoplastics, pesticides). That strategy should include research on cell-line assays and non-targeted analysis to identify and prioritize unknowns. This program should also address ecosystem impacts of such compounds (alone and in mixtures).

4e. **Microplastics:** The research plan for microplastics does not illustrate how ORD will address nanoplastics, which preliminary research suggests is an even greater concern for human and ecosystem health than microplastics. We are also concerned that ORD's efforts are presently focused on measurement processes, with less clarity about how toxicology will be examined, from individuals to food web effects. In conversation, ORD indicated that they are presently focusing on developing assessment methods as the logical first step for microplastics research, which is still in its infancy. The BOSC agrees with that assertion, but the StRAP

would be improved by providing a more holistic vision of where the research is headed in the longer term and why they are limiting themselves to that one area in this three-year window.

4f. **Interagency Aquatic Resources Mapping:** The BOSC applauds your resource mapping efforts, but asks for greater effort in headwaters, where surface drainage begins. While the development of map products is not specifically an EPA activity, products derived from those maps do assist EPA in its regulatory and research work. We encourage the agency to continue to pursue the development of spatial tools that augment measurement of flow paths and connectivity.

4g. **Loading quantification:** As environmental flows become more variable as a result of changing precipitation patterns, the BOSC would like greater emphasis placed on mass loading of nutrients and contaminants instead of concentration.

4h. **Recovery and adaptation from impacts:** The climate change focus appears to be on quantifying gradual rates of change (multi-decade, century, millennial). ORD should consider some change as inevitable, near-term and begin research on paths for recovery once stressors have abated.

Recommendations

The Workgroup offers the following recommendations:

1. Improve the balance between meeting the immediate needs of customers and anticipating emerging issues. This recommendation is elaborated on in response to Charge Question 2.

2. Add a section that highlights how climate change and EJ issues are being addressed, including a discussion about partnerships with other federal agencies and specific strategies for engaging EJ communities. ORD should develop a comprehensive strategic plan for its climate change research programs that is well-integrated within the ORD, the Agency and is contextualized within the activities of other Federal agencies. Specific strategies for engaging EJ communities should be a part of this strategy document.

Charge Question 2

With the objective of maintaining a dynamic research organization at the forefront of environmental science, are there emerging or additional public health and/or environmental challenges where this national research program should consider investing resources?

Narrative

The SSWR program is ambitious and covers a broad set of issues encompassing detection and assessment of watershed threats and stressors, ecosystem and human health responses, and remedial actions to both natural and built infrastructure. The next generation of issues will be strongly driven by climate extremes and vulnerable humans and ecosystems. Jurisdiction over these issues falls across several government agencies, thus multi-agency strategies are essential for addressing issues such as climate change, cumulative impacts and environmental justice (EJ).

The program managers have included a number of new research areas, but these are mostly "tweaks" at the margins of existing programs and mostly address current rather than emerging issues. Cross-cutting issues have been identified in the StRAP (Appendix 4) and ORD research program activities have been documented. Since there are multiple areas of responsibility across various government agencies, it would be helpful for these issues to be identified in the plan. In preparation of this StRAP EPA has engaged partners at many levels, both inside and outside the Agency. Addressing current partner needs, however, does not prepare EPA-ORD for future threats. Therefore, we recommend a three-part strategy including: 1) Create a formal framework for conducting horizon scanning that is robust enough to detect both suspected as well as unknown threats and stressors, 2) Develop a recommended distribution of resources that are deployed for "current" versus "future-looking" / emerging issues that you use for selecting among potential projects, and 3) Identify a specific process for sunsetting programs and projects to ensure you have resources for adopting new research directions.

Deployment of a horizon scanning system within the Agency would help to inform distribution of resources for dealing with 'known', 'suspected', and 'unknown' threats and would help identify the skillsets and research needs of the future. A horizon scanning process would: a) identify available monitoring datasets; b) identify knowledge that informs the behavior and consequences of potential threats and stressors; c) identify the appropriate tools for detecting and quantifying the level of risk of threats and stressors; and d) define the criteria leading to further research or Agency action. In the development of a horizon scanning framework stakeholders or partners with knowledge or mandates to anticipate future threats should be consulted; for example, military, energy sectors, and banking sectors rely heavily on scenario analyses that help them anticipate emerging trends, such as climate change, and issues relevant to their missions. Partnerships with scientific societies would also provide 'horizon scanning' capabilities that could help inform a forward-looking research agenda. A National Academy of Science committee is currently addressing the issue of horizon scanning. While EPA is not directly involved in this endeavor, the outcome will guide the process and the necessary skillsets and tools required for the future. Given the Agency's unique mission as both a regulatory body and a research organization, ORD should be prepared to offer its own perspective on the appropriate process for a mission-driven research organization.

ORD engages its partners throughout the research cycle, and especially during the StRAP planning process. ORD staff have expressed the concern that the focus on delivering solutions to partner needs necessarily creates a focus around current issues. Yet, as the nation's premier research organization charged with protecting and restoring the integrity of the Nation's waters and drinking water supplies (in response to the Clean Water Act, the Safe Drinking Water Act, Resource Conservation and Recovery Act, and the Comprehensive Environmental Response Compensation and Liability Act), ORD must be positioned to respond to future threats and stressors. Thus, in addition to a horizon scanning framework that will identify such new and emerging threats, ORD must reserve a portion of its (scarce) resources to fund personnel and infrastructure needed to anticipate and respond to research that is forward-thinking rather than focused on the moment. Therefore, we recommend that the Agency establish a policy that

appropriately prioritizes allocation and deployment of resources between current (stakeholder-driven) versus future-looking issues.

The third component of our recommendation stems from the reality that resources are finite and must be deployed strategically against the current and forward-looking issues. Thus, for every new program that is initiated, an established program must be reduced or closed out to free up resources. Programs are eliminated when they have met their objectives, when the underlying issue is no longer relevant to the organization, or when resources are needed to meet another, more critical objective. We recommend ORD develop a clear set of criteria for strategically sunsetting research programs and projects. Such a process must be transparent, time-bound, and considerate of the human resources that are affected. Where possible, consideration should be given to a possible transfer of responsibilities to other organizations.

The BOSC has identified a number of emerging issues (or existing issues that are believed to be under-represented in the research agenda) that it believes should be addressed or activities enhanced. We group these into four categories: next generation monitoring and assessment tools; emerging contaminants; climate change; and cross-cutting issues. Of special note, further work is recommended on: change detection and big data / machine learning (necessary components of horizon scanning); toxicologic and ecosystem health impacts from microplastics (details lacking in SSWR3.4); ocean acidification (mentioned but with no specific activities identified); impacts of wildfire on human and ecosystem health; and quantification and management of blue carbon (but see SSWR 2.1). While some of these issues are mentioned in Appendix 2 or 3, outputs or programs are poorly explained in the StRAP. Specifically, increasing wildfires, droughts and temperatures will result in water standards exceedances, loss of cold water and pollution sensitive species, increased anoxia and decreasing flows all of which will increase impairments and 303(d) listings. Partnerships with NOAA, USFWS and USGS will benefit a collective assessment and mitigation strategy.

Finally, there is concern that, given the importance of water for both environmental and human health, overall consideration of environmental health focused around water-related issues lags behind that of human health. While there are specific projects, especially in Topics 1 and 2 (Watersheds; Nutrients and HABS), there are a number of gaps (and opportunities) that have been identified to address ecosystem level impacts of, e.g., contaminants, cyano-based toxins, stormwater, and treated wastewater. Given the tight connection between human health and environmental health, and the rapid pace of change in ecosystems due to climate and land use change, there is little time to waste in identifying drivers and solutions to environmental degradation. EPA is uniquely positioned to be a leader or a partner in addressing the co-benefits of a clean environment (including air and water).

Strengths

- ORD has undertaken an extensive process of engagement with stakeholders including government agencies, Tribal organizations, NGO's as well as EPA programs, regions, states, and tribes.

- Increased emphasis on climate as a driver of human and environmental health issues is to be commended. While ORD-wide coordination was addressed in Appendix 4, collaborations and partnerships with other agencies should be documented in a similar manner to ensure maximum coordination and identify gaps.

- The StRAP identifies activities associated with mapping and modeling of surface water resources and coordination activities with the Interagency Aquatic Resources Mapping Workgroup. Mapping is acknowledged as an important inter-governmental activity, but many regulatory and research activities within EPA are highly dependent on many of the map products; the BOSC applauds active engagement in these discussions and urges further refinement of products that help to define flow paths, measure change, and enhance cumulative impacts modeling.

- Consideration of climate change impacts on indicators and assessment approaches for the National Assessment surveys along with use of DNA technology and remote sensing tools.

- The BOSC was pleased to see further attention to water quality benefits modeling (SSWR1.3) to support economic analyses and to help address disparities in derived benefits by underserved communities.

- Emphasis on water infrastructure (for both potable and non-potable reuse); increased resilience of infrastructure to natural disasters (particularly flooding) and climate change.

- The StRAP articulates cross-cutting activities and the roles of the different programs within EPA to achieve those. These complex issues require close coordination across the agency and it is hoped there are formal mechanisms in place to both promote collaborations as well as to ensure dissemination of research outcomes.

Suggestions

1. First and foremost, consideration of future issues must be strategic, with partnerships and collaborations with other government agencies, as well as Tribes, academic institutions, and non-governmental organizations. Most of these issues have components being addressed by other agencies, e.g., NOAA, USFWS, USDA, NIEHS, so coordination is essential. These should be defined in advance, and formal consultation strategies in place to maximize data and information exchange and optimal uptake of research outcomes. Such collaborations should be assessed on a regular basis through implementation of assessment metrics.
2. Advanced Monitoring Technologies and Analytical Tools:
    a. Given the dynamic, non-linear trajectory of environmental change that the globe in undergoing at this time, advancements in field-based data collection technologies (e.g., sensor networks), processing and analysis methods must be a priority along with advancements in specific forms of information gathering, interpretation, and use by stakeholders that respond to ongoing and new challenges, including those related to change detection.
    b. Develop a framework for an Early Warning System that can identify and prioritize emerging (suspected) threats and stressors along with the developed infrastructure to identify an

unknown (unknown) threat. Such a system relies on existing monitoring and analytical methods capable of detecting novel threats (e.g., pathogen, invasive species, chemicals), as well as disturbances that exceed thresholds or are outside normal range of variation. Advanced monitoring and analytical tools are essential to the deployment of such a framework (see below).

c. Continue development and adoption of molecular tools (eDNA, biomarkers, barcoding, omics) for environmental monitoring and assessment.

d. Explore further development and use of remotely sensed data and sampling for detecting ecological phenomena and environmental change over both space and time, at both short and long-time scales.

e. Engagement with intergovernmental groups promoting enhanced mapping at scales ranging from local to regional should be a priority and should consider how additional mapping tools (e.g., LIDAR; hyperspectral, etc.) can be used to enhance the map products to improve decision making, (e.g., in detecting topographic features, quantifying connectivity, defining flow networks, change detection)

f. Highlighted attention towards big data analyses (in the case of watersheds, involving these sources of information that may include flow rates, loads, temperature, etc.) and use of machine learning approaches; data visualization tools are essential for communicating data outputs from these data types.

g. Advance methods for data analytics and interpretation based on varied sources with different types and ranges of uncertainties.

h. Given the emphasis on community science, consider how the collective amount of data that can be derived from crowd sourcing can be applied to augment data for the SSWR research areas (such as stream flows, turbidity, fish kills, etc). A co-benefit is that community-derived monitoring may provide a mechanism for engaging EJ communities.

i. Investigate opportunities to include traditional knowledge into research and monitoring programs; traditional knowledge can be especially insightful in terms of assessing climate change impacts and for designing climate change adaptation strategies.

3. **Emerging Contaminants**

a. The European Union is a leader in the realm of ecosystem protection management, with very robust research programs to address chemical exposures in human and ecosystems, climate and microplastics; some of their research programs may serve as a model for EPA-ORD.

b. Microplastics (SSWR3.4). Plan to expand the micro and nano plastics research program beyond methods development is laudable. The focus of the research on impacts on aquatic resources, however, is narrowly focused on the toxicologic impacts of bio-based plastics on aquatic life and assessing exposure of coral to microplastics and elevated temperatures. There are still large uncertainties and methodological challenges with assessing nanoplastics, which are likely a larger threat to both humans and ecosystems than microplastics. Ecosystem level impacts such as disruption to the food web and other ecosystem processes (e.g., decomposition) should be considered.

c. While the Agency's focus is on threats such as lead and PFAS, other contaminants including hormones, antibiotic resistant genes, pharmaceuticals, pesticides and microplastics, tire particles - both alone and in mixtures- are threats that must be addressed, especially in vulnerable humans and ecosystems. In particular, there is additional need for development of analytical methods for non-target contaminants.

d. Contaminants are not just a threat to humans and wildlife populations- they also threaten critical ecosystem processes (primary production, decomposition), food webs, and biodiversity. Pesticides, such as neonicotinoids, are known to cause large scale ecosystem impacts. Toxicology endpoints and thresholds for human and wildlife as well as ecosystem processes should be considered, with special attention to drivers influenced by rapidly changing climatic conditions.

4. Climate Change:

a. Ocean acidification is a critical issue that is under-represented in ORD's research portfolio. It is also unclear how EPA plans to partner with NOAA on this shared issue.

b. Blue carbon: need to consider carbon storage tied up in marine and freshwater systems, along with carbon dynamics in wetland soils and vegetation.

c. Hydrology: suggest additional consideration of environmental flows on biotic communities and ecosystem processes; focus on nutrient loading rather than concentration in surface water flows. Increasing drought and extreme events are altering large areas of the U.S.

d. A key gap that has been identified is the role of wildfires and drought on human and ecosystem health (A cross-cutting issue and identified in Appendix 2 by PRST). Wildfires impact nearby and regional communities' health through degraded air and water quality.

e. Storage and release of legacy nutrients (especially in soil) will be increasingly problematic due to increasing intensity of storms; nutrient cycling / retention will be accelerated with increasing temperatures.

f. HABs: toxins are receiving considerable attention, but the ecosystem impacts of these toxins are not being addressed well. Impacts on ecosystem processes and biodiversity should receive additional attention. Vulnerability of ecosystems to blooms as a function of both climate and other drivers (e.g., land-derived nutrient loading).

g. Pathogen redistribution: climate change is affecting the distribution of infectious diseases in a number of ways: weather patterns are changing, creating more favorable environments for many pathogens; zoonotic diseases are becoming more prevalent as humans encroach on wildlife habitats; air pollution is transferring airborne viruses; melting permafrost has the potential to release ancient diseases; and warming climates could facilitate new mutations of existing pathogens. These factors are influenced by air quality, and surface and drinking water quality.

h. The impacts of climate change are occurring unevenly across different geographies, communities, and ecosystem types. These differential impacts affect both the regulatory endpoints (criteria, permits) as well as the monitoring and assessment data required to both set and enforce them. While ORD is already assessing the impacts of climate on assessment indicators and endpoints, we also recommend that the rate and trajectory of

recovery from both short-term and long-term disturbances should be addressed.

Recommendations

The Workgroup offers the following recommendations:

1. Create a strategy or framework for conducting horizon scanning (a systematic assessment of emerging threats and stressors that also can detect unknown-unknown threats) that can inform the distribution of resources- include stakeholder engagement that addresses emergingissues.
2. Develop a set of criteria and process for sunsetting programs.
3. Define a desired ratio for agency investments between “current” and “future looking” topics.