BOSC

BOARD OF SCIENTIFIC COUNSELORS

April 21, 2022

Maureen R. Gwinn, PhD
Acting Assistant Administrator
Office of Research and Development
U.S. Environmental Protection Agency

Dear Dr. Gwinn:

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

The BOSC was reconstituted in 2017 with an Executive Committee and five subcommittees aligned with each of the National Research Programs (part of the Health and Environmental Risk Assessment program is reviewed in conjunction with the Chemical Safety for Sustainability program). Four of the subcommittees, Chemical Safety for Sustainability and Health and Environmental Risk Assessment, Sustainable and Healthy Communities, Safe and Sustainable Water Resources, and Air, Climate, and Energy met in October–December 2021 culminating in an Executive Committee meeting in January 2022. This report represents the cumulative effort of the subcommittees and the Executive Committee.

We anticipate that this report will assist ORD in evaluating the strength and relevance of these 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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BOARD OF SCIENTIFIC COUNSELORS

REVIEW OF U.S. EPA OFFICE OF RESEARCH AND DEVELOPMENT'S RESEARCH PROGRAMS

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Tom Tracy, Designated Federal Officer

March 25, 2021

A 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 CHEMICAL SAFETY FOR SUSTAINABILITY AND HEALTH AND ENVIRONMENTAL RISK ASSESSMENT SUBCOMMITTEE

RESPONSES TO CHARGE QUESTIONS

BOSC Chemical Safety for Sustainability and Health and Environmental Risk Assessment Subcommittee

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EPA Contact
Tom Tracy, Designated Federal Officer

December 10, 2021

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

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LIST OF ACRONYMS

ACE	Air, Climate, and Energy
BOSC	U.S. EPA Board of Scientific Counselors
CSS	Chemical Safety for Sustainability
CSS-HERA	Chemical Safety for Sustainability and Health and Environmental Risk Assessment
CPHEA	U.S. EPA Center for Public Health and Environmental Assessment
CPSC	Consumer Product Safety Commission
CTS	Chemical Transformation Simulator
EPA	U.S. Environmental Protection Agency
HERA	Health and Environmental Risk Assessment
HSRP	Homeland Security Research Program
NAM	New Approach Methodology
NIOSH	National Institute of Occupational Health and Safety
OPP	U.S. EPA Office of Pesticide Programs
ORD	U.S. EPA Office of Research and Development
OCSPP	U.S. EPA Office of Chemical Safety and Pollution Prevention
PRST	Programs, regions, states, and tribes
RACT	Research Area Coordination Team
RARE	Regional Applied Research Effort
SHC	Sustainable and Healthy Communities
SSWR	Safe and Sustainable Water Resources
StRAP	Strategic Research Action Plan
TSCA	Toxic Substances Control Act

INTRODUCTION

To protect human health and the environment, the U.S. Environmental Protection Agency (EPA or the Agency) 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. EPA's Chemical Safety for Sustainability (CSS) National Research Program is designed to support EPA's priority of reducing risks associated with exposure to chemicals in commerce, consumer products, food, and the environment. 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. They are two of the Agency's six, highly integrated national research programs. The other four are Air, Climate, and Energy (ACE), 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 implementation of research and development, specifically focused on partner-focused solutions-driven examples that encompass the entirety of the research topics and research areas, as was outlined at the strategic level in the CSS 2019–2022 StRAP document, which was previously reviewed by the Subcommittee.

Overall, the Subcommittee was impressed with the progress shown by the CSS program and with the impact of the science presented at the meeting. The Subcommittee felt the charge questions, the topics presented at the meeting, and the overall meeting content was informative, efficient, and relevant. Presentations included partners illustrating the utility of the examples highlighted in the agenda segments. The presented materials were on point regarding the charge question topics. The CSS program has a unique challenge in that they function both to deliver research outputs with high utility to enable risk-based decisions to partners and stakeholders and to function as an innovation engine to drive the new science that is the basis for the future of hazard identification and risk assessment. Maintaining an appropriate balance within the programs between these two missions will be critical for the continued leadership of the CSS program in ORD. The Subcommittee feels that the CSS program is currently managing this challenge rather effectively through the quality of the basic science carried out under the StRAP and the delivery of research products to partners and stakeholders.

Interim reviews of progress toward achieving the outputs for the research areas can be difficult because the meeting agendas do not allow sufficient time to review all the research areas defined in the StRAP and the corresponding implementation plans. Moving forward to the next StRAP period, the Subcommittee suggests that the CSS program provide a high-level summary of progress against the goals of the StRAP as read-ahead materials to identify areas that are progressing well versus areas where a course correction might be warranted. The Subcommittee feels that this summary would place the specific agenda topics for a given review meeting in context and keep the Subcommittee informed without having to review all aspects in each meeting.

CHARGE QUESTIONS AND CONTEXT

The CSS-HERA Subcommittee was charged with addressing a series of questions about the CSS Research Program. Charge questions were as follows:

> Q.1: A portion of the CSS portfolio focuses on development of databases, tools, and strategic frameworks to support decision making by partners. These products often demonstrate an integration of multiple lines of research. Building on the case study examples, what suggestion(s) or recommendation(s) does the Subcommittee offer to strengthen integration and utility of CSS research products?
>
> Q.2: A primary goal of the CSS program is to conduct solutions-driven research, and to translate research to meet partner and stakeholder needs. As one implementation strategy to achieve this goal, research products may be planned and implemented in collaboration with partners. Noting the examples presented in Session 2, please provide specific suggestions to further strengthen the solutions-driven aspect of the CSS portfolio to best meet partner and stakeholder needs.

The responses of the CSS-HERA Subcommittee to the charge questions are contained in the following sections.

SUBCOMMITTEE RESPONSES TO CHARGE QUESTIONS

Charge Question 1

> Q.1: A portion of the CSS portfolio focuses on development of databases, tools, and strategic frameworks to support decision making by partners. These products often demonstrate an integration of multiple lines of research. Building on the case study examples, what suggestion(s) or recommendation(s) does the Subcommittee offer to strengthen integration and utility of CSS research products?

Narrative

The CSS presentations to the BOSC Subcommittee outlined methods, data, information, and tools currently provided by ORD to EPA partners and stakeholders to enable informed decisions about chemicals that involve potential risks to human and ecological health. Information was divided into key areas including planning, implementation, and delivery by Research Area Coordination Teams (RACTs) with specific objectives, such as expanding the involvement and collaboration of partners. Previous recommendations from the BOSC that have been incorporated into the current CSS program portfolio were also highlighted. Examples include the evaluation of in-home chemical exposures identifying active exposure stressors from complex mixtures and identifying sensitive subpopulations such as pregnant women and developing offspring. Importantly, the CSS program highlighted the establishment of research grants to develop innovative approaches for the assessment of chemical mixture toxicities.

Examples of current progress included the collaboration between the CSS program and the Office of Pesticide Programs (OPP) scientists to develop a nano determination framework with an example of using nanomaterials for the delivery of pesticides. The presentation highlighted the obvious conclusion that the

program is in an early stage, and it was not clear what the final product would be and the timeline of development and implementation.

The presentations highlighting the question "does a chemical present unreasonable risks to human health and/or the environment?" displayed the CSS program tool, the Chemical Transformation Simulator (CTS). CTS provides estimated and measured physicochemical property values for both the parent and the transformed compounds. CTS is a web-based tool highly useful within the CSS program and for external uses. The workflows are very user friendly and provide linkage to several predictive tools. This was an excellent example of a wide-range usage of a CSS program developed tool.

The presentation on EPA's Emergency Response Authorities and Responsibilities showed the collaborative work designed to understand and deal with unknown chemical spills and degradation products and/or chemical mixtures of hazardous chemicals. This work is still at an early stage, and it will be interesting to see an actual real-world scenario where this could be used. This is obviously a case-by-case project.

For the next Subcommittee meeting, CSS should present a clear outline of the stages of various programs and collaborations and the timelines to achieve expected or desired outcomes. This will be referred to as a "matrix" and it should provide a clear picture of problem identification, development of tools and programs to deal with identified problems, and projected timelines to achieve solutions.

Strengths

- The CSS program has continued to develop, advance, and use new predictive technologies for chemical toxicity evaluation which aid in the subsequent assessment and management of chemical risks. Several tools were discussed and examples given where use and adoption is currently occurring, although it was recognized that some of the tools are nascent and that logically, over time, other regions and partners will utilize and exploit these tools and products.
- The CSS program is leveraging open-source analytical tools such as Google Analytics to gain a better understanding of potential CSS program tool usage, and potentially identify and fill data gaps in multiple tool development strategies. This also potentially expands the open-source aspect of model validation through published papers and reports. It does not address privately stored data not accessible via open-source means.
- In recent meetings and through reports, the BOSC provided ORD feedback regarding more actively engaging partners/users and stakeholders around addressing their needs and skill sets required to use new approach methods (NAMs), familiarity with the methods and intended use for each. During the recent CSS program review, presenters provided examples of how they have been doing this and also provided how partner feedback was incorporated into method development. In addition, presenters addressed questions around data source, methods workflows and outlined the intention to get models upgraded as more data are generated/published.
- Specific to the nanomaterial framework, a clear problem was identified and addressed by bringing together Agency and academic experts for regular meetings where the scientific approach was discussed, which led to development and publication of the framework. Furthermore, where framework developers are fully integrated into the problem-solving process, there is greater chance for acceptance and confidence of the approach. Presuming the nanomaterial pesticide case study occurred as part of a RACT, the project also speaks to the value of RACTs as a mechanism for problem formulation, planning, and iteration of CSS program products between the CSS program and partner staff.

Suggestions

- The Subcommittee suggests the CSS program develop a matrix/framework to better track how CSS research products are developed and maintained within the CSS program and integrated and utilized by partners and stakeholders in and outside of the RACTs. Key elements of the matrix could include how research products within the CSS program are defined and developed, mechanism of outreach to partners and stakeholders, problem definition, identifying and refining CSS program products to meet partner and stakeholder needs, and impact of CSS program products on solutions for a specific decision context (e.g., screening level assessment, qualitative/quantitative risk assessment, remediation goals, setting of permissible exposure levels). We see utility in a formal tracking framework as a tool for communicating success stories and for defining where resources should be placed based on what is being used versus not used.
- There seems to be a continued need to increase outreach out to programs, regions, states, and tribes (PRST) to identify their needs, relative to the portfolio of products the CSS program is developing and will develop in the future. Specifically, the Subcommittee suggests that a workable process be identified and implemented for how this outreach should best occur, a process that might involve other parts of the Agency (e.g., EPA Tribal Program Managers: https://www.epa.gov/tribal/epa-tribal-program-managers).
- The Subcommittee encourages the continued focus on key research and development by EPA/CSS program staff and professionals, while suggesting the outsourcing of lower complexity projects (e.g., product upkeep, database upkeep, outreach, communication to PRST) to external contractors where possible and appropriate. For example, CTS is an important tool developed by CSS program scientists to predict transformation products of organic chemicals in environmental and biological systems and is suggested for use in the Toxic Substances Control Act (TSCA) new chemical reviews. For biological transformation relevant to human health, the Subcommittee suggests CSS program scientists investigate underlying data and assumptions used in the current reaction libraries (i.e., Human Phase I Metabolism last updated in 2016 and Biotransformer Mammalian Metabolism) to determine if metabolism predictions are based on state-of-the-art scientific understanding.
- There was little to no discussion about the overall importance of translational science in the process of CSS (and HERA) program work and development of tools and application of tools to accomplish solutions to human and environmental issues. As an example, there was no discussion about collaboration with EPAs Center for Public Health and Environmental Assessment (CPHEA) which provides science needed to understand complex relationships between humans and nature. The Subcommittee would encourage exploration or delineation of these possible within-EPA collaborative opportunities that support assessments and policy to protect human health and ecological integrity.
- To further strengthen solutions-driven products focused on meeting partner and stakeholder needs, the Subcommittee suggests that the CSS program accelerate efforts to demonstrate scientific confidence in computational methods, biological activity profiling methods, and advanced exposure prediction models.

Recommendations

The Subcommittee offers the following recommendations:

Recommendation 1.1: The Subcommittee recommends the continued focus on NAM validation and appropriate documentation to ensure sufficient scientific confidence in using NAMs and other 21st Century research tools in the appropriate decision-making context. Equally important is a framework for updating and refreshing NAMs and other research tools as new science develops.

Recommendation 1.2: The Subcommittee recommends that the CSS program establish an outreach program that leverages existing Agency resources and processes for the specific purpose of partner and stakeholder engagement. This would help the primary scientific staff focus on the development and validation of NAMs while providing support in the communication with partners and stakeholders.

Charge Question 2

Q.2: A primary goal of the CSS program is to conduct solutions-driven research, and to translate research to meet partner and stakeholder needs. As one implementation strategy to achieve this goal, research products may be planned and implemented in collaboration with partners. Noting the examples presented in Session 2, please provide specific suggestions to further strengthen the solutions-driven aspect of the CSS portfolio to best meet partner and stakeholder needs.

Narrative

The CSS program plays a vital role in responding to the research needs of its partners and stakeholders. Partners include EPA program and regional offices, states, and tribal communities. Stakeholders include others with interest in the CSS program's research portfolio. CSS program staff illustrated solutions-driven research designed to meet partner and stakeholder needs with three case studies:

1. "Cross-Governmental Collaboration: Characterization of Emissions and Exposure due to 3D Printing."
    - EPA ORD is collaborating with the EPA Office of Chemical Safety and Pollution Prevention (OCSPP), the Consumer Product Safety Commission (CPSC), the National Institute of Occupational Health and Safety (NIOSH), and the National Institute of Standards and Technology. This work is clearly solutions-driven and is responsive to ORD partners and stakeholders.
2. "Regional Collaboration: Evaluating Chemical Toxicity on Listed Species (R10 Regional Applied Research Effort, or RARE, project)."
    - EPA ORD is collaborating with EPA Region 10.
3. "Program Office Collaboration: Biosolids Evaluations."
    - EPA ORD is collaborating with the EPA Office of Water.

The case studies represent only a fraction of the CSS program's larger body of valuable work, much of which CSS program scientists described in earlier Subcommittee meetings. These efforts demonstrate how the CSS program is translating its research through successful collaborations with a variety of

partners. The CSS program is to be commended for its use of RACTS to define and formulate products that respond to partner and stakeholder needs and to iterate on CSS product development and delivery to partners.

During the meeting, Annette Guiseppi-Elie defined the term "products" broadly to include peer-reviewed publications, frameworks, tools, models, databases, software, and any other tangible technical deliverable. We use this broad definition in our response to the charge question.

Strengths

- There is a clear mechanism to identify research needs of partners through the RACTs, which appear to be quite successful.
- There is a demonstrated success in building research efforts, specifically in response to partner and stakeholder needs, and delivering value and solutions through CSS program activities.
- There is clear evidence that the tools developed by the CSS program over the last decade are being tailored to provide effective solutions to current science policy needs. The R10 RARE project provides a clear example of the constructive use of CSS program science.
- The 3D printer case study illustrates how CSS program scientists are attuned to ways that they can contribute value to a collaboration and are willing to cede other areas of expertise and science policy to its partners or stakeholders. In this specific case study, CSS program scientists identified a gap they could fill in the governmental research, specifically, the evaluation of the chemical composition of the plastics used in the printers and the prediction of exposure to printer emissions.
- The Subcommittee was particularly pleased to see collaborations between the CSS program and CPSC. The latter agency has many chemical issues under its purview and can greatly benefit from CSS program expertise and solutions-oriented research. In turn, the CSS program can benefit by CPSC expertise and existing infrastructure for communicating findings to its stakeholders and the public.
- The R10 RARE project presentation included a graphic illustrating the relationships among the R10 product and other CSS program products (Slide title "Bringing Together CSS Data and Tools"). The Subcommittee was told that some CSS products incorporated in the R10 product are updated regularly and, consequently, the R10 product is updated simultaneously. We commend the CSS program for this efficient approach to product development.

Suggestions

- The Subcommittee has not heard examples of research conducted to address the needs of tribal community partners. The Subcommittee suggests that the CSS program redouble efforts to identify tribal community needs and develop solutions that can be used by tribal community partners.
- In a past meeting, the Subcommittee heard about an important collaboration with the state of Minnesota, and we encourage more efforts to support the CSS program's state partners.
- The Subcommittee suggests that the CSS program continue to seek opportunities to serve the research needs of agencies, such as CPSC and NIOSH, that can benefit from CSS program research tools and capabilities and that have less internal capacity in exposure science, toxicology, and other areas of CSS areas of expertise.
- The CSS program plans to continue its use of RACTs to define, formulate, and refine products that respond to partner and stakeholder needs. The Subcommittee suggests that RACT members not

only consider technical improvements, but also modifications that might eliminate barriers to their uptake among CSS program partners.

- The CSS program continues to develop excellent products and makes an effort to measure their uptake by partners and stakeholders (e.g., number of website downloads). What is less clear is the extent to which CSS program partners understand how the various products might support their own missions and responsibilities. Product uptake could suffer without this understanding. To help increase understanding of CSS products, the Subcommittee suggests expanding on the R10 RARE project graphic (mentioned above under Strengths) to include a graphical depiction of relationships among CSS program tools and methods. The graphic could be interactive, allowing the user to click on each circle with a product name on it, and view general information about the product (e.g., its stage and timeline for development and availability, its functions, when it was last updated and when the next update will occur, and example applications or case studies). Such a graphic could help CSS program partners and stakeholders navigate more easily through the various products, identify those of greatest utility for them, and illustrate possible applications based on the CSS program's past successful collaborations.
- The CSS program is successfully using RACTs to identify research needs of its partners, and it presented a beneficial collaboration with some stakeholders (i.e., CPSC and NIOSH). However, the CSS program did not describe specific processes and activities for identifying its broad range of stakeholders (e.g., the private sector and community groups) and for engaging with them. The Subcommittee suggests that the CSS program provide clarity on when and how it engages with its stakeholders, in part so that the stakeholders themselves understand the role that they can play in maximizing the utility and application of CSS products.
- The Subcommittee suggests that the CSS program expand on its training courses to reach even more partners and stakeholders by sharing CSS product instructional materials with educators. For example, the CSS program might improve outreach to its tribal partners by sharing instructional materials with tribal community colleges. Technology transfer should be combined with a mechanism to get feedback on how to optimize product utility and accessibility.

Recommendations

The Subcommittee offers the following recommendations:

Recommendation 2.1: The Subcommittee recommends that the CSS program prioritize solutions-oriented research to address evolving partner and stakeholder needs including climate change-related challenges and environmental justice concerns.

Recommendation 2.2: The Subcommittee recommends that the CSS program utilize feedback from partners and stakeholders on emerging environmental concerns that can be addressed by repurposing/modifying existing or developing new tools. These stakeholder feedback and engagement activities should be an integral component of research planning, working with the outreach program recommended in Charge Question 1.

SUMMARY LIST OF RECOMMENDATIONS

Charge Question 1: A portion of the CSS portfolio focuses on development of databases, tools, and strategic frameworks to support decision making by partners. These products often demonstrate an integration of multiple lines of research. Building on the case study examples, what suggestion(s) or recommendation(s) does the Subcommittee offer to strengthen integration and utility of CSS research products?

- **Recommendation 1.1:** The Subcommittee recommends the continued focus on NAM validation and appropriate documentation to ensure sufficient scientific confidence in using NAMs and other 21st Century research tools in the appropriate decision-making context. Equally important is a framework for updating and refreshing NAMs and other research tools as new science develops.
- **Recommendation 1.2:** The Subcommittee recommends that the CSS program establish an outreach program that leverages existing Agency resources and processes for the specific purpose of partner and stakeholder engagement. This would help the primary scientific staff focus on the development and validation of NAMs while providing support in the communication with partners and stakeholders.

Charge Question 2: A primary goal of the CSS program is to conduct solutions-driven research, and to translate research to meet partner and stakeholder needs. As one implementation strategy to achieve this goal, research products may be planned and implemented in collaboration with partners. Noting the examples presented in Session 2, please provide specific suggestions to further strengthen the solutions-driven aspect of the CSS portfolio to best meet partner and stakeholder needs.

- **Recommendation 2.1:** The Subcommittee recommends that the CSS program prioritize solutions-oriented research to address evolving partner and stakeholder needs including climate change-related challenges and environmental justice concerns.
- **Recommendation 2.2:** The Subcommittee recommends that the CSS program utilize feedback from partners and stakeholders on emerging environmental concerns that can be addressed by repurposing/modifying existing or developing new tools. These stakeholder feedback and engagement activities should be an integral component of research planning, working with the outreach program recommended in Charge Question 1.

APPENDIX A: MEETING AGENDA

Day 1: Thursday, November 4, 2021, Eastern Standard Time

TIME (EST)	AGENDA ACTIVITY	PRESENTER(S)
12:00 – 12:10	Meeting kick off/FACA rules/expectations/logistics	Tom Tracy (OSAPE) DFO
12:10 – 12:15	ORD Welcome	Wayne Cascio (ORD) Acting Principal Deputy Assistant Administrator for Science
12:15 – 12:25	Subcommittee Chair Opening Remarks and Introductions	Katrina Waters Chair
12:25 – 12:45	Chemical Safety for Sustainability Overview	Annette Guiseppi-Elie (ORD) Acting National Program Director, CSS
12:45 – 1:00	Summary of Feb 2021 NAMs-focused BOSC meeting	Kathie Dionisio (ORD) Principal Associate National Program Director, CSS
CSS SESSION 1: Integration and Utility of CSS Research		
1:00 – 1:10	Introduction to Charge Question 1	Annette Guiseppi-Elie (ORD) Acting National Program Director, CSS
1:10 – 1:40	The Development and Use of the Chemical Transformation Simulator for New and Existing Chemicals	Caroline Stevens (ORD/CEMM) & Marcy Card (OCSPP/OPPT)
1:40 – 2:10	The Use of Non-Targeted Analysis for Rapid and Emergency Response	Seth Newton (ORD/CCTE) & Christina Langlois-Miller (OLEM)
2:10 – 2:20	**BREAK**	
2:20 – 2:50	A Framework for Evaluating Engineered Nanomaterials within EPA's Pesticide Program	Chunming Su (ORD/CESER) & Andrew Byro (OCSPP/OPP)
2:50 – 3:45	BOSC Subcommittee Discussion and Question and Answer Session (with Presenters)	Katrina Waters Chair
3:45 – 4:45	BOSC Subcommittee Deliberations	Katrina Waters Chair
4:45	**ADJOURN**	

Day 2: Friday, November 5, 2021, Eastern Standard Time

TIME (EST)	AGENDA ACTIVITY	PRESENTER(S)
12:00 – 12:10	Public comments	Tom Tracy (OSAPE) DFO
12:10 – 12:15	BOSC Subcommittee Chair Opening Remarks	Katrina Waters Chair
CSS SESSION 2: Solutions-Driven Research to Meet Partner Needs		
12:15 – 12:25	Introduction to Charge Question 2	Annette Guiseppi-Elie (ORD) Acting National Program Director, CSS
12:25 – 12:55	Cross-Governmental Collaboration: Characterization of Emissions and Exposure due to 3D Printing	Todd Luxton (ORD/CESER)
12:55 – 1:25	Regional Collaboration: Evaluating Chemical Toxicity on Listed Species (R10 RARE project)	Dan Villeneuve (ORD/CCTE) & Mark Jankowski (R10)
1:25 – 1:55	Program Office Collaboration: Biosolids Evaluations	Caroline Ring (ORD/CCTE) & David Tobias (OW)
1:55 – 2:50	BOSC Subcommittee Discussion and Question and Answer Session (with Presenters)	Katrina Waters Chair
2:50 – 3:00	**BREAK**	
3:00 – 3:30	Application of Cost Effectiveness and Value of Information Analyses in Evaluating the Utility of Toxicity-Testing Methodologies	Paul Price (ORD)
CLOSING		
3:30 – 3:45	Closing statement and response	Annette Guiseppi-Elie (ORD) Acting National Program Director, CSS
3:45 – 4:45	BOSC Subcommittee Deliberations	Katrina Waters Chair
4:45	**ADJOURN**	

CCTE = Center for Computational Toxicology and Exposure
CEMM = Center for Environmental Measurement and Modeling
CESER = Center for Environmental Solutions and Emergency Response
CSS = Chemical Safety for Sustainability
OLEM = Office of Land and Emergency Management
OCSPP = Office of Chemical Safety and Pollution Prevention
OPP = Office of Pesticide Programs
OPPT = Office of Pollution Prevention and Toxics
ORD = Office of Research and Development
OSAPE = Office of Science Advisor, Policy and Engagement
OW = Office of Water
R10 = EPA Region 10

APPENDIX B: MATERIALS

Material Provided in Advance of the Meeting

Materials to Support the Charge Questions

- Agenda
- Charge Questions
- Meeting Presentations

Informational Materials

- Virtual Participation Guide
- CSS BOSC November 2021 Supplemental Materials PowerPoint

BOSC
BOARD OF SCIENTIFIC COUNSELORS

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

RESPONSES TO CHARGE QUESTIONS

BOSC Sustainable and Healthy Communities Subcommittee

Courtney Flint, Ph.D. (Chair)
Utah State University

Elena Irwin, Ph.D.
Ohio State University

Barrett Ristroph, Ph.D., J.D.
Ristroph Law, Planning, and Research

Matthew Naud, MPP, MS (Vice Chair)
adapt.city LLC

James Kelly, MS
Minnesota Department of Health

Leslie Rubin, M.D.
Morehouse School of Medicine

Jay Golden, Ph.D.
Syracuse University

Rainer Lohmann, Ph.D.
The University of Rhode Island

Derek Shendell, D. Env, MPH
NJ Safe Schools Program; Rutgers School of Public Health

Kimberly Gray, Ph.D.
Northwestern University

Jonathan Meiman, M.D.
Wisconsin Division of Public Health

Michael Steinhoff, MPA, MSES
Kim Lundgren Associates, Inc.

Donald Nelson, Ph.D.
University of Georgia

EPA Contact
Tom Tracy, Designated Federal Officer

January 3, 2022

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

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LIST OF ACRONYMS

BOSC	EPA Board of Scientific Counselors
C&D	Construction and demolition materials
CBA	Cost/benefit analysis
CGE	Computable General Equilibrium
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
I/O	Input output
LCA	Life-cycle analysis
LEAF	Leaching Environmental Assessment Framework
NAICS	North American Industry Classification System
ORD	EPA Office of Research and Development
PFAS	Per- and polyfluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sufonic acid
SHC	Sustainable and Healthy Communities
SMM	Sustainable Materials Management
StRAP	Strategic Research Action Plan
USDA	U.S. Department of Agriculture
USEEIO	US-Environmentally-Extended Input-Output

INTRODUCTION

ORD has been conducting research on reducing waste throughout its life cycle, including consideration of reuse of construction and demolition debris and the potential for leaching of reused and landfilled materials. ORD asked for input from BOSC SHC on two charge questions regarding this research. BOSC SHC met by video conference to consider the questions as a group, in addition to several smaller group meetings to work out detailed answers. This report notes the strengths of SHC's work in waste reduction, provides suggestions to make the work stronger, and offers specific recommendations that SHC could implement.

CHARGE QUESTIONS AND CONTEXT

Q.1: SHC expanded its research on life cycle inventories and methodologies in response to OLEM, regional, and state priorities under the Resource Conservation and Recovery Act (RCRA), which focuses on reducing material use at the source and recovering and reusing valuable materials from waste streams. ORD is focusing on the development of US-Environmentally-Extended Input-Output (USEEIO) economy-wide life cycle models to support key functionalities of various waste reduction, recovery, and reuse tools, as well as potential refinements or enhancements to the underlying datasets and models of those tools.

What recommendations does the BOSC have to improve ORD's USEEIO life-cycle model?

What recommendations can the BOSC SC offer to facilitate increased usability of ORD's life cycle inventories and methodologies by EPA and state- or tribal-delegated programs?

Q.2: SHC expanded its research on waste recovery and beneficial reuse in response to OLEM's priorities of improved methods for sorting construction and demolition materials for reuse and regarding source term development to evaluate potential leaching from beneficial use, land disposal, and remediation. ORD research addresses effective and efficient materials reuse, protecting health and the environment while reducing natural resources consumption, waste generation, and the volume of materials disposed into landfills.

What recommendations can the BOSC offer to facilitate increased usability of ORD's construction and demolition materials research by EPA and state- or tribal-delegated programs?

What recommendations can the BOSC offer to improve future leaching predictions through increased use of the Leaching Environmental Assessment Framework (LEAF)?

The responses of the SHC Subcommittee to the charge questions are contained in the following section.

SUBCOMMITTEE RESPONSES TO CHARGE QUESTIONS

Charge Question 1

Q.1: SHC expanded its research on life cycle inventories and methodologies in response to OLEM, regional, and state priorities under the Resource Conservation and Recovery Act (RCRA), which focuses on reducing material use at the source and recovering and reusing valuable materials from waste streams. ORD is focusing on the development of US-Environmentally-Extended Input-Output (USEEIO) economy-wide life cycle models to support key functionalities of various waste reduction, recovery, and reuse tools, as well as potential refinements or enhancements to the underlying datasets and models of those tools.

What recommendations does the BOSC have to improve ORD's USEEIO life-cycle model?

What recommendations can the BOSC SC offer to facilitate increased usability of ORD's life cycle inventories and methodologies by EPA and state- or tribal-delegated programs?

Narrative

The proliferation of waste worldwide has resulted in significant environmental degradation with contamination of our soil, our waters, and our air. It is, therefore, critical that we control our use and contain our abuse of our natural resources with thoughtful and measured strategies. Solid waste management in general is decentralized and local in nature, driven by market influences and available resources. The U.S. Environmental Protection Agency (EPA), by bringing a national data-driven perspective to the issue, can help inform state and local policies that can drive improvements across the nation. EPA's Office of Research and Development (ORD) has been able to gather important information on the waste stream despite the absence of a legal mandate for companies to report information on their waste streams.

Businesses and all levels of government are now incorporating climate considerations and the United Nations Sustainable Development Goals that include minimizing the impact of water and other resource use into their decision-making and metrics. U.S. agencies and organizations have recognized their ability to impact national and international goals extending beyond their operational or geographic boundaries. To date, the ability of these agencies and organizations to engage in consumption-based accounting has been limited by data accessibility and specialized knowledge to interpret the results. ORD has made great progress on developing a suite of input-output economic and environmental modeling tools at the national scale. The U.S. Environmentally-Extended Input-Output (USEEIO) model provides a comprehensive framework for examining and understanding resource use and helping to inform strategies that reduce waste and pollution. These tools can help federal and state agencies, companies, and other local users to zero-in on environmental impact hotspots across the supply chain that are driven by both production and consumption sector-specific activities. ORD also recognizes the value of these tools in estimating and understanding the role of supply chains within state greenhouse gas (GHG) inventories and consumption-based inventories.

ORD's Board of Scientific Counselors (BOSC) Sustainable and Healthy Communities (SHC) Subcommittee commends EPA's work to improve our national, regional, and state level understanding of solid waste management. We highlight strengths and offer suggestions to better account for the social and economic dimensions of life-cycle analysis, climate change, data precision and security, and improving the ability of consumers and policy makers to use EPA's tools. Such accounting involves the process of communicating knowledge, information, and best practices developed by ORD for all its products. Expanding the inputs

to the USEEIO model and expanding the number of users (through partnerships, outreach, and developing guidance) will increase the sustainability and utility of this tool.

Strengths

BOSC SHC outlines strengths as follows:

- Accessibility: The economic input output (I/O) component provides for an easier and more accessible tool to examine environmental impact flows of the economy as compared to process life-cycle analysis (LCA). The Free Life Cycle Inventory leverages freeware open LCA. Publication of the complete model outputs as well as "finished" supply chain emissions factors provide multiple entry points for different practitioners to utilize the research products.
- Comprehensiveness: USEEIO builds on and updates prior works by Carnegie Mellon Economic I/O LCA, allowing for an economy-wide view of the impact of consumption activity.
- Applications for States and Managers: USEEIO is designed to power many other tools and applications, providing multiple points of entry for a variety of practitioners and use cases. The development of models by U.S. states is encouraging, as it can provide context-relevant and possibly more visible outcomes from policies informed by the model.
- National Sustainable Materials Management (SMM) Prioritization Tool: This tool is an example of an excellent application, with heatmaps that show potential areas of significant opportunity for environmental improvement for individual goods and services.
- Facts and Figures: EPA has done an excellent job building a history of U.S. solid waste management data as evidenced in the *Facts and Figures* report – with nearly 60 years of data from 1960–2018. The Facts and Figures Reporting Program and the Data Quality Assessment under Output 7.2 (Data and Methods to Advance EPA's SMM) are providing critical updates to ensure the reliability of the information in a foundational report that is utilized widely by the solid waste management community.
- Food Waste: Research on the overall impact of food waste demonstrates the need to prioritize support for state and local efforts to address this critical issue.
- Recycling Strategy: EPA's National Recycling Strategy to reduce contamination, improve processing efficiency, and improve recycled materials markets provides a sound and reasonable approach to the issue.
- Per- and Polyfluoroalkyl Substances (PFAS): EPA is considering the effects of PFAS on the food waste stream and how this limits composting.
- Greenhouse gases: EPA has demonstrated connections between solid waste (specifically food waste) and GHG emissions, which will be useful in meeting national commitments that the United States could make regarding emissions reductions.

Suggestions

BOSC SHC outlines suggestions as follows:

- Social and Equitable Dimensions: Although EPA has focused on technology and strategy, there has not been significant consideration of the human element in the life-cycle process, e.g., social disparities related to the generation of waste; the contamination of soil, water, and air; and the resulting degradation of ecosystems and their services as well as human illnesses. For example,

recycling is an uneven practice among individuals, neighborhoods, communities, counties, states, and regions. The practice of recycling has psychological, sociological, economic, and political elements. There are some areas in the country that have separate collections with designated containers for regular trash, recyclables, and composting material, whereas other parts of the country have only trash collection. Social dimensions of LCA are particularly relevant for populations who are vulnerable as a consequence of where they live, their built and natural environment, their socioeconomic status, and their political status. For example, waste facilities are often located in or near low-income, disadvantaged neighborhoods, leading to the unequal distribution of adverse environmental burdens and consequent health disparities. Thus, EPA should factor in Social LCA in addition to Environmental LCA, including consideration of (1) how consumption and production decisions in one location are driving negative social and health impacts in surrounding areas, (2) how marketing affects food buying and eating habits, and (3) how food buying and eating habits are, in turn, impacting food harvesting, production, packaging, and distribution. Further, EPA could specifically consider the impacts of inequitable access to recycling services across the United States, especially in rural areas, and the costs/benefits of improving collection systems.

- North American Industry Classification System (NAICS) Codes: ORD should consider partnering with appropriate government agencies including Census, the U.S. Department of Agriculture (USDA), and the U.S. Department of Energy (DOE) to evaluate the benefits of updating the NAICS codes used to classify businesses that would be relevant to USEEIO modeling, particularly biobased feedstocks, biobased products, and sustainable chemistry.
- Price Changes: A significant limitation of the I/O modeling approach is the underlying assumption of Leontief production, which implies constant input coefficients that are invariant to price changes. The approach ignores input substitution effects that will happen if increasing scarcity of some inputs results in higher prices. To address this limitation, the team should explore integration of the environmental impact modeling with standard multi-sector market equilibrium models. Computable General Equilibrium (CGE) models offer one approach. EPA should continue their collaboration with the National Center for Environmental Economics to explore potential integration of the environmental impacts data and supply chain modeling with the Standards-Based Active Guideline Environment (SAGE) model.
- Climate Change Effects: The ongoing dynamic among human activities, with associated production of waste and pollution, including methane, is integrally intertwined with climate change. Thus, consideration of waste management is a critical element in efforts to reduce GHG emissions and meet national targets. ORD should explain how it is factoring in the potential of cumulative impacts of climate change and the resulting complications to the waste stream. At a larger scale, EPA might want to address climate change in more detail in the next SHC Strategic Research Action Plan (StRAP)
- Local Policy Scenario Planning: The USEEIO tools allow for attribution of environmental impacts across the supply chain, but are less useful for policy analysis and scenarios, especially at local levels. To be more effective for this purpose, ORD should explore consequential LCA approaches that describe how flows would change in response to a given decision. To do so, ORD would have to consider how to model the marginal (versus average) impacts of decisions on environmental outcomes. Marginal data would be needed to represent the effects of a specific change in the production or consumption of goods or services on the environmental impacts across the supply

chain. EPA should also consider ecosystem services along the supply chain and how local demand and supply of these service influences the net social damages of production and consumption activities.

- Expansion: Integration of the waste modeling with the USEEIO model is a great step towards a fuller accounting of material flows across sectors within the United States and between the United States and other countries. EPA, in partnership with other federal agencies, should keep working towards a comprehensive, economy-wide accounting of the material flows into and out of the U.S. economy, including solid, gaseous, and liquid materials and wastes. The ORD team noted that they are working with other federal agencies who are also interested in this goal.
- Guidance/Standardization: States and localities are always refining their processes for performing GHG inventories (which is an input for State-EEIO) and waste characterizations for local policy development. There are few if any guiding documents that define how those characterizations should be performed in a standardized way. By sharing more information on how material types are defined, ideal sampling procedures, and other methods, EPA could provide guidance to perform those assessments. This should produce more-compatible results and lead to less friction for practitioners to incorporate these SHC products into local policy making. Further, with many entry points into various USEEIO products, some additional "way finding" for matching an output to particular use cases could be helpful for adoption. EPA could consider providing guidance with examples of what inputs will lead to what outputs. EPA could engage with standard setting and capacity building organizations such as the U.S. Climate Alliance and EPA State and Local Programs Office to provide guidance.
- Alternative Models and Cost/Benefit Analysis (CBA): The USEEIO model is at the core of a number of associated research projects as well as multiple ORD developed tools, datasets, and other products. However, the current structure based on a combination of economic I/O models and attributional LCA is one of many possible ways of assessing economy-wide environmental impacts, and other methodologies might be better suited to a range of specific questions. For example, CBA offers an alternative approach to assessing the sustainability impacts of a given production or consumption decision. Given the prevalence of CBA in assessing the impacts of government policies, ORD should consider ways that the USEEIO models could be augmented to evaluate the lifecycle impacts of alternative policies (or other scenarios) by assessing the trade-offs between changes in the social costs of environmental impacts versus the consumer benefits of the final goods and services. Further, while USEEIO and the state models are comprehensive, useful tools for environmental LCA, ORD should consider whether there is a risk in having so many analyses hinge on USEEIO, and whether other models should also be cultivated and maintained.
- Data Precision/Transparency: EPA reports that only 21% of the data in the *Facts and Figures* report are measured data; most are assumptions or calculations. While we recognize it is outside the direct purview of ORD, it would seem that improving voluntary data reporting would be beneficial and preferable to improving models and assumptions regarding materials management. While data collection methods are being updated, there will continue to be limitations and a need to rely on models for gap filling. This should be acknowledged in the *Facts and Figures* report where it is relevant for interpretation and directing appropriate use of the information presented. This is very important in developing trust and credibility, which is especially important when it becomes necessary to provide information that is critical to decision-making regarding health and the environment.

- Data Security: To ensure compliance with health privacy laws, particularly in regard to health-related data and personal information at more local/granular levels, EPA could give further consideration to ensuring online data security for local (county, town/city) and private sector organization users of the various modeling tools. While the national and state-level agency users might not encounter privacy/security concerns (data are not proprietary and are available to the public on environmental quality and health), the potential users at more granular levels will have access to, and likely want to use, other data about adverse health outcomes, indicators of socioeconomic status and susceptibility and vulnerability, etc.
- Research to Aid Consumers: ORD has identified quantifying the environmental implications of sending food waste "down the drain" (versus composting or putting in the garbage) as a potential area for future research. This theme and similar research that allows well-meaning consumers to make informed decisions should go forward. Similar research to inform consumers could include research on when it is beneficial (in terms of energy use) to recycle and when it is not.
- Prevention Methods: Working upstream wherever possible will be more cost-effective than downstream efforts. For example, reducing the types or colors of plastic packaging used by manufacturers could lead to more efficient sorting and recycling of empty containers. While such regulation is beyond the purview of ORD, ORD could (1) conduct its own research on the effect of recycling strategies such as using different types of plastic packaging, and (2) encourage industry and manufacturers who have a vested interest in potential regulation to do their own research and development to develop alternative planet-friendly alternatives.
- Outreach/Messaging: While general public outreach and education might be beyond the purview of ORD, ORD could have a role in helping to better "translate" its research to the general public in a manner that improves environmental literacy and encourages people to change their minds and practices. To avoid reinventing the wheel each time ORD needs to communicate something new and important with end-users, there is a need for communication methods that engage the desired audiences in learning about a particular tool *and* convince them to adopt and incorporate it into their work. Such a communication methods should (1) harness the collaboration of social scientists that can address some of the human dimensions related to basic research into best practices for business, industry, agriculture, the financial sector, and the general public, (2) involve professionals skilled in explaining scientific and technical information in terms that are meaningful to lay audiences, and (3) build on existing networks and relationships and facilitate the flow of information through these existing systems with appropriate modifications for each message. One such potential network is in the EPA regional offices, where the connections and the relationships exist with regional, state, and local communities, agencies, academic, business organizations, and individuals, including non-governmental agencies. The relationships that EPA/ORD has with other federal agencies can be harnessed by this system.
- Potential Partnerships: ORD should consider various partnerships to leverage its work. First, EPA could consider working with National Renewable Energy Laboratory and USDA on bio-based and safer chemical data. Second, ORD should consider working with the network of university LCA researchers, as university courses could lead to greater uptake of these methods by trained practitioners. Third, ORD researchers should continue to strengthen their ties with the National Center for Environmental Economics researchers to extend the types of analyses that are possible with the USEEIO suite of models. Finally, EPA/ORD should consider reaching out through regional offices to strategize with state, tribal, and local governments on modifying and restructuring

practices to reduce waste and improve efficiency. Regional EPA offices might be better able to reach the targeted audiences and develop the necessary relationships and partnerships to explore strategies and implement changes in practice.

Recommendations

BOSC SHC concludes with three multi-faceted recommendations:

Recommendation 1.1: Additional Inputs: Investigate how the USEEIO model could be adjusted to include additional considerations, particularly Social and/or Consequential LCA that also incorporate ecosystem services. Further, ORD should pursue applications that combine the rich set of impact indicators in the USEEIO model with other types of economic models, including CBA, CGE, and/or econometric models that are able to account for the effect of price changes on consumption and production decisions. In the event that NAICS codes are updated, information relevant to biobased feedstocks and other products and sustainable chemistry should also be included in the model.

Recommendation 1.2: Outreach and Partnerships: Work with regional partners to develop an interactive communication and outreach strategy for end users/practitioners to highlight the utility of the USEEIO model to answer practical questions and work with the network of university LCA researchers to include the USEEIO model in their curricula so that greater exposure to the USEEIO model via university courses would lead to greater uptake of these methods by trained practitioners.

Recommendation 1.3: Guidance/Standardization: Engage with standard setting and capacity building organizations for states such as the EPA State and Local Programs Office to shape how state level GHG inventories and other impact assessments are performed and reported in order to facilitate continuous updates of State-EEIO with high quality updates that capture differences in the carbon intensity of the economies of states enacting low-carbon and resource efficient policies.

Charge Question 2

Q.2. SHC expanded its research on waste recovery and beneficial reuse in response to OLEM's priorities of improved methods for sorting construction and demolition materials for reuse and regarding source term development to evaluate potential leaching from beneficial use, land disposal, and remediation. ORD research addresses effective and efficient materials reuse, protecting health and the environment while reducing natural resources consumption, waste generation, and the volume of materials disposed into landfills.

What recommendations can the BOSC offer to facilitate increased usability of ORD's construction and demolition materials research by EPA and state- or tribal-delegated programs?

What recommendations can the BOSC offer to improve future leaching predictions through increased use of the Leaching Environmental Assessment Framework (LEAF)?

Narrative

The SHC program's Research Area 8 focuses on waste recovery and beneficial use of materials to promote sustainability. This involves not only the recovery of construction and demolition materials (C&D), but also the development of a system—Leaching Environmental Assessment Framework (LEAF)—to assure that recovered materials will not leach and impact human health and the environment. Through the LEAF program, the SHC program has undertaken lab and field assessments of targeted inorganic chemical compounds—mainly metals (arsenic, boron, chromium and lead)—and organic chemical compounds including those that attach/adsorb to particulate matter (soil/dust) as well as those of emerging concern like the PFAS (e.g., perfluorooctane sufonic acid, or PFOS, and perfluorooctanoic acid, or PFOA). Contaminated materials assessed by LEAF besides C&D materials include mining/coal mining slag, coal fly ash waste, biosolids, etc. Research also considers cross-contamination of materials, e.g., mixtures of chemical pollutants. Beyond the re-use of materials, LEAF also evaluates whether and how disposed materials can be safely contained.

The BOSC SHC Subcommittee commends ORD for developing research outputs that will have practical use in the construction arena, in addition to assuring public safety in the face of leachate. The Subcommittee points out strengths and offer suggestions and recommendations on how to increase the applicability of the research.

Strengths

BOSC SHC outlines the strengths first of LEAF, then of C&D:

LEAF:

- Acceptability: The LEAF method is well accepted by stakeholders. EPA's standards for LEAF are comparative to those in Europe.
- Applicability: EPA has been able to use LEAF with both inorganic chemicals, complex mixtures of chemicals and organic chemicals, including PFAS.
- Scope: EPA is considering emerging concerns that will affect interactions, including PFAS and climate change.

C&D:

- Quantification: EPA has made strides in identifying and quantifying the relative percentages of materials found in C&D.
- Areas for Improvement: EPA has identified areas of C&D materials that are not effectively recycled (e.g., dry wall) and how to change this.
- Barriers: EPA is taking into consideration the barriers to reusing C&D materials including emerging threats such as PFAS.

Suggestions

BOSC SHC outlines suggestions, first for LEAF, then for C&D:

LEAF:

- Uncertainties: ORD could consider how the LEAF model should be changed in the coming decades, not only due to climate change, but also other factors, including how materials might break down

over time. It would be helpful for ORD to explain how the LEAF model accounts for these uncertainties.

- Salt-water Intrusion: ORD might want to examine the effect of saltwater intrusion on metals leaching in LEAF given the likelihood of more frequent storm surges and salt-water intrusion in ocean coastal zones and the greater potential for corrosion.
- Geographic Variability: There are obvious benefits to standardized methods, such as LEAF. That said, given the huge climatic range of conditions present across both the continental United States (arctic, desert, coastal zones) and islands/territories, ORD could consider how to factor in additional/optional tests that could be of use to regions that are very different in climate (e.g., arctic or desert). This could increase the usability of this tool, if ORD believes some states and tribes are reluctant to apply it given the available conditions in LEAF.

C&D:

- Disaster-damaged Materials: At present, ORD has not included analysis of C&D from communities (homes, office buildings, stores/businesses, schools, etc.) in response and recovery situations after hurricanes, tornados, or urban/suburban flooding due to short, intense rainfall and/or stormwater/combined sewer overflows. Therefore, other potential concerns like damaged asbestos and gypsum containing C&D or interior finish materials (due to loose fibers which can become airborne) as well as mold (various genera and species) remain unidentified and thus neither characterized nor quantified. This could be an area of future research activity.
- Limits of Reuse: ORD could consider at what point materials can no longer be safely reused (i.e., indicate how many times particular materials can be recycled before the leach rate changes). In addition, ORD could explore the recycling/reuse of contaminated materials that are subsequently used in construction, including the use of concrete blocks or something else with high volume/weight in its original or recycled/repurposed form. This is an opportunity to bridge research between C&D and LEAF.
- Certainty of Recovery Rate: ORD has focused on quantifying the uncertainty of municipal waste streams, but there is less precision regarding the degree of recovery of the C&D waste stream. There are assumptions of high recovery, but there might be a need to indicate the degree of certainty of these assumptions.
- Tracking: ORD should study the value of including various types of tracking devices (e.g., radio chips) in construction materials to assess whether this allows people to better identify and recycle the materials later. This could contribute to Output 8.1 (better characterizing and tracking segments) and Output 8.2 (product labeling).
- Reefs: Some jurisdictions[1] have used C&D material as a basis for offshore reefs but there does not appear to be clear, recent guidance on what C&D materials are most appropriate to use and how they should be arranged. ORD could consider research that tracks existing uses of C&D as reefs and develop guidelines for C&D use. In partnership with entities such as the U.S. Army Corps of Engineers, ORD could also consider related coastal applications such as erosion control.

Both:

- Partnerships: EPA could consider the potential for additional deliberate strategic partnerships along the lines of the work with U.S. Department of Defense (DoD) on PFAS. This could build the capacity to use LEAF by other agencies charged with cleanups. EPA could consider holding joint

[1] https://patch.com/new-york/tarrytown/recycled-tzb-materials-become-artificial-reefs

sessions/webinars/workshops with state agencies, tribal, or regional groups, including industry/trade organizations and associations of local/county governments (e.g., Association of State and Territorial Health Officials, Association of State and Territorial Solid Waste Officials, and National Association of City and County Health Officials), who have a vested interested in the most accurate science.

- Research Dissemination: EPA should develop a definitive dissemination plan, considering how to present the results of both LEAF and C&D research to industry and local decision-makers (including tribal communities) in a "user-friendly" manner so that the information is fully utilized by governmental agencies and the private sector. For example, EPA could develop and foster a community of practitioners and users, working with states, localities, and tribal communities through regular webinars, fact sheets, How-to Guides, and virtual workshops featuring case studies. Increased usability might transcend traditional ORD activities and includes partnering with communication and outreach specialists.

Recommendations

BOSC SHC concludes with two key recommendations:

Recommendation 2.1: Research Dissemination: ORD should develop a definitive dissemination plan to present the results of both LEAF and C&D research to industry and local decision-makers in a "user-friendly" manner so that the information can be used by local decision-makers and companies.

Recommendation 2.2. Range of Conditions: ORD should consider expanding the LEAF model to include a broader range of climatic conditions potentially impacting leaching of chemicals of concern. This includes diverse conditions that currently exist across the United States, as well as any future conditions that occur as a result of climate change.

SUMMARY LIST OF RECOMMENDATIONS

Charge Question 1: SHC expanded its research on life cycle inventories and methodologies in response to OLEM, regional, and state priorities under the Resource Conservation and Recovery Act (RCRA), which focuses on reducing material use at the source and recovering and reusing valuable materials from waste streams. ORD is focusing on the development of US-Environmentally-Extended Input-Output (USEEIO) economy-wide life cycle models to support key functionalities of various waste reduction, recovery, and reuse tools, as well as potential refinements or enhancements to the underlying datasets and models of those tools.

What recommendations does the BOSC have to improve ORD's USEEIO life-cycle model?

What recommendations can the BOSC SC offer to facilitate increased usability of ORD's life cycle inventories and methodologies by EPA and state- or tribal-delegated programs?

- **Recommendation 1.1:** Additional Inputs: Investigate how the USEEIO model could be adjusted to include additional considerations, particularly Social and/or Consequential LCA that also incorporate ecosystem services. Further, ORD should pursue applications that combine the rich

set of impact indicators in the USEEIO model with other types of economic models, including CBA, CGE, and/or econometric models that are able to account for the effect of price changes on consumption and production decisions. In the event that NAICS codes are updated, information relevant to biobased feedstocks and other products and sustainable chemistry should also be included in the model.

- **Recommendation 1.2:** Outreach and Partnerships: Work with regional partners to develop an interactive communication and outreach strategy for end users/practitioners to highlight the utility of the USEEIO model to answer practical questions and work with the network of university LCA researchers to include the USEEIO model in their curricula so that greater exposure to the USEEIO model via university courses would lead to greater uptake of these methods by trained practitioners.
- **Recommendation 1.3:** Guidance/Standardization: Engage with standard setting and capacity building organizations for states such as the EPA State and Local Programs Office to shape how state level GHG inventories and other impact assessments are performed and reported in order to facilitate continuous updates of State-EEIO with high quality updates that capture differences in the carbon intensity of the economies of states enacting low-carbon and resource efficient policies.

Charge Question 2: SHC expanded its research on waste recovery and beneficial reuse in response to OLEM's priorities of improved methods for sorting construction and demolition materials for reuse and regarding source term development to evaluate potential leaching from beneficial use, land disposal, and remediation. ORD research addresses effective and efficient materials reuse, protecting health and the environment while reducing natural resources consumption, waste generation, and the volume of materials disposed into landfills.

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APPENDIX A: MEETING AGENDA

Day 1: Thursday, October 28, 2021, Eastern Daylight Time

TIME (EDT)	TOPIC	PRESENTER
12:00 – 12:15	Sign on and Technology check	
12:15 – 12:25	Meeting Kickoff/FACA Rules/Expectations/Logistics	**Tom Tracy**, DFO, OSAPE
12:25 – 12:40	Welcome	**Chris Frey**, ORD, DAA for Science Policy
12:40 – 12:50	Subcommittee Chair Opening Remarks and Introductions	**Courtney Flint**, Chair
12:50 – 1:10	SHC Opening Comments	**Maureen Gwinn**, NPD, SHC
1:10 – 1:25	Research Implementation Engagement between ORD and OLEM	**Carolyn Hoskinson**, Director, ORCR/OLEM
1:25 – 1:35	Implementation of Life Cycle Models, Inventories, and Methodologies Research in CESER	**Greg Sayles,** Director, CESER
1:35 – 1:50	**15-Minute Break**	
Charge Question 1: Improvements to USEEIO Life Cycle Model and Increased Usability of Life Cycle Inventories and Methodologies **Charles Maurice** | Associate NPD, SHC		
1:50 – 2:05	USEEIO national models and applications	**Wes Ingwersen,** CESER
2:05 – 2:20	USEEIO state models and applications	**Wes Ingwersen,** CESER
2:20 – 2:35	BOSC Subcommittee Discussion and Q/As	**Courtney Flint**, Chair, BOSC Subcommittee
2: 35– 2:50	Materials life cycle applications and tools - National facts and figures on material, waste, and recycling programs	**Dave Meyer,** CESER
2:50 – 3:05	BOSC Subcommittee Discussion and Q/As	**Courtney Flint**, Chair, BOSC Subcommittee
3:05 – 3:20	Developing life cycle models for managing plastics - Understanding material flows, processes, and potential consequences	**Ray Smith,** CESER
3:20 – 3:35	BOSC Subcommittee Discussion and Q/As	**Courtney Flint**, Chair, BOSC Subcommittee
3:35 – 3:50	Food waste management applications - Holistic and foundational organic waste management	**Shannon Kenny**, OSAPE
3:50 – 4:05	BOSC Subcommittee Discussion and Q/As	**Courtney Flint**, Chair, BOSC

TIME (EDT)	TOPIC	PRESENTER
		Subcommittee
4:05 – 4:15	Wrap-up Day 1	**Courtney Flint**, Chair, BOSC Subcommittee

Day 2: Friday, October 29, 2021, Eastern Daylight Time

TIME (EDT)	TOPIC	PRESENTER
12:00 – 12:15	Sign on and Technology check	
12:15 – 12:20	BOSC Subcommittee Chair Opening Remarks	**Courtney Flint**, Chair
12:20 – 12:30	Public Comments	**Tom Tracy**, DFO, OSAPE
12:30 – 12:40	Implementation of Waste Recovery and Beneficial Use Research in CESER	**Greg Sayles**, CD, CESER
Charge Question 2: Increased useability of construction/demolition materials research and the Leaching Environmental Assessment Framework (LEAF) **Carlos Nunez** | Assistant CD, CESER		
12:40– 12:55	Leaching Tests to develop source terms to evaluate potential leaching from waste beneficial use, land disposal, and treatment	**Susan Thorneloe**, CESER
12:55 – 1:10	BOSC Subcommittee Discussion and Q/As	**Courtney Flint**, Chair, BOSC Subcommittee
1:10 – 1:25	Current and future focus for Leaching Environmental Assessment Framework (LEAF)	**Susan Thorneloe**, CESER
1:25 – 1:40	BOSC Subcommittee Discussion and Q/As	**Courtney Flint**, Chair, BOSC Subcommittee
1:40 – 1:55	**15-Minute Break**	
1:55 – 2:10	Technology-Enabled Construction and Demolition Debris Recovery	**Thabet Tolaymat**, CESER
2:10 – 2:25	BOSC Subcommittee Discussion and Q/As	**Courtney Flint,** Chair, BOSC Subcommittee
2:25 – 2:35	Wrap up Day 2	**Courtney Flint,** Chair, BOSC Subcommittee
2:35 – 4:00	BOSC Subcommittee Deliberations	**Courtney Flint,** Chair, BOSC Subcommittee
4:00 – 4:30	BOSC Subcommittee Summarize Back and Final Q/As	**Courtney Flint,** Chair, BOSC Subcommittee

APPENDIX B: MATERIALS

Material Provided in Advance of the Meeting

Materials to Support the Charge Questions

- Agenda
- Charge questions
- Final presentations
- Research Area Descriptions
- SHC Final StRAP (FY 2019–2022)

Informational Materials

- Bibliography of Relevant Research
- Bibliography of Relevant Research
- Virtual Participation Guide

BOSC
BOARD OF SCIENTIFIC COUNSELORS

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

RESPONSES TO CHARGE QUESTIONS

BOSC Safe and Sustainable Water Resources Subcommittee

Joseph Rodricks, Ph.D., DABT (Chair)
Ramboll Environ

Scott Ahlstrom, PE, PMP
Corix Utilities

Jared Bales, Ph.D., M.S.
Consortium of Universities for the Advancement of Hydrologic Science, Inc.

Elizabeth Boyer, Ph.D., M.S.
Penn State University

Steve Carr, Ph.D.
Los Angeles County Sanitation District

Shahid Chaudhry, M.Sc.
California Energy Commission

David Cole, M.S.
Oregon Department of Environmental Quality

Joel Ducoste, Ph.D., BCEEM
North Carolina State University

Elizabeth Fassman-Beck, Ph.D., M.Sc.
Southern California Coastal Water Research Project

Fred Hitzhusen, Ph.D.
The Ohio State University (Retired)

Lucinda Johnson, Ph.D.
University of Minnesota Duluth's Natural Resources Research Institute

Kate Lajtha, Ph.D.
Oregon State University

Michelle Lorah, Ph.D.
U.S. Geological Survey

John Lowenthal, M.S., PWS, PWD
Cardno

Tim Verslycke, Ph.D.
Gradient

Stephen Weisberg, Ph.D.
Southern California Coastal Water Research Project Authority

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Louisiana State University

EPA Contact
Tom Tracy, Designated Federal Officer

January 28, 2022

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

CONTENTS

LIST OF ACRONYMS

BMP	Best Management Practices
BOSC	EPA's Board of Scientific Counselors
CDC	Centers for Disease Control and Prevention
CSO	Combined sewer overflow
EPA	U.S. Environmental Protection Agency
HAB	Harmful algal bloom
MS4 NPDES	National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
NTP	National Toxicology Program
ORD	EPA's Office of Research and Development
SSWR	Safe and Sustainable Water Resources
TMDL	Total maximum daily load
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

CHARGE QUESTIONS AND CONTEXT

The U.S Environmental Protection Agency (EPA) Board of Scientific Counselors (BOSC) Safe and Sustainable Water Resources (SSWR) Subcommittee was charged with addressing a series of questions about nutrients and harmful algal blooms (HABs), focused on Research Areas 4, 5, and 6. Charge questions were as follows:

> Q.1. Nutrient pollution is the most widespread water quality problem facing the United States, with far-ranging consequences for environmental condition, economic prosperity, and human health and well-being. Current SSWR in Research Area 5 focuses on nutrient-related impacts in watersheds and waterbodies to support determining protective endpoints for aquatic life in different water body types. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of this research area and on (a) any new or emerging sensitive aquatic life endpoints, and (b) methods, sensors, and/or nutrient indicators for assessing aquatic life endpoints, particularly under changing climate conditions?
>
> Q.2. While EPA, states, and tribes have made great efforts toward reducing nutrient pollution nationwide, it is still a challenge to identify best practices for implementing interventions and tracking their effectiveness to meet nutrient reduction goals in a comprehensive manner. To address this issue, SSWR Research Area 6 focuses on 1) applying tools, technologies, and best practices for nutrient management, 2) monitoring and tracking the effectiveness of nutrient reduction strategies, and 3) working closely with stakeholders to apply management practices and monitoring within their nutrient reduction programs. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of this research area, particularly related to evaluating the effectiveness of nonpoint source nutrient reductions at local to large regional scales?
>
> Q.3. Harmful algal blooms are complex ecological events that are affected by a variety of factors, including nutrient availability, water temperature, weather patterns, solar irradiation, limnology, and competing microorganisms. Much is still unknown regarding the human and environmental health effects of toxins produced during blooms. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of the HABs portfolios, particularly in a) determining the toxicity of HABs, and b) developing the capacity to forecast HAB events to prevent or mitigate exposure?

The responses of the SSWR Subcommittee to the charge questions are contained in the following section.

SUBCOMMITTEE RESPONSES TO CHARGE QUESTIONS

Charge Question 1

> Q.1. Nutrient pollution is the most widespread water quality problem facing the United States, with far-ranging consequences for environmental condition, economic prosperity, and human health and well-being. Current SSWR in Research Area 5 focuses on nutrient-related impacts in watersheds and waterbodies to support determining protective endpoints for aquatic life in different water body types. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of this research area and on (a) any new or emerging sensitive aquatic life endpoints, and (b) methods, sensors, and/or nutrient indicators for assessing aquatic life endpoints, particularly under changing climate conditions.

Narrative

The Subcommittee endorses the EPA Office of Research and Development's (ORD's) nutrient research strategy, which focuses on developing biological endpoint indicators to measure eutrophication, rather than quantifying nutrient concentrations. This is the correct approach because individual nutrient concentrations are not themselves of concern, and only invoke an ecological response under select antecedent conditions in the system of concern.

As part of that strategy, ORD is examining and/or developing a diverse suite of potential indicators, from those operating at the cellular level to the community level. The charge question asks whether ORD should add further develop any new methods, sensors, or indicators for assessing aquatic life endpoints. The Subcommittee agrees that the existing set of indicators ORD is examining are appropriate, representative of the state of the art, and considers an appropriate range of sensitivity. ORD should focus their efforts on more thorough research implementation of their present indicator set, rather than diluting that effort through developing a larger range of indicators.

The Subcommittee identified three areas where the research could be improved. The first is a need to create linkage between the biological endpoints under development and the critical nutrient thresholds triggering those responses. While focusing on biological endpoints is the right approach for assessing if a problem exists, after a problem is identified the manager must determine to what levels, the nutrients in the system, either concentrations or loads, must be reduced to alleviate the negative ecological condition. For some indicators, such as dissolved oxygen, establishing that linkage should be straightforward. For others, such as community response indicators, that linkage will be challenging. For each indicator, ORD should strive to produce three products: (1) a conceptual model of how nutrients affect the indicator response, including how other factors modify that relationship, (2) verification through field observation and experimentation that the conceptual model is valid, and (3) quantification of the relationship between nutrients and the indicator response. The Subcommittee believes ORD must expend more effort in this part of the nutrient research strategy to achieve those objectives.

Communication of their research strategy is a second area where EPA could improve. The presentation to the Subcommittee focused on the research associated with the individual indicators and lacked integration across indicators and other components of the nutrient program. There was no integrative document offered explaining the overall endpoint strategy, or the approach used to select the indicators that ORD studied. The Subcommittee even had a difficult time deciphering which research projects were associated with Research Areas 4 versus 5.

The ORD scientists convinced the Subcommittee that such strategic thinking exists, but ORD needs to inform others about that strategy and should create a document to achieve this goal. In particular, the strategy should include the following three parts: (1) how and why the focus is on biological endpoints, rather than on nutrient concentrations, (2) how ORD selected the suite of indicators, and what metrics ORD used to determine if an indicator was developed sufficiently for application, and (3) how ORD creates a linkage between the endpoints and the nutrient exposure leading to impairment. The target audience for this document should include the management community that ORD hopes will adopt the indicators, such as EPA's Office of Water and state regulatory managers. It should also include scientists external to ORD who work on eutrophication issues so these scientists can see how their work might complement and integrate into ORD's development efforts.

The third ORD should focus on is scaling the research to national applicability. ORD has done a good job of testing indicators across a wide range of systems but has not illustrated how ORD will account for site-specific factors that affect indicator performance. The Subcommittee believes that factors associated with

geography, such as temperature and rainfall patterns, will have substantial effects on indicator responses, as will system size. Quantifying those performance modifiers likely requires a factorial examination of sampling site characteristics. At present, it appears ORD has studied each of the indicators at only one or two sites. This does not allow for a controlled consideration of those factors. ORD should develop a strategy for scaling indicators that work well at the initial research sites to assess response across a wide range of site types. Such benchmarking should also consider how climate change may affect future expectations for these indicators.

Strengths

- Basing research on biological indicators rather than on the underlying nutrient concentrations is the proper approach.
- The indicators ORD has considered represents an appropriate range of potential biological responses that cover a spectrum of sensitivities to stress.
- ORD conducts the work over a wide spatial range of geographical systems. This is important because the effects of nutrients can differ substantially across systems with different flow characteristics, weather patterns, and biological baselines.

Suggestions

- Develop a clearer strategy for assessing how well indicators scale across systems of different sizes and geography.

Recommendations

The Subcommittee offers two recommendations to support the relevant Agency priorities:

Recommendation 1.1: Expand the research to better define the linkage between endpoints ORD is developing and the nutrient concentrations that trigger changes in those endpoints.

Recommendation 1.2: Create a document describing a coherent structure for ORD's nutrient research strategy, and then organize the list of projects around that structure. The strategy document should detail the indicator selection process, including the rationale for selection and metrics for determining success.

Charge Question 2

> Q.2. While EPA, states, and tribes have made great efforts toward reducing nutrient pollution nationwide, it is still a challenge to identify best practices for implementing interventions and tracking their effectiveness to meet nutrient reduction goals in a comprehensive manner. To address this issue, SSWR Research Area 6 focuses on 1) applying tools, technologies, and best practices for nutrient management, 2) monitoring and tracking the effectiveness of nutrient reduction strategies, and 3) working closely with stakeholders to apply management practices and monitoring within their nutrient reduction programs. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of this research area, particularly related to evaluating the effectiveness of nonpoint source nutrient reductions at local to large regional scales?

Narrative

The Subcommittee applauds the overall research strategy to assess nutrient impacts and develop reduction strategies. The approach correctly recognizes that favorable environmental outcomes require a suite of solutions, and ORD must integrate them through modeling to optimize deployment of assets throughout a watershed. ORD's work to advance that modeling is well done.

ORD has also incorporated development/assessment of an appropriate range of potential solutions into their research strategy, including structural best management practices (BMPs), non-structural conservation practices, and project-specific restoration activities. The Subcommittee commends ORD for considering more novel approaches, such as market-based nutrient trading. Developing this broad toolbox is appropriate.

The Subcommittee also commends ORD for implementing a case study approach, which allows ORD to illustrate how the range of solution types can be effectively used in combination. Moreover, the case studies allow ORD to demonstrate the monitoring technologies to assess conditions and quantify possible improvements that result from management actions. In addition, the case studies illuminate the value of partnerships in implementing the newly developed tools. Watershed-based management requires involving many types of groups. ORD has done a great job of attracting partners to develop those approaches in the case studies.

The lack of a clear linkage between source identification and the rest of the research strategy dismayed the Subcommittee. The findings from the source identification work should drive which inputs deserve the greatest research investment, but that connection is not obvious in some cases. For instance, the Subcommittee questioned the research emphasis on atmospheric inputs, which might seem more appropriate if it were placed into context of other sources in a nutrient budget.

The Subcommittee would like to see ORD expand the modeling effort to increase focus on nutrient inputs from urban stormwater. Present efforts focus on nutrients derived from agriculture and urban wastewater treatment plant discharges, but non-point source pollution from urban stormwater runoff is a major contributor to receiving water nutrient loads. Reducing nutrient loads from urban runoff is also a major driver for BMP implementation by states, Departments of Transportation, and other local jurisdictions across the country. This implementation is necessary to comply with existing Clean Water Act requirements (e.g., the National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System or MS4 NPDES, total maximum daily load, or TMDL, regulations, or combined sewer overflow, or CSO, mitigation requirements). This BMP implementation results in billion-dollar public agency investments. Omitting urban stormwater runoff as a nutrient source, and urban stormwater BMPs as solutions in the watershed-scale modeling, is incongruous with this level of investment resulting from EPA regulatory activity.

A second area for potential improvement involves enhancing management solutions and tools focused on legacy nutrient-dominated systems. Many of the nutrient impairments experienced around the country result from historic nutrient inputs that have not exited the system, rather than from new inputs. This is particularly true in estuarine systems where bottom sediments have received high carbon and nutrient loads. Turbulent flows accompanying storms can resuspend nutrient-laden sediments. The bulk of ORD's management actions are focused on reducing new sources. This is appropriate. However, ORD should also explore conducting case studies in systems where remnant historical inputs contribute meaningfully to illustrate how applying the newly developed tools work across a range of system types.

A third area for improvement involves enhancing communication. The Subcommittee recognizes ORD appropriately conducted case studies in at least three different parts of the country, in specific local

watersheds. ORD should integrate their findings across case studies to develop a set of lessons learned based on commonalities across systems. Moreover, the lessons learned should include what aspects of the monitoring programs provided the best feedback for adaptive management. ORD should compile these findings into guidance documents that communicate best practices to the range of stakeholders that ORD identifies as their target audiences. The targeted managers can then adopt the newly developed ORD tools. ORD needs to develop and implement an effective outreach strategy to provide the regional managers ORD scientists that the managers can rely on to help with applying those tools. This communication must be interactive so all involved, including the non-profit organizations and other stakeholders, can agree on the proper management approaches to implement.

Strengths

- The research involves developing/evaluating state-of-the-art technologies. ORD recognizes the research requires a toolbox of solutions.
- The strategy appropriately relies on modeling to integrate individual technologies into a watershed-based management strategy.
- ORD's case study approach is instructive and adaptable.

Suggestions

- Expand the present modeling focus to recognize the important role of urban stormwater sources and BMPs.
- Increase emphasis on developing management solutions and tools applicable to legacy-nutrients-dominated systems.
- Establish a better connection between the source identification research and the BMP practices under development.

Recommendations

The Subcommittee offers this recommendation to support the relevant Agency priorities:

Recommendation 2.1: ORD should develop and provide an effective communication strategy, focused on lessons learned that are transferable to managers over a range of different geographic and spatial scales.

Charge Question 3

Q.3. Harmful algal blooms are complex ecological events that are affected by a variety of factors, including nutrient availability, water temperature, weather patterns, solar irradiation, limnology, and competing microorganisms. Much is still unknown regarding the human and environmental health effects of toxins produced during blooms. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of the HABs portfolios, particularly in a) determining the toxicity of HABs, and b) developing the capacity to forecast HAB events to prevent or mitigate exposure?

Narrative

The ORD research program on HABs attempts to encompass the full range of health and ecological problems associated with their presence in both freshwater and marine systems. The rapid growth of cyanobacteria or algae in virtually all types of water bodies ("blooms") produce a range of toxins, all with complex chemistries that can harm exposed people, pets, and other animals, and significantly alter local ecologies. Some of these toxins display serious acute forms of toxicity, although the possibility that some have long-term health effects due to chronic exposures has been inadequately investigated. The ORD research program is directed at identifying the factors that control bloom development and bloom toxicity, diversity and toxicities of HABs, and are developing the capacity to forecast HAB events and mitigate exposures.

ORD presentations to the Subcommittee left the impression that the Agency has a well-thought-out and organized research program, with a staff of dedicated scientists, but who are faced with substantial challenges. These challenges relate to understanding the health and ecological effects of toxins that occur in mixtures of varying composition (and many of which are not readily available for study or are very costly to investigate) and are problematic in identifying and controlling the complex environmental causes of blooms. The Subcommittee is nevertheless quite impressed with ORD's research program and hopes its suggestions and recommendations will serve to draw greater attention to its importance.

Strengths

- Many agencies of the federal government (EPA, U.S. Geological Survey, or USGS, the National Oceanic and Atmospheric Administration, or NOAA, the U.S. Department of Agriculture, or USDA, the Centers for Disease Control and Prevention, or CDC, etc.) have programs directed to investigate and manage the HAB problem, and almost all states have some degree of activity. These multiagency efforts are clearly necessary to deal with the HABs problem, and it is apparent that ORD representatives are in several ways connected to the wider range of governmental efforts. The recognition of the importance of these connections is a strength of the ORD research program.
- The ORD's toxicity testing program, though limited in scope (for the reasons mentioned above) is beginning to uncover data that are likely to be more useful for identifying toxicity thresholds, which are necessary for risk management of greater numbers and types of toxins. The program is beginning to focus on in vitro methods and recognizes that inhalation of aerosols could be a significant route of exposure. The so-called "beaches" epidemiology study is a major step toward gaining understanding of the true population disease impact of HABs; although such studies are time consuming and expensive, they represent true progress in documenting human health impacts under a multiple stressor regime.
- The Subcommittee was greatly impressed by the breadth and diversity of approaches to investigating capacities and tools for bloom prediction, and toward understanding of the important drivers of blooms and the means for controlling them. The pathways to progress on these topics have been well crafted and include cutting edge approaches and techniques, ranging from molecular qPCR to remote sensing. The modeling efforts span a range of spatial scales and objectives – from site-specific predictions of bloom occurrence and toxicity to nationwide observations of bloom frequency and extent. The rates of progress in this area of research will, as it does in research pertaining to health and ecological effects, depend on the nature and magnitude of support given by the EPA to the ORD HABs effort, and the strength and consistency of inter-agency collaborations.

Suggestions

- **<u>Determining Toxicity of HABs</u>**

- TOXICITY TESTING: The National Toxicology Program (NTP) undertakes toxicity testing on substances for which the government is responsible for data development. NTP has outstanding staff and resources for this purpose. ORD is encouraged to engage in discussions with NTP regarding testing of HABs toxins. The heavy burden on ORD might be significantly relieved if a collaboration with NTP can be achieved. (The size of the toxicology staff devoted to the ORD HABs program is clearly inadequate.)
- EXPOSURE PROFILES: The Subcommittee requests further information about the types and relative importance of exposure pathways under consideration (e.g., ingestion, bathing, use of contaminated water for gardening, lawn watering), and on populations that might experience repeated exposures over extended periods of time. Particular attention to underserved communities is critical.
- REPEAT DOSE TOXICITY STUDIES: To the extent it is feasible to obtain sufficient quantities of test materials, toxicity studies involving repeated exposures to HABs toxins should be undertaken. Again, NTP collaboration should be beneficial.
- DETERMINATION OF TOXICITY THRESHOLDS: Methods for using toxicity test data to identify toxicity thresholds are unclear and should be elaborated, and, if possible, subjected to peer review.
- EPIDEMIOLOGICAL STUDIES: ORD scientific skills might be joined with those of CDC to study population effects of HABs, to begin to determine their true public health and other societal impact.

- **Forecasting HABs to Mitigate/Prevent Exposure**
  - MODELING: Models predicting bloom occurrence and toxicity should explicitly incorporate climate driven variables at scales ranging from watershed to regional and beyond.
  - LINK TO NUTRIENTS: HAB development is highly dependent upon nutrient concentrations, among other environmental drivers. Although it is highly likely that the nutrient research informs the HAB research program, this integration was not well articulated during the presentations. The Subcommittee suggests that critical interactions across these programs be described to ensure the best possible outcomes, leading towards the important goal of preventing blooms before they start.
- **Additional Suggestions Related to the HAB Research Program**
  - SOCIAL/ECONOMIC: Consider further studies quantifying social and economic factors; economic studies should include both market and non-market studies of these impacts.
  - ECOSYSTEM IMPACTS: Ecosystem level impacts of algal toxins, especially under changing climatic conditions should be considered.
  - INTEGRATION: The study of HABs is a crowded space, including numerous federal, tribal, state, and local agencies as well as numerous academic institutions, as noted above. Further, EPA's own program is diverse and extensive, covering field, modeling, and laboratory studies. Ad hoc communication within the Agency does not ensure that the programs are well-integrated; therefore, the Subcommittee suggests that a structured system (roadmap) be implemented within EPA to ensure information flow across program areas and maximize uptake of new learning (e.g., through regularly scheduled information exchanges, identification of "point-persons" designated to serve as liaison between research teams, exchange/internal review of manuscripts, etc.) Field-based discoveries of bloom dynamics are important for predictive models, and subsequently for setting priorities for toxicity testing. Such information is generated and used in different parts of ORD and to ensure optimal consideration must be deliberately transmitted to appropriate researchers.

Recommendations

The Subcommittee offers this recommendation to support the relevant Agency priorities:

Recommendation 3.1: Ensure that model development and validation capture a range of critical ecosystem types as well as study sites that represent different community types.

SUMMARY LIST OF RECOMMENDATIONS

Charge Question 1: Nutrient pollution is the most widespread water quality problem facing the United States, with far-ranging consequences for environmental condition, economic prosperity, and human health and well-being. Current SSWR in Research Area 5 focuses on nutrient-related impacts in watersheds and waterbodies to support determining protective endpoints for aquatic life in different water body types. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of this research area and on (a) any new or emerging sensitive aquatic life endpoints, and (b) methods, sensors, and/or nutrient indicators for assessing aquatic life endpoints, particularly under changing climate conditions?

- **Recommendation 1.1:** Expand the research to better define the linkage between endpoints ORD is developing and the nutrient concentrations that trigger changes in those endpoints.
- **Recommendation 1.2:** Create a document describing a coherent structure for ORD's nutrient research strategy, and then organize the list of projects around that structure. The strategy document should detail the indicator selection process, including the rationale for selection and metrics for determining success.

Charge Question 2: While EPA, states, and tribes have made great efforts toward reducing nutrient pollution nationwide, it is still a challenge to identify best practices for implementing interventions and tracking their effectiveness to meet nutrient reduction goals in a comprehensive manner. To address this issue, SSWR Research Area 6 focuses on 1) applying tools, technologies, and best practices for nutrient management, 2) monitoring and tracking the effectiveness of nutrient reduction strategies, and 3) working closely with stakeholders to apply management practices and monitoring within their nutrient reduction programs. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of this research area, particularly related to evaluating the effectiveness of nonpoint source nutrient reductions at local to large regional scales?

- **Recommendation 2.1:** ORD should develop and provide an effective communication strategy, focused on lessons learned that are transferable to managers over a range of different geographic and spatial scales.

Charge Question 3: Harmful algal blooms are complex ecological events that are affected by a variety of factors, including nutrient availability, water temperature, weather patterns, solar irradiation, limnology, and competing microorganisms. Much is still unknown regarding the human and environmental health effects of toxins produced during blooms. What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of the HABs portfolios, particularly in a) determining the toxicity of HABs, and b) developing the capacity to forecast HAB events to prevent or mitigate exposure?

- **Recommendation 3.1:** Ensure that model development and validation capture a range of critical ecosystem types as well as study sites that represent different community types.

APPENDIX A: MEETING AGENDA

Wednesday, December 1, 2021

Time (EDT)	Topic		Presenter
11:45-12:00	Sign on and Technology Check		
12:00-12:15	Welcome and Opening Remarks		Tom Tracy (DFO) Joseph Rodricks (SSWR BoSC Chair)
12:15-12:20	ORD Welcome		Christopher Frey (Deputy Assistant Administrator for Science Policy; ORD Assistant Administrator Nominee)
12:20-12:30	SSWR Overview and Charge Questions		Suzanne van Drunick (SSWR National Program Director)
12:30-12:35	Nutrients and Harmful Algal Blooms (HABs)		Anne Rea (Sr Science Advisor, Nutrients & HABs Topic Lead)
12:35-1:35	Research Area 5: *Science to Support Nutrient-Related Water Quality Goals*		
	12:35-12:55	Overview of Research Area 5: *Science to Support Nutrient-Related Water Quality Goals: Research Highlights*	Heather Golden (ORD, CEMM)
	12:55-1:15	*Research focused on novel methods to assess nutrient indicators*	Cheryl Brown (ORD, CPHEA)
	1:15-1:35	*Research focused on vulnerability to and recovery from excess nutrients*	Kate Schofield (ORD, CPHEA)
1:35-2:35	BoSC Discussion of Charge Question 1		Joseph Rodricks (SSWR BoSC Chair)
2:35-2:45	Break		
2:45-3:45	Research Area 6: *Nutrient Reduction Strategies & Assessment*		
	2:45-3:05	Overview of Research Area 6: *Nutrient Reduction Strategies & Assessment: Research Highlights*	Yongping Yuan (ORD, CEMM)

	3:05-3:25	*Tools and approaches for implementing and tracking nutrient reductions*	Jana Compton (ORD, CPHEA),
	3:25-3:45	*Best practices for integrated nutrient management programs*	Chris Nietch (ORD, CEMM)
3:45-4:45	BoSC Discussion of Charge Question 2		Joseph Rodricks (SSWR BoSC Chair)
4:45-4:55	Public Comments		Tom Tracy (DFO)
4:55-5:00	Wrap up		Joseph Rodricks (SSWR BoSC Chair)
5:00	Adjourn		

Thursday, December 2, 2021

Time (EDT)	Topic		Presenter
11:45-12:00	Sign on and Technology Check		
12:00-12:10	Welcome and Opening Remarks		Tom Tracy (DFO) Joseph Rodricks (SSWR BoSC Chair)
12:10-1:10	Overview of Research Area 4: *Assessment and Management of HABs*		
	12:10-12:30	Research Area 4: *Assessment and Management of HABs: Research Highlights*	Nick Dugan (ORD, CESER)
	12:30-12:50	*Research focused on HAB toxicity*	Elizabeth Hilborn (ORD, CPHEA)
	12:50-1:10	*Research focused on predictive capability and future forecasting*	Blake Schaeffer (ORD, CEMM)
1:10-2:10	BoSC Discussion of Charge Question 3		Joseph Rodricks (SSWR BoSC Chair)
2:10-2:20	Break		
2:20-4:15	Charge Question Breakout Groups (Committee members will be preassigned to specific charge questions)		BOSC and ORD
4:15-4:45	Charge Question Break-out Group Report Outs		Charge Question Leads
4:45-5:00	Next Steps		Joseph Rodricks (SSWR BoSC Chair) Suzanne van Drunick (NPD, SSWR) Joe Williams (Principal Associate NPD, SSWR) Tom Tracy (DFO)
5:00	Adjourn		

APPENDIX B: MATERIALS

Material Provided in Advance of the Meeting

- Meeting Agenda
- Charge Questions
- All Presentations
- Research Area 5 – Supplemental Materials for the BOSC Review
- Zoom Virtual Participation Guide

Material Provided During or After the Meeting

- Zoom Recordings
- Zoom Live Captioning Transcripts
- Zoom Chat Transcripts

BOSC
BOARD OF SCIENTIFIC COUNSELORS

REPORT OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY BOARD OF SCIENTIFIC COUNSELORS AIR, CLIMATE, AND ENERGY (ACE) SUBCOMMITTEE

RESPONSES TO CHARGE QUESTIONS

BOSC Air, Climate, and Energy Subcommittee

Charlette Geffen, Ph.D. (Chair)
Pacific Northwest National Laboratory

Sandra Smith, M.S. (Vice Chair)
Retired

Viney Aneja, Ph.D.
North Carolina State University

Jeffrey Arnold, Ph.D.
U.S. Army Corps of Engineers

Bart Croes, P.E., M.S.
Retired

Jennifer Hains, Ph.D.
Minnesota Dept of Health

Cara Keslar, P.E., M.S.
Wyoming Dept of Environmental Quality

Michael Kleinman, Ph.D.
University of California, Irvine

Myron Mitchell, Ph.D.
State University of New York

Louie Rivers III, Ph.D.
North Carolina State University

Annette Rohr, Sc.D.
Electric Power Research Institute

Constance Senior, Ph.D.
Clean Energy

Art Werner, Ph.D.
Retired

EPA Contact
Tom Tracy, Designated Federal Officer

February 3, 2022

A 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

The mission of the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD) is to provide the best available science and technology to inform and support public health and environmental decision-making at the federal, state, tribal, and local levels, addressing critical environmental challenges and anticipating future needs through leading-edge research. The ORD's Air, Climate, and Energy (ACE) research program focuses on the science and engineering needed to improve air quality, reduce the number of nonattainment areas in the United States, and protect public health and the environment, including an emphasis on addressing the Administration priorities of addressing the climate crisis and environmental justice issues. The ACE program is one of the Agency's six highly integrated national research programs. The other five are Chemical Safety for Sustainability (CSS), Homeland Security (HS), Health and Environmental Risk Assessment (HERA), Safe and Sustainable Water Resources (SSWR), and Sustainable and Healthy Communities (SHC).

ORD developed Strategic Research Action Plans (StRAPs) to guide each research program. The 2019–2022 StRAP[2] for the ACE program articulates the program objectives and a four-year strategy for delivering air, climate, and energy-related research to address EPA's strategic objectives and mandates, as identified in the FY 2018–2022 EPA Strategic Plan (EPA Strategic Plan)[3]. It is the third such strategic planning exercise in this format (previous StRAPs covered 2012–2016 and 2016–2019).

The EPA Board of Scientific Counselors (BOSC) ACE Subcommittee was asked in 2019 to review and comment on the strategic directions and priorities of the program as articulated in the third StRAP. Subsequently, the Subcommittee undertook a review of the program's implementation of the research priorities. This is the second of two reports in 2021 (the first is dated August 2021) that convey the findings of the implementation review. All BOSC reports can be found on the EPA BOSC website.[4]

BACKGROUND

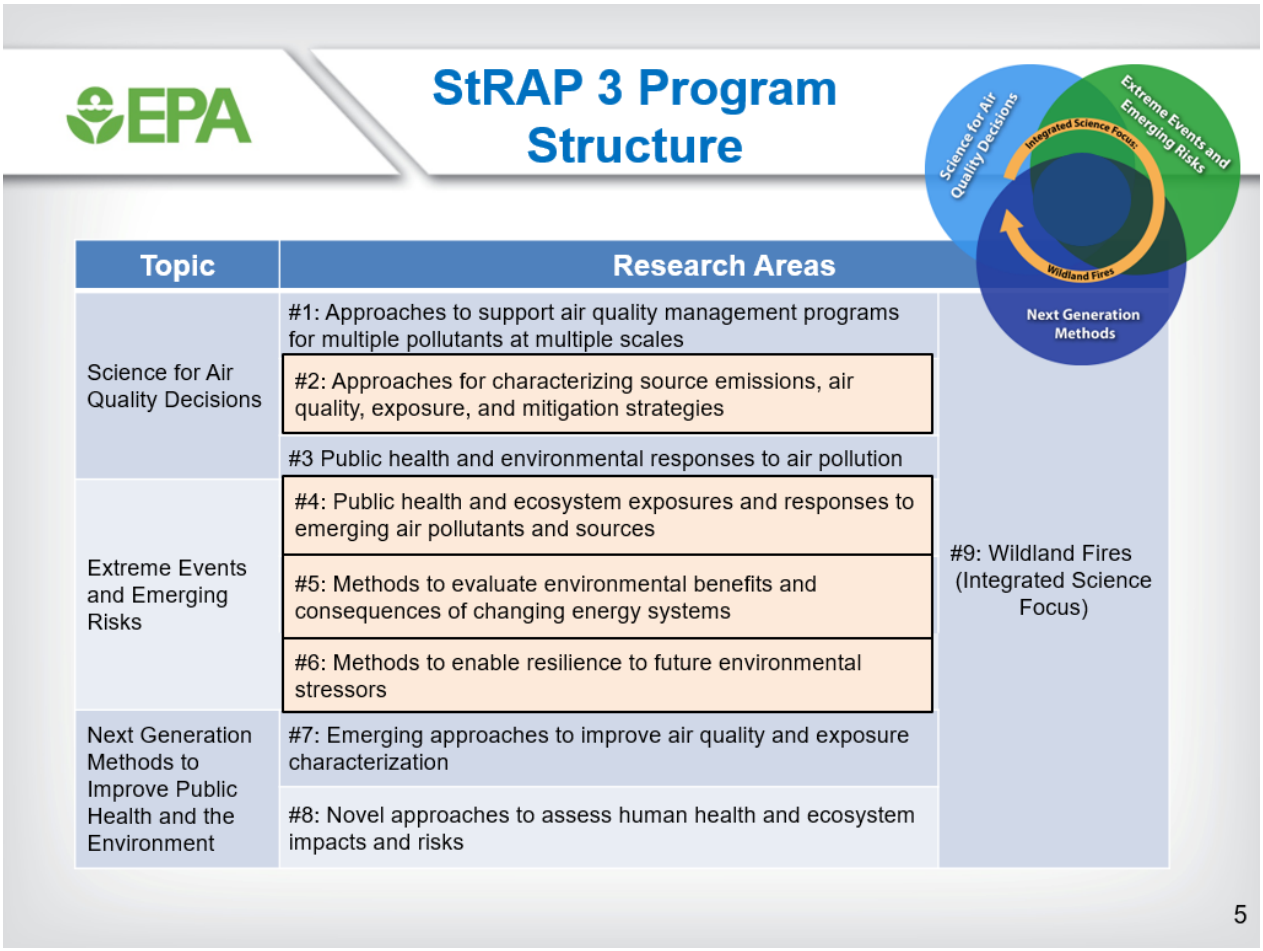
The current ACE research program is organized around three interrelated topics: (1) Science for Air Quality Decisions; (2) Extreme Events and Emerging Risks; and (3) Next Generation Methods to Improve Public Health and the Environment. The ACE StRAP further subdivided each of the three high-level research topics into eight research areas, plus an integrated research area focused on wildland fires. The following figure from a presentation by the program to the BOSC is an overview of the ACE program structure, showing the three research topics and nine research areas.

[2] Air and Energy National Research Program, *Strategic Research Action Plan, 2019 – 2022*, EPA 601K20003 March 2020, available at https://www.epa.gov/sites/production/files/2020-10/documents/A-E_fy19-22_strap_final_2020.pdf

[3] Working Together, FY 2018-2022 U.S. EPA Strategic Plan, available at https://www.epa.gov/planandbudget/strategicplan

[4] https://www.epa.gov/bosc/air-and-energy-subcommittee

Figure 1. Overview of the ACE Research Program Structure



The August 2021 BOSC ACE report focused on research implementation in six of the nine research areas: 1, 2 (with an emphasis on criteria pollutants), 3, 7, 8, and 9. This report focuses on implementation of research in Research Areas 4, 5, and 6, with an additional review of Research Area 2 emphasizing air toxics and emerging pollutants of concern rather than criteria air pollutants (highlighted in Figure 1 above).

In October 2021, the ACE program provided the Subcommittee with review materials relating to research in the research areas under review and three charge questions to guide Subcommittee deliberations. Subsequently, the ACE Subcommittee:

1. Met virtually with the ACE National Program Director and program staff on October 12–14, 2021;
2. Deliberated as a group on the charge questions; and
3. Divided into three charge question teams to draft initial responses to each charge question.

The BOSC ACE Subcommittee meeting agenda (Appendix A) and briefing materials (listed in Appendix B) are available on EPA's website.[5]

The three Subcommittee charge question teams drafted specific responses to each charge question after the October 2021 meeting and the Subcommittee met again on October 27, 2021 to discuss and review

[5] https://www.epa.gov/bosc

progress and key themes for charge question responses as an entire Subcommittee. A more complete draft report, including overview and summary materials prepared by the Chair and Vice Chair of the Subcommittee, was discussed by the Subcommittee in a meeting of the entire Subcommittee on November 12, 2021.

The report was then further revised based on Subcommittee member comments and discussions during that meeting and finalized in the BOSC Executive Committee meeting on February 3-4, 2022. The recommendations of the ACE Subcommittee in the report are based on material provided to us prior to and after the October 2021 meeting, presentations made during the three-day meeting, and deliberations both during and after the meeting.

CHARGE QUESTIONS AND CONTEXT

The ACE Subcommittee was charged with three questions as follows:

> Q.1: The ACE research program is implementing research to develop new methods to quantify source and near-source emissions, as well as ambient levels, of toxic air pollutants and contaminants of emerging concern. These methods are needed to identify pollutant sources and levels of exposure for communities and individuals.
>
> *What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of its air toxics and contaminants of emerging concern measurements methods research, and how this research will improve our understanding of these pollution sources and exposures, particularly for disproportionately impacted communities? [RA1, RA2, RA4]*
>
> Q.2: Climate change is expected to continue to increase the negative environmental and human health impacts of wildfires, flooding, drought, and other extreme events. Developing the knowledge and approaches to build resilience and adapt to these events is critical to preparing communities and protecting vulnerable populations and ecosystems.
>
> *What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of research to understand effects of climate-driven changes on natural and human systems, adverse impacts on human health and the environment from climate stressors, and approaches to prevent or reduce these impacts? [RA6]*
>
> Q.3: The Nation's energy and transportation systems are experiencing major transformations in response to economic drivers and to meet the Biden Administration's goal of net-zero carbon emissions by 2050. Understanding the dynamic changes in these complex, interconnected systems is important for understanding impacts of policies and technology changes on emissions of greenhouse gases, air pollutants, and other health and environmental impacts.
>
> *What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of its research portfolio to gain a better understanding of how energy and transportation systems may evolve and the consequences for emissions and other impacts. [RA5]*

Overall, the Subcommittee found that the ACE program has made significant progress in support of their strategic priorities, with important and impactful products and outcomes. The quality and impact of the science done in the program is excellent. Details are provided in the specific responses to the charge questions, below. This review also provided an opportunity to revisit topics brought up in earlier meetings

by the Subcommittee, including climate change, environmental justice, partner engagement, and a clearer integration of energy within the research portfolio. The scientific community increasingly recognizes the importance and urgency of addressing climate change. While rewarding to see the "C" (Climate) in ACE reinstated, the Subcommittee acknowledges that the program has continued to work on this important issue, integrating it into their strategic priorities and plans. The ACE program has successfully designed and executed research projects that address key science questions in a way that is relevant to partners and decision-makers. This proactive approach will also be required to address Administration priorities on environmental justice. While EPA has done impactful research on environmental justice issues in the past four years (the cycle of this StRAP), a continued focus on prioritizing this area of research is important to ensure that the health of disproportionately impacted communities is understood and protected. The foundational research conducted over the years by the ACE program has positioned the team well for today's scientific challenges and poses new opportunities for EPA to take a leadership role in addressing our most pressing environmental problems.

The Subcommittee was also impressed with the breadth and depth of the research staff. Researchers having a diversity of backgrounds, training, and expertise are clearly engaged across the program, bringing new ideas and talents to ACE research at ORD. The Subcommittee encourages the program to continue to work to balance the immediate and shorter-term interests of partners and stakeholders with the longer-term requirements for EPA researchers and their science communities to ensure that the ACE program and ORD have a place for exploratory research on relevant topics. This will help the program continue to lead advancements in environmental science and provide the basis for addressing problems that are not yet evident or well understood. Overall, the Subcommittee believes the ACE program is well positioned for success, now and in the next strategic planning cycle.

SUBCOMMITTEE RESPONSES TO CHARGE QUESTIONS

The Subcommittee appreciates the efforts of the ACE program leadership and staff in providing well-organized background materials, clear presentations, and an opportunity to discuss ongoing research projects with program leadership as well as the scientists. The opportunity to hear from and engage with scientists from other geographic locations was particularly appreciated, highlighting the breadth of expertise across the program and the strong connection with regional offices and their specific needs and issues.

The ACE program has continued to make advances in stakeholder and community engagement and outreach. The Subcommittee noted that user needs and perspectives are an important part of the research project design. Increasingly, the team is integrating multiple science disciplines and perspectives to create a more holistic product. The Rubbertown Next Generation Emissions Measurement Project is just one example of successful community outreach and response (CQ1). Other examples include climate relevant information and tools provided to decision-makers (CQ2). The program has developed and is implementing a more formalized structure for partner engagement, including feedback loops, which is clearly benefiting their accomplishments. The Subcommittee encourages continued collaboration with state agencies and other research entities in both its measurement and modeling programs. The cross-cutting ORD research and planning on ethylene oxide (EtO), per- and polyfluoroalkyl substances (PFAS), and volatile chemical products (VCPs) are specific examples of how these partnerships enhance the ability of citizens to make informed decisions on potential exposure and risk (CQ1).

The implementation of research in this StRAP demonstrates that the ACE program is truly integrating social sciences and a systems approach into their program. This has been an early goal of the program leaders, and the investments in social science capabilities and perspectives have served the Agency well, enabling the ACE program to readily integrate the priorities of the new Administration in their research portfolio. It was evident in discussions with the scientists and in the review of the products that the ACE program has made a good start on effectively embedding a focus on environmental justice into the planning and implementation of research projects. Specific products such as the Odor Explorer app and other tools in the Air Sensors Toolbox are specially designed for use by and to provide value to disproportionately impacted communities. These successes demonstrate how the research conducted by ACE can help make substantial progress in protecting the health of these communities. The Subcommittee encourages the ACE program to continue to prioritize the focus on environmental justice as it works to develop and implement its next StRAP.

The Subcommittee was pleased to see the "E" (Energy) in ACE given significant focus at this review. The research and the key products presented by the team reflected an appropriate and timely integration of energy production and its impacts across the research portfolio. That strong linkage was seen both in considering new measurements (brake and tire wear, CQ1) and in the modeling activities (CQ3). Increasing the regional specificity of the models is critical for use by decision-makers and communities. The City-based Optimization Model for Energy Technologies (COMET; CQ3) is an excellent example of a tool that cities and states can use to support long-term energy sector planning. It was clear from the review that the modeling tools and databases developed by the ACE program are increasingly valued and used by both researchers and policymakers outside of EPA. The "science to solutions" perspectives employed by the program are applauded. Additional resources might be required to support the scientists in accomplishing the effective dissemination of results and tools to a broad set of stakeholders.

Specific responses to each of the three charge questions follow below. The responses highlight strengths of the ACE program research areas and provide suggestions on progress to date and potential enhancements to the research program. The responses also include one or more specific recommendations for action by the ACE program leadership and staff for each charge question.

Charge Question 1

> Q.1. The ACE research program is implementing research to develop new methods to quantify source and near-source emissions, as well as ambient levels, of toxic air pollutants and contaminants of emerging concern. These methods are needed to identify pollutant sources and levels of exposure for communities and individuals.
>
> *What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of its air toxics and contaminants of emerging concern measurements methods research, and how this research will improve our understanding of these pollution sources and exposures, particularly for disproportionately impacted communities? [RA1, RA2, RA4]*

Narrative

The ACE program continues to make good progress on the science behind the measurement methods and on the supporting programs for air toxics and emerging pollutants of concern. The technical work the ACE program has undertaken in Research Areas 2 and 4 is excellent. The treatment of specific toxics and emerging pollutants using a systems or life-cycle approach is evidenced in the advances made to understand PFAS measurement and fate and transport by: (1) development of a method to measure

source emissions, (2) ambient measurement approaches, (3) deposition measurement approaches, and (4) research into mitigation and destruction. ACE program scientists continue to be leaders in developing and testing measurement methods for source characterization, ambient concentrations, and community exposure. These actions dovetail with the larger effort across EPA programs to understand and mitigate PFAS.

To continue its record of success, the ACE program work must balance the interests of EPA partners and stakeholders inside and outside the laboratories with those of the wider ACE research and community partners. Striking the proper balance of work for immediate Agency responses and a commitment to longer-term research on topics relevant to ACE missions and goals will help ensure that the ACE program and ORD as a whole can continue leading advancements in environmental science, while providing regional offices, state and local agencies, and tribal communities with critical information needed to solve regulatory challenges of air toxics and emerging pollutants of concern.

The ACE Subcommittee commends EPA and the ACE program on the extensive work done to characterize VCPs, PFAS, EtO, and other pollutants of concern. Additionally, the work to assess community exposure and bring citizen science into the research plan is commendable. Tools such as the Odor Explorer app and projects such as leveraging of the National Atmospheric Deposition Program (NADP) network in Wisconsin in tribal community areas show that the ACE program is committed to understanding issues in communities. As air quality continues to improve and more areas come into compliance with the National Ambient Air Quality Standards (NAAQS), it is important to highlight the impacts that air pollution continues to have on holistic health, especially for disproportionately impacted communities. The air regulatory community continues to need new insights and tools to address emerging and even more complex pollutants. It is reassuring that the ACE program understands this challenge with its focus on the holistic exploration of climate change on air quality, health, ecosystems, and infrastructure.

The Subcommittee urges the ACE program to continue and expand on the use of community tools to address issues particularly in areas with environmental justice issues. We encourage continued work on the Odor Explorer app, particularly on expanding guidance on how to interpret findings with this tool, as well the development of data that EPA can incorporate into the EJSCREEN tool. It is critical for the community to understand the potential health impacts from exposures and how to use this information to make informed decisions. Communities need guidance on understanding the severity of pollution exposure including knowing which exposures are acceptable, and which should be avoided.

During the meeting, Dr. Alice Gilliland asked the ACE Subcommittee, “What insights can you offer on the paradigm between use of federal reference methods (FRMs)/federal equivalent methods (FEMs) and sensors that we face as ORD supporting our internal regulatory partners?” The Subcommittee encourages the ACE program to explore creative ways to use sensors to identify potential hotspots and high levels of toxic pollutants (or proxies of toxic pollutants). The ACE program is in a good position to then recommend strategies for how state and local agencies and tribal communities might follow up to better understand the severity and potential risks of a specific pollutant and to provide recommendations/strategies to protect public health. For example, the ACE program needs to be able to advise communities on which odors are toxic and which are just nuisance odors.

Strengths

- The research into VCPs, and in particular, the work to characterize VCP emission using the VCPy tool is an important step to understanding the contribution that these products have on secondary organic aerosols and ozone formation. The Subcommittee commends the ACE program for the time-sensitive

work in characterizing VCPs from sanitizing products that have increased in use since the onset of Coronavirus Disease 2019 (COVID-19).

- The Rubbertown Next Generation Emissions Measurement Project is an example of effective community outreach and a strength of the ACE program's ability to characterize source emissions, air quality, and exposure as well as to investigate public health impacts, environmental exposures, and responses to emerging air pollutants of concern. The ACE program has conducted strong outreach with the community to develop and test the Odor Explorer app. This program will have broad impact in how state and local agencies and tribal communities respond to frequent and difficult community concerns around odors and their health impacts.
- The ACE program is doing commendable work by using a holistic health approach to air pollution and associated health effects. This approach has been needed for a long time to more fully understand how communities are impacted by pollution. Community concerns should be prioritized given limited funding and staff capabilities.
- The extensive work into developing methods to characterize stack and fugitive emissions for air toxics from facilities is an important step to understanding the sources and how to control for those pollutants.
- Efforts going into developing new methods for emerging pollutants of concern have been extremely important. This review demonstrated a large portfolio of specific methods in the outputs of the research area. This could serve as a blueprint to apply to other areas.
- Work on fenceline monitoring in combination with drones to achieve curtain monitoring is especially valuable and we encourage the ACE program to expand this work.
- The ACE program is doing excellent work in PFAS/PFOS. This is a great example of a useful framework for attacking complex problems.
- The Subcommittee commends the ACE program on their work on the SPECIATE database and using that information to estimate source emissions and exposures and to develop mitigation strategies.
- We commend the ACE program on the characterization of emissions from light- and heavy-duty vehicles, specifically brake and tire wear emissions. This work will assist the Agency's understanding of vehicle emissions as the fleet moves to more electrified vehicles. We encourage the ACE program to coordinate with the Office of Transportation and Air Quality (OTAQ) on the needed improvements/enhancements to tire and brake wear emission models. We also encourage the program, primarily through ORD's Center for Public Health and Environmental Assessment (CPHEA), to work on understanding how these exposures impact public health, especially in disproportionately impacted communities.

Suggestions

- We recognize and commend ORD's current focus on expanding the scientific foundation for identifying and quantifying PFAS in the environment through the development of validated analytical methods for specific PFAS and the use of non-targeted analysis methods, including total organic fluoride (TOF). We encourage the ACE program to continue research into measurement of PFAS, both specific compounds and indicator compounds. In conducting this research, it is important to articulate that only certain PFAS target compounds will be measured. The Subcommittee encourages additional research on understanding the role of air transport and deposition, and subsequent multimedia transport leading to human exposure.
- We encourage leveraging existing nation-wide networks such as NADP to eventually achieve greater understanding of transport and fate of PFAS emissions and other pollutants. In many cases the most difficult and expensive part of an ambient and source test program is collecting samples. Piggybacking on NADP sample collection by modifying test devices to collect additional samples could be cost-

effective. Analytical techniques might require additional resources. We encourage the ACE program to continue collaboration with state agencies and other research entities on developing these methods and developing sensors to get meaningful data.

- The Subcommittee commends the ACE program on the development of the Odor Explorer app. We suggest more guidance from the program on how communities can use sensors with the Odor Explorer app to better understand possible pollutants of concern. Additionally, the Subcommittee suggests the program increase coordination with states and local agencies and tribal communities, especially those with odor standards, so they can follow up on odor reports. This app could also help identify new and emerging pollutants of concern and we encourage the ACE program to couple this with onsite monitoring.
- The Subcommittee suggests that the ACE program continue exploration and development of measurement techniques and instrumentation for field deployment to estimate concentrations and spatial coverage of non-NAAQS pollutants of health concern. For example, the program could propose research to identify sensors with high potential for characterizing a larger suite of volatile organic compounds (VOCs), which are important for secondary aerosol formation, ozone formation, and near-source exposures to toxics. All of this possible work would have high applicability for populations in disproportionately impacted communities and ones with special sensitivities.
- Next Generation Emission Monitoring (NGEM) research using mobile monitoring (e.g., cars instrumented with monitoring equipment) is a good way of surveying pollutant distribution by neighborhood. Building mobile sensor packages that could be added to vehicles might also enhance our ability to investigate smoke from wildfires. The ACE program should connect this work with the Air Sensors toolbox to help citizen scientists use these tools and provide guidance on how to understand results from their investigations.
- The Subcommittee suggests that the ACE program provide more information on clearly delineating how to represent VCPs as a subset of total VOCs and put this in perspective with relation to the other sources of VOCs. The Subcommittee encourages the program, through CPHEA (in coordination with other ORD research programs), to develop information on how emerging pollutants of concern impact public health and to provide understanding of the severity of different concentrations so citizens can make informed decisions to avoid exposure.
- The U.S. Department of Agriculture's (USDA's) BioPreferred Program has been encouraging and certifying thousands of chemicals and products manufactured from natural sources to replace fossil-fuel-derived products. Coordination with this program could aid the ACE program in staying ahead of the game.

Recommendations

The Subcommittee offers the following recommendations:

Recommendation 1.1: Coordinate with states to provide recommendations for consistent and standardized procedures to collect and analyze EtO samples. Recommendations are needed in particular to ensure more sensitive methods are applied consistently and can be compared across agencies.

Recommendation 1.2: Develop a strategy for considering health-related outcomes research to help prioritize the specific compounds and related chemical and/or physical properties to focus on in understanding the impact of VCPs and secondary organic aerosols (SOA) on health and the environment.

Recommendation 1.3: Develop materials (documents/tools) to help the public better understand the outcomes and implications of the significant amount of health-effects research ongoing in the ACE program. Prioritization of public messaging will enable citizens to make more informed choices to avoid exposure.

Charge Question 2

Q.2. Climate change is expected to continue to increase the negative environmental and human health impacts of wildfires, flooding, drought, and other extreme events. Developing the knowledge and approaches to build resilience and adapt to these events is critical to preparing communities and protecting vulnerable populations and ecosystems.

What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of research to understand effects of climate-driven changes on natural and human systems, adverse impacts on human health and the environment from climate stressors, and approaches to prevent or reduce these impacts? [RA6]

Narrative

The Subcommittee thanks the ACE program team for the fullness of the information relevant to climate change provided before and during the review meeting. The time and attention given to preparing for the meeting makes the Subcommittee's review easier and improves our final product. The careful attention by the ACE program to the climate questions described in its StRAP and in the products listed in the tables firmly makes the point that climate change is not only a change happening in the future but is a crucially important set of global, regional, and profoundly local changes happening now. Reducing emissions of the two most important greenhouse gases that drive climate change – carbon dioxide (CO_2) and methane (CH_4) – has the added benefit of reducing emissions of particulate matter less than 2.5 microns ($PM_{2.5}$) and hydrocarbons that are ozone precursors. The Subcommittee is very pleased to see the attention that the ACE program has given to characterizing and understanding both current and projected future changes in climate and the effects of these changes on the ACE and EPA mission.

The climate-relevant information and tools for accessing and using that information created with support from the ACE program have broad applications, extending from climate model scenarios selection using EPA's Locating and Selecting Scenarios Online (LASSO) tool through land-use scenarios with EPA's Integrated Climate and Land-Use Scenarios (ICLUS) project, to assessment methods for specific types of adaptation and resilience actions with the Coastal Resilience and Watersheds tools. Work on these tools has successfully processed and packaged science and engineering research from parts of the ACE program for applications by non-technical practitioners for climate adaptation and mitigation, making for technically sound information to inform practical decision-making. The increased emphasis on this type of processing and packaging is a strong sign of the ACE program's enhanced relevance inside EPA and for EPA's overall communication of its mission and products to help sustain the human and natural environment under conditions of changing climate and current significant impacts. This translation aspect of the work created with ACE program support for the term of this review is sufficiently strong that the charge question might better be stated to include not only science to understand climate change impacts, but also to understand and inform long- and short-term responses to impacts across all EPA mission areas.

Not all climate-relevant research area outputs are completely explained or connected to each other in the overall ACE program, however. Product ACE.6.1.3, the dynamically downscaled extreme weather

projections, for example, is important even though very similar products have been developed outside the ACE program. Using the newly developed model outputs to drive new research on the production of precipitation intensity, duration, and frequency (IDF) curves, Product ACE.6.1.4, is a good step toward improved decision-making processes (even though the connection between new IDF curves and the ACE program is not always obvious). Moreover, no set procedure exists for creating IDF curves or for changing those to account for changing climate, so the utility of another set of downscale futures to create another set of IDF curves might not be high.

For this topic, the ACE program could perhaps create a set of products more closely aligned to their StRAP. This could be done by focusing on the particular strengths of the atmospheric modelers in the ACE program who have a deep and rich history of running models in weather mode to support air quality modeling that are similar to the regional climate models used for the IDF curves. In this way, the strengths of ACE program scientists can be focused on improving techniques and answering science questions nearer to the central topics of the program while strengthening links between atmospheric model applications and use for surface water hydrology.

Strengths

- The ACE program has a large breadth of research projects related to climate that are addressing issues associated with measurements, data evaluation, and interpretation. Modeling is appropriately being used to facilitate synthesis efforts and to address practical applications. The Subcommittee also applauds the development of tools that can be used by a wide range of users, facilitated by collaboration with those who have specific experience in user design.
- The ACE program is responding well to the Administration's focus on climate change and environmental justice. A focus on environmental justice has been well integrated into the ACE program, and, as mentioned earlier in this report, is important for serving the acute needs of disproportionately impacted communities.
- Continued development of extant models and the evolution of new models relevant to specific aspects of climate change is noteworthy. The ACE program has substantially advanced the characterization and understanding of climate change science and climate change effects using new and enhanced combinations of models. EPA clearly recognizes the importance in quantifying the linkages between energy production and its impact on the environment and the climate. More emphasis is needed on the precise identification and estimation of fugitive emissions, including short-lived greenhouse gas (GHG) emissions.
- The Subcommittee applauds the ACE program's development and expansion of CMAQ (Community Multiscale Air Quality Modeling System). CMAQ was originally developed as a model for predicting and simulating air pollutants both spatially and temporally for an urban airshed. The model with various modifications has been extended for use in evaluating linkages between air quality and climate, human health effects of pollutants, contributions of forest fires to air pollutants, watershed acidification, etc. The ACE program appears to have increased the number of scientists working on specific problems and StRAP elements. Bringing in new people with novel ideas for advancing the ACE and EPA missions is a welcome sign.
- The BOSC has previously suggested that more intention be given to the "E" (Energy) aspects of "ACE". The materials provided to the Subcommittee during the October 2021 meeting provide an excellent description of new and continuing work focused on energy. These recent efforts have been effectively integrated into the climate and air pollution research of the ACE program.

Suggestions

- We recognize that EPA has performed some work on impacts of climate change on ecological communities such as salmon populations. However, relative to impacts on humans, there has been much less focus on climate impacts on the non-human environment and the complex connections between humans and the environment in which they live. Climate change is having deleterious effects on the biota; for example, food sources, breeding seasons, habitats, and life-cycle patterns are all being disrupted. It is estimated that about 30 percent of all animal and plant species could become extinct by 2070 due to climate change. These impacts have both indirect and direct impacts on humans. The transmission of diseases, diminishment of food and water resources, loss of living space, and extreme weather events will all affect humans and the other plants and animals on the planet. For these reasons, the Subcommittee suggests that the next StRAP include additional research on climate impacts and climate change mitigation or adaptation strategies on non-human populations and ecosystems.
- The Subcommittee would like to see the ACE program produce a synopsis of Agency models currently in use related to climate change, including a table of inputs and outputs, information on temporal and spatial scales, demonstrated applications, and known limitations for use. Furthermore, it would help potential users to know the background and training needed to run each of the models. Where these models are key elements of individual StRAP products, this should be identified. It would also be helpful to indicate which of the models are research-grade and which are production-ready.
- It would be helpful to extend the focus of modeling beyond deterministic representations of results to outputs that represent the probabilistic character of using projected future climate conditions so that results of stand-alone and integrated modeling studies can be presented more fully. This approach is particularly important for results designed for use by non-technical practitioners who would not be familiar with techniques for modeling future climate scenarios. This could be especially helpful for disproportionately impacted communities experiencing some of the most serious effects of climate change.
- We suggest the ACE program consider explicitly identifying products that integrate or synthesize the primary research for the specific purpose of informing mitigation or adaptation decisions, and the types of decisions for which different products are most appropriate. . These products are important elements of helping the public and others understand the impact and use of the science, translating it for their decision-making needs.

Recommendations

The Subcommittee offers the following recommendations:

Recommendation 2.1: Provide information to users within the ACE program and ORD and to the public that helps explain potential applications of existing and developing models for describing and evaluating current conditions and future projections related to climate change threats and impacts. It would be most helpful for this information to include summaries of completed projects, which include model evaluation steps and records of how models were chosen for specific questions.

Recommendation 2.2: Ensure that climate-relevant emissions from agricultural operations, chiefly of CH_4, reduced and oxygenated nitrogen, and VOCs, are included in the modeling and observational work across the ACE program. We encourage the program to build on the success of previous

collaborations and expand connections to USDA and the Agricultural Research Service (ARS), for example, to help address key data and information gaps.

Charge Question 3

Q.3: The Nation's energy and transportation systems are experiencing major transformations in response to economic drivers and to meet the Biden Administration's goal of net-zero carbon emissions by 2050. Understanding the dynamic changes in these complex, interconnected systems is important for understanding impacts of policies and technology changes on emissions of greenhouse gases, air pollutants, and other health and environmental impacts.

What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of its research portfolio to gain a better understanding of how energy and transportation systems may evolve and the consequences for emissions and other impacts. [RA5]

Narrative

ACE Research Area 5 is focused on methods (i.e., models, tools, and databases) to evaluate the environmental benefits and consequences of changing energy systems in the United States. The priorities and direction for this research area generally come from program and regional offices as the former consider new regulatory scenarios or international obligations and the latter support planning of the energy transition in cities and regions that often have unique constraints. While much of the modeling effort is focused on air quality, multimedia impacts have become important: for example, regional water use in future energy scenarios or soil and water impacts from renewable fuel production. Significant model development efforts have been invested in making the Global Change Analysis Model (GCAM-USA) more accessible to a wide range of analysts and decision-makers through the use of the GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator (GLIMPSE) tool. ORD developed the EPAUS9rT database for use with the TIMES model, which has been used to examine future scenarios for green hydrogen use in the transportation section and sector decarbonization strategies. The ACE program developed COMET, an evaluation tool for cities and states that can support long-term energy sector planning, taking into account sustainability, resilience, and equity. As mandated by Congress, the ACE program is leading work on The Third Triennial Biofuels report to Congress. This work involves modeling and analysis of the effects of the Renewable Fuel Standard (RFS) Program on air, water, and soil, terrestrial and aquatic ecosystems, and international impacts. The ACE program collaborates within EPA (program and regional offices), with other agencies, and with outside groups on these efforts. Significant research is published in the peer-reviewed literature.

The current Administration's emphasis is on combating climate change and ensuring environmental justice. The Subcommittee notes that it will be critical to ensure that environmental justice is fully considered in the context of the energy transformation to renewable sources. The potential exists for disproportionate impacts through legacy site retirement/redevelopment, siting of new generation assets (e.g., renewables), and the emerging green hydrogen economy. Support for these areas can be enhanced when prioritizing resource allocation for future modeling and database research as discussed below. The modeling tools and databases developed by the ACE program are increasingly valued and used by researchers and policymakers within and external to EPA. Dissemination of these products for effective use requires technical support and science translation skills, which will require rethinking staffing needs and reward structures within ORD.

Strengths

- The ACE program has developed a strong suite of energy and transportation models forecasting multi-pollutant air emissions at different geographic (global, national, community-level) and time (near-term, 2050) scales for a wide range of sectors and policies (e.g., electric vehicle, or EV, and hydrogen use in transportation, deep energy system decarbonization). ACE energy modeling is clearly valued by EPA program and regional offices.
- EPA is working with other agencies (e.g., USDA, the U.S. Department of Energy [DOE], the National Oceanic and Atmospheric Administration [NOAA]) to assess the impacts to date (i.e., air, water, and soil quality; water availability, terrestrial and aquatic ecosystems; wetlands; invasive species, international effects) as well as likely future effects of the RFS Program. The Third Triennial Biofuels report is in progress and ORD is conducting key modeling analyses. For example, the ACE program used the EPIC (Environmental Policy Integrated Climate) model to conclude that grassland-to-cropland conversion increased soil, nutrient, and carbon losses in the Midwest between 2008 and 2016 (Zhang et al., 2021).[6]
- The ACE program has a good track record of peer-reviewed publications reporting energy modeling frameworks and results. The Subcommittee applauds the effective dissemination of energy system models to a variety of users, facilitated by the ACE program. For example, dissemination to EPA regions (e.g., Connecticut analysis of state clean energy and climate policies and their multi-pollutant, environmental impacts to help attain the ozone NAAQS) and other users. The ACE program is also proactive in interacting with users and stakeholders. An excellent example is the interactions with international universities and developing countries that use the EPAUS9r-TIMES energy system optimization model.
- The ACE program has productive and important partnerships with other offices and agencies, as well as with external groups such as the Energy Modeling Forum, for testing and improving models. For example, ACE program researchers have participated in a variety of cross-agency workgroups. These include a DOE-led workgroup on carbon capture and sequestration, an ongoing workgroup on "Scenarios and Interoperability," workgroups on annual updates to Annual Energy Outlook such as "Oil and Gas Workgroup" and the "DOE-DOT-EPA Information Exchange on Connected, Autonomous, Shared, Electric Vehicles." ACE program researchers also collaborate through Interagency Agreements (IAs). These include a previous IA with the National Renewable Energy Laboratory (NREL) in which they obtained characterizations of wind resources and recent and ongoing IAs with the Pacific Northwest National Laboratory (PNNL) for GCAM-related research. These engagements help ensure that the ACE program scientists are engaged with and influential in the broader research community.

Suggestions

- The Subcommittee suggests that the ACE program consider adding a capability to quantify the health impacts of building decarbonization activities in response to clean energy policies. The ACE program is already investigating the benefits of reduced residential wood combustion, but this could be expanded to include ventilation and filtration changes to reduce energy use while preserving and improving indoor air quality, and reduction of indoor combustion resulting from all-electric houses.
- The Subcommittee suggests that the ACE program consider adding a capability to COMET to quantify the health benefits from increases to active modes of transportation in response to clean transportation and sustainable community policies, including more walking and cycling.

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[6] Zhang, et al. (2021) Grassland-to-cropland conversion increased soil, nutrient, and carbon losses in the US Midwest between 2008 and 2016, Environ. Res. Lett., 16 (5): 054018, https://iopscience.iop.org/article/10.1088/1748-9326/abecbe.

- The Subcommittee suggests that the ACE program consider an explicit focus on the short-lived climate pollutants (i.e., CH_4, hydrofluorocarbons [HFCs], black carbon, VOCs/carbon monoxide [CO]). The recently released Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) concludes that reducing emissions of these pollutants is an important component of a broader approach to limiting warming. In many cases, these short-lived climate pollutants intersect with energy systems, such as fugitive CH_4 releases from oil and gas production and landfill gas capture systems, low-GWP (global warming potential) refrigerants (e.g., ammonia, propane) that can be deployed safely and can be less expensive and more energy efficient than HFCs, and black carbon and VOC/CO reductions from clean energy and transportation policies. In some cases, these sectors intersect with environmental justice issues, such as co-emitted toxics from combustion processes that are disproportionately located in some communities already impacted by other pollution sources.
- The Subcommittee suggests that the research on scenario development be evaluated and potentially expanded to ensure that emerging energy technologies and systems are sufficiently addressed. For example, hydrogen and other energy carriers (e.g., ammonia, synthetic hydrocarbons) are expected to play a more prominent role in the energy system in the coming years but are not currently reflected in the ACE program's modeling activities or projections. Ad-hoc coordination across groups on these issues may be inadequate.
- The Subcommittee notes that the reward structure for ORD/ACE program scientists currently favors traditional scientific metrics (e.g., publication record). This focus can potentially impede the dissemination of research results to some stakeholders, as well as support to users of different models and tools, since these activities are not key performance metrics. The Subcommittee suggests that ORD and the ACE program consider alternative reward structures to ensure that a broader definition of scientific leadership is recognized and prioritized.

Recommendations

The Subcommittee offers the following recommendations:

Recommendation 3.1: Include the impacts of policies and technology changes on communities with environmental justice issues in the ACE program's work on the changing energy and transportation systems. These communities have historically suffered disproportionately poor health outcomes related to air pollution generated from industrial processes and the transportation system.

Recommendation 3.2: Prioritize two specific areas in terms of continued support and additional assistance: (1) more intentional coordination with the user community on outreach, training, and support for tools and databases; and (2) approaches to optimize dissemination of information and model results to a broad set of stakeholders.

SUMMARY LIST OF RECOMMENDATIONS

Charge Question 1: The ACE research program is implementing research to develop new methods to quantify source and near-source emissions, as well as ambient levels, of toxic air pollutants and contaminants of emerging concern. These methods are needed to identify pollutant sources and levels of exposure for communities and individuals.

What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of its air toxics and contaminants of emerging concern measurements methods research, and how this research will improve our understanding of these pollution sources and exposures, particularly for disproportionately impacted communities? [RA1, RA2, RA4]

- **Recommendation 1.1:** Coordinate with states to provide recommendations for consistent and standardized procedures to collect and analyze EtO samples. Recommendations are needed in particular to ensure more sensitive methods are applied consistently and can be compared across agencies.
- **Recommendation 1.2:** Develop a strategy for considering health-related outcomes research to help prioritize the specific compounds and related chemical and/or physical properties to focus on in understanding the impact of VCPs and secondary organic aerosols (SOA) on health and the environment.
- **Recommendation 1.3:** Develop materials (documents/tools) to help the public better understand the outcomes and implications of the significant amount of health-effects research ongoing in the ACE program. Prioritization of public messaging will enable citizens to make more informed choices to avoid exposure.

Charge Question 2: Climate change is expected to continue to increase the negative environmental and human health impacts of wildfires, flooding, drought, and other extreme events. Developing the knowledge and approaches to build resilience and adapt to these events is critical to preparing communities and protecting vulnerable populations and ecosystems.

What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of research to understand effects of climate-driven changes on natural and human systems, adverse impacts on human health and the environment from climate stressors, and approaches to prevent or reduce these impacts? [RA6]

- **Recommendation 2.1:** Provide information to users within the ACE program and ORD and to the public that helps explain potential applications of existing and developing models for describing and evaluating current conditions and future projections related to climate change threats and impacts. It would be most helpful for this information to include summaries of completed projects, which include model evaluation steps and records of how models were chosen for specific questions.
- **Recommendation 2.2:** Ensure that climate-relevant emissions from agricultural operations, chiefly of CH_4, reduced and oxygenated nitrogen, and VOCs, are included in the modeling and observational work across the ACE program. We encourage the program to build on the success of previous collaborations and expand connections to USDA and the Agricultural Research Service (ARS), for example, to help address key data and information gaps.

Charge Question 3: The Nation's energy and transportation systems are experiencing major transformations in response to economic drivers and to meet the Biden Administration's goal of net-zero carbon emissions by 2050. Understanding the dynamic changes in these complex, interconnected systems is important for understanding impacts of policies and technology changes on emissions of greenhouse gases, air pollutants, and other health and environmental impacts.

What suggestion(s)/recommendation(s) does the Subcommittee have on ORD's implementation of its research portfolio to gain a better understanding of how energy and transportation systems may evolve and the consequences for emissions and other impacts. [RA5]

- **Recommendation 3.1:** Include the impacts of policies and technology changes on communities with environmental justice issues in the ACE program's work on the changing energy and transportation systems. These communities have historically suffered disproportionately poor health outcomes related to air pollution generated from industrial processes and the transportation system.
- **Recommendation 3.2:** Prioritize two specific areas in terms of continued support and additional assistance: (1) more intentional coordination with the user community on outreach, training, and support for tools and databases; and (2) approaches to optimize dissemination of information and model results to a broad set of stakeholders.

APPENDIX A: MEETING AGENDA

Tuesday, October 12, 2021

Time (EDT)	Agenda Activity	Presenter
10:30 – 11:00	Sign on & Technology Check	
11:00 – 11:15	Welcome and Opening Remarks	Tom Tracy, Designated Federal Officer (DFO) Charlette Geffen, ACE BOSC SC Chair Sandy Smith, ACE BOSC SC Vice Chair
11:15 -11:30	ORD Welcome	Wayne Cascio, ORD Acting Principal Deputy Assistant Administrator for Science
11:30 – 11:45	Overview of ACE BOSC SC Meeting Format and Charge Questions	Bryan Hubbell ACE National Program Director (NPD)
11:45 – 11:55	Update on BOSC EC PFAS Research Discussion	Susan Burden, OSAPE
Charge Question 1		
11:55 – 12:10	**CQ1:** Science Needs Related to Air Toxic Sources and Emerging Contaminants (Research Areas 2 and 4)	Bryan Hubbell, ACE NPD
12:10 – 12:25	Approaches for Addressing Scientific Challenges and Key Uncertainties in Characterizing Air Toxics and Contaminants of Emerging Concern	Alice Gilliland, Acting Center Director, Center for Environmental Measurement and Modeling (CEMM)
12:25 – 1:55	Research to Understand Source Emissions and Ambient Concentrations of Air Toxics and Contaminants of Emerging Concern	Tiffany Yelverton, CEMM Richard Shores, CEMM Alan Vette, CEMM Chet Wayland, OAR
1:55 – 2:10	**BREAK**	
2:10 – 4:10	**Meet the Scientists, Session #1**	
	Room A	
	Air Toxics – Source Measurement and Methods, Session Lead	Wyat Appel, CEMM
	PFAS Methods Development	Jeff Ryan, CEMM
	Fenceline Measurements and Methods Development	Eben Thoma, CEMM
	PFAS Incineration	Jonathan Krug, CEMM
	Room B	
	Air Toxics – Ambient Measurement and Methods, Session Lead	Mike Hays, CEMM
	VOCs/Odor Explore App	Rachelle Duvall, CEMM
	EtO Ambient Measurement and Methods Development	Ingrid George, CEMM
	Air Toxics Ambient Measurement and Methods Development	Tamira Cousett, CEMM
	Room C	
	Air Toxics Modeling and Databases, Session Lead	Donna Schwede, CEMM

Time (EDT)	Agenda Activity	Presenter
	Incorporating PFAS into the CMAQ Model	Emma D'Ambro, CEMM
	Updates to the SPECIATE database	George Pouliot, CEMM
	Adding VCP Chemistry to CMAQ	Havala Pye, CEMM
4:10 – 4:25	**BREAK**	
4:25 – 4:40	Public Comments	Tom Tracy, DFO
4:40 – 5:15	Clarification Questions from BOSC SC	Charlette Geffen, ACE BOSC SC Chair Sandy Smith, ACE BOSC SC Vice Chair
5:15 – 6:15	Working Session for BOSC SC Discussion	

Wednesday, October 13, 2021

Time (EDT)	Agenda Activity	Presenter
10:30 – 11:00	Sign on & Technology Check	
11:00 – 11:15	Welcome Back	Tom Tracy, DFO Charlette Geffen, ACE BOSC SC Chair Sandy Smith, ACE BOSC SC Vice Chair
Charge Question 2		
11:15 -11:30	**CQ2:** Science Needs to Understand Climate Change Impacts (Research Area 6)	Andy Miller, ACE Associate NPD for Climate
11:30 – 11:45	Approaches to Understand and Prepare for Climate-Driven Impacts	Tim Watkins or TBD, Acting Center Director, Center for Public Health and Environmental Assessment (CPHEA)
11:45 – 1:15	Research to Understand Climate Impacts and to Enable Resilience	Peter Beedlow, CPHEA Britta Bierwagen, CPHEA Chris Weaver, CPHEA Stephanie Santell, OW Dan Brown, R10 Jeremy Martinich, OAP
1:15 – 1:30	**BREAK**	
1:30 – 3:30	**Meet the Scientists, Session #2**	
	Room A	
	Water Quality and Aquatic Resources, Session Lead	Darrell Winner, CPHEA
	Stormwater Best Management Practices	Tom Johnson, CPHEA
	Adaptation Planning Frameworks	Jordan West, CPHEA
	Regional Watershed Resilience	Naomi Detenbeck, CEMM
	Room B	
	Ecosystem Effects, Session Lead	Peter Beedlow, CPHEA
	Coldwater Fish Refugia	Joe Ebersole, CPHEA
	Nutrient Transport	Jana Compton, CPHEA
	Room C	
	Scenarios and Impacts, Session Lead	Tanya Spero, CEMM
	Global Change Explorer	Phil Morefield, CPHEA

Time (EDT)	Agenda Activity	Presenter
	Storm IDF curves	Anna Jalowska, CPHEA
3:30 – 3:45	**BREAK**	
3:45 – 4:15	Public Comments	Tom Tracy, DFO, OSAPE
4:15 – 4:45	Clarification Questions from BOSC SC	Charlette Geffen, ACE BOSC SC Chair Sandy Smith, ACE BOSC SC Vice Chair
4:45 – 5:30	Working Session for BOSC SC Discussion	

Thursday, October 14, 2021

Time (EDT)	Agenda Activity	Presenter
10:30 – 11:00	Sign on & Technology Check	
11:00 – 11:15	Welcome Back	Tom Tracy, DFO, OSAPE Charlette Geffen, ACE BOSC SC Chair Sandy Smith, ACE BOSC SC Vice Chair
Charge Question 3		
11:15 – 11:25	**CQ3:** Science Needs for Impacts of Changing Energy Systems (Research Area 5)	Sherri Hunt, ACE Principal Associate NPD
11:25 – 12:15	Approaches and Research to Understand Impacts of Changing Energy Systems	Darrell Winner, CPHEA Rebecca Dodder, CEMM Marcus Sarofim, OAP Shutsu Wong (R1)
12:15 – 12:30	**BREAK**	
12:30 – 2:00	**Meet the Scientists Session #3**	
	Room A	
	Energy Systems Modeling and Databases, Session Lead	Tom Pierce, CEMM
	GLIMPSE	Dan Loughlin, CEMM
	EPAUS9r-TIMES	Carol Lenox, CEMM
	CoMET	Ozge Kaplan, CEMM
	Room B	
	Biofuels, Session Lead	Britta Bierwagen, CPHEA
	Biofuels Report to Congress	Chris Clark, CPHEA
	Terrestrial Effects of Land Use Change	Steve LeDuc, CPHEA
2:00 – 2:15	**BREAK**	
2:15 – 3:15	Revitalizing Research to Address the Challenge of Climate Change	Bryan Hubbell, ACE NPD Andy Miller, ACE ANPD for Climate
3:15 – 4:00	Clarification Questions from BOSC SC	Charlette Geffen, ACE BOSC SC Chair Sandy Smith, ACE BOSC SC Vice Chair
4:00 – 5:00	BOSC SC Workgroup Breakouts	
5:00 – 5:45	BOSC SC Workgroup Reports	
5:45 – 6:00	Wrap up and Next Steps	Charlette Geffen, ACE BOSC SC Chair Sandy Smith, ACE BOSC SC Vice Chair
6:00	Adjourn	Tom Tracy, DFO

APPENDIX B: MATERIALS

Material Provided in Advance of the Meeting

- Agenda
- Charge questions
- Summary of Product and Output Information for the Air and Energy 2019-2022 StRAP
- CQ1: Science Needs Related to Air Toxic Sources and Emerging Contaminants
- CQ2: Science Needs to Understand Climate Change Impacts
- CQ3: Science Needs for Impacts of Changing Energy Systems
- Projects Relevant to the Charge Questions and Supported through the Science to Achieve Results (STAR) Extramural Grants and Other Supplemental Internal ORD programs
- Tools and Resources Developed by ORD to Understand Impacts of the Changing Climate and Inform Adaptation

Material Provided During or After the Meeting

- PowerPoint presentation slides presented during the meeting
- ORD responses to BOSC follow-up questions