

**Preliminary Comments from Members of the Chartered SAB and BOSC on ORD draft
Strategic Research Action Plans and Cross-Cutting Roadmaps Listed by Charge Question
List of comments received as of July 22, 2014**

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General comments

General Comments from Dr. Viney Aneja

The US Environmental Protection Agency's Strategic Research Action Plans (StRAP), 2016-2019, and the Power Point presentations are well articulated and comprehensive. They, in general, address environmental protection issues for 2020 and beyond in a broad framework. However, the documents may be strengthened by incorporating some of the suggestions provided.

General Comments from Dr. Terry Daniel

At some point, early on in the StRAPs (or in some separate over-arching document) readers (and relevant others) need to be reminded that EPA was founded and has been charged to protect the environment and human health. All regulation writing, enforcing and complying has been in the service of these higher goals. Much has been accomplished over the past decades through this approach, but the world today and that can be anticipated for tomorrow requires a new approach. The reorganization and redirection of ORD over the past decade and the specific research plans presented in the 2016-2019 StRAPs are directed toward providing the scientific foundation for a new integrated systems approach that attends to broader goals of enhanced and sustained health of the environment and the health and well-being of human communities. The current documents seem to assume that this is well understood and accepted across the various audiences that may be exposed to these documents or to the actions and programs that they will foster and support. To the extent that client/public understanding and support is lacking, the ORD (and the Agency more generally) should consider making a more concerted effort to "prepare the ground" for the new directions they intend to pursue in the coming decades.

Comments from Dr. James Opaluch responding to Questions 1 and 2

In general, users of ORD research need more information on the reliability of models and forecasts. I'd recommend more effort on carrying out and presenting results of uncertainty analysis, including such things as statistical reliability of models, contexts where models are tested and found to be reliable, as well as contexts where models are not as reliable or where reliability has not been established. Essential elements include model validation, calibration and sensitivity analyses.

EPA research should focus more on issues of behavior and behavior change. Developing effective technologies and management practices is essential. But technologies and management practices will not be effective if people do not use them, or do not use them correctly. EPA needs a comprehensive program on to better understand behavior, barriers to adopting appropriate management practices and behavior change so we can better understand barriers to compliance with EPA programs and what we can do to overcome those barriers in order to improve compliance.

1. ORD's Strategic Directions

1a. Considering the proposed research directions and focus, how well is ORD as a whole poised to support EPA in meeting the goals of the EPA Strategic Plan?

Comments from Dr. George Alexeeff

The EPA Strategic Plan identifies 5 major goals:

Goal 1: Addressing Climate Change and Improving Air Quality

Goal 2: Protecting America's Waters

Goal 3: Cleaning Up Communities and Advancing Sustainable Development

Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution.

Goal 5: Protecting Human Health and the Environment by Enforcing Laws and Assuring ORD has developed Strategic Research Action Plans for each of these goals.

On the surface it appears that ORD is well poised to support the goals of the strategic plan. Regarding Goal 1. Addressing Climate Change and Improving Air Quality

Overall the research plan supports the EPA strategic plan to address climate change, improve air quality, protect the ozone layer and reduce radiation exposure. The research focusses on assessing impacts, reducing emissions, and preparing for climate change. These three areas are further addressed by 5 topic areas (MDST, EM, NMP, CIMA, and SEE).

It would be nice if the Anticipated Research Accomplishments and Research Topics were organized by research focus and/or topic area instead of a long list.

One area of importance is the interaction of climate change with air pollution. It is hard to see where that research is occurring if it is.

Another area of importance is the change in energy resources and their impact on air pollution.

I could not find discussion of emerging energy sources. For example, where the expansion of natural gas and oil extraction in the US is being addressed.

There should be more discussion of conducting monitoring of methane, VOCs and other hazardous air pollutants.

There should be a clear discussion of the need to assess the impact to local and regional air quality from the transport and the refining of nonconventional oil products and the environmental justice concerns associated with those activities.

Regarding Topics 1 and 2 there should be discussion of life-cycle analyses for the climate impact of various fuel choices including nonconventional ones. The analysis should also consider fugitive emissions and flaring impacts.

Regarding Goal 2. Protecting America's Waters

The EPA strategic plan describes this goal as: *Protect and restore waters to ensure that drinking water is safe and sustainably managed, and that aquatic ecosystems sustain fish, plants, wildlife, and other biota, as well as economic, recreational, and subsistence activities.* The Strategic Research Action Plan focuses on the related objectives.

The research approach is to move toward safe and sustainable water resources. The organization of the strategic research action plan does not exactly mirror EPA's strategic goals. Reorganization of the strategic research plan document would help address the question of "how well is ORD as a whole poised to support EPA in meeting the goals of the EPA Strategic Plan?"

For example it appears that meeting the goal to *Protect and restore waters to ensure that drinking water is safe and sustainably managed*, is discussed under water systems. The anticipated research outcomes include treatment and increasing reuse of water and components in water.

There should be more of an emphasis on treatment technologies for waters that were previously considered non-potable or present in aquifers that were too deep for drilling. Further research should be conducted to address groups of contaminants instead of focusing on individual contaminants.

Under watershed sustainability I think there needs to be some discussion of water use demands, availability and alternatives in order to meet the demands.

The green infrastructure research is essential for sustainability.

Regarding Goal 3. Cleaning Up Communities and Advancing Sustainable Development

The proposed SHC Actions are clearly discussed in the context of the goals for the EPA Strategic Plan in the slide presentation, but not in the plan. The Actions are aligned with the goal for cleaning up communities and advancing sustainable development and considering cross cutting strategies of working toward a sustainable future, working to make visible difference in communities, and launching a new era of state, tribal, local, and international partnerships.

The research plan should follow the lead of the slide presentation to be more consistent in its organization with the EPA Strategic Plan.

The SHC had identified four “themes” with specific projects: Decision support and innovation, community well-being, sustainable approaches for contaminated sites and materials management, and integrated solutions for sustainable communities. In the strategic action plan these are referred to as “research objectives.” It would be easier to evaluate if the terms were consistent between the slide presentation and the Research Action Plan.

The linkage between the EPA’s strategic goals and the research objectives should be more clearly laid out. Possibly the use of consistent terminology will help.

Regarding cleaning up communities and advancing sustainable development, the research program could benefit by including the following activities:

A clear description of the meaning of sustainability. What factors could be monitored or evaluated as a community moves toward sustainability?

The numbering system between Research Topics and Appendix A are inconsistent. The terms used in Appendix A do not line up with those under research topics.

Regarding Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution.

The EPA strategic plan describes this goal as: *Reduce the risk and increase the safety of chemicals and prevent pollution at the source.*

In discussing the applied research under this goal, the strategic research action plan refers to assessing the safety of high-priority chemicals. What chemicals are these?

Advancing our understanding of the cumulative risks that may result from multiple chemical and non-chemical stressors is an important bullet in the applied research. This issue is also included the Human Health Risk Assessment research program.

The ultimate goals include providing information to support Agency and program decisions. How do we know this will be accomplished?

Regarding Homeland Security Research Program

This StRAP addressed the EPA Strategic Plan goals of: Goal 2: Protecting America’s Waters; Goal 3: Cleaning Up Communities and Advancing Sustainable Development; and Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution. This research program appears to be very customer oriented and based on developing practical solutions to potential problems.

One concern that I have is in the absence of research that identifies the end of a threat and the ability to return to the location of the exposure/release without adverse consequences. The provisional advisory levels were developed to avoid potential danger and weight action with inaction. These levels do not represent levels for safely reoccupying an area. For example a 1-hour level triggering mild adverse effects is not equivalent to a level that can be safely inhabited 24-7, especially if it continues to produce transient effects. This is especially true for indoor contamination. Another example is the recent contamination of the Elk River; the level developed based on short term exposure could not address long-term exposures, nor could it allay the concerns of citizens who could still smell or taste the contaminant.

Regarding Human Health Risk Assessment:

This Strategic Research Action Plan addresses all of the goals of the EPA Strategic Plan. The StRAP is to characterize risks, refine risk assessments, and ensure application by stakeholders. This StRAP is fairly straightforward and consists of proceeding to the next logical phases of risk assessment. The research program is well-designed to consider additional complexities of risk assessment and to address questions and exceptions to the standard risk assessment procedures.

Many of the issues being addressed by the research program are to answer questions that occur not only at the Agency level but also by the Regions, States and Tribes. It would be helpful if the program provided clear guidance to these entities as the StRAP is completes a research project so that the issue is not addressed again and again by the regions. For example, mode of action for development of mouse lung tumors. After the workshop it would be helpful if the Agency then concisely provided provisional guidance to this issue in a clear statement. Not necessarily closing the issue but stating that based on the following major points the Agency recommends the following regarding the mode of action. Otherwise the Agency ends in an endless loop of review without the staff experts providing guidance to EPA stakeholders. The PPRTVs are a perfect example of moving forward based on the information available.

As discussed in: the National Research Council's Science and Decisions: Advancing Risk Assessment (2009), cumulative risk assessment is not necessarily quantitative, and it seem that the approaches being considered are strictly quantitative. An important point of the NRC evaluation of cumulative risk assessment is missing in the research discussion; the need for simpler analytic tools. Just as Tox21 has provided a new look into assessing hazard and risk, there needs to be an effort to develop tools that are simpler and address community issues.

Comments from Dr. Viney Aneja

ORD has both the technical and management skills to effectively address and support EPA in meeting the goals of the EPA's Strategic Plan. However, this can only be achieved if EPA maintains and increases its *intellectual foundation* (i.e. Post Doc Fellows, etc.) to continue to meet the environmental challenges that it faces, and will continue to face in the coming years.

Comments from Dr. Joseph Arvai

- I can speak most directly to the StRAP focused on Sustainable and Healthy Communities (SHC). Regarding, SHC, my view is that ORD has done an excellent job in terms of preparing an overarching vision that will support the EPA in meeting the goals laid out in the Strategic Plan (2014-18).
 - Indeed, I would go so far as to suggesting that the emphasis on developing engagement, outreach, and decision-support tools in the SHC StRAP will be helpful in terms of meeting each of the four goals outlines in the agency's Strategic Plan: Climate Change & Air Quality; America's Waters; Communities and Sustainable Development; and Enforcing

Laws and Ensuring Compliance.

- Each of these four goals involves many layers of decision making, which unfold in an environment where resources spent on issue can't be spent on another. Therefore, tradeoffs will be inevitable. It's my view that the general approaches and research areas in the SHC StRAP will also be most useful in terms of helping the agency confront these tradeoffs.
- In terms of the other StRAPs, a cursory review of them leads me to believe that they too are on track in terms of helping the EPA to meet its goals outlined the Strategic Plan.
- However, because each of the StRAPs is quite broad in terms of their approach, it's difficult to predict how successful any of them might be.
 - For example, each StRAP strikes me as being quite ambitious, which I believe to be a good thing. However, tempered against the realities of developing the science agendas and tools outlined in each StRAP, it's hard to believe that all the EPA's strategic goals will be advanced within the time frames set forth by ORD (2016-19) or the agency as a whole (2014-18).
 - Also, each StRAP will require significant resources; achievement of the agency's strategic goals will hinge upon the availability of these resources in the future.

Comments from Dr. Ingrid Burke

It is difficult to address this question without more information on funding and personnel within the organization. The budget seems large and well-distributed across programs, though the allocation of funding to cross-cutting initiatives is missing and it's not clear how the agency will prioritize activities associated with the cross-cutting activities.

It seems as though there is opportunity to identify an additional Cross-Cutting Research Program: Sustainability. Given the importance of sustainability approaches to EPA (e.g. the Green Book and the ongoing NRC study on sustainability in EPA, and the fact that the overall strategic plan says that a cross-cutting STRATEGY is "working toward a sustainable future), it seems like an important omission that needs to be rectified. I strongly recommend declaring Sustainability to be a major cross-cutting research area. Since the cross-cutting research doesn't seem to have budgets or personnel, it doesn't require additional resources, but rather, provides an additional opportunity for integration.

The array of research labs and the array of university grants do not reflect the distribution of the regions most likely to suffer water issues over the coming decades (the middle of the country). I know I bring this up most every meeting, but the geography of EPA research has a big hole in it, and it's a hole that matters (the headwaters of all the water for the western part of the continent, and a good deal of the east as well). This is water that supports agriculture, energy production, and municipalities.

Even after a few years on the SAB, I still have difficulty connecting the passive voice ("this will be done") with resources and personnel on the ground. This makes it hard for me to evaluate the capability of the organization to follow through on these important strategic plans.

Comments from Dr. Edward Carney

On a high, overall level, the draft ORD research plans appear to be well aligned with the overarching goals of EPA.

Comments from Dr. Peter Chapman

- The goals of the EPA Strategic Plan are laudable; ORD has clearly spent a great deal of time in determining the proposed research directions and focus and should be commended for doing so,

particularly for attempting to think outside the box (“change the paradigm”) of current regulatory constraints while still attempting to meet those constraints.

- However, I am concerned regarding the balance between strategizing and actually doing the work; strategizing cannot be a continual process of reinvention without allowing sufficient resources to actually accomplish what has been strategized.
- In this regard, it is not clear that ORD has sufficient resources to support EPA in meeting all of the goals of the Strategic Plan without further prioritization (see Response to Charge Question 1b, below); as noted in the StRAP for Chemical Safety for Sustainability (p8), it difficult at best to do all that is strategized “within a budgetary environment that is often unpredictable” and although various StRAP discuss focusing on a small number of research topics “for optimal impact”, the number of topics appears to be relatively large.
- The need for international cooperation is appropriately emphasized but the StRAPs and Roadmaps do not take advantage of knowledge that is international rather than US-centric and appear in some cases to be “reinventing the wheel”; for example, the Chemical Safety for Sustainability StRAP does not mention two major international programs of direct relevance to that StRAP, namely the EU Reach Program, and the Canadian Priority Chemicals Substances List.
- Dissemination of information does not explicitly consider social media; it should.

Comments from Mr. Shahid Chaudry

- ORD is at the helm of promoting and coordinating research and developing solutions to fulfill EPA’s mission of protecting human health and the environment by achieving five strategic goals and by developing and implementing cross-agency strategies.
- EPA relies on ORD “to produce the science, research, methods, and tools needed to pursue the Agency’s mission” and making “efforts on tackling the complex, interconnected environmental challenges that require innovative thinking, new tools and sustainable approaches”.

Comments from Dr. Terry Daniel

The StRAPs respond well to the Agency’s Strategic Plan. In many places it seems that the research plans and the strategic plan must have co-evolved. In fact it is remarkable that this close correspondence has survived several significant changes in top leadership in the Agency as well as within ORD.

Comments from Dr. George Daston

I believe that ORD has the expertise and focus to support the goals of the Agency and its strategic plan. While I have few concerns about ORD’s capabilities, I do have a concern with its capacity to meet all of the Agency’s needs. The budget for the research programs as a whole is not adequate and ORD is understaffed for the job that it has.

Comments from Dr. Joel Ducoste

- The overall plan seems to be well orchestrated with many research objectives, challenges/research questions, needs described, and potential outcomes defined.
- The overall plan is ambitious. Some description of when specific project efforts/tasks will be completed to meet a research objective has been provided. However, many of these research efforts/tasks are listed without providing a timeline for how long it would take. I think it might have been better to provide a shorter list of potential high priority research projects and display a rough

timeline (start to intended completion) for those projects. As listed in the documents provided, it is hard to provide feedback on whether many of these projects will be performed/completed by 2019.

Comments from Dr. David Dzombak

The plans and research directions for the six ORD research programs are generally well aligned to support EPA in meeting the goals of the EPA Strategic Plan. The challenge is that many of the planned activities are weakly funded, often leading to narrow project scopes and modest impact. Considering the broad mission and range of expectations for what EPA is supposed to be doing and investigating, and the reality of steadily declining ORD budgets, there is no easy way to address this shortcoming. I hope that SAB and BOSC can help ORD prioritize, rather than just expanding the list of research that EPA should be doing by virtue of its broad mission.

Comments from Dr. Taylor Eighmy regarding ACE

Regarding ACE, the 2014-2018 EPA Strategic Plan has four very specific areas of focus: two phases of GHG reductions (using emission standards) from mobile sources (vehicles and trucks) as well as approaches to consider for stationary sources, air quality improvement, ozone layer protection, and radiation exposure protection. ORD is poised to address these four areas.

Comments from Dr. Elaine Faustman

I applaud EPA's proposed research plans and especially their request for input from the SAB/BOSC while these plans are in development. There has clearly been high level strategic thinking in coordinating these efforts and this is evident from the smallest detail such as consistent framing to details on how the programs support a sustainability vision. This represents a large "sea change" that has progressively developed over the past few years but obviously leaped forward with this last iteration and implementation of this vision.

There has been an amazing amount of thinking that has taken place and this is clear in areas of methods development, implementation ideas and cross ORD Research Programs. Less clear (and requiring some additional thinking or linking) are the reciprocal arrows from the targeted ORD programs by the targets (i.e. one program says they are producing products for another, yet the target program is silent). Also requiring further clarification is identification of criteria for acceptance of products and declarations of successful products. The proposed NAS report may help in this area but both the producer of the products as well as the recipients should be involved in establishing this criteria. (I suspect that there are some real success stories to be told that have not yet been called out. There may also be some challenges)

Additional clarification of cross program road-maps and how they will be supported and interact with the well-defined research program categories is needed.

In summary, I am looking forward to these discussions and feel welcomed and engaged by EPA as they work through their strategic planning.

Comments from Dr. Courtney Flint

- The alignment of program areas with the strategic plan goals makes a great deal of sense given the high degree of complexity and interaction among the focal areas.
- One way to better live up to the principle of being "responsive to informing policy" (EPA ORB Overview teleconference slides 6/24/14) and the core value of "transparency" (Strategic Plan Introduction, p.4) is to expand the use of the "dashboard for decision makers" articulated by the CSS program (StRAP Overview) into other ORD dimensions and programs.

- The strategic goal “Working to Make a Visible Difference in Communities” could be better operationalized. It will be important to clearly outline how the various community-based approaches will be coordinated. Given the heterogeneity in communities across the country, truly making a difference will require a flexible, adaptive set of tools and approaches that can be applied to fit a variety of unique circumstances. It is not fully clear that this challenge has been fully thought through in the elements of this particular goal.
- Regarding the goal of “Working Toward a Sustainable Future”, there is a stated intention to expand conversation on “environmentalism”. This is a curious word and it is not well defined. Further, it is not particularly clear how this will be done, at what scale, and for what particular purpose.
- The goal of being guided by the best possible data and research is valuable, but it is not particularly clear in the documents how this will be assured. What criteria will guide this pursuit of high quality data and research? I think it is worth being explicit about this.
- In Goal 3, “Cleaning Up Communities and Advancing Sustainable Development”, it is stated that environmental justice, children’s health and sustainable development are not mutually exclusive. Yet, this is not always evident and “trade-offs” are not uncommon in programmatic or local decision-making. This is just one example of how the integrated, sustainability approach is laudable, but not particularly well operationalized for how to achieve the triple-bottom-line goals associated with complex systems and how to work through the inevitable conflicts and tradeoff scenarios that dominate decision-making. There is no one litmus test for evaluating programs or tools on the basis of “sustainability”, but a broad set of principles can be operationalized more clearly for this purpose. The sustainability principles behind EPA’s efforts are not easy to find and not applied consistently across tools and programs.
- At least on paper, the EPA structure of programs, regional programs, and roadmaps for integration seems well orchestrated to not only provide the depth outlined in the strategic goals, but to integrate cross-cutting themes. It will be helpful to take good ideas that emerge in programs or regions and apply them more broadly. For example, the notion of cluster organizations intended to fast-track innovations (SSWR briefing materials) and the dashboard for decision makers (CSS) could be useful concepts for other programs.
- The term “transdisciplinary” is used in a number of places as engaging beyond science, but it is not fully clear as to whether this engagement is meant to be included at all phases of work from conceptualization forward (as is intended by common interpretations of the term). There is some language to suggest that the beyond science engagement is still within the academic and highly professional fields rather than incorporating practitioners.

Comments from Dr. Robert Johnston

- The Office of Research and Development (ORD) appears to be well-poised to support the goals of the EPA Strategic Plan in many but not all areas. The Strategic Research Action Plans (StRAPs) and associated briefing materials do a good job of conveying a complex and interlinked research strategy designed to meet the Agency’s strategic goals. ORD’s plans are impressive given stable or declining funding (in real terms) across program areas, although there is some concern that the more ambitious rhetoric may not match concrete research deliverables in some cases.

- In terms of strategic emphasis, clarity, and motivations, the StRAPs are best developed in ORD's traditional areas of strength in areas such as the natural sciences, risk assessment and human health. The draft StRAPs provide a good roadmap for continuing progress in these areas.
- Past reviews of ORD have noted a lack of a clear research agenda and expertise required to address important social, economic and behavioral dimensions of EPA's goals. This shortcoming continues here. The Early Draft StRAPs are not well-developed in social, economic and behavioral sciences and in cross-cutting areas that involve these sciences. Although social, economic and behavioral aspects are mentioned in the StRAPs, the discussion is less sophisticated and developed compared to parallel topics in natural science, risk and health. Although the relative importance of social sciences varies across ORD program areas, social and human dimensions are relevant to all areas.
 - The 2011 Office of Research and Development (ORD) New Strategic Research Directions: A Joint Report of the Science Advisory Board (SAB) and ORD Board of Scientific Councilors (BOSC) concluded that "[A]ll the systems of interest to EPA include human behavior. Research on relevant aspects of human behavior is crucial to understanding the systems and implementing solutions or programs that follow from them. Increased emphasis on social, behavioral and decision sciences within ORD is needed for the new research programs to be successful. The SAB and BOSC recommend that ORD take specific steps to enhance its expertise and research in these areas." Given this recommendation, it would be useful for the Early Draft StRAPs to address the steps that have been taken in this area.
 - At least half of StRAPs (including Homeland Security (HS), Human Health Risk Assessment (HHRA) and Chemical Safety and Sustainability (CSS)) include little or no substantive discussion of social, behavioral or economic dimensions of their research agendas. Others mention these components (Air Climate and Energy (ACE), Sustainable Water Resources (SSWR)), but include either no (ACE) or few (SSWR) related research objectives. Only one area (Sustainable and Healthy Communities, SHC) includes a substantive presentation of a social and economic research agenda, and here the clarity and depth of this presentation could be improved (see my specific comments on SHC below).
- The 2011 National Academy of Sciences report, *Sustainability and the US EPA*, recommends that (p. 5) the Agency develop "specific processes for incorporating sustainability into decisions and actions. As part of the framework, EPA should incorporate upfront consideration of sustainability options and analyses that cover the three sustainability pillars (social, environmental, and economic), as well as trade-off considerations into its decision making." Although sustainability is presented as a central cross-cutting focus of the StRAPs, the formal role of sustainability is presented only in abstract terms, and sustainability tradeoffs are not considered. The StRAPs do not convey a research agenda driven by the type of detailed, transparent consideration of sustainability recommended by the NAS report. The overall Agency strategic plan appears to adopt the original NEPA definition: "conditions under which humans and nature can exist in productive harmony and fulfill the social, economic, and other requirements of present and future generations," yet the specific manifestation of the sustainability concept and relevance for each program's research remains largely abstract and unstated. In at least one of the StRAPs (HHRA), the word sustainability could be entirely stricken from the document without any obvious impact. All of the StRAPs would benefit from a clearer treatment of sustainability and how the concept influences the specific research that is proposed. What *specific* changes in ORD's proposed research strategies have resulted from the incorporation of sustainability as a guiding theme?
- The StRAPs begin with broad aspirational statements of program purpose. However, due to unavoidable funding limitations, the anticipated research accomplishments address only a small

portion of each program's aspirational goals (e.g., as characterized in Program Vision statements). It would be useful if each StRAP could provide information on priority areas of each program purpose that are being well-addressed by the proposed research accomplishments, as well as those that still require attention.

- Some of the StRAPs do not sufficiently address concerns related to the users and uses of the science, and particularly those involving non-federal stakeholders. In some cases, users and uses of ORD research outputs are well-specified, particularly where these are solely within US EPA. However, the StRAPs (and SHC in particular) also propose numerous tools and databases to be used by non-federal stakeholders to inform decisions. The StRAPs do not discuss the often significant challenges in developing tools that are both usable (e.g., by non-scientists) and sufficiently accurate to improve decision-making. Rather, the StRAPs often seem to underplay the challenges in developing valid, broadly applicable, science-based decision-support tools.
 - Also unacknowledged is the fact that inaccurate, overgeneralized, or misused tools can lead to decisions that are worse (e.g., in terms of promoting community or EPA goals) than those that would have otherwise occurred. A more detailed discussion of users and uses of science outputs would ensure that ORD's research is useful in terms of promoting EPA's mission and goals. This should include information on how the proposed tools and data are intended to inform decisions and the risks in doing so, and the challenges involved in developing useful decision support tools. Finally, additional detail regarding how the programs intend to coordinate with users would be useful in some cases.

Comments from Dr. Kimberly Jones

ORD's collective StRAPs address all five (5) strategic goals laid out in EPA's strategic plan 2014-2018. The individual research action plans are well directed to meet the overall strategies outlined in EPA's Strategic Plan. Prioritization of the research needs would enable more streamlined and goal-oriented research activities. Prioritization should emphasize areas where EPA will uniquely contribute to the research agenda.

Comments from Dr. Catherine Karr

Overall, the strategic plans outlined by ORD appear to align well with the overall EPA Strategic Plan, suggesting ORD is poised to meet its goals given resources to accomplish the ambitious plans. How the ORD /Agency will incorporate a useful ongoing evaluation of its success in meeting the goals is not clearly described.

Transparency is identified as a core value in the Administrator's Strategic Plan and accessibility to within and extramural EPA data/information is identified as a key challenge within ORD's strategic plan. Both would benefit from an emphasis on state of the art information management that provides the optimal interface(s) for the interdisciplinary scientists engaged in the EPA research agenda and its applications with the wealth of science products held or used by the agency programs. Development of overall strategic plan goals in the arena of information management science that serves and integrates the NRPs and cross cutting areas may help assure resources and commitment to this aspect

Comments from Dr. Nancy Kim

- As a whole and recognizing that the StRAPs and roadmaps are at different stages in development,

ORD appears to be poised to help meet the goals of the EPA Strategic Plan; however, some of the roadmaps and StRAPs need to be more focused and ORD needs to prioritize its projects.

- HSRP comments
- Slide 6 of the HSRP presentation shows an alignment with EPA's Strategic Plan. This information is missing from the StRAP and should be added.
- ORD is poised to support EPA in meeting the goals of the EPA Strategic Plan. However, the ORD program StRAPs should contain information on how they are supporting EPA's strategic plan by mapping their research areas to specific strategic goals (or cross-agency strategies) and objectives and by providing at least a few examples of their outputs which will help meet the strategic goals.

Comments from Dr. Francine Laden

The proposed research directions and focus appear to meet the goals of the EPA Strategic Plan. However, it is difficult to assess at this time how well ORD is poised to carry out the research agendas outlined in these documents.

Comments from Dr. Lois Lehman-McKeeman

Generally well positioned overall. Exposure assessment, application of dose response relationships to risk assessment and in vitro to in vivo extrapolation are areas that are going to require significant advancements in order to meet the goals of the EPA strategic plan. [these will be a common theme in my general responses].

Comments from Dr. Elizabeth Matsui

- Overall, the StRAPs address all five stated goals in the EPA Strategic Plan and are comprehensive.
- Although it is clear that the topics/subject matter in the StRAPs are aligned with the Strategic Plan, some key points are unclear, and maybe unclear as a result of the sheer breadth of the EPA's Strategic Plan making it difficult to more explicitly address points such as:
 - The lack of clear delineation between foundational research and testing of interventions vs. implementation of research findings and assessment of the implementation. Providing some structure - perhaps using the translational T0-T5 paradigm of the NIH - would improve clarity and provide a context for describing how a given program will be approached.
- As always, one can view the environment through the lens of the environment or one can view it through the lens of human health, or through both lenses. There should be a greater emphasis on human health outcomes, where appropriate. For example, the plans for Children's Environmental Health and Sustainable and Healthy Communities, could benefit from greater involvement of physicians with public health expertise. One example where this kind of expertise would be helpful is in defining health outcomes that are the priority of EPA, since it will be critically important to have health outcomes that are measurable by validated tools, that are meaningful, and that are selected based on a public health rationale (i.e. most common disease, disease that is increasing at a rapid rate, diseases of greatest severity, etc.). Well-being, at this current time, appears to be difficult to measure and will have limited power to speak to those in positions to effect change. On the other hand, being able to demonstrate a decrease in a common conditions, such as diabetes or asthma or obesity, is a much more powerful concept specifically because these conditions are understood to be of great public health burden and because there are excellent validated tools to measure these conditions.
- A strong commitment to development of tools for use by communities is expressed in the StRAPs. However, it is unclear whether there is a strategy for assessing: the use of these tools (how many

people use them, who uses them) and the impact of these tools (the effect of using the tools on key exposure and health outcomes). It would be important to include a research strategy to assess these tools.

Comments from Dr. Kristina Mena

EPA wants innovative strategies/approaches, and the ORD research plans also state innovation as a driver

ORD's research programs demonstrate concerted efforts to not only identify critical research objectives, but also show how these objectives – and potential action plans – overlap

A greater inclusion of community-based participatory research (CBPR, some researchers have other names for this) and environmental justice would further support the goals in the EPA Strategic Plan (2014-2018)

Comments from Dr. Surabi Menon

ORD has a huge task ahead to meet the goals outlined under the Strategic Plan. The research direction appears comprehensive, and has the right emphasis on measurement and evaluation and also linkages between the various program elements and crosscutting topics. The strategic measurement framework, if followed through, would deliver important metrics that can be tracked to evaluate impact. A learning component should also be built in at the end of year 1 or 2, to see what has worked and not worked as the program and measurement systems are implemented and that should allow ORD to adapt as needed.

Comments from Dr. James Mihelcic

- The documents which I reviewed indicate that ORD as a whole is poised to support EPA in meeting the goals of the EPA Strategic Plan.

Comments from Dr. Earthea Nance

1a. Overall, this is an impressive step forward. The research directions and focus are clearly stated in general and indicate that ORD is well positioned to contribute to the goals of the EPA Strategic Plan. Lots of progress is evident since 2011. My comments are around the edges of the strategy, not the direction as a whole.

Comments from Dr. Paula Olsiewski

I have reviewed the six early draft Strategic Research Action Plans for 2016-2019: Air, Climate, and Energy (ACE), Safe and Sustainable Water Resources (SSWR), Sustainable and Health Communities (SHC), Chemical Safety for Sustainability (CSS), Human Health Risk Assessment (HHRA), and Homeland Security (HS).

The AEC StRAP supports Goal 1 “Addressing Climate Change and Improving Air Quality.”

The SSWR StRAP supports Goal 2 “Protecting America’s Waters.”

The SHC StRAP supports Goal 3 “Cleaning Up Communities and Advancing Sustainable Development.”

The CSS StRAP supports Goal 4 “Ensuring the Safety of Chemicals and Preventing Pollution.”

The HHRA StRAP supports all four goals.

The HS StRAP supports Goals 2, 3 and 4.

Taken together, the six early draft StRAPs demonstrate that ORD is well poised to meet the goals of the EPA Strategic Plan.

Comments from Dr. Duncan Patten

Following are EPA's strategic goals:

Goal 1: Addressing Climate Change and Improving Air Quality

Goal 2: Protecting America's Waters

Goal 3: Cleaning Up Communities and Advancing Sustainable Development

Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution

Goal 5: Protecting Human Health and the Environment by Enforcing Laws and Assuring

Compliance

Achieving these goals will require more integration among ORD six programs than appears on surface (see response to Charge Question 2c below). For example, protecting America's Waters will require close integration among the Water Program, SH Community program which works on watersheds, and Homeland Security program which protects communities, landscapes and people. Whether this integration is truly taking place is uncertain.

In general, the structure of ORD and its six programs that have some cross over is appropriate to address the EPA strategic plan goals but details as described above raises potential questions of true integration. The cross over and integration among the six programs is critical to address both human and ecosystem issues and the stressors that exist or will arise in the future.

Comments from Mr. Richard Poirot

ORD's recent reorganization and consolidation with focus on 6 major research program areas – combined with a limited number of focused, flexible cross-cutting research strategies - appears to be well-suited to meeting the currently-emphasized goals in EPA's 2014-2018 Strategic Plan, and should also allow for future shifts in emphasis without need for major changes in organizational structure.

Flat funding over the past 15 years, taxed by persistent, cumulative inflationary losses raises questions about the sustainability of these critical research programs in the future. Some planning consideration might be given to most efficient means for accommodating expected future funding constraints. Effective communication of the useful results and applications of past and current EPA research programs should also be emphasized to assure public visibility of and support for these programs.

Comments from Dr. Kenneth Reckhow

Two major weaknesses in the EPA ORD proposed research directions and focus:

In the SSWR StRAP, there is no mention of scientific uncertainty; this is a serious omission.

Modeling and assessments of impacts of proposed management actions **MUST** be accompanied by a defensible quantitative statement of uncertainty. If stakeholders and/or decision makers are considering management actions based in part on modeling/assessment provided under SSWR, they must be provided with some measure of the confidence (uncertainty) in the science. For too long and too often, EPA has failed to insist on this requirement for predictive models; as a consequence EPA ORD has tended to stress large elaborate models that appear to be motivated by the false assumption that models must be sufficiently detailed so the modelers can "get the processes right." This is an absurd goal that will likely never be achieved. The result of stressing the development of elaborate models is that these models are overparameterized. Among experienced hydrologic modelers, it is well-recognized that many "sets" of parameter values will fit large simulation models about equally well; similar predictions can be obtained by simultaneously manipulating several parameter values in concert. This is plausible in part because all models are approximations of actual ecosystem processes, and because all parameters

represent aggregate processes (spatially and temporally averaged at some implicit scale) and are unlikely to be represented by a fixed constant across scales. In addition, many mathematical structures impart extreme correlation among model parameters, even when the model is over-determined. This condition, called “equifinality,” is well-documented in the hydrologic sciences, but the concept rarely has been discussed in the water quality modeling research literature.

I do not suggest that EPA ORD should suspend work on the overparameterized models; rather, I recommend a multiple modeling approach. A single elaborate deterministic model, such as that presented in the *Nitrogen and Co-pollutants Roadmap*, shares a critical shortcoming with the most sophisticated meteorological model; both are deterministic simplifications of an extremely complex system. Uncertainty in complex meteorology models is often handled by running multiple models and presenting an “envelope” of storm trajectory paths; this is based on the assumption that the true path of a storm is likely captured in the envelope of trajectories. Rather than urge EPA ORD to develop and run multiple models, I recommend that EPA ORD routinely require development and application of a second model to focus on what an overparameterized model cannot do – uncertainty analysis of model forecasts. This second model will be simpler than the overparameterized deterministic model; simplicity is necessary to facilitate uncertainty analysis. This multiple models approach has been recommended in other situations, such as in the Chesapeake Bay Program, to address the need for uncertainty analysis.

A second major concern to me is how EPA ORD prioritizes research and monitoring. To be specific, how does EPA ORD identify the most critical data collection needs? The best approach for the design of a water monitoring program is based on recognition that new data collection (or, in general, new research) should be considered a “value of information assessment” (VOIA). That is, new monitoring (or new research) should be undertaken if the value (for informing decisions) of the new data/research justifies funding the effort. In general, proposed EPA ORD projects involve good science and good scientists, but that alone does not warrant funding. Funded projects should be restricted to those that provide the greatest information/knowledge gain, given ORD objectives. In many cases, a VOIA can be undertaken using sensitivity analysis.

To help fix ideas, consider the following example. An agency wants to quantify internal phosphorus (P) loads from the sediments in a lake for eutrophication assessment and modeling. The lake is a large artificial impoundment with nutrient-rich soils that were flooded when a dam was closed thirty years ago. It is believed that the lake sediments could be an important source of phosphorus to the lake water column, particularly under certain conditions (e.g., anoxia). In essence, we would like to quantify current internal P loads, and we would like to predict future internal P loads associated with watershed load reductions. We begin this VOIA with what we already know about internal load. Assume we determine that there are no lake-specific internal loading estimates. Well, are there estimates of internal P loading for nearby or similar lakes? In fact, there are literally dozens of studies of internal phosphorus loads to waterbodies; even though they may not be nearby, can’t we estimate internal load from one or more of these studies? Should we undertake in-lake monitoring to estimate current and future internal loads? How variable in space and time is internal loading expected to be in our lake? Is limited space/time scale monitoring in our lake more informative for our purpose than use of analyses from the existing literature? Perhaps we can measure current internal loading, but does that tell us anything about future internal loading when external loads and lake chemistry may change with future watershed management actions? This is the type of thinking and analysis that should be undertaken in VOIA, and hence should be part of EPA ORD’s research/monitoring research prioritization. This response to Charge Question #1 is relevant for all charge questions.

Comments from Dr. James Sanders

ORD has made great progress in integrating and bringing their program plans to the current state. I

believe that they are poised to tackle many of the questions that face the nation at this time. Given that we live in a time of declining budgets and manpower, the agency will have to continue to focus in on its most pressing issues, which will leave some areas less examined. However, the process of integrating programs across the divisions and offices is the correct approach for the agency to be taking.

Comments from Dr. Ponisseril Somasundaran

Excellent coverage on cross cutting of local/state/ indigenous

The Strategic Research Action Plans (StRAPs), cover a broad range of important areas which need immediate as well as long term attention. Some important topics such as ecological sustainability, focusing on water management in specific sectors such as pharmaceuticals, mining and oil spill, may need special attention

In view of the potential for exponential growth in the application of nanoparticles, we need to pay special attention to Nanoparticles' effect, high throughput characterization and monitoring mechanisms, mitigation in complex real environment, their ultimate fate and transport" Note that most of the techniques used to characterize coarse particles do not work for nanoparticles ; in fact they can yield wrong and misleading results

Comments from Dr. Daniel Stram

- Goal 1: Addressing Climate Change and Improving Air Quality
 - The Air Climate Energy (ACE) research program directly addresses this overall goal. Material presented during ACE briefing session demonstrates commitments to enhancing science for understanding the impact, reducing emissions, and preparing for the consequences of green house and criteria air pollutants.
 - There is little mention of EPA's third objective for Goal 1 protecting and restoring the ozone layer in the draft strategic plans. The need of understanding climate change impact on stratospheric ozone, is discussed briefly in the climate roadmap. It is unclear if ozone layer protection science needs generally are to be addressed by EPA.
 - No mention of research related to the 4th objective, "Minimizing exposure to radiation" anywhere in the draft ACE StrAP or in any of the documents provided. EPA has historically been, of all federal government, the most actively involved in developing guidance for such activities as safe handling of contaminated materials from operating governmental and civilian plants and facilities and cleanup efforts and authors the "Multi-Agency Radiation Survey and Site Investigation Manual". EPA also provides federal guidance on developing cancer risk coefficients for environmental exposure to radionuclides and develops radiogenic cancer risk models and projections for the U.S. population. Given that exposure to radiation exposure is increasing primarily from medical (treatment and diagnostic) sources this seems like an important missing topic.
- Goal 2: Protecting America's Waters
 - The objectives here of protecting human health and protecting and restoring watersheds and aquatic ecosystems are addressed clearly in the SSWR document
- Goal 3: Cleaning up communities and Advancing Sustainable development

- This is partially addressed in the HS and SHC draft StrAPs and is mentioned in passing in the EJ cross-cutting document
- Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution
- Goal 4 is addressed within the CSS document
- Goal 5: Protecting Human Health by Enforcing Laws and Assuring Compliance
 - This goal (perhaps rightly) is largely unaddressed within the various research program documents. It seems possible that some of the tools developed in various programs e.g. detection of contaminants by the HSRP could be of importance

Comments from Dr. John Tharakan

- Research directions and focus provide a fairly good roadmap for ORD to support EPA Strategic Plan goals, which include addressing climate change and improving air quality, protecting waters, cleaning up communities through sustainable development, ensuring chemical safety and preventing pollution, and protecting human health and environment through enhanced enforcement and compliance.
- SHC research direction and focus also supports EPA Cross-Agency Strategies, including working towards a sustainable future, making a difference in communities, launching an era of state, tribal, local and international partnership, and embracing EPA as a high performance organization.

Comments from Dr. Jeanne VanBriesen

Overall the StRAP topics and the cross cutting strategy plans are well aligned with the strategic plan goals and the cross-agency strategies. The topical foci selected by ORD poise it well to support EPA's over-arching programmatic vision.

In terms of meeting the specific goals of the EPA strategic plan, this is more difficult to assess from the ORD documents. It is unclear from the broad topical information provided in ORD's plans whether sufficient resources (funding and FTEs) are available to provide sufficient scientifically-grounded information to inform the decisions to be made to support the strategic plan. The strategic plan notes a priority of 'advancing research efforts to provide relevant, robust, and transparent scientific data to support the agency's policy and decision-making needs.' The research plans are relevant, and there is discussion of transparency and openness in sharing of data and results. This is good. Whether the research efforts can be robust and provide adequate information to address the many, many issues where additional knowledge is needed to inform policy decisions designed to achieve environmental benefits is unclear. Many of the plan documents lack timelines with clear metrics and detailed budget and effort assignments, making it difficult to determine if adequate research progress will be made on key questions within the timeline of the strategic plan goals. The goals of the strategic plan are sufficiently broad that the current research portfolio provides good alignment; however, the specific targeted agency priorities in each section of the strategic plan are narrow and have clearly defined quantitative metrics. It is not clear from the strategic plan or from the ORD plans that additional research is needed specifically in support of these priorities. If support from ORD for these specific agency priorities is needed, the ORD plans are not clear on which research projects are aligned with the priorities. I would have liked to see explanation of the assessment that the priority items are not in need of additional research or that specific projects are aligned with those priorities and the projects are likely to produce results in time for use in support of those priorities. This would more closely align ORDs plans with EPA's strategic plan, ensuring that ORD is poised to support the strategic plan.

Comments from Dr. Katherine von Stackelberg

Without knowing any details about Agency resources, personnel, personnel education and backgrounds, etc. it would seem ORD is reasonably well-poised to support EPA in meeting the goals as identified in the Strategic Plan, with some clarifications warranted.

The overall mission of the Agency, protection of human health and the environment, has not changed, although the realignment several years ago of ORD's research program consolidated specific research areas down to the current six, with an emphasis on "sustainability" as a central, organizing theme across all of the research. Indeed, a quick search of the 95 page Strategic Plan reveals 85 instances of "sustainable" and 32 of "sustainability," although neither of these words are ever defined (in any way) in that document. Moreover, use of terms related to sustainability varies across the individual program-specific Strategic Plans (StRAPs) as shown in Table 1.

The Sustainable and Health Communities Strategic Plan (SHC StRAP), by contrast, focuses on the three "pillars" of sustainability (see comments on that under 2a, below), but these pillars are never once mentioned in the overall Strategic Plan. However, I did note that the Strategic Plan tends to focus on environmental issues, specifically, while, for example, the SHC StRAP with its emphasis on communities and human well-being goes well beyond the "environment" per se and identifies "economic" and "social" research as being integral to sustainability science (again, see comments on that in 2 and 4 below).

So while ORD appears well-poised to support the Agency more broadly through the various research programs, this reviewer finds there continue to be challenges with the concept of "sustainability" across the Agency: how it is defined, implemented, and how to operationalize that seemingly central organizing theme across the research programs. Environmental protection is central to sustainability, and, coincidentally, to the Agency mission. Currently, the StRAPs emphasize human well-being as the primary objective, and while there is a recognition that human well-being depends on the environment, the environment itself is secondary to this notion of human well-being. That, coupled with an implicit assumption that growth-based economic metrics can be compatible with sustainability, undermines ORD's ability to provide true research leadership.

Comments from Dr. Peter Wilcoxon

- Overall, ORD's activities are tightly aligned with EPA's strategic plan. ORD has structured its activities well, providing a major research program tightly linked to each of EPA's main goals.
- Stakeholder input within the agency is strong. ORD's activities are tightly linked to EPA's program offices and regions.

1b. What are the SAB/BOSC perspectives overall on the proposed research directions providing research to address environmental issues of 2020 and beyond?

Comments from Dr. George Alexeeff

Clearly there are transboundary, regional and local issues to address. They may be related, but they may or may not significantly influence one another. Previously much of the focus was on regional issues (e.g., air quality basins), more recently on transboundary issues (e.g., climate change) and now the focus is also on local/community issues.

Collection of data at the community level is essential for identifying local health concerns and informing the community. Research is needed to identify what factors are beneficial or detrimental to communities, and ways to measure them simply through an indicator system.

The research should include management strategies to meet these goals. Moving from a command-

control system based on exceeding a predefined risk level to one of constant reduction of more hazardous or toxic options. Thus there should be more research how to identify for products that are less hazardous from a life-cycle perspective.

Since Tox21 conclusions will be based on a different set of inferences, a new decision strategy should be developed. For example we spend many resources debating why the animal models we developed do or do not apply to humans. It is important that we have a decision strategy that keeps us from falling into the same traps with in vitro systems. If the models cannot be used in a straight-forward manner for decision-making then they probably will not be helpful.

The application of Tox21 research results needs to be more clearly laid out with assurances that they will satisfy statutory requirements. For example, is the research expected to replace the current quantitative analyses, or will it be applied in more of a hazard-based approach?

More emphasis needs to be placed in biological monitoring.

Efforts need to be made to develop simpler analytic methods that can satisfy risk management decisions.

Comments from Dr. Viney Aneja

The environmental issues we confront and will continue to face in the future are complex, deep and extensive, and widespread in their impacts. In general, ORD is conducting the necessary research to address emerging environmental issues. However, here are some additional suggestions:

- One of the environmental challenges we face (both nationally and globally) is associated with intensive agricultural (both crop and animal) emissions and discharge (variety of N, S, C compounds, pathogens, and PM). Increasing demand for food, feed, fiber, and fuel owing to population increase coupled with climate change will only exacerbate the environmental problems. How best to address this complex issue needs addressing.
- Natural (e.g. forest fires, storms, earthquakes, etc.) and anthropogenic (e.g. 9/11, industrial accidents, railroad accidents, etc.) disasters will require EPA to have the necessary ability to respond to the environmental consequences effectively and creatively as potential future environmental challenges.
- Incorporate Life Cycle Analysis and System approach to multi-pollutant abatement as a way to make decisions and articulating sustainable solutions.
- Monitoring- To meet its mission, EPA needs an understanding of long term changes in the environment and rates at which pollutants (e.g. ammonia) are entering the environment.
- Environmental consequences (air, water, soil, ecology, and human health) associated with active, abandoned, and reclaimed mountain top coal mining sites and associated infrastructure.

Comments from Dr. Joseph Arvai

- Once again, I can speak most directly to the SHC StRAP. I am pleased with the breadth of proposed research directions set forth in the StRAP. I find them to be complete, achievable (time and resources permitting; see above) and critical for the agency in terms of meeting its strategic goals.
- One concept that I did not think received enough attention in any of the sStRAPs was that of 'adaptive management'. The StRAPs for Safe and Sustainable Water Resources as well as the PowerPoint slides for SHC mention adaptive management, but do not expand upon how this concept may advance the research agenda of ORD, or the strategic goals of the agency. This is a shortcoming in my view, especially given the prominence of adaptive management in discussion

about decision-support, environment and sustainability, and decision making under uncertainty.

Comments from Dr. Edward Carney

There is a clear emphasis on research to support a sweeping modernization of EPA programs and practices. The evaluation and incorporation of new computational and biotechnology-related tools and a move toward systems-level thinking is a common theme across all of the StRAPs. In fact, ORD is unquestionably the global leader in this movement, with resources which are far and away more extensive than any other organization of its kind.

While the draft StRAPs all list numerous research products, the vision for how these research products will be applied at the level of the program offices is less clear. Creating a steady stream of these application products is necessary to sustain the drive of modernization to 2020 and beyond.

Comments from Dr. Peter Chapman

- The key stressors facing humanity in the future are, in order of importance: global climate change, habitat loss, introduced/invasive species, eutrophication, and chemical contamination.
- These five key stressors should be cross-cutting issues in each of the StRAP, appropriately prioritized; however, this is not uniformly the case across all StRAPs – there is not a single StRAP that considers all of these cross-cutting issues.
- Life Cycle Assessment (LCA) is critically important in terms of both eutrophication and chemical contamination and their modification by the other three key stressors facing humanity; the Innovative Research Approach on page 18 of the Chemical Safety for Sustainability StRAP of harmonizing LCA with comparative risk analysis is a critical but not trivial task that should be emphasized and prioritized relative to the above-noted cross-cutting issues (i.e., key stressors facing humanity in the future) – it deserves higher visibility and attention.
- Prioritization is urgently required relative to the most important stressor, global climate change (Landis WG, Durda JL, Brooks ML, Chapman PM, Menzie C, Stahl RG Jr, Stauber JL. 2014. Ecological risk assessment in the context of global climate change. *Environ Toxicol Chem* 32: 1-14); for example, sea level rise inundating significant coastline areas with consequent adverse direct and indirect effects is clearly more important than an oil spill (which is catastrophic in the short term but relatively insignificant in the longer term).
- The documents need to explicitly recognize that, associated with global climate change, increased natural variability (stochasticity) reflects a changing natural environment with some changes positive (e.g., in terms of introduced species, the historical introduction of rainbow trout globally), others negative or even neutral; it is futile to attempt to maintain the status quo, the science should provide the basis for management to maintain ecosystem services but not necessarily the original species complement/environmental matrices that comprised those services.
- In this regard, the documents all need to recognize that everything that human beings do has environmental consequences; no actions are environmentally neutral – for example, sewage treatment has environmental consequences including habitat loss, greenhouse gases, increased energy use, disposal of sludge. This is not the case across all documents; however, the Air, Climate, and Energy StRAP does mention [p9] “without unintended environmental consequences...co-benefits and potential need for trade-offs”.
- The term “sustainable” is generally used in all of the documents provided but is only defined in the Safe and Sustainable Water Resources StRAP (page 12) per NEPA (1969 not 1970); this definition, which is adopted in the NAS document Sustainability and the U.S. EPA should appear in all the documents in the Introduction for clarity and consistency relative to the overall goal of sustainability that crosses all documents.

- In addition to including the generic definition of sustainability in all the documents, where the term is used specific to an activity, it should also be defined in terms of that activity; the key factors to be sustained in the environment are ecosystem services focused on protection goals (human values) for the environment. For example, what are “sustainable chemicals”?

Comments from Mr. Shahid Chaudry

- Research directions are established in consultation with advisors and input from a wide spectrum of partners, stakeholders, and experts to address specific research needs to meet EPA’s mission of protecting human health and the environment. Further, research work is conducted in cross-cutting scientific disciplines in close collaboration with interagency and outside stakeholders to deliver results that meet the needs of decision-makers and establish a broad scientific foundation for a sustainable future.

Comments from Dr. Terry Daniel

The SHC StRAP presents the problem statement:

EPA is pursuing a cross-Agency strategy to advance optimized, sustainable environmental, economic and social/health outcomes through Agency decisions and actions, recognizing that the Agency’s traditional approaches to risk reduction and pollution control cannot always fully achieve long-term and broad environmental quality and human health and well-being goals.

This statement reflects the continuing tension between the traditional single-threat/single-medium, source regulation focus of the Agency and the emerging trans-disciplinary vision directed toward achieving more holistic, sustainable positive outcomes that has guided ORD’s recent reorganization and research planning efforts. The StRAPs for 2016-2019 (to address Agency issues expected for 2020 and beyond) seem fully committed to carrying on in this new direction. Previous reviews from the SAB, the BOSC and other science advisory units outside the Agency have strongly supported and encouraged this new direction which is well founded in contemporary science and sustainability concepts. However, the traditional "protect against specific immediate environmental risks" perspective is still widely held across Agency clients/publics and regulated industries to the point that it may be thought to be the only true and legitimate purpose for EPA. Indeed, there are still many places within the Agency where this more traditional view is strongly held. The ORD is clearly aware of this situation and of the possible hurdles that it presents for achieving the bold research and development plans they have presented. However, there does not appear to be any particular plan or set of activities intended to justify the new perspective or to secure and sustain the support of skeptical clients/publics, regulated industries and relevant EPA offices outside of ORD. Neither is there any specific research proposed for evaluating how well the changes in perspectives proposed by ORD are being understood, accepted and supported outside and inside the Agency.

Comments from Dr. George Daston

The research programs and plans are well suited to meet the needs of the Agency for the near future. At some point, it will be necessary to prioritize research that has a longer-term focus. For example, a great deal of the research in the CSS program is devoted to developing and implementing hazard and exposure screening systems that will improve prioritization of chemicals for risk assessment, which has been an unmet need of the Agency for a long time. As this problem is increasingly solved, other unmet needs in chemical assessment, such as improving the relevance and throughput of chemical risk assessment, as well as tackling the problem of multiple exposures and cumulative risk, will become more important. ORD does have some effort in developing computational and systems biology models that will be

important in this effort, but would be in better shape to address long-term problems if it could devote more resources sooner to this cutting-edge research area.

There are two issues that I would like to see EPA work with other federal agencies to address over the course of the next decade. The first is to continue to work closely with the Department of Energy in providing input into how the US can meet its often paradoxical goals of energy independence, greenhouse gas reduction, and environmental quality. Because of EPA's significant expertise in applied life sciences, it would be useful to engage DOE and other relevant agencies in the development of synthetic biology methods, which are already in R&D in the private sector as an alternative means of chemical synthesis and renewable biobased energy. The second is to partner with other public health agencies to start to do risk assessment in a way that takes into account all of the factors that are health-adverse and health-promoting. We have already identified the disease states that can be attributed largely to a single cause (like cigarette smoking and lung cancer); the rest will only be solved by understanding the interplay between multiple factors including nutrition, social factors, stress, and chemical exposure. EPA has some expertise in thinking about solving health problems in this way through its environmental justice program and should start to develop the partnerships that will be needed to tackle risk assessment in a public health, disease-focused way.

Comments from Dr. Joel Ducoste

- I am fine with the planned research direction overall within each of the 5 strategic research directions. The reports are detailed and provide a reasonable overall vision and plan to address environmental issues for 2020 and potentially beyond.

Comments from Dr. David Dzombak

ORD has made significant progress in placing ORD research in a framework of major environmental challenges confronting the U.S. for the coming decades, including climate change, increased nutrient loadings, and others. The cross-cutting roadmaps provide frameworks for integrating research across ORD programs and offices, and with other agencies, and keeping ORD research forward looking.

Comments from Dr. Taylor Eighmy regarding ACE

Within the budget and FTE limitations within ORD and EPA, the ACE research focus seems proactive and as balanced as possible amongst the four focus areas.

Comments from Dr. Elaine Faustman

I am not clear why the year 2020 was chosen for the target for this question except that it represents approximately an additional 5 years of research. If someone had told me that we would have the extensive Comp Tox program a decade ago I would not have been even 50% as optimistic as I now am in looking at the results, so I will try to address these comments with this background in place. Yes!!! My answer would be enthusiastic as I expect to see this same level of tremendous progress. I do feel it is very important for ORD to look carefully at the criteria it will develop for acceptance and application of their products and I think there have been some excellent efforts towards education, sharing and outreach towards the development of these criteria however sustained efforts are needed to match the methods and outputs with the applications among and across regions and stakeholders. Excellent progress, excellent directions.

Comments from Dr. Courtney Flint

- The documentation provided by the EPA/ORD clearly indicates acknowledgement of complexity

and the likelihood of emergent issues moving forward as indicated in the Goals of the Strategic Plan. Further, the conceptual space and resources for innovations in the program areas is anticipatory of future needs.

- More could be developed, however, to outline more precisely how these longer-term focal points and emergent issues might be better anticipated. Early risk detection efforts could be better articulated across the different goal areas. A considerable amount of work outlined in the strategic plans involve assessment efforts, yet these may not be tuned to pick up on outliers that might be emerging and trend analysis to monitor trajectories of issues not yet in the cross-hairs of EPA programs and research. In some places, this may require some “cultural” changes in programs as to what the relevant time horizons and evaluation indicators should be.
- Goal 5 on Protecting Human Health and Environment by Enforcing Laws and Assuring Compliance emphasizes large, complex cases as the top priority. A risk inherent in this approach is that the smaller, but perhaps bell-weather cases of problems to come may be ignored, thus becoming the large, complex cases of 2020 and beyond and perpetuating the cycle of environmental problems and unsustainability.
- There is considerable focus on cultivating a “New Era of Partnerships” but little on how to maintain partnering relationships for the long-term. Without attention to relationship maintenance, it may well be that these emerging partnerships may erode by the 2020+ time horizon.
- Another longer-term consideration is the very rapid pace of technological advancements. Thinking out to a longer time horizon on technology development, particularly related to cyber-infrastructure, would be helpful for developing tools and processes that can evolve as technology changes.
- As uncertainty about projected impacts from climate change decreases with the ability to adjust models according to experience in the near term, our projections of mid-term (2020+) impacts and risks should become more accurate. Dedicating some resources to this time horizon in terms of how climate change may impact the various EPA program areas would be prudent.

Comments from Dr. Robert Johnston

- Although the goal of the StRAPs is to guide ORD program areas from 2016-2019, it would be useful for the StRAPs to incorporate a prospective, forward-looking discussion of research needed to address environmental issues of 2020 and beyond. This would include a discussion of the balance between ORD’s current strategic allocation of effort and expertise and that which might be needed to address future challenges. Currently, the StRAPs include no discussion of relationships between research proposed to address the needs of 2016-2019 and the science that may be needed to address issues emerging beyond 2020. A brief, prospective discussion of these relationships would help clarify whether ORD is well-positioned to address these challenges, and to identify long-term strategic changes that might be required.
- Looking forward to the environmental issues of 2020 and beyond, EPA will require science to guide decisions under conditions that will differ (perhaps considerably) from those of today. The foreseeable driving forces of these changes include climate change, evolving social systems, technologies affecting the extraction and use of energy, and continued transformations of land use and cover. These and other important drivers are associated with considerable uncertainty, and their combined effect will influence all areas of the Agency’s mission. Some of these concerns are addressed by the Climate Change Research cross-cutting theme. In other cases, individual StRAPs highlight proactive research to address emerging areas of importance (e.g., the SSWR discussion of proactive research to assess life-cycle impacts of water, energy, mineral and materials). However, many of the StRAPs give little attention to the emerging areas of science necessary to address the

- environmental challenges of 2020 and beyond, as well as the uncertainties that must be confronted.
- Among the consequences of ORD's relative lack of resources in social sciences is an apparent lack of focus on the behavioral, social and economic changes that may accompany the global environmental changes of 2020 and beyond. The environmental consequences of global climate change will likely drive long-term change in social systems and behavior that may serve to mitigate or further exacerbate these consequences. Currently, ORD is inadequately positioned and resourced to address these behavioral, social and economic dynamics and their implications for EPA's mission. For example, the four specific "social systems" issues mentioned by the draft Climate Change cross-cutting roadmap (p. 16) reflect only a narrow portion of the relevant social issues that may arise. More comprehensive issues are only mentioned in abstract terms, but no specific research agenda or topics are proposed.
 - Looking forward to 2020 and beyond, the tradeoffs involved in different definitions of sustainability (what is to be sustained and for whom) will become increasingly apparent and important. As noted above, while mentioning sustainability repeatedly, the StRAPs give little attention to the specifics and tradeoffs implied by different sustainable futures. What does sustainability imply as one looks forward to 2020 and beyond? How might this influence the research agenda at ORD?

Comments from Dr. Kimberly Jones

The research directions are well developed, with rationale for the major research goals. The cross-cutting areas are critical for meeting the broad objectives laid out in the Strategic Plan.

Comments from Dr. Catherine Karr

The research directions described capture the core and relevant themes that have emerged to ensure public and ecosystem health. The research directions as articulated provide a flexible framework to adapt to evolving environmental issues in the near and far term.

Some attention to the importance of developing the new generation of interdisciplinary environmental health scientists is not discussed and should be highlighted. Training programs that foster environmental health research and problem solving that bring together trainees in the social, exposure, information, economic, medical, and public health sciences could be considered.

Comments from Dr. Nancy Kim

- ORD's proposed research directions are focused on the near future (e.g. 2016-2019) rather than on 2020 and beyond. Adding to each StRAP and roadmap a section whose purpose is to describe research needs of the next decade (2020s) would force the discussion. The section should also show how those needs identify which present research areas may no longer be needed, how a research area may evolve, and what new areas may need to be developed. The exercise would also help direct their current research projects and objectives into the future.

Comments from Dr. Francine Laden

I feel that the proposed research directions if successfully implemented will provide the research necessary to address the environmental issues of 2020 and beyond.

Comments from Dr. Lois Lehman-McKeeman

Generally well directed to continue to address issues. One potential gap is that in moving to more in vitro systems for hazard identification, it is unclear how in extrapolation to in vivo systems will be achieved.

Modeling (PBPK and BBDR) are noted throughout, but it is not made very clear how this will be accomplished. Additionally, there seems to be good integration across the various strategic plans. The research directions for CSS are interwoven with HHRA, and this integration is well positioned overall. It was not very clear how ecological modeling and lifecycle analytics would be carried out overall, so it is not entirely clear how these efforts will address advancing the science to address environmental issues of 2020 and beyond.

Comments from Dr. Elizabeth Matsui

- The climate change strategic plan and focus on in utero and early childhood exposures should serve the Agency well in regards to addressing environmental issues of 2020 and beyond.
- The EPA's Strategic Research Directions could be strengthened by developing a clearer and more explicit plan for addressing this issue:
 - The agency should consider developing a more explicit and/or clearer approach for identifying the priority areas for 2020 and beyond (selecting the one issue in each area that is identified as likely to be the largest environmental and/or public health problem of 2020 and beyond, for example)?
 - In addition, the agency should consider articulating research tools/approaches to address the priority areas for 2020 and beyond. For example, if obesity is a priority area, then a research program would need to focus on environmental obesogens and approaches to reducing exposure to the obesogens.

Comments from Dr. Kristina Mena

- The research programs and topics described in ORD's StRAPs are critical to address current and future environmental issues
- Seeking input from stakeholders representing a range of subpopulations during all stages of the research process would be beneficial to the StRAPs – including identifying research objectives at the start

Comments from Dr. Surabi Menon

The research directions presented in the strategic plan has been outlined fairly well and does include a full assessment of needs and priorities. However, I think the plans could do more to specify what are near-term priorities, including timeline (2014 to 2018 or 2020), and what are long-term objectives, again what timeline is considered for long-term (2030 or 2050 or 2100), that can be achieved by meeting near-term goals. This helps us better follow how research is being set up to achieve success both for near-term and long-term goals. There seemed to be more detail provided on what is needed and what the challenges are and perhaps less detail on how some of the challenges will be met – e.g. what models are being used, how gaps are identified (some of this pertain to the ACE strategic research plan) and then research conducted, and what lessons are being drawn from the international community that can help inform ORD's strategic research questions. I don't think these are all easy to identify, but it would be useful to ensure that the research plans include a systematic way of addressing these questions.

Comments from Dr. James Mihelcic

Based on our state of knowledge, the proposed research directions are forward thinking to address environmental issues of 2020 and beyond. However, there are a few research directions EPA could improve to address environmental issues of 2020 and beyond.

- EPA needs to develop a long term plan (versus short term hiring of postdocs or supporting external

- research) on how to better integrate behavioral science into their long term research.
- EPA should better emphasize and integrate the overarching priority (SSWR slide #9 of July 17 presentation by Dr. van Drunick) to transform the concept of ‘waste’ to ‘resource’ in their technology and policy research innovations.
 - Regarding the draft plan for Chemical Safety for Sustainability STRAP, the three overarching priorities, as written, are related to a past paradigm of addressing impact of existing chemical and materials/products. The overarching priorities should be written as developing leadership in areas that minimize or eliminate hazard through source reduction and green molecular design and the processes used to synthesize those molecules (note that the topic of green chemistry is mentioned later in the CSS STRAP, strategic goals 4, ensuring chemical safety; however, it should be an overarching priority to address current and future environmental issues).
 - It is a mistake to wait until later years to include sustainability assessments such as life cycle assessment in development of any new strategies and technology. Sustainability frameworks that include tools such as LCA are the way to ensure continuous quality improvements throughout the many stages of research innovation.

Comments from Dr. Earthea Nance

1b. In comparing the ORD Strategy to the EPA Strategy, I noticed that communities and sustainability are identified as cross-cutting issues by EPA, while in the ORD Plan sustainable communities is an individual research area. This might be interpreted as ORD elevating the importance of the issue beyond the EPA. Perhaps this was already explained and I missed it. It seems that the top priority goals should be aligned. Moreover, the ORD Strategy lacks research on compliance and enforcement, which is an individual goal.

Comments from Dr. Paula Olsiewski

Overall, the six draft StRAPs provide solid roadmaps that will enable ORD to support EPA to address environmental issues of 2020 and beyond.

Comments from Mr. Richard Poirot

The currently defined major research program areas are individually well-focused but collectively quite comprehensive, and encompass several fundamental environmental concepts – climate, sustainability, health, community, energy, security – which seem likely to remain important issues in 2020 and beyond. If flexibility is maintained and encouraged in identifying, prioritizing and refocusing the major program elements and various crosscutting research strategies, ORD should be well-poised to address emerging research needs in the future.

Comments from Dr. Ponisseril Somasundaran

For securing environmental protection and sustainability in 2020 and beyond, the needed concerted effort in developing a model, that would *promote greener materials and processes*, is lacking. It would be important to predict the indirect long term impact of current technologies on the range of six topics that have been prioritized.

With respect to the definition of sustainability, is it necessary to meet all of today’s perceived “needs”, Society should consider what excesses can be controlled or sacrificed for the sake of the future generations.

Many events listed in Figure 1 can happen at the same time; cumulative vulnerability, for example, in the case of a landslide followed by a spill, needs to be considered.

With respect to interaction between contaminants, both beneficial and antagonistic effects need to be considered

While addressing the effect on humans, how much attention is paid to organisms and effects streaming up through the food chain

Also, more serious attempt has to be made to coordinate the different metrics and technologies that are being developed internationally. Note that tolerance of different populations to toxins can vary significantly, thus the prevalence of diseases in different corners of the world varies markedly. While Alzheimer's is becoming prevalent in the West, it is not as prevalent in the East
Effectiveness of scientific findings is often reduced due to decisions at political levels, what can be done to educate legislators with real life examples?

How often is it updated as more information comes in?

While children are receiving special attention, as they should, older vulnerable population seems to be less in the forefront; they make as big, if not more, of an impact on the consumption of nation's resources..

Sediments, land and ground water are considered, but it is the interfaces that are critical in determining transport and fate.

Page9, 3 last Para: Along with reduce and reuse, designing materials and products with a view to making it easier to disassemble and reuse is important

Comments from Dr. Daniel Stram

- All programs appear to be looking at problems that will remain of importance in 2020 and beyond. Looking much beyond 2020 means dealing with a higher level of uncertainty about what environmental concerns will be faced, dependent for example on such aspects as the rate of impact of climate change on temperatures, sea levels, storm patterns and ecosystems which are relevant to many EPA research programs (not just climate change and homeland security).
- Again there is surprising lack of discussion, except in the homeland security document, about research concerning radiological exposures, and nothing about research on minimization of exposures in the non-disaster setting, both topics likely to remain of relevance in 2020 and beyond.

Comments from Dr. John Tharakan

- Believe the proposed research directions look ahead and forward and are well positioned to address environmental issues of the future – 2020 and beyond. Caveat would be to build enough flexibility into the research plan to be able to address any emerging environmental issues.
- Biggest issue facing communities are the local impacts of climate change. These need to be more clearly integrated into proposed research directions to be able to address issues of 2020 and beyond.

Comments from Dr. Jeanne VanBriesen

The proposed research directions are important and clearly relevant for environmental issues of 2020. The balance between current research needs to answer existing questions and research to better inform

likely emerging problems is difficult to ascertain from the plans. A more specific articulation of the plans for identifying emerging research needs should be included in the StRAPs. Some critical emerging issues are described in the plans, and this is good. What was missing is a method by which emerging research needs that have not yet been thought of will be considered and then integrated into research plans.

Comments from Dr. Katherine von Stackelberg

As noted in several of the StRAPs, the obvious, localized, and sector-specific environmental issues facing the country when the EPA was founded have since evolved to more complex, geographically diverse, and interconnected problems (e.g., climate change, hypoxic zones, etc.).

That said, it can be argued that the most obvious environmental issue for 2020 and beyond is the reconciliation of a finite planet and associated natural capital with the growth- and market-based economic framework that emphasizes labor, physical, and financial capital seemingly without end. Metrics of economic success (e.g., GDP, “growth” of the economy as evidenced by increased jobs, increased productivity, etc.) fail to account for natural capital, either in terms of use (e.g., detriment to the environment) or benefits (Costanza et al. 2012). Although “ecosystem services” attempts to operationalize natural capital by defining environmental processes in terms of benefits to humans (e.g., pollination, erosion control, and so on), there is very little supporting structure for metrics related to the benefits these services provide.

Clearly, much of this is beyond EPA purview. But what is within EPA purview is protection of the environment, the natural capital upon which all life depends, and EPA should focus its efforts in that direction as the only Agency with that mandate. To that end, I find the individual StRAPs differ in their focus on environmental issues per se, which seems to arise largely as a consequence of the ways in which “sustainability” is defined and operationalized.

Moreover, because ecosystem services are defined as the benefits provided by the environment (and benefits, by definition, are benefits to *humans*), there is no particular rationale or basis for focusing on ecological health (except insofar as it relates to human well-being), and this is reflected in both the Strategic Plan (nine instances of the word “ecological” – NO instances of the word “ecology” but 109 instances of “human” and 94 of “human health”) as well as the individual StRAPs (see a summary below in Table 1). “Ecological risk” occurs, as a phrase, only two times in the CSS and HHRA StRAPs and NEVER appears in any of the other StRAPs, including SHC! “Ecosystem services” appears twice in HHRA, seven times in SSWR, and ten times in SHC, but always in the context of “human well-being.”

Document	“Sustainable” used in text	“Sustainability” used in text	“Ecology” used in text	“Ecological” used in text
Strategic Plan (95 pp)	85	32	0	9
SHC (36 pp)	58	76	1	11
HHRA (34 pp)	6	9	1	12
SSWR (36 pp)	41	37	0	11
CSS (24 pp)	28	12	0	22
ACE (24 pp)	29	7	0	3
HS (22 pp)	11	10	0	1

Table 1: Instances of Terms Related to Sustainable and Ecology Across the StRAPs

Comments from Dr. Peter Wilcoxon

- ORD’s focuses on climate adaptation and reactive nitrogen are very good: both will be an increasingly important problems in the post-2020 period.
- Carbon sequestration (including underground injection) is likely to be increasingly important post-2020 and further emphasis could be placed on understanding its environmental implications.

2. Program Specific Charge Questions –

General comments from Dr. Joel Ducoste in response to 2a and 2b

- The early drafts of StRAP (2016-2019) seem to support the agency’s objective and cross cutting strategies quite well. The overall research goals provided are quite ambitious as mentioned earlier. It may have been better to provide a ranked priority list for all proposed research activities so that we could evaluate whether the topics could be achieved within this time frame.

Comments from Dr. Catherine Karr in response to 2a, 2b, and 2c as they apply to children’s environmental health

2a – the research directions contribute to a science base in support of the the overall Agency commitment to ensuring a focus on children’s environmental health with specific call for applied research under Goal 3 and 4. (cleaning up communities and advancing sustainable development, ensuring safety of chemicals and preventing pollution).

2b. The key ceh issues of 2020 and beyond include chronic diseases of childhood and cumulative impacts (chemical and non chemical stressors across the lifestages) which are integrated within the research directions. There will be a need for the next generation of ceh researchers who can work in an interdisciplinary context and synthesize and integrate the evolving science base. Enhanced efficiency of the translation of the science base to policy and practice is needed now and will continue to be important as the products and achievements of the science program manifest.

2c. the role of ceh evidence needs across epa programs is well described within the “drivers” section (epa program drivers). In addition, the four research emphasis areas involve cross cutting issues relevant to ACE, CSS, HHRA, SHC, SSW and HHRA. Table 2 provides a graphic representation of the relationship of the research priority areas and these NRPs.

General comments from Dr. George Alexeeff in response to 2a

In general the research directions are well designed and support objectives as described above.

General comments from Dr. Elaine Faustmani in response to 2a with special focus on CSS, HHRA and SSWR

At the time of submission of these comments I have primarily focused on three research programs (CSS and HHRA and SSWR) and I will use these as my examples for my comment responses below on ORD programs.

In general, as I have stated under my responses to 1a and 1b the research directions identified in each of these programs are significant and well identified. They address both issues of national and regional importance and support the overall mission of EPA to protect human health and the environment. They are moving to proactive versus reactive policies and approaches and that is very important and provides a critical public health context of prediction rather than reviewing retrospectively past impacts. This proactivity does not come without challenges and one of these is to ensure that the level of prediction will match the question as well as match the criteria for acceptance and implementation. I think the agency has undertaken a robust path in this direction.

Some additional linkage with the recipients of the products from the research programs is merited and needs to be acknowledged by both the product creator and product recipient.

General comments from Dr. Elizabeth Matsui in response to 2a

- The inclusion of *in utero* and early childhood exposures is appropriate in the strategic plans focused on children’s environmental health, in particular with respect to children’s environmental health issues that are likely to be important in 2020 and beyond, but it is not clear that the plan includes similar emphasis on research that is further along the translational spectrum, such as intervention studies, which would be poised to have a more near-term impact on children’s environmental health. A balanced portfolio – in terms of having research that will result in both near-term and longer-term impacts is important for a variety of reasons, including the importance of improving child health for today’s children as well as future generations.
- Environmental health research has never been more complicated. Although the tools that are now available are powerful, and the Agency’s documents clearly articulate this notion, we are now in an era of human epidemiologic and clinical trial studies that require very very large sample sizes. Specific examples of the kinds of studies that are needed include those that examine gene*environment interactions, EWAS studies, and exposome and mixture studies, along with chronic exposure studies. These require extremely large sample sizes. The only way that these types of studies can be done with limited resources is through partnerships with others. Although there are nods to partners throughout the strategic research plan documents, a more explicit strategy to fund studies that add exposure assessment onto established, large cohorts and populations could be an important solution to the problem of very big science and limited resources. There are many many studies with banked biospecimens that could be used to address these critically important research questions. In addition, a plan to work with US population based surveys such as NHANES and NHIS to advocate for inclusion of key exposure biomarkers could also be an avenue for maximizing the impact of ORD funds.

- “Sustainability” and “healthy” are two important conceptual areas that should be addressed, but the distinction between these two concepts is often quite muddy. These concepts, while sometimes positively correlated with one another, sometimes are not related. Working towards using sustainable building materials and minimizing the impact of the built environment on the natural environment has clear implications for the health of humanity in the long term, but sometimes “sustainability” can cause unintended adverse health effects. One example is that more tightly sealed homes, which are more energy efficient, are at risk of having higher concentrations of indoor exposures that are detrimental to human health. The Agency should consider stating clear definitions of these two terms and addressing the nuanced relationship between these two concepts.
- An explicit commitment to long term follow-up of study populations that have already been assembled would strengthen the EPA’s positioning for environmental health issues of 2020 and beyond as it is these kind of data that are needed to understand the effects of chronic exposure.
- A commitment to supporting research that would assess the impact of regulation (and other such tools that have been implemented) would serve to provide key data to shape future research priorities but would also serve to highlight the impact of EPA’s efforts. A good example of this kind of work is the ecologic studies done in Scotland after a smoking ban was instituted. There are many large study populations that can be used for ecologic studies of the effects of regulation or other intervention on an environmental exposure.
- There is a stated commitment to supporting efforts to disseminate research findings, however there are gaps in what is described. These gaps include:
 - There is little mention of implementation science, which is needed to study how best to implement interventions that have been shown to work at the clinical trial stage of the translational spectrum.
 - The discussion of supporting programs to disseminate research findings seems to stop short of including scientifically rigorous assessment of the effects of disseminating research findings or implementing interventions on both exposures and health outcomes in communities.
 - There is emphasis on the development of tools that can be used by communities to assess risk and plan, but it is not clear that there is a plan to support research aimed at understanding how often the various tools are used, by whom, whether they lead to any change in the community or action by the community, and whether that change has beneficial effects.
- In some of the strategic plans and roadmaps that include a human health component, there seems to be much greater emphasis on the ends of the translational research spectrum and less emphasis on the “middle” of this spectrum. The emphasis appears to be on both foundational research (animal models, toxicology studies, observational cohorts) and then, at the other end, community action. The pieces that appear to be quite limited are: the development of interventions, the science of implementing proven interventions, the science of assessing the impact of implementing the intervention on environment and health outcomes, and then the science of dissemination. These are all of the steps between the foundational work and the activity of disseminating tools and/or results of studies.

General comments from Dr. Elizabeth Matsui in response to 2b

- The agency should consider developing a more explicit and/or clearer approach for identifying the priority areas for 2020 and beyond (selecting the one issue in each area that is identified as likely to be the largest environmental and/or public health problem of 2020 and beyond, for example)?

- In addition, the agency should articulate research tools/approaches to address the priority areas for 2020 and beyond. For example, if obesity is a priority area, then a research program would need to focus on environmental obesogens and approaches to reducing exposure to the obesogens.

General comments from Dr. Elizabeth Matsui in response to 2c

- In general, much attention has been focused on integration.
- It is difficult to judge how effective the integration would be from the documents provided.

Comments from Dr. Surabi Menon in response to 2a for all programs

EPA's strategic plan has 5 main goals and each of the StRAP's and combinations of them try to address the various goals. I think this is probably the best way to support the Agency objectives identified within the Goals. It does seem fairly comprehensive and the StRAPs seem to have an exhaustive list of activities to support the strategic plan. It would be useful to see how the various plans cross-link and where research efforts under one StRAP strengthen or advance the other StRAP's objectives. So in this regard, for communicating the value of the 6 StRAP's contributions to the overall strategic plan, as well as that of the cross-cutting elements, a framework diagram would be very useful. This could be created in the form of a story board at a high level, to show how the topics in the various StRAPs relate to the main objectives of the EPA, and within those linkages what are useful metrics that can be tracked to see how well they are delivering to the objectives. This can better help diagnose problems and evaluate performance.

Comments from Dr. Surabi Menon in response to 2b for all programs

Please see responses to 1b.

Comments from Dr. Surabi Menon in response to 2c for all programs

I do think a strong effort was made to address integration and overlap between the different plans. This was identified quite clearly at least in the cross-cutting research plan and within the individual plans. What was not clear was how the integration was being implemented and if some research plan failed to meet the objectives outlined that were considered essential for integration, how would that affect the objectives of the linked research plan.

Since these are to be further explored as the research plans are being developed, **timelines, metrics and evaluation of how this integration is being implemented**, should be a strong component of each research plan. This will help ensure objectives for integration are being met systematically and at the right time.

Comments from Dr. Duncan Patten in response to 2a, 2b and 2c for all programs

Response to 2a. Each program has its own emphasis but together they appear to address the overall EPA Strategic Plan. One still has a sense of independence among the programs and yet the overall plan will require major cross walking among the programs and this is not that evident except where ORD has created a few cross cutting research efforts.

Response to 2b. EPA ORD has come a long way in ensuring some integration among programs. It now recognizes that solving human health and well being cannot be accomplished through addressing individual issues or individual components of the human environment. Thus, the integrated, adaptive management approach for the future is appropriate and necessary.

Response to 2c. Integration certainly is a common theme but the cross cutting issues, which should be the foundation of an integration program, only touch on a few issues and do not produce a truly cross cutting, integrated program. Climate change, for example, is an integrated program but, if so, then major components of water, air, communities and FEGS, and other programs should be designated for an integrated approach to climate change. Perhaps it is, but six silos still exist with only limited cross silo integration. Some improvement over 13 but still separated by separate goals. Unfortunately, **this lack of extensive integration across programs is, in part, budget driven not research need driven.**

Air, Climate and Energy

Comments from Ms. Sandra Smith focusing on Question 1a as it relates to ACE

- It is unclear from the documents I reviewed that ORD has a formalized process in place to identify, evaluate, and prioritize emerging issues. There is evidence in the draft ACE plan that this is being done, but it comes across as a bit haphazard. The draft ACE plan acknowledges a shift in emphasis, continued from the previous plan, to science supporting existing policies and regulations with a focus on problem solution and less so on problem identification. It is appropriate to focus on resolving the problems we know about, but important to continue looking for the problems of the future.
- The EPA Strategic Plan lists four objectives under Goal 1: Addressing Climate Change and Improving Air Quality – 1) Address climate change; 2) Improve air quality; 3) Restore and protect ozone layer; and 4) Minimize exposure to radiation. The ACE plan does not explicitly support the third and fourth objectives. The emphasis on the first two objectives may be appropriate, but the lack of emphasis on the third and fourth objectives perhaps should be explained.
- The third objective under Goal 1 in the EPA Strategic Plan (improve air quality) is stated as follows: “Achieve and maintain health- and welfare-based air pollution standards and reduce risk from toxic air pollutants and indoor air contaminants.” The ACE plan addresses research to support NAAQS but is very quiet about air toxics. The emphasis may be appropriate, but there is no evidence presented on the underpinning of the decision to de-emphasize air toxics.

Comments from Ms. Sandra Smith focusing on Question 1b as it relates to ACE

- Comments above on 1a are relevant to this question as well. In general, the decision logic used to reach the proposed research directions is not completely transparent, so it is difficult for the reader to judge how appropriate these directions are without bringing in their own biases. The reduced emphasis on problem identification in the draft ACE plan worries me concerning the Agency’s ability to predict the environmental issues of 2020 and beyond.

2a. How well will the research directions in the Early Draft StRAP (2016-2019) for ACE support EPA in achieving the relevant Agency objectives and cross-cutting strategies, as described in the EPA Strategic Plan (2014 -2018)?

Comments from Dr. Viney Aneja

The Early Draft StRAP (2016-2019) supports EPA in achieving the relevant Agency objectives and

cross-cutting strategies.

Comments from Dr. Ingrid Burke

The research directions are closely related to the agency level Strategic Plan. As I elaborate below, I am less convinced that many of the specific objectives and questions are tractable. The use of case studies in the presentations was very effective in showing that the work is focused. The intractability only partly a criticism; I think the most important questions facing society are not necessarily those that lead to clear answers. Still, this is exactly the problem that our citizens have in understanding and valuing the work of the EPA. More case studies in the prospectuses and plans would have been useful.

Comments from Dr. Peter Chapman

- Given that this StRAP does not mention ecosystem services, or key issues related to global climate change specifically habitat changes and invasive/introduced species, I do not believe the support is adequate; it needs to be improved, see additional comments and questions below.
- Fully agree with the issues (p3) of health-related stressors including vector-borne diseases.
- Rather than (p4) “Protecting health and environment from the impacts of climate change”, the emphasis should be on adaptation as these changes will occur and the status quo cannot be maintained.
- Fully agree with considering international emissions (p10).
- Does EPA truly believe that a majority of the population will use data provided by EPA for (p11) “informed personal decision-making”?
- Bulleted challenges on p11 are well articulated
- The arguably most important Research Accomplishment should be the third to last bullet on p12 rewritten as follows: “Develop a synthesis and assessment of potential climate change effects on ecosystem services and human health and well-being”.

Comments from Dr. Courtney Flint

Regarding SEE, there should be more inclusion of the coordinating efforts with DOE, DOT/FHWA, USDA and NOAA around alternative fuels, vehicle standards, conservation, renewables scenarios selection.

Comments from Dr. Courtney Flint

- ACE – Integration of these domains is probably the clearest example of the full embrace of complex systems linkages necessary for a sustainability approach to global challenges.
- ACE – It is useful to have social factors at the nexus of the air-climate-energy nexus but awareness and perception are missing in the conceptual framework and are important behavioral and policy drivers, not just for individuals, but also for institutions and governance at multiple scales.
- ACE – Stated acknowledgement that benefits from clean air achievements not shared by all and emphasis on fence line monitoring in a number of places is a missed opportunity to explicitly bridge to the environmental justice and children’s health roadmaps.
- ACE – Consider impacts of emission reduction regulations on certain populations – i.e. vehicle loss/cost in rural communities reliant on personal vehicles due to lack of public transport. Beware of shifting burdens – this connects to the roadmap on environmental justice.

Comments from Dr. Francine Laden

The research objectives outlined in the ACE stRAP are directly aligned with the Agency priorities,

goals, and cross-cutting strategies described in the EPA strategic plan. Specifically they are focused on improving air quality, addressing climate change and advancing sustainable development.

Comments from Dr. Richard Poirot

The ACE StRAP does an excellent job identifying and articulating the ACE-related research objectives and priorities to support the Agency objectives and cross-cutting strategies described in the EPA 2014-2018 Strategic Plan. The StRAP's expected accomplishments are tightly focused, would provide many valuable insights, but also seem to be extremely ambitious. It might be useful to separate these accomplishments in to near-term and longer-term time frames, as some of these seem likely to remain as important "deliverables" – for continuing development and refinement – over time frames extending well beyond the period of the current Strategic Plan.

The StRAP's program design combines continuing links to past research efforts with a timely shift from problem identification to problem solutions. Many various opportunities for integration between ACE and the other 5 research program areas are identified and linked to specific cross-cutting roadmaps. There is also a timely shift of emphasis from the 2012 plan toward several specific research topics more reflect of current and future information needs.

The 5 major research topic areas identified in the ACE plan are well-suited to link past research efforts with changing current and future information needs, with each topic including both near-term and longer-term research aims. Some specific thoughts on each of these topics are:

- **Research Topic 1 (NAAQS and Multipollutant):**

It should be recognized that the NAAQS are (have been) fundamentally single pollutant approaches. A thoughtful consideration of what specific multi-pollutant combinations may lend themselves to future NAAQS (and how much discretion the Agency has) could be helpful. It may also be productive to periodically consider if NAAQS might be proposed for other common pollutants (or if current criteria pollutants might in some cases be more efficiently controlled by other non-NAAQS mechanisms).

EPA seems to all but have abandoned the concept of separate secondary (environment and/or welfare-protecting) standards, which could conceivably be excellent regulatory tools for dealing with long-term problems. The best attempts at multi-pollutant NAAQS to date have been for secondary NAAQS, such as consideration of a secondary (SO_x + NO_x) AAPI, and a secondary "PM light extinction" NAAQS. Quite possibly it may be easier to refine these and develop other multi-p secondary NAAQS, where the time restrictions on implementation are more flexible.

NAAQS reviews have to be strictly focused on setting appropriate levels of standards without any allowed consideration of the implementation phase. This doesn't mean that EPA NAAQS-related research needs to be similarly restricted, and advance consideration of alternative implementation strategies to reduce single or multipollutant effects might be a productive area for future research.

Current forecasting and reporting of the (single pollutant) Air Quality Index (AQI) has become an important component of AQ health protection. Conceivably this is an area where a multi-pollutant index and/or advisory messaging system might be developed in advance of the more formally restricted NAAQS. For example, the Canadian multipollutant Air Quality Health Index (AQHI) appears to be intelligently derived, and given its shorter 4-hour averaging time can also be reported in near-real-time – while the US AQI lags a day behind the data.

- **Research Topic 2 (Emissions and Measurements)**

It remains surprising how our continuous PM measurements remain inconsistent (across methods, over space and time, and with filter FRMs) after the many years of experience. This impedes the ability to use continuous PM_{2.5} data for compliance determination, for spatial and temporal trends analysis, and for

developing future NAAQS revisions over shorter averaging times. An area of useful research might be to determine if more consistent methods can be developed – especially if these could better reflect the true nature of particles in the ambient air and/or human exposures over larger population areas.

Alternatively, a large part of the problem is our highly flawed (operational) partly dried, filter-based definition of PM_{2.5} mass in the first place. A careful reconsideration of alternative metrics (area, number, volume, size, composition) by which PM could be more precisely defined – and more reflective of health or environmental effects – would be a useful research topic.

Better, faster, and more spatially and temporally consistent ways of generating and updating emissions inventory data – for criteria pollutants, hazardous air contaminants and greenhouse gases seems to be an historically neglected area of EPA (and state, and academic) research. For GHG emissions in particular, there's a need to better account for full life-cycle emissions – especially for many so-called biofuels.

- **Research Topic 3 (Modeling and Decision Support)**

EPA has done excellent work in developing, refining, and distributing (the models and processed results from) multi-pollutant regional-scale air quality models like CMAQ and benefits models like BENMAP. Additional refinement of such models – for example to include estimated effects of various regional and national strategies on hazardous pollutants and GHG emissions will be useful.

It will also be increasingly necessary to link regional and global models and to find better ways of combining the longer future time scales and broader spatial scales of global climate models with smaller, shorter time scale air quality tools used by local, state & regional decision-makers.

- **Research Topic 4 (Climate Impacts and Mitigation)**

The ACE plan notes the importance of identifying which populations and ecosystems face greatest risks from adverse impacts of climate change. It will also be important to conduct or support similar activities on regional, state and local bases. Tools that engage and empower local communities to make informed decisions on best mitigation and adaptation strategies will be especially useful.

This is an area where EPA should be encouraged to collaborate extensively with other federal agencies that have complementary skills and resources. There may also be excellent opportunities for effective EPA contributions to international climate mitigation and adaptation efforts.

- **Research Topic 5: Sustainable Energy Evaluation**

The planned emphasis on emerging fuels, resources and technologies (rather than on current environmental conditions) promises to provide a usefully different and highly complementary perspective to the other ACE research topics. While the plan indicates an intentional de-emphasis on biofuels, I hope this will not curtail continued work on calculating life-cycle CAP, HAC and GHG emissions of biomass combustion – of various types and combustion scales. Evaluating CAP, HAC and GHG implications of the various “biofuels” used replace fossil fuels in the transportation sector (for example as under annual biofuel content determinations under the EISA act) is an area where additional scientific clarity is still much needed.

Comments from Ms. Sandra Smith

- Five goals are highlighted in the EPA Strategic Plan, the first of which is addressing climate change and improving air quality. As discussed above under charge question 1a, the four specific objectives listed for this goal are to: 1) address climate change; 2) improve air quality; 3) restore and protect the ozone layer; and 4) minimize exposure to radiation. The EPA Strategic Plan goes on to discuss specific strategies to meet these objectives, identifies external factors and emerging

issues for each objective, and specifies strategic measures for each objective. The draft ACE plan does not read as if it flows from the objectives, specific strategies to meet the objectives, and strategic measure for each objective from the EPA Strategic Plan.

- The decision logic used to arrive at the five research topics listed in Table 1 of the draft ACE plan is again a bit cloudy to me. When there is clear articulated logic flow from point a (for example, Goal 1 in the EPA Strategic Plan) to point x (for example, ACE Research Topic 2 in the draft ACE plan), it is easier to trace the flow backward in order to make judgments concerning how well the research topic will support EPA in achieving the Agency's objectives. Was there a larger candidate list of research topics that were evaluated and winnowed down to the selected five topics?
- The ACE Research Topics arrived at in Section VIII of the draft plan are very broadly drawn in this draft of the plan. For example, the ACE Research Topic 4 [Climate Impacts, Mitigation and Adaptation (CIMA)] is very generally discussed in four paragraphs in the plan using language and making points that have in many cases already appeared in the document. There is not much more specificity in the draft ACE plan on this research topic than appears in the EPA Strategic Plan. I do realize that the material that ultimately appears in Appendix A, Table of Proposed Outputs, will provide much more specificity, so perhaps this feedback is premature.

Comments from Dr. Peter Wilcoxon

- The ACE StRAP does an excellent job of drawing out the tight links between air, climate and energy. Its three key research objectives: (1) assessing impacts, (2) preventing and reducing emissions, and (3) responding to changes in climate and air quality, are well designed to support EPA's strategic plan. The list of anticipated research accomplishments would clearly contribute to the strategic plan, although it is a long list and it seems unlikely that all will actually be accomplished.

2b. What are the SAB/BOSC perspectives on the proposed research directions in the ACE StRAP providing research to address environmental issues of 2020 and beyond?

Comments from Dr. Viney Aneja

This is addressed in 1b.

Comments from Dr. Ingrid Burke

The research directions for the Air program are extremely broad, and I have a bit of concern about whether they will result in tangible progress.

Comments from Dr. Peter Chapman

- See comments above.

Comments from Dr. Taylor Eighmy

- Generally, for ACE, there is good alignment on direction and broad jurisdictional issues facing EPA.

Comments from Dr. Courtney Flint

- The ACE and CSS programs plans differentiate near-term and long-term research aims in a helpful manner.

Comments from Ms. Francine Laden

The research directions in the ACE StRAP appear appropriate. They focus on (1) assessing impacts at all levels - individual to global, (2) preventing and reducing emissions, with a focus on multi-pollutants, and (3) preparing and responding to changes in climate and air quality. These directions will provide research relevant to 2020 and beyond, as well as today. Although the StRAP does mention identification and assessment of susceptible populations and the need for integration with behavioral science, this area should be expanded. It is crucial that air pollution and climate change is considered together with and in the context of individual behaviors, lifestyle choices, and other concurrent exposures.

Comments from Mr. Richard Poirot

It can be anticipated that most of the currently-identified ACE research topics will remain important 6 years hence. The flexible ACE StRAP structure, and recent past experience with responsive shifts in ACE research priorities, and the plan's stated intention to shift future focus more toward climate and energy issues - all suggest that a major change in ACE research directions is not likely to be required in 6 years. In somewhat different terms, I don't view any of the current ACE research activities as putting "wasted emphasis on past issues which diverts scarce resources away from other more important emerging issues..."

Comments from Ms. Sandra Smith

- See response to charge question 1b
-

Comments from Dr. Peter Wilcoxon

- The ACE StRAP's emphasis on climate adaptation is very good: as noted above, that will be a critical issue post-2020.
- ACE should consider undertaking more research on the environmental implications of carbon sequestration (particularly underground injection), which will be more important post-2020.
- ACE should also consider undertaking research on the environmental implications of geoengineering. Geoengineering is not likely to be deployed soon but much needs to be learned about its possible consequences and long delays in research mean that studies should begin soon.

2c. For ACE, do the presentation and plan indicate that ORD is designing for integration, where appropriate, on topics that are relevant to other research programs?

Comments from Dr. Viney Aneja

Yes.

Comments from Dr. Ingrid Burke

So far, the plans mostly give lip service to the integration across research programs. There are lists of related projects and products that relate to other programs, but few tangible descriptions of the relationships that do/will exist. It would be really great to have examples.

Comments from Dr. Peter Chapman

- ORD is attempting to design for integration, but not always to the extent necessary or appropriate (see comments above).

Comments from Dr. Taylor Eighmy

- The specific focus on climate change as a cross cutting component of ORD's focus is appropriately supportive of integration

Comments from Dr. Francine Laden

- Yes, the procedures and plans do address the need for communicating across disciplines, departments, agencies, and stakeholder with the specific purpose to integrate across research programs.

Comments from Mr. Richard Poirot

The ACE StRAP indicates that the ACE Research program clearly recognizes areas of productive interaction with, and is well-poised to integrate activities with, virtually all of the other national research program areas. The plan clearly identifies ACE formal integration through participation in virtually all of the cross-cutting roadmap areas (Climate, Nitrogen, Children's Health, Environmental Justice). The planned continuing interaction among the national program directors, their stakeholders and partner agencies and the regional offices seem to provide a sound structure to assure that this integration is responsive and efficient.

Comments from Ms. Sandra Smith

Integration with the other research programs is well described in The ACE StRAP.

Comments from Dr. Peter Wilcoxon

- Yes, ACE is clearly tightly integrated into the climate change crosscutting roadmap, and the other three roadmaps also have significant involvement by ACE

Chemical Safety for Sustainability

2a. How well will the research directions in the Early Draft StRAP (2016-2019) for CSS support EPA in achieving the relevant Agency objectives and cross-cutting strategies, as described in the EPA Strategic Plan (2014 -2018)?

Comments from Dr. Edward Carney

The alignment of the CSS research program to EPA's strategic plan is clearly delineated. CSS aligns most directly with EPA Strategic Goal 4, but also supports all four of EPA's cross-agency strategies.

In support of EPA's high level goals, CSS is particularly noteworthy as it is driving a major paradigm shift in the way chemical safety is evaluated, not just at EPA, but across the entire field of chemical safety assessment. The program's use of risk-based approaches which combine hazard identification, dose-response assessment (including "tipping points") and exposure is the right way to go, as it enables the Agency to move more quickly and efficiently, and to focus on the problems that will have the greatest impact on public health.

The program's use of high throughput methods is another critical component which advances the Agency's protection goals as it enables a preliminary assessment of the large number of lower production volume chemicals which to date are often evaluated by non-testing methods (e.g., QSAR, read-across).

One item which deserves stronger emphasis in the CSS StRAP is the need to increase confidence in new approaches by transparently and directly addressing areas of greatest uncertainty. For example, the limited metabolic capability of most in vitro systems is a fundamental limitation which can lead to both false positives and false negatives with in vitro assays. These challenges need to be confronted head on with focused research. If not, the program offices, other regulatory agencies and stakeholders will never gain enough confidence to base important decisions on these new methods.

Comments from Dr. Peter Chapman

- This StRAP does not mention ecosystem services nor does it discuss the effects of global climate change on chemical safety – thus I do not believe the support is fully adequate; it needs to be improved, see additional comments and questions below.
- Fully agree regarding “better informed, more timely decisions about chemicals” (p 3), to “accelerate the pace of decision making” (pp5-6), and “agile responses” but question both timeliness and agility, which have not typically been EPA strong points – how will this change?
- What are “sustainable chemicals” (p5)?
- Fully agree with “engaging international partners” (p5); this needs to be a priority.
- What are “tipping points” (p7)?
- Fully agree with incorporating LCA but give it more prominence – see Response re LCA to 1b, above.
- Devoting (p8) “nearly half of the programmatic resources...to research translation and knowledge delivery” further reduces resources to do the actual work – are there still enough resources overall?
- P11 provides a list of recent historic CSS Star Grant Topics, but there is nothing about present or planned Star Grant Topics, there should be (as is the case in the Roadmaps).
- Care is needed in developing rapid screening approaches so that time and cost (p19) do not override technical defensibility; the “and/or” separating time and cost from uncertainty is worrisome in this regard.

Comments from Dr. George Daston related to the CSS and HHRA StRAPs

The StRAP plans for the CSS and HHRA programs are well-suited to supporting the Agency’s strategies and are cross-cutting. The CSS program in particular has realized that the tools it is developing are transformative and may be unfamiliar to staff in program offices and regions who are distant from the research and have long-standing ways of doing their work. Accordingly, the CSS has invested considerable effort in developing dashboards as a way to make new technologies more accessible, and hopefully more user friendly, to the practitioners in the field. As for the HHRA program, its work products such as IRIS assessments and PPRTVs and among the most used in the Agency, across programs and regions.

Comments from Dr. Taylor Eighmy

As noted above regarding SEE, there should be more inclusion of the coordinating efforts with DOE, DOT/FHWA, USDA and NOAA around likely scenarios for alternative fuels, vehicle standards, conservation, renewables and the reasons for their selection. The efforts to identify future likely scenarios should be elucidated in the ACE StRAP. Further, the selection of governing scenarios and models should be explained a bit more.

Comments from Dr. Courtney Flint

- CSS and SHC – These programs very clearly integrate cross-cutting strategies in their Strategic Plans.
- CSS – The life cycle analytics approach will likely help frame the pursuit of sustainability objectives, but needs further operationalization and criteria for evaluation.
- CSS – Stakeholder engagement is only briefly mentioned with few details on “who” stakeholders are and how to operationalize this notion of engagement, potentially limiting the degree to which tools and research will make a visible difference in diverse communities.

Comments from Dr. Lois Lehman-McKeeman

The research directions are focused on what appears to be highest priority issues for the EPA and should be well positioned to achieving the Agency’s objectives. [did not identify a real gap in the overall research direction.]

2b. What are the SAB/BOSC perspectives on the proposed research directions in the CSS StRAP providing research to address environmental issues of 2020 and beyond?

Comments from Dr. Edward Carney

The CSS research program is on a path to revolutionize chemical safety assessment. The program is poised to start delivering well-defined, practical and broadly accepted solutions to agency problems within the 2016-2019 time frame. By 2020 the proverbial honeymoon will definitely be over, and it will be essential that solutions such as integrated approaches to testing and assessment (IATAs) which are fit for specific regulatory purposes are delivered and used within the Agency. It would be helpful if the StRAP articulated a vision the long-range vision for the future beyond 2020.

Another consideration for 2020 and beyond is the impact of European and Asia-Pacific REACH programs which will have required extensive animal testing on mid- to lower production volume chemicals by then (next REACH deadline is in 2018). Is there a danger that the some benefits of CSS research will have be pre-empted because of this required animal testing? Is there an opportunity for EPA to influence the trajectory of global REACH programs by offering more attractive alternatives?

Comments from Dr. Peter Chapman

- See comments above.

Comments from Dr. George Daston related to CSS and HHRA

As noted in my response to question 1, there may be a need to invest more in long-term research that will address problems that will be faced ten years from now. Both the CSS and HHRA programs do have some investment in methods that are emerging and will be important in the long term. It will be important to resist the temptation to deprioritize these programs in order to overcome budgetary constraints on more urgent deliverables.

Comments from Dr. Courtney Flint

- The ACE and CSS programs plans differentiate near-term and long-term research aims in a helpful

manner.

- CSS – Emphasis on prediction will help anticipate longer-term issues.

Comments from Dr. Lois Lehman-McKeeman

There is a clear need to build knowledge and expertise in this area, so the overall objectives address this emerging need. It is not made very clear how life cycle analytics will be developed or carried out, and this is an important plank of the strategic plan

2c. For CSS, do the presentation and plan indicate that ORD is designing for integration, where appropriate, on topics that are relevant to other research programs?

Comments from Dr. Edward Carney

There is a clear emphasis on integration in the CSS StRAP. In fact the words “integration” or “integrate” are mentioned 35 times! The plans regarding communication, education and translation and application should be especially impactful in this regard. While there are clear benefits to integration, I would only caution that it needs to be balanced with the burden placed on staff (especially scientific staff) associated with extensive planning and complex matrix management. Obviously, ORD is in the best position to determine the optimal balance.

- Comments from Dr. Peter Chapman
- ORD is attempting to design for integration, but not always to the extent necessary or appropriate (see comments above).

Comments from Dr. George Daston related to CSS and HHRA

The programs that I reviewed show clear evidence that the program directors understand their role in serving a larger, integrated organization. The focus is on delivering research products that are broadly applicable.

Comments from Dr. Lois Lehman-McKeeman

Yes, efforts to integrate across programs is very evident throughout. If achieved, this integration could be highly effective and productive. The integration noted by CSS relative to integrating the tools from HHRA is also evidence. This integrative effort is a strength of the overall strategic plan.

Homeland Security

2a. How well will the research directions in the HS Early Draft StRAP (2016-2019) support EPA in achieving the relevant Agency objectives and cross-cutting strategies, as described in the EPA Strategic Plan (2014 -2018)?

Comments from Dr. Peter Chapman

- This StRAP fittingly attempts to move beyond terrorist activities to natural disasters both to humans and to ecosystem services (e.g., related to global climate change)(pp2-3) but is still focused on the former not the latter, thus it does not fit well with the other StRAP and ecosystem services are not a focus; it needs to be improved, see additional comments and questions below.
- What is meant by “Developing resilience at the community and water utility level”?
- Figure 2 and the text mention “sustainability”, which needs to be defined as used herein.

- Disasters can be both acute and short-term (e.g., oil spills) and chronic and long-term (e.g., sea level rise); relative intensity, duration, and time scales need to be considered.
- Ecosystem services are not a primary focus.
- Fully agree (top of p6) re the goal “to deliver science syntheses in the hands of end users” – a critical feature required of all StRAPs.
- Table 1, when risk assessment is mentioned is this HHRA, ERA, or both? Unclear.
- Fully agree with all Anticipated Research Accomplishments on p 8.
- Figure 3 (p9) is good.
- Partner and Stakeholder Involvement (p10) is inadequate.
- This StRAP seems primarily focused on drinking water systems – is this intentional as given resource limitations there is a need for a tight focus, or is this simply a hold-over from the original goal of Homeland Security to protect against terrorist threats (e.g., to drinking water systems)?

Comments from Dr. Nancy Kim

- The research directions in the HSRP StRAP should help achieve EPA’s objectives and cross-cutting strategies. However, the HSRP StRAP should be revised to add specific examples of HSRP’s objectives and research outputs that support EPA’s Strategic Plan.

Comments from Dr. Courtney Flint

- Emphasis on resilience could be better defined and operationalized. This is a term fraught with competing interpretations and measurement difficulties

Comments from Dr. H. Keith Moo-Young

The Homeland Security StRAP will provide the research direction to achieve relevant Agency objectives. Moreover, the Homeland Security Research Program conducts applied research and provides technical support to achieve the Agency’s mission. In its current format, The Homeland Security StRAP provides a concise synopsis of the research direction. The StRAP clearly points out the linkage of the research to the overall EPA strategic plan. In particular, the StRAP uses a system approach to achieve the objectives for the Agency. The Homeland Security Research Program provides clear diagrams of how the systems approach aims to protect and our nation’s water systems, indoor and outdoor disasters, and effectively provide laboratory support through a nationwide network.

The Homeland Security StRAP does provide a cross cutting strategy. Homeland Security works with the Offices of Water, Chemical Safety and Pollution Prevention, Solid Waste and Emergency Response, Air and Radiation, water utilities, and each of the Agency’s regional offices to determine the priorities and provide technical support. Homeland Security is cataloged under EPA Goal 2 , 3 and 4, respectively. This program is informed by stakeholder needs, thus the applied research nature of the work is timely and applicable.

Comments from Dr. Paula Olsiewski

The early draft HS StRAP outlines three research objective areas: 1.) Systems approach to water security and resilience, 2.) Systems approach to community resilience to disasters, including cleanup of contamination of indoor/outdoor areas, and 3.) Technical support for partner preparedness, response and remediation. These research directions are well planned and provide strong support to the EPA in achieving the relevant objectives and cross-cutting strategies as described in the strategic plan. Given the cyber threats are increasing, ORD should consider whether timing of the research plans to address cybersecurity issues (page 11), with associated anticipated outputs FY 17 (page 20) and FY 19 (page

22) should be accelerated.

Comments from Dr. Daniel Stram

The EPA Strategic Plan (2014-2018) only mentions in passing the EPA role in Homeland Security Research or other HS-related tasks so it is not easy to respond in a very specific manner to this question as stated, therefore I have tried to give general comments.

- The Homeland Security Research Program (HSRP) now interprets its mandate (originally focused on terrorism) more broadly to research in support of the EPA's response to disasters in general. Recent examples of such disasters include Hurricane Sandy, The Deepwater oil spill, the West Virginia (Elk River) contamination, and (outside the US) the Fukushima nuclear plant accident. One important question, only partly answered in the materials is "How can this broadening of mandate take place without over extending (or greatly enlarging) financial and scientific commitment to the HSRP?".
- The HSRP program differs from most other applied research programs in that the threats being addressed are unpredictable, one does not really know what a terrorism incident or natural disaster that affect areas of EPA responsibility would really consist of, where it would occur, or what special demands on the EPA would be made in such an event.
- As described in the draft StRAP disaster-related responsibilities of the EPA are categorized into
 - protection from, detection of, and recovery from contamination of drinking water systems
 - remediation of contaminated areas outdoors or indoors
 - developing laboratory capacity to analyze for CRB agents during monitoring or in response to disasters

These clearly relate to Goal 2 and 3 of the EPA SP 2014-2018, "Protecting America's Waters" and "Cleaning up Communities and Advancing Sustainable Development" and therefore HSRP research has the potential to directly address these two goals as well as a number of the other elements of the EPA SP 2014-2018, e.g. objectives within Goals 1-4 (such as minimization of radiation exposure). The research objectives of developing tools for the evaluation (short term) and improvement (long term) of water system operational resilience, optimizing sampling, improving laboratory capability and capacity, risk assessment, and decontamination seem appropriate and clearly related to EPA SP Goal 2, A key aspect will be testing of some of these tools at the mockup water system facility described in Dr. Sayles' presentation (in Idaho).

- The second research objective: providing a systems approach to resilience to disasters (including cleanup) is certainly relevant to EPA SP Goal 3, however the implementation and utilization of some of the research products, for example a tool to support community resilience from environmental disasters is hard to visualize or to evaluate promise for. Others are far more concrete such as the probabilistic risk assessment tool for anthrax exposure -- clearly a worthy aim -- and the update of selected analytic methods and sample collection documents. Employing some objective criteria (as incorporated into a "systems-based tool") in assessing the susceptibility/resilience of all communities to a list of possible threats seems like a very worthy goal, but likely one requiring immense data collection and consolidation only portions of which could rely on existing computerized and accessible data; it is unclear whether local/government involvement would be needed for developing the data needed for the tool or in applying the tool for local decision-making, if so the relevance of the tool when used by local officials, not just when used in the hands of skilled EPA scientists or technologists, would need assessment .

2b. What are the SAB/BOSC perspectives on the proposed research directions in the HS StRAP providing research to address environmental issues of 2020 and beyond?

Comments from Dr. Peter Chapman

- See comments above.

Comments from Dr. Courtney Flint

- HS – The Homeland Security program’s framework on “all hazards” should facilitate understanding of the interactions among a complex set of hazards, rather than a stove-pipe approach to preparedness. This should better equip communities in the long run.

Comments from Dr. Nancy Kim

- See response to 1b.

Comments from Dr. H. Keith Moo-Young

The systems approach and all hazards approach of the Homeland Security StRAP provide for appropriate integration with other EPA programs. Because of the Homeland Security mission of being technical support, they are customer driven in providing timely solution to real world problems. Moreover, the program supports time critical and mission critical responses to all hazards and disasters so their result must be timely and concise. The program uses a systems approach to respond to disasters, and developing new products and solutions to assist with timely mitigation and remediation. The agency should also be commended on linking the program to sustainability through the programs response and approach to resiliency after the disaster.

The Homeland security program’s topics are relevant to the other research programs in the Agency’s plan. In particular, the work conducted in water systems has a direct tie to protecting America’s water systems. The research conducted on CBRNE hazards has direct correlation to the Safe and Sustainable Communities research program. Moreover, the focus on fate and transport provides the Homeland Security Program with a research niche that can be leveraged throughout the agency. This can become a unique capability if it is appropriately resourced in the future.

Comments from Dr. Paula Olsiewski

The proposed long term research directions for the Homeland Security research program are appropriate.

Comments from Dr. Daniel Stram

- The general approaches listed of providing tools, technologies, and data to increase water system resiliency, assist in the prevention and detection of contamination, exposure minimization, decontamination, etc., appear to be relevant for 2020 and beyond. There is every expectation that threats of accidental contamination will continue as infrastructure ages, affecting ad hoc waste containment schemes (e.g. of radionuclides at DOE and civilian nuclear sites, or of chemicals such as at Elk River) employed either in the absence of better solutions or simply to save money. In other cases identification of the specific threats that will be faced in the future is fraught with ambiguity. Climate change (warmer temperatures rising sea levels) represent many threats to coastal infrastructure that could produce chemical releases and contamination but the intensity and immediacy of these threats clearly depend on the as yet unknown rate of sea level increase or increases in frequency in destructive storms. Terrorist threats may be even more unpredictable, and perception of community level of treat can vary greatly among stakeholders. Over the long term developing tools aimed at assessing the susceptibility/resilience of all communities to a list of possible threats seems desirable but not easy.

2c. For HS, do the presentation and plan indicate that ORD is designing for integration, where appropriate, on topics that are relevant to other research programs?

Comments from Dr. Peter Chapman

- ORD is attempting to design for integration, but not always to the extent necessary or appropriate (see comments above).

Comments from Dr. Nancy Kim

- The HSRP StRAP mentions coordination and partnership throughout the document, thus implying integration throughout the document. However, examples should be added that specifically mention integration. For example, the table in Appendix B could add partners' names for specific objectives and provide information about integration. HSRP should identify other areas in the document where integrations could be easily added.

Comments from Dr. Courtney Flint

HS – Research links to other federal, state, tribal, and local programs do not appear to be well-articulated. Given the numerous entities tasked with disaster preparedness, hazard mitigation, and emergency response throughout the country, this program risks reinventing wheels if relationships with other external partners are not well conceptualized and facilitated.

Comments from Dr. Paula Olsiewski

The early draft HS StRAP is well designed for integration with the other research programs- see diagram on page 11.

Comments from Dr. Daniel Stram

- The HSRP is forced to deal with a higher level of uncertainty about what threats and disasters will be faced with than are most other parts of the ORD. Despite this it is clear that the HSRP must collaborate (in a mutually beneficial manner) with other research programs (Water and Chemicals), especially in understanding the long term fate of contamination from various chemicals and sources, exposure assessment, and risk assessment could involve similar issues in both cases.

Human Health Risk Assessment

Comments from Dr. George Daston related to questions 2a, 2b, and 2c

Please see comments posted under the CSS program for responses to 2a, 2b, and 2c for both CSS and HHRA.

2a. How well will the research directions in the HHRA Early Draft StRAP (2016-2019) support EPA in achieving the relevant Agency objectives and cross-cutting strategies, as described in the EPA Strategic Plan (2014 -2018)?

Comments from Dr. Peter Chapman

- This StRAP is largely chemical-specific and does not fully consider sustainability; it seems at odds with the StRAP Sustainable and Healthy Communities and should more probably be a component of that StRAP.

- A good example of risk:benefit characterization is that of tuna and mercury – balancing the health benefits of eating tuna against the mercury they contain. Along the same lines the amelioration by selenium of mercury human health effects would have been a good example.
- Page 6: how are Science Challenges 1 (effects of chemicals) and 2 (impacts of criteria air pollutants) different?
- Page 6, Science Challenge 3: what is meant by “emerging exposures”?
- Page 7, Science Challenge 1: what is meant by “automated data mining”?
- Page 7, agree re Science Challenge 2.
- Page 7, Science Challenge 3: what is meant by “support sustainability”?
- Page 8, “different species” – of humans? Does not make sense.
- The issue of chemical mixtures is not explicitly considered beyond a mention at the top of p17.
- Ideally this research would provide credible, easily understandable information to communities to allow them to minimize / manage risks.
- Why is the PPRTV program not part of the focus of the July SAB/BOSC meeting (p 18)?

Comments from Dr. Courtney Flint

- HHRA and SHC – Emphases on connecting research with decision-making are valuable frameworks likely to help with partnerships as well as making a visible difference in communities. The diagram for risk-based decisions outlined in HHRA StRAP materials (and the dashboard concept from CSS) could be adapted to other programs. Thinking about sustainability criteria in these relationships will also be helpful.

Comments from Dr. Lois Lehman-McKeeman

The research directions are focused on what appears to be highest priority issues for the EPA and should be well positioned to achieving the Agency’s objectives. [did not identify a real gap in the overall research direction.]

2b. What are the SAB/BOSC perspectives on the proposed research directions in the HHRA StRAP providing research to address environmental issues of 2020 and beyond?

Comments from Dr. Peter Chapman

- See comments above.

Comments from Dr. Courtney Flint

- HHRA – Emphasis on stakeholder engagement, problem formulation and scoping, and place-based assessments are likely to help this program anticipate emergent issues.

Comments from Dr. Lois Lehman-McKeeman

For this strategic plan the continued advancement of analytical approaches and more inclusion of systems biology perspectives are paramount (and it is appropriately noted that this is a focus of the review). Advancing more rapid hazard identification and prioritization for further evaluation is going to require the application of new tools, but application of such tools requires research to objectively and rigorously determine what tools will be most accurate and most useful. The research that is carried out in these areas will be critical and the Agency is challenged to not accept them a priori, but rather after carefully determining that they provide valuable new ways to identify hazards.

2c. For HHRA, do the presentation and plan indicate that ORD is designing for integration, where appropriate, on topics that are relevant to other research programs?

Comments from Dr. Peter Chapman

- ORD is attempting to design for integration, but not always to the extent necessary or appropriate (see comments above).

Comments from Dr. Courtney Flint

- HHRA – well-positioned to address all EPA ORD goals as well as cross-cutting themes. Human health sits at the center of many of the program objectives and the HHRA documents appear to acknowledge these key linkages (particularly through consideration of the application range of program tools and data/research).
- HHRA & SHC – HHRA’s cumulative risk assessment conceptual framework includes a rich set of indicators that would be useful for conceptualization of community well-being in SHC and beyond. The vulnerability factors and cultural and behavioral factors articulated go beyond classic health dimension – this is laudable.
-

Comments from Dr. Lois Lehman-McKeeman

Yes, efforts to integrate across programs is very evident throughout. If achieved, this integration could be highly effective and productive. The integration noted by CSS relative to integrating the tools from HHRA is also evidence. This integrative effort is a strength of the overall strategic plan.

Safe and Sustainable Water Resources

General comment from Dr. Kenneth Reckhow

The Early Draft StRAP is, perhaps intentionally at this point, quite broad-brush. Except for the comments expressed above for Charge Question #1, I do not have any major concerns with the research plans. However, having been involved with oversight of previous EPA ORD research programs (e.g., Ecosystem Services), I remain concerned that silo approaches may still remain. In addition, I observed within the ESRP an inability to coordinate internal silos (e.g., monitoring and modeling), and inadequate external peer review and oversight for internal EPA ORD research. This needs to change.

2a. How well will the research directions in the SSWR Early Draft StRAP (2016-2019) support EPA in achieving the relevant Agency objectives and cross-cutting strategies, as described in the EPA Strategic Plan (2014 -2018)?

Comments from Dr. Peter Chapman

- Given that this StRAP, which would have been expected to emphasize ecosystem services, does not do so – they are mentioned but not central (e.g., not on pp 9-11 where they should be), I do not believe the support is adequate; it needs to be improved, see additional comments and questions below.
- However, I am glad to see invasive species highlighted.
- Fully agree with the second and third full paragraphs on page 4, well written and well thought out.
- Fully agree with the second sentence of the 2nd bullet on p8.
- Fully agree with avoiding the “‘siloed’ approach” and “A systems-level view of integrated water

services...to develop optimal solutions” (p12).

- Disagree (p13, top) that nutrients “are perhaps the most widespread and prevalent threats to watershed sustainability” – ahead of nutrients come global climate change, habitat change, and invasive/introduced species in that order, as previously noted.
- What exactly is meant by “watershed sustainability”? – as noted previously every specific use of “sustainability” needs to be defined.
- Assume “economic valuation research” (p13) refers to ecosystem services?
- Please further explain “tipping points” (p14) as this term is also used, without any explanation, in the StRAP Chemical Change for Sustainability.
- Fully agree with last sentence under third bullet, p14.
- Page 14, 4th bullet – good to see invasive aquatic species mentioned, but they are not restricted to ballast water; invasions will occur geographically due to global climate change and there are other human mediated routes for invasion / introduction – need to be more holistic and complete.
- Page 14,6th bullet, fully agree, good to consider the positives and negatives.
- Page 21, fully agree with Research Objective 1 – very important.
- Page 22, last bullet – only mention of “life cycle costs”, LCA should be given more prominence.
- Page 23, good information re ongoing community GI pilots, good initiative.
- Fully agree that water reuse is a major issue to be addressed – both perception and reality.

Comments from Mr. Shahid Chaudry

- SSWR StRAP is very well developed in consultation with advisors and input from a wide spectrum of partners, stakeholders, and experts to address their specific research needs.
- Evaluating the impacts of climate change on water resources in the longer run and subsequent impacts on all other areas should be prime focus of research.
- Since “Waste” is not “Waste” anymore; the term “Waste” must not be used at all and should be replaced with “Resource” or “Secondary Source”.
- Information dissemination is equally important as finding solutions, so there should be more emphasis on publicizing research outcome and best practices to encourage adoption of more appropriate and relevant technologies and practices.

Comments from Dr. David Dzombak

The research directions in the draft SSWR StRAP are well aligned with the objectives of the EPA Strategic Plan.

Comments from Dr. Courtney Flint

- SSWR – Cluster organizations for fast tracking innovations is a good idea and will likely support partnerships and have wide-reaching benefits. This is an approach that could be applied elsewhere.
- SSWR and SHC – As stated, linkages with the environmental justice and children’s health roadmaps are not yet fully explored in these programs.

Comments from Dr. Kimberly Jones

The research directions in the SSWR StRAP (2016-2019) will support the overall objectives in the Strategic Plan.

Comments from Dr. Kristina Mena

- SSWR StRAP FY16-19 promotes the development of and research in “innovative” strategies to

address water resources; innovation is a theme in the EPA Strategic Plan (2014-2018)

- Besides innovation, the EPA Strategic Plan (2014-2018) emphasizes the need to partner with a variety of stakeholders to engage the community and foster collaborations; this is not promoted to a great extent in the SSWR StRAP FY16-19
- Key focus areas related to our aging water infrastructure, water protection during accidents or natural disasters, and increased water demands that are stressed in the EPA Strategic Plan (2014-2018) are described within the research topics listed in the SSWR StRAP FY16-19

Comments from Dr. James Mihelcic

- The SSWA STRAP is integrated with the Nitrogen and Co-Pollutant Cross-Cutting Research Roadmap and well organized into four research topics Watershed Sustainability, Nutrients, Green Infrastructure, and Water Systems. One suggestion for the SSWA STRAP is that EPA can do a much better job at integrating the overarching priority (SSWR slide #9 of July 17 presentation by Dr. van Drunick) to transform the concept of ‘waste’ to ‘resource’ in their technology and policy innovation.

Comments from Dr. James Sanders

SSWR has defined the directions and has large-scale outlines for its activities for the coming years. It is not possible to examine at close detail what will actually be accomplished, but I am comfortable that the general guidelines are in place. However, resources are limited, the work load is large, and the number of FTEs available has declined recently. In addition, the agency’s expertise doesn’t always line up well with the tasks at hand. For example, ORD expertise in communicating needs is lacking. How will they find that expertise? Will this be accomplished through partnerships with others, will future hiring be targeted to fill such gaps (and if so, how does that impact the other areas of expertise needed)?

Comments from Dr. Jeanne VanBriesen

The research topics, objectives and example projects in the SSWR plan provide reasonable support for the overall objectives of strategic plan. However, since the projects are only examples, it is difficult to assess the full breadth and depth of the planned research to evaluate how well these plans will enable EPA to meet the goals of the strategic plan. The SSWR StRAP states in the introduction that it is designed to support the strategic plan. Details of the alignment should be more explicit. Which research areas and research projects are in support of which parts of the strategic plan?

Of particular concern is that the SSWR draft plan does not provide a clear alignment with the priority goals in the strategic plan associated with water. The SSWR StRAP does not include a clear description of which research plans are in support of Agency Priority objectives 1 or 2 under goal 2 associated with small drinking water system support and nonpoint source pollution, respectively.

An agency priority objective within goal 2 (protecting America’s waters) is focused on nonpoint source program enhancement. The Strategic plan notes that EPA has a strong commitment to address nitrogen and phosphorus pollution, and programs for controlling nonpoint sources of pollution are key to reducing nutrient impairment. This aligns most clearly with the nutrients research topic in the SSWR StRAP FY16-19. However, the topic of nutrients begins with a discussion of the linkages with water and wastewater treatment capabilities. This is relevant, of course, but nonpoint sources of nutrients are usually dominant and more difficult to control, and a focus on nonpoint source pollution would be better aligned with goal 2 in the strategic plan. It is unclear why this link is not more prominent in this section of the StRAP. The nutrient research plan within the SSWR StRAP appears more focused on impacts – of

climate change, land use changes, etc. – rather than on control strategies. A mention of ‘sustainable nutrient removal technologies’ appears again to focus on *point source* nutrient loads (wastewater treatment plants) and misses the opportunity to align this area with the focus on nonpoint sources that is in the strategic plan. A discussion within Research objective 2 mentions non points source BMPs, but it is buried rather than highlighted. None of the examples of specific research needs discusses the need for improved understanding of the barriers to implementation of nutrient BMPs at the field scale in agriculturally-dominated watersheds. This likely will require research in collaboration with social scientists, economists, and agricultural engineers. An appreciation for this is implied in objective 3 around communication; however, again, no direct link to the agency priority objective goal 2 is made.

An agency priority objective within goal 2 is focused on small drinking water systems. The SSWR StRAP includes a statement in support of this focus area in Research Topic 4; however, few details appear to be aligned with small system needs. Further, there is a statement that small scale research can be translated to larger systems; however, insufficient detail is provided to assess this claim. The suggestion that centralized small systems or clustered decentralized systems are a mode of translation of this research to large systems is unsupported. These types of systems would likely benefit from research on small systems, but they are not similar to large systems. The only specific detail provided deals with the need for small systems to meet the ammonia standard; this applies to small *wastewater* systems, and EPA’s goal 2 is focused on small *drinking* water systems. The specific research needs in this section are organized across the two objectives into three projects, which is a nice structure that suggest integrated thinking about water infrastructure. However, the listed ‘potential efforts’ span dozens of areas. It is impossible to evaluate what actually is being planned.

2b. What are the SAB/BOSC perspectives on the proposed research directions in the SSWR StRAP providing research to address environmental issues of 2020 and beyond?

Comments from Dr. Peter Chapman

- See comments above.

Comments from Mr. Shahid Chaudry

- Even though overarching research on the impacts of climate change is integrated through the Climate Roadmap; SSWR StRAP strongly supports EPA’s 2nd Strategic Goal “Protecting America’s Waters” by focusing research on four interrelated topics (Watershed Sustainability, Nutrients, Green Infrastructure, and Water Systems) and several cross-cutting strategies for future sustainable water resources along with sustainable environment, economy and society. SSWR’s derives its research focus from overarching factors including changing climate, extreme events, land use, energy, agriculture and demographic scenarios. The research recognizes that drinking water, wastewater, stormwater and aquatic ecosystems are integral components of the ‘one water’ hydrologic cycle. The research activities are need based with input from the stakeholders with near-term and long-term objectives.

Comments from Dr. David Dzombak

The proposed research directions in the SSWR StRAP are forward looking and focused on high priority water resource management challenges relevant to the EPA.

The cross-cutting roadmaps represent a very important step forward for the EPA in providing a

framework for research integration on large-scale, complex environmental challenges. These roadmaps provide frameworks for integrating research across ORD programs and offices, and with other agencies, and keeping ORD research forward looking.

Comments from Dr. Kimberly Jones

The overall research directions in the SSWR StRAP are on target to address many of the environmental issues involving watershed sustainability, nutrient management, green infrastructure, and small systems. It would be advantageous to include more research efforts in evaluating the ability of water and wastewater treatment processes to remediate pathogens and emerging contaminants, especially those that may become prevalent in warmer temperatures.

Comments from Dr. Kristina Mena

- The proposed research directions in the SSWR StRAP (2014-2018) cover a range of critical water resource-related topics
- The methods to address those topics are not as defined
 - ✓ Two approaches that could be applied to many of the proposed research areas include: community-based participatory research (CBPR) and risk analysis (risk assessment, risk management and risk communication)
 - ✓ Both CBPR and risk analysis foster the integration of other StRAPs and cross-cutting areas, and allow for dialogues between or multi-directional communication among stakeholders; they also help address resource limitations and develop research that is relevant
- There could be a stronger emphasis on environmental justice issues, particularly within the watershed sustainability and water systems areas
- There is a growing research interest in the U.S. regarding water reuse; however, one challenge (of many) is how water reuse systems can be developed and monitored given the current regulatory climate
- Population growth and water system resiliency is an appropriate research topic; however, changes within population demographics and a) how water quality is impacted (i.e., hazard burden to water source) and b) how human response to/susceptibility to waterborne hazards change
- Research that promotes projects with different community stakeholders could be encouraged, such as sewage epidemiology to get a snapshot of what is happening in the community and subsequent burden to waterways (work with utilities and health departments)
- The relationship between water quality and human health (specifically those experiencing “normal life stages”) could be addressed in the water systems area
- Research directions could not only focus on how different StRAPs interrelate but also how specific components within one research area within the SSWR StRAP interrelate, such as how oil spill constituents impact the occurrence and survival of pathogens for example
- Research directions could focus on developing strategies for *prevention* rather than *response*

Comments from Dr. James Mihelcic

- Regarding the SSWA STRAP, in key research needs (page 2-3) (and a priority research area on page 25), the following statement “Continue efforts to introduce new technological applications to nitrogen and copollutant management problems, such as genomic indicators of sources and effects,

satellite monitoring of conditions, and improved sensor technologies.” This statement ignores importance of technology innovation that addresses the SSWR overarching priority (SSWR slide #9 of July 17 presentation by Dr. van Drunick) to transform the concept of ‘waste’ to ‘resource’ by recapturing and reusing commercially valuable waste stream constituents (e.g., nutrients, energy, metals).

- Regarding the SSWA STRAP, it is a major mistake to until later years to include tools of sustainability frameworks such as life cycle assessments in Project 3 (Long Term: Transformative Systems). This is because tools such as LCA should be included when making design or improvement designs which consider life cycle considerations. This is a way to include quality improvements in the early stages as the research takes place and is a key piece of sustainability framework that drives innovation.
- The SSWA and SHC STRAPs should address the specific research need of invasive aquatic species that is focused on secondary transport (which was not mentioned in the SSWA STRAP) and this should be integrated with the Sustainable and Healthy Communities STRAP as this topic may have large impact (especially in 2020 and beyond) on economic and social well-being, including public and environmental health. It also has an important link to issues of climate addressed in the AEC STRAP.

Comments from Dr. James Sanders

SSWR correctly identifies the great need to improve infrastructure of water delivery and wastewater systems. Unfortunately, the costs for retooling water infrastructure are staggering, yet the nation has no stomach at present to provide the funds for this. What role can/should EPA play in helping the public understand this need? The answer likely lies within the concept of sustainable systems and in understanding life cycle costs. I concur that this is an appropriate focus for the coming decade, and am encouraged that the pilot projects for GI may lead to potential paths forward.

Comments from Dr. Jeanne VanBriesen

For the SSWR StRAP: The research directions described appear adequate to address environmental issues that will be relevant in 2020; however, the strategic plan and the SSWR StRAP lack detailed justification for these directions being the most important. For example, within the Goal of “Protecting America’s Waters” one of two priority goals in the strategic plan is focused on improving public health protection for persons served by small drinking water systems. The goal is supported by the statement that these small systems account for more than 97 percent of public water systems in the US. This is a true statement, but equally true is that this represents only 30% of the US population. The focus may be because this is a previously underserved population, but this is not clearly stated in the plan. Justification for the priorities would enhance the credibility of the plan.

Similarly, as described above, the SSWR StRAP describes a focus on nutrients that includes little discussion of nonpoint source pollution management, which is a goal for the strategic plan, and is likely a dominant source of nutrient pollution. The introduction to the SSWR outlines a variety of important challenges in the water domain; however, it is more a list than a well-reasoned argument for these being the most important challenges we face with regard to safe and sustainable water resources. Overall the plan should include more details of how these foci were selected and how they provide the needed research to address environmental issues of 2020.

Within the SSWR draft, the different areas have multiple research objectives, and these objectives have

different lists of specific research needs. It is not clear if there is some significance to the number of needs described. For example, Topic 1, objective 1 lists 10 examples of research needs while objectives 2 and 3 list only 2 each. Is there some relevance to this? Will more effort be spent on objective 1 than 2 and 3? If so, why? Overall, it is difficult to determine prioritization within the plan. If decisions need to be made regarding scarce resources (funding and FTEs), which is likely, then which of these many important topics will receive priority? This is particularly problematic in Topic 4 which lists dozens of very broad potential efforts.

Some specific issues where proposed research directions should be clarified include:

1. I support the general concept of greater emphasis on community support tools; however, such tools need to be deployed within communities with attention to public understanding of the goals and the limitations of such tools. The stormwater/green infrastructure tools already deployed provide interesting information on a lot-by-lot basis, but its recommendations are driven by rainfall and runoff without consideration of actual on-the-ground sewer infrastructure. This limitation and the importance of it for decisions surrounding green infrastructure siting may not be clear to someone using the tool. This is just one example of how such tools can be deployed in communities without sufficient attention to deepening the understanding of the target audience to limitations of the tools.
2. The strategic plan identifies the need to assess the status of and changes in water quality through the National Aquatic Resource Surveys. However, several places in the strategic plan and the SSWR draft, it is noted that EPA and the regions and states have insufficient resources to assess the nation's waters. It is not clear how the survey described will enable adequate assessment of water resources in the country. EPA's plan to work with citizens on data collection and analysis are described in the strategic plan, but it is not clear if SSWR research will be undertaken in support of this – either on the challenges and best practices associated with working with citizens or the challenges associated with using data from citizens within decision-making.
3. The SSWR StRAP draft does a good job of discussing the importance of innovation and the potential for innovative technologies to improve management and support for water quality goals. Greater discussion of the links between what is suggested in the StRAP and what is covered in EPA's "Blueprint for integrating technology innovation into the national water program," would be helpful. Many of the ideas are similar and if the SSWR research will support those goals, this should be made more clear in the document.
4. In the final section of the SSWR StRAP, under anticipated research accomplishments, it is difficult to assess to what extent these accomplishments will be completed within the four year plan. Further, it is not clear what metrics will be used to assess meeting these goals. In mapping and predicting the physical, biological and geochemical integrity of our Nation's waters, does this include all river miles in the whole country? And, what information must be acquired and mapped to assess 'biological integrity'? To what level of detail and with what level of certainty must we know about integrity in order to identify areas most in need of protection or restoration? Similarly, it is not clear what success would look like relative to outcomes such as "anticipate any unintended consequences related to increase water permeation in soil and groundwater." The stated accomplishments are certainly of value, and I support these goals; however, I am uncertain how they will be met or evaluated.

2c. For SSWR, do the presentation and plan indicate that ORD is designing for integration, where appropriate, on topics that are relevant to other research programs?

Comments from Dr. Peter Chapman

- ORD is attempting to design for integration, but not always to the extent necessary or appropriate (see comments above).

Comments from Mr. Shahid Chaudry

- Absolutely; and that is the only way to optimize available resources. For SSWR (for example), Fig 1 / Slide 21 (SSWR Integration across ORD's Six National Research Programs) highlights this interconnection & integration very well.

Comments from Dr. David Dzombak

The proposed plans in the SSWR StRAP demonstrate awareness of related research in other ORD programs. Specific opportunities for collaboration with other ORD research projects are mentioned in the SSWR StRAP, e.g., collaboration with the SHC program discussed on pages 16 and 22. Opportunities for engagement with and leveraging of related research in other agencies, such as DOE and USDA, are generally not discussed in the SSWR StRAP, and some discussion of such opportunities should be added as the SSWR StRAP is finalized.

Comments from Dr. Courtney Flint

- SSWR - Given the ubiquitous nature of water, it is highly relevant to all ORD programs and these linkages are clearly outlined in the beginning of the SSWR StRAP.

Comments from Dr. Kimberly Jones

Yes, the integrative nature of the research programs is evident in the Cross-Cutting Roadmaps as well as the individual StRAPs.

Comments from Dr. Kristina Mena

- Yes, climate change is one example stressed in the SSWR StRAP
- Figure 1 in the SSWR StRAP shows the integration of research topics with other research programs; however, each of the research topics can easily be connected with the HHRA StRAP (not indicated)
- In the section on Safety of the Nation's Water, risk assessment, community engagement, and translation science – all of which include behavioral, cultural and economical aspects – could be incorporated
- Not only will integration of research topics lead to relevance to other research programs, they will also promote innovative approaches

Comments from Dr. James Mihelcic

- Regarding the SSWA STRAP, ORD is designing for integration, except in area of invasive species. Specific research on invasive aquatic species should be integrated with the Sustainable and Healthy Communities and AEC STRAPs.

Comments from Dr. Jeanne VanBriesen

It is not clear that the SSWR StRAP is integrated with issues of energy and climate that are addressed in the AEC. Energy-water nexus is a critical area and the need for research to deepen our understanding

of system level effects in this domain is significant. The SSWR, StRAP should provide more insights into how the research will link with energy-related research that seems to fall under the AEC StRAP.

Sustainable and Healthy Communities

General Comments from Dr. Joseph Arvai

- The document indicates on p. 3 that it was developed following “considerable” input from stakeholders. Though, as far as I can tell, the level of input from community stakeholders seems like it was minimal. This could be construed as a shortcoming of the StRAP. Indeed, I find it to be a weakness of an otherwise strong research/action plan.
- The StRAP deals with sustainability, but it does not seem to focus in on a consistent definition – or, even a general characterization – of the term. The closest the StRAP comes is in its treatment of NetZero, which is but one way of looking at sustainability. I think this would open the StRAP to criticism from reviewers and stakeholders. I know there is no single definition of sustainability that would work universally in the SHC context; however, the StRAP really should devote some column inches to providing some agency context/vision for the term.
- I think this statement from p. 8 should be slightly reworded to better reflect the mission of the agency: “What is the impact of social, economic, and environmental drivers on community public health, and how can this understanding be incorporated into decisions about sustainability?” I’d suggest changing it to “What are the impacts of environmental, social, and economic drivers on community wellbeing, and how can this understanding be incorporated into decisions about sustainability?”
- I’m very supportive of the decision-support objectives outlined in the StRAP. However, in spite of my agreement with how SHC treats decision-support, specific community decision contexts will likely require more “bespoke” decision-support approaches. In other words, a one-size-fits-all approach will probably not work. So, in addition to a general framework, capacity building at the community and EPA region level will likely be a must. Stakeholder consultation about what they’d need /want in terms of decision-support would also be quite helpful in this regard.
- The following sentence appears on p. 10: “How can communities and community stakeholders holistically evaluate their alternatives for common actions...” The term “holistically” could be construed to mean a particular kind of evaluation (as in choice experiments which rely on holistic rather than decomposed assessments of alternatives). I suggest changing this sentence to: “How can communities and community stakeholders more fully characterize and evaluate alternatives for common actions...”
- On p. 18, the acronym “LUST” seems silly to me. I’d dump it.
- The diagrams in Appendix A are hard to read, and a little confusing to me. Is there a better way to convey this information?

Comments responding to questions 2a,b,c SHC from Dr. John Tharakan

- Research directions in SHC StRAP align well with relevant Agency objectives and crosscutting strategies. However, I am hesitant to provide a blanket endorsement of the six articulated “integrated” research thrusts as configured and outlined in presentation to break-out group during teleconference call.
- Diagram suggests that Sustainable and Healthy Communities (SHC) is just one of six separate but integrated research thrusts, when in fact it should be the “Umbrella” and one of the over-arching drivers for the other research programs.
- To underscore this, I would suggest, at minimum, a slight reconfiguration of the diagram with SHC placed on the top of the diagram and represented as the umbrella containing EPA’s strategic vision

and mission. Would also suggest expanding SHC to SSHC – Safe, Sustainable and Healthy Communities – to be more in line with EPA Strategic Plan.

- Understand that ORD has re-aligned research into six integrated programs. However, the separation of SHC into a separate research program, in my view, confuses the issues and creates the impression that Safe, Sustainable and Healthy Communities can almost be achieved separately from the other five areas. (I expanded to SSHC - Safe and Sustainable: I noticed in one of the transmissions, the S for SHC was expanded as “Safe”. Perhaps that was a typo). EPA’s overall vision and mission and articulated strategic plan speaks to the **safety, health and sustainability** of communities.
- Safe, Sustainable and Healthy Community need clean water; clean air, clean and/or renewable energy; safe chemicals production, use and disposal; health and human risk assessment and Homeland Security RP [whether to address and deal with natural and/or manmade (industrial or terrorist) incidents].
- Another way of articulating the diagram would be to have SSHC as the big box in a small circle on top, with the other five arranged in a circle below with arrows interlinking all to demonstrate the collaboration and integration.

2a. How well will the research directions in the SHC Early Draft StRAP (2016-2019) support EPA in achieving the relevant Agency objectives and cross-cutting strategies, as described in the EPA Strategic Plan (2014 -2018)?

Comments from Dr. Joseph Arvai

- It’s my view that the StRAP for SHC is an excellent example of a research agenda that addresses the SHC’s programmatic goals *as well as* the agency’s strategic goals.
- I am particularly impressed the SHC StRAP in terms of its focus on developing decision-support systems, as well as in its commitment to methods for understanding and developing other essential elements of decision-support systems (e.g., identifying and/or characterizing ecosystem goods and services; defining outcome measures for programmatic performance, etc.).
 - The StRAP outlines SHC linkages to several cross-cutting agency strategies (e.g., *Working Toward a Sustainable Future; Working to Make a Visible Difference Communities; Launching a New Era of State, Tribal, Local, and International Partnerships*). I agree that the programmatic research emphasis of the SHC StRAP will help to advance the goals set forth in these strategies.
 - I would venture also that improved agency capacity in terms of decision-support would aid the agency in terms of another cross-agency strategy: Embracing EPA as a High-Performing Organization. I have previously articulated my view that renewed focus on building internal agency capacity when it comes to decision-support tools (drawn from a variety of scientific disciplines) would not only serve all levels of the EPA well; it would also work to set the agency apart from other organizations that confront decision-making on a largely *ad hoc* basis.

Comments from Dr. Peter Chapman

- I believe this StRAP supports reasonably well, but see additional comments and questions below.
- Fully agree with and support the Program Purpose Problem Statement (p4).
- Assume that “ecological services” means ecosystem services?

- Assume that the goal articulated in the title of Figure 2 (p10) “to expand community stakeholders’ capabilities to consider impacts of decision alternatives” is the overall goal of this StRAP?
- Fully agree with (p10) considering “costs, benefits, tradeoffs, and synergies...while maximizing co-benefits in the short and long terms”.
- Figure 3 (p12) is excellent.
- Project 3.62 (p18) is relatively minor compared to the major stressors facing humanity (see response to 1a, above).
- Fully agree with Topic 4,b (p18).
- What are “Sustainable Ports” (p19)?

Comments from Dr. Terry Daniel

The ecosystems services concept and approach offers an effective way to successfully integrate the Agency’s dual mandates of protecting the environment and human health. The prior SHC strategic plan (2012-2015) placed considerable emphasis on ecosystems services and explicitly invoked key concepts from this internationally developed and widely adopted framework. The current StRAP occasionally refers to “ecological goods and services,” but the ecosystems services framework does not seem to be as prominent as it was in the previous plan. If this reflects a considered decision to turn away from the ecosystems services framework, accomplishing the desired integration will be more difficult. At the same time many of the stated goals and proposed actions of the SHC research program continue to be quite consistent with the ecosystems services framework, suggesting that the writers of the StRAP may have simply decided to be less explicit about adopting the international framework.

Comments from Dr. Courtney Flint

- CSS and SHC – These programs very clearly integrate cross-cutting strategies in their Strategic Plans.
- HHRA and SHC – Emphases on connecting research with decision-making are valuable frameworks likely to help with partnerships as well as making a visible difference in communities. The diagram for risk-based decisions outlined in HHRA StRAP materials (and the dashboard concept from CSS) could be adapted to other programs. Thinking about sustainability criteria in these relationships will also be helpful.
- SSWR and SHC – As stated, linkages with the environmental justice and children’s health roadmaps are not yet fully explored in these programs.
- SHC – Well-being and sustainability are core principles in this program, but not well defined or operationalized.

Comments from Dr. Robert Johnston

- The extent to which the research directions in the SHC Early Draft StRAP support EPA in achieving Agency objectives and cross-cutting strategies varies across areas. In some areas, such as supporting the Agency goal of Cleaning Up Communities (part of EPA Strategic Plan, Goal 3), the proposed research directions coincide well with EPA goals and will likely provide needed information. In other areas—particularly those related to broader goals of Advancing Sustainable Development (another part of EPA Strategic Plan, Goal 3) and Working Toward a Sustainable Future (the first cross-agency strategy)—the contributions of the proposed research towards specific EPA goals is less clear.
- The research proposed within the SHC Early Draft StRAP is most clearly responsive to EPA strategic goals and cross-cutting themes (and is likely to provide salient information) for narrower issues related to the restoration/remediation of contaminated sites, materials management and human health. The proposed research is less responsive (and less likely to provide salient information) in areas related to transdisciplinary integration, sustainability, integrated solutions, decision-support and

innovation. These concerns largely relate to research objectives 1 and 4 in the SHC Early Draft StRAP, but are also relevant to objectives 2 and 3.

- Transdisciplinary integration—and in particular integration of expertise and methods from the social, behavioral and economic sciences—is inadequately developed. Much of the SHC Early Draft StRAP, while repeatedly mentioning economic and social issues, appears to be written from a natural sciences perspective. The research objectives and accomplishments appear to overlook the significant challenges of the social and economic science proposed within models and decision support tools.
 - Social, behavioral and economic sciences are a critical component of SHC. During the SHC briefing teleconference (July 10) it was revealed that less than approximately 5% of ORD scientists were dedicated social scientists. It was argued that this was partially offset, however, because up to 15% of ORD scientists have some interdisciplinary training in policy and social sciences. This leads to a concern that social, behavioral and economic sciences central to SHC’s mission not will conducted by experts in these fields.
- The Early Draft StRAP seems to underappreciate the difficulty of generalizing research within broadly-applicable decision support tools, and the risks in doing so. For example, page 13 states that “SHC research will, when possible ... [c]onduct fundamental research that is translated through the development of generalizable tools used to support decisions that support sustainability.” This is an extremely ambitious design principle, and the challenges involved in generalizing research in this way are given no meaningful attention by the StRAP.
 - There is ongoing natural science research within SHC that is seeking to develop a “library” of transferrable ecosystem service production functions. Among the goals of this program are to “examine the potential for transferability.” However, there is no indication of parallel research in the social, behavioral or economic sciences, and no indication that SHC has expertise in the transfer of social, behavioral and economic information between contexts of the level that would be required to develop the proposed tools.
- On page 11 of the SHC Early Draft StRAP, EnviroAtlas is described as a tool that “allows for community-scale visualization, analysis, and valuation of ecosystem service demand, supply, and beneficiaries as defined by an internationally recognized and accepted final ecosystem goods and services classification system.” This description overpromises what such a tool can realistically deliver and overlooks limitations in the state of the science. The StRAP would be improved by clear, precise expectations about what such tools can accomplish, replacing the broad, aspirational rhetoric that currently dominates the text.
 - The StRAP appears to envision EnviroAtlas as a web-based decision support tool for ecosystem service visualization and valuation. Ready-made tools such as this are increasingly common, and are generally grounded in spatial modeling and mapping of ecosystem functions. The ecological components of these models are typically much better developed than the economic components. Although these tools can be useful for visualizing services at a coarse level, they have severe shortcomings when used to visualize or quantify ecosystem service demand, value and beneficiaries. Among these shortcomings is a frequent reliance rudimentary economic social science approximations that are unlikely to provide accurate approximations (e.g., simple unit value transfers of economic value). These tools rarely account adequately for relevant factors such as: (a) the different direct and indirect ways that ecosystem service changes influence well-being across different beneficiaries; (b) behavioral responses of individuals to changes in ecosystem services; (c) differences in these impacts across different beneficiary groups; (d) variations in values related to differences in ecosystem service scope and scale; and (e) other potential welfare-relevant inconsistencies between sites

and populations. The description of EnviroAtlas and other decision support tools within the SHC Early Draft StRAP appears to overlook the general inability of these tools to account for relevant social and economic factors and variations across communities. Benefit transfer tools in economics are simply not yet developed to the point that they can be used for a universally applicable, turnkey system that predicts “valuation of ecosystem service demand, supply, and beneficiaries.”

- Similarly unrealistic perspectives on the capacity of off-the-shelf tools to support community decisions are found throughout the SHC Early Draft StRAP. For example, page 19 describes as a research topic “Reconciling Trade-offs and Quantifying Synergies across Multiple Dimensions – Produce a turnkey method with the appropriate tools to allow the stakeholders of a community to evaluate the net risk/benefits of proposed alternatives and to evaluate the contributions of those alternatives to community sustainability goals.” This is an extremely ambitious (and likely unrealistic) objective. At least from the perspective of social and economic dimensions, there are no existing “turnkey” tools that can accomplish these goals with any degree of accuracy and validity. Given this, it is unclear how SHC envisions that this “turnkey tool” will enhance community decisions. The Draft StRAP would be improved by a more concrete and realistic perspective on what integrated decisions support tools can accomplish. Decision Science and Support Tools (SHC Project 1.61), for example, seems to give primary attention to the software and tool design aspects of decision support, and little attention to the validity and accuracy of the underlying science.
- Beyond issues related to the social and economic content of the proposed decision support tools, the SHC Early Draft StRAP does not discuss the tradeoffs and challenges involved in the development and use of these tools. This relates to the general comment on users and uses of ORD information above. There are significant challenges in developing tools that are both usable (e.g., by non-scientists) and sufficiently accurate to improve decision-making. The tools and models needed to enable accurate, community-specific forecasts often place-specific, highly data-intensive and require significant expertise among users. These requirements often outstrip the capacity of local community users. In contrast, decision-support tools that are generalized and simplified for local users (e.g., minimizing data requirements) often provide only general information that can be misleading for individual communities. The SHC StRAP does not appear to recognize the challenges in developing valid, broadly applicable, science-based decision-support tools.
- The above concerns reflect a broader lack of specificity within the Early Draft StRAP regarding how decision-support tools are intended to be used and the role of SHC within communities. This observation has been made by earlier SAB/BOSC reports. For example, the 2011 Office of Research and Development (ORD) New Strategic Research Directions: A Joint Report of the Science Advisory Board (SAB) and ORD Board of Scientific Councilors (BOSC) concluded (p. 14) that “The SAB and BOSC understand the value of providing decision support for communities (“empowering” local decision making), but find that the draft framework is vague and lacks focus. The draft framework does not describe the decision-makers/stakeholders or discuss whether the objectives of decision-makers necessarily reflect community goals or EPA objectives. Essential questions regarding the definition of the relevant community and whether community objectives align with broader national objectives are not identified, much less answered, in the document.” These concerns do not appear to have been addressed in the current draft documents. The proposed decision support and information tools often seem to be motivated by a “build it and they will come” perspective towards community decision-support.
 - To what extent were tools such as EnviroAtlas and the Report on the Environment Driven by specific needs identified by community users versus data availability?

- To what extent have users been involved in the design of such information products to serve their needs?
- To what extent is strategic research planned to address these issues?
- As noted above, the SHC Early Draft StRAP would be improved by a more substantive discussion of exactly what is implied by community sustainability and the tradeoffs that are implied. That is, what is to be sustained, for whom and what does this imply for community decisions? Given that sustainability is a central aspect of the SHC program, a less generic treatment of sustainability is warranted. For example, what if a community's vision for its own sustainability does not comport with EPA's statutory or other goals?

Comments from Dr. Catherine Karr

2a. The SHC strategic plan draft identifies and articulates clear links to the Agencies Strategic Plan goal 3 and cross cutting strategies (p6). The concept of well-being as an outcome rather than reduction of specific diseases is conceptually appealing but how it will be defined, assessed, measured is not clear and should be explained.

Comments from Dr. Earthea Nance

As stated above, ORD's Strategy does not provide strong research outputs in the areas of compliance and enforcement, thus ORD will not be able to support EPA's compliance and enforcement goal.

Comments from Dr. Katherine von Stackelberg

"Sustainability" in this StRAP relies on the concept of the "three-legged stool" (i.e., environment, society, economy), and this is used as a rationale for emphasizing the necessary transdisciplinary nature of the evolving research program. However, it is fundamentally not true that all three pillars are *required* to support sustainability. The material economy is embedded in society, which, in turn, is embedded in our ecological life-support system (Costanza et al. 2012), and that life-support system (natural capital) is constrained (Baronsky et al. 2012; Rockström et al. 2009). The fact is, without natural capital, without the green infrastructure upon which all life depends, there can be no social or economic pillars. Environment is fundamental to sustainability in an era of increasing pressures on natural resources, such as feeding an expanding planet within finite boundaries, or designing strategies for mitigating environmental degradation such as hypoxic zones (e.g., Gulf), the ubiquitous use of chemicals, and so on. This reconciliation between societal goals and environmental limits is at the heart of sustainability science (Clark and Dickson 2002; National Research Council 1999a; 1999b; Kates et al. 2001; United Nations Secretary-General's High-level Panel on Global Sustainability 2012).

ORD is in a unique position to take a leadership role in defining certain aspects of sustainability science, and should take this opportunity to do so. The EPA is the only agency that can unapologetically – indeed should, must – focus on environmental protection and prioritize the science of effective natural resource management so that sustainability goals might be more effectively defined and achieved. The focus should be on the environment.

2b. What are the SAB/BOSC perspectives on the proposed research directions in the SHC StRAP providing research to address environmental issues of 2020 and beyond?

Comments from Dr. Joseph Arvai

- It's my view that the StRAP for SHC is an excellent example of a research agenda that addresses the SHC's programmatic goals as well as the agency's strategic goals.
- However, it may be worth noting that much of what can be achieved will hinge upon how "sustainability" is defined under the various research topics; for example what may (or may not) meet the threshold for "sustainability" might be quite different when making decisions about contaminated sites vs. adaptation to risks from climate change). To me, the ultimate definition of what is "sustainable" is established during the time leading up to, and following, when tradeoffs and decisions get made. The StRAP does a nice job of alluding to sustainability under different R&D areas; but perhaps it would be worthwhile to make more explicit the fact that "sustainability" is wide open to interpretation.

Comments from Dr. Peter Chapman

- See comments above.

Comments from Dr. Terry Daniel

As noted under item 1b above, the shift toward broader, more positive goals associated with individual and community health rather than focusing on specific more immediate threats may meet with resistance from some publics/clients whose expectations for the Agency have been shaped by the traditional single-threat/single-medium regulatory approach. These publics and regulated entities may require some help to understand how a systems approach, where considerations extend outward to encompass cumulative risks, expand in scope across both time and space, and include a broader array of positive effects for an expanded set of potential beneficiaries, will help to address "their" immediate concerns. This may be especially problematic when some costs or other compromises are required for some specific clients in order to reach a better outcome from a systems perspective. In this context, it should also be noted that ORD acknowledges that considerable research effort under the new StRAPs continues to be directed toward meeting "legacy" needs set out by historic mandates, making it harder to present a consistent picture of what the new systems approach is about. As a case in point, the current SHC StRAP frequently presents promulgating "regulations" and achieving "compliance with regulations" as though these were high-level, end goals for the Agency (and thus for ORD research support). This representation would seem to reinforce the wrong or at least outdated image of the Agency as a regulator of some identified source viz. some specified threat to the health of people in a designated place.

As EPA moves to implement a sustainability paradigm, ORD's role is to conduct research that supports this paradigm. SHC's plan is to conduct research on sustainability using a systems-based approach and by using case studies to illustrate community-level sustainability.

Comments from Dr. Robert Johnston

- As noted above for ORD in general, it would be useful for the SHC Early Draft StRAP to incorporate a prospective, forward-looking discussion of research that the program anticipates will be needed address environmental issues of 2020 and beyond. This would include a discussion of the balance between ORD's current strategic allocation of effort and expertise and that which might be needed to address future challenges.
- Many of the integrative decision-support tools proposed by the SHC StRAP are extremely ambitious, even when considering contemporary decision support needs. It is unclear how these tools can and will be adapted to account for changing conditions over time. It would be informative for the SHC

Early Draft StRAP to provide some discussion of how the proposed tools might be updated and adapted over time to account for broader social and ecological changes that might occur by 2020 and beyond. Will these tools be robust to future changes in social and ecological systems? If not, can they be cost-effectively updated? What changes are anticipated?

- Looking forward to 2020 and beyond, the tradeoffs involved in different definitions of community sustainability (what is to be sustained and for whom) will become increasingly relevant. Sustainability tradeoffs will likely be further exacerbated by the influences of global climate change. The SHC Early Draft StRAP gives little attention to the specifics and tradeoffs implied by different sustainable futures, particularly as one looks out beyond 2020. The general lack of attention sustainability tradeoffs within the SHC Early Draft StRAP hinders the program's ability to plan the science necessary to evaluate the tradeoffs that will affect future environmental quality and human well-being.

Comments from Dr. Catherine Karr

2b. Research directions are presented as four main topics and associated proposed projects with each. The breadth is ambitious although leverages connections of many projects with other ORD program areas and partnerships with other federal agencies. Appendix A graphic with outputs identified provides a helpful view of how evaluation of the proposed directions successes may be observed.

Comments from Dr. Earthea Nance

2b. Ecosystem services (Theme 2/Question 8) is important research that addresses environmental issues of 2020 and beyond. At first I was unclear if this research topic was positioned properly, then I thought it could be renamed to "coupled social-ecological systems," which might better capture the complex linkages involved and justify its current position.

Comments from Dr. Katherine von Stackelberg

As mentioned above, it can be argued that the key "environmental issue" for 2020 and beyond is sustainability – the ability of a constrained ecological system to meet human needs. In that sense, the SHC StRAP is presumably at the forefront in terms of emphasizing community and community support, although this reviewer finds an emphasis on "environmental" to be lacking. For example, proposed sustainability indicators (http://epa.gov/sustainability/docs/framework_for_sustainability_indicators_at_epa.pdf), which are largely taken from others, give equal weight to traditional economic indicators that are fundamentally incompatible with "sustainability" in a broader sense (e.g., the category for Economic Growth, which includes GNP, National debt/GNP, Average income, Capital imports, Foreign investment) and are also well beyond EPA's purview. I would recommend a greater emphasis on the environment and metrics related to sustainability in the context of the environment, which potentially provides an opportunity to demonstrate leadership on the incompatibility of growth-based metrics across pillars.

2c. For SHC, do the presentation and plan indicate that ORD is designing for integration, where appropriate, on topics that are relevant to other research programs?

Comments from Dr. Joseph Arvai

- It's my view that the StRAP for SHC is a little too modest (but, understandably so) in terms of how the tools being developed under this theme can be translated/adapted for use by other EPA/ORD research projects. For example, I view the model presented in Figure 2 of the StRAP (page 10) to be robust as it relates to fostering higher quality decisions. As I note above, I strongly believe the agency

should begin to develop capacity (and personnel) capable of providing wide ranging decision-support for a variety of agency activities. In my view, this would be an interdisciplinary (e.g., decision scientists, economists, applied scientists, operations researchers, etc.) group of scientists and policy advisors who understand that trans disciplinary integration will be necessary for advancing the EPA's agenda and goals in the future.

Comments from Dr. Peter Chapman

- ORD is attempting to design for integration, but not always to the extent necessary or appropriate (see comments above)

Comments from Dr. Terry Daniel

Perhaps the most relevant aspects of the SHC program with regard to sustainability research is the effort to define and test an integrated set of “indicators” of environmental, social and economic health and well-being at the community level. As these indicators are further developed and refined and their interactions are observed in multiple environmental/social/economic contexts the foundation for achieving sustainable balances among the multiple facets of community well-being will be improved. Certainly “case studies” should be an important part of any research program that seeks to accomplish these ends. However, the SHC StRAP in several places seems to present case studies as an end in themselves, rather than as a means to achieve certain research and development goals that broadly support sustainability. A good case can be made for case studies, but more care is needed to justify their use for specified purposes as a component of a broader program of research and development that incorporates multiple methods, including bench science and other more structured research designs and methods as needed

Comments from Dr. Courtney Flint

- HHRA & SHC – HHRA's cumulative risk assessment conceptual framework includes a rich set of indicators that would be useful for conceptualization of community well-being in SHC and beyond. The vulnerability factors and cultural and behavioral factors articulated go beyond classic health dimension – this is laudable.

Comments from Dr. Robert Johnston

- The SHC Early Draft StRAP suggests a high degree of integration with other ORD programs and cross-cutting areas. This integration is necessary given the multiple facets of community sustainability.
- Integration is less well developed with regard to the social, behavioral, and economic sciences. This issue was also noted by the 2011 Office of Research and Development (ORD) New Strategic Research Directions: A Joint Report of the Science Advisory Board (SAB) and ORD Board of Scientific Councilors (BOSC) (p. 17): “The Sustainable and Healthy Communities program offers many potential roles for social, behavioral, and decision sciences. Because ORD does not currently have the capacity, internally or through external funding, to conduct this research, it will be important for ORD to explore how other agencies have engaged social, behavioral, and decision scientists in place-based environmental decisions (e.g., the U.S. Forest Service; U.S. Department of Agriculture Economic Research Service; U.S. Department of Agriculture Conservation Reserve Program; the Department of the Interior; the National Oceanic and Atmospheric Administration; and the National Park Service).” It would be useful for the StRAP to clarify how SHC intends to incorporate the capacity in social, economic and behavioral sciences necessary to conduct the proposed work.

Comments from Dr. Catherine Karr

2c. Examples of links to cross cutting research roadmap activities and priorities are described including CEH, nitrogen, climate change and ej.

Comments from Dr. Earthea Nance

2c. Sometimes it is difficult to tell if a program is in the right place, or if there is enough integration. For example, Theme 3/Question 4 (contaminated groundwater) could belong in the water section. In cases like this, it would be good to include a very brief acknowledgment that the topic is cross-cutting and a very brief description of the integration strategy; in this case, a sentence or two on how the water group and the sustainable communities group will share the groundwater issue.

Comments from Dr. Katherine von Stackelberg

Yes, integration is well addressed.

3. Air, Climate and Energy Charge Questions

3a. Does the SAB/BOSC have suggestions regarding how ACE should target its efforts to understand, model, and convey the potential environmental impacts of possible energy choices?

Comments from Dr. Viney Aneja

Unconventional oil and gas production (e.g Hydraulic Fracturing) has impacts on air and water quality and climate (methane emission). The impacts on air quality associated with VOCs, hazardous air pollutants (HAPs) and other trace gases emissions needs to be monitored and modeled.

Comments from Dr. Ingrid Burke

I think that a new cross-cutting program that is called Sustainability could embrace such an effort a bit better than is appropriate for ACE alone, as the environmental impacts go far beyond atmospheric consequences.

This is a great area for STAR research, or EPA-STAR + DOE partnerships, and even for research that is focused on university-industry partnerships. Sure, industries will have a conflict of interest, but this could be a way to leverage industry resources and incentivize the development and implementation of technologies to reduce environmental impact. I think that this has a major possibility of engaging industry as partners rather than using research and resulting regulations alone.

Comments from Dr. Peter Chapman

- Consideration needs to be given to both positives and negatives of different energy choices, both direct and indirect. A good example is the promotion of biofuels to the detriment of nutrition of disadvantaged communities (e.g., higher price of corn tortillas) in some countries such as Mexico.
- Energy choices need to be put in the context of human values (i.e., ecosystem services) and needs relative to global climate change – in other words, convincing people to change for their own good and that of their descendants rather than politically forcing a change that will be resisted.
- The most obvious energy choices to minimize global climate change may not be the best choices for other reasons; consideration of trade-offs (environmental, economic, social) will be critical.
- International cooperation and information exchange are critical.

Comments from Dr. Francine Laden

ACE appears to have a solid and appropriate plan for targeting its efforts to understand, model, and

convey the potential environmental impacts of possible energy choices. Keeping on top of new technologies as they develop and designing specific evaluation plans for each is necessary and appropriate.

Comments from Dr. Surabi Menon

It would have been nice to have a preliminary executive summary in the charge plan similar to some of the other strategic research action plans to help summarise the plan.

ACE has correctly identified important changes to be anticipated within the Climate Action Plan and the evolving energy landscape, which requires a response that needs to be quick, intuitive, and multi-disciplinary and more importantly systems-based.

Based on the suggested needs for a research program, it would be useful to have a systematic evaluation from the various models (in order to have a range) to understand what the near-term (from now through 2020) and long-term (through 2050) emissions trajectories may be, and within those trajectories, what energy choices are we committing to or would commit to. This will help ACE understand, model and convey environmental impacts of possible energy choices. I did not quite see a description of how this would be incorporated within the research plan outlined.

The suggested evaluation of emission trajectories would fit within the ACE research topic CIMA (p. 17 of the strategic plan) and SEE. Under CIMA there was more emphasis placed on the adaptation side and similar emphasis on mitigation will help better understand how to avoid consequences of energy pathways. Under SEE there is some information on plans to develop methods, models and examine impacts from traditional and alternative energy systems. Here, it would be helpful to look at what the international community has focused on (IPCC AR5 work) and use that to adapt/create scenarios that pertain to ACE's evaluation of likely energy choices.

The proposed integration of MARKAL, CMAQ and BenMAP to investigate the linkages between energy pathways, transport of emissions and the health impacts is a good way forward. Transmission channels for the proposed linkages should be identified and the supporting models should be adapted to allow for full assessments. Since this is a broad topic more attention to relevant components of the transmission channel can help narrow the scope to relevant parameters, tools and indicators. This is not straightforward but requires system thinking and other experts to help ACE develop and implement this. I hope there is some mechanism within the plan to allow this to happen.

Comments from Mr. Richard Poirot

One general area where focused efforts to understand, quantify and communicate environmental impacts of alternative energy choices would be useful, relates to our current limited ability to convey quantitative estimates of environmental and public health benefits (or consequences) for air quality and climate-related effects (other than, or in addition to, those from PM mortality). For example, the last paragraph on p. 4 of the draft ACE plan proudly cites OMB estimates that the NAAQS have accounted for 94 to 97 % of estimated benefits from all EPA regulations and 60 to 87 % of estimated benefits across all federal agencies. Without intending to question the importance of this notable accomplishment, I would guess that roughly 90% of those estimated benefits were attributable to reduced/avoided mortality from particulate matter. A majority of quantified economic benefits attributed to 1990 "acid rain" controls, 1998 ("Ozone") NOx SIP Call, 2011 "Mercury and Air Toxics" Standards, and the recent Clean Power Plan "Carbon emissions Standards" have all estimated to result from reduced/avoided PM mortality, while generally benefits to the quality and sustainability of the natural environment, to human health and wellbeing (other than from PM), and to future generations are usually described only in general terms or

through example case studies.

Objectives 1 (assess impacts) and 2 (prevent and reduce emissions) 2 of the ACE StRAP do seem to clearly recognize the importance of and challenges associated with quantifying and comparing effects on human vs ecological health, comparing short-term (and relatively certain) health effects for criteria pollutants with much longer-term (and more uncertain) effects of climate-forcing pollutants, or evaluating co-benefits and potential tradeoffs in addressing multipollutant issues. But surprisingly little progress has occurred in recent years in terms of:

improving quantitative estimates for costs/benefits for ecological health or non-health human welfare effects (especially over long time periods and international spatial scales),
identifying specific multipollutant mixtures and effects metrics (combined secondary SO_x/NO_x AAPI; Canadian AQHI; regional haze algorithm, etc.),
building tools/metrics that allow quantitative considerations of co-benefits and tradeoffs for criteria pollutants, air toxics and climate-forcing pollutants – over varying space and time scales (beyond relatively simple “no regrets” concepts for controlling black carbon and methane).

Comments from Ms. Sandra Smith

- ACE will need to maintain a focus on problem identification in order to continue to foresee, and then evaluate in a timely manner, the potential consequences of evolving energy production and use patterns. Therefore, as I noted earlier, the shift in emphasis away from problem identification concerns me.
- A focus on systems and lifecycle analysis (mentioned under ACE Research Topic 5: Sustainable Energy Evaluation) is important and the development of tools to improve lifecycle analysis is an appropriate research emphasis.

Comments from Dr. Peter Wilcoxon

- This topic is very important and the StRAP could be expanded and strengthened considerably in several respects.
- First, ACE should clearly distinguish between two logically distinct activities that are conflated in the StRAP: (1) evaluating the environmental consequence of a given projected energy mix, and (2) determining changes in the energy mix caused by changes in policy.
- The first activity—evaluating a given projected fuel mix (or, more broadly, building an evaluation tool)—is a natural fit for EPA and would make good use of existing EPA tools such as CMAQ and BenMAP. It could be used to provide a very useful adjunct to activities undertaken by other agencies, such as EIA’s Annual Energy Outlook.
- The second activity—determining the effect of policy changes on the energy mix, and hence on the environment—is a very complex task. The US energy system over the coming decades will evolve due to interactions between economic factors (drilling costs, advances in combustion turbines, reductions in the cost of energy storage, etc.), the broader regulatory landscape (state utility regulations, national gas export policies, and so on), the incentives faced by individuals and firms (energy efficiency, distance from home to work, use of public transportation, tax credits, etc.), and the evolution of the broader macroeconomy (the aging of the workforce, international trade conditions, etc.). Assessing the impact of national policies in that context is difficult and ACE has few resources and little experience in the area. Rather than building that capability in-house, ACE would be better off partnering with organizations having considerable experience in that area, such as EIA, the Energy Modeling Forum (EMF), or the components of OAR that have used economic modeling to examine climate change policy and the consequences of the Clean Air Act.
- One useful approach would be for ACE to start by constructing the evaluation tool discussed above and then work with the EMF to carry out a study in which the tool would be applied to a set of EMF

model runs. The study would: (1) allow ACE and EMF to play to their own strengths; (2) would provide the kind of output that ACE seems to have in mind in its SEE topic area, and (3) would provide significant underlying research results, such as optimal ways to match the level of regional detail between energy and economic models (which are geographically coarse) and environmental damage models (which are generally much finer).

Other ACE-related comments

Comments from Ms. Sandra Smith

- One point that surfaced more than once in my responses to the charge questions is the lack of a clear logic flow from the goals identified and discussed in the EPA Strategic Plan to the research topics identified in the draft ACE plan. A stronger logic flow would 1) provide more evidence that the draft plan emphasizes the correct areas, 2) ensure that they are more clearly described, and 3) improve communication of the reasons why ORD research should focus on the areas emphasized.
- I know there have been efforts to perform comparative analysis of different environmental problems to enable prioritization of potential solutions. For example, the draft plan states that “the NAAQS has accounted for approximately 94 to 97 percent of estimated benefits from all EPA regulations and approximately 60 to 87 percent of estimated benefits across all federal agencies.” This validates in part the emphasis in the draft ACE plan on research to support NAAQS (although it does not speak to the potential for additional gains through NAAQS). If more of this kind of information were presented in the draft ACE plan, the question on whether the plan emphasizes the correct areas would be easier to answer.

4. Sustainable and Healthy Communities

4a. Does the research program contain the elements necessary to integrate these two critical elements (ecological and human health) of EPA's mission?

Comments from Dr. George Alexeeff

Yes, the research program proposes a transdisciplinary integration of community-based human health and ecosystem services into a systems approach.

The research program describes the unit of study as a community. Several descriptions of communities are given, e.g., geographic, economic base. I suggest adding vulnerable subpopulations e.g., pregnant women, farmworkers, those in poverty, as “communities”.

Comments from Dr. Joseph Arvai

- The raw materials are there, for sure. However, I am concerned about the type of stakeholder engagement that is taking place when it comes to these research areas. The StRAP refers to “considerable input” when it comes to setting the research agenda. The StRAP also refers to research on “sustainability indicators” (which I refer to above in terms of “defining outcome measures for programmatic performance”). In my view, in order for these “sustainability indicators” to be as decision-relevant as possible, they must be developed jointly with affected communities/stakeholders. Presumably this will be part of the SHC research agenda; however it should be made more explicit. Only by meaningfully engaging communities in establishing desired outcomes and “sustainability indicators” will the EPA be able to integrate “sustainable” and “healthy” when it comes to communities.

Comments from Dr. Peter Chapman

- Not alone; recommend that the Human Health Risk Assessment StRAP be part of this larger, more comprehensive StRAP. See comments above.
- During the conference call it was stated that ¼ to 1/3 of the research will be on legacy contamination and the example was given of mold in schools. Both are clearly issues of local concern but of relatively low concern compared to the global issues facing humanity: global climate change, habitat change, invasive/introduced species; efforts need to be prioritized.
- Life cycle assessment, as noted previously, needs to have greater priority.
- Invasive/introduced species are not mentioned as an issue, yet they are a major issue for sustainable and healthy communities.

Comments from Dr. Elaine Faustman

SHC's research and development on indicators and indices, ecosystem goods and services, and the EnviroAtlas make reference to specific health conditions such as asthma, but are largely oriented toward protection and promotion of more broadly-defined individual and community well-being.

Comments from Dr. Courtney Flint

- It is notable that despite having focus on ecological as well as human health, the focus of both is for better addressing human and community well-being. In other words, it is clearly implied that focusing on ecological health is not purely to serve intrinsic values of nature. This is made further clear by focusing on ecosystem services – a.k.a. the flow of benefits from nature to society. While we can and should discuss the opportunities and challenges offered by the ecosystem services approach, this is an important emphasis and should help differentiate EPA activities from those of other agencies with more orientation toward ecological well-being as conceptually separate from human well-being. The added complication, however, is how to integrate sustainability principles into these efforts and whether that takes the discussion back to the drawing board in terms of overarching orientation. The risk is having programs that are about everything, but nothing in particular – i.e. trying to do too much in every effort.
- A clear definition of “community” would be helpful, given the confusion between communities of place and communities of interest. Relatedly, considerations of processes at scales within communities (e.g. households, neighborhoods) and beyond communities (e.g. metropolitan areas, landscapes, counties, regions, states) would be helpful. This becomes important in the discussion of what the most appropriate level of analysis is for integrating sustainability principles. The larger the scale, the more daunting the complexity.
- In the construction of a community typology, it would be valuable to develop more experiential indicators or variables that capture previous trends and chronic or acute focusing events that likely affect the adaptive capacity of communities. This means going beyond readily available geographic and structural variables to capture more contextual and spatio-temporal information.
- Decision-support tools are a high priority in the SHC StRAP. However, there is little included about how these tools will be evaluated for their utility in making a difference in communities. It is often just assumed that they will help. A more adaptive approach to tool development might incorporate an iterative feedback loop in collaboration with partners and community stakeholders at earlier phases of tool development to increase their applicability across diverse circumstances. Using a robust community typology to develop nuanced considerations for tool development and deployment would also be of value.
- In figure 2 of the SHC StRAP, “reporting to stakeholders” follows scoping and options, assessment, and analysis. This positionality is problematic. Engagement with stakeholders throughout assessment and management cycles is far more likely to be a) inclusive of grounded perspective on the nature of

local problems and community decision-making needs; and b) far more likely to be implemented if community stakeholders are empowered to be part of the process from the beginning.

- A lot of the tools and metrics outlined are based on indicators from existing or expanding secondary databases. It would be worth considering a ground-truthing protocol for validation or triangulation with more local and participatory primary data collection methods and efforts.

Comments from Dr. Robert Johnston

- This aspect of SHC is largely incorporated in Community Public Health & Well-Being: SHC Project 2.62. However, the descriptions of the specific research elements in this area are insufficient to determine whether program contain the elements necessary to integrate these two critical elements of EPA's mission.
- Research on environmental and other determinants of health disparities appears to be well-developed (for example grounded in the work of the EPA-NIMHD Centers of Excellence on Environment and Health Disparities Research). However, this research program does not appear to address relationships between ecological health and human health. Rather, ongoing research seems to focus on the role of specific environmental stressors. Research explicitly linking ecological and human health is not explicitly described.
- Among the relevant strategic outputs in this area is 2.62.4, which is described as a "report on the state of the practice for integrating ecosystem good and services, human health and human well-being research for assisting communities in decision-making." This appears to be a review of scientific literature and practice, rather than new primary research to evaluate linkages between ecosystems and human health.
- A second, less directly-related strategic output is 2.62.3, "methods for cumulative, integrated assessments of chemical and non-chemical stressors and pilot application of these assessments to reduce community environmental health risks and promote community health and well-being." It is unclear to what extent this evaluation will address relationships between ecological and human health, or will rather focus primarily on individual stressors.
- Although SHC has proposed a continued development of a number of reports, metrics and indicators of environmental condition and ecological health (e.g., Indicators, Indices and the Report on the Environment: SHC Project 2.64), the specific links to human health are largely unspecified.
- In general, the content of the Early Draft StRAP is insufficiently specific to enable assessment of whether the necessary elements are present to integrate ecological and human health. The information that is present in the StRAP suggests that some efforts will be made towards integration, but that extensive work will still be required to develop this area of research.

Comments from Dr. Elizabeth Matsui

- Please see comments above about the recommendation to clearly define sustainable and healthy, and to discuss the nuanced relationship between these two concepts, which are both important, but should not be conflated.
- Another part of the strategic plan that should be revisited is the use of "well-being" as the key health outcome. Choosing this outcome, which is difficult to measure, which has less resonance and impact than an identified public health problem, and is affected by many inputs may make it difficult for the agency to study effects of environmental exposures in an impactful way or assess the effects of regulation and other interventions in a very meaningful way. See comments above pertaining to this issue.

Comments from Dr. Earthea Nance

In my view, several important elements are missing from the current research program. The program is not grounded in a critical review of past and present conditions that contribute to the lack of healthy communities and a sustainable environment, such as research on the role of subsidies, loopholes, and permit-based regulation on creating disproportionate impacts and pollution burdens; research on better accountability mechanisms; and research on community organizing as a complement to market-based and regulation-based approaches. I didn't see a plan for social policy research, nor a plan for ensuring that future decisions don't cause additional damage to already burdened communities.

Overall, the section understates the full extent of disproportionate impact. Title 6 of the Civil Rights Act and Executive Order 12898 should be mentioned up front along with the Clean Air Act, Clean Water Act, and other acts in EPA's legislative mandate. This would be appropriate given their link to the EPA's state values (Science, Transparency, Rule of Law). Not mentioned is the lack of adequate laws to cover disproportionate impacts. Research in this area could consist of modelling to predict where disproportionate impacts will occur, and research on disproportionate enforcement.

Social, economic, governance, and regulatory practices are key to sustainability, yet these research areas, which belong in the sustainable and healthy communities section, are not as strong as they could be.

Comments from Dr. Duncan Patten

The research program attempts to integrate these two elements but still appears to address them somewhat in their own silos. For example, there appears to be little evidence of attempts to integrate changing Final Ecosystem Goods and Services (FEGS) with the changing "built community" in which most humans reside. As the built community changes the role of ecosystem services may be increased or diminished. In turn, as external stressors alter ecosystem goods and services, including watershed conditions, understanding the importance of these alterations to the community (human health and well being, for example) and its built environment also gains in importance. The Eco health Relationship Browser seems to be a good initial attempt at these efforts.

As an aside, the emphasis on climate change as a stressor on FEGS diminishes the importance of so many other human and naturally influenced stressors (e.g., "mismanagement" of water resources).

In order to integrate ecological and human "health"* it is critical that the community understand what is being modified ecologically (e.g., changes in FEGS). The SHC program mentions working with stake holders but one hopes this means working with the communities as a whole and not just community leaders. Community education becomes an essential part of sustainability success. The TRIOS and DASEES programs, and the Enviroatlas, if used properly, come close to addressing these needs.

*Note: ecological or ecosystem health is not a commonly accepted concept in the ecological community. What does health mean in this concept? It does help people understand ecosystem condition as they relate it to human health and what that means.

SHC's research and development on indicators and indices, ecosystem goods and services, and the EnviroAtlas make reference to specific health conditions such as asthma, but are largely oriented toward protection and promotion of more broadly-defined individual and community well-being.

Comments from Dr. John Tharakan

- Research program contains elements necessary for integration, especially ecological and human health. However, a clear definition of community Well-being is needed.

- In addition to being clearly defined, Well-being must be community based. Well being must be contextualized for individual and particular communities. y. One community’s sense of well-being may be different from another’s, especially given the diversity and variegated nature of communities and given the diversity of economic, environmental and social stressors that different communities face.
- Providing relevant, robust and transparent data is critical but are communities and all stakeholders provided sufficient background and information to understand the data? Is local knowledge from the community integrated into the data? This must be factored into integrating between ecological and human health for well being.

Comments from Dr. Katherine von Stackelberg

“Sustainable” is addressed in the context of the three pillars (economy, social, environment) with the consequence that greater emphasis is placed on social and economy than warranted by the Agency overall mission. “Healthy” appears to refer primarily and overwhelmingly to human health with the result that any research related to ecological risk (as opposed to ecosystem services, which are, again, in the context of benefits the environment provides to humans) is seemingly entirely missing.

There is an emphasis in the SHC StRAP on decision support tools that can, ostensibly, be used by communities as they formulate policies going forward. However, there are already so many existing tools, methods, frameworks, etc. and it is difficult to know which ones are “best” and it often seems that despite so many different options, it turns out no one tool is actually appropriate for any specific situation, although they always sound good in a general sense. Is it possible to develop a one-size-fits-all approach? Will there be data and information at appropriate spatial and temporal scales? What are the metrics for success?

4b. Is increased well-being the appropriate outcome to aim for, rather than amelioration of specific health conditions? If so, does the SAB/BOSC have recommendations for shaping the Community Public Health research project more toward broader well-being impacts?

Comments from Dr. George Alexeeff

An increased well-being is a better outcome than amelioration of specific outcomes. The latter requires establishing the specific outcome which can utilize exceptional resources and is rarely successful. Many community studies that we undertook did not establish the identify a specific health condition associated with a specific exposure. Conducting such a study on a small community is likely to result in a non-statistically significant increase in the health outcome, or if the health outcome is elevated, there is likely to be an unidentified cause. However, examination of such communities can often identify addressable issues that can improve well-being.

Comments from Dr. Joseph Arvai

- See my previous comment in terms of how SHC might identify broader, more decision-relevant well-being impacts.
- As far as “well-being” as an appropriate outcome to aim for over the “amelioration of specific health conditions”, I wonder: Why not both. In a multiattribute decision making environment, both could (and probably should) be tracked simultaneously.

Comments from Dr. Peter Chapman

- Both human health (per the StRAP Human Health Risk Assessment) and "increased well being" are appropriate goals, provided the latter is set in the context of ecosystem services, specifically: cultural (recreation, spiritual value, sense of place).
- Focus the well-being impacts on the cultural components of ecosystem services not on the less specific "social determinants of health" (from the conference call).

Comments from Dr. Elaine Faustman

This reviewer is very supportive of the need to move to well-being and perhaps even use the word "thriving" communities. Most chemical and social stressors do not know that they are supposed to be disease specific hence models are needed that look across endpoints and also consider cumulative risk scenarios to explain variability in response and resilience in our communities. This is especially true for children and for differentially impacted communities (EJ issues). Programs such as the EnviroAtlas provide a geo-spatial context for organizing extant data and helping to provide a context for evaluating impacts. I have personally recommended this output and believe it exemplifies some of the sophisticated concepts such as exposome and connectome that I have seen used across some materials. Well Done!

Comments from Dr. Courtney Flint

- Well-being is a good concept for SHC to organize around, particularly in light of the focus on sustainability. While both terms are somewhat fraught with definitional ambiguity, the EPA ORD and SHC can likely help not only clarify meaning, but also operationalization and measurement of well-being as a strategic goal in coming years. Often used interchangeably with "wellness", well-being is holistic and multidimensional, going beyond physical health of individuals and communities to include social, psychological, environmental, economic, and spiritual dimensions. An important consideration in employing well-being as a central concept is that while it can be objectively measured using indicators and fairly readily available data, it is best operationalized when target populations have an opportunity to articulate the key parameters and levels of their own well-being as there is a highly subjective element to this concept that has profound implications for measuring sustainability.

Comments from Dr. Robert Johnston

- The charge question above implies that it is necessary to choose between research addressing specific health conditions and research oriented toward human well-being. However, both have an important place within SHC. For example, individual and community well-being depend on specific health outcomes. It is also well established within economics and social science that different types of health outcomes have different impacts on well-being, even for otherwise identical changes in life expectancy. Hence, for policies and programs that affect human health, analyses of human well-being require understanding of changes in specific health outcomes. As a general goal, improvements in individual and community well-being are a more appropriate—though often more difficult to quantify—target. However, it is not possible to quantify broader effects on human well-being without understanding effects on specific health outcomes.
- To the extent that individual and community well-being is the target of SHC, the program requires greater input from the social, behavioral and economic sciences. Unlike modeling of human health effects—and area with which SHC and ORD have significant expertise—modeling of human welfare is primarily an exercise in the social, behavioral and economic sciences.
- Methods used to model and quantify effects on human well-being within different SHC projects are unclear from the Early Draft StRAP and other SHC briefing materials. My understanding of these

projects is that these approaches are still being developed. During the SHC introductory briefing teleconference, it was mentioned that an SHC project has been developing an index of human well-being. However, a review of existing materials from this project (e.g., Indicators and Methods for Creating a Human Well-Being Index (HWBI) for Ecosystem Services Research, EPA 600/R-12/023) suggests this index does not necessarily correspond to prior indices established within the social, behavioral and economic sciences. As such, this effort warrants external scientific review, and would likely benefit from additional input from qualified social, economic and behavioral scientists. It would be useful for the StRAP to provide greater insight regarding exactly how ORD plans to measure human well-being and incorporate it into community-based projects and tools, and the extent to which such approaches are grounded in established scientific methods. These methods are central to the validity and usefulness of SHC efforts.

- To consider ways to shape the Community Public Health research project more toward broader well-being impacts, SHC might consider convening an expert panel (or convening a workshop) to propose specific mechanisms to accomplish this goal. This panel would ideally include economists with expertise in quantifying welfare effects related to environmental and health outcomes, as well as social and behavioral scientists with expertise in modeling human well-being. This is a well-developed area of scientific research with which SHC will require familiarity if it is to make progress linking changes in ecosystems, health and well-being. The goal would be to provide clear direction to SHC as it moves forward in this important area.

Comments from Dr. Catherine Karr

Yes, I think the concept of well-being is a useful construct. The World Health Organization has used the following to define health - “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” Developing metrics, and assessments that incorporate this wholistic notion of community level physical, mental and social well being should be the goal. This may incorporate functional as well as economically relevant metrics such as lost school days, lost sleep, lost days of work, lost physical activity or earning potential, etc.

Comments from Dr. Elizabeth Matsui

- Apart from developing a plan for identifying the key health priorities and using validated tools to measure the impact of interventions/programs on these key health priorities, one option would be to include as a research objective the development and validation of a tool to assess broader well-being. One could imagine a tool that was composed of several components that included social well-being, mental health, and physical well-being, so that each component could be examined separately along with an overall score that integrated these components.
- The risk of relying on a more global indicator of effect is that use of a new indicator is often less meaningful, and therefore less powerful than use of widely accepted and validated outcomes.
- Another issue to consider is that the health effect that would be expected from an intervention depends on the community that is being studied (what conditions, diseases are most common, what is the susceptibility profile of the community) and what exposures are being targeted (some exposures would be expected to have effects on certain organ systems while others would affect other organ systems). Use of a broader outcome such as “well-being” – even a validated one – would result in attenuated estimates of the effect of exposure reduction when that exposure affects certain health outcomes but not others. This is a major limitation of broader health outcomes.

Comments from Dr. Earthea Nance

4b. If a refinery moves in next door to me, I will not only suffer direct health impacts. My property value will permanently diminish, I will have to deal with visual and noise impacts, there will be traffic

problems and these will create secondary sources of pollution. While facing continual health risks, I also might have to deal with long-term land use change as additional plants move in. I will be burdened by the need to use my scarce resources to write letters, attend public meetings, organize, and travel in order to defend my rights to property, health, and a clean environment. So yes, well-being is the appropriate outcome.

Comments from Dr. Duncan Patten

As many health and ecosystem problems are interrelated, and particular health issues may periodically be the critical issue at any one time, addressing community health as an interrelated component of ecosystem "health" may be appropriate and necessary. If this can be described as "community well being", then perhaps that is the direction to take. But, EPA should never forget that the "community" in the concept of "community well being" is composed of people, their environment and FEGS, the latter being perhaps as important as the health program within a community because sustainability of FEGSs are what will maintain well being of humans.

As EPA moves to implement a sustainability paradigm, ORD's role is to conduct research that supports this paradigm. SHC's plan is to conduct research on sustainability using a systems-based approach and by using case studies to illustrate community-level sustainability.

Comments from Dr. John Tharakan

- See comments in answer to 4a.
- Appreciate the focus on communities, as well it should be, since we are speaking about SHC! However, not clear where race, gender, and income demographics are factored into the program design. Community diversity needs to be considered in the context of the scale of the problems that are being addressed.
- For collaborations with communities, including tribes and tribal organizations, there needs to be sufficient outreach and education built into program design.
- Denver and New Orleans are certainly different, but depending on where in Denver and where in New Orleans we are focusing our attention, the "community type" will vary. The SHC StRAP should be careful and cognizant of this in identifying and defining "communities". Commend the efforts to come up with a community "typology" but researchers and policy makers should be careful about avoiding "pigeon-holing" and "over-categorization".

Comments from Dr. Katherine von Stackelberg

"Well-being" as opposed ameliorating specific health conditions sounds like an appropriate outcome to aim for, except that putting the entire program in the context of "human well-being" creates a value-laden outcome that will differ across communities and change over time and may prove largely intractable in practice. Well-being is not defined, and in any case depends entirely on the specific stakeholders, over what temporal and spatial scales these stakeholders are aggregated, the particular issues facing that community, and so on. Although the words sound appropriate and reasonable, the outcome seems intractable, difficult if not impossible to generalize across communities, and a bit of a diversion from the primary mission of protection of the environment – particularly in a sustainability context, which emphasizes the relationship of people to their environment. Communities, consisting of individuals, may not even recognize or understand exactly how much well-being, fundamentally, depends on the environment, particularly with respect to individual behaviors that may be very much at odds with the "environment" (e.g., growth-based economy, consumption-based economy, 80%+ of people living in urban areas, industrialized and energy-based agriculture, etc.).

Also, it appears from the information available that although systems-based approaches are emphasized given the sustainability context, C-FERST, for example, appears to focus almost exclusively on contaminants in the environment: “It will incorporate the latest research estimating human exposures to toxic substances in the environment. In doing so, C-FERST will assist communities with the challenge of identifying and prioritizing environmental health issues and potential actions.” (<http://www.epa.gov/heads/c-ferst/>). But clearly socioeconomic stressors, availability of green space, and so on are linked to well-being in this context, and perhaps even more importantly, traffic, consumer products, etc. It is difficult to gauge from the information provided how well the various projects will ultimately address well-being, but in principle, of course, well-being rather than “amelioration of specific health conditions” is clearly desirable.

By definition, anything involving communities (groups of people) will require insight into their values, goals, aspirations, and views on the environment. For example, ecoAmerica (2014), in collaboration and with sponsorship from the Nature Conservancy and others, has developed a longitudinal set of American Climate and Environmental Values Surveys to assesses contemporary climate and environmental values and motivations to provide information and insights at a national scale. The ways in which “well-being” is not currently adequately captured by existing metrics is discussed in several United Nations reports (Costanza et al. 2012; United Nations 2012), and there are a number of European efforts that directly emphasize the barriers to sustainability and well-being in terms of consumption, options for consumption, growth-based economy and so on (see, for example, <http://www.scp-knowledge.eu/section/general>, <http://sspp.proquest.com/>).

4c. SHC is interested in thoughts and suggestions from the SAB/BOSC on ways to conduct research on the science of sustainability.

Comments from Dr. George Alexeeff

One of the first steps is to develop a systematic ways of identifying environmental conditions, especially those that can be measured or quantified.

In support of Strategic Goal 3, Cleaning up Communities and Advancing Sustainable Development, the proposed SHC actions are too limited or unclear. Technical support and research is needed to help identify the basic subcomponents of sustainability that support environment, society and economy. Many community members believe that when their brownfield or superfund site is cleaned up it is still not sustainable. That is, sustainability in those instances often mean meeting specific risk goals only. I think we need a new tool that can supplement risk assessment. One that takes into account whatever community information is available and can help point the community in the sustainable direction regardless of the uncertainties.

Sustainable materials management sounds like it looking to the future instead of addressing current issues. Sustainable regulatory approaches sounds like a way to make the regulation sustainable and not the community.

Research on the science of sustainability sounds good, but the direction of the research is unclear.

Comments from Dr. Joseph Arvai

- This is a difficult question to answer as I am not terribly familiar with the resource limitations and practical/legal constraints that govern ORD research. Moreover, I most familiar with research opportunities in my own field. So, I'll largely limit my comments to the decision sciences.

- However, generally speaking, I'm of the opinion that research should involve developing and empirically testing of different classes of decision-support tools via controlled field trials. These trials could be implemented as part of SHC initiatives across each of the national EPA regions. Communities across the country are clamoring for assistance as they attempt to develop solutions to sustainability challenges. Developing, implementing, and testing different classes of decision-support tools could help the agency to develop a set of best, context-dependent practices.
- I'm also of the opinion that applied field trials will probably be insufficient when it comes to fostering innovation in the decision-support research space. To this end, I would recommend that the EPA develop partnerships with the National Science Foundation (e.g., Decision, Risk, and Management Sciences within SBE) and the National Academy of Science (e.g., the Board on Environmental Change and Society) to co-sponsor research on decision-support for sustainability. Doing so would enable the agency to identify additional, promising avenues for research and practice from the broader research community.
- Finally, there are several great examples out there of research aimed at developing decision-support systems in the US, Canada, and Europe. ORD may benefit from co-sponsoring a workshop (perhaps in concert with the NAS/BECS) focused on decision-support systems for SHC. I, for one, would be interested in taking part in such a workshop, and I am certain that others would be too. Indeed, I was just part of such a workshop sponsored by the NIH and IOM. I was told following the workshop that it was instrumental in encouraging much-needed outside of the box thinking at the NIH.

Comments from Dr. Peter Chapman

- There is no such thing as the “science of sustainability”.
- There is a clear and pressing need to clearly define sustainability both generically and specifically as previously noted.
- As noted in the comments above, EPA is relying on the generic definition of sustainability in the NAS report Sustainability and the U.S. EPA. However, this definition dates from NEPA 1969 and is not only dated but arguably deficient; it needs to be updated, and specific activities defined as sustainable (e.g., “sustainable chemicals”) need specific definitions.
- Sustainable Development was first popularized in the 1987 Brundtland Report Our Common Future, as an alternative to uncontrolled production and consumption; it was defined (a vision not a hard definition) in that Report in Chapter 2 as:
- “15. In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.”
- EPA in their website www.epa.gov/sustainability/basicinfo.htm answer the question ‘What is sustainability?’ as follows, which is a vision not a hard definition:
- “Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations”
- The terms “sustainable” and “sustainability” are being used without either concern for what they may mean (politically ‘good’ terms) or how they may be interpreted/mis-interpreted.

Comments from Dr. Courtney Flint

- The SHC (and ORD materials in general) focus around the “three pillars” representation of sustainability. This is in contrast to the nested circles model emphasizing economy as part of society

and both as part of the environment – i.e. that all three components are inter-dependent and that the natural and built environment and human well-being are “inextricably linked” (SHC Draft StRAP p13). This may end up being mostly semantic, but representation is key and a full complex systems perspective (and integrated programs) on sustainability may be better off framing a fully integrated set of dimensions than conceptualizing them separately.

- Sustainability should be thought of as much about process as end-points or outcomes. As such, there are process-based indicators as well as solution-oriented evaluation metrics ORD should be concerned with.
- Given what the “E” stands for in Environmental Protection Agency, it may be that the environmental aspects of sustainability have a tendency to be prioritized. The ORD will need to wrestle with issues of priority and balance, particularly when maximization of all dimensions is difficult if not impossible (and likely at least conflictual). Creating means to achieve or at least evaluate synergy as opposed to trade-offs (or guidelines on how to handle tradeoffs where inevitable) will be helpful.
- Using the life cycle analytics approach appears useful, but social and economic aspects of life cycle impacts should be addressed as much as the more common environmental impacts if the guiding principle is to be truly on sustainability. This will also help integrate programs on various risks to different populations (and thus cross-cutting environmental justice issues).

Comments from Dr. Robert Johnston

- Currently, sustainability appears to be an abstract concept guiding SHC’s efforts, rather than a set of carefully design criteria and tradeoffs that guide concrete policy and programmatic changes.
- If sustainability is to be more than an abstract principle, SHC must consider a more explicit treatment of the concept, addressing difficult questions such as: (1) what is to be sustained? (2) whose concept or vision of sustainability is given standing? (3) how will different definitions of community be reconciled? (4) what if a community’s vision or definition of sustainability differs from that of EPA? (5) how will effects on the well-being of different beneficiaries be reconciled when choosing among different sustainable outcomes? (6) how will the Agency address difficult cases in which sustainable human well-being might be improved by actions that degrade a subset of environmental resources? Currently, the Early Draft StRAP and other SCH materials do not suggest that such issues have been considered in a specific and transparent manner that is relevant for programs and policy. Specifically, beyond the abstract NEPA definition, what does sustainability really mean within US EPA, and what concrete actions or tradeoffs does it imply?
- There is an extensive literature on transdisciplinary sustainability science – this should be among the first stops for SHC in developing new ways to conduct research on the science of sustainability.
- Systems-based sustainability research requires a transdisciplinary approach from the beginning of the project – starting with question formation and leading up through model development, data collection and empirical analysis. Too often, purportedly systems-based, transdisciplinary models are dominated by either the social or natural sciences, with oversimplified treatment of the non-dominant disciplinary area(s).
- An often underappreciated but important area of research is that on optimal approach paths to sustainable solutions. Communities may not begin at a condition that is optimal to sustain. Rather, policy goals often include some level of improvement in environmental, human health or other conditions to a desirable level, which are then sustained once they are reached. The means used to approach these conditions—and the speed with which they are approached—can have important implications for human well-being and for the feasibility of reaching desired outcomes.

Comments from Dr. Elizabeth Matsui

- It will first be important to define sustainability, and then to identify the priority outcomes of interest. These are not clearly articulated in the current document, but starting with this framework should clarify best approaches to research on the science of sustainability.

Comments from Dr. James Mihelcic

ORD should partner with NSF on ways to conduct research on the science of sustainability because NSF has been doing this already for several years through their program in Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES). NSF and EPA research missions in this important area could be quite complimentary because of their different missions of fundamental versus more application research. ORD also needs to develop a long term plan (versus short term hiring of postdocs or supporting external research) how to better integrate behavioral science into their research on the science of sustainability.

Comments from Dr. Earthea Nance

4c. Sustainability bridges the natural and social sciences to solve the interconnected problems of environmental quality and social justice. The structure of knowledge production, however, remains limited by the disciplines and dominated by the physical sciences

Comments from Dr. Duncan Patten

I do not attempt to define sustainability as EPA uses its own definition which does include the long term availability of FEES. The science of sustainability must emphasize the interrelated aspects of human actions and "well being" and the functions of human altered and natural supporting ecosystems (FEES). This is an obvious statement but it is common to pick individual issues or components that seem most important and then forget that these components do not function (or influence human well being and system sustainability) independent of each other or human actions. Most of the SHC programs recognize the integrated nature of human and natural ecosystem functions but understanding long term sustainability of either cannot be addressed through selection of what appears at any one time to be a critical and perceived as "most important" driving issue. For example, climate change is presently considered a major stressor but how it influences sustainability cannot be understood unless the research addressing this also addresses other stressors of human and ecosystem processes, some of which have been influencing the importance and levels of FEES and human wellbeing for some time.

Comments from Dr. John Tharakan

- "Sustainable" needs to be clearly, consistently defined.
- A "sustainability paradigm" and a "Systems approach" are not always equivalent, as suggested by some of the program design and research planning. One could suggest that they only become equivalent and exchangeable when these terms are defined clearly and consistently, with appropriate and sufficient contextualization and for the purposes at hand.
- Sustainability, especially in the context of engagement with tribes and tribal nations. needs to acknowledge and validate local knowledge. Tribes and Nations ["We do not own the land, we borrow it from our children and their children" to paraphrase Native American wisdom on sustainability] have indigenous knowledge on sustainability that should be part of the research and program engagement.
- Commend the transition from simple remediation to restoration and revitalization of brownfields and contaminated sites. Community input must be a key component of revitalization plans and designs, which would be an important and critical component of sustainability.

- Stakeholder identification is a key component of the Sustainability Assessment and Management. Is sufficient input sought from impacted communities to determine who participates in this?
- When conducting the Trade-offs and Synergy analysis, substantial input should be sought from impacted communities, as this speaks directly to the delicate balance between people, planet and prosperity – the three pillars of sustainability.
- Demonstrating the distributional impacts to vulnerable and disadvantaged groups and ecosystems is critical. It is not clear how these vulnerable and disadvantaged communities are being substantively engaged in the process.
- Where in the program design for sustainability assessment and management of integrated solutions does input from the affected communities come in? The impacted communities need to be part of the entire program design and process and an integral part of sustainability assessment and in the development of these integrated solutions.
- When Trade-Off/Synergy analyses are conducted, community input should be critical, as also when “Net Benefits/Risks” are analyzed and in “Valuation of Ecosystem services”?
- That “Community Health and Well being” is being monitored across the research projects and programs is commendable and the inclusion and articulation of this is an essential and critical component of SHC which underscores EPA’s strategic cross-cutting commitment to a sustainable future and making a difference in communities.

Comments from Dr. Katherine von Stackelberg

Sustainability science is increasingly well-defined and research agendas have been published; presumably these are known to ORD and can provide additional perspective (see, for example, National Research Council 1999a; 199b; 2012a; 2012b; Clark and Dickson 2003; Kates et al. 2001; Kates, 2011; National Research Council 1999; Swart et al. 2004). Of course, there are many complementary programs that may be of interest, particularly those that address barriers to sustainability (e.g., Raskin et al. 2010 and the associated Great Transition Initiative at greattransition.org) and complementary metrics to, for example, the Report on the Environment (Global Footprint Network 2012).

5. Safe and Sustainable Water Resources

General Comments from Dr. James Opaluch

EPA has proposed an extensive research program based on innovative technologies and management practices. But more focus should be given to non-structural, behavioral approaches to meeting objectives. This includes such things as market-based and other incentive-based approaches, and more generally on improving our understanding of how to increase the adoption rates desirable actions (e.g., mitigating technologies or best management practices). This involved developing a two-way communications between the agency and regulated parties.

EPA research should focus more on non-structural solutions or solving non-structural problems. For example, it is one thing to develop new and more effecting technologies for Green Infrastructure. But in order for those technologies to be effective, they need to be adopted and correctly implemented by communities. Similarly, EPA sets the goal of “EPA’s Strategic Plan to help ensure that natural and engineered water systems have the capacity and resiliency to meet current and future water needs ...” A better perspective would be to include demand management strategies in the toolkit,

To achieve these goals, EPA needs to better understand the barriers to adoption of these technologies, and how to overcome those barriers. The “communication” approach is based on a presumption that the barriers to adoption are due to inadequate information, and the problem of adoption would solved if only

the communities had adequate decision tools. In fact, barriers can take many forms, including incentives, among others. In order to improve the rate of adoption, one needs to understand what barriers are faced by potential users, and to design programs to overcome those barriers. For example, if barriers are primarily due to adverse incentives (e.g., high cost) then incentive programs might be effective. If barriers result from perceptions of collateral adverse effects (NIMBY), then those barriers need to be addressed. Identifying barriers and interventions to overcome barriers requires true two-way communications.

Some of these issues are highlighted in Research Objective 3 of the SSWR StRAP. But I fear that the suggested approach is rather one-directional. For example, the notion of “communication” seems to focus almost entirely on how EPA can communicate its results to the public. It is essential that communication be a two-way street. EPA needs to understand the perspective of its constituents, and these perspectives need to be designed into EPA programs. So it becomes not just EPA communicating its programs to the public, but rather the public becomes full partners in design of the programs.

5a. Where can EPA make a significant research contribution in moving toward a sustainable water-energy future, with consideration of energy, water, nutrients, and other resources?

Comments from Dr. Peter Chapman

- By focusing on ecosystem services, which presently are not a major focus of this StRAP.
- By structuring their research relative to the five key stressors facing humanity in the future, in order of importance (see comments re 1b, above): global climate change, habitat loss, introduced/invasive species, eutrophication, and chemical contamination.
- By emphasizing, more than water conservation, water reuse (perception will be a major barrier to wastewater reuse as has proven the case in Western Australia).

Comments from Mr. Shahid Chaudry

- Focused research to address data gaps especially in the context of emerging realities of strong relationship between water, energy, climate, & food supply chain at national, regional, and local levels.
- Developing and improving non-traditional water and wastewater treatment technologies such as desalination techniques with renewable power and waste heat (membrane distillation), forward osmosis, capacitative deionization, dewvaporation, nano-membranes, and zero liquid discharge.
- Cost effective and environmentally friendly technologies development to treat produced water, desalinating brines for ZLD, and saline aquifers.
- Climate change adaptation strategies to accommodate potentially different future hydrological conditions and improved forecasting capabilities to minimize system shocks and unexpected extremes.
- Evaluating and improving the use of water systems for energy storage.
- Improved water leak management techniques (energy savings from water conservation tend to be more economical and sustainable).
- Examining the relationship between wetland mitigation policies, constructed wetlands, and energy impacts.
- Impacts of varying water temperatures on algal blooms and consequently health impacts on humans and ecosystems.

Comments from Dr. Joel Ducoste

- As it pertains to water-energy nexus, the document really only talks about the impact of energy extraction and its effect on water quality or the energy usage of treatment systems. While that is a major concern, the document does not provide any significant discussion on the extraction of energy from wastewater streams. Research should be conducted on novel approaches to increase energy yield from wastewater streams.
- In terms of nutrient recovery, the document talks about a need for point source recovery but I did not see a discussion about non-point source recovery say for nitrogen and phosphorous through natural systems.
- I would like to have seen more discussion about some emerging contaminants from energy extraction methods and their potential influence on water treatment processes, especially related to either new or known disinfection by-products formation.

Comments from Dr. David Dzombak

The SSWR priorities are well chosen to position EPA to make significant, unique research contributions in relation to a sustainable water-energy future. In particular, the SSWR efforts under Watershed Sustainability Research Objective 2 (assess life cycle impacts of the water-energy-mineral-materials nexus) and under Water Systems Research Objective 1 (develop, evaluate, and facilitate adoption of technologies to support, advance, and transform water systems) build on the unique position of EPA with respect to water quality monitoring and regulation and also being an important driver of practice in municipal wastewater management.

Comments from Dr. Kimberly Jones

- Identify innovative ways to reduce energy requirements of treating and delivering water. Current estimates (~60-80% of cost of water) have to be reduced. Opportunities exist to develop novel, low energy alternatives for water treatment. EPA can lead this charge, as the water sector is very resistant to change.
- Attempt to quantify region-specific impact of climate change on water and energy. While we know that climate change will impact water and energy, the degree that they are impacted may change for different regions of the US.
- Develop incentives (regulatory or otherwise) to encourage use of nontraditional water sources and encourage water reuse and effective stormwater management.

Comments from Dr. Kristina Mena

- By incorporating risk assessment and CBPR approaches, a variety of considerations can be incorporated in the research design of water-related studies
- There continues to be a growing interest in water reuse research, and EPA could contribute to this movement by funding projects that address water reuse and water quality, water sustainability, and water regulations (policy)

Comments from Dr. James Mihelcic

- EPA research efforts in this area seemed focused on the impact that energy production has on water resources and water quality. This emphasis ignores the importance of technology innovation that addresses the SSWR overarching priority (SSWR slide #9 of July 17 presentation by Dr. van Drunick) to transform the concept of 'waste' to 'resource' by recapturing and reusing commercially valuable waste stream constituents (e.g., waste to energy). There is also a great opportunity for many municipal waste management facilities to become carbon neutral or serve as resource recovery

facilities. EPA research can best facilitate the transformation of the current treatment and water quality regulatory approach to one that best integrates a resource recovery paradigm; however, their research efforts in this area is narrow regarding moving towards a sustainable water-energy future.

- EPA is in a unique position where it could provide significant research contribution and leadership in determining the most economic and sustainable deployment of centralized and decentralized technologies and strategies for energy management decisions associated with management of water, stormwater, and wastewater. They are also importantly positioned to best understand how community stakeholders will interact positively or negatively with this deployment.
- EPA ORD is very good at mission orientated research that develops tools and decision support systems to advance the Nation in a more sustainable water-energy future that considers energy, water, nutrients, and other resources. They could be a leader in integrating sustainability frameworks into this strength. However, EPA is making a mistake to wait to wait to include sustainability assessments such as life cycle assessments in Project 3 (Long Term: Transformative Systems). This is because tools such as LCA should be included when making design or improvement designs which consider life cycle considerations. This is a way to include quality improvements as the research takes place and is a key piece of sustainability framework that drives innovation.
- EPA still incorrectly views the “waste to resource” priority for water systems (as stated in the SSWR STRAP), as not being green infrastructure. This is limitation in EPA thinking that may hinder advancement in broader deployment of green infrastructure that manages water provision and wastewater management as it implies to EPA’s many stakeholders that green infrastructure is something to only apply to stormwater management. This impedes advancing research contributions into moving towards water-energy nexus that emphasize waste to energy or nutrient recovery innovations.

Comments from Dr. James Sanders

Appropriate areas for research are defined. There are several, significant issues that we face, and the StRAP does include them. Two major issues for the next decade include getting a handle on nutrient management, and addressing infrastructure needs in a sustainable fashion. The agency is tackling both. The roadmaps for climate change and nitrogen provide good examples of the integration of thought and effort that is occurring within EPA in its current form, and I am pleased to see these programs maturing.

Comments from Dr. Jeanne VanBriesen

The selected foci in SSWR include watershed sustainability, nutrients, green infrastructure and stormwater and water systems. These are clearly priority foci for moving toward a sustainable water future for the country. The specific target sub topics are interesting and important, but an inadequate case is made for these being the most important near term research foci for these broad areas. As detailed above, a focus on point sources for nutrient research and a focus on small systems for drinking water research may represent important directions, but adequate justification for these choices is not provided in the documents. Particularly for nutrients, a watershed-level approach with a focus on non-point source issues and a greater focus on ecosystem valuation for water quality would likely lead to more progress toward a sustainable water future than the focus on point sources and nutrient extraction from wastewater.

EPA needs to make or support significant research contributions across all the target topical areas in ways that integrate them. The challenges associated with a path to a sustainable energy-water future cannot be considered in isolation. The “one water” framework discussed in the SSWR plan is an excellent but challenging approach. Research in water tends to occur in silos that parallel the engineering services distinctions noted in the draft; some researchers work on drinking water, others on wastewater, others on stormwater. The report draft makes a strong case for breaking down silos in our management of water,

but does not address the similar silos in the research program. Similarly, point and non-point source nutrient challenges are typically addressed by very different research teams, and it is difficult to take a watershed-wide systems approach to such research challenges. The SSWR plan makes significant advances in a systems approach by focusing on four interrelated areas, but some key intersections are not considered. For example, green infrastructure is focused on water quantity, while the potential effect of GI on nutrients (another priority area) is not discussed. This is surprising since this link is made in the nutrient cross cutting plan, thus, likely this is a focus of research. Similarly, the water systems area includes a focus on nutrient recovery from wastewater, while watershed sustainability does not mention mapping of nutrient loads across watersheds. The plan does mention that ‘additional opportunities for integration will be identified in the future,’ which is excellent. I’d recommend working with teams from across the six national research programs as well as teams within the SSWR to ensure that integration across the SSWR areas is also considered. The report states: “more specific relationships across topic area will be an important element of the detailed project management planning process.” I would urge EPA to make this THE most important element of detailed project management planning. Only by focusing research in areas that will support multiple research topics concurrently will adequate progress be made given the available resources.

6. Chemical Safety for Sustainability and Human Health Risk Assessment Charge Questions:

Comments from Dr. Lois Lehman-McKeeman on the HHRA and CSS problem statements

The problem statement identifies the needs for a “comprehensive suite of application products and analytical approaches that tailor assessments to fit the purpose of [these] various management decisions.” This seems a little generic in its scope [appreciating that problem statements are hard to craft in this regard], and overall, the key research topics seemed general as well. Some of the research objectives and challenges come closer to a real problem statement. For example (adapting from Objectives 1 and 2): There is a need to characterize the risks and potential human and environmental health impact of chemicals (from all sources), and to do so with tools that enable rapid, scientifically valid decisions.

CSS

This statement also seems a little generic, and it is more in line with HHRA and not unique to sustainability. It may be better to build from the HHRA statement to designate that beyond the establish of safe use, sustainability has unique attributes/problems and specify what those are. [not providing suggested word change in this case]

6a. Please comment on approaches the HHRA research program might target to better tailor its exposure and response assessment approaches to address fit-for-purpose characterizations (e.g., risk prioritization, risk screening, risk assessment).

Comments from Dr. Edward Carney

The StRAP does a very good job of mapping the various research projects to existing programs (e.g., IRIS, ISA). However, unless one is intimately familiar with the different risk assessment programs at EPA, it can be difficult to understand how different fit-for-purpose characterizations will plug into these existing programs.

For example, what is the value of incorporating new predictive toxicology data into risk assessments of existing chemicals which already have complete data packages? In most cases this could be counterproductive to Agency goals as it might unnecessarily prolong assessments and decision making

rather than bring them to a speedy resolution. It would seem that the new data would be applied only when there is a strong and specific need, and that they be applied in a highly targeted manner on a case-by-case basis.

Building confidence in newer approaches is of paramount importance to the long-term acceptance of these methods. To this end, more emphasis should be given to research aimed at validating or “qualifying” new methods as fit for particular purposes. Case studies would be particularly valuable in this regard.

Comments from Dr. Michael Dourson

EPA could take a note from several other risk assessment research and development organizations to establish a Threshold for Toxicological Concern for all chemicals without sufficient toxicology or epidemiology information on which to base an assessment, or for which an assessment has not already been established. The US FDA and NSF International are examples of two organizations that already do this. But others exist as well. This would help with the risk prioritization and risk screening parts of the examples above. Getting state priorities on individual chemicals or mixtures from California EPA, TCEQ or ECOS (stated partners/stakeholders) might also help tailor the program to national needs, or otherwise improve fit for purpose assessments.

Comments from Dr. Peter Chapman

- See Responses to 2a, above.
- Problem formulation will be critically important to prioritize based on potential risk (i.e., hazard) where risk assessment is required (either screening risk assessment or, in a few cases, more detailed risk assessment).
- Consider that non-linearity is a reality (e.g., hormesis); the evidence is now overwhelming.
- Prioritize, you cannot do everything and certainly not well.

Comments from Dr. George Daston

The CSS program has developed impressive new tools to aid in hazard and exposure screening and prioritization. These should be put on-line as soon as possible as they have the potential to fulfill unmet needs and to reduce uncertainty over the safety of chemicals in commerce and the environment. Tools such as ToxCast and especially ExpoCast have the potential to make a big difference in how we view the relative risk of the large number of chemicals that have yet to be assessed. ExpoCast also has considerable potential for application in community/ site-specific risk assessments, particularly in making real-time risk management decisions. I believe that there are opportunities to use these tools beyond just chemical prioritization. The HHRA program should consider whether it is possible to use these tools as the basis for generating screening level reference doses as a means of increasing the amount of information available to risk assessors in program offices and regions.

I would also like to see the HHRA program make more frequent use of tools and techniques for the use of mode of action data, especially at the molecular level (e.g., toxicogenomics), to support its risk assessments, both for hazard characterization and dose-response analysis.

Comments from Dr. Elaine Faustman

1) Tremendously interesting and innovative methods and approaches were proposed by both research programs. An example additional consideration for HHRA (see slide 14) would be inclusion of a comparable approach to exposure scenarios across platforms but that would focus on translation of the dynamics across platform. There are equivalent if not more challenges in translating a cytotoxicity

assay result or cytokine assay result across platforms as there is for dosimetry consideration in exposure. This maybe too ambitious for the next 5 years but by identifying this need it may at least make a placeholder for a very important interpretational needs.

2) In both research programs there was not any discussion of factors that contribute to variability in response beyond age and EJ. How are genetic differences being considered by these programs? Also, with the added complexity of the microbiome and genetic diversity present within these populations (within organism bacterial populations) this should be mentioned.. This is a potential emerging area as recent publications have shown differences in chemical response based on bacterial profiles present in the mammalian models.

Comments from Dr. Lois Lehman-McKeeman

It is not clear from the information provided how in vitro-to in vivo extrapolations will be carried out. It does not appear that the Agency is looking at experience with the pharmaceutical industry where such systems and tools have been utilized to a large extent and where there is a large experience base that could be informative on what approaches work or don't work well (to prevent "reinventing wheels").

Comments from Dr. Ponisseril Somasundaran

A wide range of sustainability tools are used to predict the potential impact of the use of manufactured chemicals and products (e.g., formulations). A major effort by a number of agencies has also been to develop tools to help make rapid chemical evaluations and decisions towards the adoption of sustainable processes and chemical usage. However, a major issue lies in the methodologies adopted by the individual agencies, which are often non-coherent. Even within an industry, there is significant variation in the tools used from one company to another.. Therefore, major emphasis must be given to the integration of the concepts used to develop these methodologies and then put in place a set of standards. This would be a complex undertaking considering the complexity of the environmental systems. Developing such an assessment tool, which is probably a herculean yet important task, would require long term planning in HHRA research program.

While a number of scientific tools have been developed that take into account the advancements made in genomic sequencing, research in Computational Toxicology and stem cell research, an understanding of the fundamental physical chemistry involved such as the importance of colloid and surface chemistry aspects(critical as the interaction of toxics takes place at the bio-nanointerface) has not been developed at all.

To address fit-for-purpose characterizations, both direct and indirect assessment are equally critical. While direct assessments are addressed by many research projects funded by NIH (National institute of health) and others (including National Science Foundation), a number of environmental factors are often not considered. Admittedly they are rather difficult to consider due to the lack of completeness in the assessment of the environmental conditions across USA. For example, variation in air and water quality from location to location, especially keeping in mind the locations that indulge in mining, fracing, or even locations vulnerable to natural disasters such as storms or accidents such as oil spill ,are not available and are difficult to predict.

6b. Please comment on approaches proposed by CSS and HHRA research programs to identify and integrate novel data streams to develop innovative fit-for-purpose assessment products.

Comments from Dr. Edward Carney

There is a great deal of emphasis on novel data streams in both the CSS and HHRA plans and the general approaches seem to be headed in the right direction. Science challenge 1, “Enhance data access and management systems to support transparency and efficiency” is particularly noteworthy as this should help build stakeholder confidence. To this same end, it would be also useful to develop and incorporate new approaches for ensuring quality control of high content data sets. Traditional methods of hand-checking data are not practical in a big data world. Therefore, novel QC approaches which are effective and understood by stakeholders are needed. Now would be a good time to slow down the data collection train and shift more emphasis to assessing the predictive capacity of the new methods.

With respect to the evaluation of chemical mixtures, there is a need for prioritization tools which enable the Agency to focus on those cumulative exposures which are likely to pose the greatest risk. Research has shown that, for a large majority of mixtures, cumulative risk is driven by one or a small number of components such that a cumulative risk assessment does not add value. The value to human and environmental health protection will come in being able to identify that smaller set of mixtures for which multiple chemicals are contributing to the overall risk, such that a cumulative risk assessment will make a difference. New data streams from high throughput exposure analyses and high throughput toxicity data both should be incorporated into mixtures prioritization schemes. The exposure-based biogeographical approach described in section 3.1.5. exemplifies another approach to prioritize cumulative assessments.

Comments from Dr. Peter Chapman

- Substances will be in a few cases data-rich and in most cases data-poor; this needs to be recognized and appropriate, technically defensible means to supplement data-poor substance assessments developed.
- Biomarkers can provide early warning but they can also misdirect resources and should be used appropriately and with caution.
- Focus on both adverse outcome pathways (AOP) and modes of action. AOP are appropriate for global climate change per a key publication by Agency scientists (Hooper MJ, Ankley GT, Cristol DA, Maryoung LA, Noyes PD, Pinkerton KE. 2013. Interactions between chemical and climate stressors: a role for mechanistic toxicology in assessing climate change risks. *Environ Toxicol Chem* 96: 37-37).
- There is a pressing need to terminate research projects for substances that are not proving to be major environmental concerns (e.g., nanomaterials in general) so that those resources can be reallocated to where they are most needed; the present practice of not terminating, simply adding research projects without increasing resources is, to use the term that EPA is promoting, not sustainable.

Comments from Dr. George Daston

I am very impressed with the research that has been carried out in both programs to generate and use novel data streams to fulfill their goals. The CSS has taken advantage of computational methods and high-throughput assay technology to develop data streams that are unique in toxicology and have the potential to support chemical assessment at a scale that has not been approachable previously. The HHRA program has done proof of concept work on the incorporation of toxicogenomics data in risk assessment. This work needs to be carried further into practice and become more routinely used in hazard characterization and dose response.

As noted above, the CSS program has invested to some extent in systems biology models, including computational models, that will be important in fleshing out the relationships between effects at different levels of biological organization. These will be important as the risk assessment process transitions to an adverse outcome pathway framework. Therefore, it is important for CSS to continue to invest in this research, and for HHRA to begin to develop methods for adapting the output of these methods into its risk assessments.

Comments from Dr. Michael Dourson

The CSS program appears to be heading in a direction that will yield additional information on which to base credible, fit-for-purpose, risk assessments, but a premium is needed on having erudite risk assessment scientists make the judgments on the use of these data for risk assessment, which is presumably the job of NCEA. It is hard enough for risk assessment experts to do this with existing data on occasion, and having risk assessment novices make the judgments with these new data streams would likely prove problematic. How can you tell if someone is an expert? The quote of Arnold Lehman of FDA lore (the toxicologist after which SOT named an its risk assessment award) may help: "Risk assessment is easy, you can learn it in two steps; each step takes 10 years." So look to the NCEA or other agency folks that have more than 20 years, and this is the group likely to make the best judgments. NCEA has several folks of this stature---Annie Jarabek and John Lipscomb come immediately to mind, but so do some of the Regional offices---Bob Benson of Region 8, for example; and other EPA offices such as OPP---Anna Lowit---and OW---Ed Ohanian). A number of former Agency folks exist outside of EPA now of this stature---Vicki Dellarco, Penny Fenner-Crisp and Carole Kimmel to name just three.

Comments from Dr. Elaine Faustman

1) REACH is mentioned in several places in the presentations from CSS, yet this reviewer was unclear as to what was actually coming from REACH. Who is doing a review of their successes and challenges? Is EPA involved in such an activity? So far I have not yet seen a thorough review so it would be good to see how and when "read across" methods are working and clear identification of how these lessons learned will be incorporated into EPA thinking.

2) This reviewer is still learning about the strengths and challenges in applying systematic review type approaches for a broad array of complex endpoints and chemicals yet minimal information was presented in the materials that would review and characterize when this approach is working within the IRIS program. "

Comments from Dr. Lois Lehman-McKeeman

There needs to be much more detail/information provided on the approaches that will be used to identify and integrate novel data streams into the overall research efforts and fit-for-purpose assessment products. [very difficult to address this question without more discussion]

Comments from Dr. Ponisseril Somasundaran

A major achievement could be to obtain and integrate data from the research programs/projects on Gulf of Mexico spill supported by other agencies (NIH, GOMRI (GULF OF MEXICO RESEARCH INITIATIVE)). Also, data taken from similar situations *occurring abroad* could provide valuable insights for inculcating innovative approaches in fit-for-purpose assessment products.

Also, attention needs to be given to the identification of key future challenges, such as those arising

from old urban infrastructures and aging water purification and treatment capabilities

Most importantly, interferences of chemicals and products from abroad need to be addressed.

Energy usage problems loom large for years to come. Usage and promotion of photovoltaics devices have been on the rise in order to meet the energy requirements, even though production of silicon produces most toxic polyhalogenates. Identification of futuristic challenges and development of models to predict environment challenges are essential.

6c. Are there other areas of fit-for-purpose characterizations (e.g., risk prioritization, risk screening, risk assessment) that are ripe for such collaboration/ integration?

Comments from Dr. Edward Carney

The draft StRAPs talk a lot about creating tool boxes, but are less clear on how these tools will be put into practice to support Agency decisions. In particular, new suites of assays and other assessment tools need to be packaged into testing requirements or test guidance in a manner analogous to the Agency's test guideline requirements in place today.

One area which should be given higher priority in the draft StRAP is read-across methodology done in collaboration with international agencies. Read-across methods (essentially the use of data-rich chemicals as surrogates for data poor chemicals) are central to the European Union's REACH program, REACH-like programs in the Asia-Pacific region, and are also highly useful in sustainable alternatives programs. While REACH programs are outside the direct regulatory purview of US EPA, they impact EPA indirectly in that REACH programs will require an extensive amount of animal testing on medium production volume chemicals in the coming years, resulting in a smaller universe of chemicals to which to apply newer, non-animal methods to assess safety. Read-across is the major means of reducing the burden of animal testing, and some of the new chemical and biological profiling methods coming out of ORD could be packaged into novel approaches for read-across.

Comments from Dr. Peter Chapman

- See previous comments.

Comments from Dr. George Daston

I would very much like to see more generation and analysis of toxicogenomics data from the computational toxicology program within CSS. This is a data stream that the research group within HHRA is already familiar with, and would likely make a fine adjunct to the ToxCast data stream for chemical prioritization and mode of action identification.

Comments from Dr. Michael Dourson

My impression of the CSS program is that it is highly collaborative and interactive with numerous outside parties. The supplemental material provided by Dr. Bahadori was particularly helpful in this regard. These CSS interactions will prove to be highly advantageous to EPA as it brings its limited resources to bear on this vexing area.

The same collaborative spirit appears to be developing with the risk assessment program, although I know of many folks outside of EPA (and some even within EPA) that would likely disagree with this statement. Even though the stated partners/stakeholders list is large, I am trying to envision if I spoke to

folks in these partners/stakeholders if they would agree. I am not sure that all of them would. EPA's memoranda with ATSDR and NIOSH are good, but expected. NCEA also needs to reestablish interactions with risk assessment experts in EPA's OPP--notably absent from the list of EPA partners. Furthermore, a host of organizations and individuals now exist outside of EPA that do credible risk assessment work in both methods and individual chemical assessments. All of these groups would welcome EPA risk assessment participation. The Alliance for Risk Assessment (ARA)---a stated partner--has a project on going "Beyond Science and Decisions: From Problem Formulation to Dose Response" that boast 35 case studies and 56 supporting organizations. As EPA steps forward to apply some of the findings of NAS (2009) Science and Decisions, this ARA project would be a good place to look (EPA's RAF is already a partner). The International Toxicity Estimates for Risk (ITER) database on the National Library of Medicine's Toxnet gets more hits at the NLM than the Integrated Risk Information System (IRIS). EPA would be welcome to have a larger role in this effort.

Comments from Dr. Elaine Faustman

- 1) EPA scientists have been involved in Children's Health Research Centers as well as with formative research projects from the National Children's Study. Many opportunities for lessons learned on methods and fit for purpose could be shared. (See examples from CSS webinars/training) as well as the numerous Children's Centers webinars. For example, workgroups on specific topics have been developed that could compliment efforts across the agency on topics of exposome and epigenetics. Research from the cohorts from the PM Centers as well as Children's Health Centers provide tremendously valuable populations and bio-repositories to determine fit for purpose for complex, cumulative exposures and risk based methods.
- 2) For the topic area of Emergent chemicals, additional partners on the Nano research can be identified in the NIEHS Funded Centers from Nano Go, and their Nano Consortium.
- 3) The brominated flame retardant projects were definitely interesting for characterization. Will Organophosphate based flame retardant projects also be included as they are current substitutes of potential interest?
- 4) Minimal discussion on agricultural chemicals was seen in the documents—pesticides, fungicides, neonicotinides, etc were gone and no indication of where such assessments fit. Who is addressing FIFRA?

Comments from Dr. Lois Lehman-McKeeman

It is noted that a potential project for HHRA is the development of probabilistic approaches to integrate different data type (mechanistic, in vitro, epidemiological; page 31 of HHRA), and it would seem that such approaches would be an obvious fit for CSS as well. [perhaps implicit, but not certain]. It is also not entirely clear how metabolism information (biotransformation of xenobiotics) will be utilized relative to both mammalian and non-mammalian toxicity. Hazard identification and risk assessment would be well served by successful integration of such data, so this is clearly relevant to both areas.

Comments from Dr. Ponisseril Somasundaran

There are other areas, though localized, in terms of fit-for-purpose characterizations. For example, industries develop their own *customized tools for risk prioritization*, risk screening, and risk assessment. *A unanimity in the approaches* used in the tools by the industries is necessary. Since *tools can be integrated to develop a robust assessment tool*, the products of other organizations who may have made enough advances to contribute to the fit-for-purpose characterizations should prove useful. For example:
a) in chemical and mining sectors, a number of greenness evaluation tools have already been developed,
b) Gulf of Mexico Research initiative organization can provide much needed information associated with risk prioritization, risk screening, and risk assessment of sea water, as innumerable workshops have been

conducted by chemical engineers, ecotoxicologists, policy makers etc on this issue.

There exists programs funded by NSF where industries and universities deal with a particular discipline in science. An example is I/UCRC (Industry University Collaborative Research Center). There are a number of such research centers across USA. The centers could be identified and brought under a single national umbrella to broaden the agencies' responsibilities related to water security and resilience and indoor/outdoor cleanup.

7. Homeland Security Charge Questions

7a. What advice (e.g., strategic, tactical, structural) can the SAB/BOSC give to further guide the program toward this broader role?

Comments from Dr. Peter Chapman

- Per previous comments, go beyond chemicals and drinking water systems, think more broadly relative to the five key stressors facing humanity in the future, in order of importance (see comments re 1b, above): global climate change, habitat loss, introduced/invasive species, eutrophication, and chemical contamination.

Comments from Dr. Nancy Kim

- The Homeland Security has incorporated all hazards into its StRAP quite well. Section III (Program Purpose) gives a brief summary of the transition and reasoning from the purposeful use of CBRN substances by terrorists to an all hazard approach. Both uses of its research are described throughout the document. Given the origin of the program, the terrorism aspects of the research are frequently mentioned before the all-hazard aspects in the text; as time passes, efforts should be made to have all-hazards predominate.
- Figure 1 is not particularly useful and should be removed or revised. Everything that is in the top of the pyramid ("EPA's all-hazards gaps currently not being addressed") does not necessarily flow from the bottom of the pyramid ("EPA's CBRN gaps being addressed by HRSP"). The diagram continues the emphasis on terrorism related research rather than all hazards. It does, however, provide a focus on the multiple uses of HRSP products developed for CBRN gaps and the StRAP should continue this emphasis by other means than the diagram.

Comments from Dr. Keith Moo-Young

The Homeland Security Program clearly state that they do applied research and technical support. Many of the research topics shown in the plan are aimed to develop tools and support. This is an extremely positive approach to conducting timely and use oriented research. One challenge that the program and plan may have is balancing short term needs with longer term goals. This will definitely challenge the EPA management team, however, it is the suggestion of this reviewer that EPA must prioritize and better understand how to be on the cutting edge of applied research dealing with the "All Hazards Approach".

One area of concern is the linkage of future research products listed in the narrative to the goals and objectives outlined in the plan. The Homeland Security Program should delineate how the anticipated research accomplishments for FY16-19 will achieve the goals outlined later in the document. This linkage is a key to effectively showing the reviewers that the systems approach and all hazards approaches achieve the EPA goals and objectives. In addition, this plan needs more narrative on how these projects will continue to achieve EPA objectives.

Comments from Dr. Paula Olsiewski

Broadening the definition of homeland security to include all hazards (e.g. natural disasters and industrial accidents) is appropriate. These hazards have the potential to threaten water systems, contaminate wide areas, etc., and may be more likely to occur than terrorist attacks. The big difference between natural disasters and terrorist caused disasters is *intent*, and this factor should be addressed.

Comments from Dr. Daniel Stram

- As perhaps most dramatically seen in Fukushima and Chernobyl, psychological impacts of a nuclear accident (initial fear, long term feelings of depression, loss, and hopelessness) and by extension other radiological events, can override all other effects on human health. While the effects of Fukushima (occurring within the context of a deadly earthquake and tsunami) and Chernobyl (where the accidents were followed by a long period of economic isolation and stagnation) are very likely to be at the outer extreme of those due to accidental releases, they may offer lessons to the EPA, and provide research problems for the HSRP in how to deal with the psychological side of such catastrophes.

7b How could the research program better incorporate this systems thinking and engage its partners in this systems thinking from a strategic and tactical standpoint?

Comments from Dr. Peter Chapman

- Do not understand the question.

Comments from Dr. Nancy Kim

- The question is not clear as to what “**this** systems thinking” means. As such, I’m assuming that it refers to the definition given in a foot note on page 1.
- I searched SHC’s and SSWR’s StRAPs using the words “systems approach” and found that the phrase was used 4 times in the SHC document and once in SSWR (the documents may have used other, slightly different wording about systems approaches that would have been missed by the particular search I used). As I’ve reviewed additional StRAPs, roadmaps, and presentations, all the ORD programs seem to be using the systems approach to some extent. ORD management will need to decide if it wants the programs to be consistent in their definition and use of systems thinking. Systems thinking helps in viewing and understanding a research area and can be used for a narrow project or a broad project. Either use could be valuable in organizing a specific project or a broad research program. Not all research projects may benefit from using a systems approach.
- ORD should consider defining a few words in an overarching section of its research plan for all the ORD programs. The words sustainability and systems approach or thinking are two concepts that should be defined. Doing so would help to ensure that all programs are using the same definition for these words
- One approach for HSRP to take in engaging its partners in systems thinking is to identify a particular item in the research agenda in which the systems thinking is not being used or is not being used in the same way by all partners. For this particular item, HSRP could show the benefits of using its systems approach for that research item.

Comments from Dr. Keith Moo-Young

The Homeland Security Research plan is extremely ambitious. Given the customer focused nature and timeliness of the products that the program need to develop, this reviewer is skeptical that the Homeland

Security Program can achieve its plan over the next four years with declining budgets. One of the major concerns of this reviewer is the declining budgets and FTE shown in the presentation to the SAB/BOSC. From 2012 to 2015, the Homeland Security Program will be reduced by \$11 million dollars and 11 FTE. With the ambitious research plan provided to SAB/BOSC, it seems impossible to achieve the research goals described in this document. Moreover, with two new paradigms of applied research, “Systems Approach” and “All Hazards”, the Homeland Security Program will require new scientists and engineers with different skill sets. One possible way to achieve the new human resources required would be to use the STAR fellowship program. However, with declining budgets, it may be difficult to stretch tight funding and dollars, but it seems very challenging to assume that the Homeland Security Program has the human resources to achieve the research plan. Thus, this reviewer strongly suggests that Homeland Security develop a human resource plan or attach an appendix regarding the FTE and budget required to achieve the plan presented. Once the human resources and FTE are mapped to the plan, it may be either deemed feasible or not feasible that the plan can occur with declining budgets.

The Homeland Security Program has multiple partners within the agency, and multiple constituents who require their services outside the agency. The presentation and plan outlines the partners. The plan can be strengthened if they provided the potential client for each research priority and how it can benefit both within and outside the agency.

Comments from Dr. Paula Olsiewski

The early draft HS StRAP is strong on the systems approach and I have no suggestions.

Comments from Dr. Daniel Stram

- It is not clear whether the tools to evaluate and identify improvements in their security and operational resilience in water systems are to be primarily used by EPA scientists and managers or whether personnel employed by the individual water systems or by local government are also to be users. Ideally the latter could be helpful in engaging partners and in applying the research products widely. On the other hand the technical expertise among such partners probably ranges widely. As the draft SP for HSRP is further developed these important questions should be more clearly addressed. Integrating all sources of information concerning the potential for industrial-caused contamination (plant locations, nearby chemical factories and their inventories, tank farms, runoff patterns, local streams and rivers, water system intake points, ground water chemical characteristics, pollutant characteristics, hydrology) into these tools seems like a mammoth job. But it would seem that this would be necessary to develop a system comprehensive enough to (giving a recent example) have either identified, a priori, a high potential for leakage from the Freedom Industries facility into the Elk River (perhaps leading to increased inspections) or to have immediately detected the contamination. Is this the level of detail that is being strived for by the EPA HS tool development?

8. Roadmaps for Cross-cutting Issues

8a. How effective is each Draft Roadmap in presenting a problem statement, elucidating key research topics, capturing relevant research in each of the six programs, and identifying any important scientific gaps?

General comments from Dr. Edward Carney

Overall, the Draft Roadmaps are very clear and deliberate in articulating problem statements, research topics and gaps. However, the research topics tend to be quite extensive leading one to question what are the top priorities and if all of the proposed research is really necessary to have a tangible positive

impact on public and environmental health.

Using the Children's Health road map as an example, the number of *possible* adverse outcomes is vast, but only a smaller number of adverse outcomes affecting early life stages drive overall risk assessments. The study of mixtures is another area for which prioritization is essential. Some of the new programs in high throughput toxicity testing and exposure assessment offer an opportunity to do such integrated prioritizations so that ORD resources are applied in areas which bring the greatest benefit to human and environmental health.

General comments from Dr. Peter Chapman

- The four Draft Roadmaps can be divided into two classes: inadequate and incomplete (Environmental Justice and Climate Change Research Draft Roadmaps) and generally adequate and complete (Children's Environmental Health and Nitrogen and Co-Pollutants Draft Roadmaps).

General comments from Dr. Terry Daniel

The cross-cutting issue road maps seem well thought out and promise to accomplish the intended integration of research capacities across the existing programs. How these well-intended plans work out in fact will depend upon how strongly the various participating programs and laboratories commit to the respective research collaborations proposed. Experience suggests that achieving and sustaining the needed level of commitment often depends upon how research budgets are determined and distributed and on how well individual scientist's professional goals are supported and their work is recognized and rewarded in the context of these cross-cutting research enterprises.

General comments from Dr. George Daston

I found all of the draft roadmaps to have presented clear problem statements. I found the degree to which these problem statements were followed by clearly stated research goals was uneven, and did not always seem to correspond to the stated goals of each of the program areas. I would encourage these programs to have a deeper conversation with the national program directors to determine what is possible scientifically, rather than simply presenting them with problem statements.

The climate change research and environmental justice programs appear to rely very heavily, indeed almost exclusively, on the air and communities research programs, respectively. While this makes sense, it suggests that these cross-cutting areas should be subsumed under the larger research programs if for no other reason than organizational simplification.

General comments from Dr. David Dzombak

The draft roadmaps are well organized and generally meet the goals of defining the cross-cutting problem, identifying key research questions, identifying relevant research in the six ORD programs and elsewhere in EPA, and in identifying some important science gaps and research needs. The draft roadmaps are still in development, and some are further along than others.

The cross-cutting roadmaps represent a very important step forward for the EPA. These roadmaps provide frameworks for integrating research across ORD programs and offices, and with other agencies, and keeping ORD research forward looking. Developing the roadmaps clearly has been a lot of work and engaged significant ORD resources. The investment is well justified for potential future impact on ORD and the EPA. The roadmap development and implementation process will evolve and be improved with time. The draft roadmap documents represent the first step in what hopefully will

become a staple of ORD and EPA operation.

An important element missing from the draft roadmaps is an implementation plan for each roadmap. It is unclear which group within the EPA will be assigned to keep the framework in front of ORD and EPA program office managers, keep the framework as a living, evolving document, and monitor progress on the roadmap, and be responsible for impact of the roadmap. Development of an implementation plan for each roadmap is important, at least in some initial form that can be modified with time.

General comments from Dr. Elaine Faustman

This reviewer thought the question should be reversed, how effective are the research programs in addressing these cross-cutting areas of importance. The presentations by the research programs were almost silent. More details should be added!

General comments from Dr. Nancy Kim

Developing these roadmaps in the 4 priority areas is a good step to help ensure coordination among agencies and within ORD and helps to develop an effective research agenda in developing the needed research on a specific topic and that uses resources efficiently.

- The roadmaps are in different stages of development, particularly in the analysis of scientific gaps and integration.

General comments from Dr. Elizabeth Matsui related to the Children's Health and Environmental Justice Roadmaps

With respect to the Children's Health and Environmental Justice Roadmaps, these documents reflect a large effort on the part of the Agency to take a very broad view of these environmental issues and in large part are well conceived.

There are a few areas that may benefit from some additional thought, which were mentioned in some comments above:

- There is little mention of implementation science, which is needed to study how best to implement interventions that have been shown to work at the clinical trial stage of the translational spectrum.
- The discussion of supporting programs to disseminate research findings seems to stop short of including scientifically rigorous assessment of the effects of disseminating research findings or implementing interventions on both exposures and health outcomes in communities.
- There is emphasis on the development of tools that can be used by communities to assess risk and plan, but it is not clear that there is a plan to support research aimed at understanding how often the various tools are used, by whom, whether they lead to any change in the community or action by the community, and whether that change has beneficial effects.
- In some of the strategic plans and roadmaps that include a human health component, there seems to be much greater emphasis on the ends of the translational research spectrum and less emphasis on the "middle" of this spectrum. The emphasis appears to be on both foundational research (animal models, toxicology studies, observational cohorts) and then, at the other end, community action. The pieces that appear to be quite limited are: the development of interventions, the science of implementing proven interventions, the science of assessing the impact of implementing the intervention on environment and health outcomes, and then the science of dissemination. These are all of the steps between the foundational work and the activity of disseminating tools and/or results of studies.

General comments from Dr. Duncan Patten

The problem statements and research topics are concise and relatively well presented. Gaps identified in each Draft Roadmap should be considered "a best guess" for what is known today. Roadmaps should allow for flexibility and potential for adjustment. **One worries that once "set in stone", the roadmaps will be the only guide for future action. It is not obvious in the proposed plans that adjustments can be readily made if needed.**

General comments from Mr. Richard Poirot

Taken individually, each roadmap seems effective in identifying the relevant problem statement, key research topics in the 6 program areas, and important information gaps. Considered individually, some of the cross-cutting issues are inherently broader and more complex than others (e.g. climate change vs. environmental justice), and some reflect topics with longer-term historical context (children's environmental health) than others (nitrogen & co-pollutants). That being said, the Children's Health and Nitrogen documents stand out as being the most clearly written and fully-developed roadmaps. They provide detailed identification of relevant research already underway or planned in the various program areas and identify important gaps that will need to be addressed. They also do a good job identifying specific links/partnerships with other federal agencies and international organizations, which is an area that would be useful to articulate more clearly in the climate change roadmap – as it will be especially important to coordinate with other federal agencies with unique skills and resources, and critical to participate in key international research, mitigation and adaptation efforts.

A minor comment on the Climate Roadmap is that while "research needs" emphasis is placed on the role of black carbon as a climate forcer, there might also be some emphasis on particle light adsorption at shorter (i.e. "brown") wavelengths. For example, biomass combustion typically emits relatively small amounts of "black carbon" and much larger amounts of "organic carbon" – which is often assumed to be an exclusively light scattering aerosol – even though it absorbs light quite efficiently in the shorter wavelengths.

Overall, the 4 roadmaps all provide good indications that highly productive integration activities are being undertaken. It would be productive to continue and build upon this process in the future.

General comments from Dr. James Sanders

On first reading, the plans are well considered, and the problem statements are well formulated. Without being a part of the process, it is difficult to state that they capture all the relevant research or identify all the important scientific gaps. However, they appear to focus on many important processes. As the programs continue, I expect that other gaps and research needs will be identified.

General comments from Dr. Ponisseril Somasunderan

The draft roadmap provides a basis to address the cross-cutting issues. As the roadmap is in developmental stage, *examples could be taken from models from other global EPAs to help chalk out strategies towards prioritizing key cross-cutting global research themes.*

General comments from Dr. Katherine von Stackelberg

At the 30,000 foot conceptual level, each Roadmap is successful in achieving those goals.

Children's Health

Comments from Dr. George Alexeeff

The Children's Environmental Health roadmap is a great description of the information available and needed to incorporate consideration of early life stage susceptibility and vulnerability into decision making. The roadmap identifies key research areas.

Comments from Dr. Joseph Arvai

- This roadmap is extraordinarily well done. It is clearly written, and appropriately detailed.
- The roadmap presents a clear problem statement, identifies a series of key research topics, and identifies any important scientific gaps.
- This roadmap does an excellent job in terms of addressing synergies with each of the six ORD programs.
- This roadmap should, in my opinion, serve as a template for each of the other three roadmaps.

Comments from Dr. Peter Chapman

- Problem statement: Excellent, very well done.
- Identification of key research topics: The four research areas and associated key research questions are well laid out and justified; the summary at the end of each on integrated impact is very useful.
- Capturing relevant research in each of the 6 StRAPs: Very well done, see "Other comments", below.
- Identification of scientific gaps in cross-cutting issues: Well done although the "Synthesis of Existing Gaps" remains to be completed.
- Other comments:
 - The Executive Summary is well written and very informative.
 - The Introduction is excellent, particularly the section on Scientific Drivers Related to Adverse Health Outcomes.
 - Figure 1 is excellent.
 - Agree with Table 2 showing CEH research efforts distributed across the StRAPs and four research areas. In comparison to the Environmental Justice and Climate Change Research Draft Roadmaps the cross-cutting ORD research is very well explained.
 - Tables 3-6 are very useful and informative.
 - Figure 3, the conceptual framework, is very useful as is Table 7.
 - Examples 1-3 (pp45-52) are also very useful and well done.
 - References are provided.

Comments from Dr. Joel Ducoste

- Has effectively identified the major cross cutting issues related to children's health that are relevant to research in five of the six programs
- Key research topics along with scientific gaps were identified
- The document provided a summary of both ongoing research as well as ongoing research within the 4 research areas presented. No ranked priority list was provided. However, the list of research objectives and future projects seemed reasonable for significant progress to be achieved by 2019.

Comments from Dr. Courtney Flint

- Children's Environmental Health – The problem statement and key research topics are quite well articulated, but links to the various programs is marginal at best. This is likewise true in the other directions – i.e. the StRAPs under-report links to the roadmap on CEH. Direct links are made to strategic goals on communities and chemical safety, but links to other goals are deep into the report and not fully elaborated. It seems a missed opportunity to highlight the role of water and air as

pathways for toxicity toward children as a vulnerable population (CEH Roadmap, p. 18). Further, the extensive risk assessment and decision-support tools from HHRA could be better integrated into the CEH Roadmap. There appear to be stronger connections made between CEH and SHC than other programs. (Note: the list of activities in Appendix B is more elaborate, but attention to these links could be better integrated into the text.)

Comments from Dr. Robert Johnston

- The Children’s Environmental Health cross-cutting roadmap appears to provide a comprehensive and well-organized perspective on relevant research and research gaps in this program.
- The roadmap does a good job of clarifying the research being conducted (or that will be conducted) by each ORD program, as well as that which will be conducted by ORD itself (in contrast to partners outside of ORD).

Comments from Dr. Catherine Karr

The introductory opening material might benefit from some “problem statement” commentary regarding the compelling evidence for the vulnerability of early life periods to exposure and adverse health consequences from environmental contaminants that has developed from an investment in research in this area. This would complement the introductory material regarding the agencies historic incorporation of child eh considerations into policies. This would underscore the need for ongoing focused investment in this research arena and the need to continue to facilitate links between accumulating evidence and improved evidence based policies.

The key research topics (four research priority areas) are well presented in the context of their “drivers”. The framework provided in figure 2 is excellent in its clarity and comprehensiveness.

Overall the important research gaps in each of the four priority research areas are effectively identified but in broad, unspecific terms. The importance of research that incorporates cumulative impacts of chemical and non chemical stressors is noted and of key importance. A placeholder replaced a gap synthesis section in the July 2, 2014 draft provided. Gaps that are not highlighted that should be considered include:

Expanding the priority health outcomes to include pediatric cancer (in addition to birth outcomes, neurodevelopment/neurobehavior, metabolic (obesity), and asthma/airway function. While less prevalent in the population in contrast to the other groupings, the devastating nature of this outcome in context of the emerging evidence base on links to environmental stressors as well as increasing incidence merits its inclusion as a priority health outcome endpoint for the ceh research program.

Some important “gaps” in the current ceh evidence base that should be considered for clearer emphasis/inclusion in the strategic plan include: research on environmental health among children in agricultural, rural settings, research focused on exposures and exposure-disease relationships in the peripubertal and adolescent lifestage, and research on intervention and prevention strategies that translate evidence into practice. In regards to the latter, as components of the ceh evidence base mature (e.g. role of air pollutants on asthma), research that informs effective translation of this evidence base to public health professional practice or clinical professional practice must be included in the research continuum. Data on environmental contaminant uptake in children using biomarkers in the age group under 6 years is needed to complement the rich CDC biomonitoring program which does not routinely include this lifestage (with exception of blood lead levels).

Ongoing support should be emphasized in the strategic plan for highly productive and effective research approaches including the Interdisciplinary Children's Research Centers Program, observational epidemiological studies that can assess real time exposures and multiple exposures, and studies addressing school/daycare environmental health.

Comments from Dr. Nancy Kim

- The Children's Environmental Health roadmap, in broad terms, provides much background information about the historical development of programs related to children's environmental health and scientific background in the area. It needs to be developed further to provide a useful roadmap.
 1. Information is given on page 14 in the first paragraph and last paragraph of the Purpose section. However, this description falls short of the purpose/vision/roadmap provided in the Nitrogen roadmap or the Environmental Justice roadmap. For example, integration is not mentioned; the purpose section doesn't provide much a brief summary about how about research outside of ORD or outside of EPA will be considered although outside research is considered in other sections of the roadmap. CEH is a very broad subject and relevant research is being carried out by many different researchers. As such, developing the CEH roadmap is challenging. The purpose in the Environmental Justice roadmap (since the EJ area is also very broad) may be useful to the CEH working group.
 2. In general, the roadmap includes much background information to develop the roadmap, but it needs to synthesize the information and prioritize/target specific research needs/gaps. One suggestion is to include the background information in an appendix which would allow ORD to focus on meeting the objectives/goals of the roadmap in the main part of the document.
 3. One approach to revising the CEH roadmap is to focus on one or two very specific priorities in each research area instead of trying to cover everything. Reviewing or adapting the processes used in the Nitrogen and Climate Change roadmaps may also help in revising the roadmap.

Comments from Dr. Francine :Laden

The "Children's Environmental Health Crosscutting Roadmap" is effective in presenting a problem statement, elucidating key research topics, laying out the distribution of the research areas across the six program, and identifying scientific gaps. The key research topics encompass (1) knowledge infrastructure to provide lifestage-specific data and information; (2) systems understanding of the relationship between environmental exposures and health outcomes across development; (3) methods and models to evaluate early lifestyle-specific risks and to support decisions protective of all susceptible and vulnerable early lifestages, and (4) translational research and tools to support community actions and decisions. The problem statement appropriately focuses on a lifestage approach.

Comments from Dr. Paula Olsiewski

The preliminary draft of the children's environmental health roadmap is detailed and comprehensive. One important gap is the need to include analysis of the human microbiome when evaluating environmental contributions to adverse outcomes. The human microbiome is acquired during the first three years of life and plays an important role in disease, health and allergy (<http://onlinelibrary.wiley.com/doi/10.1111/pai.12232/full>).

Comments from Dr. Daniel Stram

- Children's Health: This document seems like an excellent source of information about the agencies work on understanding science problems related to children's health research and on the resources that it can draw upon in assessing impacts of exposures on children.

Comments from Dr. John Vena

The executive summary is well written and concise. The Introduction effectively summarizes the recent actions in children's environmental health and explains the current drivers that define the need and focus of the CEH research including the strategic plan, program office developments and the state of the science. Table 1 is excellent and helpful. It is unclear as to why the following programs listed in table 1 were not discussed or referenced as drivers of the CEH research agenda:

Canada 2010 National Strategic Framework on Children's Environmental Health (http://www.hc-sc.gc.ca/ewhsemt/pubs/contaminants/framework_childrencadre_enfants/index-eng.php#a0)

European Union 2013 The Helix Project (<http://www.projecthelix.eu/>)

The life stage scope of the research is described and figure 1 is presented but the articulation of how the stages influence the research strategies could be better developed. Also, was the WHO guidance on identifying important life stages (fig. 1, pg. 7) considered and incorporated in the development of the approach?

For example it is not clear why only four adverse outcomes discussed in depth were the "outcomes of high interest".

The research scope, research areas and key research questions were masterfully developed. However several questions were raised by the translational framework:

"The second translational route lies through using knowledge of individual patterns of exposure and disease predisposition to develop community-based approaches to health promotion and risk management. Here, environmental health research and public policy can only fully empower communities to manage risks by providing a clear understanding of important exposures and where these can be locally controlled."

This statement is vague and needs further development to be meaningful.

"By requiring characterization of biologically relevant exposure, the framework presented in Fig. 2 facilitates translation of advances and findings in computational toxicology to information that can be directly used to support risk assessment for decision making and improved public health."

This seems to be overstated. Explain how?

The key research areas are well developed and described. None-the-less several issues need clarification as noted below:

Research area 1

"While much of these data may come from outside the Agency, key data required to support risk-based decisions requires targeted Agency support and the knowledge systems to facilitate integration and analysis to identify and protect susceptible

lifestages.” Explain knowledge systems.

Research Area 2

A holistic understanding of the factors that impact children’s health, specific to each stage of development, is needed in order to attribute, reduce and eliminate risks specific to the environmental exposures over which EPA has regulatory authority.

OUTCOMES highlighted: abnormal birth outcomes (neonatal mortality, premature birth, morbidity, birth defects), metabolic and endocrine imbalance (associated with obesity), cognitive disorders related to neurodevelopmental dysfunction (learning problems, attention deficit hyperactivity disorder (ADHD), autism), respiratory dysfunction such as asthma.

Other outcomes related to endocrine disruption????

“Integrated impact: Systems information across all levels of organization associated with development and childhood disease and wellbeing is incorporated into predictive modeling to inform Agency risk assessments and environmental programs.” This seems to be a lofty goal that needs to be more carefully outlined and developed.

Research Area 3

Risk assessment tools for incorporating multiple exposures across multiple vulnerable stages to estimate risks that may accrue over time.

Extend models and methods to estimate children’s exposures at spatial and temporal scales relevant to the pollutant and health endpoint of concern.

Cross Cutting Research in each of the six programs is presenting in an exemplary manner. Upon review several questions arose:

Research Area 1 pg. 23

1.2.1 Enzyme Ontogeny Databases (CSS)

Effectiveness and utility for epidemiologic studies and risk assessments???

1.3.3 Adverse Outcome Pathway Wiki (CSS)

Use outside ORD? How well developed across four outcomes of interest and others??

Pg. 39

“The NIH (including NIEHS and NICHD) is currently investing significant resources in research to increase our understanding of the fundamental shared mechanisms of complex disease, susceptibility across the life span to diseases resulting from environmental factors, and links between the totality of environmental exposures and biological pathways (National Institute of Environmental Health Sciences, 2012).”

The tables present the EHC initiatives including research agendas and community engagement but they are lacking in any information regarding the NICHD and/or the Children’s Health Study’s research agendas.

“EPA’s Strategic Plan translates this fundamental knowledge to provide a systems understanding that is necessary to adequately protect the health of children.” HOW??

Conceptual Approach

“EPA CEH Research will **apply complex systems science** to integrate the rapidly expanding body of information on children’s environments with advancing insights on developmental processes to inform the understanding of key factors contributing toward health outcomes.” Reference ES models??

Examples are excellent: Example 1: Birth Outcomes (Vascular VTMs) and Example 2: Asthma (MICA Study).

This cross cutting roadmap is superbly developed and will be a great start to integrating research on CEH across the six programs.

Comments from Dr. Peter Wilcoxon

- Children’s environmental health: very clear description of the problem and the topic’s importance to EPA. Clear and well-organized linkages between ORD programs and CEH topics. One area that wasn’t clear concerns translational research. Many partnerships were listed but it was not clear whether specific communications strategies were being tested formally, or whether the partnerships were essentially independent case studies.

Climate Change

Comments from Dr. Joseph Arvai

Again, many opportunities for synergies here. However, I had largely the same reaction to this roadmap as I had to the Environmental Justice roadmap.

In my opinion, more work needs to be done (Figure 1 and the appendices, notwithstanding) to highlight the connections between this – absolutely crucial – work on climate change and the six ORD research programs.

Comments from Dr. Peter Chapman

- Problem statement: Not provided, so could not be evaluated.
- Identification of key research topics: There should be 5 not 7 (bottom of p 4); key research topics as "Social Science Influences" and "Uncertainty" as noted (p5) are cross-cutting to all 5 research topics.
- Capturing relevant research in each of the 6 StRAPs: For Figure I the following box should be shaded gray: SHC and Air Quality.
- Identification of scientific gaps in cross-cutting issues: This is well done - lots of detail.
- Other comments:
 - No Executive Summary.
 - Introduction and Background are well done.
 - International partnerships are conspicuous by their absence.
 - Does not make sense that (p6) "emerging problems cross-cutting topic is identified as being led by the ACE program, primarily due to the fact that ACE has the lead for climate change research more broadly".
 - Page 6, Water Quality and Aquatic Ecosystems - wording suggests more marine and estuarine/coastal than freshwater.
 - Cross-cutting ORD Research is generally described well and in good detail, in particular work outside EPA.
 - What are "tipping points" (p9)?
 - Why is research "not currently being conducted to evaluate the impact of climate change on harmful algal blooms"?

- What is the "energy paradox"?
- Interesting that the primary international program is testing of cookstove performance and emissions - the justification for this program is absent.
- Excellent examples provided of the use of the STAR Program and, in the case of the ACE program (p16), the addition of a post-doctoral researcher.
- The section on Ecosystems and Land (p13) is particularly well thought out and written.
- The section on Mitigation and Associated Environmental Impacts is well written until one comes to the Research Needs, which appear to be relatively trivial in comparison to the importance of this section.
- Fully agree with the "potential for 'low probability-high consequence' impacts" (p 17).
- Example 3 on p 18 is excellent.
- Good to see that climate change is considered central to "EPA's unique niche" (first bullets on p22).
- Fully agree on the importance of syntheses (p23).
- Discussion of social sciences and technologies (p23) is useful.
- References are not provided.

Comments from Mr. Shahid Chaudry

- The roadmap clearly provides an overview of recent, ongoing, and planned research activities across ORD's six programs. The roadmap identifies knowledge gaps in climate change impacts on water quality and aquatic ecosystems, air quality, human health, land and terrestrial ecosystems, and mitigation and associated environmental impacts. Most importantly, the roadmap provides identified research needs and research activities underway to address some of the identified those needs.

Comments from Dr. Joel Ducoste

- Has effectively identified the major cross cutting issues related to climate change that are relevant to research in the six programs
- Key research topics along with scientific gaps were identified
- A priority list was provided for the research related to OW and think the topics are listed in an appropriate order of importance. However, OAR and OSWER did not rank their list. While the topics seem reasonable, I would have listed them in a different order assuming that they are listed from highest to lowest priority.

Comments from Dr. Courtney Flint

Climate Change Research – This roadmap grapples with a vast array of interconnections with ORD programs and goals in a fairly succinct manner. The identification of social dynamics as a research gap to be filled is smart. Staffing in this area will be critical for success in addressing these issues as they relate to the various cross-cutting strategies and goals.

Comments from Dr. Kimberly Jones

Climate Change Research – this Roadmap is comprehensive and truly involves each research program. On Figure 1, SSWR should have some relevant activities in air quality, as water and air quality are ultimately related as two of the three primary environmental media. Although SSWR StRAP does not specifically call out air quality, the idea of “watershed sustainability”, along with shared stressors (extreme events, land use, etc) are common problems and could be synergistically addressed.

Comments from Dr. Robert Johnston

- Climate change presents broad set of research challenges, and the cross-cutting roadmap does a commendable “first-cut” job of trying to encapsulate many of these challenges as relevant to each ORD research program. However, there are many areas in which the road-map could be improved.
- Overall, the climate change roadmap is much less detailed than other cross-cutting roadmaps. For example, while climate change is a more complex, overarching concern than either children’s health or cross-media nitrogen, the climate change roadmap is much shorter than the children’s health and nitrogen roadmaps. The treatment of relevant issues is also at a much greater level of abstraction. The gap analyses come across as much less detailed.
- The effectiveness of the roadmap is variable across different areas of science. For example, the coverage of social system influences is sparse compared to other areas given more comprehensive discussion. Moreover, there is a concern that social science issues will be given inadequate attention given that no lead program was identified for the social science cross-cutting topic.
- Compared to other roadmaps (and this is not surprising given the sweeping nature of the climate change challenge), the climate change roadmap seems to have a somewhat “shotgun” approach to the relevant research challenges and gaps – giving extensive attention to some topics while overlooking (or giving only sparse attention to) others. It is unclear to what extent research topics and gaps given attention were chosen strategically based on research needs, or opportunistically given the interests and strengths of each research program.
- As an example, research gaps related to climate effects on Water Quality and Aquatic Ecosystems (p. 9) are described in approximately one-half of a page. This discussion only begins to address the gaps in our understanding of these systems necessary to address the consequences of climate change. This seems cursory compared to the extensive and detailed gap analyses presented in other cross-cutting areas.
- Gaps in social science research are given inadequate attention. Only four cross-cutting social systems issues were identified by ORD partners (p. 16). These reflect only a miniscule fraction of the social science research issues related to the Agency’s response to climate change.
- The climate change roadmap is less well-organized than other roadmaps. In general, it comes across as unsystematic. It would be helpful to include diagrams, model schematics, tables and other organizing approaches to help convey the systematic approach that ORD is taking towards this important cross-cutting area. (The Children’s Health roadmap includes a number of examples.) Otherwise, the plan risks coming across as a mere collection of loosely-related research projects.
- It would also be useful for the plan to communicate more clearly the comparative advantage that ORD has in climate change research relative to other federal partners. That is, what areas of research are ORD uniquely positioned to move forward, given its position within EPA and relative areas of expertise? While this is implied in the discussion, it is not presented clearly.
- Given the important role of sustainability in the StRAPs and the fact that climate change presents substantial challenges to sustainable outcomes, it would be useful to include a meaningful discussion of how sustainability will be addressed with regard to climate change impacts. Currently, there is very little discussion of sustainability within the cross-cutting roadmap. Excluding research project titles and non-substantive appendices, the word sustainability appears only 4 times in the document.

Comments from Dr. Nancy Kim

- The Climate Change Research Roadmap is not as far along as the Nitrogen Roadmap. It appears to be effective in presenting a problem statement, elucidating key research topics, capturing relevant research in each of the six programs, and identifying important scientific gaps.
1. The purposes are given for the roadmap and what it is designed to do (page 4). Having a specific goal for the roadmap (see Nitrogen roadmap goal) may strengthen it.

2. The roadmap identifies research within ORD programs, but doesn't appear to capture relevant research that may be on-going in other EPA program areas although it mentions the research interests of other program areas (OSWER, OAR, OW, etc.).
3. The roadmap identifies "key research topics that align with five major areas of emphasis for EPA's regulatory and other programmatic activities" and states the science challenges for those topics. Additional support should be provided for selecting these particular challenges.

Comments from Dr. Francine Laden

The "Climate Change Research Roadmap" is effective in elucidating key research topics, capturing and laying out relevant research in each of the six programs (appropriately the role of ACE is emphasized), and identifying important scientific gaps. The Problem Statement has not been finalized for this draft. The specific discussion of gaps in the following areas is highly relevant and important: social sciences, uncertainty, decision-relevant scale, and synthesis.

Comments from Dr. Surabi Menon

The four cross-cutting roadmaps are well tied to the StRAPs and by themselves address strategic questions, and how gaps are being identified and met within the various research programs. My specific responses on how effectively the Climate road map addresses the question are listed below:

- 1) ORD has identified that it seeks integration across multiple dimensions to avoid duplication, fill gaps and provide results – how does it prioritize this within research topics? E.g. under gaps and priority research needs, best practices for communities to adapt to and mitigate climate change is identified. What would be scoped under this topic? (Appendix C did not cover it either). This topic is so broad and not well defined, and thus outlining a few basic components of research to be done under a narrower topic would be more useful.
- 2) How does ORD account for research needs not currently addressed by ORD's own research programs? A clear guideline was not included in Appendix C.
- 3) Some more thought should be given to expand the identified gaps and research under ecosystems and land, which seemed a bit cursory. Some of this work could be linked with analyzing impacts from mitigation strategies. Specific mitigation strategies linked to impacts on ecosystems could be included here.
- 4) ORD should make sure that for the focus on future conditions, uncertainty is dealt with as thoroughly as possible through scenario exercises and tracking real world trends with scenarios. This tracking exercise with real world observables, if done systematically, can be very helpful to narrow ranges of plausible future outcomes.

How does ORD help inform decision makers of the timing, magnitude and uncertainties of expected changes? This has been identified in the roadmap but how this would be presented is not clear. This communication should be considered an important element of the climate change roadmap and updates on outputs and outcomes could be included.

Comments from Dr. Paula Olsiewski

- The preliminary draft of the climate change roadmap is comprehensive. I have no suggestions.

Comments from Dr. Daniel Stram

- The Roadmap document identifies 5 research challenges, one each for the 5 areas of main emphasis of the EPA's regulatory and other programmatic activities. All 5 identify difficult problems, many involving (in statistical terms) complex interactions between climate changes and other stressors or

contaminants. The overall relevance and coordination of these aims with the research being conducted in each of the six programs seems good.

Comments from Dr. Jeanne VanBriesen

The climate change research roadmap draft presents a general overview of the problem and elucidates some research topics, but it is not clear why these research topics were selected and others were not. For example, the water quality focus is on hydrologic stationarity. This is very important, of course, and this quantity concern has quality impacts, but it is only one of many possible science challenges for this area. Why focus on hydrologic variability? There could be very good reasons, but they are not presented in the document. For the air question, the research question is two fold – how air quality affects climate and how climate affects air quality (although later in the core list only air quality impacts of climate change are listed). It is not clear why the water question is one-way only, with a focus on how climate affects water and not including how water affects climate. Given the role of water vapor in global climate, this seems odd. Is EPA focused on the effects of climate change on water, leaving the inverse to NOAA? This is suggested by the final list (pg 22) of core questions, which is even more narrowly on the impacts of climate change on water quality.

After identification of the fundamental question being one of the difficulty relying on historical data (for what is not clear), the priority research needs are then defined as falling into four main topics (as identified by OW and the regions). The alignment of these four topics with the fundamental question is unclear. How are these four main topics dominated by the difficulty in relying on historical data under varying climate conditions? I have no argument that changing climate driven demands on water treatment systems is an important area, but what does it have to do with the fundamental question of hydrologic non-stationarity? Following the identification of these priority research needs, there is then a listing of ORD's research on water issues associated with climate change. The alignment of these research projects and foci with the priority research needs or the fundamental question of non-stationarity is not clear. Thus, this plan does NOT do a good job capturing relevant research in the program. The relevance of the summarized projects to the identified needs or the overarching question is not explained. The details of the research projects are too sparse to allow the reader to assess the relevance. The described gaps seem reasonable, but the description of research inside EPA and the assessment of research taking place outside the agency is too brief to support the significance of the identified gaps.

The cross cutting issues (social science and uncertainty) are linked in the description, and the priority research needs identify only social science aspects. There is significant need to incorporate a better understanding of uncertainty across the research in the climate change area. Very little detail is provided regarding current research on uncertainty; however, this is not directly noted as a significant gap. No section on "gaps" is specifically provided for the cross-cutting areas. The section seems to focus on ORD integrated research, an interesting area, but not one relevant to addressing the cross-cutting issues of social science and uncertainty.

The synthesis of existing gaps is a list (not a synthesis) of gaps identified throughout the document. The section on synthesis highlights the need for such synthesis. This roadmap has the potential provide this integrated view of research across the agency and the remaining gaps, but it does not. The uncertainty focused section is focused on uncertainty in future state predictions (scenarios and ensembles) rather than uncertainty inherent in collected data or modeling structures used throughout the research conducted by ORD. This is a limited view of uncertainty, which should be expanded to include how model and data uncertainties are integrated into research projects and description of results.

The appendix C table of research needs and alignment with existing projects is quite helpful. It is not clear why certain priority questions have a lot of projects (e.g., ‘investigate linkages between air quality and climate change’ top of page 32) and others have only one or none. Further, some of these topics are listed with priority numbers and others are not. Is there any meaning to the priority listing? Do the research plans from the five areas address the specific needs described in the cross-cutting gap assessment? I don’t see this discussed explicitly in the SSWR StRAP.

Comments from Dr. Peter Wilcoxon

- Climate change: very clear in describing the problem, with good emphasis on the importance of adaptation. Good emphasis on the importance of social and behavioral systems and on the importance of deep uncertainty. Generally very clear about gaps and areas where research is needed but ORD is not undertaking it. Clear statement of research needs. The climate change roadmap is MUCH better than the ACE StRAP on discussing possible collaborations on energy modeling.

Environmental Justice

Comments from Dr. George Alexeeff

The Environmental Justice research roadmap provides an overarching framework for EJ research across research programs.

The expanded problem statement is good.

Understanding biological, social, spatial and environmental factors associated with vulnerable populations in communities is an important research area.

Developing decision support tools is important, yet some discussion of simpler analytic approaches should be added as well.

We have found that collaborative community discussions in our EJ approaches has improved the tools we developed and expanded our scientist’s outlook at problems.

However, the cross-research program interaction in this cross-cutting issue focusses a lot on incorporation nonchemical stressors, which is good.

Comments from Dr. Joseph Arvai

- I would characterize this roadmap document as, at best, a good place to start.
- The first 6 pages prove a history of EPA EJ activities.
- The next 4 pages provide a good glimpse into the synergies between EPA EJ and ORD’s six research areas. In my view, there are many connections to the six research areas, but the level of detail about these synergies is – in my opinion – woefully inadequate. I recommend the authors look closely at the roadmap for Children’s Environmental Health for guidance.
- I believe EJ to be an extremely important area for EPA research and, critically, practice. For this reason. I’d like to see this roadmap fleshed out.
- (To be fair, Appendix A is extremely helpful in terms of highlighting synergies across the six ORD research priorities. Personally, I’d like to see more text built around this information.)

Comments from Dr. Peter Chapman

- Problem statement: Good that both chemical and non-chemical stressors are considered, as is holistic research.
- Identification of key research topics: The three science challenges are appropriate with the proviso that more explicit consideration should be given to trade-offs (i.e., positives and negatives of any actions).

- Capturing relevant research in each of the 6 StRAPs: This is done well in Appendix A relative to the current StRAPs but subject to comments on those StRAPs as noted above; however, Table 1 (VI Summary, p 12) – box CSS and Science Challenge 3 should be gray not white.
- Identification of scientific gaps in cross-cutting issues: The need for international partnerships is notable by its absence. More importantly, no data gaps are specifically identified, thus the document is deficient.
- Other comments:
 - No Executive Summary.
 - The Introduction is generally well done in terms of setting the stage although mention of international collaborations is unfortunately absent.
 - The Purpose is also well done and the Goal clearly articulated in a text box (p6).
 - Collaborations will address many but not all of the components for which EPA does not have proven expertise (e.g., “economic and psycho-social stressors” [p7]).
 - Sections IV and V (p11) have not been completed, obviating full review of this Roadmap.
 - References are not provided.

Comments from Mr. Shahid Chaudry

- Like CC Roadmap, EJ Roadmap provides a problem statement along with identifying needed research that will result in enhancing the effectiveness of the science in meeting EPA’s needs to mitigate potential environmental risks to low income and minority communities. In this context, EJ Roadmap provides an overarching framework to ORD’s six research programs (ACE, SSWR, HS, HHRA, and CSS) to include projects that help addressing EJ challenges. It further collaborates with external partners to benefit from their relevant research. EJ Roadmap, however, neither identifies research gaps nor priority research needs.

Comments from Dr. Joel Ducoste

- Has effectively identified the major cross cutting issues related to children’s health that are relevant to research in five of the six programs
- Key research topics along with scientific gaps were identified
- The document provided a summary of both ongoing research as well as ongoing research within the 4 research areas presented. No ranked priority list was provided. However, the list of research objectives and future projects seemed reasonable for significant progress to be achieved by 2019.

Comments from Dr. Courtney Flint

- Environmental Justice – This roadmap seems the least well developed. Environmental justice is not defined or operationalized for measurement or benchmarks on progress. Links to programs are stated generally, but not specifically.

Comments from Dr. Robert Johnston

- The Environmental Justice cross-cutting roadmap does a good job of motivating the need for cross-cutting research in this area.
- Like the climate change roadmap discussed above, the environmental justice roadmap provides a relatively abstract discussion of the science. The issues are discussed in general, but the specific science proposed to address needed knowledge gaps is either omitted or discussed in general terms.
- The cross-cutting roadmap omits some of the most important sections necessary for evaluation. For example, it has no completed section on research gaps and research needs, no section providing examples of ORD integration, and no section discussing opportunities for additional integration.

- Economic, behavioral and social sciences are a central aspect of environmental justice research. Hence, I would have expected to see more thorough treatment of the role of this research within the cross-cutting roadmap. These issues are mentioned in various places, but only at a relatively general level. It would have been useful to see a presentation of research needs in this area.
 - For example, the roadmap states (p. 8) that “there is a need to focus on how the complex interactions between social, economic, biological, spatial and environmental factors result in unequal environmental health conditions or disproportionate impacts among disadvantaged population groups, communities, neighborhoods and individuals.” However, the specific research proposed or needed to evaluate these interactions is not described.
- There does not appear to be any discussion of the influence of institutional factors in environmental justice.
- Given the primary role of SHC in this cross-cutting area, a more detailed discussion of structural relationships between SHC and EJ would be informative. Some information is provided by Appendix A, but this is limited to a list of SHC projects that are viewed as relevant to this cross-cutting area.
- Some of the projects in Appendix A (Environmental Justice Research Inventory) are directly and clearly related to EJ issues. Others appear to be only indirectly or tangentially related.
- While the underlying science challenges are well-described in a general sense, the cross-cutting roadmap does not yet convey the sense that ORD research in this area is coordinated as a well-organized whole. Rather (much like Appendix A), the roadmap leads to the perception (correct or incorrect) that EJ research at ORD is a loosely-related set of projects and initiatives that have some relationship to EJ issues. I suspect that there is greater structure and coordination in EJ research than is apparent from the roadmap, but this is not communicated in the current draft. Perhaps this is because so much of the draft is incomplete. Either way, this is an area in which the roadmap could be improved.

Comments from Dr. Nancy Kim

- The Environmental Justice roadmap appears to be effective in presenting a problem statement and purpose and has begun to elucidate key research topics and to capture relevant research in each of the six programs. It has not identified important gaps.
- The sections that have been written so far appear reasonable. One suggestion is to try to focus on one or two priority areas in the final statement in each of the numbered paragraphs under science challenges and research alignment and coordination. Starting to focus on some key areas may help to focus the gap analysis,

Comments from Dr. Francine Laden

The “Environmental Justice Crosscutting Roadmap” effectively presents a problem statement incorporating the role of environmental, social and economic stressors into the assessment of environmental justice. The roadmap focuses on three science challenges: (1) understanding biological, social, spatial and environmental factors associate with vulnerable populations in communities; (2) developing decision support tools, information, mitigation and prevention strategies for EPA and community decision-making; and (3) engaging communities to build scientific capacity by sharing and translating information, tools and technologies, and by conducting collaborative research. How environmental justice is captured in each of the six programs is outlined but not developed in detail at this time.

Comments from Dr. Kristina Mena

- The Environmental Justice Cross-cutting Research Roadmap describes how environmental justice can provide the foundation for the six (6) research programs; however, in some places within Table 1 and Appendix A and Appendix B, there are not as many examples of an environmental justice presence within some research programs as might be expected – so gaps are identified
- The problem statement is well described
- The ecological model approach that includes a variety of stakeholders described in the Roadmap is effective
- The Roadmap mentions “outside scientific experts and stakeholders” who contributed to the Roadmap; what demographics do they represent?
- It is important to not only address the interactions of the various factors that may impact environmental justice, but also how people respond to these factors
- Cultural factors and those crossing our borders could be a sub-category research area
- To increase research relevance, CBPR could help incorporate environmental justice in research within the different research program areas; this approach could be used to develop relevant RFPs
- Obtaining input from communities would identify key factors that impact susceptibility and vulnerability (i.e., drive research), or determine if something else (other than the environment) is impacting susceptibility and vulnerability – and therefore their ability to effectively respond to environmental stressors

Comments from Dr. Paula Olsiewski

The preliminary draft of the environmental justice roadmap is strong. I have no suggestions.

Comments from Dr. Daniel Stram

- Environmental Justice: There are many profound health disparities between US populations. This raises many scientific questions specifically relevant to the EPA mission. For example
 - What differential/inequitable exposures to exposures/toxicants contribute most to health disparities between populations?
 - To what extent (and why) does susceptibility to environmental exposures differ between populations?
 - How do exposures interact with other stressors more prevalent in underserved/minority populations?
 - What mitigation efforts would have the most effectiveness at improving health in underserved/minority populations?

Right now the document includes all 4 of these above as one research aim “Understanding biological, social, spatial and environmental factors associated with vulnerable populations in communities” with the other 2 aims being more “technocratic” namely “Developing decision support tools, information, mitigation and prevention strategies for EPA and community decision-making”, and “Engaging communities to build scientific capacity by sharing and translating information, tools and technologies, and by conducting collaborative research”. I think that focus on the last 2 aims may be premature given gaps of knowledge regarding Aim 1.

Comments from Dr. Peter Wilcoxon

- Environmental justice: the basic science challenges identified in the roadmap are good but very high level. They are suitable for categorizing different kinds of research but don’t provide the kind of detailed research plan present in some of the other roadmaps. This is also reflected in the summary table which is really too broad to be useful. In its current form it essentially says that the EJ crosscut

is almost entirely a spinoff of SHC. In that case, is there a need for a separate crosscutting topic? Finally, the research gaps section was incomplete in the document I reviewed so I have no specific comments on that.

Nitrogen and Co-Pollutants

Comments from Dr. Viney Aneja

Effective and sustainable control strategies for the management of reactive nitrogen (Nr) and co-pollutant loadings to the environment (air, surface, and groundwater) requires collaboration on the design of cross-media, multi-agency, and multi-disciplinary integrated approach. This will allow reduction in the adverse impacts on the environment and human health. How best to achieve Nr reductions (both air and water) if voluntary framework (as indicated in The Nitrogen and Co-pollutants Cross-cutting Research Roadmap) do not work will require *regulatory framework for Nr management*. Moreover, agricultural runoffs of pollutants from non-point sources do not seem to be working with voluntary approaches. ORD needs to develop scientifically based support structure to help mitigate the Nr problem in the environment (air and water).

Comments from Dr. Joseph Arvai

- This roadmap is clearly written, and offers a series of important science challenges. I am especially impressed with how thorough, and well thought-out this roadmap is. Appendix E was very helpful.
- The roadmap presents a clear problem statement, identifies a series of key research topics, and identifies any important scientific gaps. Indeed, I'm pleased that the roadmap sets forth a series of science challenges (p. 8), which aim to address an overarching goal of informing decisions and policy choices (p. 4).
- However, the roadmap stumbles a bit in terms of capturing relevant research in each of the six ORD programs.
- It's quite clear that the roadmap ties most neatly into the ORD program focused on Safe and Sustainable Water Resources.
- However, it seems clear to me that this roadmap also should have more direct linkages into the SHC program. I make this point because many of the science challenges involve value judgments, which decision-support methods may help to elucidate. The linkages between this roadmap and SHC are underdeveloped in my opinion.
- It's worth noting, though, that the roadmap does offer a connection into the SHC program; this occurs in the section on prioritized research needs on p. 25: "Develop and integrate ecosystem service metrics and accountability measures for social and economic endpoints of concern that are integrated into exposure- response models for nitrogen and co-pollutants." I wonder this synergy shouldn't be made more explicit.

Comments from Dr. Peter Chapman

- Problem statement: The problem statement is good, in particular the summary of the 6 science challenges in the form of questions, but it and the text box (p7) fail to mention coordination outside the agencies (e.g., with industry, other levels of government, other stakeholders) and outside the US. The comment (p10) "In the longer term, this type of effort can and should be extended to the other Federal partners and states, as well" is inadequate.
- Identification of key research topics: Research topics are well identified.
- Capturing relevant research in each of the 6 StRAPs: Table 1 does this; however, additional text explanation in the main document would be useful.

- Identification of scientific gaps in cross-cutting issues: Appropriate.
- Other comments:
 - The Executive Summary is well written and very informative.
 - The Introduction is excellent, particularly the reference to both direct and indirect effects and to changes in both ecosystem structure and function, and the text box.
 - Nitrogen and co-pollutants are an international, not solely a national issue; this is not clearly identified in the document and should be along with recommendations for international partnerships.
 - Page 11, Table 1: “Research on human health impacts from air quality is well documented elsewhere...” Where?
 - Information on the STAR program funding four research centers (p14) is useful.
 - I agree with Science Challenge 6 (p14) re the need for communications and assessment of project – this should be incorporated into current research not a separate research component as it is cross-cutting.
 - The Gulf of Mexico, an important component of the research, is an obvious candidate for international cooperation.
 - The Ecosystem Services framework (pp18-19) is excellent and represents the only attempt in all of these documents to develop actual costs; the comparison to Europe is appropriate and useful (and international).
 - Figure 4 is good and useful.
 - Collaboration and leveraging (pp21-23) should consider and include international governments, agencies, and stakeholders.
 - Summary is a little too short and the last sentence of the text box “These requirements can only be met through the comprehensive adaptive management of air, land, and water” seems unrealistic.
 - References are provided.

Comments from Mr. Shahid Chaudry

Unlike above roadmaps, this roadmap provides more elaborated background information and problem statement. The roadmap clearly identifies mitigation pathways and practices in close cooperation with other federal agencies and offices within EPA as well as current and planned research efforts to achieve the goals. The roadmap also identifies research gaps and prioritizes research needs.

Comments from Dr. Joel Ducoste

- Has effectively identified the major cross cutting issues related to nitrogen and co-pollutants that are relevant to research in four of the six programs
- Key research topics along with scientific gaps were identified
- A very long list of project tasks related to each of the six science challenges is provided with potential outcome/products and dates of commencement for each task. It’s not clear if those projects started in FY12 or FY13 are completed. Other projects have the word “completed” suggesting that it has been concluded. As mentioned earlier, a ranked priority list should be made with an anticipated timeline provided for completion.

Comments from Dr. David Dzombak

- (i) There is discussion on page 9 about the importance of research coordination, and about an envisioned “cross-Agency team to identify research that informs the development of effective policies needed for successful implementation of an integrated and sustainable Nr and co-

pollutant management program.” No specific recommendations are made about the envisioned team, or about implementation of the roadmap.

- (ii) In the inventory of ongoing research and the identification of research gaps and needs, the focus is on current ORD research. Activities at other agencies are discussed, mostly in a general way, and identification of specific opportunities for leveraging and coordination of research at other agencies are few. Most obvious in this regard are the many research programs at the USDA focused on study of nutrient fate, control, and management on agricultural lands. Substantial engagement with and leveraging of USDA programs and resources should be part of ORD research on nutrients and related co-pollutants. This does not come across in the Nitrogen Roadmap.
- (iii) The 30-year, coordinated federal-state effort to understand and control nutrient inputs in the Chesapeake Bay watershed is the national, full-scale experiment in how to control nutrients on land and discharges to water. There has been much learned about monitoring and modeling of nutrients at large-watershed scale, and the effectiveness and challenges of different nutrient management approaches. The Chesapeake Bay efforts should have a central place in the Nitrogen Roadmap, but receives only limited attention, probably because ORD has not been at the center of the Chesapeake Bay restoration program. This shortcoming should be addressed before the Roadmap is finalized.
- (iv) The USDA Mississippi River Basin Healthy Watersheds Initiative includes coordinated watershed-scale and field-scale studies of nutrient fate, transport, and control, and includes development and testing of models. The MRBI initiative is another important national experimental program that should be discussed prominently in the Nitrogen Roadmap. ORD should be engaged with this effort, as recommended in several recent National Research Council reports, and as discussed at a National Research Council workshop held in St. Louis in November 2013.

Comments from Dr. Courtney Flint

- Nitrogen and Co-Pollutants – This roadmap seems written at the 10,000 feet level. More work is needed to increase levels of specificity and program integration. It is striking how little the word agriculture is used in this narrative document given the preponderance of evidence that it is a key driver of nutrient loading (a few of many research connections found in the appendix). Recent research (by me and colleagues) on farmers and nitrate management in two watersheds in Illinois (David et al. in press) highlights the complex challenges associated with managing nitrogen. Agricultural practices to address nitrate runoff from farmlands indicated mixed results. Farmers did not see nitrogen and other pollutants as particularly problematic in terms of water quality. Awareness of and willingness to adopt new water quality practices were relatively low and farmers did not indicate that federal regulations would influence their decisions or activities. Further, they articulated a complex array of agricultural decision-factors, making it challenging to isolate nutrient management from other complex issues.

Comments from Dr. Robert Johnston

- The motivation and purpose of the roadmap is clearly described, including the responsiveness of the roadmap to 2011 SAB recommendations.
- The roadmap notes (p. 5), that “Where possible, research addressing these areas in other Federal Agencies was also included, but is recognized as incomplete as of this date and in need of expanded effort.” What steps are being taken to address this gap?
- The description of specific steps to inform 2016 – 2019 ORD Research Planning in this cross-cutting area (p. 26) is useful and engenders confidence that integration will proceed as planned.

Comments from Dr. Kimberly Jones

Nitrogen and Co-Pollutants – the Nr and Co-pollutant Roadmap aims to synthesize research in a way that individual research programs cannot. It is assumed that this synthesis will help to identify research gaps and generate scientific evidence that informs decisions.

The research/management efforts (table 1) are difficult to evaluate, and I am looking forward to hearing more about that at the meeting.

Related to new centers to seek innovative approaches to nutrient management – are these centers managed jointly by different offices? How will the results be integrated into the current research roadmap?

This roadmap does a good job of identifying portions of the core research programs that are relevant in each of the research portfolio case studies. Who is in charge of synthesizing the results?

Comments from Dr. Francine Laden

“The Nitrogen and Co-Pollutants” Crosscutting Roadmap” is effective in presenting a problem statement, elucidating key science challenges, capturing relevant research in each of the six programs, and identifying any important scientific gaps. The roadmap also discusses cross-agency integration between EPA, USDA and USGS.

Comments from Dr. James Mihelcic

- In the Draft Nitrogen & Co-pollutants Cross-cutting Research Roadmap, key research needs (page 2-3) (and a priority research area on page 25), the statement “Continue efforts to introduce new technological applications to nitrogen and co-pollutant management problems, such as genomic indicators of sources and effects, satellite monitoring of conditions, and improved sensor technologies” ignores importance of technology innovation that addresses the SSWR overarching priority (SSWR slides presented by Dr. van Drunick on July 17) to “transform the concept of ‘waste’ to ‘resource’ by recapturing and reusing commercially valuable waste stream constituents (e.g., nutrients, energy, metals).
- Draft Nitrogen & Co-pollutants Cross-cutting Research Roadmap appeared weak in area of development and demonstration of resource recovery technology in nutrient management, especially across different scales of implementation (which the SAB Nr report was not also focused on).

Comments from Dr. Nancy Kim

- The Nitrogen & Co-pollutants Research Roadmap appears to be more developed than the other 3, perhaps because of EPA’s (and SAB’s) past activities in this area.
 1. The roadmap appears to be effective in presenting a problem statement, elucidating key research topics, capturing relevant research in each of the six programs, and identifying important scientific gaps. Of particular mention is a statement of for the roadmap goal, integration examples, Figure 4, the description and process followed for the gap analysis, identifying a specific process for informing the 2016-2019 ORD Research Planning (page 26).
 2. Suggestions for improvement: include a broader systems perspective in Figure 2, be explicit about the relationship between prioritized research needs and research gaps (first and second statements on page (25) (Are these research needs the gaps identified through the gap analysis?).

Comments from Dr. Paula Olsiewski

The preliminary draft of the nitrogen and co-pollutants roadmap is comprehensive. I have no suggestions.

Comments from Dr. Peter Wilcoxon

- Nitrogen: very clear description of the problem and highly responsive to previous SAB input. Very clear statement of science challenges, the need for integration, and clear linkages between programs. A particular strong point of the document is that it explicitly identifies inter-office accountability as a science challenge. Building and maintaining integration between programs is indeed a significant challenge and specifically identifying it as a research topic will lead to better understanding about what strategies work and which don't.

9. Integration across the Programs

9a. Do ORD's plans, taken collectively, indicate that integration, where appropriate, will develop the needed scientific knowledge and produce results that advance EPA's ability to address complex problems?

Comments from Dr. George Alexeeff

Clearly the agency is making efforts to integrate the science across programs. This is difficult to do and is an unending task. The integration is important to emphasize in research program plans, yet the true integration may be more effective on informal staff-to-staff interactions.

Comments from Dr. Viney Aneja

This approach is still in its infancy, but the six programs appear to be well integrated.

Comments from Dr. Joseph Arvai

- I believe the building blocks to be there. The agency's (and ORD's) objectives, as well as the science discussed in each StRAP is both important and timely (not to mention: interesting).
- I think the individual research initiatives discussed under each StRAP will indeed help the agency to address complex problems.
- However, in reading through the StRAPs, the EPA Strategic Plan, and the various roadmaps, real integration remains a challenge. For example, the StRAPs are all fairly focused in terms of speaking to the EPA Strategic Plan. Each StRAP might have benefited with a section entitled something along the lines of "Relationship to the other StRAPs." Perhaps this could come later?
- As far as the roadmaps are concerned, quality varies widely. Some of the roadmaps seem to speak more to internal agency workings than they do to the agency's strategic plan or to the ORD research programs. Moreover, some roadmaps are much clearer in terms of vision than others. I'm sure there's a good reason for this; nevertheless, a lack of integration (and consistency) among the roadmaps is a challenge that I believe needs to be overcome.
- Also regarding the roadmaps, their links into the specific science being discussed under each StRAP is weak in some cases.
- I'm not certain of ORD's plans at this stage. However, further work on the StRAPs and roadmaps seems like it's going to happen. Might I suggest that time be taken at this stage to work specifically on enhancing the level of integration amongst the different programs?

Comments from Dr. Ingrid Burke

At this point, the drafts do indicate that EPA is thinking about research integration. It is a little less clear about the products resulting in increased ability to address problems. Every one is very broad, refers to other programs, and has important goals and objectives. I remain concerned about the tractability, which I suspect will be reached by case studies that break down problems into place-based, specific problems that are less integrative and much less impactful, with a limited realm of inference.

I'd like more specific language, including examples, resources, personnel, and strategies (e.g. RFP's? Lab-based research on a special area?).

Comments from Dr. Edward Carney

The integration theme comes through loud and clear in all of the programs. This integration is the right thing to do and is necessary if EPA is to effectively address the complex issues it faces in the 21st century. For example, it seems clear that non-chemical environmental factors such as lifestyle and psychosocial variables can contribute significantly to public health problems, but investigating these problems requires systems-based, multidisciplinary approaches. Given the planning necessary to conduct integrative research, not to mention the heavy demand on research resources to conduct the work, a strict, data-driven prioritization of the problems EPA chooses to address is absolutely necessary.

Comments from Dr. Peter Chapman

- Yes, appropriate integration is not only desirable but necessary – both formally and less formally.
- However, I am not convinced that integration has proceeded sufficiently nor that in some cases it is not more honored in the breach than the observance (to quote from Hamlet).
- Integration must occur internally within EPA, external to EPA within the US with all partners, and internationally; international integration is notable by its general absence, which is disappointing as national issues can no longer be dealt with in isolation from global issues.

Comments from Mr. Shahid Chaudry

- In today's ecosystem, water, energy, air quality, climate change, nutrients, environmental health are inextricably interconnected. These complex interconnections are not only highlighted in strategic plans but are also well recognized by the scientific community. Therefore, in emerging paradigm, it is extremely important that all the issues should be investigated using integrated approach and with the participation of relevant stake holders. In this context, EPA's recent cross-agency Green Infrastructure Collaborative and its intent to engage additional public and private organizations is very timely and a step in the right direction.

Comments from Dr. Terry Daniel

On the basis of the presented research plans, the answer here is yes. However, the institutional issues cited in item 8a above (budget and individual scientist's recognition and rewards) will be critical, though they do not seem to be explicitly addressed in the StRAP documents.

Comments from Dr. George Daston

There seems to me to be good integration among the programs. I see strong evidence of research in one area supporting research in other areas, with enough overlap in expertise to allow scientists within the different programs to understand each other, but without redundancy of effort. I understand that EPA has instituted some formal means for broad communication and interaction at a technical level, such as the communities of practice started by the computational toxicology group. It is not clear to me how

widespread this concept has become. I would encourage more widespread use within ORD.

Comments from Dr. Joel Ducoste

- Yes. An active effort has been made across all programs to integrate among the different EPA offices.

Comments from Dr. Elaine Faustman

- There were numerous and very encouraging examples in CSS and HHRA to address issues of integration. The new processes within IRIS for formal public input are a great leap forward. The slides on Outreach and Translation (from CSS) presented approaches for evaluating integration and could also serve as a good model for integration and implementation across research programs

Comments from Dr. David Dzombak

The cross-cutting roadmaps represent a very important step forward for the EPA in providing a framework for research integration on large-scale, complex environmental challenges. These roadmaps provide frameworks for integrating research across ORD programs and offices, and with other agencies, and keeping ORD research forward looking. Developing the roadmaps clearly has been a lot of work and engaged significant ORD resources. The investment is well justified for potential future impact on ORD and the EPA. The roadmap development and implementation process will evolve and be improved with time. The draft roadmap documents represent the first step in what hopefully will become a staple of ORD and EPA operation.

Comments from Dr. Courtney Flint

- A considerable amount of EPA ORD focus is on the development of tools, web-based and others, to address critical challenges. Given the highly different contexts around the country and temporally dynamic circumstances and knowledge evolution, it will be important to ensure these tools are adaptable, while still maintaining core principles and methods supported by sound science. There is little, however, on how users are receiving and applying these tools or how the utility and applicability of these tools will be evaluated.
- Regional Liasons are charged with facilitating ORD Science Communication and as described, this appears to be a centralized flow of information out to the regional officers and partners with high-priority needs coming back in to strategic planning efforts. Yet, this orientation may miss critical opportunities to bring good science, ideas, and processes in addition to emerging issues and needs from the regions and partners back into ORD.
- While this phrase is not used in the EPA documentation, the “triple-bottom-line” goals of sustainability inherent ORD’s orientation toward complex problems are essential, but it will be important to share experiences across the programs on how inherent conflicts are addressed without falling into a “tradeoff” orientation, or reaching impasse due to the tangle of complexity. It’s one thing to say we must integrate environmental, economic and social processes, but it is another to do so. Thus, emphasis on “how” is now the key challenge, along with metrics to assess progress on this integration (and not just outcomes as “true” sustainability may be a long way off).
- In many places throughout the planning documentation, “stakeholder engagement” is emphasized, but “stakeholder” is rarely defined with any precision and “engagement” is rarely operationalized into a coherent process.
- Throughout the EPA ORD planning documents, there is a clear integration of partnerships with other agencies, states, tribes, and local entities. These make sense and are essential. What is less clear is a plan for maintaining these relationships over time to provide continued knowledge sharing and

application.

Comments from Dr. Robert Johnston

- Attempts at cross-program integration are evident within the StRAPs and briefing materials. Whether this develops the needed scientific knowledge to advance EPA's ability to address complex problems depends on the implementation of these proposed linkages. Often, linkages and relationships proposed in strategic planning documents occur at only a superficial level – for example sharing final results only at the end of research projects. In other cases, one research program may independently produce research projects that are reported to be “relevant” to other research programs. To the extent that these linkages are of this superficial nature, they may not provide the needed scientific knowledge. However, if the proposed linkages are implemented in a meaningful, in-depth and ongoing manner, they should help provide the integrated scientific knowledge required by the Agency.
- To be most useful, cross-program integrations should involve active collaborations from the outset of research projects – so that each project benefits from the combined expertise of multiple programs. The extent to which linkages reported in the StRAPs will promote truly integrated work is unclear. The StRAPs and briefing materials characterize cross-program linkages only in abstract terms, for example reporting broad research topics within each program that are relevant to other programs, or over which some type of otherwise unspecified interaction is planned. For example, page 8 in the SSWR StRAP states, “Watershed Sustainability has clear linkages to SHC through the EnviroAtlas and Report on the Environment, and to ACE, particularly in the realms of climate change and prediction and management of materials and waste.” It is unclear to what extent these “clear linkages” will include active cross-program collaborations, and how areas such as this will benefit from this integration.
- A good example of high-level integration is presented by Figure 4 in the HS StRAP, page 11. This plan notes that the HS program “works closely with the other five programs on topics that support the needs of its partners.” As above, however, it would be useful to understand something about the substance of what this close integration entails.
- Other areas of integration are presented as only prospective or planned. For example, page 18 in the HHRA StRAP states, “future work with the HSRP and SHC programs is expected to integrate resiliency and wellness indices under development in those programs into the CRA framework.” It would be useful to know the extent to which such integrations are under active development or are purely aspirational.
- In general, while the intent and areas of proposed interactions are presented in the StRAPs, the depth and substance of the interactions are typically unreported or vague. This makes it difficult to determine the extent to which these proposed interactions will be substantive or merely superficial.

Comments from Dr. Kimberly Jones

Integration is infused throughout the StRAPs, EPA Strategic Plan, and Roadmaps. It is great to see that a definite “lead” has been identified for each program in the Roadmaps, and each StRAP refers to activity in the cross-cutting areas. This type of integration is absolutely necessary.

Jointly funded research programs (e.g., “Adaptation to climate-driven changes in water quality” by ACE and SSWR) are a positive step in encouraging integration and should be expanded.

One uncertainty involves the budgetary and FTE support in the lead programs to support this integration. Research quality will suffer without the appropriate resources (FTE and budget) to support the

integration.

Efforts to develop synthesis documents to summarize and contextualize funded research programs and opportunities should be continued.

Comments from Dr. Catherine Karr

Integration is critical given a resource limited environment and the interdisciplinary and cross program nature and application of the science questions and products. Having an identified infrastructure to ensure integration such as the OCHP office to foster incorporation and integration of the ceh research needs and agenda is a useful model.

Integration should also be considered and described in the context of leveraging partnerships with other federal agencies doing complementary work (e.g. Systematic literature review and synthesis, database development by NTP OHAT, CDC).

Comments from Dr. Nancy Kim

The current versions of ORD's plans and roadmaps have essentially the same sections but vary in their completeness and effectiveness. Assuming the 6 StRAPs and 4 roadmaps are completed and/or revised using the more effective approaches in the 10 documents, EPA should be able to develop the needed scientific knowledge for priority areas, including advancing EPA's ability to address complex problems. In making revisions, in general the documents need to be more focused and to prioritize efforts to a greater extent. Reviewing the purpose and goal for each StRAP and roadmap should help identify ways to improve the content of each document; having a common goal and purpose (to the extent possible recognizing that the programs/research areas are different) should also help minimize the effort needed to improve the less effective documents.

Comments from Dr. Francine Laden

Yes – ORD's plans, collectively, indicate that integration will develop the needed scientific knowledge and produce results that advance EPA's ability to address complex problems. Many of the plans discuss the need to expand on the integration with social sciences; this is of high priority for advancing these goals.

Comments from Dr. Lois Lehman-McKeeman

In general, yes, the plans indicate that thoughtful integration will be developed. As noted above, careful, objective evaluations of new tools is a prerequisite to this success rather than employing new approaches without fully vetting whether they work well enough or not.

Comments from Dr. Elizabeth Matsui

- The plans for integration are broad and well considered overall.
- The primary question is what strategies can be put in place to ensure that the integration that is described in the documents is encouraged and facilitated.

Comments from Dr. Kristina Mena

- Yes, the StRAPs are closely connected to the four cross-cutting issues, and specific research topics span different research programs
- The incorporation of various stakeholders that allows for multi-directional conversations and input will foster integration

Comments from Dr. Surabi Menon

I believe the plans do their best to identify knowledge needs, gaps, results and integration. It seems like a heroic effort. Taken together they will help the Agency advance on complex issues of understanding how our energy needs are changing, how that affects the environment and people and how can we safeguard our community and resources. Can one Agency alone solve that problem? Definitely not. It takes collective efforts, and what would be useful would be to see how this effort could draw on work being done across other Agencies in other countries tasked with similar objectives. This helps look at how plans can be adapted, identify where the gaps still remain and where research can be synergistic.

Comments from Dr. James Mihelcic

- EPA has greatly improved their integration across different research program. However EPA needs to develop a long term plan (versus short term hiring of postdocs or supporting external research) on how to better integrate behavioral science into their long term research. They also need to better determine how to integrate sustainability frameworks (such as LCA) into early stages of research innovation (versus waiting until the end to assess a path forward they are already locked into).

Comments from Dr. Paula Olsiewski

After reviewing the preliminary draft StRAP's and roadmaps, I am impressed with ORD and its plans and processes. The Strategic Research Action Plans are well positioned to deliver the knowledge and results to advance EPA's agenda.

Comments from Dr. Earthea Nance

9a. It is a mammoth task to integrate on this level, and I think ORD's strategy does a great job. Further improvements can be made in real-time along the way.

Comments from Dr. Duncan Patten

Throughout most of my responses I have mentioned a greater need for integration. The cross-cutting issues are only a start but so many of the programs still function in their own silos. **Funding should be made available to cross program scientists who can visualize new integrative programs that will advance EPA-ORD's efforts at addressing additional and relevant cross cutting issues. This funding could be part of some incentive program.**

Comments from Mr. Richard Poirot

Plans alone can't guarantee that needed future integration across the formal program areas will occur. To a large extent, successful future integration will be dependent on the judgment and flexibility of the various administrators, program managers, and individual researchers. Past performance suggests that key new information needs have been identified and that successful integration has occurred to address these needs. Shrinking budget resources will present an especially challenging problem for addressing problems (climate change, for example) which are highly complex and characterized by unavoidably large future uncertainties, but which also have critical time horizons for developing actionable research results.

Comments from Dr. Ponisseril Somasunderan

ORD's plans appear to adopt approaches that are related to problems *directly relevant* to research topics such as air, water and climate quality, and the other 5 topics mentioned. These topics, in some cases, are *not connected to a number of important topics related to those arising from global interferences to the six topics programs*. In this context, not only it is important to develop scientific knowledge in the areas of specific sectors (e.g. oil and gas, mining, pharmaceuticals, international interferences to pollution), but it is

also critical to understand how complex it is in terms of the many factors involved in water, air and land pollution, chemicals imports. Due to lack of support for research for environmental impacts, and for the lack of recognized need globally to impose stringent regulations,

ORD' needs to venture to critically examine, incorporate and integrate research on topics related to water and air quality from a number of sectors mentioned above. More important, these sectors do not have known structures in place to predict the long term impacts of the materials and processes, ORD's plan may need to emphasize the need of identifying these "hidden" areas in which scientific knowledge need to be advanced and to produce results to advance EPA's ability to address as complex and long term problems as the ones mentioned above.

Major challenges with regard to environmental issues of 2020 and beyond are likely to be related to growing population and uncontrollable and unknown development in waste generation (particularly electronics, commodities, pharmaceuticals and those related to changes in lifestyle). Models that predict the contribution of each of the six topics will be critical.

Comments from Dr. Daniel Stram

- I'm not sure I understand what this question is asking. Many of the research problems raised in the roadmaps and draft strategic plans are very difficult and there is considerable uncertainty in some cases about what questions are going to be of highest future priority. Nevertheless overall I think that the ORD has presented an exciting and ambitious research program.

Comments from Dr. John Tharakan

- Believe they will, with the caveat that more articulation of community engagement and integration into the program design and implementation is developed, Also, see comments above on integration as well as conceptualization and configuration of the form and structure of the integration. Nevertheless, I believe the StRAP for the SHC will move the EPA in the direction of addressing the complex problems of the future.

Comments from Dr. Jeanne VanBriesen

It seems likely that the planned research will advance EPA's ability to address complex problems, yes. It is not clear how much integration will be involved in the plans or how the integration will provide synergy to advance the goals. The StRAP's do not make much mention of the cross-cutting plans, and the cross-cutting plans do not make much mention of the StRAP's. The projects listed in appendices for the cross-cutting plans are sometimes listed or at least described in the StRAP's, but it is very difficult to evaluate how the different plans are describing the same research portfolio and overall collective vision of ORD research.

Comments from Dr. James Sanders

I'm encouraged that they do. However, I remain discouraged that funding declines will continue to erode EPA's ability to perform the research that is needed to effectively protect the nation, and to help steward environmental resources.

Comments from Dr. Katherine von Stackelberg

In principle, yes, but significant implementation challenges exist. By taking on "sustainability" as a whole, yet "buying into" traditional metrics that emphasize conventional economic growth that considers the

environment as an externality will ultimately prove problematic. Systems- based approaches are emphasized, and yet examples abound of continued “silo” thinking and analysis – but an entire Agency that consists of individuals with individual backgrounds and training cannot be expected to adopt systems-based approaches that may be entirely unfamiliar, indeed, may not even exist! Communities, community well-being, and community values are emphasized (SHC, in particular) at the expense of the green infrastructure (environment) without which community is not even possible. The integrator is the environment itself, but the emphasis currently is on people, and that is a much more difficult entity.

Comments from Dr. Peter Wilcoxon

- ORD’s plans clearly take integration very seriously. The research programs are well structured in that respect. For example, air, climate and energy are very tightly linked and having all three integrated into a single research program is an excellent foundation. However, it will still be a challenge to build strong and deep integration in the crosscutting topics. Identifying accountability for cross-program outcomes as a research topic, as done in the nitrogen crosscutting roadmap, is very useful and could be included in the other roadmaps as well.