Scientists Endorse *Connectivity of Streams and Wetlands to Downstream Waters* as a Clear, Accurate, and Thorough Compilation of the Best Available Science

RESUBMITTED WITH ADDITIONAL SIGNATURES 12/13/13

Science Advisory Board Review Panel
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Re: Scientists Comments on *Connectivity of Streams and Wetlands to Downstream Waters*: Docket ID No. EPA-HQ-OA-2013-0582

As scientists who have spent careers studying streams and wetlands, we applaud the Environmental Protection Agency for issuing a thorough and solid report that documents the connectivity of streams and wetlands to downstream waters. We recognize the importance of compiling the best available science on wetlands and streams in order to inform policy decisions that guide national efforts to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." We appreciate the rigorous peer review underway by the Science Advisory Board (SAB) and the SAB panel of external peer-reviewers. We respectfully submit for your consideration these comments on the report, ***Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence* ("Connectivity Report").**

The undersigned are professional scientists with broad knowledge and expertise in stream and wetland ecosystems, including their physical structure, chemistry, and biology. The scientists who have signed this letter include members of the National Academy of Sciences and its scientific Boards, presidents, past-presidents, and members of national scientific organizations, and leading researchers on the ecology, water quality, and biota associated with rivers, streams, and wetlands.

Overview

In the following paragraphs, we address the SAB's technical charge to the review panel:

- The clarity and technical accuracy of the draft EPA report overall and its conceptual framework;
- Whether the literature cited, the findings, and the conclusions reflect the best available science with respect to stream connectivity and effects;
- Whether the literature cited, the findings, and the conclusions reflect the best available science with respect to the downstream connectivity and effects of floodplain wetlands and open-waters; and
- Whether the literature cited, the findings, and the conclusions reflect the best available science with respect to the downstream connectivity and effects of "unidirectional"

wetlands and open-waters located outside of floodplains.

Overall, the Connectivity Report is clear, technically accurate, largely comprehensive in its literature review, and establishes a strong presentation of the best currently available science on the physical, chemical, and biological connections by which streams, wetlands, and open-waters affect downstream waters such as rivers, lakes, and oceans.

We see opportunities for strengthening and clarifying certain aspects of report, as we explain below. We note that the report's literature cited section includes no 2013 publications, probably due to the extensive vetting this draft report has already undergone. We believe that there are additional relevant peer-reviewed articles published in 2013 and we urge the panel to incorporate these more recent publications. While our joint comments here reflect our overarching consensus comments, many of us and our colleagues may individually submit additional recommendations, particularly for supplementing the relevant scientific literature on this important issue of wetland and stream connectivity.

I. <u>The draft report is clear and technically accurate overall and in its conceptual framework</u>.

A. The draft report is grounded in well-established core scientific principles relevant to how water moves within watersheds.

The draft report is clear and technically accurate in its assessment of connectivity as a foundational concept in hydrology and freshwater ecology. We support the focus on material transport at the core of the conceptual framework, including the following:

> The structure and function of downstream waters are highly dependent on the constituent materials contributed by and transported through water bodies located elsewhere in the watershed. Most of the materials in a river, including water, sediment, wood, organic matter, nutrients, chemical contaminants, and certain organisms, originate outside of the river, from upstream tributaries, wetlands, or other components of the river system, and are transported to the river by water movement, wind, or other means. Therefore, streams and wetlands fundamentally affect river structure and function by altering transport of various types of materials to the river. This alteration of material transport depends on two key factors: (1) connectivity (or isolation) between streams, wetlands, and rivers that enables (or prevents) the movement of materials between the system components; and (2) functions within streams and wetlands that supply, remove, transform, provide refuge for, or delay transport of materials.
> Connectivity Report at 1-4.

B. Two core principles that warrant greater emphasis and explanation in the conceptual framework are those of aggregation and the use of the watershed as the appropriate geographic context.

We agree with report statements of this aggregation principle, including the following:

> …[T]o understand the health, behavior, and sustainability of downstream waters, the effects of small water bodies in a watershed need to be considered in aggregate. The contribution of material by a particular stream and wetland might be small, but the aggregate contribution by an entire class of streams and wetlands (e.g., all ephemeral streams in the river network) might be substantial." Connectivity Report at 1-14.
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> The overall strength of a connection, and the magnitude of its downstream effect, are the result of the cumulative effect of multiple, individual water bodies whose hydrology and ecology are tightly coupled with the local and regional geological and biological processes that formed them. Connectivity Report at 6-3.

However, the report would be strengthened by highlighting this principle in the conceptual framework and more carefully linking it in the framework to the discussions of integrated river systems and networks and the mechanisms of material transport to and from streams and wetlands.

Overall, this report clearly presents its findings and conclusions, and summarizes and helpfully repeats them at key junctures throughout the report. It provides context, graphics, tables, and case studies to explain its findings, and it supports its findings and conclusions with scientific evidence, models, and case studies contained in over 1,000 peer-reviewed scientific articles. In sum, the draft report is clear and technically accurate overall and in its conceptual framework.

II. The findings, the conclusions, and the literature cited generally reflect the best available science with respect to stream connectivity and effects.

We concur with the report's conclusions with respect to stream connectivity and effects, including its core conclusion that:

> All tributary streams, including perennial, intermittent, and ephemeral streams, are physically, chemically, and biologically connected to downstream rivers via channels and associated alluvial deposits where water and other materials are concentrated, mixed, transformed, and transported. Connectivity Report at 1-3, 1-6, 6-1.

We concur with the key findings with respect to stream connectivity and effects, including the following:

> Headwaters convey water into local storage compartments such as ponds, shallow aquifers, or river banks and into regional and alluvial aquifers. These local storage compartments are important sources of water for baseflow in rivers. The ability of streams to keep flowing even during dry periods typically depends on the delayed (lagged) release of local groundwater, also referred to as shallow groundwater, originating from these water sources, especially in areas with shallow groundwater tables and pervious subsurfaces. Connectivity Report at 1-7.

> Even infrequent flows through ephemeral or intermittent channels influence fundamental biogeochemical processes by connecting the channel and shallow groundwater with other landscape elements. Infrequent, high-magnitude events are especially important for transmitting materials from headwater streams in most river networks. Connectivity Report at 1-7, 4-1.
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> The connections formed by surface and subsurface streamflows act as a series of complex physical, chemical, and biological alterations that occur as materials move through different parts of the river system. The amount and quality of such materials that eventually reach a river are determined by the aggregate effect of these sequential alterations that begin at the source waters, which can be at some distance from the river. …. Stream and wetland capacities for nutrient cycling have important implications for the form and concentration of nutrients exported to downstream waters. Connectivity Report at 1-7-8.
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> Our review found strong evidence that headwater streams function as nitrogen sources (export) and sinks (uptake and transformation) for river networks….Thus, the role of streams in influencing nutrient loads can have significant repercussions for hypoxic areas in downstream waters. Connectivity Report at 1-8.
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> This review found strong evidence that headwaters provide habitat for complex life-cycle completion, refuge from predators or adverse physical conditions in rivers, and reservoirs of genetic- and species-level diversity. Connectivity Report at 1-8.

These findings and conclusions are clear, technically correct, and well-supported with citations to relevant peer-reviewed scientific literature. We note, in particular, that Section 4 of the draft report clearly, accurately, and thoroughly documents the scientific evidence of ephemeral stream connectivity, including case studies of southwestern and prairie stream systems.

III. <u>The literature cited, the findings, and the conclusions generally reflect the best available science with respect to the downstream connectivity and effects of floodplain wetlands and open-waters, though some additional emphasis and literature is warranted</u>.

We concur with the report's conclusions with respect to the downstream connectivity and effects of floodplain wetlands and open-waters, including its core conclusion that:

> Wetlands and open-waters in landscape settings that have bidirectional hydrologic exchanges with streams or rivers (e.g., wetlands and open-waters in riparian areas and floodplains) are physically, chemically, and biologically connected with rivers via the export of channel-forming sediment and woody debris, temporary storage of local groundwater that supports base flow in rivers, and transport of stored organic matter. They remove and transform excess nutrients such as nitrogen and phosphorus (P). They provide nursery habitat for breeding fish, colonization opportunities for stream invertebrates, and maturation habitat for stream insects. Moreover, wetlands in this

landscape setting serve an important role in the integrity of downstream waters because they also act as sinks by retaining floodwaters, sediment, nutrients, and contaminants that could otherwise negatively impact the condition or function of downstream waters. Connectivity Report at 1-3, 6-1.

We concur with the key findings with respect to floodplain wetlands and open waters connectivity and effects, including the following:

> The wetland literature shows that collectively, riparian wetlands improve water quality though assimilation, transformation, or sequestration of nutrients, sediment, and other pollutants – such as pesticides and metals – that can affect downstream water quality. Connectivity Report at 1-9.
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> Riparian and floodplain areas connect upland and aquatic environments through both surface and subsurface hydrologic flow paths. These areas are therefore uniquely situated in watersheds to receive and process waters that pass over densely vegetated areas and through subsurface zones before reaching streams and rivers. When contaminants reach a riparian or floodplain area, they can be sequestered in sediments, assimilated into the wetland plants and animals, transformed into less harmful forms or compounds, or lost to the atmosphere. Connectivity Report at 1-9.
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> Riparian and flood plain areas can reduce flood peaks by storing and desynchronizing floodwaters. They also can contribute to maintenance of flow by recharging alluvial aquifers. Connectivity Report at 1-9.
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> Movements of organisms connect aquatic habitats and populations in different locations – even across different watersheds – through several processes important for the survival of individuals, populations, and species, and for the functioning of the river ecosystem. For example, lateral expansion and contraction of the river in its floodplain results in an exchange of matter and organisms, including fish populations that are adapted to use floodplain habitat for feeding and spawning during high water. Refuge populations of aquatic plants in floodplains can become important seed sources for the river network, especially if catastrophic flooding scours vegetation and seed backs in other parts of the channel. Many invertebrates exploit temporary hydrologic connections between rivers and floodplain wetland habitats, moving into these wetlands to feed, reproduce, or avoid harsh environmental conditions and then returning to the river network. Connectivity Report at 1-10.

These findings and conclusions are clear, technically correct, and well-supported with citations to relevant peer-reviewed scientific literature. We believe that the findings of the report could be strengthened, and its scope and applicability made more clear, if the category of forested wetlands were to receive a more explicit treatment. This category of wetland comprises almost half of the remaining wetlands in the contiguous 48 states and, according to the latest U.S. Fish and Wildlife Service wetland status and trends report, is losing wetland acreage at a faster rate than any other wetland type. While most forested wetlands likely occur in a floodplain (bidirectional) setting, they also occur in unidirectional settings. Wherever such treatment might be placed, its explicit treatment would create a better understanding of these habitats as a category of wetland even though they may often not be flooded.

IV. The findings, the conclusions, and the literature cited, generally reflect the best science currently available with respect to the downstream connectivity and effects of "unidirectional" wetlands and open-waters located outside of floodplains, though some clarification is warranted.

A. The report's conclusions with respect to the downstream connectivity and effects of "unidirectional" wetlands and open-waters are generally accurate, but warrant clarification and refinement.

We concur with the conclusion that:

> Wetlands in landscape settings that lack bidirectional hydrologic exchanges with downstream waters (e.g., many prairie potholes, vernal pools, and playa lakes) provide numerous functions that can benefit downstream water quality and integrity. These functions include storage of floodwater; retention and transformation of nutrients, metals, and pesticides; and recharge of groundwater sources of river baseflow. The functions and effects of this diverse group of wetlands, which we refer to as "unidirectional wetlands," affect the condition of downstream waters if a surface or shallow subsurface water connection to the river network is present.
> Connectivity Report at 1-3-4, 1-10, 6-1.

However, we are particularly concerned with the breadth of the following conclusion in light of the scientific evidence and case studies presented in the draft report:

> The literature we reviewed does not provide sufficient information to evaluate or generalize about the degree of connectivity (absolute or relative) or the downstream effects of wetlands in unidirectional landscape settings. Connectivity Report at 1-4, 1-10-11, 5-2, 6-2.

The scientific literature summarized in the draft report indicates that, in fact, the type and degree of connectivity for certain unidirectional wetlands in certain regions or watersheds may be sufficiently consistent, significant, and demonstrable to establish their general and collective connectivity to downstream waters as a category of unidirectional wetlands, rather than simply case-by-case.

As one example, the draft report includes as a key finding (with which we concur) that, based on simulation studies of North Dakota and Minnesota watersheds, "the ability of potholes to modulate streamflow may be widespread across portions of the prairie pothole region (PPR)," and that "reducing wetland water storage capacity by connecting formerly isolated potholes through ditching or drainage to the Devils Lake and Red River basins could enhance stormflow and contribute to downstream flooding." Connectivity Report at 1-11. *See also,* 5-61.

The finding continues: "In many agricultural areas already crisscrossed by extensive drainage systems, total streamflow and baseflow *are* enhanced by directly connecting potholes to stream networks." Connectivity Report at 1-11. *See also*, 5-61.

The report's prairie potholes case study concludes with this finding, which seems to directly contradict the broadly-stated conclusion of concern quoted above:

> Given evidence in the current literature, however, when proper climatic or topographic conditions occur, or biotic communities are present that promote potential or observed connections, measurable influence on the physical, chemical, and biological condition and function of downstream waters is highly likely. Connectivity Report at 5-66.

Similar to the Prairie Pothole case study, the Carolina Bay case study includes findings based on peer reviewed scientific studies that would support the conclusion that such wetlands could be considered a class of waters that influence downstream waters, yet the conclusion at the end of that case study appears at odds with the scientific findings. *See* Connectivity Report at 5-53-57.

These findings alone indicate that the scientific literature does provide sufficient information to evaluate and generalize about the connectivity and downstream effects of wetlands in unidirectional landscape settings – at least on a regional or watershed basis.

B. We concur with the key findings with respect to the downstream connectivity and effects of "unidirectional" wetlands and open-waters, including the following:

> Water storage by wetlands well outside of riparian or floodplain areas can affect streamflow. Connectivity Report at 1-11.
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> Unidirectional wetlands act as sinks and transformers for various pollutants, especially nutrients, which pose a serious pollution problem in the United States….[O]nsite removal of nutrients by unidirectional wetlands is significant and geographically widespread. Connectivity Report at 1-11-12. *See also* Connectivity Report at 5-30.
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> Biological connectivity can occur between unidirectional wetlands and downstream waters through movement of amphibians, aquatic seeds, macroinvertebrates, reptiles, and mammals, including colonization by invasive species. Connectivity Report at 1-12. *See also*, Connectivity Report at 1-14.
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> Unidirectional wetlands can be hydrologically connected directly to river networks through channels, nonchannelized surface flow, or subsurface flows. Connectivity Report at 1-12.
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> Unidirectional wetlands occur along a gradient of hydrologic connectivity-isolation with respect to river networks, lakes, or marine/estuarine water bodies. This gradient includes, for example, wetlands that serve as origins for stream channels that have permanent surface water connections to the river network; wetlands with outlets to

stream channels that discharge to deep groundwater aquifers; geographically isolated wetlands that have local groundwater or occasional surface water connections to downstream waters; and isolated wetlands that have minimal hydrologic connection to other waterbodies (but which could include surface and subsurface connections to other wetlands). Connectivity Report at 1-12.

Individual wetlands that are geographically isolated could be connected to downstream waters when considered as a complex (a group of interacting wetlands)….[W]etland complexes could have connections to downstream waters through stream channels even when the individual wetland components are geographically isolated. Connectivity Report at 1-12.

C. We recommend several clarifications in the report's conclusions with respect to unidirectional wetlands and open-waters.

We advise the scientific review panel to clarify and refine the report's conclusions with respect to unidirectional wetlands and open-waters as follows:

- Clarify that the scientific literature does provide sufficient information to evaluate and generalize about the connectivity and downstream effects of wetlands in certain unidirectional landscape settings on a regional or watershed basis.

- Clarify and consistently apply the findings that: 1) downstream effects such as water storage and sediment removal arise from *isolation* rather than connectivity; and 2) these downstream effects arise from the connecting of previously isolated wetlands through ditching or drainage. Emphasize that these findings are well-documented in the scientific literature and should be thoroughly and consistently considered in assessing connectivity and downstream effects of unidirectional as well as bidirectional waters.

  The Connectivity Report repeatedly emphasizes that, "[b]oth connectivity and isolation have important effects on downstream waters." *See, e.g.,* Connectivity Report at 1-4, 5, 11, 13, 3-25, 3-29, 3-31, 3-48, 4-33, 4-68, 5-2, 5-30 (nutrient sinks), 5-36, 5-55, 5-61, 5-63, 5-66, 6-2, 6-3 . However, consideration of the downstream effects of wetland isolation seems to get short shrift in assessing connectivity/isolation of unidirectional wetlands and impacts on downstream waters. *See, e.g.,* Connectivity Report at 5-39 (Table 5-4), 5-41, 6-2.

- Clarify that scientific study is evolving and evidence of connectivity is increasingly emerging with respect to the downstream connectivity and effects of "unidirectional" wetlands and open-waters and that determinations with respect to the influence of these waters on downstream waters should not be static, but should take into account the most recent scientific evidence available. We expect that there are additional relevant peer-reviewed articles published in 2013, alone, and we urge the panel to incorporate these more recent publications and account for future scientific evidence to come.

- We suggest that the scientific evidence of the connectivity provided by avifauna, and perhaps other wildlife, be reviewed further and incorporated into the report to strengthen the information about the biological connectivity between wetlands and downstream waters. Some peer reviewed literature exists that illustrates the dependency of certain bird species, during certain times of the year, on having both wetlands (unidirectional in some cases) and downstream waters within their daily ranges. These kinds of linkages should be further researched and included, and some of the signatories here will provide specific literature citations for the panel.

Conclusion

We commend EPA and the authors of the report for their thorough and well-documented review of connectivity between downstream waters and the small streams and wetlands that occur throughout the landscape. Overall, the *Connectivity Report* is clear, technically accurate, comprehensive in its literature review, and establishes a strong foundation of the best currently available science demonstrating the physical, chemical, and biological connections by which streams, wetlands, and open-waters affect downstream waters such as rivers, lakes, and oceans.

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