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Overall Clarity and Technical Accuracy of the Draft Report

1. Please provide your overall impressions of the clarity and technical accuracy of the draft EPA Report, Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence.

The EPA Water Body Connectivity report is conceptually well developed and written in a style that is understandable to diverse groups of clientele interested in wetlands and riverine ecosystems. The report does very good job in providing many conclusions that are supported by peer-reviewed literature on hydrologic, chemical, and biological connectivity among streams, floodplains, riparian areas, wetlands (including isolated), and rivers. Major emphasis is placed on hydrologic connectivity with an assumption that material transfer follows water flow in these systems. Most part this assumption is justified, albeit very simplistic and does not recognize complex interactions among physical, chemical and biological interactions. I found this report very informative with to providing information and description of hydrologic processes involved in connectivity.

I found the report is too long and very descriptive and often repetitive. It is my understanding that the report will be used as guidelines by USEPA and other governmental agencies to support regulatory process to protect water bodies. For this reason, the report attempts to provide detailed accountability and description of issues related connectivity of these water bodies. I would like see the report focus on key issues and findings with some supporting information. Some detailed description can be in presented in boxes. This approach gives the reader to focus on main issues addressed in the report. For example, see may reports published by National Research Council.

I understand the logic for defining wetlands based on hydrologic flowpaths as bidirectional and unidirectional. I am assuming this distinction is based on the connectivity to streams and rivers. Even unidirectional wetlands may be connected to small streams via ground water and channels. So it is difficult to clearly separate the connectivity based direction hydrologic flow path, because of spatial and temporal heterogeneity of groundwater and surface flows and patchiness of wetlands in the watersheds. A clear description with a schematic drawing of bidirectional and unidirectional wetlands will be very useful and table showing how currently classified wetland will fit into these two broad groups. For example, where do bottomland hardwood forested wetlands fit into this classification.

In Chapter 2, clearly define the intended use of this document. Currently the purpose and scope of this document as defined is to review and synthesize available evidence to three questions related to connectivity of wetlands and streams to downstream water bodies. (1) What are the physical, chemical, and biological connections to and effects of ephemeral, intermittent, and perennial streams on downstream waters? (2) What are the physical, chemical, and biological connections to and effects of riparian or floodplain wetlands and open-waters (e.g., riverine wetlands, oxbow lakes) on downstream waters? and (3) What are the physical, chemical, and

biological connections to and effects of wetlands and certain open-waters that lack bidirectional hydrologic exchanges with downstream waters (e.g., most prairie potholes, vernal pools), hereafter referred to as unidirectional wetlands, on downstream waters?
The report addresses these questions with major emphasis on the role of hydrology related connectivity wetlands and streams to rivers. Obviously water flow is key to connectivity between these ecosystems including material transfer from one ecosystem to others. The report, however, does not adequately address sediment-water interactions in streams and soil-water-vegetation interactions in wetlands. Many of the biogeochemical processes are superficially mentioned.

It would have been useful to have some discussion on how external drivers such as climate change (precipitation, drought, and temperature), landuse change (urban and agricultural activities), and sea level rise will affect hydrologic, biogeochemical, and biological connectivity. Although, the focus of the report is on connectivity related to water quality, other effects including the influence of connectivity on greenhouse gas emission and sequestration macro-elements including carbon should recognized.

A brief discussion of ecosystem service values and tradeoffs associated with functions of wetlands, streams, and rivers should be included in the report.

Conceptual Framework: An Integrated, Systems Perspective of Watershed Structure and Function

> ***Charge Question 2.*** *Chapter 3 of the draft Report presents the conceptual basis for describing the hydrologic elements of a watershed; the types of physical, chemical, and biological connections that link these elements, and watershed climatic factors that influence connectivity at various temporal and spatial scales (e.g., see Figure 3-1 and Table 3-1). Please comment on the clarity and technical accuracy of this chapter and its usefulness in providing context for interpreting the evidence about individual watershed components presented in the Report.*

Include an Abstract for this chapter as it done for chapters 4 and 5.

Section 3.2- Introduction to River System - Primary focus of this section is on hydrology in river systems. This is section is well-written. I do not have expertise to provide useful comments on this section. There are other experts in the panel who are better qualified to provide comments on this section.

Section 3.3. Influence of streams and wetlands on downstream waters. This section addresses material fluxes from wetlands and streams into downstream waters.

Depending on hydrologic conditions, wetland soils and stream sediments can potentially function both as sources and sinks for macro-elements. Internal fluxes of macro-elements (such as carbon, nitrogen, phosphorus, and sulfur) and other elements should be considered in the discussion.

For example, wetlands serve as sink for nitrate nitrogen and source for ammonium nitrogen, dissolved organic matter (DOM), organic and inorganic phosphorus, metals complexed with DOM, sulfates, pesticides, and particulate matter. Wetlands accrete various contaminants in soils and serve as long storage.
Biogeochemical processes show high degree of spatial and temporal heterogeneity. These processes have major impact on downstream water quality. Biogeochemical hot spots are areas (or patches) can occur in small streams and wetlands and show disproportionately high reaction rates relative to the surrounding area. Cumulative effect of these reactions can be significant for streams and wetlands to function as sinks for contaminant removal.

Discussion on hydrologic connectivity is very good, but the linkage of hydrologic connectivity to biogeochemical connectivity needs further discussion.

Lotic Systems: Ephemeral, Intermittent, and Perennial Streams

> ***Charge Question 3(a).*** *Chapter4 of the Report reviews the literature on the directional (downstream) connectivity and effects of ephemeral, intermittent, and perennial streams (including flow-through wetlands). Please comment on whether the Report includes the most relevant published peer reviewed literature with respect to these types of streams. Please also comment on whether the literature has been correctly summarized. Please identify any published peer reviewed studies that should be added to the Report, any cited literature that is not relevant to the review objectives of the Report, and any corrections that may be needed in the characterization of the literature.*

This chapter is well written with respect to physical processes (water flow and sediment and wood transport in the water, and temperature).

Section 4.4.1
Chemical connectivity for most of part well described. When discussing nitrogen removal rates, it is important to distinguish nitrogen species (nitrate, ammonium, or organic nitrogen). What is the relative proportion of each of the nitrogen species. Many places the report refers to nitrogen loss or removal. I am assuming much of this nitrogen is nitrate. This should be clarified and processes regulating removal of nitrate, ammonium, and organic nitrogen should be discussed.

It is worth noting that nitrogen is removal is inversely related to mean stream depth. Each of the nitrogen species may respond differently to stream depth and flow.

Similarly, phosphorus removal and associated processes are not well described. What is the range of phosphorus concentrations in different streams and rivers. How the phosphorus removal is affected by stream depth and flow.

Sediment bound nitrogen and phosphorus needs to be discussed. Sediment bound nitrogen includes both organic nitrogen and ammonium nitrogen. Sediment bound phosphorus includes both organic and inorganic forms. This discussion is missing from the text

Section 4.4.2
Dissolved organic matter (DOM) and particulate organic matter (POM) transport is well described. Again, the processes and the factors regulating the breakdown of DOM and POM are described superficially. It should be noted the DOC is not same as DOM. It should not be interchanged. In addition to carbon, DOM and POM also includes organic nitrogen and organic phosphorus. What is the role of biotic and abiotic process in regulating the breakdown of DOM and POM.

Section 4.4.3.
The title 'Ions' is misleading. Refer this section to 'Electrical Conductivity or EC" that refers to 'Ionic Strength'. There is not much useful information presented in this section. The EC values provides an idea on how cations and anions composition is affected by streams flows. This section needs additional literature.

Section 4.4.4
This section is also a mixed bag. Need some careful revision of this section. Identify what contaminants are you referring to. Are these metals, toxic organic compounds, or others.

> ***Charge Question 3(b).*** *Conclusion (1) in section 1.4.1 of the Report Executive Summary discusses major findings and conclusions from the literature referenced in Charge Question 3(a) above. Please comment on whether the conclusions and findings in section 1.4.1 are supported by the available science. Please suggest alternative wording for any conclusions and findings that are not fully supported.*

Consider revising 1.4.1 section. It is very descriptive. It should be written in bulleted form, with most the detailed explanations in the main text. One has to search through the major findings. Specifically, I am referring to findings "d" and "e". Findings were primarily focused on nitrogen and it is my assumption that report refers to nitrate.

Finding should include sediment bound nutrients, DOM and POM, and other contaminants.

Lentic Systems: Wetlands and Open Waters with the Potential for Non-tidal, Bidirectional Hydrologic Flows with Rivers and Lakes

> ***Charge Question 4(a).*** *Chapter 5 of the Report reviews the literature on the directional (downstream) connectivity and effects of wetlands and certain open waters subject to non-tidal, bidirectional hydrologic flows with rivers and lakes. Please comment on whether the Report includes the most relevant published peer reviewed literature with respect to these types of wetlands and open waters. Please also comment on whether the literature has been correctly summarized. Please identify any published peer reviewed studies that should be added to the Report, any cited literature that is not*

relevant to the review objectives of the Report, and any corrections that may be needed in the characterization
of the literature.

Classifying wetlands as unidirectional and bidirectional is adding more confusion in this report. This division is based on hydrologic flows with rivers and lakes.

Riparian/floodplain wetlands are classified under both bidirectional and unidirectional and all other wetlands are considered unidirectional. I am not sure this type of division is justified and adds unnecessary confusion to the discussion on connectivity. Depending on landscape scape position, many wetlands can have both types of hydrologic flows. In my opinion, it will be best to keep the wetlands group simple as described in other EPA documents.

Wetland connectivity to streams and rivers is lot more complex (and not well studied) than connectivity of streams to rivers.

Table 5-1 is very good. It summarizes various functions in wetlands. Note that sink and transformation are not the same and they refer different things.

Sink or Source- For example, when nitrate fluxes from water column into underlying soils, then soils act sink for nitrate, while water column acts as source of nitrate. Similarly, soils or sediments can serve as source of phosphorus to the water column.

Transformation function – is a biogeochemical reaction mediated biotic and abiotic processes. For example, nitrate is used as an electron acceptor by facultative or anaerobic microbes and convert it to nitrogen gas (denitrification) or to ammonium (dissimilatory nitrate reduction ammonia). Depending on redox conditions, both reactions transform nitrate to different end products.

Physical, chemical, and biological influences of riparian/floodplain areas are adequately addressed.

A short section on basic macro-elemental cycles (carbon, nitrogen, phosphorus, and sulfur) will be very useful to the reader to see links between sources, sinks, and transformations. Include basic schematic drawings of these cycles, similar to drawing in the report on hydrologic processes.

Charge Question 4(b). *Conclusion (2) in section 1.4.2 of the Report Executive Summary discusses major findings and conclusions from the literature referenced in Charge Question 4(a) above. Please comment on whether the conclusions and findings in section 1.4.2 are supported by the available science. Please suggest alternative wording for any conclusions and findings that are not fully supported.*

Conclusions are justified based on the literature presented in the report.

Lentic systems: Wetlands and Open Waters with Potential for Unidirectional Hydrologic Flows to Rivers and Lakes, Including "Geographically Isolated Wetlands"

> ***Charge Question 5(a).*** *5(a) Section 5.4 of the draft Report reviews the literature on the directional (downstream) connectivity and effects of wetlands and certain open waters, including "geographically isolated wetlands," with potential for unidirectional hydrologic flows to rivers and lakes. Please comment on whether the Report includes the most relevant published peer reviewed literature with respect to these types of wetlands and open waters. Please also comment on whether the literature has been correctly summarized. Please identify any published peer reviewed studies that should be added to the Report, any cited literature that is not relevant to the review objectives of the Report, and any corrections that may be needed in the characterization of the literature.*

See my comments for Riparian/floodplain wetlands. Many of these comments are pertinent to this section also.

> ***Charge Question 5(b).*** *Conclusion (3) in section 1.4.3 of the Report Executive Summary discusses major findings and conclusions from the literature referenced in Charge Question 5(a) above. Please comment on whether the conclusions and findings in section 1.4.3 are supported by the available science. Please suggest alternative wording for any conclusions and findings that are not fully supported*

Conclusions are justified based on the literature presented in the report.