Missouri River Recovery Program
Independent Science Advisory Panel

Final Report on
Spring Pulses and Adaptive Management

November 30, 2011

Performed for:
U.S. Institute for Environmental Conflict Resolution
and Missouri River Recovery Implementation Committee

Performed by:
Missouri River Independent Science Advisory Panel
and Oak Ridge Associated Universities, Third Party Science Neutral

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Executive Summary

Introduction

This report to the Missouri River Recovery Implementation Committee (MRRIC) assesses the efficacy of managed spring pulse releases from Gavins Point Dam on the Missouri River in achieving expected outcomes for three listed species, pallid sturgeon, least tern, and piping plover, prescribed in Biological Opinions issued by the U.S. Fish and Wildlife Service in 2000 and 2003. The assessment is based on review and interpretation of available science and other information. The Independent Science Advisory Panel (ISAP), tasked with this review by the MRRIC, considered thousands of pages of peer-reviewed literature and agency reports, material presented to it in topical presentations and webinars, and information from agency personnel, scientists, and MRRIC committee members.

The findings presented here reflect consensus views of the panel members. The ISAP provides scientifically informed answers to discrete charge questions from the MRRIC that are intended to help improve management decisions. The ISAP largely constrained its analysis and review to the managed spring-pulse action, acknowledging that this conservation action interacts strongly with naturally occurring climatic phenomena and other management actions, including mechanical habitat creation efforts.

Conceptual Models of the Listed Species

The ISAP developed simple conceptual models for each of the three listed species. These models describe the panel's understanding of the species as they relate to abiotic and biotic variables, the hydrodynamics of the river that provide for those conditions, and the management actions that may create and sustain those conditions. These models are meant to serve as example tools for identifying the attributes of the system that should be monitored to assess a given management action, and provide templates to identify aspects of the system that are well understood, or those where there are substantive uncertainties. Such models serve as integral elements in formalizing hypothesized relationships between management actions and ecological outcomes, and intermediate steps between. Conceptual models themselves, and more quantitative models derived from them, are needed to assist in adaptive management for the species.

Status of Science Related to Expected Outcomes and Recovery

Pallid sturgeon have spawned in the lower Missouri River in all years for which data are available, with and without managed spring pulses. Based on that information, the ISAP concludes that the spring pulse management action, as currently designed, is unnecessary to serve as a cue for spawning in pallid sturgeon.

There is no evidence that food limitation constrains the population sizes, survival, or recruitment of pallid sturgeon, least tern, or piping plover on the lower Missouri River, and it has not been demonstrated that management actions would relax this limitation, if it existed. The managed spring pulse action as currently implemented appears to be inadequate to connect the main channel to much of the historic floodplain, due to channel incision and flood pulse attenuation downstream. Furthermore, there is no evidence that mechanically constructed habitat has contributed to ecological functions that floodplain connectivity might be expected to provide, in the forms of increased availability of nutrients, invertebrates, or prey fish for the three species.

Evidence suggests that there are sufficient scoured substrates and coarse sediments available in upstream reaches of the lower Missouri River to support spawning by pallid sturgeon, and that female pallid sturgeon have spawned in lower reaches at outside bends over coarse riprap, which roughly matches the substrate characteristics thought to be necessary for spawning.

Managed spring pulses from Gavins Point Dam have not been successful in creating new sandbars or scouring (and reducing vegetation cover) or otherwise conditioning existing sandbars to provide nesting habitat for least terns and piping plovers. There is no evidence that managed spring pulses have improved ecological conditions for native fish, invertebrates, or other native species, consistent with the observation that the pulses have been of such limited magnitude and duration that they appear to be unable to generate the specific habitat features and conditions that are believed to be important for those species.

Flow management via pulse releases from reservoirs is being used to support ecosystem restoration in a number of other large river systems. System-specific constraints and species needs partially limit the transferability of findings to planning efforts for the lower Missouri River. Nonetheless, there are lessons to be learned from examining successes and failures of restoration efforts, decision making processes, and adaptive management plans that have been developed elsewhere.

Status of Science Related to Hydrologic Management Actions

Channel and bank stabilization on the lower Missouri River have reduced the potential for flows to modify channel morphology, and upstream impoundments have reduced the potential for channel-changing flows. Channel incision in many reaches limits opportunities for channel connections to riparian and directly adjacent floodplain areas, and high flows in normal flow years tend not to overtop the banks to create low-velocity or low-depth conditions in many reaches. Available information suggests that there are only marginal gains to be made by continued attempts to adjust managed spring pulses without changes in channel morphology.

It appears that, given system constraints, management efforts to enhance and sustain the habitat features and conditions that are necessary to the three listed species on the lower Missouri River will require manipulation of base flows and pulse actions, combined with mechanical habitat construction activities. Decisions to implement new flow management actions with the intention of providing habitat for listed species on the lower Missouri River should be guided by quantification of the interactive relationships among hydrological actions and construction.

Evaluating Performance

A critical shortcoming in ongoing monitoring efforts, especially those targeting pallid sturgeon, is the absence of hypothesis testing that is specifically related to the management actions and expected outcomes. Performance metrics related to pallid sturgeon should be expanded from those pertaining to migration, reproductive readiness, and spawning activity, to metrics that more directly reflect population growth and recruitment.

The current science program lacks a number of the components that are essential in an adaptive management program; few data that have been collected to date can be used to evaluate management actions. Moreover, there is not a process in place by which performance metrics and other data can be employed to inform management actions. Without substantial and integrative changes in monitoring, assessment, and research programs, and without development of a structured adaptive management plan, the managed spring pulse program and accompanying recovery efforts targeting the three listed species will be uncoordinated and ineffective.

Managing Uncertainties

The managed spring pulse regime as currently implemented may be neither beneficial nor detrimental to pallid sturgeon spawning; any risks to pallid sturgeon recruitment from the managed spring pulses are unknown. Continuing with these spring pulse actions as a primary means of conserving pallid sturgeon on the Missouri River below Gavins Point Dam may contribute to a low likelihood of species recovery. There is at least some risk of detrimental effects to the least tern and piping plover through nest losses from flooding that is associated with the managed spring pulses.

From current information it is unclear whether or how habitat construction can contribute to the recovery of pallid sturgeon. Recovery of pallid sturgeon in the Missouri River ultimately may be independent of habitat construction efforts, and may instead depend on successful recruitment below the Missouri and Mississippi rivers confluence, but this is an area of substantial uncertainty. Enhanced population numbers of piping plovers and least terns that may derive from habitat restoration and construction efforts below Gavins Point Dam have unknown implications for the status, trends, and recovery of piping plover across its broader range in the northern Great Plains, or least tern across the interior of North America.

The role of naturally occurring spring pulses in contributing to habitat area and suitability for the listed species has not been adequately or systematically assessed. Spring pulses from tributaries to the lower Missouri River are likely providing ecological benefits to the three listed species, but whether these tributary pulses are sufficient to mitigate for reduction of natural main stem pulses is unknown.

Emphasis on managed spring pulses, as they are currently designed and implemented, might prevent reallocating resources and attention to more cost-effective actions that better target the three listed species.

There is no evidence that managed spring pulses as currently implemented compromise existing internal drainage capacities or groundwater elevations in ways that threaten crops and croplands. River incision has reduced the effects of managed spring pulses on lands adjacent to the main channel, and managed spring pulses are substantially attenuated as they move downstream, reducing their effects in less-incised downstream reaches. Managed spring pulses that are larger or longer in duration could increase risk to interior drainage and groundwater levels.

The effects of tributary discharges to the lower Missouri River on the ecologies of the three listed species are unknown. There is no evidence that the contemporary, minimal floodplain connectivity along the tributaries or the main channel provides essential nutrients or forage for the three species. Additionally, there is no evidence that spawning habitat is more effectively scoured in reaches affected by natural rises from tributaries. Furthermore, there is no evidence that sandbars are conditioned to serve as habitat for least terns or piping plovers more frequently on, nor are there measurable differences in catch rates of pallid sturgeon in, reaches that experience natural rises from tributaries.

Mechanically constructed habitat features may provide benefits to larval and juvenile life stages of the pallid sturgeon, but this is not supported by evidence. Monitoring and research must be designed to test specific hypotheses about the mechanisms that influence sturgeon population growth and persistence. Because it remains unclear whether pallid sturgeon are limited by the availability of food resources, questions regarding the role of levee setbacks or floodplain reconnection must first be linked to specific hypotheses about how these river features might address actual environmental stressors that may be acting on the species, such as food limitation,

Research and monitoring needs to be more narrowly focused on the specific effects of spring pulse management actions on vital demographic parameters of the three listed species.

Conclusions

Substantial new knowledge regarding pallid sturgeon, least tern, and piping plover, their habitats, and management opportunities on the lower Missouri River has accrued since publication of the 2000 and 2003 Biological Opinions for those species. The Reasonable and Prudent Alternatives (RPAs) in the biological opinions identified managed spring pulse releases from Gavins Point Dam as one of the primary means for mitigating impacts to the three listed species resulting from its operation. However, the best available scientific information indicates that the spring pulse management strategy as implemented cannot provide some of the expected outcomes and is not necessary to achieve other expected outcomes. A new management agenda using hydrological manipulations and habitat construction activities, implemented in an adaptive management framework, needs to replace the current action plan to contribute to the survival and recovery of the listed species.

Recommendations

The report offers multiple points of guidance and suggestions including:

- An adaptive management plan should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction below Gavins Point Dam, and this plan should be used to guide future management actions, monitoring, research, and assessment activities.
- The development of an adaptive management plan should be preceded by and based upon an effects analysis that incorporates new knowledge that has accrued since the 2003 Biological Opinion. A description of the necessary effects analysis is beyond the scope of the current ISAP,

but an outline of the process was presented and discussed at the September 20-21, 2011 meeting of the MRRIC Science and Adaptive Management Work Group in Omaha, and is documented in the minutes of that meeting.

- Conceptual ecological models should be developed for each of the three listed species and these models should articulate the pathways from management actions to species performance.
- Baseflow restoration should be evaluated as a potential management action.
- Monitoring programs along the lower Missouri River should be re-designed so as to determine if expected outcomes are attributable to specific management actions.
- The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
- Other managed flow programs and adaptive management plans should be evaluated as guiding models for the lower Missouri River recovery program.

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Section I—Introduction

The Independent Science Advisory Panel (ISAP), serving under the Missouri River Recovery Program (MRRP) and Missouri River Recovery Implementation Committee (MRRIC), was convened to “provide independent scientific advice and recommendations to support decisions and directions taken by the Corps.” This first report from the ISAP is in response to the January 28, 2011, charge from the MRRIC to "review metrics, monitoring, investigations, and management actions" related to managed spring pulses. Our report is intended to review pertinent information and provide a scientific analysis and guidance to the U.S. Army Corps of Engineers (USACE, or Corps), U.S. Fish and Wildlife Service (USFWS), and MRRIC regarding spring pulse management actions and expected outcomes for pallid sturgeon, least tern, and piping plover in reaches of the Missouri River below Gavins Point Dam as prescribed in the 2003 Biological Opinion. Our report is also intended to provide guidance with respect to an adaptive management plan that might better link management actions on the Missouri River to intended benefits for federally listed species.

This report focuses specifically on determinations in the 2003 Amendment to the 2000 *Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and the Operation of the Kansas River Reservoir System* (2003 Amended Biological Opinion). In that Biological Opinion, the USFWS issued a jeopardy finding on the three listed species and recommended a Reasonable and Prudent Alternative (RPA). The RPA specifically prescribed a bi-modal spring pulse release from Gavins Point Dam to enhance habitat conditions for the pallid sturgeon; the outcomes of the action were expected to include benefits to the pallid sturgeon and the two listed bird species, and contribute to the survival and recovery all three species.

We have attempted to use the most reliable, pertinent information that is available regarding the frequency and magnitude of spring pulses, implemented as water-year-specific river operations, and findings from research and monitoring that has focused on the riverscape features and resources that contribute to habitats that are essential to survival and recruitment of individuals and populations of the listed species on the Missouri River. The spring pulse management action has been implemented in the spring in several years since the agency determination was promulgated. However, in several years the action was precluded by insufficient water storage, or was obviated by greater than average flows, which together created flow conditions in the spring at or exceeding levels recommended in the Biological Opinion. Accordingly, little direct evidence is available from which the efficacy of prescribed spring pulse management actions can be evaluated. Therefore, we have supplemented that limited information with information on the listed species from elsewhere in the Missouri River basin. In addition, we draw inferences, where appropriate, from species with similar life-history characteristics from beyond the river basin in circumstances analogous to those addressed in this report.

The ISAP is aware that legally mandated Gavins Point Dam operations, channelization of the river, development on historical floodplains downstream of the dam, and myriad uses of the river's physical and biotic resources greatly constrain the potential timing and magnitude of managed spring pulses in the Missouri River below Gavins Point Dam. Given current physical system limitations and inter-annual constraints to spring pulse implementation, there is reason to question whether currently mandated spring pulse management actions contribute to enhancing habitat conditions for and increasing population sizes of pallid sturgeon, piping plover, and least tern. However, we evaluated spring pulse actions as a management tool that, at some magnitude and frequency, has the potential to benefit the listed species by contributing to enhancing and sustaining the habitats and resources used by those species.

The ISAP Role and Mode of Operation

The ISAP views our role as providing interpretations of available science and preparing scientific findings to inform the decision-making process of the MRRIC. Further, we identify gaps in information that, if filled, could enhance the knowledge upon which river management decisions can be made. We expect MRRIC to use the ISAP findings and interpretations to assess what actions are actually feasible, possible, and/or practicable given other constraints, including social constraints and existing Authorized Purposes, on the system.

The ISAP worked as a highly collaborative committee with frequent discussions and sharing of information. We reviewed documents and briefings that were provided during webinars, presentations in Kansas City, and on MRRIC websites, as well as information from agency reports and the peer-reviewed literature. Wherever and whenever possible, the panel used site-specific information relevant to the target species; it also used pertinent information from the same species from adjacent or even distant portions of the Missouri River system. The panel drew inferences from other species in similar circumstances from other river systems; it is explicitly noted when information from outside of the Missouri River basin was relied upon to inform a specific conclusion in this report. We requested additional information or interpretations from reliable sources when they were needed. We also benefitted from first-hand accounts from ongoing field studies, candid responses from agency and independent scientists to the panel's probing questions, and patient responses from the same individuals to multiple requests to revisit numerous issues of concern to this report.

All members of the ISAP considered every charge question, but panel members with expertise most relevant to particular questions provided first assessments and interpretations for the group. After multiple discussions, draft written responses were prepared by individuals and sub-groups of the ISAP; this was followed by extensive back-and-forth crafting of the text presented here. The entire ISAP reviewed all report sections; the findings presented in this report reflect consensus views of the panel members.

In a few cases, the conclusions we reached diverge from those in the Biological Opinion or stand counter to conclusions drawn by others in past reports or publications. While these differences in opinion are not substantive, it is important to recognize why divergent interpretations or conclusions may have been reached. We note that biological findings in the Biological Opinion for the three listed species were based on knowledge and understanding of the listed species and their habitats in relation to river hydrodynamics and fluvial geomorphology that were available eight years ago; since that time a substantial amount of new data and information has emerged. In addition, based on our assessment of how the system operates, we may have applied different conceptual models than those presented explicitly or implicitly in the Biological Opinion or in support documents to adaptive management and other management action plans. We may have analyzed the same data as others before us, but did so using new methods or approaches, and we may have placed different emphases on certain data if we believed that others before us did not fully appreciate the applicability of available data sets, or if we believed that others over-emphasized or otherwise misused available data. Furthermore, we may diverge in our views from other views on how specific ecological uncertainties should inform management actions.

Where the panel notes differences between the findings in this report and those of others, whether explicit or inferred, we attempt to explain the reasons for those differences to clarify our reasoning and maximize the utility of this report to natural resource managers and planners working on the Missouri River below Gavins Point Dam. We emphasize in this report that we provide science-based interpretations and findings. We recognize that our role in the greater hydrological and ecological planning process on the Missouri River is not to choose among management options, but to provide scientifically informed answers to discrete questions from the MRRIC to help inform policy recommendations that are its to make. We acknowledge the severe constraints on management of the river and its ecosystems that the MRRIC and the management agencies confront in making their policy and management recommendations and decisions. However, we have made programmatic recommendations based on our assessment that such changes are important for the future of the adaptive management program and the recovery of the three listed species.

Terminology Clarifications

In an attempt to minimize misinterpretation of our meaning, here we clarify some of the terminology we use in this report:

Managed Spring Pulse - we define this as it is currently designed and implemented. We consider the 2006 Master Manual Water Control Plan to be the design, and that its implementation over the past five years reflects the way it was designed and will continue to be implemented.

Designed vs. Implemented Spring Pulse - we use these two terms to distinguish the management action that was planned to be put into place (i.e., spring pulses at certain times and for certain durations) versus the action that has actually been implemented (i.e., due to variability in rainfall and logistical issues, there are years in which the pulses have not or will not be implemented).

Reaches of the River - where known, we identified the location on the river (e.g., river mile), or we identified the segment of river. We used the terminology for location along the Missouri River given in Jacobson et al. (2010) Table 1, as follows:

Lower Missouri River – Gavins Point Dam to the Mississippi River
Upper Missouri River – Missouri River upstream of Gavins Point Dam
Gavins Segment – Gavins Point Dam to Ponca, Nebraska
Ponca Segment – Ponca Nebraska to the Big Sioux River
Big Sioux Segment – Big Sioux River to the Platte River

Platte Segment – Platte River to the Kansas River
Grand Segment – Grand River to the Osage River
Osage Segment – Osage River to the Mississippi River

Issues to be resolved - issues for which available information is not currently sufficient to draw a reliable conclusion.

Lack of evidence or *No evidence* - no available data or applicable information appears to exist from which a conclusion can be drawn.

Constructed habitat - mechanically, that is, artificially constructed habitat; habitat not created by the river's flow hydrodynamics.

Structure of the Report Findings

We initiate this report in Section II by presenting a brief conceptual model that describes the panel's understanding of the ecology of pallid sturgeon, piping plover, and least tern, as they relate to abiotic and biotic variables for those species, the hydrodynamics of the river that provide for those conditions, and management actions that may be taken to create and sustain those conditions. The report then addresses the specific charge questions that were provided to the panel by the MRRIC. In Section III of the overall report, we answer charge questions that address the three listed species, their habitats, and the ecosystem processes that support them. In Section IV of the report, we focus on the status of science related to hydrological management actions and how those management actions have been or could be influenced by ongoing or future morphological actions (i.e., constructed habitat). We then consider in Section V aspects of evaluating the performance of the prescribed spring pulse management actions. The section considers alternate management options, monitoring and assessment, and programmatic performance measures. While we identify some shortcomings in the current monitoring programs, a more fully detailed discussion of the interagency research and monitoring scheme that is necessary to better understand the relationships between river operations and species responses is beyond the scope of this report and the timetable available to the panel for this deliverable. The panel does note that an integrated, multi-agency adaptive management program, supported by monitoring in a rigorous conceptual framework that could be used to assess the performance of the spring pulse management actions prescribed in the Biological Opinion, is not currently in place.

Recommendation

An adaptive management plan should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction below Gavins Point Dam, and this plan should be used to guide future management actions, monitoring, research, and assessment activities. The development of an adaptive management plan should be preceded by and based upon an effects analysis that incorporates new knowledge that has accrued since the 2003 Biological Opinion. A description of the necessary effects analysis is beyond the scope of the current ISAP, but an outline of the process was presented and discussed at the September 20-21, 2011 meeting of the MRRIC Science and Adaptive Management Work Group in Omaha, and is documented in the minutes of that meeting.

Section II—Conceptual Models of the Listed Species

We developed conceptual models for pallid sturgeon, least terns, and piping plovers that describe relationships between their populations, habitats, other species, and management actions that are being directed to achieve recovery objectives for those species. These conceptual models do not include all possible factors that might affect population performance, nor do they address all possible management actions that might affect demographic responses by the species. Rather, the model components and depicted relationships define the scope of our review concerning the efficacy of managed spring pulses for achieving the anticipated outcomes that are identified in the ISAP charge questions. These conceptual models serve several purposes. They facilitate identification of key metrics that should be monitored to determine if the proposed mechanistic "pathways" described or implied in the Biological Opinion are correct, and determine if the listed species are responding as predicted. The models can also serve as effective tools for identifying the attributes of the system that should be monitored to assess a given management action. Additionally, they provide a template that can be used to identify aspects of the system that are well understood, with available information that can provide reliable guidance to managers and identify aspects of the system wherein substantive uncertainties limit application of available knowledge to management. Accordingly, the conceptual models assisted us in exploring where management is being directed, where management should be directed, where management actions are constrained/not possible, and where management effects are obviated by system attributes beyond the control of conservation planners.

Recommendation

Conceptual ecological models should be developed for each of the three listed species and these models should articulate the pathways from management actions to species performance.

Pallid Sturgeon (*Scaphirhynchus albus*)

The anticipated outcomes of the managed spring pulse program, as they might potentially affect pallid sturgeon population growth are summarized in Figure 1.

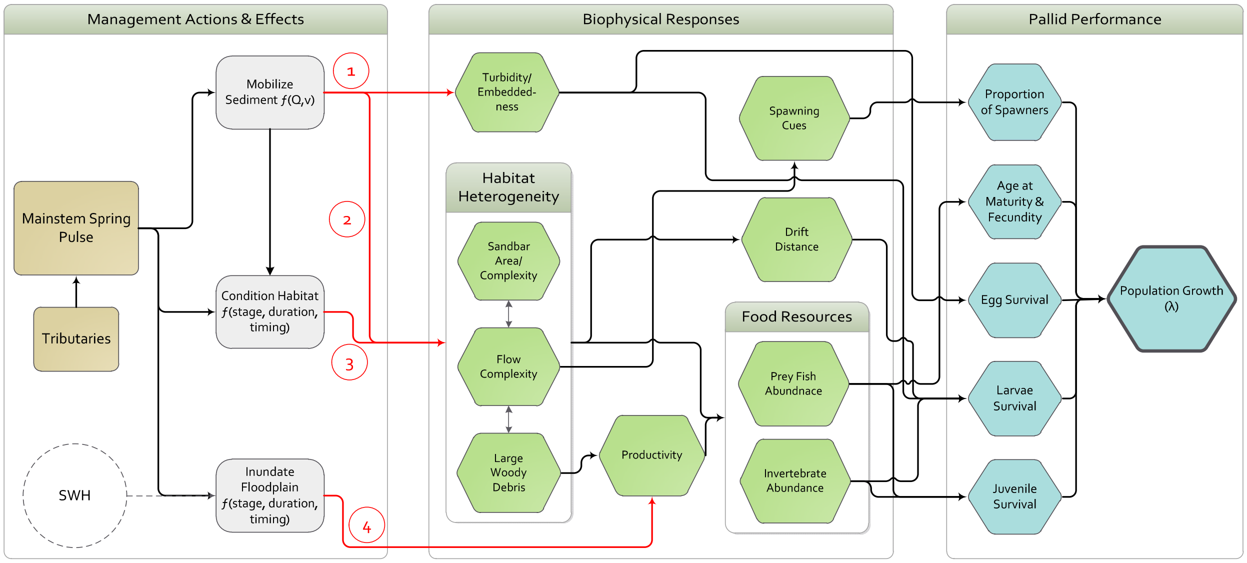

Figure 1. *Pathways through which management actions on the lower Missouri River may directly or indirectly affect pallid sturgeon population growth are illustrated. Two management actions are shown, spring pulse and construction of shallow water habitat, although the focus of this report is on managed spring pulses. Managed spring pulses can be linked to population growth in pallid sturgeon through multiple pathways (shown in red), each of which directly or indirectly alter attributes of their habitats and prey. Suggested metrics by which the managed spring pulse action may be evaluated are represented as hexagons. Variation in color among rectangles and hexagons is used to group categories and enhance readability.*

Wildhaber et al. (2007, 2011) developed a detailed conceptual life history model for pallid sturgeon and shovelnose sturgeon. Our intent was not to duplicate the Wildhaber et al. efforts, but rather to illustrate the links between the prescribed spring pulse management action and response variables that can be used to answer the charge questions provided to the ISAP by the MRRIC. Four pathways illustrate how sediment transport, conditioning of habitats, and inundation of floodplains influence biophysical processes (similar to the "condition factors" described by Wildhaber et al. [2007, 2011]), which ultimately influence pallid sturgeon population growth. For example, pathway 1 relates to sediment transport by increasing suspended sediment and reducing embeddedness of spawning areas. It is hypothesized that this process would increase egg survival by enhancing the adhesion of eggs on coarse substrates and oxygen transport. Furthermore, larval survival could be increased by reducing the efficiency of predators that feed by sight. Pathways 2 and 3 influence habitat heterogeneity, which is likely important for recovery of the lower Missouri River ecosystem and increasing pallid sturgeon population growth through increased survival of larvae and juveniles. Pathway 4 relates to inundation of the floodplain and its effect on ecosystem dynamics, and, subsequently, fecundity, survival of larvae and juveniles, and age at maturity.

We explicitly used pallid sturgeon performance metrics that are useful in age-structured models for determining population growth rate, which is the definitive success metric. We had the Bajer and Wildhaber (2007) age-structured population model in mind when we developed the conceptual model.

Thus, updating the population performance metrics as they relate to management actions will be useful in determining the mechanisms that influence pallid sturgeon population growth through adaptive management. This relatively simple conceptual model assists in identifying the metrics that should be measured in monitoring and research, if determining the effects of a managed spring pulse is the goal.

Piping Plover (*Charadrius melodus*)

The anticipated outcomes of the bi-modal spring pulse action, as they might potentially affect breeding habitat and piping plovers are summarized in Figure 2.

Habitat requirements for breeding piping plovers in the Missouri River basin are well understood. Habitat comprises sandbars, dredge islands, and river floodplains, where vegetation cover is usually less than 20 percent (Haig 1992). Breeding habitat has two fundamental attributes—areal extent and condition or suitability. The area of available habitat is fundamentally important because nesting piping plovers display agonistic behavior during the nesting period and defend a territory around the nest site, and, accordingly, the number of breeding pairs is constrained by the spatial extent of a habitat patch. Ultimately, however, the suitability of a habitat patch has a great influence on piping plover nest success, chick survival, and the number of young birds fledged per adult breeder. Suitability is a function of three aspects of nesting habitat for piping plovers: vegetation cover, substrate characteristics, and invertebrate abundance. The birds construct nests by making a small depression or scrape in bare sand. The nest may be placed near a small clump of vegetation, but plovers tend to avoid areas of evenly distributed vegetation, and 90 percent of nests occur on sandy areas with < 10 percent vegetation cover. Landform heterogeneity is important and sandbar microhabitats, such as depressions, over-wash zones, wet spots, or other landform structures offer protected feeding sites and tend to produce more invertebrate foods (LeFer et al. 2008). Both adults and juveniles appear to be sight feeders, selecting a variety of beetles (Coleoptera), bugs (Hemiptera), and flies (Diptera). Adults with broods concentrate their feeding activities within five meters of the wetted shoreline, and at depressions and wet spots that have higher prey densities (summarized in Haig 1992).

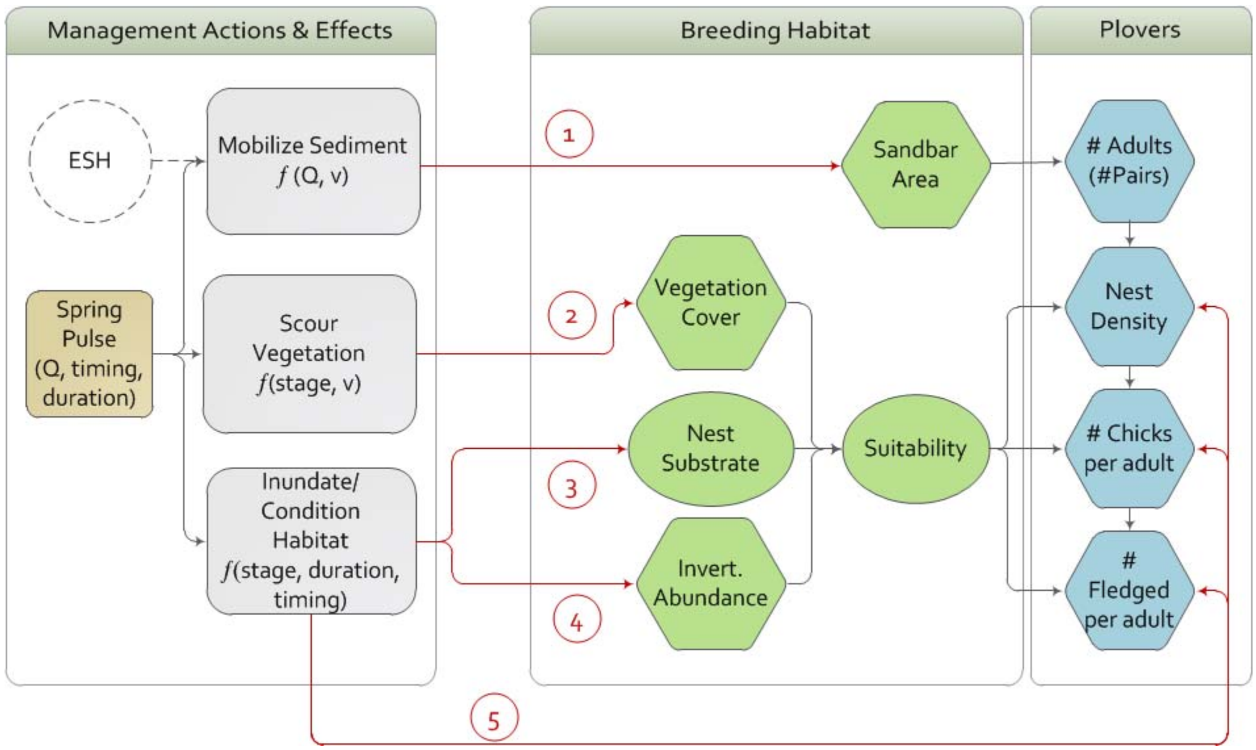

Figure 2. *Pathways through which spring pulse management actions may directly and indirectly affect breeding piping plovers on the lower Missouri River. Two management actions are shown (emergent sandbar habitat [ESH] creation and spring pulse), although the focus of this report is on spring pulse management actions. Spring pulse management actions link to plover habitat and plover populations through five pathways (shown and numbered in red), four of which indirectly affect plovers through potential changes to their habitat. The fifth pathway represents unintended consequences of habitat inundation during the nesting and brood rearing phases of reproduction. Suggested habitat and plover metrics, by which the spring pulse management actions may be evaluated, are represented as hexagons.*

Although the focus of the charge is an evaluation of a spring pulse management action implemented below Gavins Point Dam, other habitat management activities are also being undertaken for the piping plover. One of these other activities—the creation of emergent sandbar habitat—is also illustrated in Figure 1 for clarity, but we do not analyze the efficacy of the emergent sandbar habitat in this report. Additional management activities, including predator control, have been undertaken in response to situations not anticipated at the outset of the current monitoring program or in the 2000 and 2003 Biological Opinions. These other activities are only mentioned herein to the extent that they may potentially interact with managed spring pulses in achieving management objectives. The spring pulse action program potentially affects piping plover population status and trends via five distinct ecological pathways, shown by red arrows in Figure 2.

Least Tern (*Sterna antillarum*)

The anticipated outcomes of the bi-modal spring pulse management actions, as they might potentially affect breeding habitat for least terns and least tern population numbers are summarized in Figure 3. Breeding habitat for least terns has two essential components—sandbars that are used for nesting and aquatic areas that are used for feeding. Nesting occurs on sparsely vegetated sand flats, dry mudflats, sand islands, and in sand and gravel pits (summarized in Thompson et al. 1997). Nesting occurs in colonies, and least terns show site tenacity in some situations (Kirsch 1996), although ongoing studies by the U.S. Geological Survey (USGS) and the USACE reveal lower site tenacity in the Missouri River. Nesting habitat has two fundamental attributes—spatial extent and suitability. The area of available nesting habitat is fundamentally important because of colony size; hence, the number of breeding adults is ultimately limited by the extent of available habitat. The suitability of habitat has a large influence on nest success, chick survival, and the number of young fledged per breeding adult. Suitability is a function of two aspects of nesting habitat: vegetation cover and landform/landscape characteristics. Colonies are usually located on sites with no vegetation, although nests sometimes occur on sites with up to 30 percent vegetative cover (summarized in the 2000 Biological Opinion). Least tern colony sites are usually located on open expanses of sand or pebble beach within the river channel or reservoir shoreline. Least terns select sites that are well-drained and positioned well back from the water line (summarized in the 2000 Biological Opinion). There is some evidence that terns select sites that have been exposed above the water line for a longer period of time, and there also appears to be a preference for sites that occur as complexes of sandbars (summarized in the 2000 Biological Opinion). Twenty-five nesting colonies occurred on the lower Missouri River in 2005 (Lott 2006).

Interior least terns feed in a variety of shallow water areas, such as rivers, streams, sloughs, dike fields, marshes, ponds, sand pits, and reservoirs (Thompson et al. 1997). On the Mississippi River the abundance and variety of forage fish was greatest in water < 1 m in depth, in main channel and side-channel habitats, adjacent to sand islands with uniquely suitable water surface temperature, clarity, and velocity (Tibbs and Galat 1998, in Thompson et al. 1997). Least terns feed on small fishes, but will also eat invertebrates (Atwood and Kelly 1984). Based on unconsumed fish dropped in nesting colonies, narrow-bodied fish species dominate tern diets (Atwood and Kelly 1984, Wilson et al. 1993; Thompson et al. 1997). Rejected fish frequently included those with spines, body depths of >1.5 cm and lengths of >9 cm (Thompson et al. 1997). Adults present small fish (<2 cm) to chicks less than three days of age (Schweitzer and Leslie 1996). Common forage species in the Platte River, Nebraska, were red shiner (*Notropis lutrensis*), creek chub (*Semotilus atromaculatus*), and plains killifish (*Fundulus zebrinus*) (Wilson et al. 1993); forage fish selected in the Mississippi River of Missouri included shad (*Dorosoma* spp.), river carpsucker (*Carpiodes carpio*), and minnows (*Notropis* spp.) (Smith and Renken 1990).

Least tern nest colonies and shallow water feeding areas tend to be in close proximity. Jernigan et al. (1978) found that every one of 61 observed colonies in North Carolina were within 250 m of a large expanse of shallow-water (feeding) habitat. Least terns in Nebraska generally foraged within 100 m of nest colonies (Faanes 1983), and least terns in Kansas occasionally flew 3.2 to 4.8 km to feed, although terns usually foraged within 1.6 km of colony sites (Carreker 1985).

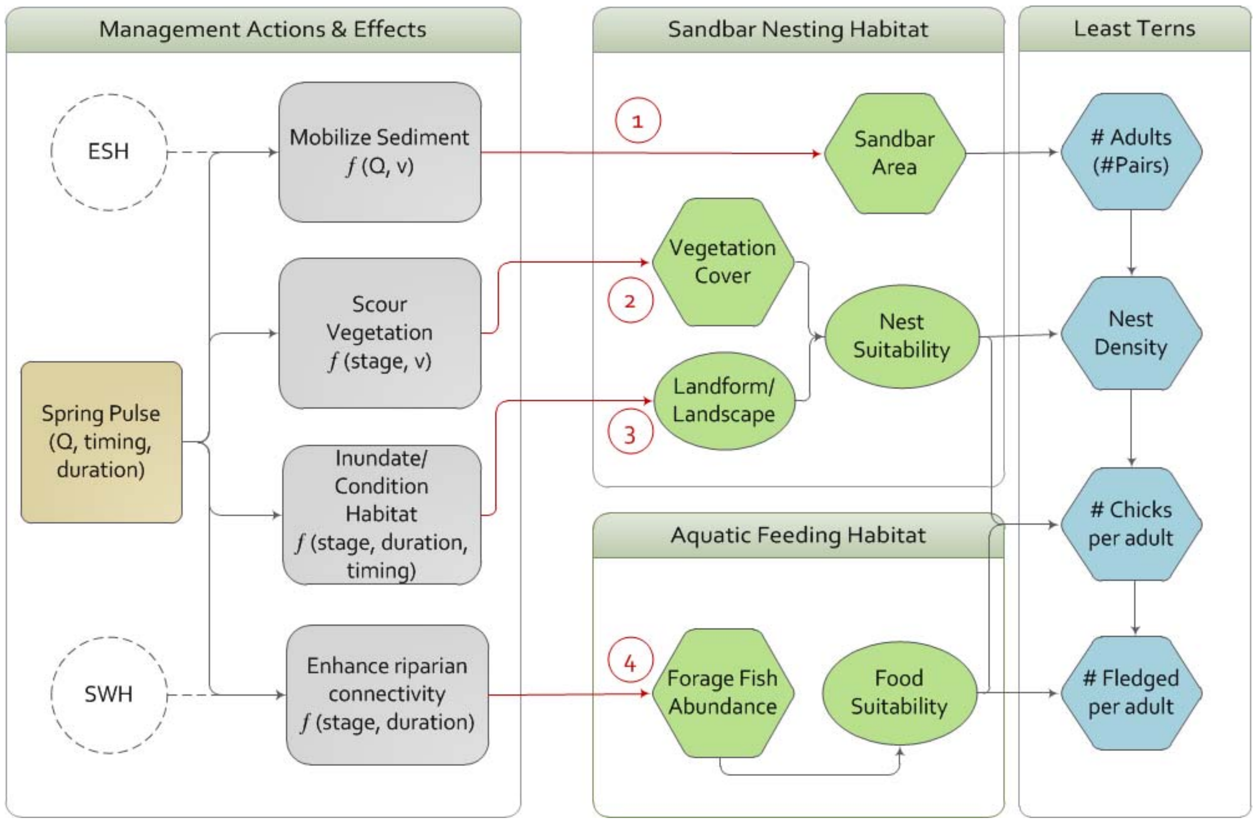

Figure 3. *Pathways through which management actions may directly and indirectly affect breeding least terns. Three management actions are shown (emergent sandbar habitat creation, spring pulse, and shallow water habitat management [SWH]), although the focus of this report is on managed spring pulses. Managed spring pulses link to tern habitat and tern populations through four pathways (shown and numbered in red), all of which indirectly affect terns through potential changes to their habitat. Suggested habitat and tern metrics, by which the spring pulse program may be evaluated, are represented as hexagons.*

This report focuses on the spring pulse management action program; however, other habitat management activities are also being undertaken that may benefit the least tern. Two other activities, creation of emergent sandbar habitat and shallow water habitat are also indicated in Figure 3. Other activities, including predator control, have been undertaken in response to situations not anticipated at time of publication of the 2000 and 2003 Biological Opinions. These other activities are only considered here to the extent that they interact with managed spring pulses to meet management objectives. The spring pulse management action program potentially affects least terns through four pathways, shown as red arrows in Figure 3.

Section III—Status of Science Related to Expected Outcomes and Recovery

Charge Question—Is there reasonable assurance, given the status of science surrounding the spring pulse management action and accompanying ecological and biological response(s) and current Missouri River channel and floodplain morphology below Gavins Point Dam, that the spring pulse management action and technical criteria will provide a spawning cue to pallid sturgeon?

Spring Pulses as Cues to Spawning

The 2000 Biological Opinion specified that the Current Water Control Plan (CWCP) negatively affected multiple aspects of the life history of the pallid sturgeon; however, the focus of the plan was on the effects acting specifically on pallid sturgeon spawning cues. Several statements asserting a relationship between pulse flows and spawning appear in the 2000 Biological Opinion:

> *"Suppression of spring flows has caused: (1) loss of spawning cues (i.e., warm water coupled with river stage increases), which triggered spawning activity in native river fish…The Current Water Control Plan does not provide spawning cues and timely flow changes for most native river fishes in the lower channelized river, including the pallid sturgeon (Figure 21).*

> *"Without the increased river flows in June and July, combined with the necessary water temperatures (i.e., > 60ºF or 15.6ºC) during that period, the spawning cues for pallid sturgeon probably are no longer present in some upper basin main stem river reaches under existing main stem dam operations."*

> *"The following types of unavoidable losses are anticipated… loss of reproduction due to missing environmental cues including spawning cues, the form and function of a natural hydrograph, warmer temperature regimes, lack of sediment or turbidity regime, inadequate quantity and quality of available habitat and sufficient aquatic nutrient input."*

The 2003 Amendment to the 2000 Biological Opinion further underscores the importance of a restored normalized hydrograph to provide spawning cues for pallid sturgeon.

> *"The Corps shall develop and complete studies to establish a long-term flow management plan for flow releases from Gavins Point Dam that will be implemented under the Master Manual. … The spring pulse shall be a bimodal release from Gavins Point Dam that provides for spawning cues and floodplain connectivity in the later spring and early summer."*

> *"Based on the effects described in the Effects of the Action it is the opinion of the Service that the flow regime elements described here will provide suitable spawning cues of enough frequency for pallid sturgeon to exploit the entire reach of the Missouri River from Gavins Point Dam to the confluence with the Mississippi River."*

> *"The homogeneity of flows as well as the reduced early flow peaks affect the behavior/movement of the sturgeon. However, the increased inflows from the tributaries in this sub-reach begin to attenuate the altered hydrology resulting from Corps operations.*

Lack of cues for spawning, lower flows for rearing of pallids, and the scarcity of habitat available in this reach all substantially reduce the fish community as a whole. The lack of spawning cues throughout this reach may be inhibiting adult fish from migrating past the confluence of the Platte River through this sub-reach to the sub-reach above Sioux City (p.167 2003 Biological Opinion).”

In 2009, the U.S. Fish and Wildlife Service prepared “The Expected Outcomes of the Restoration of a Normalized Hydrograph, Missouri River, Downstream from Gavins Point Dam.” The report asserts that restoration of the normalized hydrograph is necessary to provide suitable spawning cues for pallid sturgeon.

A lack of spawning by pallid sturgeon in response to the contemporary dampened Missouri River hydrograph below Gavins Point Dam was a reasonable assumption given the state of knowledge regarding pallid sturgeon ecology, and the lack of juvenile pallid sturgeon in samples collected by natural resource agencies prior to 2000. It was also entirely reasonable in the 2000 Biological Opinion and 2003 Amended Biological Opinion for the USFWS to assume that a spring pulse management action would provide a spawning cue, given that the species evolved with substantial spring pulses as a result of mountain snowmelt, lowland snowmelt, and rainfall. Moreover, research on white sturgeon, *Acipenser transmontanus*, indicated that discharge served as a spawning cue for that species (Anders and Beckman 1993), and discharge is a factor that can influence spawning of temperate fish species more generally (Lam 1983). Lam (1983), however, concluded that temperature and photoperiod are the most important factors that influence gonadal development and spawning in other fishes.

A spring pulse management action design intended to elicit a spawning cue in pallid sturgeon was agreed to by USFWS and Corps in 2005 (Jacobson and Galat 2008). Despite having an explicit spring pulse management action goal, the only management action that occurred in 2006 was a spring pulse in May of that year; no spring pulse management action occurred in 2007 due to high tributary discharges from James, Vermillion, and Big Sioux rivers, and only a single March spring pulse management action occurred in 2008. In 2009, a March pulse was cancelled because of flow limits, and a May pulse was initiated with a peak at 6,000 cubic feet per second for just two days. In 2010, the March and May pulses were cancelled because of downstream flow limits. Thus, there is very limited information to be gleaned from the past spring pulse management actions due to the lack of prescribed pulse events.

A retrospective analysis conducted by the Corps determined that, given lower Missouri River system constraints, a spring pulse management action might be expected to be implemented in only 30 percent of years (from information provided to the ISAP during a March 28, 2011 webinar). This conclusion seems particularly important in considering the likely efficacy of future spring pulse management actions. It does not seem to have received great consideration when developing the water control plan in support of the Biological Opinions. Moreover, the managed spring pulse is often inconspicuous below Kansas City, Missouri (i.e., Kansas, Grand, and Osage segments), because of the attenuation of the pulse as it moves downstream and masking by discharge from Missouri River tributaries (May 2, 2011 science presentations in Kansas City). Importantly, attenuation of spates (like those generated from the managed spring pulse) occurs with or without inputs from tributaries; any spate moving down a river channel will be attenuated. Expectations in the Biological Opinions for ecological effects of the negotiated designed pulse may have been optimistic due to not fully accounting for such effects.

In 2005 and 2006, research conducted on shovelnose sturgeon in the Missouri River below Gavins Point Dam was carried out in an effort to identify and refine field data collection methods for pallid sturgeon (DeLonay et al. 2009; Papoulias et al. 2011). In 2007 research focused on pallid sturgeon, using methods informed by that and other work on shovelnose sturgeon (DeLonay et al. 2009). Research activities in 2007 primarily focused on upper sections of the lower Missouri River (Gavins, Ponca, and Sioux segments). No spring pulse management action was planned for 2007—it was identified as a "control year"—however, flows from the tributaries were high, exceeding the prescribed spring pulse management action. Research in 2008 was conducted on pallid sturgeon in both upper (Gavins, Ponca, Sioux segments) and lower sections (Grand segment) of the lower Missouri River; and, again, no spring pulse management action occurred. Research in 2009 and 2010 focused on pallid sturgeon throughout the lower Missouri River system.

Assessing the Effects of a Spring Pulse on Spawning

It is important to specify a definition of "spawning cue," as considered in implementation of the Biological Opinion, in order to assess the effects of the spring pulse management actions on pallid sturgeon. Spawning cue was defined in the 2000 Biological Opinion as the movement of pallid sturgeon to spawning locations and seeking spawning habitat. More recently, a spawning cue has been defined as factors influencing "gonad maturation" (provided during the March 3, 2011 Biological Opinion webinar). The ISAP used movement to spawning location and gonad maturation as defining spawning cue (i.e., staying consistent with the language in the Biological Opinion and with the authors' intent). The USGS fisheries research scientists have further defined a spawning cue as a suite of metrics that describe fish condition months prior to spawning and those acting immediately prior to spawning (May 2, 2011 in science presentations in Kansas City). The suite of metrics that initiate the act of spawning is complex and not completely understood (DeLonay et al. 2009; Papoulias et al. 2011). The ISAP agrees that there are both abiotic and biotic factors that influence gonadal development and spawning, and it is highly likely that the factors that influence gonadal development and spawning differ.

Recognizing that female sturgeon do not release eggs unless spawning conditions are appropriate, evidence verified by marked and recaptured females indicates that shovelnose sturgeon spawned in all years studied and was predictable (see Papoulias 2011 for details). (Under conditions that are not suitable, gravid females undergo follicular atresia [Webb and Doroshov 2011]). Similarly, pallid sturgeon spawned in all years studied (DeLonay et al. 2009; A.J. DeLonay, U.S. Geological Survey, personal communication). Two marked and recaptured pallid sturgeon spawned in 2007—one between river mile 768.7 and mile 756.3, and the other between river mile 694.9 and mile 681.1 (DeLonay et al. 2009). In 2008, five marked pallid sturgeon spawned in the lower Missouri River; the most downstream site was near Glasgow, Missouri, at river mile 230.1, and the most upstream site was near Gavins Point Dam between river mile 811 and mile 790.7 (DeLonay et al. 2009; A.J. DeLonay, U.S. Geological Survey, personal communication). Interestingly, one female pallid sturgeon spawned in the unchannelized reach between Gavins Point Dam and Sioux City, Iowa, in 2008 when the discharge from Gavins Point Dam was a mirror image of the spring pulse management action (March 28, 2011 webinar). One pallid sturgeon was confirmed to have spawned in 2009 between river mile 206.5 and 206.1, and three pallid sturgeon were confirmed to have spawned in 2010 between river mile 642.7 and mile 202.0 (river mile is established on the boundary of the probable spawning extent [A.J. DeLonay, U.S. Geological Survey, personal communication]). DeLonay et al. (2009) reflected on these occurrences, concluding that data from "pallid sturgeon spawning adults from 2007 and 2008 indicate that pallid sturgeon are spawning in the lower Missouri River. Spawning is occurring at multiple locations, at different times, and under a wide range of geomorphic and hydraulic conditions. Although this study successfully documented spawning, it did not reveal whether or not spawning occurred under optimal conditions, whether or not enough eggs hatched, or whether or not young fish survived to contribute to the pallid sturgeon population."

Conclusions—Spring Pulses and Spawning

Given that the proposed spring pulse management action has not been implemented in all years, and shovelnose sturgeon and pallid sturgeon exhibited evidence of having spawned in all years studied, the ISAP concludes that the spring pulse management action, as currently designed and implemented, appears to be unnecessary to serve as a cue for spawning in pallid sturgeon.

This conclusion is corroborated in a statement by the MRRP (2010)—"Pallid sturgeon have spawned without intentional pulsed flow releases from Gavins Point Dam (DeLonay et al. 2009), but the importance of flow variability due to other sources (such as tributaries) is unknown." Papoulias et al. (2011) noted for shovelnose sturgeon that "discharge was extremely variable across study sections and years, and sturgeon exhibited no apparent discharge-associated changes in measured physiological indicators of readiness to spawn." Identifying the exact mechanism(s) that initiate spawning is challenging, and warrants further investigation, but the best available (and admittedly limited) data is what led to our conclusions here. Recent evidence of spawning by pallid sturgeon is based on the reproductive status of just 11 fish, which would typically be viewed as an insufficient sample from which to draw well-informed conclusions. Yet, if just one pallid sturgeon spawned in the lower Missouri River during the period under consideration, then it could be surmised that a spawning cue or cues, as interpreted from the charge question and the 2000 Biological Opinion, had occurred.

Summary Finding

There is no evidence that managed spring pulses are necessary to provide cues for pallid sturgeon spawning.

Charge Question—Is there reasonable assurance, given the status of science surrounding the spring pulse management action and accompanying ecological and biological response(s) and current Missouri River channel and floodplain morphology below Gavins Point Dam, that the spring pulse management action and technical criteria will: Increase nutrients, invertebrates, and forage fish for larval and juvenile pallid sturgeon and adult and young least terns, in association with floodplain connectivity and the construction of shallow water habitat?

Assumption that Spring Pulses Provide Benefits of Floodplain Connectivity

Based on the 2000 and 2003 documents, the USFWS required that the Corps "shall design and implement floodplain connectivity to produce the intended ecological functions for production of nutrients and forage fish and plankton over a range of flow regimes" (page 238). With respect to floodplain connectivity, the requirement in the 2000 Biological Opinion for a spring pulse management action had two justifications: enhancing food web productivity, and providing habitat, including spawning areas, for fish. The 2003 Amended Biological Opinion further justified a spring pulse management action based on movement of either fish to the floodplains, or materials from the floodplain to the river; however, there is a decided disconnect between the prescription for spring pulse management actions in the Biological Opinions and the rationale that the Corps has adopted for those managed pulses (e.g., pages 165, 231, 233 in the 2003 Amended Biological Opinion). While the Corps asserts that spring pulse management actions will contribute to floodplain re-connectivity, which could provide ecological benefits to listed species, the ISAP was not provided evidence that (1) the magnitudes of the managed spring pulses are great enough to cause re-connectivity with the natural floodplain, or (2) that the agency's construction of chutes, shallow water habitat, and emergent sandbar habitat contributes to the ecological functions that floodplain re-connectivity is expected to provide in the forms of increased nutrients, invertebrates, or prey fish.

Assumption that floodplain connectivity will enhance fish populations

The justification for floodplain connectivity for pallid sturgeon and other desired fishes in the lower Missouri River combines reference to the conditions under which the targeted species evolved, and observations of the ecological benefits of floodplain connectivity drawn from specific events, such as the flood of 1993. For example, the 2000 Biological Opinion (p.107) offers that "Mayden and Kuhajda (1997) describe the natural habitats to which the pallid sturgeon is adapted as: braided channels, irregular flow patterns, flooding of terrestrial habitats, extensive microhabitat diversity and turbid waters." The 2000 Biological Opinion (p.107) goes on to state that:

> *"The historic floodplain habitat of the Missouri and Mississippi rivers provided important functions for the native large-river fish. When floodflows crested the river's banks, floodplains provided the major source of organic matter, sediments and woody debris for the main stem rivers when floodflows crested the river's banks. The transition zone between the vegetated floodplain and the main channel included habitats with varied depths described as chutes, sloughs, or side channels. The chutes or sloughs between the islands and shore were shallower and had less current than the main channel. Those areas provided valuable diversity to the fish habitat and probably served as nursery and feeding areas for many aquatic species (Funk and Robinson 1974). The still waters in this transition zone allowed organic matter accumulations, important to macroinvertebrate production. Both shovelnose sturgeon and pallid sturgeon have a high incidence of aquatic invertebrates in their diet (Carlson et al. 1985; Gardner and Stewart 1987). Flood flows connected these important habitats and allowed fish from the main channel to use those habitats to exploit available food sources."*

The 2000 Biological Opinion asserts that the essential role of spring floods is in reconnecting the river with its floodplain, thus enhancing carbon availability to the greater river ecosystem. Spring flood flows introduce "detritus and other carbon sources produced on the floodplain and in off-channel wetlands to the river. Such materials are the basis of the food chain and energy flow in large, temperate rivers" (p.125) and the "spring flood pulse often provides connectivity between the floodplain to the river. For native river fish like the pallid sturgeon, this floodplain connectivity, especially during May/June, provided spawning areas for forage species, increased phytoplankton production, and redistribution of carbon to the river" (p.198). The 2000 Biological Opinion further states that floodplain connectivity of the sort associated with flood flows that occur, on average, once every three years is needed to provide the frequency necessary for pallid sturgeon spawning and survival, or as stated on page 201 of the Opinion—"Restoration of spring floods through flow management and structural reconnection of the floodplain with the river would contribute to the conditions necessary for native river fish species to successfully reproduce, including the survival of the pallid sturgeon."

The rationale for spring pulse management actions that generate floodplain connectivity evolved in the 2003Amended Biological Opinion, with the focal questions and resulting management implications referencing the timing of inundation, and acknowledging uncertainties regarding whether floodplains are important areas for fish foraging, whether they are important for flux of nutrient materials to the river, or both. "Floodplain inundation and connectivity is essential in order to maximize the production of the forage base for pallid sturgeon. The forage base production must occur at a time that coincides with larval sturgeon becoming active, free swimming feeders. Floodplains are highly productive habitats in the late spring and early summer when warm, shallow water floods over the area and produces a bloom of forage that is of the appropriate size for larval fish to eat. Since larval and juvenile pallid sturgeon feed along the river margins, the productivity must be transported from the inundated low-lying lands to the river as flows recede… Highly productive floodplains are necessary on a frequent annual basis to provide necessary life requisites for pallid sturgeon survival" (page 237).

Assessing Evidence of Food Source Limitation

The statements in the 2000 and 2003 Biological Opinions implying a critical link between floodplain overflows, nutrient food productivity, and role in fish production are based on little, if any, empirical verification from basic ecosystem-level studies of the river itself. That is, there is little documentation that carbon limitation (i.e., food source limitation) constitutes a conservation planning challenge in the river ecosystem, or that it is a constraint on survival or recruitment of pallid sturgeon.

We were unable to find robust scientific rationale for the suggestion that managed spring pulses are needed to provide basic food sources for the listed species. The Biological Opinions point to a "flood pulse concept" (Junk et al. 1989), which suggests that flow pulses transport food sources and nutrients from the floodplain to the main channel. However, this implies that the main channel ecosystem is nutrient- or food-limited, and a flushing of the floodplain serves to provide a food subsidy. An alternate rationale for floodplain connectivity could be that it is essential for pallid sturgeon to move onto the floodplain to feed; however, there is no evidence to support that assertion.

Strikingly little information exists regarding the food web of the lower Missouri River—little is known of stores and fluxes of carbon and nutrients. Berner (1951) studied the basic limnology of the lower Missouri River in the late 1940s, and provided a glimpse of the river prior to large scale alterations; while he does not provide sampling locations, best estimates place his samples from the Platte, Kansas, Grand, and Osage segments of the Missouri River, and no samples upstream of the Iowa state line. Some of the important observations included: 1) no rooted aquatic plants were found in the channel, chutes, or backwaters; 2) turbidity was as high as 4,500 ppm during floods, nearly 15 times greater than in the Mississippi River; 3) dissolved oxygen varied between 3.5 and 9.9 ppm; 4) the plankton community was extremely limited (< 70 individuals/L compared to 650,000/L in the Illinois River in the early 1900s or

50,000/L in the San Joaquin River); 5) total benthic production of the Missouri River was less than 0.7 lb/acre, compared to > 200 lbs/acre in the Illinois River; and 6) the predominant energy source for the Missouri River food web was presumed to be the organic material introduced to the river from adjacent lands and from upstream or tributary inputs.

A more recent study by Knowlton and Jones (2000) considered nutrients and productivity in the lower Missouri River from about river mile 175 to mile 250. Even under the much reduced turbidity conditions of the contemporary lower Missouri River, light is apparently the limiting factor for productivity: "Nutrient concentrations suggest that phytoplankton and benthic algae in our study area were never nutrient-limited… If nutrients are saturating, then light and temperature will largely control algal growth rates. In our study area, photosynthesis was usually, if not always, light-limited." Whether reaches closer to Gavins Point Dam would exhibit similar phenomena given different turbidity, width, and depth conditions is unclear.

Based on limited studies, it is reasonable to conclude that the primary sources of energy in the lower Missouri River ecosystem are derived from upstream riparian or tributary sources of organic material, and that there was rarely internally generated productivity within the river. However, no ready evidence exists on what fraction of the river's total organic material previously came from or could be derived from floodplain inputs, as compared to tributary or upstream inputs. In sum, based on available information, we can eliminate internal sources, but we cannot say whether floodplains are (or ever were) significant sources of energy for the lower Missouri River ecosystem, and whether floodplain reconnection is essential to the persistence and recovery of pallid sturgeon in contemporary lower Missouri River. Based on general theory on large river ecology, it is likely that floodplains, and particularly marginal riparian lands, were significant contributors to carbon and nutrients to the channel waters, but this does not mean that those sources have ever fallen below levels that might limit growth of listed and other species of conservation concern.

Neither monitoring nor research has attempted in any meaningful way to isolate the effects of flood pulses on the riverine ecosystem until very recently. Ridenour et al. (presentation at MRNRC, Nebraska City, 2011) report that during floods (not managed pulses) smaller sturgeon (i.e., < 100 mm shovelnose sturgeon; no pallid sturgeon sampled) were disproportionally located at floodplain margins, and not in inundated floodplains or main channel circumstances (keeping in mind that catchability likely decreases in main channel habitat areas during high flows). In contrast, during baseflows, age-0 shovelnose sturgeon were consistently encountered in main-channel thalweg habitat. Also, in a recent study that included the Gavins and Sioux river segments, Hay et al. (2008) found that a number of macroinvertebrate species that inhabit the lower Missouri River preferentially drift during periods of decreased flows. It is unknown what mechanisms trigger this behavior, but it may indicate that variable flows, particularly those out of marginal areas, may initiate important food-related ecosystem responses.

Floodplain areas (particularly wetlands created by flood events) consistently exhibit higher species richness, including larval and juvenile fishes, than do isolated wetlands (Galat et al. 1998); however, an essential and missing component of the pallid sturgeon studies to date is whether any pallid sturgeon have been tracked moving out of the main channel in search of food on the floodplains or marginal lands. We were provided with substantial data from telemetry of pallid sturgeon in the main channel, but are unaware of movement of pallid sturgeon out of the thalweg of the channel. If pallid sturgeon do not leave the main channel thalweg, then they could only benefit from floodplain inundation if it increased food production and those food resources were transported into the thalweg. There are no data with which to address this topic.

Floodplain Connectivity for Least Terns

There was also the assumption in the 2000 Biological Opinion that managed spring pulses might function to enhance riparian connectivity with the main river channel, and such connectivity could potentially increase the production and standing crop of small fishes used as food by least terns (Figure 3, pathway 4). This might occur through increased nutrient inputs to the river, expansion of nursery areas for small fish, or food utilized by small fish. The enhanced connectivity associated with a managed spring pulse might also have a synergistic relationship with constructed shallow water habitat in river reaches used by least terns. Such outcomes for least terns, however, are based on two assumptions: 1) that breeding populations of the species are limited by food abundance, and 2) that increased availability of forage fish will attend the management action in the proximity of tern nesting colonies. Neither assumption is supported by available scientific evidence.

Increased floodplain connectivity could potentially contribute to enhancing populations of forage fish used by least terns. Least terns feed in a variety of shallow water areas such as rivers, streams, sloughs, dike fields, marshes, ponds, sand pits, and reservoirs (Thompson et al. 1997). In the Mississippi River the abundance and variety of forage fish was greatest in water < 1 m in depth, in main channel and side-channel circumstances, adjacent to sand islands with suitable water surface temperature, clarity, and velocity (Tibbs and Galat 1998, in Thompson et al. 1997). Recent studies in the Missouri River (Stucker et al. 2011) demonstrated that forage fish abundance was inversely related to depth, and that forage fish selected by least terns are more abundant in shallow water areas. Moreover, Stucker et al. (2011) found that forage fish abundance was similar around emergent sandbar habitat habitats and natural shallow water habitats; hence, managed spring pulse actions, in combination with emergent sandbar habitat and shallow water habitat activities, could potentially benefit least terns.

For a spring pulse to be of benefit to least terns, however, it must provide for increased forage fish populations that are available to least terns in active breeding colonies. Least tern nest colonies and shallow water feeding areas tend to be in close proximity. Jernigan et al. (1978) found all of 61 observed colonies in North Carolina were within 250 m of a large expanse of shallow-water habitat. Least terns in Nebraska generally forage within 100 m of nest colonies (Faanes 1983); least terns in Kansas occasionally dispersed up to 3.2 to 4.8 km to feed, although terns usually foraged within 1.6 km of colony sites (Carreker 1985).

Floodplain connectivity achieved under the current design of the spring pulse management action is not likely to increase substantively the areal extent of floodplain inundation. Connectivity generated from a two-day May or June managed spring rise would be 3,380 to 3,456 acres, as compared to 3,282 acres without a spring rise (Jorgenson 2003b – citing USACOE 2001, pp. 7-57 through 7-61). There is no evidence to support the notion that spring pulse management actions have functioned to facilitate the production or abundance of small forage fish in shallow water habitats available to least terns.

Management actions and science regarding floodplain connectivity

The Corps has adopted an approach that focuses on the restoration and provision of shallow water habitat, emergent sandbar habitat, and chutes to provide some of the assumed benefits of floodplain connectivity. The primary justification appears to be that the shallow water habitat should provide reduced flow velocities and river depths that are thought to provide habitat for forage fish for both pallid sturgeon and least terns. However, no evidence exists that supports the contention that in-river features provide ecological functions similar to those of connected floodplains, at least in terms of food sources.

These riverscape features are not one and the same; in-channel, engineered features do not necessarily function similarly to naturally connected floodplains. Flows through shallow water are not necessarily connecting to floodplains or riparian areas via engineered chutes, and chutes are not necessarily providing substantial quantities of organic material and forage fish to the system. While results from a preliminary study to identify the best statistical design for quantifying macroinvertebrate abundance and composition across different types of constructed habitats (Sampson and Hall 2011) suggests that abundances are higher than those found by earlier studies of macroinvertebrates in the main channel, there is no evidence that engineered features support macroinvertebrate communities distinctly different from the channel in terms of food sources (i.e., what the listed species actually rely upon), or that they are similar to floodplains in function. There is no available evidence that constructed habitats provide the same or similar resources and ecological functions as floodplain reconnection. To our knowledge, current monitoring efforts are not designed to test or resolve the degree of interchangeability of shallow water habitat and floodplains in terms of provision of ecosystem services (see Section V below).

It is reasonable to infer that the historical food web that supported the pallid sturgeon and other fishes in the Missouri River system was based on the availability of organic materials generated by or derived from upstream reaches, tributaries, and along-stream riparian and floodplain areas; there was and is essentially no autochthonous (i.e., internal) production via phytoplankton generated in the lower Missouri River. However, specific knowledge regarding floodplain productivity and connectivity, and its role in the ecology of the Missouri River is very limited. Jorgensen's recent analysis (communication to ISAP in August 2011) of the frequency of overbank flows in the mainstem below the Platte River (mile 595 to 0) indicates that flows exceeding flood stage flows occurred in 18 of the 20 years from 1984-2003, but levees still remain beyond the "overbank" area and no measurements of the exchange of organic matter or ecosystem productivity related to the overbank flooding have been completed. Floodplain connectivity undoubtedly played an important ecological role historically, and perhaps still today in some reaches of the lower Missouri River, but these roles remain un-quantified. At the same time, it is unclear whether the pallid sturgeon at any life stage benefited from floodplain connectivity either actively, by moving between the river and floodplains to take advantage of floodplain resources, or passively, by utilizing resources mobilized and delivered to the river during and following floods. Accordingly, an assertion that shallow water habitat provides the same ecological function as connected floodplains lacks scientific support, because we do not understand their floodplain role, and we do not understand how pallid sturgeon use the floodplain or shallow water habitat. In certain circumstances, shallow water habitat may provide comparable hydraulic conditions, but it is unknown and remains unstudied whether shallow water habitat provides essential resources to pallid sturgeon and other desired elements of the river ecosystem.

Summary Findings

There is no evidence that managed spring pulses as implemented result in floodplain-channel connectivity.

There is no evidence that nutrients, invertebrates, or forage fish in the lower Missouri River will increase in response to the managed spring pulse and shallow water habitat.

There is no evidence to support the assertion that food is limiting, thus preventing the recovery for the pallid sturgeon and least tern.

Charge Question—Is there reasonable assurance, given the status of science surrounding the spring pulse management action and accompanying ecological and biological response(s) and current Missouri River channel and floodplain morphology below Gavins Point Dam, that the spring pulse management action and technical criteria will scour pallid sturgeon spawning areas to increase the likelihood of successful survival of pallid sturgeon eggs?

Scour of Pallid Sturgeon Spawning Areas

The 2003 Amended Biological Opinion posited that high flows are necessary to scour and condition the bed sediment of the lower Missouri River in ways that enhance habitat for the listed species. As stated on page 165 of the Amended Biological Opinion, "the altered hydrograph from Gavins Point Dam may not provide for scouring flows to keep spawning substrate suitable for spawning pallid sturgeon… The altered hydrograph is likely precluding spawning and the subsequent production of larvae in this reach [below Gavins Point Dam]." The 2003 Amended Biological Opinion also required an experimental test in the fall to understand how pulsed flows might contribute to sediment scour and 'conditioning;' however, such a test has not yet been conducted. There is limited information on how flow pulses influence sediment transport in the river, and more importantly, how targeted species specifically interact with different bed sediment sizes and mobilities.

Sediment characteristics of the lower Missouri River are segregated by reach. Upstream reaches (those most proximate to Gavins Point Dam, Gavins and Ponca river segments) contain coarse sediment, such as cobble and gravel with fairly limited quantities of sand, while farther downstream, bed sediment is predominantly sand. The managed spring pulses are most effective in scouring sediment in reaches near the dam, but effectiveness is reduced with distance from Gavins Point Dam due to attenuation—pulses have less and less scouring effect with distance from the dam.

Hard, coarse substrate may be assumed to be suitable spawning substrate for pallid sturgeon based on known spawning requirements of other sturgeon species (Bemis and Kynard 1997). Because of this requirement for coarse sediment, it might be expected that the Gavins river segment immediately downstream from Gavins Point Dam would be most conducive to spawning from the perspective of substrate quality. Sediments in this reach may be more affected by pulses as compared to tributary inputs, but this relationship is unquantified.

Further downstream from Gavins Point Dam, between river miles 230 and 269, female pallid sturgeon tracked using telemetry have been found to spawn over coarse riprap at outside bends (DeLonay et al. 2009). These revetments are essentially coarse, boulder-sized sediments, roughly matching the substrate characteristics thought to be necessary for pallid sturgeon spawning. If revetted outside bends are confirmed as conducive to successful spawning by the fish, it would follow that substrates for spawning habitat may not be a limiting factor in pallid sturgeon reproduction in the lower Missouri River. However, there is essentially no information on the survival of eggs once they are released; egg survival under varying river conditions is an important issue in need of further elucidation.

As characterized by the USGS scientists, "Among all the reaches, the [Gavins river segment] has the best prospects for natural gravel-cobble substrate thought to be required by sturgeon for spawning. The monitoring and side-scan data indicate that the substrate is mostly clean, having relatively small and discontinuous patches of sand overlying it. Flow pulses are capable of transporting the sand and flushing it from the underlying substrate; however, the large quantity of coarse substrate in the reach indicates that availability is probably not a limiting factor in sturgeon reproduction." (Elliot et al. 2009). We generally agree with this assessment, particularly that scoured sediment availability is not a limiting environmental factor for pallid sturgeon recovery; thus, spring pulse management actions specifically intended to scour spawning sediments for pallid sturgeon would appear to be unnecessary.

It is unclear if there are additional ecological benefits provided to pallid sturgeon by the mobilization of sediment. Prior to channelization and regulated flows, the lower Missouri River could be characterized as a rapidly shifting spatial mosaic of sandbars and shifting sediments. In that context, spring pulse management actions may play some role in facilitating a sediment bed set 'in motion.' Spring pulses with magnitudes as limited as a few thousand cubic feet/second above background navigation flow can result in measurable changes in bed configuration; thus, they may have some influence on channel processes, and perhaps the quantity and quality of habitat for listed species (Elliott et al. 2009). However, whether such changes in bed condition are necessary or sufficient for recovery of any individual species, such as pallid sturgeon, is unknown.

Summary Finding

There is no evidence that scoured sediment availability is a limiting factor for pallid sturgeon spawning.

Charge Question—Is there reasonable assurance, given the status of science surrounding the spring pulse management action and accompanying ecological and biological response(s) and current Missouri River channel and floodplain morphology below Gavins Point Dam, that the spring pulse management action and technical criteria will: condition new and existing emergent sandbar habitat in preparation for nesting and rearing young for Least Terns and Piping Plovers?

Conditioning New and Existing Emergent Sandbar Habitat

The 2000 Biological Opinion states that large expanses of shifting, unvegetated emergent sandbars characterized the pre-development channel of the lower Missouri River during the summer and that those sandbars were ecologically valuable, not only to nesting and foraging least terns and piping plovers, but to other shorebirds, wading birds, and a number of mammals. In the contemporary Missouri River, operations do not provide the natural spring peak flows necessary for channel maintenance, sandbar creation, and scouring of emergent vegetation. Emulating the natural flow regime to some degree has been perceived as a necessary foundation for sandbar creation, as well as scouring or covering vegetation.

Four salient aspects contribute to the potential role of managed spring pulses in the process of creating and sustaining sandbar habitat for the listed birds (again see Figures 2 and 3). It was initially hypothesized as part of the Biological Opinions that managed spring pulses 1) mobilize sediment to create new sandbars, 2) scour vegetation on existing sandbars to enhance the suitability of nesting substrates, 3) condition sandbars leading to demonstrably greater availability of invertebrate food resources for the piping plover, and 4) have potentially negative direct consequences for the birds. Each of these aspects is addressed below.

Mobilize Sediment (Figures 2 and 3, pathway 1) -- Sandbar emergence in the high-flow years of 1995-1997 has become recognized as something of a standard for habitat creation, a target to be emulated using managed spring pulse releases from Gavins Point Dam. During that period, average sandbar size increased from 11 acres to 44 acres, and bare-sand areas of size greater than one acre increased in number from 151 in 1996, to 250 in 1998 (Vander Lee 2002). The extent of suitable nesting tern and plover habitat on the Gavins Point reach increased from 3.6 acres/mile to 47.4 acres/mile; wet sand habitat, important for foraging and brooding by the piping plover, increased nearly 50 percent, from 12.5 acres/mile to 18.6 acres/mile. However, since 1998, the erosion rate of sandbars has been about 14 percent per year on the Gavins Point reach, and about 10 percent per year across the lower Missouri River.

Metrics that might be used to measure the amount or extent of habitat that may be created include attributes such as total sandbar area, number of sandbars, and sandbar size distribution. To date, however, there is no evidence that spring pulse management actions have contributed to creating new sandbars and nesting habitat below Gavins Point Dam. Spring pulse releases since 2006 do not appear to have substantially countered the base rate of sandbar loss since 1998. It should be recognized that over both short and long terms the relationship between river flows and sandbar area is complex, and that complexity must be understood and properly considered in management to achieve and maintain the extent of sandbar habitat for piping plovers that was specified in the 2000 Biological Opinion.

Scour Vegetation (Figures 2 and 3, pathway 2)—During periods of relatively low flows, such as the period beginning in 1998, the lack of high flow events allows natural vegetation succession to take place on sandbars and other exposed river floodplain areas. In the period from 1998 to 2005, “natural” vegetation rates of sandbars varied from 3 to 14 percent per year, with an average rate of 6 percent per year. At that rate of re-vegetation, even a bare sandbar has a short useful life as a suitable nesting site for piping plovers. The assumption has been that periodic spring pulse flows could reverse this trend, reset succession, and thereby contribute to maintenance of suitable nesting habitat over the long-term. Indeed, vegetation was reduced by 50 percent during high flows from 1995 to 1997 on existing sandbars, demonstrating the ability of high flows to scour vegetation (Vander Lee 2002). Those data highlight the fact that high flows can be instrumental in the maintenance of patches of nesting habitat for the piping plover and least tern (2000 Biological Opinion). The metric that might be used to judge this effect is vegetation cover, which can be measured by a number of standard techniques; however, an actual post-pulse measurement must be compared to some baseline condition to demonstrate an effect.

Spring pulse management actions from Gavins Point Dam to date, however, have not been successful in scouring and reducing vegetation cover to the extent that affected areas have become more suitable as nest sites for plovers or terns. To the contrary, it has been argued that spring pulse management actions have degraded channel elevation below Gavins Point Dam, compromising the potential for future pulses to achieve sufficient stage elevation to scour vegetation on suitable nesting substrates (Jorgensen 2003).

Condition Sandbars (Figures 2 and 3, pathways 3 and 4)—The original charge questions given to the ISAP were unclear with respect to conditioning sandbars as habitat (i.e., it was not explicit in what sense spring pulse management actions were supposed to "condition new and existing sandbar habitat"). Moreover, the 2000 Biological Opinion was not specific with regards to the expected outcomes of the reasonable and prudent alternative in this regard. Nevertheless, there seems to be at least two aspects of this expected outcome. The first is the potential effects of inundation in sculpting the sandbar landscape in several ways—consolidation of loose sandbar substrate, addition of organic and fine materials to the substrate, and the creation of depressions, over-wash zones, and moist soils that produce more invertebrates. Such conditioning caused by spring pulses is complementary with efforts to increase and enhance emergent sandbar habitat. Presumably, such conditioning would extend the longevity of newly created sandbars. The metrics that might be associated with this sculpting would need to be defined with clear articulation of the specific objectives of this management.

The second aspect of this expected outcome is the effect of inundation on enhancement of invertebrate (prey) availability for piping plovers, and to a lesser degree for least terns. This outcome would occur via spring pulse management actions, which would create water conditions that increase the invertebrate production in shoreline feeding zones and over-wash zones used by piping plovers. Metrics appropriate to assessing invertebrate abundance and density are appropriate.

Evidence is lacking to suggest that spring pulse management actions 'condition' sandbars by enhancing invertebrate availability for forage. Existing data, although limited, indicate that invertebrate catch per unit area was not significantly different between 2005 and 2006 in shoreline feeding zones used by piping plovers (Catlin 2009). There is also no information on whether spring pulses lead to the formation of sandbar micro-habitats, such as depressions, over-wash zones, wet spots, or other heterogeneities in landform structure that would tend to contribute to more invertebrates, or provide more security for feeding plovers (LeFer et al. 2008).

Potentially negative direct consequences (Figure 2, pathway 5)—It is recognized among the MRRIC, as well as in the 2003 Biological Opinion, that reduced piping plover and least tern reproduction (including nest losses) caused by a managed spring pulse (especially the May pulse) could be more than offset by increased availability of nesting habitat in subsequent years. In other words, the long-term benefits of a managed spring pulse could potentially outweigh the reduced production that occurs during the pulse years. However, as stated above, the hoped-for benefits of increased availability of nesting habitat have not occurred with managed spring pulses to date. At the same time, loss of production during the pulse years has occurred. For example, the spring pulse management action on May 18, 2009, began with an increase of 6,000 cfs to 23,000 cfs (USACOE 2010). The 6,000-cfs increase inundated five piping plover nests supporting 17 eggs; hence, in spite of the hoped-for net benefits over the long-term, the managed spring pulse program would appear to have been a net negative for piping plovers.

Summary Finding

Managed spring pulses have not been successful in scouring emergent bars or reducing the vegetation cover that is necessary to provide suitable nest sites for least terns and piping plovers.

Charge Question—Is there reasonable assurance, given the status of spring pulse flows, species recovery, and restoration of large river systems, that further investigations into and/or water management changes are needed to (i) recover the federally listed species, (ii) achieve the expected outcomes, and (iii) restore the ecosystem to prevent declines of other native species.

Managed Flows, Adaptive Management, and Other Large River Systems

As part of answering this question, it is important to point out a disconnect between the needs of listed species below Gavins Point Dam as articulated by the USFWS, and operational constrains as determined by the Corps. This disconnect is in part credited to scientific uncertainties. The USFWS modus operandi is that trials are needed in order to gain understanding of the system; the Corps' approach is almost entirely inverted—trials should not be attempted unless there is science to justify the trial. This is perhaps best illustrated on page 164 of the 2003 Amended Biological Opinion:

> "*The best available commercial and scientific information available when the 2000 Biological Opinion was prepared indicated that modification of the hydrograph in the Lower Missouri River was essential to stem the decline of species in the river. Homogeneity of flows as well as the reduced early flow peaks would interfere with the normal behavior/movement of the sturgeon to migrate upstream to utilize the habitat that is available in this reach. Operations of Gavins Point Dam result in a lack of cues to support spawning (timing, magnitude, and rate of change) and lack of low flows for rearing of young pallid sturgeon. The Corps stated that there is insufficient data to determine the timing, magnitude, or rate of change "essential" for pallid sturgeon survival. The Service agrees with the Corps that there is not a sufficient amount of information to precisely set a flow regime or to identify which element (temperature, turbidity, rate of change, magnitude of change, etc.) of the hydrograph is the most important factor (if there is only one). The concept of Adaptive Management is intended to address this kind of scientific uncertainty*."

Scientific certainty for optimizing flow regimes for specific species is not presently a realistic expectation. Such uncertainty could be used to justify the status quo (i.e., doing nothing). Alternatively, the approach embodied in adaptive management is using management changes as experiments, and through these experiments increasing knowledge for future management. There are several examples where the 'learning by doing' approach has been implemented for managed flow regime changes along Corps-regulated rivers. Some of these studies have been recently synthesized by the Sustainable Rivers Project (SRP), a partnership between the Corps and The Nature Conservancy. A useful summary of work to date is in Konrad et al. (2011). An important aspect of this type of approach is recognition that question-specific monitoring must be conducted alongside flow management decisions in order to more accurately assess efficacy.

One of the critical lessons from the SRP (i.e., flow management on other rivers) to date has been that it has demonstrated how specified hypotheses of outcomes can be directly tested during flow releases, and how these results can in turn affect future decisions. As an example, Goodman et al. (in review) evaluated several varying discharge treatments on shovelnose sturgeon spawning in the Marias River, a tributary to the upper Missouri River above Fort Peck Reservoir. They specifically tested hypotheses related to discharge timing and magnitude as a function of larval shovelnose sturgeon abundance. They concluded that discharge must reach a threshold level (28 m^3/s or 988 ft^3/s), and should be coupled with water temperatures suitable (12−24^oC) or optimal (16−20^oC) for shovelnose sturgeon embryo development, to allow for spawning in the lower Marias River. Similarly, several questions for the Savannah River management program are quite similar to those on the lower Missouri River. Will high flow releases on the Savannah River increase the provision of access for fish to the floodplain? Will high flows increase recruitment of organic material to the channel? Will high flow pulses increase striped bass and shad spawning? Clearly there are many commonalities among rivers on which flow management is being considered. Furthermore, while there are a number of specific lessons to be learned (in response to the specific charge), there are broader lessons for adaptive management on the Missouri River more generally.

There are a few examples of specific insights gained from other sites that can inform decisions on the lower Missouri River. For instance, by implementing real-time telemetry during high-flow pulses in the Savannah River (i.e., question-specific monitoring), Wrona et al. (2007) confirmed that many fish did indeed use floodplain areas to feed on invertebrates during the pulse, but that shortnose sturgeon migrated downstream and out of the river during the pulse, rather than continuing their upstream migration to spawning grounds. They used these results to speculate that future high-pulses should coincide with natural storm events to allow tributary inflow to raise water temperatures and turbidity in the river (i.e., the timing of the release was as important as the magnitude of the release for the specific species of interest).

Perhaps most importantly, more targeted and question-specific monitoring is essential to refine the magnitude of prescribed flows. For instance, the magnitude for the initial prescribed flow for the Big Cypress Creek, Texas was > 6,000 cfs to maintain connectivity of off-channel aquatic habitats. However, monitoring during pulses showed that flows of only about 2,400 cfs were sufficient for this specific purpose, and so the high pulse prescription was revised substantially downward. These types of evaluations of environmental flow prescriptions have produced enough evidence to codify prescriptions in a revised Water Control Plan, with continued evaluations ongoing for several other sites.

There are also closely aligned studies for similar species ongoing from which lessons can be drawn, particularly in programmatic strategies. For instance, studies of the shortnose sturgeon on the Savannah River and white sturgeon on the Kootenai River show that similar management challenges exist for the pallid sturgeon and white sturgeon, thus those studies might inform how managers implement flows for pallid sturgeon and interpret emerging data. For instance, on the Savannah River, preliminary results from Wrona et al. (2007) indicate that ecosystem flow restoration alone may not be adequate to restore rates of spawning success in the Savannah River, thus additional efforts are needed for enhancing spawning habitat. Also, as with the pallid sturgeon in the lower Missouri River, lack of recruitment continues to plague recovery work on the Savannah River (Wrona et al. 2007).

The ongoing program in the Kootenai River for the recovery of the white sturgeon has many commonalities with that for the pallid sturgeon in the lower Missouri River, including considerations regarding how flow pulses and monitoring plans can be developed based on lessons learned from a comparable system and comparable species. For instance, while spawning has been occurring in the Kootenai River, no larvae and few wild juveniles have been collected, despite years of intensive sampling. Moreover, the management plan for the white sturgeon notes that the "acute status of Kootenai sturgeon and current inability to compartmentalize the complex ecosystem do not afford the luxury of time for exhaustive research studies on every potential mechanism of recruitment failure. Mechanistic studies cannot replace the need for experimental evaluations of implemented adaptive management experiments" (Anders et al. 2007); real-time evaluations of what happens during and after pulses is the critical information for decision-making.

In sum, there is no confirmatory evidence from restoration via flow modification on other large river systems that flow restoration alone can recover target species comparable to the pallid sturgeon, least tern, or piping plover. However, this management approach remains in its infancy, and other flow restoration programs on large river systems, including others managed by the Corps, offer adaptive approaches to flow management to constrain expectations of flow management. Other projects in other rivers, and certainly from other rivers within the Missouri River basin (specifically the Platte River), provide opportunities for learning and can help in establishing realistic expectations. In some cases, more formalized adaptive management plans have been developed, particularly for Kootenai River targeting white sturgeon. There are additional lessons to be learned from studies elsewhere in which flow management using managed pulses is ongoing. However, the nuances of the river systems, including their constraints (including infrastructure), and the needs of species that inhabit them, makes specific lessons challenging to translate directly from one system to another.

Recommendation

Other managed flow programs and adaptive management plans for other ecosystem recovery programs should be evaluated as reference models for recovery efforts on the lower Missouri River.

Ecosystem recovery to protect other species

The Missouri River is quite different today than it was prior to the construction of dams. The river widely meandered, flooded routinely, and had extensive but dynamic floodplains fed by large volumes of sediment that moved down the river. With the huge hydrogeomorphic changes that occurred after dams were in place, significant ecosystem changes ensued. Extensive native vegetation once present on floodplains was lost and many native fish and bird species with life histories dependent on the historic flooding or sediment regime dramatically were reduced in abundance. Side channels and backwater areas that had once provided slower-moving water habitat was no longer available. As the 2002 NRC report emphasizes, the pre-dam biodiversity on the Missouri River was rich—Lewis and Clark during their expedition along the Missouri River stated that it "nourishes the willow islands, the scattered cottonwood, elm, sycamore, linden, and ash, and the groves are interspersed with hickory, walnut, coffee-nut, and oak" (page 62, NRC 2002).

Loss of overbank flooding and the extensive floodplain habitat had major consequences for ecological processes throughout the lower Missouri River. Schmulback et al. (1992) emphasized extensive negative ecological impacts on native fish and riparian plants. Many of the native fish species are declining in abundance, particularly those with preferred habitat in backwater areas, side channels, or sandbars including species of *Lepisosteus* spp. (gar), *Hybognathus* spp. (silvery minnows), *Ictiobus* spp. (buffalo fish), and *Pomoxis* spp. (crappie). Many native species of invertebrates are present in the lower Missouri River; however, a comprehensive assessment of the population sizes of these native species and the number of exotic species is not available. While such lists are not generally available for most rivers, population assessments of some of the larger and/or "charismatic" invertebrates (e.g., mussels, odonates) can be found for other systems. The most recent information on invertebrates in the lower Missouri River comes from a study (Hay et al. 2008) on invertebrate drift, and a previous study by Poulton et al. (2003); both collected samples in the main channel. Both studies found multiple species belonging to the insect orders Ephemeroptera (mayflies), Hempitera (true bugs), Trichoptera (caddisflies), and many Diptera (flies); the most abundant taxa were chironomid dipterans, simulids (blackflies), and hydropsyche caddisflies, all of which are known to be tolerant species able to withstand strong currents.

The results of Hay et al. (2008) suggest that restoration or maintenance of native species may be enhanced by providing higher levels of sediment and organic matter in transport and by increasing the extent of habitat. They reached this conclusion because changes in reservoir discharge did not seem to be linked to changes in drift density, while spatial position of invertebrates along the river, especially below Gavins Point Dam, was associated with higher drift densities, presumably because invertebrates were seeking new habitat with greater food availability; dams trap organic matter and sediment, thus reduce food levels particularly for suspension feeders, such as caddisflies and mussels. Prior work by Sandheinrich and Atchison (1986) suggested that rock structures provided important habitat for macroinvertebrates, which was confirmed by Poulton et al. (2003), who suggested that adding artificially generated substrates may help maintain native species by providing diverse and potentially more productive habitat. While none of these studies emphasized the invertebrate fauna of side-channel or shallow water habitat, clearly these two zones can provide habitats for multiple species, and restoration efforts that produce such areas may contribute to supporting remaining native species.

Species native to the lower Missouri River evolved in a system that was highly turbid, exhibited substantial shifting heterogeneity, with a dynamic channel and sediment movement, had high riparian plant species diversity, and a flow regime that included high flow events in the spring, and extremely low baseflows in the late summer. To have some certainty that restoration actions can contribute to maintaining desired native species at current levels or greater will require a management strategy that focuses on all of these historic river attributes.

Restoration to prevent further declines in listed and other desired species on the lower Missouri River should focus on restoration of ecosystem processes. We suspect that this would include providing flows higher than those currently prescribed as spring pulses from Gavins Point Dam, lower baseflows, and increases in sediment supply. Habitat for the listed and other desired species is being addressed to some extent by current management actions; however, the actions are focused on habitat for the listed species and there is no reason to believe that these actions can fulfill the specific habitat needs of the majority of native species.

Summary Findings

Flow-related restoration programs elsewhere in the country provide model approaches and learning opportunities that can be applied on the lower Missouri River.

Similar to findings for the three listed species, it is unlikely that the managed spring pulses as currently implemented will improve ecological conditions for other native species; recovery of other native species requires recovery of entire suites of ecosystem processes that are not restored under the current managed spring pulse program.

Section IV—Status of Science Related to Hydrologic Management Actions

Charge Question—1) When considering the current Missouri River form and hydrology, what is the importance of hydrology (functional/flow pulses/flow management) versus morphology (physical form/habitat creation) when considering management actions for species recovery? 2) What spring hydrologic profiles (magnitude, frequency, duration, timing, temperature, rate of change, and temporal and geographic variation) should be evaluated as part of an adaptive management program? 3) What alternatives to a spring pulse release from Gavins Point Dam are available to achieve the desired outcomes?

Importance of Hydrology and Morphology

The 2003 Biological Opinion (p.226) clearly acknowledges the important role of both hydrology and channel morphology in species survival and recovery, including aspects of the historic flow regime:

> *"Continued survival of Pallid Sturgeon depends on restoration of riverine form and functions, as well as some semblance of the pre-development or natural hydrograph. Missouri River habitat restoration is, therefore, multi-faceted and involves a combination of reservoir operational changes (e.g., hydrograph and temperature), structural modifications (e.g., chute restoration), and non-structural actions (e.g., floodplain acquisition or easements). The maximum benefits of physical habitat projects to listed species can only be realized when coupled with complementary hydrology."*

While river form (morphology) and flow (hydrology) are both critical to recovery of listed species and the ecosystems upon which they depend, findings from research from the past few years from the lower Missouri River requires reconsideration of the factors that are limiting species recovery in this highly altered river system. In most rivers, and in much previous research, flow is often considered the master variable that modifies ecosystems—not only because of its direct ecological effects, but also because of the indirect effects it has on shaping channel morphology. Yet, in the case of the highly altered lower

Missouri River, the role of flow in mediating ecosystem processes has been greatly reduced, requiring that previous assumptions about flows and ecological restoration targets be reconsidered.

Links between hydrology and morphology on the lower Missouri River are often severed during normal flow years. Channel and bank stabilization have reduced the potential for flows to physically modify the channel, and upstream impoundments reduce the potential for channel-changing flows and sediment transport through the system. It is only during unusually high-flow years that the assumed historical link between hydrology and morphology is manifested, as evidenced through the erosion of natural chutes or the deposition of sandbars. In general, managed spring pulses, as currently designed and implemented, do not result in the adjustments in channel morphology that generate habitat features essential to support the listed species. That is, given current system constraints, flow and morphology are not interconnected on much of the lower Missouri River.

In addition to channel stabilization, the channel has been designed so as to minimize in-channel condition variability across a wide range of flows. In less-engineered channels, shallow water habitat or overall flow complexity can increase dramatically as discharge decreases. However, in the channelized lower Missouri River, as flow decreases, in-channel depths and velocities remain high. Moreover, because the channel is incised in many reaches, and it is difficult to connect the channel to riparian areas, high flows tend not to overtop banks to create low velocity or low depth conditions. This further serves to de-couple hydrology from river morphology (or at least the typically assumed coupling); thus, modifying flows cannot be assumed to produce the habitat conditions that are often assumed to follow high- or low-flow events. The normally assumed relationships between hydrology and morphology are not readily applicable to the highly altered and highly engineered lower Missouri River. How flows and morphology individually, or in tandem, contribute to habitats for listed species and other desired ecosystem attributes is less intuitively straightforward than in other river systems.

The relationship between flows and morphology on the lower Missouri River has received some research attention, yet with important caveats. In a series of studies over the past five years, USGS scientists have shown that flow is in fact less of a master variable on the lower Missouri River (Jacobson and Galat 2006). Those studies used a series of hydrologic and hydraulic models to show that the ecological function of shallow water habitat is highly dependent on channel form, and less sensitive to channel flow. In a recent study, Tracy-Smith et al. (2011) used similar modeling and concluded that "…the effects of historical, pre-regulation flows in a channelized river system resulted in reduced sandbar ATTZ (aquatic terrestrial transition zone) habitat variables compared to contemporary, managed flows. This suggests that flow may not always be the primary master variable in highly engineered river systems and that rehabilitation of a river's physical morphology is equally important to realize beneficial flow effects and provide more area of channel margin ATTZ."

There are some limitations to application of findings from previous studies on the lower Missouri River. First and foremost, both studies examined only aquatic environments, particularly shallow-water habitats. There are many other ecological functions dependent on flow that were not addressed, or as Jacobson and Galat (2006) state, "Our conclusion that total S[hallow] W[ater] H[abitat] is highly sensitive to channel form addresses only one of these [ecological] functions and should not be seen as a conclusion diminishing the value of a naturalized flow regime." Nevertheless, these studies do point to a salient reality on the lower Missouri River—without form modifications, flow restoration may be ineffective for ecological recovery. Yet in addition to the lack of empirical evidence of improving shallow water habitat, it is clear that the spring pulses as currently implemented from Gavins Point Dam neither serve to cue pallid sturgeon spawning, nor increase floodplain connectivity. At the same time these studies, and some others, have described how changes in river morphology can contribute to increasing ecological responses to flow. For example, Jacobson and Galat (2006) showed that on reaches of the lower Missouri River with some semblance of pre-channelized morphology, shallow water habitat was available across a range of discharges, particularly lower discharges (see their Figure 12). As Tracy-Smith et al. (2011) stated, "Rehabilitation of channel form along the lower Missouri River could provide additional ATTZ area over a wider range of flows by changing discharge-area relations and thereby increase channel-margin ATTZ habitat availability." In addition, it is worth noting that other flow restoration programs have come to similar conclusions. Wrona et al. (2007) note that "flow restoration alone may not be adequate to restore spawning success in the Savannah River," and that mechanical restoration of spawning habitat would likely be needed.

Reliable information suggests that only marginal gains can be made by continued efforts to implement the managed spring pulses action prescribed in the Biological Opinions, under the assumption that no substantive changes in Missouri River channel morphology occur. Increases in shallow water habitat, for instance, will occur only under extremely low flows, or under extremely high flows, which inundate floodplains and riparian areas. Both of these conditions are difficult to achieve given other demands on the Missouri River hydrograph. In contrast, there may be significant gains that can be made through the manipulation of channel form, using mechanical habitat construction. While no evidence exists that such construction contributes to enhanced feeding opportunities for the three listed species, it can provide useable nesting areas for least terns and piping plovers. It may be that constructed habitat can contribute to the effectiveness of managed flow regimes in producing desired environmental conditions—whether for high flows, such as managed spring pulses, or for low flows (as discussed below).

It is important to note that constructing the physical features that serve as habitat for targeted species is a challenging avenue for aquatic species recovery and overall river restoration. Attempts to construct habitat in smaller river systems has met with limited success; management constraints can overwhelm the benefits of form and hydraulics alone (see August 2011 issue of *Ecological Applications* for a series of studies on restoration, although these are largely from small rivers and streams). There may also be unforeseen complications. For example, the gradual shift of nesting piping plovers to constructed sandbars appears to have resulted in increased densities that leave plovers more vulnerable to predators, random weather events (e.g., thunderstorms and hail), and increased aggression among nesting adult plovers. The net result has been plummeting fledging ratios, which indicate that created sandbar habitats may function as population "sinks" about three years after their establishment (Catlin et al. 2009). Additionally, work by Papanicolaou et al. (2010) on the lower Missouri River suggests that a complex relationship between discharge, inundation of shallow water habitat, and bank erosion, as under certain conditions local bank erosion may eliminate potential gains derived from shallow water habitat construction. Nevertheless, the limited gains possible via flow restoration suggest that greater consideration be given to constructed habitats.

Behind the charge question (particularly when coupled with the ongoing shallow water habitat and emergent water habitat construction work), is an apparent recognition that to meet the habitat enhancement goals of the RPA, flow management must to some extent be supplemented by constructed habitat. While the ISAP recognizes, and in fact supports, greater consideration of constructed habitats, such approaches are to date unproven, or at least have been untested in their ability to create the biophysical conditions that support recovery of the three listed species. It is important to note that should constructed habitats be a prominent future goal, it should be approached through a program utilizing mechanically constructed landscape features; the purpose of which is to contribute to meeting specific, habitat-related environmental goals. The specific, mechanistic links between the actions and expected outcomes must be articulated to guide a constructed habitat program, tested via specific monitoring data, and then assessed for whether they should continue in the future.

There are several significant concerns about relying heavily on constructed habitats for recovery of the three listed species. First, constructed habitats frequently fail to provide the full breadth of ecosystem attributes intended by management planners. Designs are often targeted at individual habitat objectives, but miss opportunities for restoration gains that meet goals that target the greater complexity of the river's ecosystems. Second, reliance on constructed habitat actions alone to create or enhance all or most of the physical habitat conditions intended to support the listed species below Gavins Point Dam is impractical; it may be effective in the short-term, but many features may need to be reconstructed so often as to be functionally unsustainable. Third, constructed habitat may diminish the potential utility of flow modifications that might be intended to complement it. As can be seen during high flow years, flow is quite capable of sculpting natural landscape features more efficiently than can be done mechanically. Moreover, once in place, the ecological gains from such features may be increased dramatically by changes in flow regime. Thus, if constructed habitat is desired, it is important to recognize that even comparatively slight adjustments in channel morphology may contribute to re-coupling morphological features and hydrology in this system.

In sum, the charge question could be viewed as setting up a false dichotomy between hydrology and morphology. Management actions targeting the listed species on the lower Missouri River must reside along a continuum from purely hydrological management to purely morphological management. Available science clearly shows that flow management alone will not lead to species recovery, as the existing channel morphology limits habitat availability (among other limitations). Likewise, constructed habitat alone might prove effective at producing measurable benefits for short periods of time, but it is a particularly expensive and likely repetitive cost management alternative. We suspect that along this continuum, there needs to be greater reliance on constructed habitat to meet conservation goals, but with continued reliance on flow management. Moving toward a best balance in management approaches will require substantial analysis of flow and form interactions, and more careful considerations of how the two interact over longer periods of time. Changes in flow morphology following the 2011 flood season should provide substantial opportunities to move in this direction.

Finally, there has been considerable constructed habitat already completed to date. Those constructed habitats span a range of sizes, locations, and ages. In many ways, this sets up an opportune experimental design to assess more carefully the effectiveness of constructed habitats in (a) creating targeted biophysical conditions, and (b) contributing to the recovery of the three listed species. As well, with the flooding of 2011, the different types and ages of constructed habitat also allow the assessment of the potential longevity and sustainability of constructed features.

Summary Finding

Morphology and flow are linked factors affecting ecological conditions. Constructed habitat is clearly required to meet population goals for the listed species, along with contributions from flow management.

Hydrologic Profiles that Should be Evaluated as Part of an Adaptive Management Program

The implicit hypothesis is that the pallid sturgeon, piping plover, and least tern (and other ecologically important species) have adapted to environmental conditions that existed in the Missouri River system prior to impoundment, and that certain aspects of the pre-impoundment hydrograph contributed to the maintenance of habitat for and continued persistence of these species. However, the relationships between the availability of any particular hydrographically generated habitat feature and species demographics remain largely uncertain. It is therefore difficult to predict the ecological outcomes that might be derived from alternative managed releases from Gavins Point Dam.

Addressing this charge question is a task beyond the capacity of the current ISAP, but it is important to note that more directed analysis needs to be given to the ecological benefits of different aspects of the lower Missouri River hydrograph (i.e., moving away from generalizations associated with the Natural Flow Regime and Flood Pulse concepts, and toward better understanding of which desired habitat attributes are generated and sustained by different hydrographs). For example:

- Higher, longer peak flows in combination with constructed habitat that is strategically positioned may allow for seasonal connectivity between the main channel and riparian areas. To date, managed spring pulses have not been able to achieve such connectivity. The ecological necessity and benefits of such connectivity are unclear.

- The duration of peak flows for the current managed pulse was set to two days because the natural hydrograph could be characterized as having relatively short peaks, and fisheries biologists believed it was the timing and magnitude of the peak or rate of rise to the peak, rather than its duration, that provided migration/spawning cues for sturgeon (Jacobson and Galat 2008). However, this set duration period for managed pulses is much shorter than duration periods observed under pre-impoundment conditions (Jacobson and Galat 2008). Higher flows may be important for conditioning sandbars for the listed birds, including increasing the availability of nutrients and invertebrates; however, relevant data on these response variables is limited. Useful information on benthic invertebrates may emerge in the future from field work assessing macroinvertebrate assemblages and densities below Fort Randall and Gavins Point, which began in 2005[1].

[1] http://www.fws.gov/greatplainsfishandwildlife/MissouriRiverMacroinvertebrateStudy.html

- Higher flows may be important for increasing the (small-scale) topographic heterogeneity of sandbars and in conditioning floodplains, both of which could influence habitat quality and productivity. Relevant data on these response variables for sandbars is extremely limited. During the high flow years from 1995 to 1997, average sandbar size increased from 11 acres to 44 acres, and bare sand areas greater than one acre in size increased from 151 in 1996, to 250 in 1998 (Vander Lee 2002). We recognize that over both short- and long-terms, the relationship between river flows and sandbar area is complex, but given the importance of shallow wet sand habitat to piping plovers and its potential importance to other species, including invertebrate prey, management options that could result in more sandbar area should not be discarded.

Before moving in the direction of altering the flow regime to facilitate any of these potential functional changes, two significant steps are needed. First, it is necessary to build more formalized and synthetic conceptual models that relate the targeted species and physical and biotic river system attributes. Based on a more formalized conceptualization of targeted species and the system, it could be hypothesized that specific aspects of the hydrograph need to be manipulated. For instance, it is currently unclear if any of the listed species, especially pallid sturgeon and least tern, are food limited, and whether main channel connectivity with the floodplain would play a role in alleviating food limitations on these species. Should it be determined that channel connectivity with the floodplain might alleviate food limitations, then the magnitude and duration of flows that allow some level of floodplain connection would become an important hydrograph feature to consider. A threshold of magnitude, duration, and timing of flows could be determined, which, if not met, would substantially decrease the effectiveness of managed flows. Such a threshold might differ among the three species, and along different segments of the river. Until specific functional relationships between river hydrology and species responses are determined–or at least speculated upon–it is difficult to justify alternative managed flow scenarios.

Second, addressing this charge question is contingent on how the twinned issues of morphology and hydrology (discussed above) are addressed. If no further changes to morphology are adopted, then there will likely be limited gains made by adjusting the magnitude of flow releases, unless those releases are extremely small or extremely large (to increase habitat or to cause channel changes). That is, if further morphology rehabilitation is not adopted, flow magnitude will need to be the focal aspect of the hydrograph that receives management (and monitoring and research) attention. We do not see these as being realistic alternatives given system constraints. However, if the rehabilitation of channel morphology is continued using chute construction, weir notching, emergent sandbar habitat construction, or other actions, then flow modifications may need to be adopted to optimize the performance of those constructed features. For instance, if chutes are constructed and are shown empirically to contribute to habitat quality for pallid sturgeon, then manipulating the magnitude of flows may be less important than manipulating its timing or duration (i.e., maximizing the efficacy of the habitat provided). Because of significant flow attenuation with distance downstream, focus should be on maximizing the effectiveness of habitat features constructed in upstream reaches (e.g., Ponca, Sioux, and Platte river segments).

Summary Finding

Alternative hydrologic profiles that are intended to contribute to developing and sustaining habitat features for the listed species should only be considered in conjunction with (a) conceptual ecological model formulation and (b) optimizing or complementing constructed habitat.

Alternatives to a Spring Pulse Release for Achieving the Desired Outcomes

There are two broad categories of alternatives to a managed spring pulse program: morphology rehabilitation and base-flow restoration. We note that the 2000 Biological Opinion anticipated managed spring pulses larger and longer in duration than those that have been implemented to date, as well as baseflows, which have not yet been implemented.

We have addressed the importance of considering morphology rehabilitation. Given that there are ongoing efforts (e.g., chute construction, weir notching), including developments of adaptive management plans for these efforts, it is clear that MRRIC and the agencies are well aware of this route as an alternative, and we think that these developments are appropriate given current understanding and constraints on the system.

It may also be useful to consider alternative managed (i.e., restored) baseflows, as these may be important to retain as potential management tools for the future (along with alternative flow release hydrographs, as addressed above). While the impact of regulation of flood flows has received considerable attention by the MRRIC and the agencies, the current minimum flows during the late summer and autumn are substantially greater than the maximum flows experienced during the same months prior to flow regulation (e.g., Figure 2A in Jacobson and Galat 2006; we note that some of the patterns in the Jacobson and Galat hydrographs may be artifacts of their modeling approach, but still rely on their analysis as representative of pre-dam conditions). While this effect is reduced with distance downstream, it is quite important in the Gavins, Ponca, and Sioux river segments (compare Figures 2A and 2B in Jacobson and Galat 2006). Because baseflows have received relatively little attention, there is limited empirical evidence or modeling from which to draw for the lower Missouri River, as well as for other rivers worldwide. As such, the ISAP is only able to recommend, at this point, that baseflow restoration be considered as a possible option, that would be experimental, and that should be considered following morphology adjustments. That said, we think that there is some justification to at least consider baseflows as an alternative to managed spring pulses:

- Seasonal baseflow manipulation may help to maintain nursery habitat for larval and juvenile pallid sturgeon (USFWS 2003).
- Seasonal baseflows can decrease in-channel velocities (particularly on channel margins) and potentially contribute to increased retention of larval and juvenile pallid sturgeon.
- Natural channel morphologies (and possibly restored channel morphologies) can provide increased levels of habitat at baseflows (compare Harman and Vermillion trends in Figure 12 of Jacobson and Galat 2006); thus, baseflow restoration may contribute to increasing the effectiveness and efficacy of ongoing constructed habitat work.
- In wet years, managed baseflows may be needed to ensure sandbars (natural and constructed) are available to nesting birds (T. Fleeger, August 2011, NERC conference, Baltimore, MD).
- Baseflows may help concentrate forage fish for pallid sturgeon and least terns, as has been shown in other river systems (Humphries et al. 1999).
- Baseflows may increase invertebrate productivity in connected backwaters and tributary mouths, as has been shown in other river systems (Humphries et al. 1999).

- Evaluation of potential baseflow management actions would acknowledge that the entire hydrograph is ecologically important, and could broaden the consideration of ecological effects of flow management beyond a short temporal window in the spring.

We recognize that there are important constraints on restoring baseflow conditions during particular windows of time; therefore, consideration of baseflow restoration should be carried out within the context of formalized conceptual models to ensure that any attempts at baseflow restoration are based on formalized hypotheses of benefits and allow for targeted monitoring and assessment. This would need to be done as an analysis of a pathway of effects—using a conceptual model, managers should estimate what changes in baseflow conditions to alter with respect to specific habitat variables, how those habitat variables would affect biophysical environment, and how those changes might affect the three listed species. This would essentially follow the pathways of effects in Figures 1 – 3, but for baseflows as the management action, rather than spring pulses.

We suspect that this approach would allow initial baseflow restoration to be conducted as short-term experiments to monitor initially the changes in physical conditions under such a flow regime (e.g., changes in shallow water habitat and exposed sand bar area). We would encourage particular focus and assessment on interactions (or synergies) between constructed habitat (such as chutes) and baseflow restoration. Through this approach, physical conditions can be assessed during a brief window of time, and then measurement of ecological responses to changed conditions. This would set the stage for more rigorously considering future attempts at baseflow restoration, as well as where and when sustained ecological monitoring should follow.

Summary Finding

Restoration of baseflows may be an effective alternative hydrologic management strategy, but one that is currently unknown.

Recommendation

Baseflow restoration should be evaluated as a potential management action.

Section V—Evaluating Performance

Research and monitoring carried out over the past several years by the USGS, Corps, and USFWS have provided significant gains in knowledge related to the three listed species, as well as hydrological and geomorphological attributes of their habitats on relevant river segments of the lower Missouri River over the past several years. Some guidance is provided below on performance metrics, environmental monitoring, and associated analyses, but future attempts to inform management actions targeting the three species on the lower Missouri River need to be based on a well-structured adaptive management process and derived from well-articulated conceptual models that link the targeted species to salient ecosystem processes. It should be noted that given the constraints of time and information access, the ISAP was unable to consider thoroughly and vet fully all of the statements in this section; this should be an area of consideration for further charge questions. That stated, in addressing these questions, considerable concerns were raised among panel members about the lack of a structured adaptive management program in support of the managed spring pulses from Gavins Point Dam specifically, and efforts to recover the listed species beyond the focal area of the 2003 Biological Opinion more generally.

Current Performance Metrics

Charge Question—Metrics: Review the current performance metrics and make recommendations including options for better, more specific, more measurable, both short and long term metrics to use in assessing the Spring Pulse expected outcomes and for use in adaptive management.

Background: Evaluation and Recommendations for Ecological Metrics

Measurable metrics relating the effects of managed spring pulse releases from Gavins Point Dam on the population status and trends as they pertain to the recovery of pallid sturgeon, piping plovers, and least terns should be consistent with generally agreed-upon conceptual models developed for the species (e.g., Figures 1, 2, and 3 or alternative agreed-upon models). The ultimate measure of programmatic success for each of the species will be derived from monitoring data which show that managed spring pulse actions manifest as a positive contribution to the population growth rate (λ) of each of the species. The following sections address current monitoring activities in relation to managed spring releases as they might contribute to the population growth rate and recovery of the species of concern.

Sturgeon migration, reproductive readiness, and successful spawning activity associated with pulses

As a result of several previous and continuing studies (e.g., DeLonay et al. 2009), there is a better understanding of the physiological processes and habitat conditions that cue spawning in sturgeon than existed at the time of the more recent Biological Opinion. However, because of the limited number of years and the low magnitude of spring pulse management actions, little is known about the effects of those actions on pallid sturgeon spawning behavior. Nevertheless, spawning has been documented for pallid sturgeon in the lower Missouri River even without a spring pulse (DeLonay et al. 2009). Given that finding, performance metrics should be changed from those pertaining to migration, reproductive readiness, and spawning activity to metrics that more directly reflect population growth (recruitment). One particularly useful monitoring program would be to use telemetered pallid sturgeon to find target spawning areas where egg survival would be measured and free embryos and larvae collected, allowing survival to be directly related to specific management actions. Tracking of pallid sturgeon with the intent of describing dispersal and migration is expensive, and often is not well coordinated with management actions.

Successful pallid recruitment to support a sustainable population

From the information provided to the ISAP, it appears that most of the sampling for pallid sturgeon is focused on obtaining relative abundance data (i.e., catch per unit effort). Although relative abundance is a metric commonly targeted in fisheries management, it is uninformative in better resolving the pallid sturgeon conceptual model and constructing an age-structured population growth model (i.e., Bajer and Wildhaber 2007). The focus for monitoring and research should begin to be recentered on resolving rates of survival of eggs, larvae, and juveniles because these metrics are central to estimating population growth rate (recruitment). Refined egg and larval sampling designs should be combined with laboratory experiments and modeling efforts in the near term to better understand the relationships between management actions and subsequent recruitment. For example, the pallid sturgeon population model developed by Bajer and Wildhaber (2007) provides an operational model that extends the available conceptual model by providing a computational approach to estimate λ. However, population projections of these age-structured demographic models are known to be very sensitive to the estimated survival rates of early life stages. The ISAP recognizes the difficulty in obtaining reliable data with respect to these early life-history metrics, but the metrics are essential to understanding and estimating population growth in the lower Missouri River. It may prove necessary to use data from a surrogate species (e.g., shovelnose sturgeon) to augment data available for pallid sturgeon. Nevertheless, understanding how management actions relate to pallid sturgeon recruitment (population growth) should be considered the most important aspect of the managed spring pulse adaptive management plan.

Conditioning of spawning beds/locations by spring pulse flows

Measuring metrics relative to conditioning spawning areas for pallid sturgeon is not worthy of further monitoring and research given the current state of knowledge. Rather, assessing egg survival at known spawning areas can be more informative and will provide information for population models and 'quality' of spawning habitat. Monitoring and research should focus on egg survival at known spawning locations and how egg survival relates to specific management actions.

Conditioning of least tern and piping plover habitats

The metrics for least terns and piping plovers are consistent with the existing conceptual model and the population models that have been developed for those species. Monitoring has thus far focused on a reasonably complete set of metrics related to nesting habitats on sandbars and demographic parameters, including numbers of nesting pairs, nest fates, and fledging success. What is most needed is to identify and measure additional metrics associated with sandbar "conditioning" and food abundance as it might be affected by managed spring pulses. Of primary importance would be additional metrics related to invertebrate abundance for the piping plover and forage fish abundance for the least tern. Additionally, metrics associated with landform heterogeneity would be an important addition to the monitoring program. Sandbar features, such as depressions, over-wash zones, or other landform structures, offer protected feeding sites, and tend to produce more invertebrate foods for piping plovers (LeFer et al. 2008b). There are also spatial and temporal aspects to invertebrate monitoring for which metrics need to be developed—adult plovers with broods concentrate their feeding activities within five meters of the wetted shoreline and depressions and wet spots that have higher prey densities (summarized by Haig 1992), and sandbar feeding zones (including created emergent sandbar habitat) must provide sufficient food abundance at the correct time for nesting piping plovers.

Increased primary and secondary productivity associated with the spring pulse

Little value can be derived from monitoring primary and secondary productivity unless it is first determined (or framed as a clear hypothesis) whether or not any of the three listed species is food limited on the lower Missouri River. Monitoring and research should identify metrics for the three species that would reflect the status of or respond to changes in productivity (e.g., body condition, individual growth rate, fitness). If such species-level metrics indicate food limitation, then it may be appropriate through monitoring or research to evaluate how management activities contribute to primary and secondary productivity in the lower Missouri River. Data collection that focuses on productivity must be designed to determine the effects of management actions on changes in productivity.

Magnitude, timing, duration of pulse, attenuation through downstream reaches

Measuring the magnitude, timing, duration, and attenuation of pulses through downstream reaches must be continued, because those metrics define the managed spring pulse action. Although these metrics are not performance metrics, they are essential to evaluating the effectiveness and efficacy of management actions.

Monitoring and Alternative Management Options

Charge Question—Review the provided list of monitoring activities and results. What changes, modifications, or additions should be considered to: 1) Improve the ability to assess the metrics, 2) Adaptively manage the pulses, 3) Determine if expected outcomes have or can be achieved.

Assessing metrics, adaptively managing pulses, and determining if expected outcomes have been achieved are significantly interrelated. A critical shortcoming in ongoing monitoring efforts, especially for the pallid sturgeon, is the absence of hypothesis testing that is specifically related to the management action and the expected outcomes. In the 2010 Pallid Sturgeon Population Assessment Project, Volume 1.5 (Welker and Drobish 2010), which the ISAP identified as the working document for the monitoring program for pallid sturgeon, the hypotheses take the form of measuring annual trends. For example, a hypothesis related to annual and long-term trends might be: "Annual trends in wild and stocked pallid sturgeon population abundance for all life stages remains constant over time." The hypotheses outlined in Welker and Drobish (2010) for pallid sturgeon monitoring are exactly the kind of hypotheses that lead to undifferentiated surveillance monitoring (Nichols and Williams, 2006). Such unfocused monitoring targets, unrelated to specific hypotheses or management actions, produce results that are problematic to interpret. And as noted by the NRC (2011, pg 72) critique of the shallow water habitat program, when such monitoring programs contain little analysis of project status, including need for modification, "they lack evaluation of those data that are relevant and necessary to understand if compliance actions are reducing jeopardy to the listed species." Criticisms noted by the NRC of the shallow water habitat monitoring program are equally valid for the managed spring pulse program. This indicates that broader programmatic evaluation of monitoring, assessment, and analysis is needed (discussed more below).

The Pallid Sturgeon Population Assessment Project, like other ongoing monitoring programs along the lower Missouri River, should be re-designed so as to implement metrics that can be used to determine if expected outcomes are attributable to specific management actions. The metrics should be illustrated using a conceptual model. From several of the presentations and annual reports presented to the ISAP, it was implied that research was intended to address hypotheses related to spring pulse management actions, and monitoring was intended to provide 'additional' information. Instead, monitoring questions should be directly tied to management actions, performance metrics, and expected outcomes; otherwise, monitoring provides unreliable knowledge about the effects of management actions and is costly without providing critical information. Research should be used to target explicit hypotheses (or complete unknowns about the system or the three species) that would be burdensome to address by the monitoring teams, or beyond the expertise and technical capabilities of the monitoring programs.

Improvements to data collection efforts will require that measurable metrics (or, the conceptual models illustrating them as performance metrics) and their relationships with management actions be quantitatively defined. It is important to avoid measuring metrics that are not related to the management actions. If monitoring is not centered on management actions, and does not directly inform the effectiveness of those actions, then it will be impossible over time to justify adapting any of the management actions. It is also critical to determine the acceptable statistical characteristics (e.g., bias, precision) of the monitored performance metrics that permit intelligent management and decision-making within an adaptive framework. The analysis of the statistical performance (i.e., power) of monitoring programs (e.g., Peery, 2004) of sturgeon population sizes is encouraged to determine the usefulness of the resulting data in supporting an adaptive decision-making framework in the lower Missouri River restoration process. In performing such analyses, it is important to recognize that different degrees of performance (i.e., selected α values) are permissible, depending on the importance of the metric in decision-making and the consequences of incorrect decisions resulting from inadequate data. This recognition can help allocate limited resources in the design of monitoring programs across a large set of metrics.

It should be recognized that even under pre-impoundment conditions, the population dynamics of species of concern fluctuated in space and time throughout the Missouri River system in relation to conditions other than flow. For example, occasional strong year classes of pallid sturgeon resulting from greater than average food availability to early life stages can sustain a population. This phenomenon can generate large temporal variances in quantifying pallid population sizes, independent of flow. Similarly, year-class population dynamics pertain to least terns and piping plover. Thus, when considering performance metrics and measures of success, acceptable fluctuations that are consistent with recovery (i.e., persistent populations) should also be evaluated. This means that the criteria for success should be developed as distributions (or fuzzy numbers) that include variances or variations characteristic of the variability that is believed to reasonably represent pre-impoundment populations. In some instances (e.g., pallid sturgeon population sizes), pre-impoundment data might not be available to characterize spatial and temporal variability to support the development of quantitative performance measures or decision criteria. More recent patterns of variability determined from ongoing monitoring programs in other portions of the Missouri River might be used in the absence of pre-impoundment data. Alternatively, spatial and temporal variability determined for other large river systems (especially the Mississippi River) might be used to define criteria for success.

Recommendation

Monitoring programs along the lower Missouri River should be designed to determine if management action outcomes are attributable to specific management actions.

Analyses, Assessments, and Performance Metrics

Charge Question—Analyses and Assessments: Discuss the methods by which the data collected through monitoring and investigations should be analyzed and compared to performance metrics. This may include a recommendation for any conceptual or numeric models that could be used in the analysis. Discuss how the data analyses could be used to influence management actions.

Adaptive management should ask the question "what are the effects of a given management action on species recovery?" and then develop an integrated monitoring, research, and assessment program to quantify and evaluate system responses to prescribed management actions. The ability to implement such an approach depends on a conceptual model that includes causal linkages and measurable metrics. Current metrics are a mix of physical and biological process and condition measures. Appropriate metrics need to be drawn from conceptual models, and explicitly related to specific management actions. For example, instead of using the current Pallid Sturgeon Population Assessment Project methods, which are designed to address annual trends and not address efficacy of management actions, it would be more appropriate to use an approach that monitors metrics identified in the conceptual model (e.g., abundance of pallid sturgeon, presence/absence of pallid sturgeon, abundance of prey species, productivity, invertebrate production, species richness, and percent of shallow water habitat) in locations and time periods directly affected by management actions. Such an approach is more congruent with a structured adaptive management process, serves to direct data collection efforts, and can more clearly address the expected outcomes. We do note that the population assessment projects may be required to meet other regulatory requirements, but they do not necessarily meet the needs of an adaptive management program which is centrally concerned with assessing management actions.

The most essential element in program assessment and synthesis for adaptive management is identifying system response criteria that will lead to change of management "trigger points." Such criteria are completely absent from the current program. Decision criteria that define success or failure need to be established and used to make decisions to either continue specific management actions or "adapt" by changing management actions. A formal process should be designed and implemented to regularly compare monitoring results with the decision criteria. Methods for comparison might range from simple qualitative assessments to rigorous statistical analysis. For example, decision criteria for the Columbia River Channel Improvement Program (CRCIP) were derived from detailed statistical analysis of pre-project physical-chemical data (from 1996-2004) that were used to evaluate any monitored changes during project construction (from 2005-2010). Univariate and multivariate comparisons of pre-project and monitoring results were performed and reported quarterly during the construction period to the CRCIP Adaptive Management Team (AMT). Other metrics concerning crab entrainment by dredging, fish stranding by commercial navigation, and changes in juvenile salmonid habitat were designed as "before and after studies." The AMT defined a consensus-based decision-making process that could continue the project, require modifications, or terminate channel modifications depending on comparisons between the derived decision criteria and results of monitoring. The adaptive management program and the decision criteria have been documented in the CRCIP Adaptive Management Plan (Bartell and Nair 2006).

The detail and rigor of the comparisons for adaptive management in the lower Missouri River restoration activities could be determined by the amount and quality of the available data and the consequences of incorrect decision-making. Regardless of whether a programmatic approach similar to that on the Columbia River might be adopted on the lower Missouri River, the development of such decision criteria should be carried out using a collaborative team to interpret complex ecological relationships and synthesize the science behind them for purposes of management implementation by non-experts.

Along with developing decision criteria, a necessary step in analysis and synthesis is to translate conceptual models into operational models that can be used to project the expected outcomes of alternative management actions on desired outcomes. Sensitivity analysis of these operational models can help determine which model components importantly influence the likelihood of success (or failure). Sensitivity results can also be used to design effective monitoring programs that focus resources on collecting those data most essential to reducing uncertainty and improving management capabilities. Such modeling should occur before any management actions are undertaken; it requires asking prior to action, "Based on current understanding, is it realistic that the proposed management action will cause measurable change?" Those models provide formal workable frameworks for evaluating the results of management actions undertaken, designing alternative actions, and forecasting their associated effects, which can then be evaluated through monitoring. The integration of operational models with corresponding monitoring programs can significantly increase the likelihood of successful management and recovery of the listed species. Models have been developed for pallid sturgeon for the lower Missouri River (again, see Bajer and Wildhaber 2007). However, there is no evidence that the models have been used to estimate the outcomes of specific management actions (e.g., managed spring pulses or emergent sandbar habitat and shallow water habitat construction) or integrated with any systematic monitoring program on the lower Missouri River.

Assessment models have been developed for the piping plover and least tern (e.g., Bonneau et al. 2011). In contrast to the assessment of pallid sturgeon, the key model components have been estimated for these listed species of birds in the Missouri River. Detailed decision criteria in relation to the number of nesting birds, hatched eggs, and surviving fledglings have been correspondingly developed. These data have been used to characterize the growth rate and projected population sizes of terns and plover, and have been used preliminarily to evaluate the management of emergent sandbar habitat (see the 2010 Annual Report Card). The modeling effort is moving in the correct direction toward operational adaptive management, and efforts to expand these models to allow more analyses of future management options should be supported.

The one potential limitation of the piping plover and least tern modeling to date, in terms of making judgments about species recovery, is that the models necessarily focus only on the lower Missouri River. The birds that breed on the Missouri River are part of greater metapopulations that occupy breeding habitat in a number of loosely connected sites that occur over much larger areas of the northern Great Plains and the interior of the United States. In recent years below Gavins Point Dam, the piping plover numbers have approached 10 percent of those of the northern Great Plains population, and least tern numbers have approached 3 percent of the interior population in some years. These demographic units, constituting those percentages of a larger census population, cannot tell the entire story of persistence and recovery for those species, and, at the same time, it would be incorrect to conclude that bird numbers below some arbitrarily selected percentage of the total are unimportant to the listed population(s) as a whole. Population persistence over the long term is related to the collective recruitment from all occupied sites, and is not necessarily dependent on any one site being occupied or available for occupancy in all years.

Population modeling for the listed birds below Gavins Point Dam needs to consider population size and dynamics beyond that planning area. The ISAP has been tasked to evaluate the effectiveness of management actions taken below Gavins Point Dam on the lower Missouri River on potential recovery of plovers and terns; however, it is not clear that achieving specific habitat management objectives in the lower Missouri River (even if that were possible) would be the most cost-effective means of achieving population recovery for these metapopulations. The MRRIC is necessarily focused on the lower Missouri River, but it may be possible to leverage resources devoted to the lower Missouri River with federal agency members of MRRIC that have a much broader geographic responsibility to begin a cooperative metapopulation modeling effort that extends beyond the boundaries of this report; metapopulation models that already have been developed (Plissner and Haig 2000) could serve as a starting point. It would be highly desirable to conduct the adaptive management of the listed bird species, to the extent practicable, at a much larger spatial scale, allowing proposed activities on the lower Missouri River to be considered in the context of the greater metapopulations of both species.

Recommendation

The agencies should identify decision criteria that can inform change of management (i.e., identify “trigger points”) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.

Monitoring and Assessment in Context of Adaptive Management

The charge question to the ISAP was to consider how the current performance metrics can be used for “assessing the Spring Pulse expected outcomes and for use in adaptive management,” and “how the data analyses could be used to influence management actions.” These questions are difficult to answer because the current science program does not have the components necessary for it to be an effective adaptive management program. It is unlikely that much of the data collected to date will be useful in evaluating management actions. As noted above, there is not a clear process in place by which performance metrics and other data can be employed to evaluate past or guide future management actions; this is the key difference between the current program and a well-structured adaptive management program. Although there is a draft Adaptive Management Strategy for shallow water habitat (April 5, 2011) and a less-mature draft emergent sandbar habitat adaptive management strategy, the effort is piecemeal; there is not a comprehensive adaptive management plan for the recovery program or for other recovery program components, all of which are interconnected in their cumulative and interactive effects.

In the NRC's evaluation of the constructed habitat program, the NRC (2011) found that "…there has been a mismatch between, on the one hand, the large amount of resources devoted to emergent sandbar habitat and shallow water habitat project construction along the river, and, on the other hand, the relatively modest efforts aimed at development of adaptive management guidance, protocols, performance goals, and stronger science-based monitoring and evaluation to guide and learn from that ongoing construction." In written consolidated comments from the USFWS/Corps to the ISAP, the agencies state that "MRERP has taken the initial steps of development CEMs [Conceptual Ecological Models] for the ecosystem along with the development of key ecological attributes and indicators to measure the conditions of the ecological attributes. A comprehensive ecosystem adaptive management will be developed as part of the MRERP." One key objective in developing a comprehensive ecosystem adaptive management program is establishing congruence with adaptive management undertaken separately for emergent sandbar habitat, shallow water habitat, and flow releases from Gavins Point Dam. Development of the comprehensive plan affords an opportunity to look across these separate project adaptive management plans and identify opportunities to coordinate monitoring programs (e.g., avoid redundant monitoring), perform assessments (e.g., evaluate results of management actions in relation to multiple performance measures), and make strategic decisions that perhaps increase the combined performance of the individual projects. These kinds of considerations continue to be topics of discussion in the development of the Corp's system-level adaptive management programs for the upper Mississippi River (e.g., Navigation and Ecosystem Sustainability Program) and the Florida Everglades (e.g., Comprehensive Everglades Restoration Program). The ISAP looks forward to the development of a comprehensive plan for the lower Missouri River and advises MRERP to complete these tasks; they should be of top priority. The lack of a guiding adaptive management plan represents a critical missing element for the implementation of the RPA from the 2003 Amended Biological Opinion, and for the entire lower Missouri River recovery program.

As suggested earlier, conceptual models that link targeted species to their habitats and the management actions that create and sustain those resources should form one of the cornerstones of adaptive management along the river. These models are also essential to evaluating monitoring program elements and the efficacy of management actions, including, for example, the managed spring pulse, as well as other actions along the lower Missouri River (e.g., see NRC 2011, pg 72). Our analysis indicates that the prescribed spring pulse actions have been implemented with inadequate strategic integration into management planning for the rest of the lower Missouri River system and have not been informed by appropriately designed monitoring or assessment schemes. Without substantial and integrative changes in monitoring, assessment, and research programs, and without development of a structured adaptive management plan, the managed spring pulse program and accompanying recovery efforts targeting the three listed species will be uncoordinated and ineffective.

Summary Findings

Some habitat and species metrics are appropriate, but many need to be reconsidered to meet the assessment needs specifically associated with the spring pulse management actions and other ongoing management efforts. The current monitoring program predominantly produces surveillance data, and has little ability to answer specific questions that could inform management actions.

Appropriate metrics (intermediate and target population growth) need to link to conceptual models for evaluation of management actions.

The lack of conceptual models, decision criteria, or an adaptive management plan compromises the ability of ongoing monitoring efforts to inform and enhance management effectiveness.

Section VI—Managing Uncertainty

Uncertainty results from an incomplete understanding of the managed system and/or from unexpected results stemming from specific management actions. In evaluating the implications of uncertainty for ecosystem management, it is useful to distinguish uncertainty from natural, spatial and temporal variability. Natural variability can be quantified to any desired degree of accuracy and precision, but cannot be reduced through increased sampling and measurement. In contrast, the uncertainties associated with incomplete understanding can be reduced through measurement and scientific study.

Risk is defined as the occurrence probability of some specified event. Risk enters into discussions of species conservation and ecosystem restoration on the lower Missouri River below Gavins Point Dam in two ways. First, there is some probability of success, namely that the desired outcomes of conservation actions will be achieved. Second, there is some probability that the management actions might result in ecological conditions that differ from those originally anticipated. In a worst case scenario, the conditions resulting from management actions might be undesirable and irreversible.

Monitoring the effects of management actions is needed to evaluate the effectiveness of those actions. Outcomes are evaluated in the context of uncertainties and risks. The hypothesis underlying the managed spring pulses from Gavins Point Dam is that the managed spring pulses will simulate a more natural hydrograph, which in turn will contribute to providing essential habitat structure and resources for pallid sturgeon, piping plovers, and least terns. However, the magnitude, duration, and timing of the managed pulses have little resemblance to historical (pre-impoundment) pulses experienced on the lower Missouri River. Without establishing quantitative causal relationships between the hydrologic characteristics of the spring pulse management action and pallid sturgeon recruitment, there is substantial risk that unreliable knowledge about the effects of spring pulse management actions on pallid sturgeon recovery will persist. As we have suggested in Section V above, the current monitoring plan will not efficiently increase knowledge of the effects of spring pulse management actions; therefore, this uncertainty and associated risk will persist unless there are substantial changes to the existing monitoring and assessment programs.

Ecological Uncertainties and Risks

Charge Question—Ecological Uncertainties and Risks: Review the following list of risks and uncertainties. Provide recommendations on how to address these uncertainties through monitoring and investigations. Provide advice regarding the effects of these risks and uncertainties on achieving the expected outcomes. Are the occurrence, timing, water quality (e.g., temperature, turbidity, etc.), and magnitude of the managed spring pulse releases from Gavins Point Dam beneficial or detrimental to pallid sturgeon spawning and recruitment?

Despite the limited number of observations, pallid sturgeon have been observed to spawn under different discharge conditions; these have not necessarily included annual, bimodal spring pulses. The currently formulated managed spring pulses may be neither beneficial nor detrimental to pallid sturgeon spawning, and the current managed spring pulse does not appear to serve as a cue for spawning. Any risks to pallid sturgeon recruitment (including risks to egg, embryo, larvae, and juvenile survival) from the managed spring pulses are unknown; however, it should be noted that our current understanding of pallid sturgeon in the lower Missouri River is limited to observations of their responses in a highly altered system. Contemporary observed pallid sturgeon behavior patterns may be quite distinct from historical behaviors given that their preferred habitats and conditions may no longer exist.

Uncertainties regarding the functional relationships between the frequency, magnitude, timing, and duration of managed releases and pallid sturgeon recruitment make it imprudent to recommend any specific effective alternate spring pulse management actions. Modifications to channel morphology are likely necessary for the system to be sensitive to changes in hydrology. Along with this, we have suggested earlier that continuing with managed spring pulses alone (i.e., without changes in channel morphology) would result in low likelihood of species recovery. Restoring baseflows for specific periods has a high level of uncertainty regarding outcomes, but if constrained initially as an experiment of short duration, baseflow restoration could be a low-risk management action.

The current absence of process-level understanding of links between hydrology and species response permits only qualitative assessment of the likely chances for successful recovery of pallid sturgeon. Reducing attending uncertainties may be difficult to achieve, however. Monitoring programs might fail to detect positive contributions to reproductive success because other hydrological confounding factors (including tributary discharges, alterations in land-use) contribute to producing low signal to noise ratios. In fact, given practical limitations to sampling efforts, it will prove challenging to detect any downriver effects of managed spring pulses from Gavins Point Dam on pallid sturgeon populations. Peery (2004) analyzed data collected for pallid sturgeon and shovelnose sturgeon in Missouri River segments below Fort Peck. The results of the study demonstrated that samples from 24 river bends, with 36 subsamples per bend, collected annually for ten years could reveal a 3 percent change in pallid population size 87 percent of the time; a 5 percent change in pallid sturgeon population size could be inferred 80 percent of the time from 36 annual subsamples each collected from 6 river bends. Recent studies suggest that a 10 percent change in pallid sturgeon abundance over a ten-year monitoring period could be reasonably detected 40-50 percent of the time (Bryan et al. 2009, Wildhaber et al. 2011). Minor adjustments to the monitoring program might increase the power of detection to as much as 80 percent (Schapaugh and Tyre 2011). The key concern in relation to adaptive management is the ten-year time span underlying the power analyses. The relevant time scale for adaptive management for releases from Gavins Point is one year given the annual releases. The corresponding number of samples required to detect annual changes in pallid sturgeon population size below Gavins Point Dam would need to increase dramatically, and may prove infeasible with current and future management resources. If spring pulse management actions at Gavins Point Dam actually were to produce substantial changes in pallid sturgeon population sizes, the number of samples required to detect such changes would correspondingly decrease. However, the magnitude and duration of managed pulses from Gavins Point Dam are substantially lower than those that occurred under the pre-impoundment conditions on the Missouri River, and affirmative impacts on pallid sturgeon population size might be subtle. As a result of these concerns, the long-term monitoring program for pallid sturgeon on the Missouri River might more effectively allocate available resources to more focused monitoring in relation to specific hypotheses concerning the effects of annual releases from Gavins Point Dam on the reproductive success and survival of early life stages of pallid sturgeon.

Can recovery of the listed species be achieved by management actions implemented in the Gavins Point reach?

Although the ISAP focused on management of river conditions in reaches below Gavins Point Dam, the ecology of piping plover, least tern, and pallid sturgeon requires that performance measures for these species be evaluated within the larger spatial context of their populations or metapopulations. Piping plover and least tern exhibit complex metapopulation structure. Enhanced population numbers derived from constructed habitat below Gavins Point Dam for these species need to be assessed in relation to the status and trends of populations as influenced by habitat quality and availability elsewhere in the Missouri River system and beyond in the northern Great Plains (piping plover) and interior of North America (least tern). Recovery of pallid sturgeon in the lower Missouri River ultimately might not depend on successful recruitment below Gavins Point Dam. Given the minimal extent of low-velocity habitat that exists downriver from Gavins Point Dam, pallid sturgeon larvae may be transported downstream at rates proportional to discharge, and exit the lower Missouri River. Such potential contributions of larval pallid sturgeon to the middle Mississippi River suggests that the importance of conservation efforts on the lower Missouri River may be realized in sustaining pallid sturgeon in a greater geographic context. Recruitment in areas where pallid sturgeon are known to spawn below Gavins Point Dam likely needs to be inferred from sampling an extensive area of the Missouri and Mississippi river basins.

Is the Gavins Point Spring Pulse Management action needed given the naturally occurring downstream pulses?

As currently designed, managed spring pulses do not appear to be necessary to cue spawning by pallid sturgeon; however, the role of naturally occurring pulses has not been adequately (or systematically) assessed. This finding is not the same as saying that managed spring pulse actions in general are not necessary or helpful in contributing to the survival and recovery of the listed species; other managed spring pulse actions could potentially be effective in achieving desired outcomes, particularly when combined with management actions, such as shallow water habitat creation.

Spring pulses from tributaries to the lower Missouri River are likely providing ecological benefits to the three listed species, but those pulses are subjected to and result from regulation to varying degrees and discharges in those tributaries are substantially restricted by system constraints. Carefully designed tributary monitoring programs, including efforts to estimate the magnitude, frequency, timing, and duration of contributions of tributaries entering the lower Missouri River to its discharge, could contribute to a better understanding and serve to isolate the contributions of tributaries from the contributions of managed spring pulses to the extent and quality of habitat for pallid sturgeon, least terns, and piping plover.

Is the performance of managed pulses delaying or hampering more meaningful pallid sturgeon recovery opportunities?

Emphasis on managed spring pulses, as they are currently designed and implemented, might reduce opportunities for allocating resources and attention to potentially more productive outcomes. As considered above, it is likely that in order for hydrological management actions to demonstrably benefit the targeted species, some level of constructed habitat features is also likely required. Therefore, focusing exclusively on flow management would come with risk in that there is a need to integrate hydrological and mechanical restoration efforts in a conceptual restoration framework, particularly via linked monitoring programs and a system-wide adaptive management program.

Are managed pulses impacting socioeconomic resources, including interior drainage and downstream groundwater levels?

There is currently no evidence that managed spring pulses compromise existing internal drainage capacities or groundwater elevations in ways that threaten crops and croplands. River incision has reduced the effects of managed spring pulses on adjacent lands, and managed spring pulses are substantially attenuated as they move downstream, reducing their effects in less-incised reaches. The limited magnitude and duration of managed spring pulses, as they are currently designed, preclude potential outcomes; larger pulses or pulses that are longer in duration might demonstrate measurable effects.

The retention of sediment behind the series of dams on the upper Missouri River and its tributaries has caused the river to incise (i.e., vertically degrade) in several reaches. An analysis by Jacobson et al. (2009) of sediment load changes and associated bed elevation changes provides considerable evidence for changes in the river's morphology, most notably the several meters of incision from Gavins Point Dam down to Omaha, and the one to two meters of incision near Kansas City. This level of vertical incision decreases potential impacts of high flows on adjacent lands. Moreover, the reach most impacted by the pulse releases is the most incised reach, which is immediately downstream of Gavins Point Dam. Any effects of a spring pulse management action will decrease with distance downstream with flow attenuation. The Corps and USGS estimate complete attenuation of spring pulse management actions from Gavins Point at Kansas City. Also, it has been estimated that a 10,000 cfs pulse would raise river stage to 2.39 feet at Sioux City, but just about 2 feet or less downstream from Omaha (see Table 3, Kelly 2000); thus, the potential effects of the proposed spring pulse management actions are likely to produce just a one- to two-foot rise in river water level upstream of Kansas City, and this level will last only briefly. Such limited vertical rise occurs within a channel that is incised up to 10 feet or more. These circumstances reduce potential impacts of the prescribed spring pulse management actions on riparian vegetation, flooding, and floodplain connectivity.

It is important to acknowledge the limited magnitude of currently prescribed spring pulse management actions. The initially proposed spring pulse management actions were of such magnitude and duration as to warrant concern over safety; the preferred alternative identified in the 1994 Draft Environmental Impact Statement was a 20,000 cfs pulse for over 90 days (April 28, 2011, presentation to the Panel). Subsequent modifications to the prescription resulted in a spring pulse management action of far lesser magnitude and duration, reducing the ability of the pulses to propagate effects into groundwater and floodplains. This reduced spring pulse management action negates concerns regarding interior drainage and groundwater.

For river water to rise to a level that would affect floodplain groundwater, it must stay high for an extended period of time, at least covering the lag between river water rise and groundwater rise. Moreover, the effects of a pulse-generated rise dissipates with distance from the river; river water rising will quickly affect lands immediately adjacent to the river, but it requires some time to affect lands more distant from the channel. Using a calibrated and well-constrained model, Kelly (2000) showed that the affect of the current spring pulse management action prescription and those higher, which might cause up to an approximately two- to three-foot rise in river stage, would be only a 0.5-one foot commensurate rise in groundwater. Using Figure 9 from Kelly (2000), a one-day rise of 1.5 feet would increase groundwater elevation by about 6 inches. Using Figure 10 of Kelly (2000), an eight-day rise of 1.5 feet would increase groundwater by about one foot. Empirical evidence and models indicate that the spring pulse management actions, as currently implemented in terms of magnitude and duration, are not affecting groundwater elevations within 3 feet of the surface to a magnitude of concern.

In addition to modeling and calibration carried out by Kelly (2000), there has been some analysis and monitoring work carried out by the Corps. Their work suggested that the spring pulse management actions, as currently implemented, have minimal effects on interior drainage. This finding is based on analysis under scenario HMU0F0 (in Corps of Engineers 2005), which is most comparable to the current spring pulse management effort. In addition, the Corps has used groundwater wells in conjunction with stream gauge data to test effects more precisely and empirically (Corps of Engineers 2009). Results illustrate that spring pulse actions in 2008 and 2009 did raise groundwater, but groundwater stayed well below elevations that would damage crops. The work by the Corps using field data collection (rather than modeling) provides reliable evidence of the effects of the pulse on groundwater. The only location below Gavins Point Dam where findings are uncertain is on the Forest City-Rulo reach, where it appears that channel constriction associated with a bluff line confounds the river-groundwater effects relationship. The Corps has appropriately interpreted available data from this location; the lack of tight correlations between river stage and groundwater indicate that an alternative source of water influences groundwater elevations at this location. Therefore, the risk posed by managed spring releases on elevated groundwater levels and associated flooding of agricultural lands appears minimal.

There is also concern that spring pulse management actions may affect water drainage infrastructure. To address this concern, the Corps conducted modeling and field studies of interior drainage (Corps of Engineers 2008). The Corps instrumented drainage infrastructure along the Missouri River; the resulting data show that spring pulse management actions have negligible influence on interior drainage in comparison with normal flow or precipitation events. Only one site, County Line Ditch at river mile 659.0, shows evidence of being impacted by river stage elevation changes caused explicitly by spring pulse management actions. The 0.78-foot rise in stage at the upstream gauge of this site indicates that a typical March spring pulse could affect drainage in unobstructed ditches with gentle slopes. However, Missouri River flows at that time are low enough that any backwater effect along the drainage ditch remains well below the banks, and no flooding to adjacent lands occurs. The Corps' data for the full monitoring period show that increases in stage produced by natural rises resulting from the large rainfalls in May and June 2008 dwarfed the increases in stage produced by the March spring pulse. In addition to these field studies, the Corps conducted modeling studies using a range of potential pulses and projected impacts on flooding (Corps of Engineers 2005). These modeling results showed that a range of spring pulse management actions would have minimal effects on interior drainage. Based on an analysis of more than 100 years of flow data, spring pulses appeared to negatively impact interior drainage less than one percent of the time (Corps of Engineers 2005).

The ISAP has been provided no information to substantiate claims that spring pulse management actions, as currently prescribed, would create flooding concerns downstream. Available evidence supports the assertion that there will be no such effects. Available data can be used to evaluate more accurately alternative spring pulse management actions and their potential effects on flooding. Available instrumentation can be used to identify the types of spring pulse management actions that are likely to affect interior drainage and/or groundwater elevations. Planners can incorporate unsteady hydraulic modeling of the lower Missouri River, and use sensitivity analysis to develop estimated relationships between the magnitude and duration of pulses and rates of attenuation, and effects of background flows on pulse attenuation.

Focused Investigations to Reduce Uncertainty

Charge Question—What focused investigations/research are necessary to reduce uncertainties and address risks associated with the spring pulse releases from Gavins Point Dam? What additions or alternatives to a spring pulse are possible to address the research needs for each of the expected outcomes (i.e., laboratory studies, inclusion of additional surrogate species)? For each investigation, describe its relationship to the outcomes/metrics, risks, and uncertainties.

For example, are investigations needed for: Relationship between flows, sediment transport/sediment availability, development of future habitat and species recovery actions on the Missouri River?

To address this question usefully, functional relationships need to be articulated between the amount, location, quality, and persistence of habitats created by sediment transport and the viability of the populations of concern. The ecological impacts, positive or negative, of sediment transport on the population dynamics of the species of interest remain uncertain. Importantly, if factors other than physical habitat structure (e.g., food availability, predation, disease, and chemical contamination) are controlling population dynamics, constructed habitat projects might prove ineffective in the recovery of the listed species. Small changes in flow can transport and shift sediment throughout downstream reaches of the lower Missouri River, particularly on the Platte, Kansas, Grand, and Osage river segments. However, the Corps has determined that managed flows from Gavins Point Dam (those that occur as part of managed spring pulse program) likely will not be sufficient to create substantial emergent sandbar habitat or shallow water habitat; hence, there appear to be threshold values of flow required to create such habitats. Knowledge of these thresholds could be used to design effective releases or be the basis for concluding that threshold flows are not a feasible management alternative, given system constraints. We suspect that morphological changes in the river following the flood event of 2011 will provide substantial information useful in considering these issues.

Are the natural rises from tributaries (i.e., frequency, duration, and magnitude) providing "sufficient" pulses to accomplish the outcomes on specific segments of the Missouri River mainstem?

Because of tributary inputs, variation in discharge in the Platte, Kansas, Grand, and Osage river segments of the lower Missouri River (i.e., below Kansas City) is more similar to historical conditions than in the upstream reaches. Although discharge in the regulated lower Missouri River more closely resembles historic conditions below Kansas City, Missouri, there is no evidence to suggest that expected management outcomes outlined in the 2000 and 2003 Biological Opinions should be measurably different above and below Kansas City. Pallid sturgeon are spawning both above and below Kansas City under varying discharge regimes. There is no evidence to suggest that the floodplain is more frequently connected below Kansas City, Missouri, in a way such that nutrients, invertebrates, and forage fish are more abundant. While Jorgenson (August 2011 communication to ISAP) notes that floods in excess of flood flow are more frequent downstream of the Platte River, the quantity of floodplain areas inundated, and subsequent effects are undocumented. There is no evidence to suggest that potential spawning substrates are more effectively scoured below Kansas City, Missouri. Likewise, there is no evidence to suggest that sandbars are conditioned so to serve as habitat more frequently below Kansas City. Similarly, there are no measurable differences in catch rates of pallid sturgeon below and above Kansas City, Missouri (Oldenburg et al. 2010). The effects of tributary discharges to the lower Missouri River from tributaries are well documented, but a direct link between those discharges and contributions to population responses by the three listed species does not exist. The lack of evidence for effects from larger tributaries is due in part to the lack of focused research or monitoring on those tributaries.

Charge Question—Can implementation of habitat creation (e.g., chutes, widening of channel, levee set back, etc.) be enhanced to contribute to Outcome #2 and aid in pallid sturgeon spawning and recruitment?

This research question is not relevant with respect to pallid sturgeon spawning, because the current information suggests that spawning is occurring in higher velocity, main channel habitats. Pallid sturgeon are spawning in the lower Missouri River under current conditions, and no evidence suggests that spawning substrates are limiting.

It is likely that construction of habitat structures may be beneficial to larval and juvenile pallid sturgeon. For instance, Galat and Zweimuller (2001) found that the majority of imperiled fishes in the Missouri River, as well as seven other large rivers globally, are fluvial specialists—they depend on the main channel for reproduction or for all of their life functions. The focus for recovery of pallid sturgeon, therefore, should be on channel complexity, and not connections with floodplains, because the Galat and Zweimuller (2001) findings, as well as other contemporary research, suggest that larval pallid sturgeon drift in the thalweg. Increasing channel complexity will likely reduce velocities and increase the availability of littoral habitats, which are hypothesized to benefit pallid sturgeon by reducing drift speed and increasing foraging opportunities, but constructed habitat is expensive and may not produce the expected outcomes. For that and other reasons, monitoring and research must be designed to test specific hypotheses that address constructed habitat for different pallid sturgeon life stages in order to identify the specific mechanisms that influence population growth and persistence. As noted earlier, it remains unclear whether pallid sturgeon are food resource limited. Questions regarding the role of levee set backs or floodplain reconnection must first be linked to specific hypotheses about how these river features might address actual environmental stressors that act on the species.

What additional investigations/research are necessary to reduce uncertainties and address risks associated with the spring pulse releases from Gavins Point Dam?

A basic understanding of the ecologies of the listed species on the lower Missouri River has contributed to some management actions below Gavins Point Dam. Nevertheless, as stated elsewhere in this report, it is essential that research and monitoring be focused on the specific effects of spring pulse management actions on those species. One aspect of assessment sampling that we see lacking is treating the managed spring pulse as the independent variable with any number of habitat or species metrics as the dependent or response variable(s). We note that in the one case this was explicitly done (Jacobson and Galat, 2006); the study showed quite clearly that hydrology was less of a limiting factor than river morphology, which allowed for more effective management guidance.

Summary Findings

Managed spring pulses as currently implemented appear to be neither beneficial nor detrimental to pallid sturgeon spawning; risks to pallid sturgeon recruitment are unknown, but unlikely to be significant. Risks from managed pulses to least tern and piping plover reproduction and recruitment exist, but are mostly managed to be minimized.

Reducing risks to species requires reducing scientific uncertainty in the biological responses of the targeted species to the managed spring pulses. This requires quantification of relationships between flow and ecological responses, and then testing the responses of those relationships by altering flow magnitude and duration, while concurrently monitoring effects.

Section VII—Conclusions

Substantial new knowledge regarding pallid sturgeon, least tern, and piping plover, their habitats, and management opportunities on the lower Missouri River has accrued since publication of the 2000 and 2003 Biological Opinions for those species. The Reasonable and Prudent Alternatives (RPAs) in the Biological Opinions identified managed spring pulse releases from Gavins Point Dam as one of the primary means for mitigating impacts to the three listed species resulting from its operation. The managed spring pulses as recommended by the Biological Opinions may be beneficial to the listed species. This assertion, however, remains largely untested because (a) the existing monitoring program is not directly testing the efficacy of the management action, and (b) the implemented spring pulse management actions have been, to date, inadequate in size and duration in comparison to what was recommended.

Based on understanding gained, the biological narrative and effects analysis in the 2000 and 2003 Biological Opinions does not accurately represent several salient ecological relationships between the listed species and landscape and hydroscape features, habitat conditions, and ecosystem processes. Drawn from this report, contemporary findings include these observations:

- Best current evidence indicates that managed spring pulse actions are not necessary to cue spawning by pallid sturgeon.
- Best current evidence indicates that managed spring pulse actions are not necessary to scour substrates for spawning by pallid sturgeon.
- No evidence exists that pallid sturgeon would benefit from floodplain connectivity.
- No evidence exists that supports the assertion that “shallow water habitat,” which may be created or enhanced by hydrological actions or mechanically constructed, is necessary to produce the prey required by the pallid sturgeon or the least tern.
- The magnitude of managed pulses as currently implemented is inadequate to enhance and sustain landscape features that provide habitat and resources for least terns and piping plovers; moreover, it is unclear whether the managed spring pulses as prescribed in the Biological Opinion would be adequate to sustain these same landscape features and resources.

Combined, these findings indicate that the RPA as it is currently being implemented does not serve to mitigate for presumptive losses of pallid sturgeon, least tern, or piping plover, or degradation of their habitats due to normal operations of Gavins Point Dam. Accordingly, if the U.S. Fish and Wildlife Service believes that normal operations continue to jeopardize the existence of pallid sturgeon, least tern, and piping plover, a new program of management actions will be required to minimize and mitigate for losses, or “take,” of those species. The review of available information by the ISAP suggests that a management plan for the three listed species on the Missouri River below Gavins Point Dam will be most effective and efficient if it considers the interactive and cumulative effects of flow management actions and habitat creation that, when combined, may provide and sustain essential resources for the species.

A structured analysis should be used to assess the effects (and associated costs) of alternative management actions on the listed species. The effects of management should be described in terms of the likelihood of species persistence or recovery. Much of the data necessary to inform an analysis of the effects of alternative management actions can be drawn from research, monitoring, and assessment efforts that have been undertaken in the Missouri River system over the past decade. An effects analysis must consider possible alternative actions within a cost-benefit analysis framework, as well as considering other socioeconomic factors. Such an effects analysis is integral to and must precede the implementation of an adaptive management plan.

A revised program of management actions, drawn from an analysis of the likely effects of alternative management actions, should be consistent with current knowledge of species-habitat relationships. It should be based on the most current knowledge regarding how hydrology and construction of habitat can be combined to create and sustain the landscape features and ecosystem processes that support viable populations of the three listed species. The revised program of management actions should be implemented as an adaptive management program that strategically employs modeling, directed monitoring, and research to increase management performance as new knowledge is acquired. Adaptive management below Gavins Point Dam should be supported by continuously updated conceptual models that relate the status of the listed species to essential physical and biotic resources, and to management opportunities that can provide those resources. Monitoring in support of adaptive management should include well-supported performance metrics, pre-negotiated management decision criteria, and quantitative measures of programmatic success. A number of essential elements for the development of an effects analysis and a comprehensive adaptive management plan for the lower Missouri River are already in hand or in development. However, these components have yet to be consolidated and synthesized as is required to develop management strategies and implement adaptive management.

The ISAP recognizes that the demographic units of the three listed species, located on the lower Missouri River below Gavins Point Dam, constitute a limited portion of the populations (or metapopulations) in the greater Missouri River system, and that each ecologically interact with conspecific individuals in other areas occupied by the species. For that reason, and to better facilitate the recovery of the listed species, any adaptive management program that includes actions on the lower Missouri River should be integrated with conservation efforts elsewhere in the system, and supported by a synthetic program of data acquisition and analyses that takes advantage of information derived from studies undertaken beyond the focal area considered in this report.

The panel encourages resource planners to glean lessons learned from large-scale efforts to implement adaptive management elsewhere. These include ongoing management approaches that link river flows, channel morphology, vegetation management, and the habitat needs of listed species on the Platte River in the Missouri River system, fisheries management efforts that include sturgeon on the Columbia River, and more general models of river system adaptive management, which include rivers targeted in the Sustainable Rivers Project and other multiagency planning efforts across the country.

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Link for public access to background materials and recorded webinars
http://projects.ecr.gov/moriversciencepanel/PanelTopics.aspx

MRRIC WebEx site for ISAP background materials and webinars (member log in required)
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APPENDIX A—PANELIST CERTIFICATIONS

I have reviewed the background material provided and contributed to the writing and revision of this report. I agree with the statements and conclusions of this report. I reassert that I do not have a conflict of interest in participating on this Independent Science Advisory Panel.

11/30/2011

Steven M. Bartell, Ph.D. Date

11/30/2011

Martin W. Doyle, Ph.D. Date

11/30/2011

Adrian H. Farmer, Ph.D. Date

11/30/2011

Christopher S. Guy, Ph.D. Date

11/30/2011

Dennis D. Murphy, Ph.D. Date

11/30/2011

Margaret A. Palmer, Ph.D. Date

APPENDIX B—PANELIST BIOS

Steven M. Bartell, Ph.D., Vice President and Technical Director at Cardno ENTRIX. Formerly a research scientist in the Environmental Sciences Division at the Oak Ridge National Laboratory, Dr. Bartell currently manages the Cardno ENTRIX office in Maryville, TN. He is also an adjunct faculty member in the Department of Ecology and Evolutionary Biology at the University of Tennessee, Knoxville.

Dr. Bartell's areas of expertise include systems ecology, ecological modeling, ecological risk analysis, risk-based decision analysis, vulnerability analysis, numerical sensitivity and uncertainty analysis, environmental chemistry, and environmental toxicology. He works with public and private clients in ecological risk assessment, environmental analysis, ecological planning, and ecosystem restoration. Dr. Bartell has conducted ecological risk assessments for a diverse set of environmental stressors: ecological disturbances from commercial navigation on the Upper Mississippi and Illinois Rivers (USACOE); risk of invasive species establishment (USDA); habitat alteration and degradation (USDOE, USACOE); multiple chemical stressors in the Patuxent River and estuary (NOAA, USEPA); radionuclides and toxic metals (several Canadian mining companies); and herbicides and pesticides (Syngenta). Bartell is currently working on large-scale projects in adaptive management and restoration for the Florida Everglades, the Lower Columbia River, and the Upper Mississippi River.

Martin W. Doyle, Ph.D., Professor of River Science and Policy in the Nicholas School of the Environment at Duke University. Dr Doyle is an environmental hydrologist and geomorphologist, with training in river engineering and earth science. His research is at the interface of science, economics, and policy of environmental management and restoration. He focuses on the use of market mechanisms for environmental restoration, and the future of river infrastructure-such as water supply dams and levees-under changing climate and increasing population.

Dr Doyle has received a Guggenheim Fellowship, a National Science Foundation Early Career Award, and the Dimitrius M Chorafas Prize (Switzerland). For his work in bridging environmental science and policy, in 2009 was named the inaugural Frederick J Clarke Scholar by the U.S. Army Corps of Engineers. In 2008 Dr Doyle was named an Aldo Leopold Leadership Fellow by Stanford University, and received a GlaxoSmithKline Faculty Fellowship for Public Policy from the Institute for Emerging Issues.

Adrian H. Farmer, Ph.D., Principal Scientist with Wild Ecological Solutions. Dr. Farmer, a least tern and piping plover specialist, conducts shorebird research, with an emphasis on effects of global change on migration schedules and fitness. As an integral part of his research on shorebird migration, he has collaborated with other scientists from North America and Europe to develop applications of dynamic programming in the study of bird migration.

Management of large river systems is of particular interest to Dr. Farmer. He has had considerable experience over the last 30 years with water and habitat management issues of the Platte River of Nebraska. Most of this work has been on modeling relationships between hydrology and crane habitat. For many years, he conducted migratory shorebird research along the Missouri River in the state of Missouri, and is familiar with the system dynamics as well as the general issues affecting bird use of that system. He has developed habitat models for both least terns and piping plovers for the U.S. Army Corps of Engineers and U.S. Bureau of Reclamation for purposes of habitat management in the Platte River and along the beaches of Fire Island, NY.

Christopher S. Guy, Ph.D., Assistant Unit Leader with the U.S. Geological Survey's Biological Resources Division at the Montana Cooperative Fishery Research Unit and Affiliate Associate Professor at Montana State University. Dr. Guy, a sturgeon specialist, conducts research contributing to understanding ecosystem-level issues that are scientifically challenging because of scale, complexity, and spatial and temporal dynamism. Most of his research falls within the broad mission of ecology of fishery and aquatic resources. A major, consistent research theme has been on native fish assemblage restoration, a prominent ecological and societal issue in Rocky Mountain and Great Plains ecosystems.

He has a comprehensive native species research program involving life history, movements, habitat use, population ecology and dynamics, exploitation, hybridization, non-native eradication, and disease components. His research includes evaluation of post-stocking dispersal of hatchery-reared pallid sturgeon; movements, diet, and habitat use of pallid sturgeon and shovelnose sturgeon; spawning locations and early life history of shovelnose sturgeon; effects of spawning location on survival of pallid sturgeon and shovelnose sturgeon; impacts of flow modifications on distribution and spawning by pallid sturgeon and shovelnose sturgeon; interactions between sauger and sympatric non-native walleye; distribution and population characteristics of non-native lake trout in Lake McDonald, Glacier National Park, with implications for suppression; landscape factors affecting the distribution and genetic diversity of bull trout and sympatric non-native lake trout in Glacier National Park; movement of resident and non-resident anglers and implications for transferring aquatic nuisance species; effects of angling on salmonids during high water temperatures; biogeographical and human influences on fish assemblages in prairie streams; and spatiotemporal dynamics of fishes in prairie streams.

Dennis D. Murphy, Ph.D., Research Professor at the University of Nevada, Reno. Dr. Murphy has worked on conflict resolution in land-use planning on private property since the first federal Habitat Conservation Plan on San Bruno Mountain.

Dr. Murphy's ongoing and recent activities in the area of conservation planning and adaptive management include service on the Science Board to the CalFed Ecosystem Restoration Planning Program for the Sacramento and San Joaquin river systems, development of a conservation strategy for the imperiled Tahoe yellow cress for the U.S. Fish and Wildlife Service, development of a watershed-based ecosystem management framework for the Truckee, Carson, and Walker hydrological units in the Humboldt-Toiyabe National Forest, and science design for the nation's largest Habitat Conservation Plan under the Endangered Species Act, in Clark County, Nevada, and several other major HCP efforts in southern California and southern Nevada. Dr. Murphy also has served as team leader for the committee of scientists carrying out the Lake Tahoe Watershed Assessment, a Presidential deliverable to the Tahoe Federal Interagency Partnership via the U.S. Forest Service and now sits with the science committee of the Tahoe Science Consortium. Dr. Murphy has testified more than a dozen times before Senate and House committees and subcommittees on issues mostly pertaining to implementation of the federal Endangered Species Act.

Margaret A. Palmer, Ph.D., Professor of Entomology and Biology at the University of Maryland and Professor and Director at Chesapeake Biological Laboratory. Dr. Palmer received her Ph.D. in oceanography, but in the last 20 years has turned her attention to freshwater systems. The broad objective of her research is to understand what controls stream ecosystem structure and function. She specifically focuses on how land use and urbanization influence stream ecosystems and on producing the best science to guide ecologically effective restoration of rivers and streams.

Dr. Palmer has more than 90 peer-reviewed publications and numerous awards including American Association for the Advancement of Science Fellow and Aldo Leopold Leadership Fellow. She currently has an active research lab of 12 graduate students, post-docs, and research technicians working on various aspects of stream ecosystem science, and is a national coordinator of the National River Restoration Science Synthesis Project.

Dr. Palmer has served on numerous advisory boards and scientific panels including for the Grand Canyon Research and Monitoring Program, National Center for Ecological Analysis and Synthesis, Freshwater & Marine Ecology Faculty of 1000, EcoHydrology Science Agenda Committee, National NEON Design Consortium and National Network Design Committee, and National Research Council Committee on River Science. Palmer led the Ecological Society of America's committee to develop an action plan for the ecological sciences for the 21st century. She was Program Director of Ecology at the National Science Foundation from 1999-2000. She also has been actively involved in scholarly work on women in science.

APPENDIX C—CHARGE DESCRIPTION #1: SPRING PULSE ADAPTIVE MANAGEMENT

Missouri River Recovery Program Independent Science Advisory Panel

I. BACKGROUND AND INTRODUCTION

The U.S. Army Corps of Engineers (Corps) - Missouri River Recovery Program (MRRP) is engaged in recovery and mitigation projects on the Missouri River, with significant efforts to restore ecosystem functions as they relate to recovering threatened and endangered species. This effort relies on collaborations with a wide range of governmental, academic, and private organizations that are working to deliver products, including extensive scientific analyses and syntheses. The Missouri River Recovery Implementation Committee (MRRIC), a group of 69 members representing various interests, tribes, and agencies, assists these efforts by developing recommendations for the agencies implementing the ecosystem management efforts.

The desire and need for well thought out science and independent scientific advice and recommendations to support decisions and directions taken by the Corps has increased, and is also desired by the MRRIC. As a result, the MRRP Integrated Science Program (ISP) has established a standing Independent Science Advisory Panel (ISAP) for the MRRP and the MRRIC, utilizing Oak Ridge Associated Universities as the Third Party Science Neutral (TPSN) contracted by the U.S. Institute for Environmental Conflict Resolution (USIECR), as a lead advisor for the management of scientific advisor selection, panel processes, and panel products. The independent science advice/reviews required are scientific in nature, and decision making and policy interpretation are left to the Corps after consideration of any consensus recommendations from MRRIC.

The initial ISAP, established in January, 2011, comprises the following members selected for a three-year term:

- Margaret A. Palmer, Ph.D. – Aquatic/Riverine Ecologist
- Martin W. Doyle, Ph.D. – River Hydrologist/Geomorphologist
- Adrian H. Farmer, Ph.D. – Least Tern/Piping Plover Specialist
- Christopher S. Guy, Ph.D. – Sturgeon Specialist
- Steven M. Bartell, Ph.D. – Quantitative Ecologist/Statistician
- Dennis D. Murphy, Ph.D. – Conservation Biologist

II. CHARGE SCOPE: SPRING PULSE AND ADAPTIVE MANAGEMENT

This document describes the first charge to the ISAP, including questions it is to consider, and the procedures and timeline that it is to follow in responding to the charge. This charge description incorporates the "Independent Science Advisory Panel Outline of Charge Scope" drafted and approved by the Corps and the MRRIC ISP Working Group (Attachment A). That document provides the background and rationale for the spring pulse and adaptive management topic area, a range of questions for the panel to consider and advise on, and a list of publications for the panel to review and consider in answering the questions. This charge description is developed pursuant to the "USACE MRRIC ISAP Approach Structure Ground Rules" (entitled "Third Party Science Neutral Support to Establish an Independent

Science Advisory Panel for the Missouri River Recovery Program") approved by MRRIC on July 21, 2010 (see Attachment B).

As described in more detail below, it is anticipated that the ISAP will have a kick-off conference call as soon as practicable in early 2011, face to face meetings concurrent with the February, May, and July MRRIC meetings, other conference calls as needed, and a collaborative SharePoint site within which to share draft materials. Opportunities for panel interaction with MRRIC participants will occur at the February and May meetings, along with a report out and discussion of findings and recommendations planned for the July meeting. The panel will submit a final written report thereafter.

III. HOW THE INDEPENDENT SCIENCE ADVISORY PANEL WORKS

1. The TPSN has contracted with the six panel members to reimburse them for their time and to coordinate travel arrangements and reimburse travel costs. Panel members will work closely with TPSN staff to minimize time spent on logistics and maximize time available for work of the panel.

2. Kick-off Conference Call: The TPSN will schedule a conference call with panel members as soon as possible after contracts are completed with all panel members. Agenda for the call will include introductions, goals and expected products, initial assignments, selection of panel chair, timeline, ground rules for operation, next steps.

3. Expected products: The ISAP will produce a report addressing the "Outline of Charge Scope" (Attachment A). The report will include:

   - Summary of the goals and objectives of the charge to the panel on spring pulse and adaptive management.
   - Summary of key points of the panel discussion and the results including consensus and/or independent opinions and recommendations regarding each question.
   - An analysis of the findings including observations of the strengths and weaknesses of the findings and any dissenting opinions. The report is to accurately present the views of the entire panel.
   - Exercises (e.g., evaluations or assessments) completed as part of the process.
   - Information considered by the panel (including copies of unpublished or other information not readily available to the public, and content of any presentations or other information received).
   - Brief summary of the panelists' qualifications.

   The Panel Chair shall be responsible for writing and editing initial, draft, and final reports, coordinating writing and review assignments among panel members. The TPSN will ensure that the report addresses Attachment A, is thorough, and is understandable. The TPSN will provide a secure collaboration SharePoint site for the panel to share and track draft materials. The report will be delivered in electronic format as a text selectable "pdf" file (portable document format created with Adobe Acrobat). The panel (or panel chair) also will present its draft report at a MRRIC meeting and have opportunity to discuss its conclusions.

4. Panel Chair: A panel chair will be chosen to ensure consideration of all technical matters amongst panelists and coalesce a final report. The method for choosing the chair will be determined by the panel members with the assistance of the TPSN. Possible options include, but

are not limited to, a different chair for each charge/topic, a chair for the full period of time (three-year term), and a rotating chair.

5. Schedule/timeline: (to be refined as the process unfolds)

Jan 2011	Kickoff conference call
Jan 2011-Feb 2011	Background reading and conference call(s) discussion, TBD
Feb 14-17 2011	Meeting, Denver; meet and greet with MRRIC, meet with ISP-WG
Feb-Apr 2011	Conference call(s) discussion, TBD; begin drafting response
May 2-5 2011	Meeting, Kansas City; meet with ISP-WG, others TBD
May-July 2011	Conference call(s) TBD; draft report
July 25-28 2011	Meeting, Great Falls; present draft report, discuss with MRRIC
Aug 2011	Conference call(s) TBD; produce near-final report
Sep 30 2011	Produce final report

6. Implementation: In coordination with the Corps, the ISP WG, and the USIECR, the TPSN will schedule face-to-face and virtual panel meetings and coordinate all logistical issues associated with carrying out the panel's charge. The TPSN will facilitate selection of the panel chair, then with the panel chair, will facilitate panel deliberations, external panel interaction, and report preparation and dissemination. The TPSN will also provide other project management duties including ensuring product completion per schedule and budget.

   Panel meetings generally are open to the public for observation (the panel may choose to deliberate some issues in executive/closed session). Opportunities to interact with the panel will be scheduled as demand dictates and as time allows. The TPSN will announce meeting times to the USIECR and ISP WG. Individuals wishing to observe or to speak with the panel are asked to coordinate with the USIECR and TPSN to ensure that logistical arrangements for the meeting can accommodate their participation.

   Key agency staff and members of MRRIC are available to provide input as necessary when requested by the panel. The TPSN and USIECR will coordinate such interaction.

7. Standing Ground Rules: To facilitate consideration of multiple perspectives on the issues, a structured process has been developed to avoid bias, ensure transparency, and guide communications between Science Advisory Panel members and the Corps, MRRIC, and other interested parties including the public. The TPSN may add to or refine these as situations warrant.

   - The TPSN will coordinate all contact between panelists and interested parties.
   - There will be no direct communication between interested parties and panelists, except as invited by the Science Advisory Panel through the TPSN.
   - All communication regarding the topics under consideration, between the Corps, MRRIC members, and panelists, will be coordinated through the TPSN. Communications between the Corps and/or MRRIC members and the panelists outside of the MRRIC process are inappropriate.
   - Questions or information received after the initial questions have been delivered to the Science Advisory Panel (including from the USIECR's Independent Science Advisory Panel web site) will be routed to the USIECR and TPSN. The USIECR and TPSN will assess the information/ questions received. The TPSN will forward to the panel information and questions that are determined to be pertinent to the proceedings. To ensure the transparency

of the process the USIECR and TPSN will inform the Corps and ISP Work Group and MRRIC of any information/questions received and the disposition of these items.

- During their deliberations, science advisors may access and reference any peer reviewed literature in their review deliberations and report(s). They also may reference other information that the panel deems credible, and include a copy of the other information with their report(s).
- The panel may make on-site visits to gain understandings in topics being addressed and to see, first-hand, the challenges and successes. (Such visits currently are not budgeted.)
- During their deliberations science advisors may (through the TPSN) invite presentations and/or request information through the USIECR from MRRIC including member agencies, Corps, or any source that they believe may be of value to their deliberations. The presenters and content of the presentations or information received will be included with their report(s).
- Science advisors may recommend the need for Independent Scientific Review.
- It is anticipated that the Science Advisory Panel will meet with the ISP WG and the Corps periodically during the advisory process and in some cases the MRRIC. These meetings will be open to MRRIC members and the public. Additional questions may be agreed to by the ISP WG/MRRIC and the agencies as the process iterates.

The MRRIC, Corps, the public, the USIECR, TPSN, and advisory panelists will follow the above ground rules and communication protocols. The USIECR and TPSN should be alerted to possible violations of the protocols, or to other undue biases or influences immediately. When the violations are related to a panel member's conduct, the USIECR and TPSN will assess the situation and act accordingly and then report back to MRRIC on disposition of the issue. If the violations are related to the MRRIC, the Charter and Operating Procedures will be used to address the situation.

Attachment A
Independent Science Advisory Panel

Final Outline of Charge Scope

TOPIC:

Missouri River Spring Pulse and Adaptive Management

PURPOSE:

To review and provide recommendations to the U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (USFWS), and the Missouri River Recovery Implementation Committee (MRRIC) on the expected outcomes for the Missouri River Gavins Point Dam spring pulse management action. To review the metrics, monitoring, investigations, and management actions and provide recommendations on their potential refinement (or any other appropriate solutions). In addition, the results of the review are intended to be used in developing an adaptive management plan.

CONTEXT/BACKGROUND:

The construction of dams and associated flow management under the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual) has provided economic and social benefits to those within and outside the basin. Environmental consequences have been associated with the damming and channelization of the Missouri River. Following the listing of the Least Tern, Piping Plover, Pallid Sturgeon, and Bald Eagle as threatened or endangered species, the USFWS provided Biological Opinions (BiOp).

In the 2003 Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and the Operation of the Kansas River Reservoir System (2003 Amended BiOp), the USFWS issued a jeopardy opinion and recommended a Reasonable and Prudent Alternative (RPA). The RPA included a bi-modal spring pulse release from Gavins Point Dam to benefit the pallid sturgeon. The expected outcomes of this portion of the RPA have been identified as:

1) Provide a spawning cue to pallid sturgeon;
2) Increase nutrients, invertebrates, and forage fish for larval and juvenile pallid sturgeon and adult and young least terns, in association with floodplain connectivity and the construction of shallow-water habitat; and
3) Scour pallid sturgeon spawning areas to increase the likelihood of successful survival of pallid sturgeon eggs and
4) Condition new and existing emergent sand bar habitat in preparation for nesting and rearing young by least terns and piping plovers.

The USACE, with input from basin constituents, developed technical criteria for the implementation of spring pulse releases from Gavins Point Dam and published the criteria in its revised 2006 Master Manual. It has been following those criteria since 2006.

In response to the 2003 Amended BiOp, the USACE is implementing the Missouri River Recovery Program (MRRP), which includes significant efforts to restore ecosystem functions as they relate to recovering threatened and endangered species. The implementation of the MRRP relies on collaboration with a wide range of governmental, academic, and private organizations that are working to deliver products, including extensive scientific analyses and syntheses. MRRIC, a group of 70 members representing various stakeholder interests, tribes, and state and federal agencies, assists these efforts by developing recommendations for the agencies implementing the ecosystem management efforts.

This document was jointly developed by USACE, USFWS, and the MRRIC Integrated Science Program Working Group (ISP WG). MRRIC members rated the spring pulse as the topic of highest interest for science review in the fall of 2009. This interest is due in large part to both the support for the concept and concerns and controversy related to this topic ranging from: questions regarding potential flooding; questions regarding the validity of the science associated with pulses; questions regarding the needs for pulses by sturgeons, terns, and plovers; desires to first pursue alternate management actions; belief that given current constraints (e.g. Master Manual) the pulse has no benefits and should be discontinued; to concerns that the current pulse may not be large enough and larger magnitude/duration pulses should be explored; and concerns that not enough data collection and analysis is ongoing to truly assess performance either way.

A review of the spring pulse topic and its associated monitoring following three applications (May 2006, March 2008, and May 2009) over the past 5 years is also consistent with the overall adaptive management approach called for in the implementation of the 2000 and 2003 Amended BiOp. The 2003 Amended BiOp recognized the uncertainty related to the management actions and biological responses and identified adaptive management (AM) as a process to address this uncertainty. The 2003 Amended BiOp RPA tasked the USACE with establishing an independent group of scientists to develop an adaptive management plan (RPA VI.A.4) for flows.

This initial charge to the ISAP is being undertaken to begin addressing the spring pulse topic leading, if supported by the science, to the eventual preparation of an adaptive management plan for spring pulse flows. Results of the response to charges below will provide input to the management agencies and MRRIC to utilize in eventually developing an adaptive management plan for the spring pulse.

INFORMATION TO BE PROVIDED TO THE PANEL:

A list of materials to be provided as background and for review by the panel is attached, Appendix A.

CHARGE QUESTIONS:

a. Goals/Objectives: Review the scientific literature (add references) related to the Gavins Point spring pulse management action and the specific expected outcomes identified in the 2003 Amended BiOp, and spring pulses generally, and respond to the following:

1) Is there reasonable assurance, given the status of science surrounding the spring pulse management action and accompanying ecological and biological response(s) and current Missouri River channel and floodplain morphology below Gavins Point Dam, that the spring pulse management action and technical criteria will achieve the expected outcomes:
   i. Provide a spawning cue to pallid sturgeon;
   ii. Increase nutrients, invertebrates, and forage fish for larval and juvenile pallid sturgeon and adult and young least terns, in association with floodplain connectivity and the construction of shallow-water habitat; and
   iii. Scour pallid sturgeon spawning areas to increase the likelihood of successful survival of pallid sturgeon eggs and
   iv. Condition new and existing emergent sand bar habitat in preparation for nesting and rearing young by least terns and piping plovers.
2) Is there reasonable assurance, given the status of science surrounding spring pulse flows, species recovery, and restoration of large river systems, that further investigation into and/or water management changes are needed to: (add references)
   i. Recover the federally listed species (i.e., pallid sturgeon, least terns, and piping plovers) under the Endangered Species Act?
   ii. Achieve expected outcomes?
   iii. Restore the ecosystem to prevent further declines of other native species?

b. Metrics: Review the following list of current performance metrics (abiotic and/or biotic). Make recommendations including options for better, more specific, more measurable, both short and long term metrics to use in assessing the Spring Pulse expected outcomes and for use in adaptive management.
Current ecological metrics:

- Sturgeon migration, reproductive readiness, and successful spawning activity associated with pulses.
- Successful pallid recruitment to support sustainable population.
- Conditioning of spawning beds/locations by spring pulse flows.
- Pre-conditioning of tern and plover habitats.
- Increased primary and secondary productivity associated with the spring pulse.
- Magnitude, timing, duration of pulse, attenuation through downstream reaches.

c. Ecological Uncertainties and Risks: Review the following list of risks and uncertainties. Identify any other major risks and uncertainties pertaining to the role of the Gavins Point spring pulse in all three species recovery. Provide recommendations on how to address these uncertainties through the monitoring and investigations (following sections). Provide advice regarding the effects of these risks and uncertainties on achieving the expected outcomes.

Uncertainties:

- Whether the occurrence, timing, water quality (e.g., temperature, turbidity, etc.), and magnitude of the spring pulse releases from Gavins Point Dam, as formulated, are beneficial or detrimental to the species spawning and recruitment?
- Linking the pulse flow events, whether managed or natural, to biological response.
- Pulse could be working, but monitoring not able to detect.
- Pulse may not be working, but unable to verify.
- To what level do pallid sturgeon need pulses from Gavins Point Dam or downstream tributaries to spawn successfully?
- Role of pulses in successful pallid sturgeon recruitment.
- Magnitude of pulse to have effect.
- Could rises on tributaries provide adequate magnitude to test efficacy?
- Effects of pulses on socioeconomic resources including interior drainage and downstream groundwater levels.
- Is the Gavins Point Spring Pulse Management action needed given the naturally occurring downstream pulses?

Uncertainty addressed through previous investigations:

- Effects on cultural resources due to reservoir fluctuations.

Risks:

- Performing pulses may ultimately be determined unnecessary; thus delaying or hampering more meaningful pallid sturgeon recovery opportunities.
- Not performing pulses (or performing inadequate pulses) may miss opportunities to assist reproduction and recruitment of listed species.
- Potential contribution of spring pulse releases' to downstream flooding and issues associated with interior drainage and downstream ground water levels.

d. Monitoring: Review the provided list of monitoring activities and results. What changes, modifications, or additions should be considered to:
1) Improve the ability to assess the metrics;
2) Adaptively manage the pulses; and
3) Determine if expected outcomes have or can be achieved.
References: Ongoing monitoring efforts are listed in Appendix A, e.1-3.

e. Investigations/Research: Review the provided list of investigations and research. What focused investigations/research are necessary to reduce uncertainties and address risks associated with the spring pulse releases from Gavins Point Dam? What additions or alternatives to a spring pulse are possible to address the research needs for each of the expected outcomes (i.e., laboratory studies, inclusion of additional surrogate species)? For each investigation, describe its relationship to the outcomes/metrics, risks, and uncertainties. For example are investigations needed to address the following:

1) Relationship between flows, sediment transport/sediment availability, development of future habitat and species recovery actions on the Missouri River.
2) Are the natural rises from tributaries (i.e. frequency, duration, and magnitude) providing "sufficient" pulses to accomplish the outcomes on specific segments of the Missouri River mainstem? (TO DO: provide list and map of segments below Gavins Points)
3) Can implementation of habitat creation (e.g., chutes, widening of channel, levee setback, etc.) be enhanced to contribute to Outcome #2 and aid in pallid sturgeon spawning and recruitment?

References: Ongoing investigation efforts are listed in Appendix A, e.1-3.

f. Analyses and Assessments: Discuss the methods by which the data collected through monitoring and investigations should be analyzed and compared to performance metrics. This may include a recommendation for any conceptual or numeric models that could be used in the analysis. Discuss how the data analyses could be used to influence management actions.

g. Management Actions:
1) When considering the current Missouri River form and hydrology, what is the importance of hydrology (functional/flow pulses/flow management) versus morphology (physical form/habitat creation) when considering management actions for species recovery?
2) What spring hydrologic profile(s) (magnitude, frequency, duration, timing, temperature, rate of change, and temporal and geographic variation) should be evaluated as part of an Adaptive Management program?
3) What alternatives to a spring pulse releases from Gavins Point Dam are available to achieve the desired outcomes?

h. Subsequent Questions: Once the ISAP issues their draft report, the USACE, USFWS, and MRRIC ISP Work Group may jointly submit appropriate follow-up questions to help inform or clarify comments or conclusions contained in the report.

INFORMATION TO BE PROVIDED TO THE PANEL

The information is directly explicit to the spring pulse charge and should be understood by the panel.

a. **Missouri River** Missouri River Basin geography, climate, historic hydrology, and the physical and hydrological changes to the river.
   1) The Missouri River Ecosystem, Exploring the Prospects for Recovery; National Research Council Report, National Academies Press, 2002. 175pp.
   2) Big River Ecology, Arthur C. Benke and Colbert E. Cushing, Chapter 10: Missouri River Basin, pp 427-482. Academic Press, 2005.
   3) Missouri River Planning: Recognizing and Incorporating Sediment Management; National Research Council Report, National Academies Press, 2010. 111pp.

b. **Missouri River System** Development of the Missouri River System and its current operation.
   1) Big Dam Era, A Legislative and Institutional History of the Pick-Sloan Missouri River Basin Program, John R. Ferrell. U.S. Government Printing Office, 1993. 228pp.
   2) Missouri River Mainstem Reservoir System Master Water Control Manual. 432pp.
   3) Environmental Assessment for the Inclusion of Technical Criteria for Spring Pulse Releases from Gavins Point Dam. 45pp.
   4) Spring Rise Formulation, FEIS and RDEIS Alternatives: Storage, Lake Level, and Flow Files - Downloadable
   5) Design of a naturalized flow regime-an example from the Lower Missouri River, USA; Robert B. Jacobson and David L. Galat, Ecohydrology 2008, vol. 1, pp 81-104.
   6) Judicial Challenges to Missouri River Mainstem Regulation; John Seeronen. Missouri Environmental Law and Policy Review, Vol.16, No.1, 2010, pp60-98.
   7) U.S. Army Corps of Engineers. 2006. Missouri River Mainstem System 2005−2006 Annual Operating Plan. January 2006.

c. **2003 Amended Biological Opinion on the Operation of the Missouri and Kansas River System and the Bank Stabilization and Navigation Project**
   1) 2003 Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. 308pp. Selected pages, 137-263
   2) Expected Outcomes of the Restoration of a Normalized Hydrograph, Missouri River, Downstream from Gavins Point; USFWS, December 16, 2009. 6pp.
   3) Actual pulse timing, magnitude, hydrographs at locations showing attenuation/magnitude.
   4) Shallow Water Habitat clarified definition, Letter to USACE from USFWS, June 29, 2009. 2pp.
   5) U.S. Fish and Wildlife Service, 2007, Pallid Sturgeon (*Scaphirhynchus albus*); 5-year review summary and evaluation: U.S. Fish and Wildlife Service, 120 pp. Federal Register 70:39326-39327. http://www.fws.gov/mountain-prairie/missouririver/Pallid_Sturgeon_5-year_review_June%202007.pdf

d. **Missouri River Recovery Program**
   1) Water Resources Development Act 2007, Section 5018

2) GAP Analysis for MRRP

e. **Integrated Science Program**

1) Spring Pulse Implementation

a. U.S. Army Corps of Engineers. 2005. Spring Pulse Flood Control and Drainage Impediment Analyses – Omaha, Nebraska to Hermann, Missouri: Missouri River Master Water Control Manual Review and Update, Missouri River Basin Water Management Division, Northwestern Division, 39 pp.

b. U.S. Army Corps of Engineers. 2008. Draft Report on 2006 Spring Pulse Monitoring: Missouri River Recovery, Integrated Science Program Report, 11pp. Roy McAllister, Project Manager.

2) Biologic Monitoring and Investigations

a. Delonay et al, 2009. Ecological requirements for Pallid Sturgeon Reproduction and Recruitment in the Lower Missouri River: A Research Synthesis 2005-2008: U.S. Geological SurveyScientific Investigations Report 2009-5201, 59 pp.

b. Korschgen, C.E., ed., 2007, Factors affecting the reproduction, recruitment, habitat and population dynamics of pallid sturgeon and shovelnose sturgeon in the Missouri River: U.S. Geological Survey Open-File Report 2007-1262, 280pp. http://pubs.usgs.gov/of/2007/1262

c. Reuter, J.M., Jacobson, R.B., Elliott, C.M., and DeLonay, A.J., 2009, Assessment of Lower Missouri River physical aquatic habitat and its use by adult sturgeon (genus Scaphirhynchus), 2005–07: U.S. Geological Survey Scientific Investigations Report 2009–5121, 81pp. http://pubs.usgs.gov/sir/2009/5121

d. DeLonay et al, 2010, Ecological requirements for pallid sturgeon reproduction and recruitment in the Lower Missouri River: annual Report 2009:U.S. Geological Survey Open File Report 2010-1215, 64 pp.

e. Brosnan, D, etal, 2008, Review of the Comprehensive Sturgeon Research Program. Sustainable Ecosystems Institute, 45pp. http://sei.org/sturgeon/review.htm.

f. Quinn, J, etal, 2005, Independent Science Review of the Pallid Sturgeon Assessment Program: Final Report, Sustainable Ecosystems Institute, 76pp. http://sei.org/sturgeon/population.htm.

g. Auer et al 2005. Independent Science Review of the Habitat Assessment and Monitoring Program Study Plan for the Missouri River. Sustainable Ecosystems Institute, 39pp. http://sei.org/sturgeon/HAMPStudyPlanISR.pdf

h. Jacobson, R.B., Johnson, H.E. III, and Dietsch, B.J., 2009, Hydrodynamic simulations of physical aquatic habitat availability for pallid sturgeon in the Lower Missouri River, at Yankton, South Dakota, Kenslers Bend, Nebraska, Little Sioux, Iowa, and Miami, Missouri 2006–07: U.S. Geological Survey Scientific Investigations Report 2009–5058, 68 p.

i. Laustrup, M.S., Jacobson, R.B., and Simpkins, D.G., 2007, Distribution of potential spawning habitat for sturgeon in the Lower Missouri River, 2003−06: U.S. Geological Survey Open-File Report 2007-1192, 26 p. *http://pubs.usgs.gov/of/2007/1192/*

j. Reuter, J.M., Jacobson, R.B., Elliott, C.M., Johnson, H.E., III, and DeLonay, A.J., 2008, Hydraulic and substrate maps of reaches used by sturgeon (Genus *Scaphirhynchus*) in the Lower Missouri River, 2005–07: U.S. Geological Survey Data Series Report 386, 442 p. *http://pubs.usgs.gov/ds/386/*

k. Bergman,H.L., Boelter,A.M., Parady,C., Fleming,T., Latka,D.C., Korschgen,C., Galat,D.L., Hill,T., Jordan,G., Krentz,S., Nelson-Stastny,W., Olson,M., Mestl,G.E., Rouse,K., and Berkley,J., 2008, Research needs and management strategies for pallid sturgeon recovery: Proceedings of a workshop held July 31-August 2, 2007, St. Louis, Missouri, Final Report to the U.S.Army Corps of Engineers.William D.Ruckelshaus Institute of Environment and Natural Resources, University of Wyoming, Laramie., (91554)

3) Interior Drainage and Groundwater Monitoring
   a. U.S. Army Corps of Engineers. 2008. 2006 Spring Pulse – Interior Drainage and Groundwater Monitoring After Action Report: Hydrologic Engineering Branch, Engineering Division, Omaha District, 51 pp. Matt Krajewski, Project Manager.
   b. U.S. Army Corps of Engineers. 2008. 2008 Spring Pulse and Rises Drainage Monitoring and Evaluation: Missouri River Recovery, Integrated Science Program Report, 153pp. Roy McAllister, Project Manager.
   c. U.S. Army Corps of Engineers. 2008. 2008 Groundwater Monitoring and Evaluation Report: Missouri River Recovery, Integrated Science Program Report, 10pp. Roy McAllister, Project Manager.
   d. U.S. Army Corps of Engineers. 2010. *In Review*: 2010 Groundwater Monitoring and Evaluation Report, Missouri River Recovery, Integrated Science Program Report, 28pp. Roy McAllister, Project Manager.
   e. U.S. Army Corps of Engineers. 2009. 2009 Groundwater Monitoring and Evaluation Report - *In Review*: Missouri River Recovery, Integrated Science Program Report, 19pp. Roy McAllister, Project Manager.

f. **<u>Missouri River Recovery Program Adaptive Management Process Framework</u>**
   1) AM Framework document - including Appendix C

g. **<u>Other Related Readings Suggested by MRRIC Members</u>**

1) Wildhaber, M.L., et al. 2007. A Conceptual Life-History Model for Pallid and Shovelnose Sturgeon: U.S. Geological Survey Circular 1315, 18 pp.
2) Elliott, C.M., Reuter, J.M., and Jacobson, R.B., 2009, Channel morphodynamics in four reaches of the Lower Missouri River, 2006–07: U.S. Geological Survey Scientific Investigations Report 2009–5074, 258 p. *http://pubs.usgs.gov/sir/2009/5074/*
3) Galat, D.L., Lipkin, R., 2000, Restoring ecological integrity of great rivers: historical hydrographs aid in defining reference conditions for the Missouri River. *Hydrobiologia* **422/423**: 29–48.
4) Jorgensen, D.G., 2009, Natural hydrograph of the Missouri River near Sioux City and the least tern and piping plover: ASCE Journal of Hydrologic Engineering, Dec. 2009, v. 14,n. 12, pp. 1365-1373
5) Caitlin et al, 2010,Discussion of "Natural Hydrograph of the Missouri River near Sioux City and the Least tern and Piping Plover" by Donald G. Jorgensen, (ASCE Journal Hydrologic Engineering , v. 14 n. 12, pp.1365 -1373), Journal Hydrologic Engineering, 2010, v. 15, n. 12, pp. 1376 – 1378..
6) Jorgensen, D. G., 2010, Closure of "Natural Hydrograph of the Missouri River near Sioux City and the Least tern and Piping Plover" by Donald G. Jorgensen, (ASCE Journal Hydrologic Engineering , v. 14, n. 12, pp. 1365 -1373), Journal Hydrologic Engineering v. 15, n. 12, pp. 1078- 1089.
7) Hedman, E.R., and Jorgensen, D.G., 1990, Surface and ground-water interaction and hydrologic budget of the Missouri River Valley Aquifer between Yankton, South Dakota and St. Louis, Missouri, U.S. Hydrologic Investigation Atlas, 721.
8) Jorgensen, D.G., Meisner, D.M., Beacom, W., and Tondreau, R.E., 2002, Review of Missouri River management alternatives and development of a preferred alternative:

Missouri River Technical Committee of Siouxland Chamber of Commerce, Sioux City Iowa, 63 p., *http://www.missouririvertechnicalteam.com*

9) Jorgensen, D.G., 2003a, Evaluation of a spring rise for the Missouri River: Missouri River Technical Committee of Siouxland Chamber of Commerce, Sioux City, Iowa, 68 p., *http://www.missouririvertechnicalteam.com*
10) Jorgensen, D.G., 2003b, Analysis of the Missouri River natural hydrograph at Sioux City, Iowa: Missouri River Technical Committee of Siouxland Chamber of Commerce, Sioux City Iowa, 38 p., *http://www.missouririvertechnicalteam.com*
11) Jorgensen, D.G., 2005, Some concepts relative to pallid sturgeon (Scaphirhynchus albus) spawning and plans to facilitate successful spawning: Missouri River Technical Committee of Siouxland Chamber of Commerce, Sioux City Iowa, 37 p., *http://www.missouririvertechnicalteam.com*
12) Jorgensen, D.G., 2006, anthropogenic changes in the Lower Missouri River Basin, their effects on pallid sturgeon and management implications: Missouri River Technical Committee of Siouxland Chamber of Commerce, Sioux City Iowa, 63 p., *http://www.missouririvertechnicalteam.com*
13) Kelly, B.P., 2000, Effects of alternative Missouri River management plans on ground-water levels in the lower Missouri River flood plain: U.S. Geological Survey Water-Resources Investigations Report 00−4052, 128 p.
14) Missouri River Mainstem Reservoir System Master Water Control Manual, Missouri River Basin Water Travel Time, Plate IV-1.

Attachment B
Third Party Science Neutral Support to Establish an Independent Science Advisory Panel for the Missouri River Recovery Program
Approved by MRRIC on July 21, 2010

(Revision in Attachment A below
ISP WG Involvement in ISAP Information/Presentation Requests
Approved by MRRIC on February 17, 2011)

IV. BACKGROUND AND INTRODUCTION

The U.S. Army Corps of Engineers (Corps) - Missouri River Recovery Program (MRRP) are engaged in large scale ecosystem management on the Missouri River, with significant efforts to restore ecosystem functions and recover threatened and endangered species. This effort relies on collaborations with a wide range of governmental, academic, and private organizations that are working to deliver products, including extensive scientific analyses and syntheses. The Missouri River Recovery Implementation Committee (MRRIC), a group of 69 members representing various interests, tribes, and agencies, assists these efforts by developing recommendations for the agencies implementing the ecosystem management efforts.

The desire and need for well thought out science and independent scientific advice and recommendations to support decisions and directions taken by the Corps has increased, and is also desired by the MRRIC. As a result, the MRRP Integrated Science Program (ISP) is working to ensure the quality, completeness, and application of scientific information in use, and is following the Office of Management and Budget's "Final Information Quality Bulletin for Peer Review" (2005). This approach is also consistent with Corps civil works review policy guidance EC 1165-2-209.

This document describes the Corps' intent to establish a standing independent Science Advisory Panel for the MRRP and the MRRIC, utilizing the Third Party Science Neutral (TPSN) contracted by the U.S. Institute for Environmental Conflict Resolution (USIECR), as a lead advisor for the management of scientific advisor selection, panel processes, and panel products.

General support tasks of the independent Science Advisory Panel could include but are not limited to the following:

- Synthesis of all available information on a specific topic which may include meetings with scientists, agency personnel and stakeholders and culminates in a written report providing independent advice and recommendations to the Corps or MRRIC.
- Scientific or technical services to gather, evaluate, and synthesize the best available information/data on a scientific topic resulting in a report to the Corps. Providing independent opinion and recommendations on the topics presented.
- Evaluation of scientific proposals and making recommendations on how to proceed.
- A standing program of independent opinions and recommendations for the overall MRRP-ISP.
- Assessment of documents (models, data, monitoring plans, management plans, and recovery actions) for contextual clarity and their application to a specific project planning effort, resulting in a letter report to the Corps.
- Responding to scientific questions from the Corps, USFWS, or MRRIC.

V. MRRP SCIENCE ADVISORY PANEL

1. A standing panel of up to 6 science advisors who will meet at least annually (and more often in the initial stages of setting up the panel and as required by specific scope of tasks). This panel will be charged with overall independent science support and technical oversight of the ISP program. In addition, the panel will be charged to provide advice on specific topics as needed. The general disciplines of expertise desired on the standing panel will be from the following areas of science including:
    a. Aquatic/Riverine Ecologist: Expertise in energy flow dynamics; flora and fauna community assemblages; river/floodplain dynamics; and knowledge of biological/physical drivers and processes.
    b. River Hydrologist/Geomorphologist: Expertise in dynamics of river and associated landforms; sediment dynamics/transport; large dryland river physical processes; and flow modeling.
    c. Least Tern/Piping Plover Specialist: Ornithological expertise in least tern and piping plover population dynamics; ecological threats; habitat, energy, and security requirements; and status of population and productivity within the interior population of least tern and Great Plaines population of piping plovers.
    d. Sturgeon Specialist: ichthyological expertise in scaphirhynchus sturgeon population dynamics; ecological threats; habitat, energy, and security requirements; knowledge of the current understanding of life history needs; and status of population and productivity within the pallid sturgeon range.
    e. Quantitative Ecologist/Statistician: Expertise in biostatistical methods, analytical tools, and the interpretation of ecological data sets; mathematical modeling; and presentation of complex analysis.
    f. Conservation Biologist: Expertise in ecological community interactions with emphasis on large river form and function; restoration and recovery at the population/ landscape scale.

2. Ad hoc specialists may be added to the standing panel, as needed, to provide expertise not represented by standing panel members for a particular topic. These individuals would serve only for the duration of the topical study for which they are selected. The type of expertise needed may be identified by the Corps or MRRIC as they develop questions to be considered by the standing panel, or by the standing panel itself if it convenes around a topic and determines additional expertise is needed. In either case, the TPSN would select a candidate and potential alternates qualified in that expertise for the panel following the criteria and selection process for the standing panel.

3. Standing panel members are expected to commit to a three year term, renewable upon review by the TPSN.

VI. SELECTION OF SCIENCE ADVISORS

1. When selecting science advisors, the TPSN shall comply with the National Academy of Science's "Policy and Procedures on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports" (2003) and the Office of Management and Budget's "Final Information Quality Bulletin for Peer Review" (2005). The TPSN shall strive to establish a panel of science advisors that demonstrates:
   a. Expertise. Varied knowledge, experience and skill.
   b. Balance. A diversity of scientific perspectives.
   c. No Conflict of Interest. No financial or other interest that impairs the panel's objectivity or gives an unfair competitive advantage to a person or organization.

2. The TPSN shall undertake a structured search process whereby they shall select science advisors that represent a broad spectrum of scientific expertise within their discipline and that have established high-caliber scientific credentials including:
   a. Widely recognized by peers for expertise in their field
   b. Strong publication record or record of scientific leadership
   c. Willingness to participate with objectivity and professionalism
   d. Track record of fair and unbiased, yet constructive, criticism
   e. Ability to function within a team and an interdisciplinary setting
   f. High standard of scientific integrity, independence, and objectivity
   g. Demonstrated ability to forge creative solutions to address identified topics or problems
   h. Knowledge and understanding of adaptive management process and application (represented in at least some members)

3. The TPSN will provide a proposed list of panelists for each position to the full MRRIC. The ISP Work Group (and any other MRRIC members who choose to participate), Corps, and USIECR will have the opportunity to review and collaboratively provide input (through a joint facilitated conference call or meeting) on the proposed panelists. All MRRIC members will also have the opportunity to provide comments to the ISP Work Group Points of Contact to bring into the conversations. The TPSN will select the standing panel members representing the general disciplines using the criteria identified above.

4. The TPSN shall recognize and provide clear direction to prospective panel members that the independent science advice/reviews required are scientific in nature and that decision making and policy interpretation are left to the Corps after consideration of any consensus recommendations from MRRIC.

VII. HOW THE INDEPENDENT SCIENCE ADVISORY PANEL WORKS

8. Task Orders/Charge Questions: Topics for the Science Advisory Panel may originate from either the Corps or MRRIC (or collectively). For each topic, initial charge questions will be drafted by the proposing entity for review and discussion. If the Corps develops the initial questions, MRRIC members will have an opportunity to provide questions they would like addressed through the ISP WG for consideration as part of the initial questions to be presented to the Science Advisory Panel for their evaluation. Ideally, the ISP WG and the Corps will agree on the questions to be delivered to the TPSN. Where there is not agreement, both the ISP WG and Corps have the option to provide questions to the TPSN.

9. Charge Description: The description of the charge to the Science Advisory Panel shall be developed as follows:

- The TPSN shall expeditiously develop a proposal containing specific instructions to the science advisors including:
    i. Description of topic.
    ii. Expected products and ground rules for operation.
    iii. How panel deliberations will be conducted, either sessions open to the general public and/or restricted to only the panel; and how findings will be presented.
        1. The TPSN shall make the science advisors aware that key agency staff and members of MRRIC are available to provide input as necessary when requested by the panel.
        2. A panel chair (and/or the full panel if desired) shall present findings to MRRIC via video teleconference or at a regularly scheduled meeting.
    iv. Schedule/timeline.
- The ISP WG, USACE, and USIECR will review and collaboratively provide input on the TPSN proposed description of the charge.
- The TPSN will provide the final charge description to the MRRIC, USACE, and USIECR.

10. Implementation: In coordination with the Corps and the ISP WG, the TPSN shall schedule the review and coordinate all logistical issues associated with carrying out the panels' charge including, but not limited to, travel, facilities, equipment, facilitators, panelists, arranging for transcription of panel discussions (if necessary), and public access (as necessary). Also see Attachment A for additional information on ISP WG involvement in information and presentation requests from the ISAP.

11. Panel Chair: A panel chair will be chosen to ensure consideration of all technical matters amongst panelists and coalesce a final report. The method for choosing the chair will be determined by the panel members with the assistance of the TPSN. Possible options include, but are not limited to, a different chair for each topic, a chair for the full period of time, and a rotating chair.

12. Facilitation: The TPSN will facilitate selection of panel chair, all panel deliberations, external panel interaction, and report preparation and dissemination. The TPSN will also provide other project management duties including ensuring product completion per schedule and budget.

13. Standing Ground Rules: To facilitate consideration of multiple perspectives on the issues, a structured process has been developed to avoid bias and guide communications between Science Advisory Panel members and the Corps, MRRIC, and other interested parties including the public. The TPSN may add to or refine these in certain situations as necessary (see How the Independent Science Advisory Panel Works, 2.a.ii. above).
    - The TPSN will coordinate all contact between candidate or selected panelists and interested parties.
    - There will be no direct communication between interested parties and candidate or selected panelists, except as invited by the Science Advisory Panel through the TPSN.
    - All communication regarding the topics under consideration, between the Corps, MRRIC members, and candidate or selected panelists, will be coordinated through the TPSN. Communications between the Corps and/or MRRIC members and the candidate or selected panelists outside of the MRRIC process are inappropriate.
    - Questions or information received after the initial questions have been delivered to the Science Advisory Panel (including from the Institute's Independent Science

Advisory Panel web site) will be routed to the Institute and TPSN. The Institute and TPSN will assess the information/ questions received. The TPSN will forward to the panel information and questions determined pertinent to the proceedings. To ensure the transparency of the process the Institute and TPSN will inform the Corps and ISP Work Group and MRRIC of any information/questions received and the disposition of these items.

- During their deliberations, science advisors may access and reference any peer reviewed literature in their review deliberations and report(s). They also may reference other information that the panel deems credible, and include a copy of the other information with their report(s).
- The panel may make on-site visits to gain understandings in topics being addressed and to see, first-hand, the challenges and successes.
- During their deliberations science advisors may (through the TPSN) invite presentations and/or request information through the Institute from MRRIC including member agencies, Corps, or any source that they believe may be of value to their deliberations. The presenters and content of the presentations or information received will be included with their report(s).
- Science advisors may recommend the need for ISR.
- It is anticipated that the Science Advisory Panel will meet with the ISP WG and the Corps periodically during the advisory process and in some cases the MRRIC. These meetings will be open to MRRIC members and the public. Additional questions may be agreed to by the ISP WG/MRRIC and the agencies as the process iterates.

14. Interaction with MRRIC: The Science Advisory Panel will interact directly with the MRRIC at the beginning (soon after the charge is given to the Advisory Panel) of their work on a particular topic and when they are ready to present their draft report and recommendations. The presentations and panel interaction with MRRIC will occur at a regular MRRIC meeting.

15. MRRIC Input/Recommendations: Once the Advisory Panel recommendations are final MRRIC will have the opportunity to develop recommendations on: 1) implementation of the Advisory Panel recommendations; and 2) the socio/economic and Tribal impacts from implementing the recommendations/alternatives presented by the Advisory Panel.

The MRRIC, Corps, the public, the Institute, TPSN, and candidate and selected advisory panelists will follow the above ground rules and communication protocols. The Institute and TPSN should be alerted to possible violations of the protocols, or to other undue biases or influences immediately. When the violations are related to a panel member's conduct, the Institute and TPSN will assess the situation and act accordingly and then the report back to MRRIC on disposition of the issue. If the violations are related to the MRRIC, the Charter and Operating Procedures will be used to address the situation.

VIII. FINAL REPORT

The Panel Chair shall be responsible for writing and editing any initial, draft, and/or final reports that are required under the task order. The TPSN should ensure that the report addresses all task order requirements, is thorough, and is understandable.

The TPSN shall deliver a final report. In general, the final report for each task order shall:

1. Summarize the goals and objectives of the charge to the panel, the process undertaken to select any additional advisory panel participants, the participants selected, a brief summary of their

qualifications, the information considered by the panel, the exercises completed as part of the process, summary of panel discussion and the results.

2. Include an analysis of the findings including observations of the strengths and weaknesses of the findings and any dissenting opinions.

3. Provide independent opinions and recommendations regarding each task request or question as assigned.

4. Accurately present the views of the entire panel.

5. Be delivered in electronic format as a text selectable “pdf” file (portable document format created with Adobe Acrobat) within the dates established in the task order schedule.

IX. LITERATURE CITED

National Academy of Sciences. 2003. Policy and Procedures on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports. May 2003. Available online at: http://www.nationalacademies.org/coi/index.html

Office of Management and Budget. 2005. Final Information Quality Bulletin for Peer Review. December 16, 2004. Available online at: http://www.whitehouse.gov/omb/memoranda/fy2005/m05-03.pdf

Attachment A

ISP WG Involvement in ISAP Information/Presentation Requests
Approved by MRRIC on February 17, 2011

1. ISAP develops an information/presentation request.

2. TPSN shares the information/presentation request with USIECR who shares with (Corps and) ISP WG.

3. ISP WG provides feedback to TPSN through a conference call to review the information/presentation request and discuss thoughts on how to address the request.

4. TPSN, in concert with ISAP, will make a final determination on how to proceed and share that with the ISP WG.

5. Presentations are provided to the ISAP during a webinar, a MRRIC meeting (not during MRRIC plenary time), or another scheduled ISAP meeting. Copies of the presentations may be shared in advance if they are available. The presentations will be recorded. The ISP WG and MRRIC members will be made aware of the presentation far enough in advance so that they can observe (but not participate in) the presentation.

6. Following the presentations, ISP WG members and MRRIC members will have an opportunity to provide pertinent additional information to the TPSN and USIECR (to also be shared with the ISP WG). Participants should share the information, or express their intent to share information in the near future, within 10 days in order to ensure the TPSN has sufficient time to assess and determine whether/how to proceed.
    a. ISP WG could request a call to discuss results
    b. The TPSN may request an ISP WG call for feedback based on additional information provided

7. The TPSN will then proceed in accordance with Section IV., #6., bullet 4 from the *USACE MRRIC ISAP Approach Structure Ground Rules - FINAL.doc* document approved by MRRIC on July 21, 2010.