TO: Management Plan and Effects Analysis Teams, MRRIC SPA Task Group

FROM: Independent Science Advisory Panel (ISAP)

RE: ISAP evaluation of EA2a – Compile and assess existing data and modeling resources that can be applied to the Effects Analysis – Final

DATE: 30 May 2014

Introduction

An early step in the analysis of effects of actions that are found to "jeopardize the continued existence" of a listed species is the identification and assessment of pertinent information on the species and the environmental factors that contribute to or compromise its survival and potential recovery. The Missouri River Recovery Program (MRRP) has sought experts from multiple disciplines to perform an effects analysis "to conceptualize and quantify the effects of system operations and actions on the listed species" (Effects Analysis Guidance Document 09 13 13 v5). Three teams of experts have been convened to describe the data, analyses, and findings from studies of the least tern, piping plover, and pallid sturgeon, along with ecological and hydrogeomorphic models which may be used in the effects analyses and, later, to predict the effects of potential management actions on these species. As outlined in the programmatic Effects Analysis Guidance Document, the charge to the Effects Analysis (EA) teams is to gather and assess the utility of existing information for use in the analysis, identify models that can be usefully applied to the analysis, and identify critical modeling or data gaps that might not be resolved within the established timeframe of the analysis. The three reports provided to the ISAP present and assess available data and models that apply to the two listed birds and the pallid sturgeon, and describe hydrogeomorphic models that will be used to link the population dynamics of the three species to the physical processes on the Missouri River that create, sustain, and degrade the landscape features that contribute to extent and quality of habitats for each species.

The intent of these documents is to describe the empirical basis for the effects analysis, identify the "best available science" that can be used to guide future management decisions, and identify uncertainties that must be addressed by management within an adaptive framework. As a comprehensive catalogue of available data and models, the reports are intended to provide insights into environmental factors that put the three species at risk of extinction. The reports should also identify present or proposed actions that address the potential for species recovery. Importantly, the three documents should provide an information base that allows scientific and technical experts, resource managers, and

concerned stakeholders to identify points of agreement and disagreement regarding knowledge about the Missouri River system. These documents will serve as a basis for exploring common concerns and differences that bear on selection of management actions under the Missouri River Recover Management Plan (MRRMP) and its implementation through adaptive management.

Here the Independent Science Advisory Panel (ISAP) reviews and evaluates three reports from the EA teams that summarize their efforts to "compile and assess existing data and modeling resources that can be applied to the [effects] analyses." The basis for our assessment includes goals stated in the Effects Analysis Guidance Document and a series of questions formulated by the Adaptive Management Integration Team and the Missouri Recovery Implementation Committee's (MRRIC's) Science and Adaptive Management (SAM) working group.

Preparing the Management Plan is being undertaken within a constrained time frame with the result that the Effect Analysis has been and will continue to be a fast-moving process. This review is restricted to EA team draft documents provided in March and early April 2014, and therefore it should be interpreted as a snapshot in time recognizing that compiling and assessing relevant information and data is an ongoing process.

Our format is to address separately for each of the three topics (birds, pallid sturgeon, and hydrogeomorphology) the questions posed on (1) data compilation and assessment (parts a-e), (2) model compilation and assessment (parts a-e), (3) data and modeling standards of practice, and (4) modeling boundary conditions. We conclude with summary thoughts and recommendations.

Birds – ***Missouri River Effects Analysis Deliverable 2a: Compilation of existing data, literature, and models for plovers and terns (Buenau et al. 2014)***

1. *Does the data compilation and assessment of their usefulness adequately anticipate information needs (as outlined in the EA guidance document) for the EA process and the development of an AM Plan?*

    a. *Was the information gathered and assessed robust enough and of adequate quality to complete the EA?*

Yes. The demographic information presented in the *Missouri River Effects Analysis Deliverable 2a* document (Buenau et al. 2014) is thorough and well organized. The combination of narrative presentation, technical appendices, and extensive cited literature

greatly facilitated review and evaluation. Presentation of salient parameters and values from previous demographic studies in expansive tables allow for convenient side-by-side comparisons of the study/sampling designs, analytical approaches, and key findings. They will allow for ready appropriation and application of available information into the ecological modeling efforts. The effects analysis will further benefit from the availability of the many published studies on least terns and piping plovers, including demographic studies with direct application in the effects analysis from both inside and outside the Missouri River basin. Because members of the bird EA team have been collecting and evaluating demographic and environmental-stressor information on least terns and piping plovers for at least five years, the team is well positioned to take on the essential tasks of model development and effects analyses.

b. Have the teams made choices between competing data sets in compiling pertinent data to be used in the EA?

There are no substantive differences of opinion among researchers regarding the basic ecology, demographic parameters, or environmental stressors that affect the two birds targeted by the effects analysis. There appears to be a common understanding of the fundamental relationships between the birds and the availability of nesting habitat, and the apparent role of habitat as a limiting factor the abundance of least terns and piping plovers in the Missouri River system. So there are no standing competing theories regarding the limiting factors that are likely to be controlling the distribution and abundance of the birds on the river system, nor "competing data sets" per se.

The population studies of the least tern and piping plover from multiple study areas, however, present a range of demographic parameter values, (e.g., adult survivorship values for the piping plover range between 0.7 and 0.8). The EA team will need to identify parameter values for the ecological models, and the choice of values may substantially influence modeling results. It is not clear from the document which parameters need to be better resolved (and this may not be clear until initial modeling efforts are carried out), but the ISAP recognizes the need to conduct thorough sensitivity analyses to identify those parameters that are most influential to model results, have the highest uncertainty, and should be the focus of additional research.

c. Were explicit criteria used as the basis for accepting or rejecting data or findings from previous work for their inclusion in the EA process?

The basis for accepting or rejecting data or findings from previous studies and reports is offered in Appendices 1- 3, which display the full breadth of empirical information from which the EA team can make defensible selections.

d. Do the data gathered include the breadth of demographic and environmental variables that can serve the EA and AM process as direct or indirect measures of program performance?

The approach to demographic modeling adopted by the team for the bird species provides the appropriate template for an effects analysis that only considers management actions within the Missouri River and reservoirs. The metapopulations of both bird species, however, utilize the Missouri River as well as habitat areas outside of the Missouri River system. The distributions of individual birds among habitats both inside and outside the system vary seasonally and inter-annually. Accordingly, the population dynamics of both species on the Missouri River are affected by environmental stressors operating outside of the planning and management areas, and such external factors may constrain the effectiveness of future management actions implemented inside the programmatic study area.

This spatial constraint is acceptable in the initial effects analyses, which consider and evaluate those management actions that were recommended in the BiOp, and that have been previously applied within the study area. At some point, however, should it become apparent that current management actions are not sufficient to assure the survival and recovery of the two birds, or are not cost-effective to accomplish the program's stated objectives, it may be necessary to consider the full spatial domain of the metapopulations by working with partner agencies to identify potential management actions that could be implemented outside the Missouri River.

e. Have critical information gaps that might constrain the EA been identified?

No gaps are readily apparent; but acknowledgement of the role of environmental stressors that operate outside the planning area to affect the population dynamics of the birds on the Missouri River should be made. As described in *1.d.* above, spatial and temporal scaling issues might influence the results and limit the interpretation of the EA.

2. Do the models compiled and assessed for their usefulness adequately anticipate information needs (as outlined in the EA guidance document) for the EA process and the development of an AM Plan?

a. Have all the models necessary to perform the EA been identified?

Of course, it is not possible to know if all relevant models have been identified. However, the identified modeling approaches that will be used to support the bird-habitat components of the EA modeling effort appear appropriate, and seem adequate to the task.

The review of available (published) models identifies those that the EA team judges to have direct application in management planning.

b. Has the basis for accepting or rejecting alternative models been described?

The document does not address the acceptance or rejection of alternative models in relation to the EA. Model selection and implementation is well underway for the plover and tern EA. It appears unlikely that the currently emphasized models will be abandoned in favor of alternatives. The document describes the characteristics and attributes of the population viability (analysis) models that are available (see pages 4-6) for the birds. Each varies in spatial and temporal context, and has distinct attributes, including features that make them potentially useful in evaluating the effects of candidate management actions.

c. Can selected models be linked and applied at the full range of temporal and spatial scales required in an EA?

At present there is not a quantitative model linking natural or managed river flows to plover or tern population viability. It appears that the bird and the habitat teams are communicating over the issue, and have a clear understanding of the variables that need to be passed from habitat to birds (i.e., sandbar state) to complete the linkage. The ISAP believes that the bird models represent the best current understanding of least tern and piping plover biology, and will be adequate for the tasks ahead. The ISAP is less confident, however, about the current capabilities for modeling the hydrogeomorphic processes that create and degrade the sandbar habitats that support the birds. The deliverable from the hydrogeomorphic team (*Models, data, and literature to support habitat analyses for the Missouri River effects analysis* – Fischenich, et al. 2014) expresses this same concern and recognizes a critical need (pg. 21) to improve the ability of hydrodynamic-fluvial process models to "predict morphological response to flow management and natural flooding, particularly the development and decay of ESH." The success of (utility of) the coupled models (birds-habitat) in management planning applications will depend importantly on the ability of the effects analysis to model realistically river-flow and sandbar dynamics. Therefore, the ISAP supports the high priority assigned to that task as described in the habitat analysis report.

d. Has available information on river operations, including dam operations rules, been compiled?

There are adequate data and model tools for modeling dam operations, including models that were utilized to develop the current Master Manual. As noted previously, however, the capacity to link hydrodynamics to the creation and persistence of nesting habitat is not

yet established. The ISAP considers this linkage as critical to the success of the effects analysis.

e. Have available data been collected that when applied will allow for an ecologically relevant range of model applications in support of the EA?

Yes, at least for modeling bird responses to within-Missouri-River-system phenomena. Additional information and data should be sought to support EA activities that address the importance of factors geographically outside the Missouri River system on the viability of terns and plovers.

3. Do the data and models compiled and assessed meet generally accepted standards for a study of this nature?

No such explicit standards exist, but the thorough nature of the data gathering effort, the review and evaluation of previous modeling efforts, and ongoing modeling efforts of the EA team (e.g., Buenau et al. 2014) – might be viewed as setting a standard, at least for the two shorebirds. To the extent that peer review of published papers (e.g., Buenau et al. 2014) implies generally accepted professional standards, the reported data collection and modeling efforts for the birds appear consistent with the state of the science.

4. Are the necessary boundary conditions for modeling identified?

The boundary conditions for the models, as well as for the effects analyses and the adaptive management program that will follow, should be explicitly linked to those described in the effects analysis guidelines document. By default, boundary conditions are being indirectly set by the structure of the models currently being developed. This is not the best approach in conservation planning, particularly in circumstances where model components are being developed by different teams – all teams should have an explicit, common understanding of boundary conditions as model development proceeds. There should be documentation of agreed-upon boundary conditions, including at least the following: 1) the spatial boundaries are set as the Missouri River and its reservoirs, from Fort Peck to the confluence with the Mississippi River, but as we note above, there may be a need to expand that spatial horizon to include the entire ranges of the Missouri River metapopulations of the two birds; 2) presumably model scenarios will be run for the typical temporal period of 50-100 years, as in cases in federal water-project planning, but the planning window (period of analysis) of the effects analysis ought to be made explicit; 3) it is essential that initial conditions for model runs – year type, hydrological conditions – also be made explicit, and 4) the future scenario(s) that will used as the "no action" scenario(s), against which "action" scenarios will be compared, should be described in detail.

Pallid Sturgeon – ***Science information to support Missouri River pallid sturgeon effects analysis (Missouri River Pallid Sturgeon Effects Analysis Team 2014)***

1. *Does the data compilation and assessment of their usefulness adequately anticipate information needs (as outlined in the EA guidance document) for the EA process and the development of an AM Plan?*

    a. *Was the information gathered and assessed robust enough and of adequate quality to complete the EA?*

Given the complex life cycle of the pallid sturgeon, which is carried out over long reaches of the Missouri River, and the inability thus far to fully understand the ecology of the fish and observe its life history directly, the ISAP recognizes the challenges of this task and the EA effort. Nevertheless, the draft Pallid Sturgeon Science Information Report (Missouri River Effects Analysis Team 2014, hereafter the pallid sturgeon report) is largely a broad overview of MRRP Programs, corresponding database management, and a listing of some available data. How those data will meet the information needs identified in the conceptual ecological models (CEMs) or contribute to performing the EA is not clear. The report provides little evidence and no quantitative relationships regarding the effects of current river operations and management actions on pallid populations and their habitats. Importantly, there is no clear connection made between the pallid sturgeon population models that are reviewed in the document and criteria required to build quantitative population models for use in the subsequent steps of the EA. The current pallid sturgeon report does not represent a state-of-the-science knowledge base that the EA can rely on and we question whether it is sufficient to "be used as another line of evidence in addition to the quantitative models in assessing the relationship of different management actions and alternatives to species response" (Project Delivery Team 28 April 2014).

The pallid sturgeon report largely reviews existing documents and programs related to the decline in pallid sturgeon numbers, the fish's biology, and its management. The report also identifies existing scientific literature on pallid sturgeon in the Missouri River and its tributaries. The document acknowledges advances in the understanding of pallid sturgeon ecology developed over the past decade, and recognizes that many information gaps and uncertainties in life-history information, population dynamics, and habitat use, as well as many essential relationships between the fish and its river environment remain. Given the lack of relevant data on pallid sturgeon, or the closely related shovelnose sturgeon, there should be additional attention paid to data from other similar species in other locations (Effects Analysis guidance document 09 13 13_V5.docx), particularly *Acipenser* species in U.S. and European rivers. It is unclear to the panel the degree to which information

extrapolated from other non-*Scaphirhynchus* species and from other rivers has been taken into account in assessing data quality (p. 9).

The Pallid Sturgeon Population Assessment Project (PSPAP), Habitat Assessment and Monitoring Project (HAMP), and Comprehensive Sturgeon Research Project (CSRP) are briefly summarized and their reports and publications identified. However, there is limited discussion (see *Evaluation and Contribution to Effects Analysis* sections) of how useful the PSPAP data are, or if they are of sufficient quality to complete the EA and parameterize pallid sturgeon population models. The cited report by Schapaugh et al. (2010) is not a "comprehensive analysis" (pg. 32) of the HAMP as stated, but a focused analysis of the HAMP's Before-After/Control-Impact (BACI) statistical design using monitoring data collected from 2007 to 2009. The primary conclusion of Schapaugh et al. (2010) is that "the assumptions of the BACI design are not being met consistently enough to detect whether SWH [shallow-water habitat] construction is effective." This finding is consistent with that of an independent science review of the HAMP statistical design conducted five years earlier (see Sustainable Ecosystems Institute 2005). The pallid sturgeon report is clearly justified in questioning the reliability of HAMP results based on these evaluations. How the HAMP was modified following recommendations from these reviews and how post-2009 HAMP results can contribute to the EA concerning the effectiveness of the SWH program and its usefulness as a management action are minimally reviewed.

Both the National Research Council (NRC 2011) and ISAP (Doyle et al 2011) concluded that a broader programmatic evaluation of these monitoring and assessment programs was needed. The ISAP anticipated that this 2a step of the EA would assess and synthesize results of the HAMP and PSPAP into comprehensive analyses of how MRRP programs for constructing shallow-water habitat, the spring-rise process, and artificial propagation have performed relative to the implicit expectations of the 2003 Biological Opinion RPAs and the associated hypotheses upon which they were based. We did not find such an analysis of these projects, but observe that the Pallid Sturgeon Science Synthesis Report (Delonay et al. 2014) reflects the data compilation and assessment that is needed to perform the EA.

The CSRP Pallid Sturgeon Science Synthesis Report (Delonay et al. 2014) is a comprehensive synthesis of the findings from the USGS research program on pallid sturgeon. The report is organized by life-history stage, consistent with the current pallid sturgeon CEM. Unfortunately, not directly linking information from that document or its summary with the Ecological Factors and Primary Responses in the draft pallid CEMs (Missouri River Pallid Sturgeon Effects Analysis Team – September 2013) or candidate dominant working hypotheses (Missouri River Pallid Sturgeon Effects Analysis Team – 28 February 2014) within the pallid sturgeon report constrains the ISAP's ability to evaluate how this material might contribute to the effects analysis.

The Upper and Lower Basin Pallid CEM spreadsheet narratives identify key variables and metrics, their importance, and key uncertainties, as well as providing references for information on environmental drivers, but the narratives offer less pertinent information for subsequent steps in an EA. Including or referencing the CEM narratives in the pallid sturgeon report would provide a key link to the CEMs and the quality of information available to complete the EA. A matrix of available data and other pertinent information on pallid sturgeon, similar to that provided for the birds in Buenau et al. (2014), and a subjective ranking of the quality of the data for the ecological factors and primary response variables that are identified in the CEMs (Missouri River Pallid Sturgeon Effects Analysis Team. September 2013) would serve to highlight existing data, and also identify data gaps.

The ISAP suggests including in the pallid sturgeon report updated versions (perhaps in appendices) of the pallid sturgeon CEMs and the species objectives statement, which have benefited from reviews by pallid sturgeon investigators, the ISAP, and the SPA, and cite references. The panel also suggests populating the revised Upper and Lower Basin Pallid CEM narrative spreadsheets for Secondary Ecological Factors and Primary and Secondary Responses, as was done for Drivers, and perhaps include it as an appendix in the pallid sturgeon report. Matrices similar to those for the birds could be adapted from those in updated Upper and Lower Basin CEM Excel narratives. In addition the pallid sturgeon EA team might explicitly identify in the pallid sturgeon report the existing information gaps that if filled would enable development of quantitative versions of the CEMs.

b. Have the teams made choices between competing data sets in compiling available data pertinent to the EA?

Competing data sets or results from previous analyses that might affect modeling outcomes for pallid sturgeon population responses should be more clearly identified in the document. Instances of debate over aspects of pallid sturgeon ecology were acknowledged in Delonay et al. (2014). For example, there are disparate results regarding timing of initiation of pallid sturgeon free-embryo drift; differences that would affect their drift distance in the Missouri River and have implications for mortality of that life stage. Also, results from telemetry studies on pallid sturgeon and shovelnose sturgeon support the hypothesis that water temperature is more closely associated with reproductive readiness than are discharge parameters. Delonay et al. also demonstrated that habitat-use data do not support the necessity of shallow-water habitat for recruitment of age-0 *Scaphirhynchus* sturgeon. Identifying competing perspectives seems warranted in the pallid sturgeon report so they can be further appraised as the EA progresses.

Guidelines for how competing hypotheses, data sets, or results would be evaluated for inclusion in the EA were not clearly described in any of the referenced documents.

c. *Were criteria clear for the acceptance or rejection of data or findings from previous work for their inclusion in the EA process?*

No, and see response to previous question. An EndNote® database for relevant scientific literature was identified along with an overview of the Oracle database used for the HAMP and PSPAP. On what basis, or whether data or findings were included or rejected in these repositories, was not directly addressed.

In some cases, for example the HAMP sampling design, programmatic shortcomings were recognized (see response to *1.a.*).

d. *Do the data gathered include a full range of demographic and environmental variables that can serve the EA and AM process as direct or indirect measures of program performance?*

The ISAP is unable to address this question given the current form of the pallid sturgeon report. Previous reviews of HAMP and PSPAP efforts concluded they were not designed to be able to assess MRRP performance, because they are lacking 1) appropriate statistical designs, 2) a credible foundation of CEMs, 3) ecologically relevant hypotheses, and 4) measures of performance (Sustainable Ecosystems Institute 2005, Schapaugh et al. 2010, NRC 2011, Doyle et al 2011). Thus, the reliability of the data generated by these programs for use in structured EA or AM processes is questionable and cannot be fully evaluated until comprehensive syntheses (similar to the CSRP) are completed. The ISAP encourages the MRRMP planners to build into the program a process for gathering and evaluating the full range of demographic and environmental variables that are currently unavailable. This can be a longer-term effort that will facilitate an ongoing effects analysis and adaptive management process.

e. *Have critical information gaps been identified?*

There remain numerous critical information gaps on all aspects of pallid sturgeon ecology and management relevant to the EA; these were adequately identified and referenced in the draft pallid sturgeon report.

2. *Do the modeling compilation and assessment of their usefulness adequately anticipate information needs (as outlined in the EA guidance document) for the EA process and the development of an AM Plan?*

a. *Were the models necessary to perform the EA identified?*

The specific model structure is still unclear in the pallid sturgeon report. The model compilation effort stands as largely a bibliographic review. The report identifies existing

Scaphirhynchus sturgeon models, but fails to identify the information needs required to translate the CEMs into quantitative models of pallid sturgeon population dynamics to be used in the EA.

The report acknowledges that the necessary stage-based population model for pallid sturgeon in the Missouri River does not presently exist, and that a population model will need to be developed, which can accept survival inputs from quantitative versions of the CEMs. There is not a clear connection made between the sturgeon population models that are reviewed in the report, and what criteria might be required to build quantitative population models to complete this step of the EA. Similarly, it is recognized that demographic parameters for quantifying CEMS and parameterizing population models need to be identified; but, this process apparently has not progressed sufficiently to report. That is a critical element needed for the evaluation presented here. A generic strategy for capitalizing on existing *Scaphirhynchus* life-cycle and population models is outlined, but how functional models might be parameterized is characterized with "the process will be identified as the need arises."

Given the lack of stage-based models for sturgeon in the Missouri River, it may be appropriate to evaluate how aspects of models used for other species in other systems might apply. The pallid sturgeon report does not include a comprehensive examination of vital rates used in models for other species or systems and how they might be adapted to the pallid sturgeon models for the Missouri River.

b. Has the basis for accepting or rejecting alternative models been described?

Stage-structured and age-structured population modeling approaches are briefly reviewed and summary arguments presented for adopting a stage-structured approach. Whether an age- or stage-structured model is used is not critical to the output (typically lambda, indicating population growth or decline); however, it is likely that sub-models will provide inputs to the global model, and these sub-models need to be described. Pallid sturgeon and shovelnose sturgeon population models are identified (Table 1), but the criteria for accepting or rejecting these or other, yet-to-be-evaluated, age- or stage-structured population models are not presented in the report.

As indicated above, input-output variables for the EA models should be described in detail and related to the CEMs, species means objectives identified, and hypotheses that will be assessed. Illustrating the linkages between each of these steps will help to demonstrate the likelihood of completing the EA.

c. Can selected models be linked and applied at the full range of temporal and spatial scales?

At present, there is not a quantitative model linking natural or managed river flows to pallid sturgeon species needs or population viability. Although the pallid sturgeon report acknowledges spatial and temporal variability, it is unclear at this time how this variability will be incorporated into a stage-structured model. We are unable to respond more fully to this question, because neither model selection nor potential components of an applicable sturgeon population model are provided.

d. Has available information on river operations, including dam operations rules, been compiled?

Yes, See the Hydrogeomorphology section of this report. As noted above, however, the capacity to link hydrodynamics to pallid sturgeon population viability under varying physical and biotic circumstances was not demonstrated in the report.

e. Have available data been collected and applied to allow for an ecologically relevant range of model applications in support of the EA?

The Panel was unable to evaluate this question because the pallid sturgeon report indicates that pallid-sturgeon-specific demographic rates and characteristics are currently being compiled (with the objective of parameterizing quantitative models based on the CEMs). What these demographic parameters are for the five pallid sturgeon life stages and two geographic regions is not reported.

3. Do the data and modeling compilation and assessment conform to acceptable standards of practice for a study of this nature?

The Panel was unable to evaluate this question because details of potential models are not provided. We recommend the pallid sturgeon EA team directly address this question as the process of building and assessing appropriate population, habitat, and bioenergetic models progresses.

4. Are the necessary boundary conditions for modeling identified?

Boundary conditions for the models are not explicitly identified in the document; sufficient details of potential models are not provided. The geographic scope of yet-to-be-described pallid sturgeon models is stated as matching that identified in the Effects Analysis Guidance Document, with the specific exclusion of reservoirs and inter-reservoir reaches. The ISAP recommends that this exclusion be reconsidered as conditions in the inter-reservoir reach between Fort Peck Dam and Lake Sakakawea are important for pallid sturgeon survival and recovery.

Hydrogeomorphology – *Models, data and literature to support habitat analysis for the Missouri River effects analysis (Fischenich et al. 2014; April 4 2014 version reviewed)*

1. *Does the data compilation and assessment of their usefulness adequately anticipate information needs (as outlined in the EA guidance document) for the EA process and the development of an AM Plan?*

    a. *Was the information gathered and assessed robust enough and of adequate quality to complete the EA?*

The hydrogeomorphic-modeling EA team has initiated an appropriate approach in identifying and compiling available data and developing relevant modeling frameworks for the Missouri River system. The ISAP is pleased to see such a comprehensive modeling and analysis approach being developed from previously existing, but not connected elements. This type of data compilation and system-wide modeling has the potential to serve many management-planning purposes.

The several hydrogeomorphic sub-teams identified in the report have inventoried relevant data and models, and have begun compiling the relevant studies and publications. However, the teams have not yet analyzed and synthesized the available studies. Synthesis in support of the overall effects analysis might prove difficult because previous modeling efforts and associated studies have been conducted (mostly) at the reach scale, or on the scale of several river miles. Translating the results of these smaller-scale modeling efforts into a comprehensive assessment relevant to the listed species may prove challenging. The approaches outlined in the report suggest that the teams have the necessary skills and experience to perform the work. Yet, it appears unlikely that all of the described model development will be completed in time to provide necessary linkages to the species models for the EA.

The hydrogeomorphic team faces a substantial challenge in compiling enormously diverse datasets in vastly different formats, scales, and resolutions. The task of building a comprehensive system-wide model necessitates compiling available data into a single coherent, internally consistent package. It is unknown to us whether the actual compilation or just the identification of pertinent data has occurred as yet. Assuming that the wide array of data can be distilled and linked into the necessary components for the models described, the team is well positioned to complete the essential tasks of model development and application.

The modeling report indicates that the hydrogeomorphic teams are attempting to anticipate the potential needs of those developing the species models to be used in the

effects analysis. It might prove most efficient, given the known constraints in time and resources, to work backwards from an understanding of the key hydrogeomorphic requirements of the species models used in the effects analysis. Additional hydrogeomorphic modeling could be implemented as needed, based on the progress of the effects analysis.

b. Have the teams made choices between competing data sets in compiling available data pertinent to the EA?

There are not conflicting data sets or conflicting interpretations of data. Rather there are different data sets that must be examined in order to identify which are most relevant for the EA. The datasets were collected at different locations and points in time for different purposes; the challenge is to identify which data to include in the EA. A concern that arises is whether there are some modeling components that should ultimately be included, but might be set aside for the time being. For example, bank stability analysis is a data-intensive modeling process that will likely provide additional insight into the management agenda necessary for a benthic fish and sand-bar-dwelling bird species, but it does not meet the criteria for a priority component in a time-constrained effects analysis.

Another area of concern is the disconnect between the types of water-quality impacts that might affect the species and the types of water-quality modeling (and resolution of modeling) that may be possible. The hydrogeomorphic teams have identified some applicable water-quality datasets, but there may be others, available perhaps from EPA or USDA. Such models and data might provide relevant information, but they may be more difficult to acquire and apply. Similarly, there are hydraulic or sediment studies that have been designed for specific purposes at local scales; the ISAP suspects that there are many water quality studies that have occurred at such lesser spatial scales that have not yet been identified for potential use in the EA effort. This is not to suggest that the EA team, necessarily, develop a comprehensive inventory of all such datasets; rather, the decision as to whether to engage in this type of data gathering and synthesis activity should be seen as an option, depending on whether the listed species are eventually found to be limited by water-quality attributes of the system.

It is unclear how the authors intend to calibrate and/or validate sediment transport, which is the most sensitive and arguably most important hydrogeomorphic aspect of the system for the listed species. As the EA team notes, there are a handful of methods to estimate constraints on sediment transport modeling, but there are few datasets available to calibrate modeling approaches. Because sediment-transport modeling is recognized as highly inaccurate, the authors should describe how they will work around or within that constraint on modeling. For example, what level of precision and/or accuracy do they

suspect that they will need to achieve for 1-D system-wide modeling (or 2-D reach modeling) to achieve the purposes of the EA?

A similar concern applies to the water-quality-modeling portion of the study. Most water-quality modeling is strongly influenced by boundary conditions (inputs) and internal dynamics, which cannot be readily transferred from one system or reach to another, thus must be directly measured. This suggests that an active and sustained water-quality-monitoring program should be developed to support the proposed water-quality modeling.

c. *Were explicit criteria used as the basis for accepting or rejecting data or findings from previous work for their inclusion in the EA process?*

The report does not identify criteria for accepting or rejecting data for inclusion in the hydrogeomorphic modeling. Because the available information is primarily hydrographic survey data, there is limited need or opportunity for accepting or rejecting data. But, apart from accepting or rejecting data, the report summarizes important data sets that have been or can be used to develop, calibrate, test, and verify the models used in the EA. The report notes that assessments of data integrity and reliability have been undertaken for only a portion of these datasets.

d. *Do the data gathered include the breadth of demographic and environmental variables that can serve the EA and AM process as direct or indirect measures of program performance?*

The hydrogeomorphic models do not directly address demographics. However, the collation of data in support of the identified models appears comprehensive and capable of broadly supporting the EA and the AM process. That group of models will serve as the foundation for the EA and AM process in the future, as well as for many other applications. However, it is unclear if the depth of analysis in the pending modeling effort will be sufficient for some of the more nuanced needs of hydraulic- and sediment-transport modeling. The authors note that 2-D modeling is state-of-the-art, thus will continue to be a constraint on the utility of the models addressing species that depend on conditions that are, by their nature, 2-D (SWH and sand-bar construction processes). The authors have identified studies and datasets that will enable them to approach this problem (see Appendix D), but experience will have to guide the team to models that are best for addressing species needs. The team might consider utilizing a combination of field measurements and modeling, rather than undertaking strictly a modeling approach. Modeling can require substantial investments of time and resources compared to direct measurement, and the sole reliance on modeling may not be an appropriate default.

e. *Have critical information gaps that might constrain the EA been identified?*

The report identifies several information gaps that might influence the results of the EA. For example, calibration and validation data for sediment transport modeling have not been comprehensively developed for the Missouri River system. Similarly, water-quality data and data describing ecosystem processes (e.g., metabolism, primary production) that may be necessary to support water-quality modeling are generally lacking. In addition, if the pallid sturgeon team identifies other potential water-quality constraints on the species that are not addressed by the models identified in the report, additional water-quality modeling capabilities will have to be identified or developed, if unavailable.

2. *Do the models compiled and assessed for their usefulness adequately anticipate information needs (as outlined in the EA guidance document) for the EA process and the development of an AM Plan?*

    a. *Have all the models necessary to perform the EA been identified?*

Highly likely (but impossible to know), with the exception of water-quality models as noted previously. The report describes a detailed modeling framework that references hydrologic, geomorphic, sediment, and water-quality modeling capabilities. These capabilities are outlined within the context of reservoir operations, river routing, and flow-and-habitat management actions. The management actions are linked to pallid sturgeon, least tern, and piping plover performance, as well as to potential interactions with other operations mandates and constraints (e.g., hydropower, flood control, water quality and supply, and recreation).

Within this framework, a comprehensive set of models has been identified. Not surprising, the list focuses on models that have been developed by the Corps (e.g., ADH) or its long-time contractor (HEC). Several of these models (HEC-ResSim, HEC-RAS) have been implemented for portions of the Missouri River. Other potentially useful models (e.g., computational fluid dynamics – Larry Webber, University of Iowa; Delft Hydraulics) were not identified. The overall data management system will benefit from using a standard modeling approach (e.g., HEC) that allows for a more dovetailed compilation of data for multiple purposes.

    b. *Has the basis for accepting or rejecting alternative models been described?*

The report describes a basis for evaluating alternative models, but there appears to be little intention to apply it. The EA team describes generalized guidance for evaluating alternative models for technical efficacy (e.g., Swannack at el. 2012). The authors recognize that, in theory, alternative models should be compared, but they state that practical considerations often preclude such comparisons. Models for the EA will be selected largely in relation to the authors' knowledge and experience. The authors discuss various sources and

implications of uncertainty inherent to model applications. The plan is to document the importance of different types of model uncertainty (e.g., Fischenich et al. 2103) as part of the overall EA process.

How models will be accepted or rejected will be an important consideration to make explicit with regard to 2-D near-bed hydraulics, sediment transport for sand-bar building, and water quality. The authors have identified the different types of models that are available, but they have not indicated whether they expect differences in model results to be sufficient to require selection among model alternatives.

c. *Can selected models be linked and applied at the full range of temporal and spatial scales required in an EA?*

Yes, presuming the models and associated data can be appropriately scaled for habitat-specific issues (including addressing SWH and ESH). For example, much of the proposed hydrogeomorphic modeling is planned as one-dimensional throughout the basin. Yet, useful linkages of modeled flows and elevations to models of the three target species will likely require at least 2-dimensional resolution (perhaps 3-D for pallids). Models of 2 and 3 dimensions (e.g., ADH) are available, but these higher-dimension models are rarely implemented at the (larger) scales commensurate with the 1-D models. Methods for downscaling and upscaling will have to be available to perform the necessary model linkages across the full range of spatial scales potentially relevant to the EA.

d. *Has available information on river operations, including dam operations rules, been compiled?*

Yes. As the authors describe, HEC ResSim provides the capability to optimize reservoir performance (e.g., pool levels, storage, inflows, releases), given rules defined in the master manual for the Missouri River. Much of this information has been compiled as evidenced by the existing HEC-ResSim (and HEC-RAS) models that have been developed for a large portion of the Missouri River.

e. *Have available data been collected that when applied will allow for an ecologically relevant range of model applications in support of the EA?*

The report states that there has been substantial coordination among the Kansas City, Omaha, and St. Louis districts, NWD Water Management, the Hydrological Engineering Center, and the National Weather Service River Forecast Center in compiling the necessary data and developing the HEC-RAS (and ResSim) models for the Missouri River basin. The result is a lengthy (observed) data set for 1898-2012, allowing for assessment of regulated

and unregulated conditions, including flows and elevations, in relation to reservoir operations.

It is less clear that sufficient water-quality data are available to support an EA or to assist in the application and evaluation of water-quality models that could be used in support of the EA.

3. *Do the data and models compiled and assessed meet generally accepted standards for a study of this nature?*

Yes. The report addresses the Corps' desire to base its assessments on models that have passed its internal model-certification process. The Corps' model-certification process is comprehensive in its evaluation of candidate models and only certified models (e.g., HEC-EFM) are to be used to support formal Corps planning activities (i.e., Principles and Guidelines). The process is based heavily on peer review of the technical merit, accuracy, and reliability of the model, as well as the model's conformance with Corps planning policy. The peer-review components of the certification process are consistent with standards that are generally accepted by the scientific community. In addition to model certification, the report mentions the development of Quality Management Plans and performing District Quality Control and Internal Technical Review for the HEC-ResSim and HEC-RAS models used in the EA assessments.

The report is less specific concerning evaluations of data quality (i.e., data quality objectives); however, it is recognized in the report that the accuracy and reliability of the model results depend in large part on the quality of the underlying data used by the models.

4. *Are the necessary boundary conditions for modeling identified?*

The report underscores the authors experience in applying several hydrogeomorphic models to evaluate river operations in relation to flood control, navigation, and sediment transport. These differently scaled models of flows and elevations imply different assumptions concerning boundary conditions (e.g., up stream flows, bathymetry, sediment type) that are familiar to the model users. The report is less specific in describing boundary conditions for water-quality modeling. Accurate and reliable sediment transport modeling at sufficient resolution to be useful in the EA remains challenging, as previously noted.

Conclusions

Describing the state of science for a complex and variable river system is challenging as is evaluating the necessarily abbreviated descriptions of its components. While it may appear

that the steps in the EA process are linear (e.g., develop CEMs → compile and assess data → develop models → propose and test hypothesized management actions), in fact the EA process is itself adaptive, particularly in light of the abbreviated MRRMP schedule. Existing data are being further evaluated, new information is introduced as it is discovered, and analyses are being continuously refined. Consequently, this evaluation and its conclusions and implications reflect the state-of-progress in data assessment and analysis at a single point in time and should be interpreted accordingly.

The task of compiling and assessing "data and modeling resources that can be applied to the Analysis," as prescribed in the *Effects Analysis Guidance Document*, is essential to the development of a management action plan for protected species on the Missouri River that meets the criteria of being informed by "the best available scientific and commercial data" as required under the Endangered Species Act. A thorough accounting of available data and models makes it possible that the effects analysis and the management agenda that will be derived from it are effective, efficient, and accountable.

The ISAP expected these EA2a state-of-the-science documents not only to present an accounting of available data and models pertinent to an analysis of the effects of Missouri River operations on the three listed species, but to convey the current understanding of 1) which river-system operations or actions are threatening the survival of the listed species and how they do so, 2) what alternative operations or actions (that might alleviate the threats) could be tested, and 3) whether the current understanding of the factors involved is sufficient to enable a quantitative modeling assessment of alternative operations or actions, or whether only enough is known for a qualitative assessment of them. Such understanding is needed to support the alternatives, consequences, and tradeoffs steps of the MRRMP to come.

For the least tern and piping plover, the ISAP concludes that the EA team understands reasonably well the life cycles and habitat requirements of these birds. The team understands reasonably well what system operations and actions affect plover and tern survival and potential for recovery. The team can relate population viability to habitat area and condition and will be able to model population viability under potential alternative management-action scenarios, if the hydrogeomorphic models can be parameterized and run at a scale relevant to the habitat. Failing that, however, planners have reasonable quantitative correlative relationships available to them from which they can infer probable bird responses to variations in natural and managed flow conditions. Should models developed exclusively from Missouri River data have low predictive power the EA Team may need to consider tern and plover population dynamics at a larger spatial scale in the future (i.e., make use of ongoing metapopulations analyses).

A similarly comprehensive understanding of the relationships between the physical and biotic attributes of the Missouri River and stage-specific performance of pallid sturgeon is not available. The draft pallid sturgeon report is not yet complete and does not clearly articulate how to move forward given the uncertainty in understanding between river operations and pallid sturgeon survival. The EA team has articulated relationships linking the fish, its habitat, and the hydrological and geomorphological characteristics of the river in conceptual ecological models based on the revised pallid sturgeon Recovery Plan (U.S. Fish and Wildlife service 2014), the USGS science synthesis (Delonay et al 2014), and many dozens of reports and published studies. The pallid sturgeon report demonstrates minimal synthesis to date of multiple years of MRRP HAMP and PSPAP data in support of the EA. The ISAP concludes from the draft pallid sturgeon report that the effects of river system operations and actions on the species are not well understood.

Subsequent to the first draft of this report the ISAP has had multiple interactions with the EA Team in Webinars and at the May 2014 MRRIC meeting. Discussions with the EA teams suggest that the data presently available may not be sufficient to produce a robust quantitative demographic model that can predict with confidence the consequences of potential management actions on pallid sturgeon population responses. In anticipation of this potential the ISAP has discussed with the EA teams and recommends:

1. Moving forward with multiple independent modeling approaches to explore the implications of model structure, parameter sensitivity, use of data from other species of sturgeon in other systems (i.e., surrogate species), and spatial and temporal scaling approaches (including linkages with the hydrogeomorphic models) to evaluate the posed hypotheses.
2. Additional focused investigations to test hypotheses (e.g., see Platte River AM Program).
3. Use of expert opinion elicitation and/or inferences from surrogate species to parameterize the numerical models for pallid sturgeon.
4. Applying selected management actions on representative river reaches to evaluate their effectiveness before being prescribed as a large-scale management alternative or in a revised Biological Opinion.
5. Prioritizing initial management hypotheses to be tested that have the highest potential benefits to the species and minimize risk to stakeholders.

These activities will assist the EA team in acquiring the necessary modeling experience to refine the EA during Phase 2, and establish the level of confidence in quantitative and qualitative predictive capabilities. The hydrogeomorphic EA team should contribute to program progress by focusing their modeling efforts in support of the species teams. The results of the modeling activities may identify areas in which rapid (re)evaluation of

available pallid sturgeon laboratory or field data could be beneficial in evaluating the hypotheses. They may also contribute to identifying issues for which new laboratory or field measurements may be needed over the longer term to support continuing effects analysis and adaptive management.

The ISAP has also offered the observation to the Management Plan and EA teams that a post-implementation adaptive management plan is not a substitute or a fix for management actions based on scientifically unsound hypotheses. It is more cost and time effective to invest in rigorous analysis of existing data and screening of potential hypotheses upfront than to implement a flawed management action, then monitor and evaluate, and then revise the action.

The ISAP is ready to discuss with the EA Team, SPA Task Group, and Management Plan Team how these and previous recommendations can be prioritized and implemented in the context of the MRRMP development, and the adaptive management process beyond.

References Cited

DeLonay, A.J., Jacobson, R.B., Chojnacki, K.A., Albers, J.L., Braaten, P.J., Bulliner, E.A., Burtner, A., Elliott, C.M., Erwin, S.O., Fuller, D.B., Hass, J.D., Ladd, H.L.A., Mestl, G.E., Papoulias, D.M., and Wildhaber, M.L., 2014, Ecological Requirements for Pallid Sturgeon Reproduction and Recruitment in the Missouri River: A Synthesis of Science, 2005 to 2012: U.S. Geological Survey Scientific Investigations Report 2014-XXXX. In review.

Doyle, M., Murphy, D., Bartell, S., Farmer, A., Guy, C.S., and Palmer, M. 2011. Final report on spring pulses and adaptive management: Missouri River Recovery Program. Independent Science Advisory Panel, U.S. Institute for Environmental Conflict Resolution, 64 p.

Fischenich, J. C., McKay, S. K., Miller, S. J., Price, D., Pruitt, B., Skaggs, L., Suedel, B. and Tazik, D. (2013). "Science-based Framework for Environmental Benefits Assessment," ERDC/EL TR-13-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

ISAP. 26 February 2014. Independent Science Advisory Panel Evaluation of Draft Species Objectives and Draft Conceptual Ecological Models (CEMs). Report to Management Plan and Effects Analysis Teams, MRRIC SPA Task Group.

Missouri River Pallid Sturgeon Effects Analysis Team. 19 March 2014 Draft. Science information to support Missouri River pallid sturgeon effects analysis.

Missouri River Pallid Sturgeon Effects Analysis Team. September 2013. Draft Upper and Lower Missouri River Basin pallid sturgeon conceptual ecological models (CEMs).

Missouri River Pallid Sturgeon Effects Analysis Team. 28 February 2014 Draft. Candidate dominant working hypotheses for population decline of pallid sturgeon in the Missouri River Basin.

Project Delivery Team. 28 April 2014. Alternatives Development Methodology & Decision Analysis Approach: Missouri River Recovery Program: Management Plan and Environmental Impact Statement. Draft Final. U.S. Army Corps of Engineers.

Schapaugh, A., Hiller, T.L., and Tyre, A.J., 2010. The Pallid Sturgeon habitat assessment and monitoring program 2007-2009. University of Nebraska, School of Natural Resources, 29 p.

Sustainable Ecosystems Institute, 2005. Independent Science Review of the Habitat Assessment and Monitoring Program Study Plan for the Missouri River. Sustainable Ecosystems Institute, 39 p.

Swannack, T. M., Fischenich, J. C. and Tazik, D. J. (2012). "Ecological Modeling Guide for Ecosystem Restoration and Management," ERDC/EL TR-12-18, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

U.S. Fish and Wildlife Service, 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: U.S. Fish and Wildlife Service, 308 p.

U.S. Fish and Wildlife Service, 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: U.S. Fish and Wildlife Service, 308 p. http://www.nwd-mr.usace.army.mil/mmanual/FinalBO2003.pdf.

U.S. Fish and Wildlife Service. 2014. Revised recovery plan for the pallid sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service, Denver, Colorado, 115 p.