US Army Corps of Engineers ®
Kansas City District

MISSOURI RIVER RECOVERY PROGRAM

Baltimore Bend Interception Rearing Complex Project
Lafayette County, Missouri

Definite Project Report and Integrated Environmental Analysis
&
Section 404(b)(1) Evaluation

July 2016

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Finding of No Significant Impact

Baltimore Bend Interception Rearing Complex Project
Lafayette County, Missouri
Definite Project Report and Integrated Environmental Analysis

The U.S. Army Corps of Engineers, Kansas City District (Corps), has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The Corps assessed the effects of the following actions in the Environmental Assessment, dated for the Baltimore Bend Interception Rearing Complex Project**.** This report is incorporated herein by reference.

The U.S. Army Corps of Engineers (USACE), Kansas City District (NWK) is proposing an interception-rearing-complex (IRC) project in the Missouri River at Baltimore Bend. Baltimore Bend is located in Lafayette County, Missouri. The goal of this project is to develop and increase IRC habitat for the federally endangered pallid sturgeon within the lower Missouri River. This project will help test the hypothesis that mostly passive free-floating pallid sturgeon embryos and larvae are entrained in the thalweg, the deepest fastest flowing portion of the channel, and are unable to move to the channel margins where environmental conditions may be more suitable for their growth and survival. This hypothesis is one of several that has recently been described in the U.S. Geological Survey's (USGS) *Missouri River Pallid Sturgeon Effects Analysis, Integrative Draft Report 2015* as a potential reason pallid sturgeon populations have declined. The specific objective of this project is to modify hydraulic conditions in order to increase interception of free-drifting embryos and larval sturgeon from the channel thalweg into the channel margins where water depths are one to three meters and velocities are 0.5 to 0.7 meters per second.

This project is being conducted as part of the Missouri River Recovery Program (MRRP). The MRRP enables the Corps to operate the Missouri River projects to meet authorized purposes without jeopardizing the continued existence of the three species listed under the Endangered Species Act (ESA): the least tern, piping plover, and pallid sturgeon. The MRRP is conducted in accordance with the *U.S. Fish and Wildlife Service 2003 Amendment to the 2000 Biological opinion on the operation and maintenance of the Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River BSNP, and operation of the Kansas River Reservoir System* (USFWS, 2003), hereafter referred to as the 2003 Amendment to the Biological Opinion. The biological opinion was prepared in accordance with the Endangered Species Act (ESA). It is expected that this project would be constructed during the 2016 to 2017 timeframe pending available funding.

In addition to the "no action" alternative, two alternatives were evaluated, including the recommended plan. The recommended plan was identified as National Environmental Restoration (NER) plan and is the environmentally preferred alternative. All practicable means to avoid and minimize adverse environmental effects have been

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incorporated into the recommended plan. The recommended plan would not result in any impacts to federally-listed threatened or endangered species or their designated critical habitat, would have no impact to sites listed on or eligible for inclusion on the National Register of Historic Places, and would not significantly affect any wetlands or water of the U.S., nor any important wildlife habitat. Therefore, no compensatory mitigation is required.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in the evaluation of the alternatives. It is my determination that the recommended plan does not constitute a major federal action that would significantly affect the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date: _____ _____

Andrew D. Sexton
Colonel, Corps of Engineers
District Commander

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1.0 Introduction

The U.S. Army Corps of Engineers, NWK (USACE) is proposing an interception-rearing-complex (IRC) project in the Missouri River at Baltimore Bend. Baltimore Bend is located in Lafayette County, Missouri. The goal of this project is to help test the hypothesis that mostly passive free-floating pallid sturgeon embryos and larvae are entrained in the thalweg, the deepest fastest flowing portion of the channel, and are unable to move to the channel margins where environmental conditions may be more suitable for their growth and survival. This hypothesis is one of several that has recently been described in the USGS's *Missouri River Pallid Sturgeon Effects Analysis, Integrative Draft Report 2015* (Effects Analysis) as a potential reason pallid sturgeon populations have declined (In review).

This project is being conducted as part of the Missouri River Recovery Program (MRRP). The MRRP enables the Corps to operate the Missouri River projects to meet authorized purposes without jeopardizing the continued existence of the three species listed under the Endangered Species Act (ESA): the least tern, piping plover, and pallid sturgeon. The MRRP is conducted in accordance with the *U.S. Fish and Wildlife Service 2003 Amendment to the 2000 Biological opinion on the operation and maintenance of the Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River BSNP, and operation of the Kansas River Reservoir System* (USFWS, 2003), hereafter referred to as the 2003 Amendment to the Biological Opinion. The biological opinion was prepared in accordance with the Endangered Species Act (ESA). It is expected that this project would be constructed during the 2016 to 2017 timeframe pending available funding.

This Definite Project Report and Integrated Environmental Analysis is tiered from of the *Final Supplemental Environmental Impact Statement (SEIS) for the Missouri River Fish and Wildlife Mitigation Project* (USACE, 2003) following the President's Council on Environmental Quality (CEQ) guidelines for Effective Use of Programmatic National Environmental Policy Act (NEPA) Reviews (CEQ, 2014). It meets the requirements of NEPA of 1969, as amended (42 U.S. Code [USC] 4321 et seq.); CEQ Regulations (40 Code of Federal Regulations [CFR] 1500 – 1508); and U.S. Army Corps of Engineers ER 200-2-2 (33 CFR 230). It also is compliant with the National Historic Preservation Act, Section 404 of the Clean Water Act (CWA), the ESA and other laws and regulations listed in Section 6.

1.1 Project Authority

The project would be completed under the authority of MRRP as derived from Water Resource Development Acts (WRDA) of 1986 (Section 601), 1999 (Section 334), and 2007 (Section 3176). This project would fit the description of the reasonable and prudent alternative for pallid sturgeon starting on page 219 of the 2003 Amendment to the Biological Opinion (USFWS, 2003). It would contribute to avoiding jeopardy to pallid sturgeon.

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1.2 Project Location

Baltimore Bend is located in the Missouri River seven miles west of Waverly, Missouri (Figure 1). The bend is 17,000-feet long and extends from about Missouri River mile 300.1 to 296.5 (Figure 2). The project area is primarily within the banks of the Missouri River. It is adjacent to Baltimore Bottoms which is owned by USFWS as part of the Big Muddy National Fish and Wildlife Refuge.

Figure 1: Baltimore Bend is located near Waverly, Missouri.

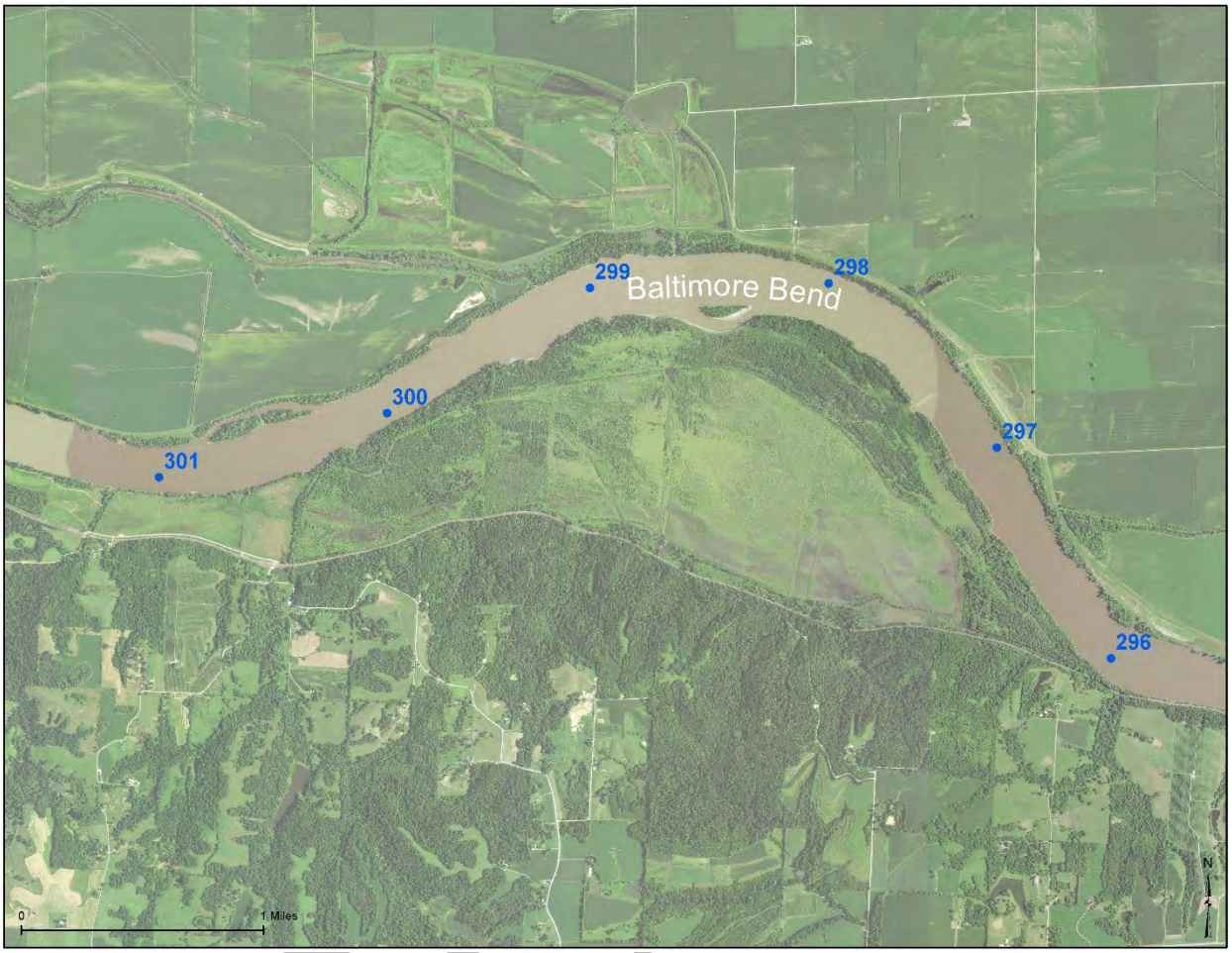

Figure 2: The Baltimore Bend IRC project area is located approximately between Missouri River miles 296 to 301.

1.3 Existing Project Conditions

The Missouri River at Baltimore Bend ranges in width from approximately 980 feet to 1,750 feet. The navigation channel is approximately 700 to 850 feet in width at the bend. The inside of the bend is dominated by a series of dike structures and a small island. The banks of the Missouri River in the project area are nearly vertical and range in height from 15 to 20 feet. The outside bend of the river is dominated by revetments and L-dikes that are part of the Missouri River Bank Stabilization and Navigation Project (BSNP). Two non-federal levees are located on the left descending bank, Baltimore Bend Levee and Sugartree Bottom Levee.

1.4 Purpose and Need/Problem and Opportunities

Since 2004, USACE has been taking numerous actions to avoid jeopardy to pallid sturgeon on the lower Missouri River that were included in the reasonable and prudent alternative from the 2003 Amendment to the Biological Opinion. These actions have included maintaining a stocking (propagation) program for pallid sturgeon, limited

testing of flow modifications, and construction of shallow-water habitat. Shallow-water habitat construction has primarily consisted of notching select BSNP dikes along the river and constructing side channels across inside bends of the Missouri River in locations where the federal government owned sufficient land to construct such features. To date, there have not been strong indications that pallid sturgeon are successfully recruiting to reproductive age naturally in the lower Missouri River. When the 2003 Amendment to the Biological Opinion was prepared, there was limited scientific knowledge about the ecological needs of pallid sturgeon. However, much has been learned since the 2003 Amendment to the Biological Opinion was prepared.

In 2013, the Missouri River Recovery Implementation Committee (MRRIC) provided a recommendation to USACE and USFWS to conduct an effects analysis of its actions to avoid jeopardy to pallid sturgeon, piping plover, and interior least turn; the three federally listed threatened and endangered species included in the 2003 Amendment to the Biological Opinion. The MRRIC, established by Section 5018 of WRDA 2007, consists of an assemblage of stakeholders who have an interest in the management of the Missouri River. The recommendation to conduct an effects analysis was based on input provided to MRRIC through an Independent Science Advisory Panel that was established in 2011, with oversight by a third party science neutral entity, to provide advice on specific topics.

The concept of an effects analysis for federal actions on the Missouri River to avoid jeopardy to the three federally listed threatened and endangered species was based on modifications to the effects analysis concept provided by Murphy and Wieland (2011). The purpose of the Missouri River effects analysis is to conceptually and quantifiably make explicit the effects of operations and actions on the listed species by specifically evaluating the effects of hydrologic and fluvial processes on the Missouri River, as well as ongoing management actions to the status and trends of the listed species and their habitats.

Numerous testable hypotheses have been developed as part of the effects analysis to better focus actions that may be undertaken as part of an adaptive management strategy to benefit pallid sturgeon populations and avoid jeopardy to this species. On the lower Missouri River, these hypotheses are related to the impact spawning cues, food and foraging habitat, free-drifting embryos and larval drift dynamics, spawning habitat, and population augmentation (stocking) of pallid sturgeon. The USACE and USFWS are currently engaged with basin stakeholders in developing the Missouri River Recovery Management Plan. This plan will incorporate information from the effects analysis into a set of management actions to benefit populations of threatened and endangered species. This plan is being developed with an adaptive management paradigm as identified in the 2003 Amendment to the Biological Opinion because of the amount of uncertainty associated with the benefits of various management actions to benefit these species. There is a particularly high amount of uncertainty associated with various management actions to benefit pallid sturgeon on the lower Missouri River. However, this plan is not yet completed. In the interim, there is a need to take actions to

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avoid jeopardy to pallid sturgeon and to begin testing hypotheses that are included in the effects analysis.

One action that can be undertaken within the existing framework of the MRRP is related to free-drifting embryos and larval pallid sturgeon drift dynamics. It has been postulated that free-drifting embryos and larval pallid sturgeon do not survive because they are unable to move from the thalweg of the river to the channel margins where conditions are believed to be more suitable for growth and survival. The purpose of this project is to test the hypothesis that re-engineering the Missouri River channel morphology in select reaches would increase channel complexity and serve specifically to promote interception and retention of free-drifting embryos and larval sturgeon in areas believed to be important for first feeding and for growth through the juvenile life stage. Testing this hypothesis in the field would reduce the amount of uncertainty associated with the effectiveness of implementing management actions to intercept free-drifting embryos and larval sturgeon on a larger scale to benefit pallid sturgeon population size.

Rearing habitat is a combination of food producing and foraging habitat, both identified in the Effects Analysis as potentially limiting factors. Foraging habitat is defined as locations in which the water depth is between one to three meters and bottom water velocities are between 0.5 to 0.7 meters per second. This project would be designed to intercept free flowing, larval-pallid-sturgeon-sized particles into the channel margins while creating rearing habitat.

1.5 Project Goals and Objectives

The goal of this project is to determine if increasing IRC results in a concomitant increase in the catch rate of age-0 sturgeon at this location.

The objective of the project is to create hydraulic conditions to intercept free-drifting embryos and larval sturgeon from the channel thalweg into the channel margins where water depths are one to three meters and velocities are 0.5 to 0.7 meters per second.

Hydraulic modeling will be used to estimate the amount of IRC that is expected to develop from alternative plans. The model will use free-drifting particles as a surrogate for free-drifting embryos. IRC units will be estimated by multiplying the interception ratio of free-drifting particles in the hydraulic model that are intercepted from the channel thalweg (quality) by the number of acres of rearing habitat, water depths of one to three meters and velocities of 0.5 to 0.7 meters per second, available in the channel margins (quantity). Further explanation of the modeling process can be found in Appendix C.

Post-construction monitoring would be conducted to measure actual changes in channel morphology and changes in catch rates of free-drifting embryos and larval sturgeon. Because of the limited population size of pallid sturgeon in the Missouri River, free-drifting embryos of all larval sturgeon, would be used as a surrogate for pallid sturgeon to determine the success of the project. It is assumed that any measures that would result in increases of interception of larval shovelnose sturgeon would also result in increases of interception of larval pallid sturgeon. Information learned from post-

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construction monitoring of this project may be used to further modify Baltimore Bend as part of an adaptive management process or used in the design of other IRCs that may be constructed in the future.

1.6 Project Constraints

Constraints are things that may need to be avoided during the planning and development of a project. There were numerous program level and site-specific constraints that have been identified for the project. These constraints include:

Missouri River Authorized Purposes: The project must not adversely impact the authorized purposes of the Missouri River Mainstem Reservoir System and the BSNP. For the Mainstem Reservoir System these include: flood control, hydropower, navigation, water supply, water quality, irrigation, recreation, and fish and wildlife. For the BSNP these include: bank stabilization and navigation.

Avoid Unacceptable Impacts to the Environment: The project must not adversely affect any threatened and endangered species or the habitat upon which they rely. Negative impacts to wetlands should be avoided, minimized, or mitigated. Significant adverse impacts to water quality and fish and wildlife should be avoided. The project should not negatively impact any existing habitat that has been constructed as part of MRRP.

Cultural/Tribal Resources: The BSNP resulted in the preservation in place of hundreds of historic shipwrecks along the Missouri River. Project features must avoid impacts to historic shipwrecks and other cultural or tribal resources. Measures must be taken to avoid and/or preserve-in-place cultural or tribal resources, including shipwrecks, if they are inadvertently discovered during construction.

Private Property: Project alternatives avoid any foreseeable effects to adjacent private property.

Public Infrastructure: The project must not adversely impact public roads, bridges, levee and drainage systems, sewer lines, drinking water intakes, or other components of public infrastructure.

Project Construction Costs: Only measures that are cost effective will be considered for implementation.

Operation and Maintenance Costs: Limited funding is available for long-term operation and maintenance.

Laws and Regulations: The project must be designed and constructed in a manner consistent with federal, state, and local laws and regulations.

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1.7 Agency and Public Coordination

Due to the technical nature of the hydraulic conditions included as part of the project objectives, alternatives were developed by USACE with input from USGS staff who were involved in preparation of the draft effect analysis report. Both the USACE and USGS have expertise in hydraulic modeling. The alternatives were shared with USFWS, Missouri Department of Conservation (MDC), U.S. Environmental Protection Agency (EPA) and Natural Resources Conservation Service (NRCS) during a meeting on December 8, 2015, to identify any agency specific concerns.

On June 23, 2016, Public Notice No. 2016-00912 was issued jointly by USACE and MDNR announcing the availability of this draft EA and draft Section 404(b)(1) Evaluation for a 30-day public comment period. Information concerning the availability of the Public Notice and draft documents has been e-mailed to entities on the NWK Regulatory Branch distribution lists. During the public comment period, the Public Notice and draft documents are available on the NWK Public Notice website at: http://www.nwk.usace.army.mil/Media/PublicNotices/PlanningPublicNotices.aspx. Hard copies are available on request. A copy of the Public Notice is included as Appendix A.

In addition, a public meeting is being held on July 13, 2016, from 5:00 p.m. to 7:00 p.m. at 111 E. Kelling Ave. in Waverly, Missouri to provide the public information on the project and to solicit comments. A copy of all public and agency comments received during the public review process will be located in Appendix B of the final environmental assessment.

2.0 Alternatives

This chapter describes the alternative formulation process and presents the final array of alternatives considered in detail for the Baltimore Bend IRC Project. Cost effectiveness and incremental cost analysis were used in conjunction with an evaluation of potential environmental impacts (Section 4) to identify the Recommended Plan.

An initial array of alternative plans was developed by combining various management measures that were expected to meet the primary project objective. A management measure is a feature, a structural element that requires construction or assembly on-site, or an activity, a non-structural action. Measures that did not meet the project objectives, project constraints, or meet the completeness, effectiveness, efficiency, and acceptability criteria described in the United States Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*P&G*) were removed from further consideration.

2.1 Management Measures

Five management measures were initially considered to develop alternative plans. These included:

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1) Remove portions of existing dikes

2) Extend portions of existing dikes

3) Top-width widening

4) Construct a side channel

5) Construct a backwater area. These are further described below.

2.1.1 Remove Portions of Existing Dikes

This measure would remove portions of existing dikes along the inside bend of the river and allow more flow across the sand beds. It is believed this would increase interception of free-drifting embryos and larval sturgeon from the channel thalweg to the channel margins and, over time, result in the development of food producing and foraging habitat. Depending on the configuration in which portions of the dikes were removed, this measure would meet the project objectives, avoid project constraints, and is technically feasible.

2.1.2 Extend Portions of Existing Dikes

This measure would extend and/or raise portions of existing dikes along the inside bend of the river to create zones of flow expansion downstream of the structures. It is believed this would increase interception of free-drifting embryos and larval sturgeon from the channel thalweg to the channel margins and, over time, result in the development of rearing habitat. It is expected that this measure would be used in combination with other measures in order to be most effective. Depending on the configuration in which portions of the dikes were extended, this measure would meet the project objectives, avoid project constraints, and is technically feasible.

2.1.3 Top-Width Widening

This measure would involve widening the top-width of the river channel and create marginal areas for pallid sturgeon foraging. In combination with other measures such as removing portions of existing dikes and constructing a series of rootless dikes this alternative would meet project objectives and is technically feasible. However, this measure is not reasonably expected to be cost effective in meeting the project objectives when compared to other measures being considered. For these reasons, it was not carried forward for further consideration.

2.1.4 Construct a Side Channel

This measure would involve construction of a side channel to the main river channel. Numerous side channels have already been constructed on the Missouri River. Gosch

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et *al*. (2015) suggest accessibility of age-0 sturgeon to some constructed side channel chutes may be limited. As such, construction of a side channel chute may limit the study design to test the hypothesis that IRCs yield increased catches of age-0 sturgeon within the lower Missouri River. For this reason, this measure was removed from further consideration.

2.1.5 Construct a Backwater Area

This measure would be similar to constructing a side channel, except that it would be closed off on one end. This measure was removed from further consideration for the following reasons. These reasons include:

1) It is known from monitoring of existing backwaters that they are ineffective in intercepting free-drifting embryos and larval sturgeon from the thalweg of the main channel, therefore not meeting the primary objective of the project.

2) Several back water areas have been constructed along the Missouri River within the Omaha District and they have not been sustainable over the long-term because of sediment deposition.

2.1.6 Summary of Management Measure Screening

The initial screening of management measures considered is summarized in Table 1. Two measures were carried forward to develop an initial array of alternatives.

Table 1: Summary of the evaluation of management measures.

Measure	**Meets Project Objectives**	**Meets Project Constraints**	**Technically Feasible**	**Carried Forward**
Remove Portions of Existing Dikes	Potentially	Yes	Yes	Yes
Extend Portions of Existing Dikes	Potentially	Yes	Yes	Yes
Top-Width Widening	Potentially	No	Yes	No
Construct a Side Channel	No	No	Yes	No
Construct Backwater Areas	No	No	Yes	No

2.2 Initial Array of Alternatives

Various combinations of the management measures that were carried forward were used to develop an initial array of alternatives using best professional judgment. Four distinct plans for dike modifications were developed with measures that consisted of

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removing portions of existing dikes and extending portions of existing dikes. These plans were combined with a set amount of sand removal in each of the four alternatives to accelerate development. Including sub-alternatives, a total of nine alternatives were developed for the initial array of alternatives, including the no-action (future without-project condition) alternative. Elevations of the dikes are described as feet above or below the construction reference plane (CRP). The CRP is used as a baseline elevation used to construct dikes and revetments on the Missouri River. It is an imaginary plane that extends the length of the river. It is technically defined as the sloping water surface elevation of a discharge that is exceeded 75 percent of the time during the navigation season.

2.2.1 No-Action/Future Without-Project Condition

The No-Action alternative would not result in any changes to Baltimore Bend to meet the project objectives. It was assumed that there would be no difference between the existing condition and the future without-project condition with regard to IRC because the river channel is stabilized by the BSNP. See Figure 3.

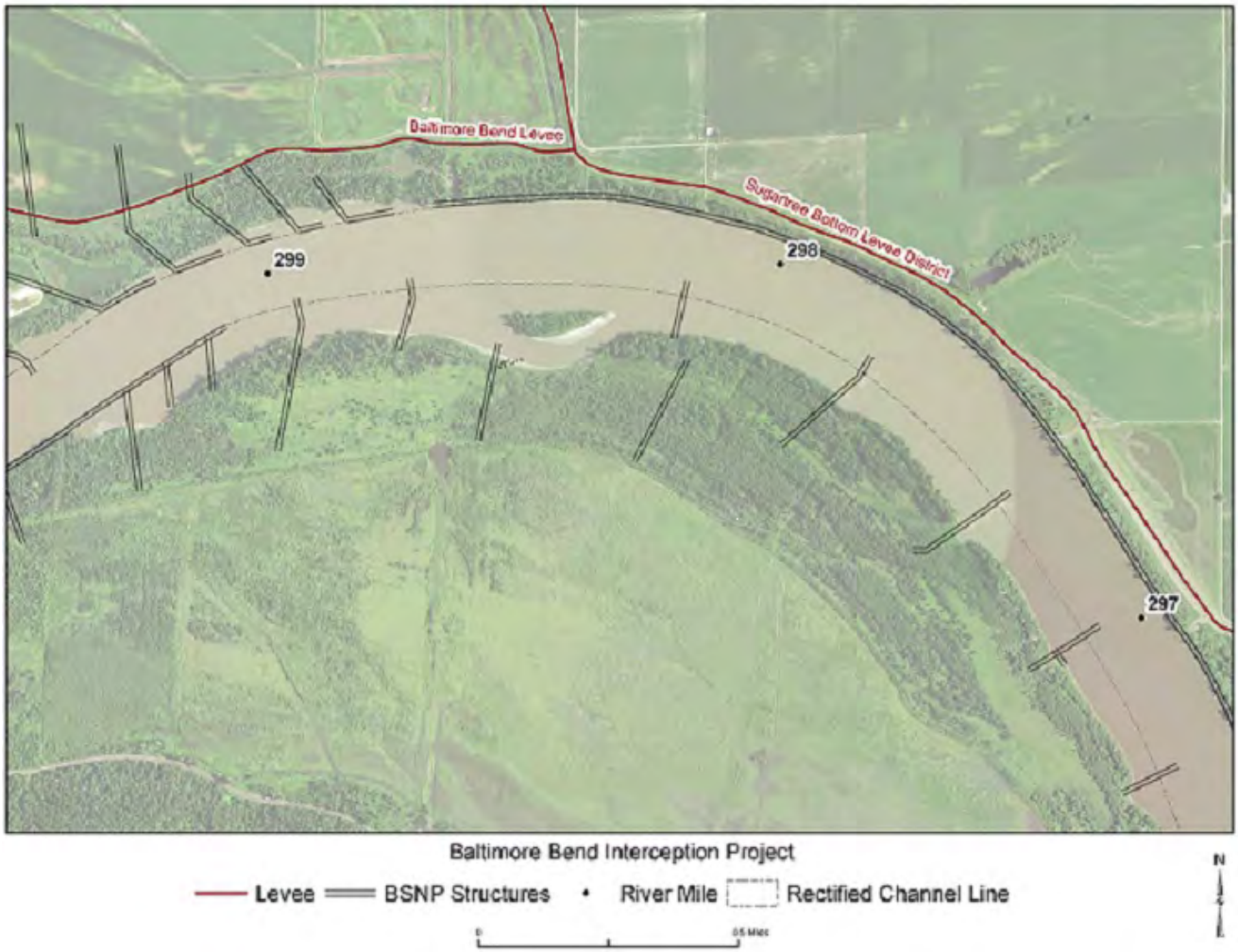

Figure 3: The No-Action/Future Without-Project Condition of the initial array of alternatives.

2.2.2 Alternative Concept 1

Alternative Concept 1 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Ten structure segments ranging from 115 to 230 feet long will be removed to an elevation of six to ten feet below the CRP. Six dikes will be extended 40 to 130 feet riverward along the existing alignment of the structure at an elevation of -4 to +3 feet above/below the CRP. Five dike structure segments will be raised to an elevation of two to three feet above the CRP ranging from 200 to 350 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat.

Alternative 1a of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This alternative will allow natural riverine processes to erode and lower the sand bed areas near the channel margin over time in order to reach the ultimate desired state of the

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geomorphology of the inside bend. See Figure 4.

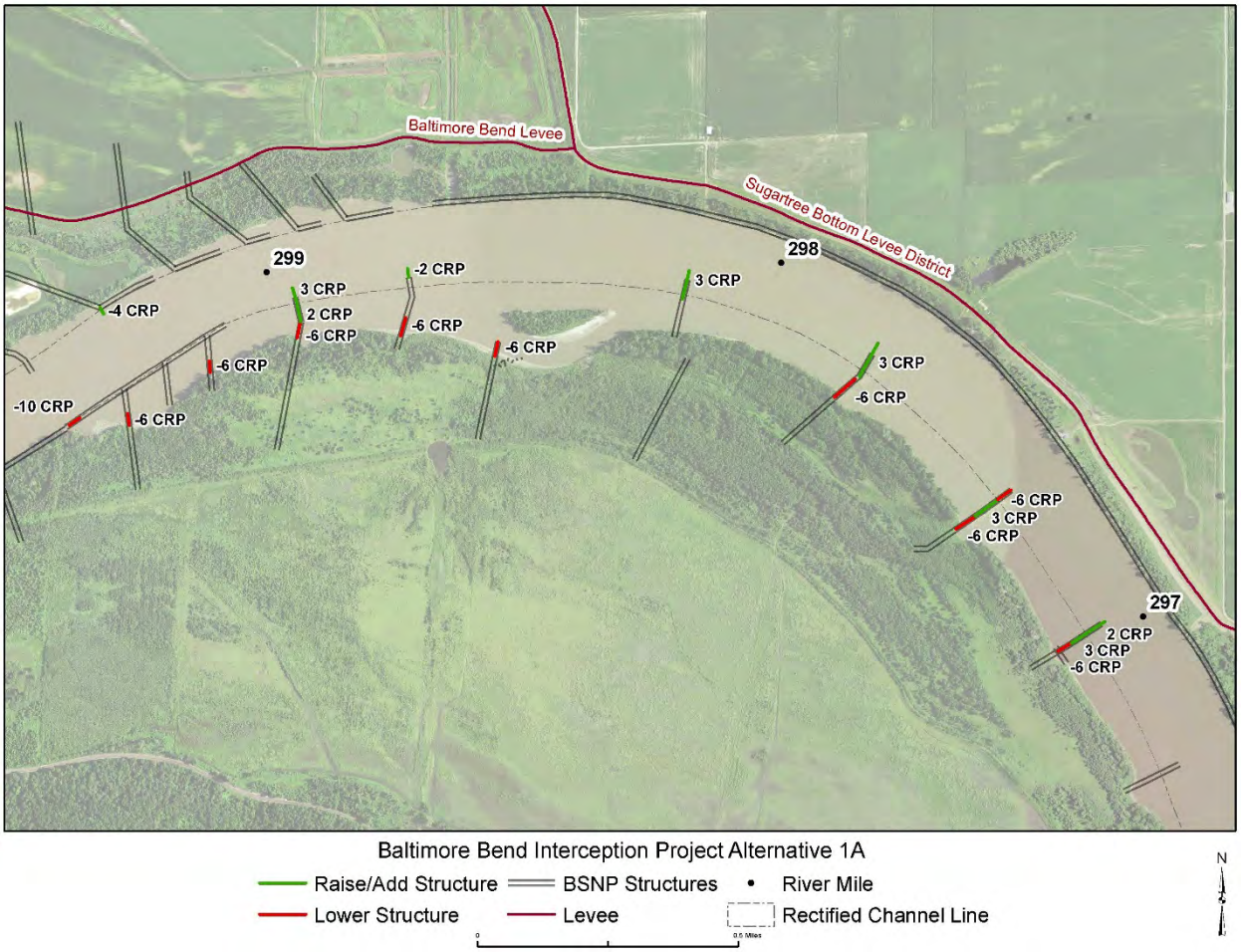

Figure 4: Alternative 1a of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

Alternative 1b of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This alternative will utilize dredging operations to accelerate the lowering and development of accessible marginal sand bed areas in order to reach the ultimate desired state of the geomorphology of the inside bend more quickly. See Figure 5.

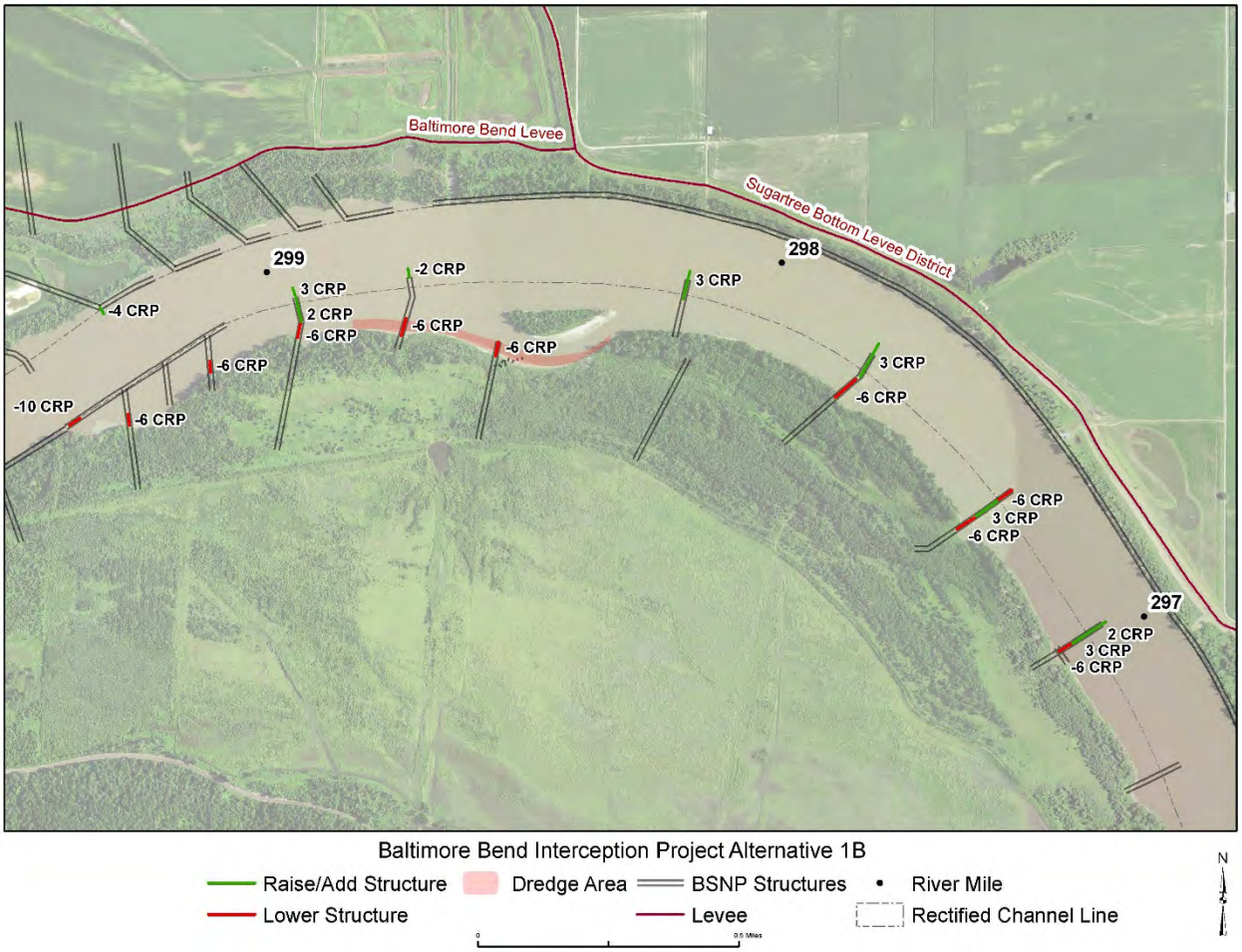

Figure 5: Alternative 1b of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

2.2.3 Alternative Concept 2

This concept includes the modifications of existing dike structures similar to Alternative 1 with the exception that the two furthest downstream dike structures from Alternative 1 are re-oriented at an angle with most of the existing structure removed. Alternative Concept 2 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Ten structure segments ranging from 115 feet to 680 feet long will be lowered to an elevation of six to ten feet below the CRP. Seven dikes will be extended 75 to 280 feet riverward at an elevation of -4 to +3 feet above/below the CRP. Three dike structure segments will be raised to an elevation of two to three feet above the CRP ranging from 200 to 260 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat. Also, the angled dike extensions are intended to direct water perpendicularly across the top of the structure towards the bank with the intent to create additional aquatic area and intercept larval sturgeon.

Alternative 2a of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This alternative will allow natural riverine processes to erode and lower the sand bed areas near the channel margin over time in order to reach the ultimate desired state of the geomorphology of the inside bend. See Figure 6.

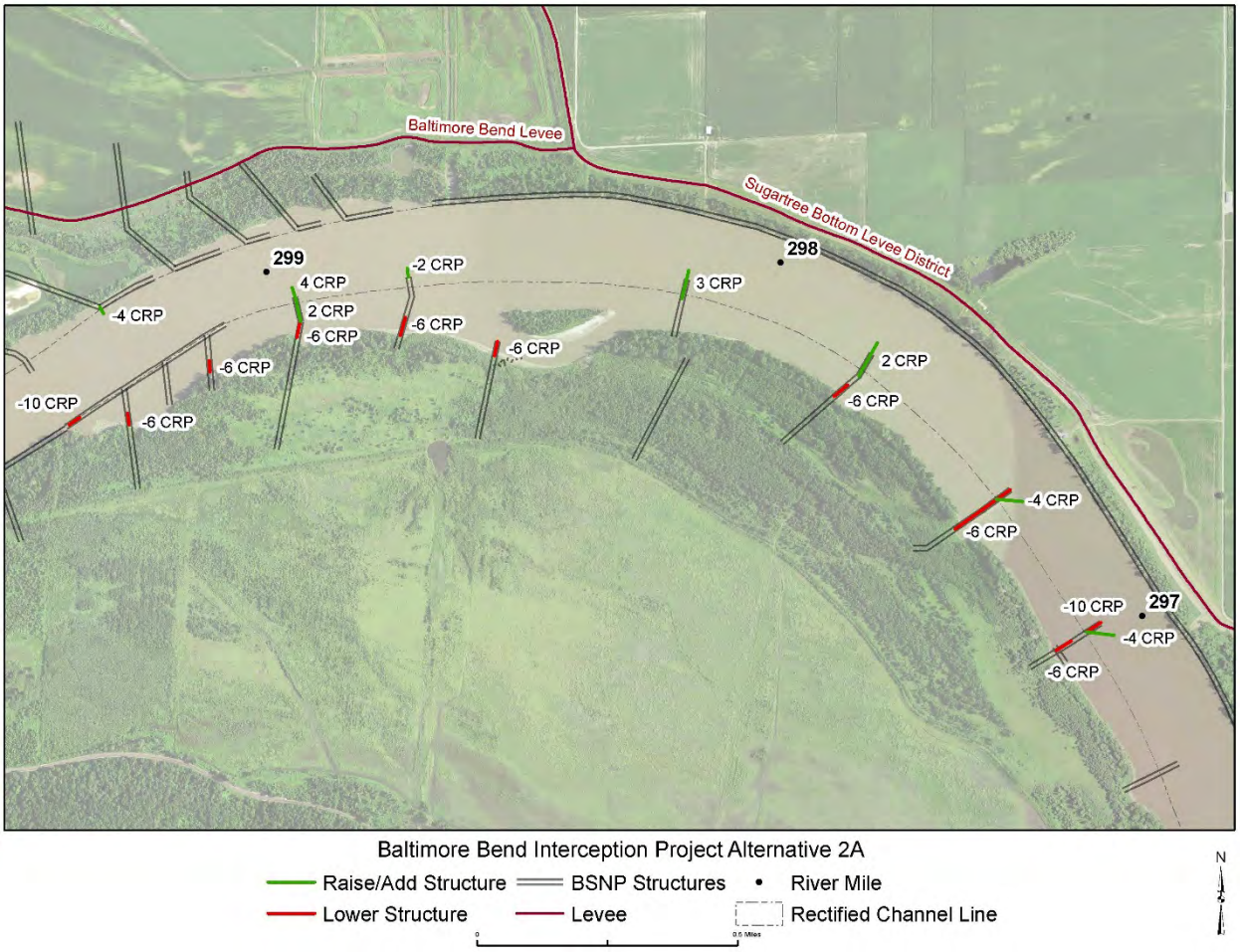

Figure 6: Alternative 2a of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

Alternative 2b of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This alternative will utilize dredging operations to accelerate the lowering and development of accessible marginal sand bed areas in order to reach the ultimate desired state of the geomorphology of the inside bend more quickly. See Figure 7.

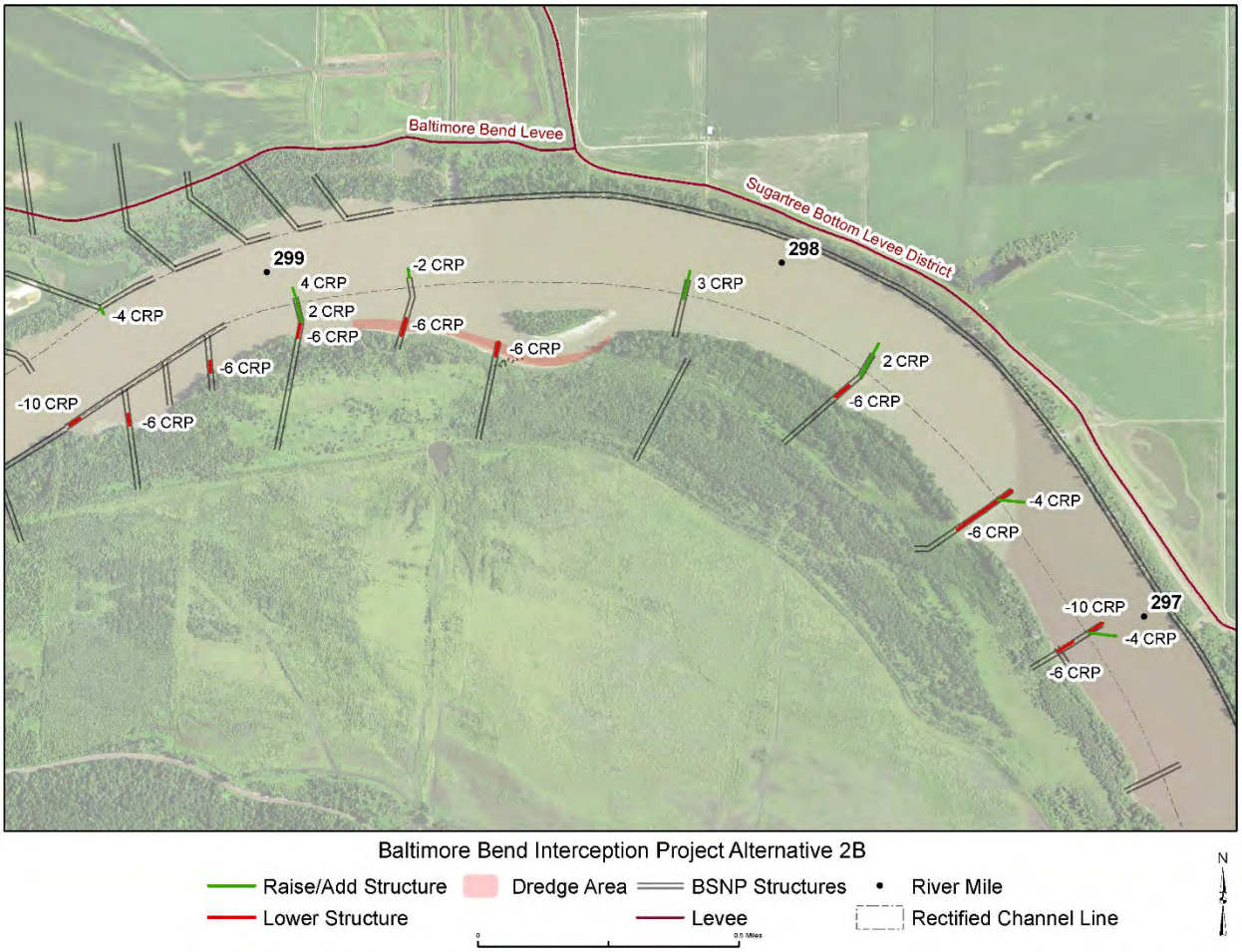

Figure 7: Alternative 2b of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

2.2.4 Alternative Concept 3

This concept includes the modifications of existing dike structures similar to Alternative 1 except the modifications differ in that all of the lowered portions of the dike structures are located on the most landward side of the structure with all of the raised portions located on the most riverside of the structures. Alternative Concept 3 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Nine structure segments ranging from 115 feet to 441 feet long will be lowered to an elevation of six to ten feet below the CRP. Six dikes will be extended 50 to 130 feet riverward at an elevation of -4 to +3 feet above/below the CRP. Five dike structure segments will be raised to an elevation of -2 to +3 feet below/above the CRP ranging from 200 to 260 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat. Also, lowering the landward portions of the structures while raising the riverward portions of the structure will provide additional aquatic area and increase interception potential for larval sturgeon.

Alternative 3a of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This alternative will allow natural riverine processes to erode and lower the sand bed areas near the channel margin over time in order to reach the ultimate desired state of the geomorphology of the inside bend. See Figure 8.

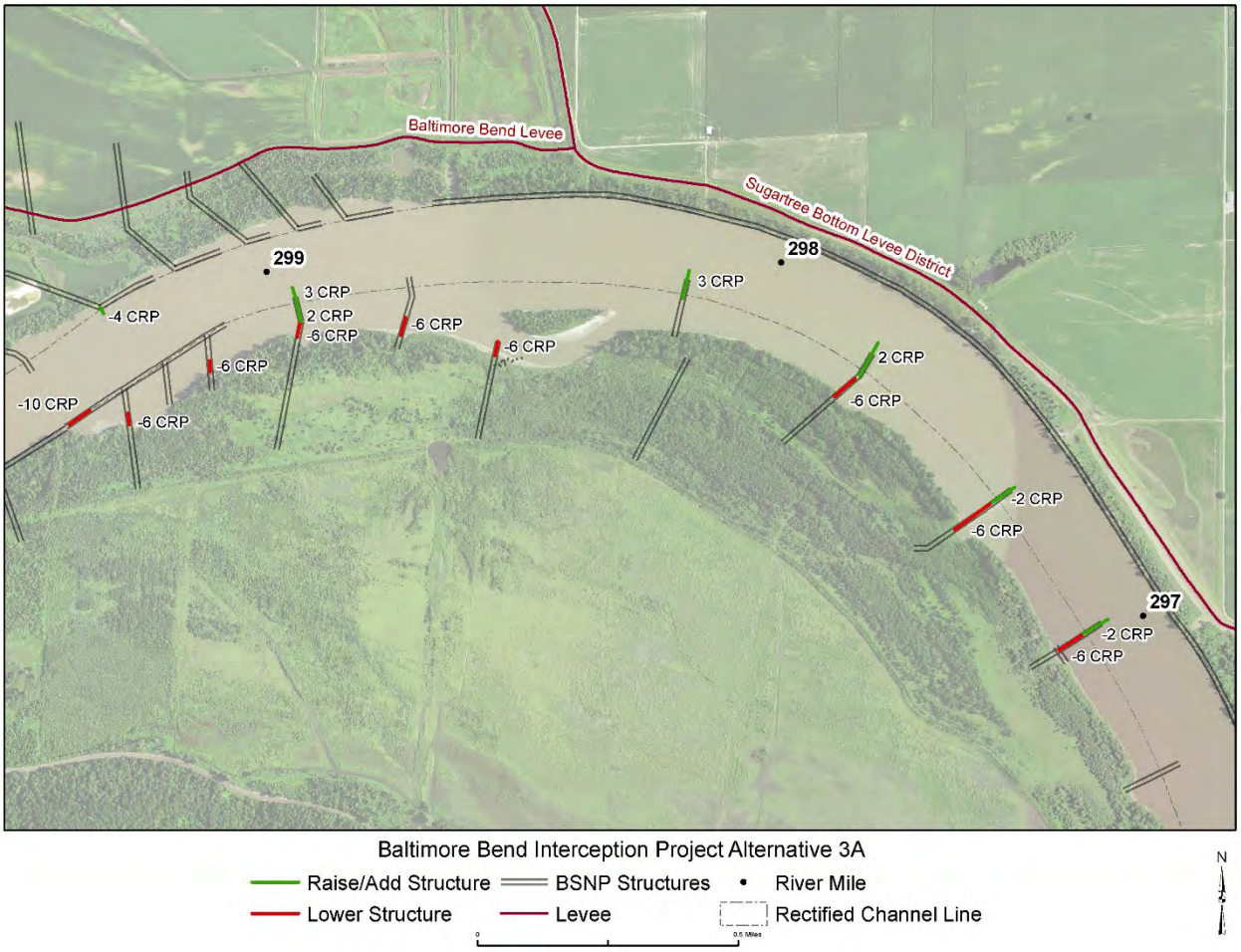

Figure 8: Alternative 3a of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

Alternative 3b of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This alternative will utilize dredging operations to accelerate the lowering and development of accessible marginal sand bed areas in order to reach the ultimate desired state of the geomorphology of the inside bend more quickly. See Figure 9.

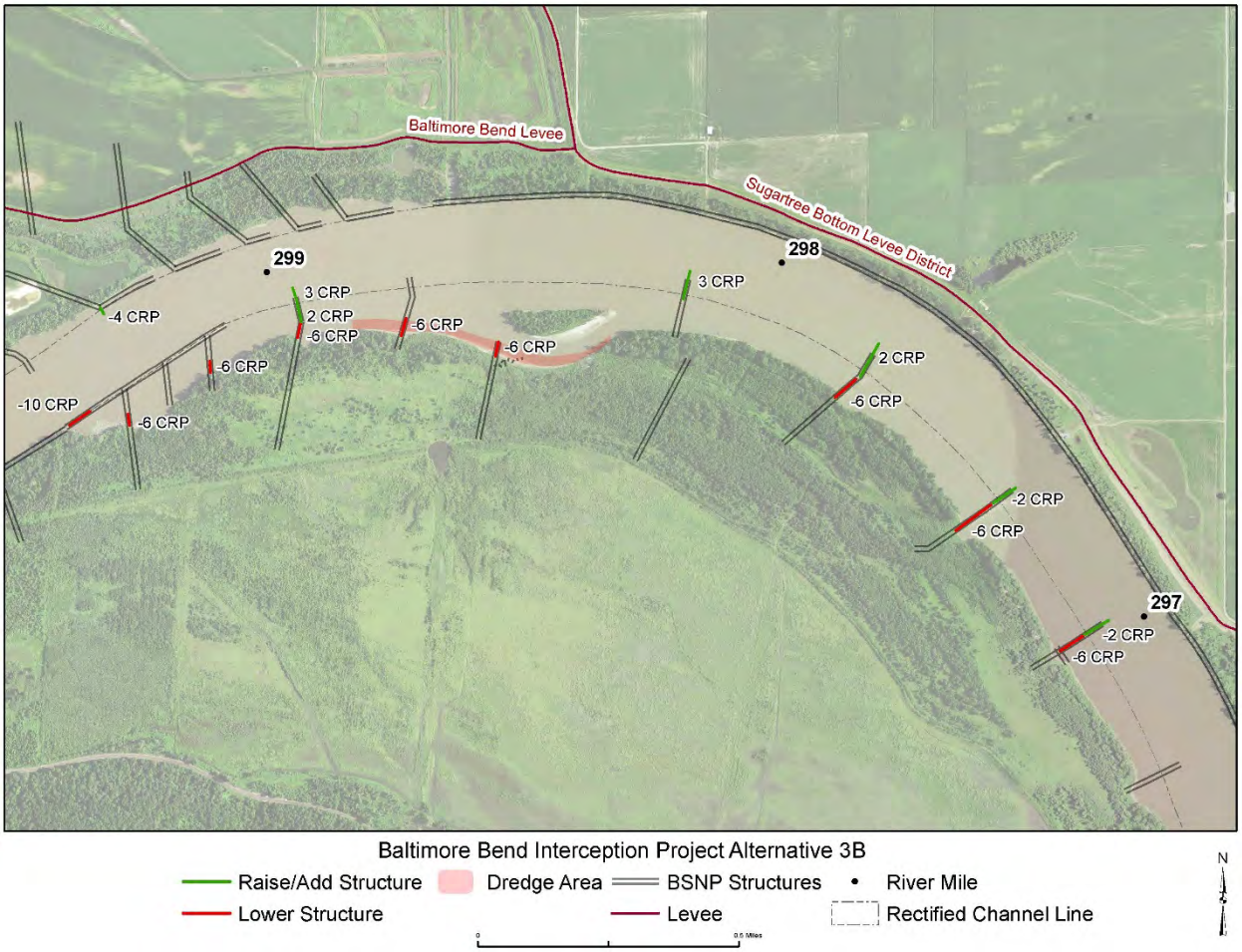

Figure 9: Alternative 3b of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

2.2.5 Alternative Concept 4

This concept includes the modifications of existing dike structures similar to Alternative 3, except one of the existing downstream structures is almost entirely removed. Alternative Concept 4 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Ten structure segments ranging from 115 feet to 350 feet long will be lowered to an elevation of six to ten feet below the CRP. Five dikes will be extended 75 to 130 feet riverward at an elevation of -4 to +2 feet above/below the CRP. Four dike structure segments will be raised to an elevation of two feet above the CRP ranging from 180 to 260 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat.

Alternative 4a of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This

alternative will allow natural riverine processes to erode and lower the sand bed areas near the channel margin over time in order to reach the ultimate desired state of the geomorphology of the inside bend. See Figure 10.

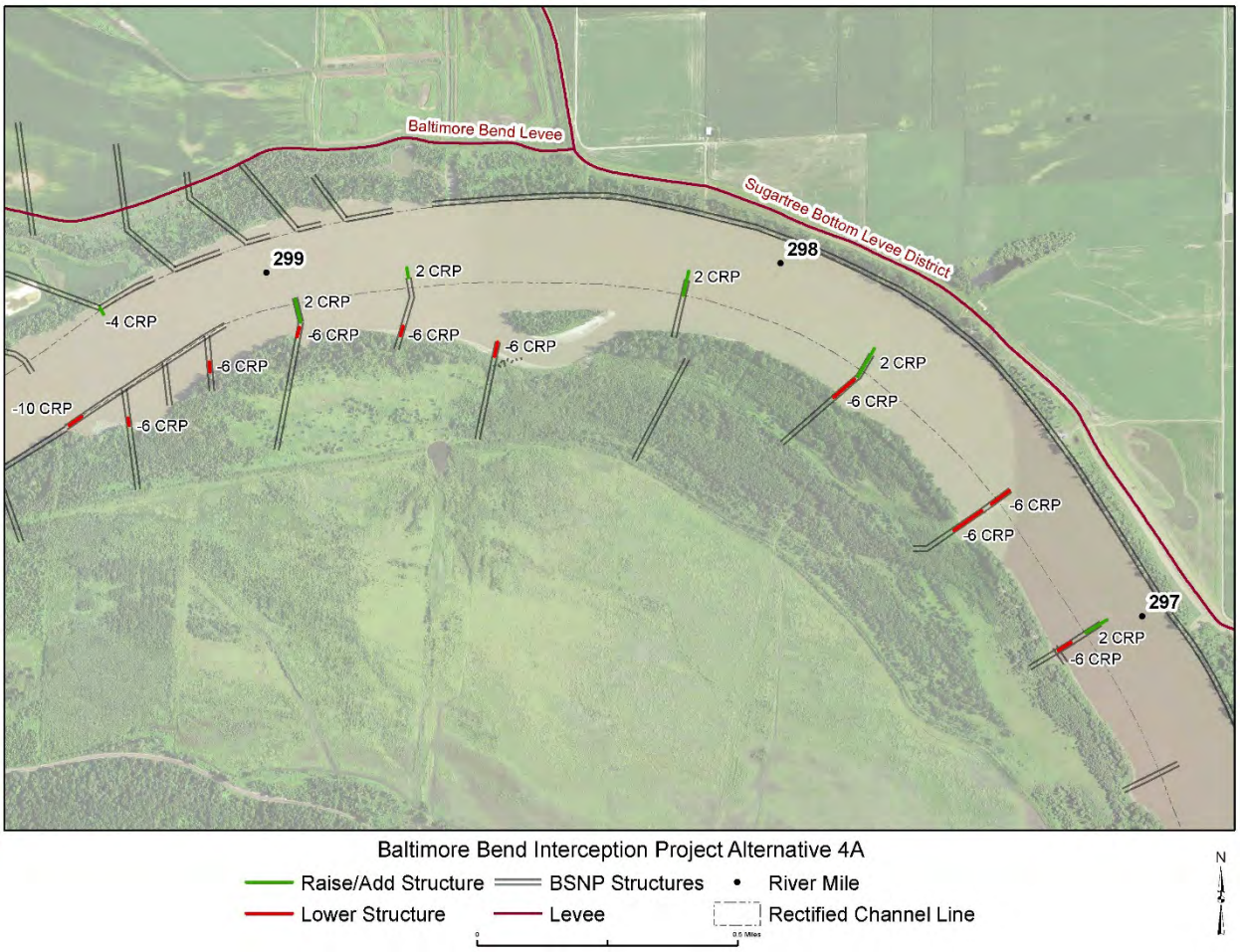

Figure 10: Alternative 4a of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

Alternative 4b of the Initial Array of Alternatives: This alternative consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes, as stated in the concept overview above. This alternative will utilize dredging operations to accelerate the lowering and development of accessible marginal sand bed areas in order to reach the ultimate desired state of the geomorphology of the inside bend more quickly. See Figure 11.

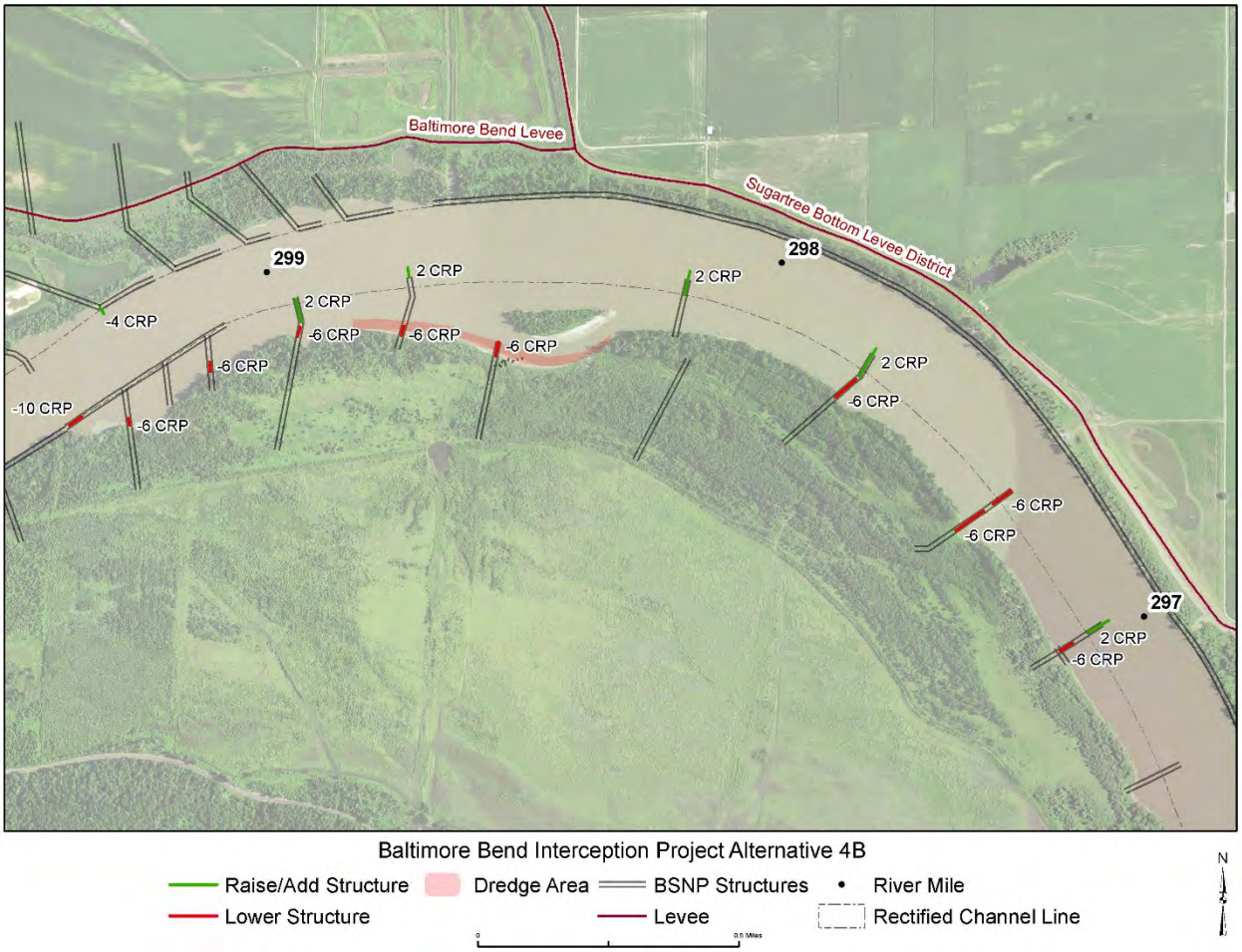

Figure 11: Alternative 4b of the initial array of alternatives. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

2.3 Evaluation of the Initial Array of Alternatives

The initial array of alternatives was evaluated using cost effectiveness and incremental cost analysis. Habitat benefits were determined by multiplying the estimated percentage of free floating particulates that would be intercepted from the thalweg of the river and transported to the channel margin by the area of suitable foraging habitat to provide interception rearing complex habitat units. Hydrodynamic modeling was used as a proxy to determine habitat suitability. Costs for each of the alternatives were also determined. A 50-year period of analysis was used to evaluate alternatives.

2.3.1 Habitat Benefits

There are currently not any biological models to quantitatively evaluate habitat suitability for free drifting embryos or larval sturgeon. The habitat requirements for these life stages of sturgeon are not well known. Although there is not a suitable biological model for sturgeon, a hydrodynamic model can be used to quantify the effectiveness of the alternatives to meet the project objectives described in Section 1.5 Goals and

Objectives. Specifically, alternatives were evaluated using a two-dimensional hydrodynamic model, Adaptive Hydraulics (ADH), version 4.5 developed by the USACE Engineering Research and Design Center, Coastal and Hydraulics Laboratory and the Particle Tracking Module (PTM) in Surface-Water Modeling System (SMS), version 11.2, developed by Aquaveo©. These analyses were used to evaluate depth, velocity magnitude, and velocity direction of various alternatives to meet the project objectives. Detailed information concerning the use of these tools, including assumptions, model calibration, and validation is included in Appendix C – Hydrodynamic Modeling.

Habitat benefits were determined by multiplying the estimated percentage of free floating particulates that would be intercepted from the thalweg of the river and transported to the channel margin by the area of suitable foraging habitat to provide interception rearing complex habitat units. Net average annual interception units (AAIU) were then determined over a 50-year period of analysis (Table 2).

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Table 2: Net average annual interception units (AAIU) for the initial array of alternatives

Initial Alternative	**Habitat Units (Year 0)**	**Habitat Units (Year 1)**	**Habitat Units (Year 2)**	**Habitat Units (Year 3)**	**Habitat Units (Year 4)**	**Habitat Units (Year 50)**	**Total AAIU**	**Net AAIU***
No-Action/Future Without-Project Condition	5.3	5.3	5.3	5.3	5.3	5.3	5.30	0.00
Initial Alternative 1a	5.3	5.8	6.4	6.9	7.5	7.5	7.41	2.11
Initial Alternative 1b	5.3	6.4	7.5	7.5	7.5	7.5	7.46	2.16
Initial Alternative 2a	5.3	6.3	7.4	8.4	9.4	9.4	9.24	3.94
Initial Alternative 2b	5.3	7.4	9.4	9.4	9.4	9.4	9.32	4.02
Initial Alternative 3a	5.3	6.2	7.1	8.0	8.9	8.9	8.76	3.46
Initial Alternative 3b	5.3	7.1	8.9	8.9	8.9	8.9	8.83	3.53
Initial Alternative 4a	5.3	6.1	7.0	7.9	8.7	8.7	8.56	3.26
Initial Alternative 4b	5.3	7.0	8.7	8.7	8.7	8.7	8.63	3.33

* Net AAIU = With-Project AAIU – Future Without-Project AAIU

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2.3.2 Cost

Preliminary cost estimates for each alternative were calculated as average annual costs over the 50-year period of analysis at the approved 2016 fiscal year interest rate of 3.125 percent. Items included in these estimates are various items associated with initial construction cost, annual operation maintenance, repair, replacement and rehabilitation, and annual monitoring costs. All estimates were based on experience from previous projects. See Table 3 for details concerning the total average annual cost estimates for each of the alternatives from the initial array.

Table 3: Total average annual costs for the initial array of alternatives.

Initial Alternative	First Cost (Includes Construction, Contingency, PED, and S&A)	Annualized First Costs	Annual OMRR&R	Annual Monitoring Costs for Adaptive Management	Total Average Annual Costs
No-Action/Future Without-Project Condition	$ -	$ -	$ -	$ -	$ -
1a	$2,084,100	$82,900	$10,500	$32,700	$126,100
1b	$3,921,000	$156,000	$10,500	$24,100	$190,600
2a	$1,934,000	$77,000	$13,600	$32,700	$123,300
2b	$3,764,500	$149,800	$13,600	$24,100	$187,500
3a	$1,941,200	$77,200	$12,500	$32,700	$122,400
3b	$3,766,700	$149,900	$12,500	$24,100	$186,500
4a	$1,920,500	$76,400	$11,800	$32,700	$120,900
4b	$3,744,400	$149,000	$11,800	$24,100	$184,900

Notes: 1) Costs are in FY16 price levels. 2) Average annual costs are calculated using FY16 interest rate of 3.125 percent and a 50-year period of analysis. 3) Interest during construction not calculated for the screening because the total durations for all alternatives are approximately one year or less.

2.3.3 Cost Effectiveness and Incremental Cost Analysis

Cost effectiveness and incremental cost analyses are valuable tools to assist in decision making when comparing the non-monetary benefits with the monetary costs of environmental plans. Cost effective alternatives are those in which no other alternative achieves a greater increase in net AAIU of IRC at a lesser cost. Best buy alternatives are the array of cost effective alternatives for which the average cost per incremental output of IRC is strictly increasing. Institute of Water Resources Planning Suite software was used to conduct cost effectiveness and incremental cost analysis.

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Alternatives were evaluated over a 50-year period of analysis. It was assumed that there would be no difference between the existing condition and the future without-project condition with regard to IRC because the river channel is stabilized by the BSNP. Each alternative was considered mutually exclusive from the others. This means that only one alternative could be implemented within the project area and that individual measures included in an alternative could not be added or subtracted to other alternatives.

From the initial array of nine alternatives, three were determined to be cost effective (Figure 12); this includes the No-Action/Future Without-Project Condition. Of the five cost effective alternatives, three were also best buy plans. The incremental cost per net AAIU ranged from $0 for the No-Action/Future Without-Project Condition to $803,000 for alternative 2b (Table 4 and Figure 13).

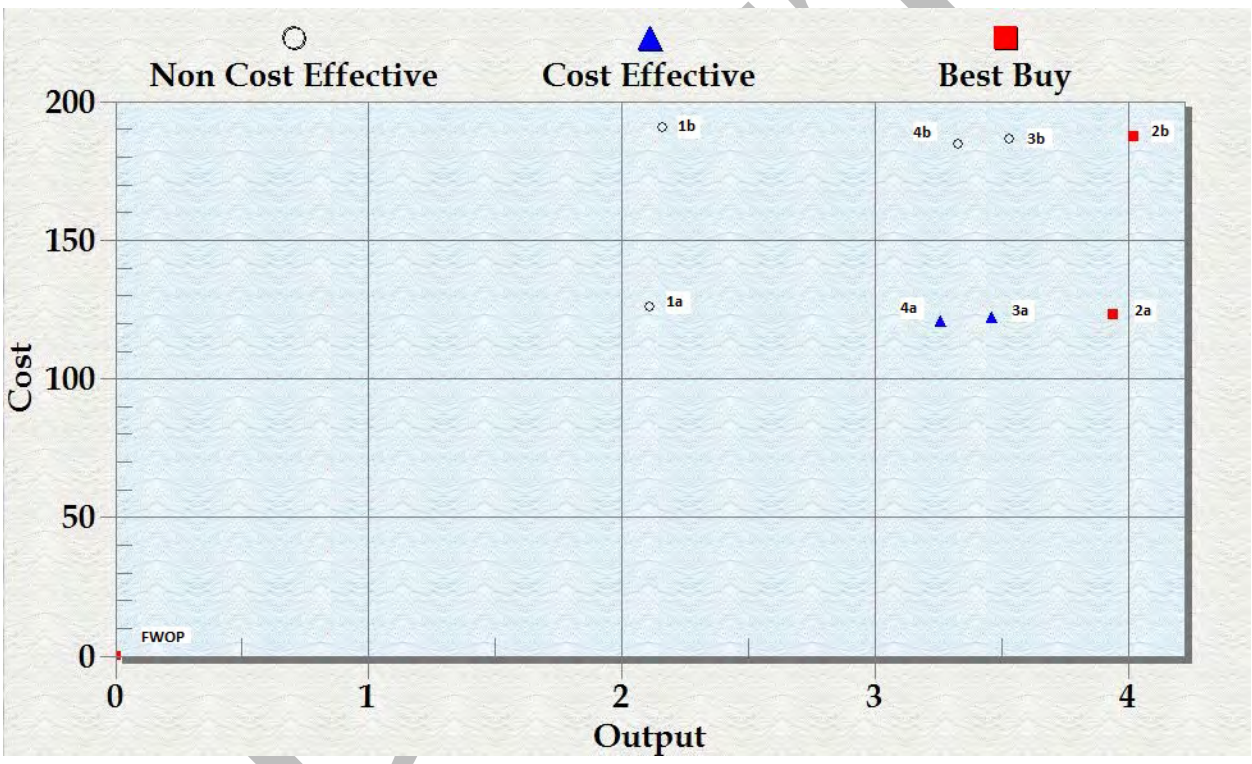

Figure 12: Identification of the cost effective (blue triangle) and best buy plans (red squares) from the initial array of 12 alternatives. Output units are net AAIU of IRC. Cost units are average annual in $1,000s.

Table 4: Incremental cost per net AAIU of IRC for the five best buy plans. All costs are average annual and in $1,000s.

Initial Alternative	Net AAIU	Average Annual Cost (1,000s)	Average Annual Costs (1,000s)/Net AAIU	Incremental Cost (1,000s)	Incremental Output (Net AAIU)	Incremental Cost (1,000s) Per Net AAIU
No-Action/ Future Without Project	0	$0.0	$0.0	$0.0	0.0	$0.0
Initial Alternative 2a	3.94	$123.3	$31.3	$123.3	3.94	$31.3
Initial Alternative 2b	4.02	$187.5	$46.6	$64.2	0.08	$803.0

* Discrepancy in numbers is due to rounding.

Figure 13: Incremental cost analysis for the best buy alternatives. Output units are net AAIU of IRC. Cost units are incremental average annual cost ($1,000s) per incremental AAIU.

2.4 Final Array of Alternatives

Each of the best buy alternatives was carried forward into the final array of alternatives without any additional modifications. For the final array of alternatives: Best Buy Plan 1 is the No-Action/Future Without-Project Condition, Best Buy Plan 2 – Modify Existing Dikes is alternative 2a from the initial array, Best Buy Plan 3 – Modify Existing Dikes with Sand Bed Removal is alternative 2b from the initial array. Based on information from the cost effectiveness and incremental cost analysis process, and an evaluation of potential impacts in Section 4 of this document, Best Buy Plan 2 was identified as the Recommended Plan. Detailed descriptions of each of the best buy plans in the final array of alternatives follow.

Best Buy Plan 1 – No-Action/Future Without-Project Condition

For the No-Action/Future Without-Project Condition, no new measures would be implemented to increase the amount of IRC. It was assumed that the existing conditions shown in Figure 14 would be maintained over the 50-year period of analysis. This is because the BSNP generally maintains the channel in a fixed location. The existing conditions have an interception ratio of 0.14 and 37.7 acres of foraging habitat, which equates to 5.3 AAIUs of IRC. This alternative serves as the baseline condition in which the other alternatives where compared. It would not meet the project objectives.

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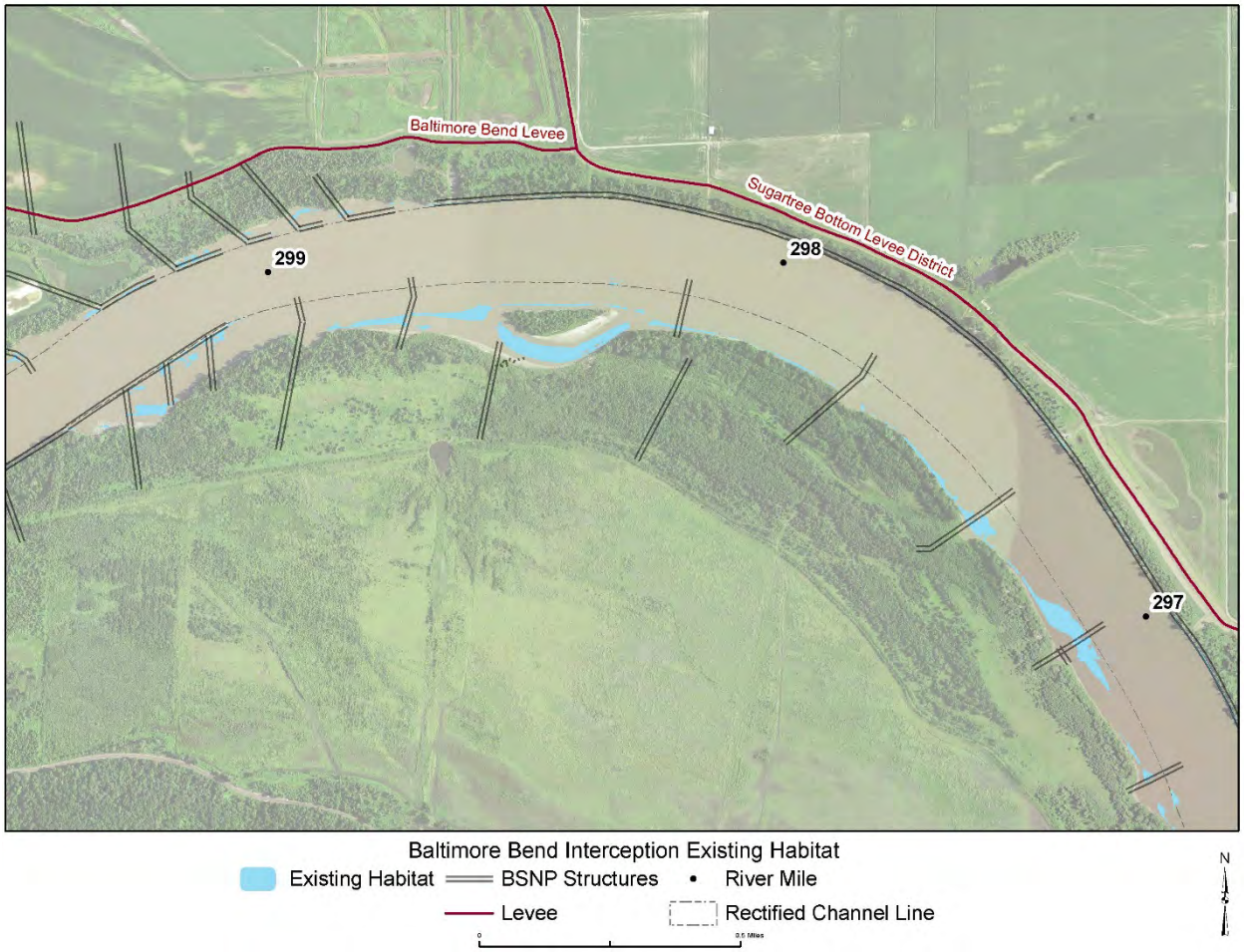

Figure 14: The No-Action/Future Without-Project Condition would not result in any changes to the amount of IRC at Baltimore Bend. There would be 5.3 AAIUs over the 50-year period of analysis.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan)

The Recommended Plan would result in an interception ratio of 0.181 and 52.1 acres of foraging habitat when fully developed. It would result in an additional 3.94 AAIUs of IRC compared to the No-Action/Future Without-Project Condition. It has an average annual cost of approximately $123,260. The average annual cost per AAIU is $31,300.

Habitat benefits would be obtained by removing portions of nine rock structures at locations A, B, C, D, E, F, G, H, I and J in Figure 15. Seven existing dikes would be extended in length and raised in height at locations 1, 2, 3, 4, 5, 6, and 7. These modifications were designed to maintain adequate flow to the navigation channel while directing flow to the channel margin to intercept free-drifting embryos and larval sturgeon. Over time, the flow directed towards the channel margin would erode portions of the existing sand bed to increase rearing habitat. It was assumed that this would occur over a four-year period, at which time the project would be considered fully developed. Four years is a reasonable time frame to assume for the project to reach full

development from introduction of the planned structures. The rate of development will largely depend on the flows experienced in the years following construction. Four years was assumed a conservative estimate, and full development will likely occur prior to four years. However, although the Missouri River is largely controlled and fixed by the BSNP, the river will change over time and changes are likely to occur after four years as well.

Approximately 10,600 cubic yards of rock, wood piling, sand, and wood or woven willow mattress removed from locations A, B, C, D, E, F, G, H, I and J would be spoiled in areas immediately downstream of the structure, reused for dike extensions, or beneficially placed along existing structures in need of repair on the left bank of the river. Approximately 20,400 cubic yards of rock would be used to extend and raise existing dikes. All construction would take place from a barge.

The sand material excavated from the river bed to construct the dikes would be integrated into the bedload of the Missouri River. Compared to the quantity of bedload material that is typically transported downstream by the Missouri River, the added amount of material would be insignificant. The Missouri River is a sand bed river that naturally transports large quantities of sand as bedload. Species that are native to the river are well suited to this environment.

Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

Best Buy Plan 3 would result in an interception ratio of 0.181 and 52.1 acres of foraging habitat when fully developed after a two-year period. It would result in an additional 4.02 AAIUs of IRC compared to the No-Action/Future Without-Project Condition. It has an average annual cost of approximately $188,000. Compared to Best Buy Plan 2, the average annual cost per AAIU for Best Buy Plan 3 is $46,700.

Habitat benefits would be obtained by removing portions of nine rock structures at locations A, B, C, D, E, F, G, H, I and J in Figure 15. Seven existing dikes would be extended in length and raised in height at locations 1, 2, 3, 4, 5, 6, and 7. These modifications were designed to maintain adequate flow to the navigation channel while directing flow to the channel margin to intercept free-drifting embryos and larval sturgeon. With this alternative, dredging of channel margin areas would accelerate the development of foraging habitat. Over time, the flow directed towards the channel margin would erode portions of the existing sand bed to increase foraging habitat. It was assumed that this would occur over a two-year period, at which time the project would be considered fully developed. Two years is a reasonable time frame to assume for the project to reach full development from introduction of the planned structures and dredging to “jump start” the development. The rate of development will largely depend on the flows experienced in the years following construction. Two years was assumed a conservative estimate, and full development will likely occur prior to four years. However, although the Missouri River is largely controlled and fixed by the BSNP, the river will change over time and changes are likely to occur after two years as well.

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Approximately 10,600 cubic yards of rock, wood piling, sand, and wood or woven willow mattress removed from locations A, B, C, D, E, F, G, H, I and J would be spoiled in areas immediately downstream of the structure, reused for dike extensions, or beneficially placed along existing structures in need of repair on the left bank of the river. In order to accelerate habitat development, approximately 195,000 cubic yards of sand would be dredged from the channel margin areas. The dredged sand would be returned to the river. Approximately 20,400 cubic yards of rock would be used to extend and raise existing dikes. All construction would take place from a barge.

The sand material excavated from the river bed to construct the dikes would be integrated into the bedload of the Missouri River. Compared to the quantity of bedload material that is typically transported downstream by the Missouri River, the added amount of material would be insignificant. The Missouri River is a sand bed river that naturally transports large quantities of sand as bedload. Species that are native to the river are well suited to this environment.

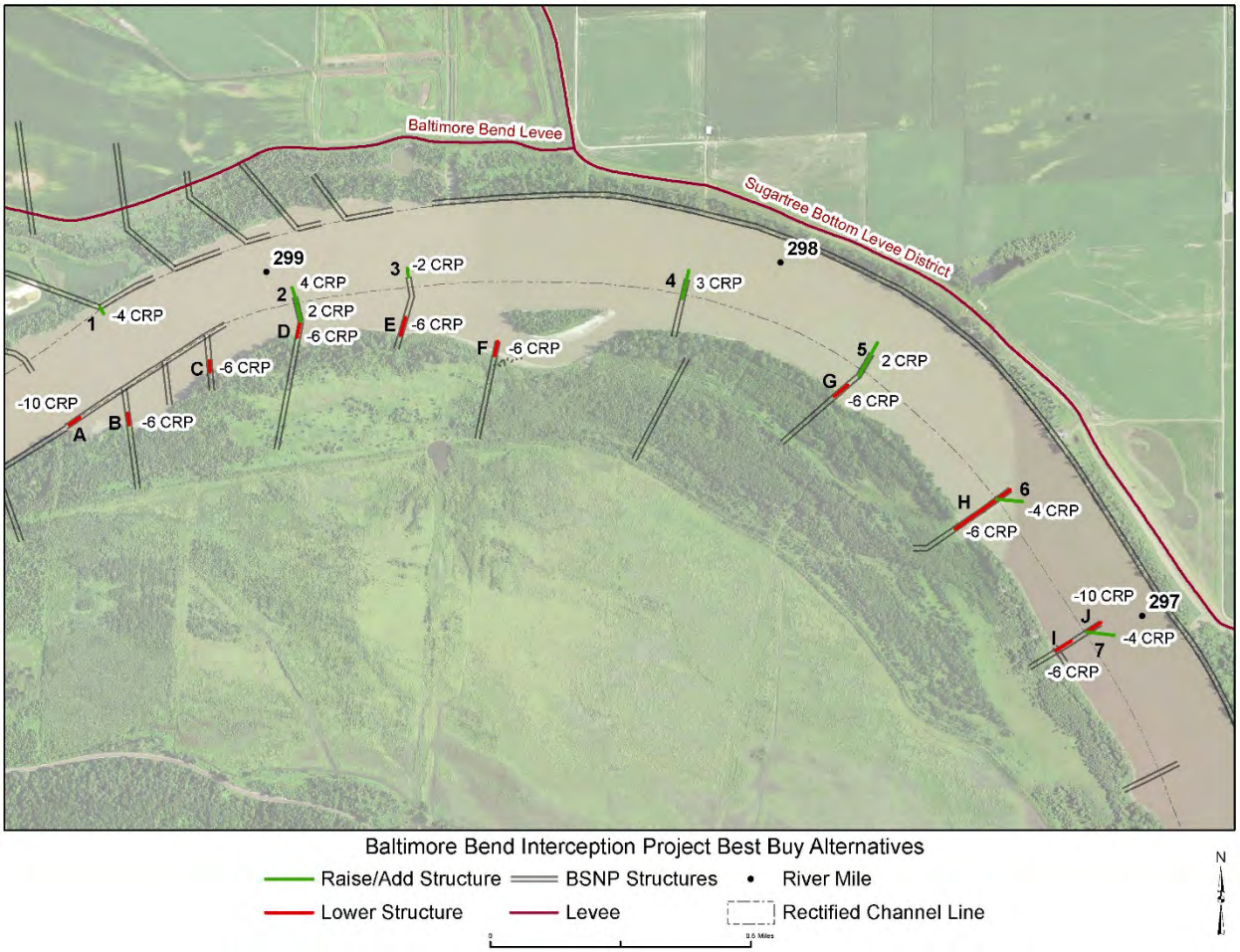

Figure 15: Best Buy Plans 2 & 3 would result in a net benefit of 9.24 AAIUs of IRC for an average annual cost of approximately $123,260 and 9.32 AAIUs of IRC for an average annual cost of approximately $187,501, respectively. Numbers with + or – in front represent the elevation in feet of the structure compared to the CRP.

2.5 Selection of the Recommended Plan

Potential environmental impacts of each of the alternatives was evaluated in Section 4 of this document. None of the alternatives would result in any significant direct, indirect, or cumulative adverse impacts to the human environment. Except for the No-Action/Future Without-Project Condition, each of the alternatives meets the project objectives and project constraints. Each alternative also meets the P&G criteria for completeness, effectiveness, efficiency, and acceptability. Completeness: the project will be complete and will not need further efforts outside project scope to function as intended. Effectiveness: is measured by the AAIU output. Efficiency: all of the plans evaluated are “Best Buy” plans. Acceptability: the plans will be in full compliance with applicable laws and policies. For these reasons, results from the cost effectiveness and incremental cost analysis was used as the primary tool to identify a recommended plan. Best Buy Plan 2: Alternative 2a – Modify Existing Dikes has been identified as the Recommended Plan. This alternative would result in a net benefit of 9.24 AAIUs with an average annual cost of approximately $123,300. The next best buy plan, Best Buy Plan 3, would result in a net benefit of 9.32 AAIU with an average annual cost of $187,500. It was determined that the additional habitat benefits (0.08 AAIUs) that would result from Best Buy Plan 3 were not worth the additional cost ($64,200 per year).

2.6 Physical and Biological Monitoring

The navigation year prior to construction, both physical and biological monitoring will occur at the project site. Following construction, the same monitoring methods will be used to determine if the project objectives have been met. Physical monitoring would consist of performing hydroacoustic depth and velocity surveys of the site at least twice per year following construction to monitor changes to the bed and variations in velocity from pre-construction conditions. Bathymetric surveys will be conducted with single-beam sonar and velocity measurements will be conducted with an acoustic Doppler current profiler. Conditions will be monitored to ensure depths and velocities are progressing in the desired direction to promote interception and increase foraging habitat as well as ensure that conditions in the main channel remain favorable for commercial navigation. Sediment will also be monitored either by physical sampling or side-scan sonar to assess how the bed sediment at the site is affected by the changes in hydrodynamics. In addition, sampling for free-drifting embryos and larval sturgeon will be conducted over multiple years to evaluate the effectiveness of the project to intercept free-drifting embryos and larval sturgeon.

3.0 Affected Environment

This section describes the affected environment within and surrounding the project

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area. It includes resources that have the potential to be affected by the proposed alternatives. Information was obtained from site visits, geographic information systems data, review of maps and aerial photography, coordination with other agencies, and previous reports.

3.1 Water Quality

The USACE maintains a water quality monitoring program for the Missouri River as part of the MRRP. The goals of the water quality program include: 1) Assess the chemical and biological variables of the mainstem river, tributaries, and created habitats relative to the mitigation, recovery, and restoration of the pallid sturgeon, other native fish species, and aquatic communities, and 2) Develop, establish and maintain a high quality, customer responsive, water quality program within the lower Missouri River basin. The water quality program conducts long-term fixed station ambient monitoring at locations on the mainstem of the river, investigative monitoring, and special studies.

Water quality parameters that are measured include total phosphorus, nitrate plus nitrite, ammonia, ortho-phosphorus, dissolved phosphorus, total Kjeldahl nitrogen, total suspended solids, suspended sediment concentration, total dissolved solids, total organic carbon, dissolved organic carbon, turbidity, chlorophyll A, total silica, and dissolved silica. Median concentrations of common water quality constituents are located in Table 5. The Baltimore Bend IRC project site is located approximately two miles upstream of the Waverly site. The Missouri River is listed on the Missouri 303(d) list of impaired waters for *Escherichia coli.*

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Table 5: Median concentrations of common water quality collected from the Missouri River between the years 2010 and 2014.

	Atchison, River Mile 423		Fort Osage, River Mile 340		Waverly, River Mile 294		Glasgow, River Mile 227		Marion, River Mile 160		Hermann, River Mile 98		Weldon Springs,* River Mile 50	
	Median	**Range**	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**
Total Phosphorus (mg/L)	0.33	0.05-2.4	0.37	0.1-2.3	0.35	0.09-2.1	0.38	0.091-2	0.385	0.11-1.8	0.34	0.11-1.4	0.3	0.12-1.9
Total Orthophosphate (mg/L)	0.087	0.024-0.24	0.12	0.053-0.21	0.115	0.052-0.21	0.1	0.059-0.24	0.099	0.056-0.49	0.087	0.05-0.2	0.09	0.026-0.16
Ammonia (mg/L)	0.056	0.01-0.32	0.09	0.03-0.29	0.068	0.01-.24	0.05	0.02-0.92	0.04	0.03-0.28	0.35	0.02-0.65	0.033	0.02-0.52
Nitrate/Nitrite (mg/L)	1.4	0.1-5.0	1.4	0.21-4.4	1.45	.22-4.7	1.2	0.2-3.8	1.3	0.17-4	0.98	0.12-3	0.9	0.1-2.9
Total Kjehldahl Nitrogen (mg/L)	0.9	0.2-8.4	1.1	0.2-6.7	1	0.25-6.7	1	0.22-6.4	1	0.33-4.6	0.89	0.38-3.6	0.78	0.35-4.2
Total Suspended Solids (mg/L)	128	25-4710	123	22.4-4140	160	28-3070	176	44-2660	203	32-1700	144	31.3-1410	132	23-1520

*Note: Water quality data was not collected at Weldon Springs in 2010.

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3.2 Wetland Resources

There are no wetlands within the project area. The project site is located within the Missouri River channel, a water of the United States. A CWA Section 404 authorization would be required for any activities that would occur below the ordinary high water mark.

3.3 Terrestrial Resources

No terrestrial resources exist within any of the proposed project footprints. The river banks are nearly vertical and range from approximately 15 to 20 feet high during typical flow conditions. The land adjacent to the project area was primarily formed from alluvium that has accreted since construction of the Missouri River BSNP.

3.4 Fish and Wildlife Resources

Fish and wildlife species present within the study area are typical of those described in the 2003 SEIS (USACE, 2003), available online at http://moriverrecovery.usace.army.mil /mrrp/f?p=136:183:0::NO::SITE_ID,PIS_ID:,#seis. Section 3.3.3 Wildlife and Section 3.3.4 Fisheries of this report are hereby incorporated by reference. Baltimore Bend provides habitat for numerous wildlife species. Additionally, the Missouri River Valley is an important nesting and feeding area within the Mississippi Flyway for many migratory birds and waterfowl species. Approximately one in every seven bird species in North America can be found along the lower Missouri River (Thogmartin, 2009).

3.5 Threatened and Endangered Species

The only federally listed threatened or endangered species that are known to occur in the Missouri River within the project area is the pallid sturgeon (Table 6). Two other federally listed species, least tern and piping plover, migrate through the area, although they are not known to nest anywhere nearby. Other federally listed threatened and endangered species located in Lafayette County, Missouri include the Indiana bat, northern long-eared bat, and rufa red knot. Areas immediately adjacent to the project area may provide suitable roosting and maternity habitat for Indiana bat and northern long-eared bat. Although not identified on USFWS county lists as being located in Lafayette County, the federally endangered gray bat may also utilize the area. Rufa red knot (an extremely rare migratory bird), is not known to be in the immediate vicinity of the project area. Additional wildlife coordination can be found in Appendix G.

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Table 6: Federally listed threatened and endangered species with potential to occur in the vicinity of the project area.

Common Name	**Scientific Name**	**Federal Status**
Pallid Sturgeon	*Scaphirhynchus albus*	Endangered
Indiana bat	Myotis sodalis	Endangered
Northern long-eared bat	Myotis septentrionalis	Threatened
Gray bat	*Myotis grisescens*	Endangered
Least Tern	*Sterna antillarum*	Endangered
Piping Plover	*Charadrius melodus*	Threatened

The adult pallid sturgeon generally occurs in the main channel of the large, turbid, free flowing Missouri River, in the lower segments of some major tributaries. Modification of the natural Missouri River hydrograph, habitat loss, fish migration blockage, pollution, hybridization, and over harvesting are likely responsible for pallid sturgeon decline (USFWS, 1993).

The Indiana bat is an endangered species that has experienced serious population declines due to habitat loss, human disturbance, and disease. Indiana bats hibernate in caves during winter and roosts in trees with loose bark in the spring and summer. The loss of wetland and riparian habitat along the Missouri River has contributed to the loss of foraging and roosting habitat for this species.

The northern long-eared bat has recently been listed as a threatened species under the Endangered Species Act. Northern long-eared bats have been experiencing rapidly declining populations due to white nose syndrome, a fungal pathogen. During winter this species of bat is known to hibernate in caves and abandoned mines. Summer habitat is not well defined, but it is believed that roosting habitat includes dead or live trees and snags with cavities, peeling or exfoliating bark, split tree trunk and/or branches. Foraging habitat includes upland and lowland woodlots and tree lined corridors. Occasionally, they may roost in structures like barns and sheds.

Gray bats live in caves year-round. They feed on flying insects present along rivers and lakes. It is expected that gray bats may use the study area for foraging.

Although no longer listed under the Endangered Species Act, the bald eagle is protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The bald eagle is commonly found as both a resident population and in higher concentrations as winter migrants in the project area. Bald eagles commonly nest along the Missouri River. USFWS reported no bald eagle nests in or adjacent to the Baltimore Bend project area. There was a nest previously reported approximately four miles upstream, along the riparian corridor of the left descending bank of the Missouri River. Bald eagles utilize large trees along the

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Missouri River for nesting, roosting, and foraging perches. Bald eagles primarily feed on fish and migratory waterfowl.

3.6 Invasive Species

Invasive species have the potential to displace native plants and animals. In accordance with Executive Order 13122, federal agencies may not authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species. Invasive aquatic species that are a concern in Missouri which have the potential to be introduced into new water bodies as a result of contaminated construction equipment include zebra mussels, quagga mussels, New Zealand mudsnails, purple loosestrife, and Eurasian watermilfoil. Common invasive fish species on the lower Missouri River include the common carp, goldfish, grass carp, silver carp, bighead carp, and western mosquitofish. It is important to note that the project is located along the Missouri River. Transport of invasive species by the river is common. Furthermore, natural erosion and deposition of material along the river can result in conditions that are susceptible to becoming established with invasive plants.

3.7 Cultural Resources

Cultural resources are defined as any area of past human activity, occupation, or use, identifiable through inventory, historical documentation, or oral evidence. Cultural resources include, but are not limited to, archeological sites, buildings or structures, cemeteries, and Native American resources including sacred sites and traditional cultural properties. Background research of the project areas were conducted to determine if any previously recorded cultural resources were present within or near them. This research included a review of the National Register of Historic Places (NRHP), the MDNR Archaeological Viewer (on-line), and pertinent cultural resource reports and shipwreck location maps on file at the NWK. The cultural resources review found no previously recorded cultural sites in the project area.

3.8 Population and Income

Baltimore Bend is located in Lafayette County, Missouri. The estimated population of Lafayette County was 32,688 people in 2014 (U.S. Census Bureau, 2014). The county experienced a population decrease of two percent from 2010 to 2014. The population of Lafayette County was roughly 94 percent white. Other ethnicities included black or Native American, Asian, and Hispanic. The median household income in Lafayette County was $51,195. This is more than the median income for the State of Missouri was $47,764 (U.S. Census Bureau, 2014).

The age distribution of Lafayette County were also similar to the State of Missouri. Approximately 20 to 25 percent of the population was younger than 18

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years old. Approximately 15 to 20 percent of the population was older than 65. The closest community to Baltimore Bend is the town of Waverly, Missouri located approximately miles from the project. The 2014 population estimate for the city was 849. The closest larger city is Higginsville, Missouri, located about 25 miles away. It had an estimated population of approximately 5,300 in 2014 (U.S. Census Bureau, 2014).

3.9 Recreation

The Missouri River is important to recreational users in the region. Baltimore Bend is located close to Waverly, Missouri. Recreational users of the Missouri River enjoy fishing, boating, canoe/kayaking, and camping. Baltimore Bend is located in an area that is a natural stopover for migratory birds. This provides additional opportunity for bird watching.

3.10 Navigation

The Missouri River from Sioux City, Iowa to its confluence with the Mississippi River just upstream of St. Louis, Missouri, a distance of 735 miles, is maintained and operated by USACE under the authority and in accordance with requirements of the Missouri River BSNP. Congress has directed USACE to maintain a nine-foot deep by 300-foot wide navigation channel along this portion of the river. In addition, the Missouri River flows are managed and operated in part, for commercial navigation on the Missouri River. Navigation on the Missouri River is limited to the normal ice-free season, with a full-length flow support season of eight months (USACE, 2001).

3.11 Flood Risk Management

There is an extensive flood risk management system (i.e., levees and dams) along the Missouri River. Levees near the property include the Baltimore Bend Levee District and Sugartree Bend Levee District. These districts are located directly on the opposite sides of the Missouri River adjacent to the projects location. No building structures, roads, or utilities exist within the project area.

3.12 Air Quality

Air quality in a given location is described by the concentrations of various pollutants in the atmosphere. The quality of the air is measured against National Ambient Air Quality Standards (NAAQS) set by the EPA. Baltimore Bend is located in an attainment area, which is an area wherein the concentrations of all criteria pollutants meet the NAAQS.

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4.0 Environmental Consequences

This section evaluates potential direct and indirect impacts to the human environment of each of the five best buy plans. The concept of "significance" used in this section considers context and intensity. Duration is also considered when evaluating potential impacts.

4.1 Water Quality

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Conditions would not adversely affect water quality. It would not result in any changes to the existing water quality of the Missouri River.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan)

The Recommended Plan may result in short-term minor impacts to water quality during project construction. There would likely be localized temporary increases to water turbidity. Based on the quantity of material that would be moved or placed below the ordinary high water mark, these impacts would be less than any of the other alternatives except for the No-Action/Future Without-Project Condition. The Recommended Plan would not result in any State of Missouri water quality standards being exceeded. Approximately 19,000 tons of rock, obtained from a commercial source, would be used to construct the dike extensions and additions. The rock would contain minimal fines and would be free of any harmful contaminants. Approximately 11,000 cubic yards of material excavated from the existing dikes would be placed in various spoil locations including deep scours downstream of the existing dikes, along the left revetment of the river bank, and newly constructed extensions and additions if the quality of excavated rock is suitable for reuse.

The Recommended Plan would be in full compliance with CWA Section 404(b)(1) Guidelines. A draft Section 404(b)(1) Evaluation for the Recommended Plan is included in Appendix D. A CWA Section 401 water quality certification is being requested at this time (Appendix E). Best Management Practices would be implemented to reduce construction related impacts. Based on these facts, it has been determined that this alternative would not result in any significant impacts to water quality of the Missouri River.

Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

Best Buy Plan 3 may result in short-term minor impacts to water quality during project construction. There would likely be localized increases to water turbidity.

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Based on the quantity of material that would be moved or placed below the ordinary high water mark, these short-term minor impacts would be greater than the Recommended Plan. However, it would not result in any State of Missouri water quality standards being exceeded. Approximately 19,000 tons of rock, obtained from a commercial source, would be used to construct the dike extensions and additions. The rock would contain minimal fines and would be free of any harmful contaminants. Approximately 11,000 cubic yards of material excavated from the existing dikes would be placed in various spoil locations including deep scours downstream of the existing dikes, along the left revetment of the river bank, and newly constructed extensions and additions if the quality of excavated rock is suitable for reuse.

Roughly 195,000 cubic yards of mostly sand material would be dredged from below the ordinary high water mark in the areas upstream and landward of the existing island. This material would be placed in the channel in a manner in which it would disperse downstream. It would not result in a net increase in material below the ordinary high water mark. This is a minimal amount of material compared to the amount of material that enters the Missouri River by natural processes on an annual basis. It has been documented by Gosch *et al.* (2013) that construction of MRRP projects on the Missouri River have not resulted in any significant impacts to water quality or exceeded state water quality criteria. If this alternative were selected for implementation, a CWA Section 404 authorization and a CWA Section 401 water quality certification would be obtained prior to project construction.

4.2 Wetland Resources

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would not result in any adverse impacts to wetland resources. No wetlands exist within or adjacent to the project area.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

Neither of these plans would result in any adverse impacts to wetland resources. No wetlands exist within or adjacent to the project area. As described in Section 4.1, the Recommended Plan would be in full compliance with CWA Section 404(b)(1) Guidelines. A draft Section 404(b)(1) Evaluation for the Recommended Plan is included in Appendix D.

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4.3 Terrestrial Resources

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would not result in any significant impacts to terrestrial resources. It is not expected that there would be any significant changes to terrestrial resources outside the project footprint would occur because of the Missouri River BSNP.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

Neither of these alternatives would result in any significant adverse impacts to terrestrial resources. No terrestrial resources are located in the project construction footprint.

4.4 Fish and Wildlife Resources

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would not result in any significant impacts to fish or wildlife resources at Baltimore Bend. Existing habitat conditions would remain relatively the same as a result of the BSNP stabilizing the river.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan)

The Recommended Plan is expected to benefit fish and other aquatic resources. The project is expected to promote interception and retention of free-drifting embryos and larval sturgeon in areas hypothesized to be appropriate rearing habitat, with sufficient prey for first feeding and for growth through the juvenile life stage. This plan would result in an interception ratio of 0.181 and 52.1 acres and foraging habitat when fully developed. It would result in an additional 3.94 AAIUs of IRC compared to the No-Action/Future Without-Project Condition. Even though this project is designed to help test the interception hypothesis not for habitat improvement, it is expected that an incidental benefit could be an improvement of the habitat in the project area due to increased flow diversity.

The sand material excavated from the river bed to construct the dikes would be integrated into the bedload of the Missouri River. Compared to the quantity of bedload material that is typically transported downstream by the Missouri River, the added amount of material would be insignificant. The Missouri River is a sand bed river that naturally transports large quantities of sand as bedload. Species that are native to the river are well suited to this environment.

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This alternative may result in minor short-term impacts to fish and wildlife during project construction. This would result from physically disturbing the river and noise from construction equipment. Fish and wildlife are expected to move from areas of disturbance during project construction. They would likely return after the project has been constructed. Benthic invertebrates would be disturbed and lost within the footprint of the dredging and material placement, however, new populations of invertebrates would be expected to repopulate the area following construction. No significant impacts to fish and wildlife are expected with this plan.

Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

Best Buy Plan 3 would result in an interception ratio of 0.181 and 52.1 acres and foraging habitat when fully developed. It would result in an additional 4.02 AAIUs of IRC compared to the No-Action/Future Without-Project Condition.

Best Buy Plan 3 is expected to have similar impacts to fish and wildlife resources as the Recommended Plan.

4.5 Threatened and Endangered Species

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would not have beneficial or negative impacts on any threatened and endangered species. At this location, there would not be any actions taken to avoid jeopardy to pallid sturgeon in accordance with the 2003 Amendment to the Biological Opinion. The hypothesis that re-engineering the Missouri River channel morphology in select reaches will increase channel complexity and serve specifically to promote interception and retention of free-drifting embryos and larval sturgeon in areas with sufficient prey for first feeding and for growth through the juvenile life stage would not be tested at this location.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan)

The Recommended Plan may affect but is not likely to adversely affect pallid sturgeon. Although incidental to the project purpose, any impacts to pallid sturgeon would be beneficial. The project is expected to promote interception and retention of free-drifting embryos and larval sturgeon in areas with sufficient prey for first feeding and for growth through the juvenile life stage. This alternative would result in an interception ratio of 0.181 and 52.1 acres and foraging habitat when fully developed. It would result in an additional 3.94 AAIUs of IRC compared to the No-Action/Future Without-Project Condition.

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This alternative would have no affect on Indiana bat, northern long-eared bat, or gray bat. The project is not located in the immediate vicinity of any caves and would not impact any trees used by these species. It would also have no affect on least tern, piping plover, or rufa red knot. These species may migrate through the region but are not known to utilize the project area.

Bald eagles are not expected to be impacted by the Recommended Plan. There are no known nests in the immediate vicinity of the project area. The nearest known nest is located approximately four miles away.

Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

Best Buy Plan 3 would have similar impacts to threatened and endangered species as the Recommended Plan. This alternative would result in an interception ratio of 0.181 and 52.1 acres and foraging habitat when fully developed. It would result in an additional 4.02 AAIUs of IRC compared to the No-Action/Future Without-Project Condition.

4.6 Invasive Species

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would have no impact on the spread of invasive species. It would not promote or prevent the spread of any invasive species.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

None of the best buy plans are expected to spread invasive species to new locations. During project construction, all equipment would be required to be free of invasive species to prevent the spread of these species to new locations. All construction activities are expected to take place from a barge. Specific measures will be included in the construction contract that requires inspection and washing of all equipment that will be used during construction. All equipment will be required to be dried if coming from another water body. The primary invasive species within the Missouri River are Asiatic carp. These species are not typically transported to new locations by construction equipment. However, all construction equipment will be required to be dried following project construction before being used on another water body. For these reason, these plans would not result in the spread of invasive species.

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4.7 Cultural Resources

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would have no affect on any historic property or cultural resource within or adjacent to the project area.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

The Recommended Plan would have no affect on any cultural resources. The project is located on accreted lands formed from construction of the BSNP and is not likely to contain any cultural resources. The Missouri State Historic Preservation Officer (SHPO) concurred with this determination in a letter dated May 4, 2016 (Appendix F). If any cultural resources were encountered during project construction, all construction would be halted and the Missouri SHPO would be notified as soon as possible in order to determine the appropriate course of action.

4.8 Population and Income

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would involve no construction activity. Therefore, no impacts to populations or income in the project area are anticipated.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

None of the best buy plans would adversely affect the makeup of the local population or their current income levels. Minor, short-term benefits from increases in local income could be realized as a result of construction activities. No adverse impacts to facilities, services, or nearby communities are expected under this alternative. The proposed project does not have a disproportionate adverse on minorities, low-income residents, or other environmental justice populations. The project is completely within the banks of the Missouri River and will modify existing structures without impacting adjacent properties based on the results of the 2-dimensional hydrodynamic modeling. See Appendix C – Hydrodynamic Modeling for details.

4.9 Recreation

Best Buy Plan 1 – No-Action/Future Without-Project Condition

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The No-Action/Future Without-Project Condition would have no adverse impacts on recreation.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

These two alternatives would have minimal temporary adverse impacts on recreation related to construction activities. There would be no significant long-term adverse impacts to recreation or aesthetics from these alternatives. For safety reasons, the public would have restricted access from work zone areas during construction.

4.10 Navigation

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would not result in any significant adverse impacts to navigation.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

These plans would not adversely impact navigation. Seven BSNP dikes would be extended or raised and nine rock structures would be removed, however project designs would not impact the authorized navigation channel. See Appendix C – Hydrodynamic Modeling for details. Remobilization of sediment from excavation and/or dredging activities is not expected to cause any shoaling.

4.11 Flood Risk Management

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action/Future Without-Project Condition would not result in adverse impacts to flood risk management.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

The Recommended Plan would not adversely impact the Baltimore Bend Levee or Sugartree Bottom Levee located immediately adjacent to the outside bend of the river. It would not adversely impact water surface elevations. See Appendix C – Hydrodynamic Modeling for details.

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4.12 Air Quality

Best Buy Plan 1 – No-Action/Future Without-Project Condition

The No-Action Alternative would not experience any construction related air quality effects and would not result in any changes to the existing air quality.

Best Buy Plan 2: Alternative 2a – Modify Existing Dikes (Recommended Plan); Best Buy Plan 3: Alternative 2b – Modify Existing Dikes with Sand Bed Removal

The project site is in an NAAQS attainment zone. This alternative would have negligible impact air quality impacts from construction activities such as rock placement and excavations. These temporary impacts would have relatively low emission levels and any air pollutants are expected to disperse quickly. No significant adverse impacts to air quality are expected from these plans.

4.13 Summary of Effects

A comparison of potential environmental, socioeconomic, and cultural resources impacts for each of the best buy plans is included in Table 7.

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Table 7: Summary of potential impacts from each of the best buy plans.

Resource Category	Best Buy Plan 1 (No-Action)	Best Buy Plan 2 (Recommended Plan)	Best Buy Plan 3
Water Quality	No impact	Short-term minor impacts resulting from localized increases in turbidity during construction.	Short-term minor impacts resulting from localized increases in turbidity during construction.
Wetland Resources	No impact	No impact	No impact
Terrestrial Resources	No impact	No impact	No impact
Fish and Wildlife Resources	No impact	Long-term minor benefits	Long-term minor benefits
Threatened and Endangered Species	No affect	Pallid sturgeon: May affect but not likely to adversely affect. Potential benefits. All others: No affect	Pallid sturgeon: May affect but not likely to adversely affect. Potential benefits. All others: No Affect
Invasive Species	No impact	No impact	No impact
Cultural Resources	No affect	No affect	No affect
Population and Income	No impact	Short-term minor beneficial impacts to income from construction activity	Short-term minor beneficial impacts to income from construction activity
Recreation	No impact	Short-term minor impact resulting from lack of accessibility during construction	Short-term minor impact resulting from lack of accessibility during construction
Navigation	No impact	No impact	No impact
Flood Risk Management	No impact	No impact	No impact
Air Quality	No impact	No impact	No impact

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4.14 Cumulative Impacts

The CEQ Regulations defines cumulative impacts as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time” (CEQ, 1997). The cumulative impacts addressed in this document consist of the impacts of multiple actions that result in similar effects on the natural resources. The geographical areas of consideration are actions located downstream of Rulo, Nebraska within/along the lower Missouri River.

Past Actions: Past actions that have significantly impacted the Missouri River include the Mainstem Reservoir System, the BSNP, and land use changes. Impacts from these activities are documented in the Missouri River Fish and Wildlife Mitigation Iowa, Nebraska, Kansas, and Missouri Final Feasibility Report and Final Environmental Impact Statement (FEIS) (USACE, 1981) and the Missouri River Bank Stabilization Fish and Wildlife Mitigation Project SEIS (USACE, 2003) and are being incorporated by reference. Since the supplemental environmental assessment was prepared in 2003, 24 shallow-water habitat projects have been constructed in Kansas and Missouri to benefit pallid sturgeon and other native aquatic species. It has not yet been documented that these projects provide significant benefits to the population of pallid sturgeon.

Present and Future Actions: Cumulative effects of the Missouri River Bank Stabilization Fish and Wildlife Mitigation Project, of which the project is a part, were discussed in the SEIS prepared in 2003 and are being incorporated by reference (USACE 2003). The SEIS is available online at http://moriverrecovery.usace.army.mil/mrrp/f?p=136:183. Other projects will be completed over the next several years to benefit pallid sturgeon. These may include modifying other existing side channels or the main channel to benefit pallid sturgeon. Future project will be more defined in the Missouri River Recovery Management Plan (Management Plan) and Environmental Impact Statement (EIS) discussed more below.

Since the SEIS was prepared in 2003, additional projects and studies that have the potential to result in cumulative impacts with the Recommended Plan have been undertaken. These other projects or studies include the Missouri River Commercial Dredging FEIS and Record of Decision, the Management Plan and Environmental Impact Statement, and the Missouri River Bed Degradation Integrated Feasibility Study and EIS.

The Missouri River Commercial Dredging FEIS and Record of Decision for Authorization of Commercial Sand and Gravel Dredging on the Lower Missouri River were prepared in 2011 as part of an evaluation for a CWA Section 404

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permit application by commercial sand and gravel mining entities to profitably obtain aggregate from the bed of the Missouri River to supply the region's construction and manufacturing needs (USACE, 2011). The Record of Decision limited the amount of aggregate that could be mined from the Missouri River and initiated an adaptive management approach in order to limit degradation, or down cutting, of the river bed and lowering of water surface elevations. As described in these documents, there was information that suggested commercial sand and gravel mining is a contributing cause to the degradation of the river bed in some locations, resulting in impacts to infrastructure. Additional information is available at http://www.nwk.usace.army.mil/Missions/RegulatoryBranch/MissouriRiverCommercialDredging.aspx.

The Management Plan and EIS is an ongoing effort to evaluate the effectiveness of current habitat development and recommend any needed modifications to more effectively create habitat and avoid jeopardy to pallid sturgeon, least terns, and piping plovers. It is being led by USACE and USFWS. Additional information is available online at http://moriverrecovery.usace.army.mil/mrrp/f?p=136:70:0::NO.

The Missouri River Bed Degradation Integrated Feasibility Study and EIS is another ongoing study within the Lower Missouri River. The purpose of the study is to develop a complete, effective, efficient, and acceptable plan to avoid additional economic impacts to federal, state, and local infrastructure resulting from the degradation of the Missouri River. The geographic scope of the study extends along the Missouri River from approximately Waverly to St. Joseph Missouri. Additional information about the study is available online at http://www.marc.org/Environment/Water-Resources/Missouri-Riverbed-Degradation/About

In addition to the three projects or studies mentioned, it is also expected that USACE may undertake other similar projects to Baltimore Bend IRC project in the future. It is expected that approximately 6 IRC pilot sites would be constructed for the necessary hypothesis testing. However, at this time, the extent of such projects is not known. More certainty will exist at such time the Draft Management Plan and EIS is finished. This is expected to be later in 2016. Other activities that have the potential to contribute to cumulative impacts are discussed as applicable for individual resource categories.

Cumulative Impact Assessment: Only resource categories that would result in at least minor impacts as a result of implementing the Recommended Plan are considered for the cumulative impact assessment. See Table 7. It is assumed that the Recommended Plan would not result in any cumulative impacts to resources. The resource categories considered for cumulative impacts include water quality, fish and wildlife, threatened and endangered species, population and income, and recreation.

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Water Quality: In the past, there have been public concerns that sediment contributions to the Missouri River from MRRP projects may adversely impact water quality and also contribute to hypoxia in the Gulf of Mexico. However, a study by the National Research Council (NRC) concluded that given the "relatively small volumes of sediment loadings" from MRRP projects on the Missouri River, "it is not appropriate to relate changes in the areal extent of the hypoxic zone to sediment and nutrient loadings" to these projects (NRC, 2011). . Also, there have been long-term declines in suspended sediment loads on the lower Missouri River (Blevins, 2006). Additional analysis by Heimann, et al. (2014) indicate that from 1993-2012 the total phosphorous loads from side channel construction accounted for only 1.9 percent of Missouri River and 0.5 percent of Mississippi River total phosphorus loads. Nitrate, the constituent most closely related to gulf hypoxia, was 0.01 percent or less of the Missouri and Mississippi River nitrate loads in the Gulf. The authors also estimated that sediment volumes from side channels, during 1993-2012, accounted for 3.1 percent and 1.5 percent of total suspended sediment loads from the Missouri and Mississippi Rivers respectively.

The Missouri River Commercial Dredging FEIS considered MRRP projects, such as the Recommended Plan, when evaluating cumulative impacts. It was stated in the EIS that "there appears to be little potential for cumulative impacts on nutrient loading and little likelihood of effects on waters meeting water quality standards" as a result of commercial sand and gravel mining (USACE, 2011). Furthermore, it is not anticipated that actions that may result from the Management Plan or the Bed Degradation Study would contribute to significant adverse cumulative impacts to water quality. These studies will also include an evaluation of any cumulative impacts. It is not expected that the Recommended Plan would result in any adverse cumulative impacts when considered with other past, present, and future projects.

Fish and Wildlife: Since the 2003 SEIS was prepared, there have been large scale improvements to fish and wildlife habitat along the Lower Missouri River. It is expected that these projects have resulted in increases to fish and wildlife populations, and increases species diversity. In addition to MRRP, other large scale efforts to improve fish and wildlife habitat include the Big Muddy National Fish and Wildlife Refuge operated by USFWS, the Wetland Reserve Program operated by the NRCS, public and private land management programs of the MDC, habitat restoration and preservation activities of the MDNR, and other efforts undertaken by individuals on private lands to benefit fish and wildlife resources. The Recommended Plan will provide a benefit to fish and wildlife resources by improving habitat diversity. It is not expected that the Recommended Plan would result in any adverse cumulative impacts when considered with other past, present, and future projects.

Threatened and Endangered Species: The Recommended Plan may affect, but is not likely to adversely affect pallid sturgeon. It may provide beneficial effects to pallid sturgeon. Information learned from this project may be used in the future as

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part of the MRRP to increase the population of pallid sturgeon. The Recommended Plan is not expected to result in any adverse impacts to pallid sturgeon populations when considered with other present and future actions described elsewhere in this section. No other threatened or endangered species would be affected by the project.

Population and Income: The Recommended Plan may result in minor short-term increases in local income as a result of construction activities. This minor project benefit is not expected to result in any cumulative impacts when considered with other past, present, and future actions described elsewhere in this section due to the short term nature of the impact during construction.

Recreation: The Recommended Plan would not result in long-term impacts to recreation. It is not expected that any of the other potential projects described elsewhere in this section would result in negative impacts to recreation. Therefore, the Recommended Plan is not expected to result in any cumulative impacts to recreation.

For reasons discussed in this section, the Recommended Plan would not result in any adverse cumulative impacts to the human environment.

5.0 Conclusions and Recommendations

The Recommended Plan would result in an additional 3.94 AAIUs of IRC for hypothesis testing compared to the No-Action/Future Without-Project Condition. This would result in a minor long-term benefit to fish and wildlife that potentially includes the federally threatened pallid sturgeon. The project would result in minor short-term impacts to water quality resulting from localized increases in turbidity during construction. There may be minor beneficial impacts to local income as a result of construction activities. The Recommended Plan would result in a minor short-term adverse impacts to recreation during construction, but it will not result in long-term impacts. It would not contribute to the spread of invasive species. It would not result in any impacts to wetlands, cultural resources, navigation, flood risk management, or air quality.

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6.0 Compliance with Environmental Quality Statutes

Compliance with environmental laws is listed in Table 8.

Table 8: Compliance with Environmental Quality Statutes.

Federal Policy	**Compliance[a]**
Archeological Resources Protection Act, 16 U.S.C. 470, et seq.	Not Applicable
Bald and Golden Eagle Protection Act of 1940, 16 U.S.C. 668-668d, et seq.	Full Compliance
Clean Air Act, as amended, 42 U.S. C. 7401-7671g, et seq.	Full Compliance
CWA (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Full Compliance
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Not Applicable
Endangered Species Act, 16 U.S.C. 1531, et seq.	Full Compliance
Environmental Justice (Executive Order 12898)	Full Compliance
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not Applicable
Farmland Protection Policy Act, 7 U.S.C. 4201, et. seq.	Full Compliance
Federal Water Project Recreation Act, 16 U.S.C. 4601-12, et seq.	Full Compliance
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Full Compliance
Floodplain Management (Executive Order 11988)	Full Compliance
Invasive Species (Executive Order 13122)	Full Compliance
Land and Water Conservation Fund Act, 16 U.S.C. 4601-4, et seq.	Not Applicable
Marine Protection Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	Not Applicable
Migratory Bird Treaty Act, as amended, 16 U.S.C. 703-712	Full Compliance
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full Compliance
National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470a, et seq.	Full Compliance
Protection & Enhancement of the Cultural Environment (Executive Order 11593)	Full Compliance
Protection of Wetlands (Executive Order 11990)	Full Compliance
Rivers and Harbors Act, 33 U.S.C. 403, et seq.	Full Compliance
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	Full Compliance
Wild and Scenic River Act, 16 U.S.C. 1271, et seq.	Not Applicable

NOTES: [a]. Not applicable. No requirements for the statute required: compliance for the current stage of planning;

Full compliance. Having met all requirements of the statute for the current stage of planning (either preauthorization or post authorization).

Partial compliance. Not having met some of the requirements that normally are met in the current stage of planning.

Noncompliance. Violation of a requirement of the statute.

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7.0 Preparers

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APPENDIX A

Public Notice

PUBLIC NOTICE

US Army Corps of Engineers

Permit No. 2016-00912
Issue Date: June 23, 2016
Expiration Date: July 22, 2016

Kansas City District

30-Day Notice

JOINT PUBLIC NOTICE: This public notice is issued jointly with the Missouri Department of Natural Resources, Water Pollution Control Program. The Missouri Department of Natural Resources will use the comments to this notice in deciding whether to grant Section 401 water quality certification. Commenters are requested to furnish a copy of their comments to the Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, Missouri 65102.

APPLICANT: U.S. Army Corps of Engineers – Kansas City District 601 East 12th Street
Kansas City, MO 64106-2896

PROJECT LOCATION (As shown on the attached drawings): The proposed project, Baltimore Bend Interception Rearing Complex Project, is located on approximately seven miles west of Waverly, Missouri within the banks of the Missouri River extending from about mile 300.1 to 296.5. The project is adjacent to Baltimore Bottoms which is owned by USFWS as part of the Big Muddy National Fish and Wildlife Refuge. See Figures 1 and 2.

AUTHORITY: The project would be completed under the authority of the Missouri River Fish and Wildlife Mitigation Project (Mitigation Project) from Water Resource Development Acts (WRDA) of 1986, 1999, and 2007. The proposed action is regulated by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act (33 USC 1344).

ACTIVITY (As shown on the attached drawings): PROPOSED WORK: Since 2004, USACE has been taking numerous actions to avoid jeopardy to pallid sturgeon on the lower Missouri River that were included in the recommended and prudent alternative from the 2003 Amendment to the Biological Opinion. These actions have included maintaining a stocking (propagation) program for pallid sturgeon, limited testing of flow modifications, and construction of shallow-water habitat. Shallow-water habitat construction has primarily consisted of notching select BSNP dikes along the river and

constructing side channels across inside bends of the Missouri River in locations where the federal government owned sufficient land to construct such features. To date, there have not been strong indications that pallid sturgeon are successfully recruiting to reproductive age naturally in the lower Missouri River. When the 2003 Amendment to the Biological Opinion was prepared, there was limited scientific knowledge about the ecological needs of pallid sturgeon. Today, knowledge about the ecologic needs of this species is still not complete. However, much has been learned since the 2003 Amendment to the Biological Opinion was prepared. The goal of this project is to determine if increasing interception rearing complexes increases the catch rate of age-0 sturgeon at this location. The objective of the project is to create hydraulic conditions to intercept free-drifting embryos and larval sturgeon from the channel thalweg into the channel margins where water depths are one to three meters and velocities are 0.5 to 0.7 meters per second.

The Recommended Plan would result in an interception ratio of 0.181 and 52.1 acres of foraging habitat when fully developed. It would result in an additional 3.94 average annual interception units of interception rearing complex above the no-action plan. Habitat benefits would be obtained by removing portions of nine rock structures at locations A, B, C, D, E, F, G, H, I and J in Figure 3. Seven existing dikes would be extended in length and raised in height at locations 1, 2, 3, 4, 5, 6, and 7. These modifications were designed to maintain adequate flow to the navigation channel while directing flow to the channel margin to intercept free-drifting embryos and larval sturgeon. Over time, the flow directed towards the channel margin would erode portions of the existing sand bed to increase rearing habitat. It was assumed that this would occur over a four-year period, at which time the project would be considered fully developed. Four years is a reasonable time frame to assume for the project to reach full development from introduction of the planned structures. The rate of development will largely depend on the flows experienced in the years following construction. Four years was assumed a conservative estimate, and full development will likely occur prior to four years. However, although the Missouri River is largely controlled and fixed by the BSNP, the river will change over time and changes are likely to occur after four years as well.

Approximately 10,600 cubic yards of rock, wood piling, sand, and wood or woven willow mattress removed from locations A, B, C, D, E, F, G, H, I and J would be spoiled in areas immediately downstream of the structure, reused for dike extensions, or beneficially placed along existing structures in need of repair on the left bank of the river. Approximately 20,400 cubic yards of rock would be used to extend and raise existing dikes. All construction would take place from a barge (Figure 3).

The sand material excavated from the river bed to construct the dikes would be integrated into the bedload of the Missouri River. Compared to the quantity of bedload material that is typically transported downstream by the Missouri River, the added amount of material would be insignificant. The Missouri River is a sand bed river that naturally transports large quantities of sand as bedload. Species that are native to the river are well suited to this environment.

The proposed action would not result in any negative impacts to any adjacent private property. The proposed action would meet the objectives of increasing interception rearing habitat for hypothesis testing. If this plan were selected for implementation, detailed engineering plans and specifications would be developed that could result in minor modifications to the quantities presented herein. The project may be constructed in phases over several years depending on the availability of funding.

WETLANDS/AQUATIC HABITAT: There are no wetlands within the project area. The project site is located within the Missouri River channel.

APPLICANT'S STATEMENT OF AVOIDANCE, MINIMIZATION, AND COMPENSATORY MITIGATION FOR UNAVOIDABLE IMPACTS TO AQUATIC RESOURCES: The proposed project has been designed to incorporate all practicable measures to avoid, minimize, and mitigate unavoidable adverse impacts to aquatic resources while still meeting the project purpose.

ADDITIONAL INFORMATION: Additional information about this application may be obtained by contacting Mr. Rick Morrow, Biologist, U.S Army Corps of Engineers, Kansas City District, ATTN: Environmental Resources Section, 601 East 12th Street, Kansas City, Missouri 64106, by email at rick.morrow@usace.army.mil, or by telephone at (816)389-3073. All comments to this public notice should be directed to the above address.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1968, as amended:
A draft environmental assessment, titled Baltimore Bend Interception Rearing Complex Project and a Section 404(b)(1) evaluation is available online at:
http://www.nwk.usace.army.mil/Media/PublicNotices/PlanningPublicNotices.aspx

The Corps has made a preliminary determination that the proposed project would not result in any significant impacts to the human environment and therefore the proposed project would support a Finding of No Significant Impact (FONSI). The Corps will utilize comments received in response to this Public Notice to complete the evaluation of the project in compliance with the requirements of NEPA, Section 404 of the Clean Water Act, and other Federal, state, and local regulations. The Corps has made a preliminary determination that the proposed project would not be contrary to the public interest and is in compliance with the Section 404(b)(1) Guidelines. The Draft Section 404(b)(1) Evaluation is included as Appendix C in the draft environmental assessment.

CULTURAL RESOURCES: An archeological background review of the project area was conducted that included an examination of the National Register of Historic Places on-line (NRHP), the Missouri Department of Natural Resources Archeological Viewer, and pertinent cultural resource reports and shipwreck location maps on file at the Kansas City District.

The Recommended Plan would be expected to have no affect on any cultural

resources. The project will be within the channel of the Missouri River. The Missouri State Historic Preservation Officer concurred with USACE determination that there would be no historic properties affected in a letter dated May 4, 2016. If cultural materials were encountered during project activities, all construction would be halted and the State Historic Preservation Officer would be notified as soon as possible in order to determine the appropriate course of action.

ENDANGERED SPECIES: The proposed action would be within the channel of the Missouri River. USACE has determined that the Recommended Plan will have no effect on the federally listed Indiana bat, gray bat, and northern long-eared bat. The Recommended Plan may affect but is not likely to adversely affect pallid sturgeon. Although incidental to the project purpose, any impacts to pallid sturgeon would be beneficial. The USFWS concurred with this determination in an email dated 21 March 2016 (Appendix G). In order to complete an evaluation of this activity, comments are solicited from the U.S. Fish and Wildlife Service and other interested agencies and individuals.

FLOODPLAINS: This activity is being reviewed in accordance with Executive Order 11988, Floodplain Management, which discourages direct or indirect support of floodplain development whenever there is a practicable alternative. By this public notice, comments are requested from individuals and agencies who believe the described work will adversely impact the floodplain.

WATER QUALITY CERTIFICATION: Section 401 of the Clean Water Act (33 USC 1341) requires that all discharges of dredged or fill material must be certified by the appropriate state agency as complying with applicable effluent limitations and water quality standards. This public notice serves as an application to the state in which the discharge site is located for certification of the discharge. The discharge must be certified before a Department of the Army permit can be issued. Certification, if issued, expresses the state's opinion that the discharge will not violate applicable water quality standards.

PUBLIC INTEREST REVIEW: The decision to issue a permit will be based on an evaluation of the probable impact including the cumulative impacts of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefits which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered including the cumulative effects thereof; among those are conservation, economics, esthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs and, in general, the needs and welfare of the people. The evaluation of the impact of the activity on the public interest will include application of the guidelines promulgated by the Administrator, Environmental Protection Agency under authority of Section 404(b) of the Clean Water

Act (33 USC 1344). The Corps of Engineers is soliciting comments from the public; Federal, state, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps of Engineers to determine whether to issue, modify, condition or deny a permit for this proposal. To make this decision, comments are used to assess impacts on endangered species, historic properties, water quality, general environmental effects, and the other public interest factors listed above.
Comments are used in preparation of an Environmental Assessment and/or an Environmental Impact Statement pursuant to the National Environmental Policy Act. Comments are also used to determine the need for a public hearing and to determine the overall public interest of the proposed activity.

COMMENTS: This notice is provided to outline details of the above-described activity so this District may consider all pertinent comments prior to determining if issuance of a permit would be in the public interest. Any interested party is invited to submit to this office written facts or objections relative to the activity on or before the public notice expiration date. Comments both favorable and unfavorable will be accepted and made a part of the record and will receive full consideration in determining whether it would be in the public interest to issue the Department of the Army authorization. Copies of all comments, including names and addresses of commenters, may be provided to the applicant. Comments should be mailed to the address shown on page 3 of this public notice.

PUBLIC HEARING: A public meeting is being held on July 13, 2016, from 5:00 p.m. to 7:00 p.m. at 111 E. Kelling Ave. in Waverly, Missouri to provide the public information on the project and to solicit comments. A copy of all public and agency comments received during the public review process will be located in Appendix B of the final environmental assessment.

Figure 1: Baltimore Bend is located near Waverly, Missouri.

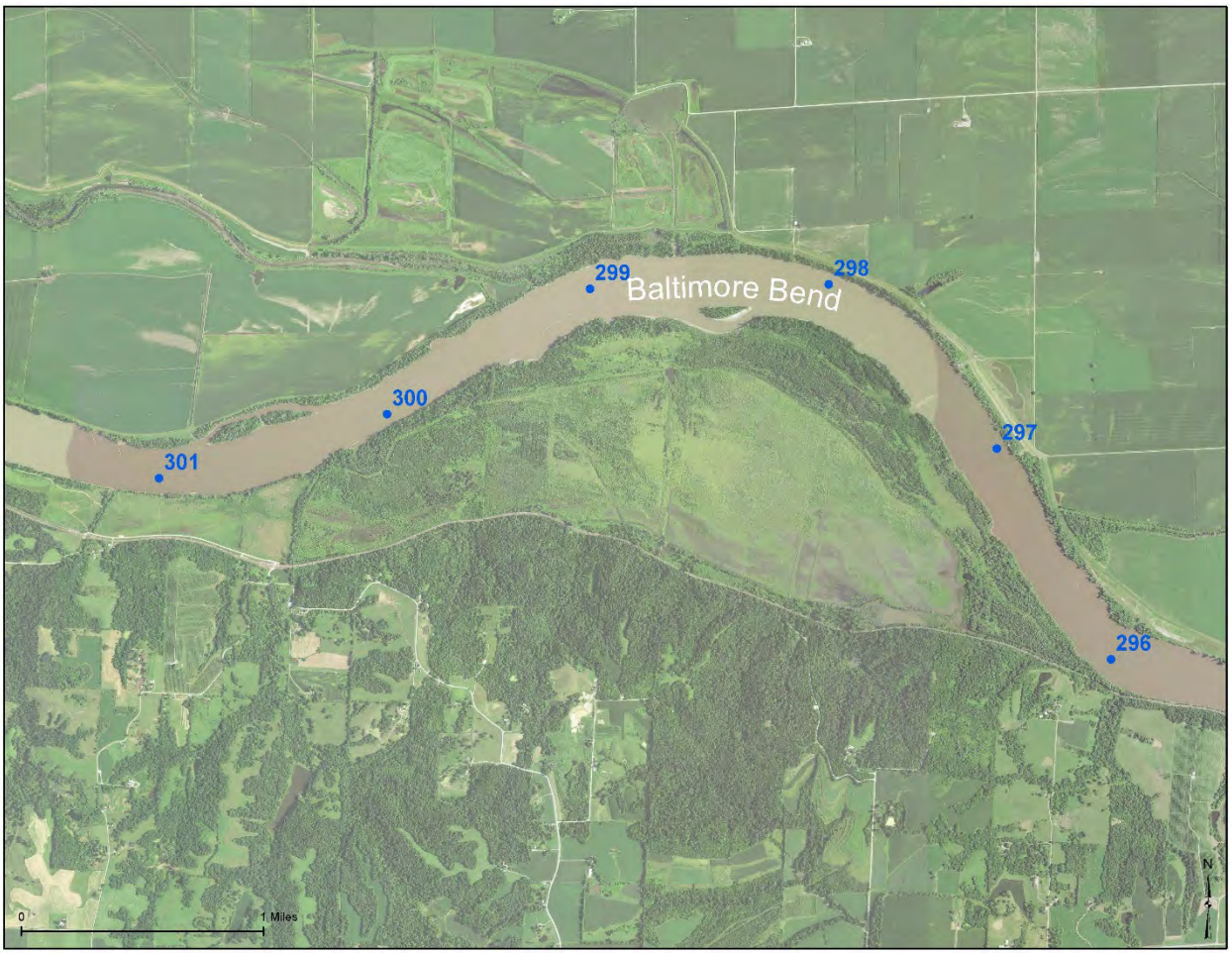

Figure 2: The Baltimore Bend IRC project area is located approximately between Missouri River miles 296 to 301.

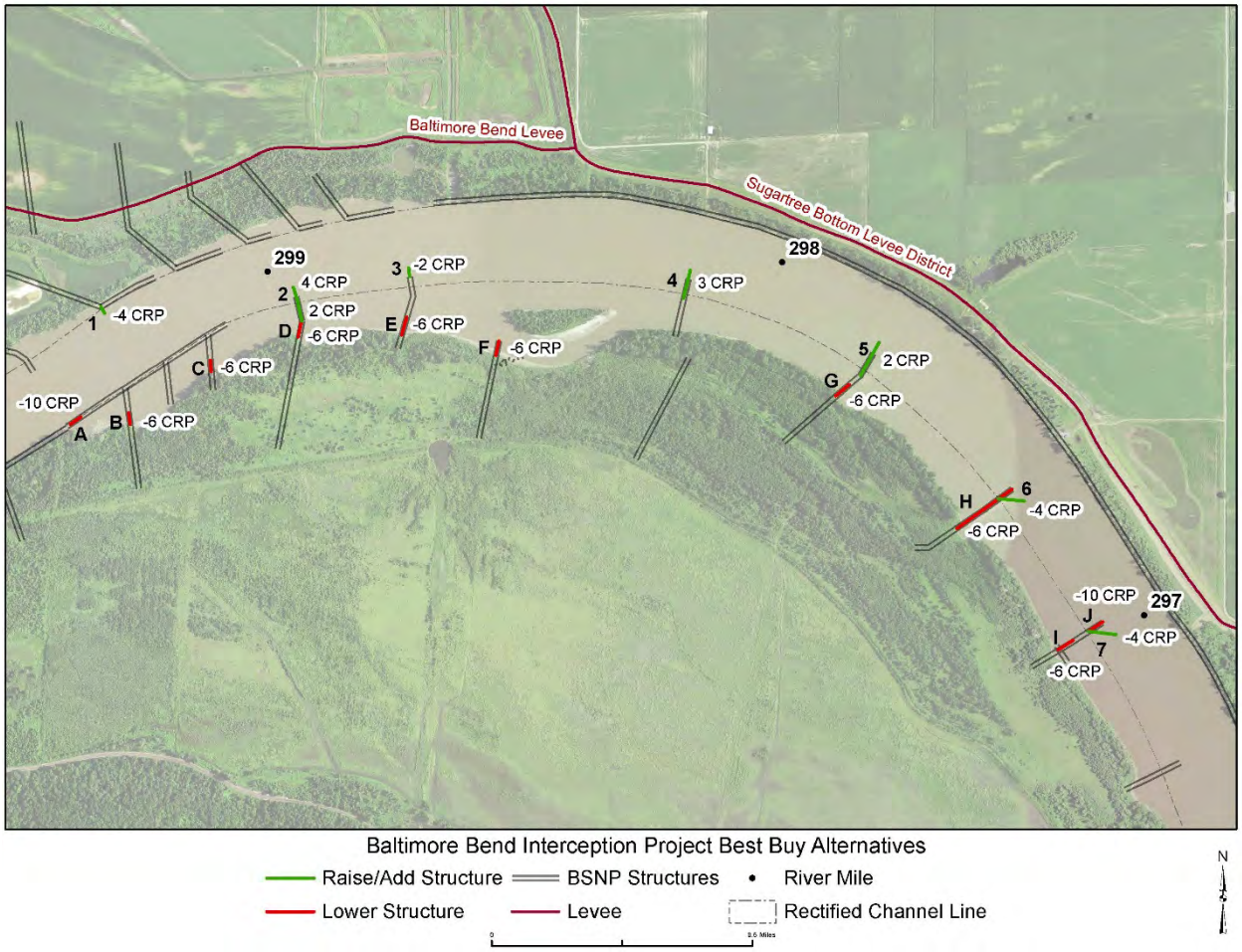

Figure 3: The proposed action to test interception rearing complex.

APPENDIX B

Public and Agency Comments
(Pending)

APPENDIX C

Hydrodynamic Modeling

US Army Corps of Engineers ®
Kansas City District

April 2016

MISSOURI RIVER RECOVERY PROGRAM

Baltimore Bend Interception Habitat Project

EVALUATION OF DESIGN ALTERNATIVES USING TWO-DIMENSIONAL ANALYSIS: ADAPTIVE HYDRAULICS MODEL DOCUMENTATION

Right Descending Bank, Missouri River - River Miles 297-300, Lafayette County, Missouri

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Conversions

1 foot = 0.3048 meters

1 ft/s = 0.3084 m/s

1 mile = 1.6093 kilometers

1.0 Background

The Baltimore Bend Interception Habitat Project (Baltimore Bend Project) is performed and funded as a part of the Missouri River Recovery Program (MRRP) to meet requirements as set forth by the Biological Opinion (BiOp) issued by the U.S. Fish and Wildlife Service in 2000 and amended in 2003. The shallow water habitat (SWH) program is a component of the BiOp's Reasonable and Prudent alternative intended to aid in the recovery of the pallid sturgeon which is being implemented under the authority of the Bank Stabilization and Navigation Program (BSNP) Fish and Wildlife Mitigation Project. The 2015 Missouri River Effects Analysis (EA) identified multiple hypotheses related to the current lack of pallid sturgeon recruitment on the lower Missouri River related to the loss of habitat and changes in hydraulic conditions as a results of the BSNP. While past MRRP projects have focused on the creation of SWH as defined in the BiOp, the EA has refined the habitat definition required for larval pallid sturgeon to include interception habitat, food-foraging habitat, and food-producing habitat. Together these habitats comprise interception and rearing complexes (IRC) that are the current focus of MRRP projects where interception of larval fish is thought to be most beneficial.

1.1 Purpose

The objective of the Baltimore Bend Project is to enhance interception and rearing habitat at the project location or, more specifically, to promote the transfer of free-drifting embryos (interception) into channel margin habitats (food-producing and foraging habitats). Two-dimensional hydrodynamic modeling of pre-project conditions and design alternatives will be used to assist with the evaluation of proposed designs. Two-dimensional analysis will be used to evaluate depth, velocity magnitude, and velocity direction of various design alternatives to (1) assess the ability of designs to intercept drifting particles (i.e. larval sturgeon) from the navigation channel to channel margins and (2) create habitat that meets the definition of food foraging habitat – depths of 3.3-9.8 feet and bottom velocities of 1.6-2.3 feet per second.

1.2 Site Description

Baltimore Bend is a 17,200-ft long bend located on the Missouri River between River Miles (RM) 296.3 and 299.5 in Lafayette County, Missouri (Table 8). The site is primarily within the banks of the Missouri River and is adjacent to Baltimore Bottoms which is owned by the US Fish and Wildlife Service (USFWS) as part of the Big Muddy Wildlife Refuge. Additionally, the Natural Resources Conservation Service (NRCS) has a permanent Wetland Reserve Program (WRP). Right bank river structures have undergone extensive notching over the years, mostly in 2004. An island exists at the apex of the bend and a shallow backward area persists downstream of the island from uncompleted chute excavation efforts in 2007. Existing conditions of the site can be seen in Figure 20.

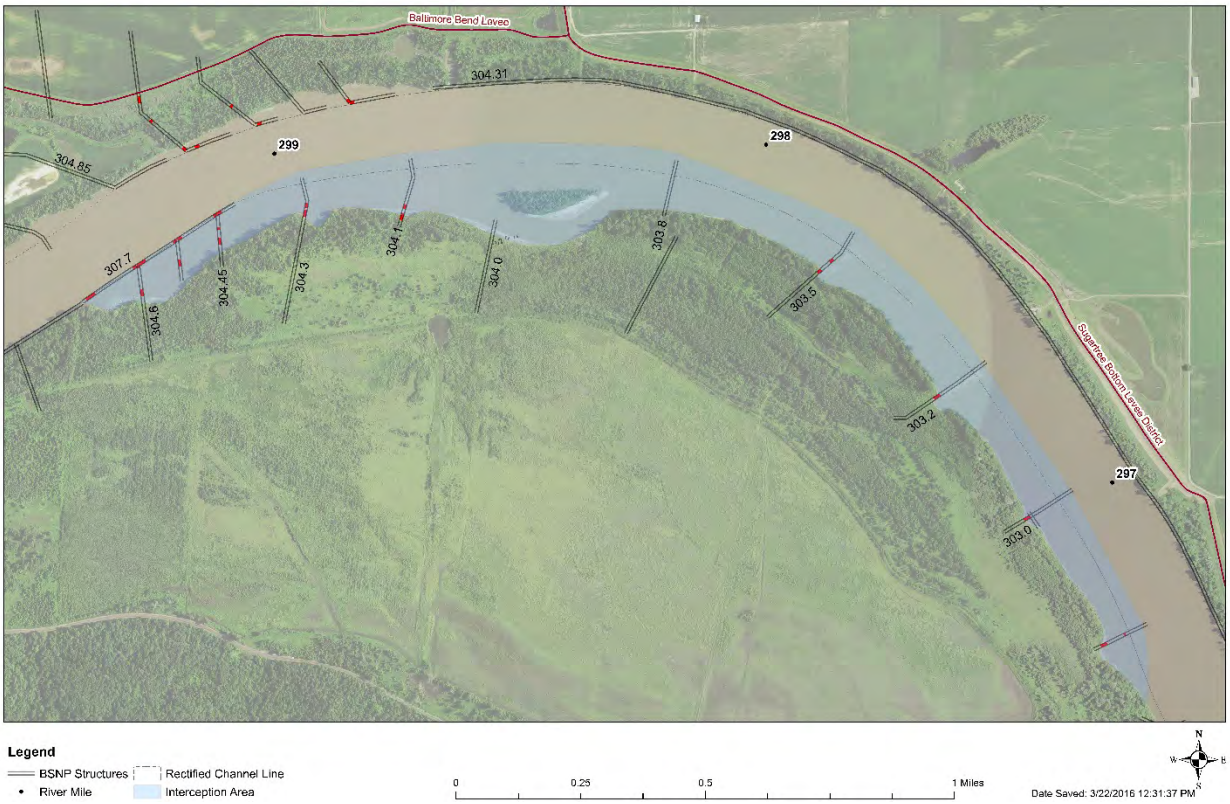


Figure 1. Baltimore Bend site map showing the existing conditions in 2015.

Table 1. Baltimore Bend Characteristics

Location	Lafayette County, Missouri
Extents	River Miles 296.3 and 299.5
Length	17,200 ft
Bend Radius	7,000 ft
Average Width	740 ft
Sinuosity	1.25
Features	Big Muddy National Wildlife Refuge; NRCS WRP; Port of Waverly boat ramp access at RM 179.6
Nearest USGS Stream-gage	USGS 06909000 - Boonville, MO - RM 293.4
CRP Discharge	45,100 cfs

2.0 Methodology

2.1 Numerical Model Preparation

A numerical simulation of flow on the Missouri River in the vicinity of Baltimore Bend was conducted to assess depths and velocities at the project site. The numerical model used for

these simulations was Adaptive Hydraulics (AdH), version 4.5. AdH is a two-dimensional hydrodynamic model which uses a finite element formulation to approximate shallow water equation solutions concerning the conservation of momentum and mass. The model was developed by the USACE Engineering Research and Design Center, Coastal and Hydraulics Laboratory. The graphical interface used for the development of the model geometry and model input controls was the Surface-Water Modeling System (SMS), version 11.2, developed by Aquaveo, LLC.

Two datasets were used for the development of the model terrain. The main channel bathymetry was primarily constructed from hydro-surveyed cross-sections conducted in 2013 by Eisenbraun & Associates. Cross section data was collected at 250-ft intervals with a single-beam sonar. The resulting data was combined and interpolated into a 3-meter digital elevation model (DEM) in ArcGIS. The floodplain and higher elevation portions of the river-bed were obtained from a 2014 low-water light-detection and ranging (LiDAR) dataset. The hydrosurveys and LiDAR bathymetry models were merged and used to develop the model mesh terrain. Where portions of the datasets overlapped, the LiDAR model was given priority. The majority of the floodplain and river-bed topography was defined using the 3-meter LiDAR. The upstream and downstream boundaries of the model and the entire topography and bathymetry are shown in Figure 21.

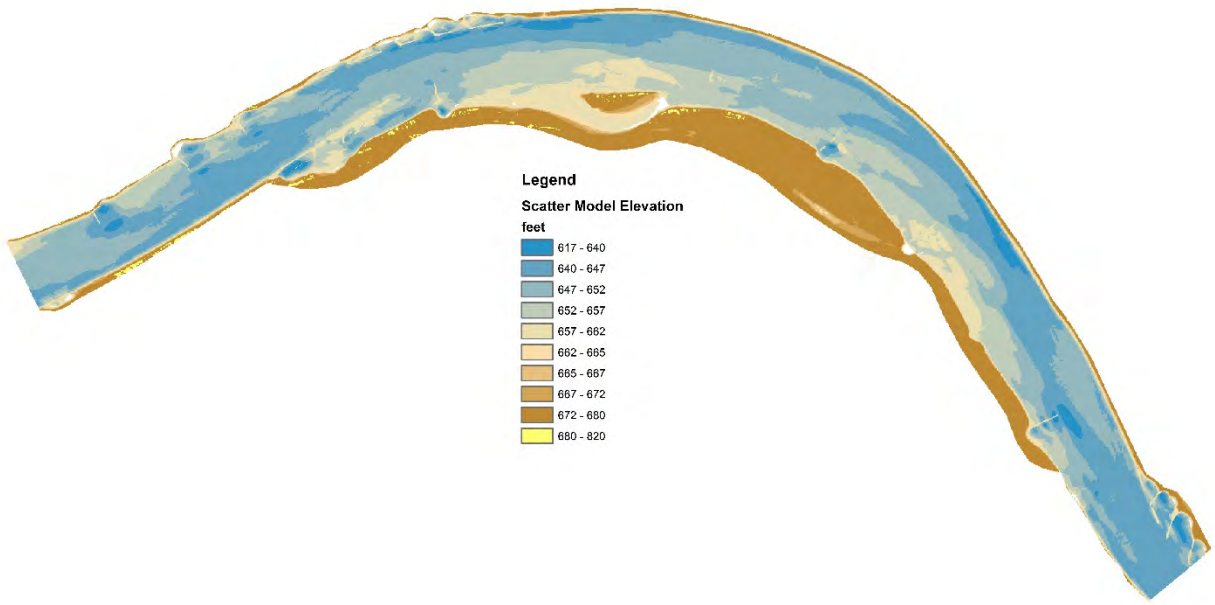


Figure 2. LiDAR and hydrosurvey terrain model used in AdH.

The model mesh was constructed in SMS with separate arcs to define the main channel, dikes, the dike field, the island, and the right channel margin areas intended for interception. AdH requires the use of triangular elements (Figure 22). Most elements vary in size, but the approximate average element size for the area of design is 200 ft^2; navigation channel elements are 480 ft^2; dike elements are 70 ft^2; the island elements are 300 ft^2; and the overbank elements are 700 ft^2. The existing conditions model is composed of 94,691 elements and 47,733 nodes.

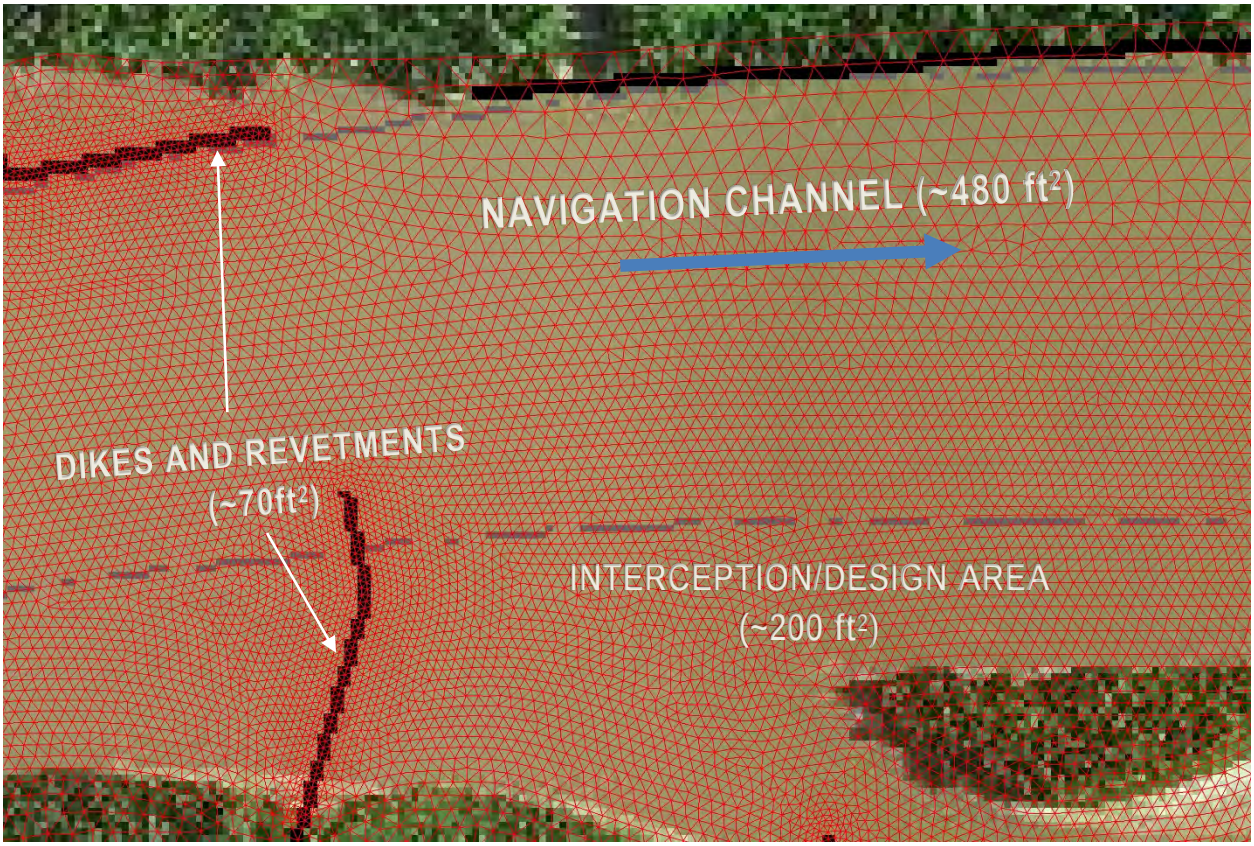


Figure 3. Example area of model mesh to illustrate the relative size of model elements for various features.

Five materials types are identified in the model for use in calibration. The primary materials types include: channel, dike field, structure, island, and floodplain. The locations and variations of roughness associated with these material types are shown in Figure 23.

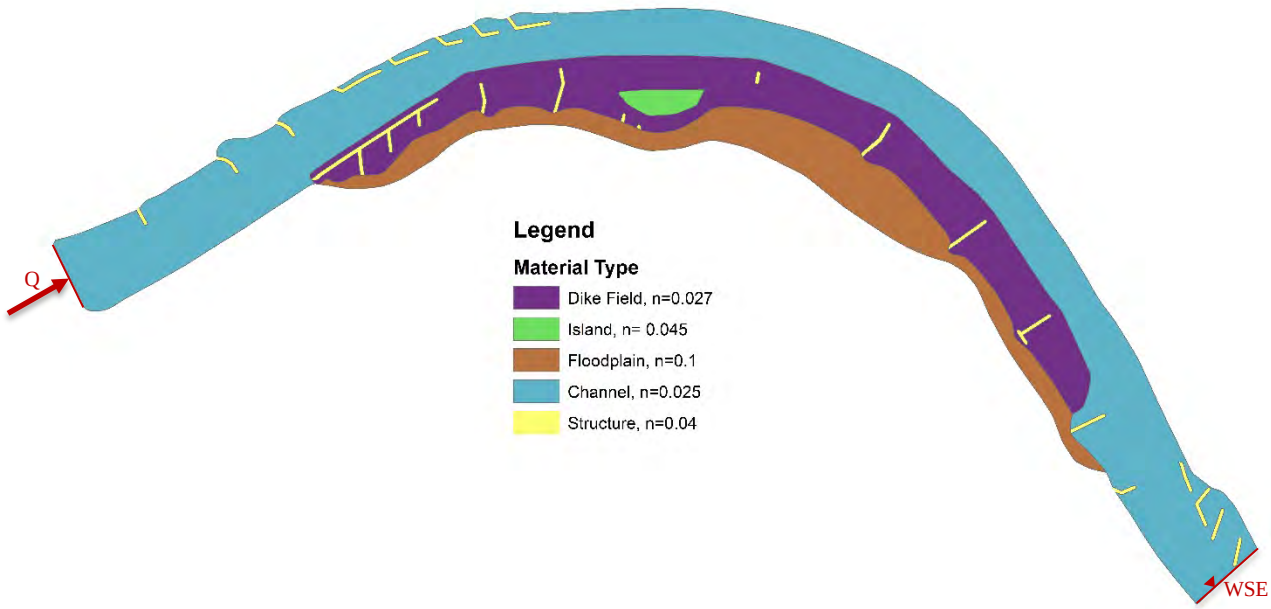


Figure 4. Model material types and roughness values.

The boundary conditions used in the model consisted of a total discharge at the upstream boundary and a water surface elevation at the downstream boundary of the model. An approximated rating curve for the downstream water surface elevation was obtained from the current MRRP HEC-RAS model of the lower Missouri River from Rulo, NE to the mouth. The nearest downstream cross-section with rating curve outputs from the 1D model are at RM 296.35. The downstream boundary of the ADH model falls at RM 296.2, within two tenths of the available rating curve. This rating curve was translated up 0.7-ft due to observed data collected on 18 September 2015 being higher than what the rating curve predicted. The simulation discharge at which the analyses will be run is close to the observed profile. Therefore the upward shift is likely accurate for this portion of the rating curve.

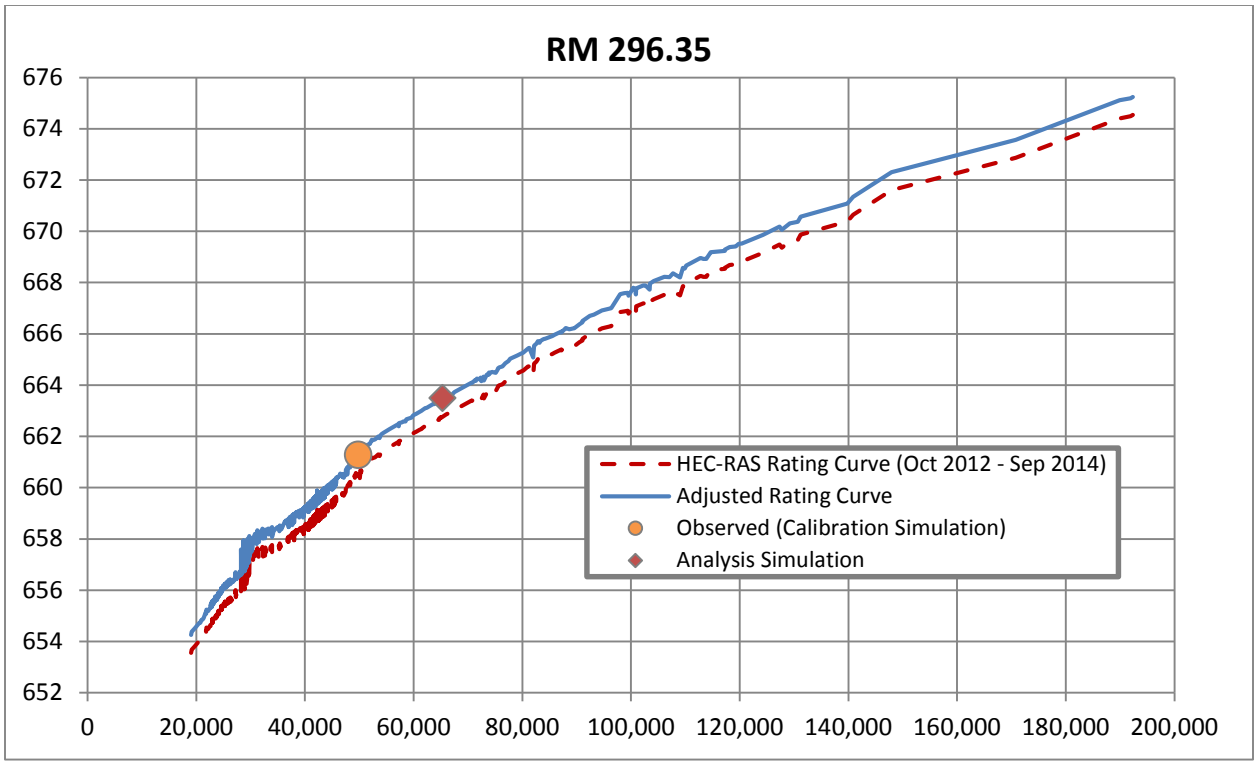


Figure 5. Downstream boundary rating curve; RM 296.35

2.2 Calibration and Validation

Calibration of the model was performed at a total discharge of 50,112 cubic feet per second (cfs) to compare with observed Acoustic Doppler Current Profiler (ADCP) and water surface profile data collected on September 18, 2015. The stage and discharge of this calibration are useful since the simulation for design alternative analyses are performed at 65,300 cfs, not much greater than the observed conditions used for calibration. This simulation analyses flow is 23% larger than the observed profile. The downstream boundary condition was 660.8-ft for the calibration simulation.

Model calibration was performed to evaluate the performance of water surface profile elevation and velocity results compared to observed data. Figure 25 shows the comparison of the two water surface elevations. Four measured points were used to create an interpolated water surface profile for comparison. The interpolated observed water surface profile resulted in a slope of 0.00054. The results of the ADH model produced a water surface profile slope of 0.00013. Overall, the average absolute difference between the modeled water surface elevations and the measured points was 0.16 ft. The observed and modeled water surfaces and the resulting slopes are in very close agreement for the downstream portion of the model from RM 296.5 to 298.5 (average absolute difference of 0.04). Upstream of RM 298.5, the model shows a slight underestimation of about 0.33 feet on average. The two most upstream observed data points were

collected along the right bank crossing control revetment which may not be representative of the water surface profile at the given cross section due to water surface fluctuations over the revetment or near existing notches. This can introduce up to 0.2 feet of error. Additional water surface elevation points at several points on a cross section would be helpful in the future for verification.

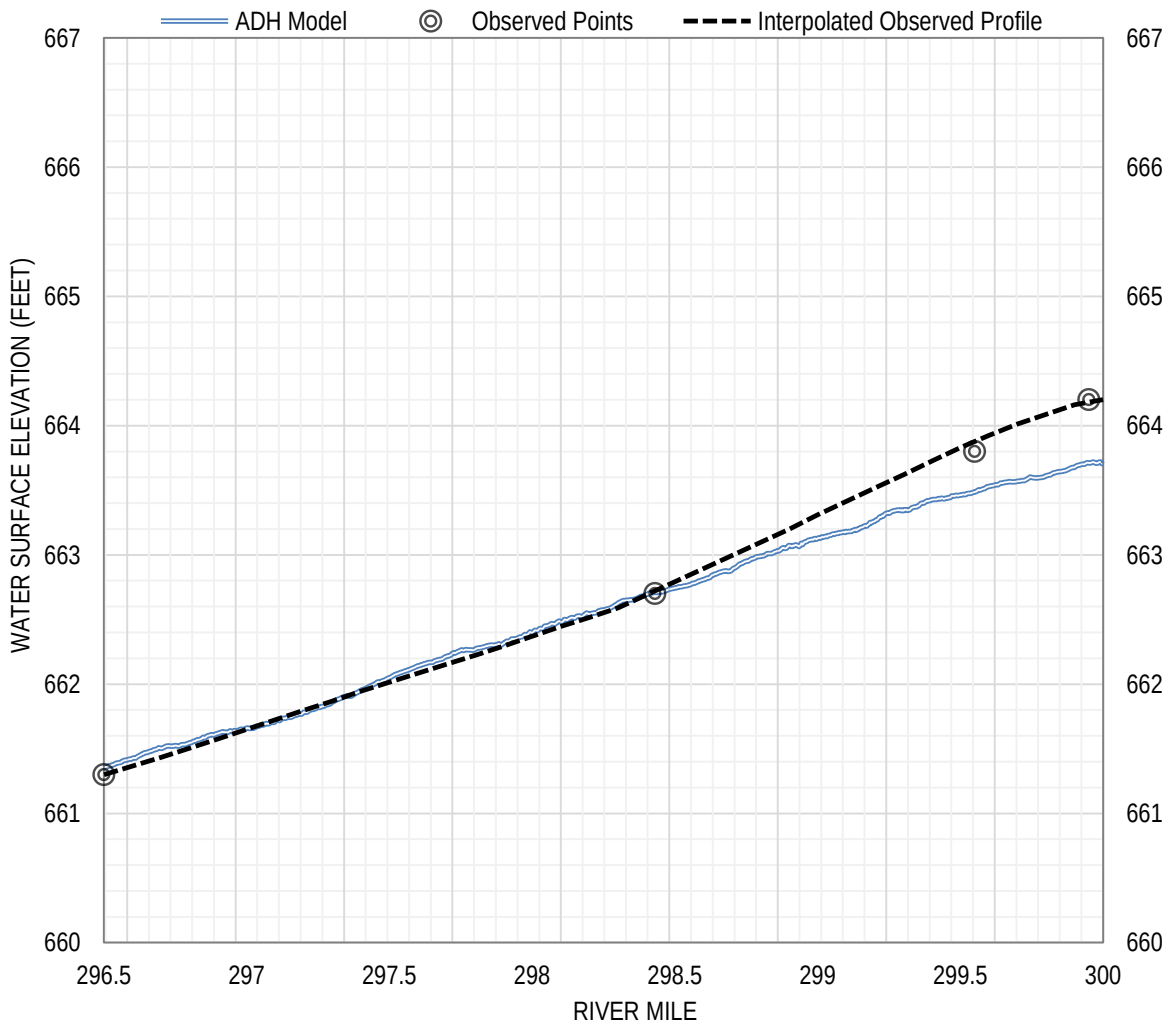


Figure 6. ADH Model water surface elevation profile comparison with observed data at 50,111 cfs.

ADCP data was collected with a 1200 kHz Rio Grande Workhorse at five locations along the main channel and one location within the adjacent natural side channel (Figure 26). Each transect consists of four discharge measurements which were averaged using Velocity Mapping Toolbox (VMT; v. 4.06) software developed by USGS to provide bins of depth-averaged

velocities every 1-meter along each transect. Observation arcs were drawn along these transects within SMS to extract depth-averaged velocity data from the ADH model. The comparison of modeled versus observed depth-averaged velocities for each transect can be seen in Figure 27. The mean difference between observed and modeled velocities at these transects was 0.007 (standard deviation [SD] 0.64) ft/s with a mean absolute difference of 0.49 (SD 0.41) ft/s (Figure 28).

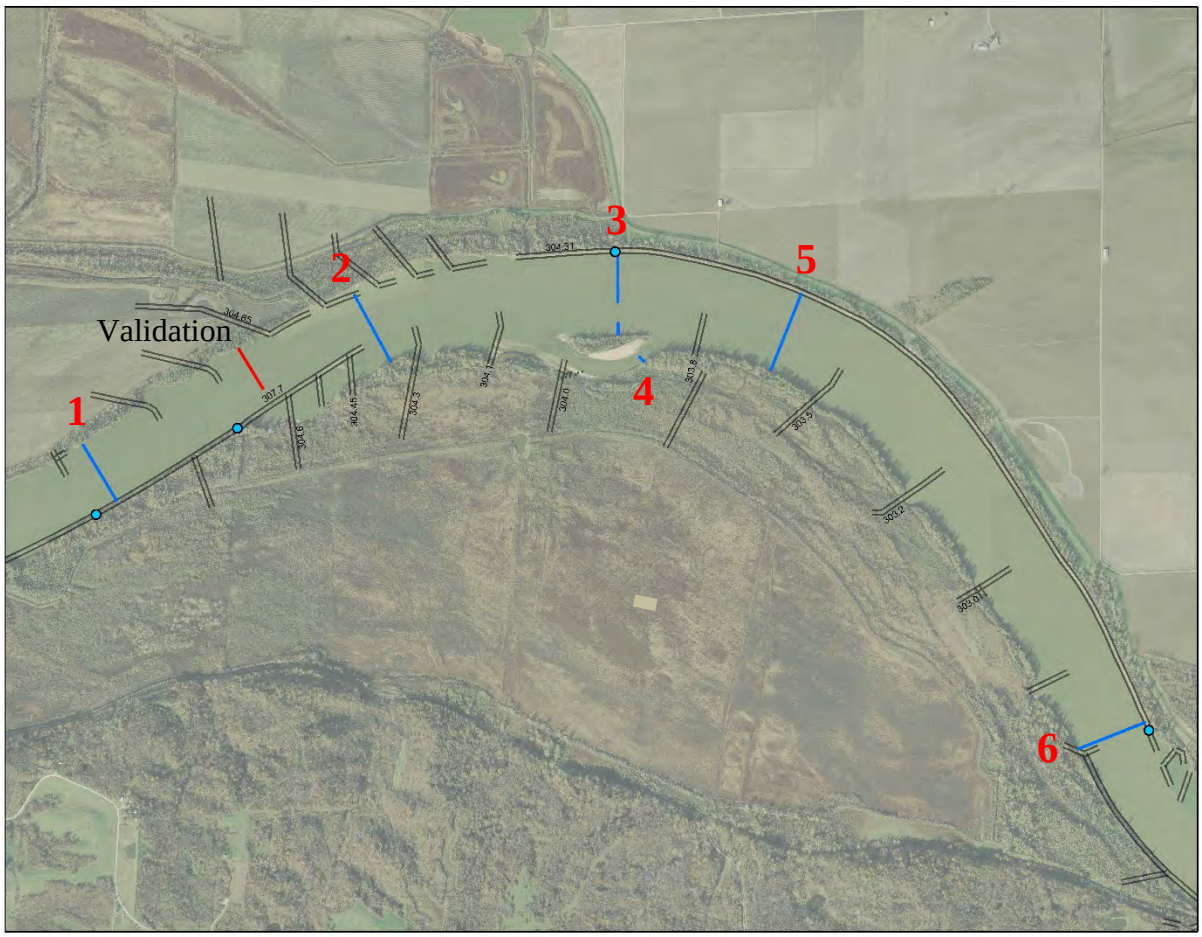


Figure 7. Acoustic Doppler Current Profiler calibration and validation transects.

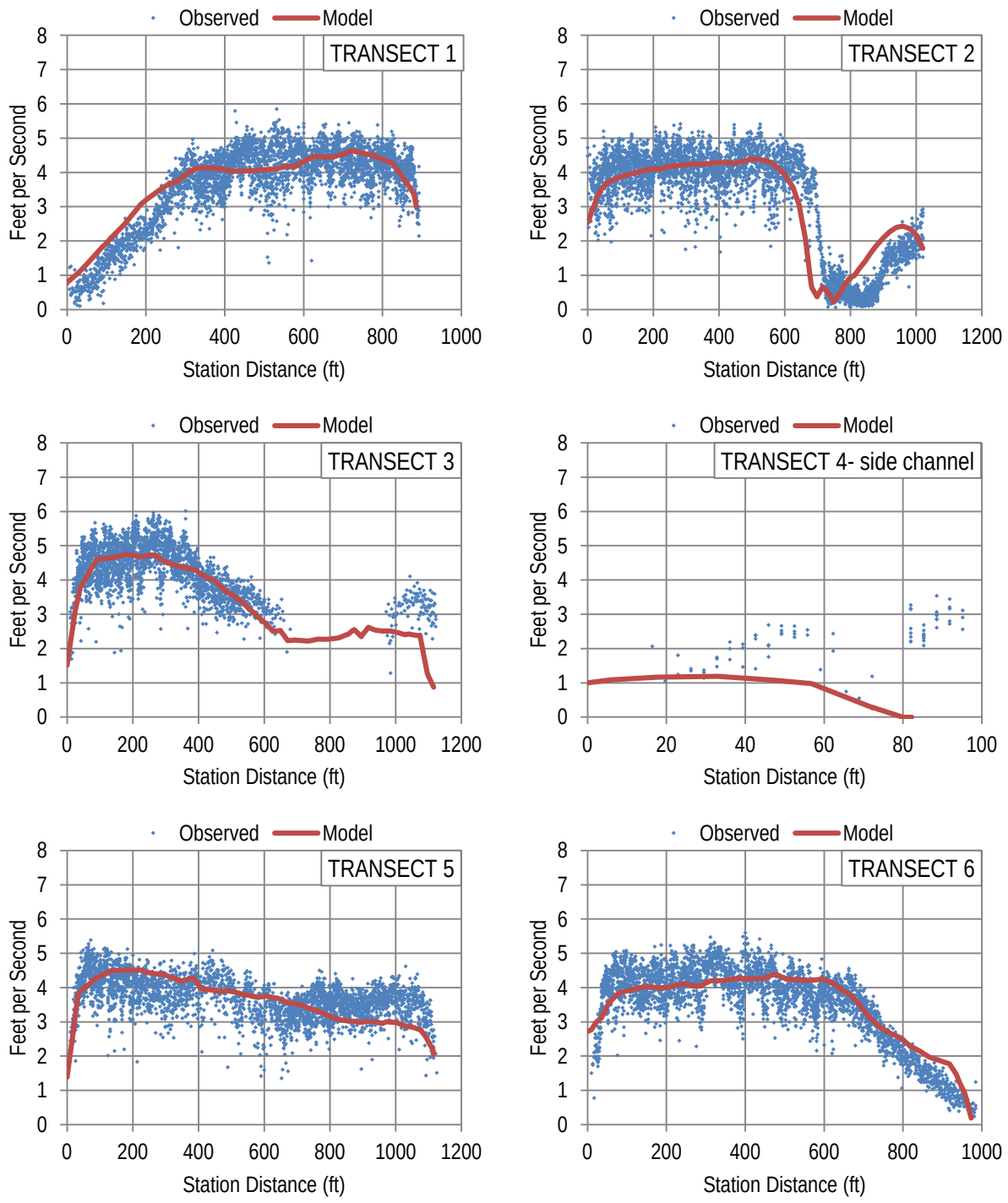


Figure 8. Comparison of depth-averaged velocities from observed ADCP transects (points) with ADH model output (line).

The largest difference is seen in transect 4. The accessibility of a full cross section in this side channel area was limited with the ADCP equipment since it was very shallow at the time of collection. Any data that was collected in the field are the higher velocities accessible in the deeper portions of this transect. This is why the model shows much lower overall values since the ADCP was not able to capture these shallow, low velocity areas.

Table 2. Mean velocity difference between modeled and observed transects.

Transect	Location	Average Velocity (ft/s)		
		Modeled	Observed	Δ
1	Upstream of Site	3.91	3.80	0.12
2	Crossing	3.22	3.21	0.01
3	Middle of Bend	4.16	4.28	-0.12
4	Side Channel	0.50	2.19	-1.7
5	Downstream of Island	3.66	3.70	-0.04
6	Downstream of Site	3.69	3.64	-0.06

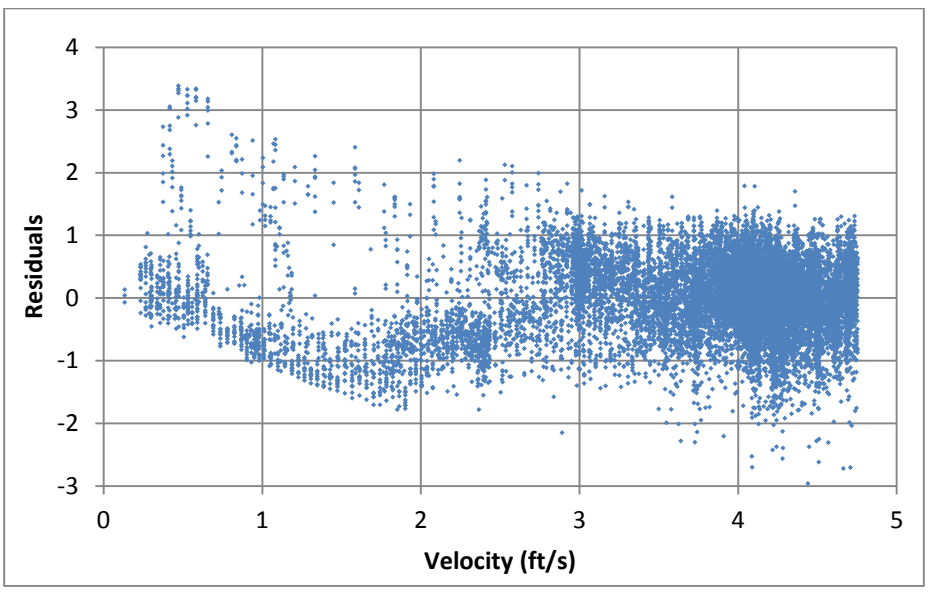


Figure 9. Residuals of modeled versus observed velocities.

Validation of the model was performed through a velocity comparison of ADCP flow measurements taken on October 14, 2015 at a single transect during a discharge of 48,134 cfs. Water surface elevation data was available for this same collection effort at RM 296 and RM 298.65 and utilized to run the validation model. A cross section selected at RM XX was utilized to validate the model velocity outputs. Mean difference between modeled and observed

velocities was -0.1 ft/s with a mean absolute difference of 0.51 (SD 0.63) ft/s. Overall, the velocities of the model and the observed transects are in close agreement.

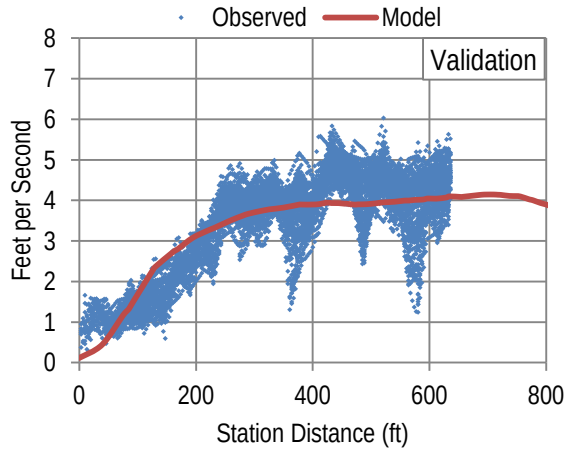


Figure 10. Validation transect comparing modeled and observed velocities at 48,134 cfs.

2.3 Development of Alternatives

Design alternatives were developed with the objective of increasing larval fish interception and acres of food-foraging habitat in the area focused around the sand bar. These design objectives are to be achieved through the modification of existing BSNP structures or construction of new rock dike structures to direct more flow through or behind the sand bar. The effect of the modifications or construction of structures on larval fish interception will be tested through the use of the Particle Tracking Module (PTM) in SMS. Four configuration plans and the existing conditions were chosen for testing with the particle tracking model. These design plans were initially chosen based on professional judgment that the design would increase flow into the sand bar area while maintaining an efficient navigation channel and working within cost constraints. Within the four configuration plans there was a sub-plan alternatives that included a construction alternatives of partial dredging and excavation. Including all sub-plan alternatives, there are a total of eight design alternatives and an existing conditions plan. All plans were modeled at their assumed full development. The eight design alternatives are described below.

2.3.1 Alterative Concept 1

Alternative Concept 1 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Ten structure segments ranging from 115 feet to 230 feet long will be removed to an elevation of -6 to -10 feet below the Construction Reference Plane. Six dikes will be extended 40 to 130 feet riverward along the existing alignment of the structure at an elevation of -4 to +3 feet above/below the Construction Reference Plane. Five dike structure

segments will be raised to an elevation of +2 to +3 feet above the Construction Reference Plane ranging from 200 to 350 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat.

Alterative Concept 1 includes two alternatives (Figure 30 through 31):

- Alternative 1a – Includes structure removals and structure additions to promote initial development of site.
- Alternative 1b – Includes structure removals and structure additions with additional dredging of the sand bed in river margin areas to accelerate development.

Alternatives 1a and 1a were modeled the same under the assumption that they would develop to the same full development end condition. Therefore only one geometry was modeled to assess these two alternatives.

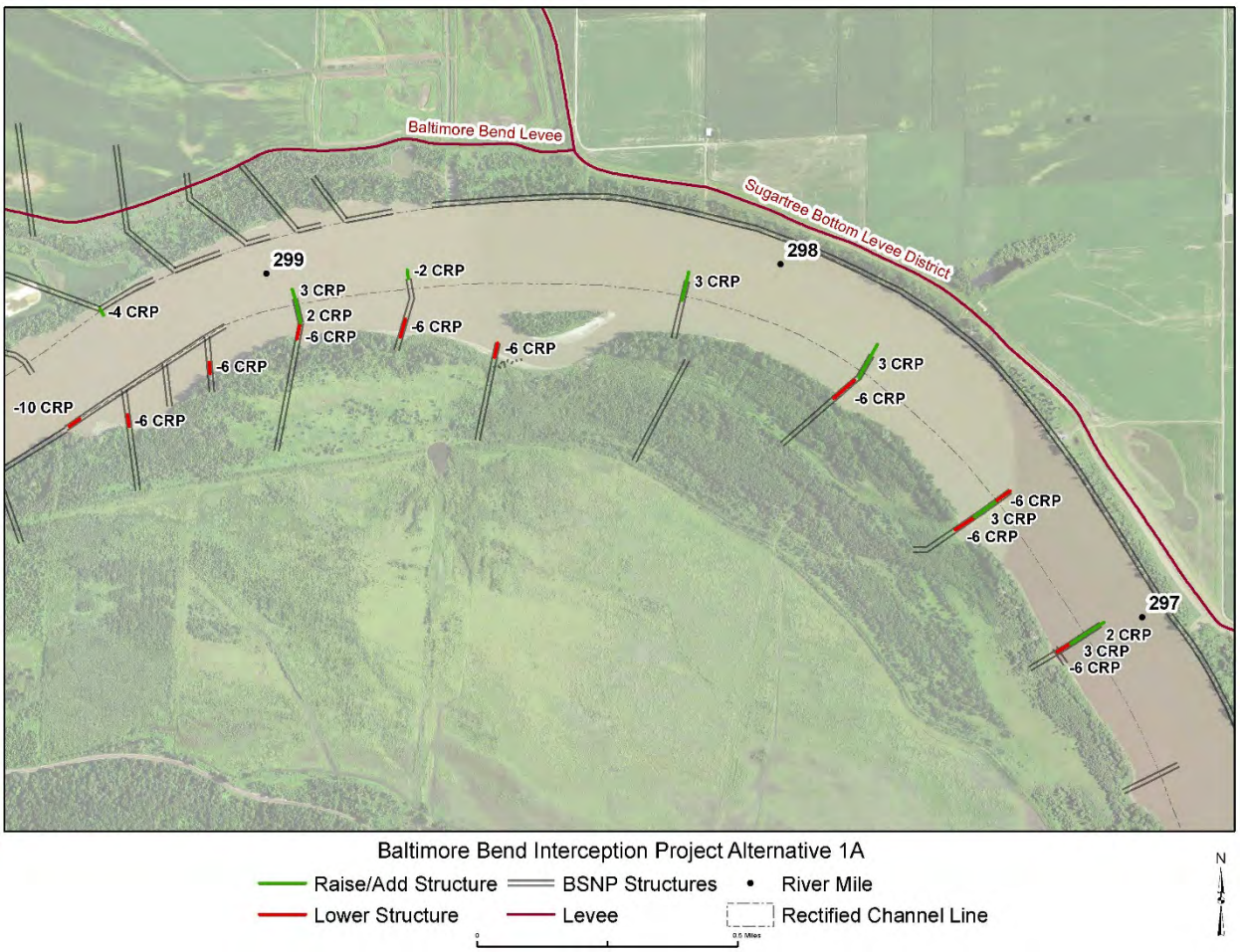


Figure 11. Alternative 1a

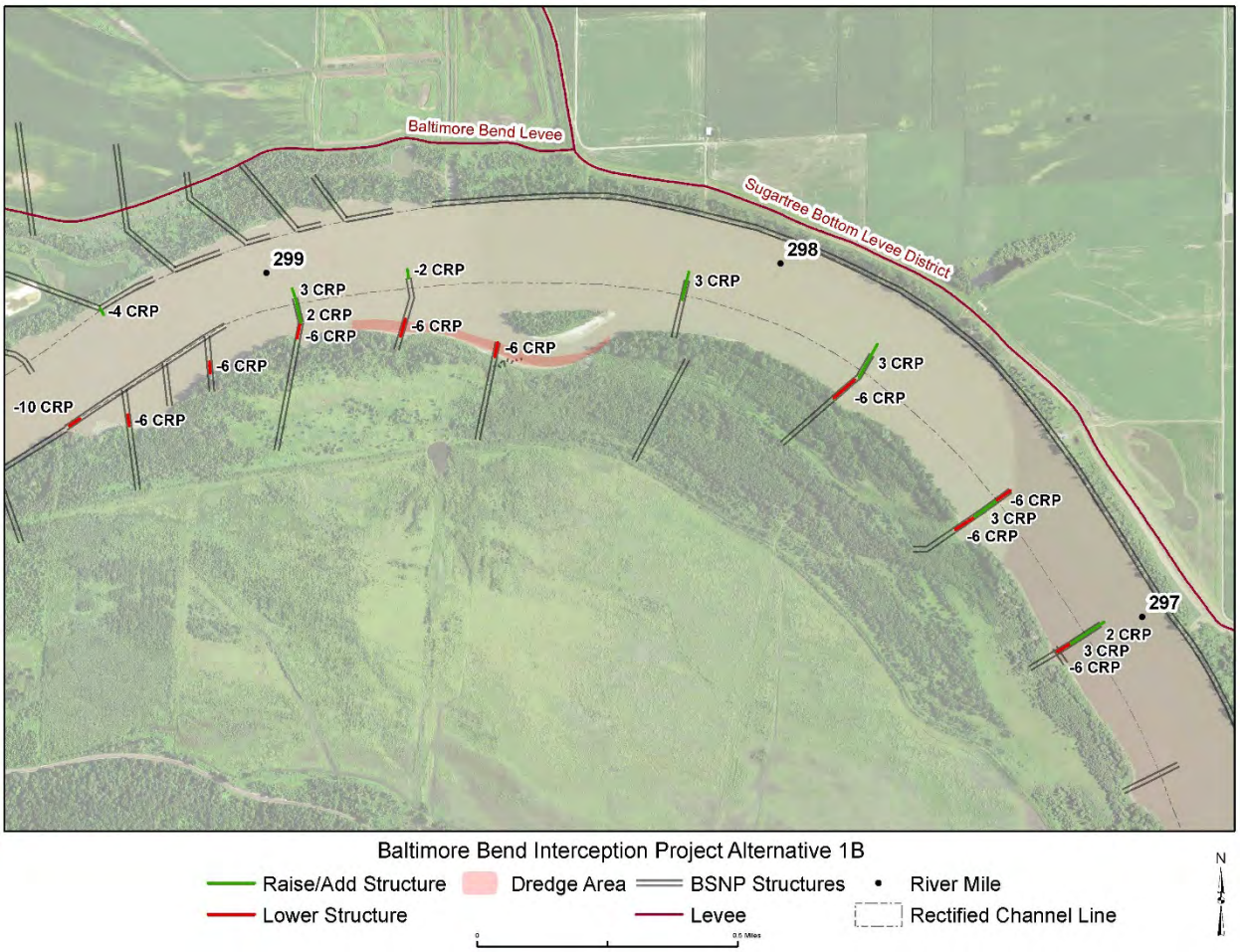


Figure 12. Alternative 1b

2.3.2 Alternative Concept 2

This concept includes the modifications of existing dike structures similar to Alternative 1 with the exception that the two furthest downstream dike structures from Alternative 1 are re-oriented at an angle with most of the existing structure removed. Alternative Concept 2 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Ten structure segments ranging from 115 feet to 680 feet long will be removed to an elevation of -6 to -10 feet below the Construction Reference Plane. Seven dikes will be extended 75 to 280 feet riverward at an elevation of -4 to +3 feet above/below the Construction Reference Plane. Three dike structure segments will be raised to an elevation of +2 to +3 feet above the Construction Reference Plane ranging from 200 to 260 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat. Also, the angled dike extensions are intended to direct water

perpendicularly across the top of the structure towards the bank with the intent to create additional aquatic area and intercept larval sturgeon.

Alternative Concept 2 includes five alternatives (Figure 32 through Figure 33):

- Alternative 2a – Includes structure removals and structure additions to promote initial development of site.
- Alternative 2b – Includes structure removals and structure additions with additional dredging of the sand bed in river margin areas to accelerate development.

Alternatives 2a and 2b were modeled the same under the assumption that they would develop to the same full development end condition. Therefore only one geometry was modeled to assess these two alternatives.

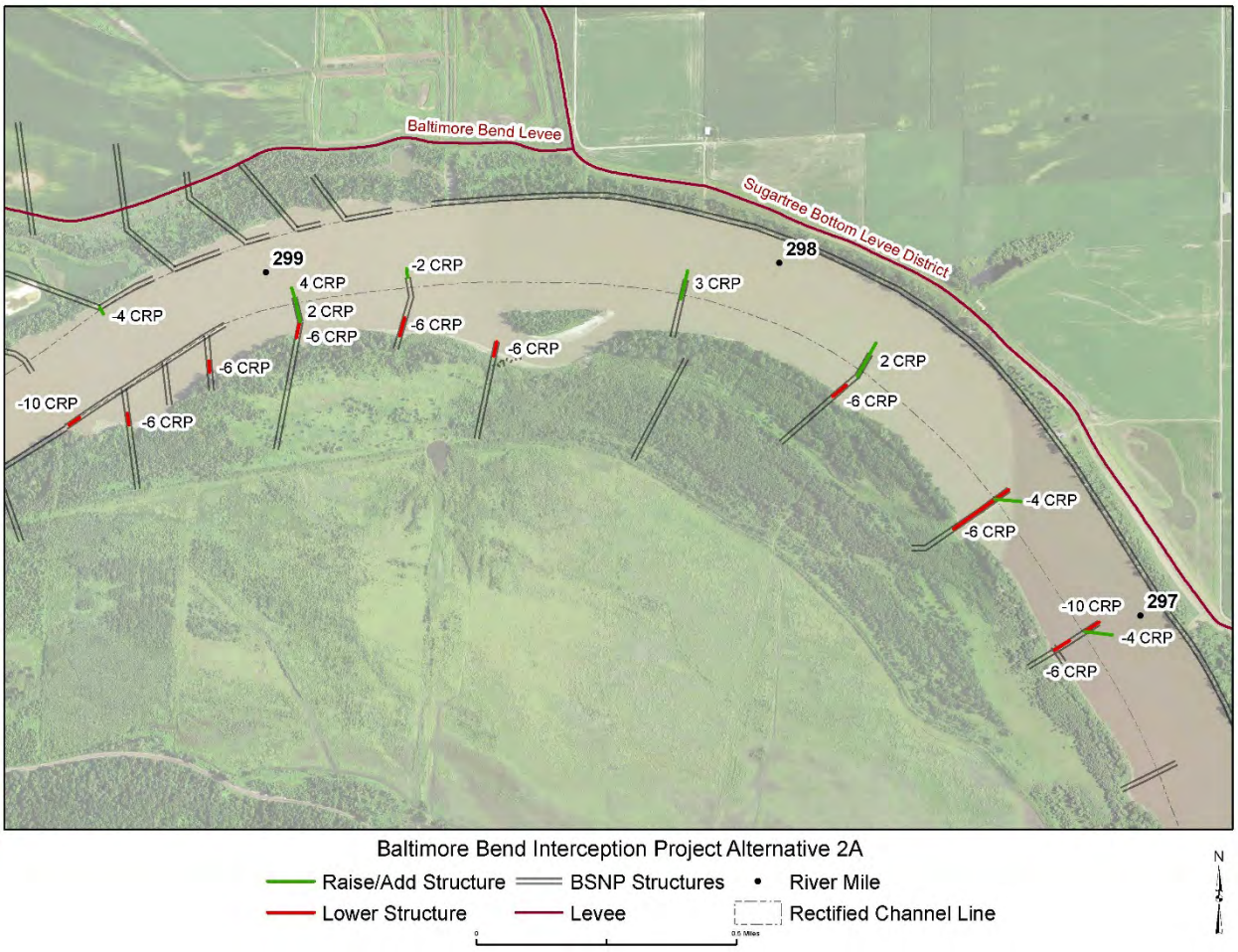


Figure 13. Alternative 2a.

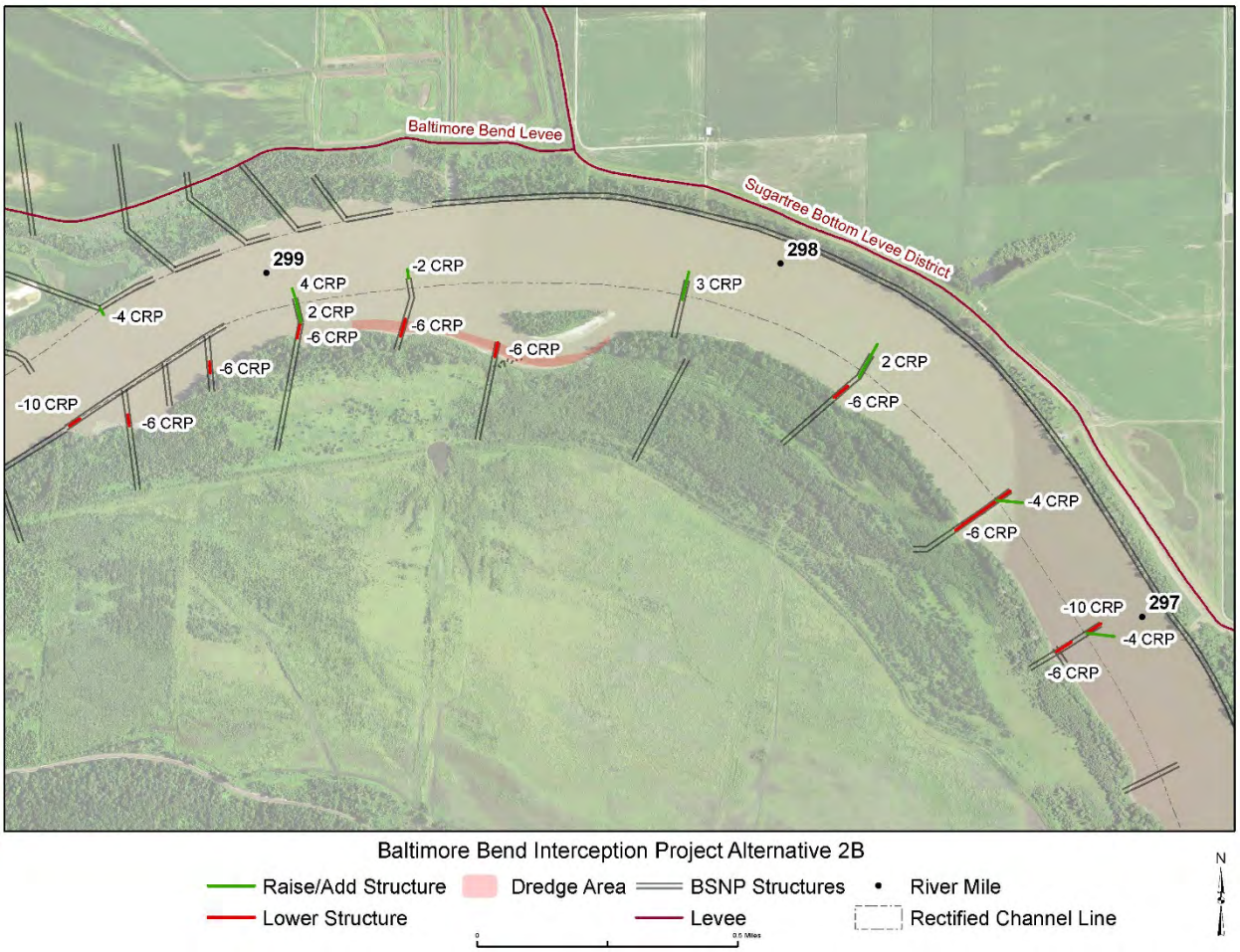


Figure 14. Alternative 2b.

2.3.3 Alternative Concept 3

This concept includes the modifications of existing dike structures similar to Alternative 1 expect the modifications differ in that all of the lowered portions of the dike structures are located on the most landward side of the structure with all of the raised portions located on the most riverside of the structures. Alternative Concept 3 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Nine structure segments ranging from 115 feet to 441 feet long will be removed to an elevation of -6 to -10 feet below the Construction Reference Plane. Six dikes will be extended 50 to 130 feet riverward at an elevation of -4 to +3 feet above/below the Construction Reference Plane. Five dike structure segments will be raised to an elevation of -2 to +3 feet below/above the Construction Reference Plane ranging from 200 to 260 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat. Also,

lowering the landward portions of the structures while raising the riverward portions of the structure will provide additional aquatic area and increase interception potential for larval sturgeon.

Plan 3 includes two alternatives (Figure 34 and Figure 35):

- Alternative 3a – Includes structure removals and structure additions to promote initial development of site.
- Alternative 3b – Includes structure removals and structure additions with additional dredging of the sand bed in river margin areas to accelerate development.

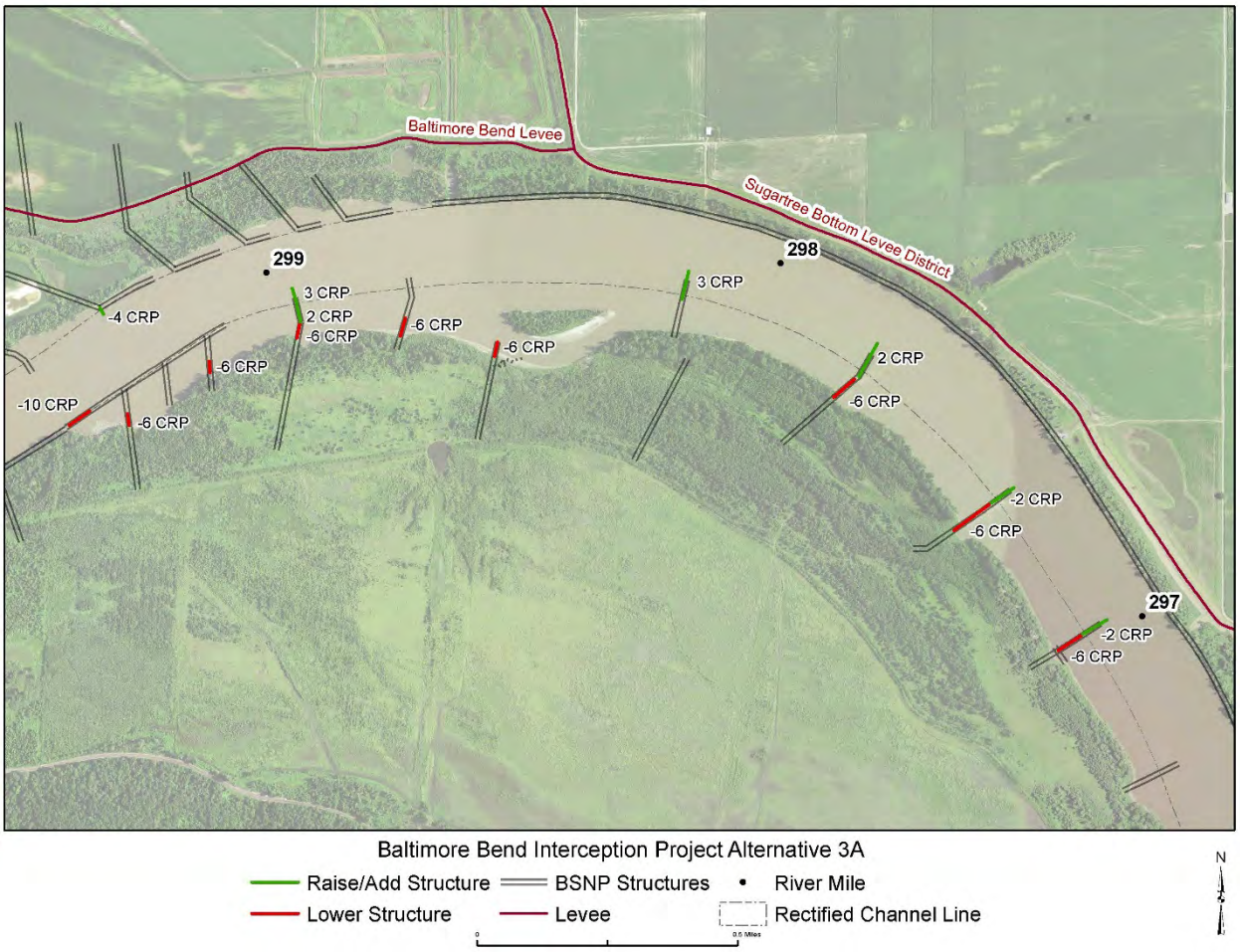


Figure 15. Alternative 3a.

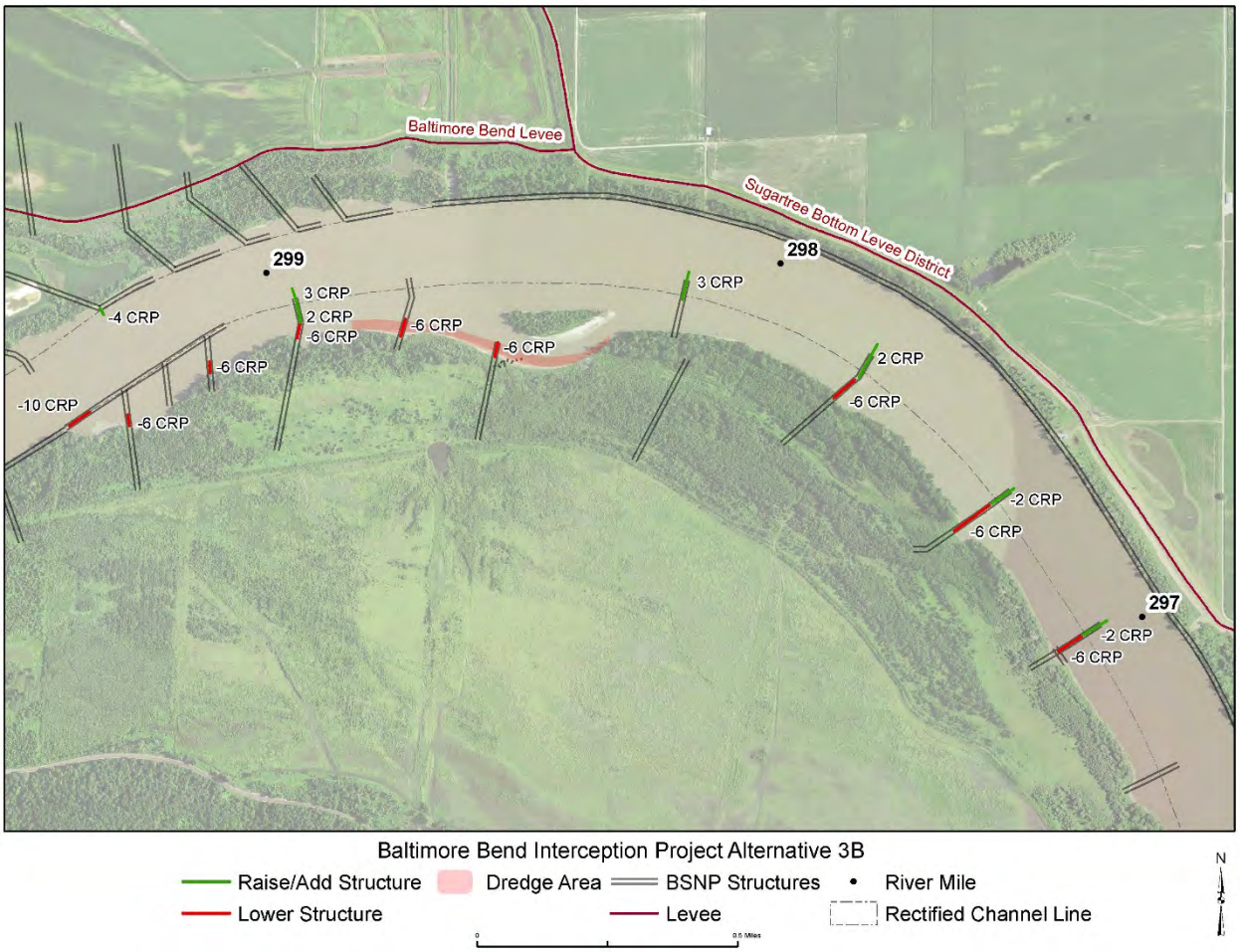


Figure 16. Alternative 3b.

2.3.4 Alternative Concept 4

3.0 This concept includes the modifications of existing dike structures similar to Alternative 3 expect one of the existing downstream structures is almost entirely removed. Alternative Concept 4 consists of removing portions of existing dikes and revetments, raising portions of existing dikes, and extending portions of existing dikes. Eleven structures will be modified in this alternative. Ten structure segments ranging from 115 feet to 350 feet long will be removed to an elevation of -6 to -10 feet below the Construction Reference Plane. Five dikes will be extended 75 to 130 feet riverward at an elevation of -4 to +2 feet above/below the Construction Reference Plane. Four dike structure segments will be raised to an elevation of +2 feet above the Construction Reference Plane ranging from 180 to 260 feet long. The purpose of the variety of modifications to structure heights is to promote flow into river margin areas while also creating additional food and foraging habitat.

Alternative Concept 4 includes two alternatives (Figure 36 and Figure 37):

- Alternative 4a – Includes structure removals and structure additions to promote initial development of site.
- Alternative 4b – Includes structure removals and structure additions with additional dredging of the sand bed in river margin areas to accelerate development.

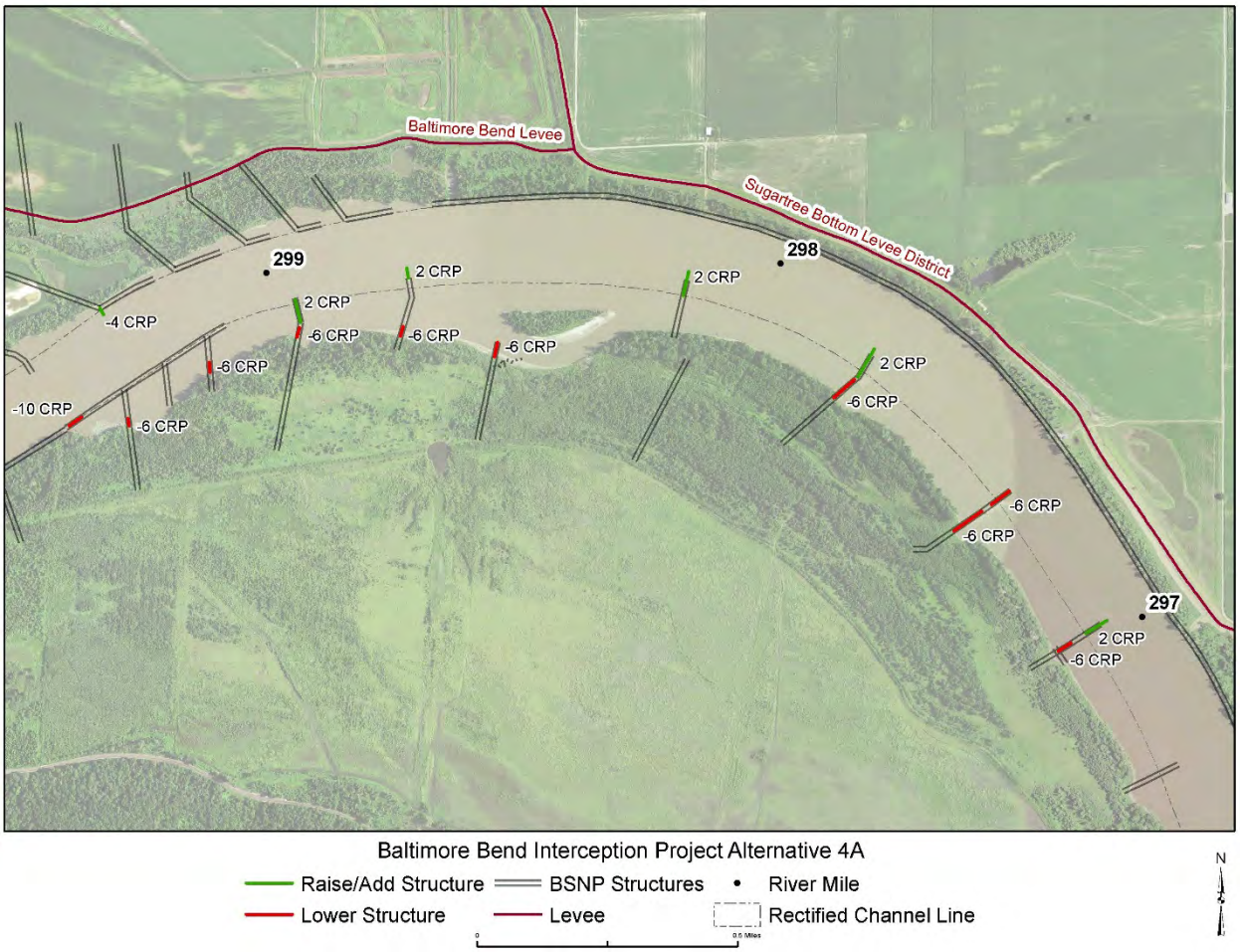


Figure 17. Alternative 4a.

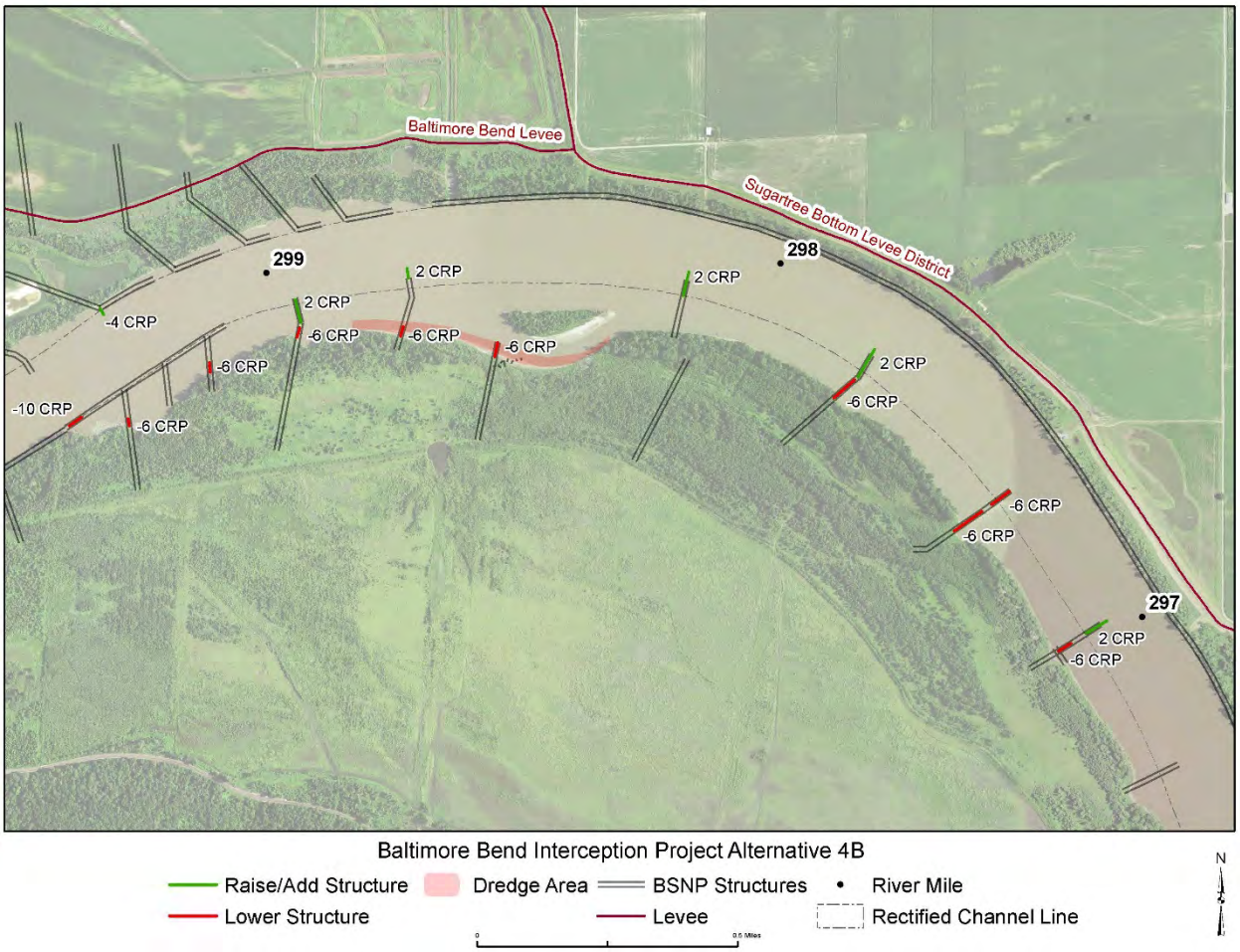


Figure 18. Alternative 4b.

3.1 Particle Tracking Model

3.1.1 Background

Larval fish drift for this project was simulated using the particle tracking model (PTM) in SMS. PTM is a model developed by the USACE Engineering Research and Design Center (ERDC) specifically to track the fate of point-source constituents such as sediments, chemicals, debris, and biologicals from local sources in complex hydrodynamic environments (McDonald et al, 2006). The model has also been used to simulate the transport of drifting larval fish with specific behavioral characteristics (Tate et al., 2010). PTM simulates transport using previous AdH hydrodynamic model output and therefore only needs a single successful hydrodynamic run to perform multiple PTM simulations. PTM can determine vertical flow changes and approximate 3D flow from 2D hydrodynamic flow fields by assuming a logarithmic velocity profile in the vertical direction. Particle characteristics and processes to be modeled, including settling velocity, critical stresses, and erosion rates, are input into PTM. If these processes for the

modeled particles are unknown, these values are calculated within the model based on verified theoretical relationships (McDonald et al., 2006). Particles can be positively, neutrally, or negatively buoyant. For the modeling of drifting larval fish, the particles are considered to be neutrally buoyant.

3.1.2 Larval Fish Simulation

The simulations for this analysis are designed to model the pathways of a drifting larval pallid sturgeon through the modeled reach and estimate how those pathways will change under a variety of design alternatives as described in the previous section. The drift dynamics of larval pallid sturgeon have been studied in the upper Missouri River and in laboratory conditions and therefore some of the characteristics of their drift are known. For instance, it has been observed that the drift rates for larval pallid sturgeon from 1-11 days post-hatch (dph) are similar to or slightly slower than the mean water column velocity, while 17 dph larval sturgeon are dispersed downstream at a much slower rate (0.6 ft/s slower than mean water velocity) owing to their transition to benthic habitats (Braaten et al., 2008). It is believed that larval pallid sturgeon must transition from drifting to benthic habitats between 11-17 dph at which time yolk reserves are depleted and exogenous feeding is initiated and likely required to survive (Braaten et al., 2008). Therefore, using neutrally buoyant particles in the PTM simulation at which the particles will move the same speed as the water to mimic drifting larval sturgeon prior to 17-dph is considered valid. The same study also showed that pallid sturgeon larvae tend to drift primarily in the lower 1.6 ft of the water column (Braaten et al., 2008). However, since the ADH model is a 2D hydrodynamic model and the effects of 3D recirculation and vertical movement are not calculated, it was decided to not restrict the movement of particles to the lower 1.6 ft of the water column, but instead allow the simulated larvae to drift as neutrally buoyant particles freely throughout the water column.

For each simulation, particles were released along a 1,008-ft long transect at the upper end of the model that spanned across the entire channel. Particles were released at a rate of approximately 336 particles per minute. The particle simulation for each alternative was run for 4 hours and included approximately 111,000 particles each. It takes about 5 minutes for a particle to reach the area of interest once released from the source line. Approximately 62% of the particles reached the area of interest during all simulations, with 38% either falling out of suspension or simply not reaching the site prior to the end of the simulation.

In order to conduct a useful comparison of design alternatives, the simulations of larval drift must be conducted at a discharge relevant to the timing of larval drift on the lower Missouri River. An analysis was conducted to assess the historical range of flows and stages on the lower Missouri River during the time that larval drift is most likely to occur to identity target conditions to run simulations. The analysis can be found in Appendix A titled “Documentation of Flows on the Missouri River Relevant to Hydrodynamic Drift Analysis of Larval Pallid

Sturgeon". The target condition chosen for the assessment was median flow from May through July – 65,300 cfs.

3.1.3 Limitations

Modeling larval sturgeon drift has several limitations in PTM and SMS. The particles simulated in PTM have simplified characteristics and since they are being modeled as neutrally buoyant, tend to act as a parcel of water would act as it travels through the model. Although this provides a conceptual passage of flowing water and where it will potentially carry suspended particles, it does not offer anything about the specific behavioral characteristics that a larval sturgeon may possess. Even though it is believed that larval sturgeon drift passively with the current, it has also been shown that they tend to be found primarily nearer to the channel bed, therefore providing an indication that not all aspects of their drift are passive. Therefore, this analysis is conducted with the understanding that PTM is modeling particles with simplified characteristics and not larvae. However, this exercise is still very useful in determining potential pathways that drifting larvae may follow and in comparing design configurations in a relative sense to determine the most useful design to promote increased interception of larval fish from the navigation channel to more beneficial channel margin habitats.

4.0 Simulation Results

4.1 Hydrodynamics

A comparison of water surface elevation profiles was conducted to assess potential differences in the modeled results between the calibrated existing conditions model and design alternatives (Figure 41; Table 10). All modeled alternatives resulted in a very slight increase in water surface elevation of about an inch within the area of interest along the sailing line. However, this increase is insignificant since it is less than the tolerances of accuracy for the model. The water surface elevations vary across the cross section more than an inch as well with the inside of the bends having a lower water surface. The most notable change in water surface elevation occurs at the upstream end of the model where the majority of flow is being diverted and the cumulative effects of downstream modifications show up in the model. The alternatives for the upstream end still shows less than two inches (0.1 feet) of difference from the existing conditions. It is likely that a slight change in roughness is warranted in some areas that were modified due to design. Roughness values during modeling of all alternatives remained the same from the calibrated existing conditions model. Also, having a boundary condition in the model further upstream would help reduce any bias. Expanding the extents of the model was not explored since the size of the model was limited by computer capacity and run time. The water surface slopes were similar for all alternatives (0.00014) and were similar to the existing conditions (0.00013).

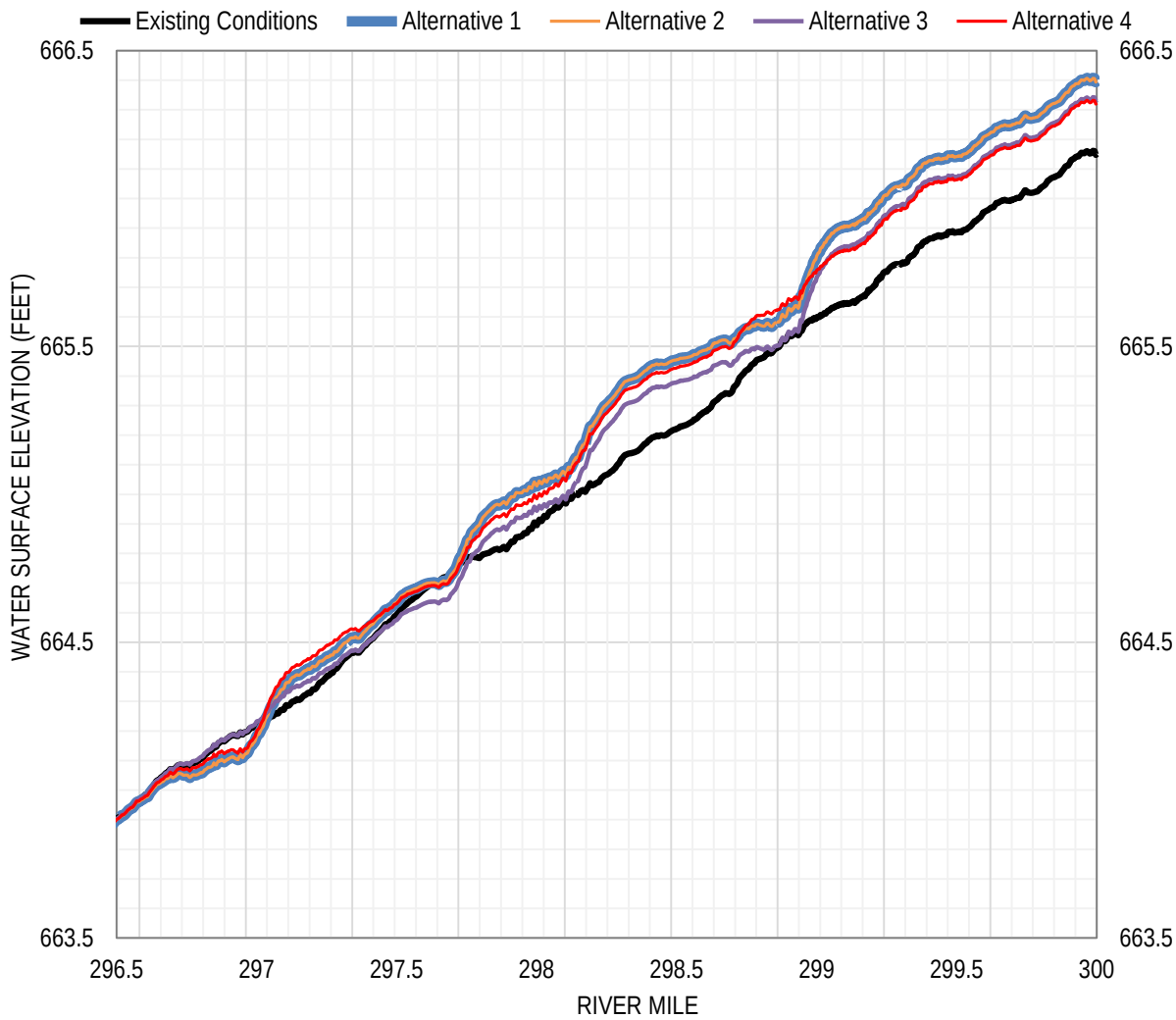


Figure 19. Water surface elevation profile for each alternative compared with the existing conditions model.

Table 3. Water surface profile comparison.

Model Geometry	Slope	Mean Difference From EC (ft)
Existing Conditions	0.00013	--
Alternative 1	0.00014	0.13
Alternative 2	0.00014	0.06
Alternative 3	0.00014	0.08
Alternative 4	0.00014	0.11

Average velocity within the navigation channel was assessed and compared between modeled alternatives at chosen transects around the area of the project site to determine if

channel velocities were significantly impacted from the proposed design changes (Figure 42). Table 11 reports the average velocities for the chosen transects and shows that very little difference was found in navigation channel velocities between the existing conditions and modeled design alternatives.

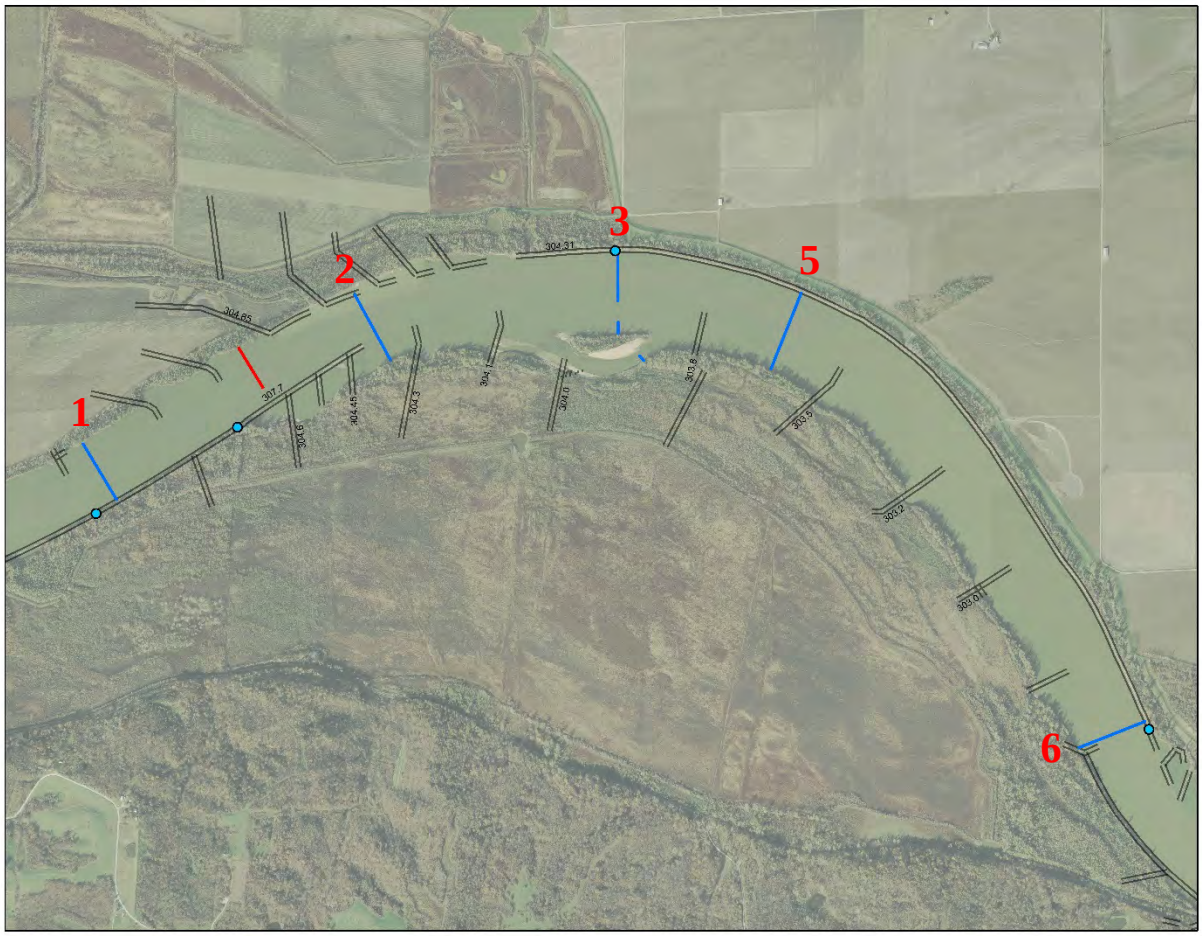
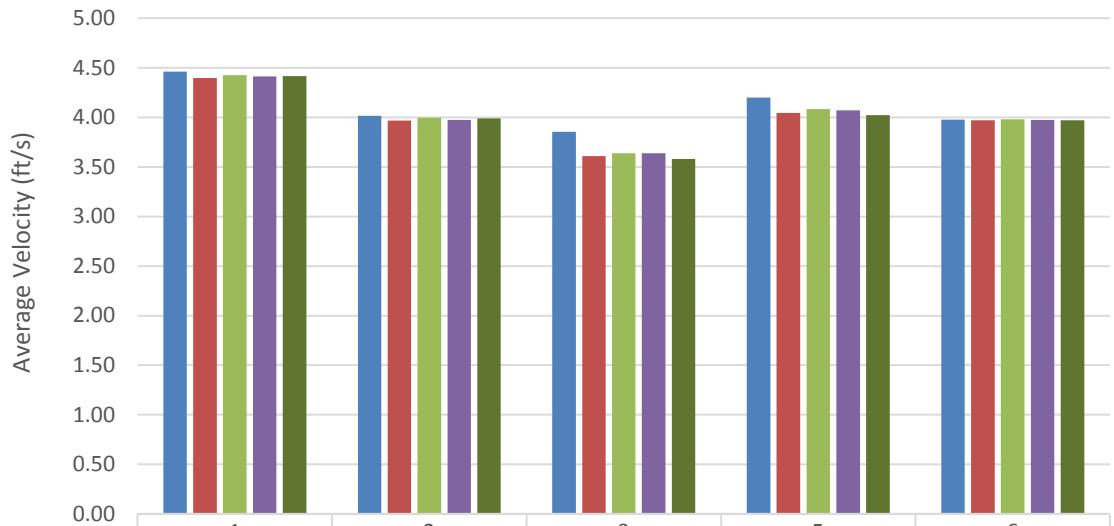


Figure 20. Navigation channel velocity comparison transects.

Table 4. Navigation channel average velocity comparison.



	1	2	3	5	6
Existing	4.46	4.02	3.86	4.20	3.98
Alternative 1	4.40	3.97	3.61	4.05	3.97
Alternative 2	4.43	4.00	3.64	4.08	3.98
Alternative 3	4.41	3.98	3.64	4.07	3.97
Alternative 4	4.42	3.99	3.58	4.02	3.97

The largest differences from the existing conditions are seen at transects 3 and 5. Both are these are located around the existing island and are likely due to increased conveyance through the side channel with the alternatives. At transect 3, no more the navigation channel was not more 0.3 ft/s slower for the most differing alternative (4). At transect 5, the greatest change is 0.18 ft/s slower for the same alternative. These results point toward very little change in velocity occurring in the navigation channel due to design modifications which indicates that the current the self-scouring ability of the navigation channel will continue to be maintained in its current state in these areas.

4.2 Foraging Habitat

Foraging habitat as defined in the EA are areas of depths between 3.3-9.8 ft combined with bottom velocities between 1.6-2.3 ft/s. In order to ensure that the conditions created by the design alternatives to increase larval interception into the channel margins also provide beneficial foraging habitat, the areas meeting this definition were quantified from the model results of the design alternatives and compared with the existing conditions model. Since the vertical distribution of velocity typically decreases with increasing depth in the real-world while the vertical distribution of velocity in the ADH model is constant (i.e. average velocity), an adjustment to the assessed velocity criteria was made. Velocity data from the Habitat Assessment

and Monitoring Program (HAMP) was assessed from 2014 and 2015 to estimate the typical difference between bottom velocity and average velocity in areas of the Missouri River where larval pallid sturgeon were captured. HAMP fish sampling crews conduct point velocity measurements at 0.2 and 0.8 depth and at the bottom. The mean difference between the average water column velocity and the bottom velocity was 0.3 (SD 0.3) ft/s (n=492). Therefore, in order to approximate when the bottom velocity would be between 1.6-2.3 in the model, it was decided to quantify areas with velocities between 1.6-2.9 ft/s (1.9-2.6 ± 0.3) from the model results coupled with depths between 3.3-9.8 ft. Figure 43 depicts the area used for quantifying and comparing acres of foraging habitat between modeled alternatives. The total area of analysis is 118 acres. The results of the analysis can be seen in Table 12.

Table 5. Foraging habitat results

Model	Foraging Habitat Acres
Existing Conditions	37.7
Alternative 1	40.9
Alternative 2	52.1
Alternative 3	49.8
Alternative 4	49.6

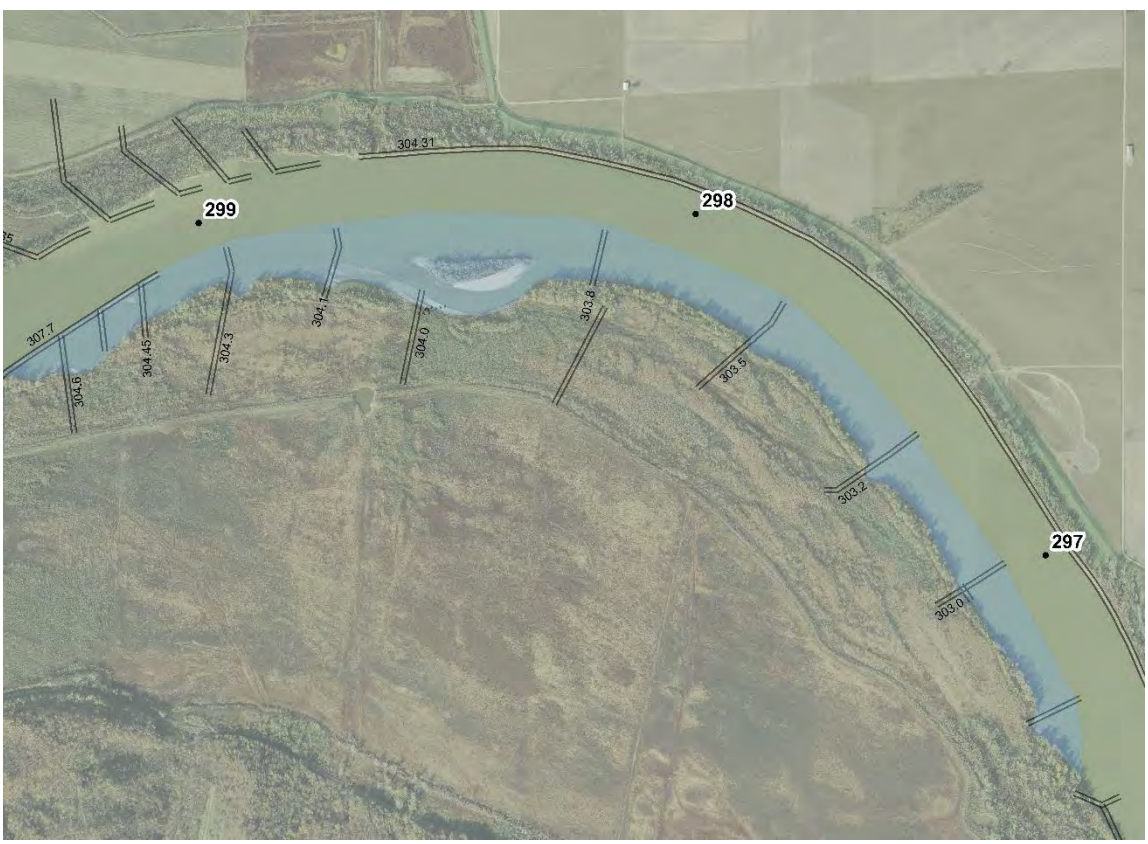


Figure 21. Area of foraging habitat analysis.

The results of the foraging habitat analysis is largely driven by velocity. Depths between 3.3-9.8 ft are common in the area of analysis within all alternatives, with the primary difference being the area of velocities between 1.6-2.9 ft/s that coincide with the required depths. Figure 44 illustrates this by depicting the depths between 3.3-9.8 ft in blue, velocities between 1.6-2.9 ft/s in yellow, and areas that coincide with both the required depths and velocities in green of Alternative 1 and Existing Conditions models. The majority of the area outside of the foraging habitat area that meets the required definition are depths that do not coincide with velocities between 1.6-2.9 ft/s. This may be an indicator that velocities act as the limiting factor in controlling the areal extents of foraging areas on the Missouri River.

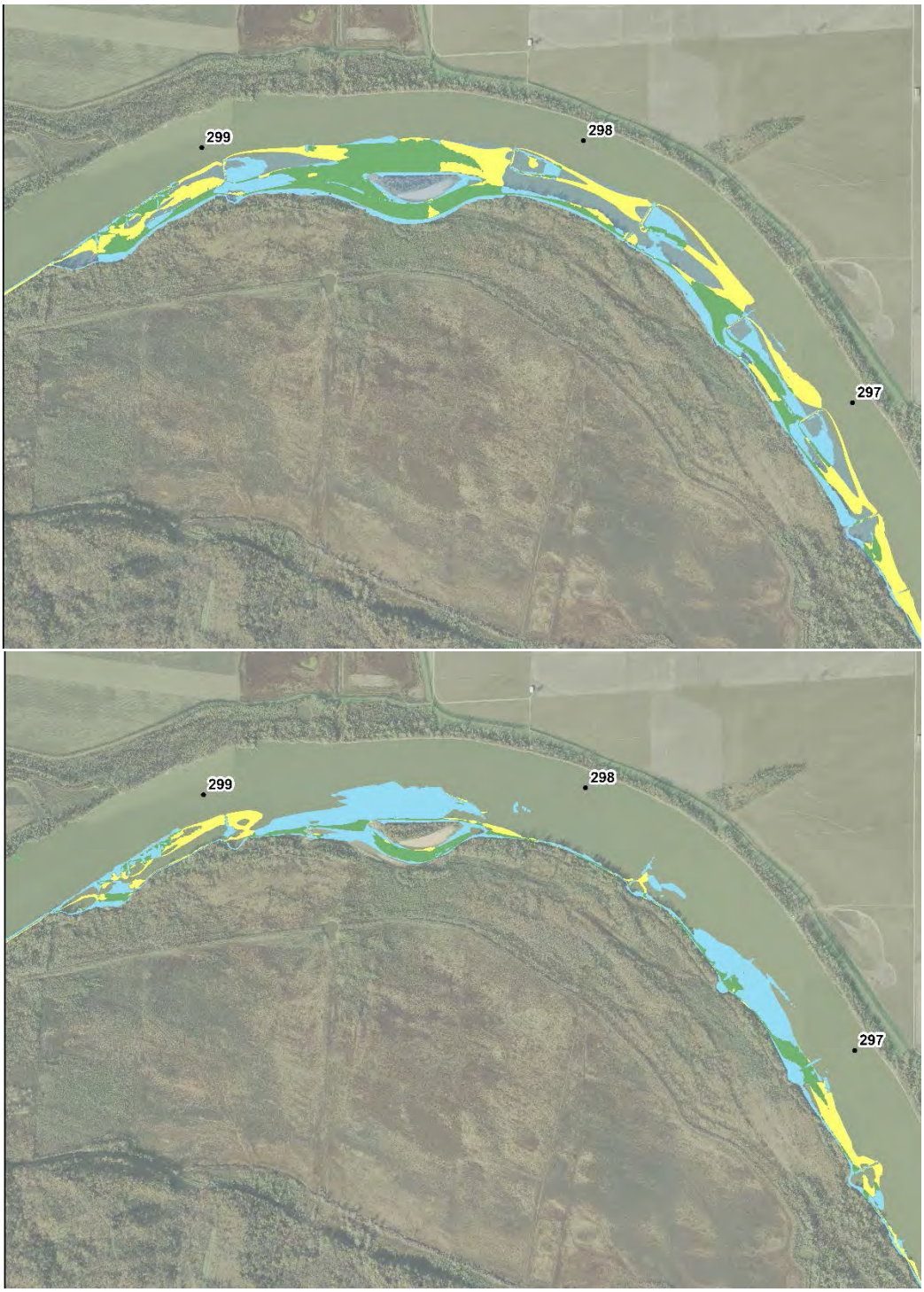


Figure 22. Foraging habitat areas of depths in blue (1-3m), velocities in yellow (0.5-0.9 m/s), and coinciding with both depth and velocity in green of Alternative 1 (top) and Existing Conditions (bottom).

4.3 Particle Tracking Results

To track the relative percent of particles entering into the area of analysis identified for interception, two traps were incorporated into the model to count particles as they passed through the trap boundaries. The traps were placed as illustrated in Figure 45. The timing of particles entering the interception area was tracked and is depicted in Figure 46. The PTM simulation ran from 16:00 to 20:00 with particles first entering the area near 16:15. The number of particles every 5 minutes entering the area appears to plateau and oscillate around a steady-state concentration for each alternative near 17:00. This indicates that the length of simulation was sufficient to reach quasi steady-state conditions relative to the hydrodynamics and provide a valid comparison of particle transport between design alternatives.

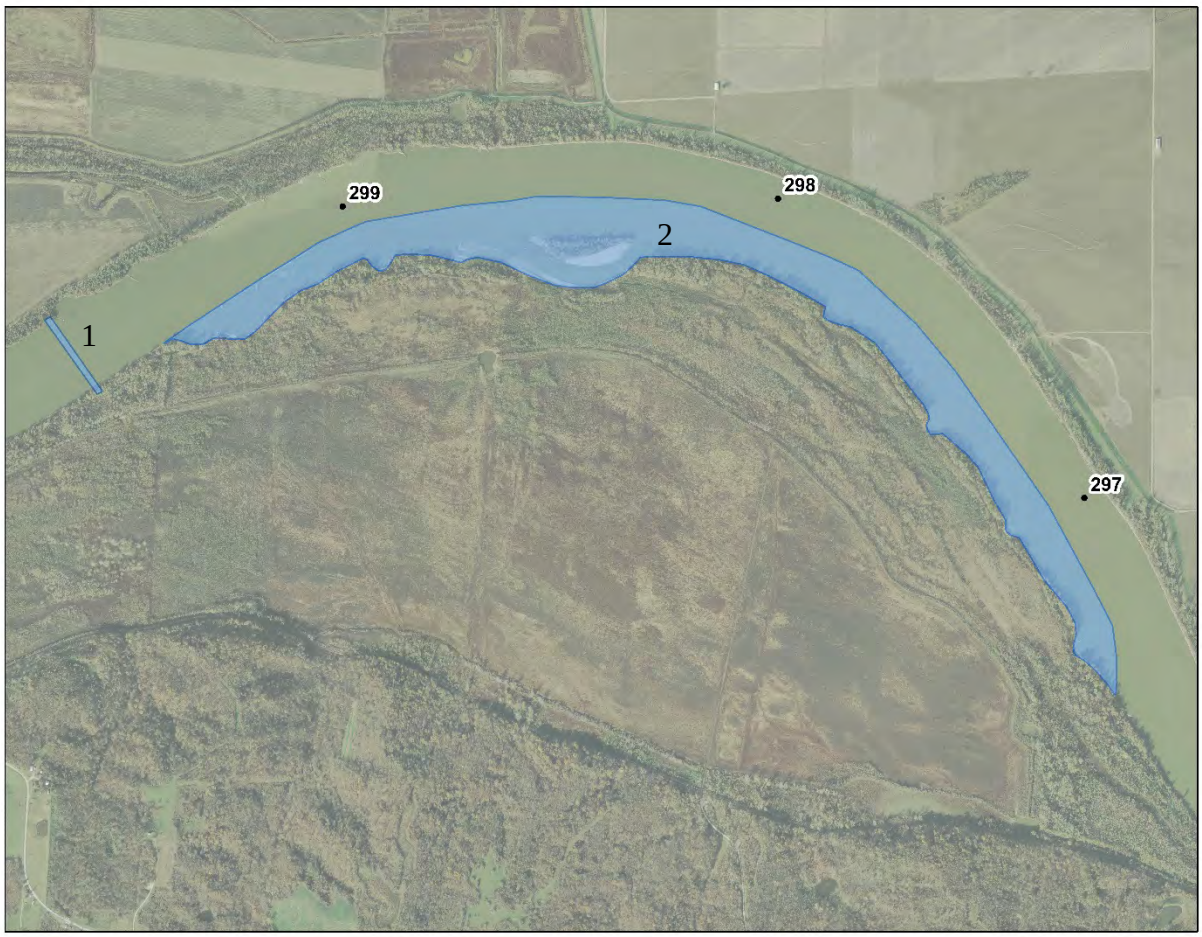


Figure 23. Location of PTM particles traps. (1) Counting total particles available for interception and (2) counting particles entering "interception" area.

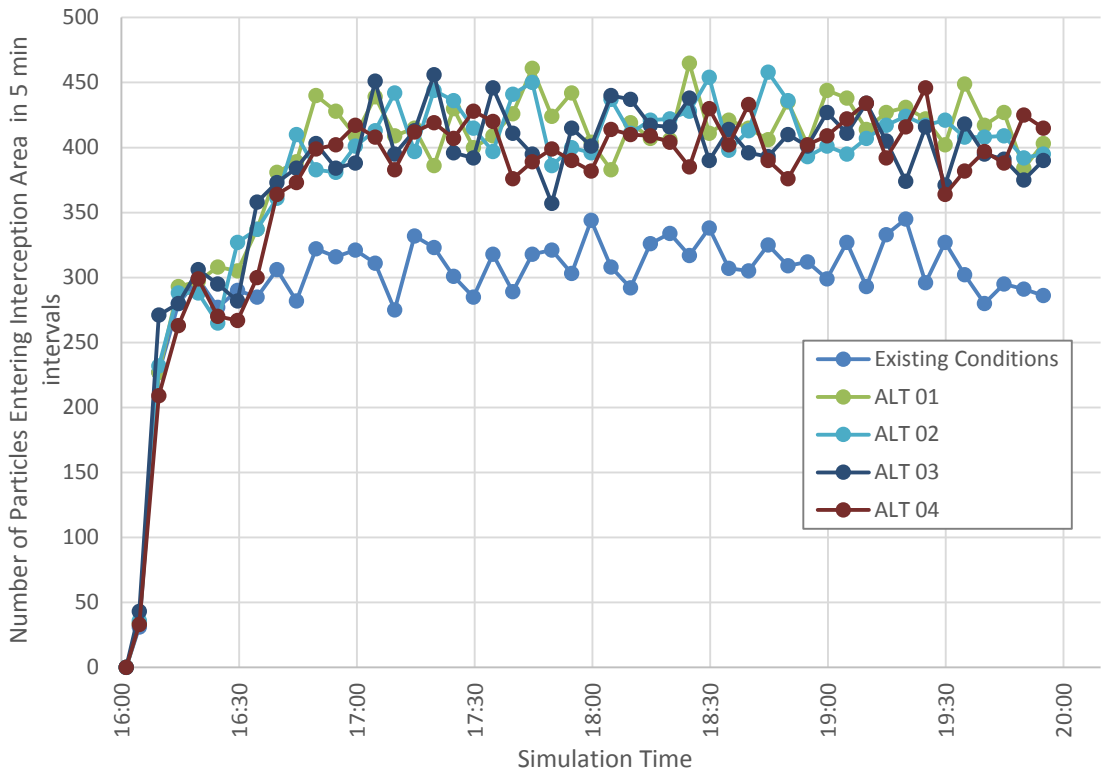


Figure 24. Timing and concentration of particles entering the interception area.

The results of the relative percent of particles intercepted into the area of analysis is provided in Table 13. The existing conditions model results in approximately 14% of particles intercepted into the area. The design alternatives varied in percent interception from 17.6-18.3%; an increase of 3.6-4.3% from existing conditions. Removal or notching of existing structures had the largest effect on interception with alternatives that had less structure removal resulting in the lowest percentages. This is likely due to the fact that removing existing structures will likely promote additional flow behind or through the dike field creating significantly more aquatic area than would exist otherwise.

Table 6. Percentage of particles intercepted into the channel margin area of analysis for the existing conditions and design alternatives models.

Model	Percent Intercepted
Existing Conditions	14.0%
Alternative 1	18.3%
Alternative 2	18.1%
Alternative 3	17.8%
Alternative 4	17.6%

5.0 Conclusions

The modeling efforts discussed in this document were performed for analyzing the current conditions at the Baltimore Bend project site and assess how potential design alternatives could promote additional interception of drifting larval fish from the Missouri River navigation channel to the channel margins which are typically more beneficial for the growth and survival of larval pallid sturgeon. The hydrodynamic model was verified to field measurements taken in 2015 and match closely to observed velocity and water surface elevation data. Modeling of various design alternatives was completed by adjusting the calibrated geometry to represent combinations of dike construction and dike removal. The hydrodynamic solutions from each of the design alternatives were then used to drive larval fish transport simulations. Although there are limitations with using simplified particles characteristics in PTM to represent larval fish with specific behavioral characteristics, using PTM in the context of simplified assumptions can provide us with valuable information on particle drift within the project site. These results provided valuable insight into the potential system changes from adding or removing river control structures on the Missouri River in this bend. They also act as a valuable tool to compare and contrast potential design alternatives to be used and documented as part of a decision making framework for this project.

The results presented in this document indicate that interception of drifting particles can be increased through the modification of existing and construction of new river control structures at the Baltimore Bend site.

6.0 References

MacDonald, N.J., Davies, M.H., Zundel, A.K., Howlett, J.D., Demirbilek, J.Z., Gailani, J.Z., Lackey, T.C., and Smith, S.J. 2006. PTM: Particle Tracking Model; Report 1: Model Theory, Implementation, and Example Applications. Technical Report. U.S. Army Corps of Engineering, Engineering Research and Development Center. ERDC/CHL TR-06-02.

Tate, J.N., Lackey, T.C., McAlpin, T.O. 2010. Seabrook Fish Larval Transport Study. Technical Report. U.S. Army Corps of Engineers, Engineer Research and Development Center. ERDC/CHL TR-10-12.

7.0 Appendix A

CENWK-ED-HR

MEMORANDUM FOR RECORD

SUBJECT: Documentation of Flows on the Missouri River Relevant to Hydrodynamic Drift Analysis of Larval Pallid Sturgeon and Design of Interception Habitat

1. References

a. DeLonay, A.J., Jacobson, R.B., Papoulias, D.M., Simpkins, D.G., Wildhaber, M.L., Reuter, J.M., Bonnot, T.W., Chojnacki, K.A., Korschgen, C.E., Mestl, G.E., and Mac, M.J., 2009, Ecological Requirements for Pallid Sturgeon Reproduction and Recruitment in the Lower Missouri River: A Research Synthesis 2005-08: U.S. Geological Survey Scientific Investigations Report 2009-5201, 59 p.

b. Erwin, S.O. and Jacobson, R.B., 2014, Influence of Channel Morphology and Flow Regime on Larval Drift of Pallid Sturgeon in the Lower Missouri River: River Research and Applications 10.1002/rra.2752

c. Keenlyne, K.D., 1997, Life History and Status of the Shovelnose Sturgeon, Scaphirhynchus platorynchus: Environmental Biology of Fishes, v. 48, p.291-298.

d. Braaten, P.J., Fuller, D.B., Holte, L.D., Lott, R.D., Viste, W., Brandt, T.F., and Legare, R.G., 2008, Drift Dynamics of Larval Pallid Sturgeon and Shovelnose Sturgeon in a Natural Side Channel of the Upper Missouri River, Montana: North American Journal of Fisheries Managament, v.28, p 808-826.

e. Braaten, P.J., Fuller, D.B., Lott, R.D., Ruggles, M.P., Brandt, T.F., Legare, R.G., Holm, R.J., 2012, An Experimental Test and Models of Drift and Dispersal Processes of Pallid Sturgeon Free Embryos in the Missouri River: Environ Bio Fish v.93 p.377-392.

2. Introduction

The transition of a pallid sturgeon in the lower Missouri River (LMOR) from a drifting free embryo to an exogenously feeding fish has been identified as a potential life-stage bottleneck (Delonay et al., 2009). Simulations of drift indicate that passively drifting larvae may be exported from the LMOR into the Mississippi River prior to completing this transition (Erwin and Jacobson, 2014). The interception habitat hypothesis asserts that newly hatched free embryos are not able to exit the navigation channel before they starve because the river lacks hydraulic conditions that would transport them into supportive channel-margin habitats with food and protection (EA reference). In order to successfully design and construct interception habitat, the

timing and duration of larval drift and the range of hydraulic and hydrologic conditions associated with that timing must be understood. The purpose of this memo is to document the historical range of flows and stages on the LMOR during the time that larval drift is most likely to occur in order to infer target conditions for engineering design and construction of interception habitat.

3. Timing of Pallid Sturgeon Spawn and Drift Stages

Reproductive shovelnose and pallid sturgeon generally move upstream beginning in the late fall and early spring and spawn in the spring and early summer (between April and July) coincident with increasing day length, increasing water temperature, and typically high river flows (Figure 4) (Keenlyne, 1997; DeLonay et al., 2009).

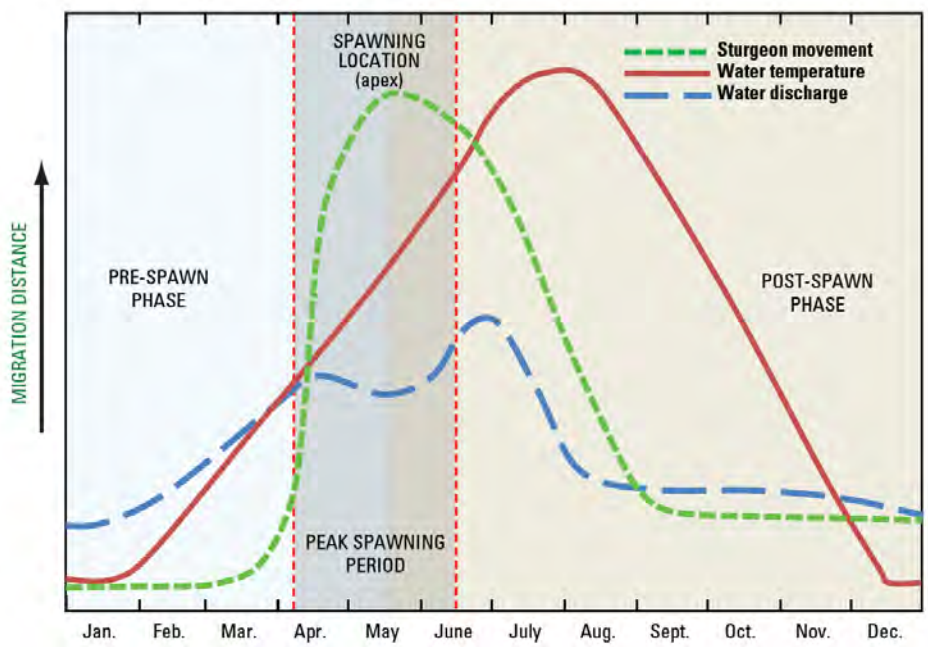


Figure 25. Conceptual model of *Scaphirhynchus* sturgeon spawning migration and behavior in the Lower Missouri River (DeLonay et al., 2009).

Incubation rates are governed by and depend upon water temperature. In a hatchery environment, fertilized eggs hatch in approximately 5-7 days (Keenlyne, 1997). Upon hatching, the transition from drifting to benthic life stage occurs at 11 to 17 days post hatch (dph) at which time yolk reserves are depleted and exogenous feeding is required to survive (Braaten et al., 2008). The total distance that sturgeon larvae drift during development is dependent on water velocity and temperature and can range up to several hundred miles downstream from spawn and hatch locations.

Considering the timing of spawning, hatching, and drifting, larvae are required to be intercepted into supportive channel margin habitats between 16 and 24 days after a successful spawn event. If peak spawning occurs from mid-April to mid-June, this puts the general timing of drift and interception from May to July.

4. Hydrologic Assessment of Relevant Stream Gages During Interception Time

To assess hydrologic conditions during times of desired interception, a stream-gage flow analysis was conducted at four relevant USGS stream-gages: St. Joseph, MO (USGS 06818000), Waverly, MO (USGS 06895500), Boonville, MO (USGS 06909000), and Hermann, MO (USGS 06934500). These four gages best represent the reach of the lower Missouri River currently targeted as most beneficial area for interception habitat (EA Reference). Analysis of post-impoundment flows from 1957 to 2015 provides a general range of discharge that can be expected to occur during the period of larval drift. The 10th, 25th, 50th, 75th, and 90th percentile flows from April through August can be seen in Figure 2. The observed values are typical of a seasonal stream hydrograph with peak flow occurring in May through June and flows tapering off in July. Quartile plots and flow percentile values during the period of drift can be seen in Figure 3 and Table 1.

The interquartile range of discharges is the most relevant range of flow to utilize for assessment and design of interception habitat because it is the most common flow range that will statistically occur during the period of larval drift. The 50th percentile, or median flow, is perhaps the most apparent discharge to use since it falls in the middle. However, the 25th and 75th percentiles are useful to assess variation around the median and should be used to evaluate conditions that will commonly occur below and above median flow. Median flows and CRP stage increase with decreasing River Mile (RM), but generally fall within the range of +1 to +6 CRP between St. Joseph, MO and Hermann, MO.

Table 7. Flow and stage percentiles for May-July from 1957-2015.

Flow Percentile	St. Joseph		Waverly		Boonville		Hermann	
	Flow (cfs)	CRP (ft)	Flow (cfs)	CRP (ft)	Flow (cfs)	CRP (ft)	Flow (cfs)	CRP (ft)
5	31,000	-3.3	34,400	-2.2	36,400	-2.3	41,300	-2.1
10	33,900	-2.6	37,800	-1.5	40,300	-1.5	46,500	-1.1
25	39,200	-1.3	45,700	0.0	50,100	0.4	59,600	1.2
50	51,000	1.3	65,300	3.0	74,300	4.0	94,400	5.8
75	69,800	4.7	94,300	6.4	114,000	8.5	148,000	11.2
90	99,370	9.3	134,000	10.0	172,000	14.1	221,000	16.4
95	121,000	12.3	169,000	12.6	218,000	16.8	264,000	18.9

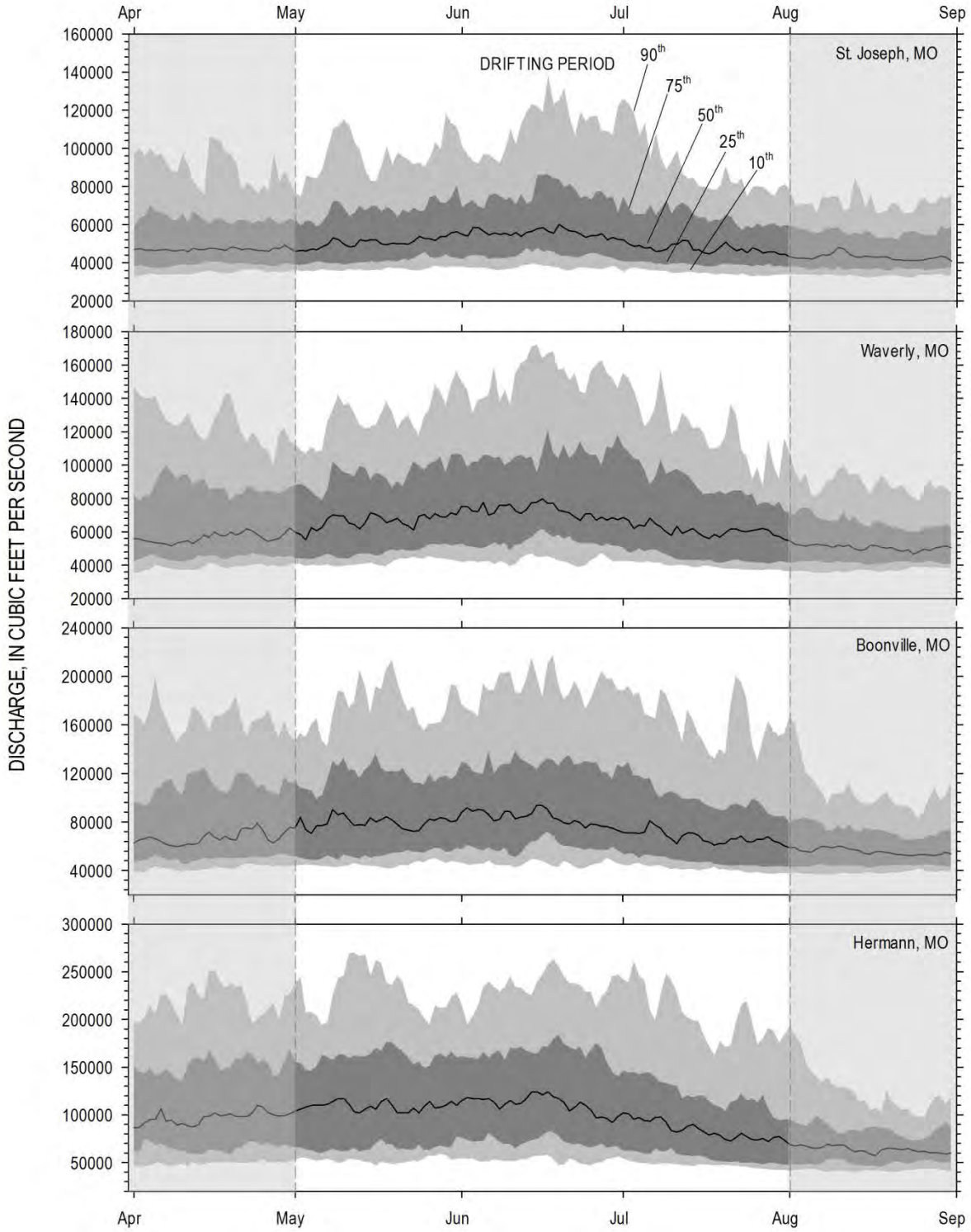


Figure 26. Hydrographs encompassing the 10th, 25th, 50th, 75th, and 90th percentile flows for the period of 1957-2015. Highlighted area illustrates the general period of post-hatch drift for larval sturgeon.

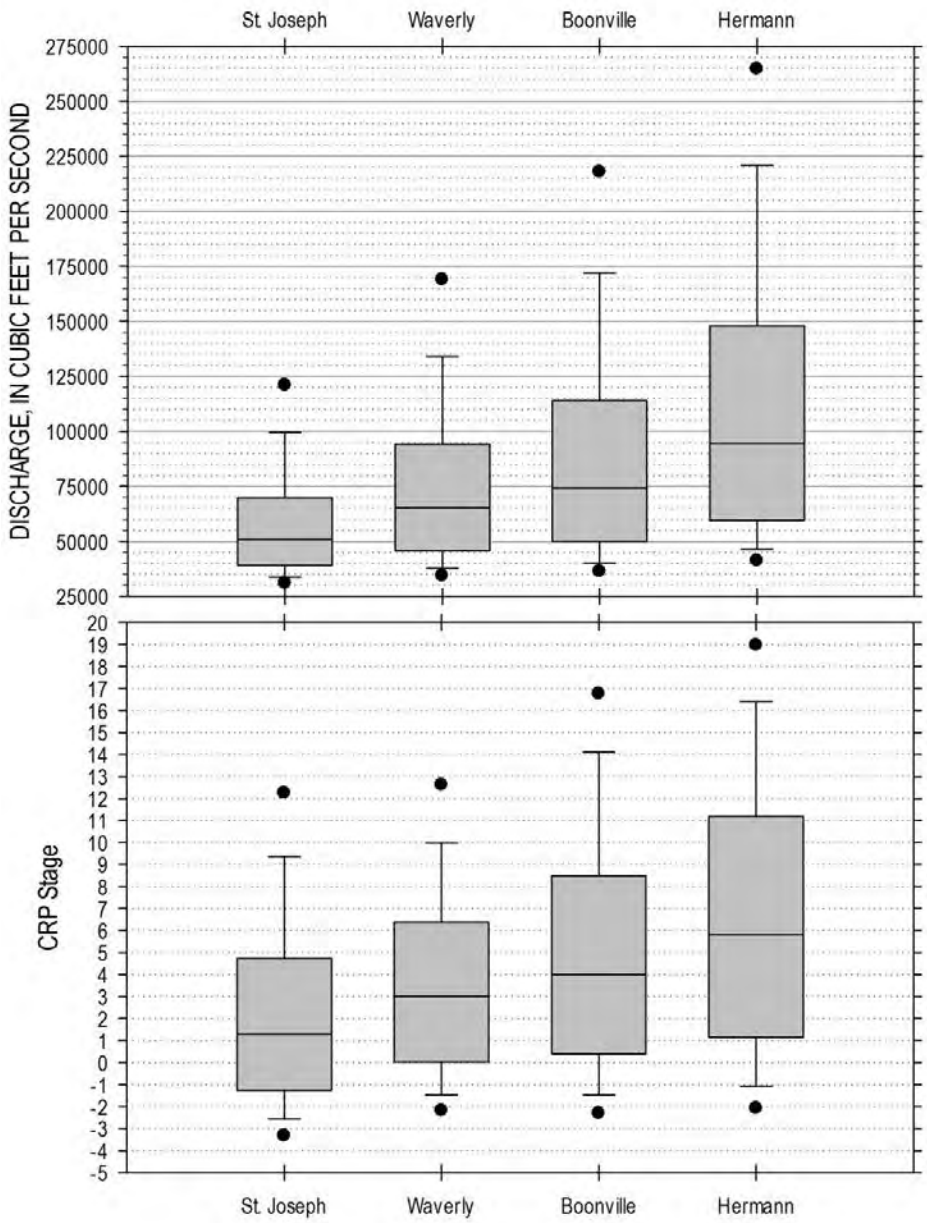


Figure 27. Quartile plots of discharge and Construction Reference Plane (CRP) stage showing 5th and 95th percentile outliers.

5. Conclusion

This memo provides a discussion of the timing of pallid sturgeon spawning and post-spawn drift and presents a flow analysis at four Missouri River stream-gages of conditions that are relevant to the larval drift stage. Based on an analysis of flows from 1957 to 2015 between May and July, the median flow CRP stage at St. Joseph, Waverly, Boonville, and Hermann are 1.3, 3.0, 4.0, and 5.8 respectively. This information along with the variation within the interquartile range should be considered when assessing and designing for interception habitat along the LMOR. The flow and stage to be used in an assessment is site specific and the location of the project site relative to the gages assessed in this memo should be evaluated.

APPENDIX D

Draft CWA Section 404(b)(1) Evaluation

Missouri River Recovery Program
Baltimore Bend Interception Rearing Complex Project
Lafayette County, Missouri

Section 404(b)(1) Evaluation

1. Introduction

This Section 404(b)(1) Evaluation is for the Missouri River Recovery Program, Baltimore Bend Interception Rearing Complex Project, Lafayette County, Missouri. The goal of this project is to develop and increase IRC for the federally endangered pallid sturgeon within the lower Missouri River. This project will help test the hypothesis that mostly passive free-floating pallid sturgeon embryos and larvae are entrained in the thalweg, the deepest fastest flowing portion of the channel, and are unable to move to the channel margins where environmental conditions may be more suitable for their growth and survival. Since 2004, USACE has been taking numerous actions to avoid jeopardy to pallid sturgeon on the lower Missouri River that were included in the recommended and prudent alternative from the U.S. Fish and Wildlife Service 2003 Amendment to the 2000 Biological opinion on the operation and maintenance of the Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River BSNP, and operation of the Kansas River Reservoir System. These actions have included maintaining a stocking (propagation) program for pallid sturgeon, limited testing of flow modifications, and construction of shallow-water habitat. Shallow-water habitat construction has primarily consisted of notching select BSNP dikes along the river and constructing side channels across inside bends of the Missouri River in locations where the federal government owned sufficient land to construct such features. To date, there have not been strong indications that pallid sturgeon are successfully recruiting to reproductive age naturally in the lower Missouri River. It has been postulated that free-drifting embryos and larval pallid sturgeon do not survive because they are unable to move from the thalweg of the river to the channel margins where conditions are believed to be more suitable for growth and survival. The purpose of this project is to test the hypothesis that re-engineering the Missouri River channel morphology in select reaches would increase channel complexity and serve specifically to promote interception and retention of free-drifting embryos and larval sturgeon in areas believed to be important for first feeding and for growth through the juvenile life stage. This evaluation meets the requirements found in 40 CFR 230, Section 404(b)(1): Guidelines for Specification of Disposal Sites for Dredged and Fill Material.

2. Project Description

a. Location: The project (Proposed Action) is located in the Missouri River seven miles west of Waverly, Missouri. The bend is 17,000-foot long and extends from about Missouri River mile 300.1 to 296.5. The project area is primarily within the banks of the Missouri River. It is adjacent to Baltimore Bottoms which is owned by USFWS as part of the Big Muddy National Fish and Wildlife Refuge.

b. General Description: A detailed description of the proposed action, including illustrations, is described in Section 2 of the Missouri River Recovery Program, Baltimore Bend Interception Rearing Complex Project, Definite Project Report and Integrated Environmental Analysis.

The proposed action would result in an interception ratio of 0.181 and 52.1 acres and foraging habitat when fully developed. It would result in an additional 3.94 AAHUs of interception-rearing-complex (IRC).

Habitat benefits would be obtained by removing portions of nine rock structures at locations A, B, C, D, E, F, G, H, I and J in Figure 1. Seven existing dikes would be extended in length and raised in height at locations 1, 2, 3, 4, 5, 6, and 7. These modifications were designed to maintain adequate flow to the navigation channel while directing flow to the channel margin to intercept free-drifting embryos and larval sturgeon. Over time, the flow directed towards the channel margin would erode portions of the existing sand bed to increase rearing habitat. It was assumed that this would occur over a four-year period, at which time the project would be considered fully developed. Four years is a reasonable time frame to assume for the project to reach full development from introduction of the planned structures. The rate of development will largely depend on the flows experienced in the years following construction. Four years was assumed a conservative estimate, and full development will likely occur prior to four years. However, although the Missouri River is largely controlled and fixed by the BSNP, the river will change over time and changes are likely to occur after four years as well.

Approximately 10,600 cubic yards of rock, wood piling, sand, and wood or woven willow mattress removed from locations A, B, C, D, E, F, G, H, I and J would be spoiled in areas immediately downstream of the structure, reused for dike extensions, or beneficially placed along existing structures in need of repair on the left bank of the river.

Approximately 20,400 cubic yards of rock would be used to extend and raise existing dikes. All construction would take place from a barge.

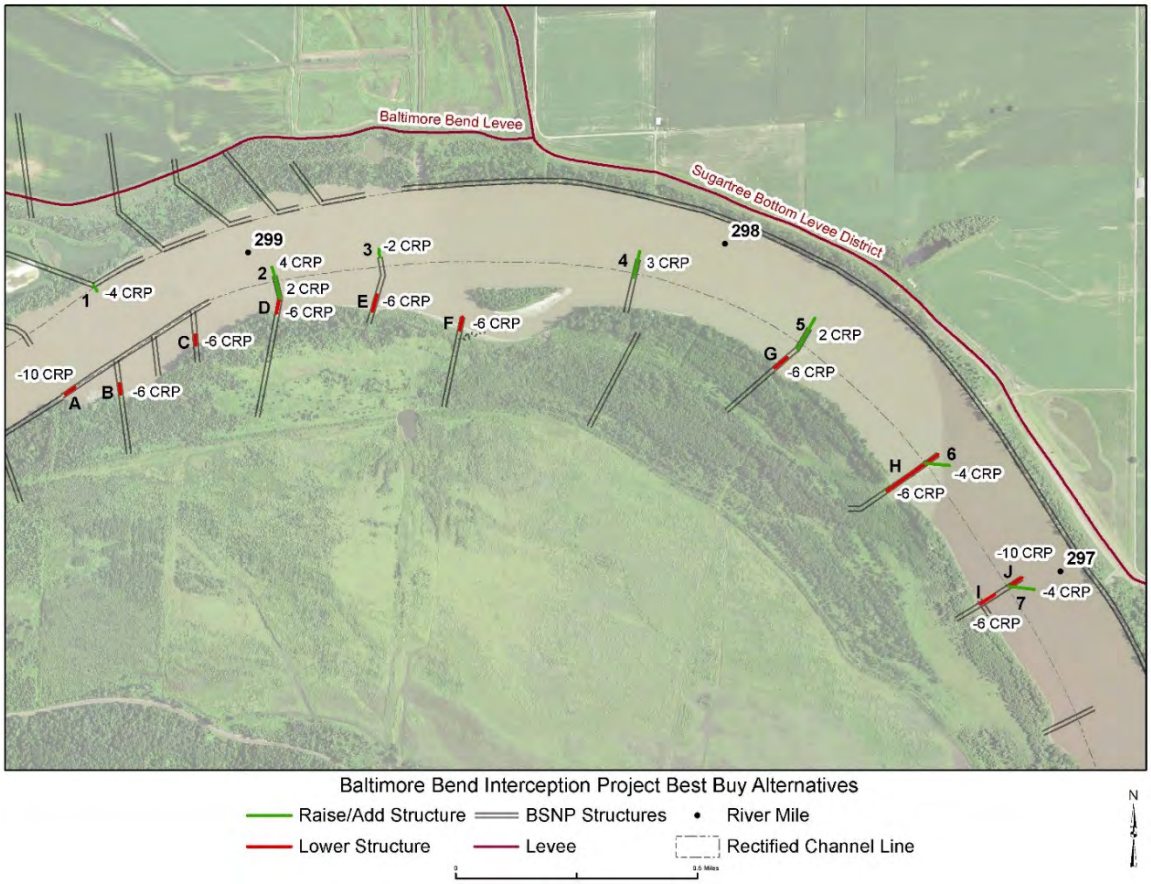


Figure 1: The Recommended Plan would result in a net benefit of 9.24 AAHUs of IRC. Numbers with + or – in front represent the elevation in feet of the structure compared to the construction reference plane.

c. Authority: The project would be completed under the authority of the Missouri River Fish and Wildlife Mitigation Project (Mitigation Project) from Water Resource Development Acts (WRDA) of 1986, 1999, and 2007. The proposed action is regulated by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act (33 USC 1344).

3. Review of Compliance (§ 230.10 a-d)

a. No practicable alternative to the proposed project would have a less adverse impact on the aquatic ecosystem while meeting the project objectives. Additional information on the impacts of various alternatives to

waters of the U.S. can be found in Section 4 of the Missouri River Recovery Program, Baltimore Bend Interception Rearing Complex Project, Definite Project Report and Integrated Environmental Analysis.

b. The proposed project would not violate any applicable state water quality standards, or applicable toxic effluent standard or prohibition under Section 307 of the Clean Water Act. The proposed project is not likely to jeopardize the continued existence of species listed as endangered or threatened under the Endangered Species Act of 1973, as amended, to result in the likelihood of the destruction or adverse modification of critical habitat. Furthermore, the proposed project would not violate the requirements of any federally designated marine sanctuary.

c. The proposed project would not cause or contribute to significant degradation of waters of the U.S. This includes no adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values.

d. Appropriate and practical steps have been taken which will minimize potential adverse impacts on the aquatic ecosystem.

4. Technical Evaluation Factors (Subparts C-F)

a. Potential Impacts on Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)

1) Substrate: The proposed action would result in the placement of rock and excavated material into the Missouri River. The Recommended Plan consists of removing portions of nine rock structures, the extension of seven existing dikes, and raising the height of seven structures. Approximately 20,400 cubic yards of rock would be used to extend and raise existing dikes. The height of the dikes would vary from two feet above to four feet below the construction reference plane. The construction reference plane is used as a baseline elevation used to construct dikes and revetments on the Missouri River. Approximately 10,600 cubic yards of rock, wood piling, sand, and wood or woven willow mattress removed from the nine rock structures and used to supplement the existing revetment structure already present on the left descending bank of Baltimore Bend.

2) Suspended particulates/turbidity: Based on experience from other similar projects, the proposed plan would result in minor, short-term impacts to suspended particulates and an increase in

turbidity during project construction. These increases would be most evident during construction when the existing rock structures are being modified using approximately 20,400 tons of clean rock and the removal of approximately 10,600 cubic yards of fill. The amount of material that would enter the river would be minimal compared to the amount of material that enters the Missouri River by natural processes. The proposed plan would not violate any general criteria of the Missouri Water Quality Standards, 10 CSR 20-7.037(3) (A)-(H).

3) **Water:** The project would not result in any long-term negative impacts to water quality.

   a) **Salinity**: Not applicable

   b) **Water Chemistry**: Minor, temporary, and localized effect to water chemistry (see below) would primarily include an increase in turbidity due to construction activities.

   c) **Clarity:** A minor temporary increase in turbidity would potentially occur during construction of the project that could impact clarity. Even at the increased level the clarity would be within baseline conditions of the Missouri River and therefore not expected to adversely impact native species.

   d) **Color:** A minor temporary change in color is possible due to the potential increased turbidity. Similar to Clarity above, any color change would be greatest during construction and would quickly become unnoticeable within a short distance downstream. Any changes in color would be expected to be within the range that is typically found where natural erosion occurs along the river or out of tributaries during high flow events and therefore not expected to adversely impact native species or result in adverse aesthetic impacts.

   e) **Odor:** No impacts are anticipated

   f) **Taste:** Not applicable

   g) **Dissolved Gas Levels:** No changes to dissolved gas levels are anticipated.

h) **Nutrients:** Any alluvial sediments and associated nutrients that may be mobilized to construct the proposed action are materials deposited from river transport that are in temporary storage in the flood plain. Under natural conditions, the river would flood, rework, remove, and deposit these materials in a dynamic fashion. Any sediment and nutrients being remobilized are not a net addition to the system. This material, or its equivalent, would have been transported through the system by natural geomorphic processes in an unaltered river. This activity will not adversely affect life forms in the immediate project area or in areas downstream.

i) **Eutrophication:** The proposed action would not result in any eutrophication to the Missouri River or other water bodies downstream. It has been documented by the National Research Council that other, larger scale, Missouri River Recovery Projects have not contributed to an increase in the areal extent of the Gulf of Mexico hypoxic zone.

4) **Current patterns and water circulation:** The intent of this project is to alter localized current patterns and water circulation within the project footprint, however the project is not intended nor is it expected to change current patterns or circulation downstream of the project. Excavated material returned to the Missouri River would not alter flow or circulation patterns substantially. The dynamic sediment transport processes are critical elements to the natural ecological function of the Missouri River. Fish and wildlife resources would not be adversely impacted by the resulting changes in current patterns and circulation. The project is designed to ensure that flows and sediment transport on the main channel of the Missouri River would not be adversely impacted. It is not anticipated that this would result in any adverse significant changes to the location, structure and dynamics of the aquatic community, or the rate and extent of the mixing of dissolved and suspended components of the water body.

5) **Normal water fluctuations:** There are no anticipated changes to normal water fluctuations that would result from the proposed project. There would not be any significant change to existing water elevation on the Missouri River within the vicinity of the project as a result of modifying existing rock structures.

6) **Salinity Gradients:** The proposed project would not impact any salinity gradients. The Missouri River is a freshwater system and this would not change as a result of the project.

b. Potential Impacts to the Biological Characteristics of the Aquatic Ecosystem (Subpart D)

1) **Threatened and endangered species:** This project "may affect but is not likely to adversely affect" pallid sturgeon. Any impacts to pallid sturgeon would be beneficial. The project is expected to promote interception and retention of free drifting embryos and larval sturgeon in areas with sufficient prey for first feeding and for growth through the juvenile life stage. The Recommended Plan would result in an interception ratio of 0.181 and 52.1 acres of foraging habitat when fully developed. It would result in an additional 3.94 AAHUs of interception rearing complex habitat compared to the No-Action/Future Without Project Condition.

   This project would have "no affect" on Indiana bat, northern long-eared bat, or gray bat. The Recommended Plan is not located in the immediate vicinity of any caves and would not impact any trees used by these species. It would also have "no affect" on least tern, piping plover, or rufa red knot. These species may migrate through the region but are not known to utilize the project area.

2) **Fish, crustaceans, mollusks, and other aquatic organisms in the food web:** The project would not result in significant adverse impacts to aquatic organisms. Minor, short-term impacts to the aquatic community may result from the smothering of immobile organisms, direct displacement of organisms, and an increase in turbidity, during project construction. The impacts may affect individual organisms in a limited stretch of the Missouri River, but would be unlikely to have a significant impact on the overall population of any particular species within the river system. Long-term, there would be a positive impact to the aquatic ecosystem by creating a more dynamic aquatic habitat condition with varying depths and water velocities. It would also result in a more dynamic geomorphic condition which would benefit native fish and wildlife. No significant adverse long-term impacts are anticipated.

3) **Other wildlife:** Wildlife associated with aquatic ecosystems includes resident and transient mammals, birds, reptiles, and amphibians. There would be minor, short-term impacts to these

types of wildlife as a result of construction activities. No significant adverse long-term impacts are anticipated.

c. Potential Impacts on Special Aquatic Sites (Subpart E)

1) **Sanctuaries and Refuges:** A Big Muddy National Fish and Wildlife Refuge that is managed by the U.S. Fish and Wildlife Service is located directly south of the project area. The project would not have any direct effect on the refuge.

2) **Wetlands:** The proposed action would not result in any direct impacts to wetlands. The project is located within the banks of the Missouri River.

3) **Mud flats:** No mud flats would be impacted by the proposed project.

4) **Vegetated shallows:** No vegetated shallows would be impacted by the proposed project. Because of the velocity of the Missouri River, little to no rooted aquatic vegetation is located within the project area.

5) **Coral reefs:** The project area does not provide the necessary environmental conditions to support corals.

6) **Riffle and pool complexes:** Because of the low gradient and sandy/silty nature of the Missouri River in the vicinity of the project site, a stable riffle and pool complex does not exist.

d. Potential Effects on Human Use Characteristics (Subpart F):

1) **Municipal and private water supplies:** The project would not impact any municipal or private water supplies. The project is designed to benefit commercial navigation on the Missouri River.

2) **Recreational and commercial fisheries:** The project would not affect the suitability of any recreational or commercial fisheries. The proposed action is expected to benefit aquatic organisms, including species targeted by recreational and commercial fisheries.

3) **Water-related recreation:** The project would not impair or destroy any resources which support recreation activities. There may be minor, short-term impacts to recreation during project construction due to restricted access.

4) **Aesthetics:** The project may result in minimal impacts to the aesthetics of the area as a result of project construction. This impact is expected to be short-term.

5) **Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves:** The project would not impact the adjacent Big Muddy National Fish and Wildlife Refuge or any of the above mentioned property types.

5. EVALUATION OF DREDGED OR FILL MATERIAL (Subpart G)

a. **General evaluation of dredged or fill material:** Fill material associated with the project would include clean rock riprap obtained from commercial sources, existing BSNP structures, or from sandbars.

b. **Chemical, biological, and physical evaluation and testing:** Prior experience indicates that commercially available rock fill would be free of chemical, biological, or other pollutants. There is no reason to believe that the clean rock fill would be a carrier of harmful contaminants.

6. DISPOSAL SITE DELINEATION (§230.11 f)

The discharge sites would be within portions of the mainstem of the Missouri River.

7. ACTIONS TO MINIMIZE ADVERSE EFFECTS (SUBPART H)

Steps to minimize impacts would include non-structural BMPs such as keeping heavy construction equipment out of the waterway whenever possible, protecting construction materials from precipitation/flooding, having spill containment plans for construction equipment, and using materials that are free from contaminants.

8. FACTUAL DETERMINATIONS (§230.11)

A review of the information in items 4 thru 7 of this report indicates that there is minimal potential for long-term environmental effects of the proposed fill. Additionally, there are not expected to be any adverse cumulative or long-term, secondary impacts as a result of the project.

9. FINDINGS (§230.12)

The proposed Missouri River Recovery Program, Baltimore Bend Interception Rearing Complex Project has been evaluated and determined to be in compliance with Clean Water Act Section 404(b)(1) guidelines,

with the inclusion of appropriate and practical conditions to minimize pollution and adverse effects on the aquatic ecosystem.

Prepared by: _____ _____

Mr. Rick Morrow Date
Biologist
Planning Branch

Reviewed by: _____ _____

Mr. Jason Farmer Date
Chief, Environmental Resources Section
Planning Branch

Approved by: _____ _____

Andrew D. Sexton Date
Colonel, Corps of Engineers
District Commander

APPENDIX E

CWA Section 401 Water Quality Certification (Pending)

APPENDIX F

Cultural Resources Coordination

CULTURAL RESOURCE ASSESSMENT
Section 106 Review

CONTACT PERSON/ADDRESS

Timothy Meade, District Archeologist
Corps of Engineers, Kansas City District
635 Federal Building
601 East 12th Street
Kansas City, Missouri 64106-2824

C:

Amber Tucker, EPA

PROJECT:

Baltimore Bend Interception-Rearing-Complex Project

FEDERAL AGENCY

COE

COUNTY:

LAFAYETTE

The State Historic Preservation Office has reviewed the information submitted on the above referenced project. Based on this review, we have made the following determination:

[ ] After review of initial submission, the project area has a low potential for the occurrence of cultural resources. A cultural resource survey, therefore, is not warranted.

[X] Adequate documentation has been provided (36 CFR Section 800.11). There will be "no historic properties affected" by the current project.

[ ] An adequate cultural resource survey of the project area has been previously conducted. It has been determined that for the proposed undertaking there will be "no historic properties affected".

For the above checked reason, the State Historic Preservation Office has no objection to the initiation of project activities. PLEASE BE ADVISED THAT, IF THE CURRENT PROJECT AREA OR SCOPE OF WORK ARE CHANGED, A BORROW AREA IS INCLUDED IN THE PROJECT, OR CULTURAL MATERIALS ARE ENCOUNTERED DURING CONSTRUCTION, APPROPRIATE INFORMATION MUST BE PROVIDED TO THIS OFFICE FOR FURTHER REVIEW AND COMMENT. Please retain this documentation as evidence of compliance with Section 106 of the National Historic Preservation Act, as amended.

By: Toni M. Prawl — **May 4, 2016**
Toni M. Prawl, Ph.D., Deputy State Historic Preservation Officer — **Date**

MISSOURI DEPARTMENT OF NATURAL RESOURCES
STATE HISTORIC PRESERVATION OFFICE
P.O. Box 176, Jefferson City, Missouri 65102
For additional information, please contact Judith Deel, (573) 751-7862. Please be sure to refer to the project number: 006-LF-16

APPENDIX G

Wildlife Coordination

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Columbia Ecological Services Field Office
101 PARK DEVILLE DRIVE, SUITE A
COLUMBIA, MO 65203
PHONE: (573)234-2132 FAX: (573)234-2181

Consultation Code: 03E14000-2016-SLI-1116 March 21, 2016
Event Code: 03E14000-2016-E-01017
Project Name: Baltimore Bend Interception Habitat

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

This response has been generated by the Information, Planning, and Conservation (IPaC) system in order to provide information on natural resources that could be affected by your project. The response is provided by the U.S. Fish and Wildlife Service (Service) under the authority of the Endangered Species Act of 1973 (16 U.S.C. 1531-1543), the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d), the Migratory Bird Treaty Act (16 U.S.C. 703-712), and the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.).

Threatened and Endangered Species

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact our office if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. **Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days.** This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

For assistance in determining if suitable habitat for listed, candidate, or proposed species occurs within your project area or if species may be affected by project activities, please visit species profiles at http://www.fws.gov/midwest/endangered/section7/s7process/lifehistory.html. Indiana bats, gray bats, and northern long-eared bats occur throughout Missouri and the information below may help in determining if your project may affect these species.

Gray bats - Gray bats roost in caves or mines year-round and use forest riparian areas for foraging. If your project will impact caves or mines or will involve tree removal around these areas (particularly within stream corridors, riparian areas, or associated upland woodlots), gray bats could be affected.

Indiana and northern long-eared bats - These species hibernate in caves or mines only during the winter. The rest of the year they roost under loose tree bark in tree crevices or cavities during the day and forage around tree canopies of floodplain, riparian, and upland forests at night. Trees which should be considered potential roosting habitat include those exhibiting loose or shaggy bark, crevices, or hollows. Tree species often include, but are not limited to: shellbark or shagbark hickory, white oak, cottonwood, and maple. If your project will impact caves or mines or will involve clearing forested habitat containing suitable roosting habitat, Indiana bats or northern long-eared bats could be affected. If your project will involve removal of over 5 acres of forested habitat, you may wish to complete a Summer Habitat Assessment prior to contacting our office in order to expedite the consultation process. The Summer Habitat Assessment Form is available in Appendix A of the most recent version of the Range-wide Indiana Bat Summer Survey Guidelines, located at www.fws.gov/midwest/Endangered/mammals/inba/ under the heading Summer Survey Guidance.

If no suitable habitat for any federally-listed, candidate, or proposed species is present, and no species or their critical habitat will be affected, then no further consultation or coordination is required. However, if any of the following apply, please contact our office for further consultation:

1. Designated critical habitat is present within the project area,
2. Suitable habitat for listed, candidate, or proposed species is present within the project area (see above for habitat descriptions for bat species), or
3. You determine that project activities may affect these species or their critical habitat (e.g., project occurs upstream or within a distance such that the species or habitat could be affected).

The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. For additional conservation measures that may benefit species identified in the enclosed list, please contact our office.

Other Considerations

Bald and Golden Eagles - Although the bald eagle has recently been removed from the endangered species list, this species and the golden eagle are protected by the Bald and Golden

Eagle Act and the Migratory Bird Treaty Act. Should bald or golden eagles occur within or near the project area please contact our office for further coordination. For communication and wind energy projects, please refer to additional guidelines below.

Migratory Birds - The Migratory Bird Treaty Act (MBTA) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Service. The Service has the responsibility under the MBTA to proactively prevent the mortality of migratory birds whenever possible and we encourage implementation of recommendations that minimize potential impacts to migratory birds. Such measures include clearing forested habitat outside of the nesting season (generally March 1 to August 31) or conducting nest surveys prior to clearing to avoid injury to eggs or nestlings.

Communication Towers - Construction of new communications towers (including radio, television, cellular, and microwave) creates a potentially significant impact on migratory birds, especially some 350 species of night-migrating birds. However, the Service has developed voluntary guidelines for minimizing impacts and these can be found at http://www.fws.gov/habitatconservation/communicationtowers.html.

Transmission Lines - Migratory birds, especially large species with long wingspans, heavy bodies, and poor maneuverability can also collide with power lines, In addition, mortality can occur when birds, particularly hawks, eagles, kites, falcons, and owls, attempt to perch on uninsulated or unguarded power poles. In order to minimize these risks, please refer to guidelines developed by the Avian Power Line Interaction Committee's and the Service at http://www.aplic.org/uploads/files/2634/APPguidelines_final-draft_Aprl2005.pdf. Implementation of these measures is especially important along sections of lines adjacent to wetlands or other areas known to support large numbers of raptors and migratory birds.

Wind Energy - To minimize impacts to migratory birds and bats, wind energy projects should follow guidelines located at http://www.fws.gov/windenergy. In addition, please refer to the Service's Eagle Conservation Plan Guidance, located at http://www.fws.gov/windenergy/eagle_guidance.html, which provides guidance for conserving bald and golden eagles in the course of siting, constructing, and operating wind energy facilities.

Next Steps

Should you determine that project activities may impact any of the natural resources described herein, please contact our office for further coordination. Letters with requests for consultation or correspondence about your project should include the Consultation Tracking Number in the header.

If you have not already done so, please contact the Missouri Department of Conservation (Policy Coordination, P. O. Box 180, Jefferson City, MO 65102) for information concerning Missouri Natural Communities and Species of Conservation Concern.

We appreciate your concern for threatened and endangered species and please feel free to contact our office with questions or for additional information.

Amy Salveter

Attachment

United States Department of Interior
Fish and Wildlife Service

Project name: Baltimore Bend Interception Habitat

Official Species List

Provided by:

Columbia Ecological Services Field Office
101 PARK DEVILLE DRIVE
SUITE A
COLUMBIA, MO 65203
(573) 234-2132

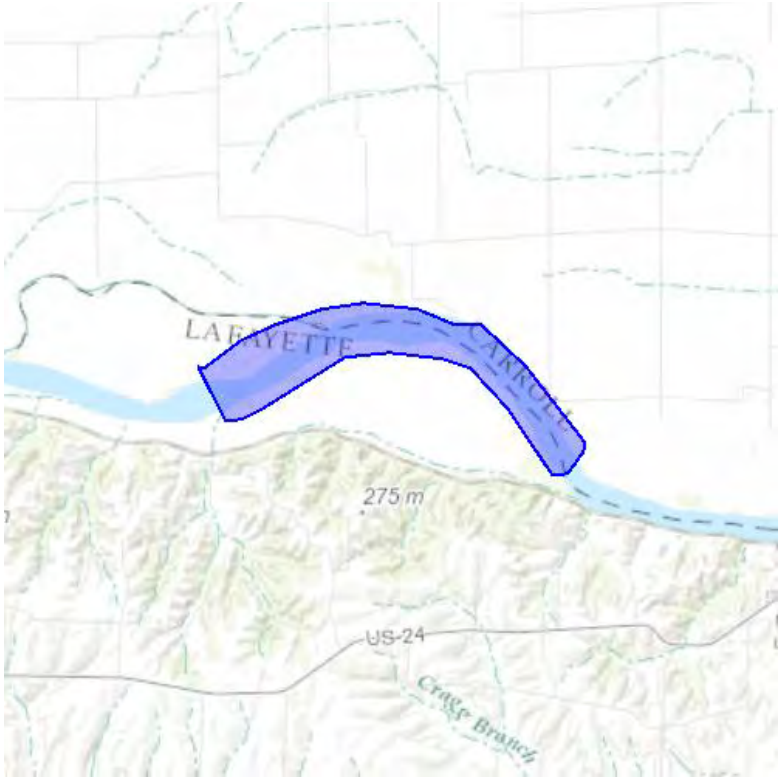
Consultation Code: 03E14000-2016-SLI-1116
Event Code: 03E14000-2016-E-01017

Project Type: Guidance

Project Name: Baltimore Bend Interception Habitat
Project Description: Modifying existing structures to increase interception of larval fish into rearing habitat

Please Note: The FWS office may have modified the Project Name and/or Project Description, so it may be different from what was submitted in your previous request. If the Consultation Code matches, the FWS considers this to be the same project. Contact the office in the 'Provided by' section of your previous Official Species list if you have any questions or concerns.

Project Location Map:



Project Coordinates: MULTIPOLYGON (((-93.59029769897461 39.24342147595056, -93.58420372009277 39.24149373569347, -93.5796546936035 39.241427260946594, -93.57218742370605 39.23590963736126, -93.56231689453125 39.226136395789844, -93.5624885559082 39.22493957879438, -93.56514930725096 39.2219474470227, -93.56772422790527 39.221814460428085, -93.57519149780273 39.23045806503116, -93.58154296875 39.235710197057486, -93.58626365661621 39.23703978837414, -93.59510421752928 39.23783753106971, -93.60274314880371 39.237106267278556, -93.61656188964844 39.23045806503116, -93.62008094787596 39.229061862530656, -93.62265586853027 39.228995376004434, -93.62746238708496 39.23590963736126, -93.62634658813475 39.235710197057486, -93.6199951171875 39.2393000357857, -93.61433029174805 39.241427260946594, -93.60651969909668 39.243487948807626, -93.59956741333008 39.24415267391341, -93.59029769897461 39.24342147595056)))

Project Counties: Carroll, MO | Lafayette, MO

Endangered Species Act Species List

There are a total of 7 threatened or endangered species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section further below for critical habitat that lies within your project. Please contact the designated FWS office if you have questions.

Birds	**Status**	**Has Critical Habitat**	**Condition(s)**
Least tern *(Sterna antillarum)* Population: interior pop.	Endangered		
Piping Plover *(Charadrius melodus)* Population: except Great Lakes watershed	Threatened	Final designated	
Red Knot *(Calidris canutus rufa)*	Threatened		
Fishes			
Pallid sturgeon *(Scaphirhynchus albus)* Population: Entire	Endangered		
Mammals			
Gray bat *(Myotis grisescens)* Population: Entire	Endangered		
Indiana bat *(Myotis sodalis)* Population: Entire	Endangered		
Northern long-eared Bat *(Myotis septentrionalis)*	Threatened		

Critical habitats that lie within your project area

There are no critical habitats within your project area.

United States Department of Interior
Fish and Wildlife Service

Project name: Baltimore Bend Interception Habitat

Appendix A: FWS National Wildlife Refuges and Fish Hatcheries

The following FWS National Wildlife Refuges and Fish Hatcheries lie fully or partially within your project area.

Big Muddy National Fish And Wildlife Refuge
4200 E. NEW HAVEN ROAD
COLUMBIA, MO 65201
(573) 876-1826

United States Department of Interior
Fish and Wildlife Service

Project name: Baltimore Bend Interception Habitat

Appendix B: FWS Migratory Birds

The protection of birds is regulated by the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA). Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). The MBTA has no otherwise lawful activities. For more information regarding these Acts see:
http://www.fws.gov/birds/policies-and-regulations/laws-legislations/migratory-bird-treaty-act.php
http://www.fws.gov/birds/policies-and-regulations/laws-legislations/bald-and-golden-eagle-protection-act.php

All project proponents are responsible for complying with the appropriate regulations protecting birds when planning and developing a project. To meet these conservation obligations, proponents should identify potential or existing project-related impacts to migratory birds and their habitat and develop and implement conservation measures that avoid, minimize, or compensate for these impacts. The Service's Birds of Conservation Concern (2008) report identifies species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become listed under the Endangered Species Act as amended (16 U.S.C 1531 et seq.).

For information about Birds of Conservation Concern, go to:
http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php

For information about conservation measures that help avoid or minimize impacts to birds, please visit:
http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php

To search and view summaries of year-round bird occurrence data within your project area, go to the Avian Knowledge Network Histogram Tools at:
http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/akn-histogram-tools.php

Migratory birds of concern that may be affected by your project:
There are 28 birds on your Migratory birds of concern list.

Species Name	Bird of Conservation Concern (BCC)	Seasonal Occurrence in Project Area
Acadian Flycatcher *(Empidonax virescens)*	Yes	Breeding

Bald eagle *(Haliaeetus leucocephalus)*	Yes	Year-round
Bell's Vireo *(Vireo bellii)*	Yes	Breeding
Bewick's Wren *(Thryomanes bewickii ssp. bewickii)*	Yes	Year-round
Black-billed Cuckoo *(Coccyzus erythropthalmus)*	Yes	Breeding
Black-crowned Night-Heron *(Nycticorax nycticorax)*	Yes	Breeding
Blue-winged Warbler *(Vermivora pinus)*	Yes	Breeding
cerulean warbler *(Dendroica cerulea)*	Yes	Breeding
Dickcissel *(Spiza americana)*	Yes	Breeding
Field Sparrow *(Spizella pusilla)*	Yes	Breeding
Fox Sparrow *(Passerella liaca)*	Yes	Wintering
Henslow's sparrow *(Ammodramus henslowii)*	Yes	Breeding
Kentucky Warbler *(Oporornis formosus)*	Yes	Breeding
Least bittern *(Ixobrychus exilis hesperis)*	No	Breeding
Loggerhead Shrike *(Lanius ludovicianus)*	Yes	Year-round
Northern Flicker *(Colaptes*	Yes	Year-round

auratus)		
Painted Bunting *(Passerina ciris)*	Yes	Breeding
Peregrine Falcon *(Falco peregrinus)*	Yes	Breeding
Pied-billed Grebe *(Podilymbus podiceps)*	Yes	Breeding
Prothonotary Warbler *(Protonotaria citrea)*	Yes	Breeding
Red-headed Woodpecker *(Melanerpes erythrocephalus)*	Yes	Year-round
Rusty Blackbird *(Euphagus carolinus)*	Yes	Wintering
Short-eared Owl *(Asio flammeus)*	Yes	Wintering
Swainson's hawk *(Buteo swainsoni)*	Yes	Breeding
Upland Sandpiper *(Bartramia longicauda)*	Yes	Breeding
Willow Flycatcher *(Empidonax traillii)*	Yes	Breeding
Wood Thrush *(Hylocichla mustelina)*	Yes	Breeding
Worm eating Warbler *(Helmitheros vermivorum)*	Yes	Breeding

Appendix C: NWI Wetlands

The U.S. Fish and Wildlife Service is the principal Federal agency that provides information on the extent and status of wetlands in the U.S., via the National Wetlands Inventory Program (NWI). In addition to impacts to wetlands within your immediate project area, wetlands outside of your project area may need to be considered in any evaluation of project impacts, due to the hydrologic nature of wetlands (for example, project activities may affect local hydrology within, and outside of, your immediate project area). It may be helpful to refer to the USFWS National Wetland Inventory website. The designated FWS office can also assist you. Impacts to wetlands and other aquatic habitats from your project may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal Statutes. Project Proponents should discuss the relationship of these requirements to their project with the Regulatory Program of the appropriate U.S. Army Corps of Engineers District.

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery and/or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Exclusions - Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Precautions - Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of

this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

The following NWI Wetland types intersect your project area in one or more locations. To understand the NWI Classification Code, see http://wetlandsfws.usgs.gov/Data/interpreters/wetlands.aspx.

Wetland Types	**NWI Classification Code**	**Total Acres**
Freshwater Emergent Wetland	PEMA	39.2
Freshwater Emergent Wetland	PEMC	3.55
Freshwater Emergent Wetland	PEMCx	0.94
Freshwater Emergent Wetland	PEMAd	12.5
Freshwater Emergent Wetland	PEMCd	123.0
Freshwater Forested/Shrub Wetland	PFO1A	308.0
Freshwater Forested/Shrub Wetland	PFO1/SS1Cx	22.5
Freshwater Forested/Shrub Wetland	PSS1A	0.498
Freshwater Forested/Shrub Wetland	PFO1/SS1A	5.02
Freshwater Forested/Shrub Wetland	PSS1Ax	0.794
Freshwater Forested/Shrub Wetland	PSS1Cx	12.8
Freshwater Forested/Shrub Wetland	PSS1/EMA	9.04
Freshwater Forested/Shrub Wetland	PFO1C	0.808
Freshwater Forested/Shrub Wetland	PSS1/FO1Cx	12.3
Freshwater Forested/Shrub Wetland	PFO1Cx	1.12

Freshwater Pond	PUBGx	10.9
Freshwater Pond	PUBFx	2.34
Other	PUS/SS1A	0.659
Riverine	R2USA	2.58
Riverine	R2UBH	551000.0