Key to PS Task Group Knowledge Summaries

Understanding is grouped by the weight of supporting evidence: “strong”, “weak or conflicting”, or “uncertain”.

"Strong evidence": Items in this list are by no means certain, and they may not be true. However, the Task Group agrees that the weight of evidence is roughly pointing in the same direction, even if some uncertainty remains.

"Weak or conflicting evidence": Items in this list either (a) have little weight of evidence (perhaps because the evidence that does exist is contradictory), OR (b) there is disagreement among Task Group members and/or the larger scientific community about where the weight of evidence lies or how strong it is. This includes disagreement about how certain to be about these items.

"Uncertain": The Task Group agrees that there is little or no evidence for these items.

"Our predictive ability...": This is a non-exhaustive list of ways of addressing some of the major uncertainties, with no judgment implied about their relative utility to the Program.

Summary: Key Messages from the PS Task Group to the GC

The knowledge summaries developed by the Task Group consolidate and synthesize the state of knowledge of pallid sturgeon in the Lower Platte river. Based on these summaries, the Task Group has identified the following key messages for the GC.

Key messages about pallid sturgeon use of the Lower Platte River

- There is increasing evidence of pallid sturgeon use of the Lower Platte River, particularly in the section below the Elkhorn.
    - Sturgeon use the deepest available water habitat.
    - Sturgeon occurrence is highest in the spring and fall.
    - There is some (but inconclusive) evidence that sturgeon use of the Lower Platte varies with discharge (more use with higher discharge).
    - There is some (but inconclusive) evidence that spawning occurs in the Lower Platte, and there is no evidence that spawning is successful.

Key messages about what would constitute an effect

- Changes in flow in the Lower Platte can affect pallid sturgeon through three main mechanisms: a) more water increases channel connectivity and therefore mobility for pallid sturgeon, b) more water may increase availability of important habitats and their overall capacity, and c) more water may minimize low flows related to fish kill events.
    - However, there is incomplete understanding of the connection between hydrology and pallid sturgeon use of the Lower Platte.

Key messages about Program's ability to cause an effect on pallid, positive or adverse

- There is limited ability for the Program to affect the hydrology of the Lower Platte river via withdrawals or additions in the Central Platte due to the magnitude of influence from the Elkhorn and Loup rivers.
    - Due to limitations in storage capacity, the downstream effects of withdrawals are smaller (more limited) than the effects of releases from upstream storage, though both effects are proportionally small even under the most extreme water management scenarios.
    - Daily hydrocycling in the Loup complicates the ability to quantify the hydrologic contribution of the Central Platte.
    - Existing flow monitoring is sufficient to guide Program operations in the limited situations when hydrologic impacts from the Central Platte are more likely.
- One positive Program effect is the protection of Service target flows in the central Platte through the State and Federal new depletions plans which limits degradation of Lower Platte River flows.

Key messages about outstanding uncertainties and/or areas of disagreement

- There is uncertainty about the combined effects of water management actions upstream of the Central Platte on hydrology in the Lower Platte, including Program water management actions – some of which may provide benefits, and some of which may have negative impacts – and non-Program actions.
    - For example, the combined effects of flow contributions from Tamarack 1 and depletions in excess to Service target flows, authorized under the new depletions plans, are not well understood.
- There is considerable uncertainty about the way that Program water management actions affect the hydrology of the Lower Platte, how changes in hydrology affect pallid sturgeon habitat, and ultimately how changes in habitat affect pallid sturgeon use of the Lower Platte.
    - Relationships between hydrology and the suitability of food resources, the suitability of spawning habitat, spawning cues, success of spawning, or larval survival are all unknown in the Lower Platte.

Use of the Lower Platte River by Juvenile and Non-reproductive Adult Pallid Sturgeon Life Stages

Juvenile and non-reproductive adult life stages have been combined due to 1) the lack of a clear delineation between these life stages and 2) the lack of any information specific to the juvenile life stage.

There is strong evidence that:

- **Pallid sturgeon occur in the Lower Platte River, mostly below the Elkhorn River confluence.**
    - Hatchery-reared pallid sturgeon have been stocked into or at the mouth of the Platte River since the late 1990s. Since 2002, 5,131 pallids have been stocked at the mouth of the Platte River and 22,436 have been stocked near the mouth of the Platte.[2]
    - Since 2009, 152 genetically confirmed pallids have been captured downstream of the Elkhorn River confluence, and 13 genetically confirmed pallids have been captured upstream of the Elkhorn River confluence. [3,4]
    - Most pallids captured in the Lower Platte River (80%) are hatchery-reared; 7% have been wild and 13% have been of unknown origin. [3,4]
- **Pallids use the deepest available water habitat in the Lower Platte**
    - They use a range of habitat, but during one study, pallids were most frequently captured in the deepest and swiftest runs of the river [6]. During another, pallids were captured more often in deeper water when water temperatures were cooler and turbidity was lower. [3]
- **Captures of pallid sturgeon in the Lower Platte River are highest during spring and fall.**
    - Pallid sturgeon have been captured every month when sampling occurred between March and November. Approximately twice as many pallids have been captured in the spring (March-May; n=72) and fall (Sept-Nov; n=61) seasons than were captured in summer (June-Aug; n=32). [2,3,4]
- **Pallid sturgeon in the Lower Platte are in good physical condition.** [3,9]
- **Low summer flows in the lower Platte increase the potential for pallid sturgeon stress and/or mortality**
    - Two pallid sturgeon mortalities were documented in 2012 downstream of the Elkhorn confluence when flow was less than 1,000 cfs and water temperature was >86°F. [7]

There is some (or conflicting) evidence that:

- Capture of pallid sturgeon in the lower Platte varies relative to discharge and season.
    - One study [5] indicated that probability of occurrence decreased with increasing distance from the Missouri River and increasing discharge in the spring and fall, and that probability of occurrence decreased with increasing discharge in the summer; another study found that discharge was not significant when comparing sites where pallids were captured and not captured. [3] Overall, there is no established relationship between discharge and flow-related variables of depth, velocity, temperature or turbidity that could be used to explain species occurrence.
- Pallid occurrence in the lower Platte decreases with increasing within-day stage change due to hydrocycling.
    - One study[8] indicated that probability of occurrence decreased with increasing coefficient of diel variation in discharge (CV) due to hydrocycling. However, there was no established relationship

between CV and flow-related variables of depth, velocity, temperature or turbidity that could be used to explain species occurrence.
  - The PPRIP Executive Director's Office conducted an internal review of the paper above and concluded the research contains a statistical error that renders the inference with regard to the relationship between the probability of pallid surgeon occurrence and coefficient of diel variation in discharge erroneous.[10]

Remaining uncertainties include:

- Limitations in sampling methodologies or analyses could affect aforementioned flow/species relationship. Factors not related to flow could also affect our understanding of flow/species relationships.
- Reasons for lack of wild pallid sturgeon in the lower Platte are unknown. It has been hypothesized that the lack of deep-water habitat (>3.28 ft) may limit larger, wild adults[3].
- Sturgeon captures that are not genetically identified cannot be conclusively included with pallid sturgeon counts. In addition to those identified here, 25 suspected pallid sturgeon (but not genetically identified) have been captured in the Lower Platte.

Our predictive ability would be enhanced if:

- Collaboration with pallid sturgeon experts identified key limitations in sampling methodologies or analyses, and through this collaboration, we develop a plan to address key limitations in future research/monitoring/analyses.
- We could improve our understanding of differences in pallid sturgeon flow- and temperature-related variables upstream to downstream and relate these differences to discharge.
- We could improve our understanding of flow- and temperature-related factors that affect pallid mortality, condition, capacity, and movement in the lower Platte River.

References

1. Peters, E. J., and J. E. Parham. 2008. Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska Game and Parks Commission, Nebraska Technical Series No. 18, Lincoln, Nebraska.

2. Huenemann, T. 2017. Central Lowlands and Interior Highlands Pallid Sturgeon Spawning and Stocking Summary (1992-2016). Prepared for the Middle Basin Pallid Sturgeon Workgroup.

3. Hamel, M.J., Pegg, M.A., Hammen, J.J. and Rugg, M.L., 2014. Population characteristics of pallid sturgeon, *Scaphirhynchus albus* (Forbes & Richardson, 1905), in the lower Platte River, Nebraska. Journal of Applied Ichthyology, 30(6), pp.1362-1370.

4. Hamel, M.J. 4/28/2017. Personal communication with John Shadle.

5. DeLonay, A.J., Chojnacki, K.A., Jacobson, R.B., Albers, J.L., Braaten, P.J., Bulliner, E.A., Elliott, C.M., Erwin, S.O., Fuller, D.B., Haas, J.D., Ladd, H.L.A., Mestl, G.E., Papoulias, D.M., and Wildhaber, M.L., 2016, Ecological requirements for pallid sturgeon reproduction and recruitment in the Missouri River—A synthesis of science, 2005 to 2012: U.S. . with appendixes, http://dx.doi.org/10.3133/sir20155145.

6. Peters, E.J., and J. E. Parham. 2004. Pallid sturgeon and sturgeon chub in the lower Platte River 2000 to 2004: Final Report to the Pallid Sturgeon / Sturgeon Chub Task Force.
7. United States Fish and Wildlife Service. 2016. Final Biological Opinion for Loup River Hydroelectric Project No.P-1256-031. Prepared for Federal Energy Regulatory Commission.
8. Hamel, M. J., Spurgeon, J. J., Pegg, M. A., Hammen, J. J. and Rugg, M. L. (2014). Hydrologic Variability Influences Local Probability of Pallid Sturgeon Occurrence in a Missouri River Tributary. *River Research and Applications*. 32(3), 320-329. DOI: 10.1002/rra.2850
9. Steffensen, K.D., and Mestl, G.E., 2016, Assessment of pallid sturgeon relative condition in the upper channelized Missouri River: Journal of Freshwater Ecology, p. 1-13. 10.1080/02705060.2016.1196465.
10. Executive Director's Office. 1 December 2014. Review of: Hydrological variability influences local probability of pallid sturgeon occurrence in a Missouri River tributary. Platte River Recovery Implementation Program, Kearney, NE.

Use of the Lower Platte River by Spawning Adult, Egg, and Larval Pallid Sturgeon Life Stages

There is not enough known about how these life stages use the Lower Platte River to amount to "strong evidence".

There is some (or conflicting) evidence that:

- Pallid sturgeon presumably spawn in the lower Platte River.
    - USGS and NGPC reported eight presumed spawning events in the lower Platte (2011-2014) by four different females. Spawning events in the Lower Platte were supported by recapture and reproductive assessment of tagged pallid sturgeon prior to entry into the Platte River (with oocytes) and following their return into the Missouri River in non-reproductive condition. However, spawning in the Lower Platte was not observed directly. [2]
    - 4 females used the lower Platte during consecutive spawning cycles across varying temperature and flow conditions. [2] However, spawning in the Lower Platte was not observed directly. [2]
    - *Scaphirhynchus* larvae have been captured suggesting spawning habitat is present in the Platte River basin.[1,3] However, these larvae were not identified to species, and could have been shovelnose sturgeon.

Remaining uncertainties include:

- Limitations in sampling methodologies and/or analyses could affect aforementioned flow/species relationships. Factors not related to flow could also affect our understanding of flow/species relationships.
- It is not known if pallids successfully reproduce in the Lower Platte – i.e., do they spawn and eggs successfully hatch?
- If spawning occurs in the Lower Platte River, it is not known where.
- If spawning occurs and eggs hatch, it is not known if pallid sturgeon free-embryos or larvae[4] remain in the Lower Platte or if some or all of them drift into the Missouri River.

Our predictive ability would be enhanced if:

- Collaboration with pallid sturgeon experts identified key limitations in sampling methodologies or analyses, and through this collaboration, developed a plan to address key limitations in future research/monitoring/analyses.
- We could improve our understanding of pallid movements and spawning habitat in the Lower Platte during the spawning period.
- We could improve our understanding of the presence/absence of free-embryos and larval pallid sturgeon in the Lower Platte River.

References

1. Peters, E. J., and J. E. Parham. 2008. Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska Game and Parks Commission, Nebraska Technical Series No. 18, Lincoln, Nebraska.
2. Ruskamp, R.L., J.D. Haas, D. Adams, A.J. DeLonay, K.A. Chojnacki, and G. Mestl. 2017. Migration and Spawning of Pallid Sturgeon in the Platte River, Nebraska. Presented at the 2017 MRRIC Annual Forum.
3. DeLonay, A.J., 5/23/2017. Personal communication with David Galat.
4. Wildhaber, M. L., A. J. DeLonay, D. M. Papoulias, D. L. Galat, R. B. Jacobson, D. G. Simpkins, P. J. Braaten, C. E. Korschgen, and M. J. Mac. 2011. Identifying structural elements needed for development of a predictive life-history model for pallid and shovelnose sturgeons. Journal of Applied Ichthyology 27:462-469.

Effects of Program Water Management on Juvenile and Non-reproductive Adult Pallid Sturgeon Life Stages

Juvenile and non-reproductive adult life stages have been combined due to 1) the lack of a clear delineation between these life stages and 2) the lack of any information specific to the juvenile life stage.

There is strong evidence that:

- Pallid sturgeon are most frequently captured in the deepest portions of the lower Platte River.[1,2]
- Very low flows in the lower Platte River can result in pallid sturgeon mortality.[3]
- PRRIP-related water activities will both decrease (withdrawals for retiming projects and new depletions) and increase (releases of new and retimed water) river stage and associated flow depth in the lower Platte River.[4]
- The magnitude of stage (and associated depth) change will be dependent on the magnitude of flow withdrawals/releases in the central Platte, flow losses and attenuation in central and lower Platte River, and lower Platte River discharge.[4]

There is some (or conflicting) evidence that:

- Flow reductions (sub-daily to seasonal) reduce the overall capacity of the Lower Platte by reducing the availability of deep water habitat used by pallid sturgeon.
    - Pallid sturgeon are most frequently captured in deepest [1,2] and swiftest waters. [1] However, there is no established relationship between pallid sturgeon capacity and quantity of deepest and swiftest waters.
- Flow reductions during low flow periods may decrease physical habitat suitability related to channel connectivity and decrease pallid sturgeon mobility.
    - The Lower Platte channel (below Elkhorn) nears full connectivity at a flow of 8,000 cfs or greater. Connectivity declines quickly below 6,000 cfs with low connectivity at flows below 3,000 cfs.[3,4] However, there is no established relationship between pallid sturgeon use and connectivity.
- Flow reductions during low flow periods increase water temperature
    - Pallid sturgeon mortalities reported in 2012 when discharge was less than 1,000 cfs and water temperature was > 86°F. [5]

Remaining uncertainties include:

- Limitations in sampling methodologies or analyses could affect aforementioned flow/species relationships. Factors not related to flow could also affect our understanding of flow/species relationships.
- The relationship between flow depth/velocity and pallid sturgeon habitat suitability and **t**he relationship between habitat suitability and pallid sturgeon occurrence/condition.

- The relationship between discharge and channel connectivity and the relationship between channel connectivity and pallid sturgeon mobility.
- Strength of any relationships between discharge, stream temperature, stream turbidity and pallid sturgeon habitat suitability/condition.
- Strength of any relationships between discharge, pallid food resources, and pallid sturgeon habitat suitability/condition.

Our predictive ability would be enhanced if:

- Collaboration with pallid sturgeon experts identified key limitations in sampling methodologies or analyses, and through this collaboration, we develop a plan to address key limitations in future research/monitoring/analyses.
- We could improve understanding of pallid sturgeon food resources and flows needed to support these resources.
- We could improve understanding of the relationship between flow and temperature exceedances detrimental to pallid sturgeon.
- We could improve our understanding of flow-related variables and pallid sturgeon capacity in the lower Platte River.
- We could improve our understanding of pallid sturgeon movements in relation to channel connectivity in the lower Platte River.

References

1. Peters, E.J., and J. E. Parham. 2004. Pallid sturgeon and sturgeon chub in the lower Platte River 2000 to 2004: Final Report to the Pallid Sturgeon / Sturgeon Chub Task Force.
2. Hamel, M.J., Pegg, M.A., Hammen, J.J. and Rugg, M.L., 2014. Population characteristics of pallid sturgeon, Scaphirhynchus albus (Forbes & Richardson, 1905), in the lower Platte River, Nebraska. Journal of Applied Ichthyology, 30(6), pp.1362-1370.
3. Peters, E. J., and J. E. Parham. 2008. Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska Game and Parks Commission, Nebraska Technical Series No. 18, Lincoln, Nebraska.
4. HDR Engineering Inc. 2009. Lower Platte River Stage Change Study Final Protocol Implementation Report. Prepared for the Platte River Recovery Implementation Program.
5. United States Fish and Wildlife Service. 2016. Final Biological Opinion for Loup River Hydroelectric Project No.P-1256-031. Prepared for Federal Energy Regulatory Commission.
6. Sinokrot, B.A. and Gulliver, J.S., 2000. In-stream flow impact on river water temperatures. Journal of Hydraulic Research, 38(5), pp.339-349

Effects of Hydrologic Change on Pallid Sturgeon Spawning, Embryos and Larvae in the Lower Platte River

There is **no evidence** specific to the Lower Platte to support understanding of effects on these life stages.

Remaining uncertainties include:

- Factors not related to flow could also affect our understanding of flow/species relationships.
- Relationship between discharge and spawning habitat availability.
- If flow-related variables in the Platte River influence spawning cues and spawning occurrence, and if so, what is the relationship between flow and spawning cues/occurrence.
- Relationship between flow-related effects to habitat and spawning success
- Relationship between flow-related effects to habitat and egg incubation success

Our predictive ability would be enhanced if:

- Collaboration with pallid sturgeon experts identified key limitations in sampling methodologies or analyses, and through this collaboration, we develop a plan to address key limitations in future research/monitoring/analyses.
- We could improve our understanding of flow-related variables that affect spawning cues, pallid movement, and access to spawning habitat in the Lower Platte River during the spawning period.
- We could improve our understanding of whether spawning cues, movement, and access to spawning habitat affects spawning occurrence, spawning success, and/or egg incubation success.

Lower Platte River Stage Change Study

There is strong evidence that:

- Stage changes in the Lower Platte River (below the Elkhorn River confluence) due to Program water management activities in the Central Platte are small enough that they are muted by additions from more proximate tributary inputs.
- The greatest potential for negative habitat impacts would occur when lower Platte River discharges are low (4,000 – 6,000 cfs) but central Platte River discharges are high enough that flow could be diverted into storage for retiming.

There is some (or conflicting) evidence that:

- Impacts to pallid sturgeon can be avoided through development of operational rules that prohibit Program diversions when lower Platte River discharges fall below 4,000 cfs. However, the relationship between sub-4,000 cfs and impacts to pallid sturgeon capacity and habitat connectivity is not known.
- Predicted changes in Lower Platte River pallid sturgeon habitat resulting from Program water management actions in the Central Platte are similarly small to undetectable and thus these changes should not provide additional stress to the pallid sturgeon population. However, uncertainties remain.

Remaining uncertainties include:

- The relationship between discharge and channel connectivity and the relationship between channel connectivity and pallid sturgeon mobility.
- The relationship between physical habitat conditions and pallid sturgeon occurrence / condition.
- Hydrocycling from the Loup River Hydroelectric Project could affect the detection of Program water.

Our predictive ability would be enhanced if:

- The stage-change study was expanded to encompass the full range of physical channel conditions in the lower Platte River.
- The stage-change study was extended upriver to include the section between the Loup and Elkhorn confluences, or upstream to the Associated Habitat Reach (Chapman).
- Resource selection analyses were developed based on physical conditions at sample and capture locations (depth, velocity, temperature). This would improve our understanding of the relationship between discharge, physical habitat conditions, and pallid sturgeon occurrence.
- Increased telemetry tracking effort in the lower Platte would improve our understanding of pallid sturgeon movements in relation to channel connectivity.

Key Messages from the EDO document:
Downstream Impacts of Program Water Management

Program water operations impacts on the lower Platte River

- Central and Lower Platte River hydrology
  - Median discharges (1995-2015) at the Grand Island, North Bend and Louisville stream gauges were 1,200 cfs, 3,930 cfs and 6,800 cfs respectively.
  - Flows from the central Platte River constitute 31% of lower Platte flows at North Bend and 18% of flows at Louisville.

- Impacts of central Platte withdrawals up to 1,000 cfs for Program retiming projects
  - Impact quantification requires understanding of relationship between flow/stage and pallid sturgeon habitat suitability/connectivity and the relationship between habitat availability and pallid sturgeon use and/or condition. These relationships are highly uncertain.
  - Based on habitat suitability and connectivity relationships from Peters and Parham 2008, reductions due to PRRIP retiming projects would generally reduce lower Platte suitability and/or connectivity by less than 5%. It is unknown whether or not changes of this magnitude are biologically important to pallid sturgeon.
  - Other factors, such as depletions authorized under the new depletions plan, may be additive to Program withdrawals and consequently have additive impact, but the combined effects are not well understood at this time.

- Impacts of late-spring pulse flow release
  - Implementation of the late-spring pulse flow release would generally increase lower Platte River habitat suitability by less than 5%. Channel connectivity below the Elkhorn River would also change little but connectivity upstream of the Elkhorn could increase by around 10% in dry to normal years. It is unknown whether or not changes of this magnitude are biologically important to pallid sturgeon.
  - Other factors, such as flow contributions from Tamarack Phase 1, may be additive to Program releases and consequently have additive benefit, but the combined effects are not well understood at this time.

External factors that will affect the Program's influence on the lower Platte

- Loup River hydrocycling
  - Within-day hydrocycling of Loup River discharge creates flow/stage fluctuations of greater amplitude than a central Platte River pulse flow release of 4,000 cfs.

- Future depletions
  - 25-year future depletions for ongoing and new activities are estimated to be 107 cfs (77,468 ac-ft) at North Bend and 459 cfs (332,316 cfs at Louisville).

DOWNSTREAM IMPACTS OF PROGRAM WATER MANAGEMENT

BACKGROUND

During the first increment of the Platte River Recovery Implementation Program (PRRIP or Program), impacts to the pallid sturgeon that are caused by Program activities or by new water related activities covered by the states' or federal depletions plans will be assessed.[1]

The geographic extent for Program and depletion-plan-related activities includes the entirety of the Platte River basin upstream of the Loup River confluence including areas of Nebraska, Wyoming and Colorado. Water activities upstream of the Loup River confluence are expected to influence the volume and timing of flow in the lower Platte River (below the Loup River confluence) to some extent. The Program does not provide coverage for water-related activities below the Loup River confluence and is not responsible for mitigating depletions associated with water-related activities that occur downstream of the Loup River confluence (Figure 1).

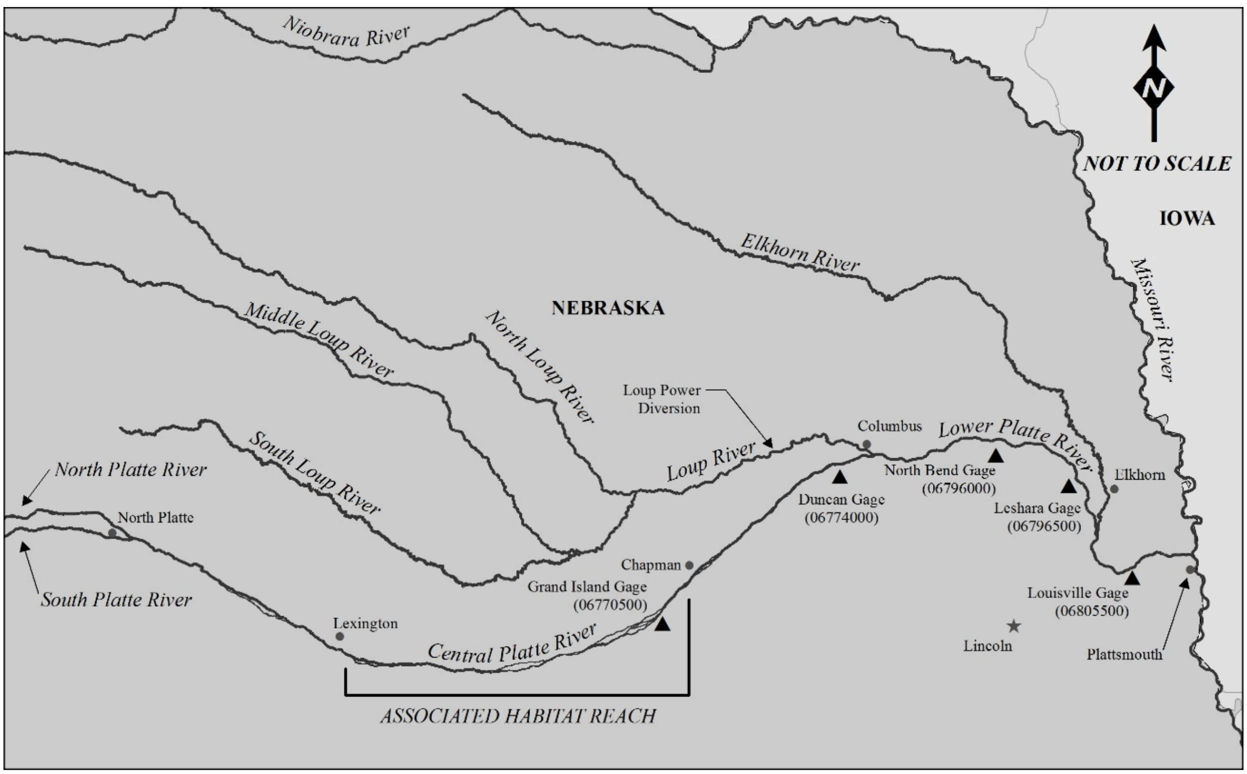

Figure 1. Major tributaries and stream gage locations discussed in this document.

[1] Depletions plans are intended to mitigate the impacts of new water related activities on the occurrence of meeting target flows and on the effectiveness of the Program in reducing shortages to target flows, whether or not the new water related activities are subject to Section 7(a)(2) of the ESA or are intended to mitigate the impacts of other new water related activities.

Program water activities and depletions plans activities broadly include:

1) Program water activities
    a. Reduce depletions to United States Fish and Wildlife Service (FWS or Service) target flows from pre 7/1/1997 activities by an average of 130,000-150,000 acre-feet (AF) annually

2) Depletions plans to offset or mitigate new depletions from activities that commenced or will commence after 7/1/1997
    a. Mitigate the adverse impacts of new water related activities on:
        i. the occurrence of FWS target flows
        ii. the effectiveness of the Program in reducing shortages to those flows
    b. Mitigation is not required for new water related activities:
        i. depletions in excess to FWS target flows
        ii. depletion of flow downstream of the Grand Island gage

The FWS calculated average annual shortages to target flows is 417,000 AF using a representative hydrograph from 1947 through 1994 measured at the Grand Island stream gage. 1997 is the GC negotiated hydrologic baseline for the Program. This hydrologic baseline represents the hydrologic record from 1947 to 1994 adjusted to reflect 1997 levels of water development and water demands on the Platte River. The Program's 1st increment water objective is to reduce Service target flows by 130 to 150 kaf at the Grand Island gage. In addition, the federal and state's new depletions plans maintain the 1997 hydrologic baseline by offsetting any new depletions to Service target flows occurring after 1997. With all 1st increment Program water actions in place, shortages to target flows at Grand Island is expected to average 267-287 kaf annually with the 130,000-150,000 AF reduction in target flow shortages and maintenance of the 1997 hydrologic baseline.

PROGRAM-RELATED WATER ACTIVITIES

Program water activities fall into two categories:

1) Retiming of water to reduce deficits
    a. Store river flow at times of excess to target flows and return or release at times of shortage

2) Addition of new water to reduce deficits
    a. Reallocation of existing irrigation (or other) water supplies to instream flows
    b. Reduced consumptive use through modified agricultural practices (conservation projects)

Depletions plans activities fall into the same categories. Most of the Program and depletion-plan water activities are expected to consist of retiming of existing flows (>70%). The remainder will consist almost entirely of reallocation of existing water supplies as no practicable conservation projects have been identified.

WATER ACTIVITY IMPACTS ON CENTRAL PLATTE RIVER HYDROLOGY

By the end of the First Increment Extension in 2032, Program and Nebraska New Depletions Plan activities[2] are expected to influence the hydrology of the Platte River in two ways:

1) Increase in volume of water downstream of the Loup River due to addition of new water to reduce deficits. Average annual volume change is expected to be on the order of 90,000 - 100,000 AF.[3]

2) Change in timing of water (hydrograph) downstream of the Loup River due to retiming projects. Timing change is expected to effect on the order of 60,000 – 70,000 AF annually as some retiming projects (like broad scale recharge) require retiming of more water than is credited to the Program.[4]

These two impacts are not mutually exclusive but overlap is generally limited. For example, retiming projects will primarily change when flow reaches the lower Platte River, but may also affect evaporation, seepage and evapotranspiration amounts, which will have a limited impact on flow volume (can be positive or negative). Likewise, reallocation of existing water supplies from surface water irrigation to the Environmental Account may slightly alter return flow patterns during the irrigation season as augmentation plans may not exactly replicate return flows.

The magnitude and timing of central Platte River hydrograph to retiming projects will be dependent upon the availability (magnitude and timing) of excess flows that can be stored, storage capacity, and the magnitude and timing of releases back to the river. Figure 2 provides a general picture of excess flow availability during the period of 1995-2015 based on Program real-time hydrologic condition.[5]

As indicated in Figure 2, excesses were frequently available during the period of November 16 through February 1. Excess flows were also available somewhat less frequently during the months of May – August. Excesses were infrequently available during the period of February 15 through May 1.

[2] The Wyoming, Colorado, and Federal depletions plans are fully operational, all existing new depletions are being mitigated and provisions are in place to mitigate future new depletions.
[3] Includes approximately 60,000 AF for Environmental Account and an additional 30,000 - 40,000 AF of water leasing by the PRRIP and State of Nebraska.
[4] For example, groundwater recharge projects result in some water coming back to the river during times of excess. Accordingly, approximately 20%-60% more water has to be retimed than is credited.
[5] Real-time hydrologic conditions were utilized in this analysis as they will most likely be used to define excesses for Program water operations.

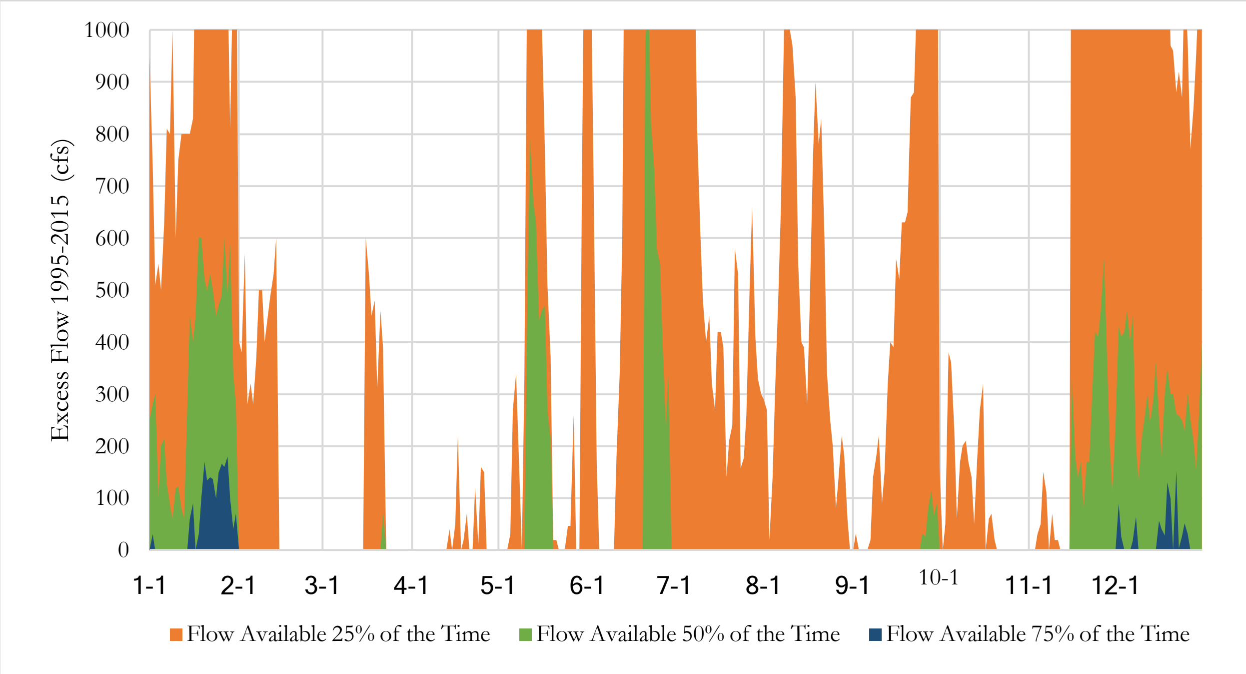

Figure 2. Excess flow availability 25%, 50%, and 75% of the time at the Overton stream gage (1995-2015) based on real-time hydrologic conditions. Excess flows are defined as flows exceeding USFWS species and pulse flow targets. Excesses were capped at 1,000 cfs to correspond with the expected First Increment diversion capacity of 1,000 cfs.

The amount of excess flow that can be stored via retiming projects will be dependent upon excess volumes, the rate at which flow can be moved into storage, and total storage volume. It is anticipated that First Increment Program and state of Nebraska water projects will have the capacity to divert approximately 1,000 cfs into recharge or storage projects.[6] Accordingly, this is the best estimate of the maximum flow reduction impact associated with Program and Nebraska water activities during the First Increment. Table 1 presents the maximum excess flow volumes that could have been diverted into retiming projects during the period of 1995-2015 given a diversion capacity of 1,000 cfs and unlimited storage capacity. The actual volume of water diverted for retiming is expected to average 60,000 AF due to limited capacity to store flows for retiming.

[6] This includes approximately 600 cfs diverted into canals for groundwater recharge and 400 cfs diverted or pumped into Program water projects.

Table 1. Maximum excess flow volume that could have been routed into retiming projects during the period of 1995-2015 using real-time hydrologic conditions and assuming a maximum diversion rate of 1,000 cfs.

	Excess Flow Volume (ac-ft)	Maximum Volume that Could Have Been Retimed @ 1,000 cfs Diversion Rate (ac-ft)
Average Volume all Years	429,561	194,457
Volume Available in 25% of Years	697,297	324,601
Volume Available in 50% of Years	214,093	115,240
Volume Available in 75% of Years	76,864	73,300

New and retimed water will be released to 1) reduce deficits to target flows and/or 2) implement other flow-management actions such as Short-Duration High Flows (SDHF). Maximum release capacity will depend on the design of future retiming projects but is generally expected to be on the order of 5,000 cfs.[7] It is anticipated that the majority of releases will be lower in magnitude, ranging from 500 – 1,500 cfs for species' flows and up to 2,500 cfs for pulse flow releases.

The Wyoming, Colorado, and Federal depletions plans are fully operational, all existing new depletions to Service target flows are being offset and provisions are in place to offset future new depletions. Nebraska intends to cost share with the Program to offset depletions to target flows since 1997.

FIRST EIGHT YEARS OF PROGRAM OPERATIONS

From 2007 to 2014, the average annual shortage to target flows at Grand Island is 504,696 AF representing eight total years of Program operation. There were six years classified as normal and two years classified as wet. No dry years were represented from 2007 through 2014. From 2007 to 2014, the annual shortages to target flows range from 18,197 AF in 2011 to 731,257 AF in 2013.

EA and Tamarack Phase 1 were in place by 2007. Pathfinder Modification and Pathfinder Municipal projects (4,800 AF) were in place by 2012. With the addition of Pathfinder Municipal water, the combined annual reduction to Service target flows is approximately 85,000 AF. Water from both Pathfinder projects are combined with the EA at Lake McConaughy, so releases from all three accounts are tracked through the central Platte River through Grand Island. Contributions from Tamarack Phase 1 are tracked to the Colorado/Nebraska state line only.

Not including contributions from Tamarack Phase 1, Program water delivered to Grand Island averaged 23,774 AF from 2007 through 2014. Of the 23,774 AF of Program water delivered to Grand Island, the average reduction to shortages at Grand Island is 20,130 AF. The range in annual reduction in target flows is 0 AF in 2010 and 2011 to 47,751 AF in 2013. No accounting procedures are currently in place to assess Program's effects average annual volume change to the Lower Platte River approximating 90,000 - 100,000 AF annually.

[7] This includes approximately 4,000 cfs from existing water projects and an additional 1,000 cfs from future projects.

The following summarizes Program Environmental Account releases from 2007 through 2014:

1. February 15 to March 15 pulse flow time period (1 out of 8 years)
2. March 23 to May 10 spring whooping crane time period (3 out of 8 years)
3. May 11 to September 15 summer time period (3 out of 8 years)
4. Flow routing test/short duration medium flow (2 out of 8 years)
5. Canal recharge (1 out of 8 years)
6. No releases due to limited release opportunities (2 out of 8 years)

	Year Type	Shortages to Target Flows (AF)	Total EA Volume at GI (AF)	EA Reduction to Shortages (AF)
2007	Normal	543,983	24,406	12,965
2008	Normal	547,055	17,834	13,569
2009	Normal	632,802	13,313	8,210
2010	Wet	267,463	0	0
2011	Wet	18,197	0	0
2012	Normal	719,543	40,906	40,906
2013	Normal	731,257	56,101	47,751
2014	Normal	577,270	37,635	37,635
2015	Wet	212,520	NA	NA
2016	Wet	NA	NA	NA

WATER OPERATIONS IMPACTS IN THE LOWER PLATTE

Figure 3 and 4 present median and mean daily discharge at the Grand Island stream gauge in the central Platte River and the North Bend and Louisville gauges in the lower Platte River for the period of 1995-2015. During this period, median discharge was 1,200 cfs at Grand Island, 3,930 cfs at North Bend and 6,800 cfs at Louisville. Average discharge was 1,672 cfs at Grand Island, 4,594 cfs at North Bend and 8,054 cfs at Louisville.

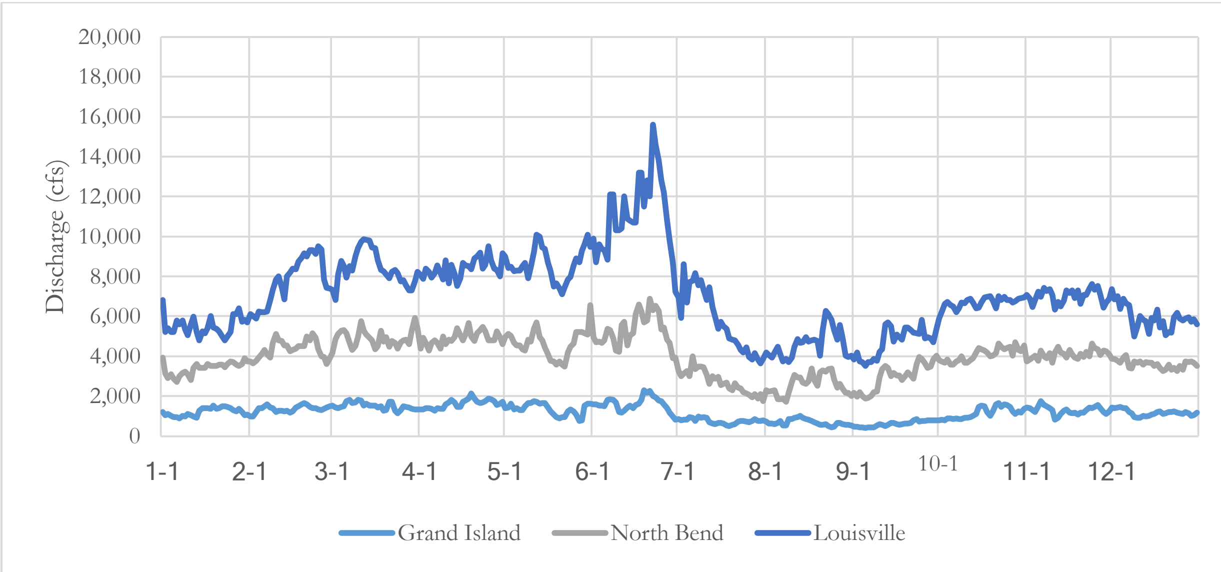

Figure 3. Median daily discharge at Grand Island, North Bend and Louisville stream gauges during the period of 1995-2015. Median discharge at Grand Island was 1,200 cfs, North bend was 3,930 cfs, and Louisville was 6,800 cfs.

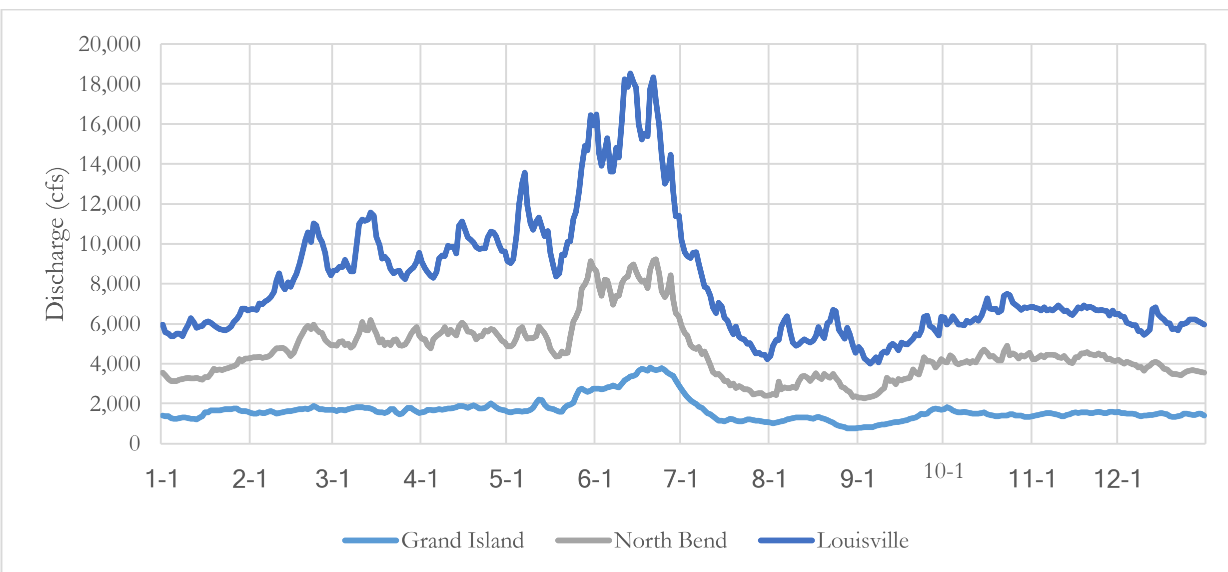

Figure 4. Mean daily discharge at Grand Island, North Bend and Louisville stream gauges during the period of 1995-2015. Average discharge at Grand Island was 1,672 cfs, North Bend was 4,594 cfs, and Louisville was 8,054 cfs.

Peters and Parham (2008) developed pallid sturgeon habitat suitability and channel connectivity relationships for the lower Platte River below the Loup River confluence. Those relationships are reproduced below in Figure 5. Those relationships were used to calculate average daily and monthly habitat suitability and channel connectivity for the North Bend and Louisville gauges during the period of 1954-2016. In addition, Program operations (as described above) were used to develop a conservative estimate of potential impacts to habitat suitability and connectivity at the two lower Platte River gauges.

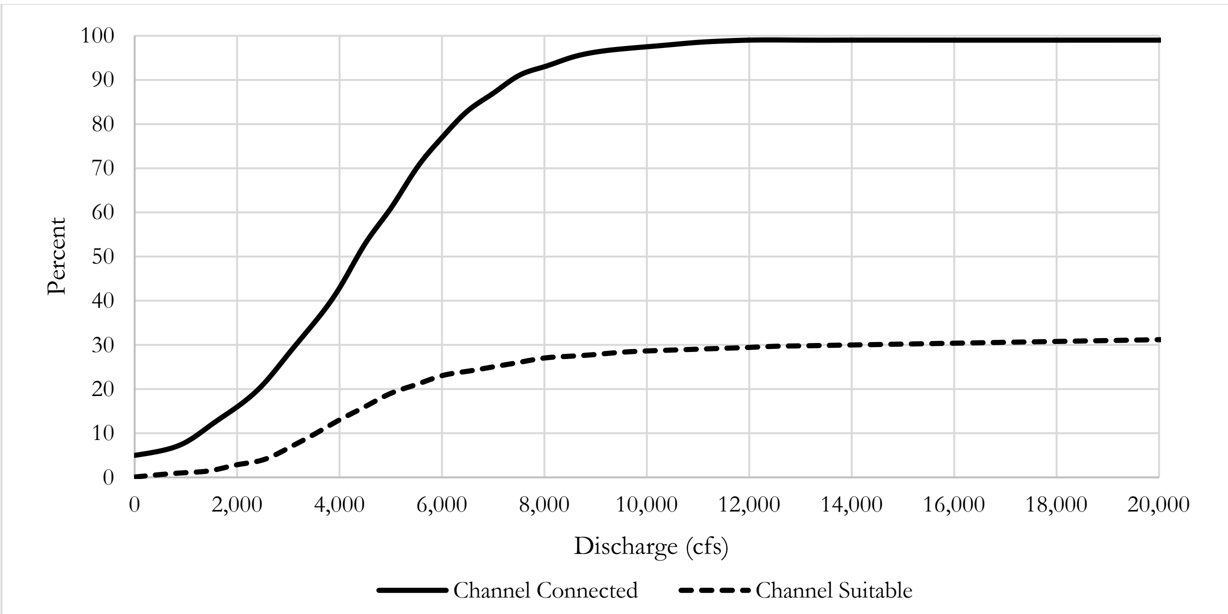

Figure 5. Lower Platte River discharge-connectivity and discharge-habitat-suitability curves for pallid sturgeon from Peters and Parham (2008). The authors developed these relationships using aerial photography from the entirety of the lower Platte River below the Loup River confluence.

IMPACTS OF WITHDRAWALS FOR RETIMING PROJECTS

Withdrawal impacts were calculated for the period of 1954-2016 based on the assumptions that 1) up to 1,000 cfs of flow could be diverted from the river into storage projects during times of excess to species and pulse flow targets, 2) storage capacity was unlimited, 3) all of the flow that was diverted would have reached the lower Platte (no losses), and none of the excess flow is released back to the river. This set of assumptions represents the maximum diversion impact scenario for combinations of projects with up to 1,000 cfs of combined diversion capacity.

Figures 6-9 present comparisons of 10^{th} percentile, median and 90th percentile habitat suitability and channel connectivity by gauge with and without the Program diversion scenario described above. As discussed above, this represents a worst-case scenario for impacts as it assumes the Program has unlimited ability to store all excesses up to 1,000 cfs above target flows and all of that flow would have reached the North Bend and Louisville gauges (i.e., no losses).

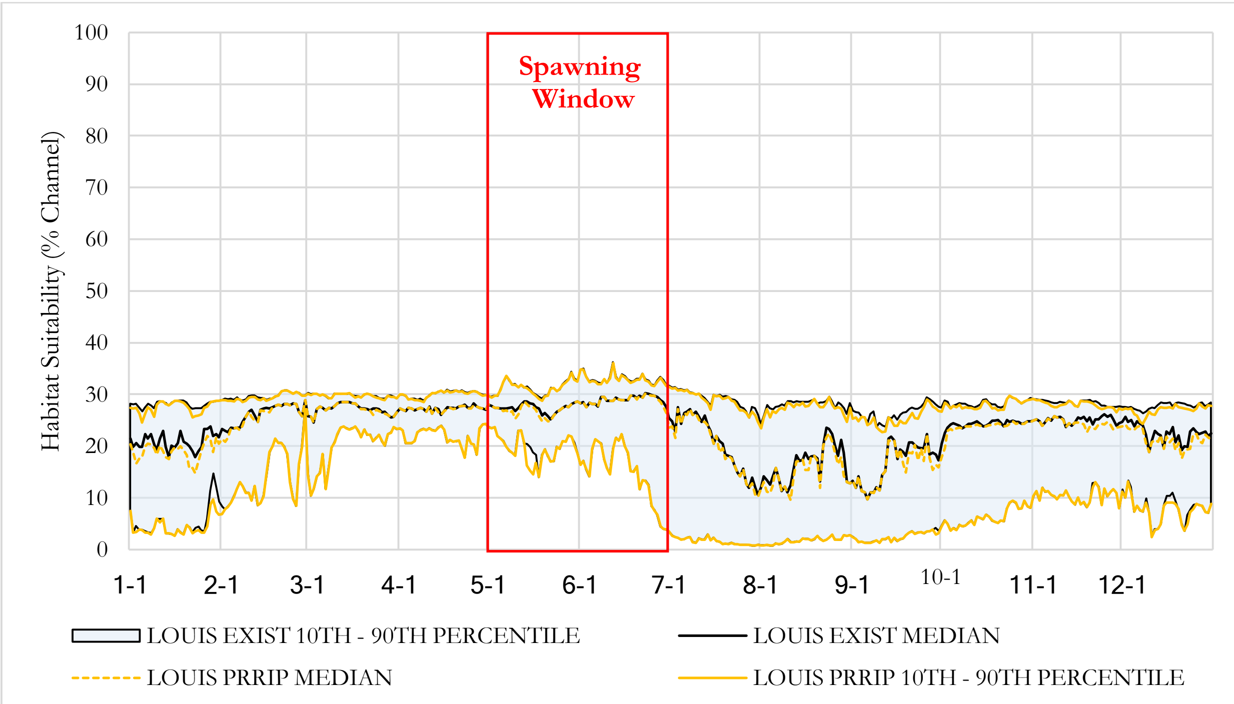

Figure 6. 10th, median, and 90th percentile habitat suitability at the Louisville (LOUIS) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

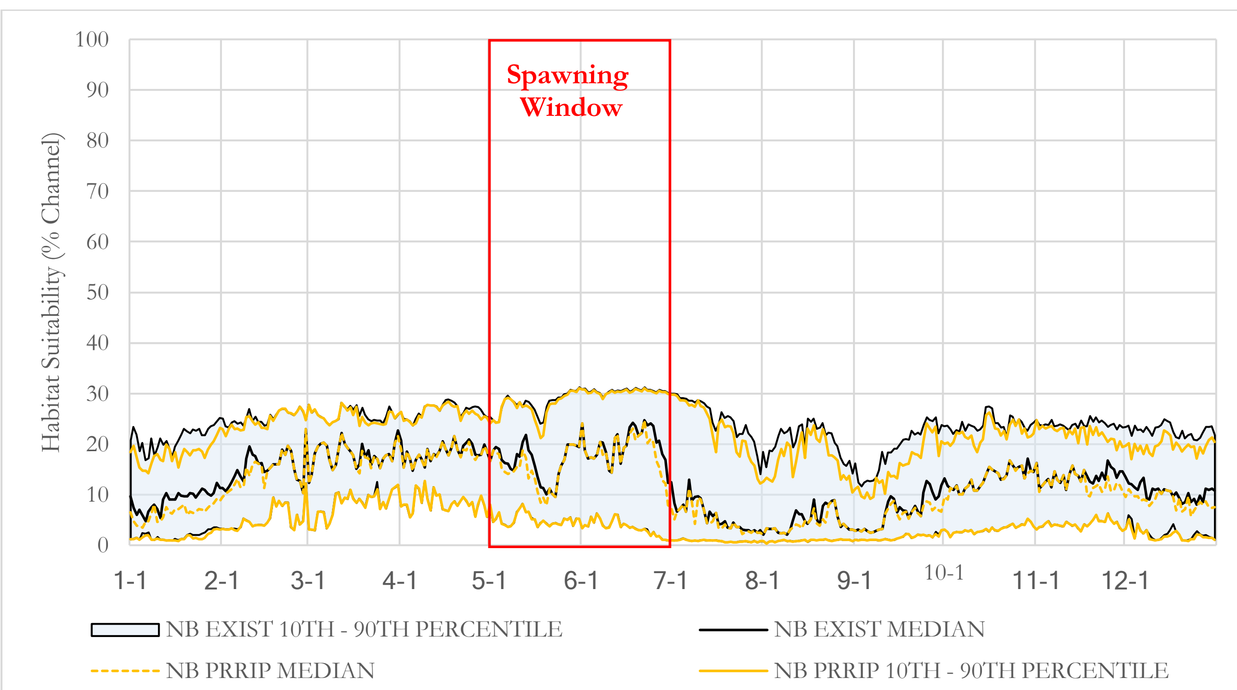

Figure 7. 10th, median, and 90th percentile habitat suitability at the North Bend (NB) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

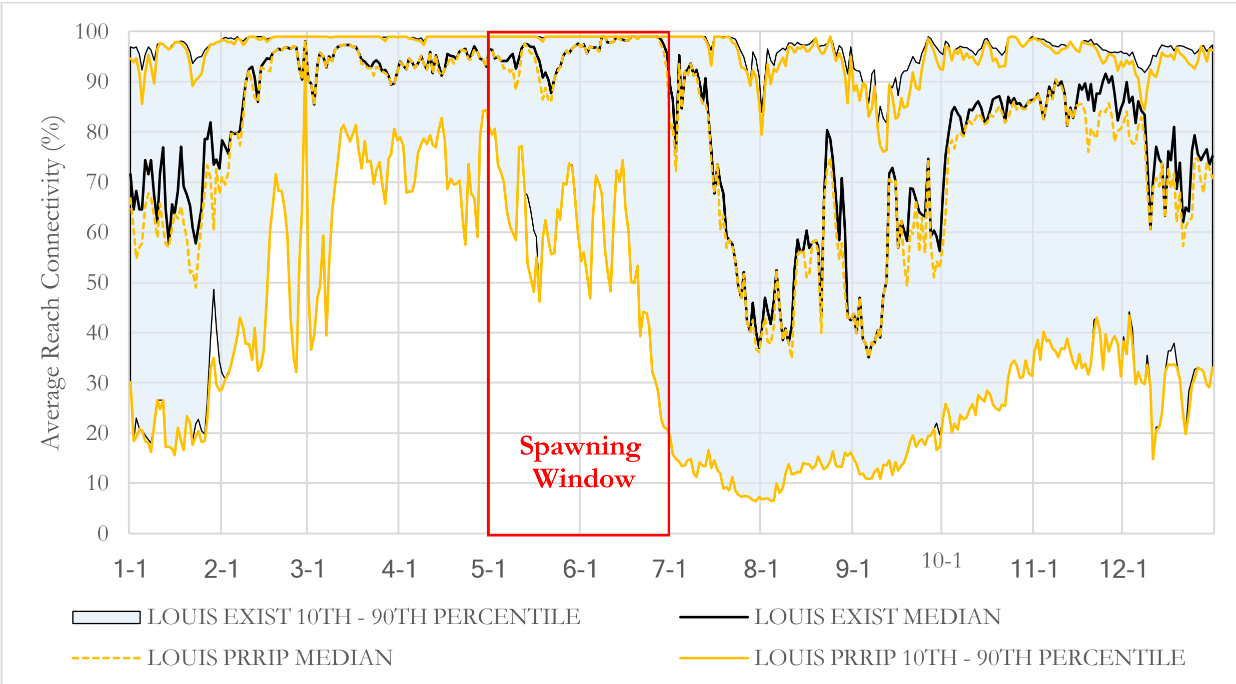

Figure 8. 10th, median, and 90th percentile reach connectivity at the Louisville (LOUIS) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

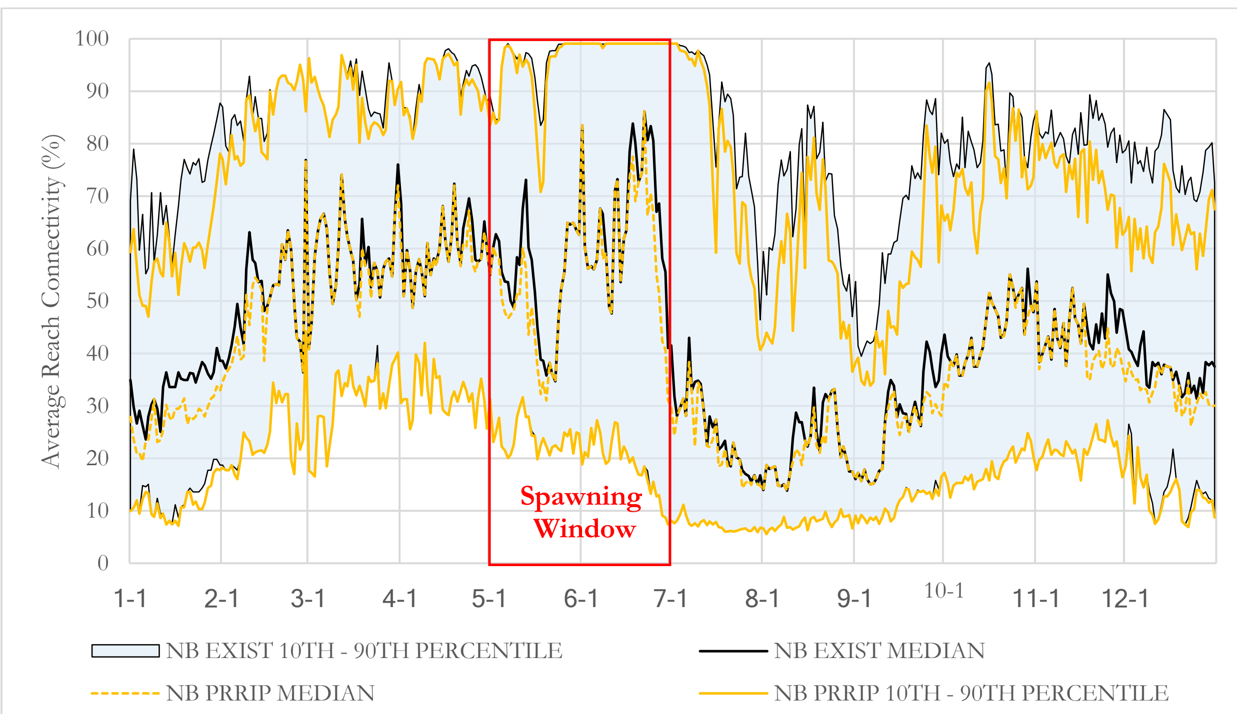

Figure 9. 10th, median, and 90th percentile reach connectivity at the North Bend (NB) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

IMPACTS OF LATE SPRING PULSE FLOW RELEASE

The late spring pulse is the sole target flow with beneficial effects directly related to the pallid sturgeon.[8] Pulse flow impacts were calculated for the period of 1954-2016 based on the assumptions that 1) sufficient volume and channel capacity was available to implement full, pulse flow releases in all normal and wet years[9] and 2) all of the flow would have reached the lower Platte River (i.e., no losses or attenuation). This set of assumptions represents the maximum release impact scenario. Figures 10-13 present 10th percentile, median and 90th percentile comparisons habitat suitability and channel connectivity by gauge with and without the Program late spring pulse flow release scenario described above. This represents a best-case scenario for impacts as it assumes that the Program has unlimited ability to release flow to achieve the pulse flow target and all of that flow would have reached the North Bend and Louisville gauges without losses or attenuation. Average annual release volume for this scenario in normal and wet years[8] was on the order of 120,000 acre-ft, indicating that this flow release would utilize all of the controllable water that will be developed during the First Increment of the Program.

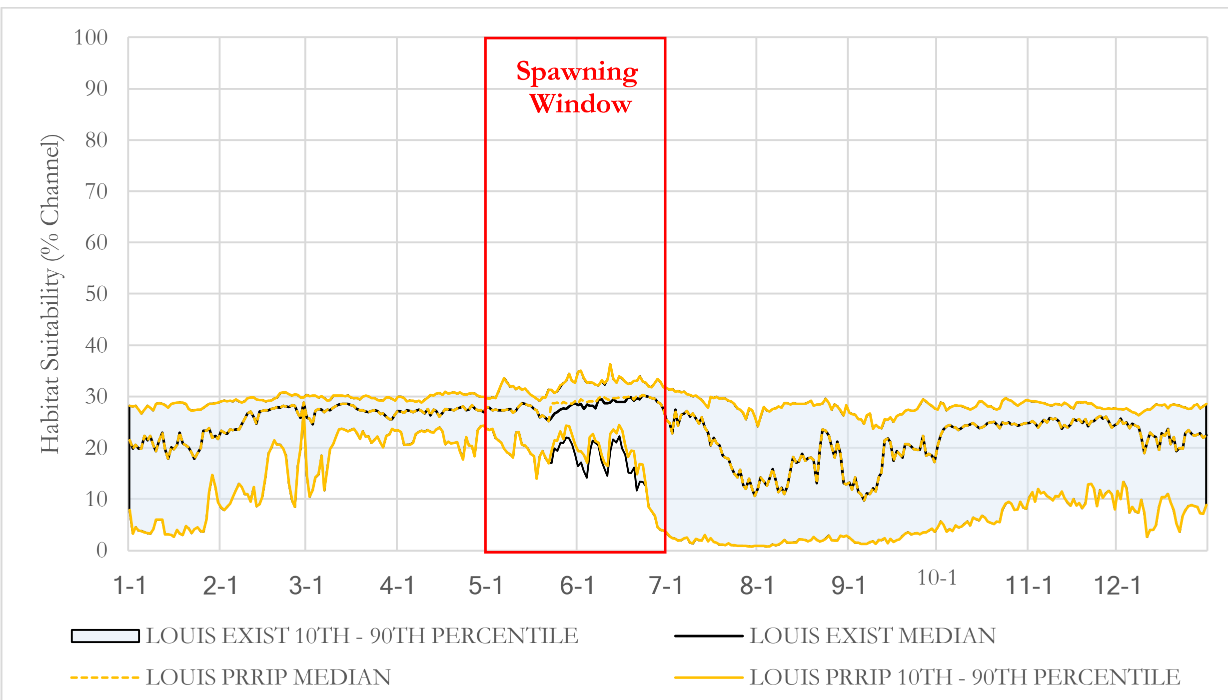

Figure 10. 10th, median, and 90th percentile habitat suitability at the Louisville (LOUIS) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

[8] Necessary effect number three for the late spring pulse is: "Help maintain and rehabilitate aquatic characteristics of large river habitats in the lower Platte River for animals such as the endangered pallid sturgeon."
[9] There is no late spring pulse target or release during dry years.

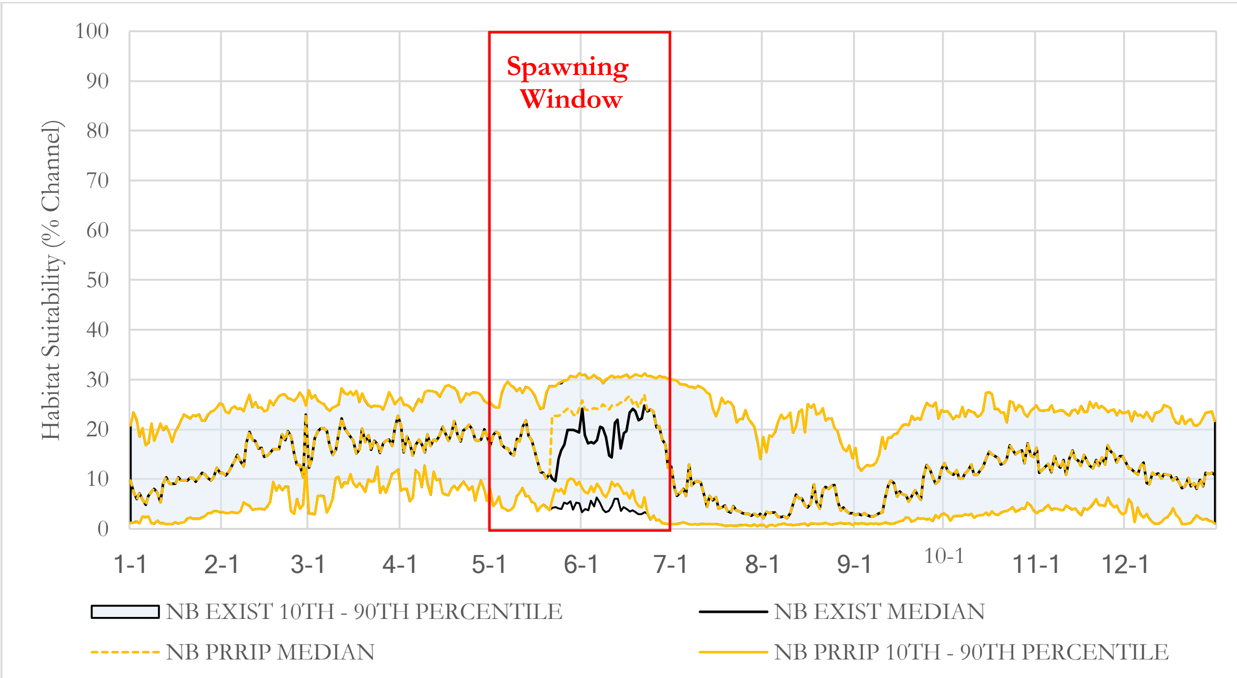

Figure 11. 10th, median, and 90th percentile habitat suitability at the North Bend (NB) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

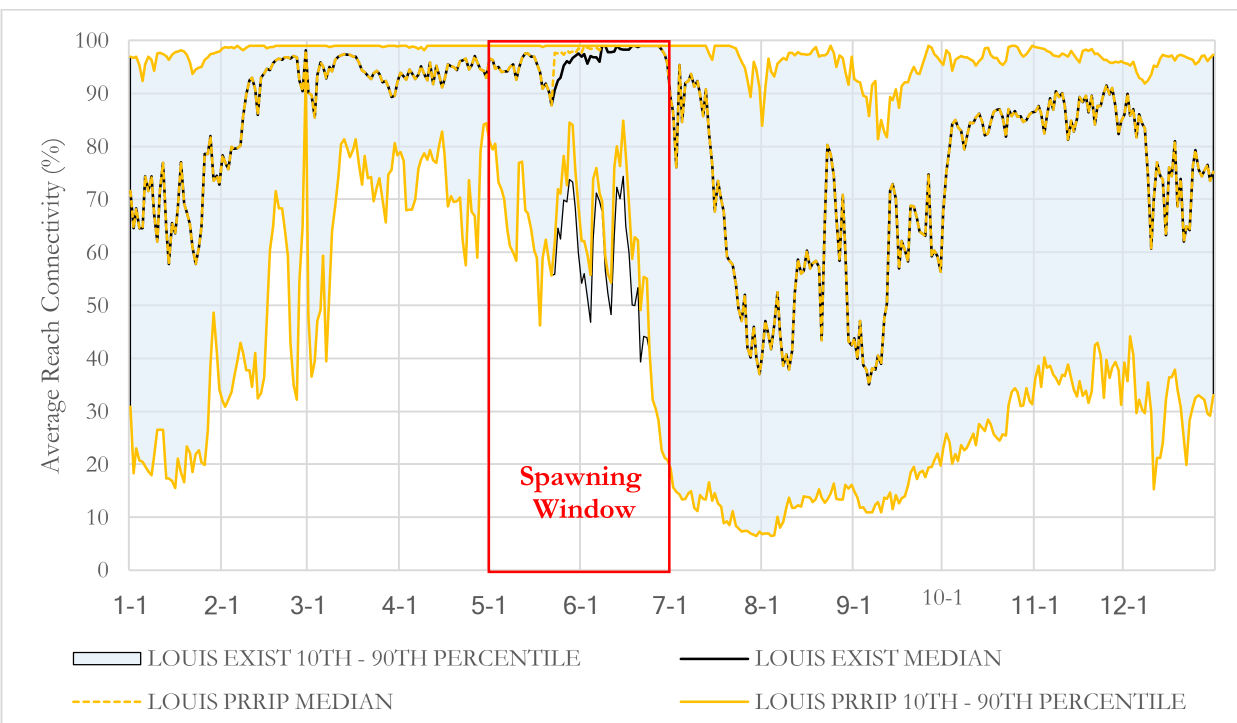

Figure 12. 10th, median, and 90th percentile reach connectivity at the Louisville (LOUIS) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

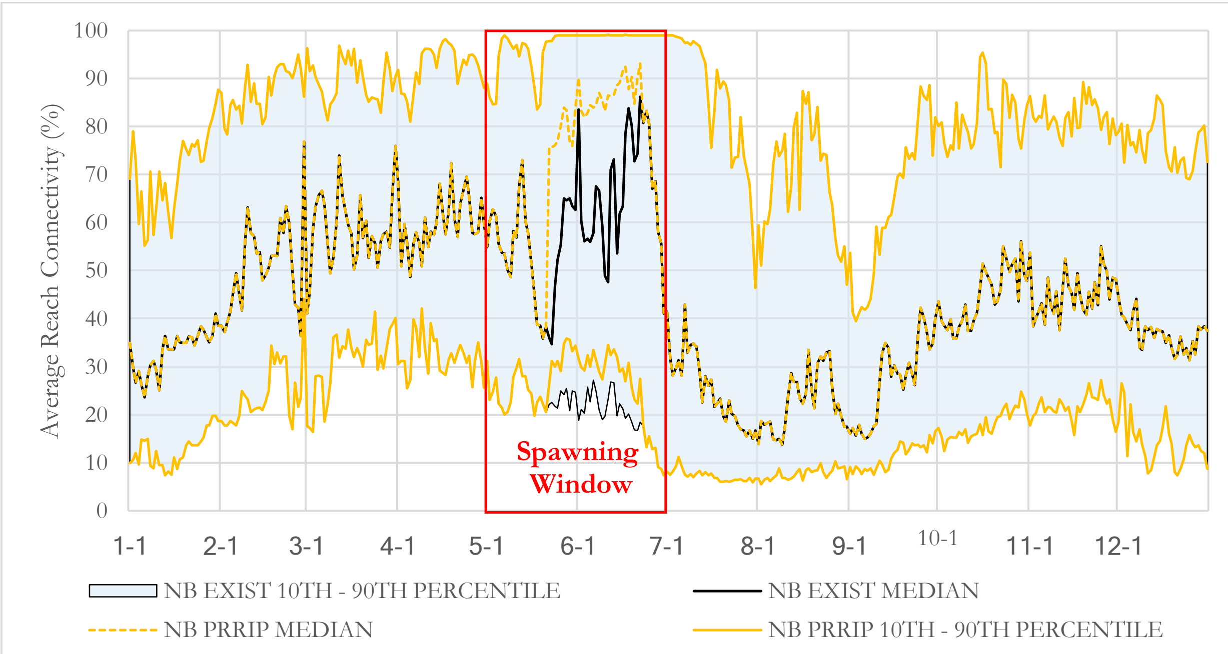

Figure 13. 10th, median, and 90th percentile reach connectivity at the North Bend (NB) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

EXTERNAL FACTORS OF INTEREST

External factors will influence the Program's impact on lower Platte River hydrology. Two of these factors are hydrocycling of Loup River flows and future lower Platte River depletions due to ongoing or new consumptive uses. Each of these factors is described briefly below.

LOUP RIVER HYDROCYCLING

The analyses presented above are all based on mean daily flow records at USGS gauges. These records do not capture sub-daily flow and stage variability due to hydrocycling of a portion of Loup River discharge. In many cases, daily hydrocycling fluctuations would be of greater magnitude than changes produced by Program flow releases. Figures 14 and 15 provide an example of the influence of lower Platte River hydrocycling on Program water released during a 2009 flow routing test. Peak release magnitude at the Grand Island gauge was approximately 4,000 cfs, which is slightly greater than the wet year late-spring pulse target of 3,700 cfs.

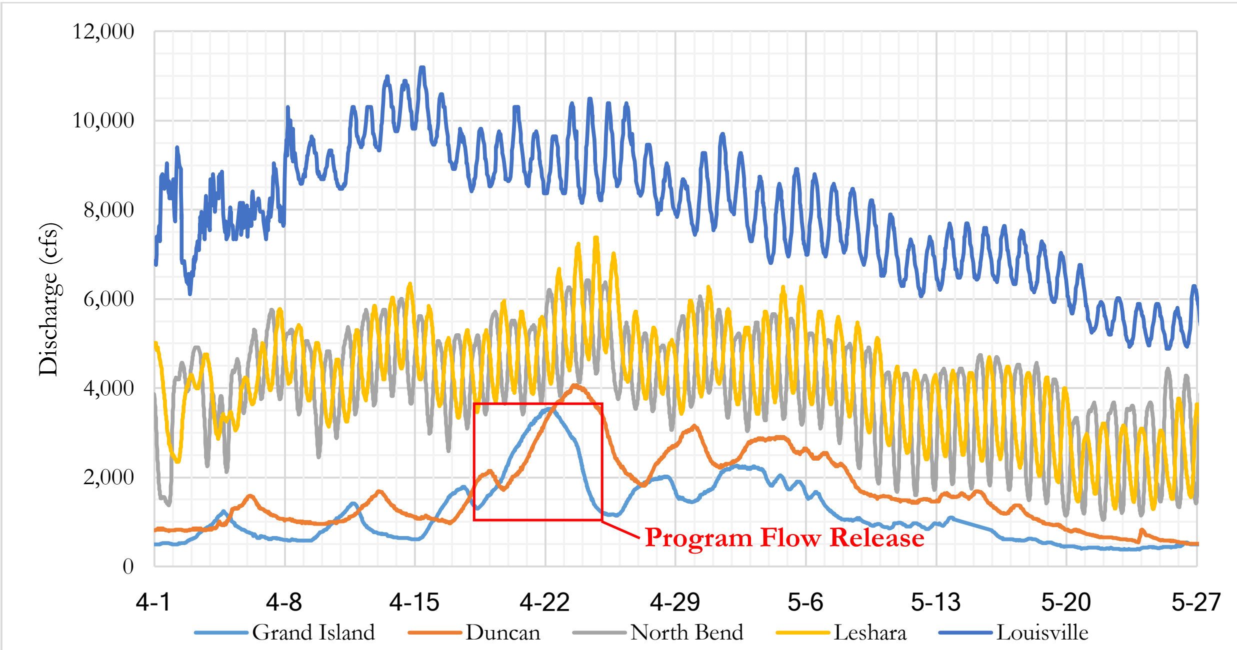

Figure 14. Real time (15 minute) river discharge at the Grand Island, Duncan, North Bend, Leshara and Louisville gauges for the April 2009 Program flow routing test. Hydrocycling-induced flow fluctuations below the Loup River confluence (North Bend, Leshara and Louisville gauges) mask the flow increase associated with the Program flow release.

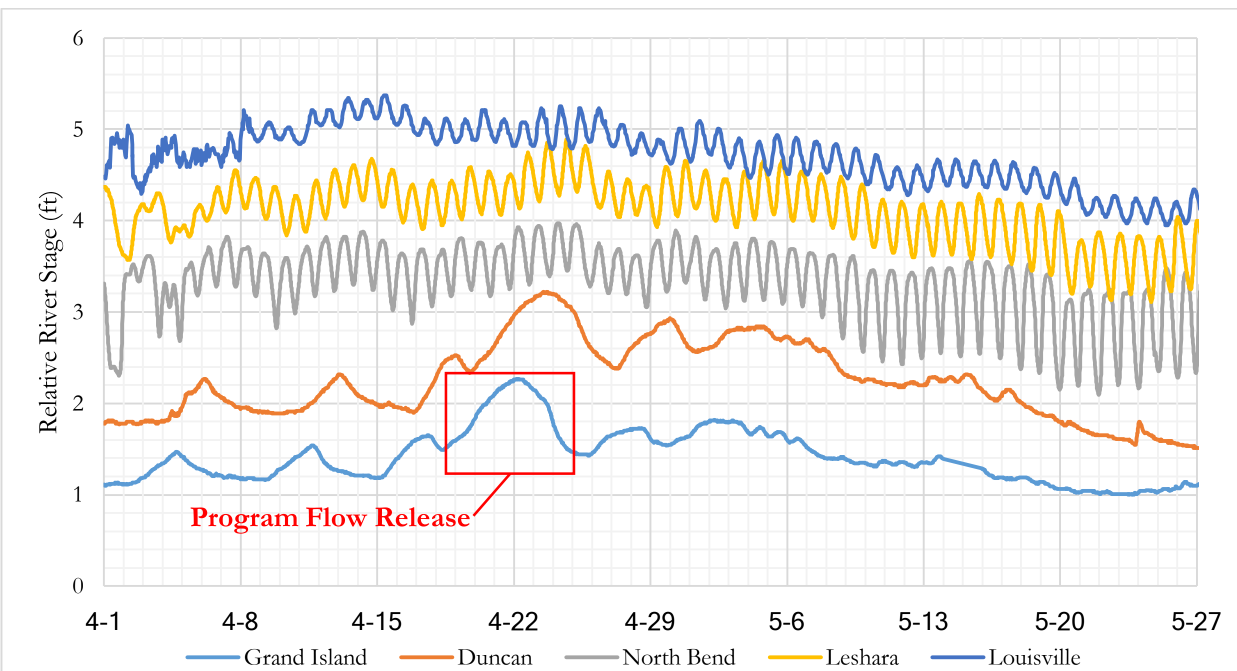

Figure 15. Real time (15 minute) river stage at the Grand Island, Duncan, North Bend, Leshara and Louisville gauges for the April 2009 Program flow routing test. Hydrocycling-induced stage fluctuations below the Loup River confluence (North Bend, Leshara and Louisville gauges) mask the stage change associated with the Program flow release.

FUTURE LOWER PLATTE RIVER DEPLETIONS

The Nebraska Department of Natural Resources (NDNR) 2017 Report on Annual Evaluation of Availability of Hydrologically Connected Water Supplies that describe the expected declines in streamflow for the lower Platte River (Figure 16). In 25 years, the lower Platte River streamflow is expected to decline by 337 cfs at the Louisville gage as a result of lag effects from existing groundwater development. NDNR expects an additional decline in streamflow of 122 cfs in 25 years based on existing trends in new water development which equates to a total decline for the Louisville gage in 25 years of 459 cfs. For the North Bend gage, the anticipated decline as a result of lag effects from existing groundwater development is 35 cfs in 25 years while there is an anticipated decline of 71 cfs from projected new water development. It is recognized that declines in base flow throughout the remainder of the first increment will increase annually, but NDNR did not provide total loss estimates for time increments less than 25 years. Total losses throughout these years would be less than 107 and 459 cfs at the North Bend and Louisville gages, respectively, or average, annual volume reductions of 77,468 AF and 332,316 AF at the North Bend and Louisville gages, respectively.

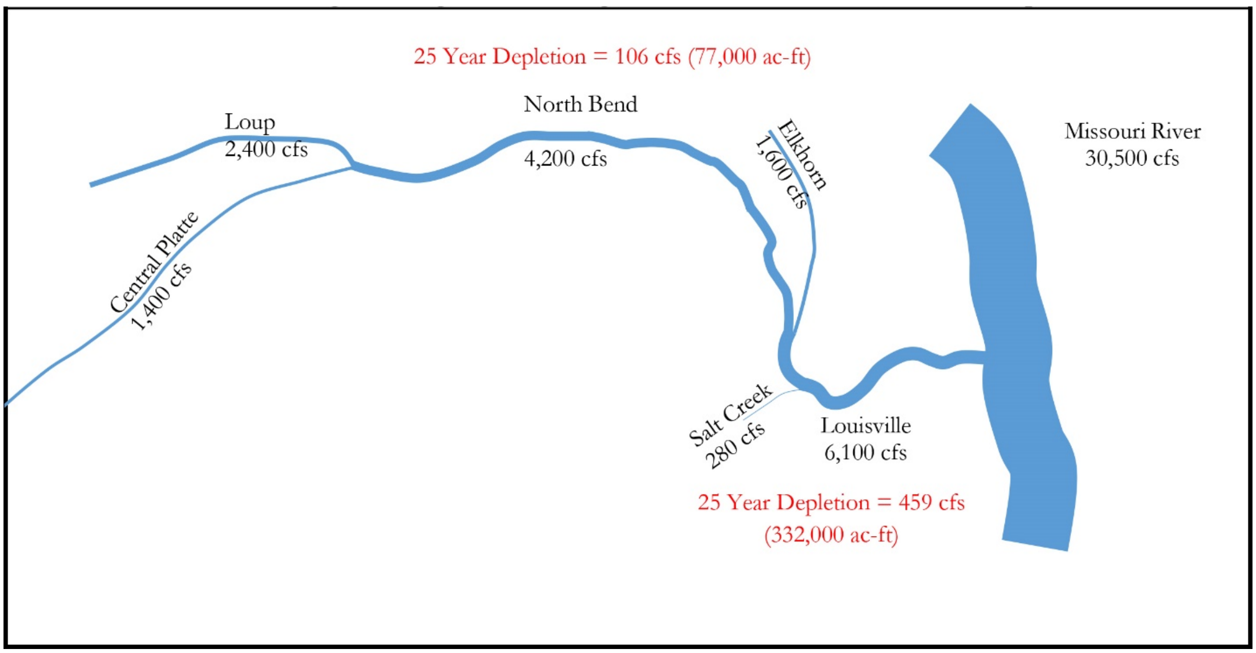

Figure 16. Median discharge during stream gauge periods (Black font) of record with anticipated future lower Platte River depletions (red font) due to ongoing and new consumptive water uses.