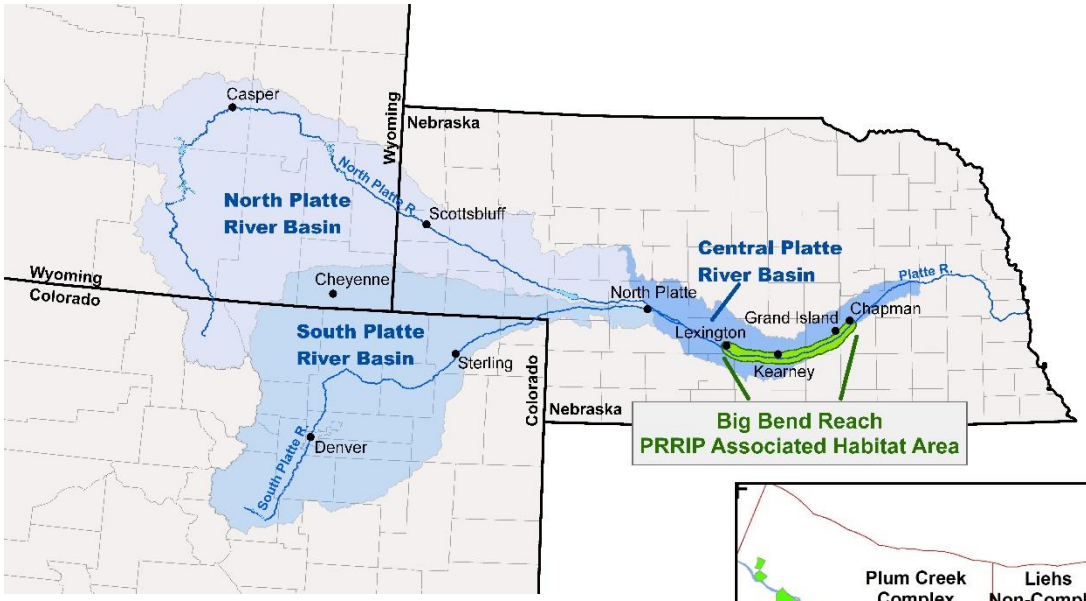
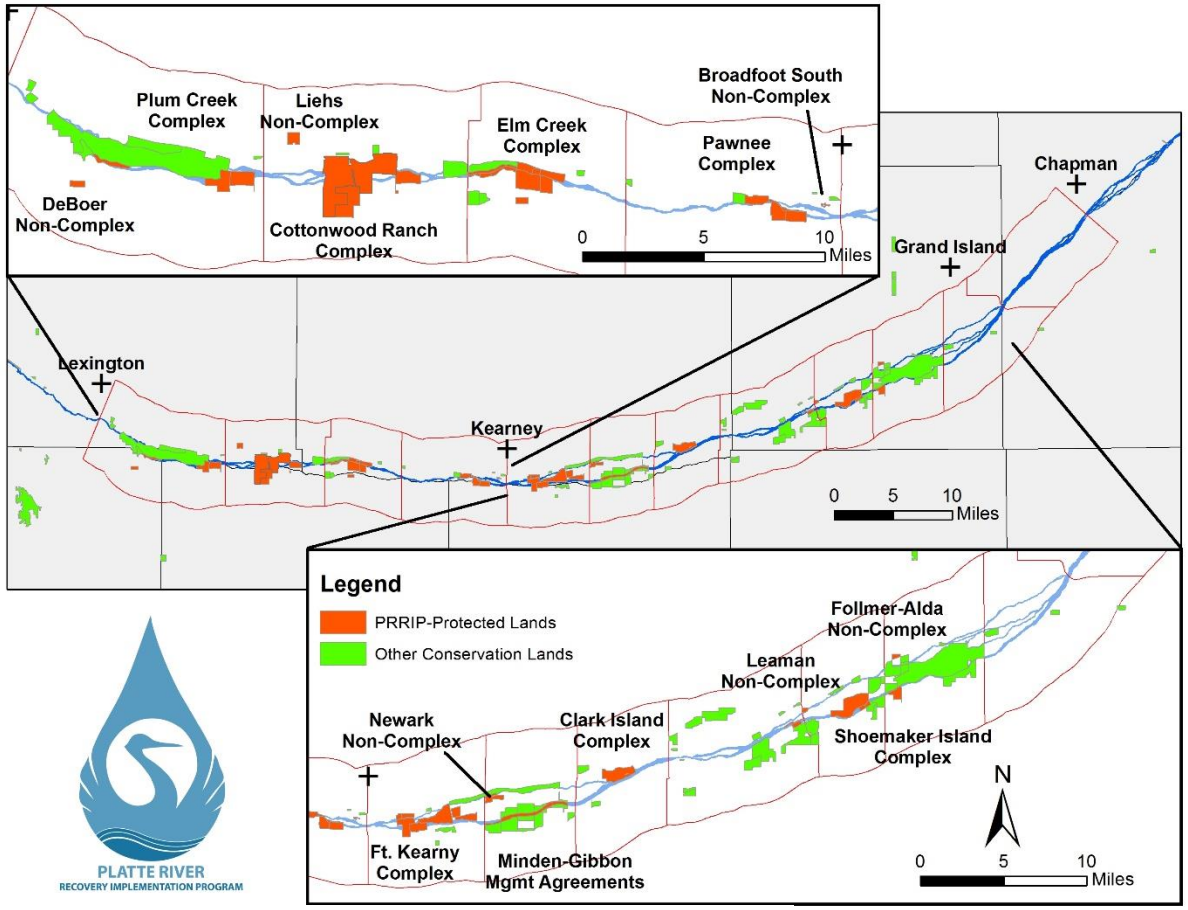
2019 State of the Platte

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM



Map depicting the Platte River system, including the Program Associated Habitat Reach on the central Platte River.



Program habitat complexes in the Associated Habitat Reach (AHR).

2019
State of the Platte

Adaptive Management Plan (AMP)
2019 “Big Question” Assessments*
September 20, 2019

*First Increment summary updated primarily with 2007-2018 data.

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PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

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INTRODUCTION

The Platte River Recovery Implementation Program's ("Program" or "PRRIP") Executive Director's Office (EDO) developed this document for the Governance Committee (GC). It is intended to serve as a synthesis of Program monitoring data, research, analysis, and associated retrospective analyses to provide important information to the GC regarding key scientific and technical uncertainties. These uncertainties form the core structure of the Program's Adaptive Management Plan (AMP) and are directly related to decisions regarding implementation of management actions, assessment of target species' response to those management actions, how best the Program can spend its resources (money, land, water, etc.), and ultimately the success or failure of the Program.

A quick reference assessment for each of ten Big Questions is provided in Table 1, followed by an assessment write-up for each Big Question. Each assessment includes information noting any updates or changes from previous State of the Platte reports. This document contains endnotes to identify key documents or data sets that are important to read and understand when reviewing this report. Those endnotes include hyperlinks to information available in the Public Library section of the Program's web site.

KEY OBSERVATIONS AND PROGRESS

The 2019 State of the Platte Report includes assessments incorporating Program data primarily from years 2007-2018. Eight of ten Big Questions are answered conclusively, one (#3) is trending in a direction that will affirm or reject important hypotheses, and one question (#9) will be addressed by the GC during the AMP update process to be implemented during the First Increment Extension (2020-2032).

TERN AND PLOVER HABITAT AND USE

Implementation of short-duration high flow (SDHF) releases as currently envisioned will not create and/or maintain in-channel islands suitable for use and productivity for terns and plovers. In 2015 and 2016 the Program completed a Structured Decision Making (SDM) process to determine how to proceed with creating tern and plover habitat within the Associated Habitat Reach (AHR). Based on the SDM process, the GC completed the final "Adjust" stage of adaptive management and decided to maintain 10 acres of on-channel moving complex approach (MCA) islands and to create an additional 60 acres of off-channel nesting habitat.

WHOOPING CRANE HABITAT AND USE

Based on the findings of habitat selection analyses and related synthesis, the Program should continue management actions that provide unobstructed channel widths (UOCWs) for whooping cranes that are ≥650 ft and unforested corridor widths that are ≥1,100 ft. Implementation of SDHF releases as currently envisioned will not create and/or maintain suitably-wide UOCW for whooping cranes. Mechanical methods such as disking and herbicide application at Program habitat complexes will create and maintain suitably wide UOCWs, though these management actions do not have the system-scale beneficial effects of natural flow events.

FORAGE AND TERN/PLOVER PRODUCTIVITY

Data analyses and syntheses indicate there is no relationship between flow and tern productivity and there is no evidence the forage base along the central Platte River limits tern and plover productivity. These same analyses and syntheses do not support Program summer flow releases to maintain the current 800 cubic feet per second (cfs) target for a diverse forage base for terns.

GLOSSARY OF ACRONYMS

ACRONYM	DEFINITION
AFY	Acre-feet per Year
AHR	Associated Habitat Reach
AMP	Adaptive Management Plan
AMWG	Adaptive Management Working Group
BQ	Big Question
CfS	Cubic Feet per Second
EDO	Executive Director's Office
FSM	Flow-Sediment-Mechanical
GC	Governance Committee
ISAC	Independent Science Advisory Committee
LTPP	Least Tern and Piping Plover
MCM	Mechanical Creation and Maintenance
NF	Nearest Forest
PRRIP or Program	Platte River Recovery Implementation Program
SDHF	Short-Duration High Flow
SoPR	State of the Platte Report
TAC	Technical Advisory Committee
USFWS	United States Fish and Wildlife Service
UOCW	Unobstructed Channel Width
WAP	Water Action Plan
WC	Whooping Crane

Summary of Key Learning from AMP Version 1.0 and the First Increment

As the Program prepares to begin the Extension, a review of implementation of AMP Version 1.0 during the First Increment reveals several key learning observations:

- ✓ *Attempts to implement the flow-sediment-mechnical (FSM) management strategy have generally produced poor results.*
  - SDHF (5,000-8,000 cfs for three (3) days at Overton, NE) is highly unlikely to create or maintain suitable least tern and piping plover nesting habitat or whooping crane roosting habitat. While unlikely to produce the hypothesized results, the Governance Committee (GC) has committed to implementing at least one SDHF release during the Extension.
  - Flow consolidation is not feasible due to legal and permitting constraints.
  - A sediment deficit exists in the south channel downstream of the J-2 Return. Five to seven years of full-scale sediment augmentation are necessary to assess efficiency and effectiveness in preventing downstream migration of incision and narrowing.[1]
  - First Increment learning occurred largely through natural flow events as the Program was unable to implement a true SDHF and was not able to conduct flow consolidation actions.
- ✓ *Implementation of the mechnical creation and maintenance (MCM) management strategy has produced mixed results.*
  - Suitable on-channel whooping crane roosting habitat can be mechanically created and maintained on Program (or other managed) lands but off-channel palustrine wetland roosting habitat is not a viable alternative to on-channel habitat due to a lack of potential restoration sites and costs associated with the creation of new wetland sites.
  - Off-channel tern and plover nesting habitat can be created and maintained using a variety of methods but on-channel nesting habitat is difficult to construct and erodes quickly.

- ✓ *The target species are responding to the implementation of Program management actions.*
  - Least tern and piping plover populations in the AHR have increased significantly and proportionately to increases in habitat availability due to Program off-channel habitat creation efforts. Productivity on off-channel habitats has been sufficient to maintain stable to growing subpopulations.
  - Based upon available data, least tern and piping plover productivity is insensitive to river flow. Periods of low flow have not reduced productivity due to a limitation in forage availability.
  - Whooping crane use of the AHR has increased significantly and proportionally to increases in habitat suitability that are in part due to Program management actions.
- ✓ *Learning related to pallid sturgeon and the Program has been limited.*
  - Translation of Program flow management actions from the central Platte to the lower Platte is difficult to detect and thus difficult to relate to effects on habitat and species response.
  - Significant uncertainty relating to the life history of pallid sturgeon on the lower Platte (use, productivity, recruitment) has limited the ability of the Program to develop a clear set of testable hypotheses, management actions, monitoring protocols, and a plan for data analysis and synthesis.

[1] Sediment augmentation is also a component of the MCM strategy.

INDEPENDENT SCIENTIFIC ADVISORY COMMITTEE (ISAC) COMMENTS ON THE 2019 STATE OF THE PLATTE REPORT

This report was discussed with and reviewed by the Program's ISAC in 2019. The ISAC provided the following comments on the 2019 State of the Platte:

•

To assist the GC with quickly evaluating the 2019 Big Question assessments, the icons in Table 1 are used to visually summarize the basic conclusion for each question. Thumbs up or down indicate a trend in the affirmative or negative and may point to the need to re-evaluate management actions based on collected data and analysis. The "unknown character" is used when there is not enough evidence to indicate a trend in either direction or more time is needed to collect appropriate data and conduct analyses. These icons are intended to provide the GC with a quick visual means to see where the Program stands each year in moving towards resolution of the Program's most significant scientific questions as they relate to management decision-making.

Each Big Question assessment includes an indicator of the "test results" for relevant priority hypothesis. Hypothesis Test Results are indicated as one of the following categories:

▲ Hypothesis answered conclusively – affirmed.

▼ Hypothesis answered conclusively – rejected.

● Hypothesis not yet answered – ongoing implementation, analysis, and synthesis.

○ Not currently being addressed through implementation of the AMP and related data analysis and synthesis.

See **Appendix A** for a more detailed status report for each priority hypothesis in the AMP.

TABLE 1. Quick Reference legend explaining icons used to assess Big Questions.

Icon	Trend or Answer Explained by Icon
	• Big Question and underlying hypotheses **answered conclusively** in the **affirmative** • Foundational documents, analysis, and other references on which this assessment is based have undergone peer review through the PRRIP peer review process and/or publication in refereed journals • Governance Committee should consider adjustments to decisions related to PRRIP management actions
	• Affirmative answer or trend, but Big Question and underlying hypotheses **NOT answered conclusively** • Assessment can be based on draft documents and analysis, but peer review and/or publication may be pending • To the extent possible, consider what information is necessary to change this designation
	• Evidence thus far is **inconclusive**; no affirmative or negative answer/trend to Big Question and underlying hypotheses • Assessment can be based on draft documents and analysis, but peer review and/or publication may be pending • To the extent possible, consider what information is necessary to change this designation
	• Negative answer or trend, but Big Question and underlying hypotheses **NOT answered conclusively** • Assessment can be based on draft documents and analysis, but peer review and/or publication may be pending • To the extent possible, consider what information is necessary to change this designation
	• Big Question and underlying hypotheses **answered conclusively** in the **negative** • Foundational documents, analysis, and other references on which this assessment is based have undergone peer review through the PRRIP peer review process and/or publication in refereed journals • Governance Committee should consider adjustments to decisions related to PRRIP management actions

TABLE 2. Big Question assessments, PRRIP First Increment (2007-2019).

PRRIP Big Question	First Increment Assessment	Basis for Assessment
<u>Implementation</u> – Program Management Actions and Habitat		
1. Will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?		<u>Conclusively answered</u>.
2. Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?		<u>Conclusively answered</u>.
3. Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?		Trending positive and certainty about the sediment deficit in the south channel above the Overton bridge; uncertainty about the role of that deficit in habitat creation and maintenance in the rest of the AHR. This Big Question will either be retained in its current form or revised and addressed through implementation of AMP Version 2.0 during the Extension.
4. Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?		<u>Conclusively answered</u>.
<u>Effectiveness</u> – Habitat and Target Species Response		
5. Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?		<u>Conclusively answered</u>.
6. Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?		<u>Conclusively answered</u>.
7. Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?		<u>Conclusively answered</u>.
8. Does forage availability limit tern and plover productivity on the central Platte River?		<u>Conclusively answered</u>.
9. Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?		This Big Question will either be retained in its current form or revised and addressed through implementation of AMP Version 2.0 during the Extension.
10. Do Program management actions in the central Platte River cumulatively 1) produce detectable changes in the physical environment (i.e. habitat) and 2) result in a detectable increase in tern, plover, and whooping crane use of the Associated Habitats?	**<u>LTPP Off-Channel</u>** Habitat Species Response **<u>WC On-Channel</u>** Habitat Species Response	<u>Conclusively answered</u>.

Big Question #1

Will implementation of Short-Duration High Flow releases produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?

The minimum sandbar height suitability criterion is ≥1.5 ft above 1,200 cfs river stage.

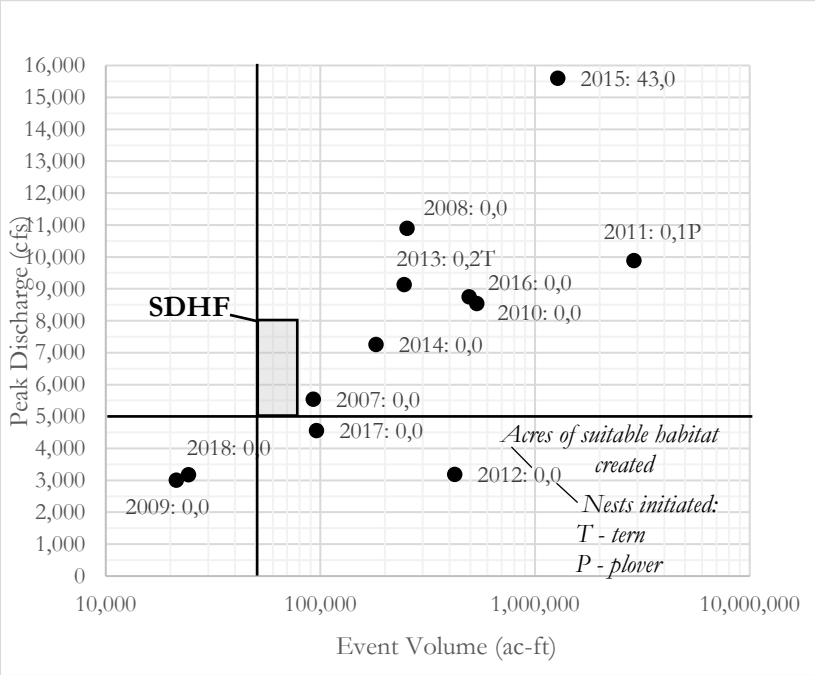


Figure 1. First Increment peak flow event magnitudes and volumes in relation to SDHF. Six events (2008, 2010, 2011, 2013, 2015, and 2016) exceeded SDHF magnitude and duration and only the extreme event in 2015 produced any suitably high sandbar nesting habitat (see Figure 2).

2019 Assessment

- Observational studies of natural high flow events since 2007 have provided sufficient data to test the hypothesis that SDHF releases will create suitably-high sandbars.
- Full SDHF magnitude of 8,000 cfs is not sufficient to create sandbars exceeding the PRRIP's minimum height suitability criterion.
- Sandbars created by SDHF releases will be inundated during the nesting season in most years.
- Peak flow magnitudes of 15,000 cfs will produce sandbars meeting the minimum height criterion. However, suitably high sandbar area would be well below the AMP objective of 10 acres per river mile.

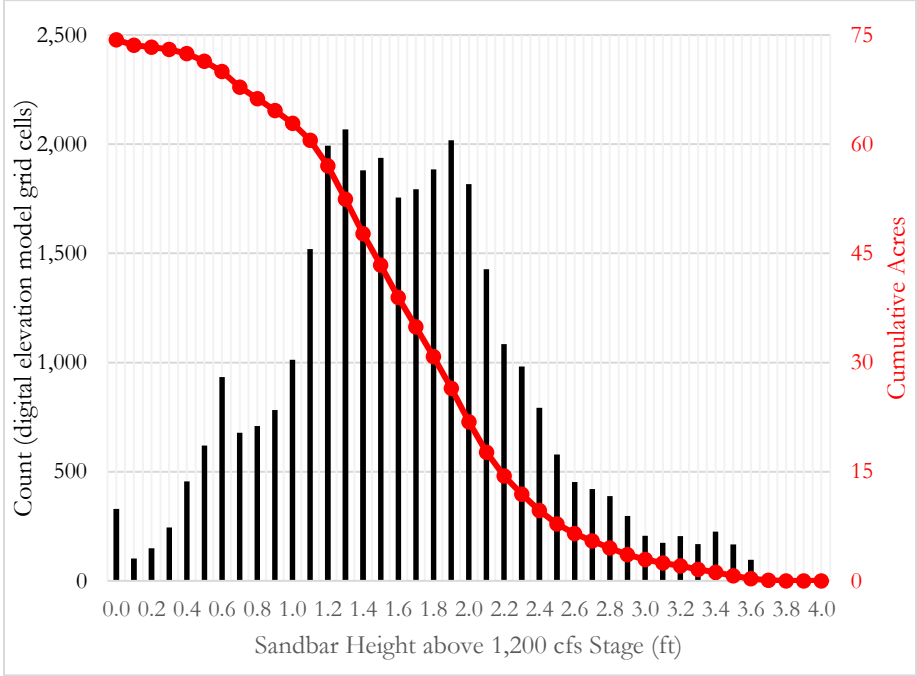


Figure 2. Distribution of emergent sandbar area produced during the 2015 peak flow event in the portion of the AHR downstream of Kearney. The 15,000 cfs event produced 43 cumulative acres (line) of sandbar habitat exceeding the minimum height suitability criterion of 1.5 ft above 1,200 cfs stage. Median height of bars was 1.6 ft above 1,200 cfs stage.

What the science says in 2019:

- The original analysis of SDHF performance assumed sandbars build to the water surface during peak flow events. The median height of sandbars formed during natural high flow events in 2010, 2011, 2014, and 2015 was 1.2 – 2.3 ft below peak stage.[1]
- Five peak flow events (2008, 2010, 2011, 2013, and 2016) that exceeded SDHF magnitude and duration did not produce sandbar habitat exceeding the minimum height criterion (Figure 1).
- A natural high flow event of 15,000 cfs in 2015 produced sandbars exceeding the minimum height criterion. The median height of sandbars formed in 2015 was 1.6 ft above 1,200 cfs stage (Figure 2).
- Approximately 43 acres of mid-channel bar area ≥1.5 ft above 1,200 cfs stage were present in the portion of the AHR downstream of Kearney in November of 2015 (Figure 2). This equates to 0.8 acres per river mile.

We estimate with confidence that:

- SDHF magnitude of 5,000 to 8,000 cfs for a duration of three days at peak would not be sufficiently long to mobilize the bed and produce suitable sandbar nesting habitat.
- Sandbars created by a full SDHF magnitude of 8,000 cfs would be 0.5 – 1.0 ft lower than the minimum height criterion and would be inundated at flows experienced in the AHR during most nesting seasons.
- Peak flow magnitudes of 15,000 cfs will produce sandbars exceeding the minimum height criterion given sufficiently long duration at peak.
- Even at a discharge magnitude of 15,000 cfs, total suitable sandbar area would be well below the AMP objective of 10 acres per river mile.

Answering BQ #1 during the First Increment

- Six tern/plover habitat synthesis chapters and associated publications serve as the best source for synthesized reference data for this question. Those chapters have been peer reviewed and accepted by the Governance Committee[2] and three of those chapters have been published.
- Geomorphic and species monitoring data collected through 2018 are consistent with and support the analyses and conclusions presented in the synthesis chapters and associated publications.

Management Implications:

- Big Question #1 has been answered with a definitive "two thumbs down." The Governance Committee completed the final "Adjust" stage of adaptive management and decided to maintain 10 acres of on-channel moving complex approach (MCA) islands and to create an additional 60 acres of off-channel nesting habitat.

Big Question #2

Will implementation of Short-Duration High Flow releases produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?

Channels with unobstructed channel widths ≥650ft and unforested corridor widths ≥1,100ft are highly suitable for whooping crane roosting. See Big Question 5.

2019 Assessment

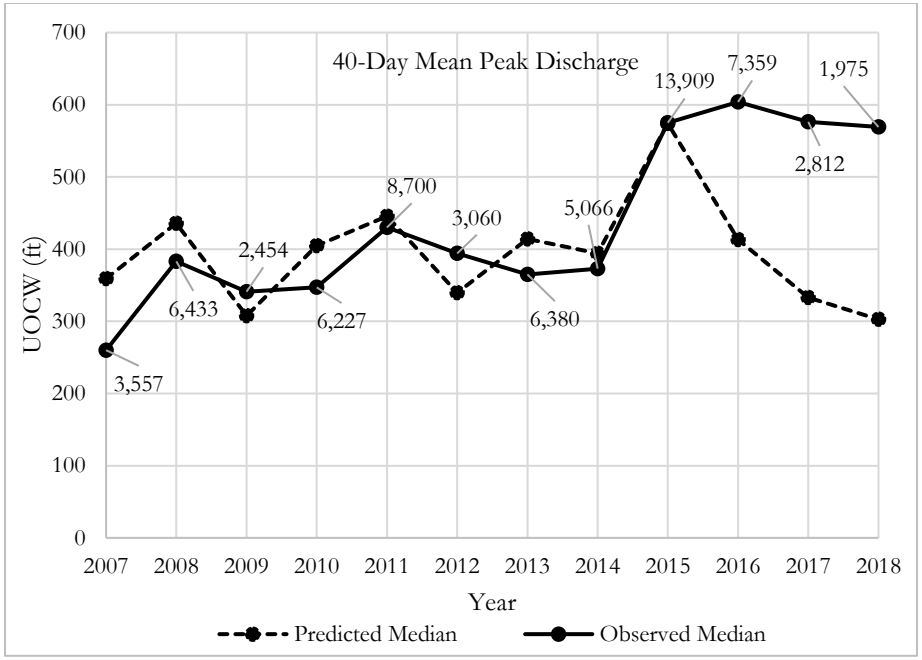


Figure 3. Observed versus predicted median unobstructed channels widths (UOCW) in the AHR during the period of 2007-2018. The UOCW model provides good predictive capacity for evaluating the efficacy of SDHF releases prior to large flood events such as occurred in 2015; however, there appears to be an additional driver (e.g., growing season flows, etc.) for maintaining channel widths once channels are wide.

- Mature phragmites plants or plant patches have a very low probability of being eroded at the highest flow magnitudes and velocities observed in the AHR. A herbicide control program is ongoing.[3]
- Program analyses strongly support the assertion of a positive relationship between peak flow magnitude and unobstructed channel width (UOCW) in the AHR. 40-day mean peak discharge is the best hydrologic predictor of UOCW. Channel maintenance following these high, long duration flow events appears to be driven by other factors (i.e., summer flows, etc.)
- The comparatively short duration and low volume of SDHF limits the predicted increase in in UOCW to ≤12 ft. SDHF duration is not sufficient to maintain UOCWs that are suitable for whooping crane roosting.
- Disking during most years in combination with herbicide application will produce suitably wide UOCWs. However, the beneficial effects of these management actions are limited to locations where they are applied.

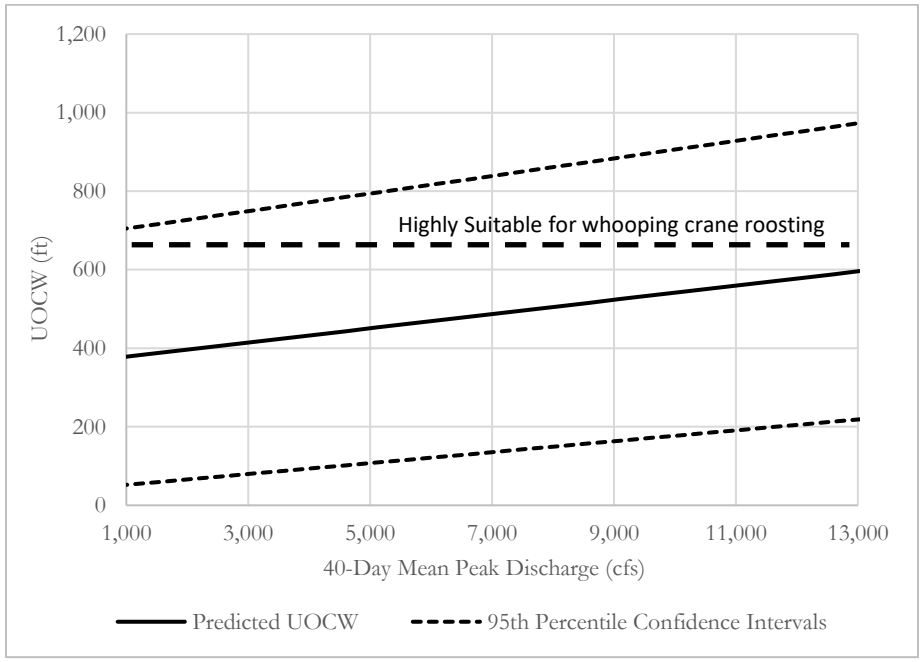


Figure 4. Modeled relationship between 40-day mean peak discharge and UOCW with spraying but no channel disking. The 40-day mean peak discharge for a full SDHF release is approximately 1,300 cfs (), resulting in a predicted UOCW of less than 400 ft. UOCWs of ~650 ft are highly suitable for whooping crane roosting.[9,10]

What the science says in 2019:

- Phragmites occurrence and percent cover declined significantly during the period of 2009-2012 and were slightly increasing to stable in more recent years. The reduction is positively correlated with herbicide application and not correlated with peak flow magnitude or inundation duration.[4]
- 40-day mean peak discharge is the best hydrologic predictor of UOCW in the AHR. Other metrics useful in predicting UOCW include bankfull wetted width, median bed material grain size, and whether spraying or disking occurred.[5]
- Predictions of mean 2007-2018 UOCW in the AHR based on these metrics are, on average, within 16% of observed, indicating good predictive ability. However, since the high-flow event in 2015, it appears other drivers (e.g., growing season flow, etc.) may influence the maintenance of unobstructed channel widths.

We estimate with confidence that:

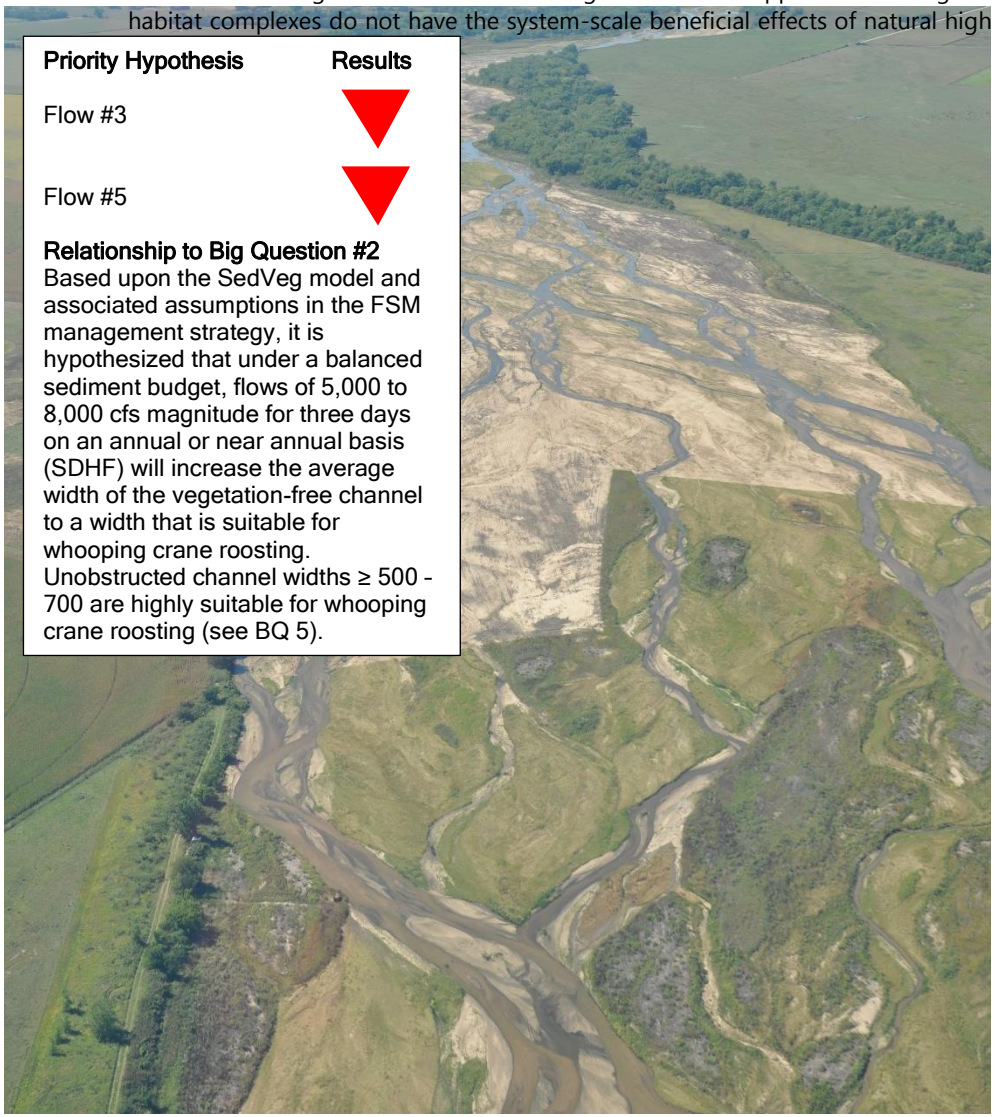
- Implementation of a three- to five-day SDHF will have a minimal influence on UOCW in the AHR during years SDHF releases could have been made would have resulted in ≤12 ft increase in the maximum unobstructed width within a year, but the effect would not carry over to subsequent years due to vegetation encroachment.
- The limited benefit of SDHF is not sufficient to produce suitably wide UOCWs during dry years.
- During wet years, flow releases are not necessary to produce suitably wide UOCWs.
- Implementation of disking and herbicide increases UOCW by an average of 126 ft, producing suitably wide UOCW.
- Mechanical management actions like disking and herbicide application do not provide the system-scale beneficial effects of natural peak flow events.

Answering BQ #2 during the First Increment

- The Program has published directed scour research which serves as the best source for synthesized reference data for phragmites scour resistance.[3]
- The Program's whooping crane data synthesis chapters and associated publications serve as the best source for synthesized reference data for the relationship between SDHF and unvegetated channel width. Those chapters have been peer reviewed and accepted by the Governance Committee[5] and have subsequently been published[11].

Management Implications:

- Implementation of SDHF releases as currently envisioned is highly unlikely to create and/or maintain suitably wide UOCWs for whooping cranes.
- Implementation of disking and herbicide application at Program habitat complexes will create and maintain suitably wide UOCWs for whooping cranes.
- Mechanical management actions like disking and herbicide application at Program habitat complexes do not have the system-scale beneficial effects of natural high



Big Question #3

Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover and whooping crane habitat?

2019 Assessment

- The south channel reach from the J2 Return to the Overton bridge is incising and narrowing due to the sediment imbalance from clear water hydropower returns. Downstream from Overton, the large degree of spatial and temporal variability in channel form makes it difficult to draw conclusions about sediment balance.
- South channel degradation has resulted in a portion of that reach transitioning from a wide braided planform to a narrow wandering planform, which is less suitable for use by the Program's target species.
- Augmentation of sediment in the south channel is necessary to slow incision and narrowing and prevent degradation from progressing downstream past the Overton bridge.
- It will be challenging to measure the effectiveness of augmentation given the desired beneficial effect is slowing and ultimately halting a long-term degradational trend to prevent degradation downstream of the Overton bridge.

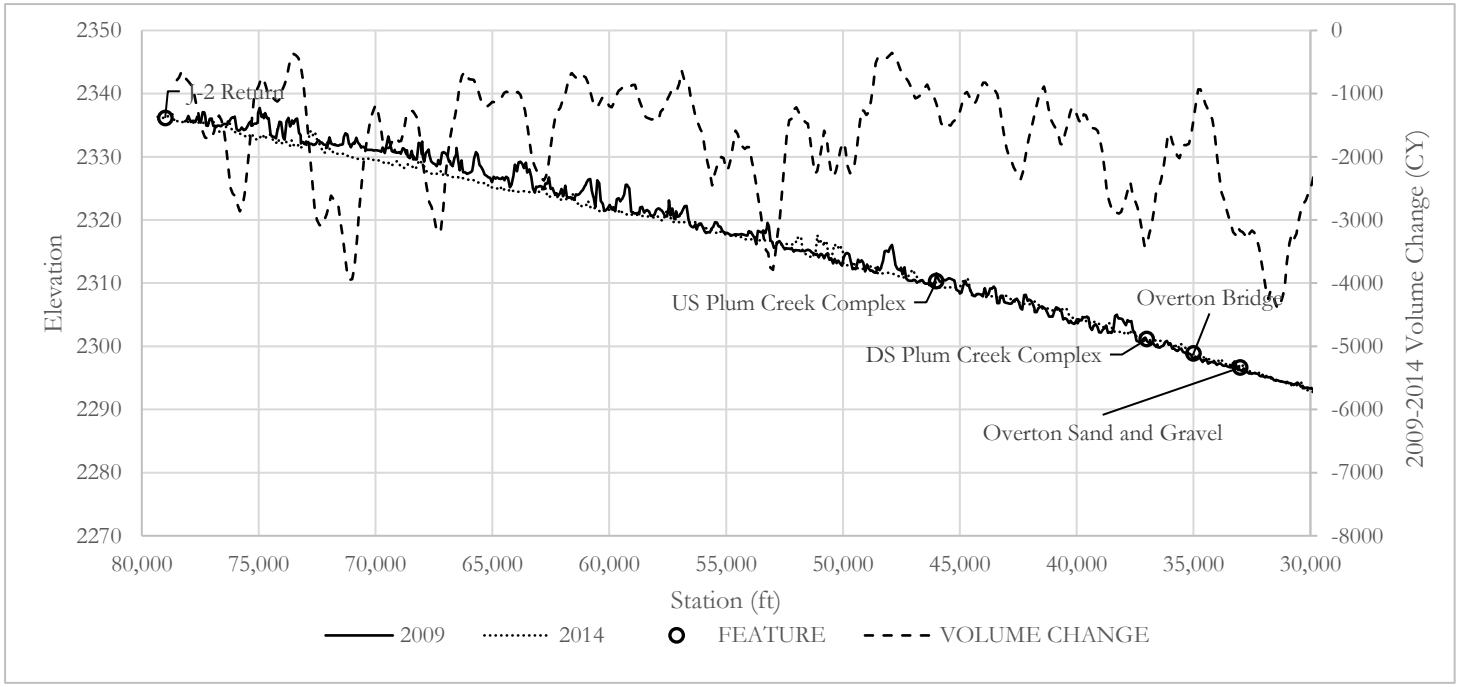


Figure 3. 2009 to 2014 longitudinal profile and volume change for the reach from J2 Return to Overton bridge. Volume change in the reach immediately downstream of the J-2 Return is caused by channel incision. Futher downstream, volume change is due primarily to channel widening.

What the science says in 2019:

- Sediment transport modeling indicates a mean annual sediment deficit of 55,000 tons in the south channel segment extending from the J2 Return downstream to the Overton bridge, ranging from 0 tons in dry years to >100,000 tons in wet years.[6]
- Between 2009 and 2014, that reach lost an average of 159,000 tons of sediment annually due to incision and lateral erosion of banks.[7]
- Incision and associated reduction in channel slope was greatest immediately downstream of the J2 Return and was negligible at the Overton bridge (Figure 3).
- Full-scale sediment augmentation will not be 100% efficient. A proportion (~10%) of the augmentation material will either be too coarse to be mobilized from the augmentation site or so fine that it is rapidly transported out of the reach.

We estimate with confidence that:

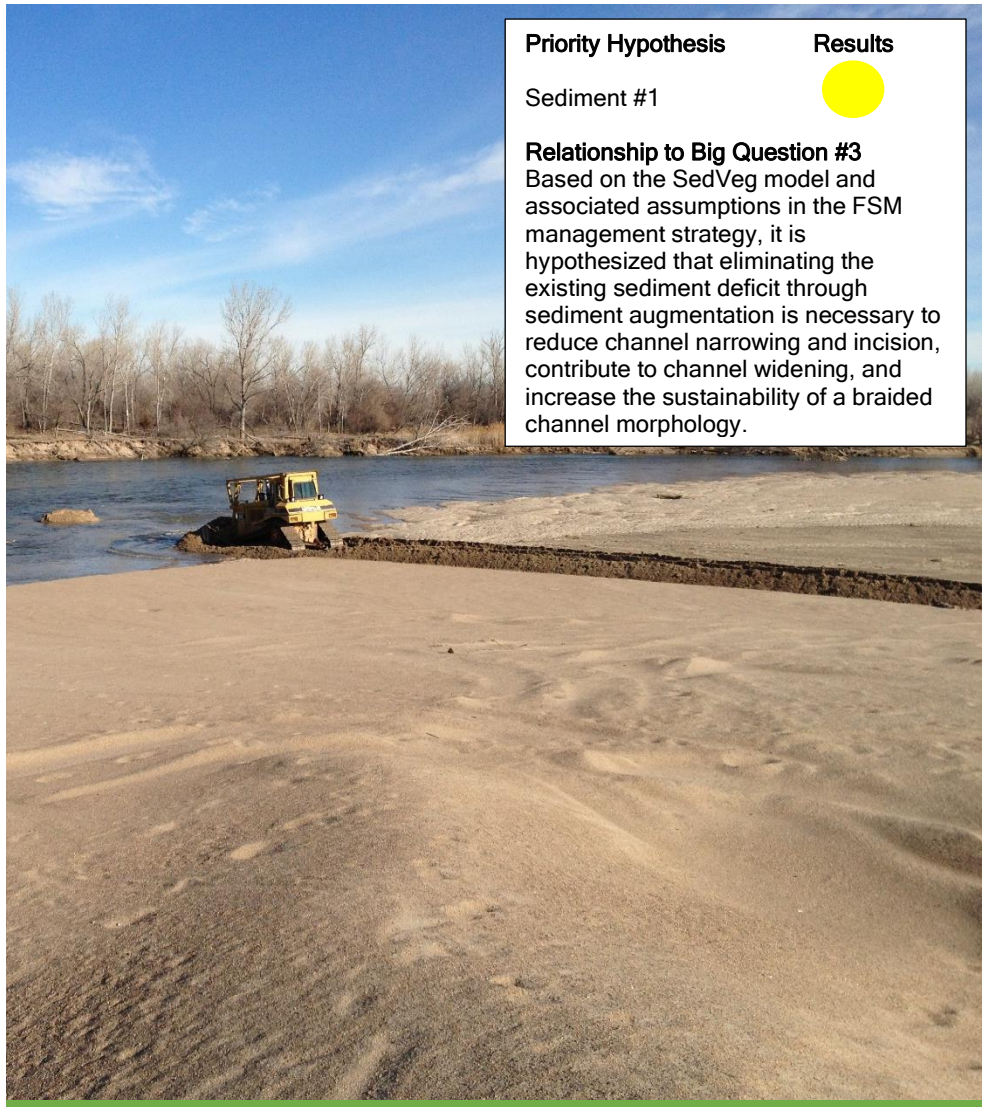
- Observed incision in narrowing and associated planform change in the south channel result in a channel configuration that is not suitable for use by the Program's target species.
- In absence of augmentation to offset the south channel deficit, incision and narrowing would progress downstream past the Overton bridge and negatively affect habitat suitability at the Program's Cottonwood Ranch complex.
- Augmentation of 60,000 to 80,000 tons of sand annually downstream of the J2 return is sufficient to allow the Program to evaluate augmentation efficiency.
- Measuring augmentation effectiveness will require assessment of changes (or lack thereof) in channel slope, volume, width, and bed material. It may be challenging to quantify beneficial effects.

Answering BQ #3 during the First Increment

- The existence and negative impacts of a sediment deficit downstream of the J2 Return has been well documented by the Program and others.
- The effectiveness of sediment augmentation in offsetting the deficit and halting degradation is not known.
- Full scale operations began in the fall of 2017 and it is anticipated that five to seven years of implementation and response monitoring will be necessary to assess augmentation efficiency and effectiveness.

Management Implications:

- If the south channel sediment deficit persists, incision and narrowing will progress downstream past the Overton bridge, negatively influencing habitat suitability in an increasingly larger portion of the AHR.
- Full scale sediment augmentation is effective in halting the long-term trend of incision and narrowing. The beneficial effects of augmentation need to be assessed through five to seven years of implementation and effectiveness monitoring that will include biannual bathymetric LiDAR collection and analysis.



Priority Hypothesis	Results
Sediment #1	

Relationship to Big Question #3
Based on the SedVeg model and associated assumptions in the FSM management strategy, it is hypothesized that eliminating the existing sediment deficit through sediment augmentation is necessary to reduce channel narrowing and incision, contribute to channel widening, and increase the sustainability of a braided channel morphology.

Big Question #4

Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?

2019 Assessment

- Peak flows in the AHR are generally not sufficient to remove mature woody vegetation or erosion-resistant species like phragmites.
- Mechanical clearing and leveling are necessary to create suitable channel configurations and facilitate channel adjustments to changes in flow and sediment.
- Ongoing mechanical management actions like herbicide application and disking are necessary to maintain suitably wide unobstructed channel widths (UOCWs) for target species.
- Flow consolidation, a mechanical management action which consists of mechanically confining 90% of total river flow into a single channel, may support the maintenance of suitable UOCWs but is not implementable due to regulatory and legal impediments.

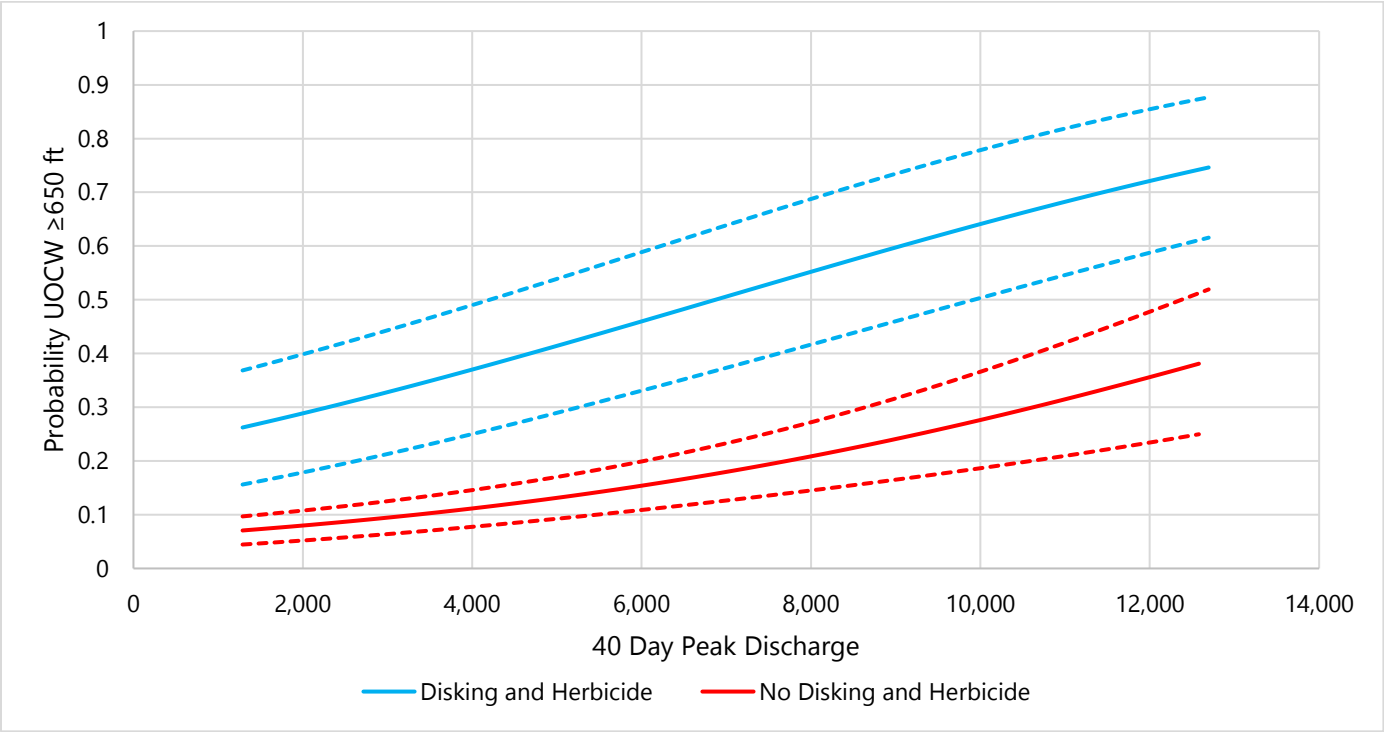


Figure 4. Predicted probability of a transect measuring ≥650 ft in unobstructed channel width (suitable for whooping cranes) in relation to 40-day peak discharge at transects with (blue solid line) or without (red dotted line) mechanical management actions in the AHR from 2007 to 2018. Dashed lines indicate 95% confidence intervals. Disking and herbicide application provides a significantly greater probability of having channels with more than 650 ft unobstructed channel widths.

What the science says in 2019:

- Phragmites is extremely erosion resistant and SDHF flow depths and velocities are only sufficient to scour the very weakest individual plants. Ability to scour woody vegetation also decreases dramatically in the year following seed germination.[8]
- Locations that are mechanically maintained through herbicide application and disking have a significantly higher probability of being suitably wide for whooping crane roosting (Figure 4).

We estimate with confidence that:

- Mechanical clearing, leveling, and channel widening are necessary to create suitably wide channels at Program habitat complexes.
- Herbicide application and disking are necessary at Program habitat complexes in most years to maintain suitably wide UOCWs.
- The beneficial effects of mechanical management actions are largely limited to the locations where they are implemented. They do not provide system-scale beneficial effects.

Answering BQ #4 during the First Increment

- The Program has published directed scour research which serves as the best source for synthesized reference data for phragmites scour resistance.[3]
- The Program's whooping crane data synthesis chapters are the best source for synthesized reference data for the relationship between mechanical actions and unvegetated channel width. Those chapters have been peer reviewed and accepted by the Governance Committee.[5]

Management Implications:

- It was originally hypothesized that mechanical actions were necessary to create desired channel configurations that would subsequently be maintained through Short Duration High Flow releases. SDHF has been shown to be ineffective at creating suitable tern and plover nesting habitat and maintaining suitable channel widths for whooping cranes. Accordingly, ongoing mechanical maintenance will be necessary to provide nesting habitat and maintain suitable UOCWs at Program habitat complexes.
- Due to regulatory and legal issues flow consolidation has been abandoned as a potential Program management action.

Priority Hypothesis **Results**

Mechanical #2

Relationship to Big Question #4
Based on the SedVeg model and associated assumptions in the FSM management strategy, it is hypothesized that designed mechanical channel alterations like flow consolidation, mechanical clearing and leveling of islands, channel widening, and vegetation clearing from banks are needed to accelerate the creation of, and/or to maintain suitably wide braided channels in the AHR.

Big Question #5

Do whooping cranes select riverine roosting habitat in proportions equal to its availability?

2019 Assessment

- Results of habitat selection analyses within the AHR and throughout the Great Plains indicate whooping cranes select unobstructed channel widths of ~650 feet and unforested corridor widths of ~1,100 disproportionately to availability.[9,10,11]

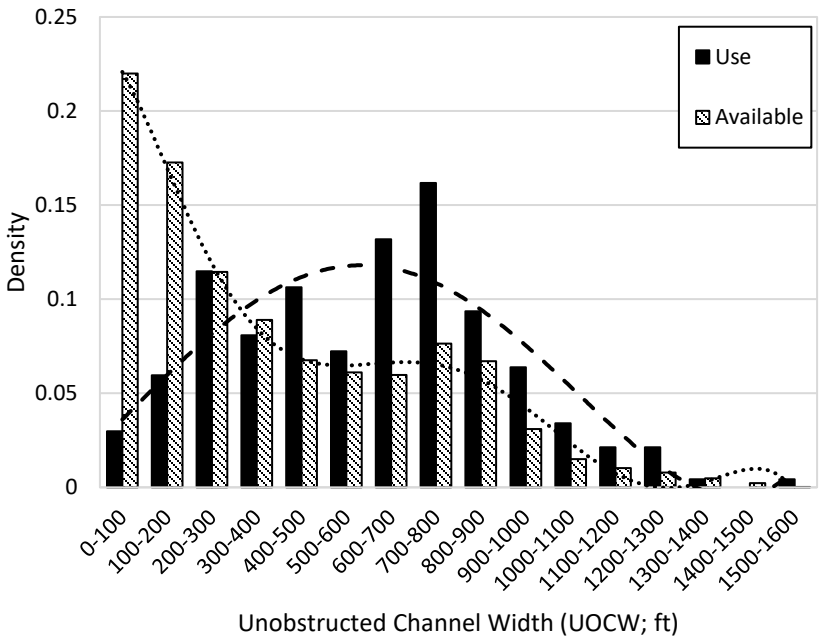


Figure 5. Distribution of unobstructed channel width (UOCW) at use (n=235) and available riverine roost locations in the Associated Habitat Reach (AHR). Use locations were selected disproportionately more than availability above 689 feet of UOCW[11]. As such the Program has agreed to manage for 650 ft channels for whooping crane roosting habitat on the central Platte River. Density curves are represented as dashed (use) or dotted (available) lines.

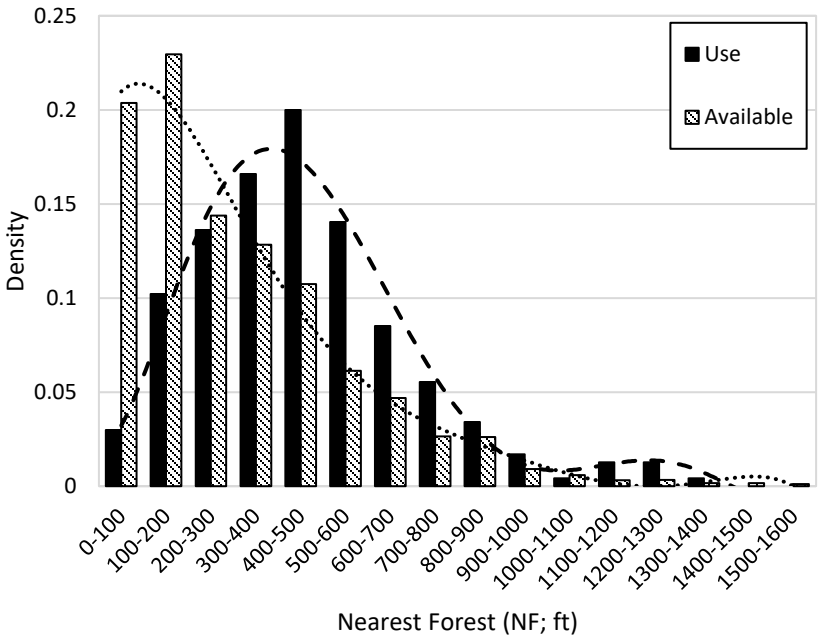


Figure 6. Distribution of nearest forest (NF) at use (n=235) and available riverine roost locations in the Associated Habitat Reach (AHR). Use locations were selected disproportionately more than availability above 594 feet of NF[11]. As such the Program has agreed to manage for total unforested corridor widths of ~1,100 ft (suitable NF roughly multiplied by 2) which would be highly favorable for whooping cranes roosting on the central Platte River. Density curves are represented as dashed (use) or dotted (available) lines.

What the science says in 2019:

- First Increment habitat management efforts implemented by the Program to date include, but are not limited to, tree removal and bank line disking to increase unobstructed view widths, channel disking and widening to increase unobstructed channel widths, and flow releases and sediment augmentation to test hypotheses related to increasing river braiding and areas of suitable depth for whooping crane roosting.

We estimate with confidence that:

- Whooping cranes select unobstructed channel widths of ≥689 feet and unforested corridor widths of ≥1,188 feet disproportionately to availability.[11]

Answering BQ #5 during the First Increment

- Detailed habitat selection analyses have been completed and have undergone the Program's independent third-party peer review[9,10] and publication[11]. The Program accepted the whooping crane habitat synthesis chapters and the WEST whooping crane report and peer reviews as final and thus Program staff consider results of these analyses to be sufficient evidence to change the assessment for this Big Question to 2 thumbs down.

Management Implications:

- Based on findings of habitat selection analyses, the Program has agreed to continue to manage to provide unobstructed channel widths that are ≥650ft and unforested corridor widths that are ≥1,100ft.

Priority Hypothesis	Results
WC 3	▼

Relationship to Big Question #5
It is hypothesized that whooping crane use is related to habitat suitability values as defined in Land Plan Table 1.

Photo Credit: Abby Jensen

Big Question #6

Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?

2019 Assessment

- Long-term monitoring and data analyses indicate there is a strong positive correlation between Program-defined suitable off-channel ***nesting*** habitat and tern and plover breeding pair counts within the AHR.[12,13] During the Program's First Increment, the tern and plover populations on the central Platte River have increased significantly and proportionately to increases in habitat availability.

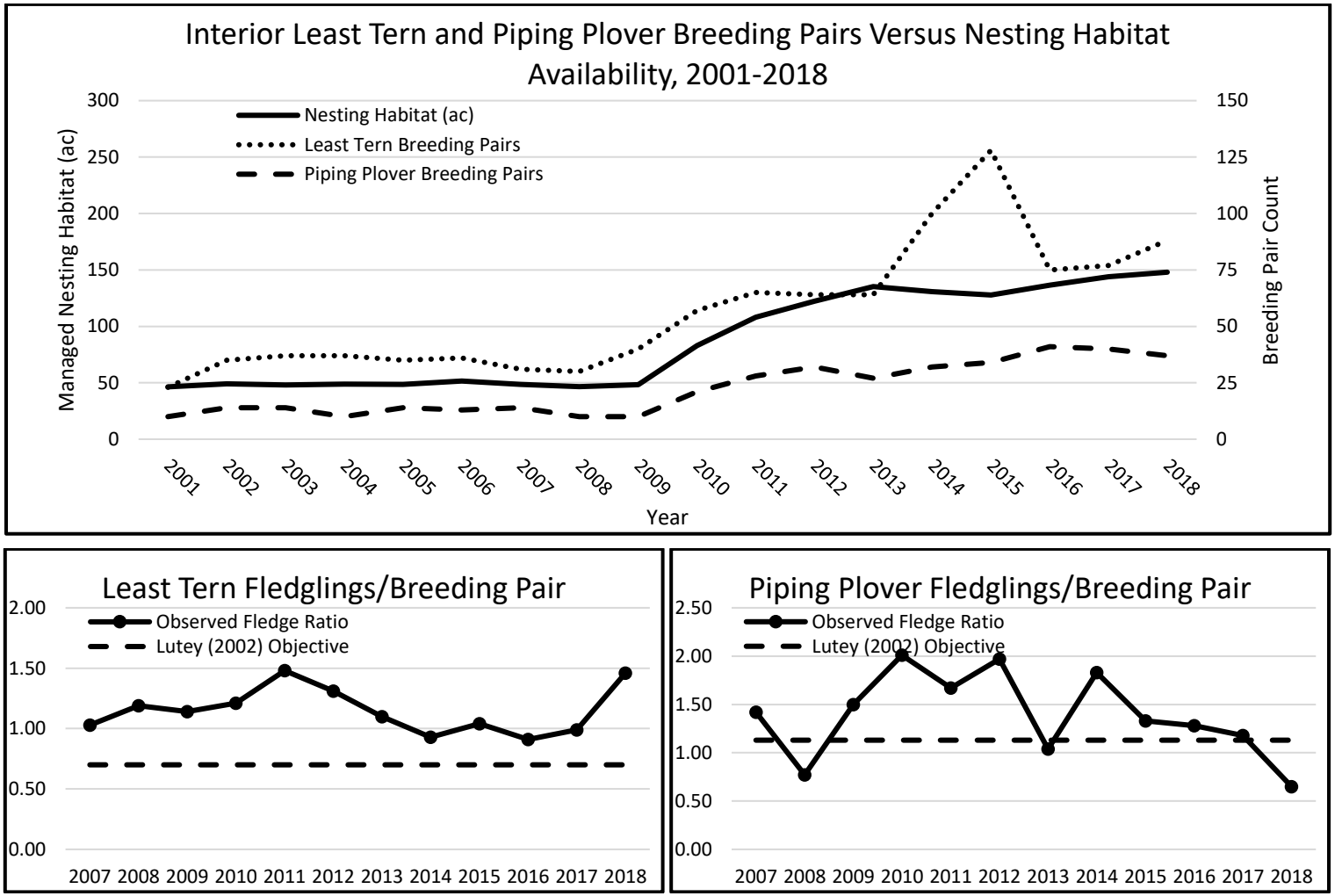


Figure 7. Tern (dotted line; top) and plover (dashed line; top) total breeding pair counts and Program (90 ac) and non-Program (60 ac) habitat availability (solid line) based on Program habitat availability assessments and tern (bottom left) and plover (bottom right) reproductive success as compared to the Lutey (2002) objectives, 2007-2018. Increased off-channel habitat availability and high reproductive success within the AHR are believed to be responsible for the increases tern and plover populations on the central Platte River.

What the science says in 2019:

- The Program and its partners have created in-channel (sandbars) and off-channel (sandpits) nesting habitat to evaluate hypothesized relationships between habitat availability and tern and plover use and productivity within the Program Associated Habitat Area. The Program has created and maintained ~90 acres of off-channel and ~65 acres of in-channel nesting habitat for terns and plovers.[11] In addition, Program partners and mining operations have constructed and/or managed ~60 acres of off-channel and ~25 acres of in-channel nesting habitat.
- Numbers of tern and plover breeding pairs have increased 4-fold within the AHR since 2001 while increases of similar magnitude have not been observed on Lake McConaughy (Dave Zorn, personal communication) or the Missouri River (http://moriverrecovery.usace.army.mil/mrrp/f?p=136:6:0::NO); although recent increases have been observed on the Missouri River. While overall numbers of tern and plover breeding pairs within the AHR have increased significantly, habitat availability and use of non-Program habitat has remained steady[11]. We have observed a high, positive correlation between tern and plover breeding pair counts and habitat availability. Program data also indicate breeding pair counts increase at a similar rate as habitat availability.
- Reproductive success, as measured by fledglings/breeding pair, have remained high and generally above the Lutey (2002) objective for maintaining stable to increasing populations within the AHR.

We estimate with confidence that:

- There is a high correlation between habitat availability and breeding pair counts and as the Program increases suitable off-channel nesting habitat, numbers of tern and plover breeding pairs within the AHR will increase until habitat availability exceeds population demands.

Answering BQ #6 during the First Increment

- Tern and plover data collected to date and published in the 2015 Breeding Pair publication[12] and 2017 tern and plover habitat selection publication[14] serves as the best source data for this question.
- The 2018 Tern and Plover Monitoring and Research Report[11] has also been reviewed and accepted by the Program and serves as additional evidence of the ongoing increasing trend in tern and plover use of the AHR.

Management Implications:

- Based on results of Program analyses, the Program has agreed to increase off-channel habitat availability by 60 acres.

Big Question #7

Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?

2019 Assessment

- Long-term monitoring and data analyses indicate both in-channel and off-channel ***nesting*** habitats are <u>not necessary</u> to maintain the central Platte River population of terns and plovers. During the Program's First Increment the increase in tern and plover populations on the central Platte River is the result of use and productivity at off-channel nesting habitats.[11] River survey and observational data, however, indicate the river is a valuable source of ***forage*** for both species as forage availability appears to be lower on off-channel habitats.[15]

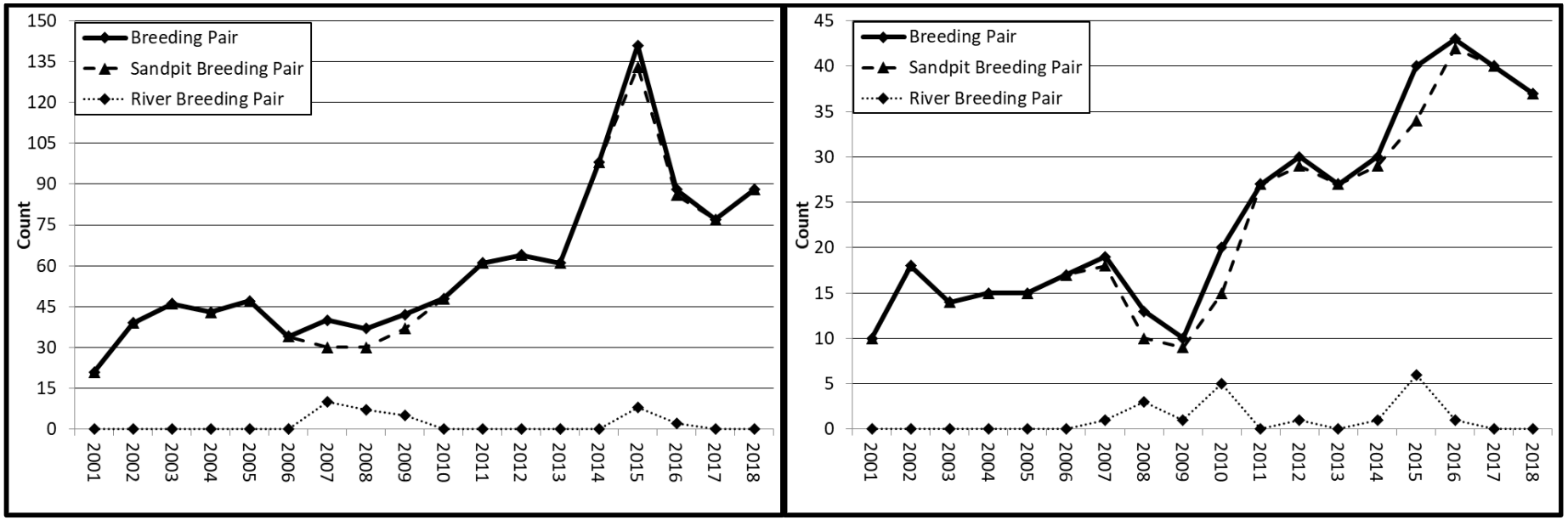


Figure 7. Annual tern (left plot) and plover (right plot) total (solid line), riverine (dotted line), and sandpit breeding pair counts (dashed line), 2001-2016. Trends in use of the AHR represent significant increases in tern and plover breeding pair counts during 2001-2018 with the most substantial increases occurring since inception of the Program. Reproductive success on and use of sandpits is believed to be responsible for the increase.

What the science says in 2019:

- The Program and its partners created in-channel (sandbars) and off-channel (sandpits) nesting habitat to evaluate hypothesized relationships between in- and off-channel habitat availability and selection of terns and plovers. Early Program efforts largely focused on off-channel nesting sites as flows and permitting challenges precluded construction of in-channel nesting islands. Program efforts in recent years were directed at maintaining off-channel nesting habitat and constructing and maintaining suitable in-channel habitat.
- The creation and maintenance of off-channel nesting habitat resulted in substantial use and productivity since 2001. During this same timeframe, in-channel habitat availability and tern and plover nesting and productivity have been sporadic and thus has not contributed to the maintenance of the central Platte River populations. Despite the limited use and productivity of in-channel nesting habitat, we observed significant increases in the numbers of tern and plover breeding pairs within the AHR from 2001-2018.[11]
- Since 2001, breeding pair counts for terns increased nearly 4-fold (21 to 88) while plover counts also increased nearly 4-fold (10 to 38); both of which represent significant increases.[11] Though populations of both species increased during this timeframe, increases of similar magnitude have not been observed on Lake McConaughy (Dave Zorn, personal communication) or the Missouri River (http://moriverrecovery.usace.army.mil/mrrp/f?p=136:6:0::NO); though recent increases have been observed on the Missouri River.
- Efforts to create and maintain suitable in-channel nesting habitat have necessarily been extensive. Though in-channel nesting habitat has contributed little to the reproductive success of both populations, ephemeral islands and river channels appear to provide an important source of forage for both terns and plovers.

We estimate with confidence that:

- Managed off-channel nesting habitat is necessary to maintain the presence of central Platte River tern and plover populations.
- Although an important forage source, direct maintenance of in-channel nesting habitat is not necessary to maintain tern and plover populations within the AHR.

Answering BQ #7 during the First Increment

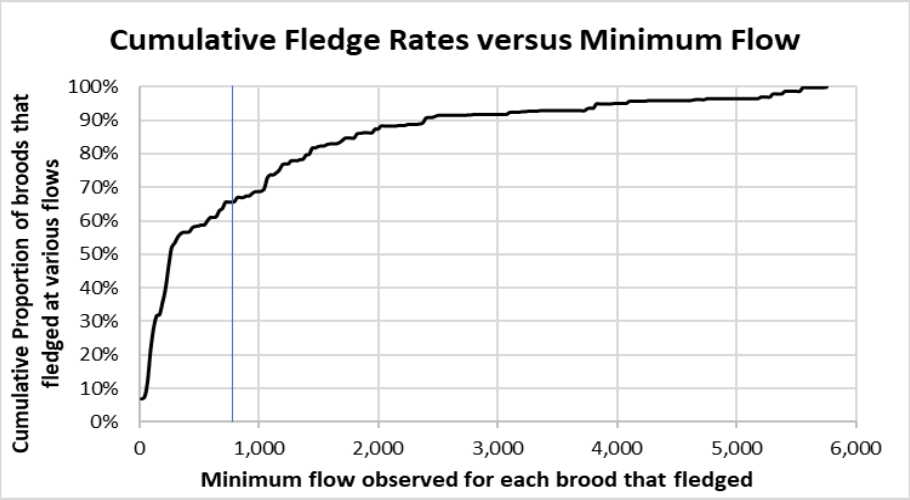
- Tern and plover monitoring data collected to date and the 2015 Breeding Pair publication[12] serve as the best source data for this question and indicate use of off-channel habitat resulted in increases in breeding pair counts and productivity within the AHR.
- The 2018 Tern and Plover Monitoring and Research Report[11] has also been reviewed and accepted by the Program and serves as additional evidence of the ongoing increasing trend in tern and plover use of the AHR attributable to use of and productivity on off-channel sites.

Management Implications:

- Based on results of Program analyses, the Program has agreed to increase off-channel habitat availability by 60 acres while creating and maintaining 10 acres of MCA islands in the channel.

Big Question #8

Does forage availability limit tern and plover productivity on the central Platte River?



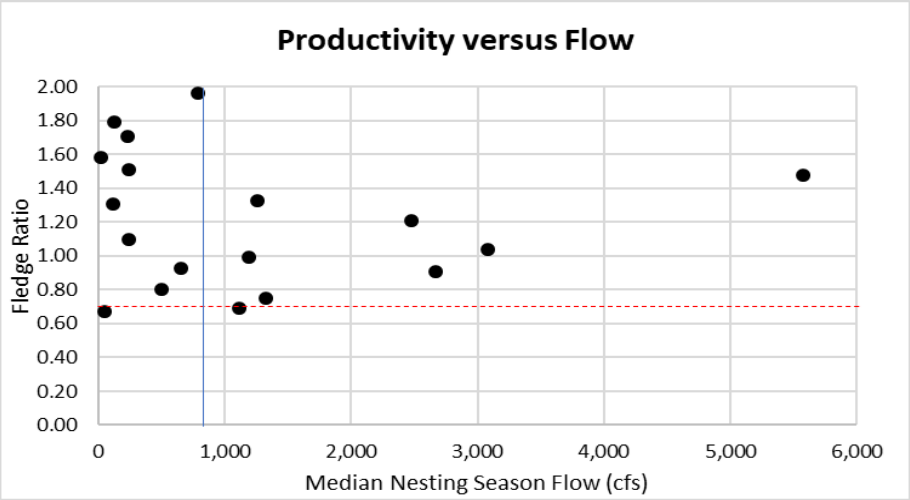


Figure 9. Cumulative proportion of least tern broods that fledged at various flows during the brood rearing season, 2001-2018 (top) and annual tern fledge ratio versus median summer flows, 2001-2018 (bottom). Blue vertical lines represent the hypothesized 800 cfs target flow and the horizontal red dashed line represents the Lutey (2002) fledge ratio objective for maintaining a stable to growing population on the central Platte River.

2019 Assessment

- Analyses of flow versus productivity[16] indicate there is no relationship between flow and tern productivity and we suspect analyses of data linking forage availability or flow and plover productivity would yield similar results. Given tern and plover productivity is high and a majority of confirmed mortalities have been attributed to adverse weather and predation, there is no evidence the forage base along the central Platte River limits tern and plover productivity. Further evaluations would involve capturing and weighing tern and plover chicks on multiple occasions to establish a more direct link between growth rates and forage abundance; however, Program stakeholders decided these additional expenses, efforts, and risk of injury to chicks are not warranted.

What the science says in 2019:

- Detailed analyses have been completed and the resulting manuscript has been published. In the publication, we synthesize independent sets of data and found no relationship between tern productivity and flow during the nesting and brood rearing season.[15,16]
- Given the high levels of productivity observed on the central Platte River, it is unlikely flow, and thus forage fish abundance, limits tern productivity. We were unable to establish the hypothesized link between flow and productivity and have used results of our retrospective analyses to definitively answer this Big Question.
- Further evaluations of BQ #8 would likely entail system-wide, intensive, summer-long forage sampling, tern and plover behavioral studies, and potentially capturing and weighing chicks on multiple occasions to attempt to establish relationships between forage abundance, flow, productivity, and long-term survival. Program stakeholders previously indicated additional expenses, efforts, and risk of injury to chicks are not warranted as it appears forage abundance and reproductive success are adequately high to support central Platte River tern and plover populations.

We estimate with confidence that:

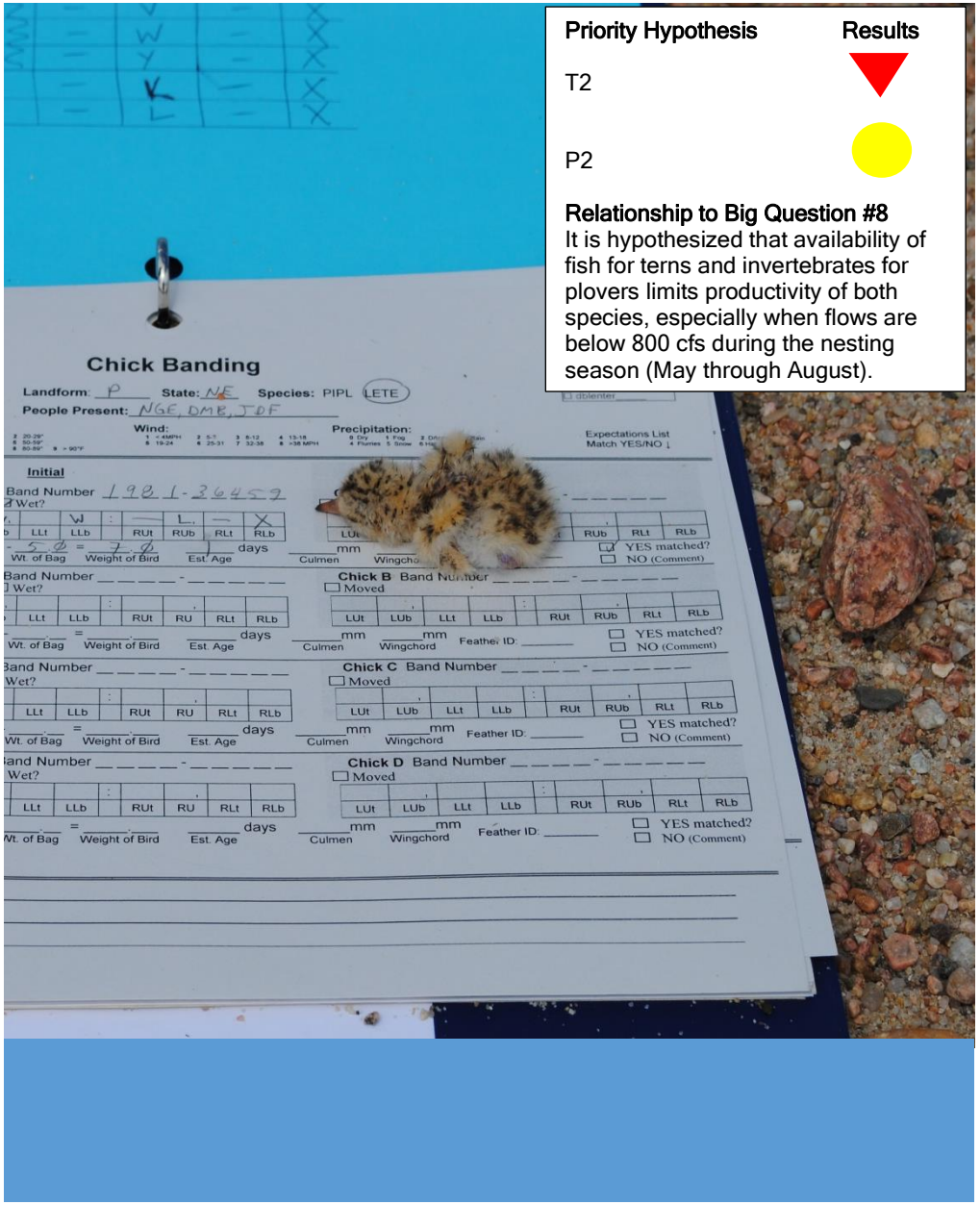
- Forage availability does not limit tern and plover productivity on the central Platte River.

Answering BQ #8 during the First Increment

- The forage fish manuscript[15] serves as the best source for synthesized reference data for this question. The results of these analyses indicate flow, and by inference forage availability, does not limit tern and plover productivity within the AHR. Program staff considered results of these analyses to be sufficient evidence to change the assessment for this Big Question to two thumbs down in 2016.
- A similar synthesis of data could be developed for plovers; however, given results of the Foraging Habits Study and high levels of productivity observed to date, there is a complete lack of evidence forage abundance limits plover productivity.

Management Implications:

- Data analysis and synthesis do not support Program summer flow releases to maintain the 800 cfs target.



Priority Hypothesis	Results
T2	▼
P2	●

Relationship to Big Question #8
It is hypothesized that availability of fish for terns and invertebrates for plovers limits productivity of both species, especially when flows are below 800 cfs during the nesting season (May through August).

Big Question #9

Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?

2019 Assessment

- The Program's Lower Platte River Stage Change Study[16] analyses concluded central Platte River flow management actions are likely to avoid adverse impacts to pallid sturgeon in the lower Platte River because the relative change in habitat due to Program water management activities would be small to undetectable.
- Based on results of the Stage Change Study, any potential impacts could be avoided through development of operational rules that prohibit Program diversions when lower Platte River discharges fall below 4,000 cfs.
- Thus, EDO followed the established process to assess this Big Question as conclusively answered with two thumbs up in 2014. In 2016, the Service concluded they "do not support two thumbs up at this time for Big Question 9 because of lingering uncertainties."
- There remains substantial scientific uncertainty about pallid sturgeon use of the lower Platte, though there has been substantial new learning about pallid sturgeon and their use of lower Platte (evidence they are there all year, spawning ground, larval drift, etc.) since the Stage Change Study was completed. At the time of Stage Change Study, the primary issue was use of the lower Platte River by a small number of adult fish.
- A 2018 EDO white paper identified substantial uncertainties with pallid sturgeon use of the lower Platte River and also uncertainties regarding the ability of the Program to conduct research alone or in partnership with entities such as the Nebraska Game & Parks Commission, the University of Nebraska-Lincoln, and/or the U.S. Geological Survey that would render useful data for GC decision-making.
- In March 2019, the GC directed the EDO to integrate pallid sturgeon uncertainties into the process for updating/revising the AMP for the Extension. That process began in May 2019.

What the science says in 2019:

- The general conclusion of the Program's Final Stage Change Study[16] is that Program water management activities will not result in measurable changes on flows in the lower Platte River and thus will result in little change to the amount of habitat available to pallid sturgeon.
- However, given that short-term connectivity could be problematic under certain, but infrequent, hydrological conditions, and assuming the biological significance of habitat connectivity for pallid sturgeon above 4,000 cfs, results of the stage change study could be used by the Program to implement proactive measures (e.g. altering excess-to-target-flow diversion timing or duration) to prevent potential negative impacts on habitat connectivity.

We estimate with confidence that:

- Flow diversions or releases by the Program would result in very small and undetectable changes in stage in the lower Platte River.
- As identified in the stage change study, these stage changes reside in the noise of gage error on the lower Platte River and thus will not result in a measurable change in lower Platte River stage.
- By extension, flow management actions that will not result in a measurable change in stage in the lower Platte River will not result in significant adverse effects on pallid sturgeon.

Answering BQ #9 during the First Increment:

- This question is not likely to be answered until the First Increment Extension. The GC began a facilitated Pallid Sturgeon Process in 2017 to help guide activities that will keep the question open until sometime during the potential First Increment Extension. That effort was integrated into the development of AMP Version 2.0 for the Program beginning in May 2019.

Management Implications:

- The primary Program water management actions that are hypothesized to result in flow and fish impacts in the lower Platte River are short-duration high flows (SDHF), target flow releases, and diverting target flow excesses.
- The Program is undergoing a process to develop flow management actions for the potential First Increment Extension.
- Central Platte River flow releases or diversions that could plausibly be detected in the lower Platte River during the potential First Increment Extension are not anticipated.

Big Question #10

Do Program management actions in the central Platte River cumulatively produce detectable changes in the physical environment (i.e. habitat) that are associated with a detectable increase in tern, plover and whooping crane use of the Associated Habitats?

The Program implements both on- and off-channel habitat creation and maintenance for the target species. The BQ 10 assessment will focus on the habitat creation strategy that has been most effective for each species. In the case of least terns and piping plovers, off-channel habitat has been most effective. In the case of whooping cranes, on-channel habitat has been most effective.

2019 Assessment for Least Tern and Piping Plover Off-Channel (OCSW) Habitat

- There is a strong positive correlation between Program-defined suitable nesting habitat and tern and plover breeding pair counts within the AHR. See BQ 6 Assessment.[11]
- During the First Increment, tern and plover populations on the central Platte River have increased significantly and proportionately to increases in habitat availability due to Program off-channel habitat creation efforts. See BQ 6 Assessment.[11]

Habitat:

Species Response:

2019 Assessment for On-Channel Whooping Crane Habitat

- Maximum unobstructed channel widths (important whooping crane habitat metric) have been significantly wider on Program lands since 2013. See Figure 10.
- There has been a significant increase in whooping crane use of Program lands since 2016.

Habitat:

Species Response:

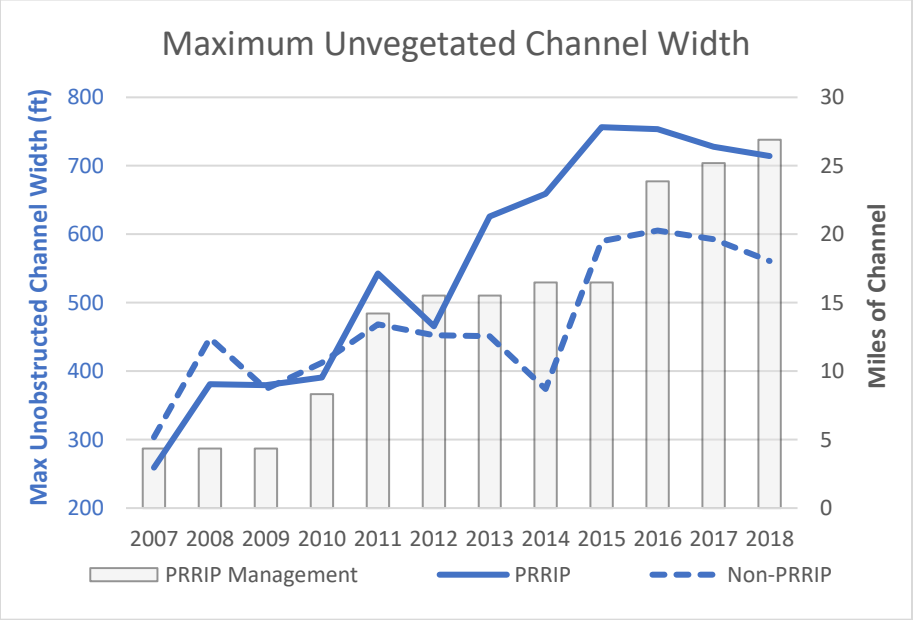


Figure 10. Unobstructed channel width (UOCW), an important whooping crane habitat suitability metric, has been wider on Program-managed lands since 2011 and substantially wider since 2013. Program lands are generally now more suitable for whooping crane roosting than non-Program lands.

What the science says in 2019:

- During the First Increment of the Program, tern and plover populations on the central Platte River have increased significantly and proportionally to increases in off-channel nesting habitat creation efforts.
- On-channel nesting habitat creation efforts have not been successful and have largely been abandoned by terns and plovers.
- During the First Increment of the Program, UOCW on Program lands transitioned from significantly narrower than non-Program lands in 2010 to significantly wider in 2013 through 2019.
- There has been a discernable trend in the proportion of the whooping crane population roosting on Program lands since 2007. There has been a significant increase in the proportion of the population using the AHR as a whole during the spring migration, but not during the fall migration period.
- There has been a discernable trend in the proportion of the whooping crane population roosting within the AHR since 2007; however wet meadow use has remained steady and low.
- Whooping cranes have used off-channel palustrine wetland sites created and maintained by the Program during the First Increment; however wetland use has remained steady and low.

We estimate with confidence that:

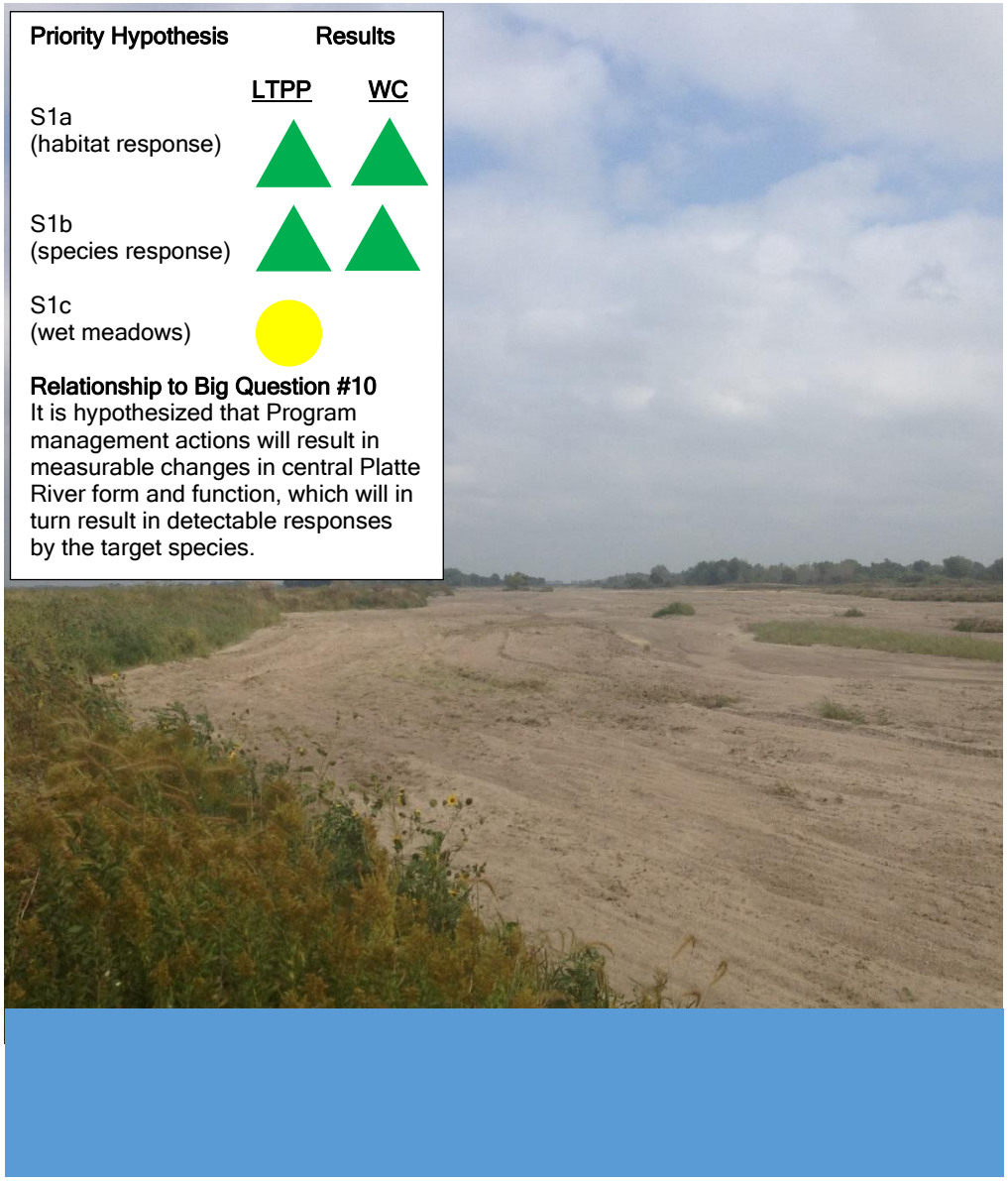
- Program efforts to create and maintain off-channel tern and plover nesting habitat have been successful.
- Program efforts to create and maintain in-channel whooping crane roosting habitat have been successful.

Answering Big Question #10 during the First Increment:

- The Program has noted trends related to the tern and plover hypotheses in response to off-channel nesting habitat and has recently observed substantial use of Program and othere conservation lands by whooping cranes.
- The Program is currently negotiating a 13-year Extension of the First Increment due in part to the fact that water objective of reducing annual shortages to target flows by 130,000-150,000 acre-feet has not been met.

Management implications:

- Synthesis of multiple lines of evidence related to this Big Question and the underlying system-level hypotheses have provided guidance to the GC regarding Program land and water management during the First Increment and will continue to into the Extension.



Additional First Increment Learning

Whooping Cranes

- Spring whooping crane migration season is shifting earlier in the year (current 95th percentile dates: March 6 – April 20).
- Fall whooping migration season is shifting later in the year (current 95th percentile dates: October 15 – November 16).
- Whooping crane migration corridor throughout the Great Plains is shifting eastward; however, use of the western portion of the AHR is increasing.
- No relationship between flow and where whooping cranes choose to roost within the central Platte River.
- Whooping crane riverine habitat selection similar throughout the Great Plains and within the AHR.
- Whooping cranes select cornfields and riverine habitats over wet meadows within the AHR; however, throughout the Great Plains whooping cranes select riverine, open water, semi-permanent wetland, and wet meadow habitats over all upland landcover classes including cornfields.

Least Terns and Piping Plovers

- Least tern and piping plover monitoring from outside the nesting colony is sufficient for documenting abundance and productivity.
- The relative probability of use for least terns and piping plovers is maximized when distance to the nearest predator perch is ≥500 feet and elevation above the waterline is 7–10 feet.
- Probability of nesting by least terns increased as distance to water increased, whereas the probability of use by piping plovers was maximized when distance to water was ~150 feet.
- Piping plover territories are ~3 acres in size on off-channel sites.
- Productivity of least terns and piping plovers is reduced during both the nesting and brood rearing stages by weather factors more than factors the Program can manage.
- Electrified predator fences and wing panels are effective at deterring terrestrial predators from off-channel nesting areas.
- Habitat management activities implemented at off-channel sites to date seem to be sufficient for maintaining high levels of productivity for least terns and piping plovers within the AHR.
- The timing the spring pulse flow coincides with the least terns and piping plovers nesting season which limits the opportunity for successful nesting within the AHR.
- Least terns and piping plovers select channels that are ≥1,200 feet wide in other river systems.
- The GC decided to forego any further in-channel island construction activities in lieu of creating an additional 60 acres of bare-sand off-channel and water (OCSW) nesting habitat and maintaining 10 acres of moving complex approach (MCA) nesting islands in the channel.
- The Service concluded that creating an additional 60 acres of off-channel nesting habitat would meet their criterion of achieving "stable or increasing populations" of least terns and piping plovers within the AHR.

Pallid Sturgeon

- No evidence pallid sturgeon use discharge as a spawning cue as the lower Platte River has been used during both low- and high-discharge years.
- All but one of the four gravid females known to have entered the Platte River to spawn did so when temperatures were <15◦C and exited when temperatures exceeded 20◦C.
- No evidence that post-spawn females exit the lower Platte River due to low discharge as females generally exited the Platte River at a higher discharge than when they entered.
- Spawned pallid sturgeon exited the lower Platte River approximately one to two weeks after a peak flow event temporarily increased discharge and depressed water temperature.
- If one assumes diurnal water temperature variation is important for spawning behavior, the Program may be able to influence this metric through flow-releases to reduce variation. However, given the magnitude and duration of any potential flow release the Program could currently make, we found our potential to reduce diurnal variation in water temperature is minute in comparison the natural variability in diurnal water temperature variation and may only be detectable at the lowest flows observed in the lower Platte River.
- Most pallids were captured below the Elkhorn River at moderate discharges (6,000–10,000 cfs) with few pallids captured at very low or very high discharges. In addition, few pallids were captured upstream of the Elkhorn River, even in seasons with moderate discharges. The lack of any discernable relationship between discharge and captures makes it difficult to conclude that differences in discharge is the main driver of the disparity in captures above and below the Elkhorn River confluence.
- When capture effort is taken into account, several stretches of river above the Elkhorn river had similar captures rates as those below the Elkhorn River.
- The only habitat metric found to be markedly different upstream and downstream of the Elkhorn River confluence is turbidity.

Sandhill Cranes

- Sandhill cranes select wide unobstructed channels with low flows (i.e., 900-ft unobstructed channel with ≤1,400 cfs).
- Spring sandhill crane migration season is shifting earlier in the year.
- Sandhill crane roosting within the AHR is shifting eastward.

Wet Meadows

- Whooping crane use of the AHR has increased during the spring migration while wet meadow use has remained stable and low.

System

- Remote channel measures are adequate for capturing channel width metrics such as maximum unvegetated channel width, total unvegetated channel width, total channel width, etc.

APPENDIX A

2019 State of the Platte Priority Hypotheses Status Table

2019 State of the Platte Priority Hypotheses Status Table. Status of AMP priority hypotheses, as listed in Table 2 of the Adaptive Management Plan (Page 70). See shape coding key at end of table.

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
System							
S1	The Platte River form can be modified by either mechanical/sediment/flow management (i.e., clear/level/pulse) or mechanical means along with non-Program managed flows (i.e., clear/level/mechanical).		#10	Geomorphology and vegetation monitoring, LiDAR and other aerial imagery, EDO analyses	▲	Collecting the data necessary to answer all S1 hypotheses. To date, *State of the Platte* evaluations focused on BQ #1-#10.	
S1a	Program channel habitat restoration actions will result in detectable change to Platte River form and function.	Cannot detect a significant effect on indicators.	#10	Geomorphology and vegetation monitoring, LiDAR and other aerial imagery, EDO analyses	▲▲	*2016 State of the Platte* – During the First Increment of the Program, UOCW on Program lands transitioned from significantly narrower than non-Program lands in 2010 to significantly wider in 2013 through 2016.	
S1b	Program land management actions (i.e., restoration into habitat complexes) will have a detectable effect on target bird species use of the associated habitats.	Cannot detect a significant effect on indicators	#10	Geomorphology and vegetation monitoring, LiDAR and other aerial imagery, bird monitoring, EDO analyses	▲▲	*2016 State of the Platte* – Monitoring and analyses indicate there is a strong positive correlation between Program-defined suitable ***nesting*** habitat and tern and plover breeding pair counts within the AHR. Less of a correlation for whooping cranes.	
S1c	Program actions will increase functional wet meadows in habitat complexes during the First Increment.		#10	N/A	○	*2016 State of the Platte* – TBD	
S2	Implementing Program land and water management actions (i.e., habitat complexes and clear/level/pulse) will have a detectable effect on other species use of the associated habitats.	Within the overall management objectives for whooping cranes, terns and plovers, and pallids sturgeon, benefits can be provided to non-target listed species and non-listed species of concern thereby reducing the likelihood of future listing and improve overall ecosystem diversity.	N/A	N/A	○		

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Terns and Plovers							
T1	Additional bare sand habitat will increase the number of adult least terns.	Bare sand is not currently limiting number of adults.	#6	PRRIP tern/plover monitoring protocol, EDO analyses, tern/plover habitat synthesis chapters	▲	*2015 State of the Platte* – Monitoring and analyses indicate there is a strong positive correlation between Program-defined suitable ***nesting*** habitat and tern and plover breeding pair counts within the AHR.	
T2	Tern productivity is related to the number of prey fish (<3 inches) and fish numbers limit tern production below 800 cfs from May-Sept.	Prey fish do not limit tern production at 799 cfs or tern production is limited by summer flows of <50 cfs.	#8	Districts' forage fish monitoring protocol, USGS foraging habits study, EDO analyses and publication	▼	*2016 State of the Platte* – Monitoring and analyses indicate there is no relationship between tern use and productivity and flow (i.e. forage fish) within the AHR.	
T2a	Flow rates influence the number and species diversity in tern prey base (fish).	Tern productivity not affected by fish community species diversity.	N/A	N/A	○		
P1	Additional bare sand habitat will increase the number of adult piping plovers.	Bare sand is not currently limiting number of adults.	#6	PRRIP tern/plover monitoring protocol, EDO analyses, tern/plover habitat synthesis chapters and associated publications	▲	*2015 State of the Platte* – Monitoring and analyses indicate there is a strong positive correlation between Program-defined suitable ***nesting*** habitat and tern and plover breeding pair counts within the AHR.	
P2	Plover productivity is related to the number of suitable macroinverts and macroinverts limit plover production below 800 cfs from May-Sept.	Macroinverts do not limit plover production at 799 cfs or plover production is limited by summer flows of <50 cfs.	#8	Districts' forage fish monitoring protocol, USGS foraging habits study, EDO analyses	●	*2016 State of the Platte* – Monitoring and analyses indicate there is likely no relationship between plover use and productivity and flow (i.e. forage fish) within the AHR.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
TP 1	Interaction of river and sandpit habitat.	LT and PP show no preference for the river over sandpits.	#7	PRRIP tern/plover monitoring protocol, EDO analyses	▼	*2015 State of the Platte* – Monitoring and analyses indicate both in-channel and off-channel ***nesting*** habitats are <u>not necessary</u> to maintain the central Platte River population of terns and plovers. However, the river is a valuable source of ***forage*** for both species as forage availability is lower on off-channel habitats.	
TP 2	The central Platte River may act as a source or sink for terns and plovers.	Currently not a sink.	N/A	PRRIP tern/plover monitoring protocol, EDO analyses	▼	*2015 State of the Platte* – Given population growth within the AHR and fledge ratios that exceed all numbers hypothesized to result in population growth, the hypothesis is <u>rejected</u>.	
TP 4d	Correlation between river island habitat and flow.		N/A	Tern/plover habitat synthesis chapters	○	<u>No need to test</u> as sandbars are not suitably high for nesting.	
TP 5	Use of riverine islands by least terns and piping plovers will increase with active channel width.	Use will not increase with channel width.	#1	Tern/plover habitat synthesis chapters	▲	<u>Hypothesis affirmed</u> in Tern/plover synthesis chapter 4.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Whooping Cranes							
WC 1	Whooping crane use will increase as function of Program land and water management activities.	Whooping crane use will not increase as function of Program land and water management activities.	N/A	WEST habitat selection report, whooping crane habitat synthesis chapters	▲	Hypothesis affirmed in 2017 and 2018 spring and fall whooping crane monitoring reports and several Program publications.	
WC 3	Whooping crane use is related to habitat suitability. The prediction of habitat suitability for whooping crane in channel habitat as a function of water depth (preferred depth?) and channel width (define as wetted width, open width, other?).	WC use of areas is not directly linked to FWS habitat suitability values.	#5	WEST habitat selection report, whooping crane habitat synthesis chapters	▼	*2016 State of the Platte* – Whooping cranes select channel widths of 650 ft and unforested corridor widths of 1,100 ft.	
WC 4	Whooping crane use of the central Platte River study area will increase proportionally to an increase in wet meadows.	WC do not use wet meadows currently and are unlikely to respond to increases in wet meadow area.	N/A	N/A	●	Evidence points to rejecting this hypothesis. Peer review of key documents will likely result in a conclusive answer in a future *State of the Platte Report*.	
WC 5	Whooping cranes are adversely affected by nocturnal disturbances that lead to flushing (walking or flying) which could lead to potential mortality.	WC are not negatively impacted by nocturnal disturbances.	N/A	N/A	○		

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Pallid Sturgeon							
PS-1	Program flow/sediment management will result in a positive species response by the pallid sturgeon in the lower Platte River.	Program flow/sediment management will result in no increase in species use/occurrence by the plaid sturgeon in the lower Platte River.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-2	Program water management will result in measurable changes on flow in the lower Platte River.	Program water management will result in statistically insignificant changes on flow in the lower Platte River.	#9	Stage change study		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-4	Flows in the lower Platte will affect pallid sturgeon habitat suitability.	Flows in the lower Platte River will have no effect on pallid sturgeon habitat suitability.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
PS-5	Pallid sturgeon habitat suitability is maximized between water temperatures of X and Y in the lower Platte River.	Pallid sturgeon use is independent of river water temperature.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-6	Increasing flow in the lower Platte will affect pallid sturgeon habitat availability.	Increasing flow in the lower Platte River will have no effect on pallid sturgeon habitat availability.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-7	Increasing habitat availability in the lower Platte will increase pallid sturgeon use.	Pallid sturgeon use is independent of lower Platte River habitat availability.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
PS-9	Increasing Program flow releases will decrease water temperatures in the lower Platte River.	River water temperature is independent of flow rate in the lower Platte River Increases in program flow releases will increase water temperatures on the lower Platte River.	N/A	N/A			
PS-11	Non-Program actions (e.g. harvest, stocking, Missouri River conditions) determine the occurrence of pallid sturgeon in the lower Platte River.	Program actions will affect the rate of occurrence of pallid sturgeon in the lower Platte River such that use is disproportionate to external factors (e.g., stocking, harvest, local conditions) relative to local population.	N/A	N/A			
Physical Processes – Flow							
Flow #1	Increasing the variation between river stage at peak (indexed by Q1.5 flow at Overton) and average flows (1,200 cfs index flow), by increasing the stage of the peak (1.5-yr) flow through Program flows, will increase the height of sand bars between Overton and Chapman by 30% to 50% from existing conditions.	Flow magnitudes and channel compilations are insufficient to generate bars high enough to provide habitat for LT and PP. Bars may quickly vegetate making them poor habitat for target species. Bars can be created/maintained by mechanical/other means.	#1	Geomorphology and vegetation monitoring, tern/plover monitoring, tern/plover habitat synthesis chapters		*2016 State of the Platte* – Full SDHF magnitude of 8,000 cfs is not sufficient to create sandbars exceeding the PRRIP's minimum height suitability criterion. Sandbars created by SDHF releases will be inundated during the nesting season in most years.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Flow #3	Increasing 1.5-yr Q with Program flows will increase local boundary shear stress and frequency of inundation at existing green line (elevation at which riparian vegetation can establish). These changes will increase riparian plant mortality along margins of channel, raising elevation of green line. Raised green line = more exposed sandbar area and wider unvegetated main channel.	Insufficient Program flows to adequately increase shear stress on banks. Plant mortality can be achieved by other means.	#2	Directed scour research, whooping crane habitat synthesis chapters	▼	*2016 State of the Platte* – The comparatively short duration and low volume of SDHF limits the predicted increase in UOCW to ≤12 ft. SDHF duration is not sufficient to create and maintain UOCWs that are suitable for whooping crane roosting.	
Flow #4	Annual riparian seedling mortality greater than 90% is required to prevent riparian encroachment on exposed bars, thereby increasing (maintaining at least 10 acres/mile) exposed bars between Overton and Grand Island that are usable as LT and PP habitat.	Riparian seedling mortality greater than 90% is needed to increase exposed bar area. Other factors drive exposed bar area instead of seedling mortality. Plant mortality can be achieved by other means.	N/A	N/A	○		
Flow #5	Increasing magnitude and duration of a 1.5-yr flow will increase riparian plant mortality along the margins of the river. There will be different relations (graphs) for different species.	Insufficient Program flows to maintain required flow durations. Plant mortality can be achieved by other means.	#2	Directed scour research, whooping crane habitat synthesis chapters	▼	*2016 State of the Platte* – Mature phragmites plants or plant patches have a very low probability of being eroded at the highest flow magnitudes and velocities observed in the AHR. An herbicide control program is ongoing	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Physical Processes – Sediment							
Sediment #1	Average sediment augmentation at Overton of 185,000 tons/yr. under existing flow regime and 225,000 tons/yr. under Governance Committee proposed flow regime achieves a sediment balance to Kearney.	Augmentation greater than or less than 225,000 tons/year is needed to balance the sediment budget and increase exposed bar area. There is no sediment imbalance. Exposed bar area or occurrence of braiding will not be affected by increased sediment. Sediment balance is insignificant except in local instances. Satisfactory bar areas can be created and maintained through strictly mechanical actions.	#3	Sediment transport modeling, results of sediment augmentation Proof of Concept experimental implementation		Augmentation of sediment in the south channel is necessary to slow incision and narrowing and prevent degradation from progressing downstream past the Overton bridge. It will be challenging to measure the effectiveness of augmentation given that the desired beneficial effect is slowing and ultimately halting of a long-term trend.	
Sediment #2	A balanced sediment budget (sediment augmentation of 225,000 tons/year near Overton under proposed Governance Committee flows) when implemented with mechanical actions (channel consolidation & widening) in anastomosed reaches will promote braided channel morphology with an average braiding index in the main channel of greater than 3.	Flows and sediment augmentation are insufficient to achieve desired braiding index.	N/A	N/A			

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Sediment #3	Increasing the average braiding index of the main channel by achieving a balanced sediment budget, increases the active unvegetated width of the main channel at an index flow of 2,000 cfs (at Overton).	Width will not change with increasing braiding index.	N/A	N/A	○		
Sediment #4	Increasing the average braiding index to greater than 3 for the main channel in the sediment deficient reach near Overton will increase and maintain exposed bar area greater than 1.5 acres in the reach between Overton and Kearney at an index flow of 1,200 cfs (at Overton).	There is no relationship between braiding index and area of exposed bars. Exposed bars may be created (maintained) through mechanical means without need to change braiding index.	N/A	N/A	○		
Physical Processes – Mechanical							
Mechanical #2	Increasing the Q1.5 in the main channel by consolidating 85% of the flow, and aided by Program flow and a sediment balance, flows will exceed stream power thresholds that will convert main channel from meander morphology in anastomosed reaches, to braided morphology with an average braiding index > 3.	Higher stream power (higher 1.5 yr. Q and/or more consolidation of side channels) needed to convert channel to braided morphology. Lower stream power will convert channel to braided morphology.	#4	Directed scour research, whooping crane habitat synthesis chapters	▲	*2016 State of the Platte –* Peak flows in the AHR are generally not sufficient to remove mature woody vegetation or erosion-resistant species like phragmites. Mechanical clearing and leveling are necessary to create suitable channel configurations and facilitate channel adjustments to changes in flow and sediment.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Mechanical #3	Reducing the number of channels in a transect to 3 or less under balanced sediment budget will convert anastomosed reaches of the Platte River between Overton and Chapman to a braided channel morphology. With proposed flow regime, should occur with greater number of channels.	Reducing the number of channels in a transect to 1 or 2 is necessary to achieve an average braiding index in the main channel of greater than 3.	N/A	N/A			
Mechanical #4	Increasing the average braiding index to greater than 3 in the main channel by channel manipulation will promote in the Platte River at the mechanically changed sites a total main channel wetted width exceeding 500 to 750 ft at an index flow of 1,700 cfs (at Overton).	A braiding index greater than 4 is needed to achieve a width greater than 500 ft. There is no relation between braiding index and channel width.	N/A	N/A			
Mechanical #5	Increasing the average braiding index to greater than 3 for the main channel by mechanical channel manipulation, will increase and maintain exposed bar area greater than 1.5 acres at mechanical changed sites at an index flow of 1,200 cfs (at Overton).	Mechanically consolidating flows will have no effect on areal extent of bars.	N/A	N/A			

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Wet Meadows							
WM-2	Wet meadows producing the optimum productivity and diversity of macro-invertebrates potentially consumed by WC exhibit certain characteristic combinations of soils, hydrology, size and location. Mormon Island and adjacent to Rowe Sanctuary have some of best existing combinations	There are too many possible combinations of site characteristics to allow for a meaningful characterization of "desirable" conditions.	N/A	N/A			
WM-3	Shallow surface water and groundwater in March and April support high productivity and diversity of macroinvertebrates as potential food sources to WC in wet meadows.		N/A	N/A			
WM-4	A predominance of organic-rich soils supports the productivity and diversity of macro-invertebrates as potential WC food sources in bottomland grasslands.	Wet meadows and their soils are too complex and variable to allow this individual factor to be effectively assessed.	N/A	N/A			
WM-8a	As the spring depth to groundwater increases, surface soils stay frozen longer. Where groundwater is closer to the surface soils thaw sooner.		N/A	N/A			

[i] Hypothesis Test Results are indicated as one of the following categories:

Hypothesis answered conclusively – affirmed.

Hypothesis answered conclusively – rejected.

Hypothesis not yet answered – ongoing implementation, analysis, and synthesis.

Not currently being addressed through implementation of the AMP and related data analysis and synthesis.

APPENDIX B

PRRIP Peer Reviewed Papers & Reports

REFEREED PUBLICATIONS

Baasch, D.M., P.D. Farrell, A.J. Caven, K.C. King, J.M. Farnsworth, and C.B. Smith. 2019. Sandhill crane use of riverine stopover sites along the central Platte River in Nebraska, USA. Monographs of the Western North American Naturalist 11:1–13.

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Farnsworth, J.M., D.M. Baasch, P.D. Farrell, and C.B. Smith. 2018. Investigating whooping crane habitat in relation to hydrology, channel morphology and a water-centric management strategy on the central Platte River, Nebraska. Heliyon. https://doi.org/10.1016/j.heliyon.2018.e00851.

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Pearse, A.T., M.J. Harner, D.M. Baasch, G.D. Wright, A.J. Caven, and K.L. Metzger. 2016. Evaluation of nocturnal roost and diurnal sites used by whooping cranes in the Great Plains, United States. Open File Report 2016–1209.

Werbylo, K.L., J.M. Farnsworth, D.M. Baasch, and P.D. Farrell. 2016. Investigating the accuracy of estimated unvegetated channel widths in a braided river system: a Platte River case study. Geomorphology 278:163–178. https://doi.org/10.1016/j.geomorph.2016.11.003

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Hefley, T.J., D.M. Baasch, A.J. Tyre, and E.E. Blankenship. 2014. Correction of location errors for species distribution models. Methods in Ecology and Evolution 5:207–214.

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APPENDIX C

PRRIP Progress - Land & Water Objectives

Land Objective

The Program's First Increment land objective is to acquire, protect, and restore 10,000 acres of habitat for the three target avian species.

As of 2019, the Program has exceeded the 10,000-acre First Increment land objective by 2,783 acres. Most of the Program's habitat lands are located in blocks referred to as habitat complexes. There are six primary habitat complexes (Cottonwood Ranch, Elm Creek, Pawnee, Fort Kearny, Clark Island, and Shoemaker Island) with additional complex habitat at four other locations (Plum Creek, Minden to Gibbon, Alda to Grand Island, and Grand Island to Chapman). In addition, the Program manages 645 acres of non-complex lands comprised of four OCSW and two palustrine wetland sites as well as 25 acres set aside for Clean Water Act compliance. A map of Program properties can be found on page 2 of this report.

Habitat Lands	Number of Acres
Plum Creek	866
Cottonwood Ranch	3,552
Elm Creek	1,438
Pawnee	742
Fort Kearny	2,190
Gibbon to Minden	834
Clark Island	784
Shoemaker Island	1,411
Alda to Grand Island	286
Grand Island to Chapman	10
Total Complex Land	**12,113**
Off-Channel Sand and Water	391
Palustrine Wetlands	254
Total Non-Complex Land	**645**
Clean Water Act Land	**25**
Grand Total	**12,783**

Water Objective

The Program's First Increment water objective is to reduce deficits to USFWS target flows by an average of 130,000 - 150,000 acre-ft annually.

As of 2019, Program water projects reduce deficits to USFWS target flows by an average of over 112,000 acre-ft annually. This includes the three original state projects with a total score of 80,000 acre-feet per year (AFY) and the five-scored water action plan (WAP) projects (Phelps County Canal Recharge, Cook Recapture Well, Pathfinder Municipal Lease, No-Cost Net Controllable Conserved, and Elwood Recharge) with a score of 12,370 AFY. Other WAP projects are active but have yet to be scored including Central Nebraska Public Power and Irrigation District surface water and recharge, Nebraska Public Power District recharge, and CPNRD Surface Water Exchange. It is anticipated that these projects will increase the water project score by approximately 20,000 AFY. A large portion of the remaining First Increment water objective was going to be provided by the J-2 Regulating Reservoir, but this project has been put on hold due to cost, land acquisition and other concerns. Consequently, the water objective will not be met prior to 2019 and Program Signatories have agreed to pursue a 13-year First Increment Extension. Projects to be implemented during the First Increment Extension include but are not limited to: broad-scale recharge projects, slurry wall storage facilities, and acquire and retire. These projects will be used to achieve a total score of 120,000 AFY. Research will then be conducted to evaluate the need for the remaining 10,000 acres prior to implementation of the projects that would be necessary to achieve the First Increment water objective.

Water Project	Score (AFY)
Three State Projects	80,000
Phelps Co. Canal Recharge	2,700
Cook Recapture Well	260
Pathfinder Municipal Lease	6,350
No-Cost Net Controllable Conserved	260
Elwood Recharge	2,800
Total	**92,370**
Other operational WAP projects that have yet to be scored	**~20,000**

ENDNOTES

[1] Program. 2016. Analysis of sandbar height distributions following First Increment peak flow events. Prepared for the Platte River Recovery Implementation Program.
[2] Program. 2015. Least tern and piping plover habitat synthesis chapters. Prepared for the Platte River Recovery Implementation Program.
[3] Bankhead et al. 2016. A combined field, laboratory and numerical study of the forces applied to, and the potential for removal of, bar top vegetation in a braided river. Earth Surface Processes and Landforms, 42(3), 439-459.
[4] Tetra Tech Inc. 2017. 2016 Final Data Analysis Report Platte River Geomorphology and In-Channel Vegetation. Prepared for the Platte River Recovery Implementation Program
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[6] Tetra Tech Inc. 2015. Model Results, Platte River Sediment-transport Modeling, South Channel at Jeffery Island. Prepared for the Platte River Recovery Implementation Program.
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[8] Pollen-Bankhead et al. 2012. Can Short Duration High Flows be used to Remove Vegetation from Bars in the Central Platte River. Prepared for the Platte River Recovery Implementation Program.
[9] See WEST Report titled Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River 02-16-16.
[10] See the Whooping Crane Synthesis Chapters 2 and 3.
[11] Baasch et al. 2019. Whooping Crane use of riverine stopover sites
[12] See PRRIP 2016 Tern and Plover Monitoring Report.
[13] Baasch et al. 2015. A comparison of breeding population estimators using nest and brood monitoring data.
[14] Baasch et al. 2017. Nest-site selection by Interior Least Terns and Piping Plovers at managed, off-channel sites along the Central Platte River in Nebraska, USA.
[15] Sherfy et al. 2012. Foraging Ecology of Least Terns and Piping Plovers Nesting on Central Platte River Sandpits and Sandbars.
[16] Baasch et al. 2017. Interior Least Tern Productivity in Relation to Flow in the Central Platte River.