PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM (PRRIP or Program) 2020-2032 Extension Adaptive Management Plan (AMP)

What are CEMs?

CEMs provide a visual framework or graphical representation for the Program's current or hypothesized understanding of the central and lower Platte River associated habitats relative to the target species. The conceptual models describe general functional relationships among essential components of the Platte River system, present an interpretation of how the Platte River system works, and reflect how Program management actions intend to alter key processes or attributes. CEMs are also used to identify areas of uncertainty relevant to Program decision-making to be evaluated and reduced through the application of adaptive management. During the Extension, the CEMs will be reviewed on a regular basis as new information becomes available and will be modified as warranted based on science learning from implementation of the AMP.

How were these CEMs developed?

The CEMs are revised versions of the CEMs included in the original AMP (Program, 2006a) that was negotiated as part of the Final Program Document (Program, 2006b). The revised CEMs were first developed by the Executive Director's Office (EDO) based on a large set of source material:

- Original CEMs and priority hypotheses in the AMP.
- Synthesized learning from the First Increment as summarized in six (6) State of the Platte reports (2012, 2013, 2014, 2015, 2016, 2019).
- Peer-reviewed Program synthesis documents – Tern and Plover Habitat Synthesis Chapters (EDO, 2015) and Whooping Crane Habitat Synthesis Chapters (EDO, 2017).
- Twenty-one (21) Program manuscripts published in refereed journals.
- CEMs developed for adaptive management programs on the Missouri River (Wildhaber et al., 2007; Buenau et al., 2016) and the Trinity River (TRRP and ESSA, 2009).
- Several publications on the subject of CEMs and their use in recovery, restoration, and adaptive management programs, including Ogden et al., 2005; Fischenich, 2008; and Nelitz et al., 2015.
- Review of publications recently provided from the U.S. Fish and Wildlife Service on the use of conceptual models in Structured Decision Making (SDM) numerical modeling exercises, including Martin et al., 2011; Stenton et al., 2011; and Webb et al., 2015.

The CEMs will be evaluated by, discussed with, and revised in conjunction with the Adaptive Management Working Group (AMWG) and the Independent Scientific Advisory Committee (ISAC) through a series of workshops and webinars in 2019 as part of the development of this revised content for the AMP. The final CEMs will be evaluated by the Technical Advisory Committee (TAC) and approved by the Governance Committee (GC) as part of approval of the revised AMP. Future updates to the CEMs will be completed by the EDO, AMWG, and TAC with input from the ISAC and will be approved by the GC.

General Structure of CEMs and Uncertainties

The three CEMs (terns/plovers, whooping cranes, and pallid sturgeon) are grouped according to a mix of nine categories (adapted from Buenau et al., 2016):

- **Drivers** are underlying factors that determine much of the dynamics of the Platte River system, but do not themselves determine physical riverine or target species responses. The drivers include social, political and economic factors in the basin that are the basis for the development and implementation of the Program and climate which is largely determinative of basin runoff.

- **Habitat management** represents management actions the Program may undertake during the Extension.

- **Physical factors** include environmental conditions that drive Platte River structure and function and that link drivers to hydrological and geomorphological responses.

- **Habitat responses** describe the expected responses of target species habitat to Program management actions and physical factors.

- **Habitat performance** includes the indicators (metrics) used to evaluate the response of target species habitat to management actions.

- **Species management** describes additional Program management actions that, in combination with habitat management, are expected to result in a target species response.

- **Productivity factors (terns/plover), use factors (whooping cranes), and species responses (pallid sturgeon** are a set of components that describe target species behavior in response to physical factors, habitat management, species management, and interactions with other species (predation).

- **Species performance** includes the indicators (metrics) used to evaluate the relationships identified in the conceptual ecological model and the responses of the target species to Program management actions.

- **Other factors** are larger-scale influences on species performance that are outside the control of the Program but that may have a large, if not determinative, effect on the species.

The CEMS were developed with enough detail to allow for continued evaluation of the depicted relationships and to identify and explore critical remaining uncertainties that can be related to Program management and decision-making.

Key to CEM Figures

The following key pertains to all of the CEMs:

- **High Effectiveness During Extension (solid boxes)** – Based on Program learning, these components and relationships are anticipated to be effective at meeting Program management objectives during the Extension. As such, these will be the primary focus of research, monitoring, and associated data analysis and synthesis during the Extension.

- **Low Effectiveness During Extension (partially transparent boxes)** – Based on Program learning, it is anticipated that these components and relationships will be ineffective at meeting Program management objectives during the Extension. As such, these will not be a focus of research, monitoring, and associated data analysis and synthesis during the Extension.

- **High Control – High Uncertainty (heavy red arrows)** – These relationships are the primary focus of adaptive management during the Extension. These represent areas of critical uncertainty that require reduction through research, monitoring, and associated data analysis and synthesis. Each heavy red arrow is accompanied by a red boxed number to identify the uncertainty. The red boxed numbers carry over to the tables that follow each CEM and provide more detail on the statement of the uncertainty as a Big Question, potential language for underlying hypotheses and competing hypotheses, potential management actions, key data to be collected, and the source of those data.

- **Low Control – High Uncertainty** (light red arrows) – These relationships indicate uncertainty but the lack of ability on the part of the Program to implement management actions to affect these relationships reduces the level of uncertainty to a second tier that likely will not be the subject of adaptive management focus during the Extension.

- **High Control – Low Uncertainty (heavy black arrows)** – These relationships can be affected by Program management actions but are not uncertain in terms of target species responses due to existing knowledge or the synthesis of Program learning from the First Increment.

- **Low Control – Low Uncertainty** (light black arrows) – These relationships are not uncertain in terms of target species responses but are also not able to be significantly affected by Program management actions.

Black boxes represent the grouping of similar components to minimize the number of connecting lines and reduce model complexity to improve readability and enhance focus on a smaller number of the most relevant uncertainties.

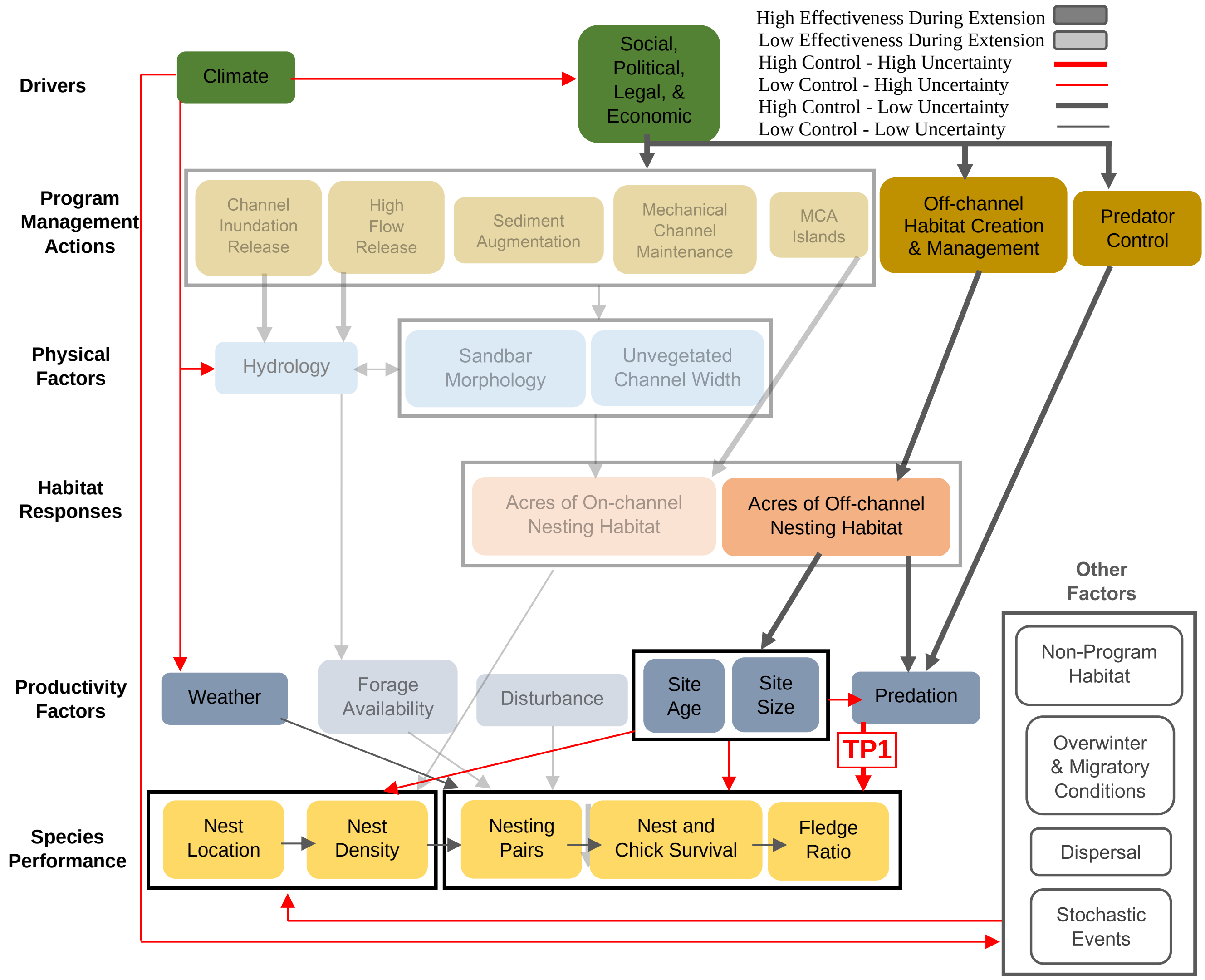
Tern and Plover Conceptual Ecological Model (CEM; Figure 1)

This section contains a brief description of the components of the CEM for least terns and piping plovers, the CEM, and a script providing an explanation of the linkages between components and hyperlinked citations to key reference documents.

Component Category	Component	Description
Drivers	Social, Political, Legal, & Economic	Actions that affect the priorities of the Program, how it is implemented, and the bounds of GC decision-making.
	Climate	Basin and regional factors affecting water supply and hydrology, such as annual precipitation, temperature, and resulting weather patterns and their timing and magnitude over multiple years. Climate conditions affect the social, political, legal, and economic factors driving Program management.
Program Management Actions	Channel Inundation Release	Flows maintained during the germination season for the purposes of reducing vegetation establishment within the channel and maintaining wide channels for the potential establishment of suitable in-channel nesting islands following natural high-flow events.
	High Flow Release	Flows of 5,000-8,000 cfs for 3-5 days during the fall to remove annual vegetation following the germination season for the potential establishment of suitable in-channel nesting islands following natural high-flow events.
	Sediment Augmentation	Annual augmentation of sediment for the purposes of reducing the sediment deficit in the channel to reduce or prevent the downstream migration of channel degradation.
	Mechanical Channel Maintenance	Channel disking, herbicide application, and mechanical channel-widening activities for future channel inundation releases to reduce vegetation establishment and remove vegetation through high flow releases for the potential establishment of suitable in-channel nesting islands following natural high-flow events.
	MCA Islands	Established vegetated islands cleared and maintained free of vegetation for the purposes of in-channel nesting islands for terns and plovers and eventual channel widening through lateral erosion for whooping cranes.
	Off-Channel Habitat Creation & Maintenance	Creation and maintenance of off-channel sand and water nesting habitat for terns and plovers.
Physical Factors	Hydrology	The movement and quantification of river and ground water through the AHR.
	Sandbar Morphology	The creation and evolution of sandbars and the factors that drive these processes. Visible result of braided river processes whereby sediment continuously erodes and deposits in the downstream direction with respect to stage and sandbars are the visible waves in which energy is dissipated.
	Unvegetated Channel Width	Width of open channel area maintained free of vegetation to encourage on-channel tern and plover nesting within the AHR
Habitat Responses	On-Channel Nesting Habitat	Suitable nesting habitat, as defined by the Program's minimum habitat criteria, created and/or maintained for the purposes of on-channel nesting by terns and plovers.
	Off-Channel Nesting Habitat	Suitable off-channel sand and water nesting habitat, as defined by the Program's minimum habitat criteria, maintained for the purposes of off-channel nesting by terns and plovers.
Species Management Actions	Predator Control	Trapping, fencing, and other activities implemented to reduce predation on tern and plover nests, chicks, and adults.
Productivity Factors	Weather	The state of the atmosphere at a place and time including heat, humidity, solar intensity, wind, rain, etc.
	Forage Availability	Availability of tern (small-bodied fish) and plover (invertebrates) forage.
	Disturbance	Any human activity that reduces the occurrence of and productivity on suitable nesting and foraging habitat.
	Site Age	The age of a nesting site since first established as suitable nesting habitat.
	Site Size	The size of a nesting site in acres
	Predation	The act of mammalian and avian predators consuming tern and plover nests, chicks, or adults.

Component Category	Component	Description
Species Performance	Nest Location	The physical location of individual tern and plover nests.
	Nest Density	Number of tern and plover nests per acre of suitable nesting habitat as defined by the Program's minimum habitat criteria.
	Nesting Pairs	Number of pairs within a site or the AHR based on the Program's definition of tern and plover pairs (Baasch et al. 2015).
	Nest & Chick Survival	The survival of tern and plover nests and chicks through hatching and fledging, respectively.
	Fledge Ratio	Number of tern and plover fledglings produced per nesting pair within a site or the AHR.
Other Factors	Non-Program Habitat	Nesting and foraging habitat outside the AHR (i.e., McConaughey, lower Platte River, Missouri River, etc.).
	Overwinter & Migratory Conditions	Other factors that reduce or enhance the survival of tern and plover fledglings and adults and ultimately influence recruitment.
	Dispersal	The process of terns and plovers distributing throughout their breeding range which include immigration and emigration.
	Stochastic Events	Factors such as disease outbreaks, etc. that reduce the overall size or health of the population.

Figure 1. Tern and Plover Conceptual Ecological Model



41 **Tern and Plover CEM Script**

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Social, Legal, Political, & Economic		Climate	Social, legal, political, & economic factors form the basis of the Program but the ability to implement the Program is influenced by climate, particularly related to water availability. Goals and objectives of the Program influence management decisions and their responses to climate.	Final Program Document; Extension Document; climate change input as part of operational model.
Climate		Hydrology	Large amount of uncertainty relative to future impacts of climate on hydrology and the ability of the Program to model potential impacts and use those modeling results in Program planning and implementation. But the Program has no control over the effects of climate on water availability.	
Climate		Weather	Uncertainty about the impacts of climate change on local weather patterns and events which can have a significant impact on tern/plover productivity, but again the Program can do little to account for this impact other than to contribute to nesting dispersal as a backstop against the effects of localized weather events (heavy rain, hailstorms, etc.).	Climate change input as part of operational model; maybe some expected productivity loss due to more frequent/intense weather events included in operational model and/or models used by the GC in SDM as part of decision-making.
Climate		Non-Program Habitat/Overwinter & Migratory Conditions/Dispersal/Stochastic Events	Uncertainty about the impacts of climate change on weather patterns and events which can have a significant impact on tern/plover survival and recruitment.	
Social, Legal, Political, & Economic		Channel Inundation Release/High Flow Release/Sediment Augmentation/Mechanical	Little uncertainty about the bounds of the Program, resources, water law, etc. that effect the amount of water and land available for management actions and in turn the ability of the Program to manage and control water, augment sand, and apply mechanical	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0
Social, Legal, Political, & Economic		Off-channel Habitat Creation and Maintenance	Little uncertainty about the bounds of the Program, resources, water law, etc. that effect the amount of water and land available for management actions and in turn the ability of the Program to create and maintain off-channel habitat in the AHR.	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0
Social, Legal, Political, & Economic		Predator Control	Little uncertainty about the bounds of the Program to manage and control predators in the AHR other than the Services' willingness to allow avian trapping at off-channel nesting sites.	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0
Channel Inundation Release		Hydrology	Little uncertainty about the relationship between Program flow management in the summer and river hydrology but the Program cannot control other important factors such as irrigation return flows, drought, and runoff events.	Gauging station data

42

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
High Flow Release		Hydrology	Little uncertainty about the relationship between peak flows and river hydrology but peak flows are currently driven by natural events over which the Program has no control. Program peak flow management is limited by the Good Neighbor Policy and conveyance constraints at the North Platte choke point.	Farnsworth et al. 2017; Farnsworth et al. 2018a; Gauging station data
Channel Inundation Release/High Flow Release/Sediment Augmentation/Mechanical Channel Maintenance/MCA Islands		Sandbar Morphology/Unvegetated Channel Width	The mix of these three Program management activities does have an impact on channel morphology and width but the largest factor now is peak flows driven by natural events outside the control of the Program, except to inform GC and determine if the peak flows may be protected.	Farnsworth et al. 2015; Farnsworth et al. 2017; Farnsworth et al. 2018a
MCA Islands		On-Channel Nesting Habitat	The Program can build and manage this habitat to specification.	Tern and Plover Final SDM Report
Off-Channel Habitat Creation & Maintenance		Off-Channel Nesting Habitat	The Program can build and manage this habitat to specification.	Baasch et al. 2017a; Farrell et al. 2018; PRRIP Tern and Plover Monitoring and Research Reports
Predator Control		Predation	Possibly some relationship between predation and older sites (predators figure it out) but there is only so much habitat that can be purchased and/or developed/managed in the AHR.	PRRIP Tern and Plover Monitoring and Research Reports
Hydrology		Sandbar Morphology/Unvegetated Channel Width	High correlation but low ability on the part of the Program to control natural peak flow events.	Farnsworth et al. 2015; Farnsworth et al. 2017; Farnsworth et al. 2018a
Hydrology		Forage Availability	Primarily an issue of forage fish for terns during the summer nesting season. Fish need water but there is no data linking low or no flows to impacts on forage availability and resulting impacts on tern productivity.	Baasch et al. 2017; Sherfy et al. 2012
Sandbar Morphology/Unvegetated Channel Width		On-Channel Nesting Habitat	Driven more by natural peak flow events but not data linking on-channel habitat availability to gains or losses in tern/plover productivity.	Farnsworth et al. 2015; Farnsworth et al. 2017; Farnsworth et al. 2018a; Farnsworth et al. 2018b
On-Channel Nesting Habitat/Off-Channel Nesting Habitat		Acres of Suitable Nesting Habitat	Direct relationship the Program can influence.	PRRIP Tern and Plover Monitoring and Research Reports
Off-Channel Nesting Habitat		Site Age/Site Size	No linkages to productivity but also driven by natural peak flow events outside the control of the Program.	PRRIP Tern and Plover Monitoring and Research Reports

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Off-Channel Nesting Habitat		Predation	Important relationship with productivity and the Program can exert a high level of control at managed sites.	PRRIP Tern and Plover Monitoring and Research Reports
Weather		Nesting Pairs/Nest & Chick Survival/Fledge Ratio	Weather is significant impact but cannot control weather events.	Farrell et al. 2018
Forage Availability		Nesting Pairs/Nest & Chick Survival/Fledge Ratio	Data from First Increment does not link flow to forage availability or productivity.	Baasch et al. 2017; Sherfy et al. 2012
Disturbance		Nesting Pairs/Nest & Chick Survival/Fledge Ratio	Impact on productivity but Program can control at managed sites.	Inside/outside monitoring data and report
Site Age/Site Size		Nesting Pairs/Nest & Chick Survival/Fledge Ratio	May be relationship between site age and productivity over time but there are only so many sites the Program can acquire and/or develop/manage due to limitations in acres, budget, etc.	PRRIP Tern and Plover Monitoring and Research Reports
Predation		Nesting Pairs/Nest & Chick Survival/Fledge Ratio	Important area for Program research - determine the impact of avian predation, types of predators, possible control methods.	
Nest Location		Nest Density	Direct relationship, outside the control of the Program.	Baasch et al. 2017a; PRRIP Tern and Plover Monitoring and Research Reports
Nest Location/Nest Density		Nesting Pairs/Nest & Chick Survival/Fledge Ratio	Direct relationship, outside the control of the Program.	Baasch et al. 2017a; Farrell et al. 2018; PRRIP Tern and Plover Monitoring and Research Reports; PRRIP Tern and Plover Final SDM Report
Nesting Pairs		Nest & Chick Survival	Direct relationship, outside the control of the Program.	Baasch et al. 2015; PRRIP Tern and Plover Monitoring and Research Reports
Nest & Chick Survival		Fledge Ratio	Direct relationship, outside the control of the Program.	PRRIP Tern and Plover Monitoring and Research Reports
Non-Program Habitat/Overwinter & Migratory Conditions/Dispersal		Nest Location/Nest Density	These factors likely have significant impacts on tern/plover use and occurrence and productivity in the AHR but are outside the control of the Program.	

44

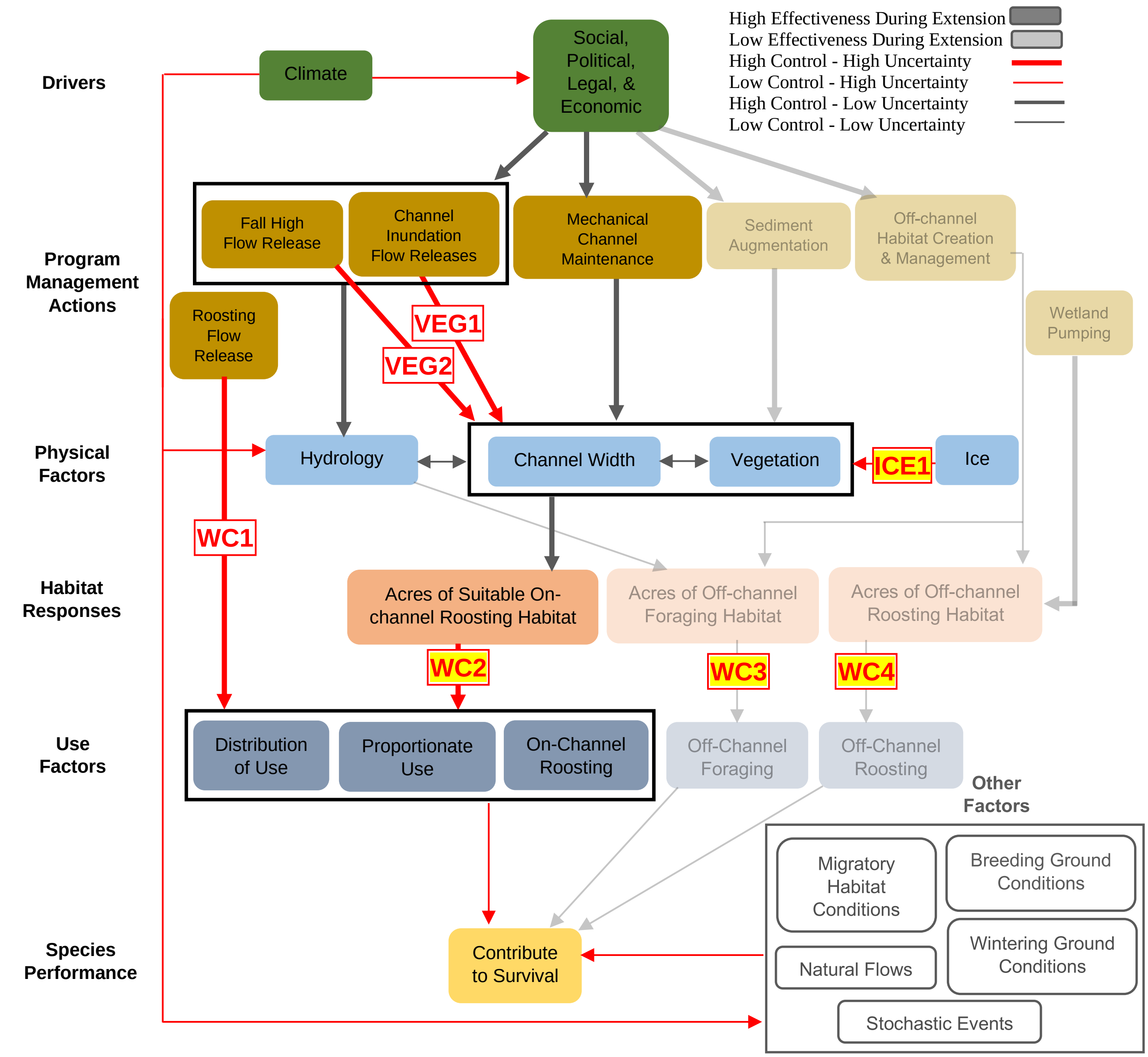
Whooping Crane CEM (Figure 2) and Sub-models (Figures 3 and 4)

This section contains a brief description of the components of the CEM for whooping cranes, the CEM, and a script providing an explanation of the linkages between components and hyperlinked citations to key reference documents. The whooping crane CEM is followed by two sub-models that represent a deeper explanation of the relationships between hydrology, vegetation, and channel width.

Component Category	Component	Description
Drivers	Social, Political, Legal, & Economic	Actions that affect the priorities of the Program, how it is implemented, and the bounds of GC decision-making.
	Climate	Basin and regional factors affecting water supply and hydrology, such as annual precipitation, temperature, and resulting weather patterns and their timing and magnitude over multiple years. Climate conditions affect the social, political, legal, and economic factors driving Program management.
Program Management Actions	Fall High Flow Release	Late summer or early fall releases of 5,000-8,000 cfs of flow for 3-5 days as measured at Overton for the purposes of removing annual vegetation established within the channel.
	Channel Inundation Flow Releases	Flows maintained during the germination season for the purposes of reducing vegetation establishment within the channel and maintaining wide unobstructed channel widths for whooping cranes.
	Sediment Augmentation	Annual augmentation of sediment for the purposes of reducing the sediment deficit in the channel to reduce or prevent the downstream migration of channel degradation.
	Mechanical Channel Maintenance	Disking, herbicide application and mechanical channel-widening activities for creating and maintaining wide unobstructed view widths for whooping cranes and prepping the channel for future summer flow releases to reduce vegetation establishment and for the removal of annual vegetation through peak flow releases.
	Off-Channel Habitat Creation & Maintenance	The creation and maintenance of suitable off-channel palustrine wetlands and wet meadow habitat for whooping cranes
	Roosting Flow Release	Flows released during the spring and fall whooping crane migration seasons for the purposes of enhancing roosting conditions and increasing whooping crane use of the AHR.
	Wetland Pumping	Augmentation of water via pumping into palustrine wetlands to increase the acres of suitable off-channel roosting area.
Physical Factors	Hydrology	The movement and quantification of river and ground water through the AHR.
	Channel Width	Width of channel unobstructed by dense vegetation ≥2-feet tall.
	Vegetation	Established, dense vegetation ≥2-feet tall.
	Ice	Establishment of ice within the channel with the potential of scouring vegetation during the winter months.
Habitat Responses	Acres of Suitable On-Channel Roosting Habitat	Acres of channel with ≥650-foot-wide unobstructed view widths and ≥1,100-foot-wide unforested corridor widths.
	Acres of Off-channel Foraging Habitat	Acres of Program-defined wet meadow habitat within the AHR.
	Acres of Off-Channel Roosting Habitat	Acres of palustrine wetlands within the AHR.
Use Factors	Distribution of Use	Distribution of whooping crane roosting within the AHR.
	Proportionate Use	Proportion of the annual population, as determined at Aransas National Wildlife Refuge, observed using the AHR through Program monitoring efforts.
	On-Channel Roosting	Abundance of whooping cranes observed roosting in the channel within the AHR.
	Off-Channel Foraging	Abundance of whooping cranes observed foraging in wet meadows within the AHR.
	Off-Channel Roosting	Abundance of whooping cranes observed roosting in palustrine wetlands within the AHR.

Component Category	Component	Description
Species Performance	Contribute to Survival	Contribution to whooping crane survival which result in population growth.
Other Factors	Migratory Habitat Conditions	Suitable roosting and foraging habitat within the migration corridor but outside the AHR.
	Natural Flows	Flows within the AHR not including EA released water or Program flow augmentation through groundwater recharge and other projects.
	Breeding Ground Conditions	Conditions on the breeding ground including nesting habitat availability and suitability, forage, weather, etc.
	Wintering Ground Conditions	Conditions on the wintering ground including forage availability, weather, etc.
	Stochastic Events	Factors such as disease outbreak, hurricane, etc. that influence the overall size or health of the population.

Figure 2. Whooping Crane Conceptual Ecological Model



86 **Whooping Crane CEM Script**

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Climate		Social, Legal, Political, & Economic	Social, legal, political, & economic factors form the basis of the Program but the ability to implement the Program is influenced by climate, particularly related to water availability. Goals and objectives of the Program influence management decisions and their responses to climate.	Final Program Document; Extension Document; climate change input as part of operational model
Climate		Hydrology	Large amount of uncertainty relative to future impacts of climate on hydrology and the ability of the Program to model potential impacts and use those modeling results in Program planning and implementation. But the Program has no control over the effects of climate on water availability yet may be able to mitigate its effects.	
Climate		Migratory Habitat Conditions/Breeding Ground Conditions/Wintering Ground Conditions/Natural Flows/Stochastic Events	Large amount of uncertainty relative to future impacts of climate on habitat and other conditions outside the AHR.	
Social, Legal, Political, & Economic		Fall High Flow Release /Channel Inundation Flows	Little uncertainty about the bounds of the Program, resources, water law, etc. that effect the amount of water available for management actions and in turn the ability of the Program to manage and control water actions in the AHR.	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0
Social, Legal, Political, & Economic		Mechanical Channel Maintenance	Little uncertainty about the bounds of the Program, resources that effect the amount of land available for management actions and in turn the ability of the Program to apply mechanical actions in the AHR.	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0
Social, Legal, Political, & Economic		Sediment Augmentation	Little uncertainty about the bounds of the Program, resources that effect the amount sediment augmentation activities and in turn the ability of the Program to augment sand in the AHR.	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0

87

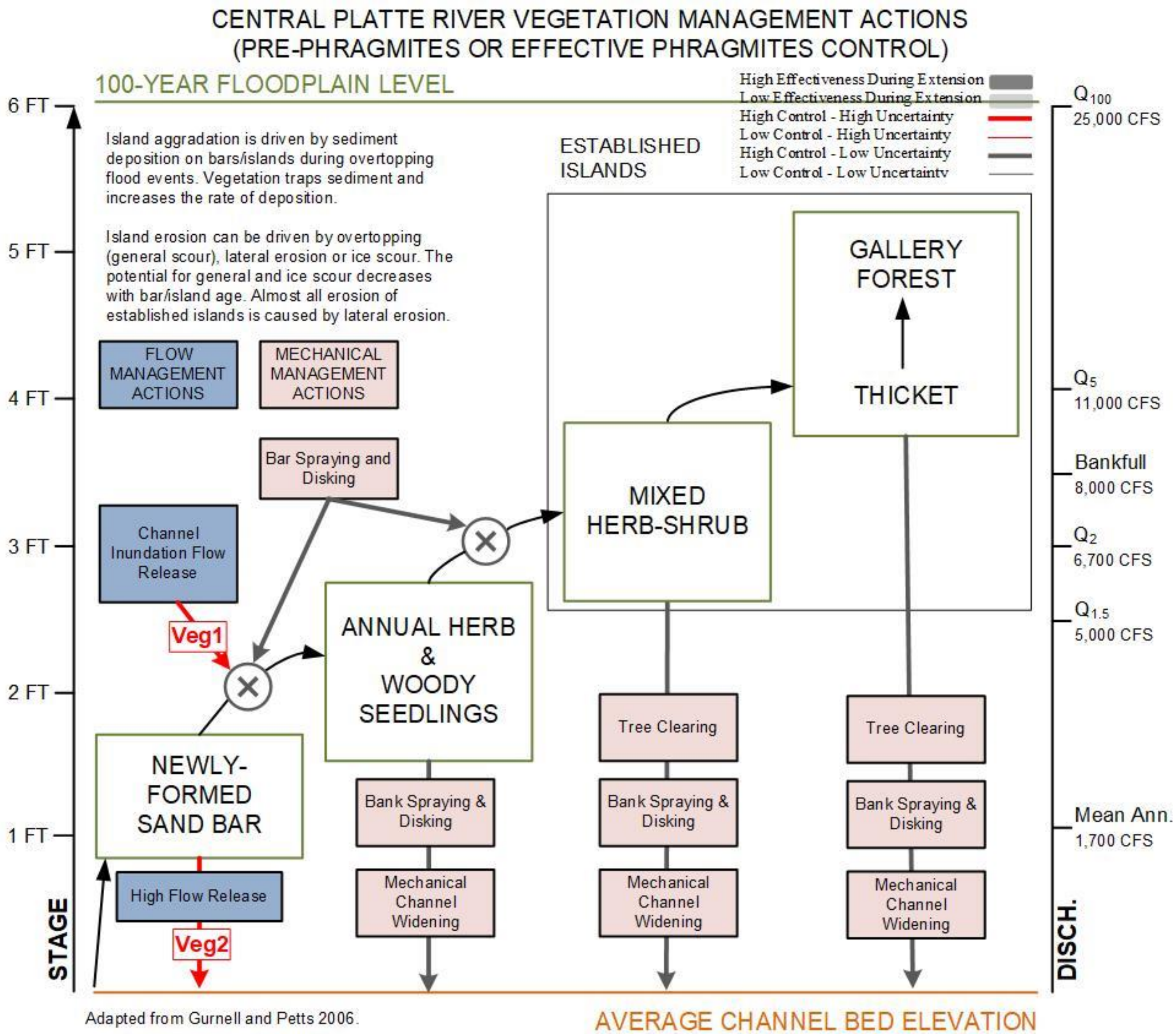
Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Social, Legal, Political, & Economic		Off-Channel Habitat Creation & Maintenance	Little uncertainty about the bounds of the Program, resources that effect the amount of land available for management actions and in turn the ability of the Program to apply mechanical actions in the AHR.	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0
Roosting Flow Release		Distribution of Use	High uncertainty about the relationship between Program flow management during migration and whooping crane use.	Baasch et al. 2017; Farnsworth et al. 2018; Gauging station data
Fall High Flow Release/Channel Inundation Flows		Hydrology	Little uncertainty about the relationship between Program flow management and river hydrology but the Program cannot control other important factors such as natural peak flow events (except to inform GC to possibly protect the peak flows).	Baasch et al. 2017; Farnsworth et al. 2018; Gauging station data
Fall High Flow Release		Channel Width/Vegetation	Important uncertainty to explore related to GC policy decision to implement a fall high flow release during the Extension and Program learning that indicates a spring SDHF as envisioned in AMP Version 1.0 will not result in intended effects on whooping crane habitat.	
Channel Inundation Flows		Channel Width/Vegetation	Important uncertainty to explore - ability of Program to manage available water to impede vegetation germination and thus maintain or expand unvegetated channel width.	
Mechanical Channel Maintenance		Channel Width/Vegetation	Strong relationship between mechanical channel maintenance and channel width and vegetation.	Tetra Tech 2014; Geomorphology and In-channel Vegetation Monitoring data
Sediment Augmentation		Channel Width/Vegetation	Relationship between sediment and channel width and vegetation but morphology largely outside of Program control due to events like natural peak flows.	Tetra Tech 2014; Geomorphology and In-channel Vegetation Monitoring data
Off-Channel Habitat Creation & Maintenance		Acres of Suitable Off-Channel Roosting Habitat	WC do use off-channel wetland areas for roosting but there is only so much of that habitat that can be acquired/developed/managed by the Program and use has been low within the AHR..	Howlin and Nasman 2017; Baasch et al. 2019a
Off-Channel Habitat Creation & Maintenance		Acres of Suitable Off-Channel Foraging Habitat	WC do use off-channel wet meadow areas for foraging but there is only so much of that habitat that can be acquired/developed/managed by the Program and use has been low within the AHR..	Howlin and Nasman 2017; Baasch et al. 2019a

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Wetland Pumping		Acres of Suitable Off-Channel Roosting Habitat	WC do use off-channel wetland areas for roosting but there is only so much of that habitat that can be acquired/developed/managed by the Program and use has been low within the AHR.	Tetra Tech 2014; Geomorphology and In-channel Vegetation Monitoring data
Hydrology		Channel Width/Vegetation	Interactive effects of hydrology, channel width, and vegetation. Influence of vegetation ratchet effect.	Farnsworth et al. 2018; Baasch et al. 2017; Pollen-Bankhead et al. 2014
Channel Width		Vegetation	Interactive effects of hydrology, channel width, and vegetation. Influence of vegetation ratchet effect.	Pollen-Bankhead et al. 2014; Baasch et al. 2017; Farnsworth et al. 2018
Hydrology		Acres of Suitable Off-Channel Foraging Habitat	Connection between Program flow management activities and wet meadow hydrology sufficient enough to improve foraging conditions for whooping cranes.	Wet meadow ground water monitoring data
Channel Width/Vegetation		Acres of Suitable On-Channel Roosting Habitat	Program mechanical management and extreme natural high flow events can have a large impact on this.	Pearse et al. 2016; Baasch et al. 2017; Howlin and Nasman 2017; Baasch et al. 2019b
Ice		Channel Width/Vegetation	Likely an important relationship to explore and understand but very difficult for the Program to control, experiment, or monitor to learn.	
Acres of Suitable On-Channel Roosting Habitat		Distribution of Use/Proportionate Use/On-Channel Roosting	Important uncertainty to explore during the Extension.	Pearse et al. 2016; Baasch et al. 2017; Howlin and Nasman 2017; Baasch et al. 2019b
Acres of Suitable Foraging Habitat		Off-Channel Foraging	Important uncertainty to explore during the Extension.	Pearse et al. 2016; Baasch et al. 2019a
Acres of Suitable Off-Channel Roosting Habitat		Off-Channel Roosting	Important uncertainty to explore during the Extension.	
Distribution of Use/Proportionate Use/On-Channel Roosting		Contribute to Survival	Migratory nature of WC and stopover use of AHR make determining this relationship difficult.	
Off-Channel Foraging		Contribute to Survival	Migratory nature of WC and stopover use of AHR make determining this relationship difficult.	
Off-Channel Roosting		Contribute to Survival	Migratory nature of WC and stopover use of AHR make determining this relationship difficult.	

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Non-Program Habitat/Natural Flows/Breeding Ground Conditions/Wintering Ground Conditions/Stochastic Events		Contribute to Survival	These factors likely have significant impacts on the whooping crane population but are outside the control of the Program.	

Annual and Perennial Vegetation Establishment Sub-model (Figure 3)
This sub-model relates the potential channel inundation flow release and the high flow release to vegetation germination and vegetation scour.

Figure 3. Annual and perennial vegetation establishment sub-model.



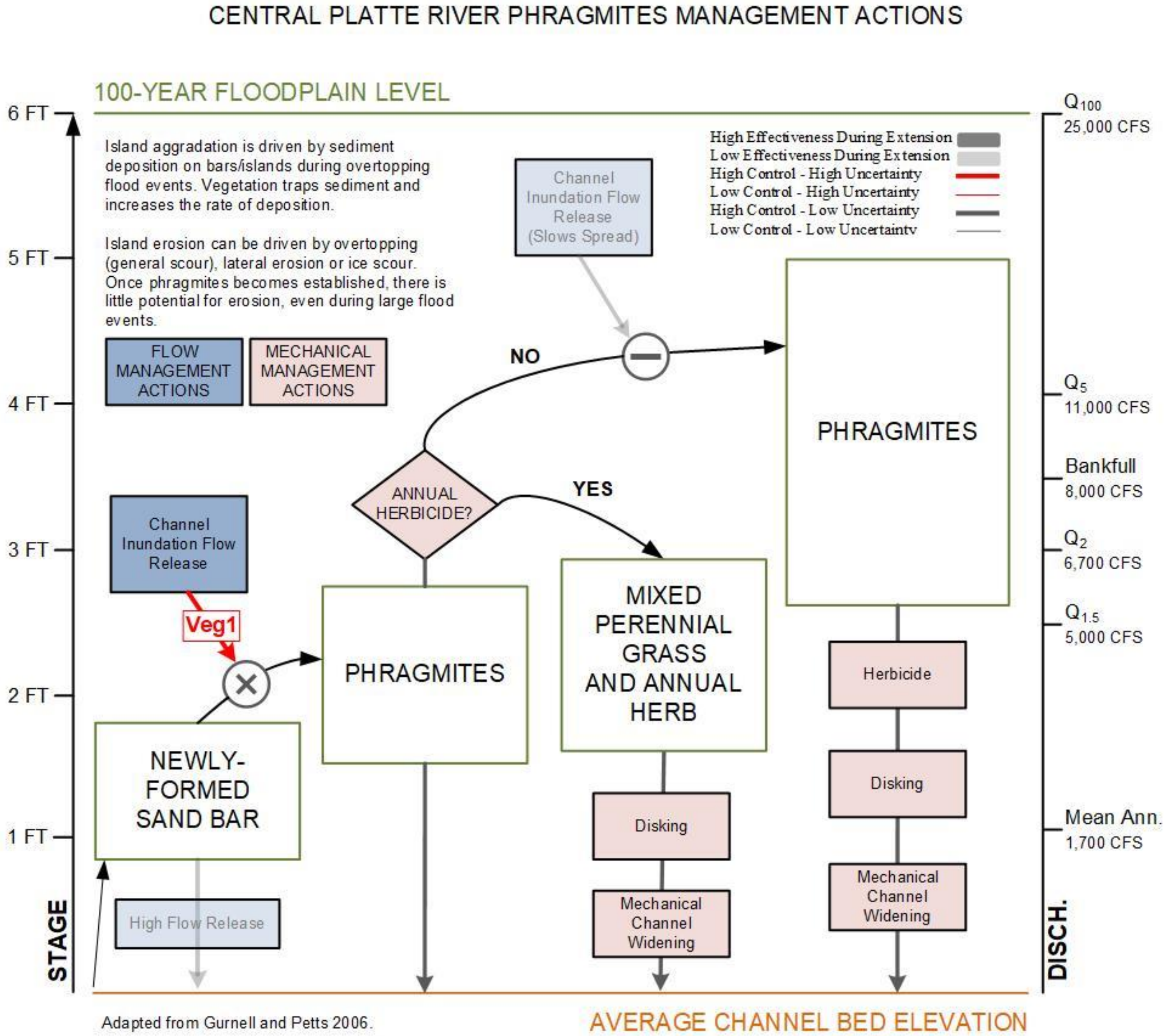
Vegetation Sub-model Script

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Channel Inundation Flow Releases		Newly Formed Sandbars	Important uncertainty to explore - ability of Program to manage available water to impede vegetation germination and thus maintain or expand unvegetated channel width.	
High Flow Release		Stage Zero Riverbed	Important uncertainty to explore related to GC policy decision to implement a release 5,000 – 8,000 cfs for three days in September during the Extension and Program learning that indicates a spring SDHF as envisioned in AMP Version 1.0 will not result in intended effects on whooping crane habitat.	
Bar Spraying/Disking		Newly Formed Sandbars/Annual Herb and Woody Seedlings	Strong relationship between mechanical channel maintenance and channel width and vegetation. These management activities take the channel back to a stage-zero riverbed.	Farnsworth et al. 2018
Mixed Herb-Shrub		Tree Clearing/Bank Spraying and Disking/Mechanical Channel Widening	Strong relationship between mechanical channel maintenance and channel width and vegetation. These management activities take the channel back to a stage-zero riverbed.	Farnsworth et al. 2018
Gallery Forest/Thicket		Tree Clearing/Bank Spraying and Disking/Mechanical Channel Widening	Strong relationship between mechanical maintenance and channel width and vegetation. These management activities take the channel back to a stage-zero riverbed.	

Phragmites Sub-Model (Figure 4)

This sub-model relates the potential channel inundation flow release to the prevention of phragmites germination.

Figure 4. Phragmites sub-model.



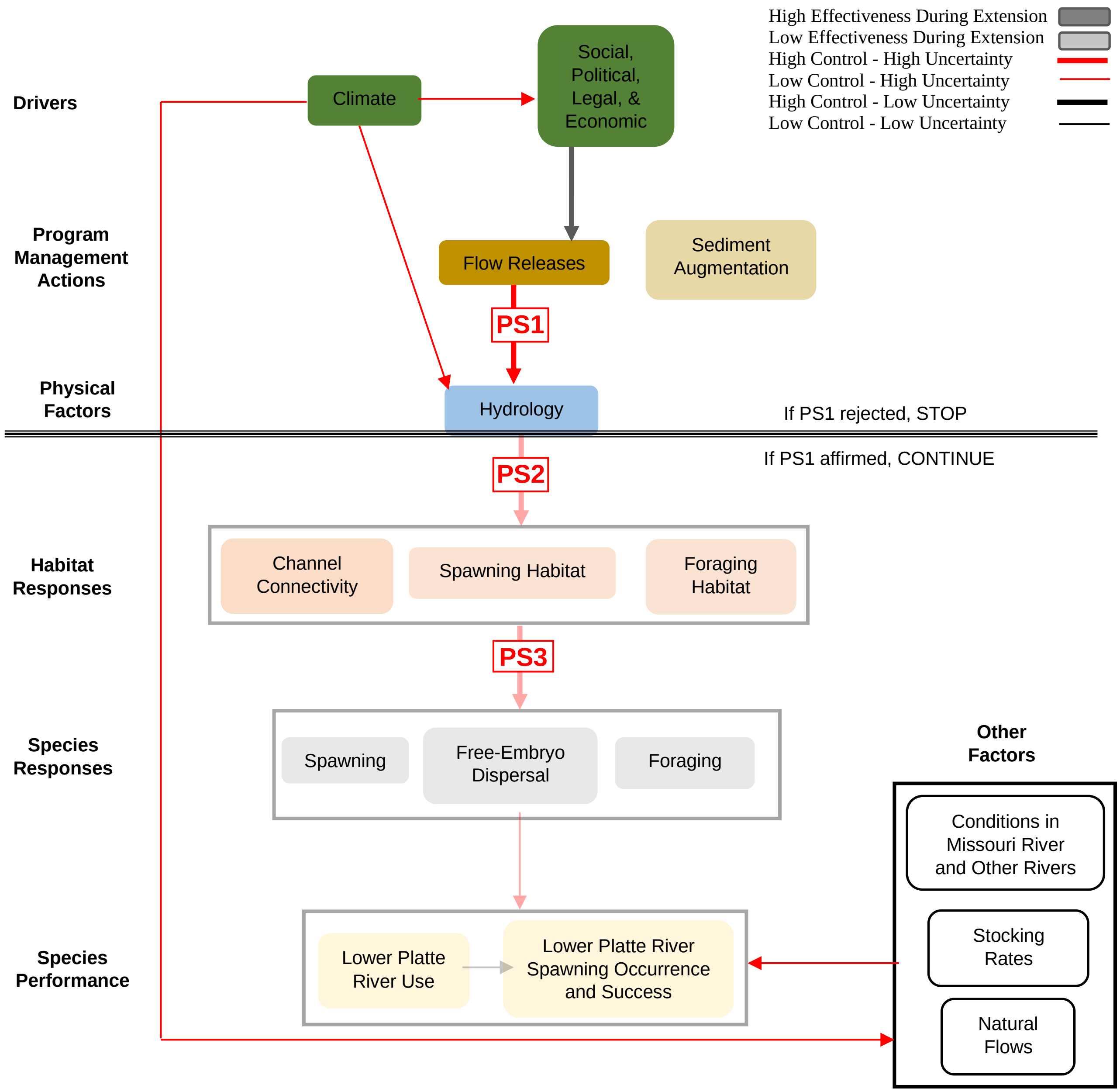
Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Channel Inundation Flow Releases		Newly Formed Sandbars	Important uncertainty to explore - ability of Program to manage available water to impede vegetation germination and thus maintain or expand unvegetated channel width.	
Annual Herbicide		Mixed Perennial Grass and Annual Herbs		Pollen-Bankhead et al. 2014; Farnsworth et al. 2018
No Annual Herbicide		Phragmites		
Mixed Perennial Grass and Annual Herbs		Disking/Mechanical Channel Widening	Strong relationship between mechanical channel maintenance and channel width and vegetation. These management activities take the channel back to a stage-zero riverbed.	
Phragmites		Herbicide/ Disking/Mechanical Channel Widening	Strong relationship between herbicide, disking, mechanical maintenance and channel width and vegetation. These management activities take the channel back to a stage-zero riverbed.	

Pallid Sturgeon CEM (Figure 5)

This section contains a brief description of the components of the CEM for pallid sturgeon, the CEM, and a script providing an explanation of the linkages between components and hyperlinked citations to key reference documents.

Component Category	Component	Description
Drivers	Social, Political, Legal, & Economic	Actions that affect the priorities of the Program, how it is implemented, and the bounds of GC decision-making.
	Climate	Basin and regional factors affecting water supply and hydrology, such as annual precipitation, temperature, and resulting weather patterns and their timing and magnitude over multiple years. Climate conditions affect the social, political, legal, and economic factors driving Program management.
Program Management Actions	Flow Releases	Flow management actions implemented by the Program to enhance pallid sturgeon use and productivity within the lower Platte River.
	Sediment Augmentation	Sediment management actions implemented by the Program to enhance pallid sturgeon use and productivity within the lower Platte River.
Physical Factors	Hydrology	The movement and quantification of river and ground water through the central and lower Platte River.
Habitat Responses	Channel Connectivity	Connectivity of the channel suitable for adult pallid sturgeon migration between deeper pools of water.
	Spawning Habitat	Areas within the lower Platte River suitable for successful pallid sturgeon spawning.
	Foraging Habitat	Areas within the lower Platte River suitable for successful pallid sturgeon foraging.
Species Responses	Spawning	Successful release and deposit eggs and sperm that result in fertile pallid sturgeon eggs.
	Juvenile Survival	Survival of sub-adult and juvenile pallid sturgeon that results in recruitment into the population and ultimately population growth.
	Adult Survival	Survival of adult pallid sturgeon that results in population maintenance and growth.
	Dispersal	The process of pallid sturgeon distributing themselves throughout their breeding range via migration and larval drift.
	Forage	Prey species suitable for pallid sturgeon consumption.
Species Performance	Lower Platte River Use	Abundance of pallid sturgeon using the lower Platte River for foraging and reproduction.
	Lower Platte River Spawning Occurrence & Success	Abundance of pallid sturgeon using the lower Platte River for successful reproduction.
	Recruitment	The result of successful reproduction and survival of juvenile pallid sturgeon until sexual maturity.
Other Factors	Missouri/Other River Conditions	Flows, pallid sturgeon habitat suitability and availability, etc. in rivers outside the lower Platte River.
	Stocking Rates	Rate of pallid sturgeon stocking within the lower Platte River and other river segments including the Missouri River, Yellowstone River, Mississippi River, etc.
	Natural Flows	Flows within the central and lower Platte River excluding EA released water or Program flow augmentation through groundwater recharge and other projects.

Figure 3. Pallid Sturgeon Conceptual Ecological Model



Sturgeon CEM Script

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Climate		Social, Legal, Political, & Economic	Social, legal, political, & economic factors form the basis of the Program but the ability to implement the Program is influenced by climate, particularly related to water availability. Goals and objectives of the Program influence management decisions and their responses to climate.	Final Program Document; Extension Document; climate change input as part of operational model
Climate		Hydrology	Large amount of uncertainty relative to future impacts of climate on hydrology and the ability of the Program to model potential impacts and use those modeling results in Program planning and implementation. But the Program has no control over the effects of climate on water availability yet may be able to mitigate its effects.	
Climate		Missouri/Other River Conditions/Stocking Rates/Natural Flows	Large amount of uncertainty relative to future impacts of climate on hydrology and the ability of the Program to model potential impacts and use those modeling results in Program planning and implementation. But the Program has no control over the effects of climate on water availability.	
Social, Legal, Political, & Economic		Flow Releases	Little uncertainty about the bounds of the Program, resources, water law, etc. that effect the amount of water available for lower Platte River pallid sturgeon-related management actions and in turn the ability of the Program to manage and control that water moving from the central Platte to the lower Platte.	Final Program Document; Extension Document; AMP Versions 1.0 and 2.0
Flow Releases		Hydrology	Little uncertainty about the relationship between Program flow management and river hydrology. Stage change study indicates there is an inability to detect Program flow management actions in the lower Platte but remaining uncertainty about this on the part of some Program parties makes this an area of high uncertainty.	Stage change study
Hydrology		Channel Connectivity/Spawning Habitat/Foraging Habitat	Part of the large amount of uncertainty regarding pallid sturgeon use, occurrence, spawning, and recruitment in the lower Platte River; the types and use of pallid sturgeon habitat in the lower Platte River; and the relationship between these habitat types and hydrology.	
Channel Connectivity/Spawning Habitat/Foraging Habitat		Spawning/Juvenile Survival/Adult Survival/Dispersal/ Forage	Part of the large amount of uncertainty regarding pallid sturgeon use, occurrence, spawning, and recruitment in the lower Platte River; the types and use of pallid sturgeon habitat in the lower Platte River; and the relationship between these habitat types and hydrology.	

Starting Component(s)	Arrow Color & Weight	Ending Component(s)	Description	Data Sources & Citations
Spawning/Juvenile Survival/Adult Survival/Dispersal/Forage		Lower Platte River Use/Lower Platte River Spawning Occurrence & Success/Recruitment	Part of the large amount of uncertainty regarding pallid sturgeon use, occurrence, spawning, and recruitment in the lower Platte River; the types and use of pallid sturgeon habitat in the lower Platte River; and the relationship between these habitat types and hydrology.	
Lower Platte River Use		Lower Platte River Spawning Occurrence & Success	Direct relationship, outside the control of the Program.	EDO White Paper
Lower Platte River Spawning Occurrence & Success		Recruitment	Direct relationship, outside the control of the Program.	
Missouri/Other River Conditions/Stocking Rates/Natural Flows		Lower Platte River Use/Lower Platte River Spawning Occurrence & Success/Recruitment	These factors likely have significant impacts on pallid sturgeon use and occurrence in the lower Platte River but are outside the control of the Program.	

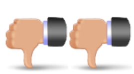
152

What are Big Questions?

The Big Questions are statements of key scientific and technical uncertainties used to communicate with the GC regarding the results of AMP implementation and progress toward meeting the management objectives. These questions and the uncertainties they describe form the core structure of the 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.

Table X below identifies the Big Questions and the underlying priority management hypotheses (and alternative hypotheses) for the Extension. The Big Questions are grouped according to the management objectives for terns/plovers, whooping cranes, and pallid sturgeon and are linked back to key areas of uncertainties identified in the corresponding CEMs. A quick-reference assessment will be provided for each Big Question starting with the beginning of Extension implementation in 2020 and will be updated each year via the annual State of the Platte Report. Each assessment will include information noting any updates or changes from previous State of the Platte reports.

To assist the GC with quickly evaluating the 2019 Big Question assessments, the following icons will be used to visually summarize the basic conclusion for each question:

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.

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 and 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 and assessing the management objectives.

<table>
<tr><th>CEM</th><th colspan="2">PRRIP Extension Big Question</th><th>2020 Assessment</th><th>Basis for Assessment</th></tr>
<tr><td colspan="5">Management Objective: Improve production of the interior least tern and piping plover from the central Platte River.
Broad Uncertainty – Relationship between avian predation and tern and plover productivity.</td></tr>
<tr><td>Tern/Plover</td><td colspan="2">1. Can the Program improve plover chick survival through additional management actions?</td><td></td><td></td></tr>
<tr><td colspan="2">Management Action</td><td colspan="3">Priority Management Hypothesis</td></tr>
<tr><td colspan="2" rowspan="3">Predator control <u>test</u>
Trapping mammalian predators at all sites and avian predators at a subset of off-channel sand and water (OCSW) habitat sites.

Other options: let sites age/veg over, tree removal</td><td colspan="3">TP1 – Avian predator control is necessary for meeting three-year running average fledge ratios and sustaining sufficient long-term tern and plover productivity within the AHR.
• Productivity at sites with avian predator control is significantly higher than at sites without avian predator control.
• Avian predator control has a biologically significant benefit for the fledge ratios of least terns and piping plovers.
• habitat quality (including the effects of predation) and the target is to maintain a fledge ratio necessary to achieve a stable or increasing population (lambda >=1) on existing sites</td></tr>
<tr><td colspan="3">Alternative Hypothesis</td></tr>
<tr><td colspan="3">TP1$_{Alt1}$ – Avian predator control is not necessary to meet three-year running average fledge ratio objectives and sustain sufficient long-term tern and plover productivity within the AHR.</td></tr>
<tr><td colspan="5">Management Objective: Contribute to the survival of whooping cranes during migration.
Broad Uncertainty – Relationship between flow, maintaining suitable unobstructed channel width (UOCW), and whooping crane use of the Associated Habitat Reach (AHR).</td></tr>
<tr><td>Whooping Crane</td><td colspan="2">2. Will flow management during the spring and fall whooping crane (WC) migration seasons, in combination with other management actions, help the Program continue to meet the WC management objective?</td><td></td><td></td></tr>
<tr><td colspan="2">Management Action</td><td colspan="3">Priority Management Hypothesis</td></tr>
<tr><td colspan="2" rowspan="3">WC migration <u>flow management</u> (spring and fall migration)
Provide a range of flows during multiple spring and fall migration seasons.</td><td colspan="3">WC1 – The frequency of WC use of the AHR declines when flows are below 1,500 cfs, but there is no incremental benefit of increasing flow above 1,500 cfs.</td></tr>
<tr><td colspan="3">Alternative Hypotheses</td></tr>
<tr><td colspan="3">WC1$_{Alt1}$ – The frequency of WC use of the AHR increases with flow.

WC1$_{Alt2}$ – The frequency of WC use of the AHR is not influenced by flow.</td></tr>
</table>

<table>
<tr><th>CEM</th><th colspan="2">PRRIP Extension Big Question</th><th>2020 Assessment</th><th>Basis for Assessment</th></tr>
<tr><td>Whooping Crane (see Vegetation Sub-Model)</td><td colspan="2">3. Can low-magnitude, long-duration flow releases during the germination period be used to maintain suitable UOCW in the channel when large natural peak flows do not occur?</td><td></td><td></td></tr>
<tr><th colspan="2">Management Action</th><th colspan="3">Priority Management Hypothesis</th></tr>
<tr><td colspan="2" rowspan="3">Flow management test
Maintain 1,200 – 2,400 cfs during June 1 – July 15 and evaluate change in UOCW annually.</td><td colspan="3">VEG1 – Maintaining average flows of 1,800 cfs during the germination period (June 1 – July 15) will prevent vegetation encroachment into the channel where it exceeds 650 ft, thereby maintaining 650 ft UOCWs for whooping cranes.</td></tr>
<tr><th colspan="3">Alternative Hypotheses</th></tr>
<tr><td colspan="3">$VEG1_{Alt1}$ – Maintaining average flows of 2,400 cfs during the germination period (June 1 – July 15) will prevent vegetation encroachment into the channel where it exceeds 650 ft, thereby maintaining 650 ft UOCWs for whooping cranes.

$VEG1_{Alt2}$ – Maintaining average flows of 1,200 cfs during the germination period (June 1 – July 15) will prevent vegetation encroachment into the channel where it exceeds 650 ft, thereby maintaining 650 ft UOCWs for whooping cranes.</td></tr>
<tr><td>Whooping Crane (see Vegetation Sub-Model)</td><td colspan="2">4. Can late summer releases of 5,000 – 8,000 cfs for 3 days remove <1-year-old vegetation in channels with 650-foot wide UOCWs?</td><td></td><td></td></tr>
<tr><th colspan="2">Management Action</th><th colspan="3">Priority Management Hypothesis</th></tr>
<tr><td colspan="2" rowspan="3">Flow management test
Implement 5,000 – 8,000 cfs releases for three days during September and evaluate change in UOCW annually.</td><td colspan="3">VEG2 – Flows of 8,000 cfs for three days in September will remove enough ≤1-year-old vegetation in channels with 650-foot wide UOCWs to maintain those widths.</td></tr>
<tr><th colspan="3">Alternative Hypotheses</th></tr>
<tr><td colspan="3">$VEG2_{Alt1}$ – Flows of 5,000 cfs for three days in September will remove enough ≤1-year-old vegetation in channels with 650-foot wide UOCWs to maintain those widths.

$VEG2_{Alt2}$ – Flows of 12,000 cfs for three or more days in September are needed to remove enough ≤1-year-old vegetation in channels with 650-foot wide UOCWs to maintain those widths.</td></tr>
</table>

CEM	PRRIP Extension Big Question	2020 Assessment	Basis for Assessment
Management Objective: *Avoid adverse impacts from Program actions on pallid sturgeon populations.* **Broad Uncertainty –** Relationship between Program water management actions and pallid sturgeon habitat availability in the lower Platte River (LPR).			
Pallid Sturgeon	**5. Are Program flow management actions detectable in the LPR?**		
Management Action	**Priority Management Hypothesis**		
Revise & expand stage change study Research uncertainty – Implement expanded stage change study in the lower Platte River below the confluence with the Elkhorn River.	**PS1** – Program flow management actions, including the diversion of flows in excess to targets, are detectable in the lower Platte River below the mouth of the Elkhorn River. Need to consider flow additions as well Are Program water withdrawals for re-timing detectable below the Loup River? Still trying to define what habitat is; piggyback on learning from Missouri River over next 3-4 years **Alternative Hypothesis** **PS1$_{Alt1}$ –** Program flow management actions are not detectable in the lower Platte River below the mouth of the Elkhorn River.		
NOTES: • *If PS1 affirmed, develop operational rules for Program water projects and water management actions, and GC decision on investigating PS2 and PS3. If PS1 rejected, STOP and GC decision on meaning of Program goal language in the Final Program Document – "testing the assumption that managing flow in the central Platte River also improves the pallid sturgeon's lower Platte River habitat."* • *PS1, PS2, & PS3 are spatially constrained by the definition of associated habitat in the Final Program Document – "With respect to the pallid sturgeon, the term "associated habitat" means the lower Platte River between its confluence with the Elkhorn River and its confluence with the Missouri River."*			
Pallid Sturgeon	**6. Do Program flow management actions influence pallid sturgeon spawning habitat in the LPR?**		
Management Action	**Priority Management Hypothesis**		
Intensive monitoring and research Research uncertainty – Implement in-depth research study in the lower Platte River below the confluence with the Elkhorn River to define spawning habitat; determine when and how pallid sturgeon use that spawning habitat; and relate spawning habitat availability to unfavorable hydrologic events.	**PS2** – Program flow management actions are detectable in the lower Platte River below the mouth of the Elkhorn River and have a detectable effect the availability of habitat utilized by pallid sturgeon for spawning. **Alternative Hypotheses** **PS2$_{Alt1}$ –** Program flow management actions do not result in a detectable effect on key metrics of pallid sturgeon spawning habitat in the lower Platte River. **PS2$_{Alt2}$ –** Program flow management actions provide a detectable contribution to the pallid sturgeon spawning cue of diurnal water temperature during the April-May spawning window.		

CEM	PRRIP Extension Big Question	2020 Assessment	Basis for Assessment
Pallid Sturgeon	**7. Do Program flow management actions influence pallid sturgeon foraging habitat in the LPR?**		

Management Action	Priority Management Hypothesis
Intensive monitoring and research Research uncertainty – Implement in-depth research study in the lower Platte River below the confluence with the Elkhorn River to define foraging habitat; determine when and how pallid sturgeon use that foraging habitat; and relate foraging habitat availability to unfavorable hydrologic events.	**PS3** – Program flow management actions are detectable in the lower Platte River below the mouth of the Elkhorn River and have a detectable effect the availability of habitat utilized by pallid sturgeon for foraging. **Alternative Hypotheses** **$PS3_{Alt1}$ –** Program flow management actions do not result in a detectable effect on key metrics of pallid sturgeon foraging habitat in the lower Platte River. **$PS3_{Alt2}$ –** Program flow management actions provide a detectable contribution to the pallid sturgeon foraging habitat metric of connectivity with channel-margin habitat during the LPR low flow period of July-August.

Terns and Plovers (Big Question #1)

Management Objective
Improve production of the interior least tern and piping plover from the central Platte River.

Broad Uncertainty
Relationship between avian predation and tern and plover productivity.

Extension Big Question
1. *Does avian predation prevent the Program from meeting the tern and plover management objective?*

AMP Management Action(s)
Predator control test – Trapping mammalian predators at all sites and avian predators at a subset of OCSW sites.

Priority Management Hypothesis
TP1 – Avian predator control is necessary to meet three-year running average fledge ratio objectives and sustain sufficient long-term tern and plover productivity within the AHR.

Alternative Hypothesis
$\mathbf{TP1_{Alt1}}$ – Avian predator control is not necessary to meet three-year running average fledge ratio objectives and sustain sufficient, long-term tern and plover productivity within the AHR.

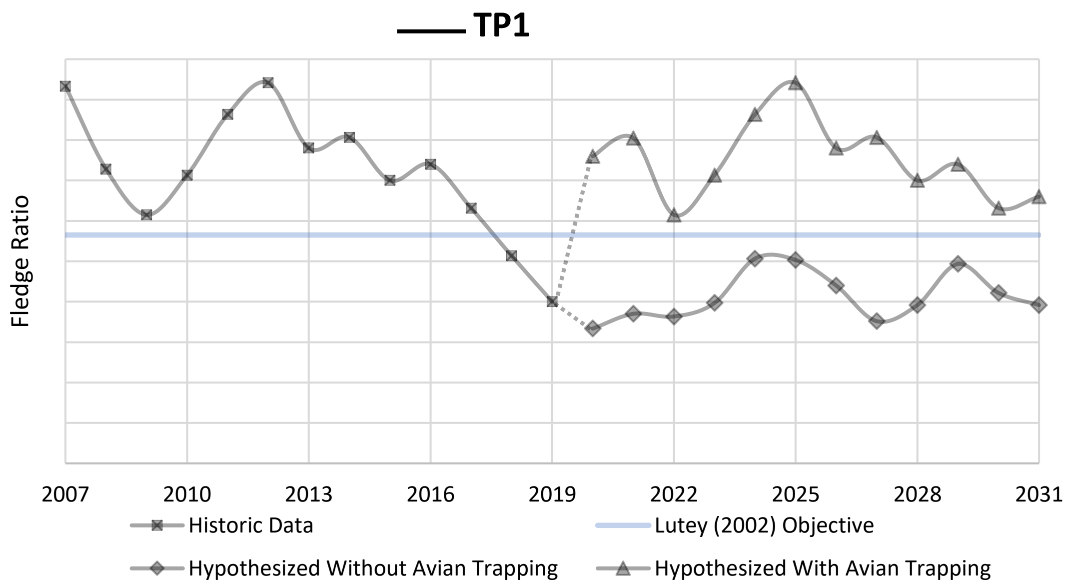
Considerations

- **Working assumption** – the Program is currently meeting the management objective and the GC decided to adjust management for terns and plovers related to OCSW habitat, MCA habitat, and flow; it is hypothesized that one of the key remaining uncertainties that might negatively affect long-term maintenance of target tern and plover fledge ratios is avian predation.
- Plover productivity has declined substantially since the Program quit increasing new habitat, sites are getting older, and it appears avian predators may be keying in on these older sites.

How do we visualize this for the GC?

- Graph, table, or other idea
- Metrics – what, why, how

Sample X-Y Graphs



- Use real data
- Separate graph for terns and plovers
- Include breeding pair numbers and fledges or total chicks produced; show trends over time
- Are we meeting the management objective? – need to see multiple metrics graphed over time, see pre-2007 numbers
- May reach plateau on breeding pairs or other numbers over time; indication we are still providing high-quality habitat

Sample Performance Indicators

- Target interior least tern fledge ratio – 0.70, three-year running average from Lutey (2002). This metric is calculated annually by the EDO based on data collected through implementation of the Program's tern and plover monitoring protocol.

- Target piping plover fledge ratio – 1.13, three-year running average from Lutey (2002). This metric is calculated annually by the EDO based on data collected through implementation of the Program's tern and plover monitoring protocol.

- Avian trapping – report presence or absence of avian trapping on Program OCSW nesting habitat site, reproductive success at trapped and non-trapped sites, and number of avian predators trapped per site.

Whooping Cranes (Big Questions #2-#4)

Management Objective
Contribute to the survival of whooping cranes during migration.

Broad Uncertainty
Relationship between flow, maintaining suitable unobstructed channel width (UOCW), and whooping crane use of the Associated Habitat Reach (AHR).

Extension Big Question
2. *Does Program flow management influence whooping crane riverine use in the AHR?*

- Is probability of WC use related to flow during the Program-defined crane migration seasons?
- Need to specify flow and what we mean by "in combination with other management actions"?
- Why do they stop?
- Why do they stay?
- Focus on impacting roosting habitat

AMP Management Action(s)
WC migration flow management (spring and fall migration) **–** Provide a range of flows during multiple spring and fall migration seasons.

Priority Management Hypothesis
WC1 – The frequency of WC use of the AHR declines when flows are below 1,500 cfs, but there is no incremental benefit of increasing flow above 1,500 cfs.

- What is the flow metric?
- What is the flow range during the WC migration season that is roosting habitat?

Alternative Hypotheses
$WC1_{Alt1}$ – The frequency of WC use of the AHR increases with flow.

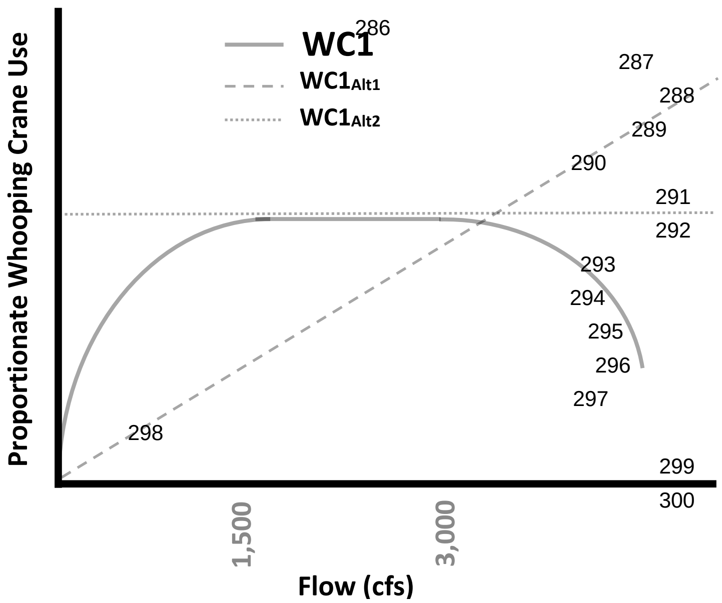
$WC1_{Alt2}$ – The frequency of WC use of the AHR is not influenced by flow.

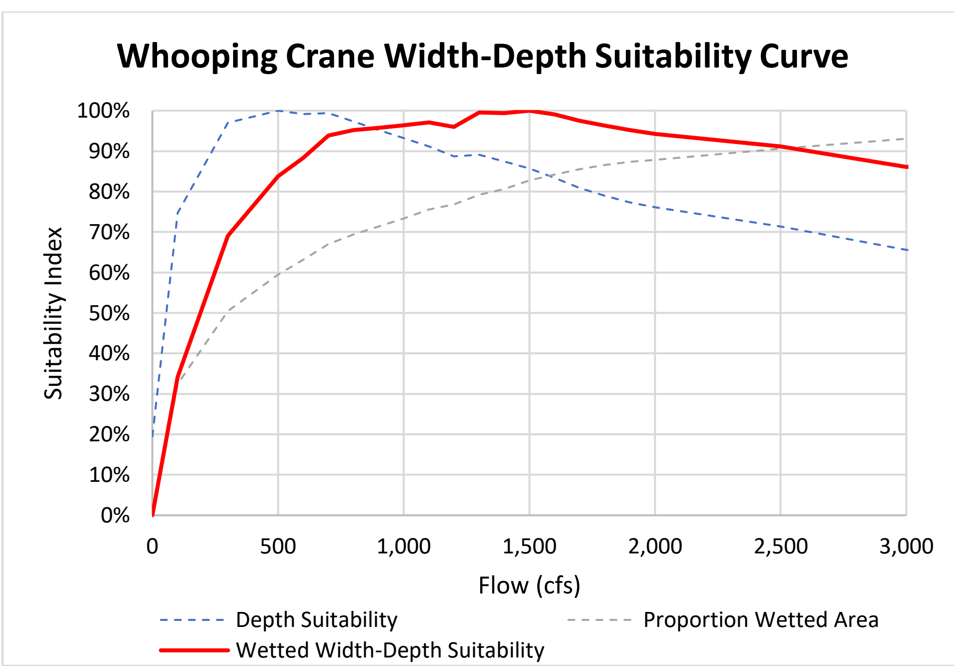
Considerations
- **Working assumption** – the Program is currently meeting the management objective; it is hypothesized that there is a narrow range of flows that may correlate to increased WC use of the AHR.
- Whooping crane use of the AHR has increased significantly during the spring migration.
- Use appears to be higher when flows are between 1,500 and 2,000 cfs (new telemetry data will be used to evaluate this further).
- Based on 2-D modeling suitable width-depth ratios are maximized when flows are between 1,500 and 2,000 cfs.
- Based on 2019 data, no use occurred until flows dropped below 3,500 cfs.

How do we visualize this for the GC?

- Graph, table, or other idea
- Metrics – what, why, how

<u>Sample X-Y Graphs</u>





Sample Performance Indicators

- Target whooping crane use of the AHR – 6% (spring) and 3.5% (fall) 5-year running average based on five-year running averages, 2007-2018 (below 2007-2015; above 2016-2018). This metric is calculated annually by the EDO based on data collected through implementation of the Program's whooping crane monitoring protocol.

Management Objective
Contribute to the survival of whooping cranes during migration.

Broad Uncertainty
Relationship between flow, maintaining suitable unobstructed channel width (UOCW), and whooping crane use of the Associated Habitat Reach (AHR).

Extension Big Question
3. *Can low-magnitude, long-duration flow releases during the germination period be used to maintain suitable UOCW in the channel when large natural peak flows do not occur?*

AMP Management Action(s)
Flow management test – Maintain 1,200 – 2,400 cfs during June 1 – July 15 and evaluate change in UOCW annually.

Priority Management Hypothesis
VEG1 – Maintaining average flows of 1,800 cfs during the germination period (June 1 – July 15) will prevent vegetation encroachment into the channel where it exceeds 650 ft, thereby maintaining 650 ft UOCWs for whooping cranes.

- Has to be a given that phrag control is ongoing; but does that mean it is not necessary to use water to control cottonwoods, etc. (if you spray one, you spray them all; same for mech.)
- Changes in channel width represented in graph assumes ongoing phrag control
- How much, how long, when
- Flow links to cockleburs and phrag
- Late season annual veg and crane obstruction

Alternative Hypotheses
$\mathbf{VEG1_{Alt1}}$ – Maintaining average flows of 2,400 cfs during the germination period (June 1 – July 15) will prevent vegetation encroachment into the channel where it exceeds 650 ft, thereby maintaining 650 ft UOCWs for whooping cranes.

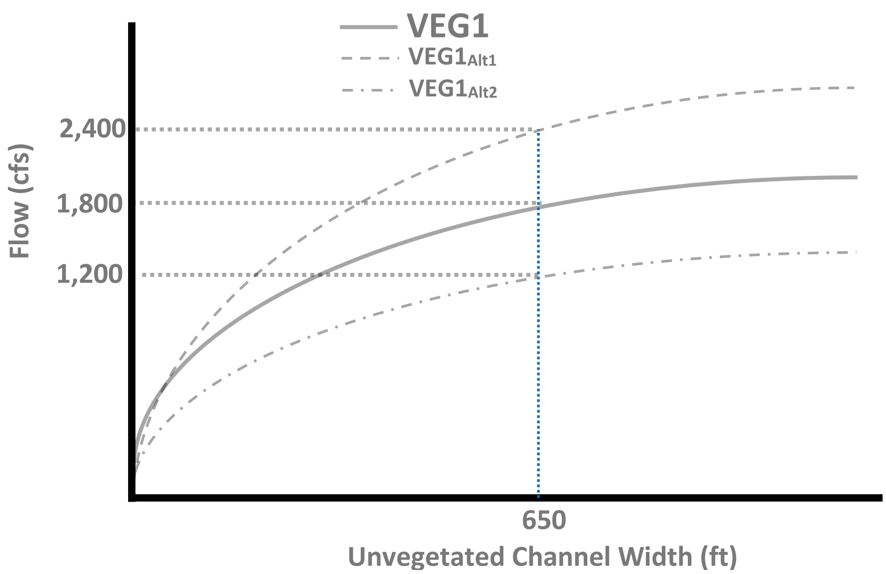
$\mathbf{VEG1_{Alt2}}$ – Maintaining average flows of 1,200 cfs during the germination period (June 1 – July 15) will prevent vegetation encroachment into the channel where it exceeds 650 ft, thereby maintaining 650 ft UOCWs for whooping cranes.

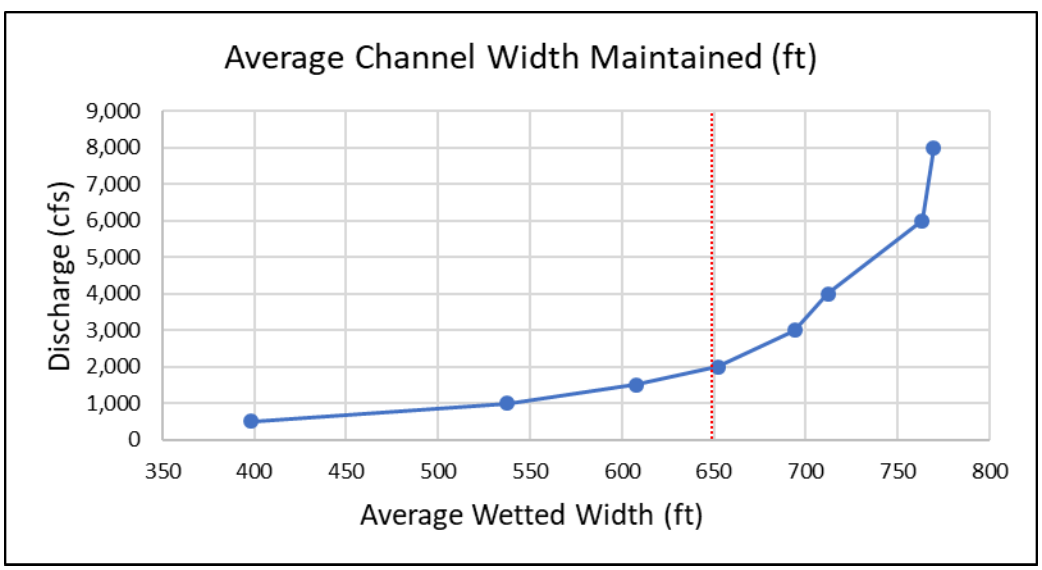
Considerations
- **Working assumption** – the Program is currently meeting the management objective; it is hypothesized that flow management during the summer vegetation germination period may have an effect on maintaining UOCW.
- Based on 2-D modeling, channels are generally >90% inundated when flows are 1,800 cfs.
- Based on recent EDO modeling efforts, it appears there is an influence of channel inundation during the germination season on maintaining unvegetated widths.
- X-Y graphs will be updated with results of final 2-D modeling efforts.

How do we visualize this for the GC?

- Graph, table, or other idea
- Metrics – what, why, how

<u>Sample X-Y Graph</u>

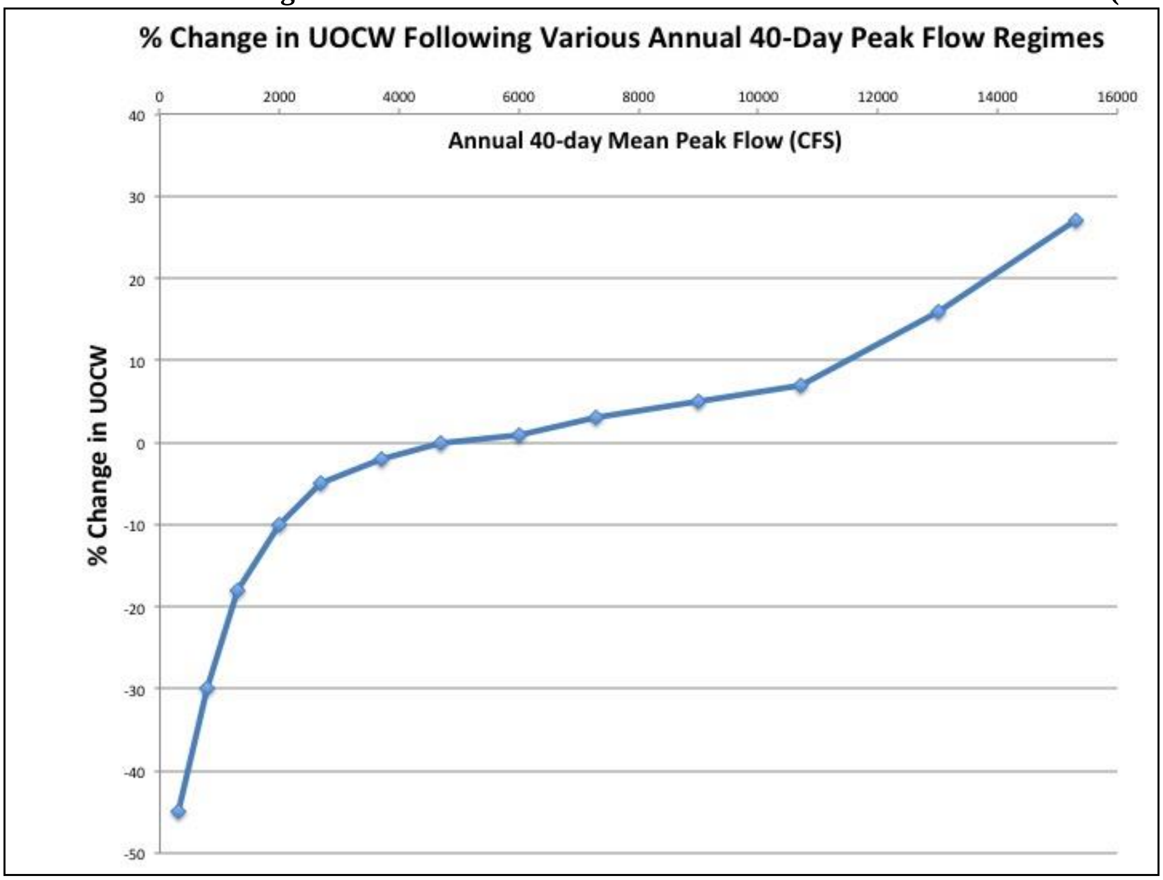




<u>Sample Performance Indicators</u>

- Target whooping crane habitat suitability – Maintain ≥650-foot wide UOCW and 1,100-foot unforested widths on PRRIP properties which are based on Program habitat selection analyses. This metric is calculated annually by the EDO based on data collected through implementation of the Program's geomorphology and vegetation monitoring protocol.

389 *Q1: Clarifying the impact of "sustained peak flows" on unobstructed channel width (UOCW) maintenance*
390 *(see Fig. 2,3 of PRRIP AMP).*
391 **What levels of 40-day annual peak flows are associated with the maintenance of stable, decreasing,**
392 **and increasing unobstructed channel widths (UOCWs)?**



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Management Objective
Contribute to the survival of whooping cranes during migration.

Broad Uncertainty
Relationship between flow, maintaining suitable unobstructed channel width (UOCW), and whooping crane use of the Associated Habitat Reach (AHR).

Extension Big Question
4. *Can late summer releases of 5,000 – 8,000 cfs for 3 days remove <1-year-old vegetation in channels with 650-foot wide UOCWs?*

AMP Management Action(s)
Flow management test – implement 5,000 – 8,000 cfs releases for three days during September and evaluate change in UOCW annually.

Priority Management Hypothesis
VEG2 – Flows of 8,000 cfs for three days in September will remove enough ≤1-year-old vegetation in channels with 650-foot wide UOCWs to maintain those widths.

Alternative Hypotheses
$VEG2_{Alt1}$ – Flows of 5,000 cfs for three days in September will remove enough ≤1-year-old vegetation in channels with 650-foot wide UOCWs to maintain those widths.

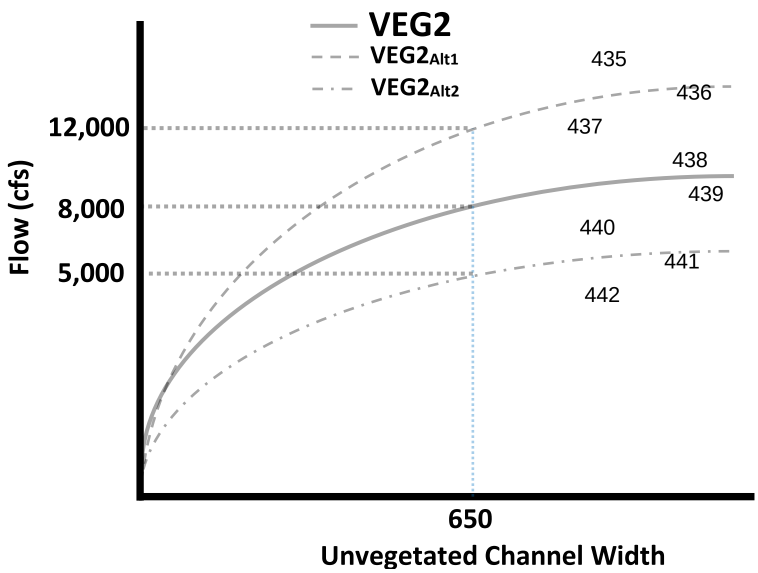
$VEG2_{Alt2}$ – Flows of 12,000 cfs for three or more days in September are needed to remove enough ≤1-year-old vegetation in channels with 650-foot wide UOCWs to maintain those widths.

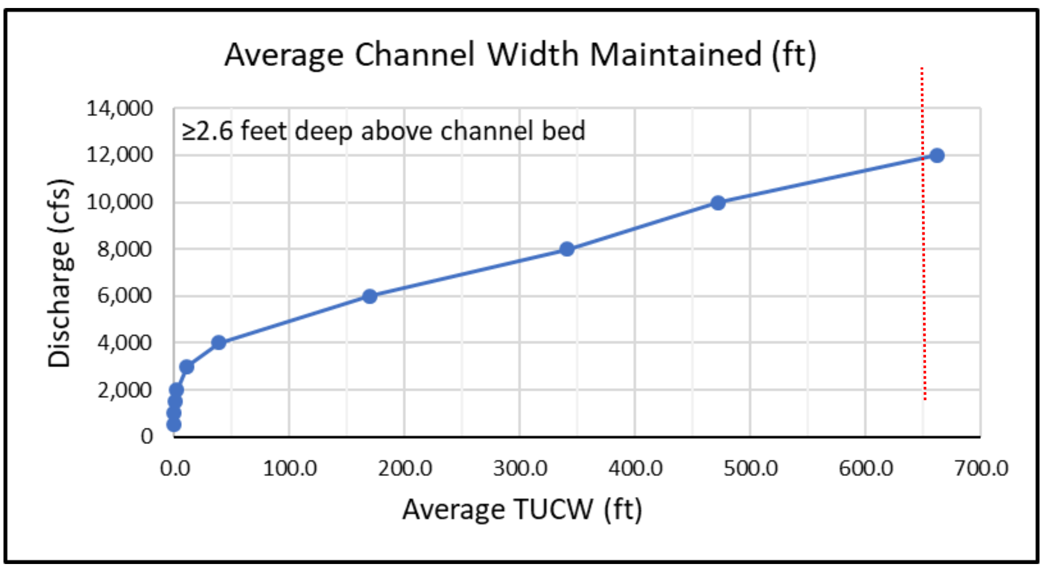
Considerations
- **Working assumption –** the Program is currently meeting the management objective; it is hypothesized that a fall SDHF may have an effect on vegetation scour and thus maintaining UOCW.
- Based on 2-D SedVeg model and Bankhead research, cottonwood seedlings can be uprooted (scoured) when inundated by 2.5-2.7 feet of flow.
- X-Y graphs will be updated with results of final 2-D modeling efforts.

How do we visualize this for the GC?

- Graph, table, or other idea
- Metrics – what, why, how

<u>Sample X-Y Graph</u>





<u>Sample Performance Indicators</u>

- Target whooping crane habitat suitability – Maintain ≥650-foot wide UOCW and 1,100-foot unforested widths on PRRIP properties which is based on Program habitat selection analyses. This metric is calculated annually by the EDO based on data collected through implementation of the Program's geomorphology and vegetation monitoring protocol.

Pallid Sturgeon (Big Questions #5-#7)

Management Objective
Avoid adverse impacts from Program actions on pallid sturgeon populations.

Broad Uncertainty
Relationship between Program water management actions and pallid sturgeon habitat availability in the lower Platte River.

Extension Big Question
5. *Are Program flow management actions detectable in the LPR?*

AMP Management Action(s)
Research uncertainty – Implement an expanded stage change study in the lower Platte River below the confluence with the Elkhorn River.

Priority Management Hypothesis
PS1 – Program flow management actions, including the diversion of flows in excess to targets, are detectable in the lower Platte River below the mouth of the Elkhorn River.

Alternative Hypothesis
PS1$_{Alta}$ – Program flow management actions are not detectable in the lower Platte River below the mouth of the Elkhorn River.

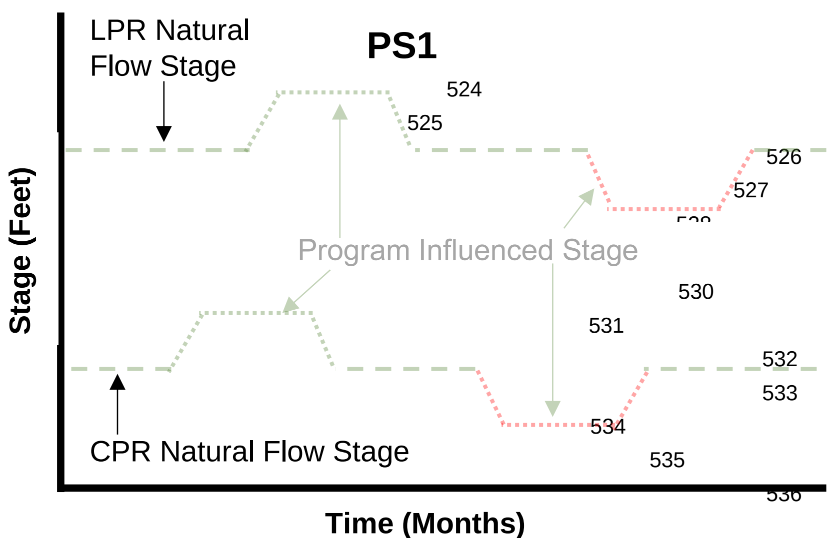
Considerations
- **Working assumption** – getting Program agreement (GC decision) on this question will determine the next steps in Program work related to pallid sturgeon. If PS1 is affirmed, the Program will develop operational rules for Program water projects and water management actions and it will be up to the GC to consider if/how to investigate Big Questions #6 and #7 and the associated priority management hypotheses (see following pages). If PS1 is rejected, the management objective will be met and it will be up to the GC to consider stopping further Program activity related to pallid sturgeon and dealing with issues related to the "testing the assumption" language in the Final Program Document; for the purposes of this hypothesis, "avoiding an adverse impact" means that Program water management actions are not detectable in the lower Platte.
- PS1 aligns with Objective #2 for pallid research during the Extension, as identified in the GC Meeting Summary – Pallid Workshop, September 13-14, 2017. Central questions:
  - Do we need to improve our tools to understand Program effects?
  - Are existing Program management actions having any effects?
- What does "detectable" mean? Needs defined for all pallid sturgeon questions and hypotheses.
- Data to be gathered and analyzed through implementation of expanded Stage Change Study or other tool as identified by the AMWG/TAC/ISAC and approved by the GC; EDO to develop scope of work; review and approval by AMWG, TAC, and ISAC; possible peer review of study scope; competitive selection for contractor; results peer reviewed through Program peer review process.
- Focus on hydrology, hydraulics, and geomorphology; attempt to detect changes in stage relative to expected Program water management actions – summer germination flow, fall SDHF, whooping crane migration flows.

- Interested in evaluating ability to detect Program flow management actions as a contribution to increasing discharge in the lower Platte River during the April-May spawning window; serves as a proxy for depth/velocity variability and channel width distribution.
- Interested in discharge and relationship to July-August diurnal water temperature – effects of Program water management actions on stage during this time period.
- If the only Program flow management action that is detectable is diverting water in excess of target flows at a time (based on historical record) when central Platte flows are exceeding targets but lower Platte flows are low at the same time, and if this diversion can be prevented in those circumstances by operational rules for Program water projects, would this still constitute as the Program meeting the management objective by "avoiding the adverse impact" of detectable flow management actions?

How do we visualize this for the GC?

- Graph, table, or other idea
- Metrics – what, why, how

<u>Sample X-Y Graph</u>



<u>Performance Indicators</u>

Stage – measurable changes in stage pre- and post-implementation of Program management actions.

Time – identify period of importance (i.e., spawning in April-May, foraging in July-August, etc.).

Management Objective
Avoid adverse impacts from Program actions on pallid sturgeon populations.

Broad Uncertainty
Relationship between Program water management actions and pallid sturgeon habitat availability in the lower Platte River.

Extension Big Question
6. *Do Program flow management action influence pallid sturgeon spawning habitat in the LPR?*

AMP Management Action(s)
Research uncertainty – Implement an in-depth research study in the lower Platte River below the confluence with the Elkhorn River to define spawning habitat; determine when and how pallid sturgeon use that spawning habitat; and relate spawning habitat availability to unfavorable hydrologic events.

Priority Management Hypotheses
PS2 – Program flow management actions are detectable in the lower Platte River below the mouth of the Elkhorn River and have detectable effect the availability of habitat utilized by pallid sturgeon for spawning.

Alternative Hypotheses
$PS2_{Alt1}$ – Program flow management actions do not result in a detectable effect on key metrics of pallid sturgeon spawning habitat in the lower Platte River, as defined by the Program.

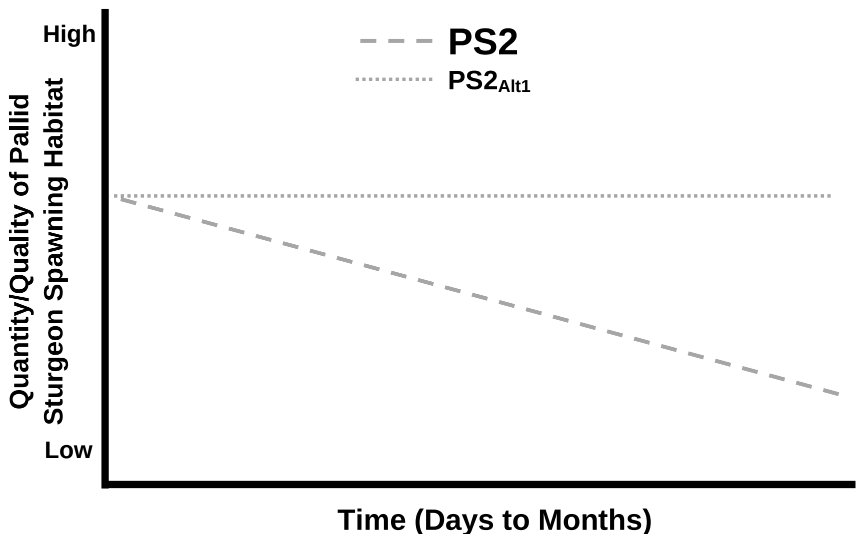
$PS2_{Alt2}$ – Program flow management actions provide a detectable contribution to the pallid sturgeon spawning cue of diurnal water temperature during the April-May spawning window.

Considerations
- **Working assumption** – PS1 is affirmed and Program flow management actions are detectable in the lower Platte River below the Elkhorn River confluence; for the purposes of this hypothesis, the "adverse impact" to be avoided is a reduction in the availability of pallid sturgeon spawning habitat as defined by the Program; possible related "adverse impact" to avoid – the potential for a "negative impact" on the spawning cue of water temperature in April-May.
- PS2 aligns with Objective #1 for pallid research during the Extension, as identified in the GC Meeting Summary – Pallid Workshop, September 13-14, 2017. Central questions:
  - When, where, and how are pallids using specific physical habitat features?
  - Define what constitutes habitat in the Platte.
  - Define unfavorable hydrologic conditions for pallid sturgeon.
- Define pallid sturgeon spawning habitat in the lower Platte River – something more than "water and sand"; need to complete this step in order to move forward; possible expert elicitation at the beginning to assist the Program with specifying what spawning habitat is in the lower Platte River (similar process to setting the minimum habitat criteria for terns/plover and whooping cranes).
- Once habitat is defined, next step is Program-organized research, attempt to do in partnership with UNL, NGPC, USGS, others; explore the relationship between use of that habitat for spawning and the spawning cue of diurnal water temperature; evaluate against an April-May spawning window.
- Consider correlations between air and water temperature, and discharge and diurnal water temperature' possible connection to turbidity.

How do we visualize this for the GC?

- Graph, table, or other idea
- Metrics – what, why, how

<u>Sample X-Y Graph from EDO</u>



<u>Performance Indicators</u>

Spawning habitat?

Time (April-May)?

Management Objective
Avoid adverse impacts from Program actions on pallid sturgeon populations.

Broad Uncertainty
Relationship between Program water management actions and pallid sturgeon habitat availability in the lower Platte River.

Extension Big Question
7. *Do Program flow management actions influence pallid sturgeon foraging habitat in the LPR?*

AMP Management Action(s)
Research uncertainty – Implement an in-depth research study in the lower Platte River below the confluence with the Elkhorn River to define foraging habitat; determine when and how pallid sturgeon use that foraging habitat; and relate foraging habitat availability to unfavorable hydrologic events.

Priority Management Hypotheses
PS3 – Program flow management actions are detectable in the lower Platte River below the mouth of the Elkhorn River and have a detectable effect the availability of habitat utilized by pallid sturgeon for foraging.

Alternative Hypotheses
$PS3_{Alt1}$ – Program flow management actions do not result in a detectable effect on key metrics of pallid sturgeon foraging habitat in the lower Platte River.

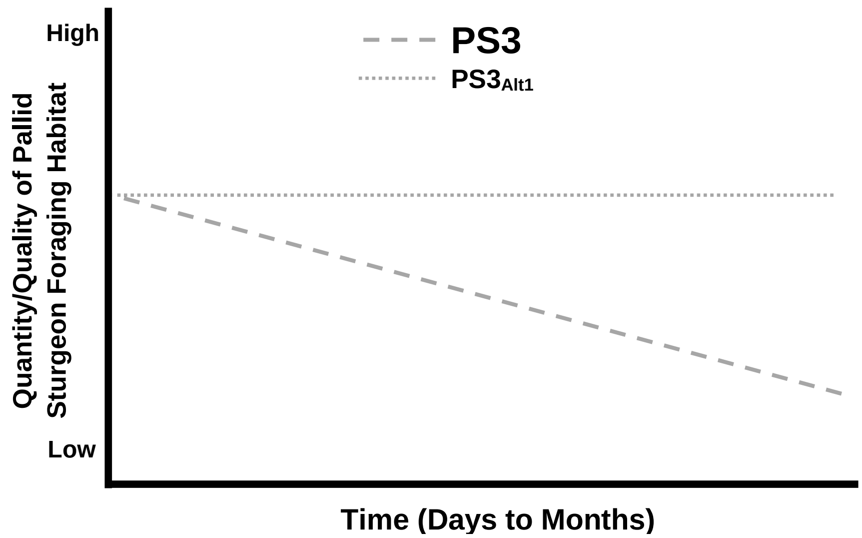
$PS3_{Alt2}$ – Program flow management actions provide a detectable contribution to the pallid sturgeon foraging habitat metric of connectivity with channel-margin habitat during the LPR low flow period of July-August.

Considerations
- **Working assumption** – PS1 is affirmed and Program flow management actions are detectable in the lower Platte River below the Elkhorn River confluence; for the purposes of this hypothesis, the "adverse impact" to be avoided is a reduction in the availability of pallid sturgeon foraging habitat as defined by the Program; possible related "adverse impact" to avoid – the potential for a "negative impact" on channel-margin habitat connectivity in July-August.
- PS3 aligns with Objective #1 for pallid research during the Extension, as identified in the GC Meeting Summary – Pallid Workshop, September 13-14, 2017. Central questions:
  - When, where, and how are pallids using specific physical habitat features?
  - Define what constitutes habitat in the Platte.
  - Define unfavorable hydrologic conditions for pallid sturgeon.
- Define pallid sturgeon foraging habitat in the lower Platte River – something more than "water and sand"; need to complete this step in order to move forward; possible expert elicitation at the beginning to assist the Program with specifying what foraging habitat is in the lower Platte River (similar process to setting the minimum habitat criteria for terns/plover and whooping cranes).
- Once habitat is defined, next step is Program-organized research, attempt to do in partnership with UNL, NGPC, USGS, others; explore the relationship between use of that habitat for foraging and channel-margin habitat connectivity; evaluate against the July-August low flow period.

How do we visualize this for the GC?

- Graph, table, or other idea
- Metrics – what, why, how

Sample X-Y Graph



Sample Performance Indicators
Spawning habitat?

Time (July-August)?

BQ5 – flow detection, use current question
Refine to capture Loup down
Focus on flow management actions that are likely to be on the table – spring WC flow, summer germination flows, fall SDHF, fall WC flow; any other target flow diversion or addition

BQ6 – spawning adults, use current question

BQ7 – embryos, larval juveniles: If, June-July AHR flow maintenance levels of 1,200-2,400 CFS proposed for whooping crane veg control (WC BQ #3) are detectable as an increase in the LPR in some water years, then, do these Program induced increases in flow in the LPR have an effect on dispersal of age-0 pallids (likely this would occur in late May early June largely depending on LPR water temperature)?

H1: Program induced increases in LPR flows during late May early June maintain habitat connectivity in the LPR and reduce isolation /stranding of age-0 pallids (likely benefit)

H2: Program induced increases in LPR flows during late May early June reduces retention (increases dispersal rate) of age-0 pallids (free-embryos and early feeding Larvae) in the LPR increasing the rate of transport to the MOR (possible adverse impact)

BQ8 – juveniles and non-reproductive adults, foraging, use current question