PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
2010 Parameter-based Research on Nest-site Selection and Reproductive Success of Interior Least Terns and Piping Plovers on the Central Platte River, Nebraska

I. INTRODUCTION

Population dynamics of interior least terns and piping plovers are greatly influenced by availability of breeding-ground habitat and nest-site selection (Ziewitz et al., 1992). Predation and flooding appear to be leading causes of nest and brood failure for interior least terns and piping plovers within the central Platte River Valley (Lingle, 1993a and 1993b); thus, interior least terns and piping plovers select nesting sites where these and other risks are reduced. Breeding-ground and nest-site selection by interior least terns and piping plovers are believed to be a hierarchical process where individuals make choices at varying spatial scales (Knetter et al., 2002). Features of the landscape (i.e., island shape and elevation, distance to predator perch or cover, nearest alternative nesting habitat, etc.) likely influence colony-level selection of breeding areas, while localized physiognomic characteristics (i.e., vegetative cover, sediment, slope, etc.) influence nest placement within the site (Smith and Renken, 1991; Flemming et al., 1992; Sidle and Kirsch, 1993; Knetter et al., 2002). Understanding important nesting habitat features at a variety of spatial scales will help us adapt our management plans and develop, manage, and conserve appropriate habitat for interior least terns and piping plovers.

This document describes methods for surveying river and sandpit habitats, locating nests and broods, and collecting and evaluating research parameters related to nest-site selection and nest and brood survival for interior least terns and piping plovers in the central Platte River valley, Nebraska. The design and implementation of this pilot-year study (2010) will be guided by the Platte River Implementation Program's (PRRIP or Program) Executive Director Office (ED Office or Program staff). The ED Office, using the Technical Advisory Committee (TAC) input, will evaluate results of this pilot-year study to determine what, if any, changes are needed in order to implement the protocol within all Program associated habitats in future years.

II. PURPOSE

This pilot-year study is designed to help refine data collection methods, determine the logistics of implementing such a study on a larger scale, and to provide a glimpse of factors that may influence interior least tern and piping plover nest-site selection and nest and brood survival along the central Platte River. Upon successful completion of this pilot-year study, we anticipate implementing a similar but refined research study directed toward evaluating Program management actions as they relate to improving the reproductive success of interior least tern and piping plover.

The objectives of this pilot study are to:

1) Quantify parameters associated with interior least tern and piping plover nest initiation and nest and brood survival at 2 areas containing riverine and sandpit nesting habitat;

2) Refine methodology and evaluate the logistics of implementing such a study within all Program associated habitats; and

3) Determine if conducting an intensive study, such as this, appears to impact interior least tern and piping plover nest and brood survival rates.

Additional long-term objectives include analyzing data as it relates to performance and decision criteria for Program hypotheses T1, P1, TP1, and TP5 outlined in the Program's Adaptive Management Plan (listed below) and to evaluate the influence the Programs Flow-Sediment-Mechanical (FSM) and Mechanical Creation and Maintenance (MCM) strategies have on habitat availability and nest-site selection and reproductive success of interior least terns and piping plovers on the central Platte River of Nebraska.

- T1 and P1 - Additional bare sand habitat will result in an increase in the number of adult interior least terns and piping plovers in the study area.
- TP1 - Interaction of river and sandpit habitat.
- TP5 - Use of riverine islands by interior least terns and piping plovers will increase as the active channel width increases.

We expect the number of interior least tern and piping plover adults observed on the river and the reproductive success of these individuals will increase as the amount of bare-sand area increases (T1, P1, and TP1) and anticipate active channel width will have a stronger influence on the reproductive rate and success of interior least terns and piping plovers as more habitat is made available (TP5). We also predict that the river, if provide adequate flow, can create and maintain suitable riverine habitat for nesting interior least terns and piping plovers (as is the case for the lower Platte River) which would reduce or eliminate our dependence on dozers and other mechanical actions to create and maintain nesting habitat on the central Platte River. These, however, are longer-term experimental objectives that we will only be able to assess after the Program's management strategies are implemented and data is collected over the course of several years.

III. DESIGN CONSIDERATIONS AND SPECIFICATIONS

III.A. Area of Interest

The 2010 interior least tern and piping plover nest-site selection research will consist of 2 focal areas along the Platte River; each area will encompass a 3-mile stretch of river and an associated off-channel sandpit. The focal area west of Kearney will include the Elm Creek river-island complex and Blue Hole sandpit site; this focal area will start at the Elm Creek (HWY 183) Bridge and will include a 3-mile reach of river downstream to the east edge of the John's Tract. The focal area east of Kearney will include the Dinan Tract and the recently purchased and enhanced Newark sandpit site; this focal area will start at the Minden (HWY 10) Bridge and will include a 3-mile reach of river downstream to the Rowe Sanctuary boat ramp. We chose these areas because only off-channel nesting has occurred west of Kearney and has occurred at the Blue Hole sandpit each year and only on-channel nesting has occurred east of Kearney and has occurred at the Dinan Tract each year since the Program was initiated in 2007.

III.B. Implementation

The proposed pilot study will be implemented for a period of 1 breeding season (2010) where habitat conditions at 2 locations will be measured prior to implementation of the Program's Flow-Sediment-Mechanical strategy (fall 2010 and spring 2011). This study is designed to complement the Program's ongoing Tern and Plover Foraging Habits Study and data collection efforts will be coordinated to limit the number of times researchers enter nesting sites. We will

also perform surveying and monitoring methods specified in the Program's Monitoring Protocol (PRRIP, 2010) within all Program associated habitat between Lexington and Chapman, Nebraska during 2010.

III.C. Sampling Design and Methods

Site visits will be conducted weekly between 1 May and 1 August; standardized field methods will be used during each visit to a nesting area. The following information will be recorded: date; time of arrival, entry into colony, and departure; weather conditions (temperature, cloud cover, wind speed and direction, and precipitation); number of interior least tern and piping plover adults, nests, and chicks present in the area; observations and band combinations of interior least terns or piping plovers banded by personnel conducting the Program's Foraging Habits Study or others conducting research on these species; and additional information as specified in this or the Program's Monitoring Protocol (PRRIP, 2010). Upon arrival during all site visits, we will visually scan potential nesting areas with binoculars or spotting scopes to determine how many interior least tern and piping plover adults, nests, chicks, and fledglings are present. Visual scans will be conducted for ≥5 minutes, or however long it takes to ensure accurate counts, and will occur from a distance to minimize disturbing birds. Following visual scans, we will enter the site and collect habitat measurements. No more than 2 visits per week will be made to any nest or brood; activity within the colony area will be limited to 20 minutes per observation period. If additional time is required to finalize data collection, the subsequent visit shall not occur until 1 hour has passed since the adults returned to their nest or brood; only 2 entries into a breeding colony will be allowed each day. All within-site observations will be conducted when the temperature is ≤90˚F (32˚C) to reduce stress and mortality to eggs and chicks.

We will evaluate habitat characteristics associated with interior least tern and piping plover nest-site selection and reproductive success at two spatial scales: 1) the macro-habitat scale (landscape-level selection), which will include features of the landscape at all observed and potential breeding habitat within the focal areas of this study; and 2) the micro-habitat scale (within-site nest placement), which will include habitat characteristics within 1 yd^2 of the nest and at random locations distributed across the river island or sandpit site containing the nest. Macro-habitat scale data will be collected to determine factors that influence landscape level nest-site selection and brood survival, whereas micro-habitat scale data will be collected to determine factors that influence within-site nest placement.

III.C.1. Macro-habitat Scale Nest-site Selection

We will assess the amount and quality of habitat available for nesting interior least terns and piping plovers by measuring the physical characteristics of all suitable river islands and sandpit sites within the focal areas of this study (see Section V) with and without nesting birds. We will visually classify vegetative canopy cover (<1%, 1–5%, 5–10%, 10–20%, and >20%), maximum height of living or current-year vegetation, percent bare ground, presence of potential nest-site furniture (non-living object within a 1-ft^2 area centered on a nest), and the predominant substrate [silt (<0.125 mm), sand (0.125–2 mm), small pebble (2–10 mm), gravel (>11–64 mm), and cobble (>64 mm)] present at 5 randomly chosen 1-yd^2 areas within each river island and sandpit site. We will also use a GIS or LRF to measure channel width (riverine sites only) and the distance from the center of each island or sandpit site to the nearest non-suitable nesting habitat

(excluding water; e.g., vegetated patch or bank line, etc.), predator perch >10 feet tall, and suitable nesting habitat of the same and alternate class (river or sandpit). As nests will be initiated throughout the breeding season, physical characteristics of all suitable river island and sandpit sites within the focal areas of this study will be measured weekly between 1 May and 1 August. Sites with nesting interior least terns or piping plovers will be visited twice each week during the breeding season to collect micro-habitat scale data as outlined in section III.C.2; macro-habitat scale data will be collected during 1 of these semi-weekly visits.

Site-specific Macro-habitat Measurements: At riverine sites, we will use a GPS unit (Trimble GeoXH or similar unit) to measure water-line elevation and surface area of each sandbar island and to create a polygon shapefile of each island by walking the perimeter and marking waypoints every 2−3 seconds (~10-yard intervals). When the perimeter of a sandbar is irregular, we will walk slower and collect more waypoints to provide a more accurate depiction of island size and shape. We will use a LRF and yard stick to measure the wetted width and the maximum depth of water between river islands and both bank lines by walking, perpendicular to river flow, from the point on the island nearest the bank line in both directions (i.e., minimum wetted width). Once we determine the location of the deepest point, a yard stick will be used to determine the depth and a GPS location will be collected. For observer safety, if depths exceed 3 feet we will record a depth of 3 feet and not proceed to determine the exact depth during the collection period. We will determine site-specific flow rates (ft^3/sec) using data collected at the nearest upstream and downstream USGS-gage station from each site as outlined in Section V.

At sandpit sites, we will use a GPS unit to delineate the size and shape of sandpit islands, measure elevation at the waterline, and to create a polygon shapefile of the nesting area by walking the along the inner sandpit-island shoreline and marking waypoints every 2−3 seconds (~10-yard intervals). Prior to or following the nesting season, we will map the bottom of shallow (<5 feet deep) sandpit lakes, for which we have access, to determine the easiest route for terrestrial predators to access sandpit islands and will record the maximum depth of water along this potential travel corridor. We will also estimate % bare sand area (<10%, 10-25%, 25-50%, 50-75% or 75-100% bare sand area) at each sandpit site and the total nesting area size based on the total size of each site and percent of the area classified as bare sand (<20% vegetative cover). Similar to river islands, when depths along potential travel corridors exceed 3 feet we will record a depth of 3 feet. Unlike river island sites, these site-specific, sandpit-island measurements will only be collected during the initial site visit unless the elevation of the waterline, measured at a single point, changes by >6 inches or when a major storm or other event results in changes in topography or shape of the island.

III.C.2. Micro-habitat Scale Nest-site Selection and Nest Survival

Similar to macro-habitat scale surveys, we will visually scan known nesting sites to locate nests and to count the number of interior least tern and piping plover adults, chicks, and fledglings present. Following visual scans we will enter the site, collect a GPS location of nests, mark nests with a numbered nest marker, float an egg (initial nest observation only), determine the fate and count the number of eggs in each nest, document the presence of adults tending each nest, and proceed to collect measurements to be used in micro-habitat scale nest-site selection or incubation-period nest survival analyses. Numbered nest markers (e.g., tongue depressor, paint stir-stick, or similar object) will be place 10 feet north of each nest, at a maximum height of 6 inches, to allow observers to easily locate and identify nests during subsequent visits. We will

use egg-floating techniques following methods of Hays and LeCroy (1971) and outlined in the U.S. Army Corps of Engineers' *Least Tern and Piping Plover Monitoring Handbook* (U.S. Army Corps of Engineers, 2009) to determine the initiation date.

When new nests are present, we will delineate the perimeter of the nesting site, as outlined in Section III.C.1, and generate 5 nest-specific random locations within the boundaries of the site. In order to minimize the amount of time spent within the nesting colony during each site visit, we will use a digital camera to collect information on micro-habitat scale characteristics present at each nest and random location; data will only be collected at random locations when nests are first observed, data collected during subsequent visits will only occur at the nest site and will be used in nest-survival analyses. The camera will be placed on a tripod stand set at a standardized height that results in a 1-yd^2 area field of view at ground level. We will place the tripod so the camera is centered on the nest or random location and collect a photo image of a 1-yd^2 area around each nest and random location during each visit. Prior to collecting the image, we will center a quadrat, delineating a 1-ft^2 area and 1-yd^2 area, on each nest or random location. A 3×5-inch card, uniquely identifying each nest or random location, will also be placed in the camera's field of view to ensure images collected at each location are properly identified. Information such as number of eggs in a nest, vegetative cover (<1%, 1–5%, 5–10%, 10–20%, and >20%), substrate [silt (<0.125 mm), sand (0.125–2 mm), small pebble (2–10 mm), gravel (>11–64 mm), and cobble (>64 mm)], distance from the center of the nest to nearest living or current year vegetation >6 inches tall within a 1-yd^2 area, and the presence of nest furniture within a 1-ft^2 area centered on each nest and random location will be determined off-site through visual examination of images. We will measure the maximum height of living vegetation within a 1-yd^2 area centered on the nest or random location. A GIS or LRF will be used to measure the distance from each nest and random location to the edge of the water, elevation above the waterline, nearest predator perch >10 feet tall, nearest non-suitable nesting habitat (excluding water), and nearest conspecific's and other species' nest located at the site. At riverine sites, we will measure the active channel width (width at 1,200cfs including land), wetted width, and maximum depth of the channels using methods outlined in Section III.C.1, and will determine time- and site-specific flow rates (ft^3/sec) using data collected at the nearest upstream and downstream USGS-gage station from each nesting colony as outlined in Section V. At the end of the nesting season, we will obtain data such as daily precipitation and maximum and minimum daily temperature from the High Plains Regional Climate Center (HPRCC) website; data collected at the HPPRC station nearest to the nesting site will be used in nest survival analyses.

III.C.3. Brood Survival

In order to determine factors that influence survival of interior least tern and piping plover broods, physical characteristics present at each river island or sandpit site containing a brood will be measured twice a week, will commence within a day of the estimated hatch date when possible, and will conclude once all broods at the site have failed or fledged. We will estimate the hatch date by adding 21 days to the date interior least tern nests were initiated and 28 days to the date piping plover nests were initiated. The fledging date will be considered to be 21 days (interior least terns) and 28 days (piping plovers) post-hatch unless more conclusive evidence, such as sustained flight, is documented prior to this date.

Similar to other surveys, we will visually scan known nesting sites from a distance to locate

broods and to count the number of interior least tern and piping plover adults, nests, chicks, and fledglings present. Following visual scans we will enter the site and use a GPS unit to delineate the perimeter and create a polygon shapefile of each site and will use a LRF and yard stick to measure the wetted width and maximum depth of water between the river island and both bank lines according to methods outlined in section III.C.1. When broods are present, we will generate and collect habitat measures at 5 observation-period specific random locations within the boundary of the brood site; the 5 random locations will be common for all broods present. In order to minimize the amount of time spent within the colony during each site visit, we will use a digital camera to collect information on habitat characteristics present at each random location; methods will be similar to those outlined in section III.C.2. Information such as vegetative cover, distance to nearest vegetation >6 inches tall, and the presence of potential nest furniture within the 1-yd^2 areas centered on each random location will be determined off-site through visual examination of images. Maximum height of living or current-year vegetation within the 1-yd^2 areas centered on each random location will be measured on site; % bare sand area at each site will be estimated. A GIS or LRF will be used to estimate active channel width at 1,200cfs, wetted width and depth of channels on each side of river islands, distance to non-suitable nesting habitat, distance to nearest predator perch >10 feet tall, and distance to and elevation above the waterline. At riverine sites, we will determine time- and site-specific flow rates (ft^3/sec) using data collected at the nearest upstream and downstream USGS-gage station from each colony as outlined in Section V. Similar to nest-survival analyses, data such as daily precipitation and maximum and minimum daily temperature collected at the HPPRC weather station nearest the brood-rearing site will be obtained and used in brood survival analyses.

III.D. Personnel

We anticipate the need to hire 3 seasonal technicians to assist the Research Coordinator, USGS-NPWRC personnel, and Program partners with efforts in collecting data outlined in this protocol and the Program's Monitoring Protocol during 2010 (PRRIP, 2010). Each crew member will participate in a federally approved, Mine Safety and Health Administration training session offered by the Tern and Plover Conservation Partnership (CFR 46) and will attend an approved bird monitoring and handling training session conducted by either the U.S. Army Corps of Engineers or the U.S. Geological Survey to meet state and federal permitting requirements. Crews of 2−3 people will survey each of the focal areas for nesting piping plovers or interior least terns and collect macro-habitat scale nest-site selection data once a week as outlined in Section III.C.1; sites with nesting or brood-rearing birds will be visited and data will be collected twice a week as outlined in Sections III.C.2 and III.C.3. The Research Implementation Coordinator will coordinate research and monitoring activities, assist with data collection (30−40 hours/week), coordinate assistance from Program partners' personnel when needed, and compile data into a single electronic database. The Program's airboat, or alternative means of transportation (4-wheeler, canoe, etc.) during periods of high or low river flow, will be used 3−4 days/week; additional days each week will be spent surveying off-channel habitat (sandpits) and entering data into an electronic database. The Research Implementation Coordinator will schedule the days each person will collect data on the river and make arrangements with Program partners if an additional airboat is periodically needed. Seasonal technicians will work 40 hours/week (including weekends) collecting and entering data; over-time work, though anticipated at times to complete field work, will be kept at a minimum. Seasonal technicians will

be scheduled to work 4 days per week and we will minimize the number of employees working on any given day as outlined in the example work-schedule table below.

IV. PRELIMINARY DATA ANALYSIS

Prior to analyzing the empirical data, we will explore ways in which management actions and parameter configurations might affect interior least tern and piping plover nest- and brood-site selection and survival. We will develop *a priori* sets of models that include various combinations of variables relative to Program priority hypotheses and management objectives for each analysis. Program R, or a similar program, will be used to develop our Bayesian random effects discrete-choice nest-site selection models (Thomas et.al, 2006) and programs such as R or MARK will be used to develop logistic-exposure nest- and brood-survival models (Shaffer, 2004; Shaffer and Thompson, 2007; Matthews et al., 2009; Schole et al., 2009). We will use results of these analyses to improve methods used to collect data in the future, to increase our understanding of factors that may influence interior least tern and piping plover macro-habitat scale nest-site selection, micro-habitat scale nest-site selection, and nest and brood survival within Program associated habitats, and to determine if methods employed appear to negatively impact nest and brood survival rates.

V. DEFINITIONS AND PARAMETER CALCULATIONS

Nest – A scrape in the sand, usually lined with pebbles, with eggs in it.

Nest Management – Management activities applied specifically to nests (i.e., exclosures).

Nesting colony – Area encompassed by multiple nests within which disturbance to one nest results in a disturbance reaction by adults of other nests. In cases where only a single nest is present, the nest will serve as the "colony" for habitat measurements.

Nest Initiation – Nest is initiated when it is constructed and at least one egg is laid.

Incubation Period – The incubation period for interior least terns and piping plovers will be considered to be 21 and 28 days from initiation, respectively.

Successful Nest – A nest is successful when at least one egg hatches.

Total Nests Initiated – Total number of nests initiated whether successful or not. This total includes first nesting attempts as well as re-nesting attempts.

Brood – 1 or more chicks that hatched from a single nest.

Brood-rearing Period – The brood-rearing period for interior least terns and piping plovers will be considered to be 21 or 28 days post-hatch, respectively, unless more conclusive evidence of fledging is documented.

Fledge – An interior least tern or piping plover chick will be considered fledged when it is 21 or 28 days old, respectively, when it is covered in unsheathed feathers, has a black eye stripe (interior least terns), and has a short tail, or when sustained flight is observed.

Successful Brood – Interior least tern or piping plover brood with ≥1 chick that fledges or survives 21 or 28 days after hatching, respectively.

Bare Sand – River island or sandpit site with <20% vegetative cover.

Bare Sand Area – Total area with <20% vegetative cover at the colony site.

Vegetative Cover – Average canopy cover determined at the macro-habitat scale by visual observations at 5 locations at each site. The observer will stand at 5 randomly chosen locations at each site and look straight down to determine the percent of bare sand area they observe within a 1-yd^2 area and will determine vegetative cover by subtracting this value from 1. For example, if the observer estimates 90% of the area is bare sand, vegetative cover at this point is 10%. For micro-habitat scale measures, vegetative cover within a 1-yd^2 area centered on the nest, brood, or random location will be estimated from photographic images using similar techniques.

Vegetation Height – Maximum height of all vegetation in a 1-yd^2 area centered on the nest or random location.

Available or Suitable Nesting Habitat – Habitat in the focal areas of this study will be classified as "available" or "suitable" if it is a river island or sandpit site with nesting interior least tern or piping plover adults, or if the riverine islands or sandpits fit the following minimum habitat criteria as defined by the Program:

Riverine Habitat

- At least **50% water** within a one quarter-mile river reach
- Within the same one quarter-mile reach of river, at least **1.5 acres of sand, 1.5 feet above 1,200 cfs reference stage in minimum channel width of 400 feet** (LiDAR [+/- 6"], RAS model; think about LiDAR every other year or every third year to get comparative data; data from Program geomorphology monitoring protocol)
- **Minimum buffer of island edge to bank of 50 feet** (Program ILT/PP protocol gets this at nest site; could measure when doing river surveys for protocol, or need additional boats/people; RAS model can give you sand area and water)
- **Less than 25% vegetative cover**; existing vegetation of 1.5 m or less in height (Program vegetation monitoring protocol – can it keep track of this changing on "habitat" over time?)
- **Edge of island at least 200 feet from any vegetation 1.5 m or higher above the top elevation** of the nesting island/bar (LiDAR)

Sandpit Habitat

- **Sandpits within Program associated habitats** along the river (for foraging)
- Per site, at least **1.5 acres of bare sand** (in a ratio of 1.5 to 4.5 acres of water)
- **Less than 25% vegetative cover** (CIR)
- **Edge of bare sand at least 200 feet from any vegetation 1.5 m or higher**

Elevation above waterline: We will determine elevation above waterline for each nest, random location, and transect point collected by subtracting the elevation of the waterline from the elevation present at these points.

Nearest Bank – Distance from each nest or random location to the nearest high bank across water measured off-site via GIS.

Active Channel (riverine) – Channels carrying water at minimum flows of 1,200 cfs.

Channel Width (riverine) – Width of entire open-channel, including land, measured from the center of river islands in a direction perpendicular to river flow.

Wetted Channel Widths (riverine) – Wetted width of the channel on each side of the nesting area measured with a survey grade GPS unit or laser-range finder.

Pond Size (sandpit) – Size of pond adjacent to sandpit sites. This parameter will be measured using a GIS.

Distance to Water – Distance a nest or randomly generated location is to the closest river channel or sandpit pond during the site visit. This parameter will be measured using a GIS.

Site Management – Non-flow related management activities applied to river island or sandpit sites (i.e. predator fencing, predator trapping, herbicide application, mowing) that occurred between the previous and current breeding seasons.

Adjacent Land Use – Land use classification within 200 feet of river island or sandpit sites.

Site-specific water flow: We will obtain maximum, minimum, and average daily discharge (ft^3/sec) as well as observation-period specific discharge data at 4 locations from the "USGS Real-Time Water Data for Nebraska" website including Overton (USGS gage 06768000), Cottonwood Ranch near Overton (USGS gage 06768035), Kearney (USGS gage 06770200), and Grand Island, Nebraska (USGS gage 06770500). We will use the location of each river island site with respect to the nearest upstream and downstream USGS gage to extrapolate flow data collected at the nearest upstream USGS gage of the site to determine site- and observation-period-specific flow at the time habitat characteristics are measured. For example, if we determine it requires 12 hours for flow at the nearest upstream gage to reach the nearest downstream gage and the river island site is located half way between these gage sites, we will record the flow that occurred at the nearest upstream gage 6 hours prior to the observation period. We will also determine site-specific flows present during nest initiation and hatching using procedures outlined above, however, maximum, minimum, and average daily USGS-gage data collected the day (estimated or observed) nests are initiated or hatched will be used. We will account for the time lag, as in the previous example, when we calculate maximum, minimum, and average daily flows. For the site in the example above, the 24-hour period maximum, minimum, and average daily flow would include 6 hours of the day previous to and 18 hours during the day nests were initiated or hatched. The accuracy of our measurements would be greatly enhanced through the purchase and installation of additional flow gages (3−5) at various habitat complexes within the focal areas of our work.

Apparent Nest Success – Total number of successful nests divided by total number of nests initiated (i.e., if 125 nests were initiated and 100 nests were successful, nest success is 80%).

Apparent Nest-based Hatching Success – Number of eggs that hatched successfully divided by total number of eggs.

Apparent Nest-based Fledging Success – Number of fledged birds per initiated nest (i.e., if 60 chicks were fledged from 50 nests, the fledging success would be 1.2 fledged birds per nest).

Apparent Hatch-based Fledging Success – Number of fledged birds per successful nest (i.e., if 60 chicks were fledged from 30 successful nests, the hatch-based fledging success fledging success would be 2.0 fledged birds per successful nest).

Work schedule during weeks we conduct research, survey the river, and monitor nesting sites between Lexington and Grand Island

Week Day	Research Coordinator	Technician 1	Technician 2	Technician 3
Monday	**Lexington–John's Tract** Survey river; Monitor nesting sites; Research at all habitat in focal area	-----	**Lexington–John's Tract** Survey river; Monitor nesting sites; Research at all habitat in focal area	**Lexington–John's Tract** Survey river; Monitor nesting sites; Research at all habitat in focal area
Tuesday	**John's Tract–Rowe Headquarters** Survey river; Monitor nesting sites; Research at all habitat in focal area	**John's Tract–Rowe Headquarters** Survey river; Monitor nesting sites; Research at all habitat in focal area	-----	**John's Tract–Rowe Headquarters** Survey river; Monitor nesting sites; Research at all habitat in focal area
Wednesday	**Rowe Headquarters–Grand Island** Finalize any river surveys; Monitor nesting sites	**Rowe Headquarters–Grand Island** Finalize any river surveys; Monitor nesting sites	**Rowe Headquarters–Grand Island** Finalize any river surveys; Monitor nesting sites	-----
Thursday	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area
Friday	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area

Work schedule during weeks we conduct research and only monitor nesting sites between Lexington and Grand Island

Week Day	Research Coordinator	Technician 1	Technician 2	Technician 3
Monday	**Lexington–John's Tract** Monitor nesting sites; Research at all habitat in focal area	-----	**Lexington–John's Tract** Monitor nesting sites; Research at all habitat in focal area	**Lexington–John's Tract** Monitor nesting sites; Research at all habitat in focal area
Tuesday	**John's Tract–Rowe Headquarters** Monitor nesting sites; Research at all habitat in focal area	**John's Tract–Rowe Headquarters** Monitor nesting sites; Research at all habitat in focal area	-----	**John's Tract–Rowe Headquarters** Monitor nesting sites; Research at all habitat in focal area
Wednesday	**Rowe Headquarters–Grand Island** Monitor nesting sites	**Rowe Headquarters–Grand Island** Monitor nesting sites	**Rowe Headquarters–Grand Island** Monitor nesting sites	-----
Thursday	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area	**Lexington–Kearney** Monitor nesting sites; Research at nest sites in focal area
Friday	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area	**Kearney–Grand Island** Monitor nesting sites; Research at nest sites in focal area

VI. LITERATURE CITED

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