Wetland Program Development Grant (WPDG) FFY 2015

Development of Wetlands in Aging Reservoirs

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Grant Recipient: Kansas Water Office

Grant Title: Development of Wetlands in Aging Reservoirs

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Project Description:

1. National Priority Area. The Kansas governor has designated the Kansas Water Office (KWO) as the coordinating state agency for the Kansas Wetland Protection Plan and program. KWO developed and oversees the Wetland Program Plan for Kansas (KS-WPP) that focuses on state and national wetland priorities. This project addresses the following core elements listed in the KS-WPP: 1) identifying reservoir wetlands enhances the state's existing wetland inventory; 2) evaluating and assessing reservoir wetlands for wetland function and condition increases knowledge about the state's wetland resources; 3) providing up-to-date spatial data and characterizing current reservoir wetland condition as well as wetland loss/gain enhances the state's wetland program, and 4) characterizing reservoir wetlands will add to the state's wetland water quality database. While focused on identifying and quantifying wetland capacity and extent, this project will provide usable information regarding items C1 and D7 of the State of Kansas's Vision 2020 recommendations (Appendix 2).

2. Description of Need. Wetland ecosystems embrace a great variety of waterbodies that includes such things as swamps, marshes, bogs, fens, wet meadows and prairies, prairie potholes, playas, vernal pools and mudflats (Keddy 2010; Batzer and Baldwin 2012; USEPA 2015). The structure and function of wetlands is so varied and dependent upon soils, climate, broad-scale and local hydrology and other physical and biological factors that it remains difficult to adequately characterize and classify every type of wetland one may encounter in today's environment. In addition to natural occurring wetlands, modern landscapes often contain artificial or created wetlands that were constructed to provide designated goods or services such as storm-water treatment and mitigation of lost wetland acres (e.g. Moshiri 1993; Mitsch 2005; Vymazal 2010).

Wetlands that are created or later developed from impounding lotic ecosystems are different from naturally occurring wetlands but nevertheless are wetlands as they possess many of the basic properties and processes associated with wetlands (Smith *et al.* 2008). Impounded wetlands often have reduced temporal productivity because of more stable water levels and longer hydroperiods, shorter life spans due to high sediment infill rates, increased nutrient and contaminant loadings, and extended hydroperiods that can cause major shifts in biota (Smith *et* *al.* 2008). Despite their shortcomings, wetlands associated with reservoirs and impoundments represent a substantial portion of today's wetland habitats in many regions of the country and provide unrecognized and underappreciated ecological goods and services to society. This project will, in part, identify, quantify and characterize some of the reservoir wetland systems found in Kansas. This synoptic survey focuses on quantifying wetland extent and location within reservoirs while assessing selected wetland elements that will help characterize the hydrology, biology, and physical and water quality properties of these systems to help determine future management opportunities. Figure 1 in Appendix 3 shows development of potential wetlands in the riverine segment of Tuttle Creek Lake in northeastern Kansas both connected to and isolated from the reservoir waterbody at or near the designated conservation pool level. Wetlands connected to the reservoir waterbody at conservation pool levels are the focus of this project. Legal protection is offered to natural wetlands by the US Army Corps of Engineers (USACE) under Section 404 (CWA) if they exhibit all of the following primary characteristics: hydrology, hydrophytes and hydric soils (see review by Strand and Rothschild 2010). It is important to understand that some areas that function ecologically as wetlands may possess only one or two of these three characteristics of jurisdictionally-defined wetlands. Such wetlands, however, perform valuable functions. US Fish and Wildlife Service (USFWS) identifies wetlands as ecosystems that are transitional between terrestrial and aquatic systems and are characterized by one or more of the following: 1) system periodically supports mostly hydrophytes; 2) bottom substrate is un-drained hydric soils; and 3) the substrate is non-soil and saturated or inundated by shallow water during the biological growing season (Cowardin *et al.* 1979).

While structural definitions (i.e. structural classification schemes) of wetlands remain somewhat elusive, wetland functions are less contentious and better accepted qualities of wetlands. USACE classified wetland functions into three broad categories (hydrological, biogeochemical, and habitat and food web support) with many specific functions and societal values listed (Smith *et al.* 1995). More recently, Tiner (2003) provided the rationale for the functional criteria used to identify wetlands of potential landscape significance in the Northeast. These functions include: 1) surface water detention, 2) coastal storm surge detention, 3) streamflow maintenance, 4) nutrient transformation, 5) sediment and other particulate retention, 6) shoreline stabilization, 7) provision of fish and shellfish habitat, 8) provision of waterfowl and waterbird habitat, 9) provision of other wildlife habitat, and 10) conservation of biodiversity.

Natural ecosystems and especially wetlands are in danger worldwide. Many anthropogenic and natural factors have contributed to wetland loss and degradation. These factors include land use change, irrigation, infrastructure development, hydrological modifications, water pollution, climate change, and sea level rise (Millennium Ecosystem Assessment 2005; Boelee *et al.* 2011). Kansas has lost about half of its natural wetlands through cropland conversion and surface and groundwater depletions (Fretwell *et al.* 1996). Many of these wetlands are irreplaceable due to the permanency of prior conversions and reductions in available water in some areas of the state. This is similar to what has happened in California's Central Valley, where more than 95 percent of the original wetland area has been lost (Gilmer *et al.* 1982) and increasing demands for water and land resources make it unrealistic to recover significant portions of the original wetland area. Wetland construction, restoration, and conservation are important considerations in both state-wide and nation-wide water resources management programs because of their role in preserving and enhancing water quantity and quality. Some of the many services wetlands can provide are: a) moderation of extreme precipitation and discharge events; b) sediment storage and load reduction into reservoirs and other water resources; and c) sequestration of pollutants and reduced downstream water resource contamination;(United Nations WWAP 2015) . These facts have prompted Kansans to focus on preserving wetland quality and identification of waterbodies and aquatic resources that provide possible wetland functions if not true wetlands by the USFWS definition. Currently, Kansas investigators are assessing the potential of farm ponds and small impoundments in providing many wetland functions either through natural aging processes such as infilling and hydrophyte community development or through possible enhancement activities (see EPA award CD 97746601-0 to the KWO, 2014).

We propose a similar approach in an assessment of the potential wetland functions of the riverine segments of a subset of the 24 federal reservoirs located throughout Kansas. These reservoirs are now decades old having mostly been constructed in the 1960s and 1970s. It appears that within the riverine segments of these reservoirs wetlands have evolved or are evolving as part of the reservoir aging process driven in part by sediment infilling and nutrient enrichment and resuspension (Jakubauskas *et al.* 2014; Dzialowski *et al.* 2008). Figure 2 in Appendix 3 illustrates the historical change of the Tuttle Creek Lake surface area. Approximately 30% of the lake surface area has been lost since establishment of the reservoir in 1962. Figure 1 shows that as the reservoir is filling with incoming sediments, the surface area converts to shallower areas where potential wetlands can exist. The shallow zone (depth < 2 m) covers approximately 8.5 km^2 (19%) of the current Tuttle Creek Lake surface area. Water quality of these reservoirs varies spatially within the lake changing temporally and probably with inflow variations, suggesting that the water components in the riverine segments will ultimately move down to deeper areas and impact the whole lake. This temporal and spatial variability can be seen in Figure 3 (Appendix 3) that shows a changing but distinct chlorophyll-a gradient in Clinton Lake for dates in June and September 1997. The understanding that riverine segments of reservoirs may function as wetland areas is not new as both Carney (2002) and Fram *et al.* (2001) included these areas as wetlands in water quality studies in Kansas and California, respectively. Additionally, Nebraska identified two types of wetlands as occurring in their reservoirs – fringe wetlands and headwater wetlands (Pegg *et al.* 2015) while Mahlke (1996) identified five types of wetland communities in Oklahoma reservoirs. In addition to the riverine areas of reservoirs as developing wetland regions, reservoir deltas that have formed at the entry points of reservoir tributaries also seem likely areas for the creation of wetlands or systems with wetland functions. Potential biodiversity increases associated with aging reservoir deltas were addressed by Johnson (2002). Johnson gives several regional examples of aging reservoirs that have developed deltas (deltaic) and riverine and shoreline (fringe) systems that have become wetlands in both form and function as outlined by USFWS (Cowardin *et al.* 1979) and others (Levine and Willard 1990; Keddy and Fraser 2000; Kusler 1990; Lewis 1995; Kentula 2000).

Please see the letters of support in Appendix 4.

3. Project Tasks. Initial efforts will identify a subset of 18 reservoirs from the 24 large federal reservoirs. Various physical, biological, hydrological, locational, and data characteristics criteria will be considered in the reservoir selection process.

Remote sensing, GIS, and Hydrology. To estimate federal reservoir surface area reductions attributable to sedimentation, we will compare original federal reservoir boundaries from USGS topographic maps to current boundaries used for recent bathymetric surveys as well as those derived from corresponding LiDAR elevation data. Historical reservoir inflow, outflow, and storage level information will be analyzed to estimate the temporal distribution of water depth in the reservoir. The most probable storage elevation will be utilized as the normal depth. The normal storage level is close to the conservation pool elevation in the eastern reservoirs where annual precipitation typically is adequate for normal lake level maintenance. In contrast, the normal storage level is lower than the conservation pool for a majority of the western reservoirs due to typically inadequate precipitation (Rahmani et al. 2015; USACE 2015). Two shallow zones, identified from recent bathymetric survey data, will be studied in this project for potential wetland function: 1) area with depth two meters or less, and 2) area with depth one meter or less. Wetland potentials will be analyzed for both low and high water conditions. Frequency distribution of flooded/dewatered periods will be examined for wetland areas. Water retention time will also be estimated using the inflow and outflow data. We will study the impacts of retention time on water quality in the reservoirs**.**

Water Quality. In this synoptic study water quality and phytoplankton samples will be drawn from a single composite sample of water collected from the upper 0.25 meters of the water column at five locations within each riverine and main basin segment. Three equally-spaced 500 ml samples will be collected along a longitudinal transect following the mid-line of the study reach from the uppermost boat accessible site to the downstream end of the segment. In addition, at the center longitudinal sampling point two samples will be collected midway between the center sample and right and left shorelines to create a perpendicular sample transect line. These five 500 ml samples will be composited into a one-gallon sample container, placed on ice, and returned to the Central Plains Center for Bioassessment (CPCB) laboratory for analyses of chlorophyll-a, TSS, and VSS while a subsample will be sent to Kansas State University (KSU) soils lab for nutrient analysis. A Horiba® Model U-52 sonde will be used to measure *in situ* water parameters.

Sediment. Sediment cores will be collected and analyzed to determine recent sediment physicochemical conditions in the study segments. The same sampling regime will be used to generate a composite sample from five samples obtained from the upper 5 – 10 cm of sediment using a small hand corer (i.e. Wildco® liner-type Hand Corer). The composite samples will be returned to the University of Kansas (KU) Pedology Laboratory for analyses of three soil particle size classes, bulk density, total phosphorus and nitrogen, and percent organic matter (see Table 1 in Appendix 3).

Biology. Because plant communities are the most recognized biological feature of wetlands and contribute greatly to habitat structure, biological sampling will focus on measures of the phytoplankton and macrophyte communities. As outlined above, a subsample of water will be retained by CPCB for phytoplankton chlorophyll-a and phaeophytin-a analyses as estimates of phytoplankton biomass. We will use the macrophyte sampling techniques employed by Kansas Department of Health and Environment that is based on the "point-quadrat method" (KDHE 2014). Specimens not identifiable in the field will be returned to the KU's McGregor Herbarium for identification. Macrophyte abundance will be reported as "percent of stations with macrophytes," and used as a surrogate of areal cover. The same metric will be applied to each species as a measure of relative species abundance, while the number of species provides an estimation of species richness. The predominant macrophyte taxa that form extensive surface or subsurface colonies (≥ 100 m^2) will be mapped. All invasive and exotic aquatic plant species noted and mapped. These include species listed in Midwest Aquatic Plant Management Society's Plant Reference Chart (http://www.mapms.org/wp-content/uploads/2013/01/plantid.pdf) and by Kansas Department of Wildlife, Parks and Tourism (KDWPT 2014). Nuisance aquatic animal species observed in these study segments will also be recorded. Finally, bird species seen adjacent to and near each site and recorded at the eBird website (http://ebird.org/content/ebird/) will be listed.

Project Goals and Objectives:

Accomplishments for this reporting period are shown in red in the following text.

Goal 1. Identify and inventory prior determined fringe, deltaic and riverine wetlands associated with major reservoirs and impoundments in Kansas

Action 1

Review NWI for listed wetlands either created by or hydrologically associated with reservoirs in Kansas. Timeframe 01/2016 to 04/2016

Progress:

We meet internally to discuss resources and plans to search in national wetland inventory for wetlands associated with reservoirs in Kansas.

Action 2

Identify and compile other sources of wetlands associated with reservoir systems in Kansas. Timeframe 01/2016 to 04/2016

Progress:

We plan to meet internally to discuss other sources of wetland associated with reservoirs in Kansas.

Goal 2. Delineate potential wetland areas in study reservoirs using existing reservoir bathymetry, historic water level data, historic and current reservoir boundaries, remote sensing and geographic information system (GIS) techniques where appropriate and available.

Action 1

Identify and map potential wetland area groups (2 groups) that have water at reservoir-designed conservation water level or current lake level: group 1 is areas $\leq$ 2 meters deep; and group 2 is areas $\leq$ 1 meter deep. Timeframe 01/2016 to 04/2016 & 01/2017 to 04/2017.

Progress:

We have started gathering hydrologic and LiDAR data for this action.
This will continue during the first quarter of 2016.

Action 2

Identify and map potential wetland pond areas and complexes that are predominately dry or hydrologically outside the reservoir conservation water level. Timeframe 01/2016 to 04/2016 & 01/2017 to 04/2017.

Progress:

We have started gathering hydrologic and LiDAR data for this action.
This will continue during the first quarter of 2016.

Goal 3. Select group 1 or group 2 conservation or current normal level potential wetland areas and main basin areas for field studies and sampling.

Action 1

Using existing remote sensing imagery and select either group 1 or 2 coverages as best estimators of potential wetland areas for field studies and synoptic sampling. Timeframe 04/2016 to 08/2016 & 04/2017 to 08/2017

Progress:

Action 2

Field reconnaissance of subset of reservoirs to validate group selection from Action 1 as best GIS-based predictor of potential wetland areas. Timeframe 06/2016 to 07/2016

Progress:

Goal 4. Use existing bathymetric, reservoir and water level data to identify and quantify a set of hydrological attributes of potential importance to wetland development and function (e.g. season water level changes, area dewatered) that can be used to characterize study areas

<u>Action 1</u>

Analyze reservoir inflow and outflow data to estimate lake retention time. Timeframe 06/2016 to 09/2016

Progress:

<u>Action 2</u>

Analyze reservoir storage level, precipitation, and evaporation information to estimate depth in low and high water conditions and examine frequency distribution of flooded/dewatered periods for potential wetland areas. Timeframe 06/2016 to 09/2016

Progress:

Goal 5. Field evaluation and sample collection in potential wetland areas identified in Goal 3. Collectively for this goal, we request $3000 each year for field supplies (boat gas and maintenance, sample containers, Horiba U-52 maintenance, plant press materials, ice, shipping, expendables, etc.) and $1,505 each year for lab fees for the KSU's Soil lab (water samples) and KU Pedology lab (soil samples, approximately 80 samples to each lab, average $68/sample).

<u>Action 1</u>

Collect a composite sample comprised of equal volumes of water or sediment from each riverine and main basin study area. Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017

Progress:

Action 2

Send water and sediment samples to laboratories for analysis of total nitrogen, total phosphorus and TOC, also sediment primary particle size categories, bulk density and percent organic matter. Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017

Progress:

Action 3

Obtain *in situ* water quality parameters at one site (center) along a depth profile in each riverine and basin study area. Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017

Progress:

Action 4

Prepare composite water samples for chlorophyll-a analysis. Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017

Progress:

Action 5

Estimate surface area of macrophytes using protocols and techniques adopted from either or both the lake and wetland field operations manuals and available in remote sensing or photographic imagery (USEPA 2011a; USEPA 2011b). Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017. Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017

Progress:

Action 6

Compile a list of all shorebirds and water birds observed at and near study sites and submitted to eBird website. Additional waterfowl use information will be sought out and incorporated when available. Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017

Progress:

Action 7

Create and populate field database as data become available, analyze data, using descriptive, graphical and statistical techniques. Timeframe 07/2016 to 10/2016 & 07/2017 to 09/2017

Progress:

Goal 6 Project Administration: Project administration

Action 1

Write QAPP. Timeframe 01/2016 to 03/2016

Progress:

During this reporting period we began the QAPP and will finalize it during the next reporting period.

Action 2

Write reports. Timeframe qtrly & 09/2017 to 12/2017

Progress:
This report serves as Report 1, completed during reporting period 2.

Goal 7 Project coordination and adaptive management efforts

Action 1

Meet annually with EPA project officers to discuss: accomplishments as measured against work plan commitments; the cumulative effectiveness of the work performed under all of the work plan components; and existing and potential problem areas. Timeframe 08/2016 & 08/2017

Progress:

Action 2

Seek suggestions for project improvement from other experts and where feasible, schedules for making improvements. Timeframe 08/2016 & 08/2017

Progress:

Obstacles/Remedies

Changes in Personnel

Equipment Purchased in Current Quarter

Upcoming Activities

Accomplishments measured against work plan commitments

Existing and potential problem areas

Cumulative effectiveness of the work performed

Suggestions for improvement including, where feasible, schedules for making improvements