Environmental Pools Recommendations
Workshop Summary

Photo by John Hickey, USACE

Kansas River Sustainable Rivers Program

August 2023

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The Nature Conservancy
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Acknowledgements

This project was made possible with support from the Sustainable Rivers Program and time and effort contributed by numerous agencies and individuals throughout the project. Development of the information detailed in this report was a collaborative effort. Input from regional and state scientists and stakeholders were critical to this effort.

The shared purpose of the project was to convene key personnel and partners to provide strong scientific and stakeholder support for the Sustainable River Program's commitment to improving ecological flows and reservoir health in the Kansas River system. Stakeholders and partners provided the input, expertise, and hypotheses on current and historical conditions as well as issues and needs.

A core team represented by the project partners led the science and technical integration effort. This group spent extensive time developing a plan for coordination and communication of science-based planning across stakeholder groups and identifying and targeting technical assistance as needed. The Nature Conservancy, Kansas and the U.S. Army Corps of Engineers, Kansas City District, initiated the project as well as provided input, guidance, and feedback throughout this initial phase.

We are grateful to everyone who has participated for their interest and contribution to improving the health of the Kansas River system. The extensive contributions and collaboration efforts from the various agencies and individuals are integral to the effort now and for future coordination and implementation efforts.

Disclaimer: Development of environmental pool management strategies are based on best available science and will be carefully balanced with the needs and requirements of partners and stakeholders, to benefit the Kansas River ecosystem while improving or not adversely affecting the system. Environmental pool plans are developed within the constraints of authorized purposes of the reservoirs, water rights, and other human use requirements, and in collaboration with stakeholders.

1.0 Sustainable Rivers Program

The Kansas River is home to many unique, threatened and endangered species and ecological habitats. For this reason, the Kansas River was added to the Sustainable Rivers Program (SRP) in 2018 to evaluate environmental flow (e-flow) opportunities, and the Kansas Environmental Pool Management (EPM) was initiated in 2023. The Sustainable Rivers Program (SRP) is a national partnership between the U.S. Army Corps of Engineers (USACE) and The Nature Conservancy (TNC). The mission of SRP is to improve the health and life of rivers by changing dam operations to restore and protect ecosystems, while maintaining or enhancing authorized uses and other project benefits. SRP began in 1998 with an initial collaboration to improve the ecological condition of Green River, Kentucky. The Program was formally established in 2002 and involved 8 river systems. At the end of Fiscal Year (FY) 2023, SRP involved work in 23 USACE Districts and 7 Divisions. Individual projects affect 90+ USACE reservoirs in 45 river systems affecting approximately 12,183 river miles (Figure 1). SRP is the largest scale and most comprehensive program for implementing environmental flows (e-flows) below USACE reservoirs and is growing.

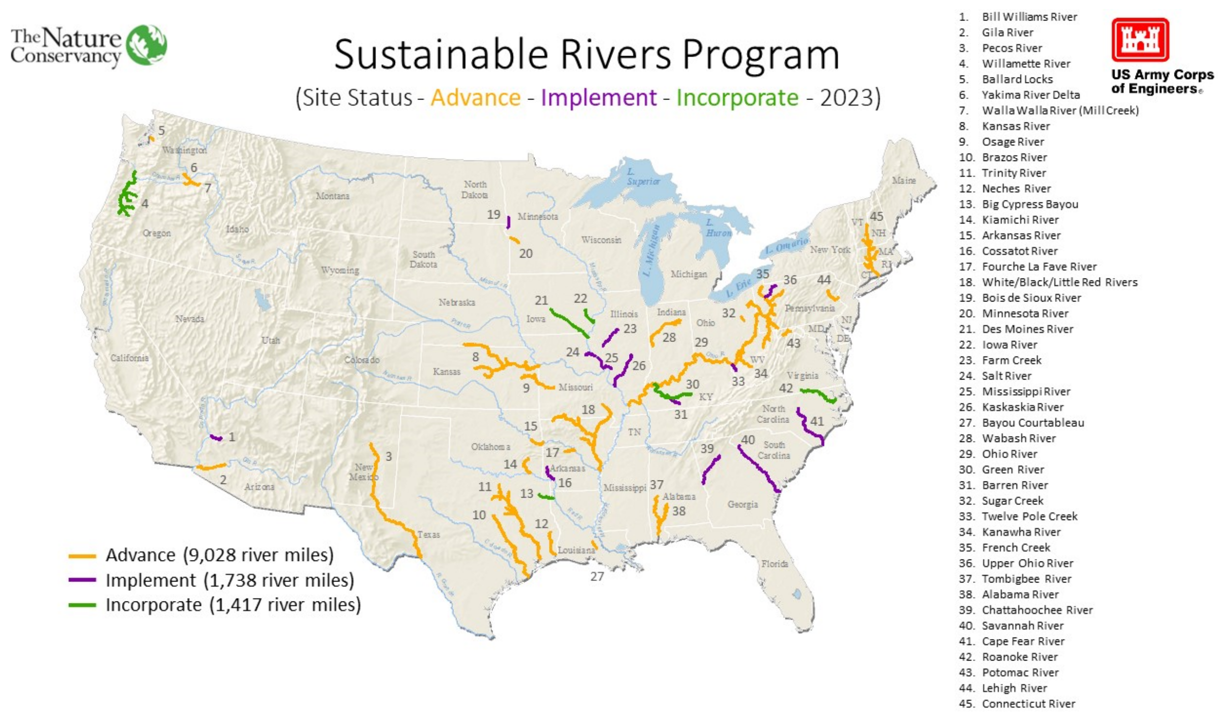

Figure 1. Status of rivers engaged in the Sustainable Rivers Program at end of FY 2023.

1.1 Environmental Pool Management

SRP expanded from traditional e-flows work in 2016 and began funding projects that targeted managing pool levels at U.S. Army Corps of Engineers reservoirs. Water level management describes the deliberate action of raising and lowering the water surface elevation of wetlands, lakes, or river pools for the purpose of stimulating aquatic seed germination, improving aquatic plant and animal diversity, consolidating wetland soils, and other ecological and environmental effects. Environmental Pool Management (EPM) is a term created by the USACE for managing pool levels to generate ecosystem benefit within a pool's operating band or routine operation limits. The suite of ecological purposes that EPM actions can target are provided in Table 1.

Table 1. Ecological targets of EPM actions.

Purpose	Description
Fish Passage	Water management actions that allow fish movement and passage (associated with conservation locking).
Fisheries (Life History Support)	Monitoring of actions that support or target fish life histories (e.g., spawning, rearing, foraging).
Mussels (Life History Support)	Monitoring of actions that support or target native mussel life histories (e.g., habitat, water levels, host fish).
Benthic (Life History Support)	Monitoring of actions that support or target E-flows that support benthic life histories (e.g., diet, physical habitat).
Herptiles (Life History Support)	Monitoring of actions that support or target herptiles (e.g., habitat [wetted back waters, old oxbows and stable water levels during freezing temps] and/or life history).
Overwinter Biota (Life History Support)	Monitoring of actions that support or target habitat or life history support of overwintering biota.
Shorebirds, Gulls, Other Water Birds (Life History Support)	Monitoring of actions that support or target habitats for shorebirds, gulls, and other water birds (e.g., exposing shallow areas for macroinvertebrate availability).
Waterfowl (Life History Support)	Monitoring of actions that support or target habitats for waterfowl (e.g., inundating oxbows and backwater areas, raise levels into food source during fall/winter migration).
Multiple Biota (Life History Support)	Monitoring of actions that target multiple biotas simultaneously through life history support and/or habitat access.
Invasive Species (Suppress/Restrict)	Monitoring of actions that limit invasive species spread (e.g., phragmites, salt cedar, Johnson grass)
Floodplain Connectivity	Monitoring or analysis of actions that target land/water interactions within the floodplain for some environmental or ecological benefit (not associated with specific floodplain vegetation targets).
Vegetation - Wetlands	Monitoring or analysis of actions that target promoting healthy wetlands.
Vegetation - Riparian	Monitoring or analysis of actions targeting desirable vegetation or other life cycle processes in riparian areas.
Sediment Passage	Monitoring or analysis of actions that help manage sediment in the system (e.g., reintroduce in sediment starved areas or flush).
Physical habitat creation (use of dredged material, oxbows/floodplain restoration)	Monitoring or analysis of actions that create physical habitat.
Pool Rate of Change - Shoreline Integrity (Water Quality)	Monitoring or analysis of actions that preserve streambanks (e.g., limit rate of water elevation change).

Debris Management	Monitoring or analysis of actions that address issues with accumulating debris.
Harmful/Nuisance Algal Blooms (Disrupt/Disperse)	Monitoring or analysis of actions that limits development of harmful and/or nuisance algal blooms (e.g., limit nutrient sources or decrease retention times).
Water Temperature Management	Monitoring or analysis of actions that target temperature related issues or concerns.
Water Quality (Temperature, Nutrients, Dissolved Gases, Turbidity)	Monitoring or analysis of actions that target nutrient issues or concerns.

To date, EPM has been implemented successfully at three other SRP sites. The St. Louis District has two EPM projects: the Mississippi River - Locks and Dams 24-26 which addresses vegetation, waterfowl, shorebirds, and fisheries; and the Kaskaskia River uses EPM to address vegetation and waterfowl in three reservoirs. The Rock Island District has been engaged in EPM work on the Des Moines River and Red Rock Lake and targets vegetation, shorebirds, and more recently they have been exploring benefits of EPM to herptiles. The flexibility to perform EPM varies within current USACE pool operating manuals.

The objectives of the Kansas EPM are to maximize ecological function within Harlan County and Milford Reservoirs on the Republican River, Wilson Reservoir on the Saline River, and Kanopolis Reservoir on the Smoky Hill River. The Kansas EPM work for all four reservoirs share common goals, in addition to individual reservoir needs. These shared goals are:

- Mimic natural systems with more variations in pool elevation to create more dynamic habitat.
- A summer pool elevation drawdown to expose mud flat areas and allow annual plant production to be flooded later is beneficial to fish, shorebird, and waterfowl species.
- Low water releases over a long period of time are beneficial to fish, shorebird, and waterfowl species depending on the timing.

Existing Lake Level Management Plans (LLMP) for each of the Kansas EPM reservoirs describe a range of possible target pool elevations that may be used to meet the needs of various authorized purposes such as fish and wildlife, flood control, and recreation. The flexibility of the LLMP improves the ability to target seasonal pool fluctuations for creation of shoreline waterfowl hunting habitat, improve habitat for fish and wildlife around the reservoirs, and support diverse wetland vegetation. It is anticipated that the LLMPs will fluctuate to some degree from year to year to allow for optimization of benefits per the various authorized purposes.

2.0 Summary of Ecology/Lake Level Recommendations

During the SRP environmental pool (e-pools) workshop, experts worked through a series of tasks and questions to draft an e-pools sequence for specific lake elevations at four reservoirs located in the Kansas River basin. A list of the four reservoirs considered is included below and shown in Figure 2.

2.1 Focus Reservoirs

- Milford Lake is located in east central Kansas in parts of Clay, Dickinson, and Geary Counties. The reservoir is created through impoundment of the Republican River. Nearby towns include Junction City, Milford, and Wakefield, Kansas.

- Kanopolis Lake is located in central Kansas in Ellsworth County. The reservoir is created through impoundment of the Smoky Hill River. Nearby towns include Kanopolis and Marquette, Kansas.

- Wilson Lake is located in west central Kansas in Russell and Lincoln Counties. The reservoir is created through impoundment of the Saline River. The closest towns are Wilson and Sylvan Grove, Kansas.

- Harlan County Lake is located in south central Nebraska with parts of the lake extending into Phillips County, Kansas. The reservoir is created through impoundment of the Republican River. The two closest towns are Republican City and Alma, Nebraska.

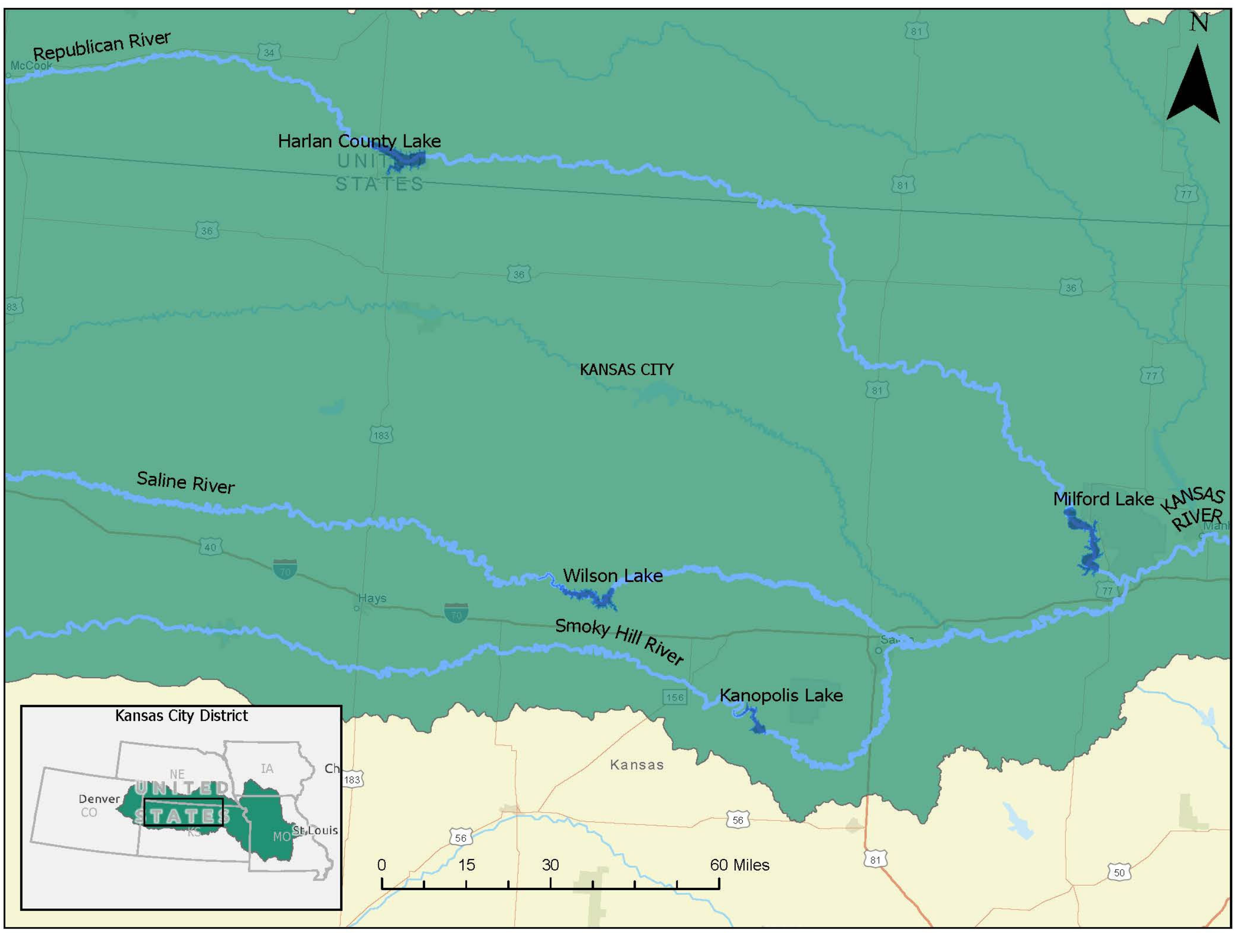

Figure 2. SRP EPM focus reservoirs.

The four reservoirs were selected for e-pools management based on the significance of being located within the migratory shorebird and waterfowl central flyway, as well as synergies with Water Control Manual updates either occurring or set to occur at the four reservoirs.

3.0 Workshop Goals and Agenda

The Kansas River, Environmental Pool Management SRP team successfully hosted a technical partners e-pools workshop in August of 2023 and produced a sequence EPM strategies for Milford, Kanopolis, Wilson, and Harlan County Lakes. The goal of the workshop was to develop an e-pools sequence, identify target elevations for the e-pools sequence, and integrate the sequence and target elevations into a corresponding pool level management guide curve. The Regime Prescription Tool (RPT) was used for each reservoir to help record the sequence, target elevations, and guide curve. The full workshop agenda and list of participants are included in Appendix A and Appendix B, respectively.

The 1.5-day workshop started with a half day site visit to the Wilson Lake project. The visit began with a tour of the control tower that included discussion on the lake project history, flood control operations and limitations, lake project authorized purposes, and downstream impacts. Following the control tower tour, the group travelled to Horseshoe Bend at the upper end of Wilson Lake. The group was able to get a vista view of Horseshoe Bend as well as a closer look along the shoreline. During the site visit, group discussions focused on habitat types, key species, invasive species presence, and environmental effects of pool management.

Day two of the workshop was a classroom setting that began with a welcome and participant introduction, review of the SRP process, review of notes from the kickoff meeting that was held on February 28th, 2023 (Appendix D), and discussion of desired workshop outcomes. Next was an overview of the LLMP for each of the four USACE reservoirs followed by a presentation over existing authorized purposes for each reservoir to provide a background to potential e-pools development constraints. Experts were instructed to focus on their ecological targets, such as feasibility of hitting target pool elevations to enhance different habitat types, without consideration of current constraints.

The following two workshop sessions focused on determining the sequence of e-pools management through a calendar year, as well as determining target elevations throughout the sequence for each lake. The goal for the sequence for e-pools management was to determine the target species, the habitat types that support the target species, the type of pool level manipulation that supports the habitat types, and whether the sequence needed to be lake specific or could be generally applied across four lakes. To determine the target elevations during the e-pools sequence, the group reviewed GIS data at all four lakes that included elevation-area curves, bathymetry, and LiDAR. The GIS data was utilized to inform lake surface area at +/- 1.0-foot elevation intervals from multipurpose pool, 1.0-foot water depth area at +/- 1.0-foot elevation intervals from multipurpose pool, and land base 1.0-foot high or lower at +/- 1.0-foot elevation intervals from multipurpose pool, and difference in lake surface area at +/- 0.5-foot elevation intervals from multipurpose pool.

The group received instruction for the following break-out session working groups and an overview of the RPT software, for use in visualizing e-pools prescriptions. Experts were broken into two different groups: 1) fish/wet, and 2) birds/dry. Group 1, fish/wet addressed fisheries, and other organisms of lotic environments. Group 2, birds/dry addressed birds, herptiles, aquatic mammals, and environmental targets within inundated and exposed shoreline habitats. The initial plan was to separate the group into four different groups for the breakout sessions and have each group represent each lake. Initial discussions during the workshop determined the most productive approach was to separate the group into 1) fish/wet, and 2) birds/dry and cover all four lakes. The two groups were asked to develop lake level management guide curves for their species at each lake and apply the guide curve to the RPT. At the end of the breakout session, experts at each lake and for each group presented the lake level management guide curves using the RPT. The workshop ended with conclusion and parting discussions, which included opportunities, uncertainties, next steps, research needs, and concluding thoughts.

4.0 Lake Characteristics and USACE Operations

4.1 Lake Characteristics

The four reservoirs are located on tributaries to the Kansas River to include the Republican, Saline, and Smoky Hill Rivers. The construction and impoundment of these streams was authorized under various Flood Control Acts for the main purpose of flood control. The reservoirs are located in rural counties dominated by agricultural industry and production that include common farming and ranching activities. The states of Nebraska and Kansas rank 48th and 49th in the nation, respectively, in percent of public land, and the four reservoirs offer thousands of land acres for public use. The reservoirs provide great value regionally and to the nation both in flood risk reduction cost saving and outdoor recreation economy.

4.1.1 Milford

Milford Lake is located in North Central Kansas and comprises a total of 44,231 acres (ac) owned in fee. The dam embankment is located at mile 8.3 on the Republican River with the lake extending into Clay, Geary, Riley, and Dickinson counties at the 1176.2 feet above mean sea level (ft; elevations mentioned herein are in feet above mean sea level and are referred to in units of ft) flood pool elevation totally 32,200 ac. Multipurpose elevation is 1144.4 ft with a multipurpose pool of 15,600 ac and surrounding land base of 28,631 ac. The flood control pool, elevation 1144.4 to 1176.2 ft, is used for the storage of flood inflow when drainage into the lake exceeds the acceptable amount of discharge to downstream areas. The multipurpose pool provides 388,816 ac-ft of storage for recreation, water supply, fish and wildlife, and navigation.

Milford Lake is an independent unit in a coordinated system of lakes providing flood control and multipurpose storage within the Kansas River Basin. The drainage area of Milford Lake is 3,796 square miles, located below the Harlan County Dam on the main stem of the Republican River and the Lovewell Dam on White Rock Creek. The multipurpose pool will be regulated in accordance with a yearly agreement between the USACE and the Kansas Water Resources Board. The maximum controlled outflow from the control pool is 22,500 cubic feet per second (cfs); however, the minimum low-flow release from the multipurpose pool to satisfy downstream requirements is 25 cfs.

Milford Lake is within the Flint Hills Uplands of the Osage Plains section of the Central Lowlands Physiographic Province. Climax vegetation is comprised of a mixture of the tall and mid-sized grasses characteristic of the true prairie. Grassland in the area is locally referred to as “ordinary upland.” The region consists of maturely to sub-maturely dissected plains. Topographic features in the vicinity of the dam include the valley floodplain, the bluffs, and the loess-mantled uplands characteristic of the Republican River Valley complex. The valley is approximately a mile wide at the point of embankment, with low terraces rising to the steep limestone bluffs. Upstream and downstream from the embankment on both sides of the valley are narrow, steep ravines which cut into the bluffs by small intermittent streams (USACE 2021c).

4.1.2 Kanopolis Lake

Kanopolis Lake is located on the Smoky Hill River in Central Kansas and comprises a total of 21,017 ac owned in fee. At elevation 1463.0 ft the multipurpose pool covers 3,406 ac and can expand to as much as 13,958 ac at elevation 1508.0 ft following periods of heavy rain as excess runoff is impounded to prevent downstream flooding.

The entire project area lies within the Plains Border section of the Great Plains physiographic province. The area is characterized by undulating hills and broad valley topography with elevations near the lake ranging from 1,285 to 1,631 ft. The topography of the Kanopolis Lake area is characterized by broad, maturely dissected uplands with occasional low eastward-facing escarpments. The uplands are fairly level but are subject to erosion by water and wind. The early land surface was a smooth mantle deposited by eastwardly flowing streams carrying heavy sediment loads from the Rocky Mountains. Floodplain alluvium ranges up to 60 ft in depth near the lake and consists of thin clays and silts blanketing and interlacing with gravely sands and basal sandy gravels. High terraces and the valley walls contain up to 40-ft thickness of gravely sands and clays (USACE 2021b).

4.1.3 Wilson Lake

Wilson Project is located on the Saline River in North Central Kansas an area of well-defined hills and valleys with numerous sandstone outcrops. Elevation ranges from 1,440 ft in the area below the dam to 1,780 ft at the western end of the project. At multipurpose pool Wilson Lake covers 9,045 ac and can expand to as much as 35,670 ac during periods of heavy rain as excess runoff is impounded to prevent downstream flooding. Wilson Lake works in conjunction with several other lakes operated by the Corps to provide flood protection for the Kansas River Basin and the lower Missouri and Mississippi Rivers. Wilson Lake has approximately 100 miles of mostly rocky shoreline. The Lake has approximately 242,528 ac-ft of storage for multipurpose and sedimentation and at flood control pool increases to 511,000 ac-ft of storage. There are 12,842 ac of fee land above the multipurpose pool of 1516.0 ft.

The Saline River and Hell Creek are the major sources of surface water in the Wilson Lake. The Saline River basin is long and narrow with a total drainage of 1,917 square miles above Wilson Dam. The lake falls within the area of the Dakota Aquifer. The Dakota aquifer system consists of sandstone bodies deposited about 100 million years ago during the Cretaceous Period. The discontinuous sandstone bodies are lens shaped, rather than flat and continuous. Typically, the best sandstone aquifers are up to 100 ft thick, 1.5 miles wide, and 20 miles or more long. Outcrops of these thick, alluvial sandstone bodies form the bluffs and canyons along the Saline River valley in the vicinity and upstream of Wilson Reservoir in Russell County. Ground water from the Dakota aquifer is used for domestic, municipal, industrial, and agricultural purposes.

Wilson Lake occupies a broad, flat flood plain that is deeply cut into the surrounding uplands. The local geographic unit is the Smoky Hills. The Smoky Hills are made up of a maturely dissected belt, 20 to 40 miles wide, lying on the eastern border of the dissected High Plains province which forms the eastern edge of the High Plains. Much of the area around Wilson Lake is characterized by relatively high hills with steep foot slopes to the shoreline. Away from the river valley, the topography is less severe with indistinct terraces, dissected escarpments and rolling hills. Wilson Lake has one of the lowest sedimentation rates of any of the Corps Lakes located in Kansas. The annual depletion rate from sediments is just 0.09% per year

(Rahmani et. al. 2018). The sedimentation rate is 265 ac-ft per year. Shoreline erosion and deposition of silt have become been an increasing concern at Wilson Lake (USACE 2021d).

4.1.4 Harlan County Lake

Harlan County Dam is located on the Republican River in south central Nebraska, approximately two miles south of Republican City, Nebraska, eight miles east of Alma, Nebraska, and 14 miles west of Franklin, Nebraska. Elevation ranges from 1,885 ft in the area below the dam to 2,012 ft at the western end of the project. At multipurpose pool Harlan County Lake covers 13,240 ac and can expand to as much as 22,790 ac at elevation 1,973.5 ft during periods of heavy rain as excess runoff is impounded to prevent downstream flooding. At multipurpose pool, 1946 ft, Harlan County Lake’s shoreline extends 75 miles. The lake supplies irrigation water for 23,000 ac of cropland in Nebraska and 32,000 ac in Kansas. Indirectly attributed to releases from Harlan County Lake are an additional 13,000 irrigated ac of land in Kansas through the Lovewell Reservoir by means of a diversion from the Republican River.

The total drainage area above the Harlan County Dam is 20,751 square miles of which 7,215 square miles do not contribute to surface runoff. Harlan County is one unit in a system of multipurpose reservoirs on the Republican River. This system is now composed of the Bonny Lake in Colorado (not currently holding water); Enders Reservoir, Swanson Lake, Hugh Butler Lake, Harry Strunk Lake, and Harlan County Reservoir in Nebraska; and Norton Reservoir in Kansas. Lovewell Reservoir and Milford Lake are also in the Republican River basin downstream from Harlan County. The Harlan County Dam regulates the runoff from as uncontrolled area of 8,561 square miles. Tributaries and drainages emptying into the lake are generally moderate to gentle sloping and covered with grass and woody vegetation. The maximum controlled outflow from the control pool is 20,700 cfs.

The surrounding topography of Harlan County Lake is gently rolling to hilly with some areas of steeply sloped drainage’s eroding into wind deposited (loess) soils predominant of the area. Variation extremes range from 1885 ft to 2012 ft. The climate in the Harlan County Lake area is characterized by that of the Central Great Plains Region. Typically, the area experiences warm to hot summers and cold dry winters. Due to the intense erosion by wave action on the loess soils, the shoreline is predominantly high vertical bluffs. Periods of low pool elevation result in large expanses of "mudflats" extending hundreds of yards out to the lake water edge (USACE 2021a).

4.2 Lake Level Management Plans

Lake level management plans (LLMPs) may be implemented in whole or in part depending on the needs of other project purposes based on the hydrologic conditions that exist at the time. This may be critical if either drought or severely wet basin conditions occur. Periods of drought may preclude targeted drawdowns below the top of multipurpose pool. Inflow bypass may be necessary to satisfy downstream water right demand, as required by the Kansas Department of Agriculture, Division of Water Resources, which may prevent planned pool rises. If wet basin conditions prevail, the retention of even a modest amount of water in the flood pool during the primary flood runoff season will have to be adjusted lower or forgone. A description of each of the four reservoirs’ LLMP are summarized below.

4.2.1 Milford Lake

The current Milford Lake LLMP is summarized below and in Figure 3.

- October 1 to January 1: Maintain the lake elevation at least 1.0 ft over conservation pool. The goal of the fall and winter rise is to keep the lake elevation up as long as possible for waterfowl habitat, while at the same time realizing that the lake elevation needs to be drawn down prior to the lake freezing. This cold weather flexibility can be achieved through the local lake personnel that monitor the lake conditions and make recommendations to adjust the drawdown date and/or discharge rate that will achieve the greatest benefit.
- January 1 to February 1: Begin controlled drawdown of lake elevation as winter conditions allow, with a maximum release of 2000 cfs to reach winter target elevation of 1141.4 ft msl.
- February 1 to June 1: Maintain the lake elevation at 1141.4 ft. This will eradicate exposed zebra mussels and provide clear spawning areas for walleye.
- June 1 to June 15: Allow the lake elevation to gradually increase to 1143.0 ft. Maximum discharge should not exceed 2000 cfs.
- June 15 to August 1: Maintain lake elevation at 1143.0 ft. The fisheries program prefers that lake elevations remain steady or slowly rise. Optimal maximum discharge should not exceed 2000 cfs. If there is a large inflow event and the pool rises above conservation pool, discharge should only bring the pool back down to 1144.4 ft. Re-vegetation and seeding of shoreline will be accomplished while lake is below 1144.4 ft.
- August 1 to October 1: Hold discharge to minimum outflows and allow the lake elevation to increase and then be maintained at 1145.4 ft.

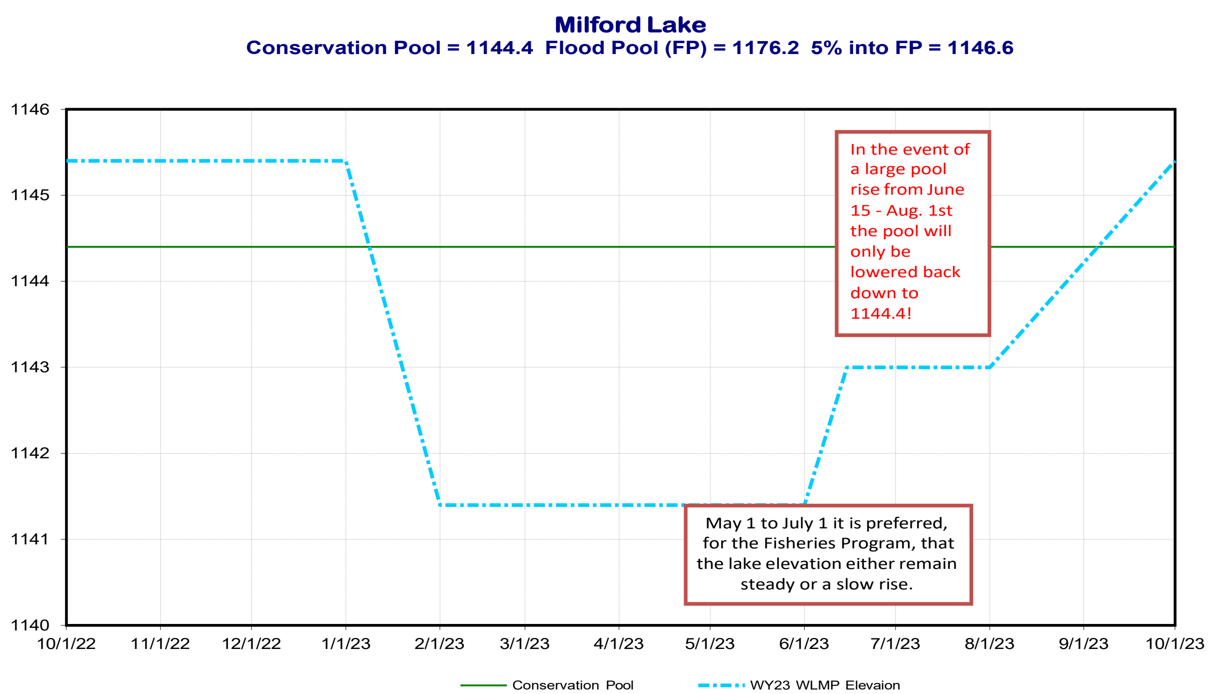

Figure 3. Milford Lake, LLMP for 2023.

4.2.2 Kanopolis Lake

The current Kanopolis Lake LLMP is summarized below and in Figure 4.

- October 1 to January 1: Retain inflows in an attempt to increase the pool to 1467.5 ft.
- January 1 to January 15: Draw pool down to 1463.0 ft to reduce the possibility of ice damage, and notching will be used to accomplish this unless there are extenuating circumstances. This date depends on whether or not ice forms, and if ice forms earlier or later, pool will be lowered accordingly.
- January 15 to March 15: Hold the pool at 1463.0 ft.
- March 15 to May 15: Allow pool to increase to 1467.5 ft and stabilize. Attempt to mediate inflows and outflows to preclude major elevation swings, and limit outflows to the uncontrolled port (if possible). Rapid drawdowns should be avoided during this time, if possible.
- May 15 to September 30: Between elevations 1463.0 ft and 1467.5 ft, releases should be made through the uncontrolled port. History shows that the pool will naturally decrease during this period, but an attempt will be made to hold as much of this increased pool as possible to provide for maximum recreation benefits.

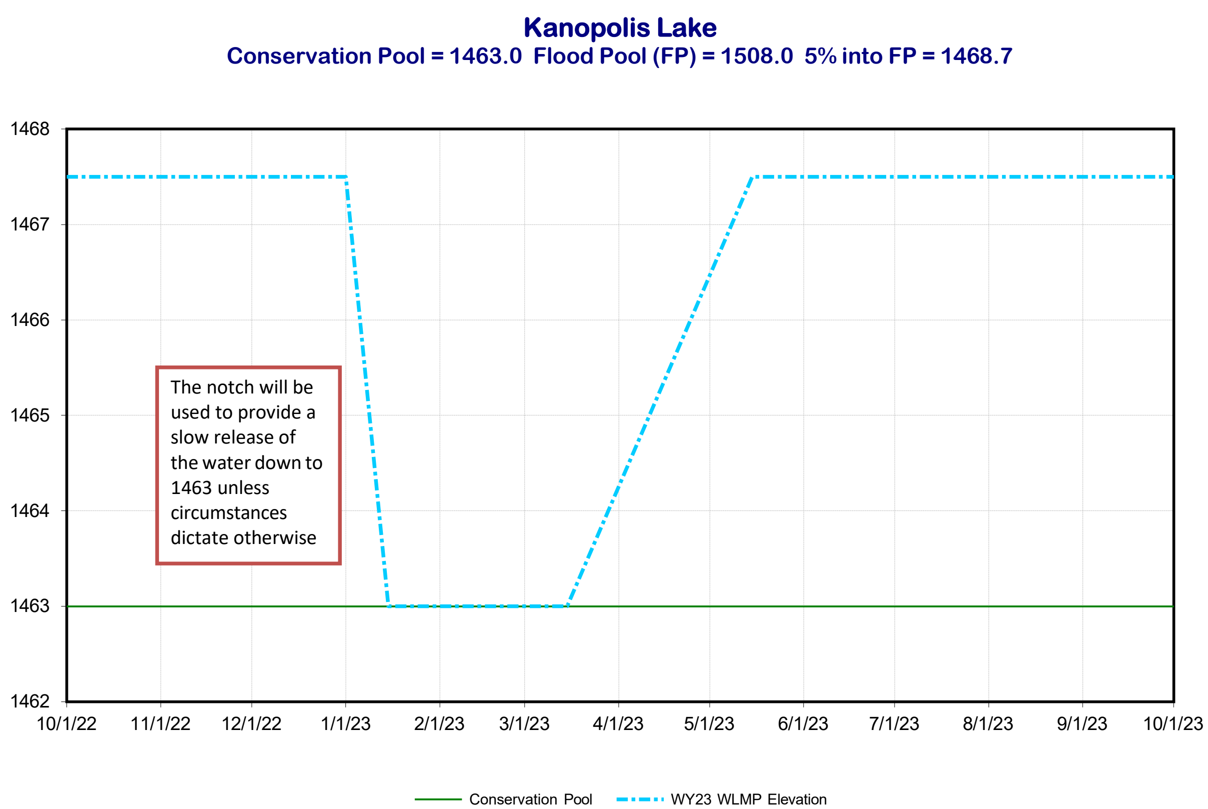

Figure 4. Kanopolis Lake, LLMP for 2023.

4.2.3 Wilson Lake

The current Wilson Lake LLMP is summarized below and in Figure 5.

- October 1 to October 15: Lower the water level to 1515.5 ft to manage aggressive phragmites that go into dormancy late October.
- October 15 to February 1: Maintain the water level at 1515.5 ft to expose sandbars to endangered whooping cranes for spring and fall migrations and reduce shoreline erosion in park areas.
- February 1 to March 15: Maintain the water level at or below 1516.0 ft to prevent ice damage, maintain shoreline protection and provide a buffer for spring rains.
- March 15 to June 1: A stable or slightly rising water level up to 1516.5 ft is preferred for game fish spawning purposes. Rapid drawdowns should be avoided during March, April, and May, if possible. Rainfall events during this period will be captured and held up to elevation 1516.5 ft even if it is early in this segment.
- June 1 to September 15: Maintain the water level at 1516.5 ft to help prevent expansion of aggressive phragmites.

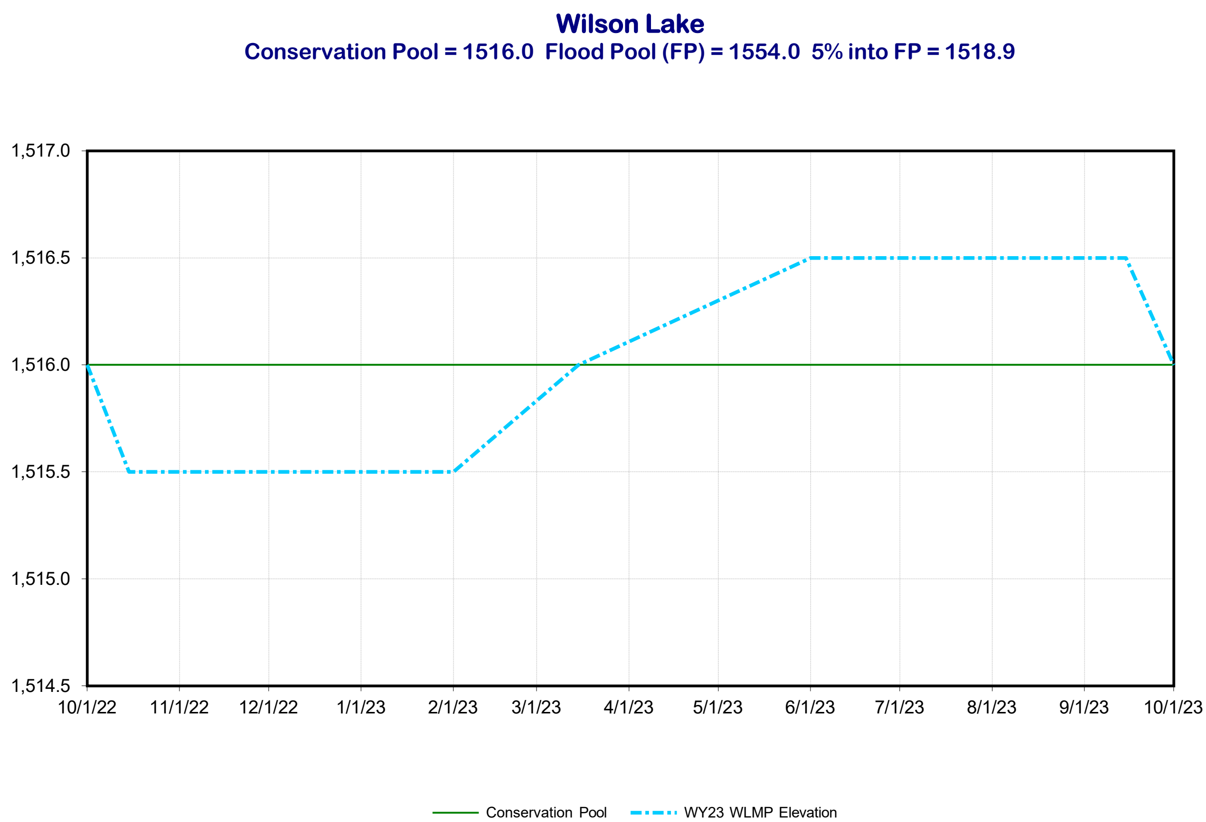

Figure 5. Wilson Lake, LLMP for 2023.

4.2.4 Harlan County

Harlan County Lake does not operate under a LLMP like the other reservoirs. Instead, water use is allocated based on the lake elevations depicted in Figure 6 below. Irrigation season typically runs from June to the end of Septembers depending on precipitation levels throughout the summer.

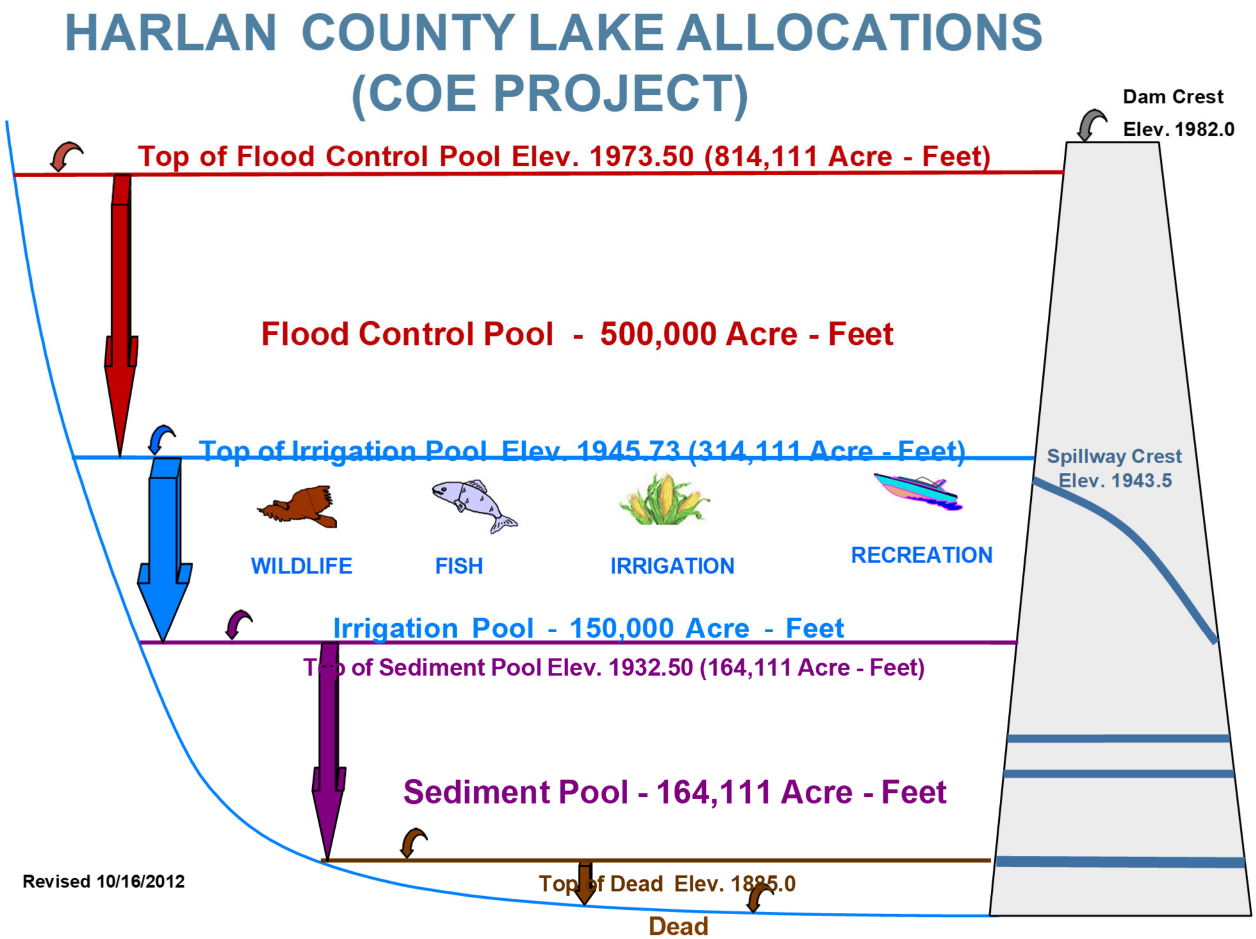

Figure 6. Harlan County Lake water allocation.

4.3 Authorized Purposes

Lake projects serve as a critical drinking water supply for more than 600,000 people in addition to being used for irrigation, municipal wastewater and industrial discharges, power generation, and as a source of commercial sand and gravel. Additionally, recreation use in the Kansas River Basin to include but not limited to boating, kayaking, camping, picnicking, fishing, swimming, hunting, wildlife viewing, etc. provides substantial benefits to the local, regional, and national economy.

Each USACE reservoir operates for specific congressionally authorized purposes and has a Water Control Manual which details the rules and regulations specific to each reservoir. The following sections summarize the main rules used to regulate releases in both flood control and multipurpose pools. Within the Kansas River Basin, the congressionally authorized purposes include flood control, water supply, water quality, fish and wildlife, recreation, navigation support, and irrigation. Table 2 summarizes the authorized purposes for each reservoir.

Table 2. Reservoir authorized purposes.

Reservoir	Flood Control	Water Supply	Water Quality	Fish & Wildlife	Recreation	Navigation	Irrigation
Harlan County	X			X	X		X
Wilson	X		X	X	X		
Kanopolis	X	X	X	X	X		X
Milford	X	X	X	X	X	X	

5.0 Pool-Ecology Relationships for Workshop

Pool-ecology relationships focused on two groups: fishes and birds. The fish focus group were primarily targeting life history support for sport fishes. The bird/other fauna focus group primarily concentrated on life history support needs for migratory waterfowl, shorebirds, and the endangered whooping crane as well as herptiles and overwintering furbearers. The sections below provide the summary of group discussion and RPT outputs of each breakout group.

5.1 Fish

Experts on fish were asked to consider the life history needs of fishes within each reservoir throughout the year. The group ran through the RPT exercise for Milford Reservoir, and briefly covered the other three reservoirs; generally, the recommendations would apply broadly to all reservoirs except where noted below. The group had consensus was that flooding vegetation was necessary for successful spawning; however, the timing of flooding vegetated areas differs between reservoirs and, to some extent, by species. For example, walleye spawn is observed in March, white bass in April, and large/smallmouth bass in May. Wilson Reservoir sees natural reproduction of various bass species and walleye, while at Harlan County Reservoir spawning of the same species is generally two weeks behind Wilson Reservoir being located further north. Raising pool levels in summer after vegetation has established would allow young of the year (y-o-y) and juvenile fishes to seek refuge in the vegetation and escape predators. The group also was in general agreement that implementing pool raises to accommodate all life history stages is not necessary every year, but every other or every three to four years would help promote a more sustainable sport fishery.

An example RPT output for Milford Lake representing a average year is shown in Figure 7. General recommendations across all four reservoirs for annual patterns included:

- The more water the better for all fish species.
- A spring drawdown in early March to expose mudflats for seed germination and vegetation recruitment, which is needed for spawning and cover as well as make forage habitat available as macroinvertebrate colonization correlates with this timing.
- A stable to slow rise in pool level from mid-March to early June benefits spawning fish.

- Summer drawdowns to promote vegetation growth followed by inundation would benefit fish species.
- Consider habitat connectivity at different pool elevations.
- Consider delaying pool releases while fish are spawning on riprap on or near the dam structure to prevent fish entrainment and habitat loss.

Winter: No discrete recommendations for winter pool levels were realized; however, operations may consider stable pool conditions to minimize stranding and/or freezing of fish.

Spring: The spawning sequence of fish species should be considered. A spring drawdown should consider walleye that are beginning to stage on rock structures near the face of the dam in early March. The drawdown would function as a transition between the stable overwinter condition and the stable to rising spring spawn. Additionally, a spring drawdown will expose prey and macroinvertebrates. A spring drawdown for fish may not need to occur every year. Conceptually, a multi-year sequence with vegetation recruitment followed by inundation of that vegetation to promote recruitment of a strong year class of fishes. If pool levels are high and above multipurpose pool elevation, it was recommended holding pool level to optimize rearing habitat for y-o-y fish. If pool levels are low and below multipurpose pool elevation, then the timing could be a good opportunity to recruit vegetation for future cover in following year(s). Spring drawdowns should consider keeping water on vegetation for rearing habitat for as long as possible as this would be beneficial to maximize fish population and recruitment success.

Summer: Pool drawdown considerations for fish primarily targets promoting vegetation growth; however, drawdowns that remove water from vegetation will expose y-o-y fish to predation as they retreat to open water. Additionally, catfish species typically spawn June to July, and they are cavity spawners. A slow pool rise in summer months is optimal.

Fall: No discrete recommendations for fall pool levels were discussed for fish; however, operations may consider slow rises. Acute raising or dropping of pool levels will be most impactful to recruitment success.

Habitat: Fish habitat varies by species and by life stage. The target fisheries specifically discussed in the workshop included the following sport fish: walleye, saugeye, blue and channel catfish, white bass, largemouth and smallmouth bass, and black and white crappie. Habitat heterogeneity within the reservoirs at different times of year is an important consideration at all four reservoirs. Generally, discussed in the workshop were the availability of quality deep water habitats for pelagic predatory and adult fish; and shallow habitats for spawning and cover for y-o-y, juvenile, and prey fish species.

Overall, the fish experts' recommendations were that at all four reservoirs the more water the better for all fish species, a stable to rising pool elevation during spawn (mid-March through early June), with late summer drawdowns for vegetation growth followed by inundation would benefit the fisheries. Additionally, recommendations to avoid high releases that create fish entrainment and considerations of habitat connectivity at different pool elevations were also discussed. It was recommended drawdowns and/or pool rises consider a biennial or triennial targeted elevation change versus on an annual basis.

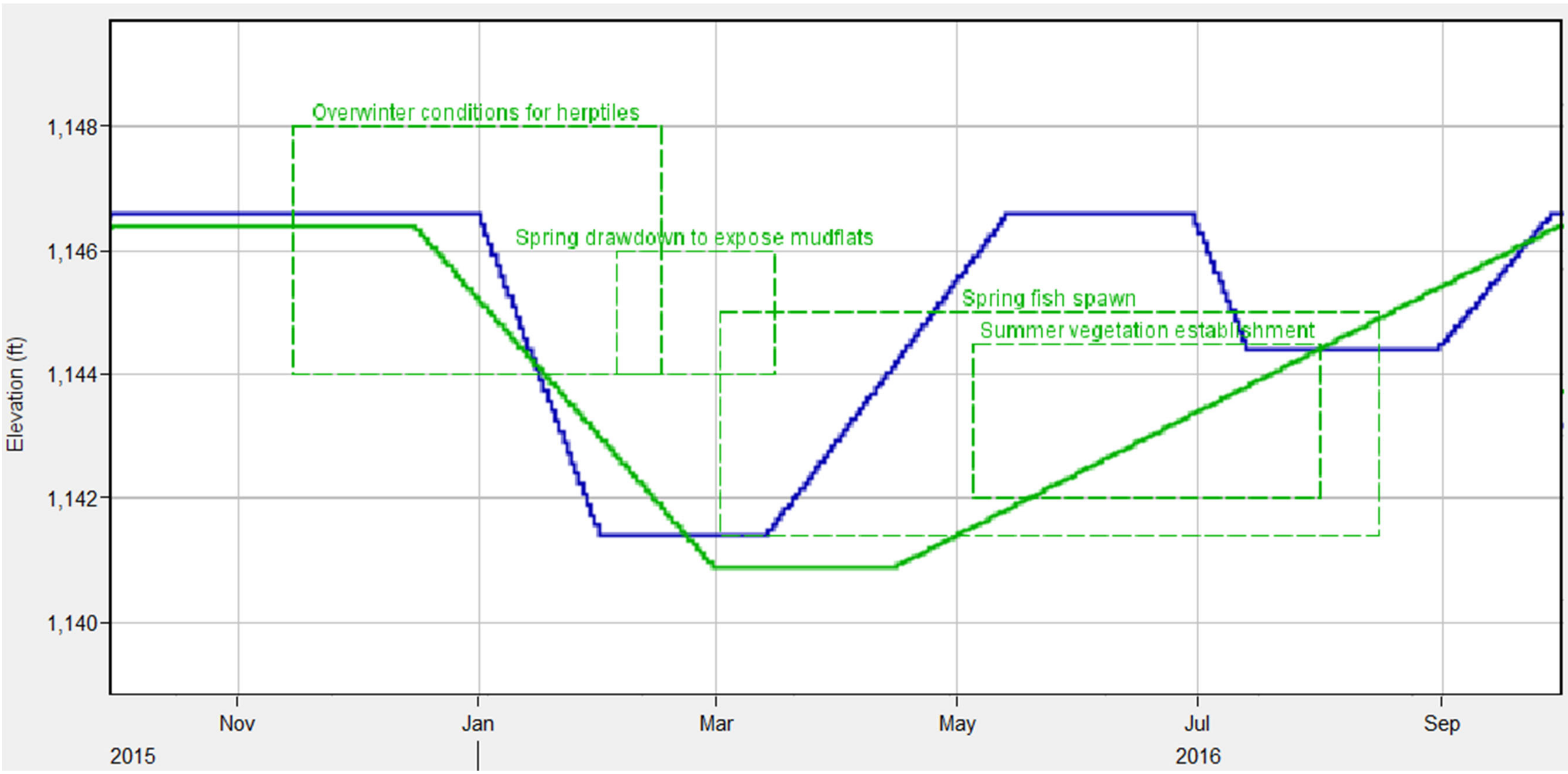

Figure 7. Recommended e-pools elevations, considerations, and guide curve, average year.

5.2 Birds

Experts on birds and other fauna were asked to consider the life history needs of these species throughout the year, and how EPM would support those needs.

There was general agreement that management should focus on an approximate three-year cycle due to natural variability in precipitation and the nature of forage production for ducks. A low water year(s) that allow growth of plants such as smartweed on the mudflats could be followed by a year(s) where the mudflats are inundated. Reservoirs will focus on different species goals in different years based on pool and river conditions. For example, Wilson Reservoir might be managed one year for fall migration, and the following year for spring migration. Another possibility discussed might be to focus management on fish in a flood year and focus on bird habitat in a dry year. Management can also be adaptive. For example, if there is a big flood year resulting in mudflat and shoreline scour, the next year might focus on vegetation recruitment.

An example RPT output for Wilson Lake representing a dry year is shown in Figure 8. General recommendations for annual patterns included:

- A high, stable pool in the winter, to provide overwinter habitat for herptiles and winter-denning furbearers.
- Shallow mudflats and forage production for spring bird migrations.
- Summer drawdown for vegetation establishment.
- Shallow water, vegetation inundation, and forage production for fall bird migrations.

Winter: Hibernating animals, such as herptiles, beaver, and muskrat may be exposed by sudden changes in pool level during winter. The recommendation was to keep the pool high during winter months, avoiding any sudden changes or drops to the pool level. Pool changes could begin in March and should be gradual whether rising or falling.

Spring: When managing pools for birds, a spring drawdown can expose mudflats for food production and habitat. The drawdown should be started 10 to 15 days prior to expected migrating bird arrivals, to facilitate invertebrate production and seed establishment. Waterfowl are typically utilizing the four reservoirs in late February through early April. Shorebirds typically arrive between April 15 and May 15. Some shorebirds may arrive in early March, but these species are typically less of a conservation concern. Endangered Whooping cranes typically arrive around April 1. A slow pool drawdown should be targeted to begin around first of April and continue through May 15. Perennial vegetation will favor a May to June drawdown, while seed producing annuals will favor a June to early July drawdown.

Summer: There was discussion that in some years, reservoirs should be kept high in summer for fish spawn. In those years, it was recommended to keep pool levels high as long as possible. The following year, the reservoir should be drawn down in the summer to allow vegetation to grow in the summer. Summer drawdown should begin between June 1 and July 1. Smartweed takes 2 to 4 weeks to germinate, and 60 to 90 days to mature. The summer drawdown should be timed for smartweed and other plants to have seed available for the shorebird fall migration, typically occurring July 15 to September 15. At Milford Reservoir, there is a need to keep at least 500 cfs flowing between June 15 to July 15 for nutrient management. Flooding might need to be delayed until July or August when nutrient loading issues are present. A late summer rise (August – September) would also avoid flooding annual vegetation, but this will be dependent on the precipitation pattern in any given year.

Fall: The fall waterfowl migration typically occurs between September 1 and December 31. Waterfowl generally utilize the reservoirs from mid-October through mid-December. As mentioned above the fall shorebird migration occurs between July and September. Unlike the spring migration, the fall migration is more dispersed, and the reservoirs won't see as many shorebirds at one time. Most birds will favor water at 8 inches or less. Some shorebirds, like Phalaropes, can swim and will utilize deeper water. Whooping cranes may arrive between October 10 and November 10.

Habitat: Most waterfowl and shorebirds will be looking for shallow water, so the best habitat opportunities will be in the backwaters of the reservoirs. Most shorebirds utilize shallow water habitat 8 inches (in) deep or less while waterfowl utilize 11 in deep or less shallow water for feeding. Whooping cranes favor mudflats and shallow water less than 1 ft deep. On occasions whooping cranes will wade into water up to 1 ft deep. This habitat may be categorized as palustrine wetlands. However, these areas may be dry in drought years or average years. In those years, they will utilize lacustrine wetlands in early March and April.

In the group discussions, it was generally agreed that whooping cranes would likely only utilize reservoirs like Wilson during extreme drought years (e.g., 2013 - 2015). However, Kanopolis reservoir could be managed more effectively for whooping cranes due to the abundance of shallow water habitat. Perennial vegetation that remains standing after the first frost would be a deterrent to whooping crane use as whooping cranes will generally avoid areas with visual obstructions.

At Kanopolis Reservoir, there are 230 ac of wetlands that could be flooded for bird habitat. This is difficult to achieve with the current guide curve. A higher/revised guide curve in the LLMP would provide more flexibility for floodwaters to be held longer, creating a water source for the wetlands. That water can then be managed with a water control structure in the wetlands. The reservoir would not have to be held at the high pool level for very long to provide enough water for the wetlands. It was also noted that there is flexibility in the upper limit of the pool elevation of +5% or about 2 ft.

Dabbling ducks eat mostly seeds during spring migration, so they need shallow flooded annual plants. Increasing the upper limit of the pool could create many more acres of dabbling duck habitat in average water years. Phragmites has become an issue at reservoirs and is outcompeting other native forage plants and creating a monoculture. Phragmites is a non-native invasive plant the grows up to 16 ft annually and spreads rapidly. It grows in wetlands type areas and in standing water. The timing of pool level management may provide positive or negative impacts to the spread of phragmites.

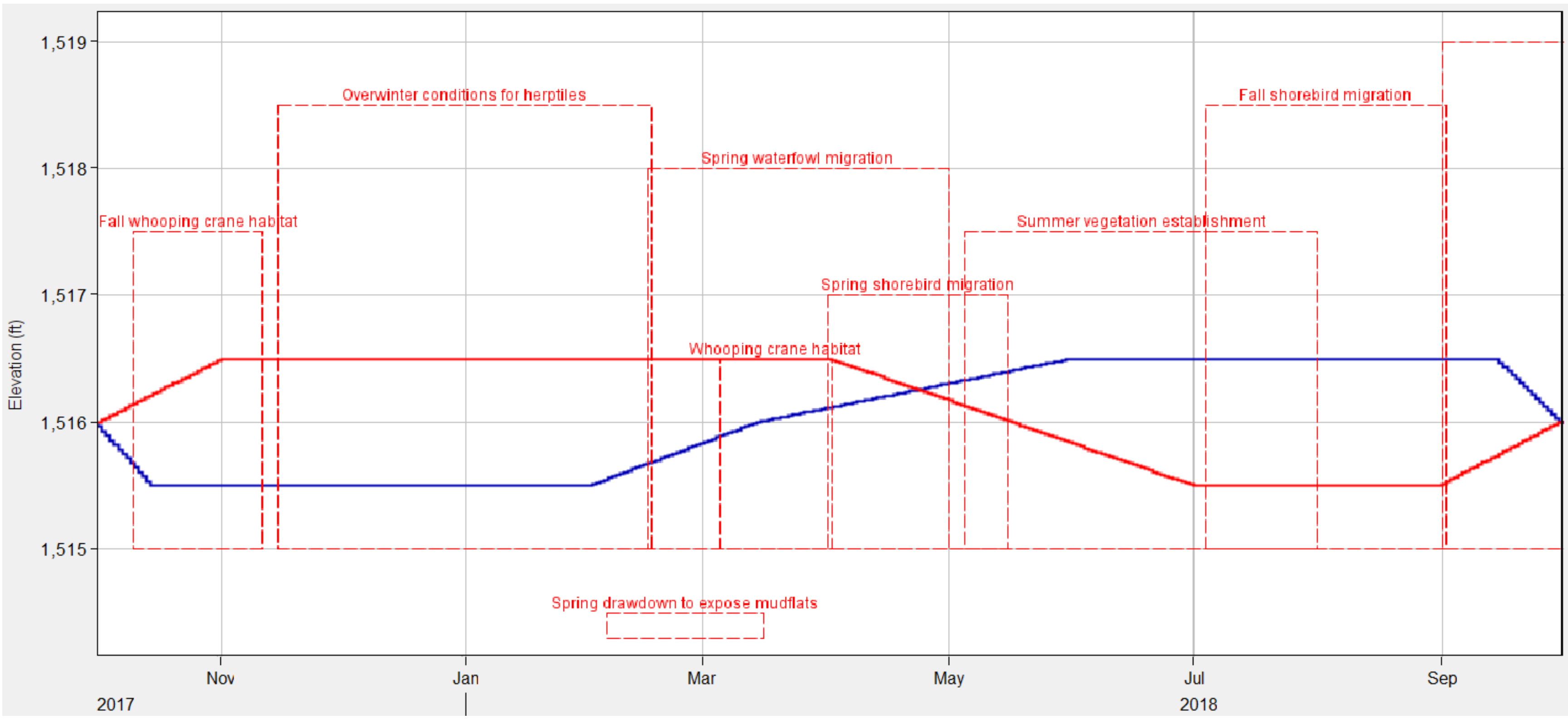

Figure 8. Recommended e-pools elevations, considerations, and guide curve, dry year.

Release attenuation: It was generally recommended that reservoir releases should be lengthened or attenuated to avoid dramatic changes in reservoir level any time of the year. Exceptions would be when there is a need to quickly dry shallow habitat for vegetation management. High releases may also be needed to scour habitat downstream after a dry year with vegetation encroachment.

Guide curve: It is important to note that the recommended e-pools guide curve is almost the exact inverse of the current guide curve in the LLMP. The e-pools strategy would represent a cultural change in reservoir management. There would need to be strong communication between lake level managers and wildlife managers to resolve these differences. The e-pools guide curve will also need to be resolved with the e-flow recommendations on the Kansas River, as well as the project purposes of the reservoir. As noted at the beginning of this section, management will need to be adaptive, and different targets may be achieved in different years at different reservoirs.

6.0 GIS-Ecology Relationships for Workshop

The approach to e-pools management focused on how the timing and target of lake elevation change affects wildlife. Fish and bird habitat is distributed horizontally and vertically across the reservoirs and for the focus of e-pools management includes food, reproduction, and protection/shelter. To better inform decision making by the experts, GIS data (i.e., bathymetry, LiDAR, and elevation-area curves for each lake) was utilized to show specific changes to habitat at various elevations. Experts were encouraged to utilize the GIS data to determine the greatest return on habitat without deviating too far from the multipurpose elevation for each reservoir. GIS data and maps were created to support the three habitat criteria listed below.

1. Lake surface area w/ depths +/- multipurpose pool:
    - More water is more habitat for all fish species
    - Show habitat connectivity throughout each reservoir

2. Shallow water habitat (1 ft depth or less) at various lake levels +/- multipurpose pool:
    - Habitat for migratory shorebirds
    - Habitat for migratory waterfowl
    - Habitat for juvenal fish

3. Mudflat land base 1 ft above lake level at various elevations +/- multipurpose pool:
    - Habitat for migratory shorebirds
    - Habitat for vegetation establishment

6.1 Lake Project Elevation-Area Curves

The USACE Kansas City District - Water Management created elevation area curve tables utilizing LiDAR, bathymetry, pool volume, and surface area data. Tabulated data show the change in area at various lake elevation intervals above and below multipurpose pool. For the workshop +/- 5 ft elevation from multipurpose pool was utilized at 0.5 ft intervals. A simple excel equation was utilized to determine the difference in the change of pool area (Acre Difference) at the 0.5 ft intervals. Tables are provided for each lake with rows yellow highlighting representing the greatest area gained or lost throughout the 0.5 ft pool elevation change +/- 5 ft elevation from the multipurpose pool. The greatest area gained or lost throughout pool manipulation represents greatest potential to create habitat for fish and birds either through shallow water habitat or exposed mudflat.

6.1.1 Milford Lake

Figure 9 and Table 3 show the elevation area curve data for Milford Lake and results of the Eisenbraun October 2009 (Eisenbraun and Associates 2009) bathymetric survey combined with March 2010 LiDAR data.

Figure 9. Milford Lake elevation-area curve chart.

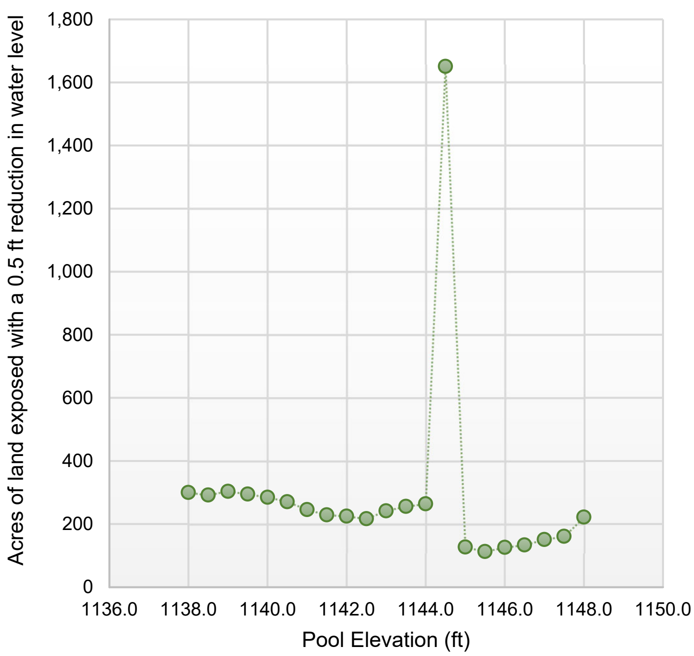

Table 3. Milford Lake elevation area curve +/- 5 ft from multipurpose pool of 1144.4 ft msl.

Pool Elevation	Pool Volume	Pool Acres	Acre Difference
1138.0	284,223	12,128	300
1138.5	290,362	12,428	292
1139.0	296,648	12,720	304
1139.5	303,084	13,024	295
1140.0	309,670	13,319	285
1140.5	316,402	13,604	271
1141.0	323,272	13,875	246
1141.5	330,272	14,121	229
1142.0	337,390	14,350	225
1142.5	344,620	14,575	217
1143.0	351,961	14,792	242
1143.5	359,415	15,034	256
1144.0	366,995	15,290	264
[1]1144.5	374,705	15,554	1,651
1145.0	383,164	17,205	127
1145.5	391,796	17,332	113
1146.0	400,484	17,445	126
1146.5	409,233	17,571	134
1147.0	418,047	17,705	151
1147.5	426,934	17,856	161
1148.0	435,900	18,017	222

[1] The area curve at elevation 1144.5 ft shows the greatest change in water surface area and potential habitat throughout Milford Lake. The peak is just beyond the multipurpose elevation of 1144.4 ft. The peak likely indicates the sediment deltas at the upper end of the reservoir where the Republican River meets the main body of the reservoir at 1144.5 ft.

6.1.2 Kanopolis Lake

Figure 10 and Table 4 show elevation area curve data for Kanopolis Lake and are results of the Kansas Biological Survey October 2007 (Kansas Biological Survey 2007) bathymetric survey combined with June 2010 LiDAR data.

Figure 10. Kanopolis Lake elevation-area curve chart.

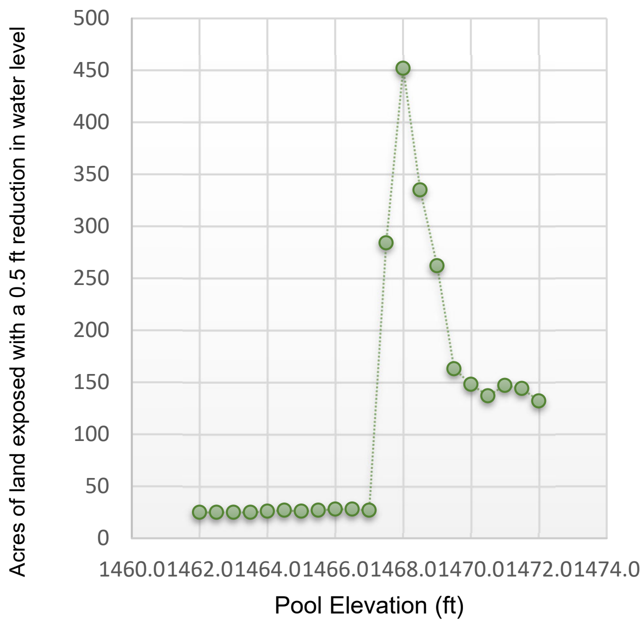

Table 4. Kanopolis Lake elevation area curve +/- 5 ft from multipurpose pool of 1463.0 ft msl.			
Pool Elevation	Pool Volume	Pool Acres	Acre Difference
1460.0	39,698	2,788	42
1460.5	41,103	2,830	42
1461.0	42,528	2,872	29
1461.5	43,972	2,901	24
1462.0	45,428	2,925	25
1462.5	46,897	2,950	25
*1463.0	48,378	2,975	25
1463.5	49,872	3,000	25
1464.0	51,378	3,025	26
1464.5	52,897	3,051	27
1465.0	54,430	3,078	26
1465.5	55,975	3,104	27
1466.0	57,534	3,131	28
1466.5	59,107	3,159	28
1467.0	60,693	3,187	27
1467.5	62,293	3,214	284
[2]1468.0	63,944	3,498	452
1468.5	65,816	3,950	335
1469.0	67,876	4,285	262
1469.5	70,087	4,547	163
1470.0	72,401	4,710	148

[2] The area curve at elevation 1468.0 ft shows the greatest gain in water surface area and maximum potential habitat throughout Kanopolis Lake. The peak is not near the multipurpose elevation of 1463.0 ft, but just beyond the target elevation of 1467.5 ft where the reservoir is managed approximately eight months of the year. The peak likely indicates sediment deltas at the upper end of the reservoir where the Smoky Hill River meets the main body of the reservoir at 1468.0 ft.

6.1.3 Wilson Lake

Figure 11 and Table 5 show elevation area curve data for Wilson Lake and are results of the Kansas Biological Survey July to October 2008 (Kansas Biological Survey 2008) bathymetric survey combined with June 2010 LiDAR data.

Figure 11. Wilson Lake elevation-area curve chart.

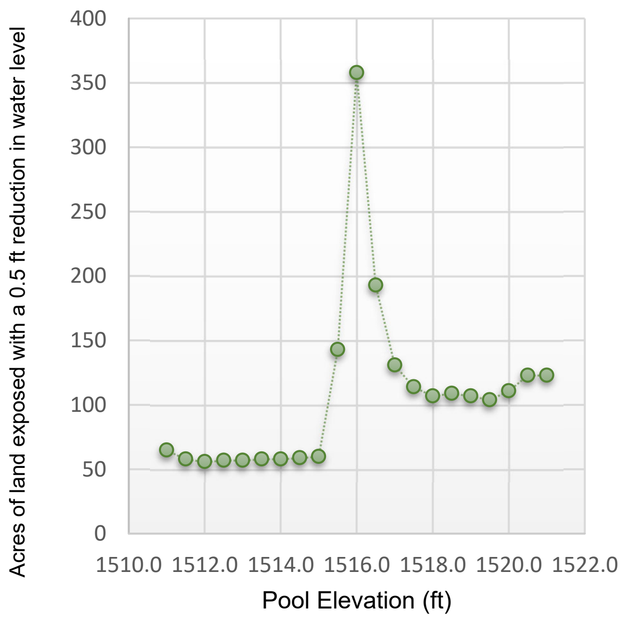

Table 5. Wilson Lake elevation area curve +/- 5 ft from multipurpose pool of 1516.0 ft msl.			
Pool Elevation	Pool Volume	Pool Acres	Acre Difference
1511.0	194,875	7,966	65
1511.5	198,876	8,031	58
1512.0	202,905	8,089	56
1512.5	206,964	8,145	57
1513.0	211,051	8,202	57
1513.5	215,167	8,259	58
1514.0	219,310	8,317	58
1514.5	223,484	8,375	59
1515.0	227,685	8,434	60
1515.5	231,918	8,494	143
[3]1516.0	236,188	8,637	358
1516.5	240,577	8,995	193
1517.0	245,123	9,188	131
1517.5	249,746	9,319	114
1518.0	254,431	9,433	107
1518.5	259,171	9,540	109
1519.0	263,965	9,649	107
1519.5	268,814	9,756	104
1520.0	273,715	9,860	111
1520.5	278,671	9,971	123
1521.0	283,685	10,094	123

[3] The area curve at elevation 1516.0 ft shows the greatest gain in water surface area and maximum potential habitat throughout Wilson Lake. The peak is right at multipurpose elevation of 1516.0 ft. The peak likely indicates the sediment deltas at the upper end of the reservoir where the Saline River meets the main body of the reservoir at 1516.0 ft.

6.1.4 Harlan County Lake

Figure 12 and Table 6 show elevation area curve data for Harlan County Lake and are results of bathymetric and land survey of the sediment ranges June 2000, tables dated January 2001 (Harlan County 2000).

Figure 12. Harlan County Lake elevation-area curve chart.

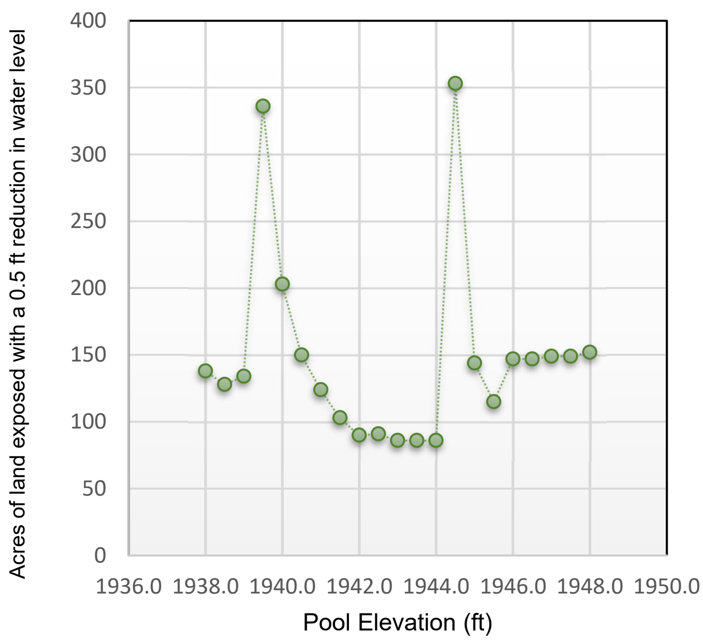

Table 6. Harlan County Lake elevation area curve +/- 5 ft from multipurpose pool 1516.0 ft msl.

Pool Elevation	Pool Volume	Pool Acres	Acre Difference
1938.0	219,910	10,987	138
1938.5	225,470	11,125	128
1939.0	231,030	11,253	134
[4]1939.5	236,774	11,387	336
1940.0	242,518	11,723	203
1940.5	248,468	11,926	150
1941.0	254,418	12,076	124
1941.5	260,513	12,200	103
1942.0	266,608	12,303	90
1942.5	272,805	12,393	91
1943.0	279,002	12,484	86
1943.5	285,287	12,570	86
1944.0	291,572	12,656	86
[5]1944.5	298,001	12,742	353
1945.0	304,448	13,095	144
1945.5	311,068	13,239	115
1946.0	317,687	13,383	147
1946.5	324,452	13,530	147
1947.0	331,217	13,677	149
1947.5	338,130	13,826	149
1948.0	345,043	13,975	152

6.2 Lake Bathymetry and LiDAR

Maps were created by USACE Engineering Research and Development Center cartographers using bathymetry and LiDAR data for each reservoir. Maps show changes in pool disposition at different elevations and include surface area, depth, location, and connectivity. Unfortunately, due to data gaps portions of the maps Milford, Kanopolis and Harlan County are missing. Following the workshop, GIS work will continue to locate missing data and refine the maps in order to produce finer details and data. The current maps are included in Appendix C.

[4] The area curve at elevations 1939.5 ft and 1944.5 ft show the greatest gain in water surface area and habitat throughout Harlan County Lake. The first peak likely indicates the sediment deltas at the upper end where the Republican River meets the main body of the reservoir at 1944.5 ft.

[5] The second peak at 1939.5 ft is unique, and it may indicate a sediment plateau created by significant shoreline erosion.

7.0 Summary of Regime Prescription Tool

A sequence of e-pools considerations was developed by the workshop group based on the life histories of ecological communities of management interest. Each consideration was specified per the communities of interest, seasonality, desired pool dynamic, justification, and any uncertainties. The collective seasonality of all considerations spanned the entire year (Table 7; Figure 13). Considerations focused on fish and birds, including shorebirds, waterfowl, and whooping cranes, as well as herptiles and aquatic mammals. Each consideration is detailed below and ordered per occurrence in water year.

Table 7. Summary of Regime Prescription Tool results.

Pool Prescription	Dates	Pool Dynamic	Details, Purpose, Benefits
Herptile Overwintering	Nov 15 – Feb 15	Stable	• Prevent stranding or freezing.
Spring Mudflat Habitat	Feb 5 – Mar 15	Falling	• Create mudflat habitat. • Expose invertebrate food source. • Promote perennial plant seed establishment.
Spring Waterfowl Migration	Feb 15 – Apr 30	Stable to Rising	• Maximize pool habitat 11 in deep or less.
Spring/Summer Fish Spawn	Mar 2 – Aug 15	Stable to Rising	• Promote nest and egg integrity. • Inundate vegetation to create cover. • Maximize habitat for y-o-y fish.
Spring Whooping Crane Migration	Mar 5 – Apr 1	Stable to Falling	• Promote roosting and forage habitat. • Maximize water depths up to 12 in.
Spring Shorebird Migration	Apr 1 – May 15	Stable to Falling	• Create mudflat habitat. • Expose invertebrate food source.
Summer Vegetation Habitat	May 5 – Jul 31	Falling	• Promote annual plant seed establishment. • Create future habitat for fish and waterfowl.
Fall Shorebird Migration	Jul 4 – Sep 1	Stable to Rising	• Maximize shallow water 8 in deep or so. • Create mudflat habitat. • Expose invertebrate food source.
Fall Waterfowl Migration	Sep 1 – Dec 31	Stable to Rising	• Inundate vegetation to promote food source. • Maximize water depths up to 11 in. • Connect habitat in upper reaches of reservoirs.
Fall Whooping Crane Migration	Oct 10 – Nov 10	Stable to Falling	• Maximize shallow water habitat up to 12 in deep. • Create mudflat habitat.

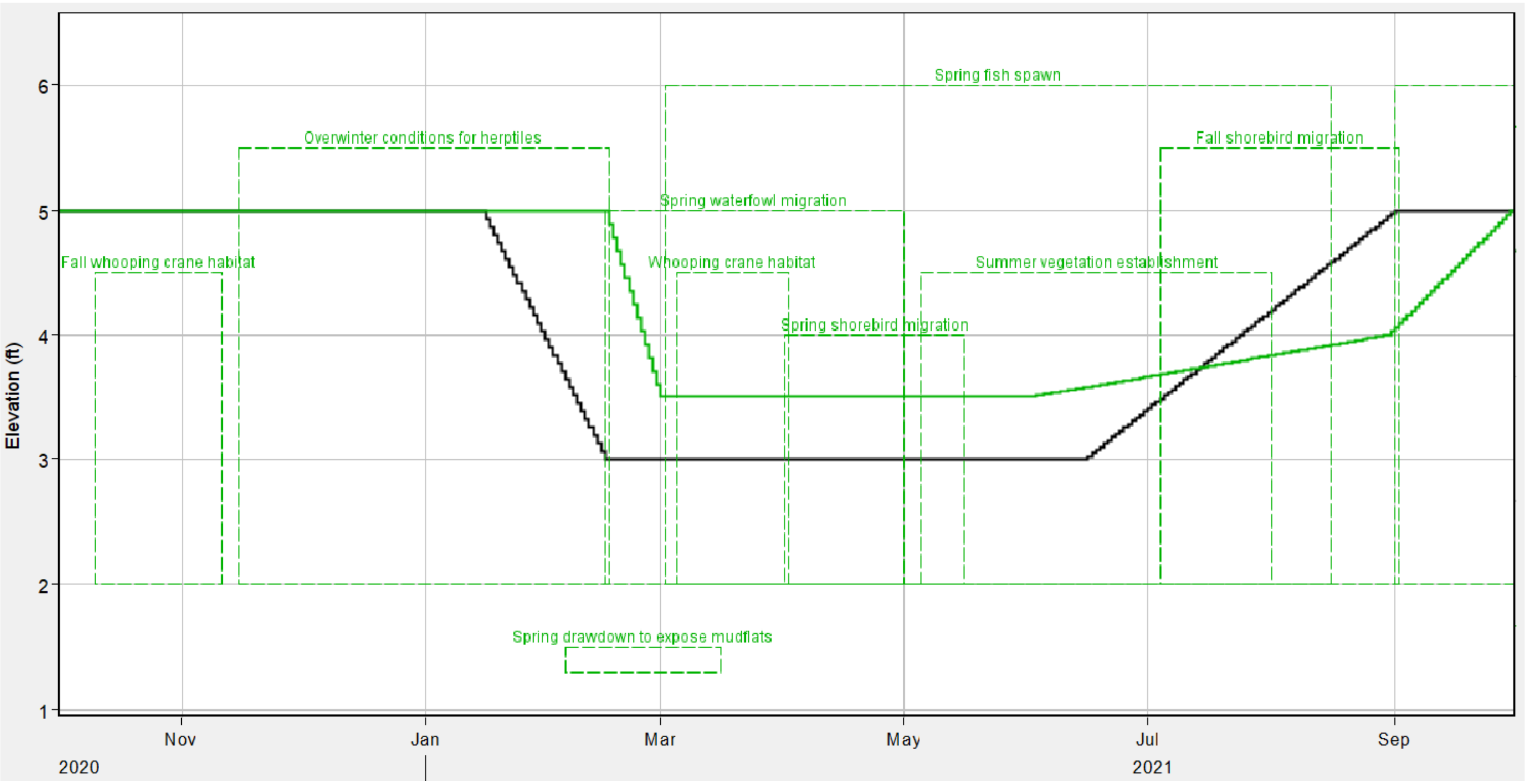

Figure 13. Sequence of environmental pool considerations. Magnitude of high and low elevation levels are not important in this figure. Those were set to separate labels for legibility.

Winter herptile habitat: Season November 15 to February 15. The desired pool dynamic is to maintain a stable pool to minimize stranding or freezing. There are uncertainties about this consideration such as limited knowledge about where overwintering herptiles tend to position within reservoirs (i.e., coves, deltas, riverine, etc.) and whether herptiles require water to overwinter (some species can overwinter in mud and leaf litter as opposed to water). Start of season is a function of air temperatures and is likely to begin when overnight freezes become common. Keeping water on shallow water habitat for herptiles could also have benefits for waterfowl. Higher waters during the October to early November timeframe would impact availability of whooping crane habitat.

Spring mudflat habitat: Season February 5 to March 15. A spring drawdown would function as a transition between the stable overwinter condition for herptiles (above) and the stable spring spawn for fish species (below). The drawdown would create mudflats and expose invertebrates as forage source for shorebirds. A spring drawdown would not be beneficial for migrating waterfowl as it is better to have the aquatic habitat for those birds. Most drawdown benefits related for waterfowl would involve provision of nesting and fledgling habitat, which would need to occur months later.

Spring waterfowl migration: Season February 15 to April 30. Geese are typically among the first species to begin their northbound migration and tend to be followed seasonally by duck species. Maintaining pools to maximize habitat with depths up to 11 in, especially for dabbling ducks, would be desired.

Spring/Summer fish spawn: Season March 2 to August 15. The desired pool dynamic is to have a stable pool during fish spawning season for nest and egg incubation integrity. The sequence of species spawning begins with walleye staging in March, then white bass, crappie, large and smallmouth bass, shad, and flathead catfish (most of which spawn by mid-July). Rearing habitat for y-o-y fish is enhanced by cover, especially inundated vegetation. It is important to note that ideal spawning conditions do not need to and are unlikely to occur every year. Conceptually, a multi-year sequence with vegetation recruitment followed in the next year by inundation of that vegetation to promote recruitment of a strong year class of fishes would be a viable strategy. Keeping water on vegetation for as long as possible would be beneficial for provision of rearing habitat.

Spring Whooping crane migration: Season March 5 to April 1. The Central Flyway Whooping cranes migrate between Wood-Buffalo National Park in Canada and the Gulf Coast of Texas. Their northbound migration occurs in early spring. Desirable stopover habitats for resting and forage are exposed or shallow pool areas with sparse vegetation and water depths up to 12 in.

Spring shorebird migration: Season April 1 to May 15. Pool drawdown beginning around April 1 would expose substrates and associated invertebrates thereby providing forage opportunities for migrating shorebirds. Shorebirds need habitats relatively clear of vegetation (25% or less of cover). Shorebird migration peaks between April 15 and May 15.

Summer vegetation habitat establishment: Season May 5 to July 31. Desired pool dynamic is a drawdown to promote vegetative growth, which in turn will help provide forage and cover for fish and waterfowl. Importantly, there are multiple considerations for this component. Too much high vegetation discourages species like shorebirds and cranes. This drawdown could also have water quality benefits by flushing nutrients from reservoir and stranding and desiccating algae. Need to be aware of the potential to promote establishment of invasive species of vegetation. Drawdowns that remove water from vegetation will expose young-of-year fish to predation as they retreat from cover to open water (see spring fish spawn above).

Fall shorebird migration: Season July 4 to September 1. The fall shorebird migration period is much longer than the spring as different species begin to migrate south through the flyway. Habitat criteria are consistent though. As for the spring migration, shorebirds utilize shallow or exposed wet substrates to forage on resident invertebrates. This habitat needs to be relatively clear of vegetation (25% or less of cover) with water depths up to 8 in. Fall shorebird migration is largely completed in west central Kansas by September 1. Waterfowl and rail migrations follow seasonally.

Fall waterfowl migration: Season September 1 to December 31. The fall bird migration period is longer than spring as different species migrate south on the flyway. Habitat criteria are consistent though. Waterfowl and rail migrations follow shorebirds, seasonally, with geese being among the last species migrating south through the flyway. Waterfowl utilize upper reaches and coves of reservoirs during the early fall migration between September and November, while during the late fall migration between December and January waterfowl utilize open water. Maintaining pools to provide habitat with depths up to 11 in, especially for dabbling ducks, would be desired.

Fall whooping crane migration: Season October 10 to November 10. Lower water levels would be desirable with exposed flats providing habitat and forage opportunities for whooping cranes.

8.0 Unification

As previously stated, the two breakout groups created e-pools prescriptions for fish and bird species. The intent of the workshop was to develop environmental pool management guide curves that benefited the two groups at each reservoir. During the breakout sessions each group was able to develop e-pools management guide curves indicating ideal pool level management prescriptions throughout the year that would benefit different life stages of their respective focus targets (i.e., fish, birds, other fauna). Additionally, each group recognized the importance the other group’s e-pools management prescriptions in creating future habitat when desirable pool conditions were not available. For example:

- A stable to rising pool in the spring and summer creates ideal habitat for fish spawning and rearing, but dry years with a low to falling pool promote vegetation growth that become future fish habitat once inundated with water.
- A falling pool in the spring or fall creates mudflats and exposes invertebrate ideal for migrating shorebirds and whooping cranes, but wet years with high, rising pools reduces vegetation encroachment to exposed mudflat areas.

Within the bird breakout group, it was recognized that beneficial habitat for shorebirds and whooping cranes did not necessarily match that of waterfowl. In addition, the shorebird and waterfowl migration tend to occur during different periods and duration of time creating opportunities for species specific prescriptions. Shorebirds and whooping cranes generally prefer shallow water near exposed mudflats that are void of vegetation, where waterfowl generally prefer shallow water that inundates nearby vegetation. E-pool prescriptions that favor falling pool levels that create mudflats in April or May benefit shorebirds, which also leads to promoting annual vegetation growth that could later be inundated with water in the fall providing a beneficial food source for waterfowl.

When reviewing the fish e-pools guide curve created using the RPT, the prescriptions align with what would be considered a normal to wet year where pool elevations remain at or above multipurpose pool. The stable to rising pool protects the integrity of fish nests and eggs during the spawn and inundates vegetation to provide rearing habitat and y-o-y cover from prey. When reviewing the bird e-pools guide curve created in RPT, the prescriptions align with what would be considered a dry year where pool elevations remain below multipurpose. The falling pool exposes mudflats and encourages perennial or annuals plants to germinate and grow providing future habitat in the form of food or shelter.

During the workshop, experts recommended the ability to identify an environmental cue that would trigger the application of the bird or fish e-pools guide curve. The trigger would likely consider pool elevation and precipitation at key periods throughout the year. Another recommendation was to copy the current Clinton Lake LLMP that is based upon alternating year plans. One plan enhances conditions for migratory waterfowl (i.e., Wildlife Plan), the other plan enhances conditions for fisheries (i.e., Fisheries Plan). Further discussion will need to occur to determine how each guide curve will be implemented to each LLMP.

9.0 Next Steps in the E-pools Process

Future work for FY24 for the Kansas River EMP project is currently being planned, and the EPM SRP team plans to pursue the following next steps dependent on funding:

- Add Perry Lake, Kansas and Tuttle Creek Lake, Kansas to the Kansas River EPM SRP project.
- Complete GIS models and data sets of lake elevations for shallow water habitat criteria for all six lake projects prioritizing the four current lakes from the 2023 e-pools workshop.
- Complete an e-pools workshop with technical partners for Perry and Tuttle Creek Lakes with summary to be included as an addendum to this workshop report.
- Analyze proposed e-pools strategies for nutrient loading, Kansas River SRP team e-flows, and climate change resiliency.
- Host an e-pools workshop for stakeholders with interests in water management at the six lake projects.
- Complete an e-pools management proposal to be implemented to the 2025 Lake Level Management Plans.

10.0 References

Eisenbraun and Associates. 2009. Milford Lake bathymetric survey combined with March 2010 LiDAR data.

Kansas Biological Survey. 2007. Kanopolis Lake bathymetric survey combined with June 2010 LiDAR data.

Kansas Biological Survey. 2008. Wilson Lake bathymetric survey combined with June 2010 LiDAR data.

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USACE. 2021a. Operational Management Plan: Harlan County Lake. Kansas City District.

USACE. 2021b. Operational Management Plan: Kanopolis Lake. Kansas City District.

USACE. 2021c. Operational Management Plan: Milford Lake. Kansas City District.

USACE. 2021d. Operational Management Plan: Wilson Lake. Kansas City District.

Appendix A: Agenda - E-pools workshop

SRP - Pool Level Management at MI, KA, WI, & HC
Environmental Pools Workshop

August 15, 2023

Optional Lake Site Visit

Location:
Wilson Lake Project Office
4860 Outlet Blvd
Sylvan Grove, KS 67648

13:00 Arrive at Wilson Lake Project Office before traveling to Control Tower

13:15 Arrive at Control Tower to review dam operations and outlet releases

14:00 Travel to Horseshoe Bend

14:30 Arrive at Horseshoe Bend to review shallow water habitat

15:15 Depart Horseshoe Bend and travel back to Wilson Lake Project Office

15:45 End tour

August 16, 2023

Location:
North Central Kansas Technical College
3033 US-24
Beloit, KS 67420

Virtual participants connected via Webex.

Workshop Agenda

09:00 Welcome & Introductions – Kyle Ruona, USACE KC

09:15 Review of SRP Process – Rheannon Hart & John Hickey, USACE SRP

09:30 Review previous meeting notes and workshop goals – Ruona, USACE KC

10:00 Review and discuss current Lake Level Management Plans (LLMP) – Brian Twombly & Ruona, USACE KC

- Review current LLMP for each lake. Discuss each lake project's authorized purposes, as well as other lake level management considerations and limitations.

10:30 Determine the sequence of e-pools management – Ruona, USACE KC

- Determine target species for e-pools management, lake habitat types that support the target species, the sequence of pool level manipulation that supports habitat types beneficial for target species throughout a calendar year, and if the target species, habitat types, and sequence is lake specific or general?

11:00 Review GIS data for MI, KA, WI, & HC Lakes – Ruona, USACE KC

- GIS data for each lake project include lake water surface area w/ depths +/- multipurpose pool, shallow water habitat (1' depth) at various lake levels +/- multipurpose pool, and mudflat land base 1' above lake level at various elevations +/- multipurpose pool.
- Determine if GIS data represents the various targeted species habitat types.

12:00 Lunch

13:00 Break out session: Apply GIS data to sequence of e-pools management to determine lake level management guide curve for each lake project. Utilize GIS data to inform target elevations during sequence of e-pools management that optimize target species habitat types.

- Group 1: Milford Lake
- Group 2: Kanopolis
- Group 3: Wilson
- Group 4: Harlan County

14:00 Break out session: Apply each lake specific e-pool management guide curve with target elevations and sequence to the Regime Prescription Tool software (RPT). Provide brief overview of RPT software before the breakout session. Review Kansas River RPT e-flows before breakout session.

- Group 1: Milford
- Group 2: Kanopolis
- Group 3: Wilson
- Group 4: Harlan County

15:00 Open discussion, workshop summary, future virtual workshop(s), and FY24 SRP proposal.

15:30 Adjourn

Appendix B: List of participants

Name	Agency/Title	Name	Agency/Title
Kyle Ruona	USACE, KC Ops	Heidi Mehl	TNC, KS
Tom Zikmund	USACE, HC	Becca Winterringer	TNC, HQ
Bryson Hellmuth	USACE, HC	Emily Kovar	TNC, KS
Ryan Williams	USACE, KA	Ryan Moon	TNC, KS
Nolan Fisher	USACE, WI	Robert Penner	TNC, KS
Clint Mason	USACE, KC Ops	Elsi Miller	TNC, KS
Curtis Keller	USACE, KC Ops	John Reinke	KDWP, Fisheries
Brian Twombly	USACE, KC H&H	Travis Riley	KDWP, Fisheries
Paul Simon	USACE, KC H&H	Scott Waters	KDWP, Public Lands
John Hickey	USACE, SRP	Brian Serpan	KDWP, Public Lands
Rheannon Hart	USACE, SRP	Scott Thomasson	KDWP, Public Lands
Marvin Boyer	USACE, KC PL	Tom Bidrowski	KDWP, Migratory Birds
Laura Totten	USACE, KC PL	Justin Wren	KDWP, Public Lands
Emily Nziramasanga	USACE, KC H&H	Richard Schultheis	KDWP, Migratory Birds
Seth Lerman	USACE, KC PL	Brett Miller	KDWP, Fisheries
Jake Jung	USACE, ERDC	Brad Eifert	NG&P[1], Fisheries
Todd Steissberg	USACE, ERDC	Ted LaGrange	NG&P[1], Wetlands
Lauren Melendez	USACE, ERDC	Chris Thornton	Ducks Unlimited
Dave Baasch	The Crane Trust	Erica Gnuse	Ducks Unlimited

[1] Nebraska Game and Parks (NG&P)

Appendix C: Lake maps, figures C1 to C4.

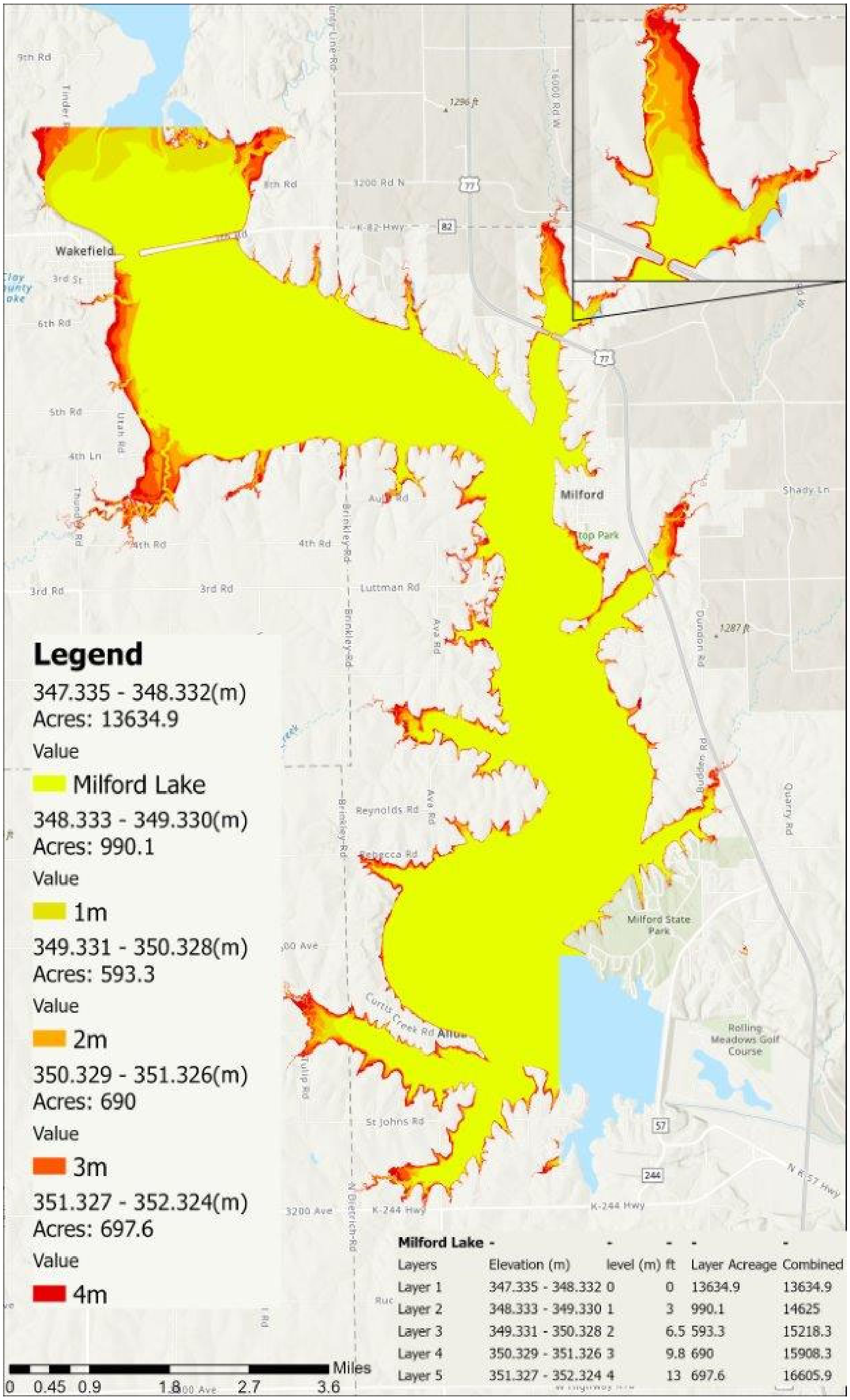
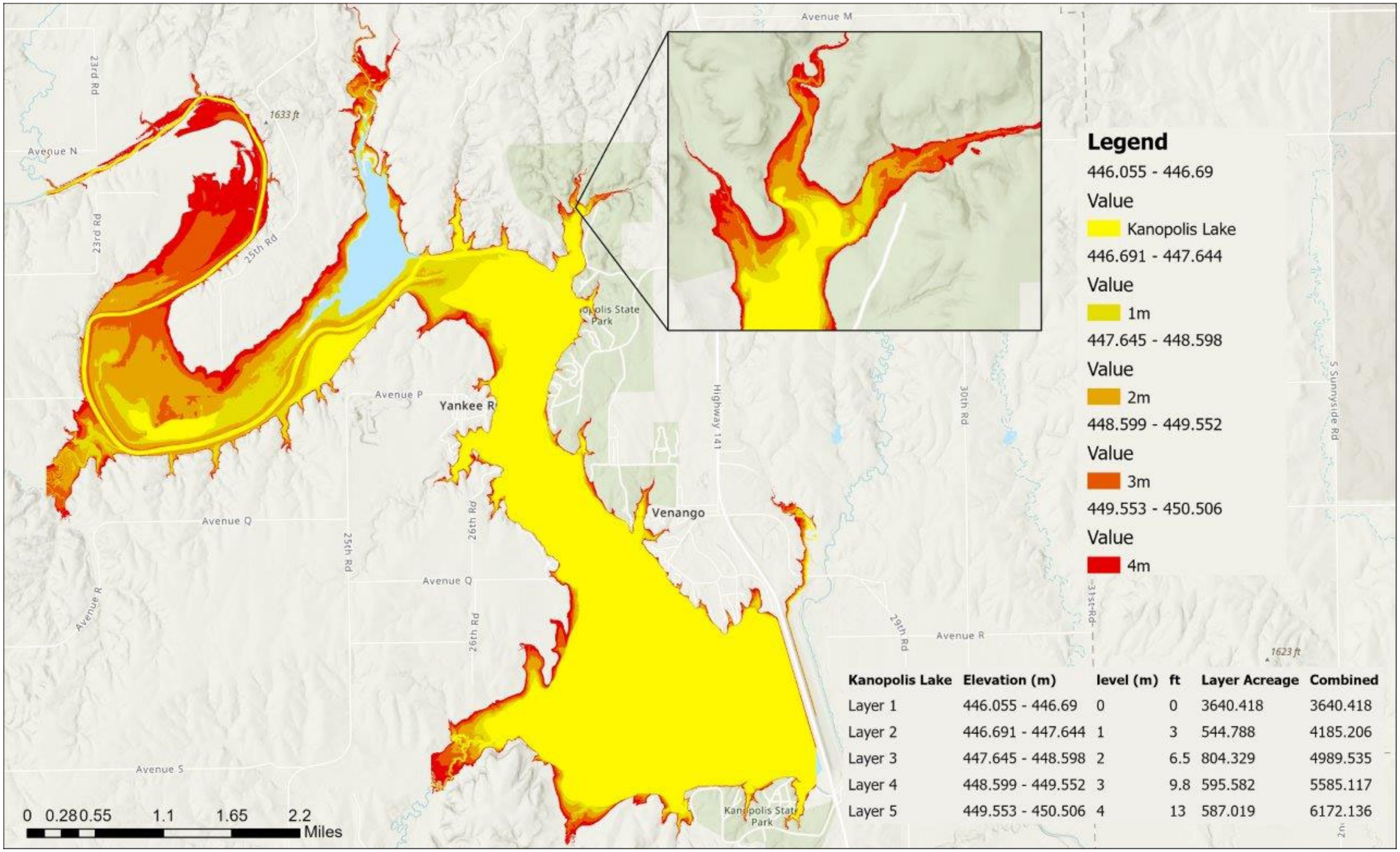
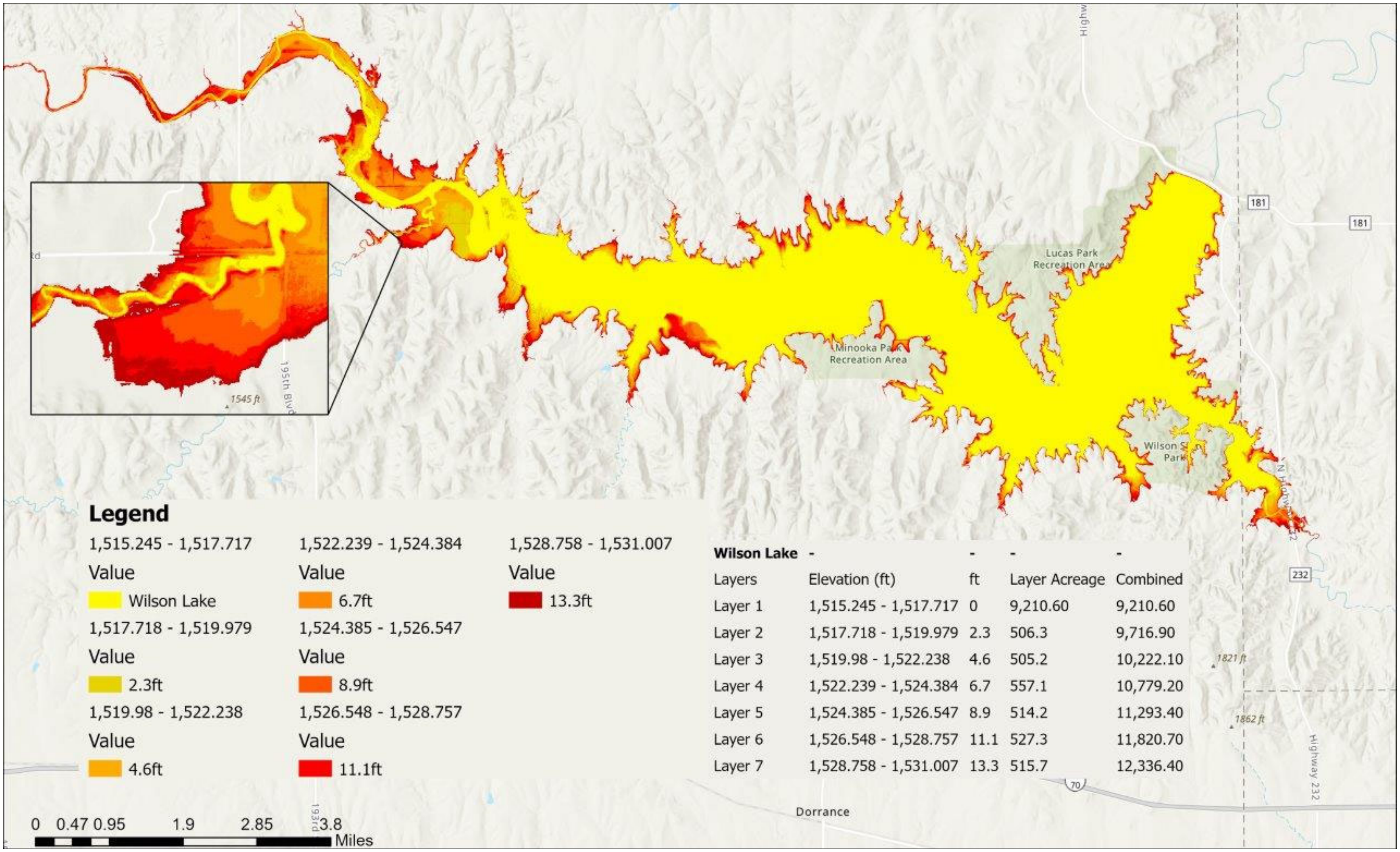


Figure C1. Elevation contours for Milford Lake.



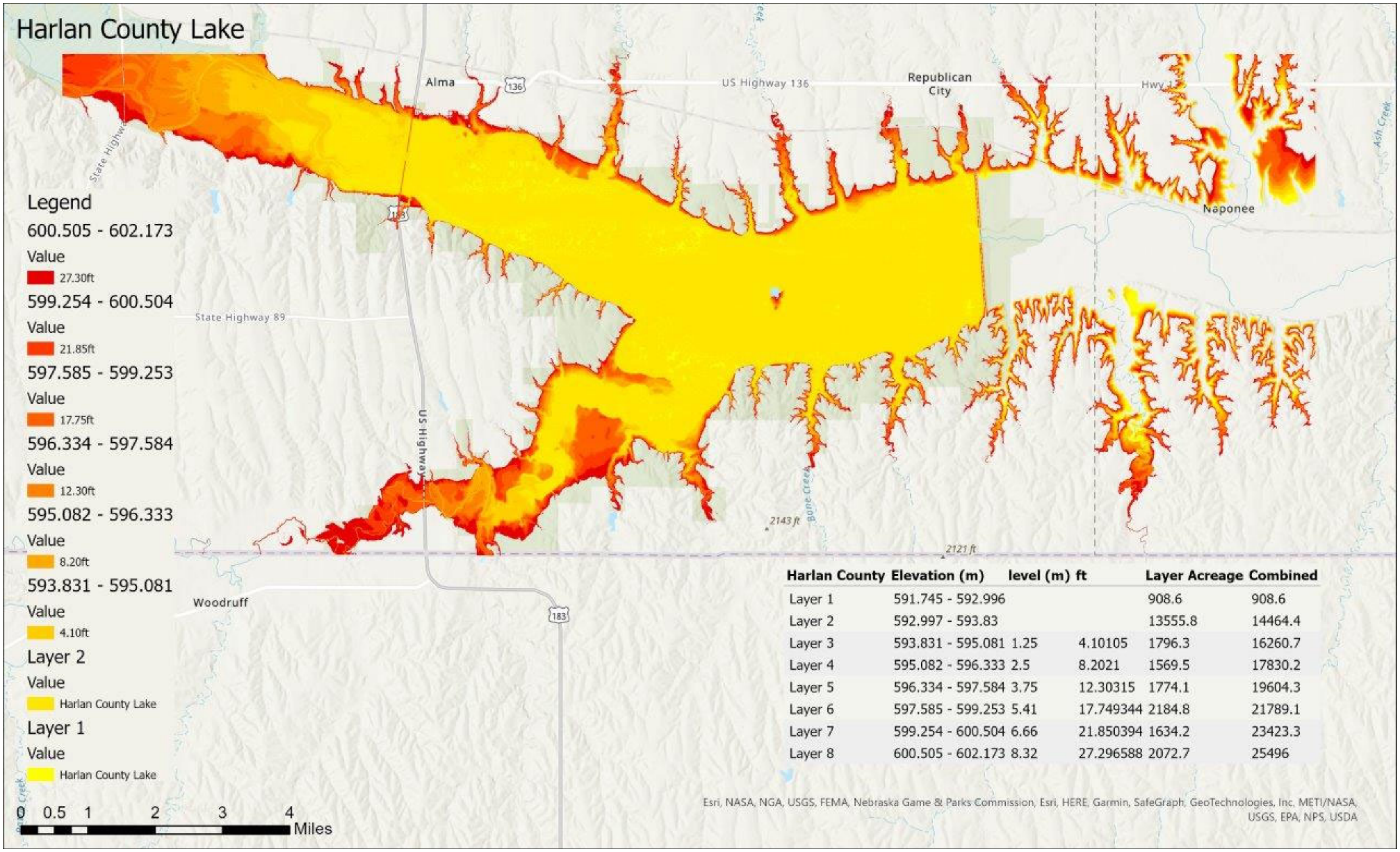
Kanopolis Lake	Elevation (m)	level (m)	ft	Layer Acreage	Combined
Layer 1	446.055 - 446.69	0	0	3640.418	3640.418
Layer 2	446.691 - 447.644	1	3	544.788	4185.206
Layer 3	447.645 - 448.598	2	6.5	804.329	4989.535
Layer 4	448.599 - 449.552	3	9.8	595.582	5585.117
Layer 5	449.553 - 450.506	4	13	587.019	6172.136

Figure C2. Elevation contours for Kanopolis Lake.



Wilson Lake	-	-	-	-
Layers	Elevation (ft)	ft	Layer Acreage	Combined
Layer 1	1,515.245 - 1,517.717	0	9,210.60	9,210.60
Layer 2	1,517.718 - 1,519.979	2.3	506.3	9,716.90
Layer 3	1,519.98 - 1,522.238	4.6	505.2	10,222.10
Layer 4	1,522.239 - 1,524.384	6.7	557.1	10,779.20
Layer 5	1,524.385 - 1,526.547	8.9	514.2	11,293.40
Layer 6	1,526.548 - 1,528.757	11.1	527.3	11,820.70
Layer 7	1,528.758 - 1,531.007	13.3	515.7	12,336.40

Figure C3. Elevation contours for Wilson Lake.



Harlan County	Elevation (m)	level (m)	ft	Layer Acreage	Combined
Layer 1	591.745 - 592.996			908.6	908.6
Layer 2	592.997 - 593.83			13555.8	14464.4
Layer 3	593.831 - 595.081	1.25	4.10105	1796.3	16260.7
Layer 4	595.082 - 596.333	2.5	8.2021	1569.5	17830.2
Layer 5	596.334 - 597.584	3.75	12.30315	1774.1	19604.3
Layer 6	597.585 - 599.253	5.41	17.749344	2184.8	21789.1
Layer 7	599.254 - 600.504	6.66	21.850394	1634.2	23423.3
Layer 8	600.505 - 602.173	8.32	27.296588	2072.7	25496

Figure C4. Elevation contours for Harlan County Lake.

Appendix D: E-pools kick-off meeting summary

Sustainable Rivers Program – Pool Level Management for Environmental Benefits at Harlan County, Wilson, Kanopolis, and Milford Lakes

09:00 – 12:00 Tuesday, February 28th, 2023
Webex

Participants

Name	Agency/Title	Name	Agency/Title
Kyle Ruona	USACE, Conservation Biologist	Robert Penner	TNC, Avian Conservation Manager
Brian Twombly	USACE, Hydraulic Engineer	Chris Thornton	Ducks Unlimited, Biologist
Curtis Keller	USACE, Conservation Biologist	Joel Jorgensen	NG&P, Nongame Bird Program Manager
Laura Totten	USACE, Planner	Brett Miller	KDWP, District Fisheries Biologist
Marvin Boyer	USACE, Limnologist	Scott Waters	KDWP, District Fisheries Biologist
John Hickey	USACE, Hydraulic Engineer	Scott Thomasson	KDWP, KA/WI Wildlife Area Manager
Bryson Hellmuth	USACE, HC Park Manager	Travis Riley	KDWP, District Fisheries Biologist
Ryan Williams	USACE, KA Park Manager	*Brad Eifert,	NG&P, Fisheries Biologist
Nolan Fisher	USACE, WI Park Manager	*John McKinney	NG&P, Waterfowl Program Manager
*Tom Bidrowski	KDWP, Migratory Game Bird Program Manager	*Ted LaGrange	NG&P, Wetland Program Manager
*Rich Schultheis	KDWP, Migratory Game Bird Coordinator		

*conversation separate from 2/28 meeting

1. The U.S. Army Corps of Engineers (USACE), Kansas City District (NWK) hosted a meeting with partners from The Nature Conservancy (TNC), Kansas Department of Wildlife & Parks (KDWP), Nebraska Game & Fish (NG&F), and Kansas & Nebraska Ducks Unlimited (DU) on 28 February 2023 for the Sustainable Rivers Program – Pool Level Management for Environmental Benefits at Harlan County, Wilson, Kanopolis, and Milford lakes. The primary purpose of the meeting was to allow regional biologists and representatives for the four lakes to gather, discuss, and identify focal species and the shallow water habitat criteria needed to optimize habitat provided within the context of pool management for all operating purposes. During the meeting an overview of the project was discussed to include the scope of work, schedule, and intended outcomes. Specific conversation topics included water management, fish, shorebird, and waterfowl considerations related to pool level management for environmental benefits.

2. Kick-off Meeting Discussion

    a. Water management considerations for pool level management

        i. Pool rises – current Lake Level Management Plans (LLMPs) allow small, temporary rises into the flood control pool for e-benefits limited to a 5% rise of flood pool or less.
        ii. Pool drawdowns – would need to consider effects on water supply storage at all 4 lakes, as well as irrigation at Harlan County Lake.
        iii. Water control manual updates, which include LLMPs, are being initiated at the four lakes projects and will occur over the next 5-10 years. This creates an opportunity to provide considerations and potentially implementation of pool level management for environmental benefits.

    b. Fish considerations for pool level management

        i. Generally, the more water the better with regards to fish species.
        ii. Shallow water habitat beneficial for sportfish (walleye, white bass, wiper, channel catfish, largemouth bass, and crappie) can range from 1 to 5 feet in depth.
        iii. Most sportfish spawn in April and May. Catfish species spawn in late May and June. Maintaining a stable pool level around multipurpose elevation or 1 to 3 feet higher with a slow and steady rise is ideal and most beneficial to fish species during the spawn.
            1. A Kansas State University study at Tuttle Creek and Milford Lakes showed strong recruitment during high water years for catfish species.
        iv. High water releases should be avoided during spawning season to avoid loss of habitat and loss of fish. Below are approximations of what is considered a low and high water release per location as it pertains to fish loss.
            1. Harlan County – low water release is considered 100 cfs, high water release is considered 500 cfs. At 1,150 cfs releases channel capacity becomes an issue. Tainter gate surface releases in the spring should be avoided at Harlan County Lake to prevent unnecessary fish loss.
            2. Wilson – low water release is considered 15 cfs, high water release is considered 750 cfs or greater.
            3. Kanopolis – low water release is considered 100 - 200 cfs, high water release is considered 1,000 cfs or greater.
            4. Milford – information unavailable at the time of meeting.
            5. Low water releases over a long period of time are more beneficial to fish species that inhabit these lakes than high water releases over a short duration.
        v. Overall vegetative habitat is lacking at the four lakes. Summer drawdowns to allow vegetation growth followed by inundation of vegetation would be beneficial for fish species.

vi. Consider habitat connectivity at different pool elevations. Sedimentation, shoreline erosion, and other features have created barriers that disconnect water resources at various pool elevations.

c. Shorebird considerations for pool management

i. Shorebirds spring migration through the four-lake region occurs during the months of April and May.
ii. Shorebird shallow water habitat is considered 8" or less with the addition of mud flats composed of wet and dry mud and sparse vegetation consisting of less than 25% ground cover.
iii. Slow water releases in the spring beginning in March would create exposed mud flats with exposed invertebrate food beneficial for migrating shorebirds. Generally, dynamic water levels that perpetually create shallow water habitat is beneficial to shorebirds.
iv. Backwater coves with shallow water habitat enhanced from shoreline erosion or sedimentation is beneficial to migrating shorebirds.
v. Whooping cranes utilize up to 1 to 2 feet deep water for feeding but tend to roost in deeper water.

d. Waterfowl considerations for pool management

i. Waterfowl shallow water habitat for feeding is considered 11 inches or less for dabbling ducks (mallard, pintail, teal, wigeon, gadwall) and 18-20 inches for diving ducks (redhead, scaup, goldeneye, merganser).
ii. During the fall migration waterfowl has a plant food focus for feeding that is enhanced by high water inundating the vegetation.
iii. During the spring migration waterfowl has an invertebrate food focus that is enhanced by removing water creating mudflats with exposed invertebrates for feed.
iv. During the early fall migration from September to Thanksgiving the particular migrating waterfowl species tend to utilize upper reaches of lakes. During the late migration from Thanksgiving to late winter the particular migrating waterfowl species utilize the open water bodies of lakes.
v. A late summer pool drawdown to allow annual plant production in mud flat areas, later to be flooded in the fall would be beneficial to migrating waterfowl. The slow pool rise in the fall would begin in August and end following the first frost.

e. Other species considerations for pool management

i. None at this time, but still seeking input.

f. Comments

i. Generally, fish populations are more stable and are able to recover faster compared to bird populations.
ii. Determine that low pool elevations do not impact water intake structures for developed wetlands.

iii. An increase in water releases during cold winter months with significant ice cover will create more open water downstream for migrating waterfowl.
iv. High water flows remove woody vegetation from streams and create exposed sandbars beneficial to migratory shorebirds and waterfowl.
v. Low water elevations would impact recreational uses at the four lake projects.

g. Concerns

i. By manipulating pool elevation, we may be creating an opportunity for invasive species to become established i.e., phragmites.
ii. Harmful Algal Blooms have previously occurred at 3 of the 4 lakes. Drawdowns from spring to mid-summer have been ineffective in preventing HABs. A post July 4th drawdown may be more beneficial and effective at preventing HABs.

h. Common themes amongst all species

i. Mimic natural systems with more variations in pool elevation to create more dynamic habitat.
ii. A late summer pool elevation drawdown to expose mud flat areas and allow annual plant production to be flooded later is beneficial to fish, shorebird, and waterfowl species.
iii. Low water releases over a long period of time are beneficial to fish, shorebird, and waterfowl species.

3. Due Outs

a. Regional spring and fall waterfowl migration historical data – McKinney, Bidrowski, KDWP wildlife area managers
b. Historical fish survey data for lakes – Eifert, Miller, Riley, Waters
c. Historical hydrograph for lakes – Ruona, Twombly
d. Gather necessary GIS data to begin modelling – Ruona, Keller

4. Next Steps

a. Review meeting summary for accuracy and consistency. Add comments as needed.
b. Review historic hydrograph data for each lake to determine the likelihood that pool level management for environmental benefits is feasible.
c. Begin developing GIS modelling for each lake to target elevations below and above lake multipurpose elevation and determine acres of exposed mud flats, shallow water, and total water.
d. Utilize the Regime Prescription Tool where applicable.