Heron Lake Management Plan
DOW #32005700
December 2021

Prepared By:

Maggie Gross and Brian Nyborg

Please Direct Questions To:

Maggie Gross - Wildlife Lake Specialist
Minnesota Department of Natural Resources
175 County Road 26, Windom, MN 56101
Phone: (507) 832-6016
Email: margaret.gross@state.mn.us

Table of Contents

Figures

Appendices

Attachments

General Lake Information

- County: Jackson
- Location: T103N/104N, R36W/37W, Section(s) 2-4, 7, 10-15, 17-21, 23-30, 33-35
- Size: 7,997 acres (entire basin)
    - Heron Lake is divided into four sub-basins:
        1. Duck Lake (DOW# 32005702) – 462 acres
        2. North Marsh (DOW# 32005701) – 1,075 acres
        3. North Heron (DOW# 32005705) – 3,381 acres
        4. South Heron (DOW# 32005707) – 3,079 acres
    - Special considerations: All acre and mile values were obtained using Minnesota Department of Natural Resources (DNR) data and Geographic Information System (GIS) software.
- Shoreline: 66 miles
- Access: Four public water accesses are present, one on Jack Creek and three on South Heron (Attachment A).
- Watershed: Des Moines River, West Fork Des Moines - Headwaters
    - Watershed area: 283,930 acres (444 square miles)
    - Watershed-to-lake ratio: 36:1
    - Inlets: Many intermittent streams and ditches inlet into Heron Lake, but Okabena Creek, Jack Creek, Judicial Ditch (J.D.) 3, J.D. 17, and J.D. 31 are the primary inlets (Attachment A).
    - Land Use: Recreation, row-crop agriculture, and pasture.
- Depth: Average depth is around 2.9 feet (ft.) at normal summer pool, with a maximum depth closer to 6.5 ft. The greatest depth ever recorded was around 12.0 ft. in 1947.
- Outlet: The Heron Lake Outlet stream, which is located on the northeast side of North Marsh (Attachment A). This stream eventually outlets into the West Fork of the Des Moines River.
- Water control structure: The outlet for Heron Lake is controlled by a dam that consists of a 60.25 ft. reinforced concrete weir, two 5 ft. stop-log bays fitted with removable steel gates, and a 40 ft. hydraulic gate (Attachment B). The hydraulic gate can be operated between 1400.2 ft. and 1396.2 ft. (i.e., the sill elevation). The concrete weir and the stop-log bays have a crest elevation of 1399.5 ft.
    - Special considerations: Elevations listed in this management plan are in NGVD 29 datum unless otherwise indicated.
        - To convert NGVD 29 to NAVD 88, add 0.47 ft.
- Ordinary High Water Level:
    1. Duck Lake (established in 1987) – 1403.0 ft.
    2. North Marsh (established in 1978) – 1401.0 ft.
    3. North Heron (established in 1978) – 1401.0 ft.
    4. South Heron (established in 1979) – 1403.0 ft.
- Water level readings: Water level readings have been taken periodically since 1907 on North Marsh (Figure 1), North Heron (Figure 2), and South Heron (Figure 3). Water level readings are only displayed from 1987 onward because the Heron Lake water control structure was significantly modified in 1987.

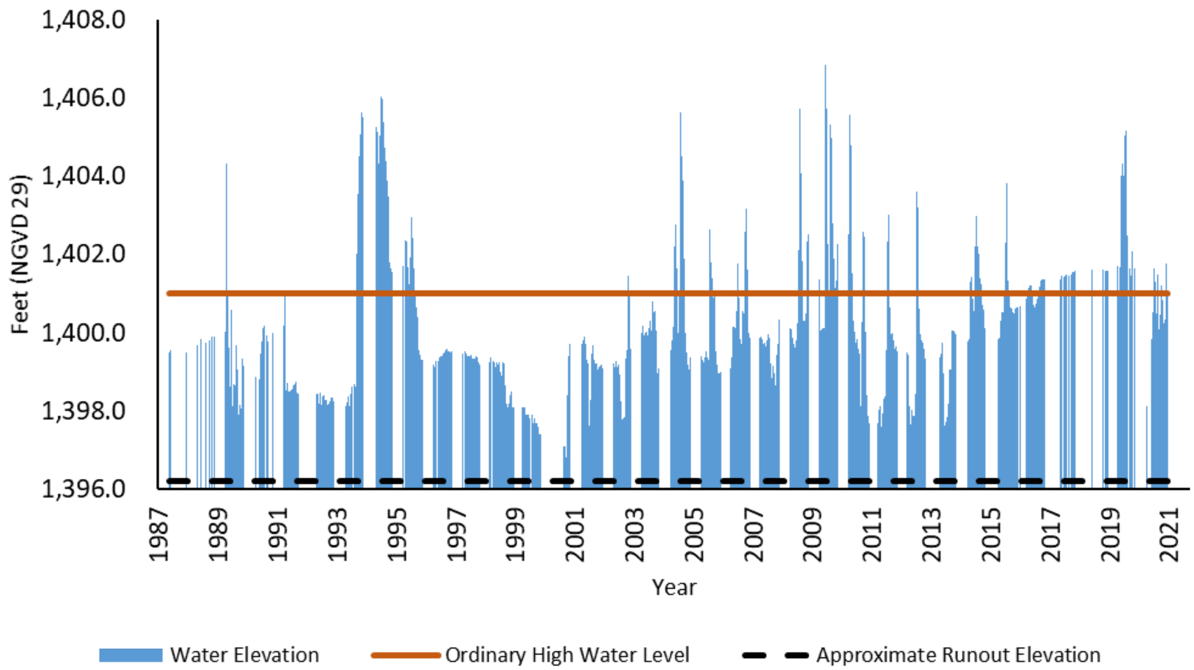


Figure 1. Water level readings, ordinary high water level, and approximate runout elevation for North Marsh from 1987 to 2021.

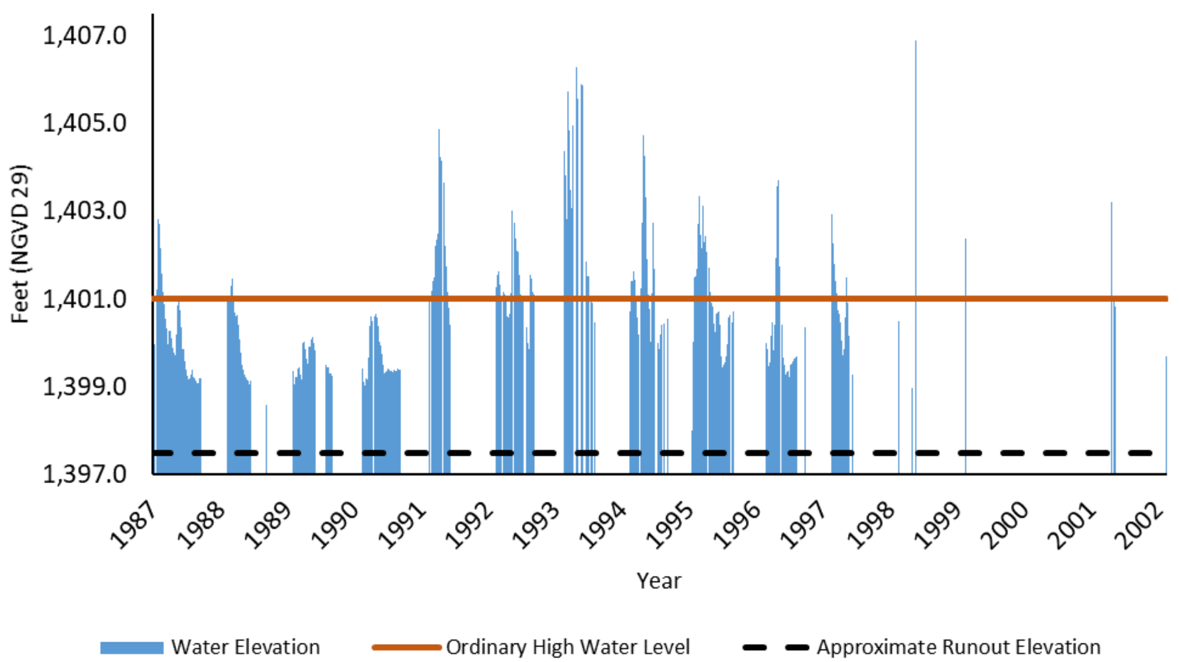


Figure 2. Water level readings, ordinary high water level, and approximate runout elevation for North Heron from 1987 to 2002.

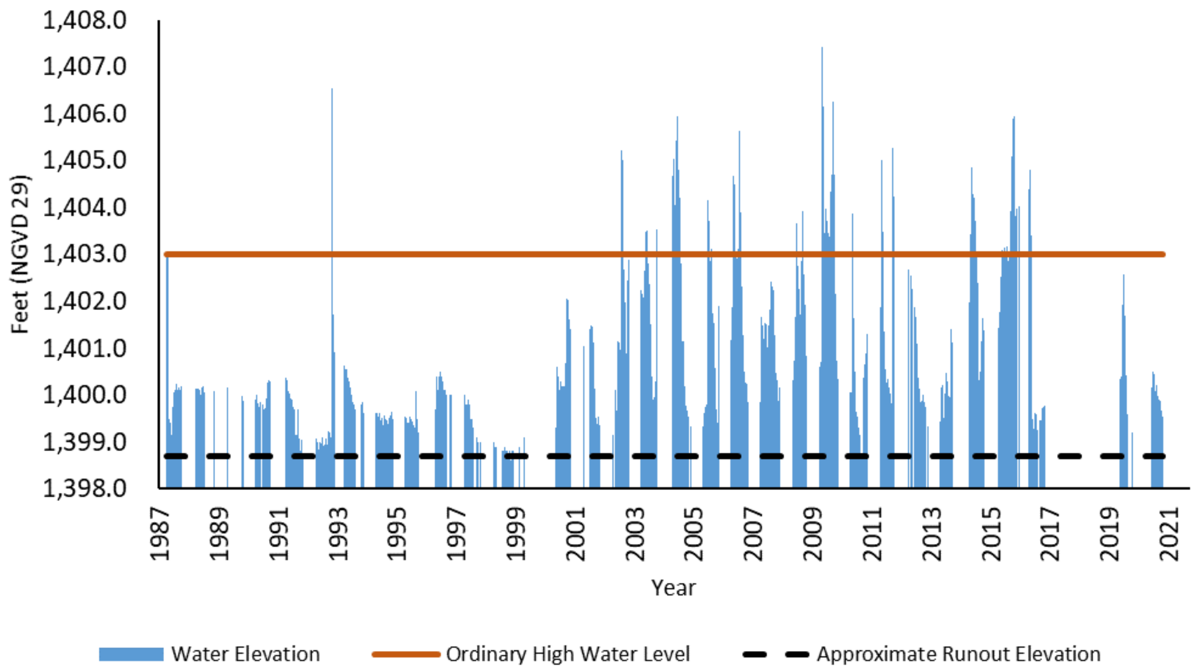


Figure 3. Water level readings, ordinary high water level, and approximate runout elevation for South Heron from 1987 to 2021.

Background Information

Heron Lake is a shallow lake that stretches about 15 miles between the towns of Heron Lake and Lakefield. This lake has a long and unique history, with DNR involvement since the late 1930s. Traditionally, Heron Lake provided habitat for vast numbers of waterfowl, waterbirds, aquatic furbearers, and other wildlife species. One of the most notable waterbirds that utilized the exceptional wildlife habitat in Heron Lake was the black-crowned night heron. Heron Lake was named after these birds, which nested on the lake in considerable numbers at the time of European settlement.

Historically, there have been many concerns with the water levels in Heron Lake. Farmers called for enlarging the existing drainage channels and removing the extensive aquatic vegetation growing in these channels in the early 20th century because high water levels periodically inundated agricultural land. Other citizens were opposed to such actions, expressing their concern that any major alterations of the existing drainage characteristics might adversely affect the lake levels and wildlife habitat. The drainage controversy remained unresolved until the drought of the late 1920s, when the major focus of public concern shifted to the unusually low water levels of Heron Lake. In 1931, the Jackson County Board was petitioned by various citizens to establish water levels for Heron Lake, which was completed by a civil engineer named A.E. Wallace. The established water levels were 1399.6 ft. for North Heron and 1400.8 ft. for South Heron. Drainage issues concerning Heron Lake, as well as the effect of water levels on adjacent agricultural lands and wildlife habitat, continue to be a topic of dispute to this day.

Heron Lake originally had an estimated 8,251 acres of lakebed, which is more than the current lakebed estimate of 7,997 acres. The difference in the acres of lakebed could be attributed to improved survey technology, changes in land use practices, and implementation of artificial drainage systems (i.e., dikes, pumps, tile lines, and ditches). An extensive network of tile lines, drainage ditches, and dikes have been installed within the Heron Lake watershed throughout the last century to carry away surface water and provide adequate drainage for agriculture. This conversion from prairie to intensive row crop agriculture has resulted in the drainage of 99.3% of the original wetlands and the destruction of 99% of the native prairie in the Heron Lake watershed. Therefore, the water supply from ground water and precipitation across the Heron Lake watershed far exceeds what is needed to sustain a normal pool elevation in the basin during most years.

Heron Lake consists of four sub-basins: Duck Lake, North Marsh, North Heron, and South Heron. Duck Lake is approximately 2.25 miles in length and has an average depth of about 2.4 ft., with a substrate consisting of mud and detritus. North Marsh is approximately 2.5 miles long and has an average depth of about 1.6 ft., with a substrate consisting of primarily mud. North Marsh is the shallowest sub-basin of Heron Lake. North Heron is approximately 3.25 miles in length and has an average depth of 2.7 ft. North Heron's substrate consists of a mixture of silt, clay, and muck. South Heron is the longest, deepest sub-basin and has an average water depth of 3.1 ft., is approximately 7.5 miles in length, and has a substrate that consists of a mixture of sand, silt, and clay.

A channel system connects the four sub-basins of Heron Lake during periods with average or low water levels. South Heron is connected to North Heron by Division Creek and North Heron is connected to North Marsh by the Heron Lake Outlet stream (Attachment A). Duck Lake is separated from the other three sub-basins by Minnesota Highway 60 but is connected to North Marsh by a metal sheet pile structure with steel stoplogs. Water flows from South Heron into North Heron, then from North Heron into North Marsh. Duck Lake flows into North Marsh as well. The runout elevation for the Duck Lake metal sheet pile structure is 1401.8 ft., but the approximate bottom elevation is unknown. Recent survey data recorded an approximate runout elevation of 1396.2 ft. for North Marsh, 1397.5 ft. for North Heron, and 1398.7 ft. for South Heron. Survey data from 2019–2021 also indicated that 1395.2 ft. is the lowest bottom elevation for North Marsh, 1396.4 ft. is the lowest bottom elevation for North Heron, and 1396.0 ft. is the lowest bottom elevation for South Heron.

Three major dams were constructed within Heron Lake to retain water during dry years and manage water levels. The first major dam was constructed in 1932 in Division Creek, at the outlet of South Heron. Little is known about this dam other than that it was a temporary wood and sheet piling structure, with a crest elevation of 1401.0 ft. (local datum), which remained in place until 1947. The second major dam was the Dalziel Dam and was in the Heron Lake Outlet stream between North Heron and North Marsh. The original Dalziel Dam was constructed in 1940 and measured about 30 ft. in length, had a minimum crest elevation of 1397.4 ft. (local datum), and consisted of flax straw bales and wood planks. The Dalziel Dam was improved each year and by 1980, it had a total length of 125 ft., a crest elevation around 1400.4 ft. (local datum), and contained a 36 ft. long wooden stop-log structure with seven stop-log bays. The Dalziel Dam was primarily managed by private citizens. In 1987, the DNR requested the Dalziel Dam be removed and this request was controversial. However, a settlement was reached between the DNR and the owners of the Dalziel Dam, and it was removed in 1999.

The third major dam for Heron Lake is called the State Dam and located in North Marsh, at the outlet for the lake. The State Dam is still in place and has a long history dating back to 1932. The original State Dam was a temporary rock dam, but in 1937, the Works Progress Administration constructed a permanent dam that consisted of 19 five-foot wide concrete stop-log bays. The State Dam in-stream piers were built to an elevation of 1401.2 ft., the stop-logs were installed to an elevation of 1399.7 ft., and the sill elevation was 1396.2 ft. There was a lot of unauthorized manipulation of the State Dam, so the DNR Division of Waters installed galvanized steel stop-logs, with a steel bar welded into the stop-log slots, to prevent the unwanted removal of stop-logs in 1967. Nonetheless, people continued to vandalize the State Dam and it was largely destroyed by dynamite in 1969. Following the dynamite event, the DNR gave local citizens permission to close the dynamited section by the placement of power poles during the waterfowl hunting season.

The State Dam was renovated in 1987. The existing in-stream piers were cut down from 1401.2 ft. to 1400.2 ft. and ten of the original 19 stop-log bays were filled with concrete to an elevation of 1400.2 ft. Of the remaining nine stop-log bays, two were fitted with removable steel maintenance gates and seven were converted to one 40 ft. wide bay with a hydraulic gate capable of being opened to any level between 1400.2 ft. and 1396.2 ft. (Attachment B). Additionally, an electric fish barrier was installed downstream of the State Dam in 1991 (Attachment C). The fish barrier was installed to inhibit destructive bottom-feeding fish from migrating into Heron Lake from the West Fork of the Des Moines River. The most recent modification to the State Dam occurred in 2006 when the concrete weir was lowered to 1399.5 ft. This modification reduced the head-to-tail water elevation difference and improved water flow.

Important Consideration: When the hydraulic gate on the State Dam is open, downstream channel restrictions control the outflow of Heron Lake. If the hydraulic gate is closed and the water level is around one foot above the crest of the dam, the downstream channel also controls the outflow. Consequently, during a flood, the downstream channel controls the outflow of Heron Lake, not the State Dam, regardless of the position of the hydraulic gate.

There has been extreme competition among different user groups throughout the history of Heron Lake for access to the renowned waterfowl hunting areas and exceptional fish and wildlife habitat within the basin. Therefore, several important regulations have been implemented across parts of the Heron Lake system. In 1906, the riparian landowners around North Heron implemented an informal agreement that is still in effect today. This agreement imposed self-regulations among the landowners and included restrictions on hunting hours and boat movements. The idea behind this agreement was to give waterfowl a chance to rest without boating and hunting disturbance. These restrictions, along with other factors that limit public access, have significantly limited hunters from using boats on the open water portions of North Heron and North Marsh.

Heron Lake was designated as a Wildlife Lake (Minnesota Statute [M.S.] 97A.101) in 1973. The goal of Wildlife Lake designation was to improve Heron Lake for waterfowl, furbearers, and other species of wildlife traditionally found in southern Minnesota by managing water levels, controlling undesirable fish populations, and making enhancements within the Heron Lake watershed. All sub-basins, except for Duck Lake, were included in the Wildlife Lake designation. Duck Lake was not included because it has an independent low water runout and alteration was not required to achieve the management goals of the other sub-basins. In 1986, part of South Heron was designated as Migratory Waterfowl Feeding and Resting Area (M.S. 97A.095; Attachment D). Under this designation, no motorboat use is allowed during the open waterfowl season, except electric trolling motors with battery power of 12 volts or less, to limit waterfowl disturbance. In 1990, part of North Heron also was designated as a Migratory Waterfowl Feeding and Resting Area (Attachment D). Furthermore, the DNR commissioner implemented surface use regulations (M.S. 97A.101) in 1999 on Division Creek, North Heron, and North Marsh (Attachment E). These surface use restrictions state that no motorboat use, except electric trolling motors with battery power of 12 volts or less, is allowed March 1 through July 31.

Important Consideration: The remainder of this management plan will only focus on survey data and management objectives for the part of Heron Lake that is designated as a Wildlife Lake (i.e., North Marsh, North Heron, and South Heron).

There were four earlier management plans for Heron Lake, written in 1972, 1984, 1988, and 1998. The management goals and objectives across all these plans were similar. In general, the management strategies in these plans focused on manipulating water levels to improve wildlife habitat, reducing rough fish (e.g., common carp, black bullheads, fathead minnows) populations, conducting channel improvements in some of the inlets and outlets of Heron Lake, and implementing Best Management Practices (BMPs; i.e., practices to protect water and soil resources) throughout the Heron Lake watershed (Appendix A).

Many groups have assisted and advised the DNR in managing Heron Lake over the course of its history. Of these groups, four principal organizations have helped facilitate major improvement efforts within Heron Lake and its watershed. The first group was The North Heron Lake Game Producers Association (NHLGPA), which was established in 1965 and remains active now. This group consists of landowners around North Heron and some additional local citizens. The main goal of this group is to protect and restore North Heron. The second organization was the Heron Lake Taskforce, established in 1982. This group consisted of DNR employees, the Heron Lake Watershed District (HLWD) board, and three citizen members. The Heron Lake Taskforce is no longer in existence. The third organization was the Heron Lake Area Restoration Association (HLARA), established in 1989. This group consisted of county board members, HLWD members, municipality and township board members, and representatives from other private organizations. The focus of this group was to restore Heron Lake and its watershed to a waterbird migration and production area of international significance. The HLARA is no longer active. Finally, the Heron Lake Waterfowl Working Group (HLWWG) was established in 2018. This group consists of representatives from the DNR, NHLGPA, HLWD, University of Minnesota, Pheasants Forever, Ducks Unlimited, The Nature Conservancy, Delta Waterfowl, U.S. Fish and Wildlife Service, Heron Lake Farms, and The Minnesota Land Trust. The purpose of this group is to initiate measures that increase breeding and migratory waterfowl habitat and use throughout the Heron Lake watershed by applying BMPs on agricultural lands, strategically acquiring lands (i.e., fee title or easement acquisitions), building partnerships, and practicing adaptive shallow lake management principles. The HLWWG is still active today.

Water Quality

Water quality measurements (e.g., alkalinity, nitrogen, conductivity) have been taken intermittently on Heron Lake since 1932. These measurements have been collected by a variety of organizations including the Minnesota Pollution Control Agency (MPCA) Citizen Lake Monitoring Program, DNR Section of Wildlife, DNR Section of Fisheries, DNR Division of Ecological and Water Resources, and HLWD. The amount of total phosphorus in water samples increased from 1947 to 1981, then consistently decreased until 1991. Total phosphorus values fluctuated from 1991 to 2009 and dramatically decreased from 2009 to 2019 (Figure 4). The lowest total phosphorus value across all water samples (n = 43) was 0.03 milligrams per liter (mg/L) and the highest value was 0.91 mg/L, with the average being around 0.20 mg/L. The 2019 water samples (n = 30) had an average total phosphorus value of 0.12 mg/L, which is slightly higher than the established MPCA total phosphorus impairment threshold (i.e., 0.09 mg/L; Western Corn Belt Plains area). However, the average total phosphorus increased in 2020 (0.37 mg/L; n = 3). Average Secchi disk readings improved from 1947 to 2019 (Figure 5). Furthermore, the average Secchi disk reading in 2019 was the highest across all years (1.7 ft.; n = 10), but was still less than the established MPCA Secchi disk impairment threshold (i.e., 2.3 ft.; Western Corn Belt Plains area).

The impairment thresholds established by MPCA are eutrophication standards for shallow lake ecosystems. These standards have been created to help establish a balanced population of aquatic plants that supports a broad array of aquatic life uses and recreation (Class 2b & 2c water quality standards; Minnesota Rule [M.R.] Chapter 7050, 2002). Maintaining these standards promotes the establishment of native plants while minimizing dominance of non-native species and nuisance algal blooms. Managing total phosphorus concentrations below a range that promotes excessive algal growth is an important consideration of this plan. Nonetheless, water transparency is the most significant threshold in relation to lake health and submersed aquatic plant abundance in southwest Minnesota. For that reason, water clarity will be the most important measure when contemplating managed drawdowns.

The improvement in water clarity and decrease in total phosphorus from 2009 to 2019 can probably be attributed a strong northern pike and walleye year class in Heron Lake, as well as various nutrient reduction projects within the Heron Lake watershed. Stocking predator fish (e.g., northern pike, walleye, and yellow perch) may reduce nuisance fish species (e.g., black bullheads, common carp, fathead minnows) that impair water clarity (Appendix B). Anglers reported excellent northern pike and walleye fishing on Heron Lake during the fall of 2017 and the winter of 2017-2018. These northern pike and walleye were most likely from the 2016 stocking by the DNR Section of Fisheries. In addition, the HLWD has implemented several nutrient reduction projects within the Heron Lake watershed. These projects included septic system improvements for areas around Heron Lake, increased use of cover crops, and wetland and stream enhancement.

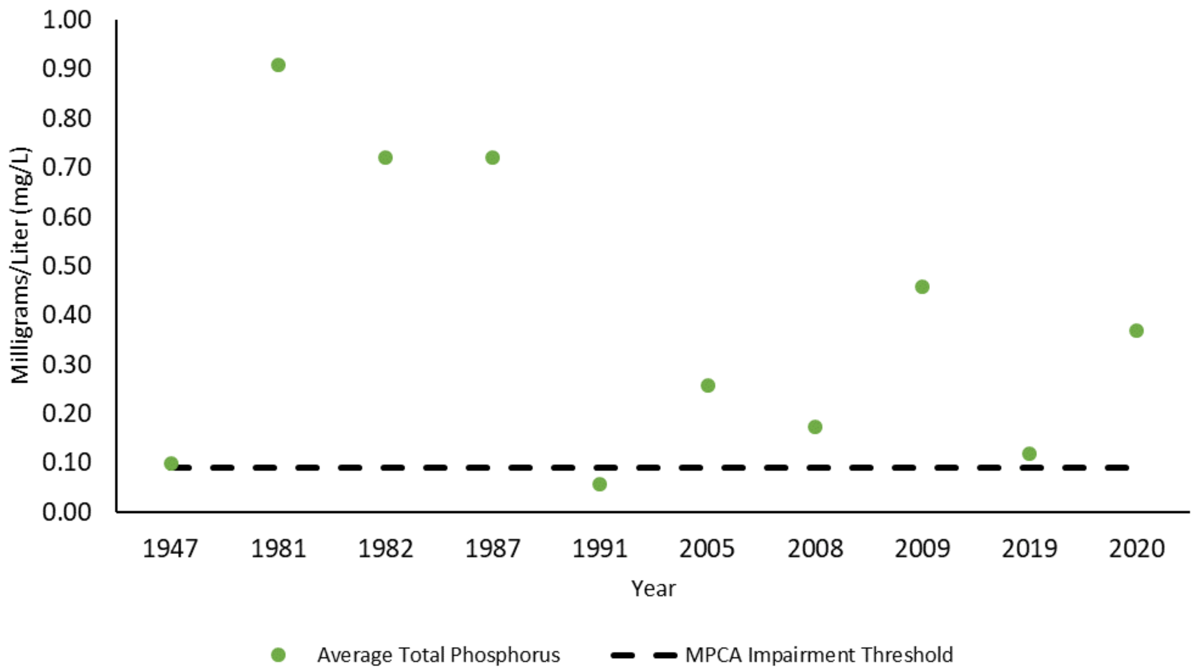


Figure 4. Average total phosphorus in water samples collected from Heron Lake during 1947–2020.

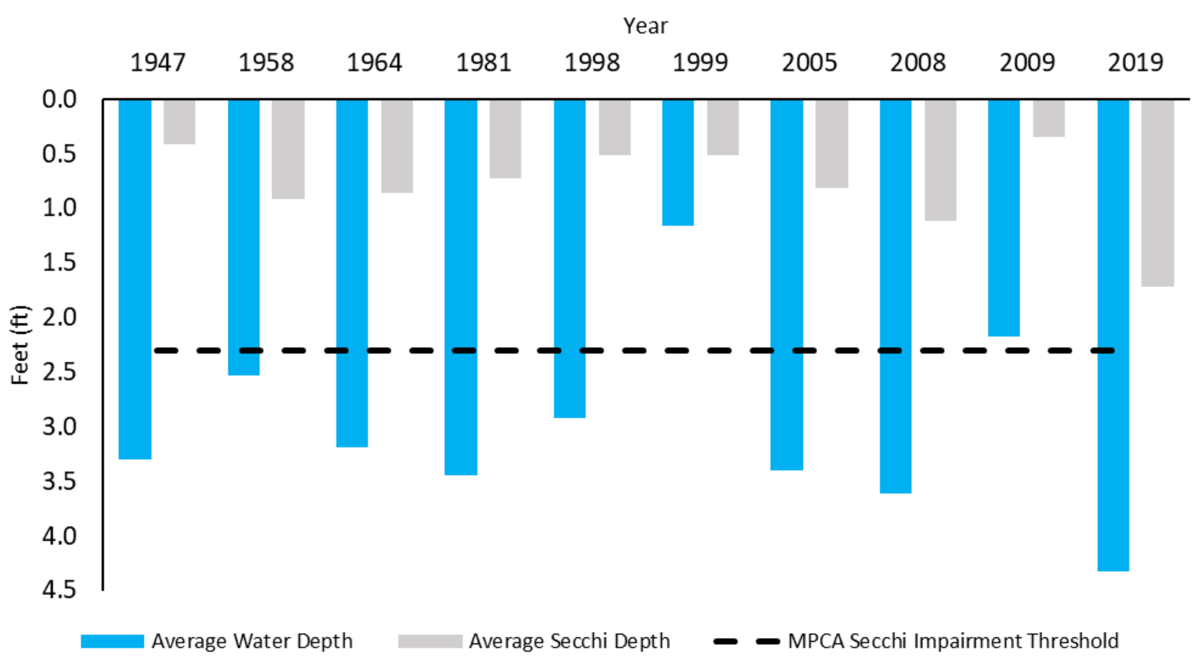


Figure 5. Average water and Secchi depth readings recorded during game and wildlife lake surveys for Heron Lake during 1947–2019.

Fish and Wildlife Habitat

The Heron Lake watershed consists of 3.6% permanent cover (i.e., Permanent Wetland Preserve easements, Reinvest in Minnesota easements, wildlife management areas, and waterfowl production areas; 10,242 acres) and 0.2% temporary cover (i.e., Conservation Reserve Enhancement Program lands; 526 acres). Additionally, there are 15 major lakes above Heron Lake in its watershed, which support a variety of fish species (e.g., northern pike, common carp, and black bullheads) and ultimately provide a source of fish for Heron Lake during high water periods. These lakes are Lake Flahtery (491 acres), Teal Lake (90 acres), First Fulda (123 acres), Second Fulda (64 acres), Willow Lake (85 acres), Unnamed Lake (73 acres), Corabelle Lake (108 acres), Jack Lake (81 acres), West Graham (557 acres), East Graham (521 acres), and Sieverding Marsh (100 acres). Other priority shallow lakes near Heron Lake are Teal Lake and Timber Lake. Heron Lake and Teal Lake are the only designated Wildlife Lakes (M.S. 97A.101) in Jackson County. There are two Wildlife Management Areas (WMA) near Heron Lake, Heron Meadows WMA and Heron Lake WMA. Heron Meadows WMA is located on the west side of North Marsh and Heron Lake WMA is divided into several units that are located on the west side of North Heron and South Heron (Attachment A).

There is a long history of Heron Lake providing habitat for waterfowl, aquatic furbearers, and other wildlife common to southwest Minnesota. There also is archaeological evidence that Heron Lake was an important resource for Native Americans for thousands of years. Surveys of the area in the early 19th century noted large numbers of black-crowned night herons and Franklin's gulls. Other nesting birds have included Canada geese, trumpeter swans, thousands of waterfowl, American white pelicans, and double-crested cormorants. Muskrats also were abundant, with as many as 5,000 muskrats taken by trappers in a single day. As a result, Heron Lake quickly became one of the most renowned waterfowl hunting lakes in Minnesota. During the period of 1880–1900, about 25 to 30 market hunters hunted Heron Lake. Daily bags of 90–100 ducks per hunter were common, a majority of which were canvasbacks. These large canvasback groups, consisting of as many as 700,000 birds, were often observed feeding on wild celery during fall migration. Unfortunately, the once pristine wildlife habitat within Heron Lake has deteriorated since the early 1900s due to intense agricultural practices and other land use changes.

A calcareous fen (EOID #9198) was identified by the DNR in a wetland complex adjacent to the southeast end of South Heron in 1986 (Appendix C). Fens are rare natural ecosystems that have special protections in Minnesota (M.S. 103G.223). The Heron Lake fen was reassessed by the DNR Division of Ecological and Water Resources in 2018 and is in good to fair condition. The fen is located on a hillside between LiDAR estimated elevations 1407 ft. and 1416 ft., which is approximately 4-13 ft. above the ordinary high water level of South Heron. The dominant plant species observed during this assessment were narrowleaf cattail, porcupine sedge, prairie sedge, yellow widelip orchid, and spring cress.

There have been four game lake surveys and six wildlife lake surveys conducted on Heron Lake since 1947. Across all surveys, the average lake depth has increased by 1 ft. (Figure 5). This increase in water is likely the result of increased surface water runoff rather than deepening of the lakebed. Recorded depths ranged from 0.5 ft. to 12 ft. deep. Sago pondweed was the most dominant plant species observed across all surveys (Figure 6), but the percentage of points with submersed aquatic vegetation varied from year to year. Although sago pondweed is considered an important waterfowl food, it is not a good indicator of water quality conditions because it tolerates high nutrient concentrations better than many other species of aquatic vegetation. The greatest lakewide species richness (S) for aquatic vegetation (i.e., submersed, floating-leaf, and emergent vegetation) was observed in 1958 (S = 9), followed by 1964 (S = 7), 1981 (S = 7), and 2019 (S = 7).

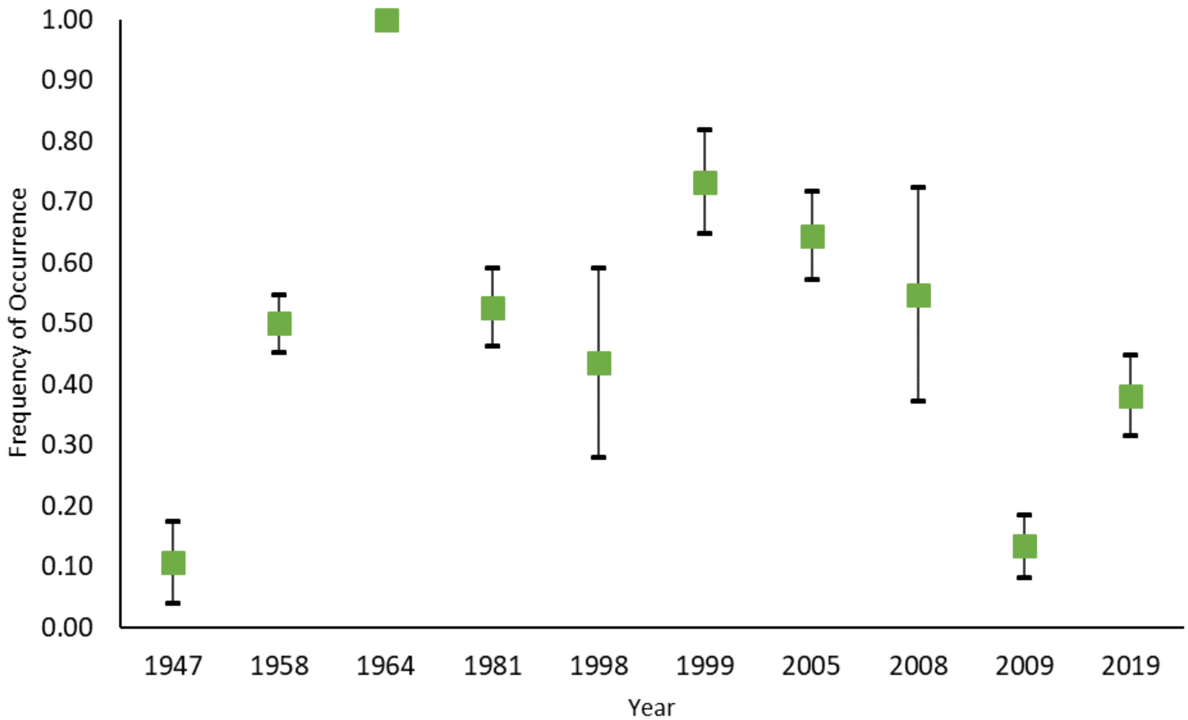


Figure 6. Frequency of occurrence for sago pondweed recorded during the game and wildlife lake surveys from 1947 to 2019.

Heron Lake has always been connected to the Des Moines River system and thus fish have continually been a part of the lake ecosystem. South Heron has consistently had the best fish habitat, when compared to the other sub-basins in the Heron Lake system. In the past, South Heron provided excellent spawning habitat for walleye, northern pike, and other panfish species (e.g., yellow perch, black crappies). North Marsh and North Heron also once provided adequate spawning habitat for fish. The abundant aquatic vegetation across Heron Lake used to provide nursery habitat for small fish as well, which protected them from a variety of predators (e.g., bitterns, gulls, terns). Unfortunately, the fish habitat conditions deteriorated rapidly after common carp were either introduced or migrated into Heron Lake in 1918. Around this same time, silt deposition accelerated in Heron Lake from the drainage ditches in its watershed. The combination of increased rough fish activity and siltation caused the water to become more turbid, ultimately degrading the water quality and fish habitat in Heron Lake.

There have been 13 fish netting surveys conducted on South Heron since 1947. One fish survey was conducted on North Heron and North Marsh in 1947, but these sub-basins have not been sampled more recently because shallow water depths preclude effective fish sampling. The latest fish netting survey for South Heron occurred in 2017. Black bullheads were the most dominant fish species observed across all fish netting surveys, followed by fathead minnows and common carp. However, the numbers of common carp and black bullheads have decreased since 1981 (Figure 7).

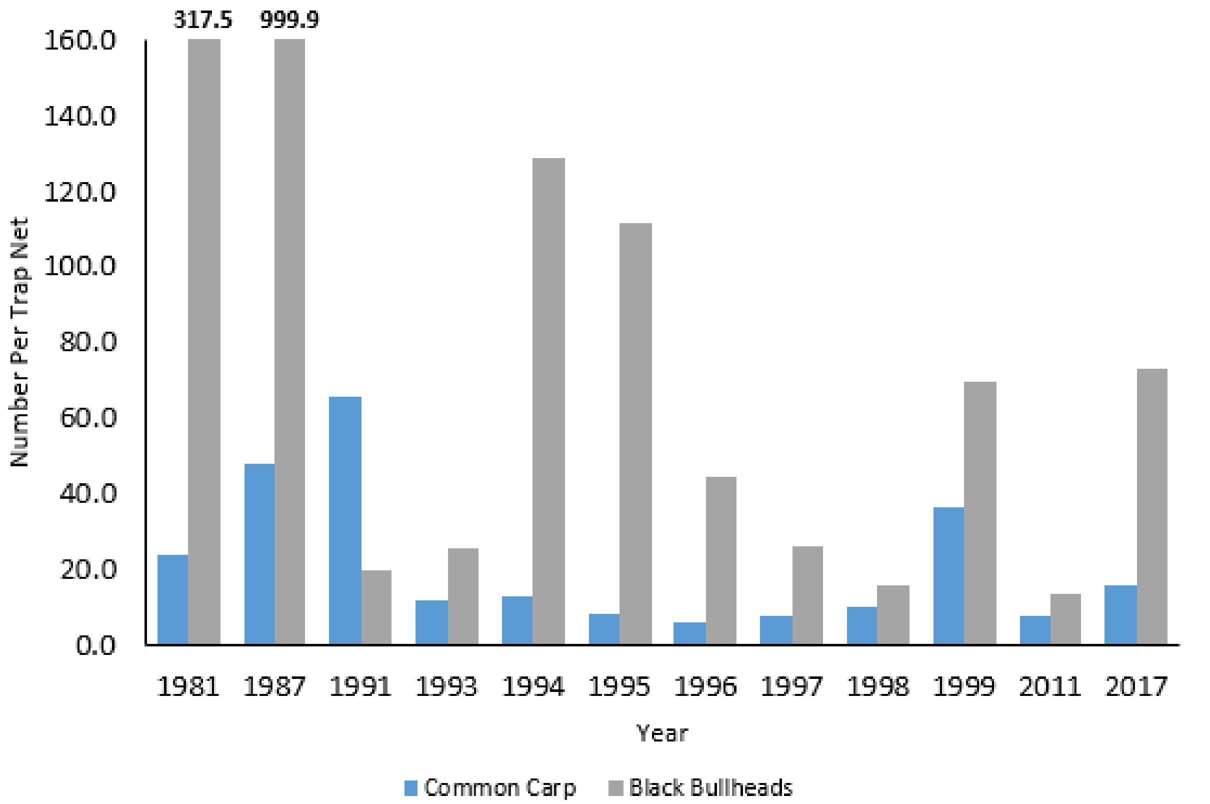


Figure 7. Numbers of common carp and black bullheads caught in standard trap nets from 1981 to 2017. Data from the 1947 fish netting survey were excluded due to the use of different survey techniques. Black bullhead numbers exceeded the bounds of this graph in 1981 and 1987, so the number per trap net is displayed above the bars for these years.

Wildlife Use

The wildlife use information for Heron Lake was collected during game lake surveys, wildlife lake surveys, fish netting surveys, a brood count survey, and waterfowl surveys. The waterfowl brood count survey occurred in 1970 and the waterfowl surveys were conducted intermittently from 1906 to 2008. Mallards were the most common wildlife species observed throughout all surveys, followed by canvasbacks, American coots, Canada geese, green-winged teal, and American white pelicans. Mink, raccoons, muskrats, beavers, painted turtles, and snapping turtles also have been observed on Heron Lake. Other wildlife observations have included chorus frogs, leeches, dragonflies, chironomids, and whirligig beetles.

Heron Lake has a rich history of waterfowl hunting, especially North Marsh and North Heron. South Heron provided hunting opportunities equal to or greater than that of North Heron prior to 1900, but South Heron's waterfowl habitat has since deteriorated. For example, the emergent vegetation in South Heron is now restricted to a narrow fringe around the shoreline and mainly consists of hybrid cattail and some bulrush species. Waterfowl hunting on North Marsh and North Heron remains at a level exceeding most hunting areas in southwest Minnesota today. However, the presence of rough fish and poor water quality in Heron Lake has reduced its value as a waterfowl feeding and brooding area.

Muskrats were abundant on Heron Lake during the early 1900s, but their utilization of Heron Lake has declined dramatically since then. Lake survey data from 2005–2021 indicates that there is little evidence of muskrats using Heron Lake (i.e., ≤ 2 muskrat huts and no individuals observed), despite the dense stands of cattails on North Marsh and North Heron. The lack of muskrat use on Heron Lake is likely due to its extreme water level fluctuations from increased use of artificial drainage systems and excessive precipitation across its watershed, as well as the tendency of North Marsh and North Heron to freeze to the bottom even in years when the lake is at full pool elevation. For example, the DNR has documented that storm flooding can cause water levels to rise about 3 ft. within 48 hours and late spring runoff can cause the water levels to increase by 4.0–6.0 ft. in Heron Lake. The DNR also confirmed that North Marsh and North Heron would freeze to the bottom during winter when water levels at the State Dam are at or below full pool elevation (i.e., 1399.5 ft.) using bathymetry data collected during winter 2021. Muskrats prefer to utilize basins with relatively stable water levels that range from 0.5–2.0 ft. This water level range provides an optimum depth for muskrat lodge construction and reproductive success. Muskrats also require water under the ice to access their dens and forage for food during the winter months. The DNR cannot legally increase the full pool elevation of Heron Lake (M.R. 6115) and there is not a feasible way to reduce the water level fluctuations within Heron Lake, given the size of its watershed, so it would be difficult for large muskrat populations to be sustained in the basin.

Fishery

South Heron is the only sub-basin that the DNR Section of Fisheries actively manages for fish, in coordination with the DNR Section of Wildlife. Historical fish management activities have included predator fish stocking, the use of liquid rotenone, and rough fish (e.g., common carp, black bullheads) removal. South Heron is currently managed as a “boom or bust” fishery that mainly consists of predatory fish (i.e., northern pike, walleye, and yellow perch), which help control some rough fish populations (Appendix B). It is important to note that recreational fishing may be a byproduct of stocking predator fish in some years, but creating a recreational fishery is not the primary goal of this management strategy.

The primary role of northern pike in the Heron Lake system is to help control fathead minnows and other juvenile forage fish (Appendix B). Northern pike eggs were stocked in 1930 and fry were stocked in 1964, 1998, 2009, 2014, and 2016. In addition, northern pike adults were stocked in 1998 and 1999. Walleye also provide a means of controlling rough fish populations in Heron Lake, especially young black bullheads (i.e., fry, fingerlings, and small adults) and fathead minnows (Appendix B). Walleye fry were stocked in 1930, 1980, 2011, 2012, 2013, 2014, 2015, 2016, and 2017. The walleye fry post 2011 were part of an advantageous stocking effort that occurred due to the availability of surplus walleye fry. Yellow perch can help control fathead minnow populations as well (Appendix B). Yellow perch fry were stocked in the mid-1940s, adults were stocked in 1980, and yearlings were stocked in 1982. Yellow perch have not been stocked recently because most yellow perch populations in southwest Minnesota are naturally reproducing and self-sustaining. Northern pike, walleye, and yellow perch populations in Heron Lake have been monitored since 1947 because of their role as predatory fish and as popular game fish species in Minnesota (Figure 8).

Rotenone, a common piscicide, has only been used once in Heron Lake, during the winter of 1997-1998. A rotenone application was determined to be feasible by the DNR Section of Wildlife because there was a drought in 1997 and a partial fish winterkill was anticipated in Heron Lake. In preparation for the rotenone treatment, local commercial fishing operations removed approximately 265,000 lbs. of common carp during the fall of 1997. The rotenone treatment was done by drilling holes through the ice and applying liquid rotenone directly into the water using a pump and a long piece of polyvinyl chloride (PVC) pipe with an elbow at the end. Shortly after the rotenone treatment, a late winter warming period resulted in dilution of the rotenone in the treatment area. Consequently, there was only a partial rotenone-induced fish kill. Following this rotenone treatment, approximately 35,000 northern pike fry were stocked to promote additional common carp control in Heron Lake. An additional 4,200 winter rescue northern pike were stocked during the winter of 1998-1999.

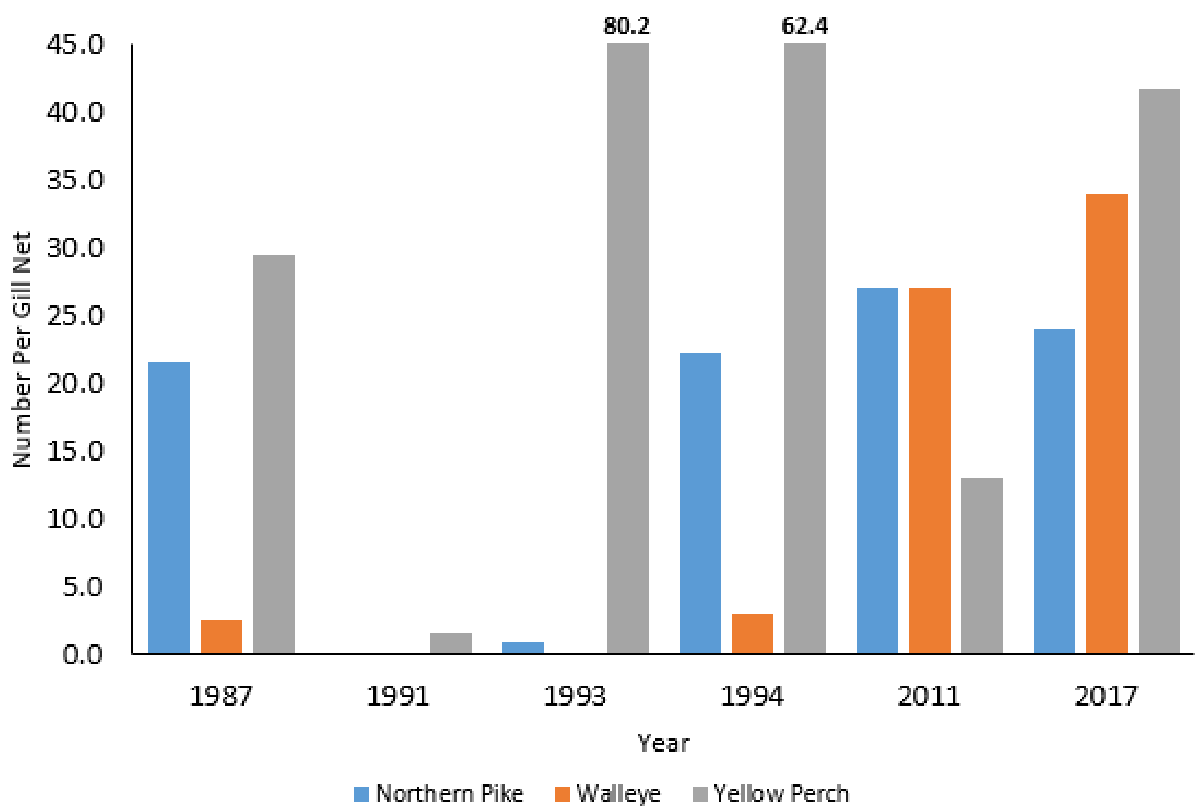


Figure 8. Numbers of northern pike, walleye, and yellow perch caught in standard gill nets during Heron Lake fish netting surveys from 1987 to 2017. Data from the 1947 fish netting survey were excluded due to the use of different survey techniques. Yellow perch numbers exceeded the bounds of this graph in 1993 and 1994, so the number per gill net is displayed above the bars for these years.

South Heron has historically been a popular fishing lake and it currently is a well-known fishing spot for local anglers. The primary game fish species in South Heron are northern pike, walleye, and yellow perch. According to the 2017 fish survey conducted on South Heron, there is an abundance of large northern pike and moderate sized walleye. Yellow perch populations also are self-sustaining in South Heron. It is important to know that the fish species in Heron Lake follow a “boom or bust” cycle. A “boom or bust” management regime hinges on a couple year classes of a particular fish species thriving and moving through the population until they succumb to either angler harvest or natural mortality (e.g., winterkill event). The mortality of those year classes provides conditions for another strong year class to move through the population. These cycles are largely determined by changing habitat conditions within the Heron Lake system and are evident when looking at numbers of northern pike, walleye, and yellow perch caught in gill nets from 1987 to 2017 (Figure 8).

Management Goals and Objectives

Goal: Optimize aquatic plant growth to improve water clarity and enhance fish and wildlife habitat.

- **Objective 1:** Promote growth of emergent and submersed aquatic vegetation through active water level management.
- **Objective 2:** Monitor fish community structure and sustain high predator fish populations through regular stocking.
- **Objective 3:** Promote BMPs within the Heron Lake watershed to prevent further degradation of water quality and identify projects to reduce external nutrient loading.

Proposed Management Actions to Achieve Objectives

Action 1: Repair or modify the existing water control structure.
The existing water control structure for Heron Lake (i.e., the State Dam) is 117.5 ft. in length and consists of a 60.25 ft. reinforced concrete weir, two 5 ft. stop-log bays fitted with removable steel gates, and a 40 ft. hydraulic gate. The two steel gates are only removed for maintenance purposes and the hydraulic gate can be opened to any level from 1400.2 ft. to 1396.2 ft. The concrete weir and the stop-log bays have a crest elevation of 1399.5 ft. The State Dam, and a small parcel on the Heron Lake Outlet stream, is owned by the State of Minnesota. The DNR Division of Ecological and Water Resources administers management activities at the State Dam and the DNR Section of Wildlife operates the dam. Access to the dam for construction, operation, and maintenance is by easement over private property.

The 40 ft. hydraulic gate is currently inoperable because the hydraulic cylinders that raise and lower the gate need replacement. Therefore, the hydraulic gate is presently fixed at an elevation of 1399.8 ft. The DNR will hire an engineering consultant to evaluate design options for repair or modification.

Action 2: Conduct periodic managed drawdowns, when climatic conditions provide an opportunity, to achieve a lower managed pool elevation as authorized by M.S. 97A.101.
Heron Lake is a designated Wildlife Lake under M.S. 97A.101. Wildlife lake designation gives the DNR the discretion to restrict motorized watercraft use and manage water levels (e.g., conduct periodic lake drawdowns) to benefit wildlife. A lake drawdown is the temporary lowering of water levels in a lake. Drawdowns are used to mimic natural low water periods because years with below average precipitation are occurring less frequently than in the past. Shallow lake ecosystems are adapted to periods of low water levels, but often deteriorate during periods of high or stable water levels. Therefore, drawdowns are an effective tool for shallow lake management.

Drawdowns on shallow lake basins enhance the abundance and diversity of aquatic vegetation. Bottom sediments hold a large, viable seed bank from the aquatic plants that historically grew in a basin. However, many species of emergent and submersed aquatic vegetation require a period of drying before their seeds will germinate. This dry period is most easily achieved by conducting a managed drawdown. Furthermore, drawdowns help consolidate bottom sediments and accelerate decomposition of organic material, which can provide a more stable substrate for aquatic plant growth. Drawdowns also are used to reduce or manage the fish community within a basin. These conditions (i.e., dense beds of aquatic vegetation and a reduced population of rough fish) help improve water quality and clarity, increase aquatic invertebrate abundance, and provide sufficient habitat resources for a variety of native fish and wildlife species.

Important Legal Considerations: A drawdown is a temporary lowering of water levels in a lake. The DNR will return water levels in Heron Lake to the normal managed pool elevation following a managed drawdown (M.R. 6115.0221). Drawdowns would not, and could not, be done at times that would cause any downstream flooding damage to private property or roads.

The opportunity for conducting a temporary drawdown will be limited given the size of the Heron Lake watershed. Therefore, if a drawdown appears feasible based on climatic conditions, the DNR will consider implementing a drawdown to the maximum extent possible. Managed drawdowns will primarily be used to improve wildlife habitat rather than create water storage. It is anticipated that managed drawdowns would typically occur mid-August into early June of the following year. However, a managed drawdown will be considered anytime Heron Lake is experiencing a year with average or below average precipitation (i.e., water elevation at the state dam is ≤ 1400.00 ft.) and at least one of the following drawdown triggers are met:

- Average summer Secchi disk reading from June–September falls below 2.3 ft.;
- Submersed aquatic plants cover less than 70% of the lake using present day systematic point sample stations;
- Undesirable fish are present at densities high enough to affect water quality and habitat conditions.

It should be noted that the timing of a managed drawdown will be adaptive and based on local land conditions. The water levels in Heron Lake also will be monitored regularly during a managed drawdown, in case adjustments need to be made to the hydraulic gate on the State Dam. The DNR's drawdown timeline for Heron Lake can be adjusted if weather patterns, ice conditions, management objectives, or water flows indicate the need. Prior to conducting a drawdown, the DNR Section of Wildlife will notify the DNR Area Hydrologist and other stakeholders, as necessary. Given the current design of the State Dam, 1396.2 ft. (i.e., the sill elevation) is the lowest elevation Heron Lake could reach. The DNR does not anticipate being able to remove all the water from Heron Lake due to limited outlet capacity and other structural limitations. Using pumps to supplement a gravity drawdown in Heron Lake will not be considered because pumping such a large basin would not be practical. Drawdown efforts will take precedence over other management alternatives whenever the DNR has an opportunity to conduct a managed drawdown.

Desired outcomes of a managed drawdown are as follows:

- Average summer Secchi disk reading from June–September exceeds 2.3 ft.;
- Average summer total phosphorus and chlorophyll-a levels from June–September are below MPCA impairment thresholds for shallow lakes in southwest Minnesota (i.e., total phosphorus < 0.09 mg/L and chlorophyll-a < 0.03 mg/L);
- Aquatic plant diversity and lake wide plant species richness of 9 or more;
- Submersed aquatic plants cover at least 70% of the lake using present day systematic point sample stations;
- A substantial increase in waterfowl use, especially during spring and fall migrations;
- A high predator fish population established in the lake to control less desirable fish.

Important Consideration: If hybrid cattail becomes overly abundant because of drawdown conditions, the DNR can pursue necessary permits and consider available tools to help control it.

The primary intent of a managed drawdown is to expose lakebed and/or increase the likelihood of fish winterkill. However, DNR personnel should examine the existing habitat conditions, migration patterns, and the needs of game and nongame species to limit unintended adverse impacts when determining the drawdown timeline. For example, if pursing a later season drawdown, the DNR should think about providing a shallow pool area as refuge for hibernating reptiles and amphibians. It also is worth noting that periodic drawdowns will presumably have minimal impact on aquatic furbearers, such as muskrats, because other habitat factors limit muskrat populations in Heron Lake. Heron Lake should refill rather quickly when coming out of a drawdown because of its large watershed. Consequently, DNR personnel also will need to consider the impact that changing water levels might have on wildlife and the flow to downstream areas when refilling Heron Lake after a drawdown.

Important Consideration: A managed drawdown should not affect the Heron Lake calcareous fen (EOID #9198) because the fen is located approximately 4-13 ft. above the ordinary high water level for South Heron (Appendix C).

The DNR understands that conducting a drawdown on Heron Lake may cause some access issues for both waterfowl hunting and fishing, but access issues would only be temporary. It is likely that the DNR will only be able to attempt a drawdown on Heron Lake approximately once every 8–10 years. If waterfowl hunters are not able to access Heron Lake during a drawdown, they will still be able to take advantage of other nearby field hunting opportunities and waterfowl areas (e.g., Teal WMA, Timber Lake WMA, and Christiania Waterfowl Production Area). Anglers also will still be able to utilize other fishing lakes in the area, such as Talcot Lake, East and West Graham Lake, and Clear Lake.

Action 3: Update the fisheries lake management plan for Heron Lake in coordination with the DNR Section of Fisheries.

The current fisheries lake management plan (2012) only includes stocking rates for South Heron, so an updated plan is needed to account for all the acres in the system and align with the goals of this wildlife plan. The DNR Section of Fisheries, in collaboration with the DNR Section of Wildlife, will complete an updated fisheries lake management plan by January 1, 2023. **The updated fisheries lake management**

plan will outline specific stocking rates and frequency, as well as a schedule for fish population assessments while adhering to this general framework:

- Yellow perch will not be stocked in Heron Lake because they already reproduce naturally within the Heron Lake watershed, and it would be detrimental to increase the amount of planktivores in this system.
- Heron Lake will be stocked with walleye fry following any substantial natural or induced fish mortality event (e.g., winterkill) at a rate of up to 1,000 fry per littoral acre.
- Walleye fry will be stocked outside of substantial mortality events if surplus fry are available.
- Northern pike will be stocked following substantial fish mortality events, but their stocking rates may vary depending on availability and regional priority.
- Fish population assessments will be conducted on a regular basis to monitor fish assemblages within Heron Lake.
- All fish management options, excluding aeration systems, will be considered to enhance Heron Lake (e.g., rotenone treatments, installation of additional fish barriers, stocking of additional fish species), especially as new information or techniques become available.

Support for stocking predator fish in Heron Lake can be found in Figure 9, which indicates predator fish stocking is useful in lakes where fish are present and not otherwise easily removed. Northern pike and walleye are native predator fish in the Des Moines River watershed. Walleye are readily available for stocking in southwest Minnesota, but the supply of northern pike is more variable because there is only one northern pike fish hatchery in the state. The DNR is exploring options to increase the availability of northern pike for stocking efforts in Heron Lake because of their role in shallow lake fish management (Appendix B). Stocking of predator fish may occasionally provide recreational fishing opportunities in Heron Lake, but sustaining a recreational fishery is not the primary goal of this management strategy.

Predator fish stocking has been used to reduce or manage fish communities in other shallow lake ecosystems. Shallow lakes have been shown to exist in two or more alternative stable states, typically a clear water state or a turbid water state. Research has shown that fish are one of the best predictors of shifts to the turbid state (Figure 9), with increasing likelihood of turbid lakes with elevated biomass of planktivorous (e.g., fathead minnows) and benthivorous fish (e.g., common carp, black bullheads; Appendix B). Planktivorous fish target aquatic microorganisms that feed on algae (i.e., zooplankton), which increases algae (i.e., phytoplankton) abundance within a basin. Benthivorous fish stir up bottom sediments by their feeding activity and increase nutrient loading by disturbing sediments and excretion. Increases in algae, sediment, and nutrients (e.g., phosphorus, nitrogen) in the water column all result in a reduction of submersed aquatic vegetation, habitat complexity, and predation refuge for aquatic invertebrates. Shallow lakes usually remain in a turbid water condition until the abundance of planktivorous and benthivorous fish declines to levels low enough to allow zooplankton to again reduce algal abundance, facilitating a shift back to the aquatic vegetation dominated clear water state.

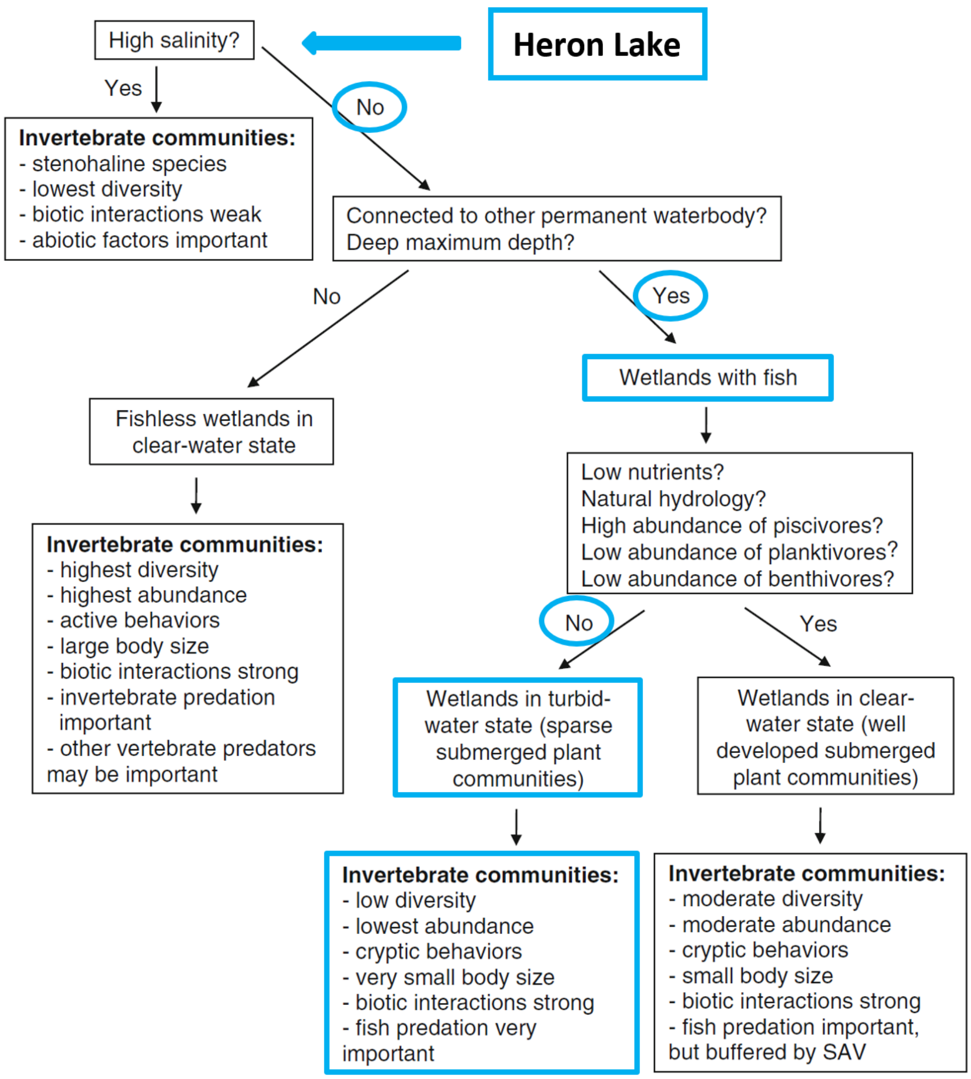


Figure 9. Diagram summarizing the relationships among fish, submersed aquatic vegetation, aquatic invertebrates, and other characteristics of shallow lake ecosystems (Zimmer et al. 2016; Appendix B). Current relationships for Heron Lake are outlined in blue.

Action 4: Collect water level information, precipitation records, and bathymetric data in addition to conducting detailed watershed modeling to help guide future management activities.

The DNR needs detailed information about water levels, precipitation patterns, bathymetric features, and watershed characteristics to make the most informed management decisions for Heron Lake. Currently, there is only one permanent staff gage to measure water levels on Heron Lake, which is located at the State Dam. To collect more frequent and accurate water level data, the DNR Section of Wildlife is working with the DNR Division of Ecological and Water Resources to install a radar data logger on the State Dam and a water level logger at Heron Lake WMA (i.e., the southern portion of the West Heron Unit; Attachment A). Both the radar data logger and the water level logger will have the ability to automatically log and transmit water level and temperature data. These data will be made available on the DNR's Cooperative Stream Gage website at Cooperative Stream Gage Homepage.

Precipitation information for Heron Lake is typically collected by the State Climatology Office or the HLWD. The DNR Section of Wildlife plans to supplement the State Climatology Office and HLWD's precipitation data by installing an automated rain gage at the State Dam to record local precipitation information. There also has not been a complete bathymetry investigation for Heron Lake, so a more detailed bathymetric survey should be conducted. Knowing more about the bottom and runout elevations for each of the Heron Lake sub-basins will allow the DNR to quantify the impacts of future drawdowns on the Heron Lake system. Furthermore, the DNR plans to seek funding and work with either the DNR Division of Ecological and Water Resources or a consultant to develop a detailed hydrologic model for Heron Lake to help guide future management activities (e.g., water level management, targeting priority problems in the watershed, strategic land acquisition).

Action 5: Collaborate with local partners to identify strategic watershed management opportunities and promote BMPs in the watershed.
Conservation work within the watershed is an important tool in shallow lake management. The protection of existing habitats and restoration of critical areas within the watershed are vital to sustaining water quality and habitat conditions within the lake. The DNR will continue to coordinate with local partners (e.g., HLWD, Soil and Water Conservation Districts, HLWWG) to target conservation programs and land stewardship improvements within the Heron Lake watershed. For instance, the DNR is currently working with the HLWD and the HLWWG to implement the first phase of the Heron Lake Area Conservation Partnership project. This project is funded by the Lessard-Sams Outdoor Heritage Council and aims to protect 402 acres of prairie and wetlands within the Heron Lake watershed. The DNR also supports the HLWD's efforts to upgrade local septic systems, promote the use of cover crops, enhance wetlands, restore prairie, and improve water clarity and reduce sediment runoff in the inlet streams and ditches (i.e., Okabena Creek, Jack Creek, J.D. 14, and J.D. 3) within the Heron Lake watershed.

Monitoring

The DNR will conduct wildlife lake surveys at least once every five years, using systematic point sampling methodology, to calculate aquatic plant distribution, diversity, and abundance for general monitoring purposes. Water quality parameters also will be monitored annually, using an approved water quality-sampling regime. In addition, the DNR will conduct both pre- and post-drawdown monitoring to determine drawdown success. An existing permanent water level gage is located at the State Dam to monitor water levels and measure downstream conditions during a managed drawdown and outside the drawdown period (stipulated by M.R. 6115.0221).

Management Plan Revisions

The management plan for Heron Lake will be revisited as necessary to assess the effectiveness of the plan and determine if changes and/or updates are required. Modifications to this management plan will be made in cooperation with partners and stakeholders. Any substantial changes to this plan will require additional public engagement.

Heron Lake (DOW# 32005700), Jackson County

Management Plan

Signature/Approval Sheet

Signature	Date
X Brian Nyborg Digitally signed by Brian Nyborg Date: 2021.12.13 08:11:00 -06'00' Brian Nyborg Area Wildlife Manager	12/13/21
X Ryan Doorenbos Digitally signed by Ryan Doorenbos Date: 2021.12.13 08:16:19 -06'00' Ryan Doorenbos Area Fisheries Manager	12/13/21
X David Trauba Digitally signed by David Trauba Date: 2021.12.13 08:24:06 -06'00' David Trauba Regional Wildlife Manager	12/13/21
X Kelly Straka Digitally signed by Kelly Straka Date: 2021.12.20 15:52:21 -06'00' Kelly Straka Wildlife Section Manager	
X David Olfelt Digitally signed by David Olfelt Date: 2021.12.30 10:46:11 -06'00' Dave Olfelt Division of Fish & Wildlife Director	

Summary of Previous Management Strategies

Strategy	Summary
Initiate a temporary water level drawdown on Heron Lake, starting after fall waterfowl hunting season. Water levels should remain normal or slightly high during the fall hunting season to facilitate boating in Heron Lake, but be lowered during the winter.	•Temporary water level drawdowns have been attempted on Heron Lake several times, but few achieved what was intended (i.e., increased abundance of emergent and submersed aquatic vegetation). Above average precipitation and excessive surface water runoff from artificial drainage systems, combined with the small channel capacity of the Heron Lake Outlet stream have made water level drawdowns difficult. Therefore, drawdowns have only been attempted in years with average or below average precipitation.
Maintain and manage water levels to provide desirable habitat for fish and wildlife, as well as reduce flooding.	•There have been several different strategies for managing water levels in Heron Lake, but the most recent management plan promoted a more open condition of the State Dam and lower in-lake water levels.
Restrain undesirable fish from entering through the outlet dam.	•A temporary fish barrier was installed in the Heron Lake Outlet stream in 1990 and a permanent electric fish barrier was installed in 1991. This barrier was installed to inhibit downstream fish access and prevent destructive bottom-feeding fish from migrating into Heron Lake from the West Fork of the Des Moines River.
Manage Heron Lake for wildlife purposes with an emphasis toward fish management on South Heron. Fish management should mainly focus on reducing rough fish populations (e.g., common carp and black bullheads).	•The installation of the electric fish barrier, in conjunction with commercial fishing, liquid rotenone application, and periodic temporary water level drawdowns, were the main tools used to manage undesirable fish. The DNR Division of Fish and Wildlife supplemented these management efforts with various stockings of predatory fish (i.e., walleye, bass, northern pike, yellow perch, and black crappies) to provide additional rough fish control and increase fishing opportunities.
Conduct channel improvements in Division Creek and the Heron Lake Outlet Stream, as well as install a water control structure on the south side of North Heron, to help facilitate a drawdown.	•There has been a large accumulation of silt in Heron Lake's outlet channels, which has prevented the lowering of water levels. In 1998 and 1999, the DNR Section of Wildlife used a barge with 3 ft. propellers (a.k.a. "Cookie Cutter") to dislodge silted-in high spots from most of Division Creek. About 3,500 ft. of the Heron Lake Outlet stream also was cleaned by lowering high spots to an elevation of 1397.0 ft. in 2000. Division Creek was again cleaned out in the spring of 2000. Furthermore, the channel from the mouth of Okabena Creek into South Heron, which totaled approximately 450 ft., was cleaned out in 2001. All channel cleanouts were conducted using either the Cookie Cutter or other heavy machinery. •The idea of installing a water control structure on the south side of North Heron was proposed, but never implemented.
Make improvements within Heron Lake's watershed. Suggested improvements included acquiring land, installing aeration systems and stocking predatory game fish in some of the bigger lakes within the watershed, promoting minimum tillage of croplands, and improving wastewater treatment systems for some of the major towns.	•Most of the watershed improvement efforts occurred during the 1990s. The major accomplishments of these efforts were: •Acquiring 5,700 acres of marginal farmland (i.e., fee title or private land perpetual easements) and converting these acres into wetland/prairie complexes. •Implementing Clean Water Partnership Phase I and II. These phases identified pollution sources throughout Heron Lake's watershed, drastically improved the wastewater treatment system for the city of Worthington, implemented Best Management Practices (BMPs; i.e. practices to protect water and soil resources) on over 150 farms, and established the Heron Lake Environmental Learning Center (now called the Prairie Ecology Bus Center) to promote resource education throughout southwest Minnesota.

Piscivore Research Annotated Bibliography

Herwig, B. R., M. A. Hanson, J. R. Reed, B. G. Parsons, A. J. Potthoff, M. C. Ward, K. D. Zimmer, M. G. Butler, D. W. Willis, and V. A. Snook. 2004. Walleye stocking as a tool to suppress fathead minnows and improve habitat quality in semi-permanent and permanent wetlands in the prairie pothole region of Minnesota. Minnesota Department of Natural Resources (Special Publication 159), Minnesota, USA.

Without winterkill events or predators, fathead minnows (Pimephales promelas) often reach very high densities. Large populations of fathead minnows can influence both aquatic invertebrate abundance and community structure in wetlands. Fathead minnows also cause reductions in herbivorous zooplankton leading to reduced water clarity, loss of aquatic vegetation, and a shift to a turbid water state. This study evaluated the effectiveness of walleye (Sander vitreus) stocking to suppress fathead minnow populations in a group of wetlands in western Minnesota. The authors hypothesized that reducing the amount of fathead minnows in the study wetlands would enhance invertebrate populations and induce a shift from a turbid water state to a clear water state. Walleye fry were stocked into six wetlands, advanced walleye (i.e., age-1 and older) were stocked into six additional wetlands, and six other wetlands served as reference sites during 2001 and 2002. Wetlands stocked with walleye fry experienced a significant reduction in fathead minnow abundance, as well as an increase in Daphnia spp. and other macroinvertebrates. Phytoplankton abundance and turbidity also decreased in these wetlands, especially during the second year of the study, which helped promote aquatic vegetation growth and trigger a shift to a clear water state in years following the study. Furthermore, invertebrate populations exhibited a positive response to the walleye fry treatment, despite dietary dependence of walleye on invertebrates once prey fish were eliminated. Wetlands stocked with advanced walleye experienced modest suppression of fathead minnows, which resulted in only a few habitat improvements in these basins. The authors recommend stocking walleye fry on an as needed basis to reduce fathead minnow populations in Minnesota wetlands and ensure persistent clear water conditions.

Meijer, M. L., E. Jeppesen, E. van Donk, B. Moss, M. Scheffer, E. Lammens, E. van Nes, J. A. van Berkum, G.J. de Long, B. A. Faafeng, and J. P. Jensen. 1994. Long-term responses to fish-stock reduction in small shallow lakes: interpretation of five-year results of four biomanipulation cases in the Netherlands and Denmark. Hydrobiologia 275:457–466.

Changes in fish composition and abundance within shallow lakes can cause a shift from a turbid water state to a clear water state. While many studies have investigated the short-term effects of changes in fish populations, there is still much controversy on the long-term stability of a clear water state. Therefore, the authors of this study observed the effects of a fish population reduction in three Dutch lakes and one Danish lake over 4-5 years. Fish populations were reduced by physically removing fish from the basin, achieving a fish winterkill, and/or stocking predator fish (i.e., northern pike [Esox Lucius]). The response of each basin varied, but in general, a reduction in fish led to lower chlorophyll-a levels, high water clarity, and an increase in aquatic vegetation abundance. The authors also observed that lakes tended to switch to a clear water state faster when there was a low biomass of planktivorous fish and that these clear water conditions could remain irrespective of nutrient levels for at least five years following a reduction in fish populations. The authors suggest that managers should reduce fish populations in shallow lakes by either removing fish and/or increasing the predation pressure on young-of-the-year cyprinids by stocking predator fish to promote the clear water state in shallow lake ecosystems.

Potthoff, A. J., B. R. Herwig, M. A. Hanson, K. D. Zimmer, M. G. Butler, J. R. Reed, B. G. Parsons, and M. C. Ward. 2008. Cascading food-web effects of piscivore introductions in shallow lakes. Journal of Applied Ecology 45:1170–1179.

Anthropogenic landscape modifications have resulted in increased water level depths and greater connectivity among shallow lakes throughout parts of the Prairie Pothole Region of North America. Increased water depths and connectivity has created conditions favorable for planktivorous fish populations, such as fathead minnows (Pimephales promelas). This study investigates the effects of experimental introductions of piscivorous walleye (Sander vitreus) into shallow prairie lakes with high turbidity and dense populations of fathead minnows. Study lakes were distributed across western Minnesota, in the eastern part of the Prairie Pothole Region. All sites contained fathead minnows and occasionally, low densities of other planktivorous fishes. Lakes were randomly assigned to one of three treatments, blocked according to initial fathead minnow densities (e.g., low, medium, or high) based on surveys conducted prior to assignment of the treatments. Stocking walleye fry resulted in significantly lower densities of fathead minnows and higher densities of aquatic invertebrates. These results indicate stocking piscivorous fish has potential to improve ecological characteristics of shallow lakes and facilitate a shift to a clear water state. The authors suggest managers consider stocking piscivorous fish, ideally in conjunction with watershed level restoration measures, to improve ecological characteristics in shallow lakes.

Skov, C., O. Lousdal, P. H. Johansen, and S. Berg. 2003. Piscivory of 0+ pike (Esox lucius L.) in a small eutrophic lake and its implication for biomanipulation. Hydrobiologia 506:481–487.

Shallow lake research has focused on the idea that a substantial reduction of the planktivorous fish population in a basin often results in trophic changes that lead to a distinct increase in zooplankton and reduction in phytoplankton. Predatory fish (e.g., northern pike [Esox lucius L.]) stocking has been used in previous studies to reduce planktivorous fish populations. The objective of this five-year study is to describe the feeding habits of age-0+ northern pike in a small shallow lake that was stocked with northern pike fry. The authors also wanted to link northern pike feeding habits to the sizes of age-0+ northern pike and prey fish, as well as document fish abundance and distribution within the lake. Overall, age-0+ northern pike followed a sequence of diet shifts where prey size increased as northern pike length increased. As fish predation increased, prey fish began to display predator avoidance behavior, which decreased prey fish availability for northern pike. Results imply that during the first couple of months following a stocking event, fish predation among age-0+ northern pike might not be the dominating feeding practice, despite a high abundance of potential prey fish. The authors recommend stocking larger sizes of northern pike and/or at higher densities than used in their study, which should maximize predation and outcomes of future stocking events.

Skov, C., and P. A. Nilsson. 2007. Evaluating stocking of young-of-the-year pike Esox lucius as a tool in the restoration of shallow lakes. Freshwater Biology 52:1834-1845.

Stocking of predator fish in shallow lakes to reduce cyprinid (i.e., carp and minnows) densities is a common approach in lake restorations, but the effectiveness of this management strategy is uncertain. This study focused on evaluating the effectiveness of using northern pike (Esox lucius) stocking by creating a model with parameters that were obtained from field surveys and relevant literature. The model assessed age-0 northern pike consumption in relation to different survival and growth patterns, timing of stocking, intensity of predation, and age-0 cyprinid growth patterns and productivity. All model parameters were determined to be important variables for predicting the effects of northern pike stocking on cyprinids. However, body size at stocking, cyprinid production, and northern pike survival were the best indicators of stocking success across all model parameters. Using biomanipulation in lakes with turbid water to improve water quality is an intricate task. This study demonstrates that natural biological variation may have a substantial influence on the success of predator fish stockings and there are limited circumstances where predator fish stocking will produce the desired outcomes as part of a lake restoration project. The authors suggest that future research should incorporate spatially explicit and individual based models to have a greater understanding of the effects of predator fish stocking in shallow lake systems. The authors also recommend that shallow lake managers stock northern pike at larger sizes and time stocking events to coincide with cyprinid hatching to enhance the success of stocking programs.

Ward, M. C. 2003. Food habits and consumption estimates of walleyes stocked as a tool to suppress fathead minnow populations in west-central Minnesota wetlands. Thesis, South Dakota State University, Brookings, USA.

State and federal waterfowl biologist typically manage wetland ecosystems to exist in a clear water, aquatic plant dominated state. However, abundant fathead minnow (Pimephales promelas) populations often prevent the clear water state from occurring. This study evaluated the success of two different walleye (Sander vitreus) stocking treatments on the suppression of fathead minnow populations. Six wetlands were stocked with age-1+ walleyes and six other wetlands were stocked with walleye fry during spring of 2001 and 2002. Walleye food habits were then assessed in these wetlands monthly through the summer. In the wetlands that were stocked with age-1+ walleyes, walleye consumption of fathead minnows did not exceed fathead minnow production. These estimates indicate that stocking densities of age-1+ walleyes were too low. However, fathead minnow suppression did occur in the wetlands stocked with walleye fry. Therefore, the author recommends stocking walleye fry stocking is a tool for reducing fathead minnow abundance in wetland ecosystems.

Zimmer, K. D., M. A. Hanson, and D. A. Wrubleski. 2016. Invertebrates in permanent wetlands (long-hydroperiod marshes and shallow lakes). Pages 251–286 in D. Batzer and D. Boix, editors. Invertebrates in freshwater wetlands. Springer International Publishing, Switzerland.

This book chapter focuses on permanently flooded wetlands, which are defined as lentic freshwaters with relatively shallow depths and the presence of water, except during extreme droughts. Submersed and emergent aquatic plants cover most of these basins, which support aquatic invertebrate communities, and fish may or may not be present. Biotic interactions are more influential on the condition of permanent wetlands than abiotic factors. Interactions among aquatic invertebrates, aquatic plants, and fish are complex in permanent wetlands and play key roles in generating alternative stable states. An abundance and diversity of aquatic plants tends to increase aquatic invertebrate species richness and abundance by providing increased living space and food within the water column. On the other hand, the presence of planktivorous and benthivorous fish has been shown to reduce aquatic invertebrate biomass, production, and species richness by degrading water quality and aquatic plant communities.

Permanent wetlands have been shown to exist in two or more alternative stable states, typically a clear water state or a turbid water state. Aquatic invertebrates help stabilize the clear water state by maintaining low phytoplankton densities and grazing on epiphyton. This activity reduces shading of submersed aquatic vegetation that would otherwise occur from an overgrowth of surface associated algae. Permanent wetlands usually remain in a clear water condition until planktivorous and benthivorous fish become overly abundant. Planktivorous fish feed on zooplankton, which increases phytoplankton densities, and benthivorous fish stir up bottom sediments while feeding and excrete excess nutrients into the water column. Increases in phytoplankton abundance, a reduction in water clarity, and an increase in internal nutrient loading can cause a permanent shift from a clear water state to a turbid water state in a wetland.

The authors of this chapter advise that researchers and wetland managers conduct a broader evaluation of the role of aquatic invertebrates in maintaining high water quality and healthy ecological communities in permanent wetlands. Understanding the roles of aquatic invertebrates in controlling the abundance of periphyton and phytoplankton, as well as the influence of fish on aquatic invertebrates, are key to anticipating transitions between clear and turbid water states. The authors also suggest that future conservation strategies include measures to retain high densities of aquatic invertebrates in permanent wetlands, which would help ensure these wetlands will continue to provide benefits to wildlife and humans. Finally, the authors challenge wetland scientists to explore new approaches that may help clarify the roles of aquatic invertebrates in maintaining water quality and ecological integrity of permanent wetlands so these functions will be more widely recognized and valued by an increasingly diverse, urban society.

Zimmer, K., B. Herwig, D. Larson, N. Ganzel, C. Hegedus, and R. Klaras. 2019. Fish stocking following shallow lake rehabilitation – opportunities and consequences for shallow lake management.

University of St. Thomas and Minnesota Department of Natural Resources (Final Report), Minnesota, USA.

Stocking yellow perch (Perca flavescens) and northern pike (Esox lucius) following a water level drawdown and fish removal is a common approach to reduce nuisance fishes that impair water quality in shallow lake ecosystems. However, effectiveness of this management strategy is uncertain. This study assessed the impact of stocking yellow perch and northern pike following lake manipulations such as drawdowns or rotenone treatments in four shallow lakes in southern Minnesota. An additional un-stocked lake served as a reference lake. The authors quantified fish diets, fish consumption rates, and assessed energy sources and trophic position of fish using stable isotopes. They also estimated relative abundance and size structure of fish species in each lake and quantified several ecosystem characteristics. Results indicated effects of northern pike and yellow perch stocking are variable among lakes, but stocking may increase abundance of macroinvertebrates and potentially zooplankton over short time periods. Stocked fish also may partially mitigate the negative impacts of undesirable planktivorous and benthivorous fish. However, there was no evidence that predatory fish can stabilize lakes in a clear water state. Managers should consider these relationships, along with the valued fishery stocked fish present in these systems, when stocking decisions are made on a lake-by-lake basis.

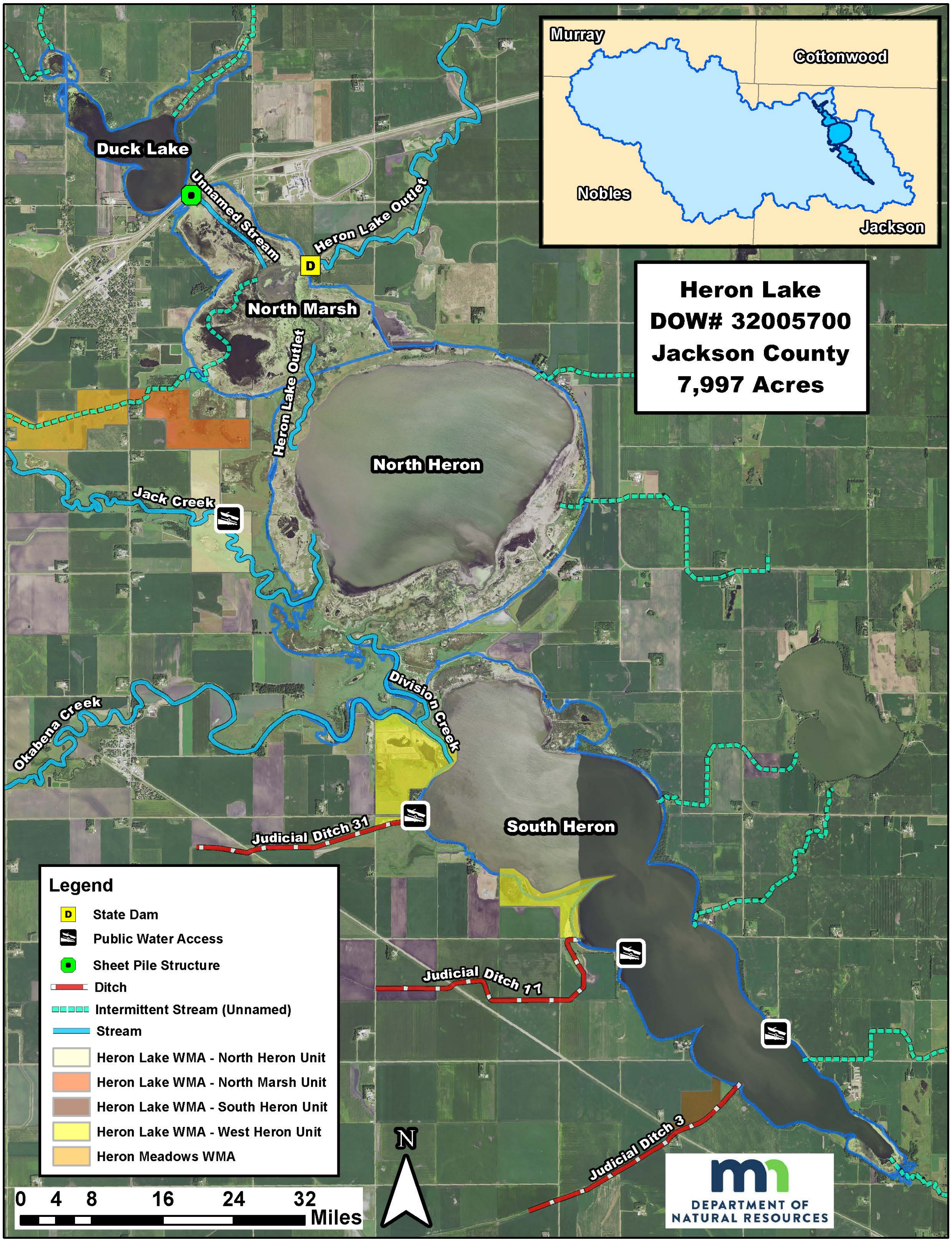
Heron Lake Calcareous Fen Information

Calcareous fens are rare and distinctive peat-accumulating wetlands that depend on a constant supply of groundwater rich in minerals. This mineral-rich environment supports diverse and rare plant communities that can tolerate low oxygen conditions, calcium carbonate deposits, low nutrient availability, and relatively cold organic soils (e.g., peat). Fens are one of the rarest natural ecosystems in the world and are threatened throughout most of their range by land use changes, urbanization, and changes in ground water supply. In Minnesota, fens have special protections under M.S. 103G.223. This statute states that calcareous fens may not be filled, drained, or otherwise degraded, unless the commissioner, under an approved management plan, decides some alteration is necessary.

The Heron Lake calcareous fen (EOID #9198) is a peat apron formation that occurs within a larger wetland complex adjacent to the southeast end of South Heron. This fen was first discovered in 1986 and ranks in good to fair condition, as assessed by the DNR's Ranking Guidelines (2018). The fen is classified as a southwest type OPp93b, using the [Native Plant Communities of Minnesota classification system](), and covers a hillside between LiDAR estimated elevations 1407 ft. and 1416 ft., which is approximately 4–13 ft. above the ordinary high water level for South Heron. Narrowleaf cattail (*Typha angustifolia*) is present inside the fen, but sparse in the more open pockets that retain open pools and flowing groundwater channels. The dominance of narrowleaf cattail in the lower wetland areas and its presence inside the fen indicates an influx of surface water and runoff. Additionally, porcupine sedge (*Carex hystericina)*, prairie sedge (*Carex prairea*), yellow widelip orchid (*Liparis loeselii*), and spring cress (*Cardamine bulbosa*) were found in the interior pockets of the fen.

Figure C1. South Heron Lake wetlands calcareous fen location map. Map consists of a DNR base map layer with South Heron Lake wetlands calcareous fen location represented as a blue dot. South Heron Lake wetlands calcareous fen is 0.8 miles northwest of Lakefield in Jackson County, MN. Fen center located at UTM X 323691.8, UTM Y 4839961.4 (NAD 83, UTM Zone 15).

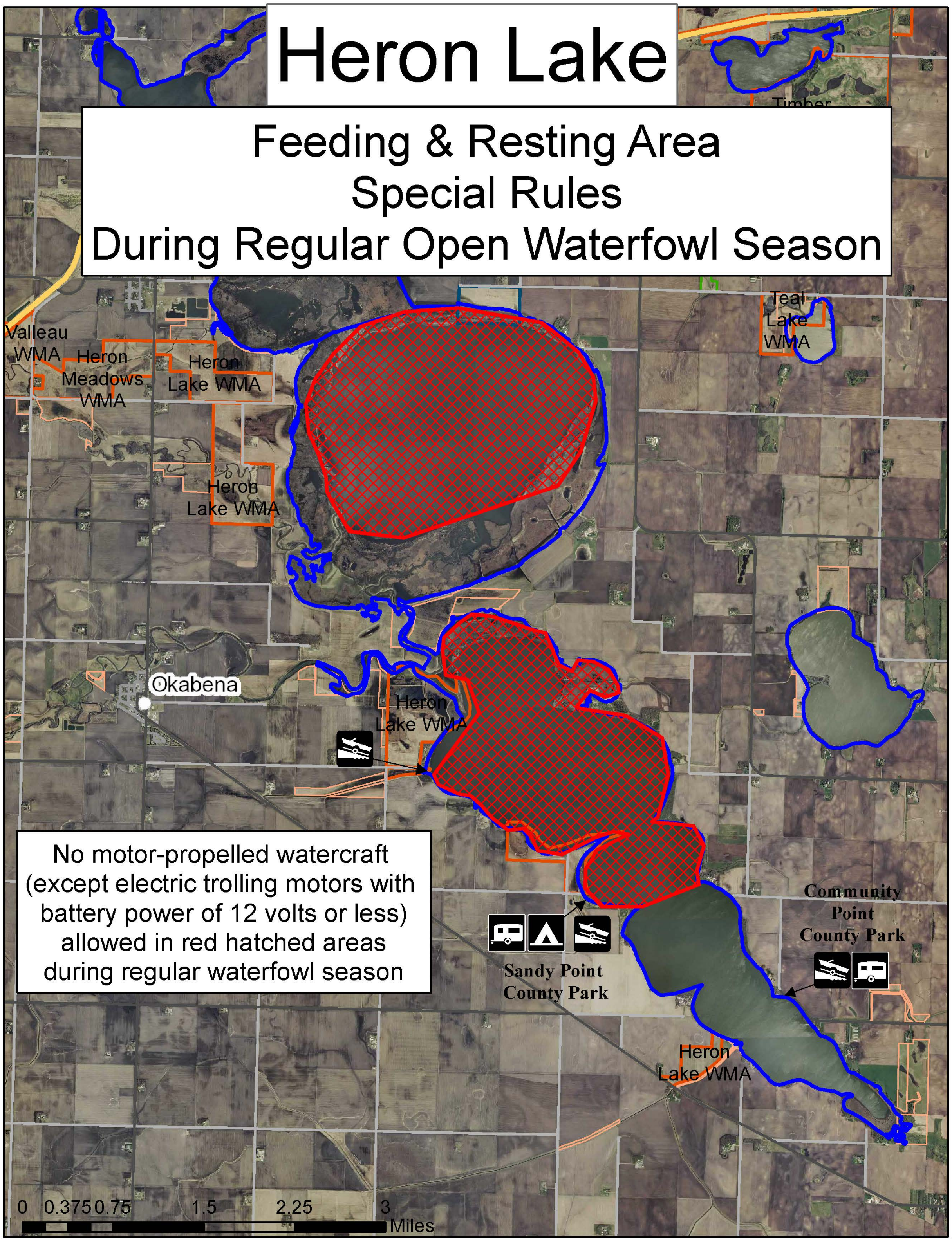
Figure C2. LEFT: Center of one of the more open pockets of calcareous fen. Low-growing sedges intergrade with narrowleaf cattail (Typha angustifolia). RIGHT: Low-growing sedges with narrowleaf cattail throughout the interior of the community with taller shrubs in the background. Both areas had typical fen structure and wetland associates present. DNR field staff collected data on hydrology, soils, and vegetation. Photos taken June 2018.



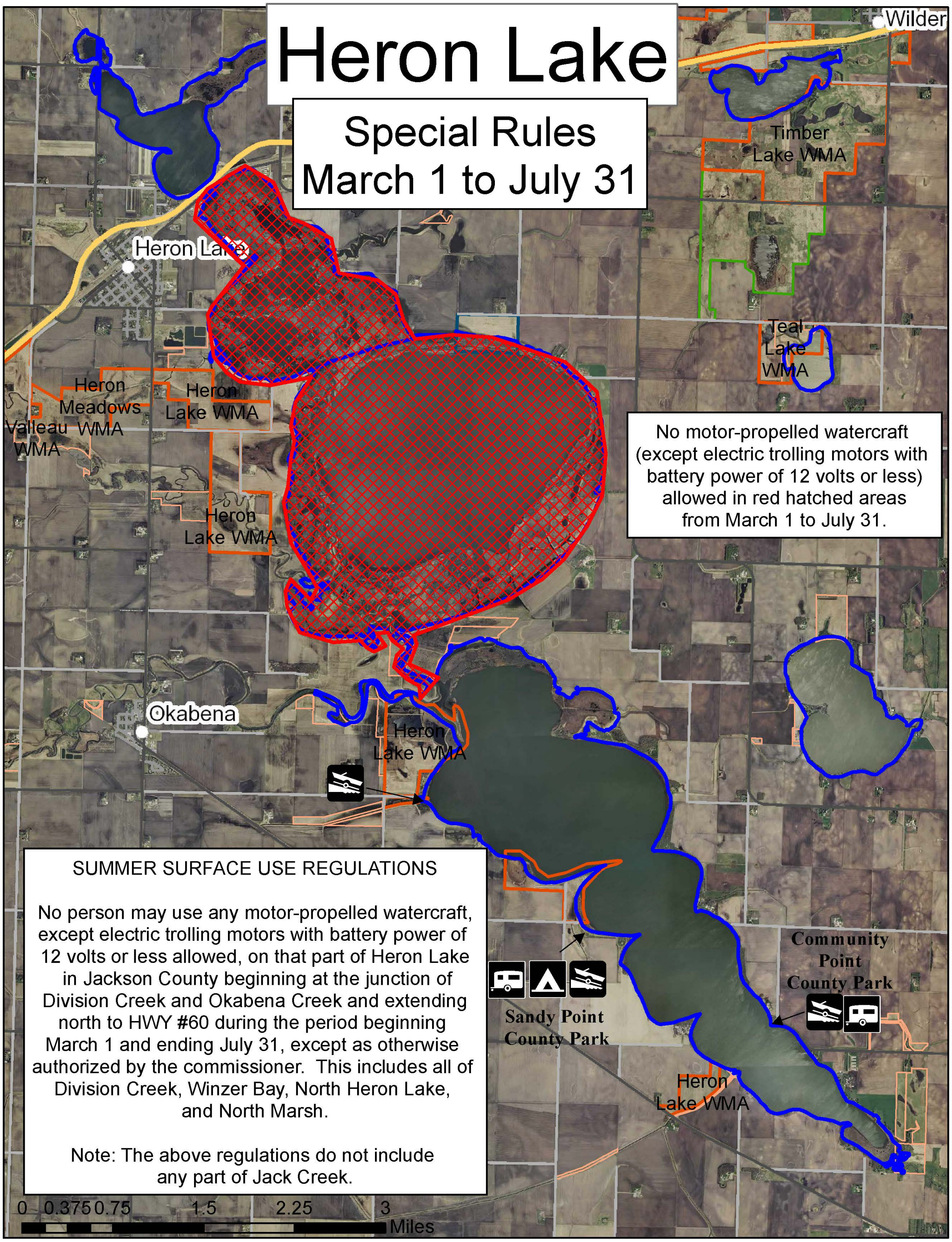
Attachment A. Map of Heron Lake illustrating the different sub-basins, wildlife management areas, inlets, outlets, public water accesses, Duck Lake sheet pile structure, and State Dam.

Attachment B. Picture of the State Dam that displays the location of the concrete weir, stop-log bays, and hydraulic gate.

Attachment C. Photo of the Heron Lake electric fish barrier.



Attachment D. Map illustrating the location of the migratory waterfowl feeding and resting areas in South Heron and North Heron.



Attachment E. Map displaying the location of the summer surface use restriction areas in North Heron and North Marsh.