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For the Middle Cedar Watershed Management Authority

Rodgers Park Lake Feasibility Study

Twin culverts, main entrance road to Rodgers Park

02.27.2020

water ecology community

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EXECUTIVE SUMMARY

The following feasibility study was developed as a component of the Middle Cedar Watershed Management Plan (MCWMP). The MCWMP was funded using federal funds from the U.S. Department of Housing and Urban Development pursuant to Title I of the Housing and Community Development Act of 1974. The Iowa Economic Development Authority (IEDA) was awarded a Community Development Block Grant National Disaster Resilience (CDBG-NDR) Federal award B-13-DS-19-0001 and awarded a portion of those funds to Benton County through grant 13-NDRI-006 to develop the MCWMP. This feasibility study was developed as a case study to address flooding, water quality, and erosion issues within Rodgers Park and Rodgers Park Lake. The contributing drainage area to Rodgers Park Lake is the study area included in this feasibility study. Within this document, the term subwatershed is used to describe the contributing drainage area to Rodgers Park Lake.

To address flooding concerns in the park, a hydrologic and hydraulic model was built to simulate the contributing drainage area and the pipe network within the park. The factors contributing to flooding were identified and solutions to address the flooding were evaluated. To address water quality concerns in Rodgers Park Lake, a suite of agricultural best management practices (BMPs) as determined by the Agricultural Conservation Practices Framework (ACPF) was evaluated. The number of BMPs and potential phosphorus removal performance of the suite of conservation practices was determined and summarized. The effectiveness of the grade stabilization structures at reducing erosion issues within the direct drainage area to Rodgers Park Lake were evaluated for each of the three main erosion complexes.

Recommendations to address flooding, water quality and erosion issues have been identified and are summarized in this study with estimated costs and a quantification of potential benefits.

PROJECT BACKGROUND

Rodgers Park is a county park located approximately three miles from the City of Vinton in Benton County, IA. It is central feature is the 22-acre Rodgers Park Lake, which has a maximum depth of 18 feet. Water leaves the lake through an 8-foot diameter concrete culvert attached to a 10-foot square standpipe. During high flows, water flows through an emergency spillway that is 75 feet wide. The drainage area to the lake is over 1,900 acres of predominantly agricultural land (**Figure 1**). To enter the lake the majority of water flows through two culverts, two 8 foot by eight 8-foot box culverts at 20th Avenue Drive and two 48 inch corrugated metal pipes at the main entrance road to the park.

County and park staff have frequently noticed silt, manure, and crop residue entering the lake following rain events, which has contributed to chronic algae blooms. In 2016, the Iowa DNR conducted a gully assessment as a first step toward addressing these sources of sediment and organic material. The assessment identified six notable gullies in the bluffs surrounding the lake (**Figure 2**), the worst of which were located on the pasture land southeast of the lake. These two gullies are roughly 1,200 feet and 700 feet long, respectively, and have estimated erosion rates of 169 tons per year and 99 tons per year, respectively.

Staff have also noticed periodic flooding occurring at two locations: just west of the park's nature center on 20th Avenue Drive, and at the main entrance to the park (**Figure 3**). The roads have been previously damaged to the point of requiring repairs at both of these locations as a direct result of this flooding.

The following feasibility study describes the methodology used to identify potential projects in the contributing drainage area to Rodgers Park Lake for flood control, water quality improvements, and erosion control, including estimates of associated costs and benefits of implementation.

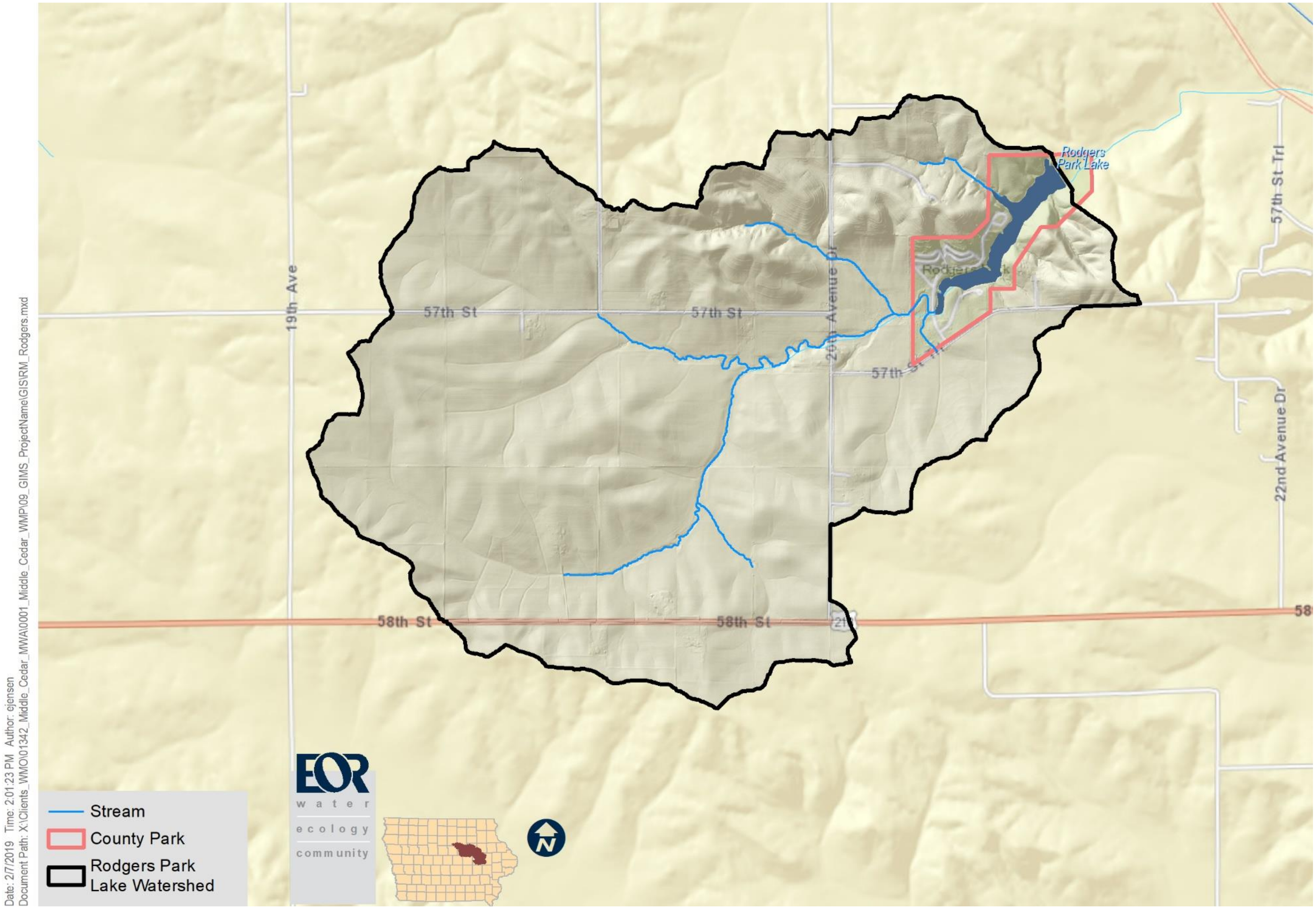

Figure 1 Rodgers Park Lake contributing drainage area.

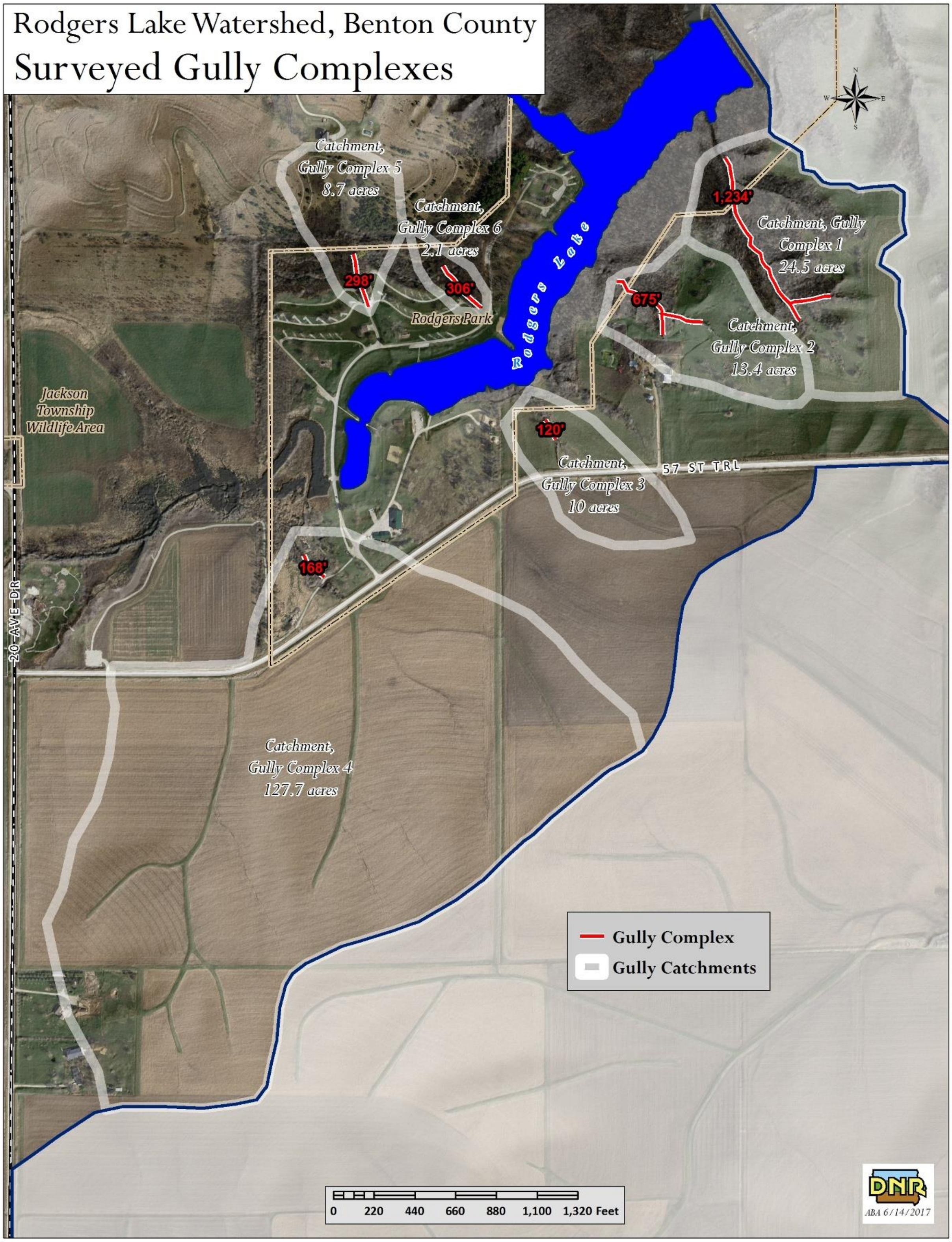

Figure 2. Gully assessment results for Rodgers Park Lake (Iowa DNR).

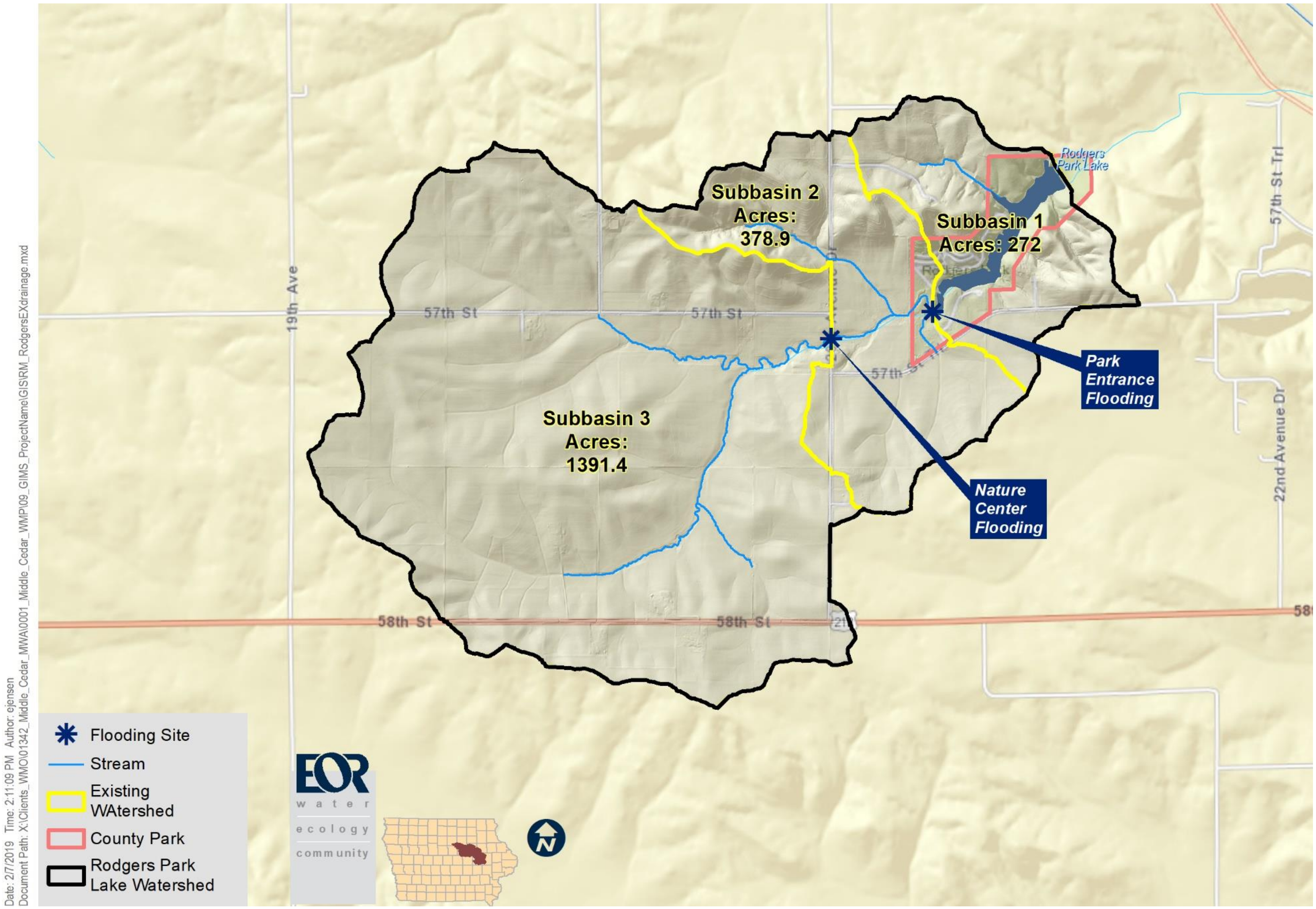

Figure 3. Flooding sites in the Rodgers Park Lake contributing drainage area.

METHODS

BMP Siting

A number of terrain-dependent agricultural best management practices (BMPs) were identified through use of the Agricultural Conservation Practices Framework (ACPF). Additional non–terrain-dependent BMPs were also analyzed for this feasibility study. Terrain-dependent BMPs are practices in which practicality and cost-effectiveness is dependent on landscape characteristics (e.g. topography, soils, land-use). For example, the optimal locations for riparian buffers are at the intersections between perennial streams and areas of relatively high overland runoff (i.e. where significant runoff flow from agricultural fields enters the stream via the riparian zone). As another example, impoundments such as water and sediment control basins (WASCOBs) need to be sited where high runoff and erosion potential exist and where topography is conducive to impounding significant runoff after construction of a berm/embankment. These practices are shown in **Figure 4**. By contrast, non-terrain-dependent BMPs are those involving elective cropping practices such as nutrient management, tillage, cover crops and land retirement. This type of BMP was included in the analysis based on the area of agricultural land available in the contributing drainage area.

The suite of BMPs included in this analysis are: riparian buffers, grassed waterways, WASCOBs, nutrient removal wetlands, cover crops, perennial cover, no-till, and nutrient and fertilizer management. **Table 1** shows the total number of practices identified in the contributing drainage area along with the estimated phosphorus reduction achieved by implementation.

Table 1. Estimated number of potential BMPs and phosphorus reduction in the Rodgers Park Lake contributing drainage area.

BMP Type	Maximum Potential Implementation	Phosphorus Removal Efficiency of Practice	Phosphorus Load Reduction (lbs/year)
Phosphorus management: Placement Control	1,578 acres	30%	663
Phosphorus Management: Rate Control	1,578 acres	17%	829
Phosphorus Management: Source Control	1,578 acres	46%	1,016
No-Till	1,578 acres	90%	1,988
Perennial Cover	1,578 acres	34%	758
Cover Crops	1,578 acres	29%	640
Wetland	3	60%	900
Grassed Waterway	15 miles	58%	1,309
WASCOBs	29	85%	352
Riparian Buffer: Deep-Rooted Vegetation Buffer	1 mile	58%	11
Riparian Buffer: Multi-Species Buffer	0.4 miles	58%	94
Riparian Buffer: Stiff Stemmed Grass Buffer	1.4 miles	58%	223
Riparian Buffer: Stream Stabilization Buffer	4 miles	58%	134

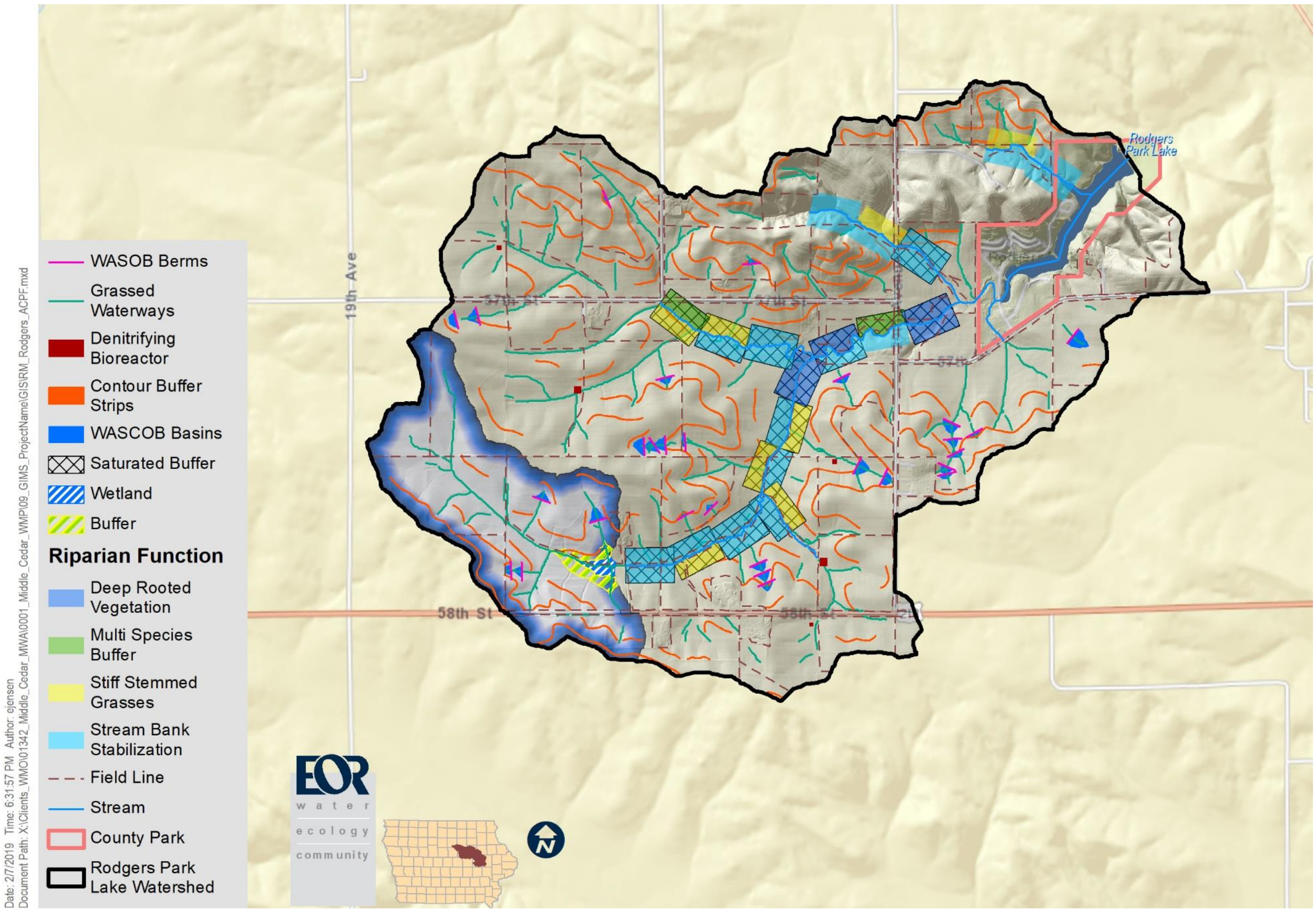

Figure 4. ACPF identified BMPs in the Rodgers Park Lake contributing drainage area.

Hydrologic and Hydraulic Modeling

Hydrologic and hydraulic modeling was conducted to assess the efficacy of proposed BMPs intended to (a) reduce sediment and phosphorus loading to the lake, and (b) mitigate flooding at key locations within the contributing drainage area.

Model Construction

Modeled drainage areas for the two flooding locations and proposed structures were delineated from a 2-meter resolution Light Detection and Ranging (LiDAR) from the Iowa LiDAR Mapping Project. The runoff curve numbers for the subcatchments were estimated using the 2011 National Land Cover Dataset and the Soil Survey Geographic Database. Design storm events were derived using Atlas 14 precipitation frequency estimates from National Oceanic Atmospheric Administration along with the Midwest and Southeast States 4 rainfall distribution. Runoff was simulated using Soil Conservation Service TR-20.

Proposed BMP Locations

Proposed flood control structures were sited based on ACPF findings **(Figure 4**) and along major tributaries to the unnamed stream flowing to the lake (**Figure 5**). The hypothetical wetlands were sized using recommendations from the following resources:

- The Iowa Stormwater Manual Chapter 8-Stormwater Wetlands
- Iowa CREP Wetland Guidelines
- Natural Resources Conservation Service (NRCS) Conservation Practice Standard 378

All wetlands had a standard outlet consisting of a weir controlled stand pipe where the weir was sized to meet the 1-year, 24 hour storm and the stand pipe orifice was sized to meet the 10-year, 24-hour storm. For large rain events (up to the 100-year, 24-hour storm) an emergency spillway was sized to safely pass the storm discharge. Three wetland sites were included in proposed model, one of which was also sited using ACPF. The approximate sizes for the permanent pool and live storage are shown in **Table 2**. The locations of the wetlands are shown in **Figure 5**.

Table 2. Approximate drainage area, wetland area, permanent pool storage, and live storage for potential wetlands.

Site	Drainage Area (ac)	Wetland Area (ac)	Permanent Pool Storage (ac-ft)*	Live Storage (ac-ft)
Wetland 1	262.9	9.5	24	51
Wetland 2	135.1	6	14	21
Wetland 3	504.7	20	60	119

*Assumes 4 feet of stage at the control structure.

Proposed grade stabilization structures were sited based on the Iowa DNR gully assessment and the feasibility of the proposed locations. In general, the grade stabilization structures were placed at the head of the gully and were sized to control the rate of flow through the existing gully. Sizing was based on criteria from NRCS Conservation Practice Standard 410 for closed conduit embankment structures. The primary outlet was modeled as a single culvert sized to control a 10-year 24-hour storm. An emergency spillway was included to bypass the 100-year 24-hour storm. The approximate sizes for the three grade stabilization structures are shown in **Table 3**, and the locations are shown in **Figure 5**.

Table 3. Approximate sizes for grade stabilization structures.

Site	Drainage Area (ac)	Flow Path Length (ft)	Height (ft)	Length (ft)	Area (ac)	Volume (ac-ft)
Grade Stabilization 1	9.2	1,234	8	140	0.35	1.9
Grade Stabilization 2	10.1	675	8	250	0.42	2.4
Grade Stabilization 3	14.0	120	9	150	0.69	3.8

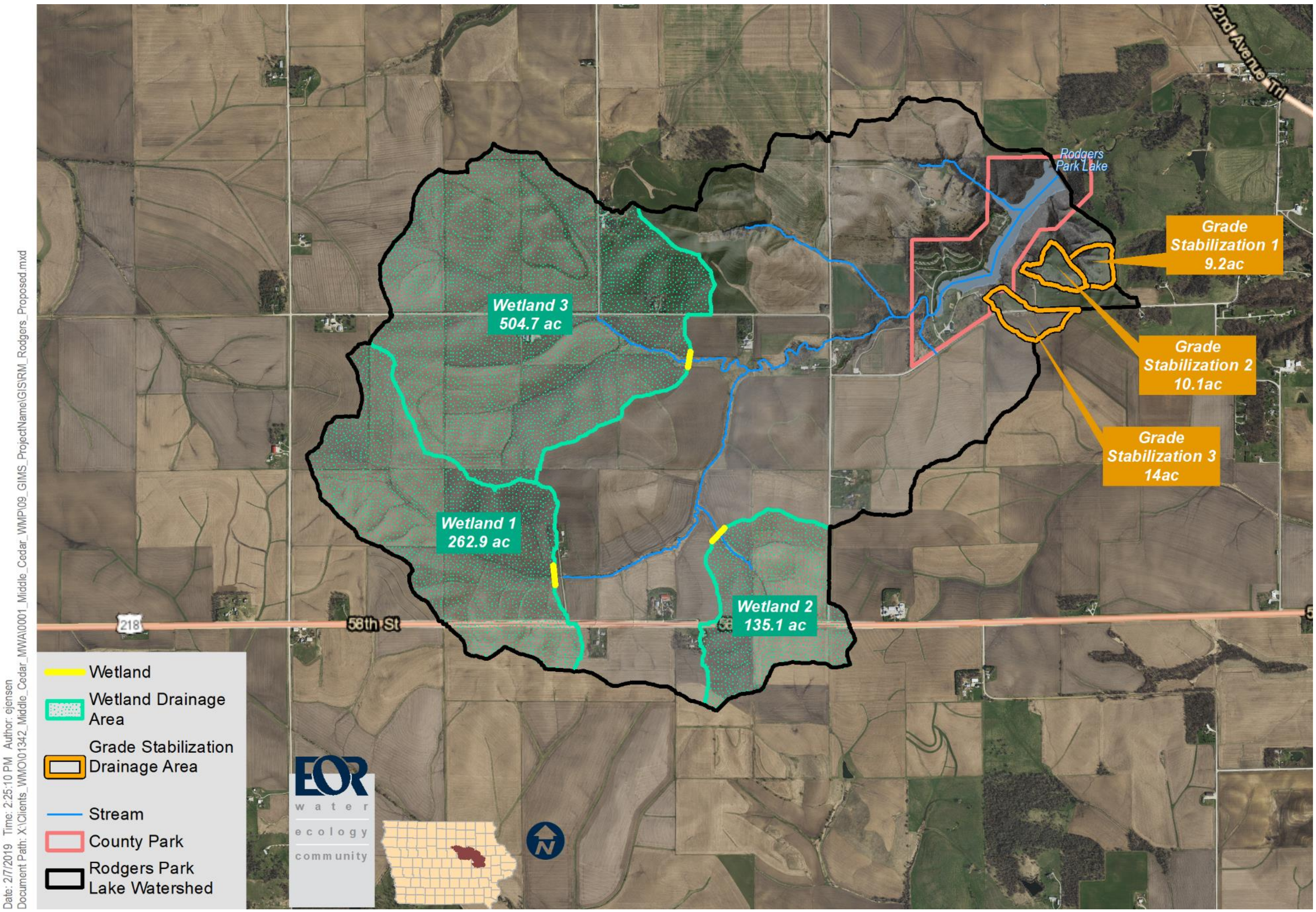

Figure 5. Proposed locations for flood control wetlands and grade stabilization structures.

RESULTS

Existing and proposed conditions were modeled for the full spectrum of design storm events including the 1-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year 24-hour storms.

Flood Control

The effectiveness of the flood control wetlands was evaluated by estimating the stage at the two flooding sites (the nature center and the main entrance to the park). Rodgers Park Lake water levels were also modeled to determine whether the outlet of the lake had sufficient capacity for the storm events. The design storm flood elevations under existing and proposed conditions are shown at each location in **Figure 6**, **Figure 7**, and **Figure 8**, respectively.

At the 20th Avenue Drive crossing, the wetlands were very effective at reducing peak flood elevations. The wetlands prevented flooding up to the 50-year, 24-hour storm event compared to the existing conditions which had flooding during the 25-year, 24-hour event. The wetlands were most effective at reducing the 25-year, 24-hour storm event with a maximum decrease in peak elevation of over 2 feet (**Figure 6**). For larger events the effectiveness decreased as more flow bypassed the wetlands through the emergency spillway.

At the main entrance to the park, the wetlands were less effective and did not prevent flooding during any storm event. The maximum benefit was a decrease of just over a foot of elevation during the 100-year, 24-hour storm event (**Figure 7**).

At Rodgers Park Lake, the wetlands reduced flooding by as much as 1.5 feet during the 50-year, 24-hour storm events (**Figure 8**). In fact, overall the wetlands were more effective at Rodgers Park Lake than at the entrance to the park. In addition, the water levels in Rodgers Park Lake were lower than the water levels upstream of the main entrance. This elevation difference indicates that the culverts underneath the main entrance are limiting flow into Rodgers Park Lake and are causing flooding upstream. One approach to mitigate this issue is to raise the road elevation and install larger culverts that will increase the capacity to Rodgers Park Lake.

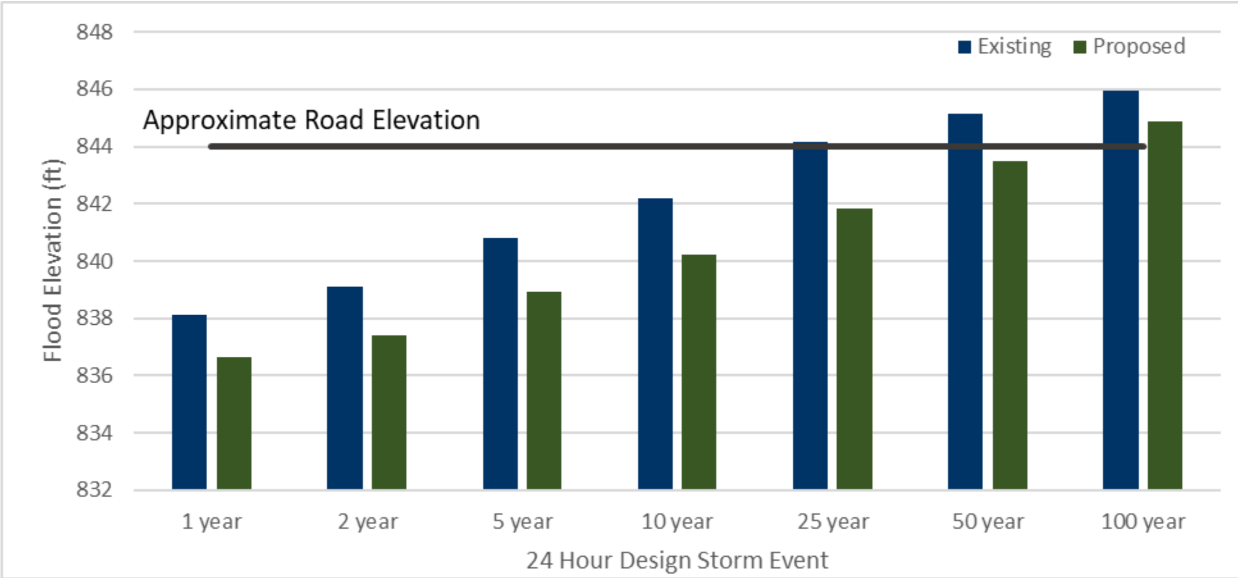

Figure 6. Existing and proposed design storm flood elevations at 20th Avenue Drive near the nature center

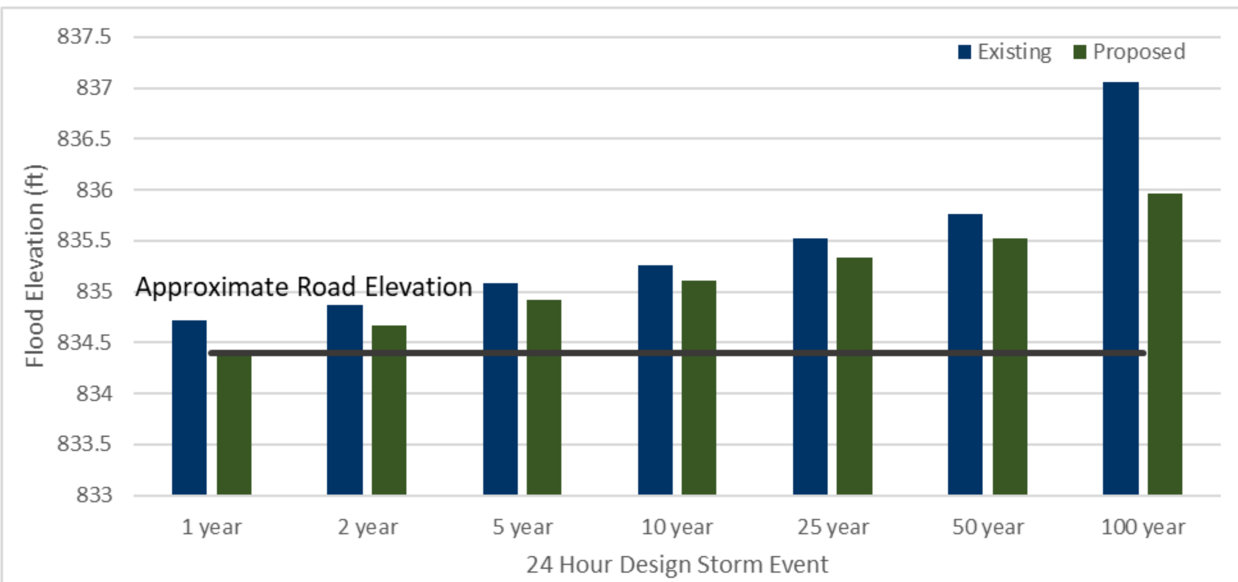

Figure 7. Existing and proposed design storm flood elevations at the main entrance to the park

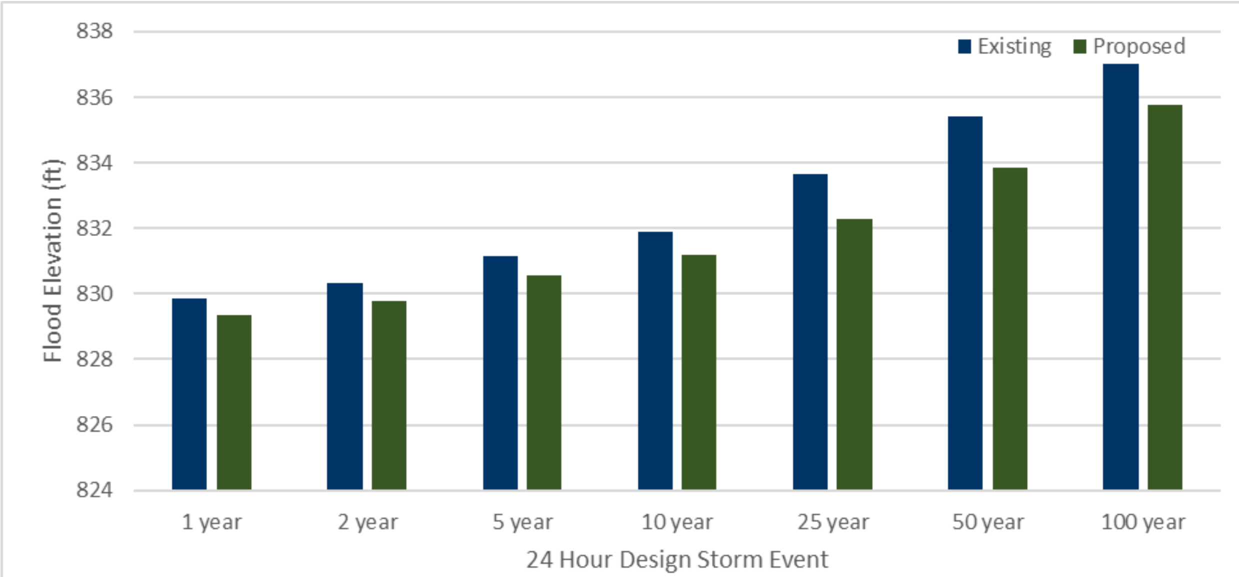

Figure 8. Existing and proposed design storm flood elevations at Rodgers Park Lake

Erosion Control

The effectiveness of the grade stabilization structures at reducing erosion was evaluated by estimating the mean velocity of discharge for different design storm events and comparing them to NRCS stable velocities. The mean velocities were calculated for a typical cross section of the gully complex and the mean slope of the gully complex. A structure was beneficial if the mean velocity was less than 6 feet per second, the maximum allowable velocity for a vegetated channel based on the NRCS National Engineering Handbook Part 654. The results for the three gully complexes are shown in **Figure 9**, **Figure 10**, and **Figure 11,** respectively.

A grade stabilization structure was effective at reducing the risk of erosion at the first gully complex, located farthest east and over 1,200 feet long. While existing conditions had erosive velocities for all storm events, the proposed conditions were able to control the rate of flow up to the 10-year, 24-hour storm event. The grade stabilization structure was most effective at the 10-year, 24-hear storm event with a maximum velocity decrease of over 3 feet per second. For larger events the effectiveness decreased as more water flowed through the emergency spillway (**Figure 9**). In addition to the grade stabilization structure, trees and other vegetation will need to be cleared and grass will need to be planted to fully stabilize the first gully.

A grade stabilization structure was effective at reducing the risk of erosion at the second gully complex, located in the middle of the three complexes southeast of the lake and roughly 700 feet long. While existing conditions had erosive velocities for all storm events, the proposed conditions were able to control the rate of flow up to the 10-year, 24-hour storm event. Similar to the first grade stabilization structure, the second grade stabilization structure was most effective at the 10-year, 24-hour storm event with a maximum velocity decrease of over 3 feet per second. For larger events the effectiveness decreased as more water flowed through the emergency spillway (**Figure 10**). In addition to the grade stabilization structure, trees and other vegetation will need to be cleared and grass will need to be planted to fully stabilize the second gully.

A grade stabilization structure was effective at reducing the risk of erosion at the third gully complex, located the farthest west of the three gully complexes southeast of the lake and over 100 feet long. The existing conditions at this gully complex was less severe than the other two gully complexes. Only extreme storm events greater than the 25-year, 24-hour storm event were above the erosive velocity of 6 feet per second. With the proposed grade stabilization structure, the maximum benefit occurred during the 25-year, 24-hour storm with a velocity reduction close to 3 feet per second and the grade stabilization was effective at all storm events (**Figure 11**). The conditions at this gully complex were less severe and the grade stabilization as modeled was predicted to reduce the velocity below the threshold. To stabilize the third gully complex vegetation clearing and planting of grass should be enough to stabilize the gully. A similar approach should be used on the rest of the gully complexes as well.

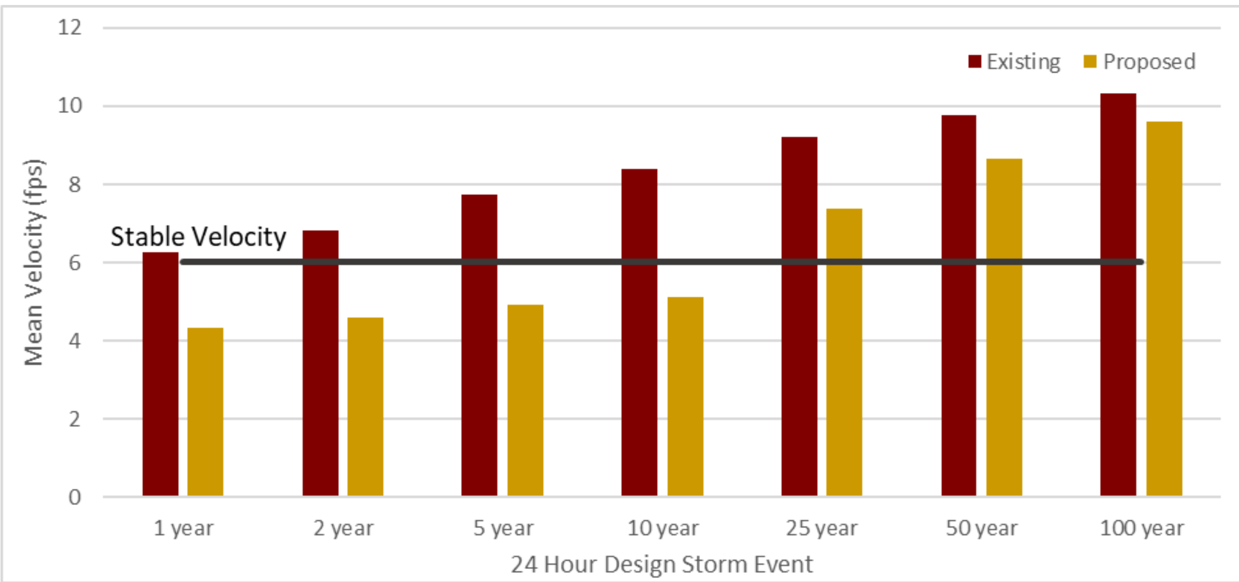

Figure 9. Existing and proposed estimated mean velocity for gully complex 1.

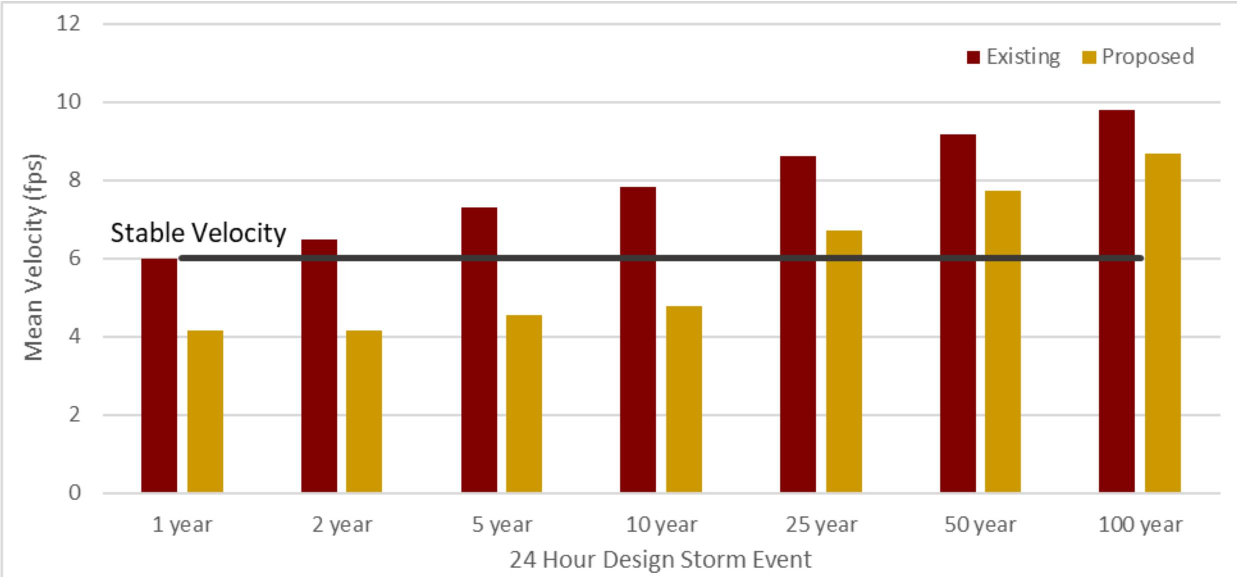

Figure 10. Existing and proposed estimated mean velocity for gully complex 2.

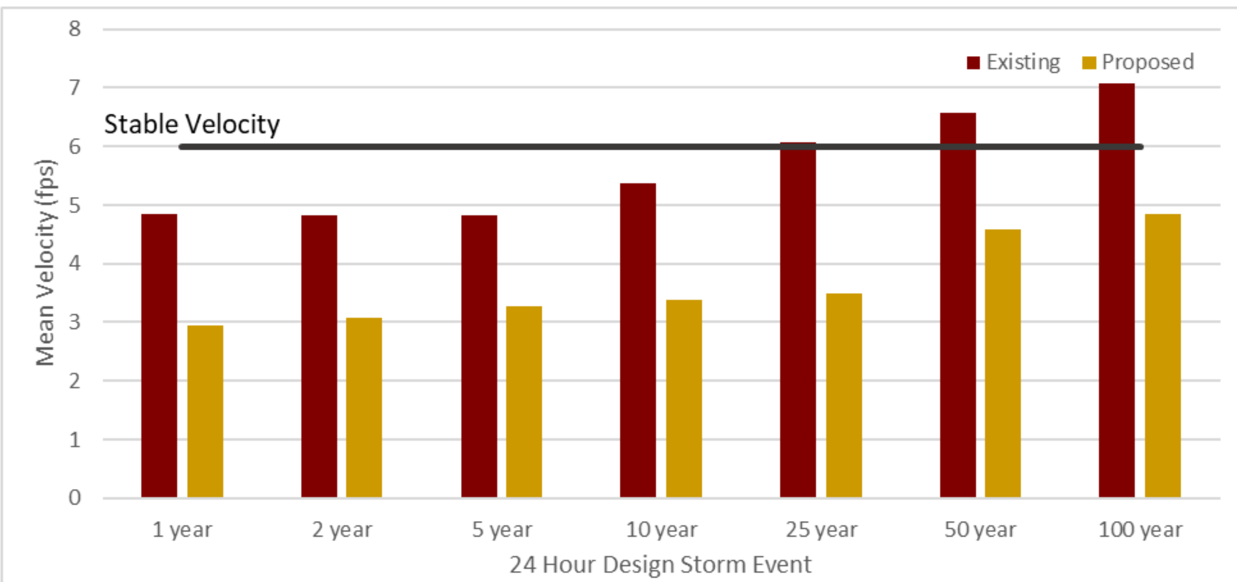

Figure 11. Existing and proposed estimated mean velocity for gully complex 3.

RECOMMENDATIONS

To mitigate both the flooding and water quality problems in Rodgers Park Lake, four approaches are recommended. An initial estimate of the cost associated with each recommendation is shown in **Table 4**.

Table 4. Initial conservative cost estimate for each recommendation.

Recommendations	Cost
1. 3 Wetlands	$1,416,000
2. Park Entrance Culvert	$370,500
3. 3 Grade Stabilization Structures	$452,300
4. Prioritized Phosphorus focused BMPS	$280/acre-lb. of P

Priority Recommendation 1: Construct three wetlands to reduce flooding at 20th Avenue Drive and the entrance to Rodgers Park.

Three hypothetical wetlands were shown to be effective at controlling flooding at 20th Avenue Drive near the nature center. Constructed wetlands at the proposed locations would be expected to reduce the impact of large flood events and capture nutrients that would normally flow to the lake. A conservative initial cost estimate broken down by property acquisition, construction costs, and professional fees cost for this project is shown in **Table 5**. Property acquisition costs are based on land values calculated from acrevalue.com. The construction costs are based on NRCS values used for similar Middle Cedar WMA engineering projects and assumes there will be a competitive bid process. The professional fees cost includes planning, engineering, and design; administration; and bidding and construction administration.

Table 5. Initial conservative cost estimate for the recommended flood control wetlands.

Site ID	Property Acquisition Estimate	Construction Cost Estimate	Professional Fees Cost Estimate*	Total Cost Estimate	Cost Per Acre-Foot of Storage
Wetland 1	$65,400	$245,700	$61,400	$372,500	$4,948
Wetland 2	$31,000	$156,000	$39,000	$226,000	$6,492
Wetland 3	$124,700	$538,200	$134,600	$797,400	$4,446
Totals	**$221,100**	**$939,900**	**$235,000**	**$1,396,000**	**N/A**

*Changes in scope of construction may increase fees.

Priority Recommendation 2: Increase the elevation of the entrance road to Rodgers Park and increase the culvert capacity to the stream.

Initial modeling of the culverts at 20th Avenue Drive, the main entrance to the lake, and the lake water levels indicated that the culvert capacity at the main entrance to the lake is under sized causing the road to flood. Increasing the road elevation and installing an outlet structure with greater capacity is recommended. Greater capacity at the main entrance road will increase the lake levels during flood events but will reduce flooding upstream of the park entrance. An initial conservative cost estimate for this project is $370,500 (**Table 6)**. The construction cost estimate for the park entrance modification was based on Iowa Department of Transportation unit prices. Similar assumptions were used to estimate the professional fees cost.

Table 6. Initial conservative cost estimate for the recommended park entrance improvements.

Site ID	Construction Cost Estimate	Professional Fees Cost Estimate*	Total Cost Estimate
Park Entrance	$296,400	$74,100	$370,500

Priority Recommendation 3: Construct three grade stabilization structures to control the rate of flow through existing gully complexes.

Grade stabilization structures should be constructed on all gullies, where feasible, to control the rate of flow. For this feasibility study, three such structures were evaluated, including the two most severe gullies. The third gully was chosen based on the available space in the area. In addition to the grade stabilization structures, the gullies need to be further stabilized by clearing trees and brush that shade the gully, planting grass that will stabilize the soil, and installing a series of rock check dams. It may be necessary to rock the entire channel, but successful stability has been proven with the siting of a series of rock check dams. A similar strategy should be used in the three smaller gullies. An initial conservative cost estimate for this project is $452,302.50 (**Table 7**). Construction cost estimates were based on NRCS unit cost values used for similar Middle Cedar Watershed Management Authority engineering projects and assumes a public bidding process for one single project. For the professional fees similar assumptions were used for the cost estimate. Property acquisition was not considered at this time but should be evaluated. Construction access will be required.

Table 7. Initial conservative cost estimate for the three grade stabilization structures.

Site ID	Construction Cost Estimate	Professional Fees Cost Estimate*	Total Cost Estimate[7]	Cost Per Linear Foot of Ravine
Gully Site 1	$192,300	$48,100	$240,300	$194.76
Gully Site 2	$120,100	$30,000	$150,200	$222.44
Gully Site 3	$49,500	$12,400	$61,800	$515.13
Totals	**$361,800**	**$90,500**	**$452,300**	**N/A**

*Changes in scope of construction may increase fees

Priority Recommendation 4: Prioritize future water quality BMP implementation in the contributing drainage area to Rodgers Park Lake on practices that capture and limit phosphorus loads to the lake. The four most beneficial practices in the Rodgers Park Lake contributing drainage area for phosphorus removal include: no-till, nutrient and fertilizer management, wetlands, and grassed waterways. In addition to prioritizing these practices, priority in the contributing drainage area should be focused on high runoff areas where the practices will have the potential to capture most pollutants. These areas are shown in red in **Figure 12**. The construction of the three wetlands and three grade stabilization structures will also reduce phosphorus loads to the lake. Costs and phosphorus removal performance for water quality BMPs can be found in **Table 1**. The average cost to remove a pound of phosphorus is $280 per acre.

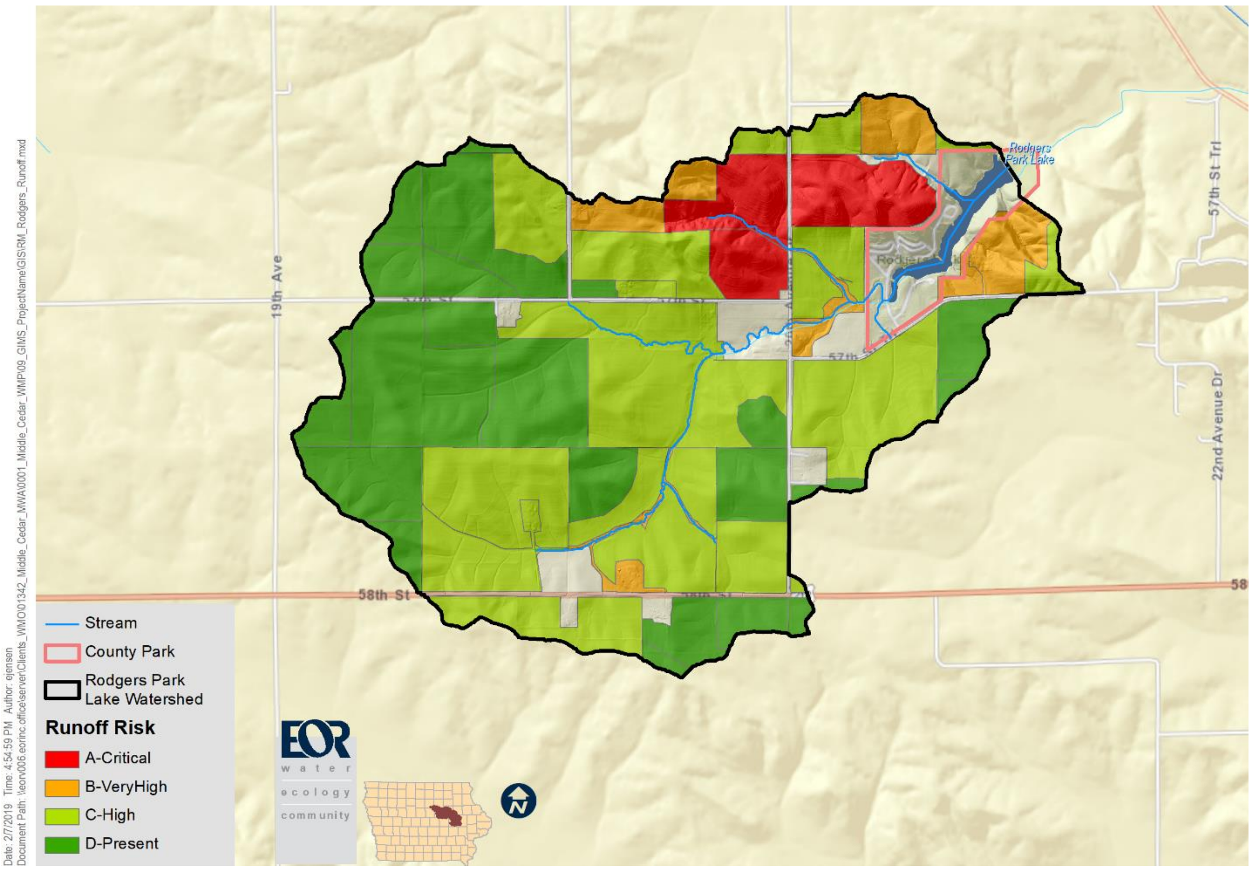

Figure 12. Priority areas for water quality BMPs in the Rodgers Park Lake contributing drainage area based on runoff risk.