

POTENTIAL RESERVOIR EVALUATION

PREPARED FOR

**LOWER ELKHORN
NATURAL RESOURCES DISTRICT**

NORFOLK, NEBRASKA

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EXECUTIVE SUMMARY

At the request of the Lower Elkhorn Natural Resources District (LENRD), Olsson Associates performed a preliminary evaluation of ten potential dam sites. Nine of these sites are located within the LENRD boundary. One site (Bell Creek Reservoir) is located in the adjacent Papio-Missouri River Natural Resources District (NRD).

The intent of this preliminary evaluation is to rank each site according to a system established for this study. The criteria were based on controlling flooding downstream, available water supply, water quality, structure costs, land acquisition, channel conveyance, delivery distance and aquifer recharge. Environmental impacts appear to be similar at all sites and were therefore not considered in the ranking. All ranking criteria were applied equally to each site. For example the cost of land acquisition was set at \$6,500 per acre regardless of land use, location, or appraised value. Evaluating all sites in the same manner provided the best approach to ranking the sites and establishing which sites could be considered for additional investigation.

The sites were organized into three tiers based on their potential benefits to the LENRD and residents of the district. Tier Three sites are sites that are the least feasible as determined by this evaluation and do not warrant further evaluation at this time. Tier Two sites provide minimal water supply benefits but have potential to be optimized to do more. These sites also impact several structures. Tier One sites provide very good water supply benefits when balanced with potential cost.

The Tier One sites are Plum Creek, Dog Creek, Cuming Creek, West Fork Maple Creek, and Battle Creek. Dog Creek has the smallest water supply volume of the sites in Tier One, but offers low relative costs. As evaluated, this site impacts three structures; one of these is a residence. Many benefits could be realized by the district through the construction of the Dog Creek Reservoir. These possible benefits include flow augmentation, flood control, water quality improvements and recharge to the City of Wayne's well fields. Plum Creek offers the greatest water supply volume and would be considered the largest project in this tier. This site would offer significant benefits to the LENRD and surrounding communities. There are two structures identified in the Flood Pool of the Plum Creek Site.

Should the LENRD determine to continue this evaluation process, one possible course of action is to determine one or two sites that are deemed the most feasible and meet the LENRD's goals. A more in-depth evaluation of the site(s) would provide a more refined opinion of cost, geotechnical evaluation and conceptual layout of the structure (s).

The following report details the methodology used in the evaluation and specific site characteristics.

I. INTRODUCTION

The purpose of this report is to outline the process used to evaluate nine potential reservoir sites within the LENRD. An additional site was evaluated in the Papio-Missouri River NRD. The sites were previously identified by the LENRD as providing possible benefits including flood control, recreation, stream flow augmentation, recharge, and water quality. The sites are, in no particular order: Battle Creek, Bell Creek, Cuming Creek, Dog Creek, East Fork Maple Creek, Pebble Creek, Plum Creek, Silver Creek, and Snyder Reservoir. An additional site, West Fork Maple Creek, was included at request of the LENRD. A map of these sites is located in Figure 1. These sites were ranked according to criteria outlined in this report.

II. METHODOLOGY

Using available Light Detection and Ranging (LiDAR) data, the watershed at each site was delineated using ArcGIS software. All LiDAR data was obtained from the Nebraska Department of Natural Resources (NDNR), with the exception of Battle Creek. Without LiDAR data readily available, a 10-foot Digital Elevation Map (DEM) was used for Madison County. Previously identified dam locations were used for Pebble Creek, Silver Creek, Battle Creek, and Plum Creek. Dam locations at East Fork Maple Creek, Bell Creek, Snyder Reservoir, Cuming Creek, Dog Creek, and West Fork Maple Creek were moved upstream to minimize inundation of existing structures. All sites were mapped using Nebraska State Plane Coordinate System (NAD 1983). World Map Imagery (2015) from ESRI was used to identify surrounding structures.

The maximum top of dam elevation for each structure was set at the highest possible elevation that would have a minimal impact to surrounding structures. This elevation was designated as the top of the 100-year Flood Pool.

Stage-storage relationships (tables) for each site were determined using the Area and Volume tool in ArcGIS on the LiDAR raster datasets. Storage was determined at 5-foot intervals in lower portions of the reservoir and 2-foot increments above the principal spillway. Storage for each site was calculated in acre-feet and was an input parameter in HydroCAD.

Watershed characteristics for each site were used in HydroCAD to model the effects of the 100-year, 24-hour precipitation event. A 100-year, 24-hour rainfall depth of 6.1" was used for all sites (National Weather Service 1963). Drainage area and time of concentration calculations were performed for each site. A curve number of 82 was assumed for all sites. This is the typical value for farmsteads on Hydrologic Soil Group C. Drainage areas were found in acres from delineated watershed boundaries in ArcGIS. Time of concentration values were calculated using the Kirpich equation:

$$t_c(\text{min.}) = 0.0078L^{0.770}S^{-0.385}$$

where L is the channel flow length (feet) from the furthest point in the watershed to the dam location, and S is the main-channel slope. The Kirpich equation can be applied to watersheds ranging from 0.25 square miles to 150 square miles (Roussel et al. 2005). The channel flow length was calculated using a perennial stream network in ArcGIS (USGS National Hydrography Dataset). The slope was found using 1-foot contour elevations developed from LiDAR data at the furthest upstream point in the watershed and dam location.

For this preliminary evaluation, the same sized outlet was used at all sites to model the principal spillway in HydroCAD. The top of the Water Supply Pool elevation (bottom of Flood Pool) was determined to be the highest elevation possible to contain the 100-year, 24-hour flood volume below the top of dam. Further design would warrant outlet optimization at each site.

Delivery distances for each site were calculated as the stream length from the dam location to the intersection of the Elkhorn River and the LENRD boundary using ArcGIS. This

comparison criteria gives an indication of each site's flood control and stream flow augmentation benefits. The dam location on Bell Creek resides in the Papio-Missouri River NRD, and was given a delivery distance of zero.

Preliminary dam centerlines were set at each location based on existing topography and the identified maximum top of dam elevation. The dam centerline shapefiles were imported to AutoCAD to determine preliminary embankment fill volumes. Volumes were calculated using an 18-foot top width of dam, and 3:1 side slopes to the existing land surface.

III. EVALUATION CRITERIA

Each reservoir site was evaluated against seven criteria: available water supply, downstream channel capacity, flood control, delivery distance to the LENRD boundary, number of structures inundated, and relative cost. Environmental impacts appear to be similar for each site, therefore environmental impacts was not considered as a ranking factor.

A. Available Water Supply

The available water supply was determined as volume of water above the Dead Pool and below the maximum riser elevation. The maximum elevation that the riser could be set at was determined based on the necessary storage to maintain the 100-year water surface elevation below the top of dam. LiDAR data was used to develop the storage capacity of the reservoir. For this initial screening of alternatives, it was assumed that sufficient storm water runoff is available to maintain the Water Supply Pool.

To translate the volumes of potential water supply into potential streamflow augmentation flow rates one can consider that 1000 acre-feet of water will provide a flow of approximately 100 cfs for 5 days. If higher flow rates are desired the time is adjusted proportionally down, and vice versa. So, a water supply of 10,000 acre-feet will provide flows of 100 cfs for 50 days or flows of 500 cfs for 10 days.

B. Downstream Channel Capacity

The reservoir downstream channel capacity is defined as the quantity of water that can flow within the stream without exceeding the banks. The stream channel capacity can also be defined as the quantity of water that can flow within the channel without flooding the overbank areas. Downstream channel capacity was evaluated for the potential reservoir sites. The evaluation utilized the Hydrologic Engineering Center's River Analysis System (HEC-RAS) software. HEC-RAS models were constructed using available LiDAR and USGS 10-foot contour elevation data for the potential sites. ArcGIS software was used to process the elevation data for use in HEC-RAS. Stream channels were modeled for 2.5 miles downstream of the potential reservoir sites. It was chosen to model the stream channel immediately downstream of the potential reservoir to attempt to identify the most restrictive channel geometry. The ArcGIS software allowed for flowline, bank station, and cross section attributes to be derived from the elevation data. These attributes were evaluated in HEC-RAS to determine the discharge capacity of the most restrictive cross section. The cross section was then used to determine the stream channel capacity for the potential reservoir site. Arbitrary discharge values were used in the HEC-RAS models since the reservoirs would augment streamflow. Channel capacity does not appear to be a concern for any of the sites.

C. Flood Control

Each of the sites was sized to maintain storm water runoff from the 100-year (1% return frequency) storm below the proposed auxiliary spillway elevation. The release rates from the dam will need to be determined based on the desired benefits for the specific dam. It is assumed that the LENRD will desire to have the released water stay within the defined channel, and therefore provide flood control benefits to downstream landowners and residents. In areas where a dam can be located above a populated area, greater flood

control benefits are assumed due to the additional health and human safety concerns. Flood control benefits in non-populated areas are still achieved for agricultural ground, roads, and infrastructure.

D. Delivery Distance

Reservoirs were also rated based on the distance upstream from the LENRD boundary. If a desired outcome of the reservoir is to augment downstream water users, the travel distance to that point must be factored in. Efficiencies in delivery are gained the closer a reservoir is located to the ultimate point of demand. For this rating the LENRD boundary was arbitrarily selected as the reference point. The distance from the LENRD boundary to the Lincoln Water System wellfield at Ashland is approximately 39 miles.

E. Structures Inundated

The goal of this analysis was to evaluate structure location that minimizes the impact/displacement of as few upstream residents as possible while still achieving beneficial goals of the district, residents, environment, and state. In some situations alternate locations in the watershed were selected that would reduce impacts to local residents. In other watersheds alternative locations were not feasible, so the proposed location was evaluated and locations of inundated houses were noted. Resident locations were obtained by reviewing aerial photography. Field verifications were not performed, so it is possible some houses identified may be vacant or abandoned. It is also possible that additional houses could have been constructed after the date of the aerial photography.

F. Relative Cost of Facility and Land Rights

A Rough Order of Magnitude (ROM) cost was derived for each of the proposed facilities. The ROM is an estimation of the level of effort and cost to complete. The main purpose of the ROM is to provide the district with information necessary to compare relative costs between projects. To determine the ROM, construction cost opinions were based on size of the facility. Land rights were based on the number of acres below the 100 year storm elevation.

G. Aquifer Recharge Benefits

A qualitative assessment of the potential benefits of each reservoir was also conducted using information from the Water Inventory Report prepared for the LENRD by Olsson Associates and dated March 15, 2015. Figure 2 is a recreation of a figure from that report adding the potential reservoir sites from this study. This figure shows the mean annual groundwater recharge across the LENRD. Figure 3 is a recreation of another figure from that report adding the potential reservoir sites from this study. This figure shows areas that would be desirable locations for intentional groundwater recharge projects.

For the purpose of this study reservoir sites are designated as high, medium, and low potential for aquifer recharge benefits. Reservoirs are considered to have a better recharge potential if they are located in areas that already generate higher rates of recharge from precipitation and if they are located upstream from larger areas that are desirable for intentional groundwater recharge projects. The actual potential benefits for each site will depend on local site characteristics such as soil types. A quantitative assessment of actual recharge benefits for these sites is beyond the scope of this study.

H. Other Considerations

Each of the sites evaluated would provide benefits to water quality. In Nebraska, a majority of the sedimentation to reservoirs originates in their respective watersheds and is transported during runoff events. Suspended sediment transports nutrients, pesticides, and other organic compounds. All of these contribute to reduction in water quality and can affect aquatic habitat and human health. Since all of the sites would have similar benefits, this factor was not used as a ranking criteria.

Any of the proposed structures will be subject to regulations authorized under Section 404 of the Clean Water Act (33 U.S.C. 403). A National Pollution Discharge Elimination System (NPDES) permit would also be required for disturbance of greater than one acre of land. Other federal, state, and local permits applicable to the proposed project would need to be obtained. The dams may be considered a High Hazard Potential Structure and require review and permitting by the State of Nebraska Department of Natural Resources.

In addition to permitting, intensive coordination with the county and The Nebraska Department of Roads may be necessary in order to obtain their required approval of the final design plans. For this initial evaluation all sites appear similar, with no significant differences between sites, and therefore this coordination was not used as an evaluation criteria.

IV. SITE CHARACTERISTICS

A. East Fork Maple Creek Reservoir

The proposed site on East Fork Maple Creek is located in Township 19 North, Range 4 East, and Sections 26 and 27 in Colfax County (Figure 4). The location of the dam was moved 0.2 miles upstream from the original dam site provided by the LENRD for this evaluation. The re-location of this dam alleviated the risk of inundation for two structures. This site as evaluated is located approximately 38 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 62,156 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and three structures are identified near the edge of the Pool. An additional structure is at risk of inundation by the 100-year flood. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 21,500 cfs. The total surface area of the Flood Pool is approximately 1,030 acres, resulting in three possible road closures or modifications. This reservoir is located in an area with relatively low natural recharge and is not upstream of any significant desirable areas for intentional groundwater recharge projects.

Construction of the East Fork Maple Creek Reservoir would provide benefits to the LENRD and those living in the district. These benefits could include flood control and water quality. However, streamflow augmentation does not seem feasible at this site. This structure could provide flood control for downstream land and structures. The absence of a substantial Water Supply Pool at this site makes it a good candidate for a dry dam. The East Fork Maple Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. Streamflow augmentation was not considered feasible at this site due to the limited storage capacity. This site is ranked as low potential for aquifer recharge.

B. Pebble Creek Reservoir

The proposed site on Pebble Creek is located in Township 20 North, Range 6 East, and Section 28 in Dodge County (Figure 5). The site evaluated is located approximately 35 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 99,377 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and twelve structures are identified near the edge of the Pool. There are two structures inundated by the 100-year flood as evaluated. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 35,500 cfs. The total surface area of the Flood Pool is approximately 1,167 acres, resulting in five possible road closures or modifications. Special attention should be paid to the potential modification of Highway 91. This reservoir is located in an area with relatively higher natural recharge and is not upstream of any significant desirable areas for intentional groundwater recharge projects.

Construction of the Pebble Creek Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, streamflow augmentation, and aquifer recharge. This structure

could provide flood control for downstream land and structures. The Pebble Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 1.2 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as medium potential for aquifer recharge.

C. Bell Creek Reservoir

The proposed site on Bell Creek is located in Township 19 North, Range 9 East, and Section 25 in Washington County (Figure 6). This site is within the Papio-Missouri River NRD. The location of the dam was moved 2.9 miles upstream from the original dam site provided by the LENRD for this evaluation. The re-location of this dam site alleviated the risk of inundation for five structures. This site as evaluated is located approximately 13 miles upstream of the confluence with the Elkhorn River, and has an approximate drainage area of 85,970 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and four structures are identified near the edge of the Pool. There are no structures inundated by the 100-year flood as evaluated. Preliminary modeling of the site indicated that the 100-year inflow to this dam is approximately 23,600 cubic feet per second (cfs). The total surface area of the Flood Pool is approximately 1,983 acres, resulting in five possible road closures or modifications. As this site is not located within the LENRD it would not provide aquifer recharge benefits in the LENRD.

Construction of the Bell Creek Reservoir would provide minimal benefits to the LENRD and those living in the district. If this structure is to be used for streamflow augmentation, water could be released for 1.7 days using a release rate of 400 cfs and assuming an initially full reservoir. An aquifer recharge potential ranking for this site is not applicable.

D. Snyder Reservoir

The proposed site on a tributary of Pebble Creek is located in Township 20 North, Range 5 East, and Sections 14 and 23 in Dodge County (Figure 7). The location of the dam was moved 2.6 miles upstream on the north fork from the original dam site provided by the LENRD for this evaluation. The re-location of this dam alleviated the risk of inundation for three structures. This site as evaluated is located approximately 43 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 18,021 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and eight structures are identified near the edge of the Pool. There are no structures inundated by the 100-year flood as evaluated. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 12,500 cfs. The total surface area of the Flood Pool is approximately 511 acres, resulting in five possible road closures or modifications. Special attention should be paid to the potential modification of Highway 91. This reservoir is located in an area with relatively higher natural recharge and is not upstream of any significant desirable areas for intentional groundwater recharge projects.

Construction of the Snyder Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, streamflow augmentation and aquifer recharge. This structure could provide flood control for downstream land and structures; especially to the town of Snyder. Snyder Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 2 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as medium potential for aquifer recharge.

E. Silver Creek Reservoir

The proposed site on Silver Creek is located in Township 19 North, Range 6 East, and Section 2 in Dodge County (Figure 8). This site as evaluated is located approximately 25 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 28,160 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and eight structures are identified near the edge of the Pool. There is one structure inundated by the 100-year flood as evaluated. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 10,100 cfs. The total surface area of the Flood Pool is approximately 403 acres, resulting in three possible road closures or modifications. This reservoir is located in an area with relatively higher natural recharge and is not upstream of any significant desirable areas for intentional groundwater recharge projects.

Construction of the Silver Creek Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, streamflow augmentation and aquifer recharge. This structure could provide flood control for downstream land and structures; especially to the town of Scribner. Silver Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 1.7 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as medium potential for aquifer recharge.

F. Battle Creek Reservoir

The proposed site on Battle Creek is located in Township 23 North, Range 3 West, and Section 23 in Madison County (Figure 9). This site as evaluated is located approximately 110 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 47,622 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and seven structures are identified near the edge of the Pool. There are eight structures inundated by the 100-year flood as evaluated. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 18,600 cfs. The total surface area of the Flood Pool is approximately 1634 acres, resulting in five possible road closures or modifications. This reservoir is located in an

area with relatively higher natural recharge and is upstream of significant desirable areas for intentional groundwater recharge projects.

Construction of the Battle Creek Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, streamflow augmentation and aquifer recharge. This structure could provide flood control for downstream land and structures; especially to the town of Battle Creek. Battle Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 13.8 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as high potential for aquifer recharge.

G. Cuming Creek Reservoir

The proposed site on Cuming Creek is located in Township 20 North, Range 7 East, and Section 8 and 9 in Dodge County (Figure 10). The location of the dam was moved 3.3 miles upstream from the original dam site provided by the LENRD for this evaluation. The re-location of this dam alleviated the risk of inundation for five structures. This site as evaluated is located approximately 29 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 53,003 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and six structures are identified near the edge of the Pool. An additional six structures are at risk of inundation by the 100-year flood. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 15,300 cfs. The total surface area of the Flood Pool is approximately 1,170 acres, resulting in eight possible road closures or modifications. This reservoir is located in an area with relatively higher natural recharge and is not upstream of any significant desirable areas for intentional groundwater recharge projects.

Construction of the Cuming Creek Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, streamflow augmentation and aquifer recharge. This structure could provide flood control for downstream land and structures; especially to the town of Scribner. Cuming Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 12.2 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as medium potential for aquifer recharge.

H. West Fork Maple Creek Reservoir

The proposed site on West Fork Maple Creek is located in Township 20 North, Range 2 East, and Section 1 in Colfax County (Figure 11). This site as evaluated is located approximately 64 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 34,946 acres. Current upstream land use is

primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and eight structures are identified near the edge of the Pool. There are four additional structures at risk of inundation by the 100-year flood. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 14,500 cfs. The total surface area of the Flood Pool is approximately 1,364 acres, resulting in seven possible road closures or modifications. Special attention should be paid to the potential modification of Highway 91. Further design would evaluate the possibility of a road dam on 570th Avenue. This reservoir is located in an area with relatively low natural recharge and is not upstream of any significant desirable areas for intentional groundwater recharge projects.

Construction of the West Fork Maple Creek Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, and streamflow augmentation. This structure could provide flood control for downstream land and structures; especially to the town of Clarkson. West Fork Maple Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 16 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as low potential for aquifer recharge.

I. Dog Creek Reservoir

The proposed site on Dog Creek is located in Township 27 North, Range 3 East, and Section 26 in Wayne County (Figure 11). This site as evaluated is located approximately 85 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 28,124 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and eight structures are identified near the edge of the Pool. There are three structures inundated by the 100-year flood as evaluated; one of these is a residence. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 9,200 cfs. The total surface area of the Flood Pool is approximately 1,029 acres, resulting in five possible road closures or modifications. This reservoir is located in an area with relatively higher natural recharge and is not upstream of any significant desirable areas for intentional groundwater recharge projects.

Construction of the Dog Creek Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, streamflow augmentation and aquifer recharge. Due to the proximity of the reservoir to the Wayne wellfields, recharge to the City of Wayne's wellfield is a potential benefit that could be evaluated further. This structure could provide flood control for downstream land and structures; especially to the town of Wayne. Dog Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 9.8 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as medium potential for aquifer recharge.

J. Plum Creek Reservoir

The proposed site on Plum Creek is located in Township 23 North, Range 6 East, and Sections 29 and 32 in Dodge County (Figure 12). This site as evaluated is located approximately 52 miles upstream of the intersection of the LENRD boundary and the Elkhorn River, and has a drainage area of 94,996 acres. Current upstream land use is primarily agriculture. The Flood Pool is set at the 100-year flood elevation, and five structures are identified near the edge of the Pool. There are two structures inundated by the 100-year flood as evaluated. Preliminary modeling of this site indicated that the 100-year inflow to this dam is approximately 27,200 cfs. The total surface area of the Flood Pool is approximately 3,168 acres, resulting in nine possible road closures or modifications. Further design would evaluate the possibility of a road dam on N Road. This reservoir is located in an area with relatively higher natural recharge and is upstream of significant desirable areas for intentional groundwater recharge projects.

Construction of the Plum Creek Reservoir would provide several benefits to the LENRD and those living in the district. These benefits could include flood control, water quality improvements, recreation, streamflow augmentation and aquifer recharge. This structure could provide flood control for downstream land and structures. Plum Creek Reservoir would provide water quality benefits by capturing sediment and nutrients contained in runoff. If desired by the district, a recreational component can be included as part of the final design. If this structure is to be used for streamflow augmentation, water could be released for 25.3 days using a release rate of 400 cfs and assuming an initially full reservoir. This site is ranked as high potential for aquifer recharge.

V. RECOMMENDATION

The sites were organized into three tiers based on their potential benefits to the LENRD. Tier Three sites are sites that are not feasible as determined by this evaluation and do not warrant any further study. Tier Two sites provide little water supply benefits but could be optimized to do so. These sites also impact several structures. If revisited, further research should be done to examine whether a different dam location would be appropriate. Tier One sites provide very good water supply benefits when balanced with potential cost. All ten sites are ranked in tiers and compared in the Reservoir Matrix (Table 1).

Sites designated Tier Three include Pebble Creek and East Fork Maple Creek. Both of these sites have very small Water Supply Pools, and high relative costs. The Tier Two sites are Silver Creek, Snyder Creek, and Bell Creek. These sites have a high cost in comparison to their water supply benefits and have much lower storage compared to the Tier One sites. The Tier One sites are Plum Creek, Dog Creek, Cuming Creek, West Fork Maple Creek, and Battle Creek. Cuming Creek, West Fork Maple Creek, and Battle Creek have very good water supply benefits, but would potentially inundate several structures. If relocation of these structures is not a concern, these are desirable sites. Dog Creek has the smallest water supply volume of the sites in Tier One, but offers low relative costs. As evaluated, this site impacts three structures. Plum Creek offers the greatest water supply volume and would be considered the largest project in this tier. This site would offer significant benefits to the LENRD and surrounding communities. There are two structures identified in the Flood Pool of this site. If design could address potential inundation of these structures, Plum Creek appears to be the best overall option.

Table 1. Reservoir Matrix organizing each site into tiers for comparison purposes.

	Site	Water Supply (acre-feet)	Structures Potentially Impacted	Cost Estimate ¹	Cost/Water Supply (\$/acre-foot)	Land Rights (acres)	100-Year Flow (cfs)	Delivery Distance (mi.)	Aquifer Recharge Potential
Tier One	Plum	20,000	2	> \$25 Million	1,300	3,170	27,000	52	High
	Dog	8,000	3	\$5-10 Million	800	770	9,200	85	Medium
	Cuming	10,000	6	\$5-10 Million	800	700	15,000	29	Medium
	West Fork Maple	13,000	4	\$10-15 Million	800	1,400	15,000	64	Low
	Battle	12,000	8	\$10-15 Million	1,100	1,650	18,600	110	High
Tier Two	Silver	1,300	1	< \$5 Million	2,700	400	10,000	25	Medium
	Snyder	1,500	0	< \$5 Million	2,800	500	23,000	42	Medium
	Bell	1,500	0	< \$5 Million	1,700	200	24,000	0	N/A
Tier Three	Pebble	1,000	2	\$10-15 Million	10,000	1,200	36,000	35	Medium
	East Fork Maple	150	1	\$5-10 Million	50,000	1,000	21,000	38	Low
¹ Cost estimate solely based on land rights and fill costs for comparison purposes only.									

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Figures