

APPENDIX D: INVESTIGATION AND ANALYSIS

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D 1. INTRODUCTION

This appendix presents information that supports the formulation, evaluation, and conclusions of the West Branch Thirty-Two Mile Creek Plan. The outline is organized under major headings that allow the reader who is not familiar with the details of the watershed and the analysis leading to the conclusions to be able to form a conclusion and form an opinion on the adequacy of the Plan. The appendix follows USDA NRCS Watershed Program Manuals and guidance previously referenced in the Plan. The appendix is intended to supplement information contained in the Plan.

The appendix was written by the consultant in collaboration with the Local Project Sponsor and Nebraska NRCS Engineering team; and in consultation with other federal, state, and local agencies; property owners, and subconsultants. These stakeholders worked together to incrementally analyze a cost-effective alternative meeting social, political, and economic acceptability.

D 2. HYDROLOGIC ANALYSIS

Hydrologic analysis was conducted using various methods depending on the unique flow characteristics and potential flood risk reduction solutions for the watershed. In general, modeling parameters were developed in accordance with appropriate engineering-based methods by professional engineers licensed in the State of Nebraska. Each of the models developed were calibrated using the best available scientific data including results from other studies.

The WFPO Project Area includes the entire West Branch Thirty-Two Mile Creek Watershed. There are two communities within the Project Area: The Villages of Kenesaw and Juniata. The watershed is located exclusively within Adams County. The Villages of Kenesaw and Juniata are both located in the upper portions of the watershed.

The following sections outline available background data, data sources, and other methods used in the development of the baseline hydrologic conditions within the study area.

D 2.01 EXISTING STUDIES

WATERSHED WORK PLAN - 1965

The Thirty-Two-Mile Creek Watershed Work Plan (1965 Plan) was prepared in 1965 under the authority of PL-566. It was prepared by the Adams County Soil and Water Conservation District and the Thirty-Two-Mile Creek Watershed Conservancy District with assistance from the Soil Conservation Service. Once fully implemented, the project was designed to reduce the average annual floodwater damage to crops and pasture by 54 percent. The plan included the construction of six floodwater retarding structures, 1.0 mile of levee (K-Dike) and 0.8 mile of diversion channel with controlled inlet. Construction was completed in 1973.

DAM ASSESSMENT REPORT

A Dam Assessment Report for Thirty-Two Mile Creek Dam K (which was constructed as part of the 1965 Watershed Work Plan) was completed in 2016 using as-built plans (Amec and EA, 2016). The evaluation included dam breach analysis and hazard classification, geotechnical assessment, hydrologic and hydraulic analyses, and alternatives evaluation. Originally designed as a Low Hazard structure, the assessment reclassified it as a Significant Hazard. The primary factors driving the increase in hazard classification were inundation of one home and roadway flooding during a dam breach scenario. Alternative recommended upgrades included replacing the principal spillway with a 42-inch reinforced concrete pipe and modifying the auxiliary spillway by raising its crest elevation and widening the bottom. These changes were all based on a contributing drainage area of 9.23 square miles from the as-built plans.

KENESAW DRAINAGE STUDY

JEO Consulting Group, Inc., completed a Drainage Improvement Evaluation for the Village of Kenesaw in October 2009. The primary purpose of the study was to inventory and evaluate the existing drainage system, report deficiencies, and develop and provide conceptual projects to reduce existing flooding problems. For this study, limited survey was collected, and three site visits were completed. Key observations included the determination of significant field flooding areas that appeared to act as detention basins and the observation that limited downstream flow capacity caused by culvert crossings increased upstream flooding. Six problem areas and nine potential projects were identified in the study.

FLOOD INSURANCE STUDY

The most recent FEMA Flood Insurance Rate Maps (FIRMs) and Flood Insurance Study (FIS) for Adams County in Nebraska were published in July 2018. The FIRM and FIS update, which was completed by the NeDNR, included a detailed hydrologic analysis for the entire watershed and a detailed hydraulic analysis of the tributaries through the Village of Juniata. It also included a basic hydraulic analysis of Thirty-Two Mile Creek from the confluence with Little Blue River to approximately 5,500 feet upstream of N Roseland Ave (located downstream of Kenesaw). As part of the detailed study an HEC-HMS version 4.0 hydrologic model was completed for the entire Thirty-Two Mile watershed and an HEC-RAS version 4.1.0 hydraulic model for Juniata. The HEC-HMS Model results were compared to the previous FIS and flows calculated using USGS and NeDOT regression equations. The basic hydraulic analysis for the remainder of the watershed outside Juniata was completed using the Nebraska Flood Assessment Calculation Tool (NFACT).

D 2.02 HYDROLOGIC METHODOLOGY

BASE MODEL

The FIS HEC-HMS model and supporting data was obtained from the NeDNR and reviewed. Per the accompanying West Branch Thirty-Two Mile Creek Watershed Hydrologic Report, the model was developed using LiDAR data collected by the NRCS in 2009, NRCS Web Soil Survey Data and 2011 National Land Cover Database. The LiDAR data was used to define the sub-basin boundaries and routed reach lengths as shown in Figure 1. The model was set up using the SCS Curve Number, SCS Unit Hydrograph and Muskingham-Cunge methods for Loss, Transform, and Routing, respectively. Seven reservoirs, including Thirty-Two Mile C, D, E, H, J, K and Idlewild Dam, were modeled using reservoir routing data obtained from NeDNR's Dam Safety division. The Hydrologic Report stated:

According to NDNR dam safety guidelines, a reservoir must pass 70% of the Probable Maximum Precipitation to be able to provide flood control benefits. Through this process, it was determined that for the 100, 100 plus, and 500 year storms the dams do not provide a flood control function, except for Thirty-Two Mile Creek H. Therefore, for these return periods, two model results were generated – one with all of the dams operating, and one with only Thirty-Two Mile Creek H.

Hypothetical storms were created based off NOAA Atlas 14 Precipitation Frequency data assuming a SCS Type II distribution. An areal adjustment factor of 0.94 was applied based on the total drainage area and storm duration. As there are no stream gages in the vicinity, model results were compared to the previous FIS, the flows calculated with the Beckman regression equations and the flows calculated with the Strahm regression equations. Reported results of the comparison are shown below in Table 1.

Table 1: Comparison of Hydrologic Results

Stream	Return Period	Existing FIS (6/18/1990)	1976 Beckman Regression	2005 Strahm Regression	NeDNR HEC-HMS
Main Ditch (just upstream of South Street)	10 Year	NA	343.2	493.2	487.5
	25 Year	NA	649.8	809.6	676.6
	50 Year	NA	1,009.4	1,123.3	838.9
	100 Year	1,428	1,487.4	1,506.9	1,1013.9
	100 Year plus	NA	2,037.7**	2,154.9***	1,399.3
	500 Year	NA	NA	3,035.3	1,477.7
East Tributary (at mouth)	10 Year	NA	NA	NA	329.1
	25 Year	NA	NA	NA	451.6
	50 Year	NA	NA	NA	555.5
	100 Year	690	NA	NA	666.9
	100 Year plus	NA	NA	NA	908.7
	500 Year	NA	NA	NA	957.7

*The 100+ year is the upper limit of the 90% confidence interval of the NOAA Atlas 14 100-year return period.

**The Mean Standard Error for the Beckman Region 5 Q100 was 37%

***The Standard Error of Estimate for Strahm Big Blue River region equations for the 100-year return period is 43%

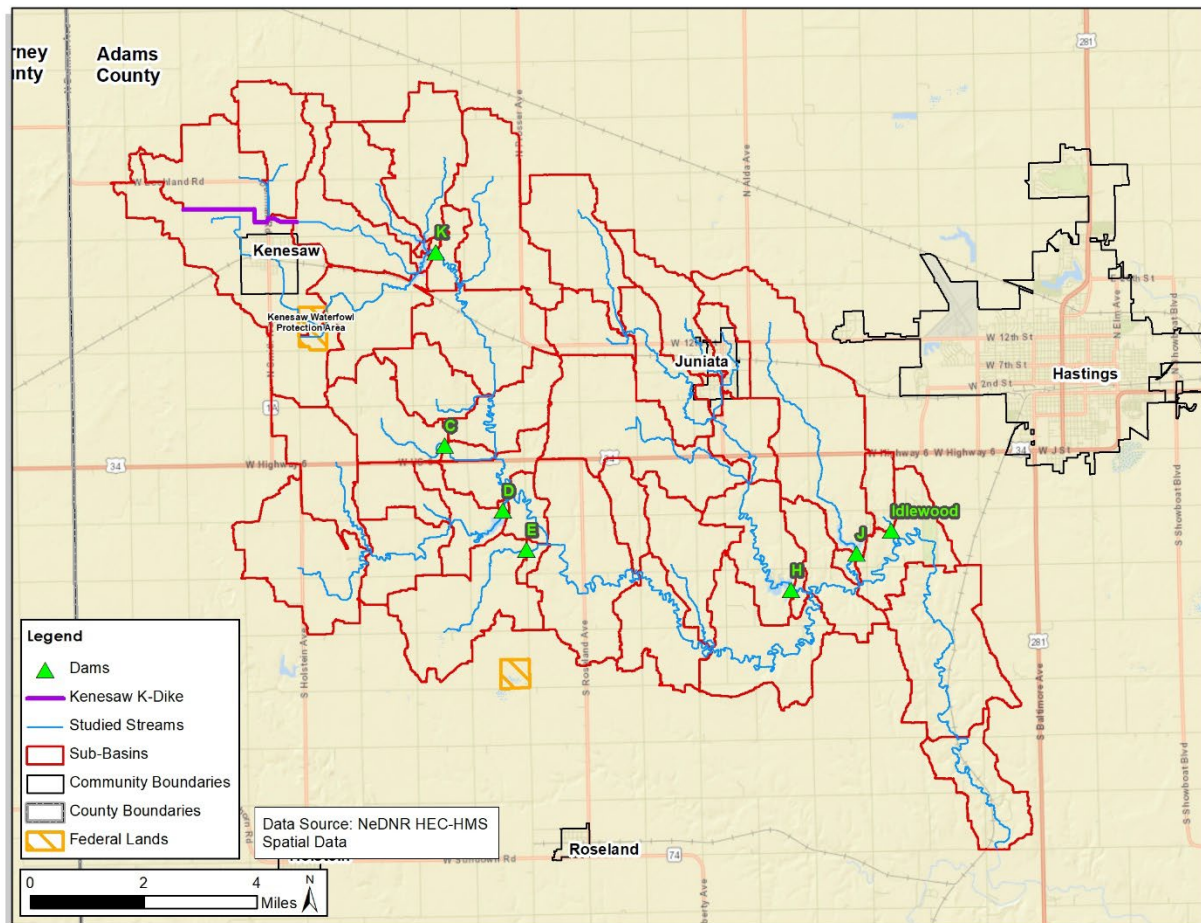


Figure 1: Hydrologic Model Overview

MODEL VALIDATION

NeDNR model delineations and parameters were reviewed and compared to updated data and previous studies. Current model parameters in comparison to the 1965 Watershed Work Plan are shown in Table 2. Watershed delineations comparisons are shown in Figure 2. As can be seen, the contributing drainage area to Dam K in the current HEC-HMS model is more than twice the drainage area identified in the 1965 Plan. The 1965 Plan identified large non-contributing drainage areas to the north and west as well as the drainage area which drains to the Kenesaw Waterfowl Protection Area (WPA) southwest of the dam. Close review of LiDAR collected in 2018 indicates

additional drainage areas which were identified as non-contributing in the 1965 plan, actually do contribute to the watershed during extreme events.

The WPA and the additional drainage area to the north provide detention but during extreme events less frequent than the 100-Year 24-Hour storm event the depressions are filled and additional flows are conveyed to Dam K. While not as significant of a difference, a close review of the terrain also found similarly large depressions areas upstream of dams E and H.

Table 2: Parameter Comparisons to 1965 Plan

	HEC-HMS Model Values	Dam As- Built Values
Dam C		
Drainage Area (sqmi)	2.3	2.1
Curve Number	80.2	77
TOC (hours)	3.40	3.25
Dam D		
Drainage Area (sqmi)	10.4	10.7
Curve Number	78.0	77
TOC (hours)	5.8	11
Dam E		
Drainage Area (sqmi)	3.7	2.3
Curve Number	81.4	76
TOC (hours)	3.8	2.5
Dam H		
Drainage Area (sqmi)	17.5	15.6
Curve Number	81.1	76
TOC (hours)	7.0	15
Dam J		
Drainage Area (sqmi)	6.5	6.8
Curve Number	81.7	74
TOC (hours)	5.2	8
Dam K		
Drainage Area (sqmi)	24.5	9.2
Curve Number	76.4	77
TOC (hours)	8.5	3.5



The NeDNR HEC-HMS model was modified to include the storage provided by the WPA, the drainage area and depression provided by the additional area to the north, the depression areas upstream of dams E and H and where more detail was desired. In the base model sub-basin W440 extended to the watershed boundary to the west, K-Dike to the north and to the WPA wetlands to the south. This basin was further divided to evaluate potential flood risk mitigation projects in the vicinity of Kenesaw. Updated sub-basins are shown in Figure 3.

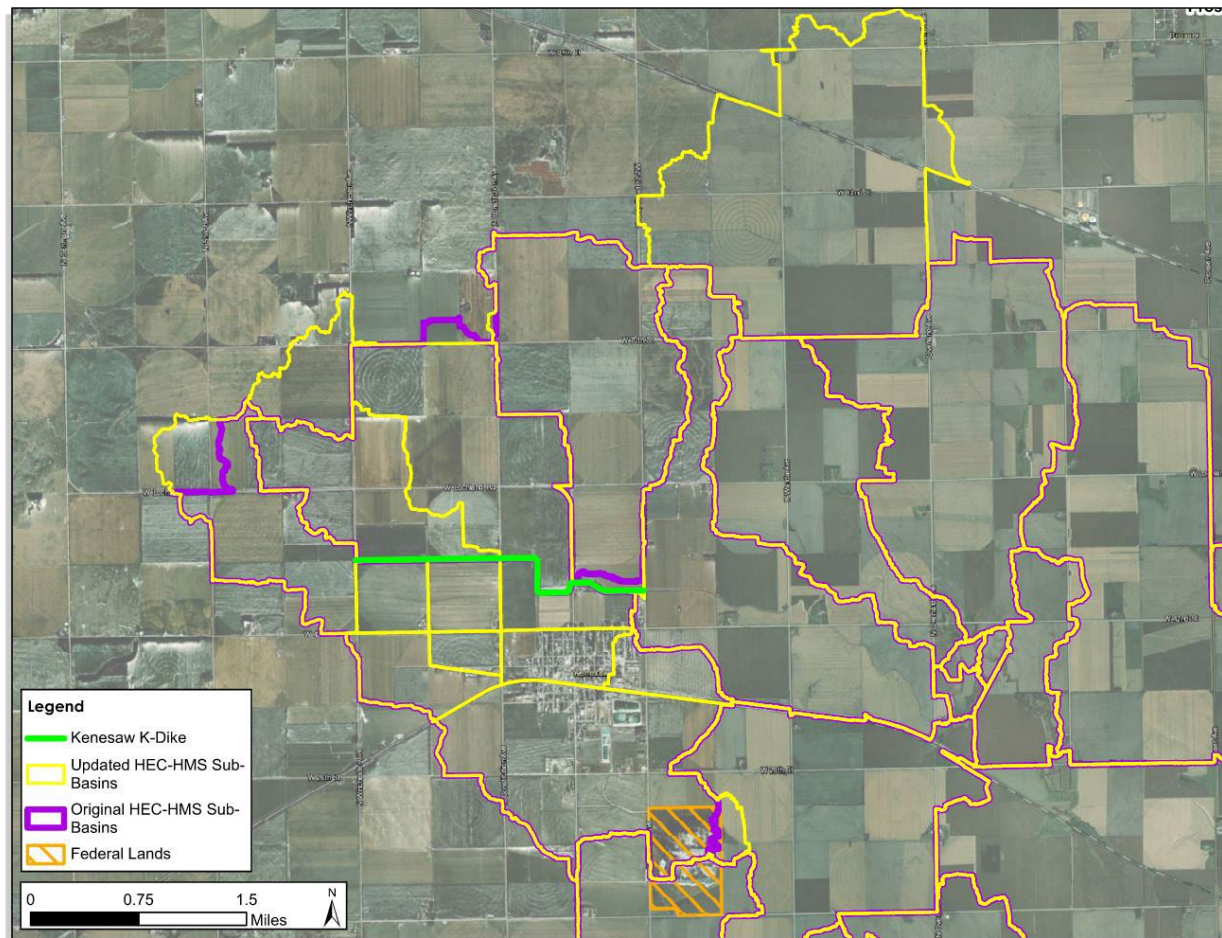


Figure 3: Revised Kenesaw Drainage Basins

Sub-basin parameters were determined using the same processes and methodologies as the base HEC-HMS model. The updated peak flow results for W440 are shown in Table 3. As can be seen the updated model resulted in slightly higher peak flows than the effective base model results at the outlet of sub-basin W440. Given the slight increase in contributing drainage area with the updated analysis this was seen as acceptable and conservative for the purposes of this study.

Table 3: Revised Peak Flows (cfs)

Location	Percent Annual Chance				
	10%	4%	2%	1%	0.20%
W440_Upper	47.8	68.8	87.2	107.4	161.1
W440_Upper_0	125.0	181.1	230.4	285.0	431.0
W440_Upper_1	29.8	42.2	52.9	64.6	95.7
W440_Upper_2	33.2	47.3	59.5	73.0	108.8
W440_Middle	67.9	96.0	120.3	147.0	217.2
W440_Middle_1	29.3	41.5	52.0	63.6	94.0
W440_Middle_2	67.9	99.6	127.2	157.9	239.5
W440_Middle_3	93.2	133.0	167.5	205.2	304.1
W440_Lower	156.6	223.3	281.6	346.2	518.3
Revised HEC-HMS model outlet peak	426.7	608.4	786.6	986.0	1516.5
Effective HEC-HMS model outlet peak	377.5	541	684	840.6	1260.7

Reservoirs were added to the model to represent the WPA detention area, the northern detention area and the depression areas upstream of dams E and H. The reservoirs were modeled using stage storage tables calculated using the 2018 LiDAR data set and an overflow weir outlet based on the overtopping locations.

D 2.03 BASELINE HYDROLOGIC CONDITIONS

In the hydraulic analysis section of this appendix, hydrologic conditions for the HEC-HMS model will be utilized in simulating regional flooding. Figure 4 shows the locations where unsteady flows are taken from the HEC-HMS model for the hydraulic modeling. Peak flows at these locations are shown in Table 4 for each flow event.

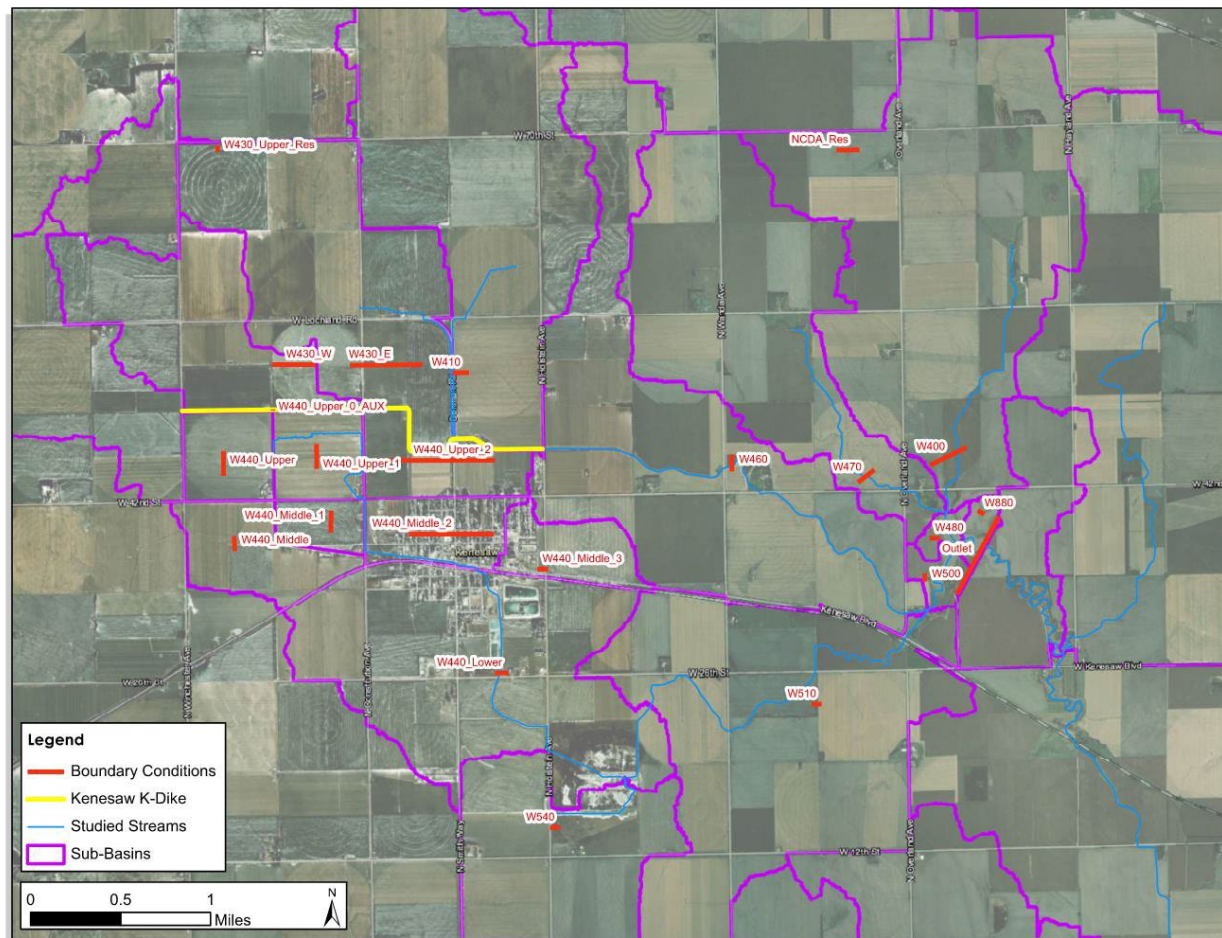


Figure 4: Hydraulic Model Inflow Locations

Table 4: Hydrologic Peak Flows

Flow Location	HMS Model Peak Flow (cfs)				
	10-Year	25-Year	50-Year	100-Year	500-Year
NCD_A_Res	0	0	0	0	27
Outlet	3,063	4,399	5,765	7,395	13,795
W400	547	762	946	1,147	1,673
W410	159	227	286	352	526
430_Upper_Res	16	17	17	17	18
W430_W	88	126	160	197	295
W430_E	86	121	151	185	273
W440_Lower	157	223	282	346	518
W440_Middle	68	96	120	147	217
W440_Middle_1	29	42	52	64	94
W440_Middle_2	68	100	127	158	240
W440_Middle_3	93	133	168	205	304
W440_Upper	48	69	87	107	161
W440_Upper_0_AUX	31	34	36	37	42
W440_Upper_1	30	42	53	65	96
W440_Upper_2	33	47	60	73	109
W460	386	543	678	825	1,213
W470	370	525	657	803	1,186
W480	16	21	25	29	41
W500	64	84	101	119	165
W510	531	732	903	1,090	1,574
W540	149	210	261	319	470
W880	58	76	90	105	144

D 3. HYDRAULIC ANALYSIS

The purpose of this section is to outline the hydraulic analysis completed as part of the WFPO planning process for the West Branch Thirty-Two Mile Creek Watershed. This hydraulic model was used to establish existing conditions and serve as a baseline for evaluating engineering alternatives identified as part of the planning process. West Branch Thirty-Two Mile Creek has a history of documented flooding events. Prior flood events, studies and relevant information were taken into consideration with this hydraulic modeling effort and report, including those mentioned previously.

D 3.01 HYDRAULIC METHODOLOGY

Following discussions with local residents and stakeholders and a screening level review of other areas in the watershed, it was determined the focus of the proposed alternatives would be on the Village of Kenesaw. The hydraulic analyses were completed in HEC-RAS Version 6.4.1. Flooding recurrence intervals modeled include 10-, 25-, 50-, 100-, and 500-year. Terrain data for the analyses was obtained from the most recent USGS 2018 LiDAR and supplemented as needed. Numerous break lines were incorporated within the model to enforce important topographic features (roadway embankments, berms, channel bottoms, etc.) into the 2D grid to shape the modeled flow of water to natural topographic features. Manning's roughness coefficients of the channels and floodplains were based off 2019 NLCD land use data. Table 5 shows the different land uses and associated Manning's n values used in the model.

Table 5: Manning's n-Values Used in HEC-RAS Model

NLCD Value	NLCD Land Cover Type	Manning's n-value	NLCD Value	NLCD Land Cover Type	Manning's n-value
11	Open Water	0.03	43	Mixed Forest	0.075
21	Developed, Open Space	0.045	52	Shrub	0.04
22	Developed, Low Intensity	0.06	71	Grassland/Herbaceous	0.05
23	Developed, Medium Intensity	0.065	81	Pasture/Hay	0.035
24	Developed, High Intensity	0.075	82	Cultivated Crops	0.045
31	Barren Land	0.03	90	Woody Wetlands	0.045
41	Deciduous Forest	0.085	95	Emergent Herbaceous Wetlands	0.04
42	Evergreen Forest	0.085	--	--	--

A 2D HEC-RAS model was created for the Village of Kennesaw and surrounding areas. A grid cell size of 100 ft x 100 ft was used to provide a sufficient resolution of model outputs while also maintaining reasonable computing run times. A depiction of the hydraulic model setup is provided in Figure 5. There is only one outflow boundary condition where flow can leave the model, which is the outlet structures for dam K. This outflow boundary condition was set based on the elevation discharge data in the HEC-HMS model for dam K. There were also numerous inflow boundaries

used to model the different hydrographs from each sub basin as modeled in HEC-HMS. The different boundary conditions were paired with flow hydrographs from the HMS output at various points throughout the model. The model was run for a time of two days.

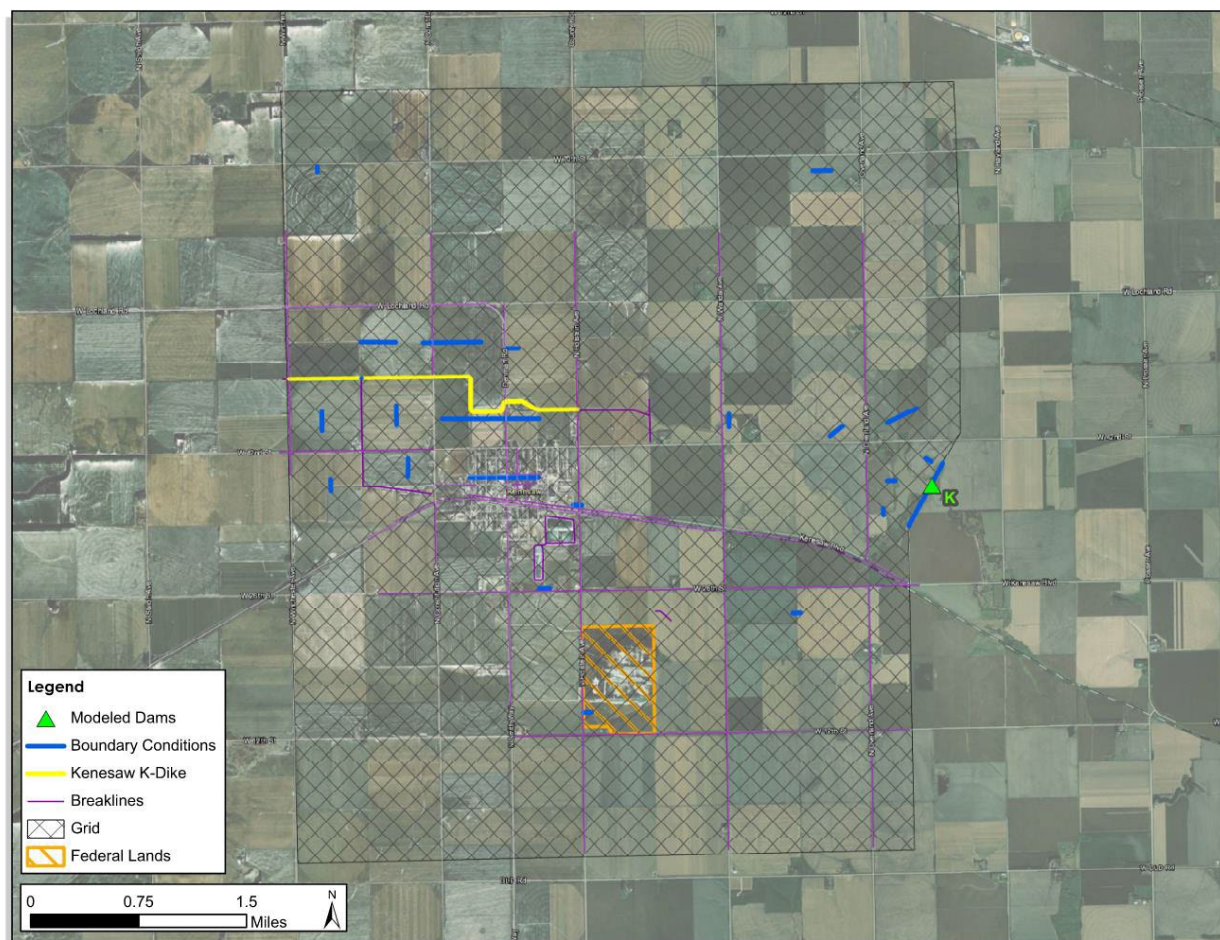


Figure 5: Extents for Kenesaw Hydraulic Modeling

D 3.02 BASELINE HYDRAULIC RESULTS

Three key drainage areas were identified which ultimately resulted in flood damages within the project area. These locations are identified as the Area North of K-Dike, the Northwest Area and the Urban Drainage area.

The area north of K-Dike includes runoff which flows towards K-Dike directly north of the Village. Construction of K-Dike was completed in 1973 as part of the Thirty-Two Mile Watershed Work Plan. The structure consists of a compacted earthen embankment north of Kenesaw. At the east

end of the embankment a control structure consisting of a 30" CMP and low water crossing at North Holstien Avenue and a diversion channel were constructed to divert the runoff to K Dam. Per the Thirty-Two Mile Work Plan, runoff from the 100-Year frequency storm event impounded by the levee would be released, evaporate or infiltrate into the soil in four to seven days. The 30" CMP pipe was designed to convey up to the 25-Year frequency event with flows greater than the 25-Year event being conveyed by both the pipe and the low water crossing.

The existing baseline hydraulic results, which assumed the levee structure properly functioned during the storm events, was reviewed to identify any potential deficiencies. Analysis of the performance of K-Dike focused on both the structure's original design functionality and current regulatory agency guidance in relation to the existing baseline conditions and found it to be deficient based on both criteria. This levee system would fall under Class I levee system per NRCS 356-CPS, March 2022. NRCS design criteria deficiencies are shown in Table 6. The hydrologic results also showed the duration of flooding north of K-Dike for the 100-Year 24-hour flood event persists for more than twelve days.

Table 6: K-Dike Regulatory Deficiencies

Classification	Material	Design Max High-Water Height (ft)	Minimum Storm Design Frequency (yr)	Freeboard in Feet ¹	Top Width in Feet ²	Side Slope Ratio ³	Seepage and Stability Berm Width in Feet ⁴
Class I	Mineral Soils	5'	100	1	10*	Varies - 3:1 and 2:1*	0'
Meets NRCS Design Criteria				No	Yes	No	No

* Based on As-Built

¹ NRCS Design Criteria for freeboard is H/3 (feet).

² NRCS Design Criteria is top width of 10 feet.

³ NRCS Design Criteria is 3:1 side slope ratio.

⁴ NRCS Design Criteria is 12-foot-wide seepage and stability berm

Given the levee deficiencies the hydraulic model was run using FEMA Natural Valley procedures which is how the area is currently reflected on the effective FIRM map. This approach assumes the levee has no effect on floodwaters and was used as a screening level representation of the probable future without project condition in which the existing levee no longer provides reliable flood risk reduction. This method does not explicitly simulate a levee breach. A levee breach, depending on the location, may result in far greater potential flooding and damages as the peak flow, depths and velocities may be higher. Flooding during a 100-Year event without the existing levee are shown in Figure 6. Please note that additional flooding recurrence intervals were modeled and investigated, the 100-year event is shown for illustration purposes only. This scenario is conservatively considered the probable future without project baseline condition.

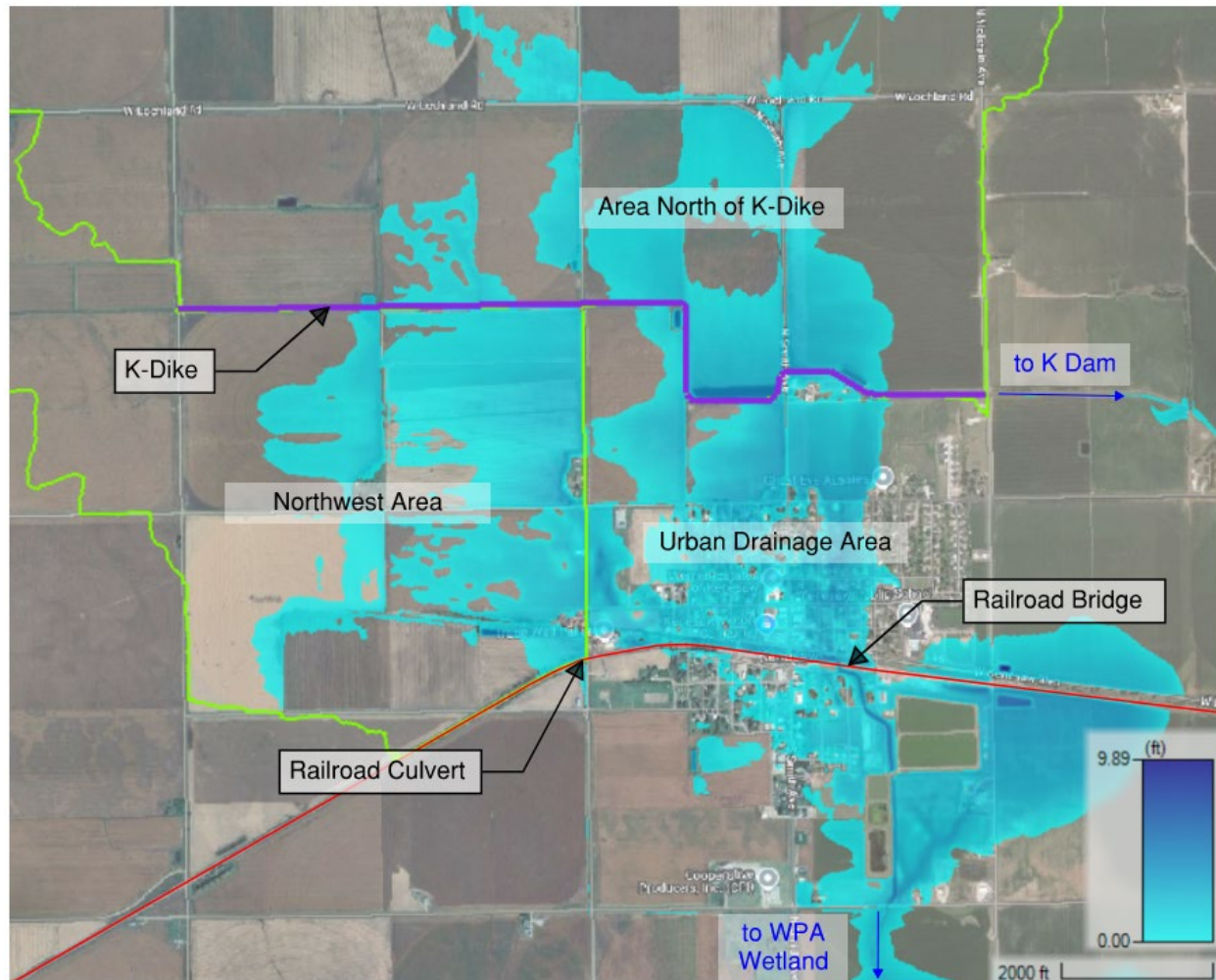


Figure 6: Kenesaw 100-Year Flood Extents (No Levee/Natural Valley)

The urban drainage area (Figure 7) includes the runoff produced by rainfall directly on the Village and the area just north of the Village but south of K-Dike. This runoff is collected by the city storm sewer system or overland flows towards the bridge through the railroad embankment and ultimately discharges to the WPA wetlands.

The northwest area (Figure 7) includes runoff from the west which flows towards North Constitution Avenue. While some flows are conveyed south through the railroad embankment via twin 24" pipes, most of the flow is conveyed to the east towards the Village via roadway overtopping of North Constitution Avenue and two culvert crossings. During the 100-Year storm event, this results in approximately 174 acre-feet and a peak flow of 230 cfs flowing towards the village. Please note that additional flooding recurrence intervals were modeled and investigated, the 100-year event is shown for illustration purposes only.



D 4. PREFERRED ALTERNATIVE ANALYSIS AND DESIGN

The results of the baseline hydraulic analysis and risk assessment were utilized as an evaluation tool to compare the effectiveness of alternatives in reducing flooding damages in the watershed. A variety of potential alternatives were considered, evaluated, and documented within the watershed plan. Through this alternative evaluation process, a preferred alternative was selected which consisted of modernization of K-Dike, channel improvements and grade stabilization, and a detention cell. The impacts from the proposed levee improvements and channel work to the existing K-Dam were also evaluated and it was found they necessitated the need to remove and replace K-Dam as well.

D 4.01 SITE IDENTIFICATION

Potential project sites were identified and analyzed using several factors including aerial imagery, publicly available GIS data, topographic data, field investigation, previous studies, and information gained through stakeholder and public involvement. Locations of existing infrastructure were taken into consideration to avoid and minimize as many impacts as possible. The preferred alternative for Kenesaw is a combination of individual alternatives. Sites selected for individual alternatives served as a starting point for the final preferred alternative.

Existing sensitive resources were also considered when choosing potential site locations. Stream and woodland corridors, wetlands, and habitat for threatened and endangered species were identified and used in conjunction with the other data collected.

D 4.02 SITE PRIORITIZATION

DETENTION CELL: DC1-10

After analyzing several potential locations to site a stormwater detention pond, DC1-10 was selected based on its proximity to the existing drainageway flowing east (south of and parallel to Kenesaw Blvd) through Kenesaw. Additionally, the existing upstream ditch could be improved alongside a road raise along Constitution Ave to convey flow to the detention pond that would otherwise flood Kenesaw from the west. The selected site is an odd-shaped farm field that utilizes gravity irrigation, whereas other sites were within fields irritated by pivot irrigation systems. Thus, it is anticipated that the landowner at site DC1-10 will be more willing to sell the property and the costs will be lower than if another site had been selected. DC1-10 is an independent measure within the larger preferred alternative. Site DC1-10 addresses floodwater originating west of Kenesaw which flows directly into the community. Sites L1-1, G2-2, and F8-3 are interdependent

measures which collectively address floodwater originating north of Kenesaw which is intercepted by the K-Dike.

K-DIKE MODERNIZATION: L1-1

L1-1 is aimed at improving the existing levee north of Kenesaw, colloquially referred to as K-Dike. Consequently, the only effective location for this individual measure is the location in the preferred alternative along the existing K-Dike alignment. Analysis of K-Dike focused on both the structure's original design functionality and current regulatory agency guidance. Improvements along the existing alignment are proposed where K-Dike does not currently meet NRCS and FEMA design criteria requirements. It was also noted that the duration of flooding north of K-Dike persists for more than twelve days while the original design memo stated a duration of flooding of four to seven days. Improvements are proposed to reduce the ponding duration to better align with the original design intent.

CHANNEL IMPROVEMENTS AND GRADE STABILIZATION: G2-2

Grade stabilization was included for the existing ditch that routes water away from the K-Dike into the West Branch Thirty-Two Mile Creek, which connects to the downstream Dam K reservoir. G2-2 was sited to address current stream stability issues that would otherwise likely worsen due to increased peak flows resulting from upsizing culverts at upstream road crossings (included in the L1-1 design).

K-DAM REMOVAL AND REPLACEMENT: F8-3

F8-3 was included due to the current identified deficiencies and the increased peak flows resulting from upsizing culverts at upstream road crossings (included in the L1-1 design). The previously identified non-contributing drainage areas were found to be contributing during extreme storm events, including runoff from the Freeboard Hydrograph event. The dam therefore does not meet current standards and given the age of the structure being beyond the design life it was determined it should be removed and replaced. After analyzing the K-Dams's existing hazard classification, nearby structures/homesteads, and topographical constraints, it was decided to site F8-3 on the existing Dam K alignment.

D 4.03 SITE SPECIFIC DESIGN INFORMATION

SITE DC1-10

DC1-10 is located to the west of the community of Kenesaw. The detention cell is bounded by Constitution Ave to the east and Elevator Rd and the railroad to the south. The relationship between the detention cell's bottom elevation and surrounding topography limits the western extent of the detention cell due to increasingly large excavation depths.

The upstream ditch is designed to work in tandem with the Constitution Ave road raise to convey flow to the detention cell that would otherwise enter Kenesaw from the west. As flow accumulates in the ditch and backs up into the detention cell, the existing 24" RCP located south of Elm St would function as the systems primary outlet, slowly releasing stormwater east into Kenesaw's interior drainage system. The existing twin 24" steel culverts running under the railroad in the southeast corner of the detention cell would function as the secondary outlet, draining south. No alteration or replacement of these culverts is required.

The detention cell has a 59-acre footprint and provides 161 acre-feet of storage. Detention cell side slopes are designed as 6:1 (H:V), and the bottom slopes east at a 0.10% slope. The proposed Constitution Ave road raise is approximately 1.5 feet maximum above existing grade to provide consistent ditch capacity and prevent concentrated overtopping. The ditch runs parallel to and west of Constitution Ave, draining north to south. The ditch would be widened to facilitate floodwater conveyance, with dimensions consisting of a 10-foot-wide bottom with 4:1 (H:V) side slopes. Three precast plank bridges and one set of twin 24" RCPs are proposed for various roadway/driveway crossings along the ditch.

Figure 8 shows an overview of the ditch, road raise, and stormwater detention cell. Structural details are included in the Structural Tables in Chapter 7 of the Plan-EA and supporting drawings are included in Appendix C. The improvements are designed under the following CPS codes:

- CPS 362: Diversion
- CPS 378: Pond
- CPS 578: Stream Crossing
- CPS 582: Open channel
- CPS 620: Underground outlet
- CPS 658: Wetland creation

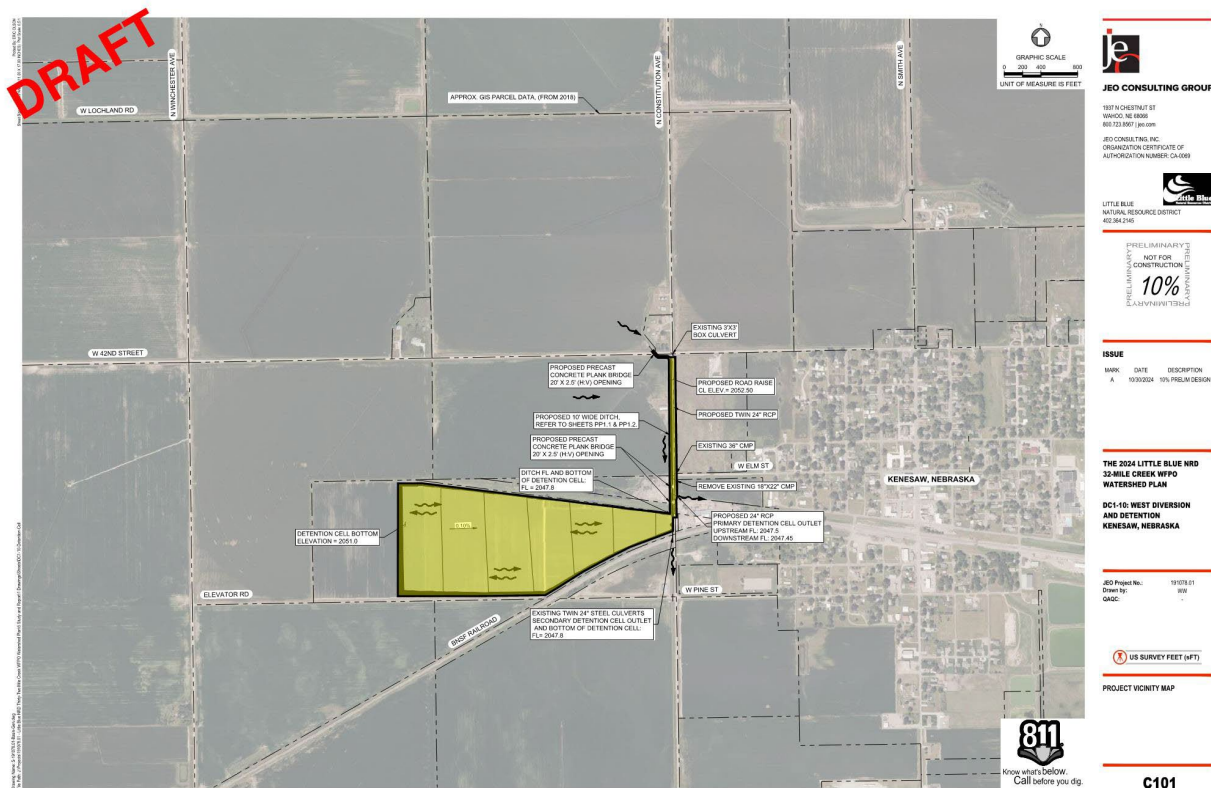


Figure 8: DC1-10 Location

SITE L1-1

As mentioned above, the existing K-Dike is located north of Kenesaw. In its current state, K-Dike stops floodwater from entering Kenesaw and a drainage ditch on the north side of K-Dike drains this redirected flow east, into the West Branch 32-Mile Creek and downstream to the K-Dam. The L1-1 improvements will support the original intent of K-Dike: to reduce the risk of flooding in Kenesaw due to surface runoff from the north. Improvements were based on the 100-year modeled water surface elevation, plus 3.5 feet freeboard (minimum). Top of levee elevation and geotechnical seepage mitigation requirements heavily influenced the extent of improvements along the existing levee. Figure 9 shows the K-Dike alignment with grading extents of improvements. The improvements concentrate earth fill to the landward side of K-Dike with a 4:1 (H:V) landward slope and maximum top of levee elevation raises of approximately 2.0 to 2.5 feet.

For seepage mitigation, seepage berms and toe trench trains were implemented into the design. A 150-foot-wide seepage berm was preferred where space permitted. The seepage berm varies in height as the top-of-seepage-berm elevation matches the 100-yr WSE. The toe trench drains were implemented where other existing infrastructure conflicted with the space requirements of a seepage berm. The L1-1 improvements also include upsizing roadway culverts at three channel crossings along the drainage channel north of K-Dike. These new culverts will reduce K-Dike's

time-to-drain, reducing damages to crop ground where flood water ponds for extended periods of time. Structural details are included in the Structural Tables in Chapter 7 of the Plan-EA and supporting drawings are included in Appendix C. The improvements are designed under the following CPS codes:

- CPS 356 Dike and levee (Class 1)
- CPS 578: Stream Crossing
- CPS 606 Subsurface drain
- CPS 620 Underground outlet

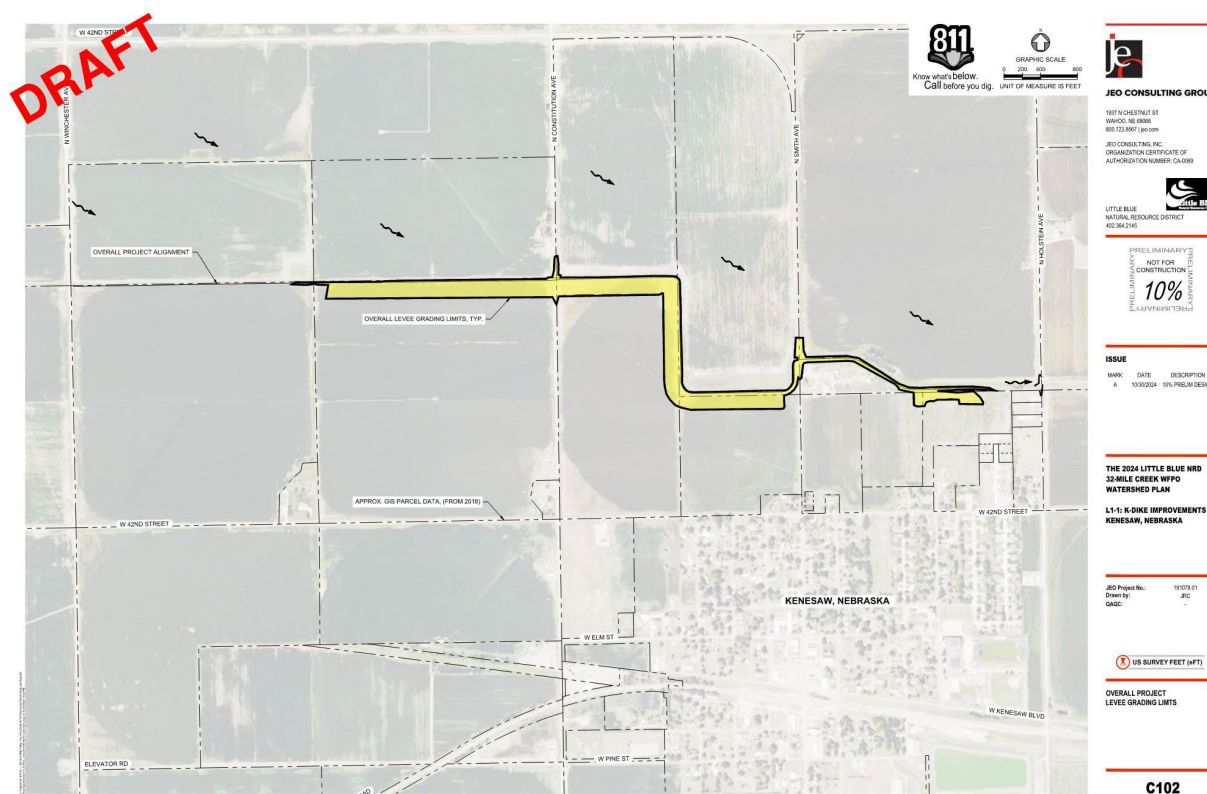


Figure 9: L1-1 Location

SITE G2-2

Just downstream of L1-1, the West Branch Thirty-Two Mile Creek is incised and actively eroding. In anticipation of increased peak flows due to the L1-1 improvements, G2-2 serves to stabilize the channel grade of the creek. G2-2 is a network of three rock riprap plunge pools (located at the downstream end of existing culverts) and four rock riprap weirs. The plunge pools are located at the Wanda Ave, 42nd St, and Overland Ave roadway culvert outlets, aiming to dissipate energy and reduce scouring effects. The weirs were sited along the creek at locations with minimal meandering to prevent the creek from flanking the structure.

The primary weir structure is located roughly six hundred feet downstream of the 42nd St crossing. The reach between 42nd St and this weir is visibly unstable, eroding the roadway embankment. The weir is sized to eliminate an existing head cut and rebuild a stable streambed slope. Immediately downstream of this weir is a smaller weir intended to produce scour-reducing tailwater for the upstream weir. While this larger weir structure is sited to address the 42nd St reach, the remaining three weirs intend to promote stability and prepare the creek for increases peak flows due to the L1-1 improvements. Figure 10 shows the G2-2 stabilization measures. Structural details are included in the Structural Tables in Chapter 7 of the Plan-EA and supporting drawings are included in Appendix C. The grade stabilization structures are designed under the following CPS codes:

- CPS 342: Critical area planting
- CPS 410: Grade stabilization structure
- CPS 584: Channel bed stabilization

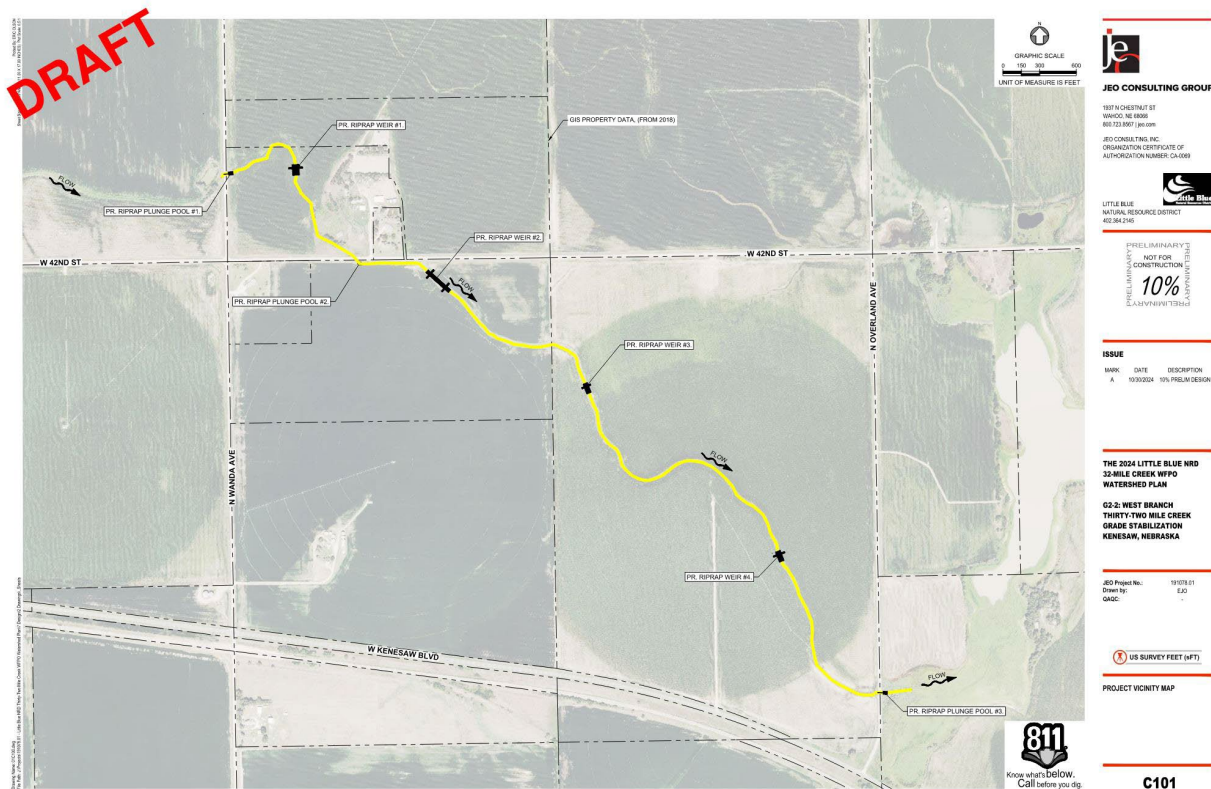


Figure 10: G2-2 Location

SITE F8-3

Site F8-3 is a new significant hazard earth embankment dam southeast of the Village of Kenesaw and will be built on the site of an existing dam. Building on an existing dam site would involve

deconstruction of the current dam structure, which would include removal of the principal spillway, seepage control features, stripping of topsoil, and removal of accumulated sediment in the existing pool area. To evaluate the condition of the dam embankment and determine whether portions of the dam core can be reused, additional soil borings would be taken during the final design stage of the future project.

The dam includes a 48" reinforced concrete pressure pipe (RCP) principal spillway conduit, a concrete riser, and two vegetated earthen auxiliary spillways. The concrete riser's top weir is a Dx3D style structure. The earthen auxiliary spillways were sized to pass the necessary design flows for a significant hazard class structure while maintaining stability and integrity and optimizing earthwork volumes. The dam will have perimeter fencing along the auxiliary spillway and dam embankment and rock riprap shore protection will be installed on the upstream face of the dam. Sediment removal will take place in the permanent pool to reach 100-year sediment life. Any spoils will be spread on neighboring fields within the ARA at the landowners' direction.

Additional site information, including critical elevations and sediment volumes, are included in the structural tables presented in Chapter 7 of the Plan-EA. Conceptual plans with critical elevations and auxiliary spillway configurations are included in Appendix C.

The LBNRD plans to work with Adams County to implement zoning regulations and to restrict development in the breach paths of all dams, existing and proposed during the design phase. This will help ensure that the hazard potential classifications of dam structures are not forced to increase in the future.

Figure 11 shows F8-3's extents of improvements. Structural details are included in the Structural Tables in Chapter 7 of the Plan-EA and supporting drawings are included in Appendix C. The dam is designed under the following CPS codes:

- CPS 402: Dam

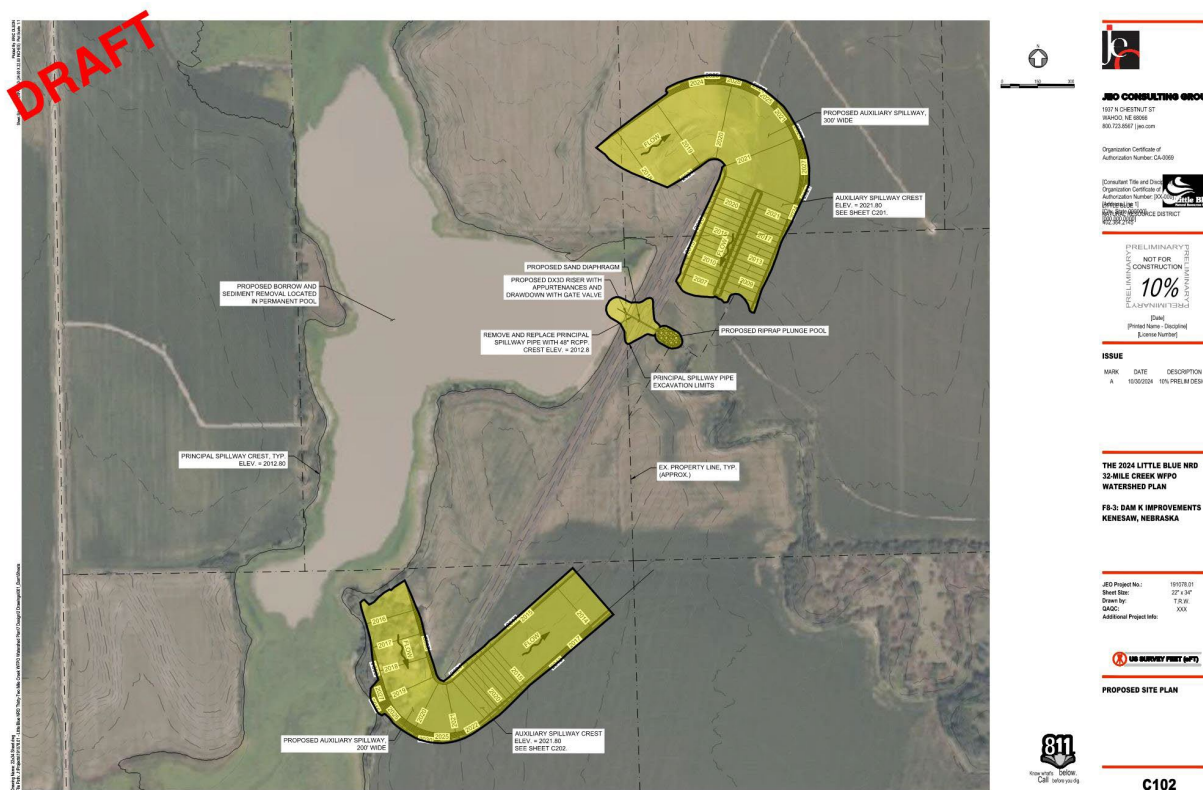


Figure 11: F8-3 Location

Auxiliary Spillway Stability and Integrity Analyses

SITES was utilized to complete an auxiliary spillway stability and integrity analysis in accordance with AH-667. Inputs were formulated using as-built soil borings and the best available geotechnical data including as-built borings and additional borings collected near the site as a part of this effort.

This data was then used as auxiliary spillway material inputs in SITES. The stability of the auxiliary spillway was tested using the 6-hour stability design hydrograph, while the integrity of the auxiliary spillway was tested using the 24-hour freeboard hydrograph.

For SITES, plasticity index, percent clay, and representative diameter of material (in inches) are necessary to define the material makeup of the auxiliary spillway. As-built soil borings were relatively vague and only provided the soil type. It was found that most of the material at the existing site was CL, with some variances. Using nearest available soil boring data, engineering judgement, and a conservative approach, a plasticity index of 20, percent clay of 32%, and representative diameter of 0.03 inches was used to define the auxiliary spillway material at all depths. Additional geotechnical investigations will be completed during design of the dam to better define material types at the site.

In addition to auxiliary spillway material, auxiliary spillway surface conditions were also defined for the integrity analysis. These conditions include Vegetal Retardance Curve Index, Vegetal Cover Factor, Maintenance Code, and Potential Root Depth (ft). The Vegetal Retardance Curve Index defines the overall roughness of the surface. In this case, a Manning's n-value of 0.03 was used (practical range of 0.02 to 0.06). The Vegetal Cover Factor describes the uniformity of vegetal cover in the immediate vicinity of the erodible bed. The cover factor ranges from 0.00 for non-vegetated surfaces to 0.87 for typical turf grass sod covers, while a typical bunch grass cover would have a vegetal cover factor of 0.5. The maintenance code describes the overall uniformity of the cover in the channel. A maintenance code of 1 describes uniform cover over the entire area subject to flow. A maintenance code of 2 considers minor discontinuities in the cover while a maintenance code of 3 considers major discontinuities in the cover. The Potential Root Depth is defined as the depth to which roots could reasonably penetrate under good growing conditions. Further information on these parameters is in the SITES manual. See Table 7 below for the auxiliary surface parameters.

Table 7: Auxiliary Spillway Surface Parameters

Maint. Code	Veg. Retrd. Curve Index	Veg. Cover Factor	Potential Root Depth (ft)
1	0.03	0.7	1.5

Table 8 summarizes the auxiliary spillway stability. The AH-667 adjusted allowable stress (psf) of 0.190 correlates with the conservative plasticity index of 20 and auxiliary spillway operation frequency of 2%.

Table 8: Auxiliary Spillway Stability Analysis

SITE ID	Dia. Surface Material (in)	Total Stress (psf)	Effective Stress (psf)	AH 667 Adj. Allowable Stress (psf)	SITES 6-hr SDH Soil Effective Stress (psf)
F8-3	0.04	0.60	0.048	0.190	0.048

Stability is defined as SITES' 6-hr Stability Design Hydrograph (SDH) actual effective stress being less than the adjusted AH-667 allowable effective soil stress. As can be seen in Table 8, the proposed auxiliary spillways remain stable for the 6-hour SDH. The integrity of the dam is also

found to be maintained for the 24-hour Freeboard Hydrograph (FBH). While a head cut does exist, it did not reach the start of the level section, thus not breaching the dam.

D 4.04 PROPOSED CONDITIONS HYDROLOGY

Dam performance was modeled in SITES modeling software developed by NRCS in accordance with Part 2 of TR-210-60 Earth Dams and Reservoirs. The proposed structure is designed to meet the Significant Hazard criteria. Appropriate hydrographs used for design were determined as reported in Table 9.

Table 9: Significant Hazard Design Rainfall Depths

Design Hydrograph	Requirement	Rainfall Depth
Principal Spillway (24-hr)	P50	5.82
Auxiliary Spillway (6-hr)	P100+0.12(PMP-P100)	7.21
Freeboard (24-hr)	P100+0.40(PMP-P100)	12.73

Stage storage curves were based off the as-built plans. Using the requirements outlined in TR-210-60 different outlet configurations and design were iterated on until the alignments described in the previous sections were finalized.

D 4.05 PROPOSED CONDITIONS HYDRAULICS

Hydraulics for the proposed conditions were analyzed in HEC-RAS using the existing conditions hydraulic model as a baseline to evaluate the effectiveness of the preferred alternative in reducing flooding damages. The proposed K-Dike improvements and detention cell can be used in combination to mitigate flooding within the Village of Kenesaw and diminish any residual flooding. The K-Dike levee was designed to prevent flooding within Kenesaw and have three to four feet of freeboard during a 100-Year flooding event. Results of 100-Year flooding with the proposed Improvements are shown in Figure 12

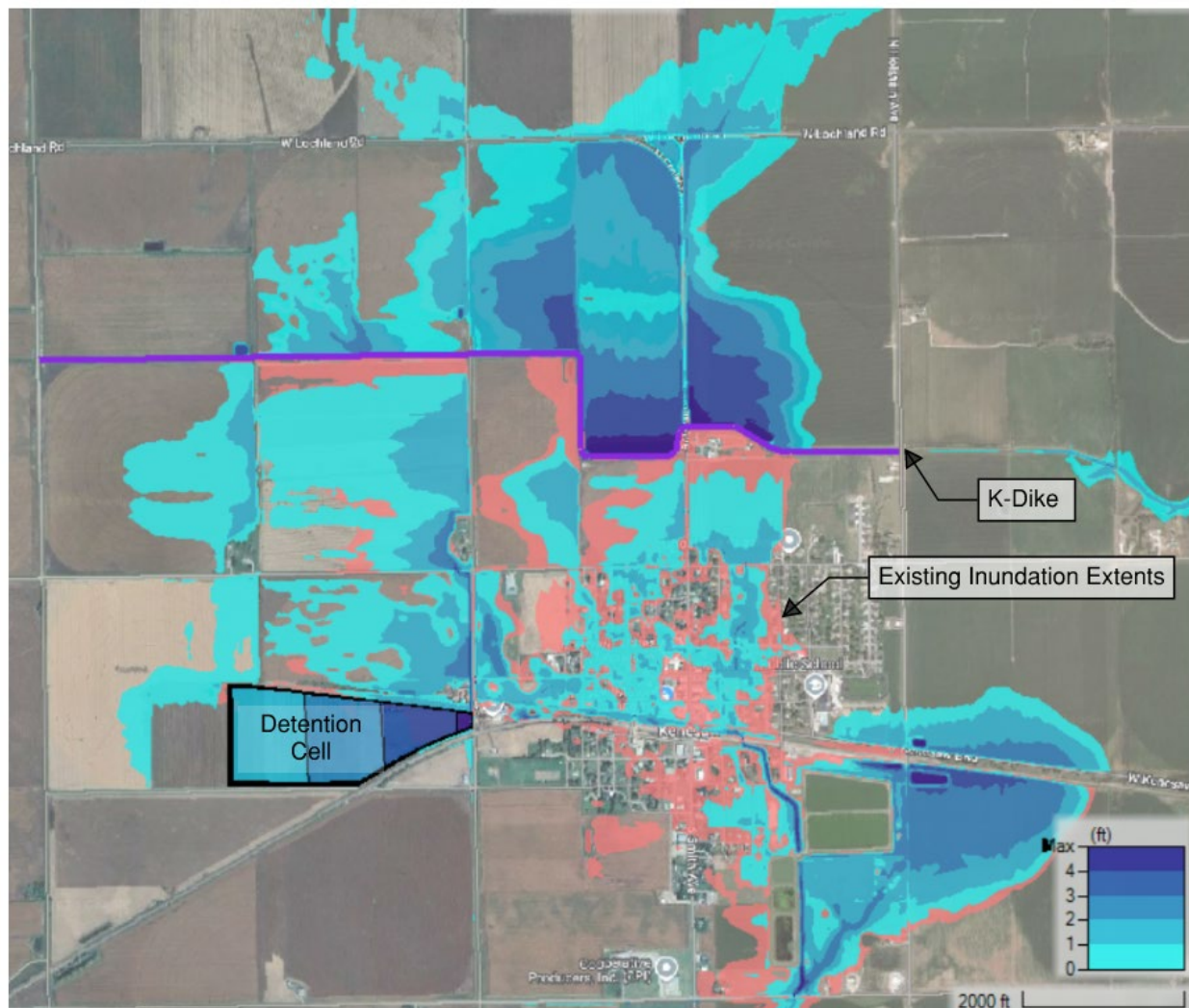


Figure 12: Proposed 100-Year Flood Extents and Depth

RESIDUAL RISK AND AVOIDANCE OF DOWNSTREAM IMPACTS

Flooding depths were reduced by approximately 3-ft in the Village of Kenesaw area due to the proposed levee and detention cell improvements. Several properties were also removed from the modeled flood extents due to this reduction. See Figure 13 for a comparison of the existing natural valley and proposed 100-yr flooding depths. The inclusion of K-Dike results in larger inundation extents and depths north of K-Dike. This is being partially mitigated by increasing the pipe sizes which drain the area and convey flows towards K Dam. Upsizing the existing pipes reduces the

flooding duration from over ten days to three days. There still remains residual risk due to the potential for levee failure. This is further discussed in the next section.

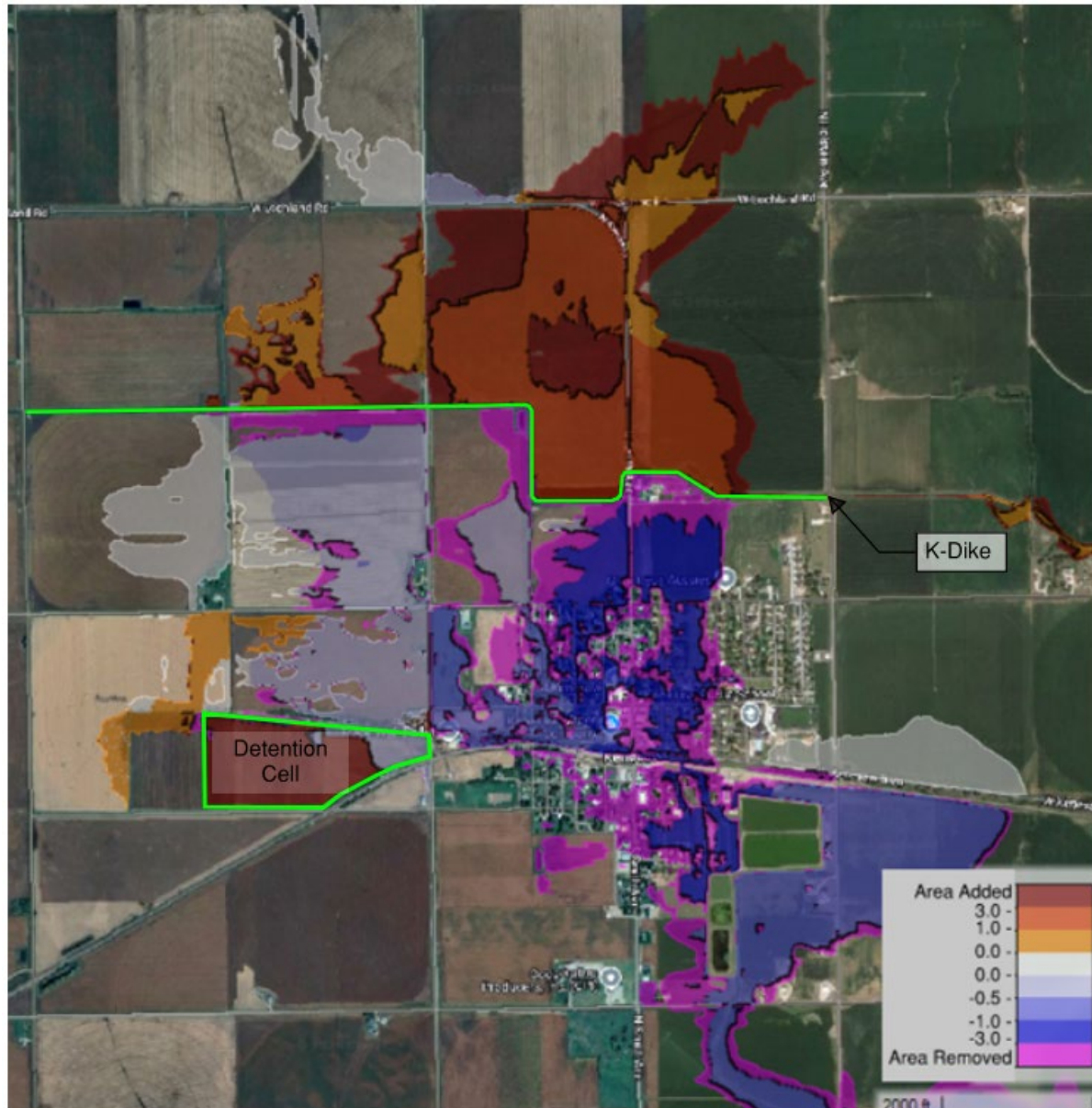


Figure 13: Proposed 100-Year Flood Extents

There is also residual risk downstream of the proposed K Dam F8-3. The dams' principal spillway is designed for the 50-year (significant hazard) frequency event. Anything greater than this event may result in the activation of the auxiliary spillway and additional flows downstream of the dam.

However, breach mapping of the dam provides the most extreme scenario of any residual risk downstream of the dam and very few structures are shown to be impacted. Breach mapping is discussed in the next section.

D 4.06 DAM AND LEVEE BREACH ANALYSIS

DAM BREACH HYDROLOGY

Peak breach discharge for the structure was estimated using the methodology outlined in Part 1 of TR 210-60 Earth Dams and Reservoirs. Geometry for the proposed dam was based on the cross-sections and elevations noted within the proposed plans. The breach elevation was assumed to be at the top of dam. A summary of breach flows and breach conditions is provided in Table 10.

Table 10: Proposed Breach Parameters

Parameter	F8-3
Top of Dam Elevation	2025.0
Auxiliary #1 Spillway Elevation	2021.8
Auxiliary #2 Spillway Elevation	2021.8
Breach Elevation	2025.0
Volume at Breach (Acre-Ft)	3356.4
Tailwater Elevation	1998.8
Peak Breach Discharge (cfs)	20,100

DAM BREACH HYDRAULICS

Breach routings were completed in HEC-RAS version 6.5 using the same terrain and parameters used for the proposed conditions hydraulics. Therefore, the underlying terrain assumes the construction of the dam. The Breach hydrograph was introduced to the mesh directly downstream of the dam and routed through the 2D model to provide an estimation of flooding extent and severity should sudden dam failure occur.

A breach map for the dam is included in Appendix C. Highway 34, a railroad embankment and one farmhouse were identified within the flow path of the dam breach. A closer review indicated the Highway is overtopped to a maximum depth of 0.8 feet and a maximum depth times velocity of 2.8 ft ft/sec. The house is inundated to a maximum depth of 0.8 feet and a maximum depth

times velocity of 0.6 ft ft/sec. The railroad does not overtop. Based on these findings, the dam is assumed to be a significant hazard dam.

LEVEE BREACH ANALYSIS

A levee breach analysis was completed in HEC-RAS following FEMA's Levee Breach Analysis Guidance (February 2018) to evaluate the potential hydraulic impacts of a levee failure with the proposed alternative. In accordance with the Structural-Based Inundation Procedure, two breach locations were modeled. The breach was triggered using the "User Entered Data" method, with initiation set at the peak stage of the base-flood hydrograph (2057.2 ft), consistent with FEMA guidance for piping failures.

The proposed conditions geometry was modified to include the potential breach locations and parameters defined using engineering judgment. The final bottom elevation was set at approximately the levee toe elevation, with side slopes of 1H:1V to represent likely bank stability post-failure. Although FEMA defaults recommend a minimum width of 100 ft for cohesive (clay) levees, a 200 ft width was selected based on adjacent structures and the levee profile. Breach progression was modeled as linear over the specified formation time. Table 11 summarizes the primary model parameters.

Table 11: Levee Breach Parameters

Parameter	L1-1
Station	235
Breach Method	User Entered Data
Final Bottom Width	200 ft
Final Bottom Elevation	2050 ft
Breach Weir Coefficient	2.6
Breach Formation Time	1 hr
Failure Mode	Piping
Piping Elevation	2051.0 ft
Starting Water Surface Elevation	2057.2 ft

A sensitivity analysis was performed to evaluate the influence of breach width and formation time. In the sensitivity run, the final bottom width was increased to 200 ft and the breach formation time decreased to 0.1 hour. Table 12 summarizes the results.

Table 12: Levee Breach Sensitivity

Scenario	Bottom Width (ft)	Breach Formation Time (hr)	Change in Peak WSE (ft)
Base	200	1.0	0
Sensitivity	450	0.1	<0.25

Results indicate that for the modeled location, moderate changes to breach geometry and formation time within the tested range had minimal effect on peak water surface elevations. This suggests that downstream flooding is driven more by the overall hydraulic conditions and hydrograph volume than by small variations in breach parameters.

A breach map for the levee is included in Appendix C.

D 4.07 NRCS ENGINEERING JOB CLASSIFICATIONS

In accordance with NRCS requirements, the proposed measures were assigned an engineering job classification based on controlling factors included in the National Engineering Manual. The controlling factors and classifications are assigned to hazard potential for all practices and factors like design capacity, drainage area, etc. for specific conservation practice codes. Part 501, Subpart A (Rev. 10-2024) of the Nebraska Engineering Manual and Part 520, Subpart C of the National Engineering Manual were referenced to complete this review. This information for the proposed structures is summarized Table 13.

Table 13: Engineering Job Classification

Site	Job Class Controlling Factors ¹	Designer Determination	Assigned Job Classification ⁴
DC1-10	Box Culvert (Area of Opening)	50ft ²	VI
L1-1	Hazard Potential	High ² (Class 1) ³	VII
	Levee (Water Height)	7ft	
G2-2	Rock Chutes (Capacity)	873cfs	VI
	Rock Chutes (Net Drop)	4ft	
F8-3	Hazard Potential	Significant ²	VI
	Contributing Drainage Area	14.6 mi ²	
	Height x Storage	93,408 Ac-Ft ²	
	Effective Height	28ft	

¹Job class controlling factors highlighted blue were used to assign the appropriate job classification for each site. These factors were selected as they had the highest job classification for their associated site.



²Refer to Part 520, Subpart C of the National Engineering Manual for hazard potential definitions.

³Refer to CPS 356 for Dike and Levee classifications.

⁴Refer to Part 501, Subpart A of the Nebraska Engineering Manual for job class controlling factor thresholds.

A preliminary fault analysis was completed using the USGS Quaternary Faults map. Per this analysis, neither site is located near any active faults. Any full seismic evaluations required due to corresponding engineering job classifications will be completed during the design phase.

D 5. GEOLOGY

A preliminary level geological investigation, including subsurface sampling, was performed to support the design of the preferred alternative and characterize borrow material. The purpose was to identify any geologic conditions or hazards to address in the design, construction, or operation of the preferred alternative. Field investigations were completed by Thiele Geotech, Inc. in June 2024. A summary is included below. The full report is attached in Appendix E.

The fieldwork included ten test borings drilled throughout the proposed alternative's site. The soils encountered primarily consisted of fill, loess, and alluvial deposits ranging in moisture content, consistency, and plasticity. Groundwater was not encountered in any of the test borings and is not anticipated to impact construction activities. However, groundwater is noted to be carefully observed during future investigations and construction as seasonal fluctuations in groundwater are possible. It was found that the excavated site soils will generally be suitable for reuse as structure fill. The following key findings and recommendations were identified, and have been considered during the development of the Plan-EA:

- Excavated site soils will generally be suitable for reuse as structure fill; however, moderate to significant moisture conditioning should be anticipated. Appropriate measures should be taken to classify borrow material that would need to be used if excavated material is unable to dried to appropriate moisture conditions.
- Compressible soils (alluvium, loess) exist in the test boring materials, and fill added upon these soils can cause them to consolidate. Final settlement rates would be dependent upon final grading plans, which will determine how much settlement can be allowed and how long construction and fill placement can be delayed.
- It is anticipated that high plasticity alluvial clay soils with lower sand content and assumed lower permeabilities are present within the footprint of the detention cell based off current drilling as well as previous investigative experience within the area. This material could be mined and compacted as a suitable clay liner. If these materials are not found, and if more impermeable conditions are required of the cell, additional treatment such as bentonite to the base clay liner of the detention cell may be needed and should be studied during final design.

A detailed level geological investigation will be completed during the design phase and has been included in the project costs.

D 6. ECONOMIC ANALYSIS

D 6.01 INTRODUCTION

The 32-Mile Creek Watershed is located in southern Nebraska and covers an area of approximately 65,734 acres in Adams County. The watershed is also located within the Little Blue Natural Resources District (LBNRD). The watershed contains two incorporated communities: Kenesaw and Juniata, which have experienced severe flooding events in the past. Between 1996 and 2020 multiple riverine flash flood events occurred in the watershed, resulting in millions of dollars of damage.

The project is needed because of the watershed's long history of repetitive flood damage. Flooding impacts the local economy, makes travel difficult or impossible, threatens lives, and damages structures and property. As a result, the primary objective of the watershed plan is to reduce flood damage within and near the village of Kenesaw, where some of the most extensive flood damage has occurred in the past. Kenesaw and Juniata account for a majority of the watershed's population, with a combined total of 1,661 people living in the two villages as of 2020.

The objective of this report is to estimate the benefits and costs of the preferred alternative considered as part of the 32-Mile Creek Watershed Plan and Environmental Assessment (EA). The proposed alternative is evaluated in conformance with the Principles, Requirements and Guidelines for federal investments in water resource projects (DM 9500-13). Specifically, this report uses an ecosystem services framework to consider the benefits and costs of the preferred alternative. Those benefits and costs are compared against a baseline of no action, which is also referred to as the Future Without Federal Investment (FWOFI).

This report is structured into the following sections:

- Federal Guidelines of National Economic Efficiency Analysis of Watershed Improvement Measures
- Alternatives and Ecosystem Services Evaluated
- Benefit-Cost Analysis Data and Methodology
- Current Economic Costs
- Economic and Structural Tables

D 6.02 FEDERAL GUIDELINES OF NATIONAL ECONOMIC EFFICIENCY ANALYSIS OF WATERSHED IMPROVEMENT MEASURES

The benefit-cost analysis (BCA) conducted as part of this report uses federal water resource project and National Resources Conservation Service (NRCS) guidelines for the evaluation of benefits and costs of the No Action and preferred alternative, relying primarily on the Principles, Requirements and Guidelines (PR&G)(DM 9500-013), the Water Resources Handbook for Economics (Part 611), and the National Watershed Program Manual (Title 390-NWPM, Part 500).

With the passage of the 2007 Water Resources Development Act, Congress directed the federal government to update and consolidate its past guidance on evaluating the costs and benefits of federal investments. The original Principles and Guidelines (P&G) was replaced by Principles, Requirements and Guidelines (PR&G). The PR&G allow for:

...maximizing public benefits (of all types) relative to costs, the use of quantified and unquantified information in the tradeoff analysis, flexibility in decision making to promote localized solutions, ability to rely on the best available science and objectivity, and advance transparency for Federal investments in water resources (CEQ 2014).

The PR&G further state:

Federal investments in water resources as a whole should strive to maximize public benefits, with appropriate consideration of costs. Public benefits encompass environmental, economic and social goals; include monetary and non-monetary effects; and allow for the consideration of both quantified and unquantified measures (CEQ 2014).

The PR&G requires benefits and costs to be evaluated in an ecosystem service framework. An ecosystem is a natural unit of living and non-living things that function together to create goods and services valued by people (Olander et al., 2016). Ecosystem services is a broad term used to describe the benefits humanity receives from ecosystems as a byproduct of their functioning.

By putting nature at the center, ecosystem services frameworks give economic, social, and environmental costs and benefits equal standing in decision-making processes and therefore help to accomplish the federal objective of maximizing national economic efficiency, ensuring federal investments protect and restore ecosystem functions and values and avoid irreversible impacts. Economic efficiency requires that resources are used in their highest valued use. Projects that create more benefits than costs utilize resources more efficiently than baseline conditions and therefore increase national economic efficiency.

The four-category ecosystem framework adopted in the PR&G, and utilized in this report, is shown in Table 14.

Table 14: Ecosystem Services Framework Used to Evaluate Benefits and Costs

Service Type	Examples
Provisioning	The supply of food, fuel, fiber, water, timber, and genetic resources
Regulating	The regulation of air, climate, natural hazards, water quality, pests, and disease
Cultural	Services that enhance cultural values, like aesthetics, recreation, tourism, and spiritual or religious values
Supporting	Nutrient cycling, soil formation, and primary production

Source: USDA 2017

GUIDING PRINCIPLES¹

In addition to requiring projects to be evaluated using an ecosystem service framework, the PR&G also seek to promote projects that fulfill guiding principles related to federal investments in water resources. These include:

- **Healthy and Resilient Ecosystems** – Federal investments in water resources should protect and restore functions of ecosystems and mitigate any unavoidable damage to these natural systems.
- **Sustainable Economic Development** – Federal investments in water resources should encourage sustainable economic development that improve the economic well-being of the Nation for present and future generations through the sustainable use and management of water resources.
- **Floodplains** – Federal investments in water resources should avoid the unwise use of flood prone-areas and avoid and minimize adverse impacts and vulnerabilities in any case in which a flood-prone area must be used. Federal investments should seek to reduce the Nation’s vulnerability to floods and storms.
- **Public Safety** – Federal investments in water resources should avoid, reduce, or mitigate risks to people, including both loss of life and injury, from natural events.
- **Environmental Justice** – Federal investments in water resources should ensure that disproportionately high and adverse public safety, human health, or environmental burdens of projects on tribal, minority, or low-income populations are identified, mitigated, or eliminated.
- **Watershed Approach** - Federal investments in water resources should use a watershed approach that properly frames a problem by evaluating it on a systems level that identifies root causes and interconnectedness of watershed problems that enables the design of solutions that considers the benefits of water resources for a wide range of stakeholders within and around the watershed.

¹ DM 9500-013

The Watershed Plan and Environmental Assessment for the Project considered these principles in the characterization of flood mitigation challenges and shortages of recreation opportunities faced by stakeholders in the watershed and the formulation of solutions as defined in the preferred alternative.

D 6.03 PREFERRED ALTERNATIVE AND ECOSYSTEM SERVICES EVALUATED

To reduce flood damage in the 32-Mile Creek watershed a single action alternative was carried forward for additional analysis. The action alternative, which is also the preferred alternative, would construct a detention cell as well as investing in dam improvements, a levee, and grade control. Together, the works of improvement of the preferred alternative meet the project's purpose and need and achieve the project's objectives of reducing flood damage in the watershed. The analysis also considered a non-structural alternative.

The no action alternative, also known as the Future Without Federal Investment (FWOFI), describes the most likely future if no federal investment is made in the watershed. Under the FWOFI, flooding would continue to cause damage in the watershed under all flood frequencies.

The economic analysis analyzed the costs and benefits of all FWOFI and preferred alternative.

TYPES OF SERVICES IMPACTED

Chapter 3.07 of the watershed plan-EA shows the causal chain describing how the preferred alternative would create social benefits and costs in the 32-Mile Creek watershed. The change in watershed structure would improve the regulation of flood damage, leading to reduced flood damage to buildings and business and personal income. In addition, the preferred alternative will reduce flood insurance administration costs and road damage. The preferred alternative will also increase wetland habitat, leading to an increase in the value of provisioning services in the watershed.

ABILITY TO CHARACTERIZE, QUANTIFY, AND MONETIZE SERVICES

The ecosystem services can be characterized, quantified, and monetized to varying degrees. Modelling impacts from mitigating flood risk to buildings and businesses requires a large amount of data and sophisticated geospatial models depicting hydrologic conditions in the watershed under different climate and weather conditions. While these barriers are high, publicly available models, such as U.S. Federal Emergency Management Authority's (FEMA) HAZUS model, are commonly used to quantify and value flood damages to the buildings and businesses. Changes to flood insurance administration costs were estimated based on the number of active flood insurance policies in Kenesaw. Changes to road damage were estimated based on the linear miles of roadway that would be overtopped under different flood frequencies. Changes to wetland

values were quantified based on the acres of additional wetland created by the preferred alternative and the estimated value of an acre of wetland in Nebraska.

METRICS TO EVALUATE SERVICES

This section describes metrics used to measure changes to ecosystem services that are quantified and valued as part of this analysis. Damages to buildings, including contents and inventories, are quantified in terms of the number of buildings and the overall square footage of building space damaged by flooding. Lost personal and business income is also measured in terms of square feet of building space damaged, as discussed in more detail in Section 4, below. Flood insurance administrative cost savings were measured using the number of policies in place and the cost of administering each policy. Road damage was measured in linear feet and wetlands were measured in acres.

PRIORITIZING SERVICES

Services were prioritized based on their expected contribution to the project's primary objectives of reducing flood damage in the 32-Mile Creek watershed. As a result, the analysis prioritized the regulating services impacted by the flood control measures proposed to be installed in the watershed.

SUMMARY AND COMPARISON OF ECOSYSTEM SERVICE CHANGES

A summary of the preferred alternative's impact on ecosystem services in the 32-Mile Creek watershed and fulfillment of federal investment principles in water resources is shown in Chapter 5 of the watershed plan.

In terms of benefits and costs, the preferred alternative's combined investment in the watershed would generate economic returns in excess of the upfront installation and ongoing management costs as compared to the FWOFI. The preferred alternative would invest an average annual amount of \$630,100 in built infrastructure to reduce flood damage in the 32-Mile Creek watershed while the discounted annualized value of the benefits generated by the project amounts to about \$878,900, outweighing the preferred alternative's expense.

D 6.04 NATIONAL ECONOMIC EFFICIENCY BENEFIT-COST ANALYSIS DATA AND METHODOLOGY

Benefits and costs were calculated based on the expected effects of the preferred alternative on regulating ecosystem services as compared against the FWOFI. Effects of the preferred alternative were evaluated over a 100-year period of analysis, which includes five years of construction as well as the 100-year life over which most works of improvement are expected to have significant beneficial effects. Interest during the 6-year construction phase was calculated using the mid-life full expenditure method.

Projected benefits and costs are based on a full employment economy and assume no change in relative prices during the period of analysis. Benefits and costs are discounted using the discount rate for Federal projects of 2.75 percent for 2024 (USACE, 2023). Results are reported in current-year values and average annual values in 2024 dollars.

To assess the economic benefits and costs of the preferred alternative, appropriate methods were used to quantify and value the impacts of the preferred alternative as compared to the FWOFI. Flood damage to buildings, businesses, and employees under the FWOFI and preferred alternative was estimated using the H&H analysis in conjunction with GIS-based models as discussed in more detail below. In all of the analyses discussed below, the unit of analysis is the system of projects combined under the preferred alternative.

REDUCED BUILDING-RELATED DAMAGE

Reduced building-related damages were estimated with the HAZUS model. The HAZUS model, endorsed by the NRCS for watershed planning and developed by FEMA, serves as a robust tool for estimating flood damage across various scenarios. The models' primary strength lies in its ability to quickly produce estimates using user-defined H&H modeling and pre-packaged building data, making it well-suited for widespread and integrated flood risk assessments. However, this convenience comes with a tradeoff in precision; HAZUS may not provide the same level of detail for building-specific flood depth damages as models like HEC-FDA. On the other hand, models like HEC-FDA are specifically designed for detailed flood risk analysis but demand more time, specialized expertise, and detailed data, which can limit their accessibility for large flood inundation areas with diverse building inventories.

Still, peer-reviewed comparisons that applied the HAZUS and HEC-FDA models to several different study areas, found the outputs from HAZUS are similar and consistent with those from HEC-FDA, while requiring a fraction of the time and effort to produce.² Based on these reviews and to best utilize the limited resources available in preparing the watershed plan, the project team chose to utilize HAZUS to estimate building-related flood damage reductions.

The HAZUS model runs on standard GIS software and addresses damage associated with almost all parts of the built environment. The model can estimate the value of a wide range of different types of flood loss. The model contains different loss modules, which the user has the option of including in their total damage calculation. The modules for reduced property loss, which are time-independent, include:

- Building repair and replacement cost;
- Building content loss; and

² Ding, A., White, J. F., Ullman, P. W., & Fashokun, A. O. (2008). "Evaluation of hazus-mh flood model with local data and other program." *Nat. Hazards Rev.*, 10.1061/(ASCE)1527-6988(2008)9:1(20), 1527-6996.

- Building inventory loss.

The sum of these losses constitutes building-related losses in the benefit-cost analysis.

To estimate building-related damage, the model works in a two-step process, which includes a flood risk projection step and a flood loss estimation step. In the flood risk projection step, the user defines flood risk in terms of parameters like flood frequency, discharge, and ground elevation in the study area. In the second step, damages are calculated based on the flood risk projections developed in the first step and using default functions relating depth to damage (depth-damage functions) from the U.S. Army Corps of Engineers (USACE) and building inventory and valuation data from the U.S. Census (FEMA, 2022). The model combines this information to produce spatial and tabular data describing flood losses in monetary terms.

An important part of estimating reduced flood damage is identifying the number, value, type, and other characteristics of at-risk building stock. The HAZUS model's General Building Stock data (GBS) includes information on residential, commercial, industrial, agricultural, religious, government, and education buildings for each Census block in the study area. For modeling simplicity, HAZUS assumes building inventory is evenly distributed across a census block, such that building damage estimates represent averages across their respective block.

Each building type is associated with a corresponding occupancy classification, of which there are seven categories in the HAZUS model:

- Residential
- Commercial
- Industrial
- Agricultural
- Religion
- Government
- Education

Table 15, below, shows the square footage of building types damaged by flooding under each storm event frequency in the 32-Mile Creek watershed for the preferred alternative.

Table 15: Damaged Square Footage ('000s) of Buildings by Occupancy Type Under FWOFI and Preferred Alternative for 10-500 Year Flood Frequencies

Occupancy Type	500-Year		100-Year		50-Year		25-Year		10-Year	
	FWOFI	Preferred Alternative	FWOFI	Preferred Alternative	FWOFI	Preferred Alternative	FWOFI	Preferred Alternative	FWOFI	Preferred Alternative
Residential	291.97	95.92	235.00	95.80	206.30	56.28	177.16	48.23	136.28	38.74
Commercial	8.74	2.22	5.93	2.28	4.62	1.22	3.95	1.03	3.04	0.89
Industrial	2.21	0.49	1.75	0.46	1.55	0.13	1.33	0.06	0.81	0.04
Agricultural	4.76	0.38	4.13	1.08	3.85	0.07	3.49	0.04	3.01	0.02
Religious	6.21	0.09	4.18	0.06	2.88	0.00	1.47	0.00	0.60	0.00
Government	0.45	0.05	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01
Education	1.89	0.20	0.14	0.14	0.11	0.11	0.08	0.09	0.04	0.04
Total	316.23	99.35	251.15	99.86	219.34	57.85	187.51	49.46	143.79	39.75

Source: HAZUS v5.1.

As the existing conditions data shows, flooding poses significant risks to a variety of building types in the Village of Kenesaw. For single-family dwellings, manufactured housing, and multifamily units, floodwaters can severely damage foundations, electrical systems, and personal property. Manufactured homes, in particular, are more vulnerable due to their lightweight construction.

Other structures, like retail and wholesale businesses are at risk of losing inventory and having their operations disrupted, while professional/technical services, banks, and medical offices/clinics may face service interruptions and loss of essential records. Flooding also impacts industrial sectors like agricultural processing and light industry, leading to potential contamination risks and operational shutdowns.

To assess damages to structures under the FWOFI and Preferred Alternative, the model combined the general building stock data from Table 2 with the H&H data and building-specific depth-damage curves to estimate the building-related losses for the study area's general building stock under the FOWFI and preferred alternative. Flood extent and depth data was input into the HAZUS model using depth grids from five return periods (10%, 4%, 2%, 1%, and 0.2% annual chance floods, or 10-, 25-, 50-, 100-, and 500-year return periods) developed as outputs from the H&H for the FWOFI or existing conditions. The HAZUS model's methods for calculating building-related losses are discussed below.

Depreciated Building Replacement Costs

Damage to buildings under the FWOFI and preferred alternative were calculated by estimating the cost to repair or replace flood-damaged structures and their contents. Building repair and replacement cost estimates are based on the full replacement cost less depreciation model, whereby losses from flood-damaged buildings are calculated assuming the full value of damages, less depreciation, are restored.

Replacement cost data is stored in the HAZUS model at the Census Block level for each building type. The replacement cost values used by the HAZUS model were depreciated by the study team based on the median age and assumptions regarding the typical condition of structures in the watershed. According to the U.S. Census' American Community Survey, the average home in Kenesaw is about 60 years old.³ A visual survey of residential neighborhoods in the village conducted via Google Earth and Zillow showed that homes are generally maintained in above-average condition.

³ U.S. Census Bureau. "Selected Housing Characteristics." American Community Survey, ACS 5-Year Estimates Data Profiles, Table DP04, 2022, <https://data.census.gov/table/ACSDP5Y2022.DP04?t=Housing:Housing%20Units&g=160XX00US3124950,3125160> Accessed on November 4, 2024.

This information was cross-referenced with the Swift Estimator, which provides a depreciation curve for structures of various ages.⁴ Based on the median age and assumed condition of buildings in the 32-Mile Creek watershed, the Swift Estimator recommended using a depreciation rate of 15 percent, which was applied to the replacement cost values provided by HAZUS as shown in Table 16.

Table 16: Replacement Cost Values for Buildings (2024 \$)

Occupancy Type	HAZUS Replacement Cost per Sq. Ft.	Depreciation Factor	Depreciated Replacement Cost per Sq. Ft. Used in the BCA
Residential	\$201.07	15%	\$170.91
Commercial	\$178.05	15%	\$151.34
Industrial	\$152.35	15%	\$129.49
Agricultural	\$228.64	15%	\$194.34
Religion/Non-profit	\$305.08	15%	\$259.31
Government	\$144.00	15%	\$122.40
Education	\$241.96	15%	\$205.66

Note: Replacement costs are reported in costs per square foot for multiple occupancy type sub-categories based on the weighted average of values used in the analysis of building damages in the 32-Mile Creek watershed, NE.

Source: HAZUS v.5.1.

Building Content Loss

The HAZUS model estimates damages to building contents as a percentage of the structure replacement value as shown in Table 17. Contents in the model include furniture, equipment, computers, appliances, clothing, and personal possessions. Contents do not include things like light fixtures, ceiling lamps, or other mechanical or electronic components that are integral to the structure of a building.

Table 17: Building Content Loss as a Percent of Building Replacement Value

Occupancy Type	Content Value as Percent of Building Replacement Value
Residential	50%
Commercial	105%
Industrial	140%
Agricultural	100%
Religious	-
Government	125%

⁴ SwiftEstimator. (2020). Swift Estimator User Guide. Retrieved from <https://www.swiftestimator.com/UserGuide>.

Education	125%
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Source: HAZUS v.5.1.

Business Inventory Damages

Many building occupancy types have more than one inventory-depth-damage curve associated with them. In these cases, the HAZUS model averages the relevant depth-damage functions to form a single average function for the entire building occupancy class. The HAZUS model uses this information along with information on total damaged floor area, annual gross sales per square foot, and business inventory as a percent of annual gross sales, to calculate the total inventory damage for each building type. The gross revenue per square foot and business inventory as a percentage of gross revenue are shown in Table 18.

Table 18: Business Inventory Losses as a Percent of Gross Sales per Square Foot (2024 \$)

Occupancy Type	Gross Revenue per Sq. Ft.	Business Inventory as Percent of Gross Revenue
Commercial	\$82.20	12%
Industrial	\$735.60	4%
Agricultural	\$187.20	8%

Source: HAZUS v.5.1.

REDUCED BUSINESS INCOME AND WAGE LOSS

HAZUS calculates business interruption costs, including proprietor income loss and employee wage loss by building type. These losses were included in the BCA as a regional effect. In the model, business income and wage losses depend on the amount of time it takes to restore the building where the business resides in addition to restocking its inventory. Restoration time accounts for physical restoration, clean-up, inspections, permits, and contractor availability. Restoration times increase with flood depth and also vary based on building type. Restoration times range from a low of a few months for structures with minimal flooding to a high of several years. For many commercial businesses, restoring lost inventory and equipment accounts for the largest share of restoration time.

The equations below show how HAZUS calculates business income and wage losses following flood events:

- **Income Loss_i** = $\sum (1-IRF_i) \times FA_{i,j} \times Inc_j \times RT_{i,j}$
- **Wage Loss_i** = $\sum (1-WRF_i) \times FA_{i,j} \times WA_j \times RT_{i,j}$

The parameters of the above equations are defined as:

- *i* is the building type of the impact structure

- IRF_i is the income recapture factor for building type i
- WRF_i is the wage recapture factor for building type i
- FA_i is the income per day (per sq. ft.) for building type i
- INC_i is the business income per day (per sq. ft.) for building type i
- WA_i is the wage per day (per sq. ft.) for building type i
- RT_{ij} is the restoration time, measured in days, for building type i and flood depth j .

The equations represent income and wage loss as a function of the length of time needed to restore business operations as well as the ability of businesses and employees to recapture their respective incomes and wages. For example, according to the wage loss equation, employees who are able to recover their full wage following a flood event would have a recapture rate of one, which would mean they would not lose any wages as a result of the flood. Lower recapture rates would lead to high damages, all else equal. The income and wage recapture rates used by the HAZUS model ensure that estimates of income and wage loss only include actual losses rather than deferred economic activity. The equations also reflect the productivity of the business as measured by income generated per square foot.

The parameters used to calculate reduced business income and wage losses under the preferred alternative and FWOPI are shown in Table 19. The restoration times shown in the table are based on expert opinion and account for various factors like physical restoration, clean-up, inspections, permits, approval processes, and delays due to contractor availability. Table 19 also displays the income recapture rates, annual business income generation rates, and daily wage rates per square foot used in the analysis.

Table 19: Parameters Used to Calculate Business Income Loss and Wage Loss (2024 \$)

Occupancy Type	Restoration Time (Days)	Income Recapture Rate	Daily Business Income per Sq. Ft. per Year	Daily Wage per Sq. Ft.
Residential	180 – 720	0%	\$0	\$0
Commercial	180 – 900	68%	\$0.20	\$0.48
Industrial	0 – 900	80%	\$0.10	\$0.42
Agricultural	0 -210	67%	\$0.05	\$0.17
Religious	180 – 900	80%	\$0.16	\$2.46
Government	360 – 900	80%	\$0.10	\$0.14
Education	360 - 900	83%	\$0.10	\$0.67

Source: HAZUS v.5.1.

NREH Part 611.0403 states that the benefit of reducing business income losses from flood risk reduction can be included as part of the benefit-cost ratio when interview data are collected to verify that losses are not compensated for by postponement of an activity or transfer of the economic activity to other establishments.

To validate the nature of business income and wage related losses estimated by HAZUS, a survey of business owners was conducted by the Lower Loup Natural Resource District (LLNRD) to estimate the impact of a 100-year flood event on their business revenue and employee wages.

LLNRD approached a sample of businesses to participate in the interviews utilizing NRCS Form ECN-003 (NREH Part 611, Appendix 4A, Form NRCS-ECN-003). The LLNRD engaged in structured dialogues with each business to ensure uniformity in questioning and responses. Confidentiality was assured to encourage participation and information sharing. In total, 11 businesses completed the questionnaires.

The responding businesses spanned various sectors, including retail trade, professional and business services, financial services, and information services. They employed between one and 15 people, averaging about 4 employees per enterprise. Considering the types of businesses and limited commercial development in rural watersheds, it's unlikely that a large amount of commercial activity impacted by flooding would shift to other businesses since most businesses in rural areas face little to no direct competition. Flooding would also affect their customers, so even if there were direct business competitors, the demand for goods and services by impacted residents would be greatly reduced during the post-flood recovery period.

For many rural retail businesses, lost sales are unlikely to be recovered. For instance, restaurant patrons will not order additional meals to compensate for missed purchases during flood-induced closures, and gas station customers cannot fill their tanks twice to make up for unpurchased fuel. These flood-related losses in transactions cannot be recovered and reflect real and lasting losses of business income and employee wages.

The comparison of income losses estimated with the survey results and the HAZUS model showed that HAZUS produced conservative estimates. On this basis, the HAZUS estimates of income losses are carried forward as national effects in the benefit-cost analysis following guidance in NREH Part 611.0403.

REDUCED ROADWAY DAMAGE

Flood events can cause significant physical damage to local roads, creating hundreds of thousands of dollars in repair costs. JEO Consulting Group estimated the physical extent of roadways impacted by flooding under flood frequencies ranging from 10 years to 500 years. According to the analysis, between 9,946 linear feet and 13,194 linear feet of roads within the watershed would be overtopped by flood waters under different flood frequencies. The impacted sections of road would need to be cleaned, flood debris would need to be removed, and roads would need to be milled, and repaved.

While flood depth is an important determinant for assessing building damage, flood damage to roads is primarily a function of velocity. As a result, there are no depth-damage functions relating flood depths to road damages. To estimate the reduction in road-related damages that would be expected under the preferred alternative, the analysis assumes 85 percent of flooded road surfaces have to be cleaned and that 10 percent of road surfaces have to be replaced following

other NRCS watershed studies.⁵ That study used civil engineers to estimate cleaning, repair, and replacement costs for arterial, collector, and local roads. To be conservative, this study uses cleaning and replacement costs for local roads to estimate damage reductions since they are the lowest cost roads to clean, repair, and replace. Assumptions and estimates used in the analysis are shown in Table 20.

Table 20: Paved Road Cleaning, Repair, and Replacement Assumptions

Road and Flood Characteristics	Value
Local road width	20 feet
Debris depth	2 feet
Debris (CY/LF)	1.48
Construction Items	Value
Debris removal	\$30/CY
Local road replacement	\$172/LF

Source: Allen Dam Preliminary Draft Supplemental
EA, Economic Appendix. 2023

Based on the information and assumptions in Table 20 and Table 21, the analysis estimates the reduced damages to roadways under the preferred alternative as shown in Table 21. As the table shows, the reduction in damages ranges from a low of about \$510,200 under the 10-year event to more than \$783,400 under the 50-year event. On an annualized basis, damages would be reduced by approximately \$60,400.

Table 21: Estimated Reduction in Road Damage Under the Preferred Alternative (2024 \$)

Metrics	Flood Return Interval				
	500-Year	100-Year	50-Year	25-Year	10-Year
Total Road Damage (Linear Feet)	13,194	12,442	15,272	12,882	9,946
Cleaning Costs (85% at \$30/LF)	\$336,447	\$317,271	\$389,436	\$328,491	\$253,623
Replacement Costs (15% at \$172/LF)	\$340,405	\$321,004	\$394,018	\$332,356	\$256,607
Total Road Damage (\$)	\$676,852	\$638,275	\$783,454	\$660,847	\$510,230

⁵ Allen Dam Preliminary Draft Supplemental EA, Economic Appendix. 2023. Available at: <https://www.nrcs.usda.gov/sites/default/files/2023-02/MA%20Allen%20Dam%20Prelim%20Draft%20Suppl%20Plan%20EA%20-%20Econ%20Appendix%20D4%202.22.2023.pdf>

ADMINISTRATIVE COST SAVINGS TO THE NATIONAL FLOOD INSURANCE PROGRAM (NFIP)

The preferred alternative reduces the size of the 100-year floodplain, which in turn lowers the number of properties required to participate in the National Flood Insurance Program (NFIP). Property owners must participate in the NFIP if their property is located in a FEMA-designated Special Flood Hazard Area (SFHA) and they have a federally-backed mortgage or loan. In these high-risk zones, flood insurance is mandatory to comply with federal regulations.

Removing homes from the 100-year floodplain results in administrative cost savings for the NFIP program. Based on NRCS technical guidance and a FEMA actuarial rate review, the administrative cost associated with each NFIP policy is estimated at approximately \$410 per year in 2024 dollars. This figure was updated from a 2015 NRCS estimate using the Bureau of Economic Analysis (BEA) Gross Domestic Product Implicit Price Deflator (Townsend, 2016; FEMA, 2011; BEA, 2020).

Data from the NFIP program indicated that there are 37 flood insurance policies in force in Kenesaw as of 2024.⁶ Based on this number, removing these homes from the floodplain would reduce annual NFIP administrative cost savings by approximately \$15,200.

WETLAND CREATION BENEFITS

Wetlands are extremely productive ecosystems, capable of producing a variety of public benefits. Previous studies of wetland values have shown that wetlands provide recreational opportunities, including fishing, bird watching, hunting, and boating. Wetlands also provide important habitat for aquatic and avian species, in addition to regulating water flows and improving water quality.

The wetlands included in the preferred alternative would be created as part of the project and would therefore have a different value than existing wetlands. Still, created wetlands can produce ecosystem service values. A 2015 study of wetlands created for mitigation compliance with Section 404 of the Clean Water Act found that mitigation wetlands create similar values to original wetlands when they are properly constructed.

The study used data from 33 independent valuation studies from across the U.S. found that wetlands created for mitigation create approximately \$9,000 to \$66,000 per acre in annual ecosystem service benefits (Table 22). The study also used the data to estimate state-specific wetland value transfer functions, which accounted for several ecosystem services. The study controlled for regional variability of wetland values by including variables characterizing the geographic locations of wetlands included in the meta-analysis. The study used the function to

⁶ <https://nfipservices.floodsmart.gov/reports-flood-insurance-data>

estimate that wetlands in Nebraska produce an average of approximately \$9,000 in ecosystem services each year.

Table 22: Average Value Per Acre for Individual Wetland Ecosystem Services Produced by Wetland Mitigation (2024 \$)

Ecosystem Service	Annual Average Benefit Per Acre	Annual Average Benefit Per Acre (Lower Bound)
Recreational Fishing	\$3,972	\$552
Bird Hunting	\$4,094	\$569
Bird Watching	\$19,384	\$2,695
Water Quality Protection	\$13,866	\$1,929
Water Supply Protection	\$10,211	\$1,420
Commercial Fishing	\$11,792	\$1,639
Flood Control	\$2,503	\$392
National Average	\$65,820	\$9,195
State of Nebraska	\$8,960	\$3,888

Source: Adusumilli, N. 2015. *Valuation of Ecosystem Services From Wetlands Mitigation in the United States*. Land, 4(1).

Note: Values from Adusumilli, N. 2015. were updated to 2024 dollars using the Bureau of Labor Statistics Inflation Calculator.

Based on geospatial analysis, the preferred alternative would create a total of approximately 56 acres of wetlands while impacting an area of about 10.3 acres of existing wetland, for a net addition of 45.7 acres of wetlands. The acres were multiplied by \$9,000 to estimate the average annual value of ecosystem services from wetlands under the preferred alternative. In total, the preferred alternative will create an annual total of \$411,300 in annual benefits. In the benefit-cost analysis the annual benefits were discounted over a 100-year period at a rate of 2.75 percent and reported as average annualized values.

COSTS

Preliminary engineering work on design, permitting, construction, and operation and maintenance requirements for the structures included as part of the preferred alternative was completed. The cost estimates were allocated to cost categories, which included:

- Land acquisitions
- Design and engineering
- Project administration
- Permitting
- Construction
- Professional services

Costs were estimated using the bottom-up approach. This method breaks projects and structures into lower-level components and then costs those components for their direct costs, including labor, materials, and professional services. In addition, installation cost estimates include cost contingencies of 15 percent for construction. Table 23, Table 24, Table 25, and Table 26 show

the estimated installation costs for all the structures included in the preferred alternative. Table 27 includes the estimated installation costs for the nonstructural alternative.

Table 23: Estimated Installation Costs of Structure DC1-10 (2024 \$)

Item #	Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION - FEDERAL SHARE					
1.	Mobilization	LS	1	\$339,000	\$339,000
2.	Bonding and Insurance	LS	1	\$113,000	\$113,000
3.	Clearing and Grubbing	LS	1	\$379,000	\$379,000
4.	Remove Tree, >24" Dia.	EA	7	\$2,500	\$17,500
5.	Earthwork Measured in Embankment (Cut)	CY	542,640	\$5	\$2,713,200
6.	Earthwork Measured in Embankment (Fill)	CY	5,650	\$8	\$45,200
7.	Rock Riprap	TONS	1,200	\$100	\$120,000
8.	Silt Fence, Low Porosity	LF	12,000	\$4	\$48,000
9.	Seeding, Fertilizer and Mulch	ACRE	76	\$5,000	\$380,000
10.	Stabilized Construction Entrance	EA	2	\$5,000	\$10,000
11.	Temporary Traffic Control Measures	LS	1	\$30,000	\$30,000
Construction Subtotal					\$4,194,900
Contingency 15%					\$629,300
Total Opinion of Construction Cost					\$4,824,200
CONSTRUCTION - LOCAL SHARE					
1.	Concrete Slab Bridge with Ancillaries	LS	3	\$202,500	\$607,500
2.	Crushed Rock Base Course	TONS	150	\$60	\$9,000
3.	Crushed Rock Surface Course	TONS	1,150	\$60	\$69,000
4.	Remove Existing Pipe	LF	295	\$50	\$14,750
5.	24" RCP, Class III	LF	200	\$250	\$50,000
6.	24" RCP Flared End Section	EA	6	\$2,500	\$15,000
Construction Subtotal					\$765,300
Contingency 15%					\$114,800
Total Opinion of Construction Cost					\$880,100
PROPERTY RIGHTS					
1.	Permanent Land	Acre	70	\$15,000	\$1,050,000
Subtotal					\$1,050,000
Legal Fees and Appraisals 15%					\$157,500
Total Opinion of Property Cost					\$1,207,500



Item #	Description	Unit	Quantity	Unit Price	Total
PROFESSIONAL SERVICES					
1.	Engineering (Including Geology)	LS	1	\$712,700	\$712,700
2.	Permitting	LS	1	\$228,200	\$228,200
3.	Construction Observation	LS	1	\$570,500	\$570,500
4.	Project Administration (Sponsor)	LS	1	\$142,700	\$142,700
5.	Project Administration (NRCS)	LS	1	\$142,700	\$142,700
Total Opinion of Professional Services Cost					\$1,796,800
SUMMARY					
CONSTRUCTION - FEDERAL SHARE					\$4,824,200
CONSTRUCTION - LOCAL SHARE					\$880,100
PROPERTY RIGHTS					\$1,207,500
PROFESSIONAL SERVICES					\$1,796,800
TOTAL OPINION OF PROJECT COST					\$8,708,600

Prepared September 2024 by JEO Consulting Group Inc. JEO's Opinions of Probable Cost provided for herein are to be made on the basis of JEO's experience and qualifications and represent JEO's best judgment. However, since JEO has no control over the cost of labor, materials, equipment, or services furnished by others, or over the Contractor's methods of determining prices, or over competitive bidding or market conditions, JEO cannot and does not guarantee that proposals, bids, or actual construction cost will not vary from Opinions of Probable Cost prepared by JEO.

Table 24: Estimated Installation Costs of Structure F8-3 (2024 \$)

Item #	Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION - FEDERAL SHARE					
1.	Mobilization	LS	1	\$214,000	\$214,000
2.	Bonding and Insurance	LS	1	\$72,000	\$72,000
3.	Clearing and Grubbing	LS	1	\$50,000	\$50,000
4.	Demolition	LS	1	\$50,000	\$50,000
5.	Remove Tree, >24" Dia.	EA	25	\$2,500	\$62,500
6.	Site Access and Restoration	LS	1	\$10,000	\$10,000
7.	Topsoil, Strip, Salvage, Respread	LS	1	\$70,000	\$70,000
8.	Dewatering & Management of Water	LS	1	\$75,000	\$75,000
9.	Removal of Principal Spillway Pipe and Riser	LS	1	\$130,000	\$130,000
10.	Earthwork Measured in Embankment (Cut)	CY	62,195	\$5	\$310,975
11.	Earthwork Measured in Embankment (Fill)	CY	10,000	\$5	\$50,000
12.	Dx3D Riser w. Appurtenances and Drawdown w. Gate Valve	LS	1	\$250,000	\$250,000
13.	48" RCPP Spillway Pipe	LF	160	\$1,500	\$240,000
14.	Riprap and Bedding - Riser	TON	200	\$100	\$20,000
15.	Riprap and Bedding - Plunge Pool	TON	700	\$100	\$70,000
16.	Riprap and Bedding - Shoreline	TON	1,500	\$100	\$150,000
17.	Fine Aggregate - Diaphragm, Foundation, Drain (Placeholder)	TON	1,000	\$90	\$90,000
18.	Pipe Support	LS	1	\$20,000	\$20,000
19.	Temporary Erosion Control	LS	1	\$50,000	\$50,000
20.	Seeding, Fertilizer and Mulch	ACRE	10	\$7,500	\$75,000
21.	Fencing	LF	10,000	\$8	\$80,000
22.	Pivot Modification/Removal	EA	2	\$70,000	\$140,000
23.	100-yr Sediment Storage Excavation	CY	171,000	\$5	\$855,000
Construction Subtotal					\$3,134,500
Contingency 15%					\$470,200
Total Opinion of Construction Cost					\$3,604,700
PROPERTY RIGHTS					
1.	Permanent Land	ACRE	25	\$15,000	\$375,000
2.	Temporary Easement	ACRE	5	\$5,000	\$25,000
Land Acquisition Subtotal					\$400,000
Legal Fees & Land Appraisals 15%					\$60,000
Total Opinion of Property Rights Cost					\$460,000



ESTIMATE OF QUANTITIES					
Item #	Description	Unit	Quantity	Unit Price	Total
PROFESSIONAL SERVICES					
1.	Engineering (Including Geology)	LS	1	\$776,800	\$776,800
2.	Permitting	LS	1	\$144,200	\$144,200
3.	Construction Observation	LS	1	\$360,500	\$360,500
4.	Project Administration (Sponsor)	LS	1	\$90,200	\$90,200
5.	Project Administration (NRCS)	LS	1	\$90,200	\$90,200
Total Opinion of Professional Services Cost					\$1,461,900
SUMMARY					
CONSTRUCTION - FEDERAL SHARE					\$3,604,700
CONSTRUCTION - LOCAL SHARE					\$0
PROPERTY RIGHTS					\$460,000
PROFESSIONAL SERVICES					\$1,461,900
TOTAL OPINION OF PROJECT COST					\$5,526,600

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Table 25: Estimated Installation Costs of Structure L1-1 (2024 \$)

Item #	Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION - FEDERAL SHARE					
1.	Mobilization	LS	1	\$159,000	\$159,000
2.	Bonding and Insurance	LS	1	\$53,000	\$53,000
3.	Clearing and Grubbing	LS	1	\$187,000	\$187,000
4.	Earthwork Measured in Embankment (Fill)	CY	73,500	\$12	\$882,000
5.	Silt Fence, Low Porosity	LF	20,220	\$4	\$80,880
6.	Seeding, Fertilizer and Mulch	ACRE	38	\$5,000	\$190,000
7.	Stabilized Construction Entrance	EA	4	\$5,000	\$20,000
8.	Crushed Rock Surface Course	TONS	3,300	\$60	\$198,000
9.	Remove 21" CMP and Ancillary Items	LS	1	\$10,000	\$10,000
10.	24" RCP Class III	LF	20	\$250	\$5,000
11.	24" RCP Flared End Section	LS	1	\$2,500	\$2,500
12.	24" Concrete Headwall and Mounted Slide Gate	LS	1	\$12,500	\$12,500
13.	Toe Drain Pipe	LF	1,000	\$200	\$200,000
14.	Temporary Traffic Control Measures	LS	1	\$20,000	\$20,000
Construction Subtotal					\$2,019,900
Contingency 15%					\$303,000
Total Opinion of Construction Cost					\$2,322,900
CONSTRUCTION - LOCAL SHARE					
1.	Crushed Rock Surface Course	TONS	380	\$60	\$22,800
2.	Remove Existing Pipe	LF	329	\$50	\$16,450
3.	60" RCP, Class III	LF	335	\$325	\$108,875
4.	60" RCP Flared End Section	EA	6	\$3,750	\$22,500
5.	Rock Riprap	TONS	640	\$100	\$64,000
6.	Crushed Rock Base Course	TONS	80	\$60	\$4,800
7.	Remove Asphalt	SY	1,200	\$30	\$36,000
8.	Asphalt Concrete	TONS	500	\$60	\$30,000
Construction Subtotal					\$305,500
Contingency 20%					\$45,900
Total Opinion of Construction Cost					\$351,400



Item #	Description	Unit	Quantity	Unit Price	Total
PROPERTY RIGHTS					
1.	Permanent Land	ACRE	41	\$15,000	\$615,000
Land Acquisition Subtotal					\$615,000
Legal Fees & Land Appraisals				15%	\$92,250
Total Opinion of Property Rights Cost					\$707,250
PROFESSIONAL SERVICES					
1.	Engineering (Including Geology)	LS	1	\$427,900	\$427,900
2.	Permitting	LS	1	\$107,000	\$107,000
3.	Construction Observation	LS	1	\$267,500	\$267,500
4.	Project Administration (Sponsor)	LS	1	\$66,900	\$66,900
5.	Project Administration (NRCS)	LS	1	\$66,900	\$66,900
Total Opinion of Professional Services Cost					\$936,200
SUMMARY					
CONSTRUCTION - FEDERAL SHARE					\$2,322,900
CONSTRUCTION - LOCAL SHARE					\$351,400
PROPERTY RIGHTS					\$707,250
PROFESSIONAL SERVICES					\$936,200
TOTAL OPINION OF PROJECT COST					\$4,317,750

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Table 26: Estimated Installation Costs of Structure G2-2 (2024 \$)

Item #	Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION - FEDERAL SHARE					
1.	Mobilization	LS	1	\$85,000	\$85,000
2.	Bonding and Insurance	LS	1	\$29,000	\$29,000
3.	Clearing and Grubbing	LS	1	\$14,000	\$14,000
4.	Rock Riprap, NDOT Type C	TONS	10,670	\$100	\$1,067,000
5.	Silt Fence, Low Porosity	LF	1,200	\$4	\$4,800
6.	Seeding, Fertilizer and Mulch	ACRE	2.8	\$10,000	\$28,000
7.	Stabilized Construction Entrance	EA	3	\$5,000	\$15,000
Construction Subtotal					\$1,242,800
Contingency 15%					\$186,500
Total Opinion of Construction Cost					\$1,429,300
PROPERTY RIGHTS					
1.	Permanent Land	ACRE	2.75	\$15,000	\$41,322
Land Acquisition Subtotal					\$41,323
Legal Fees & Land Appraisals 30%					\$12,397
Total Opinion of Property Rights Cost					\$53,720
PROFESSIONAL SERVICES					
1.	Engineering (Including Geology)	LS	1	\$228,700	\$228,700
2.	Permitting	LS	1	\$57,200	\$57,200
3.	Construction Observation	LS	1	\$143,000	\$143,000
4.	Project Administration (Sponsor)	LS	1	\$35,800	\$35,800
5.	Project Administration (NRCS)	LS	1	\$35,800	\$35,800
Total Opinion of Professional Services Cost					\$500,500
SUMMARY					
CONSTRUCTION - FEDERAL SHARE					\$1,429,300
CONSTRUCTION - LOCAL SHARE					\$0
PROPERTY RIGHTS					\$53,720
PROFESSIONAL SERVICES					\$500,500
TOTAL OPINION OF PROJECT COST					\$1,983,520

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Table 27: Estimated Installation Costs of the Nonstructural Alternative (2024 \$)

Item #	Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION - FEDERAL SHARE					
1.	Mobilization	LS	1	\$512,000	\$512,000
2.	All Properties, Elevation	SF	281,965	\$60	\$16,917,900
3.	Utility Disconnection, Extension, and Reconnection	EA	191	\$20,000	\$3,820,000
4.	All Properties, Sewer Backflow Prevention	EA	191	\$3,600	\$687,600
5.	Temporary Housing / Resident Relocation	EA	50	\$8,000	\$400,000
6.	All Properties, Ancillary Items (Including Replacement of Comparable Facilities or Features)	EA	191	\$10,000	\$1,910,000
Construction Subtotal					\$24,247,500
Contingency 30%					\$7,274,300
Total Opinion of Construction Cost					\$31,521,800
PROFESSIONAL SERVICES					
1.	Engineering (Including Geology)	LS	1	\$5,043,500	\$5,043,500
2.	Permitting	LS	1	\$1,260,900	\$1,260,900
3.	Construction Observation	LS	1	\$3,152,200	\$3,152,200
4.	Project Administration (Sponsor)	LS	1	\$788,100	\$788,100
5.	Project Administration (NRCS)	LS	1	\$788,100	\$788,100
Total Opinion of Professional Services Cost					\$11,032,800
SUMMARY					
CONSTRUCTION - FEDERAL SHARE					\$31,521,800
CONSTRUCTION - LOCAL SHARE					\$0
PROPERTY RIGHTS					\$0
PROFESSIONAL SERVICES					\$11,032,800
TOTAL OPINION OF PROJECT COST					\$42,554,600

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OTHER DIRECT COSTS AND ADVERSE EFFECTS

According to the P&G:

Other direct costs and adverse effects include uncompensated losses caused by the installation, operation, maintenance, and replacement of a project or group of projects. These other direct costs and adverse impacts can include costs caused by downstream flood damages caused by channel modifications, levies, dikes, and other structures, erosion of land along streambanks created by dams that prevent sediment export downstream, and through lost use value of the land where flood mitigation structures are cited (NRCS, 2014).

The preferred alternative has one category of other direct costs. The nature of and methods used to calculate these other direct costs are discussed in more detail below.

Operations and Maintenance

Once the structures are built, overheads for operations and maintenance will be required for the structures to continue generating benefits. Operations and maintenance costs for the structural alternative were estimated by JEO using a bottom-up approach and are shown in Table 28, below. Operations and maintenance costs for the nonstructural alternative were estimated based on 0.75% of the sub-total construction costs.

Table 28: Estimated Annual Operations and Maintenance Costs of Structures in the Preferred Alternative (2024 \$)

Alternative	Annual O&M Costs
Structural Alternative	
DC1-10	\$37,202
F8-3	\$23,509
L1-1	\$17,441
G2-2	\$9,321
Total Annual O&M Costs	\$87,473
Nonstructural Alternative	
Total Annual O&M Costs	\$181,856

Source: JEO Consulting Group Inc.

LAGS OF BENEFITS AND COSTS

The benefits and costs of the preferred alternative occur at different points in time. The installation of improvements is anticipated to occur over a five-year period. After installation, the benefits of improvements are anticipated to accrue over the following 100 years. The sum of the discounted stream of operations and maintenance (O&M) costs and benefits equal their present value. The

present value of each stream was divided by the present value of an annuity of one over a 100-year period under a 3.25 percent discount rate.

Operations and maintenance (O&M) costs were assumed to begin following the five-year installation period. The annual value of O&M costs was discounted at a rate of 2.75 percent, projected over a 100-year period and summed. The sum of the discounted stream of O&M costs were divided by the present value of annuity based on the 100-year period and a discount rate of 2.75 percent. Building-related damage reductions were assumed to begin after the five-year installation period to be as conservative as possible.

D 6.05 CURRENT ECONOMIC DAMAGES

Average annualized flood damages under the FWOFI were estimated to serve as a benchmark of comparison with the preferred alternative and are shown in Table 29, (NWPM 501.36). In total, average annualized national flood losses under the FWOFI are approximately \$715,500 per year, including \$376,500 of building-related losses, \$263,400 of business income and wage losses, \$15,200 of flood insurance administrative costs, and \$60,400 of road damages.

Table 29: Average Annualized Flood Damages Under Existing Conditions (2024 \$)

Alternative	Building -related Losses	Business Income and Wage Losses	Flood Insurance Administration Costs	Road Damage	Average Annual National Damages
FWOFI	\$376,500	\$263,400	\$15,200	\$60,400	\$715,500

Notes: All damages are agriculture related. Totals may not sum due to rounding. Building losses includes losses to structures as well as structure contents and business inventories. Prepared: December 2024. Price base: 2024 dollars amortized over 100 years at a discount rate of 2.75 percent.

D 6.06 ECONOMIC TABLES

The results of the BCA for the preferred alternative are compared against the damages under the FWOFI and serve as the best estimate of the additional economic value that would be created under the preferred alternative. Results are presented using the Economic Tables (NWPM Part 506, NRCS 2014b), which are located in Chapter 7 of the Plan-EA.

D 6.07 ECONOMIC REFERENCES

- Allen Dam Preliminary Draft Supplemental EA, Economic Appendix. 2023
- Adusumilli, N. 2015. Valuation of Ecosystem Services From Wetlands Mitigation in the United States. *Land*, 4(1).
- Bureau of Economic Analysis (BEA). Implicit Price Deflators for Gross Domestic Product. Accessed December 2024. Available at: <https://apps.bea.gov/>
- Council on Environmental Quality. 2014. DM 9500-13: Principles, Requirements, and Guidelines for Federal Investments in Water Resources. Available at: https://obamawhitehouse.archives.gov/sites/default/files/docs/prg_interagency_guidelines_12_2014.pdf
- Ding, A., White, J. F., Ullman, P. W., & Fashokun, A. O. 2008. Evaluation of HAZUS-MH Flood Model with Local Data and Other Program. *Nat. Hazards Rev.*, 10.1061/(ASCE)1527-6988(2008)9:1(20), 1527-6996.
- Federal Emergency Management Agency, National Flood Insurance Program. 2011. Actuarial Rate Review. Available at: https://www.fema.gov/media-library-data/20130726-1809-25045-6893/actuarial_rate_review2011.pdf
- Federal Emergency Management Agency. 2022. HAZUS 5.1 Release Notes. Available at: https://www.fema.gov/sites/default/files/documents/fema_hazus-5.1-release-notes.pdf
- Federal Emergency Management Agency. 2022. HAZUS Flood Technical Manual. HAZUS v.5.1. Available at: <https://www.fema.gov/flood-maps/tools-resources/flood-map-products/hazus/user-technical-manuals>
- Federal Emergency Management Agency, National Flood Insurance Program. 2024. Flood Insurance Data and Analytics. Available at: <https://nfipservices.floodsmart.gov/reports-flood-insurance-data>
- Olander, R.J. Johnson, H. Tallis, J. Kagan, L. Maguire, S. Polasky, D. Urban, J. Boyd, L. Wainger, and M. Palmer. 2016. Best Practices for Integrating Ecosystem Services into Federal Decision Making. Durham: National Ecosystem Services Partnership, Duke University.
- SwiftEstimator. 2020. Swift Estimator User Guide. Retrieved from <https://www.swiftestimator.com/UserGuide>.
- Townsley, George. Agricultural Economist, NRCS National Water Management Center. 2017. Watershed Rehabilitation Planning Series Webinar 8 – Economics Issues and Procedures in Watershed Rehabilitation Economic Analysis.
- USACE. 2023. Economic Guidance Memorandum 24-01, Federal Interest Rates for Corps of Engineers Projects for FY2024. Available at: <https://www.hec.usace.army.mil/confluence/fdadocs/fdatutorials/files/173934355/183108488/1/1708625852532/EGM24-01-2.pdf>
- U.S. Census Bureau. "Selected Housing Characteristics." American Community Survey, ACS 5-Year Estimates Data Profiles, Table DP04, 2022, Year Structure Built. Accessed on November 2024
- U.S. Department of Agriculture Natural Resource Conservation Service. 1998. Part 611 National Resource Economics Handbook for Economics. Available at: <https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=28583.wba>
- U.S. Department of Agriculture Natural Resource Conservation Service. 2014. Title 390 - National Watershed Program Manual.

D 7. CULTURAL RESOURCES

D 7.01 SITE INVESTIGATION

The presence of historic properties and cultural resources within the Area of Potential Effect (APE) at each project site was investigated by professional archeologists and an architectural historian who meet the Secretary of Interior's Standards for Archeology and Historic Preservation. Field investigations were completed by a qualified archeological consultant between late June and early November 2024.

The full cultural resources inventory report is available by request. A redacted version is provided in Appendix E. Archaeological site and historic building location information has been removed from the report per Section 304 of the National Historic Preservation Act and Nebraska Revised Statute 84-712.05 ([14] and [15]).

D 7.02 POST-REVIEW DISCOVERY PROCEDURES

Once NHPA Section 106 consultation is complete for this project, there is still potential for ground disturbance to expose cultural materials that were not identified by the cultural resources inventory. If any evidence of cultural resources is encountered during construction, all activities will be halted immediately and NRCS will proceed in accordance with the regulation on post-review discoveries (36 CFR § 800.13) by following the procedures outlined in the NRCS Cultural Resources Handbook. Those procedures are described below.

Where construction has not yet begun and a cultural resource is discovered after Section 106 review is complete, the NRCS shall seek avoidance or minimization strategies and/or resolution of adverse effects in accordance with 36 CFR Part 800.6 in consultation with the SHPO and consulting Tribes.

The NRCS shall ensure that every contract for this project includes provisions for halting work/construction in the area when potential historic properties are discovered or when unanticipated effects to historic properties are found after implementation, installation, or construction has begun. When such a discovery occurs, the Sponsoring Local Organization (SLO) or their contractor shall immediately notify the NRCS State Conservationist's Office, Cultural Resource Specialist (CRS), supervisory NRCS personnel for the area, and the landowner.

The NRCS CRS shall inspect the discovery within 24 hours if weather permits. The CRS shall establish a protective buffer zone surrounding the discovery in consultation with the local NRCS official (field office supervisor or District or Area Conservationist), concerned Indian tribes, the SHPO, the NRCS State engineering or program supervisor, as appropriate), and SLO. This action may require inspection by Tribal cultural resources experts in addition to the CRS.

All NRCS contact with media shall occur only under the direction of the NRCS Public Affairs Officer, as appropriate, and the State Conservationist. Security shall be established to protect the resources/historic properties, workers, and private property. Local law enforcement authorities will be notified in accordance with applicable State law and NRCS policy in order to protect the resources. Construction and/or work may resume outside the buffer only when the State Conservationist determines it is appropriate and safe for the resources and workers.

The NRCS CRS shall notify the SHPO, concerned Indian Tribes, and the Advisory Council on Historic Preservation no later than 48 hours after the discovery. The NRCS CRS will describe NRCS's assessment of the National Register eligibility of the property, as feasible, and the proposed actions to resolve any adverse effects to historic properties. The eligibility determination may require the assessment and advice of concerned Indian Tribes, the SHPO, and technical experts (such as historic landscape architects) not employed by NRCS. NRCS shall take any comments provided into account and carry out appropriate actions to resolve any adverse effects. NRCS shall provide a report to the SHPO, Tribes, and the ACHP of the actions when they are completed.

HUMAN REMAINS

When human remains are discovered, the NRCS shall follow all applicable federal, tribal, and state burial laws and ordinances, and related human rights and health statutes, where appropriate. NRCS shall refer to the ACHP's Policy Statement regarding Treatment of Burial Sites, Human Remains and Funerary Objects and the ACHP's Section 106 Archaeology Guidance. NRCS shall also follow USDA and NRCS policy on treatment of human remains and consultation.

All the measures proposed in this Watershed Plan will be installed on non-federal, non-Tribal land. Therefore, any human remains discovered during construction will be subject to protection under the Unmarked Human Burial Sites and Skeletal Remains Protection Act (Nebraska Revised Statutes 12-1201 to 12-1212). Per Nebraska Revised Statute 12-1205, all ground disturbing activities in the area shall stop immediately. The remains shall be covered and/or protected in place in such a manner that minimizes further exposure of and damage to the remains. SLO or it's contractor shall contact local law enforcement within 48 hours of the discovery. Per Nebraska Revised Statute 12-1207 and 12-1208, disposition of the human remains shall be the responsibility of the county attorney and/or History Nebraska. Construction may resume once all human remains and/or burial goods have been removed from the project area, and the State Conservationist determines it is appropriate and safe for the resources and workers.