

Supplemental Watershed Plan No. 5 and Environmental Assessment for the Rehabilitation of Floodwater Retarding Structure No. 21-A Cottonwood Creek Watershed

Saunders County, Nebraska

Appendix D: Investigation and Analysis



In Cooperation With:



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D1 Introduction

This appendix provides supporting documentation for the Cottonwood 21-A Supplemental Plan- EA and provides further details and clarification on the procedures and data used in formulating the rehabilitation plan. The design and evaluation of alternatives were guided by established design criteria for earthen embankment dams, ensuring compliance with both NRCS and NeDNR standards. Each alternative was assessed for its effectiveness and efficiency in achieving project goals while adhering to accepted practices.

D2 Hydrology and Hydraulics

D2.1 BACKGROUND

In November 2019, the Nebraska Department of Natural Resources – Dam Safety Division prepared a memorandum outlining findings on the current condition and deficiencies in the hydraulic capacity of the structure. The report indicated that the structure could only pass 37% of the probable maximum flood (PMF) without overtopping the dam's left abutment. Additionally, the physical features of the structure were compared to the original construction plans to assess accuracy and their direct impact on the reduction of hydraulic capacity.

The deficiencies highlighted in the NeDNR Dam Safety periodic inspection reports reveal that the dam is in poor condition as of the 2019 inspection and following NeDNR hydraulic memorandum. These issues could potentially lead to catastrophic failure, necessitating rehabilitation efforts to ensure the dam functions and operates as intended. Hydrologic and hydraulic investigations included an analysis of the upstream rainfall runoff relationships within the watershed, calibrated against previous models and reports.

D2.2 DATA COLLECTION

Various documents and datasets were collected to support the hydrologic and hydraulic modeling and alternative development. A data collection summary is provided in Table D2.1. TFG is The Flatwater Group, Inc. and JEO is JEO Consulting Group.

Table D2.1: Data Collection Summary

Category	Data	Source	Notes
Reports and Studies	Flood Insurance Study – Saunders County, Nebraska	FEMA 2016	Brief mention of Malmo
	Flood Insurance Rate Map - 310200	FEMA 2010	Effective map outlining Special Flood Hazard Area
	Watershed Work Plan for Cottonwood Creek Watershed, January 1965	SCS 1965	1965 Plan has 12 Flood Retarding Structures (FRS)
	NRCS - Dam Assessment Report, September 2022	Prepared by JEO 2022	Assessment confirmed High Hazard Potential classification, Prepared Breach Analysis, and downstream impact

Category	Data	Source	Notes
	Peak Breach Discharge Report	NeDNR 2011	Breach volume calculation to support hydraulic study by NeDNR
Design and As-Built Plans	Cottonwood 21-A As-Built Plans, July 1983	NeDNR 1983	As-builts and design plans (dates vary).
	NeDNR Dam Inspection Reports	NeDNR 2023	Used to support hydrologic modeling of FRS spillways.
	Mainelli Wagner Survey	NeDNR 2020	Dam Centerline and Auxiliary Spillway Crest were surveyed.
Field Reconnaissance	NRCS Geology Report	NRCS 1972	Geologic investigation summary, field data and logs.
	Hydraulic Structure Data – Cottonwood 21-A	TFG 2023	Basic dimensions were obtained from Plans and confirmed, Field Survey of structure – Dam profile, AS profile, PS Key Elevations.
	Hydraulic Structure Data	TFG 2023	Bathymetric survey data was collected of existing pool area.
	Hydraulic Structure Data – DS of Cottonwood 21-A in Breach Zone	TFG 2023	Survey data was collected for hydraulic opening size and elevations for modeling efforts.
Hydrology and Hydraulics	Hydrologic & Hydraulic Analysis of Cottonwood 21-A	NeDNR 2019	Memorandum of H&H review of the structure to determine adequacy in meeting criteria.
	NOAA Atlas 14 Precipitation Data	NOAA 2023	Used for meteorologic inputs.
	NRCS Web Soil Survey Data	NRCS 2023	Used to develop loss parameters.
	NeDNR Dam Inventory Application	NeDNR 2023	Dam location and data.
	NebraskaMAP Bridge Dataset	NDOT 2023	Available hydraulic structure data for structures with >20 ft span for Saunders County
	Hec-RAS 2D Breach Model	NRD 2023	Dam Assessment Breach Model.
Reference Data and Terrain	Aerial Imagery - Historical	gWorks 2023	For Saunders County
	2020 1-meter LiDAR Data	USGS 2020	For Site Stage Storage and existing conditions terrain data.
	2023 Parcel Data	gWorks 2023	Parcel Boundaries and Valuation Data

Source: Author Date

Notes: Use 'Source/Note' for table sources and notes.

D2.3 WATERSHED CHARACTERISTICS AND MODELING APPROACH

This section describes the characteristics of the Cottonwood Creek 21-A watershed and the hydrologic and hydraulic modeling approach developed based on the watershed characteristics and resultant flow patterns.

D2.3.1 Watershed Characteristics

To develop accurate hydrologic models for the project area, understanding the soil types is essential to compute the runoff parameters for populating the NRCS Water Resources Site Analysis Computer Program (SITES) model. This ensures accurate representation of routing conditions for the structure and supports additional breach analysis and computations. The hydraulic and hydrologic data from the original design plans were referenced and verified during the 2022 NRCS Dam Assessment. This information will be utilized in developing models throughout the alternatives analysis.

The Hydrologic Soil Group report generated by the United States Department of Agriculture (USDA) NRCS Web Soil Survey indicates approximately 95 percent of the entire watershed has a Group C rating. These soils have a slow infiltration rate when thoroughly wet. These consist primarily of soils having a layer that impedes the downward movement of water or soils of moderately fine or fine texture and have a slow rate of water transmission.

The watershed's current land use is centered around row crop production with some small areas of pasture, upstream impoundments, home-sites, and tree groves. Row crop production is generally contoured and terraced due to the rolling hills and steeper slopes. The Group C rating and current land use or cover type provides clarification on the appropriate Soil Conservation Service (SCS) runoff curve number as defined by NRCS Technical Release 55 (TR-55), which is used when populating the SITES model hydrologic information.

D2.3.2 Modeling Approach

The existing conditions SITES model has been developed to reflect the upstream watershed conditions. In addition, the existing conditions model was calibrated to accurately reflect the findings shown in the NRCS Dam Assessment report, address any deficiencies, and update information obtained as part of the field reconnaissance and data collection.

The base model was modified to represent potential improvements planned and developed through the alternatives analysis. Alternatives being developed will be focused on meeting current NRCS and NeDNR safety and performance standards.

The NRCS 2022 Dam Assessment reviewed the 100-year principal spillway hydrograph that will serve as the basis of analysis for downstream flood protection within the Special Flood Hazard Area (SFHA). To fully evaluate the flood protection provided by the structure, a SITES model was developed to identify the resulting 100-year water surface elevation with updated stage storage information. The peak runoff inflows and peak discharges were evaluated for the decommissioning and non-structural alternatives to fully understand the downstream impact and flood protection the structure provides.

D2.4 EXISTING CONDITIONS

D2.4.1 Hydrologic Modeling

Watershed Delineation

The watershed boundary was delineated using available topographic LiDAR data in conjunction with the Environmental Protection Agency (EPA) WATERS data catchment area and hydrologic unit information. This exercise confirmed the accuracy of the original hydrologic design data.

Loss Method

The SCS Rainfall-Runoff Method was used as the loss method for the watershed. TR-55 provides appropriate curve numbers based on cover type, treatment practice, and hydrologic condition. This information also confirmed the original hydrologic design data.

Meteorologic Model

The probable maximum precipitation (PMP) rainfall depth is obtained from the December 2008 NeDNR study completed statewide for the State of Nebraska. The values for the 6, 12, and 24-hour PMP values are provided by this report and used in development of the 5-point 24-hour NRCS Dimensionless Rainfall Distribution.

NOAA Atlas 14 outlines the average recurrence interval events and associated point precipitation depths used in development of meteorological data and rainfall data.

Control Specifications

The principal spillway hydrograph design storm for a high hazard potential dam, as outlined in TR-60: Figure 2-1 (TR 210-60, March 2019), specifies that the maximum frequency use of the auxiliary spillway is not greater than the 100-year 24-hour storm event.

The stability design and freeboard hydrograph design storms are a function of the 100-year storm and the PMP as defined by the NRCS TR-60 equations.

D2.4.2 Hydraulic Modeling

The USACE Hydrologic Engineering Center's River Analysis System software, HEC-RAS, was used to perform hydraulic modeling. The 2D hydraulic model was initially developed as part of the NRCS Dam Assessment phase in 2022. This model was obtained from NRCS to best utilize available data and evaluate the downstream breach impacts of the selected alternative.

Boundary Conditions

Three types of boundary conditions were applied to the model; these include flow hydrographs, precipitation (in this case, rainfall excess), and normal depth. These three types of boundary conditions are discussed further in the following paragraphs.

D2.4.3 Sediment Accumulation

The original design plans detailed the estimated sediment accumulation that affects the overall volume storage and hydraulic capacity of the structure. Design plans from 1983 included as-built contours that were digitized to develop an original conditions surface that accurately represented the original lake

bottom elevations. Contours and elevations were adjusted to account for the conversion from NGVD27 vertical datum to the current NAVD88 elevations and develop accurate comparison data.

A bathymetric survey was completed as part of this study in 2023 to accurately measure the current sediment accumulation. Survey control and bathymetric survey data were compiled to develop a current conditions surface that reflects elevations below the water and represents the current bottom of lake surface. Typical sedimentation calculations assume that approximately 90% of sediment runoff ultimately reaches the lake and becomes submerged, while the remaining 10% of sediment is deposited in the upstream reaches of the lake. This assumption is used for all calculations and comparisons for accumulated sediment.

Stage storage tables were developed for the original conditions and current conditions to understand key controls and elevations to references and comparisons. Civil3D volumetric surface analysis tools were used to compare the original surface data to the current conditions surface data. The permanent water surface elevation is considered to be 1286.54 at the orifice crest in the outlet structure. The volumetric comparison between original storage and the current storage shows that 35.61 acre-feet of submerged sediment has accumulated since construction was completed. Over the last 40 years, calculations indicate that approximately 0.89 acre-feet of submerged sediment accumulates each year. The watershed experiences a respective 0.44 acre-feet/year of sediment for each square mile of contributing drainage area.

The design phase of the project will incorporate the required storage for expected future sedimentation to meet the design requirements for the life of the structure.

D3 Geotechnical Considerations

The geological and geotechnical review for this dam rehabilitation project began with a comprehensive evaluation of legacy documentation, including original geology investigations, soil boring logs, geological profiles, and historical design reports. This review was essential to understanding the original design intent, identifying any limitations or unique considerations that influenced the initial construction, and informing the current planning and design process.

A key focus of the review was the subsurface static water level and its potential influence on both historical construction activities and current site conditions. This factor was carefully considered in the development of a drilling plan that would enhance the understanding of subsurface conditions while maintaining the operational safety and integrity of the dam. The plan prioritized targeted drilling and sampling in areas where subsurface water pressures could pose a risk, particularly avoiding conditions that might inadvertently create artesian pressures.

The original geological profile was instrumental in evaluating the location, depth, and extent of the existing cut-off wall or core trench in relation to subsurface stratigraphy. This helped refine the understanding of seepage control measures and informed the design of potential rehabilitation alternatives.

Exploratory drilling and soil sampling were planned to support the alternatives analysis, with a focus on material characteristics, laboratory test results, and overall suitability for embankment and auxiliary spillway construction. A collaborative drilling plan was developed with input from geologists, geotechnical engineers, and dam design engineers to ensure that the investigation would yield meaningful data for both planning and preliminary design. Seven new boring and sampling locations were selected within the proposed auxiliary spillway footprints to supplement the original ten test holes aligned along the dam centerline. These original borings provided a solid baseline of subsurface conditions, but additional data was needed to evaluate the high hazard alternative spillway configurations.

During the review of historical boring logs, potential pressurized zones were identified, particularly in the west abutment, where subsurface lenses may have contributed to elevated water levels and potential seepage conditions. Due to concerns about artesian conditions and the adequacy of existing data, no new borings were conducted along the dam embankment centerline. The alternatives under consideration were consistent in scope and did not vary significantly, allowing for detailed geological testing to be deferred to the design phase, where consolidation, settlement, and slope stability analyses will be performed. The original geology report with the geological profile and boring logs, in addition to the proposed drilling plan and memorandum can be found in Appendix E.

Following the completion of drilling and sampling, laboratory testing was conducted by the Lincoln Soil Mechanics Laboratory. Tests included dispersion potential, optimum compaction and Proctor characteristics, shear strength, and head cut erodibility index evaluations. These results supported the alternatives analysis and informed the integrity assessment of the preferred rehabilitation alternative. The full report and auxiliary spillway summary for Cottonwood 21-A can be found in Appendix E.

The current rehabilitation plan includes two primary alternatives: widening the existing auxiliary spillway to 175 feet or constructing a new 200-foot-wide spillway on the east side of the dam. A geologic investigation was conducted to evaluate site conditions for both options, with soil samples obtained and tested to support the SITES analysis. This analysis was completed as part of the hydraulics assessment and routing using the SITES software, which ensures spillway stability under extreme hydrological events, preventing structural failure and potential downstream consequences. Specific geological information is input into the model to evaluate the head cutting potential and risk of breach in the spillway level section.

Further geological investigations will be necessary during the design phase in an effort to fully review the anticipated geological and geotechnical performance of the structure. These will include detailed soil property evaluations and spillway profile development.

D4 Alternative Screening & Analyses

This section documents the alternatives considered and screening results that determined the alternatives that advanced for quantitative evaluation.

D4.1 ALTERNATIVE DESCRIPTIONS

The intent of each alternative is to take into consideration the impacts on the surrounding environment, incorporate stakeholder's goals, and most importantly meet parameters defined by NeDNR Dam Safety for the respective hazard classification.

D4.1.1 Alternative 1- No Action/Future Without Federal Investment (FWOFI)

This alternative assumes an uncontrolled breach of the structure. Most likely cause of breach would be due to dam overtopping because of inadequate auxiliary spillway capacity. This alternative assumes that no post-breach restoration/reclamation of the dam structure would occur.

D4.1.2 Alternative 2- LPNNRD Financed Alternative

This alternative is most likely course of action if there was no federal assistance and the LPNNRD receives an order from NeDNR dam safety to resolve non-conformance. LPNNRD would be required to maintain dam to NeDNR design standards. The NRCS would relinquish their federal interest in the dam and the structure would no longer be within the PL 566 program. Therefore, NRCS design criteria would not apply.

This alternative would include extension of dam embankment on east end of downstream side to protect embankment toe and contain flows in the auxiliary spillway outlet channel. County road profile would not change.

D4.1.3 Alternative 3- Dam Decommissioning

This alternative would include dam removal and modification to the county road to perform as a grade control structure.

This alternative includes site reclamation back to pre-project (no dam) conditions and installation of an adequately sized county road culvert to meet NRCS design standards. The NRCS would also maintain an easement for downstream culvert outlet riprap protection. This alternative would have no flood control benefits.

D4.1.4 Alternative 4- Structural Rehabilitation – to High Hazard –New East Auxiliary Spillway with Road Raise

This alternative would maintain High Hazard classification and meet current criteria. The dam must effectively contain and route the PMF safely through the auxiliary spillway. The road would be partially filled and a new auxiliary spillway would be excavated in the abutment to the east. A berm and diversion channel will be constructed to protect an existing cemetery in the event of a PMF that activates the new auxiliary spillway and flows through an existing ephemeral stream channel.

D4.1.5 Alternative 5- Structural Rehabilitation – to High Hazard – Widen Existing Auxiliary Spillway with Road Raise

This alternative would maintain High Hazard classification and meet current criteria. The dam must effectively contain and route the PMF safely through the auxiliary spillway. The existing auxiliary spillway would be modified and the county road would be improved.

D4.1.6 Alternative 6 – Non-Structural Rehabilitation to Significant Hazard Potential

This alternative would rehabilitate the floodwater structure to Significant Hazard status. To meet these criteria, downstream impacts and potential loss of life must be removed and modifications must be made to embankment to fully contain the FBH. This alternative would also include the buyout of three homes downstream in the breach zone. In addition, downstream easements or zoning would be required within the breach inundation area.

D4.1.7 Alternative 7 – Structural Rehabilitation to Low Hazard

This alternative would rehabilitate the floodwater structure to Low Hazard status. It could be mentioned that this alternative would involve the need for downstream easements or zoning within the dam breach areas. In addition, downstream easements or zoning would be required within the breach inundation area.

D4.2 ALTERNATIVE ANALYSES

Each alternative was evaluated against meeting the purpose and need, reasonableness under NEPA, practicability under the 404(b)(1) Guidelines, and the PR&Gs. Table D4.1 presents the results of screening of the range of alternatives and identifies the alternatives that advanced for detailed evaluation in the Watershed Plan-EA.

Table D4.1: Range of Alternatives Considered

Alternatives	Alternative Description	Purpose and Need	Reasonableness (NEPA)	Practicability (Cost, Logistics, Technology – 404(b)(1) Guidelines)	PR&G (Completeness, Effectiveness, Efficiency, Acceptability)	Disposition of Options (Consideration for More Detail Study or Elimination)
Alternative 1 - No Action/FWOFI	This alternative assumes an uncontrolled breach of the structure. Most likely cause of breach would be due to dam overtopping because of inadequate auxiliary spillway capacity. This alternative assumes that no post-breach restoration/reclamation of the dam structure would occur.	No	No. This alternative does not bring the dam into compliance with current NRCS and NeDNR dam performance, design, and safety standards.	No. This alternative does not bring the dam into compliance with current NRCS and NeDNR dam performance, design, and safety standards.	No. This alternative does not bring the dam into compliance with current NRCS and NeDNR dam performance, design, and safety standards.	Although the alternative does not meet Purpose and Need, it will be carried forward for further study.
Alternative 2 - LPNNRD Financed Alternative	This alternative is most likely course of action if there was no federal assistance and the LPNNRD receives an order from NeDNR dam safety to resolve non-conformance. SLO would be required to maintain dam to NeDNR design standards. The NRCS would relinquish their federal interest in the dam and the structure would no longer be within the PL 566 program. Therefore,	No. Passing the PMP is part of the overall flood risk management of the structure. The potential for an uncontrolled breach is inconsistent with the purpose of maintaining downstream flood damage reduction benefits.	Yes, other than the project not meeting purpose and need.	Yes, other than the project not meeting purpose and need.	No, this is not acceptable because it does not meet the federal objective relative to avoiding unwise use of floodplains and flood-prone areas.	This alternative will not be carried forward for detailed analysis as it does not satisfy the project purpose and need nor is it acceptable as it does not meet the federal objective in avoiding unwise use of floodplains and flood-prone areas.

Alternatives	Alternative Description	Purpose and Need	Reasonableness (NEPA)	Practicability (Cost, Logistics, Technology – 404(b)(1) Guidelines)	PR&G (Completeness, Effectiveness, Efficiency, Acceptability)	Disposition of Options (Consideration for More Detail Study or Elimination)
	NRCS design criteria would not apply. This alternative would include extension of dam embankment on east end of downstream side to protect embankment toe and contain flows in the auxiliary spillway outlet channel. County road profile would not change.					
Alternative 3 - Dam Decommissioning	This alternative would include dam removal and modification to the county road to perform as a grade control structure. This alternative includes site reclamation back to pre-project (no dam) conditions and installation of an adequately sized county road culvert to meet NRCS design standards. The NRCS would also maintain an easement for downstream culvert outlet riprap protection. This alternative would	Yes	Alternative would create the need to re-map the FEMA 100-year floodplain and would likely result in four (4) residences within the 100-year floodplain. Dam decommissioning is not a reasonable alternative due to the potential social and	Decommissioning would reduce pond fringe wetlands, wetland habitat, water quality benefits, and increase negative impacts to downstream crop production, public infrastructure, and private homes.	No. Cost of dam decommissioning is not insignificant due to the amount of reclamation needed. Alternative would create the need to re-map the FEMA 100-year floodplain and would likely result in four (4) residences within the 100-year floodplain. Downstream bridges and culverts are not sized correctly and would need replacement (at County's/Community	This alternative will not be carried forward because it is not reasonable, inefficient, and unacceptable to sponsor or community due cost, loss of flood benefits, loss of recreational benefits and habitat.

Alternatives	Alternative Description	Purpose and Need	Reasonableness (NEPA)	Practicability (Cost, Logistics, Technology – 404(b)(1) Guidelines)	PR&G (Completeness, Effectiveness, Efficiency, Acceptability)	Disposition of Options (Consideration for More Detail Study or Elimination)
	have no flood control benefits.		environmental impacts.		expense) to minimize roadway overtopping and additional flood damages. The cost of dam decommissioning and loss of benefits creates an inefficient and unacceptable alternative.	
Alternative 4 - Structural Rehabilitation Option 1 to High Hazard - New East Auxiliary Spillway with Road Raise	This alternative would maintain High Hazard classification and meet current criteria. The dam must effectively contain and route the PMF safely through the auxiliary spillway. The road would be partially filled and a new auxiliary spillway would be excavated in the abutment to the east.	Yes	Yes	Yes. There are layout/logistical benefits to position the auxiliary spillway in a location that eliminates constructing the auxiliary spillway on the public road. The integrity of the auxiliary spillway would also be improved.	Yes	This alternative will be carried forward for further study.
Alternative 5 - Structural Rehabilitation Option 2 to High Hazard - Widen Existing Auxiliary Spillway with Road Raise	This alternative would maintain High Hazard classification and meet current criteria. The dam must effectively contain and route the PMF safely through the auxiliary spillway. The	Yes	Yes	Yes	Yes	This alternative will be carried forward for further study.

Alternatives	Alternative Description	Purpose and Need	Reasonableness (NEPA)	Practicability (Cost, Logistics, Technology – 404(b)(1) Guidelines)	PR&G (Completeness, Effectiveness, Efficiency, Acceptability)	Disposition of Options (Consideration for More Detail Study or Elimination)
	existing auxiliary spillway would be modified and the county road would be improved.					
Alternative 6 - Structural Rehabilitation to Significant Hazard	This alternative would rehabilitate the floodwater structure to Significant Hazard status. To meet these criteria, downstream impacts and potential loss of life must be removed and modifications must be made to embankment to fully contain the FBH. This alternative would also include the buyout of three homes downstream in the breach zone.	No. This alternative does not meet the purpose and need of maintaining existing flood damage reduction benefits.	Yes	Yes	Yes. While this alternative may not be supported by the owners of the three (3) residences needing to be purchased and/or the one (1) additional residence that would require flood proofing, the alternative is generally considered acceptable.	This alternative will be carried forward as the non-structural option.
Alternative 7 - Structural Rehabilitation to Low Hazard	This alternative would rehabilitate the floodwater structure to Low Hazard status.	No. This alternative does not comply with Low Hazard dam design criteria based on the downstream flood impact to U.S. Highways 92 and 77. To meet Low Hazard status,	Yes, other than the project not meeting purpose and need.	Yes, other than the project not meeting purpose and need.	No, this is not acceptable because it does not meet the federal objective relative to avoiding unwise use of floodplains and flood-prone areas.	This alternative will not be carried forward as it does not meet the purpose and need of maintaining existing flood damage reduction benefits.

Alternatives	Alternative Description	Purpose and Need	Reasonableness (NEPA)	Practicability (Cost, Logistics, Technology – 404(b)(1) Guidelines)	PR&G (Completeness, Effectiveness, Efficiency, Acceptability)	Disposition of Options (Consideration for More Detail Study or Elimination)
		the breach inundation downstream may not overflow a main roadway by more than 1' of depth and where failure may damage Highway 92 and U.S. Highway 77, which are main roadways. Therefore, this alternative does not meet the purpose and need of maintaining existing flood damage reduction benefits.				

D5 Economics

D5.1 INTRODUCTION

The Natural Resources Conservation Service (NRCS) and Sponsoring Local Organization (SLO) are seeking to develop a Supplemental Watershed Plan for the Cottonwood 21-A Floodwater Retarding Structure. Recently multiple deficiencies have been identified during periodic inspections. The Watershed Work Plan Agreement for the Cottonwood Creek Watershed was prepared in 1965. In 1969, Supplement 1 of the watershed plan provided for the administration of contracts. In 1971, Supplement 2 of the watershed plan provided for assistance and funds to comply with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970. In 1981, Supplement 3 amended the watershed plan for mitigation features. In 1983, Supplement 4 of the watershed plan provided for construction of Cottonwood 21-A as a Hazard Class C structure as defined by the State of Nebraska Department of Water Resources under the authority of Sections 3 and 4 of the Watershed Protection and Flood Prevention Act (Public Law [PL] 83-566). The embankment structure is located on an upper tributary of Cottonwood Creek, just North of the town of Malmo, Nebraska.

The upstream watershed includes the dam site, permanent pool, and contributing drainage area of 1,427 acres. This includes smaller tributaries as well as other grade control and impoundment structures. The downstream impact area includes the dam, low lying areas around the town of Malmo, and the Cottonwood Creek main channel branch extending to approximately Highway 92 and the confluence of Wahoo Creek. At this location, the breach inundation zone is fully contained within the defined 1% chance special flood hazard area or Zone A floodplain.

The structure was originally constructed in 1983 and classified as a Hazard Class C structure as defined by the (then) State of Nebraska Department of Water Resources. A Dam Assessment Report was prepared by a consultant for the NRCS and the Lower Platte North NRD (LPNNRD) in September of 2022. This assessment provided an evaluation and review of the existing structures' capacity and performance. This assessment follows the minimum design criteria defined by Technical Release-60 (TR-60, 1990) for a High Hazard Potential Dam.

The NRCS dam assessment states Cottonwood Creek Site 21-A (Dam) does not meet current standards. To address these deficiencies, the NRCS and LPNNRD needed to create a Supplemental Watershed (Rehabilitation) Plan. This analysis provides a discussion of the economic framework, methodology, and results for the alternatives within the Supplemental Watershed (Rehabilitation) Plan.

D5.2 FEDERAL GUIDELINES OF NATIONAL ECONOMIC EFFICIENCY ANALYSIS OF DAM REHABILITATION

A National Economic Efficiency (NEE) benefit cost analysis (BCA) has been performed to evaluate benefits of the proposed alternative(s). The evaluation includes an identification of damages sustained under the Future Without Federal Investment (FWOFI) condition and estimates the benefits associated with each alternative. This analysis relies on federal water resource project and NRCS guidelines for the evaluation of NEE benefits and costs. These guidelines rely primarily on the Principles, Requirements, and Guidelines (PR&G) (CEQ, 2014), the NRCS Natural Resources Economics Handbook (NRCS 1998), and the National Watershed Program Manual (NRCS 2015b).

With the passage of the 2007 Water Resources Development Act, federal agencies were directed to update the original Principles and Guidelines (P&G) from 1983. This update resulted in the creation of the PR&G. The revised purpose of the PR&G is to 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.”

Further expanding the guidance on benefits, the PR&G states:

“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.”

The PR&G guides projects to be evaluated from an ecosystem services perspective. In order to receive Federal investment, water projects must strive to:

“...protect and restore the functions of ecosystems and mitigate any unavoidable damage to these natural systems.”

The updated PR&G gives equal standing to economic, social, and environmental impacts when selecting the preferred alternative. This includes both monetized and non-monetized valuation methods. This allows the analysis to fully articulate the impacts the project provides. The equal standing also allows the project to best meet the Federal objective of maximizing public benefits and costs, while ensuring the protection of ecosystem services.

D5.3 ECOSYSTEM SERVICES EVALUATED

The evaluation of environmental impacts of the proposed project was conducted using methods outlined in the Department Manual 9500-013 Guidance for Conducting Analyses Under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies and Federal Water Resources Investments (PR&G) completed in 2017 (USDA).

The PR&G requirements outline an evaluation of the ecosystem service of each environmental resource as appropriate. Ecosystem services are defined as the benefits (goods and services) people obtain from ecosystems. Once the framework is outlined, an economic analysis is conducted to assign monetary values to resources based on the ecological principles of the project. Ecosystem services are categorized into the following four groups:

- Provisioning services are tangible goods provided for direct human use and consumption, such as food, fiber, water, timber, or biomass. Within this watershed, these types of tangible goods would include agricultural crop production.
- Regulating services maintain a world in which it is possible for people to live, providing critical benefits that buffer against environmental catastrophe – examples include flood and disease control, water filtration, climate stabilization, or crop pollination. The Cottonwood 21-A dam structure provides flood control benefits and water quality improvements through sediment capture.

- Supporting services refer to the underlying processes maintaining conditions for life on Earth, including nutrient cycling, soil formation, and primary productions. In this watershed, Cottonwood 21-A provides fish and wildlife habitat as well as stream and wetland habitat.
- Cultural services make the world a place in which people want to live – recreational use, spiritual, aesthetic viewsheds, or tribal values. The Cottonwood 21-A waterbody provides fishing and passive recreational use as well as a positive aesthetic viewshed.

D5.4 NATIONAL ECONOMIC EFFICIENCY BENEFIT-COST ANALYSIS DATA AND METHODOLOGY

For the completion of the National Economic Efficiency (NEE), a benefit-cost analysis (BCA) was conducted for the USDA, NRCS, and the LPNNRD (SLO). The NRCS and SLO are seeking to develop a Supplemental Watershed Plan for the Cottonwood 21-A Floodwater Retarding Structure. This analysis will compare a set of alternatives to assist in the selection of the preferred alternative. The Preferred Alternative is expected to continue to provide resilience to the community by reducing the damages flooding causes in the watershed. The benefits and costs of each alternative will be estimated and compared to the FWOFI. The benefit categories analyzed within this BCA include avoided flood damages to structures and agriculture.

Estimated benefits and costs are based on full employment with no relative change in prices over the project's life. The analysis estimates the effects of each alternative over a 100-year project life (U.S. Water Resources Council 1983). All economic damages, benefits, and costs use the base fiscal year (FY) 2024. Benefits and costs have been discounted while converted to an average annual, following the FY 2024 federal interest rate of 2.75 percent (OMB Circular A-94, 2023).

In order to ensure "reasonable reality" is captured within this analysis, a set of storm events were analyzed to determine which recurrence intervals to use for the economic analysis. These events aim to capture any possible differences in damages between the FWOFI and the Action alternatives. For the purpose of flood damage mitigation projects, the most and least frequent events analyzed need to bracket the impacts. Meaning that events more frequent than the analysis will not produce any damages. While events less frequent than the analysis will produce flooding conditions similar for both the FWOFI and all Action Alternatives. The other in between events were selected based on their ability to accurately depict a hypothetical depth damage curve. This means no large jumps for the frequent events, where the system is more volatile. This process included a series of discussions with the project team to ensure accuracy was maintained. The final recurrence intervals selected were the 1-, 10-, 50-, 100-, 500-, and 1000-yr events.

Depth rasters were developed for the FWOFI and each Action Alternative for each flood event described above. The depth of inundation above foundation height was extracted at each structure. At each structure, the depth, structure type, structure value, contents value, and displacement values were then used to determine the total damage under each alternative and flood event combination. For each alternative, the total damage for each structure was summed up and then annualized by flood event. The difference in total damage from the FWOFI and each Action alternative results in each Action alternative's benefit.

D5.4.1 Alternative 1 No Action/Future Without Federal Investment

This alternative represents the project area as it currently stands. Without Federal funding, the Sponsor is most likely to select the No Action/FWOFI alternative. Under this alternative, it is assumed an uncontrolled breach of the dam will occur. The most likely cause of breach would be due to dam overtopping because of inadequate auxiliary spillway capacity. This alternative also assumes that no post-breach restoration/reclamation of the dam structure would occur. Though no costs are associated with this alternative flooding damages will continue to occur.

D5.4.2 Action Alternatives

Channel conveyance includes a combination of channel improvements, associated flood protection berms, diversion channels, and the creation of an auxiliary spillway as necessary. Channel improvements would increase the capacity of the conveyance system through modification of the channel alignment and/or replace the undersized spillway to provide protection from a defined flood event. Flood protection berms include the implementation of flood projection barriers to provide a flood damage reduction for specific areas of interest. Based on hydraulic modeling, berm locations were identified to redirect flows away from flood prone structures. Diversions would redirect excess flows upstream and construct a diversion around the urban area to reduce flows to no-damage flows.

Alternative 4 New East Auxiliary Spillway with Road Raise

This alternative maintains the dam at a High Hazard classification to meet current criteria. The dam must effectively contain and route the PMF (Probably Maximum Flood) safely through the auxiliary spillway. The road will be partially filled, and a new auxiliary spillway would be excavated in the abutment to the east.

Alternative 5 Widen the Existing Spillway

This alternative maintains the dam at a High Hazard classification to meet current criteria. The dam must effectively contain and route the PMF safely through the auxiliary spillway. The existing auxiliary spillway will be modified, and the county road will be improved.

Alternative 6 Structural Rehabilitation to Significant Hazard Potential

This alternative would reduce the dam hazard classification from a High Hazard to a Significant Hazard classification through a combination of structural rehabilitation measures and downstream risk reduction strategies. The proposed structural improvements to the dam and spillway system are less extensive than those required for full High Hazard rehabilitation and are intended to minimize long-term operational burdens associated with maintenance, inspections, and owner liability.

As part of the alternative, three downstream residential properties located within the modeled breach inundation area would be acquired and the residences removed from the breach zone. In addition, a perpetual “no-build” easement would be required across downstream properties within the designated breach area to restrict future construction of occupied structures and other improvements that could increase downstream hazard exposure. The easement would serve as a long-term non-structural measure necessary to maintain the Significant Hazard classification for the operational life of the dam.

D5.5 BENEFITS ANALYSIS

Economic benefits and impacts were calculated based on the expected effects of the Action Alternative and the specific project components. For the Cottonwood 21-A project, the Action Alternative includes a

combination of channel improvements, associated flood protection berms, diversion channels, and spillway adjustments as necessary.

The Action Alternatives provide two types of analyzed benefits: a reduction in damages to structures and a reduction in agricultural losses. All economic benefits calculated assume that the improvements are expected to be fully developed by 100 years after project construction. The following sections describe the development of these benefits categories.

Avoided Structure Damages

The avoided structure damage benefit represents the avoided damages to structures within the project area. Hydraulics and hydrology (H&H) model flood impact results for the future No Action/FWOFI 100-year floodplain is used to define an inventory of all potential structures that could be affected by flooding. Affected structures are assigned flood depths for each of the 6 return periods under the No Action/FWOFI and Action Alternatives.

Data about each structure was obtained from the USA Structures shapefile provided by the Federal Emergency Management Agency (FEMA). This was used to link the flood depths to translate depth of flooding into monetary estimates of flood-related damages with each return period. Collected data from the USA Structures shapefile include structure type (residential, non-residential), foundation type, number of stories, structure size (square feet), number of floors, and assessed value. To determine the depreciated replacement value (DRV), the data provided was input to Marshall and Swift's SwiftEstimator.

Depth-damage functions link H&H floodplain results with data on values of structures and contents and elevations to determine the monetary value of flood damages. These functions identify the percentage of damage to the structures and contents for each stage of flooding. Functions for damages to residential structures and contents have been obtained from the U.S. Army Corps of Engineers EGM 04-01 (USACE, 2003). Contents values for all properties are expressed as a percentage of total structure value. Within the USACE depth damage curves, there is a content-to-structure value ratio for each occupancy type. The ratio for residential structures is 100 percent of structure value, whereas for nonresidential structures it varies between 6 and 85 percent depending on the occupancy type.

This benefit category is summarized by Action Alternative in Table 1 below. The table values represent the average annual benefit to structures for the Action Alternatives.

Table D5.1: Estimated Average Annual Avoided Structure Damage Benefits. Cottonwood 21-A (FY 2024 \$s, 2.75% Discount Factor).

Action Alternative	Improvement	Average Annual Benefit
Alt 4 New East Auxiliary Spillway with Road Raise	Maintain High Hazard Potential classification, and build new auxiliary spillway	\$65,973
Alt 5 Widen the Existing Spillway	Maintain High Hazard Potential classification, and widen auxiliary spillway	\$66,116
Alt 6 Structural Rehab to Significant Hazard Potential	Rehabilitate the dam to Significant Hazard Potential status. Buyout 3 homes in the downstream breach area.	\$65,925

Avoided Agricultural Damage

The project area is primarily rural, therefore agricultural damages due to flooding occur frequently without flood mitigation. Crop damages are estimated using the areas impacted by flooding for each return period for the FWOFI and Action Alternatives. The approach implemented here follows a relatively simplified approach, which generates a reasonable order of magnitude measure of impact and is assumed to be sufficient for this assessment of potential economic feasibility.

In this analysis, the H&H data is intersected with CropScape data for the project area to calculate flooded acres of land by crop type. The crops included in the analysis include irrigated corn, dryland corn, soybeans, winter wheat, and hay/alfalfa. The USDA's National Agricultural Statistics Service (NASS) was used to determine the average acreage, yield, and price received for each crop type. Crop budgets produced by the University of Nebraska's Agricultural Extension was used to determine the cost to produce each crop type. This data was collected and averaged for the years of 2014 through 2022. This information was then entered into the flood damage model. Table 2 includes the average inputs used for each crop.

Table D5.2: Crop Inputs (Averaged Over 2014-2022, FY 2024 \$\$)

Crop	% Share	Acreage	Yield	Price Received (\$/Yield)	Crop Budget (\$/Acre)
Corn, Irrigated	39.72%	63,186	206.68	\$5.53	\$1,053.81
Corn, Dryland	60.28%	116,877	174.58	\$5.53	\$643.52
Soybeans	34.14%	166,856	55.82	\$13.82	\$632.42
Winter Wheat	0.07%	1,164	63.07	\$7.37	\$441.39
Alfalfa	1.06%	7,513	4.26	\$157.16	\$625.55
Other Hay/ Non Alfalfa	0.63%	7,046	1.90	\$119.99	\$298.31

The model computes the damage frequency for each return period by multiplying the acreage damaged (by crop type) with the value per acre for each crop. These results are then summed to determine the annual damages by Action Alternative. The benefits are then compared with the annualized cost of the alternative. Annual avoided damage to agriculture for each project are shown below in Table D5.3.

Table D5.3: Estimated Average Annual Avoided Agriculture Damage Benefits. Cottonwood 21-A (FY 2024 \$\$, 2.75% Discount Factor).

Project	Improvement	Average Annual Benefit
Alt 4 New East Auxiliary Spillway with Road Raise	Maintain High Hazard Potential classification, and build new auxiliary spillway	\$78,923
Alt 5 Widen the Existing Spillway	Maintain High Hazard Potential classification, and widen auxiliary spillway	\$79,389
Alt 6 Structural Rehab to Significant Hazard Potential	Rehabilitate the dam to Significant Hazard Potential status. Buyout 3 homes in the downstream breach area.	\$78,938

D5.6 ESTIMATED COSTS

Project capital, operations, and maintenance (O&M) costs are estimated in 2024 dollars for each project alternative (See Tables D5.4, D5.5, and D5.7). Costs for each project measure are included as separate items. The annualized costs will be compared to annualized benefits for each measure. O&M costs for each alternative are assumed to be 0.5% of the capital cost. Present value and annualized costs are computed with a 2.75% discount rate over 100 years.

Table D5.4: Estimated Alternative 4 New East Auxiliary Spillway with Road Raise Installation Costs. Cottonwood 21-A (FY 2024 \$s, NWPM 506.11)

Description	Quantity	Unit	\$/Unit	Total
Mobilization	1	LS	\$239,318	\$239,318
Clearing and Grubbing	0.4	AC	\$25,000	\$10,000
Traffic Control	1	LS	\$15,000	\$15,000
Utility Relocated	600	LF	\$35	\$21,000
Remove and Replace Power Line	1,250	LF	\$45	\$56,250
Stripping and Topsoiling - Dam	1,600	CY	\$4.5	\$7,200
Stripping and Topsoiling - Spillway	4,700	CY	\$4.5	\$21,150
Stripping and Topsoiling - Spoils	3,636	CY	\$4.5	\$16,362
Stripping and Topsoiling - Seepage Blanket	506	CY	\$4.5	\$2,277
Demo - Fenceline	3,790	LF	\$3	\$11,370
Install Fenceline	5,305	LF	\$12	\$63,660
Remove and Salvage Road Gravel	6,264	SY	\$3	\$18,792
Road Embedment	6,264	SY	\$2.25	\$14,094
6" of 3" Crushed Rock	1,566	TN	\$65	\$101,790
4" of Crushed Rock Surfacing	1,034	TN	\$45	\$46,530
Excavation - Spillway	71,000	CY	\$3.5	\$248,500
Embankment - Fill Embankment (CIP)	18,750	CY	\$2.5	\$46,875
Embankment - Seepage Blanket	2,300	CY	\$3.5	\$8,050
Embankment - Spoils	47,000	CY	\$1.5	\$70,500
Riprap Shoreline Protection	4,628	TN	\$90	\$416,520
Toe Drain - 47B	557	CY	\$160	\$89,120
Toe Drain Outlet Pipe	30	LF	\$140	\$4,200
Slotted Toe Drain Pipe	220	LF	\$140	\$30,800
Riprap Toe Drain Outlet Protection	15	TN	\$85	\$1,275
Erosion and Sediment Control	1	LS	\$150,000	\$150,000
Seeding and Mulching	24	O	\$4,500	\$108,000

Description	Quantity	Unit	\$/Unit	Total
Cemetery Berm Fill	770	CY	\$7	\$5,390
Cemetery Fence	200	LF	\$20	\$4,000
Cemetery Seeding/Mulching	1.5	AC	\$4,500	\$6,750
Subtotal Construction				\$1,834,774
Contingency				\$366,955
Total Construction				\$2,201,729
Additional Costs				
Cemetery Easement - Permanent	0.5	AC	\$9,000	\$4,500
Cemetery Easement - Temporary	1.5	AC	\$1,000	\$1,500
Cemetery Easement - Legal	1.0	LS	\$7,000	\$7,000
Permanent Easement - Spillway	6.0	AC	\$9,000	\$54,000
Temporary Easement - Staging Area	3.0	AC	\$2,500	\$7,500
Flood Pool Easement	47.0	AC	\$1,000	\$47,000
Flood Pool Easement - Legal	1.0	LS	\$30,000	\$30,000
Flowage Easement	72.0	AC	\$500	\$36,000
Flowage Easement - Legal	1.0	LS	\$100,000	\$100,000
Engineering Services	1.0	LS	\$176,000	\$515,000
Permitting	1.0	LS	\$88,000	\$88,000
Construction Services	1.0	LS	\$176,000	\$176,000
Project Administration	1.0	LS	\$44,035	\$44,035
Total Additional Costs				\$1,110,535
Total Project Costs				\$3,312,263
Project O&M				\$3,868

Table D5.5: Estimated Alternative 5 Widen the Existing Spillway Installation Costs. Cottonwood 21-A (FY 2024 \$s, NWPM 506.11)

Description	Quantity	Unit	\$/Unit	Total
Mobilization	1	LS	\$243,263	\$243,263
Clearing and Grubbing	0.4	AC	\$25,000	\$10,000
Traffic Control	1	LS	\$15,000	\$15,000
Utility Relocated	1,275	LF	\$35	\$44,625
Remove and Replace Power Line	1,760	LF	\$45	\$79,200
Stripping and Topsoiling - Dam	3,880	CY	\$4.50	\$17,460
Stripping and Topsoiling - Spillway	4,862	CY	\$4.50	\$21,879
Stripping and Topsoiling - Spoils	2,752	CY	\$4.50	\$12,384
Stripping and Topsoiling - Seepage Blanket	506	CY	\$4.50	\$2,277
Demo - Fenceline	3,790	LF	\$3	\$11,370
Install Fenceline	6,220	LF	\$12	\$74,640
Remove and Salvage Road Gravel	6,264	SY	\$3	\$18,792

Description	Quantity	Unit	\$/Unit	Total
Road Embedment	6,264	SY	\$2.25	\$14,094
6" of 3" Crushed Rock	1,566	TN	\$65	\$101,790
4" of Crushed Rock Surfacing	1,034	TN	\$45	\$46,530
Excavation - Spillway	68,000	CY	\$3.50	\$238,000
Embankment - Fill Embankment (CIP)	22,500	CY	\$2.50	\$56,250
Embankment - Seepage Blanket	2,300	CY	\$3.50	\$8,050
Embankment - Spoils	36,000	CY	\$1.50	\$54,000
Riprap Shoreline Protection	4,628	TN	\$90	\$416,520
Toe Drain - 47B	557	CY	\$160	\$89,120
Toe Drain Outlet Pipe	30	LF	\$140	\$4,200
Slotted Toe Drain Pipe	220	LF	\$140	\$30,800
Riprap Toe Drain Outlet Protection	15	TN	\$85	\$1,275
Erosion and Sediment Control	1	LS	\$150,000	\$150,000
Seeding and Mulching	23	AC	\$4,500.00	\$103,500
Subtotal Construction				\$1,865,020
Contingency				\$373,004
Total Construction				\$2,238,024
Additional Costs				
Permanent Easement - Spillway	12.0	AC	\$9,000	\$108,000
Temporary Easement - Staging Area	3.0	AC	\$1,000	\$3,000
Flood Pool Easement	36.0	AC	\$1,000	\$36,000
Flood Pool Easement - Legal	1.0	LS	\$30,000	\$30,000
Engineering Services	1.0	LS	\$179,000	\$515,000
Permitting	1.0	LS	\$90,000	\$90,000
Construction Services	1.0	LS	\$179,000	\$179,000
Project Management	1.0	LS	\$45,000	\$45,000
Total Additional Costs				\$1,006,000
Total Project Costs				\$3,244,024
Project O&M				\$4,407

To support development of the Environmental Assessment (EA), rehabilitation alternatives analysis, and Benefit-Cost Analysis (BCA) for the dam rehabilitation project, an evaluation of downstream residential properties and breach inundation impacts was completed to develop planning-level cost estimates associated with the Significant Hazard rehabilitation alternative. Under this alternative, the dam would be rehabilitated to achieve a reduction in hazard classification from High Hazard to Significant Hazard through a combination of structural improvements and non-structural mitigation measures. A key component of this alternative includes acquisition and relocation of three residential properties located within the modeled breach inundation zone downstream of the dam. The evaluated properties include:

- Property 1 – 212 Concord Street, Malmo, Nebraska
- Property 2 – 326 Center Avenue, Malmo, Nebraska
- Property 3 – 337 Ridgewood Avenue, Malmo, Nebraska.

To establish planning-level property acquisition costs, publicly available real estate market information was reviewed utilizing the Zillow real estate platform and associated “Zestimate” property valuation ranges. The estimated market value ranges were used as the basis for acquisition cost assumptions. These values represent estimated parcel acquisition costs only and do not include additional relocation assistance, moving expenses, replacement housing differentials, legal fees, or other costs that may ultimately be required during final implementation and right-of-way acquisition activities. Table D5.6 below includes the properties in question.

Table D5.6: Breach Impact Zone Properties

Property	Beds/ Baths	Lot Size (Acres)	Finished Area (Square Footage)	Zestimate
212 Concord Street	2/1	4.3	1,260	\$129,700
326 Center Avenue	3/1	0.48	1,914	\$174,200
337 Ridgewood Avenue	3/1	0.32	1,520	\$54,816

In addition to residential acquisitions, the Significant Hazard rehabilitation alternative also includes implementation of a perpetual flowage or “no-build” easement across portions of the downstream breach inundation area. The easement area generally extends through the mapped breach zone upstream of the location where modeled breach flows return to the normal channel and overbank flow regime. The purpose of the easement is to limit future occupied structures, residential development, and other improvements within the breach hazard area in order to maintain the reduced hazard classification for the life of the rehabilitated dam.

Based on discussions with the local Natural Resources District (NRD) and NRCS representatives regarding historical easement acquisition practices and recent regional land values, agricultural property within the easement area was estimated to have a fair market value ranging from approximately \$13,000 to \$17,000 per acre. For planning purposes, an average land value of approximately \$15,000 per acre was utilized. Consistent with prior NRD easement acquisition practices, the estimated easement compensation value was assumed to be 30 percent of the underlying fair market value to reflect the partial restriction of future development rights while maintaining agricultural use of the property. This resulted in an estimated easement acquisition value of approximately \$4,500 per acre.

The estimated easement unit value was then applied to the approximately 268 acres identified within the breach inundation easement area upstream of the defined return-flow transition line utilized in the rehabilitation plan and hydraulic modeling analysis. These planning-level cost estimates were developed solely to support comparative alternative evaluation, environmental documentation, and preliminary BCA development and should not be considered formal appraisals or final right-of-way acquisition values. The breach impact area analyzed for this alternative is located below in Figure 1.

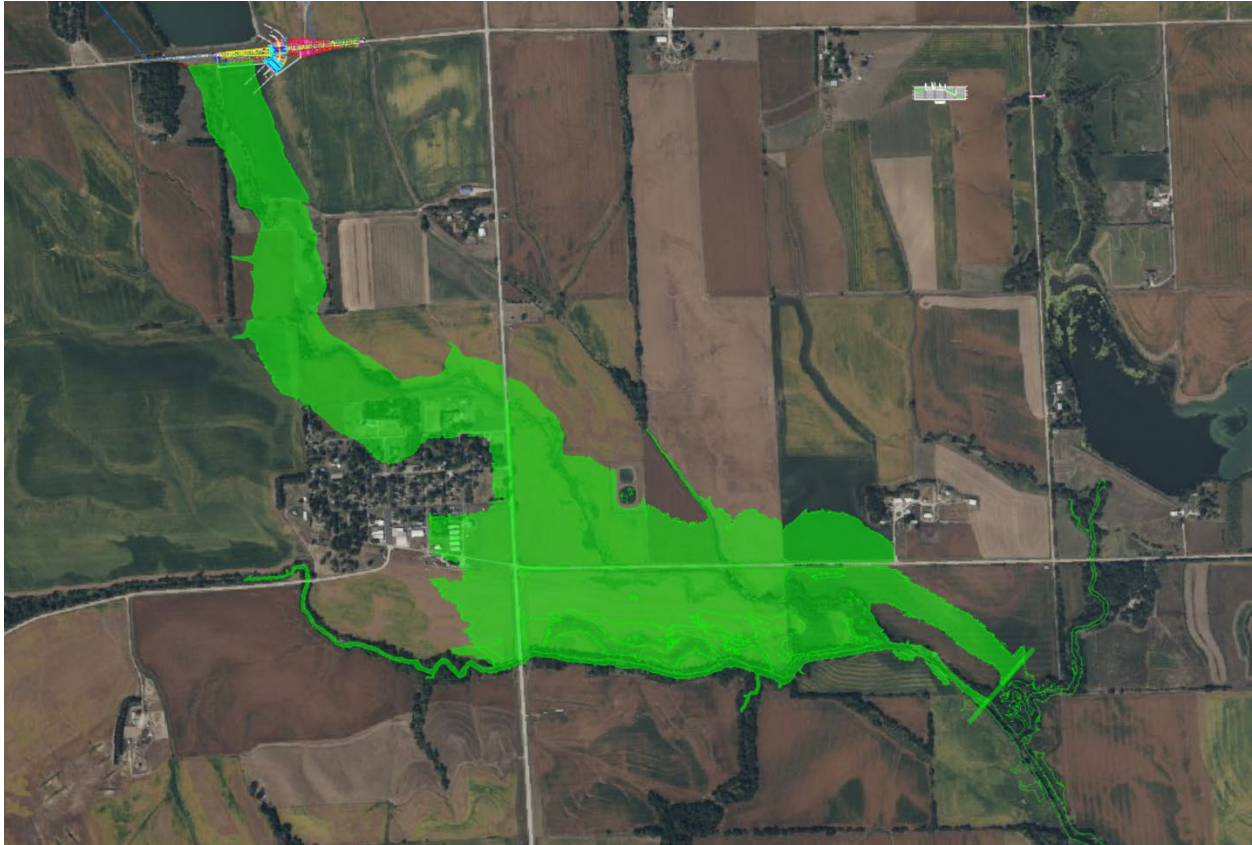


Figure 5.1: Alternative 6 Breach Area

Table D5.7: Estimated Alternative 6 Structural Rehabilitation to Significant Hazard Potential Construction Costs. Cottonwood 21-A (FY 2024 \$s, NWPM 506.11)

Description	Quantity	Unit	\$/Unit	Total
Mobilization	1	LS	\$154,789.80	\$154,759.80
Clearing and Grubbing	0.4	AC	\$25,000	\$10,000
Traffic Control	1	LS	\$15,000	\$15,000
Utility Relocated	1,275	LF	\$35	\$44,625
Remove and Replace Power Line	1,500	LF	\$45	\$67,500
Stripping and Topsoiling - Dam	2,850	CY	\$4.50	\$12,825
Stripping and Topsoiling - Spillway	860	CY	\$4.50	\$3,870
Stripping and Topsoiling - Seepage Blanket	506	CY	\$4.50	\$2,277
Demo - Fenceline	2,190	LF	\$3	\$6,570
Install Fenceline	3,650	LF	\$12	\$43,800
Remove and Salvage Road Gravel	3,750	SY	\$3	\$11,250
Road Embedment	3,750	SY	\$2.25	\$8,437.50
6" of 3" Crushed Rock	930	TN	\$65	\$60,450
4" of Crushed Rock Surfacing	615	TN	\$45	\$27,675
Excavation - Spillway	1,725	CY	\$3.50	\$6,037.5

Description	Quantity	Unit	\$/Unit	Total
Embankment - Fill Embankment (CIP)	12,900	CY	\$2.50	\$32,250
Embankment - Seepage Blanket	2,300	CY	\$3.50	\$8,050
Riprap Shoreline Protection	4,628	TN	\$90	\$416,520
Toe Drain - 47B	557	CY	\$160	\$89,120
Toe Drain Outlet Pipe	30	LF	\$140	\$4,200
Slotted Toe Drain Pipe	220	LF	\$140	\$30,800
Riprap Toe Drain Outlet Protection	15	TN	\$85	\$1,275
Erosion and Sediment Control	1	LS	\$40,000	\$40,000
Seeding and Mulching	8	AC	\$4,500.00	\$36,000
Subtotal Construction	\$1,186,492			
Contingency	\$237,298.40			
Total Construction	\$1,423,790.40			
Additional Costs				
212 Concord – Residence Buyout	1	LS	\$160,000	\$160,000
326 Center Avenue – Residence Buyout	1	LS	\$210,000	\$210,000
337 Ridgewood Avenue – Residence Buyout	1	LS	\$100,000	\$100,000
Permanent Easement - Spillway	4.0	AC	\$9,000	\$36,000
Temporary Easement - Staging Area	3.0	AC	\$2,500	\$7,500
Flood Pool Easement	13.0	AC	\$1,000	\$13,000
Flood Pool Easement - Legal	1.0	LS	\$30,000	\$30,000
Flowage Easement – Breach Zone	268	AC	\$4,500	\$1,206,000
Flowage Easement – Legal	79	EA	\$4,000	\$316,000
Engineering Services	1.0	LS	\$145,000	\$145,000
Permitting	1.0	LS	\$85,000	\$85,000
Construction Services	1.0	LS	\$145,000	\$145,000
Project Management	1.0	LS	\$45,000	\$45,000
Total Additional Costs	\$2,498,500			
Total Project Costs	\$3,922,290			
Project O&M	\$3,341			

D5.7 COMPARISON OF BENEFITS AND COSTS

The NEE analysis results compare the benefits added by each alternative. These serve as the best estimates to the economic value the preferred alternative would provide. Results are presented following NRCS guidelines (NWPM Part 506, NRCS 2014b). Table D5.8 summarizes the average annual NEE benefits and costs for the with-project alternative in the Cottonwood 21-A project area. Both action alternatives are economically justified for PL 83-566 funding.

Table D5.8: Comparison of NEE Benefits and Costs. Cottonwood 21-A, Nebraska (FY 2024 \$s, 2.75% Discount Factor).

Project	Land Treatment	Total Damage reduction benefit, average annual	Total Average Annual Project Costs	NEE Metrics	
				Benefit Cost Ratio	Net Benefits
Alt 4 New East Auxiliary Spillway with Road Raise	Maintain High Hazard classification, and build new auxiliary spillway	\$144,896	\$101,428	1.43	\$43,468
Alt 5 Widen the Existing Spillway	Maintain High Hazard classification, and widen auxiliary spillway	\$145,505	\$99,957	1.46	\$45,548
Alt 6 Structural Rehab to Significant Hazard Potential	Rehabilitate dam to Significant Hazard Potential	\$144,863	\$118,869	1.22	\$25,994

D6 Appendix D References

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