Investigation and Analysis Report for the North Ogden Project

Appendix D

Fourmile Creek Subwatershed
Weber County, Utah

The purpose of the Investigation and Analysis Appendix is to present information that supports the evaluation and conclusions of the Watershed Plan and Environmental Assessment (Plan-EA). Refer to the Appendix E of the Watershed Plan EA for the Technical Memos referenced in this study.

July 2024

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D.1 Introduction

The North Ogden Project is located within the Fourmile Creek Subwatershed, located in North Ogden City, Weber County, Utah. The project is to construct a reservoir and facilities for Weber Box Elder Conservation District (WBECD also known as Pineview Water Systems) and North Ogden City for the use of secondary irrigation, flood control, and recreation. The project location is at 150 East and 2300 North in North Ogden City.

This document summarizes the investigations and analyses completed for the planning and engineering of North Pine Reservoir in preparation for the Environmental Assessment of the Project. This includes a summary of the hydraulics and hydrology for flood control and agricultural water delivery system improvements, breach analysis, geotechnical studies, alternatives, and the economical analysis. The basis for the planning engineering investigations and analysis are the current North Ogden City Standards, NRCS standards, and Utah Division on Dam Safety criteria and standards. Additional information relevant to each of the sections provided in this report is available as part of the administrative record for the project.

The summary information for the embankment and reservoir is shown in Table 1. All elevations provided in this report are in North American Vertical Datum of 1988 (NAVD88).

Table 1. Embankment and Reservoir Summary

Feature	Dimension
Maximum Dam Height	5.5 ft
Dam Crest Elevation	4346.6
Auxiliary Spillway Crest Elevation	4344.6
Principle Spillway Crest Elevation	4343.6
Lowest Natural Ground Elevation at Dam	4341.1
Max Depth of Water Above Natural Ground (Auxiliary Spillway – Natural Ground Elevation)	3.5 ft
Reservoir Capacity at Auxiliary Spillway	42.5 ac-ft
Reservoir Capacity above Lowest Natural Ground Elevation	9.1 ac-ft
Reservoir Capacity Below Natural Ground Elevation	33.4 ac-ft
Agricultural Irrigation Capacity	20.5 ac-ft
Flood Control Capacity	22.0 ac-ft
Dam Crest Length	1,090 ft
Dam Crest Width	8 ft
Upstream Slope of Dam	3H : 1V
Downstream Slope of Dam	2.5H : 1V

D.2 Design Criteria

The proposed detention basin will be designed to meet the requirements of the NRCS, Utah Division of Dam Safety, and North Odgen City. The design requirements are identified in Utah's Administrative Code R655-11, NRCS Technical Release 60 and the National Engineering Handbook. Other Utah or NRCS codes as applicable will also be followed.

D.3 Flood Control Hydrologic and Hydrology Analysis

The North Ogden storm drain and flood control system currently serves all areas within the City boundaries. Six main drainage channels convey water through the city. They are Barrett Canyon, Willow Springs, Mountain Water, Rice Creek, North Ogden Canyon, and Coldwater. The existing and proposed detention basins are located at the bottom end of the Barrett Canyon watershed. These drainage channels are collected, and the flood waters are transferred through the North Ogden system. The City standards require piping to be designed to convey the 10-year storm event and the 100-year storm event be conveyed in the street piping and the street right-of-way.

The city requires local detention basins be constructed with new land developed and the city has also constructed large regional detention basins to hold water from large storm events. These regional detention basins act as debris basins and detention basins to restrict downstream flows and prevent flooding of the city. Local detention basins for specific developments are required by City ordinace to be sized to hold the 10-year storm event with release rate of no more than 0.1 cfs/acre of the area draining to the detention basin. The regional basins are required by City ordinance to be sized to hold the 100-year storm event with a realease of no more than 0.1 cfs/acre of the area draining to the detention basin. These detention basins vary in size based on the capacity of the existing channels and pipes. Most of these detention basins are located within the city limits and not necessarily at the base of a canyon.

The existing and proposed detention basins in this study are regional detention basins and the existing detention basin only stores storm water runoff. The proposed detention basin will be a joint use between the city and Pineview Irrigation. The irrigation storage will be 20 ac-ft and the flood control storage will be 22 ac-ft. The irrigation company will have the capability to pump down the proposed detention basin to provide an additional 10 ac-ft of storage for larger storm events. Refer to Technical Memo No. 001 Hydraulics and Hydrology prepared by J-U-B for additional information.

The North Ogden drainage system was modeled by North Ogden City as part of their Storm Water Capital Facilities Plan update in 2018. The method selected for modeling their study was HEC-1 and a list of the input parameters can be found in their Capital Facilities Plan. The parameters include soil conditions, rainfall loss methods, storm events, rainfall distribution, and lag time. The Capital Facilities Plan states "After collaboration with consultants that work with the Federal Emergency Management Agency (FEMA) it was decided to analyze the city's storm water system using the (NOAA) 6-hour storm event with a Temporal Distribution Area 1, 2nd Quartile, 50% probability for the Semiarid Southwest." These are the storm and hydrographs that were used in the model. Since the North Pine

Reservoir lies within the North Ogden drainage system it was reasonable to use the same storm and model to size the North Pine Reservoir.

Because of property constraints, the largest the proposed detention basin is able to detain is a maximum of 22 ac-ft for flood control. This is approximately 3.1 ac-ft larger than the existing detention basin. Pineview irrigation is able to draw down an additional 10 ac-ft of the allocated irrigation portion of the storage prior to a large storm event, see TM-001 for more information.

To keep the proposed flood path the same as existing, existing storm drain boxes at 2700 North and 2550 North will be used to restrict flow to 125 cfs and 75 cfs, respectively. The box at 2550 North will remain connected to the existing storm drain system along 2550 North and flows above 75 cfs will flow in the existing 2550 North storm drain system. The box at 2700 North will remain connect to the UDOT storm drain system along 2700 North and flows above 125 cfs will flow in existing UDOT storm drain system and also surface flow into 2700 North and continue west in the curb and gutter.

Additional storage is being consided and will be added in the future to continue to reduce the amount of flooding in this area

D.4 Spillways

The principal spillway for the pond will be a 6 foot by 6 foot concrete box structure located inside of the pond. The concrete structure will be piped through the embankment and connect onto the storm drain system of North Ogden City. The storm drain system has a maximum capacity of 20 cfs. Flows above 20 cfs will be detained in the ponds and released at 20 cfs.

The auxiliary spillway is designed to carry the 150 cfs flow. The width of the auxiliary spillway is 30 feet. The auxiliary spillway will be concrete lined from inside the pond to the street approximately 15 feet away. The auxiliary spillway will match the slope of the embankment at 2.5:1 or 40%. All the spillway area will be protected with a concrete liner and discharged onto an asphalt street. With concrete liner, asphalt, and low berm height there is very minimal, if any, threat of eroding the embankment from flows in the auxiliary spillway.

D.5 Agricultural Water Hydrologic and Hydrology Analysis

The District provides pressure irrigation for lawn and garden use in North Ogden and surrounding cities. Water for agricultural irrigation is provided by the North Ogden Canal Company. As land is developed from agricultural to residential the water right is converted from the North Ogden Canal Company to the Weber-Box Elder Conservation District for use in the pressurized lawn and garden sysem. The only system that has been analyzed is the WBECD pressure irrigation system. The system has been modeled for current and futures demands. Refer to Technical Memo No. 001 Hydraulics and Hydrology prepared by J-U-B for additional information.

WBECD has a water right for 44,175 acre-feet. The water right is owned by the Bureau of Recamalation and has been desigated to for use in the WBECD pressurized system.

The system will provide pressure irrigation water for Unit I of the District's system. Unit I has an area of 2,753 acres and serves 2,309 parcels. Irrigation water will be delivered from the North Ogden Canal to the storage pond beginning at a rate of 5 cfs. This will increase over time to approximately 9 cfs as demand on the pressure irrigation system increases with development.

The system was modelled using 8.5 gpm per developed acre for the peak hour demand for the existing and future buildout scenarios. This demand was calculated by using a water meter from the West View Reservoir pump station and dividing the peak hour flowrate by the total developed parcel acreage of the service area for the West View Reservoir. This demand factor was then used for all of the parcel areas in Unit I. The existing peak hour demand is 9,470 gpm. The future peak hour demand is 20,950 gpm. The HGL elevation of the pumps must maintain the same pressures in the existing Unit I system of 70 psi or 162' of head.

The storage requirement to meet this demand in Unit I is 28.0 acre-feet. The water will be stored in the North Pine Reservoir and then pumped into the existing piped system. Most of the piping for Unit I is currently in place. Only a few distribution pipes near the pump house are needed to operate the pump station. Table 2 below shows how the values for demand, reservoir volume, and hydraulic grade lines (HGL) are split between the existing West View pump station and the proposed North Ogden booster pump station.

Table 2. Unit I Pump Station Summary

Category	Total Unit I	West View Pump Station	North Pine Pump Station
Total Area	2,753 Acres	1,025 Acres	1,728 Acres
Existing Developed Area	888 Acres	398 Acres	490 Acres
Existing Peak Instantaneous (8.5 gpm/developed acre)	7,550gpm	3,386 gpm	4,164 gpm
Future Developed Area	2,464	398 Acres	2,066 Acres
Future Peak Instantaneous (8.5 gpm/developed acre)	20,950 gpm	3,386 gpm	17,564 gpm
Reservoir Volume	28.0 Ac-ft	7.5 Ac-ft	20.5 Ac-ft
HGL (From pump station)	-	4,529 ft	4,506 ft

To meet the agricultural demands on the system, a 20.5 acre-foot irrigation water storage pond will need to be constructed in the North Pine Reservoir and 7.5 acre-feet will be stored in the existing West View Reservoir. A pump station will also need to be constructed that

is capable of delivering the required peak day and peak hour demands and match the existing system pressure.

D.6 Flooding and Breach Risk Analysis

The potential impacts to downstream structures and people due to a breach of the dam were evaluated. The flood inundation analysis consists of modeling a breach of North Pine Reservoir embankment under sunny day conditions per Technical Release 60 (TR-60) NRCS, 2005 and Utah Dam Safety criteria. The study, inundation maps, model information and report are contained in Technical Memo No. 002 Flooding and Risk Analysis prepared by J-U-B.

The majority of the water storage, 19.1 acre-feet, is below natural ground with 9.1 acre-feet above natural ground to the principal spillway.The embankment height is 5.5 feet above natural ground with a maximum water depth of 3.5 feet above natural ground. A breach of the embankment will flow through residential, commercial, and agricultural properties. The peak breach discharge flowrate is 850 cfs. The inundation area covers approximately 83 acres and affects 219 homes (210 homes < 1 foot and 9 homes > 1 foot). and 5 roads. The population at risk (PAR) is 27 people with a fatality rate of 0 people. The structure has been preliminarily classified as a low hazard dam by NRCS. The Utah Division of Dam Safety has preliminarily classified the dam as a low hazard dam. The Utah Division of Dam Safety cannot finalize their classification until final construction plans are submitted.

D.7 Sedimentation

The North Ogden Project will relocate and enlarge an existing North Ogden City detention pond. The existing detention pond has been in service for several years and has not had issues with sediment in the pond. WBECD will construct a 20.5 acre-foot storage pond on their system. The water for the irrigation pond comes through their canal system with a minimal sediment load. The pond will be concrete lined. Any sediment coming into the pond will be removed annually.

D.8 Geotechnical Analysis

A Geotechnical study of the North Pine Reservoir site was completed in 2017. Refer to the Geotechnical Engineering Report, North Ogden Duo Use Reservoir, 2350 North 150 East North Ogden, Utah prepared by Teracon Consultants, Inc, Terracon Project No 61175090 dated August 13, 2017.

Three borings were conducted on the site to depths of 7 to 23.5 feet below the existing ground surface using a truck-mounted hydraulic drill rig. One Cone Penetrometer Test was completed to a depth of 20 feet below existing grade. Samples of the soil encountered in the borings were obtained using the split barrel and modified California ring sampling procedures.Samples were tested in the laboratory. These tests included natural moisture content, dry density, liquid and plastic limit determinations, mechanical gradations, one-dimensional collision tests, pH, resistivity, and soluble sulfate content.

Laboratory tests on a representative sample showed a resistivity value of 4,290 ohm-cm and pH measure value of 8.20 Water soluble sulfate testing showed a value of 6.85 parts per million and chloride at 8.16 parts per million. On-site soils are not considered aggressive to buried steel based on laboratory test results. Based on the test results, sulfate exposure to concrete appears to be negligible.

The site borings showed fill and topsoil for the top 0.5 feet. Below the topsoil, layers of lean clay extended to the bottom of the borings. Groundwater was encountered approximately 3 to 5 feet below the existing surface. Groundwater elevations will fluctuate depending on the season, snow melt, irrigation, etc.

The berm around the pond should be constructed using low permeability lean clay soils. The native lean clays may be used if the amount passing the #200 screen is in excess of 75%. The materials, construction and compaction methods should meet the requirements of the geotechnical report.

The geotechnical report contains guidelines for the materials and construction methods for the buildings, trails, and parking lots on the site. Refer to the geotechnical report for these guidelines.

D.9 Seismic Analysis

A seismic study was completed as part of the geotechnical report. For the seismic design, the soils were classified as Site Class E. Table 3 gives the seismic design considerations for the North Pine Reservoir Site from the geotechnical report. The embankment needs to be designed to meet these loadings and the NRCS and Utah Division of Dam Safety seismic design requirements.

Table 3. Seismic Considerations

DESCRIPTION	VALUE
2012 International Building Code Site Classification (IBC)	E
Site Latitude	41.30175
Site Longitude	-111.97715
So PGA	0.629 g
Ss Spectral Acceleration for a Short Period	1.480 g
Ss Spectral Acceleration for a 1-Second Period	0.539 g
Fa Site Coefficient for a Short Period	0.900
Fv Site Coefficient for a 1-Second Period	2.400

The property is located within the Intermountain Seismic Belt where the potential for active faulting and related earthquakes is present. Based upon published geologic maps, no active faults travers through or are immediately adjacent to the site. The site is not located within local fault study zones. The nearest mapped fault trace is the Wasatch Fault locate about 2 miles east of the site.

According to liquefaction maps for Weber County, the site is located within an area designated as "Moderate to High" in liquefaction potential. Based on the subsurface soil conditions and laboratory results, soils vulnerable for potential liquefaction were not encountered within boring locations.

D.10 Water Quality

The water for the irrigation pond is supplied from Pineview Reservoir and from the Ogden River. The flood water in the detention pond that will be combined with the irrigation water and will need to be monitored to ensure that the agricultural water is not contaminated. With the flood water filling the detention pond only during storm events, it is not anticipated to cause water quality issues with the irrigation water.

D.11 Alternatives

Alternatives that were investigated as part of the study include No Action, constructing a smaller combined irrigation and flood control pond, construction of the pond on a different site, and only constructing the irrigation pond. The preferred alternative gave the greatest benefit to the systems and population in North Ogden City by combining the needed ponds from both systems into one. Refer to the Plan-EA for a more detailed discussion on the alternatives.

D.12 Preferred Alternative Cost Estimate

The cost estimate for the preferred alternative is $15,224,407.50. The cost estimate is broken out in Table 4 Agricultural Water Management, Table 5 Flood Control and Dentention Facilities, and Table 6 Recreational Facilities.

Table 4. Agricultural Water Management

Item		Quantity 2/	Units	Estimated Unit Cost 3/	Total Construction Cost 4/
1	Excavation and haul off for irrigation pond	34,500	Cubic Yard	$25.00	**$862,500**
2	6" Reinforced concrete Pond liner	131,100	Square Foot	$20.00	**$2,622,000**
3	Drainage below pond liner	1	Lump Sum	$200,000.00	**$200,000**
4	Supply piping	1	Lump Sum	$75,000.00	**$75,000**
5	Site Preparation	1	Lump Sum	$20,000.00	**$20,000**
6	Traveling Screen	1	Lump Sum	$80,000.00	**$80,000**
7	SCADA	1	Lump Sum	$40,000.00	**$40,000**

Item		Quantity 2/	Units	Estimated Unit Cost 3/	Total Construction Cost 4/
8	Dewatering	90	Days	$500.00	**$45,000**
9	Irrigation pump house and inlet structure	1	Lump Sum	$2,500,000.00	**$2,500,000**
10	Ramp from parking lot to irrigation pond	460	Square Foot	$8.00	**$3,680**
11	Distribution piping	1	Lump Sum	$300,000.00	**$300,000**
12	Electrical service	1	Lump Sum	$60,000.00	**$60,000**
	Construction Subtotal				**$6,808,180**
	Construction Contingency	15%			**$1,021,227**
	Construction Total				**$7,829,407**
	Engineering (8% Design, 8% Construction)	16%			**$1,089,309**
	Project Admiration (NRCS)	4%			**$272,327**
	Project Admiration (Sponsor)	1	Lump Sum		**$4,000**
	Permits	1	Lump Sum		**$15,000**
	Total Agricultural Water Management				**$9,210,043**

Table 5. Flood Control and Dentention Facilities

Item		Quantity	Units	Estimated Unit Cost	Total Construction Cost
1	Mobilization and SWPPP	1	Lump Sum	$60,000.00	**$60,000**
2	Excavation and haul off for detention	37,333	Cubic Yard	$25.00	**$933,325**
3	Clear and grub temporary access roadway. Haul and dispose of materials.	450	Linear Foot	$4.00	**$1,800**

Item		Quantity	Units	Estimated Unit Cost	Total Construction Cost
4	Temporary 12' wide gravel access road	450	Linear Foot	$35.00	**$15,750**
5	Basin outlet control structure	1	Each	$30,000.00	**$30,000**
6	Emergency overflow	1	Each	$15,000.00	**$15,000**
7	10' rock apron around edge of water	1,300	Ton	$90.00	**$117,000**
8	Chain link fence around detention basin with privacy slats	1,650	Linear Foot	$40.00	**$66,000**
9	15" RCP Pipe	268	Linear Foot	$110.00	**$29,480**
10	24" RCP Pipe	2,650	Linear Foot	$150.00	**$397,500**
11	54" RCP Pipe	1,050	Linear Foot	$260.00	**$273,000**
12	54" flared end section	1	Lump Sum	$5,000.00	**$5,000**
13	Lower existing 36" RCP Pipe	500	Linear Foot	$125.00	**$62,500**
14	Catch basins	14	Each	$4,500.00	**$63,000**
15	Manhole	6	Each	$10,000.00	**$60,000**
16	72" diameter manhole	1	Each	$15,000.00	**$15,000**
17	8'x8' junction box	3	Each	$15,000.00	**$45,000**
18	Basin inlet control structure and sediment trap	1	Each	$50,000.00	**$50,000**
19	Surface improvements on 2600 North (repair UDOT sidewalk, park stirp, etc.)	1	Lump Sum	$8,000.00	**$8,000**
20	Re-Grading at 2550 N basin	1	Lump Sum	$5,000.00	**$5,000**

Item		Quantity	Units	Estimated Unit Cost	Total Construction Cost
21	Asphalt patch	900	Square Feet	$8.00	**$7,200**
	Construction Subtotal				**$2,259,555**
	Construction Contingency	15%			**$338,933**
	Construction Total				**$2,598,488**
	Engineering (8% Design, 8% Construction)	16%			**$361,529**
	Project Admiration (NRCS)	4%			**$90,382**
	Project Admiration (Sponsor)	1	Lump Sum		**$4,000**
	Permits	1	Lump Sum		**$15,000**
	Total Flood Control and Detention				**$3,069,399**

Table 6. Recreational Facilities

Item		Quantity 2/	Units	Estimated Unit Cost 3/	Total Construction Cost 4/
1	Clear and grub roadway. Haul and dispose of materials. Fine grade and prepare site.	450	Linear Foot	$10.00	**$4,500**
2	Import fill material to subgrade	1,000	Ton	$22.00	**$22,000**
3	Construct roadway section	450	Linear Foot	$275.00	**$123,750**
4	Sanitary sewer Line	460	Linear Foot	$80.00	**$36,800**
5	Sewer manhole	2	Each	$8,000.00	**$16,000**

Item		Quantity 2/	Units	Estimated Unit Cost 3/	Total Construction Cost 4/
6	Parking lot	13,180	Square Foot	$5.00	**$65,900**
7	Wrought iron fence around basin at entry	450	Linear Foot	$65.00	**$29,250**
8	6 foot wrought iron entry gate	1	Each	$5,000.00	**$5,000**
9	30 foot wrought iron parking lot gate	1	Each	$15,000.00	**$15,000**
10	8' wide aphalt trail around top of berm	13,240	Square Foot	$4.00	**$52,960**
11	Linear playground Including safety surfacing	1	Lump Sum	$200,000.00	**$200,000**
12	Restroom	1	Each	$200,000.00	**$200,000**
13	Bowery (20' x 20')	1	Lump Sum	$165,000.00	**$165,000**
14	Circular pavilion	1	Lump Sum	$40,000.00	**$40,000**
15	Concrete stairs	1,000	Square Foot	$20.00	**$20,000**
16	Trees	218	Each	$450.00	**$98,100**
17	Shrubs	98	Each	$75.00	**$7,350**
18	Landscaping fabric and bark	3,100	Square Foot	$5.00	**$15,500**
19	Landscaping grass & sprinkler	87,450	Square Foot	$2.25	**$196,763**
20	Landscaping fabric and rock	12,520	Square Foot	$6.00	**$75,120**
21	Park benches on concrete slab	18	Each	$1,500.00	**$27,000**
22	Picnic table on concrete slab	5	Each	$2,500.00	**$12,500**
23	Suspended concrete observation platform with guardrail	2	Each	$100,000.00	**$200,000**

	Item	Quantity 2/	Units	Estimated Unit Cost 3/	Total Construction Cost 4/
24	Cantilever pergola	2	Each	$175,000.00	**$350,000**
25	Park area lights	10	Each	$5,000.00	**$50,000**
26	Bypass pump and waterfall feature	1	Lump Sum	$95,000.00	**$95,000**
27	Park information signs	1	Lump Sum	$5,000.00	**$5,000**
28	Park entry monument sign	1	Lump Sum	$15,000.00	**$15,000**
29	Park security equipment	1	Lump Sum	$35,000.00	**$35,000**
	Construction Subtotal				**$2,178,493**
	Construction Contingency	15%			**$326,774**
	Construction Total				**$2,505,267**
	Engineering (8% Design, 8% Construction)	16%			**$348,559**
	Project Admiration (NRCS)	4%			**$87,140**
	Project Admiration (Sponsor)	1	Lump Sum		**$4,000**
	Permits	0	Lump Sum		**$0**
	Total Recreation Facilities				**$2,944,966**

D.13 Economic Evaluation

Benefits were calculated for flooding reduction, water conservation, and recreation. Flood damage reduction benefits were assessed based on the equivalent annual damage reduction expected through implementation of the With Project Alternative (Action Alternative) as compared with the Without Project Alternative (No Action Alternative) baseline. Assumptions and calculations of flood and watershed protection damage reduction benefits are provided below. Benefits for water conservation are based on the market value of water in the project area. Recreation benefits are based on estimated usage of new facilities and the value of fishing trips estimated by academic studies and state natural resource agencies.

D.13.1 Damage Reduction Benefits

Damage reduction benefits were calculated for flooding and watershed protection. Benefits were assessed based on the equivalent annual damage reduction expected through implementation of the With Project Alternative (Action Alternative) as compared with the Without Project Alternative (No Action Alternative) baseline. Assumptions and calculation of flood and watershed protection damage reduction benefits are provided below.

D.13.2 Flood Damage Reduction Benefits

The Without Project Alternative does not include flood protection measures. The With Project Alternative includes a new storage reservoir and stormwater drain improvements that will reduce flood levels. The period of analysis for all alternatives is 102 years, accounting for a 100-year project life, and a 2-year installation period. All costs and benefits were discounted to a net present value, then annualized over the 100-year evaluation period using the FY2020 Federal Water Resources Discount Rate of 2.75%. Average annual flood damages were calculated using the cumulative probability method as specified in the URB1 manual (SCS 1990). The 10-, 25-, 50-, 100-, and 500-year storm events for each alternative were modeled using WMS. Mapping of the flood extents, and inundation to structures, transportation infrastructure, and lands was calculated through GIS analysis. Inundated structures were classified into one of three categories: inundated 1 to 2 feet, inundated 2 to 3 feet, or inundated 3 feet or more, for each storm event. Depth-damage functions were collected from the U.S. Army Corps of Engineers (USACE 1985 and 1992) to use for each type of structure. These types included permanent homes, commercial buildings, and apartments. Most of the structures damaged were homes. The majority of the homes in the damage area are one-story no basement, so this damage function was used as a proxy for all homes inundated. For the commercial buildings and apartments, separate damage functions were used. Average values for structures were calculated from data collected from property tax records. Due to the high number of homes affected, a sample of these was used. A replacement value was estimated for each structure based on this data to apply to the depth-damage functions. Contents values were estimated at 50 percent for homes and apartments, and 100 percent for businesses. The tables below show the number of structures inundated for both the with and without project condition, and average annual damage calculations.The 10- and 25- year events are omitted as there was basically no inundation or change in inundation.

Table 7. Buildings Inundated without Project Alternative

Event	Homes	Commercial	Apartments	Present Value Total	Average Annual Total
50 Year	45	0	0	$ 7,144,494	$ 71,445
100 Year	58	8	0	$ 16,456,937	$ 131,655
500 Year	282	12	0	$ 45,674,538	$ 91,349
Total					$ 294,450

Table 8. Buildings Inundated with Project Alternative

Event	Homes	Commercial	Apartments	Present Value Total	Average Annual Total
50 Year	0	0	0	$ -	$ -
100 Year	49	6	0	$ 10,088,635	$ 80,709
500 Year	254	11	0	$ 38,682,079	$ 77,364
Total					$ 158,073

The benefit is the difference between the existing and with project condition, or $136,376. This value was discounted to a present value and amortized over the project life, 100 years. Agricultural flood damage was estimated using procedures outlined in SCS Technical Note UD-28 (SCS 1972). Monthly damage factors for hay were used for estimation, as the land inundated was pasture. A 2018 enterprise crop budget for alfalfa hay was used from Ohio State University to estimate an annual return per acre. A monthly flash flood distribution for Utah was estimated from the National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NWS WR-147 (NOAA 1979). Using the damage factors, crop value, and flood distribution, a weighted per acre damage was estimated. This was applied to the acres flooded by storm event to arrive at an average annual flood damage for agricultural land. There is uncertainty in using older data for precipitation, however for this analysis this was the best data available. The average annual damage came to about $90 per acre in average annual figures.

D. 13.3 Floodwater

Table 5 provides floodwater damage reduction benefits calculated for the With Project and Without Project Alternatives, and the resulting damage reduction.

Table 9. Floodwater Damage Reduction Benefits

Item	Estimated Average Annual Damage Reduction Benefits[1]		
	With Project	Without Project	Damage Reduction
Residential	$265,600	$137,600	$128,000
Commercial	$27,800	$19,900	$7,900
Crop and Pasture	$200	$100	$100
Total	**$293,600**	**$157,600**	**$136,000**

1-Price base 2023. Calculated using FY 2020 Water Resources Discount Rate (2.75%), annualized over 100 years, using a 102-year period of analysis.

D.13.4 Water Efficiency

Project measures are projected to save 1,674 acre-feet per year. This will free up additional water for irrigation usage. This was estimated to create a benefit of .5 tons increase in yields on irrigated lands, which was estimated at approximately 5,400 acres. This equates to $380,366 in additional income per year.

D.13.5 Recreation

The proposed action alternative would create additional recreation opportunities in the form of open space, a walking path, public amenities, a children's playground, restrooms, kayaking, paddle boarding, and public parking around the newly formed reservoir. In order to assess the economic impact of increased recreation opportunities from the project measures, data from a previous study was utilized. The study for the construction of the Dry Creek Reservoir in Utah looked at three water bodies of similar size and amenities, namely Salem Pond (17 acres), Willow Pond (4 acres), and Tibble Fork (10 acres). The Utah Department of Wildlife Resources (UDWR) surveyed anglers at these water bodies for several months to estimate future usage, resulting in an average number of trips per month. Using this information, a projected annual usage was estimated for the proposed North Ogden reservoir (1,483 trips per year).

Blue Ribbon Fisheries (BRF) are waters that provide highly satisfying fishing and outdoor experiences for diverse groups of anglers and enthusiasts. Blue Ribbon status indicates that a water has been reviewed by UDWR biologists and the Advisory Council, and can provide high fishing quality, quality outdoor recreational experiences, quality fish habitat and economic benefits at the regional scale (Kim, 2013).

The Department of Applied Economics at Utah State University (Kim, 2013) reported a $84 per trip value for fishing at Blue Ribbon Fisheries (BRF) in Utah. The UDWR referenced this value in estimating the economic value of ponds in Utah. They indicated that visits to water bodies like the ones surveyed, and the proposed North Ogden reservoir, would not qualify as a visit to a BRF. They suggested for the former project (Dry Creek) a value of $40 per trip. To be conservative, a value of $20 per trip was used to estimate the benefits of this project, accounting for the fact that usage would most likely be local, and pull existing usage from other local water bodies. Also, data from the previous study was for angling,

while usage at the proposed North Ogden reservoir would be non-angling activities. 1,483 trips per month x $20/trip equates to $29,659 per month. Multiplied by nine months of usage per year equates to $267,000 per year. This figure was discounted to a present value, then annualized over 100 years.

D.13.6 Benefit Cost Ratio

The total project average annual economic benefit is $749,100 for the Preferred Alternative, and the benefit cost ratio is 1.31. The Net Annual Economic Benefit for the Preferred Alternative is $175,200. Table 10 provides the calculated annual benefits, costs, benefit cost ratios, and net annual benefits for each of the project measures.

Table 10. Benefit Cost Ratios[1]

Project Measure	Total Annual Benefits	Total Annual Costs	Benefit Cost Ratio	Net Annual Economic Benefit
Agricultural Water Management	$360,300	$328,200	1.10	$32,100
Flood Control	$136,000	$88,600	1.53	$47,400
Recreation	$252,800	$157,100	1.61	$95,700
Total	**$749,100**	**$573,900**	**1.31**	**$175,200**

1- Price base 2023. Calculated using FY 2020 Water Resources Discount Rate (2.75%), annualized over 100 years, using a 102-year period of analysis.

D.14 References

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