Technical Memorandum

To: Papio-Missouri River NRD
From: FYRA Engineering
Re: Dam Sites WP-6&7 Technical Memorandum
Date: 301 October 2015

1 INTRODUCTION

This technical memorandum (TM) was prepared to summarize the results of the preliminary design efforts associated with the initial design study for the West Branch Papillion Creek Regional Detention structures 6 and 7 (hereinafter referred to as WP-6 and WP-7.)

2 BACKGROUND

Sites WP-6&7 were identified in the Papillion Creek Partnership's Watershed Management Plan to provide regional detention in the Papillion Creek Watershed. This sub-watershed is one of the most rapidly developing watersheds in the metropolitan area and these sites were selected at the time the Plan was developed to maximize flood control, given what open ground remains in the area. These two sites were at the top of the list of the NRD's re-prioritization study recently conducted.

The NRD desired a preliminary design and feasibility report to identify the land rights needed to construct the dams, identify any potential synergies with the grading of the adjacent developments, and the appropriate land rights could be set aside for dam construction while final design and permitting phases of the dam were conducted. This TM is a result of that effort.

2.1 SITE WP-6

Site WP-6 is situated north of Cornhusker Road between 114th and 120th Streets in Sarpy County. The dam is located in the eastern extents of the property to maximize the controlled drainage area. See Figure 1. At this location, the dam controls approximately 1,270 acres drained by Schram Creek. The main parcel where the dam is located is currently in agricultural production. There is interest in the land outside of the proposed dam land rights boundaries within the parcel, but no formal platting process has been initiated. Piecemeal development is occurring all around the parcel on all sides. See Synergies with Development section below.

Looking at Figure 1, improvements to the western part of Cornhusker Road between 114th and 120th Streets are anticipated in the near future. The crossing over Schram Creek offers an opportunity to create a water quality basin upstream (south) of Cornhusker Road. (See Reservoir Sustainability write up below.) All other surrounding arterials are already improved.

2.2 SITE WP-7

Site WP-7 is situated south of Cornhusker Road and east of 108th Street in Sarpy County. The dam is located in the northern extents of the property to maximize the controlled drainage area. See Figure 1. At this location, the dam controls approximately 470 acres drained by an unnamed tributary to Schram Creek. The main parcel where the dam is located is currently in agricultural production. Residential developments planned around the dam and reservoir are currently undergoing the platting process. See Synergies with Development section below.

Looking at Figure 1, improvements to Lincoln Road from 114th east is anticipated in the near future. The area upstream (south) of the crossing over the unnamed tributary is already developed close to the stream alignment, which limits the opportunity to create a water quality basin south of Lincoln Road. Options on the downstream side of the road were pursued (See Reservoir Sustainability write up below). Cornhusker Road will be improved to the north. Some dam alternatives analyze incorporating the roadway into the dam embankment. All other surrounding roadways are part of residential developments that are already platted or in the platting process.

3 PROJECT HYDROLOGY

For the purpose of developing preliminary design alternatives, a rainfall-runoff model was prepared using HEC-HMS. The watersheds were broken down into multiple sub-basins to provide a working model that could be used for future land use changes as well as for assessing the potential changes in project hydrology of the frequent (less magnitude) events by water quality basins.

Different precipitation models were used to model the design storms considered for this exercise. The magnitude and source of those storms is shown in Table 1 below. See Appendix A for site specific data.

Table 1. Design Storm Information

Design Storm	Duration	Frequency	Rainfall (in)	Source
(PSH)	24 hours	0.2% (500-year)	9.82	NOAA Atlas 14
(PSH)	10 days	0.2% (500-year)	13.6	TP-49
(SDH)	Not Used			
(FBH)	6 hour	PMF	20.34	NE Statewide PMF Study
(FBH)	24 hour	PMF	23.82	NE Statewide PMF Study

4 PROJECT HYDRAULICS

For the Principal Spillway Hydrograph (PSH) routings, the HEC-HMS model was used, inputting a stage-discharge spillway rating curve exported from a separate SITES model. The model used a 48" diameter lined cylinder pressure pipe with a standard NRCS design Dx3D concrete riser. The HEC-HMS model was then used to calculate reservoir elevations during the PSH event. Stage-volume reservoir relationships were developed using available LiDAR topographic data.

Due to the lack of geotechnical information available at this time, a Spillway Design Hydrograph runoff model was not developed. During final design, this will be developed in which to perform a spillway integrity/stability analysis using WinDAM or a similar modeling suite. Preliminary analyses were performed using standard methods to assess attack and resistance calculations to provide preliminary design auxiliary spillway widths.

The SITES Model was also used to develop a stage-discharge rating curve for dam alternatives with an earth cut auxiliary spillway. For the fixed crest and fuse plug alternatives, similar stage-discharge curves were developed using spreadsheet-based calculations. This hydraulic information was input into the HEC-HMS model to route approximate maximum reservoir elevations during a PMF event. 6 and 24-hour duration events were all modeled with the most conservative (highest) maximum reservoir water surface serving as the PMF peak elevation. See Appendix B for site specific results for the alternatives assessed.

At this time, neither dam breach routings nor downstream constriction hydraulic routings were performed. Both will be a requirement of final design services.

5 RESERVOIR DESIGN

5.1 RESERVOIR SUSTAINABILITY

Because of the proximity of the reservoirs to planned development in the area, a significant emphasis was placed on analyzing the useful life of the future reservoirs. The main reservoirs themselves were planned using an adopted sustainability ratio of a minimum of 2.5%. This would indicate that the *area* of the planned reservoir was no less than 2.5% of the area of the contributing watershed. This corresponds to a 40:1 watershed to lake ratio (another statistic used in reservoir planning, and the simple inverse of the sustainability ratio). In addition to this statistic, the storage at the permanent pool (in watershed inches) was also assessed. This information is presented in Table 2 below with similar information for Walnut Creek Lake (Papio Dam Site 21), Prairie Queen Lake (WP-5) and Dam 15-A. The permanent pool elevations selected for sites WP-6 and WP-7 based on the information presented in Appendix C.

Table 2. Sustainability Analysis Summary

	WP-6	WP-7	Walnut Creek Lake	Prairie Queen Lake	Dam Site 15-A
Lake Size (acres)	34.3	12.5	105	125	225
Drainage Area (acres)	1,270	470	2,112	3,320	7,104
Volume of Permanent Storage (acre-ft)	240.5	71.2	1,041	1,660	2,060
Watershed/Lake Area	37	38	20	27	32

Sustainability (%)	2.7%	2.7%	5%	3.8%	3.2%
Storage (WsIn)	2.3	1.8	5.9	6.0	3.5

5.2 WATER QUALITY BASINS

Incorporating water quality basins upstream of the reservoirs can have a major impact on reservoir sustainability. The primary function of a water quality basin is to trap sediment upstream of the reservoir and prevent transport of this material into the main body. This concentrates the material into a smaller, more manageable location and prevents reduction of the water volume in the reservoir, which is beneficial to maintaining water quality and planned lake depths. Pollutant load reductions can be expected, specifically those with the affinity to adhere to sediment particles that will settle out. When designed correctly, water quality basins can also reduce the dissolved pollutant loads through biological uptake of wetland vegetation (although to realize the full benefit this must be paired with a wetland harvesting maintenance plan). A water quality basin can also extend the time it takes for water to transfer into the lake, providing additional die off time for bacteria. Any increase in surface area provided by the water quality basin provides more UV contact that helps reduce bacteria counts.

A few minor additions can be incorporated into the basin design to improve the basin's function. The configuration of the riser structure can increase the drawdown time for smaller events that often have the greatest impact on water quality (generally the first 0.5 inches of runoff). In summary, additional earthwork grading that increases storage capacity, the creation of wetlands and increasing the surface area will collectively improve the basin's performance. These components were considered during the development of the water quality basin design concept for each site.

5.2.1 SEDIMENT LOADING

Both sites have watersheds currently transitioning from primarily agricultural to urban. A goal is to protect the main reservoirs at WP-6&7 to the greatest extent possible within the lands of the project and maximize the ability of the water quality basins to handle the transition period of the sediment loading to the site. To determine the water quality basin's ability to handle this transitioning period, a sediment load analysis was performed for each site. Assumptions that were applied include the following:

- The watershed will be developed from primarily agricultural to entirely urban within 10 years after the basins are implemented
- During development, control practices will contain 50% of the sediment load from the construction site
- The water quality basin will trap an average of 70% of the incoming sediment over its useful life

Collectively, these three factors guided recommendations for preliminary water quality basin sizes to be considered at the sites and explained below. The sediment loading for the first ten years will have a comparatively very high annual load, assuming development continues at its current rate. Once the watershed is completely urbanized, the sediment load drastically decreases, and more urban related pollutants will be the focus of concern. For the sediment loading calculations, see Appendix D.

5.2.2 SITE WP-6

Existing Conditions

The proposed water quality basin would be located where Schram Creek currently intersects Cornhusker road. The road embankment would be used to divide the water quality basin to the south from the main body of the reservoir. This crossing was previously identified as a road structure grade stabilization site S-22 by NRCS. The NRCS project was never constructed, but could potentially create opportunities for design coordination and additional funding during the final design phase. The drainage area to this location is 1,038 acres of what is currently, primarily agricultural ground. A 120" diameter reinforced concrete pipe (RCP) conveys the Schram Creek flows beneath Cornhusker Road today.

Basin Sizing and Design

Table 3 shows the results of the sediment loading over 50 years when applying the assumptions described above and how much sediment would accumulate in the water quality basin over time.

Table 3. WP-6 Sediment Load Results

Year	Annual Sediment Volume (tons)	Sediment Accumulation (acre-ft)
1	4,289	3.4
2	3,899	6.5
3	3,508	9.3
4	3,118	11.8
5	2,728	14.0
6	2,338	15.9
7	1,947	17.4
8	1,557	18.7
9	1,167	19.6
10	507	20.0
11-50	42	20.0-20.6

A stage storage table for the proposed water quality basin was developed to compare the storage available behind Cornhusker Road to capture the accumulating sediment load.

Table 4. WP-6 Stage Storage

Elevation	Area (acre)	Volume (acre-ft)
1048	0.0	0.0
1050	0.1	0.1
1052	0.2	0.4
1054	0.4	1.0
1056	0.7	2.1
1058	1.2	3.9
1060	1.8	6.8
1061	2.1	8.7
1062	2.5	11.0
1063	2.8	13.6
1064	3.3	16.7
1065	3.7	20.2
1066	4.3	24.2
1068	5.7	34.3
1070	9.1	49.2
1072	12.3	70.6
1074	15.2	98.0
1076	18.9	132.1
1078	22.9	173.9
1080	27.4	224.2

The results indicate that 20.0 acre-ft of storage would capture the load associated with the upcoming development. This corresponds approximately with elevation 1065 in the stage storage table, which raises the permanent pool elevation of the water quality basin one foot higher than the planned permanent pool of the reservoir of 1064. A one foot raise in the permanent pool is a feasible option that has been accounted for in the hydraulic routings of the main dam. Preliminary modeling indicates this reduction in flood storage (due to volume of additional, permanent storage in the water quality basin) did not raise the 500-year PSH routing results, due to the rounding to the nearest half foot for control elevations. Elevation 1065 would provide adequate storage, however Table 4 indicates that the basin would be nearly full once the transition of the watershed is complete if no future excavation/maintenance is performed.

A water quality basin design concept at WP-6's Schram Creek/Cornhusker Road is illustrated in Figure 2. In order to raise the permanent pool to 1065, the existing road culvert would be replaced and raised to outlet above the main reservoir level. For increased trapping efficiency, the riser can be configured with a dual stage design or similar modification. No additional grading was included in preliminary quantities to create wetland features or additional storage capacity. These opportunities will be explored during final design. Coordination for Cornhusker Road improvements or development fill needs should be continued, and any borrow needs should be excavated from within the water quality basin.

A smaller, unnamed tributary to the WP-6 reservoir is located to the east. Cornhusker Road traverses the tributary and a 60" diameter RCP culvert controls 56 acres above Cornhusker Road. Because Cornhusker Road has already been improved in this location, additional modification of the site is not proposed as part of this project, nor would impact sediment loading to the main reservoir significantly. The area is forecasted to develop in the near future, and therefore it seems prudent to plan for the developer(s) to incorporate some stormwater management facilities in this area to reduce pollutant loading to the main reservoir.

5.2.3 SITE WP-7

Existing Conditions

There is plenty to consider when selecting a location for the WP-7 water quality basin near upstream end of the reservoir. As mentioned previously, development south of the proposed Lincoln Road limits the amounts of area and storage that could be allotted for the basin. The crossing at the current alignment of Lincoln Road is an existing NRCS grade stabilization structure, S-21, with the road on top of the embankment constructed for this site. The structure controls approximately 370 acres of drainage area through a 48" CMP with a 60" CMP riser. The area and storage capacity between the proposed Lincoln Road and the NRCS structure is also limited. It appears feasible to keep the NRCS structure in place and use the old current Lincoln Road alignment that will be abandoned as the new entrance into the recreation area around WP-7. This will be dependent on the future design of the new Lincoln Road. Therefore, it was concluded that the best option was to create a new embankment feature farther downstream in the upper reaches of the reservoir (to potentially be paired as a trail crossing, see the Recreational Facilities section below) in order have sufficient space to create the water quality basin. Moving the basin downstream increases the drainage area to approximately 415 acres.

Basin Sizing and Design

Table 5 shows the results of the sediment loading over 50 years when applying the assumptions described above and how much sediment would accumulate in the water quality basin over time.

Table 5. WP-7 Sediment Load Results

Year	Annual Sediment Volume (tons)	Sediment Accumulation (acre-ft)
1	1,719	1.4
2	1,562	2.6
3	1,406	3.7
4	1,250	4.7

5	1,093	5.6
6	937	6.4
7	780	7.0
8	624	7.5
9	468	7.8
10	203	8.0
11-50	17	8.0-8.3

A stage storage table for the water quality basin was developed to compare the storage available behind proposed embankment to capture the accumulating sediment load.

Table 6. WP-7 Stage Storage

Elevation	Area (acre)	Volume (acre-ft)
1046	0.0	0.0
1048	0.1	0.2
1050	0.2	0.5
1052	0.4	1.2
1054	0.6	2.3
1056	0.8	3.6
1058	0.9	5.3
1060	1.5	7.7
1062	2.2	11.5
1064	3.2	16.9

The results indicate that 8.0 acre-ft of storage would capture the load associated with the upcoming development. This storage would be achieved between 1060 and 1062, which is substantially higher than the planned permanent pool elevation of the reservoir of 1056. Any raise in permanent pool needs to be accounted for in the hydraulic routings of the main dam. Preliminary modeling indicates the reduction in flood storage from raising the water quality basin pool elevation all the way to 1062 did not raise the 500-year (PSH) routing results, due to the rounding to the nearest half foot for control elevations. By setting the pool elevation at 1060 and excavating the material needed to construct the embankment, at least one additional acre-ft of storage would be achieved, providing a minimum of 8.7 acre-ft of sediment storage capacity. With the additional excavation, deeper water and wetland features could be created within the basin. The basin would provide adequate storage to protect the reservoir during development, however Table 4 indicates that the basin would be nearly full once transition of the watershed is complete if no future excavation/maintenance is performed. This concept is illustrated in Figure 3.

5.2.4 LONGEVITY

As the sites' sediment loading and basin capacity indicate, both water quality basins could be near capacity after the first ten years. The basins would likely resemble a shallow wetland rather than an open water basin.

A key to balancing the challenges with the water quality of the basins and to a lesser degree, the main reservoir, is to manage expectations with what is feasible to deliver. A relatively small additional investment in improvements to the water quality basin can go a long way for extending the useful life of the main reservoir. However, the smaller the initial additional investments in the water quality basin, the sooner it can be expected to see deteriorating water quality in the basin. Managing those expectations through the education of the stakeholders and within the efforts of any watershed protection efforts conducted can help to minimize unrealistic expectations.

The most interested parties in the vicinity of the water quality basin are likely to be future homeowners in the area, although regular recreators from the area will also have a vested interest. For this reason, there is an excellent opportunities to work with developers and their grading and SWPPP/PCSWMP efforts to increase the volume in the basin area and therefore, the long term water quality. Some ideas are explored below in the Synergies with Development section.

5.3 WATER QUALITY EXPECTATIONS

If done properly, water quality planning on proposed recreational reservoirs can result in increased public awareness, enhanced fish and wildlife resources, a maximization of beneficial uses, extended reservoir life, and financial support for the project. Water quality data from the streams that will feed each reservoir has been collected over the last several months. This information will provide insight as to what uses the reservoirs can support in addition to aiding in reservoir design and watershed planning during final design and into the future as watershed protection practices are conducted.

5.3.1 SAMPLE COLLECTION AND TARGET PARAMETERS

One stream site at each proposed reservoir location was targeted for runoff sampling in anticipation of recreational features planned for each site that may include full body contact in the reservoir. A total of six runoff events were sampled between the dates of May 9, 2015 and August 4, 2015 at both sites. Samples were collected in accordance with monitoring procedures utilized by the Nebraska Department of Environmental Quality. Parameters monitored at both sites include total suspended solids, suspended sediment, total nitrogen, total phosphorus, *E.coli* bacteria, atrazine, acetachlor, and metolachlor. The analysis of bacteria and pesticide samples was performed by the Nebraska Department of Environmental Quality while sediment and nutrient samples were analyzed by the Nebraska Department of Health and Human Services Environmental Laboratory. Results are displayed in Appendix E.

5.3.2 DATA USAGE

Water quality planning efforts for both reservoirs will include defining the scope, duration, magnitude, and extent of potential problems. Water quality information gathered in the first phase of this project will serve as the basis for the following next steps during final design:

- estimate annual pollutant loads,
- estimate reservoir loading capacity based on reservoir volumes,
- establish reservoir water quality goals based on beneficial uses,
- identify pollutant load reductions needed to meet water quality goals, and
- develop strategies to address pollutant sources.

Beneficial uses provided by each reservoir, as defined by Nebraska Water Quality Standards, will include Aesthetics, Primary Contact Recreation, and Aquatic Life. While both reservoirs will have the primary contact recreation designation (i.e. swimming), Site 6 has been targeted for possible development of this use.

5.4 FISHERY ENHANCMENTS

Similarly, some fishery enhancements and reservoir grading for dam embankment borrow are likely to occur, but are most likely going to be confined to the main reservoir to improve lake depths, add depth diversity, and provide a borrow source close to the dam to reduce hauling costs.

6 DAM EMBANMKMENT DESIGN

6.1 DAM TYPES

The NRD wishes to identify any project features that can provide any cost savings. For this reason, three dam types were identified to be investigated.

A "traditional" layout of a dam with auxiliary spillway was studied at each dam location. This dam type represents all of the Papio Creek Watershed dams built to date. The earthen dam would possess outlet works with a principal spillway constructed of concrete pressure pipe, reinforced concrete riser and a reinforced concrete energy dissipation basin. The earth cut auxiliary spillway would be excavated around the dam abutment to convey less frequent flows during extreme runoff events. The auxiliary spillway also provides borrow required to build a portion of the dam embankment. One advantage of this configuration is that flood control is maximized and that it is a design that most dam owners and designers are very familiar with. Drawbacks are that the auxiliary spillways can encompass costly real estate and act as a barrier to transportation corridors and other land uses in an urban environment. The auxiliary spillway configuration also can have a significant effect on the dam alignment and position.

A "fixed crest" spillway was studied at each site. This configuration has a (usually) level concrete weir in which flood flows pass over. The flow is conveyed in an open rectangular concrete channel often referred to as a "chute." Energy dissipation is incorporated into the chute design. Advantages of this dam configuration include the lack of an earth cut auxiliary spillway which makes the land required for the dam area much smaller. The lack of borrow from the earth cut spillway allows the reservoir to serve as a borrow source Flexibility in the location of the dam alignment is also a plus. Drawbacks are that the flood reduction benefits can be somewhat reduced, depending on the design of the permanent and auxiliary outflow crests (if even separate.) If the fixed crest spillway is set at the permanent pool elevation, a principal spillway conduit is not required. In this design the fixed crest will be set at the 500-year PSH elevation, and since the flood storage between the permanent pool and auxiliary spillway is incorporated into the design, a principal spillway conduit is required and the same flood control benefits as the other spillway configurations analyzed will be achieved.

A "fuse plug" spillway is also a dam without an earth cut auxiliary spillway. This dam configuration incorporates a rectangular concrete chute into the dam embankment, but the chute is blocked, or "plugged" with a "fuse" built of clay and sand that is designed to overtop at a pre-determined elevation and erode away, therefore opening the chute up to the reservoir where flood flows can pass. A series of images to explain this process are included as Figure 4. One advantage of this dam configuration are that there is no earth cut auxiliary spillway which provides similar benefits to those described above in the fixed crest spillway description. The fuse plug, because it erodes away and exposes a greater flow depth than the fixed crest spillway, saves concrete in the chute design and can reduce the length of bridges that may need to span the spillway. Like the fixed crest spillway, since flood storage is incorporated into the dam design, it can provide the same flood control benefits as a traditional dam with an earth cut auxiliary spillway. Disadvantages are that if the fuse ever fully erodes, it will have to be rebuilt. The cost of rebuilding the fuse would not be prohibitive, and is not likely to happen at frequent intervals.

6.2 DAM ALIGNMENTS

Multiple dam centerline alignments were studied that facilitate the dam type most suitable for the site. Whenever a dam alignment moved, changes to reservoir sustainability and permanent pool elevation, stage storage, reservoir routings and land rights requirements were reassessed. One of the largest challenges was moving dams upstream to allow an auxiliary spillway return flow path to reach the flood plain. In a rapidly developing urban environment, often the expenses to move the dam upstream were cost prohibitive (due to impacts of existing infrastructure) or land rights were not available. In such small watersheds, even small changes in dam alignment can have a significant effect on the above.

6.3 TEMPLATE DESIGN

The dam templates were designed with several factors in mind as discussed below moving from the upstream side of the embankment to the downstream side (see Figure 5 for a typical maximum section and principal spillway section);

The upstream 4H:1V slope connects the existing ground with the flat, ten foot wide buttress that is designed to hold the riprap protection for the permanent pool. The height of the riprapped slope is a function of the required wave protection above and below the permanent pool elevation for the dam which is configured based upon fetch length and effective wave height. The 3H:1V slope above the buttress connects the buttress to the twelve foot wide, 24H:1V access berm which provides vehicular access across the face of the dam for maintenance and inspection. The access berm will be surfaced with aggregate. The 3H:1V slope above the access berm connects the access berm to the fourteen foot wide top of dam. The top of dam will be sloped 2% back towards the reservoir upon final grading. On the downstream side of the dam, the 3H:1V slope connects the top of dam with the top of the stability berm. The 100' wide, 50H:1V stability berm provides slope stability protection for the dam. The 3H:1V slope connects the stability berm to the downstream existing ground.

6.4 DAM ALTERNATIVES SUMMARY

In summary, after preliminary meetings with NRD staff and management, four dam configurations were studied for WP-6 and four were studied for WP-7. A summary of the dam alternatives considered are shown in the tables below.

Table 7. WP-6 Summary of Studied Alternatives

Alternative	Description
6-1	Fuse plug spillway
6-2	Fixed crest spillway
6-3	Earth cut spillway (optimized configuration of original concept)
6-4	Earth cut spillway - upstream alignment (not advanced into analysis stage)

Table 8. WP-7 Summary of Studied Alternatives

Alternative	Description
7-1	Fuse/fixed crest spillway with road on top of dam alignment (not advanced into analysis stage)
7-2	Fuse plug spillway - road on stability berm
7-3	Fixed crest spillway - road on stability berm
7-4	Earth cut spillway - upstream alignment (optimized configuration of original concept)

Each site had an alternative that was not taken into a more detailed analysis stage upon discussions with the P-MRNRD. In brief summary, different dam alignments were assessed for each site. Placing the dam as far downstream as possible will maximize the flood control benefits and create a larger pool that maximizes water quality and recreation opportunities. Alignments were moved upstream to assess any improvement to the hydraulics of a conventional earth cut auxiliary spillway. However, Alternative 6-4 for WP-6 had too large of a reduction in flood control and pool size with the upstream alignment, and the P-MRNRD was not interested in pursuing this option. All the alternatives taken into the next analysis stage for WP-6 are on the same downstream alignment. For WP-7, Alternative 7-1 had greater potential permitting impacts and risk concerns with the road on the top of the dam, and was eliminated from consideration. A description of the alternatives moved into the analysis stage are described in the following sections, and the detailed layouts are shown in Figures 6-13. All alternatives include a 48" principal spillway pipe and impact basin and all auxiliary crests were set at the routed 500-year PSH elevation.

6.4.1 WP-6 Alternative 6-1

This alternative used the most downstream dam alignment and incorporated a 25-foot wide fuse plug auxiliary spillway within the northern end of the earthen embankment. The fuse plug spillway aligns with the twin 12' x 12' box culverts downstream, and the footprint of the dam and spillway is limited to embankment and channel area since there is no auxiliary spillway cut into the abutment. Hydraulic routings resulted in a lower top of dam (elevation 1078.5) than the following alternatives due to the hydraulic capacity of the fuse plug spillway during design flood events. The location of this embankment maximizes flood control and the potential water quality at the site by controlling as large a drainage area as possible and creating as large of a reservoir as possible within the available land rights.

6.4.2 WP-6 Alternative 6-2

Alternative 6-2 is very similar to Alternative 6-1. The same downstream dam alignment was used and the auxiliary spillway is also located within the earthen embankment, but in the form of a fixed crest spillway. The fixed crest weir requires a wider spillway width than the fuse plug to in order to increase the flow capacity and keep the top of dam elevation relatively low. A 60-foot wide fixed crest spillway resulted in a top of dam elevation of 1081. The flood control and water quality benefits would be the same due to the same dam alignment and permanent pool elevation.

6.4.3 WP-6 Alternative 6-3

This alternative also used the most downstream alignment possible to construct the dam embankment and auxiliary spillway upstream of 114th Street. The dam embankment is a "traditional" layout with a 150-foot conventional, earth cut auxiliary spillway. The auxiliary spillway fits well north of the dam in the site west of 114th Street, and although there is not a large, open return path for the auxiliary spillway flow, the area between the dam embankment and the twin 12' x 12' box culvert will be flooded during any sizable auxiliary spillway flows and will help to dissipate energy from the auxiliary spillway flow. The flood control and water quality benefits would be the same due to the same dam alignment and permanent pool elevation.

6.4.4 WP-7 Alternative 7-2

This alternative used the downstream dam alignment that locates the proposed Cornhusker Road alignment on the stability berm on the downstream side of the dam. A 25-foot wide fuse plug auxiliary spillway is located within the eastern end of the earthen embankment that would require a bridge where Cornhusker Road traverses the spillway chute. The footprint of proposed spillway is contained within the limits of the embankment since there is no auxiliary spillway cut into the abutment, which reduces required land rights in the area. Hydraulic routings resulted in a lower top of dam (elevation 1071.5) than the following alternatives due to the high hydraulic capacity of the fuse plug spillway during design flood events. The location of this embankment maximizes flood control and the potential water quality at the site by controlling as large a drainage area as possible and creating as large of a reservoir as possible within the available land rights. Using the wider downstream stability berm versus the top of dam also reduces stream impacts by not having to widen the top of dam to accommodate the roadway and bridge.

6.4.5 WP-7 Alternative 7-3

Alternative 7-3 is very similar to Alternative 7-2. The same downstream dam alignment was used and the auxiliary spillway is also located within the earthen embankment, but in the form of a fixed crest spillway. The fixed crest weir requires a slightly wider spillway width than the fuse plug in order to increase the flow capacity and keep the top of dam elevation relatively low. A 35 foot wide fixed crest spillway resulted in a top of dam elevation of 1072. The flood control and water quality benefits would be the same as Alternative 7-2 due to the same dam alignment and permanent pool elevation.

6.4.6 WP-7 Alternative 7-4

It is not feasible to place the traditional dam and conventional earth cut spillway on the downstream alignment. Land rights and utilities presented challenges, but the primary reason is due to the complications of the roadway geometrics required to route a roadway through the earth cut spillway. Design requirements of the roadway's vertical curve would have a significant effect on hydraulics. Therefore, an alignment farther upstream was selected to fit a 125-foot earth cut spillway and return water flow into the site on the upstream side of the proposed Cornhusker Road. The upstream alignment created a slight decrease in the drainage area captured, and had a greater impact on the lake size and reservoir sustainability analysis, which ultimately resulted in an increased permanent pool elevation to compensate.

7 PROJECT PERMITTING

7.1 EXISTING RESOURCES

Both the WP-6 and WP-7 sites are currently in agricultural production but are mostly surrounded by recently completed or platted residential and commercial developments. Wetland delineations for the sites were conducted in June 2015; delineation reports have been prepared separately (FHU, August 2015).

7.2 SITE WP-6

The wetlands delineated within the WP-6 environmental study area (ESA) were primarily palustrine emergent temporarily or seasonally flooded wetlands (PEMA or PEMC) located along stream channels or within floodplain depressions, and within siltation basins. Some patches of palustrine forested temporarily flooded (PFOA) wetlands were also located along stream channels. Palustrine scrub-shrub temporarily flooded (PSSA) wetlands were present within the study area, but only within the siltation basins. A total of 25 wetlands and 3 channels were located within the ESA.

The identified wetlands were primarily located along stream channel fringes, banks, adjacent terraces, or within adjacent floodplain depressions. Most wetlands were PEMA/PEMC and located along the stream fringes or lower shelves near the base of the stream banks. As the main channel (Channel 1) flows north, it becomes deeply entrenched with banks approximately 10 to 20 feet high in some places. Seeps were occasionally present, allowing the wetland vegetation to extend up the banks away from the stream channel. Near the south end of the study area, south of Ballpark Way, a large PEMA/PEMC wetland dominated the low areas of the valley, extending from the stream channel into adjacent terraces and occupying much of the floodplain west of the channel. Several siltation basins were present in the uplands near the channels. Most of these contained a dense fringe of PSSA wetland circling an area of PEMA/PEMC, and were the only locations of PSSA wetlands within the study area. Siltation basin wetlands include Wetland 5a, 5b, 7a, 7b, 8, 14a, 14b, 16a, 16b, 27a, 27b, 32, and 33. They appear to have been constructed for nearby urban development, or possibly planned future development in the area. A PFOA wetland was located along the southwest end of the secondary channel (Channel 30) that flows into the main channel of the site, beginning just north of Lincoln Road.

The dominant species in the PEMA/PEMC wetlands were reed canarygrass (*Phalaris arundinacea*) and equisetum (*Equisetum hyemale*). The PFOA wetlands were dominated by silver maples (*Acer saccharinum*) and peachleaf willow (*Salix amygdaloides*) in the canopy and reed canarygrass (*Phalaris arundinacea*) in the understory. The PSSA wetlands were dominated by sandbar willow (*Salix interior*), peachleaf willow (*Salix amygdaloides*), and eastern cottonwood (*Populus deltoides*).

Other water resources found within the ESA include a perennial channel flowing north through the site (Channel 1) and serving as a tributary to West Papillion Creek. This channel ranged from approximately 3 to 8 feet wide. Toward the south end of the study area, it was located within a large reed canarygrass wetland and was difficult to observe through the thick vegetation. Further north, it becomes deeply entrenched, with occasional patches of wetlands along its fringes or lower shelves. This channel would be dammed near the north end of the site. Another smaller perennial channel (Channel 30) flows northeast and is a tributary to the larger channel. This channel also contained patches of wetland along its fringes and within its floodplain. An ephemeral channel (Channel 37) flows into Channel 1 near the north end of the site; however, this channel did not contain a defined bed and bank or Ordinary High Water Mark. An estimate of delineated wetlands and channel length is presented in Table 9 by location in the proposed project area.

Table 9. WP-6 Estimate of Delineated Wetlands and Channel Length

	WETLANDS (acres)					CHANNEL (linear ft)
	TOTAL	PEMA/ PEMC	PSSA	PFOA	Open Water	
Jurisdictional Wetlands	9.0	7.6	-	1.5	-	
Silt Basin Wetlands (Non-Jurisdictional)	1.7	0.5	0.5	-	0.6	
TOTAL WP-6 Wetlands (Entire Study Area)	10.7	8.1	0.5	1.5	0.6	
Dam & Spillway Footprint (earth fill)	0.02	0.02	-	-	-	535
Below Normal Pool Elevation (inundated)	0.7	0.7	-	-	-	5800
SUBTOTAL: Anticipated Impacts for 404 Permit	**0.7**	0.7	-	-	-	6300
Below Top of Dam Elevation	1.4	1.4	-	-	-	8260

7.3 SITE WP-7

The wetlands delineated within the ESA were primarily palustrine emergent temporarily or seasonally flooded wetlands (PEMA or PEMC) located along stream channels or within floodplain depressions, and within a siltation basin. Some patches of palustrine forested temporarily flooded (PFOA) wetlands were also located along the stream channel at the south end. A total of 4 wetlands, 1 open water area, and 1 channel were located within the ESA. Many of the wetlands consisted of multiple patches.

The identified wetlands were primarily located along stream channels or within adjacent floodplain depressions. The vast majority of wetlands were located south of where 108th Street meets West Lincoln Road; only a few patches were located north of this area along the stream fringes or atop the adjacent bank. Most wetlands were either PEMA/PEMC or PFOA wetlands located along the riparian areas of the channel. North of where 108th Street meets West Lincoln Road, the channel was entrenched with banks approximately 10 to 20 feet high. A large siltation basin was present near the southeast end of the study area, south of West Lincoln Road, and is associated with ongoing construction activities. A PEMA/PEMC wetland has formed along the east side of the basin (Wetland 7a), but the remainder of the basin is open water (Wetland 7b).

The dominant species in the PEMA/PEMC wetlands were reed canarygrass (*Phalaris arundinacea*) and stinging nettle (*Urtica dioica*). The PFOA wetlands were dominated by green ash (*Fraxinus pennsylvanica*), peachleaf willow (*Salix amygdaloides*), and eastern cottonwood (*Populus deltoides*) in the canopy and reed canarygrass (*Phalaris arundinacea*) in the understory. Other water resources found within the ESA include a perennial channel flowing north through the site and serving as a tributary to West Papillion Creek (Channel 1). This channel ranged from approximately 3 feet wide to 8 feet wide. To the north, the channel becomes deeply entrenched, with only a few small patches of wetlands located along its fringes or atop its bank. The project would dam the channel near the north end of the site. An estimate of delineated wetlands and channel length is presented in Table 10 by location in the proposed project area.

Table 10. WP-7 Detention Site: Estimate of Delineated Wetlands and Channel Length.

	WETLANDS (acres)					CHANNEL (linear ft)
	TOTAL	PEMA/ PEMC	PSSA	PFOA	Open Water	
Jurisdictional Wetlands	1.1	0.7	-	0.4	-	
Silt Basin Wetlands (Non-Jurisdictional)	0.9	0.2	-	-	0.7	
TOTAL WP-7 Wetlands (Entire Study Area)	2.0	0.9	-	0.4	0.7	
Dam & Spillway Footprint (earth fill)	0.01	0.01	-	-	-	535
Below Normal Pool Elevation (inundated)	0.04	0.04	-	-	-	2200
SUBTOTAL: Anticipated Impacts for 404 Permit	**0.05**	0.05	-	-	-	2700
Below Top of Dam Elevation	1.1	0.7	-	0.4	0.06	3290

7.4 PROJECTED IMPACTS TO WETLANDS AND WATERS OF THE US

The project would result in unavoidable impacts (estimated using alternative layouts for the purpose of determining a potential scale of magnitude of the impacts) including:

- Construction of the WP-6 dam and spillway would require fill in an estimated 0.02 acres of PEMA/PEMC wetlands and 500 linear ft of channel. An estimated 0.7 acres of PEMA/PEMC wetlands and 5,300 linear feet of channel would be inundated within the permanent pool.

- Construction of the WP-7 dam and spillway would require fill in an estimated 0.01 acres of PEMA/PEMC wetlands and 500 linear ft of channel. An estimated 0.05 acres of PEMA/PEMC wetlands and 2,200 linear feet of channel would be inundated within the permanent pool.

- In total, the project would impact an estimated 0.03 acres of PEMA/PEMC wetlands and 1,000 linear feet of perennial stream channel for earth fill for the dam and spillway at both sites. An estimated total of 0.75 acres of PEMA/PEMC wetlands and 7,500 linear feet of perennial stream channel inundated below the normal pool elevation at both sites.

A summary of impacts is provided in Table 11.

Table 11. Estimated Impacts for 404 Permit

	WETLANDS (acres)					CHANNEL (linear ft)
	TOTAL	PEMA/ PEMC	PSSA	PFOA	Open Water	
WP-6 Impacts for Dam, Spillway & Normal Pool	0.7	0.7	-	-	-	5,800
WP-7 Impacts for Dam, Spillway & Normal Pool	0.05	0.05	-	-	-	2,700
Anticipated Impacts for 404 Permit TOTAL PROJECT	**0.75**	0.75	-	-	-	8,500

7.5 PERMITS REQUIRED

Permits and approvals required for the WP-6 and WP-7 Project are listed in Table 12.

Table 12. Permits and Approvals

PERMIT OR APPROVAL	GRANTING AGENCY	REASON
Section 404 Permit in compliance with Clean Water Act	US Army Corps of Engineers	This permit is required for discharge of fill into wetlands and waters of the US. The application will likely require an alternatives analysis and mitigation plan similar to other recent NRD projects.
Section 401 Water Quality Certification in compliance with Clean Water Act	Nebraska Department of Environmental Quality	This certification is required as part of the Section 404 permit issuance.
National Pollutant Discharge Elimination System – General Stormwater Discharge Permit for Construction Activities – in compliance with Clean Water Act	Nebraska Department of Environmental Quality	This permit is required for construction sites greater than 1 acre in size to allow discharge of stormwater off site. The permit requires preparation of a Stormwater Pollution Prevention Plan (SWPPP) and includes permit-specified mitigation to control erosion and sedimentation, and to prevent stormwater pollution. The Papillion Creek Watershed Partnership has developed a process to address NPDES permits.
Grading Permit	Papillion Creek Watershed Partnership-City of Papillion	Required for construction sites to comply with the requirements of the Papillion Creek Partnership.
Post-Construction Storm Water Management Plan	Papillion Creek Watershed Partnership-City of Papillion	Required for construction sites to comply with the requirements of the Papillion Creek Partnership.
Floodplain Development Permit	City of Papillion/Sarpy County	This permit is required for various types of floodway/floodplain development as part of participation in FEMA's National Flood Insurance

		Program. The permit is issued by the state-designated agency as authorized by FEMA.
Section 7 of the Endangered Species Act	US Fish and Wildlife Service	Consultation with the USFWS is required to address potential impacts to T&E species and their habitat.
Section 106 of the National Historic Preservation Act	Nebraska State Historic Preservation Office	Consultation with the NeSHPO is required to address potential impacts to historic properties, including archeological sites.
Approval of Plans for Dams	Nebraska Department of Natural Resources	Before constructing, reconstructing, enlarging, altering, breaching, removing, or abandoning any dam in Nebraska, the Dam Owner must obtain the approval of the Department.
Permit to Impound Water	Nebraska Department of Natural Resources	A storage permit is required if the dam has an impounding capacity of more than 15 acre-feet below the lowest open overflow or the water in the reservoir will be pumped or released for a beneficial purpose.

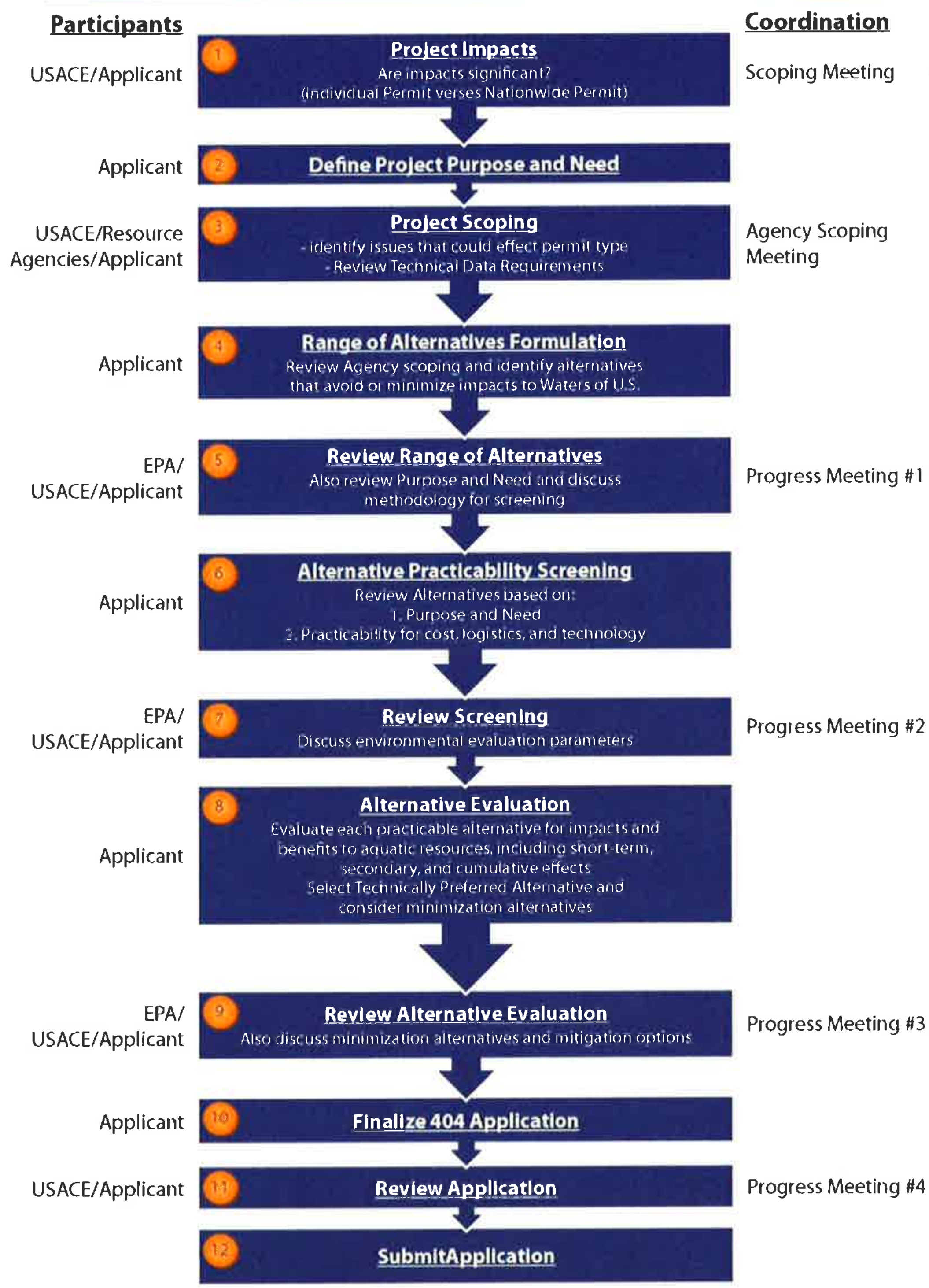
Agency letters were sent in September of 2015. Consideration should be given to contracting for an archeological survey this fall, during final design. Field work needs to be done when the crops are out, but before the snow.

The following recommendations are proposed for consideration for the WP-6 & WP-7 project. The approach is based on review of PMRNRD's WP-5 and DS-15A permit applications and requirements, as well as experience with CPNRD's Silver/Prairie/Moores Creek Flood Control project.

1. Based on the final design alternatives, weigh submitting either one 404 permit application for the two sites, or separate applications.

2. Generally follow the application process for WP-5 and DS-15A described in the flow chart below.

Coordination Process for Section 404 Permitting



3. Put design alternatives into minimization alternatives at end of report.

4. Submit one mitigation plan for the two sites.

5. Based on previous projects, the Corps required channel rehabilitation/bioengineering along a nearby degraded stream segment and 5 years of monitoring. Need to identify a location. Construct concurrent with first dam. A Nebraska Stream Conditions Assessment Procedure (NeSCAP) is being prepared for both dam sites. The NeSCAP will provide additional guidance regarding suitable locations and amount of mitigation required.

6. Need 50-ft buffer zone around normal pool and any mitigation areas, with protective easement/deed restriction.

8 RECREATIONAL FACILITIES

The preliminary design study for recreational facilities and uses evaluated each of the two project reservoirs as individual developments as well as the interconnectivity to the sequence of flood control installations within the Papillion/Highway 370 corridor. See Figures 14 and 15. Each project reservoir has positive opportunities to be recreational destinations with emphasis towards trail and water sport usage as well as serving as catalyst for future development through interlocal or separate party commitments. The following summary categorizes by reservoir project area WP-6 or 7 recreational emphasis to site access, trails, and associated day use amenities.

8.1 SITE WP-6

The predominant limit of recreational use of WP-6 is focused on the primary reservoir limits north of Cornhusker Road between 114th and 120th Streets. Reservoir limits south of Cornhusker Road are recommended to be managed as un-programmed natural areas with limited access provisions.

8.1.1 SITE ACCESS

Taking into consideration the topography of the reservoir project area as well as surrounding current and future land uses, a single park entry is recommended off of 120th Street. This park entry shall serve the extents of the P-MRNRD public use facilities as part of the initial reservoir construction. Pending interlocal agreements with the City of Papillion, Sarpy County, or other agency, a proposed future access is proposed off of Cornhusker Road to access a complementary day use area adjacent to the southeast shore of the reservoir.

Site access off of 114th Street is presented as maintenance and emergency access to the project reservoir only by vehicle. Trail connectivity to the 114th Street corridor is presented as an adjacent/shared alignment to the maintenance access.

While recommended as un-programmed natural space south of Cornhusker Road, a limited aggregate parking area is proposed for the public to access the south reservoir area by foot.

All site access points will be proposed as gate and fence controlled in like fashion to other P-MRNRD facilities.

8.1.2 TRAIL CONNECTIONS

As with other P-MRNRD facilities, WP-6 provides opportunity for a concrete hiking/bicycling multi-use trail to circumnavigate the reservoir. It is proposed that trail alignments remain predominantly near the water body and limit slope gradients to less than 5% (1 foot in 20 feet) unless necessary to increase for limited distances. Where possible, the trail will provide a constructed transition between lake fringe conservation buffers and uplands. Trail shall be constructed to widths and profiles matching P-MRNRD design standards of other recreational trail installations.

Concurrent with the preliminary design study of WP-6, development of a revised Sarpy County Trail Master Plan is being conducted. The WP-6 trail system is proposed to link directly to the County regional trail system and become inclusive to trail linkages between all flood control reservoir facilities (Walnut Creek, WP-7, Prairie Queen, and Chalco Hills Recreation Areas). WP-6 will additionally benefit from the County regional trail system by providing direct linkages to the downtown core of the City of Papillion, local Papillion-LaVista Public Schools, surrounding residential neighborhoods and other land uses.

8.1.3 DAY USE FACILITIES

While all existing flood control reservoir day use facilities provide a diversity of public use amenities, it is appropriate for WP-6 to provide like uses the public is accustomed to with a P-MRNRD installation. Primary programmed uses for WP-6 focus upon hiking/bicycling trail use, picnicking, shoreline fishing, and boat ramp water access. The following is a summary of proposed day use facilities for WP-6:

- Concrete boat ramp with adjacent floating dock for motorboat as well as non-motorized watercraft water access. Motorboat usage shall be restricted to no-wake speeds.
- One (1) day use picnic shelter with associated table and grill provisions.
- Waterless toilet facility with single male and female stalls.
- 1.5 mile concrete multi-use trail – single loop circumnavigating reservoir.
- Ten (10) stabilized shore fishing extensions into the lake (9 aggregate paved and 1 ADA compliant surface). Fishing extensions allowing shore anglers to gain better access to deeper waters.
- Aggregate parking access to un-programmed natural space for foot hiking, birding, and passive recreation south of Cornhusker Road.
- Paved parking lot with 20 boat trailer parking stalls.

All recreational facilities – their incorporation and location shall be in response to final reservoir flood control design criteria and P-MRNRD preferences and be refined as necessary during final design.

8.2 SITE WP-7

8.2.1 SITE ACCESS

Site access to WP-7 is influenced by road to dam alignment of extending Cornhusker Road as well as the platting of surrounding residential land uses abutting the reservoir boundary. Proposed single entry gate and drive to day use facilities off of Lincoln Street south of reservoir body. Similar P-MRNRD gating and monument marker as provided at other reservoir recreation areas.

Vehicular access off of Cornhusker Road to dam structure shall be maintenance and emergency response only with appropriate notification signage and gating.

8.2.2 TRAIL CONNECTIONS

As with other P-MRNRD facilities, WP-7 provides opportunity for a concrete hiking/bicycling multi-use trail to follow the boundary of the reservoir. As gradients become steeper within the east and northeast boundaries of the site, a trail that crosses the reservoir at a designed sediment/forebay structure is proposed for consideration. Preliminary design study proposes a culvert or bridge crossing at this forebay weir as necessary to not obstruct the flow and function of the flood control installation. This results in a ¾ mile trail opportunity within the project area. Consideration of a full circumnavigating trail will be further studied in final design of earthwork and at the request of the P-MRNRD.

It is proposed that trail alignments remain predominantly near the water body and limit slope gradients to less than 5% (1 foot in 20 feet) unless necessary to increase for limited distances. Where possible, the trail will provide a constructed transition between lake fringe conservation buffers and uplands. Trail shall be constructed to widths and profiles matching P-MRNRD design standards of other recreational trail installations.

Concurrent with the preliminary design study of WP-7, development of a revised Sarpy County Trail Master Plan is being conducted. The WP-7 trail system is proposed to link directly to the County regional trail system as a primary Cornhusker Road to Lincoln Street linkage. It will become inclusive to trail linkages between all flood control reservoir facilities and surrounding communities as described in WP-6 trail connections.

8.2.3 DAY USE FACILITIES

While all existing flood control reservoir day use facilities provide a diversity of public use amenities, it is appropriate for WP-7 to provide like uses the public is accustomed to with a P-MRNRD installation. It is valuable to note a unique difference in WP-7 to the other locally approximate recreation areas. Due to the size of the permanent pool being smaller than its local counterpart reservoirs, WP-7 may be specifically attractive to a different slice of the public.

As 'universally accessible' recreational provisions are gaining awareness of their necessity, there is an opportunity through a shorter trail loop and additional detail to shelters, restrooms, and water access to serve the 'differently-abled' in the community. Design solutions should consider needs of not only the disabled or elderly, but also young families or temporally impaired individuals seeking a small scale manageable area to recreate.

In additional to dry-land uses, the WP-7 permanent pool provides opportunity to designate motor less watercraft use only without compromising the other 4 local reservoir provisions for motorboat users. While a relatively minor distinction, an exclusive paddle-only water body becomes unique to specific user groups.

The following is a summary of proposed day use facilities for WP-7:

- Paved access to stabilized shoreline landing/launch area.
- One (1) universally accessible floating kayak and canoe launch.
- One (1) day use picnic shelter with associated table and grill provisions – fully accessible.
- Waterless accessible toilet facility with single male and female stalls.
- ¾ mile concrete multi-use trail – single loop circumnavigating reservoir.
- ¼ mile primitive grass or gravel trail.
- Seven (7) stabilized shore fishing extensions into the lake (5 aggregate paved and 2 ADA compliant surface). Fishing extensions allowing shore anglers to gain better access to deeper waters.
- Concrete parking area.

All recreational facilities – their incorporation and location shall be in response to final reservoir flood control design criteria and P-MRNRD preferences and be refined as necessary during final design.

9 PROJECT ECONOMICS

9.1 CAPITAL COSTS

The capital costs for the project are summarized below. A breakdown of the costs are provided in Appendix F.

Table 13. WP-6 Alternatives Cost Assessment Summary

Alternative	Construction Costs	Land Rights	Dam Total		Water Quality Basin	Recreation	Project Total
6-1: Fuse Plug	$1,980,198	$4,840,000	$6,820,198				$8,837,198
6-2: Fixed Crest	$2,264,130	$5,375,000	$7,639,130		$42,000	$1,975,000	$9,656,130
6-3: Earth Cut	$873,934	$5,170,000	$6,043,934				$8,060,934

Table 14. WP-7 Alternatives Cost Assessment Summary

<table>
<tr><th>Alternative</th><th>Construction Costs</th><th>Land Rights</th><th>Cost Sharing</th><th>Dam Total</th><th></th><th>Water Quality Basin</th><th>Recreation</th><th>Project Total</th></tr>
<tr><td>7-2: Fuse Plug</td><td>$2,131,958</td><td>$2,210,000</td><td>($500,000)</td><td>$3,841,958</td><td rowspan="3"></td><td rowspan="3">$19,000</td><td rowspan="3">$1,375,000</td><td>$5,235,958</td></tr>
<tr><td>7-3: Fixed Crest</td><td>$2,314,422</td><td>$2,275,000</td><td>($500,000)</td><td>$4,089,422</td><td>$5,483,422</td></tr>
<tr><td>7-4: Earth Cut</td><td>$683,496</td><td>$2,365,000</td><td>$0</td><td>$3,048,496</td><td>$4,442,496</td></tr>
</table>

9.2 LAND RIGHTS

Land Rights maps showing all current parcel ownership were prepared for the design alternatives study. Easements owned by third parties and major utilities were added where information was readily available. Future road right of way widths were also included. A preliminary land rights map was prepared for the recommended alternative at each site to estimate land rights costs, see Figures 16 and 17.

9.3 SYNERGIES WITH DEVELOPMENT

Land development and related infrastructure improvements have continued at a steady if not accelerated pace, especially in the vicinity of WP-7. The following is a summary of development activities and road improvements in and around each dam site. The City of Papillion, through recent annexation efforts, contains both sites in its Extra Terratorial Jurisdiction (ETJ) planning area, and therefore, will conduct all development-related platting reviews.

9.3.1 SITE WP-6

There is considerable interest on the tracts of land surrounding WP-6. At this time, there are no submitted plats with the exception of the final phases of the North Shore development to the southwest of the dam site, but the main parcel owner at WP-6 is under way getting that land prepared for future development. The City of Papillion envisions the land surrounding the future lake as a combination of office, light industrial and commercial land uses. In general, much of the development community envisions the land around the lake as ideal for a larger portion of residential development. Until this land use issue can be resolved or the market changes considerably development interest in the land surrounding WP-6 may be sporadic.

In order to accommodate the development in the watershed that has occurred to date and is anticipated to continue, an 18" sanitary sewer line has been constructed by the City of Papillion to service the new development and placed along the south side of Schram Creek through the project area. The lowest manhole rim elevation in near the main body of the reservoir is 1068, which is four foot above the recommended main reservoir elevation of 1064. The lowest manhole rim elevation in the area of the water quality basin is 1070.3, which is 5.3 ft above the recommended water quality basin pool elevation of 1065. The sanitary sewer alignment is located outside of the permanent pool and no manholes are inundated by the permanent pool. Hydraulic routings will need to be firmed up during final design, but it appears that the lowest manhole is near the 25-year frequency pool elevation.

One significant transportation improvement in the WP-6 vicinity is the construction of Cornhusker Road between 126th Street and 120th Street associated with the North Shore development. Construction of this segment of road is scheduled for the fall of 2015. Future improvement to Cornhusker will continue each from 120th Street to 114th Street, which includes the road crossing Schram Creek where the proposed water quality basin feature is to be located. Coordinating this effort could allow for excavation of material from the water quality basin to provide fill required for the road improvements. The outlet structure for the basin will have to be sized in conjunction with the design requirements for the road and its future uses. Potential partnering opportunities also exist with the NRCS since this is the location of their proposed road dam structure S-22.

9.3.2 SITE WP-7

To the south of WP-7, two developments have been final platted and infrastructure improvements in some degree of completion. The Granite Falls project contains a new P-LV Middle School, multi-family and single family residential. The school is slated to open in the fall of 2016 and is under construction. The primary infrastructure improvement that has an impact on WP-7 is the vacation of 108th Street along the section line and realigning it through the subdivision in a configuration that connects at 108th and Highway 370 and terminates at Lincoln Road at a point ¼ mile east of 108th Street. This road is called Wittmus Drive. Wittmus Drive paving has been completed. The project was funded through an inter-local Agreement between Sarpy County, P-LV Schools and the SID with Sarpy County generally funding 1/3 of the cost and the other parties 2/3. This similar type of arrangement may be available to be utilized for the construction of Cornhusker Road along the north side of WP-7.

The Granite Falls development is also obligated to construct approximately a ¼ mile of Lincoln Road along its north frontage from Wittmus Drive to 108th Street and it is likely that a similar inter-local Agreement with Sarpy County will be used to fund this project. The construction for this portion of Lincoln is likely to occur in 2017 in conjunction with the Granite Falls North subdivision (discussed later) and their obligation to construct a section of Lincoln Road to the west.

To service these new developments, a 30" sanitary sewer line has recently been constructed and placed west of the unnamed tributary through the project area. The lowest manhole rim elevation in near the main body of the reservoir is 1067.23, which is 11.23 ft above the pool elevation of 1056. The lowest manhole rim elevation in the area of the water quality basin is 1065.03, which is 5.03 ft above the water quality basin elevation of 1060. The sanitary sewer alignment is located outside of the permanent pool and no manholes are inundated by the permanent pool. Hydraulic routings indicate that they are located outside the 100-year pool.

Sarpy County has initiated the design of improvements to Lincoln Road from 96th Street west to Wittmus Drive, providing a hard surfaced roadway for access to the new school. The design is in progress and the County intends to construct this segment of roadway in 2016, prior to the school opening.

Two other developments south of Lincoln Road have also occurred, being Kingsbury Hills Replat II, the balance of the Kingsbury Hills project and Granite Falls Commercial, located just north of Highway 370 between 108th and 114th Streets. These projects have no significant impact on WP-7 with the exception of the aforementioned vacation of 108th Street.

North of Lincoln Road two projects have been initiated, both single family residential projects and both having direct impacts on proposed WP-7. Granite Falls North is located immediately west of WP-7. The current status is that the preliminary plat has been approved by the Papillion Planning Commission. From a land platting perspective impacts to WP-7 have been eliminated. The City of Papillion has requested, and the developer has agreed, to plat the land immediately adjacent to the west side of WP-7 as an outlot until such time as the definite design parameters of WP-7 are known. At that time, the outlot would be replatted as single family lots, accommodating the final dam design. From a road infrastructure perspective this development will have an obligation, together with Sarpy County to construct Lincoln Road from what was 108th Street west to 114th Street. A condition imposed by the City of Papillion is that 108th Street must remain open to traffic until such time a Lincoln Road is constructed all the way to 114th Street. Lincoln Road, between 108th and 114th Street is anticipated to be constructed no earlier than 2017.

Granite Lake is a subdivision immediately east of WP-7. The current status is that the Preliminary Plat has been submitted to the City of Papillion but it has not been forwarded to the Planning Commission for consideration. This is primarily due to comments received from the P-MRNRD regarding some lots in the original submittal extending into areas below the anticipated top of dam elevation and also questioning the platting of certain areas until it is known what kind of spillway structure will be utilized in the design. It is anticipated that the preliminary plat will be reconfigured and re-submitted when the spillway type and top of dam elevation are determined. Until that time no further action will take place on this proposed development.

The Granite Lake project also incorporates two significant arterial street improvements; the extension of Wittmus Drive from Lincoln Road to Cornhusker Road and also Cornhusker Road from Wittmus Drive westerly to connect to existing Cornhusker Road. This segment of Cornhusker Road will partially traverse across the dam embankment of WP-7. It is likely that Sarpy County will participate in the funding of both these projects. It is also very likely that subject to an acceptable SID financing structure that the SID will be able to provide a significant contribution to the portion of Cornhusker Road paving going across the dam structure. The exact alignment and configuration of Cornhusker Road is not yet determined, being subject in large part to the final configuration of the dam. It would be very beneficial to all parties if construction of the dam and construction of Cornhusker Road could be timed to occur at approximately the same time.

The two projects adjacent to WP-7 also provide very real opportunities to complement one another in at least two other areas besides road construction, those being PCSMP facilities and grading. Specifically, there may be opportunities to over-excavate the normal pool of the dam reservoir to provide PCSMP benefits to the development while providing additional cut needed for the dam embankment. Also, if the grading for the development and the dam could occur at the same time both projects could balance earthwork requirements together instead of individually. Besides providing some economics of scale for the unit price of earthwork there is also the opportunity to raise and lower street grades in the subdivision so that grading quantities balance for both projects together.

9.4 BENEFITS

Both WP-6 and WP-7 provide significant benefits to the area including flood control, water quality, stream grade stabilization, habitat creation, and recreation. They also provide a significant impact to the planned development around the area by improving property values and attracting unique developments that likely would not have occurred without the sites.

Collectively, these benefits help to justify the projects to the NRD constituents and to potential funding agencies outside of the NRD. The detailed benefits of each will be included in funding applications to be prepared during the final design phase.

10 RECOMMENDATIONS

From the information presented above, and other supporting information available, recommendations for the dam configurations to carry forward in final design are presented below.

10.1 WP-6 RECOMMENDED DESIGN

For the WP-6 site, to maximize the flood control and water quality benefits of the site, and to make the best use of the lands available, moving the dam as far downstream within the project area is recommended. Because 114th Street is already improved, incorporating the roadway into the dam is not feasible. So an alignment as close to 114th Street as possible is desired.

Also considering costs and dam function, there is room to excavate an auxiliary spillway around the left abutment. Some erosion control/prevention steps will need to be taken at the terminus of the auxiliary spillway, which will be addressed in final design during the spillway integrity analysis. Available land rights also support and work well with an earth-cut auxiliary spillway at this site, and therefore, Alternative 6-3 is recommended for final design.

10.2 WP-7 RECOMMENDED DESIGN

For the WP-7 site, to maximize the flood control and water quality benefits of the site, and to make the best use of the lands available, moving the dam as far downstream within the project area is also recommended. Because Cornhusker Road is not yet improved, incorporating the roadway into the dam has merit.

A dam configuration with an earth cut auxiliary spillway is not feasible at the northern extents of the property due to the challenges of traversing the auxiliary spillway with the Cornhusker Road alignment. And to move the dam upstream, south of Cornhusker Road, so that an auxiliary spillway can be incorporated, significantly reduces the available permanent pool size and therefore, water quality benefits due to the upstream land rights and roadway infrastructure constraints on the project. Additionally, the auxiliary spillway on an upstream alignment would have a significant impact to the adjacent residential development.

For the reasons stated above and considering project costs and synergies with infrastructure and the surrounding developments, alternatives 7-2 and 7-3 are recommended for further analysis and final design. Both alternatives are similar, so cost refinement and design coordination with Sarpy County and the City of Papillion will help to select the best alternative for this site.

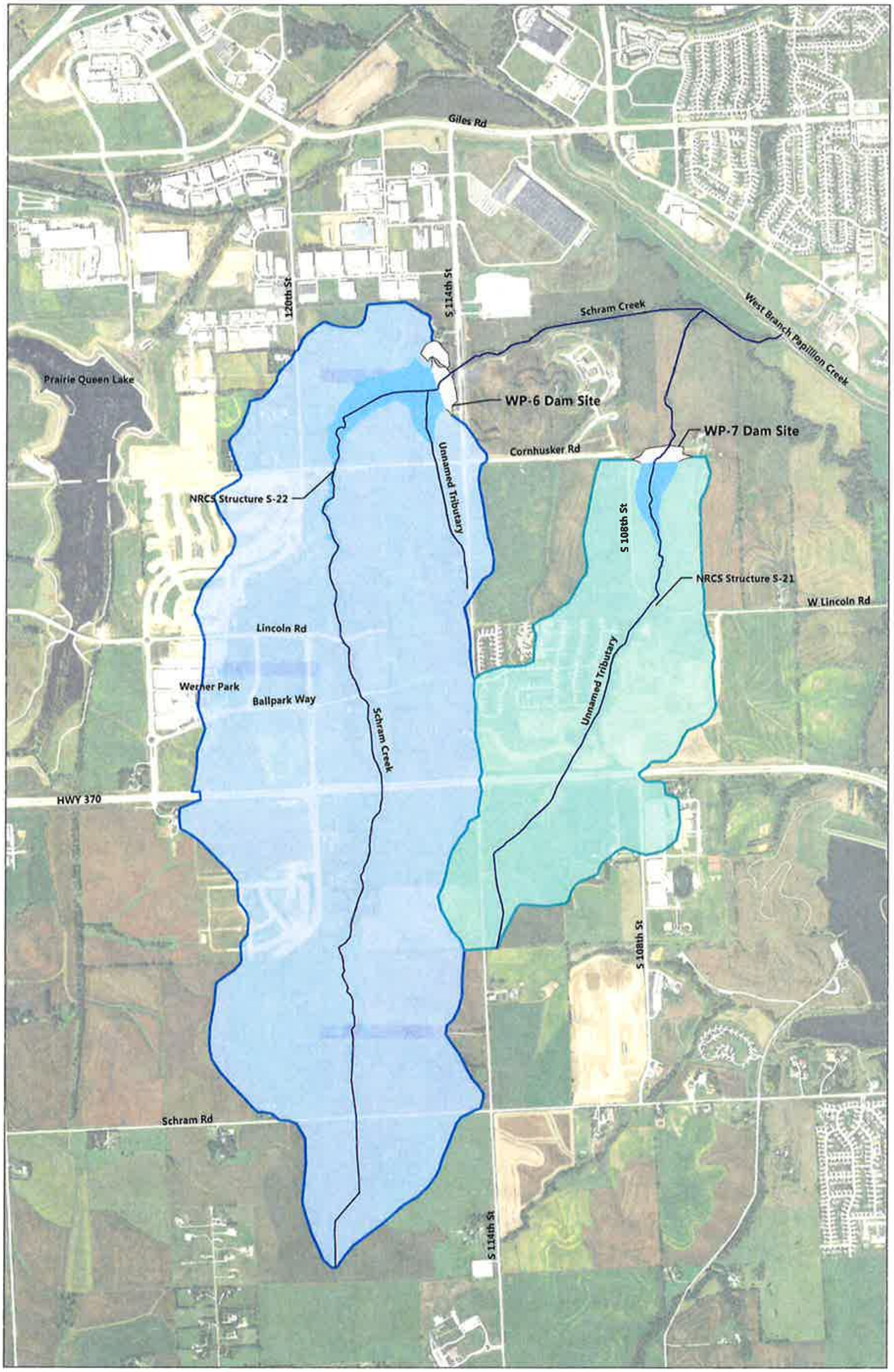


Figure 1. WP-6&7 Location Map

WP-6&7 Preliminary Design
Papio-Missouri River NRD

FYRA

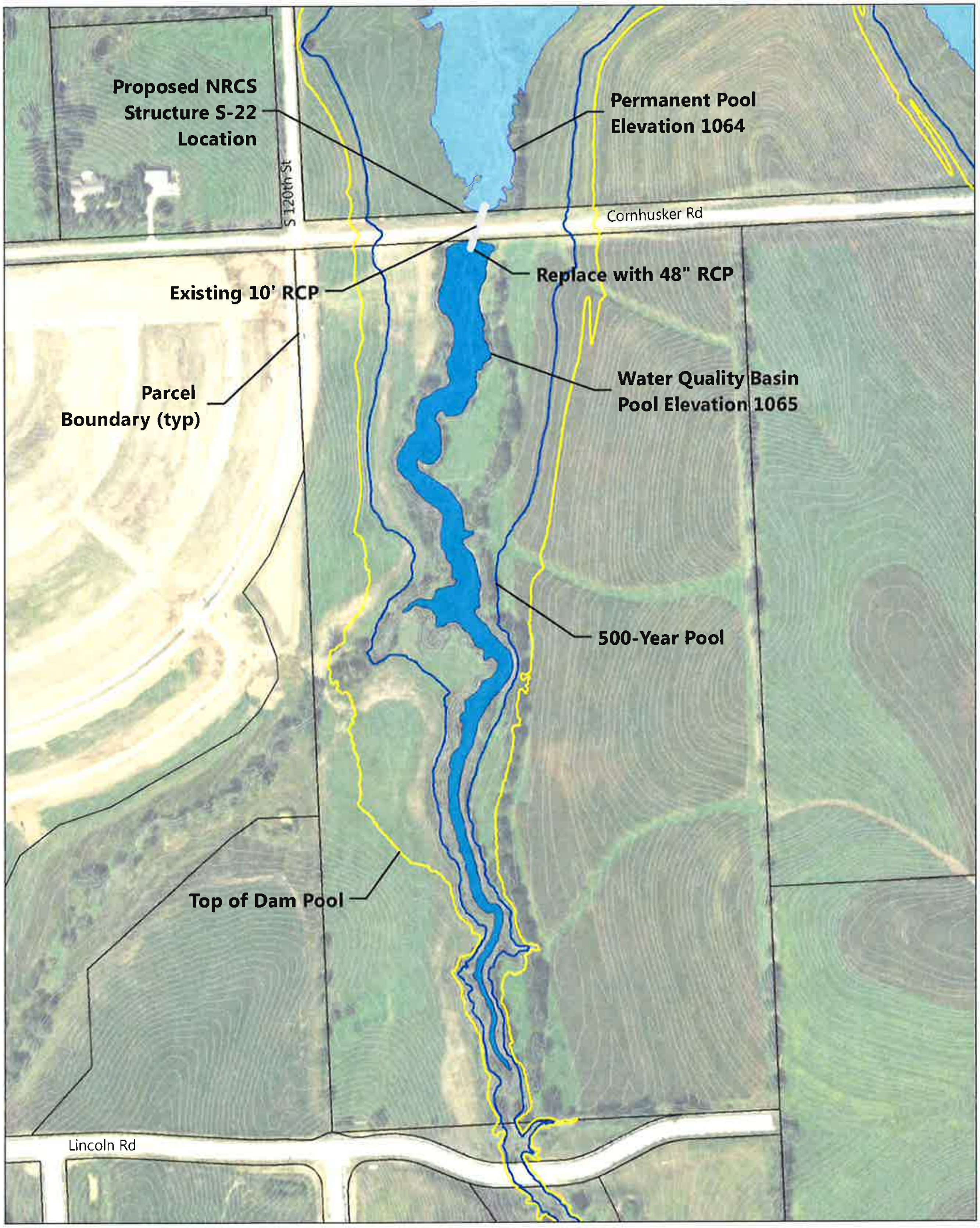


Figure 2. WP-6 Water Quality Basin Design Concept

WP-6&7 Preliminary Design
Papio-Missouri River NRD

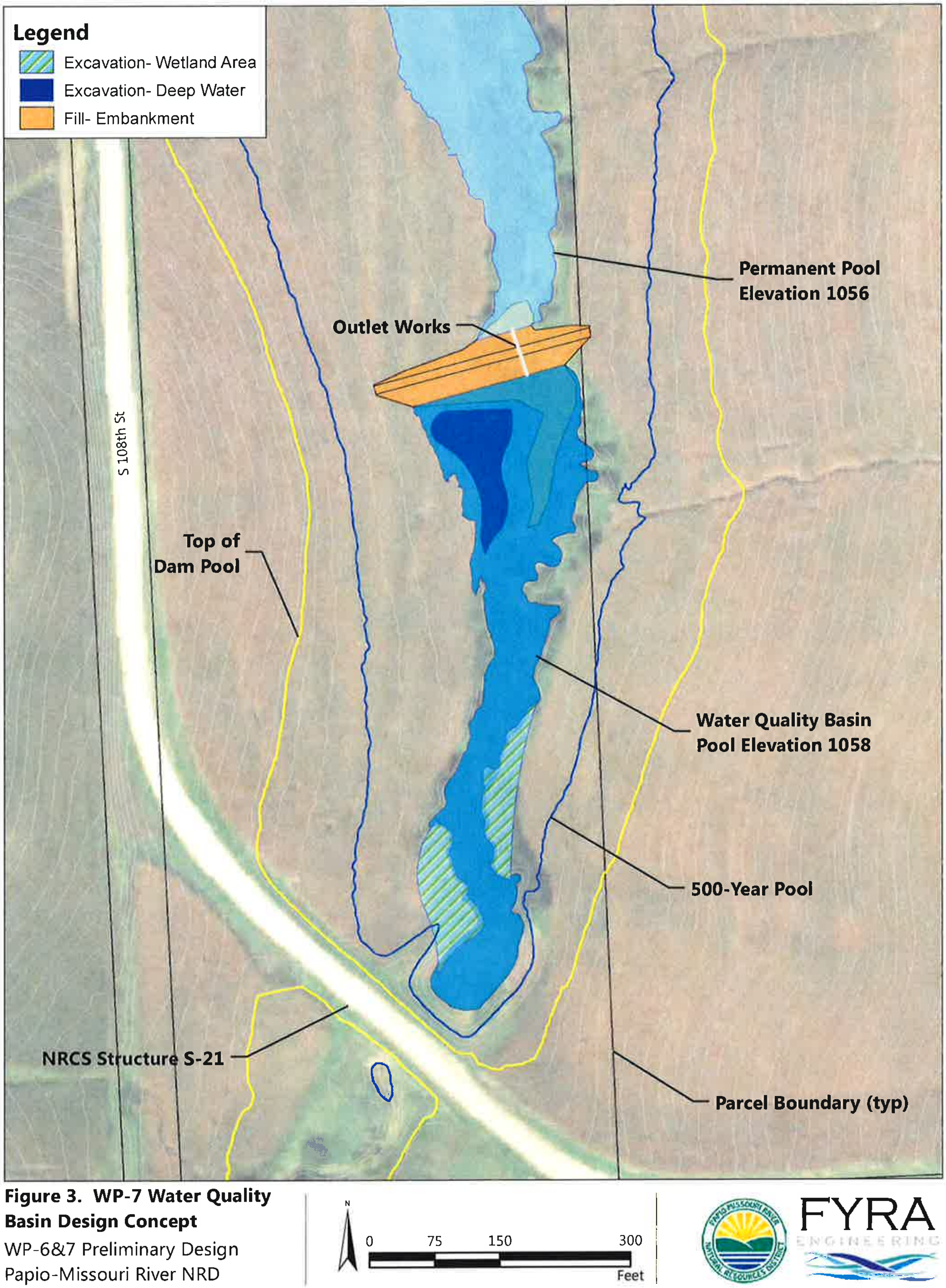


Figure 3. WP-7 Water Quality Basin Design Concept

WP-6&7 Preliminary Design

Papio-Missouri River NRD

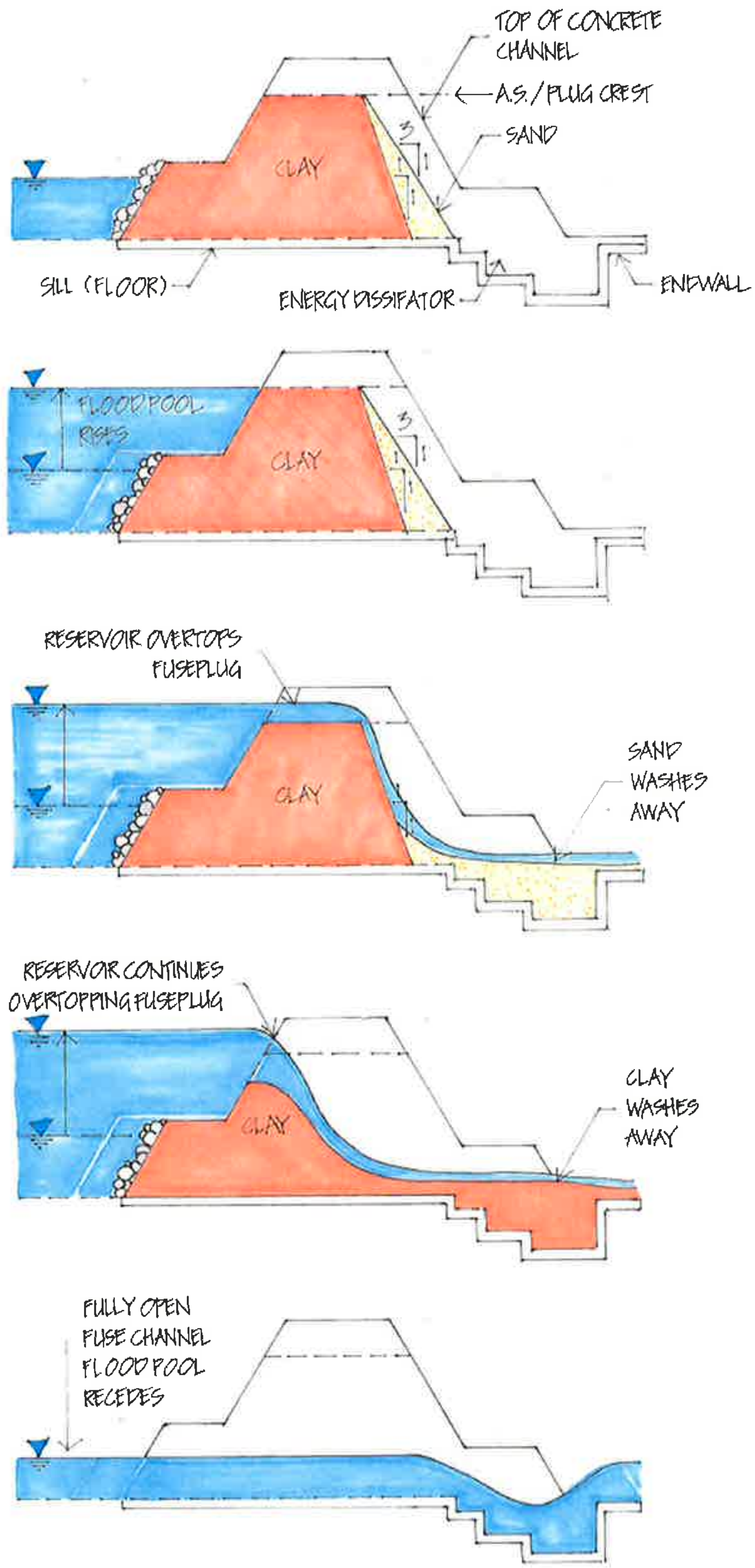
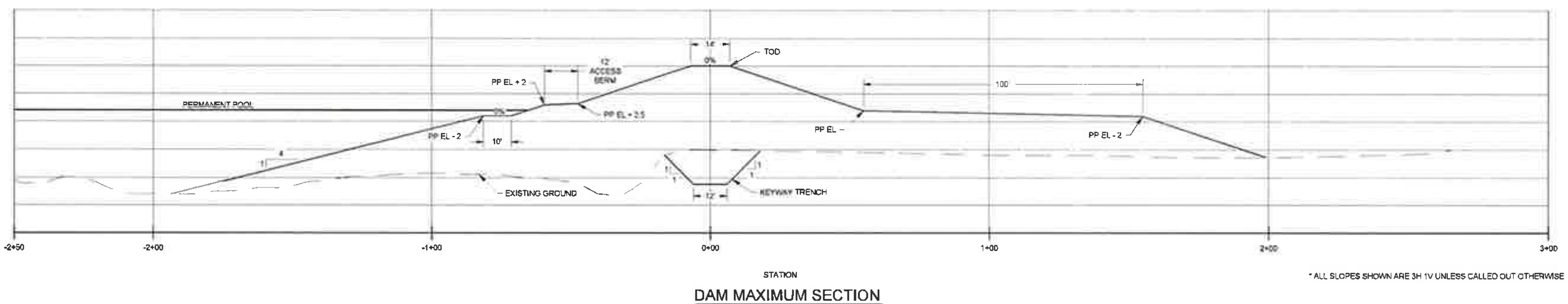


Figure 4. Fuse Plug Auxiliary Spillway Process

WP-6&7 Preliminary Design
Papio-Missouri River NRD



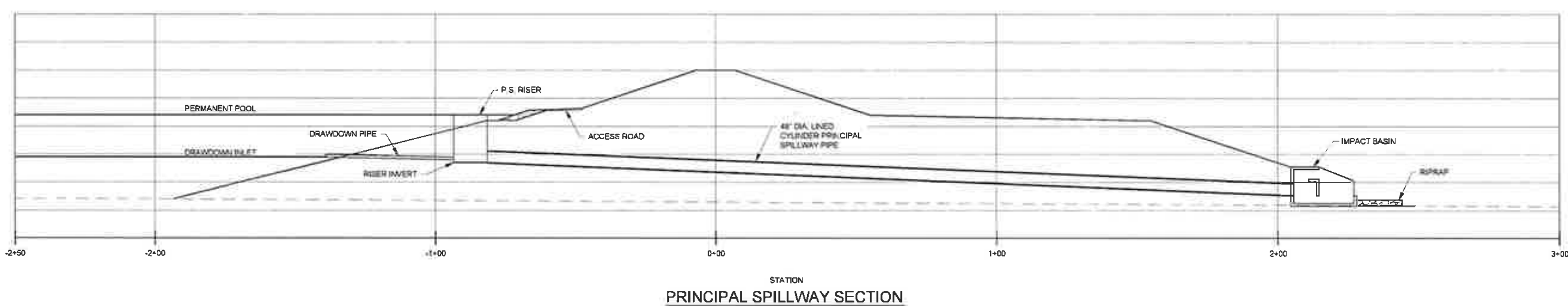


Figure 5. Typical Dam Sections

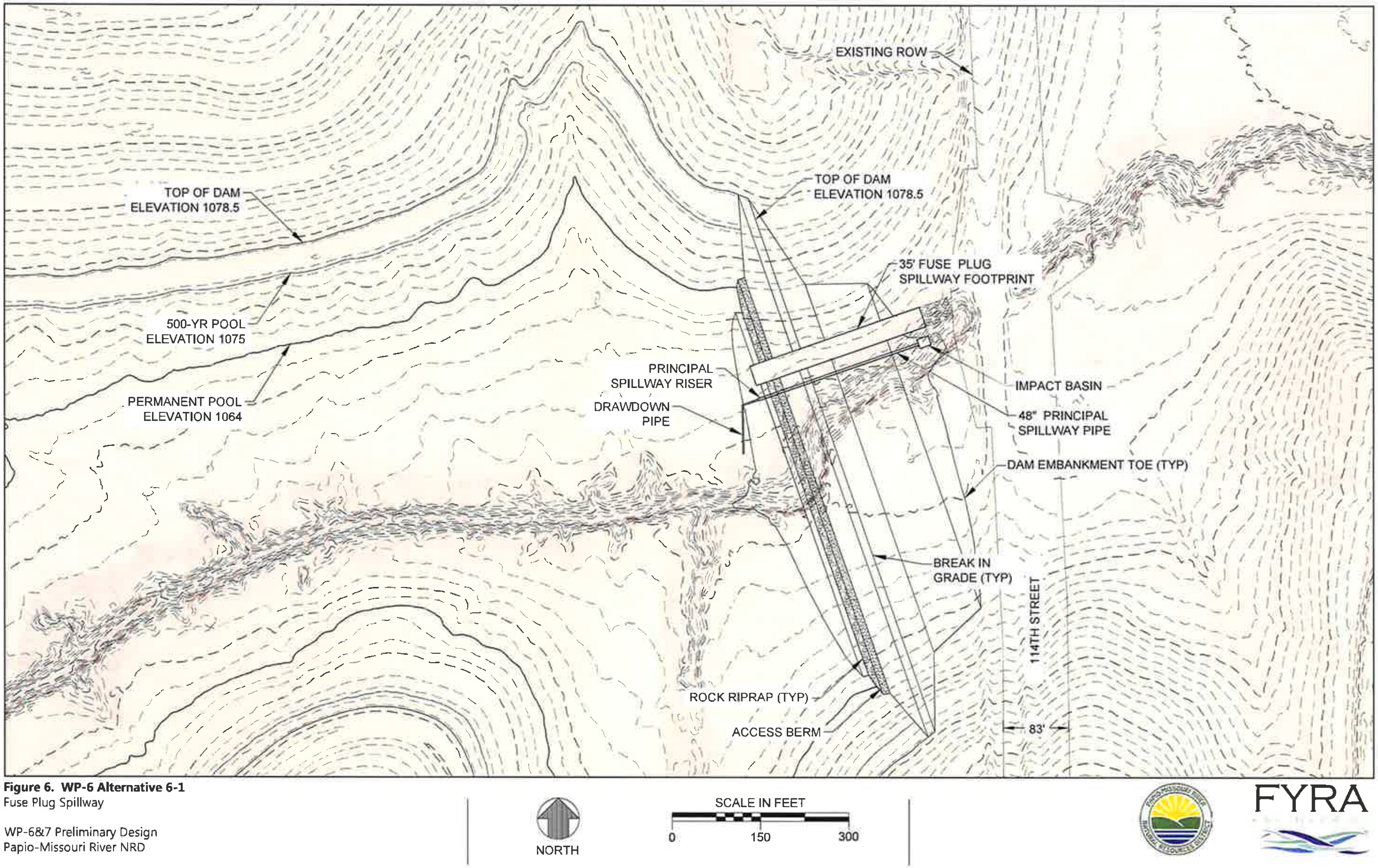


Figure 6. WP-6 Alternative 6-1
Fuse Plug Spillway

WP-6&7 Preliminary Design
Papio-Missouri River NRD

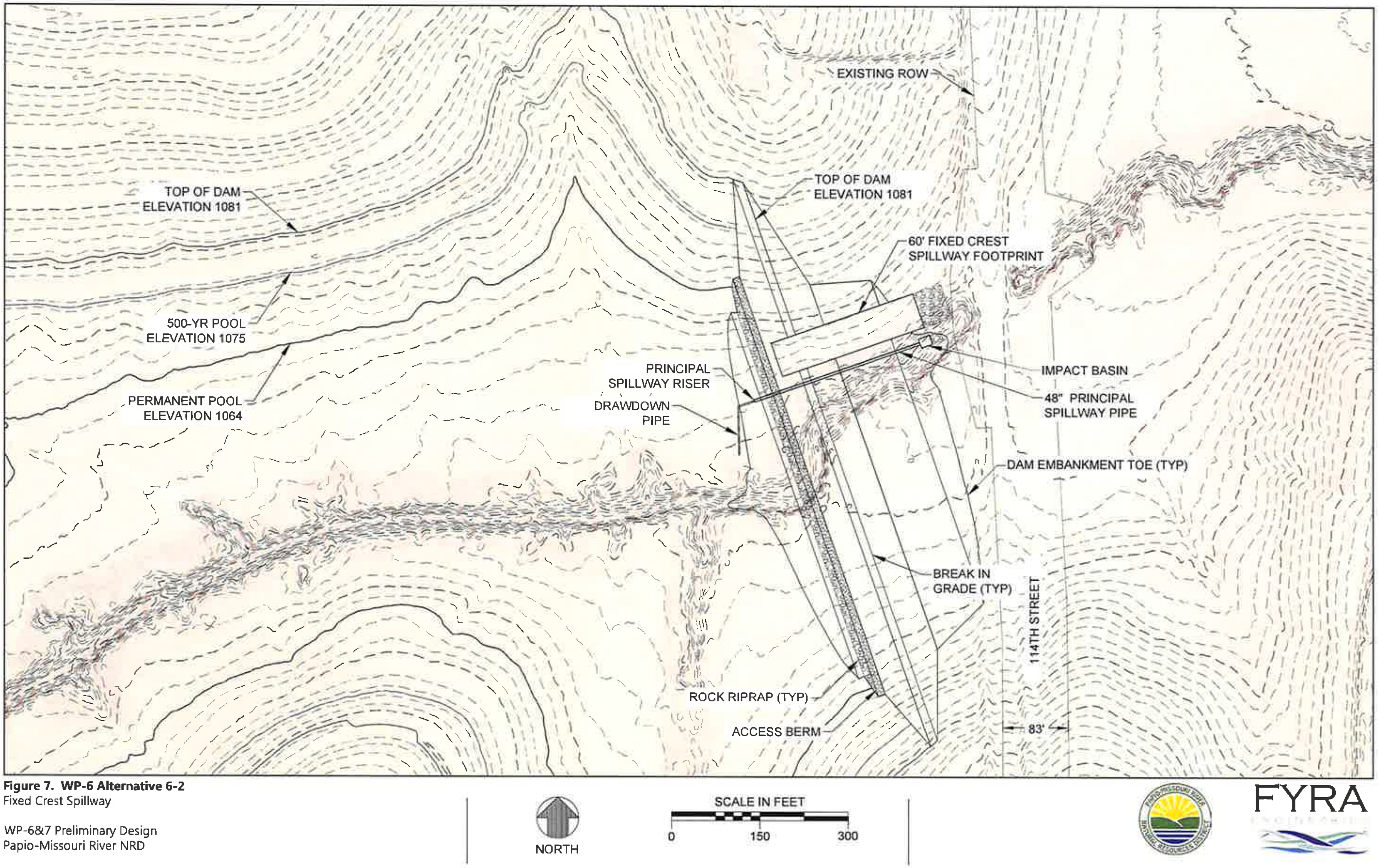
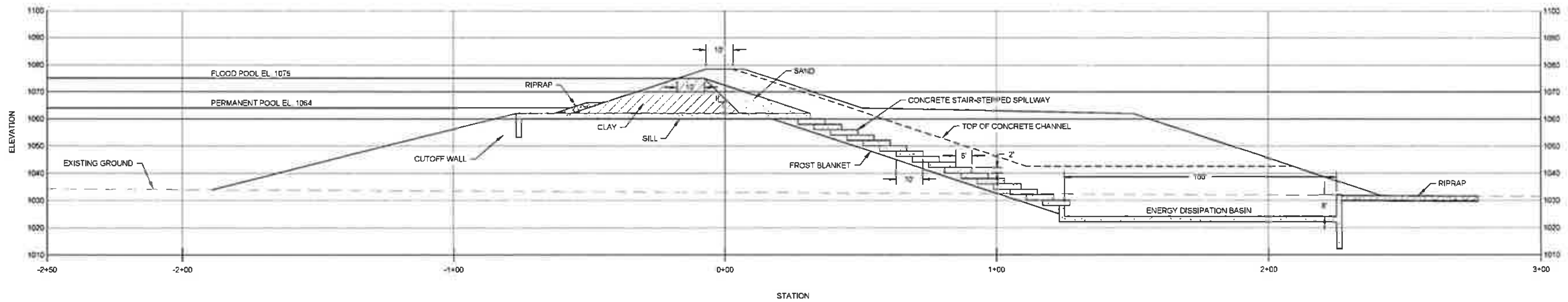
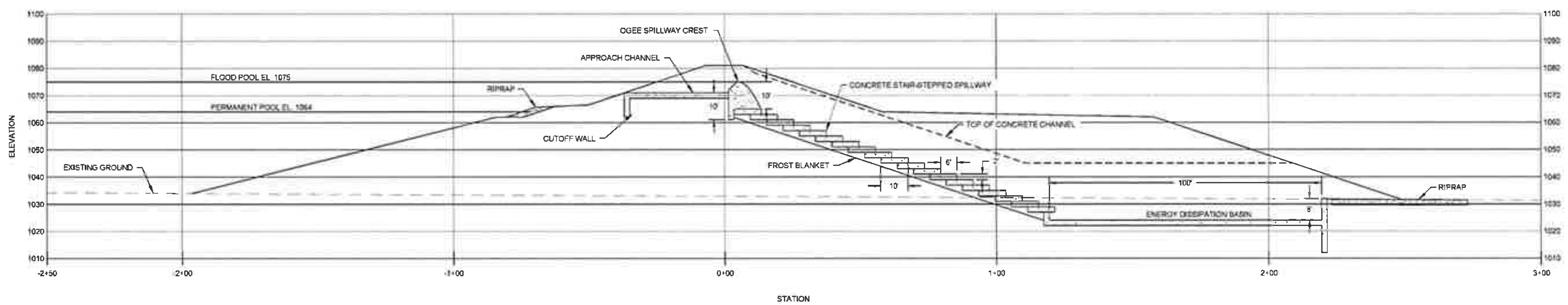


Figure 7. WP-6 Alternative 6-2
Fixed Crest Spillway

WP-6&7 Preliminary Design
Papio-Missouri River NRD



FUSE PLUG SPILLWAY SECTION



FIXED CREST SPILLWAY SECTION

Figure 8. WP-6 Fuse Plug and Fixed Crest Sections

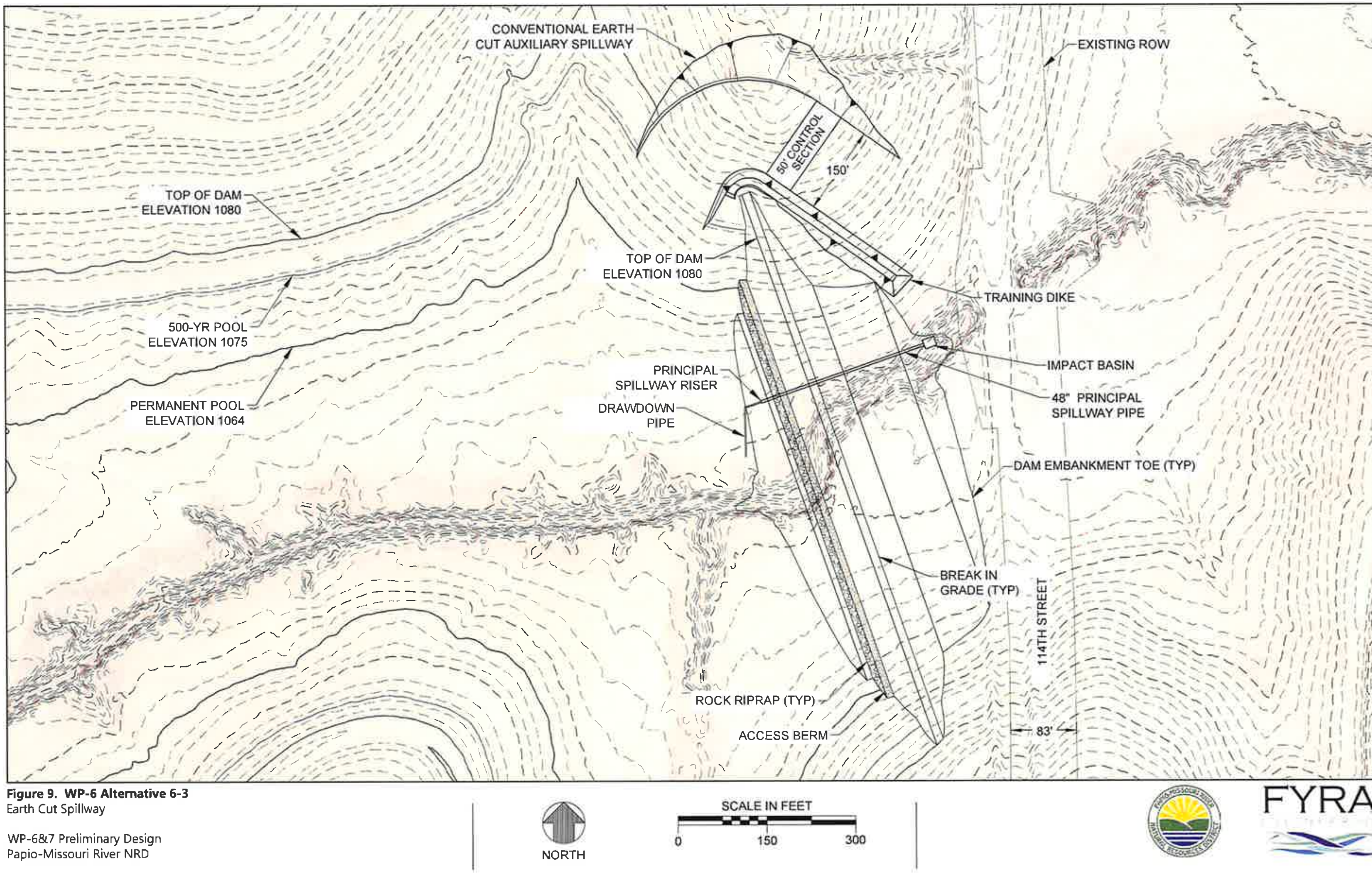


Figure 9. WP-6 Alternative 6-3
Earth Cut Spillway

WP-6&7 Preliminary Design
Papio-Missouri River NRD

FYRA

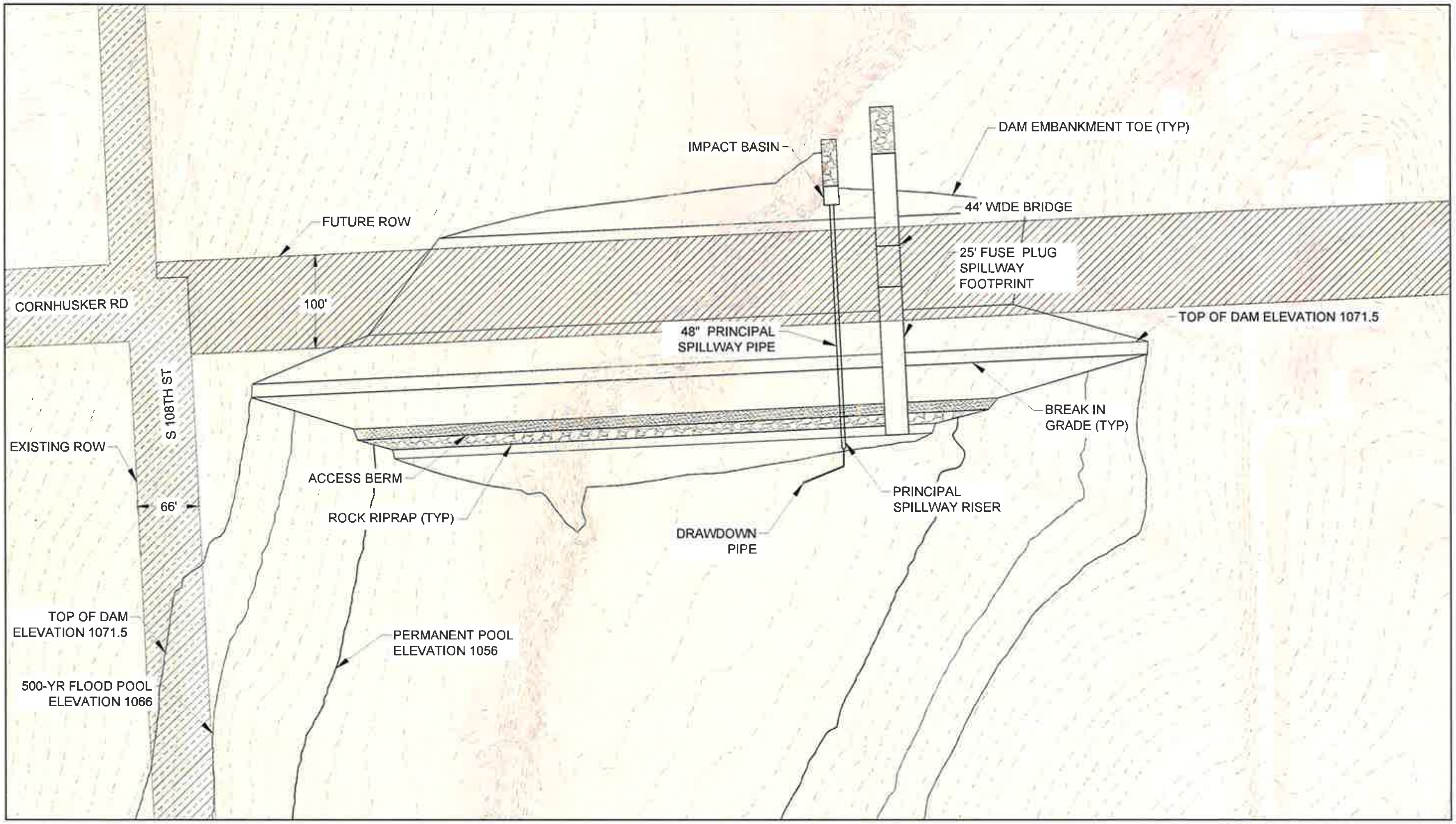


Figure 10. WP-7 Alternative 7-2
Fuse Plug Spillway - Road on Stability Berm

WP-6&7 Preliminary Design
Papio-Missouri River NRD

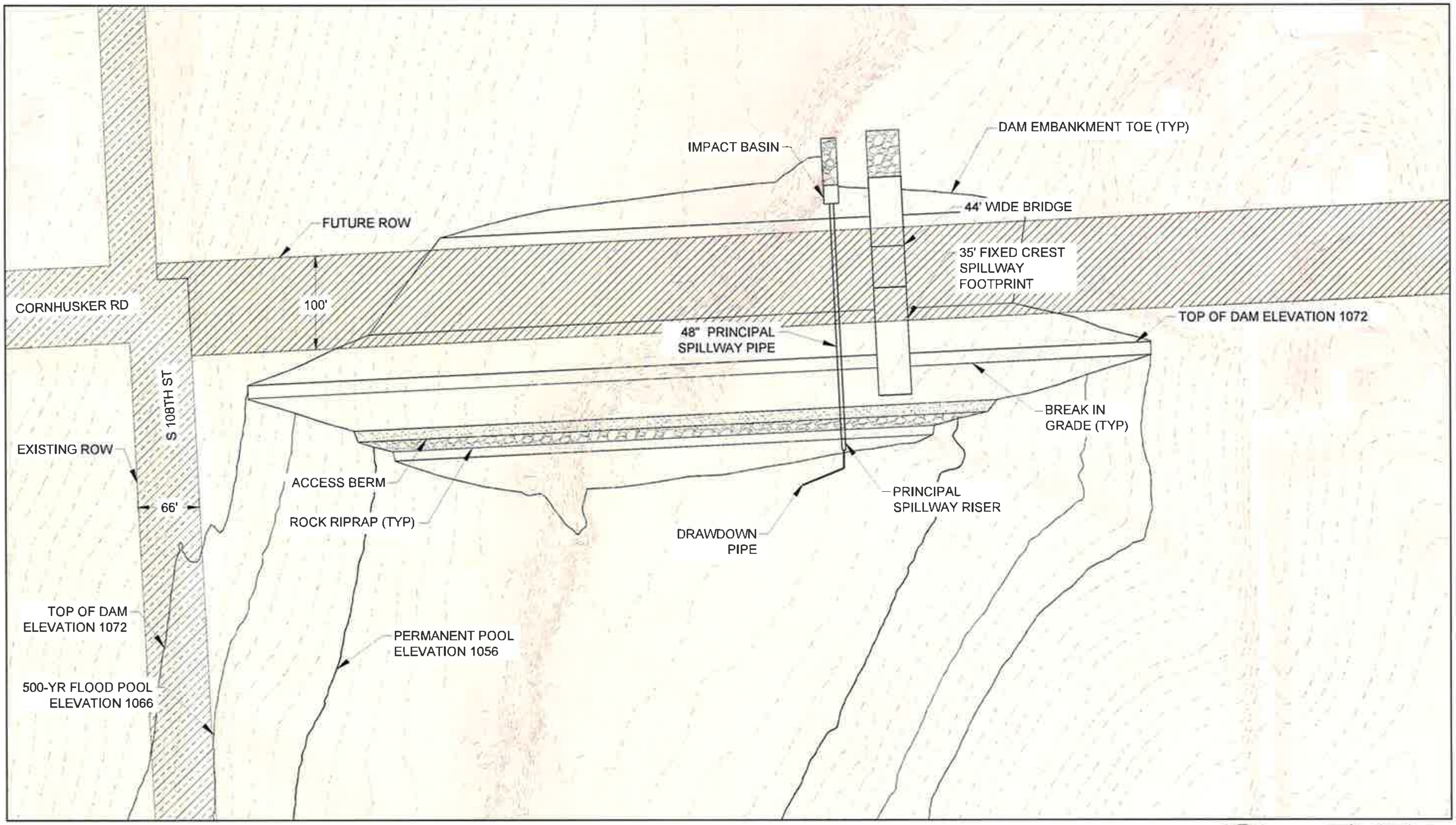


Figure 11. WP-7 Alternative 7-3
Fixed Crest Spillway - Road on Stability Berm

WP-6&7 Preliminary Design
Papio-Missouri River NRD

NORTH

SCALE IN FEET
0 100 200

FYRA

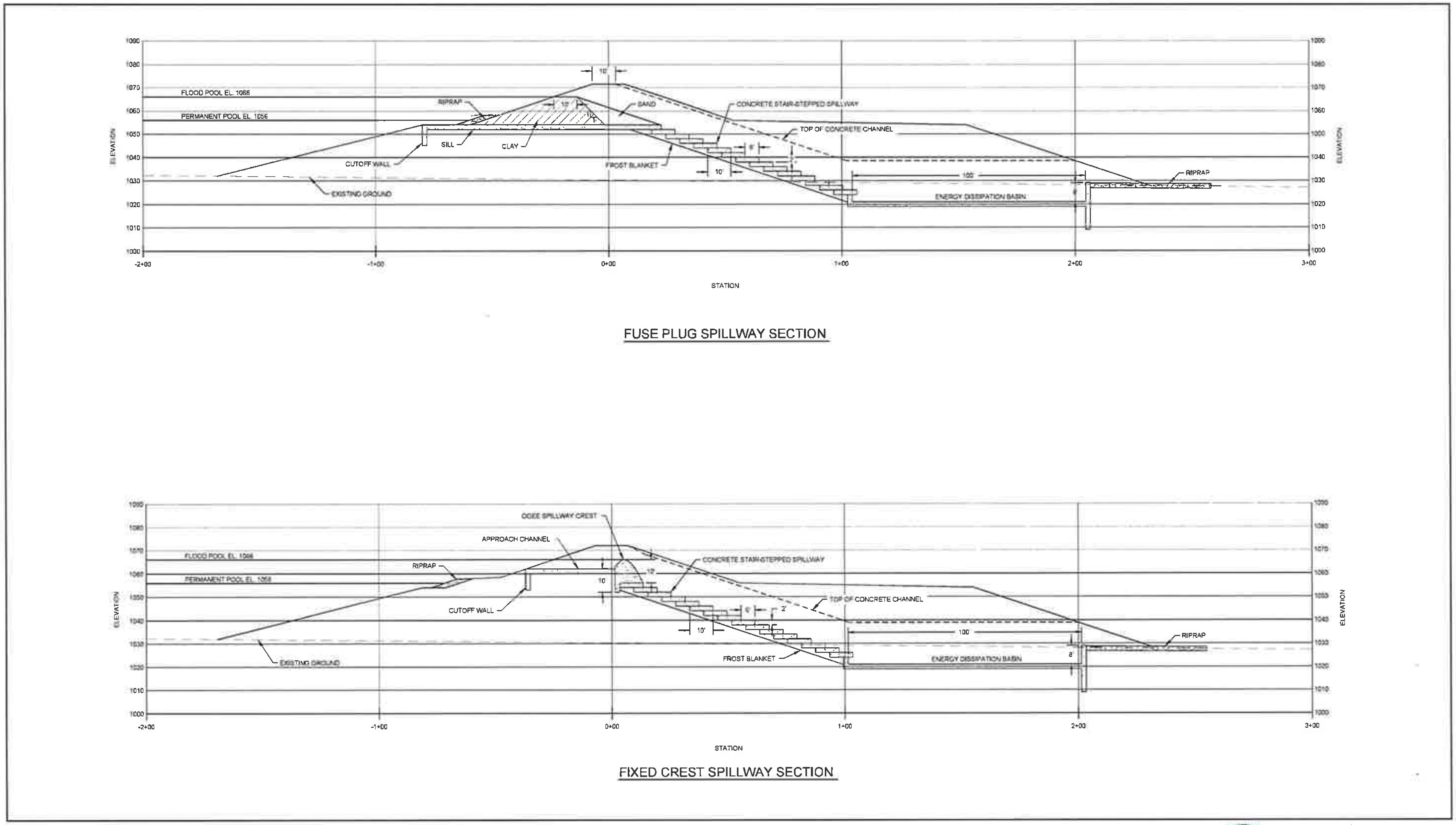


Figure 12. WP-7 Fuse Plug and Fixed Crest Sections

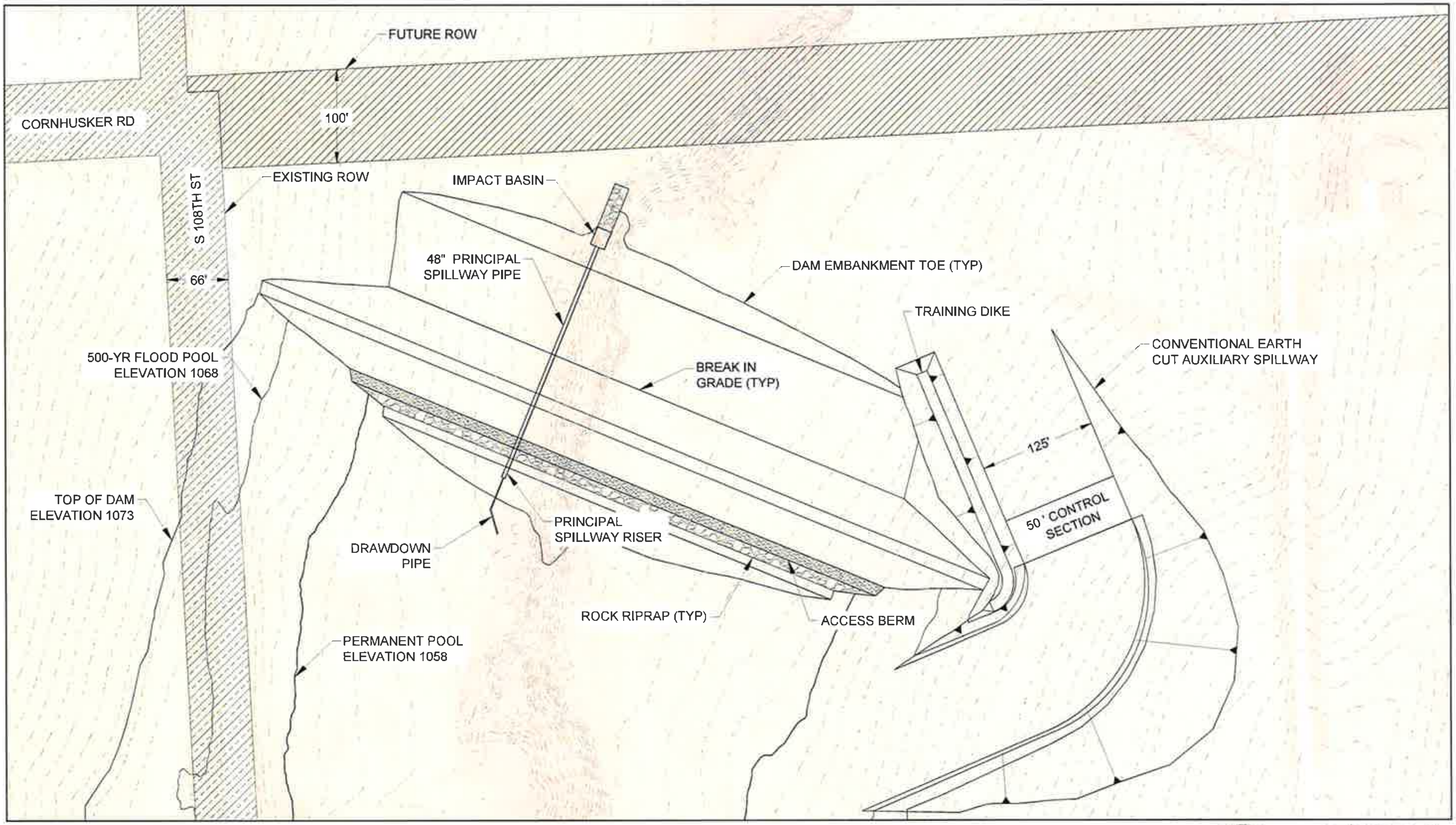
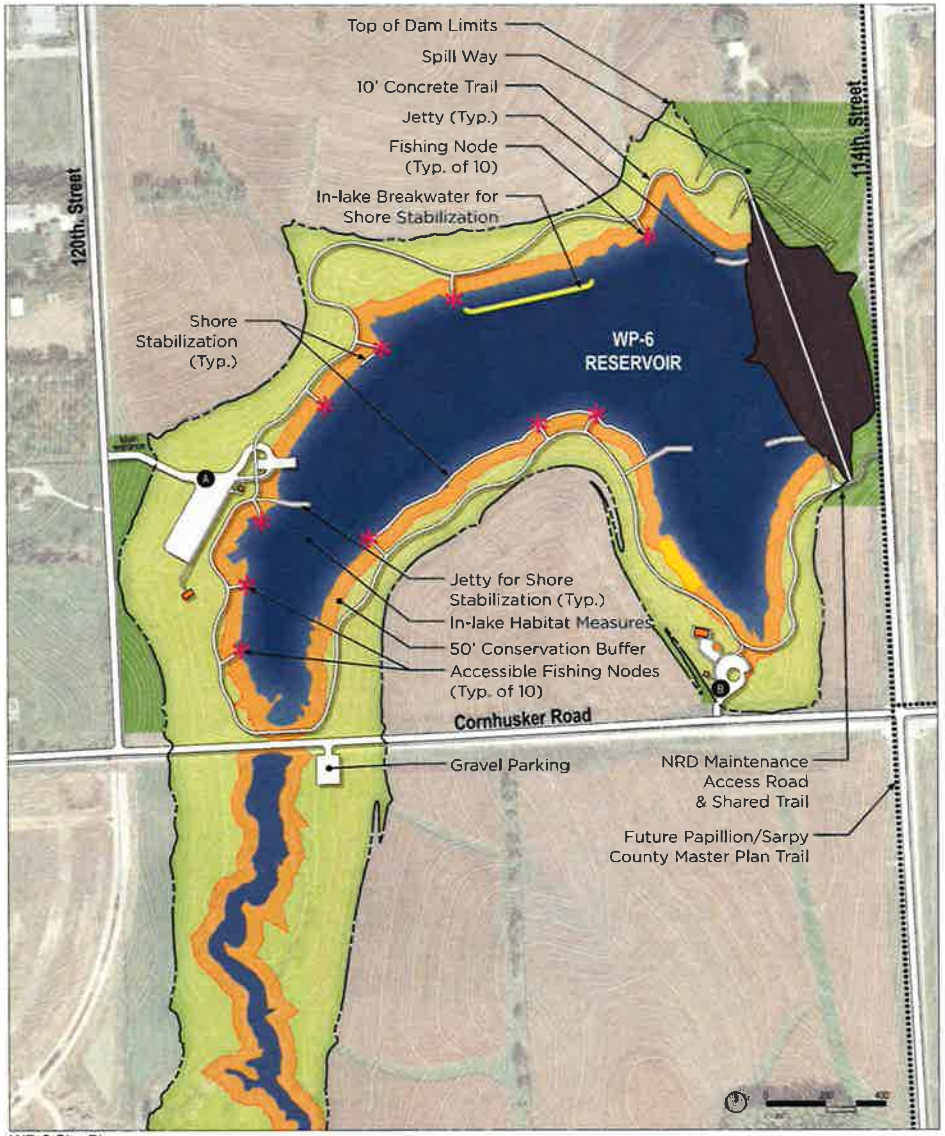


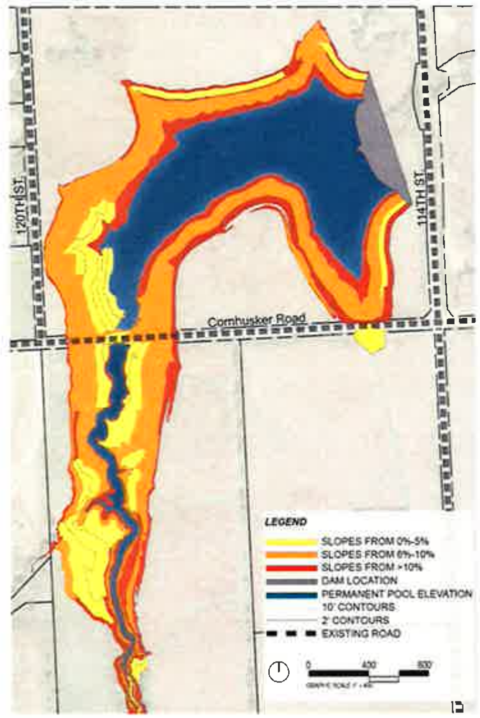
Figure 13. WP-7 Alternative 7-4
Earth Cut Spillway - Upstream Alignment

WP-6&7 Preliminary Design
Papio-Missouri River NRD

WP-6



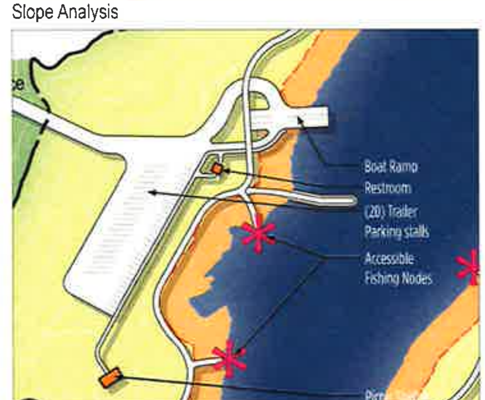
WP-6 Site Plan



Slope Analysis

Accessible ramp and launch.

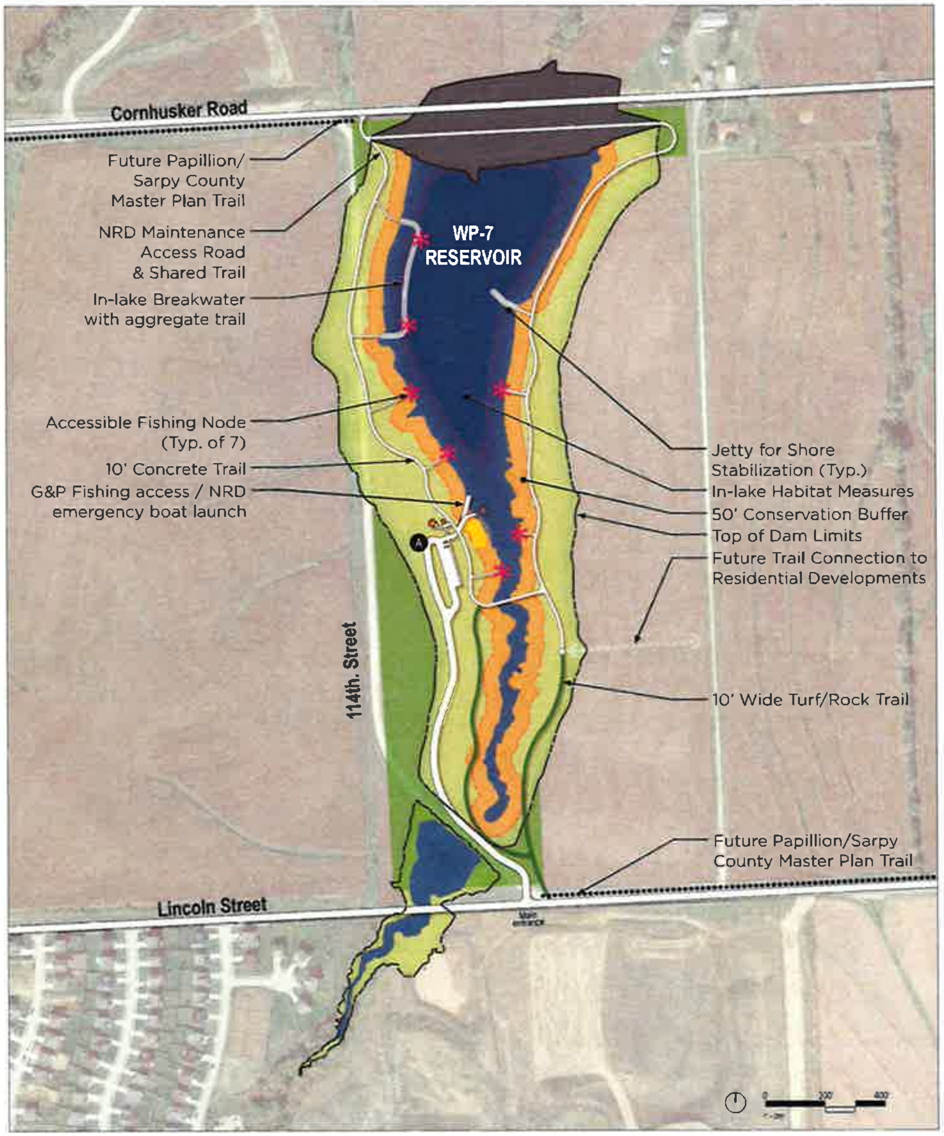
Future Parking, playground, and restrooms.



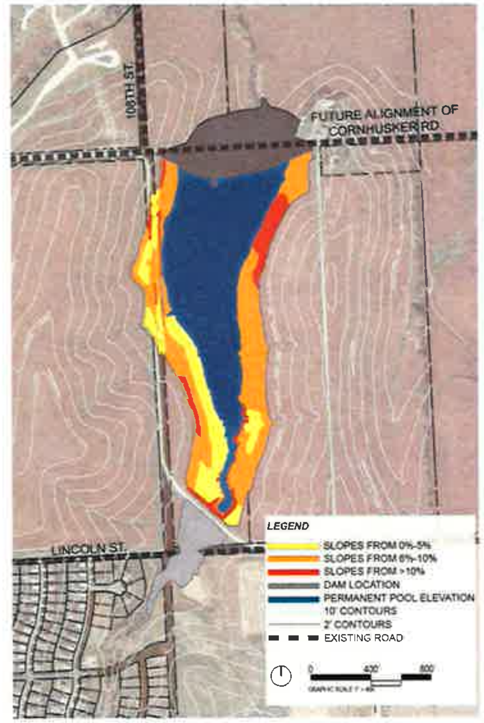
A Boat ramp & water access

B Future Picnic Shelter & Park Playground.

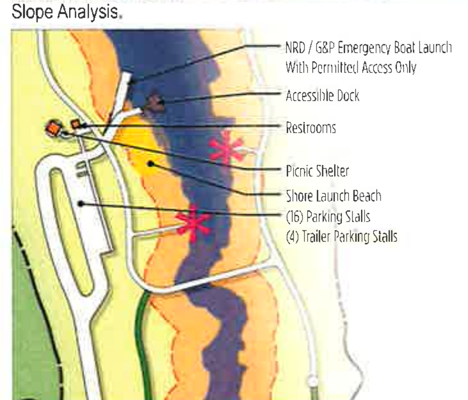
WP-7



WP-7 Site Plan.



Slope Analysis.



A Boat ramp & water access.

Accessible ramp and launch.

Fishing Node.

Picnic Shelter.

Tract Number	Parcel ID	Total Parcel Area (acres)	Dam/Spillway Area (acres)	Permanent Pool Area (acres)	500-Year Pool Area (acres)	Top of Dam Area (acres)	Additional Purchase (acres)	Total Project Area (acres)
1	010385347	152.7	7.6	30.9	24.3	8.3	5.0	76.1
2	010522298	78.9	---	3.2	13.0	9.5	---	25.7
3	011592009	1.5	---	---	0.8	0.1	---	0.9
4	011592008	6.6	---	---	0.2	0.5	---	0.7
Total Purchase			7.6	34.1	38.3	18.4	5.0	103.4
Within Existing ROW			---	---	1.4	0.5	---	1.9
Total Project Area			7.6	34.1	39.7	18.9	5.0	105.3

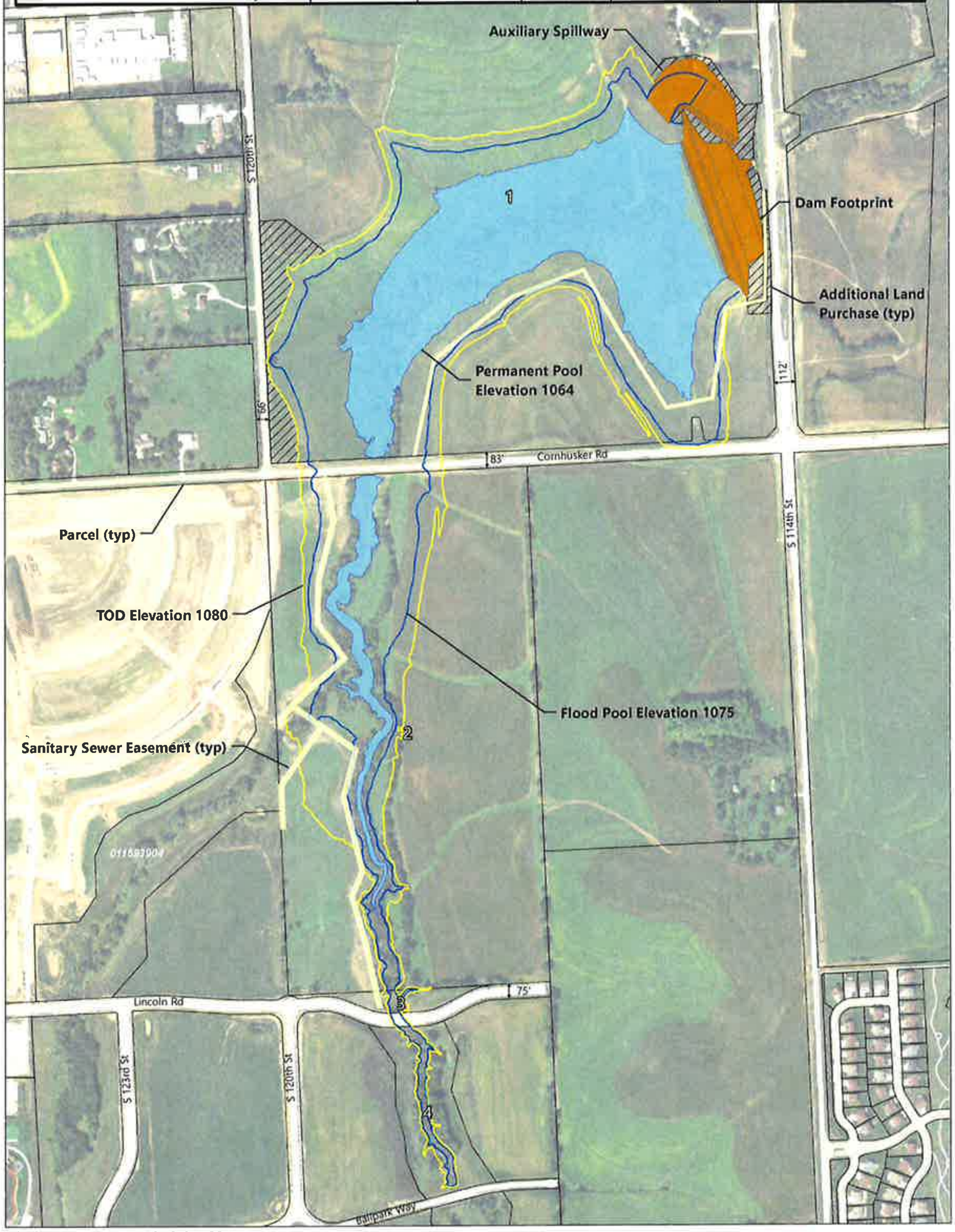


Figure 16. WP-6 Land Rights Map

N
0 250 500 1,000
Feet

FYRA

WP-6&7 Preliminary Design
Papio-Missouri River NRD

Tract Number	Parcel ID	Total Parcel Area (acres)	Dam/Spillway Area (acres)	Permanent Pool Area (acres)	500-Year Pool Area (acres)	Top of Dam Area (acres)	Additional Purchase (acres)	Future ROW Area (acres)	Drainageway Easement (acres)	Total Project Area (acres)
1	10462740	50.5	0.2*	---	---	---	---	0.3	---	0.5
2	10462775	64.6	0.4*	---	---	---	0.1*	0.5	---	1.0
3	10522662	114.4	---	---	---	0.7	---	---	---	0.7
4	10522670	30.6	1.0*	10.5	9.6	3.4*	5.1*	0.8	TBD	30.4
5	11039329	72.3	1.0	2.2	3.9	3.2	0.4	0.6	---	11.3
6	11596960	5.1	---	---	---	0**	---	---	0.1	0.1
7	11596993	41.6	---	---	---	0.2	---	0.0	TBD	0.2
Total Purchase			2.6	12.7	13.5	7.5	5.6	2.2	0.1	44.2
Within Existing ROW			---	---	0.30	1.2	---	---	---	1.5
Total Project Area			2.6	12.7	13.8	8.7	5.6	2.2	0.1	45.7

*additional area for this category reported as Future ROW Area

**area for this category reported as Drainageway Easement

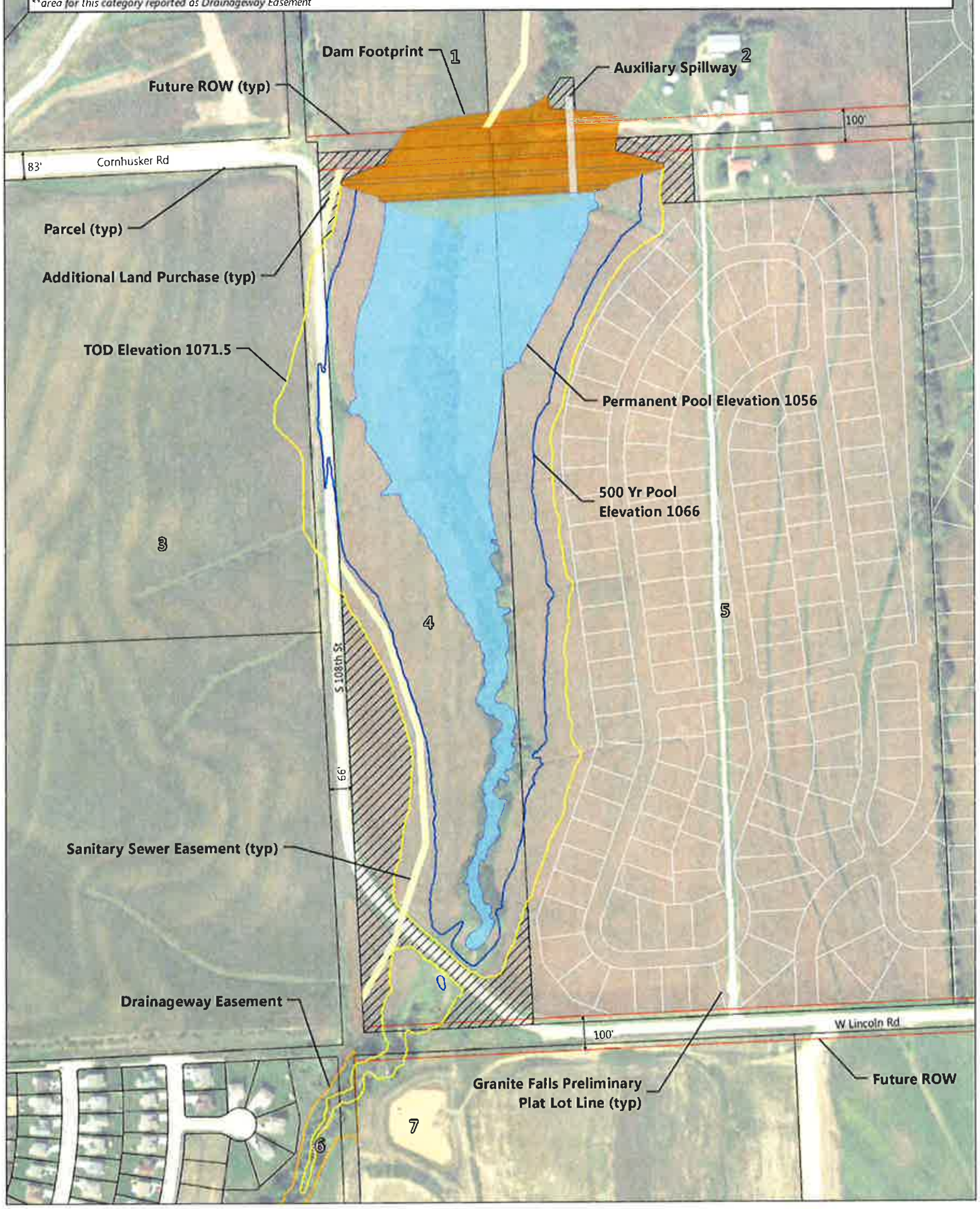


Figure 17. WP-7 Land Rights Map

0 150 300 600 Feet

FYRA

APPENDIX A

HYDROLOGY

WP-6

Table A1. WP-6 Hydrologic Summary

Design Storm	Data	Downstream Alignment	Upstream Alignment
	Drainage Area (acres)	1,270	1,247
PSH, 24-hour*	Peak Inflow (cfs)	1,390	1,365
	Inflow Volume (acre-ft)	810	795
PSH, 10-day	Peak Inflow (cfs)	775	760
	Inflow Volume (acre-ft)	860	840
FBH, 6-hour	Peak Inflow (cfs)	10,230	9,965
	Inflow Volume (acre-ft)	2,030	2,000
FBH, 24-hour	Peak Inflow (cfs)	4,160	4,090
	Inflow Volume (acre-ft)	2,270	2,230

**results reported for the Atlas 14 3rd Quartile temporal distribution*

WP-7

Table A2. WP-7 Hydrologic Summary

Design Storm	Data	Downstream Alignment	Upstream Alignment
	Drainage Area (acres)	470	456
PSH, 24-hour*	Peak Inflow (cfs)	560	550
	Inflow Volume (acre-ft)	320	310
PSH, 10-day	Peak Inflow (cfs)	355	355
	Inflow Volume (acre-ft)	360	350
FBH, 6-hour	Peak Inflow (cfs)	6,315	6,155
	Inflow Volume (acre-ft)	760	740
FBH, 24-hour	Peak Inflow (cfs)	1,550	1,510
	Inflow Volume (acre-ft)	860	840

**results reported for the Atlas 14 3rd Quartile temporal distribution*

APPENDIX B

HYDRAULICS

WP-6

Table B1. WP-6 Hydraulic Routings Summary

Alternative	Description	Permanent Pool Elev	PSH* Routing	AS Crest Elev	FBH** Routing	Top of Dam Elev
6-1	Fuse plug spillway	1064	1074.6-1074.9	1075.0	see Table B2 for varied width results	
6-2	Fixed crest spillway	1064	1074.6-1074.9	1075.0	see Table B4 for varied width results	
6-3	Earth cut spillway	1064	1074.6-1074.9	1075.0	1079.9	1080.0
6-4	Earth cut spillway - upstream alignment	did not advance into next stage of analysis				

**24-hr design storm dictates, range represents results from various temporal distributions*

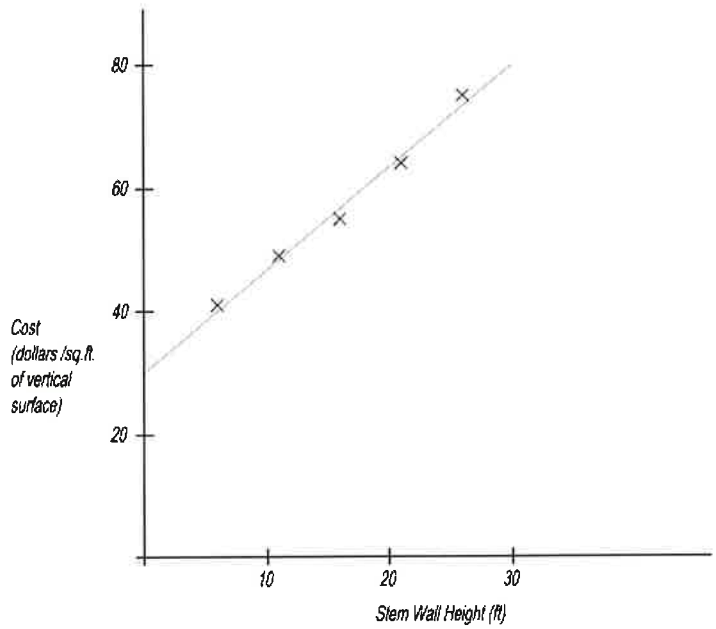
***6-hr design storm dictates*

Table B2. WP-6 Fuse Plug Spillway Width Routings

Spillway Width	Sill Elevation	FBH* Routing	Top of Dam Elev
25	1061	1079.25	1079.5
	1064	1079.59	1080.0
35	1061	1078.48	1078.5
	1064	1078.90	1079.0
45	1061	1078.20	1078.5
	1064	1078.52	1079.0
55	1061	1077.84	1078.0
	1064	1078.19	1078.5

**6-hr design storm dictates*

Figure B1. Cost Estimating Graphs (provided by E&A) used for WP-6



CANTILEVER RETAINING WALL COST CHART

Table B3. WP-6 Fuse Plug Spillway Cost Analysis

Spillway Information		Approximate Costs ($)				
Width	Sill Elevation	Wall	Sill/Energy Dissipation	Embankment	Top of Dam Land Rights	Total
25	1061	$550,000	$235,000	$325,000	$4,555,000	$5,115,550
	1064	$500,000	$235,000	$335,000	$4,735,000	$5,805,000
35	**1061***	**$525,000**	**$320,000**	**$305,000**	**$4,430,000**	**$5,580,000**
	1064	$490,000	$325,000	$320,000	$4,530,000	$5,665,000
45	1061	$525,000	$415,000	$305,000	$4,430,000	$5,675,000
	1064	$490,000	$420,000	$320,000	$4,530,000	$5,760,000
55	1061	$515,000	$500,000	$305,000	$4,325,000	$5,645,000
	1064	$480,000	$505,000	$305,000	$4,430,000	$5,720,000

**Selected alternative advanced into next stage of analysis*

Table B4. WP-6 Fixed Crest Spillway Width Routings

Crest Width	FBH* Routing	Top of Dam Elev
25	>1081.0	>1081.0
35	>1081.0	>1081.0
45	>1081.0	>1081.0
55	>1081.0	>1081.0
60	1081.0	1081.0

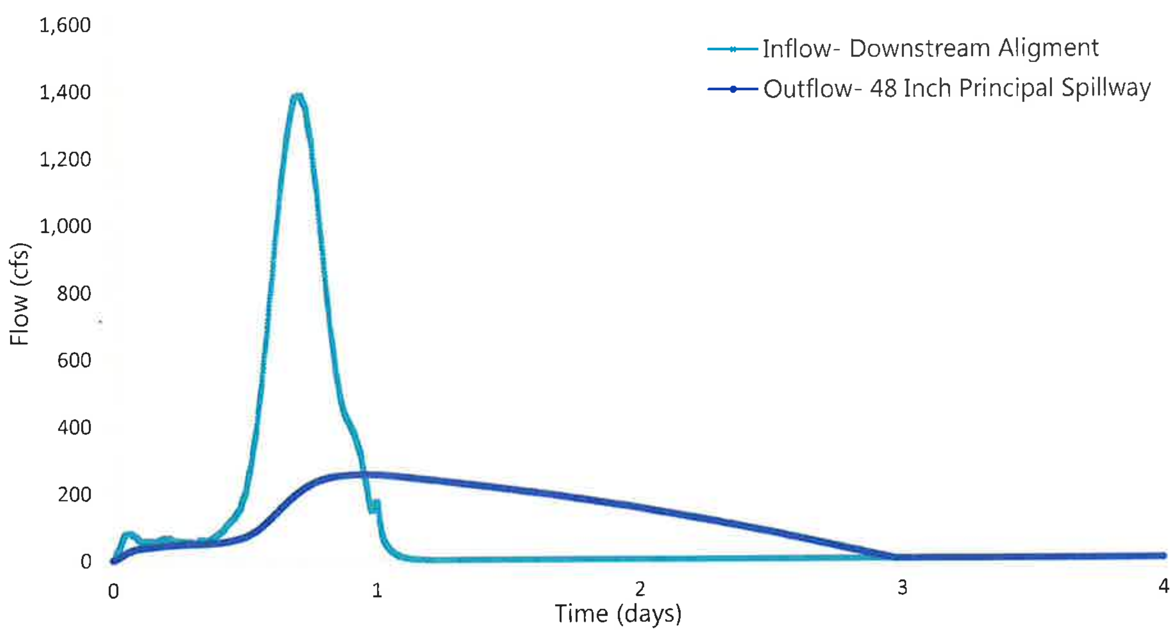
**6-hr design storm dictates; results with greater than 6 ft of flow height above AS crest elevation were eliminated*

Table B5. WP-6 Fixed Crest Spillway Cost Analysis

Spillway Information		Approximate Costs ($)				
Width	Sill Elevation	Wall	Sill/Energy Dissipation	Embankment	Top of Dam Land Rights	Total
60*	**1071**	**$560,000**	**$620,000**	**$350,000**	**$4,955,000**	**$6,485,000**

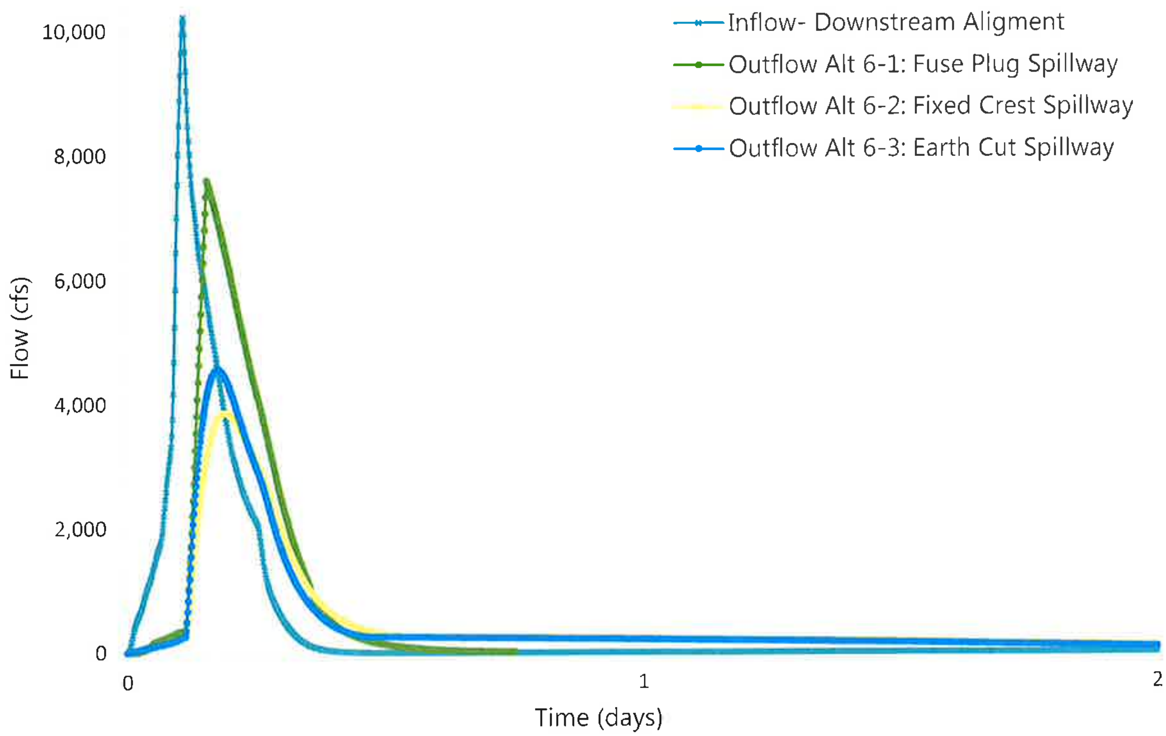
**Selected alternative advanced into next stage of analysis*

Figure B2. WP-6 PSH Inflow and Outflow Hydrographs



**results reported for the 500-year, 24-hour Atlas 14 3rd quartile temporal distribution*

Figure B3. WP-6 FBH Inflow and Outflow Hydrographs



WP-7

Table B6. WP-7 Hydrologic Summary

Alternative	Description	Permanent Pool Elev	PSH* Routing	AS Crest Elev	FBH** Routing	Top of Dam Elev
7-1	Fuse/fixed crest spillway - road on top of dam alignment	did not advance into next stage of analysis				
7-2	Fuse plug spillway - road on stability berm	1056	1064.0-1065.6	1066.0	see Table B7 for varied width results	
7-3	Fixed crest spillway - road on stability berm	1056	1064.0-1065.6	1066.0	see Table B9 for varied width results	
7-4	Earth cut spillway along upstream alignment	1058	1066.2-1068.0	1068.0	1072.6	1073.0

**24-hr design storm dictates, range represents results from various temporal distributions*

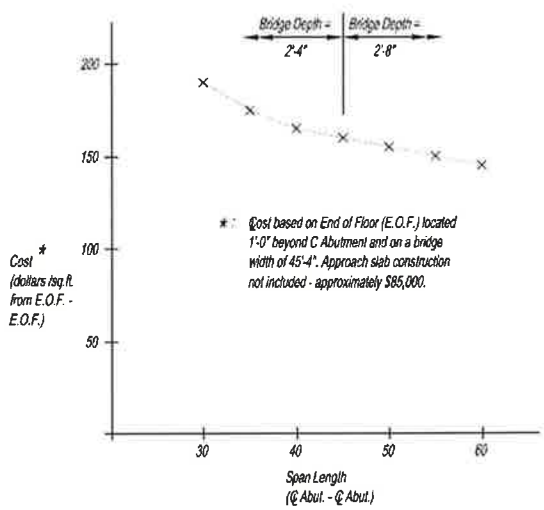
***6-hr design storm dictates*

Table B7. WP-7 Fuse Plug Spillway Width Routings

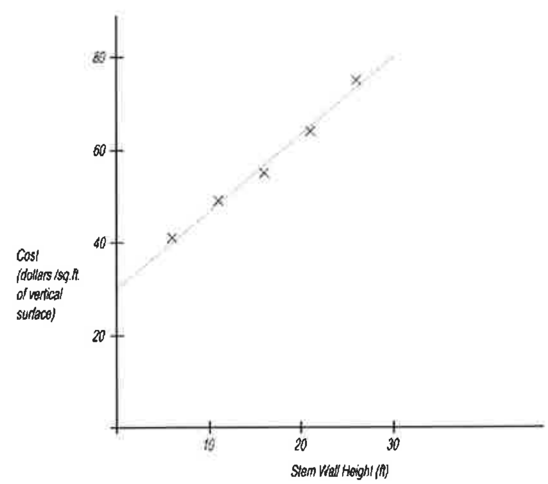
Spillway Width	Sill Elevation	FBH* Routing	Top of Dam Elev
25	1053	1070.88	1071.0
	1056	1071.13	1071.5
35	1053	1070.35	1070.5
	1056	1070.62	1071.0
45	1053	1069.98	1070.0
	1056	1070.23	1070.5
55	1053	1069.65	1070.0
	1056	1069.94	1070.0

**6-hr design storm dictates*

Figure B4. Cost Estimating Graphs (provided by E&A) used for WP-7



BRIDGE COST CHART



CANTILEVER RETAINING WALL COST CHART

Table B8. WP-7 Fuse Plug Spillway Cost Analysis

Spillway Information		Approximate Costs ($)					
Width	Sill Elevation	Bridge	Wall	Sill/Energy Dissipation	Embankment	Top of Dam Land Rights	Total
25	1053	$345,000	$490,000	$240,000	$260,000	$1,850,000	$3,185,000
	1056*	**$345,000**	**$445,000**	**$245,000**	**$270,000**	**$1,870,000**	**$3,175,000**
35	1053	$365,000	$480,000	$335,000	$255,000	$1,780,000	$3,215,000
	1056	$365,000	$440,000	$340,000	$260,000	$1,850,000	$3,255,000
45	1053	$420,000	$475,000	$425,000	$250,000	$1,705,000	$3,275,000
	1056	$420,000	$430,000	$430,000	$255,000	$1,780,000	$3,315,000
55	1053	$460,000	$470,000	$520,000	$250,000	$1,705,000	$3,405,000
	1056	$460,000	$420,000	$520,000	$250,000	$1,705,000	$3,355,000

Selected alternative advanced into next stage of analysis

Table B9. WP-7 Fixed Crest Spillway Width Routings

Crest Width	FBH* Routing	Top of Dam Elev
25	1072.3	1072.5
35	1071.7	1072.0
45	1071.3	1071.5
55	1071.0	1071.5

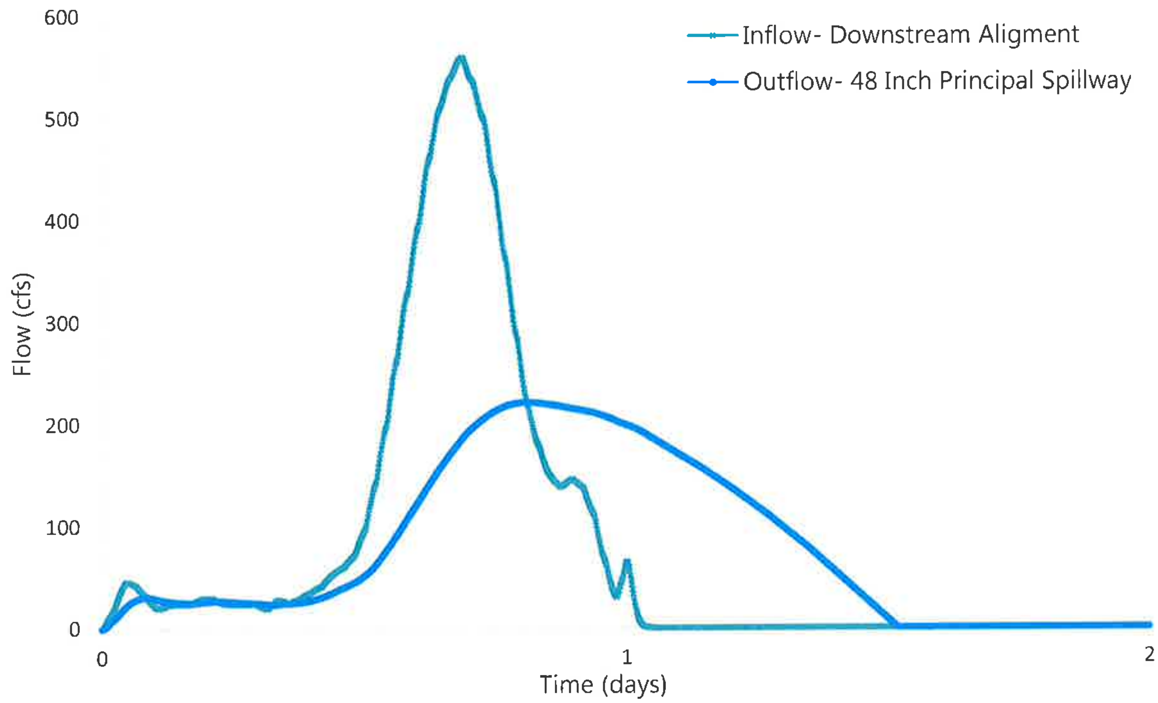
6-hr design storm dictates

Table B10. WP-7 Fixed Crest Spillway Cost Analysis

Spillway Information		Approximate Costs ($)					
Width	Sill Elevation	Bridge	Wall	Sill/Energy Dissipation	Embankment	Top of Dam Land Rights	Total
25	1062	$345,000	$535,000	$240,000	$285,000	$2,080,000	$3,485,000
35	**1062**	**$365,000**	**$510,000**	**$335,000**	**$275,000**	**$1,995,000**	**$3,480,000**
45	1062	$420,000	$490,000	$430,000	$270,000	$1,920,000	$3,530,000
55	1062	$460,000	$490,000	$525,000	$270,000	$1,920,000	$3,665,000

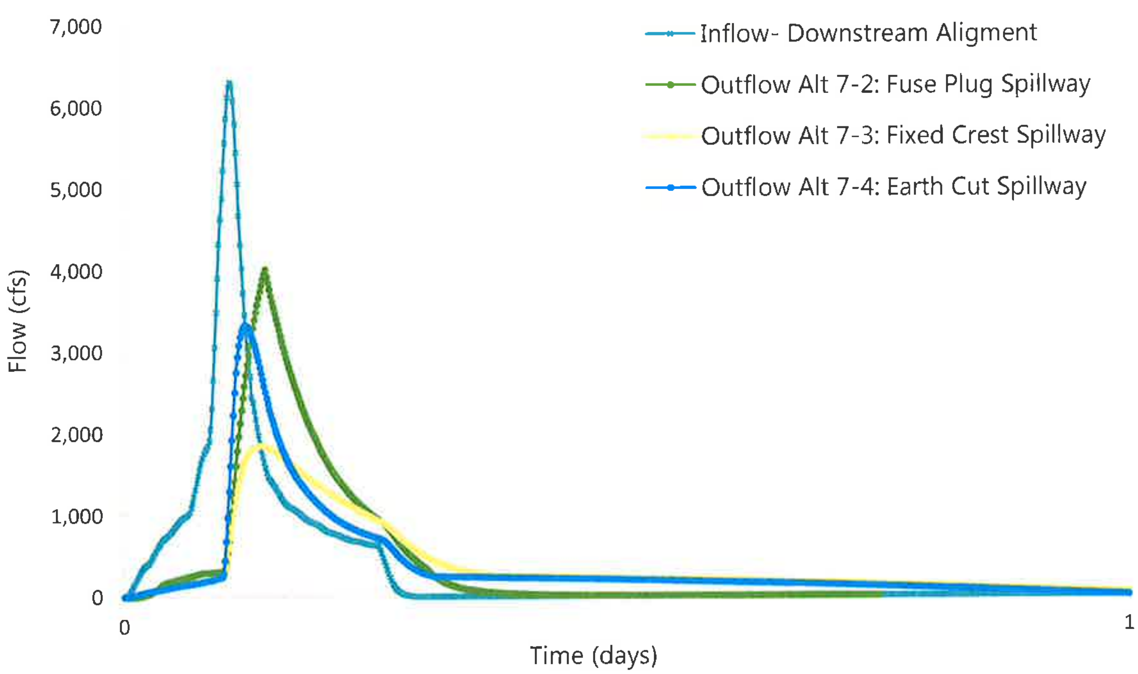
Selected alternative advanced into next stage of analysis

Figure B5. WP-7 PSH Inflow and Outflow Hydrographs



**results reported for the 500-year, 24-hour Atlas 14 3rd quartile temporal distribution*

Figure B6. WP-7 FBH Inflow and Outflow Hydrographs



APPENDIX C

RESERVOIR SUSTAINABILITY ANALYSIS

(Preferred permanent pool elevation in bold for each alternative)

WP-6

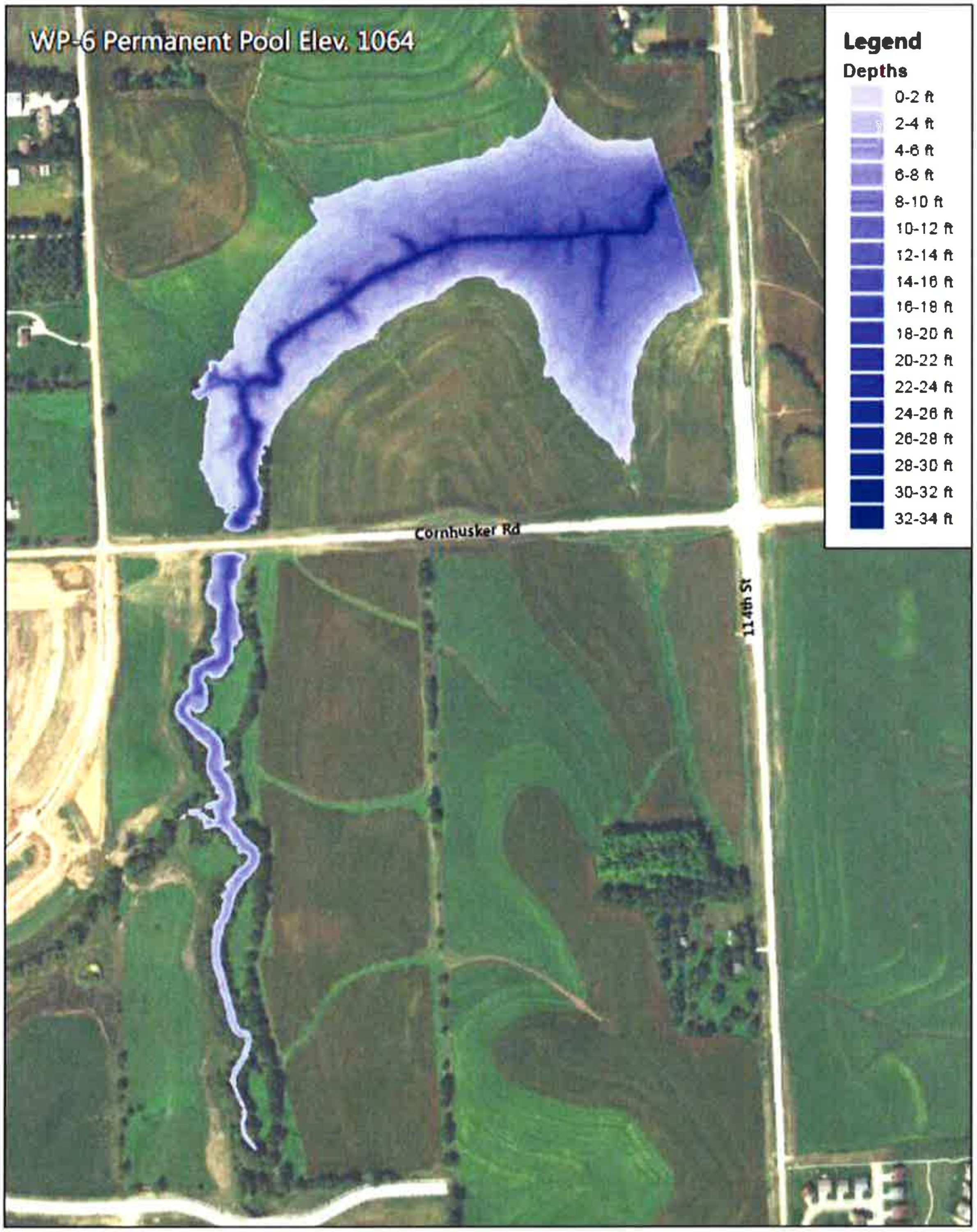
Table C1. WP-6 Downstream Alignment

Elevation	Area (acre)	Volume (acre-ft)	Mean Depth (ft)	Sustainability Ratio	Storage (WsIn)
1034	0.0	0.0	0.0	0.0%	0.00
1036	0.1	0.1	1.0	0.0%	0.00
1038	0.1	0.3	2.1	0.0%	0.00
1040	0.4	0.8	1.9	0.0%	0.01
1042	0.8	2.1	2.5	0.1%	0.02
1044	1.4	4.3	3.1	0.1%	0.04
1046	1.9	7.5	4.0	0.1%	0.07
1048	2.4	11.8	4.9	0.2%	0.11
1050	3.4	17.5	5.2	0.3%	0.17
1052	5.4	26.4	4.8	0.4%	0.25
1054	8.4	40.2	4.8	0.7%	0.38
1056	12.1	60.8	5.0	1.0%	0.58
1058	16.7	89.5	5.4	1.3%	0.85
1060	22.1	128.3	5.8	1.7%	1.21
1061	25.0	151.8	6.1	2.0%	1.44
1062	27.9	178.3	6.4	2.2%	1.69
1063	31.1	207.8	6.7	2.5%	1.97
1064	**34.3**	**240.5**	**7.0**	**2.7%**	**2.28**
1065	37.6	276.5	7.4	3.0%	2.62
1066	40.8	315.7	7.7	3.2%	2.99
1068	47.3	403.9	8.5	3.7%	3.82
1070	55.9	507.1	9.1	4.4%	4.80
1072	63.8	626.9	9.8	5.0%	5.94
1074	70.7	761.3	10.8	5.6%	7.21
1076	78.3	910.3	11.6	6.2%	8.62
1078	86.5	1075.2	12.4	6.8%	10.18
1080	94.7	1256.4	13.3	7.5%	11.90
1081	99.1	1353.9	13.7	7.8%	12.82

Table C2. WP-6 Upstream Alignment

Elevation	Area (acre)	Volume (acre-ft)	Mean Depth (ft)	Sustainability Ratio	Storage (WsIn)
1036	0.0	0.0	0.0	0.0%	0.00
1038	0.0	0.0	1.0	0.0%	0.00
1040	0.2	0.3	1.4	0.0%	0.00
1042	0.5	1.1	2.0	0.0%	0.01
1044	0.9	2.6	2.7	0.1%	0.02
1046	1.3	4.8	3.7	0.1%	0.05
1048	1.7	7.8	4.6	0.1%	0.08
1050	2.2	11.7	5.3	0.2%	0.11
1052	3.2	17.1	5.3	0.3%	0.17
1054	5.1	25.5	5.0	0.4%	0.25
1056	7.9	38.5	4.9	0.6%	0.37
1058	11.9	58.2	4.9	1.0%	0.56
1060	16.8	86.8	5.2	1.4%	0.84
1061	19.7	105.0	5.3	1.6%	1.02
1062	22.3	125.9	5.6	1.8%	1.22
1063	25.3	149.7	5.9	2.0%	1.45
1064	28.2	176.4	6.3	2.3%	1.71
1065	**31.1**	**206.0**	**6.6**	**2.5%**	**1.99**
1066	34.4	239.0	6.9	2.8%	2.31
1068	40.5	313.8	7.8	3.3%	3.03
1070	48.7	403.0	8.3	3.9%	3.90
1072	56.2	507.9	9.0	4.5%	4.91
1074	62.7	626.7	10.0	5.1%	6.06
1076	69.9	759.3	10.9	5.6%	7.34
1078	77.5	906.7	11.7	6.2%	8.77
1080	85.2	1069.4	12.5	6.9%	10.34
1081	89.5	1156.7	12.9	7.2%	11.19
1082	94.6	1248.8	13.2	7.6%	12.08

Figure C1. WP-6 Preferred Downstream Alignment and Pool Bathymetry Map



WP-7

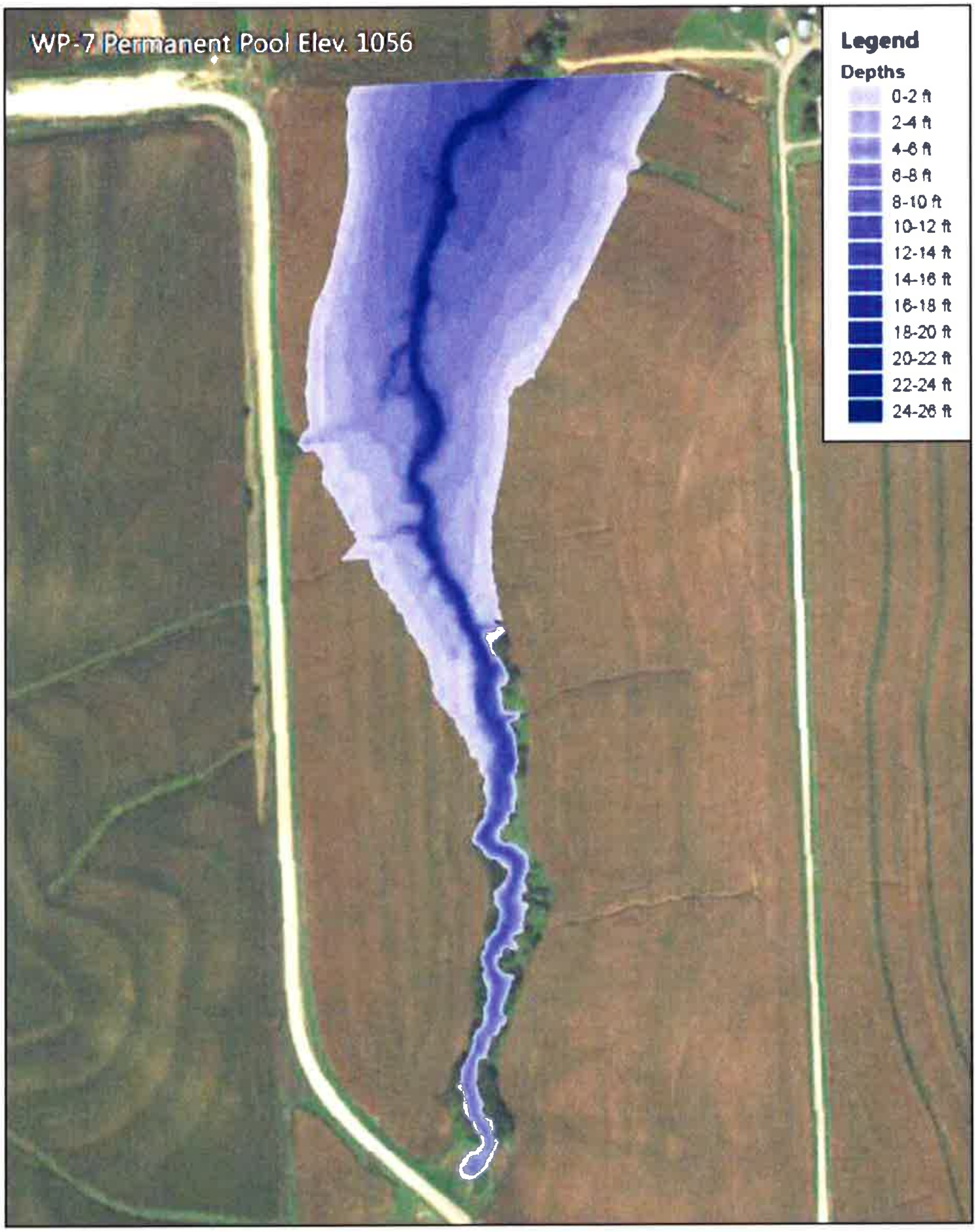
Table C3. WP-7 Downstream Alignment

Elevation	Area (acre)	Volume (acre-ft)	Mean Depth (ft)	Sustainability Ratio	Storage (WsIn)
1034	0.0	0.0	0.0	0.0%	0.00
1036	0.1	0.1	1.2	0.0%	0.00
1038	0.2	0.4	1.7	0.0%	0.01
1040	0.4	1.0	2.4	0.1%	0.03
1042	0.7	2.2	3.0	0.2%	0.06
1044	1.0	3.9	3.9	0.2%	0.10
1046	1.7	6.6	3.9	0.4%	0.17
1048	3.2	11.5	3.6	0.7%	0.29
1050	5.0	19.6	3.9	1.1%	0.50
1052	7.2	31.8	4.4	1.5%	0.82
1054	9.8	48.8	5.0	2.1%	1.25
1056	**12.5**	**71.2**	**5.7**	**2.7%**	**1.83**
1057	14.0	84.4	6.0	3.0%	2.17
1058	15.3	99.1	6.5	3.3%	2.54
1059	16.8	115.2	6.8	3.6%	2.95
1060	18.2	132.7	7.3	3.9%	3.40
1062	21.1	172.0	8.2	4.5%	4.41
1064	23.9	217.0	9.1	5.1%	5.57
1066	27.2	268.2	9.9	5.8%	6.88
1068	30.5	325.9	10.7	6.5%	8.36
1070	34.1	390.5	11.4	7.3%	10.02
1072	39.9	464.5	11.7	8.5%	11.92
1073	43.3	506.1	11.7	9.3%	12.99

Table C4. WP-7 Upstream Alignment

Elevation	Area (acre)	Volume (acre-ft)	Mean Depth (ft)	Sustainability Ratio	Storage (WsIn)
1034	0.0	0.0	0.0	0.0%	0.00
1036	0.0	0.0	1.0	0.0%	0.00
1038	0.1	0.1	1.2	0.0%	0.00
1040	0.3	0.5	1.9	0.1%	0.01
1042	0.5	1.3	2.5	0.1%	0.03
1044	0.8	2.5	3.3	0.2%	0.07
1046	1.1	4.4	4.0	0.2%	0.12
1048	1.6	7.1	4.4	0.4%	0.19
1050	2.7	11.4	4.2	0.6%	0.30
1052	4.4	18.5	4.2	1.0%	0.48
1054	6.5	29.4	4.5	1.4%	0.77
1056	8.8	44.7	5.1	1.9%	1.17
1057	10.1	54.1	5.3	2.2%	1.42
1058	**11.3**	**64.8**	**5.7**	**2.5%**	**1.70**
1059	12.6	76.8	6.1	2.8%	2.01
1060	13.9	90.0	6.5	3.0%	2.36
1062	16.4	120.3	7.3	3.6%	3.15
1064	19.0	155.8	8.2	4.2%	4.08
1066	22.0	196.7	9.0	4.8%	5.16
1068	24.9	243.6	9.8	5.4%	6.38
1070	27.9	296.3	10.6	6.1%	7.77
1072	31.9	358.2	11.2	7.0%	9.39
1073	34.1	391.0	11.5	7.4%	10.25

Figure C2. WP-7 Preferred Downstream Alignment and Pool Bathymetry Map



SEDIMENT LOADING CALCULATIONS

WP-6

Table D1. WP-6 Sediment Load Summary

Year	% Land in Ag	Load From Ag (tons)	% Land in Construction	Load From Construction (tons)	% Land in Urban	Load From Urban (tons)	Total Annual Watershed Load (tons)	Total Annual Streambank Erosion Load (tons)	Annual Sediment Volume (tons)	Annual Sediment Volume (ac-ft)	Cumulative Sediment Storage w/ 70% Trapping Efficiency (ac-ft)
1	85%	3,353	10%	934	5%	1	4,288	2,573	4,289	4.9	3.4
2	75%	2,958	10%	934	15%	3	3,896	2,337	3,899	4.5	6.5
3	65%	2,564	10%	934	25%	5	3,503	2,102	3,508	4.0	9.3
4	55%	2,169	10%	934	35%	7	3,111	1,867	3,118	3.6	11.8
5	45%	1,775	10%	934	45%	9	2,719	1,631	2,728	3.1	14.0
6	35%	1,381	10%	934	55%	11	2,326	1,396	2,338	2.7	15.9
7	25%	986	10%	934	65%	13	1,934	1,160	1,947	2.2	17.4
8	15%	592	10%	934	75%	16	1,541	925	1,557	1.8	18.7
9	5%	197	10%	934	85%	18	1,149	689	1,167	1.3	19.6
10	0%	0	5%	467	95%	20	487	292	507	0.6	20.0
11-50	0%	0	0%	0	100%	21	21	12	42	0.02	20.0-20.6

WP-7

Table D4. WP-7 Sediment Load Summary

Year	% Land in Ag	Load From Ag (tons)	% Land in Construction	Load From Construction (tons)	% Land in Urban	Load From Urban (tons)	Total Annual Watershed Load (tons)	Total Annual Streambank Erosion Load (tons)	Annual Sediment Volume (tons)	Annual Sediment Volume (ac-ft)	Cumulative Sediment Storage w/ 70% Trapping Efficiency (ac-ft)
1	85%	1,344	10%	374	5%	0	1,718	1,031	1,719	2.0	1.4
2	75%	1,186	10%	374	15%	1	1,561	937	1,562	1.8	2.6
3	65%	1,028	10%	374	25%	2	1,404	842	1,406	1.6	3.7
4	55%	869	10%	374	35%	3	1,247	748	1,250	1.4	4.7
5	45%	711	10%	374	45%	4	1,090	654	1,093	1.2	5.6
6	35%	553	10%	374	55%	5	932	559	937	1.1	6.4
7	25%	395	10%	374	65%	5	775	465	780	0.9	7.0
8	15%	237	10%	374	75%	6	618	371	624	0.7	7.5
9	5%	79	10%	374	85%	7	461	276	468	0.5	7.8
10	0%	0	5%	187	95%	8	195	117	203	0.2	8.0
11-50	0%	0	0%	0	100%	8	832%	5	17	0.0	8.0-8.3

APPENDIX E

Water Quality Sampling Results

Figure E1. Water Quality Sampling Locations

Figure E2. Metolachlor Sampling Results

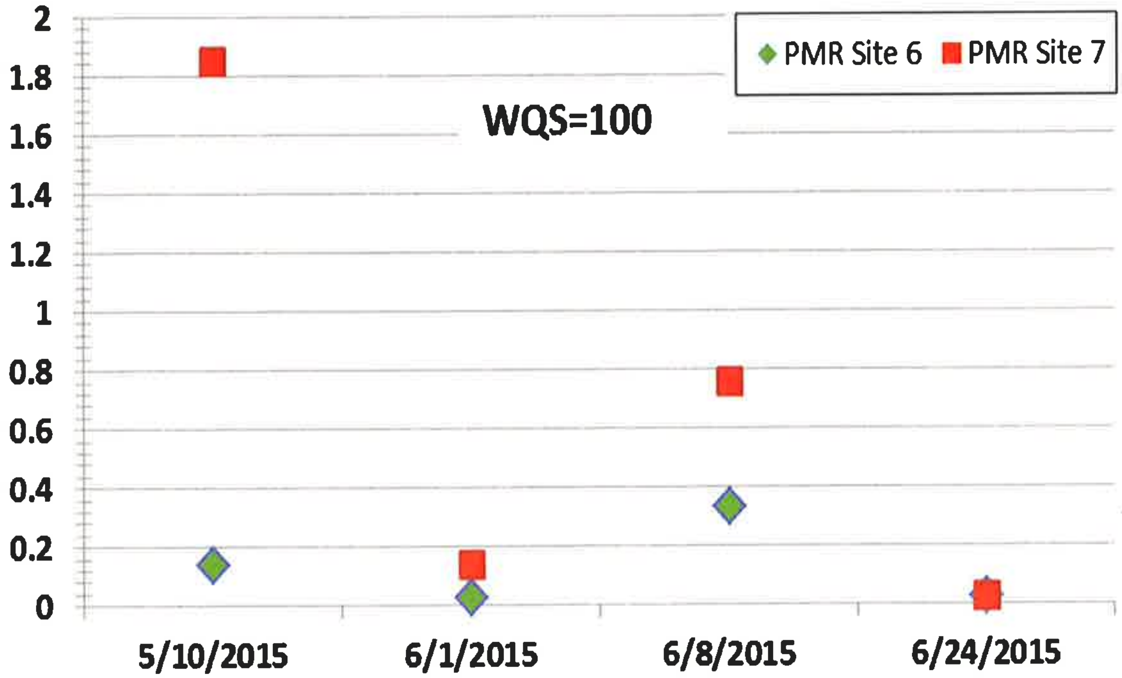


Figure E3. Total Phosphorus Sampling Results

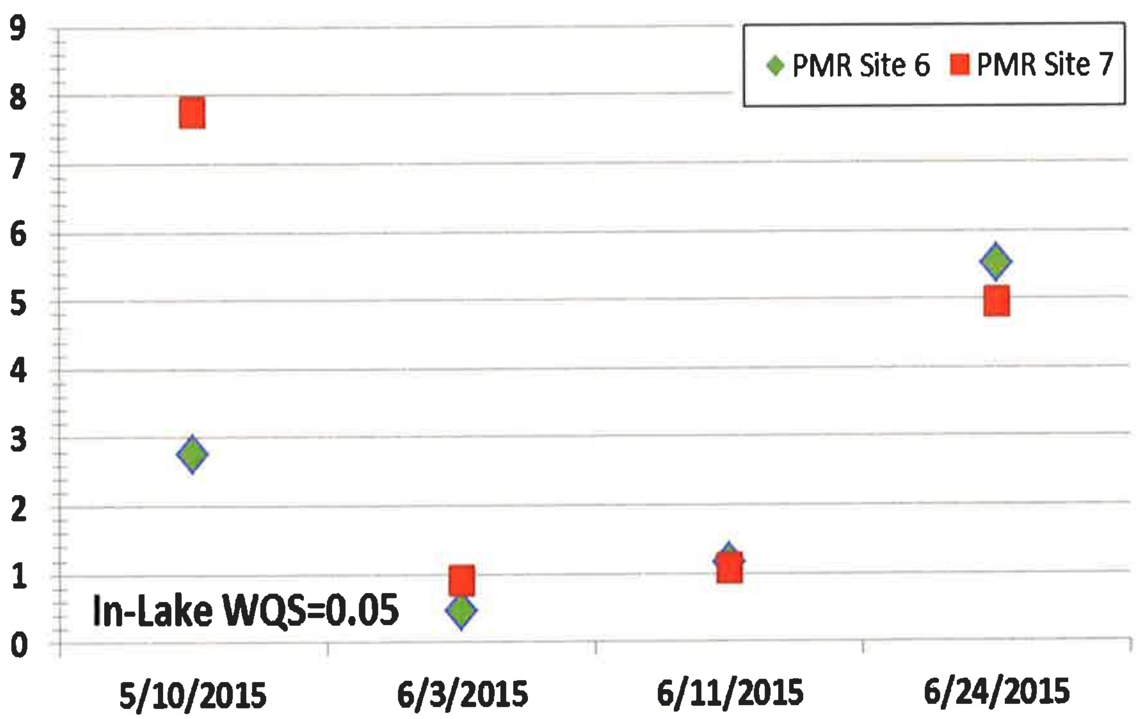


Figure E4. Total Nitrogen Sampling Results

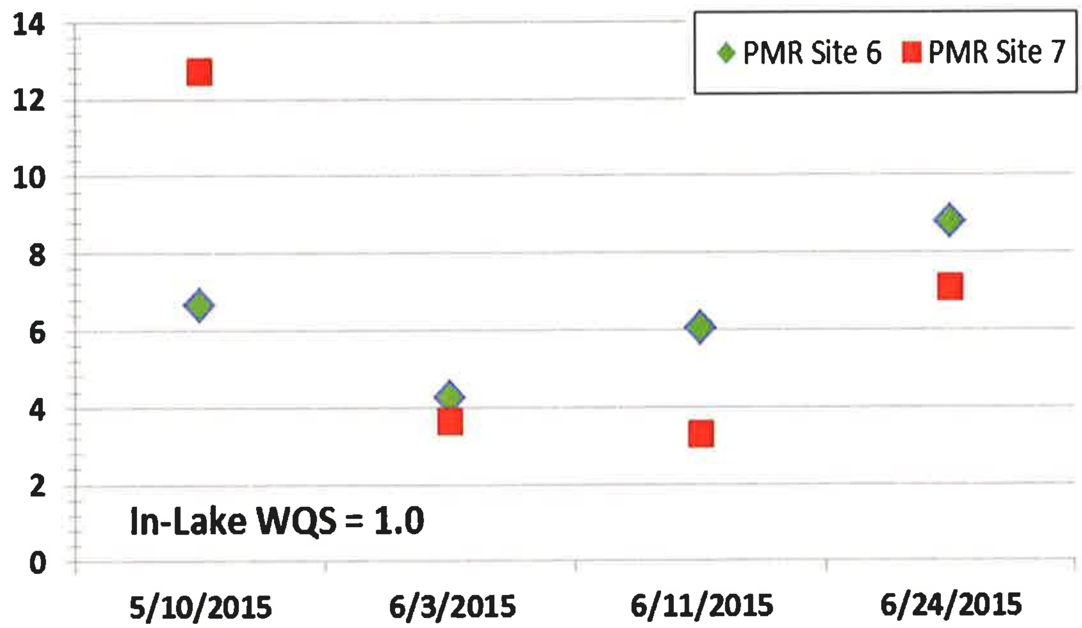


Figure E5. Sediment Sampling Results

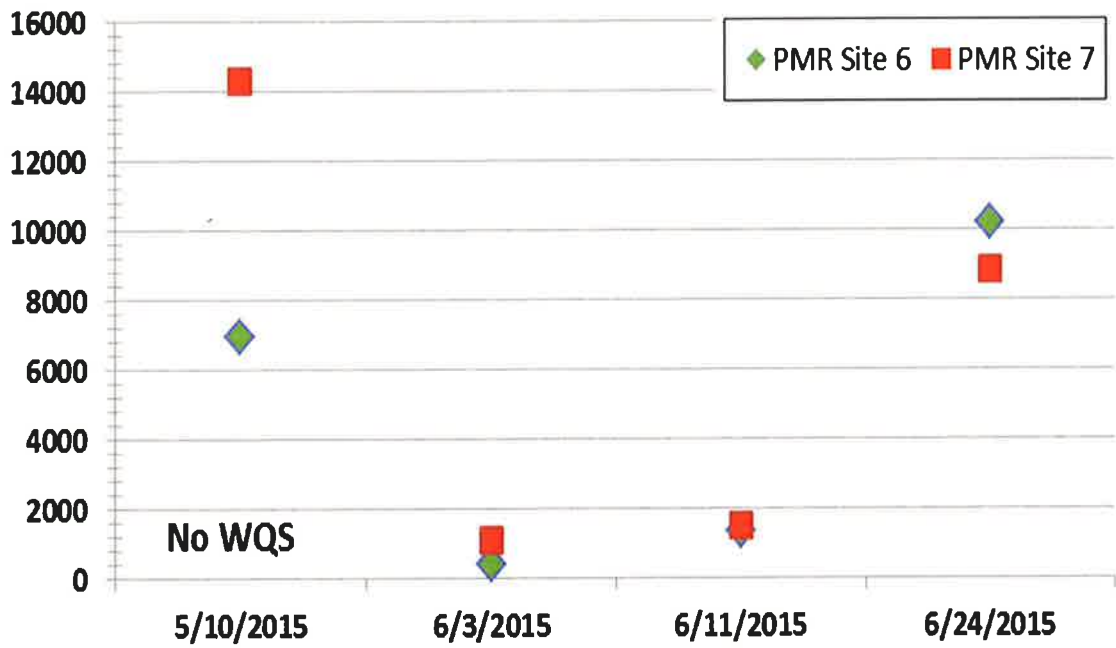


Table E1. Water Quality Sampling Results

	Sampling Date and Location											
	5/10/2015		6/3/2015		6/11/2015		6/24/2015		7/28/2015		8/4/2015	
	Site 6	Site 7	Site 6	Site 7	Site 6	Site 7	Site 6	Site 7	Site 6	Site 7	Site 6	Site 7
Total Phosphorus (mg/L)	2.77	7.77	0.47	0.92	1.16	1.08	5.51	4.95	0.54	0.68	0.26	0.24
Nitrate-Nitrogen (mg/L)	2.41	0.409	3.05	1.22	3.58	1.04	0.74	0.46	2.54	0.83	2.95	2.31
Kjeldahl Nitrogen (mg/L)	4.24	12.3	1.19	2.44	2.46	2.26	8.03	6.61	1.26	1.83	0.80	0.71
Total Suspended Solids (mg/L)	2690	1260	346	910	1080	1100	8050	6580	316	638	62	37
Suspended Sediment (mg/L)	6960	14300	431	1090	1370	1490	10200	8870	346	700	71.3	23.3
Acetachlor (µg/L)	3.78	0.76	0.68	1.05	1.39	0.84	1.71	0.91	0.05	0.10	0.05	0.14
Metolachlor (µg/L)	0.14	1.85	0.03	0.14	0.33	0.76	0.03	0.03	0.07	0.03	0.09	0.04
Atrazine (µg/L)	0.12	2.4	0.43	1.21	0.99	0.88	3.26	2.53	0.03	0.13	0.03	0.13
Bacteria (colonies/100mls)	9208	19863	7701	10462	17730	4350	24200	19863	24196	24196	8164	4312

CAPITAL COSTS BREAKDOWN TABLES

WP-6

Table F1. WP-6 Alternative 6-1 Dam Cost Breakdown

Item	Quantity	Unit	Unit Cost	Cost
Mobilization/General	1	LS	$150,015	$150,015
Dam Embankment	120,000	CY	$2.50	$300,000
Fuse Plug Fill- Clay	1,000	CY	$12.00	$12,000
Fuse Plug Fill- Sand	340	TN	$30.00	$10,200
Principal Spillway Pipe	275	FT	$550.00	$151,250
Drawdown Pipe and Valve	110	FT	$250.00	$27,500
Common Excavation	12,000	CY	$2.00	$24,000
Aggregate Fill	300	TN	$30.00	$9,000
Rock Riprap	1,030	TN	$60.00	$61,800
Seeding	8.0	AC	$1,800.00	$14,400
Structural Concrete	1,515	CY	$500.00	$757,500
Non-Structural Concrete	530	CY	$250.00	$132,500
			Subtotal	$1,650,165
			20% Contingency	$330,033
			TOTAL	**$1,980,198**

Table F2. WP-6 Alternative 6-1 Land Rights Breakdown

Item	Area*	Unit	Unit Cost	Cost
Dam and Spillway	4.0	AC	$50,000	$200,000
Permanent Pool	34.3	AC	$50,000	$1,715,000
Top of Dam	52.7	AC	$50,000	$2,635,000
Additional Purchase (estimated)	5.8	AC	$50,000	$290,000
TOTAL	**96.8**			**$4,840,000**

**area within existing ROW not included*

Table F3. WP-6 Alternative 6-2 Dam Cost Breakdown

Item	Quantity	Unit	Unit Cost	Cost
Mobilization/General	1	LS	$171,525	$171,525
Dam Embankment	130,000	CY	$2.50	$325,000
Principal Spillway Pipe- 48" RCP	290	FT	$550.00	$159,500

Drawdown Pipe and Valve	110	FT	$250.00	$27,500
Common Excavation	12,650	CY	$2.00	$25,300
Aggregate Fill	310	TN	$30.00	$9,300
Rock Riprap	1,175	TN	$60.00	$70,500
Seeding	8.0	AC	$1,800.00	$14,400
Structural Concrete	1,755	CY	$500.00	$877,500
Non-Structural Concrete	825	CY	$250.00	$206,250
			Subtotal	$1,886,775
			20% Contingency	$377,355
			TOTAL	**$2,264,130**

Table F4. WP-6 Alternative 6-2 Land Rights Breakdown

Item	Area*	Unit	Unit Cost	Cost
Dam and Spillway	4.4	AC	$50,000	$220,000
Permanent Pool	34.3	AC	$50,000	$1,715,000
Top of Dam	63.1	AC	$50,000	$3,155,000
Additional Purchase (estimated)	5.7	AC	$50,000	$285,000
TOTAL	**107.5**			**$5,375,000**

**area within existing ROW not included*

Table F5. WP-6 Alternative 6-3 Dam Cost Breakdown

Item	Quantity	Unit	Unit Cost	Cost
Mobilization/General	1	LS	$66,208	$66,208
Dam Embankment	133,800	CY	$2.50	$334,325
Principal Spillway Pipe	280	FT	$550.00	$154,000
Drawdown Pipe and Valve	110	FT	$250.00	$27,500
Common Excavation	12,220	CY	$2.00	$24,431
Aggregate Fill	310	TN	$30.00	$9,240
Rock Riprap	885	TN	$60.00	$52,959
Seeding	13.0	AC	$1,800.00	$23,615
Structural Concrete	75	CY	$500.00	$36,000
Non-Structural Concrete	55	CY	$550.00	$28,600
			Subtotal	$728,279
			20% Contingency	$145,656
			TOTAL	**$873,934**

Table F6. WP-6 Alternative 6-3 Land Rights Breakdown

Item	Area*	Unit	Unit Cost	Cost
Dam and Spillway	7.6	AC	$50,000	$380,000
Permanent Pool	34.1	AC	$50,000	$1,705,000
500-Year Pool	38.3	AC	$50,000	$1,915,000
Top of Dam	18.4	AC	$50,000	$920,000
Additional Purchase (estimated)	5.0	AC	$50,000	$250,000
TOTAL	**103.4**			**$5,170,000**

**area within existing ROW not included*

Table F7. WP-6 Water Quality Basin Design Concept Cost Estimate

Item	Quantity	Unit	Unit Cost	Cost
Remove Existing 10' Dia. RCP	1	LS	$3,000.00	$3,000
Outlet Works	1	LS	$35,000.00	$35,000
			Subtotal	$35,000
			20% Contingency	$7,000
			TOTAL	**$42,000**

Table F8. WP-6 Recreation Facilities Cost Estimate

	Quantity	Unit	Unit Price ($)	Cost ($)
Multi-Use Concrete Trail				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$9,500.00	$9,500
Field Staking and Surveying	1	LS	$11,000.00	$11,000
Site Improvements				
8' wide x 5" Concrete Trail with earthwork	10,000	LF	$48.00	$480,000
10' wide aggregate trail	670	LF	$30.00	$20,100
Stormwater Culverts/Mitigation Measures	4	EA	$2,500.00	$10,000
Slope Retaining and Soil Stabilization Measures	1	LS	$12,000.00	$12,000
Signage	1	LS	$2,500.00	$2,500
120th Street Entry Drive, Parking and Boat Ramp				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$8,000.00	$8,000

Field Staking and Surveying	1	LS	$4,500.00	$4,500
Site Improvements				
7" Concrete Drive and Parking	5,050	SY	$48.00	$242,400
Boat Ramp and Dock Construction	1	EA	$40,000.00	$40,000
Vehicle Access Control and Soil Stabilization Measures	1	LS	$6,500.00	$6,500
Site Lighting	1	LS	$25,000.00	$25,000
Entry Gate and Signage	1	LS	$5,500.00	$5,500
Public Amenity Facilities				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$8,000.00	$8,000
Field Staking and Surveying	1	LS	$4,500.00	$4,500
Site Improvements				
(1) 16 x 24 Picnic Shelter with pad, tables, and grills	1	LS	$20,000.00	$20,000
Vault Toilet 2-Stall Unit (Romtec)	1	EA	$50,000.00	$50,000
5" Pedestrian Concrete Walks	4500	SF	$4.00	$18,000
Signage	1	LS	$1,000.00	$1,00
Stormwater Management BMPs	1	LS	$8,000.00	$8,000
Fisheries				
(9) Aggregate and Sheet Pile Shore Fishing Landings	9	EA	$15,000.00	$135,000
(1) ADA Concrete and Sheet Pile Shore Fishing Landings	1	EA	$18,000.00	$18,000
Shoreline Protection	1200	FT	$21.00	$25,200
Offshore Breakwater/Trail	500	FT	$185.00	$92,500
Breakwater Jetty	4	EA	$6,000.00	$24,000
Vegetation Barriers	10	EA	$1,500.00	$15,000
Underwater Shoals	10	EA	$1,500.00	$15,000
Shoreline Scallops	5	EA	$5,000.00	$25,000
In-lake "Rock Star" Habitat	25	EA	$2,800.00	$70,000
Shoreline Access Bumpouts	10	EA	$5,000.00	$50,000
Cove Enhancement Excavation	3000	CY	$5.00	$15,000
Cornhusker Road Natural Area Parking				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$4,500.00	$4,500
Field Staking and Surveying	1	LS	$1,500.00	$1,500
Site Improvements				
6" Aggregate Paving	860	SY	$18.00	$15,480

Entry Gate	1	LS	$2,400.00	$2,400
Site Lighting	1	LS	$4,000.00	$4,000
Signage	1	LS	$1,200.00	$1,200
Site Vegetation Restoration				
Turf and Grasses				
Fescue turfgrass / Hydromulch (day use area)	3	Acre	$1,500.00	$4,500
Overland Rural NRD Mix / Crimp Straw	60	Acre	$1,800.00	$108,000
Stream mitigation - channel stabilization plantings	1.5	Acre	$1,800.00	$2,700
Stream mitigation - vegetated buffer plantings	6	Acre	$1,800.00	$10,800
Trees				
2" Caliper Trees (day use/fish bump outs	50	EA	$350.00	$17,500
Mulch	20	CY	$45.00	$900
	SUBTOTAL			$1,644,680
	20% Contingency			$328,936
	TOTAL			**$1,973,616**

WP-7

Table F9. WP-7 Alternative 7-2 Dam Cost Breakdown

Item	Quantity	Unit	Unit Cost	Cost
Mobilization/General	1	LS	$121,512	$121,512
Dam Embankment	123,000	CY	$2.50	$307,500
Fuse Plug Fill- Clay	280	CY	$4.00	$1,120
Fuse Plug Fill- Sand	140	TN	$30.00	$4,200
Principal Spillway Pipe	250	FT	$550.00	$137,500
Drawdown Pipe and Valve	70	FT	$250.00	$17,500
Common Excavation	1,200	CY	$2.00	$2,400
Aggregate Fill	230	TN	$30.00	$6,900
Rock Riprap	900	TN	$60.00	$54,000
Seeding	5	AC	$1,800.00	$9,000
Bridge	1	LS	$350,000	$350,000
Structural Concrete	1,265	CY	$500.00	$632,500
Non-Structural Concrete	370	CY	$250.00	$92,500
			Subtotal	$1,776,632
			20% Contingency	$355,326
			TOTAL	**$2,131,958**

Table F10. WP-7 Alternative 7-2 Land Rights Breakdown

Item	Area*	Unit	Unit Cost	Cost
Dam and Spillway	4.2	AC	$50,000	$210,000
Permanent Pool	12.7	AC	$50,000	$635,000
500-Year Pool	13.5	AC	$50,000	$675,000
Top of Dam	8.0	AC	$50,000	$400,000
Additional Purchase (estimated)	5.8	AC	$50,000	$290,000
TOTAL	**44.2**			**$2,210,000**

**area within future ROW and drainage easement included in anticipated purchase cost; existing ROW not included*

Table F11. WP-7 Alternative 7-3 Dam Cost Breakdown

Item	Quantity	Unit	Unit Cost	Cost
Mobilization/General	1	LS	$134,335	$134,335
Dam Embankment	124,000	CY	$2.50	$310,000
Principal Spillway Pipe	255	FT	$550.00	$140,250
Drawdown Pipe and Valve	70	FT	$250.00	$17,500
Common Excavation	12,000	CY	$2.00	$24,000
Aggregate Fill	270	TN	$30.00	$8,100
Rock Riprap	950	TN	$60.00	$57,000
Seeding	5.0	AC	$1,800.00	$9,000
Bridge	1	LS	$360,000	$360,000
Structural Concrete	1,480	CY	$500.00	$740,000
Non-Structural Concrete	350	CY	$250.00	$87,500
			Subtotal	$1,928,685
			20% Contingency	$385,737
			TOTAL	**$2,314,422**

Table F12. WP-7 Alternative 7-3 Land Rights Breakdown

Item	Area*	Unit	Unit Cost	Cost
Dam and Spillway	4.2	AC	$50,000	$210,000
Permanent Pool	12.6	AC	$50,000	$630,000
Top of Dam	23.2	AC	$50,000	$1,160,000
Additional Purchase (estimated)	5.5	AC	$50,000	$275,000
TOTAL	**45.5**			**$2,275,000**

**area within future ROW and drainage easement included in anticipated purchase cost; existing ROW not included*

Table F13. WP-7 Alternative 7-4 Dam Cost Breakdown

Item	Quantity	Unit	Unit Cost	Cost
Mobilization/General	1	LS	$51,780	$51,780
Dam Embankment	91,000	CY	$2.50	$227,500
Principal Spillway Pipe	260	FT	$550.00	$143,000
Drawdown Pipe and Valve	70	FT	$250.00	$17,500
Common Excavation	10,600	CY	$2.00	$21,200
Aggregate Fill	240	TN	$30.00	$7,200
Rock Riprap	700	TN	$60.00	$42,000
Seeding	8.0	AC	$1,800.00	$14,400
Structural Concrete	65	CY	$500.00	$32,500
Non-Structural Concrete	50	CY	$250.00	$12,500
			Subtotal	$569,580
			20% Contingency	$113,916
			TOTAL	**$683,496**

Table F14. WP-7 Alternative 7-4 Land Rights Breakdown

Item	Area*	Unit	Unit Cost	Cost
Dam and Spillway	6.5	AC	$50,000	$325,000
Permanent Pool	11.3	AC	$50,000	$565,000
Top of Dam	20.0	AC	$50,000	$1,000,000
Additional Purchase (estimated)	9.5	AC	$50,000	$475,000
TOTAL	**47.3**			**$2,365,000**

**area within future ROW and drainage easement included in anticipated purchase cost; existing ROW not included*

Table F15. WP-7 Water Quality Basin Design Concept Cost Estimate

Item	Quantity	Unit	Unit Cost	Cost
Fill	3,808	CY	$2.50	$9,520
Outlet Works	1	LS	$6,300.00	$6,300
			Subtotal	$15,820
			20% Contingency	$3,164
			TOTAL	**$18,984**

Table F16. WP-7 Recreation Facilities Cost Estimate

	Quantity	Unit	Unit Price ($)	Cost ($)
Multi-Use Concrete Trail				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$7,500.00	$7,500
Field Staking and Surveying	1	LS	$8,500.00	$8,500
Site Improvements				
8' wide x 5" Concrete Trail with earthwork	4,900	LF	$48.00	$235,200
10' wide aggregate trail	460	LF	$30.00	$13,800
Mowed grass trail	1,850	LF	-	-
Stormwater Culverts/Mitigation Measures	2	EA	$2,500.00	$5,000
Weir Bridge Crossing	1	LS	$75,000.00	$75,000
Slope Retaining and Soil Stabilization Measures	1	LS	$9,500.00	$9,500
Signage	1	LS	$1,000.00	$1,000
Lincoln Street Entry Drive and Parking				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$4,500.00	$4,500
Field Staking and Surveying	1	LS	$2,500.00	$2,500
Site Improvements				
7" Concrete Drive and Parking	5000	SY	$48.00	$240,000
Vehicle Access Control and Soil Stabilization Measures	1	LS	$6,500.00	$6,500
Site Lighting	1	LS	$25,000.00	$25,000
Stormwater Management BMPs	1	LS	$8,000.00	$8,000.00
Entry Gate and Signage	1	LS	$5,500.00	$5,500
Water Access Amenities				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$1,500.00	$1,500
Field Staking and Surveying	1	LS	$900.00	$900
Site Improvements				
NRD and G&P Access Ramp (Fleximat and Planks)	1	LS	$18,000.00	$18,000
Stabilized Beach Landing (Fleximat and Aggregate shore launch)	2500	SF	$6.00	$15,000
Floating Universal Access Transfer and Launch	1	LS	$28,000.00	$28,000
Signage	1	LS	$1,200.00	$1,200

Public Amenity Facilities				
Site Preparation				
Sediment and Erosion Control Measures	1	LS	$1,500.00	$1,500
Field Staking and Surveying	1	LS	$1,500.00	$1,500
Site Improvements				
(1) 16x24 Picnic Shelter with pad, tables, and grills	1	LS	$20,000.00	$20,000
Vault Toilet 2-Stall Unit (Romtec)	1	EA	$50,000.00	$50,000
5" Pedestrian Concrete Walks	1800	SF	$4.00	$7,200
Signage	1	LS	$1,000.00	$1,000
Fisheries				
(5) Aggregate and Sheet Pile Shore Fishing Landings	5	EA	$15,000.00	$75,000
(2) ADA Concrete and Sheet Pile Shore Fishing Landings	2	EA	$18,000.00	$36,000
Offshore Breakwater/Trail	350	FT	$185.00	$64,750
Breakwater Jetty	1	EA	$6,000.00	$6,000
Vegetation Barriers	6	EA	$1,500.00	$9,000
Underwater Shoals	4	EA	$1,500.00	$6,000
Shoreline Scallops	4	EA	$5,000.00	$20,000
In-lake "Rock Star" Habitat	10	EA	$2,800.00	$28,000
Shoreline Access Bumpouts	6	EA	$5,000.00	$30,000
Site Vegetation Restoration				
Turf and Grasses				
Fescue turfgrass / Hydromulch (day use area)	2	Acre	$1,500.00	$3,000
Overland Rural NRD Mix / Crimp Straw	25	Acre	$1,800.00	$45,000
Stream mitigation - channel stabilization plantings	1	Acre	$1,800.00	$1,800
Stream mitigation - vegetated buffer plantings	5	Acre	$1,800.00	$9,000
Trees				
2" Caliper Trees (day use and fish bump outs)	50	EA	$350.00	$17,500
Mulch	20	CY	$45.00	$900
	SUBTOTAL			$1,145,250
	20% Contingency			$229,050
	TOTAL			**$1,374,300**