Kansas Water Office

MARYSVILLE DAM
WATER TABLE R[illegible]ORATION
PRELIMINARY ENG[illegible]RING S[illegible]DY - DRAFT

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WRS WATER RESOURCES SOLUTIONS

DRAFT

COMPLETED FOR THE KANSAS WATER OFFICE

AUGUST 28, 2023

SUBMITTED BY: WATER RESOURCES SOLUTIONS

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August 28, 2023

Ms. Amelia Nill
Water Resource Planner
Kansas Water Office
900 WS Jackson St., Suite 404
Topeka, KS 66612

Subject: Marysville Dam Water Table Restoration Preliminary Engineering Study - draft report

Dear Ms. Nill:

Water Resources Solutions, LLC, is pleased to present this Marysville Dam Water Table Restoration Preliminary Engineering Study draft report to the Kansas Water Office.

Within this report, you will find the study methodology, watershed geomorphic assessment and hydraulic assessment, alternative conceptual solutions considered for reconstruction and rehabilitation of the dam with engineer's opinions of probable costs, and our recommendations.

If you have any questions or require additional information, please contact me at (913) 302-1030.

Sincerely,
Water Resources Solutions, LLC

Donald W. Baker, P.E., D. WRE, CPESC

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PROJECT SUMMARY AND SCOPE

This water table restoration study for the Kansas Water Office investigates the existing condition and potential design solutions to restore the normal pool elevation of the Big Blue River, in an effort to mitigate groundwater loss to nearby agriculture and adverse effects of the breach on the district water supply wells. It includes a watershed assessment, geomorphic assessment, base mapping, hydraulic assessment, and conceptual design options to create a budget for potential future efforts.

BACKGROUND

The Marysville Dam construction on the Big Blue River was finalized in 1864 by Perry Hutchinson, to provide waterpower to his sawmill on the east side of the river. Later that same year, he opened a flour mill. In 1929, the Big Blue Power Company began work on a double-turbine electric plant that sits on the west end of the dam. The power company made improvements to the rock-filled crib dam by placing a concrete slab overlay on it. The City of Marysville took possession of the dam in the late 1960s when the power company ceased operations (Kopp, 2018).

Improvements to the dam were considered in 1984 and 2009. In 1984, repair of the dam was studied as part of the feasibility assessment for a new surface water intake for the City of Marysville. The rate of deterioration was determined to be very aggressive, and the life of the structure was estimated at three to five years. The 2009 study concluded that the loss of the mill pond behind the dam would affect groundwater and well levels for approximately 1.5 miles upstream of the dam location (Kopp, 2018).

The dam failed during a high flow event on May 4, 2018. This dam was in place for over 100 years prior to its collapse Kopp, 2018).

Based on their report, Schwab-Eaton reported the top-of-dam elevation to be 1138 (Schwab-Eaton, 2009).

Figure 1. Former Marysville Dam showing hydroelectric plant (foreground)

Figure 2. Marysville Dam breach (looking northeast)

Figure 3. Marysville Dam breach (looking south)

WATERSHED ASSESSMENT

The Marysville low-head dam site is located approximately 1.5 miles west of Marysville, Kansas (Kopp, 2018). It is located at a sharp bend in the Big Blue River as it turns south to run down the west side of Marysville.

FLOWRATE INFORMATION

Based on the U.S. Geological Survey's web-based geographic information system application StreamStats report for the dam site location, the drainage area to the dam site is 4,771 square miles (USGS, 2019). The following table provides the flowrates for statistical flood events.

The maximum recorded flow for the Big Blue River at Marysville is 55,600 cubic feet per second in 1951.

Table 1: Watershed flow rates per statistical flood event

Annual Exceedance Probability	Flowrate
50 Percent	12,700
20 Percent	27,100
10 percent	40,200
4 Percent	60,300
2 Percent	78,00
1 Percent	96,100
0.5 Percent	120,000
0.2 Percent	152,000

BASE MAPPING

Lidar information for the area was obtained from the Kansas Geological Survey's Data Access and Support Center website (DASC, 2023). The lidar data was created in 2018, which pre-dates the breach of the dam on May 4, 2018. As a result, the stated water surface elevation is higher than the existing condition in the river from the dam upstream for a significant distance.

A limited post-breach LiDAR scan was performed upstream of the dam by the U.S. Army Corps of Engineers Kansas City District in 2022 (USACE, 2023). Several bathymetric cross sections were also surveyed and provided as part of this data package. The bathymetric cross-sections were used to define the channel bed upstream of the Marysville dam for use in the hydraulic model.

The base mapping for the design of this project is based on a hybrid of the available sources. The 2018 DASC data was used except where the USACE survey and interpolated bathymetric data could be supplemented to improve the accuracy of the channel data. No bathymetric data was collected downstream of the dam breach; therefore, it has not been included for this preliminary study.

Further study and survey must be completed during the design phase for any proposed dam structure. The 2022 USACE lidar survey and the Kansas DASC data result in a discrepancy in the water surface behind the dam of 1.8 feet.

GEOMORPHIC ASSESSMENT

GEOLOGY

As with much of northern Kansas, the geology around Marysville is comprised of alternating layers of shales and limestones with some occasional sandstones.

Based on the geotechnical investigation report performed for Schwab-Eaton in 2009, the Big Blue River has incised on to the Blue Springs Shale Member of the Chase Group of the Wolfcompton Series at the dam location (GeoSource, 2009). The soils above this shale layer that comprise the river banks and floodplain were characterized as sands and silty sands. A profile showing the vertical relationship of the formations is shown in Figure 4.

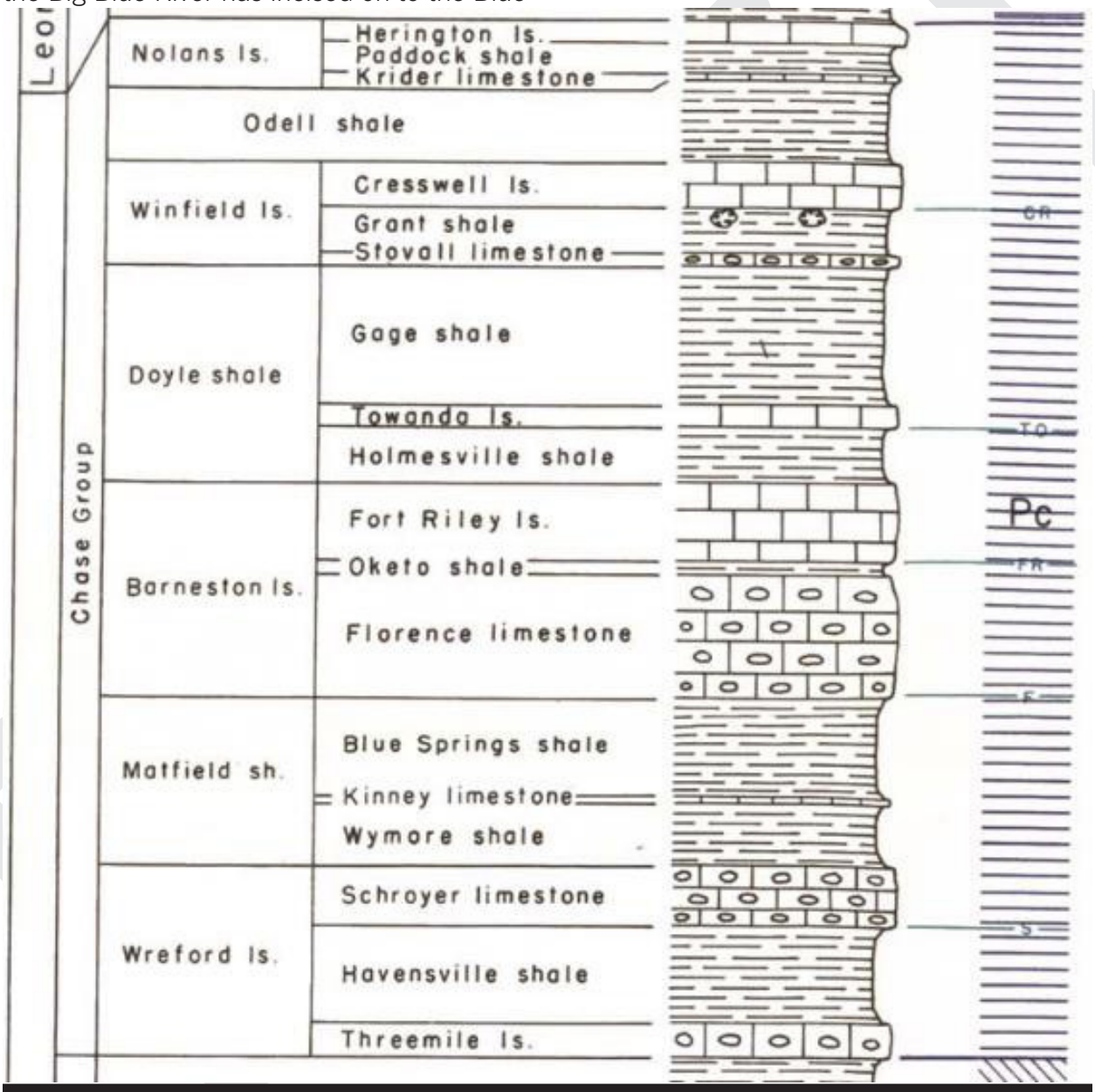

Figure 4. Geologic profile of formations near dam site (adapted from KGS, 1951)

EFFECT OF MARYSVILLE DAM

Without the Marysville Dam controlling the water surface elevation, the Big Blue River has lowered its baseflow water surface by up to 3 feet. The effects of this change can be observed in the water surface well over a mile upstream of the dam site. One prominent tributary that enters the Big Blue River just north of the dam site shows major head cutting because of the new water surface.

Historic Aerial imagery and conceptual modeling both reveal that the breach of the dam has altered the base flow patterns such that the established bank scour on the east side of the dam has filled in and is now only wetted in storm flow events.

Figure 5. Tributary exhibiting headcutting due to reduced water surface elevations

Figure 6. Headcutting just upstream of the failed dam site

HYDRAULIC ASSESSMENT

In order to assess the hydraulic conditions of the Big Blue River at the site of the Marysville Dam, a conceptual HEC-RAS 6.4 two-dimensional model was created by using the data prepared and combined as described in the Base Mapping section of this report. Flow data was acquired from the USGS StreamStats statistical model based on the gauge station at the U.S. Highway 36 Bridge, less than one mile downstream of the dam location.

Using the statistically derived storm events, flows up to the expected 100-year occurrence interval storm were routed through the model to determine the controlling event and to predict the effects of the breached dam condition. This model was also used in order to compare potential rehabilitation options and more accurately determine their design parameters.

The effective Federal Emergency Management Center National Flood Insurance Program Flood Insurance Study for the region was published in 2017. Information about the modeling is limited in the FEMA flood Flood Insurance Study report and states that either HEC-RAS version 4.1 or version 4.0 was used.

Because this model was finalized prior to the dam failure, the effective model includes the non-breached Marysville Dam. Design alternatives will only need to ensure that the flood elevations match the effective mapped elevations upstream and downstream of the project reach. The upstream limit of the detailed study is located at the downstream end of the failed dam; therefore, any structures placed upstream of that limit will not require FEMA permitting. The Zone AE elevations in the detailed study end at the site of the Dam, so elevations upstream are not determined.

CONCEPTUAL DESIGN OPTIONS

PREVIOUSLY CONSIDERED ALTERNATIVES

Based on published reports, there have been several discussions over the years with regard to the reconstruction and rehabilitation of the dam. In 2009, a feasibility study report, funded by the Kansas State Conservation Commission was completed for the Washington County Rural Water District No. 1 by Schwab-Eaton P.A. (Schwab-Eaton, 2009). It noted:

> "Repair and rehabilitation of the existing structure was deemed to be the most practical but still came with a cost-prohibitive minimum price tag of $4.36 million."
> -Ken Kopp 2018

Based on the Turner Construction Cost Index, which has an index of 832 in 2009 and 1,349 in the first quarter of 2023, the 2009 construction cost would be $7.1 Million in 2023 dollars.

DESIGN COST CONSIDERATIONS

Further study and survey must be completed to ensure the new structure is at an equivalent elevation to the breached dam. The data used to set the elevation was based on the 2022 USACE Lidar Survey and the accuracy of the data and consideration of possible settlement creates a discrepancy in the water surface upstream of the dam of 1.8 feet when compared to the DASC Data. Additionally, a down-

stream Bathymetric survey would likely be necessary to accurately ensure alternatives do not increase the water surface elevation downstream.

ALTERNATIVE 1 – ENGINEERED ROCK GRADE CONTROL

This alternative describes the option to construct a rock-fill water level control and grade control dam to replace the function of the failed Marysville Dam.

GEOMETRY AND LAYOUT

The top of the engineered rock grade control would be set at elevation 1138. This is the same elevation as the failed Marysville Dam. The crest length is approximately 204 feet long. The breadth of the crest is 30 feet. The grade control slopes downstream from the crest at a 20-foot to 1-foot gradual slope in order to provide a ramp that is negotiable for fish. The plan, section, and profile drawings of the proposed engineered rock grade control are shown in Figure 7 through Figure 9 on the following pages.

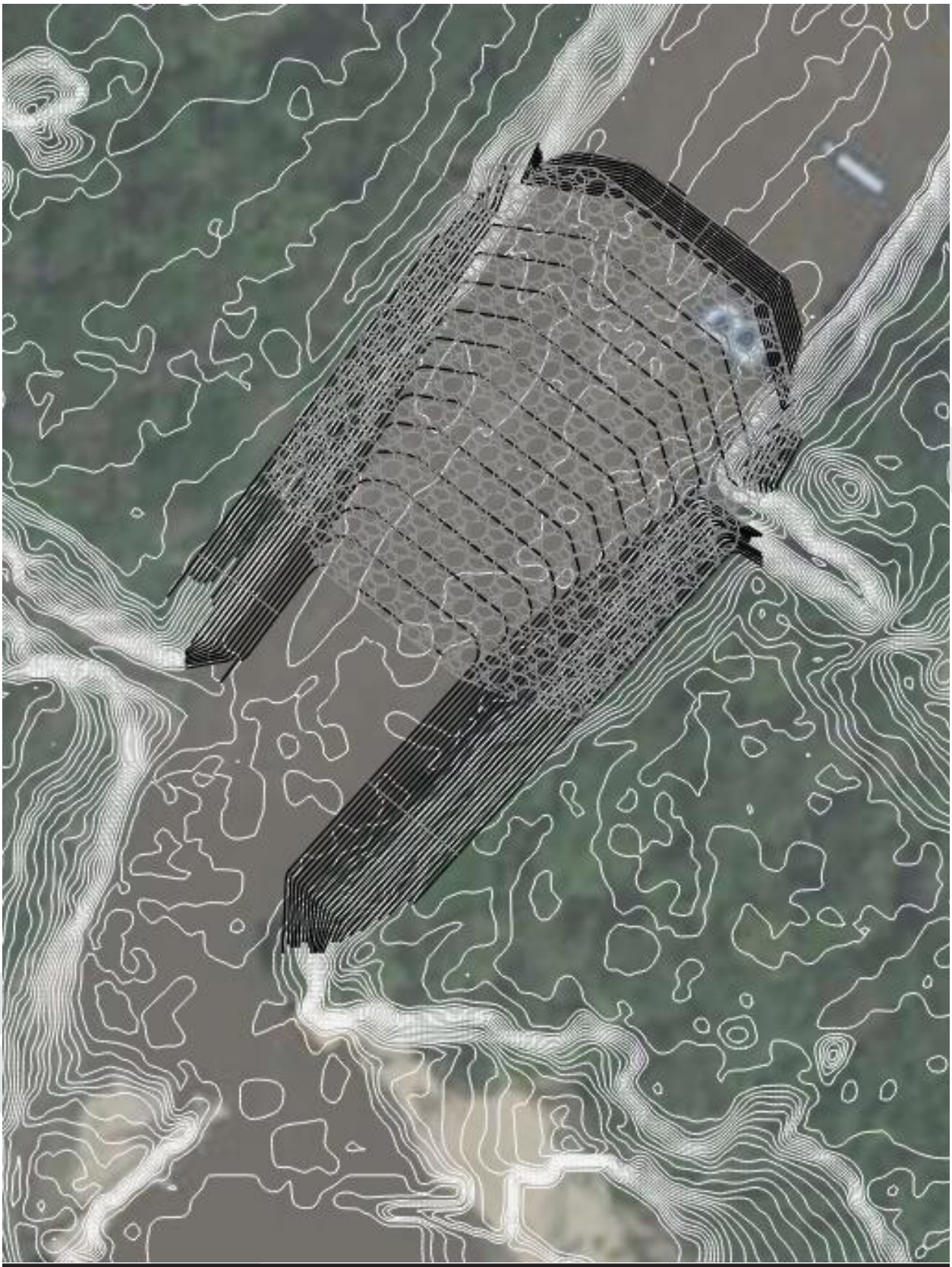

Figure 7. Plan of the engineered rock grade control

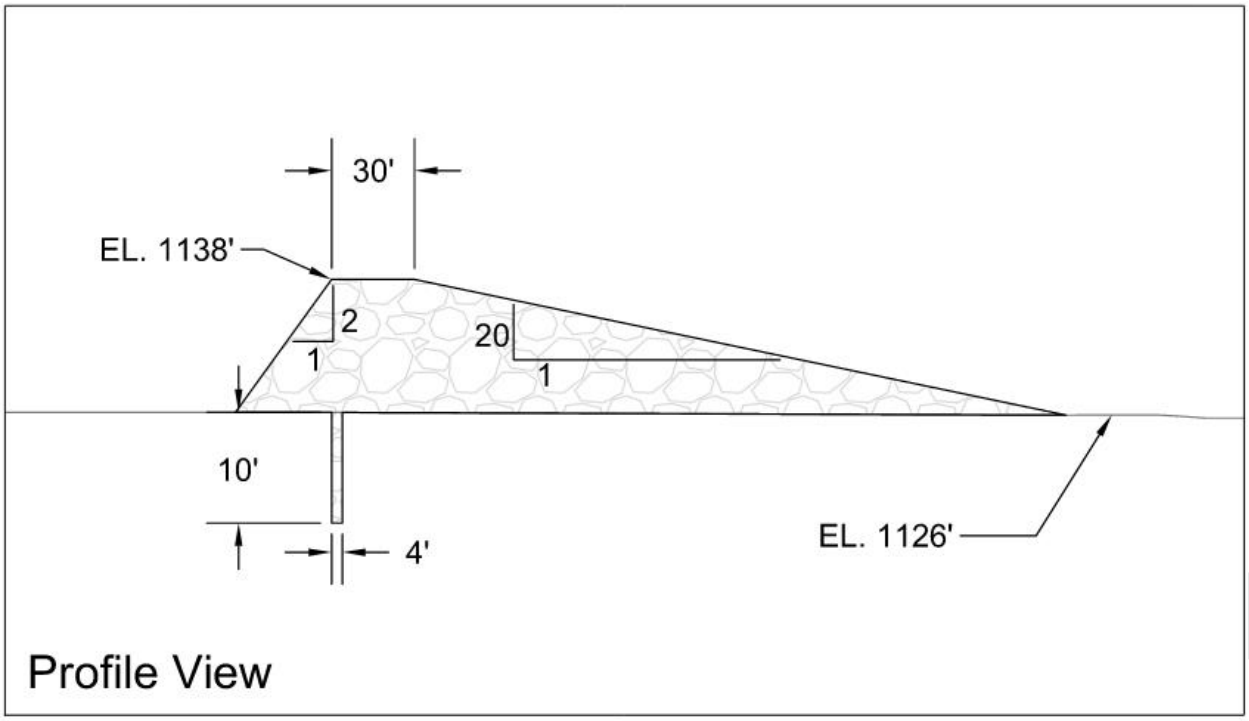

Figure 8. Profile of the engineered rock grade control

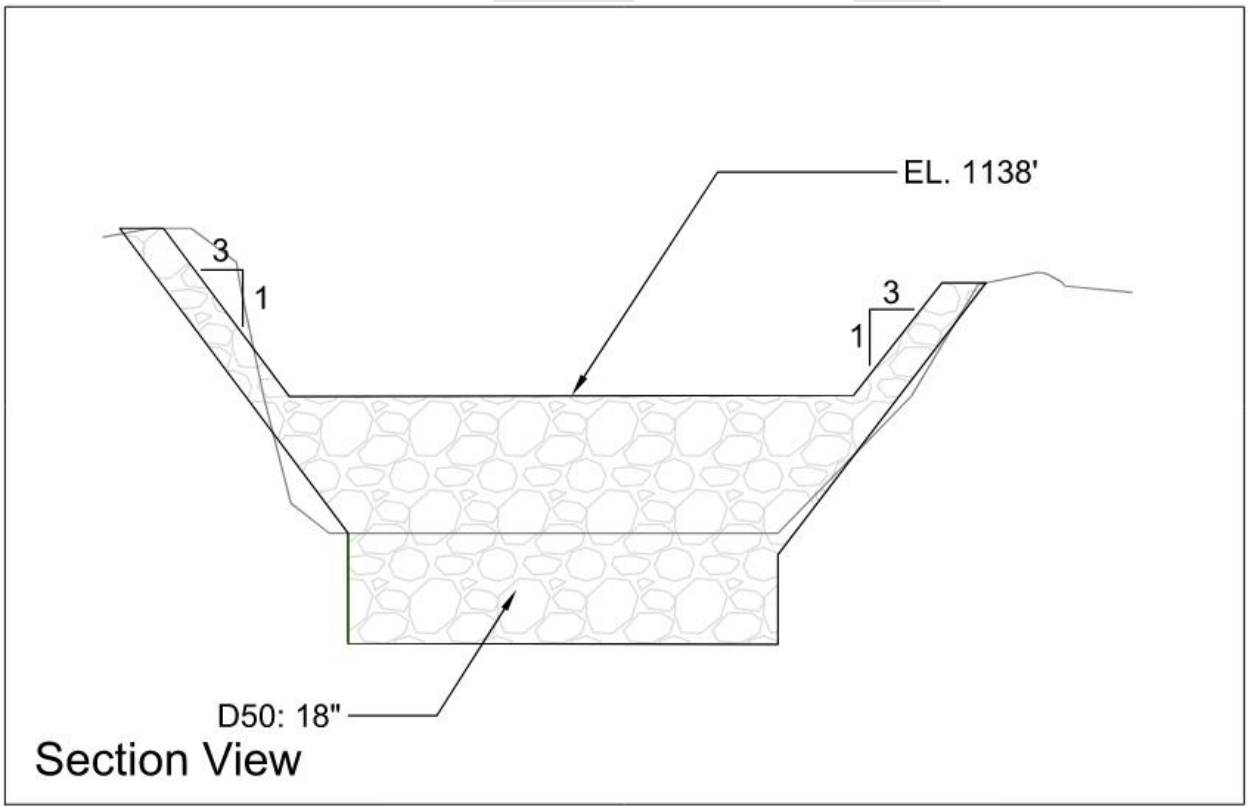

Figure 9. Section view of the engineered rock grade control

HYDROLOGY AND HYDRAULICS

The two-dimensional and three-dimensional hydraulic analysis of the alternatives is in progress. This section will be completed for the final submission upon completion of the modeling.

PROPERTY IMPACTS

The property impacts related to this alternative will be associated with access easements, grading, and access restoration. The grade control will be located entirely below the banks of the river.

Two required access easements are envisioned. One access will be on the north and west side of the river. The properties along this route that will be impacted include the Farmers Cooperative property, City of Marysville property, and the Landoll property. The second access would be on the south and east side of the river, across the Maryed Enterprises, Vering, and Landoll properties. The restoration of the access paths on these three properties will need to be completed.

The structure would reside on the Farmers Cooperative and Landoll properties. All grading associated with the structure would also occur on these properties.

PERMITTING

Permits for the construction of this project will be required from the USACE and the Kansas Department of Agriculture, Division of Water Resources (KDWR). Because the project lies upstream of the detailed FEMA Flood Insurance Study area, no FEMA permit will be required. A floodplain development permit will likely be required from Marshall County.

The USACE Section 404 permit is required for any activity that discharges dredged or fill material into a water of the United States. The Big Blue River qualifies as a water of the United States.

A stream obstruction permit will be required from KDWR. This permit will result in the permitting of the structure as a dam since it will be greater than six feet tall and hold back more than 50 acre-feet of water. As part of the permitting process, a dam stability analysis will need to be completed, along with a dam breach analysis that includes flood inundation mapping and an emergency action plan.

COST

The opinion of probable construction cost for this project is $4,147,520. The opinion of probable project cost is $4,782,650. A detailed cost estimate is provided in Table 2.

Table 2: Opinion of probable cost for alternative 1

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	$223,890	$223,890
2	Clearing, Grubbing and Site Preparation	LS	1	$139,930	$139,930
3	Erosion and Sediment Control	LS	1	$27,990	$27,990
4	Riprap Slope Protection (18" D_{50})	CY	4267	$130	$554,710
5	Engineered Rock Grade Control (18" D_{50})	CY	16533	$130	$2,149,290
6	Site Restoration	SY	9459	$10	$94,590
				Subtotal	$3,190,400
				30% Contingency	$957,120
				Total Construction Cost	$4,147,520
				Access Easement @ $1,000 per Acre	$3,000
				Permanent Easement @ $1,000 per Acre	$10,000
				Design Fee	$622,130
				Total	**$4,782,650**

ADVANTAGES AND DISADVANTAGES

The primary advantages of this alternative include the following:

- The project can be constructed with minimal diversion of the river
- The final structure will allow aquatic organism passage past the obstruction
- The project's relatively simple earthwork construction can be completed by a single contractor.

The primary disadvantages of this alternative include:

- Higher relative cost compared to other alternatives
- A larger relative construction footprint due to the longer length of the structure

ALTERNATIVE 2 – CONCRETE DAM

The second alternative includes the construction of a concrete dam to mimic the failed concrete dam. The dam would be designed with an ogee spillway.

GEOMETRY AND LAYOUT

As with the top of the engineered rock grade control, the top of the concrete dam crest would be set at elevation 1138. The crest length is approximately 233 feet long. The crest of the concrete dam is in the shape of an ogee. The ogee shape is a mathematical curve that approximates the nappe of the flowing water over a sharp crested weir. The ogee for this alternative was designed based on the water surface at the top of bank and then evaluated for efficiency in conveying the 100-year (1% percent annual exceedance) flow over the crest.

The plan, section and profile views of the proposed structure are shown in Figure 10 through Figure 12.

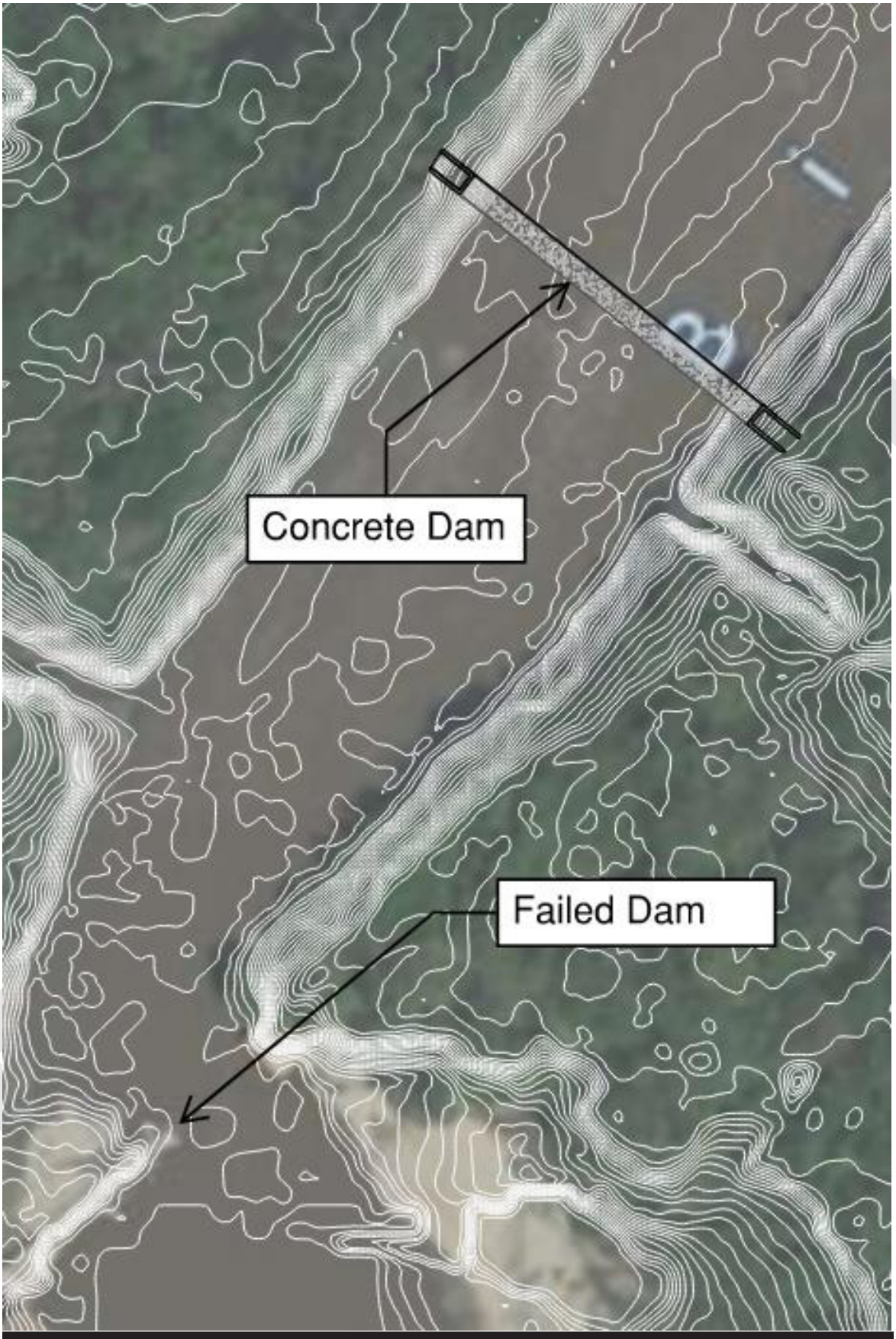

Figure 10. Plan of the concrete dam

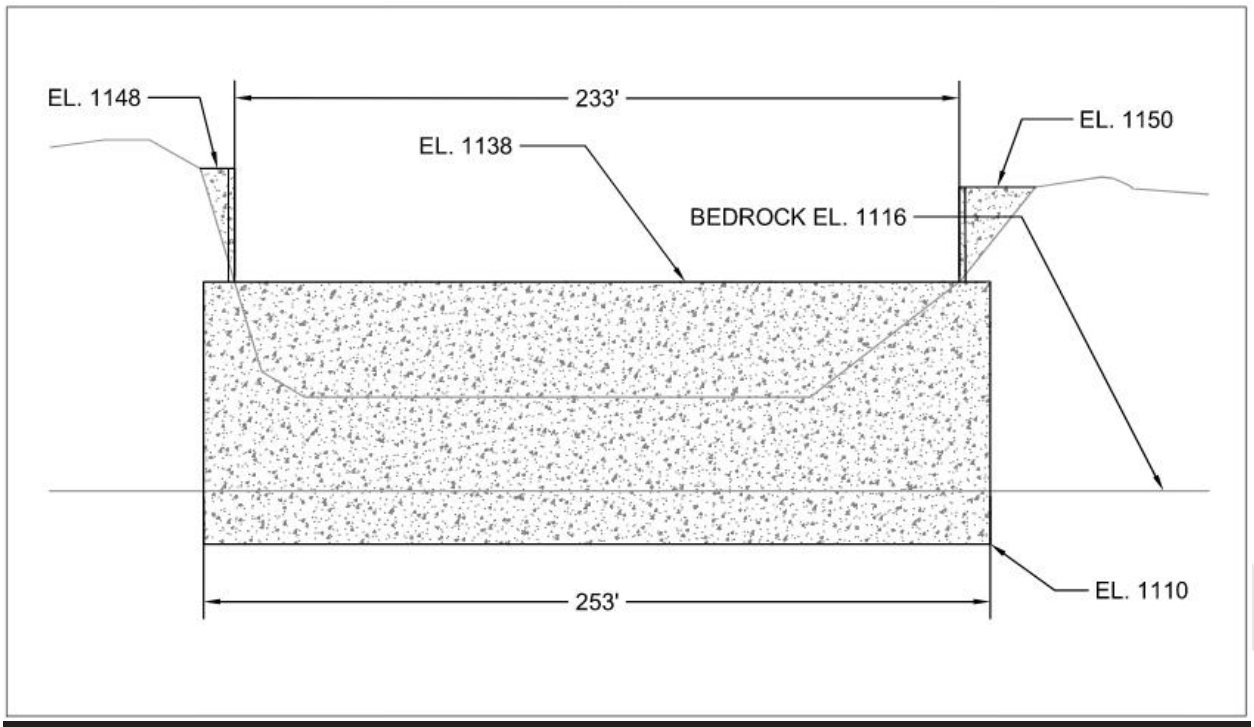

Figure 11. Profile of the concrete dam

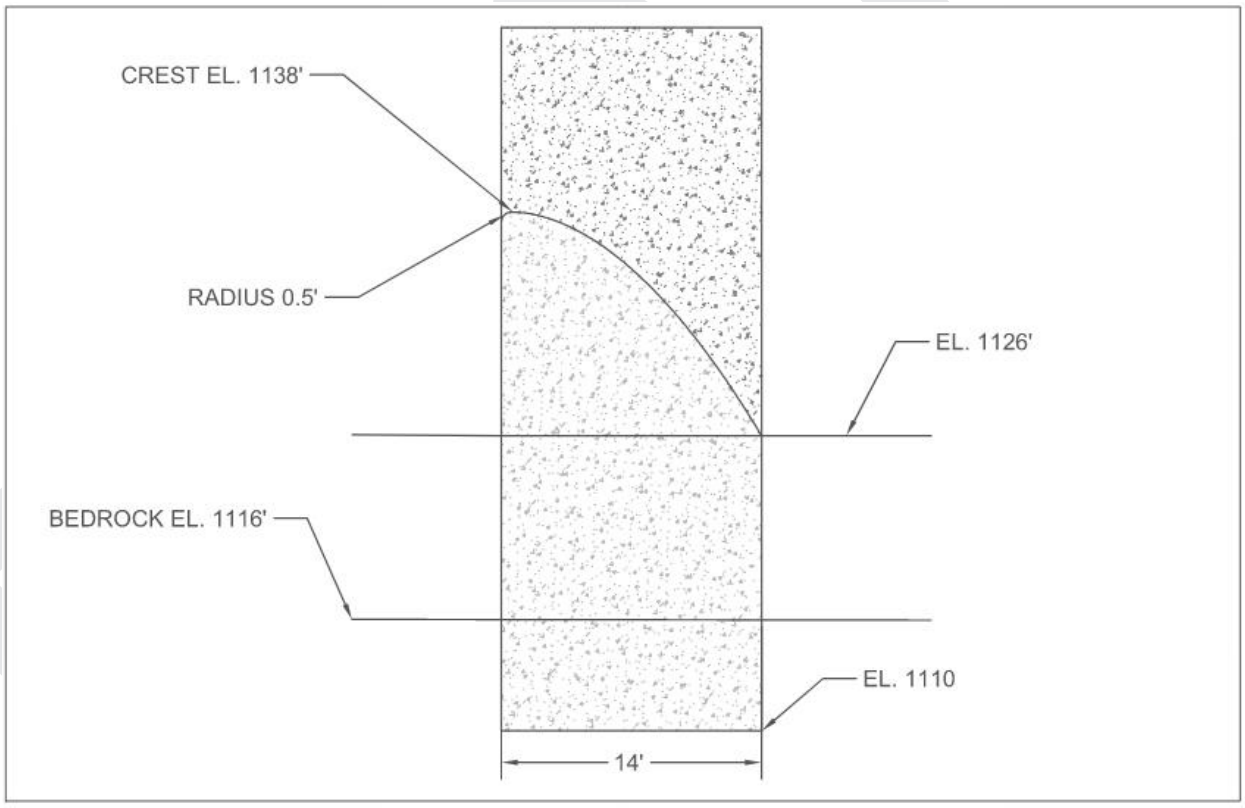

Figure 12. Section view of the concrete dam

HYDROLOGY AND HYDRAULICS

The two-dimensional and three-dimensional hydraulic analysis of the alternatives is in progress. This section will be completed for the final submission upon completion of the modeling.

PROPERTY IMPACTS

The property impacts related to this alternative will be associated with access easements, grading, and access restoration. The grade control will be located entirely below the banks of the river.

Two required access easements are envisioned. One access will be on the north and west side of the river. The properties along this route that will be impacted include the Farmers Cooperative property, City of Marysville property, and the Landoll property. The second access would be on the south and east side of the river, across the Maryed Enterprises and Vering properties. The restoration of the access paths on these properties will need to be completed.

The structure would reside on the Farmers Cooperative and Landoll properties. All grading associated with the structure would also occur on these properties.

PERMITTING

Permits for the construction of this project will be required from the USACE and the Kansas Department of Agriculture, Division of Water Resources (KDWR). Because the project lies upstream of the detailed FEMA Flood Insurance Study area, no FEMA permit will be required. A floodplain development permit will likely be required from Marshall County.

The USACE Section 404 permit is required for any activity that discharges dredged or fill material into a water of the United States. The Big Blue River qualifies as a water of the United States.

A stream obstruction permit will be required from KDWR. This permit will result in the permitting of the structure as a dam since it will be greater than six feet tall and hold back more than 50 acre-feet of water. As part of the permitting process, a dam stability analysis will need to be completed, along with a dam breach analysis that includes flood inundation mapping and an emergency action plan.

COST

The opinion of probable construction cost for this project is $6,414,200. The opinion of probable project cost is $7,384,330. A detailed cost estimate is provided in Table 3.

Table 3: Opinion of probable cost for alternative 2

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	$325,120	$325,120
2	Clearing, Grubbing and Site Preparation	LS	1	$203,200	$203,200
3	Erosion and Sediment Control	LS	1	$40,640	$40,640
4	Rock Excavation	CY	787	225	$177,075
5	Wingwall	CY	100	1,200	$120,000
6	Grading/Fill	CY	102	$40	$4,080
7	Concrete Dam	CY	3186	$1,200	$3,823,200
8	Temporary Diversion	LS	1	$167,000	$167,000
9	Site Restoration	SY	7373	$10	$73,730
				Subtotal	$4,934,045
				30% Contingency	$1,480,200
				Total Construction Cost	$6,414,200
				Access Easement @ $1000 per Acre	$3,000
				Permanent Easement @ $5000 per Acre	$5,000
				Design Fee	$962,130
				Total	**$7,384,330**

ADVANTAGES AND DISADVANTAGES

The primary advantage of this structure includes the following:

- The ability to determine the flowrate over the structure is relatively more precise.

The primary disadvantages of this alternative include:

- The river must be temporarily diverted around the construction area during construction
- The structure creates an impediment to aquatic organism movement through this reach of river. This option would probably not receive a good review from natural resource agencies due to this impediment.

ALTERNATIVE 3 – CELLULAR COFFERDAM

This alternative includes the construction of a cellular cofferdam similar to the diversion dams located on the Kansas River in Topeka and Wyandotte County.

GEOMETRY AND LAYOUT

The top of the cellular cofferdam would be set at elevation 1138. The crest length is approximately 222 feet long.

Figure 13. Cellular cofferdam example, on the Kansas River at Topeka (Google Earth)

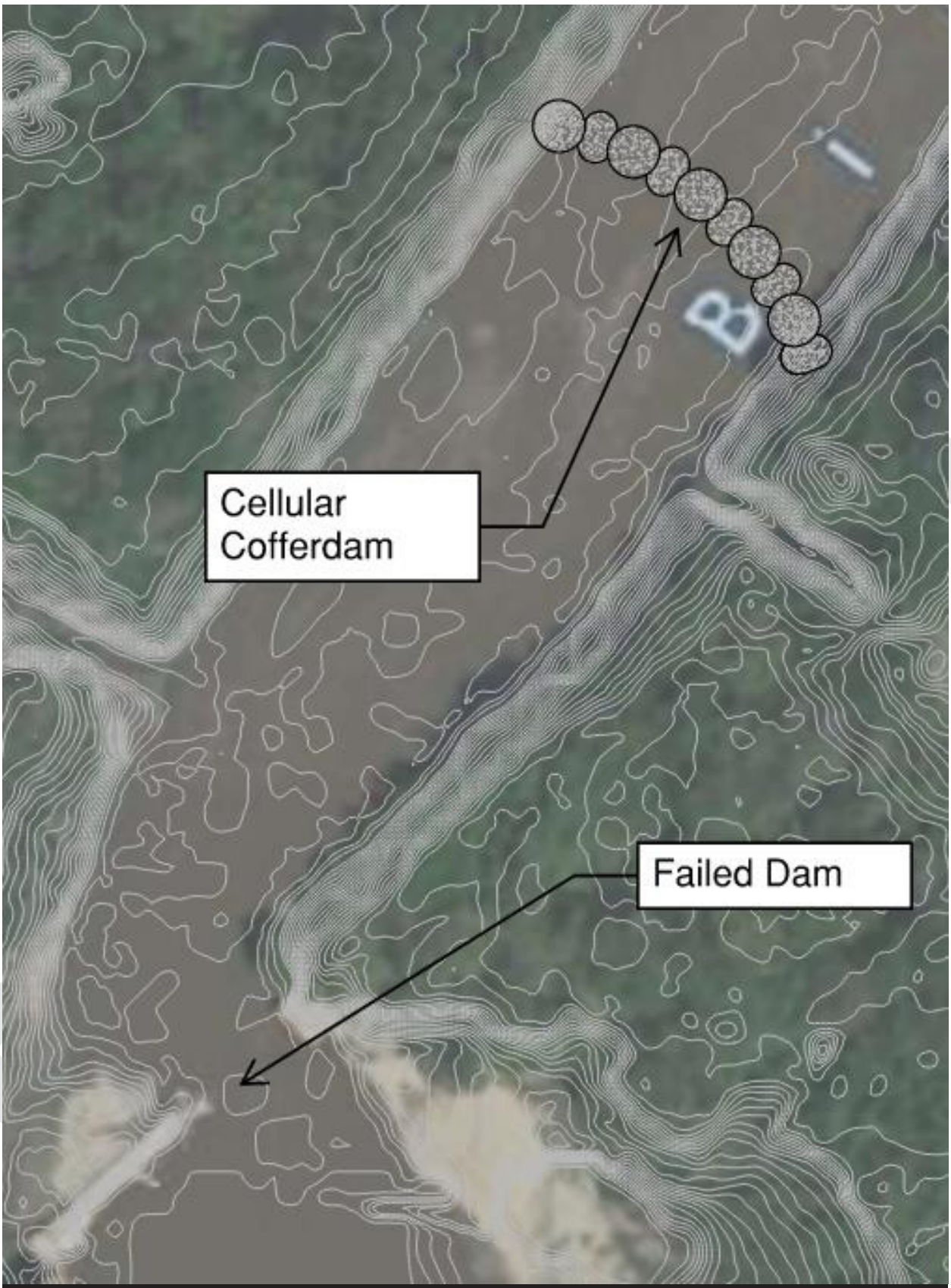

Figure 14. Plan of the cellular cofferdam

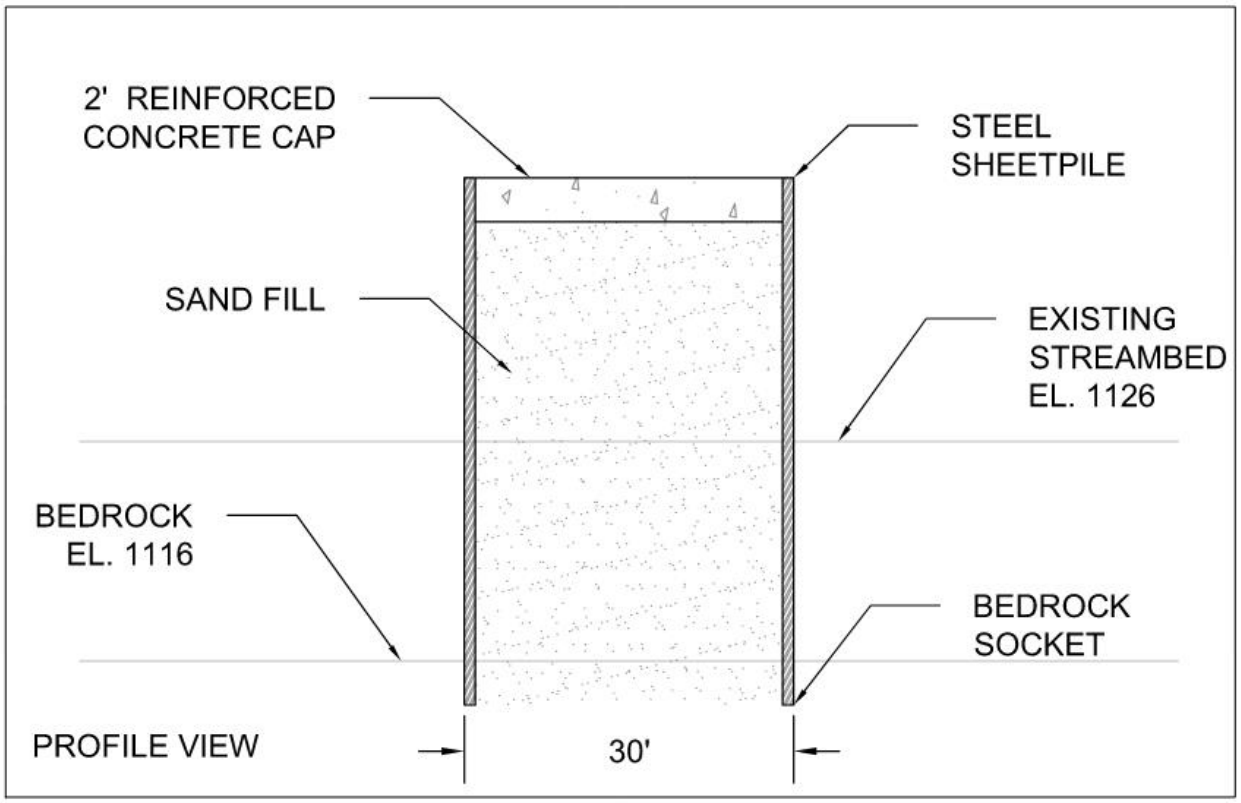

Figure 15. Profile of the cellular cofferdam

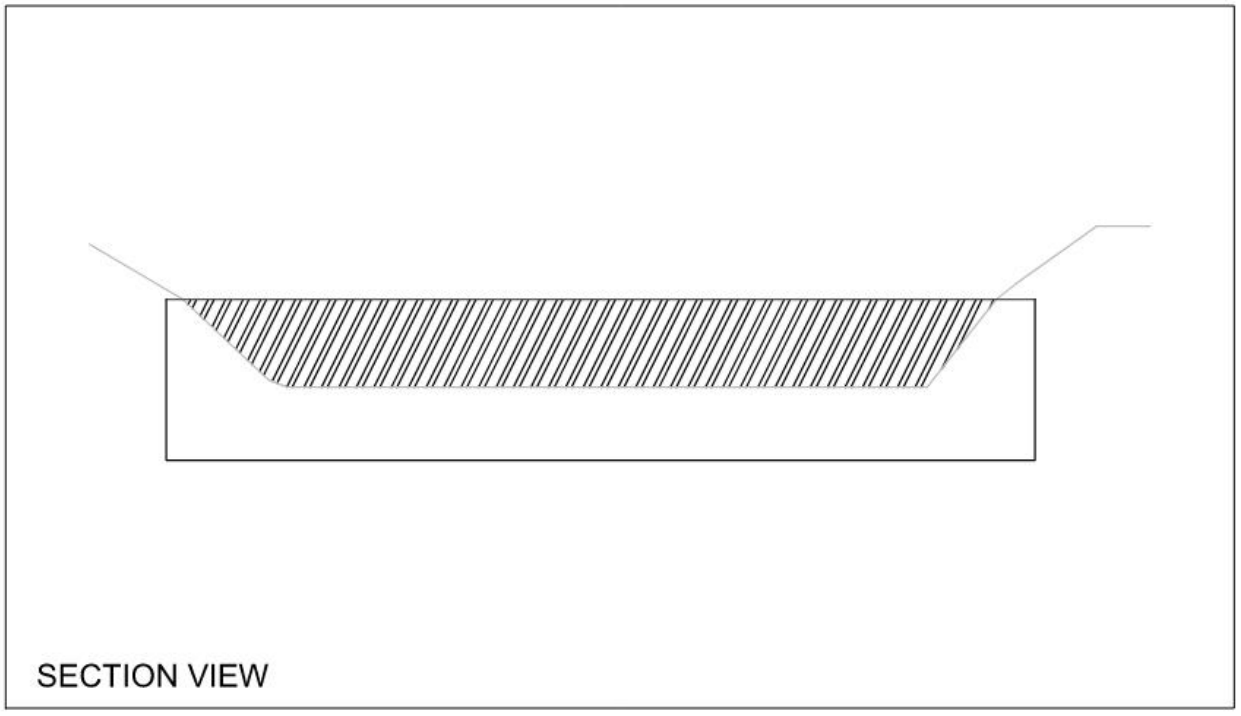

Figure 16. Section view of the cellular cofferdam

HYDROLOGY AND HYDRAULICS

The two-dimensional and three-dimensional hydraulic analysis of the alternatives is in progress. This section will be completed for the final submission upon completion of the modeling.

PROPERTY IMPACTS

The property impacts related to this alternative will be associated with access easements, grading, and access restoration. The grade control will be located entirely below the banks of the river.

Two required access easements are envisioned. One access will be on the north and west side of the river. The properties along this route that will be impacted include the Farmers Cooperative property, City of Marysville property, and the Landoll property. The second access would be on the south and east side of the river, across the Maryed Enterprises, Vering, and Farmers Co-op properties. The restoration of the access paths on these three properties will need to be completed.

The structure would reside on the Farmers Cooperative and Landoll properties. All grading associated with the structure would also occur on these properties.

PERMITTING

Permits for the construction of this project will be required from the USACE and the Kansas Department of Agriculture, Division of Water Resources (KDWR). Because the project lies upstream of the detailed FEMA Flood Insurance Study area, no FEMA permit will be required. A floodplain development permit will likely be required from Marshall County.

The USACE Section 404 permit is required for any activity that discharges dredged or fill material into a water of the United States. The Big Blue River qualifies as a water of the United States.

A stream obstruction permit will be required from KDWR. This permit will result in the permitting of the structure as a dam since it will be greater than six feet tall and hold back more than 50 acre-feet of water. As part of the permitting process, a dam stability analysis will need to be completed, along with a dam breach analysis that includes flood inundation mapping and an emergency action plan.

COST

The opinion of probable construction cost for this project is approximately $2,362,900. The opinion of probable project cost is $2,843,480. A detailed cost estimate is provided in Table 4.

Table 4: Opinion of probable cost for alternative 3

Item No.	Item Description	Unit	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	$127,550	$127,380
2	Clearing, Grubbing and Site Preparation	LS	1	$79,720	$79,610
3	Erosion and Sediment Control	LS	1	$15,950	$15,930
4	Rock Excavation	CY	431	$230	$99,130
5	Steel Sheet Pile	SF	14,256	$50	$712,800
6	Sandfill, Placement and Compaction	CY	4,628	$60	$277,680
7	Reinforced Concrete Cap	CY	431	$1,000	$431,000
8	Site Restoration	SY	7,373	$10	$73,730
				Subtotal	$1,817,560
				30% Contingency	$545,300
				Total Construction Cost	$2,362,900
				Access Easement @ $1000 per Acre	$3,000
				Permanent Easement @ $5000 per Acre	$5,000
				Design Fee	$472,580
				Total	**$2,843,480**

ADVANTAGES AND DISADVANTAGES

The primary advantage of the cellular cofferdam structure is that it can be constructed without diversion of the river.

The primary disadvantage of the cellular cofferdam structure is the impediment to aquatic species movement up and down the river.

RECOMMENDATIONS

While Alternative 3 – Cellular Cofferdam is the cheapest of the three alternatives, it is recommended that Alternative 1 – Engineered Rock Grade Control be pursued. Alternative 1 provides the best opportunity for longevity and minimal maintenance.

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