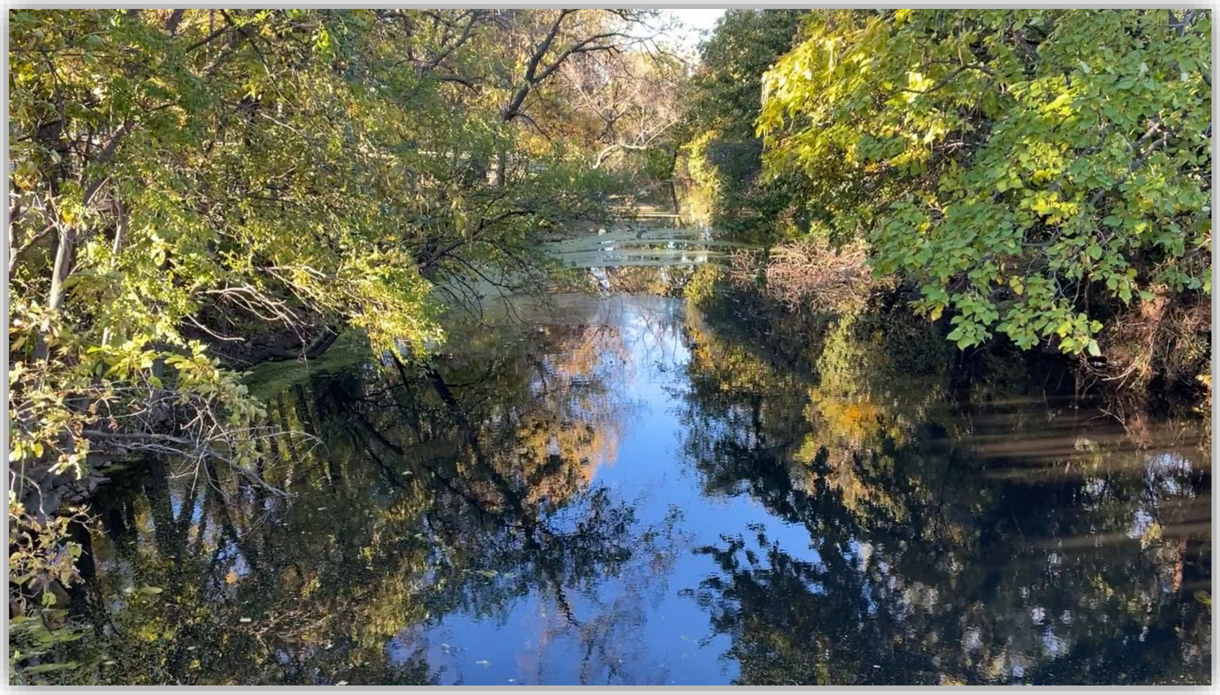

Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix A1 – Hydrology and Hydraulics Assessment

September 2025

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1 INTRODUCTION

The Smoky Hill River Renewal Master Plan was adopted by the City of Salina, Kansas (City), in 2010 and identifies the community's priorities and goals for the renewal of the Old Smoky Hill River channel that extends 6.8 miles through the center of Salina. The original river alignment through town was isolated in the 1960's by the construction of a flood control levee and a bypass channel on the Smoky Hill River, see Figure 1-1. The original river alignment, hereinafter referred to as the Old Smoky Hill River, presently has no sustained base flow and has accumulated large quantities of sediment and urban debris.

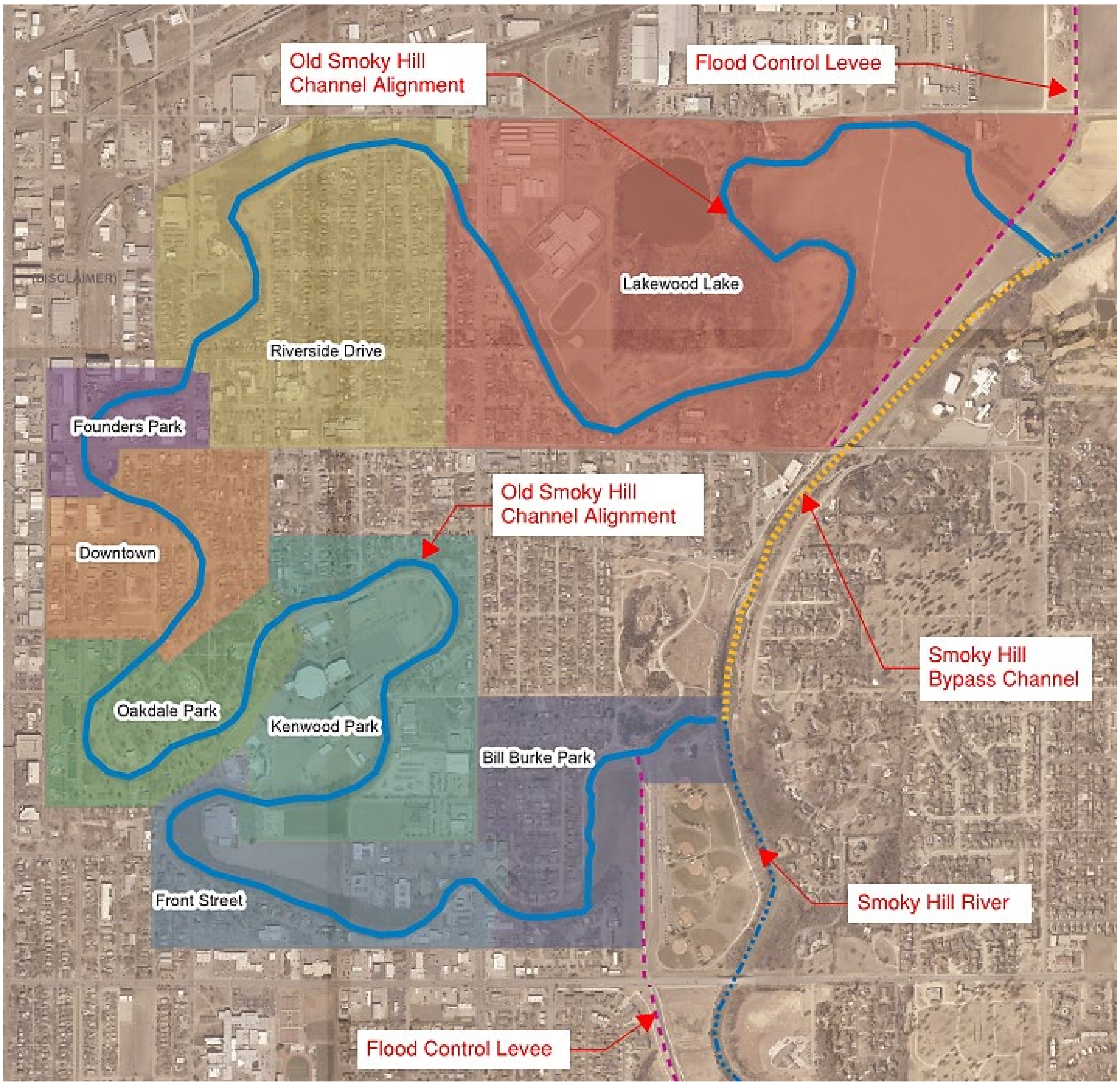


Figure 1-1: Planning Area Context Map

The only surface water that currently reaches the Old Smoky Hill River is from interior storm sewer discharge, which has intermittent and unpredictable flows. Figure 1-2 is a photograph of the typical conditions that can be found along much of the Old Smoky Hill River.

Figure 1-2: Existing Old Smoky Hill channel taken during the winter of 2017 (courtesy of the City of Salina).

The revised Master Plan, developed in 2019 through extensive public outreach, refined the previous Master Plan completed in 2010. The 2019 Master Plan shall be referred to as the Master Plan for the purposes of this report. A foundational element of the Master Plan is to re-establish base flow and restore the aquatic ecosystem functionality. There are plugged culverts and up to seven feet of sediment removal needed to restore gravity flow. Since there was no base flow or adequate gravity drainage slope, the Old Smoky Hill River was managed as a ponding area behind the FEMA certified levee. As the system is restored to a flowing functional aquatic system, there will be hydrologic and hydraulic changes that are the focus of this appendix. Under a full build out scenario, the undersized roadway crossings will be replaced with bridges and adequately sized culverts. While the City is pursuing funding for the full build out of the Master Plan, the ecosystem enhancement alternatives presented herein have been evaluated and modeled using the elements the City will construct to support the ecosystem goals. The

City has adequate funding for these elements and intends to have the elements either installed prior to or concurrent with federally funded habitat enhancements. The Master Plan was the starting point for the USACE Smoky Hill River Aquatic Ecosystem Restoration Project (project).

In addition to the riverine elements, the project has the opportunity to develop an aquatic passage between Lakewood Lake and the Old Smoky Hill River. Lakewood Lake is currently isolated from the riverine habitat but acts as a storage area during flood events when river levels overtop the perimeter trail and overflow into the lake area. The history of Lakewood Lake and construction drawings are documented in the feasibility study and this appendix focuses on the hydrology and hydraulic impacts of interconnecting the channel and the lake.

2 Purpose

This appendix documents the hydrologic and hydraulic changed conditions from the project. The changes are compared to the Federal Emergency Management Agency (FEMA) effective models and a project model developed specifically for this project. The FEMA effective model (effective April 18, 2018) (FEMA 2018) was modeled in Computational Hydraulics International (CHI) Personal Computer -Stormwater Management Model (PCSWMM) for both hydrology and hydraulics (Version 5.0.022 in May of 2013). It was completed in 2013 as part of the Interior Drainage Analysis (IDA) Salina Levee Project.

The IDA report included a Joint Probability Analysis using USACE standards to develop the final static ponding 1% annual chance water surface elevation (WSEL). The Joint Probability Analysis is described in Exhibit E of the Interior Drainage Analysis Report for the Salina Levee Project (Exhibit A of this document).

PCSWMM is often used for urban storm sewer drainage networks, including detention and pond areas. PCSWMM serves the purposes of managing the floodplain for the existing conditions, but it has limitations when modeling flowing riverine systems with bridges. Since baseflow is to be reintroduced into the channel and the undersized culverts are to be replaced with either bridges or larger culverts, Unsteady State Hydrologic Engineering Center River Analysis System (HEC-RAS V 5.0.7) was chosen to model the Old Smoky Hill channel hydrology and hydraulics for the purposes of this study.

PCSWMM still is used for the hydrology from the contributing drainage area to the channel. The PCSWMM model was refined to delineate the contributing drainage at each storm outfall entering into the Old Smoky Hill River, increasing the total number of contributing basins from 15 in the FEMA effective model to 87 in this project model. Furthermore, the existing condition hydrology and hydraulics incorporated additional survey data collected in 2017.

The Unsteady HEC-RAS was used to develop a with-project model to evaluate hydraulic performance of the analyzed alternatives considered for the project effort. Multiple alternatives were modeled in detail with the intent of meeting the aquatic restoration goals and being supportive of the long-term Master Plan implementation. Channel sections and riffle-pool sequenced sections were both considered and are presented in Section 5.

3 Background

The City has a long history of flooding and the federal flood control levee constructed in the 1960's resolved the most severe flooding. The following sections discuss the historic condition (pre-levee) as well as the residual flooding that currently occurs within the City.

3.1 Flood History

Much of this section has been adopted from the Saline County, Kansas, 1986 and 2018 Flood Insurance Studies (FEMA 2018). The data indicates a long history of flooding along streams in the Salina, Kansas area. The greatest known flood in Salina occurred in 1844. The Junction City Weekly Union dated June 13, 1867, reported, "Water higher at Salina than it has been since the great flood of 1844. It was four feet higher at that time." The flood of August 1858 reached a stage about 5 feet lower than that of 1844. The July 10, 1895, flood at Salina reached about the same stage as that of 1867. The second greatest known flood occurred on May 29, 1903. The floods of August 1927 and June 1938 are possibly the third and fourth highest floods which predate the Smoky Hill River flood control levee.

More recently, the City experienced significant flooding events in 2007. Low lying areas and streets in the interior of the levee system can be flooded because of storm runoff exceeding the stormwater system's maximum capacity. Drainage area in several locations is affected by surface runoff from adjacent watersheds. The most critical condition affecting the drainage problem is an extended period of above-normal rainfall immediately followed by a high-intensity storm. A study of rainfall records indicates that an extended period of above-normal rainfall occurs every six or seven years.

Listed below are a few excerpts from the Salina Journal concerning previous flood events:

> May 26, 1903 – "The worst flood in the history of Salina is now raging and the entire portion of the city north of the Union Pacific and west of the Missouri Pacific tracks is entirely submerged. Portions of the city south of the Union Pacific tracks and west of Ninth Street, north of Ash are flooded and the waters are still rising." *This flooding event was prior to the construction of the Salina Flood Control Project, completed in 1961.*
>
> October 20, 1941 – "Caught flat footed by a flood which mushroomed overnight to record proportions Salina stood knee deep in muddy water this afternoon from the troublesome Dry Creek watershed and waited apprehensively for what may yet come from up the Smoky Hill Valley. In four hours Salina's beleaguered east side was flooded and water ran sidewalk deep through many parts of the business district." *This flooding event was prior to the construction of the Salina Flood Control Project, completed in 1961.*

July 13, 1951 – “More than three-fourths of the city was under water Friday, but no casualties had been reported. In some areas overflows were reported dropping.” *This flooding event was prior to the construction of the Salina Flood Control Project, completed in 1961.*

May 23, 1971 – “The mighty little Mulberry Creek flexing its watery muscles after long years of placid living drove members of some 20 families from their homes west of Salina Saturday, then Saturday began mauling parts of north Salina.” *This flooding event was outside of the area protected by the Salina Flood Control Project.*

May 20, 1974 – “Mulberry Creek rose rapidly Sunday closing 5th Street Road and flooding areas near the US-81 and I-70 interchange.” *This flooding event was outside of the area protected by the Salina Flood Control Project.*

May 2007 - The City experienced two floods in the month of May 2007. The first flood was from May 5th through May 9th. The second flood was from May 24th through May 27th. The flooding was generally located within Mulberry Creek on the north side of the City and flooding within the project area did not occur. Following is the summary of the flood fighting efforts the City performed.

- The Street Division began barricading City streets due to high water on May 6th. After barricading, the City began pumping water. At 8 a.m. on May 6th, the City began filling sandbags. The sandbags were placed in the gaps of the levee around 4 p.m. on May 6th. The locations where sandbags were placed in the Levee gaps included West State Street, West Old 40 Highway, and the two railroad gaps (one at the Union Pacific Railroad and the other at K&O Railroad.) The City rerouted Old 40 Highway traffic through the lot of Reece Construction on West North Street.
- On Tuesday, May 8th, the City opened the areas which had previously been sandbagged. On Thursday, May 17th, the began rebuilding Stimmel Road which had sustained damage due to the high water.
- On May 24th, the City had a second flood. There was more water outside of the City limits than what was experienced with the first flood and flooding inside the levee system was minimal. All activities were directed toward keeping the flood waters outside of the Levee System. The City did sandbagging on West State Street, West Old 40 Highway, North 9th at Thomas Park, and the two railroad tracks (one at Union Pacific Railroad and the other at K&O Railroad.)
- When waters receded from the second flood, there was additional damage to Stimmel Road. Repair work was also needed to the road shoulder of North 9th Street. Due to the water being higher in the second flood, there was more damage than what was experienced with the first flood.

Table 3-1 lists the ten largest annual peaks at the United States Geological Survey (USGS) gauge on the Smoky Hill River near Mentor, Kansas.

Table 3-1: Smoky Hill River - Ten Largest Annual Peaks

Year	Discharge (cfs)
May 1903	32,000*
August 1927	25,500*
June 1938	24,000*
October 1973	20,300
July 1951	20,000
June 1993	13,100
May 1929	13,000*
August 1928	13,000*
July 1950	11,200
June 1949	10,400

* Pre-dates Kannapolis Reservoir

It should be noted that the City indicated the 1993 flood had minimal impact on the City's interior drainage area. The Smoky Hill River did experience a minor flood stage and a long duration of above normal stage. The 1993 Smoky Hill River flooding was used for calibration of the FEMA effective model and is shown in Table 3-1 as the sixth highest recorded peak flow.

3.2 Existing FIS Models

The Flood Insurance Study (FIS)(FEMA 2018) and related models dated September 30, 2016, were obtained to develop an existing conditions model. The FIS covering the Old Smoky Hill River is an interior drainage study and no floodway was identified. The model has undergone several iterations dating back to 1986. The City feels the PCSWMM model is a fair representation of the flooding the community experiences. However, as previously discussed, the hydraulic model selected for this Project was an unsteady solution of HEC-RAS, which will more appropriately model the proposed Master Plan and the Project channel ecosystem restoration improvements.

The effective hydrology model was inadequate for capturing the full complexities of the flow dynamics as the model condensed the 77 stormwater outfalls into 15; therefore, a higher resolution model that takes all 77 outfalls into account was needed for the following two reasons:

- First, the impact on channel flow rate from frequent storms is significant, and an understanding of wet weather water surface elevations at specific locations is necessary to design individual channel features that are located adjacent to the channel.

- Second, to minimize trash and other pollutants from the channel, stormwater best management practices (BMPs) will be designed to retrofit some of the existing outfalls. The peak discharge rates at each outfall is needed to size and design the BMPs. Therefore, a revised PCSWMM model was created for hydrology that included a more detailed drainage area delineation.

At the time of this writing, the City does not desire to use the new existing conditions model for remapping of the regulatory FEMA floodplain for the DOT RAISE Grant Project. Rather, it will be used as a project tool that models modification impacts and to inform design. Either a Physical Map Revision (PMR) or a Letter of Map Revision (LOMR) could be completed at the project conclusion to incorporate the Project channel modifications and resulting changes to water surface elevations. Obtaining a Conditional Letter of Map Revision (CLOMR) prior to commencement of construction activities would be beneficial to better portray the inundation risk to properties within the floodplain. The project model results have been shared with the City's floodplain administrator and the City will be evaluating if a PMR, LOMR or CLOMR will be pursued.

4 Existing Conditions

4.1 Effective Flood Insurance Study (FIS)

The original SWMM model appears to have been created several decades ago for the purpose of evaluating the interior levee drainage and updated multiple times in the interim. It was updated most recently in 2013, for an interior drainage analysis (IDA) as part of the Salina Levee Project and is the basis for the Old Smoky Hill Channel data included in the FIS, 20169CV000A, dated April 18, 2018 (FEMA 2018).

The effective PCSWMM model used 15 large sub-basins to introduce flow into the channel, which appears appropriate given the model's purpose and the City's management of the floodplain. However, this resolution is too coarse for the purposes of this study; therefore, the PCSWMM hydrology model was enhanced by re-delineating to each of the 77 storm sewer outfalls. This higher resolution model provides more detail on the flow dynamics within the Old Smoky Hill River as well as providing the basic elements required for BMPs with the intent to control trash and improve water quality.

4.2 Interior Drainage Analysis Update

A copy of the effective Smoky Hill River (exterior) HEC-RAS model and the HEC-SSP (Statistical Software Package) model were obtained from the City's floodplain administrator. An analysis was performed in accordance with EM 1110-2-1413 Hydrologic Analysis of Interior Areas. When the Smoky Hill River is not at flood stage, interior flows pass by gravity through the existing 78" culvert under the levee exit. During a large flood on the Smoky Hill River, the levee gates close, and an existing pump station with a capacity of approximately 53 cfs is activated to pump interior water to the exterior. Under these conditions, interior runoff is stored in Lakewood Lake and the channel until the pump station evacuates the water. This configuration would persist until the exterior stage draws down below the interior stage and the channel would flow by gravity.

A coincident-frequency analysis develops the probability distribution of stage at the interior side of the levee from a flow-probability curve for the interior runoff and also a duration-based probability distribution of the exterior stage. These probability distributions for the interior runoff and exterior stage are considered together using conditional probability. Conditional probability refers to the probability of occurrence (or exceedance) of one state of a property of the system, given a specified state of a second property upon which the first depends. The resulting probability estimates are conditional probability estimates; that are "conditioned" on occurrence of the specified state of the exterior stage. The coincident-frequency analysis method is an application of the total probability method. Total probability refers to the probability of occurrence (or exceedance) of a specified condition within the system, considering all possible combinations of contributing conditions.

The existing IDA model includes 13 levee culvert outfalls. Only two levee outfalls are within the project limits: the levee entrance and outlet at stations 0+00 and 685+50 (see Figure 4-1 for locations). Usually the IDA is only analyzed for levee outfalls, however, the Old Smoky Hill River entrance at Station 0+00 serves as an outlet during flood events due to reverse flow caused by the sediment in the channel and undersized culverts downstream. One correction was required to the IDA model. It was determined that a scour keyway that was part of the USACE Emergency Repair of Flood Protection Project for the Salina Levee System at Levee Station 0+00 was not included in the FIS exterior model and thus not reflected in the interior drainage coincidence analysis. The keyway crest is at elevation 1215.39 ft. NAVD88 compared to the channel flowline in the exterior model of 1209.30 ft. NAVD88. Adding in the keyway raises the FIS exterior water surface elevations that directly impacts the HEC-SSP interior drainage analysis results. The IDA was completed for both levee connections and the drainage response curves are presented in Table 4-1.

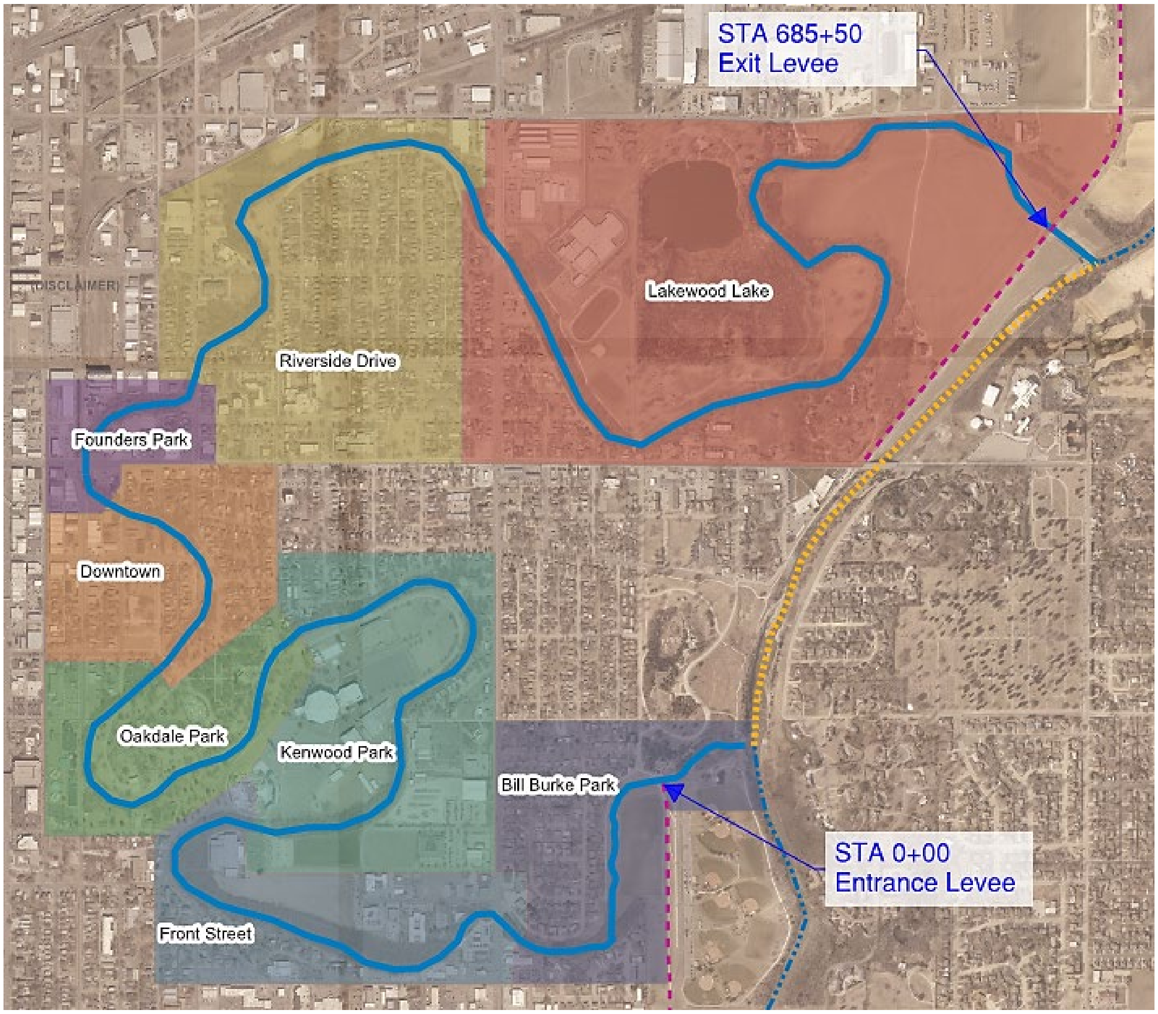


Figure 4-1: STA 0+00 and 685+50 Locations

Table 4-1: Updated Interior Drainage Response Curves for the Levee Intake and Outlet

STA 0+00 Entrance Levee			STA 685+50 Exit Levee		
% Chance Exceedance	Interior T.W. Elev. (Ft.)	Exterior Elev. (ft.)	% Chance Exceedance	Interior T.W. Elev. (Ft.)	Exterior Elev. (ft.)
0.2%	1224.7	1217.9	0.2%	1215.4	N.D.*
1%	1224.3	1220.6	1%	1212.2	1201.1
2%	1222.7	1218.4	2%	1210.5	1202.0
4%	1221.6	1217.3	4%	1209.3	1203.9
10%	1220.8	1217.2	10%	1208.3	1205.5
20%	1220.1	1216.9	20%	1207.6	1203.3
50%	1219.1	1216.5	50%	1206.8	1201.4
99%	1218.7	1216.7	99%	1206.6	1202.1

***N.D. stands for Normal Depth. Normal depth implies the exterior river is below flood stage and the interior has a free exit.**

The boundary conditions (or exterior river elevations) were updated in the project HEC-RAS model such that the interior tailwater elevations match that shown in the drainage response curves. The 1% AEP (entrance at Sta. 0+00) interior tail water in the previous IDA was 1219.44 and the revised interior TW is 1224.3, meaning the interior 1% AEP water surface increased by 4.9 ft. versus the FEMA effective model. The exterior river flood stage is contained within the existing high ground along the bypass channel and within the FEMA certified levee. The City's floodplain administrator as well as the consultants that developed the effective model have been notified about the discrepancy.

The new downstream levee (outlet at Sta. 685+50) 1% interior tailwater elevation is 1212.2 versus the existing tailwater elevation of 1207.6, meaning the interior 1% water surface is approximately 4.6 ft. higher than the existing analysis indicated.

The purpose of re-evaluating the coincidence analysis is to obtain accurate boundary conditions for the project model. All design considerations will be made with the higher interior elevations established through the updated coincidence. The City does not desire to re-map the existing conditions to reflect the higher interior elevations but will evaluate a PMR, LOMR or CLOMR as the master plan implementation and DOT RAISE Grant Project progress.

At a 1% AEP, the exterior elevations are less than the interior elevations for both the levee inlet and outlet. This implies the interior urban flooding condition with the Smoky Hill River near normal stage is the 1% AEP. Based on the analysis, the joint probability of a high exterior stage that requires closing the gate and large interior storms occurring at the same time exceeds the 1% AEP and hence coincidence is low. It is surmised the upstream reservoir (Kanopolis) on the Smoky Hill River tends to lower the peak flows and hence lower the frequency and severity of the exterior high stages.

4.3 Project Hydrology

4.3.1 Water Balance Executive Summary

The previous technical memo, Restored Channel Water Balance (March 30, 2018), is attached in Exhibit B of this appendix. The following is a copy of the Restored Channel Water Balance exhibit executive summary:

"The Smoky Hill River Renewal Master Plan was adopted by the City of Salina in 2010 and identified the community's priorities and goals for the renewal of the original alignment of the Smoky Hill River. HDR, Inc. (HDR) has been tasked with refining those goals and development of the conceptual and preliminary design of the project. This technical memorandum documents refined estimates of the restored channel water balance, including infiltration and evapotranspiration (ET) losses, as water is diverted into and recirculated through the Smoky Hill River Renewal Project during drought conditions.

The segment of old channel considered includes the portions landward (west) of the Smoky Hill River levee. Total channel length evaluated is 38,820 feet, and total channel area is 34.2 acres. It is assumed the existing sediment in the channel bottom will be excavated resulting in an average water depth of three (3) to six (6) feet. Thirty-one (31) channel segments were evaluated and three (3) independent parameter values were modified in a sensitivity analysis to provide bounds on calculated channel infiltration loss estimates. Actual calculations of channel infiltration rates were determined by using Darcy's Law, and an empirical equation to estimate vertical hydraulic gradient, as modified from the Green-Ampt infiltration equation for trenches, and a siltation/biofouling correction factor. Infiltration rates calculated compare favorably to those from a correlation of grain size and published infiltration rates for large-scale infiltration facilities.

Soil borings near the channel were completed using hollow stem rotary augers and the samples within the channel bottom were completed using a combination of hand augers and Geoprobe. The soils encountered at the excavation grade reveal overall estimates of infiltration rates from 1.6 to 15.7 cfs, including infiltration losses and ET. In terms of yearlong totals, the estimated overall losses are between 1,570 and 10,420 acre-feet, as much as 2.8 times larger than previous estimates for the Smoky Hill River Renewal Project. Channel segments with the largest infiltration rates and sandy or coarse-grained soils at shallow depths have been identified—these segments are associated with Sample IDs: 1, 7, 18, 19, 20, 21, 22, 22a, 26, 27, and 30 (centered on River Stations: 1200, 5600, 6300, 11000, 12200, 13500, 14600, 15800, and 28600).

Actively mitigating exposure of high-permeability sandy sediments during excavation is recommended to reduce channel infiltration losses. When sandy segments are capped with clay, the estimated total losses are estimated to range from 550 to 2,540 acre-feet. These overall losses along the entire channel length are 65 percent and 76 percent less than losses calculated without mitigation."

4.3.2 Water Supply Alternatives Evaluation

The previous technical memo, Water Supply Alternatives Evaluation (July 26, 2018), is attached in Exhibit C of this appendix. The following is a copy of the Water Supply Alternatives exhibit executive summary:

"The Smoky Hill River Renewal Project's (Project) primary source of water will be from the Smoky Hill River main channel. This channel has a large drainage area and will be able to supply adequate water (10 cubic feet per second) to more than offset infiltration and evaporation 89.5 percent of the time during the recreation season and 86.4 percent of the time during the off season.

A supplemental source of water is required to improve the reliability of maintaining water within the old river channel during drought conditions. Drought operations would not meet the full project flows, but rather be focused on maintaining a full channel. Restored Channel Water Balance Technical Memo dated March 30, 2018, estimated annual water lost through infiltration and evaporation as 550 acre-feet (ac-ft) to 10,420 ac-ft. For the purpose of this memo an annual water loss of 2,540 ac-ft, which is approximately 3.8 cubic feet per second (cfs), is assumed based on evaporation and mitigating sand layers at the bottom of the excavated channel. To improve the water supply to 99.0 percent reliability would require 219 ac-ft (3.8 cfs x 29 days). 99.9

percent reliability requires 407 ac-ft (3.8 cfs x 54 days) and the historic drought of record requires 3,995 ac-ft (3.8 cfs x 530 days).

This study evaluated four potential supplemental sources of water during drought operations; 1) water pumped from Lakewood Park Lake, 2) potential to supply golf courses with wastewater treatment plant effluent and divert existing golf course rights to the Project, 3) additional storage in Lakewood Park Lake due to raised surface water levels, and 4) purchased storage in Lake Kanopolis.

Purchasing storage in Lake Kanopolis through the Lower Smoky Hill Access District had the highest reliability and lowest life cycle cost of the options evaluated and is the recommended supplemental water supply source. Cost per 100 ac-ft of 2060 storage (discount from present day storage by reservoir siltation) is estimated at $53,135 initial costs, plus $4,650 annually for the first 20 years, and $600 annually for an additional 20 years. One full year of supply (2,540 ac-ft) equates to $1,350,000 in initial costs and a life cycle cost of $2,821,912."

4.3.3 Flood Hydrology

The effective PCSWMM model was revised by sub-dividing the large sub-basins to calculate the flows entering the Old Smoky Hill channel at each storm outlet. The boundary conditions were obtained from the previously developed SWMM model.

Salina's storm sewer system drains approximately 4.6 mi^2 (2,944 acres) of urban, industrial, commercial, and residential property through 77 storm and 10 non-point outfalls to the Old Smoky Hill River. The average sub-basin size is approximately 40 acres with a range of 0.5 to 300 acres and approximately half of the sub-basins are less than 20 acres in size. Figure 4-1 shows the general drainage areas compared to all storm sewer outfall locations, broken out by reach and contributing drainage zones.

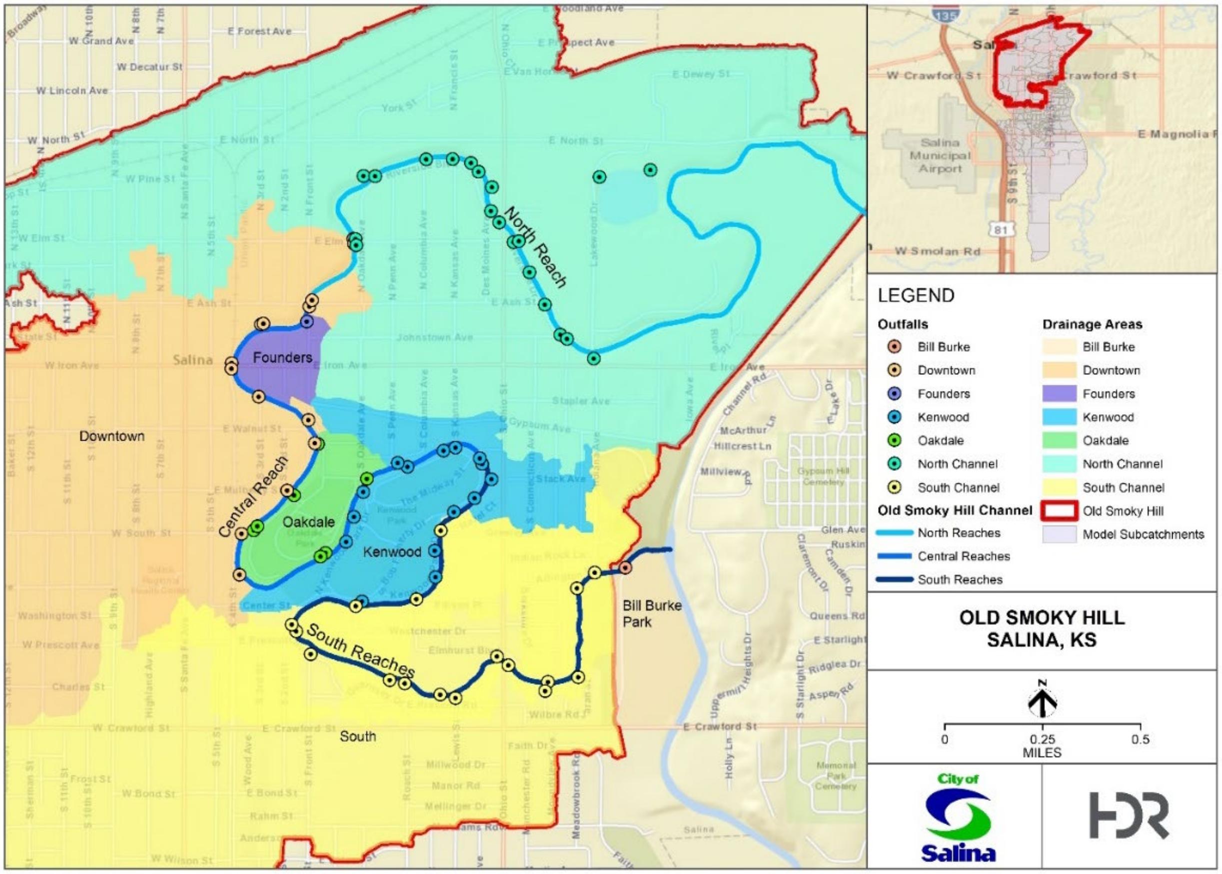


Figure 4-2: Original drainage area with 77 pipe outfalls added

Most of the stormwater outfalls are smaller diameter pipes (< 30”). Table 4-2 shows the breakdown of outfall sizes.

Table 4-2: Outfall Pipe Sizes

Outfall Pipe Sizes	Outfall Count
< 18 IN	26
18 - 30 IN	33
36 - 54 IN	13
<60 IN	3
66 IN	1
10-FT x 8-FT Box	1
TOTAL	**77**

The impervious surface was delineated by digitizing and classifying aerial imagery as part of the hydrologic model for the Salina Levee Certification (2013). The impervious surface of the total drainage area is 53% with a greater percent of imperviousness in the downtown area and less in the residential areas (see Figure 4-2). Through a GIS exercise, the percent impervious for each new sub-basin was extracted and applied in the updated hydrology model.

Updated curve numbers were calculated using the most recent National Land Cover Database (NLCD) (NRCS 2016), soil classifications, and zoning. Since the effective model uses percent impervious and curve number to calculate runoff, the assigned curve numbers only represent the pervious space and not the combined pervious/impervious weighted averages.

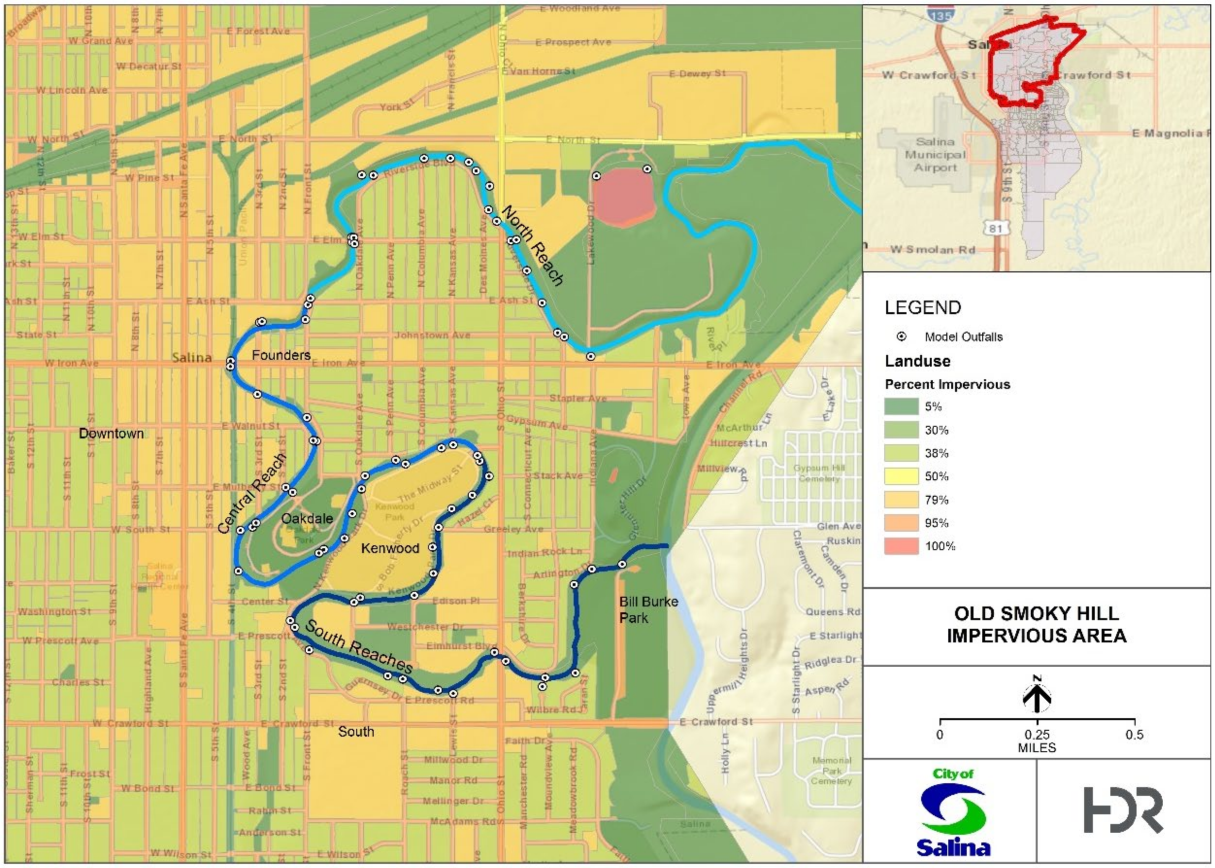


Figure 4-3: Drainage area impervious surface developed as part of the 2013 FEMA floodplain mapping updates.

The land use classifications are also based on the aerial photography used for the 2013 model and are shown in Figure 4-3. Combining updated 2016 soils information from the USDA/NRCS with the 2013 land use (Figure 4-2), new curve numbers were calculated for and applied to the newly delineated sub-basins in the updated hydrology model.

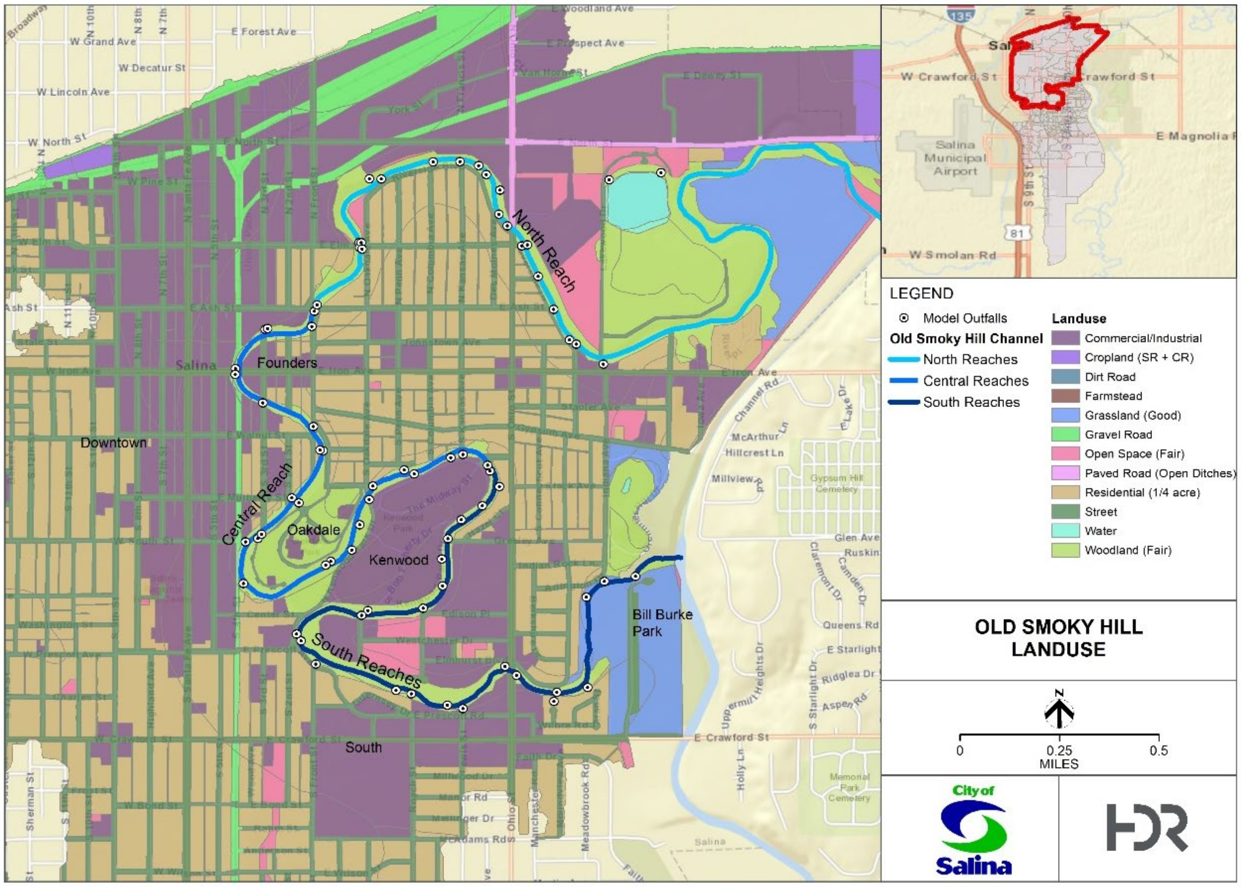


Figure 4-4: Drainage area land use based on aerial images and Kansas Land Cover Pattern.

Table 4-3: 24-hr KDOT and NOAA Atlas 14 Rainfall Depths for Salina, KS.

AEP %	KDOT Precipitation Depths (in.)	NOAA Atlas 14 Precipitation Depths (in.)
50%	3.12	3.13
20%	4.08	3.89
10%	4.80	4.58
4%	5.76	5.6
2%	6.48	6.46
1%	7.20	7.37
0.2%	8.92	9.72

Original rainfall depths used in the 2013 model were from the Kansas Department of Transportation (KDOT) Rainfall Intensity Tables, which were updated with 2016 NOAA Atlas 14 rainfall depths. The previous study used an SCS Type II distribution, which is also no longer recommended. Table 4-3 presents the KDOT and NOAA Atlas 14 precipitation depths for the 50% through 0.2 % AEP. Figure 4-4 shows the cumulative precipitation comparison for the 1% AEP.

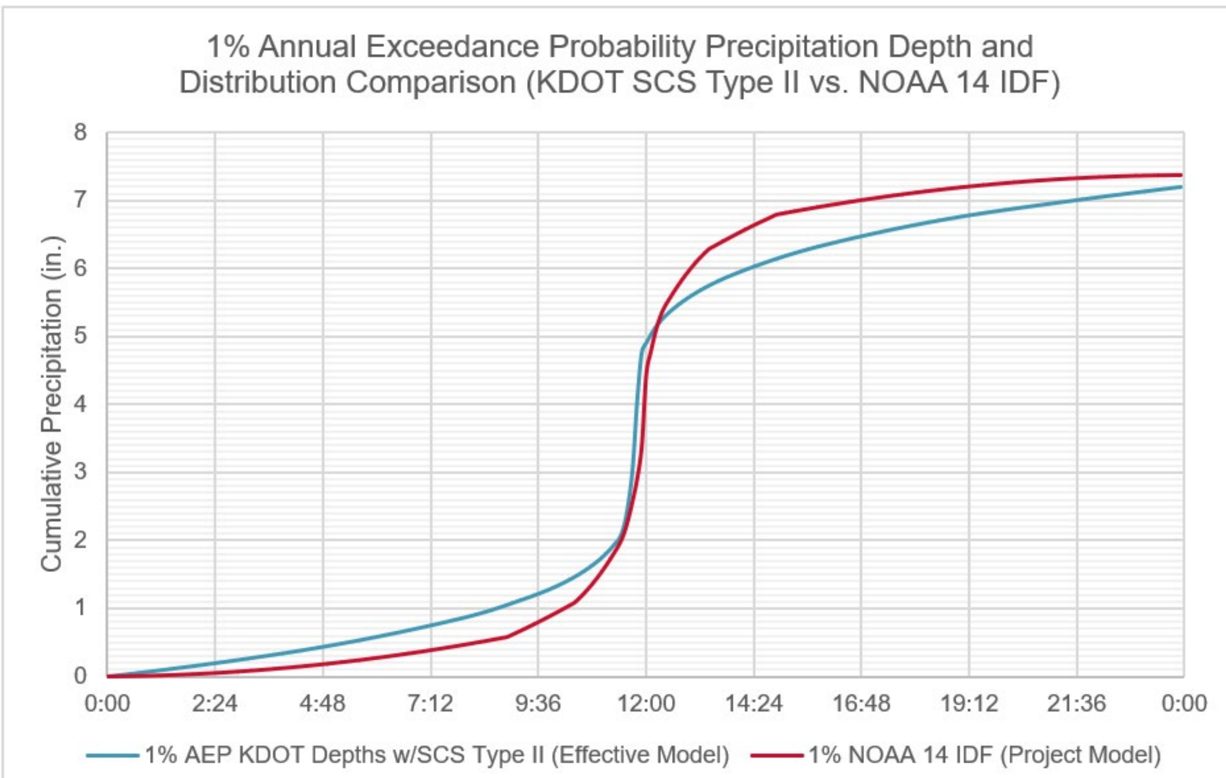


Figure 4-5: Cumulative Precipitation Depths for KDOT Depths with SCS Type II Distribution and NOAA Atlas 14 IDF

Figure 4-5 presents the full extents of the contributing sub-catchments to the project area and Figure 4-6 and Figure 4-7 present a closer look at the sub-catchments and outfalls in the updated model. Table 4-4 shows the PCSWMM sub-catchment input parameters as well as flows at the outfalls.

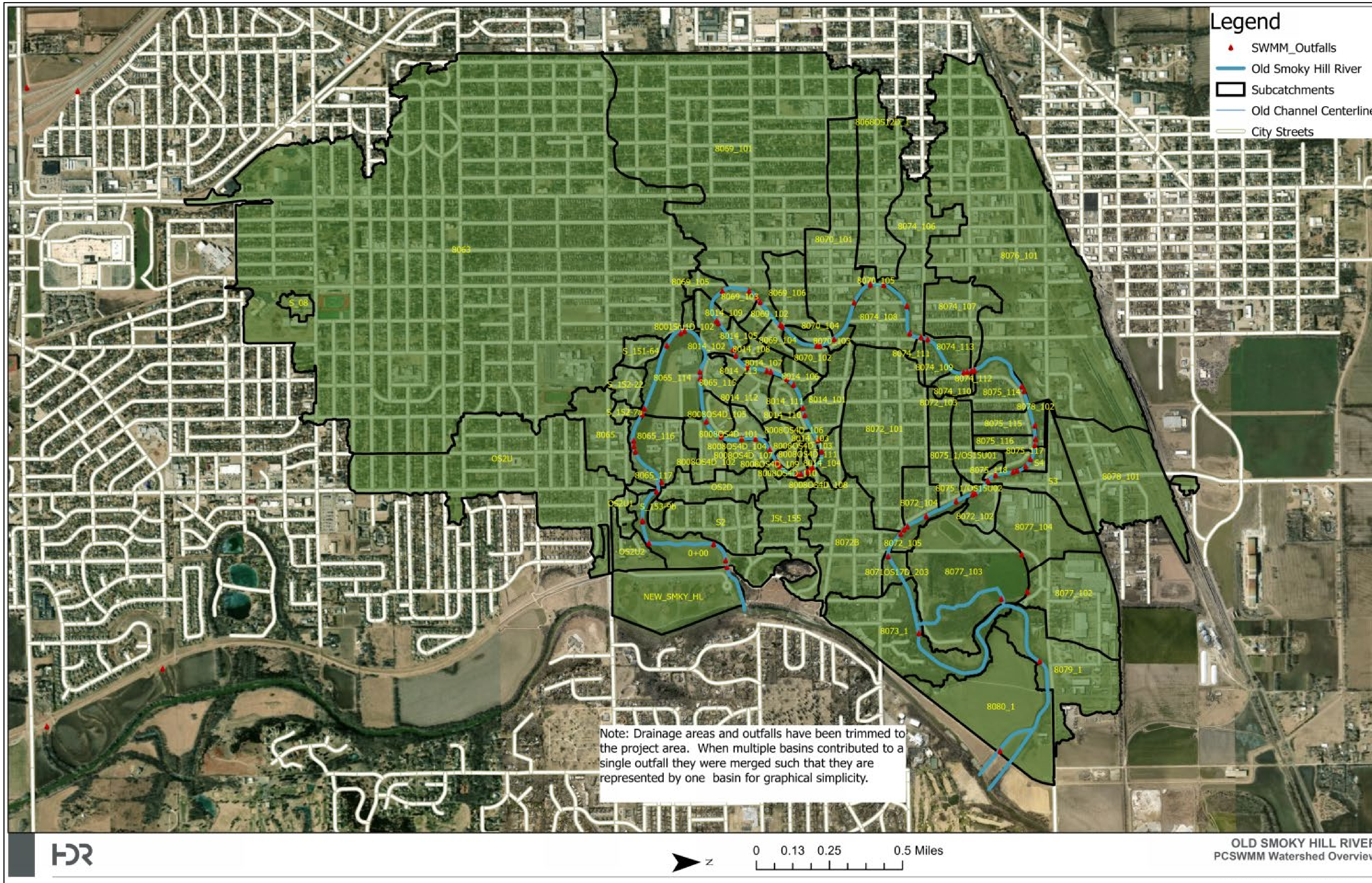


Figure 4-6: PCSWMM Subcatchment and Outfall Location Overview

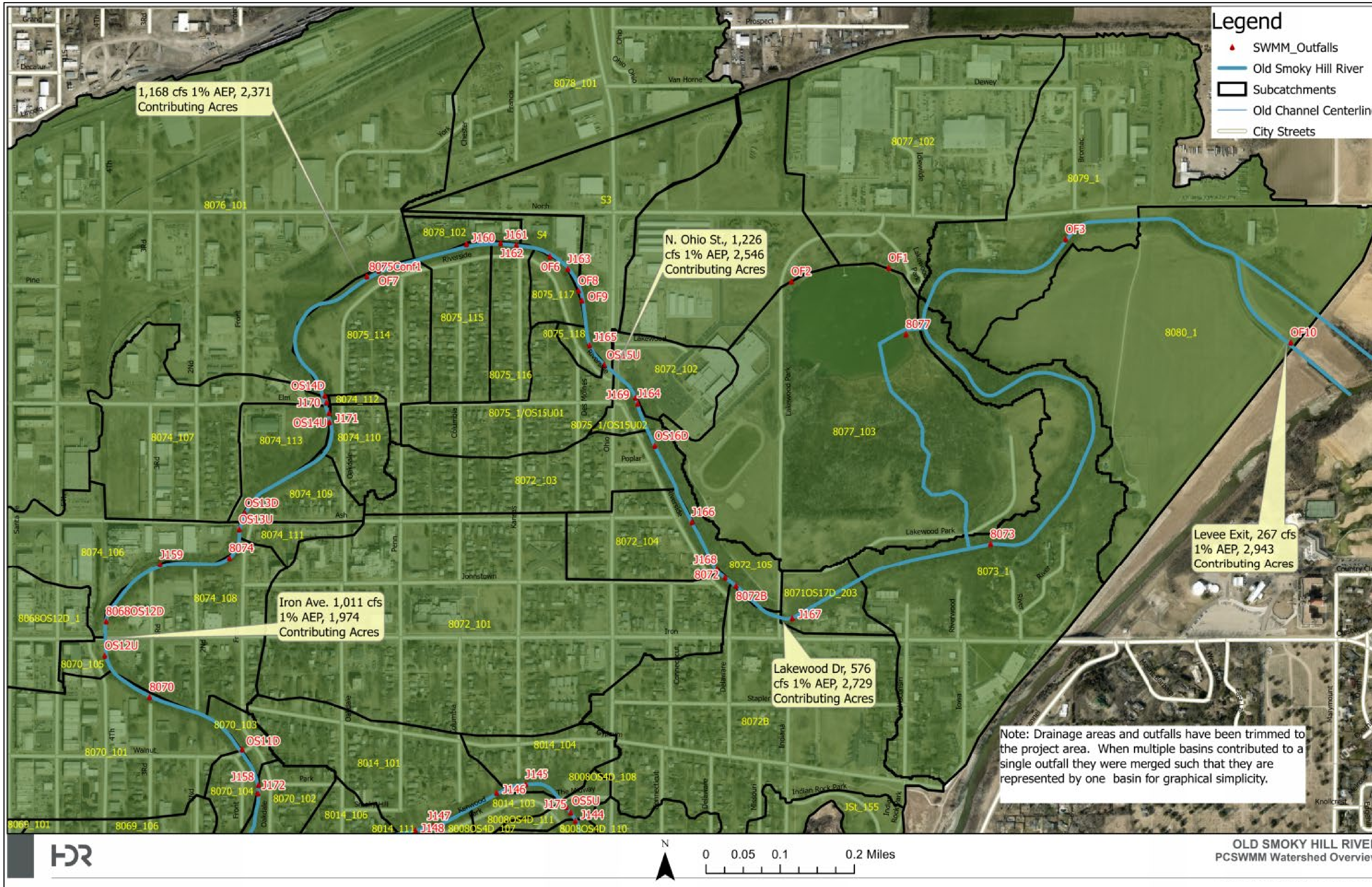


Figure 4-7: PCSWMM Subcatchment and Outfall Exhibit (North of Iron Ave.)

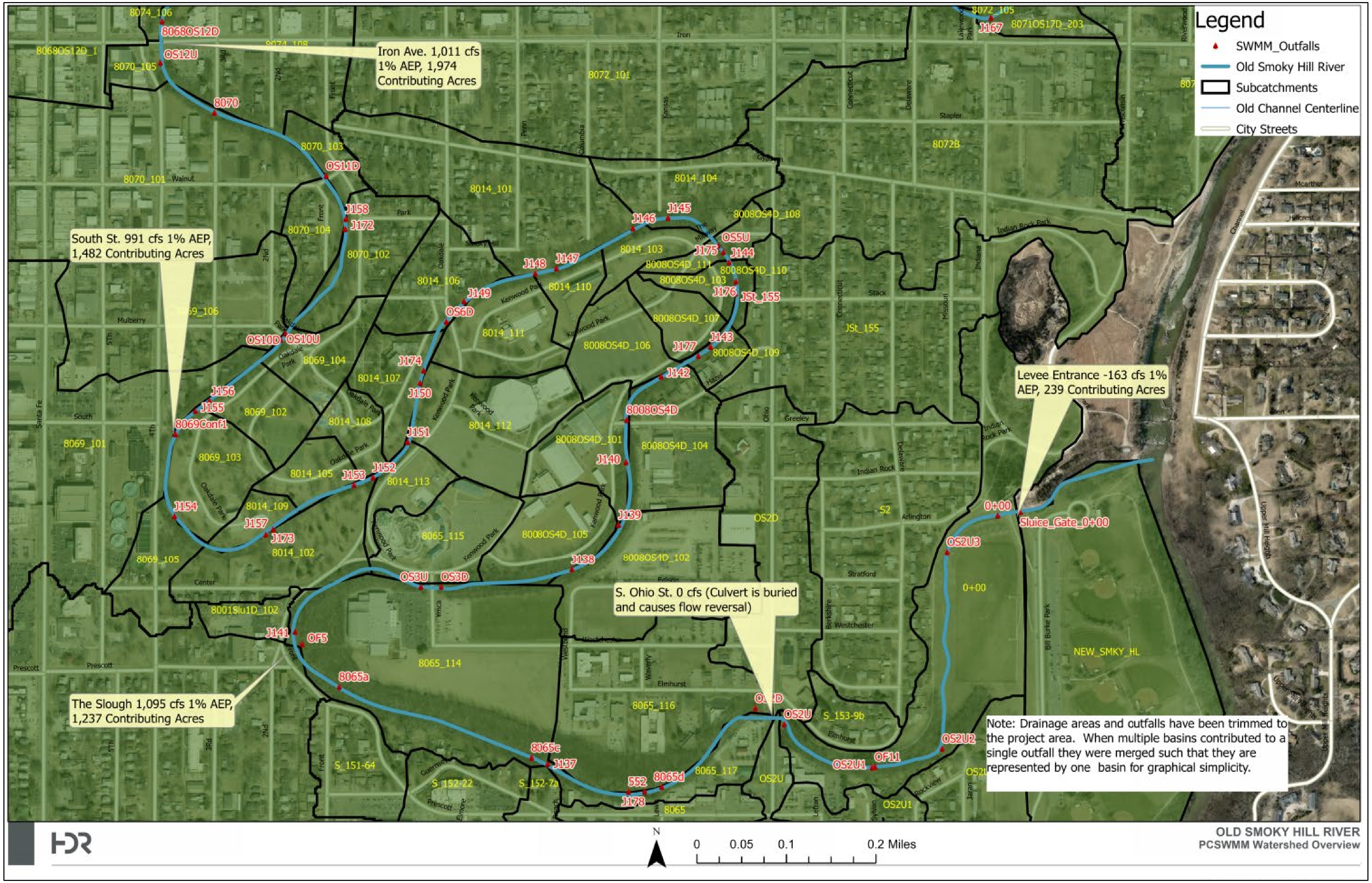


Figure 4-8: PCSWMM Subcatchment and Outfall Exhibit (South of Iron Ave.)

Table 4-4: PCSWMM Subcatchment Parameters and Outfall Flows

Name	Outlet*	Area (ac)	Characteristic Basin Width (ft)	Longest Flow Path (ft)	Slope (%)	Imperv. (%)	Curve Number**	100% AEP Flow (cfs)***	50% AEP Flow (cfs)***	20% AEP Flow (cfs)***	10% AEP Flow (cfs)***	4% AEP Flow (cfs)***	2% AEP Flow (cfs)***	1% AEP Flow (cfs)***	0.2% AEP Flow (cfs)***
8001Slu1D_102	J141	2.6	149	772	2.8	71	70	8	10	13	15	19	21	24	30
8008OS4D_101	J140	7.0	569	537	2.5	63	61	20	24	31	37	46	52	59	75
8008OS4D_102	J138	15.0	537	1,216	2.5	66	69	41	49	64	77	94	108	122	155
8008OS4D_103	J144	1.9	229	362	2.5	52	60	5	6	8	9	11	13	15	19
8008OS4D_104	8008OS4D	9.7	446	948	2.5	63	65	26	32	41	49	61	70	79	100
8008OS4D_105	J139	7.5	311	1,051	2.5	55	59	17	21	27	33	41	47	54	70
8008OS4D_106	J142	6.2	322	838	2.5	74	64	19	23	30	36	43	49	55	69
8008OS4D_107	J143	3.5	304	501	2.5	65	60	10	12	16	19	23	27	30	38
8008OS4D_108	OS5U	1.5	192	350	2.5	60	61	4	5	7	8	10	12	13	17
8008OS4D_109	J177	1.8	233	333	2.5	39	60	3	4	6	7	9	11	12	16
8008OS4D_110	J176	0.9	334	118	2.5	22	59	1	2	3	3	4	5	6	8
8008OS4D_111	J175	1.2	262	195	2.5	70	60	4	5	6	7	9	10	11	14
8014_101	J148	20.9	1,125	810	2.8	55	68	53	64	84	102	126	145	165	211
8014_102	J157	10.9	642	740	2.8	30	66	16	20	28	36	47	55	65	87
8014_103	J146	3.0	271	484	2.8	60	59	8	10	13	16	19	22	25	32
8014_104	J145	8.7	320	1,185	2.8	49	67	19	23	30	36	46	53	61	79
8014_105	J153	3.5	306	493	2.8	18	58	3	4	6	8	11	14	17	23
8014_106	J149	7.0	429	713	2.8	41	67	14	17	23	29	36	43	49	64
8014_107	J174	5.1	355	624	2.8	22	61	5	7	10	13	18	22	26	36
8014_108	J152	3.3	374	380	2.8	26	59	4	5	8	10	13	16	19	26
8014_109	J173	2.2	261	362	2.8	20	58	2	3	4	6	8	10	12	16
8014_110	J147	2.8	219	563	2.8	66	60	8	10	13	16	19	22	24	31
8014_111	OS6D	7.8	402	844	2.8	65	61	22	26	34	40	49	57	64	81
8014_112	J150	11.6	10,000	50	2.8	78	66	45	53	66	77	92	103	115	142
8014_113	J151	3.6	186	844	2.8	74	67	11	14	18	21	26	29	33	41
8065_114	OS3U	33.0	1,292	1,113	2.7	31	64	47	57	78	97	126	150	175	238

Name	Outlet*	Area (ac)	Characteristic Basin Width (ft)	Longest Flow Path (ft)	Slope (%)	Imperv. (%)	Curve Number**	100% AEP Flow (cfs)***	50% AEP Flow (cfs)***	20% AEP Flow (cfs)***	10% AEP Flow (cfs)***	4% AEP Flow (cfs)***	2% AEP Flow (cfs)***	1% AEP Flow (cfs)***	0.2% AEP Flow (cfs)***
8065_115	OS3D	8.5	332	1,121	2.7	66	65	23	28	37	44	54	62	70	89
8065_116	552	21.9	646	1,476	2.7	54	65	49	59	77	93	116	134	153	198
8065_117	J178	5.1	683	327	2.7	48	62	12	15	20	24	30	35	40	52
8068OS12D_1	8068OS12D	56.5	737	3,342	2.9	71	71	126	154	202	244	303	350	398	512
8069_101	8069Conf1	309.5	3,454	3,904	3.0	59	72	450	535	682	804	960	1123	1235	1553
8069_102	J156	5.1	323	681	3.0	35	59	8	10	14	17	22	26	30	41
8069_103	J155	7.3	403	792	3.0	18	58	6	8	12	15	21	26	31	44
8069_104	OS10D	5.2	387	580	3.0	32	60	8	10	13	17	22	26	31	41
8069_105	J154	5.8	308	815	3.0	53	70	15	18	23	28	35	40	46	59
8069_106	OS10U	20.1	785	1,112	3.0	74	69	62	75	96	114	140	159	178	224
8070_101	8070	61.7	2,006	1,340	2.9	70	70	175	211	274	327	402	460	518	655
8070_102	J158	7.7	487	685	2.9	41	63	15	18	25	30	39	45	52	68
8070_103	OS11D	2.6	346	330	2.9	53	60	7	8	11	13	16	19	21	27
8070_104	J172	4.6	248	814	2.9	42	60	9	11	14	17	22	26	30	39
8070_105	OS12U	2.0	195	451	2.9	53	68	5	7	9	10	13	15	17	21
8071OS17D_203	J167	6.6	423	678	3.4	26	60	31	38	51	63	78	91	104	135
8072_101	8072	87.5	917	4,157	3.1	62	70	166	203	267	323	405	470	537	701
8072_102	J169	9.9	10,000	43	3.1	80	60	39	45	56	65	78	88	98	120
8072_103	OS16D	20.3	1,491	594	3.1	50	68	49	61	81	98	122	141	160	206
8072_104	J166	12.8	738	754	3.1	55	64	32	39	51	61	76	88	99	128
8072_105	J168	6.6	613	469	3.1	13	60	5	7	10	14	20	26	31	44
8073_1	8073	63.0	27,430	100	3.8	34	66	144	186	251	307	386	449	513	666
8074_106	J159	42.6	25,000	74	3.0	80	65	167	197	244	284	339	381	423	521
8074_107	J170	28.3	603	2,046	3.0	72	69	74	89	116	139	172	198	223	284
8074_108	8074	24.8	640	1,690	3.0	66	61	63	76	98	117	145	166	188	241
8074_109	OS13D	5.9	348	739	3.0	32	61	9	11	15	19	25	29	34	46
8074_110	OS14U	6.1	336	797	3.0	50	64	14	17	23	27	34	40	45	59
8074_111	OS13U	3.1	254	526	3.0	65	62	9	11	14	17	21	24	27	33

Name	Outlet*	Area (ac)	Characteristic Basin Width (ft)	Longest Flow Path (ft)	Slope (%)	Imperv. (%)	Curve Number**	100% AEP Flow (cfs)***	50% AEP Flow (cfs)***	20% AEP Flow (cfs)***	10% AEP Flow (cfs)***	4% AEP Flow (cfs)***	2% AEP Flow (cfs)***	1% AEP Flow (cfs)***	0.2% AEP Flow (cfs)***
8074_112	OS14D	0.6	68	407	3.0	69	60	2	2	3	4	5	5	6	7
8074_113	J171	7.9	343	1,007	3.0	28	64	11	13	18	23	30	36	42	57
8075_1/OS15U01	OS15U	16.7	932	780	3.1	55	67	43	52	68	82	102	117	133	170
8075_1/OS15U02	J164	2.0	306	285	3.1	46	60	4	6	8	9	12	13	15	20
8075_114	OF7	18.1	552	1,428	3.1	46	62	35	42	55	67	85	99	114	150
8075_115	J160	11.0	321	1,488	3.1	52	65	24	29	38	45	57	66	75	98
8075_116	J161	7.4	239	1,343	3.1	49	64	15	19	25	30	37	44	50	65
8075_117	J163	3.8	329	501	3.1	33	60	6	8	10	13	17	20	24	32
8075_118	J165	1.5	188	343	3.1	48	60	3	4	6	7	9	10	11	15
8076_101	8075Conf1	289.3	1,872	6,731	2.8	63	69	32	44	60	76	97	113	124	133
8077_102	OF1	54.8	774	3,082	2.7	68	63	119	145	189	227	282	325	370	479
8077_103	8077	85.8	1,632	2,290	2.7	28	70	107	131	175	217	281	335	392	537
8077_104	OF2	37.0	783	2,061	2.7	56	63	79	95	124	149	185	215	245	319
8078_101	OF9	101.5	1,770	2,499	2.8	55	71	69	84	111	134	167	191	216	263
8078_102	J162	3.9	116	1,475	3.1	51	60	8	10	13	16	19	23	26	34
NEW_SMKY_HL	Sluice_Gate_0+00	50.4	906	2,424	2.0	20	67	45	55	73	91	120	144	171	243
S_151-64	8065a	7.6	280	1,182	2.9	64	70	21	25	32	39	48	55	62	79
S_152-22	8065c	8.7	356	1,061	2.7	76	70	27	33	42	50	61	69	78	97
S_152-7a	J137	3.2	187	753	2.7	75	69	11	13	16	19	24	27	30	37
S_153-9b	OF11	3.5	182	844	2.9	54	65	9	10	14	16	20	22	23	24
S2	OS2U3	29.9	1,129	1,155	3.0	56	70	74	90	107	113	119	125	130	144
S4	OF6	3.9	371	461	3.2	25	60	5	6	9	12	16	19	22	31
8079_1	OF3	54.7	500	4,769	3.2	52	62	89	108	141	170	212	247	283	374
8080_1	OF10	75.9	500	6,609	3.2	6	61	19	24	33	41	56	70	87	138
OS2D	OS2D	19.9	960	903	2.9	72	69	53	59	68	76	86	95	103	125
OS2U	OS2U	142.1	61,892	100	3.0	60	76	135	138	141	144	147	150	153	160
OS2U1	OS2U1	5.7	2,429	102	2.7	75	70	13	14	16	17	19	20	22	26
OS2U2	OS2U2	16.6	6,506	111	3.2	39	70	12	12	13	14	14	15	16	16

Name	Outlet*	Area (ac)	Characteristic Basin Width (ft)	Longest Flow Path (ft)	Slope (%)	Imperv. (%)	Curve Number**	100% AEP Flow (cfs)***	50% AEP Flow (cfs)***	20% AEP Flow (cfs)***	10% AEP Flow (cfs)***	4% AEP Flow (cfs)***	2% AEP Flow (cfs)***	1% AEP Flow (cfs)***	0.2% AEP Flow (cfs)***
8065	8065d	28.3	4,739	260	2.5	80	70	44	50	61	71	86	99	115	137
JSt_155	JSt_155	35.6	941	1,645	3.3	47	70	61	74	98	119	152	177	203	266
8072B	8072B	57.7	8,215	306	3.2	60	71	114	119	128	138	153	166	179	212
0+00	0+00	34.1	847	1,755	3.4	16	65	17	17	17	17	17	17	17	17
8063	OF5	970.7	4,266	9,912	3.0	56	78	585	639	732	809	912	993	1097	1753
*Some outfalls have more than one contributing basin in the PCSWMM model. The multiple basins were combined into one for graphical simplicity but remain separate in the model.															
**Curve numbers represent undeveloped conditions since percent impervious is used to capture the developed surfaces.															
***All flows are reported for the outfall, not the subcatchment (i.e. the combined flows for outfalls with multiple subcatchments).															

4.4 Existing Conditions Project Hydraulic Modeling

An unsteady-state HEC-RAS model in Version 5.0.7 was developed to represent the existing in channel water surface elevations for the project area by incorporating the hydrology refinements discussed in the previous section. Again, the purpose of the existing conditions model is not for a Letter of Map Revision (LOMR) or a Physical Map Revision (PMR), but to set the existing project condition.

4.4.1 Surface

The City of Salina contracted with Quantum Spatial, Inc. to collect new LiDAR imagery in 2020 for the areas surrounding the Old Smoky Hill Channel. The LiDAR data was acquired on January 26, 2020, using an Optech Orion H300 LiDAR from a Piper Navajo aircraft flying at approximately 4,400 feet.

The surface was delivered in ESRI TIN format (Kansas State Plane, North Zone, NAD83 (2011) NAVD88, US Survey Ft.) and has < 1 foot root mean square error (RMSE) horizontal accuracy and near 0.04 feet RMSE vertical accuracy. The ESRI TIN was converted to a geoTIFF with 1 foot cell spacing that RAS Mapper could read in directly. An overview of the terrain as seen in RAS Mapper is presented in Figure 4-8.

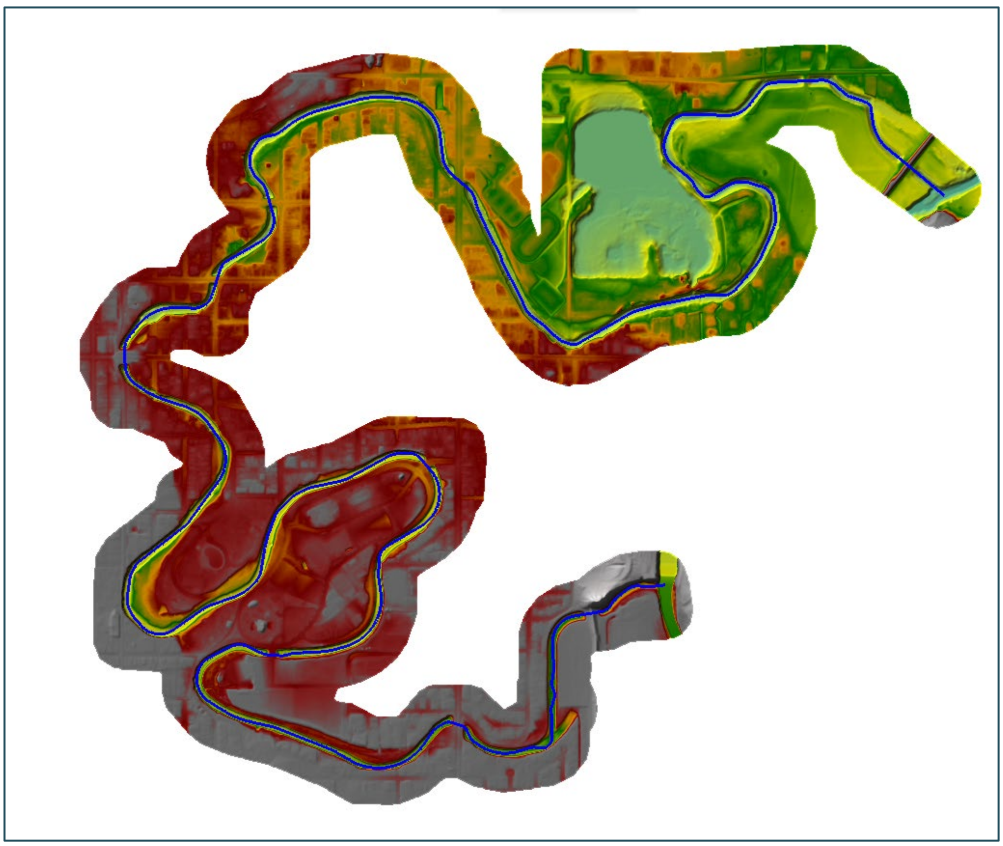


Figure 4-9: Quantum LiDAR as a RAS Mapper Terrain

To supplement the data, Kaw Valley Engineers (KVE) performed a hydraulic structures field survey for each structure that crosses the Old Smoky Hill River channel in the summer of 2017 (Kansas State Plane, North Zone, NAD83 (2011) NAVD88, US Survey Ft.). KVE also collected channel cross section spot elevations at approximately 200 feet intervals for the entirety of the Old Smoky Hill Channel.

The field collected spot elevations above the water elevations were compared to the LiDAR collected bare earth shots for quality assurance purposes. Not all points make a good comparison such as retaining walls, headwalls, bridge low chords, and handrails (etc.) so they were selectively filtered out. Only applicable channel and ground shots were included for the topo to LiDAR comparison and consist of channel flow line, toe of bank, top of bank, edge of water, and ground elevation shots.

Figure 4-10 and Figure 4-11 present the elevation differences in plan view for the applicable shots as described above. Shots that were within 1 foot are represented as a hollow black circle, shots that are greater than 1 foot (suggesting LiDAR higher than Topo) are represented as filled blue circles, and shots that were less than negative 1 foot are represented as filled red circles (suggesting LiDAR is lower than Topo). A typical trend is identified as shots near the thalweg of the channel are typically blue suggesting the LiDAR channel bottom is the water surface at the time of the data collection. A Root Mean Square Error (RMSE) of 0.69 feet is calculated for all the points considered.

Defining the water in the channel at the time of collection is important but doesn’t lead to an accurate assessment as to the integrity of the LiDAR data. Therefore, a further examination of the flowline and ground shots were analyzed. Figure 4-9 presents a box and whisker chart for the differences calculated for ground elevation and flow line shots between the field collected topographic shots and the LiDAR derived elevations.

The flowline chart shows a wider range in calculated differences which is anticipated knowing there were varying water depths in the channel during the time of collection. A RMSE of 1.57 is calculated for the flow line shots meaning a depth of 1.57 feet is representative of the dataset. On the other hand, the ground shot chart shows a tighter range of values with a RMSE of 0.24 suggesting the LiDAR to be within 0.24 feet of the field topographic shots.

The 1.57 feet of average water depth doesn’t have a significant impact on the flood modeling for the existing conditions and therefore no adjustments were made to the channel cross sections such as adding the bathymetry from the field shots. The depth of water will have implications for the proposed alternatives quantities of excavation. If left alone, excavation quantities will likely be high as it is including the water volume so an uncertainty will be documented to the estimated volume of water for each alternative. Further inspection may be warranted for the selected alternative prior to the development of the 30% plans. It is recommended that the average water depth over the small bottom portion of the channel is included as part of the contingencies with the opinion of probable construction costs included in the feasibility study.

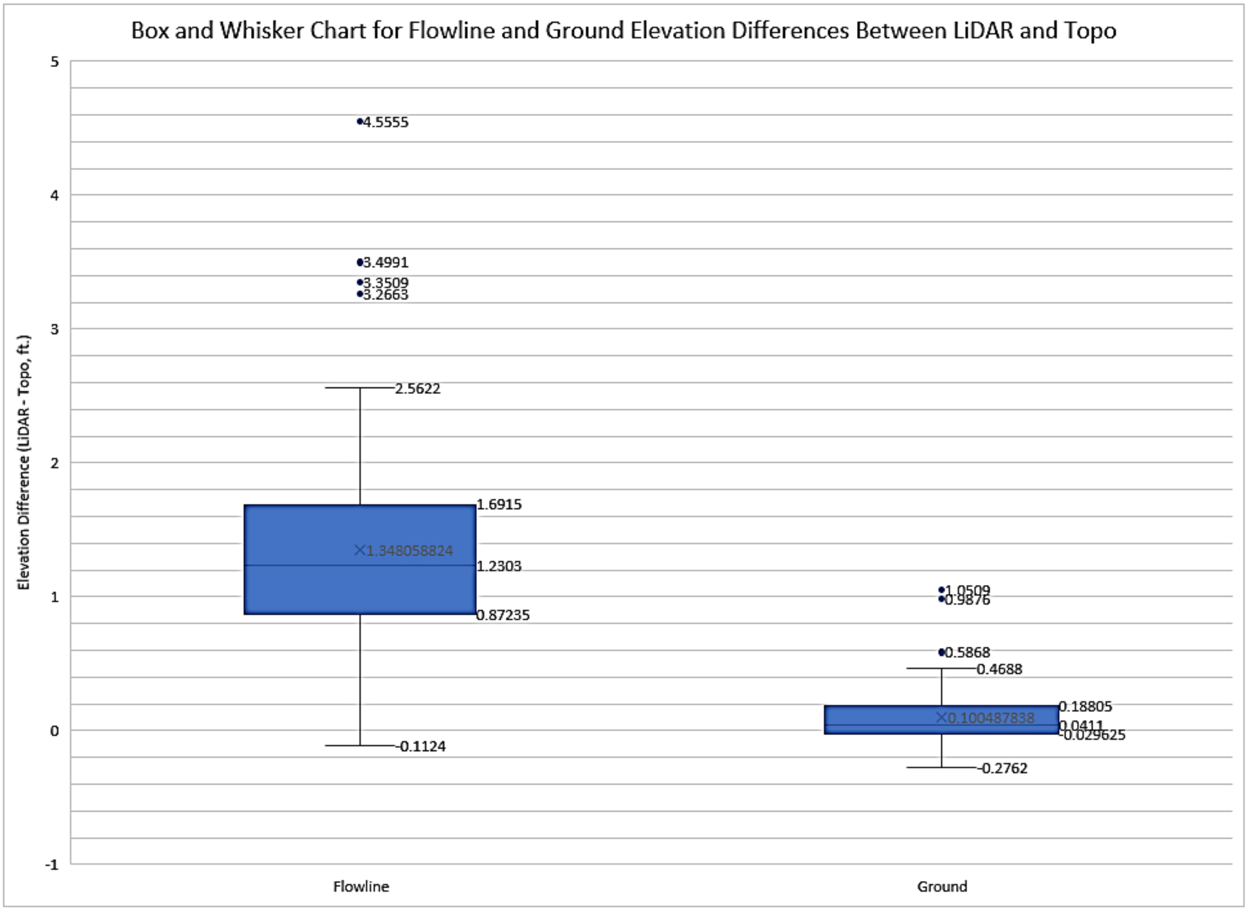


Figure 4-10: Box and Whisker Chart for Flowline and Ground Elevation Differences Between LiDAR and Topographic Field Shots

Figure 4-11: Kaw Valley Topographic Field Shot and Quantum LiDAR Differences (LiDAR minus Topo) South of Iron Ave.

Figure 4-12: Kaw Valley Topographic Field Shot and Quantum LiDAR Differences (LiDAR minus Topo) North of Iron Ave.

Hydraulic crossings and structures were surveyed and translated into the new existing conditions model. Comparing the record drawings culvert flow lines, to the current channel elevations, it appears several locations are experiencing deposition. Table 4-5 shows the main stem culverts elevations, channel elevations approximately 100 feet upstream and the apparent feet of deposition that has occurred. It should be noted many of the culverts have standing water at the entrance and/or exit. This is due to the localized higher culvert velocities moving the fine grain sediments through the structure and minimizing the deposition within the structure.

Table 4-5: Old Smoky Hill Culvert Data Including Estimated Channel Deposition

Culvert Location	HEC-RAS Station	Record Drawing Date	Culvert Size	Upstream Flowline (Ft. NAVD88)	Channel Elevation (Ft. NAVD 88)	Approximate Channel Deposition[1] (Ft.)
Levee (Entrance)	355+68	1961	54” RCP Gatewell	1208.3[(2)]	1213.07	4.77
South Ohio Street	327+06	1961	84” CMP	1205.0	1215.0	10.0
YMCA Driveway	283+52	1993 (Replaced 84” CMP)	7’x4’ RCB	1210.34	1211.4	1.06
The Midway	250+47	1977	10'x6'	1208.76	1210.92	2.16
Iron Avenue	170+52	1984 (Conc. Haunched Girder Bridge Removed)	9’x9’ RCB	1203.89	1204.61	0.72
Ash Street	155+66	1960	12’x12’ RCB	1196.39	1199.74	3.35
Elm Street	144+27	1960	10’x10’ RCB	1195.39	1200.46	5.07
North Ohio Street	108+36	2016	12’x12’ RCB	1195.95	1196.19	0.24
Walker Driveway	21+00	UKN	96” CMP	1196.45	1197.59	1.14
Levee (Outlet)	5+20	1961	84” RCP Gatewell and Pump Station	1195.72	1196.69	0.97

Notes:

1. The field topographic survey information upstream of the entrance scour pool was used.
2. Channel and culvert downstream elevations were used.

4.4.2 Model Development and General Assumptions

The new existing conditions model was built using RAS Mapper Version 5.0.7, which allows the user similar functions to HEC-GeoRAS. The horizontal datum used is North American Datum (NAD) 1983 State Plane Kansas North FIPS 1501 Feet and the North American Vertical Datum of 1988 (NAVD 88) was used for all vertical applications.

- The existing river centerline was developed using the terrain and survey data.
- Cross sections were placed a minimum of 100 feet spacing for a more stable unsteady solution. See Figure 4-12, Figure 4-13,Figure 4-14 for existing conditions HEC-RAS cross section plan view layouts.
- Horizontal Manning's n values for the channel range from 0.035 (typical channel section) to 0.045 (heavily vegetated), while overbanks typically range from 0.065 to 0.12 (depending on the density of trees and vegetation).
- Structure elevations (i.e. bridges and culverts) were based on topographic survey information collected by Kaw Valley Engineering dated 2017.
- An inline structure with a weir coefficient of 2.6 was used to represent the "Western Star Mill" dam (with the crest elevation ranging from 1212.64 to 1212.47 ft NAV88) located just downstream of Iron Ave (Cross Section (CX) 16574).

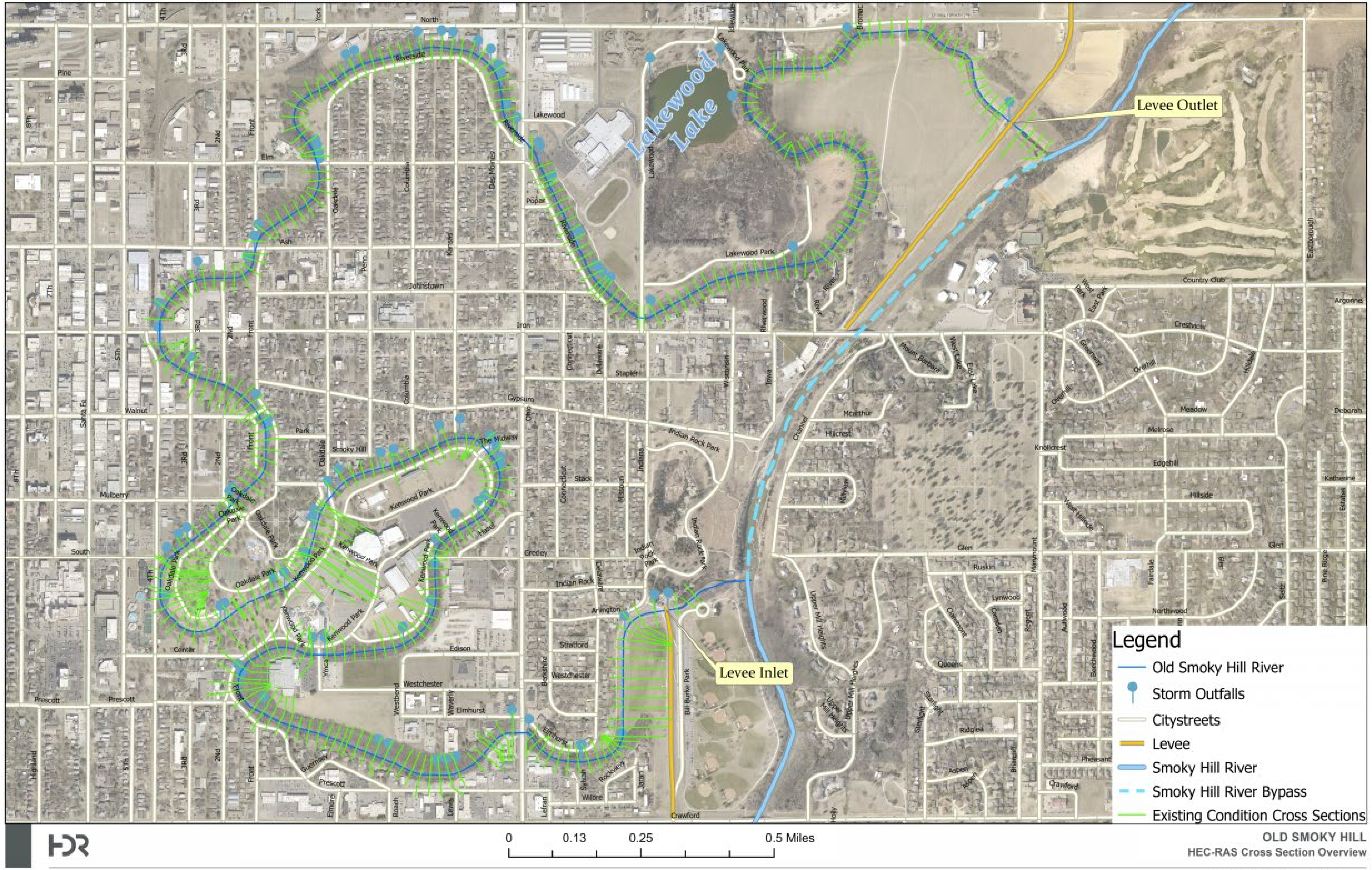


Figure 4-13: Existing Condition HEC-RAS Cross Section Overview

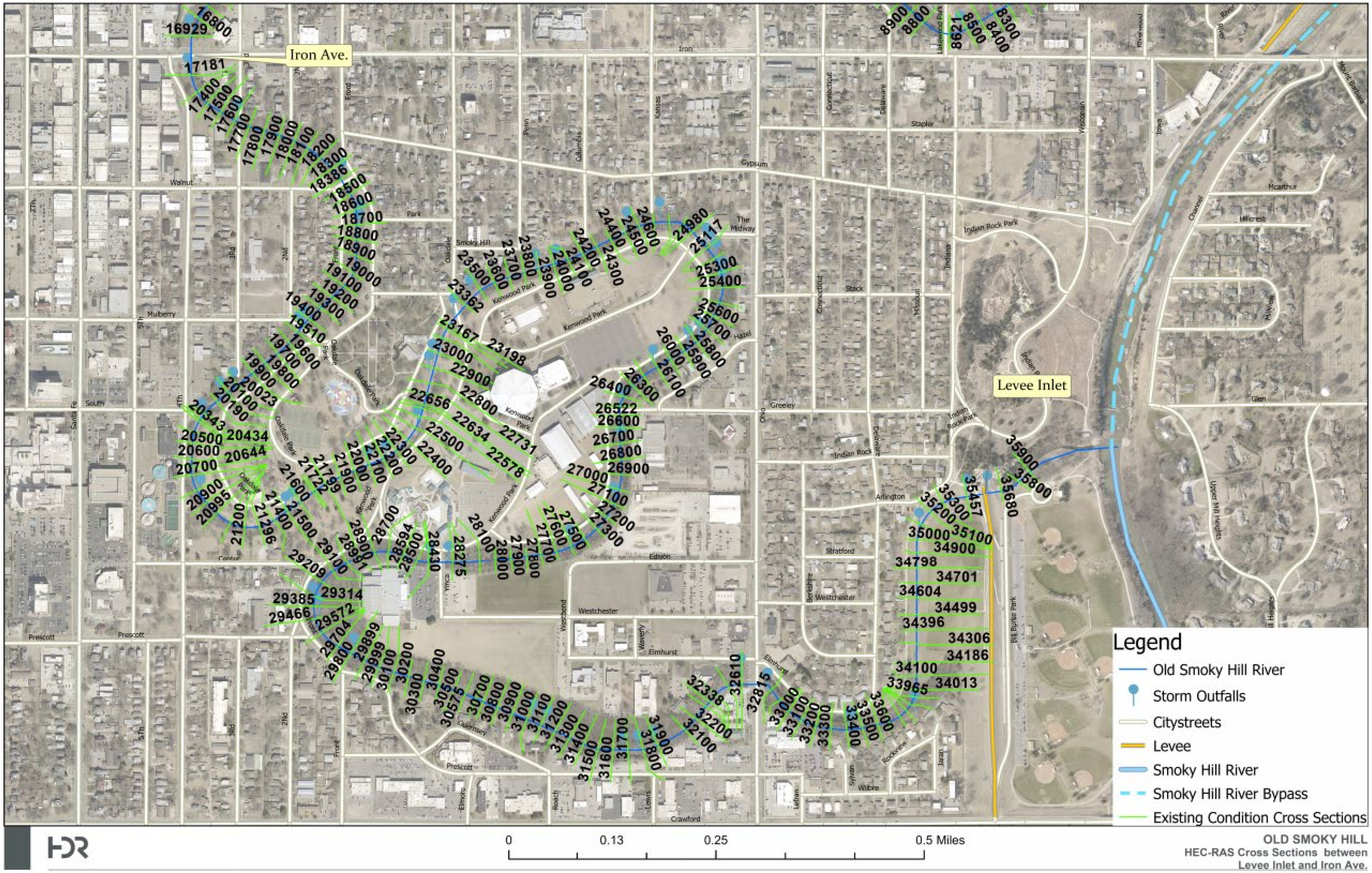


Figure 4-14: Existing Conditions HEC-RAS Cross Sections (Levee Inlet to Iron Ave.)

Figure 4-15: Existing Conditions HEC-RAS Cross Sections (Iron Ave. to Levee Outlet)

4.4.3 Bridge Assumptions

- All bridges are assigned “Pressure and/or Weir” for high flow methods.
- Four bridges have piers: Oakdale (CX 23304), Pedestrian CX 2 (CX 21714), Mulberry (CX 19481), and Lakewood Drive (CX 8647).

  Pier Shape:

  1. Oakdale: Square (4 @ 1.5’ wide)
  2. Pedestrian CX 2: Square (2 @ 1.2’ wide)
  3. Mulberry: Round (2 @ 2.5’ wide)
  4. Indiana Ave.: Round (2 @ 3.5’ wide)
- Low chords were calculated using deck shots minus the deck thickness called out in Kaw Valley Engineering structure notes, Table 4-6 presents the existing condition bridge deck and low chord elevations along with flood stages for the 4%, 2%, and 1% AEPs.

Table 4-6: Existing Conditions Bridge Structure Elevations and Flood Stages for 4%, 2%, and 1% AEPs

Bridge	Low Chord EL, ft.	Deck Thickness, ft.	Deck EL, ft.	4% AEP EL	2% AEP EL	1%AEP EL	Overtopping Storm (AEP)
Greely Ave.	1220.96	2.30	1223.26	1220.78	1221.84	1223.68	1%
Oakdale Ave.	1222.04	1.30	1223.34	1220.29	1221.99	1223.42	1%
Pedestrian Bridge #1	1219.53	0.75	1220.28	1220.22	1221.94	1223.37	2%
Pedestrian Bridge #2	1224.28	1.20	1225.48	1220.12	1221.88	1223.32	<1%
Pedestrian Bridge #3	1219.24	0.75	1219.99	1220.03	1221.83	1223.30	>4%
Mulberry St.	1222.58	1.90	1224.48	1219.96	1221.78	1223.26	<1%
Walnut St.	1217.47	6.00	1223.47	1219.80	1221.67	1223.17	<1%
Lakewood Park Bridge	1216.32	1.20	1217.52	1209.90	1210.81	1212.46	<1%
Indiana Ave.	1213.45	1.90	1215.35	1209.53	1210.72	1212.40	<1%

4.4.4 Lakewood Lake

A storage area is included for Lakewood Lake in addition to a lateral structure between cross sections 4800 and 3800. Currently, the lake is isolated from the channel by a small dike (walking path) with a top elevation of 1206.10. The lake does not have an outlet until the water reaches the top of dike, which is nearly 13 feet higher than the average lake level.

The history of Lakewood Lake, including its development as a sand and gravel pit, ownership changes, its current use as flood storage as well as efforts to mitigate low water levels is detailed in the feasibility study. There are no record design or construction documents for Lakewood Lake but part of the dike (walking trail) was repaired in 2009. The Old Smoky Hill channel overtopped the dike and water flowing from the channel and into the lake eroded a section of the dike.

The Old Smoky Hill River channel flowline is above the existing lake level and, during major flood events, the channel flows will overtop the dike and flow into the lake. The lake functions as an off-line storage facility and was modeled with PCSWMM as part of the FEMA effective model. Within HEC-RAS project model, the dike is modeled as a lateral structure that is connected to a storage area representing Lakewood Lake, refer Figure 4-15 for profile (derived from LiDAR). The lateral structure uses the standard HEC-RAS weir equation with a top width of 10 feet and a weir coefficient of 2.0.

Due to recent heavy rains, the lake was approximately 5 feet deeper than typical during the LiDAR collection, meaning using the LiDAR will underestimate the available storage without adjustment. To account for this, the storage curve from the effective model was compared to the LiDAR and the bottom 4.87 feet of storage from the effective model curve was spliced into the storage curve developed from the LiDAR. Figure 4-16 shows the storage curves from the effective model (orange), LiDAR derived (blue) and adjusted (green). Visual inspection suggests good agreement between the storage curve used in the effective model and that of the adjusted curve derived from the LiDAR.

When the channel depth increases past the lateral weir crest of 1206.10, the flows will pass into Lakewood Lake until the lake and the channel reach equilibrium. As the flow into this reach decreases, the channel flood elevations will begin to drop, and the flow will pass from the lake and back into the channel. Once the lake elevation decreases below the weir crest, no additional outflow from the lake occurs.

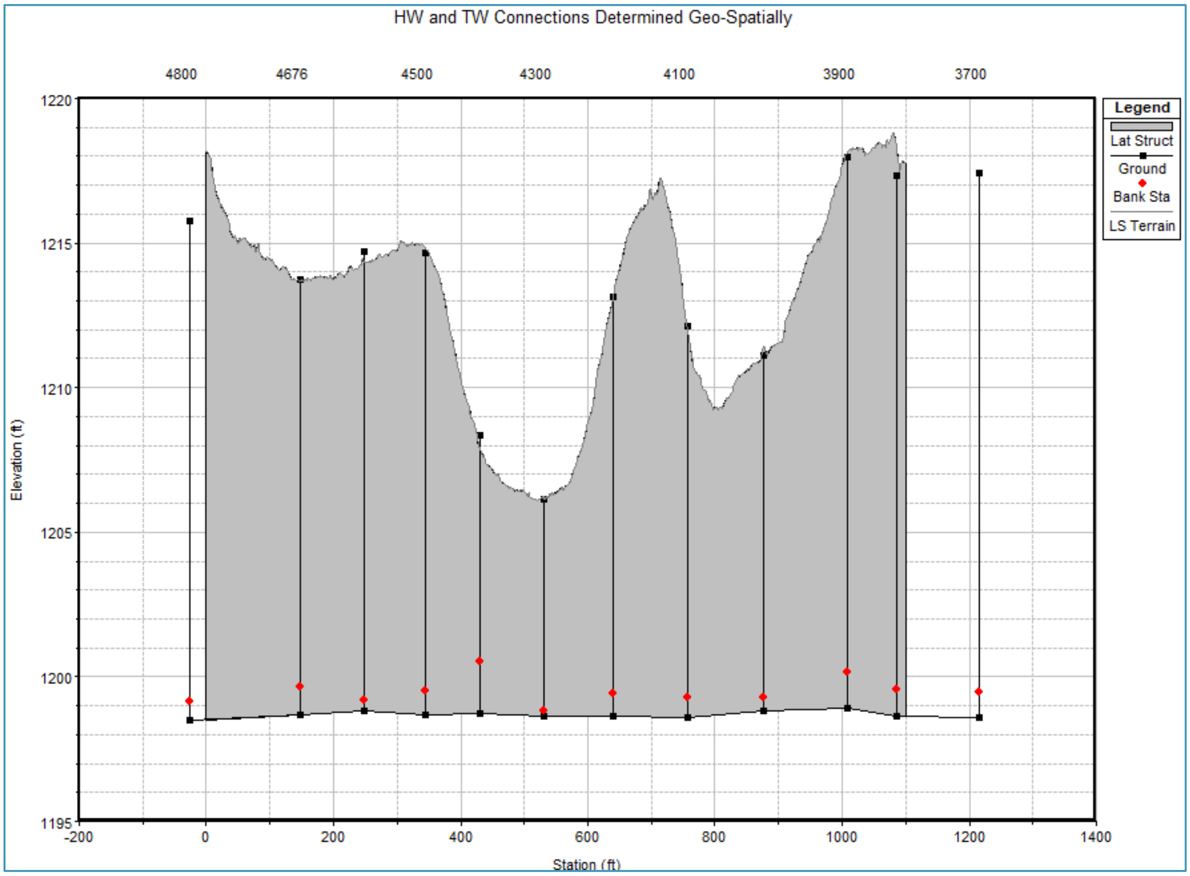


Figure 4-16: Lakewood Lake Lateral Weir Profile

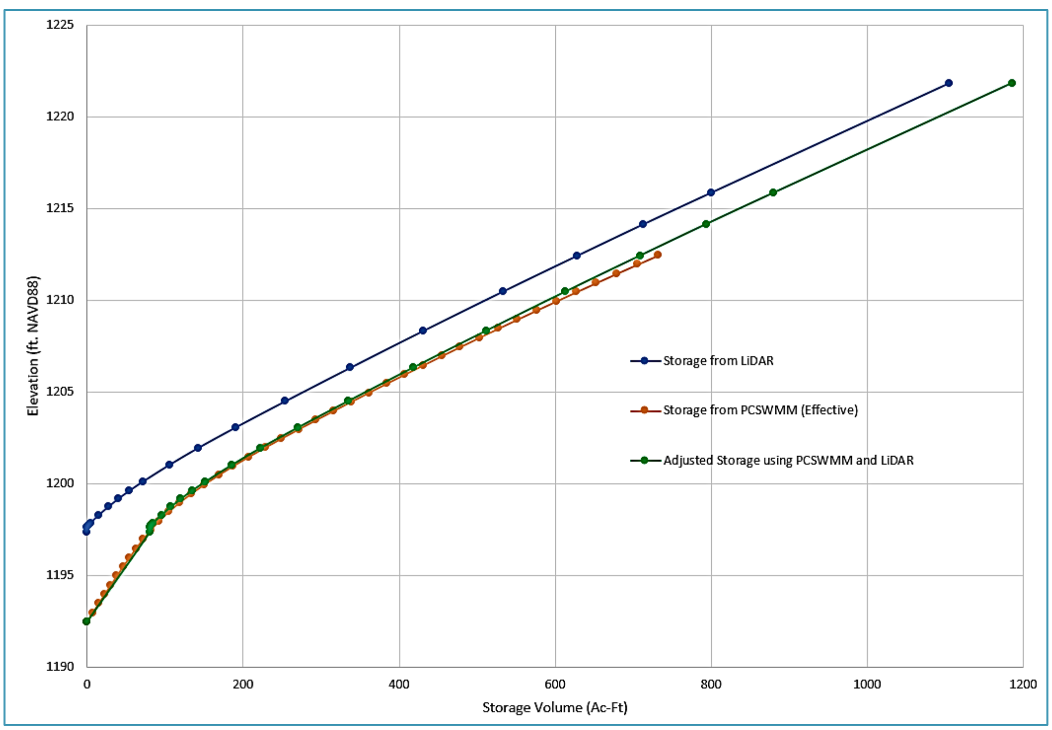


Figure 4-17: Lakewood Lake Storage Area - Volume Curve

4.4.5 S. Ohio St. Crossing

As built records show an 84” CMP is installed at the South Ohio Street roadway crossing. At the time of the field survey, the inlet and outlet could not be found. Based on as-built records the existing 84” CMP has a flow line near 1205.0 however the surrounding channel is nearly 10 feet above that at elevation 1215.0. Reviewing the as-built records, it appears this culvert was purposely placed below a gravity sanitary sewer line and below the channel invert, effectively creating a syphon. The municipal storm sewer pipe within South Ohio Street tee’s into this culvert below ground without a manhole. The connection could not be observed, however the municipal system is able to drain indicating a flow path exists.

When the city opens the upstream levee culvert and water is allowed to pond at the upstream entrance, eventually water will pass through this area and flow to downstream areas. The City indicates it may take days for the flow to progress to downstream areas. It is unclear if the water is progressing downstream through groundwater seepage or through the culvert itself.

To account for the blockage and the municipal stormwater pipes, the FEMA effective model shows a 36” diameter pipe near the channel grades that would allow local stormwater flow to pass underneath S. Ohio St. The FEMA 1% AEP water surface profile is discontinuous with a lower water surface elevation on the upstream side of South Ohio and higher water surface elevation on the downstream side. This is reversed from a normal open flowing culvert. The FEMA effective model shows flow reversal on the upstream side of South Ohio with water flowing backward, out of the levee entrance culvert.

The HEC-RAS project model continues the FEMA effective model routing of the local municipal stormwater system in South Ohio and assumptions on the culvert entrance being blocked. This condition aligns with field observations and City staff descriptions of the system operation. Under all future with-project models, this crossing is replaced and open gravity flow is restored.

4.4.6 Unsteady Flow Data and Parameters

There are 87 total outfalls whose hydrographs are used as inflows into the Old Smoky Hill River channel, 77 of which are storm pipe outlets. A DSS containing all 87 hydrographs was created using output from the modified PCSWMM model. The unsteady flow data is set to read from the DSS before each simulation. The outfall locations were identified by using the City GIS data and the Kaw Valley Engineering field survey. Normal depth with a friction slope of 0.004 is the downstream boundary condition and the levee gates remain open consistent with the updated interior drainage analysis.

Effective peak flows (for 10%, 4%, 2%, and 1% AEPs) published in the FIS # 20169V000A are presented in Table 4-7 for the Old Smoky Hill River. Similarly, peak flows for the same locations but from the project model (HEC-RAS) are presented in Table 4-8 along with the calculated departure between the project model (HEC-RAS) and the published values. Comparisons of the effective FEMA WSEL (1% FIS), the WSEL (1% Existing) computed as part of this study for the existing conditions, and the

WSEL (1% Future without Project (FWOP)) is shown in Figure 4-17 and Figure 4-18. The following results are based on the original FWOP definition described in section 4.5.1. The updated FWOP description is included in Appendix A2.

Table 4-7: Published Old Smoky Hill River Flows from FIS #20169CV000A (April 18, 2018)

Location	Drainage Area (Square Miles)	10% AEP Flow, cfs	4% AEP, cfs	2% AEP, cfs	1% AEP, cfs
At Levee - CS 0+00	-	NA	NA	NA	NA
S Ohio St	0.42	90	90	110	130
At YMCA	1.6	380	530	630	910
At Midway Avenue	1.8	410	540	610	840
At Walnut Street	2.5	660	740	750	770
At Iron Avenue	2.6	800	900	970	1,020
At Elm Street	2.9	690	750	790	820
At Ohio Street & Riverside Drive	3.6	740	860	920	1,010
At Indiana Avenue	3.8	810	980	1,090	1,240
Outlet At Levee CS 685+50	4.6	330	320	370	410

Table 4-8: Project Model (HEC-RAS) Existing Condition Flows and Flow Differences (Project - Effective)

Location	Drainage Area (Square Miles)	10% AEP, cfs	4% AEP, cfs	2% AEP, cfs	1% AEP, cfs
At Levee - CS 0+00	Peak Flow	-152	-166	-170	-159
	Flow Difference (Project-Effective)	-	-	-	-
S. Ohio St. (0.42 SQMI)	Peak Flow	-59	-59	-53	-38
	Flow Difference (Project-Effective)	-149	-149	-163	-168
At YMCA (1.6 SQMI)	Peak Flow	602	808	948	1,119
	Flow Difference (Project-Effective)	+222	+278	+318	+209
At Midway Avenue (1.8 SQMI)	Peak Flow	588	826	976	1,101
	Flow Difference (Project-Effective)	+178	+286	+366	+261
At Walnut Street (2.5 SQMI)	Peak Flow	692	871	952	1,013
	Flow Difference (Project-Effective)	+32	+131	+202	+243
At Iron Avenue (2.6 SQMI)	Peak Flow	742	895	976	1,036
	Flow Difference (Project-Effective)	-+58	-+5	+6	+16
At Elm Street (2.9 SQMI)	Peak Flow	764	917	999	1,059
	Flow Difference (Project-Effective)	+74	+167	+209	+239
At Ohio Street & Riverside Drive (3.6 SQMI)	Peak Flow	882	1,058	1,165	1,250
	Flow Difference (Project-Effective)	+142	+198	+245	+240
At Indiana Avenue (3.8 SQMI)	Peak Flow	944	1,105	1,222	1,371
	Flow Difference (Project-Effective)	+134	+125	+132	+131
Outlet At Levee CS 685+50 (4.6 SQMI)	Peak Flow	302	418	509	581
	Flow Difference (Project-Effective)	-28	+98	+139	+171

Figure 4-18 presents a graphical comparison of the published FIS and project model 1% AEP flows.

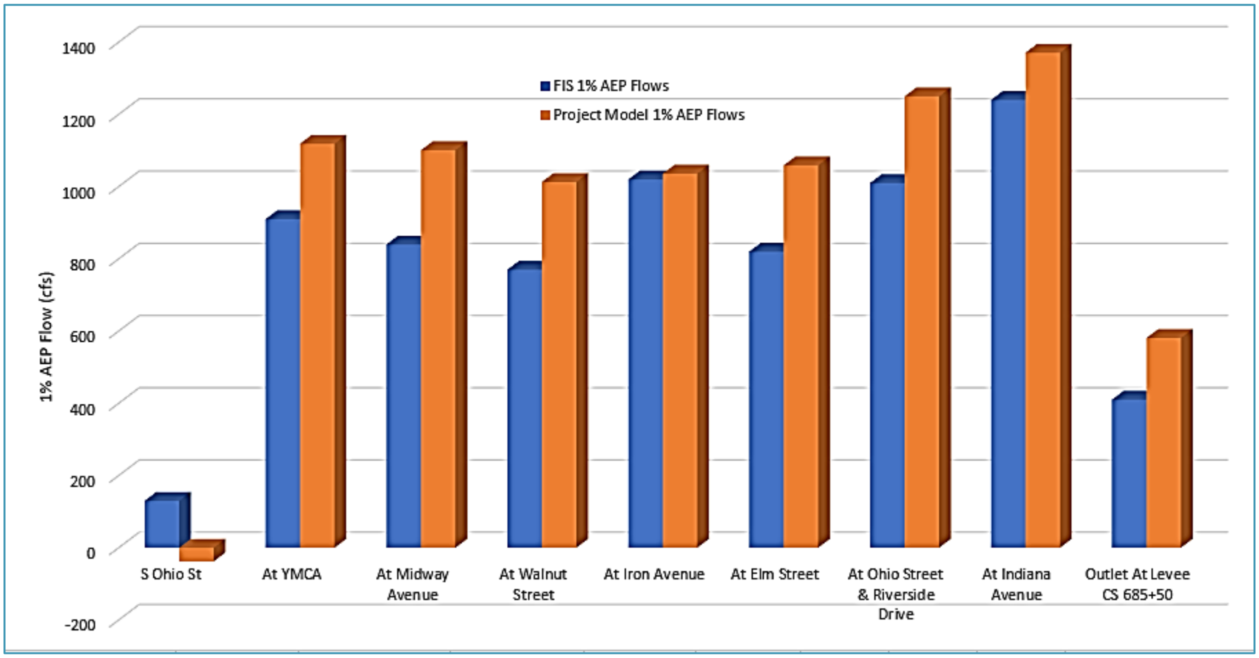


Figure 4-18: Published FIS and Project Existing Conditions Model 1% AEP Flow Comparison

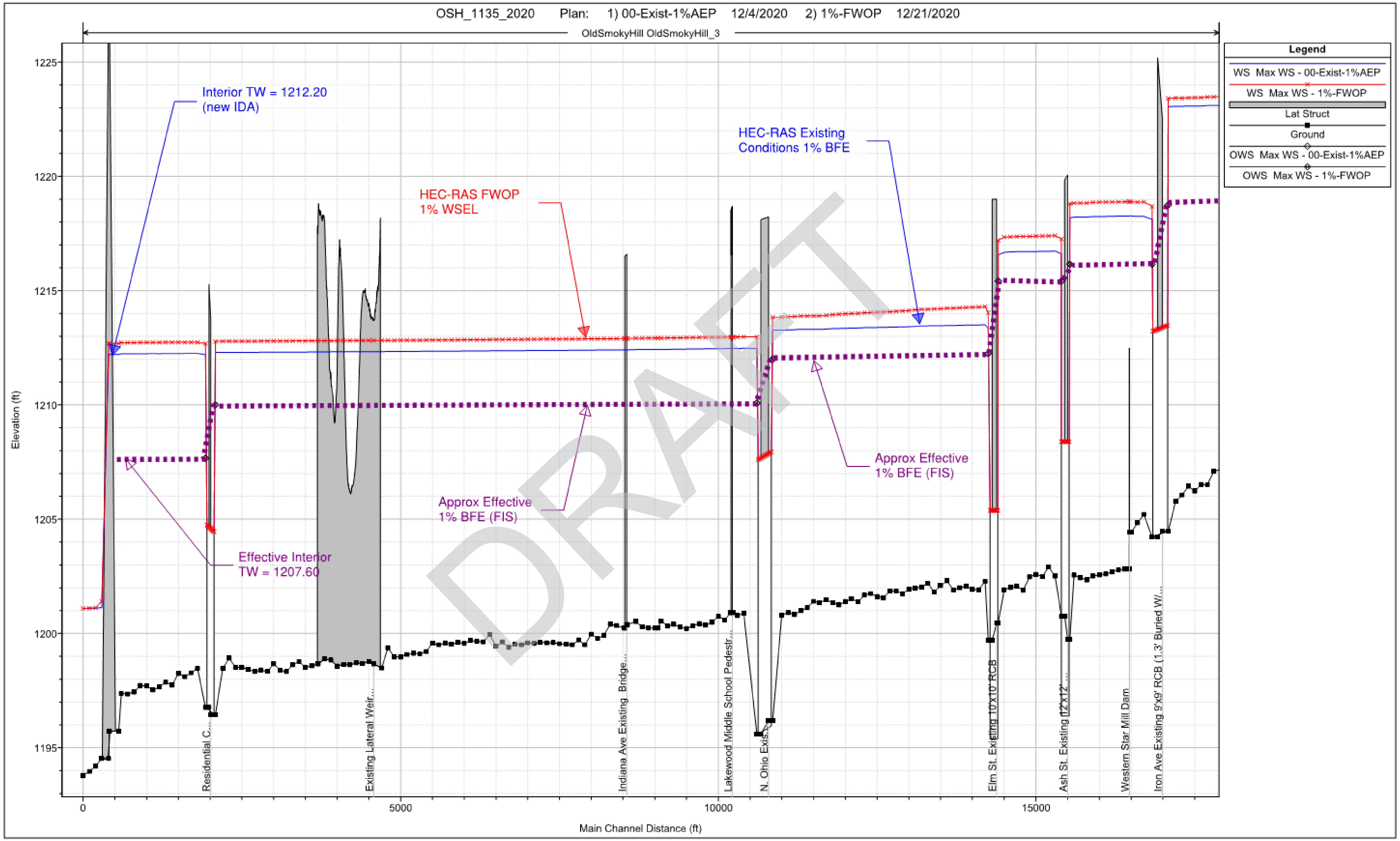


Figure 4-19: Existing Conditions 1% BFE compared to FIS (Ohio Street to The Midway).

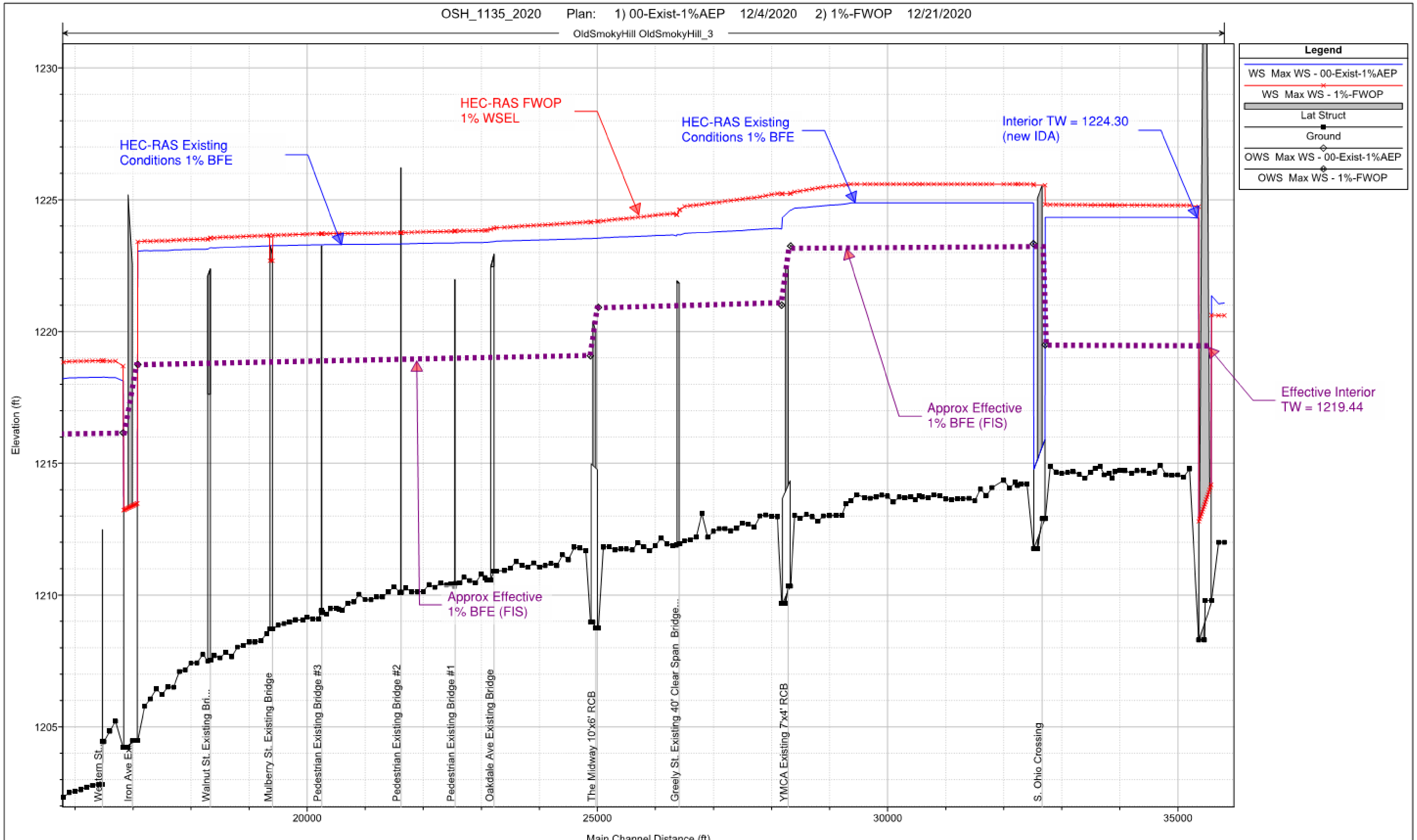


Figure 4-20: Existing Conditions 1% BFE compared to FIS (The Midway to Smoky Hill River).

The HEC-RAS existing condition project model 1% BFE is higher than the effective 1% BFE (FIS #20169CV000A April 18, 2018) throughout the entire Old Smoky Hill River Channel Reach. There are many factors that play a part in the increased water surface elevations but the most notable changes spur from the corrected interior drainage analysis that increased the boundary conditions on the entrance and exit levee by over four feet and the changes to the rainfall depths (KDOT depths to NOAA Atlas 14) and distributions (SCS Type II to Symmetric, refer Table 4-3 and Figure 4-4). The changes to the rainfall in combination with the updated IDA have a significant impact on the starting water surface elevations that translates into higher elevations throughout the reach.

In addition to the increase in rainfall depth higher runoff rates were calculated. A more detailed surficial soils map was available from the NRCS that covered the interior drainage area. The more detailed map showed a higher presence of C and D soils (poor draining) which decrease the infiltration and increased the volume of runoff. The effective model used 2013 land use map whereas the project model used the 2016 land use for percent impervious within the interior drainage. The percent impervious slightly increased. The increase in runoff volume from changes in the infiltration and land cover change was minor and found not to be a major reason for flow differences.

Some other differences between the models that may contribute to variances in the computed water surface elevations include:

1. The FEMA effective model typically utilized one cross section to represent a reach. A reach was typically defined between roadway crossings. The project HEC-RAS model has a detailed cross section every 200 feet. The increased density of cross sections improves the hydraulic computations as it captures more channel dynamics. In comparing channel storage volumes, the FEMA Effective model single cross section per reach appears to have slightly overrepresented available in channel storage volume.
2. The FEMA effective model channel Manning’s n value (typically 0.02-0.045) spanned from top of bank to top of bank. Field and aerial observations show heavily vegetated banks and side slopes validating a higher Manning’s n inside the top of banks is necessary. The project model uses a higher Manning’s n value which is more repetitive of field conditions but also results in higher stages.
3. A larger head loss is observed at Iron Street in the HEC-RAS model when compared to the effective model (refer to Figure 4-19). The culvert geometry, roughness, and loss coefficients are similar between the two models but Western Star Mill Weir (located just downstream of the model) is not included in the FEMA effective model. Western Star Mill Weir is approximately 8 feet tall and 10 feet tall on the upstream and downstream sides, respectively. It will have more of an impact on lower flood stages but may account for some of the additional head loss seen at the Iron Avenue 9x9 RCB culvert.

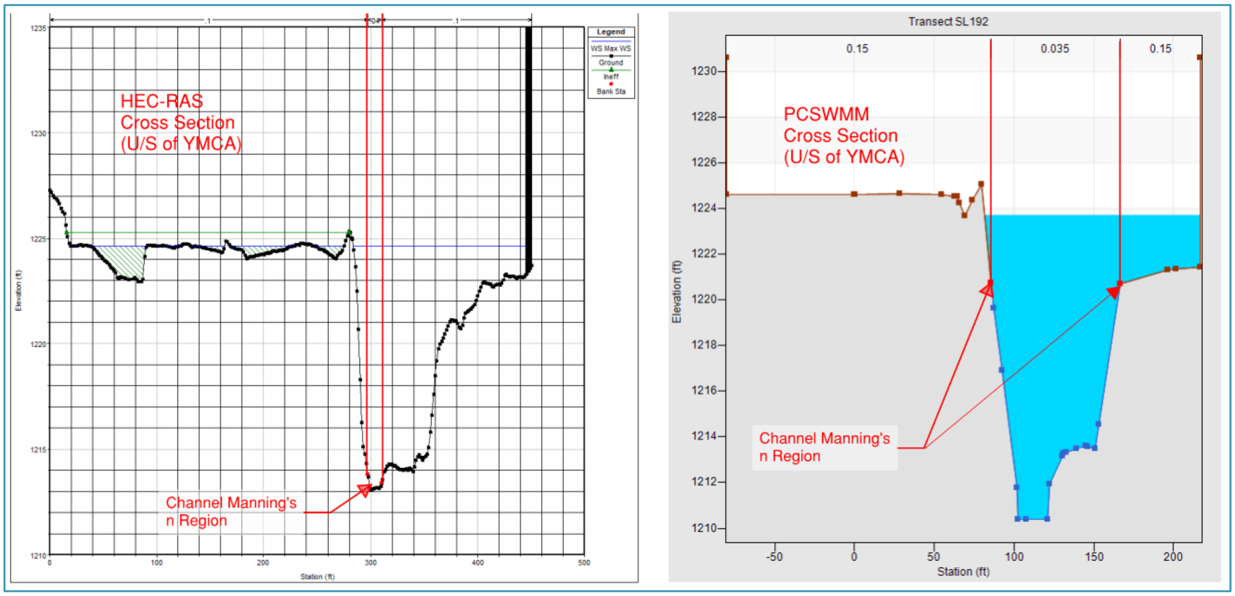


Figure 4-21: Cross Section Comparison between SWMM and HEC-RAS Upstream of YMCA

The difference in the modeled 1% BFE is likely explained by the multitude of model differences described above. The project model utilizes newer information including survey, rainfall, land use, vegetation conditions and watershed soils. The project model also utilizes a more refined watershed sub-divided model that aligns to the existing outfalls into the system. Further, moving hydraulic modeling platform from PCSWMM over to unsteady HEC-RAS allows for the implicit solutions of bridge hydraulics.

4.4.7 Existing Conditions Project Model Interpretation

Results from this analysis generally show higher flows and water surface elevations throughout the Old Smoky Hill River when comparing it to the published values. As previously mentioned, the purpose for converting the hydraulic model over to HEC-RAS is it is better suited to meet the USACE ecosystem modeling requirements.

The Flood Rate Insurance Maps (FIRM) #20169C0229C, #20169C0228C, #20169C0226C, and #20169C0227C generally show the 1% AEP BFE within the channel banks or in the non-developed fringes (not including urban flooding near the residential and downtown areas), refer to Figure 4-20 for a screenshot of the referenced FIRMs.

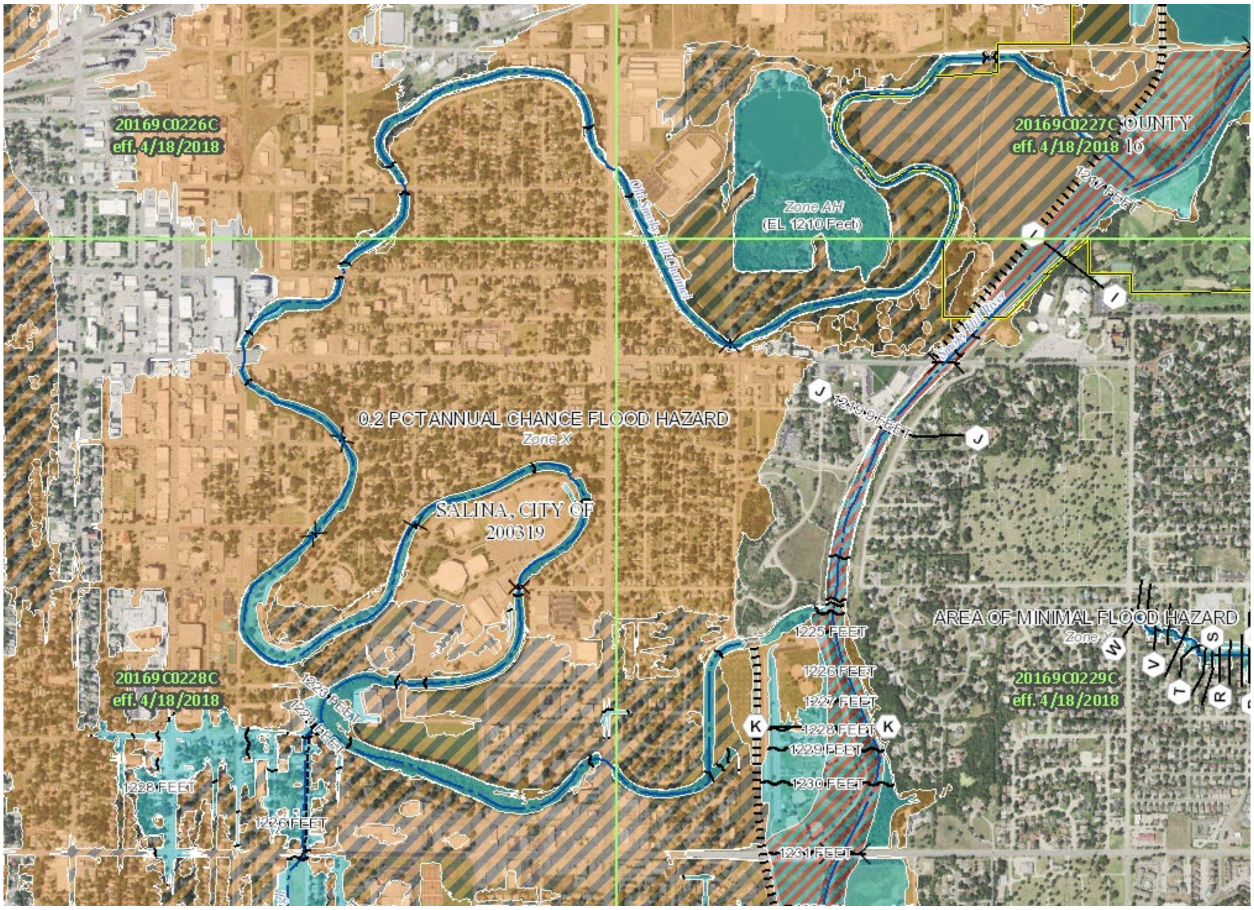


Figure 4-22: Screenshot of Old Smoky Hill River Flood Insurance Rate Map (FIRM)

Figure 4-21 compares the effective1% AEP inundation boundary and the 1% AEP inundation boundary mapped from the existing conditions model. As anticipated from the profiles, the results from the existing conditions project model show more inundation areas than the FEMA effective floodplain limits. The higher predicted 1% AEP stage for existing conditions are attributable to better available data and more detailed modeling as discussed in the prior section. Some areas that are impacted:

- Residential and businesses up and downstream of South Ohio Street
- YMCA crossing and Kenwood Park Road
- Overtopping at The Midway crossing
- Areas near the event center
- Increased flooding in right over bank in Oakdale Park
- Residential and businesses between Oakdale Park and Iron Avenue

Like the effective mapping, the 1% AEP is mostly contained within the channel banks downstream of Iron Avenue and no notable flooding increases are evident. In general, the existing conditions model doesn't suggest major flooding issues until the 0.2% AEP and less frequent events.

The velocities throughout the channel are generally slow (1-3 fps) through the channel for all the events included in the analysis. The main reason for this is due to the undersized culverts that act as a bottleneck, backing up, slowing down, and detaining the flow. Similarly, shear stresses are low suggesting a reasonably stable environment where minimal erosion is anticipated. Most of the existing banks and channel bottom have well established vegetative cover with mature trees. Channel stability will be examined in more detail for the selected alternative to check for instabilities resulting from the improvements.

4.5 Future Conditions with and without Project

4.5.1 Future Land Use and Channel Conditions

The City of Salina developed a Comprehensive Plan that was adopted by the City Commission in 2010. The proposed zoning and land use developed as a part of the Comprehensive Plan was analyzed for this project to check if the future land use would raise the percent impervious within the contributing drainage areas.

Figure 5-1 shows the future land use GIS shapefile and the contributing drainage areas. After close examination, it was determined the contributing drainage area is already developed and the future zoning does not change either the percent impervious or the curve number. Therefore, the existing conditions percent impervious and curve numbers are used in all future conditions' scenarios.

The future without project (FWOP) definition in this Appendix A1 was created prior to additional bridge and levee outlet culvert updates included with the RAISE Grant that is being pursued by the City of Salina. The updated FWOP conditions are assessed in Appendix A2 - Section 2.1. The following results in this Appendix A1 use an outdated definition as defined in the following paragraph. We considered the comparison between alternatives utilizing the FWOP conditions, as described below, to be a fair comparison to inform the tentatively selected plan (TSP). The FWOP is refined in Appendix A2 with additional information to further inform the impacts associated with the TSP.

For the original FWOP condition, it is assumed the channel will remain in its current vegetative state, have no sustained base flow, but the blockage at South Ohio Street roadway crossing will be removed and the culvert replaced with a larger structure. The FWOP applies the average annual deposition depths established for each reach in the Sediment Transport Analysis (also part of this project). The average annual depths were forecasted out 50 years and the calculated 50-year depths were applied to the cross sections using the fixed sediment elevation tool in HEC-RAS. The average increase in 1% WSEL is approximately 0.5 feet with a maximum increase of 1.33 feet.

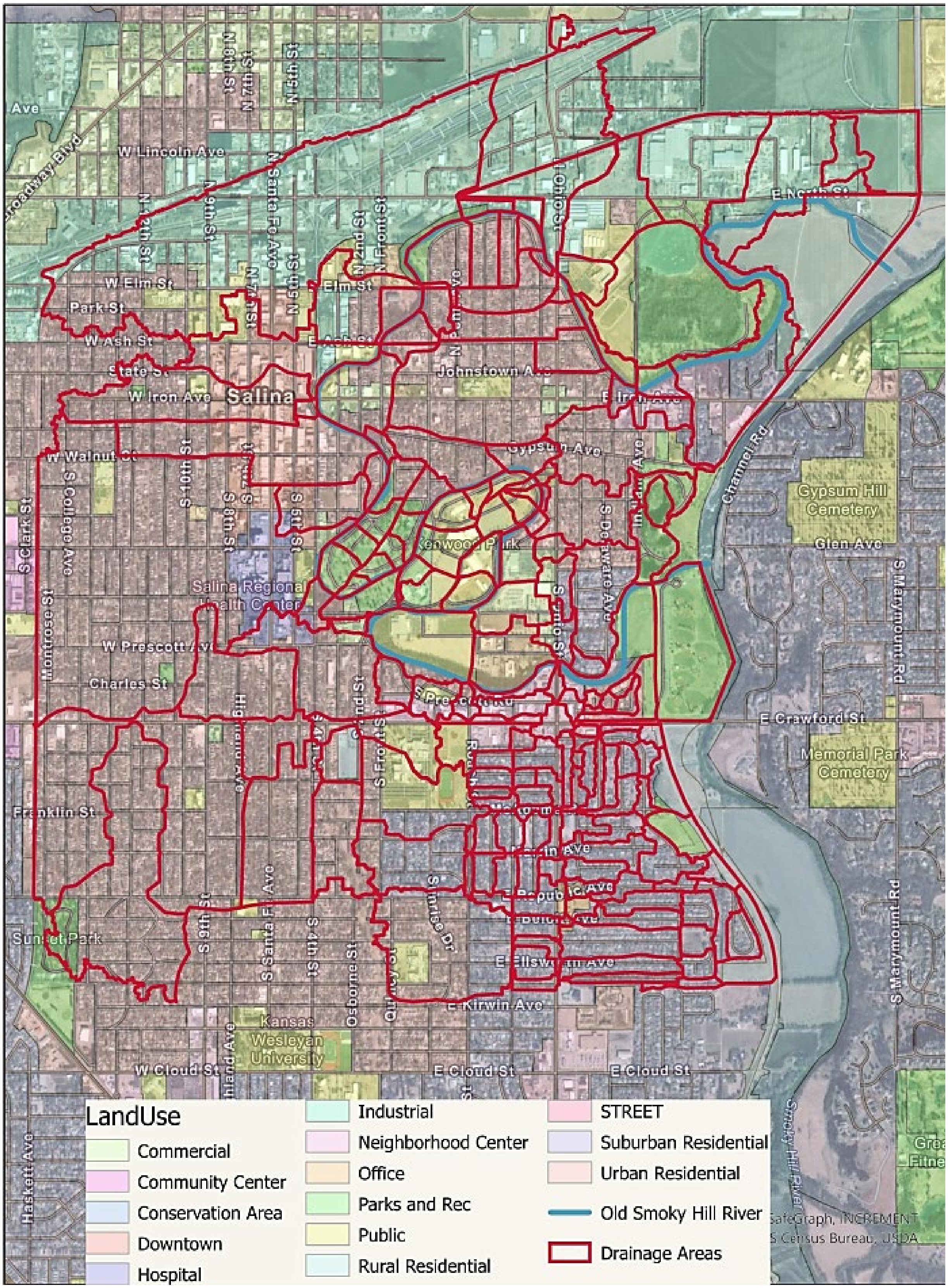


Figure 5-23: Future Land Use Exhibit and Contributing Drainage Areas Exhibit

4.5.2 Future Conditions with Project: Sponsor Constructed Features

The Salina Master Plan referenced earlier includes adding shared use paths, boardwalks, plazas, boat/kayak launches, and replacing undersized culverts with bridges (or adequately sized culverts). However, the Master Plan will be built in phases depending in part on grant funding timing. The primary goal identified in the Master Plan is to restore base flow. The City has adequate funding and will be self-performing the following features to support the ecosystem goals:

The FWP definition in this Appendix A1 was created prior to the bridge and levee outlet culvert updates included with the RAISE Grant. The following results in this Appendix A1 use the outdated definition and provide a fair comparison between alternatives. The updated sponsor constructed features are assesed for the TSP in Appendix A2 – Section 2.1.2 and 2.1.7.

- Securing remaining rights of way and easements. Approximately, 70% of the Old Smoky River channel is currently within City owned rights of way.
- Replacing the buried 84” CMP at S. Ohio St. with a low flow 7’x8’ RCB and a 12’x8’ RCB. The 12’x8’ RCB will carry floodwater and will also function as a pedestrian underpass. Work at this location includes installing new sanitary sewer pump station to eliminate the previous stormwater syphon and replacing other associated utilities.
- Construction of a 12’x8’ RCB under North Ohio. This culvert will mitigate induced flooding from Lakewood Lake backwater and also serve as a bike trail underpass.
- Construction of a pedestrian bridge on the existing trail at Lakewood Lake. The pedestrian bridge will allow Lakewood Lake to be connected to the channel and maintain the perimeter pedestrian path.

All future conditions with project scenarios use the above-mentioned sponsor improvements that are expected to be completed prior to construction of the ecosystem restoration project. It is anticipated as grant funds are received, the sponsor constructed features will be incorporated into hydrology and hydraulics sequencing plan. Figure 5-2 presents a reach keymap that shows the South Reach (between entrance levee and Iron Ave) and the North Reach (between Iron Ave and levee exit) which are applicable to all alternatives.

Figure 5-24: Alternative Reach Keymap

4.5.3 Future Conditions with Project: Alternative A1

Alternative A1 was not selected as the TSP.

As discussed in the feasibility study, restoring base flow to the Old Smoky Hill River channel is limited to the city's acquired surface water rights (Water Appropriation #47,510). The warm season (May-Sept) baseflow of 80 cfs is anticipated with 10 cfs in the cold season (Oct-April). The allowable diversion rate is 100 cfs and under all seasons, 30 cfs must remain in the Smoky Hill River after diverting baseflow to the Old Smoky Hill River channel (i.e. there must be at least 110 cfs in the river pre-diversion to divert 80 cfs). The base flow rates are common to all alternatives evaluated.

The base flow is desired to flow by gravity (no pumps) which limits the available hydraulic gradient through the project reach and also necessitates sediment removal to restore an adequate channel profile. The upstream boundary condition is the Smoky Hill River water surface elevation at the diversion, which is on the upstream side of the scour key. With the Smoky Hill River at the minimum regulatory flow of 30 cfs, the water surface on the upstream side of the scour key is 1215.6 ft. This elevation is used on all alternatives as the upstream water surface boundary condition and sets the available hydraulic head for base flow conditions.

Alternative A1 description, program elements and ecosystem benefits are discussed in the feasibility report and this evaluation focuses on the hydrology and hydraulic performance of each alternative. Alternative A1 is designed as a minimalistic (lowest cost) approach to re-introduce baseflow and was presented as a temporary solution in the Master Plan as a pilot channel. Alternative A1 considers reintroducing baseflow via an excavated water supply channel between the entrance levee and Mulberry Street, see Figure 5-3 (South Reach) and Figure 5-4 (North Reach). The profile was chosen to tie into existing culvert flow lines, and the new culvert at South Ohio Street. The proposed excavated channel daylights at Mulberry Street. The existing channel downstream of Mulberry Street has adequate capacity to convey the flows through the remaining downstream reach and out the existing culvert at the levee exit. The existing Western Star Mill weir is a stream obstruction and would be replaced with step pools. The upper most step pool would match the existing Western Star Mill weir elevation (1212.5). The proposed channel and water surface profiles are shown in Figure 5-5.

The water supply channel cross section is an excavated trapezoid with a 5-foot bottom and 3:1 sides that daylights within the existing channel bottom. Figure 5-6 presents a typical cross section for this alternative and since the excavation depth varies, the top width also varies from 30 feet to 50 feet wide as shown in Figures 5-3 and 5-4.

The reestablished baseflow provides a reliable water source to over 6 miles of the Old Smoky Hill River channel and an interconnect with Lakewood Lake. The interconnection would restore the lake to its historic elevation and also provide a deep-water refuge for aquatic species. The habitat gains are presented in the feasibility study and are quantified in the habitat modeling. Preliminary estimates show the volume of excavation to be around 42,500 CY which is the least of all alternatives considered.

Gates and a sedimentation pond are proposed on the wet side of the levee entrance and the hydraulic loss is included in the HEC-RAS model. The required hydraulic head at the entrance works for 80 cfs for this alternative is 1216.7 which is 1.1 ft. higher than the target, meaning 80 cfs would only be diverted when the Smoky Hill River has flows in excess of 500 cfs. The diverted baseflow would be around 55 cfs when the Smoky Hill River is flowing at 110 cfs (minimum river flow for allowed 80 cfs diversion). Alternative 1 reintroduces baseflow into the Old Smoky Hill River but does not have the full hydraulic capacity to meet the desired goals of the Master Plan.

The dredged material (roughly 42,500 CY) would be placed to create wetlands at the historic elevation of Lakewood Lake. This alternative would reconnect the channel to Lakewood Lake, which is currently separated by a dike except during extreme flood events. A portion of the dike would be removed allowing water to equalize between the channel and lake. To support the wetland creation, a grade control structure is proposed downstream of Lakewood Lake and upstream of the residential driveway crossing (refer Figure 5-4). Restoring the lake to its historic elevation results in a loss of temporary stormwater storage (detention). During a 1% AEP, this results in a higher tail water condition for the upstream culverts and could impact private property. To avoid induced flooding, a 12-foot x 8-foot RCB is proposed at North Ohio Street. This culvert will also function as a pedestrian underpass under dry weather conditions.

Figure 5-25: Alternative A1 Reach 1 Plan View

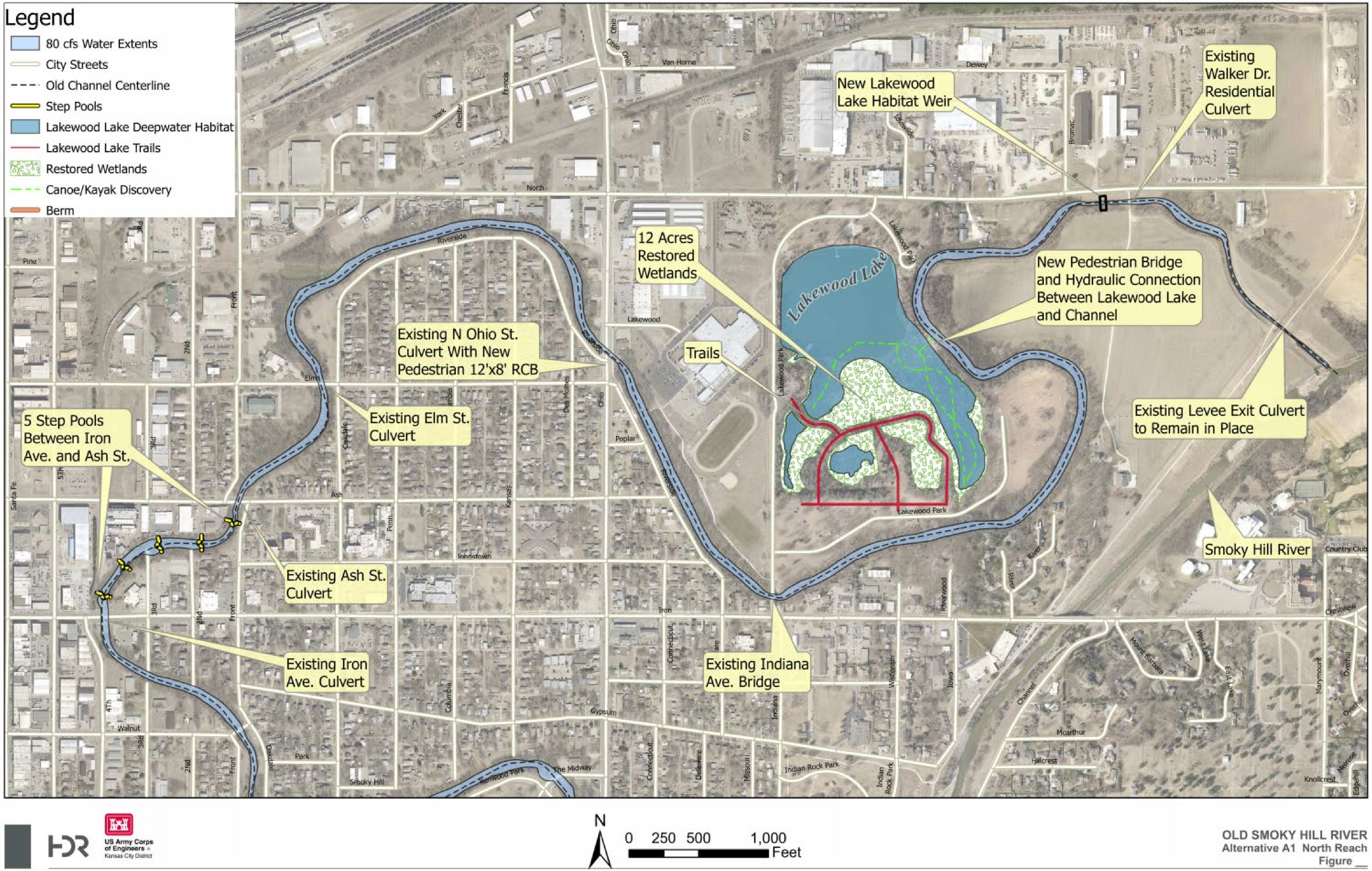


Figure 5-26: Alternative A1 Reach 2 Plan View

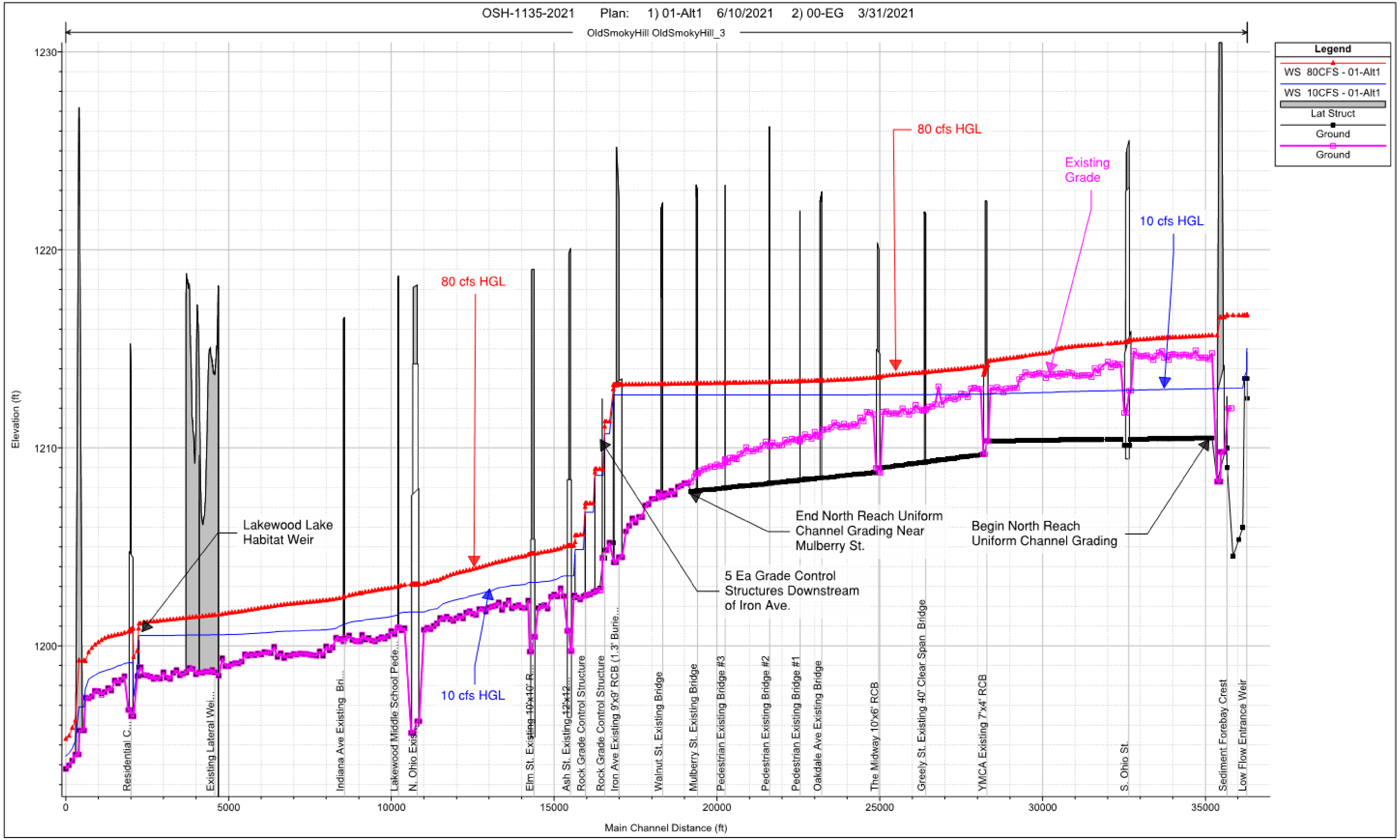


Figure 5-27: Alternative A1 Hydraulic Profile for 10 and 80 cfs

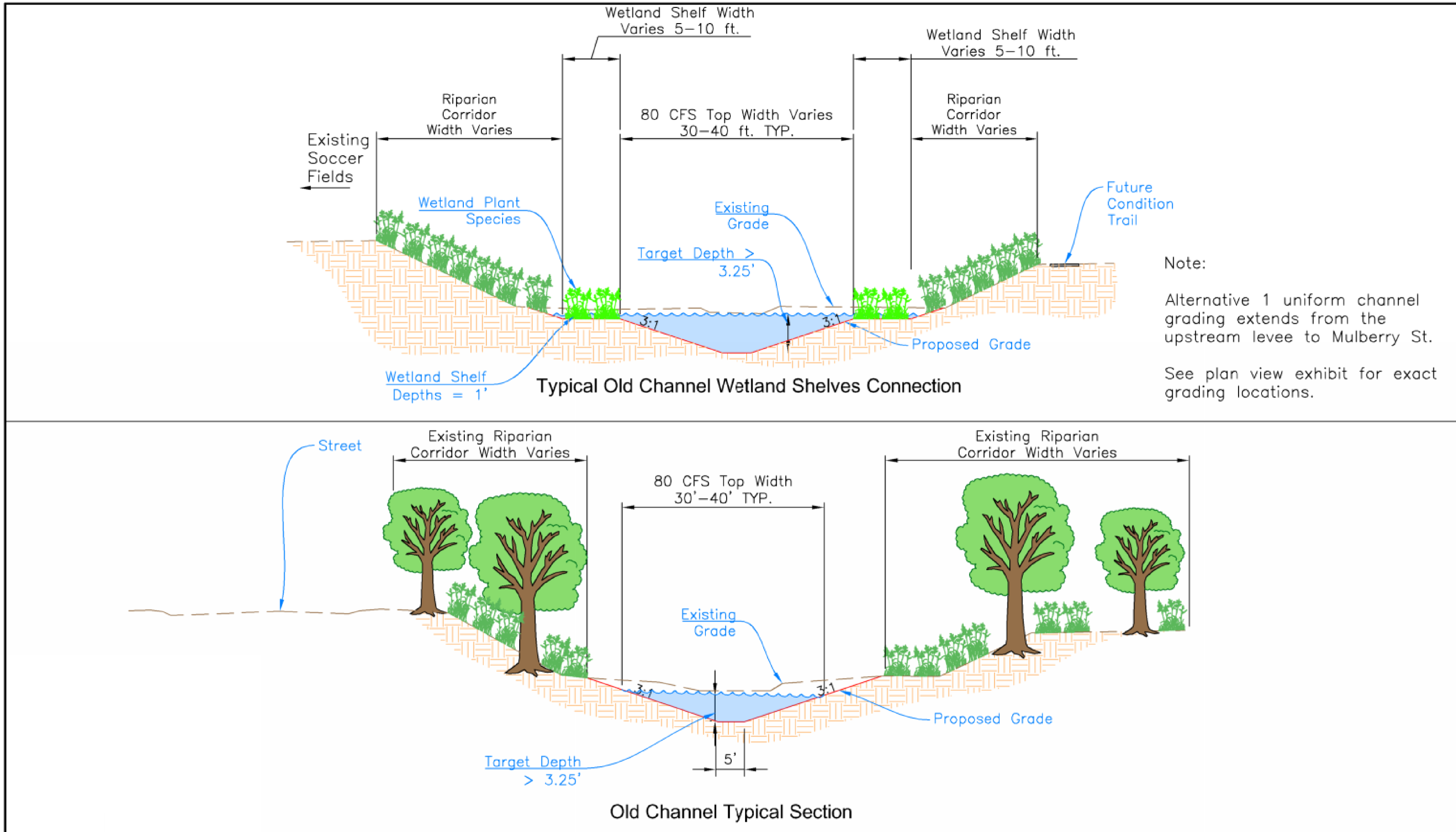


Figure 5-28: Alternative A1 Typical Sections

4.5.4 Future Conditions with Project: Alternative A2

Alternative A2 was not selected as the TSP.

Alternative A2 considers pool and riffles sections between the upstream levee to a location just downstream of Oakdale Avenue in Kenwood Park. Figure 5-7 (South Reach) and Figure 5-8 (North Reach) presents the plan view extents for the Alternative A2 improvements.

See Figure 5-9 for the 10 and 80 cfs Alternative A2 profiles and see Figure 5-10 and Figure 5-11 for the typical riffle and pool sections. The pool inverts were set and held constant to 1208.3 which matches the entrance levee culvert outlet which is also what is thought to be the historic channel elevations. There are glides and runs in between the pools and riffles and are set on a slightly steeper slope than the riffle to riffle slope.

Since the base flow functions by gravity, the channel sizing must accommodate the hydraulic grade line to convey the full 80 cfs base flow without exceeding 1215.4 feet at the upstream end. To achieve this, the riffles had to be roughly 3.25-feet deep on average. Shallower riffles would cause the interior WSEL to be higher than the exterior resulting in an ineffective system.

The hydraulically calculated riffle depth and the pool depth based on matching the upstream culvert was cross evaluated for typical natural channel riffle to pool depth ratios. A dissertation, *Geomorphic Equations and Methods for Natural Channel Design (Shelley 2012),* developed an equation (Equation 1) to estimate the pool depth as a function of riffle depth from using 123 reference reaches in Kansas:

Equation 1: Pool depth as a function of riffle depth:

$$y_{pool} = 1.086 y_{riffle} + 1.249$$

Using a riffle depth of 3.25 feet, a pool depth of 4.8 feet is calculated. The 95% confidence limits indicate the pool depths would range from 3.8 feet – 5.8 feet for natural stable channels in this part of Kansas. The average pool depths as proposed for Alternative A2 average 5.5 feet, placing them on the deeper side but within the 95% confidence limits. Figure 5-10 and Figure 5-11 present Alternative A2 typical sections.

The dredged material (roughly 62,500 CY) would be placed to create wetlands at the historic elevation of Lakewood Lake. This alternative would reconnect the channel to Lakewood Lake, which is currently separated by a dike except during extreme flood events. A portion of the dike would be removed allowing water to equalize between the channel and lake. To support the wetland creation, a grade control structure is proposed downstream of Lakewood Lake and upstream of the residential driveway crossing (refer Figure 5-4). Restoring the lake to its historic elevation results in a loss of temporary stormwater storage (detention). During a 1% AEP, this results in a higher tail water condition for the upstream culverts and could impact private property. To avoid induced flooding, a 12-foot x 8-foot RCB is proposed at North Ohio Street. This culvert will also function as a pedestrian underpass under dry weather conditions.

Alternative A2 provides additional (compared to Alternative A1) aquatic ecosystem restoration and habitat by introducing the pool and riffles. In addition, it has increased hydraulic performance at the entrance, conveying higher baseflows than Alternative A1.

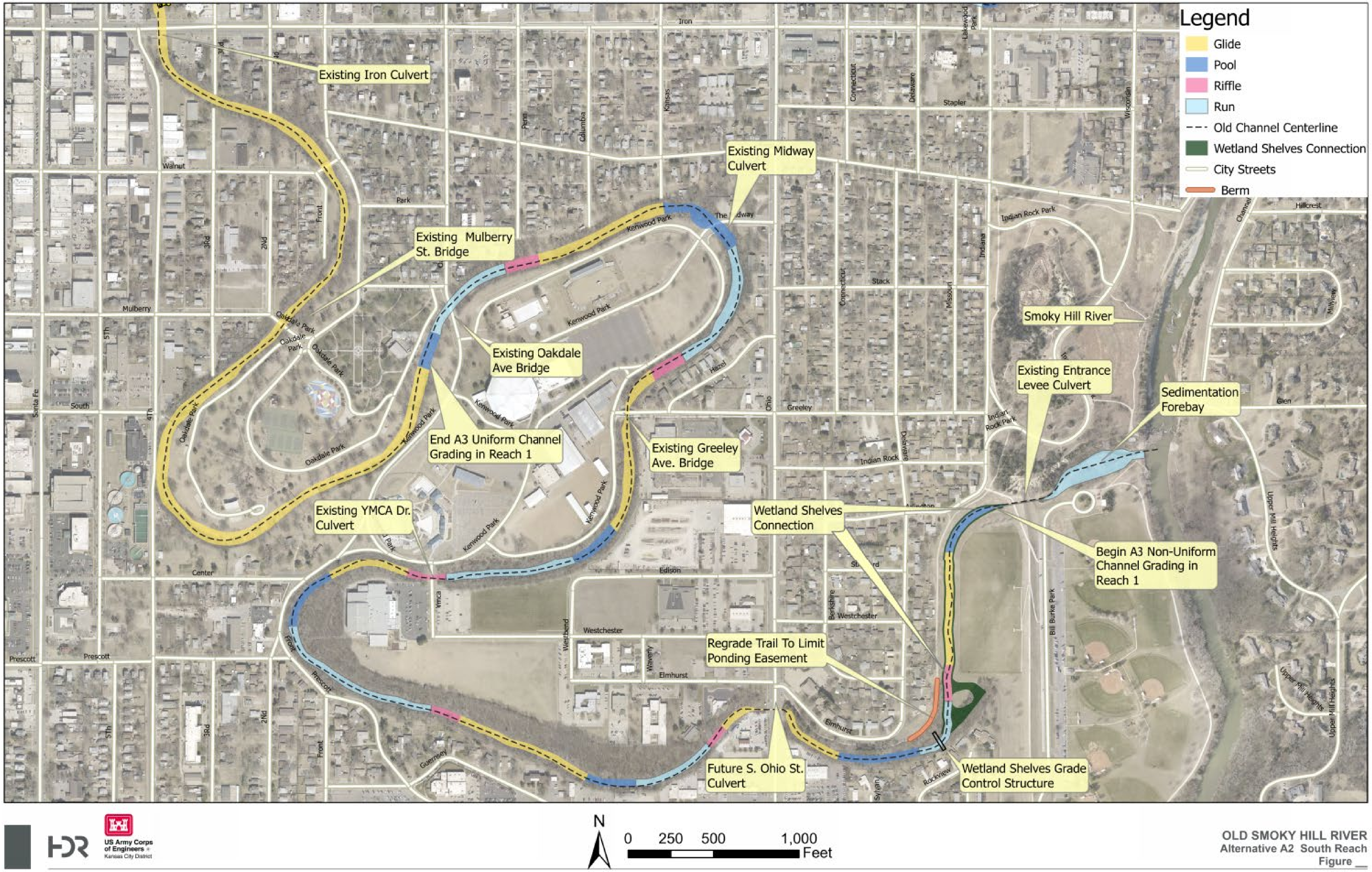


Figure 5-29: Alternative A2 Improvements Plan View (Reach 1)

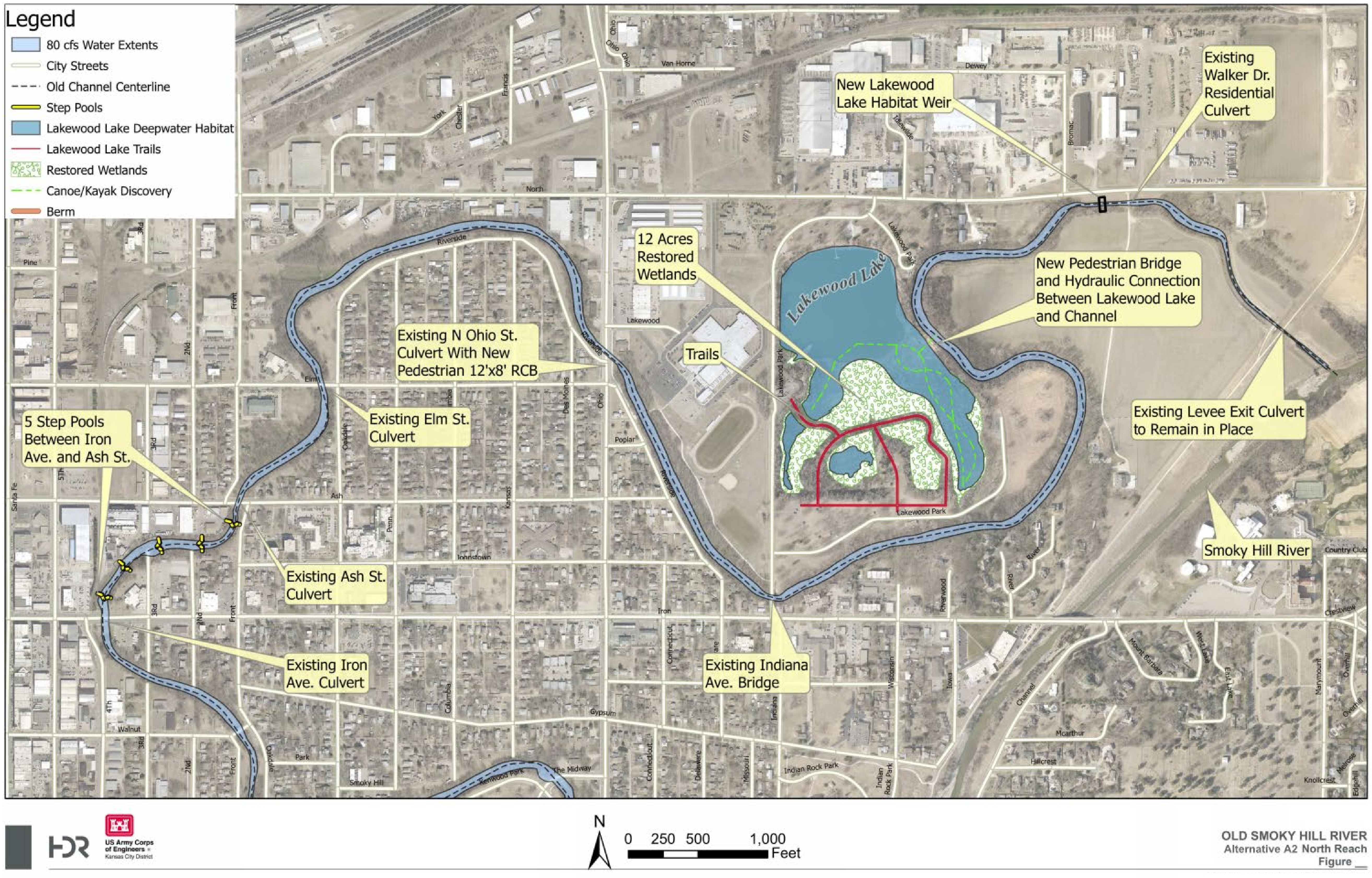


Figure 5-30: Alternative A2 Improvements Plan View (Reach 2)

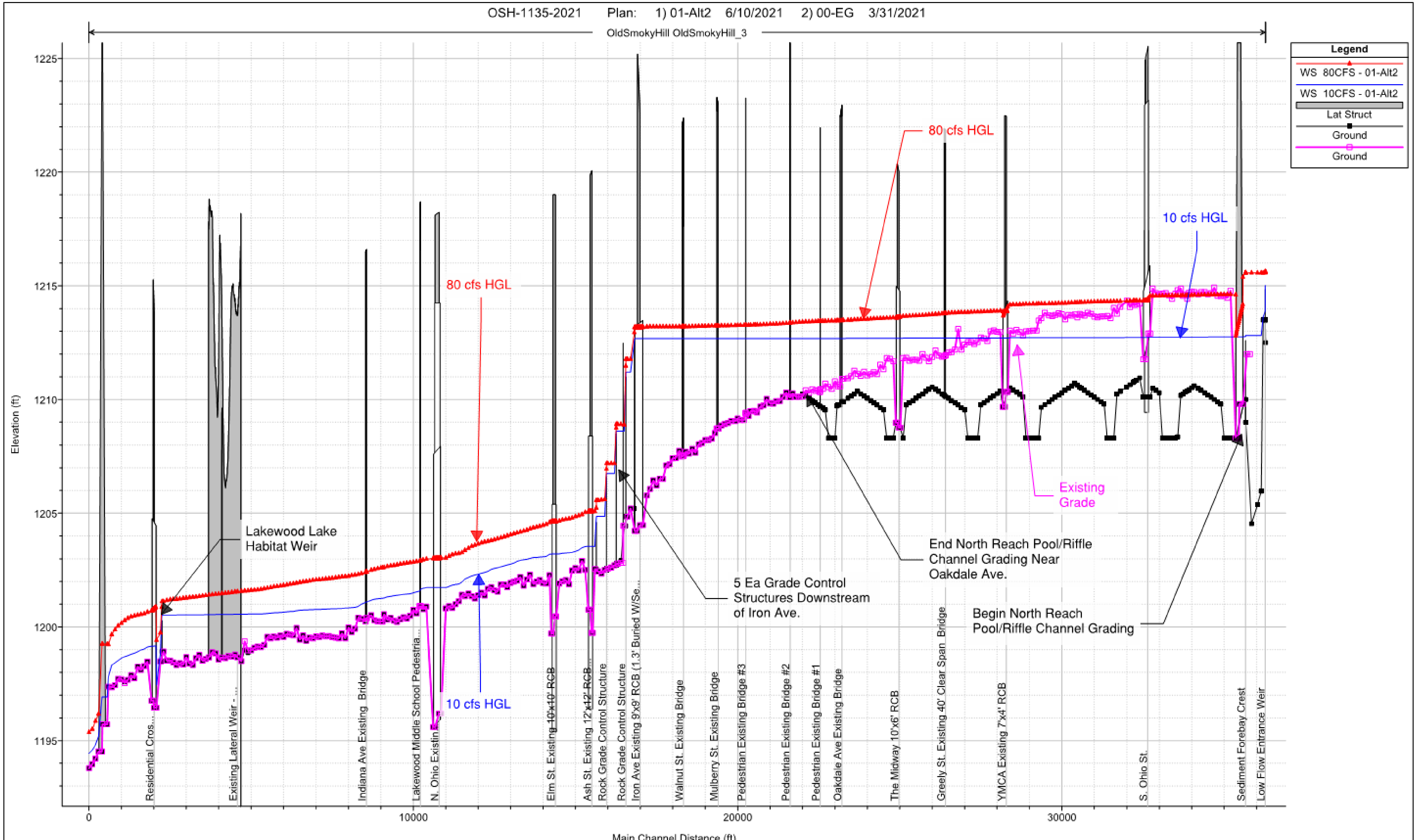


Figure 5-31: Alternative A2 Channel and 80 CFS Profile

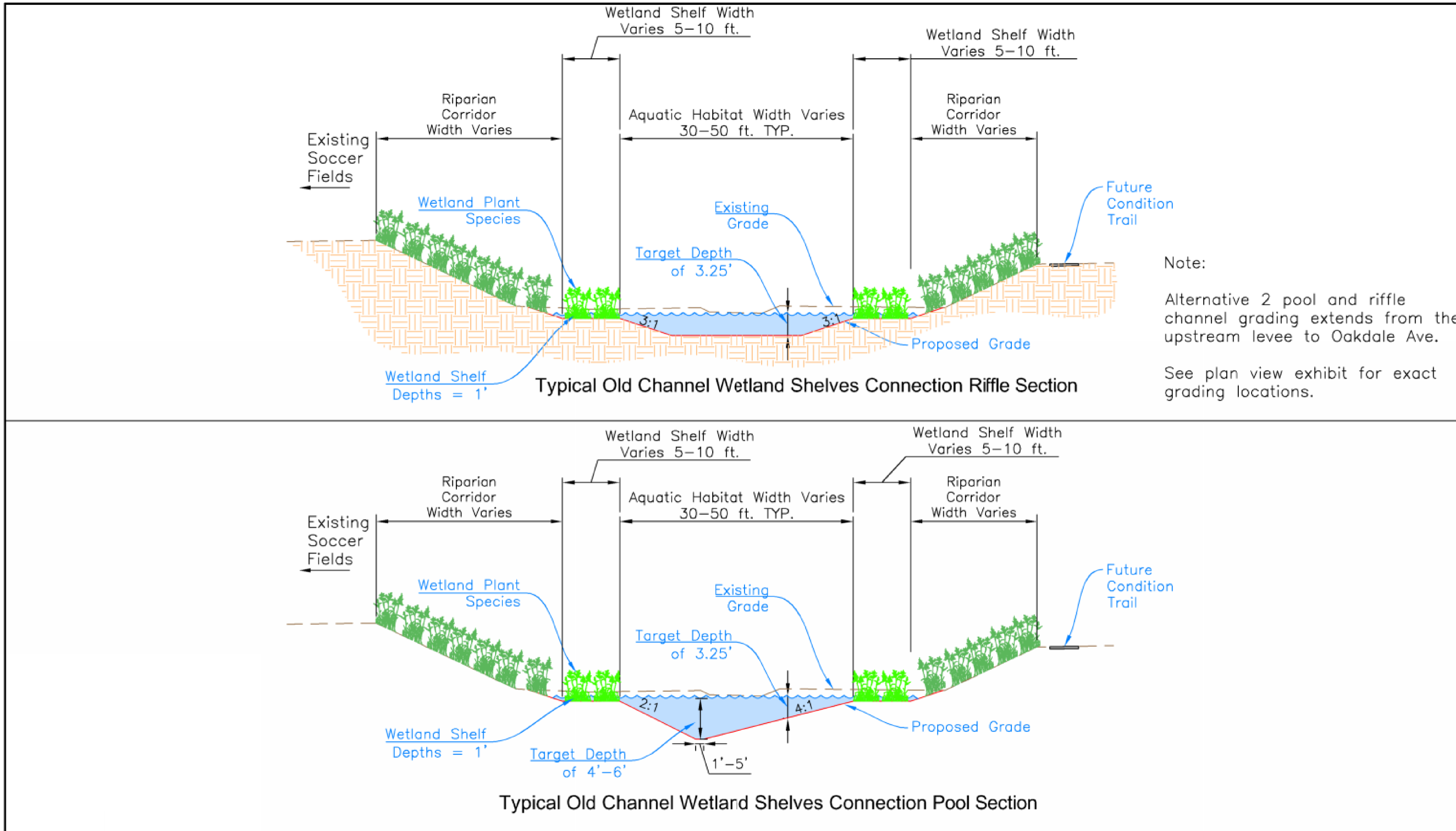


Figure 5-32: Alternative A2 Typical Sections

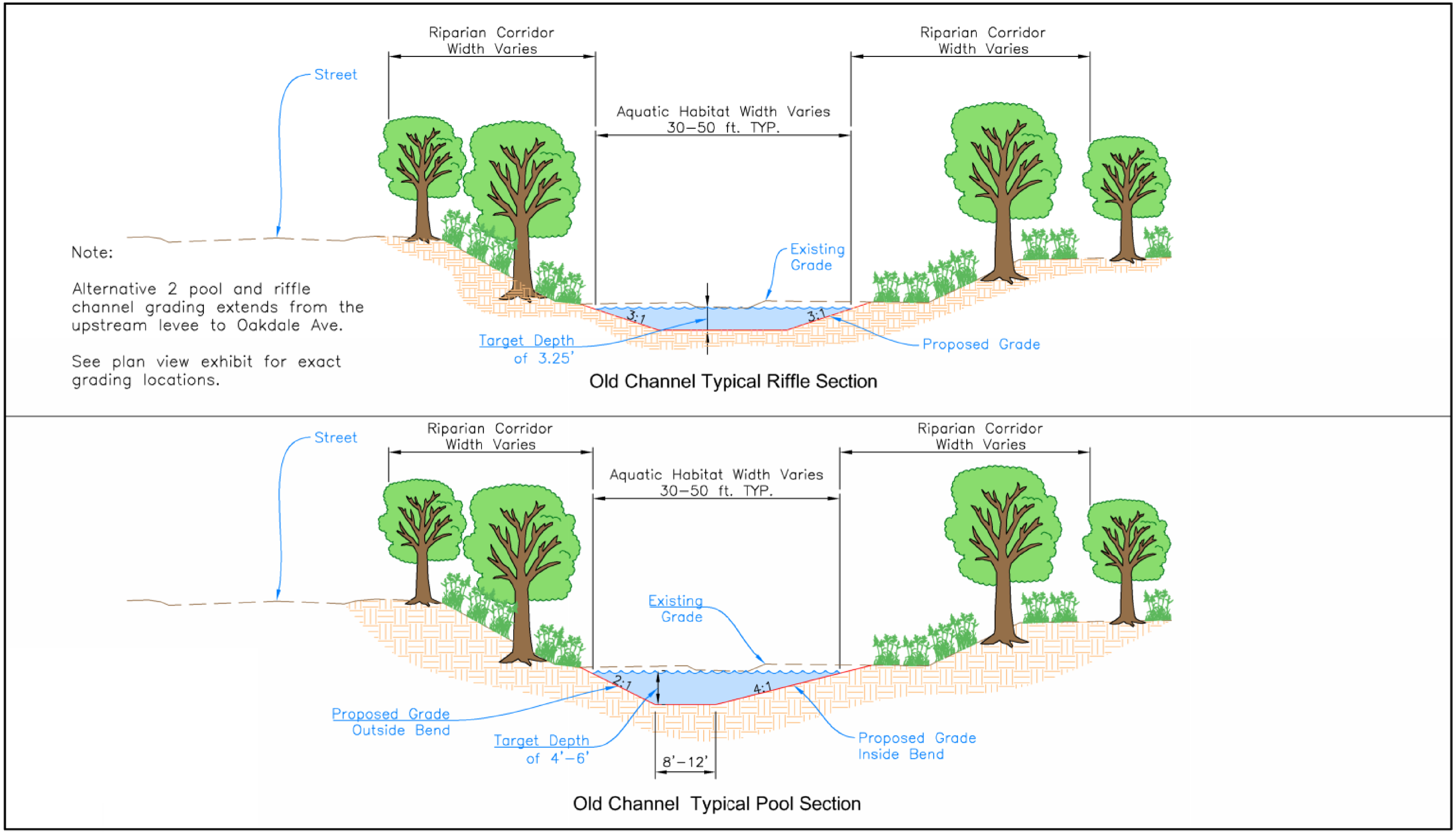


Figure 5-33: Alternative A2 Typical Sections

4.5.5 Future Conditions with Project: Alternative A3

Alternative A3 was selected as the TSP. For more information and updated profiles see Appendix A2 – Section 2.2.

Alternative A3 considers pools and riffles in both the South and North reach. Figure 5-12 (South Reach) presents the Alternative A3 channel grading plan view layout extents starting at the entrance levee culvert and ending just downstream of Oakdale Avenue where diminishing returns occur if the grading continued. The area between the step pools (near Iron Street) and the termination of the non-uniform grading near Oakdale Avenue is considered a long glide with increasingly deep waters due to the downstream step pools. For cost-effectiveness reasons, the upstream pools were raised 1 foot compared to that in Alternative A2.

Downstream of the step pools near Ash Street, the grading resumes and continues downstream of Lakewood Lake, see Figure 5-13 (North Reach).

Figure 5-14 shows the Alternative A3 channel profile compared to the existing grade and includes the 10 and 80 cfs HGL. Like Alternative A2, the riffle depths were maintained at approximately 3.25 feet to convey 80 cfs while leaving 30 cfs within the Smoky Hill River.

Figure 5-15 presents the typical wetland shelves connection sections and Figure 5-16 presents a typical riffle section featuring a 22 foot bottom width, a 40 foot water top width, and approximately 39-inches of water depth. The grading connects to the existing banks with the intent of not disturbing the established trees and vegetation that overhang the channel bottom.

Figure 5-16 also presents a typical pool section having a bottom width of 10 feet, water width of 40 feet, approximately 5 feet deep, steeper (2:1) slopes on the outside bend, and flatter (4:1) slopes on the inside bend similar to a natural channel. Like the riffle section, the intent is to connect into the existing banks without disturbing the established vegetation and trees.

This alternative produces roughly 105k CY of dredged material that would be used to create additional wetlands within Lakewood Lake when compared to Alternatives A1 or A2. This alternative would reconnect the channel to Lakewood Lake, which is currently separated by a dike except during extreme flood events. A portion of the dike would be removed allowing water to equalize between the channel and lake. To support the wetland creation, a grade control structure is proposed downstream of Lakewood Lake and upstream of the residential driveway crossing (refer Figure 5-13). Restoring the lake to its historic elevation results in a loss of temporary stormwater storage (detention). During a 1% AEP, this results in a higher tail water condition for the upstream culverts and could impact private property. To avoid induced flooding, a 12-foot x 8-foot RCB is proposed at North Ohio Street. This culvert will also function as a pedestrian underpass under dry weather conditions.

This Alternative adds additional aquatic ecosystem restoration and habitat through the expanded improvements in reach 2. However, Alternative A3 will have additional costs associated with the expanded improvements.

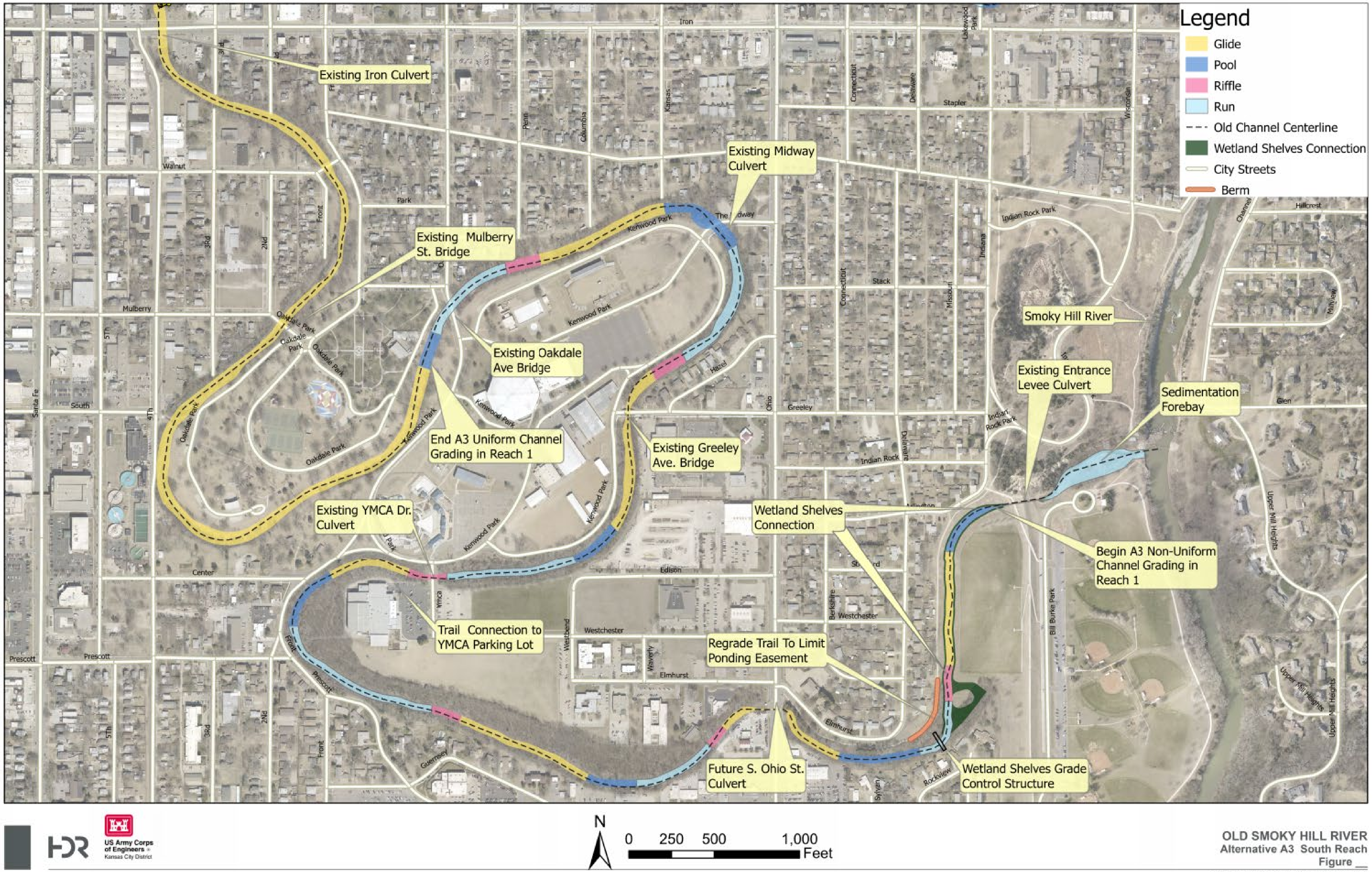


Figure 5-34: Alternative A3 Non-Uniform Channel Grading Plan View Layout (Reach 1)

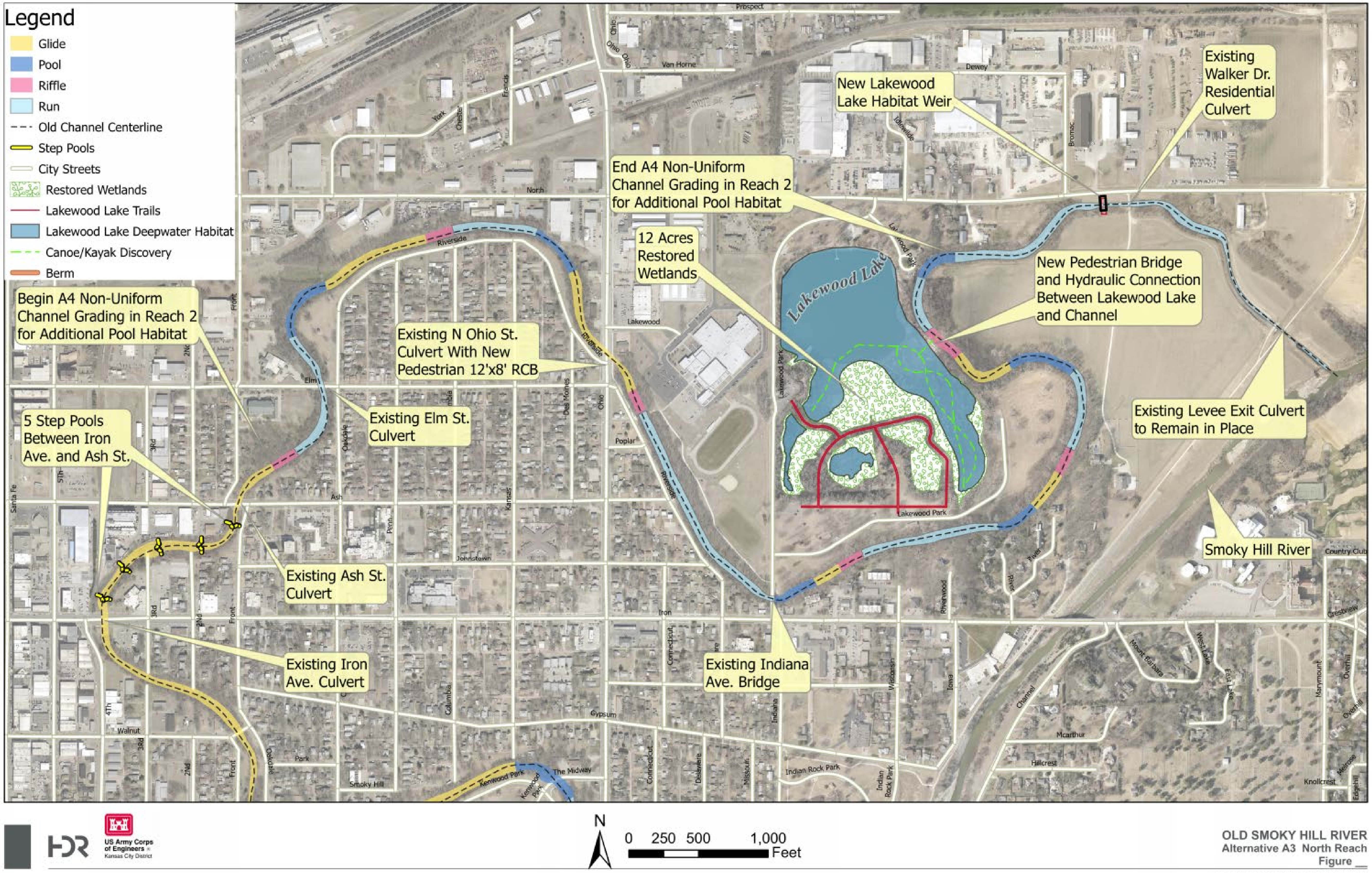


Figure 5-35: Alternative A3Non-Uniform Channel Grading Plan View Layout (Reach 2)

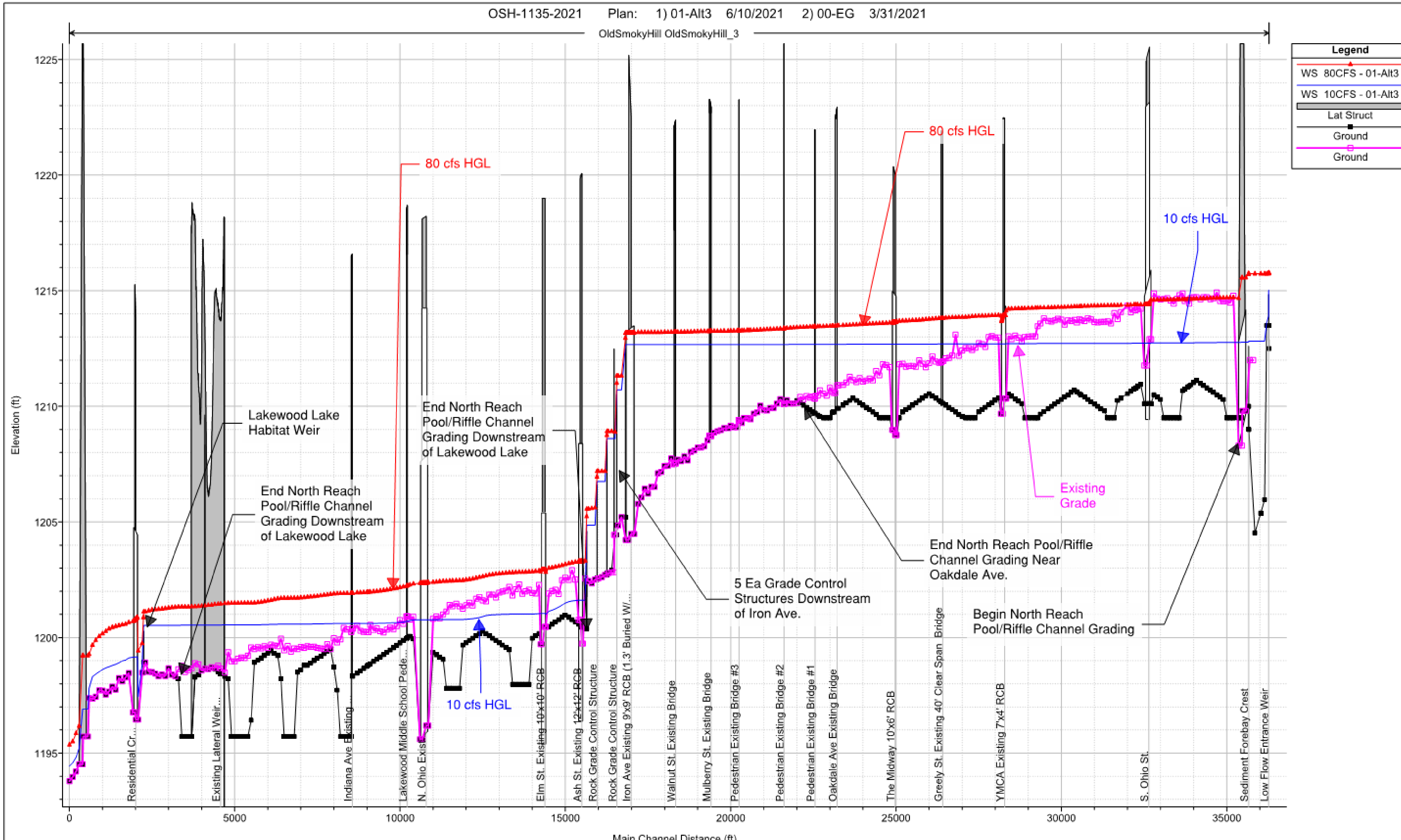


Figure 5-36: Alternative A3 Channel Profile and 80 cfs HGL

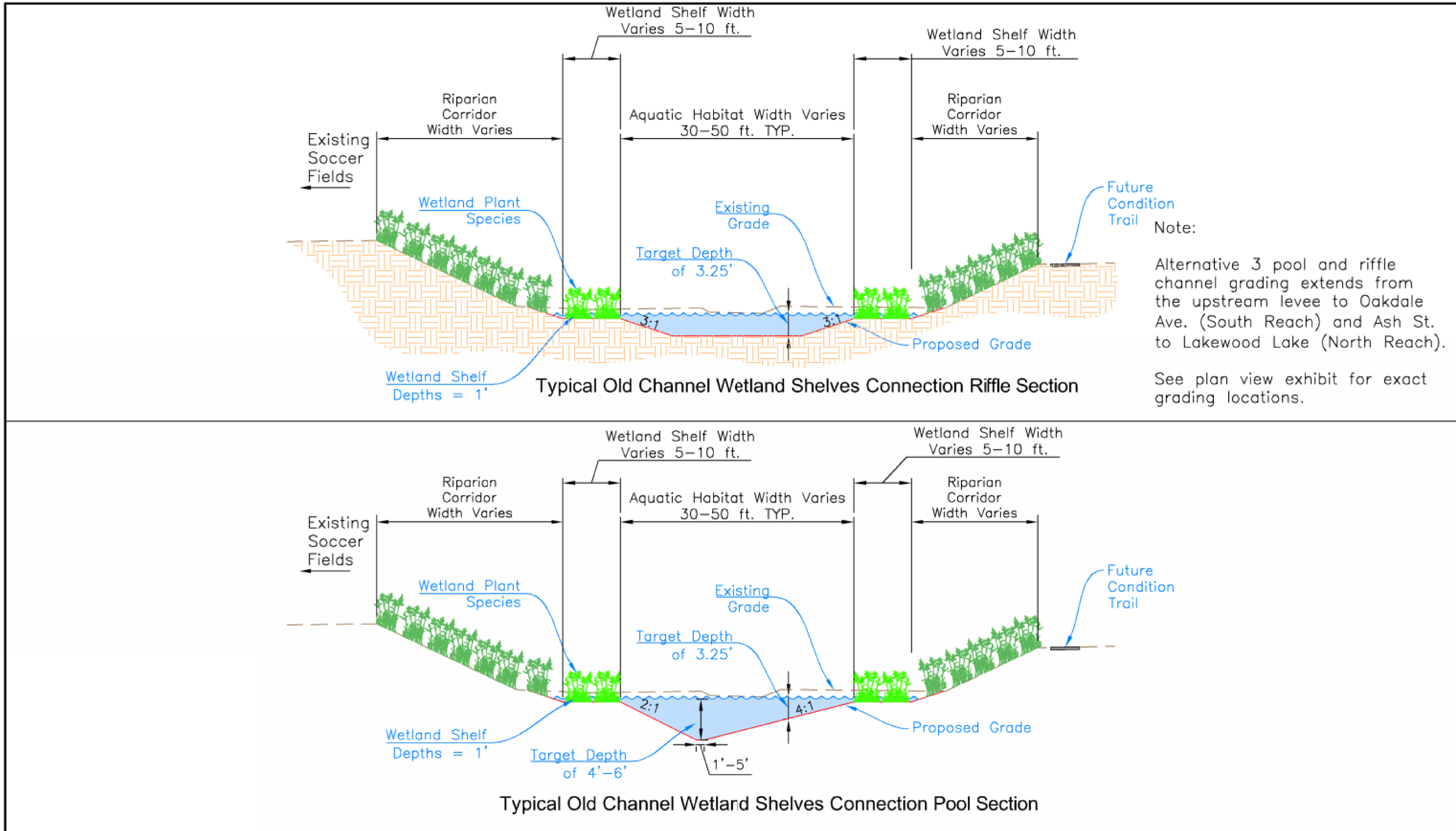


Figure 5-37: Alternative A3 Non-Uniform Channel Typical Wetland Shelve Sections

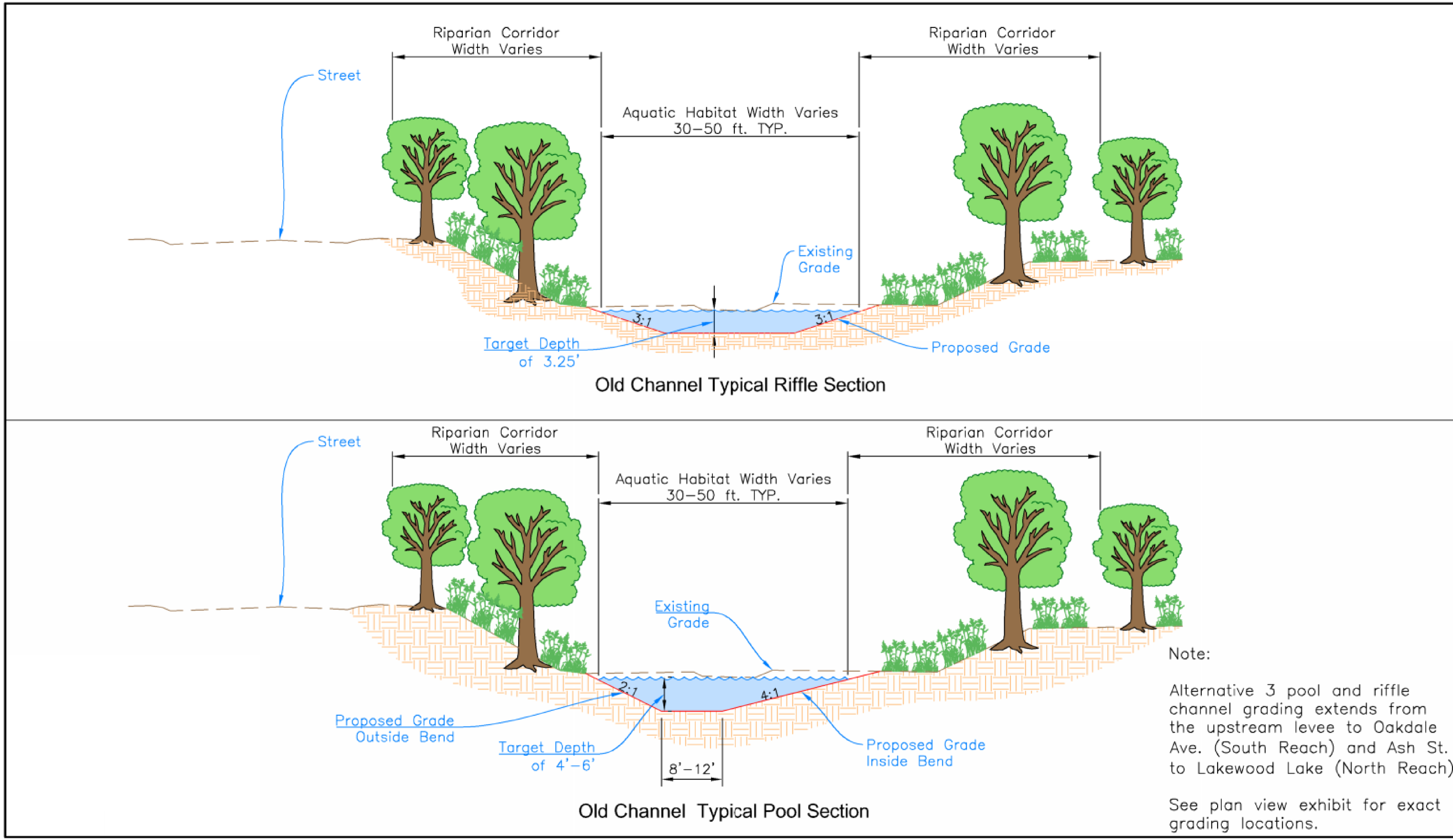


Figure 5-38: Alternative A3 Non-Uniform Channel Typical Pool and Riffle Sections

4.5.6 Future Conditions with Project: Alternative A4

Alternative A4 was not selected as the TSP.

Alternative A4 expands on the concepts introduced for Alternative A3 by deepening the pools in the South Reach and implementing more of the Master Plan improvements for Lakewood Lake. The additional improvements involve an additional Lakewood Lake connection that would create a looped reach with additional canoe/kayak waterways, paths/trails, and pedestrian/vehicular bridges. Restoring the lake to its historic elevation results in a loss of temporary stormwater storage (detention). During a 1% AEP, this results in a higher tail water condition for the upstream culverts and could impact private property. To avoid induced flooding, a 12-foot x 8-foot RCB is proposed at North Ohio Street. This culvert will also function as a pedestrian underpass under dry weather conditions.

Figure 5-17 (South Reach) and Figure 5-18 (North Reach) shows the Alternative A4 plan view pool and riffle locations. Similar to the previous alternatives, a grade control structure is proposed between Lakewood Lake and the residential culvert crossing to provide a more consistent Lakewood Lake water levels (especially at lower flows) to support the wetland creation.

Figure 5-19 presents the Alternative A4 channel profile showing the pools, riffles, glides, and runs in addition to the 80 cfs HGL. The depths of water of the riffles is again near 3 feet and ranges between 5 feet and 7 feet over the pools, see Figure 5-20 and Figure 5-21 present the Alternative A4 typical sections.

Alternative A4 provides the greatest aquatic ecosystem restoration and habitat benefits but comes at a cost of being the most expensive Alternative.

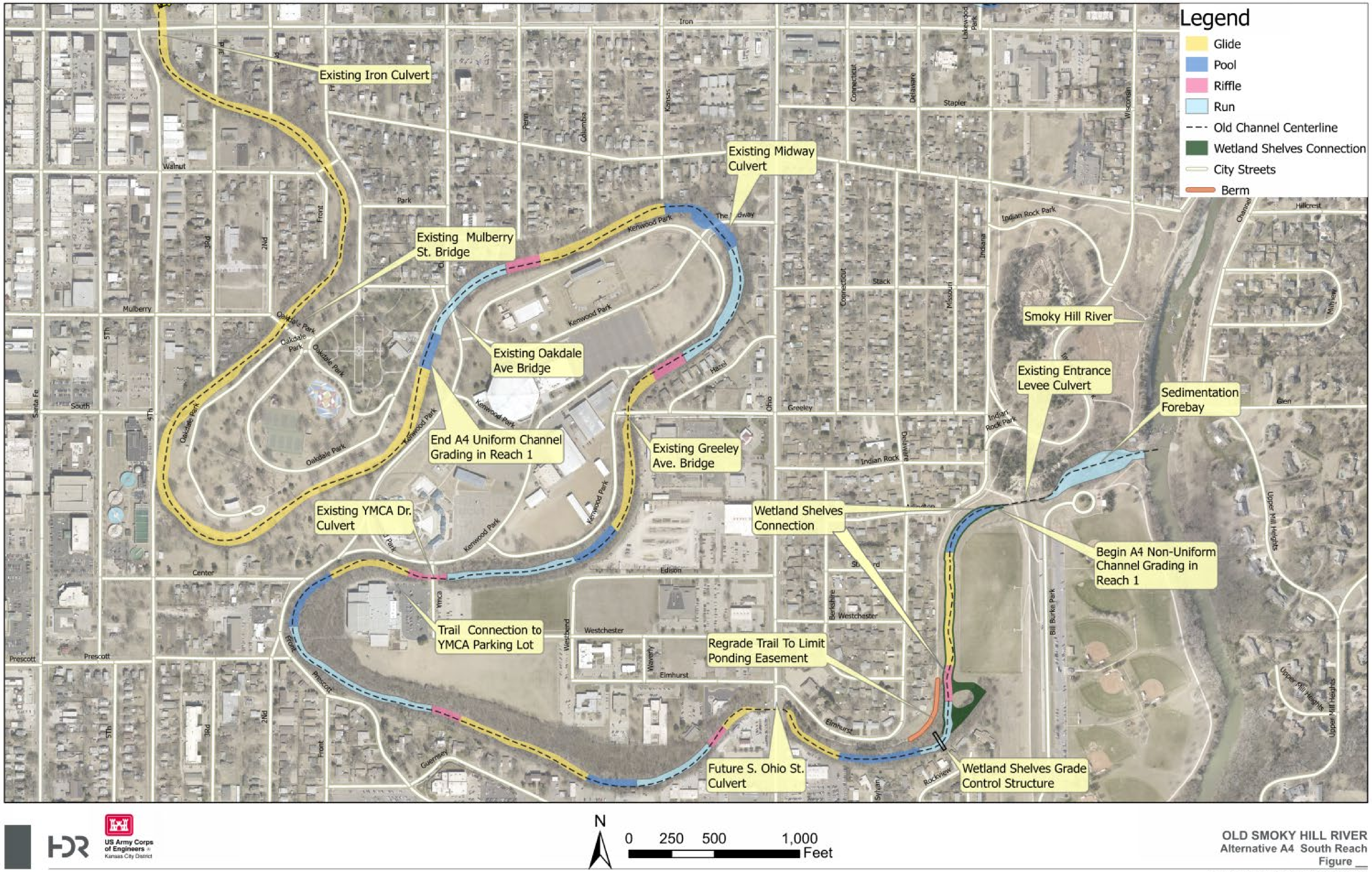


Figure 5-39: Alternative A4 Non-Uniform Channel Layout (Reach 1)

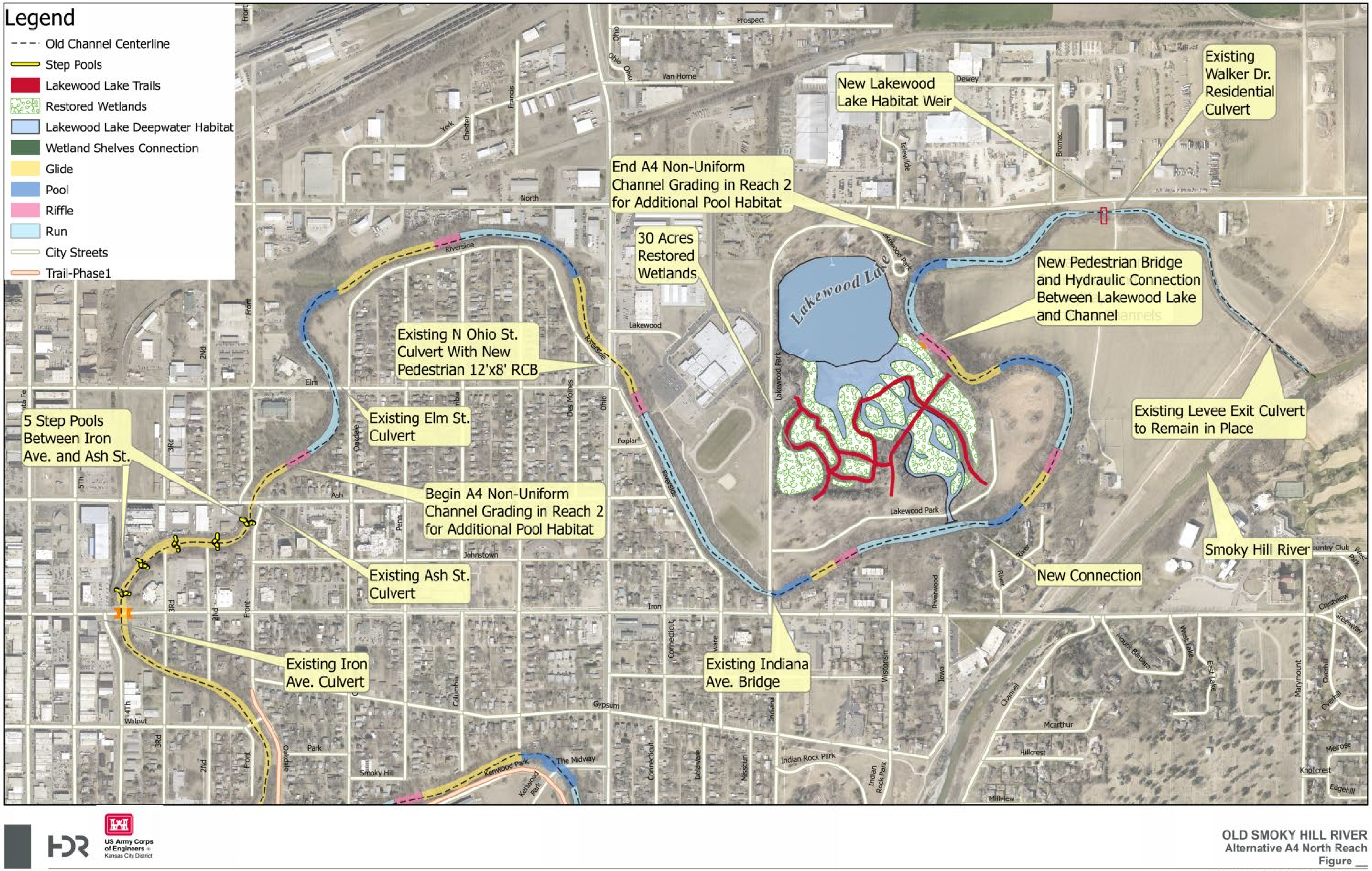


Figure 5-40: Alternative A4 Non-Uniform Channel Layout (Reach 2)

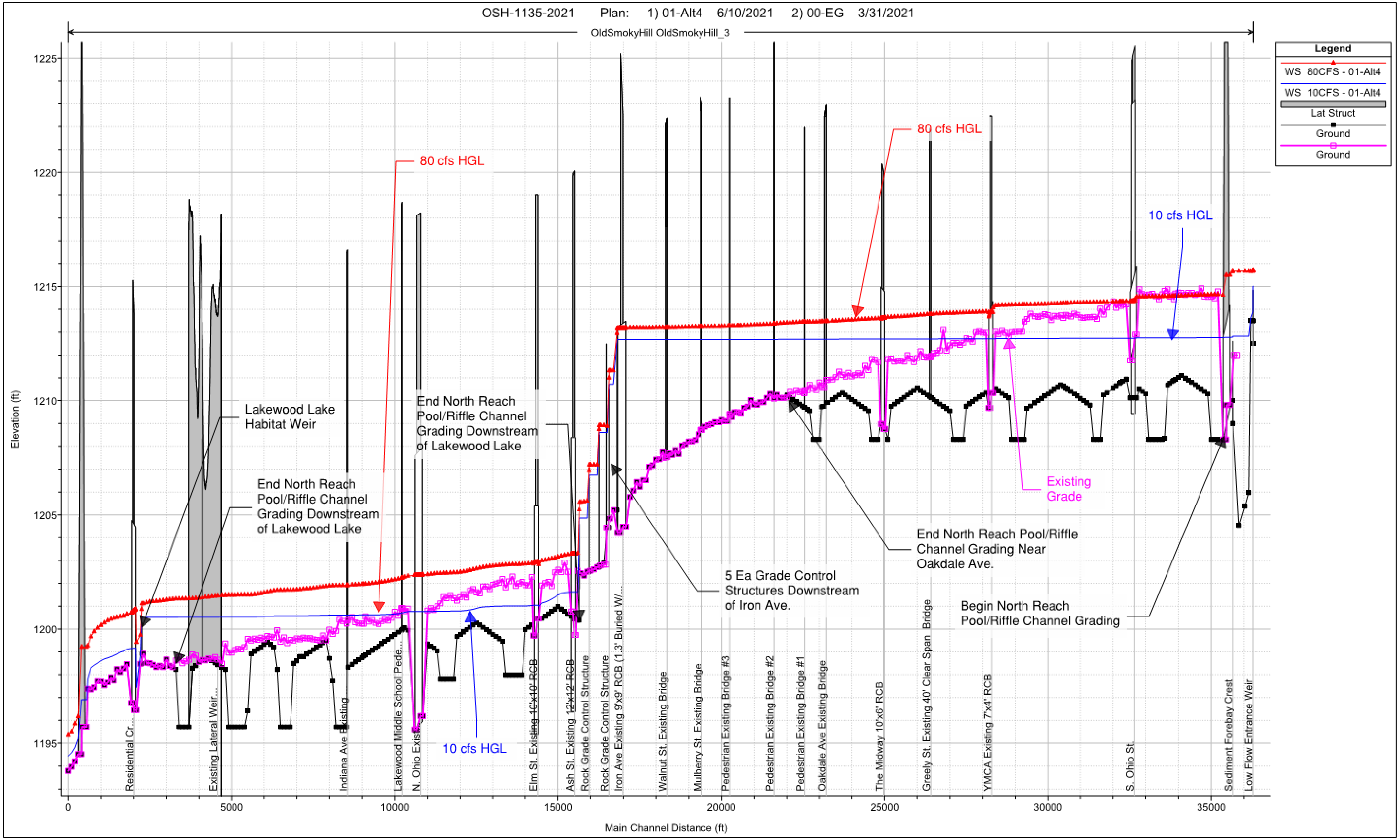
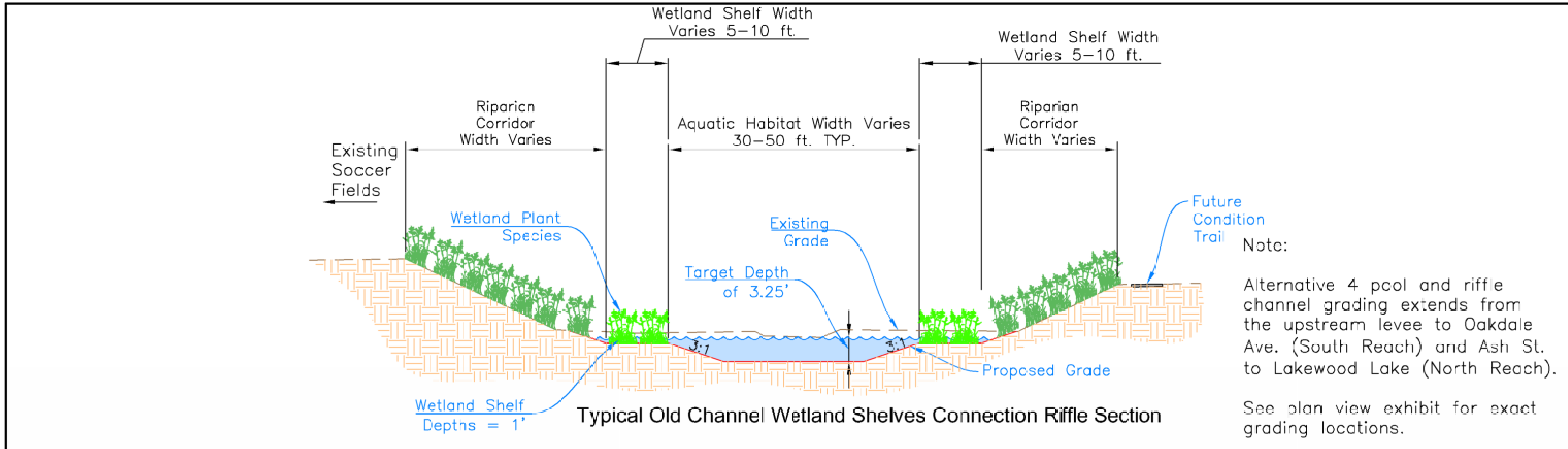
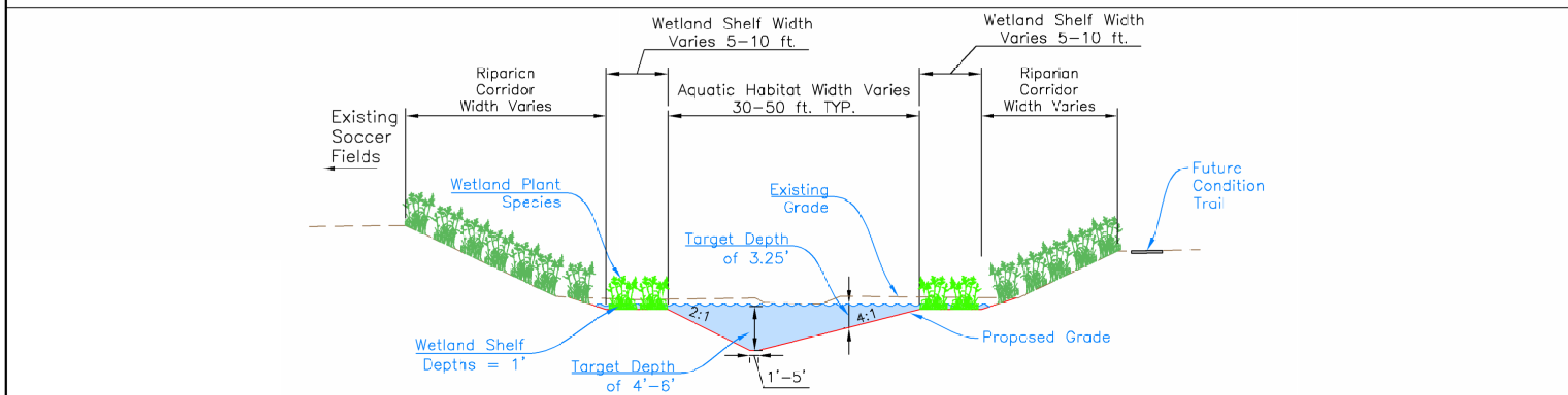


Figure 5-41: Alternative A4 Channel Profile and 80 cfs HGL



Typical Old Channel Wetland Shelves Connection Riffle Section



Typical Old Channel Wetland Shelves Connection Pool Section

Figure 5-42: Alternative A4 Non-Uniform Channel Typical Wetland Shelve Sections

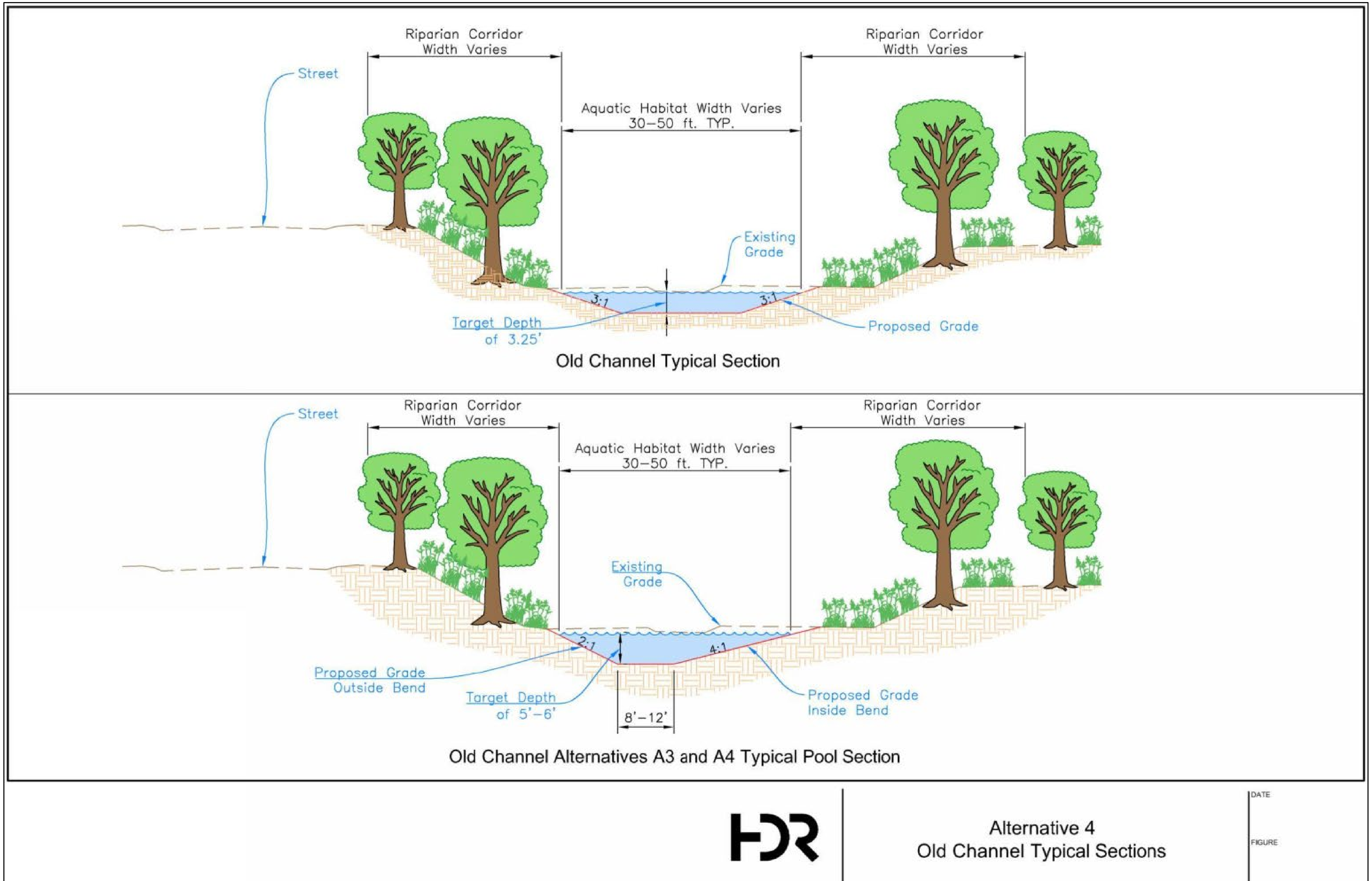


Figure 5-43: Alternative A4 Non-Uniform Channel Typical Pool and Riffle Section

5 References

Federal Emergency Management Agency. 2018. Flood Insurance Study, Volume 1 of 1, Saline County, Kansas and Incorporated Areas. Flood Insurance Study Number 20169CV000A, Version Number 2.2.2.2. April.

Natural Resource Conservation District. 2016. National Land Cover Database 2016 Products (ver. 3.0), November.

6 List of Exhibits

Exhibit A: Interior Drainage Analysis Report

Exhibit B: Restored Channel Water Balance

Exhibit C: Water Supply Alternatives Evaluation

Exhibit A. Interior Drainage Analysis Report

Smoky Hill River GI Study
Draft Integrated Feasibility Report and Environmental Assessment

September 2025

U.S. Army Corps of Engineers
Kansas City District

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Note: USACE EM1110-2-1413 Guidelines have been included in digital format in Appendix E of this levee certification package.

PROJECT OVERVIEW

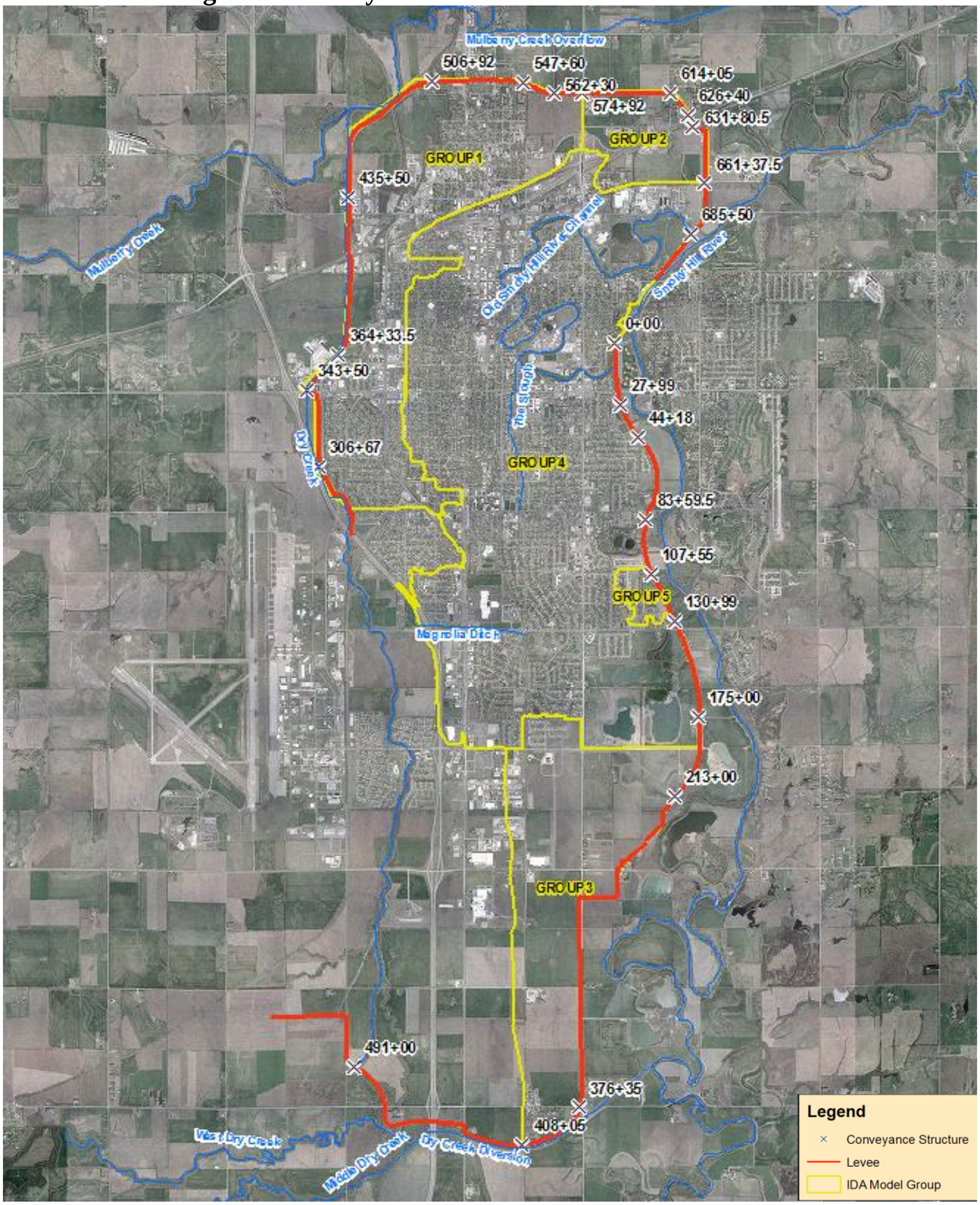
Phase II of the Salina Levee Project studies the City of Salina Flood Control Levee System along the Saline River, the Smoky Hill River, Mulberry Creek, Dry Creek, Middle Dry Creek, West Dry Creek, and the Dry Creek Diversion in Saline County, Kansas. The purpose of the interior drainage analysis (IDA) is to determine the location and extent of interior flooding in the levee system. These services are required to be completed as part of achieving FEMA levee accreditation through certification under 44 CFR 65.10. These services are not an all-inclusive scope of work required for certification, and additional analyses may be required. This new study was performed to reflect updates to the topography data and stormwater network.

A total of 24 conveyance structures (CS) through the levee were identified, located at levee stations 0+00, 27+99, 44+18, 83+59.5, 107+55, 130+99, 175+00, 213+00, 306+67 (Private), 343+50, 364+33.5, 376+35, 408+05, 435+50, 491+00, 506+92, 547+60, 562+30, 574+92, 614+05, 626+40, 631+80.5, 661+37.5, and 685+50. The interior drainage areas were modeled using three PC-SWMM models, which include all CS locations, except CS 491+00, studied as part of this project scope.

The structure located at levee station 491+00 was assumed to remain closed for this interior analysis. Ponding associated with CS 491+00 contributes to the Dry Creek channel (flowing away from the levee) and therefore does not pond adjacent to the levee system. An interior drainage analysis was not necessary for this structure.

This report describes the hydrology and hydraulic methods used on the interior watersheds, the methods used to develop the interior floodplains, as well as how the exterior boundary condition was determined (for example, Coincident Frequency Analysis for independent levee systems or specific time series conditions for dependent levee systems).

Figure 1: Conveyance Structure and Levee Locations



SUMMARY OF METHODS

The Salina Flood Control Levee System hydrology, hydraulics, and ponding areas were reviewed to determine dependent and independent outfall boundary conditions. Typically, dependent systems assume that the outfall boundary condition is most likely affected by flooding of the riverine system during the same storm event. Independent systems typically assume that the boundary condition of the outfall location is most likely not affected by flooding of the riverine system for the same storm event; instead, it is computed as a probabilistic event. For independent systems the USACE Coincident Frequency Analysis procedures are commonly used to compute the probable interior ponding water surface elevation.

The CS locations at stations 0+00, 27+99, 44+18, 83+59.5, 107+55, 130+99, 175+00, 213+00, 574+92, 614+05, 626+40, 631+80.5, 661+37.5, and 685+50 were evaluated using an independent system in which the backwater of the Smoky Hill River affects the outfall boundary condition. The riverine analysis for the Smoky Hill River uses historic USGS gage records to determine exterior discharges for the study area. The water surface elevations for the Smoky Hill River were determined from a steady-state HEC-RAS hydraulic model. A PC-SWMM model was developed to represent the interior conditions. A summary of interior drainage Coincident Frequency Analysis that was applied is as follows:

1. Develop the interior hydrologic and hydraulic models utilizing PC-SWMM.
2. Determine the interior water surface elevation as a response to the exterior stages or closure of outlet structure.
3. Determine the exterior percent chance of exceedance based on a pertinent nearby gage or historical flow values.
4. Determine the exterior stage discharge relationship from hydraulic modeling.
5. Define the association of exterior percent chance of exceedance (flow-based) to the interior stage-flow relationship determined in step 2.
6. Combine the interior and exterior percent chance exceedance frequency to calculate the 100-year interior water surface elevation.

The analysis performed for levee stations 306+6, 343+50, 364+33.5, 376+35, 408+05, 435+50, 506+92, 547+60, and 562+30 is primarily affected by Dry Creek, Mulberry Creek, Mulberry Creek Overflow, and the Dry Creek Diversion. Therefore, the interior analysis was performed assuming a dependent levee system in which the interior water surface elevation and conveyance structure outflow hydrograph were determined through balancing tailwater elevations from an unsteady-state HEC-RAS model for Dry Creek, Mulberry Creek, Mulberry Creek Overflow, and the Dry Creek Diversion with interior drainage outflow conditions. The following general approach was taken for this analysis:

1. Develop the interior hydrologic and hydraulic models utilizing PC-SWMM.
2. Determine the 1% annual chance interior water surface elevation using the unsteady-state HEC-RAS time-stage rating curve as the downstream boundary condition.
3. Balance the tailwater condition and interior drainage outflow to develop the final interior drainage tailwater condition.

INTERIOR SYSTEM ANALYSIS

PC-SWMM version 5.0.022 software was used to perform the interior drainage runoff and hydraulic analysis. The PC-SWMM model runs on the US EPA SWMM5 engine and requires the same input files; therefore, these models can be opened and run within EPA SWMM5, which is a free downloadable program. The required inputs and data sources for the interior system models are listed below. All elevations represented in this report and throughout this analysis are in the NAVD 88 vertical datum. A total of three interior drainage models were developed; one model for Group 1, one model for Group 2, and a single model containing Group 3, Group 4, and Group 5. Group 1, and 2 are developed in enough detail to establish ponding areas adjacent to the levee system. The model containing Group 3, 4, and 5 was developed with a level of detail sufficient to map flooding areas within the City of Salina to the extent of the previous FEMA analysis. Figure 1 depicts the approximate area which is included in each model Group.

Drainage Area Delineations

Initial drainage areas were determined based on automated delineations using Arc Hydro functionality with GIS software. Delineations were then checked and manually edited as necessary based on 2011 LIDAR topography.

Hydrology Transform Method

PC-SWMM hydrology uses the runoff block method to transform rainfall to runoff. This method uses flow length, basin width, and basin slope to determine the shape of the runoff hydrograph. The flow length parameter is not an exact measurement but is used to approximate overland flow length and a fraction of sheet and shallow concentrated flow. The flow length was computed as the length of the TR-55 sheet and shallow concentrated flow regimes of the longest flow path. For highly developed areas, a maximum allowable flow length was used. Flow width is automatically calculated by dividing sub-basin area by flow length. Basin slope was calculated for each basin from the LIDAR topography data. Some areas that were not representative of the overall basin were removed from this calculation, including road embankments, stream banks, and other anomalies.

Infiltration Method

The PC-SWMM runoff block method allows the utilization of a form of the Curve Number infiltration method, based on Natural Resource Conservation District (NRCS) Technical Release TR-55. Land use data was digitized based on aerial photography, supplemented with the 2005 Level IV Kansas Land Cover Patterns and the City of Salina's parcel data. Thirteen land use designations were used to represent the project area. The land use designations were joined with soil data to come up with an area-weighted curve number for each drainage basin. Soil data was obtained from the NRCS Soil Data Mart. Table 1 displays the land use categories associated curve numbers for each soil type, and the percent impervious.

Table 1: Landuse, Curve Number, and Percent Impervious Designations						
Landuse Code	Landuse Description	Pervious CN For Soil Hydro Group				Percent Impervious
		A	B	C	D	
12	Residential (Medium Density)	38	61	74	80	38
11	Commercial/Industrial	36	60	74	79	79
20	Agricultural	66	77	84	87	5
13	Open Land - Fair	46	67	78	83	5
30	Grassland-Good	46	67	78	83	5
32	Grassland-Fair	36	59	73	79	5
40	Woods	33	58	72	78	5
50	Water	100	100	100	100	100
31	Farmstead	42	64	75	81	30
70	Paved open ditches	68	80	86	88	50
71	Dirt road	71	81	86	89	5
72	Gravel Road	75	84	89	91	5
73	Street	98	98	98	98	95

As depicted in Table 1, pervious curve numbers were developed for each landuse/soil type using TR-55 guidance, assuming the impervious percentage listed in Table 1. Typical SWMM methodology separates the pervious areas from impervious areas for infiltration calculations. Therefore, the curve number listed above only represents the pervious areas of the landuse. Composite curve numbers for each subbasin were determined using an automated area-weighting process. Composite impervious percentages for each subbasin were also computed using an automated area-weighting process associated with the landuse types that intersect the individual subbasin area.

Routing Method

The dynamic wave routing method was used so that the models can properly estimate reverse flow in pipes, backwater flows, and open channel flows.

Links

Links are used to represent open channels, pipe networks, pumps, weirs, or orifices. Pipe lengths, diameter, roughness coefficients, and entrance and exit loss coefficients were established based on the Operation and Maintenance Manual (OMM), data from the City of Salina, and high resolution aerial photography. This data was used to establish pipe diameter and material. Cross-section shapes and weir dimensions were estimated based on elevation data using GIS processes and adjusted as necessary based on engineering judgment. In the Group 1 model, streets with the same general size and shape were represented with typical transects to represent the basic flow area. Three typical transects were used to represent the different sized streets. Curb inlets were generally represented by orifice links within SWMM. The curb inlet dimensions were derived, where possible, from the City of Salina stormwater data. For some locations, in which City data was not available, the curb inlet dimensions were estimated based on engineering judgment and measurements taken from high resolution aerial imagery.

Pumps

Pump stations, designed for the levee system, are located at structures 435+50, 506+92, and 685+50 to assist with pumping water out of interior ponding areas. The pumps located at 435+50 are designed for immediate local drainage runoff and do not meet Corps of Engineers inspection checklist requirements. Therefore, these pumps were not included in this analysis as a flood control structure. The pump stations located at 506+92 (Dry Creek Pump Station) and 685+50 (Smoky Hill Pump Station) meet Corps of Engineers inspection checklist requirements and were included in this analysis as flood control structures. The operation and design pump capacity information was derived from the OMM and incorporated in this analysis. Table 2 identifies the pumps included as part of this interior drainage analysis.

Table 2: Pump Information

Location	Pump No	Model	Manufacturer	Start Depth* (ft) (NAVD88)	Stop Depth* (ft) (NAVD88)	Max 1% Flow Rate (cfs)
Dry Creek Pump Station 506+92	1	3-Phase 16" Pump	Cascade	1207.39	1205.39	15.0
	2	3-Phase 16" Pump	Cascade	1208.39	1206.14	15.0
Smoky Hill Pump Station 685+50	1	3-Phase 16" Pump	Cascade	1203.39	1200.39	17.9
	2	3-Phase 16" Pump	Cascade	1204.14	1201.14	17.9
	3	3-Phase 16" Pump	Cascade	1204.89	1201.89	17.4

*Elevations computed as OMM elevations (NGVD29) plus 0.39 foot datum conversion.

Nodes

Nodes are used to assign junctions, storage areas, or outfalls. Junction invert and maximum depth elevations were taken from the OMM, the City of Salina's spatial stormwater data, or estimated from the 1-meter LIDAR topography. Maximum depth elevations were set, where possible, based on data provided by the City of Salina. In some areas pipe invert depths were not available. Therefore, the maximum depth was initially set assuming the LIDAR surface elevation invert minus 2.5 feet of surface cover. The computed depths and corresponding stormwater system profiles were then evaluated and, if necessary, corrections made based on the City of Salina Stormwater Criteria and appropriate engineering judgment. Outfalls were placed at all conveyances through the levee on the downstream side of each conveyance structure. Tide gates or flap gates were used to prevent backflow through the conveyance structures.

Storage nodes were used where significant ponding may result from backwater or from a depression (pond). In locations where ponding did occur, a storage node was used with an associated depth-storage rating curve. Depth-storage rating curves were estimated from 1-meter LIDAR topography using an automated area-volume tool within GIS at a minimum of 0.5-foot intervals. Outflow conveyance systems of storage areas were derived from the OMM or data provided by the City of Salina. The City of Salina Stormwater Criteria requires detention ponds to be designed to a minimum of a 25-year 24-hour storm event. In several instances, detention basins were designed without gravity outlets, and the only/primary means of conveyance is via small pumping plants. In general, the pump capacity is insignificant with very little contribution to the peak of flood events, especially those events greater than the 25-year 24-hour storm. Therefore, small insignificant pumping plants were assumed to not be flood control structures and were not included in this analysis. The runoff collected by these detention areas were allowed to fill until overtopping, in which the overflow runoff was modeled and carried through the system.

Rainfall Distribution

An SCS Type II rainfall distribution with a 5-minute time interval was used for the 2-, 5-, 10-, 50-, 100- and 500-year storm events. Rainfall depths used were 3.12, 4.08, 4.80, 5.76, 6.48, 7.20, and 8.92 inches respectively. The Kansas Department of Transportation *Rainfall Intensity Tables for Counties in Kansas* was used to develop the rainfall depths for the 2- to 100-year storm events. The 500-year depth was extrapolated from the derived rainfall depths described above using TP-40 procedures.

EXTERIOR SYSTEM ANALYSIS

The hydrology and hydraulic analyses produced as part of the Kansas Department of Agriculture Salina Levee PMR project were used as the basis of the exterior system analysis. Detailed hydrology and hydraulics were performed for the Dry Creek, Dry Creek Diversion, Mulberry Creek, Mulberry Creek Overflow, Saline River, and Smoky Hill River which included rainfall-runoff & gage hydrology and steady & unsteady HECRAS hydraulic analyses.

As previously indicated, the exterior tailwater conditions were considered to be either independent or dependent systems depending on the conveyance structure location. As indicated during levee inspections and documentation, levee station 491+00 was assumed to be closed during flood events. Therefore, no further analysis was performed for this structure.

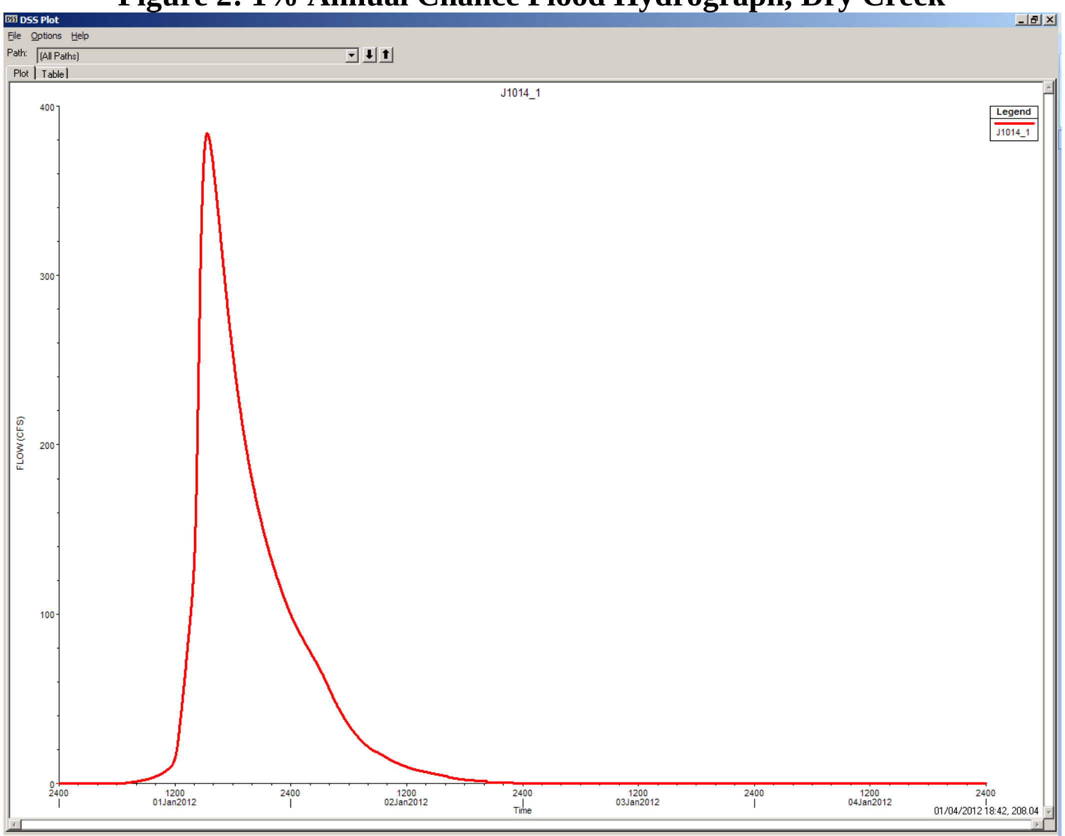
Special considerations were given to conveyance structures 626+40 and 631+80.5 with respect to tailwater conditions. These structures are located at the northeast corner of the levee system in which initial indications suggest that they could be impacted by Smoky Hill River, Saline River, or Mulberry Creek Overflow flood conditions. Further investigation revealed that the Saline River and Smoky Hill River 1% annual chance water surface elevations were much too low to impact the conveyance structures. In addition, the flooding effects from the Mulberry Creek Overflow are impeded by an area of high ground located to the north of the conveyance structures and between the structures and the Mulberry Creek Overflow. These conveyance structures are not affected by riverine tailwater conditions up to the 0.2% annual chance frequency event. Therefore, the outfall conditions within the PC-SWMM model for these conveyance structure locations were assumed to be free flow.

The following discusses dependent and independent analyses in more detail.

DEPENDENT SYSTEM

The analysis performed for levee stations 306+67, 343+50, 364+33.5, 376+35, 408+05, 435+50, 506+92, 547+60, and 562+30 is primarily affected by Dry Creek, Mulberry Creek, Mulberry Creek Overflow, and the Dry Creek Diversion. Therefore, the interior analysis was performed assuming a dependent levee system in which the interior water surface elevation was determined through unsteady-state HEC-RAS models for Dry Creek, Mulberry Creek, Mulberry Creek Overflow, and the Dry Creek Diversion. Flood frequency hydrographs were developed using HEC-HMS modeling. Figure 2 represents the 1% Annual Chance flood frequency curve used as input for the unsteady models at a single location. The flood frequency hydrographs were ran through the unsteady-state models to develop time-stage relationships at selected cross section locations. The time-stage relationship was taken from the unsteady-state models for each drainage structure outfall location and was used as the downstream boundary condition in the PC-SWMM model to develop maximum interior ponding water surface elevations.

Figure 2: 1% Annual Chance Flood Hydrograph, Dry Creek



For the unsteady model containing Dry Creek, Mulberry Creek, and Mulberry Creek Overflow, flows through levee structures were taken from the PC-SWMM model and also ran through the unsteady model. The following general approach summarizes this analysis:

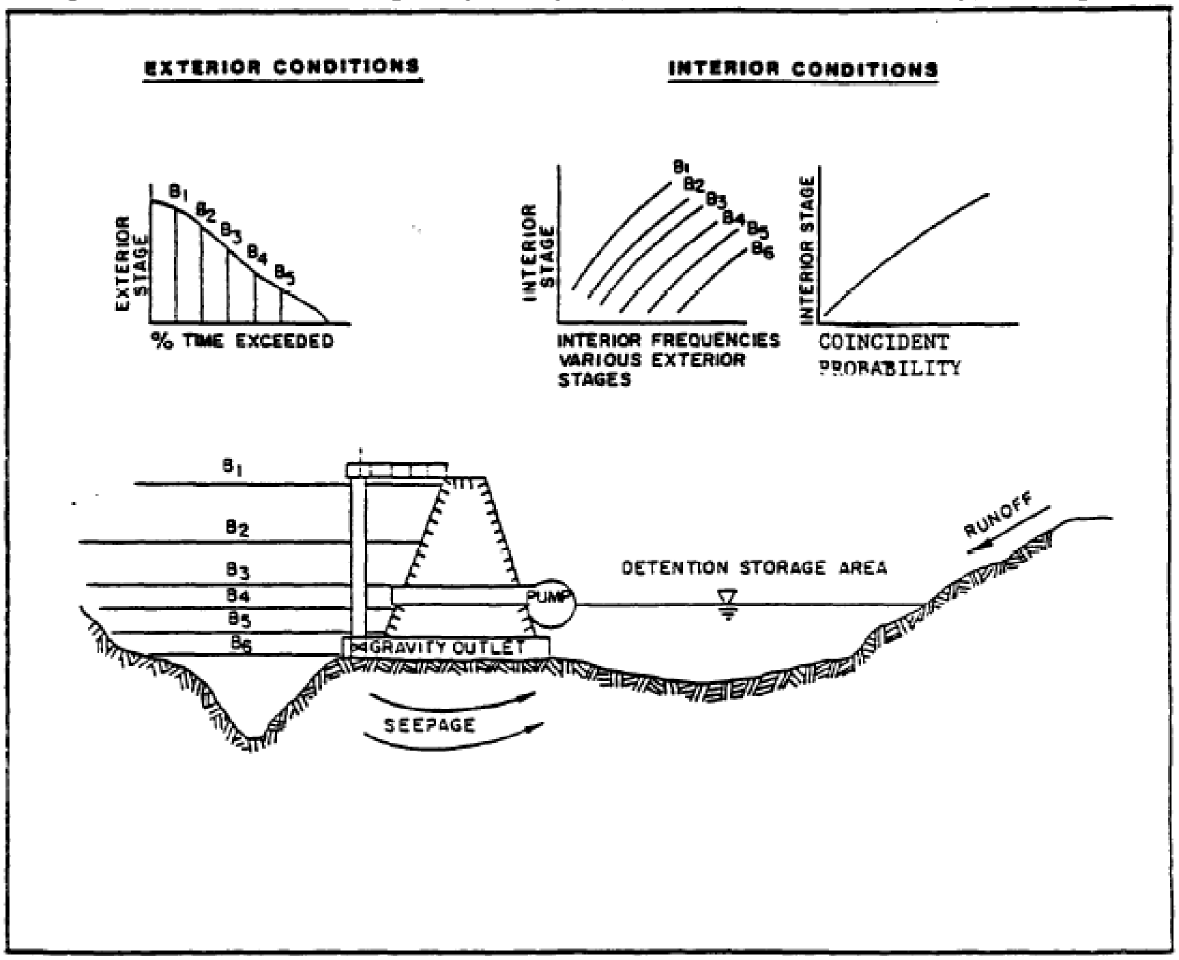
1. Initial stage-time rating curves were derived from the unsteady-state HEC-RAS model at the outfall locations of the Salina interior PC-SWMM model.
2. The initial stage-time rating curves were then applied as the initial tailwater condition for the Salina interior PC-SWMM models.
3. The PC-SWMM models were then ran to compute contributing outfall discharge hydrographs.
4. The initial contributing discharge hydrographs from the PC-SWMM models were input into the unsteady-state HEC-RAS model. The unsteady-state HEC-RAS model were reran.

A comparison of the stage-time rating curves was made between the initial and updated model and the above process was repeated until any differences were within appropriate engineering tolerances.

INDEPENDENT SYSTEM

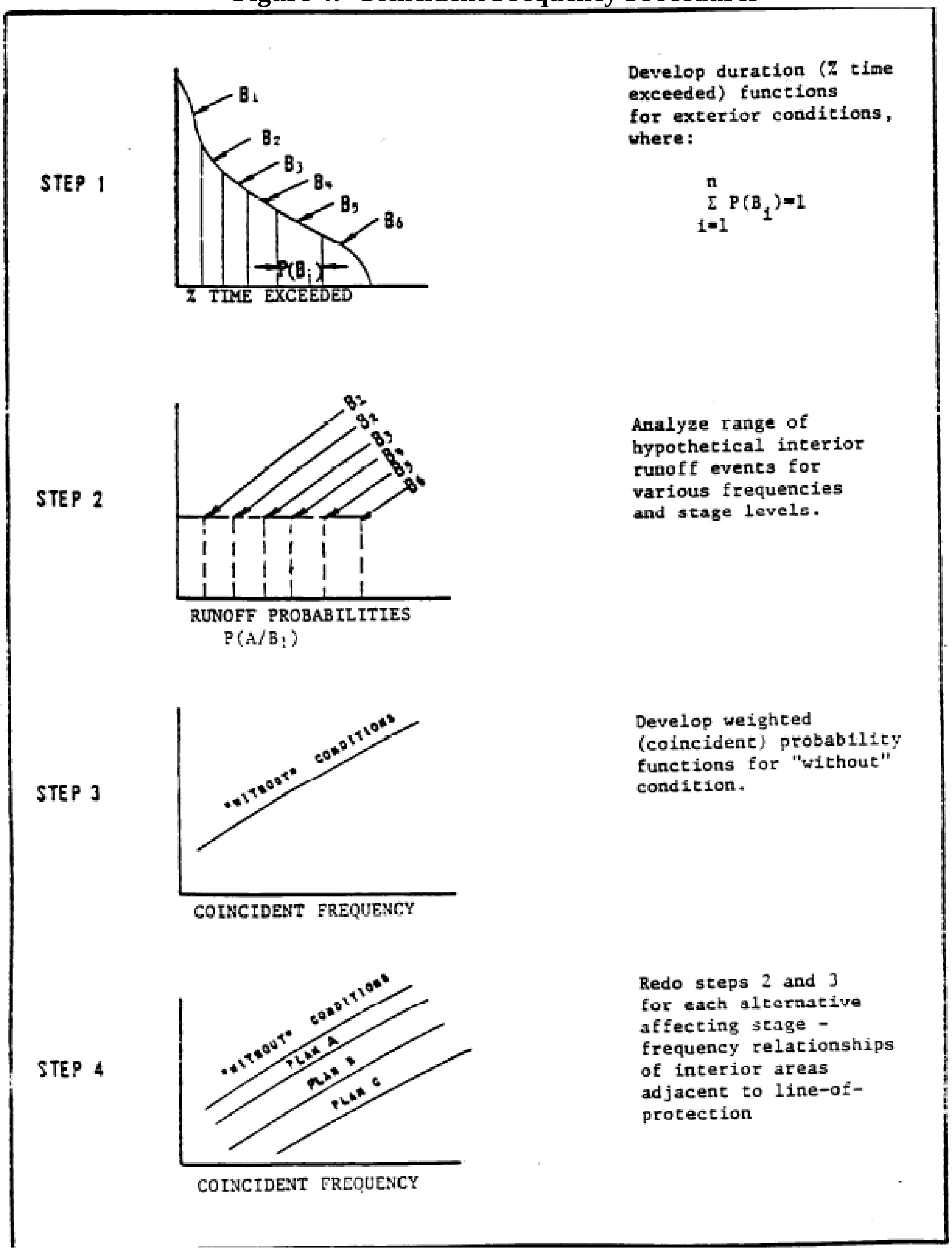
The Coincident Frequency Analysis (or Total Probability Theorem) was utilized for this independent system analysis of the Smoky Hill River and interior drainage areas as outlined in USACE EM1110-2-1413 procedures. Figure 3, taken from USACE EM1110-2-1413, depicts the general concept of the Coincident Frequency Analysis as it relates exterior riverine stages to interior drainage levee systems. To complete the Coincident Frequency Analysis, the statistical software package HEC-SSP developed by the USACE was utilized. This program includes functions for developing the exceedance duration analysis of the exterior system and Coincident Frequency Analysis in accordance with USACE EM1110-2-1413 guidelines.

Figure 3: Coincident Frequency Analysis (Joint or Total Probability) Concept



In summary the procedures identified in USACE EM1110-2-1413 consist of 4 general steps. The four general steps are shown in Figure 4, taken from USACE EM1110-2-1413, below.

Figure 4: Coincident Frequency Procedures



To summarize, Step 1 is performed to define the exterior river probability elevation and Step 2 computes the probability of exceeding a given interior ponding elevation given a particular exterior river stage described in Step 1. Steps 3 and 4 utilize the Total Probability Theorem Equation, taken from USACE EM1110-2-1413, to compute the 1% probability of exceeding a given interior ponding elevation.

Total Probability Theorem Equation

$$P(A) = \sum_{i=1}^{n} (P(A/B_i) \times P(B_i))$$

where: $P(A)$ = probability of exceeding a given interior ponding elevation

$P(B_i)$ = probability river is at the specific stage interval (i), where i assumes full range of values which have affect on pond elevation.

$P(A/B_i)$ = probability of exceeding a given pond elevation if the river stage is at the stage interval described in step 1.

The following discussion provides additional details regarding each step of the Coincident Frequency Analysis as utilized for the independent system analysis of the Smoky Hill River and interior drainage areas.

STEP 1 – EXTERIOR PROBABILITY ANALYSIS [P(B_i)]

Step 1 of the procedure develops percent time (%T) exceedance functions of the exterior systems. An exterior analysis of the Smoky Hill River was performed for outfall locations at structures 0+00, 27+99, 44+18, 83+59.5, 107+55, 130+99, 175+00, 213+00, 574+92, 614+05, 661+37.5, and 685+50 so that a Coincident Frequency Analysis could be developed representing the effect of the independent Smoky Hill River backwater. Structures 408+05 and 376+35 were also considered for the Coincident Frequency Analysis, but it was determined that the effect of the Smoky Hill River on these structures was insignificant.

AMEC utilized USGS Gage 06866500 as shown below to define %T discharge exceedance curves for the Smoky Hill River. Daily mean flow was downloaded from the USGS (http://waterdata.usgs.gov/nwis/sw) and percent exceedance duration was calculated.

USGS Gage 06866500
Smoky Hill River near Mentor, Kansas
Daily stream flow data available 1923 - 2012
Drainage area 8,341 square miles

Due to the construction of a reservoir on the Smoky Hill River upstream of this gage, records prior to June of 1948 were excluded from this analysis. Records after December of 2001 were also excluded because the gage was moved from its previous location at Magnolia Road to a new location near Mentor, KS in March of 2002.

The %T discharge exceedance curves were developed from the USGS gage data using HEC-SSP. Nine points were used to define the shape of the %T discharge exceedance curve. These points were then defined as the exterior discharge index. Each user defined discharge index was chosen to represent an exceedance probability interval. Figure 5 represents the exterior time exceedance curves with corresponding discharge index's and probability intervals for USGS 06866500. For the exceedance interval that includes the range zero to 1.05%, a lower flow value was initially selected. However, it was determined that this flow resulted in an exterior water surface elevation that has no impact on structures 175+00 and 661+37.5. To ensure a conservative estimate of the interior ponding area, the maximum flow of 18,500cfs was used to represent this interval of the exceedance curve, as shown in the figure 5. The resulting exterior water surface elevation covers the outlet of 175+00 and partially covers structure 661+37.5.

Figure 5 – USGS 06866500 Time Exceedance with Discharge Index and Intervals

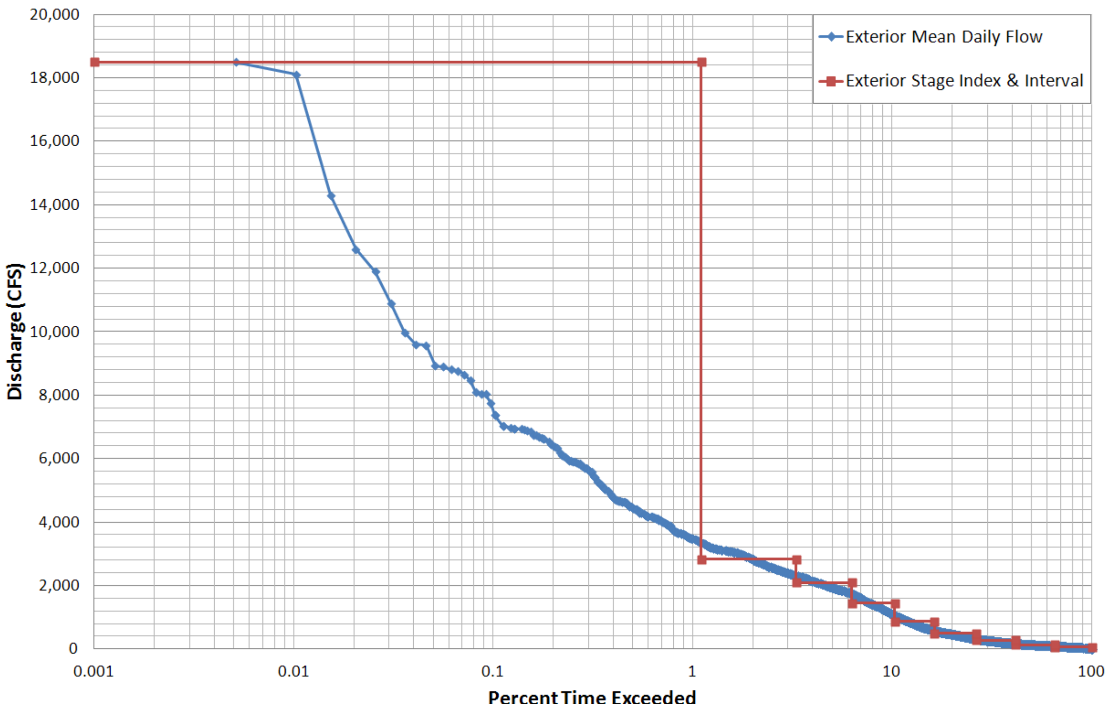


Table 3 represents the selected discharge indices and computed exterior probability as derived from Figure 5 for USGS 06866500.

Table 3: USGS 06866500 - Exterior %T Discharge Exceedance for Coincident Frequency Analysis				
Exterior Interval	Exterior Discharge Interval Probability	HEC-SSP Interval Discharge Index	Discharge Interval Upper Limit	Discharge Interval Lower Limit
Interval 1	35.0	60.0	92.0	1.4
Interval 2	23.8	134.0	171.0	92.0
Interval 3	15.0	281.7	320.0	171.0
Interval 4	10.0	493.5	581.0	320.0
Interval 5	6.0	871.0	1070.0	581.0
Interval 6	4.0	1436.0	1750.0	1070.0
Interval 7	3.0	2089.2	2330.0	1750.0
Interval 8	2.2	2835.4	3440.0	2330.0
Interval 9	1.1	18500.0	18500.0	3440.0

These user selected discharge index values, represented in Table 3, were then entered into a riverine HEC-RAS model to translate %T discharge exceedance into %T water surface exceedance for each cross section within the model. From this HEC-RAS model, AMEC derived the exterior water surface elevations for each exceedance interval at each conveyance structure location from the nearest HEC-RAS cross section. Table 4 below provides an example of a final exterior probability curve at a particular conveyance structure.

Table 4: Example Exterior Probability Stage Index Values [P(B_i)] – 0+00		
Exterior Interval	Exterior Interval Probability	Water Surface Elevation (NAVD88 Feet)
Interval 1	35.00	1224.62
Interval 2	23.75	1215.48
Interval 3	15.00	1214.50
Interval 4	10.00	1213.48
Interval 5	6.00	1212.41
Interval 6	4.00	1211.49
Interval 7	3.00	1210.82
Interval 8	2.20	1210.20
Interval 9	1.05	1209.80

STEP 2 – INTERIOR PROBABILITY ANALYSIS [P(A/B_i)]

AMEC then used the PC-SWMM interior drainage model to compute peak interior water surface elevations adjacent to the levee for each storm recurrence interval (0.2, 1, 2, 10, 20, and 50 % chance exceedance events) based on each exterior interval stage tailwater condition shown in Table 4. Table 5 is an example summarizing the interior water surface elevations for each combination of exterior and interior events, called a Response Curve Table in HEC-SSP.

Table 5: Example Interior System Results (NAVD88 Feet) from Exterior Tailwater and Interior Storm Conditions - 0+00									
Interior Storm Event (% Annual Chance)	BC 1* 1209.81	BC 2* 1210.22	BC 3* 1210.86	BC 4* 1211.56	BC 5* 1212.50	BC 6* 1213.60	BC 7* 1214.63	BC 8* 1215.62	BC 9* 1224.79
50%	1215.40	1215.40	1215.41	1215.43	1215.57	1216.00	1216.53	1217.03	1218.78
20%	1216.44	1216.43	1216.43	1216.44	1216.55	1216.90	1217.47	1217.94	1220.79
10%	1217.10	1217.10	1217.10	1217.11	1217.20	1217.50	1218.07	1218.53	1222.19
2%	1218.36	1218.36	1218.36	1218.37	1218.43	1218.67	1219.20	1219.67	1223.55
1%	1218.85	1218.85	1218.85	1218.86	1218.91	1219.12	1219.64	1220.10	1223.92
0.20%	1219.92	1219.92	1219.92	1219.92	1219.95	1220.12	1220.59	1221.05	1224.69
*Elevation values have been rounded to the nearest hundredth									

In order to find the 1% annual chance interior ponding elevation, HEC-SSP creates intermediate response frequency tables that summarize the exceedance percent for a range of interior ponding elevations. Table 6 below provides an example of the intermediate probabilities for the interior ponding elevations given each exterior stage index.

Table 6: Example Intermediate Probabilities (%) for Given Exterior and Interior Conditions [P(A|B$_i$)] - 0+00									
Interior Ponding Elev.* (NAVD88 feet)	BC 1*	BC 2*	BC 3*	BC 4*	BC 5*	BC 6*	BC 7*	BC 8*	BC 9*
1215.40	50.00	50.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1215.89	34.62	34.48	34.64	35.11	39.21	100.00	100.00	100.00	100.00
1216.38	21.44	21.21	21.23	21.48	24.39	36.19	100.00	100.00	100.00
1216.87	13.01	12.96	12.96	13.10	14.55	20.88	38.15	100.00	100.00
1217.36	7.58	7.58	7.58	7.67	8.43	11.98	22.98	38.16	100.00
1217.84	4.22	4.22	4.22	4.28	4.70	6.65	13.21	22.56	100.00
1218.33	2.08	2.08	2.08	2.12	2.33	3.43	7.26	12.82	100.00
1218.82	1.04	1.04	1.04	1.06	1.14	1.59	3.72	7.02	49.29
1219.31	0.62	0.62	0.62	0.63	0.66	0.81	1.69	3.60	41.19
1219.80	0.27	0.27	0.27	0.27	0.29	0.44	0.83	1.63	33.46
1220.29	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.81	26.37
1220.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	20.14
1221.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.07
1221.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.61
1222.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.48
1222.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.68
1223.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.15
1223.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.49
1224.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
1224.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
*Elevation and Probability values have been rounded to the nearest hundredth									

STEP 3 and 4 – TOTAL PROBABILITY ANALYSIS [P(A)]

AMEC computed the Coincident Frequency Analysis for each 1% Chance of Exceedance Interior Ponding Elevation using HEC-SSP. The calculations within HEC-SSP use [P(Bi)] from Table 4, [P(A/Bi)] from Table 6, and the Total Probability Theorem Equation to develop [P(A)] for a range of interior ponding elevations. An example of the calculations used to compute the Exceedance Probabilities for an elevation of 1218.33 feet at structure 0+00 is shown below.

Example Calculation

[Stage Index 1] [Stage Index 2] [Stage Index 9]
(Table 4)(Table 6) + (Table 4)(Table 6) + … + (Table 4)(Table 6) = (Exceedance Probability)

For Structure 0+00

[1209.81] [1210.22] [1210.86] [1211.56] [1212.50]
(0.35)(0.0208) + (0.2375)(0.0208) + (0.15)(0.0208) + (0.1000)(0.0212) + (0.060)(0.0233) +

[1213.60] [1214.63] [1215.62] [1224.79]
(0.04)(0.0343) + (0.03)(0.0726) + (0.022)(0.1282) + (0.0105)(1.00)

= 0.036 (Exceedance Probability for interior ponding of 1218.33 feet)

This calculation is done across the range of elevations within HEC-SSP. Table 7 summarizes the calculated exceedance probabilities.

Table 7: Example HEC-SSP Computed Exceedance Probability Curve - 0+00	
Exceedance (%)	**Interior Ponding Elev. (NAVD88 feet)**
70.625	1,215.40
41.612	1,215.89
27.034	1,216.38
16.984	1,216.87
9.921	1,217.36
6.034	1,217.84
3.574	1,218.33
1.789	1,218.82
1.157	1,219.31
0.669	1,219.80
0.308	1,220.29
0.22	1,220.78
0.169	1,221.27
0.132	1,221.76
0.099	1,222.25
0.06	1,222.73
0.033	1,223.22
0.016	1,223.71
0.007	1,224.20
0.002	1,224.69

From the computed exceedance probabilities for the range of interior ponding elevations, HEC-SSP interpolates to produce ponding elevations at relevant exceedance probabilities. Table 8 summarizes these results.

Table 8: Example HEC-SSP Computed Probability for Desired Frequency - 0+00	
Exceedance (%)	**Interior Ponding Elev. (NAVD88 feet)**
0.2	1,220.96
0.5	1,219.99
1.0	1,219.44
2.0	1,218.75
4.0	1,218.23
10.0	1,217.35
20.0	1,216.71
50.0	1,215.75
80.0	1,215.40

While the above example only provides calculations for conveyance structure 0+00 of the Coincident Frequency Analysis, an identical process within HEC-SSP was used for each conveyance structure.

As a final step, a PC-SWMM model was developed with an exterior tailwater condition derived from the Coincident Frequency Analysis. This tailwater condition was set to an elevation that caused the calculated 1% Coincident Frequency Analysis Interior Ponding Elevation to occur with a 1% annual chance interior rainfall event (as opposed to a lower interior rainfall event with a higher exterior stage, or vice versa, which could be the case with a Coincident Frequency Analysis). The process was repeated for the 10%, 2%, and 0.2% annual chance events. These were considered the final models for evaluating interior ponding. Should changes occur to the interior drainage areas, which affect hydrology and/or hydraulics, the Coincident Frequency Analysis should be recomputed. The models provided only represent the current conditions and therefore should not be used to predict, without modifications and additional coincident frequency analyses, the 1% interior ponding elevation as a result of future conditions or changes.

HYDROLOGY RESULTS

The 1% annual chance peak discharges, rounded to the nearest 10 cfs, computed as part of this interior drainage analysis for select location along the Magnolia Road Ditch, The Slough, and the Old Smoky Hill River Channel are compared to the preliminary FEMA FIS discharges in Table 9.

Table 9: Comparison of 1% Annual Chance Peak Discharges (cfs)

Location	AMEC SWMM Link	Drainage Area* (sq miles)	Preliminary FIS	AMEC PC-SWMM
Magnolia Road Ditch				
At Edward Street	L76	0.16	540	480
Just upstream of Railroad & Belmont Boulevard	L10-C	0.2	500	470
Just downstream of Railroad & Belmont Boulevard	L54	0.36	230	160
Just downstream of Magnolia Road	L193	0.43	NA	280
At Outlet of Interstate I35	L72	1.17	775	400
The Slough				
At Cloud Street	L86	0.07	325	560
At Claflin Avenue	L90	0.21	580	690
At Minneapolis Avenue	L99	0.31	730	870
At Wilson Street	L107	0.63	1,220	1,680
At Crawford Avenue Surface	W1	0.93	950	640
At Crawford Avenue Stormwater Pipe	L185-C	0.93		550
At Prescott Avenue Surface	W2	0.95	1,090	380
At Prescott Avenue Stormwater Pipe	L185-C	0.95		550

Table 9: Comparison of 1% Annual Chance Peak Discharges (cfs)				
Location	**AMEC SWMM Link**	**Drainage Area* (sq miles)**	**Preliminary FIS**	**AMEC PC-SWMM**
Old Smoky Hill River Channel				
At Ohio Street	L136_1	0.42	500	130
At YMCA	L138	1.63	1,010	910
At Midway Avenue	L142	1.78	990	840
At Walnut Street	L151	2.47	750	770
At Iron Avenue	L155	2.6	710	1,020
At Elm Street	L160	2.88	700	820
At Ohio Street & Riverside Drive	L165	3.61	990	1,010
At Indiana Avenue	L187	3.82	970	1,240
Outlet At Levee CS 685+50	685+50D	4.55	500	410
*Drainage area in several locations is affected by surface runoff from adjacent watersheds.				

In comparing the computed peak discharges, the interior drainage analysis is significantly different than the previous FIS. The peak discharges in the Preliminary FIS were generated from hydrologic and hydraulic analyses using XP-SWMM Version 10.01. In comparing the two SWMM models, this new interior drainage analysis includes greater detail in regards to storage connectivity, stormwater routing, and surface water routing. A comparison to the rural regression equation was not performed because they are not applicable to urban stormwater systems such as this analysis.

Peak discharges, rounded to the nearest 10 cfs, developed as part of this interior drainage analysis are summarized in Table 10 below.

Table 10: Interior Drainage Analysis - Summary of Discharges						
Stream	Drainage Area** (sq miles)	Annual Chance Peak Discharge (CFS)				
		0.2%	1.0%	2.0%	4.0%	10.0%
Magnolia Road Ditch*						
At Edward Street	0.16	580	480	430	390	320
Just upstream of Railroad & Belmont Boulevard	0.2	470	470	470	350	340
Just downstream of Railroad & Belmont Boulevard	0.36	170	160	150	120	100
Just downstream of Magnolia Road	0.43	310	280	250	200	140
At Outlet of Interstate I35	1.17	380	400	400	400	370
The Slough*						
At Cloud Street	0.07	740	560	220	170	130
At Claflin Avenue	0.21	970	690	310	250	190
At Minneapolis Avenue	0.31	1,440	870	760	650	400
At Wilson Street	0.63	2,260	1,680	1,450	1,040	600
At Crawford Avenue Surface	0.93	2,140	640	160	0	0
At Crawford Avenue Stormwater Pipe	0.93	600	550	520	460	400
At Prescott Avenue Surface	0.95	1,350	380	0	0	0
At Prescott Avenue Stormwater Pipe	0.95	600	550	520	460	400
Old Smoky Hill River Channel*						
At Ohio Street	0.42	260	130	110	90	90
At YMCA	1.63	1,740	910	630	530	380
At Midway Avenue	1.78	1,290	840	610	540	410
At Walnut Street	2.47	900	770	750	740	660
At Iron Avenue	2.6	1,110	1,020	970	900	800
At Elm Street	2.88	900	820	790	750	690
At Ohio Street & Riverside Drive	3.61	1,110	1,010	920	860	740
At Indiana Avenue	3.82	1,660	1,240	1,090	980	810
Outlet At Levee CS 685+50	4.55	470	410	370	320	330
*Streams were studied using SWMM methods, therefore discharges may decrease going downstream.						
**Drainage area in several locations is affected by surface runoff from adjacent watersheds.						

HYDRAULIC RESULTS

The City of Salina experienced significant flooding events in 2007, and areas of high-water caused by these events were considered. Actual depths were not available for calibration, but water surface results from the interior drainage analysis were compared to the areas of high-water noted by the City of Salina. Conversely, areas where the city noted an absence of high-water during the flooding event were also compared. A summary of these comparisons is shown in Table 11.

Table 11: Comparison of Model Results with High-Water Observations		
Location	**Description of Observed High-Water**	**Description of Model Results**
South of Otto Street near Saturn Avenue	High-water in this area confirmed	Flooding in this area is predicted by model
Within the area bounded by Broadway Avenue, Cloud Street, and the Railroad	High-water in this area confirmed	Outside of detailed study area; flooding was not mapped
Near the intersection of Cherokee Drive and Comanche Drive	High-water in this area confirmed	Flooding predicted by model but does not meet mapping criteria
Near the intersection of Ohio Street and Republic Avenue	No high-water. Minor street ponding.	Flooding in streets but not impacting homes.
Near the intersection of Ohio Street and Crawford Road	No high-water. Minor street ponding.	Flooding primarily in streets. Potentially impacts two buildings, but survey may remove them from floodplain

Table 12 presents the static water surface elevations, rounded to the nearest tenth of a foot, for the interior ponding locations adjacent to the levee system as a result of this dependent and independent Coincident Frequency Analysis.

Table 12: Interior Ponding Elevations Adjacent To Levee					
Levee Conveyance Structure	**Percent Exceedance Water Surface Elevation (NAVD88 Feet)**				
	10.0%	**4.0%**	**2.0%**	**1.0%**	**0.2%**
0+00	1217.4	1218.2	1218.8	1219.4	1221.0
27+99	1223.1	1224.3	1224.9	1225.4	1226.0
44+18	1223.1	1223.5	1223.8	1224.3	1225.4
83+89.5	1223.4	1224.4	1225.3	1227.2	1229.0
107+55	1227.4	1228.0	1228.4	1228.9	1229.5
130+99	1227.9	1228.4	1229.0	1229.7	1230.7
175+00	1234.9	1235.0	1235.0	1235.0	1235.1
213+00	1237.3	1237.9	1238.5	1239.2	1240.5
306+67	1227.3	1228.1	1228.6	1228.9	1229.7
343+50	1229.3	1229.5	1229.6	1229.7	1230.0
364+33.5	1226.8	1227.9	1228.1	1228.3	1228.7
376+35	1261.6	1261.7	1261.7	1261.7	1261.8
408+05	1267.1	1267.2	1267.4	1267.5	1267.7

Table 12: Interior Ponding Elevations Adjacent To Levee					
Levee Conveyance Structure	Percent Exceedance Water Surface Elevation (NAVD88 Feet)				
	10.0%	4.0%	2.0%	1.0%	0.2%
435+50	1222.9	1223.0	1223.1	1223.2	1223.4
491+00	No interior ponding.				
506+92	1215.5	1216.8	1217.5	1218.2	1219.9
547+60	1214.7	1215.8	1216.0	1216.1	1216.2
562+30	1212.7	1212.9	1213.4	1214.2	1216.2
574+92	1214.9	1215.0	1215.1	1215.1	1215.3
614+05	1214.3	1214.4	1214.7	1215.0	1215.3
626+40	1213.1	1213.3	1213.5	1213.7	1214.1
631+80.5	1212.3	1212.4	1212.5	1212.7	1213.0
661+37.5	1213.2	1213.4	1213.5	1213.7	1213.9
685+50	1205.5	1206.1	1206.8	1207.6	1209.1

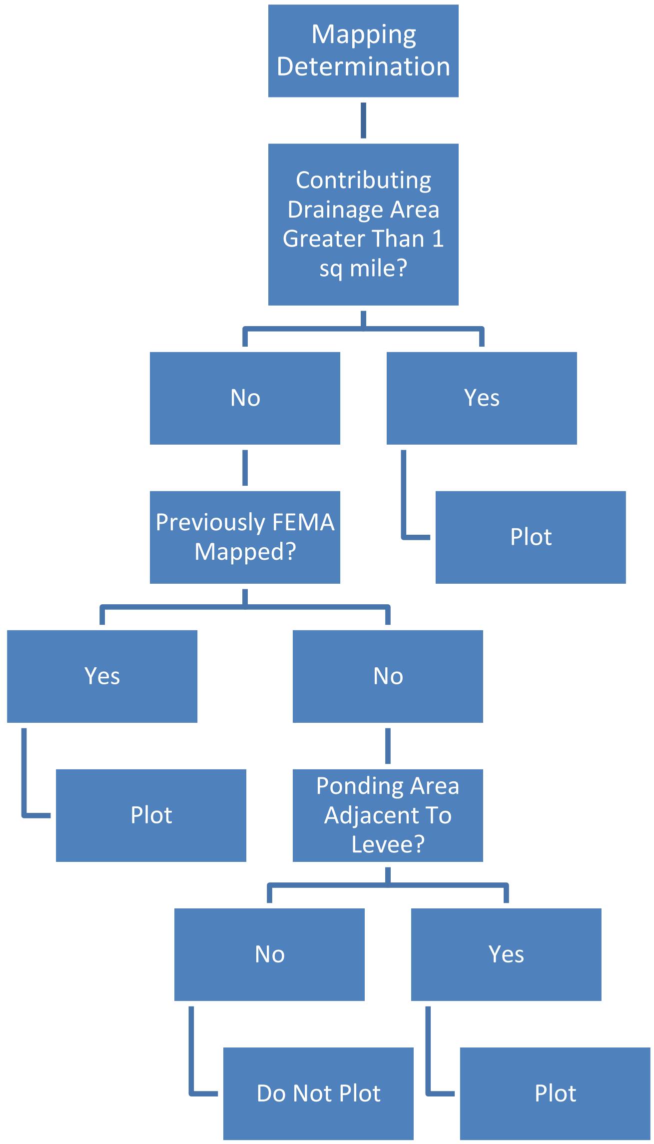
FLOODPLAIN MAPPING & CONCLUSION

Engineering judgment was used to determine what level of detail was necessary to adequately represent rainfall runoff and its travel path to and through the conveyance structures in the levee system. Some areas may include more detail based on the complexity of the system or to help the modeler better simulate existing conditions and produce more accurate results.

It is important to note that the PC-SWMM models for Groups 1, 2, 3, and 5 were used to analyze the interior drainage hydrology and are not meant to be used as hydraulic models. The results of these groups show that the amount of water ponding in the interior system is mainly a function of total volume of water draining to each outlet. While the timing of the hydrograph and level of detail along the routing flow paths is important, the volume and exterior stage elevations mainly control the final flooding elevation. Only water surface elevations adjacent to the levee are meant to be mapped within Groups 1, 2, 3, and 5.

The PC-SWMM model for Group 4 includes enough detail to accurately compute surface flood elevations for several locations throughout the watershed. Extra detail was given to those areas previously mapped and/or those areas in which additional conveyance was necessary. In general, the Group 4 PC-SWMM model represents several locations within the City of Salina in which low lying areas and streets are flooding as a result of storm runoff exceeding the stormwater system’s maximum capacity. Figure 6 was utilized to determine which surface flooding areas would be included on the FEMA flood maps.

Figure 6: Determination of Mapping



The PC-SWMM models developed as part of this interior drainage analysis have been included in current FEMA Data Capture Standards (DCS) Hydrology and Hydraulic format in this levee certification package. In order to best represent typical SWMM methodology the Hydrology DCS submission only includes the subbasin runoff input and output data while the Hydraulic DCS submission includes the routing of the runoff hydrographs (cumulative peak discharges along the system) and the computed water surface elevations. An exact representation of the SWMM model was included in shapefile form in the “Supplemental Data” folder of the submission. The shapefiles included in the “Supplemental Data” folder include the input parameters and output results for both free flow and Joint Probability Analysis conditions.

The ponding areas and associated base flood elevations have been included in map and digital format with this levee certification package. A floodplain mapping submission and digital DFIRM database can be found in this Levee certification package.

Disclaimer: This interior drainage analysis is currently in process as part of the Salina Levee Certification Project. As the levee certification project is completed components may require adjustment during the FEMA hydrologic and hydraulic phase of the riverine systems.

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Exhibit B. Restored Channel Water Balance

Smoky Hill River GI Study
Draft Integrated Feasibility Report and Environmental Assessment

September 2025

U.S. Army Corps of Engineers
Kansas City District

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Executive Summary

The Smoky Hill River Renewal Master Plan was adopted by the City of Salina in 2010 and identified the community's priorities and goals for the renewal of the original alignment of the Smoky Hill River. HDR, Inc. (HDR) has been tasked with refining those goals and development of the conceptual and preliminary design of the project. This technical memorandum documents refined estimates of the restored channel water balance, including infiltration and evapotranspiration (ET) losses, as water is diverted into and recirculated through the Smoky Hill River Renewal Project during drought conditions.

The segment of old channel considered includes the portions landward (west) of the Smoky Hill River levee. Total channel length evaluated is 38,820 ft, and total channel area is 34.2 acres. It is assumed the existing sediment in the channel bottom will be excavated resulting in an average water depth of three (3) to six (6) feet. Thirty-one (31) channel segments were evaluated and three (3) independent parameter values were modified in a sensitivity analysis to provide bounds on calculated channel infiltration loss estimates. Actual calculations of channel infiltration rates were determined by using Darcy's Law, and an empirical equation to estimate vertical hydraulic gradient, as modified from the Green-Ampt infiltration equation for trenches, and a siltation/biofouling correction factor. Infiltration rates calculated compare favorably to those from a correlation of grain size and published infiltration rates for large-scale infiltration facilities.

Soil borings near the channel were completed using hollow stem rotary augers and the samples within the channel bottom were completed using a combination of hand augers and Geoprobe. The soils encountered at the excavation grade reveal overall estimates of infiltration rates from 1.6 to 15.7 cfs, including infiltration losses and ET. In terms of yearlong totals, the estimated overall losses are between 1,570 and 10,420 acre-feet, as much as 2.8 times larger than previous estimates for the Smoky Hill River Renewal Project. Channel segments with the largest infiltration rates and sandy or coarse-grained soils at shallow depths have been identified—these segments are associated with Sample IDs: 1, 7, 18, 19, 20, 21, 22, 22a, 26, 27, and 30 (centered on River Stations: 1200, 5600, 6300, 11000, 12200, 13500, 14600, 15800, and 28600).

Actively mitigating exposure of high-permeability sandy sediments during excavation is recommended to reduce channel infiltration losses. When sandy segments are capped with clay, the estimated total losses are estimated to range from 550 to 2,540 acre-feet. These overall losses along the entire channel length are 65 percent and 76 percent less than losses calculated without mitigation.

1.0 Introduction & Purpose

The old Smoky Hill channel meanders 6.8 miles through Salina, Kansas. The original channel alignment (old channel) through town was isolated from flow in the 1960's by the construction of a levee and a bypass channel on the Smoky Hill River. The old channel has no sustained base flow and has accumulated sediment. The old channel continues to receive stormwater flows from approximately 75 storm sewer outfalls. The City of Salina has obtained a water right to divert a portion of the Smoky Hill base flow into the old channel (#47,510, priority date April 5, 2010). However, due to the sedimentation and various undersized culverts a restoration effort is needed.

The Smoky Hill River Renewal Master Plan was adopted by the City of Salina in 2010 and identified the community's priorities and goals for the renewal of the original alignment of the Smoky Hill River. HDR, Inc. (HDR) has been tasked with refining those goals and development of the conceptual and preliminary design of the project. This technical memorandum documents refined estimates of the restored channel water balance, including infiltration and evapotranspiration (ET) losses, as water is diverted into and recirculated through the Smoky Hill River Renewal Project during drought conditions with recreation season and off-season flows. The supplement Water Supply Alternatives Evaluation technical memorandum discusses several potential sources of water during drought conditions and the amount of flow available from each potential source.

2.0 Methods

The evaluation of the Smoky Hill River restored channel water balance considered losses caused by infiltration into the underlying channel bed, evaporation from open water and transpiration from the vegetation (evapotranspiration). Channel bed infiltration losses were analyzed at 31 segments of the channel, each centered on Geoprobe sampling/logging locations (**Figure 1**). The total length of old channel considered includes the portions landward (west) of the Smoky Hill River levee. Channel length and total open water area include a proposed connection between the restored Smoky Hill channel and Lakewood Lake. This additional connection accounts for 3,953 feet of length, and 2.17 acres of channel area. Total channel length evaluated is 38,820 feet, and total channel area is 34.2 acres. Channel length was measured in the ArcGIS environment (NAD83 StatePlane Kansas North FIPS 1501 [US Feet] projection). Channel area was determined by multiplying channel length by channel top width (assumed 40 feet everywhere, except at Lakewood Park where 21 and 28 feet were used).

Channel bed saturated hydraulic conductivity (*K*) estimates are based on a review of field logs and lab test results from soil samples obtained from sediment cores, and review of the hydraulic profiling tool (HPT) probe logs, each of which were taken from channel and near-channel locations. At each sampling/logging site, the sediment cores were collected within a few feet of the HPT logs. Environmental Priority Service, Inc. (EPS) performed HPT profiling and dual tube soil sampling via a track-mounted Geoprobe 6620DT rig (**Figure 2**).

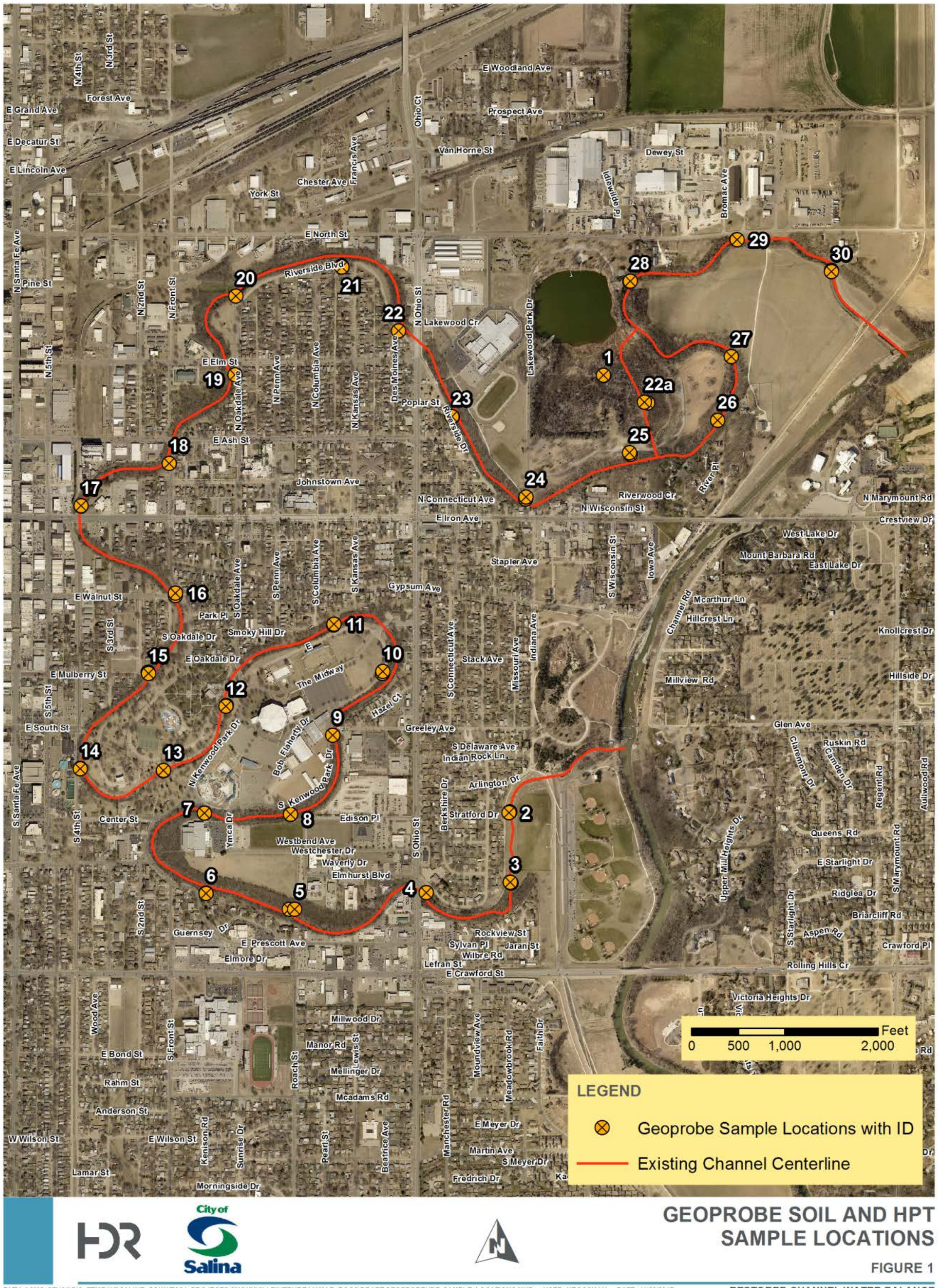


Figure 1 – Geoprobe Soil and Hydraulic Profiling Tool (HPT) Sample Locations

Figure 2 – Geoprobe Track-Mounted Unit at the Bottom of the Channel (Sample ID 12)

The sampling/logging was completed between September 20, and October 27, 2017. Soil samples were sent to the geotechnical lab (GSI Engineering, Inc.) for moisture and grain size analysis. Approximate sampling locations were coordinated by HDR, with final coordinates obtained by EPS (**Figure 1**). Ground surface elevations were determined via U.S. Geological Survey 2011 LiDAR (published October 2014) at the final sample locations.

EPS rented a crane to facilitate access to several locations that were advanced through the channel bottom sediments. Eleven locations (Sample IDs: 5, 6, 10, 18, 19, 20, 21, 22, 23, 24, and 25) were moved to the banks immediately adjacent to the channel due to conflicts with overhead power lines, thick tree canopy, steep side slopes, and in some cases deep ponded water. The borings at the top of bank were useful to evaluate the alluvial sediments that would remain after construction near the channel banks. Sample ID 22 was not sampled for laboratory analysis, but the HPT probe log was collected. Soil texture was approximated at this location based on comparison of the HPT profile with the HPT profile and soil logs from other sample locations. Two other cores/logs were collected at Lakewood Park (Sample IDs 1 and 22a), with coring and logging beginning at land surface.

As a worst case with respect to channel infiltration losses, it was assumed that the restored channel bed will require five (5) ft of sediment excavation along its full length in order to reach the design channel elevation. However, no excavation of sediment for the creation of channels in Lakewood Park is planned (affecting Sample IDs 1 and 22a). In this study, a deeper excavation depth is assumed than previously evaluated (cf., Smoky Hill River Renewal Master Plan Engineering Issues Report, WWE [2010]), in which case the *K* of shallow sediments (two-foot depth) were tested from only five locations along the channel. While the previous tests revealed fat clay and sediments with very low *K* values (ranging from 1E-05 to 7.7E-4 ft/d), that evaluation by KAW Valley Engineering, Inc. did not adequately quantify the depth to which excavation can safely be performed before any underlying high-permeability sediments are penetrated.

For this study the depth to higher permeability sediments was determined by evaluating the soil texture identified on soil logs, grain size distribution data (from lab testing), and HPT profiles (electrical conductivity [EC], injection pressure, and injection flow rate). The findings are presented herein as depth to the "first high-permeability soil layer" and have a considerable influence or impact on the computed water loss/infiltration rates if occurring near the excavation grade. Injection flow rate recorded during advance of the HPT tool is generally high in unsaturated soils, and because of injection at pressure, is generally not comparable to infiltration rates computed herein.

For reasons stated above, sediments sampled within the upper five feet of the channel were not considered in infiltration calculations since these sediments would be removed during construction. Soil texture recorded on soil logs by EPS from depths greater than five feet were assigned a USDA texture classification and expected *K* value based on typical values found in the soil hydrology literature (Rawls, 1982, Table 2). Soil texture classes for Sample ID 1 and 22a were also compared to, and generally correspond with those recorded by, KAW Valley Engineering, Inc. (2017). These *K* values form the basis for initial estimates of computed infiltration rates. Saturated hydraulic conductivity values reported by Rawls (1982) range from 0.047 ft/d for clay, to 16.54 ft/d for sand. Hydraulic conductivity was also estimated using the Hazen equation based on the D_{10} size of sediments from grain size analysis. Hazen-derived *K* values from sediments collected nearest the assumed excavation grade (seven samples) were compared to those obtained from the soil hydrology literature (Rawls, 1982), for verification purposes. In addition, it was noted that the *K* for clay obtained by KAW Valley Engineering, Inc., is of the same order of magnitude as that published in the hydrogeology literature (e.g., Freeze and Cherry, 1979).

Where "No Recovery" was noted on EPS soil logs, soils were classified as silt loam. This is in accordance with discussions between HDR and EPS of the most likely soil type. At 17 of the 31 Geoprobe boring locations, intervals listed as "No Recovery" were found at depths directly below the assumed excavation grade. It is noted that silt loam has a hydraulic conductivity of more than 10 times that of clay used as initial estimates in this study (0.535 ft/d vs. 0.047 ft/d).

If depth from the excavation grade to the first low-permeability soil layer was greater than two feet, or if the thickness of the first low-permeability soil layer was less than one foot, then the more coarse soil layer below excavation grade was used in assigning hydraulic conductivity. This likely resulted in the estimated *K* values that are higher than the actual effective values associated with a layered soil system. This is because of the controlling nature of low-permeability soil on the overall effective hydraulic conductivity. Even relatively thin low *K* soil layers have the potential to create localized perched water-table conditions, which would reduce the overall hydraulic gradient, and thereby limit infiltration.

The above described approach or methodology would seemingly calculate higher infiltration losses than would otherwise be anticipated during operation of the water recirculation plan. However, it is important to note the effects on infiltration losses caused by this conservatively estimated vertical *K* could be offset by the potential for lateral seepage of water along interfaces of layered soils beneath and away from the channel, which would not be accounted for by one-dimensional vertical profiling. In other words, the results may be overly conservative from a one-dimensional point of view, but potentially less conservative from a two- or three-dimensional point of view. The basis for considering this is that the sedimentary structures and strata deposited by meandering streams is spatially complex and the Geoprobe samples/logs indicate the potential for some low *K* soil layers to be disconnected across the long distances between sample locations (average is ~1,200 feet). Still, the overall approach is considered conservative (potentially high) for estimating water infiltration losses.

Actual calculations of channel infiltration rates were determined by using Darcy's Law, and an empirical equation to estimate vertical hydraulic gradient, as modified from the Green-Ampt infiltration equation for trenches, and a siltation/biofouling correction factor, all of which are described by Massmann (2003). Massmann (2003) provides the following equations used in estimating infiltration losses, beginning with Darcy's Law, written as follows:

Equation 1

$$f = 0.5Ki$$

where *f* is specific discharge or infiltration rate (uncorrected) of water through a unit cross-section of channel bed in in/hr, *K* is saturated hydraulic conductivity in ft/d, *i* is hydraulic gradient in ft/ft, and the factor of 0.5 converts from units of ft/d to in/hr.

Based on results of computer simulations for infiltration trenches (Massmann, 2003), the effective gradient under long-term steady-state conditions can be approximated with the following expression:

Equation 2

$$i \cong \frac{D_{wt} + D_{channel}}{78(K^{0.05})}$$

where D_{wt} is the depth from the base of the channel to groundwater in feet, and $D_{channel}$ is the depth of water in the channel in feet. Depth to groundwater is typically below the channel bottom for most of its length (WWE, 2010), and during a summer drought, depth to groundwater is anticipated to be even deeper. For this evaluation, depth to groundwater used in calculations had an average of 15.1 feet, and ranged from a low of 1.0 foot to a high of 24.0 feet along the channel length. The D_{wt} was evaluated using groundwater elevations (in observation wells) recorded in 1957 and 2010 water supply investigations (Wilson and Company, 1957; HDR, 2010), and from Lakewood Lake monitoring wells (KAW Valley Engineering, 2017). Channel bottom elevations were determined using drawings of the channel invert of the existing channel in the 2010 Master Plan (WWE, 2010), from which the assumed excavation depth of 5 feet was subtracted. The D_{wt} becomes shallower in the downstream direction. Depth to groundwater decreases from an estimated 24.0 feet, to an estimated 1.0 foot, and this leads to the vertical hydraulic gradient decreasing by about 85 percent along the channel, based on Equation 2.

Siltation, biofouling, and hydrocompaction of channel bottom sediments can occur over time reducing the infiltration rates. The correction factor for siltation and biofouling (assumed to include any hydrocompaction effects) is multiplied by the infiltration rate given by Equation 1, yielding the following expression:

Equation 3

$$f_{corr} = \left(CF_{silt/bio}\right)f$$

where f_{corr} is the corrected infiltration rate in in/hr, and $CF_{silt/bio}$ is the correction factor for siltation and biofouling. Table 6 of Massmann (2003) provides a rubric for estimating $CF_{silt/bio}$. To account for variability in the correction factor, two different values were used for evaluation scenarios. For Scenario A, a value of 0.8 was used, and for Scenario B, a value of 0.75 was used. Siltation and biofouling are expected because there is not sufficient pre-treatment of the storm water and because the channel is located beneath trees and other vegetation. A higher value is used for Scenario A to capture a deeper depth of water in the channel, which inherently would have a smaller impact of siltation and biofouling of the bottom sediment, as well as produce higher potential for lateral infiltration into the channel sides/banks.

Infiltration rates calculated using Equations 1–3 were compared against measured long-term infiltration rates for full-scale facilities that was correlated to grain size distribution data (ASTM D422) which was presented by WDOE (2001), for verification purposes and as the basis for addressing a range of possible infiltration rates. Based on the correlation by WDOE (2001), a regression equation was developed (power function) to estimate infiltration rates from grain size data collected in this study. **Table 1** lists the published values of the D_{10} grain size of sediments (10 percent of sediments finer) and the related measured long-term infiltration rates (after WDOE, 2001). The regression equation obtained takes on the following form, $f = 24.831(D_{10})^{1.1374}$, where D_{10} is in mm, and f is in in/hr. WDOE (2001) states that rates shown in **Table 1** are for homogeneous soil conditions, and that if more than one soil unit is encountered within six feet of the base of the facility (or 2.5 times the proposed maximum water design depth), use the lowest infiltration rate determined from each of the soil units as the representative infiltration rate. It should be noted that the soils forming the basis of the correlation would be classified as sands or sandy gravels, and no data was available for finer soils (WDOE, 2001).

Table 1 – Infiltration Rates Based on ASTM D422 Grain Size Analyses (from Table 3.8 in Vol. III, WDOE, 2001)

D_{10} Size from ASTM D422 Soil Gradation Test, mm	Estimated Long-Term Infiltration Rate, in/hr
>0.4	9
0.3	6.5
0.2	3.5
0.1	2.0
0.05	0.8

3.0 Scenarios Evaluated

The old Smoky Hill restored channel water balance, including flow rates and associated infiltration and ET losses, was evaluated under two flow conditions. It is anticipated the project will utilize a seasonal flow variation, with higher flows during the warmer months. The seasonal flow variation and timing will be developed as part of the Section 1135 Smoky Hill River Aquatic Ecosystem Restoration Feasibility Study (1135 Study) being performed by the USACE, Kansas City District. The results of the 1135 Study are not yet available and for this analysis it is assumed —Scenario A: Recreation season flow—has a flow rate of 80 cfs, and the second —Scenario B: Off-season flow—has a flow rate which may be as low as 10 cfs. Ten (10) cfs is considered the lowest range of normal operation. These form the basis of conservative (high) estimates of seasonal losses (in cfs) and yearlong losses (in acre-feet per year), as the combined flows over the course of year result in flows nearly equaling the existing water right for diversions.

Calculations of yearlong infiltration losses assume a 5-month recreation season (May–Sept.) with the higher 80 cfs flow, and a seven-month off-season (Oct.–Apr.) with flow of 10 cfs. To represent drought conditions, ET losses assume a rate 25 percent larger than the monthly average evaporation for months where data exists (Apr.–Oct.), and a rate 75 percent less during winter months (Nov.–Mar.). These factors were chosen to account for the typically hotter than normal temperatures and lower than normal dew points common for drought conditions. No rainfall is included in the channel water balance to represent a conservative drought condition. Hydrologic characteristics assumed for these two scenarios are listed in **Table 2**. The channel bottom profile will be developed through the 1135 Study and for the purpose of this analysis; it is assumed the average water depths were 5.9 feet and 2.6 feet for Scenarios A and B, respectively.

Table 2 – Hydrologic Characteristics of Channel Water Balance Scenarios

Scenario	Channel Flow Rate	Channel Top Width	Average Water Depth	Depth to Water Table	Mean ET Rate	Total Channel Area
	(cfs)	(ft)	(ft)	(ft)	(in/d)	(acres)
Scenario A: Recreation Season Flow	80	40	5.9	1.0–24.0 (15.1 avg)	0.39	34.2
Scenario B: Off-Season Flow	10	40	2.6	1.0–24.0 (15.1 avg)	0.10	34.2

Apart from the flow conditions assessed, the seasonal and yearlong losses caused by infiltration were also evaluated for conditions with and without mitigating exposure of high-permeability (sandy) soils while excavating channel sediments during construction. Therefore, losses caused by infiltration were evaluated for soils encountered during sampling/logging, and a separate case that assumes replacement of exposed sandy soils by compacted clay.

4.0 Range of Parameters Evaluated

To address the potential uncertainty of parameter values, three parameters in Equations 1–3 were varied from initial estimates at each channel segment to achieve lower and upper bounds of infiltration rates and overall water losses. These three parameters are K, D_{wt}, and $CF_{silt/bio}$, all of which were varied from initial estimates in combination. While varying the parameters individually was considered, evaluating the combined influence of parameter uncertainty leads to the greatest range. Evapotranspiration losses are generally small compared to infiltration rates, and thus held fixed at initially determined values in calculations of overall channel losses.

For calculations for the case when exposure of high-permeability (sandy) soils during channel construction is not mitigated, the following adjustments were made to initial parameter values: (1) the hydraulic conductivity (K) of channel bed sediments were varied by ±100 percent; (2) depth to groundwater (D_{wt}) was varied by ±2 feet, with a minimum value set at 1.0 feet; and (3) $CF_{silt/bio}$ was varied by ±0.2. The sensitivity of infiltration losses to these parameter changes from largest to smallest is as follows: K, $CF_{silt/bio}$, and then D_{wt}. The lower bound of the value of K for clay was assigned a value of 7.7E-4 ft/d—based on the largest lab measurement from channel bed clays by KAW Valley Engineering, Inc. (WWE, 2010). Therefore, clay K values were evaluated between a range from 7.7E-4 and 0.094 ft/d (initial estimate equals 0.047 ft/d). The magnitude of the ranges assessed is somewhat arbitrary but based on professional judgment meant to reflect expected possible variations in channel infiltration losses. Despite this, there is no guarantee expressed that parameter ranges evaluated will fully encapsulate actual realized infiltration rates and channel losses. For conditions in which exposure of sandy soils while excavating during channel construction is mitigated, by placement of compacted clay, the same ranges were applied to parameter values as described above, with one key exception: (1) for the sandy channel segments (7 classified as sand, loamy sand or sandy loam), *K* was assigned that of clay. The range of parameters evaluated and their initial estimates, expressed as average among channel segments, are displayed in **Table 3**.

Table 3 – Average Channel Segment Values of Initial, Lower and Upper Bounds of Parameter Values

Parameter Set	Scenarios A & B Saturated Hydraulic Conductivity With Exposed Sands, *K*	Scenarios A & B Saturated Hydraulic Conductivity Without Exposed Sands, *K*	Scenarios A & B Depth to Groundwater, D_{wt}	Scenario A Siltation and Biofouling Correction Factor, $CF_{silt/bio}$	Scenario B Siltation and Biofouling Correction Factor, $CF_{silt/bio}$
	(ft/d)	(ft/d)	(ft)	(-)	(-)
Lower Bounds	0.85	0.17	13.2	0.6	0.55
Initial Estimates	1.71	0.35	15.1	0.8	0.75
Upper Bounds	3.42	0.70	17.1	1.0	0.95

5.0 Results

Hydraulic conductivity estimates using the Hazen equation (based on the D_{10} from grain size analyses) range from 0.005 to 60.1 ft/d (seven samples). These values have a slightly larger range than the initial *K* values assigned based on soil texture from Geoprobe cores and associated literature values—the latter ranging from 0.047 ft/d for clay, to 16.5 ft/d for sand. Excluding the highest value of 60.1 ft/d, the highest *K* is 11.6 ft/d, similar to that of a loamy sand or sand. The value of 60.1 ft/d is from sediments 2–4 feet below excavation grade at Sample ID 28 where fine to coarse sand was sampled and EC values are lower than 20 mS/m. Sediments directly above this have EC values of ~25–40 mS/m. Chen et al. (2008), using Geoprobe EC logs and falling head permeameter tests on sediments sampled along the Platte River, central Nebraska, concluded that EC values for sand and gravel are around 2–30 mS/m, often greater than 80 mS/m for silt and clay, and generally 40–60 mS/m for silt and fine sand. The lowest value obtained with this method (0.005 ft/d) is for a soil layer from Sample ID 14 classified as sandy clay with a 0.63 fraction of fines (silt and clay), collected from 3.6–5 feet below excavation grade. The EC values for this interval are about 40–60 mS/m. These results generally corroborate the assignment methodology and *K* values used in calculations of infiltration rates. See the **Appendix** to this technical memorandum for HPT profiles (EC, injection pressure, and injection flow rate) from all 31 Geoprobe sample locations. In general, sandy layers have lower EC and pressure values, and silt and clay layers have higher EC and pressure values. Therefore, the EC and pressure curves in the **Appendix** provide a quick visual estimate of the relative hydraulic conductivity of the sediments encountered.

The vertical hydraulic gradient calculated using Equation (2) varies from 0.085 to 0.51 ft/ft for Scenario A and from 0.044 to 0.45 ft/ft for Scenario B among individual channel segments, considering the range of K and D_{wt} described above in Section 4.0.

From Equation (3), using initial estimates of parameter values with K based on the sediments encountered directly beneath the excavation grade, the calculated corrected infiltration rates range from 0.003 to 2.20 in/hr for Scenario A and from 0.002 to 1.84 in/hr for Scenario B (assuming no mitigation for exposed sands). Considering the range of K, D_{wt} and $CF_{silt/bio}$ described in Section 4.0, infiltration rates range from 0 to 5.68 in/hr for Scenario A and from 0 to 4.84 in/hr for Scenario B, among individual channel segments, without mitigation for exposed sands (**Tables 4 and 5**).

Long-term infiltration rates for full-scale infiltration facilities correlated to grain size analysis data (ASTM D422) presented by WDOE (2001), were compared to grain size analyses of sediments collected in this study nearest the assumed excavation grade. **Table 6** lists the calculated long-term infiltration rates based on the regression of the D_{10} size to the published long-term infiltration rates. Rates from this calculation (shown in **Table 6**) range from 0.01 to 2.77 in/hr, which are fully encapsulated by the range calculated for Scenarios A and B, when the parameter uncertainty range is considered.

Table 4 – Scenario A: Recreation Season Flow (80 cfs) Channel Infiltration Rates

Parameter Set	Min	Max	Mean	Median	Total[a]
	(in/hr)	(in/hr)	(in/hr)	(in/hr)	(cfs)
Lower Bounds	0.000	0.80	0.06	0.03	2.1
Initial Estimates	0.003	2.20	0.17	0.07	5.9
Upper Bounds	0.009	5.68	0.46	0.18	15.7

[a]Assumes a total channel area of 34.2 acres

Table 5 – Scenario B: Off-Season Flow (10 cfs) Channel Infiltration Rates

Parameter Set	Min	Max	Mean	Median	Total[a]
	(in/hr)	(in/hr)	(in/hr)	(in/hr)	(cfs)
Lower Bounds	0.000	0.65	0.05	0.02	1.6
Initial Estimates	0.002	1.84	0.14	0.06	4.7
Upper Bounds	0.005	4.84	0.37	0.15	12.8

[a]Assumes a total channel area of 34.2 acres

Table 6 – Infiltration Rates Estimated Based on ASTM D422 Grain Size Analysis from This Study

Sample ID	Sample Interval Depth Below Existing Channel, ft	D_{10} Size from ASTM D422 Soil Gradation Test, mm	Estimated Long-Term Infiltration Rate, in/hr
3	8–10	0.0596	1.00
7	5–9.6	0.0127	0.17
13	11–12.6	0.064	1.09
14	8.6–10	0.0013	0.01
27	3.7–7.4	0.0346	0.54
28	7–9	0.1456	2.77
1	3.6–4.6	0.029	0.44

During times with recreation season flow (Scenario A), infiltration causes an overall channel water loss of between 2.1 and 15.7 cfs. Initial estimates of parameter values cause overall channel infiltration losses at a rate of 5.9 cfs for Scenario A (**Table 4**). During times with off-season flow (Scenario B), infiltration causes an overall channel water loss of between 1.6 and 12.8 cfs, with initial estimates of parameter values leading to overall channel infiltration losses at a rate of 4.7 cfs (**Table 5**). When losses to infiltration in sandy segments are mitigated by replacement by clay, the calculated infiltration losses are drastically reduced. Infiltration losses calculated under these conditions range from 0.5 to 3.5 cfs for Scenario A and from 0.3 and 2.9 cfs for Scenario B.

Calculated ET rates for the channel during summer drought conditions and the rest of year, as well as the total water lost to ET over a year, are presented in **Table 7**. Evapotranspiration rates from Apr. through Oct. amount to a total channel loss of 0.32 cfs (230 acre-ft); while ET rates from Nov. through Mar. cause a total channel loss of 0.06 cfs (40 acre-ft). Along the entire length of channel, yearlong losses due to ET equal 270 acre-ft. This rate does not vary between the scenarios evaluated since the total channel area has assumed to remain equal.

The total water losses, including infiltration and ET, are listed in **Table 8**. Yearlong losses due to infiltration are the sum of Scenario A and Scenario B losses, equaling 1,300–10,150 acre-ft along the full length of the channel. Combining these yearlong losses (from infiltration and ET) yields a total loss of 1,570–10,420 acre-ft per year. These values decrease when infiltration losses are mitigated by replacing expose sands with clay. Total yearlong losses due to infiltration in this case are 280–2,270 acre-ft, and those due to infiltration and ET are 550–2,540 acre-ft.

Table 7 – Drought Condition and Yearlong Evapotranspiration Rates

Highest Monthly ET[a]	Apr.–Oct. Mean ET Rate	25% Increase—Apr.–Oct. Mean ET Rate	Nov.–Mar. Mean ET Rate	Annual Rate[b]	Annual Total[b]
(in/d)	(in/d)	(in/d)	(in/d)	(cfs)	(acre-ft)
0.37	0.31	0.39	0.10	0.373	270

[a]Highest ET is for the month of July from Kanapolis Dam pan evaporation data (1949–1978); Source: Farnsworth and Thompson (1982)
[b]Assumes a total channel area of 34.2 acres; rounding is done once after summing Apr.–Oct. and Nov.–Mar. ET losses

Table 8 – Total Water Losses (Infiltration and Evapotranspiration)

Parameter Set	Scenario A: 5-Month Volume Lost to Infiltration	Scenario B: 7-Month Volume Lost to Infiltration	Annual Volume Lost to ET	Combined Yearlong Total Volume Lost
	(acre-ft)	(acre-ft)	(acre-ft)	(acre-ft)
Lower Bounds	630	670	270	1,570
Initial Estimates	1,790	1,990	270	4,050
Upper Bounds	4,740	5,410	270	10,420
Lower Bounds[a]	140	140	270	550
Initial Estimates[a]	400	440	270	1,110
Upper Bounds[a]	1,060	1,210	270	2,540

[a]Assumes all seven sandy channel segments have exposed sands replaced by clay

Figure 3 illustrates the estimates of hydraulic conductivity and volumetric loss of water to infiltration into the channel bed for each segment along the length of the channel under conditions in which sands are exposed during excavation. Additionally, **Figure 3** also provides ancillary information, including whether the Geoprobe sampling/logging was performed in the channel bottom or on the adjacent banks, the length and area of the channel segments evaluated, and the river stations most closely located to the Geoprobe sample locations. From **Figure 3** it can be concluded that the majority of channel segments have infiltration losses of less than 0.04 cfs for the low parameter estimates (see “Lower Bound” in **Table 3**), and that the majority of segments have infiltration losses of less than 0.3 cfs for the high parameter estimates (see “Upper Bound” in **Table 3**). Segments with larger infiltration rates include those associated with Sample IDs: 7 (River Station 28600), 18–20 (River Stations 13500–15800), 22 (River Station 11000), and 26–27 (River Stations 5600–6300). Of these sandy river segments with larger infiltration rates, Sample IDs 18–20 and 22 were located on top of the channel banks. HPT profiles and soil samples generally reveal coarser-grained sediments from sample sites located on the banks, with the exception of Sample IDs 5, 6, and 10.

Yearlong infiltration losses have been mapped (**Figure 4**) along each channel segment to display the relative contributions of each segment to the overall infiltration loss. Infiltration rates shown on **Figure 4** represent those from use of initial parameter estimates and assume no mitigation of exposed sands.

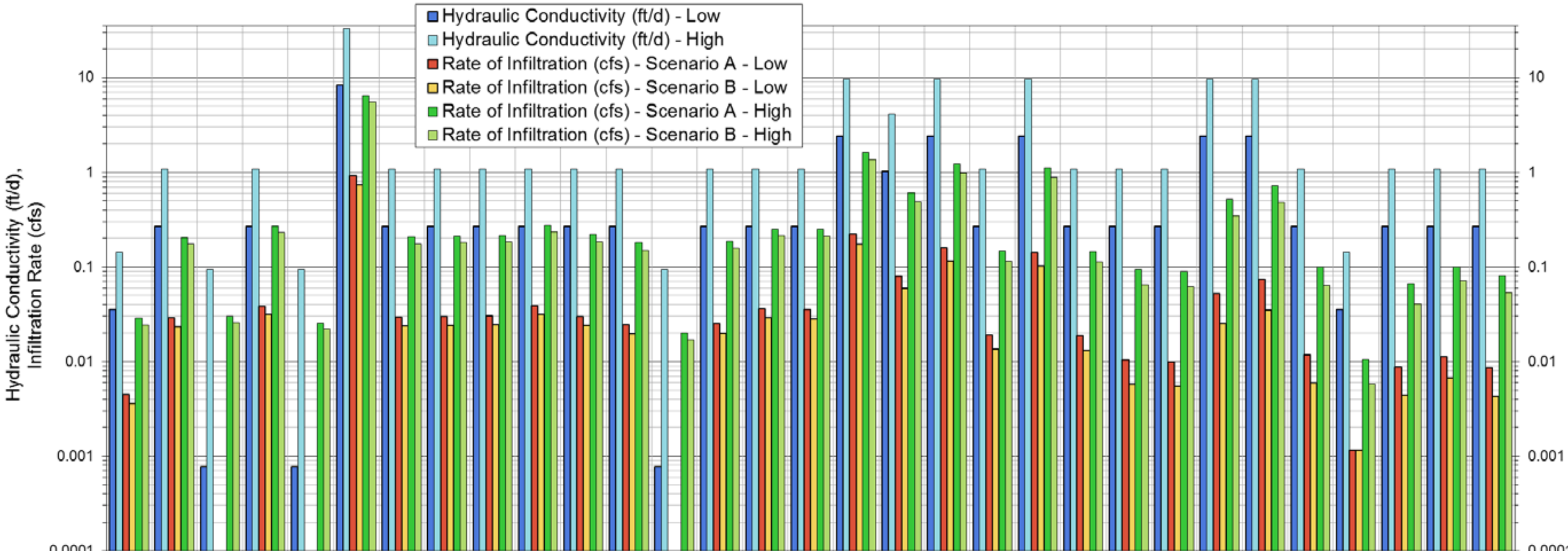
Table 9 displays the approximate depths to, and elevation of the top of, the first high-permeability soil layer. This was based on interpretation of HPT profiles, soil logs and lab test results of grain size distribution and soil type. Those with depths less than ~6 feet (excluding Lakewood Park) include Sample IDs: 7, 18, 20, 21, 27, and 30. Lakewood Park Geoprobe samples (1, and 22a) also revealed a shallow depth to high-permeability sediments.

6.0 Discussion and Recommendations

The approach and results presented in this study provide improved estimates of infiltration and ET losses during the recreation season and off-season along 31 channel segments, and the combined total losses over a given year along the entire restored Smoky Hill River channel. Overall infiltration rates previously reported are less than 2 cfs (WWE, 2010). The amount of excavation within the channel bottom will be developed during the 1135 Study. It is assumed an average of 5 feet of excavation will be considered during the 1135 Study which will result in average water depths between 2.6 feet and 5.9 feet. The soils analyzed at that depth within this study and reveal overall infiltration rates that could equal 1.6 to 15.7 cfs. In terms of yearlong totals, WWE (2010) reported channel losses of 1,544 to 3,716 acre-feet, whereas total losses calculated in this study are between 1,570 and 10,420 acre-feet, as much as 2.8 times larger, when the deeper soils are evaluated and assuming no active reduction in the exposure of high-permeability sandy sediments occurring at excavation grade.

The types and thickness of channel and near-channel sediments control the channel bed hydraulic conductivity. Therefore, the infiltration is affected by factors such as stream morphology, the erosion and deposition process, transport and settling of fine materials, as well as sedimentary structure and grain-size distribution (Wang et al., 2016). The evaluation performed in this study reveals the distinctly different silt-clay layers and sandy layers from the HPT profiles at the 31 sampled locations. While this is a large improvement on spatial coverage, this study may not fully quantify the variations among the entire channel. The exact location of the sand seems both in depth and horizontally as well as the thickness will vary greatly in alluvial deposits which poses multiple challenges in both quantifying the losses and for the design of mitigation strategies. Some sand seems maybe interconnected allowing large volumes to be infiltrated where as some may be isolated allowing only a finite amount of infiltration, which further complicates the analysis.

For conditions in which the exposure of sandy high-permeability sediments are not monitored and mitigated during channel construction, several assumptions were made that are thought to assess worst-case conditions for estimating channel water losses, thereby making the estimates conservative (high). Here is a summary of the assumptions having the largest impact on the resulting channel water losses (infiltration and ET rates):



	Ch	Ch	Ch	Bk	Bk	Ch	Ch	Ch	Bk	Ch	Ch	Ch	Ch	Ch	Ch	Ch
Hydraulic Conductivity (ft/d) - Low	0.04	0.27	0.0008	0.27	0.0008	8.27	0.27	0.27	0.27	0.27	0.27	0.27	0.0008	0.27	0.27	0.27
Hydraulic Conductivity (ft/d) - High	0.14	1.07	0.09	1.07	0.09	33.08	1.07	1.07	1.07	1.07	1.07	1.07	0.09	1.07	1.07	1.07
Rate of Infiltration (cfs) - Scenario A - Low	0.004	0.029	0.000	0.039	0.000	0.912	0.029	0.030	0.030	0.039	0.030	0.025	0.000	0.025	0.036	0.036
Rate of Infiltration (cfs) - Scenario B - Low	0.004	0.023	0.000	0.031	0.000	0.736	0.024	0.024	0.024	0.032	0.024	0.020	0.000	0.020	0.029	0.028
Rate of Infiltration (cfs) - Scenario A - High	0.029	0.203	0.030	0.271	0.026	6.484	0.206	0.210	0.213	0.275	0.221	0.181	0.020	0.187	0.252	0.251
Rate of Infiltration (cfs) - Scenario B - High	0.024	0.173	0.026	0.232	0.022	5.522	0.176	0.179	0.182	0.235	0.184	0.150	0.017	0.156	0.215	0.212
Channel Length (ft)	967	1007	1478	1345	1254	1233	1022	1039	1057	1364	1300	1061	1213	1143	1246	1324
Channel Area (acres)	0.888	0.925	1.357	1.235	1.152	1.132	0.938	0.954	0.971	1.253	1.194	0.974	1.114	1.050	1.144	1.216
River Station	34900	34100	32800	31100	30200	28600	27700	26600	25600	24400	22900	21800	20700	19400	18400	16900
Sample ID	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

	Bk	Bk	Bk	Bk	Bk	Bk	Bk	Bk	Ch	Ch	Ch	Ch	Ch	LW	LW
Hydraulic Conductivity (ft/d) - Low	2.41	1.02	2.41	0.27	2.41	0.27	0.27	0.27	2.41	2.41	0.27	0.04	0.27	0.27	0.27
Hydraulic Conductivity (ft/d) - High	9.62	4.08	9.62	1.07	9.62	1.07	1.07	1.07	9.62	9.62	1.07	0.14	1.07	1.07	1.07
Rate of Infiltration (cfs) - Scenario A - Low	0.223	0.079	0.159	0.019	0.142	0.019	0.010	0.010	0.053	0.073	0.012	0.001	0.009	0.011	0.009
Rate of Infiltration (cfs) - Scenario B - Low	0.174	0.060	0.115	0.013	0.102	0.013	0.006	0.005	0.025	0.035	0.006	0.001	0.004	0.007	0.004
Rate of Infiltration (cfs) - Scenario A - High	1.626	0.602	1.229	0.147	1.118	0.144	0.094	0.090	0.518	0.721	0.100	0.010	0.067	0.100	0.081
Rate of Infiltration (cfs) - Scenario B - High	1.355	0.487	0.976	0.116	0.879	0.113	0.064	0.062	0.344	0.478	0.063	0.006	0.041	0.071	0.054
Channel Length (ft)	1185	1190	1199	1212	1148	1189	1242	1187	933	1298	1593	1252	1186	2294	1659
Channel Area (acres)	1.088	1.093	1.101	1.113	1.054	1.092	1.140	1.090	0.857	1.192	1.463	1.150	1.089	1.106	1.066
River Station	15800	14600	13500	12200	11000	9900	8700	7400	6300	5600	3700	2400	1200		
Sample ID	18	19	20	21	22	23	24	25	26	27	28	29	30	1	22a

Notes:

Ch = sampling/logging in channel bottom

Bk = sampling/logging on the top of channel bank

LW = sampling/logging in Lakewood Park

Figure 3 – Range of Hydraulic Conductivity and Volumetric Infiltration Rates (Logarithmic Scale) by Channel Segment for the Case with No Mitigation of Sands

Table 9 – Depth to First High-Permeability Soil Layer by Channel Segment

Sample ID	River Station	Depth to First High-Permeability Soil Layer (ft)	Elevation of First High-Permeability Soil Layer (ft NAVD88)	Notes
2	34900	8.0	1208.8	Levee to mid-way point with 3
3	34100	8.0	1207.8	
4	32800	9.2	1208.5	
5	31100	12.3	1200.7	Boring on top of bank; excavation estimated 6.5 ft depth below start of HPT
6	30200	>15.1	1200.0	Boring on top of bank; excavation estimated 6.5 ft depth below start of HPT
7	28600	5.9	1206.1	
8	27700	8.6	1203.4	
9	26600	14.6	1197.9	
10	25600	6.1	1205.4	Boring on top of bank; excavation estimated 6.5 ft depth below start of HPT
11	24400	9.4	1202.2	
12	22900	12.4	1200.3	
13	21800	6.1	1203.6	
14	20700	12.1	1196.8	
15	19400	10.4	1197.6	
16	18400	15.2	1202.2	
17	16900	6.8	1200.5	
18	15800	2.0	1204.7	Boring on top of bank; excavation estimated 7 ft depth below start of HPT
19	14600	7.3	1199.8	Boring on top of bank; excavation estimated 5.5 ft depth below start of HPT
20	13500	0.0	1205.4	Boring on top of bank; excavation estimated 6 ft depth below start of HPT
21	12200	4.1	1205.8	Boring on top of bank; excavation estimated 8 ft depth below start of HPT
22	11000	7.7	1195.2	Boring on top of bank; excavation estimated 6.5 ft depth below start of HPT
23	9900	9.2	1199.5	Boring on top of bank; excavation estimated 6.5 ft depth below start of HPT
24	8700	9.7	1194.7	Boring on top of bank; excavation estimated 6.5 ft depth below start of HPT
25	7400	11.0	1198.4	Boring on top of bank; excavation estimated 6.5 ft depth below start of HPT
26	6300	5.8	1194.5	
27	5600	3.5	1197.5	
28	3700	6.0	1192.0	
29	2400	11.8	1186.4	
30	1200	3.3	1196.7	
1		3.1	1197.2	Lakewood Park
22a		1.9	1196.2	Lakewood Park

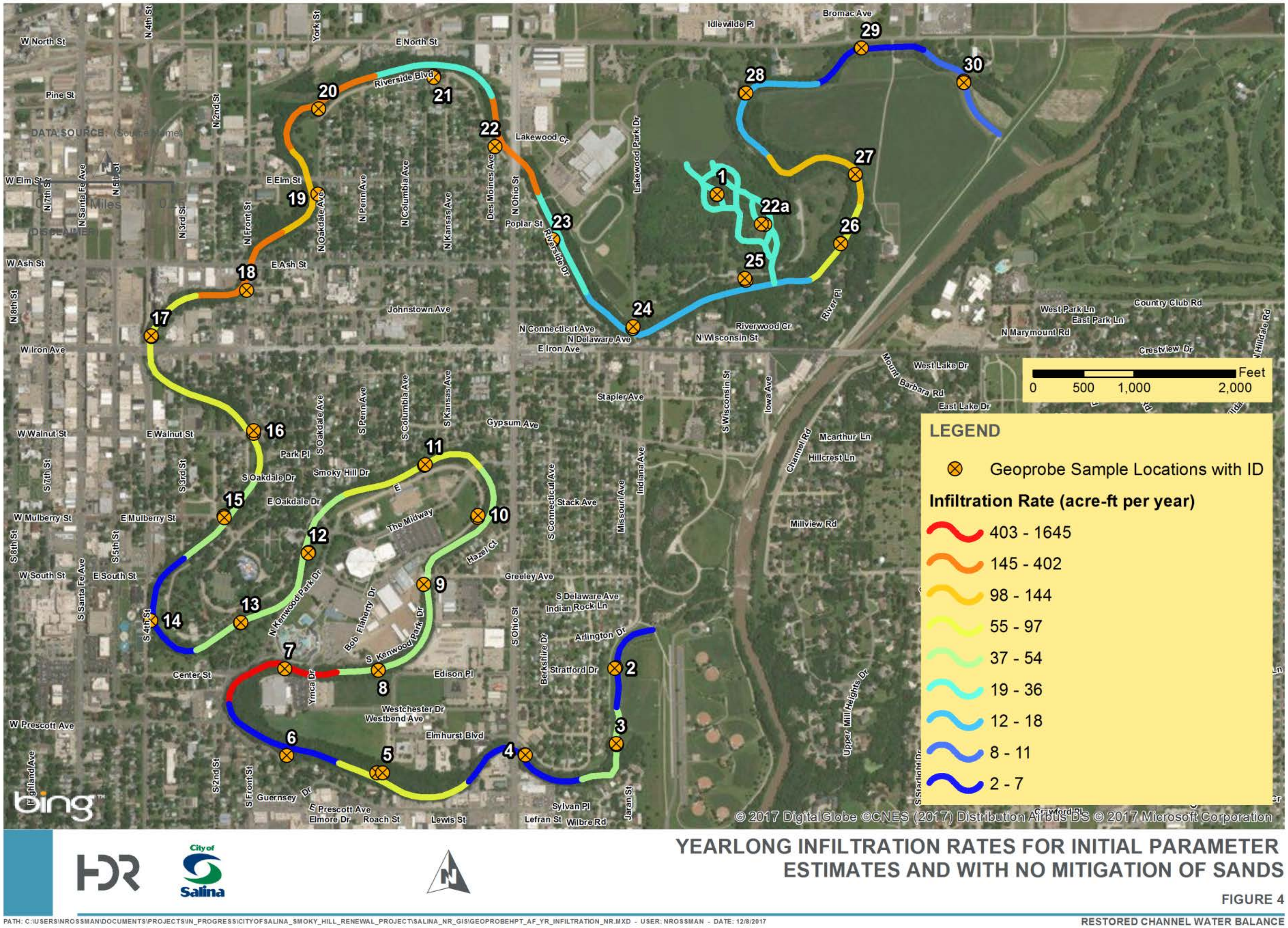


Figure 4 – Yearlong Infiltration Rates by Channel Segment for Initial Parameter Estimates and the Case with No Mitigation of Sands

- Use of literature values for saturated hydraulic conductivity based on soil texture (initial estimate and upper bound for clay is about 100 times greater than values reported by WWE (2010) and by Freeze and Cherry (1979)
- Excavation to create a 5-foot depth of water (except at Lakewood Park)
- Soil texture of layers found directly beneath the excavation grade were used in computations (excludes the potential for infiltration reduction caused by extensive low-permeability layers at deeper depths)
- Silt loam assumed for sample intervals with no sample recovery (17 of 31 samples)
- Channel top width of 40 feet everywhere (except at Lakewood Park) for both scenarios
- No concrete/impermeable channel bed along any length of channel
- 2.17 acres of channel will be constructed connecting the channel with Lakewood Lake
- Evapotranspiration occurs at rate 25 percent larger than mean, and there is no rainfall

It is important to point out that the majority of losses are due to infiltration when sandy high-permeability sediments are not sealed during channel construction (ET is about 3–17 percent of infiltration losses in this case), and that the majority of infiltration losses are focused at these channel segments. In fact, 78 percent of infiltration losses with recreation season flows (Scenario A) occur from just seven of the 31 segments evaluated (23 percent). If these seven segments were designed to have sandy materials replaced by clay (K = 0.0008—0.05 ft/d), the total infiltration losses calculated would be 0.5 to 3.5 cfs for Scenario A, and 0.3 to 2.9 cfs for Scenario B. When combined with ET losses, yearlong losses would range from 550 to 2,540 acre-feet. These overall losses along the entire channel length are 65 percent and 76 percent less than those calculated without mitigation efforts.

During the seven-month long off-season, keeping the channel wet, or maintaining pools, requires about as much water as lost to infiltration and ET. This could require approximately 5.0 cfs without mitigating for sandy reaches. Considering the uncertainty range of parameter values used in calculations, however, that estimate may vary from approximately 2.0 to 13.2 cfs. When sandy segments have sands replaced by clay, these losses in the off-season decrease, resulting in estimated flows required to maintain pools equal to approximately 0.7–3.3 cfs.

Areas of concern that are relatively sandy or have coarse-grained sediment at shallow depths, include channel segments associated with Sample IDs: 1, 7, 18, 19, 20, 21, 22, 22a, 26, 27, and 30 (centered on River Stations: 1200, 5600, 6300, 11000, 12200, 13500, 14600, 15800, and 28600).

In order to mitigate or reduce excessive infiltration losses, it is recommended that a geotechnical engineer be on site periodically during construction to evaluate exposed sediments. Sufficient low-permeability sediment (ideally >50 percent fines) should be kept in place where present and when possible. If relatively high-permeability sediments (e.g., sandy soils with less than 20 percent fines) are exposed as construction proceeds, it is recommended that those areas be improved by over-excavating and replacing with one foot of compacted clay. The compacted clayey soils may be segregated from surficial sediments excavated elsewhere along the channel.

It should be expected that higher infiltrations rates would exist when the channel is initially excavated and placed into service. Over time, the infiltration rate will decrease from the reduction of the hydraulic gradient as moisture content of the soil increases and from the natural process of fine-grained suspended solids moving through the system and being pulled into infiltration areas. Similar processes might be needed following maintenance excavation. The water level will be lowered to support the maintenance activities but some ponded water may remain in the channel. The excavation operator may not be able to fully observe the surficial soils and may inadvertently expose sand seems. If it is believed a sand seem is exposed, local clayey soils or bentonite can be used to aid in sealing the channel bottom.

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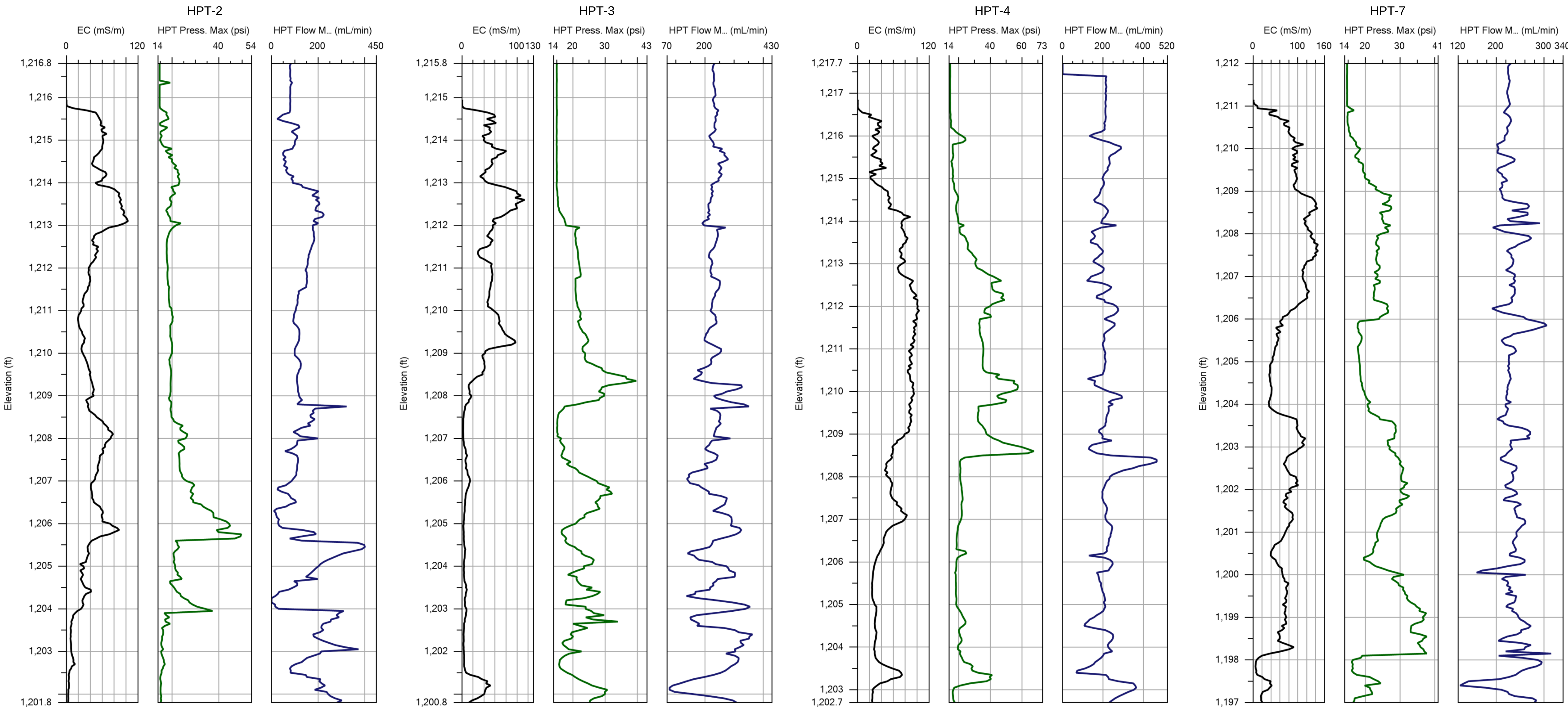
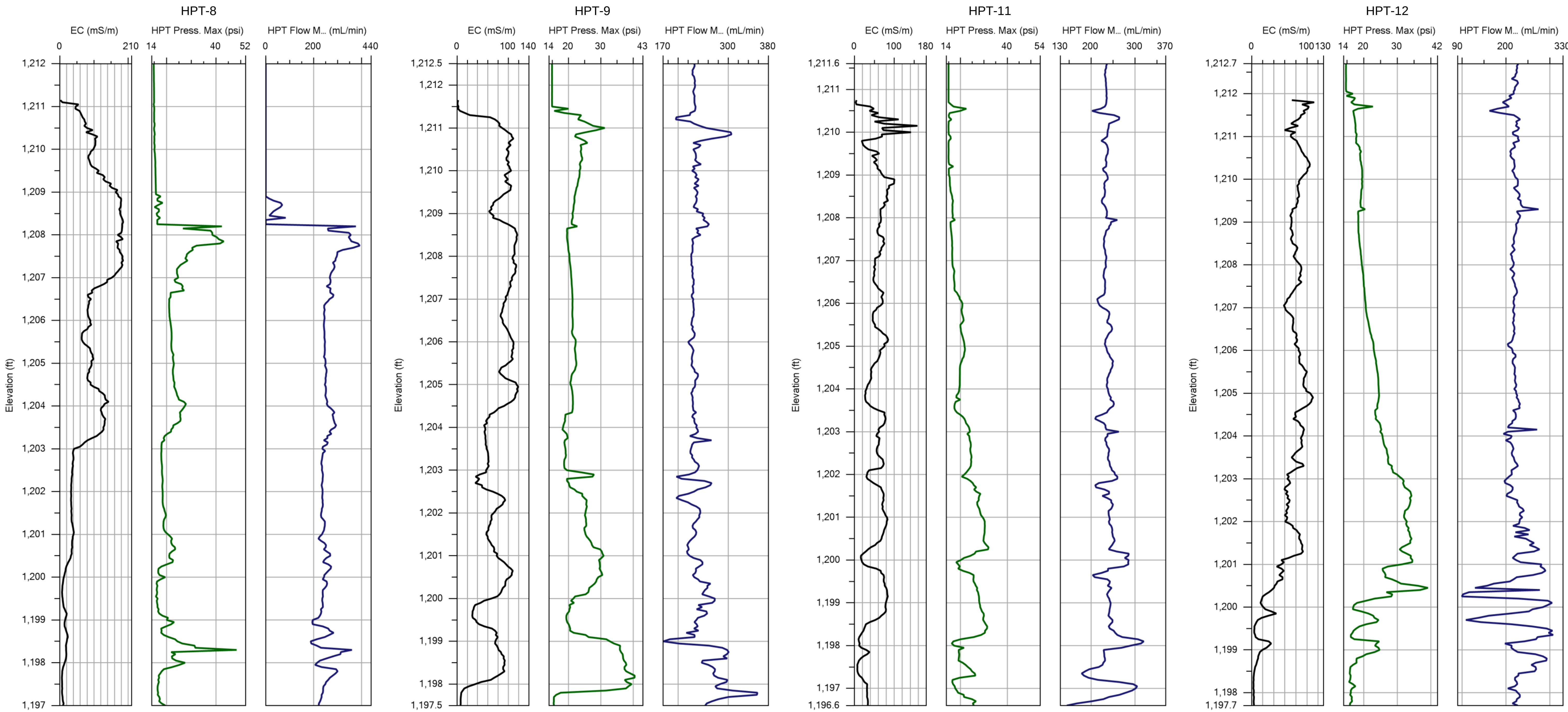
Appendix

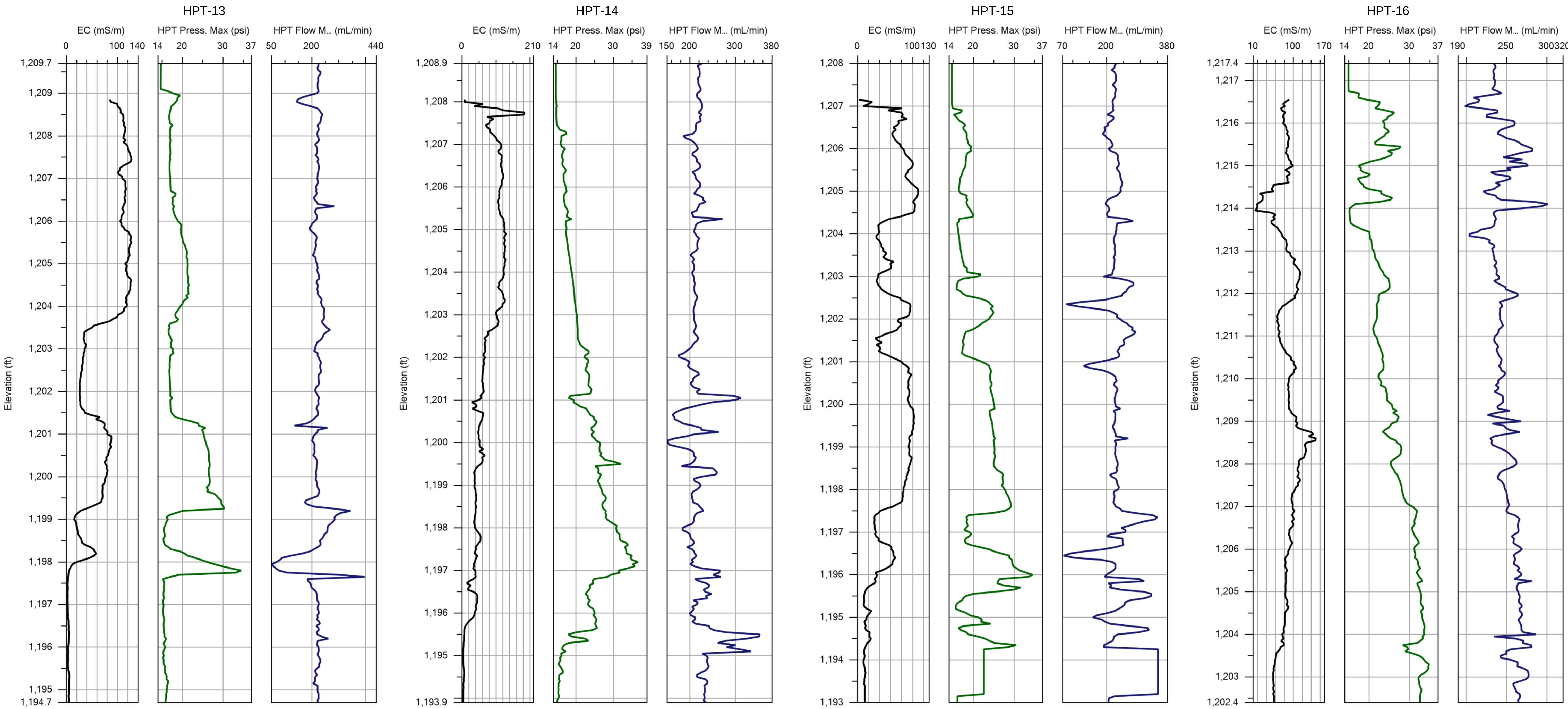
Geoprobe Hydraulic Profiling Tool (HPT) Profiles for Sampling/Logging in Channel Bottom



Geoprobe Hydraulic Profiling Tool (HPT) Profiles for Sampling/Logging in Channel Bottom (Continued)



Geoprobe Hydraulic Profiling Tool (HPT) Profiles for Sampling/Logging in Channel Bottom (Continued)



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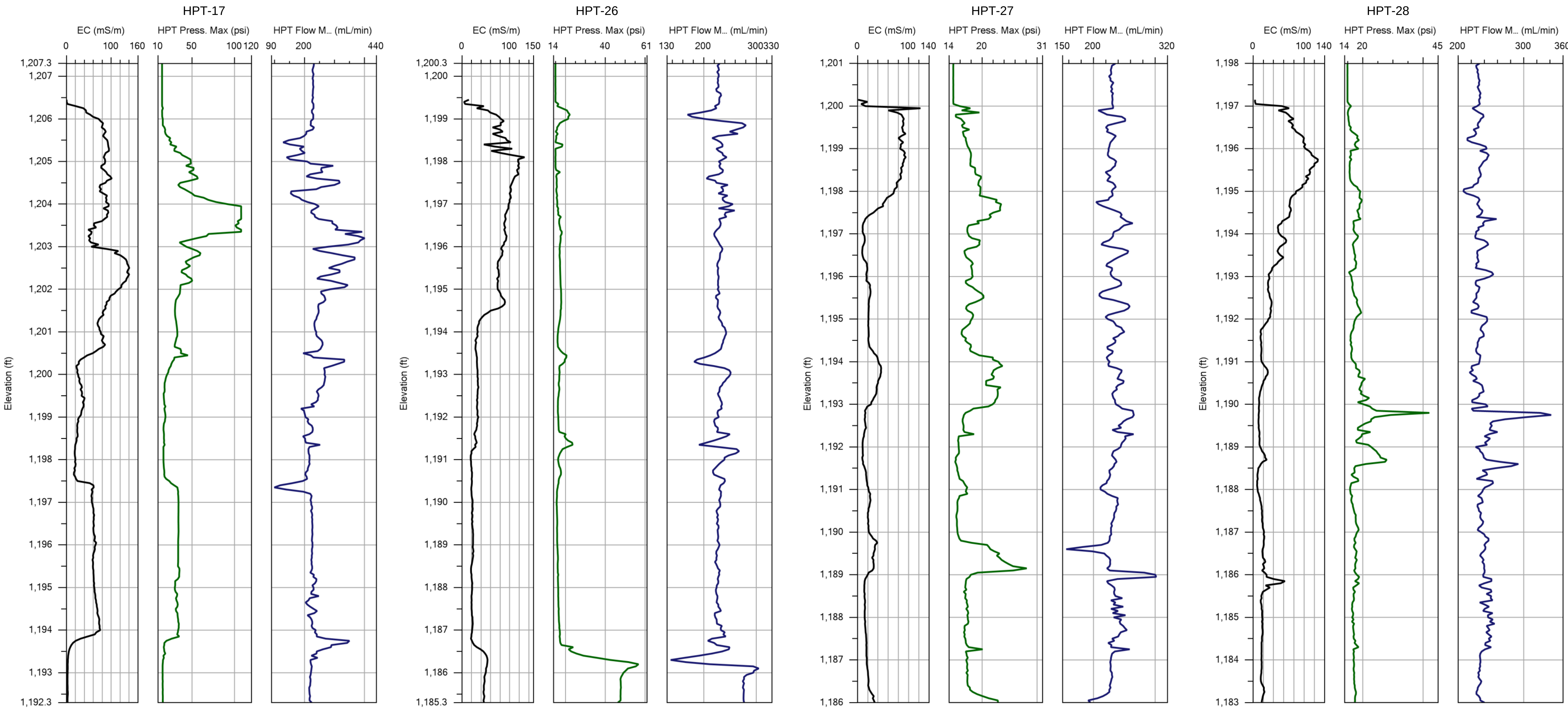

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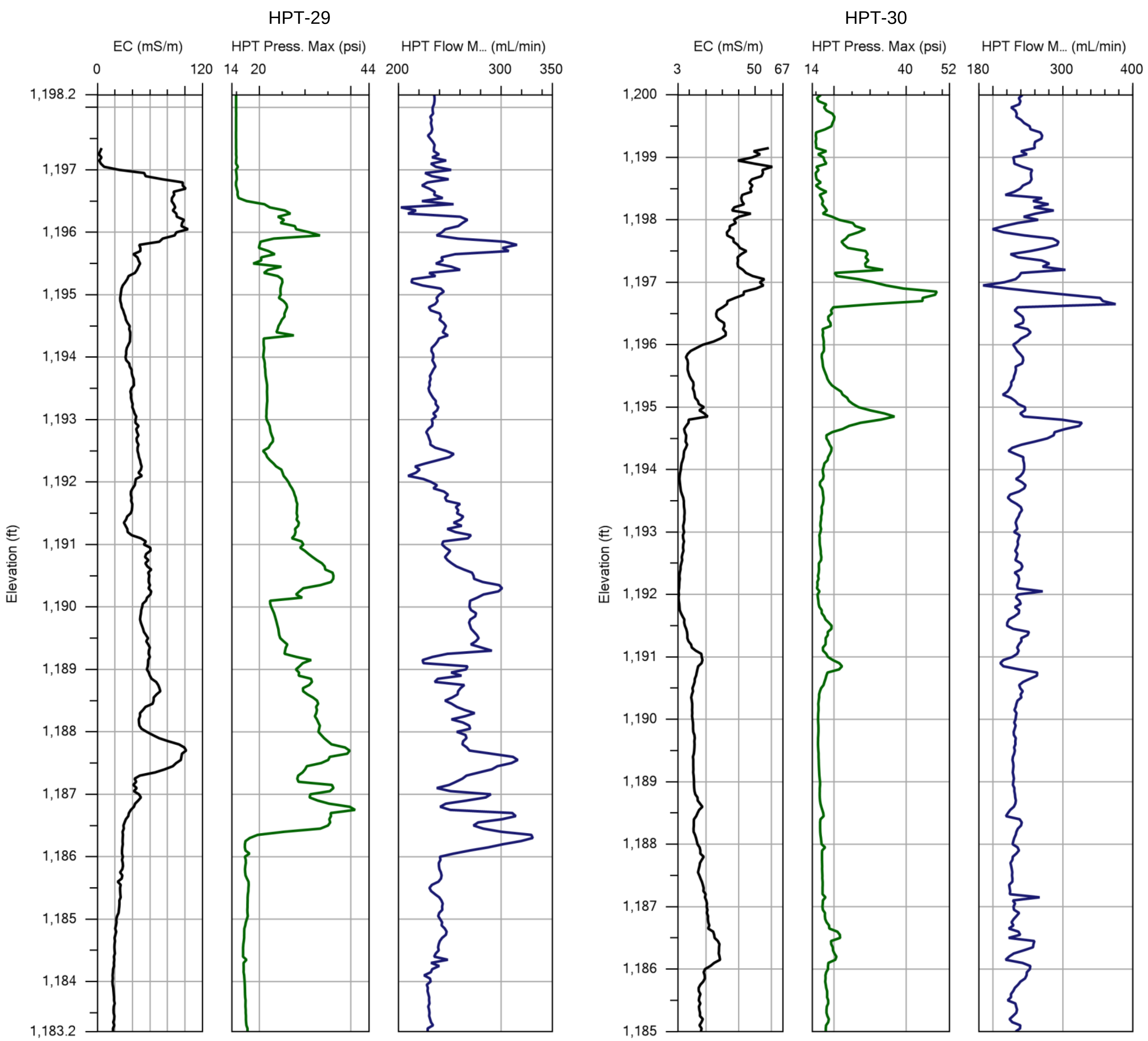
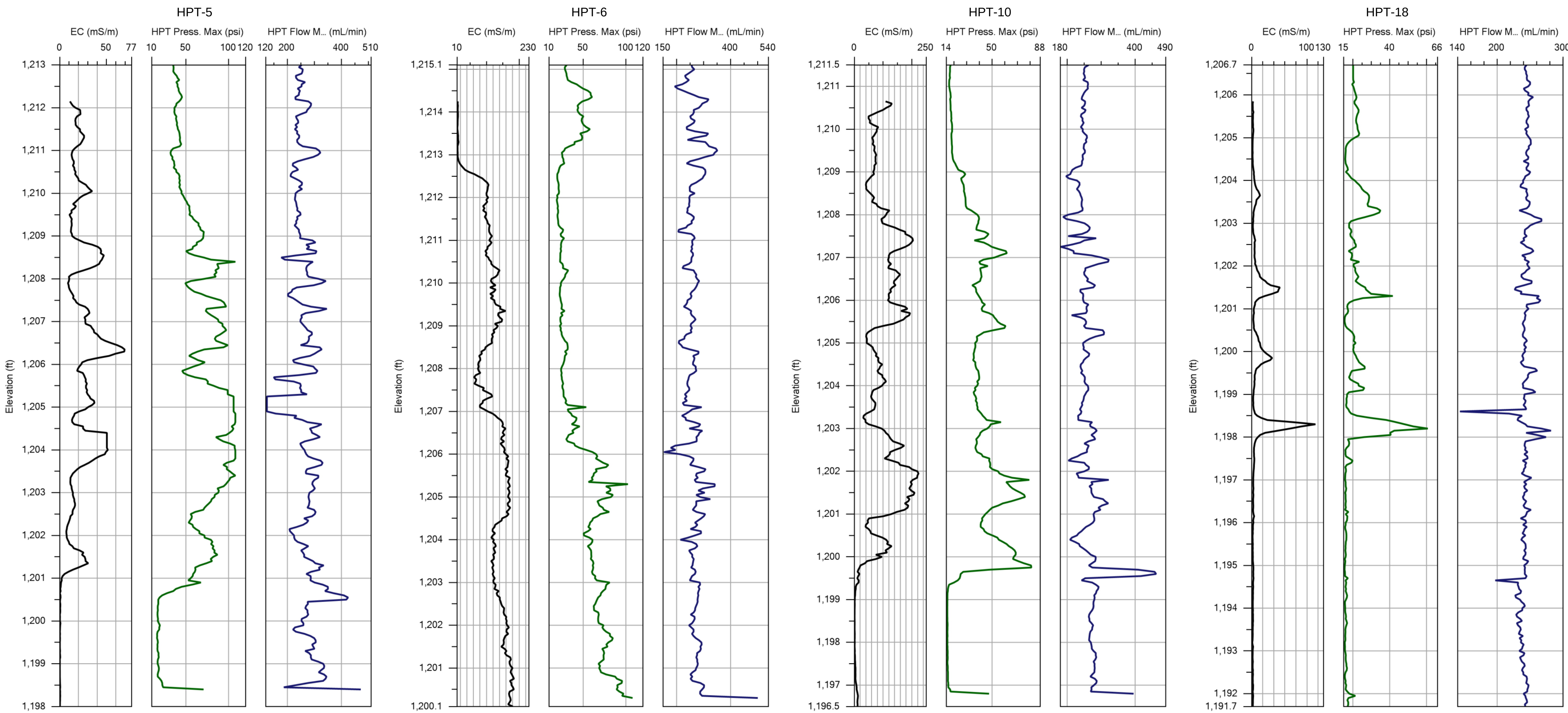


Geoprobe Hydraulic Profiling Tool (HPT) Profiles for Sampling/Logging on Top of Bank



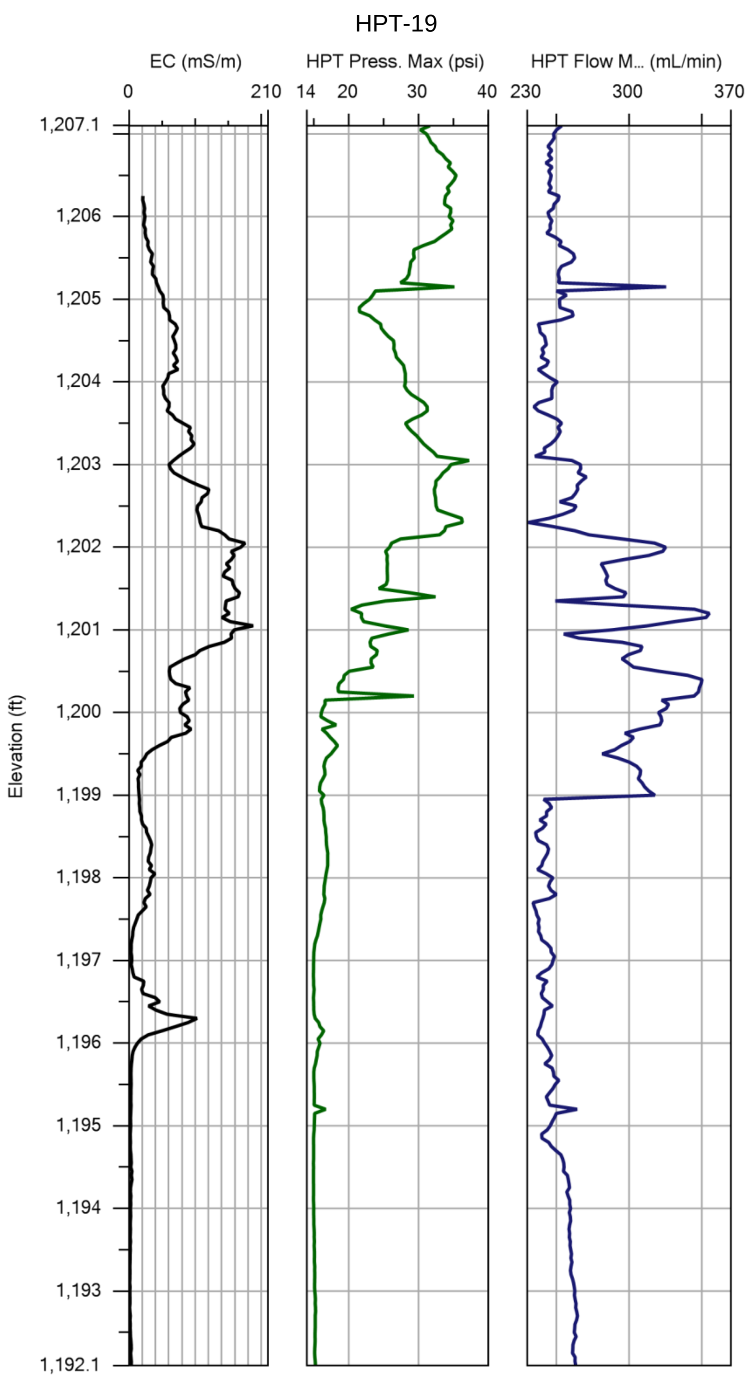
Top of bank at 1223.0 ft, top of channel at 1211.5 ft

Top of bank at 1225.1 ft, top of channel at 1213.6 ft

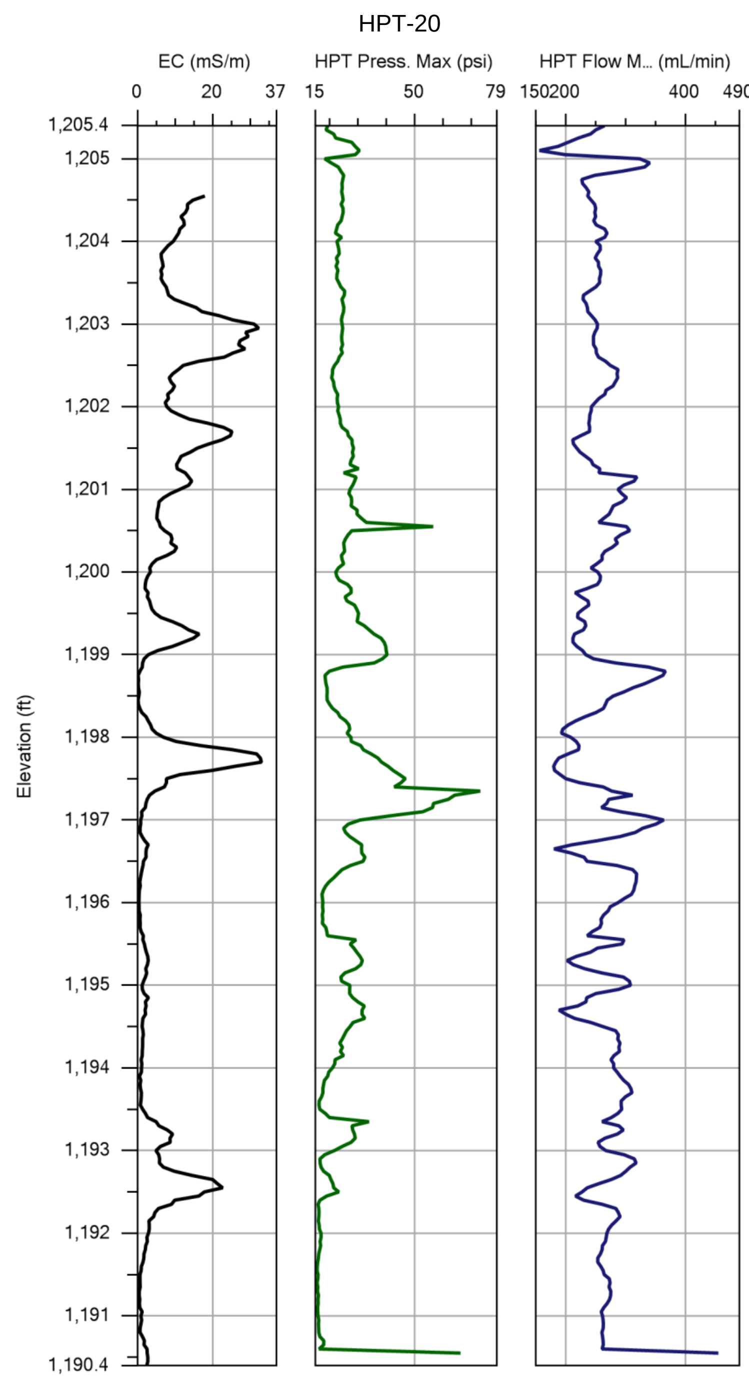
Top of bank at 1221.5 ft, top of channel at 1210.0 ft

Top of bank at 1221.7 ft, top of channel at 1204.7 ft

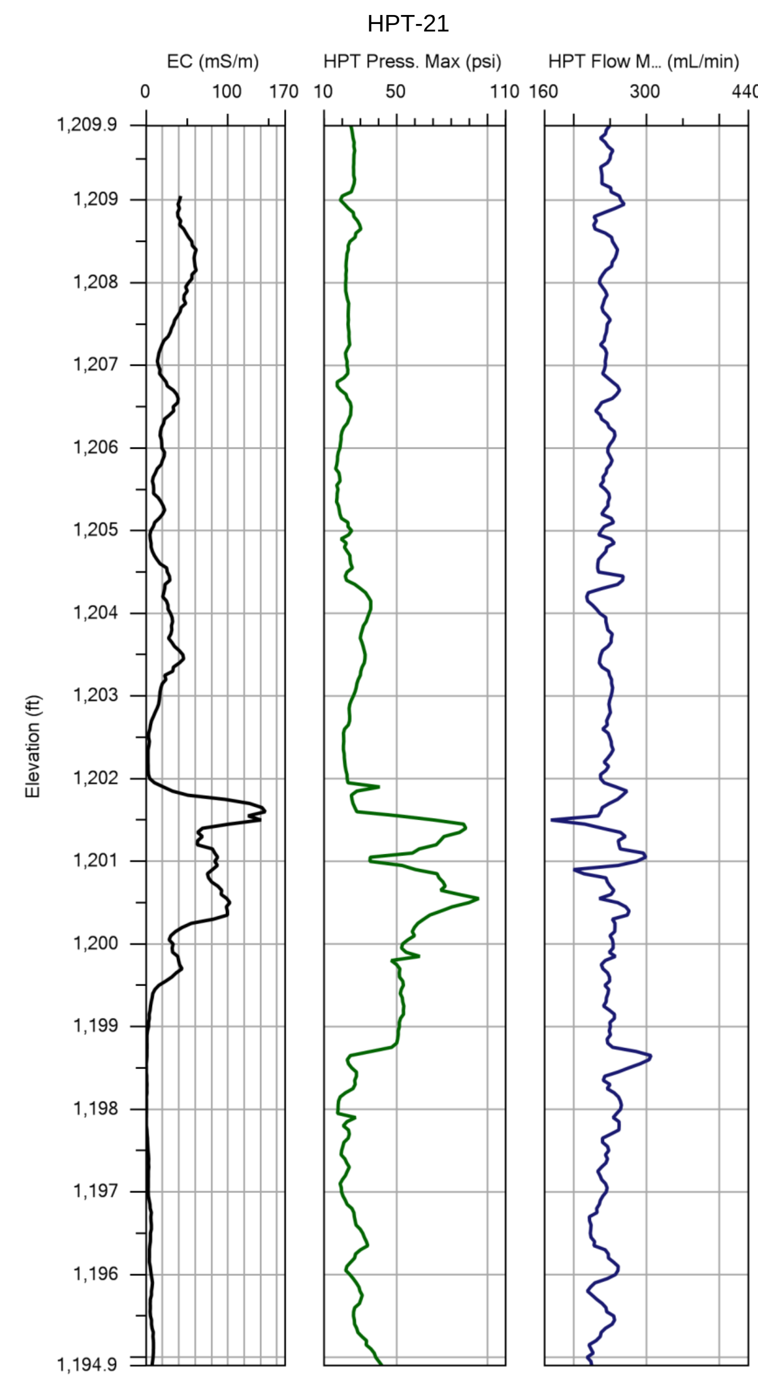
Geoprobe Hydraulic Profiling Tool (HPT) Profiles for Sampling/Logging on Top of Bank (Continued)



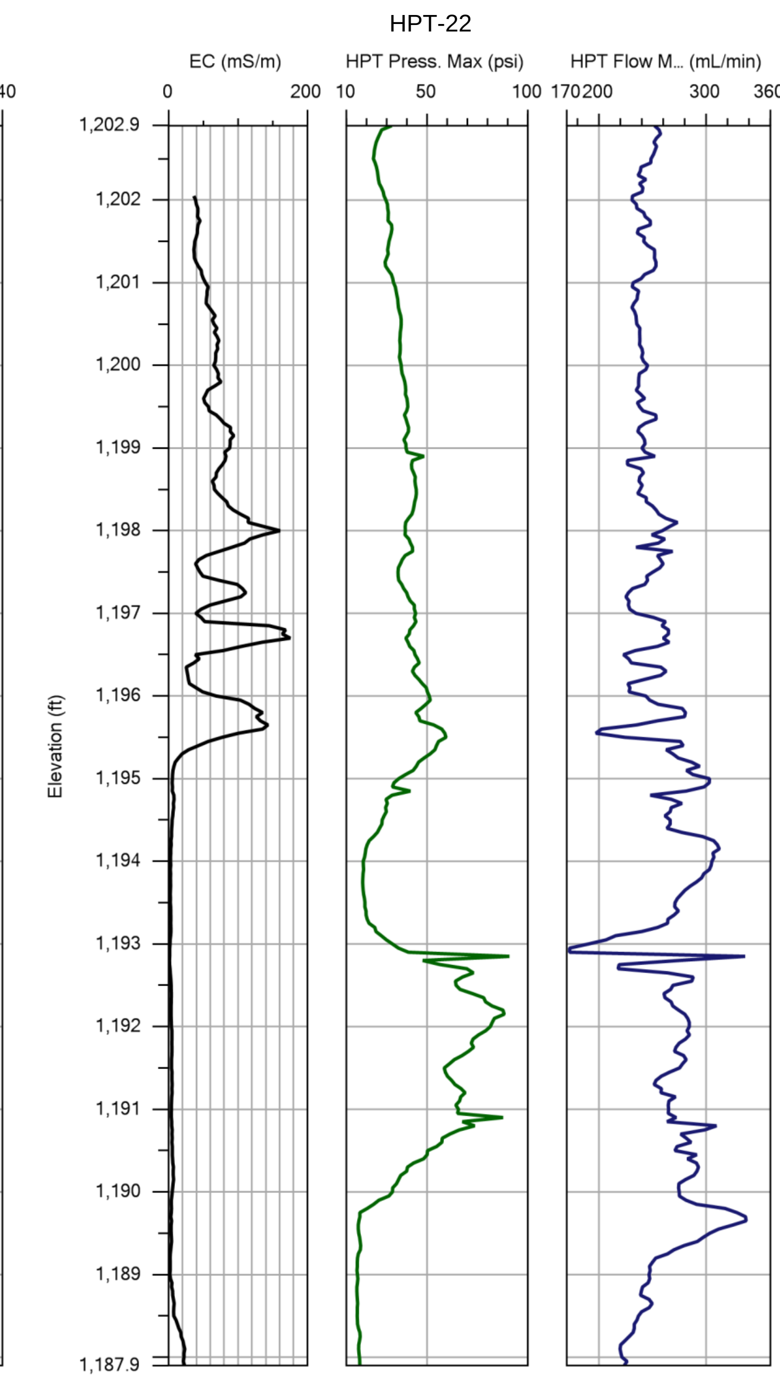
Top of bank at 1220.1 ft, top of channel at 1206.6 ft



Top of bank at 1215.4 ft, top of channel at 1204.4 ft

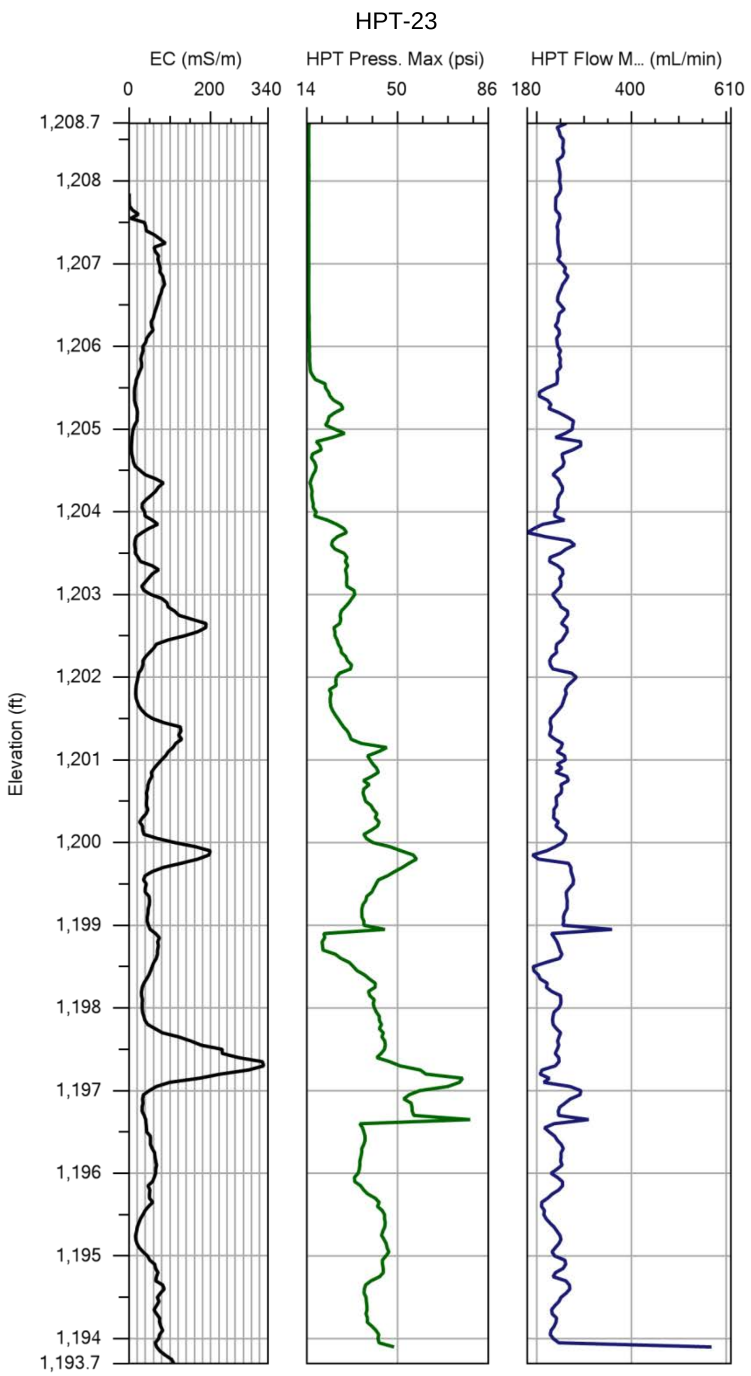


Top of bank at 1219.9 ft, top of channel at 1206.9 ft

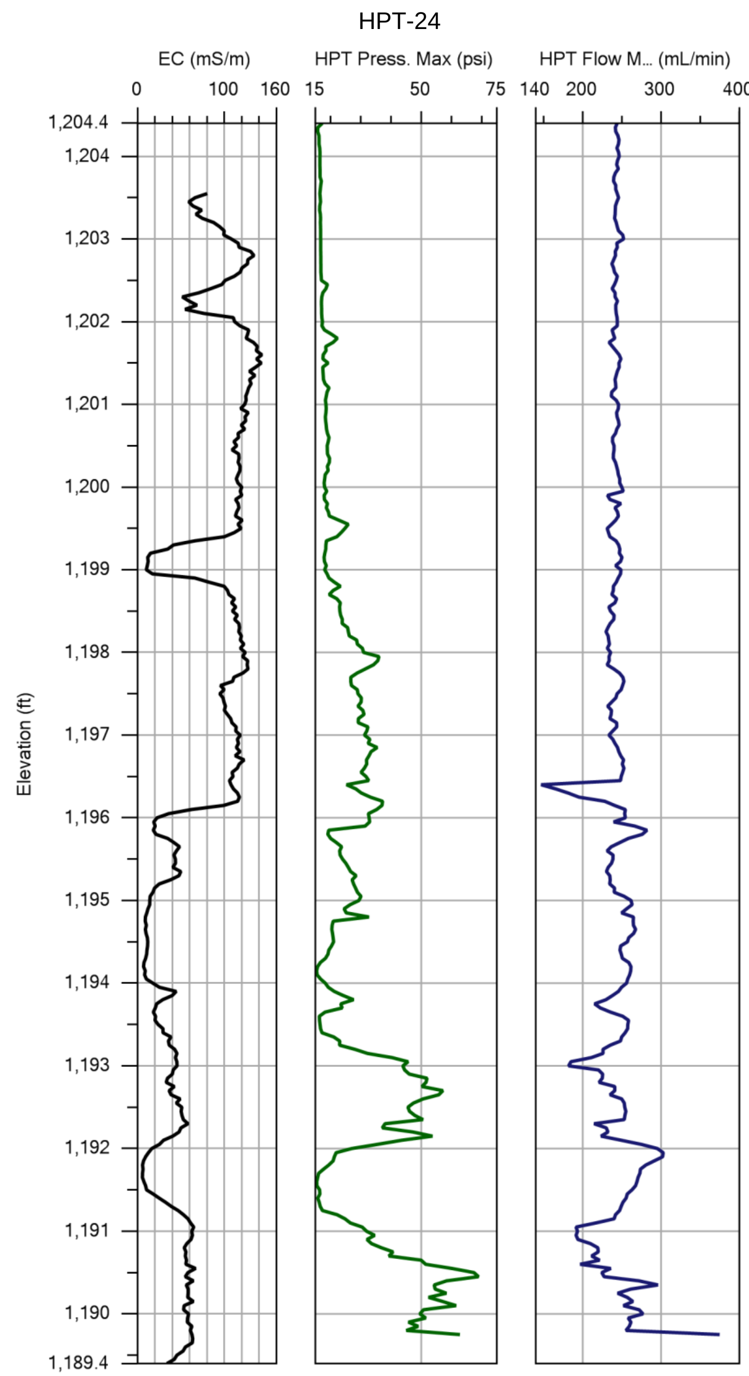


Top of bank at 1217.9 ft, top of channel at 1204.4 ft

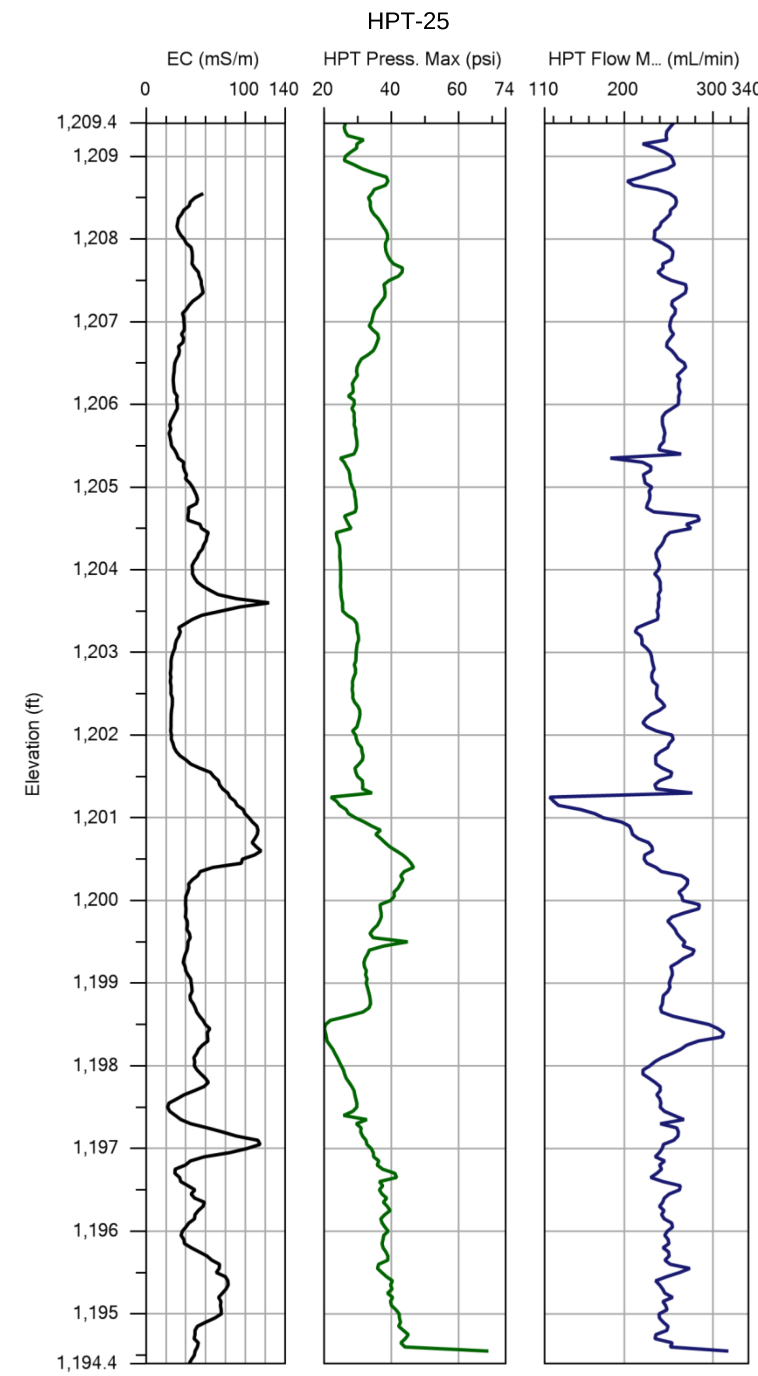
Geoprobe Hydraulic Profiling Tool (HPT) Profiles for Sampling/Logging on Top of Bank (Continued)



Top of bank at 1218.7 ft, top of channel at 1206.2 ft



Top of bank at 1214.4 ft, top of channel at 1202.9 ft



Top of bank at 1219.4 ft, top of channel at 1207.9 ft

Geoprobe Hydraulic Profiling Tool (HPT) Profiles for Sampling/Logging in Lakewood Park

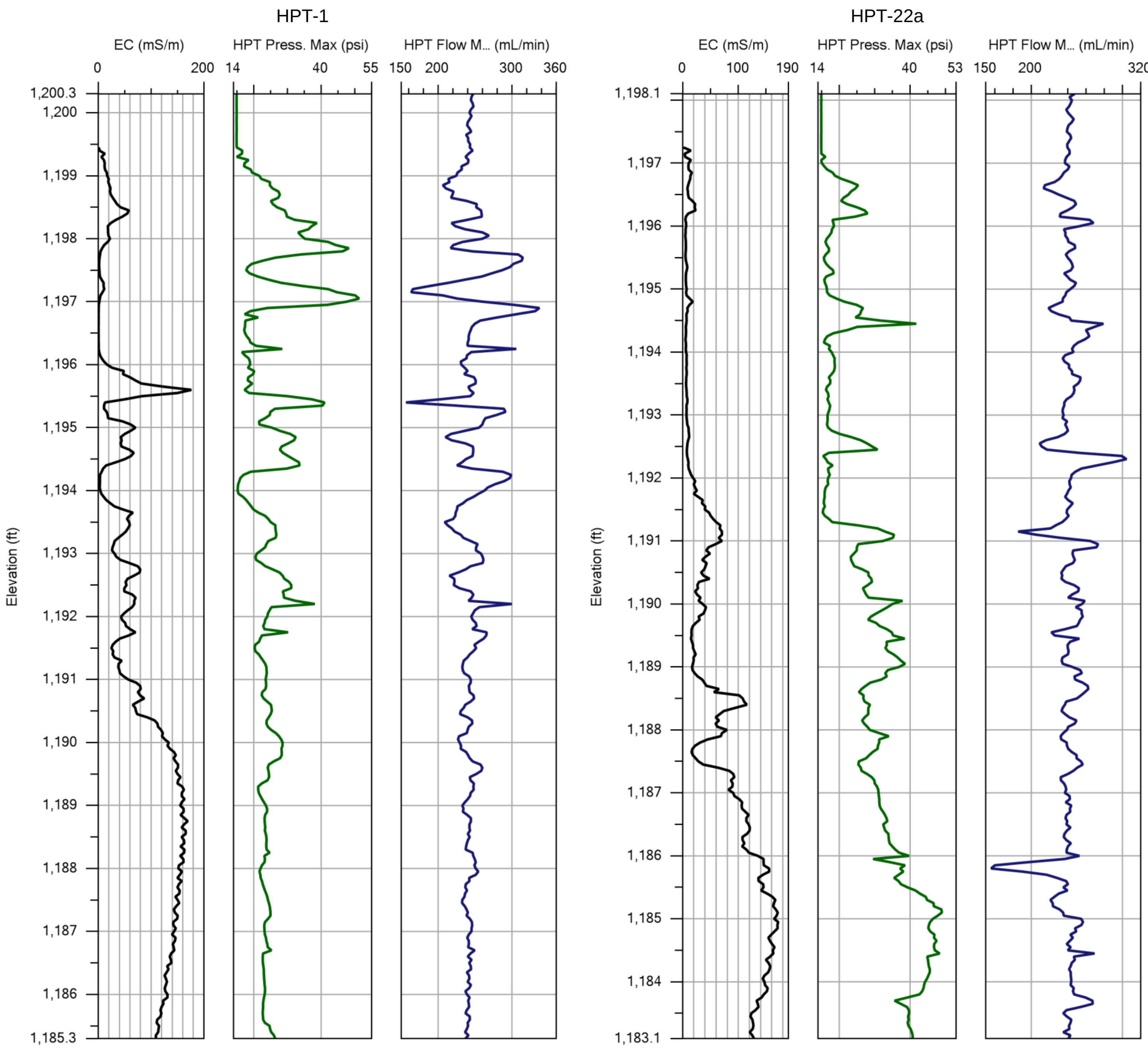


Exhibit C. Water Supply Alternatives Evaluation

Smoky Hill River GI Study
Draft Integrated Feasibility Report and Environmental Assessment

September 2025

U.S. Army Corps of Engineers
Kansas City District

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Executive Summary

The Smoky Hill River Renewal Project's (Project) primary source of water will be from the Smoky Hill River main channel. This channel has a large drainage area and will be able to supply adequate water (10 cubic feet per second) to more than offset infiltration and evaporation 89.5 percent of the time during the recreation season and 86.4 percent of the time during the off season.

A supplemental source of water is required to improve the reliability of maintaining water within the old river channel during drought conditions. Drought operations would not meet the full project flows, but rather be focused on maintaining a full channel. Restored Channel Water Balance Technical Memo dated March 30, 2018 estimated annual water lost through infiltration and evaporation as 550 acre-feet (ac-ft) to 10,420 ac-ft. For the purpose of this memo an annual water loss of 2,540 ac-ft, which is approximately 3.8 cubic feet per second (cfs), is assumed based on evaporation and mitigating sand layers at the bottom of the excavated channel. To improve the water supply to 99.0 percent reliability would require 219 ac-ft (3.8 cfs x 29 days). 99.9 percent reliability requires 407 ac-ft (3.8 cfs x 54 days) and the historic drought of record requires 3,995 ac-ft (3.8 cfs x 530 days).

This study evaluated four potential supplemental sources of water during drought operations; 1) water pumped from Lakewood Park Lake, 2) potential to supply golf courses with wastewater treatment plant effluent and divert existing golf course rights to the Project, 3) additional storage in Lakewood Park Lake due to raised surface water levels, and 4) purchased storage in Lake Kanopolis.

Purchasing storage in Lake Kanopolis through the Lower Smoky Hill Access District had the highest reliability and lowest life cycle cost of the options evaluated and is the recommended supplemental water supply source. Cost per 100 ac-ft of 2060 storage (discount from present day storage by reservoir siltation) is estimated at $53,135 initial costs, plus $4,650 annually for the first 20 years, and $600 annually for an additional 20 years. One full year of supply (2,540 ac-ft) equates to $1,350,000 in initial costs and a life cycle cost of $2,821,912.

1.0 Introduction & Purpose

The City of Salina, Kansas (City) plans to renew the old Smoky Hill River channel that meanders through the City. The channel would be turned into an amenity for the City that would allow non-motorized water traffic along the full reach of the channel and into Lakewood Park Lake. The Smoky Hill River Renewal Project's (Project) primary source of water will be from the Smoky Hill River main channel, however there will be times that the Project's surface water right will limit the amount of water available for the Project. A supplemental source of water is required to ensure adequate depth and flow of water within the old river channel.

While a water recirculation system could prevent stagnation of water in the channel, make-up water will be required to offset that lost by evaporation and by infiltration into the underlying alluvial formation. The infiltration and evaporation losses are estimated at 550 acre-feet (ac-ft) to 10,420 ac-ft annually. The large range is due to the presence of sand seams within the channel excavation area which is documented in the Restored Channel Water Balance Technical Memo dated March 30, 2018. At the current stage of preliminary design, infiltration and evaporation losses are estimated at 0.8 to 3.8 cubic feet per second (cfs) during the recreational season (May – September), and at 0.4 to 3.0 cfs during the off season (October – April). These preliminary design infiltration rates assume that higher conductivity sand layers will be sealed off and result in estimated infiltration and evaporation losses of 550 ac-ft to 2,540 ac-ft annually.

For the purposes of this technical memorandum, it is assumed that the desired flow through the system is 80 cfs during the recreational season and 10 cfs during the off season. It is assumed the flow through the restored channel is allowed to diminish to zero during the cold winter months of December, January and February if there are not adequate flows within Smoky Hill River to meet appropriation rights. The flow during the recreation season, however is intended to remain mostly uninterrupted, but might be less than the 80 cfs desired. Short interruptions in the flow during night time hours and during low use times might be feasible within the recreation season.

Several water sources to provide the desired flow to the Project were considered in this study. The primary source of water for the Project is from the Smoky Hill River under Water Appropriation #47,510. This water right can only be used when flow in the River at the upstream Mentor gaging station is above 40 cfs. During drought conditions the Smoky Hill River flows may drop below the 40 cfs trigger level and prevent use of Water Appropriation #47,510 for water flow through the Project. One of HDR's tasks is to complete a Water Supply Alternative Analysis of Water Appropriation #47,510 and potential supplemental water supply sources that might be available during these low river flow conditions. This memorandum discusses the conceptual plans and costs for the supplemental water supply alternatives.

Identified potential supplemental water source alternatives reviewed in this memo include:

- Water pumped from Lakewood Park Lake.
- Potential to supply golf courses with reused wastewater treatment plant effluent and divert existing golf course rights to the Project.
- Additional storage in Lakewood Park Lake due to raised surface water levels.
- Lower Smoky Hill Access District storage in Lake Kanopolis.

2.0 Primary Water Supply

2.1 Water Appropriation #47,510 - Smoky Hill River

Water Appropriation #47,510 is anticipated to serve as the main source of water for the Project. The City applied for Water Appropriation #47,510 on April 5, 2010. The water appropriation was approved as a recreation use surface water right to be drawn from the Smoky Hill River near the upstream end of the old Smoky Hill channel.

Water Appropriation #47,510 allows for the following surface water use:

- A maximum diversion rate of 44,880 gallons per minute (100 cfs).
- An annual quantity not to exceed 28,952 acre-feet (ac-ft).

The annual quantity equates to continuous use at 40 cfs, or a higher flow during the recreation season followed by a lower flow during the winter months. A flow of 80 cubic feet per second (cfs) during the recreational season (May – September), and 10 cfs during the off season (October – April) would fit within the current water right. A copy of the Approval of Application and Permit to Proceed is included in Appendix A of this memorandum.

2.2 Conditions of Use

The Kansas Division of Water Resources (DWR) Approval of Application stipulates several conditions as to when Water Appropriation #47,510 can be used. Condition paragraphs #18 through #22 define the City's ability to use this appropriation:

18. *That diversion of natural flows shall not take place unless there is water available to satisfy all demands by senior water rights and permits.*
19. *That during the period October 1 through June 30, the verbal or written permission of the Chief Engineer, or an authorized representative of the Chief Engineer, shall be obtained in order to divert water each time the applicant desires to divert water.*
20. *That during the period July 1 through September 30 each calendar year, no direct diversions of surface water shall be permitted unless written permission is obtained from the Chief Engineer, or the Chief Engineer's authorized representative.*
21. *That the diversion of surface water authorized herein shall be allowed only when flows in the Smoky Hill River at the U.S. Geological Survey stream gage No. 06866500 located near Mentor, Kansas are equal to or greater than 40 c.f.s. The City of Salina will be responsible for monitoring this stream gage to ensure that adequate flow is present prior to, and during, any diversion of surface water, and that permission has been granted to divert water as discussed in Paragraph Nos. 19 and 20 above.*
22. *That the maximum rate of diversion shall be limited to the flow at the U.S. Geological Survey stream gage No. 06866500 located near Mentor, Kansas, less 30 c.f.s., to ensure that some volume of water remains in the river below the point of diversion when diversion of water is occurring*.

2.3 Potential to Use Water Appropriation #47,510

DWR conditions require that no water can be diverted to the Project under this water appropriation unless stream flow at the Mentor, Kansas gaging station is greater than or equal to 40 cfs. At 40 cfs, the Project could be allowed to divert 10 cfs. Project stream flow diversion could increase to the full 100 cfs allowed under the appropriation when stream flow at the Mentor, Kansas gage is greater than or equal to 130 cfs. For this technical memorandum, historic U.S. Geological Survey (USGS) flow rate data at the Mentor, Kansas gage station (No. 06866500) was analyzed to determine probability of the Project to obtain target diversion rates of 10 cfs, 40 cfs, and 80 cfs from the Smoky Hill River. These target rates correspond to minimum river flow rates of 40 cfs, 70 cfs and 110 cfs.

USGS daily flow rate data measured at the Mentor gage were analyzed for the time period January 1, 1949 through December 31, 2016. Daily records are available for analysis starting in the 1920's, but were not used due to the fact that Kanopolis Lake was not filled until July of 1948. The total contributing drainage area to the gage near Mentor, Kansas is 8,341 square miles and Kanopolis Reservoir controls 7,857 square miles of the total.

The data were broken down into a variety of different ways including mean daily discharge percentiles, consecutive days without registering minimum flow rates, and percent chance any given day of any given month minimum flow rates were not reached. Summarization tables for each of those statistically relevant breakdowns are presented in this section. Generally there are lower flow rates through the winter months and higher flow rates through the summer months.

Figure 1 presents average daily flow recorded at the Mentor gage from January 1, 1949 through December 31, 2016. For this period of record, having 40 cfs of flow in the river has usually occurred, however there have been periods of eight months or more where daily average flow stayed below 40 cfs. The 557-day period from September 19, 2005 through March 29, 2007 only recorded 27 days with average flows above 40 cfs.

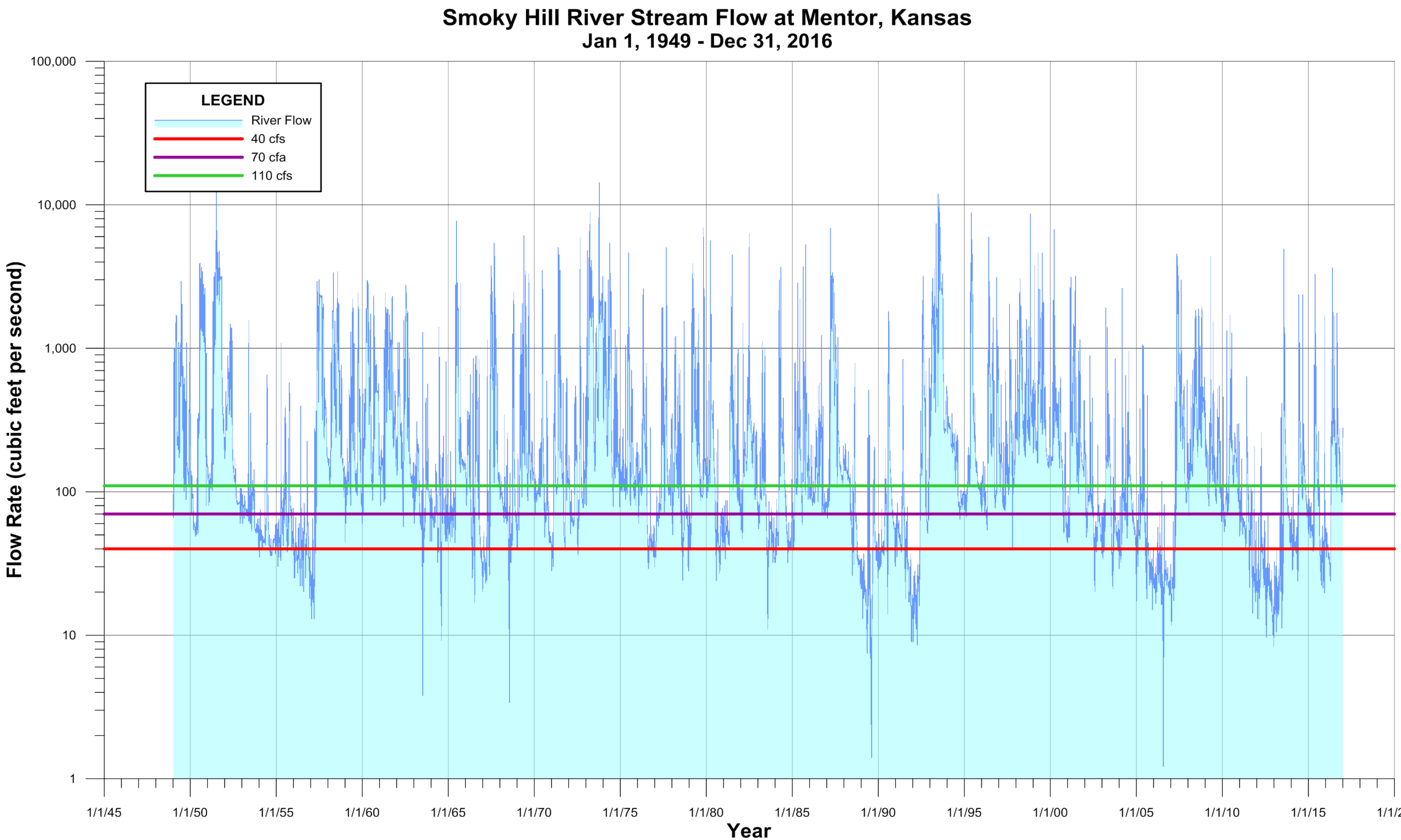

Figure 1 – Smoky Hill River Daily Average Flow Rate; 1949 to 2016

2.3.1 Mean Daily Discharge percentiles

Mean daily average flow rate was examined to evaluate probability of Smoky Hill River flows being adequate to support partial to full use of Water Appropriation #47,510.

Table 1 presents mean daily discharge percentiles by month, as calculated from daily average flow rates at the USGS gage in Mentor, Kansas. Mean daily discharge percentiles by day of the year are presented in Figure 2.

Table 1 - Mean Daily Discharge (cfs) Percentiles

Percentile	5	10	15	20	25	30	35	40	45	50	55	60	65	70
January	20	27	35	42	47	52	59	67	74	81	90	97	111	128
February	23	30	40	46	51	56	62	71	78	87	98	113	127	151
March	21	28	40	47	54	60	68	83	91	102	115	132	157	191
April	26	40	45	54	64	74	85	95	103	114	130	154	186	221
May	28	35	49	60	72	83	100	122	149	180	213	256	312	425
June	37	54	72	96	120	144	173	202	230	268	318	375	462	575
July	19	35	44	57	73	98	120	135	151	171	201	234	279	365
August	26	33	44	53	67	86	102	113	123	139	164	199	248	332
September	32	40	46	55	66	83	98	114	134	151	177	221	259	306
October	26	36	44	54	64	72	79	88	97	109	128	156	176	196
November	24	35	43	47	54	63	70	79	89	99	107	119	137	150
December	21	30	38	44	48	53	61	71	82	91	100	115	130	146

Average daily flow rates are higher during the recreation season (May – Sept.) and lower during the off season. In particular, flow rates were lower during the winter period of December 21 through February 15. On average, approximately 88 percent of the stream flows exceeded the 40 cfs trigger to use Water Appropriation #47,510, with an 89.5 percent exceedance during the recreation season and an 86.4 percent exceedance during the off season. Approximately 50 percent exceeded the 110 cfs flow to meet the 80 cfs diversion desired during the recreation season.

With the May 2017 signing of the Lower Smoky Hill Water Supply Access District Operations Agreement it is anticipated that daily flow releases from Kanopolis Lake will be modified to sustain higher minimum flows of 30 cfs during the recreational season and 20 cfs during the off season.

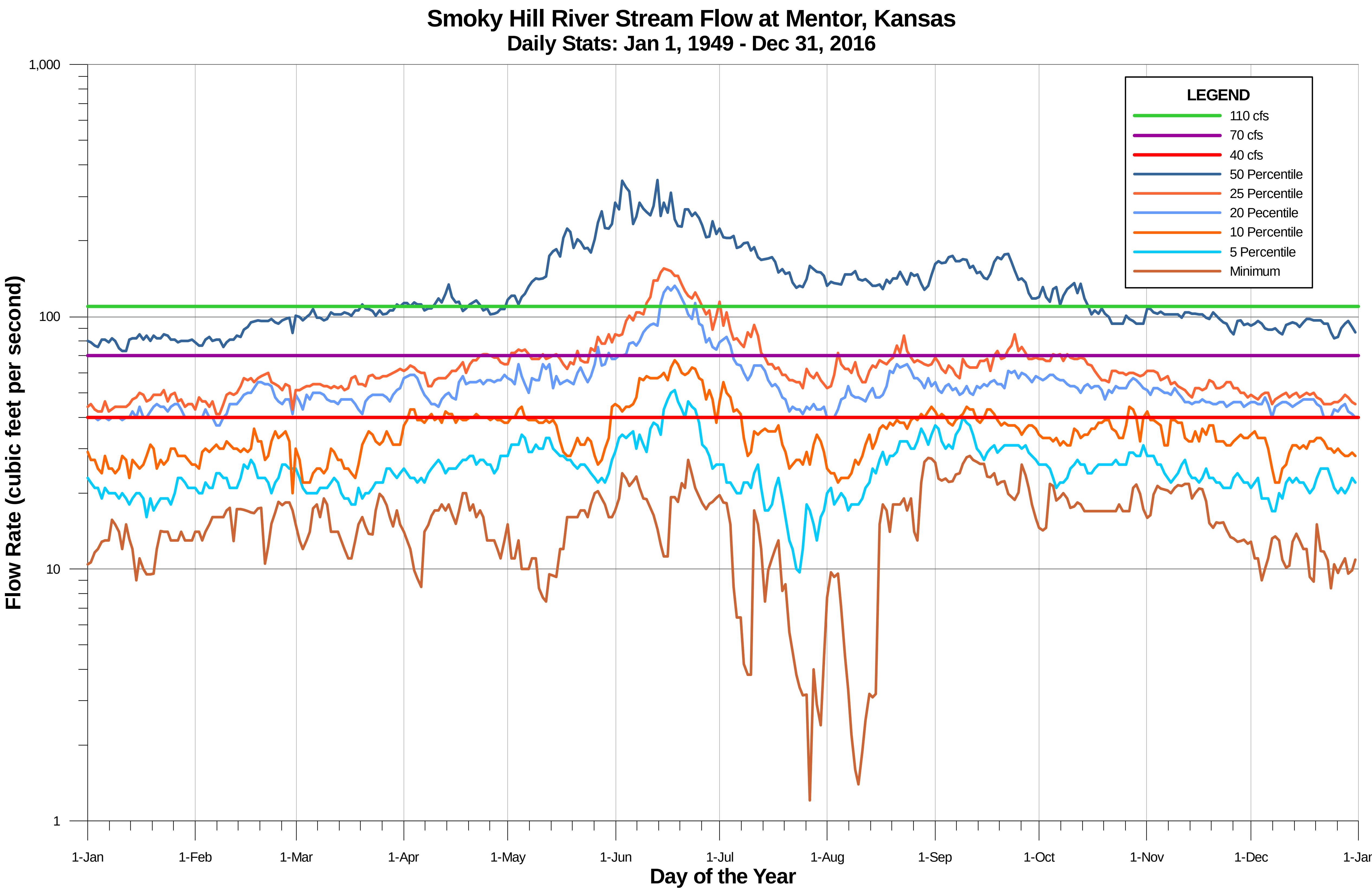

Figure 2 – Smoky Hill River Daily Average Flow Rate Statistics; 1949 - 2016

2.3.2 Mean Daily Discharge Exceeding Desired Flows

Mean daily average flow rate was evaluated for percentage of days meeting desired flows rates, and for extent of time discharge did not meet desired flows rates. Tables 2 through 4 present results for percent of the time daily average flow rates have historically met target flow rates.

Table 2 - Percentage of Days Under 40 cfs

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Days Under 40 cfs	371	292	297	196	228	114	285	270	197	238	243	326
Total Days	2,108	1,921	2,108	2,040	2,108	2,040	2,108	2,108	2,040	2,108	2,040	2,108
Percent Under 40 cfs	17.6%	15.2%	14.1%	9.6%	10.8%	5.6%	13.5%	12.8%	9.7%	11.3%	11.9%	15.5%

Table 3 - Percentage of Days Under 70 cfs

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Days Under 70 cfs	874	796	738	565	505	299	520	549	517	579	706	818
Total Days	2,108	1,921	2,108	2,040	2,108	2,040	2,108	2,108	2,040	2,108	2,040	2,108
Percent Under 70 cfs	41.5%	41.4%	35.0%	27.7%	24.0%	14.7%	24.7%	26.0%	25.3%	27.5%	34.6%	38.8%

Table 4 - Percentage of Days Over 110 cfs

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Days Over 110 cfs	726	793	1012	1031	1276	1581	1405	1304	1285	1066	888	885
Total Days	2,108	1,921	2,108	2,040	2,108	2,040	2,108	2,108	2,040	2,108	2,040	2,108
Percent Over 110 cfs	34.4%	41.3%	48.0%	50.5%	60.5%	77.5%	66.7%	61.9%	63.0%	50.6%	43.5%	42.0%

Duration of consecutive days that did not meet target flow rates during the 68-year period of record were reviewed and summarized in Table 5.

Table 5 - Consecutive Days Registering Target Flow Rates

Flow Rate (cfs)	Consecutive Days	Total Occurrences	Recreation Period Occurrences
< 40	30	18	8
	45	11	6
	60	8	3
	120	4	0
< 70	30	61	30
	45	41	21
	60	31	15
	120	14	2
> 110	30	83	51
	45	59	50
	60	42	43
	120	27	17

Throughout the 24,837 days of data analyzed, there was a consistent two percent chance that any given day throughout any given year was part of at least a 30 consecutive day streak of flow under 40 cfs past the Mentor gage.

Exceptionally low flow rates register for an approximate two-month period during the winter, from the second half of December through the first half of February, while June has an exceptionally high average flow rate during the summer. Each of these exceptions are extracted and compared to their respective seasons, side by side in Tables 6 through 9.

Table 6 - Percentage of Days Under 40 cfs during Winter Months

	Dec. 21 – Feb 15	Oct. – April less Dec. 21 – Feb. 15
Days Under 40 cfs	687	1276
Total Days	3876	10557
Percentage	17.7%	12.1%

Table 7 - Percentage of Days Under 40 cfs during Summer Months

	June	May - Sept. less June
Days Under 40 cfs	114	980
Totals Days	2040	8364
Percentage	5.6%	11.7%

Table 8 - Percentage of Days Under 70 cfs during Summer Months

	June	May -Sept. less June
Days Under 70 cfs	299	2091
Total Days	2040	8364
Percentage	14.7%	25.0%

Table 9 - Percentage of Days Over 110 cfs during Summer Months

	June	May - Sept. less June
Days Over 110 cfs	1576	5242
Total Days	2040	8364
Percentage	77.3%	62.7%

Based on the 68 years of data analyzed, for any given day from December 21st to February 15th, flow past the Mentor, Kansas gage has had the highest probability of registering under a minimum flow rate of 40 cfs at 17.7 percent. Excluding that two-month stretch, there was a 12.1 percent probability the gage will not register a flow rate of at least 40 cfs on any given day from October through April.

On any given day throughout the summer months, the data yielded a 25.0 percent probability of not registering a minimum flow rate of 70 cfs, except for the month of June where the probability drops to 14.7 percent. The data also shows that there was a 62.7 percent probability of registering a flow rate of at least 110 cfs from May through September (excluding June) and a 77.3 percent probability during June. There have been registered flow rates under 40 cfs during the month of June as well, occurring 5.6 percent of the time, and 11.7 percent of the time for May through September (excluding June).

Based on this analysis winter flows will frequently fall below Project goals of 10 cfs; however, given the limited use, this may not require use of a supplemental source.

HDR also examined frequency and duration of periods when flow fell below 40 cfs and the Project goal of 10 cfs could not be obtained. Some of the water source alternatives are limited into how much total volume they can supply annually or without being replenished. The frequency and duration of shortages during the recreation season, and the full year minus January and February (when the Project may not need flow), was used to estimate the potential volume a supplemental source would need to provide. Table 10 presents the number of consecutive days the Project is not expected to obtain flow under Water Appropriation #47,510 99 and 99.9 percent of the time.

Table 10 - Number of Consecutive Days not Meeting 40 CFS at Mentor

Attainment Frequency	Recreation Season (May – Sept.)	Annual Minus Jan.-Feb. (March – Dec.)
99 Percentile	29	74
99.9 Percentile	54	117

A water supply source of 219 acre-feet (ac-ft) would be able to maintain water in the channel 99 percent of the time during the recreation season (29-day continuous need of approximately 3.8 cfs). A water supply volume of 407 ac-ft would meet the water supply 99.9 percent of the time during recreational season (54-day continuous need of 3.8 cfs).

Of note is that during certain time periods (1988 -1989, 1991-1992, 2005 - 2006, and 2011 - 2013) consecutive days below 40 cfs at Mentor was extreme. There were 222 consecutive days and 266 consecutive days over the 1988/1989 and 1991/1992 timeframes respectively. The period from the end of 2005 through early 2007 was characterized by 103 of the 104 last days in 2005 under 40 cfs, 345 of 365 days in 2006 under 40 cfs, and 76 of the first 87 days of 2007 under 40 cfs. In these cases, if storage in Kanopolis Lake were used to supply the Project for a period of 54 days, that storage volume is not anticipated to replenish itself between periods of being drawn down.

3.0 Supplemental Water Supply Alternatives

3.1 Water Right #47,509 - Lakewood Park Lake

This groundwater appropriation was anticipated to serve as a back-up source of water for the Project when stream conditions do not allow for diversion from the Smoky Hill River under Water Appropriation #47,510. The City applied for Water Appropriation #47,509 on April 5, 2010. This groundwater appropriation was approved as a recreation use right to be drawn from the lake located in Lakewood Park. The lake is a former sand and gravel mining pit that is thought to be connected to groundwater and classified as a groundwater pit by the DWR.

Water Appropriation #47,509 allows for the following groundwater use:

- A maximum diversion rate of 4,500 gallons per minute (10 cfs).
- An annual quantity not to exceed 1,785 acre-feet (ac-ft).

The annual quantity equates to continuous use at 2.5 cfs. A copy of the Approval of Application and Permit to Proceed is included in Appendix A of this memorandum.

3.1.1 Conditions of Use

The Kansas DWR Approval of Application stipulated several conditions as to when Water Appropriation #47,509 can be used. Condition paragraphs #17 through #19 define the City's ability to use this appropriation:

17. *That the applicant shall ensure that water diverted under authority of this permit be returned to the groundwater pit described in Paragraph No. 3 of this permit, such that the use of water would be considered nonconsumptive to the source of supply.*
18. *That in order to prevent unreasonable lowering of the water level in the groundwater pit (Lakewood Park Lake), the applicant shall cease diversion when the surface water level in the groundwater pit is at or below elevation 1,194.1 feet mean sea level, as measured at the dock on the north side of Lakewood Park Lake.*
19. *That the groundwater pit shall be constructed, maintained, and operated in a manner that will prevent degradation to the water quality of the source of supply which would cause impairment to existing water rights.*

It is unknown upon what criteria the DWR based the 1,194.1-foot trigger point. A 2010 survey of the lake provided in the Wright Water Engineers report (2010) indicated that the lake water surface elevation was 1,194.5 feet mean sea level (msl) at the time of survey. This 2010 recorded elevation might have been the only basis DWR had for this determination.

3.1.2 Potential to Use Water Appropriation #47,509

In order to determine the viability of this water appropriation, the City needed to perform a pump test of the lake and observe drawdown in and adjacent to the lake.

Monitoring Well and Lake Staff Gage Installation

Kaw Valley Engineering (KVE) was retained to install four monitoring wells adjacent to the lake during June 2017. The monitoring wells were drilled and installed through the full extent of the alluvial sediments, down to the underlying Wellington Shale bedrock. The boring logs are in Appendix B. Overall the unconsolidated deposits adjacent to the lake consisted of silts and silty sands to a depth of 12 to 22 feet below ground, underlain by sand and gravel to a depth of 34 to 52 feet below ground. Figure 4 presents locations of the four monitoring wells. The KVE monitoring well installation report is included in Appendix B of this technical memorandum.

The City installed a staff gage near the dock on the north side of the lake and surveyed elevations for the gage and all four monitoring wells. The City began collecting water levels in the lake and the four monitoring wells in August. Groundwater level below the lake was approximately 2.5 feet below lake surface elevation.

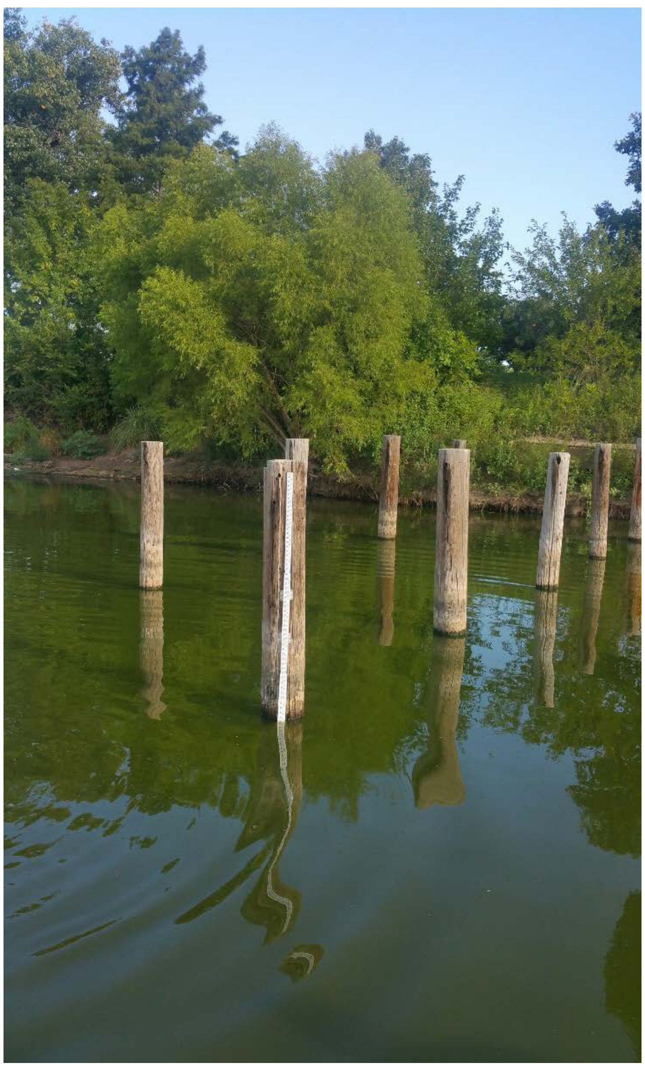

Figure 3 - Lakewood Park Lake Staff Gage

Figure 4 – Monitoring Well Locations

Pumping Test on Lakewood Park Lake

The City obtained Temporary Permit File No. 20170196 from the Kansas DWR that allowed the City to pump groundwater from Lakewood Park Lake at a rate not to exceed 1,100 gpm, and for a total quantity not to exceed 3.96 million gallons. A copy of the Temporary Permit is included in Appendix A of this memorandum.

On September 19, 2017 at 8:04 AM, the City initiated a 60-hour constant rate pumping test on the lake at a rate of 1,000 gpm. The pumped water was discharged to the adjacent old Smoky Hill channel. Pumping was stopped on September 21, 2017 at 8:02 PM. In total, 3.46 million gallons of water were pumped from the lake. Water levels were monitored before, during, and after the testing in the lake and the four adjacent monitoring wells. Daily precipitation was also recorded. Water level data is included in Appendix C of this memorandum.

Figure 5 presents the water level monitoring data for the period of August 1 through November 30. Several conclusions were drawn from the water level data:

- Groundwater levels in the monitoring wells are several feet below water level in the lake, indicating that the lake is not well connected to the aquifer, despite the bottom of the lake being at an elevation of 1186.5 feet msl (WWE, 2010).
- Groundwater levels in the monitoring wells indicate an east to west gradient and possibly reflect drawdown in the aquifer from the City's production wells.
- It is assumed the Smoky Hill River on the wet side of the flood control levee is a losing reach and likely supports the east to west gradient. The Smoky Hill River by-pass channel has a series of weirs that were constructed for channel stability. At the beginning of the by-pass channel (near Bill Burke Park) the top of the weir is 1215.39 and as a result the base flows are maintained at or above 1215.4 (approximately 22 feet higher than the lake surface). The stream elevations east of the Lake on the wet side of the flood control levee, at the outlet of the Old Smoky Hill channel, is 1194.89 feet which is still higher than the lake level at the time of the pump test.
- The Old Smoky Hill channel bottom is also higher than the lake surface. The residential culvert downstream of the Lake has a flow line of 1196.4.
- Water level in the lake decreased approximately 0.8 feet during the test. Surface area of the lake is approximately 584,250 square feet at the 1192 to 1193 foot elevation (WWE, 2010), indicating that approximately 3.50 million gallons of water was depleted from the lake's volume. Therefore, little to no water was removed from the aquifer.
- Water levels in the monitoring wells showed a minor decrease (0.05 to 0.1 feet) during the pumping test at MW-1, MW-3, and MW-4; but this was most likely a pressure response to the lake levels declining since any flow would have still been from the higher lake levels to the lower groundwater level.
- Water levels in the lake were never above the 1194.1-foot msl trigger level that would enable use of Water Appropriation #47,509.

Viability of Water Appropriation #47,509

Based on the pumping test, Water Appropriation #47,509 does not appear viable for the Project. The lake appears to be isolated from the regional groundwater table and hence it is not producing groundwater, making the appropriation unusable. In addition, lake levels were below the DWR trigger level of 1194.1 feet msl that would allow any use.

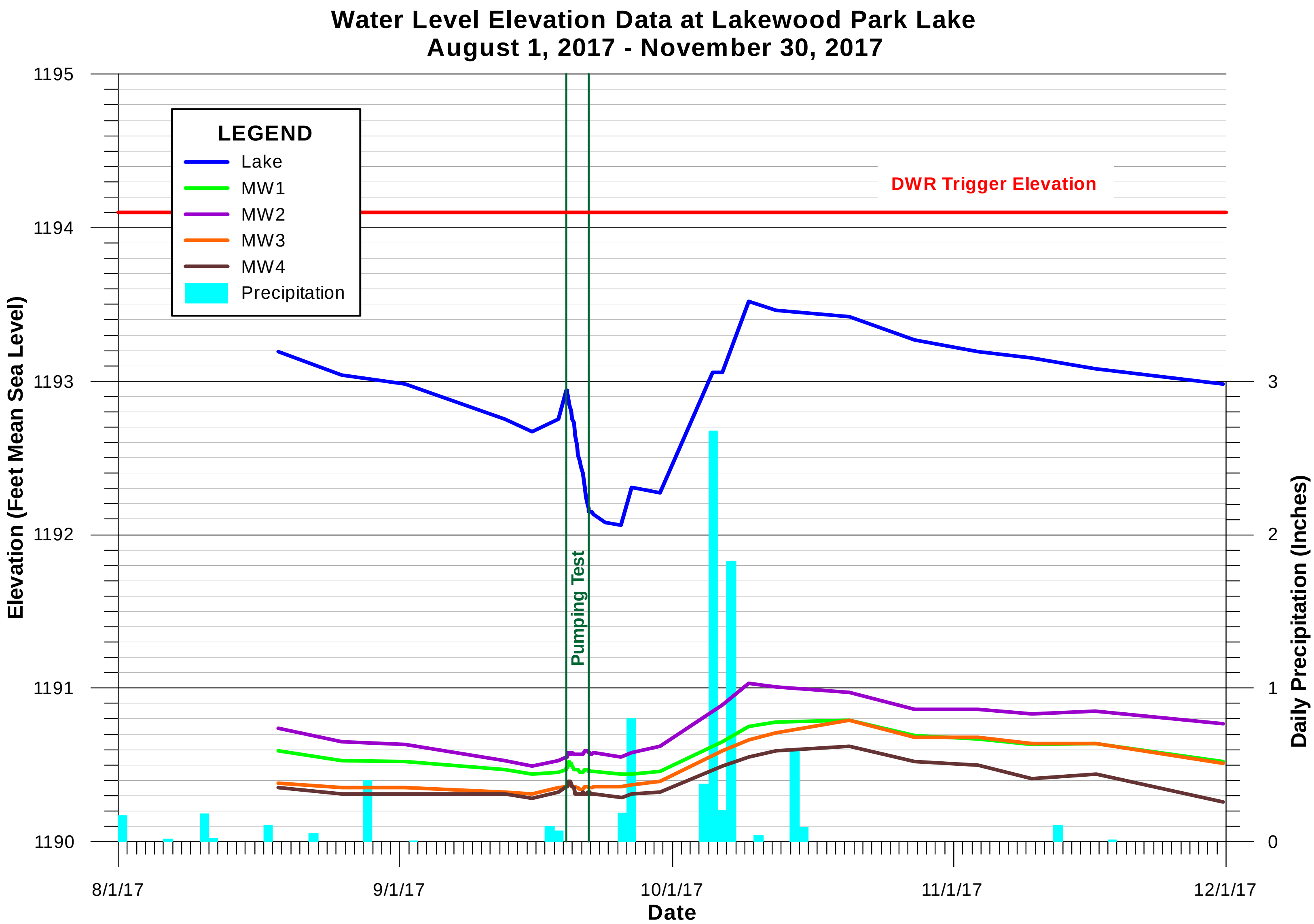

Figure 5 – Lakewood Park Lake Water and Groundwater Levels before, during and after the pump test.

3.2 Golf Course Irrigation Supply and Publicly Owned Re-use Water

Water reuse was identified as a water source option during HDR's feasibility study of the City's wastewater treatment plant (2017). WWTP effluent could be used, with no additional treatment, to indirectly supply the Smoky Hill River Renewal Project by supplying irrigation water for golf courses. In turn, water rights allocated to irrigate the golf courses could be used as a drought supply for the Project. Figure 6 presents the locations of golf courses identified in HDR's WWTP feasibility study. Table 11 presents a summary of the water rights for the three golf courses.

Table 11 - Summary of Water Rights for the Three Salina Golf Courses

Water Right ID	Source of Water	Status	Acres Irrigated	Net Authorized Annual Use (ac-ft)	Net Authorized Diversion Rate (gpm)
City of Salina Municipal Golf Course					
#38486	Groundwater	Certificate Issued	167	55	300
#38487	Groundwater	Certificate Issued		62.5	300
#38488	Groundwater	Certificate Issued		31	285
#38489	Groundwater	Certificate Issued		55	240
#44271	Surface Water	Certificate Issued		33	1,580
Subtotal - Irrigation			167	236.5	2,705
Salina Country Club					
#3049	Groundwater	Certificate Issued	116	22.5	150
#10118	Groundwater	Certificate Issued	118	78	160
#17288	Groundwater	Certificate Issued	118	114	350
#29837	Groundwater	Certificate Issued	118	93	310
Subtotal - Irrigation			118	307.5	970
Great Life Golf and Fitness (Pestinger Enterprises)					
#7848	Groundwater	Certificate Issued	124.8	62.33	180
#35065	Groundwater	Certificate Issued		61.6	115
#42901	Surface Water	Certificate Issued		117	405
Subtotal - Irrigation			124.8	240.93	700
Total - Irrigation			409.8	784.93	4,375

When converting irrigation water rights to use for the Project, annual quantities are reduced to reflect the consumptive portion of the irrigation water right. In Saline County, the conversion amount would be 0.9 ac-ft per certified acre irrigated.

Figure 6 – Location of Golf Courses and potential water supply pipelines.

With the conversion to 100 percent consumptive use, the golf course water rights should allow usage as listed in Table 12. Ten cfs would be the desired rate, while 3.8 cfs and 3.0 cfs represent offset of evaporation and infiltration during the recreation and off seasons.

Table 12 - Golf Course Water Right Conversion to 100 Percent Consumptive Use.

Golf Course	Acres Authorized	Quantity (ac-ft /yr)	Days at 10 cfs	Days at 3.8 cfs	Days at 3.0 cfs
Salina Municipal	167	150.3	7.6	19.9	25.3
Salina Country Club	118	106.2	5.4	14.1	17.8
Great Life (Elk's)	124.8	112.3	5.7	14.9	18.9
Total	409.8	368.8	18.6	48.9	62

Potential to Move and Use Water Rights

In general, groundwater wells can only be moved 0.5 miles from the permitted location. The groundwater rights at the three golf courses are on the east side of the Smoky Hill River and would require a pipeline to take the water across the river and to the upstream segment of the Project in Bill Burke Park.

Surface water rights can be conveyed along natural stream ways, and might have the ability to be withdrawn from another location along the river – i.e. at the Project headworks. In looking at the two surface water rights associated with the golf courses, the following was determined:

- Water Appropriation #44,271 on the Salina Municipal Golf Course:
    - Has a priority date of July 3, 2000.
    - Is limited to all natural flows of an unnamed tributary to East Dry Creek not needed to satisfy vested rights and prior appropriations to be incrementally accumulated as space becomes available to a maximum extent of 80.4 ac-ft per year in a reservoir.
    - During the period October 1 through June 30, the verbal or written permission of the Chief Engineer, or an authorized representative of the Chief Engineer, shall be obtained in order to divert water each time the applicant desires to divert water.
    - During the period July 1 through September 30, no direct diversions shall be permitted unless written permission is obtained from the Chief Engineer or the Chief Engineer's authorized representative.
- Water Appropriation #42,901 on the Great Life Golf Course (Elk's):
    - Has a priority date of July 25, 1997.
    - Is from the Smoky Hill River and is limited to 112.3 ac-ft/yr and a maximum rate of 405 gpm (0.9 cfs).
    - During the period October 1 through June 30, the verbal or written permission of the Chief Engineer, or an authorized representative of the Chief Engineer, shall be obtained in order to divert water each time the applicant desires to divert water.
    - During the period July 1 through September 30, no direct diversions shall be permitted.

The restrictions on the surface water rights at the golf courses are anticipated to be similar to those on Water Appropriation #47,510, and represent little to no opportunity for water to supplement Water Appropriation #47,510. Removal of the surface water component from the water rights portfolios will limit maximum instantaneous rate for each golf course:

- Salina Municipal = 1,125 gpm (2.51 cfs)
- Salina Country Club = 970 gpm (2.16 cfs)
- Great Life (Elks) = 295 gpm (0.66 cfs)

As a result, this supplemental supply option would require the full allocation from minimally two golf courses to offset evaporative and seepage losses.

The following are potential limitations of this option:

- Permitting risk with DWR on conversion of the water rights to recreational use and use in a different location. It is suggested that the conversion be temporary to continue to allow use of the water for irrigation at the golf courses.
- This option requires agreement by the other two golf courses to allow use of water rights for that reason.

Infrastructure Requirements

Conveyance infrastructure of WWTP effluent to the golf courses would include constructing a storage tank, a high service pump station, and conveyance piping to the golf courses. Conveyance infrastructure of groundwater from the golf course to the headworks of the Project would include collection piping from the wells at the golf courses to the Project and a river crossing. The approximate planning level alignment is shown in Figure 6 and the order of magnitude cost is shown in Table 13.

Table 13 - Capital Costs for Golf Course Irrigation Supply and Publicly Owned Re-Use Water Alternative

CITY OF SALINA

WWTP Reuse and Golf Course Irrigation Well Diversion Supply

Preliminary Opinion of Probable Construction Cost

Item No.	Description	Units		Unit Price	Price	Comments
1	Mobilization, Bonds	1	LS	$ 150,000.00	$ 150,000	
2	Erosion and Sediment Control	1	LS	$ 45,000.00	$ 45,000	
3	Traffic Control	1	LS	$ 60,000.00	$ 60,000	
4	Replace Well Pump	10	LS	$ 50,000.00	$ 500,000	Assumes no power or well casing upgrades required
5	Flow Meter w/ Vault	3	LS	$ 35,000.00	$ 105,000	
6	Directional Drilled 8-Inch HDPE Force Main (1)	5,900	LF	$ 180.00	$ 1,062,000	
7	Open Cut 8-Inch HDPE Force Main (2)	600	LF	$ 70.00	$ 42,000	
8	Directional Drilled 10-Inch HDPE Force Main (1)	9,500	LF	$ 190.00	$ 1,805,000	
9	Open Cut 10-Inch HDPE Force Main (2)	1,000	LF	$ 75.00	$ 75,000	
10	Directional Drilled 16-Inch HDPE Force Main (1)	5,900	LF	$ 220.00	$ 1,298,000	
11	Open Cut 16-Inch HDPE Force Main (2)	600	LF	$ 90.00	$ 54,000	
12	Energy Dissipater Discharge Structure	1	LS	$ 8,000.00	$ 8,000	
13	Utility Relocations	1	LS	$ 145,000.00	$ 145,000	
14	Driveway Restoration (2)	17	EA	$ 975.00	$ 16,575	Assume 10' x 14' concrete per open cut driveway
15	Road Pavement Restoration (2)	670	SY	$ 65.00	$ 43,550	Assume concrete repair area 10' x 600' for open cut portion
16	Topsoil, Seeding, Fertilizing, and Mulch (2)	6,750	SY	$ 1.50	$ 10,125	Assume 2000' x 30'
				SUBTOTAL:	$ 5,419,250	
				Engineering, Survey and Const. Inspection (22%):	$ 1,192,235	
				Contingencies (30%):	$ 1,625,775	
				WWTP Reuse Pump, Storage and Pipeline Construction Cost per WWTP Feasibility Study (3)	$ 8,183,000	
				TOTAL CONSTRUCTION:	$ 16,420,260	

(1) Directional drilling assumes bedrock is sufficiently deep to accommodate pipe. Also assumes minimal existing utility conflicts.

(2) Assumes 90% of the pipe will be bored in place. Some amount of surface restoration is anticipated at utility relocates and boring pit locations.

(3) Costs of reuse facility improvements required from WWTP to Golf Courses from TM 6 (Effluent Reuse Opportunities) of the WWTP Feasibility Study

3.3 Increased Storage in Lakewood Park Lake

Preliminary design for the Project calls for connecting the Old Smoky Hill channel to Lakewood Park Lake for canoe access between the two. Given the higher surface water elevation anticipated in the channel, surface water elevation in the lake is expected to rise to 1199 (+/-) feet mean sea level (msl) during operation of the project at 80 cfs. The Wright Water Engineers 2010 bathymetric survey of the lake indicates surface area to be approximately 615,000 ft^2. The approximately 615,000 ft^3 per foot of increase in lake storage between elevations 1194.1 feet and 1199 feet msl would result in 3 million cubic feet of storage. Should the lake recirculation system be constructed, it is possible to drawdown this storage to an elevation of 1194.1 feet msl to offset system losses in the more critical portions of the Project.

It is anticipated that raising the lake's surface elevation and using the lake for surface water storage will require an additional surface water right.

An available lake storage of 3 million cubic feet of water could offset 9.1 days of Project water losses at 3.8 cfs during recreation season, and 11.6 days of Project water losses at 3.0 cfs during off season.

3.3.1 Lake Water Recirculation System

The lake water recirculation system is presented in a separate technical memorandum entitled "Lakewood Park Lake Pump Station and Force Main Conceptual Design" and is included in Appendix D.

The system consists of a pump station located at the Lakewood Park Lake and a force main located within the right of way of Indiana Avenue. The force main outlet will be located at the old Smoky Hill River channel in Bill Burke Park. Two pumping rates were evaluated - a 2 cfs pump rate and a 10 cfs pump rate.

3.4 Kanopolis Water Access District Storage

Kanopolis Lake is a federally authorized reservoir built in the 1940's with federally authorized purposes of flood control, irrigation, recreation, fish and wildlife, water quality, downstream low flow augmentation, navigation, hydroelectric power, and water supply. The irrigation purpose could not be implemented until an irrigation district had been created. Navigation and hydroelectric power are no longer operating purposes.

When the reservoir went into service in 1948 it had an original multipurpose pool capacity of 73,200 ac-ft that, with a 100-year design life and a designated sedimentation rate of 451 ac-ft /yr, was expected to dwindle to 28,100 ac-ft (38.4 percent of original) by 2048. As of 2017 the multipurpose pool was estimated at 44,535 ac-ft indicating only a 415 ac-ft /yr sedimentation rate.

With the creation of the Lower Smoky Hill Water Supply Access District in 2011, both the City and a coalition of surface water irrigators (Lower Smoky Hill Irrigation District – formed in 2013) were able to contract with the Kansas Water Authority at the end of 2016 to purchase storage space in the reservoir. Membership in the Access District is voluntary and may include municipal, industrial, recreational, and irrigation users in the reach of the Smoky Hill River below the reservoir. Storage in the reservoir is held under Water Reservation Rights #40,090-AR-24 and 40,090-AR-25, with a priority date of October 29, 1990.

Currently the 44,535 ac-ft of storage as estimated in 2017 is allocated as follows:

Table 14 - Kanopolis Lake Multipurpose Pool Storage Allocation – 2017.

Water Use	Storage (ac-ft)	Percent of Pool	Yield (MGD)
Water Quality (USACE)	23,782	53.40	0
Water Supply	20,753	46.60	8.2
Water Marketing	*10,408*	*23.37*	*4.1*
Access District	*10,345*	*23.23*	*4.1*
Reserve Capacity	*0*	*0*	*0*
Total	44,535	100.00	8.2

Reservoir storage is purchased as a percentage of total reservoir volume, so as the pool volume decreases with time due to sedimentation so will the ac-ft of volume that was purchased. For the Access District purchase the City purchased 7,733 ac-ft (17.20 percent) and the Irrigation District purchased 2,711 ac-ft (6.03 percent) of the 2016 total multipurpose pool of 44,953 ac-ft. Once the reservoir reaches its design life around year 2056, the City anticipates its reduced storage will be around 4,660 ac-ft. The water supply storage in Kanopolis purchased by the Access District can be utilized to supplement the Smoky Hill River stream flow to provide the ability for Access District members to make use of their reasonable and justified authorized quantities under their water rights through drought conditions.

Of the 23.37 percent of storage in the Water Marketing Pool, 6 percent (2,700 ac-ft in 2016) has been signed to a multi-year contract with Post Rock Rural Water District lasting through 2041. The remaining 17.37 percent available in the Marketing Pool equals about 7,741 ac-ft in the 2017 reservoir volume. Several pending applications have been filed on this remaining amount:

- Post Rock Rural Water District: 2,240 ac-ft
- McPherson Board of Public Utilities: 11,201 ac-ft
- City of Russell: 1,427 ac-ft
- White Energy Partners: 1,688 ac-ft

As discussed previously, a 99 percent system reliability during the recreation season would require 219 ac-ft of water (3.8 cfs over 29 days). In order to keep the channel full of water over the entire recreation season at 99.9 system reliability would require 407 ac-ft (3.8 cfs x 54 days). However, it has been noted that the September 2005 – March 2007 low river flow period would have resulted in 530 out of 557 days with no diversion allowed. To fully supply 3.8 cfs over that period would have required 3,995 ac-ft (3.8 cfs x 530 days). To meet that volume of storage in 2060 would require 6,560 ac-ft which is approximately 14.6 percent of the remaining 17.37 percent available in the Marketing Pool.

The City's cost per percent of the reservoir storage (445 ac-ft in 2017, 271 ac-ft in 2060) is approximately $144,000 in initial capital costs, plus an estimated annual maintenance fee of $12,600 per percent of storage for 20 years and $1,625 per percent of storage for an additional 20 years. The cost per ac-ft is calculated based on the 2060 volume of 271 ac-ft per percent of reservoir storage. This results in a per ac-ft cost of $531.35 initial cost plus an annual $46.50 maintenance fee for the first 20 years then $6.00 for an additional twenty years.

For the purpose of this study, we assume that the high end of annual water losses (550 to 2,540 ac-ft/yr) from the Project would need to be purchased. The initial cost and 20-year life cycle cost for a full year supply of 2,540 ac-ft is $1,350,000 and $1,407,949 respectively.

Yield of the reservoir is modeled as reservoir outflow to the Smoky Hill River under a drought similar to what Kansas experienced in the 1950's. The 1950's drought has been referred to as a 2 percent occurrence drought. As indicated in Table 14, the City's current allotment of 17.2 percent should equal approximately 3 MGD or 3,400 ac-ft /yr flow into the stream during a 2 percent drought occurrence under normal operations. This does not account for the City's storage volume being utilized to create higher flows in the river.

An operations agreement between the Kansas Water Office, the Division of Water Resources, and the Access District was signed in May 2017. This agreement discusses how lake releases will be allocated to the different storage owners.

4.0 Cost Estimates

Capital cost and life cycle costs were calculated for the various options. The following assumptions were used for the calculations:

- Construction capital costs include 22% for Engineering, Survey and Construction Inspection.
- Construction capital costs include 30% contingency.
- Life analysis period for present worth calculations is 20 years.
- Annual maintenance of constructed facilities is assumed to be 2% of initial capital cost.
- Interest rate used for present worth calculation is 5%.
- Average unit power cost for pumping is assumed to be $0.10/kWh.
- Combined motor and pump efficiency of 60% is assumed for pump energy usage.

4.1 Water Appropriation #47,510 - Smoky Hill River

The Kansas DWR fees of approximately $6,440 for this appropriation have already been paid by the City of Salina. There is no other capital or annual fees associated with this appropriation. Consequently this supply alternative has no life cycle cost associated with it.

4.2 Water Appropriation #47,509 – Lakewood Park Lake

This option was determined to be a non-viable option. Consequently capital and life cycle costs were not developed for this alternative.

4.3 Golf Course Irrigation Supply and Publicly Owned Re-use Water

Cost for conveyance infrastructure of WWTP effluent to the golf courses would include constructing a storage tank, a high service pump station, and conveyance piping to the golf courses. The capital cost for construction of this portion of the required improvements was previously estimated at $8,183,000 in TM 6 (Effluent Reuse Opportunities) of the Salina WWT Feasibility Study (HDR, 2017). Cost for collecting and piping the groundwater from the irrigation wells to the Project is estimated at $8,237,260. See Table 15 for capital cost calculations.

The life cycle cost for this alternative assumed an annual pumpage volume of 368 ac-ft at 220 feet of total dynamic head to pump from the WWTP to the golf courses and then from the golf courses to the discharge point in the old Smoky Hill River channel near Bill Burke Park. See Table 15 for calculation of life cycle cost.

Table 15 - Life Cycle Cost for Golf Course Irrigation Supply and Publicly Owned Re-Use Water Alternative

Cost Component	Annual Cost	Present Worth Cost
Capital Cost		$16,420,260
Operating Power Cost	$13,805	$172,038
Maintenance Cost	$328,405	$4,092,655
Total Present Worth		**$20,684,953**

4.4 Increased Storage in Lakewood Park Lake

Capital cost for this option includes construction of a recirculation system from Lakewood Park Lake to a discharge point in the old Smoky Hill River channel near Bill Burke Park. A separate technical memorandum entitled "Lakewood Park Lake Pump Station and Force Main Conceptual Design" (Appendix D) has a capital cost of $2,361,472 for a 2 cfs recirculation system, and $2,935,272 for a 10 cfs recirculation system.

The life cycle cost for this alternative assumes an annual pumpage volume of 124 ac-ft at 100 feet of total dynamic head. The life cycle cost also assumes the 10 cfs recirculation system will be constructed. See Table 16 for calculation of life cycle cost.

Table 16 - Life Cycle Cost for Increased Storage in Lakewood Park Lake Alternative

Cost Component	Annual Cost	Present Worth Cost
Capital Cost		$2,935,272
Operating Power Cost	$2,114	$26,350
Maintenance Cost	$58,386	$731,600
Total Present Worth		**$3,693,221**

4.5 Kanopolis Water Access District Storage

No construction of additional facilities is required for this alternative. Consequently the capital cost for this alternative is the $1,350,000 fee for purchase of the water storage. There is also an annual fee of $10,185 charged for the first 20 years and $1,315 for an additional 20 years for maintaining the storage. See Table 17 for life cycle cost for this alternative.

Table 17 - Life Cycle Cost for Kanopolis Water Access District Storage Alternative

Cost Component	Annual Cost	Present Worth Cost
Capital Cost (Storage Purchase)		$1,350,000
Annual Maintenance Cost	$118,110	$1,471,912
Total Present Worth		**$2,821,912**

5.0 Recommendations

The Table 18 summarizes the water supply volume, capital costs and life cycle costs for the options evaluated.

Table 18 - Summary of Water Supply Volume, Capital Costs and Life Cycle Costs for the Evaluated Options

Water Supply Option	Ac-Ft Available	Potential Use	Type of Source	Capital Costs	Life Cycle Costs
Smoky Hill River		Primary	Surface Water	$0	$0
Lakewood Park Lake	N/A	Supplemental	Groundwater	N/A	N/A
Golf Course Irrigation Supply	369	Supplemental	Groundwater and Surface Water	$16,420,260	$20,684,953
Increase Storage in Lakewood Park Lake	124	Supplemental	Surface Water	$2,935,272	$3,693,221
Kanopolis Water Access District		Supplemental	Surface Water	$1,350,000 (2,540 ac-ft)	$2,821,912

The Smoky Hill River will be the primary source of water for the Old Smoky Hill Channel Renewal Project (Water Appropriation #47,510). For aesthetic purposes, 80 cfs is the desired flow during the recreation season and this flow can be met approximately 65.8 percent of the days based on the historical records. The surface water right identifies that when the Smoky Hill River flows are less than 40 cfs, as measured at the stream gage near Mentor, the Project will not be allowed to divert water. It is anticipated 10.5 percent of the days during the recreation season will have shortages (less than 40 cfs) based on the historical records. The shortages were generally short in duration and 99 percent of the shortages were less than 30 days in duration.

Approximately 219 ac-ft is needed over a 29-day duration to raise the reliability of the water supply during the recreation season from 89.5 percent to 99 percent. The 219 ac-ft would offset the volume of water lost to seepage and evaporation in the renewed Old Smoky Hill channel. This volume would not create a flowing river and may not fully meet the aesthetic goals so it is considered the minimum needed. For additional reliability, we recommend that an amount of 2,540 ac-ft be purchased to offset a full year of losses. For this volume of water, the Kanopolis Water Access District had the lowest life cycle cost and is the recommended supplemental water supply source the City should further evaluate.

Increasing the storage in Lakewood Park also appeared to be viable to cover short-term (9 to 12 days) periods where the City cannot use Water Appropriation #47,510, but has a larger life cycle cost. This option might have merit if the stored water is pumped to recreate a recirculation system. The supplemental supply to offset seepage and evaporation (3.8 cfs) could be supplied by Kanopolis Water Access District with up to 10 cfs being pumped from the lake to meet aesthetic goals and to assist with non-motorized boat navigation. The pumped water would flow through the system and back into Lakewood Park Lake making a sustainable closed looped system. The re-circulation system does not need to be constructed during the Phase I Project and could be added during a subsequent phase.

6.0 References

HDR, Inc., 2017. *Salina WWTP Feasibility Study – TM 6: Effluent Reuse Opportunities (Draft)*. Prepared for City of Salina, June 2017, Lee's Summit, Missouri.

Kansas Water Office, 2017. *Reservoir Information* webpage. Accessed at http://kwo.ks.gov/reservoirs, November 17, 2017.

United States Geological Survey, 2017. *USGS 06866500 Smoky Hill R Nr Mentor, KS*. National Water Information System: Web Interface accessed at https://waterdata.usgs.gov/ks/nwis/inventory/?site_no=06866500, November 17, 2017.

Wright Water Engineers, Inc., 2010. *Smoky Hill River Renewal Master Plan: Engineering Issues*. Prepared for Design Studios West, August 11, 2010, Denver, Colorado.

Appendices

Appendix A: Water Rights

Appendix B: KVE Monitoring Well Installation Report

Appendix C: Lakewood Park Lake Pumping Test Data

Appendix D: Lakewood Park Lake Pump Station and Force Main Conceptual Design

Appendix A: Water Rights

Division of Water Resources
109 SW 9th Street, 2nd Floor
Topeka, Kansas 66612-1283

AD ASTRA PER ASPERA
Kansas
Kansas Department of Agriculture

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www.ksda.gov/dwr

Dale A. Rodman, Secretary
David W. Barfield, Chief Engineer

Sam Brownback, Governor

May 31, 2011

CITY OF SALINA
300 WEST ASH
PO BOX 736
SALINA KS 67402-0736

RE: Appropriation of Water, File Nos. 47,509 and 47,510

Dear Sir or Madam:

There are enclosed permits to appropriate water authorizing you to proceed with construction of the proposed diversion works (except those dams and stream obstructions regulated by K.S.A. 82a-301 through 305a), to divert such unappropriated water as may be available from the source and at the locations specified in the permits, and to use it for the purpose and at the locations described in the permits. Your attention is directed to the enclosures and to the terms, conditions, and limitations specified in these permits. A water meter is required on each of the proposed diversion works, and you must install them prior to water being put to beneficial use in order for you to maintain accurate records of water use. The meters should be used to provide the information required on the annual water use reports.

Failure to notify the Chief Engineer of the Division of Water Resources of the completion of the diversion works within the time allowed, or within any authorized extension of time thereof, will result in the dismissal of these permits. Enclosed are forms which may be used to notify the Chief Engineer that the proposed diversion works have been completed.

All requests for extensions of time to complete diversion works, or to perfect appropriations, must be submitted to the Chief Engineer before the expiration of time originally set forth in these permits to complete diversion works or to perfect an appropriation. If for any reason, you require an extension of time, you must request it before the expiration of time set forth in each of these permits. Failure to comply with this regulation will result in the dismissal of your permits or your water rights. Any request for an extension of time shall be accompanied by the required statutory fee, which is currently $100.00 for each file.

There is also enclosed an information sheet setting forth the procedure to obtain Certificates of Appropriation which will establish the extent of your water rights. If you have any questions, please contact our office. If you wish to discuss a specific file, please have the file number ready so that we may help you more efficiently.

Sincerely,

Brent A. Turney, L. G.
Change Application Unit Supervisor
Water Appropriation Program

BAT:dws
Enclosures
pc: Stockton Field Office
Luca DeAngelis, P.E., P.G., HDR Engineering, Inc.

THE STATE OF KANSAS

KANSAS DEPARTMENT OF AGRICULTURE
Dale A. Rodman, Secretary of Agriculture

DIVISION OF WATER RESOURCES
David W. Barfield, Chief Engineer

APPROVAL OF APPLICATION
and
PERMIT TO PROCEED

(This Is Not a Certificate of Appropriation)

This is to certify that I have examined Application, **File No. 47,509** of the applicant

City of Salina
300 West Ash
Post Office Box 736
Salina, Kansas 67402-0736

for a permit to appropriate water for beneficial use, together with the maps, plans and other submitted data, and that the application is hereby approved and the applicant is hereby authorized, subject to vested rights and prior appropriations, to proceed with the construction of the proposed diversion works (except those dams and stream obstructions regulated by K.S.A. 82a301 through 305a, as amended), and to proceed with all steps necessary for the application of the water to the approved and proposed beneficial use and otherwise perfect the proposed appropriation subject to the following terms, conditions and limitations:

1. That the priority date assigned to such application is **April 5, 2010.**

2. That the water sought to be appropriated shall be used for recreational use within the original Smoky Hill River channel traversing Sections 7, 8, and 18, Township 14 South, Range 2 West; and Sections 12 and 13, Township 14 South, Range 3 West, all in Saline County, Kansas.

3. That the authorized source from which the appropriation shall be made is groundwater from the alluvial aquifer, to be withdrawn by means of an existing groundwater pit (Lakewood Park Lake), with a geographic center located in the Southwest Quarter of the Northeast Quarter of the Southwest Quarter (SW¼ NE¼ SW¼) of Section 7, more particularly described as being near a point 1,800 feet North and 3,325 feet West of the Southeast corner of said section, in Township 14 South, Range 2 West, Saline County, Kansas, located substantially as shown on the topographic map accompanyingthe application.

4. That the appropriation sought shall be limited to a maximum diversion rate not in excess of **4,500 gallons per minute (10 c.f.s.)** and to a quantity not to exceed **1,785 acre-feet** of water for any calendar year.

5. That installation of works for diversion of water shall be completed on or before **December 31, 2012** or within any authorized extension thereof. The applicant shall notify the Chief Engineer and pay the statutorily required field inspection fee of $400.00 when construction of the works has been completed. Failure to timely submit the notice and the fee will result in revocation of the permit. Any request for an extension of time shall be submitted prior to the expiration of the deadline and shall be accompanied by the required statutory fee of $100.00.

WATER METER REQUIRED

6. That the proposed appropriation shall be perfected by the actual application of water to the proposed beneficial use on or before **December 31, 2016** or any authorized extension thereof. Any request for an extension of time shall be submitted prior to the expiration of the deadline and shall be accompanied by the required statutory fee of $100.00.

7. That the applicant shall not be deemed to have acquired a water appropriation for a quantity in excess of the amount approved herein nor in excess of the amount found by the Chief Engineer to have been actually used for the approved purpose during one calendar year subsequent to approval of the application and within the time specified for perfection or any authorized extension thereof.

8. That the use of water herein authorized shall not be made so as to impair any use under existing water rights nor prejudicially and unreasonably affect the public interest.

9. That the right of the appropriator shall relate to a specific quantity of water and such right must allow for a reasonable raising or lowering of the static water level and for the reasonable increase or decrease of the streamflow at the appropriator's point of diversion.

10. That this permit does not constitute authority under K.S.A. 82a-301 through 305a to construct any dam or other obstruction; nor does it grant any right-of-way, or authorize entry upon or injury to, public or private property.

11. That all diversion works constructed under the authority of this permit into which any type of chemical or other foreign substance will be injected into the water pumped from the diversion works shall be equipped with an in-line, automatic quick-closing, check valve capable of preventing pollution of the source of the water supply. The type of valve installed shall meet specifications adopted by the Chief Engineer and shall be maintained in an operating condition satisfactory to the Chief Engineer.

12. That an acceptable water flow meter shall be installed and maintained on the diversion works authorized by this permit in accordance Kansas Administrative Regulations 5-1-4 through 5-1-12 adopted by the Chief Engineer. This water flow meter shall be used to provide an accurate quantity of water diverted as required for the annual water use report (including the meter reading at the beginning and end of the report year).

13. That the applicant shall maintain accurate and complete records from which the quantity of water diverted during each calendar year may be readily determined and the applicant shall file an annual water use report with the Chief Engineer by March 1 following the end of each calendar year. Failure to file the annual water use report by the due date shall causethe applicant to be subject to a civil penalty.

14. That no water user shall engage in nor allow the waste of any water diverted under the authority of this permit.

15. That failure without cause to comply with provisions of the permit and its terms, conditions and limitations will result in the forfeiture of the priority date, revocation of the permit and dismissal of the application.

16. That the right to appropriate water under authority of this permit is subject to any minimum desirable streamflow requirements identified and established pursuant to K.S.A. 82a-703c for the source of supply to which this water right applies.

17. That the applicant shall ensure that water diverted under authority of this permit be returned to the groundwater pit described in Paragraph No. 3 of this permit, such that the use of water would be considered essentially nonconsumptive to the source of supply.

WATER METER REQUIRED

18. That in order to prevent unreasonable lowering of the water level in the groundwater pit (Lakewood Park Lake), the applicant shall cease diversion when the surface water level in the groundwater pit is at or below elevation 1,194.1 feet mean sea level, as measured at the dock on the north side of Lakewood Park Lake.

19. That the groundwater pit shall be constructed, maintained and operated in a manner that will prevent degradation to the water quality of the source of supply which would cause impairment to existing water rights.

20. That the Chief Engineer specifically retains jurisdiction in this matter with authority to make such reasonable reductions in the approved rate of diversion and quantity authorized to be perfected, and such changes in other terms, conditions, and limitations set forth in this approval and permit to proceed as may be deemed to be in the public interest.

This Order shall become a final agency action, as defined by K.S.A. 77-607(b), without further notice to the parties, if a request for hearing or a petition for administrative review is not filed as set forth below.

Request for Hearing. According to K.A.R. 5-14-3(c), any party who desires a hearing must submit a request within 15 days after the date shown on the Certificate of Service attached to this Order. Filing a request for a hearing will give you the opportunity to submit additional facts for consideration, contest any findings made by the Chief Engineer, or present any other information you believe should be considered in this matter. A timely-filed request for hearing will stay the deadline for requesting administrative review of this Order pending the outcome of the hearing.

Petition for Review. The applicant, if aggrieved by this Order, may petition for administrative review, pursuant to K.S.A. 82a-711(c) and K.S.A. 82a-1901(a). The petition must be filed within 30 days after the date shown on the Certificate of Service attached to this Order and must set forth the basis for the review, unless stayed by the timely filing of a request for hearing.

Any request for hearing or petition for administrative review shall be in writing and shall be submitted to the attention of: Chief Legal Counsel, Kansas Department of Agriculture, 109 SW 9th Street, 4th Floor, Topeka, Kansas 66612, Fax: (785) 368-6668.

Dated at Topeka, Kansas, this 25th day of May, 2011.

DIVISION OF WATER RESOURCES
DAVID W. BARFIELD
CHIEF ENGINEER
KANSAS DEPARTMENT of AGRICULTURE

David W Barfield

David W. Barfield, P.E.
Chief Engineer
Division of Water Resources
Kansas Department of Agriculture

State of Kansas)
) SS
County of Shawnee)

The foregoing instrument was acknowledged before me this 25th day of May, 2011, by David W. Barfield, P.E., Chief Engineer, Division of Water Resources, Kansas Department of Agriculture.

NOTARY PUBLIC OFFICIAL SEAL STATE OF KANSAS
SHERYL P FERGEL
MY COMMISSION EXPIRES
January 5, 2014

Sheryl P Fergel

Notary Public

CERTIFICATE OF SERVICE

On this 31st day of May, 2011, I hereby certify that the foregoing Approval of Application and Permit to Proceed, File No. 47,509, dated May 25, 2011 was mailed postage prepaid, first class, US mail to the following:

CITY OF SALINA
300 WEST ASH
PO BOX 736
SALINA KS 67402-0736

With photocopies to:

HDR ENGINEERING INC
% LUCA DEANGELIS PE PG
4435 MAIN ST STE 1000
KANSAS CITY MO 64111-1856

Stockton Field Office

Amanda Humsaker
Division of Water Resources

Division of Water Resources
109 SW 9th Street, 2nd Floor
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Dale A. Rodman, Secretary
David W. Barfield, Chief Engineer

Kansas Department of Agriculture

Sam Brownback, Governor

May 31, 2011

CITY OF SALINA
300 WEST ASH
PO BOX 736
SALINA KS 67402-0736

RE: Appropriation of Water, File Nos. 47,509 and 47,510

Dear Sir or Madam:

There are enclosed permits to appropriate water authorizing you to proceed with construction of the proposed diversion works (except those dams and stream obstructions regulated by K.S.A. 82a-301 through 305a), to divert such unappropriated water as may be available from the source and at the locations specified in the permits, and to use it for the purpose and at the locations described in the permits. Your attention is directed to the enclosures and to the terms, conditions, and limitations specified in these permits. A water meter is required on each of the proposed diversion works, and you must install them prior to water being put to beneficial use in order for you to maintain accurate records of water use. The meters should be used to provide the information required on the annual water use reports.

Failure to notify the Chief Engineer of the Division of Water Resources of the completion of the diversion works within the time allowed, or within any authorized extension of time thereof, will result in the dismissal of these permits. Enclosed are forms which may be used to notify the Chief Engineer that the proposed diversion works have been completed.

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There is also enclosed an information sheet setting forth the procedure to obtain Certificates of Appropriation which will establish the extent of your water rights. If you have any questions, please contact our office. If you wish to discuss a specific file, please have the file number ready so that we may help you more efficiently.

Sincerely,

Brent A. Turney, L. G.
Change Application Unit Supervisor
Water Appropriation Program

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Luca DeAngelis, P.E., P.G., HDR Engineering, Inc.

THE STATE OF KANSAS

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David W. Barfield, Chief Engineer

APPROVAL OF APPLICATION
and
PERMIT TO PROCEED

(This is not a Certificate of Appropriation)

This is to certify that I have examined Application **File No. 47,510** of the applicant

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300 West Ash
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for a permit to appropriate water for beneficial use, together with the maps, plans and other submitted data, and that the application is hereby approved and the applicant is hereby authorized, subject to vested rights and prior appropriations, to proceed with the construction of the proposed diversion works (except those dams and stream obstructions regulated by K.S.A. 82a-301 through 305a, as amended), and to proceed with all steps necessary for the application of the water to the approved and proposed beneficial use and otherwise perfect the proposed appropriation subject to the following terms, conditions and limitations:

1. That the priority date assigned to such application is **April 5, 2010.**

2. That the water sought to be appropriated shall be used for recreational use within the original Smoky Hill River channel traversing Sections 7, 8, and 18, Township 14 South, Range 2 West; and Sections 12 and 13, Township 14 South, Range 3 West, all in Saline County, Kansas.

3. That the authorized source from which the appropriation shall be made is surface water from the Smoky Hill River, to be diverted at a point located in the Northeast Quarter of the Northeast Quarter of the Southwest Quarter (NE¼ NE¼ SW¼) of Section 18, more particularly described as being near a point 2,500 feet North and 3,000 feet West of the Southeast corner of said section, in Township 14 South, Range 2 West, in Saline County, Kansas, located substantially as shown on the topographic map accompanying the application.

4. That the appropriation sought shall be limited to a maximum diversion rate not in excess of **44,880 gallons per minute** (100 cubic feet per second) and to a quantity not to exceed **28,952 acre-feet** of water for any calendar year.

5. That installation of works for diversion of water shall be completed on or before **December 31, 2012** or within any authorized extension thereof. The applicant shall notify the Chief Engineer and pay the statutorily required field inspection fee, which is currently $400.00, when construction of the works has been completed. Failure to timely submit the notice and the fee will result in revocation of the permit. Any request for an extension of time shall be submitted prior to the expiration of the deadline and shall be accompanied by the required statutory fee, which is currently $100.00.

6. That the proposed appropriation shall be perfected by the actual application of water to the proposed beneficial use on or before **December 31, 2016** or any authorized extension thereof. Any request for an extension of time shall be submitted prior to the expiration of the deadline and shall be accompanied by the required statutory fee, which is currently $100.00.

7. That the applicant shall not be deemed to have acquired a water appropriation for a quantity in excess of the amount approved herein nor in excess of the amount found by the Chief Engineer to have been actually used for the approved purpose during one calendar year subsequent to approval of the application and within the time specified for perfection or any authorized extension thereof.

8. That the use of water herein authorized shall not be made so as to impair any use under existing water rights nor prejudicially and unreasonably affect the public interest.

9. That the right of the appropriator shall relate toa specific quantity of water and such right must allow for a reasonable raising or lowering of the static water level and for the reasonable increase or decrease of the streamflow at the appropriator's point of diversion.

10. That this permit does not constitute authority under K.S.A. 82a-301 through 305a to construct any dam or other obstruction; nor does it grant any right-of-way, or authorize entry upon or injury to, public or private property.

11. That all diversion works constructed under the authority of this permit into which any type of chemical or other foreign substance will be injected into the water pumped from the diversion works shall be equipped with an in-line, automatic quick-closing, check valve capable of preventing pollution of the source of the water supply. The type of valve installed shall meet specifications adopted by the Chief Engineer and shall be maintained in an operating condition satisfactory to the Chief Engineer.

12. That an acceptable water flow meter shall be installed and maintained on the diversion works authorized by this permit in accordance Kansas Administrative Regulations 5-1-4 through 5-1-12 adopted by the Chief Engineer. This water flow meter shall be used to provide an accurate quantity of water diverted as required for the annual water use report (including the meter reading at the beginning and end of the report year).

13. That the applicant shall maintain accurate and complete records from which the quantity of water diverted during each calendar year may be readily determined and the applicant shall file an annual water use report with the Chief Engineer by March 1 following the end of each calendar year. Failure to file the annual water use report by the due date shall cause the applicant to be subject to a civil penalty.

14. That no water user shall engage in nor allow the waste of any water diverted under the authority of this permit.

15. That failure without cause to comply with provisionsof the permit and its terms, conditions and limitations will result in the forfeiture of the priority date, revocation of the permit and dismissal of the application.

16. That the stream flow shall not be stopped at the first riffle below the point of diversion while diversion is taking place under the authority of this water right or permit.

17. That the right to appropriate water under authority of this permit is subject to any minimum desirable streamflow requirements identified and established pursuant to K.S.A. 82a-703c for the source of supply to which this water right applies.

18. That diversion of natural flows shall not take place unless there is water available to satisfy all demands by senior water rights and permits.

19. That during the period October 1 through June 30, the verbal or written permission of the Chief Engineer, or an authorized representative of the Chief Engineer, shall be obtained in order to divert water each time the applicant desires to divert water.

20. That during the period July 1 through September 30 each calendar year, no direct diversions of surface water shall be permitted unless written permission is obtained from the Chief Engineer, or the Chief Engineer's authorized representative.

21. That the diversion of surface water authorized herein shall be allowed only when flows in the Smoky Hill River at the U.S. Geological Survey stream gage No. 06866500 located near Mentor, Kansas are **equal to or greater than 40 c.f.s.** The City of Salina will be responsible for monitoring this stream gage to ensure that adequate flow is present prior to, and during, any diversion of surface water, and that permission has been granted to divert water asdiscussed in Paragraph Nos. 19 and 20 above.

22. That the maximum rate of diversion shall be limited to the flow at the U.S. Geological Survey stream gage No. 06866500 located near Mentor, Kansas, **less 30 c.f.s.**, to ensure that some volume of water remains in the river below the point of diversion when diversion of water is occurring.

23. That the Chief Engineer specifically retains jurisdiction in this matter with authority to make such reasonable reductions in the approved rate of diversion and quantity authorized to be perfected, and such changes in other terms, conditions, and limitations set forth in this approval and permit to proceed as may be deemed to be in the public interest

This Order shall become a final agency action, as defined by K.S.A. 77-607(b), without further notice to the parties, if a request for hearing or a petition for administrative review is not filed as set forth below.

Request for Hearing. According to K.A.R. 5-14-3(c), any party who desires a hearing must submit a request within 15 days after the date shown on the Certificate of Service attached to this Order. Filing a request for a hearing will give you the opportunity to submit additional facts for consideration, contest any findings made by the Chief Engineer, or present any other information you believe should be considered in this matter. A timely-filed request for hearing will stay the deadline for requesting administrative review of this Order pending the outcome of the hearing.

Petition for Review. The applicant, if aggrieved by this Order, may petition for administrative review, pursuant to K.S.A. 82a-711(c) and K.S.A. 82a-1901(a). The petition must be filed within 30 days after the date shown on the Certificate of Service attached to this Order and must set forth the basis for the review, unless stayed by the timely filing of a request for hearing.

Any request for hearing or petition for administrative review shall be in writing and shall be submitted to the attention of: Chief Legal Counsel, Kansas Department of Agriculture, 109 SW 9th Street, 4th Floor, Topeka, Kansas 66612, Fax: (785) 368-6668.

Dated at Topeka, Kansas, this 25th day of May, 2011.

DIVISION OF WATER RESOURCES
DAVID W. BARFIELD
CHIEF ENGINEER
KANSAS DEPARTMENT of AGRICULTURE

David W Barfield

David W. Barfield, P.E.
Chief Engineer
Division of Water Resources
Kansas Department of Agriculture

State of Kansas)
) SS
County of Shawnee)

The foregoing instrument was acknowledged before me this 25th day of May, 2011, by David W. Barfield, P.E., Chief Engineer, Division of Water Resources, Kansas Department of Agriculture.

OFFICIAL SEAL
SHERYL P FERGEL
MY COMMISSION EXPIRES
January 5, 2014

Sheryl P Fergel
Notary Public

CERTIFICATE OF SERVICE

On this 31st day of May, 2011, I hereby certify that the foregoing Approval of Application and Permit to Proceed, File No. 47,510, dated May 25, 2011 was mailed postage prepaid, first class, US mail to the following:

CITY OF SALINA
300 WEST ASH
PO BOX 736
SALINA KS 67402-0736

With photocopies to:

HDR ENGINEERING INC
% LUCA DEANGELIS PE PG
4435 MAIN ST STE 1000
KANSAS CITY MO 64111-1856

Stockton Field Office

Amanda Humaker
Division of Water Resources

1320 Research Park Drive
Manhattan, Kansas 66502
(785) 564-6700

Kansas
Department of Agriculture
agriculture.ks.gov

900 SW Jackson, Room 456
Topeka, Kansas 66612
(785) 296-3556

Jackie McClaskey, Secretary

Governor Sam Brownback

RECEIVED
8-30-17

August 17, 2017

CITY OF SALINA
DIRECTOR OF UTILITIES
PO BOX 736
SALINA KS 67402-0736

RE: Temporary Permit
File No. 20170196

Dear Sir or Madam:

Your application for temporary permit to appropriate water for beneficial use has been examined, approved, and a permit is enclosed.

The approval of your application constitutes a temporary permit to appropriate water for beneficial use, as set forth in the application. This permit does not give authority to any right-of-way, or authorize injury to, or trespass upon public or private property, does not constitute authority under K.S.A. 82a 301 through 305 to construct any dam or other obstruction; nor does it obviate the necessity of assent from Federal or Local Governmental authorities, when necessary. Records must be maintained from which the quantity of water actually diverted may be readily determined.

K.S.A. 82a-728 sets forth, in essence, that it is unlawful to divert or threaten to divert water for the type of use you propose without first acquiring approval of the Chief Engineer of the Division of Water Resources. <u>K.S.A. 82a-737 sets forth that violation of the Kansas Water Appropriation Act, any adopted rule or regulation, or any order of the Chief Engineer, may be subject to a civil penalty of up to $1000, per violation</u>. Each day that any such violation occurs can be considered a separate offense.

If you have any questions, please contact our office at (785) 564-6643.

Sincerely,

Austin McColloch

Austin McColloch
Environmental Scientist
Water Appropriation Program

Enclosures
pc:

CERTIFICATE OF SERVICE

On this 17th day of August, 2017 I hereby certify that the attached Approval of Application for Temporary Permit, File No. 20170196, dated August 16, 2017 was mailed postage prepaid, first class, US mail to the following:

CITY OF SALINA
DIRECTOR OF UTILITIES
PO BOX 736
SALINA KS 67402-0736

with photocopies to:

Austin McColloch

Staff

THE STATE OF KANSAS

KANSAS DEPARTMENT OF AGRICULTURE
Jackie McClaskey, Secretary of Agriculture

DIVISION OF WATER RESOURCES
David W. Barfield, Chief Engineer

APPROVAL OF APPLICATION
FOR
TEMPORARY PERMIT

This is to certify that I have examined Application, **File No. 20170196,** of the applicant

CITY OF SALINA
DIRECTOR OF UTILITIES
PO BOX 736
SALINA KS 67402-0736

for a **temporary permit** to appropriate water for beneficial use, together with the maps, plans and other submitted data, and that the application is hereby approved and the applicant is hereby authorized, subject to vested rights and prior appropriations, to proceed with the construction of the proposed diversion works (except those dams and stream obstructions regulated by K.S.A. 82a 301 through 305a, as amended), and to proceed with all steps necessary for the application of the water to the approved and proposed beneficial use subject to the following terms, conditions and limitations:

1. That the priority date assigned to such application is **August 16, 2017**.

2. That the water sought to be appropriated shall be used for recreational use in the Southwest Quarter (SW¼) of Section 7, Township 14 South, Range 2 West, Saline County, Kansas.

3. That the authorized source from which the appropriation shall be made is groundwater to be withdrawn by means of a pumpsite located in the Southwest Quarter of the Northeast Quarter of the Southwest Quarter (SW¼ NE¼ SE¼) of Section 7, more particularly described as being near a point 1,800 feet North and 3,325 feet West of the Southeast corner of said section, in Township 14 South, Range 2 West, Saline County, Kansas.

4. That the appropriation sought shall be limited to a maximum diversion rate not in excess of **1,100 gallons per minute** and to a quantity not to exceed **3.96 million gallons of water**.

5. That the applicant shall not be deemed to have acquired a water appropriation for a quantity in excess of the amount approved herein.

6. That the use of water herein authorized shall not be made so as to impair any use under existing water rights nor prejudicially and unreasonably affect the public interest.

7. That the temporary permit shall relate to a specific quantity of water and must allow for a reasonable raising or lowering of the static water level and for the reasonable increase or decrease of the streamflow at the authorized point of diversion.

8. That this temporary permit does not constitute authority under K.S.A. 82a 301 to 305a to construct any dam or other obstruction; nor does it grant any right-of-way, or authorize entry upon or injury to, public or private property.

(over)

9. That all diversion works constructed under the authority of this temporary permit into which any type of chemical or other foreign substance will be injected into the water pumped from the diversion works shall be equipped with an in-line, automatic quick-closing check valve capable of preventing pollution of the source of the water supply. The type of valve installed shall meet specifications adopted by the Chief Engineer and shall be maintained in an operating condition satisfactory to the Chief Engineer.

10. That the applicant shall maintain accurate and complete records from which the quantity of water diverted for the duration of the temporary permit may be readily determined.

11. That no water user shall engage in nor allow the waste of any water diverted under the authority of this temporary permit.

12. That failure without cause to comply with provisions of this temporary permit and its terms, conditions and limitations will result in the forfeiture of the priority date, revocation of the permit and dismissal of the application.

13. That this temporary permit is subject to any minimum desirable streamflow requirements identified and established pursuant to K.S.A. 82a-703c.

14. That the effective date of this temporary permit is **August 16, 2017.**

15. **That this temporary permit shall expire on September 30, 2017 and its priority forfeited, in accordance with K.S.A. 82a-727.**

16. **That an acceptable water flowmeter is required and must be installed prior to using water, records of the quantity of water used must be maintained and must also be made available to Chief Engineer or his agents, upon request. Additional information about water meter requirements, including a current list of acceptable meters and installation criteria is available on our website at: http://agriculture.ks.gov/meters.**

This is a final agency action. If you choose to appeal this decision or any finding or part thereof, you must do so by filing a petition for review in the manner prescribed by the Kansas Act for Judicial Review and Civil Enforcement of Agency Actions (KJRA K.S.A. 77-601 et seq.) within 30 days of service of this order. Your appeal must be made with the appropriate district court for the district of Kansas. The Chief Legal Counsel for the Kansas Department of Agriculture, 1320 Research Park Drive, Manhattan, Kansas 66502, is the agency officer who will receive service of a petition for judicial review on behalf of the Kansas Department of Agriculture, Division of Water Resources. If you have questions or would like clarification concerning this order, you may contact the Chief Engineer.

Ordered this 17th day of August, 2017, in Topeka, Shawnee County, Kansas.

Austin McColloch

FOR: David W. Barfield, P.E.
Chief Engineer
Division of Water Resources
Kansas Department of Agriculture

Appendix B: KVE Monitoring Well Installation Report

MONITORING WELL INSTALLATION REPORT
LAKEWOOD LAKE
12345 COLLEGE BOULEVARD
SALINA, KANSAS

Prepared For:

HDR ENGINEERING, INC.
2139 East Primrose, Suite E
Salina, Kansas 65804

Prepared By:

KAW VALLEY ENGINEERING, INC.
14700 West 114th Terrace
Lenexa, Kansas 66215

July 14, 2017

Project No. **E17G1693**

KAW VALLEY ENGINEERING, INC.

Office: 913.894.5150
Fax: 913.894.5977
Web: www.kveng.com
Address: 14700 West 114th Terrace
Lenexa, KS 66215

July 14, 2017 **E17G1693**

Mr. Eric Dove
HDR Engineering, Inc.
2139 East Primrose, Suite E
Springfield, MO 65804

**RE: SMOKY HILL RIVER RENEWAL PROJECT
LAKEWOOD LAKE MONITORING WELL INSTALLATION
SALINA, KANSAS**

Dear Mr. Dove:

This Monitoring Well Installation Report provides the details of the June 2017 field effort by Kaw Valley Engineering (KVE) to install four (4) monitoring wells at Lakewood Lake in Salina, Kansas. These wells were installed at locations selected by HDR and are part of the Smoky Hill River Renewal Project.

KVE June 2017 Field Work

Four (4) monitoring wells, MW-1 through MW-4, were drilled by KVE between June 22 and 28, 2017, at locations provided by HDR on an aerial photograph. The well locations were identified in the field by KVE personnel using the aerial photograph and a hand held GPS instrument. All wells were drilled at their pre-determined locations with the exception of MW-2. Due to steeply sloping conditions on the southeast corner of the lake, HDR approved moving MW-2 approximately 60 feet northeast to a location adjacent to the walking trail on the east side of the lake.

The borings were advanced using a CME-750 ATV mounted drill rig using 4-inch diameter continuous flight augers. Once the water table was reached, the hole was washbored the remaining depth to the top of the Wellington Shale bedrock, driving 4-inch steel casing to the bottom of the boring. Soil samples were collected from four (4) intervals in the top 10 feet of the boring and at approximate 5-foot intervals throughout the remainder of the boring using a split barrel sampler.

Soil Stratigraphy/Geology

Lakewood Lake is located within the ancestral river valley of the Smoky Hill River with the east side of the lake located within a few feet of the oxbow lake that was formerly the central channel of the river. This channel was cutoff during the completion of a flood control levee constructed by the U.S. Army Corps of Engineers in the mid 1960s. Soil sediments in this area consist of alluvial and terrace valley fill, ranging from clay to gravel sized sediments up to 60 feet thick.

Monitoring wells MW-1, MW-2, and MW-4 were located at similar elevations on the north, east, and west sides of the lake, respectively, while MW-3 was located on the south side of the lake at a lower elevation (see Plate 1). The soil stratigraphy of MW-1, MW-2, and MW-4 generally consisted of poorly graded, light brown, loose to medium dense, poorly graded silt or silty fine sand, from the surface down to approximately 18 to 22 feet. Underlying these sediments was a gray, poorly graded, medium to coarse grained sand with pebbles, that became orange/brown, coarse grained sand to pebble sized material within 10 to 15 feet of bedrock. MW-2 and MW-4 exhibited one or two thin, gray to dark gray, soft, silty clay layers between 30 and 40 feet. The upper 3 feet of MW-3 displayed a primarily brown lean clay with a rusty mottling overlying a poorly graded orange/brown, medium grained sand. From 8 to 22 feet was a very soft, light brown to gray, clayey silt that was saturated at 14 feet. Below this interval and down to bedrock was poorly graded, light brown to orange/brown, medium to coarse grained sand and pebbles.

The bedrock underlying the Smoky Hill River Valley is formed by the upper portion of the Wellington Shale, which lies in sharp contrast to the overlying alluvial sediments. At the locations drilled, the Wellington was mostly a blue-gray or maroon, blocky to sub-fissile, weathered shale, with infrequent rust colored laminations. The top of the Wellington was recorded at 49.8 feet in MW-1, 51.7 feet in MW-2, 34.3 feet in MW-3, and 49.7 feet in MW-4. Penetration into the Wellington ranged from 0.5 to 4.0 feet in the monitoring well borings. Copies of the boring logs for each of the monitoring wells are included in Plates 2 through 5.

Well Installation

Subsequent to the completion of drilling, permanent monitoring wells were installed in each of the four borings. The monitoring wells were constructed of 2-inch diameter Schedule 40 PVC riser, with a 10-foot, 0.010-inch slotted Schedule 40 PVC screen, and a 6 inch PVC well point at the bottom of the well. A filter fabric "sock" was installed over the screened interval and secured onto the lower 2 feet of the PVC riser to provide additional filtering. Once the well was in place at the bottom of the boring, the steel casing was slowly removed to allow natural sand and gravel to fill in around the well casing. Bentonite pellets followed by bentonite chips were placed into the open borehole, being hydrated every 5 feet, to create a seal around the casing to the ground surface. A pressure relief slot was cut into the top of the PVC casing of each well, just below the locking well cap.

Each well was completed with a 5-foot long protective steel casing, set 2 feet into the bentonite seal. Each steel casing was finished with a concrete pad around the base and a 1/4-inch diameter weep hole drilled 2 inches above the concrete pad. Pad locks (keyed alike) were attached to each of the locking caps and adhesive, reflective well numbers were affixed to one side of the steel casing. The well location, top of the PVC casing, and the top of the concrete pad were surveyed by a Kaw Valley Engineering, Inc. field crew. Well construction diagrams of each well are included in Plates 6 through 9.

Well Development

The monitoring wells were developed using a plastic disposable bailer attached to a nylon cord and a 1.75 inch diameter electric downhole pump. The downhole pump ran at a uniform flow rate of 1.25 gallons per minute with power supplied by a 12-volt car battery.

The bailer was used to surge the water in each well to agitate any drilling fluid or silt sized sediment accumulation, and then immediately bailed. The downhole pump was then used to surge and remove additional fine sediments along the length of the screen at intervals of 1 to 2 feet. This procedure was repeated until the groundwater no longer appeared turbid. A total of 65 gallons of groundwater was removed from MW-1, 90 gallons from MW-2, 65 gallons from MW-3, and 95 gallons from MW-4. In all four wells, the groundwater returned to static level in less than one minute once the pump was shut off.

CLOSURE

* * * * * *

The following plates are attached to and complete this report:

Plate 1 - Monitoring Well Locations

Plates 2 through 5 - Logs of Borings

Boring Log Reference Legend

Plates 6 through 9 -- Well Installation Logs

* * * * * *

We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions or comments.

Respectfully submitted,

Kaw Valley Engineering, Inc.

L. Kristopher Moore — James M. Barry

L. Kristopher Moore
Geologist

James M. Barry, R.G.
Geologist

Copies submitted (2)

MONITORING WELL LOCATIONS

PLATE 1

SMOKY HILL RIVER RENEWAL PROJECT
LAKEWOOD LAKE
SALINA, KANSAS

KAW VALLEY ENGINEERING

APPROVED BY: JAN	NOT TO SCALE	E17G1693

LOG OF BORING MW-1

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: HDR
PROJECT: Smoky Hill River Renew. Salina, KS
NUMBER: E17G1693-R2
LOCATION: Lakewood Lake, Salina, KS, 67401

DATE(S) DRILLED: 6/22/17 - 6/22/17
DRILLING METHOD(S): 4" CFA, Washbore
DRILL RIG: CME750
DRILL RIG OPERATOR: Les Scott
LOGGED BY: Kris Moore

GROUNDWATER INFORMATION:
Water level while boring: 22'
Water level upon completion: N/A

SURFACE ELEVATION: 1212.06'

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			T = 50=0										SILT: Light brown; dry — 1211.0'
													CONCRETE FILL — 1209.6'
	5		T = 1/1/3										SILT: Light brown; loose: slightly moist — 1205.1'
			T = 1/2/2										SILTY SAND: Light brown; slightly clayey; very loose; moist — 1204.6'
	10		T = 1/3/3										LEAN CLAY: Brown mottled with rust; stiff; moist; with silt — 1202.6'
													SILTY SAND: Light brown; loose — 1202.1'
													LEAN CLAY: Dark brown mottled with rust; stiff; moist; with silt — 1198.1'
	15		T = 3/4/6										SILTY SAND: Light brown; medium dense; moist; with silt; becomes fine to medium grained at 19'; orange/tan; loose; slightly moist
	20		T = 3/5/7										— 1190.1'
	25		T = 3/3/3										POORLY GRADED SAND: Gray; medium to coarse grained; with pea gravel; flowing; from 32'-40' becomes red/brown with iron concretions; medium dense
	30		T = 14/6/8										
	35		T = 10/13/17										
	40		T = 7/9/8										— 1168.1'
	45		T = 6/5/5										POORLY GRADED SAND: Orange/brown; medium dense; coarse grained; flowing; at 49' becomes primarily pebble to cobble-sized material — 1162.3'
	50		T = 9/12/18										SHALE: Wellington Shale; blue/gray, weathered, sub-fissile — 1161.6'
													BOTTOM OF HOLE AT 50.5
	55												
	60												

BORING TERMINATED AT 50.5'

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial Conditions: Grass

LOG OF BORING MW-2

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: HDR
PROJECT: Smoky Hill River Renew. Salina, KS
NUMBER: E17G1693-R2
LOCATION: Lakewood Lake, Salina, KS, 67401

DATE(S) DRILLED: 6/27/17 - 6/28/17
DRILLING METHOD(S): 4" CFA, Washbore
DRILL RIG: CME750
DRILL RIG OPERATOR: Les Scott
LOGGED BY: Kris Moore

GROUNDWATER INFORMATION:
Water level while boring: 23'
Water level upon completion: N/A

SURFACE ELEVATION: 1216.42'

FIELD DATA			LABORATORY DATA									
DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
0–3.5		T = 6/8/8										LEAN CLAY: Light brown; with silt and organics; dry to slightly moist; at 3' becomes more silty — 1212.9'
3.5–12		T = 2/2/3 T = 2/3/2 T = 1/2/1										SILT: Light brown; loose; dry to slightly moist; becomes sandy at 7.5' — 1204.4'
12–18		T = 2/3/3										POORLY GRADED SAND: Light brown/orange; fine grained; loose; dry — 1198.4'
18–27		T = 2/3/4 T = 2/4/6										POORLY GRADED SAND: Light brown/orange; medium to coarse grained; loose; slightly moist; at 23' becomes coarse with some pea sized gravel grains — 1189.4'
27–29.5		T = 2/3/1										POORLY GRADED SAND: Gray brown; coarse grained; loose; flowing; with pebbles — 1186.9'
29.5–34.5												CLAYEY SAND: Dark gray with darker gray staining; with fine sand — 1181.9'
34.5–35		T = 4/5/3										LEAN CLAY: Gray; soft; with sand — 1181.4'
35–40		T = 5/2/3										POORLY GRADED SAND: Gray; coarse grained; loose; with pebbles — 1176.4'
40–41												LEAN CLAY: Dark gray; soft; with silt — 1175.4'
41–49.5		T = 6/8/9										POORLY GRADED SAND: Gray; coarse grained; loose; with pebbles — 1166.9'
49.5–52		T = 8/10/41										POORLY GRADED SAND: Medium to coarse grained; with orange clay; at 50' rounded rust colored pea size quartz; medium dense — 1166.4' / 1164.7'
52–55.5		T = 6/8/9										SANDSTONE: Boulder; light brown/brown; fine to medium grained; well cemented; hard — 1160.9'
												SHALE: Dark gray to blue/gray; with silt laminations; subfissile
												BOTTOM OF HOLE AT 55.5'

BORING TERMINATED AT 55.5'

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial Conditions: Woods-brush/scrub trees

LOG OF BORING MW-3

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: HDR
PROJECT: Smoky Hill River Renew. Salina, KS
NUMBER: E17G1693-R2
LOCATION: Lakewood Lake, Salina, KS, 67401

DATE(S) DRILLED: 6/28/17 - 6/29/17
DRILLING METHOD(S): 4" CFA, Washbore
DRILL RIG: CME750
DRILL RIG OPERATOR: Les Scott
LOGGED BY: Kris Moore

GROUNDWATER INFORMATION:
Water level while boring: 15'
Water level upon completion: N/A

SURFACE ELEVATION: 1198.41'

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			T = 3/3/2										SILT: Light brown; loose; dry; with organic material 1197.4'
													LEAN CLAY: Brown mottled with rust; sitff; moist 1195.4'
	5		T = 3/3/3										POORLY GRADED SAND: Brown/orange; medium grained; loose; moist
			T = 2/3/2										1190.4'
	10		T = WOH*										SILT: Light brown; with roots; at 14' becomes gray and clayey; at 14.5-15' becomes slightly sandy; very soft; saturated
	15		T = 1/1/1										1180.4'
	20		T = WOH										SILT: Gray; very soft; with clay 1176.4'
	25		T = 2/1/1										POORLY GRADED SAND: Light brown; fine to medium grained; very loose; flowing 1169.4'
	30		T = 1/1/1										POORLY GRADED SAND: Brown in gray clayey matrix; medium to coarse grained; very loose 1166.9'
			T = 8/9/10										POORLY GRADED SAND: Orange/brown, coarse grained; medium dense; with pebbles 1164.1'
	35												SHALE: Blue/gray with rust colored laminations; subfissile to blocky 1162.9'
													BOTTOM OF HOLE AT 35.5'
	40												
	45												
	50												
	55												
	60												

BORING TERMINATED AT 35.5'

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial Conditions: Wooded with cat tail undergrowth
*WOH - Weight of hammer

LOG OF BORING MW-4

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: HDR
PROJECT: Smoky Hill River Renew. Salina, KS
NUMBER: E17G1693-R2
LOCATION: Lakewood Lake, Salina, KS, 67401

DATE(S) DRILLED: 6/26/17 - 6/27/17
DRILLING METHOD(S): 4" CFA, Washbore
DRILL RIG: CME750
DRILL RIG OPERATOR: Les Scott
LOGGED BY: Kris Moore

GROUNDWATER INFORMATION:
Water level while boring: 32'
Water level upon completion: N/A

SURFACE ELEVATION: 1216.66'

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
	0–4		T = 2/4/5										FAT CLAY: Dark brown; stiff; dry; with trace silt
	4–7		T = 4/7/7										1212.7' SILT: Light brown; medium dense; dry
	7–18		T = 5/6/7; T = 4/5/6; T = 5/6/6										1209.7' SILTY SAND: Light brown; fine grained; medium dense; dry; with silt; at 14' less silt
	18–23		T = 6/8/9										1198.7' POORLY GRADED SAND: Light brown to light orange; fine grained; medium dense; dry; at 21' with pebbles
	23–29		T = 5/5/3										1193.7' POORLY GRADED SAND: Brown; fine to coarse grained; with pebbles; at 24' very moist; at 24.5' some clay; at 25-29' flowing; loose
	29–32		T = 3/2/2										1187.7' LEAN CLAY: Gray/dark gray; stiff; moist; with silt
	32–37		T = 12/9/9										1184.7' POORLY GRADED SAND: Gray; medium to coarse grained; pebble sized fresh chert; medium dense
	37–49.7		T = 8/10/12; T = 5/6/9										1179.7' POORLY GRADED SAND: Gray; coarse grained; with pebbles; at 44' becomes medium to coarse grained; at 47' becomes orange/brown; coarse grained; medium dense
	49.7–53.5		T = 6/6/7; T = 12/10/9										1167.0' SHALE: Blue/gray; blocky; very silty; at 52.7' becomes blue/gray and maroon; subfissile
	53.5		BORING TERMINATED AT 53.5'										1163.2' BOTTOM OF HOLE AT 53.5'

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial Conditions: Not noted.

BORING LOG REFERENCE LEGEND

DESCRIPTIVE SOIL CLASSIFICATION

Soil description is based on the Unified Soil Classification System as outlined in ASTM Designation D-2487. The Unified Soil Classification group symbol for soil descriptions shown on the boring logs corresponds with the group names listed below. The description includes soil constituents, consistency, relative density, color and any other appropriate descriptive terms. Geologic description of bedrock, when encountered, is also shown in the description column. Refer to the appropriate notes for bedrock classification.

Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name
GW	Well graded gravel	SW	Well graded sand	CL	Lean clay	CH	Fat clay
GP	Poorly graded gravel	SP	Poorly graded sand	ML	Silt	MH	Elastic silt
GM	Silty gravel	SM	Silty sand	OL	Organic clay Organic silt	OH	Organic clay Organic silt
GC	Clayey gravel	SC	Clayey sand			PT	Peat

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf

< 500	Very Soft
500 – 1,000	Soft
1,001 – 2,000	Firm
2,001 – 4,000	Stiff
4,001 – 8,000	Very Stiff
8,001 – 16,000	Hard
> 16,000	Very Hard

RELATIVE PROPORTIONS

Descriptive Term(s) (Components also Percent in Sample)	Sand & Gravel Percent of Dry Wt.	Fines Percent of Dry Wt.
Trace	< 15	<5
Some	15 – 29	5 - 12
Modifier	> 30	> 12

RELATIVE DENSITY OF COARSE-GRAINED SOILS

N - (blows/ft)	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50+	Very Dense

GRAIN SIZE TERMINOLOGY

Major Component	Size Range
Cobbles	12 in to 3 in
Gravel	3 in to #4 sieve
Sand	#4 to #200 sieve
Silt or Clay	Passing #200 sieve

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. In pervious soil the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with only short-term observation.

DEFINITIONS OF ABBREVIATIONS

CR – Core recovery, length of core recovered in each run compared to the length drilled expressed as percent
LL – Liquid limit of specimen
N – Number of blows to penetrate last 12 inches with 140-pound hammer in standard penetration test
Blow count reported for each 6-inch interval on logs
PL – Plastic limit of specimen
RQD – Rock quality designation, aggregate length of core pieces greater than 4 inches long, expressed as percent of length drilled
TW – Thin walled tube
SS – Standard penetration test
NQ2 – 2 inches diameter core
CFA – Continuous flight augers
HSA – Hollow stem augers
EOB – End of boring

KAW VALLEY ENGINEERING

WELL INSTALLATION LOG

LOG NO.: **MW-1**

SHEET 1 OF 1

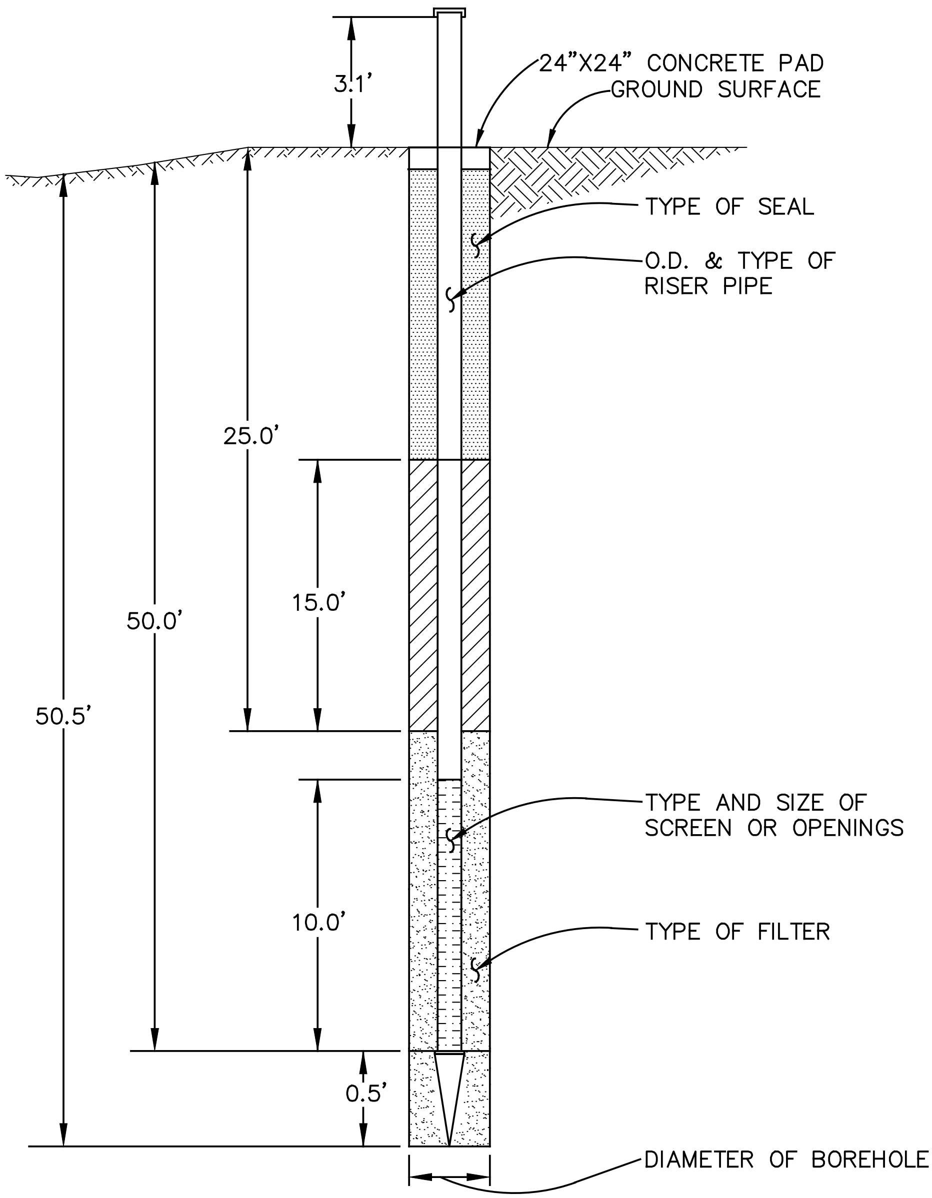
CLIENT: HDR ENGINEERING	*PROJECT:* SMOKY HILL RIVER RENEWAL	*PROJECT NO.:* E17G1693

LOCATION: NEAR NORTH ENTRANCE	*ELEVATION (DATUM):* 1,212.06'	*TOTAL DEPTH:* 50.5'	*DATE START:* 6/22/17

SURFICIAL CONDITIONS: GRASS	*LOGGED BY:* KRIS MOORE	*DATE FINISH:* 6/23/17

COORDINATES: NORTHING:187822.3107 EASTING:1429857.0435	*APPROVED BY:* LKM

DRILLING CONTRACTOR: KAW VALLEY	*DRILL RIG:* CME-750	*DRILLER:* LES SCOTT	*METHOD:* CFA/WASH BORE



3/8" BENTONITE HOLE PLUG 10' TO SURFACE

2" DIA PVC SCH 40 RISER

BENTONITE PELLETS FROM 25' TO 10'

2" DIA 10 SLOT SCREEN W/ FILTER SOCK 50' TO 40'

NATURAL SAND/GRAVEL

BOTTOM OF HOLE 50.5'
BOTTOM OF WELL POINT 50.5'

4.0" DIAMETER

METHOD OF INSTALLATION:

CONTINUOUS FLIGHT AUGERS TO 25';

WASH BORE 25' TO 50.5'

PLATE 6

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WELL INSTALLATION LOG

LOG NO.: **MW-2**

SHEET 1 OF 1

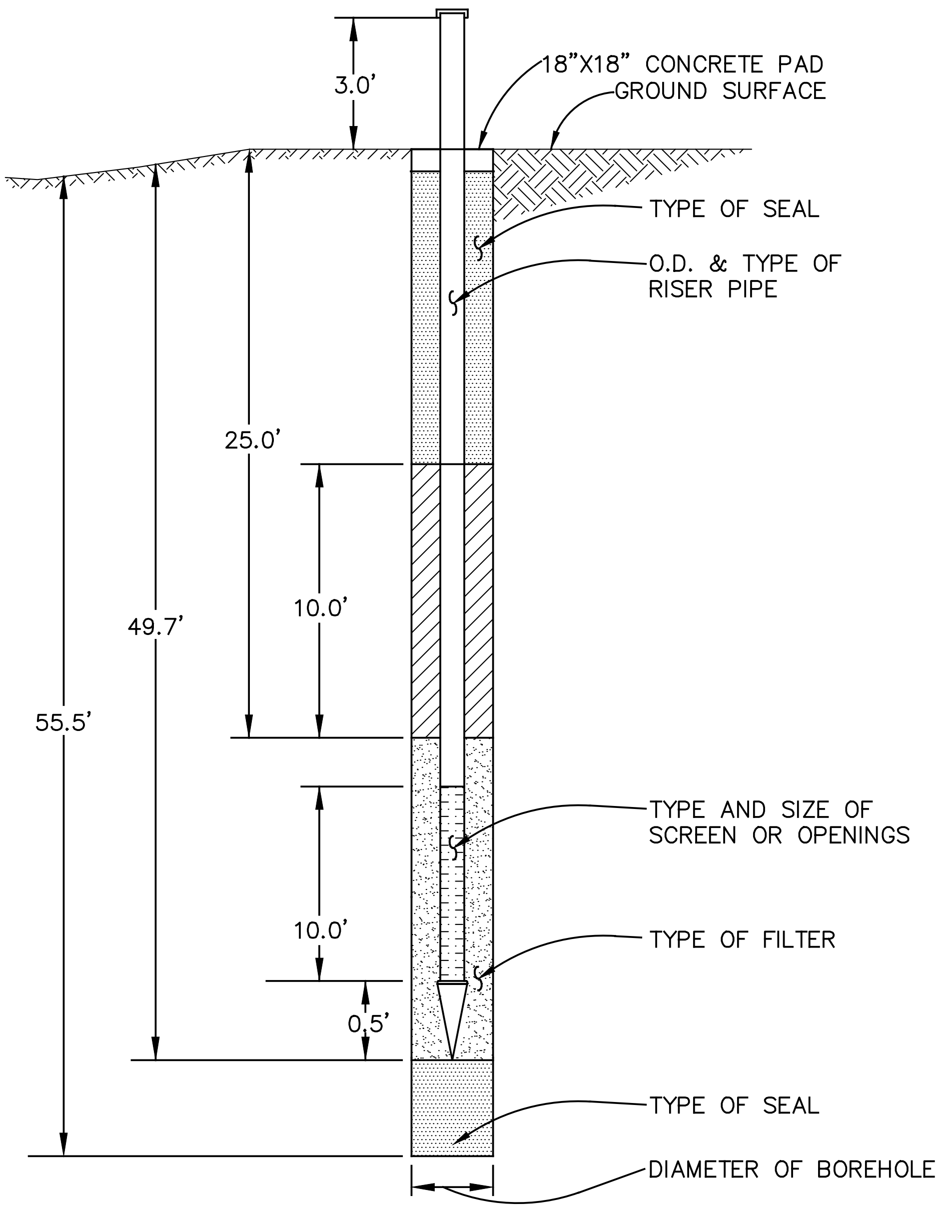
CLIENT: HDR ENGINEERING	PROJECT: SMOKY HILL RIVER RENEWAL	PROJECT NO.: E17G1693

LOCATION: EAST SIDE OF LAKE ALONG TRAIL	ELEVATION (DATUM): 1,216.42	TOTAL DEPTH: 49.7'	DATE START: 6/27/17

SURFICIAL CONDITIONS: BRUSH & SCRUB TREES	LOGGED BY: KRIS MOORE	DATE FINISH: 6/28/17

COORDINATES: NORTHING:187056.6019 EASTING: 1430208.8161	APPROVED BY: LKM

DRILLING CONTRACTOR: KAW VALLEY	DRILL RIG: CME-750	DRILLER: LES SCOTT	METHOD: CFA/WASH BORE



BENTONITE HOLE PLUG 15' TO SURFACE

2" DIA PVC SCH 40 RISER

BENTONITE PELLETS FROM 25' TO 15'

2" DIA 10 SLOT SCREEN W/ FILTER SOCK 49.2' TO 39.2'

NATURAL SAND/GRAVEL

BOTTOM OF HOLE 55.5' BACKFILL W/ SAND TO 49.7'

4.0" DIAMETER

METHOD OF INSTALLATION:

CONTINUOUS FLIGHT AUGERS TO 25';

WASH BORE 30' TO 55.5'

PLATE 7

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WELL INSTALLATION LOG

LOG NO.: **MW-3**

SHEET 1 OF 1

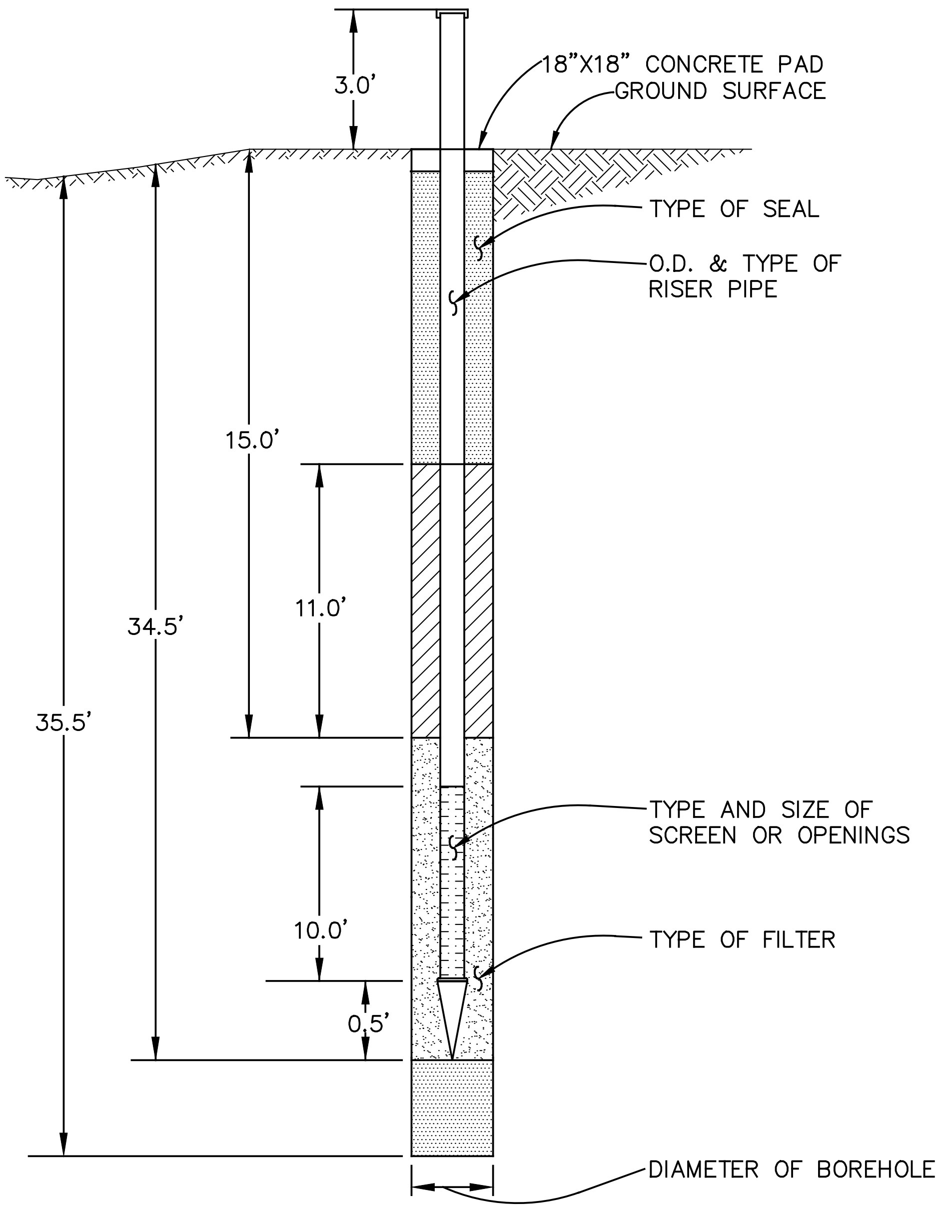
CLIENT:	PROJECT:	PROJECT NO.:
HDR ENGINEERING	SMOKY HILL RIVER RENEWAL	E17G1693

LOCATION:	ELEVATION (DATUM):	TOTAL DEPTH:	DATE START:
SOUTH SIDE OF LAKE ALONG TRAIL	1,198.41'	34.5'	6/28/17

SURFICIAL CONDITIONS:	LOGGED BY:	DATE FINISH:
WOODED W/ UNDERGROWTH	KRIS MOORE	6/29/17

COORDINATES:	APPROVED BY:
NORTHING:186618.1323 EASTING:1429698.7236	LKM

DRILLING CONTRACTOR:	DRILL RIG:	DRILLER:	METHOD:
KAW VALLEY	CME-750	LES SCOTT	CFA/WASH BORE



BENTONITE HOLE PLUG
4' TO SURFACE

2" DIA PVC SCH 40 RISER

BENTONITE PELLETS
FROM 15' TO 4'

2" PVC SCH 40 10 SLOT
SCREEN W/ FILTER SOCK
FROM 34' TO 24'

NATURAL SAND/GRAVEL

BOTTOM OF WELL POINT 34.5'
BOTTOM OF HOLE 35.5'

4.0" DIAMETER

METHOD OF INSTALLATION:

CONTINUOUS FLIGHT AUGERS TO 15';

WASH BORE 15' TO 35.5'

PLATE 8

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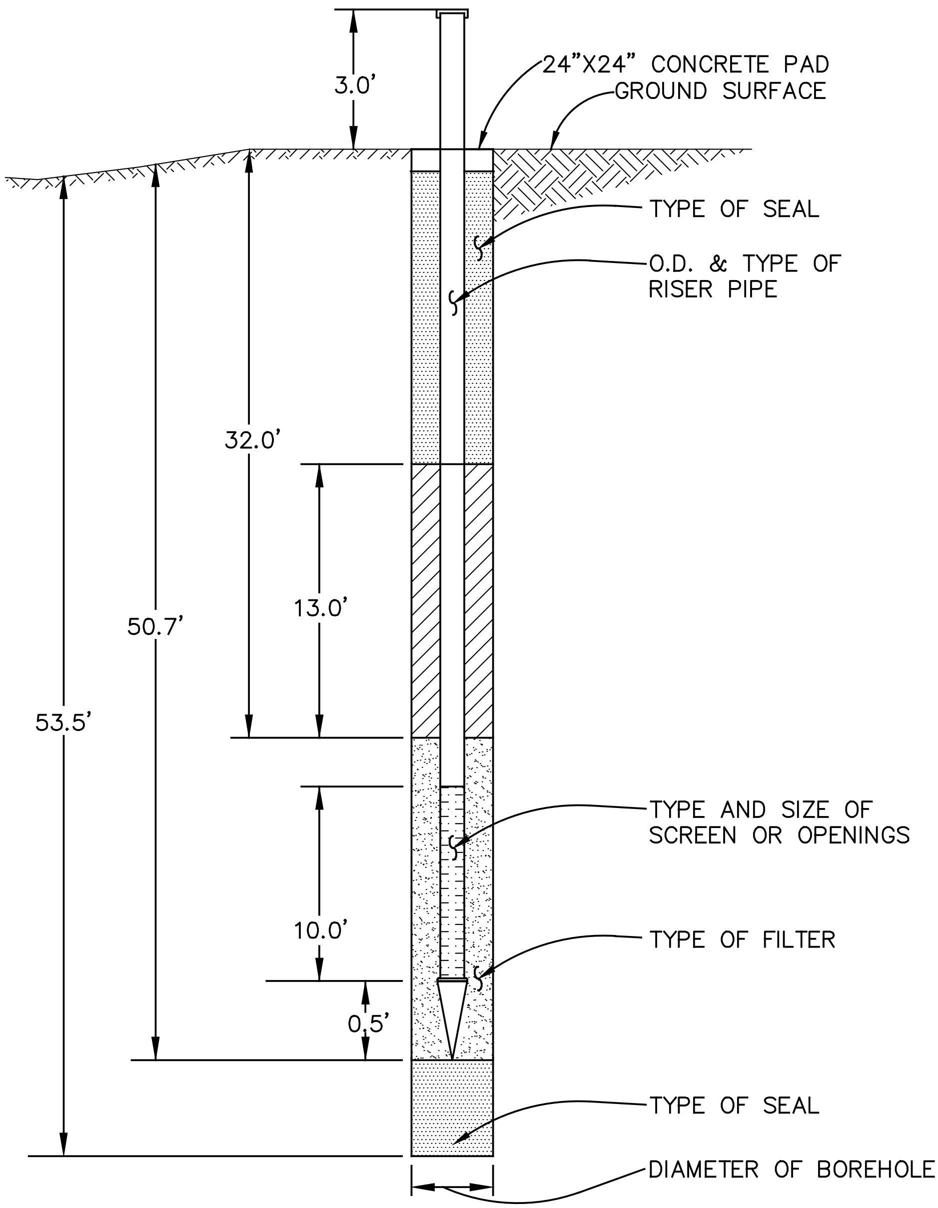
WELL INSTALLATION LOG

LOG NO.: **MW-4**

SHEET 1 OF 1

CLIENT: HDR ENGINEERING	PROJECT: SMOKY HILL RIVER RENEWAL	PROJECT NO.: E17G1693
LOCATION: WEST SIDE OF LAKE ALONG ROAD	ELEVATION (DATUM): 1,216.66 / TOTAL DEPTH: 50.7'	DATE START: 6/26/17
SURFICIAL CONDITIONS: LEVEL GROUND COVERED W/ SOIL & GRASS	LOGGED BY: KRIS MOORE	DATE FINISH: 6/27/17
COORDINATES: NORTHING:187436.7114 EASTING:1429198.0379	APPROVED BY: LKM	
DRILLING CONTRACTOR: KAW VALLEY / DRILL RIG: CME-750	DRILLER: LES SCOTT	METHOD: CFA/WASH BORE



BENTONITE HOLE PLUG
19' TO SURFACE

2" DIA PVC SCH 40 CASING

BENTONITE PELLETS
FROM 32' TO 19'

2" PVC SCH 40 10 SLOT
SCREEN W/ FILTER SOCK
FROM 50.2' TO 40.2'

NATURAL SAND/GRAVEL

BOTTOM OF WELL POINT 50.7'
BACKFILL W/ SAND TO 50.7'
BOTTOM OF HOLE 53.5'

4.0" DIAMETER

METHOD OF INSTALLATION:

CONTINUOUS FLIGHT AUGERS TO: 32'

WASH BORE: 32' TO 53.5'

PLATE 9

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Appendix C: Lakewood Park Lake Pumping Test Data

Lakewood Lake Testing

2017 Measure Monitor Wells to top of yellow well enclosure with cover open

CALCULATED DATA

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
	Gallons	Feet	Feet	Feet	Feet	Feet	Comments	
REFERENCE	McCrometer MG908 Serial # 13-00754 - ID = 8.071"	Staff Gauge set on pier near the dock - north side. Staff gauge set so that the feet on the gauge are at Elevation 1194.00' = 4' - 0"	Top of steel enclosure painted yellow with cover open = 1215.19'	Top of steel enclosure painted yellow with cover open = 1219.33'	Top of steel enclosure painted yellow with cover open = 1201.51'	Top of steel enclosure painted yellow with cover open = 1219.66'		
	Elevations		1215.19	1219.33	1201.51	1219.66		
8/2/2017	City Survey	1193.20					August	
Time							8/1/2017	0.13" to 0.20"
8/18/2017		1193.19	1190.59	1190.74	1190.38	1190.35	8/6/2017	0.01" to 0.02"
Time		3:02 PM	3:10 PM	3:20 PM	3:43 PM	3:31 PM	8/10/2017	0.16" to 0.20"
8/25/2017		1193.04	1190.53	1190.65	1190.35	1190.31	8/11/2017	0.02" to 0.03"
Time		1:38 PM	1:44 PM	1:51 PM	2:07 PM	1:58 PM	8/17/2017	0.08" to 0.13"
9/1/2017		1192.98	1190.52	1190.63	1190.35	1190.31	8/22/2017	0.04" to 0.07"
Time		2:53 PM	2:58 PM	3:12 PM	3:27 PM	3:20 PM	8/28/2017	0.21" to 0.59"
9/12/2017		1192.75	1190.47	1190.53	1190.32	1190.31		
Time		2:03 PM	2:09 PM	2:16 PM	2:33 PM	2:23 PM	September	

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
9/15/2017	Very windy	1192.67	1190.44	1190.49	1190.31	1190.28	9/2/2017	0.01"
Time		12:43 PM	12:47 PM	12:55 PM	1:12 PM	1:18 PM	9/16/2017	0.03" to 0.11"
9/18/2017		1192.75	1190.45	1190.53	1190.35	1190.32	9/17/2017	0.07" to 0.13"
Time		11:21 AM	11:25 AM	12:05 PM	12:18 PM	12:11 PM	9/18/2017	0.02" to 0.12"
9/19/2017	15,584,600	1192.94	1190.47	1190.55	1190.36	1190.36	9/19/2017	0.76" to 1.10"
Time	7:30 AM	7:30 AM	7:35 AM	7:45 AM	7:56 AM	7:51 AM		
9/19/2017	15,584,600							
Time	8:04 AM	BEGIN PUMPING	1000 GPM					
9/19/2017	15,613,000							
Time	8:32 AM	PROBLEM WITH PUMP HOSE						
9/19/2017	15,617,500							
Time	8:37 AM	STOP PUMP						
9/19/2017	15,617,500							
Time	8:45 AM +/-	RE- START PUMP						
9/19/2017			1190.48	1190.55	1190.36	1190.36		
Time			8:38 AM	8:45 AM	8:56 AM	8:50 AM		
9/19/2017	15,643,000	1192.94	1190.48	1190.55	1190.36	1190.36		
Time	9:07 AM	9:05 AM	9:11 AM	9:18 AM	9:30 AM	9:25 AM		
9/19/2017	15,671,500	1192.94	1190.48	1190.56	1190.36	1190.36		
Time	9:37 AM	9:35 AM	9:40 AM	9:47 AM	9:58 AM	9:52 AM		

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
9/19/2017	15,695,200	1192.92	1190.48	1190.56	1190.36	1190.36		
Time	10:01 AM	10:03 AM	10:08 AM	10:13 AM	10:25 AM	10:19 AM		
9/19/2017	15,728,900	1192.92						
Time	10:36 AM	10:30 AM						
9/19/2017	15,754,500	1192.92	1190.49	1190.57	1190.37	1190.36		
Time	11:02 AM	10:59 AM	11:00 AM	11:08 AM	11:19 AM	11:13 AM		
9/19/2017	15,810,000	1192.90	1190.49	1190.57	1190.37	1190.37	WINDY	
Time	12:00 PM	12:02 PM	12:03 PM	12:07 PM	12:19 PM	12:12 PM		
9/19/2017	15,844,400						WINDY	
Time	12:35 PM							
9/19/2017	15,868,600	1192.90	1190.51	1190.57	1190.37	1190.38	WINDY	
Time	1:00 PM	12:55 PM	1:02 PM	1:09 PM	1:22 PM	1:15 PM		
9/19/2017	15,923,000	1192.88	1190.51	1190.58	1190.37	1190.39	WINDY	
Time	1:57 PM	1:55 PM	1:59 PM	2:05 PM	2:15 PM	2:12 PM		
9/19/2017	16,033,000	1192.85	1190.52	1190.57	1190.37	1190.39	WINDY	
Time	3:56 PM	3:59 PM	4:02 PM	4:06 PM	4:18 PM	4:13 PM		
9/19/2017	16,150,000	1192.83	1190.51	1190.58	1190.37	1190.39		
Time	5:58 PM	5:55 PM	6:00 PM	6:05 PM	6:25 PM	6:10 PM		
9/19/2017	16,265,000	1192.81	1190.51	1190.57	1190.37	1190.38		
Time	7:57 PM	7:55 PM	8:00 PM	8:05 PM	8:16 PM	8:11 PM		

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
9/20/2017	16,500,000	1192.75	1190.49	1190.58	1190.36	1190.36	9/20/2017	none
Time	12:00 AM	12:02 AM	12:05 PM	12:18 AM	12:30 AM	12:23 AM		
9/20/2017	16,728,700	1192.73	1190.47	1190.57	1190.36	1190.35		
Time	3:54 AM	3:56 AM	4:03 AM	4:10 AM	4:20 AM	4:16 AM		
9/20/2017	16,968,700	1192.65	1190.47	1190.57	1190.36	1190.31	CALM	
Time	8:00 AM	8:00 AM	8:00 AM	8:09 AM	8:23 AM	8:15 AM		
9/20/2017	17,202,700	1192.58	1190.47	1190.57	1190.35	1190.31		
Time	12:00 PM	12:00 PM	12:02 PM	12:10 PM	12:28 PM	12:20 PM		
9/20/2017	17,435,300	1192.52	1190.47	1190.57	1190.35	1190.31		
Time	4:00 PM	4:00 PM	4:02 PM	4:08 PM	4:23 PM	4:16 PM		
9/20/2017	17,675,100	1192.48	1190.45	1190.57	1190.34	1190.31		
Time	8:08 PM	8:05 PM	8:10 PM	8:18 PM	8:36 PM	8:28 PM		
9/21/2017	17,890,100	1192.44	1190.45	1190.57	1190.34	1190.31	9/21/2017	none
Time	11:51 PM	11:53 PM	11:59 PM	12:06 AM	12:18 AM	12:24 AM		
9/21/2017	18,123,900	1192.40	1190.45	1190.57	1190.34	1190.32		
Time	3:52 AM	3:55 AM	4:00 AM	4:10 AM	4:19 AM	4:28 AM		
9/21/2017	18,366,500	1192.31	1190.47	1190.59	1190.36	1190.31		
Time	8:03 AM	8:00 AM	8:01 AM	8:08 AM	8:22 AM	8:15 AM		
9/21/2017	18,594,500	1192.25	1190.47	1190.59	1190.36	1190.31	BREEZY	
Time	12:00 PM	12:00 PM	11:58 AM	12:06 PM	12:18 PM	12:12 PM		

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
9/21/2017	18,821,000	1192.19	1190.47	1190.59	1190.36	1190.32	WINDY	
Time	4:01 PM	4:00 PM	4:03 PM	4:10 PM	4:26 PM	4:17 PM		
9/21/2017	18,988,900	1192.17	1190.46	1190.58	1190.35	1190.31	WINDY	
Time	7:00 PM	7:00 PM	7:03 PM	7:08 PM	7:29 PM	7:21 PM		
9/21/2017	19,047,100			**TOTAL GALLONS PUMPED =**	**3,462,500**		WINDY	
Time	8:02 PM	STOP PUMP						
9/21/2017		1192.15	1190.47	1190.58	1190.35	1190.32	WINDY	
Time		7:58 PM	8:07 PM	8:11 PM	8:21 PM	8:16 PM		
9/21/2017		1192.15	1190.47	1190.58	1190.35	1190.32	WINDY	
Time		8:30 PM	8:33 PM	8:38 PM	8:47 PM	8:43 PM		
9/21/2017		1192.15	1190.46	1190.58	1190.35	1190.32	WINDY	
Time		8:59 PM	9:02 PM	9:07 PM	9:17 PM	9:13 PM		
9/21/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		9:32 PM	9:34 PM	9:40 PM	9:49 PM	9:44 PM		
9/21/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		10:00 PM	10:03 PM	10:08 PM	10:20 PM	10:15 PM		
9/21/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		11:00 PM	11:03 PM	11:07 PM	11:19 PM	11:13 PM		
9/22/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		12:00 AM	12:03 AM	12:08 AM	12:20 AM	12:15 AM	9/22/2017	none

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
9/22/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		1:00 AM	1:03 AM	1:07 AM	1:19 AM	1:13 AM		
9/22/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		2:00 AM	2:03 AM	2:08 AM	2:20 AM	2:14 AM		
9/22/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		3:54 AM	4:01 AM	4:09 AM	4:18 AM	4:13 AM		
9/22/2017		1192.15	1190.46	1190.57	1190.35	1190.31	WINDY	
Time		3:54 AM	4:01 AM	4:09 AM	4:18 AM	4:13 AM		
9/22/2017		1192.13	1190.46	1190.58	1190.36	1190.31	WINDY	
Time		8:00 AM	8:15 AM	8:25 AM	8:42 AM	8:34 AM		
	END OF TEST							
9/23/2017		1192.08					WINDY	
		4:30 PM					9/23/2017	none
9/25/2017		1192.06	1190.44	1190.55	1190.36	1190.29	9/24/2017	none
		9:04 AM	9:30 AM	9:41 AM	9:47 AM	9:56 AM		
9/26/2017		1192.31	1190.44	1190.58	1190.37	1190.31	9/25/2017	0.13" to 0.25"
		1:05 PM	1:21 PM	1:27 PM	1:45 PM	1:38 PM	9/26/2017	0.75" to 0.86"
9/26/2017	City Survey	1192.29						

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
9/29/2017		1192.27	1190.46	1190.62	1190.39	1190.32		
		3:30 PM	3:36 PM	3:45 PM	3:59 PM	3:52 PM		
10/3/2017		1192.19	1190.42	1190.55	1190.37	1190.28		
before rain		1:40 PM	1:45 PM	1:52 PM	2:07 PM	1:59 PM	October	
10/5/2017		1193.06					10/4/2017	0.10" to 0.65"
		12:05 PM					10/5/2017	2.60" to 2.75"
10/6/2017		1193.06	1190.65	1190.89	1190.59	1190.49	10/6/2017	0.17" to 0.24"
		1:35 PM	1:39 PM	1:48 PM	2:03 PM	1:56 PM	10/7/2017	1.66" to 2.00"
10/9/2017		1193.52	1190.75	1191.03	1190.66	1190.55		
		11:05 AM	11:10 AM	11:19 AM	11:34 AM	11:27 AM	10/10/2017	0.02" to 0.06"
10/12/2017		1193.46	1190.78	1191.01	1190.71	1190.59	10/11/2017	0.11" to 0.15"
		10:28 AM	10:33 AM	10:45 AM	20:59 AM	10:52 AM	10/14/2017	0.59" to 0.61"
10/20/2017		1193.42	1190.79	1190.97	1190.79	1190.62	10/15/2017	0.09" to 0.10"
		12:43 PM	12:49 PM	12:56 PM	1:16 PM	1:06 PM		
10/27/2017		1193.27	1190.69	1190.86	1190.68	1190.52		
		4:10 PM	4:17 PM	4:24 PM	4:36 PM	4:30 PM		
11/3/2017		1193.19	1190.67	1190.86	1190.68	1190.50	11/1/2017	snow flurries
		3:40 PM	3:45 PM	3:54 PM	4:08 PM	4:01 PM		
11/9/2017		1193.15	1190.63	1190.83	1190.64	1190.41		
		1:46 PM	1:54 PM	2:00 PM	2:13 PM	2:07 PM		

Date	Flowmeter Totalizer	Lake Level Elevation	MW 1 Level Elevation	MW 2 Level Elevation	MW 3 Level Elevation	MW 4 Level Elevation	Rainfall	CoCoRaHS
11/16/2017		1193.08	1190.64	1190.85	1190.64	1190.44	11/12/2017	0.08" to 0.13"
		3:08 PM	3:14 PM	3:19 PM	3:30 PM	3:25 PM	11/18/2017	0.02"
11/30/2017		1192.98	1190.52	1190.77	1190.51	1190.26		
		2:47 PM	2:52 PM	3:02 PM	3:11 PM	3:06 PM	11/30/2017	none

Lakewood Lake Testing

2017 Measure Monitor Wells to top of yellow well enclosure with cover open

FIELD DATA

Date	Flowmeter Totalizer	Lake Level +/- 0.25"	MW 1 Level	MW 2 Level	MW 3 Level	MW 4 Level	Rainfall	CoCoRaHS
	Gallons	Ft - inches	Feet	Feet	Feet	Feet	Comments	
REFERENCE	McCrometer MG908 Serial # 13-00754 - ID = 8.071"	Staff Gauge set on pier near the dock - north side. Staff gauge set so that the feet on the gauge are at Elevation 1194.00' = 4' - 0"	Top of steel enclosure painted yellow with cover open = 1215.19'	Top of steel enclosure painted yellow with cover open = 1219.33'	Top of steel enclosure painted yellow with cover open = 1201.51'	Top of steel enclosure painted yellow with cover open = 1219.66'		
	Elevations	1193.20	1215.19	1219.33	1201.51	1219.66		
8/2/2017	City Survey	3'-2.40"					August	
Time							8/1/2017	0.13" to 0.20"
8/18/2017		3'-2.25"	24.60'	28.59'	11.13'	29.31'	8/6/2017	0.01" to 0.02"
Time		3:02 PM	3:10 PM	3:20 PM	3:43 PM	3:31 PM	8/10/2017	0.16" to 0.20"
8/25/2017		3' - 0.50"	24.66'	28.68'	11.16'	29.35'	8/11/2017	0.02" to 0.03"
Time		1:38 PM	1:44 PM	1:51 PM	2:07 PM	1:58 PM	8/17/2017	0.08" to 0.13"
9/1/2017		2'-11.75"	24.67'	28.70'	11.16'	29.35'	8/22/2017	0.04" to 0.07"
Time		2:53 PM	2:58 PM	3:12 PM	3:27 PM	3:20 PM	8/28/2017	0.21" to 0.59"
9/12/2017		2' - 9.00"	24.72'	28.80'	11.19'	29.35'		
Time		2:03 PM	2:09 PM	2:16 PM	2:33 PM	2:23 PM	September	
9/15/2017	Very windy	2' - 8" +/-	24.75'	28.84'	11.20'	29.38'	9/2/2017	0.01"
Time		12:43 PM	12:47 PM	12:55 PM	1:12 PM	1:18 PM	9/16/2017	0.03" to 0.11"

Date	Flowmeter Totalizer	Lake Level +/- 0.25"	MW 1 Level	MW 2 Level	MW 3 Level	MW 4 Level	Rainfall	CoCoRaHS
9/18/2017		2' - 9.00"	24.74'	28.80'	11.16'	29.34'	9/17/2017	0.07" to 0.13"
Time		11:21 AM	11:25 AM	12:05 PM	12:18 PM	12:11 PM	9/18/2017	0.02" to 0.12"
9/19/2017	15,584,600	2' - 11.25"	24.72'	28.78'	11.15'	29.30'	9/19/2017	0.76" to 1.10"
Time	7:30 AM	7:30 AM	7:35 AM	7:45 AM	7:56 AM	7:51 AM		
9/19/2017	15,584,600							
Time	8:04 AM	BEGIN PUMPING	1000 GPM					
9/19/2017	15,613,000							
Time	8:32 AM	PROBLEM WITH PUMP HOSE						
9/19/2017	15,617,500							
Time	8:37 AM	STOP PUMP						
9/19/2017	15,617,500							
Time	8:45 AM +/-	RE- START PUMP						
9/19/2017			24.71'	28.78'	11.15'	29.30'		
Time			8:38 AM	8:45 AM	8:56 AM	8:50 AM		
9/19/2017	15,643,000	2' - 11.25"	24.71'	28.78'	11.15'	29.30'		
Time	9:07 AM	9:05 AM	9:11 AM	9:18 AM	9:30 AM	9:25 AM		
9/19/2017	15,671,500	2'-11.25"	24.71'	28.77'	11.15'	29.30'		
Time	9:37 AM	9:35 AM	9:40 AM	9:47 AM	9:58 AM	9:52 AM		
9/19/2017	15,695,200	2' - 11.00"	24.71'	28.77'	11.15'	29.30'		
Time	10:01 AM	10:03 AM	10:08 AM	10:13 AM	10:25 AM	10:19 AM		

Date	Flowmeter Totalizer	Lake Level +/- 0.25"	MW 1 Level	MW 2 Level	MW 3 Level	MW 4 Level	Rainfall	CoCoRaHS
9/19/2017	15,728,900	2' - 11.00"						
Time	10:36 AM	10:30 AM						
9/19/2017	15,754,500	2' - 11.00" +/-	24.70'	28.76'	11.14'	29.30'		
Time	11:02 AM	10:59 AM	11:00 AM	11:08 AM	11:19 AM	11:13 AM		
9/19/2017	15,810,000	2' - 10.75" +/-	24.70'	28.76'	11.14'	29.29'	WINDY	
Time	12:00 PM	12:02 PM	12:03 PM	12:07 PM	12:19 PM	12:12 PM		
9/19/2017	15,844,400						WINDY	
Time	12:35 PM							
9/19/2017	15,868,600	2' - 10.75" +/-	24.68'	28.76'	11.14'	29.28'	WINDY	
Time	1:00 PM	12:55 PM	1:02 PM	1:09 PM	1:22 PM	1:15 PM		
9/19/2017	15,923,000	2' - 10.50" +/-	24.68'	28.75'	11.14'	29.27'	WINDY	
Time	1:57 PM	1:55 PM	1:59 PM	2:05 PM	2:15 PM	2:12 PM		
9/19/2017	16,033,000	2' - 10.25" +/-	24.67'	28.76'	11.14'	29.27'	WINDY	
Time	3:56 PM	3:59 PM	4:02 PM	4:06 PM	4:18 PM	4:13 PM		
9/19/2017	16,150,000	2' - 10.00" +/-	24.68'	28.75'	11.14'	29.27'		
Time	5:58 PM	5:55 PM	6:00 PM	6:05 PM	6:25 PM	6:10 PM		
9/19/2017	16,265,000	2' - 9.75" +/-	24.68'	28.76'	11.14'	29.28'		
Time	7:57 PM	7:55 PM	8:00 PM	8:05 PM	8:16 PM	8:11 PM		
9/20/2017	16,500,000	2' - 9.00" +/-	24.70'	28.75'	11.15'	29.30'	9/20/2017	none
Time	12:00 AM	12:02 AM	12:05 PM	12:18 AM	12:30 AM	12:23 AM		

Date	Flowmeter Totalizer	Lake Level +/- 0.25"	MW 1 Level	MW 2 Level	MW 3 Level	MW 4 Level	Rainfall	CoCoRaHS
9/20/2017	16,728,700	2' - 8.75"	24.72'	28.76'	11.15'	29.31'		
Time	3:54 AM	3:56 AM	4:03 AM	4:10 AM	4:20 AM	4:16 AM		
9/20/2017	16,968,700	2' - 7.75"	24.72'	28.76'	11.15'	29.35'	CALM	
Time	8:00 AM	8:00 AM	8:00 AM	8:09 AM	8:23 AM	8:15 AM		
9/20/2017	17,202,700	2' - 7.00"	24.72'	28.76'	11.16'	29.35'		
Time	12:00 PM	12:00 PM	12:02 PM	12:10 PM	12:28 PM	12:20 PM		
9/20/2017	17,435,300	2' - 6.25"	24.72'	28.76'	11.16'	29.35'		
Time	4:00 PM	4:00 PM	4:02 PM	4:08 PM	4:23 PM	4:16 PM		
9/20/2017	17,675,100	2' - 5.75"	24.74'	28.76'	11.17'	29.35'		
Time	8:08 PM	8:05 PM	8:10 PM	8:18 PM	8:36 PM	8:28 PM		
9/21/2017	17,890,100	2' - 5.25"	24.74'	28.76'	11.17'	29.35'	9/21/2017	none
Time	11:51 PM	11:53 PM	11:59 PM	12:06 AM	12:18 AM	12:24 AM		
9/21/2017	18,123,900	2' - 4.75"	24.74'	28.76'	11.17'	29.34'		
Time	3:52 AM	3:55 AM	4:00 AM	4:10 AM	4:19 AM	4:28 AM		
9/21/2017	18,366,500	2' - 3.75"	24.72'	28.74'	11.15'	29.35'		
Time	8:03 AM	8:00 AM	8:01 AM	8:08 AM	8:22 AM	8:15 AM		
9/21/2017	18,594,500	2' - 3.00"	24.72'	28.74'	11.15'	29.35'	BREEZY	
Time	12:00 PM	12:00 PM	11:58 AM	12:06 PM	12:18 PM	12:12 PM		
9/21/2017	18,821,000	2' - 2.25" +/-	24.72'	28.74'	11.15'	29.34'	WINDY	
Time	4:01 PM	4:00 PM	4:03 PM	4:10 PM	4:26 PM	4:17 PM		

Date	Flowmeter Totalizer	Lake Level +/- 0.25"	MW 1 Level	MW 2 Level	MW 3 Level	MW 4 Level	Rainfall	CoCoRaHS
9/21/2017	18,988,900	2' - 2.00" +/-	24.73'	28.75'	11.16'	29.35'	WINDY	
Time	7:00 PM	7:00 PM	7:03 PM	7:08 PM	7:29 PM	7:21 PM		
9/21/2017	19,047,100						WINDY	
Time	8:02 PM	STOP PUMP						
9/21/2017		2' - 1.75" +/-	24.72'	28.75'	11.16'	29.34'	WINDY	
Time		7:58 PM	8:07 PM	8:11 PM	8:21 PM	8:16 PM		
9/21/2017		2' - 1.75" +/-	24.72'	28.75'	11.16'	29.34'	WINDY	
Time		8:30 PM	8:33 PM	8:38 PM	8:47 PM	8:43 PM		
9/21/2017		2' - 1.75" +/-	24.73'	28.75'	11.16'	29.34'	WINDY	
Time		8:59 PM	9:02 PM	9:07 PM	9:17 PM	9:13 PM		
9/21/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		9:32 PM	9:34 PM	9:40 PM	9:49 PM	9:44 PM		
9/21/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		10:00 PM	10:03 PM	10:08 PM	10:20 PM	10:15 PM		
9/21/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		11:00 PM	11:03 PM	11:07 PM	11:19 PM	11:13 PM		
9/22/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		12:00 AM	12:03 AM	12:08 AM	12:20 AM	12:15 AM	9/22/2017	none
9/22/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		1:00 AM	1:03 AM	1:07 AM	1:19 AM	1:13 AM		

Date	Flowmeter Totalizer	Lake Level +/- 0.25"	MW 1 Level	MW 2 Level	MW 3 Level	MW 4 Level	Rainfall	CoCoRaHS
9/22/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		2:00 AM	2:03 AM	2:08 AM	2:20 AM	2:14 AM		
9/22/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		3:54 AM	4:01 AM	4:09 AM	4:18 AM	4:13 AM		
9/22/2017		2' - 1.75" +/-	24.73'	28.76'	11.16'	29.35'	WINDY	
Time		3:54 AM	4:01 AM	4:09 AM	4:18 AM	4:13 AM		
9/22/2017		2' - 1.50" +/-	24.73'	28.75'	11.15'	29.35'	WINDY	
Time		8:00 AM	8:15 AM	8:25 AM	8:42 AM	8:34 AM		
	END OF TEST							
9/23/2017		2' - 1.00" +/-					WINDY	
		4:30 PM					9/23/2017	none
9/25/2017		2' - 0.75" +/-	24.75'	28.78'	11.15'	29.37'	9/24/2017	none
before rain		9:04 AM	9:30 AM	9:41 AM	9:47 AM	9:56 AM		
9/26/2017		2' - 3.75" +/-	24.75'	28.75'	11.14'	29.35'	9/25/2017	0.13" to 0.25"
		1:05 PM	1:21 PM	1:27 PM	1:45 PM	1:38 PM	9/26/2017	0.75" to 0.86"
9/26/2017	City Survey	1192.29						
9/29/2017		2' - 3.25"	24.73'	28.71'	11.12'	29.34'		
		3:30 PM	3:36 PM	3:45 PM	3:59 PM	3:52 PM		
10/3/2017		2' - 2.25"	24.77'	28.78'	11.14'	29.38'		
before rain		1:40 PM	1:45 PM	1:52 PM	2:07 PM	1:59 PM	October	

Date	Flowmeter Totalizer	Lake Level +/- 0.25"	MW 1 Level	MW 2 Level	MW 3 Level	MW 4 Level	Rainfall	CoCoRaHS
10/5/2017		3' - 0.75"					10/4/2017	0.10" to 0.65"
		12:05 PM					10/5/2017	2.60" to 2.75"
10/6/2017	Brown/Red Material on probe at MW 2	3' - 0.75" +/-	24.54'	28.44'	10.92'	29.17'	10/6/2017	0.17" to 0.24"
		1:35 PM	1:39 PM	1:48 PM	2:03 PM	1:56 PM	10/7/2017	1.66" to 2.00"
10/9/2017	Brown/Red Material on probe at MW 2	3' - 6.25"	24.44'	28.30'	10.85'	29.11'		
		11:05 AM	11:10 AM	11:19 AM	11:34 AM	11:27 AM	10/10/2017	0.02" to 0.06"
10/12/2017	Windy	3' - 5.50" +/-	24.41'	28.32'	10.80'	29.07'	10/11/2017	0.11" to 0.15"
		10:28 AM	10:33 AM	10:45 AM	20:59 AM	10:52 AM	10/14/2017	0.59" to 0.61"
10/20/2017	Windy	3' - 5.00" +/-	24.40'	28.36'	10.72'	29.04'	10/15/2017	0.09" to 0.10"
		12:43 PM	12:49 PM	12:56 PM	1:16 PM	1:06 PM		
10/27/2017		3' - 3.25" +/-	24.50'	28.47'	10.83'	29.14'		
		4:10 PM	4:17 PM	4:24 PM	4:36 PM	4:30 PM		
11/3/2017		3' - 2.25" +/-	24.52'	28.47'	10.83'	29.16'	11/1/2017	snow flurries
		3:40 PM	3:45 PM	3:54 PM	4:08 PM	4:01 PM		
11/9/2017		3' - 1.75" +/-	24.56'	28.50'	10.87'	29.25'		
		1:46 PM	1:54 PM	2:00 PM	2:13 PM	2:07 PM		
11/16/2017		3' - 1.00" +/-	24.55'	28.48'	10.87'	29.22'	11/12/2017	0.08" to 0.13"
		3:08 PM	3:14 PM	3:19 PM	3:30 PM	3:25 PM	11/18/2017	0.02"
11/30/2017		2' - 11.75" +/-	24.67'	28.56'	11.00'	29.40'		
		2:47 PM	2:52 PM	3:02 PM	3:11 PM	3:06 PM	11/30/2017	none

Appendix D: Lakewood Park Lake Pump Station and Force Main Conceptual Design

HDR

Smoky Hill River Renewal
Salina, KS

Technical Memo

Smoky Hill River Renewal

Lakewood Park Lake
Pump Station and Force Main
Conceptual Design

Salina, Kansas
May 4, 2018

JEREMY H. ENGLISH
LICENSED
14883
KANSAS
PROFESSIONAL ENGINEER

5-4-18

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1.0 Introduction & Purpose

During drought conditions the Smoky Hill River flows may drop low enough to prevent adequate water flow through the Smoky Hill River Renewal Project. One of HDR's tasks was to complete an analysis of the primary and supplemental water supply alternatives for the River Renewal Project, as outlined in a separate technical memorandum titled "Water Supply Alternatives Evaluation". Some of those alternatives require a recirculation system for the supplemental water supply, or as an option to enhance water quality and project aesthetics for other supplemental supply alternatives. The purpose of this memorandum is to discuss the conceptual plan for the pump station and force main required for the recirculation system.

The recirculation system consists of a pump station located at Lakewood Park Lake and a force main located within the right of way of Indiana Avenue. The force main outlet will be located at the old Smoky Hill River channel in Bill Burke Park. After flowing through the river channel the water will return to the lake via two culverts/bridges designed to keep the channel and lake at the same water elevation and allow canoe/kayak access between the channel and lake. See Figure 1 for general layout of the pump station and force main.

The water right for Lakewood Park Lake (#47,509) is limited to a maximum flow rate of 10 cfs. Additionally the Smoky Hill Master Plan calculated 2 cfs would be the minimum necessary to maintain a full channel. Therefore two cubic feet per second (cfs) and 10 cfs pump rates were used in the analysis to determine appropriate force main and pump sizing.

Under normal channel flow conditions the lake and channel elevation is expected to be maintained at an approximate elevation of 1199 feet msl. Additionally, water right #47,509 only allows pumping at lake levels above elevation 1,194.1 feet msl. These two elevations were used as the upstream head range for the pump station.

0 Feet 400

LAKEWOOD PARK LAKE

PUMP STATION AND FORCE MAIN

FIGURE 1

PATH: F:\KS\SALINE_COUNTY\01_PROJECTS\SMOKYHILLRIVERURBAN\MAP_DOCS\DRAFT\SALINAKS_BASEMAP_LAKEWOODFORCEMAIN.MXD - USER: DCOOK - DATE: 4/6/2018

SALINA, KS

2.0 Pump Station and Force Main

The pump station and force main were evaluated for the two pump flow rate scenarios of 2 cfs (900 GPM) and 10 cfs (4,500 GPM).

2.1 Force Main

The force main route will extend from the pump station south along the east side of the Lakewood Park road to Iron Ave. The force main will then continue south along the west side of Indiana Avenue until it discharges into an energy dissipater at the old Smoky River channel in Bill Burke Park. The low points of the force main are at the lake and the two Smoky Hill River channel locations. The high point of the force main is approximately elevation 1,232 feet msl near the south end of the force main on Indiana Avenue. Total length of the force main is approximately 5,200 feet, but will vary depending on final pump station placement. Installation of the force main will utilize directional drilling throughout most of the alignment to reduce disruption to street traffic and restoration of roads, driveways and yards.

The recommended force main diameter size for the 2 cfs pump option is 10-inch HDPE, with a resulting pipe velocity of approximately 3.7 feet/second. The recommended main diameter size for the 10 cfs option is a 16-inch HDPE, with a resulting pipe velocity of 7.2 feet/second. See Figure 2 for elevation profile of the force main.

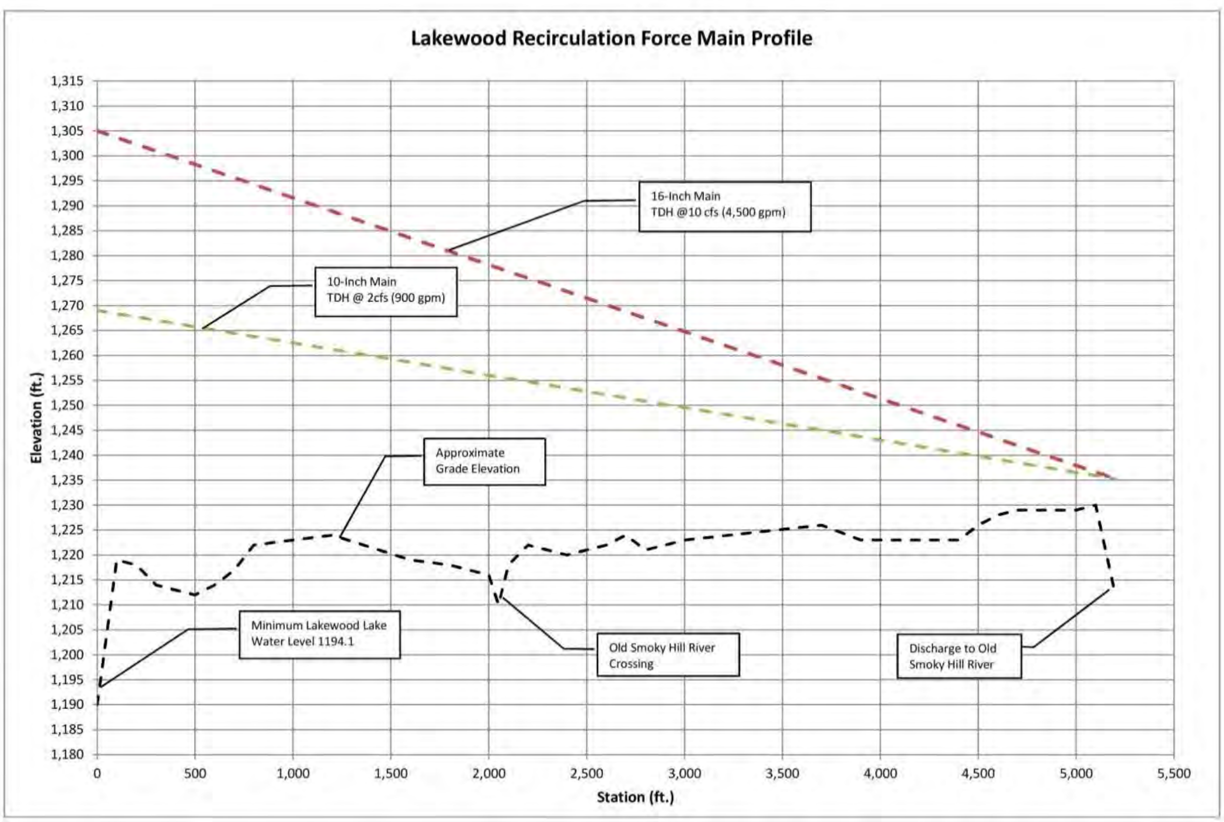


Figure 2 - Force Main Profile

2.2 Pump Station

The pump station will be located on the southwest corner of Lakewood Park Lake east of the park road. Grading and rock rip rap will be required for proper placement of the pump station and to minimize length of the 24-inch diameter inflow piping from the intake structure. The 24-inch piping is sized for the 10 cfs flow, and is recommended for either pumping rate option, to allow for potential future increase in flow of the 2 cfs option.

The intake structure will be placed such that the opening of the inlet will be below the minimum pumping water elevation of 1,194.1 feet msl and above the lake bottom elevation of 1,187 feet msl. The intake structure will have a trash screen protecting the opening, which will require regular inspection and cleaning. The trash screen is sized for a 0.5 fps entrance velocity to minimize entrance losses and minimize impingement potential. The minimum open area of the trash rack is four times the size of the 24-inch RCP to decrease the frequency of the rack cleaning. The trash rack would be on guide rails that would allow it to be temporarily removed for inspection and cleaning. An elevated walkway from the pump station to the intake structure would allow staff to access the intake structure. The pump station plan and section view is shown in Figure 3.

PROJECT MANAGER ERIC DOVE
CIVIL
PLOT STAMP
PROJECT NUMBER 00000000010059165

ISSUE	DATE	DESCRIPTION
-	-	-

PRELIMINARY NOT FOR CONSTRUCTION

ELECTRONIC SEAL AND SIGNATURE HAVE BEEN REMOVED. THIS SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT

Smoky Hill River Renewal
Salina, Kansas

RECIRCULATION SYSTEM INTAKE
LAKEWOOD PARK LAKE
PLAN AND PROFILE

FILENAME 00C-BP01-10.dwg
SCALE HZ:1" = 10' VT:1" = 5'

SHEET
FIGURE 3

The 2 cfs pumping option would be a duplex pump station with two identical 40-HP pumps. One pump operating would supply the 2 cfs flow with the second pump serving as redundancy and allow pump cycling.

The 10 cfs pumping option would be a triplex pump station with three identical 125-HP pumps. Two pumps operating at the same time would supply the 10 cfs flow with the third pump serving as redundancy and allow pump cycling. System head curves are shown in Figure 4.

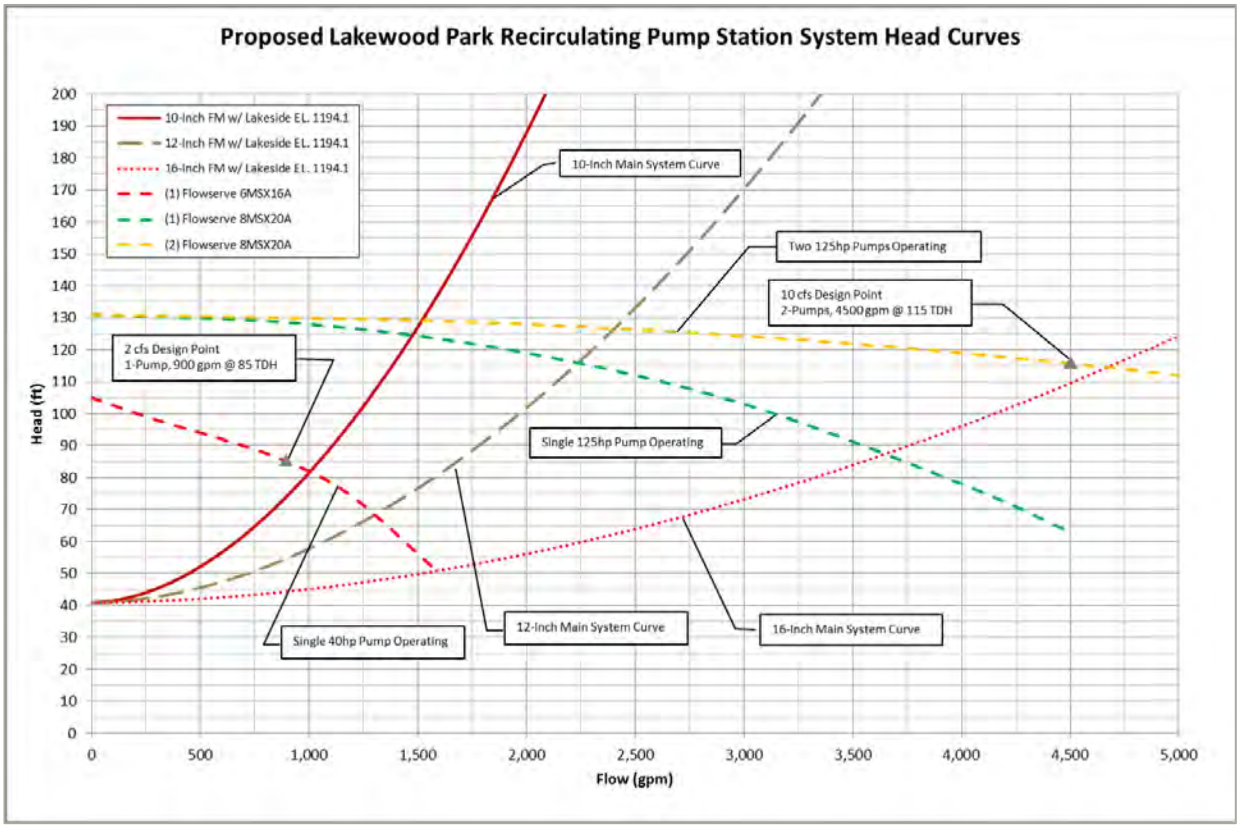


Figure 4 - Pump Station System Head Curves

Both pump station options are expected to require 480-Volt 3-phase power. It is assumed that the existing overhead power lines along the west side of the park road can supply the required power to the pump station. Actual power supply available will need to be verified during design to ensure proper design of the pump station.

3.0 Lakewood Park Lake Return Structure

After the pumped water has passed through the Old Smoky Hill River channel it will return to the lake through two proposed culverts/bridges designed to keep the channel and lake at the same water elevation and allow canoe/kayak access between the channel and lake. A proposed sill downstream of the last culvert will maintain normal lake levels at an approximate elevation of 1199 feet msl. See Figure 5 for a plan and section view of proposed lake return structure.

ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER ERIC DOVE
CIVIL
PLOT STAMP
PROJECT NUMBER 00000000010059165

PRELIMINARY NOT FOR CONSTRUCTION

ELECTRONIC SEAL AND SIGNATURE HAVE BEEN REMOVED. THIS SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT

Smoky Hill River Renewal
Salina, Kansas

LAKEWOOD PARK LAKE
RECIRCULATION SYSTEM INLET
PLAN AND PROFILE

FILENAME 00C-BP01-50.dwg
SCALE HZ:1" = 10' VT:1" = 5'
SHEET FIGURE 5

4.0 Cost Estimates

Cost Estimates for the 2-cfs and 10-cfs pumping options are shown in Tables 1 and 2. The proposed culvert/bridge return structures between river channel and lake are not included in the costs.

Table 1 - Option 1 (2-cfs) Pumping System Cost Estimate

CITY OF SALINA
Lakewood Park Lake Recirculation 2 cfs Pumping System - Option 1
Preliminary Opinion of Probable Construction Cost

Item No.	Description	Units		Unit Price	Price	Comments
1	Mobilization, Bonds	1	LS	$ 50,000.00	$ 50,000	
2	Erosion and Sediment Control	1	LS	$ 15,000.00	$ 15,000	
3	Traffic Control	1	LS	$ 20,000.00	$ 20,000	
4	Duplex Pump Station w/ Valve Vault	1	LS	$ 375,000.00	$ 375,000	Installed including excavation, fill and telemetry connections
5	Pump Station Electrical Power Supply	1	LS	$ 50,000.00	$ 50,000	Assumes power available from existing park road lines
6	Pump Station Flow Meter w/ Vault	1	LS	$ 35,000.00	$ 35,000	Assume mag meter in vault structure
7	Directional Drilled 10-Inch HDPE Force Main (1)	4,700	LF	$ 190.00	$ 893,000	
8	Open Cut 10-Inch HDPE Force Main (2)	500	LF	$ 75.00	$ 37,500	
9	Energy Dissipater Discharge Structure	1	LS	$ 8,000.00	$ 8,000	
10	24-inch RCP Storm Sewer	50	LF	$ 130.00	$ 6,500	
11	Utility Relocations	1	LS	$ 50,000.00	$ 50,000	
12	Driveway Restoration (2)	4	EA	$ 975.00	$ 3,900	Assume 10' x 14' concrete per open cut driveway
13	Road Pavement Restoration (2)	110	SY	$ 65.00	$ 7,150	Assume concrete repair area 10' x 100' for open cut portion
14	Topsoil, Seeding, Fertilizing, and Mulch (2)	1,700	SY	$ 1.50	$ 2,550	Assume 500' x 30'
				SUBTOTAL:	$ 1,553,600	
				Engineering, Survey and Const. Inspection (22%):	$ 341,792	
				Contingencies (30%):	$ 466,080	
				TOTAL CONSTRUCTION:	$ 2,361,472	

(1) Directional drilling assumes bedrock is sufficiently deep to accommodate pipe. Also assumes minimal existing utility conflicts.

(2) Assumes 90% of the pipe will be bored in place. Some amount of surface restoration is anticipated at utility relocates and boring pit locations.

Table 2 - Option 2 (10-cfs) Pumping System Cost Estimate

CITY OF SALINA

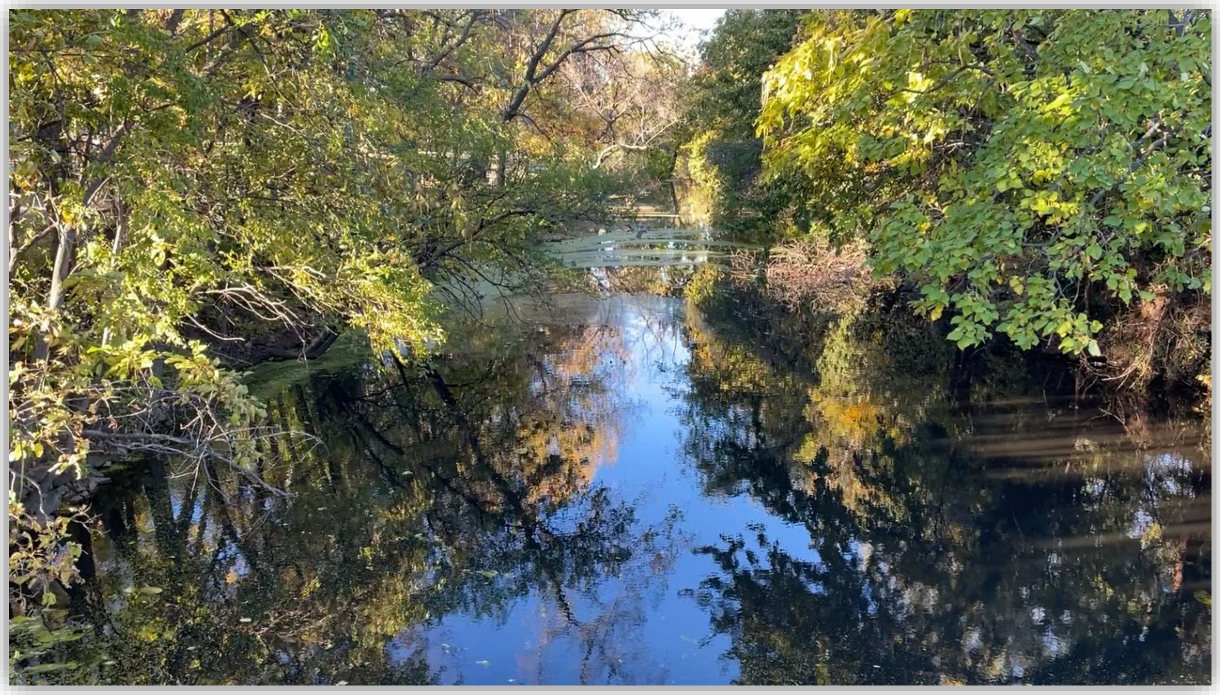
Lakewood Park Lake Recirculation 10 cfs Pumping System - Option 2

Preliminary Opinion of Probable Construction Cost

Item No.	Description	Units		Unit Price	Price	Comments
1	Mobilization, Bonds	1	LS	$ 50,000.00	$ 50,000	
2	Erosion and Sediment Control	1	LS	$ 15,000.00	$ 15,000	
3	Traffic Control	1	LS	$ 20,000.00	$ 20,000	
4	Triplex Pump Station w/ Valve Vault	1	LS	$ 575,000.00	$ 575,000	Installed including excavation, fill and telemetry connections
5	Pump Station Electrical Power Supply	1	LS	$ 65,000.00	$ 65,000	Assumes power available from existing park road lines
6	Pump Station Flow Meter w/ Vault	1	LS	$ 45,000.00	$ 45,000	Assume mag meter in vault structure
7	Directional Drilled 16-Inch HDPE Force Main (1)	4,700	LF	$ 220.00	$ 1,034,000	
8	Open Cut 16-Inch HDPE Force Main (2)	500	LF	$ 90.00	$ 45,000	
9	Energy Dissipater Discharge Structure	1	LS	$ 12,000.00	$ 12,000	
10	24-inch RCP Storm Sewer	50	LF	$ 130.00	$ 6,500	
11	Utility Relocations	1	LS	$ 50,000.00	$ 50,000	
12	Driveway Restoration (2)	4	EA	$ 975.00	$ 3,900	Assume 10' x 14' concrete per open cut driveway
13	Road Pavement Restoration (2)	110	SY	$ 65.00	$ 7,150	Assume concrete repair area 10' x 100' for open cut portion
14	Topsoil, Seeding, Fertilizing, and Mulch (2)	1,700	SY	$ 1.50	$ 2,550	Assume 500' x 30'
				SUBTOTAL:	$ 1,931,100	
				Engineering, Survey and Const. Inspection (22%):	$ 424,842	
				Contingencies (30%):	$ 579,330	
				TOTAL CONSTRUCTION:	$ 2,935,272	

(1) Directional drilling assumes bedrock is sufficiently deep to accommodate pipe. Also assumes minimal existing utility conflicts.

(2) Assumes 90% of the pipe will be bored in place. Some amount of surface restoration is anticipated at utility relocates and boring pit locations.



Smoky Hill River GI Study

Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix A2 – Future Without Project Condition and TSP Evaluation

September 2025

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1 PURPOSE

The purpose of this appendix is to supplement Appendix A1. This supplementation is due to updates in the future without project (FWOP) conditions and the decision on a tentatively selected plan to represent the future with project (FWP) condition. Alternative 3 was chosen as the tentatively selected plan and is the only FWP condition analyzed in this appendix. Alternatives 1, 2, and 4 were not assessed in this appendix, and they are documented in Appendix A1 – Section 5. This document preserves efforts to refine the FWOP and FWP hydraulic models to accurately represent the induced impact assessment. Induced impacts are defined as changes caused by the FWP in comparison to the FWOP that relate to stage frequencies, flow frequencies, or duration.

This appendix (A2) supports and supplants parts of Appendix A1 – Hydrology & Hydraulics Analysis Technical Report. Appendix A1 focused on existing conditions and alternatives 1 through 4, whereas this appendix focuses on FWOP and FWP (alternative 3 as selected in the TSP). Sections of appendix A1 that are crossed out have been deemed inapplicable and replaced by sections in this appendix.

2 HYDRAULIC MODEL DEVELOPMENT

This report section documents the hydraulic model development of a Hydrologic Engineering Center River Analysis System (HEC RAS) model for the FWOP and Alternative 3 (hereon referenced as FWP) conditions. The model adopted both unsteady and steady computational modules. Unsteady and steady computational modules were both used because unsteady flow plans are better tailored to identify impacts of the project. Steady flow analysis was used to evaluate low flows, including recreation season flows, because they are not as complex. HEC RAS software version 6.6 was used in this assessment. All elevations throughout the report are documented in the North American Vertical Datum of 1988 (NAVD88). Table 2.1 provides geometry information.

Table 2.1. Geometry File Information

Title	File Title	File Number	Description
Existing Conditions	OSH_Exist_2020	G02	From HDR. Representative of existing conditions.
Alternative 2	OSH_PropCond Geometry_2025_Alt2 FutureUSACE	G04	From HDR. Representative of Alternative 2. Includes RAISE Grant bridges.
Alternative 3	OSH-Alt3-1%	G01	From HDR. Representative of Alternative 3. Does not include RAISE Grant bridges.
Low Flow FWOP	OSH_FWOP_ USACE_Steady	G24	Same as the standard FWOP geometry but without gatewell operations.
Low Flow FWP	OSH_FWP_ USACE_Steady	G25	Same as the standard FWP geometry but without gatewell operations.

Title	File Title	File Number	Description
Standard FWOP	OSH_FWOP_ USACE_Unsteady-V2	G50	Geometry described in Section 2.1.
Standard FWP	OSH_FWP_ USACE_Unsteady-V2	G49	Geometry described in Section 2.2.
Standard 0.2% FWOP	OSH_FWOP_ USACE_Unsteady - V2-0.2%	G47	Geometry described in Section 2.1 but with larger Storage Areas due to increased inundation.
Standard 0.2% FWP	OSH_FWP_ USACE_Unsteady - V2-0.2%	G48	Geometry described in Section 2.2 but with larger Storage Areas due to increased inundation.
Post TSP Design Refinements FWOP	OSH_FWOP_ USACE_Unsteady-V3	G54	Geometry described in Section 2.1 with additional changes described in Section 2.3.
Post TSP Design Refinements FWP	OSH_FWP_ USACE_Unsteady-V3	G53	Geometry described in Section 2.2 with additional changes described in Section 2.3.
Post TSP Design Refinements 0.2 % FWOP	OSH_FWOP_ USACE_Unsteady - V3-0.2%	G51	Same as the Post TSP Design Refinements FWOP geometry but with larger Storage Areas due to increased inundation.
Post TSP Design Refinements 0.2% FWP	OSH_FWP_ USACE_Unsteady - V3-0.2%	G52	Same as the Post TSP Design Refinements FWP geometry but with larger Storage Areas due to increased inundation.

2.1 FWOP Geometry

The FWOP condition consists of existing channel cross sections and vegetation, as well as existing channel structures (Western Star Mill Weir, levee intake gate) as described in Appendix A1 – Section 4.4. Along with proposed Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grant bridges, and proposed levee outlet structure. The RAISE grant bridges are assumed to be completed regardless of the outcomes of this project and are therefore considered part of the FWOP. The FWOP is also assumed to include an additional pipe planned to supplement the existing 78” reinforced concrete pipe (RCP) gatewell at Station 685+50 in the Salina, Kansas Federal Levee Section 1 because it is associated with the RAISE grant bridge construction.

2.1.1 Existing Channel Cross Sections

The FWOP geometry was formed from the existing conditions geometry. This geometry has the existing channel cross sections. The existing channel cross sections are based on LiDAR flown in 2020 along with a spot elevation survey for quality assurance, as documented in Section 4.4.1 of Appendix A1 – Hydrology &

Hydraulics Analysis Technical Report. A comparison of the FWOP (black) and the FWP (pink) channel can be seen in Figure 2.8 and Figure 2.9 in Section 2.2.1.

2.1.2 FWOP Bridges

The FWOP geometry was formed from the existing conditions geometry. This geometry has the existing bridge and culvert structures. Seven of the nineteen bridges will be replaced as part of the RAISE grant bridge design, with an eighth gaining the addition of a trailway culvert. The remaining twelve bridges in the geometry file remain as modelled in OSH_Exist_2020 to match existing conditions.

The FWOP geometry was altered to include the eight RAISE grant bridges, including the nearest upstream (US) and downstream (DS) cross sections, with updated ineffective flow areas and roughness coefficients. These are named South Ohio Street, YMCA Drive, The Midway, Iron Avenue, Ash Street, Elm St, North Ohio Street, and Lakewood Park and their locations can be seen below in Figure 2.1. The RAISE grant bridge designs and bounding cross sections were copied from the alternative 2 geometry. Changes in bridge design can be seen below in Figure 2.2.

The elevated opening at N Ohio St is a trailway culvert as shown in Figure 2.1. For modelled culvert and bridge opening sizing see Table 2.2.

Lakewood Park is modelled as a lateral structure in the hydraulic model.

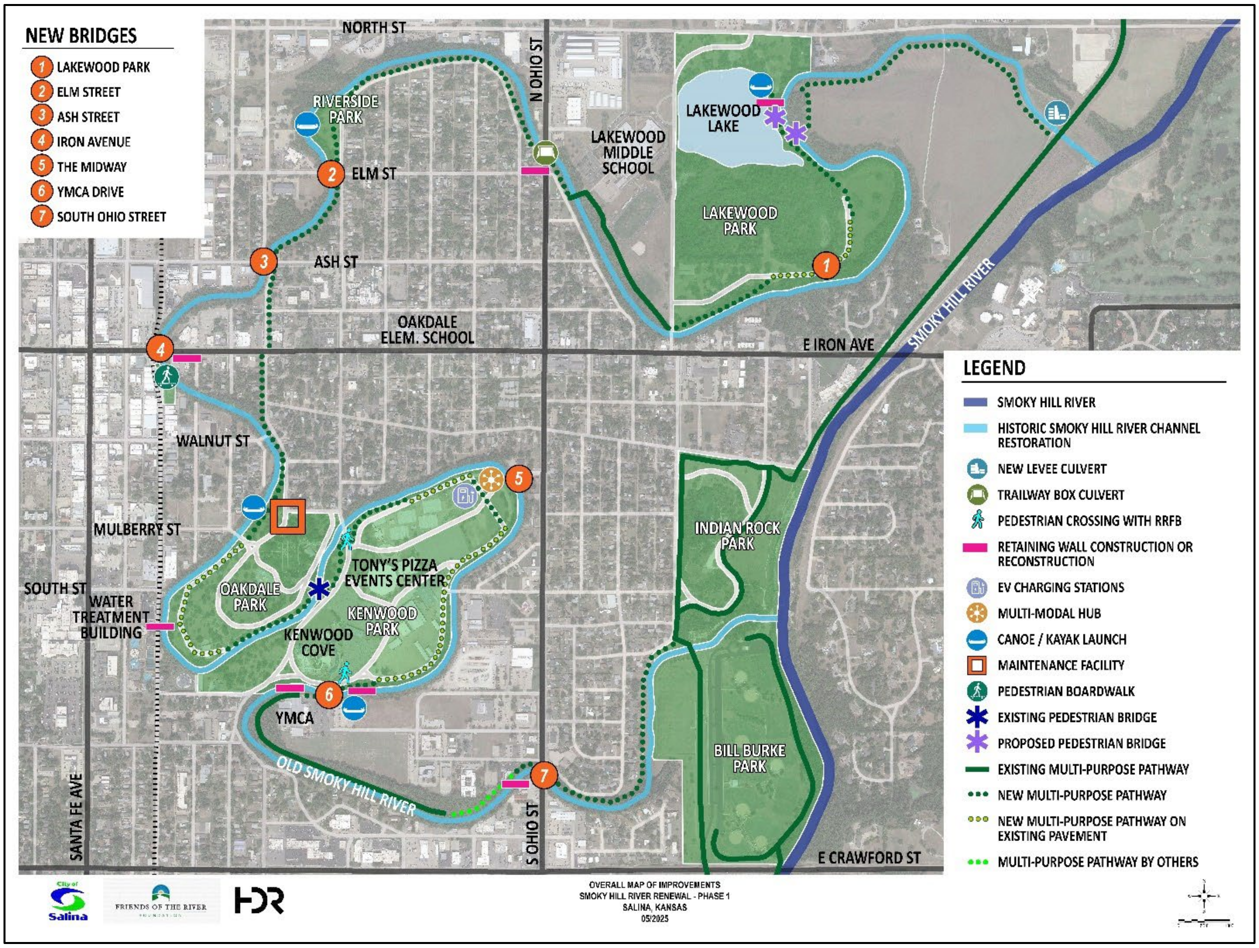


Figure 2.1. RAISE Grant Bridge Locations

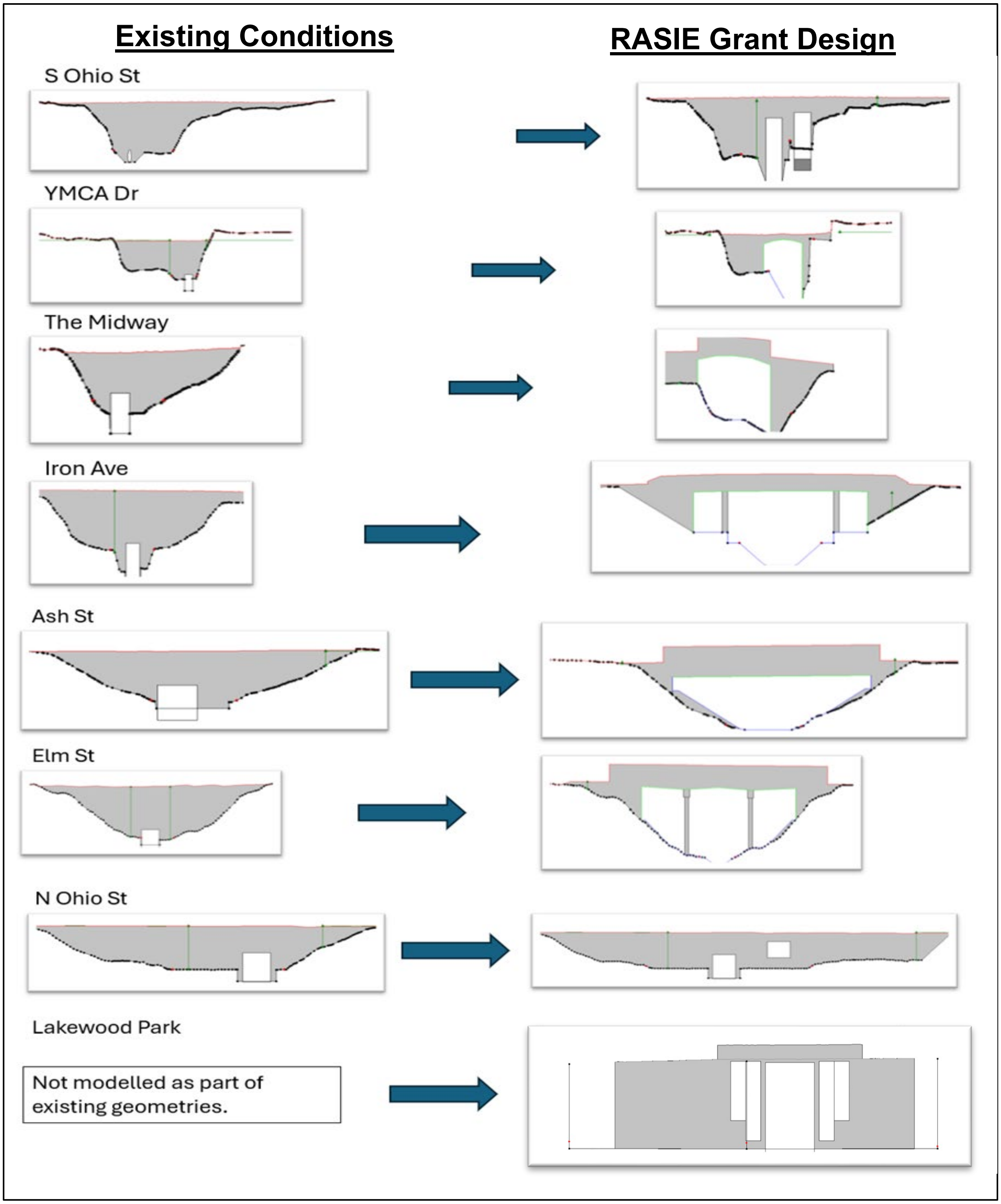


Figure 2.2. Comparison of Existing and RAISE Grant Bridge Design

Table 2.2. RAISE Bridges Modeled Opening Area

Location	Existing Structure Type	Existing Openings (ft²)	RAISE Design Structure Type	RAISE Design Openings (ft²)
S Ohio St	Culvert	7	Culvert	230
YMCA Dr	Culvert	28	Bridge	260
The Midway	Culvert	60	Bridge	860
Iron Ave	Culvert	81	Bridge	1240
Ash St	Culvert	144	Bridge	690
Elm St	Culvert	100	Bridge	1000
N Ohio St	Culvert	144	Culvert	240
Lakewood Park	N/A	N/A	Culvert	1190

2.1.3 Lakewood Lake Lateral Structures

There are two lateral structures associated with Lakewood Lake. On the south side near River Station 7300, a new RAISE grant bridge has been added as part of FWOP with multiple culvert openings. On the east side near River Station 4600, there is currently no culvert in the lateral structure, so the WSE must reach 1206.1 ft to overtop the controlling terrain and allow flow to enter the lake. Plan (left) and profile designs (south – bottom right and east – top right) can be seen in Figure 2.3 below.

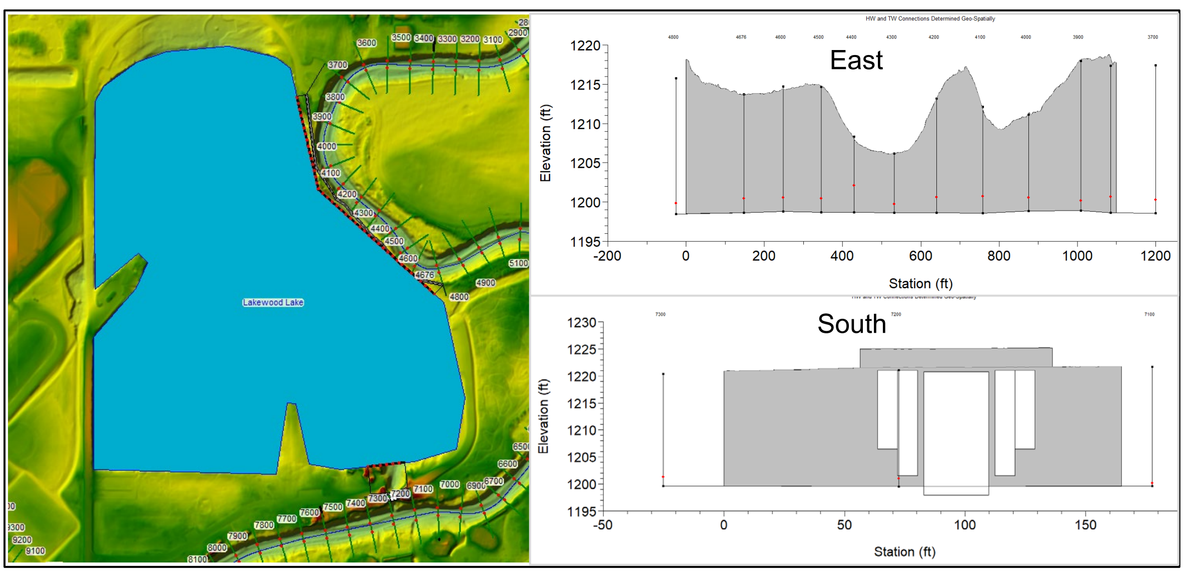


Figure 2.3. FWOP Lakewood Lake Lateral Structures

2.1.4 Existing Levee Intake Structure

No changes are planned at the existing levee gatewell structure in the Salina, Kansas Federal Levee Section II at Station 0+00 on the upstream end of the old channel where the Smoky Hill River will supply flow to the project. The existing structure was originally designed and constructed to provide flow to the old channel through a 54-inch diameter pipe with a sluice gate to control flow with an invert elevation of 1209.26 feet NAVD88. In section 30.b of the Salina, Kansas Federal Levee Design Manual (DM) 1, it mentions that the levee intake gatewell can intake water into the interior “to satisfy cooling water requirements". This is relevant, as the FWP conditions plan to have the intake gatewell allow flows into the leveed area.

The 1978 Salina, Kansas Federal Levee Operational Drawings note 5 on sheet 3 for levee gatewells to be operated as follows:

"Action is initiated ½ foot below gate invert elevation on all structures" and "Sluice gates and valves should remain open whenever the water will flow towards the river and closed when it will not. After closure, the landward water level elevation should be observed. Whenever it exceeds the river water surface elevation (WSE) again, open the sluice gate".

The gate feature in the hydraulic model is limited to using square shapes and the 54-inch diameter intake structure pipe, which has a 15.9 square foot opening, was modeled with an equivalent area box culvert approximated with 4 foot by 4 foot square dimensions with a submerged orifice flow coefficient of 0.89 (typically 0.8) to account for losses from the increase in wetted perimeter and match the flow hydrograph of the circular pipe. An elevation-controlled gate feature was added to the unsteady flow plan, as shown below in Figure 2.4. Whenever the WSE riverside of the levee is greater than the WSE landside of the levee, then the gate closes in 1 minute. Whenever the WSE riverside of the levee is less than the WSE landside of the levee, then the gate is opened in 1 minute. It is assumed that these operations begin for events equal to or greater than the 99% AEP event.

The low flow runs using the steady flow plans do not have a gate implemented in the inline structure at the levee intake structure due to the riverside WSE not reaching flood action stage and the requirement for flow from the Smoky Hill River to support the interior channel target flow.

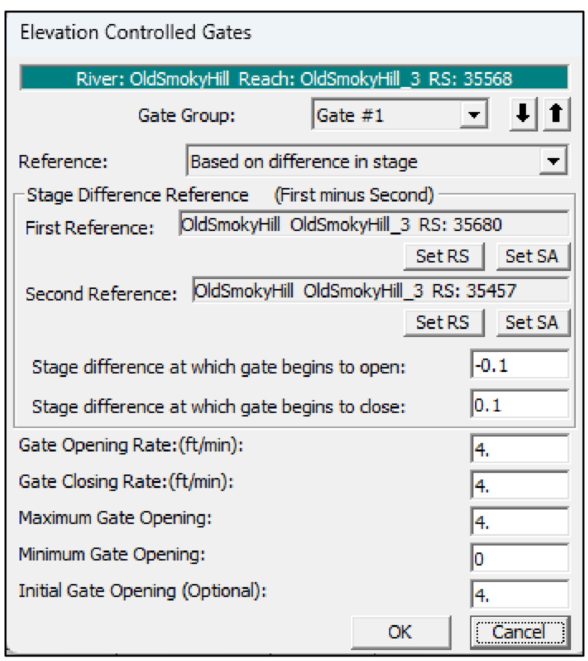


Figure 2.4. Elevation Controlled Gate Feature

The scour key just upstream of the sediment forebay entrance on the Smoky Hill River will be relied upon to create a WSE high enough for flow diversion into the old smoky hill channel. The scour key has an elevation of 1214 ft, whereas the sediment forebay crest has a minimum elevation of 1213.50 ft.

See Figure 2.6 for a map with the levee intake structure location.

2.1.5 Storage Area Extents

Due to the larger inundation extents for the 0.2% AEP event, two geometries were developed. One with storage areas that can encompass the inundation extents up to the 1% AEP event that will be used for the 99% to 1% AEP events, and another with larger storage areas created specifically for the 0.2% runs to ensure accurate inundation mapping. See the comparison below in Figure 2.5.

“Farm North” and “East Farm Area” storage-elevation relationships are created from the terrain.

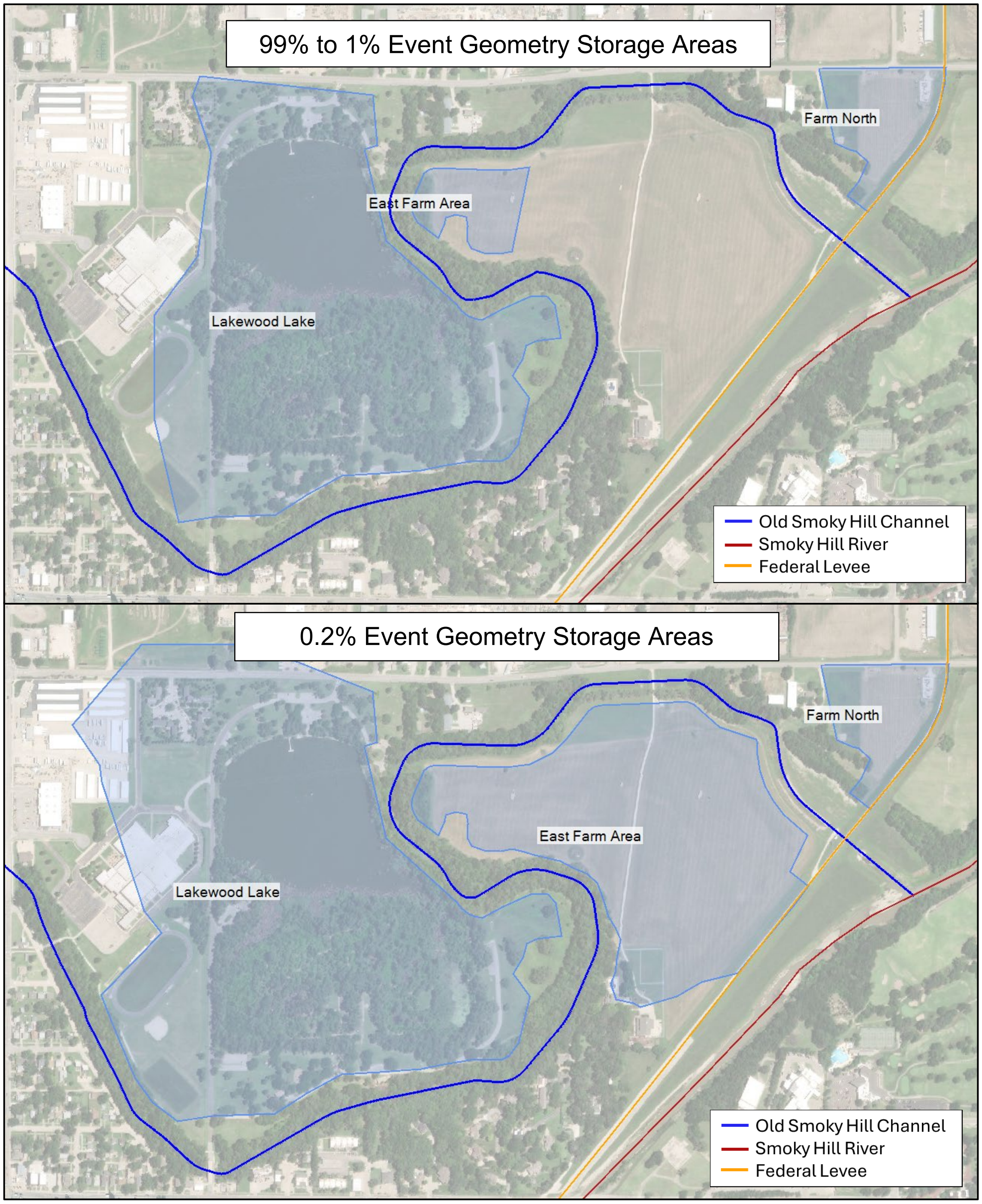


Figure 2.5. Storage Area Geometry Extents

2.1.6 FWOP Lakewood Lake Storage-Elevation Relationship

The FWOP Lakewood Lake storage-elevation curve was created by incorporating the "adjusted storage using PCSWMM and LiDAR" curve in Figure 4-17 in Appendix A1 with the LiDAR created storage-elevation relationship. The adjusted storage curve was used for elevations below the minimum LiDAR value (1197 ft), then the adjusted storage value (71.52 ac-ft) at the minimum LiDAR value was added to all LiDAR created storage values to ensure accurate storage-elevation data.

Due to the larger inundation extents for the 0.2% AEP event, two geometries were developed. One with a storage area that can encompass the inundation extents up to the 1% AEP event that will be used for the 99% to 1% AEP events, and another with a larger storage area created specifically for the 0.2% runs to ensure accurate inundation mapping.

The two FWOP storage-elevation relationships can be found in Table 2.3 and Table 2.4 and Figure 2.16 and Figure 2.17 in section 2.2.6.

The initial WSE in Lakewood Lake is 1201.5 ft for FWOP, based on Appendix C2 – Sheet A3-14.

Uncertainty below elevation 1192.53 ft can be reduced by incorporating bathymetric data into the storage-elevation curve. Additional data in the form of bathymetry would allow for the storage-elevation curve to be representative of the entire lake volume, not just the volume above the water level at the time of LiDAR acquisition. This would allow for a more representative water surface in the channel near Lakewood Lake for scenarios where the water surface of the lake is below 1192.53 ft.

2.1.7 Proposed Levee Outlet Structure

There is an existing 78-inch diameter sluice gate and flap gate at the outlet structure through the levee at the downstream end at levee station 685+50. The gatewell is modeled as an inline structure with a pipe with intake and outlet inverts set at elevations 1195.72 ft and 1194.61 ft. Due to the increase in conveyance from the RAISE grant bridges, a second sluice gate and flap gate opening was added for outflow back into the main channel. A 48-inch diameter sluice gate and flap gate were added on the outlet structure through the levee on the downstream end to increase conveyance area with intake and outlet inverts set at elevations 1199 ft and 1194.61 ft. Plan and section view can be seen in Figure 2.6 and Figure 2.7 below. Both culverts are modeled with flaps to prevent negative flow in the hydraulic model.

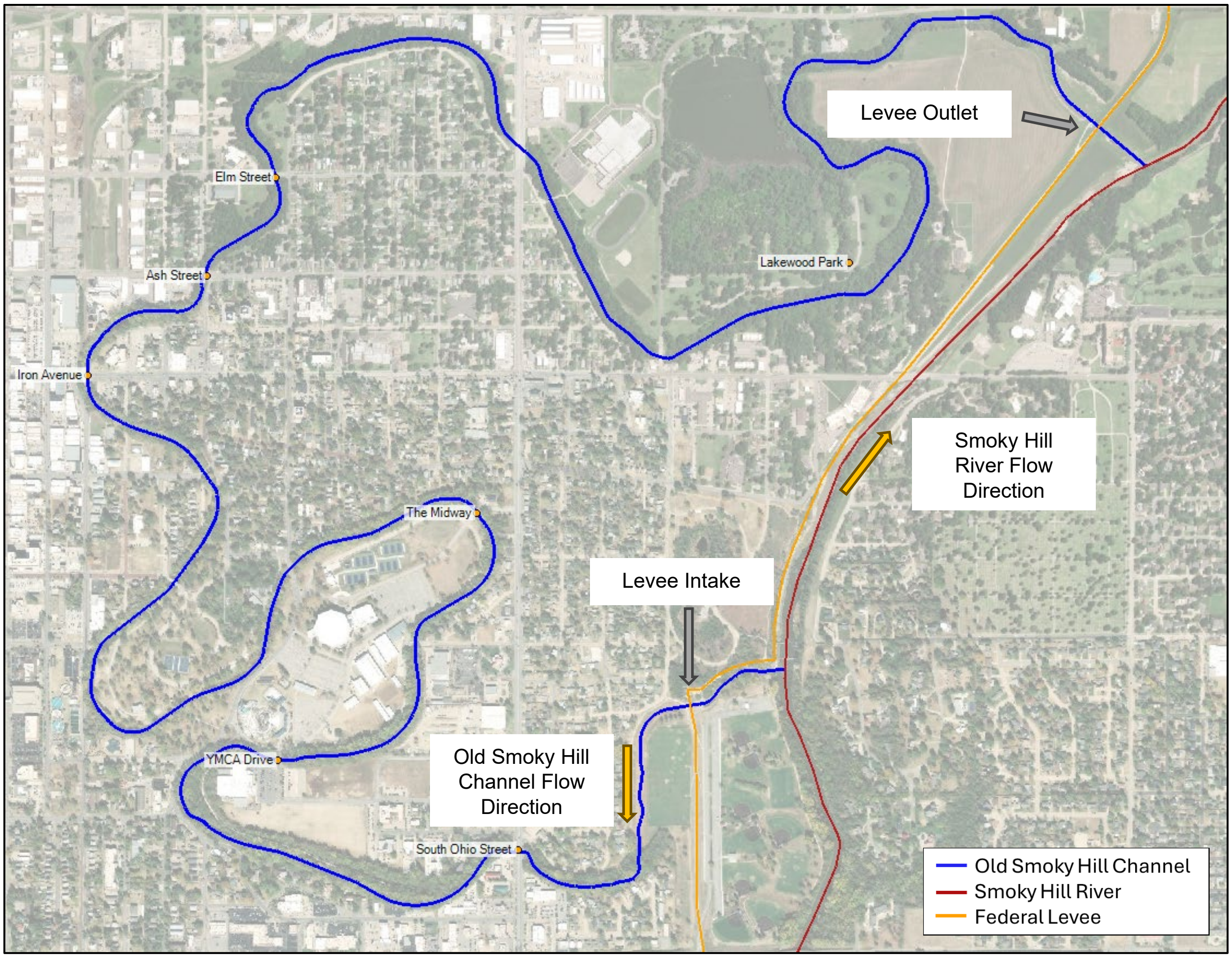


Figure 2.6. Plan View of Outlet Structure at Downstream End of Project

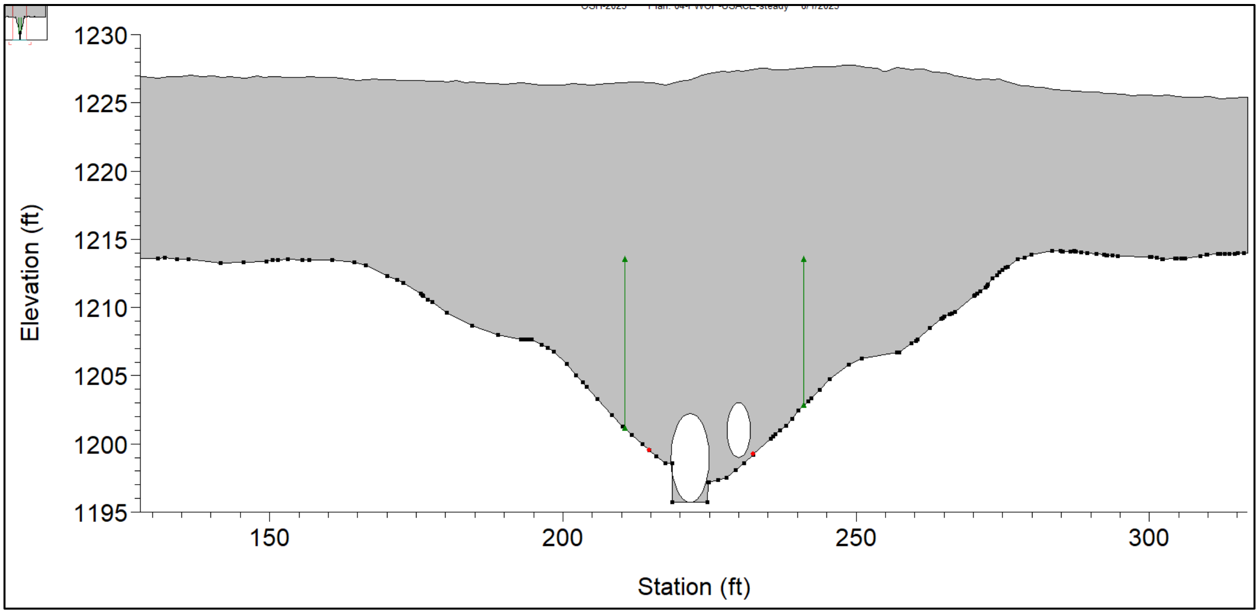


Figure 2.7. Section view of Sluice Gates of Outlet Structure at Downstream End of Project

2.2 FWP Geometry

The alternative 3 design has been chosen as the tentatively selected plan, is the only alternative assessed in this appendix, and is referenced as the FWP condition. FWP condition consists of deepened channel cross sections, removal of the existing Western Star Mill Weir and replacement with five grade control weirs, proposed Lakewood Lake control weir, proposed wetland shelf weir, the existing levee intake gate, proposed Lakewood Lake eastern culvert, proposed RAISE grant bridges, proposed sediment forebay, and proposed levee outlet structure. The RAISE grant bridges are assumed to be completed regardless of the outcomes of this project, so they are considered as part of the FWP. The proposed levee outlet structure is associated with the RAISE grant bridge construction due to the increased conveyance, so it is also considered part of the FWP.

2.2.1 Proposed Channel Cross Sections

The FWP geometry was formed from the alternative 2 geometry. This geometry has many of the FWP conditions modelled. However, the alternative three channel cross sections had to be imported from the alternative three geometry file. The FWP cross sections are deeper than the FWOP across two stretches in the old Smoky Hill Channel that are excavated for the project. A comparison of representative excavation locations with FWOP (pink) and FWP (black) channel cross sections can be seen in Figure 2.8. Comparison of the channel bottom can be seen in profile in Figure 2.9 below.

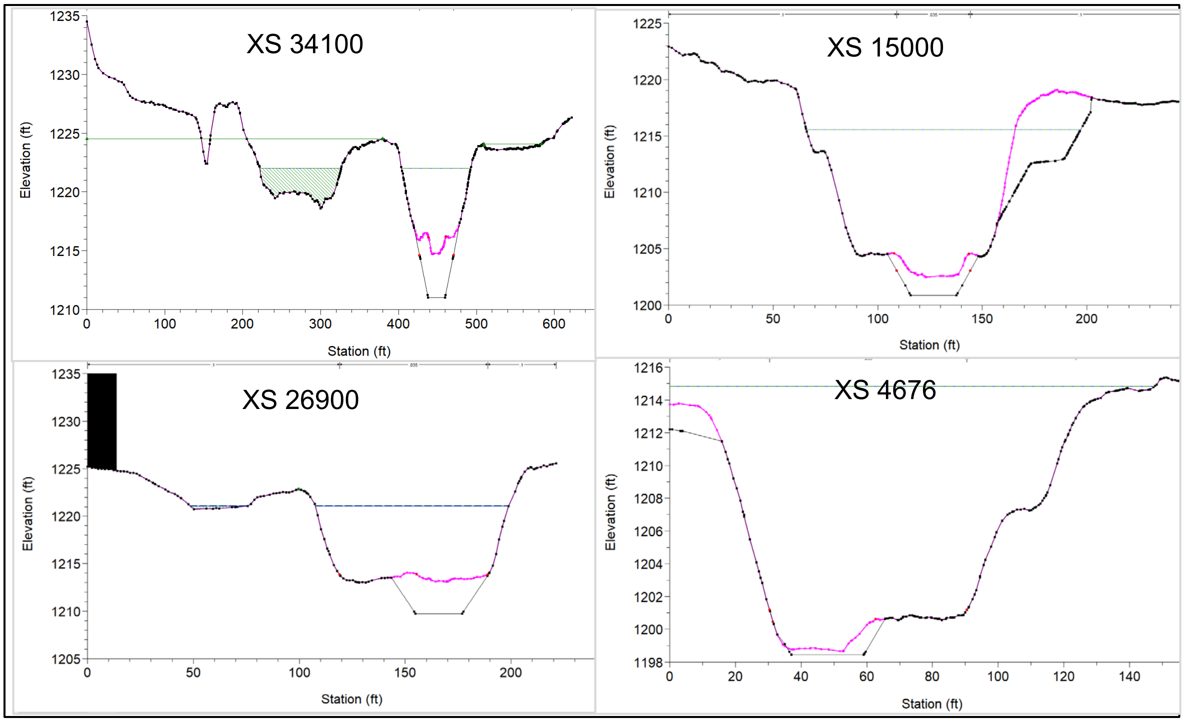


Figure 2.8. Comparison of FWOP (pink) and FWP (black) Channel Cross Sections

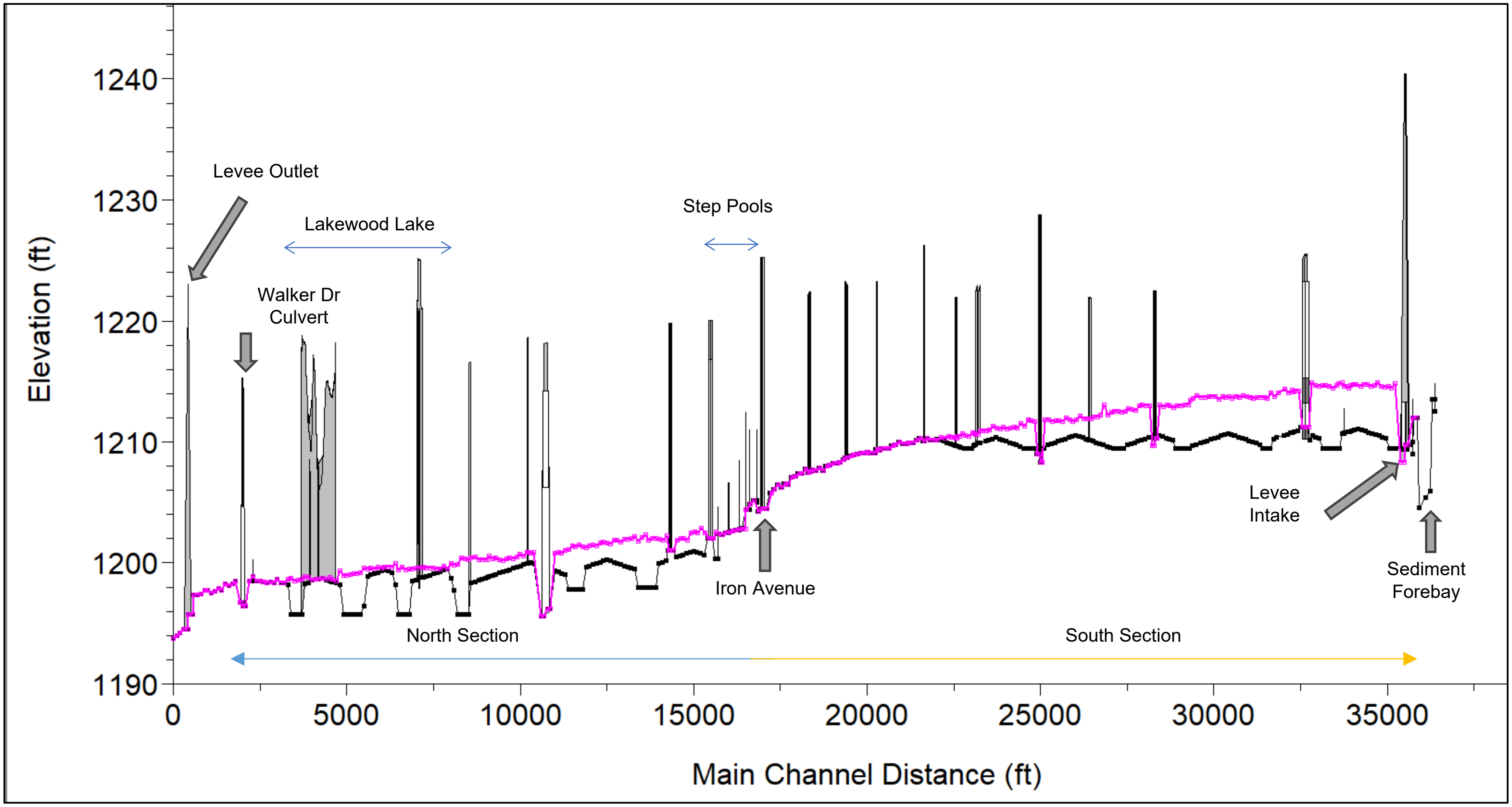


Figure 2.9. Profile Comparison of Channel Bottom for FWOP (pink) and FWP (black)

2.2.2 FWP Bridges

The FWP bridges will be the same as the FWOP geometry. See section 2.1.2 for more information.

2.2.3 Lakewood Lake Lateral Structures

There are two lateral structures associated with Lakewood Lake. On the south side, a new RASIE grant bridge has been added as part of FWOP with multiple culvert openings. On the east side, a culvert is added, currently sized to be a 37' x 10' Conspan arch. Plan (left) and profile designs (south – top right and east – bottom right) can be seen in Figure 2.10 below.

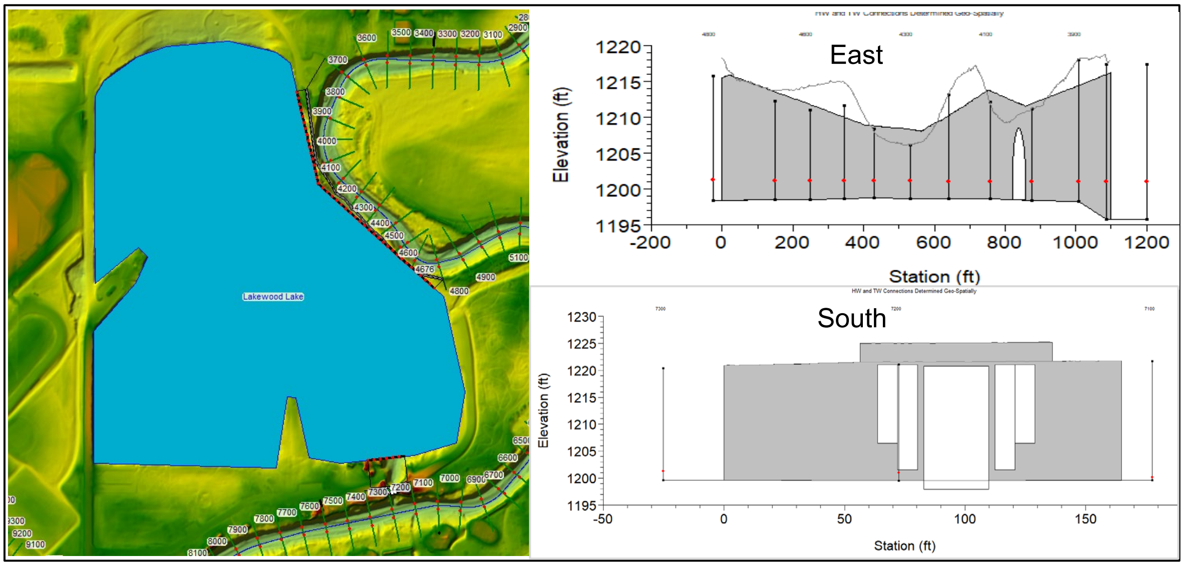


Figure 2.10. FWP Lakewood Lake Lateral Structures

2.2.4 Sediment Forebay

The sediment forebay has two weirs, the low flow entrance weir with an elevation of 1214.84 ft and the sediment forebay crest weir with an elevation of 1213.5 ft. These are both greater than the invert of the intake structure at 1209.26 ft. Whereas the low flow entrance weir is higher than the invert of the Smoky Hill Scour Key at 1214 ft. Plan and section views can be seen below in Figure 2.11 and Figure 2.12.

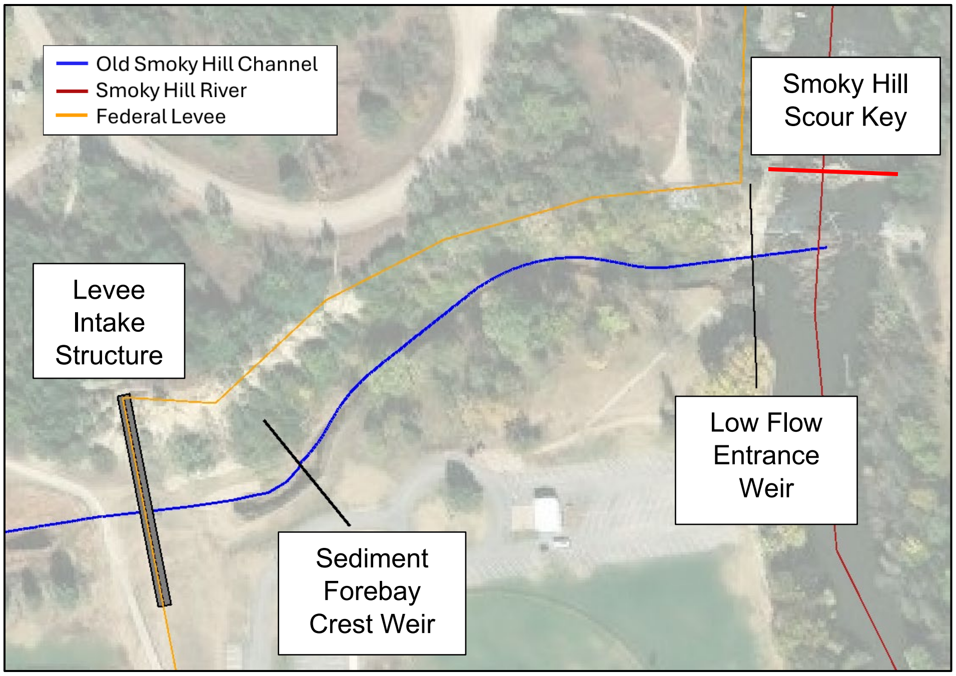


Figure 2.11. Sediment Forebay Plan View

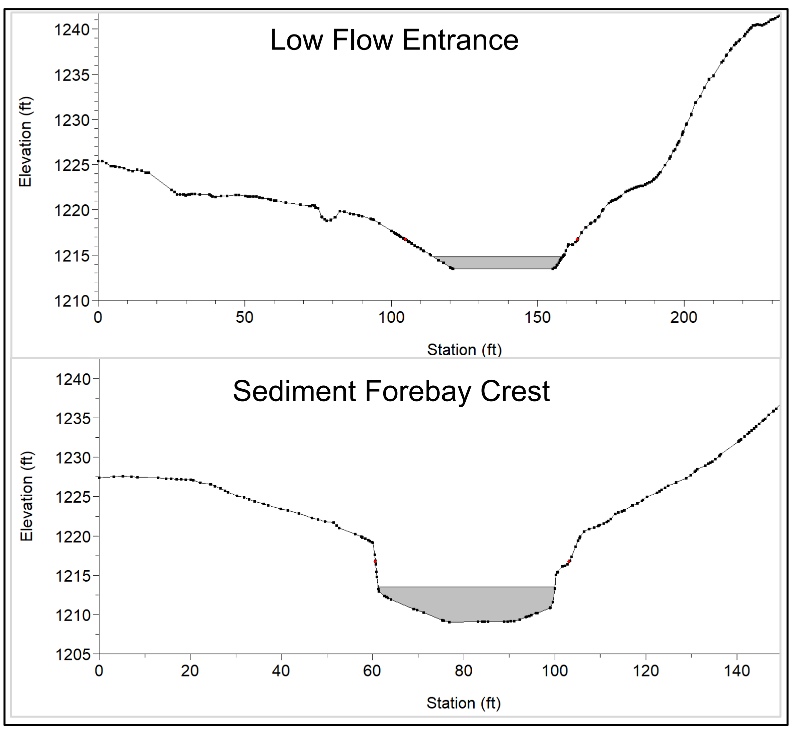


Figure 2.12. Section View of Sediment Forebay Weirs

2.2.5 Proposed Weir Structures

There are three categories of new weir structures included in the FWP.

Five new step pool grade control weirs are proposed to replace the Western Star Mill weir and provide a gradual slope with five step pools. The changes can be seen below in Figure 2.13.

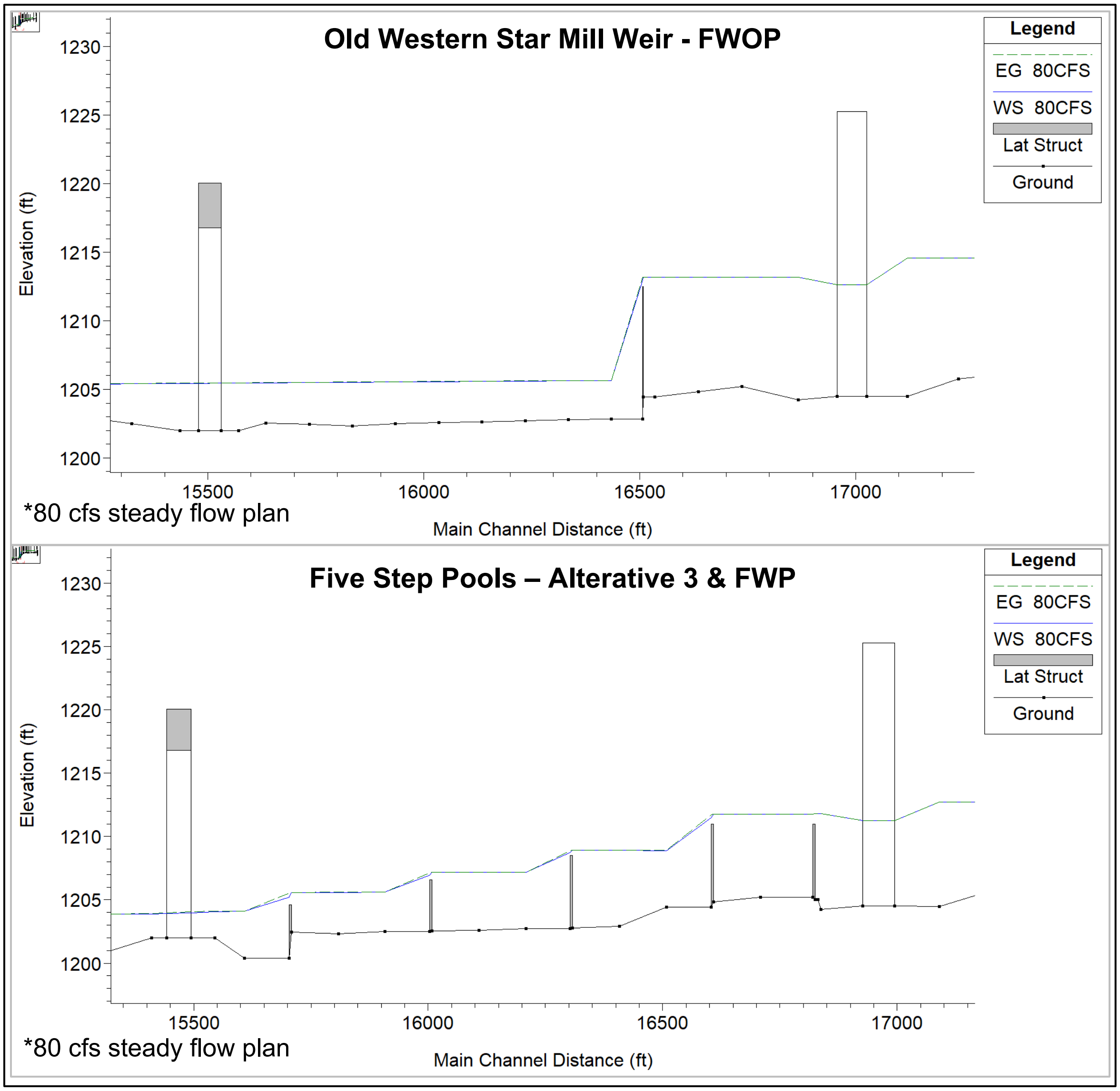


Figure 2.13. Comparison of the Old Western Star Mill Weir and the Proposed Five Step Pools

One new water level control weir downstream of Lakewood Lake is part of FWP. The weir is set at an elevation of 1220.2 ft, and its location can be seen in Figure 2.14 below.

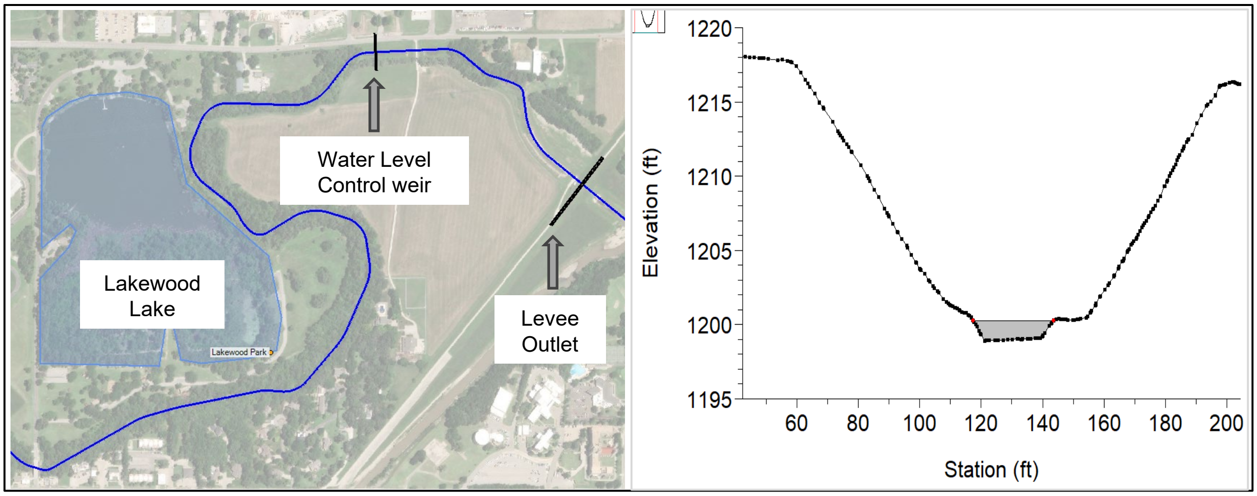


Figure 2.14. Lakewood Lake Water Level Control Weir Plan and Section View.

One new wetland shelf weir upstream of South Ohio Street will be part of FWP. With no drawings provided from HDR, it is assumed to be 2 ft tall (elevation 1212.75 ft)and located at XS 33800. Its location and section can be seen below in Figure 2.15.

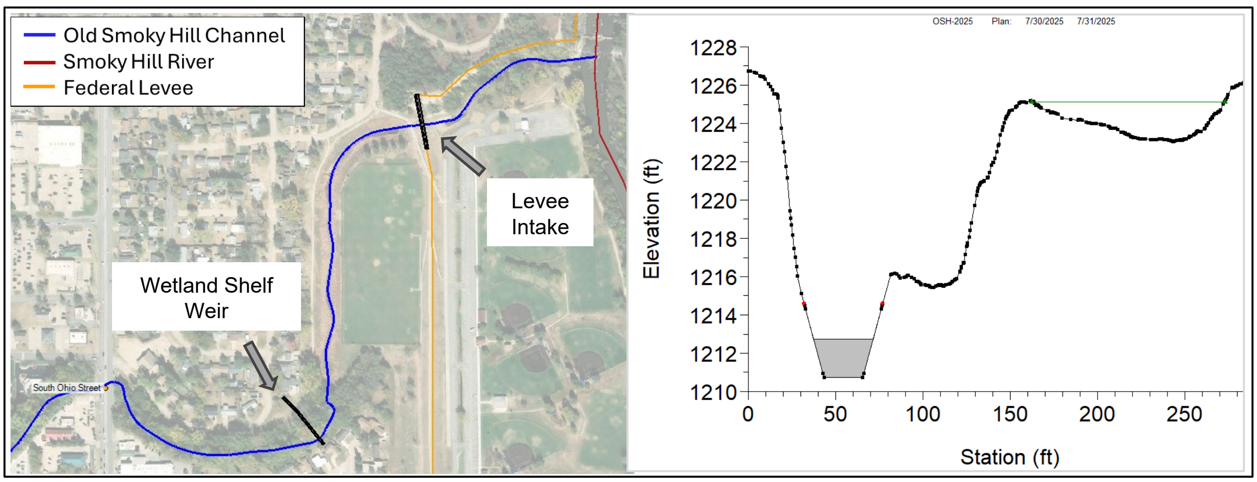


Figure 2.15. S Ohio St Wetland Shelf Weir Plan and Section View

2.2.6 FWP Lakewood Lake Storage-Elevation Relationship

The FWOP Lakewood Lake storage-elevation curve was created by incorporating the “adjusted storage using PCSWMM and LiDAR” curve in Figure 4-17 in Appendix A1 with the LiDAR created storage-elevation relationship. The adjusted storage curve was used for elevations below the minimum LiDAR value (1197 ft), then the adjusted storage value (71.52 ac-ft) at the minimum LiDAR value was added to all LiDAR created storage values to ensure accurate storage-elevation data.

Then, to account for fill being added to Lakewood Lake to create more wetland area, the FWOP storage-elevation curve will be adjusted. The assumption is that fill will be spread evenly across elevations 1200 ft to 1210 ft. The fill volume is estimated to be 2,862,000 cubic ft or 65.7 ac-ft. 6.57 ac-ft of fill is placed in at one-foot intervals from

1200 ft to 1210 ft. For example, at 1204 ft, 6.57 ac-ft/ft multiplied by 4 ft equals 26.28 ac-ft of additional fill for FWP in addition to the FWOP curve.

Due to the larger inundation extents for the 0.2% AEP event, two geometries were developed. One with a storage area that can encompass the inundation extents up to the 1% AEP event that will be used for the 99% to 1% AEP events, and another with a larger storage area created specifically for the 0.2% runs to ensure accurate inundation mapping. For a plan view comparison of storage area extents, see section 2.1.6.

The two FWOP storage-elevation relationships can be found in Table 2.3 and Table 2.4 and Figure 2.16 and Figure 2.17.

The initial WSE in Lakewood Lake is 1201.5 ft for FWP, based on Appendix C2 – Sheet A3-14.

Uncertainty below elevation 1192.53 ft can be reduced by incorporating bathymetric data into the storage-elevation curve. Additional data in the form of bathymetry would allow for the storage-elevation curve to be representative of the entire lake volume, not just the volume above the water level at the time of LiDAR acquisition. This would allow for a more representative water surface in the channel near Lakewood Lake for scenarios where the water surface of the lake is below 1192.53 ft.

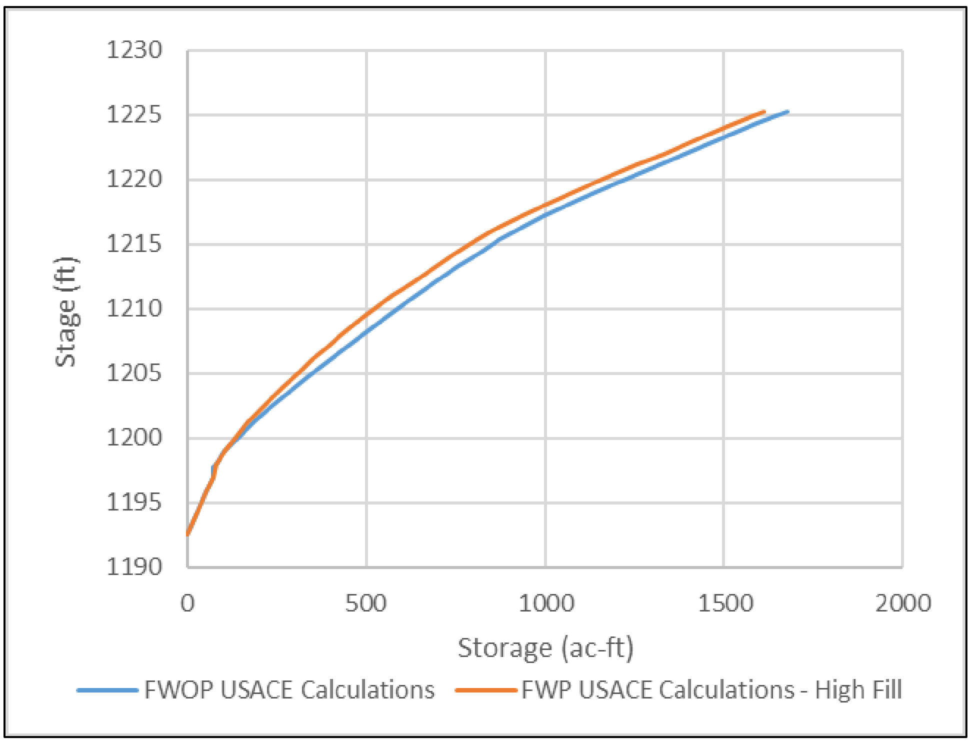


Figure 2.16. 99% to 1% Events - Storage-Elevation Curve Comparison

Table 2.3. 99% to 1% Events - Lakewood Lake Storage Area Curves

FWOP USACE Calculations	FWOP USACE Calculations	FWP USACE Calculations	FWP USACE Calculations	FWP USACE Calculations
Elevation (ft)	Storage above Existing WSE (ac-ft)	Elevation (ft)	Storage above Existing WSE (ac-ft)	Percent Fill Added
1192.5	0	1192.5	0	0
1193	8	1193	8	0
1194	24	1194	24	0
1195	40	1195	40	0
1196	56	1196	56	0
1197	72	1197	72	0
1198	80	1198	80	0
1199	107	1199	107	0
1200	140	1200	133	10
1201	177	1201	164	20
1202	217	1202	198	30
1203	260	1203	234	40
1204	305	1204	272	50
1205	350	1205	311	60
1206	396	1206	350	70
1207	443	1207	390	80
1208	491	1208	432	90
1209	540	1209	474	100
1210	589	1210	523	100
1211	639	1211	574	100
1212	691	1212	625	100
1213	744	1213	678	100
1214	798	1214	733	100
1215	856	1215	790	100
1216	917	1216	851	100
1217	985	1217	920	100
1218	1062	1218	996	100
1219	1143	1219	1077	100
1220	1227	1220	1161	100
1221	1311	1221	1246	100
1222	1396	1222	1330	100
1223	1481	1223	1415	100
1224	1565	1224	1500	100
1225.3	1675	1225.3	1609	100

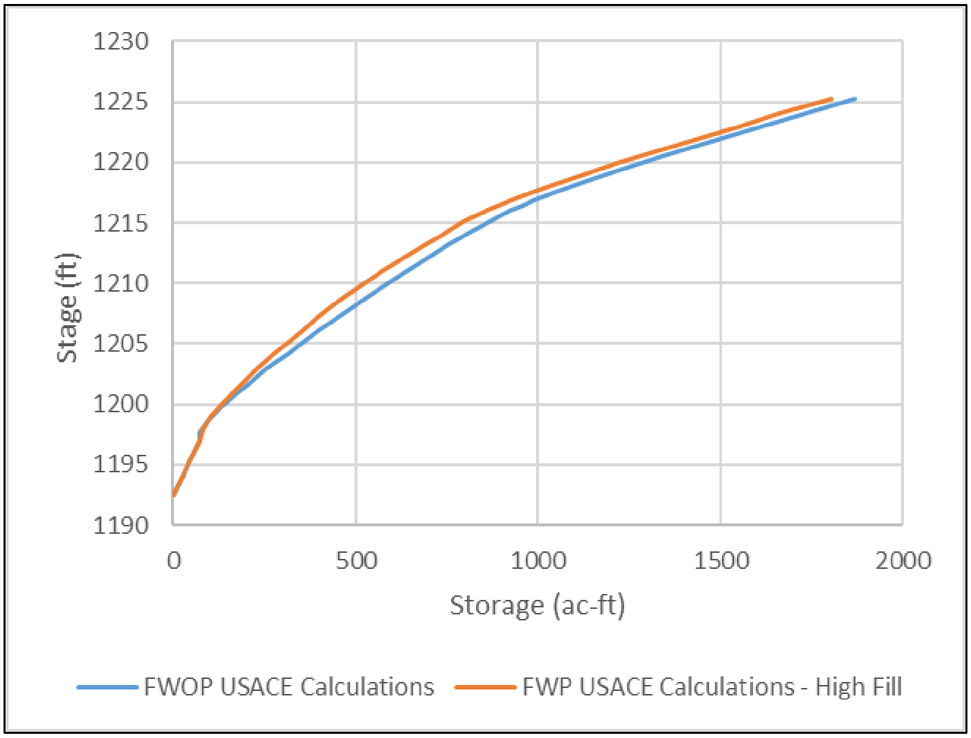


Figure 2.17. 0.2% Event - Storage-Elevation Curve Comparison

Table 2.4. 0.2% Event - Lakewood Lake Storage Area Curves

FWOP USACE Calculations	**FWOP USACE Calculations**	**FWP USACE Calculations**	**FWP USACE Calculations**	**FWP USACE Calculations**
Elevation (ft)	Storage above Existing WSE (ac-ft)	Elevation (ft)	Storage above Existing WSE (ac-ft)	Percent Fill Added
1192.5	0	1192.5	0	0
1193	8	1193	8	0
1194	24	1194	24	0
1195	40	1195	40	0
1196	56	1196	56	0
1197	72	1197	72	0
1198	80	1198	80	0
1199	107	1199	107	0
1200	140	1200	133	10
1201	177	1201	164	20
1202	217	1202	198	30
1203	260	1203	234	40
1204	305	1204	272	50
1205	350	1205	311	60

FWOP USACE Calculations	FWOP USACE Calculations	FWP USACE Calculations	FWP USACE Calculations	FWP USACE Calculations
Elevation (ft)	Storage above Existing WSE (ac-ft)	Elevation (ft)	Storage above Existing WSE (ac-ft)	Percent Fill Added
1206	396	1206	350	70
1207	443	1207	391	80
1208	491	1208	432	90
1209	540	1209	474	100
1210	590	1210	524	100
1211	640	1211	575	100
1212	692	1212	626	100
1213	745	1213	680	100
1214	800	1214	735	100
1215	859	1215	793	100
1216	924	1216	859	100
1217	1002	1217	936	100
1218	1091	1218	1025	100
1219	1188	1219	1123	100
1220	1291	1220	1226	100
1221	1398	1221	1332	100
1222	1508	1222	1442	100
1223	1617	1223	1551	100
1224	1727	1224	1661	100
1225.3	1869	1225.3	1803	100

2.2.7 FWP Storage Areas Extents

The storage area extents will be the same as the FWOP geometry. See section 2.1.6 for more information.

2.2.8 Existing Levee Intake Structure

The existing intake structure at the levee on the upstream end of the channel will be the same as the FWOP geometry. See section 2.1.4 for more information.

2.2.9 Proposed Levee outlet Structure

The proposed outlet structure will be the same as the FWOP geometry. See section 2.1.6 for more information.

2.3 Standard Flow Plans

Standard flow plans are defined as the flow plans run with the most representative geometries for FWOP and FWP. See Table 2.5 below for HEC-RAS plan, geometry, and flow file information for the standard flow plans. Table 2.6 below shows the unsteady model calculation details.

Table 2.5. Standard Flow Plan Information

Scenario	Plan Name	Plan File	Geom File	Flow File	Notes
FWOP low flows (steady)	04-FWOP-USACE-steady	P32	G24	F01	Base FWOP geometry, no intake gate operations. 1, 6, 10, 40, 50, 60, 70, 80, and 160 cfs are run as steady flows.
FWP-Alt 3 low flows (steady)	05-Alt3-USACE-steady	P30	G25	F08	Base FWP geometry, no intake gate operations. 1, 6, 10, 40, 50, 60, 70, 80, and 160 cfs are run as steady flows.
Standard FWOP frequency floods (unsteady)	04-FWOP-USACE-99%AEP thru 0.2%AEP	P09, P11-P14, P16, P60	G21	U08-U05, U03, U01, U22	Original FWOP geometry, with intake gate operations. 99%, 50%, 20%, 10%, 2%, 1%, and 0.2% AEP flow events.
Standard FWP-Alt 3 frequency floods (unsteady)	05-Alt3-USACE-99%AEP thru 0.2%AEP	P22-P26, P28, P61	G23	U02, U04, U10, U14-U16, U19	Original FWP geometry, with intake gate operations. 99%, 50%, 20%, 10%, 2%, 1%, and 0.2% AEP flow events.
FWOP frequency floods -Post TSP Design Refinements (unsteady)	04-FWOP-USACE-99%AEP thru 0.2%AEP-PostTSPRefinements	P83-P85, P89-P92	G51, G54	U08-U05, U03, U01, U22	FWOP geometry with post TSP design refinement, with intake gate operations. 99%, 50%, 20%, 10%, 2%, 1%, and 0.2% AEP flow events.
FWP-Alt 3 frequency floods -Post TSP Design Refinements (unsteady)	05-Alt3-USACE-99%AEP thru 0.2%AEP	P86-P88, P93-96	G52, G53	U02, U04, U10, U14-U16, U19	FWP geometry with post TSP design refinement, with intake gate operations. 99%, 50%, 20%, 10%, 2%, 1%, and 0.2% AEP flow events.

Table 2.6. Unsteady Model Calculation Details

Unsteady Model Calculation Detail	Applied Setting
Computation Interval	10 second
Equation Set	Skyline/Gaussian
Hydrograph Output Interval	5 minute
Mapping & Detailed Output Timestep	1 hour
Boundary Conditions	Constant Stage Hydrograph

2.4 Riverside Water Surface Elevation Conditions

The riverside WSE conditions were set from Table 4-1 in Appendix A1 and shown in Table 2.7 below, with more information in Appendix A1 Section 4.2 and Appendix A Exhibit A – Interior Drainage Analysis Report. Locations 0+00 and 685+50 represent the intake and outlet locations respectively as shown in Figure 2.18 below. The upstream boundary condition locations are different from FWOP to FWP due to the addition of the sediment forebay in the FWP. Both locations exterior tailwater conditions were evaluated using an independent system in which the backwater of the Smoky Hill River affects the outfall boundary condition. The riverine analysis for the Smoky Hill River used rainfall-runoff & gage hydrology and steady & unsteady HECRAS hydraulic analyses.

The Coincident Frequency Analysis (or Total Probability Theorem) was utilized for this independent system analysis of the Smoky Hill River and interior drainage areas as outlined in USACE EM1110-2-1413 procedures.

Table 2.7. Flood Frequency Stage Boundary Conditions (Appendix A1 – Table 4-1)

Table 4-1: Updated Interior Drainage Response Curves for the Levee Intake and Outlet

STA 0+00 Entrance Levee			STA 685+50 Exit Levee		
% Chance Exceedance	Interior T.W. Elev. (Ft.)	Exterior Elev. (ft.)	% Chance Exceedance	Interior T.W. Elev. (Ft.)	Exterior Elev. (ft.)
0.2%	1224.7	1217.9	0.2%	1215.4	N.D.*
1%	1224.3	1220.6	1%	1212.2	1201.1
2%	1222.7	1218.4	2%	1210.5	1202.0
4%	1221.6	1217.3	4%	1209.3	1203.9
10%	1220.8	1217.2	10%	1208.3	1205.5
20%	1220.1	1216.9	20%	1207.6	1203.3
50%	1219.1	1216.5	50%	1206.8	1201.4
99%	1218.7	1216.7	99%	1206.6	1202.1

*N.D. stands for Normal Depth. Normal depth implies the exterior river is below flood stage and the interior has a free exit.

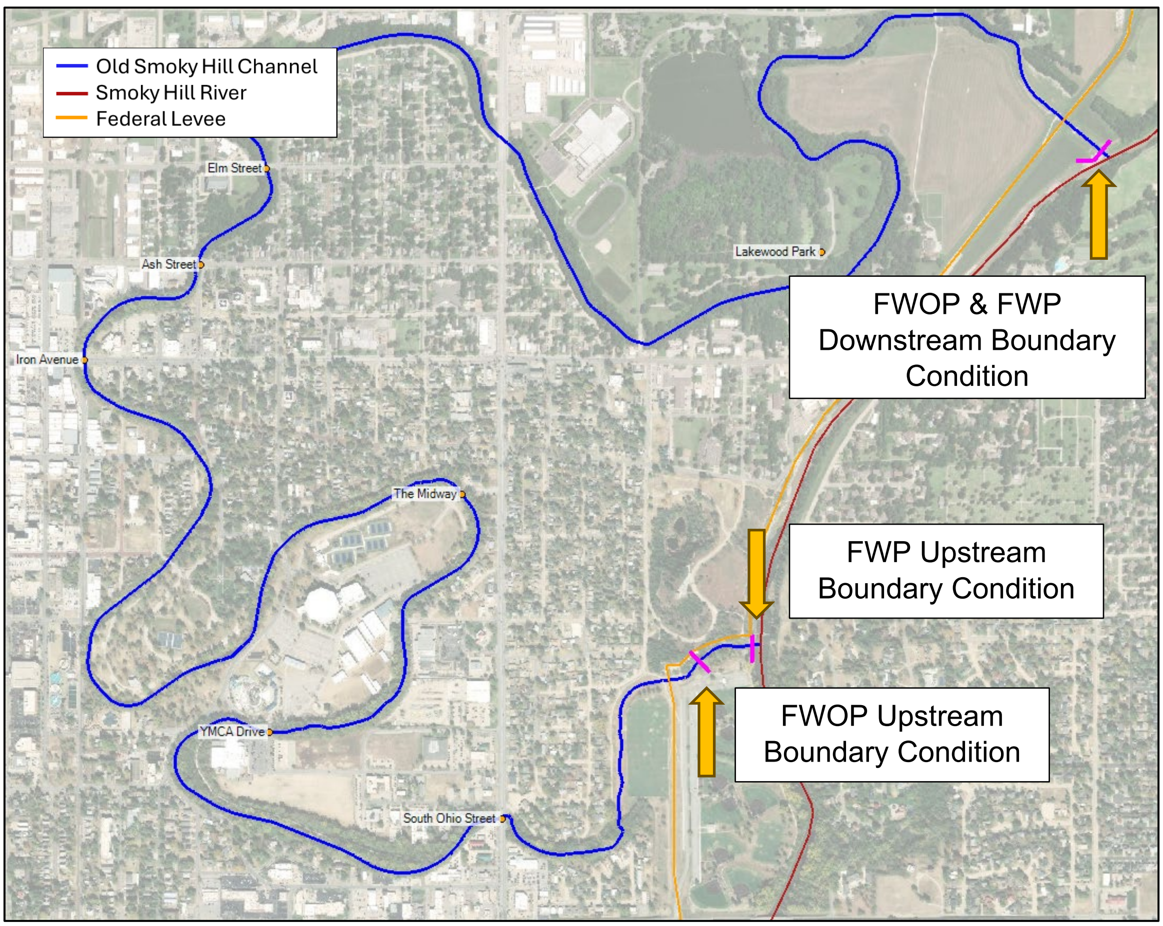


Figure 2.18. Stage Hydrograph Boundary Condition Locations

2.5 Manning's n-values

Horizontal Manning's n values for the channel range from 0.035 (typical channel section) to 0.045 (heavily vegetated), while overbanks typically range from 0.065 to 0.12 (depending on the density of trees and vegetation).

The channel manning's n-value ranged from 0.04 to 0.035 in the FWOP geometry. The channel manning's n-value is set at 0.04 from cross section 34013 to 25200 and 0.035 for the rest of the channel. This Manning's n-value delineation was set by HDR and based on vegetation from aerial imagery and confirmed with HEC RAS Hydraulic Reference Manual Table 3-1 Manning's "n" Values.

The channel manning's n-value is set at 0.035 for the entirety of the FWP geometry. A 0.035 manning's n-value is the assumption for the excavated and maintained channel.

The overbank (left and right) manning's n-value are decreased from 0.08 in the FWOP geometry to 0.065 in the FWP geometry from cross sections 16800 to 15800. This range is the stretch of channel where the five new step pools will be implemented. The implementation of the step pools will result in a decrease in vegetation density along the overbanks.

2.6 Terrain Creation

A terrain was created for the FWOP and the FWP. The channel cross sections from the FWOP and the FWP geometries were exported and combined with LiDAR to create new terrains. These terrains will be used to compare extents, depths, and WSE in RAS Mapper.

2.7 Sensitivity Testing Flow Plans

The following scenarios were identified as possible conditions where the assumptions made in the standard flow plans could change. See Table 2.8 below for HEC-RAS plan, geometry, and flow file information for the sensitivity testing flow plans.

Table 2.8. Sensitivity Testing Flow Plan Information

Scenario	Plan Name	Plan File	Geom File	Flow File	Notes
Non-Maintained Channel	S1	P38-41	G26-29	F01, F08, U01, U16	Steady and unsteady plans. FWP and FWOP plans.
Debris on Bridge Openings	S2	P42-44, P51	G30-33	F01, F08, U01, U16	Steady and unsteady plans. FWP and FWOP plans.
Upstream Intake Sluice Gate	S3	P45-48, P52-55	G34-36, G38,	F01, F08, U01, U16	Steady and unsteady plans. FWP and FWOP plans. Alternatives A and B.
Downstream Outlet Sluice & Flap Gates	S4	P56-59	G39-42	F01, F08,	Steady and unsteady plans. FWP and FWOP plans.

Scenario	Plan Name	Plan File	Geom File	Flow File	Notes
				U01, U16	
Lakewood Lake Initial WSE	S5	P62-65	G21, G23-25	U24-25, U27-29	Unsteady plans only. FWP and FWOP plans. Alternatives A and B.
Fill Volume Placed in Lakewood Lake for FWP	S6	P66-72, P75	G44, G46	F01, F08, U01-08, U10, U14-16, U19, U22	Steady and unsteady plans. FWP plans only. Alternative A only. Alternative B is standard flow plans.
Removal of Hydraulic Control from 96-inch Residential Culvert (XS 2100)	S7	P73-74	G43, G45	U01, U16	Unsteady plans only. FWP and FWOP plans.

2.7.1 Non-Maintained Channel

The non-maintained channel scenario is one where operations and maintenance is not accomplished. The maintenance we are recommending is to control invasive species, manage woody growth, and support a vibrant and diverse habitat, possibly requiring physical removal of unwanted growth (Appendix K – Section 2.2). The channel has growth of heavy vegetation and a stretch of channel from XS 22000 to 15502 has woody debris along the channel. The entire channel is increased to a manning's n of 0.045 and the stretch with woody debris is increased to a manning's n of 0.08.

2.7.2 Debris on Bridge Openings

The debris on bridge openings scenario is one where debris has accumulated on bridges during a storm event or was not removed after a prior storm event. This debris will block portions of culverts or get stuck on piers.

For this sensitivity test, a 6 ft wide and 4 ft tall section of debris is stuck on the piers of Oakdale Avenue Bridge (XS 23304) and 50% of the 96-inch Walker Dr culvert (XS 2100) is blocked.

2.7.3 Upstream Intake Sluice Gate

The upstream intake sluice gate scenario has two scenarios. Scenario A, where the sluice gate is always open, and Scenario B, where the sluice gate is always closed.

2.7.4 Downstream Outlet Sluice & Flap Gates

The downstream outlet sluice & flap gate scenario is one where the secondary culvert pipe is either never constructed or stuck closed/completely blocked by debris.

2.7.5 Lakewood Lake Initial WSE

The change in initial WSE of Lakewood Lake scenario has two additional scenarios for the initial WSE shown in Table 2.9 below. Scenario A is one where the lake is at pre-project typical WSE and scenario B is one where the lake is “full”, which is defined as the elevation to overtop the embankment.

Table 2.9. Change in Lakewood Lake Initial WSE Scenarios

Conditions	Initial WSE (ft) standard	Initial WSE (ft) scenario A	Initial WSE (ft) scenario B
FWOP	1201.5	1192.53	1206.1
FWP	1201.5	1192.53	1206.1

2.7.6 Fill Volume Placed in Lakewood Lake for FWP

This scenario is meant to cover the range of possible fill placed in Lakewood Lake. The standard FWP geometry assumes approximately 105,000 cubic yards of fill is being placed in Lakewood Lake. The lowest possible amount of fill being placed in Lakewood Lake is 37,772 cubic yards, which is scenario A modeled in this sensitivity test.

2.7.7 Removal of Hydraulic Control from 96-inch Walker Dr Culvert (XS 2100)

The 96-inch culvert at XS 2100 is the hydraulic control for the 1% and 0.2% AEP flow plans. This culvert is not part of the project, so a plan to view what would occur if the culvert was removed or sized up in the future was included as a sensitivity test.

3 FWOP AND ORIGINAL FWP HYDRAULIC MODEL RESULTS

This section documents the results from the hydraulic model.

3.1 Profile Comparisons

This section will compare profiles for recreation flows as well as larger storm events and compile pertinent information. Figure 3.1 shows locations of cross sections chosen to represent specific reaches and paint a picture of the trends across the entire old Smoky Hill channel.

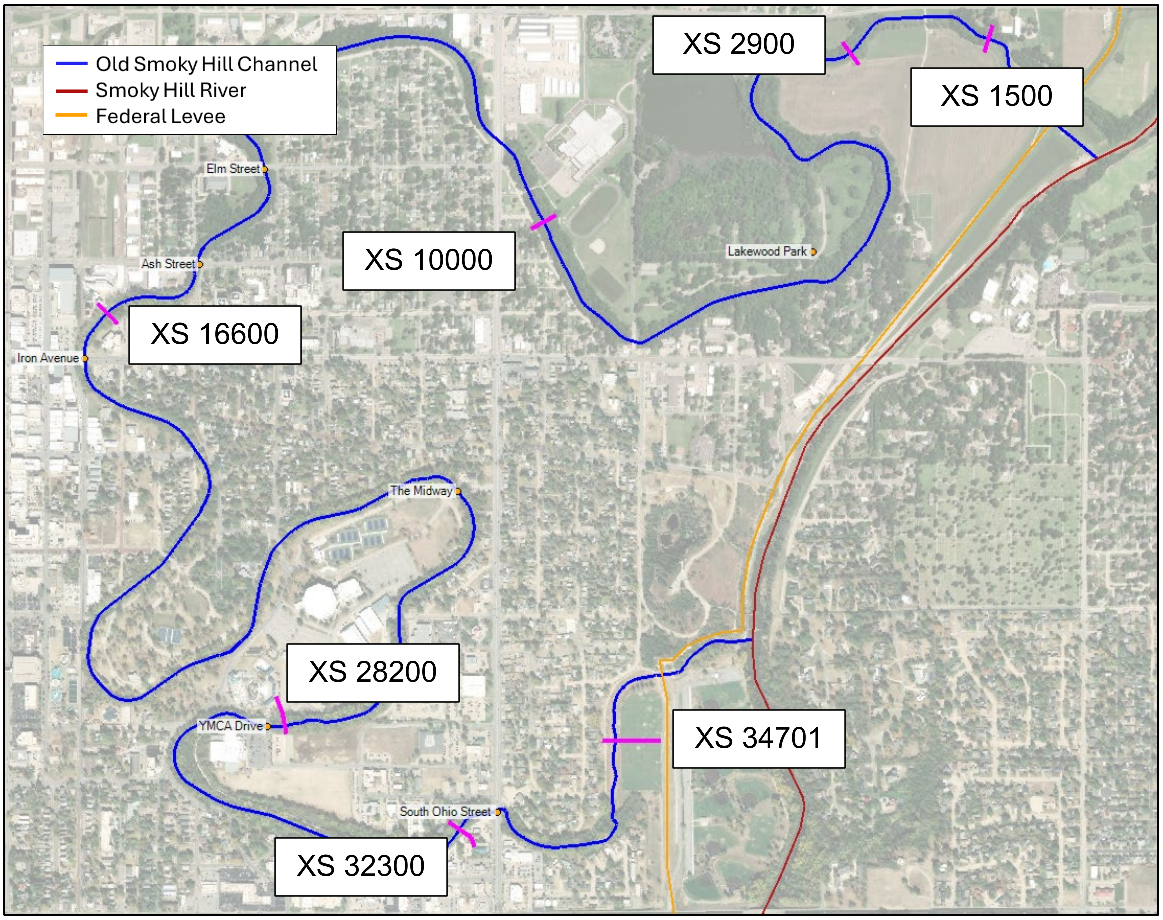


Figure 3.1. Flow-Stage-Frequency Data Collection Locations

3.1.1 Low Flow Scenarios

The typical recreation season flows for the restored channel will range from 40 cfs to 80 cfs. The extents resulting from these flows are encompassed entirely in the channel. For these low flow plans, the old western star mill weir is the hydraulic control for the FWOP and the step pool weirs that are replacing the old western star mill weir are the hydraulic control for FWP. The new Lakewood Lake water level control weir (XS 2345) is also a hydraulic control for FWP at the downstream end of the project.

The target WSE of 1201.5 ft in Lakewood Lake for the 80 cfs flow has been verified in the FWP flow plan.

Figure 3.2 compares 80 cfs flows across FWOP and FWP.

Table 3.1 and Table 3.2 compare the flow-stage relationships across flows ranging from 1 cfs to 80 cfs for FWOP and FWP at the cross-section data collection locations defined in Figure 3.1.

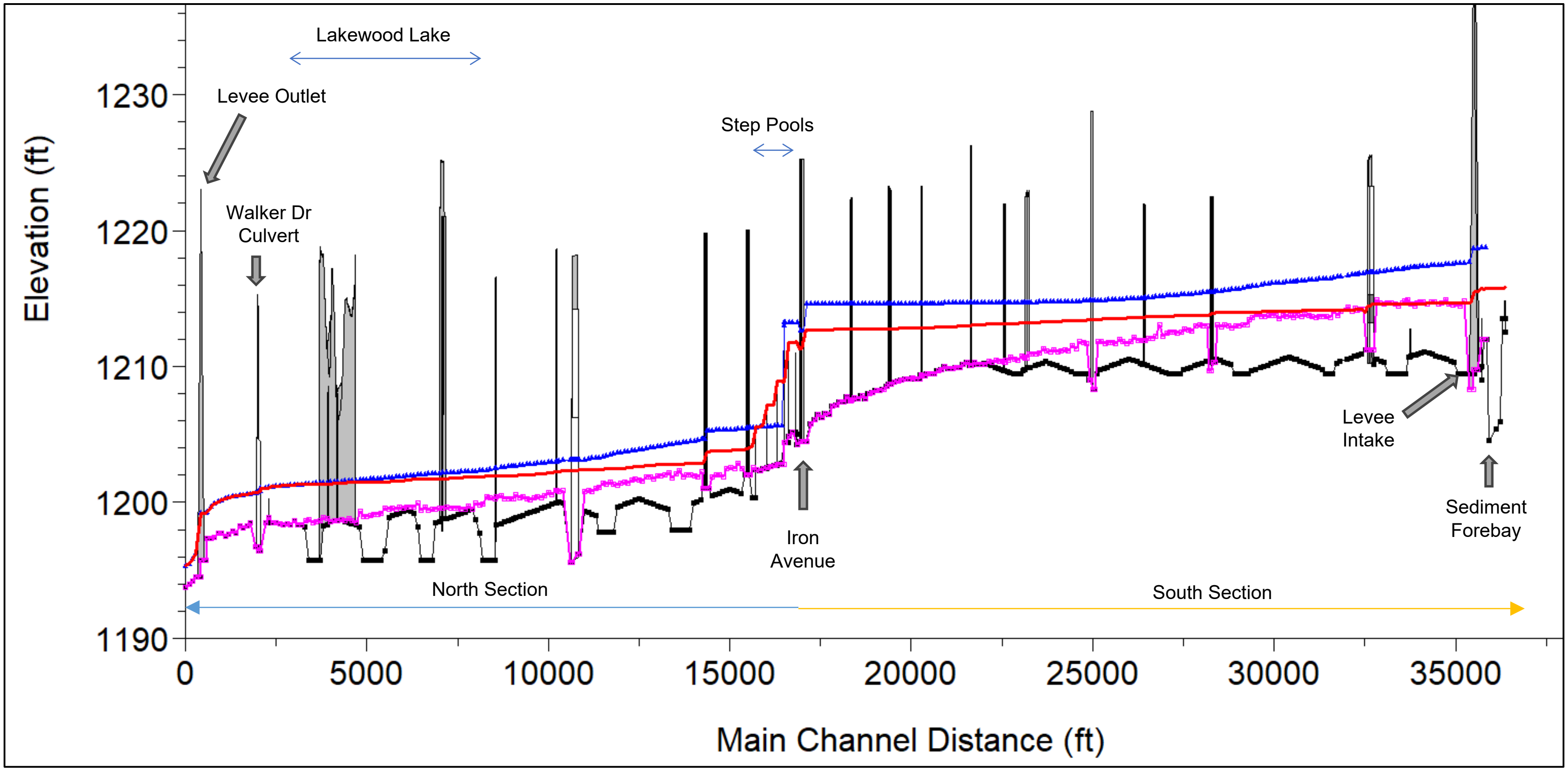


Figure 3.2. 80 cfs FWOP (blue) vs Original FWP (red) profile comparison with the geometry profiles (pink for FWOP and black for FWP)

Table 3.1. FWOP Low Flow Plans – Flow-Stage Relationships

Low Flow Event (cfs)	Stage (ft) at XS 34701	Stage (ft) at XS 32300	Stage (ft) at XS 28200	Stage (ft) at XS 16600	Stage (ft) at XS 10000	Stage (ft) at XS 2900	Stage (ft) at XS 1500
1	1215.3	1214.8	1214.0	1212.6	1200.9	1199.1	1198.2
10	1216.0	1215.3	1214.2	1212.7	1201.4	1199.5	1198.8
40	1216.9	1216.1	1214.9	1213.0	1202.3	1200.4	1199.8
50	1217.0	1216.3	1215.0	1213.0	1202.4	1200.6	1200.0
60	1217.2	1216.5	1215.2	1213.1	1202.6	1200.8	1200.1
70	1217.3	1216.6	1215.3	1213.1	1202.8	1201.0	1200.3
80	1217.5	1216.8	1215.5	1213.2	1202.9	1201.2	1200.5

Table 3.2. FWP Low Flow Plans – Flow-Stage Relationships

Low Flow Event (cfs)	Stage (ft) at XS 34701	Stage (ft) at XS 32300	Stage (ft) at XS 28200	Stage (ft) at XS 16600	Stage (ft) at XS 10000	Stage (ft) at XS 2900	Stage (ft) at XS 1500
1	1212.8	1211.9	1211.9	1208.5	1200.3	1200.3	1198.2
10	1213.0	1212.2	1212.1	1208.6	1200.7	1200.5	1198.8
40	1213.8	1213.2	1213.0	1208.8	1201.5	1200.9	1199.8
50	1214.0	1213.5	1213.2	1208.8	1201.7	1201.0	1200.0
60	1214.3	1213.7	1213.4	1208.8	1201.9	1201.1	1200.2
70	1214.5	1214.0	1213.6	1208.9	1202.0	1201.2	1200.3
80	1214.7	1214.2	1213.8	1208.9	1202.2	1201.3	1200.5

3.1.2 Frequency Flood Flow Scenarios

These high flow scenarios represent different magnitudes of storm events occurring in the restored channel. They range from 99% AEP (1-year return period) to 0.2% AEP (500-year return period) to show a range of possible flood events. Figure 3.3 shows all the standard flow plan (section 2.3) profiles for FWP. Figure 3.4 shows the extents of the 99% AEP, and 0.2% AEP events laid over imagery.

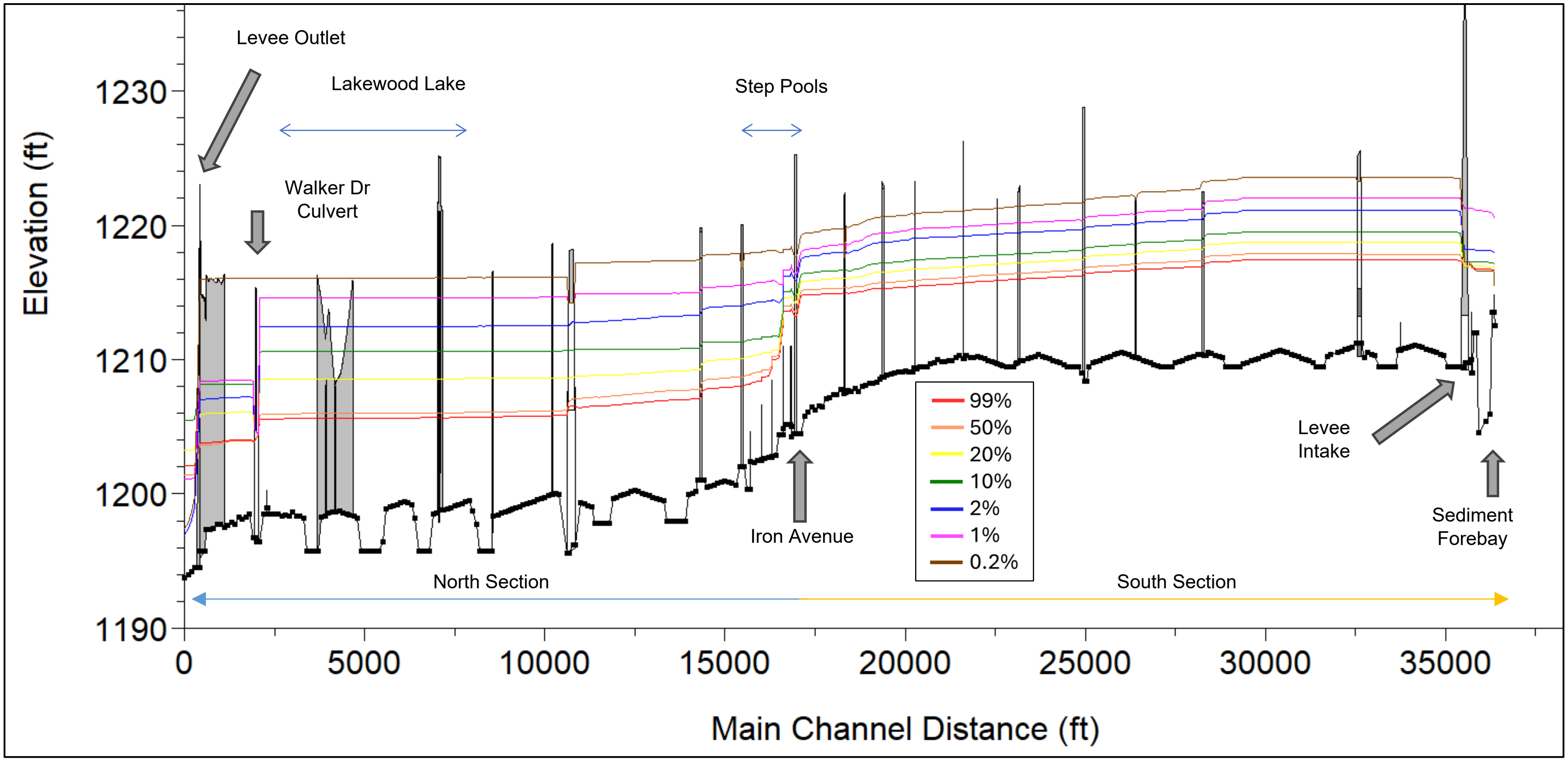


Figure 3.3. 99% to 0.2% AEP Original FWP flow profiles

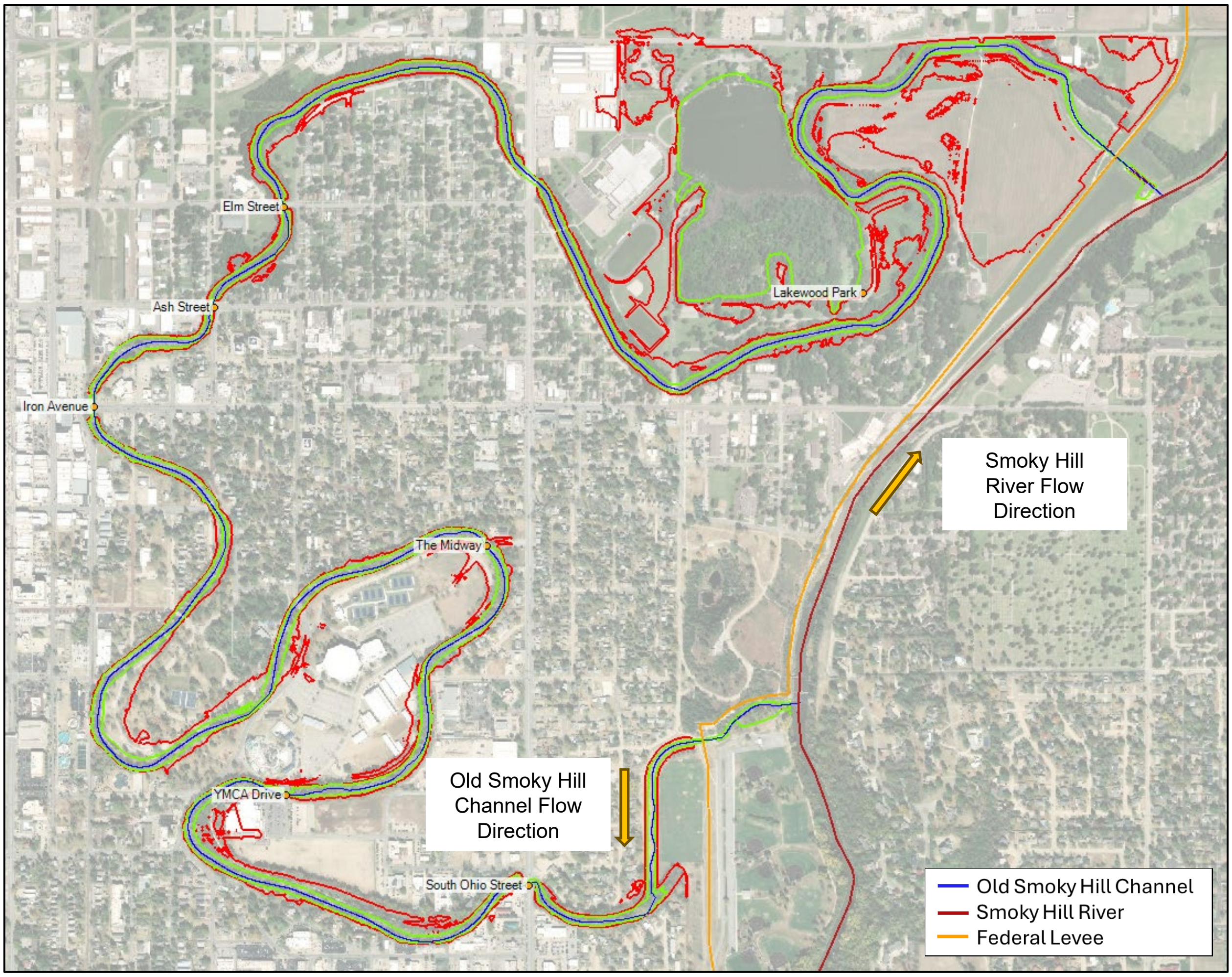


Figure 3.4. FWP 99% AEP Extents (green) compared to Original FWP 0.2% AEP Extents (red)

Table 3.4 through Table 3.10 present the flow-stage-frequency relationship. The variables presented are the maximum water surface and the flow at the time of the maximum water surface. This will assist in understanding the changes in stage and flow at the highest impact areas. The pink cross sections in Figure 3.1 show the locations where data was collected for flow-stage-frequency tables.

The 2% AEP flood frequency event is the first event where water begins to get out of bank. Table 3.3 below shows the top of bank elevations at the locations defined in Figure 3.1.

Table 3.3. Approximate Bank Full Information

Variable	Stage (ft) at XS 34701	Stage (ft) at XS 32300	Stage (ft) at XS 28200	Stage (ft) at XS 16600	Stage (ft) at XS 10000	Stage (ft) at XS 2900	Stage (ft) at XS 1500
Top of Bank Elevation (ft)	1225.9	1223.9	1223.4	1223.1	1219.1	1214.6	1212.7

Table 3.4. Flow-Stage-Frequency at XS 34701 (Upstream of S Ohio St)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1218.6	1217.4	-120	-75
50%	1219.0	1217.8	-139	-98
20%	1219.9	1218.7	-172	-122
10%	1220.6	1219.5	-195	-140
2%	1222.2	1221.1	-231	-173
1%	1223.1	1222.0	-144	-96
0.2%	1224.4	1223.5	-260	-248

Table 3.5. Flow-Stage-Frequency at XS 32300 (Downstream of S Ohio St)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1218.7	1217.4	-47	1
50%	1219.2	1217.9	-52	-10
20%	1220.0	1218.8	-75	-23
10%	1220.7	1219.5	-80	-21
2%	1222.2	1221.1	-76	-14
1%	1223.2	1222.0	14	70
0.2%	1224.5	1223.5	-78	-59

Table 3.6. Flow-Stage-Frequency at XS 28200 (Downstream of YMCA Dr)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1218.2	1216.9	374	403
50%	1218.7	1217.4	430	464
20%	1219.5	1218.2	558	608
10%	1220.1	1218.9	675	737
2%	1221.6	1220.4	925	1005
1%	1222.3	1221.2	1119	1205
0.2%	1223.9	1222.7	1458	1593

Table 3.7. Flow-Stage-Frequency at XS 16600 (At Western Star Mill Weir)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1214.8	1210.1	553	560
50%	1215.0	1210.4	687	680
20%	1215.5	1210.9	941	931
10%	1215.9	1211.7	1162	1114
2%	1216.8	1214.2	1734	1687
1%	1217.2	1215.6	2006	1940
0.2%	1218.5	1218.0	2192	1748

Table 3.8. Flow-Stage-Frequency at XS 10000 (Downstream of N Ohio St)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1206.2	1205.8	593	307
50%	1206.7	1206.2	741	348
20%	1208.1	1208.6	365	371
10%	1210.0	1210.6	338	365
2%	1212.0	1212.5	543	552
1%	1214.4	1214.6	568	599
0.2%	1216.1	1216.1	841	812

Table 3.9. Flow-Stage-Frequency at XS 2900 (Upstream of Walker Dr Culvert)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1205.1	1205.6	275	301
50%	1205.5	1206.0	317	339
20%	1207.9	1208.5	358	382
10%	1209.9	1210.6	353	381
2%	1211.9	1212.4	553	568
1%	1214.3	1214.6	588	615
0.2%	1216.0	1216.1	72	85

Table 3.10. Flow-Stage-Frequency at XS 1500 (Downstream of Walker Dr Culvert)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1203.7	1204.0	277	303
50%	1203.7	1203.9	319	341
20%	1205.8	1206.1	361	385
10%	1207.8	1208.2	356	384
2%	1206.9	1207.2	557	572
1%	1208.7	1208.5	591	619
0.2%	1215.9	1216.0	138	157

3.2 FWOP vs Original FWP Water Surface Profile and Extents Comparison

This section presents induced impacts for assistance in creating the real estate takings analysis. Induced impacts are defined as changes caused by the FWP in comparison to the FWOP that relate to stage frequencies, flow frequencies, or duration.

3.2.1 Difference in 2% AEP Event Water Surface

Induced impacts for this project were estimated by comparing peak WSE between the FWOP and FWP conditions. Induced impacts occur when the impacts of the project cause the FWP WSE to be different than the FWOP WSE. See Figure 3.5 for a comparison of the profiles for FWOP (blue) and FWP (red) for the 2% AEP event along with the geometry profiles (pink for FWOP and black for FWP).

Figure 3.6 compares the WSE for FWOP and FWP for the 2% AEP event in units of feet of change. Red represents locations where the FWP WSE is more than 0.1 ft greater than the FWOP conditions. Blue represents where the FWOP WSE is more than 0.1 ft greater than the FWP conditions. Grey represents locations where the WSE is within 0.1 ft of each other.

The FWP WSE is a maximum of 0.5 ft higher than the FWOP WSE in the northern section of river surrounding Lakewood Lake. There are some locations in the southern section of river where the FWP WSE is higher than the FWOP WSE due to slight changes resulting from the channel excavation or new flow paths under bridges. Changes in model extents lead to the sedimentation basin showing completely as increased extents. With removal of the sedimentation basin area and other inaccurate terrain modification areas, the total induced impacts area is approximately 0.67 acres.

Figure 3.7 shows locations where there are differences in extents between FWOP and FWP for the 2% AEP event. Red represents locations where there are increases in stage from FWOP to FWP (FWP extents larger than FWOP extents). Blue represents locations where there are reductions in stage from FWOP to FWP (FWOP extents larger than FWP extents).

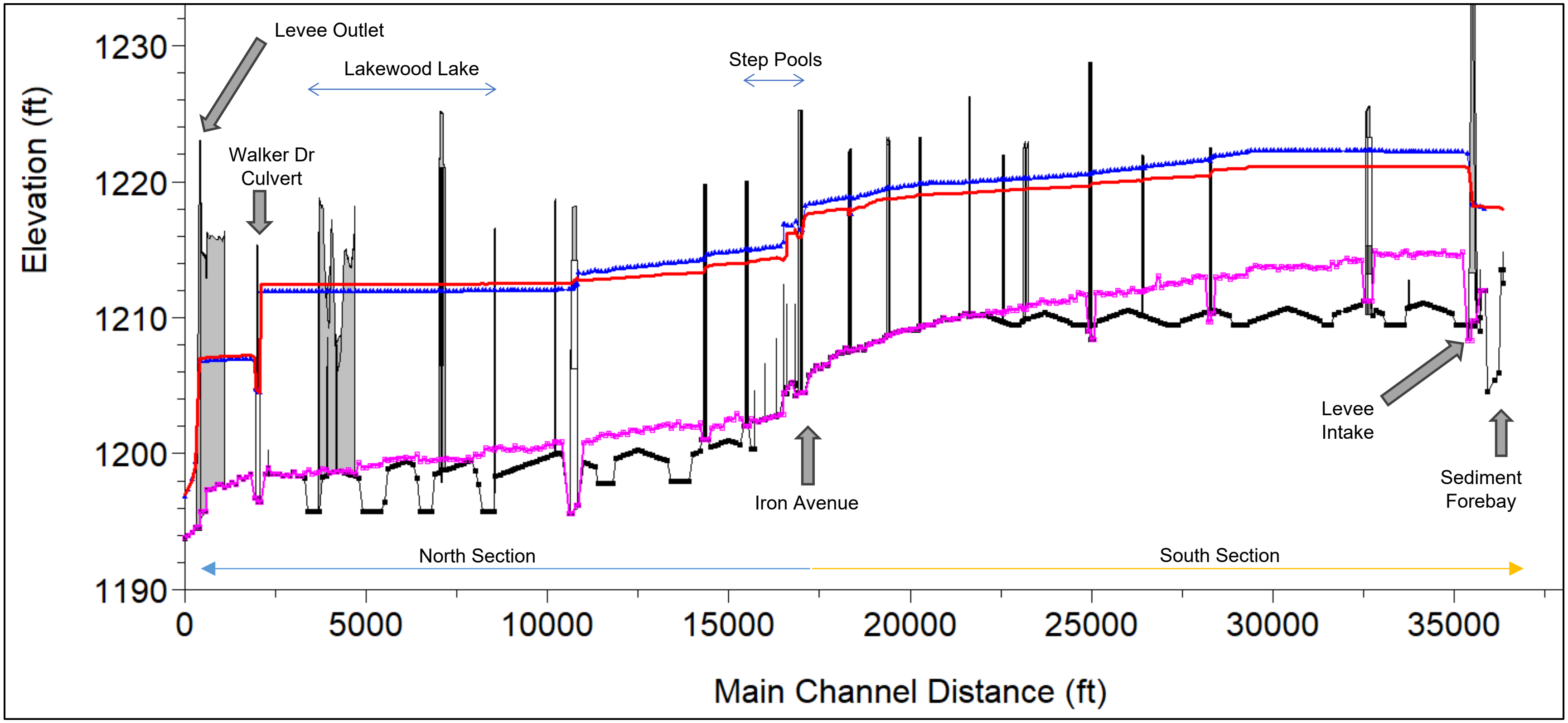


Figure 3.5. 2% AEP FWOP (blue) vs Original FWP (red) profile comparison with the geometry profiles (pink for FWOP and black for FWP)

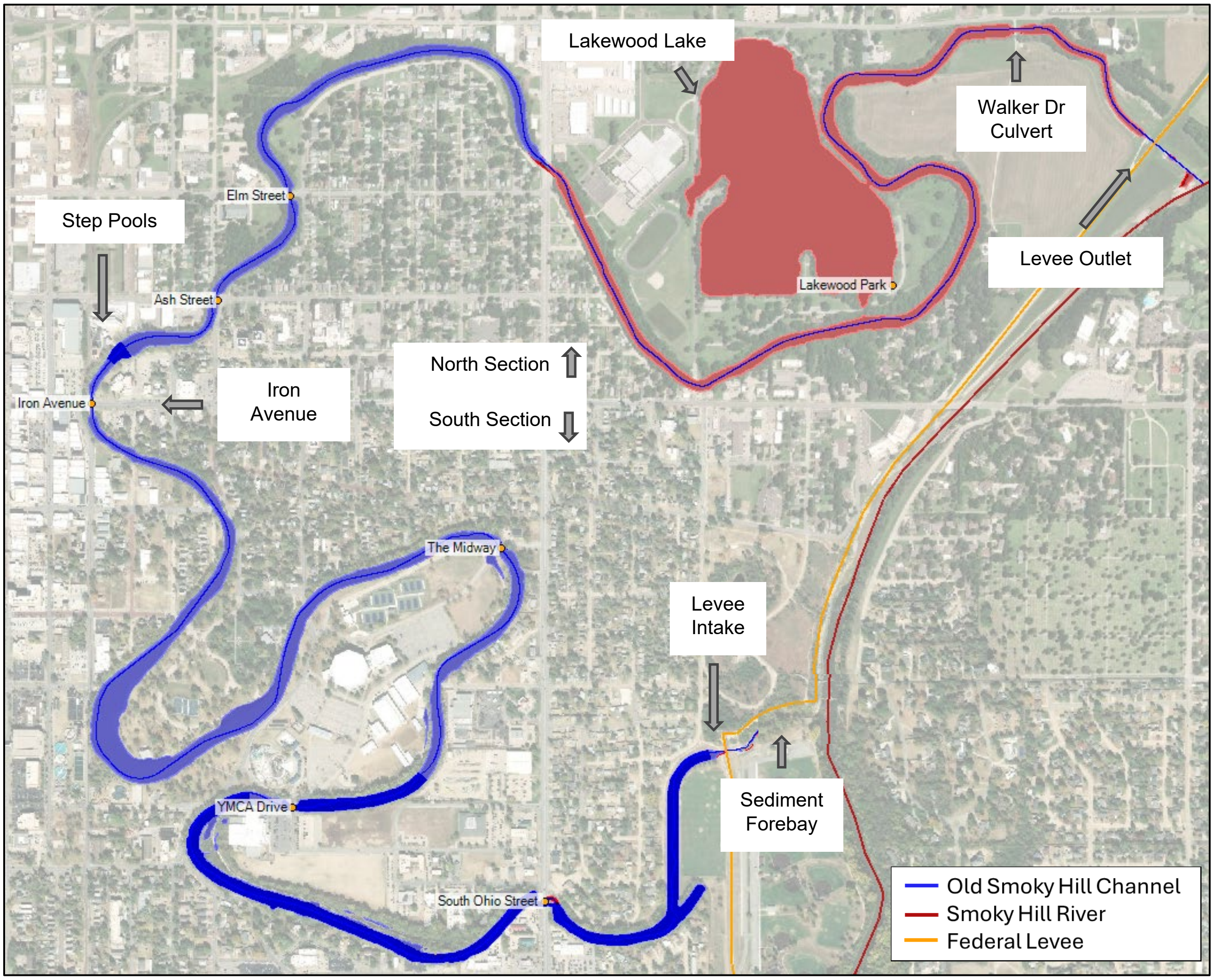


Figure 3.6. 2% AEP FWOP vs Original FWP WSE Feet of Change Comparison

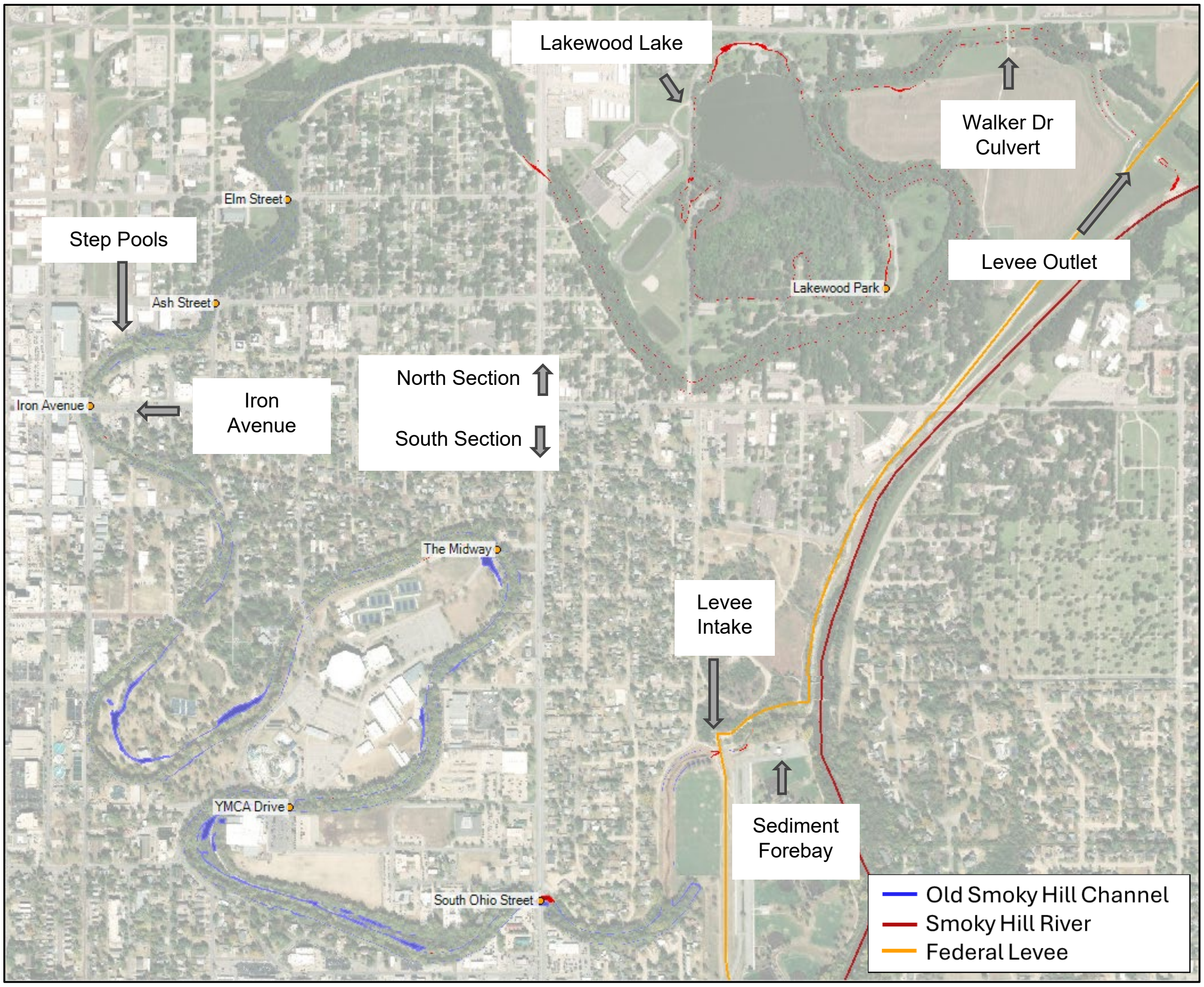


Figure 3.7. 2% AEP FWOP vs Original FWP Impact Extents

3.2.2 Difference in 1% AEP Event Water Surface

Induced impacts for this project were estimated by comparing peak WSE between the FWOP and FWP conditions. Induced impacts occur when the impacts of the project cause the FWP WSE to be different than the FWOP WSE. See Figure 3.8 for a comparison of the profiles for FWOP (blue) and FWP (red) for the 1% AEP event along with the geometry profiles (pink for FWOP and black for FWP).

Figure 3.9 compares the WSE for FWOP and FWP for the 1% AEP event in units of feet of change. Red represents locations where the FWP WSE is more than 0.1 ft greater than the FWOP conditions. Blue represents where the FWOP WSE is more than 0.1 ft greater than the FWP conditions. Grey represents locations where the WSE is within 0.1 ft of each other.

The FWP WSE is a maximum of 0.3 ft higher than the FWOP WSE in the northern section of river surrounding Lakewood Lake. There are some locations in the southern section of river where the FWP WSE is higher than the FWOP WSE due to slight changes resulting from the channel excavation or new flow paths under bridges.

Changes in model extents lead to the sedimentation basin showing completely as increased extents. With removal of the sedimentation basin and other inaccurate terrain modification areas, the total induced impacts area is approximately 1.30 acres.

Figure 3.10 shows locations where there are differences in extents between FWOP and FWP for the 1% AEP event. Red represents locations where there are increases in stage from FWOP to FWP (FWP extents larger than FWOP extents). Blue represents locations where there are reductions in stage from FWOP to FWP (FWOP extents larger than FWP extents).

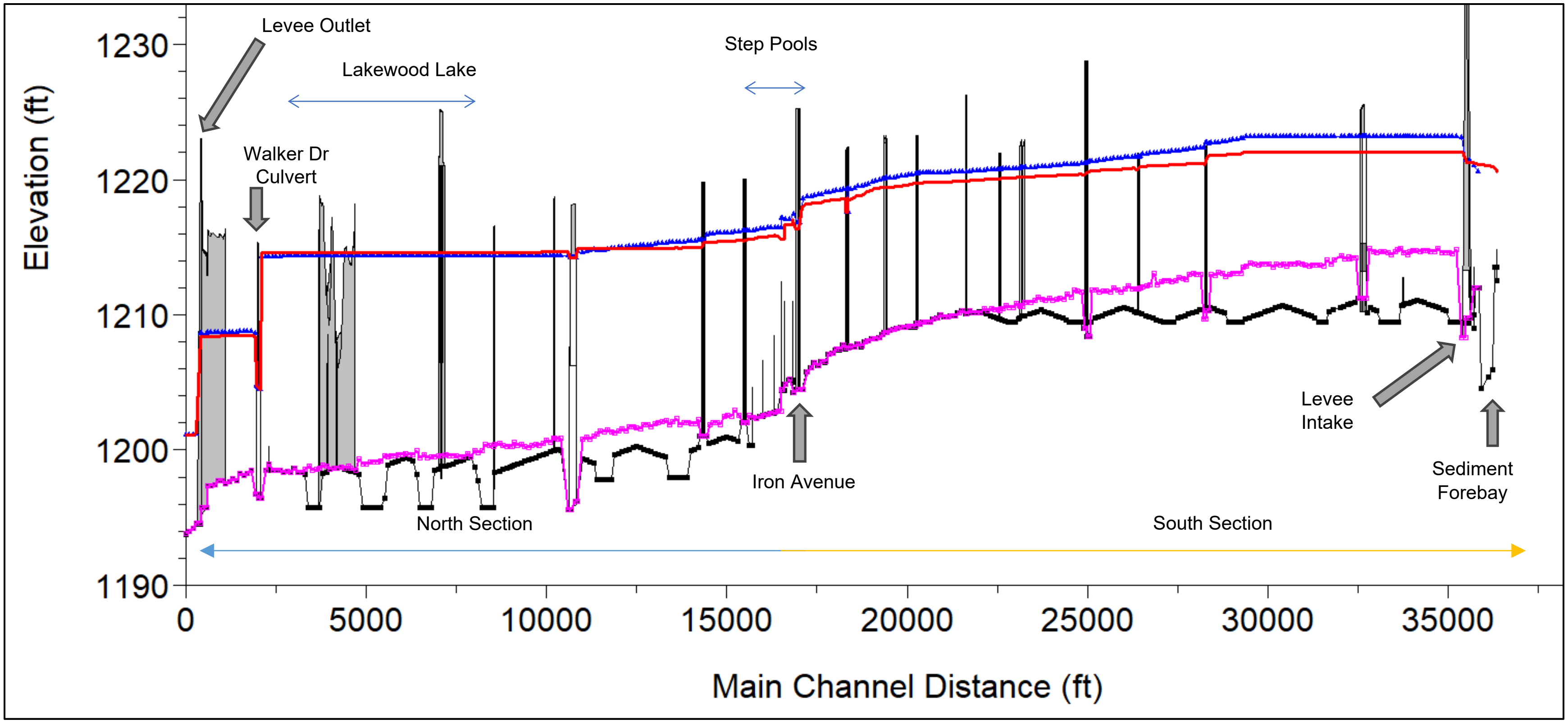


Figure 3.8. 1% AEP FWOP (blue) vs Original FWP (red) profile comparison with the geometry profiles (pink for FWOP and black for FWP)

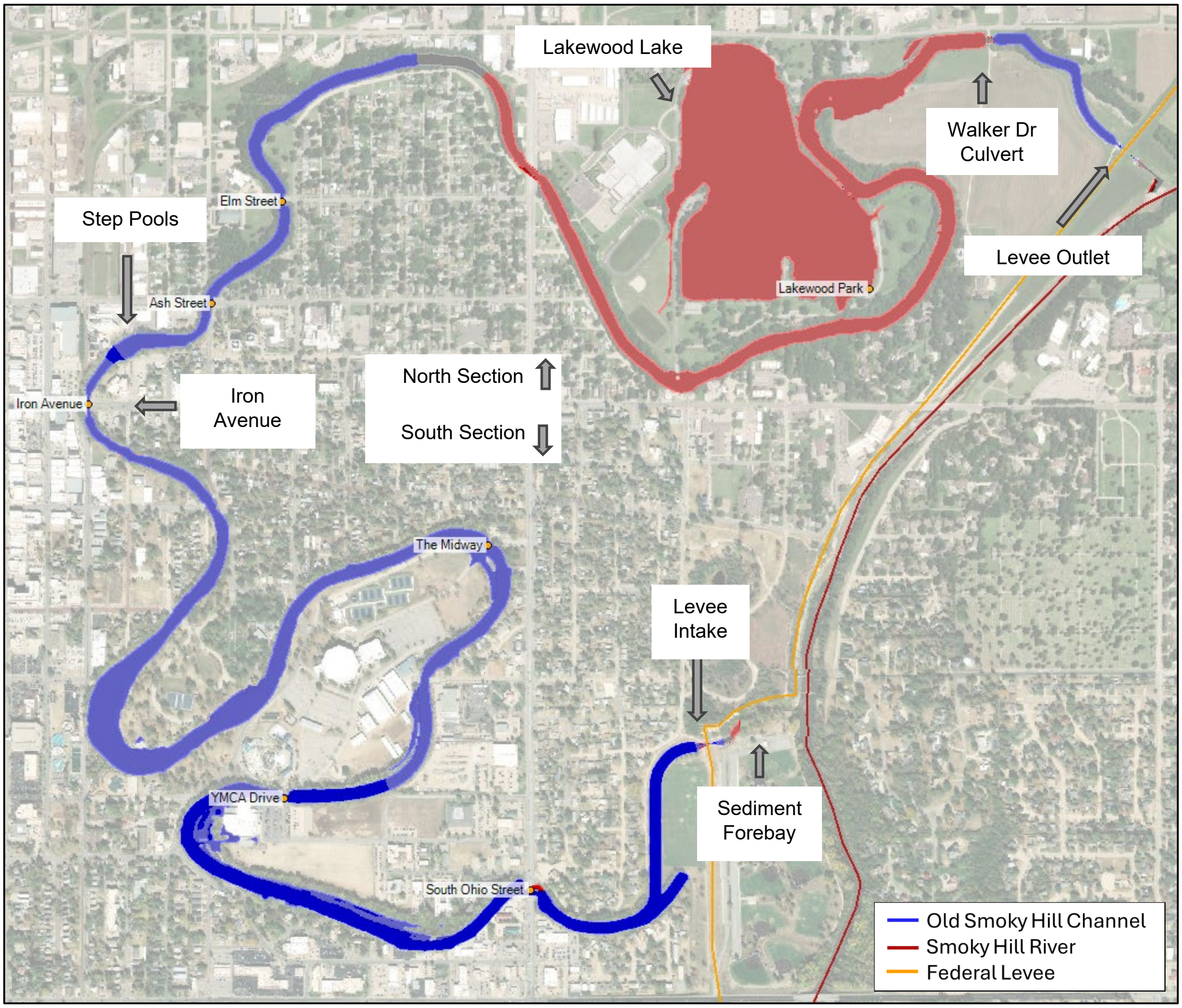


Figure 3.9. 1% AEP FWOP vs Original FWP WSE Feet of Change Comparison

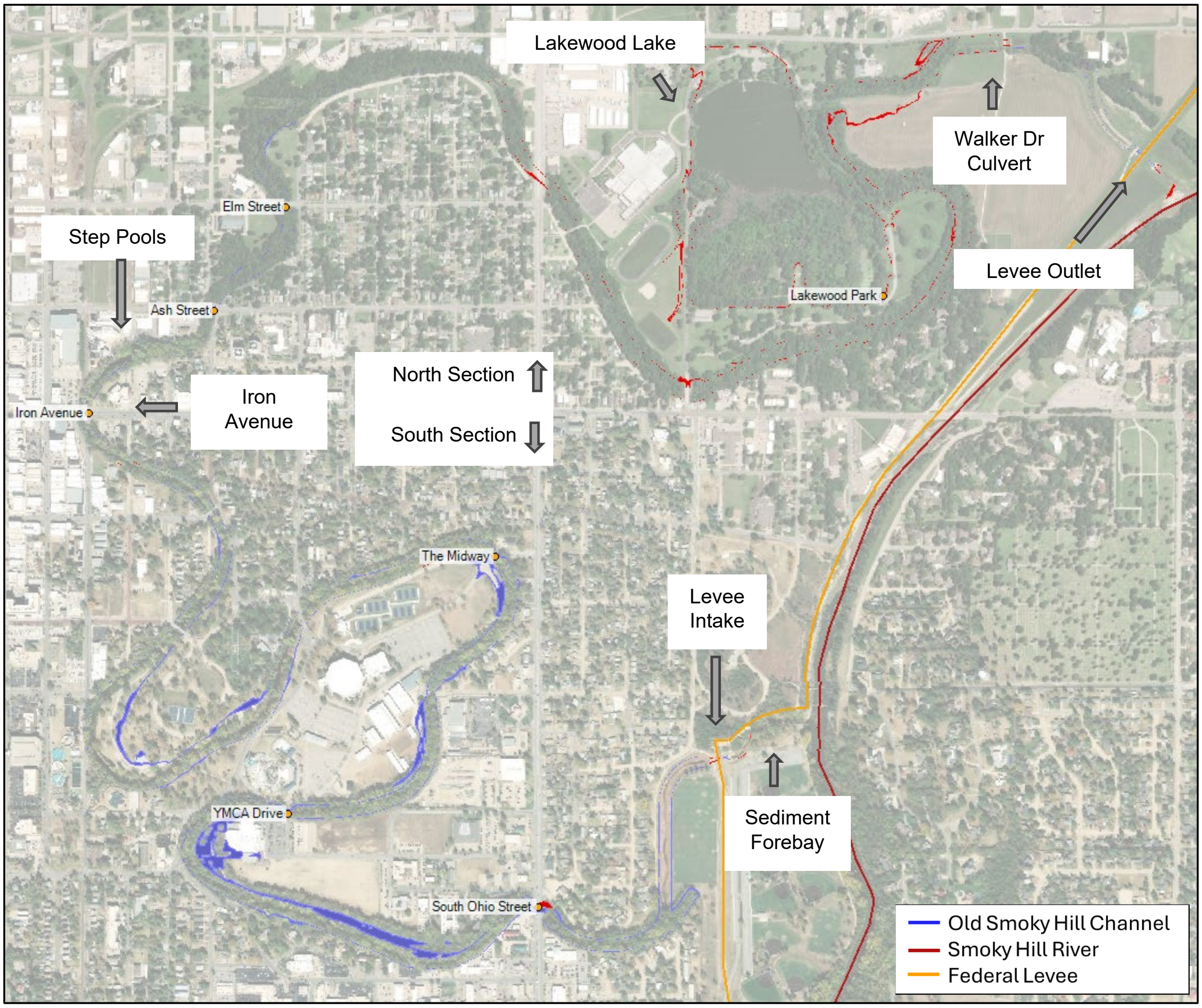


Figure 3.10. 1% AEP FWOP vs Original FWP Impact Extents

3.2.3 Difference in 0.2% AEP Event Water Surface

Induced impacts for this project were estimated by comparing peak WSE between the FWOP and FWP conditions. Induced impacts occur when the impacts of the project cause the FWP WSE to be different than the FWOP WSE. See Figure 3.11for a comparison of the profiles for FWOP (blue) and FWP (red) for the 0.2% AEP event along with the geometry profiles (pink for FWOP and black for FWP).

Figure 3.12 compares the WSE for FWOP and FWP for the 0.2% AEP event in units of feet of change. Red represents locations where the FWP WSE is more than 0.1 ft greater than the FWOP conditions. Blue represents where the FWOP WSE is more than 0.1 ft greater than the FWP conditions. Grey represents locations where the WSE is within 0.1 ft of each other. The FWP WSE is a maximum of 0.2 ft higher than the FWOP WSE in the northern section of river. There are some locations in the southern section of river where the FWP WSE is higher than the FWOP WSE due to slight changes resulting from the channel excavation or new flow paths under bridges. Changes in model extents lead to the sedimentation basin showing completely as increased extents. With removal of the sedimentation basin area, the total induced impacts area is approximately 1.49 acres.

Figure 3.13 shows locations where there are differences in extents between FWOP and FWP for the 0.2% AEP event. Red represents locations where there are increases in stage from FWOP to FWP (FWP extents larger than FWOP extents). Blue represents locations where there are reductions in stage from FWOP to FWP (FWOP extents larger than FWP extents).

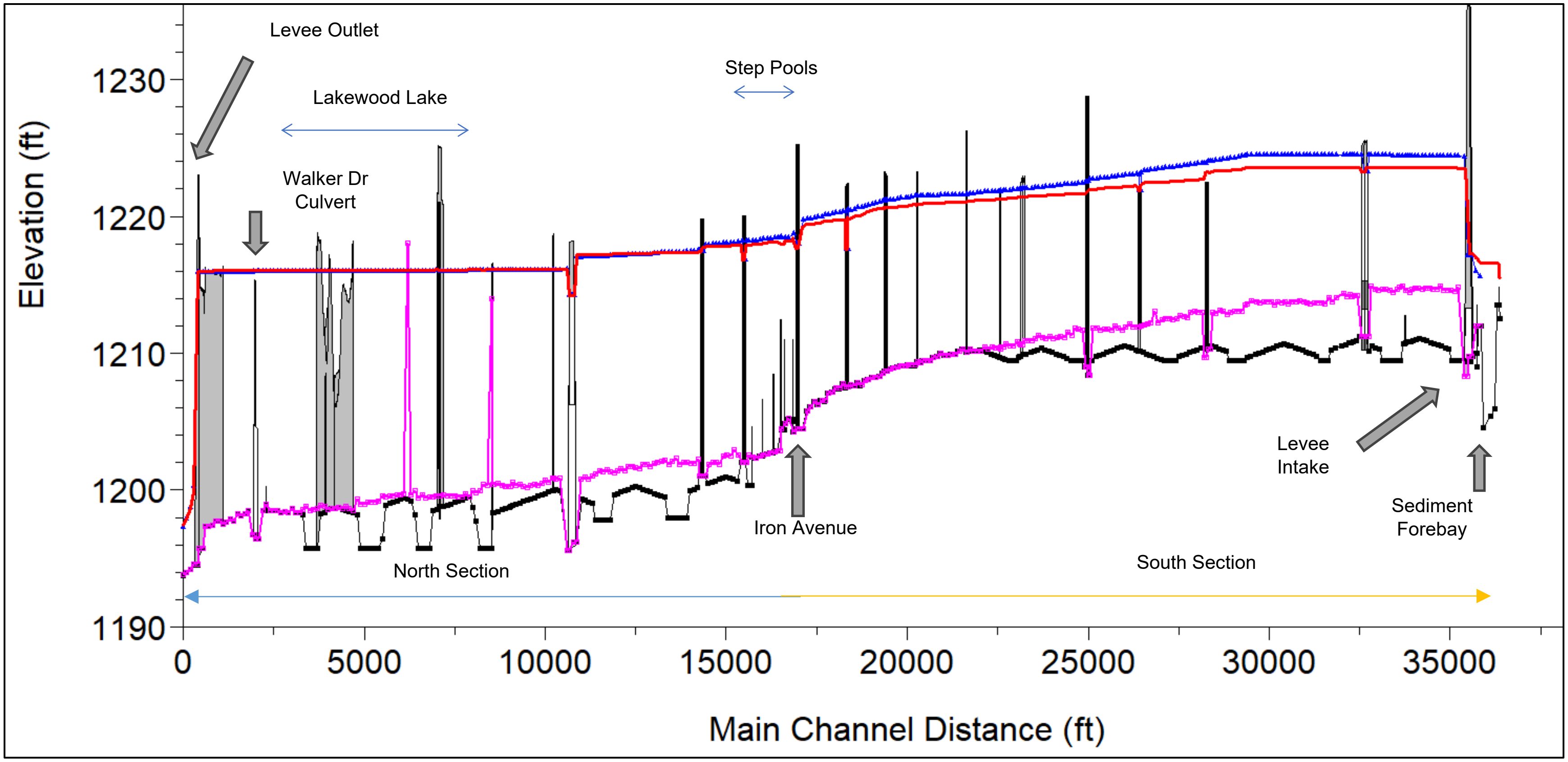


Figure 3.11. 0.2% AEP FWOP (blue) vs Original FWP (red) profile comparison with the geometry profiles (pink for FWOP and black for FWP)

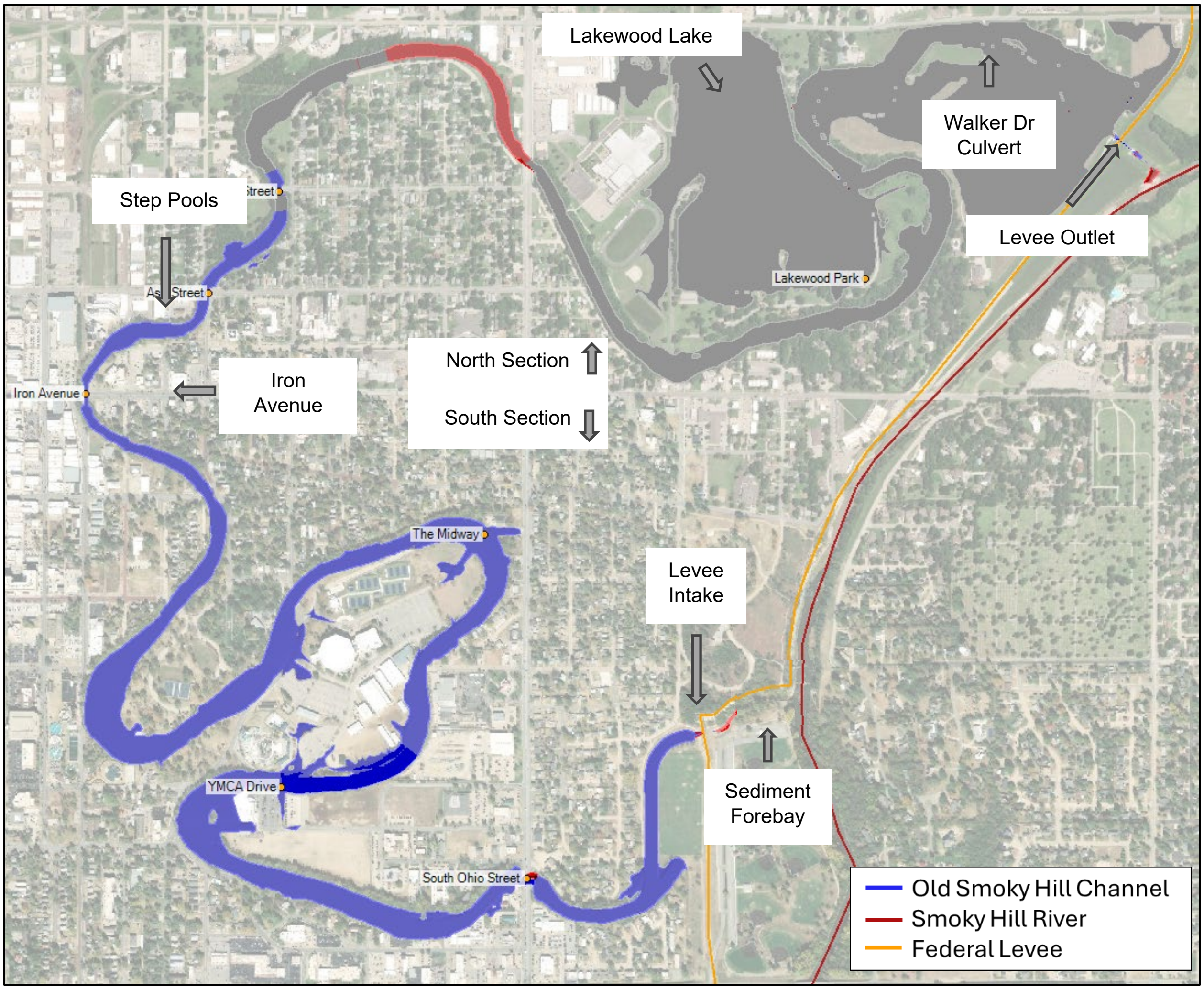


Figure 3.12. 0.2% AEP FWOP vs Original FWP WSE Comparison

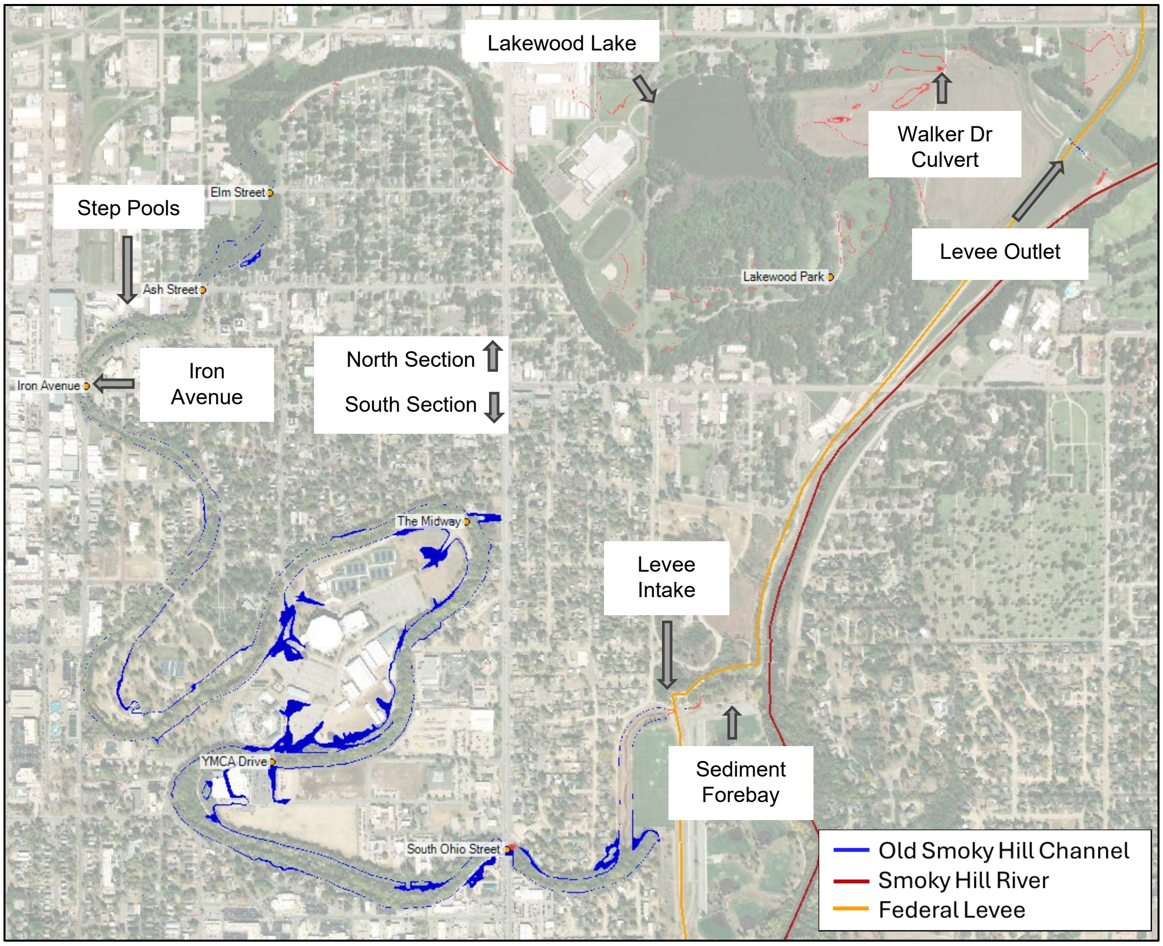


Figure 3.13. 0.2% AEP FWOP vs Original FWP Impact Extents

3.3 Sensitivity Analysis

These analyses will be used to inform possible future scenarios that are not part of the FWOP or FWP as well as possible post TSP design refinements to the FWP design.

These analyses were completed at an earlier stage of the modelling process and due to time and budget constraints have not been updated with the current geometry. The resulting trends are still accurate, however the values associated with them are outdated.

3.3.1 Non-Maintained Channel

The section of woody debris in the channel from XS 22000 to 15502 causes a maximum increase in WSE of 1.3 ft for the 1% AEP event from XS 23000 to 25000 and an average increase in stage of 0.9 feet in areas upstream of the woody debris range as shown in Figure 3.14. This is due to a 13% decrease in flow rate from maintained (1425 cfs) to non-maintained (1235 cfs) at XS 22000. The increase in WSE is enough in some locations from XS 19600 to 35467 to extend out of the channel where the standard 1% FWP event is contained within the channel. This indicates that if woody debris is not periodically removed and allowed to accumulate in the channel, that these areas will experience an increase in water surface elevation that may result in impacts during flood flows.

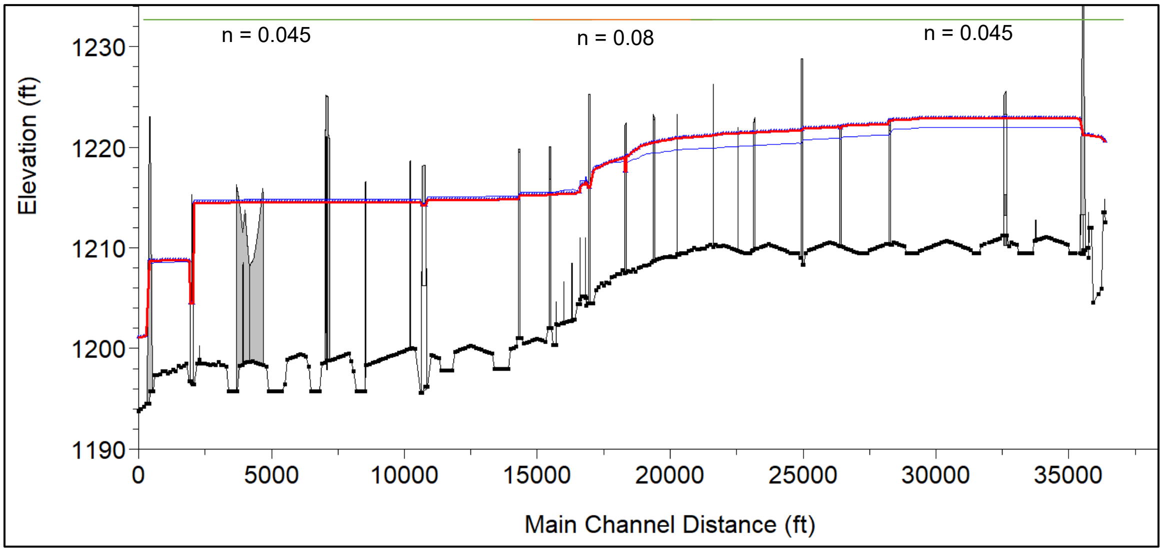


Figure 3.14. 1% AEP FWP (blue) vs FWP Non-Maintained Channel (red) profile comparison

3.3.2 Debris on Bridge Openings

The debris on the piers of the Oakdale Avenue bridge did not impact the WSE.

The debris blockage of 50% of the 96-inch Walker Dr culvert caused an average of 1.4 ft of WSE increase from XS 16600 to 2100 as well as the bridge structure at Walker Dr with the 96-inch culvert to overtop as shown in Figure 3.15. This is due to a 15% decrease in total flow rate across the culvert XS from unblocked (623 cfs of culvert flow) to 50% blocked (339 cfs of culvert flow and 190 cfs of weir flow). The increase in WSE is enough in some locations from XS 16900 to 2100 to extend out of the channel where the standard 1% FWP event is contained within the channel. This indicates that if woody debris is not periodically removed and allowed to accumulate at bridges and culverts, that these areas could experience an increase in water surface elevation, depending on location, that may result in impacts during flood flows.

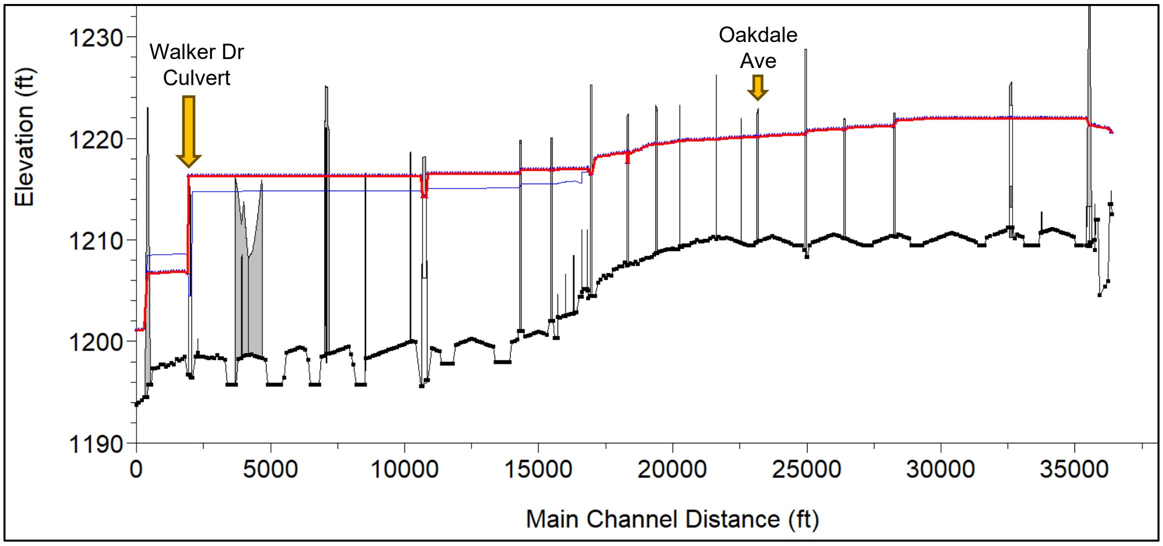


Figure 3.15. 1% AEP FWP (blue) vs FWP Bridge Debris (red) profile comparison

3.3.3 Upstream Intake Sluice Gate

The always open gate scenario lets in 140 to 260 cfs of flow when the standard gate operations would have the gates closed, which is why the WSE is an average of 0.3 ft higher in the northern section and 1.4 ft higher on average in the southern section for the always open scenario than the standard gate operations scenario as shown in Figure 3.16. The increase in WSE is enough in some locations in the southern section to extend out of the channel where the standard 1% FWP event is contained within the channel. It is recommended that gate operations continued to be followed per the 1978 Salina, Kansas Federal Levee Operational Drawings sheet 3.

The always closed gate scenario WSE is an average of 0.1 ft higher in the northern section and 0.2 ft higher on average in the southern section than the standard gate operations scenario as seen in Figure 3.17. This is due to the WSE landside of the levee being higher than the WSE riverside of the levee for a majority of the event, so it can no longer flow out into the channel, causing an increase of approximately 1.1 million cubic feet (110 cfs increase for 3 hours) of water doing downstream. The increase in WSE is enough in some locations in the southern section to extend out of the channel where the standard 1% FWP event is contained within the channel. It is recommended that gate operations continued to be followed per the 1978 Salina, Kansas Federal Levee Operational Drawings sheet 3.

However, the always closed scenario is an average of 0.1 ft lower in the northern section and 1.1 ft lower on average in the southern section than the always open scenario on average.

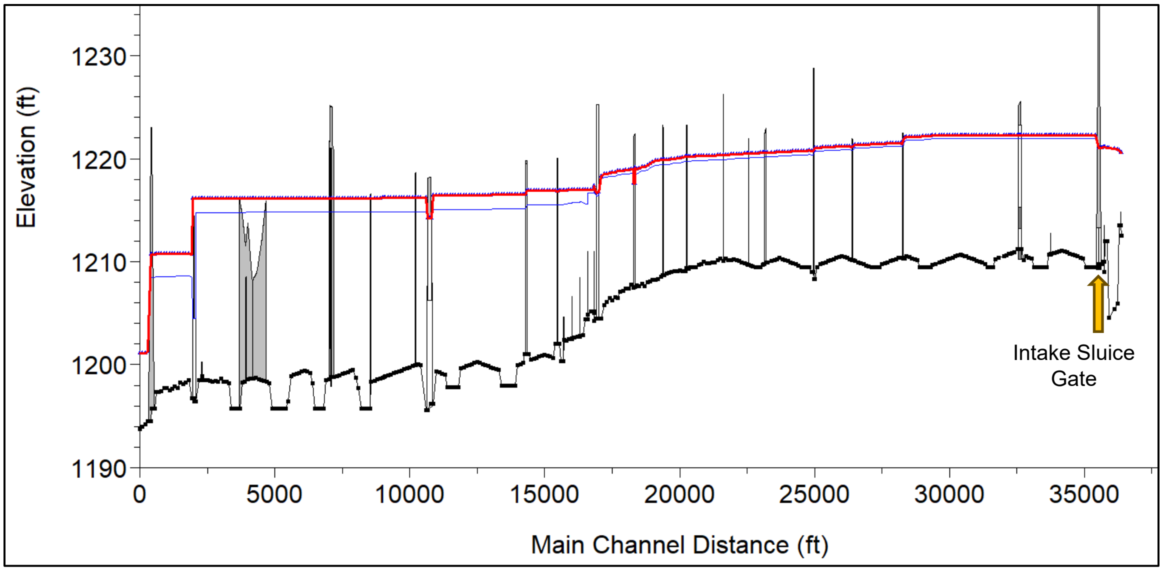


Figure 3.16. 1% AEP FWP (blue) vs FWP Intake Gate Always Open (red) profile comparison

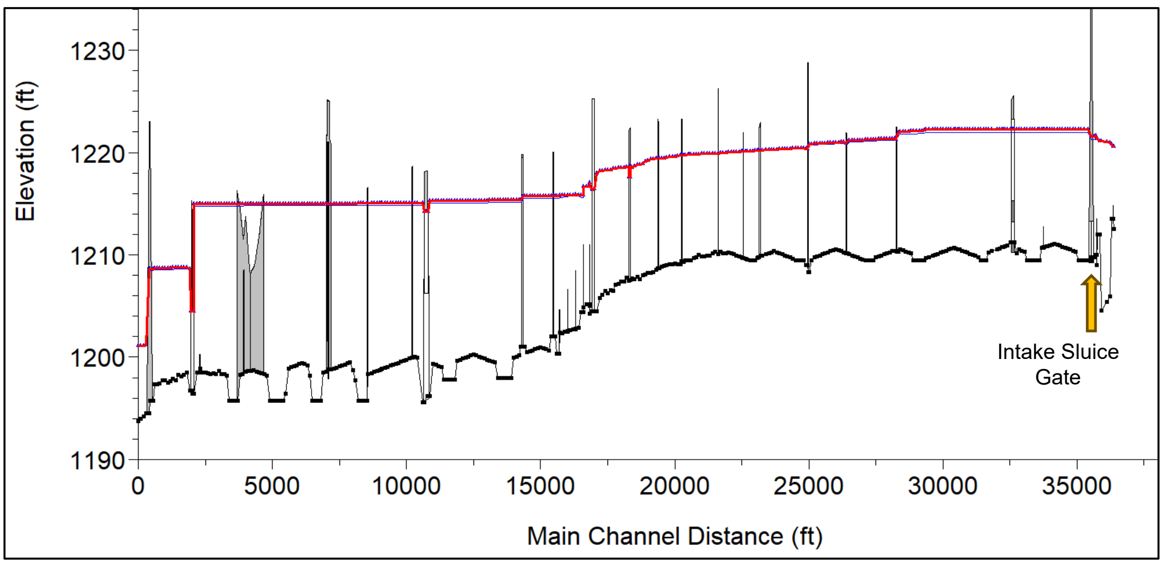


Figure 3.17. 1% AEP FWP (blue) vs FWP Intake Gate Always Closed (red) Profile Comparison

3.3.4 Downstream Outlet Sluice & Flap Gates

The blockage/removal of the secondary 48-inch outlet culvert causes an average of a 2.2 ft raise in WSE at the downstream levee (XS 660 to 2100), with a less significant average raise of 0.4 ft in WSE from XS 2100 to 16600 as shown in Figure 3.18. This is due to a 14% decrease in flow rate through the outlet levee structure from the standard FWP (632 cfs) to the blockage scenario (542 cfs). The increase in WSE is enough in some locations from XS 9000 to 660 to extend out of the channel where the standard 1% FWP event is contained within the channel. This indicates that if conveyance area is lost, blocked, or not designed large enough, that these areas will experience an increase in water surface elevation that may result in impacts during flood flows.

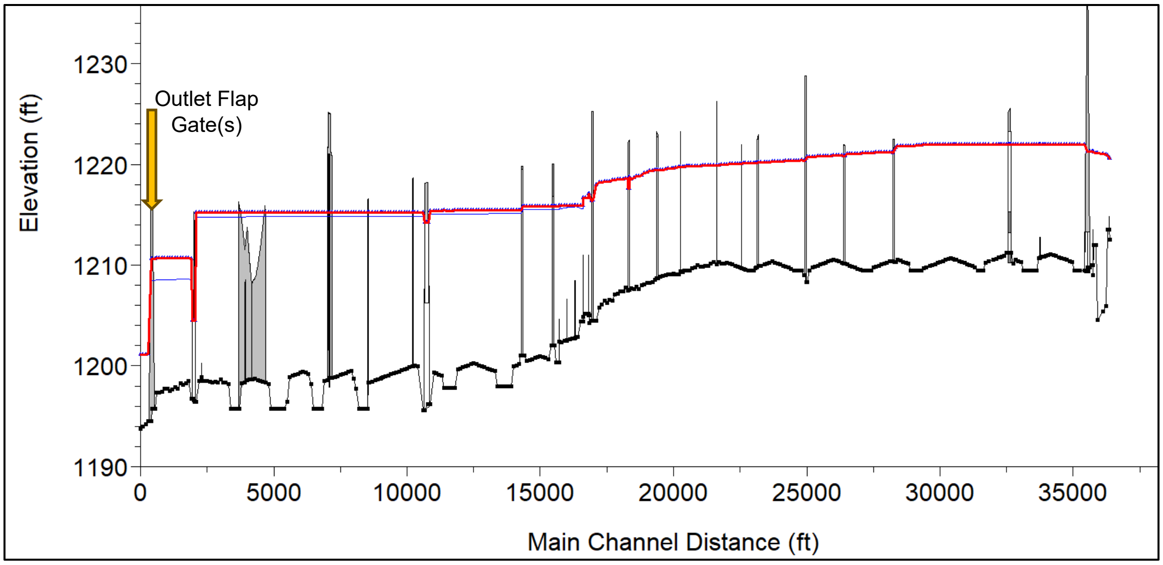


Figure 3.18. 1% AEP FWP (blue) vs FWP Secondary Outlet Gate Blocked (red) Profile Comparison

3.3.5 Lakewood Lake Initial WSE

The “empty” scenario and the recreation flow scenario have no significant difference in WSE in the channel.

The completely full scenario for the initial WSE of Lakewood Lake raises the WSE on average by 0.4 ft from the recreation flows scenario from the downstream levee outlet to the five step-pool weirs (XS 16900 to 660) as shown in Figure 3.19. This is due to a 107% increase in filled storage area of Lakewood Lake from the initial elevation of 1201.5 ft (171 ac-ft) to 1206.1 ft (355 ac-ft). The increase in WSE is enough in some locations from XS 10700 to 660 to extend out of the channel where the standard 1% FWP event is contained within the channel. This indicates that if the Lakewood Lake initial WSE changes, that these areas could experience an increase in water surface elevation that may result in impacts during flood flows.

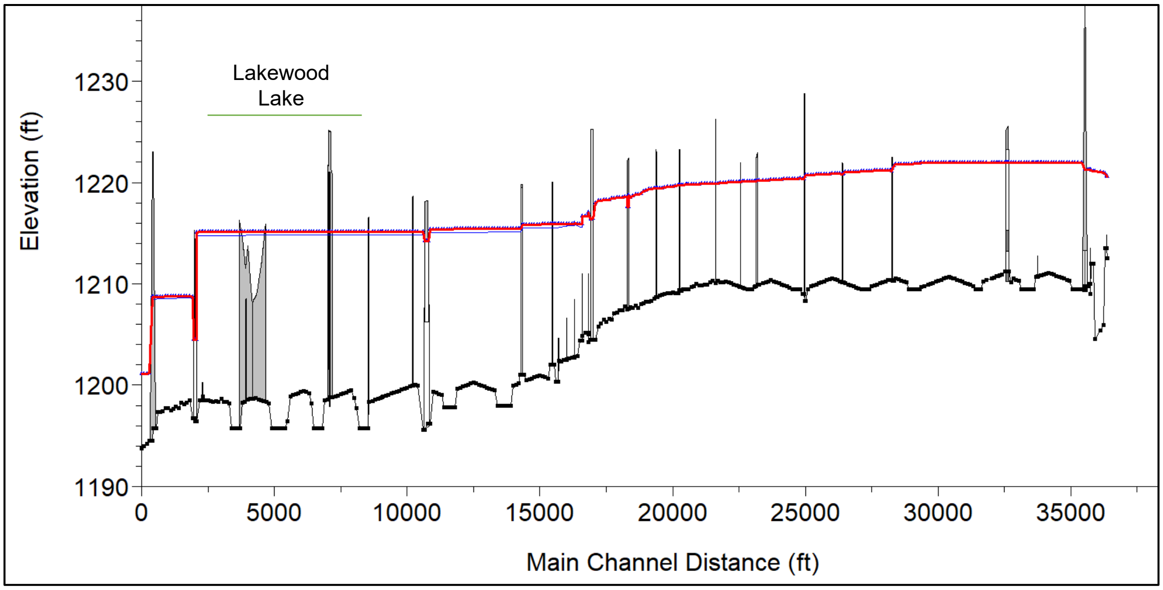


Figure 3.19. 1% AEP FWP (blue) vs FWP "Full" Initial Lakewood Lake WSE (red) Profile Comparison

3.3.6 Fill Volume Placed in Lakewood Lake for FWP

The scenario with the lowest amount of fill being placed in Lakewood Lake (37,772 cubic yards), leads to an average of 0.2 ft reduction in WSE from the standard geometry (105,000 cubic yards), as shown in Figure 3.20. This is due to a 6% decrease in storage area of Lakewood Lake from the 37,772 CY fill scenario (763 ac-ft) to the 105,000 CY fill scenario (720 ac-ft) at an elevation of 1214 ft. There is either no change or a decrease in stages, so this scenario was contained within the channel to a similar or lesser extent than the standard 1% FWP event. This indicates that if the amount of fill placed into Lakewood Lake reduces from current design, that these areas will experience a decrease in water surface elevation.

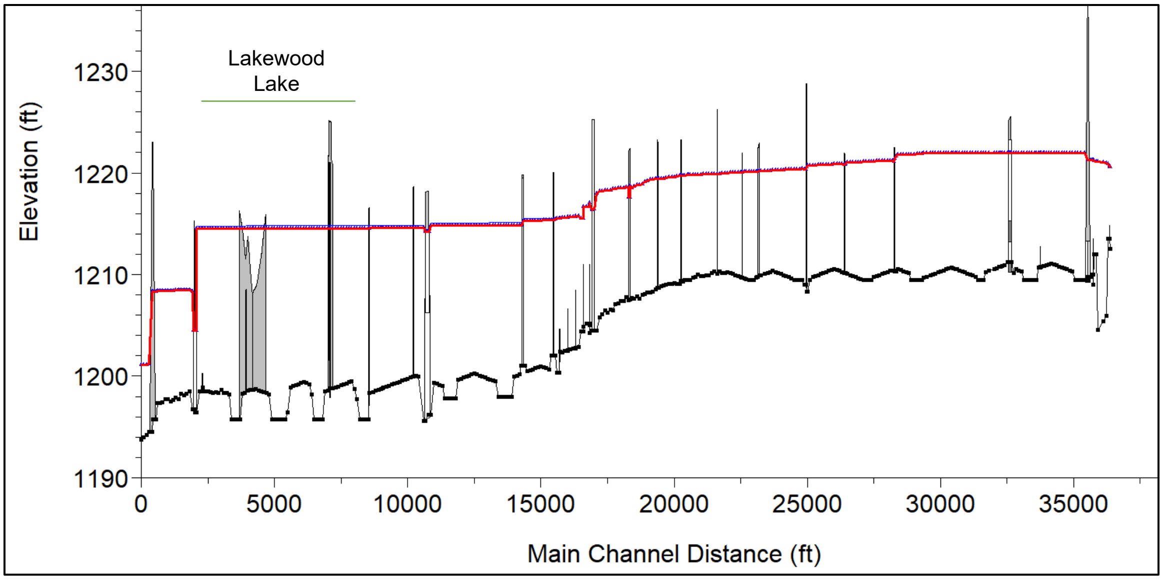


Figure 3.20. 1% AEP FWP (blue) vs FWP Lower Fill Volume in Lakewood Lake WSE (red) Profile Comparison

3.3.7 Removal of Hydraulic Control from 96-inch Walker Dr Culvert (XS 2100)

With removal of Hydraulic control from the 96-inch culvert, the WSE upstream of the culvert reduced by an average of 0.9 ft and the WSE downstream of the culvert increased by an average of 4.8 ft as shown in Figure 3.21. This is due to the removal of the hydraulic control at the culvert when expanding it, along with a 22% increase in flow rate from the standard FWP event (623 cfs) to the expanded culvert in this sensitivity scenario (759 cfs). The increase in WSE is enough in some locations from XS 2100 to 660 to extend out of the channel where the standard 1% FWP event is contained within the channel. This indicates that if hydraulic control is reduced or removed from Walker Dr, that the areas upstream of Walker Dr will experience a decrease in water surface elevation, however the areas downstream will experience an increase in water surface elevation that may result in impacts during flood flows.

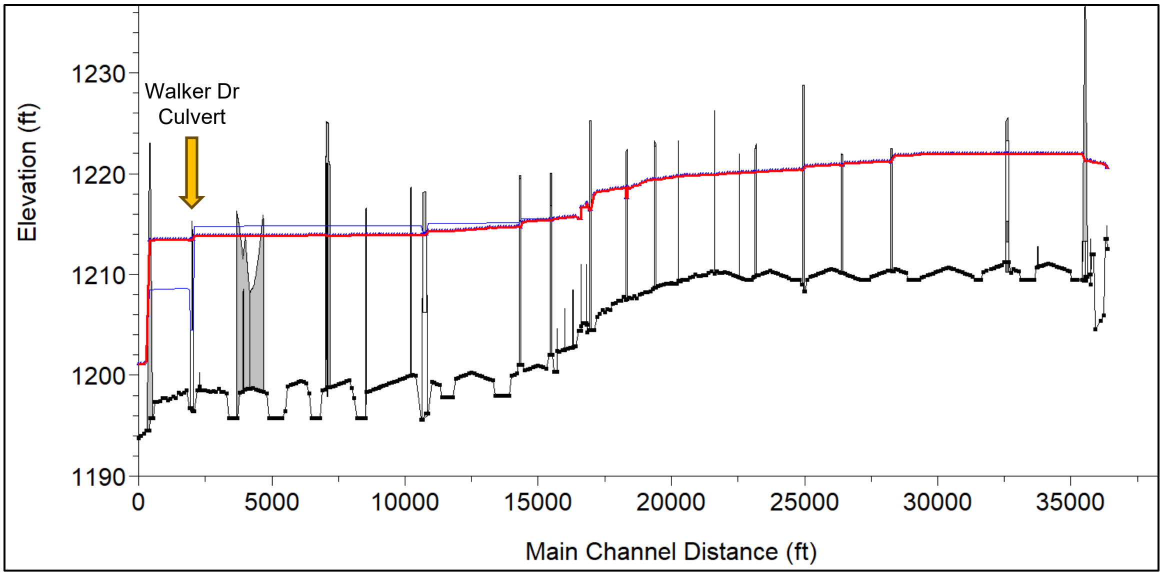


Figure 3.21. 1% AEP FWP (blue) vs FWP Removal Hydraulic Control from 96-inch Culvert (red) Profile Comparison

3.3.8 Sensitivity Analysis Conclusions

Test 2 - Debris on Bridge Openings, Test 4 - Downstream Outlet Sluice & Flap Gates, and Test 7 - Removal of Hydraulic Control from 96-inch Walker Dr Culvert (XS 2100) are the three most impactful sensitivity tests in the area of high interest near and downstream of Lakewood Lake. They show that the conveyance area at Walker Dr and the downstream levee outlet are critical influences on the WSE in the area of high interest near and downstream of Lakewood Lake. These analyses will be used to develop post TSP design refinements in Section 4.1.

4 POST TSP DESIGN REFINEMENTS

This section documents the design changes made from the original FWP design and provides the results from the hydraulic model.

4.1 Geometry Changes

Design refinements were made to the original alternative 3 design to reduce the number of induced impacts. The induced impact cost will be compared between the original alternative 3 design and the refined alternative 3 design. Two design changes were implemented as part of the refinement process.

The Walker Dr culvert in the original FWP design was to remain as is existing, an 8 ft circular culvert. It was recognized that this culvert was a hydraulic control and increasing the WSE in the Lakewood Lake area in sensitivity test number 7 (section 3.3.7). The original culvert is replaced with two 7 ft circular culverts in the refined design. These changes can be seen in Figure 4.1. This design is the smallest conveyance area using standard sized culverts to lower the FWP WSE below the FWOP WSE.

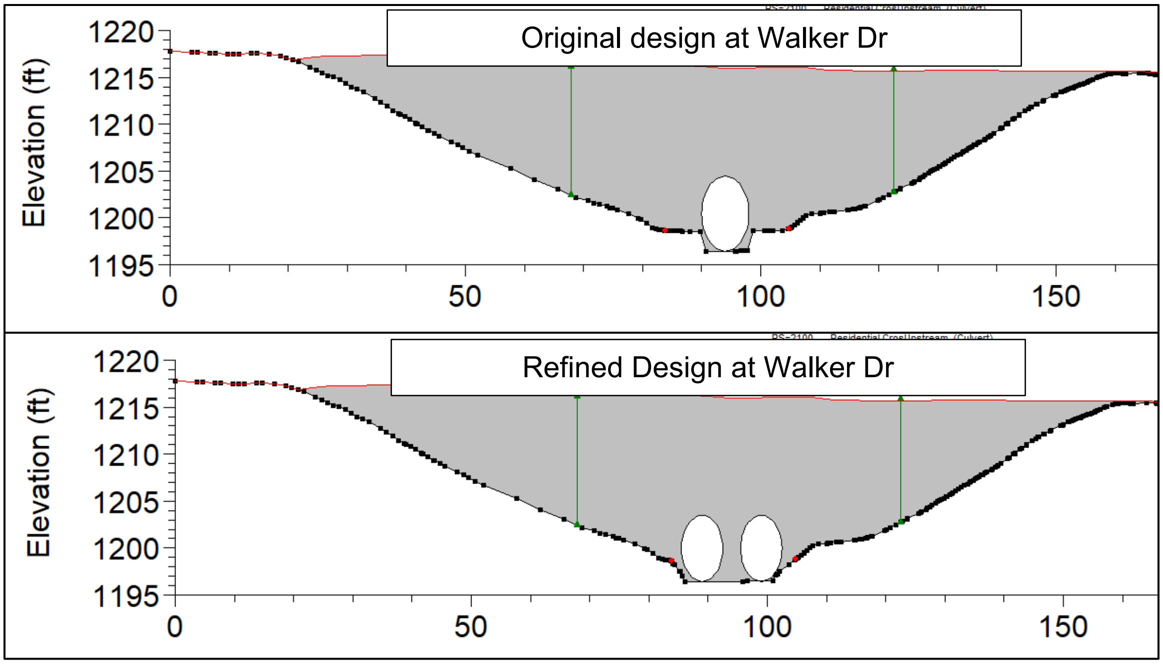


Figure 4.1. Original and Refined Walker Dr Culvert Design (XS 2100)

The secondary culvert in the levee outlet structure in the original FWP design was to be a 4 ft circular culvert. This is increased to a 6.5 ft circular culvert to match the existing culvert, since more flow is passed through the Walker Dr culverts in the refined design. This change can be seen in Figure 4.2. This refined culvert sizing lowers the FWP WSE to a point where the number of induced impacts is minimized to a reasonable level (increasing the culvert size any further, would likely cost more than the reduction in cost of flowage easement).

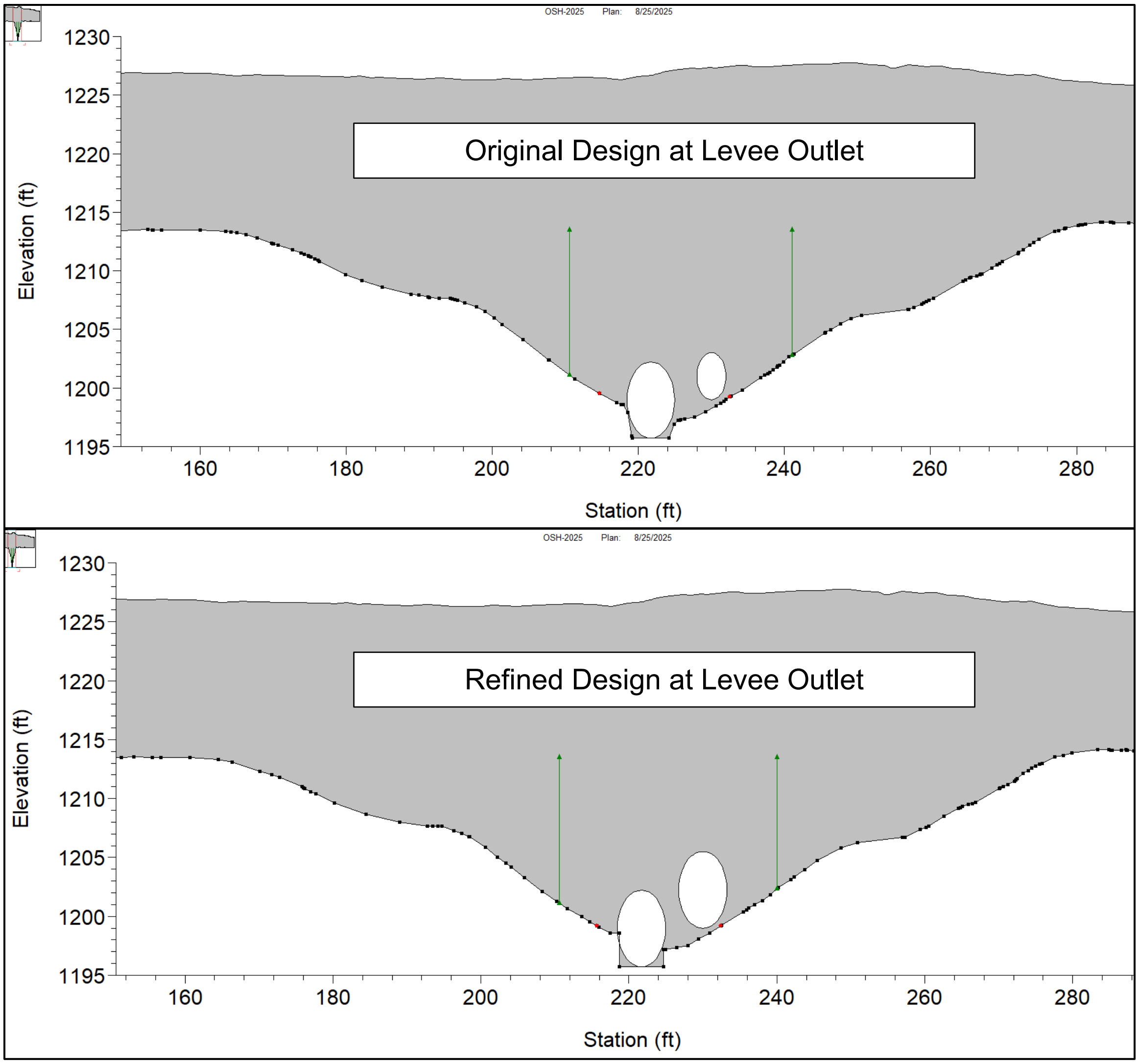


Figure 4.2. Original and Refined Levee Outlet Culvert Design (XS 508)

4.2 Profile Comparisons

This section will compare profiles for the refined design flow plans for larger storm events and compile pertinent information. Figure 3.1 shows locations of cross sections chosen to represent specific reaches and paint a picture of the trends across the entire old Smoky Hill channel.

4.2.1 Low Flow Scenarios

The low flow results are not impacted by the refined design. See section 3.1.1 for more information.

4.2.2 Frequency Flood Flow Scenarios

These high flow scenarios represent different magnitudes of storm events occurring in the restored channel. They range from 99% AEP (1-year return period) to 0.2% AEP (500-year return period) to show a range of possible flood events. Figure 4.3 shows all the standard flow plan (section 2.3) profiles for FWP. Figure 4.4 shows the extents of the 99% AEP, and 0.2% AEP events laid over imagery.

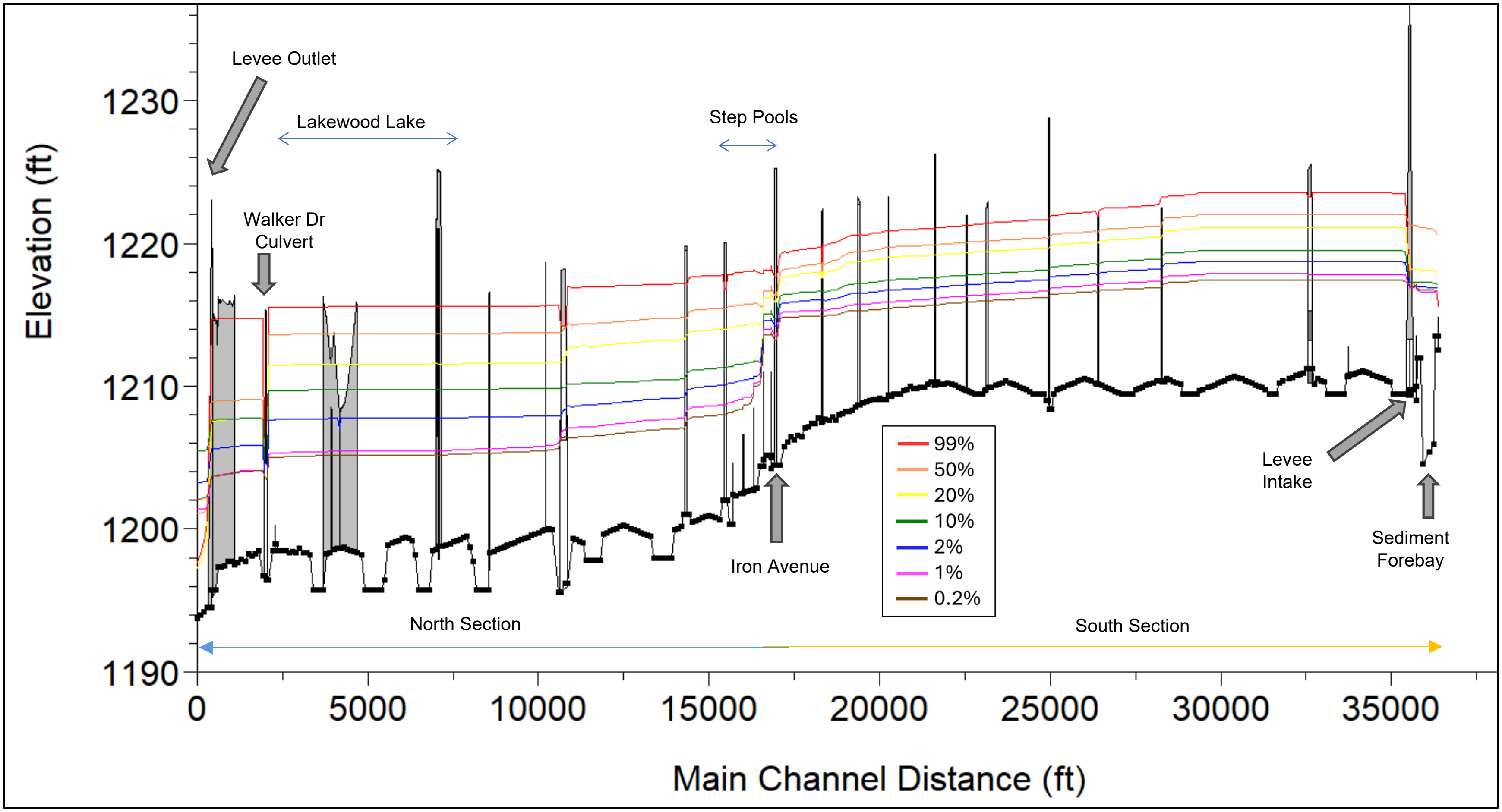


Figure 4.3. 99% to 0.2% AEP Refined FWP flow profiles

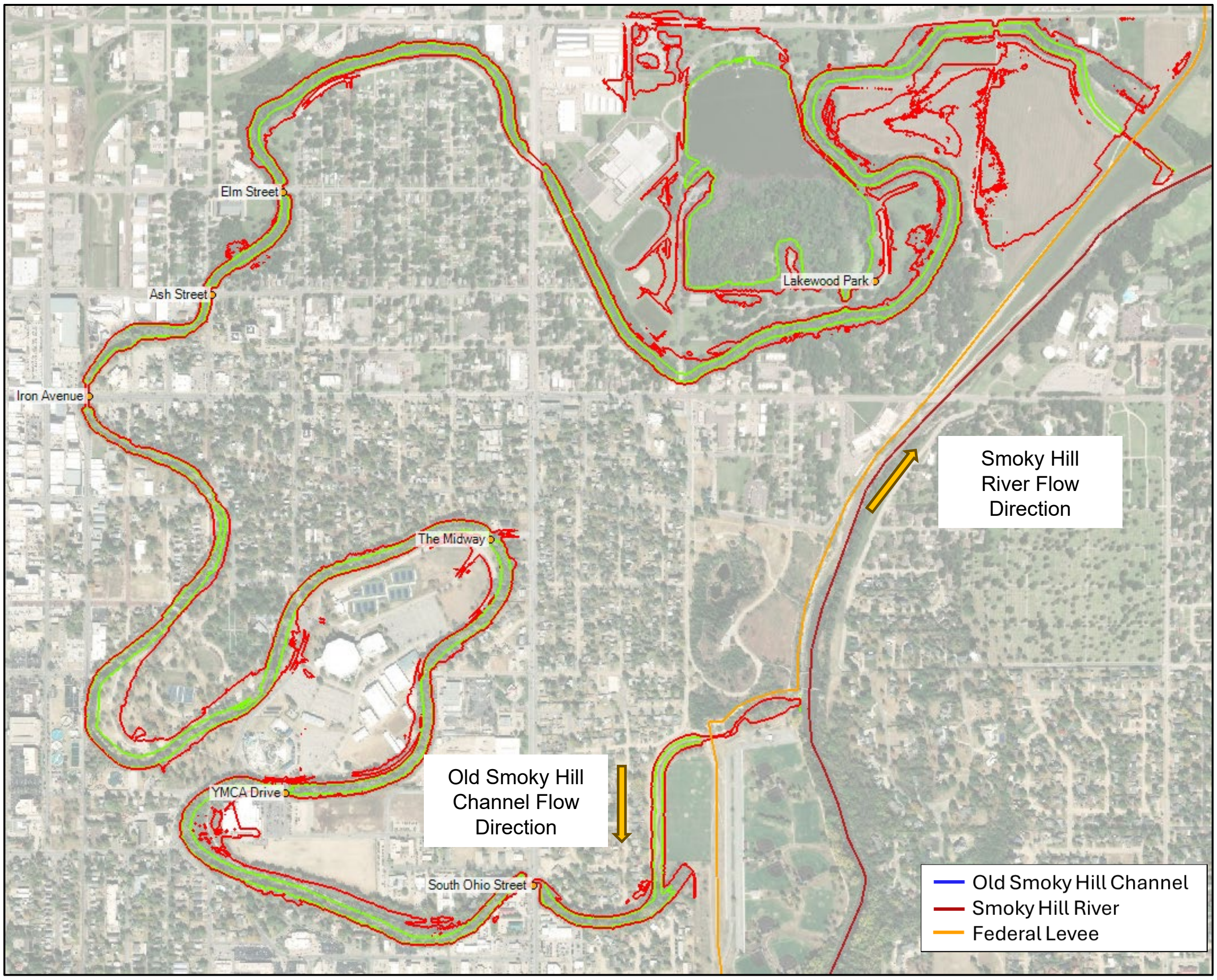


Figure 4.4. Refined FWP 99% AEP Extents (green) compared to Refined FWP 0.2% AEP Extents (red)

Table 4.1 through Table 4.7 present the flow-stage-frequency relationship. The variables presented are the maximum water surface and the flow at the time of the maximum water surface. This will assist in understanding the changes in stage and flow at the highest impact areas. The pink cross sections in Figure 3.1 show the locations where data was collected for flow-stage-frequency tables.

The 2% AEP flood frequency event is the first event where water begins to get out of bank. Table 3.3 shows the top of bank elevations at the locations defined in Figure 3.1.

Table 4.1. Refined Flow-Stage-Frequency at XS 34701 (Upstream of S Ohio St)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
0.2%	1224.4	1223.5	-260	-248
1%	1223.1	1222.0	-144	-96
2%	1222.2	1221.1	-231	-174
10%	1220.6	1219.5	-195	-140
20%	1219.9	1218.7	-172	-122
50%	1219.0	1217.8	-139	-98

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
99%	1218.6	1217.4	-120	-75

Table 4.2. Refined Flow-Stage-Frequency at XS 32300 (Downstream of S Ohio St)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
0.2%	1224.5	1223.5	-78	-58
1%	1223.2	1222.0	14	69
2%	1222.2	1221.1	-77	-13
10%	1220.7	1219.5	-80	-21
20%	1220.0	1218.8	-75	-23
50%	1219.2	1217.9	-52	-10
99%	1218.7	1217.4	-46	1

Table 4.3. Refined Flow-Stage-Frequency at XS 28200 (Downstream of YMCA Dr)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
0.2%	1223.9	1222.7	1459	1592
1%	1222.3	1221.2	1119	1205
2%	1221.6	1220.4	925	1006
10%	1220.1	1218.9	675	738
20%	1219.5	1218.2	558	607
50%	1218.7	1217.4	430	463
99%	1218.2	1216.9	373	402

Table 4.4. Refined Flow-Stage-Frequency at XS 16600 (At Western Star Mill Weir)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
0.2%	1218.5	1217.9	2202	2354
1%	1217.2	1215.6	2006	1950
2%	1216.8	1214.2	1734	1693
10%	1215.9	1211.7	1162	1116
20%	1215.5	1210.9	940	930
50%	1215.0	1210.4	687	680
99%	1214.7	1210.1	552	560

Table 4.5. Refined Flow-Stage-Frequency at XS 10000 (Downstream of N Ohio St)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
0.2%	1215.8	1215.6	1155	1068
1%	1214.1	1213.7	642	776
2%	1211.8	1211.6	598	697
10%	1209.7	1209.8	393	500
20%	1207.9	1207.9	446	490
50%	1206.7	1205.8	740	423
99%	1206.1	1205.5	591	396

Table 4.6. Refined Flow-Stage-Frequency at XS 2900 (Upstream of Walker Dr Culvert)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
0.2%	1215.7	1215.6	260	337
1%	1214.0	1213.6	654	787
2%	1211.7	1211.5	595	708
10%	1209.6	1209.7	401	511
20%	1207.6	1207.7	395	491
50%	1205.4	1205.4	324	390
99%	1205.0	1205.1	285	352

Table 4.7. Refined Flow-Stage-Frequency at XS 1500 (Downstream of Walker Dr Culvert)

Event (AEP)	FWOP Stage (ft)	FWP Stage (ft)	FWOP Flow (cfs)	FWP Flow (cfs)
0.2%	1214.8	1214.8	263	339
1%	1207.1	1209.1	658	792
2%	1205.9	1207.8	598	712
10%	1206.9	1207.8	404	515
20%	1205.1	1205.8	398	494
50%	1203.4	1204.1	327	393
99%	1203.5	1204.0	287	354

4.3 FWOP vs Refined FWP Water Surface Profile and Extents Comparison

This section presents induced impacts for assistance in creating the real estate takings analysis. Induced impacts are defined as changes caused by the FWP in comparison to the FWOP that relate to stage frequencies, flow frequencies, or duration.

4.3.1 Difference in 2% AEP Event Water Surface

Induced impacts for this project were estimated by comparing peak WSE between the FWOP and FWP conditions. Induced impacts occur when the impacts of the project cause the FWP WSE to be different than the FWOP WSE. See Figure 4.5 for a comparison of the profiles for FWOP (blue) and FWP (red) for the 2% AEP event along with the geometry profiles (pink for FWOP and black for FWP).

Figure 4.6 compares the WSE for FWOP and FWP for the 2% AEP event in units of feet of change. Red represents locations where the FWP WSE is more than 0.1 ft greater than the FWOP conditions. Blue represents where the FWOP WSE is more than 0.1 ft greater than the FWP conditions. Grey represents locations where the WSE is within 0.1 ft of each other.

The FWP WSE is a maximum of 1.9 ft higher than the FWOP WSE in the northern section of river surrounding Lakewood Lake. There are some locations in the southern section of river where the FWP WSE is higher than the FWOP WSE due to slight changes resulting from the channel excavation or new flow paths under bridges. Changes in model extents lead to the sedimentation basin showing completely as increased extents. With removal of the sedimentation basin area and other inaccurate terrain modification areas, the total induced impacts area is approximately 0.28 acres.

Figure 4.7 shows locations where there are differences in extents between FWOP and FWP for the 2% AEP event. Red represents locations where there are increases in stage from FWOP to FWP (FWP extents larger than FWOP extents). Blue represents locations where there are reductions in stage from FWOP to FWP (FWOP extents larger than FWP extents).

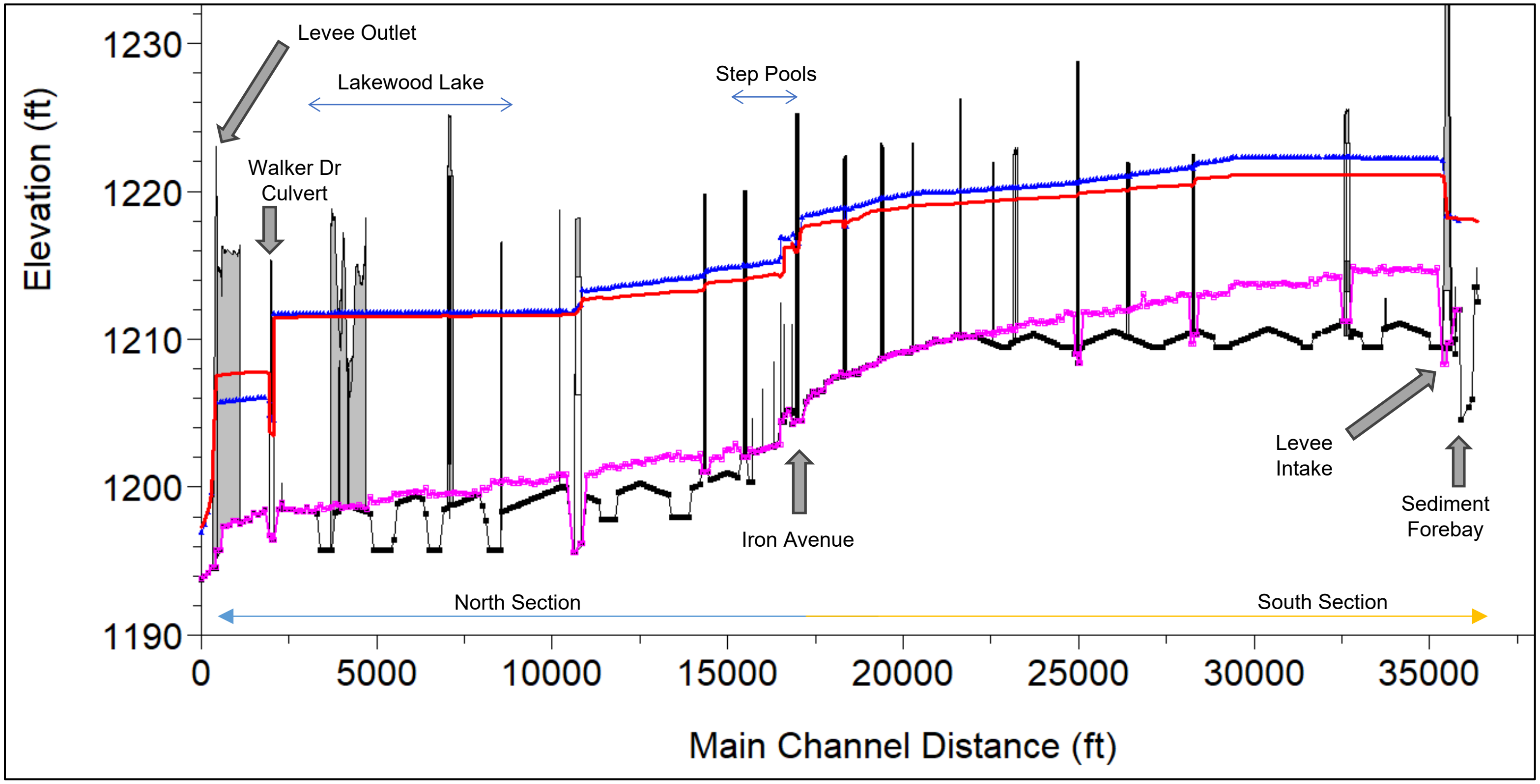


Figure 4.5. 2% AEP FWOP (blue) vs Refined FWP (red) profile comparison with the geometry profiles (pink for FWOP and black for FWP)

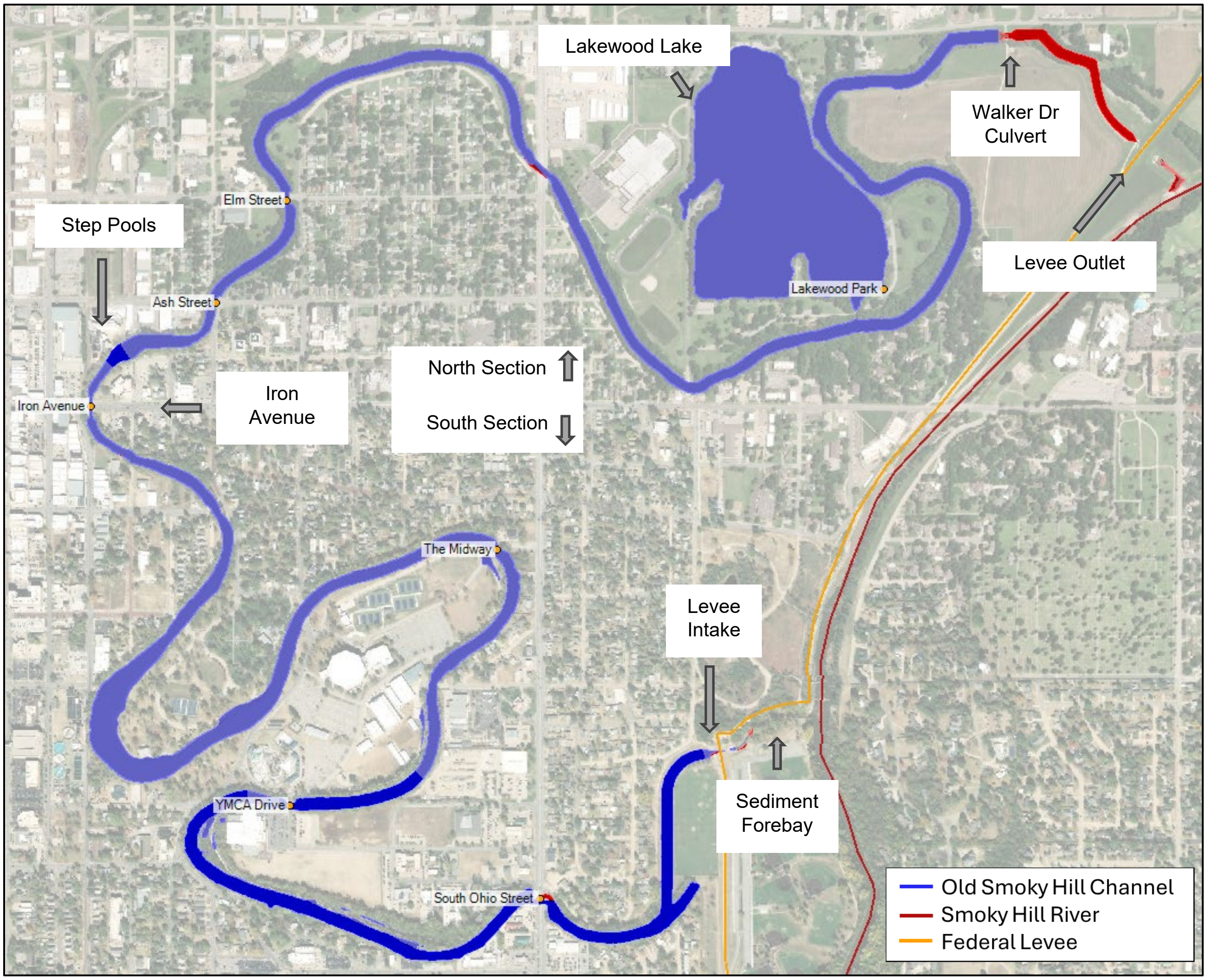


Figure 4.6. 2% AEP FWOP vs Refined FWP WSE Feet of Change Comparison

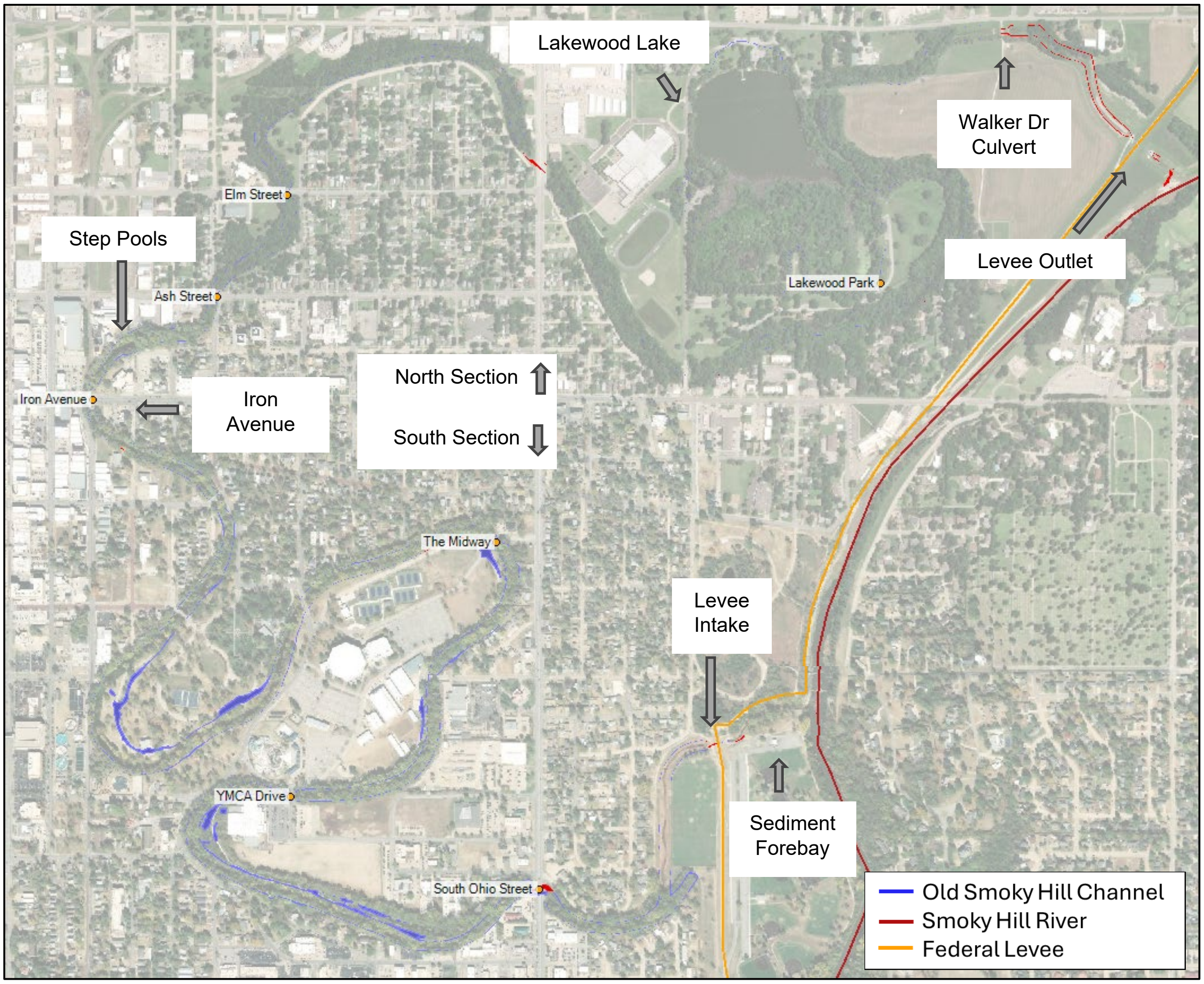


Figure 4.7. 2% AEP FWOP vs Refined FWP Impact Extents

4.3.2 Difference in 1% AEP Event Water Surface

Induced impacts for this project were estimated by comparing peak WSE between the FWOP and FWP conditions. Induced impacts occur when the impacts of the project cause the FWP WSE to be different than the FWOP WSE. See Figure 4.8 for a comparison of the profiles for FWOP (blue) and FWP (red) for the 1% AEP event along with the geometry profiles (pink for FWOP and black for FWP).

Figure 4.9 compares the WSE for FWOP and FWP for the 1% AEP event in units of feet of change. Red represents locations where the FWP WSE is more than 0.1 ft greater than the FWOP conditions. Blue represents where the FWOP WSE is more than 0.1 ft greater than the FWP conditions. Grey represents locations where the WSE is within 0.1 ft of each other.

The FWP WSE is a maximum of 2.0 ft higher than the FWOP WSE in the northern section of river surrounding Lakewood Lake. There are some locations in the southern section of river where the FWP WSE is higher than the FWOP WSE due to slight changes resulting from the channel excavation or new flow paths under bridges.

Changes in model extents lead to the sedimentation basin showing completely as increased extents. With removal of the sedimentation basin and other inaccurate terrain modification areas, the total induced impacts area is approximately 0.47 acres.

Figure 4.10 shows locations where there are differences in extents between FWOP and FWP for the 1% AEP event. Red represents locations where there are increases in stage from FWOP to FWP (FWP extents larger than FWOP extents). Blue represents locations where there are reductions in stage from FWOP to FWP (FWOP extents larger than FWP extents).

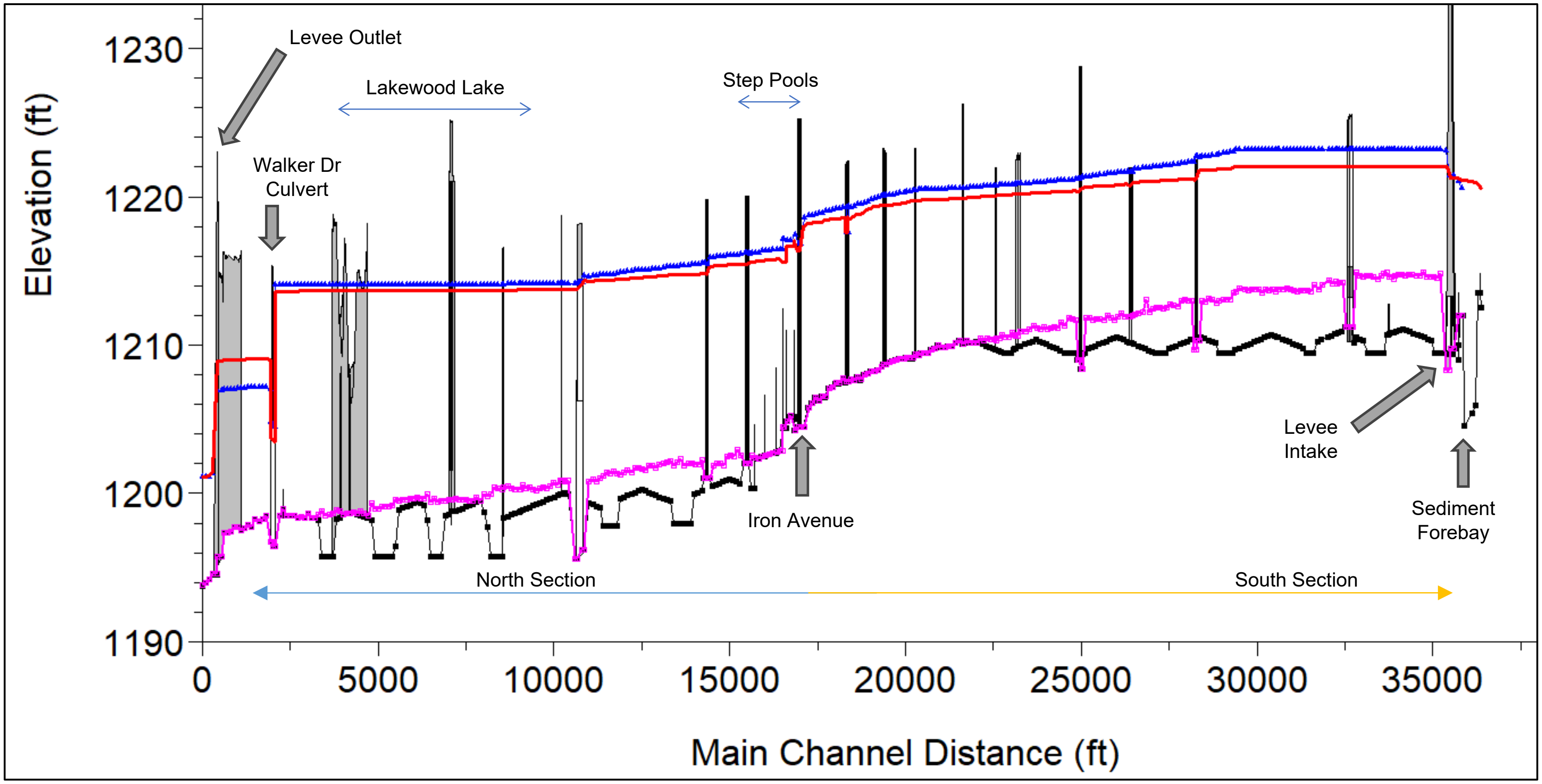


Figure 4.8. 1% AEP FWOP (blue) vs Refined FWP (red) profile comparison with the geometry profiles (pink for FWOP and black for FWP)

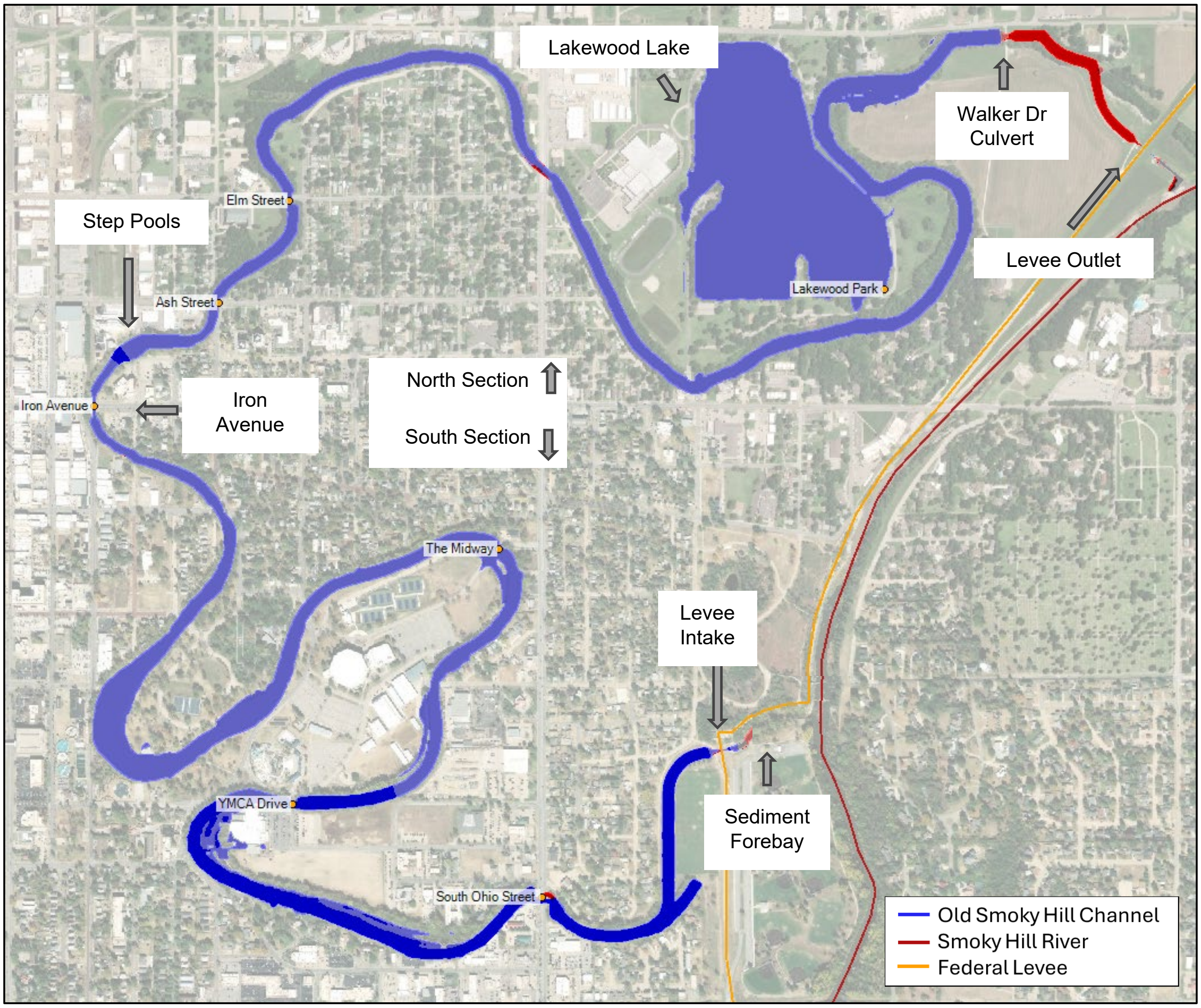


Figure 4.9. 1% AEP FWOP vs Refined FWP WSE Feet of Change Comparison

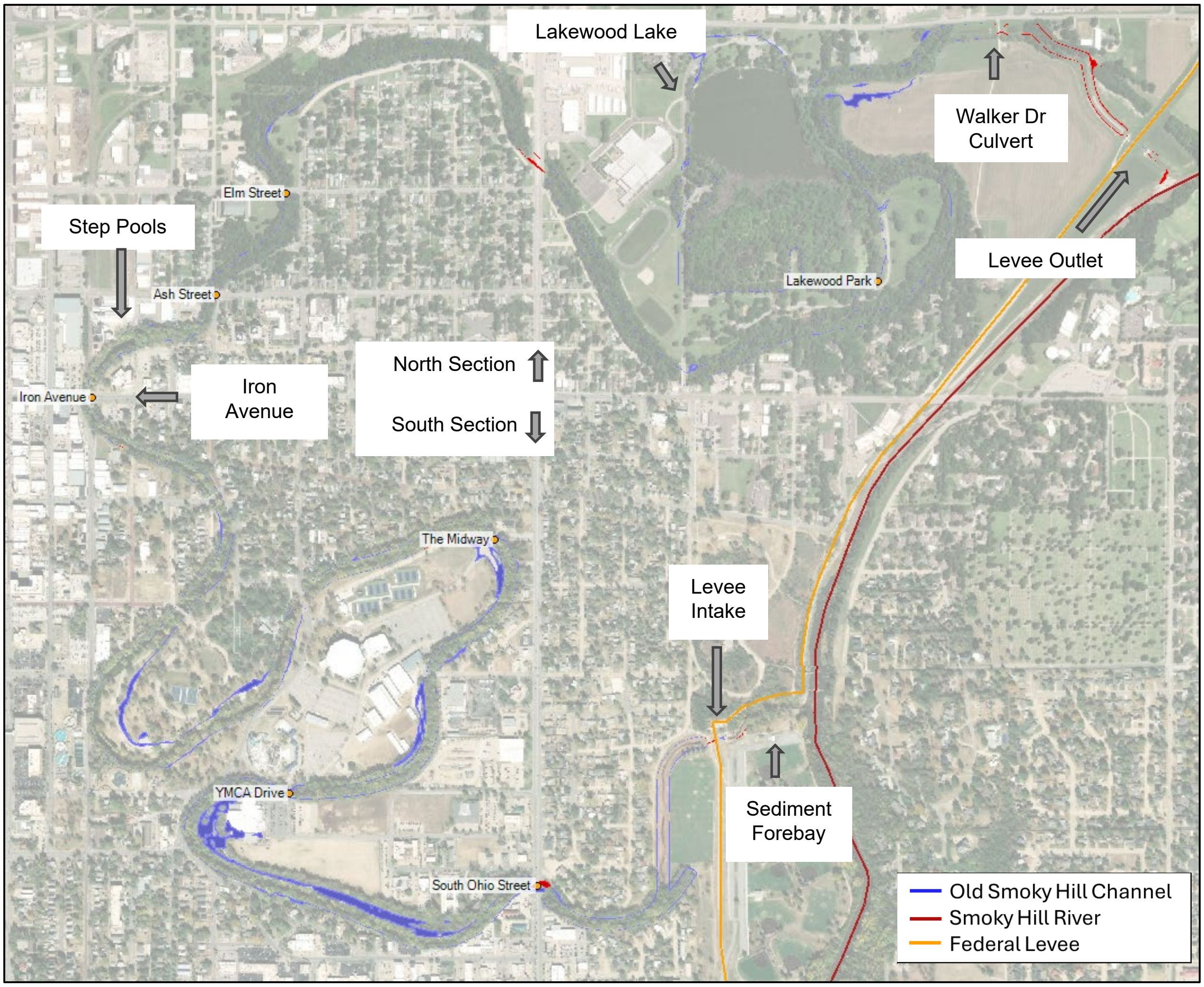


Figure 4.10. 1% AEP FWOP vs Refined FWP Impact Extents

4.3.3 Difference in 0.2% AEP Event Water Surface

Induced impacts for this project were estimated by comparing peak WSE between the FWOP and FWP conditions. Induced impacts occur when the impacts of the project cause the FWP WSE to be different than the FWOP WSE. See Figure 4.11 for a comparison of the profiles for FWOP (blue) and FWP (red) for the 0.2% AEP event along with the geometry profiles (pink for FWOP and black for FWP).

Figure 4.12compares the WSE for FWOP and FWP for the 0.2% AEP event in units of feet of change. Red represents locations where the FWP WSE is more than 0.1 ft greater than the FWOP conditions. Blue represents where the FWOP WSE is more than 0.1 ft greater than the FWP conditions. Grey represents locations where the WSE is within 0.1 ft of each other. The FWP WSE is a maximum of 0.0 ft higher than the FWOP WSE in the northern section of river. There are some locations in the southern section of river where the FWP WSE is higher than the FWOP WSE due to slight changes resulting from the channel excavation or new flow paths under bridges. Changes in model extents lead to the sedimentation basin showing completely as increased extents. With removal of the sedimentation basin area, the total induced impacts area is approximately 0 acres.

Figure 4.13 shows locations where there are differences in extents between FWOP and FWP for the 0.2% AEP event. Red represents locations where there are increases in stage from FWOP to FWP (FWP extents larger than FWOP extents). Blue represents locations where there are reductions in stage from FWOP to FWP (FWOP extents larger than FWP extents).

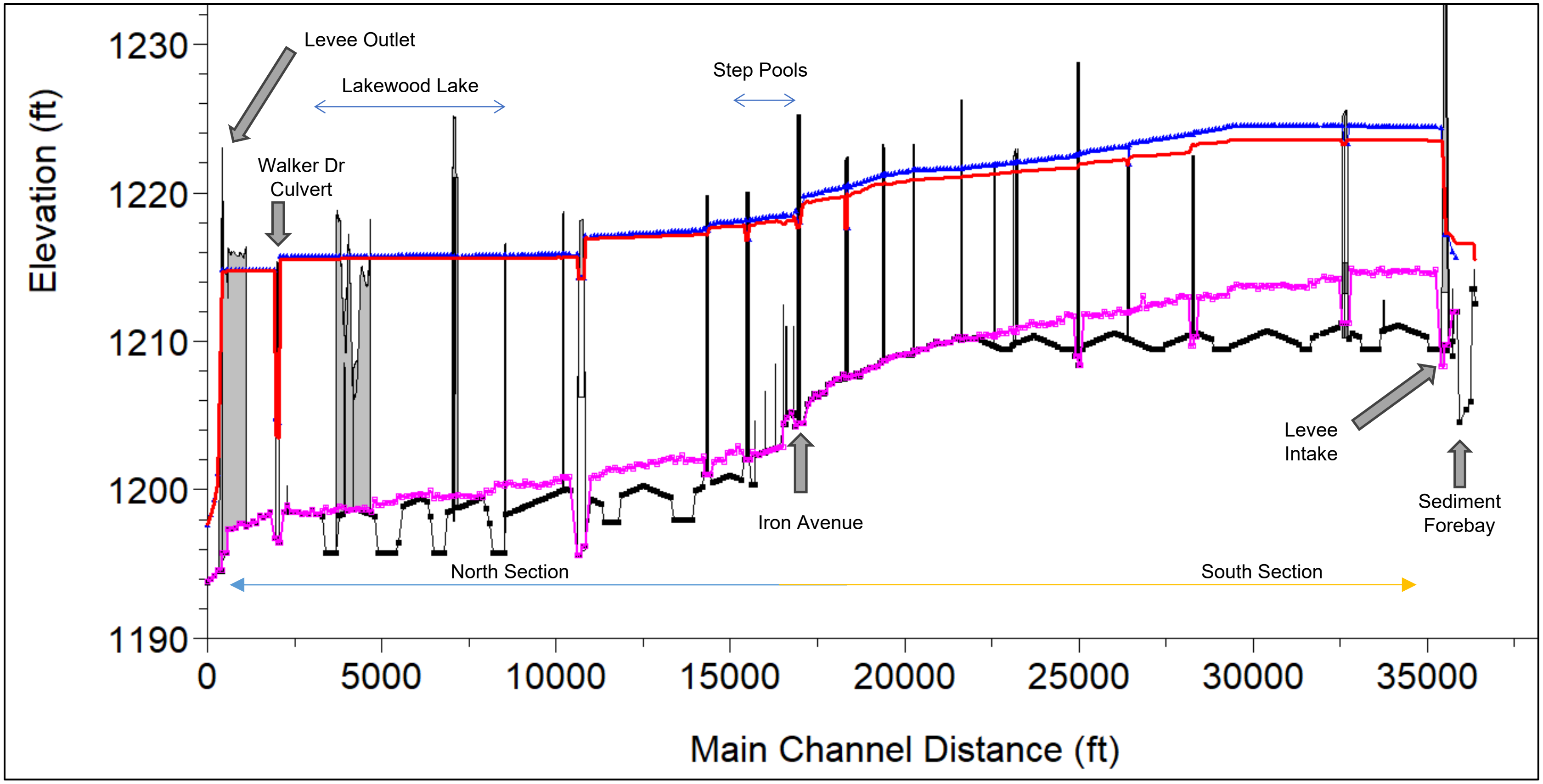


Figure 4.11. 0.2% AEP FWOP (blue) vs Refined FWP (red) profile comparison with the geometry profiles (pink for FWOP and black for FWP)

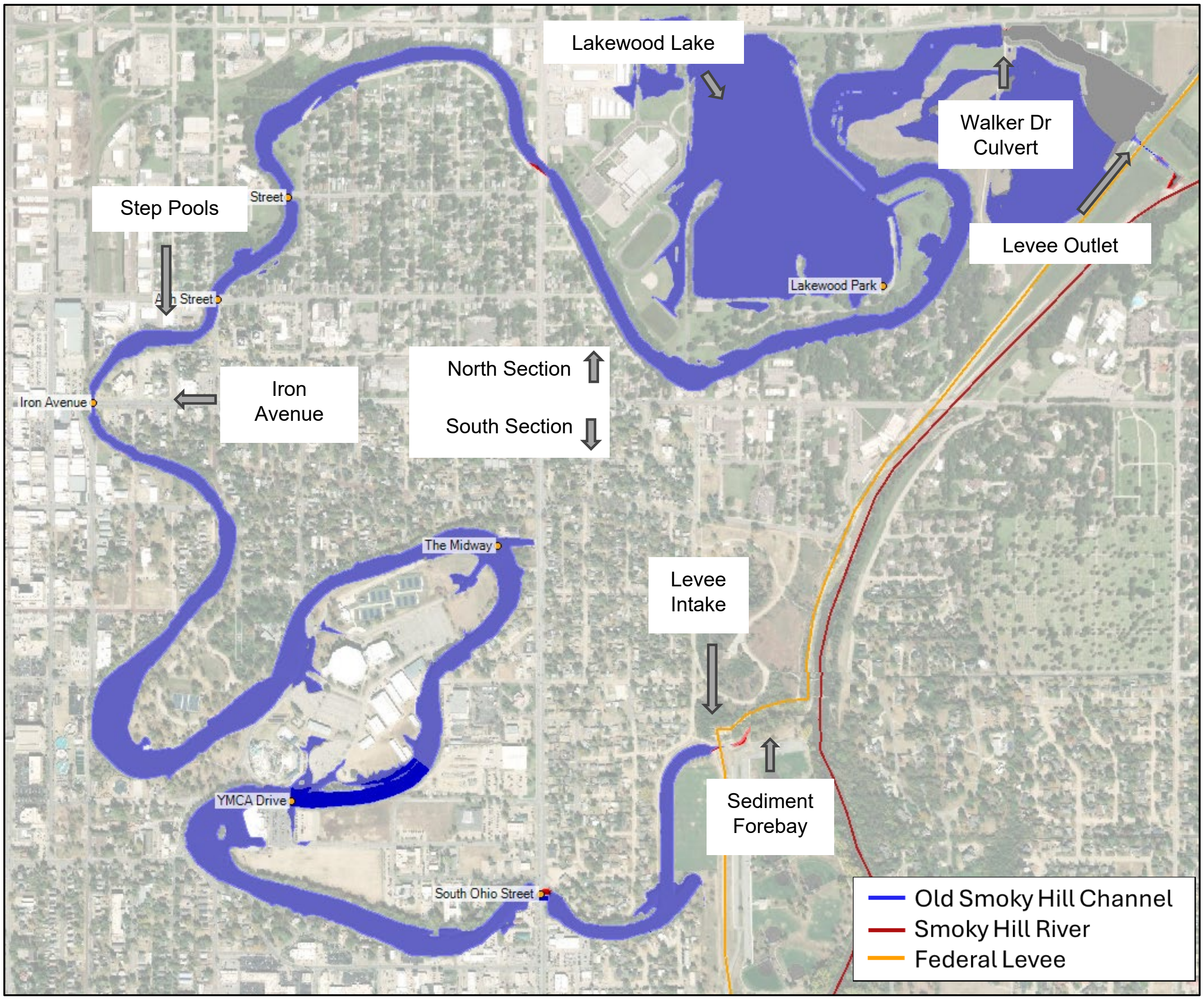


Figure 4.12. 0.2% AEP FWOP vs Refined FWP WSE Comparison

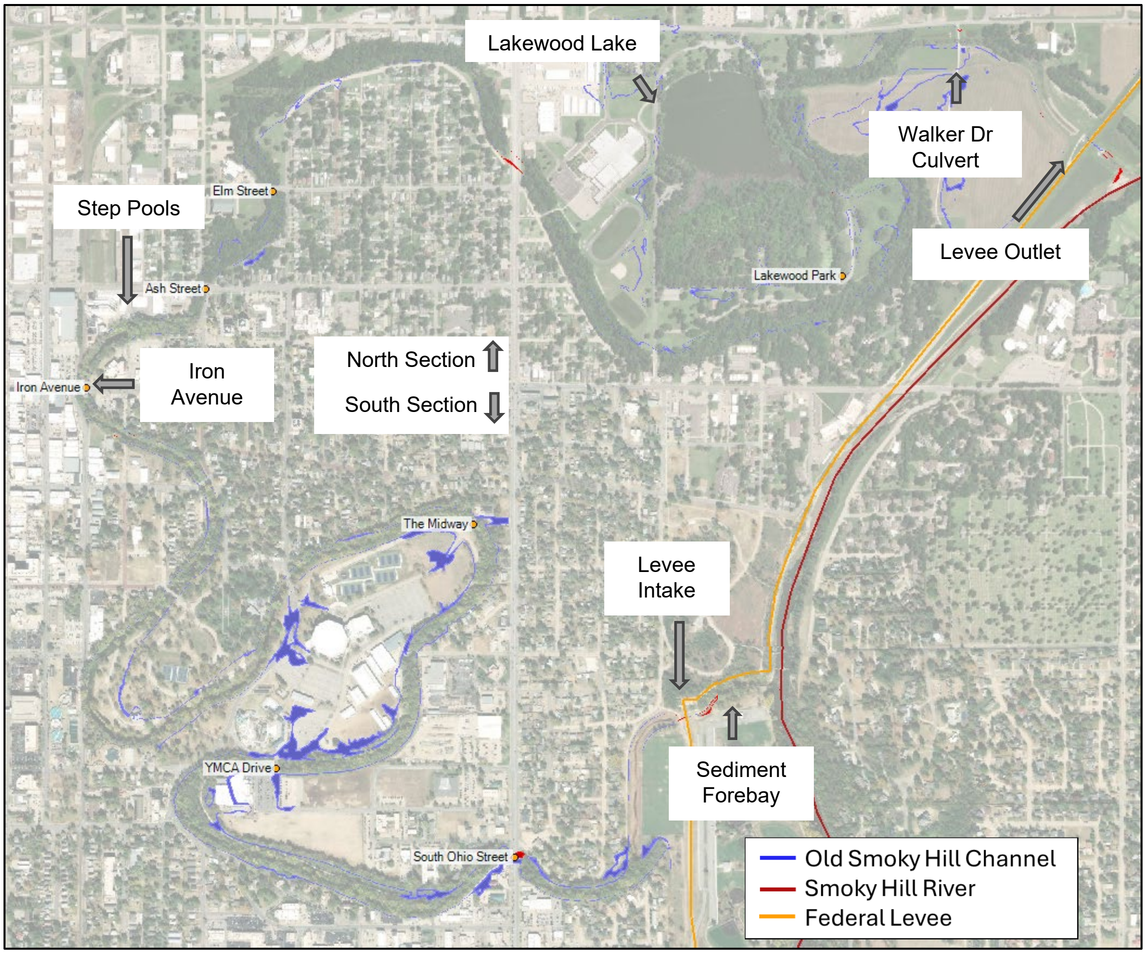


Figure 4.13. 0.2% AEP FWOP vs Refined FWP Impact Extents

5 Other Topics

5.1 Restored Channel Water Balance Infiltration

Appendix A Exhibit B – Resorted Water Channel Balance presents improved estimates of infiltration in the Old Smoky Hill Channel and provides recommendations to reduce infiltration rates.

It concludes that the majority of flow losses are due to infiltration when sandy high-permeability sediments are not sealed during channel construction and that the majority of infiltration losses are focused at seven of the thirty-one channel segments. It continues stating that if these seven segments were designed to have sandy materials replaced by clay, the total infiltration losses along the entire channel length are approximately 70 percent less (550 to 2,540 ac-ft per year) than those calculated without mitigation efforts (1,570 to 10,420 ac-ft per year).

There is uncertainty in the performance of the clay capping of high-permeability areas. Design of these clay caps will be a post-TSP refinement.

6 REFERENCE LIST

The following references were used in the development of this appendix.

USACE (1978) *Operational Drawings.* Flood Protection Project, Smoky Hill River, Salina, Kansas. U.S. Army Corps of Engineers, Kansas City District (NWK). Kansas City, MO. September 1978.

USACE (1958) *Design Memorandum No. 1.* Flood Protection Project, Smoky Hill River, Salina, Kansas. U.S. Army Corps of Engineers, Kansas City District (NWK). Kansas City, MO. February 1958.

HDR (2021) *Hydrology & Hydraulics Analysis Technical Report.* Section 1135 Smoky Hill River Aquatic Ecosystem Restoration Project, Salina, Kansas. HDR Inc. June 2021.

AMEC (2013) *Interior Drainage Analysis Report.* Salina Levee Project, Smoky Hill River, Salina, Kansas. AMEC. May 2013.

HDR (2018) *Restored Channel Water Balance Technical Memo.* Smoky Hill River Renewal Project, Smoky Hill River, Salina, Kansas. HDR Inc. March 2018.

HDR (2018) *Water Supply Alternatives Evaluation Technical Memo.* Smoky Hill River Renewal Project, Smoky Hill River, Salina, Kansas. HDR Inc. June 2018.

ATTACHMENT A1 - 2% TO 0.2% ORIGINAL FWOP & FWP PROFILE OUTPUT TABLES FOR MAXIMUM WATER SURFACE CONDITIONS

HEC-RAS Plan: 04-FWOP-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	35900	Max WS	0	1212.00	1218.0		1217.95	0.000000	0.00	106.35	24.44	0.00
OldSmokyHill_3	35800	Max WS	136	1212.00	1218.1		1218.17	0.000107	1.17	121.30	28.21	0.09
OldSmokyHill_3	35680	Max WS	72	1209.80	1218.3	1211.80	1218.31	0.000254	1.12	64.37	24.79	0.10
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-267	1208.30	1222.0		1222.17	0.000851	-3.17	84.21	87.86	0.17
OldSmokyHill_3	35300	Max WS	-267	1214.81	1222.2		1222.18	0.000033	-0.78	380.69	91.25	0.06
OldSmokyHill_3	35200	Max WS	-250	1214.50	1222.2		1222.19	0.000021	-0.69	416.36	91.25	0.05
OldSmokyHill_3	35100	Max WS	-250	1214.57	1222.2		1222.19	0.000020	-0.68	420.80	91.35	0.05
OldSmokyHill_3	35000	Max WS	-231	1214.56	1222.2		1222.19	0.000012	-0.52	479.95	93.88	0.04
OldSmokyHill_3	34900	Max WS	-231	1214.56	1222.2		1222.19	0.000013	-0.54	476.81	95.64	0.04
OldSmokyHill_3	34798	Max WS	-231	1214.94	1222.2		1222.19	0.000012	-0.53	483.21	98.20	0.04
OldSmokyHill_3	34701	Max WS	-231	1214.69	1222.2		1222.19	0.000013	-0.54	471.46	95.01	0.04
OldSmokyHill_3	34604	Max WS	-231	1214.67	1222.2		1222.20	0.000012	-0.53	485.41	97.97	0.04
OldSmokyHill_3	34499	Max WS	-231	1214.72	1222.2		1222.20	0.000012	-0.52	486.68	95.54	0.03
OldSmokyHill_3	34396	Max WS	-231	1214.72	1222.2		1222.20	0.000012	-0.51	490.84	98.64	0.03
OldSmokyHill_3	34306	Max WS	-231	1214.64	1222.2		1222.20	0.000011	-0.50	505.99	98.58	0.03
OldSmokyHill_3	34186	Max WS	-231	1214.72	1222.2		1222.20	0.000020	-0.70	486.74	181.29	0.05
OldSmokyHill_3	34100	Max WS	-231	1214.75	1222.2		1222.20	0.000021	-0.71	454.26	196.02	0.05
OldSmokyHill_3	34013	Max WS	-231	1214.69	1222.2		1222.21	0.000050	-0.96	591.75	214.10	0.06
OldSmokyHill_3	33965	Max WS	-231	1214.44	1222.2		1222.21	0.000030	-0.74	643.31	186.98	0.05
OldSmokyHill_3	33914	Max WS	-231	1214.62	1222.2		1222.21	0.000019	-0.58	762.66	151.58	0.04
OldSmokyHill_3	33833	Max WS	-216	1214.58	1222.2		1222.21	0.000028	-0.72	665.29	120.17	0.05
OldSmokyHill_3	33766	Max WS	-216	1214.90	1222.2		1222.21	0.000027	-0.69	646.76	109.91	0.05
OldSmokyHill_3	33673	Max WS	-216	1214.81	1222.2		1222.21	0.000030	-0.73	548.13	94.16	0.05
OldSmokyHill_3	33600	Max WS	-217	1214.66	1222.2		1222.22	0.000031	-0.76	494.39	83.30	0.05
OldSmokyHill_3	33500	Max WS	-216	1214.44	1222.2		1222.22	0.000026	-0.71	496.43	87.17	0.05
OldSmokyHill_3	33400	Max WS	-215	1214.59	1222.2		1222.22	0.000020	-0.62	514.64	87.34	0.04
OldSmokyHill_3	33300	Max WS	-208	1214.69	1222.2		1222.22	0.000025	-0.69	495.39	83.62	0.05
OldSmokyHill_3	33200	Max WS	-208	1214.66	1222.2		1222.23	0.000024	-0.67	514.84	86.36	0.04
OldSmokyHill_3	33100	Max WS	-208	1214.62	1222.2		1222.23	0.000032	-0.79	446.96	77.42	0.05
OldSmokyHill_3	33000	Max WS	-208	1214.66	1222.2		1222.23	0.000022	-0.63	488.50	84.10	0.04
OldSmokyHill_3	32900	Max WS	-208	1214.88	1222.2		1222.23	0.000022	-0.64	569.39	105.73	0.04
OldSmokyHill_3	32815	Max WS	-88	1211.25	1222.2		1222.24	0.000006	-0.38	320.89	89.68	0.02
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-89	1211.25	1222.2		1222.25	0.000002	-0.15	500.39	114.06	0.01
OldSmokyHill_3	32500	Max WS	-89	1214.22	1222.2		1222.25	0.000004	-0.28	518.36	87.34	0.02
OldSmokyHill_3	32400	Max WS	-76	1214.22	1222.2		1222.25	0.000003	-0.23	548.73	86.19	0.02
OldSmokyHill_3	32338	Max WS	-76	1214.16	1222.2		1222.25	0.000003	-0.26	496.51	80.57	0.02
OldSmokyHill_3	32300	Max WS	-76	1214.28	1222.2		1222.25	0.000003	-0.25	502.02	82.76	0.02
OldSmokyHill_3	32200	Max WS	-77	1214.11	1222.2		1222.25	0.000003	-0.23	562.81	90.63	0.01
OldSmokyHill_3	32100	Max WS	-76	1214.35	1222.2		1222.25	0.000002	-0.22	526.53	85.41	0.01
OldSmokyHill_3	31900	Max WS	-76	1214.09	1222.2		1222.25	0.000003	-0.26	450.97	73.82	0.02
OldSmokyHill_3	31800	Max WS	-43	1213.78	1222.2		1222.25	0.000001	-0.18	463.07	77.04	0.01
OldSmokyHill_3	31700	Max WS	-40	1214.09	1222.2		1222.25	0.000001	-0.17	379.51	62.12	0.01
OldSmokyHill_3	31600	Max WS	-26	1213.59	1222.2		1222.25	0.000000	-0.10	390.36	95.28	0.01
OldSmokyHill_3	31500	Max WS	-26	1213.69	1222.2		1222.25	0.000000	-0.08	503.45	137.07	0.01
OldSmokyHill_3	31400	Max WS	-26	1213.66	1222.2		1222.25	0.000000	-0.07	627.11	151.00	0.00
OldSmokyHill_3	31300	Max WS	-26	1213.67	1222.2		1222.25	0.000000	-0.09	621.13	128.52	0.01
OldSmokyHill_3	31200	Max WS	-26	1213.62	1222.2		1222.25	0.000000	-0.07	615.53	122.64	0.00
OldSmokyHill_3	31100	Max WS	-24	1213.66	1222.2		1222.25	0.000000	-0.07	593.08	133.41	0.00
OldSmokyHill_3	31000	Max WS	-19	1213.78	1222.2		1222.25	0.000000	-0.06	591.46	150.26	0.00
OldSmokyHill_3	30900	Max WS	-19	1213.84	1222.2		1222.25	0.000000	-0.06	610.77	146.21	0.00
OldSmokyHill_3	30800	Max WS	-19	1213.72	1222.2		1222.25	0.000000	-0.06	615.60	155.62	0.00
OldSmokyHill_3	30700	Max WS	-19	1213.73	1222.2		1222.25	0.000000	-0.05	585.10	96.46	0.00
OldSmokyHill_3	30651	Max WS	-19	1213.76	1222.2		1222.25	0.000000	-0.05	622.42	116.90	0.00
OldSmokyHill_3	30575	Max WS	-19	1213.62	1222.2		1222.25	0.000000	-0.05	634.49	134.87	0.00
OldSmokyHill_3	30500	Max WS	-19	1213.78	1222.2		1222.25	0.000000	-0.05	672.77	128.62	0.00
OldSmokyHill_3	30400	Max WS	-20	1213.70	1222.2		1222.25	0.000000	-0.05	637.92	114.86	0.00
OldSmokyHill_3	30300	Max WS	-20	1213.72	1222.2		1222.25	0.000000	-0.05	625.69	94.71	0.00
OldSmokyHill_3	30200	Max WS	-20	1213.56	1222.2		1222.25	0.000000	-0.05	675.16	132.49	0.00
OldSmokyHill_3	30100	Max WS	-20	1213.75	1222.2		1222.25	0.000000	-0.05	636.64	104.89	0.00
OldSmokyHill_3	29999	Max WS	-19	1213.79	1222.2		1222.25	0.000000	-0.05	656.92	125.27	0.00
OldSmokyHill_3	29899	Max WS	-20	1213.74	1222.2		1222.25	0.000000	-0.05	653.26	118.85	0.00
OldSmokyHill_3	29800	Max WS	-15	1213.69	1222.2		1222.25	0.000000	-0.03	701.29	146.07	0.00
OldSmokyHill_3	29704	Max WS	-15	1213.72	1222.2		1222.25	0.000000	-0.05	657.14	111.09	0.00
OldSmokyHill_3	29572	Max WS	-15	1213.81	1222.2		1222.25	0.000000	-0.04	627.89	149.11	0.00
OldSmokyHill_3	29466	Max WS	-14	1213.59	1222.2		1222.25	0.000000	-0.03	675.32	138.04	0.00
OldSmokyHill_3	29385	Max WS	908	1213.50	1222.2		1222.22	0.000224	2.21	658.73	123.47	0.14
OldSmokyHill_3	29314	Max WS	909	1213.03	1222.1		1222.21	0.000354	2.90	598.67	170.38	0.17
OldSmokyHill_3	29209	Max WS	909	1213.06	1222.1		1222.17	0.000391	2.91	555.16	135.93	0.18
OldSmokyHill_3	29100	Max WS	909	1213.03	1222.1		1222.13	0.000314	2.66	608.02	205.70	0.16
OldSmokyHill_3	28991	Max WS	909	1213.00	1222.0		1222.10	0.000323	2.77	588.61	126.51	0.17
OldSmokyHill_3	28900	Max WS	908	1212.85	1222.0		1222.07	0.000395	3.09	582.28	104.28	0.19
OldSmokyHill_3	28800	Max WS	909	1213.03	1221.9		1222.03	0.000350	2.89	576.56	90.99	0.17
OldSmokyHill_3	28700	Max WS	907	1213.12	1221.9		1222.00	0.000446	3.22	578.20	111.37	0.20
OldSmokyHill_3	28594	Max WS	907	1212.92	1221.9		1221.95	0.000290	2.59	582.27	88.69	0.16
OldSmokyHill_3	28500	Max WS	907	1213.01	1221.8		1221.92	0.000271	2.50	630.62	90.51	0.15
OldSmokyHill_3	28430	Max WS	928	1210.34	1221.8	1214.69	1221.89	0.000299	2.38	528.92	85.10	0.14

HEC-RAS Plan: 04-FWOP-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	925	1209.69	1221.6		1221.64	0.000246	2.48	629.59	93.39	0.14
OldSmokyHill_3	28200	Max WS	925	1212.97	1221.6		1221.62	0.000221	2.19	617.81	91.39	0.14
OldSmokyHill_3	28100	Max WS	930	1212.97	1221.5		1221.60	0.000295	2.54	637.84	104.79	0.16
OldSmokyHill_3	28000	Max WS	929	1213.03	1221.5		1221.57	0.000313	2.69	632.60	92.86	0.16
OldSmokyHill_3	27900	Max WS	928	1213.00	1221.5		1221.54	0.000323	2.69	610.53	89.70	0.17
OldSmokyHill_3	27800	Max WS	927	1212.59	1221.4		1221.50	0.000274	2.53	596.88	85.66	0.15
OldSmokyHill_3	27700	Max WS	926	1212.69	1221.4		1221.47	0.000225	2.27	610.71	91.77	0.14
OldSmokyHill_3	27600	Max WS	926	1212.75	1221.4		1221.45	0.000308	2.64	579.18	87.30	0.16
OldSmokyHill_3	27500	Max WS	935	1212.53	1221.4		1221.42	0.000239	2.31	616.25	90.73	0.14
OldSmokyHill_3	27400	Max WS	935	1212.45	1221.3		1221.39	0.000256	2.40	630.10	89.24	0.15
OldSmokyHill_3	27300	Max WS	934	1212.53	1221.3		1221.37	0.000263	2.47	632.20	95.58	0.15
OldSmokyHill_3	27200	Max WS	933	1212.53	1221.3		1221.34	0.000240	2.40	606.27	91.57	0.14
OldSmokyHill_3	27100	Max WS	938	1212.45	1221.2		1221.32	0.000246	2.41	603.52	106.21	0.15
OldSmokyHill_3	27000	Max WS	936	1212.19	1221.2		1221.30	0.000318	2.76	605.10	116.28	0.17
OldSmokyHill_3	26900	Max WS	936	1213.09	1221.2		1221.26	0.000269	2.39	631.96	120.69	0.15
OldSmokyHill_3	26800	Max WS	934	1212.22	1221.2		1221.23	0.000242	2.32	654.40	127.66	0.14
OldSmokyHill_3	26700	Max WS	938	1212.12	1221.1		1221.21	0.000250	2.41	590.52	120.32	0.15
OldSmokyHill_3	26600	Max WS	935	1212.06	1221.1		1221.19	0.000311	2.71	565.57	85.37	0.16
OldSmokyHill_3	26522	Max WS	929	1211.97	1221.0	1216.08	1221.18	0.000641	3.90	355.30	66.58	0.23
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	924	1211.94	1220.9		1221.12	0.000549	3.62	358.46	69.85	0.22
OldSmokyHill_3	26400	Max WS	927	1211.88	1221.0		1221.06	0.000239	2.36	628.17	93.55	0.14
OldSmokyHill_3	26300	Max WS	933	1211.94	1221.0		1221.04	0.000282	2.54	616.67	93.82	0.15
OldSmokyHill_3	26200	Max WS	933	1212.17	1220.9		1221.01	0.000355	2.82	648.56	119.57	0.17
OldSmokyHill_3	26100	Max WS	935	1211.88	1220.9		1220.96	0.000201	2.16	645.17	98.21	0.13
OldSmokyHill_3	26000	Max WS	934	1211.71	1220.9		1220.95	0.000203	2.15	630.47	90.72	0.13
OldSmokyHill_3	25900	Max WS	930	1211.87	1220.9		1220.93	0.000283	2.57	632.13	91.85	0.16
OldSmokyHill_3	25800	Max WS	929	1212.01	1220.8		1220.90	0.000188	2.07	669.76	107.00	0.13
OldSmokyHill_3	25700	Max WS	930	1211.72	1220.8		1220.88	0.000284	2.56	601.56	88.07	0.16
OldSmokyHill_3	25600	Max WS	925	1211.75	1220.8		1220.85	0.000205	2.20	641.34	89.27	0.13
OldSmokyHill_3	25500	Max WS	964	1211.75	1220.8		1220.82	0.000229	2.33	663.93	97.57	0.14
OldSmokyHill_3	25400	Max WS	965	1211.72	1220.7		1220.80	0.000233	2.32	654.34	108.14	0.14
OldSmokyHill_3	25300	Max WS	963	1211.87	1220.7		1220.78	0.000378	2.95	587.14	145.50	0.18
OldSmokyHill_3	25200	Max WS	957	1211.81	1220.7		1220.74	0.000312	2.68	588.51	127.97	0.16
OldSmokyHill_3	25117	Max WS	958	1208.41	1220.7	1212.73	1220.69	0.000489	1.59	738.06	144.75	0.08
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	942	1208.97	1220.5		1220.59	0.000194	2.30	529.00	100.97	0.13
OldSmokyHill_3	24900	Max WS	939	1211.71	1220.5		1220.58	0.000196	2.35	646.63	103.05	0.15
OldSmokyHill_3	24800	Max WS	933	1211.78	1220.5		1220.56	0.000259	2.79	588.48	91.04	0.17
OldSmokyHill_3	24700	Max WS	938	1211.84	1220.5		1220.53	0.000185	2.32	648.41	93.89	0.14
OldSmokyHill_3	24600	Max WS	938	1211.34	1220.5		1220.51	0.000153	2.16	688.11	99.86	0.13
OldSmokyHill_3	24500	Max WS	934	1211.53	1220.4		1220.49	0.000175	2.25	618.48	92.88	0.14
OldSmokyHill_3	24400	Max WS	934	1211.13	1220.4		1220.47	0.000152	2.15	642.78	88.89	0.13
OldSmokyHill_3	24300	Max WS	931	1211.19	1220.4		1220.46	0.000154	2.17	636.62	88.85	0.13
OldSmokyHill_3	24200	Max WS	924	1211.13	1220.4		1220.44	0.000193	2.50	636.35	91.14	0.15
OldSmokyHill_3	24100	Max WS	924	1211.08	1220.4		1220.42	0.000193	2.45	601.42	86.29	0.15
OldSmokyHill_3	24000	Max WS	922	1211.22	1220.3		1220.40	0.000186	2.44	639.43	92.60	0.15
OldSmokyHill_3	23900	Max WS	914	1211.08	1220.3		1220.38	0.000185	2.44	649.58	95.10	0.15
OldSmokyHill_3	23800	Max WS	930	1211.12	1220.3		1220.36	0.000183	2.44	638.89	111.16	0.15
OldSmokyHill_3	23700	Max WS	930	1211.28	1220.3		1220.34	0.000145	2.13	630.64	95.25	0.13
OldSmokyHill_3	23600	Max WS	926	1211.06	1220.3		1220.32	0.000160	2.26	637.14	90.70	0.14
OldSmokyHill_3	23500	Max WS	926	1210.94	1220.3		1220.31	0.000162	2.28	662.37	93.29	0.14
OldSmokyHill_3	23362	Max WS	924	1210.95	1220.2	1214.17	1220.28	0.000156	2.23	675.83	100.12	0.13
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	924	1210.60	1220.2		1220.25	0.000118	1.96	680.25	95.30	0.12
OldSmokyHill_3	23167	Max WS	920	1210.66	1220.2		1220.24	0.000143	2.16	668.34	100.28	0.13
OldSmokyHill_3	23100	Max WS	927	1210.81	1220.2		1220.23	0.000168	2.35	698.49	109.43	0.14
OldSmokyHill_3	23000	Max WS	922	1210.50	1220.2		1220.22	0.000115	1.95	711.64	110.66	0.12
OldSmokyHill_3	22900	Max WS	927	1210.56	1220.2		1220.20	0.000107	1.88	780.23	121.79	0.11
OldSmokyHill_3	22800	Max WS	932	1210.71	1220.1		1220.19	0.000113	1.93	752.46	117.19	0.11
OldSmokyHill_3	22731	Max WS	932	1210.47	1220.1		1220.18	0.000127	2.05	747.04	119.62	0.12
OldSmokyHill_3	22656	Max WS	927	1210.44	1220.1	1213.82	1220.18	0.000153	2.28	684.43	105.51	0.13
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	927	1210.34	1220.1		1220.17	0.000155	2.28	676.06	108.83	0.13
OldSmokyHill_3	22578	Max WS	927	1210.41	1220.1		1220.16	0.000132	2.12	719.95	120.26	0.12
OldSmokyHill_3	22500	Max WS	926	1210.38	1220.1		1220.14	0.000141	2.21	705.92	131.50	0.13
OldSmokyHill_3	22400	Max WS	915	1210.44	1220.1		1220.13	0.000190	2.54	661.16	166.40	0.15
OldSmokyHill_3	22300	Max WS	915	1210.31	1220.1		1220.11	0.000186	2.57	711.54	185.92	0.15
OldSmokyHill_3	22200	Max WS	912	1210.44	1220.0		1220.09	0.000153	2.27	798.24	214.83	0.13
OldSmokyHill_3	22100	Max WS	911	1210.16	1220.0		1220.07	0.000131	2.16	806.42	206.23	0.12
OldSmokyHill_3	22000	Max WS	908	1210.12	1220.0		1220.06	0.000139	2.23	739.22	169.41	0.13
OldSmokyHill_3	21900	Max WS	902	1210.13	1220.0		1220.04	0.000127	2.10	667.36	112.80	0.12
OldSmokyHill_3	21799	Max WS	894	1210.28	1220.0		1220.03	0.000160	2.37	655.58	122.83	0.14
OldSmokyHill_3	21722	Max WS	887	1210.11	1219.9	1213.66	1220.02	0.000204	2.71	609.76	124.65	0.15
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	894	1210.11	1219.9		1220.01	0.000210	2.76	609.90	122.68	0.16
OldSmokyHill_3	21600	Max WS	887	1210.31	1219.9		1219.98	0.000176	2.46	691.26	131.69	0.14

HEC-RAS Plan: 04-FWOP-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	21500	Max WS	892	1210.14	1219.9		1219.96	0.000107	1.93	815.62	174.48	0.11
OldSmokyHill_3	21400	Max WS	894	1209.94	1219.9		1219.95	0.000068	1.52	913.35	223.16	0.09
OldSmokyHill_3	21296	Max WS	894	1209.94	1219.9		1219.94	0.000071	1.58	889.42	198.64	0.09
OldSmokyHill_3	21200	Max WS	894	1209.81	1219.9		1219.93	0.000082	1.69	921.25	196.69	0.10
OldSmokyHill_3	21100	Max WS	885	1209.84	1219.9		1219.92	0.000063	1.47	929.54	230.00	0.09
OldSmokyHill_3	20995	Max WS	885	1210.03	1219.9		1219.91	0.000076	1.63	896.96	191.32	0.09
OldSmokyHill_3	20900	Max WS	875	1209.75	1219.9		1219.91	0.000086	1.74	861.76	210.12	0.10
OldSmokyHill_3	20800	Max WS	881	1209.72	1219.9		1219.89	0.000060	1.44	958.60	236.13	0.08
OldSmokyHill_3	20700	Max WS	871	1209.45	1219.9		1219.89	0.000073	1.62	961.08	234.70	0.09
OldSmokyHill_3	20644	Max WS	871	1209.47	1219.9		1219.88	0.000057	1.39	929.62	230.33	0.08
OldSmokyHill_3	20600	Max WS	871	1209.50	1219.9		1219.88	0.000057	1.40	990.53	247.77	0.08
OldSmokyHill_3	20500	Max WS	871	1209.50	1219.8		1219.87	0.000083	1.71	848.95	244.56	0.10
OldSmokyHill_3	20434	Max WS	859	1209.31	1219.8		1219.87	0.000090	1.79	865.47	269.88	0.10
OldSmokyHill_3	20363	Max WS	847	1209.38	1219.8	1212.87	1219.88	0.000154	2.37	624.60	278.18	0.13
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	847	1209.41	1219.8		1219.86	0.000129	2.17	686.03	274.58	0.12
OldSmokyHill_3	20300	Max WS	859	1209.12	1219.8		1219.84	0.000037	1.19	1069.61	254.27	0.07
OldSmokyHill_3	20190	Max WS	1516	1209.13	1219.7		1219.81	0.000264	3.06	935.03	215.22	0.18
OldSmokyHill_3	20100	Max WS	1524	1209.16	1219.7		1219.80	0.000349	3.58	816.85	186.35	0.20
OldSmokyHill_3	20023	Max WS	1529	1209.08	1219.7		1219.77	0.000338	3.60	779.76	168.31	0.20
OldSmokyHill_3	19900	Max WS	1529	1209.08	1219.6		1219.72	0.000258	3.14	813.07	143.20	0.18
OldSmokyHill_3	19800	Max WS	1529	1208.97	1219.6		1219.70	0.000270	3.21	745.25	131.27	0.18
OldSmokyHill_3	19700	Max WS	1529	1208.94	1219.5		1219.68	0.000315	3.48	637.50	98.43	0.19
OldSmokyHill_3	19600	Max WS	1529	1208.88	1219.5		1219.65	0.000335	3.65	701.38	99.59	0.20
OldSmokyHill_3	19510	Max WS	1528	1208.73	1219.5	1212.74	1219.61	0.000217	2.96	796.05	103.09	0.16
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1528	1208.72	1219.5		1219.57	0.000272	3.29	842.67	106.21	0.18
OldSmokyHill_3	19400	Max WS	1528	1208.54	1219.4		1219.58	0.000450	4.30	766.52	111.17	0.23
OldSmokyHill_3	19300	Max WS	1557	1208.31	1219.4		1219.54	0.000456	4.30	715.10	116.83	0.23
OldSmokyHill_3	19200	Max WS	1557	1208.24	1219.3		1219.50	0.000482	4.42	687.11	119.18	0.24
OldSmokyHill_3	19100	Max WS	1555	1208.22	1219.2		1219.46	0.000536	4.57	644.95	128.26	0.25
OldSmokyHill_3	19000	Max WS	1555	1208.09	1219.1		1219.43	0.000704	5.25	555.18	103.24	0.29
OldSmokyHill_3	18900	Max WS	1553	1208.03	1219.0		1219.35	0.000661	4.87	468.86	90.37	0.27
OldSmokyHill_3	18800	Max WS	1551	1207.68	1218.9		1219.28	0.000639	4.83	427.46	76.45	0.27
OldSmokyHill_3	18700	Max WS	1559	1207.84	1218.9		1219.20	0.000465	4.16	467.58	86.95	0.23
OldSmokyHill_3	18600	Max WS	1565	1207.62	1218.8		1219.18	0.000687	5.12	459.15	100.02	0.28
OldSmokyHill_3	18500	Max WS	1563	1207.72	1218.7		1219.10	0.000668	4.92	396.56	55.75	0.28
OldSmokyHill_3	18438	Max WS	1563	1207.54	1218.8	1212.83	1219.04	0.000437	4.20	610.13	86.15	0.23
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1563	1207.53	1218.8		1219.01	0.000401	4.09	653.62	88.37	0.22
OldSmokyHill_3	18300	Max WS	1562	1207.75	1218.8		1218.97	0.000437	4.23	673.03	87.12	0.23
OldSmokyHill_3	18200	Max WS	1565	1207.44	1218.7		1218.92	0.000390	4.02	664.23	86.51	0.22
OldSmokyHill_3	18100	Max WS	1562	1207.44	1218.7		1218.88	0.000398	4.11	722.36	94.76	0.22
OldSmokyHill_3	18000	Max WS	1562	1207.16	1218.7		1218.85	0.000453	4.44	686.97	88.15	0.24
OldSmokyHill_3	17900	Max WS	1562	1207.12	1218.6		1218.79	0.000323	3.71	664.29	88.66	0.20
OldSmokyHill_3	17800	Max WS	1561	1206.53	1218.6		1218.77	0.000406	4.33	700.07	80.57	0.22
OldSmokyHill_3	17700	Max WS	1554	1206.54	1218.5		1218.75	0.000528	4.88	527.49	63.96	0.25
OldSmokyHill_3	17600	Max WS	1643	1206.25	1218.4		1218.67	0.000417	4.37	635.87	78.69	0.23
OldSmokyHill_3	17500	Max WS	1643	1206.45	1218.4		1218.62	0.000368	4.03	601.96	72.60	0.21
OldSmokyHill_3	17400	Max WS	1641	1206.07	1218.3		1218.60	0.000503	4.89	566.08	68.95	0.25
OldSmokyHill_3	17300	Max WS	1643	1205.81	1218.3		1218.53	0.000323	3.89	654.47	77.81	0.20
OldSmokyHill_3	17181	Max WS	1734	1204.48	1218.2	1212.54	1218.47	0.000652	4.61	573.07	89.19	0.25
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	1734	1204.22	1217.0		1217.28	0.000493	4.20	513.55	73.61	0.22
OldSmokyHill_3	16800	Max WS	1734	1205.22	1216.7		1217.29	0.001139	6.73	425.32	69.72	0.36
OldSmokyHill_3	16700	Max WS	1734	1204.84	1216.7		1217.13	0.000748	5.58	484.94	78.70	0.30
OldSmokyHill_3	16600	Max WS	1734	1204.49	1216.8	1211.62	1216.99	0.000653	3.95	566.99	104.94	0.26
OldSmokyHill_3	16574		Inl Struct									
OldSmokyHill_3	16500	Max WS	1616	1202.84	1215.2		1215.23	0.000030	1.19	1607.60	148.57	0.06
OldSmokyHill_3	16400	Max WS	1616	1202.78	1215.2		1215.23	0.000031	1.22	1530.80	150.90	0.06
OldSmokyHill_3	16300	Max WS	1641	1202.75	1215.2		1215.24	0.000130	2.40	1115.32	120.04	0.13
OldSmokyHill_3	16200	Max WS	1641	1202.62	1215.1		1215.23	0.000172	2.88	1018.00	111.73	0.15
OldSmokyHill_3	16100	Max WS	1641	1202.56	1215.1		1215.22	0.000181	2.95	933.47	104.90	0.15
OldSmokyHill_3	16000	Max WS	1639	1202.50	1215.1		1215.20	0.000200	3.08	849.48	94.00	0.16
OldSmokyHill_3	15900	Max WS	1639	1202.34	1215.0		1215.20	0.000318	3.87	573.08	66.36	0.20
OldSmokyHill_3	15800	Max WS	1637	1202.44	1215.0		1215.16	0.000303	3.78	636.77	73.21	0.19
OldSmokyHill_3	15700	Max WS	1654	1202.56	1214.9		1215.13	0.000324	3.77	638.90	75.24	0.20
OldSmokyHill_3	15635	Max WS	1654	1202.00	1214.9	1207.30	1215.11	0.000406	3.93	644.23	75.60	0.19
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1656	1202.00	1215.0		1215.03	0.000403	2.05	874.48	104.92	0.10
OldSmokyHill_3	15400	Max WS	1654	1202.54	1214.9		1215.01	0.000235	3.28	814.11	86.45	0.17
OldSmokyHill_3	15300	Max WS	1655	1202.93	1214.8		1215.00	0.000324	3.76	751.19	81.59	0.20
OldSmokyHill_3	15200	Max WS	1655	1202.50	1214.8		1214.95	0.000201	3.07	778.77	88.43	0.16
OldSmokyHill_3	15100	Max WS	1655	1202.59	1214.8		1214.93	0.000193	3.02	844.55	89.58	0.16
OldSmokyHill_3	15000	Max WS	1653	1202.48	1214.8		1214.91	0.000209	3.13	867.18	97.92	0.16
OldSmokyHill_3	14900	Max WS	1655	1201.88	1214.8		1214.90	0.000239	3.43	882.28	95.60	0.17
OldSmokyHill_3	14800	Max WS	1655	1202.06	1214.8		1214.86	0.000161	2.80	892.65	90.32	0.14
OldSmokyHill_3	14700	Max WS	1659	1202.03	1214.7		1214.86	0.000236	3.40	909.51	93.70	0.17

HEC-RAS Plan: 04-FWOP-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	14600	Max WS	1661	1201.91	1214.7		1214.85	0.000320	3.94	767.29	85.14	0.20
OldSmokyHill_3	14507	Max WS	1679	1201.00	1214.6	1207.41	1214.82	0.000496	4.48	757.63	89.13	0.22
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	1679	1201.00	1214.2		1214.34	0.000266	3.27	844.93	94.19	0.16
OldSmokyHill_3	14300	Max WS	1679	1202.28	1214.2		1214.32	0.000198	2.91	791.22	87.21	0.16
OldSmokyHill_3	14200	Max WS	1680	1201.94	1214.1		1214.31	0.000313	3.64	734.77	82.66	0.19
OldSmokyHill_3	14100	Max WS	1678	1201.94	1214.1		1214.28	0.000231	3.30	814.17	88.47	0.17
OldSmokyHill_3	14000	Max WS	1678	1202.06	1214.1		1214.25	0.000233	3.27	841.13	90.54	0.17
OldSmokyHill_3	13900	Max WS	1678	1202.00	1214.1		1214.23	0.000279	3.56	811.33	88.89	0.18
OldSmokyHill_3	13800	Max WS	1678	1201.91	1214.1		1214.20	0.000254	3.46	800.74	91.56	0.18
OldSmokyHill_3	13700	Max WS	1678	1202.31	1214.1		1214.17	0.000218	3.14	1007.97	108.37	0.16
OldSmokyHill_3	13600	Max WS	1678	1202.09	1214.0		1214.15	0.000249	3.39	879.72	97.33	0.18
OldSmokyHill_3	13500	Max WS	1676	1201.84	1214.0		1214.12	0.000185	2.94	939.67	104.96	0.15
OldSmokyHill_3	13400	Max WS	1676	1202.19	1214.0		1214.10	0.000216	3.13	921.33	104.66	0.16
OldSmokyHill_3	13300	Max WS	1676	1202.09	1214.0		1214.08	0.000232	3.18	970.24	99.66	0.17
OldSmokyHill_3	13200	Max WS	1676	1202.00	1213.9		1214.07	0.000285	3.64	875.16	95.01	0.19
OldSmokyHill_3	13100	Max WS	1783	1201.94	1213.9		1214.03	0.000277	3.61	818.61	87.17	0.19
OldSmokyHill_3	13000	Max WS	1794	1201.75	1213.8		1214.01	0.000345	4.02	842.23	98.03	0.21
OldSmokyHill_3	12900	Max WS	1794	1201.88	1213.8		1213.97	0.000307	3.81	870.93	95.66	0.20
OldSmokyHill_3	12800	Max WS	1794	1201.88	1213.8		1213.93	0.000304	3.74	857.91	90.11	0.19
OldSmokyHill_3	12700	Max WS	1794	1201.56	1213.8		1213.89	0.000213	3.13	842.92	87.64	0.16
OldSmokyHill_3	12600	Max WS	1793	1201.66	1213.7		1213.88	0.000242	3.36	869.07	91.74	0.17
OldSmokyHill_3	12500	Max WS	1794	1201.75	1213.7		1213.86	0.000291	3.72	896.04	95.39	0.19
OldSmokyHill_3	12400	Max WS	1801	1201.69	1213.7		1213.81	0.000178	2.87	870.23	89.23	0.15
OldSmokyHill_3	12300	Max WS	1800	1201.38	1213.6		1213.81	0.000275	3.63	791.13	87.97	0.19
OldSmokyHill_3	12200	Max WS	1800	1201.56	1213.6		1213.78	0.000226	3.26	816.63	87.32	0.17
OldSmokyHill_3	12100	Max WS	1803	1201.41	1213.6		1213.76	0.000285	3.68	796.64	83.86	0.19
OldSmokyHill_3	12000	Max WS	1808	1201.25	1213.6		1213.73	0.000283	3.62	821.65	86.59	0.19
OldSmokyHill_3	11900	Max WS	1807	1201.34	1213.5		1213.71	0.000300	3.78	814.40	90.04	0.19
OldSmokyHill_3	11800	Max WS	1810	1201.47	1213.4		1213.69	0.000397	4.29	635.56	75.44	0.22
OldSmokyHill_3	11688	Max WS	1810	1201.35	1213.4		1213.65	0.000404	4.33	652.17	76.27	0.22
OldSmokyHill_3	11600	Max WS	1811	1201.41	1213.4		1213.61	0.000382	4.18	732.87	79.81	0.22
OldSmokyHill_3	11500	Max WS	1812	1201.15	1213.4		1213.55	0.000251	3.43	879.92	92.39	0.18
OldSmokyHill_3	11400	Max WS	1812	1201.03	1213.4		1213.51	0.000132	2.58	985.56	98.44	0.13
OldSmokyHill_3	11300	Max WS	1856	1200.84	1213.3		1213.51	0.000297	3.75	852.99	90.05	0.19
OldSmokyHill_3	11200	Max WS	1856	1200.94	1213.3		1213.49	0.000301	3.80	821.72	85.79	0.19
OldSmokyHill_3	11100	Max WS	1856	1200.81	1213.2		1213.47	0.000350	4.10	706.80	75.74	0.21
OldSmokyHill_3	10956	Max WS	1867	1196.19	1213.3		1213.37	0.000095	2.18	1464.09	197.82	0.10
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	548	1195.60	1212.0		1212.06	0.000011	0.69	1140.73	157.39	0.03
OldSmokyHill_3	10500	Max WS	549	1200.88	1212.0		1212.06	0.000032	1.14	802.62	94.04	0.06
OldSmokyHill_3	10400	Max WS	549	1200.80	1212.0		1212.05	0.000032	1.18	830.17	101.48	0.06
OldSmokyHill_3	10335	Max WS	548	1200.91	1212.0	1203.31	1212.05	0.000035	1.20	819.69	95.21	0.06
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	548	1200.91	1212.0		1212.04	0.000038	1.26	771.30	90.16	0.07
OldSmokyHill_3	10200	Max WS	546	1200.59	1212.0		1212.04	0.000026	1.07	861.94	96.14	0.06
OldSmokyHill_3	10100	Max WS	542	1200.75	1212.0		1212.04	0.000032	1.16	786.68	90.17	0.06
OldSmokyHill_3	10000	Max WS	543	1200.50	1212.0		1212.03	0.000018	0.89	788.48	85.90	0.05
OldSmokyHill_3	9900	Max WS	545	1200.38	1212.0		1212.03	0.000021	0.96	781.83	87.89	0.05
OldSmokyHill_3	9800	Max WS	540	1200.44	1212.0		1212.03	0.000031	1.18	816.03	93.19	0.06
OldSmokyHill_3	9700	Max WS	542	1200.36	1212.0		1212.03	0.000032	1.20	823.49	95.18	0.06
OldSmokyHill_3	9600	Max WS	542	1200.22	1212.0		1212.02	0.000030	1.16	829.56	91.50	0.06
OldSmokyHill_3	9500	Max WS	542	1200.29	1212.0		1212.02	0.000031	1.18	798.36	88.62	0.06
OldSmokyHill_3	9400	Max WS	539	1200.41	1212.0		1212.02	0.000032	1.21	763.28	85.59	0.06
OldSmokyHill_3	9300	Max WS	540	1200.34	1212.0		1212.01	0.000030	1.16	784.78	86.55	0.06
OldSmokyHill_3	9200	Max WS	540	1200.56	1212.0		1212.01	0.000033	1.17	754.14	94.15	0.06
OldSmokyHill_3	9148	Max WS	540	1200.25	1212.0		1212.01	0.000030	1.15	747.67	84.18	0.06
OldSmokyHill_3	9100	Max WS	548	1200.27	1212.0		1212.01	0.000016	0.86	843.30	90.05	0.04
OldSmokyHill_3	9000	Max WS	546	1200.25	1212.0		1212.01	0.000026	1.07	762.77	90.90	0.06
OldSmokyHill_3	8900	Max WS	543	1200.31	1212.0		1212.00	0.000032	1.20	723.61	86.04	0.06
OldSmokyHill_3	8800	Max WS	545	1200.53	1212.0		1212.00	0.000026	1.09	808.14	93.77	0.06
OldSmokyHill_3	8668	Max WS	545	1200.39	1212.0	1202.91	1212.00	0.000047	1.47	693.62	92.36	0.08
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	544	1214.00	1212.0		1211.99	0.000163		750.20	95.49	0.00
OldSmokyHill_3	8500	Max WS	540	1200.37	1212.0		1211.98	0.000029	1.13	805.80	94.63	0.06
OldSmokyHill_3	8400	Max WS	543	1200.41	1212.0		1211.98	0.000023	1.02	786.27	88.59	0.05
OldSmokyHill_3	8300	Max WS	542	1199.94	1212.0		1211.98	0.000023	1.04	797.38	86.97	0.05
OldSmokyHill_3	8200	Max WS	542	1199.79	1212.0		1211.98	0.000024	1.07	844.44	94.83	0.05
OldSmokyHill_3	8100	Max WS	542	1199.97	1212.0		1211.97	0.000024	1.06	854.31	101.31	0.05
OldSmokyHill_3	8000	Max WS	541	1199.51	1212.0		1211.97	0.000016	0.87	851.98	86.44	0.04
OldSmokyHill_3	7900	Max WS	541	1199.72	1212.0		1211.97	0.000023	1.06	877.74	98.79	0.05
OldSmokyHill_3	7800	Max WS	539	1199.50	1212.0		1211.97	0.000018	0.95	868.15	96.81	0.05
OldSmokyHill_3	7700	Max WS	538	1199.53	1212.0		1211.97	0.000022	1.05	868.71	96.68	0.05
OldSmokyHill_3	7600	Max WS	537	1199.56	1212.0		1211.96	0.000022	1.05	828.68	89.61	0.05
OldSmokyHill_3	7500	Max WS	537	1199.59	1211.9		1211.96	0.000020	1.00	862.04	90.68	0.05
OldSmokyHill_3	7400	Max WS	538	1199.59	1211.9		1211.96	0.000018	0.94	982.75	100.77	0.05
OldSmokyHill_3	7300	Max WS	537	1199.63	1211.9		1211.96	0.000018	0.94	922.65	100.21	0.05
OldSmokyHill_3	7275		Lat Struct									

HEC-RAS Plan: 04-FWOP-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	7200	Max WS	514	1199.58	1211.9		1211.96	0.000017	0.91	944.60	106.07	0.05
OldSmokyHill_3	7100	Max WS	208	1199.59	1212.0		1211.96	0.000002	0.33	987.08	105.65	0.02
OldSmokyHill_3	7000	Max WS	214	1199.50	1212.0		1211.96	0.000003	0.41	841.60	94.59	0.02
OldSmokyHill_3	6900	Max WS	213	1199.53	1212.0		1211.96	0.000003	0.40	842.29	100.97	0.02
OldSmokyHill_3	6800	Max WS	213	1199.41	1212.0		1211.96	0.000003	0.40	848.69	89.85	0.02
OldSmokyHill_3	6700	Max WS	213	1199.62	1212.0		1211.96	0.000003	0.41	882.38	99.61	0.02
OldSmokyHill_3	6600	Max WS	213	1199.46	1212.0		1211.96	0.000004	0.43	845.32	92.57	0.02
OldSmokyHill_3	6500	Max WS	213	1199.95	1212.0		1211.96	0.000003	0.39	840.43	101.55	0.02
OldSmokyHill_3	6400	Max WS	212	1199.64	1212.0		1211.96	0.000003	0.37	892.31	94.03	0.02
OldSmokyHill_3	6300	Max WS	213	1218.07	1212.0		1211.95	0.000015		879.61	91.70	0.00
OldSmokyHill_3	6200	Max WS	212	1199.70	1212.0		1211.95	0.000003	0.39	895.37	90.46	0.02
OldSmokyHill_3	6100	Max WS	213	1199.62	1212.0		1211.95	0.000003	0.38	883.76	87.53	0.02
OldSmokyHill_3	6000	Max WS	212	1199.63	1212.0		1211.95	0.000004	0.42	865.82	93.90	0.02
OldSmokyHill_3	5900	Max WS	213	1199.56	1212.0		1211.95	0.000003	0.36	941.59	103.38	0.02
OldSmokyHill_3	5800	Max WS	212	1199.59	1212.0		1211.95	0.000003	0.40	870.98	102.52	0.02
OldSmokyHill_3	5700	Max WS	212	1199.50	1212.0		1211.95	0.000003	0.39	874.61	93.95	0.02
OldSmokyHill_3	5600	Max WS	213	1199.57	1212.0		1211.95	0.000003	0.38	1018.27	112.23	0.02
OldSmokyHill_3	5500	Max WS	213	1199.22	1212.0		1211.95	0.000003	0.37	1004.99	110.90	0.02
OldSmokyHill_3	5400	Max WS	213	1199.12	1211.9		1211.95	0.000004	0.43	917.42	97.45	0.02
OldSmokyHill_3	5300	Max WS	213	1199.14	1211.9		1211.95	0.000003	0.41	900.74	98.64	0.02
OldSmokyHill_3	5200	Max WS	212	1199.09	1211.9		1211.95	0.000002	0.31	973.87	99.16	0.02
OldSmokyHill_3	5100	Max WS	212	1198.99	1211.9		1211.95	0.000004	0.41	960.31	104.91	0.02
OldSmokyHill_3	5000	Max WS	213	1198.99	1211.9		1211.95	0.000003	0.41	964.19	103.87	0.02
OldSmokyHill_3	4900	Max WS	213	1199.38	1211.9		1211.95	0.000003	0.38	1007.00	103.60	0.02
OldSmokyHill_3	4800	Max WS	213	1198.50	1211.9		1211.95	0.000002	0.36	1087.81	117.89	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	212	1198.66	1211.9		1211.95	0.000003	0.40	961.36	106.02	0.02
OldSmokyHill_3	4600	Max WS	212	1198.79	1211.9		1211.95	0.000002	0.34	1038.37	106.81	0.02
OldSmokyHill_3	4500	Max WS	212	1198.69	1211.9		1211.95	0.000003	0.37	1005.87	100.87	0.02
OldSmokyHill_3	4400	Max WS	220	1198.73	1211.9		1211.95	0.000004	0.41	977.42	112.57	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	271	1198.63	1211.9		1211.95	0.000004	0.47	1057.39	106.92	0.02
OldSmokyHill_3	4200	Max WS	361	1198.66	1211.9		1211.95	0.000009	0.69	1018.57	109.00	0.03
OldSmokyHill_3	4100	Max WS	361	1198.56	1211.9		1211.95	0.000007	0.62	1111.20	127.04	0.03
OldSmokyHill_3	4000	Max WS	537	1198.84	1211.9		1211.95	0.000022	1.06	1045.11	119.92	0.05
OldSmokyHill_3	3900	Max WS	553	1198.91	1211.9		1211.94	0.000019	1.00	1017.72	113.86	0.05
OldSmokyHill_3	3800	Max WS	553	1198.66	1211.9		1211.94	0.000017	0.96	957.89	101.05	0.05
OldSmokyHill_3	3700	Max WS	553	1198.59	1211.9		1211.94	0.000017	0.95	1003.60	100.99	0.05
OldSmokyHill_3	3600	Max WS	553	1198.52	1211.9		1211.94	0.000021	1.06	1016.57	106.31	0.05
OldSmokyHill_3	3500	Max WS	553	1198.78	1211.9		1211.93	0.000019	0.99	1039.15	102.90	0.05
OldSmokyHill_3	3400	Max WS	553	1198.62	1211.9		1211.93	0.000016	0.92	1009.12	101.63	0.05
OldSmokyHill_3	3300	Max WS	553	1198.34	1211.9		1211.93	0.000017	0.97	953.86	95.47	0.05
OldSmokyHill_3	3200	Max WS	553	1198.38	1211.9		1211.93	0.000017	0.96	927.13	94.90	0.05
OldSmokyHill_3	3100	Max WS	553	1198.66	1211.9		1211.93	0.000016	0.92	944.92	116.67	0.05
OldSmokyHill_3	3000	Max WS	553	1198.34	1211.9		1211.93	0.000015	0.88	946.63	96.31	0.04
OldSmokyHill_3	2900	Max WS	553	1198.41	1211.9		1211.92	0.000018	0.97	978.08	105.91	0.05
OldSmokyHill_3	2800	Max WS	553	1198.34	1211.9		1211.92	0.000020	1.05	999.96	109.06	0.05
OldSmokyHill_3	2700	Max WS	553	1198.47	1211.9		1211.92	0.000018	0.99	982.90	105.82	0.05
OldSmokyHill_3	2600	Max WS	557	1198.50	1211.9		1211.92	0.000016	0.92	1012.01	108.56	0.04
OldSmokyHill_3	2500	Max WS	557	1198.53	1211.9		1211.92	0.000023	1.11	870.91	112.79	0.05
OldSmokyHill_3	2400	Max WS	557	1198.93	1211.9		1211.91	0.000014	0.84	917.47	109.03	0.04
OldSmokyHill_3	2300	Max WS	557	1198.50	1211.9		1211.91	0.000012	0.82	943.44	110.36	0.04
OldSmokyHill_3	2183	Max WS	557	1196.44	1211.9		1211.91	0.000017	0.96	672.15	109.26	0.04
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	557	1196.78	1206.8		1207.12	0.000647	4.36	127.68	86.30	0.25
OldSmokyHill_3	1900	Max WS	557	1198.47	1207.0		1206.99	0.000094	1.64	455.36	83.52	0.10
OldSmokyHill_3	1800	Max WS	557	1198.28	1207.0		1206.98	0.000073	1.45	553.58	87.33	0.09
OldSmokyHill_3	1700	Max WS	557	1198.12	1207.0		1206.97	0.000051	1.24	612.55	86.32	0.08
OldSmokyHill_3	1600	Max WS	557	1198.25	1206.9		1206.97	0.000084	1.59	548.98	82.96	0.10
OldSmokyHill_3	1500	Max WS	557	1197.76	1206.9		1206.96	0.000061	1.37	574.68	85.65	0.08
OldSmokyHill_3	1400	Max WS	557	1197.88	1206.9		1206.95	0.000060	1.33	560.45	84.11	0.08
OldSmokyHill_3	1300	Max WS	557	1197.69	1206.9		1206.94	0.000117	1.82	380.40	67.78	0.11
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	557	1197.53	1206.9		1206.93	0.000120	1.89	351.71	68.32	0.11
OldSmokyHill_3	1100	Max WS	557	1197.72	1206.9		1206.92	0.000137	2.00	332.23	66.09	0.12
OldSmokyHill_3	1000	Max WS	557	1197.72	1206.9		1206.91	0.000148	2.05	314.03	59.90	0.13
OldSmokyHill_3	900	Max WS	557	1197.44	1206.8		1206.89	0.000161	2.22	303.86	59.48	0.13
OldSmokyHill_3	800	Max WS	557	1197.35	1206.8		1206.88	0.000144	2.12	321.22	63.71	0.13
OldSmokyHill_3	700	Max WS	557	1197.38	1206.8		1206.86	0.000149	2.18	317.80	63.19	0.13
OldSmokyHill_3	660	Max WS	565	1195.72	1206.8	1200.67	1206.85	0.000199	2.38	242.84	58.99	0.14
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	565	1194.57	1199.3	1199.59	1201.99	0.020301	13.07	43.28	12.31	1.09
OldSmokyHill_3	300	Max WS	565	1194.22	1198.1		1198.74	0.006292	6.46	87.57	31.42	0.68
OldSmokyHill_3	200	Max WS	565	1193.97	1197.3		1198.15	0.008810	7.23	78.17	30.50	0.80
OldSmokyHill_3	100	Max WS	565	1193.86	1196.8	1195.81	1196.92	0.001312	2.69	256.39	185.71	0.31

HEC-RAS Plan: 04-FWOP-USACE-1%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	35900	Max WS	0	1212.00	1220.6		1220.58	0.000000	0.00	204.22	54.26	0.00
OldSmokyHill_3	35800	Max WS	282	1212.00	1221.1		1221.10	0.000097	1.46	231.61	53.58	0.09
OldSmokyHill_3	35680	Max WS	137	1209.80	1221.4	1212.85	1221.46	0.000117	1.15	118.94	51.88	0.08
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-181	1208.30	1223.1		1223.15	0.000289	-1.96	92.35	92.38	0.10
OldSmokyHill_3	35300	Max WS	-181	1214.81	1223.1		1223.14	0.000008	-0.43	471.58	96.23	0.03
OldSmokyHill_3	35200	Max WS	-164	1214.50	1223.1		1223.15	0.000005	-0.37	506.19	95.40	0.02
OldSmokyHill_3	35100	Max WS	-164	1214.57	1223.1		1223.15	0.000005	-0.37	511.63	97.13	0.02
OldSmokyHill_3	35000	Max WS	-144	1214.56	1223.1		1223.15	0.000003	-0.28	572.22	98.55	0.02
OldSmokyHill_3	34900	Max WS	-144	1214.56	1223.1		1223.15	0.000003	-0.28	570.76	100.44	0.02
OldSmokyHill_3	34798	Max WS	-144	1214.94	1223.1		1223.15	0.000003	-0.28	579.57	103.20	0.02
OldSmokyHill_3	34701	Max WS	-144	1214.69	1223.1		1223.15	0.000003	-0.28	564.39	99.45	0.02
OldSmokyHill_3	34604	Max WS	-144	1214.67	1223.1		1223.15	0.000003	-0.28	581.80	103.81	0.02
OldSmokyHill_3	34499	Max WS	-144	1214.72	1223.1		1223.15	0.000003	-0.27	580.25	100.52	0.02
OldSmokyHill_3	34396	Max WS	-145	1214.72	1223.1		1223.15	0.000003	-0.27	587.28	103.34	0.02
OldSmokyHill_3	34306	Max WS	-145	1214.64	1223.1		1223.15	0.000003	-0.27	602.13	103.34	0.02
OldSmokyHill_3	34186	Max WS	-144	1214.72	1223.1		1223.15	0.000005	-0.37	577.24	199.40	0.02
OldSmokyHill_3	34100	Max WS	-145	1214.75	1223.1		1223.15	0.000005	-0.38	542.66	220.27	0.02
OldSmokyHill_3	34013	Max WS	-145	1214.69	1223.1		1223.15	0.000010	-0.46	801.05	229.80	0.03
OldSmokyHill_3	33965	Max WS	-145	1214.44	1223.1		1223.15	0.000007	-0.38	824.97	198.79	0.02
OldSmokyHill_3	33914	Max WS	-145	1214.62	1223.1		1223.15	0.000005	-0.31	898.64	162.57	0.02
OldSmokyHill_3	33833	Max WS	-129	1214.58	1223.2		1223.15	0.000006	-0.37	780.55	131.01	0.02
OldSmokyHill_3	33766	Max WS	-129	1214.90	1223.2		1223.15	0.000006	-0.36	751.71	120.11	0.02
OldSmokyHill_3	33673	Max WS	-129	1214.81	1223.2		1223.15	0.000007	-0.38	638.34	97.88	0.02
OldSmokyHill_3	33600	Max WS	-130	1214.66	1223.2		1223.15	0.000007	-0.40	574.06	86.42	0.02
OldSmokyHill_3	33500	Max WS	-129	1214.44	1223.2		1223.15	0.000006	-0.37	580.02	91.76	0.02
OldSmokyHill_3	33400	Max WS	-127	1214.59	1223.2		1223.15	0.000005	-0.32	598.58	92.30	0.02
OldSmokyHill_3	33300	Max WS	-120	1214.69	1223.2		1223.15	0.000006	-0.35	575.16	87.58	0.02
OldSmokyHill_3	33200	Max WS	-120	1214.66	1223.2		1223.15	0.000005	-0.34	597.04	90.43	0.02
OldSmokyHill_3	33100	Max WS	-120	1214.62	1223.2		1223.16	0.000007	-0.40	520.88	81.65	0.02
OldSmokyHill_3	33000	Max WS	-120	1214.66	1223.2		1223.16	0.000005	-0.32	568.65	89.00	0.02
OldSmokyHill_3	32900	Max WS	-120	1214.88	1223.2		1223.16	0.000005	-0.33	672.56	120.66	0.02
OldSmokyHill_3	32815	Max WS	2	1211.25	1223.2		1223.16	0.000000	0.01	372.34	107.10	0.00
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	1	1211.25	1223.2		1223.16	0.000000	0.00	561.04	117.14	0.00
OldSmokyHill_3	32500	Max WS	1	1214.22	1223.2		1223.16	0.000000	0.00	603.12	110.00	0.00
OldSmokyHill_3	32400	Max WS	15	1214.22	1223.2		1223.16	0.000000	0.04	628.98	92.40	0.00
OldSmokyHill_3	32338	Max WS	15	1214.16	1223.2		1223.16	0.000000	0.05	571.48	85.65	0.00
OldSmokyHill_3	32300	Max WS	14	1214.28	1223.2		1223.16	0.000000	0.04	579.11	86.83	0.00
OldSmokyHill_3	32200	Max WS	15	1214.11	1223.2		1223.16	0.000000	0.04	646.68	94.13	0.00
OldSmokyHill_3	32100	Max WS	15	1214.35	1223.2		1223.16	0.000000	0.04	606.39	90.52	0.00
OldSmokyHill_3	31900	Max WS	15	1214.09	1223.2		1223.16	0.000000	0.05	521.65	91.38	0.00
OldSmokyHill_3	31800	Max WS	56	1213.78	1223.2		1223.16	0.000002	0.22	544.92	136.12	0.01
OldSmokyHill_3	31700	Max WS	60	1214.09	1223.2		1223.16	0.000002	0.22	441.06	110.01	0.01
OldSmokyHill_3	31600	Max WS	73	1213.59	1223.2		1223.16	0.000002	0.25	497.87	157.80	0.01
OldSmokyHill_3	31500	Max WS	74	1213.69	1223.2		1223.16	0.000002	0.21	635.93	187.72	0.01
OldSmokyHill_3	31400	Max WS	74	1213.66	1223.2		1223.15	0.000001	0.17	757.27	213.73	0.01
OldSmokyHill_3	31300	Max WS	74	1213.67	1223.2		1223.16	0.000002	0.24	738.04	196.76	0.01
OldSmokyHill_3	31200	Max WS	74	1213.62	1223.2		1223.15	0.000001	0.17	719.11	168.09	0.01
OldSmokyHill_3	31100	Max WS	76	1213.66	1223.2		1223.15	0.000001	0.18	717.85	195.84	0.01
OldSmokyHill_3	31000	Max WS	81	1213.78	1223.2		1223.15	0.000002	0.23	738.68	185.07	0.01
OldSmokyHill_3	30900	Max WS	81	1213.84	1223.2		1223.15	0.000002	0.22	722.64	179.84	0.01
OldSmokyHill_3	30800	Max WS	81	1213.72	1223.2		1223.15	0.000002	0.23	755.92	186.88	0.01
OldSmokyHill_3	30700	Max WS	81	1213.73	1223.2		1223.15	0.000002	0.22	686.62	165.66	0.01
OldSmokyHill_3	30651	Max WS	81	1213.76	1223.2		1223.15	0.000001	0.19	764.94	169.16	0.01
OldSmokyHill_3	30575	Max WS	81	1213.62	1223.2		1223.15	0.000002	0.20	767.01	156.24	0.01
OldSmokyHill_3	30500	Max WS	81	1213.78	1223.2		1223.15	0.000001	0.18	812.78	171.89	0.01
OldSmokyHill_3	30400	Max WS	81	1213.70	1223.2		1223.15	0.000002	0.20	759.24	151.63	0.01
OldSmokyHill_3	30300	Max WS	81	1213.72	1223.2		1223.15	0.000002	0.20	743.30	150.96	0.01
OldSmokyHill_3	30200	Max WS	81	1213.56	1223.2		1223.15	0.000002	0.20	811.38	163.80	0.01
OldSmokyHill_3	30100	Max WS	81	1213.75	1223.2		1223.15	0.000001	0.19	749.86	148.64	0.01
OldSmokyHill_3	29999	Max WS	81	1213.79	1223.2		1223.15	0.000001	0.19	772.64	131.03	0.01
OldSmokyHill_3	29899	Max WS	81	1213.74	1223.2		1223.15	0.000001	0.19	796.96	184.12	0.01
OldSmokyHill_3	29800	Max WS	86	1213.69	1223.2		1223.15	0.000001	0.17	818.41	233.96	0.01
OldSmokyHill_3	29704	Max WS	86	1213.72	1223.2		1223.15	0.000003	0.27	811.53	313.60	0.02
OldSmokyHill_3	29572	Max WS	86	1213.81	1223.2		1223.15	0.000002	0.25	782.16	322.45	0.01
OldSmokyHill_3	29466	Max WS	86	1213.59	1223.2		1223.15	0.000001	0.17	815.45	336.58	0.01
OldSmokyHill_3	29385	Max WS	1104	1213.50	1223.1		1223.13	0.000243	2.47	846.13	325.73	0.15
OldSmokyHill_3	29314	Max WS	1105	1213.03	1223.0		1223.15	0.000487	3.63	783.60	282.11	0.21
OldSmokyHill_3	29209	Max WS	1106	1213.06	1223.0		1223.09	0.000498	3.51	716.33	216.51	0.21
OldSmokyHill_3	29100	Max WS	1105	1213.03	1222.9		1223.03	0.000392	3.18	805.98	242.03	0.19
OldSmokyHill_3	28991	Max WS	1104	1213.00	1222.9		1222.98	0.000350	3.08	717.00	155.29	0.18
OldSmokyHill_3	28900	Max WS	1103	1212.85	1222.8		1222.97	0.000491	3.67	709.86	173.53	0.21
OldSmokyHill_3	28800	Max WS	1104	1213.03	1222.8		1222.91	0.000440	3.45	683.38	156.04	0.20
OldSmokyHill_3	28700	Max WS	1103	1213.12	1222.7		1222.86	0.000446	3.43	675.81	121.54	0.20
OldSmokyHill_3	28594	Max WS	1103	1212.92	1222.7		1222.81	0.000302	2.83	658.99	92.18	0.16
OldSmokyHill_3	28500	Max WS	1102	1213.01	1222.7		1222.78	0.000286	2.74	708.43	93.67	0.16
OldSmokyHill_3	28430	Max WS	1126	1210.34	1222.7	1215.19	1222.75	0.000318	2.61	601.23	86.98	0.15

HEC-RAS Plan: 04-FWOP-USACE-1%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1118	1209.69	1222.4		1222.44	0.000273	2.75	706.21	102.70	0.15
OldSmokyHill_3	28200	Max WS	1119	1212.97	1222.3		1222.41	0.000234	2.40	697.54	120.11	0.14
OldSmokyHill_3	28100	Max WS	1124	1212.97	1222.3		1222.39	0.000328	2.85	727.91	119.10	0.17
OldSmokyHill_3	28000	Max WS	1122	1213.03	1222.3		1222.36	0.000334	2.95	705.86	100.74	0.17
OldSmokyHill_3	27900	Max WS	1121	1213.00	1222.2		1222.33	0.000351	2.98	681.49	95.47	0.18
OldSmokyHill_3	27800	Max WS	1120	1212.59	1222.2		1222.29	0.000299	2.79	664.07	102.07	0.16
OldSmokyHill_3	27700	Max WS	1119	1212.69	1222.2		1222.26	0.000248	2.53	685.33	107.07	0.15
OldSmokyHill_3	27600	Max WS	1117	1212.75	1222.1		1222.24	0.000336	2.93	649.64	98.91	0.17
OldSmokyHill_3	27500	Max WS	1129	1212.53	1222.1		1222.20	0.000257	2.55	687.69	116.26	0.15
OldSmokyHill_3	27400	Max WS	1127	1212.45	1222.1		1222.17	0.000275	2.64	699.56	126.57	0.16
OldSmokyHill_3	27300	Max WS	1126	1212.53	1222.1		1222.15	0.000281	2.71	706.45	129.37	0.16
OldSmokyHill_3	27200	Max WS	1126	1212.53	1222.0		1222.12	0.000262	2.65	672.44	122.17	0.15
OldSmokyHill_3	27100	Max WS	1130	1212.45	1222.0		1222.09	0.000262	2.63	675.20	132.17	0.15
OldSmokyHill_3	27000	Max WS	1127	1212.19	1222.0		1222.07	0.000345	3.04	672.64	132.74	0.18
OldSmokyHill_3	26900	Max WS	1129	1213.09	1221.9		1222.03	0.000287	2.62	702.33	131.46	0.16
OldSmokyHill_3	26800	Max WS	1125	1212.22	1221.9		1222.00	0.000263	2.57	728.67	149.19	0.15
OldSmokyHill_3	26700	Max WS	1129	1212.12	1221.9		1221.97	0.000270	2.65	654.34	167.43	0.15
OldSmokyHill_3	26600	Max WS	1128	1212.06	1221.8		1221.95	0.000336	2.98	630.13	120.84	0.17
OldSmokyHill_3	26522	Max WS	1117	1211.97	1221.7	1216.48	1221.94	0.000693	4.28	389.52	70.46	0.25
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1105	1211.94	1221.7		1221.86	0.000591	3.96	393.25	73.06	0.23
OldSmokyHill_3	26400	Max WS	1117	1211.88	1221.7		1221.79	0.000260	2.60	696.86	96.97	0.15
OldSmokyHill_3	26300	Max WS	1119	1211.94	1221.7		1221.78	0.000353	3.00	693.01	133.19	0.18
OldSmokyHill_3	26200	Max WS	1113	1212.17	1221.6		1221.74	0.000393	3.13	747.59	149.19	0.19
OldSmokyHill_3	26100	Max WS	1116	1211.88	1221.6		1221.69	0.000244	2.51	730.72	141.46	0.15
OldSmokyHill_3	26000	Max WS	1111	1211.71	1221.6		1221.66	0.000216	2.35	695.56	93.15	0.14
OldSmokyHill_3	25900	Max WS	1107	1211.87	1221.6		1221.65	0.000303	2.80	697.71	94.32	0.16
OldSmokyHill_3	25800	Max WS	1106	1212.01	1221.5		1221.61	0.000198	2.24	746.29	111.75	0.13
OldSmokyHill_3	25700	Max WS	1106	1211.72	1221.5		1221.59	0.000304	2.79	664.17	98.53	0.16
OldSmokyHill_3	25600	Max WS	1104	1211.75	1221.5		1221.56	0.000222	2.41	704.65	115.66	0.14
OldSmokyHill_3	25500	Max WS	1151	1211.75	1221.5		1221.54	0.000262	2.62	737.04	153.02	0.15
OldSmokyHill_3	25400	Max WS	1148	1211.72	1221.4		1221.52	0.000287	2.72	727.86	173.30	0.16
OldSmokyHill_3	25300	Max WS	1143	1211.87	1221.4		1221.49	0.000395	3.18	671.37	210.17	0.19
OldSmokyHill_3	25200	Max WS	1139	1211.81	1221.3		1221.44	0.000335	2.93	649.26	161.94	0.17
OldSmokyHill_3	25117	Max WS	1141	1208.41	1221.3	1213.08	1221.39	0.000627	1.88	808.82	182.65	0.10
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1114	1208.97	1221.2		1221.27	0.000201	2.44	588.04	138.04	0.13
OldSmokyHill_3	24900	Max WS	1111	1211.71	1221.2		1221.26	0.000214	2.59	714.09	157.26	0.15
OldSmokyHill_3	24800	Max WS	1101	1211.78	1221.1		1221.24	0.000278	3.05	650.59	142.73	0.18
OldSmokyHill_3	24700	Max WS	1106	1211.84	1221.1		1221.21	0.000197	2.53	712.01	120.92	0.15
OldSmokyHill_3	24600	Max WS	1103	1211.34	1221.1		1221.18	0.000168	2.38	756.96	114.28	0.14
OldSmokyHill_3	24500	Max WS	1095	1211.53	1221.1		1221.17	0.000185	2.43	681.78	97.47	0.14
OldSmokyHill_3	24400	Max WS	1095	1211.13	1221.1		1221.15	0.000161	2.33	702.44	90.96	0.14
OldSmokyHill_3	24300	Max WS	1088	1211.19	1221.1		1221.13	0.000163	2.34	696.47	92.15	0.14
OldSmokyHill_3	24200	Max WS	1084	1211.13	1221.0		1221.12	0.000206	2.71	697.59	94.07	0.16
OldSmokyHill_3	24100	Max WS	1084	1211.08	1221.0		1221.10	0.000226	2.78	661.28	104.27	0.16
OldSmokyHill_3	24000	Max WS	1083	1211.22	1221.0		1221.07	0.000208	2.71	702.44	103.75	0.16
OldSmokyHill_3	23900	Max WS	1075	1211.08	1221.0		1221.05	0.000208	2.72	714.66	106.62	0.16
OldSmokyHill_3	23800	Max WS	1093	1211.12	1220.9		1221.03	0.000229	2.86	718.49	132.36	0.16
OldSmokyHill_3	23700	Max WS	1093	1211.28	1220.9		1221.00	0.000158	2.34	695.04	101.55	0.14
OldSmokyHill_3	23600	Max WS	1088	1211.06	1220.9		1220.98	0.000172	2.46	696.91	93.59	0.14
OldSmokyHill_3	23500	Max WS	1080	1210.94	1220.9		1220.96	0.000171	2.45	723.44	95.42	0.14
OldSmokyHill_3	23362	Max WS	1087	1210.95	1220.9	1214.43	1220.94	0.000167	2.42	741.26	102.41	0.14
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1083	1210.60	1220.8		1220.90	0.000126	2.13	742.47	97.97	0.12
OldSmokyHill_3	23167	Max WS	1083	1210.66	1220.8		1220.90	0.000153	2.34	734.14	104.02	0.13
OldSmokyHill_3	23100	Max WS	1081	1210.81	1220.8		1220.89	0.000177	2.53	770.80	115.65	0.14
OldSmokyHill_3	23000	Max WS	1086	1210.50	1220.8		1220.87	0.000123	2.12	784.50	116.00	0.12
OldSmokyHill_3	22900	Max WS	1087	1210.56	1220.8		1220.85	0.000114	2.03	860.48	127.72	0.12
OldSmokyHill_3	22800	Max WS	1093	1210.71	1220.8		1220.84	0.000121	2.09	829.54	126.07	0.12
OldSmokyHill_3	22731	Max WS	1093	1210.47	1220.8		1220.83	0.000148	2.32	828.73	147.41	0.13
OldSmokyHill_3	22656	Max WS	1087	1210.44	1220.8	1214.06	1220.82	0.000177	2.57	756.75	125.16	0.14
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1093	1210.34	1220.7		1220.81	0.000171	2.51	748.37	119.75	0.14
OldSmokyHill_3	22578	Max WS	1087	1210.41	1220.7		1220.80	0.000149	2.36	809.37	150.85	0.13
OldSmokyHill_3	22500	Max WS	1086	1210.38	1220.7		1220.79	0.000172	2.55	801.90	191.61	0.14
OldSmokyHill_3	22400	Max WS	1080	1210.44	1220.7		1220.77	0.000191	2.67	781.29	211.32	0.15
OldSmokyHill_3	22300	Max WS	1080	1210.31	1220.7		1220.75	0.000191	2.72	850.34	233.15	0.15
OldSmokyHill_3	22200	Max WS	1077	1210.44	1220.7		1220.73	0.000152	2.37	943.11	233.55	0.13
OldSmokyHill_3	22100	Max WS	1076	1210.16	1220.7		1220.71	0.000126	2.21	943.11	218.07	0.12
OldSmokyHill_3	22000	Max WS	1073	1210.12	1220.6		1220.70	0.000161	2.50	853.34	184.81	0.14
OldSmokyHill_3	21900	Max WS	1066	1210.13	1220.6		1220.68	0.000140	2.31	741.64	124.39	0.13
OldSmokyHill_3	21799	Max WS	1059	1210.28	1220.6		1220.67	0.000185	2.66	738.86	151.03	0.15
OldSmokyHill_3	21722	Max WS	1051	1210.11	1220.6	1213.99	1220.66	0.000219	2.93	692.91	139.72	0.16
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1051	1210.11	1220.6		1220.65	0.000223	2.96	691.16	136.17	0.16
OldSmokyHill_3	21600	Max WS	1051	1210.31	1220.6		1220.62	0.000188	2.67	778.21	144.00	0.15

HEC-RAS Plan: 04-FWOP-USACE-1%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	21500	Max WS	1065	1210.14	1220.6		1220.59	0.000115	2.09	931.87	190.25	0.12
OldSmokyHill_3	21400	Max WS	1059	1209.94	1220.5		1220.58	0.000075	1.67	1064.40	257.87	0.09
OldSmokyHill_3	21296	Max WS	1059	1209.94	1220.5		1220.57	0.000074	1.67	1020.50	250.48	0.09
OldSmokyHill_3	21200	Max WS	1050	1209.81	1220.5		1220.56	0.000083	1.78	1052.36	295.19	0.10
OldSmokyHill_3	21100	Max WS	1050	1209.84	1220.5		1220.55	0.000067	1.59	1053.45	302.06	0.09
OldSmokyHill_3	20995	Max WS	1050	1210.03	1220.5		1220.54	0.000081	1.76	1022.16	214.10	0.10
OldSmokyHill_3	20900	Max WS	1040	1209.75	1220.5		1220.54	0.000089	1.85	999.77	234.82	0.10
OldSmokyHill_3	20800	Max WS	1047	1209.72	1220.5		1220.52	0.000062	1.53	1116.51	265.76	0.09
OldSmokyHill_3	20700	Max WS	1036	1209.45	1220.5		1220.52	0.000076	1.73	1116.92	274.61	0.10
OldSmokyHill_3	20644	Max WS	1035	1209.47	1220.5		1220.51	0.000061	1.50	1090.62	270.51	0.08
OldSmokyHill_3	20600	Max WS	1035	1209.50	1220.5		1220.51	0.000062	1.52	1159.08	283.81	0.09
OldSmokyHill_3	20500	Max WS	1023	1209.50	1220.5		1220.50	0.000084	1.80	1015.62	290.12	0.10
OldSmokyHill_3	20434	Max WS	1023	1209.31	1220.5		1220.50	0.000088	1.86	1045.45	299.58	0.10
OldSmokyHill_3	20363	Max WS	1010	1209.38	1220.4	1213.15	1220.50	0.000147	2.41	808.35	305.91	0.13
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1010	1209.41	1220.4		1220.49	0.000124	2.22	868.69	303.11	0.12
OldSmokyHill_3	20300	Max WS	1023	1209.12	1220.4		1220.47	0.000040	1.29	1241.95	300.75	0.07
OldSmokyHill_3	20190	Max WS	1767	1209.13	1220.4		1220.45	0.000270	3.23	1083.96	253.63	0.18
OldSmokyHill_3	20100	Max WS	1777	1209.16	1220.3		1220.43	0.000357	3.78	945.91	219.50	0.21
OldSmokyHill_3	20023	Max WS	1782	1209.08	1220.3		1220.41	0.000338	3.74	889.38	178.75	0.20
OldSmokyHill_3	19900	Max WS	1782	1209.08	1220.2		1220.36	0.000267	3.33	904.10	149.59	0.18
OldSmokyHill_3	19800	Max WS	1782	1208.97	1220.2		1220.33	0.000281	3.41	827.88	135.36	0.19
OldSmokyHill_3	19700	Max WS	1782	1208.94	1220.1		1220.31	0.000349	3.81	703.09	111.68	0.21
OldSmokyHill_3	19600	Max WS	1782	1208.88	1220.1		1220.28	0.000366	3.97	763.43	104.42	0.21
OldSmokyHill_3	19510	Max WS	1782	1208.73	1220.1	1213.07	1220.23	0.000240	3.23	859.80	106.99	0.17
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1781	1208.72	1220.1		1220.19	0.000301	3.60	907.07	109.39	0.19
OldSmokyHill_3	19400	Max WS	1781	1208.54	1220.0		1220.20	0.000502	4.70	834.76	119.10	0.25
OldSmokyHill_3	19300	Max WS	1813	1208.31	1219.9		1220.16	0.000495	4.65	785.77	123.10	0.25
OldSmokyHill_3	19200	Max WS	1813	1208.24	1219.9		1220.12	0.000525	4.79	759.58	128.03	0.25
OldSmokyHill_3	19100	Max WS	1813	1208.22	1219.8		1220.07	0.000570	4.89	720.99	132.89	0.26
OldSmokyHill_3	19000	Max WS	1812	1208.09	1219.7		1220.05	0.000786	5.74	617.80	117.50	0.31
OldSmokyHill_3	18900	Max WS	1812	1208.03	1219.6		1219.96	0.000725	5.29	522.56	102.71	0.29
OldSmokyHill_3	18800	Max WS	1811	1207.68	1219.5		1219.89	0.000719	5.31	474.38	96.02	0.29
OldSmokyHill_3	18700	Max WS	1816	1207.84	1219.5		1219.79	0.000521	4.56	522.94	115.07	0.25
OldSmokyHill_3	18600	Max WS	1824	1207.62	1219.3		1219.77	0.000757	5.56	515.15	110.03	0.30
OldSmokyHill_3	18500	Max WS	1824	1207.72	1219.3		1219.68	0.000763	5.44	425.52	58.43	0.30
OldSmokyHill_3	18438	Max WS	1826	1207.54	1219.4	1213.25	1219.61	0.000492	4.60	656.03	86.77	0.24
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1824	1207.53	1219.3		1219.53	0.000459	4.50	696.80	88.91	0.24
OldSmokyHill_3	18300	Max WS	1822	1207.75	1219.3		1219.49	0.000502	4.67	715.30	88.36	0.25
OldSmokyHill_3	18200	Max WS	1822	1207.44	1219.2		1219.44	0.000472	4.55	706.70	98.91	0.24
OldSmokyHill_3	18100	Max WS	1825	1207.44	1219.2		1219.39	0.000468	4.59	767.67	99.11	0.24
OldSmokyHill_3	18000	Max WS	1811	1207.16	1219.1		1219.35	0.000521	4.90	727.87	89.81	0.25
OldSmokyHill_3	17900	Max WS	1811	1207.12	1219.1		1219.28	0.000375	4.11	705.14	91.73	0.22
OldSmokyHill_3	17800	Max WS	1807	1206.53	1219.0		1219.25	0.000473	4.80	736.42	82.09	0.24
OldSmokyHill_3	17700	Max WS	1797	1206.54	1218.9		1219.24	0.000621	5.42	554.80	65.90	0.28
OldSmokyHill_3	17600	Max WS	1902	1206.25	1218.9		1219.14	0.000488	4.85	669.28	80.04	0.25
OldSmokyHill_3	17500	Max WS	1902	1206.45	1218.8		1219.08	0.000433	4.47	632.14	73.50	0.23
OldSmokyHill_3	17400	Max WS	1900	1206.07	1218.7		1219.06	0.000596	5.44	593.58	69.91	0.28
OldSmokyHill_3	17300	Max WS	1900	1205.81	1218.7		1218.97	0.000382	4.32	685.83	79.04	0.22
OldSmokyHill_3	17181	Max WS	2006	1204.48	1218.6	1213.15	1218.91	0.000755	5.08	607.46	90.34	0.27
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2006	1204.22	1217.5		1217.74	0.000569	4.62	544.07	75.61	0.24
OldSmokyHill_3	16800	Max WS	2006	1205.22	1217.1		1217.76	0.001337	7.45	449.67	71.06	0.40
OldSmokyHill_3	16700	Max WS	2006	1204.84	1217.1		1217.57	0.000882	6.19	512.52	80.26	0.33
OldSmokyHill_3	16600	Max WS	2006	1204.49	1217.2	1212.01	1217.40	0.000734	4.33	600.30	105.91	0.28
OldSmokyHill_3	16574		Inl Struct									
OldSmokyHill_3	16500	Max WS	1864	1202.84	1216.5		1216.49	0.000028	1.24	1795.14	150.58	0.06
OldSmokyHill_3	16400	Max WS	1866	1202.78	1216.5		1216.49	0.000030	1.27	1722.12	154.29	0.06
OldSmokyHill_3	16300	Max WS	1896	1202.75	1216.4		1216.49	0.000120	2.46	1267.73	123.09	0.12
OldSmokyHill_3	16200	Max WS	1896	1202.62	1216.4		1216.49	0.000159	2.96	1160.99	115.88	0.14
OldSmokyHill_3	16100	Max WS	1894	1202.56	1216.4		1216.48	0.000167	3.02	1067.90	108.97	0.15
OldSmokyHill_3	16000	Max WS	1894	1202.50	1216.3		1216.46	0.000185	3.17	969.98	97.47	0.15
OldSmokyHill_3	15900	Max WS	1889	1202.34	1216.2		1216.46	0.000294	3.98	658.68	69.73	0.19
OldSmokyHill_3	15800	Max WS	1889	1202.44	1216.2		1216.43	0.000280	3.89	731.24	76.68	0.19
OldSmokyHill_3	15700	Max WS	1907	1202.56	1216.2		1216.40	0.000295	3.86	736.34	78.93	0.19
OldSmokyHill_3	15635	Max WS	1909	1202.00	1216.2	1207.78	1216.38	0.000375	4.02	742.40	79.38	0.19
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1911	1202.00	1216.2		1216.30	0.000356	2.05	1010.52	109.59	0.10
OldSmokyHill_3	15400	Max WS	1907	1202.54	1216.1		1216.29	0.000218	3.38	924.94	88.83	0.17
OldSmokyHill_3	15300	Max WS	1913	1202.93	1216.1		1216.27	0.000299	3.88	857.24	85.89	0.19
OldSmokyHill_3	15200	Max WS	1911	1202.50	1216.1		1216.22	0.000187	3.17	894.20	98.02	0.16
OldSmokyHill_3	15100	Max WS	1911	1202.59	1216.1		1216.21	0.000181	3.13	960.59	93.71	0.15
OldSmokyHill_3	15000	Max WS	1911	1202.48	1216.1		1216.19	0.000193	3.23	993.93	101.44	0.16
OldSmokyHill_3	14900	Max WS	1911	1201.88	1216.0		1216.18	0.000225	3.55	1007.83	101.75	0.17
OldSmokyHill_3	14800	Max WS	1909	1202.06	1216.0		1216.14	0.000151	2.91	1010.08	94.31	0.14
OldSmokyHill_3	14700	Max WS	1916	1202.03	1216.0		1216.14	0.000223	3.54	1031.80	98.55	0.17

HEC-RAS Plan: 04-FWOP-USACE-1%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	14600	Max WS	1918	1201.91	1215.9		1216.13	0.000298	4.07	878.95	90.04	0.20
OldSmokyHill_3	14507	Max WS	1939	1201.00	1215.9	1207.87	1216.11	0.000457	4.58	874.71	93.80	0.21
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	1941	1201.00	1215.5		1215.65	0.000247	3.36	970.98	98.48	0.16
OldSmokyHill_3	14300	Max WS	1941	1202.28	1215.5		1215.63	0.000180	2.99	908.13	91.56	0.15
OldSmokyHill_3	14200	Max WS	1942	1201.94	1215.5		1215.63	0.000283	3.73	845.81	86.65	0.19
OldSmokyHill_3	14100	Max WS	1940	1201.94	1215.5		1215.60	0.000214	3.41	933.79	94.08	0.17
OldSmokyHill_3	14000	Max WS	1940	1202.06	1215.4		1215.57	0.000214	3.37	962.76	98.06	0.17
OldSmokyHill_3	13900	Max WS	1939	1202.00	1215.4		1215.56	0.000256	3.66	932.09	98.30	0.18
OldSmokyHill_3	13800	Max WS	1940	1201.91	1215.4		1215.53	0.000241	3.62	931.69	113.68	0.18
OldSmokyHill_3	13700	Max WS	1940	1202.31	1215.4		1215.49	0.000198	3.22	1156.65	119.40	0.16
OldSmokyHill_3	13600	Max WS	1940	1202.09	1215.3		1215.48	0.000227	3.48	1011.33	101.57	0.17
OldSmokyHill_3	13500	Max WS	1940	1201.84	1215.3		1215.45	0.000173	3.06	1087.85	124.34	0.15
OldSmokyHill_3	13400	Max WS	1939	1202.19	1215.3		1215.44	0.000196	3.21	1064.74	112.39	0.16
OldSmokyHill_3	13300	Max WS	1939	1202.09	1215.3		1215.41	0.000214	3.28	1105.84	104.43	0.16
OldSmokyHill_3	13200	Max WS	1938	1202.00	1215.3		1215.41	0.000259	3.74	1004.34	99.25	0.18
OldSmokyHill_3	13100	Max WS	2059	1201.94	1215.2		1215.37	0.000254	3.72	938.05	92.19	0.18
OldSmokyHill_3	13000	Max WS	2073	1201.75	1215.2		1215.35	0.000310	4.10	976.65	103.12	0.20
OldSmokyHill_3	12900	Max WS	2073	1201.88	1215.1		1215.32	0.000280	3.90	1002.17	100.58	0.19
OldSmokyHill_3	12800	Max WS	2073	1201.88	1215.1		1215.29	0.000278	3.85	981.31	94.25	0.19
OldSmokyHill_3	12700	Max WS	2073	1201.56	1215.1		1215.24	0.000194	3.22	962.57	90.50	0.16
OldSmokyHill_3	12600	Max WS	2073	1201.66	1215.1		1215.23	0.000221	3.45	995.65	96.67	0.17
OldSmokyHill_3	12500	Max WS	2072	1201.75	1215.1		1215.22	0.000266	3.82	1027.71	100.52	0.19
OldSmokyHill_3	12400	Max WS	2080	1201.69	1215.1		1215.17	0.000162	2.95	992.87	92.48	0.15
OldSmokyHill_3	12300	Max WS	2080	1201.38	1215.0		1215.17	0.000250	3.72	912.97	92.38	0.18
OldSmokyHill_3	12200	Max WS	2080	1201.56	1215.0		1215.14	0.000207	3.36	937.64	92.93	0.16
OldSmokyHill_3	12100	Max WS	2083	1201.41	1214.9		1215.13	0.000260	3.78	912.56	87.08	0.18
OldSmokyHill_3	12000	Max WS	2089	1201.25	1214.9		1215.10	0.000257	3.72	942.42	90.83	0.18
OldSmokyHill_3	11900	Max WS	2089	1201.34	1214.9		1215.08	0.000271	3.87	939.26	93.11	0.19
OldSmokyHill_3	11800	Max WS	2090	1201.47	1214.8		1215.07	0.000355	4.37	741.33	79.08	0.21
OldSmokyHill_3	11688	Max WS	2089	1201.35	1214.8		1215.03	0.000362	4.41	760.10	81.22	0.22
OldSmokyHill_3	11600	Max WS	2093	1201.41	1214.8		1214.99	0.000346	4.28	845.39	84.13	0.21
OldSmokyHill_3	11500	Max WS	2093	1201.15	1214.8		1214.93	0.000227	3.51	1009.56	95.78	0.17
OldSmokyHill_3	11400	Max WS	2094	1201.03	1214.8		1214.89	0.000122	2.66	1124.43	102.83	0.13
OldSmokyHill_3	11300	Max WS	2150	1200.84	1214.7		1214.90	0.000271	3.85	979.81	93.44	0.19
OldSmokyHill_3	11200	Max WS	2150	1200.94	1214.7		1214.88	0.000276	3.92	943.10	90.12	0.19
OldSmokyHill_3	11100	Max WS	2149	1200.81	1214.6		1214.86	0.000319	4.21	813.69	78.64	0.20
OldSmokyHill_3	10956	Max WS	2162	1196.19	1214.7		1214.76	0.000090	2.26	1644.21	201.61	0.10
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	571	1195.60	1214.4		1214.40	0.000006	0.59	1411.78	168.03	0.03
OldSmokyHill_3	10500	Max WS	570	1200.88	1214.4		1214.40	0.000017	0.96	1035.11	103.94	0.05
OldSmokyHill_3	10400	Max WS	570	1200.80	1214.4		1214.40	0.000017	0.97	1077.20	108.37	0.05
OldSmokyHill_3	10335	Max WS	570	1200.91	1214.4	1203.37	1214.40	0.000019	1.00	1052.41	102.93	0.05
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	567	1200.91	1214.4		1214.40	0.000020	1.05	992.62	97.40	0.05
OldSmokyHill_3	10200	Max WS	566	1200.59	1214.4		1214.39	0.000014	0.90	1097.12	103.47	0.04
OldSmokyHill_3	10100	Max WS	567	1200.75	1214.4		1214.39	0.000017	0.98	1007.26	97.59	0.05
OldSmokyHill_3	10000	Max WS	568	1200.50	1214.4		1214.39	0.000010	0.76	1000.58	95.11	0.04
OldSmokyHill_3	9900	Max WS	568	1200.38	1214.4		1214.39	0.000012	0.82	1002.83	100.00	0.04
OldSmokyHill_3	9800	Max WS	567	1200.44	1214.4		1214.39	0.000017	1.00	1043.37	99.17	0.05
OldSmokyHill_3	9700	Max WS	565	1200.36	1214.4		1214.39	0.000018	1.01	1060.00	105.15	0.05
OldSmokyHill_3	9600	Max WS	567	1200.22	1214.4		1214.38	0.000017	0.99	1055.75	100.44	0.05
OldSmokyHill_3	9500	Max WS	567	1200.29	1214.4		1214.38	0.000017	1.00	1015.65	95.34	0.05
OldSmokyHill_3	9400	Max WS	564	1200.41	1214.4		1214.38	0.000018	1.03	975.29	93.74	0.05
OldSmokyHill_3	9300	Max WS	566	1200.34	1214.4		1214.38	0.000017	0.99	998.70	94.69	0.05
OldSmokyHill_3	9200	Max WS	567	1200.56	1214.4		1214.38	0.000018	0.98	987.06	101.77	0.05
OldSmokyHill_3	9148	Max WS	571	1200.25	1214.4		1214.38	0.000017	0.99	959.88	95.94	0.05
OldSmokyHill_3	9100	Max WS	577	1200.27	1214.4		1214.38	0.000009	0.74	1065.42	97.44	0.04
OldSmokyHill_3	9000	Max WS	574	1200.25	1214.4		1214.38	0.000015	0.92	991.76	104.04	0.04
OldSmokyHill_3	8900	Max WS	574	1200.31	1214.4		1214.37	0.000018	1.02	938.70	95.39	0.05
OldSmokyHill_3	8800	Max WS	572	1200.53	1214.4		1214.37	0.000015	0.93	1042.18	105.21	0.04
OldSmokyHill_3	8668	Max WS	571	1200.39	1214.4	1203.09	1214.37	0.000026	1.24	931.93	146.56	0.06
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	576	1214.00	1214.4		1214.38	0.000081		986.58	141.70	0.00
OldSmokyHill_3	8500	Max WS	575	1200.37	1214.4		1214.38	0.000018	1.03	1079.07	159.71	0.05
OldSmokyHill_3	8400	Max WS	574	1200.41	1214.4		1214.38	0.000013	0.87	1007.46	96.45	0.04
OldSmokyHill_3	8300	Max WS	577	1199.94	1214.4		1214.37	0.000013	0.90	1026.97	105.07	0.04
OldSmokyHill_3	8200	Max WS	577	1199.79	1214.4		1214.37	0.000014	0.93	1082.05	103.99	0.04
OldSmokyHill_3	8100	Max WS	575	1199.97	1214.4		1214.37	0.000014	0.92	1110.18	122.52	0.04
OldSmokyHill_3	8000	Max WS	576	1199.51	1214.4		1214.37	0.000009	0.77	1075.46	107.46	0.04
OldSmokyHill_3	7900	Max WS	573	1199.72	1214.4		1214.37	0.000014	0.93	1141.86	123.50	0.04
OldSmokyHill_3	7800	Max WS	574	1199.50	1214.4		1214.37	0.000011	0.83	1122.66	117.00	0.04
OldSmokyHill_3	7700	Max WS	573	1199.53	1214.4		1214.37	0.000013	0.91	1115.60	118.53	0.04
OldSmokyHill_3	7600	Max WS	573	1199.56	1214.4		1214.37	0.000013	0.91	1052.13	96.42	0.04
OldSmokyHill_3	7500	Max WS	573	1199.59	1214.4		1214.37	0.000012	0.87	1089.87	99.24	0.04
OldSmokyHill_3	7400	Max WS	574	1199.59	1214.4		1214.36	0.000011	0.82	1236.79	111.21	0.04
OldSmokyHill_3	7300	Max WS	575	1199.63	1214.4		1214.36	0.000011	0.83	1176.62	110.97	0.04
OldSmokyHill_3	7275		Lat Struct									

HEC-RAS Plan: 04-FWOP-USACE-1%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	7200	Max WS	542	1199.58	1214.4		1214.36	0.000010	0.78	1221.32	127.33	0.04
OldSmokyHill_3	7100	Max WS	235	1199.59	1214.4		1214.36	0.000001	0.30	1254.52	120.41	0.01
OldSmokyHill_3	7000	Max WS	239	1199.50	1214.4		1214.36	0.000002	0.38	1090.49	107.90	0.02
OldSmokyHill_3	6900	Max WS	238	1199.53	1214.4		1214.36	0.000002	0.36	1106.09	121.16	0.02
OldSmokyHill_3	6800	Max WS	239	1199.41	1214.4		1214.36	0.000002	0.37	1081.83	109.00	0.02
OldSmokyHill_3	6700	Max WS	239	1199.62	1214.4		1214.36	0.000002	0.37	1133.60	112.41	0.02
OldSmokyHill_3	6600	Max WS	239	1199.46	1214.4		1214.36	0.000002	0.40	1082.89	112.92	0.02
OldSmokyHill_3	6500	Max WS	239	1199.95	1214.4		1214.36	0.000002	0.35	1100.25	112.99	0.02
OldSmokyHill_3	6400	Max WS	239	1199.64	1214.4		1214.36	0.000002	0.35	1142.57	114.24	0.02
OldSmokyHill_3	6300	Max WS	239	1218.07	1214.4		1214.36	0.000010		1111.91	103.38	0.00
OldSmokyHill_3	6200	Max WS	238	1199.70	1214.4		1214.36	0.000002	0.36	1124.05	100.13	0.02
OldSmokyHill_3	6100	Max WS	238	1199.62	1214.4		1214.36	0.000002	0.35	1104.78	98.41	0.02
OldSmokyHill_3	6000	Max WS	237	1199.63	1214.4		1214.36	0.000002	0.38	1104.86	107.23	0.02
OldSmokyHill_3	5900	Max WS	237	1199.56	1214.4		1214.36	0.000002	0.33	1204.86	126.45	0.02
OldSmokyHill_3	5800	Max WS	238	1199.59	1214.4		1214.36	0.000002	0.37	1135.23	132.88	0.02
OldSmokyHill_3	5700	Max WS	239	1199.50	1214.4		1214.36	0.000002	0.37	1122.82	125.60	0.02
OldSmokyHill_3	5600	Max WS	238	1199.57	1214.4		1214.36	0.000002	0.35	1313.05	130.79	0.02
OldSmokyHill_3	5500	Max WS	238	1199.22	1214.4		1214.36	0.000002	0.34	1288.92	123.50	0.02
OldSmokyHill_3	5400	Max WS	237	1199.12	1214.4		1214.36	0.000002	0.39	1171.92	114.39	0.02
OldSmokyHill_3	5300	Max WS	238	1199.14	1214.4		1214.36	0.000002	0.37	1157.95	113.23	0.02
OldSmokyHill_3	5200	Max WS	238	1199.09	1214.4		1214.36	0.000001	0.29	1236.82	120.19	0.01
OldSmokyHill_3	5100	Max WS	236	1198.99	1214.4		1214.36	0.000002	0.38	1232.06	124.43	0.02
OldSmokyHill_3	5000	Max WS	237	1198.99	1214.4		1214.36	0.000002	0.37	1222.92	112.95	0.02
OldSmokyHill_3	4900	Max WS	238	1199.38	1214.4		1214.36	0.000002	0.35	1280.52	121.75	0.02
OldSmokyHill_3	4800	Max WS	236	1198.50	1214.4		1214.36	0.000002	0.32	1389.47	135.00	0.01
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	238	1198.66	1214.4		1214.36	0.000002	0.37	1240.16	132.24	0.02
OldSmokyHill_3	4600	Max WS	239	1198.79	1214.4		1214.36	0.000002	0.33	1310.77	129.42	0.01
OldSmokyHill_3	4500	Max WS	239	1198.69	1214.4		1214.36	0.000002	0.35	1261.42	113.68	0.02
OldSmokyHill_3	4400	Max WS	245	1198.73	1214.4		1214.36	0.000002	0.37	1256.21	123.25	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	270	1198.63	1214.4		1214.36	0.000002	0.39	1320.67	113.00	0.02
OldSmokyHill_3	4200	Max WS	329	1198.66	1214.4		1214.36	0.000004	0.52	1296.55	123.43	0.02
OldSmokyHill_3	4100	Max WS	336	1198.56	1214.4		1214.36	0.000003	0.47	1451.00	146.99	0.02
OldSmokyHill_3	4000	Max WS	495	1198.84	1214.3		1214.35	0.000010	0.80	1348.99	133.88	0.04
OldSmokyHill_3	3900	Max WS	588	1198.91	1214.3		1214.35	0.000011	0.87	1305.73	135.80	0.04
OldSmokyHill_3	3800	Max WS	588	1198.66	1214.3		1214.35	0.000011	0.84	1227.16	158.05	0.04
OldSmokyHill_3	3700	Max WS	584	1198.59	1214.3		1214.35	0.000011	0.88	1326.99	172.95	0.04
OldSmokyHill_3	3600	Max WS	579	1198.52	1214.3		1214.35	0.000014	0.97	1327.15	158.15	0.04
OldSmokyHill_3	3500	Max WS	575	1198.78	1214.3		1214.35	0.000013	0.91	1337.46	151.83	0.04
OldSmokyHill_3	3400	Max WS	571	1198.62	1214.3		1214.35	0.000009	0.79	1291.03	156.36	0.04
OldSmokyHill_3	3300	Max WS	570	1198.34	1214.3		1214.35	0.000011	0.86	1256.32	174.25	0.04
OldSmokyHill_3	3200	Max WS	574	1198.38	1214.3		1214.35	0.000010	0.84	1269.17	180.73	0.04
OldSmokyHill_3	3100	Max WS	581	1198.66	1214.3		1214.34	0.000010	0.80	1337.58	191.67	0.04
OldSmokyHill_3	3000	Max WS	588	1198.34	1214.3		1214.34	0.000010	0.80	1254.09	193.74	0.04
OldSmokyHill_3	2900	Max WS	588	1198.41	1214.3		1214.34	0.000011	0.85	1249.14	121.60	0.04
OldSmokyHill_3	2800	Max WS	588	1198.34	1214.3		1214.34	0.000012	0.91	1275.43	118.51	0.04
OldSmokyHill_3	2700	Max WS	587	1198.47	1214.3		1214.34	0.000011	0.86	1262.71	172.82	0.04
OldSmokyHill_3	2600	Max WS	592	1198.50	1214.3		1214.34	0.000009	0.80	1299.41	162.52	0.04
OldSmokyHill_3	2500	Max WS	592	1198.53	1214.3		1214.34	0.000012	0.90	1163.94	129.49	0.04
OldSmokyHill_3	2400	Max WS	591	1198.93	1214.3		1214.33	0.000007	0.70	1198.96	122.90	0.03
OldSmokyHill_3	2300	Max WS	592	1198.50	1214.3		1214.33	0.000007	0.68	1225.84	122.88	0.03
OldSmokyHill_3	2183	Max WS	591	1196.44	1214.3		1214.33	0.000011	0.84	804.93	124.73	0.04
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	591	1196.78	1208.6		1208.88	0.000404	3.88	152.54	95.34	0.20
OldSmokyHill_3	1900	Max WS	591	1198.47	1208.7		1208.77	0.000047	1.32	614.12	93.73	0.07
OldSmokyHill_3	1800	Max WS	591	1198.28	1208.7		1208.76	0.000040	1.22	714.24	91.93	0.07
OldSmokyHill_3	1700	Max WS	591	1198.12	1208.7		1208.76	0.000029	1.07	771.50	91.08	0.06
OldSmokyHill_3	1600	Max WS	591	1198.25	1208.7		1208.76	0.000048	1.37	710.36	95.65	0.08
OldSmokyHill_3	1500	Max WS	591	1197.76	1208.7		1208.75	0.000035	1.17	741.64	97.55	0.06
OldSmokyHill_3	1400	Max WS	591	1197.88	1208.7		1208.75	0.000033	1.14	717.88	90.90	0.06
OldSmokyHill_3	1300	Max WS	591	1197.69	1208.7		1208.74	0.000062	1.52	509.62	81.77	0.08
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	591	1197.53	1208.7		1208.74	0.000056	1.47	485.24	77.56	0.08
OldSmokyHill_3	1100	Max WS	591	1197.72	1208.7		1208.73	0.000063	1.55	462.72	76.38	0.09
OldSmokyHill_3	1000	Max WS	591	1197.72	1208.7		1208.73	0.000071	1.62	438.14	75.35	0.09
OldSmokyHill_3	900	Max WS	591	1197.44	1208.7		1208.72	0.000076	1.74	433.21	78.57	0.09
OldSmokyHill_3	800	Max WS	591	1197.35	1208.7		1208.71	0.000066	1.63	458.98	80.10	0.09
OldSmokyHill_3	700	Max WS	591	1197.38	1208.7		1208.70	0.000070	1.69	455.18	82.24	0.09
OldSmokyHill_3	660	Max WS	600	1195.72	1208.6	1200.77	1208.70	0.000111	2.02	299.68	78.41	0.11
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	54	1194.57	1201.2		1201.16	0.000069	0.88	61.04	13.55	0.06
OldSmokyHill_3	300	Max WS	603	1194.22	1201.1		1201.28	0.000688	3.03	199.11	41.04	0.24
OldSmokyHill_3	200	Max WS	48	1193.97	1201.1		1201.11	0.000003	0.23	208.80	37.95	0.02
OldSmokyHill_3	100	Max WS	84	1193.86	1201.1	1194.66	1201.10	0.000000	0.07	1166.97	221.76	0.01

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	35900	Max WS	0	1212.00	1215.6		1215.62	0.000000	0.00	58.76	17.54	0.00
OldSmokyHill_3	35800	Max WS	-305	1212.00	1216.0		1216.28	0.002525	-4.29	71.07	19.18	0.39
OldSmokyHill_3	35680	Max WS	-305	1209.80	1217.1	1215.02	1217.85	0.016612	7.00	43.58	21.58	0.78
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-305	1208.30	1224.3		1224.45	0.000594	-3.00	101.67	97.59	0.14
OldSmokyHill_3	35300	Max WS	-305	1214.81	1224.4		1224.43	0.000011	-0.57	599.38	102.53	0.03
OldSmokyHill_3	35200	Max WS	-288	1214.50	1224.4		1224.43	0.000008	-0.52	633.25	101.89	0.03
OldSmokyHill_3	35100	Max WS	-288	1214.57	1224.4		1224.43	0.000008	-0.51	640.62	103.40	0.03
OldSmokyHill_3	35000	Max WS	-260	1214.56	1224.4		1224.43	0.000005	-0.41	703.24	105.18	0.02
OldSmokyHill_3	34900	Max WS	-260	1214.56	1224.4		1224.44	0.000005	-0.41	704.38	107.39	0.02
OldSmokyHill_3	34798	Max WS	-260	1214.94	1224.4		1224.44	0.000005	-0.40	716.14	108.94	0.02
OldSmokyHill_3	34701	Max WS	-260	1214.69	1224.4		1224.44	0.000005	-0.41	697.23	106.84	0.02
OldSmokyHill_3	34604	Max WS	-260	1214.67	1224.4		1224.44	0.000005	-0.40	719.48	109.96	0.02
OldSmokyHill_3	34499	Max WS	-260	1214.72	1224.4		1224.44	0.000005	-0.40	713.90	107.05	0.02
OldSmokyHill_3	34396	Max WS	-261	1214.72	1224.4		1224.44	0.000005	-0.39	725.00	111.06	0.02
OldSmokyHill_3	34306	Max WS	-261	1214.64	1224.4		1224.44	0.000004	-0.39	740.12	111.29	0.02
OldSmokyHill_3	34186	Max WS	-261	1214.72	1224.4		1224.44	0.000009	-0.56	708.89	261.17	0.03
OldSmokyHill_3	34100	Max WS	-261	1214.75	1224.4		1224.44	0.000014	-0.69	714.82	397.10	0.04
OldSmokyHill_3	34013	Max WS	-261	1214.69	1224.4		1224.44	0.000016	-0.65	1139.06	350.61	0.04
OldSmokyHill_3	33965	Max WS	-261	1214.44	1224.4		1224.44	0.000011	-0.53	1082.33	302.86	0.03
OldSmokyHill_3	33914	Max WS	-261	1214.62	1224.4		1224.44	0.000008	-0.47	1088.16	249.67	0.03
OldSmokyHill_3	33833	Max WS	-245	1214.58	1224.4		1224.44	0.000013	-0.59	944.15	218.51	0.03
OldSmokyHill_3	33766	Max WS	-245	1214.90	1224.4		1224.45	0.000013	-0.58	902.03	215.13	0.03
OldSmokyHill_3	33673	Max WS	-245	1214.81	1224.4		1224.45	0.000015	-0.63	772.52	159.49	0.04
OldSmokyHill_3	33600	Max WS	-245	1214.66	1224.4		1224.45	0.000016	-0.65	690.03	112.98	0.04
OldSmokyHill_3	33500	Max WS	-244	1214.44	1224.4		1224.45	0.000013	-0.60	708.34	112.90	0.03
OldSmokyHill_3	33400	Max WS	-241	1214.59	1224.4		1224.45	0.000010	-0.53	726.92	109.41	0.03
OldSmokyHill_3	33300	Max WS	-229	1214.69	1224.4		1224.45	0.000013	-0.58	697.40	106.75	0.03
OldSmokyHill_3	33200	Max WS	-229	1214.66	1224.4		1224.45	0.000012	-0.57	723.40	109.77	0.03
OldSmokyHill_3	33100	Max WS	-229	1214.62	1224.4		1224.45	0.000016	-0.66	633.13	98.64	0.04
OldSmokyHill_3	33000	Max WS	-229	1214.66	1224.5		1224.45	0.000011	-0.54	704.94	129.74	0.03
OldSmokyHill_3	32900	Max WS	-229	1214.88	1224.5		1224.46	0.000011	-0.53	870.15	162.00	0.03
OldSmokyHill_3	32815	Max WS	-97	1211.25	1224.5		1224.46	0.000003	-0.33	464.46	142.56	0.02
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-97	1211.25	1224.5		1224.47	0.000001	-0.12	649.85	152.27	0.01
OldSmokyHill_3	32500	Max WS	-97	1214.22	1224.5		1224.47	0.000002	-0.24	788.14	183.69	0.01
OldSmokyHill_3	32400	Max WS	-78	1214.22	1224.5		1224.47	0.000001	-0.19	773.48	141.38	0.01
OldSmokyHill_3	32338	Max WS	-78	1214.16	1224.5		1224.47	0.000002	-0.22	724.21	168.21	0.01
OldSmokyHill_3	32300	Max WS	-78	1214.28	1224.5		1224.47	0.000001	-0.20	698.53	204.89	0.01
OldSmokyHill_3	32200	Max WS	-78	1214.11	1224.5		1224.47	0.000001	-0.18	779.45	164.00	0.01
OldSmokyHill_3	32100	Max WS	-78	1214.35	1224.5		1224.47	0.000001	-0.18	738.53	121.49	0.01
OldSmokyHill_3	31900	Max WS	-79	1214.09	1224.5		1224.47	0.000002	-0.22	697.19	196.93	0.01
OldSmokyHill_3	31800	Max WS	-26	1213.78	1224.5		1224.47	0.000000	-0.09	760.16	227.58	0.01
OldSmokyHill_3	31700	Max WS	-23	1214.09	1224.5		1224.47	0.000000	-0.08	638.32	230.12	0.00
OldSmokyHill_3	31600	Max WS	-5	1213.59	1224.5		1224.47	0.000000	-0.01	695.00	199.76	0.00
OldSmokyHill_3	31500	Max WS	-5	1213.69	1224.5		1224.47	0.000000	-0.01	878.17	222.12	0.00
OldSmokyHill_3	31400	Max WS	-5	1213.66	1224.5		1224.47	0.000000	-0.01	1090.91	226.46	0.00
OldSmokyHill_3	31300	Max WS	-5	1213.67	1224.5		1224.47	0.000000	-0.01	1002.68	205.83	0.00
OldSmokyHill_3	31200	Max WS	-6	1213.62	1224.5		1224.47	0.000000	-0.01	1011.57	200.77	0.00
OldSmokyHill_3	31100	Max WS	-2	1213.66	1224.5		1224.47	0.000000	0.00	982.56	206.82	0.00
OldSmokyHill_3	31000	Max WS	5	1213.78	1224.5		1224.47	0.000000	0.01	988.45	196.01	0.00
OldSmokyHill_3	30900	Max WS	5	1213.84	1224.5		1224.47	0.000000	0.01	961.15	196.79	0.00
OldSmokyHill_3	30800	Max WS	4	1213.72	1224.5		1224.47	0.000000	0.01	1008.08	196.78	0.00
OldSmokyHill_3	30700	Max WS	4	1213.73	1224.5		1224.47	0.000000	0.01	919.84	187.45	0.00
OldSmokyHill_3	30651	Max WS	4	1213.76	1224.5		1224.47	0.000000	0.01	997.58	182.30	0.00
OldSmokyHill_3	30575	Max WS	4	1213.62	1224.5		1224.47	0.000000	0.01	1011.45	207.92	0.00
OldSmokyHill_3	30500	Max WS	4	1213.78	1224.5		1224.47	0.000000	0.01	1054.90	203.34	0.00
OldSmokyHill_3	30400	Max WS	4	1213.70	1224.5		1224.47	0.000000	0.01	979.61	193.02	0.00
OldSmokyHill_3	30300	Max WS	4	1213.72	1224.5		1224.47	0.000000	0.01	960.41	175.04	0.00
OldSmokyHill_3	30200	Max WS	4	1213.56	1224.5		1224.47	0.000000	0.01	1040.89	184.48	0.00
OldSmokyHill_3	30100	Max WS	4	1213.75	1224.5		1224.47	0.000000	0.01	954.13	161.52	0.00
OldSmokyHill_3	29999	Max WS	3	1213.79	1224.5		1224.47	0.000000	0.01	950.43	139.84	0.00
OldSmokyHill_3	29899	Max WS	4	1213.74	1224.5		1224.47	0.000000	0.01	1064.72	223.60	0.00
OldSmokyHill_3	29800	Max WS	10	1213.69	1224.5		1224.47	0.000000	0.02	1222.63	449.62	0.00
OldSmokyHill_3	29704	Max WS	9	1213.72	1224.5		1224.47	0.000000	0.02	1409.73	566.11	0.00
OldSmokyHill_3	29572	Max WS	9	1213.81	1224.5		1224.47	0.000000	0.02	1308.67	499.70	0.00
OldSmokyHill_3	29466	Max WS	9	1213.59	1224.5		1224.47	0.000000	0.01	1421.79	514.95	0.00
OldSmokyHill_3	29385	Max WS	1432	1213.50	1224.4		1224.47	0.000202	2.47	1425.09	476.68	0.14
OldSmokyHill_3	29314	Max WS	1434	1213.03	1224.4		1224.47	0.000338	3.31	1321.81	430.16	0.18
OldSmokyHill_3	29209	Max WS	1433	1213.06	1224.3		1224.45	0.000432	3.60	1200.19	437.70	0.20
OldSmokyHill_3	29100	Max WS	1433	1213.03	1224.3		1224.39	0.000325	3.18	1246.35	361.98	0.17
OldSmokyHill_3	28991	Max WS	1433	1213.00	1224.2		1224.36	0.000343	3.33	1035.24	273.24	0.18
OldSmokyHill_3	28900	Max WS	1432	1212.85	1224.2		1224.34	0.000418	3.71	962.85	186.49	0.20
OldSmokyHill_3	28800	Max WS	1433	1213.03	1224.2		1224.29	0.000399	3.60	922.05	178.89	0.19
OldSmokyHill_3	28700	Max WS	1433	1213.12	1224.1		1224.26	0.000470	3.86	888.79	176.18	0.21
OldSmokyHill_3	28594	Max WS	1432	1212.92	1224.1		1224.19	0.000310	3.14	788.64	150.62	0.17
OldSmokyHill_3	28500	Max WS	1432	1213.01	1224.1		1224.17	0.000329	3.22	883.79	156.46	0.17
OldSmokyHill_3	28430	Max WS	1459	1210.34	1224.0	1216.11	1224.14	0.000367	3.06	770.88	145.86	0.16

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1459	1209.69	1223.9		1223.99	0.000253	2.90	956.91	260.18	0.15
OldSmokyHill_3	28200	Max WS	1458	1212.97	1223.9		1223.99	0.000275	2.89	960.45	289.40	0.16
OldSmokyHill_3	28100	Max WS	1464	1212.97	1223.8		1223.95	0.000334	3.20	964.81	392.17	0.18
OldSmokyHill_3	28000	Max WS	1464	1213.03	1223.8		1223.92	0.000342	3.32	917.48	250.05	0.18
OldSmokyHill_3	27900	Max WS	1464	1213.00	1223.8		1223.88	0.000348	3.30	866.26	205.88	0.18
OldSmokyHill_3	27800	Max WS	1464	1212.59	1223.7		1223.85	0.000292	3.07	874.63	215.55	0.17
OldSmokyHill_3	27700	Max WS	1464	1212.69	1223.7		1223.82	0.000270	2.93	893.07	202.80	0.16
OldSmokyHill_3	27600	Max WS	1464	1212.75	1223.7		1223.81	0.000414	3.60	855.71	234.91	0.20
OldSmokyHill_3	27500	Max WS	1475	1212.53	1223.6		1223.75	0.000300	3.06	898.03	216.70	0.17
OldSmokyHill_3	27400	Max WS	1475	1212.45	1223.6		1223.73	0.000354	3.32	885.61	194.23	0.18
OldSmokyHill_3	27300	Max WS	1475	1212.53	1223.6		1223.69	0.000313	3.16	952.86	175.62	0.17
OldSmokyHill_3	27200	Max WS	1475	1212.53	1223.5		1223.66	0.000319	3.23	833.65	172.86	0.17
OldSmokyHill_3	27100	Max WS	1480	1212.45	1223.5		1223.63	0.000323	3.23	867.54	235.66	0.17
OldSmokyHill_3	27000	Max WS	1480	1212.19	1223.5		1223.61	0.000435	3.77	892.06	279.59	0.20
OldSmokyHill_3	26900	Max WS	1480	1213.09	1223.4		1223.55	0.000352	3.23	889.09	171.81	0.18
OldSmokyHill_3	26800	Max WS	1480	1212.22	1223.4		1223.51	0.000295	3.01	956.72	171.05	0.16
OldSmokyHill_3	26700	Max WS	1484	1212.12	1223.4		1223.48	0.000296	3.06	935.34	200.89	0.17
OldSmokyHill_3	26600	Max WS	1483	1212.06	1223.3		1223.46	0.000368	3.44	826.34	155.05	0.19
OldSmokyHill_3	26522	Max WS	1481	1211.97	1223.2	1217.19	1223.47	0.000727	4.83	458.37	135.74	0.26
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1480	1211.94	1223.0		1223.28	0.000654	4.56	459.69	126.48	0.25
OldSmokyHill_3	26400	Max WS	1481	1211.88	1223.1		1223.19	0.000286	2.99	840.58	142.17	0.16
OldSmokyHill_3	26300	Max WS	1488	1211.94	1223.1		1223.17	0.000345	3.26	889.80	181.80	0.18
OldSmokyHill_3	26200	Max WS	1488	1212.17	1223.0		1223.13	0.000367	3.34	955.92	150.76	0.18
OldSmokyHill_3	26100	Max WS	1491	1211.88	1223.0		1223.09	0.000246	2.77	935.82	167.21	0.15
OldSmokyHill_3	26000	Max WS	1491	1211.71	1223.0		1223.06	0.000240	2.72	828.27	139.27	0.15
OldSmokyHill_3	25900	Max WS	1491	1211.87	1222.9		1223.05	0.000376	3.42	846.47	145.52	0.19
OldSmokyHill_3	25800	Max WS	1492	1212.01	1222.9		1223.00	0.000240	2.72	937.57	167.27	0.15
OldSmokyHill_3	25700	Max WS	1494	1211.72	1222.9		1222.99	0.000397	3.50	829.57	148.49	0.19
OldSmokyHill_3	25600	Max WS	1492	1211.75	1222.8		1222.94	0.000290	3.02	873.07	153.40	0.16
OldSmokyHill_3	25500	Max WS	1539	1211.75	1222.8		1222.91	0.000297	3.06	953.54	171.37	0.17
OldSmokyHill_3	25400	Max WS	1540	1211.72	1222.8		1222.88	0.000289	3.00	971.55	188.85	0.16
OldSmokyHill_3	25300	Max WS	1541	1211.87	1222.7		1222.87	0.000492	3.88	916.32	225.03	0.21
OldSmokyHill_3	25200	Max WS	1543	1211.81	1222.7		1222.81	0.000370	3.37	878.86	205.27	0.18
OldSmokyHill_3	25117	Max WS	1543	1208.41	1222.7	1213.65	1222.73	0.000715	2.16	1008.90	229.79	0.11
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1543	1208.97	1222.5		1222.59	0.000262	3.01	750.41	235.46	0.15
OldSmokyHill_3	24900	Max WS	1542	1211.71	1222.4		1222.59	0.000333	3.54	891.09	228.31	0.20
OldSmokyHill_3	24800	Max WS	1543	1211.78	1222.4		1222.59	0.000471	4.32	821.81	220.31	0.24
OldSmokyHill_3	24700	Max WS	1550	1211.84	1222.4		1222.51	0.000328	3.56	876.10	214.70	0.20
OldSmokyHill_3	24600	Max WS	1549	1211.34	1222.4		1222.47	0.000245	3.13	936.72	205.71	0.17
OldSmokyHill_3	24500	Max WS	1551	1211.53	1222.3		1222.44	0.000269	3.20	833.70	171.54	0.18
OldSmokyHill_3	24400	Max WS	1552	1211.13	1222.3		1222.41	0.000219	2.96	819.90	154.33	0.16
OldSmokyHill_3	24300	Max WS	1552	1211.19	1222.3		1222.39	0.000217	2.94	813.95	117.80	0.16
OldSmokyHill_3	24200	Max WS	1552	1211.13	1222.3		1222.37	0.000278	3.41	818.14	102.91	0.18
OldSmokyHill_3	24100	Max WS	1550	1211.08	1222.2		1222.36	0.000324	3.61	809.98	149.84	0.20
OldSmokyHill_3	24000	Max WS	1552	1211.22	1222.2		1222.32	0.000309	3.58	844.13	144.40	0.19
OldSmokyHill_3	23900	Max WS	1551	1211.08	1222.2		1222.29	0.000310	3.59	855.70	142.07	0.19
OldSmokyHill_3	23800	Max WS	1571	1211.12	1222.1		1222.26	0.000298	3.53	887.25	155.70	0.19
OldSmokyHill_3	23700	Max WS	1569	1211.28	1222.1		1222.21	0.000211	2.93	818.52	109.97	0.16
OldSmokyHill_3	23600	Max WS	1570	1211.06	1222.1		1222.19	0.000243	3.16	812.66	107.29	0.17
OldSmokyHill_3	23500	Max WS	1570	1210.94	1222.1		1222.17	0.000238	3.13	836.80	99.63	0.17
OldSmokyHill_3	23362	Max WS	1575	1210.95	1222.0	1215.08	1222.13	0.000230	3.07	862.20	106.51	0.17
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1575	1210.60	1222.0		1222.07	0.000178	2.73	857.73	196.49	0.15
OldSmokyHill_3	23167	Max WS	1576	1210.66	1222.0		1222.07	0.000218	3.01	858.56	142.30	0.16
OldSmokyHill_3	23100	Max WS	1582	1210.81	1222.0		1222.06	0.000273	3.38	918.53	169.73	0.18
OldSmokyHill_3	23000	Max WS	1582	1210.50	1221.9		1222.03	0.000207	2.95	960.54	267.67	0.16
OldSmokyHill_3	22900	Max WS	1586	1210.56	1221.9		1222.01	0.000207	2.95	1066.91	285.49	0.16
OldSmokyHill_3	22800	Max WS	1596	1210.71	1221.9		1221.99	0.000210	2.97	1084.32	313.03	0.16
OldSmokyHill_3	22731	Max WS	1596	1210.47	1221.9		1221.98	0.000229	3.10	1095.90	422.20	0.17
OldSmokyHill_3	22656	Max WS	1596	1210.44	1221.8	1214.75	1221.97	0.000281	3.48	931.83	317.04	0.19
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1596	1210.34	1221.8		1221.94	0.000287	3.48	918.97	241.88	0.19
OldSmokyHill_3	22578	Max WS	1595	1210.41	1221.8		1221.92	0.000231	3.15	1004.06	243.79	0.17
OldSmokyHill_3	22500	Max WS	1599	1210.38	1221.8		1221.90	0.000223	3.12	1040.47	232.47	0.17
OldSmokyHill_3	22400	Max WS	1598	1210.44	1221.8		1221.87	0.000235	3.17	1031.01	236.75	0.17
OldSmokyHill_3	22300	Max WS	1599	1210.31	1221.8		1221.85	0.000212	3.06	1110.33	245.15	0.16
OldSmokyHill_3	22200	Max WS	1600	1210.44	1221.8		1221.82	0.000177	2.74	1203.20	246.14	0.15
OldSmokyHill_3	22100	Max WS	1600	1210.16	1221.7		1221.80	0.000153	2.62	1183.52	227.25	0.14
OldSmokyHill_3	22000	Max WS	1602	1210.12	1221.7		1221.79	0.000202	3.00	1056.49	192.83	0.16
OldSmokyHill_3	21900	Max WS	1601	1210.13	1221.7		1221.78	0.000237	3.22	903.44	199.59	0.17
OldSmokyHill_3	21799	Max WS	1597	1210.28	1221.6		1221.76	0.000260	3.38	908.05	167.89	0.18
OldSmokyHill_3	21722	Max WS	1598	1210.11	1221.6	1214.96	1221.74	0.000320	3.78	848.02	158.09	0.20
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1285	1210.11	1221.6		1221.67	0.000216	3.11	840.61	156.28	0.16
OldSmokyHill_3	21600	Max WS	1285	1210.31	1221.6		1221.64	0.000184	2.82	933.66	163.57	0.15

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	21500	Max WS	1294	1210.14	1221.6		1221.62	0.000109	2.18	1136.06	211.73	0.12
OldSmokyHill_3	21400	Max WS	1288	1209.94	1221.6		1221.60	0.000068	1.69	1345.75	299.22	0.09
OldSmokyHill_3	21296	Max WS	1280	1209.94	1221.6		1221.59	0.000065	1.68	1239.69	259.26	0.09
OldSmokyHill_3	21200	Max WS	1280	1209.81	1221.6		1221.58	0.000076	1.82	1299.00	319.27	0.10
OldSmokyHill_3	21100	Max WS	1271	1209.84	1221.5		1221.58	0.000068	1.71	1365.62	353.59	0.09
OldSmokyHill_3	20995	Max WS	1245	1210.03	1221.5		1221.57	0.000072	1.78	1263.10	292.11	0.09
OldSmokyHill_3	20900	Max WS	1245	1209.75	1221.5		1221.56	0.000076	1.83	1256.58	265.71	0.10
OldSmokyHill_3	20800	Max WS	1244	1209.72	1221.5		1221.55	0.000053	1.51	1406.96	296.91	0.08
OldSmokyHill_3	20700	Max WS	1235	1209.45	1221.5		1221.54	0.000063	1.68	1412.21	298.54	0.09
OldSmokyHill_3	20644	Max WS	1225	1209.47	1221.5		1221.54	0.000052	1.48	1389.19	314.93	0.08
OldSmokyHill_3	20600	Max WS	1225	1209.50	1221.5		1221.54	0.000053	1.50	1470.18	339.27	0.08
OldSmokyHill_3	20500	Max WS	1215	1209.50	1221.5		1221.53	0.000067	1.72	1340.85	325.67	0.09
OldSmokyHill_3	20434	Max WS	1204	1209.31	1221.5		1221.53	0.000068	1.73	1374.73	327.55	0.09
OldSmokyHill_3	20363	Max WS	1183	1209.38	1221.5	1213.42	1221.53	0.000104	2.16	1143.70	332.02	0.11
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1194	1209.41	1221.5		1221.51	0.000091	2.03	1197.50	327.12	0.11
OldSmokyHill_3	20300	Max WS	1204	1209.12	1221.5		1221.50	0.000034	1.26	1567.17	324.39	0.07
OldSmokyHill_3	20190	Max WS	2054	1209.13	1221.4		1221.48	0.000211	3.05	1370.69	287.44	0.16
OldSmokyHill_3	20100	Max WS	2065	1209.16	1221.4		1221.47	0.000272	3.52	1187.95	233.26	0.18
OldSmokyHill_3	20023	Max WS	2070	1209.08	1221.3		1221.45	0.000275	3.60	1084.27	186.84	0.19
OldSmokyHill_3	19900	Max WS	2068	1209.08	1221.3		1221.42	0.000235	3.33	1069.03	161.01	0.17
OldSmokyHill_3	19800	Max WS	2068	1208.97	1221.3		1221.40	0.000247	3.40	976.10	141.80	0.18
OldSmokyHill_3	19700	Max WS	2066	1208.94	1221.2		1221.38	0.000311	3.83	826.11	117.93	0.20
OldSmokyHill_3	19600	Max WS	2066	1208.88	1221.2		1221.35	0.000344	4.10	878.75	112.37	0.21
OldSmokyHill_3	19510	Max WS	2066	1208.73	1221.2	1213.38	1221.31	0.000230	3.36	979.00	115.39	0.17
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	2064	1208.72	1221.1		1221.27	0.000291	3.76	1027.80	118.08	0.19
OldSmokyHill_3	19400	Max WS	2062	1208.54	1221.1		1221.28	0.000472	4.85	969.27	132.49	0.24
OldSmokyHill_3	19300	Max WS	2091	1208.31	1221.0		1221.23	0.000444	4.68	922.39	130.91	0.24
OldSmokyHill_3	19200	Max WS	2091	1208.24	1221.0		1221.19	0.000463	4.79	902.95	135.27	0.24
OldSmokyHill_3	19100	Max WS	2087	1208.22	1220.9		1221.15	0.000491	4.84	871.90	141.31	0.25
OldSmokyHill_3	19000	Max WS	2078	1208.09	1220.8		1221.14	0.000669	5.66	756.28	129.53	0.29
OldSmokyHill_3	18900	Max WS	2076	1208.03	1220.7		1221.06	0.000628	5.27	650.32	124.87	0.27
OldSmokyHill_3	18800	Max WS	2070	1207.68	1220.6		1221.00	0.000624	5.30	599.72	124.25	0.27
OldSmokyHill_3	18700	Max WS	2079	1207.84	1220.6		1220.91	0.000453	4.55	672.24	148.43	0.24
OldSmokyHill_3	18600	Max WS	2082	1207.62	1220.5		1220.90	0.000637	5.46	655.11	131.74	0.28
OldSmokyHill_3	18500	Max WS	2077	1207.72	1220.4		1220.84	0.000696	5.57	507.50	84.27	0.29
OldSmokyHill_3	18438	Max WS	2083	1207.54	1220.5	1213.60	1220.75	0.000436	4.63	756.40	88.05	0.23
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	2074	1207.53	1220.3		1220.58	0.000419	4.57	790.58	90.08	0.23
OldSmokyHill_3	18300	Max WS	2074	1207.75	1220.3		1220.55	0.000466	4.78	810.31	92.98	0.24
OldSmokyHill_3	18200	Max WS	2076	1207.44	1220.3		1220.51	0.000442	4.68	818.35	112.18	0.24
OldSmokyHill_3	18100	Max WS	2076	1207.44	1220.2		1220.46	0.000447	4.76	877.79	112.03	0.24
OldSmokyHill_3	18000	Max WS	2075	1207.16	1220.2		1220.42	0.000491	5.04	825.31	94.67	0.25
OldSmokyHill_3	17900	Max WS	2069	1207.12	1220.1		1220.35	0.000352	4.23	805.61	99.17	0.21
OldSmokyHill_3	17800	Max WS	2070	1206.53	1220.1		1220.33	0.000459	5.00	825.94	86.91	0.24
OldSmokyHill_3	17700	Max WS	2067	1206.54	1220.0		1220.32	0.000601	5.65	627.23	70.30	0.28
OldSmokyHill_3	17600	Max WS	2140	1206.25	1219.9		1220.22	0.000445	4.91	757.76	83.64	0.24
OldSmokyHill_3	17500	Max WS	2139	1206.45	1219.9		1220.16	0.000395	4.54	713.00	75.65	0.22
OldSmokyHill_3	17400	Max WS	2136	1206.07	1219.8		1220.16	0.000545	5.51	671.33	72.73	0.27
OldSmokyHill_3	17300	Max WS	2135	1205.81	1219.8		1220.07	0.000352	4.39	774.27	82.91	0.21
OldSmokyHill_3	17181	Max WS	2201	1204.48	1219.7	1213.52	1220.01	0.000613	4.88	712.23	94.21	0.25
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2198	1204.22	1218.7		1218.97	0.000447	4.39	643.32	81.08	0.22
OldSmokyHill_3	16800	Max WS	2191	1205.22	1218.4		1219.00	0.000993	6.94	549.61	76.67	0.35
OldSmokyHill_3	16700	Max WS	2191	1204.84	1218.4		1218.84	0.000664	5.79	625.48	86.03	0.29
OldSmokyHill_3	16600	Max WS	2192	1204.49	1218.5	1212.25	1218.71	0.000494	3.98	726.28	109.80	0.24
OldSmokyHill_3	16574		Inl Struct									
OldSmokyHill_3	16500	Max WS	2187	1202.84	1218.4		1218.43	0.000024	1.26	2090.64	153.97	0.06
OldSmokyHill_3	16400	Max WS	2186	1202.78	1218.4		1218.43	0.000025	1.28	2026.65	159.69	0.06
OldSmokyHill_3	16300	Max WS	2227	1202.75	1218.4		1218.44	0.000100	2.48	1513.04	129.90	0.11
OldSmokyHill_3	16200	Max WS	2227	1202.62	1218.3		1218.43	0.000133	2.97	1392.58	123.08	0.13
OldSmokyHill_3	16100	Max WS	2227	1202.56	1218.3		1218.42	0.000139	3.02	1285.87	115.17	0.14
OldSmokyHill_3	16000	Max WS	2227	1202.50	1218.3		1218.41	0.000154	3.18	1165.15	102.66	0.14
OldSmokyHill_3	15900	Max WS	2227	1202.34	1218.2		1218.42	0.000247	4.00	799.93	74.62	0.18
OldSmokyHill_3	15800	Max WS	2227	1202.44	1218.2		1218.39	0.000235	3.91	888.26	83.62	0.18
OldSmokyHill_3	15700	Max WS	2251	1202.56	1218.2		1218.36	0.000244	3.86	897.53	85.13	0.18
OldSmokyHill_3	15635	Max WS	2253	1202.00	1218.2	1208.39	1218.35	0.000313	4.01	905.45	86.26	0.18
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	2254	1202.00	1218.2		1218.24	0.000282	1.99	1229.97	115.34	0.09
OldSmokyHill_3	15400	Max WS	2253	1202.54	1218.1		1218.24	0.000187	3.44	1102.44	93.90	0.16
OldSmokyHill_3	15300	Max WS	2258	1202.93	1218.1		1218.23	0.000252	3.92	1031.68	93.32	0.18
OldSmokyHill_3	15200	Max WS	2258	1202.50	1218.0		1218.18	0.000165	3.27	1239.87	221.79	0.15
OldSmokyHill_3	15100	Max WS	2258	1202.59	1218.0		1218.17	0.000160	3.23	1194.56	214.24	0.15
OldSmokyHill_3	15000	Max WS	2258	1202.48	1218.0		1218.15	0.000164	3.26	1203.76	146.22	0.15
OldSmokyHill_3	14900	Max WS	2258	1201.88	1218.0		1218.14	0.000200	3.66	1225.20	128.27	0.16
OldSmokyHill_3	14800	Max WS	2258	1202.06	1218.0		1218.10	0.000134	3.00	1206.47	117.49	0.14
OldSmokyHill_3	14700	Max WS	2264	1202.03	1218.0		1218.11	0.000209	3.74	1239.87	126.79	0.17

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	14600	Max WS	2269	1201.91	1217.9		1218.11	0.000265	4.20	1073.07	109.10	0.19
OldSmokyHill_3	14507	Max WS	2296	1201.00	1217.9	1208.39	1218.09	0.000410	4.73	1079.54	117.30	0.21
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	2294	1201.00	1217.5		1217.65	0.000214	3.41	1178.52	110.51	0.15
OldSmokyHill_3	14300	Max WS	2296	1202.28	1217.5		1217.63	0.000149	3.02	1097.80	98.31	0.14
OldSmokyHill_3	14200	Max WS	2295	1201.94	1217.5		1217.64	0.000242	3.81	1032.56	103.13	0.18
OldSmokyHill_3	14100	Max WS	2295	1201.94	1217.4		1217.61	0.000189	3.53	1187.31	149.34	0.16
OldSmokyHill_3	14000	Max WS	2293	1202.06	1217.4		1217.59	0.000193	3.53	1211.17	146.61	0.16
OldSmokyHill_3	13900	Max WS	2293	1202.00	1217.4		1217.58	0.000249	3.97	1232.08	193.53	0.18
OldSmokyHill_3	13800	Max WS	2293	1201.91	1217.4		1217.54	0.000201	3.63	1253.12	191.36	0.16
OldSmokyHill_3	13700	Max WS	2292	1202.31	1217.4		1217.51	0.000185	3.43	1510.04	219.27	0.16
OldSmokyHill_3	13600	Max WS	2292	1202.09	1217.3		1217.51	0.000223	3.79	1334.07	204.20	0.17
OldSmokyHill_3	13500	Max WS	2291	1201.84	1217.3		1217.47	0.000146	3.10	1418.43	212.54	0.14
OldSmokyHill_3	13400	Max WS	2291	1202.19	1217.3		1217.45	0.000167	3.27	1315.20	178.13	0.15
OldSmokyHill_3	13300	Max WS	2292	1202.09	1217.3		1217.43	0.000179	3.31	1349.17	160.33	0.15
OldSmokyHill_3	13200	Max WS	1776	1202.00	1217.3		1217.37	0.000136	2.98	1254.48	167.64	0.14
OldSmokyHill_3	13100	Max WS	1896	1201.94	1217.2		1217.35	0.000132	2.95	1162.62	145.64	0.13
OldSmokyHill_3	13000	Max WS	1880	1201.75	1217.2		1217.34	0.000154	3.18	1218.95	162.72	0.14
OldSmokyHill_3	12900	Max WS	1883	1201.88	1217.2		1217.32	0.000142	3.07	1231.30	130.90	0.14
OldSmokyHill_3	12800	Max WS	1866	1201.88	1217.2		1217.31	0.000136	2.98	1192.27	107.13	0.14
OldSmokyHill_3	12700	Max WS	1866	1201.56	1217.2		1217.28	0.000094	2.47	1159.09	97.99	0.11
OldSmokyHill_3	12600	Max WS	1863	1201.66	1217.2		1217.28	0.000105	2.64	1213.26	108.97	0.12
OldSmokyHill_3	12500	Max WS	1833	1201.75	1217.2		1217.27	0.000124	2.89	1255.33	114.76	0.13
OldSmokyHill_3	12400	Max WS	1838	1201.69	1217.2		1217.25	0.000078	2.27	1213.34	121.20	0.10
OldSmokyHill_3	12300	Max WS	1825	1201.38	1217.2		1217.25	0.000114	2.78	1136.27	113.86	0.13
OldSmokyHill_3	12200	Max WS	1825	1201.56	1217.1		1217.23	0.000094	2.51	1167.90	117.21	0.11
OldSmokyHill_3	12100	Max WS	1800	1201.41	1217.1		1217.23	0.000116	2.80	1116.37	103.11	0.13
OldSmokyHill_3	12000	Max WS	1811	1201.25	1217.1		1217.21	0.000112	2.73	1152.90	101.25	0.12
OldSmokyHill_3	11900	Max WS	1798	1201.34	1217.1		1217.21	0.000117	2.82	1158.70	107.07	0.13
OldSmokyHill_3	11800	Max WS	1783	1201.47	1217.1		1217.20	0.000146	3.12	928.53	87.73	0.14
OldSmokyHill_3	11688	Max WS	1774	1201.35	1217.1		1217.19	0.000149	3.15	959.76	97.58	0.14
OldSmokyHill_3	11600	Max WS	1775	1201.41	1217.1		1217.17	0.000145	3.09	1050.46	99.68	0.14
OldSmokyHill_3	11500	Max WS	1781	1201.15	1217.1		1217.14	0.000098	2.57	1238.00	112.59	0.12
OldSmokyHill_3	11400	Max WS	1779	1201.03	1217.1		1217.12	0.000052	1.92	1371.24	115.68	0.09
OldSmokyHill_3	11300	Max WS	1827	1200.84	1217.0		1217.13	0.000114	2.78	1207.23	107.37	0.12
OldSmokyHill_3	11200	Max WS	1815	1200.94	1217.0		1217.12	0.000119	2.86	1170.14	117.43	0.13
OldSmokyHill_3	11100	Max WS	1802	1200.81	1217.0		1217.11	0.000128	2.97	1009.66	89.59	0.13
OldSmokyHill_3	10956	Max WS	1821	1196.19	1217.0		1217.07	0.000038	1.61	1946.31	209.46	0.07
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	919	1195.60	1216.1		1216.11	0.000011	0.84	1607.84	175.56	0.04
OldSmokyHill_3	10500	Max WS	919	1200.88	1216.1		1216.11	0.000029	1.36	1218.84	113.90	0.06
OldSmokyHill_3	10400	Max WS	921	1200.80	1216.1		1216.11	0.000029	1.37	1265.30	113.96	0.06
OldSmokyHill_3	10335	Max WS	922	1200.91	1216.1	1204.02	1216.10	0.000032	1.42	1232.23	109.82	0.07
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	921	1200.91	1216.1		1216.10	0.000034	1.49	1161.97	103.65	0.07
OldSmokyHill_3	10200	Max WS	921	1200.59	1216.1		1216.09	0.000025	1.30	1283.35	118.01	0.06
OldSmokyHill_3	10100	Max WS	875	1200.75	1216.1		1216.09	0.000028	1.34	1183.17	112.07	0.06
OldSmokyHill_3	10000	Max WS	841	1200.50	1216.1		1216.08	0.000015	1.00	1169.32	108.12	0.05
OldSmokyHill_3	9900	Max WS	845	1200.38	1216.1		1216.08	0.000017	1.08	1181.47	118.13	0.05
OldSmokyHill_3	9800	Max WS	843	1200.44	1216.1		1216.08	0.000026	1.32	1216.90	109.06	0.06
OldSmokyHill_3	9700	Max WS	841	1200.36	1216.1		1216.08	0.000026	1.34	1247.95	118.08	0.06
OldSmokyHill_3	9600	Max WS	840	1200.22	1216.1		1216.08	0.000025	1.30	1230.97	108.25	0.06
OldSmokyHill_3	9500	Max WS	836	1200.29	1216.1		1216.08	0.000025	1.31	1181.92	103.71	0.06
OldSmokyHill_3	9400	Max WS	834	1200.41	1216.1		1216.07	0.000027	1.35	1140.93	104.47	0.06
OldSmokyHill_3	9300	Max WS	832	1200.34	1216.1		1216.07	0.000025	1.31	1175.68	122.44	0.06
OldSmokyHill_3	9200	Max WS	831	1200.56	1216.0		1216.07	0.000025	1.27	1165.21	112.66	0.06
OldSmokyHill_3	9148	Max WS	834	1200.25	1216.0		1216.07	0.000024	1.28	1138.94	127.44	0.06
OldSmokyHill_3	9100	Max WS	844	1200.27	1216.0		1216.06	0.000014	0.97	1245.84	128.10	0.04
OldSmokyHill_3	9000	Max WS	832	1200.25	1216.0		1216.06	0.000021	1.18	1208.24	152.34	0.05
OldSmokyHill_3	8900	Max WS	836	1200.31	1216.0		1216.07	0.000029	1.41	1149.94	196.41	0.06
OldSmokyHill_3	8800	Max WS	828	1200.53	1216.0		1216.06	0.000023	1.25	1338.45	224.22	0.06
OldSmokyHill_3	8668	Max WS	828	1200.39	1216.0	1203.76	1216.06	0.000034	1.53	1124.08	242.04	0.07
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	827	1214.00	1216.0		1216.05	0.000101		1158.00	256.54	0.00
OldSmokyHill_3	8500	Max WS	810	1200.37	1216.0		1216.04	0.000024	1.28	1391.77	244.59	0.06
OldSmokyHill_3	8400	Max WS	817	1200.41	1216.0		1216.04	0.000018	1.12	1186.95	146.25	0.05
OldSmokyHill_3	8300	Max WS	811	1199.94	1216.0		1216.04	0.000018	1.13	1253.90	191.13	0.05
OldSmokyHill_3	8200	Max WS	811	1199.79	1216.0		1216.03	0.000019	1.18	1342.59	188.96	0.05
OldSmokyHill_3	8100	Max WS	811	1199.97	1216.0		1216.03	0.000020	1.17	1340.14	159.59	0.05
OldSmokyHill_3	8000	Max WS	809	1199.51	1216.0		1216.03	0.000013	0.96	1264.58	119.32	0.04
OldSmokyHill_3	7900	Max WS	811	1199.72	1216.0		1216.03	0.000019	1.16	1363.07	147.60	0.05
OldSmokyHill_3	7800	Max WS	809	1199.50	1216.0		1216.03	0.000015	1.06	1346.47	162.22	0.05
OldSmokyHill_3	7700	Max WS	808	1199.53	1216.0		1216.03	0.000020	1.20	1354.98	171.29	0.05
OldSmokyHill_3	7600	Max WS	801	1199.56	1216.0		1216.03	0.000019	1.19	1234.57	150.04	0.05
OldSmokyHill_3	7500	Max WS	801	1199.59	1216.0		1216.02	0.000017	1.11	1277.24	149.66	0.05
OldSmokyHill_3	7400	Max WS	804	1199.59	1216.0		1216.02	0.000015	1.04	1429.81	130.92	0.05
OldSmokyHill_3	7300	Max WS	799	1199.63	1216.0		1216.02	0.000015	1.03	1374.76	133.60	0.05
OldSmokyHill_3	7275		Lat Struct									

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	7200	Max WS	759	1199.58	1216.0		1216.02	0.000014	1.00	1484.20	203.12	0.04
OldSmokyHill_3	7100	Max WS	333	1199.59	1216.0		1216.02	0.000002	0.38	1470.71	140.42	0.02
OldSmokyHill_3	7000	Max WS	337	1199.50	1216.0		1216.02	0.000003	0.47	1278.12	120.44	0.02
OldSmokyHill_3	6900	Max WS	337	1199.53	1216.0		1216.02	0.000003	0.46	1343.23	159.90	0.02
OldSmokyHill_3	6800	Max WS	337	1199.41	1216.0		1216.02	0.000003	0.47	1303.59	144.33	0.02
OldSmokyHill_3	6700	Max WS	336	1199.62	1216.0		1216.02	0.000003	0.47	1334.81	127.98	0.02
OldSmokyHill_3	6600	Max WS	334	1199.46	1216.0		1216.02	0.000003	0.49	1282.00	124.20	0.02
OldSmokyHill_3	6500	Max WS	336	1199.95	1216.0		1216.02	0.000003	0.43	1318.40	150.91	0.02
OldSmokyHill_3	6400	Max WS	335	1199.64	1216.0		1216.02	0.000003	0.44	1406.15	208.18	0.02
OldSmokyHill_3	6300	Max WS	335	1218.07	1216.0		1216.02	0.000022		1356.26	197.34	0.00
OldSmokyHill_3	6200	Max WS	335	1199.70	1216.0		1216.02	0.000003	0.48	1484.79	352.61	0.02
OldSmokyHill_3	6100	Max WS	336	1199.62	1216.0		1216.01	0.000003	0.46	1472.79	368.27	0.02
OldSmokyHill_3	6000	Max WS	336	1199.63	1216.0		1216.01	0.000003	0.49	1374.01	215.60	0.02
OldSmokyHill_3	5900	Max WS	335	1199.56	1216.0		1216.01	0.000003	0.43	1466.06	170.31	0.02
OldSmokyHill_3	5800	Max WS	335	1199.59	1216.0		1216.01	0.000003	0.48	1413.29	201.34	0.02
OldSmokyHill_3	5700	Max WS	336	1199.50	1216.0		1216.01	0.000003	0.47	1356.40	185.98	0.02
OldSmokyHill_3	5600	Max WS	336	1199.57	1216.0		1216.01	0.000003	0.45	1555.80	185.80	0.02
OldSmokyHill_3	5500	Max WS	335	1199.22	1216.0		1216.01	0.000003	0.45	1526.52	186.18	0.02
OldSmokyHill_3	5400	Max WS	334	1199.12	1216.0		1216.01	0.000004	0.52	1382.57	174.55	0.02
OldSmokyHill_3	5300	Max WS	335	1199.14	1216.0		1216.01	0.000003	0.46	1350.19	119.32	0.02
OldSmokyHill_3	5200	Max WS	334	1199.09	1216.0		1216.01	0.000002	0.37	1443.21	128.87	0.02
OldSmokyHill_3	5100	Max WS	334	1198.99	1216.0		1216.01	0.000003	0.47	1443.74	131.53	0.02
OldSmokyHill_3	5000	Max WS	333	1198.99	1216.0		1216.01	0.000003	0.46	1417.47	120.47	0.02
OldSmokyHill_3	4900	Max WS	335	1199.38	1216.0		1216.01	0.000003	0.43	1490.58	162.35	0.02
OldSmokyHill_3	4800	Max WS	334	1198.50	1216.0		1216.01	0.000002	0.44	1707.16	260.79	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	334	1198.66	1216.0		1216.01	0.000003	0.49	1523.06	219.66	0.02
OldSmokyHill_3	4600	Max WS	335	1198.79	1216.0		1216.01	0.000002	0.43	1580.44	209.84	0.02
OldSmokyHill_3	4500	Max WS	339	1198.69	1216.0		1216.01	0.000003	0.46	1486.78	167.78	0.02
OldSmokyHill_3	4400	Max WS	349	1198.73	1216.0		1216.01	0.000003	0.46	1476.66	147.08	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	366	1198.63	1216.0		1216.01	0.000003	0.47	1542.46	158.09	0.02
OldSmokyHill_3	4200	Max WS	409	1198.66	1216.0		1216.01	0.000005	0.59	1551.08	167.50	0.03
OldSmokyHill_3	4100	Max WS	415	1198.56	1216.0		1216.01	0.000003	0.52	1733.22	173.60	0.02
OldSmokyHill_3	4000	Max WS	588	1198.84	1216.0		1216.01	0.000010	0.87	1599.98	165.90	0.04
OldSmokyHill_3	3900	Max WS	759	1198.91	1216.0		1216.01	0.000014	1.03	1580.60	180.28	0.04
OldSmokyHill_3	3800	Max WS	730	1198.66	1216.0		1216.01	0.000011	0.92	1535.94	191.44	0.04
OldSmokyHill_3	3700	Max WS	684	1198.59	1216.0		1216.01	0.000010	0.88	1615.44	176.05	0.04
OldSmokyHill_3	3600	Max WS	643	1198.52	1216.0		1216.01	0.000012	0.94	1600.26	194.91	0.04
OldSmokyHill_3	3500	Max WS	600	1198.78	1216.0		1216.00	0.000009	0.81	1590.26	153.53	0.04
OldSmokyHill_3	3400	Max WS	502	1198.62	1216.0		1216.00	0.000005	0.64	1560.16	164.08	0.03
OldSmokyHill_3	3300	Max WS	403	1198.34	1216.0		1216.00	0.000004	0.52	1548.05	177.06	0.02
OldSmokyHill_3	3200	Max WS	304	1198.38	1216.0		1216.00	0.000002	0.38	1572.62	185.00	0.02
OldSmokyHill_3	3100	Max WS	205	1198.66	1216.0		1216.00	0.000001	0.24	1694.04	244.38	0.01
OldSmokyHill_3	3000	Max WS	97	1198.34	1216.0		1216.00	0.000000	0.12	1691.01	311.79	0.01
OldSmokyHill_3	2900	Max WS	72	1198.41	1216.0		1216.00	0.000000	0.10	1590.11	246.03	0.00
OldSmokyHill_3	2800	Max WS	71	1198.34	1216.0		1216.00	0.000000	0.11	1628.55	249.65	0.00
OldSmokyHill_3	2700	Max WS	71	1198.47	1216.0		1216.00	0.000000	0.09	1623.46	248.32	0.00
OldSmokyHill_3	2600	Max WS	76	1198.50	1216.0		1216.00	0.000000	0.10	1612.15	206.24	0.00
OldSmokyHill_3	2500	Max WS	76	1198.53	1216.0		1216.00	0.000000	0.10	1394.10	159.07	0.00
OldSmokyHill_3	2400	Max WS	76	1198.93	1216.0		1216.00	0.000000	0.08	1419.32	157.93	0.00
OldSmokyHill_3	2300	Max WS	76	1198.50	1216.0		1216.00	0.000000	0.08	1463.63	181.45	0.00
OldSmokyHill_3	2183	Max WS	70	1196.44	1216.0		1216.00	0.000000	0.10	906.29	191.60	0.00
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	69	1196.78	1215.9		1215.93	0.000001	0.27	252.38	167.84	0.01
OldSmokyHill_3	1900	Max WS	82	1198.47	1215.9		1215.93	0.000000	0.09	1447.53	155.19	0.00
OldSmokyHill_3	1800	Max WS	83	1198.28	1215.9		1215.93	0.000000	0.09	1548.20	185.58	0.00
OldSmokyHill_3	1700	Max WS	90	1198.12	1215.9		1215.93	0.000000	0.09	1604.35	200.68	0.00
OldSmokyHill_3	1600	Max WS	106	1198.25	1215.9		1215.93	0.000000	0.13	1696.87	269.27	0.01
OldSmokyHill_3	1500	Max WS	138	1197.76	1215.9		1215.93	0.000000	0.15	1725.93	248.26	0.01
OldSmokyHill_3	1400	Max WS	162	1197.88	1215.9		1215.93	0.000000	0.17	1561.55	182.56	0.01
OldSmokyHill_3	1300	Max WS	168	1197.69	1215.9		1215.93	0.000001	0.22	1200.52	320.09	0.01
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	184	1197.53	1215.9		1215.93	0.000000	0.12	2554.99	453.22	0.01
OldSmokyHill_3	1100	Max WS	238	1197.72	1215.9		1215.93	0.000000	0.18	2441.51	548.16	0.01
OldSmokyHill_3	1000	Max WS	311	1197.72	1215.9		1215.93	0.000001	0.25	2369.39	560.00	0.01
OldSmokyHill_3	900	Max WS	393	1197.44	1215.9		1215.93	0.000001	0.34	2310.10	570.10	0.01
OldSmokyHill_3	800	Max WS	478	1197.35	1215.9		1215.93	0.000002	0.43	2255.85	563.02	0.02
OldSmokyHill_3	700	Max WS	535	1197.38	1215.9		1215.93	0.000003	0.50	2176.11	549.86	0.02
OldSmokyHill_3	660	Max WS	834	1195.72	1215.9	1201.58	1215.94	0.000016	1.07	1676.85	572.80	0.04
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	835	1194.57	1200.3	1201.03	1204.21	0.025314	15.87	52.60	12.92	1.21
OldSmokyHill_3	300	Max WS	835	1194.22	1198.8		1199.67	0.007204	7.61	109.70	33.81	0.74
OldSmokyHill_3	200	Max WS	835	1193.97	1197.9		1199.07	0.010786	8.79	94.94	31.88	0.90
OldSmokyHill_3	100	Max WS	835	1193.86	1197.3	1196.41	1197.36	0.001286	2.84	338.03	196.95	0.31

HEC-RAS Plan: 05-Alt3-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	36405	Max WS	0	1212.50	1218.0		1217.95	0.000000	0.00	311.22	135.05	0.00
OldSmokyHill_3	36394.74	Max WS	-52	1213.50	1218.0	1213.90	1217.96	0.000005	0.23	227.09	67.60	0.02
OldSmokyHill_3	36393		Inl Struct									
OldSmokyHill_3	36392.76	Max WS	-52	1213.50	1218.0		1217.97	0.000005	-0.23	226.52	67.10	0.02
OldSmokyHill_3	36327	Max WS	129	1213.50	1218.1		1218.06	0.000031	0.58	235.47	77.50	0.05
OldSmokyHill_3	36269	Max WS	115	1205.97	1218.1		1218.09	0.000000	0.11	1081.33	132.76	0.01
OldSmokyHill_3	36150	Max WS	80	1205.38	1218.1		1218.11	0.000000	0.05	1473.69	165.60	0.00
OldSmokyHill_3	35948	Max WS	21	1204.53	1218.1		1218.13	0.000000	0.02	980.61	119.07	0.00
OldSmokyHill_3	35900	Max WS	14	1212.00	1218.1		1218.14	0.000001	0.13	110.52	24.97	0.01
OldSmokyHill_3	35800	Max WS	8	1212.00	1218.2		1218.16	0.000000	0.07	121.71	28.29	0.01
OldSmokyHill_3	35770	Max WS	6	1209.00	1218.2	1209.25	1218.16	0.000000	0.02	326.67	43.91	0.00
OldSmokyHill_3	35764		Inl Struct									
OldSmokyHill_3	35756	Max WS	6	1210.00	1218.2		1218.16	0.000000	0.03	226.32	38.49	0.00
OldSmokyHill_3	35680	Max WS	0	1209.80	1218.2	1209.83	1218.17	0.000000	0.00	62.25	24.43	0.00
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-212	1209.50	1221.0		1221.11	0.000124	-2.41	87.67	82.68	0.13
OldSmokyHill_3	35300	Max WS	-212	1209.50	1221.1		1221.08	0.000006	-0.45	530.47	84.90	0.03
OldSmokyHill_3	35200	Max WS	-195	1209.50	1221.1		1221.08	0.000005	-0.41	535.94	85.26	0.02
OldSmokyHill_3	35100	Max WS	-194	1209.50	1221.1		1221.08	0.000004	-0.39	554.10	84.08	0.02
OldSmokyHill_3	35000	Max WS	-173	1210.30	1221.1		1221.08	0.000003	-0.32	595.39	88.24	0.02
OldSmokyHill_3	34900	Max WS	-173	1210.40	1221.1		1221.08	0.000003	-0.33	593.13	89.16	0.02
OldSmokyHill_3	34798	Max WS	-174	1210.50	1221.1		1221.08	0.000003	-0.33	595.92	91.60	0.02
OldSmokyHill_3	34701	Max WS	-173	1210.60	1221.1		1221.08	0.000003	-0.34	575.02	88.48	0.02
OldSmokyHill_3	34604	Max WS	-174	1210.70	1221.1		1221.08	0.000003	-0.34	578.90	91.68	0.02
OldSmokyHill_3	34499	Max WS	-174	1210.80	1221.1		1221.08	0.000003	-0.34	575.64	90.15	0.02
OldSmokyHill_3	34396	Max WS	-174	1210.90	1221.1		1221.08	0.000003	-0.34	574.38	91.56	0.02
OldSmokyHill_3	34306	Max WS	-174	1210.99	1221.1		1221.08	0.000004	-0.34	571.03	92.43	0.02
OldSmokyHill_3	34186	Max WS	-174	1211.11	1221.1		1221.08	0.000004	-0.38	546.51	164.40	0.02
OldSmokyHill_3	34100	Max WS	-174	1211.02	1221.1		1221.08	0.000004	-0.39	530.19	181.69	0.02
OldSmokyHill_3	34013	Max WS	-174	1210.93	1221.1		1221.08	0.000005	-0.42	527.78	203.45	0.02
OldSmokyHill_3	33965	Max WS	-174	1210.88	1221.1		1221.08	0.000005	-0.40	603.68	171.43	0.02
OldSmokyHill_3	33914	Max WS	-174	1210.83	1221.1		1221.08	0.000004	-0.35	785.62	133.87	0.02
OldSmokyHill_3	33833	Max WS	-159	1210.75	1221.1	1211.87	1221.08	0.000003	0.33	725.62	113.63	0.02
OldSmokyHill_3	33800		Inl Struct									
OldSmokyHill_3	33766	Max WS	-159	1210.68	1221.1		1221.09	0.000003	-0.32	723.52	106.74	0.02
OldSmokyHill_3	33673	Max WS	-159	1209.50	1221.1		1221.09	0.000002	-0.26	717.74	90.46	0.01
OldSmokyHill_3	33600	Max WS	-159	1209.50	1221.1		1221.09	0.000003	-0.33	597.98	80.50	0.02
OldSmokyHill_3	33500	Max WS	-159	1209.50	1221.1		1221.09	0.000002	-0.30	639.43	82.61	0.02
OldSmokyHill_3	33400	Max WS	-157	1209.50	1221.1		1221.09	0.000003	-0.32	603.33	82.25	0.02
OldSmokyHill_3	33300	Max WS	-150	1209.50	1221.1		1221.09	0.000003	-0.31	598.10	80.46	0.02
OldSmokyHill_3	33200	Max WS	-149	1209.50	1221.1		1221.09	0.000003	-0.30	612.74	82.75	0.02
OldSmokyHill_3	33100	Max WS	-149	1210.30	1221.1		1221.09	0.000003	-0.31	551.62	72.92	0.02
OldSmokyHill_3	33000	Max WS	-150	1210.40	1221.1		1221.09	0.000003	-0.31	579.00	78.75	0.02
OldSmokyHill_3	32900	Max WS	-150	1210.50	1221.1		1221.09	0.000003	-0.31	637.97	96.70	0.02
OldSmokyHill_3	32815	Max WS	-27	1210.12	1221.1		1221.09	0.000000	-0.05	722.62	131.59	0.00
OldSmokyHill_3	32773	Max WS	-26	1211.25	1221.1		1221.09	0.000001	-0.12	269.37	76.40	0.01
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-28	1211.25	1221.1		1221.09	0.000000	-0.07	429.07	111.55	0.00
OldSmokyHill_3	32500	Max WS	-28	1210.95	1221.1		1221.09	0.000000	-0.10	472.81	83.26	0.01
OldSmokyHill_3	32400	Max WS	-13	1210.85	1221.1		1221.09	0.000000	-0.03	617.35	83.33	0.00
OldSmokyHill_3	32338	Max WS	-14	1210.79	1221.1		1221.09	0.000000	-0.03	548.12	77.11	0.00
OldSmokyHill_3	32300	Max WS	-14	1210.75	1221.1		1221.09	0.000000	-0.03	556.85	78.18	0.00
OldSmokyHill_3	32200	Max WS	-13	1210.65	1221.1		1221.09	0.000000	-0.03	644.24	87.00	0.00
OldSmokyHill_3	32100	Max WS	-14	1210.55	1221.1		1221.09	0.000000	-0.03	602.75	79.04	0.00
OldSmokyHill_3	31900	Max WS	-13	1210.35	1221.1		1221.09	0.000000	-0.03	520.54	68.15	0.00
OldSmokyHill_3	31800	Max WS	30	1210.25	1221.1		1221.09	0.000000	0.06	541.77	70.75	0.00
OldSmokyHill_3	31700	Max WS	33	1209.50	1221.1		1221.09	0.000000	0.07	558.24	76.79	0.00
OldSmokyHill_3	31600	Max WS	48	1209.50	1221.1		1221.09	0.000000	0.10	573.85	80.31	0.01
OldSmokyHill_3	31500	Max WS	48	1209.50	1221.1		1221.09	0.000000	0.10	551.42	74.81	0.01
OldSmokyHill_3	31400	Max WS	48	1209.80	1221.1		1221.09	0.000000	0.09	667.75	90.26	0.01
OldSmokyHill_3	31300	Max WS	48	1209.90	1221.1		1221.09	0.000000	0.09	679.10	90.86	0.01
OldSmokyHill_3	31200	Max WS	48	1210.00	1221.1		1221.09	0.000000	0.09	663.27	88.97	0.01
OldSmokyHill_3	31100	Max WS	50	1210.10	1221.1		1221.09	0.000000	0.10	638.07	87.85	0.01
OldSmokyHill_3	31000	Max WS	56	1210.20	1221.1		1221.09	0.000000	0.11	634.60	84.43	0.01
OldSmokyHill_3	30900	Max WS	56	1210.30	1221.1		1221.09	0.000000	0.11	640.40	84.65	0.01
OldSmokyHill_3	30800	Max WS	56	1210.40	1221.1		1221.09	0.000000	0.12	632.73	85.30	0.01
OldSmokyHill_3	30700	Max WS	56	1210.50	1221.1		1221.09	0.000000	0.12	612.39	80.22	0.01
OldSmokyHill_3	30651	Max WS	56	1210.55	1221.1		1221.09	0.000000	0.10	639.09	86.11	0.01
OldSmokyHill_3	30575	Max WS	56	1210.63	1221.1		1221.09	0.000000	0.12	635.42	86.23	0.01
OldSmokyHill_3	30500	Max WS	56	1210.70	1221.1		1221.09	0.000000	0.12	669.93	93.70	0.01
OldSmokyHill_3	30400	Max WS	56	1210.60	1221.1		1221.09	0.000000	0.12	645.99	89.96	0.01
OldSmokyHill_3	30300	Max WS	56	1210.50	1221.1		1221.09	0.000000	0.12	640.89	85.41	0.01
OldSmokyHill_3	30200	Max WS	56	1210.40	1221.1		1221.09	0.000000	0.11	683.08	92.84	0.01
OldSmokyHill_3	30100	Max WS	56	1210.30	1221.1		1221.09	0.000000	0.11	665.23	88.33	0.01
OldSmokyHill_3	29999	Max WS	56	1210.20	1221.1		1221.09	0.000000	0.11	680.80	88.18	0.01
OldSmokyHill_3	29899	Max WS	56	1210.10	1221.1		1221.09	0.000000	0.11	676.92	89.06	0.01
OldSmokyHill_3	29800	Max WS	62	1210.00	1221.1		1221.09	0.000000	0.11	720.87	100.25	0.01
OldSmokyHill_3	29704	Max WS	61	1209.90	1221.1		1221.09	0.000000	0.11	713.43	91.66	0.01

HEC-RAS Plan: 05-Alt3-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	29572	Max WS	62	1209.77	1221.1		1221.09	0.000000	0.11	690.35	88.87	0.01
OldSmokyHill_3	29466	Max WS	61	1209.66	1221.1		1221.09	0.000000	0.10	784.39	101.83	0.01
OldSmokyHill_3	29385	Max WS	989	1209.50	1221.0		1221.06	0.000096	1.67	720.61	88.95	0.09
OldSmokyHill_3	29314	Max WS	990	1209.50	1221.0		1221.06	0.000164	2.18	612.16	81.90	0.12
OldSmokyHill_3	29209	Max WS	990	1209.50	1221.0		1221.04	0.000156	2.06	592.61	76.56	0.12
OldSmokyHill_3	29100	Max WS	990	1209.50	1221.0		1221.02	0.000166	2.18	609.56	78.23	0.12
OldSmokyHill_3	28991	Max WS	990	1209.50	1220.9		1221.00	0.000169	2.20	605.30	79.81	0.12
OldSmokyHill_3	28900	Max WS	990	1210.12	1220.9		1220.99	0.000152	2.07	611.58	81.48	0.12
OldSmokyHill_3	28800	Max WS	989	1210.22	1220.9		1220.97	0.000158	2.10	607.77	79.42	0.12
OldSmokyHill_3	28700	Max WS	989	1210.32	1220.9		1220.96	0.000167	2.13	590.96	88.88	0.12
OldSmokyHill_3	28594	Max WS	989	1210.43	1220.9		1220.94	0.000113	1.93	598.52	84.72	0.11
OldSmokyHill_3	28500	Max WS	989	1210.52	1220.9		1220.93	0.000104	1.83	648.71	87.77	0.11
OldSmokyHill_3	28430	Max WS	1012	1210.34	1220.8	1214.92	1220.92	0.000482	2.98	456.79	67.39	0.18
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1005	1210.35	1220.4		1220.54	0.000505	3.22	517.07	86.89	0.20
OldSmokyHill_3	28200	Max WS	1005	1210.36	1220.4		1220.49	0.000179	2.09	623.74	87.48	0.12
OldSmokyHill_3	28100	Max WS	1011	1210.26	1220.4		1220.48	0.000174	2.08	648.24	91.61	0.12
OldSmokyHill_3	28000	Max WS	1010	1210.16	1220.4		1220.46	0.000179	2.16	639.38	89.47	0.12
OldSmokyHill_3	27900	Max WS	1010	1210.06	1220.4		1220.44	0.000174	2.14	631.00	86.58	0.12
OldSmokyHill_3	27800	Max WS	1009	1209.96	1220.4		1220.42	0.000172	2.13	615.65	82.62	0.12
OldSmokyHill_3	27700	Max WS	1009	1209.86	1220.4		1220.40	0.000112	1.89	627.07	85.72	0.11
OldSmokyHill_3	27600	Max WS	1010	1209.76	1220.3		1220.39	0.000102	1.82	613.30	81.65	0.11
OldSmokyHill_3	27500	Max WS	1020	1209.50	1220.3		1220.38	0.000120	1.85	604.19	84.08	0.11
OldSmokyHill_3	27400	Max WS	1020	1209.50	1220.3		1220.37	0.000109	1.75	621.68	86.57	0.11
OldSmokyHill_3	27300	Max WS	1020	1209.50	1220.3		1220.36	0.000229	2.40	614.69	87.34	0.14
OldSmokyHill_3	27200	Max WS	1018	1209.50	1220.3		1220.33	0.000127	1.90	587.94	83.14	0.12
OldSmokyHill_3	27100	Max WS	1025	1209.55	1220.3		1220.32	0.000123	2.07	621.08	89.10	0.12
OldSmokyHill_3	27000	Max WS	1024	1209.65	1220.3		1220.31	0.000101	1.77	633.28	84.42	0.11
OldSmokyHill_3	26900	Max WS	1023	1209.75	1220.3		1220.30	0.000089	1.66	672.41	89.18	0.10
OldSmokyHill_3	26800	Max WS	1023	1209.85	1220.2		1220.29	0.000094	1.71	672.21	91.50	0.10
OldSmokyHill_3	26700	Max WS	1026	1209.95	1220.2		1220.28	0.000126	1.98	604.88	82.63	0.12
OldSmokyHill_3	26600	Max WS	1026	1210.05	1220.2		1220.27	0.000135	2.06	580.92	82.07	0.12
OldSmokyHill_3	26522	Max WS	1025	1210.13	1220.1	1214.22	1220.27	0.000403	3.35	369.56	62.98	0.20
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1017	1210.19	1220.0		1220.20	0.000457	3.61	360.84	65.75	0.21
OldSmokyHill_3	26400	Max WS	1023	1210.25	1220.1		1220.15	0.000108	1.78	633.86	89.69	0.11
OldSmokyHill_3	26300	Max WS	1029	1210.35	1220.1		1220.14	0.000221	2.30	615.36	88.81	0.14
OldSmokyHill_3	26200	Max WS	1028	1210.45	1220.0		1220.12	0.000228	2.36	637.02	98.99	0.14
OldSmokyHill_3	26100	Max WS	1034	1210.55	1220.0		1220.09	0.000116	1.80	616.08	87.63	0.11
OldSmokyHill_3	26000	Max WS	1029	1210.45	1220.0		1220.08	0.000235	2.39	608.91	88.09	0.14
OldSmokyHill_3	25900	Max WS	1030	1210.35	1220.0		1220.06	0.000119	1.83	625.21	89.47	0.11
OldSmokyHill_3	25800	Max WS	1030	1210.25	1220.0		1220.05	0.000128	1.92	648.93	99.53	0.12
OldSmokyHill_3	25700	Max WS	1032	1210.15	1220.0		1220.03	0.000120	1.86	606.64	85.05	0.11
OldSmokyHill_3	25600	Max WS	1034	1210.05	1220.0		1220.02	0.000103	1.73	635.59	86.89	0.11
OldSmokyHill_3	25500	Max WS	1072	1209.95	1220.0		1220.01	0.000114	1.84	660.19	93.27	0.11
OldSmokyHill_3	25400	Max WS	1071	1209.85	1219.9		1220.00	0.000205	2.30	656.25	91.92	0.13
OldSmokyHill_3	25300	Max WS	1068	1209.75	1219.9		1219.98	0.000230	2.43	594.93	89.56	0.14
OldSmokyHill_3	25200	Max WS	1071	1209.50	1219.9		1219.95	0.000159	1.95	615.10	84.68	0.12
OldSmokyHill_3	25117	Max WS	1067	1208.41	1219.9	1212.95	1219.91	0.000826	1.97	661.03	97.40	0.11
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1030	1208.97	1219.6		1219.74	0.000355	2.92	454.56	82.23	0.17
OldSmokyHill_3	24900	Max WS	1033	1209.50	1219.7		1219.71	0.000124	1.80	629.94	94.63	0.12
OldSmokyHill_3	24800	Max WS	1030	1209.50	1219.6		1219.70	0.000147	2.02	570.69	88.14	0.13
OldSmokyHill_3	24700	Max WS	1041	1209.50	1219.6		1219.68	0.000118	1.77	628.33	91.35	0.11
OldSmokyHill_3	24600	Max WS	1036	1209.50	1219.6		1219.67	0.000095	1.65	685.47	96.33	0.10
OldSmokyHill_3	24500	Max WS	1036	1209.65	1219.6		1219.66	0.000116	1.82	628.03	89.68	0.11
OldSmokyHill_3	24400	Max WS	1038	1209.75	1219.6		1219.65	0.000106	1.74	637.17	86.94	0.11
OldSmokyHill_3	24300	Max WS	1033	1209.85	1219.6		1219.64	0.000110	1.76	627.56	86.71	0.11
OldSmokyHill_3	24200	Max WS	1031	1209.95	1219.6		1219.63	0.000117	1.81	619.53	88.55	0.11
OldSmokyHill_3	24100	Max WS	1028	1210.05	1219.6		1219.61	0.000125	1.88	594.10	84.29	0.12
OldSmokyHill_3	24000	Max WS	1028	1210.15	1219.5		1219.60	0.000119	1.83	624.17	89.31	0.11
OldSmokyHill_3	23900	Max WS	1022	1210.25	1219.5		1219.59	0.000118	1.81	616.09	89.68	0.11
OldSmokyHill_3	23800	Max WS	1038	1210.35	1219.5		1219.57	0.000127	1.89	597.46	88.64	0.12
OldSmokyHill_3	23700	Max WS	1035	1210.25	1219.5		1219.56	0.000126	1.89	600.56	88.65	0.12
OldSmokyHill_3	23600	Max WS	1032	1210.15	1219.5		1219.54	0.000122	1.84	604.18	88.03	0.12
OldSmokyHill_3	23500	Max WS	1029	1210.05	1219.5		1219.53	0.000109	1.74	632.38	90.70	0.11
OldSmokyHill_3	23362	Max WS	1035	1209.91	1219.5	1213.35	1219.51	0.000109	1.74	647.28	95.84	0.11
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1028	1209.75	1219.4		1219.48	0.000102	1.71	646.50	92.36	0.11
OldSmokyHill_3	23167	Max WS	1032	1209.72	1219.4		1219.48	0.000109	1.77	641.52	96.48	0.11
OldSmokyHill_3	23100	Max WS	1032	1209.50	1219.4		1219.47	0.000114	1.79	647.84	104.64	0.11
OldSmokyHill_3	23000	Max WS	1028	1209.50	1219.4		1219.46	0.000113	1.78	651.65	104.71	0.11
OldSmokyHill_3	22900	Max WS	1033	1209.50	1219.4		1219.45	0.000154	2.24	714.70	115.06	0.13
OldSmokyHill_3	22800	Max WS	1035	1209.55	1219.4		1219.43	0.000144	2.23	707.99	111.64	0.13
OldSmokyHill_3	22731	Max WS	1032	1209.62	1219.4		1219.42	0.000161	2.35	697.38	111.24	0.14
OldSmokyHill_3	22656	Max WS	1035	1209.70	1219.4	1212.99	1219.40	0.000111	1.82	641.14	100.09	0.11
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1028	1209.70	1219.3		1219.39	0.000108	1.79	641.78	101.52	0.11

HEC-RAS Plan: 05-Alt3-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	22578	Max WS	1028	1209.77	1219.3		1219.39	0.000100	1.70	668.27	102.10	0.10
OldSmokyHill_3	22500	Max WS	1027	1209.85	1219.3		1219.38	0.000154	2.27	643.58	105.13	0.13
OldSmokyHill_3	22400	Max WS	1023	1209.95	1219.3		1219.35	0.000218	1.74	587.93	122.03	0.14
OldSmokyHill_3	22300	Max WS	1018	1210.05	1219.3		1219.33	0.000169	1.67	613.00	129.72	0.13
OldSmokyHill_3	22200	Max WS	1017	1210.15	1219.3		1219.32	0.000123	1.51	682.31	147.70	0.11
OldSmokyHill_3	22100	Max WS	1007	1210.25	1219.3		1219.31	0.000103	1.66	672.01	155.45	0.11
OldSmokyHill_3	22000	Max WS	1006	1210.12	1219.2		1219.29	0.000119	1.79	635.16	119.32	0.11
OldSmokyHill_3	21900	Max WS	991	1210.12	1219.2		1219.28	0.000147	2.01	584.18	104.00	0.13
OldSmokyHill_3	21799	Max WS	975	1210.27	1219.2		1219.26	0.000167	2.15	565.81	108.11	0.14
OldSmokyHill_3	21722	Max WS	969	1210.10	1219.2	1213.47	1219.25	0.000182	2.26	522.02	100.21	0.14
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	958	1210.10	1219.2		1219.23	0.000180	2.23	523.15	101.38	0.14
OldSmokyHill_3	21600	Max WS	963	1210.31	1219.2		1219.21	0.000139	1.92	598.14	110.82	0.12
OldSmokyHill_3	21500	Max WS	976	1210.12	1219.2		1219.20	0.000102	1.67	693.06	147.10	0.11
OldSmokyHill_3	21400	Max WS	978	1209.93	1219.2		1219.19	0.000090	1.57	767.64	154.77	0.10
OldSmokyHill_3	21295	Max WS	972	1209.93	1219.1		1219.17	0.000087	1.55	741.80	168.23	0.10
OldSmokyHill_3	21200	Max WS	966	1209.82	1219.1		1219.16	0.000081	1.47	774.04	177.83	0.09
OldSmokyHill_3	21100	Max WS	959	1209.83	1219.1		1219.15	0.000074	1.43	786.25	175.28	0.09
OldSmokyHill_3	20995	Max WS	953	1210.03	1219.1		1219.15	0.000100	1.66	752.75	177.34	0.10
OldSmokyHill_3	20900	Max WS	940	1209.74	1219.1		1219.13	0.000110	1.75	707.11	167.66	0.11
OldSmokyHill_3	20800	Max WS	946	1209.69	1219.1		1219.12	0.000081	1.51	785.77	205.89	0.09
OldSmokyHill_3	20700	Max WS	939	1209.43	1219.1		1219.11	0.000087	1.58	787.94	204.86	0.10
OldSmokyHill_3	20644	Max WS	939	1209.47	1219.1		1219.10	0.000092	1.62	760.77	195.06	0.10
OldSmokyHill_3	20600	Max WS	939	1209.50	1219.1		1219.10	0.000077	1.46	823.35	182.85	0.09
OldSmokyHill_3	20500	Max WS	931	1209.49	1219.1		1219.09	0.000092	1.62	684.36	158.41	0.10
OldSmokyHill_3	20434	Max WS	923	1209.28	1219.0		1219.08	0.000103	1.72	667.58	213.33	0.11
OldSmokyHill_3	20363	Max WS	907	1209.34	1219.0	1212.81	1219.07	0.000127	1.93	527.84	160.34	0.12
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	907	1209.41	1219.0		1219.06	0.000115	1.84	555.61	193.51	0.11
OldSmokyHill_3	20300	Max WS	923	1209.10	1219.0		1219.06	0.000049	1.24	883.36	228.04	0.07
OldSmokyHill_3	20190	Max WS	1580	1209.10	1218.9		1219.01	0.000200	2.35	778.66	177.37	0.15
OldSmokyHill_3	20100	Max WS	1588	1209.16	1218.9		1218.99	0.000243	2.66	688.39	145.38	0.16
OldSmokyHill_3	20023	Max WS	1593	1209.05	1218.9		1218.97	0.000274	2.84	657.19	136.79	0.17
OldSmokyHill_3	19900	Max WS	1593	1209.06	1218.8		1218.94	0.000225	2.58	703.50	135.11	0.16
OldSmokyHill_3	19800	Max WS	1593	1208.97	1218.8		1218.92	0.000277	2.89	642.99	126.60	0.18
OldSmokyHill_3	19700	Max WS	1593	1208.92	1218.7		1218.89	0.000309	3.06	568.84	83.27	0.19
OldSmokyHill_3	19600	Max WS	1593	1208.86	1218.8		1218.86	0.000233	2.67	630.15	86.74	0.16
OldSmokyHill_3	19510	Max WS	1593	1208.72	1218.8	1212.46	1218.84	0.000178	2.36	719.38	98.56	0.14
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1593	1208.72	1218.7		1218.82	0.000158	2.20	767.38	103.13	0.13
OldSmokyHill_3	19400	Max WS	1593	1208.53	1218.7		1218.82	0.000205	2.50	690.82	103.22	0.15
OldSmokyHill_3	19300	Max WS	1621	1208.28	1218.7		1218.79	0.000251	2.70	642.11	101.38	0.17
OldSmokyHill_3	19200	Max WS	1620	1208.22	1218.6		1218.77	0.000261	2.75	623.44	86.96	0.17
OldSmokyHill_3	19100	Max WS	1620	1208.22	1218.5		1218.75	0.000528	3.93	558.82	120.66	0.24
OldSmokyHill_3	19000	Max WS	1620	1208.09	1218.4		1218.71	0.000681	4.48	488.04	92.44	0.27
OldSmokyHill_3	18900	Max WS	1617	1208.03	1218.3		1218.65	0.000928	5.17	404.43	80.22	0.31
OldSmokyHill_3	18800	Max WS	1617	1207.66	1218.2		1218.55	0.000892	5.12	370.39	69.54	0.31
OldSmokyHill_3	18700	Max WS	1623	1207.83	1218.2		1218.46	0.000647	4.42	408.48	69.89	0.26
OldSmokyHill_3	18600	Max WS	1628	1207.62	1218.0		1218.39	0.000849	4.96	388.16	79.13	0.30
OldSmokyHill_3	18500	Max WS	1627	1207.70	1217.9		1218.30	0.000883	4.99	351.66	52.63	0.30
OldSmokyHill_3	18438	Max WS	1630	1207.53	1218.1	1212.56	1218.23	0.000388	3.40	544.91	85.38	0.21
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1630	1207.50	1218.0		1218.15	0.000318	3.06	582.54	87.43	0.19
OldSmokyHill_3	18300	Max WS	1628	1207.75	1218.0		1218.12	0.000285	2.80	605.47	85.17	0.18
OldSmokyHill_3	18200	Max WS	1631	1207.43	1218.0		1218.09	0.000284	2.83	598.47	82.71	0.18
OldSmokyHill_3	18100	Max WS	1632	1207.42	1218.0		1218.06	0.000238	2.60	652.34	90.68	0.16
OldSmokyHill_3	18000	Max WS	1630	1207.16	1217.9		1218.04	0.000261	2.73	622.82	85.62	0.17
OldSmokyHill_3	17900	Max WS	1628	1207.10	1217.9		1218.01	0.000272	2.87	600.31	84.63	0.17
OldSmokyHill_3	17800	Max WS	1632	1206.51	1217.9		1217.98	0.000212	2.60	643.77	78.63	0.15
OldSmokyHill_3	17700	Max WS	1626	1206.52	1217.8		1217.96	0.000387	3.49	483.83	61.45	0.21
OldSmokyHill_3	17600	Max WS	1710	1206.23	1217.8		1217.91	0.000302	3.06	583.07	76.53	0.18
OldSmokyHill_3	17500	Max WS	1708	1206.44	1217.7		1217.88	0.000329	3.24	552.45	71.02	0.19
OldSmokyHill_3	17400	Max WS	1708	1206.06	1217.7		1217.84	0.000371	3.44	521.00	67.32	0.20
OldSmokyHill_3	17300	Max WS	1709	1205.78	1217.7		1217.81	0.000267	2.94	603.45	75.99	0.17
OldSmokyHill_3	17181	Max WS	1794	1204.48	1217.4	1212.06	1217.78	0.000900	5.07	518.77	86.25	0.28
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	1794	1204.22	1216.4		1216.78	0.000813	5.04	467.70	70.37	0.28
OldSmokyHill_3	16923	Max WS	1794	1205.00	1216.5	1210.91	1216.73	0.001394	3.70	522.41	73.43	0.22
OldSmokyHill_3	16917		Inl Struct									
OldSmokyHill_3	16800	Max WS	1794	1205.21	1216.2		1216.60	0.000895	5.03	391.08	66.09	0.31
OldSmokyHill_3	16700	Max WS	1794	1204.84	1216.2	1211.26	1216.52	0.000687	4.52	445.43	74.54	0.27
OldSmokyHill_3	16653		Inl Struct									
OldSmokyHill_3	16600	Max WS	1687	1204.44	1214.2		1214.99	0.002278	7.13	257.06	81.52	0.48
OldSmokyHill_3	16500	Max WS	1680	1202.91	1214.4		1214.48	0.000143	2.33	776.52	100.76	0.12
OldSmokyHill_3	16400	Max WS	1713	1202.78	1214.4	1205.49	1214.46	0.000048	1.38	1286.24	138.81	0.07
OldSmokyHill_3	16356		Inl Struct									
OldSmokyHill_3	16300	Max WS	1705	1202.71	1214.4		1214.44	0.000145	2.30	820.78	109.62	0.13
OldSmokyHill_3	16200	Max WS	1705	1202.61	1214.3		1214.43	0.000179	2.56	746.70	103.00	0.14

HEC-RAS Plan: 05-Alt3-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	16100	Max WS	1705	1202.56	1214.3	1206.84	1214.41	0.000144	2.33	817.04	100.07	0.13
OldSmokyHill_3	16058		Inl Struct									
OldSmokyHill_3	16000	Max WS	1701	1202.51	1214.3		1214.39	0.000238	3.08	687.24	95.85	0.17
OldSmokyHill_3	15900	Max WS	1701	1202.34	1214.2		1214.38	0.000274	3.39	724.40	85.48	0.18
OldSmokyHill_3	15800	Max WS	1715	1202.44	1214.2	1207.51	1214.35	0.000332	3.66	591.42	79.28	0.20
OldSmokyHill_3	15743		Inl Struct									
OldSmokyHill_3	15700	Max WS	1715	1200.38	1214.1		1214.29	0.000247	3.52	700.68	76.84	0.17
OldSmokyHill_3	15635	Max WS	1710	1202.00	1214.0	1207.41	1214.29	0.000571	4.44	579.30	73.07	0.23
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1707	1202.00	1214.0		1214.18	0.000399	3.70	777.67	100.72	0.19
OldSmokyHill_3	15400	Max WS	1707	1200.67	1214.0		1214.13	0.000176	3.03	831.85	84.74	0.15
OldSmokyHill_3	15300	Max WS	1712	1200.77	1214.0		1214.12	0.000196	3.20	782.67	79.10	0.16
OldSmokyHill_3	15200	Max WS	1711	1200.87	1214.0		1214.09	0.000183	2.99	801.84	118.55	0.15
OldSmokyHill_3	15100	Max WS	1711	1200.97	1213.9		1214.07	0.000186	3.00	869.72	120.44	0.15
OldSmokyHill_3	15000	Max WS	1709	1200.87	1213.9		1214.05	0.000165	2.84	909.99	123.15	0.14
OldSmokyHill_3	14900	Max WS	1709	1200.77	1213.9		1214.04	0.000189	3.14	896.86	115.23	0.16
OldSmokyHill_3	14800	Max WS	1709	1200.67	1213.9		1214.02	0.000183	3.10	907.36	115.28	0.15
OldSmokyHill_3	14700	Max WS	1713	1200.57	1213.9		1214.00	0.000174	3.02	906.46	93.78	0.15
OldSmokyHill_3	14600	Max WS	1718	1200.47	1213.8		1213.99	0.000194	3.20	773.87	82.24	0.16
OldSmokyHill_3	14507	Max WS	1732	1201.00	1213.7	1207.54	1214.01	0.000701	5.07	680.28	86.20	0.26
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	1729	1201.00	1213.3		1213.46	0.000375	3.68	760.02	91.43	0.19
OldSmokyHill_3	14300	Max WS	1731	1200.17	1213.3		1213.43	0.000194	3.15	808.39	85.24	0.16
OldSmokyHill_3	14200	Max WS	1732	1200.07	1213.3		1213.41	0.000196	3.17	774.22	80.46	0.16
OldSmokyHill_3	14100	Max WS	1729	1199.97	1213.3		1213.39	0.000182	3.07	820.25	85.94	0.15
OldSmokyHill_3	14000	Max WS	1730	1197.97	1213.3		1213.37	0.000151	2.87	883.19	88.63	0.14
OldSmokyHill_3	13900	Max WS	1728	1197.97	1213.2		1213.35	0.000143	2.73	863.86	86.93	0.13
OldSmokyHill_3	13800	Max WS	1728	1197.97	1213.2		1213.34	0.000137	2.63	842.40	87.54	0.13
OldSmokyHill_3	13700	Max WS	1730	1197.97	1213.2		1213.32	0.000114	2.41	1056.98	106.59	0.12
OldSmokyHill_3	13600	Max WS	1729	1197.97	1213.2		1213.31	0.000136	2.66	923.34	95.22	0.13
OldSmokyHill_3	13500	Max WS	1729	1197.97	1213.2		1213.30	0.000123	2.50	966.77	101.75	0.12
OldSmokyHill_3	13400	Max WS	1729	1199.47	1213.2		1213.29	0.000133	2.60	945.47	100.96	0.13
OldSmokyHill_3	13300	Max WS	1729	1199.57	1213.2		1213.27	0.000130	2.54	1002.84	97.08	0.13
OldSmokyHill_3	13200	Max WS	1728	1199.67	1213.2		1213.26	0.000127	2.50	895.90	93.36	0.13
OldSmokyHill_3	13100	Max WS	1833	1199.77	1213.1		1213.24	0.000173	2.92	836.88	85.05	0.15
OldSmokyHill_3	13000	Max WS	1845	1199.87	1213.1		1213.23	0.000191	3.10	846.78	95.65	0.15
OldSmokyHill_3	12900	Max WS	1845	1199.97	1213.1		1213.21	0.000184	3.00	882.00	93.54	0.15
OldSmokyHill_3	12800	Max WS	1844	1200.07	1213.1		1213.18	0.000167	2.84	866.48	88.39	0.14
OldSmokyHill_3	12700	Max WS	1843	1200.17	1213.0		1213.17	0.000198	3.11	842.08	86.36	0.16
OldSmokyHill_3	12600	Max WS	1844	1200.27	1213.0		1213.16	0.000236	3.43	856.93	89.83	0.17
OldSmokyHill_3	12500	Max WS	1845	1200.17	1213.0		1213.12	0.000161	2.77	888.57	93.76	0.14
OldSmokyHill_3	12400	Max WS	1851	1200.07	1213.0		1213.11	0.000154	2.71	874.18	87.87	0.14
OldSmokyHill_3	12300	Max WS	1850	1199.97	1213.0		1213.10	0.000194	3.08	786.03	85.84	0.16
OldSmokyHill_3	12200	Max WS	1849	1199.87	1212.9		1213.08	0.000217	3.32	816.17	85.47	0.17
OldSmokyHill_3	12100	Max WS	1851	1199.77	1212.9		1213.06	0.000221	3.37	804.22	82.40	0.17
OldSmokyHill_3	12000	Max WS	1855	1199.67	1212.9		1213.04	0.000208	3.27	838.60	84.59	0.16
OldSmokyHill_3	11900	Max WS	1855	1197.80	1212.9		1213.02	0.000192	3.22	850.29	88.58	0.16
OldSmokyHill_3	11800	Max WS	1857	1197.80	1212.8		1213.00	0.000239	3.58	682.57	73.81	0.17
OldSmokyHill_3	11688	Max WS	1856	1197.80	1212.8		1212.97	0.000208	3.30	702.53	74.46	0.16
OldSmokyHill_3	11600	Max WS	1857	1197.80	1212.8		1212.95	0.000199	3.27	789.27	78.37	0.16
OldSmokyHill_3	11500	Max WS	1859	1197.80	1212.8		1212.92	0.000112	2.35	921.11	90.66	0.12
OldSmokyHill_3	11400	Max WS	1859	1199.05	1212.8		1212.91	0.000106	2.33	992.57	96.11	0.12
OldSmokyHill_3	11300	Max WS	1902	1199.15	1212.8		1212.90	0.000151	2.76	884.44	88.71	0.14
OldSmokyHill_3	11200	Max WS	1901	1199.25	1212.8		1212.89	0.000198	3.21	844.99	84.35	0.16
OldSmokyHill_3	11100	Max WS	662	1199.35	1212.7		1212.76	0.000026	1.14	655.64	62.31	0.06
OldSmokyHill_3	10956	Max WS	1913	1196.19	1212.8		1212.82	0.000069	1.77	1393.41	196.28	0.09
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	550	1195.60	1212.5		1212.54	0.000010	0.66	1196.45	159.68	0.03
OldSmokyHill_3	10500	Max WS	548	1199.95	1212.5		1212.54	0.000015	0.82	963.14	106.19	0.04
OldSmokyHill_3	10400	Max WS	550	1200.05	1212.5		1212.53	0.000012	0.74	947.04	111.22	0.04
OldSmokyHill_3	10335	Max WS	550	1199.99	1212.5	1202.35	1212.53	0.000013	0.77	907.39	96.64	0.04
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	550	1199.95	1212.5		1212.53	0.000014	0.82	855.92	91.53	0.04
OldSmokyHill_3	10200	Max WS	549	1199.86	1212.5		1212.53	0.000011	0.72	932.79	97.69	0.04
OldSmokyHill_3	10100	Max WS	553	1199.76	1212.5		1212.53	0.000012	0.74	871.94	91.43	0.04
OldSmokyHill_3	10000	Max WS	552	1199.66	1212.5		1212.52	0.000012	0.74	863.63	87.39	0.04
OldSmokyHill_3	9900	Max WS	551	1199.56	1212.5		1212.52	0.000012	0.77	856.12	90.22	0.04
OldSmokyHill_3	9800	Max WS	545	1199.46	1212.5		1212.52	0.000011	0.73	900.62	94.61	0.04
OldSmokyHill_3	9700	Max WS	550	1199.36	1212.5		1212.52	0.000011	0.74	913.27	97.23	0.04
OldSmokyHill_3	9600	Max WS	550	1199.26	1212.5		1212.52	0.000011	0.75	923.25	92.91	0.04
OldSmokyHill_3	9500	Max WS	549	1199.16	1212.5		1212.52	0.000011	0.74	891.20	89.97	0.04
OldSmokyHill_3	9400	Max WS	547	1199.06	1212.5		1212.52	0.000012	0.77	856.19	87.08	0.04
OldSmokyHill_3	9300	Max WS	544	1198.96	1212.5		1212.52	0.000011	0.75	879.05	87.93	0.04
OldSmokyHill_3	9200	Max WS	550	1198.86	1212.5		1212.52	0.000012	0.77	870.40	96.21	0.04
OldSmokyHill_3	9148	Max WS	555	1198.81	1212.5		1212.52	0.000012	0.77	850.81	86.04	0.04
OldSmokyHill_3	9100	Max WS	560	1198.76	1212.5		1212.51	0.000009	0.70	943.75	91.79	0.03
OldSmokyHill_3	9000	Max WS	554	1198.66	1212.5		1212.51	0.000012	0.81	883.67	92.69	0.04
OldSmokyHill_3	8900	Max WS	556	1198.56	1212.5		1212.51	0.000016	0.94	834.88	87.92	0.05

HEC-RAS Plan: 05-Alt3-USACE-2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	8800	Max WS	554	1198.46	1212.5		1212.51	0.000014	0.89	925.50	95.62	0.04
OldSmokyHill_3	8668	Max WS	553	1198.33	1212.5	1201.06	1212.51	0.000033	1.26	790.57	95.61	0.06
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	553	1195.72	1212.5		1212.51	0.000012	0.82	925.18	97.14	0.04
OldSmokyHill_3	8500	Max WS	555	1195.72	1212.5		1212.50	0.000012	0.84	974.31	97.15	0.04
OldSmokyHill_3	8400	Max WS	555	1195.72	1212.5		1212.50	0.000012	0.84	938.49	89.97	0.04
OldSmokyHill_3	8300	Max WS	554	1195.72	1212.5		1212.50	0.000008	0.69	960.81	90.09	0.03
OldSmokyHill_3	8200	Max WS	552	1197.72	1212.5		1212.50	0.000011	0.81	969.54	96.63	0.04
OldSmokyHill_3	8100	Max WS	553	1198.72	1212.5		1212.50	0.000010	0.72	956.58	102.78	0.04
OldSmokyHill_3	8000	Max WS	555	1199.50	1212.5		1212.50	0.000010	0.70	905.80	87.91	0.04
OldSmokyHill_3	7900	Max WS	553	1199.40	1212.5		1212.50	0.000011	0.75	948.11	102.02	0.04
OldSmokyHill_3	7800	Max WS	552	1199.30	1212.5		1212.50	0.000016	0.91	931.41	100.27	0.04
OldSmokyHill_3	7700	Max WS	552	1199.20	1212.5		1212.50	0.000019	1.01	930.40	98.91	0.05
OldSmokyHill_3	7600	Max WS	550	1199.10	1212.5		1212.49	0.000010	0.73	903.33	91.08	0.04
OldSmokyHill_3	7500	Max WS	553	1199.00	1212.5		1212.49	0.000015	0.91	932.47	92.54	0.04
OldSmokyHill_3	7400	Max WS	553	1198.90	1212.5		1212.49	0.000015	0.89	1057.18	102.85	0.04
OldSmokyHill_3	7300	Max WS	553	1198.80	1212.5		1212.49	0.000015	0.90	999.31	102.57	0.04
OldSmokyHill_3	7275		Lat Struct									
OldSmokyHill_3	7200	Max WS	530	1198.80	1212.5		1212.49	0.000014	0.86	1024.59	109.72	0.04
OldSmokyHill_3	7100	Max WS	248	1198.60	1212.5		1212.49	0.000002	0.29	1072.12	106.92	0.01
OldSmokyHill_3	7000	Max WS	250	1198.50	1212.5		1212.49	0.000002	0.35	927.02	100.07	0.02
OldSmokyHill_3	6900	Max WS	251	1195.72	1212.5		1212.49	0.000002	0.35	991.95	104.38	0.02
OldSmokyHill_3	6800	Max WS	252	1195.72	1212.5		1212.49	0.000002	0.38	981.19	91.83	0.02
OldSmokyHill_3	6700	Max WS	250	1195.72	1212.5		1212.49	0.000002	0.39	1024.76	101.51	0.02
OldSmokyHill_3	6600	Max WS	252	1195.72	1212.5		1212.49	0.000002	0.35	990.07	95.30	0.02
OldSmokyHill_3	6500	Max WS	251	1198.22	1212.5		1212.49	0.000003	0.38	964.01	105.10	0.02
OldSmokyHill_3	6400	Max WS	252	1199.22	1212.5		1212.49	0.000003	0.41	954.97	96.57	0.02
OldSmokyHill_3	6300	Max WS	251	1199.32	1212.5		1212.49	0.000003	0.41	938.08	93.38	0.02
OldSmokyHill_3	6200	Max WS	251	1199.42	1212.5		1212.49	0.000004	0.43	951.39	92.28	0.02
OldSmokyHill_3	6100	Max WS	252	1199.32	1212.5		1212.49	0.000003	0.42	941.71	89.07	0.02
OldSmokyHill_3	6000	Max WS	251	1199.22	1212.5		1212.49	0.000004	0.44	933.20	96.47	0.02
OldSmokyHill_3	5900	Max WS	251	1199.12	1212.5		1212.49	0.000003	0.40	1011.75	105.43	0.02
OldSmokyHill_3	5800	Max WS	251	1199.02	1212.5		1212.48	0.000004	0.44	940.33	104.54	0.02
OldSmokyHill_3	5700	Max WS	251	1198.92	1212.5		1212.48	0.000003	0.43	943.60	96.63	0.02
OldSmokyHill_3	5600	Max WS	250	1196.42	1212.5		1212.48	0.000001	0.31	1206.83	116.85	0.01
OldSmokyHill_3	5500	Max WS	250	1195.72	1212.5		1212.48	0.000002	0.36	1150.69	114.54	0.02
OldSmokyHill_3	5400	Max WS	251	1195.72	1212.5		1212.48	0.000003	0.39	1041.82	100.20	0.02
OldSmokyHill_3	5300	Max WS	250	1195.72	1212.5		1212.48	0.000002	0.33	1049.57	102.04	0.02
OldSmokyHill_3	5200	Max WS	251	1195.72	1212.5		1212.48	0.000001	0.28	1107.63	101.45	0.01
OldSmokyHill_3	5100	Max WS	251	1195.72	1212.5		1212.48	0.000001	0.28	1098.67	106.69	0.01
OldSmokyHill_3	5000	Max WS	251	1195.72	1212.5		1212.48	0.000001	0.28	1102.49	105.36	0.01
OldSmokyHill_3	4900	Max WS	251	1198.22	1212.5		1212.48	0.000001	0.28	1104.06	105.94	0.01
OldSmokyHill_3	4800	Max WS	250	1198.32	1212.5		1212.48	0.000002	0.34	1164.98	121.00	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	251	1198.44	1212.5		1212.48	0.000003	0.41	1043.08	121.38	0.02
OldSmokyHill_3	4600	Max WS	250	1198.52	1212.5		1212.48	0.000003	0.37	1120.23	117.41	0.02
OldSmokyHill_3	4500	Max WS	250	1198.62	1212.5		1212.48	0.000001	0.27	1078.61	114.85	0.01
OldSmokyHill_3	4400	Max WS	250	1198.71	1212.5		1212.48	0.000002	0.30	1037.57	113.67	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	250	1198.63	1212.5	1200.14	1212.48	0.000001	0.28	1114.99	107.83	0.01
OldSmokyHill_3	4278		Bridge									
OldSmokyHill_3	4200	Max WS	250	1198.65	1212.5		1212.47	0.000002	0.28	1077.00	111.10	0.01
OldSmokyHill_3	4100	Max WS	321	1198.57	1212.5		1212.47	0.000002	0.34	1182.18	138.95	0.02
OldSmokyHill_3	4000	Max WS	560	1198.39	1212.5		1212.47	0.000007	0.61	1143.57	132.39	0.03
OldSmokyHill_3	3900	Max WS	568	1198.29	1212.5		1212.47	0.000008	0.67	1104.11	115.75	0.03
OldSmokyHill_3	3800	Max WS	568	1195.72	1212.5		1212.47	0.000006	0.62	1116.18	103.08	0.03
OldSmokyHill_3	3700	Max WS	568	1195.72	1212.5		1212.47	0.000007	0.63	1128.41	107.32	0.03
OldSmokyHill_3	3600	Max WS	568	1195.72	1212.5		1212.47	0.000010	0.80	1155.50	109.38	0.04
OldSmokyHill_3	3500	Max WS	568	1195.72	1212.5		1212.47	0.000009	0.76	1179.52	105.23	0.03
OldSmokyHill_3	3400	Max WS	568	1198.22	1212.5		1212.47	0.000007	0.62	1086.68	103.13	0.03
OldSmokyHill_3	3300	Max WS	568	1198.32	1212.5		1212.46	0.000008	0.67	1013.48	97.14	0.03
OldSmokyHill_3	3200	Max WS	568	1198.39	1212.5		1212.46	0.000010	0.72	980.25	100.08	0.04
OldSmokyHill_3	3100	Max WS	568	1198.66	1212.5		1212.46	0.000015	0.91	1011.92	138.17	0.04
OldSmokyHill_3	3000	Max WS	568	1198.34	1212.5		1212.46	0.000013	0.87	999.82	102.29	0.04
OldSmokyHill_3	2900	Max WS	568	1198.41	1212.4		1212.46	0.000016	0.95	1035.55	108.06	0.05
OldSmokyHill_3	2800	Max WS	568	1198.34	1212.4		1212.46	0.000019	1.03	1059.19	111.45	0.05
OldSmokyHill_3	2700	Max WS	568	1198.47	1212.4		1212.46	0.000016	0.97	1040.19	107.67	0.05
OldSmokyHill_3	2600	Max WS	572	1198.50	1212.4		1212.45	0.000014	0.90	1070.75	110.22	0.04
OldSmokyHill_3	2500	Max WS	572	1198.53	1212.4		1212.45	0.000020	1.07	932.62	116.26	0.05
OldSmokyHill_3	2400	Max WS	572	1198.93	1212.4	1201.60	1212.45	0.000012	0.82	976.97	112.31	0.04
OldSmokyHill_3	2345		Inl Struct									
OldSmokyHill_3	2300	Max WS	572	1198.50	1212.4		1212.44	0.000011	0.79	1002.50	113.01	0.04
OldSmokyHill_3	2183	Max WS	572	1196.44	1212.4		1212.44	0.000016	0.94	701.15	112.08	0.04
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	572	1196.78	1207.1		1207.38	0.000624	4.36	131.17	87.58	0.25
OldSmokyHill_3	1900	Max WS	572	1198.47	1207.2		1207.24	0.000088	1.61	476.94	84.99	0.10
OldSmokyHill_3	1800	Max WS	572	1198.28	1207.2		1207.23	0.000054	1.21	576.28	88.05	0.08
OldSmokyHill_3	1700	Max WS	572	1198.12	1207.2		1207.23	0.000048	1.24	634.89	86.93	0.07

HEC-RAS Plan: 05-Alt3-USACE-2%AEP   River: OldSmokyHill   Reach: OldSmokyHill_3   Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	1600	Max WS	572	1198.25	1207.2		1207.22	0.000080	1.58	570.54	84.27	0.10
OldSmokyHill_3	1500	Max WS	572	1197.76	1207.2		1207.22	0.000058	1.36	597.12	87.68	0.08
OldSmokyHill_3	1400	Max WS	572	1197.87	1207.2		1207.21	0.000042	1.11	582.85	84.99	0.07
OldSmokyHill_3	1300	Max WS	572	1197.69	1207.2		1207.20	0.000109	1.80	398.24	68.93	0.11
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	572	1197.53	1207.2		1207.19	0.000111	1.85	369.81	69.84	0.11
OldSmokyHill_3	1100	Max WS	572	1197.72	1207.1		1207.18	0.000125	1.96	349.87	67.50	0.12
OldSmokyHill_3	1000	Max WS	572	1197.72	1207.1		1207.17	0.000136	2.01	330.21	61.96	0.12
OldSmokyHill_3	900	Max WS	572	1197.44	1207.1		1207.16	0.000149	2.18	320.29	62.59	0.13
OldSmokyHill_3	800	Max WS	572	1197.35	1207.1		1207.14	0.000136	2.10	338.98	68.66	0.12
OldSmokyHill_3	700	Max WS	572	1197.38	1207.1		1207.13	0.000137	2.14	335.07	65.43	0.12
OldSmokyHill_3	660	Max WS	580	1195.72	1207.0	1200.74	1207.12	0.000204	2.35	246.51	60.82	0.13
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	580	1194.52	1199.0	1199.53	1202.09	0.015498	14.03	41.38	11.85	1.18
OldSmokyHill_3	300	Max WS	580	1194.21	1198.0		1198.79	0.005677	7.12	86.14	31.27	0.68
OldSmokyHill_3	200	Max WS	575	1193.97	1197.4		1198.24	0.007052	7.52	80.32	30.73	0.75
OldSmokyHill_3	100	Max WS	580	1193.79	1197.0	1196.03	1197.06	0.001286	2.03	287.30	188.59	0.29

HEC-RAS Plan: 05-Alt3-USACE-01%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	36405	Max WS	0	1212.50	1220.6		1220.58	0.000000	0.00	609.44	145.79	0.00
OldSmokyHill_3	36394.74	Max WS	176	1213.50	1220.6	1214.39	1220.61	0.000010	0.45	452.38	105.16	0.03
OldSmokyHill_3	36393		Inl Struct									
OldSmokyHill_3	36392.76	Max WS	-309	1213.50	1220.6		1220.63	0.000030	-0.80	439.19	97.42	0.06
OldSmokyHill_3	36327	Max WS	147	1213.50	1220.8		1220.85	0.000006	0.37	478.85	101.85	0.02
OldSmokyHill_3	36269	Max WS	126	1205.97	1220.9		1220.94	0.000000	0.09	1493.26	157.24	0.00
OldSmokyHill_3	36150	Max WS	90	1205.38	1221.0		1221.03	0.000000	0.05	1980.28	182.41	0.00
OldSmokyHill_3	35948	Max WS	34	1204.53	1221.1		1221.11	0.000000	0.03	1363.47	139.71	0.00
OldSmokyHill_3	35900	Max WS	25	1212.00	1221.1		1221.13	0.000001	0.13	235.42	59.81	0.01
OldSmokyHill_3	35800	Max WS	13	1212.00	1221.2		1221.22	0.000000	0.06	239.91	55.31	0.00
OldSmokyHill_3	35770	Max WS	9	1209.00	1221.2	1209.30	1221.23	0.000000	0.02	475.00	57.12	0.00
OldSmokyHill_3	35764		Inl Struct									
OldSmokyHill_3	35756	Max WS	9	1210.00	1221.2		1221.23	0.000000	0.03	354.25	51.02	0.00
OldSmokyHill_3	35680	Max WS	0	1209.80	1221.3	1209.83	1221.25	0.000000	0.00	115.70	49.76	0.00
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-136	1209.50	1222.0		1222.05	0.000039	-1.43	95.22	87.91	0.07
OldSmokyHill_3	35300	Max WS	-136	1209.50	1222.0		1222.03	0.000002	-0.25	614.32	90.66	0.01
OldSmokyHill_3	35200	Max WS	-119	1209.50	1222.0		1222.03	0.000001	-0.22	619.98	90.47	0.01
OldSmokyHill_3	35100	Max WS	-119	1209.50	1222.0		1222.03	0.000001	-0.21	637.39	90.40	0.01
OldSmokyHill_3	35000	Max WS	-96	1210.30	1222.0		1222.03	0.000001	-0.16	681.94	93.15	0.01
OldSmokyHill_3	34900	Max WS	-96	1210.40	1222.0		1222.03	0.000001	-0.16	680.95	94.98	0.01
OldSmokyHill_3	34798	Max WS	-96	1210.50	1222.0		1222.03	0.000001	-0.16	685.84	97.22	0.01
OldSmokyHill_3	34701	Max WS	-96	1210.60	1222.0		1222.03	0.000001	-0.16	661.65	94.21	0.01
OldSmokyHill_3	34604	Max WS	-96	1210.70	1222.0		1222.03	0.000001	-0.16	668.80	97.12	0.01
OldSmokyHill_3	34499	Max WS	-96	1210.80	1222.0		1222.03	0.000001	-0.16	663.96	94.82	0.01
OldSmokyHill_3	34396	Max WS	-96	1210.90	1222.0		1222.03	0.000001	-0.16	664.52	97.73	0.01
OldSmokyHill_3	34306	Max WS	-96	1210.99	1222.0		1222.03	0.000001	-0.17	661.74	97.79	0.01
OldSmokyHill_3	34186	Max WS	-96	1211.11	1222.0		1222.03	0.000001	-0.19	632.06	179.22	0.01
OldSmokyHill_3	34100	Max WS	-96	1211.02	1222.0		1222.03	0.000001	-0.19	612.04	193.40	0.01
OldSmokyHill_3	34013	Max WS	-96	1210.93	1222.0		1222.03	0.000001	-0.20	725.37	211.83	0.01
OldSmokyHill_3	33965	Max WS	-96	1210.88	1222.0		1222.03	0.000001	-0.19	772.47	184.66	0.01
OldSmokyHill_3	33914	Max WS	-96	1210.83	1222.0		1222.03	0.000001	-0.17	916.78	150.84	0.01
OldSmokyHill_3	33833	Max WS	-81	1210.75	1222.0	1211.48	1222.03	0.000001	0.15	836.40	119.13	0.01
OldSmokyHill_3	33800		Inl Struct									
OldSmokyHill_3	33766	Max WS	-81	1210.68	1222.0		1222.03	0.000001	-0.14	826.04	109.32	0.01
OldSmokyHill_3	33673	Max WS	-80	1209.50	1222.0		1222.03	0.000000	-0.12	805.09	93.53	0.01
OldSmokyHill_3	33600	Max WS	-81	1209.50	1222.0		1222.03	0.000001	-0.15	675.47	82.80	0.01
OldSmokyHill_3	33500	Max WS	-81	1209.50	1222.0		1222.03	0.000000	-0.14	719.77	86.53	0.01
OldSmokyHill_3	33400	Max WS	-79	1209.50	1222.0		1222.03	0.000001	-0.15	683.31	86.51	0.01
OldSmokyHill_3	33300	Max WS	-71	1209.50	1222.0		1222.03	0.000000	-0.13	675.59	83.06	0.01
OldSmokyHill_3	33200	Max WS	-71	1209.50	1222.0		1222.03	0.000000	-0.13	692.53	85.74	0.01
OldSmokyHill_3	33100	Max WS	-71	1210.30	1222.0		1222.03	0.000000	-0.14	622.40	76.52	0.01
OldSmokyHill_3	33000	Max WS	-70	1210.40	1222.0		1222.03	0.000000	-0.13	655.50	83.02	0.01
OldSmokyHill_3	32900	Max WS	-71	1210.50	1222.0		1222.03	0.000000	-0.13	732.61	103.87	0.01
OldSmokyHill_3	32815	Max WS	54	1210.12	1222.0		1222.03	0.000000	0.08	851.89	144.19	0.00
OldSmokyHill_3	32773	Max WS	55	1211.25	1222.0		1222.03	0.000002	0.22	310.32	86.22	0.01
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	53	1211.25	1222.0		1222.03	0.000001	0.12	492.46	114.43	0.01
OldSmokyHill_3	32500	Max WS	54	1210.95	1222.0		1222.03	0.000001	0.17	552.14	86.27	0.01
OldSmokyHill_3	32400	Max WS	70	1210.85	1222.0		1222.03	0.000000	0.12	696.55	85.66	0.01
OldSmokyHill_3	32338	Max WS	69	1210.79	1222.0		1222.03	0.000001	0.14	621.59	79.81	0.01
OldSmokyHill_3	32300	Max WS	70	1210.75	1222.0		1222.03	0.000001	0.14	631.75	81.77	0.01
OldSmokyHill_3	32200	Max WS	70	1210.65	1222.0		1222.03	0.000000	0.12	727.18	90.09	0.01
OldSmokyHill_3	32100	Max WS	69	1210.55	1222.0		1222.03	0.000000	0.12	679.39	84.39	0.01
OldSmokyHill_3	31900	Max WS	69	1210.35	1222.0		1222.03	0.000000	0.14	586.26	72.46	0.01
OldSmokyHill_3	31800	Max WS	119	1210.25	1222.0		1222.03	0.000002	0.22	610.20	75.75	0.01
OldSmokyHill_3	31700	Max WS	122	1209.50	1222.0		1222.03	0.000002	0.25	631.99	80.95	0.01
OldSmokyHill_3	31600	Max WS	139	1209.50	1222.0		1222.03	0.000002	0.27	650.85	92.20	0.01
OldSmokyHill_3	31500	Max WS	140	1209.50	1222.0		1222.02	0.000002	0.27	627.72	109.71	0.01
OldSmokyHill_3	31400	Max WS	140	1209.80	1222.0		1222.02	0.000001	0.24	760.54	121.37	0.01
OldSmokyHill_3	31300	Max WS	138	1209.90	1222.0		1222.02	0.000001	0.24	769.49	109.80	0.01
OldSmokyHill_3	31200	Max WS	139	1210.00	1222.0		1222.02	0.000001	0.24	748.39	115.56	0.01
OldSmokyHill_3	31100	Max WS	141	1210.10	1222.0		1222.02	0.000002	0.26	723.30	96.57	0.01
OldSmokyHill_3	31000	Max WS	148	1210.20	1222.0		1222.02	0.000002	0.27	716.40	115.45	0.01
OldSmokyHill_3	30900	Max WS	147	1210.30	1222.0		1222.02	0.000002	0.28	726.62	102.98	0.01
OldSmokyHill_3	30800	Max WS	147	1210.40	1222.0		1222.02	0.000002	0.28	720.53	130.47	0.02
OldSmokyHill_3	30700	Max WS	147	1210.50	1222.0		1222.02	0.000002	0.28	688.61	83.31	0.02
OldSmokyHill_3	30651	Max WS	148	1210.55	1222.0		1222.02	0.000002	0.25	721.25	95.80	0.01
OldSmokyHill_3	30575	Max WS	147	1210.63	1222.0		1222.02	0.000002	0.29	721.29	124.56	0.02
OldSmokyHill_3	30500	Max WS	147	1210.70	1222.0		1222.02	0.000002	0.29	761.43	112.69	0.02
OldSmokyHill_3	30400	Max WS	147	1210.60	1222.0		1222.02	0.000002	0.28	732.86	101.23	0.02
OldSmokyHill_3	30300	Max WS	147	1210.50	1222.0		1222.02	0.000002	0.28	722.66	91.18	0.02
OldSmokyHill_3	30200	Max WS	149	1210.40	1222.0		1222.02	0.000002	0.28	775.32	108.23	0.01
OldSmokyHill_3	30100	Max WS	147	1210.30	1222.0		1222.02	0.000002	0.26	749.57	96.33	0.01
OldSmokyHill_3	29999	Max WS	146	1210.20	1222.0		1222.02	0.000002	0.26	772.65	119.88	0.01
OldSmokyHill_3	29899	Max WS	145	1210.10	1222.0		1222.02	0.000002	0.26	766.60	114.31	0.01
OldSmokyHill_3	29800	Max WS	151	1210.00	1222.0		1222.02	0.000002	0.25	817.50	118.67	0.01
OldSmokyHill_3	29704	Max WS	152	1209.90	1222.0		1222.02	0.000002	0.24	800.50	96.60	0.01

HEC-RAS Plan: 05-Alt3-USACE-01%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	29572	Max WS	151	1209.77	1222.0		1222.02	0.000002	0.25	776.34	128.23	0.01
OldSmokyHill_3	29466	Max WS	152	1209.66	1222.0		1222.02	0.000002	0.23	880.28	143.04	0.01
OldSmokyHill_3	29385	Max WS	1187	1209.50	1221.9		1221.99	0.000102	1.82	814.51	116.69	0.10
OldSmokyHill_3	29314	Max WS	1188	1209.50	1221.9		1221.98	0.000173	2.37	700.08	153.30	0.13
OldSmokyHill_3	29209	Max WS	1188	1209.50	1221.9		1221.96	0.000164	2.25	672.82	112.74	0.12
OldSmokyHill_3	29100	Max WS	1188	1209.50	1221.9		1221.95	0.000174	2.38	706.51	151.60	0.13
OldSmokyHill_3	28991	Max WS	1187	1209.50	1221.8		1221.93	0.000185	2.45	684.87	111.18	0.13
OldSmokyHill_3	28900	Max WS	1187	1210.12	1221.8		1221.91	0.000163	2.28	690.92	93.23	0.12
OldSmokyHill_3	28800	Max WS	1187	1210.22	1221.8		1221.89	0.000167	2.29	682.45	88.35	0.12
OldSmokyHill_3	28700	Max WS	1186	1210.32	1221.8		1221.88	0.000178	2.33	682.52	110.50	0.13
OldSmokyHill_3	28594	Max WS	1187	1210.43	1221.8		1221.86	0.000117	2.09	677.29	88.43	0.12
OldSmokyHill_3	28500	Max WS	1186	1210.52	1221.8		1221.85	0.000107	1.98	729.94	90.37	0.11
OldSmokyHill_3	28430	Max WS	1213	1210.34	1221.7	1215.43	1221.84	0.000495	3.18	519.80	81.40	0.18
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1205	1210.35	1221.2		1221.35	0.000517	3.46	587.02	90.66	0.20
OldSmokyHill_3	28200	Max WS	1205	1210.36	1221.2		1221.30	0.000191	2.29	693.84	89.86	0.13
OldSmokyHill_3	28100	Max WS	1211	1210.26	1221.2		1221.28	0.000186	2.27	721.66	94.33	0.13
OldSmokyHill_3	28000	Max WS	1210	1210.16	1221.2		1221.26	0.000192	2.37	710.85	91.88	0.13
OldSmokyHill_3	27900	Max WS	1209	1210.06	1221.2		1221.24	0.000187	2.34	699.99	88.77	0.13
OldSmokyHill_3	27800	Max WS	1210	1209.96	1221.1		1221.22	0.000186	2.34	681.26	84.78	0.13
OldSmokyHill_3	27700	Max WS	1209	1209.86	1221.1		1221.20	0.000120	2.07	695.78	89.49	0.12
OldSmokyHill_3	27600	Max WS	1208	1209.76	1221.1		1221.19	0.000110	2.00	678.85	85.64	0.11
OldSmokyHill_3	27500	Max WS	1221	1209.50	1221.1		1221.17	0.000126	2.02	671.68	88.66	0.12
OldSmokyHill_3	27400	Max WS	1221	1209.50	1221.1		1221.16	0.000114	1.91	690.34	88.54	0.11
OldSmokyHill_3	27300	Max WS	1219	1209.50	1221.1		1221.15	0.000245	2.62	685.62	94.18	0.15
OldSmokyHill_3	27200	Max WS	1219	1209.50	1221.1		1221.12	0.000134	2.07	653.47	84.92	0.12
OldSmokyHill_3	27100	Max WS	1224	1209.55	1221.0		1221.11	0.000133	2.27	691.67	93.30	0.12
OldSmokyHill_3	27000	Max WS	1225	1209.65	1221.0		1221.10	0.000107	1.93	700.02	101.30	0.11
OldSmokyHill_3	26900	Max WS	1223	1209.75	1221.0		1221.08	0.000095	1.82	742.71	116.07	0.10
OldSmokyHill_3	26800	Max WS	1223	1209.85	1221.0		1221.08	0.000100	1.87	744.52	125.58	0.11
OldSmokyHill_3	26700	Max WS	1228	1209.95	1221.0		1221.07	0.000134	2.17	669.48	115.66	0.12
OldSmokyHill_3	26600	Max WS	1226	1210.05	1221.0		1221.05	0.000144	2.25	645.47	85.01	0.13
OldSmokyHill_3	26522	Max WS	1217	1210.13	1220.9	1214.64	1221.05	0.000429	3.65	405.18	65.99	0.20
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1197	1210.19	1220.8		1220.98	0.000479	3.89	397.29	69.06	0.22
OldSmokyHill_3	26400	Max WS	1217	1210.25	1220.9		1220.92	0.000113	1.93	703.16	93.03	0.11
OldSmokyHill_3	26300	Max WS	1214	1210.35	1220.8		1220.91	0.000231	2.49	683.77	92.57	0.14
OldSmokyHill_3	26200	Max WS	1210	1210.45	1220.8		1220.89	0.000243	2.57	718.37	116.67	0.15
OldSmokyHill_3	26100	Max WS	1215	1210.55	1220.8		1220.86	0.000118	1.93	683.61	91.90	0.12
OldSmokyHill_3	26000	Max WS	1210	1210.45	1220.8		1220.85	0.000243	2.56	675.98	90.33	0.15
OldSmokyHill_3	25900	Max WS	1214	1210.35	1220.8		1220.82	0.000122	1.97	693.38	91.41	0.12
OldSmokyHill_3	25800	Max WS	1210	1210.25	1220.7		1220.81	0.000130	2.06	726.45	106.34	0.12
OldSmokyHill_3	25700	Max WS	1212	1210.15	1220.7		1220.79	0.000123	2.00	671.73	87.83	0.12
OldSmokyHill_3	25600	Max WS	1211	1210.05	1220.7		1220.78	0.000105	1.85	701.86	88.99	0.11
OldSmokyHill_3	25500	Max WS	1264	1209.95	1220.7		1220.77	0.000118	1.98	731.57	97.21	0.12
OldSmokyHill_3	25400	Max WS	1265	1209.85	1220.7		1220.76	0.000217	2.49	726.36	103.74	0.14
OldSmokyHill_3	25300	Max WS	1262	1209.75	1220.6		1220.74	0.000248	2.66	667.05	135.24	0.15
OldSmokyHill_3	25200	Max WS	1264	1209.50	1220.6		1220.71	0.000167	2.11	679.15	126.65	0.12
OldSmokyHill_3	25117	Max WS	1261	1208.41	1220.6	1213.26	1220.66	0.000863	2.11	732.96	143.89	0.11
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1226	1208.97	1220.4		1220.48	0.000352	3.06	516.21	86.22	0.17
OldSmokyHill_3	24900	Max WS	1232	1209.50	1220.4		1220.45	0.000129	1.96	700.44	97.93	0.12
OldSmokyHill_3	24800	Max WS	1225	1209.50	1220.4		1220.44	0.000153	2.18	636.15	90.72	0.13
OldSmokyHill_3	24700	Max WS	1235	1209.50	1220.4		1220.42	0.000122	1.91	696.02	93.64	0.12
OldSmokyHill_3	24600	Max WS	1229	1209.50	1220.4		1220.41	0.000100	1.79	757.14	99.31	0.11
OldSmokyHill_3	24500	Max WS	1220	1209.65	1220.3		1220.40	0.000120	1.96	694.43	92.20	0.12
OldSmokyHill_3	24400	Max WS	1221	1209.75	1220.3		1220.39	0.000110	1.87	701.23	88.72	0.11
OldSmokyHill_3	24300	Max WS	1220	1209.85	1220.3		1220.38	0.000114	1.90	691.37	88.46	0.11
OldSmokyHill_3	24200	Max WS	1213	1209.95	1220.3		1220.36	0.000120	1.94	684.85	90.83	0.12
OldSmokyHill_3	24100	Max WS	1212	1210.05	1220.3		1220.35	0.000130	2.03	656.21	86.09	0.12
OldSmokyHill_3	24000	Max WS	1216	1210.15	1220.3		1220.34	0.000123	1.98	690.24	92.15	0.12
OldSmokyHill_3	23900	Max WS	1209	1210.25	1220.3		1220.32	0.000123	1.96	682.94	94.55	0.12
OldSmokyHill_3	23800	Max WS	1230	1210.35	1220.2		1220.31	0.000132	2.04	664.07	106.01	0.12
OldSmokyHill_3	23700	Max WS	1229	1210.25	1220.2		1220.29	0.000132	2.05	666.15	92.39	0.12
OldSmokyHill_3	23600	Max WS	1224	1210.15	1220.2		1220.28	0.000127	2.00	668.91	90.49	0.12
OldSmokyHill_3	23500	Max WS	1226	1210.05	1220.2		1220.27	0.000115	1.89	699.22	93.24	0.11
OldSmokyHill_3	23362	Max WS	1227	1209.91	1220.2	1213.59	1220.25	0.000114	1.89	718.64	100.23	0.11
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1224	1209.75	1220.2		1220.21	0.000108	1.85	714.34	95.13	0.11
OldSmokyHill_3	23167	Max WS	1220	1209.72	1220.2		1220.21	0.000113	1.91	712.56	100.06	0.11
OldSmokyHill_3	23100	Max WS	1230	1209.50	1220.1		1220.20	0.000119	1.94	725.14	109.03	0.12
OldSmokyHill_3	23000	Max WS	1232	1209.50	1220.1		1220.19	0.000120	1.94	729.37	110.44	0.12
OldSmokyHill_3	22900	Max WS	1232	1209.50	1220.1		1220.18	0.000163	2.43	799.87	121.35	0.14
OldSmokyHill_3	22800	Max WS	1237	1209.55	1220.1		1220.16	0.000155	2.43	790.41	116.84	0.13
OldSmokyHill_3	22731	Max WS	1233	1209.62	1220.1		1220.15	0.000174	2.57	779.67	118.64	0.14
OldSmokyHill_3	22656	Max WS	1237	1209.70	1220.1	1213.27	1220.13	0.000119	1.98	714.78	104.97	0.12
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1235	1209.70	1220.1		1220.12	0.000117	1.96	716.85	108.28	0.12

HEC-RAS Plan: 05-Alt3-USACE-01%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	22578	Max WS	1233	1209.77	1220.1		1220.11	0.000108	1.87	746.01	118.81	0.11
OldSmokyHill_3	22500	Max WS	1233	1209.85	1220.0		1220.11	0.000179	2.57	728.72	130.57	0.14
OldSmokyHill_3	22400	Max WS	1233	1209.95	1220.0		1220.08	0.000207	1.82	682.54	163.46	0.14
OldSmokyHill_3	22300	Max WS	1230	1210.05	1220.0		1220.06	0.000163	1.77	724.29	185.66	0.13
OldSmokyHill_3	22200	Max WS	1229	1210.15	1220.0		1220.04	0.000120	1.61	815.38	212.58	0.11
OldSmokyHill_3	22100	Max WS	1221	1210.25	1220.0		1220.03	0.000108	1.80	804.83	204.09	0.11
OldSmokyHill_3	22000	Max WS	1217	1210.12	1220.0		1220.02	0.000126	1.96	730.55	166.89	0.12
OldSmokyHill_3	21900	Max WS	1206	1210.12	1219.9		1220.00	0.000158	2.22	661.06	112.06	0.13
OldSmokyHill_3	21799	Max WS	1197	1210.27	1219.9		1219.99	0.000183	2.38	647.79	121.51	0.14
OldSmokyHill_3	21722	Max WS	1181	1210.10	1219.9	1213.80	1219.97	0.000200	2.51	601.16	123.02	0.15
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1185	1210.10	1219.9		1219.96	0.000202	2.50	600.96	120.99	0.15
OldSmokyHill_3	21600	Max WS	1172	1210.31	1219.9		1219.93	0.000151	2.12	682.56	129.21	0.13
OldSmokyHill_3	21500	Max WS	1192	1210.12	1219.9		1219.91	0.000110	1.83	805.60	171.18	0.11
OldSmokyHill_3	21400	Max WS	1191	1209.93	1219.9		1219.90	0.000099	1.74	900.00	220.82	0.11
OldSmokyHill_3	21295	Max WS	1185	1209.93	1219.8		1219.89	0.000092	1.68	877.09	198.33	0.10
OldSmokyHill_3	21200	Max WS	1178	1209.82	1219.8		1219.88	0.000085	1.60	908.95	196.24	0.10
OldSmokyHill_3	21100	Max WS	1181	1209.83	1219.8		1219.87	0.000080	1.57	918.07	225.03	0.09
OldSmokyHill_3	20995	Max WS	1159	1210.03	1219.8		1219.86	0.000102	1.78	884.02	190.92	0.11
OldSmokyHill_3	20900	Max WS	1159	1209.74	1219.8		1219.85	0.000118	1.92	846.64	209.71	0.12
OldSmokyHill_3	20800	Max WS	1151	1209.69	1219.8		1219.83	0.000084	1.63	941.19	235.79	0.10
OldSmokyHill_3	20700	Max WS	1155	1209.43	1219.8		1219.82	0.000091	1.71	943.42	234.38	0.10
OldSmokyHill_3	20644	Max WS	1147	1209.47	1219.8		1219.82	0.000095	1.74	910.86	224.05	0.10
OldSmokyHill_3	20600	Max WS	1143	1209.50	1219.8		1219.81	0.000081	1.58	972.08	232.38	0.10
OldSmokyHill_3	20500	Max WS	1126	1209.49	1219.8		1219.80	0.000097	1.76	828.61	230.22	0.11
OldSmokyHill_3	20434	Max WS	1122	1209.28	1219.7		1219.79	0.000108	1.86	841.60	267.03	0.11
OldSmokyHill_3	20363	Max WS	1109	1209.34	1219.7	1213.12	1219.79	0.000148	2.19	599.28	272.23	0.13
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1105	1209.41	1219.7		1219.77	0.000130	2.07	662.16	267.95	0.12
OldSmokyHill_3	20300	Max WS	1118	1209.10	1219.7		1219.76	0.000052	1.35	1049.08	249.29	0.08
OldSmokyHill_3	20190	Max WS	1866	1209.10	1219.6		1219.72	0.000201	2.49	913.23	208.46	0.15
OldSmokyHill_3	20100	Max WS	1876	1209.16	1219.6		1219.70	0.000249	2.84	798.64	176.79	0.17
OldSmokyHill_3	20023	Max WS	1882	1209.05	1219.5		1219.68	0.000281	3.04	763.08	165.41	0.18
OldSmokyHill_3	19900	Max WS	1881	1209.06	1219.5		1219.65	0.000231	2.75	800.18	142.52	0.16
OldSmokyHill_3	19800	Max WS	1881	1208.97	1219.5		1219.63	0.000283	3.08	732.28	130.71	0.18
OldSmokyHill_3	19700	Max WS	1881	1208.92	1219.4		1219.59	0.000330	3.33	627.30	93.15	0.19
OldSmokyHill_3	19600	Max WS	1881	1208.86	1219.4		1219.56	0.000250	2.91	692.18	98.83	0.17
OldSmokyHill_3	19510	Max WS	1881	1208.72	1219.4	1212.75	1219.54	0.000191	2.57	788.59	102.62	0.15
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1881	1208.72	1219.4		1219.53	0.000169	2.39	839.38	106.13	0.14
OldSmokyHill_3	19400	Max WS	1881	1208.53	1219.4		1219.52	0.000219	2.72	764.02	110.94	0.16
OldSmokyHill_3	19300	Max WS	1912	1208.28	1219.4		1219.49	0.000266	2.93	716.07	117.37	0.17
OldSmokyHill_3	19200	Max WS	1912	1208.22	1219.3		1219.46	0.000278	2.99	691.29	120.35	0.18
OldSmokyHill_3	19100	Max WS	1912	1208.22	1219.2		1219.45	0.000542	4.19	643.29	128.19	0.25
OldSmokyHill_3	19000	Max WS	1911	1208.09	1219.1		1219.41	0.000722	4.84	552.24	102.41	0.28
OldSmokyHill_3	18900	Max WS	1911	1208.03	1218.9		1219.36	0.000983	5.59	458.84	88.35	0.32
OldSmokyHill_3	18800	Max WS	1910	1207.66	1218.8		1219.26	0.000961	5.57	416.24	74.76	0.32
OldSmokyHill_3	18700	Max WS	1917	1207.83	1218.8		1219.15	0.000705	4.83	454.91	79.42	0.28
OldSmokyHill_3	18600	Max WS	1925	1207.62	1218.6		1219.08	0.000921	5.41	442.33	96.92	0.31
OldSmokyHill_3	18500	Max WS	1924	1207.70	1218.5		1218.98	0.000971	5.48	384.21	54.77	0.32
OldSmokyHill_3	18438	Max WS	1925	1207.53	1218.7	1212.93	1218.90	0.000418	3.71	599.51	86.05	0.22
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1926	1207.50	1218.6		1218.74	0.000353	3.36	632.32	88.17	0.20
OldSmokyHill_3	18300	Max WS	1925	1207.75	1218.6		1218.71	0.000315	3.09	654.25	86.58	0.19
OldSmokyHill_3	18200	Max WS	1929	1207.43	1218.5		1218.68	0.000315	3.13	645.81	85.36	0.19
OldSmokyHill_3	18100	Max WS	1928	1207.42	1218.5		1218.65	0.000263	2.86	704.56	93.70	0.17
OldSmokyHill_3	18000	Max WS	1927	1207.16	1218.5		1218.62	0.000290	3.01	671.31	87.77	0.18
OldSmokyHill_3	17900	Max WS	1927	1207.10	1218.4		1218.59	0.000307	3.19	648.04	87.48	0.19
OldSmokyHill_3	17800	Max WS	1926	1206.51	1218.4		1218.56	0.000241	2.89	687.77	79.99	0.17
OldSmokyHill_3	17700	Max WS	1924	1206.52	1218.3		1218.53	0.000447	3.90	516.91	63.16	0.22
OldSmokyHill_3	17600	Max WS	2010	1206.23	1218.3		1218.47	0.000341	3.38	624.57	78.25	0.20
OldSmokyHill_3	17500	Max WS	2009	1206.44	1218.2		1218.44	0.000375	3.59	590.25	72.20	0.21
OldSmokyHill_3	17400	Max WS	2009	1206.06	1218.2		1218.40	0.000425	3.82	556.27	68.60	0.22
OldSmokyHill_3	17300	Max WS	2009	1205.78	1218.2		1218.36	0.000305	3.26	643.68	77.53	0.19
OldSmokyHill_3	17181	Max WS	2102	1204.48	1217.9	1212.85	1218.33	0.001023	5.57	561.73	88.30	0.30
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2102	1204.22	1216.9		1217.34	0.000940	5.59	502.29	72.99	0.30
OldSmokyHill_3	16923	Max WS	2102	1205.00	1217.0	1211.32	1217.28	0.001578	4.08	559.98	75.83	0.24
OldSmokyHill_3	16917		Inl Struct									
OldSmokyHill_3	16800	Max WS	2102	1205.21	1216.7		1217.15	0.001012	5.55	422.87	69.54	0.33
OldSmokyHill_3	16700	Max WS	2102	1204.84	1216.7	1211.70	1217.05	0.000780	4.99	481.39	78.71	0.29
OldSmokyHill_3	16653		Inl Struct									
OldSmokyHill_3	16600	Max WS	1940	1204.44	1215.6		1216.20	0.002072	6.18	351.57	87.62	0.45
OldSmokyHill_3	16500	Max WS	1947	1202.91	1215.8		1215.92	0.000124	2.35	931.91	115.29	0.12
OldSmokyHill_3	16400	Max WS	1975	1202.78	1215.9	1205.70	1215.90	0.000041	1.40	1488.95	143.82	0.07
OldSmokyHill_3	16356		Inl Struct									
OldSmokyHill_3	16300	Max WS	1974	1202.71	1215.8		1215.88	0.000120	2.29	985.25	118.52	0.12
OldSmokyHill_3	16200	Max WS	1975	1202.61	1215.8		1215.87	0.000148	2.55	902.82	112.51	0.13

HEC-RAS Plan: 05-Alt3-USACE-01%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	16100	Max WS	1973	1202.56	1215.8	1207.13	1215.86	0.000121	2.33	963.46	102.31	0.12
OldSmokyHill_3	16058		Inl Struct									
OldSmokyHill_3	16000	Max WS	1973	1202.51	1215.7		1215.84	0.000197	3.06	829.31	99.63	0.16
OldSmokyHill_3	15900	Max WS	1969	1202.34	1215.7		1215.83	0.000232	3.40	850.70	88.04	0.17
OldSmokyHill_3	15800	Max WS	1984	1202.44	1215.6	1207.88	1215.81	0.000275	3.63	712.27	85.49	0.18
OldSmokyHill_3	15743		Inl Struct									
OldSmokyHill_3	15700	Max WS	1985	1200.38	1215.6		1215.77	0.000223	3.59	815.66	79.53	0.16
OldSmokyHill_3	15635	Max WS	1979	1202.00	1215.5	1207.94	1215.77	0.000485	4.43	690.89	77.36	0.21
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1979	1202.00	1215.5		1215.67	0.000336	3.67	933.10	107.21	0.18
OldSmokyHill_3	15400	Max WS	1979	1200.67	1215.5		1215.63	0.000160	3.11	960.22	87.53	0.15
OldSmokyHill_3	15300	Max WS	1981	1200.77	1215.5		1215.61	0.000178	3.28	903.97	85.96	0.15
OldSmokyHill_3	15200	Max WS	1977	1200.87	1215.4		1215.57	0.000157	2.99	984.77	126.96	0.14
OldSmokyHill_3	15100	Max WS	1979	1200.97	1215.4		1215.57	0.000159	3.00	1055.25	126.80	0.14
OldSmokyHill_3	15000	Max WS	1976	1200.87	1215.4		1215.55	0.000142	2.84	1100.38	130.30	0.14
OldSmokyHill_3	14900	Max WS	1976	1200.77	1215.4		1215.54	0.000166	3.16	1073.26	119.91	0.15
OldSmokyHill_3	14800	Max WS	1974	1200.67	1215.4		1215.53	0.000160	3.12	1082.96	117.98	0.15
OldSmokyHill_3	14700	Max WS	1980	1200.57	1215.4		1215.51	0.000157	3.10	1053.37	101.92	0.14
OldSmokyHill_3	14600	Max WS	756	1200.47	1215.4		1215.39	0.000025	1.24	901.77	86.02	0.06
OldSmokyHill_3	14507	Max WS	749	1201.00	1215.4	1205.42	1215.39	0.000080	1.86	824.01	91.53	0.09
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	749	1201.00	1214.9		1214.97	0.000043	1.36	915.58	96.48	0.07
OldSmokyHill_3	14300	Max WS	749	1200.17	1214.9		1214.97	0.000023	1.19	952.34	89.32	0.06
OldSmokyHill_3	14200	Max WS	744	1200.07	1214.9		1214.96	0.000023	1.19	912.39	85.01	0.06
OldSmokyHill_3	14100	Max WS	740	1199.97	1214.9		1214.96	0.000021	1.15	968.91	91.52	0.05
OldSmokyHill_3	14000	Max WS	747	1197.97	1214.9		1214.96	0.000018	1.09	1035.85	92.49	0.05
OldSmokyHill_3	13900	Max WS	745	1197.97	1214.9		1214.96	0.000017	1.03	1014.67	91.33	0.05
OldSmokyHill_3	13800	Max WS	739	1197.97	1214.9		1214.96	0.000016	0.98	999.49	103.36	0.05
OldSmokyHill_3	13700	Max WS	727	1197.97	1214.9		1214.95	0.000013	0.88	1242.12	114.05	0.04
OldSmokyHill_3	13600	Max WS	733	1197.97	1214.9		1214.95	0.000016	0.98	1091.53	100.06	0.05
OldSmokyHill_3	13500	Max WS	730	1197.97	1214.9		1214.95	0.000014	0.92	1149.79	115.30	0.04
OldSmokyHill_3	13400	Max WS	730	1199.47	1214.9		1214.95	0.000015	0.95	1128.55	109.23	0.04
OldSmokyHill_3	13300	Max WS	726	1199.57	1214.9		1214.95	0.000015	0.93	1177.81	103.11	0.04
OldSmokyHill_3	13200	Max WS	726	1199.67	1214.9		1214.95	0.000014	0.91	1064.65	98.06	0.04
OldSmokyHill_3	13100	Max WS	828	1199.77	1214.9		1214.94	0.000022	1.14	995.43	91.10	0.05
OldSmokyHill_3	13000	Max WS	832	1199.87	1214.9		1214.94	0.000024	1.19	1027.35	102.04	0.06
OldSmokyHill_3	12900	Max WS	826	1199.97	1214.9		1214.94	0.000023	1.15	1059.13	99.47	0.05
OldSmokyHill_3	12800	Max WS	831	1200.07	1214.9		1214.94	0.000021	1.10	1034.51	93.38	0.05
OldSmokyHill_3	12700	Max WS	826	1200.17	1214.9		1214.94	0.000024	1.20	1007.41	89.94	0.06
OldSmokyHill_3	12600	Max WS	816	1200.27	1214.9		1214.94	0.000028	1.30	1040.77	101.43	0.06
OldSmokyHill_3	12500	Max WS	823	1200.17	1214.9		1214.93	0.000019	1.05	1071.43	99.72	0.05
OldSmokyHill_3	12400	Max WS	817	1200.07	1214.9		1214.93	0.000018	1.02	1046.08	92.01	0.05
OldSmokyHill_3	12300	Max WS	815	1199.97	1214.9		1214.93	0.000022	1.15	959.35	92.03	0.05
OldSmokyHill_3	12200	Max WS	813	1199.87	1214.9		1214.93	0.000025	1.24	990.26	92.20	0.06
OldSmokyHill_3	12100	Max WS	813	1199.77	1214.9		1214.92	0.000025	1.26	973.10	86.94	0.06
OldSmokyHill_3	12000	Max WS	807	1199.67	1214.9		1214.92	0.000023	1.21	1014.70	90.35	0.06
OldSmokyHill_3	11900	Max WS	808	1197.80	1214.9		1214.92	0.000022	1.20	1034.34	93.11	0.05
OldSmokyHill_3	11800	Max WS	804	1197.80	1214.9		1214.92	0.000027	1.32	841.69	79.33	0.06
OldSmokyHill_3	11688	Max WS	804	1197.80	1214.9		1214.91	0.000023	1.22	864.76	81.77	0.06
OldSmokyHill_3	11600	Max WS	805	1197.80	1214.9		1214.91	0.000022	1.21	958.97	84.58	0.05
OldSmokyHill_3	11500	Max WS	808	1197.80	1214.9		1214.91	0.000012	0.87	1113.83	96.18	0.04
OldSmokyHill_3	11400	Max WS	806	1199.05	1214.9		1214.91	0.000012	0.86	1199.08	103.19	0.04
OldSmokyHill_3	11300	Max WS	830	1199.15	1214.9		1214.91	0.000017	1.02	1076.42	93.85	0.05
OldSmokyHill_3	11200	Max WS	827	1199.25	1214.9		1214.91	0.000022	1.18	1031.65	90.95	0.05
OldSmokyHill_3	11100	Max WS	827	1199.35	1214.9		1214.91	0.000023	1.20	811.96	85.21	0.06
OldSmokyHill_3	10956	Max WS	832	1196.19	1214.9		1214.90	0.000008	0.65	1667.41	202.11	0.03
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	595	1195.60	1214.6		1214.65	0.000007	0.60	1440.84	169.14	0.03
OldSmokyHill_3	10500	Max WS	594	1199.95	1214.6		1214.65	0.000010	0.75	1197.55	117.40	0.04
OldSmokyHill_3	10400	Max WS	599	1200.05	1214.6		1214.65	0.000008	0.67	1188.37	116.48	0.03
OldSmokyHill_3	10335	Max WS	596	1199.99	1214.6	1202.43	1214.65	0.000008	0.70	1119.25	103.36	0.03
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	598	1199.95	1214.6		1214.65	0.000009	0.74	1057.14	98.14	0.04
OldSmokyHill_3	10200	Max WS	595	1199.86	1214.6		1214.65	0.000007	0.66	1146.66	104.55	0.03
OldSmokyHill_3	10100	Max WS	599	1199.76	1214.6		1214.65	0.000008	0.68	1072.66	99.13	0.03
OldSmokyHill_3	10000	Max WS	599	1199.66	1214.6		1214.64	0.000008	0.68	1057.37	96.39	0.03
OldSmokyHill_3	9900	Max WS	599	1199.56	1214.6		1214.64	0.000008	0.70	1058.86	101.58	0.03
OldSmokyHill_3	9800	Max WS	597	1199.46	1214.6		1214.64	0.000008	0.67	1106.74	100.00	0.03
OldSmokyHill_3	9700	Max WS	597	1199.36	1214.6		1214.64	0.000008	0.68	1129.02	106.56	0.03
OldSmokyHill_3	9600	Max WS	598	1199.26	1214.6		1214.64	0.000008	0.68	1129.29	101.42	0.03
OldSmokyHill_3	9500	Max WS	593	1199.16	1214.6		1214.64	0.000007	0.67	1088.36	96.21	0.03
OldSmokyHill_3	9400	Max WS	599	1199.06	1214.6		1214.64	0.000008	0.71	1049.17	94.76	0.03
OldSmokyHill_3	9300	Max WS	594	1198.96	1214.6		1214.64	0.000008	0.70	1073.50	95.78	0.03
OldSmokyHill_3	9200	Max WS	597	1198.86	1214.6		1214.64	0.000008	0.71	1081.62	102.55	0.03
OldSmokyHill_3	9148	Max WS	603	1198.81	1214.6		1214.64	0.000008	0.70	1045.05	97.65	0.03
OldSmokyHill_3	9100	Max WS	608	1198.76	1214.6		1214.64	0.000006	0.65	1145.27	98.50	0.03
OldSmokyHill_3	9000	Max WS	606	1198.66	1214.6		1214.64	0.000009	0.75	1093.75	111.54	0.03
OldSmokyHill_3	8900	Max WS	607	1198.56	1214.6		1214.64	0.000011	0.87	1030.70	96.52	0.04

HEC-RAS Plan: 05-Alt3-USACE-01%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	8800	Max WS	607	1198.46	1214.6		1214.64	0.000010	0.83	1141.28	141.70	0.04
OldSmokyHill_3	8668	Max WS	599	1198.33	1214.6	1201.20	1214.64	0.000022	1.14	1010.35	175.40	0.05
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	605	1195.72	1214.6		1214.63	0.000008	0.76	1137.60	172.55	0.03
OldSmokyHill_3	8500	Max WS	600	1195.72	1214.6		1214.63	0.000009	0.80	1238.25	164.47	0.03
OldSmokyHill_3	8400	Max WS	601	1195.72	1214.6		1214.62	0.000009	0.78	1137.25	97.72	0.03
OldSmokyHill_3	8300	Max WS	601	1195.72	1214.6		1214.62	0.000006	0.64	1170.80	107.35	0.03
OldSmokyHill_3	8200	Max WS	602	1197.72	1214.6		1214.62	0.000008	0.75	1185.49	124.68	0.03
OldSmokyHill_3	8100	Max WS	600	1198.72	1214.6		1214.62	0.000007	0.67	1190.17	128.56	0.03
OldSmokyHill_3	8000	Max WS	599	1199.50	1214.6		1214.62	0.000007	0.64	1110.76	109.94	0.03
OldSmokyHill_3	7900	Max WS	602	1199.40	1214.6		1214.62	0.000008	0.69	1191.11	126.76	0.03
OldSmokyHill_3	7800	Max WS	598	1199.30	1214.6		1214.62	0.000011	0.84	1164.41	123.81	0.04
OldSmokyHill_3	7700	Max WS	601	1199.20	1214.6		1214.62	0.000013	0.92	1156.69	129.36	0.04
OldSmokyHill_3	7600	Max WS	599	1199.10	1214.6		1214.62	0.000007	0.67	1103.51	97.15	0.03
OldSmokyHill_3	7500	Max WS	600	1199.00	1214.6		1214.62	0.000011	0.84	1137.05	100.72	0.04
OldSmokyHill_3	7400	Max WS	598	1198.90	1214.6		1214.62	0.000010	0.82	1285.55	112.43	0.04
OldSmokyHill_3	7300	Max WS	599	1198.80	1214.6		1214.62	0.000010	0.82	1227.99	112.79	0.04
OldSmokyHill_3	7275		Lat Struct									
OldSmokyHill_3	7200	Max WS	574	1198.80	1214.6		1214.62	0.000010	0.80	1277.78	135.84	0.04
OldSmokyHill_3	7100	Max WS	275	1198.60	1214.6		1214.62	0.000001	0.28	1314.07	122.46	0.01
OldSmokyHill_3	7000	Max WS	280	1198.50	1214.6		1214.62	0.000002	0.33	1151.88	108.61	0.02
OldSmokyHill_3	6900	Max WS	280	1195.72	1214.6		1214.62	0.000002	0.34	1232.51	126.29	0.01
OldSmokyHill_3	6800	Max WS	280	1195.72	1214.6		1214.62	0.000002	0.37	1194.61	115.05	0.02
OldSmokyHill_3	6700	Max WS	280	1195.72	1214.6		1214.62	0.000002	0.37	1252.04	117.01	0.02
OldSmokyHill_3	6600	Max WS	279	1195.72	1214.6		1214.62	0.000002	0.34	1207.24	117.01	0.01
OldSmokyHill_3	6500	Max WS	278	1198.22	1214.6		1214.62	0.000002	0.35	1197.93	114.16	0.02
OldSmokyHill_3	6400	Max WS	279	1199.22	1214.6		1214.62	0.000002	0.39	1183.99	116.81	0.02
OldSmokyHill_3	6300	Max WS	278	1199.32	1214.6		1214.62	0.000002	0.38	1147.81	104.99	0.02
OldSmokyHill_3	6200	Max WS	278	1199.42	1214.6		1214.62	0.000003	0.41	1157.23	101.20	0.02
OldSmokyHill_3	6100	Max WS	279	1199.32	1214.6		1214.62	0.000002	0.40	1143.01	113.87	0.02
OldSmokyHill_3	6000	Max WS	279	1199.22	1214.6		1214.62	0.000003	0.41	1152.43	130.23	0.02
OldSmokyHill_3	5900	Max WS	279	1199.12	1214.6		1214.62	0.000002	0.38	1252.72	134.92	0.02
OldSmokyHill_3	5800	Max WS	279	1199.02	1214.6		1214.62	0.000003	0.43	1185.30	144.96	0.02
OldSmokyHill_3	5700	Max WS	279	1198.92	1214.6		1214.62	0.000003	0.41	1173.93	129.24	0.02
OldSmokyHill_3	5600	Max WS	279	1196.42	1214.6		1214.61	0.000001	0.30	1474.26	133.06	0.01
OldSmokyHill_3	5500	Max WS	279	1195.72	1214.6		1214.62	0.000002	0.34	1406.33	124.81	0.01
OldSmokyHill_3	5400	Max WS	279	1195.72	1214.6		1214.61	0.000002	0.37	1273.14	116.03	0.02
OldSmokyHill_3	5300	Max WS	279	1195.72	1214.6		1214.61	0.000001	0.31	1282.61	114.21	0.01
OldSmokyHill_3	5200	Max WS	279	1195.72	1214.6		1214.61	0.000001	0.26	1348.28	121.73	0.01
OldSmokyHill_3	5100	Max WS	280	1195.72	1214.6		1214.61	0.000001	0.27	1346.22	125.57	0.01
OldSmokyHill_3	5000	Max WS	279	1195.72	1214.6		1214.61	0.000001	0.27	1334.82	115.38	0.01
OldSmokyHill_3	4900	Max WS	280	1198.22	1214.6		1214.61	0.000001	0.26	1353.07	122.68	0.01
OldSmokyHill_3	4800	Max WS	280	1198.32	1214.6		1214.61	0.000001	0.32	1439.20	146.25	0.01
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	278	1198.44	1214.6		1214.61	0.000002	0.39	1312.71	140.39	0.02
OldSmokyHill_3	4600	Max WS	268	1198.52	1214.6		1214.61	0.000002	0.35	1383.07	137.22	0.02
OldSmokyHill_3	4500	Max WS	250	1198.62	1214.6		1214.61	0.000001	0.23	1329.92	121.80	0.01
OldSmokyHill_3	4400	Max WS	222	1198.71	1214.6		1214.61	0.000001	0.22	1287.91	124.75	0.01
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	178	1198.63	1214.6	1199.95	1214.61	0.000000	0.17	1350.42	115.00	0.01
OldSmokyHill_3	4278		Bridge									
OldSmokyHill_3	4200	Max WS	178	1198.65	1214.6		1214.61	0.000000	0.17	1328.69	131.00	0.01
OldSmokyHill_3	4100	Max WS	243	1198.57	1214.6		1214.61	0.000001	0.22	1490.74	165.96	0.01
OldSmokyHill_3	4000	Max WS	478	1198.39	1214.6		1214.61	0.000003	0.44	1455.42	161.09	0.02
OldSmokyHill_3	3900	Max WS	615	1198.29	1214.6		1214.61	0.000006	0.61	1379.99	155.08	0.03
OldSmokyHill_3	3800	Max WS	615	1195.72	1214.6		1214.61	0.000005	0.58	1384.64	185.80	0.03
OldSmokyHill_3	3700	Max WS	610	1195.72	1214.6		1214.61	0.000005	0.59	1436.04	173.37	0.03
OldSmokyHill_3	3600	Max WS	607	1195.72	1214.6		1214.61	0.000008	0.76	1449.42	158.57	0.03
OldSmokyHill_3	3500	Max WS	605	1195.72	1214.6		1214.61	0.000007	0.72	1461.36	152.06	0.03
OldSmokyHill_3	3400	Max WS	601	1198.22	1214.6		1214.60	0.000005	0.56	1380.41	161.88	0.03
OldSmokyHill_3	3300	Max WS	598	1198.32	1214.6		1214.60	0.000005	0.60	1309.86	174.57	0.03
OldSmokyHill_3	3200	Max WS	598	1198.39	1214.6		1214.60	0.000006	0.64	1317.75	181.24	0.03
OldSmokyHill_3	3100	Max WS	605	1198.66	1214.6		1214.60	0.000010	0.81	1387.50	193.17	0.04
OldSmokyHill_3	3000	Max WS	615	1198.34	1214.6		1214.60	0.000010	0.83	1307.70	216.48	0.04
OldSmokyHill_3	2900	Max WS	615	1198.41	1214.6		1214.60	0.000012	0.90	1283.47	145.56	0.04
OldSmokyHill_3	2800	Max WS	615	1198.34	1214.6		1214.60	0.000013	0.94	1311.22	158.27	0.04
OldSmokyHill_3	2700	Max WS	615	1198.47	1214.6		1214.60	0.000011	0.88	1309.43	187.53	0.04
OldSmokyHill_3	2600	Max WS	619	1198.50	1214.6		1214.60	0.000010	0.82	1342.86	171.29	0.04
OldSmokyHill_3	2500	Max WS	619	1198.53	1214.6		1214.60	0.000013	0.92	1197.75	131.67	0.04
OldSmokyHill_3	2400	Max WS	619	1198.93	1214.6	1201.70	1214.59	0.000008	0.72	1230.96	124.45	0.03
OldSmokyHill_3	2345		Inl Struct									
OldSmokyHill_3	2300	Max WS	619	1198.50	1214.6		1214.58	0.000007	0.70	1256.74	124.58	0.03
OldSmokyHill_3	2183	Max WS	619	1196.44	1214.6		1214.58	0.000011	0.86	818.55	126.45	0.04
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	619	1196.78	1208.4		1208.64	0.000480	4.16	148.78	93.94	0.22
OldSmokyHill_3	1900	Max WS	619	1198.47	1208.5		1208.51	0.000058	1.44	589.94	92.28	0.08
OldSmokyHill_3	1800	Max WS	619	1198.28	1208.5		1208.51	0.000037	1.12	690.68	91.27	0.07
OldSmokyHill_3	1700	Max WS	619	1198.12	1208.5		1208.50	0.000035	1.15	748.01	90.36	0.06

HEC-RAS Plan: 05-Alt3-USACE-01%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	1600	Max WS	619	1198.25	1208.5		1208.50	0.000058	1.48	685.67	94.37	0.08
OldSmokyHill_3	1500	Max WS	619	1197.76	1208.5		1208.49	0.000042	1.27	716.34	96.55	0.07
OldSmokyHill_3	1400	Max WS	619	1197.87	1208.5		1208.49	0.000030	1.02	694.69	89.74	0.06
OldSmokyHill_3	1300	Max WS	619	1197.69	1208.4		1208.48	0.000075	1.64	490.07	73.57	0.09
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	619	1197.53	1208.4		1208.48	0.000069	1.61	464.76	76.49	0.09
OldSmokyHill_3	1100	Max WS	619	1197.72	1208.4		1208.47	0.000078	1.70	442.51	75.04	0.09
OldSmokyHill_3	1000	Max WS	619	1197.72	1208.4		1208.46	0.000087	1.77	418.12	72.94	0.10
OldSmokyHill_3	900	Max WS	619	1197.44	1208.4		1208.45	0.000095	1.91	412.16	76.66	0.10
OldSmokyHill_3	800	Max WS	619	1197.35	1208.4		1208.45	0.000083	1.80	437.38	78.82	0.10
OldSmokyHill_3	700	Max WS	619	1197.38	1208.4		1208.44	0.000087	1.86	432.83	80.21	0.10
OldSmokyHill_3	660	Max WS	628	1195.72	1208.4	1200.90	1208.43	0.000147	2.17	285.37	75.72	0.11
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	64	1194.52	1201.2		1201.25	0.000049	1.03	62.11	13.38	0.07
OldSmokyHill_3	300	Max WS	40	1194.21	1201.1		1201.13	0.000002	0.22	199.06	41.14	0.02
OldSmokyHill_3	200	Max WS	-9	1193.97	1201.1		1201.11	0.000000	-0.05	208.87	37.89	0.00
OldSmokyHill_3	100	Max WS	81	1193.79	1201.1	1194.64	1201.10	0.000000	0.07	1167.49	221.83	0.01

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	36405	Max WS	0	1212.50	1215.5		1215.50	0.000000	0.00	119.62	49.72	0.00
OldSmokyHill_3	36394.74	Max WS	6	1213.50	1215.5	1213.60	1215.50	0.000001	0.07	83.74	48.75	0.01
OldSmokyHill_3	36393		Inl Struct									
OldSmokyHill_3	36392.76	Max WS	-296	1213.50	1216.5		1216.59	0.000821	-2.16	137.03	56.72	0.25
OldSmokyHill_3	36327	Max WS	-296	1213.50	1216.6		1216.64	0.000756	-2.14	138.41	54.23	0.24
OldSmokyHill_3	36269	Max WS	-296	1205.97	1216.6		1216.63	0.000004	-0.33	894.20	123.86	0.02
OldSmokyHill_3	36150	Max WS	-296	1205.38	1216.6		1216.63	0.000002	-0.24	1234.43	156.87	0.02
OldSmokyHill_3	35948	Max WS	-296	1204.53	1216.6		1216.63	0.000006	-0.37	805.79	113.65	0.02
OldSmokyHill_3	35900	Max WS	-296	1212.00	1216.6		1216.84	0.001855	-3.91	75.95	19.27	0.33
OldSmokyHill_3	35800	Max WS	-296	1212.00	1216.8		1216.99	0.001265	-3.40	87.71	22.08	0.28
OldSmokyHill_3	35770	Max WS	-296	1209.00	1216.9	1210.96	1216.97	0.000067	1.08	273.98	42.75	0.08
OldSmokyHill_3	35764		Inl Struct									
OldSmokyHill_3	35756	Max WS	-296	1210.00	1217.0		1217.00	0.000171	-1.63	181.90	30.78	0.11
OldSmokyHill_3	35680	Max WS	-296	1209.80	1217.3	1214.94	1218.11	0.013444	7.70	47.04	22.13	0.50
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-296	1209.50	1223.5		1223.58	0.000128	-2.79	106.25	93.81	0.13
OldSmokyHill_3	35300	Max WS	-296	1209.50	1223.5		1223.53	0.000004	-0.45	755.62	98.30	0.02
OldSmokyHill_3	35200	Max WS	-279	1209.50	1223.5		1223.53	0.000004	-0.42	760.22	97.55	0.02
OldSmokyHill_3	35100	Max WS	-279	1209.50	1223.5		1223.53	0.000004	-0.41	779.30	99.00	0.02
OldSmokyHill_3	35000	Max WS	-248	1210.30	1223.5		1223.53	0.000002	-0.34	826.62	100.40	0.02
OldSmokyHill_3	34900	Max WS	-248	1210.40	1223.5		1223.53	0.000002	-0.34	828.35	102.54	0.02
OldSmokyHill_3	34798	Max WS	-248	1210.50	1223.5		1223.53	0.000002	-0.34	837.37	105.01	0.02
OldSmokyHill_3	34701	Max WS	-248	1210.60	1223.5		1223.53	0.000003	-0.35	807.90	101.57	0.02
OldSmokyHill_3	34604	Max WS	-249	1210.70	1223.5		1223.53	0.000003	-0.35	820.65	105.69	0.02
OldSmokyHill_3	34499	Max WS	-248	1210.80	1223.5		1223.53	0.000003	-0.35	811.44	102.53	0.02
OldSmokyHill_3	34396	Max WS	-249	1210.90	1223.5		1223.53	0.000003	-0.35	816.40	105.19	0.02
OldSmokyHill_3	34306	Max WS	-248	1210.99	1223.5		1223.53	0.000003	-0.35	813.61	105.38	0.02
OldSmokyHill_3	34186	Max WS	-249	1211.11	1223.5		1223.53	0.000004	-0.41	775.20	206.05	0.02
OldSmokyHill_3	34100	Max WS	-249	1211.02	1223.5		1223.53	0.000004	-0.42	752.39	232.69	0.02
OldSmokyHill_3	34013	Max WS	-249	1210.93	1223.5		1223.53	0.000004	-0.42	1056.83	278.33	0.02
OldSmokyHill_3	33965	Max WS	-248	1210.88	1223.5		1223.53	0.000004	-0.41	1060.06	251.61	0.02
OldSmokyHill_3	33914	Max WS	-250	1210.83	1223.5		1223.53	0.000003	-0.37	1132.38	199.58	0.02
OldSmokyHill_3	33833	Max WS	-233	1210.75	1223.5	1212.17	1223.53	0.000003	0.36	1019.80	167.39	0.02
OldSmokyHill_3	33800		Inl Struct									
OldSmokyHill_3	33766	Max WS	-234	1210.68	1223.5		1223.53	0.000003	-0.36	993.72	153.08	0.02
OldSmokyHill_3	33673	Max WS	-233	1209.50	1223.5		1223.53	0.000002	-0.30	949.73	100.80	0.01
OldSmokyHill_3	33600	Max WS	-234	1209.50	1223.5		1223.53	0.000003	-0.38	803.04	87.97	0.02
OldSmokyHill_3	33500	Max WS	-235	1209.50	1223.5		1223.53	0.000002	-0.35	854.55	94.99	0.02
OldSmokyHill_3	33400	Max WS	-231	1209.50	1223.5		1223.53	0.000003	-0.37	818.77	94.94	0.02
OldSmokyHill_3	33300	Max WS	-218	1209.50	1223.5		1223.54	0.000003	-0.35	804.54	90.14	0.02
OldSmokyHill_3	33200	Max WS	-219	1209.50	1223.5		1223.54	0.000003	-0.35	825.89	94.26	0.02
OldSmokyHill_3	33100	Max WS	-219	1210.30	1223.5		1223.54	0.000003	-0.36	742.42	84.18	0.02
OldSmokyHill_3	33000	Max WS	-219	1210.40	1223.5		1223.54	0.000003	-0.36	786.15	92.93	0.02
OldSmokyHill_3	32900	Max WS	-220	1210.50	1223.5		1223.54	0.000003	-0.36	910.68	150.10	0.02
OldSmokyHill_3	32815	Max WS	-85	1210.12	1223.5		1223.54	0.000000	-0.11	1090.11	174.55	0.01
OldSmokyHill_3	32773	Max WS	-86	1211.25	1223.5		1223.54	0.000003	-0.29	395.80	109.82	0.02
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-86	1211.25	1223.5		1223.54	0.000001	-0.15	594.93	124.14	0.01
OldSmokyHill_3	32500	Max WS	-86	1210.95	1223.5		1223.54	0.000002	-0.23	701.20	132.59	0.01
OldSmokyHill_3	32400	Max WS	-59	1210.85	1223.5		1223.54	0.000000	-0.09	832.16	107.20	0.00
OldSmokyHill_3	32338	Max WS	-58	1210.79	1223.5		1223.54	0.000000	-0.10	748.68	95.86	0.01
OldSmokyHill_3	32300	Max WS	-59	1210.75	1223.5		1223.54	0.000000	-0.10	760.81	90.75	0.01
OldSmokyHill_3	32200	Max WS	-59	1210.65	1223.5		1223.54	0.000000	-0.09	867.49	115.43	0.00
OldSmokyHill_3	32100	Max WS	-59	1210.55	1223.5		1223.54	0.000000	-0.09	813.59	93.07	0.00
OldSmokyHill_3	31900	Max WS	-59	1210.35	1223.5		1223.54	0.000000	-0.10	712.48	143.99	0.01
OldSmokyHill_3	31800	Max WS	-5	1210.25	1223.5		1223.54	0.000000	-0.01	758.02	186.62	0.00
OldSmokyHill_3	31700	Max WS	0	1209.50	1223.5		1223.54	0.000000	0.00	785.17	158.64	0.00
OldSmokyHill_3	31600	Max WS	23	1209.50	1223.5		1223.54	0.000000	0.04	845.76	169.18	0.00
OldSmokyHill_3	31500	Max WS	23	1209.50	1223.5		1223.54	0.000000	0.04	846.22	198.82	0.00
OldSmokyHill_3	31400	Max WS	24	1209.80	1223.5		1223.54	0.000000	0.04	999.35	221.89	0.00
OldSmokyHill_3	31300	Max WS	23	1209.90	1223.5		1223.54	0.000000	0.04	988.05	200.78	0.00
OldSmokyHill_3	31200	Max WS	23	1210.00	1223.5		1223.54	0.000000	0.04	932.18	189.87	0.00
OldSmokyHill_3	31100	Max WS	27	1210.10	1223.5		1223.54	0.000000	0.04	946.71	199.90	0.00
OldSmokyHill_3	31000	Max WS	36	1210.20	1223.5		1223.54	0.000000	0.06	959.06	188.03	0.00
OldSmokyHill_3	30900	Max WS	35	1210.30	1223.5		1223.54	0.000000	0.06	923.20	188.38	0.00
OldSmokyHill_3	30800	Max WS	36	1210.40	1223.5		1223.54	0.000000	0.06	960.55	190.44	0.00
OldSmokyHill_3	30700	Max WS	34	1210.50	1223.5		1223.54	0.000000	0.06	875.55	174.54	0.00
OldSmokyHill_3	30651	Max WS	34	1210.55	1223.5		1223.54	0.000000	0.05	954.74	175.55	0.00
OldSmokyHill_3	30575	Max WS	34	1210.63	1223.5		1223.54	0.000000	0.06	947.29	184.61	0.00
OldSmokyHill_3	30500	Max WS	33	1210.70	1223.5		1223.54	0.000000	0.06	996.98	179.94	0.00
OldSmokyHill_3	30400	Max WS	32	1210.60	1223.5		1223.54	0.000000	0.05	939.65	160.93	0.00
OldSmokyHill_3	30300	Max WS	31	1210.50	1223.5		1223.54	0.000000	0.05	921.90	158.51	0.00
OldSmokyHill_3	30200	Max WS	31	1210.40	1223.5		1223.54	0.000000	0.05	1003.58	171.64	0.00
OldSmokyHill_3	30100	Max WS	31	1210.30	1223.5		1223.54	0.000000	0.05	943.98	152.68	0.00
OldSmokyHill_3	29999	Max WS	30	1210.20	1223.5		1223.54	0.000000	0.05	967.73	133.92	0.00
OldSmokyHill_3	29899	Max WS	28	1210.10	1223.5		1223.54	0.000000	0.04	1011.23	196.79	0.00
OldSmokyHill_3	29800	Max WS	37	1210.00	1223.5		1223.54	0.000000	0.05	1044.61	373.65	0.00
OldSmokyHill_3	29704	Max WS	34	1209.90	1223.5		1223.54	0.000000	0.05	1118.46	426.18	0.00

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	29572	Max WS	34	1209.77	1223.5		1223.54	0.000000	0.05	1074.29	411.19	0.00
OldSmokyHill_3	29466	Max WS	32	1209.66	1223.5		1223.54	0.000000	0.04	1209.37	452.09	0.00
OldSmokyHill_3	29385	Max WS	1561	1209.50	1223.5		1223.52	0.000111	2.08	1179.72	421.94	0.10
OldSmokyHill_3	29314	Max WS	1563	1209.50	1223.4		1223.52	0.000192	2.72	1062.56	389.34	0.14
OldSmokyHill_3	29209	Max WS	1563	1209.50	1223.4		1223.50	0.000176	2.55	985.43	335.71	0.13
OldSmokyHill_3	29100	Max WS	1564	1209.50	1223.4		1223.48	0.000191	2.71	1066.71	315.33	0.14
OldSmokyHill_3	28991	Max WS	1563	1209.50	1223.4		1223.46	0.000202	2.78	921.81	220.79	0.14
OldSmokyHill_3	28900	Max WS	1563	1210.12	1223.3		1223.44	0.000179	2.60	924.12	190.42	0.13
OldSmokyHill_3	28800	Max WS	1563	1210.22	1223.3		1223.42	0.000189	2.66	890.20	170.99	0.13
OldSmokyHill_3	28700	Max WS	1562	1210.32	1223.3		1223.40	0.000188	2.62	869.08	158.04	0.13
OldSmokyHill_3	28594	Max WS	1562	1210.43	1223.3		1223.38	0.000124	2.37	815.18	94.32	0.12
OldSmokyHill_3	28500	Max WS	1562	1210.52	1223.3		1223.37	0.000117	2.27	874.93	129.50	0.12
OldSmokyHill_3	28430	Max WS	1597	1210.34	1223.2	1216.37	1223.35	0.000530	3.49	655.59	123.35	0.19
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1591	1210.35	1222.7		1222.85	0.000531	3.88	732.42	120.60	0.21
OldSmokyHill_3	28200	Max WS	1593	1210.36	1222.7		1222.79	0.000204	2.60	848.60	142.84	0.14
OldSmokyHill_3	28100	Max WS	1601	1210.26	1222.7		1222.77	0.000200	2.59	888.46	122.42	0.14
OldSmokyHill_3	28000	Max WS	1601	1210.16	1222.7		1222.76	0.000214	2.74	851.45	109.21	0.14
OldSmokyHill_3	27900	Max WS	1600	1210.06	1222.6		1222.74	0.000208	2.70	837.47	104.03	0.14
OldSmokyHill_3	27800	Max WS	1600	1209.96	1222.6		1222.71	0.000204	2.68	818.19	106.71	0.14
OldSmokyHill_3	27700	Max WS	1600	1209.86	1222.6		1222.69	0.000130	2.37	841.88	139.49	0.13
OldSmokyHill_3	27600	Max WS	1599	1209.76	1222.6		1222.67	0.000119	2.29	817.00	134.15	0.12
OldSmokyHill_3	27500	Max WS	1615	1209.50	1222.6		1222.66	0.000132	2.29	810.64	140.71	0.12
OldSmokyHill_3	27400	Max WS	1614	1209.50	1222.6		1222.65	0.000119	2.16	843.38	142.52	0.12
OldSmokyHill_3	27300	Max WS	1615	1209.50	1222.5		1222.64	0.000263	2.98	829.47	137.70	0.16
OldSmokyHill_3	27200	Max WS	1615	1209.50	1222.5		1222.61	0.000140	2.35	794.99	138.73	0.13
OldSmokyHill_3	27100	Max WS	1621	1209.55	1222.5		1222.60	0.000145	2.59	831.01	147.46	0.13
OldSmokyHill_3	27000	Max WS	1622	1209.65	1222.5		1222.58	0.000116	2.21	835.30	169.74	0.12
OldSmokyHill_3	26900	Max WS	1622	1209.75	1222.5		1222.57	0.000102	2.08	881.31	151.10	0.11
OldSmokyHill_3	26800	Max WS	1622	1209.85	1222.5		1222.56	0.000109	2.15	907.32	165.31	0.12
OldSmokyHill_3	26700	Max WS	1629	1209.95	1222.5		1222.55	0.000148	2.50	844.62	198.54	0.13
OldSmokyHill_3	26600	Max WS	1629	1210.05	1222.4		1222.54	0.000158	2.60	784.70	143.56	0.14
OldSmokyHill_3	26522	Max WS	1628	1210.13	1222.3	1215.45	1222.55	0.000479	4.22	472.53	116.05	0.22
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1628	1210.19	1222.1		1222.39	0.000567	4.60	462.46	83.09	0.24
OldSmokyHill_3	26400	Max WS	1628	1210.25	1222.2		1222.30	0.000125	2.23	835.43	105.57	0.12
OldSmokyHill_3	26300	Max WS	1638	1210.35	1222.2		1222.30	0.000284	3.01	843.77	142.79	0.16
OldSmokyHill_3	26200	Max WS	1638	1210.45	1222.2		1222.27	0.000275	2.99	910.12	149.79	0.16
OldSmokyHill_3	26100	Max WS	1644	1210.55	1222.2		1222.23	0.000132	2.25	856.36	141.99	0.12
OldSmokyHill_3	26000	Max WS	1644	1210.45	1222.1		1222.23	0.000280	3.01	800.99	95.01	0.16
OldSmokyHill_3	25900	Max WS	1644	1210.35	1222.1		1222.19	0.000137	2.30	820.41	104.90	0.13
OldSmokyHill_3	25800	Max WS	1645	1210.25	1222.1		1222.18	0.000147	2.40	874.08	161.21	0.13
OldSmokyHill_3	25700	Max WS	1649	1210.15	1222.1		1222.16	0.000142	2.35	794.89	142.45	0.13
OldSmokyHill_3	25600	Max WS	1649	1210.05	1222.1		1222.15	0.000122	2.19	825.75	146.91	0.12
OldSmokyHill_3	25500	Max WS	1703	1209.95	1222.1		1222.13	0.000134	2.31	901.75	163.00	0.13
OldSmokyHill_3	25400	Max WS	1704	1209.85	1222.0		1222.13	0.000267	3.00	908.03	179.83	0.16
OldSmokyHill_3	25300	Max WS	1705	1209.75	1222.0		1222.12	0.000312	3.25	836.85	221.64	0.17
OldSmokyHill_3	25200	Max WS	1708	1209.50	1222.0		1222.07	0.000196	2.50	827.26	200.32	0.13
OldSmokyHill_3	25117	Max WS	1708	1208.41	1221.9	1213.86	1222.01	0.001218	2.71	890.93	219.24	0.14
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1708	1208.97	1221.7		1221.80	0.000398	3.53	630.65	163.71	0.19
OldSmokyHill_3	24900	Max WS	1708	1209.50	1221.7		1221.77	0.000153	2.34	836.58	180.09	0.13
OldSmokyHill_3	24800	Max WS	1708	1209.50	1221.6		1221.75	0.000186	2.64	759.13	179.68	0.15
OldSmokyHill_3	24700	Max WS	1716	1209.50	1221.7		1221.73	0.000146	2.30	822.43	158.25	0.13
OldSmokyHill_3	24600	Max WS	1717	1209.50	1221.6		1221.72	0.000123	2.18	894.59	162.55	0.12
OldSmokyHill_3	24500	Max WS	1720	1209.65	1221.6		1221.71	0.000151	2.41	819.58	128.02	0.13
OldSmokyHill_3	24400	Max WS	1719	1209.75	1221.6		1221.69	0.000138	2.29	816.87	93.20	0.13
OldSmokyHill_3	24300	Max WS	1719	1209.85	1221.6		1221.68	0.000143	2.32	808.04	95.45	0.13
OldSmokyHill_3	24200	Max WS	1719	1209.95	1221.6		1221.66	0.000152	2.40	804.50	99.36	0.13
OldSmokyHill_3	24100	Max WS	1719	1210.05	1221.6		1221.65	0.000167	2.52	781.77	122.96	0.14
OldSmokyHill_3	24000	Max WS	1722	1210.15	1221.5		1221.63	0.000158	2.45	817.62	110.84	0.14
OldSmokyHill_3	23900	Max WS	1722	1210.25	1221.5		1221.61	0.000156	2.42	814.11	113.28	0.14
OldSmokyHill_3	23800	Max WS	1743	1210.35	1221.5		1221.60	0.000165	2.50	826.48	141.60	0.14
OldSmokyHill_3	23700	Max WS	1743	1210.25	1221.5		1221.58	0.000167	2.52	792.49	104.81	0.14
OldSmokyHill_3	23600	Max WS	1743	1210.15	1221.5		1221.56	0.000163	2.47	786.36	99.80	0.14
OldSmokyHill_3	23500	Max WS	1743	1210.05	1221.5		1221.55	0.000146	2.33	818.47	97.22	0.13
OldSmokyHill_3	23362	Max WS	1750	1209.91	1221.4	1214.13	1221.53	0.000145	2.33	846.55	104.47	0.13
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1750	1209.75	1221.4		1221.48	0.000140	2.31	835.09	101.22	0.13
OldSmokyHill_3	23167	Max WS	1750	1209.72	1221.4		1221.47	0.000148	2.39	840.56	109.12	0.13
OldSmokyHill_3	23100	Max WS	1758	1209.50	1221.4		1221.46	0.000154	2.41	868.30	129.20	0.13
OldSmokyHill_3	23000	Max WS	1757	1209.50	1221.4		1221.45	0.000154	2.40	873.99	184.13	0.13
OldSmokyHill_3	22900	Max WS	1762	1209.50	1221.3		1221.44	0.000215	3.01	956.98	188.39	0.16
OldSmokyHill_3	22800	Max WS	1773	1209.55	1221.3		1221.43	0.000247	3.31	943.20	250.15	0.17
OldSmokyHill_3	22731	Max WS	1773	1209.62	1221.3		1221.41	0.000273	3.46	956.49	203.06	0.18
OldSmokyHill_3	22656	Max WS	1773	1209.70	1221.3	1213.90	1221.37	0.000159	2.50	867.38	166.55	0.14
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1773	1209.70	1221.3		1221.35	0.000157	2.47	861.41	148.04	0.14

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	22578	Max WS	1773	1209.77	1221.3		1221.34	0.000143	2.34	924.85	178.82	0.13
OldSmokyHill_3	22500	Max WS	1777	1209.85	1221.2		1221.34	0.000260	3.35	936.97	220.89	0.18
OldSmokyHill_3	22400	Max WS	1777	1209.95	1221.2		1221.29	0.000210	2.09	927.79	231.51	0.14
OldSmokyHill_3	22300	Max WS	1776	1210.05	1221.2		1221.27	0.000173	2.05	994.41	239.25	0.13
OldSmokyHill_3	22200	Max WS	1780	1210.15	1221.2		1221.26	0.000132	1.89	1093.14	240.16	0.12
OldSmokyHill_3	22100	Max WS	1780	1210.25	1221.2		1221.25	0.000130	2.17	1064.56	222.30	0.12
OldSmokyHill_3	22000	Max WS	1782	1210.12	1221.2		1221.24	0.000159	2.41	948.39	189.06	0.14
OldSmokyHill_3	21900	Max WS	1782	1210.12	1221.1		1221.22	0.000220	2.85	806.79	156.66	0.16
OldSmokyHill_3	21799	Max WS	1782	1210.27	1221.1		1221.20	0.000251	3.04	814.40	161.25	0.17
OldSmokyHill_3	21722	Max WS	1780	1210.10	1221.0	1214.67	1221.19	0.000277	3.21	760.27	148.67	0.18
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1780	1210.10	1221.0		1221.16	0.000280	3.20	754.80	146.00	0.18
OldSmokyHill_3	21600	Max WS	1782	1210.31	1221.0		1221.13	0.000212	2.75	846.29	151.33	0.16
OldSmokyHill_3	21500	Max WS	1793	1210.12	1221.0		1221.10	0.000148	2.32	1024.38	198.72	0.13
OldSmokyHill_3	21400	Max WS	1795	1209.93	1221.0		1221.08	0.000126	2.15	1190.03	277.60	0.12
OldSmokyHill_3	21295	Max WS	1794	1209.93	1221.0		1221.07	0.000122	2.11	1121.63	254.92	0.12
OldSmokyHill_3	21200	Max WS	1794	1209.82	1221.0		1221.06	0.000116	2.04	1164.30	309.80	0.12
OldSmokyHill_3	21100	Max WS	1793	1209.83	1221.0		1221.05	0.000111	2.01	1173.03	342.04	0.11
OldSmokyHill_3	20995	Max WS	1794	1210.03	1221.0		1221.04	0.000145	2.31	1123.85	241.41	0.13
OldSmokyHill_3	20900	Max WS	1793	1209.74	1221.0		1221.02	0.000160	2.44	1108.42	247.19	0.14
OldSmokyHill_3	20800	Max WS	1798	1209.69	1220.9		1221.01	0.000117	2.10	1240.19	280.93	0.12
OldSmokyHill_3	20700	Max WS	1799	1209.43	1220.9		1220.99	0.000127	2.20	1242.24	285.60	0.12
OldSmokyHill_3	20644	Max WS	1795	1209.47	1220.9		1220.99	0.000135	2.25	1212.48	287.60	0.13
OldSmokyHill_3	20600	Max WS	1797	1209.50	1220.9		1220.98	0.000116	2.06	1287.34	293.37	0.12
OldSmokyHill_3	20500	Max WS	1795	1209.49	1220.9		1220.97	0.000141	2.30	1147.04	313.94	0.13
OldSmokyHill_3	20434	Max WS	1794	1209.28	1220.9		1220.96	0.000150	2.38	1177.05	316.21	0.13
OldSmokyHill_3	20363	Max WS	1272	1209.34	1220.9	1213.34	1220.91	0.000108	2.03	939.41	318.03	0.11
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1254	1209.41	1220.8		1220.89	0.000093	1.89	995.25	311.38	0.10
OldSmokyHill_3	20300	Max WS	1509	1209.10	1220.9		1220.89	0.000058	1.53	1369.35	312.96	0.08
OldSmokyHill_3	20190	Max WS	2192	1209.10	1220.8		1220.88	0.000163	2.44	1199.23	269.85	0.14
OldSmokyHill_3	20100	Max WS	2199	1209.16	1220.8		1220.87	0.000204	2.79	1046.88	227.19	0.16
OldSmokyHill_3	20023	Max WS	2203	1209.05	1220.7		1220.85	0.000228	2.97	971.99	182.58	0.16
OldSmokyHill_3	19900	Max WS	2202	1209.06	1220.7		1220.82	0.000195	2.75	974.97	153.61	0.15
OldSmokyHill_3	19800	Max WS	2202	1208.97	1220.7		1220.81	0.000239	3.08	892.07	138.54	0.17
OldSmokyHill_3	19700	Max WS	2201	1208.92	1220.6		1220.78	0.000292	3.40	756.34	114.34	0.19
OldSmokyHill_3	19600	Max WS	2201	1208.86	1220.6		1220.75	0.000223	2.98	814.83	107.63	0.16
OldSmokyHill_3	19510	Max WS	2201	1208.72	1220.6	1213.06	1220.73	0.000173	2.65	914.92	111.43	0.14
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	2202	1208.72	1220.6		1220.71	0.000153	2.47	968.44	114.07	0.14
OldSmokyHill_3	19400	Max WS	2201	1208.53	1220.6		1220.70	0.000196	2.79	904.55	126.47	0.15
OldSmokyHill_3	19300	Max WS	2226	1208.28	1220.5		1220.68	0.000230	2.96	862.17	127.26	0.17
OldSmokyHill_3	19200	Max WS	2225	1208.22	1220.5		1220.66	0.000240	3.02	844.09	132.76	0.17
OldSmokyHill_3	19100	Max WS	2226	1208.22	1220.4		1220.66	0.000443	4.12	805.90	137.82	0.23
OldSmokyHill_3	19000	Max WS	2225	1208.09	1220.3		1220.63	0.000602	4.81	696.22	125.26	0.26
OldSmokyHill_3	18900	Max WS	2225	1208.03	1220.2		1220.59	0.000813	5.53	586.86	114.35	0.30
OldSmokyHill_3	18800	Max WS	2224	1207.66	1220.1		1220.51	0.000808	5.56	534.99	111.79	0.30
OldSmokyHill_3	18700	Max WS	2229	1207.83	1220.1		1220.41	0.000595	4.83	594.64	132.01	0.26
OldSmokyHill_3	18600	Max WS	2235	1207.62	1220.0		1220.36	0.000739	5.29	585.75	120.81	0.29
OldSmokyHill_3	18500	Max WS	2235	1207.70	1219.8		1220.29	0.000829	5.54	461.94	74.16	0.30
OldSmokyHill_3	18438	Max WS	2236	1207.53	1220.0	1213.29	1220.20	0.000352	3.72	712.55	87.59	0.20
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	2235	1207.50	1219.7		1219.91	0.000309	3.42	736.00	89.30	0.19
OldSmokyHill_3	18300	Max WS	2235	1207.75	1219.7		1219.88	0.000274	3.14	757.28	89.89	0.18
OldSmokyHill_3	18200	Max WS	2237	1207.43	1219.7		1219.86	0.000275	3.18	757.52	106.66	0.18
OldSmokyHill_3	18100	Max WS	2237	1207.42	1219.7		1219.83	0.000230	2.91	820.46	103.32	0.16
OldSmokyHill_3	18000	Max WS	2237	1207.16	1219.7		1219.81	0.000254	3.07	777.44	91.78	0.17
OldSmokyHill_3	17900	Max WS	2237	1207.10	1219.6		1219.78	0.000271	3.25	756.40	94.43	0.18
OldSmokyHill_3	17800	Max WS	2237	1206.51	1219.6		1219.76	0.000218	2.98	785.08	84.30	0.16
OldSmokyHill_3	17700	Max WS	2237	1206.52	1219.5		1219.73	0.000405	4.02	595.13	68.58	0.22
OldSmokyHill_3	17600	Max WS	2298	1206.23	1219.5		1219.68	0.000294	3.40	721.33	82.16	0.19
OldSmokyHill_3	17500	Max WS	2298	1206.44	1219.5		1219.65	0.000326	3.63	679.27	74.79	0.20
OldSmokyHill_3	17400	Max WS	2297	1206.06	1219.4		1219.62	0.000369	3.85	641.51	71.56	0.21
OldSmokyHill_3	17300	Max WS	2297	1205.78	1219.4		1219.58	0.000265	3.29	740.53	81.27	0.18
OldSmokyHill_3	17181	Max WS	2353	1204.48	1219.2	1213.35	1219.57	0.000811	5.34	677.73	92.33	0.27
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2347	1204.22	1218.3		1218.71	0.000729	5.35	610.78	79.39	0.27
OldSmokyHill_3	16923	Max WS	2352	1205.00	1218.4	1211.61	1218.66	0.001206	3.92	670.92	82.16	0.21
OldSmokyHill_3	16917		Inl Struct									
OldSmokyHill_3	16800	Max WS	2336	1205.21	1218.2		1218.57	0.000712	5.17	538.27	87.89	0.28
OldSmokyHill_3	16700	Max WS	2334	1204.84	1218.2	1212.00	1218.50	0.000549	4.64	609.63	91.78	0.25
OldSmokyHill_3	16653		Inl Struct									
OldSmokyHill_3	16600	Max WS	1748	1204.44	1218.0		1218.18	0.000514	3.85	538.93	101.58	0.24
OldSmokyHill_3	16500	Max WS	2330	1202.91	1218.1		1218.19	0.000095	2.30	1201.22	119.50	0.11
OldSmokyHill_3	16400	Max WS	2351	1202.78	1218.1	1205.96	1218.17	0.000033	1.39	1824.93	151.98	0.06
OldSmokyHill_3	16356		Inl Struct									
OldSmokyHill_3	16300	Max WS	2348	1202.71	1218.1		1218.16	0.000088	2.21	1271.49	132.23	0.11
OldSmokyHill_3	16200	Max WS	2345	1202.61	1218.1		1218.15	0.000107	2.45	1175.78	126.01	0.12

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	16100	Max WS	2344	1202.56	1218.1	1207.50	1218.14	0.000090	2.28	1201.19	105.74	0.11
OldSmokyHill_3	16058		Inl Struct									
OldSmokyHill_3	16000	Max WS	2345	1202.51	1218.0		1218.12	0.000145	2.95	1070.22	110.71	0.14
OldSmokyHill_3	15900	Max WS	2342	1202.34	1218.0		1218.12	0.000182	3.36	1060.62	97.41	0.15
OldSmokyHill_3	15800	Max WS	1762	1202.44	1218.0	1207.56	1218.04	0.000112	2.61	923.38	96.42	0.12
OldSmokyHill_3	15743		Inl Struct									
OldSmokyHill_3	15700	Max WS	1765	1200.38	1217.9		1218.01	0.000103	2.68	1005.32	83.83	0.11
OldSmokyHill_3	15635	Max WS	1754	1202.00	1217.9	1207.48	1218.01	0.000203	3.20	882.90	85.39	0.14
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1754	1202.00	1217.9		1217.96	0.000138	2.63	1196.85	114.69	0.12
OldSmokyHill_3	15400	Max WS	1754	1200.67	1217.9		1217.94	0.000073	2.33	1174.45	93.72	0.10
OldSmokyHill_3	15300	Max WS	1752	1200.77	1217.9		1217.94	0.000080	2.44	1150.83	112.44	0.11
OldSmokyHill_3	15200	Max WS	1747	1200.87	1217.8		1217.91	0.000067	2.17	1426.28	237.68	0.10
OldSmokyHill_3	15100	Max WS	1750	1200.97	1217.9		1217.92	0.000071	2.23	1387.34	227.20	0.10
OldSmokyHill_3	15000	Max WS	1747	1200.87	1217.9		1217.91	0.000059	2.05	1427.13	147.30	0.09
OldSmokyHill_3	14900	Max WS	1744	1200.77	1217.8		1217.91	0.000071	2.31	1373.86	129.89	0.10
OldSmokyHill_3	14800	Max WS	1743	1200.67	1217.8		1217.90	0.000070	2.28	1378.70	134.91	0.10
OldSmokyHill_3	14700	Max WS	1747	1200.57	1217.8		1217.89	0.000072	2.33	1324.72	145.23	0.10
OldSmokyHill_3	14600	Max WS	1745	1200.47	1217.8		1217.89	0.000079	2.44	1130.03	105.32	0.10
OldSmokyHill_3	14507	Max WS	1748	1201.00	1217.8	1207.56	1217.90	0.000245	3.63	1067.90	116.34	0.16
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	1753	1201.00	1217.4		1217.48	0.000129	2.63	1165.42	109.66	0.12
OldSmokyHill_3	14300	Max WS	1749	1200.17	1217.4		1217.47	0.000073	2.33	1181.77	97.98	0.10
OldSmokyHill_3	14200	Max WS	1750	1200.07	1217.4		1217.46	0.000075	2.38	1135.42	102.41	0.10
OldSmokyHill_3	14100	Max WS	1751	1199.97	1217.4		1217.45	0.000072	2.32	1258.58	148.87	0.10
OldSmokyHill_3	14000	Max WS	1748	1197.97	1217.4		1217.44	0.000062	2.20	1322.18	145.13	0.09
OldSmokyHill_3	13900	Max WS	1750	1197.97	1217.4		1217.43	0.000059	2.11	1354.12	193.29	0.09
OldSmokyHill_3	13800	Max WS	1750	1197.97	1217.4		1217.43	0.000052	1.95	1365.66	189.91	0.08
OldSmokyHill_3	13700	Max WS	1751	1197.97	1217.4		1217.42	0.000045	1.82	1644.96	219.13	0.08
OldSmokyHill_3	13600	Max WS	1748	1197.97	1217.4		1217.42	0.000056	2.06	1458.99	205.08	0.09
OldSmokyHill_3	13500	Max WS	1752	1197.97	1217.4		1217.41	0.000046	1.85	1531.58	212.82	0.08
OldSmokyHill_3	13400	Max WS	1751	1199.47	1217.4		1217.41	0.000050	1.94	1425.80	179.78	0.08
OldSmokyHill_3	13300	Max WS	1746	1199.57	1217.4		1217.40	0.000049	1.89	1464.45	161.21	0.08
OldSmokyHill_3	13200	Max WS	1746	1199.67	1217.3		1217.40	0.000047	1.85	1358.16	171.89	0.08
OldSmokyHill_3	13100	Max WS	1880	1199.77	1217.3		1217.39	0.000066	2.21	1256.50	147.58	0.10
OldSmokyHill_3	13000	Max WS	1885	1199.87	1217.3		1217.39	0.000070	2.28	1308.68	169.17	0.10
OldSmokyHill_3	12900	Max WS	1881	1199.97	1217.3		1217.38	0.000069	2.24	1323.07	140.96	0.10
OldSmokyHill_3	12800	Max WS	1883	1200.07	1217.3		1217.37	0.000062	2.11	1281.05	120.38	0.09
OldSmokyHill_3	12700	Max WS	1883	1200.17	1217.3		1217.37	0.000074	2.32	1236.11	112.60	0.10
OldSmokyHill_3	12600	Max WS	1878	1200.27	1217.3		1217.36	0.000084	2.50	1292.52	110.72	0.11
OldSmokyHill_3	12500	Max WS	1879	1200.17	1217.3		1217.35	0.000058	2.04	1325.68	117.86	0.09
OldSmokyHill_3	12400	Max WS	1883	1200.07	1217.3		1217.34	0.000056	2.01	1285.91	113.00	0.09
OldSmokyHill_3	12300	Max WS	1881	1199.97	1217.3		1217.34	0.000069	2.25	1196.85	107.97	0.10
OldSmokyHill_3	12200	Max WS	1873	1199.87	1217.3		1217.34	0.000078	2.43	1236.63	112.74	0.10
OldSmokyHill_3	12100	Max WS	1875	1199.77	1217.2		1217.33	0.000080	2.47	1186.23	94.06	0.11
OldSmokyHill_3	12000	Max WS	1877	1199.67	1217.2		1217.32	0.000075	2.40	1231.52	94.90	0.10
OldSmokyHill_3	11900	Max WS	1877	1197.80	1217.2		1217.31	0.000072	2.38	1266.98	108.45	0.10
OldSmokyHill_3	11800	Max WS	1872	1197.80	1217.2		1217.31	0.000088	2.62	1034.58	88.55	0.11
OldSmokyHill_3	11688	Max WS	1870	1197.80	1217.2		1217.30	0.000076	2.42	1069.90	99.76	0.10
OldSmokyHill_3	11600	Max WS	1870	1197.80	1217.2		1217.29	0.000075	2.43	1168.99	102.39	0.10
OldSmokyHill_3	11500	Max WS	1875	1197.80	1217.2		1217.27	0.000041	1.74	1350.24	120.07	0.07
OldSmokyHill_3	11400	Max WS	1877	1199.05	1217.2		1217.27	0.000039	1.72	1453.38	116.67	0.07
OldSmokyHill_3	11300	Max WS	1930	1199.15	1217.2		1217.27	0.000055	2.04	1306.90	111.31	0.09
OldSmokyHill_3	11200	Max WS	1922	1199.25	1217.2		1217.27	0.000074	2.40	1261.15	122.26	0.10
OldSmokyHill_3	11100	Max WS	1918	1199.35	1217.2		1217.26	0.000076	2.38	1020.85	97.65	0.10
OldSmokyHill_3	10956	Max WS	1940	1196.19	1217.2		1217.24	0.000025	1.30	1967.71	210.30	0.05
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	831	1195.60	1216.1		1216.14	0.000009	0.75	1612.20	175.71	0.03
OldSmokyHill_3	10500	Max WS	827	1199.95	1216.1		1216.14	0.000013	0.93	1379.36	128.25	0.04
OldSmokyHill_3	10400	Max WS	808	1200.05	1216.1		1216.14	0.000010	0.80	1364.17	120.42	0.04
OldSmokyHill_3	10335	Max WS	811	1199.99	1216.1	1202.78	1216.14	0.000011	0.85	1275.55	107.68	0.04
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	814	1199.95	1216.1		1216.13	0.000012	0.91	1206.57	103.92	0.04
OldSmokyHill_3	10200	Max WS	815	1199.86	1216.1		1216.13	0.000010	0.81	1312.11	118.22	0.04
OldSmokyHill_3	10100	Max WS	812	1199.76	1216.1		1216.13	0.000010	0.83	1229.06	112.68	0.04
OldSmokyHill_3	10000	Max WS	812	1199.66	1216.1		1216.13	0.000010	0.83	1207.00	108.69	0.04
OldSmokyHill_3	9900	Max WS	805	1199.56	1216.1		1216.13	0.000011	0.85	1217.68	119.18	0.04
OldSmokyHill_3	9800	Max WS	812	1199.46	1216.1		1216.13	0.000010	0.83	1260.38	109.71	0.04
OldSmokyHill_3	9700	Max WS	807	1199.36	1216.1		1216.13	0.000010	0.82	1296.05	118.41	0.04
OldSmokyHill_3	9600	Max WS	814	1199.26	1216.1		1216.13	0.000010	0.84	1284.26	108.72	0.04
OldSmokyHill_3	9500	Max WS	802	1199.16	1216.1		1216.13	0.000010	0.82	1235.51	105.29	0.04
OldSmokyHill_3	9400	Max WS	807	1199.06	1216.1		1216.13	0.000011	0.87	1196.37	104.91	0.04
OldSmokyHill_3	9300	Max WS	801	1198.96	1216.1		1216.12	0.000010	0.85	1233.11	124.77	0.04
OldSmokyHill_3	9200	Max WS	807	1198.86	1216.1		1216.12	0.000010	0.86	1239.88	113.30	0.04
OldSmokyHill_3	9148	Max WS	816	1198.81	1216.1		1216.12	0.000010	0.86	1206.79	130.89	0.04
OldSmokyHill_3	9100	Max WS	820	1198.76	1216.1		1216.12	0.000009	0.79	1308.10	130.84	0.03
OldSmokyHill_3	9000	Max WS	815	1198.66	1216.1		1216.12	0.000011	0.92	1297.76	174.31	0.04
OldSmokyHill_3	8900	Max WS	815	1198.56	1216.1		1216.12	0.000016	1.10	1229.62	197.69	0.05

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	8800	Max WS	817	1198.46	1216.1		1216.12	0.000014	1.04	1421.80	226.22	0.04
OldSmokyHill_3	8668	Max WS	810	1198.33	1216.1	1201.82	1216.12	0.000028	1.36	1180.19	243.71	0.06
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	813	1195.72	1216.1		1216.11	0.000011	0.93	1290.15	257.59	0.04
OldSmokyHill_3	8500	Max WS	813	1195.72	1216.1		1216.11	0.000012	0.98	1527.87	245.68	0.04
OldSmokyHill_3	8400	Max WS	808	1195.72	1216.1		1216.10	0.000012	0.98	1302.81	152.92	0.04
OldSmokyHill_3	8300	Max WS	811	1195.72	1216.1		1216.10	0.000008	0.79	1385.01	192.07	0.03
OldSmokyHill_3	8200	Max WS	808	1197.72	1216.1		1216.10	0.000011	0.92	1431.38	189.62	0.04
OldSmokyHill_3	8100	Max WS	804	1198.72	1216.1		1216.10	0.000009	0.81	1410.01	166.47	0.04
OldSmokyHill_3	8000	Max WS	805	1199.50	1216.1		1216.10	0.000009	0.78	1281.50	123.75	0.03
OldSmokyHill_3	7900	Max WS	797	1199.40	1216.1		1216.10	0.000010	0.83	1442.51	208.55	0.04
OldSmokyHill_3	7800	Max WS	803	1199.30	1216.1		1216.10	0.000014	1.03	1369.97	166.36	0.04
OldSmokyHill_3	7700	Max WS	798	1199.20	1216.1		1216.10	0.000018	1.16	1377.67	172.15	0.05
OldSmokyHill_3	7600	Max WS	803	1199.10	1216.1		1216.10	0.000009	0.83	1273.28	156.14	0.04
OldSmokyHill_3	7500	Max WS	796	1199.00	1216.1		1216.10	0.000014	1.03	1310.84	159.18	0.04
OldSmokyHill_3	7400	Max WS	800	1198.90	1216.1		1216.10	0.000014	1.01	1460.18	131.90	0.04
OldSmokyHill_3	7300	Max WS	799	1198.80	1216.1		1216.09	0.000013	1.00	1407.86	134.90	0.04
OldSmokyHill_3	7275		Lat Struct									
OldSmokyHill_3	7200	Max WS	755	1198.80	1216.1		1216.09	0.000012	0.96	1522.35	204.18	0.04
OldSmokyHill_3	7100	Max WS	367	1198.60	1216.1		1216.09	0.000002	0.33	1509.93	141.45	0.01
OldSmokyHill_3	7000	Max WS	373	1198.50	1216.1		1216.09	0.000002	0.40	1320.94	121.00	0.02
OldSmokyHill_3	6900	Max WS	376	1195.72	1216.1		1216.09	0.000002	0.41	1450.37	160.65	0.02
OldSmokyHill_3	6800	Max WS	376	1195.72	1216.1		1216.09	0.000003	0.45	1398.98	144.76	0.02
OldSmokyHill_3	6700	Max WS	376	1195.72	1216.1		1216.09	0.000003	0.46	1433.53	128.46	0.02
OldSmokyHill_3	6600	Max WS	375	1195.72	1216.1		1216.09	0.000002	0.41	1386.21	124.47	0.02
OldSmokyHill_3	6500	Max WS	375	1198.22	1216.1		1216.09	0.000002	0.43	1398.49	151.73	0.02
OldSmokyHill_3	6400	Max WS	371	1199.22	1216.1		1216.09	0.000003	0.47	1433.99	208.57	0.02
OldSmokyHill_3	6300	Max WS	371	1199.32	1216.1		1216.09	0.000003	0.48	1380.77	208.93	0.02
OldSmokyHill_3	6200	Max WS	375	1199.42	1216.1		1216.09	0.000004	0.53	1519.42	353.63	0.02
OldSmokyHill_3	6100	Max WS	373	1199.32	1216.1		1216.09	0.000004	0.51	1512.78	373.62	0.02
OldSmokyHill_3	6000	Max WS	373	1199.22	1216.1		1216.09	0.000003	0.50	1408.13	225.44	0.02
OldSmokyHill_3	5900	Max WS	374	1199.12	1216.1		1216.09	0.000003	0.47	1493.99	170.77	0.02
OldSmokyHill_3	5800	Max WS	374	1199.02	1216.1		1216.09	0.000004	0.52	1443.20	204.49	0.02
OldSmokyHill_3	5700	Max WS	374	1198.92	1216.1		1216.09	0.000003	0.51	1389.25	187.59	0.02
OldSmokyHill_3	5600	Max WS	375	1196.42	1216.1		1216.09	0.000002	0.37	1697.61	186.52	0.02
OldSmokyHill_3	5500	Max WS	374	1195.72	1216.1		1216.09	0.000002	0.44	1626.72	187.18	0.02
OldSmokyHill_3	5400	Max WS	373	1195.72	1216.1		1216.09	0.000003	0.47	1467.91	179.70	0.02
OldSmokyHill_3	5300	Max WS	372	1195.72	1216.1		1216.09	0.000002	0.38	1454.94	119.73	0.02
OldSmokyHill_3	5200	Max WS	372	1195.72	1216.1		1216.09	0.000001	0.32	1533.64	129.25	0.01
OldSmokyHill_3	5100	Max WS	373	1195.72	1216.1		1216.09	0.000001	0.32	1535.96	131.81	0.01
OldSmokyHill_3	5000	Max WS	374	1195.72	1216.1		1216.09	0.000001	0.32	1509.57	120.58	0.01
OldSmokyHill_3	4900	Max WS	372	1198.22	1216.1		1216.09	0.000001	0.31	1544.88	173.33	0.01
OldSmokyHill_3	4800	Max WS	373	1198.32	1216.1		1216.09	0.000002	0.40	1759.97	295.67	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	366	1198.44	1216.1		1216.09	0.000003	0.48	1578.53	220.27	0.02
OldSmokyHill_3	4600	Max WS	362	1198.52	1216.1		1216.09	0.000002	0.44	1635.37	210.47	0.02
OldSmokyHill_3	4500	Max WS	345	1198.62	1216.1		1216.09	0.000001	0.29	1538.72	168.03	0.01
OldSmokyHill_3	4400	Max WS	315	1198.71	1216.1		1216.09	0.000001	0.28	1488.24	147.87	0.01
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	259	1198.63	1216.1	1200.16	1216.09	0.000001	0.23	1555.46	158.86	0.01
OldSmokyHill_3	4278		Bridge									
OldSmokyHill_3	4200	Max WS	261	1198.65	1216.1		1216.09	0.000001	0.23	1564.03	167.50	0.01
OldSmokyHill_3	4100	Max WS	305	1198.57	1216.1		1216.09	0.000001	0.25	1746.47	173.60	0.01
OldSmokyHill_3	4000	Max WS	512	1198.39	1216.1		1216.09	0.000002	0.42	1699.46	165.90	0.02
OldSmokyHill_3	3900	Max WS	721	1198.29	1216.1		1216.08	0.000006	0.65	1638.52	180.53	0.03
OldSmokyHill_3	3800	Max WS	748	1195.72	1216.1		1216.08	0.000005	0.63	1665.48	191.47	0.03
OldSmokyHill_3	3700	Max WS	702	1195.72	1216.1		1216.08	0.000005	0.60	1693.93	176.14	0.03
OldSmokyHill_3	3600	Max WS	657	1195.72	1216.1		1216.08	0.000007	0.74	1697.13	196.64	0.03
OldSmokyHill_3	3500	Max WS	616	1195.72	1216.1		1216.08	0.000005	0.65	1687.25	153.62	0.03
OldSmokyHill_3	3400	Max WS	519	1198.22	1216.1		1216.08	0.000002	0.43	1621.41	164.26	0.02
OldSmokyHill_3	3300	Max WS	418	1198.32	1216.1		1216.08	0.000002	0.37	1570.18	177.21	0.02
OldSmokyHill_3	3200	Max WS	320	1198.39	1216.1		1216.08	0.000001	0.31	1588.85	185.62	0.01
OldSmokyHill_3	3100	Max WS	221	1198.66	1216.1		1216.08	0.000001	0.26	1713.80	247.40	0.01
OldSmokyHill_3	3000	Max WS	112	1198.34	1216.1		1216.08	0.000000	0.13	1716.16	314.94	0.01
OldSmokyHill_3	2900	Max WS	85	1198.41	1216.1		1216.08	0.000000	0.11	1610.00	250.93	0.00
OldSmokyHill_3	2800	Max WS	82	1198.34	1216.1		1216.08	0.000000	0.12	1648.62	251.47	0.01
OldSmokyHill_3	2700	Max WS	81	1198.47	1216.1		1216.08	0.000000	0.10	1643.41	250.44	0.00
OldSmokyHill_3	2600	Max WS	87	1198.50	1216.1		1216.08	0.000000	0.11	1628.73	212.43	0.00
OldSmokyHill_3	2500	Max WS	86	1198.53	1216.1		1216.08	0.000000	0.11	1406.95	162.36	0.00
OldSmokyHill_3	2400	Max WS	86	1198.93	1216.1	1199.84	1216.08	0.000000	0.09	1432.15	163.40	0.00
OldSmokyHill_3	2345		Inl Struct									
OldSmokyHill_3	2300	Max WS	87	1198.50	1216.1		1216.08	0.000000	0.09	1478.00	182.29	0.00
OldSmokyHill_3	2183	Max WS	78	1196.44	1216.1		1216.08	0.000000	0.11	917.96	191.87	0.00
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	77	1196.78	1216.0		1216.02	0.000002	0.31	255.18	170.32	0.02
OldSmokyHill_3	1900	Max WS	93	1198.47	1216.0		1216.02	0.000000	0.10	1461.37	160.49	0.00
OldSmokyHill_3	1800	Max WS	94	1198.28	1216.0		1216.02	0.000000	0.09	1564.68	187.62	0.00
OldSmokyHill_3	1700	Max WS	103	1198.12	1216.0		1216.02	0.000000	0.10	1622.28	209.31	0.00

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	1600	Max WS	123	1198.25	1216.0		1216.02	0.000000	0.16	1719.69	271.33	0.01
OldSmokyHill_3	1500	Max WS	157	1197.76	1216.0		1216.02	0.000000	0.17	1747.87	249.99	0.01
OldSmokyHill_3	1400	Max WS	183	1197.87	1216.0		1216.02	0.000000	0.16	1577.75	187.65	0.01
OldSmokyHill_3	1300	Max WS	189	1197.69	1216.0		1216.02	0.000001	0.25	1214.81	320.26	0.01
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	207	1197.53	1216.0		1216.02	0.000000	0.14	2594.56	457.66	0.01
OldSmokyHill_3	1100	Max WS	262	1197.72	1216.0		1216.02	0.000001	0.20	2489.15	548.16	0.01
OldSmokyHill_3	1000	Max WS	337	1197.72	1216.0		1216.02	0.000001	0.26	2417.45	560.00	0.01
OldSmokyHill_3	900	Max WS	423	1197.44	1216.0		1216.02	0.000002	0.36	2358.59	570.10	0.01
OldSmokyHill_3	800	Max WS	518	1197.35	1216.0		1216.01	0.000003	0.46	2303.44	577.30	0.02
OldSmokyHill_3	700	Max WS	601	1197.38	1216.0		1216.01	0.000004	0.55	2219.05	551.44	0.02
OldSmokyHill_3	660	Max WS	832	1195.72	1216.0	1201.59	1216.01	0.000016	1.03	1709.57	572.80	0.04
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	832	1194.52	1199.8	1200.86	1204.36	0.018504	17.09	48.73	12.22	1.32
OldSmokyHill_3	300	Max WS	832	1194.21	1198.7		1199.69	0.006369	8.42	105.84	33.37	0.74
OldSmokyHill_3	200	Max WS	832	1193.97	1197.9		1199.15	0.008588	9.17	96.18	31.99	0.85
OldSmokyHill_3	100	Max WS	832	1193.79	1197.4	1196.26	1197.50	0.001321	2.27	369.47	210.11	0.30

ATTACHMENT A2 - 2% TO 0.2% REFINED FWOP & FWP PROFILE OUTPUT TABLES FOR MAXIMUM WATER SURFACE CONDITIONS

HEC-RAS Plan: 04-FWOP-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	35900	Max WS	0	1212.00	1218.0		1217.95	0.000000	0.00	106.35	24.44	0.00
OldSmokyHill_3	35800	Max WS	136	1212.00	1218.1		1218.17	0.000107	1.17	121.30	28.21	0.09
OldSmokyHill_3	35680	Max WS	72	1209.80	1218.3	1211.80	1218.31	0.000254	1.12	64.37	24.79	0.10
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-267	1208.30	1222.0		1222.17	0.000851	-3.17	84.21	87.86	0.17
OldSmokyHill_3	35300	Max WS	-267	1214.81	1222.2		1222.18	0.000033	-0.78	380.69	91.25	0.06
OldSmokyHill_3	35200	Max WS	-250	1214.50	1222.2		1222.19	0.000021	-0.69	416.36	91.25	0.05
OldSmokyHill_3	35100	Max WS	-250	1214.57	1222.2		1222.19	0.000020	-0.68	420.80	91.35	0.05
OldSmokyHill_3	35000	Max WS	-231	1214.56	1222.2		1222.19	0.000012	-0.52	479.95	93.88	0.04
OldSmokyHill_3	34900	Max WS	-231	1214.56	1222.2		1222.19	0.000013	-0.54	476.81	95.64	0.04
OldSmokyHill_3	34798	Max WS	-231	1214.94	1222.2		1222.19	0.000012	-0.53	483.21	98.20	0.04
OldSmokyHill_3	34701	Max WS	-231	1214.69	1222.2		1222.19	0.000013	-0.54	471.46	95.01	0.04
OldSmokyHill_3	34604	Max WS	-231	1214.67	1222.2		1222.20	0.000012	-0.53	485.41	97.97	0.04
OldSmokyHill_3	34499	Max WS	-231	1214.72	1222.2		1222.20	0.000012	-0.52	486.68	95.54	0.03
OldSmokyHill_3	34396	Max WS	-231	1214.72	1222.2		1222.20	0.000012	-0.51	490.84	98.64	0.03
OldSmokyHill_3	34306	Max WS	-231	1214.64	1222.2		1222.20	0.000011	-0.50	505.99	98.58	0.03
OldSmokyHill_3	34186	Max WS	-231	1214.72	1222.2		1222.20	0.000020	-0.70	486.74	181.29	0.05
OldSmokyHill_3	34100	Max WS	-231	1214.75	1222.2		1222.20	0.000021	-0.71	454.26	196.02	0.05
OldSmokyHill_3	34013	Max WS	-231	1214.69	1222.2		1222.21	0.000050	-0.96	591.75	214.10	0.06
OldSmokyHill_3	33965	Max WS	-231	1214.44	1222.2		1222.21	0.000030	-0.74	643.31	186.98	0.05
OldSmokyHill_3	33914	Max WS	-232	1214.62	1222.2		1222.21	0.000019	-0.58	762.66	151.58	0.04
OldSmokyHill_3	33833	Max WS	-216	1214.58	1222.2		1222.21	0.000028	-0.72	665.29	120.17	0.05
OldSmokyHill_3	33766	Max WS	-216	1214.90	1222.2		1222.21	0.000027	-0.69	646.76	109.91	0.05
OldSmokyHill_3	33673	Max WS	-216	1214.81	1222.2		1222.21	0.000030	-0.73	548.13	94.16	0.05
OldSmokyHill_3	33600	Max WS	-216	1214.66	1222.2		1222.22	0.000031	-0.76	494.39	83.30	0.05
OldSmokyHill_3	33500	Max WS	-217	1214.44	1222.2		1222.22	0.000026	-0.71	496.43	87.17	0.05
OldSmokyHill_3	33400	Max WS	-215	1214.59	1222.2		1222.22	0.000020	-0.62	514.74	87.34	0.04
OldSmokyHill_3	33300	Max WS	-208	1214.69	1222.2		1222.22	0.000025	-0.69	495.39	83.62	0.05
OldSmokyHill_3	33200	Max WS	-208	1214.66	1222.2		1222.23	0.000024	-0.67	514.84	86.36	0.04
OldSmokyHill_3	33100	Max WS	-208	1214.62	1222.2		1222.23	0.000032	-0.79	446.96	77.42	0.05
OldSmokyHill_3	33000	Max WS	-208	1214.66	1222.2		1222.23	0.000022	-0.63	488.50	84.10	0.04
OldSmokyHill_3	32900	Max WS	-208	1214.88	1222.2		1222.23	0.000022	-0.64	569.39	105.73	0.04
OldSmokyHill_3	32815	Max WS	-89	1211.25	1222.2		1222.24	0.000006	-0.38	320.89	89.68	0.02
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-89	1211.25	1222.2		1222.25	0.000002	-0.15	500.39	114.06	0.01
OldSmokyHill_3	32500	Max WS	-89	1214.22	1222.2		1222.25	0.000004	-0.28	518.36	87.34	0.02
OldSmokyHill_3	32400	Max WS	-77	1214.22	1222.2		1222.25	0.000003	-0.23	548.73	86.19	0.02
OldSmokyHill_3	32338	Max WS	-76	1214.16	1222.2		1222.25	0.000003	-0.26	496.51	80.57	0.02
OldSmokyHill_3	32300	Max WS	-77	1214.28	1222.2		1222.25	0.000003	-0.25	502.02	82.76	0.02
OldSmokyHill_3	32200	Max WS	-77	1214.11	1222.2		1222.25	0.000003	-0.23	562.81	90.63	0.01
OldSmokyHill_3	32100	Max WS	-77	1214.35	1222.2		1222.25	0.000002	-0.22	526.53	85.41	0.01
OldSmokyHill_3	31900	Max WS	-76	1214.09	1222.2		1222.25	0.000003	-0.26	450.97	73.82	0.02
OldSmokyHill_3	31800	Max WS	-43	1213.78	1222.2		1222.25	0.000001	-0.18	463.07	77.04	0.01
OldSmokyHill_3	31700	Max WS	-40	1214.09	1222.2		1222.25	0.000001	-0.17	379.51	62.12	0.01
OldSmokyHill_3	31600	Max WS	-26	1213.59	1222.2		1222.25	0.000000	-0.10	390.36	95.28	0.01
OldSmokyHill_3	31500	Max WS	-26	1213.69	1222.2		1222.25	0.000000	-0.08	503.45	137.07	0.01
OldSmokyHill_3	31400	Max WS	-26	1213.66	1222.2		1222.25	0.000000	-0.07	627.11	151.00	0.00
OldSmokyHill_3	31300	Max WS	-26	1213.67	1222.2		1222.25	0.000000	-0.09	621.13	128.52	0.01
OldSmokyHill_3	31200	Max WS	-26	1213.62	1222.2		1222.25	0.000000	-0.07	615.53	122.64	0.00
OldSmokyHill_3	31100	Max WS	-25	1213.66	1222.2		1222.25	0.000000	-0.07	593.08	133.41	0.00
OldSmokyHill_3	31000	Max WS	-19	1213.78	1222.2		1222.25	0.000000	-0.06	591.46	150.26	0.00
OldSmokyHill_3	30900	Max WS	-19	1213.84	1222.2		1222.25	0.000000	-0.06	610.77	146.21	0.00
OldSmokyHill_3	30800	Max WS	-19	1213.72	1222.2		1222.25	0.000000	-0.06	615.60	155.62	0.00
OldSmokyHill_3	30700	Max WS	-19	1213.73	1222.2		1222.25	0.000000	-0.06	585.10	96.46	0.00
OldSmokyHill_3	30651	Max WS	-19	1213.76	1222.2		1222.25	0.000000	-0.05	622.42	116.90	0.00
OldSmokyHill_3	30575	Max WS	-20	1213.62	1222.2		1222.25	0.000000	-0.05	634.49	134.87	0.00
OldSmokyHill_3	30500	Max WS	-19	1213.78	1222.2		1222.25	0.000000	-0.05	672.77	128.62	0.00
OldSmokyHill_3	30400	Max WS	-20	1213.70	1222.2		1222.25	0.000000	-0.05	637.92	114.86	0.00
OldSmokyHill_3	30300	Max WS	-20	1213.72	1222.2		1222.25	0.000000	-0.05	625.69	94.71	0.00
OldSmokyHill_3	30200	Max WS	-20	1213.56	1222.2		1222.25	0.000000	-0.05	675.16	132.49	0.00
OldSmokyHill_3	30100	Max WS	-20	1213.75	1222.2		1222.25	0.000000	-0.05	636.64	104.89	0.00
OldSmokyHill_3	29999	Max WS	-19	1213.79	1222.2		1222.25	0.000000	-0.05	656.92	125.27	0.00
OldSmokyHill_3	29899	Max WS	-20	1213.74	1222.2		1222.25	0.000000	-0.05	653.26	118.85	0.00
OldSmokyHill_3	29800	Max WS	-15	1213.69	1222.2		1222.25	0.000000	-0.03	701.29	146.07	0.00
OldSmokyHill_3	29704	Max WS	-15	1213.72	1222.2		1222.25	0.000000	-0.05	657.14	111.09	0.00
OldSmokyHill_3	29572	Max WS	-16	1213.81	1222.2		1222.25	0.000000	-0.05	627.89	149.11	0.00
OldSmokyHill_3	29466	Max WS	-16	1213.59	1222.2		1222.25	0.000000	-0.03	675.32	138.04	0.00
OldSmokyHill_3	29385	Max WS	908	1213.50	1222.2		1222.22	0.000224	2.21	658.73	123.47	0.14
OldSmokyHill_3	29314	Max WS	910	1213.03	1222.1		1222.21	0.000354	2.90	598.67	170.38	0.17
OldSmokyHill_3	29209	Max WS	909	1213.06	1222.1		1222.17	0.000391	2.91	555.16	135.93	0.18
OldSmokyHill_3	29100	Max WS	909	1213.03	1222.1		1222.13	0.000314	2.66	608.02	205.70	0.16
OldSmokyHill_3	28991	Max WS	909	1213.00	1222.0		1222.10	0.000323	2.77	588.61	126.51	0.17
OldSmokyHill_3	28900	Max WS	909	1212.85	1222.0		1222.07	0.000395	3.10	582.28	104.28	0.19
OldSmokyHill_3	28800	Max WS	908	1213.03	1221.9		1222.03	0.000349	2.89	576.56	90.99	0.17
OldSmokyHill_3	28700	Max WS	907	1213.12	1221.9		1222.00	0.000447	3.22	578.20	111.37	0.20
OldSmokyHill_3	28594	Max WS	907	1212.92	1221.9		1221.95	0.000289	2.59	582.37	88.69	0.16
OldSmokyHill_3	28500	Max WS	906	1213.01	1221.8		1221.92	0.000270	2.50	630.62	90.51	0.15
OldSmokyHill_3	28430	Max WS	929	1210.34	1221.8	1214.71	1221.89	0.000299	2.38	528.92	85.10	0.14

HEC-RAS Plan: 04-FWOP-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	925	1209.69	1221.6		1221.64	0.000246	2.48	629.59	93.39	0.14
OldSmokyHill_3	28200	Max WS	925	1212.97	1221.6		1221.62	0.000221	2.19	617.81	91.39	0.14
OldSmokyHill_3	28100	Max WS	930	1212.97	1221.5		1221.60	0.000295	2.54	637.94	104.83	0.16
OldSmokyHill_3	28000	Max WS	929	1213.03	1221.5		1221.57	0.000313	2.69	632.60	92.86	0.16
OldSmokyHill_3	27900	Max WS	928	1213.00	1221.5		1221.54	0.000323	2.69	610.53	89.70	0.17
OldSmokyHill_3	27800	Max WS	927	1212.59	1221.4		1221.50	0.000274	2.53	596.88	85.66	0.15
OldSmokyHill_3	27700	Max WS	927	1212.69	1221.4		1221.47	0.000225	2.27	610.71	91.77	0.14
OldSmokyHill_3	27600	Max WS	926	1212.75	1221.4		1221.45	0.000308	2.64	579.18	87.30	0.16
OldSmokyHill_3	27500	Max WS	936	1212.53	1221.4		1221.42	0.000239	2.32	616.25	90.73	0.14
OldSmokyHill_3	27400	Max WS	936	1212.45	1221.3		1221.40	0.000256	2.41	630.19	89.24	0.15
OldSmokyHill_3	27300	Max WS	934	1212.53	1221.3		1221.37	0.000263	2.47	632.20	95.58	0.15
OldSmokyHill_3	27200	Max WS	934	1212.53	1221.3		1221.34	0.000240	2.40	606.27	91.57	0.14
OldSmokyHill_3	27100	Max WS	939	1212.45	1221.2		1221.32	0.000247	2.41	603.52	106.21	0.15
OldSmokyHill_3	27000	Max WS	938	1212.19	1221.2		1221.30	0.000319	2.77	605.10	116.28	0.17
OldSmokyHill_3	26900	Max WS	936	1213.09	1221.2		1221.26	0.000269	2.38	631.96	120.69	0.15
OldSmokyHill_3	26800	Max WS	935	1212.22	1221.2		1221.23	0.000243	2.33	654.40	127.66	0.14
OldSmokyHill_3	26700	Max WS	937	1212.12	1221.1		1221.21	0.000249	2.40	590.52	120.32	0.15
OldSmokyHill_3	26600	Max WS	935	1212.06	1221.1		1221.19	0.000311	2.71	565.57	85.37	0.16
OldSmokyHill_3	26522	Max WS	929	1211.97	1221.0	1216.08	1221.18	0.000641	3.90	355.30	66.58	0.23
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	924	1211.94	1220.9		1221.12	0.000549	3.62	358.46	69.85	0.22
OldSmokyHill_3	26400	Max WS	926	1211.88	1221.0		1221.06	0.000238	2.35	628.17	93.55	0.14
OldSmokyHill_3	26300	Max WS	933	1211.94	1221.0		1221.04	0.000282	2.54	616.67	93.82	0.15
OldSmokyHill_3	26200	Max WS	933	1212.17	1220.9		1221.01	0.000355	2.82	648.68	119.59	0.17
OldSmokyHill_3	26100	Max WS	934	1211.88	1220.9		1220.96	0.000200	2.16	645.17	98.21	0.13
OldSmokyHill_3	26000	Max WS	932	1211.71	1220.9		1220.95	0.000202	2.15	630.56	90.72	0.13
OldSmokyHill_3	25900	Max WS	930	1211.87	1220.9		1220.93	0.000283	2.57	632.13	91.85	0.16
OldSmokyHill_3	25800	Max WS	929	1212.01	1220.8		1220.90	0.000188	2.07	669.76	107.00	0.13
OldSmokyHill_3	25700	Max WS	930	1211.72	1220.8		1220.88	0.000284	2.56	601.56	88.07	0.16
OldSmokyHill_3	25600	Max WS	927	1211.75	1220.8		1220.85	0.000206	2.21	641.43	89.27	0.13
OldSmokyHill_3	25500	Max WS	965	1211.75	1220.8		1220.82	0.000229	2.33	664.02	97.58	0.14
OldSmokyHill_3	25400	Max WS	967	1211.72	1220.7		1220.80	0.000234	2.33	654.34	108.14	0.14
OldSmokyHill_3	25300	Max WS	960	1211.87	1220.7		1220.78	0.000377	2.94	587.14	145.50	0.18
OldSmokyHill_3	25200	Max WS	957	1211.81	1220.7		1220.74	0.000312	2.68	588.51	127.97	0.16
OldSmokyHill_3	25117	Max WS	960	1208.41	1220.7	1212.74	1220.69	0.000491	1.60	738.06	144.75	0.08
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	942	1208.97	1220.5		1220.59	0.000194	2.30	529.09	101.07	0.13
OldSmokyHill_3	24900	Max WS	939	1211.71	1220.5		1220.58	0.000196	2.35	646.63	103.05	0.15
OldSmokyHill_3	24800	Max WS	936	1211.78	1220.5		1220.56	0.000260	2.80	588.48	91.04	0.17
OldSmokyHill_3	24700	Max WS	941	1211.84	1220.5		1220.53	0.000186	2.33	648.41	93.89	0.14
OldSmokyHill_3	24600	Max WS	938	1211.34	1220.5		1220.51	0.000153	2.16	688.21	99.87	0.13
OldSmokyHill_3	24500	Max WS	934	1211.53	1220.4		1220.49	0.000175	2.25	618.48	92.88	0.14
OldSmokyHill_3	24400	Max WS	934	1211.13	1220.4		1220.47	0.000152	2.15	642.78	88.89	0.13
OldSmokyHill_3	24300	Max WS	931	1211.19	1220.4		1220.46	0.000154	2.17	636.62	88.85	0.13
OldSmokyHill_3	24200	Max WS	927	1211.13	1220.4		1220.44	0.000195	2.51	636.35	91.14	0.15
OldSmokyHill_3	24100	Max WS	920	1211.08	1220.4		1220.42	0.000192	2.44	601.42	86.29	0.15
OldSmokyHill_3	24000	Max WS	926	1211.22	1220.3		1220.40	0.000187	2.45	639.43	92.60	0.15
OldSmokyHill_3	23900	Max WS	918	1211.08	1220.3		1220.38	0.000187	2.45	649.67	95.11	0.15
OldSmokyHill_3	23800	Max WS	930	1211.12	1220.3		1220.36	0.000183	2.44	639.00	111.21	0.15
OldSmokyHill_3	23700	Max WS	926	1211.28	1220.3		1220.34	0.000143	2.12	630.64	95.25	0.13
OldSmokyHill_3	23600	Max WS	926	1211.06	1220.3		1220.32	0.000160	2.26	637.24	90.71	0.14
OldSmokyHill_3	23500	Max WS	922	1210.94	1220.3		1220.31	0.000160	2.27	662.37	93.29	0.14
OldSmokyHill_3	23362	Max WS	924	1210.95	1220.2	1214.17	1220.28	0.000156	2.23	675.83	100.12	0.13
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	920	1210.60	1220.2		1220.25	0.000117	1.95	680.25	95.30	0.12
OldSmokyHill_3	23167	Max WS	924	1210.66	1220.2		1220.25	0.000144	2.17	668.34	100.28	0.13
OldSmokyHill_3	23100	Max WS	927	1210.81	1220.2		1220.23	0.000168	2.35	698.49	109.43	0.14
OldSmokyHill_3	23000	Max WS	922	1210.50	1220.2		1220.22	0.000115	1.95	711.64	110.66	0.12
OldSmokyHill_3	22900	Max WS	927	1210.56	1220.2		1220.20	0.000107	1.88	780.23	121.79	0.11
OldSmokyHill_3	22800	Max WS	932	1210.71	1220.1		1220.19	0.000113	1.93	752.46	117.19	0.11
OldSmokyHill_3	22731	Max WS	932	1210.47	1220.1		1220.18	0.000126	2.05	747.16	119.64	0.12
OldSmokyHill_3	22656	Max WS	927	1210.44	1220.1	1213.82	1220.18	0.000153	2.28	684.43	105.51	0.13
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	922	1210.34	1220.1		1220.17	0.000154	2.27	676.06	108.83	0.13
OldSmokyHill_3	22578	Max WS	927	1210.41	1220.1		1220.16	0.000132	2.12	719.95	120.26	0.12
OldSmokyHill_3	22500	Max WS	926	1210.38	1220.1		1220.14	0.000141	2.21	705.92	131.50	0.13
OldSmokyHill_3	22400	Max WS	920	1210.44	1220.1		1220.13	0.000193	2.56	661.16	166.40	0.15
OldSmokyHill_3	22300	Max WS	915	1210.31	1220.1		1220.11	0.000186	2.57	711.54	185.92	0.15
OldSmokyHill_3	22200	Max WS	912	1210.44	1220.0		1220.09	0.000153	2.27	798.24	214.83	0.13
OldSmokyHill_3	22100	Max WS	905	1210.16	1220.0		1220.07	0.000129	2.15	806.42	206.23	0.12
OldSmokyHill_3	22000	Max WS	908	1210.12	1220.0		1220.06	0.000139	2.23	739.22	169.41	0.13
OldSmokyHill_3	21900	Max WS	902	1210.13	1220.0		1220.04	0.000127	2.10	667.36	112.80	0.12
OldSmokyHill_3	21799	Max WS	894	1210.28	1220.0		1220.03	0.000160	2.37	655.58	122.83	0.14
OldSmokyHill_3	21722	Max WS	887	1210.11	1219.9	1213.66	1220.02	0.000204	2.71	609.76	124.65	0.15
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	887	1210.11	1219.9		1220.01	0.000206	2.73	609.90	122.68	0.16
OldSmokyHill_3	21600	Max WS	887	1210.31	1219.9		1219.98	0.000176	2.46	691.26	131.69	0.14

HEC-RAS Plan: 04-FWOP-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	21500	Max WS	900	1210.14	1219.9		1219.96	0.000109	1.95	815.62	174.48	0.11
OldSmokyHill_3	21400	Max WS	894	1209.94	1219.9		1219.95	0.000068	1.52	913.35	223.16	0.09
OldSmokyHill_3	21296	Max WS	894	1209.94	1219.9		1219.94	0.000071	1.58	889.42	198.64	0.09
OldSmokyHill_3	21200	Max WS	894	1209.81	1219.9		1219.93	0.000082	1.69	921.25	196.69	0.10
OldSmokyHill_3	21100	Max WS	885	1209.84	1219.9		1219.92	0.000063	1.47	929.54	230.00	0.09
OldSmokyHill_3	20995	Max WS	885	1210.03	1219.9		1219.91	0.000076	1.63	896.96	191.32	0.09
OldSmokyHill_3	20900	Max WS	875	1209.75	1219.9		1219.91	0.000086	1.74	861.99	210.13	0.10
OldSmokyHill_3	20800	Max WS	881	1209.72	1219.9		1219.89	0.000060	1.44	958.60	236.13	0.08
OldSmokyHill_3	20700	Max WS	871	1209.45	1219.9		1219.89	0.000073	1.62	961.31	234.70	0.09
OldSmokyHill_3	20644	Max WS	871	1209.47	1219.9		1219.88	0.000057	1.39	929.62	230.33	0.08
OldSmokyHill_3	20600	Max WS	871	1209.50	1219.9		1219.88	0.000057	1.40	990.53	247.77	0.08
OldSmokyHill_3	20500	Max WS	859	1209.50	1219.8		1219.87	0.000081	1.69	848.95	244.56	0.10
OldSmokyHill_3	20434	Max WS	859	1209.31	1219.8		1219.87	0.000090	1.79	865.47	269.88	0.10
OldSmokyHill_3	20363	Max WS	834	1209.38	1219.8	1212.85	1219.88	0.000149	2.33	624.60	278.18	0.13
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	847	1209.41	1219.8		1219.86	0.000129	2.17	686.03	274.58	0.12
OldSmokyHill_3	20300	Max WS	847	1209.12	1219.8		1219.84	0.000036	1.17	1069.61	254.27	0.07
OldSmokyHill_3	20190	Max WS	1516	1209.13	1219.7		1219.81	0.000264	3.06	935.03	215.22	0.18
OldSmokyHill_3	20100	Max WS	1524	1209.16	1219.7		1219.80	0.000349	3.58	816.85	186.35	0.20
OldSmokyHill_3	20023	Max WS	1529	1209.08	1219.7		1219.77	0.000338	3.60	779.76	168.31	0.20
OldSmokyHill_3	19900	Max WS	1529	1209.08	1219.6		1219.73	0.000257	3.14	813.21	143.21	0.18
OldSmokyHill_3	19800	Max WS	1529	1208.97	1219.6		1219.70	0.000271	3.21	745.25	131.27	0.18
OldSmokyHill_3	19700	Max WS	1529	1208.94	1219.5		1219.68	0.000315	3.48	637.60	98.48	0.19
OldSmokyHill_3	19600	Max WS	1529	1208.88	1219.5		1219.65	0.000335	3.65	701.38	99.59	0.20
OldSmokyHill_3	19510	Max WS	1528	1208.73	1219.5	1212.74	1219.61	0.000217	2.96	796.05	103.09	0.16
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1528	1208.72	1219.5		1219.57	0.000272	3.29	842.67	106.21	0.18
OldSmokyHill_3	19400	Max WS	1528	1208.54	1219.4		1219.58	0.000450	4.30	766.52	111.17	0.23
OldSmokyHill_3	19300	Max WS	1557	1208.31	1219.4		1219.54	0.000456	4.30	715.10	116.83	0.23
OldSmokyHill_3	19200	Max WS	1557	1208.24	1219.3		1219.50	0.000482	4.43	687.11	119.18	0.24
OldSmokyHill_3	19100	Max WS	1555	1208.22	1219.2		1219.46	0.000536	4.57	644.95	128.26	0.25
OldSmokyHill_3	19000	Max WS	1555	1208.09	1219.1		1219.43	0.000704	5.25	555.18	103.24	0.29
OldSmokyHill_3	18900	Max WS	1553	1208.03	1219.0		1219.35	0.000662	4.87	468.86	90.37	0.27
OldSmokyHill_3	18800	Max WS	1551	1207.68	1218.9		1219.28	0.000639	4.83	427.46	76.45	0.27
OldSmokyHill_3	18700	Max WS	1559	1207.84	1218.9		1219.20	0.000465	4.16	467.58	86.95	0.23
OldSmokyHill_3	18600	Max WS	1563	1207.62	1218.8		1219.18	0.000685	5.11	459.15	100.02	0.28
OldSmokyHill_3	18500	Max WS	1563	1207.72	1218.7		1219.10	0.000668	4.92	396.56	55.75	0.28
OldSmokyHill_3	18438	Max WS	1563	1207.54	1218.8	1212.83	1219.04	0.000438	4.20	610.13	86.15	0.23
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1563	1207.53	1218.8		1219.01	0.000401	4.09	653.62	88.37	0.22
OldSmokyHill_3	18300	Max WS	1562	1207.75	1218.8		1218.97	0.000437	4.23	673.03	87.12	0.23
OldSmokyHill_3	18200	Max WS	1565	1207.44	1218.7		1218.92	0.000390	4.02	664.23	86.51	0.22
OldSmokyHill_3	18100	Max WS	1565	1207.44	1218.7		1218.88	0.000399	4.12	722.36	94.76	0.22
OldSmokyHill_3	18000	Max WS	1562	1207.16	1218.7		1218.85	0.000453	4.44	686.97	88.15	0.24
OldSmokyHill_3	17900	Max WS	1562	1207.12	1218.6		1218.79	0.000323	3.71	664.29	88.66	0.20
OldSmokyHill_3	17800	Max WS	1562	1206.53	1218.6		1218.77	0.000405	4.33	700.16	80.57	0.22
OldSmokyHill_3	17700	Max WS	1554	1206.54	1218.5		1218.75	0.000528	4.88	527.55	63.96	0.25
OldSmokyHill_3	17600	Max WS	1643	1206.25	1218.4		1218.67	0.000416	4.37	635.95	78.70	0.23
OldSmokyHill_3	17500	Max WS	1643	1206.45	1218.4		1218.62	0.000368	4.03	601.96	72.60	0.21
OldSmokyHill_3	17400	Max WS	1643	1206.07	1218.3		1218.60	0.000505	4.90	566.08	68.95	0.25
OldSmokyHill_3	17300	Max WS	1643	1205.81	1218.3		1218.53	0.000323	3.89	654.47	77.81	0.20
OldSmokyHill_3	17181	Max WS	1734	1204.48	1218.2	1212.55	1218.48	0.000651	4.61	573.16	89.20	0.25
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	1734	1204.22	1217.0		1217.28	0.000492	4.20	513.55	73.61	0.22
OldSmokyHill_3	16800	Max WS	1734	1205.22	1216.7		1217.29	0.001139	6.73	425.32	69.72	0.36
OldSmokyHill_3	16700	Max WS	1734	1204.84	1216.7		1217.13	0.000748	5.58	484.94	78.70	0.30
OldSmokyHill_3	16600	Max WS	1734	1204.49	1216.8	1211.64	1216.99	0.000653	3.95	566.99	104.94	0.26
OldSmokyHill_3	16574		Inl Struct									
OldSmokyHill_3	16500	Max WS	1616	1202.84	1215.2		1215.22	0.000030	1.19	1605.23	148.55	0.06
OldSmokyHill_3	16400	Max WS	1618	1202.78	1215.2		1215.21	0.000032	1.23	1528.24	150.86	0.06
OldSmokyHill_3	16300	Max WS	1644	1202.75	1215.2		1215.22	0.000131	2.40	1113.29	120.00	0.13
OldSmokyHill_3	16200	Max WS	1641	1202.62	1215.1		1215.21	0.000173	2.89	1016.10	111.67	0.15
OldSmokyHill_3	16100	Max WS	1641	1202.56	1215.1		1215.20	0.000182	2.95	931.67	104.85	0.15
OldSmokyHill_3	16000	Max WS	1641	1202.50	1215.1		1215.18	0.000202	3.09	847.78	93.94	0.16
OldSmokyHill_3	15900	Max WS	1639	1202.34	1215.0		1215.18	0.000320	3.88	571.88	66.31	0.20
OldSmokyHill_3	15800	Max WS	1639	1202.44	1215.0		1215.15	0.000305	3.79	635.45	73.17	0.19
OldSmokyHill_3	15700	Max WS	1652	1202.56	1214.9		1215.11	0.000325	3.78	637.47	75.18	0.20
OldSmokyHill_3	15635	Max WS	1656	1202.00	1214.9	1207.31	1215.09	0.000410	3.94	642.79	75.55	0.20
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1656	1202.00	1214.9		1215.01	0.000406	2.06	872.60	104.84	0.10
OldSmokyHill_3	15400	Max WS	1654	1202.54	1214.9		1214.99	0.000237	3.29	812.47	86.42	0.17
OldSmokyHill_3	15300	Max WS	1658	1202.93	1214.8		1214.98	0.000327	3.77	749.63	81.52	0.20
OldSmokyHill_3	15200	Max WS	1656	1202.50	1214.8		1214.93	0.000202	3.08	777.01	88.34	0.16
OldSmokyHill_3	15100	Max WS	1654	1202.59	1214.8		1214.91	0.000194	3.02	842.76	89.53	0.16
OldSmokyHill_3	15000	Max WS	1655	1202.48	1214.8		1214.89	0.000211	3.14	865.23	97.86	0.16
OldSmokyHill_3	14900	Max WS	1655	1201.88	1214.7		1214.88	0.000241	3.43	880.37	95.52	0.17
OldSmokyHill_3	14800	Max WS	1654	1202.06	1214.7		1214.84	0.000161	2.81	890.84	90.26	0.14
OldSmokyHill_3	14700	Max WS	1659	1202.03	1214.7		1214.84	0.000238	3.41	907.54	93.62	0.17

HEC-RAS Plan: 04-FWOP-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	14600	Max WS	1661	1201.91	1214.7		1214.83	0.000322	3.95	765.58	85.06	0.20
OldSmokyHill_3	14507	Max WS	1681	1201.00	1214.6	1207.40	1214.80	0.000500	4.49	755.76	89.05	0.22
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	1681	1201.00	1214.2		1214.32	0.000269	3.28	842.86	94.13	0.16
OldSmokyHill_3	14300	Max WS	1679	1202.28	1214.2		1214.30	0.000199	2.92	789.39	87.15	0.16
OldSmokyHill_3	14200	Max WS	1680	1201.94	1214.1		1214.29	0.000315	3.65	732.95	82.60	0.19
OldSmokyHill_3	14100	Max WS	1679	1201.94	1214.1		1214.25	0.000233	3.31	812.23	88.39	0.17
OldSmokyHill_3	14000	Max WS	1680	1202.06	1214.1		1214.23	0.000235	3.28	839.13	90.49	0.17
OldSmokyHill_3	13900	Max WS	1680	1202.00	1214.1		1214.21	0.000282	3.57	809.37	88.83	0.18
OldSmokyHill_3	13800	Max WS	1679	1201.91	1214.0		1214.18	0.000256	3.47	798.63	91.33	0.18
OldSmokyHill_3	13700	Max WS	1678	1202.31	1214.0		1214.14	0.000219	3.14	1005.49	108.31	0.17
OldSmokyHill_3	13600	Max WS	1677	1202.09	1214.0		1214.13	0.000251	3.40	877.49	97.27	0.18
OldSmokyHill_3	13500	Max WS	1677	1201.84	1214.0		1214.10	0.000186	2.95	937.26	104.83	0.15
OldSmokyHill_3	13400	Max WS	1677	1202.19	1214.0		1214.08	0.000217	3.14	918.92	104.56	0.16
OldSmokyHill_3	13300	Max WS	1677	1202.09	1213.9		1214.06	0.000234	3.19	967.94	99.58	0.17
OldSmokyHill_3	13200	Max WS	1676	1202.00	1213.9		1214.04	0.000286	3.64	872.98	94.96	0.19
OldSmokyHill_3	13100	Max WS	1784	1201.94	1213.8		1214.01	0.000279	3.62	816.51	87.09	0.19
OldSmokyHill_3	13000	Max WS	1795	1201.75	1213.8		1213.99	0.000348	4.03	839.87	97.96	0.21
OldSmokyHill_3	12900	Max WS	1796	1201.88	1213.8		1213.94	0.000310	3.82	868.64	95.59	0.20
OldSmokyHill_3	12800	Max WS	1795	1201.88	1213.8		1213.91	0.000307	3.75	855.66	90.04	0.19
OldSmokyHill_3	12700	Max WS	1794	1201.56	1213.7		1213.87	0.000215	3.14	840.74	87.60	0.16
OldSmokyHill_3	12600	Max WS	1795	1201.66	1213.7		1213.85	0.000245	3.37	866.79	91.68	0.18
OldSmokyHill_3	12500	Max WS	1794	1201.75	1213.7		1213.83	0.000293	3.73	893.66	95.32	0.19
OldSmokyHill_3	12400	Max WS	1802	1201.69	1213.7		1213.79	0.000180	2.87	867.99	89.17	0.15
OldSmokyHill_3	12300	Max WS	1802	1201.38	1213.6		1213.79	0.000278	3.64	788.84	87.86	0.19
OldSmokyHill_3	12200	Max WS	1801	1201.56	1213.6		1213.75	0.000228	3.27	814.27	87.25	0.17
OldSmokyHill_3	12100	Max WS	1804	1201.41	1213.6		1213.74	0.000287	3.69	794.36	83.81	0.19
OldSmokyHill_3	12000	Max WS	1809	1201.25	1213.5		1213.70	0.000286	3.64	819.32	86.49	0.19
OldSmokyHill_3	11900	Max WS	1809	1201.34	1213.5		1213.68	0.000303	3.80	811.97	89.98	0.20
OldSmokyHill_3	11800	Max WS	1811	1201.47	1213.4		1213.67	0.000401	4.31	633.45	75.36	0.22
OldSmokyHill_3	11688	Max WS	1810	1201.35	1213.4		1213.62	0.000407	4.34	650.04	76.17	0.22
OldSmokyHill_3	11600	Max WS	1813	1201.41	1213.4		1213.58	0.000386	4.19	730.55	79.72	0.22
OldSmokyHill_3	11500	Max WS	1813	1201.15	1213.4		1213.52	0.000253	3.44	877.25	92.31	0.18
OldSmokyHill_3	11400	Max WS	1814	1201.03	1213.4		1213.48	0.000134	2.58	982.81	98.33	0.13
OldSmokyHill_3	11300	Max WS	1857	1200.84	1213.3		1213.49	0.000300	3.76	850.38	89.98	0.19
OldSmokyHill_3	11200	Max WS	1857	1200.94	1213.3		1213.46	0.000304	3.81	819.23	85.71	0.20
OldSmokyHill_3	11100	Max WS	1857	1200.81	1213.2		1213.44	0.000353	4.11	704.54	75.68	0.21
OldSmokyHill_3	10956	Max WS	1869	1196.19	1213.3		1213.34	0.000096	2.19	1460.20	197.73	0.10
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	601	1195.60	1211.9		1211.87	0.000014	0.77	1119.61	156.40	0.04
OldSmokyHill_3	10500	Max WS	598	1200.88	1211.9		1211.87	0.000040	1.27	785.21	93.22	0.07
OldSmokyHill_3	10400	Max WS	597	1200.80	1211.8		1211.87	0.000041	1.31	811.24	100.93	0.07
OldSmokyHill_3	10335	Max WS	597	1200.91	1211.8	1203.43	1211.87	0.000044	1.33	801.94	94.66	0.07
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	597	1200.91	1211.8		1211.86	0.000048	1.40	754.40	89.61	0.08
OldSmokyHill_3	10200	Max WS	596	1200.59	1211.8		1211.85	0.000033	1.19	843.83	95.55	0.06
OldSmokyHill_3	10100	Max WS	598	1200.75	1211.8		1211.85	0.000041	1.31	769.58	89.69	0.07
OldSmokyHill_3	10000	Max WS	598	1200.50	1211.8		1211.85	0.000023	1.00	772.21	85.37	0.05
OldSmokyHill_3	9900	Max WS	598	1200.38	1211.8		1211.84	0.000027	1.08	765.13	87.08	0.06
OldSmokyHill_3	9800	Max WS	594	1200.44	1211.8		1211.84	0.000040	1.32	798.19	92.58	0.07
OldSmokyHill_3	9700	Max WS	590	1200.36	1211.8		1211.84	0.000040	1.33	805.28	94.48	0.07
OldSmokyHill_3	9600	Max WS	592	1200.22	1211.8		1211.83	0.000038	1.29	811.94	91.01	0.07
OldSmokyHill_3	9500	Max WS	586	1200.29	1211.8		1211.83	0.000038	1.30	781.30	88.11	0.07
OldSmokyHill_3	9400	Max WS	586	1200.41	1211.8		1211.83	0.000041	1.34	746.74	84.98	0.07
OldSmokyHill_3	9300	Max WS	585	1200.34	1211.8		1211.82	0.000037	1.28	767.95	86.01	0.07
OldSmokyHill_3	9200	Max WS	582	1200.56	1211.8		1211.82	0.000041	1.29	735.68	93.24	0.07
OldSmokyHill_3	9148	Max WS	588	1200.25	1211.8		1211.82	0.000038	1.28	731.16	83.43	0.07
OldSmokyHill_3	9100	Max WS	590	1200.27	1211.8		1211.81	0.000020	0.94	825.73	89.30	0.05
OldSmokyHill_3	9000	Max WS	591	1200.25	1211.8		1211.81	0.000032	1.18	744.92	90.21	0.06
OldSmokyHill_3	8900	Max WS	589	1200.31	1211.8		1211.81	0.000040	1.32	706.56	85.33	0.07
OldSmokyHill_3	8800	Max WS	591	1200.53	1211.8		1211.80	0.000033	1.20	789.56	92.90	0.06
OldSmokyHill_3	8668	Max WS	585	1200.39	1211.8	1203.13	1211.81	0.000058	1.62	675.17	91.34	0.08
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	584	1200.25	1211.8		1211.80	0.000032	1.16	730.70	94.68	0.06
OldSmokyHill_3	8500	Max WS	586	1200.37	1211.8		1211.79	0.000036	1.24	787.34	93.63	0.07
OldSmokyHill_3	8400	Max WS	585	1200.41	1211.8		1211.79	0.000028	1.12	768.97	88.01	0.06
OldSmokyHill_3	8300	Max WS	581	1199.94	1211.8		1211.78	0.000028	1.13	780.35	85.90	0.06
OldSmokyHill_3	8200	Max WS	583	1199.79	1211.8		1211.78	0.000029	1.18	825.72	94.27	0.06
OldSmokyHill_3	8100	Max WS	581	1199.97	1211.8		1211.78	0.000030	1.15	834.31	100.71	0.06
OldSmokyHill_3	8000	Max WS	582	1199.51	1211.8		1211.78	0.000019	0.95	834.91	85.92	0.05
OldSmokyHill_3	7900	Max WS	578	1199.72	1211.8		1211.77	0.000028	1.16	858.27	97.86	0.06
OldSmokyHill_3	7800	Max WS	582	1199.50	1211.8		1211.77	0.000023	1.04	849.02	95.45	0.05
OldSmokyHill_3	7700	Max WS	581	1199.53	1211.8		1211.77	0.000027	1.15	849.55	95.89	0.06
OldSmokyHill_3	7600	Max WS	575	1199.56	1211.8		1211.77	0.000027	1.14	810.82	89.08	0.06
OldSmokyHill_3	7500	Max WS	576	1199.59	1211.7		1211.76	0.000025	1.09	843.98	90.05	0.06
OldSmokyHill_3	7400	Max WS	580	1199.59	1211.7		1211.76	0.000022	1.03	962.68	100.03	0.05
OldSmokyHill_3	7300	Max WS	576	1199.63	1211.7		1211.76	0.000022	1.03	902.57	99.53	0.05
OldSmokyHill_3	7275		Lat Struct									

HEC-RAS Plan: 04-FWOP-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	7200	Max WS	554	1199.58	1211.7		1211.76	0.000021	0.99	923.45	104.50	0.05
OldSmokyHill_3	7100	Max WS	230	1199.59	1211.8		1211.76	0.000003	0.37	966.11	105.12	0.02
OldSmokyHill_3	7000	Max WS	234	1199.50	1211.8		1211.76	0.000004	0.46	822.90	93.56	0.02
OldSmokyHill_3	6900	Max WS	235	1199.53	1211.8		1211.76	0.000004	0.45	822.31	99.89	0.02
OldSmokyHill_3	6800	Max WS	236	1199.41	1211.8		1211.76	0.000004	0.45	830.79	89.21	0.02
OldSmokyHill_3	6700	Max WS	236	1199.62	1211.8		1211.76	0.000004	0.46	862.53	98.88	0.02
OldSmokyHill_3	6600	Max WS	236	1199.46	1211.8		1211.76	0.000005	0.49	826.89	91.74	0.02
OldSmokyHill_3	6500	Max WS	235	1199.95	1211.8		1211.76	0.000004	0.44	820.28	100.02	0.02
OldSmokyHill_3	6400	Max WS	236	1199.64	1211.8		1211.76	0.000004	0.42	873.62	92.99	0.02
OldSmokyHill_3	6300	Max WS	236	1199.66	1211.8		1211.76	0.000004	0.43	861.34	91.00	0.02
OldSmokyHill_3	6200	Max WS	236	1199.70	1211.8		1211.76	0.000004	0.44	877.44	89.81	0.02
OldSmokyHill_3	6100	Max WS	235	1199.62	1211.8		1211.75	0.000004	0.43	866.38	87.02	0.02
OldSmokyHill_3	6000	Max WS	235	1199.63	1211.8		1211.76	0.000005	0.47	847.22	92.96	0.02
OldSmokyHill_3	5900	Max WS	235	1199.56	1211.8		1211.75	0.000004	0.41	921.09	102.57	0.02
OldSmokyHill_3	5800	Max WS	235	1199.59	1211.8		1211.75	0.000004	0.45	850.65	101.76	0.02
OldSmokyHill_3	5700	Max WS	235	1199.50	1211.8		1211.75	0.000004	0.44	856.00	93.08	0.02
OldSmokyHill_3	5600	Max WS	236	1199.57	1211.8		1211.75	0.000004	0.42	996.07	110.83	0.02
OldSmokyHill_3	5500	Max WS	235	1199.22	1211.8		1211.75	0.000004	0.42	982.93	109.72	0.02
OldSmokyHill_3	5400	Max WS	235	1199.12	1211.8		1211.75	0.000005	0.48	898.13	96.53	0.02
OldSmokyHill_3	5300	Max WS	235	1199.14	1211.7		1211.75	0.000004	0.46	881.12	97.65	0.02
OldSmokyHill_3	5200	Max WS	235	1199.09	1211.7		1211.75	0.000002	0.35	954.10	98.54	0.02
OldSmokyHill_3	5100	Max WS	235	1198.99	1211.7		1211.75	0.000005	0.47	939.39	104.29	0.02
OldSmokyHill_3	5000	Max WS	235	1198.99	1211.7		1211.75	0.000004	0.46	943.47	103.39	0.02
OldSmokyHill_3	4900	Max WS	233	1199.38	1211.7		1211.75	0.000004	0.42	986.36	102.91	0.02
OldSmokyHill_3	4800	Max WS	235	1198.50	1211.7		1211.75	0.000003	0.40	1064.33	116.94	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	234	1198.66	1211.7		1211.75	0.000004	0.45	940.14	105.09	0.02
OldSmokyHill_3	4600	Max WS	233	1198.79	1211.7		1211.75	0.000003	0.38	1016.96	106.10	0.02
OldSmokyHill_3	4500	Max WS	235	1198.69	1211.7		1211.75	0.000003	0.42	985.75	100.25	0.02
OldSmokyHill_3	4400	Max WS	241	1198.73	1211.7		1211.75	0.000005	0.46	954.83	112.20	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	298	1198.63	1211.7		1211.75	0.000005	0.53	1035.92	106.58	0.03
OldSmokyHill_3	4200	Max WS	403	1198.66	1211.7		1211.75	0.000012	0.78	996.62	108.19	0.04
OldSmokyHill_3	4100	Max WS	404	1198.56	1211.7		1211.75	0.000010	0.70	1085.64	125.94	0.04
OldSmokyHill_3	4000	Max WS	585	1198.84	1211.7		1211.74	0.000027	1.18	1020.84	119.19	0.06
OldSmokyHill_3	3900	Max WS	595	1198.91	1211.7		1211.74	0.000024	1.10	994.43	113.27	0.06
OldSmokyHill_3	3800	Max WS	595	1198.66	1211.7		1211.74	0.000021	1.05	937.28	100.11	0.05
OldSmokyHill_3	3700	Max WS	594	1198.59	1211.7		1211.74	0.000021	1.03	983.08	100.10	0.05
OldSmokyHill_3	3600	Max WS	595	1198.52	1211.7		1211.73	0.000026	1.16	994.86	105.44	0.06
OldSmokyHill_3	3500	Max WS	595	1198.78	1211.7		1211.73	0.000023	1.08	1018.05	102.03	0.05
OldSmokyHill_3	3400	Max WS	595	1198.62	1211.7		1211.73	0.000020	1.01	988.25	100.91	0.05
OldSmokyHill_3	3300	Max WS	595	1198.34	1211.7		1211.73	0.000021	1.06	934.27	94.80	0.05
OldSmokyHill_3	3200	Max WS	595	1198.38	1211.7		1211.72	0.000021	1.05	907.60	93.72	0.05
OldSmokyHill_3	3100	Max WS	595	1198.66	1211.7		1211.72	0.000020	1.01	921.06	113.47	0.05
OldSmokyHill_3	3000	Max WS	595	1198.34	1211.7		1211.72	0.000018	0.96	926.85	94.87	0.05
OldSmokyHill_3	2900	Max WS	595	1198.41	1211.7		1211.72	0.000022	1.06	956.03	105.06	0.05
OldSmokyHill_3	2800	Max WS	595	1198.34	1211.7		1211.72	0.000025	1.15	977.26	108.11	0.06
OldSmokyHill_3	2700	Max WS	595	1198.47	1211.7		1211.71	0.000022	1.08	960.87	105.02	0.05
OldSmokyHill_3	2600	Max WS	599	1198.50	1211.7		1211.71	0.000019	1.01	989.29	107.88	0.05
OldSmokyHill_3	2500	Max WS	599	1198.53	1211.7		1211.71	0.000029	1.22	847.38	111.31	0.06
OldSmokyHill_3	2400	Max WS	599	1198.93	1211.7		1211.70	0.000017	0.93	894.69	107.82	0.05
OldSmokyHill_3	2300	Max WS	599	1198.50	1211.7		1211.70	0.000015	0.90	920.38	109.35	0.04
OldSmokyHill_3	2183	Max WS	599	1196.44	1211.7		1211.70	0.000021	1.05	660.61	108.12	0.05
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	598	1196.78	1205.8		1206.24	0.001097	5.26	113.75	80.95	0.32
OldSmokyHill_3	1900	Max WS	599	1198.47	1206.0		1206.04	0.000181	2.08	377.27	77.88	0.14
OldSmokyHill_3	1800	Max WS	599	1198.28	1206.0		1206.02	0.000136	1.81	469.91	84.80	0.12
OldSmokyHill_3	1700	Max WS	599	1198.12	1206.0		1206.01	0.000091	1.53	529.45	84.33	0.10
OldSmokyHill_3	1600	Max WS	598	1198.25	1206.0		1206.00	0.000152	1.97	469.57	79.03	0.13
OldSmokyHill_3	1500	Max WS	598	1197.76	1205.9		1205.98	0.000110	1.70	492.15	81.90	0.11
OldSmokyHill_3	1400	Max WS	598	1197.88	1205.9		1205.97	0.000109	1.64	478.83	80.47	0.11
OldSmokyHill_3	1300	Max WS	597	1197.69	1205.9		1205.96	0.000218	2.28	314.51	62.11	0.15
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	597	1197.53	1205.9		1205.94	0.000244	2.48	284.70	62.02	0.16
OldSmokyHill_3	1100	Max WS	595	1197.72	1205.8		1205.92	0.000278	2.62	267.12	58.57	0.17
OldSmokyHill_3	1000	Max WS	594	1197.72	1205.8		1205.89	0.000288	2.61	255.23	51.25	0.17
OldSmokyHill_3	900	Max WS	592	1197.44	1205.8		1205.86	0.000310	2.82	245.54	50.28	0.18
OldSmokyHill_3	800	Max WS	587	1197.35	1205.8		1205.84	0.000267	2.64	260.22	52.21	0.17
OldSmokyHill_3	700	Max WS	579	1197.38	1205.7		1205.83	0.000274	2.72	255.78	52.98	0.17
OldSmokyHill_3	660	Max WS	585	1195.72	1205.7	1200.74	1205.82	0.000341	2.88	210.22	47.63	0.18
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	632	1194.57	1199.6	1199.98	1202.57	0.021816	13.86	45.61	12.47	1.13
OldSmokyHill_3	300	Max WS	626	1194.22	1198.2		1198.96	0.006614	6.78	92.38	31.94	0.70
OldSmokyHill_3	200	Max WS	620	1193.97	1197.4		1198.34	0.009313	7.59	81.67	30.82	0.82
OldSmokyHill_3	100	Max WS	613	1193.86	1196.9	1196.16	1197.00	0.001301	2.72	271.47	186.94	0.31

HEC-RAS Plan: 04-FWOP-USACE-1%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	35900	Max WS	0	1212.00	1220.6		1220.58	0.000000	0.00	204.22	54.26	0.00
OldSmokyHill_3	35800	Max WS	282	1212.00	1221.1		1221.10	0.000097	1.46	231.61	53.58	0.09
OldSmokyHill_3	35680	Max WS	137	1209.80	1221.4	1212.85	1221.46	0.000117	1.15	118.94	51.88	0.08
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-181	1208.30	1223.1		1223.15	0.000289	-1.96	92.35	92.38	0.10
OldSmokyHill_3	35300	Max WS	-181	1214.81	1223.1		1223.14	0.000008	-0.43	471.58	96.23	0.03
OldSmokyHill_3	35200	Max WS	-164	1214.50	1223.1		1223.15	0.000005	-0.37	506.19	95.40	0.02
OldSmokyHill_3	35100	Max WS	-164	1214.57	1223.1		1223.15	0.000005	-0.37	511.63	97.13	0.02
OldSmokyHill_3	35000	Max WS	-144	1214.56	1223.1		1223.15	0.000003	-0.28	572.22	98.55	0.02
OldSmokyHill_3	34900	Max WS	-144	1214.56	1223.1		1223.15	0.000003	-0.28	570.76	100.44	0.02
OldSmokyHill_3	34798	Max WS	-144	1214.94	1223.1		1223.15	0.000003	-0.28	579.57	103.20	0.02
OldSmokyHill_3	34701	Max WS	-144	1214.69	1223.1		1223.15	0.000003	-0.28	564.39	99.45	0.02
OldSmokyHill_3	34604	Max WS	-144	1214.67	1223.1		1223.15	0.000003	-0.28	581.80	103.81	0.02
OldSmokyHill_3	34499	Max WS	-145	1214.72	1223.1		1223.15	0.000003	-0.27	580.25	100.52	0.02
OldSmokyHill_3	34396	Max WS	-144	1214.72	1223.1		1223.15	0.000003	-0.27	587.28	103.34	0.02
OldSmokyHill_3	34306	Max WS	-145	1214.64	1223.1		1223.15	0.000003	-0.26	602.13	103.34	0.02
OldSmokyHill_3	34186	Max WS	-145	1214.72	1223.1		1223.15	0.000005	-0.37	577.24	199.40	0.02
OldSmokyHill_3	34100	Max WS	-144	1214.75	1223.1		1223.15	0.000005	-0.38	542.66	220.27	0.02
OldSmokyHill_3	34013	Max WS	-145	1214.69	1223.1		1223.15	0.000010	-0.46	801.05	229.80	0.03
OldSmokyHill_3	33965	Max WS	-145	1214.44	1223.1		1223.15	0.000007	-0.38	824.97	198.79	0.02
OldSmokyHill_3	33914	Max WS	-145	1214.62	1223.1		1223.15	0.000005	-0.31	898.64	162.57	0.02
OldSmokyHill_3	33833	Max WS	-129	1214.58	1223.2		1223.15	0.000006	-0.37	780.55	131.01	0.02
OldSmokyHill_3	33766	Max WS	-129	1214.90	1223.2		1223.15	0.000006	-0.36	751.71	120.11	0.02
OldSmokyHill_3	33673	Max WS	-130	1214.81	1223.2		1223.15	0.000007	-0.38	638.34	97.88	0.02
OldSmokyHill_3	33600	Max WS	-130	1214.66	1223.2		1223.15	0.000007	-0.40	574.06	86.42	0.02
OldSmokyHill_3	33500	Max WS	-130	1214.44	1223.2		1223.15	0.000006	-0.37	580.02	91.76	0.02
OldSmokyHill_3	33400	Max WS	-127	1214.59	1223.2		1223.15	0.000005	-0.32	598.58	92.30	0.02
OldSmokyHill_3	33300	Max WS	-120	1214.69	1223.2		1223.15	0.000006	-0.35	575.16	87.58	0.02
OldSmokyHill_3	33200	Max WS	-120	1214.66	1223.2		1223.15	0.000005	-0.34	597.04	90.43	0.02
OldSmokyHill_3	33100	Max WS	-120	1214.62	1223.2		1223.16	0.000007	-0.40	520.88	81.65	0.02
OldSmokyHill_3	33000	Max WS	-121	1214.66	1223.2		1223.16	0.000005	-0.32	568.65	89.00	0.02
OldSmokyHill_3	32900	Max WS	-121	1214.88	1223.2		1223.16	0.000005	-0.33	672.56	120.66	0.02
OldSmokyHill_3	32815	Max WS	2	1211.25	1223.2		1223.16	0.000000	0.01	372.34	107.10	0.00
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	0	1211.25	1223.2		1223.16	0.000000	0.00	561.04	117.14	0.00
OldSmokyHill_3	32500	Max WS	1	1214.22	1223.2		1223.16	0.000000	0.00	603.12	110.00	0.00
OldSmokyHill_3	32400	Max WS	15	1214.22	1223.2		1223.16	0.000000	0.04	628.98	92.40	0.00
OldSmokyHill_3	32338	Max WS	15	1214.16	1223.2		1223.16	0.000000	0.05	571.48	85.65	0.00
OldSmokyHill_3	32300	Max WS	14	1214.28	1223.2		1223.16	0.000000	0.04	579.11	86.83	0.00
OldSmokyHill_3	32200	Max WS	15	1214.11	1223.2		1223.16	0.000000	0.04	646.68	94.13	0.00
OldSmokyHill_3	32100	Max WS	15	1214.35	1223.2		1223.16	0.000000	0.04	606.39	90.52	0.00
OldSmokyHill_3	31900	Max WS	15	1214.09	1223.2		1223.16	0.000000	0.05	521.65	91.38	0.00
OldSmokyHill_3	31800	Max WS	56	1213.78	1223.2		1223.16	0.000002	0.22	544.92	136.12	0.01
OldSmokyHill_3	31700	Max WS	60	1214.09	1223.2		1223.16	0.000002	0.22	441.06	110.01	0.01
OldSmokyHill_3	31600	Max WS	74	1213.59	1223.2		1223.16	0.000002	0.25	497.87	157.80	0.01
OldSmokyHill_3	31500	Max WS	74	1213.69	1223.2		1223.16	0.000002	0.21	635.93	187.72	0.01
OldSmokyHill_3	31400	Max WS	74	1213.66	1223.2		1223.15	0.000001	0.17	757.27	213.73	0.01
OldSmokyHill_3	31300	Max WS	74	1213.67	1223.2		1223.16	0.000002	0.24	738.04	196.76	0.01
OldSmokyHill_3	31200	Max WS	74	1213.62	1223.2		1223.15	0.000001	0.17	719.11	168.09	0.01
OldSmokyHill_3	31100	Max WS	76	1213.66	1223.2		1223.15	0.000001	0.18	717.85	195.84	0.01
OldSmokyHill_3	31000	Max WS	81	1213.78	1223.2		1223.15	0.000002	0.23	738.68	185.07	0.01
OldSmokyHill_3	30900	Max WS	81	1213.84	1223.2		1223.15	0.000002	0.22	722.64	179.84	0.01
OldSmokyHill_3	30800	Max WS	81	1213.72	1223.2		1223.15	0.000002	0.23	755.92	186.88	0.01
OldSmokyHill_3	30700	Max WS	81	1213.73	1223.2		1223.15	0.000002	0.22	686.62	165.66	0.01
OldSmokyHill_3	30651	Max WS	81	1213.76	1223.2		1223.15	0.000001	0.19	764.94	169.16	0.01
OldSmokyHill_3	30575	Max WS	81	1213.62	1223.2		1223.15	0.000002	0.20	767.01	156.24	0.01
OldSmokyHill_3	30500	Max WS	81	1213.78	1223.2		1223.15	0.000001	0.18	812.78	171.89	0.01
OldSmokyHill_3	30400	Max WS	81	1213.70	1223.2		1223.15	0.000002	0.20	759.24	151.63	0.01
OldSmokyHill_3	30300	Max WS	81	1213.72	1223.2		1223.15	0.000002	0.20	743.30	150.96	0.01
OldSmokyHill_3	30200	Max WS	81	1213.56	1223.2		1223.15	0.000002	0.20	811.38	163.80	0.01
OldSmokyHill_3	30100	Max WS	81	1213.75	1223.2		1223.15	0.000001	0.19	749.86	148.64	0.01
OldSmokyHill_3	29999	Max WS	81	1213.79	1223.2		1223.15	0.000001	0.19	772.64	131.03	0.01
OldSmokyHill_3	29899	Max WS	81	1213.74	1223.2		1223.15	0.000001	0.19	796.96	184.12	0.01
OldSmokyHill_3	29800	Max WS	86	1213.69	1223.2		1223.15	0.000001	0.17	818.41	233.96	0.01
OldSmokyHill_3	29704	Max WS	85	1213.72	1223.2		1223.15	0.000003	0.27	811.53	313.60	0.02
OldSmokyHill_3	29572	Max WS	86	1213.81	1223.2		1223.15	0.000002	0.25	782.16	322.45	0.01
OldSmokyHill_3	29466	Max WS	85	1213.59	1223.2		1223.15	0.000001	0.17	815.45	336.58	0.01
OldSmokyHill_3	29385	Max WS	1104	1213.50	1223.1		1223.13	0.000243	2.47	846.13	325.73	0.15
OldSmokyHill_3	29314	Max WS	1105	1213.03	1223.0		1223.15	0.000487	3.63	783.60	282.11	0.21
OldSmokyHill_3	29209	Max WS	1105	1213.06	1223.0		1223.09	0.000498	3.51	716.33	216.51	0.21
OldSmokyHill_3	29100	Max WS	1105	1213.03	1222.9		1223.03	0.000392	3.18	805.98	242.03	0.19
OldSmokyHill_3	28991	Max WS	1104	1213.00	1222.9		1222.98	0.000350	3.08	717.00	155.29	0.18
OldSmokyHill_3	28900	Max WS	1104	1212.85	1222.8		1222.97	0.000491	3.67	709.86	173.53	0.21
OldSmokyHill_3	28800	Max WS	1103	1213.03	1222.8		1222.91	0.000439	3.45	683.38	156.04	0.20
OldSmokyHill_3	28700	Max WS	1103	1213.12	1222.7		1222.86	0.000446	3.43	675.81	121.54	0.20
OldSmokyHill_3	28594	Max WS	1103	1212.92	1222.7		1222.81	0.000303	2.83	658.99	92.18	0.16
OldSmokyHill_3	28500	Max WS	1102	1213.01	1222.7		1222.78	0.000286	2.74	708.43	93.67	0.16
OldSmokyHill_3	28430	Max WS	1125	1210.34	1222.7	1215.19	1222.75	0.000317	2.61	601.23	86.98	0.15

HEC-RAS Plan: 04-FWOP-USACE-1%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1120	1209.69	1222.4		1222.44	0.000274	2.75	706.21	102.70	0.15
OldSmokyHill_3	28200	Max WS	1119	1212.97	1222.3		1222.41	0.000234	2.40	697.54	120.11	0.14
OldSmokyHill_3	28100	Max WS	1125	1212.97	1222.3		1222.39	0.000329	2.85	727.91	119.10	0.17
OldSmokyHill_3	28000	Max WS	1123	1213.03	1222.3		1222.36	0.000335	2.96	705.86	100.74	0.17
OldSmokyHill_3	27900	Max WS	1120	1213.00	1222.2		1222.33	0.000350	2.98	681.49	95.47	0.18
OldSmokyHill_3	27800	Max WS	1119	1212.59	1222.2		1222.29	0.000298	2.79	664.07	102.07	0.16
OldSmokyHill_3	27700	Max WS	1119	1212.69	1222.2		1222.26	0.000248	2.53	685.33	107.07	0.15
OldSmokyHill_3	27600	Max WS	1118	1212.75	1222.1		1222.24	0.000337	2.93	649.64	98.91	0.17
OldSmokyHill_3	27500	Max WS	1128	1212.53	1222.1		1222.20	0.000257	2.55	687.69	116.26	0.15
OldSmokyHill_3	27400	Max WS	1127	1212.45	1222.1		1222.17	0.000275	2.64	699.56	126.57	0.16
OldSmokyHill_3	27300	Max WS	1126	1212.53	1222.1		1222.15	0.000281	2.71	706.45	129.37	0.16
OldSmokyHill_3	27200	Max WS	1125	1212.53	1222.0		1222.12	0.000261	2.65	672.44	122.17	0.15
OldSmokyHill_3	27100	Max WS	1129	1212.45	1222.0		1222.09	0.000262	2.63	675.20	132.17	0.15
OldSmokyHill_3	27000	Max WS	1126	1212.19	1222.0		1222.07	0.000344	3.04	672.55	132.71	0.17
OldSmokyHill_3	26900	Max WS	1127	1213.09	1221.9		1222.03	0.000287	2.62	702.33	131.46	0.16
OldSmokyHill_3	26800	Max WS	1125	1212.22	1221.9		1222.00	0.000263	2.57	728.67	149.19	0.15
OldSmokyHill_3	26700	Max WS	1127	1212.12	1221.9		1221.97	0.000269	2.64	654.34	167.43	0.15
OldSmokyHill_3	26600	Max WS	1125	1212.06	1221.8		1221.95	0.000334	2.97	630.13	120.84	0.17
OldSmokyHill_3	26522	Max WS	1117	1211.97	1221.7	1216.48	1221.94	0.000693	4.28	389.52	70.46	0.25
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1105	1211.94	1221.7		1221.86	0.000591	3.96	393.25	73.06	0.23
OldSmokyHill_3	26400	Max WS	1113	1211.88	1221.7		1221.79	0.000258	2.59	696.86	96.97	0.15
OldSmokyHill_3	26300	Max WS	1117	1211.94	1221.7		1221.78	0.000351	2.99	693.01	133.19	0.18
OldSmokyHill_3	26200	Max WS	1111	1212.17	1221.6		1221.74	0.000392	3.13	747.59	149.19	0.18
OldSmokyHill_3	26100	Max WS	1116	1211.88	1221.6		1221.69	0.000244	2.51	730.58	141.44	0.15
OldSmokyHill_3	26000	Max WS	1109	1211.71	1221.6		1221.66	0.000215	2.34	695.56	93.15	0.14
OldSmokyHill_3	25900	Max WS	1107	1211.87	1221.6		1221.65	0.000303	2.80	697.71	94.32	0.16
OldSmokyHill_3	25800	Max WS	1106	1212.01	1221.5		1221.61	0.000198	2.24	746.29	111.75	0.13
OldSmokyHill_3	25700	Max WS	1104	1211.72	1221.5		1221.59	0.000303	2.79	664.17	98.53	0.16
OldSmokyHill_3	25600	Max WS	1104	1211.75	1221.5		1221.56	0.000222	2.41	704.65	115.66	0.14
OldSmokyHill_3	25500	Max WS	1152	1211.75	1221.5		1221.54	0.000262	2.62	737.04	153.02	0.15
OldSmokyHill_3	25400	Max WS	1150	1211.72	1221.4		1221.52	0.000288	2.72	727.86	173.30	0.16
OldSmokyHill_3	25300	Max WS	1143	1211.87	1221.4		1221.49	0.000395	3.18	671.37	210.17	0.19
OldSmokyHill_3	25200	Max WS	1142	1211.81	1221.3		1221.44	0.000336	2.94	649.26	161.94	0.17
OldSmokyHill_3	25117	Max WS	1138	1208.41	1221.3	1213.07	1221.39	0.000624	1.87	808.82	182.65	0.10
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1114	1208.97	1221.2		1221.27	0.000201	2.44	588.04	138.04	0.13
OldSmokyHill_3	24900	Max WS	1107	1211.71	1221.2		1221.26	0.000212	2.58	714.19	157.30	0.15
OldSmokyHill_3	24800	Max WS	1098	1211.78	1221.1		1221.24	0.000276	3.04	650.59	142.73	0.18
OldSmokyHill_3	24700	Max WS	1107	1211.84	1221.1		1221.21	0.000197	2.53	712.01	120.92	0.15
OldSmokyHill_3	24600	Max WS	1100	1211.34	1221.1		1221.18	0.000167	2.37	756.96	114.28	0.14
OldSmokyHill_3	24500	Max WS	1099	1211.53	1221.1		1221.17	0.000186	2.44	681.87	97.47	0.15
OldSmokyHill_3	24400	Max WS	1095	1211.13	1221.1		1221.15	0.000161	2.33	702.44	90.96	0.14
OldSmokyHill_3	24300	Max WS	1092	1211.19	1221.1		1221.13	0.000164	2.35	696.47	92.15	0.14
OldSmokyHill_3	24200	Max WS	1088	1211.13	1221.0		1221.12	0.000207	2.72	697.59	94.07	0.16
OldSmokyHill_3	24100	Max WS	1084	1211.08	1221.0		1221.10	0.000226	2.78	661.28	104.27	0.16
OldSmokyHill_3	24000	Max WS	1083	1211.22	1221.0		1221.07	0.000208	2.71	702.55	103.78	0.16
OldSmokyHill_3	23900	Max WS	1075	1211.08	1221.0		1221.05	0.000208	2.72	714.66	106.62	0.16
OldSmokyHill_3	23800	Max WS	1093	1211.12	1220.9		1221.03	0.000229	2.86	718.49	132.36	0.16
OldSmokyHill_3	23700	Max WS	1089	1211.28	1220.9		1221.00	0.000157	2.33	695.04	101.55	0.14
OldSmokyHill_3	23600	Max WS	1084	1211.06	1220.9		1220.98	0.000170	2.45	696.91	93.59	0.14
OldSmokyHill_3	23500	Max WS	1084	1210.94	1220.9		1220.96	0.000172	2.46	723.44	95.42	0.14
OldSmokyHill_3	23362	Max WS	1087	1210.95	1220.9	1214.43	1220.94	0.000167	2.42	741.26	102.41	0.14
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1078	1210.60	1220.8		1220.90	0.000125	2.12	742.47	97.97	0.12
OldSmokyHill_3	23167	Max WS	1078	1210.66	1220.8		1220.90	0.000152	2.33	734.14	104.02	0.13
OldSmokyHill_3	23100	Max WS	1086	1210.81	1220.8		1220.89	0.000178	2.54	770.80	115.65	0.14
OldSmokyHill_3	23000	Max WS	1081	1210.50	1220.8		1220.87	0.000122	2.11	784.50	116.00	0.12
OldSmokyHill_3	22900	Max WS	1087	1210.56	1220.8		1220.85	0.000114	2.03	860.48	127.72	0.12
OldSmokyHill_3	22800	Max WS	1098	1210.71	1220.8		1220.84	0.000122	2.10	829.54	126.07	0.12
OldSmokyHill_3	22731	Max WS	1098	1210.47	1220.8		1220.83	0.000149	2.33	828.87	147.45	0.13
OldSmokyHill_3	22656	Max WS	1093	1210.44	1220.8	1214.07	1220.82	0.000178	2.58	756.75	125.16	0.15
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1088	1210.34	1220.7		1220.81	0.000170	2.50	748.37	119.75	0.14
OldSmokyHill_3	22578	Max WS	1087	1210.41	1220.7		1220.80	0.000149	2.36	809.52	150.87	0.13
OldSmokyHill_3	22500	Max WS	1091	1210.38	1220.7		1220.79	0.000173	2.57	801.90	191.61	0.14
OldSmokyHill_3	22400	Max WS	1080	1210.44	1220.7		1220.77	0.000191	2.67	781.29	211.32	0.15
OldSmokyHill_3	22300	Max WS	1080	1210.31	1220.7		1220.75	0.000191	2.72	850.34	233.15	0.15
OldSmokyHill_3	22200	Max WS	1083	1210.44	1220.7		1220.73	0.000153	2.38	943.11	233.55	0.13
OldSmokyHill_3	22100	Max WS	1077	1210.16	1220.7		1220.71	0.000126	2.21	943.32	218.08	0.12
OldSmokyHill_3	22000	Max WS	1067	1210.12	1220.6		1220.70	0.000159	2.49	853.34	184.81	0.14
OldSmokyHill_3	21900	Max WS	1066	1210.13	1220.6		1220.68	0.000140	2.31	741.64	124.39	0.13
OldSmokyHill_3	21799	Max WS	1059	1210.28	1220.6		1220.67	0.000185	2.66	738.86	151.03	0.15
OldSmokyHill_3	21722	Max WS	1051	1210.11	1220.6	1214.00	1220.66	0.000219	2.93	692.91	139.72	0.16
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1051	1210.11	1220.6		1220.65	0.000223	2.96	691.30	136.18	0.16
OldSmokyHill_3	21600	Max WS	1043	1210.31	1220.6		1220.62	0.000185	2.65	778.21	144.00	0.15

HEC-RAS Plan: 04-FWOP-USACE-1%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	21500	Max WS	1057	1210.14	1220.6		1220.59	0.000113	2.07	931.87	190.25	0.12
OldSmokyHill_3	21400	Max WS	1059	1209.94	1220.5		1220.58	0.000075	1.67	1064.40	257.87	0.09
OldSmokyHill_3	21296	Max WS	1059	1209.94	1220.5		1220.57	0.000074	1.67	1020.50	250.48	0.09
OldSmokyHill_3	21200	Max WS	1050	1209.81	1220.5		1220.56	0.000083	1.78	1052.36	295.19	0.10
OldSmokyHill_3	21100	Max WS	1050	1209.84	1220.5		1220.55	0.000067	1.59	1053.66	302.14	0.09
OldSmokyHill_3	20995	Max WS	1050	1210.03	1220.5		1220.54	0.000081	1.76	1022.16	214.10	0.10
OldSmokyHill_3	20900	Max WS	1040	1209.75	1220.5		1220.54	0.000089	1.85	999.77	234.82	0.10
OldSmokyHill_3	20800	Max WS	1047	1209.72	1220.5		1220.52	0.000062	1.53	1116.51	265.76	0.09
OldSmokyHill_3	20700	Max WS	1047	1209.45	1220.5		1220.52	0.000078	1.75	1116.92	274.61	0.10
OldSmokyHill_3	20644	Max WS	1035	1209.47	1220.5		1220.51	0.000061	1.50	1090.62	270.51	0.08
OldSmokyHill_3	20600	Max WS	1035	1209.50	1220.5		1220.51	0.000062	1.52	1159.39	283.83	0.09
OldSmokyHill_3	20500	Max WS	1023	1209.50	1220.5		1220.50	0.000084	1.80	1015.62	290.12	0.10
OldSmokyHill_3	20434	Max WS	1023	1209.31	1220.5		1220.50	0.000088	1.86	1045.45	299.58	0.10
OldSmokyHill_3	20363	Max WS	1010	1209.38	1220.4	1213.14	1220.50	0.000147	2.41	808.35	305.91	0.13
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1010	1209.41	1220.4		1220.49	0.000124	2.22	868.69	303.11	0.12
OldSmokyHill_3	20300	Max WS	1023	1209.12	1220.4		1220.47	0.000040	1.29	1241.95	300.75	0.07
OldSmokyHill_3	20190	Max WS	1767	1209.13	1220.4		1220.45	0.000270	3.23	1083.96	253.63	0.18
OldSmokyHill_3	20100	Max WS	1776	1209.16	1220.3		1220.43	0.000357	3.78	945.91	219.50	0.21
OldSmokyHill_3	20023	Max WS	1782	1209.08	1220.3		1220.41	0.000338	3.74	889.38	178.75	0.20
OldSmokyHill_3	19900	Max WS	1782	1209.08	1220.2		1220.36	0.000267	3.33	904.10	149.59	0.18
OldSmokyHill_3	19800	Max WS	1782	1208.97	1220.2		1220.33	0.000281	3.41	827.88	135.36	0.19
OldSmokyHill_3	19700	Max WS	1782	1208.94	1220.1		1220.31	0.000349	3.81	703.09	111.68	0.21
OldSmokyHill_3	19600	Max WS	1782	1208.88	1220.1		1220.28	0.000366	3.97	763.43	104.42	0.21
OldSmokyHill_3	19510	Max WS	1781	1208.73	1220.1	1213.07	1220.23	0.000240	3.23	859.80	106.99	0.17
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1782	1208.72	1220.1		1220.19	0.000301	3.60	907.07	109.39	0.19
OldSmokyHill_3	19400	Max WS	1782	1208.54	1220.0		1220.20	0.000503	4.71	834.76	119.10	0.25
OldSmokyHill_3	19300	Max WS	1813	1208.31	1219.9		1220.16	0.000495	4.65	785.77	123.10	0.25
OldSmokyHill_3	19200	Max WS	1813	1208.24	1219.9		1220.12	0.000524	4.79	759.70	128.04	0.25
OldSmokyHill_3	19100	Max WS	1812	1208.22	1219.8		1220.07	0.000569	4.88	720.99	132.89	0.26
OldSmokyHill_3	19000	Max WS	1812	1208.09	1219.7		1220.05	0.000786	5.74	617.80	117.50	0.31
OldSmokyHill_3	18900	Max WS	1812	1208.03	1219.6		1219.96	0.000726	5.29	522.56	102.71	0.29
OldSmokyHill_3	18800	Max WS	1811	1207.68	1219.5		1219.89	0.000719	5.31	474.38	96.02	0.29
OldSmokyHill_3	18700	Max WS	1816	1207.84	1219.5		1219.79	0.000521	4.56	522.94	115.07	0.25
OldSmokyHill_3	18600	Max WS	1824	1207.62	1219.3		1219.77	0.000757	5.56	515.15	110.03	0.30
OldSmokyHill_3	18500	Max WS	1820	1207.72	1219.3		1219.68	0.000759	5.43	425.52	58.43	0.30
OldSmokyHill_3	18438	Max WS	1824	1207.54	1219.4	1213.25	1219.61	0.000491	4.60	656.03	86.77	0.24
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1824	1207.53	1219.3		1219.53	0.000458	4.50	696.88	88.91	0.24
OldSmokyHill_3	18300	Max WS	1824	1207.75	1219.3		1219.49	0.000503	4.67	715.38	88.36	0.25
OldSmokyHill_3	18200	Max WS	1825	1207.44	1219.2		1219.44	0.000473	4.56	706.70	98.91	0.24
OldSmokyHill_3	18100	Max WS	1822	1207.44	1219.2		1219.39	0.000467	4.58	767.67	99.11	0.24
OldSmokyHill_3	18000	Max WS	1815	1207.16	1219.1		1219.35	0.000523	4.91	727.87	89.81	0.25
OldSmokyHill_3	17900	Max WS	1811	1207.12	1219.1		1219.28	0.000375	4.11	705.14	91.73	0.22
OldSmokyHill_3	17800	Max WS	1807	1206.53	1219.0		1219.25	0.000473	4.80	736.42	82.09	0.24
OldSmokyHill_3	17700	Max WS	1802	1206.54	1218.9		1219.24	0.000625	5.44	554.80	65.90	0.28
OldSmokyHill_3	17600	Max WS	1902	1206.25	1218.9		1219.14	0.000488	4.85	669.28	80.04	0.25
OldSmokyHill_3	17500	Max WS	1902	1206.45	1218.8		1219.08	0.000433	4.47	632.14	73.50	0.23
OldSmokyHill_3	17400	Max WS	1900	1206.07	1218.7		1219.06	0.000596	5.44	593.58	69.91	0.28
OldSmokyHill_3	17300	Max WS	1902	1205.81	1218.7		1218.97	0.000383	4.33	685.83	79.04	0.22
OldSmokyHill_3	17181	Max WS	2006	1204.48	1218.6	1213.15	1218.91	0.000755	5.08	607.46	90.34	0.27
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2006	1204.22	1217.5		1217.74	0.000569	4.62	544.07	75.61	0.24
OldSmokyHill_3	16800	Max WS	2006	1205.22	1217.1		1217.76	0.001337	7.45	449.67	71.06	0.40
OldSmokyHill_3	16700	Max WS	2006	1204.84	1217.1		1217.57	0.000882	6.19	512.60	80.26	0.33
OldSmokyHill_3	16600	Max WS	2006	1204.49	1217.2	1212.03	1217.40	0.000734	4.33	600.30	105.91	0.28
OldSmokyHill_3	16574		Inl Struct									
OldSmokyHill_3	16500	Max WS	1868	1202.84	1216.4		1216.47	0.000028	1.24	1791.98	150.55	0.06
OldSmokyHill_3	16400	Max WS	1868	1202.78	1216.4		1216.47	0.000030	1.27	1718.88	154.22	0.06
OldSmokyHill_3	16300	Max WS	1897	1202.75	1216.4		1216.47	0.000121	2.47	1265.15	123.03	0.12
OldSmokyHill_3	16200	Max WS	1897	1202.62	1216.4		1216.47	0.000160	2.97	1158.33	115.80	0.14
OldSmokyHill_3	16100	Max WS	1900	1202.56	1216.4		1216.45	0.000169	3.04	1065.40	108.90	0.15
OldSmokyHill_3	16000	Max WS	1895	1202.50	1216.3		1216.44	0.000186	3.18	967.84	97.41	0.16
OldSmokyHill_3	15900	Max WS	1893	1202.34	1216.2		1216.44	0.000297	3.99	657.08	69.67	0.19
OldSmokyHill_3	15800	Max WS	1891	1202.44	1216.2		1216.41	0.000282	3.90	729.40	76.61	0.19
OldSmokyHill_3	15700	Max WS	1910	1202.56	1216.2		1216.38	0.000298	3.88	734.45	78.86	0.19
OldSmokyHill_3	15635	Max WS	1913	1202.00	1216.2	1207.80	1216.36	0.000379	4.04	740.49	79.31	0.19
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1913	1202.00	1216.2		1216.27	0.000359	2.06	1008.00	109.48	0.10
OldSmokyHill_3	15400	Max WS	1910	1202.54	1216.1		1216.26	0.000220	3.39	922.89	88.79	0.17
OldSmokyHill_3	15300	Max WS	1915	1202.93	1216.1		1216.25	0.000302	3.89	855.18	85.81	0.19
OldSmokyHill_3	15200	Max WS	1913	1202.50	1216.1		1216.20	0.000188	3.18	891.85	96.79	0.16
OldSmokyHill_3	15100	Max WS	1915	1202.59	1216.1		1216.18	0.000183	3.14	958.35	93.61	0.15
OldSmokyHill_3	15000	Max WS	1913	1202.48	1216.0		1216.17	0.000194	3.23	991.49	101.37	0.16
OldSmokyHill_3	14900	Max WS	1913	1201.88	1216.0		1216.16	0.000227	3.56	1005.38	101.64	0.17
OldSmokyHill_3	14800	Max WS	1913	1202.06	1216.0		1216.12	0.000153	2.92	1007.73	94.22	0.14
OldSmokyHill_3	14700	Max WS	1919	1202.03	1216.0		1216.12	0.000226	3.55	1029.43	98.46	0.17

HEC-RAS Plan: 04-FWOP-USACE-1%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	14600	Max WS	1922	1201.91	1215.9		1216.11	0.000301	4.08	876.70	89.93	0.20
OldSmokyHill_3	14507	Max WS	1943	1201.00	1215.9	1207.88	1216.09	0.000462	4.59	872.36	93.65	0.22
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	1945	1201.00	1215.5		1215.63	0.000250	3.38	968.52	98.38	0.16
OldSmokyHill_3	14300	Max WS	1943	1202.28	1215.5		1215.61	0.000181	3.00	905.84	91.48	0.15
OldSmokyHill_3	14200	Max WS	1944	1201.94	1215.4		1215.61	0.000286	3.75	843.55	86.56	0.19
OldSmokyHill_3	14100	Max WS	1944	1201.94	1215.4		1215.57	0.000216	3.42	931.35	93.95	0.17
OldSmokyHill_3	14000	Max WS	1942	1202.06	1215.4		1215.55	0.000216	3.38	960.21	97.45	0.17
OldSmokyHill_3	13900	Max WS	1942	1202.00	1215.4		1215.53	0.000259	3.67	929.54	97.82	0.18
OldSmokyHill_3	13800	Max WS	1942	1201.91	1215.3		1215.51	0.000243	3.63	928.73	113.51	0.18
OldSmokyHill_3	13700	Max WS	1944	1202.31	1215.4		1215.47	0.000200	3.24	1153.43	119.03	0.16
OldSmokyHill_3	13600	Max WS	1940	1202.09	1215.3		1215.46	0.000229	3.49	1008.69	101.47	0.17
OldSmokyHill_3	13500	Max WS	1942	1201.84	1215.3		1215.42	0.000175	3.07	1084.50	123.74	0.15
OldSmokyHill_3	13400	Max WS	1940	1202.19	1215.3		1215.41	0.000198	3.22	1061.71	112.15	0.16
OldSmokyHill_3	13300	Max WS	1942	1202.09	1215.3		1215.39	0.000216	3.29	1103.03	104.33	0.16
OldSmokyHill_3	13200	Max WS	1942	1202.00	1215.2		1215.38	0.000262	3.75	1001.56	99.16	0.18
OldSmokyHill_3	13100	Max WS	2063	1201.94	1215.2		1215.34	0.000257	3.74	935.37	92.07	0.18
OldSmokyHill_3	13000	Max WS	2076	1201.75	1215.1		1215.33	0.000314	4.12	973.66	102.99	0.20
OldSmokyHill_3	12900	Max WS	2076	1201.88	1215.1		1215.29	0.000283	3.92	999.25	100.43	0.19
OldSmokyHill_3	12800	Max WS	2076	1201.88	1215.1		1215.26	0.000281	3.86	978.59	94.12	0.19
OldSmokyHill_3	12700	Max WS	2075	1201.56	1215.1		1215.22	0.000196	3.23	959.94	90.43	0.16
OldSmokyHill_3	12600	Max WS	2075	1201.66	1215.1		1215.20	0.000223	3.46	992.85	96.55	0.17
OldSmokyHill_3	12500	Max WS	2076	1201.75	1215.0		1215.19	0.000269	3.84	1024.79	100.36	0.19
OldSmokyHill_3	12400	Max WS	2084	1201.69	1215.0		1215.14	0.000164	2.96	990.09	92.40	0.15
OldSmokyHill_3	12300	Max WS	2083	1201.38	1215.0		1215.14	0.000253	3.73	910.20	92.27	0.18
OldSmokyHill_3	12200	Max WS	2083	1201.56	1215.0		1215.11	0.000209	3.37	934.86	92.59	0.17
OldSmokyHill_3	12100	Max WS	2086	1201.41	1214.9		1215.10	0.000263	3.80	909.87	87.01	0.19
OldSmokyHill_3	12000	Max WS	2091	1201.25	1214.9		1215.07	0.000260	3.73	939.60	90.74	0.18
OldSmokyHill_3	11900	Max WS	2092	1201.34	1214.9		1215.05	0.000274	3.88	936.37	93.04	0.19
OldSmokyHill_3	11800	Max WS	2093	1201.47	1214.8		1215.04	0.000359	4.39	738.73	79.00	0.22
OldSmokyHill_3	11688	Max WS	2093	1201.35	1214.7		1215.00	0.000367	4.43	757.41	81.07	0.22
OldSmokyHill_3	11600	Max WS	2096	1201.41	1214.7		1214.96	0.000350	4.30	842.53	84.01	0.21
OldSmokyHill_3	11500	Max WS	2096	1201.15	1214.8		1214.90	0.000230	3.52	1006.39	95.69	0.17
OldSmokyHill_3	11400	Max WS	2097	1201.03	1214.8		1214.86	0.000124	2.67	1121.03	102.74	0.13
OldSmokyHill_3	11300	Max WS	2153	1200.84	1214.7		1214.87	0.000274	3.86	976.63	93.36	0.19
OldSmokyHill_3	11200	Max WS	2152	1200.94	1214.7		1214.85	0.000279	3.93	940.04	90.00	0.19
OldSmokyHill_3	11100	Max WS	2152	1200.81	1214.6		1214.83	0.000322	4.22	811.02	78.56	0.20
OldSmokyHill_3	10956	Max WS	2166	1196.19	1214.7		1214.73	0.000091	2.27	1639.81	201.52	0.10
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	648	1195.60	1214.2		1214.16	0.000009	0.68	1383.28	166.93	0.03
OldSmokyHill_3	10500	Max WS	646	1200.88	1214.1		1214.16	0.000023	1.11	1009.28	102.70	0.05
OldSmokyHill_3	10400	Max WS	647	1200.80	1214.1		1214.16	0.000024	1.13	1050.19	107.67	0.06
OldSmokyHill_3	10335	Max WS	646	1200.91	1214.1	1203.53	1214.15	0.000026	1.16	1026.80	101.91	0.06
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	642	1200.91	1214.1		1214.15	0.000027	1.21	968.16	96.66	0.06
OldSmokyHill_3	10200	Max WS	645	1200.59	1214.1		1214.14	0.000020	1.05	1071.15	102.54	0.05
OldSmokyHill_3	10100	Max WS	642	1200.75	1214.1		1214.14	0.000024	1.14	982.82	96.48	0.06
OldSmokyHill_3	10000	Max WS	642	1200.50	1214.1		1214.14	0.000014	0.88	976.81	93.67	0.04
OldSmokyHill_3	9900	Max WS	644	1200.38	1214.1		1214.14	0.000016	0.95	977.71	98.51	0.05
OldSmokyHill_3	9800	Max WS	644	1200.44	1214.1		1214.14	0.000024	1.16	1018.28	98.48	0.06
OldSmokyHill_3	9700	Max WS	640	1200.36	1214.1		1214.14	0.000024	1.17	1033.36	103.68	0.06
OldSmokyHill_3	9600	Max WS	642	1200.22	1214.1		1214.13	0.000023	1.15	1030.27	99.33	0.06
OldSmokyHill_3	9500	Max WS	638	1200.29	1214.1		1214.13	0.000023	1.15	991.45	94.47	0.06
OldSmokyHill_3	9400	Max WS	639	1200.41	1214.1		1214.13	0.000025	1.19	951.42	92.76	0.06
OldSmokyHill_3	9300	Max WS	639	1200.34	1214.1		1214.13	0.000023	1.14	974.51	93.52	0.05
OldSmokyHill_3	9200	Max WS	635	1200.56	1214.1		1214.12	0.000024	1.13	961.01	101.01	0.05
OldSmokyHill_3	9148	Max WS	640	1200.25	1214.1		1214.12	0.000023	1.13	935.36	94.25	0.05
OldSmokyHill_3	9100	Max WS	650	1200.27	1214.1		1214.12	0.000012	0.85	1040.41	96.53	0.04
OldSmokyHill_3	9000	Max WS	643	1200.25	1214.1		1214.12	0.000020	1.05	965.16	101.55	0.05
OldSmokyHill_3	8900	Max WS	643	1200.31	1214.1		1214.12	0.000024	1.17	914.13	94.41	0.06
OldSmokyHill_3	8800	Max WS	645	1200.53	1214.1		1214.12	0.000020	1.07	1015.18	103.20	0.05
OldSmokyHill_3	8668	Max WS	644	1200.39	1214.1	1203.29	1214.12	0.000035	1.42	902.99	107.14	0.07
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	644	1200.25	1214.1		1214.11	0.000019	1.02	958.57	121.86	0.05
OldSmokyHill_3	8500	Max WS	642	1200.37	1214.1		1214.11	0.000025	1.18	1035.87	155.85	0.06
OldSmokyHill_3	8400	Max WS	643	1200.41	1214.1		1214.10	0.000018	1.00	981.00	95.35	0.05
OldSmokyHill_3	8300	Max WS	640	1199.94	1214.1		1214.10	0.000018	1.02	998.40	102.67	0.05
OldSmokyHill_3	8200	Max WS	640	1199.79	1214.1		1214.10	0.000018	1.05	1053.56	102.46	0.05
OldSmokyHill_3	8100	Max WS	640	1199.97	1214.1		1214.10	0.000019	1.03	1078.14	112.05	0.05
OldSmokyHill_3	8000	Max WS	639	1199.51	1214.1		1214.10	0.000012	0.87	1046.24	103.96	0.04
OldSmokyHill_3	7900	Max WS	638	1199.72	1214.1		1214.10	0.000018	1.05	1108.66	118.53	0.05
OldSmokyHill_3	7800	Max WS	641	1199.50	1214.1		1214.09	0.000015	0.95	1090.55	114.83	0.04
OldSmokyHill_3	7700	Max WS	638	1199.53	1214.1		1214.09	0.000017	1.04	1083.86	109.66	0.05
OldSmokyHill_3	7600	Max WS	640	1199.56	1214.1		1214.09	0.000018	1.04	1025.45	95.57	0.05
OldSmokyHill_3	7500	Max WS	638	1199.59	1214.1		1214.09	0.000016	0.99	1062.40	97.81	0.05
OldSmokyHill_3	7400	Max WS	638	1199.59	1214.1		1214.09	0.000014	0.93	1205.99	109.38	0.04
OldSmokyHill_3	7300	Max WS	635	1199.63	1214.1		1214.09	0.000014	0.93	1145.90	109.25	0.04
OldSmokyHill_3	7275		Lat Struct									

HEC-RAS Plan: 04-FWOP-USACE-1%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	7200	Max WS	609	1199.58	1214.1		1214.08	0.000013	0.90	1186.99	121.75	0.04
OldSmokyHill_3	7100	Max WS	269	1199.59	1214.1		1214.09	0.000002	0.35	1221.49	118.13	0.02
OldSmokyHill_3	7000	Max WS	272	1199.50	1214.1		1214.08	0.000003	0.44	1060.60	107.19	0.02
OldSmokyHill_3	6900	Max WS	273	1199.53	1214.1		1214.08	0.000003	0.43	1073.07	117.59	0.02
OldSmokyHill_3	6800	Max WS	273	1199.41	1214.1		1214.08	0.000003	0.43	1052.07	105.62	0.02
OldSmokyHill_3	6700	Max WS	273	1199.62	1214.1		1214.08	0.000003	0.43	1103.11	108.74	0.02
OldSmokyHill_3	6600	Max WS	273	1199.46	1214.1		1214.08	0.000003	0.46	1053.21	103.67	0.02
OldSmokyHill_3	6500	Max WS	272	1199.95	1214.1		1214.08	0.000003	0.41	1069.01	111.85	0.02
OldSmokyHill_3	6400	Max WS	273	1199.64	1214.1		1214.08	0.000003	0.40	1111.07	112.42	0.02
OldSmokyHill_3	6300	Max WS	273	1199.66	1214.1		1214.08	0.000003	0.41	1083.41	101.72	0.02
OldSmokyHill_3	6200	Max WS	272	1199.70	1214.1		1214.08	0.000003	0.42	1096.36	98.95	0.02
OldSmokyHill_3	6100	Max WS	271	1199.62	1214.1		1214.08	0.000003	0.41	1077.83	96.34	0.02
OldSmokyHill_3	6000	Max WS	272	1199.63	1214.1		1214.08	0.000003	0.45	1075.90	103.64	0.02
OldSmokyHill_3	5900	Max WS	272	1199.56	1214.1		1214.08	0.000003	0.39	1171.10	113.40	0.02
OldSmokyHill_3	5800	Max WS	272	1199.59	1214.1		1214.08	0.000003	0.43	1099.82	120.15	0.02
OldSmokyHill_3	5700	Max WS	272	1199.50	1214.1		1214.08	0.000003	0.42	1089.27	113.86	0.02
OldSmokyHill_3	5600	Max WS	270	1199.57	1214.1		1214.08	0.000003	0.40	1276.89	129.35	0.02
OldSmokyHill_3	5500	Max WS	271	1199.22	1214.1		1214.08	0.000003	0.39	1254.74	122.37	0.02
OldSmokyHill_3	5400	Max WS	270	1199.12	1214.1		1214.08	0.000003	0.46	1140.38	112.54	0.02
OldSmokyHill_3	5300	Max WS	272	1199.14	1214.1		1214.08	0.000003	0.43	1126.63	112.10	0.02
OldSmokyHill_3	5200	Max WS	271	1199.09	1214.1		1214.08	0.000002	0.34	1203.65	118.48	0.02
OldSmokyHill_3	5100	Max WS	272	1198.99	1214.1		1214.08	0.000003	0.45	1197.70	122.71	0.02
OldSmokyHill_3	5000	Max WS	272	1198.99	1214.1		1214.08	0.000003	0.43	1191.93	110.42	0.02
OldSmokyHill_3	4900	Max WS	272	1199.38	1214.1		1214.08	0.000003	0.41	1246.95	120.66	0.02
OldSmokyHill_3	4800	Max WS	271	1198.50	1214.1		1214.08	0.000002	0.38	1352.52	131.31	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	271	1198.66	1214.1		1214.08	0.000003	0.43	1203.67	130.15	0.02
OldSmokyHill_3	4600	Max WS	271	1198.79	1214.1		1214.08	0.000002	0.37	1276.31	120.51	0.02
OldSmokyHill_3	4500	Max WS	271	1198.69	1214.1		1214.08	0.000002	0.40	1230.26	110.92	0.02
OldSmokyHill_3	4400	Max WS	277	1198.73	1214.1		1214.08	0.000003	0.43	1222.42	119.11	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	297	1198.63	1214.1		1214.08	0.000003	0.43	1289.48	111.56	0.02
OldSmokyHill_3	4200	Max WS	356	1198.66	1214.1		1214.08	0.000005	0.57	1262.56	120.93	0.03
OldSmokyHill_3	4100	Max WS	364	1198.56	1214.1		1214.08	0.000004	0.52	1410.31	144.98	0.02
OldSmokyHill_3	4000	Max WS	554	1198.84	1214.1		1214.08	0.000013	0.91	1311.79	131.74	0.04
OldSmokyHill_3	3900	Max WS	654	1198.91	1214.1		1214.07	0.000015	0.99	1269.69	122.97	0.05
OldSmokyHill_3	3800	Max WS	654	1198.66	1214.1		1214.07	0.000014	0.95	1186.56	130.22	0.04
OldSmokyHill_3	3700	Max WS	651	1198.59	1214.1		1214.07	0.000015	1.00	1278.10	172.48	0.05
OldSmokyHill_3	3600	Max WS	645	1198.52	1214.1		1214.07	0.000019	1.11	1282.47	157.70	0.05
OldSmokyHill_3	3500	Max WS	642	1198.78	1214.1		1214.07	0.000017	1.04	1294.39	151.60	0.05
OldSmokyHill_3	3400	Max WS	638	1198.62	1214.1		1214.07	0.000012	0.90	1247.62	151.07	0.04
OldSmokyHill_3	3300	Max WS	636	1198.34	1214.1		1214.07	0.000013	0.94	1207.47	168.73	0.04
OldSmokyHill_3	3200	Max WS	641	1198.38	1214.1		1214.06	0.000014	0.96	1217.91	180.24	0.04
OldSmokyHill_3	3100	Max WS	649	1198.66	1214.1		1214.06	0.000013	0.91	1283.67	186.39	0.04
OldSmokyHill_3	3000	Max WS	654	1198.34	1214.1		1214.06	0.000012	0.90	1202.38	170.06	0.04
OldSmokyHill_3	2900	Max WS	654	1198.41	1214.0		1214.06	0.000014	0.97	1214.78	118.58	0.04
OldSmokyHill_3	2800	Max WS	654	1198.34	1214.0		1214.06	0.000016	1.04	1241.76	116.96	0.05
OldSmokyHill_3	2700	Max WS	654	1198.47	1214.0		1214.05	0.000014	0.97	1217.77	133.63	0.04
OldSmokyHill_3	2600	Max WS	658	1198.50	1214.0		1214.05	0.000012	0.91	1254.49	147.23	0.04
OldSmokyHill_3	2500	Max WS	658	1198.53	1214.0		1214.05	0.000017	1.04	1127.11	127.26	0.05
OldSmokyHill_3	2400	Max WS	658	1198.93	1214.0		1214.05	0.000010	0.80	1164.03	121.27	0.04
OldSmokyHill_3	2300	Max WS	658	1198.50	1214.0		1214.05	0.000009	0.78	1190.82	121.16	0.04
OldSmokyHill_3	2183	Max WS	658	1196.44	1214.0		1214.05	0.000014	0.95	789.17	122.83	0.04
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	658	1196.78	1207.0		1207.40	0.000849	5.06	130.10	87.16	0.29
OldSmokyHill_3	1900	Max WS	658	1198.47	1207.2		1207.22	0.000118	1.86	473.89	84.79	0.11
OldSmokyHill_3	1800	Max WS	658	1198.28	1207.2		1207.21	0.000093	1.66	572.76	87.87	0.10
OldSmokyHill_3	1700	Max WS	658	1198.12	1207.2		1207.20	0.000065	1.43	631.50	86.83	0.09
OldSmokyHill_3	1600	Max WS	658	1198.25	1207.2		1207.19	0.000108	1.83	567.02	84.06	0.11
OldSmokyHill_3	1500	Max WS	658	1197.76	1207.1		1207.18	0.000078	1.58	593.16	87.25	0.09
OldSmokyHill_3	1400	Max WS	658	1197.88	1207.1		1207.17	0.000076	1.53	578.44	84.85	0.09
OldSmokyHill_3	1300	Max WS	658	1197.69	1207.1		1207.16	0.000149	2.09	394.25	68.67	0.13
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	658	1197.53	1207.1		1207.15	0.000151	2.16	365.62	69.47	0.13
OldSmokyHill_3	1100	Max WS	658	1197.72	1207.1		1207.13	0.000172	2.28	345.35	67.17	0.14
OldSmokyHill_3	1000	Max WS	658	1197.72	1207.0		1207.12	0.000187	2.34	325.68	61.42	0.14
OldSmokyHill_3	900	Max WS	658	1197.44	1207.0		1207.10	0.000207	2.55	315.19	61.95	0.15
OldSmokyHill_3	800	Max WS	658	1197.35	1207.0		1207.08	0.000188	2.45	333.19	67.50	0.14
OldSmokyHill_3	700	Max WS	658	1197.38	1207.0		1207.06	0.000189	2.50	329.23	64.51	0.15
OldSmokyHill_3	660	Max WS	667	1195.72	1206.9	1201.05	1207.05	0.000259	2.75	247.82	60.10	0.16
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	667	1194.57	1201.3		1203.09	0.009782	10.61	62.90	13.69	0.75
OldSmokyHill_3	300	Max WS	599	1194.22	1201.1		1201.29	0.000675	3.00	199.60	41.07	0.24
OldSmokyHill_3	200	Max WS	52	1193.97	1201.1		1201.11	0.000004	0.25	208.80	37.95	0.02
OldSmokyHill_3	100	Max WS	84	1193.86	1201.1	1194.66	1201.10	0.000000	0.07	1166.97	221.76	0.01

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	35900	Max WS	0	1212.00	1215.6		1215.62	0.000000	0.00	58.76	17.54	0.00
OldSmokyHill_3	35800	Max WS	-305	1212.00	1216.0		1216.28	0.002524	-4.29	71.07	19.18	0.39
OldSmokyHill_3	35680	Max WS	-305	1209.80	1217.1	1215.02	1217.85	0.016612	7.00	43.58	21.58	0.78
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-305	1208.30	1224.3		1224.45	0.000594	-3.00	101.67	97.58	0.14
OldSmokyHill_3	35300	Max WS	-305	1214.81	1224.4		1224.43	0.000011	-0.57	599.28	102.53	0.03
OldSmokyHill_3	35200	Max WS	-288	1214.50	1224.4		1224.43	0.000008	-0.52	633.15	101.88	0.03
OldSmokyHill_3	35100	Max WS	-288	1214.57	1224.4		1224.43	0.000008	-0.51	640.50	103.39	0.03
OldSmokyHill_3	35000	Max WS	-260	1214.56	1224.4		1224.43	0.000005	-0.41	703.14	105.18	0.02
OldSmokyHill_3	34900	Max WS	-260	1214.56	1224.4		1224.43	0.000005	-0.41	704.28	107.38	0.02
OldSmokyHill_3	34798	Max WS	-260	1214.94	1224.4		1224.43	0.000005	-0.40	716.03	108.93	0.02
OldSmokyHill_3	34701	Max WS	-260	1214.69	1224.4		1224.44	0.000005	-0.41	697.13	106.83	0.02
OldSmokyHill_3	34604	Max WS	-260	1214.67	1224.4		1224.44	0.000005	-0.40	719.37	109.96	0.02
OldSmokyHill_3	34499	Max WS	-260	1214.72	1224.4		1224.44	0.000005	-0.40	713.79	107.04	0.02
OldSmokyHill_3	34396	Max WS	-260	1214.72	1224.4		1224.44	0.000005	-0.39	724.88	111.05	0.02
OldSmokyHill_3	34306	Max WS	-260	1214.64	1224.4		1224.44	0.000004	-0.39	740.01	111.29	0.02
OldSmokyHill_3	34186	Max WS	-261	1214.72	1224.4		1224.44	0.000009	-0.56	708.77	261.07	0.03
OldSmokyHill_3	34100	Max WS	-260	1214.75	1224.4		1224.44	0.000014	-0.69	714.61	397.02	0.04
OldSmokyHill_3	34013	Max WS	-261	1214.69	1224.4		1224.44	0.000016	-0.65	1138.72	350.59	0.04
OldSmokyHill_3	33965	Max WS	-261	1214.44	1224.4		1224.44	0.000011	-0.53	1082.13	302.83	0.03
OldSmokyHill_3	33914	Max WS	-261	1214.62	1224.4		1224.44	0.000008	-0.47	1088.01	249.46	0.03
OldSmokyHill_3	33833	Max WS	-244	1214.58	1224.4		1224.44	0.000013	-0.59	944.01	218.47	0.03
OldSmokyHill_3	33766	Max WS	-244	1214.90	1224.4		1224.44	0.000013	-0.58	901.78	215.06	0.03
OldSmokyHill_3	33673	Max WS	-244	1214.81	1224.4		1224.45	0.000015	-0.63	772.41	159.44	0.04
OldSmokyHill_3	33600	Max WS	-244	1214.66	1224.4		1224.45	0.000016	-0.65	689.94	112.94	0.04
OldSmokyHill_3	33500	Max WS	-244	1214.44	1224.4		1224.45	0.000013	-0.60	708.23	112.81	0.03
OldSmokyHill_3	33400	Max WS	-241	1214.59	1224.4		1224.45	0.000010	-0.53	726.81	109.39	0.03
OldSmokyHill_3	33300	Max WS	-229	1214.69	1224.4		1224.45	0.000013	-0.58	697.30	106.69	0.03
OldSmokyHill_3	33200	Max WS	-229	1214.66	1224.4		1224.45	0.000012	-0.57	723.29	109.75	0.03
OldSmokyHill_3	33100	Max WS	-229	1214.62	1224.4		1224.45	0.000016	-0.66	633.03	98.60	0.04
OldSmokyHill_3	33000	Max WS	-229	1214.66	1224.4		1224.45	0.000011	-0.54	704.82	129.72	0.03
OldSmokyHill_3	32900	Max WS	-229	1214.88	1224.5		1224.45	0.000011	-0.53	869.99	161.98	0.03
OldSmokyHill_3	32815	Max WS	-96	1211.25	1224.5		1224.46	0.000003	-0.33	464.28	142.39	0.02
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-96	1211.25	1224.5		1224.46	0.000001	-0.12	649.78	152.15	0.01
OldSmokyHill_3	32500	Max WS	-96	1214.22	1224.5		1224.47	0.000002	-0.23	787.96	183.67	0.01
OldSmokyHill_3	32400	Max WS	-78	1214.22	1224.5		1224.46	0.000001	-0.19	773.36	141.34	0.01
OldSmokyHill_3	32338	Max WS	-78	1214.16	1224.5		1224.46	0.000002	-0.22	724.06	168.18	0.01
OldSmokyHill_3	32300	Max WS	-78	1214.28	1224.5		1224.46	0.000001	-0.20	698.44	204.87	0.01
OldSmokyHill_3	32200	Max WS	-78	1214.11	1224.5		1224.46	0.000001	-0.18	779.34	163.96	0.01
OldSmokyHill_3	32100	Max WS	-78	1214.35	1224.5		1224.46	0.000001	-0.18	738.41	121.47	0.01
OldSmokyHill_3	31900	Max WS	-78	1214.09	1224.5		1224.47	0.000002	-0.21	697.19	196.93	0.01
OldSmokyHill_3	31800	Max WS	-26	1213.78	1224.5		1224.47	0.000000	-0.09	759.94	227.57	0.01
OldSmokyHill_3	31700	Max WS	-23	1214.09	1224.5		1224.47	0.000000	-0.08	638.15	230.03	0.00
OldSmokyHill_3	31600	Max WS	-5	1213.59	1224.5		1224.47	0.000000	-0.01	694.85	199.73	0.00
OldSmokyHill_3	31500	Max WS	-5	1213.69	1224.5		1224.47	0.000000	-0.01	877.95	222.12	0.00
OldSmokyHill_3	31400	Max WS	-5	1213.66	1224.5		1224.47	0.000000	-0.01	1090.69	226.46	0.00
OldSmokyHill_3	31300	Max WS	-5	1213.67	1224.5		1224.47	0.000000	-0.01	1002.48	205.83	0.00
OldSmokyHill_3	31200	Max WS	-5	1213.62	1224.5		1224.47	0.000000	-0.01	1011.37	200.76	0.00
OldSmokyHill_3	31100	Max WS	-2	1213.66	1224.5		1224.47	0.000000	0.00	982.36	206.81	0.00
OldSmokyHill_3	31000	Max WS	5	1213.78	1224.5		1224.47	0.000000	0.01	988.26	196.00	0.00
OldSmokyHill_3	30900	Max WS	5	1213.84	1224.5		1224.47	0.000000	0.01	960.96	196.79	0.00
OldSmokyHill_3	30800	Max WS	5	1213.72	1224.5		1224.47	0.000000	0.01	1007.89	196.78	0.00
OldSmokyHill_3	30700	Max WS	5	1213.73	1224.5		1224.47	0.000000	0.01	919.66	187.42	0.00
OldSmokyHill_3	30651	Max WS	5	1213.76	1224.5		1224.47	0.000000	0.01	997.41	182.29	0.00
OldSmokyHill_3	30575	Max WS	4	1213.62	1224.5		1224.47	0.000000	0.01	1011.25	207.91	0.00
OldSmokyHill_3	30500	Max WS	5	1213.78	1224.5		1224.47	0.000000	0.01	1054.71	203.28	0.00
OldSmokyHill_3	30400	Max WS	4	1213.70	1224.5		1224.47	0.000000	0.01	979.42	193.01	0.00
OldSmokyHill_3	30300	Max WS	4	1213.72	1224.5		1224.47	0.000000	0.01	960.24	175.03	0.00
OldSmokyHill_3	30200	Max WS	5	1213.56	1224.5		1224.47	0.000000	0.01	1040.71	184.47	0.00
OldSmokyHill_3	30100	Max WS	5	1213.75	1224.5		1224.47	0.000000	0.01	953.98	161.51	0.00
OldSmokyHill_3	29999	Max WS	5	1213.79	1224.5		1224.46	0.000000	0.01	950.30	139.83	0.00
OldSmokyHill_3	29899	Max WS	5	1213.74	1224.5		1224.46	0.000000	0.01	1064.51	223.56	0.00
OldSmokyHill_3	29800	Max WS	10	1213.69	1224.5		1224.46	0.000000	0.02	1222.26	449.51	0.00
OldSmokyHill_3	29704	Max WS	10	1213.72	1224.5		1224.46	0.000000	0.02	1409.17	566.09	0.00
OldSmokyHill_3	29572	Max WS	9	1213.81	1224.5		1224.46	0.000000	0.02	1308.18	499.45	0.00
OldSmokyHill_3	29466	Max WS	11	1213.59	1224.5		1224.46	0.000000	0.02	1421.28	514.90	0.00
OldSmokyHill_3	29385	Max WS	1432	1213.50	1224.4		1224.46	0.000202	2.47	1424.63	476.64	0.14
OldSmokyHill_3	29314	Max WS	1433	1213.03	1224.4		1224.47	0.000338	3.31	1321.39	430.12	0.18
OldSmokyHill_3	29209	Max WS	1433	1213.06	1224.3		1224.45	0.000432	3.60	1199.76	437.67	0.20
OldSmokyHill_3	29100	Max WS	1433	1213.03	1224.3		1224.39	0.000325	3.18	1246.00	361.94	0.17
OldSmokyHill_3	28991	Max WS	1433	1213.00	1224.2		1224.36	0.000343	3.33	1034.97	273.21	0.18
OldSmokyHill_3	28900	Max WS	1433	1212.85	1224.2		1224.33	0.000418	3.71	962.67	186.48	0.20
OldSmokyHill_3	28800	Max WS	1433	1213.03	1224.2		1224.29	0.000399	3.60	921.88	178.89	0.19
OldSmokyHill_3	28700	Max WS	1433	1213.12	1224.1		1224.26	0.000470	3.86	888.43	176.10	0.21
OldSmokyHill_3	28594	Max WS	1433	1212.92	1224.1		1224.19	0.000310	3.14	788.54	150.34	0.17
OldSmokyHill_3	28500	Max WS	1433	1213.01	1224.1		1224.17	0.000329	3.22	883.64	156.44	0.17
OldSmokyHill_3	28430	Max WS	1459	1210.34	1224.0	1216.11	1224.13	0.000368	3.06	770.73	145.84	0.16

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1459	1209.69	1223.9		1223.99	0.000253	2.90	956.66	260.13	0.15
OldSmokyHill_3	28200	Max WS	1459	1212.97	1223.9		1223.99	0.000275	2.89	959.88	289.39	0.16
OldSmokyHill_3	28100	Max WS	1465	1212.97	1223.8		1223.95	0.000332	3.19	964.21	387.73	0.17
OldSmokyHill_3	28000	Max WS	1465	1213.03	1223.8		1223.92	0.000343	3.32	916.99	249.89	0.18
OldSmokyHill_3	27900	Max WS	1465	1213.00	1223.8		1223.88	0.000348	3.30	865.86	205.71	0.18
OldSmokyHill_3	27800	Max WS	1465	1212.59	1223.7		1223.85	0.000292	3.07	874.42	215.49	0.17
OldSmokyHill_3	27700	Max WS	1464	1212.69	1223.7		1223.82	0.000270	2.93	892.67	202.69	0.16
OldSmokyHill_3	27600	Max WS	1464	1212.75	1223.6		1223.81	0.000415	3.60	854.99	234.33	0.20
OldSmokyHill_3	27500	Max WS	1476	1212.53	1223.6		1223.75	0.000301	3.06	897.61	216.02	0.17
OldSmokyHill_3	27400	Max WS	1476	1212.45	1223.6		1223.72	0.000355	3.33	885.23	194.05	0.18
OldSmokyHill_3	27300	Max WS	1476	1212.53	1223.6		1223.69	0.000313	3.16	952.32	175.59	0.17
OldSmokyHill_3	27200	Max WS	1475	1212.53	1223.5		1223.66	0.000319	3.23	833.32	172.84	0.17
OldSmokyHill_3	27100	Max WS	1481	1212.45	1223.5		1223.63	0.000324	3.23	866.85	235.03	0.17
OldSmokyHill_3	27000	Max WS	1480	1212.19	1223.4		1223.61	0.000436	3.77	891.46	279.34	0.20
OldSmokyHill_3	26900	Max WS	1480	1213.09	1223.4		1223.55	0.000352	3.23	888.73	171.78	0.18
OldSmokyHill_3	26800	Max WS	1480	1212.22	1223.4		1223.51	0.000296	3.02	956.39	171.03	0.16
OldSmokyHill_3	26700	Max WS	1484	1212.12	1223.4		1223.48	0.000296	3.06	934.75	200.89	0.17
OldSmokyHill_3	26600	Max WS	1483	1212.06	1223.3		1223.46	0.000368	3.44	826.02	155.02	0.19
OldSmokyHill_3	26522	Max WS	1482	1211.97	1223.2	1217.19	1223.46	0.000728	4.84	458.24	135.72	0.26
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1481	1211.94	1223.0		1223.28	0.000655	4.56	459.60	126.46	0.25
OldSmokyHill_3	26400	Max WS	1481	1211.88	1223.1		1223.19	0.000286	2.99	840.36	142.13	0.16
OldSmokyHill_3	26300	Max WS	1488	1211.94	1223.1		1223.17	0.000345	3.26	889.51	181.72	0.18
OldSmokyHill_3	26200	Max WS	1488	1212.17	1223.0		1223.13	0.000368	3.34	955.46	150.76	0.18
OldSmokyHill_3	26100	Max WS	1492	1211.88	1223.0		1223.09	0.000246	2.77	935.52	167.06	0.15
OldSmokyHill_3	26000	Max WS	1491	1211.71	1223.0		1223.06	0.000240	2.72	827.96	139.08	0.15
OldSmokyHill_3	25900	Max WS	1492	1211.87	1222.9		1223.05	0.000377	3.42	846.04	145.50	0.19
OldSmokyHill_3	25800	Max WS	1492	1212.01	1222.9		1223.00	0.000241	2.72	937.08	167.25	0.15
OldSmokyHill_3	25700	Max WS	1494	1211.72	1222.8		1222.99	0.000398	3.50	829.14	148.47	0.19
OldSmokyHill_3	25600	Max WS	1493	1211.75	1222.8		1222.94	0.000291	3.02	872.77	153.38	0.16
OldSmokyHill_3	25500	Max WS	1539	1211.75	1222.8		1222.91	0.000297	3.06	953.02	171.34	0.17
OldSmokyHill_3	25400	Max WS	1540	1211.72	1222.8		1222.88	0.000290	3.00	971.00	188.82	0.16
OldSmokyHill_3	25300	Max WS	1541	1211.87	1222.7		1222.87	0.000493	3.89	915.64	225.02	0.21
OldSmokyHill_3	25200	Max WS	1543	1211.81	1222.7		1222.81	0.000370	3.38	878.26	205.25	0.18
OldSmokyHill_3	25117	Max WS	1543	1208.41	1222.7	1213.65	1222.73	0.000717	2.16	1008.27	229.50	0.11
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1543	1208.97	1222.5		1222.59	0.000263	3.01	749.49	235.34	0.15
OldSmokyHill_3	24900	Max WS	1543	1211.71	1222.4		1222.59	0.000334	3.54	890.42	228.23	0.20
OldSmokyHill_3	24800	Max WS	1543	1211.78	1222.4		1222.58	0.000472	4.32	820.95	219.94	0.24
OldSmokyHill_3	24700	Max WS	1550	1211.84	1222.4		1222.51	0.000329	3.56	875.24	214.63	0.20
OldSmokyHill_3	24600	Max WS	1550	1211.34	1222.3		1222.46	0.000245	3.13	935.89	205.41	0.17
OldSmokyHill_3	24500	Max WS	1552	1211.53	1222.3		1222.44	0.000270	3.20	833.03	171.49	0.18
OldSmokyHill_3	24400	Max WS	1551	1211.13	1222.3		1222.41	0.000219	2.96	819.47	154.09	0.16
OldSmokyHill_3	24300	Max WS	1551	1211.19	1222.3		1222.39	0.000218	2.94	813.55	117.50	0.16
OldSmokyHill_3	24200	Max WS	1550	1211.13	1222.2		1222.37	0.000278	3.41	817.73	102.89	0.18
OldSmokyHill_3	24100	Max WS	1550	1211.08	1222.2		1222.35	0.000324	3.61	809.23	149.63	0.20
OldSmokyHill_3	24000	Max WS	1552	1211.22	1222.2		1222.32	0.000310	3.58	843.40	144.33	0.19
OldSmokyHill_3	23900	Max WS	1551	1211.08	1222.1		1222.28	0.000310	3.59	855.13	142.01	0.19
OldSmokyHill_3	23800	Max WS	1570	1211.12	1222.1		1222.25	0.000298	3.53	886.47	155.59	0.19
OldSmokyHill_3	23700	Max WS	1570	1211.28	1222.1		1222.21	0.000212	2.93	817.97	109.87	0.16
OldSmokyHill_3	23600	Max WS	1570	1211.06	1222.1		1222.19	0.000243	3.17	812.22	107.25	0.17
OldSmokyHill_3	23500	Max WS	1571	1210.94	1222.1		1222.16	0.000239	3.14	836.39	99.62	0.17
OldSmokyHill_3	23362	Max WS	1575	1210.95	1222.0	1215.08	1222.13	0.000230	3.07	861.67	106.49	0.17
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1576	1210.60	1222.0		1222.07	0.000179	2.73	857.21	194.11	0.15
OldSmokyHill_3	23167	Max WS	1576	1210.66	1222.0		1222.07	0.000219	3.02	857.98	141.75	0.16
OldSmokyHill_3	23100	Max WS	1583	1210.81	1222.0		1222.06	0.000274	3.39	917.81	169.11	0.18
OldSmokyHill_3	23000	Max WS	1583	1210.50	1221.9		1222.03	0.000208	2.95	959.68	267.27	0.16
OldSmokyHill_3	22900	Max WS	1587	1210.56	1221.9		1222.01	0.000208	2.96	1065.52	285.38	0.16
OldSmokyHill_3	22800	Max WS	1596	1210.71	1221.9		1221.99	0.000211	2.97	1082.85	312.19	0.16
OldSmokyHill_3	22731	Max WS	1596	1210.47	1221.9		1221.98	0.000230	3.11	1093.79	420.74	0.17
OldSmokyHill_3	22656	Max WS	1596	1210.44	1221.8	1214.75	1221.96	0.000282	3.48	930.90	315.12	0.19
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1596	1210.34	1221.8		1221.94	0.000287	3.48	917.82	237.31	0.19
OldSmokyHill_3	22578	Max WS	1597	1210.41	1221.8		1221.92	0.000232	3.15	1002.95	243.10	0.17
OldSmokyHill_3	22500	Max WS	1599	1210.38	1221.8		1221.89	0.000224	3.12	1039.31	232.14	0.17
OldSmokyHill_3	22400	Max WS	1599	1210.44	1221.8		1221.87	0.000236	3.18	1029.85	236.69	0.17
OldSmokyHill_3	22300	Max WS	1598	1210.31	1221.8		1221.84	0.000212	3.07	1108.86	245.09	0.16
OldSmokyHill_3	22200	Max WS	1600	1210.44	1221.8		1221.81	0.000178	2.75	1201.73	246.08	0.15
OldSmokyHill_3	22100	Max WS	1602	1210.16	1221.7		1221.80	0.000154	2.62	1182.38	227.20	0.14
OldSmokyHill_3	22000	Max WS	1603	1210.12	1221.7		1221.78	0.000203	3.00	1055.33	192.79	0.16
OldSmokyHill_3	21900	Max WS	1600	1210.13	1221.7		1221.78	0.000238	3.22	902.44	199.54	0.17
OldSmokyHill_3	21799	Max WS	1598	1210.28	1221.6		1221.75	0.000261	3.38	907.03	167.84	0.18
OldSmokyHill_3	21722	Max WS	1590	1210.11	1221.6	1214.94	1221.74	0.000317	3.76	847.08	158.01	0.20
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1279	1210.11	1221.6		1221.67	0.000214	3.10	840.30	156.24	0.16
OldSmokyHill_3	21600	Max WS	1279	1210.31	1221.6		1221.64	0.000183	2.80	933.34	163.46	0.15

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	21500	Max WS	1287	1210.14	1221.6		1221.61	0.000108	2.17	1135.62	211.68	0.12
OldSmokyHill_3	21400	Max WS	1298	1209.94	1221.6		1221.60	0.000069	1.70	1345.17	299.15	0.09
OldSmokyHill_3	21296	Max WS	1281	1209.94	1221.6		1221.59	0.000065	1.68	1239.25	259.24	0.09
OldSmokyHill_3	21200	Max WS	1281	1209.81	1221.6		1221.58	0.000076	1.82	1298.49	319.23	0.10
OldSmokyHill_3	21100	Max WS	1256	1209.84	1221.5		1221.57	0.000067	1.69	1364.88	353.56	0.09
OldSmokyHill_3	20995	Max WS	1247	1210.03	1221.5		1221.57	0.000073	1.78	1262.60	292.02	0.09
OldSmokyHill_3	20900	Max WS	1228	1209.75	1221.5		1221.56	0.000074	1.81	1256.06	265.67	0.10
OldSmokyHill_3	20800	Max WS	1237	1209.72	1221.5		1221.55	0.000053	1.50	1406.34	296.83	0.08
OldSmokyHill_3	20700	Max WS	1237	1209.45	1221.5		1221.54	0.000063	1.68	1411.63	298.50	0.09
OldSmokyHill_3	20644	Max WS	1227	1209.47	1221.5		1221.54	0.000052	1.48	1388.54	314.86	0.08
OldSmokyHill_3	20600	Max WS	1227	1209.50	1221.5		1221.54	0.000053	1.51	1469.52	339.12	0.08
OldSmokyHill_3	20500	Max WS	1217	1209.50	1221.5		1221.53	0.000068	1.73	1340.21	325.64	0.09
OldSmokyHill_3	20434	Max WS	1206	1209.31	1221.5		1221.53	0.000068	1.74	1374.05	327.52	0.09
OldSmokyHill_3	20363	Max WS	1185	1209.38	1221.5	1213.43	1221.53	0.000104	2.17	1143.05	331.98	0.11
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1196	1209.41	1221.5		1221.51	0.000092	2.03	1196.82	327.09	0.11
OldSmokyHill_3	20300	Max WS	1196	1209.12	1221.5		1221.50	0.000033	1.26	1566.50	324.35	0.06
OldSmokyHill_3	20190	Max WS	2058	1209.13	1221.4		1221.48	0.000212	3.06	1370.10	287.42	0.16
OldSmokyHill_3	20100	Max WS	2067	1209.16	1221.4		1221.47	0.000273	3.52	1187.47	233.24	0.18
OldSmokyHill_3	20023	Max WS	2070	1209.08	1221.3		1221.45	0.000276	3.60	1083.91	186.82	0.19
OldSmokyHill_3	19900	Max WS	2072	1209.08	1221.3		1221.42	0.000236	3.33	1068.56	160.98	0.17
OldSmokyHill_3	19800	Max WS	2072	1208.97	1221.3		1221.39	0.000248	3.41	975.67	141.78	0.18
OldSmokyHill_3	19700	Max WS	2068	1208.94	1221.2		1221.38	0.000312	3.84	825.76	117.91	0.20
OldSmokyHill_3	19600	Max WS	2068	1208.88	1221.2		1221.35	0.000345	4.10	878.40	112.33	0.21
OldSmokyHill_3	19510	Max WS	2068	1208.73	1221.2	1213.38	1221.31	0.000230	3.37	978.65	115.37	0.17
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	2066	1208.72	1221.1		1221.26	0.000292	3.77	1027.46	118.05	0.19
OldSmokyHill_3	19400	Max WS	2064	1208.54	1221.1		1221.27	0.000473	4.86	968.86	132.46	0.25
OldSmokyHill_3	19300	Max WS	2097	1208.31	1221.0		1221.23	0.000447	4.70	921.87	130.87	0.24
OldSmokyHill_3	19200	Max WS	2095	1208.24	1221.0		1221.19	0.000466	4.80	902.27	135.24	0.24
OldSmokyHill_3	19100	Max WS	2093	1208.22	1220.9		1221.15	0.000495	4.85	871.33	141.28	0.25
OldSmokyHill_3	19000	Max WS	2083	1208.09	1220.8		1221.14	0.000674	5.68	755.63	129.48	0.29
OldSmokyHill_3	18900	Max WS	2080	1208.03	1220.7		1221.06	0.000632	5.28	649.56	124.77	0.27
OldSmokyHill_3	18800	Max WS	2077	1207.68	1220.6		1221.00	0.000629	5.32	598.86	124.14	0.28
OldSmokyHill_3	18700	Max WS	2086	1207.84	1220.6		1220.91	0.000457	4.57	671.21	148.29	0.24
OldSmokyHill_3	18600	Max WS	2087	1207.62	1220.5		1220.90	0.000643	5.48	654.05	131.61	0.28
OldSmokyHill_3	18500	Max WS	2081	1207.72	1220.4		1220.83	0.000700	5.58	506.74	84.15	0.29
OldSmokyHill_3	18438	Max WS	2088	1207.54	1220.5	1213.60	1220.75	0.000439	4.64	755.69	88.04	0.23
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	2078	1207.53	1220.3		1220.57	0.000421	4.58	789.85	90.08	0.23
OldSmokyHill_3	18300	Max WS	2078	1207.75	1220.3		1220.54	0.000469	4.79	809.56	92.94	0.24
OldSmokyHill_3	18200	Max WS	2080	1207.44	1220.3		1220.50	0.000444	4.69	817.34	112.03	0.24
OldSmokyHill_3	18100	Max WS	2077	1207.44	1220.2		1220.45	0.000449	4.77	876.89	111.96	0.24
OldSmokyHill_3	18000	Max WS	2077	1207.16	1220.2		1220.41	0.000493	5.05	824.46	94.58	0.25
OldSmokyHill_3	17900	Max WS	2076	1207.12	1220.1		1220.35	0.000355	4.25	804.72	98.99	0.21
OldSmokyHill_3	17800	Max WS	2076	1206.53	1220.1		1220.32	0.000463	5.02	825.07	86.86	0.24
OldSmokyHill_3	17700	Max WS	2072	1206.54	1219.9		1220.31	0.000606	5.67	626.45	70.25	0.28
OldSmokyHill_3	17600	Max WS	2145	1206.25	1219.9		1220.21	0.000449	4.92	756.76	83.59	0.24
OldSmokyHill_3	17500	Max WS	2145	1206.45	1219.9		1220.15	0.000399	4.55	712.09	75.62	0.23
OldSmokyHill_3	17400	Max WS	2141	1206.07	1219.8		1220.15	0.000550	5.53	670.39	72.69	0.27
OldSmokyHill_3	17300	Max WS	2144	1205.81	1219.8		1220.06	0.000355	4.41	773.28	82.87	0.21
OldSmokyHill_3	17181	Max WS	2209	1204.48	1219.7	1213.53	1220.00	0.000620	4.91	710.82	94.15	0.25
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2207	1204.22	1218.7		1218.96	0.000453	4.41	641.94	81.01	0.22
OldSmokyHill_3	16800	Max WS	2200	1205.22	1218.4		1218.98	0.001008	6.98	548.00	76.58	0.35
OldSmokyHill_3	16700	Max WS	2202	1204.84	1218.4		1218.83	0.000675	5.83	623.68	85.97	0.29
OldSmokyHill_3	16600	Max WS	2202	1204.49	1218.5	1212.29	1218.69	0.000502	4.00	724.38	109.75	0.24
OldSmokyHill_3	16574		Inl Struct									
OldSmokyHill_3	16500	Max WS	2197	1202.84	1218.4		1218.41	0.000025	1.27	2087.11	153.92	0.06
OldSmokyHill_3	16400	Max WS	2197	1202.78	1218.4		1218.40	0.000025	1.29	2022.98	159.62	0.06
OldSmokyHill_3	16300	Max WS	2239	1202.75	1218.3		1218.41	0.000102	2.50	1510.04	129.82	0.12
OldSmokyHill_3	16200	Max WS	2237	1202.62	1218.3		1218.41	0.000135	2.99	1389.62	122.92	0.14
OldSmokyHill_3	16100	Max WS	2239	1202.56	1218.3		1218.40	0.000141	3.05	1283.12	115.07	0.14
OldSmokyHill_3	16000	Max WS	2238	1202.50	1218.3		1218.39	0.000157	3.20	1162.68	102.58	0.15
OldSmokyHill_3	15900	Max WS	2234	1202.34	1218.2		1218.40	0.000250	4.02	797.99	74.55	0.18
OldSmokyHill_3	15800	Max WS	2230	1202.44	1218.2		1218.37	0.000237	3.92	886.08	83.52	0.18
OldSmokyHill_3	15700	Max WS	2255	1202.56	1218.2		1218.34	0.000246	3.88	895.41	85.04	0.18
OldSmokyHill_3	15635	Max WS	2258	1202.00	1218.1	1208.41	1218.32	0.000317	4.03	903.24	86.18	0.18
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	2258	1202.00	1218.2		1218.21	0.000285	2.00	1227.20	115.29	0.09
OldSmokyHill_3	15400	Max WS	2258	1202.54	1218.1		1218.21	0.000188	3.45	1100.11	93.82	0.16
OldSmokyHill_3	15300	Max WS	2264	1202.93	1218.0		1218.20	0.000255	3.93	1029.26	93.18	0.18
OldSmokyHill_3	15200	Max WS	2264	1202.50	1218.0		1218.16	0.000167	3.29	1234.11	221.41	0.15
OldSmokyHill_3	15100	Max WS	2262	1202.59	1218.0		1218.14	0.000162	3.24	1189.01	212.93	0.15
OldSmokyHill_3	15000	Max WS	2262	1202.48	1218.0		1218.13	0.000165	3.28	1200.13	136.50	0.15
OldSmokyHill_3	14900	Max WS	2262	1201.88	1218.0		1218.12	0.000202	3.67	1221.74	127.78	0.17
OldSmokyHill_3	14800	Max WS	2262	1202.06	1218.0		1218.08	0.000135	3.01	1203.43	116.72	0.14
OldSmokyHill_3	14700	Max WS	2270	1202.03	1217.9		1218.09	0.000211	3.76	1236.58	126.45	0.17

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	14600	Max WS	2275	1201.91	1217.9		1218.08	0.000268	4.22	1070.02	108.90	0.19
OldSmokyHill_3	14507	Max WS	2303	1201.00	1217.8	1208.41	1218.07	0.000415	4.75	1076.27	117.01	0.21
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	2303	1201.00	1217.5		1217.63	0.000217	3.43	1175.54	110.30	0.15
OldSmokyHill_3	14300	Max WS	2303	1202.28	1217.5		1217.61	0.000151	3.03	1095.04	98.20	0.14
OldSmokyHill_3	14200	Max WS	2302	1201.94	1217.4		1217.61	0.000245	3.83	1029.57	102.87	0.18
OldSmokyHill_3	14100	Max WS	2302	1201.94	1217.4		1217.58	0.000192	3.55	1182.99	149.12	0.16
OldSmokyHill_3	14000	Max WS	2302	1202.06	1217.4		1217.56	0.000196	3.55	1206.92	145.88	0.16
OldSmokyHill_3	13900	Max WS	2302	1202.00	1217.4		1217.56	0.000253	4.00	1226.28	193.14	0.18
OldSmokyHill_3	13800	Max WS	1747	1201.91	1217.4		1217.45	0.000117	2.77	1247.63	189.11	0.13
OldSmokyHill_3	13700	Max WS	2300	1202.31	1217.4		1217.49	0.000187	3.45	1503.67	218.77	0.16
OldSmokyHill_3	13600	Max WS	1744	1202.09	1217.3		1217.43	0.000129	2.89	1331.64	203.00	0.13
OldSmokyHill_3	13500	Max WS	1747	1201.84	1217.3		1217.40	0.000085	2.37	1415.45	212.30	0.11
OldSmokyHill_3	13400	Max WS	1744	1202.19	1217.3		1217.40	0.000097	2.49	1314.13	177.61	0.11
OldSmokyHill_3	13300	Max WS	1747	1202.09	1217.3		1217.38	0.000104	2.52	1348.85	160.28	0.12
OldSmokyHill_3	13200	Max WS	1744	1202.00	1217.3		1217.38	0.000131	2.93	1256.85	169.09	0.13
OldSmokyHill_3	13100	Max WS	1868	1201.94	1217.3		1217.36	0.000127	2.91	1164.81	146.00	0.13
OldSmokyHill_3	13000	Max WS	1872	1201.75	1217.2		1217.36	0.000152	3.17	1221.41	163.87	0.14
OldSmokyHill_3	12900	Max WS	1863	1201.88	1217.2		1217.34	0.000138	3.03	1233.42	133.26	0.14
OldSmokyHill_3	12800	Max WS	1860	1201.88	1217.2		1217.32	0.000135	2.97	1193.88	107.20	0.14
OldSmokyHill_3	12700	Max WS	1854	1201.56	1217.2		1217.30	0.000092	2.45	1160.66	98.07	0.11
OldSmokyHill_3	12600	Max WS	1857	1201.66	1217.2		1217.29	0.000104	2.63	1215.00	109.04	0.12
OldSmokyHill_3	12500	Max WS	1838	1201.75	1217.2		1217.29	0.000125	2.90	1257.04	115.12	0.13
OldSmokyHill_3	12400	Max WS	1844	1201.69	1217.2		1217.26	0.000079	2.27	1215.28	121.28	0.10
OldSmokyHill_3	12300	Max WS	1838	1201.38	1217.2		1217.27	0.000115	2.80	1137.98	113.95	0.13
OldSmokyHill_3	12200	Max WS	1834	1201.56	1217.2		1217.25	0.000095	2.52	1169.77	117.35	0.11
OldSmokyHill_3	12100	Max WS	1826	1201.41	1217.1		1217.25	0.000119	2.84	1117.92	103.21	0.13
OldSmokyHill_3	12000	Max WS	1818	1201.25	1217.1		1217.23	0.000113	2.74	1154.52	101.34	0.12
OldSmokyHill_3	11900	Max WS	1809	1201.34	1217.1		1217.22	0.000118	2.84	1160.31	107.21	0.13
OldSmokyHill_3	11800	Max WS	1797	1201.47	1217.1		1217.22	0.000148	3.14	929.76	87.82	0.14
OldSmokyHill_3	11688	Max WS	1797	1201.35	1217.1		1217.20	0.000153	3.19	961.13	97.78	0.14
OldSmokyHill_3	11600	Max WS	1798	1201.41	1217.1		1217.19	0.000149	3.13	1051.85	99.87	0.14
OldSmokyHill_3	11500	Max WS	1798	1201.15	1217.1		1217.16	0.000100	2.59	1239.58	112.80	0.12
OldSmokyHill_3	11400	Max WS	1799	1201.03	1217.1		1217.14	0.000053	1.94	1372.98	115.78	0.09
OldSmokyHill_3	11300	Max WS	1855	1200.84	1217.1		1217.15	0.000117	2.82	1208.63	107.49	0.13
OldSmokyHill_3	11200	Max WS	1843	1200.94	1217.0		1217.14	0.000122	2.91	1171.67	118.16	0.13
OldSmokyHill_3	11100	Max WS	1825	1200.81	1217.0		1217.13	0.000131	3.01	1010.73	89.69	0.13
OldSmokyHill_3	10956	Max WS	1861	1196.19	1217.1		1217.08	0.000040	1.64	1948.13	209.53	0.07
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	1192	1195.60	1215.9		1215.87	0.000020	1.10	1579.91	174.61	0.05
OldSmokyHill_3	10500	Max WS	1189	1200.88	1215.8		1215.87	0.000051	1.79	1190.35	112.03	0.08
OldSmokyHill_3	10400	Max WS	1191	1200.80	1215.8		1215.87	0.000051	1.81	1236.60	112.97	0.08
OldSmokyHill_3	10335	Max WS	1189	1200.91	1215.8	1204.45	1215.86	0.000056	1.87	1204.37	108.72	0.09
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	1183	1200.91	1215.8		1215.86	0.000061	1.95	1135.38	102.56	0.09
OldSmokyHill_3	10200	Max WS	1178	1200.59	1215.8		1215.85	0.000044	1.69	1253.14	116.07	0.08
OldSmokyHill_3	10100	Max WS	1165	1200.75	1215.8		1215.85	0.000052	1.82	1154.03	109.67	0.08
OldSmokyHill_3	10000	Max WS	1155	1200.50	1215.8		1215.83	0.000030	1.39	1141.65	103.28	0.06
OldSmokyHill_3	9900	Max WS	1147	1200.38	1215.8		1215.83	0.000034	1.49	1151.54	110.05	0.07
OldSmokyHill_3	9800	Max WS	1147	1200.44	1215.8		1215.83	0.000051	1.82	1188.10	106.03	0.08
OldSmokyHill_3	9700	Max WS	1142	1200.36	1215.8		1215.83	0.000052	1.85	1216.17	116.47	0.08
OldSmokyHill_3	9600	Max WS	1138	1200.22	1215.8		1215.82	0.000049	1.79	1201.76	106.55	0.08
OldSmokyHill_3	9500	Max WS	1138	1200.29	1215.8		1215.82	0.000050	1.81	1153.80	101.30	0.08
OldSmokyHill_3	9400	Max WS	1128	1200.41	1215.8		1215.81	0.000052	1.86	1112.08	102.20	0.08
OldSmokyHill_3	9300	Max WS	1128	1200.34	1215.8		1215.81	0.000049	1.81	1143.27	112.58	0.08
OldSmokyHill_3	9200	Max WS	1126	1200.56	1215.8		1215.80	0.000050	1.75	1133.81	109.77	0.08
OldSmokyHill_3	9148	Max WS	1127	1200.25	1215.8		1215.80	0.000047	1.76	1104.08	119.27	0.08
OldSmokyHill_3	9100	Max WS	1136	1200.27	1215.8		1215.79	0.000026	1.33	1210.42	121.88	0.06
OldSmokyHill_3	9000	Max WS	1131	1200.25	1215.8		1215.79	0.000041	1.64	1165.36	146.20	0.07
OldSmokyHill_3	8900	Max WS	1119	1200.31	1215.7		1215.79	0.000050	1.82	1094.40	176.08	0.08
OldSmokyHill_3	8800	Max WS	1119	1200.53	1215.7		1215.79	0.000045	1.72	1275.24	209.43	0.08
OldSmokyHill_3	8668	Max WS	1112	1200.39	1215.7	1204.38	1215.79	0.000066	2.11	1089.49	232.61	0.10
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	1109	1200.25	1215.7		1215.77	0.000038	1.55	1126.79	231.16	0.07
OldSmokyHill_3	8500	Max WS	1102	1200.37	1215.7		1215.77	0.000046	1.74	1322.65	224.08	0.08
OldSmokyHill_3	8400	Max WS	1106	1200.41	1215.7		1215.76	0.000036	1.55	1149.49	117.74	0.07
OldSmokyHill_3	8300	Max WS	1094	1199.94	1215.7		1215.76	0.000035	1.54	1199.64	176.62	0.07
OldSmokyHill_3	8200	Max WS	1099	1199.79	1215.7		1215.75	0.000038	1.64	1287.03	186.36	0.07
OldSmokyHill_3	8100	Max WS	1101	1199.97	1215.7		1215.75	0.000039	1.61	1293.62	149.85	0.07
OldSmokyHill_3	8000	Max WS	1098	1199.51	1215.7		1215.74	0.000025	1.33	1229.23	117.98	0.06
OldSmokyHill_3	7900	Max WS	1084	1199.72	1215.7		1215.74	0.000036	1.58	1319.77	141.11	0.07
OldSmokyHill_3	7800	Max WS	1077	1199.50	1215.7		1215.74	0.000029	1.43	1300.12	147.84	0.06
OldSmokyHill_3	7700	Max WS	1082	1199.53	1215.7		1215.74	0.000034	1.56	1304.26	162.29	0.07
OldSmokyHill_3	7600	Max WS	1075	1199.56	1215.7		1215.73	0.000035	1.56	1191.40	130.28	0.07
OldSmokyHill_3	7500	Max WS	1075	1199.59	1215.7		1215.73	0.000033	1.52	1238.50	121.32	0.07
OldSmokyHill_3	7400	Max WS	1077	1199.59	1215.7		1215.72	0.000028	1.41	1391.49	120.90	0.06
OldSmokyHill_3	7300	Max WS	1073	1199.63	1215.7		1215.72	0.000028	1.41	1334.69	128.32	0.06
OldSmokyHill_3	7275		Lat Struct									

HEC-RAS Plan: 04-FWOP-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	7200	Max WS	1013	1199.58	1215.7		1215.72	0.000026	1.34	1423.16	186.85	0.06
OldSmokyHill_3	7100	Max WS	458	1199.59	1215.7		1215.72	0.000004	0.54	1429.27	137.07	0.02
OldSmokyHill_3	7000	Max WS	465	1199.50	1215.7		1215.72	0.000006	0.67	1242.33	118.06	0.03
OldSmokyHill_3	6900	Max WS	465	1199.53	1215.7		1215.72	0.000006	0.65	1295.57	156.73	0.03
OldSmokyHill_3	6800	Max WS	464	1199.41	1215.7		1215.72	0.000006	0.67	1260.55	142.49	0.03
OldSmokyHill_3	6700	Max WS	464	1199.62	1215.7		1215.72	0.000006	0.66	1296.66	126.33	0.03
OldSmokyHill_3	6600	Max WS	463	1199.46	1215.7		1215.72	0.000007	0.70	1244.77	123.16	0.03
OldSmokyHill_3	6500	Max WS	462	1199.95	1215.7		1215.72	0.000006	0.61	1273.92	139.83	0.03
OldSmokyHill_3	6400	Max WS	463	1199.64	1215.7		1215.72	0.000005	0.62	1343.51	206.62	0.03
OldSmokyHill_3	6300	Max WS	463	1199.66	1215.7		1215.72	0.000006	0.62	1298.40	189.06	0.03
OldSmokyHill_3	6200	Max WS	461	1199.70	1215.7		1215.72	0.000006	0.63	1379.47	342.29	0.03
OldSmokyHill_3	6100	Max WS	462	1199.62	1215.7		1215.72	0.000006	0.65	1367.60	335.47	0.03
OldSmokyHill_3	6000	Max WS	462	1199.63	1215.7		1215.72	0.000007	0.70	1314.67	185.07	0.03
OldSmokyHill_3	5900	Max WS	460	1199.56	1215.7		1215.72	0.000005	0.60	1415.02	168.87	0.03
OldSmokyHill_3	5800	Max WS	460	1199.59	1215.7		1215.72	0.000006	0.67	1353.58	191.11	0.03
OldSmokyHill_3	5700	Max WS	460	1199.50	1215.7		1215.71	0.000006	0.64	1304.45	158.78	0.03
OldSmokyHill_3	5600	Max WS	463	1199.57	1215.7		1215.71	0.000005	0.62	1501.71	172.97	0.03
OldSmokyHill_3	5500	Max WS	460	1199.22	1215.7		1215.71	0.000005	0.62	1472.95	164.05	0.03
OldSmokyHill_3	5400	Max WS	461	1199.12	1215.7		1215.71	0.000007	0.70	1335.07	138.57	0.03
OldSmokyHill_3	5300	Max WS	457	1199.14	1215.7		1215.71	0.000006	0.64	1314.23	118.14	0.03
OldSmokyHill_3	5200	Max WS	461	1199.09	1215.7		1215.71	0.000004	0.52	1404.38	127.50	0.02
OldSmokyHill_3	5100	Max WS	458	1198.99	1215.7		1215.71	0.000006	0.66	1403.94	130.33	0.03
OldSmokyHill_3	5000	Max WS	460	1198.99	1215.7		1215.71	0.000006	0.65	1381.09	119.69	0.03
OldSmokyHill_3	4900	Max WS	460	1199.38	1215.7		1215.71	0.000005	0.61	1448.39	129.87	0.03
OldSmokyHill_3	4800	Max WS	461	1198.50	1215.7		1215.71	0.000005	0.60	1630.37	239.53	0.03
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	454	1198.66	1215.7		1215.71	0.000006	0.66	1456.80	212.66	0.03
OldSmokyHill_3	4600	Max WS	447	1198.79	1215.7		1215.71	0.000004	0.56	1518.39	194.66	0.02
OldSmokyHill_3	4500	Max WS	445	1198.69	1215.7		1215.71	0.000005	0.60	1437.24	154.43	0.03
OldSmokyHill_3	4400	Max WS	447	1198.73	1215.7		1215.71	0.000005	0.61	1432.58	141.94	0.03
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	444	1198.63	1215.7		1215.71	0.000004	0.58	1495.23	151.89	0.03
OldSmokyHill_3	4200	Max WS	495	1198.66	1215.7		1215.71	0.000007	0.73	1500.00	167.50	0.03
OldSmokyHill_3	4100	Max WS	502	1198.56	1215.7		1215.71	0.000006	0.64	1680.28	173.60	0.03
OldSmokyHill_3	4000	Max WS	794	1198.84	1215.7		1215.71	0.000020	1.21	1548.40	165.90	0.05
OldSmokyHill_3	3900	Max WS	1054	1198.91	1215.7		1215.70	0.000029	1.47	1523.37	179.68	0.06
OldSmokyHill_3	3800	Max WS	1033	1198.66	1215.7		1215.70	0.000024	1.34	1474.94	191.02	0.06
OldSmokyHill_3	3700	Max WS	981	1198.59	1215.7		1215.70	0.000022	1.30	1559.39	175.37	0.06
OldSmokyHill_3	3600	Max WS	929	1198.52	1215.7		1215.70	0.000026	1.38	1540.46	168.64	0.06
OldSmokyHill_3	3500	Max WS	873	1198.78	1215.7		1215.69	0.000020	1.21	1541.35	153.15	0.05
OldSmokyHill_3	3400	Max WS	756	1198.62	1215.7		1215.69	0.000013	0.99	1507.90	163.44	0.04
OldSmokyHill_3	3300	Max WS	634	1198.34	1215.7		1215.69	0.000009	0.85	1492.03	176.41	0.04
OldSmokyHill_3	3200	Max WS	518	1198.38	1215.7		1215.69	0.000006	0.67	1514.42	183.51	0.03
OldSmokyHill_3	3100	Max WS	398	1198.66	1215.7		1215.69	0.000003	0.49	1618.52	234.18	0.02
OldSmokyHill_3	3000	Max WS	278	1198.34	1215.7		1215.69	0.000002	0.35	1594.73	298.74	0.02
OldSmokyHill_3	2900	Max WS	260	1198.41	1215.7		1215.69	0.000002	0.36	1514.23	237.17	0.02
OldSmokyHill_3	2800	Max WS	262	1198.34	1215.7		1215.69	0.000002	0.40	1551.72	238.85	0.02
OldSmokyHill_3	2700	Max WS	261	1198.47	1215.7		1215.69	0.000002	0.34	1546.85	239.38	0.01
OldSmokyHill_3	2600	Max WS	268	1198.50	1215.7		1215.69	0.000001	0.33	1547.75	200.67	0.01
OldSmokyHill_3	2500	Max WS	267	1198.53	1215.7		1215.69	0.000002	0.36	1347.64	140.75	0.02
OldSmokyHill_3	2400	Max WS	268	1198.93	1215.7		1215.69	0.000001	0.28	1373.09	141.40	0.01
OldSmokyHill_3	2300	Max WS	267	1198.50	1215.7		1215.69	0.000001	0.27	1408.45	166.06	0.01
OldSmokyHill_3	2183	Max WS	268	1196.44	1215.7		1215.69	0.000002	0.35	879.58	186.79	0.01
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	244	1196.78	1214.8		1214.78	0.000016	1.03	236.38	126.81	0.04
OldSmokyHill_3	1900	Max WS	245	1198.47	1214.8		1214.77	0.000001	0.28	1286.27	131.61	0.01
OldSmokyHill_3	1800	Max WS	245	1198.28	1214.8		1214.77	0.000001	0.30	1364.07	144.78	0.01
OldSmokyHill_3	1700	Max WS	245	1198.12	1214.8		1214.77	0.000001	0.27	1413.03	144.09	0.01
OldSmokyHill_3	1600	Max WS	248	1198.25	1214.8		1214.77	0.000002	0.34	1450.89	188.15	0.01
OldSmokyHill_3	1500	Max WS	263	1197.76	1214.8		1214.77	0.000001	0.32	1490.58	178.61	0.01
OldSmokyHill_3	1400	Max WS	276	1197.88	1214.8		1214.77	0.000001	0.31	1375.44	135.04	0.01
OldSmokyHill_3	1300	Max WS	279	1197.69	1214.8		1214.77	0.000002	0.40	1042.33	249.81	0.02
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	293	1197.53	1214.8		1214.77	0.000001	0.24	2045.90	403.05	0.01
OldSmokyHill_3	1100	Max WS	347	1197.72	1214.8		1214.77	0.000002	0.36	1819.06	517.78	0.02
OldSmokyHill_3	1000	Max WS	432	1197.72	1214.8		1214.77	0.000003	0.49	1734.98	534.06	0.02
OldSmokyHill_3	900	Max WS	539	1197.44	1214.8		1214.77	0.000006	0.68	1668.52	538.58	0.03
OldSmokyHill_3	800	Max WS	665	1197.35	1214.8		1214.76	0.000010	0.87	1612.30	531.79	0.04
OldSmokyHill_3	700	Max WS	779	1197.38	1214.8		1214.76	0.000016	1.09	1534.73	537.43	0.05
OldSmokyHill_3	660	Max WS	1074	1195.72	1214.7	1202.20	1214.78	0.000085	2.35	983.23	572.80	0.10
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	1074	1194.57	1201.0	1202.27	1206.04	0.029256	17.97	59.74	13.44	1.29
OldSmokyHill_3	300	Max WS	1074	1194.22	1199.3		1200.38	0.007889	8.44	127.27	35.85	0.79
OldSmokyHill_3	200	Max WS	1074	1193.97	1198.3	1198.19	1199.81	0.012322	9.98	107.62	32.82	0.97
OldSmokyHill_3	100	Max WS	1074	1193.86	1197.6	1196.57	1197.69	0.001306	2.96	403.59	210.85	0.31

HEC-RAS Plan: 05-Alt3-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	36405	Max WS	0	1212.50	1218.0		1217.95	0.000000	0.00	311.22	135.05	0.00
OldSmokyHill_3	36394.74	Max WS	-52	1213.50	1218.0	1213.90	1217.96	0.000005	0.23	227.09	67.60	0.02
OldSmokyHill_3	36393		Inl Struct									
OldSmokyHill_3	36392.76	Max WS	-52	1213.50	1218.0		1217.97	0.000005	-0.23	226.52	67.10	0.02
OldSmokyHill_3	36327	Max WS	129	1213.50	1218.1		1218.06	0.000031	0.58	235.47	77.50	0.05
OldSmokyHill_3	36269	Max WS	115	1205.97	1218.1		1218.09	0.000000	0.11	1081.33	132.76	0.01
OldSmokyHill_3	36150	Max WS	80	1205.38	1218.1		1218.11	0.000000	0.05	1473.69	165.60	0.00
OldSmokyHill_3	35948	Max WS	21	1204.53	1218.1		1218.13	0.000000	0.02	980.61	119.07	0.00
OldSmokyHill_3	35900	Max WS	14	1212.00	1218.1		1218.14	0.000001	0.13	110.52	24.97	0.01
OldSmokyHill_3	35800	Max WS	8	1212.00	1218.2		1218.16	0.000000	0.07	121.71	28.29	0.01
OldSmokyHill_3	35770	Max WS	6	1209.00	1218.2	1209.25	1218.16	0.000000	0.02	326.67	43.91	0.00
OldSmokyHill_3	35764		Inl Struct									
OldSmokyHill_3	35756	Max WS	6	1210.00	1218.2		1218.16	0.000000	0.03	226.32	38.49	0.00
OldSmokyHill_3	35680	Max WS	0	1209.80	1218.2	1209.83	1218.17	0.000000	0.00	62.25	24.43	0.00
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-212	1209.50	1221.0		1221.11	0.000124	-2.41	87.67	82.68	0.13
OldSmokyHill_3	35300	Max WS	-212	1209.50	1221.1		1221.08	0.000006	-0.45	530.39	84.89	0.03
OldSmokyHill_3	35200	Max WS	-195	1209.50	1221.1		1221.08	0.000005	-0.41	535.94	85.26	0.02
OldSmokyHill_3	35100	Max WS	-194	1209.50	1221.1		1221.08	0.000004	-0.39	554.01	84.07	0.02
OldSmokyHill_3	35000	Max WS	-173	1210.30	1221.1		1221.08	0.000003	-0.32	595.39	88.24	0.02
OldSmokyHill_3	34900	Max WS	-173	1210.40	1221.1		1221.08	0.000003	-0.33	593.13	89.16	0.02
OldSmokyHill_3	34798	Max WS	-174	1210.50	1221.1		1221.08	0.000003	-0.33	595.83	91.59	0.02
OldSmokyHill_3	34701	Max WS	-174	1210.60	1221.1		1221.08	0.000003	-0.34	575.02	88.48	0.02
OldSmokyHill_3	34604	Max WS	-174	1210.70	1221.1		1221.08	0.000003	-0.34	578.90	91.68	0.02
OldSmokyHill_3	34499	Max WS	-174	1210.80	1221.1		1221.08	0.000003	-0.34	575.64	90.15	0.02
OldSmokyHill_3	34396	Max WS	-174	1210.90	1221.1		1221.08	0.000003	-0.34	574.38	91.56	0.02
OldSmokyHill_3	34306	Max WS	-174	1210.99	1221.1		1221.08	0.000004	-0.34	571.03	92.43	0.02
OldSmokyHill_3	34186	Max WS	-174	1211.11	1221.1		1221.08	0.000004	-0.38	546.51	164.40	0.02
OldSmokyHill_3	34100	Max WS	-174	1211.02	1221.1		1221.08	0.000005	-0.39	530.19	181.69	0.02
OldSmokyHill_3	34013	Max WS	-174	1210.93	1221.1		1221.08	0.000005	-0.42	527.78	203.45	0.02
OldSmokyHill_3	33965	Max WS	-174	1210.88	1221.1		1221.08	0.000005	-0.40	603.51	171.42	0.02
OldSmokyHill_3	33914	Max WS	-174	1210.83	1221.1		1221.08	0.000004	-0.35	785.62	133.87	0.02
OldSmokyHill_3	33833	Max WS	-158	1210.75	1221.1	1211.87	1221.08	0.000003	0.33	725.62	113.63	0.02
OldSmokyHill_3	33800		Inl Struct									
OldSmokyHill_3	33766	Max WS	-159	1210.68	1221.1		1221.09	0.000003	-0.32	723.52	106.74	0.02
OldSmokyHill_3	33673	Max WS	-159	1209.50	1221.1		1221.09	0.000002	-0.26	717.74	90.46	0.01
OldSmokyHill_3	33600	Max WS	-159	1209.50	1221.1		1221.09	0.000003	-0.33	597.98	80.50	0.02
OldSmokyHill_3	33500	Max WS	-159	1209.50	1221.1		1221.09	0.000002	-0.30	639.43	82.61	0.02
OldSmokyHill_3	33400	Max WS	-157	1209.50	1221.1		1221.09	0.000003	-0.32	603.33	82.25	0.02
OldSmokyHill_3	33300	Max WS	-150	1209.50	1221.1		1221.09	0.000003	-0.31	598.10	80.46	0.02
OldSmokyHill_3	33200	Max WS	-150	1209.50	1221.1		1221.09	0.000003	-0.30	612.74	82.75	0.02
OldSmokyHill_3	33100	Max WS	-149	1210.30	1221.1		1221.09	0.000003	-0.31	551.62	72.92	0.02
OldSmokyHill_3	33000	Max WS	-150	1210.40	1221.1		1221.09	0.000003	-0.31	579.00	78.75	0.02
OldSmokyHill_3	32900	Max WS	-149	1210.50	1221.1		1221.09	0.000003	-0.31	637.97	96.70	0.02
OldSmokyHill_3	32815	Max WS	-27	1210.12	1221.1		1221.09	0.000000	-0.05	722.62	131.59	0.00
OldSmokyHill_3	32773	Max WS	-27	1211.25	1221.1		1221.09	0.000001	-0.12	269.37	76.40	0.01
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-29	1211.25	1221.1		1221.09	0.000000	-0.07	429.07	111.55	0.00
OldSmokyHill_3	32500	Max WS	-28	1210.95	1221.1		1221.09	0.000000	-0.10	472.81	83.26	0.01
OldSmokyHill_3	32400	Max WS	-14	1210.85	1221.1		1221.09	0.000000	-0.03	617.35	83.33	0.00
OldSmokyHill_3	32338	Max WS	-14	1210.79	1221.1		1221.09	0.000000	-0.03	548.12	77.11	0.00
OldSmokyHill_3	32300	Max WS	-13	1210.75	1221.1		1221.09	0.000000	-0.03	556.85	78.18	0.00
OldSmokyHill_3	32200	Max WS	-14	1210.65	1221.1		1221.09	0.000000	-0.03	644.24	87.00	0.00
OldSmokyHill_3	32100	Max WS	-13	1210.55	1221.1		1221.09	0.000000	-0.03	602.75	79.04	0.00
OldSmokyHill_3	31900	Max WS	-14	1210.35	1221.1		1221.09	0.000000	-0.03	520.54	68.15	0.00
OldSmokyHill_3	31800	Max WS	30	1210.25	1221.1		1221.09	0.000000	0.06	541.77	70.75	0.00
OldSmokyHill_3	31700	Max WS	33	1209.50	1221.1		1221.09	0.000000	0.07	558.24	76.79	0.00
OldSmokyHill_3	31600	Max WS	48	1209.50	1221.1		1221.09	0.000000	0.10	573.85	80.31	0.01
OldSmokyHill_3	31500	Max WS	48	1209.50	1221.1		1221.09	0.000000	0.10	551.42	74.81	0.01
OldSmokyHill_3	31400	Max WS	48	1209.80	1221.1		1221.09	0.000000	0.09	667.75	90.26	0.01
OldSmokyHill_3	31300	Max WS	48	1209.90	1221.1		1221.09	0.000000	0.09	679.10	90.86	0.01
OldSmokyHill_3	31200	Max WS	48	1210.00	1221.1		1221.09	0.000000	0.09	663.27	88.97	0.01
OldSmokyHill_3	31100	Max WS	50	1210.10	1221.1		1221.09	0.000000	0.10	638.07	87.85	0.01
OldSmokyHill_3	31000	Max WS	56	1210.20	1221.1		1221.09	0.000000	0.11	634.52	84.42	0.01
OldSmokyHill_3	30900	Max WS	56	1210.30	1221.1		1221.09	0.000000	0.12	640.32	84.64	0.01
OldSmokyHill_3	30800	Max WS	57	1210.40	1221.1		1221.09	0.000000	0.12	632.65	85.29	0.01
OldSmokyHill_3	30700	Max WS	56	1210.50	1221.1		1221.09	0.000000	0.12	612.39	80.22	0.01
OldSmokyHill_3	30651	Max WS	56	1210.55	1221.1		1221.09	0.000000	0.10	639.09	86.11	0.01
OldSmokyHill_3	30575	Max WS	57	1210.63	1221.1		1221.09	0.000000	0.12	635.42	86.23	0.01
OldSmokyHill_3	30500	Max WS	56	1210.70	1221.1		1221.09	0.000000	0.12	669.93	93.70	0.01
OldSmokyHill_3	30400	Max WS	56	1210.60	1221.1		1221.09	0.000000	0.12	645.99	89.96	0.01
OldSmokyHill_3	30300	Max WS	56	1210.50	1221.1		1221.09	0.000000	0.12	640.89	85.41	0.01
OldSmokyHill_3	30200	Max WS	56	1210.40	1221.1		1221.09	0.000000	0.11	683.08	92.84	0.01
OldSmokyHill_3	30100	Max WS	56	1210.30	1221.1		1221.09	0.000000	0.11	665.14	88.32	0.01
OldSmokyHill_3	29999	Max WS	56	1210.20	1221.1		1221.09	0.000000	0.11	680.72	88.17	0.01
OldSmokyHill_3	29899	Max WS	56	1210.10	1221.1		1221.09	0.000000	0.11	676.83	89.06	0.01
OldSmokyHill_3	29800	Max WS	62	1210.00	1221.1		1221.09	0.000000	0.11	720.87	100.25	0.01
OldSmokyHill_3	29704	Max WS	61	1209.90	1221.1		1221.09	0.000000	0.11	713.43	91.66	0.01

HEC-RAS Plan: 05-Alt3-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	29572	Max WS	62	1209.77	1221.1		1221.09	0.000000	0.11	690.35	88.87	0.01
OldSmokyHill_3	29466	Max WS	61	1209.66	1221.1		1221.09	0.000000	0.10	784.29	101.82	0.01
OldSmokyHill_3	29385	Max WS	989	1209.50	1221.0		1221.06	0.000096	1.67	720.61	88.95	0.09
OldSmokyHill_3	29314	Max WS	990	1209.50	1221.0		1221.06	0.000164	2.18	612.16	81.90	0.12
OldSmokyHill_3	29209	Max WS	991	1209.50	1221.0		1221.04	0.000157	2.07	592.61	76.56	0.12
OldSmokyHill_3	29100	Max WS	990	1209.50	1221.0		1221.02	0.000166	2.19	609.56	78.23	0.12
OldSmokyHill_3	28991	Max WS	990	1209.50	1220.9		1221.00	0.000169	2.20	605.22	79.80	0.12
OldSmokyHill_3	28900	Max WS	989	1210.12	1220.9		1220.99	0.000152	2.07	611.58	81.48	0.12
OldSmokyHill_3	28800	Max WS	990	1210.22	1220.9		1220.97	0.000158	2.10	607.69	79.41	0.12
OldSmokyHill_3	28700	Max WS	990	1210.32	1220.9		1220.95	0.000167	2.13	590.88	88.85	0.12
OldSmokyHill_3	28594	Max WS	989	1210.43	1220.9		1220.94	0.000113	1.93	598.44	84.72	0.11
OldSmokyHill_3	28500	Max WS	990	1210.52	1220.9		1220.93	0.000105	1.83	648.62	87.76	0.11
OldSmokyHill_3	28430	Max WS	1012	1210.34	1220.8	1214.92	1220.92	0.000482	2.98	456.72	67.39	0.18
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1004	1210.35	1220.4		1220.54	0.000505	3.22	516.99	86.89	0.20
OldSmokyHill_3	28200	Max WS	1006	1210.36	1220.4		1220.49	0.000179	2.09	623.66	87.48	0.12
OldSmokyHill_3	28100	Max WS	1012	1210.26	1220.4		1220.48	0.000174	2.08	648.15	91.61	0.12
OldSmokyHill_3	28000	Max WS	1011	1210.16	1220.4		1220.46	0.000179	2.17	639.28	89.46	0.12
OldSmokyHill_3	27900	Max WS	1011	1210.06	1220.4		1220.44	0.000174	2.14	631.00	86.58	0.12
OldSmokyHill_3	27800	Max WS	1011	1209.96	1220.4		1220.42	0.000173	2.14	615.57	82.61	0.12
OldSmokyHill_3	27700	Max WS	1010	1209.86	1220.4		1220.40	0.000112	1.89	627.07	85.72	0.11
OldSmokyHill_3	27600	Max WS	1009	1209.76	1220.3		1220.39	0.000102	1.82	613.30	81.65	0.11
OldSmokyHill_3	27500	Max WS	1021	1209.50	1220.3		1220.38	0.000120	1.85	604.19	84.08	0.11
OldSmokyHill_3	27400	Max WS	1020	1209.50	1220.3		1220.37	0.000109	1.75	621.68	86.57	0.11
OldSmokyHill_3	27300	Max WS	1019	1209.50	1220.3		1220.36	0.000228	2.40	614.69	87.34	0.14
OldSmokyHill_3	27200	Max WS	1019	1209.50	1220.3		1220.33	0.000128	1.90	587.94	83.14	0.12
OldSmokyHill_3	27100	Max WS	1023	1209.55	1220.3		1220.32	0.000123	2.07	621.08	89.10	0.12
OldSmokyHill_3	27000	Max WS	1023	1209.65	1220.3		1220.31	0.000100	1.77	633.28	84.42	0.11
OldSmokyHill_3	26900	Max WS	1022	1209.75	1220.3		1220.30	0.000089	1.66	672.41	89.18	0.10
OldSmokyHill_3	26800	Max WS	1023	1209.85	1220.2		1220.29	0.000094	1.71	672.12	91.50	0.10
OldSmokyHill_3	26700	Max WS	1027	1209.95	1220.2		1220.28	0.000126	1.98	604.88	82.63	0.12
OldSmokyHill_3	26600	Max WS	1027	1210.05	1220.2		1220.27	0.000135	2.07	580.84	82.07	0.12
OldSmokyHill_3	26522	Max WS	1023	1210.13	1220.1	1214.21	1220.27	0.000401	3.34	369.56	62.98	0.20
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1017	1210.19	1220.0		1220.20	0.000457	3.61	360.78	65.74	0.21
OldSmokyHill_3	26400	Max WS	1024	1210.25	1220.1		1220.15	0.000108	1.78	633.86	89.69	0.11
OldSmokyHill_3	26300	Max WS	1030	1210.35	1220.1		1220.14	0.000221	2.30	615.36	88.81	0.14
OldSmokyHill_3	26200	Max WS	1026	1210.45	1220.0		1220.12	0.000228	2.36	636.92	98.98	0.14
OldSmokyHill_3	26100	Max WS	1031	1210.55	1220.0		1220.09	0.000115	1.80	615.99	87.63	0.11
OldSmokyHill_3	26000	Max WS	1029	1210.45	1220.0		1220.08	0.000235	2.39	608.91	88.09	0.14
OldSmokyHill_3	25900	Max WS	1030	1210.35	1220.0		1220.06	0.000119	1.84	625.12	89.47	0.11
OldSmokyHill_3	25800	Max WS	1029	1210.25	1220.0		1220.05	0.000128	1.92	648.83	99.52	0.12
OldSmokyHill_3	25700	Max WS	1031	1210.15	1220.0		1220.03	0.000120	1.86	606.64	85.05	0.11
OldSmokyHill_3	25600	Max WS	1030	1210.05	1220.0		1220.02	0.000102	1.72	635.51	86.88	0.11
OldSmokyHill_3	25500	Max WS	1075	1209.95	1220.0		1220.01	0.000115	1.84	660.19	93.27	0.11
OldSmokyHill_3	25400	Max WS	1070	1209.85	1219.9		1220.00	0.000204	2.29	656.16	91.91	0.13
OldSmokyHill_3	25300	Max WS	1069	1209.75	1219.9		1219.98	0.000230	2.43	594.93	89.56	0.14
OldSmokyHill_3	25200	Max WS	1067	1209.50	1219.9		1219.95	0.000158	1.94	615.10	84.68	0.12
OldSmokyHill_3	25117	Max WS	1064	1208.41	1219.9	1212.95	1219.91	0.000821	1.97	661.03	97.40	0.11
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1028	1208.97	1219.6		1219.74	0.000353	2.92	454.56	82.23	0.17
OldSmokyHill_3	24900	Max WS	1033	1209.50	1219.7		1219.71	0.000124	1.80	629.94	94.63	0.12
OldSmokyHill_3	24800	Max WS	1030	1209.50	1219.6		1219.70	0.000147	2.02	570.69	88.14	0.13
OldSmokyHill_3	24700	Max WS	1041	1209.50	1219.6		1219.68	0.000118	1.77	628.33	91.35	0.11
OldSmokyHill_3	24600	Max WS	1038	1209.50	1219.6		1219.67	0.000096	1.66	685.47	96.33	0.10
OldSmokyHill_3	24500	Max WS	1036	1209.65	1219.6		1219.66	0.000116	1.82	628.03	89.68	0.11
OldSmokyHill_3	24400	Max WS	1036	1209.75	1219.6		1219.65	0.000106	1.73	637.17	86.94	0.11
OldSmokyHill_3	24300	Max WS	1031	1209.85	1219.6		1219.64	0.000109	1.75	627.56	86.71	0.11
OldSmokyHill_3	24200	Max WS	1028	1209.95	1219.6		1219.63	0.000116	1.81	619.53	88.55	0.11
OldSmokyHill_3	24100	Max WS	1025	1210.05	1219.6		1219.61	0.000125	1.88	594.10	84.29	0.12
OldSmokyHill_3	24000	Max WS	1030	1210.15	1219.5		1219.60	0.000119	1.84	624.17	89.31	0.11
OldSmokyHill_3	23900	Max WS	1022	1210.25	1219.5		1219.59	0.000118	1.81	616.09	89.68	0.11
OldSmokyHill_3	23800	Max WS	1041	1210.35	1219.5		1219.57	0.000128	1.89	597.46	88.64	0.12
OldSmokyHill_3	23700	Max WS	1038	1210.25	1219.5		1219.56	0.000127	1.89	600.56	88.65	0.12
OldSmokyHill_3	23600	Max WS	1032	1210.15	1219.5		1219.54	0.000122	1.84	604.18	88.03	0.12
OldSmokyHill_3	23500	Max WS	1032	1210.05	1219.5		1219.53	0.000110	1.74	632.38	90.70	0.11
OldSmokyHill_3	23362	Max WS	1038	1209.91	1219.5	1213.36	1219.51	0.000110	1.75	647.28	95.84	0.11
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1028	1209.75	1219.4		1219.48	0.000102	1.71	646.50	92.36	0.11
OldSmokyHill_3	23167	Max WS	1028	1209.72	1219.4		1219.48	0.000108	1.77	641.52	96.48	0.11
OldSmokyHill_3	23100	Max WS	1032	1209.50	1219.4		1219.47	0.000114	1.79	647.84	104.64	0.11
OldSmokyHill_3	23000	Max WS	1035	1209.50	1219.4		1219.46	0.000115	1.79	651.65	104.71	0.11
OldSmokyHill_3	22900	Max WS	1029	1209.50	1219.4		1219.45	0.000153	2.23	714.70	115.06	0.13
OldSmokyHill_3	22800	Max WS	1035	1209.55	1219.4		1219.43	0.000144	2.23	707.99	111.64	0.13
OldSmokyHill_3	22731	Max WS	1035	1209.62	1219.4		1219.42	0.000162	2.36	697.38	111.24	0.14
OldSmokyHill_3	22656	Max WS	1035	1209.70	1219.4	1212.99	1219.40	0.000111	1.82	641.14	100.09	0.11
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1028	1209.70	1219.3		1219.39	0.000108	1.79	641.78	101.52	0.11

HEC-RAS Plan: 05-Alt3-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	22578	Max WS	1027	1209.77	1219.3		1219.38	0.000100	1.70	668.16	102.09	0.11
OldSmokyHill_3	22500	Max WS	1027	1209.85	1219.3		1219.38	0.000154	2.27	643.58	105.13	0.13
OldSmokyHill_3	22400	Max WS	1023	1209.95	1219.3		1219.35	0.000218	1.74	587.93	122.03	0.14
OldSmokyHill_3	22300	Max WS	1018	1210.05	1219.3		1219.33	0.000169	1.67	613.00	129.72	0.13
OldSmokyHill_3	22200	Max WS	1017	1210.15	1219.3		1219.32	0.000123	1.51	682.31	147.70	0.11
OldSmokyHill_3	22100	Max WS	1012	1210.25	1219.3		1219.31	0.000104	1.67	672.01	155.45	0.11
OldSmokyHill_3	22000	Max WS	1001	1210.12	1219.2		1219.29	0.000117	1.78	635.16	119.32	0.11
OldSmokyHill_3	21900	Max WS	996	1210.12	1219.2		1219.28	0.000148	2.03	584.18	104.00	0.13
OldSmokyHill_3	21799	Max WS	975	1210.27	1219.2		1219.26	0.000167	2.15	565.81	108.11	0.14
OldSmokyHill_3	21722	Max WS	969	1210.10	1219.2	1213.47	1219.25	0.000182	2.26	522.02	100.21	0.14
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	963	1210.10	1219.2		1219.23	0.000182	2.24	523.15	101.38	0.14
OldSmokyHill_3	21600	Max WS	969	1210.31	1219.2		1219.21	0.000141	1.93	598.14	110.82	0.12
OldSmokyHill_3	21500	Max WS	976	1210.12	1219.2		1219.20	0.000102	1.67	693.06	147.10	0.11
OldSmokyHill_3	21400	Max WS	978	1209.93	1219.2		1219.19	0.000090	1.57	767.64	154.77	0.10
OldSmokyHill_3	21295	Max WS	972	1209.93	1219.1		1219.17	0.000087	1.55	741.80	168.23	0.10
OldSmokyHill_3	21200	Max WS	966	1209.82	1219.1		1219.16	0.000081	1.47	774.04	177.83	0.09
OldSmokyHill_3	21100	Max WS	959	1209.83	1219.1		1219.15	0.000074	1.43	786.25	175.28	0.09
OldSmokyHill_3	20995	Max WS	953	1210.03	1219.1		1219.15	0.000100	1.66	752.75	177.34	0.10
OldSmokyHill_3	20900	Max WS	946	1209.74	1219.1		1219.13	0.000111	1.76	707.11	167.66	0.11
OldSmokyHill_3	20800	Max WS	946	1209.69	1219.1		1219.12	0.000081	1.51	785.77	205.89	0.09
OldSmokyHill_3	20700	Max WS	939	1209.43	1219.1		1219.11	0.000087	1.58	787.94	204.86	0.10
OldSmokyHill_3	20644	Max WS	946	1209.47	1219.1		1219.11	0.000093	1.63	760.77	195.06	0.10
OldSmokyHill_3	20600	Max WS	939	1209.50	1219.1		1219.10	0.000077	1.46	823.35	182.85	0.09
OldSmokyHill_3	20500	Max WS	923	1209.49	1219.1		1219.09	0.000091	1.61	684.36	158.41	0.10
OldSmokyHill_3	20434	Max WS	923	1209.28	1219.0		1219.08	0.000103	1.72	667.58	213.33	0.11
OldSmokyHill_3	20363	Max WS	907	1209.34	1219.0	1212.81	1219.07	0.000127	1.93	527.84	160.34	0.12
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	907	1209.41	1219.0		1219.06	0.000115	1.84	555.61	193.51	0.11
OldSmokyHill_3	20300	Max WS	931	1209.10	1219.0		1219.06	0.000050	1.25	883.36	228.04	0.07
OldSmokyHill_3	20190	Max WS	1580	1209.10	1218.9		1219.01	0.000200	2.35	778.66	177.37	0.15
OldSmokyHill_3	20100	Max WS	1588	1209.16	1218.9		1218.99	0.000243	2.66	688.39	145.38	0.16
OldSmokyHill_3	20023	Max WS	1593	1209.05	1218.9		1218.97	0.000274	2.84	657.19	136.79	0.17
OldSmokyHill_3	19900	Max WS	1593	1209.06	1218.8		1218.94	0.000225	2.58	703.50	135.11	0.16
OldSmokyHill_3	19800	Max WS	1593	1208.97	1218.8		1218.92	0.000277	2.89	642.99	126.60	0.18
OldSmokyHill_3	19700	Max WS	1593	1208.92	1218.7		1218.89	0.000309	3.06	568.92	83.27	0.19
OldSmokyHill_3	19600	Max WS	1593	1208.86	1218.8		1218.86	0.000233	2.67	630.15	86.74	0.16
OldSmokyHill_3	19510	Max WS	1593	1208.72	1218.8	1212.46	1218.84	0.000178	2.36	719.38	98.56	0.14
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1593	1208.72	1218.7		1218.82	0.000158	2.20	767.38	103.13	0.13
OldSmokyHill_3	19400	Max WS	1593	1208.53	1218.7		1218.82	0.000205	2.50	690.82	103.22	0.15
OldSmokyHill_3	19300	Max WS	1621	1208.28	1218.7		1218.79	0.000251	2.70	642.11	101.38	0.17
OldSmokyHill_3	19200	Max WS	1620	1208.22	1218.6		1218.77	0.000261	2.75	623.44	86.96	0.17
OldSmokyHill_3	19100	Max WS	1620	1208.22	1218.5		1218.75	0.000528	3.93	558.82	120.66	0.24
OldSmokyHill_3	19000	Max WS	1620	1208.09	1218.4		1218.71	0.000681	4.48	488.04	92.44	0.27
OldSmokyHill_3	18900	Max WS	1619	1208.03	1218.3		1218.65	0.000930	5.17	404.43	80.22	0.31
OldSmokyHill_3	18800	Max WS	1617	1207.66	1218.2		1218.55	0.000892	5.12	370.39	69.54	0.31
OldSmokyHill_3	18700	Max WS	1623	1207.83	1218.2		1218.46	0.000647	4.42	408.48	69.89	0.26
OldSmokyHill_3	18600	Max WS	1628	1207.62	1218.0		1218.39	0.000849	4.96	388.16	79.13	0.30
OldSmokyHill_3	18500	Max WS	1627	1207.70	1217.9		1218.30	0.000883	4.99	351.66	52.63	0.30
OldSmokyHill_3	18438	Max WS	1630	1207.53	1218.1	1212.56	1218.23	0.000388	3.40	544.91	85.38	0.21
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1630	1207.50	1218.0		1218.15	0.000318	3.06	582.54	87.43	0.19
OldSmokyHill_3	18300	Max WS	1628	1207.75	1218.0		1218.12	0.000285	2.80	605.47	85.17	0.18
OldSmokyHill_3	18200	Max WS	1631	1207.43	1218.0		1218.09	0.000284	2.83	598.47	82.71	0.18
OldSmokyHill_3	18100	Max WS	1632	1207.42	1218.0		1218.06	0.000238	2.60	652.34	90.68	0.16
OldSmokyHill_3	18000	Max WS	1630	1207.16	1217.9		1218.04	0.000261	2.73	622.82	85.62	0.17
OldSmokyHill_3	17900	Max WS	1628	1207.10	1217.9		1218.01	0.000271	2.87	600.31	84.63	0.17
OldSmokyHill_3	17800	Max WS	1630	1206.51	1217.9		1217.98	0.000212	2.60	643.77	78.63	0.15
OldSmokyHill_3	17700	Max WS	1626	1206.52	1217.8		1217.96	0.000387	3.49	483.83	61.45	0.21
OldSmokyHill_3	17600	Max WS	1709	1206.23	1217.8		1217.91	0.000301	3.06	583.07	76.53	0.18
OldSmokyHill_3	17500	Max WS	1709	1206.44	1217.7		1217.88	0.000330	3.24	552.45	71.02	0.19
OldSmokyHill_3	17400	Max WS	1708	1206.06	1217.7		1217.84	0.000371	3.44	521.00	67.32	0.20
OldSmokyHill_3	17300	Max WS	1709	1205.78	1217.7		1217.81	0.000268	2.94	603.45	75.99	0.17
OldSmokyHill_3	17181	Max WS	1794	1204.48	1217.4	1212.06	1217.78	0.000900	5.07	518.77	86.25	0.28
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	1794	1204.22	1216.4		1216.78	0.000813	5.04	467.70	70.37	0.28
OldSmokyHill_3	16923	Max WS	1794	1205.00	1216.5	1210.91	1216.73	0.001394	3.70	522.41	73.43	0.22
OldSmokyHill_3	16917		Inl Struct									
OldSmokyHill_3	16800	Max WS	1794	1205.21	1216.2		1216.60	0.000895	5.03	391.08	66.09	0.31
OldSmokyHill_3	16700	Max WS	1794	1204.84	1216.2	1211.26	1216.52	0.000687	4.52	445.43	74.54	0.27
OldSmokyHill_3	16653		Inl Struct									
OldSmokyHill_3	16600	Max WS	1693	1204.44	1214.2		1214.99	0.002302	7.16	256.66	81.49	0.49
OldSmokyHill_3	16500	Max WS	1688	1202.91	1214.4		1214.47	0.000145	2.34	775.61	100.72	0.12
OldSmokyHill_3	16400	Max WS	1717	1202.78	1214.4	1205.50	1214.46	0.000048	1.39	1285.12	138.79	0.07
OldSmokyHill_3	16356		Inl Struct									
OldSmokyHill_3	16300	Max WS	1711	1202.71	1214.4		1214.43	0.000147	2.31	819.81	109.56	0.13
OldSmokyHill_3	16200	Max WS	1709	1202.61	1214.3		1214.42	0.000180	2.57	745.77	102.94	0.14

HEC-RAS Plan: 05-Alt3-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	16100	Max WS	1711	1202.56	1214.3	1206.84	1214.40	0.000145	2.34	816.13	100.05	0.13
OldSmokyHill_3	16058		Inl Struct									
OldSmokyHill_3	16000	Max WS	1706	1202.51	1214.2		1214.38	0.000240	3.10	686.19	95.82	0.17
OldSmokyHill_3	15900	Max WS	1706	1202.34	1214.2		1214.37	0.000277	3.41	723.47	85.46	0.18
OldSmokyHill_3	15800	Max WS	1724	1202.44	1214.1	1207.51	1214.34	0.000337	3.68	590.47	79.22	0.20
OldSmokyHill_3	15743		Inl Struct									
OldSmokyHill_3	15700	Max WS	1724	1200.38	1214.1		1214.28	0.000250	3.54	699.68	76.82	0.17
OldSmokyHill_3	15635	Max WS	1716	1202.00	1214.0	1207.40	1214.28	0.000578	4.47	578.28	73.02	0.23
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1715	1202.00	1214.0		1214.17	0.000404	3.72	776.26	100.66	0.19
OldSmokyHill_3	15400	Max WS	1713	1200.67	1214.0		1214.12	0.000178	3.05	830.67	84.72	0.15
OldSmokyHill_3	15300	Max WS	1717	1200.77	1214.0		1214.10	0.000198	3.21	781.48	79.06	0.16
OldSmokyHill_3	15200	Max WS	1716	1200.87	1213.9		1214.07	0.000185	3.00	800.06	118.47	0.15
OldSmokyHill_3	15100	Max WS	1718	1200.97	1213.9		1214.06	0.000188	3.01	867.91	120.38	0.15
OldSmokyHill_3	15000	Max WS	1717	1200.87	1213.9		1214.04	0.000167	2.85	908.14	123.06	0.14
OldSmokyHill_3	14900	Max WS	1714	1200.77	1213.9		1214.03	0.000191	3.15	895.02	115.20	0.16
OldSmokyHill_3	14800	Max WS	1714	1200.67	1213.9		1214.01	0.000185	3.11	905.51	115.25	0.15
OldSmokyHill_3	14700	Max WS	1721	1200.57	1213.9		1213.99	0.000176	3.04	904.96	93.69	0.15
OldSmokyHill_3	14600	Max WS	1722	1200.47	1213.8		1213.97	0.000196	3.22	772.47	82.21	0.16
OldSmokyHill_3	14507	Max WS	1738	1201.00	1213.7	1207.53	1213.99	0.000710	5.09	678.73	86.14	0.26
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	1736	1201.00	1213.3		1213.44	0.000380	3.70	758.38	91.37	0.19
OldSmokyHill_3	14300	Max WS	1736	1200.17	1213.3		1213.41	0.000196	3.17	806.77	85.20	0.16
OldSmokyHill_3	14200	Max WS	1737	1200.07	1213.3		1213.40	0.000198	3.19	772.70	80.41	0.16
OldSmokyHill_3	14100	Max WS	1736	1199.97	1213.2		1213.37	0.000184	3.09	818.63	85.89	0.15
OldSmokyHill_3	14000	Max WS	1736	1197.97	1213.2		1213.35	0.000153	2.89	881.51	88.58	0.14
OldSmokyHill_3	13900	Max WS	1736	1197.97	1213.2		1213.34	0.000145	2.74	862.21	86.89	0.13
OldSmokyHill_3	13800	Max WS	1737	1197.97	1213.2		1213.32	0.000139	2.65	840.64	87.48	0.13
OldSmokyHill_3	13700	Max WS	1737	1197.97	1213.2		1213.30	0.000115	2.42	1054.95	106.55	0.12
OldSmokyHill_3	13600	Max WS	1735	1197.97	1213.2		1213.29	0.000138	2.68	921.45	95.17	0.13
OldSmokyHill_3	13500	Max WS	1736	1197.97	1213.2		1213.28	0.000125	2.51	964.73	101.68	0.12
OldSmokyHill_3	13400	Max WS	1736	1199.47	1213.2		1213.27	0.000134	2.62	943.45	100.88	0.13
OldSmokyHill_3	13300	Max WS	1736	1199.57	1213.2		1213.25	0.000132	2.56	1000.89	97.04	0.13
OldSmokyHill_3	13200	Max WS	1735	1199.67	1213.1		1213.24	0.000129	2.52	893.94	93.31	0.13
OldSmokyHill_3	13100	Max WS	1842	1199.77	1213.1		1213.22	0.000175	2.94	835.01	84.99	0.15
OldSmokyHill_3	13000	Max WS	1854	1199.87	1213.1		1213.21	0.000194	3.12	844.68	95.59	0.16
OldSmokyHill_3	12900	Max WS	1855	1199.97	1213.1		1213.19	0.000188	3.02	879.94	93.47	0.15
OldSmokyHill_3	12800	Max WS	1853	1200.07	1213.0		1213.16	0.000169	2.86	864.54	88.34	0.15
OldSmokyHill_3	12700	Max WS	1853	1200.17	1213.0		1213.15	0.000201	3.14	840.09	86.33	0.16
OldSmokyHill_3	12600	Max WS	1853	1200.27	1213.0		1213.14	0.000240	3.45	854.87	89.77	0.17
OldSmokyHill_3	12500	Max WS	1854	1200.17	1213.0		1213.10	0.000164	2.79	886.31	93.70	0.14
OldSmokyHill_3	12400	Max WS	1859	1200.07	1213.0		1213.08	0.000156	2.73	872.07	87.82	0.14
OldSmokyHill_3	12300	Max WS	1858	1199.97	1212.9		1213.07	0.000197	3.10	783.96	85.77	0.16
OldSmokyHill_3	12200	Max WS	1859	1199.87	1212.9		1213.06	0.000221	3.34	814.03	85.40	0.17
OldSmokyHill_3	12100	Max WS	1862	1199.77	1212.9		1213.04	0.000225	3.39	802.16	82.34	0.17
OldSmokyHill_3	12000	Max WS	1866	1199.67	1212.9		1213.01	0.000212	3.30	836.40	84.51	0.16
OldSmokyHill_3	11900	Max WS	1866	1197.80	1212.8		1212.99	0.000195	3.25	847.99	88.52	0.16
OldSmokyHill_3	11800	Max WS	1867	1197.80	1212.8		1212.98	0.000243	3.61	680.58	73.74	0.17
OldSmokyHill_3	11688	Max WS	1868	1197.80	1212.8		1212.95	0.000213	3.33	700.52	74.38	0.16
OldSmokyHill_3	11600	Max WS	1870	1197.80	1212.8		1212.93	0.000203	3.30	787.08	78.30	0.16
OldSmokyHill_3	11500	Max WS	1870	1197.80	1212.8		1212.89	0.000114	2.37	918.65	90.59	0.12
OldSmokyHill_3	11400	Max WS	1871	1199.05	1212.8		1212.88	0.000108	2.35	989.89	95.99	0.12
OldSmokyHill_3	11300	Max WS	1914	1199.15	1212.8		1212.87	0.000154	2.78	881.95	88.64	0.14
OldSmokyHill_3	11200	Max WS	1913	1199.25	1212.7		1212.87	0.000202	3.24	842.55	84.28	0.16
OldSmokyHill_3	11100	Max WS	1913	1199.35	1212.7		1212.84	0.000221	3.31	651.53	62.22	0.17
OldSmokyHill_3	10956	Max WS	1924	1196.19	1212.7		1212.79	0.000070	1.79	1389.67	196.20	0.09
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	707	1195.60	1211.7		1211.67	0.000021	0.92	1095.95	155.39	0.05
OldSmokyHill_3	10500	Max WS	697	1199.95	1211.6		1211.67	0.000031	1.14	871.58	102.84	0.06
OldSmokyHill_3	10400	Max WS	702	1200.05	1211.6		1211.66	0.000026	1.03	850.47	109.02	0.06
OldSmokyHill_3	10335	Max WS	700	1199.99	1211.6	1202.61	1211.66	0.000027	1.07	823.55	94.16	0.06
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	698	1199.95	1211.6		1211.66	0.000030	1.13	776.40	88.96	0.06
OldSmokyHill_3	10200	Max WS	697	1199.86	1211.6		1211.65	0.000023	1.00	847.93	94.94	0.05
OldSmokyHill_3	10100	Max WS	697	1199.76	1211.6		1211.65	0.000024	1.02	792.27	89.25	0.05
OldSmokyHill_3	10000	Max WS	697	1199.66	1211.6		1211.65	0.000024	1.02	787.59	84.80	0.05
OldSmokyHill_3	9900	Max WS	696	1199.56	1211.6		1211.65	0.000025	1.05	778.01	86.28	0.06
OldSmokyHill_3	9800	Max WS	695	1199.46	1211.6		1211.64	0.000024	1.01	817.92	91.93	0.05
OldSmokyHill_3	9700	Max WS	694	1199.36	1211.6		1211.64	0.000024	1.02	828.59	93.92	0.05
OldSmokyHill_3	9600	Max WS	697	1199.26	1211.6		1211.64	0.000024	1.02	841.79	90.60	0.05
OldSmokyHill_3	9500	Max WS	695	1199.16	1211.6		1211.64	0.000023	1.01	812.25	87.56	0.05
OldSmokyHill_3	9400	Max WS	695	1199.06	1211.6		1211.64	0.000025	1.06	779.81	84.28	0.06
OldSmokyHill_3	9300	Max WS	692	1198.96	1211.6		1211.63	0.000024	1.04	801.64	85.50	0.05
OldSmokyHill_3	9200	Max WS	695	1198.86	1211.6		1211.63	0.000024	1.06	785.97	92.44	0.05
OldSmokyHill_3	9148	Max WS	701	1198.81	1211.6		1211.63	0.000024	1.05	775.40	82.69	0.05
OldSmokyHill_3	9100	Max WS	705	1198.76	1211.6		1211.63	0.000019	0.95	863.20	88.59	0.05
OldSmokyHill_3	9000	Max WS	705	1198.66	1211.6		1211.63	0.000026	1.11	801.99	89.47	0.06
OldSmokyHill_3	8900	Max WS	701	1198.56	1211.6		1211.63	0.000033	1.28	757.32	84.65	0.06

HEC-RAS Plan: 05-Alt3-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	8800	Max WS	699	1198.46	1211.6		1211.62	0.000029	1.21	840.95	91.99	0.06
OldSmokyHill_3	8668	Max WS	695	1198.33	1211.6	1201.49	1211.62	0.000067	1.73	706.29	90.42	0.08
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	695	1195.72	1211.6		1211.61	0.000024	1.11	838.75	93.66	0.05
OldSmokyHill_3	8500	Max WS	692	1195.72	1211.6		1211.61	0.000023	1.12	888.40	92.82	0.05
OldSmokyHill_3	8400	Max WS	694	1195.72	1211.6		1211.60	0.000024	1.13	857.83	87.38	0.05
OldSmokyHill_3	8300	Max WS	696	1195.72	1211.6		1211.60	0.000017	0.93	881.55	85.07	0.05
OldSmokyHill_3	8200	Max WS	695	1197.72	1211.6		1211.60	0.000023	1.10	883.01	93.64	0.05
OldSmokyHill_3	8100	Max WS	694	1198.72	1211.6		1211.59	0.000021	0.99	864.25	100.14	0.05
OldSmokyHill_3	8000	Max WS	693	1199.50	1211.6		1211.59	0.000020	0.95	826.87	85.45	0.05
OldSmokyHill_3	7900	Max WS	693	1199.40	1211.6		1211.59	0.000023	1.02	857.69	96.86	0.05
OldSmokyHill_3	7800	Max WS	693	1199.30	1211.6		1211.59	0.000032	1.24	842.42	94.49	0.06
OldSmokyHill_3	7700	Max WS	692	1199.20	1211.6		1211.59	0.000039	1.38	841.43	95.10	0.07
OldSmokyHill_3	7600	Max WS	693	1199.10	1211.6		1211.58	0.000022	1.00	821.01	88.66	0.05
OldSmokyHill_3	7500	Max WS	691	1199.00	1211.6		1211.58	0.000031	1.24	848.86	89.58	0.06
OldSmokyHill_3	7400	Max WS	690	1198.90	1211.6		1211.58	0.000029	1.21	964.20	99.26	0.06
OldSmokyHill_3	7300	Max WS	690	1198.80	1211.6		1211.58	0.000030	1.21	906.58	98.82	0.06
OldSmokyHill_3	7275		Lat Struct									
OldSmokyHill_3	7200	Max WS	663	1198.80	1211.6		1211.57	0.000027	1.17	926.30	103.20	0.06
OldSmokyHill_3	7100	Max WS	307	1198.60	1211.6		1211.57	0.000003	0.39	975.38	104.84	0.02
OldSmokyHill_3	7000	Max WS	312	1198.50	1211.6		1211.57	0.000005	0.48	839.51	92.69	0.02
OldSmokyHill_3	6900	Max WS	312	1195.72	1211.6		1211.57	0.000004	0.47	898.86	99.15	0.02
OldSmokyHill_3	6800	Max WS	311	1195.72	1211.6		1211.57	0.000005	0.50	898.70	88.61	0.02
OldSmokyHill_3	6700	Max WS	311	1195.72	1211.6		1211.57	0.000005	0.52	933.28	98.15	0.02
OldSmokyHill_3	6600	Max WS	311	1195.72	1211.6		1211.57	0.000004	0.46	904.85	90.91	0.02
OldSmokyHill_3	6500	Max WS	312	1198.22	1211.6		1211.57	0.000005	0.51	870.64	98.15	0.03
OldSmokyHill_3	6400	Max WS	312	1199.22	1211.6		1211.57	0.000006	0.56	868.53	92.29	0.03
OldSmokyHill_3	6300	Max WS	310	1199.32	1211.6		1211.57	0.000006	0.54	853.81	90.25	0.03
OldSmokyHill_3	6200	Max WS	310	1199.42	1211.6		1211.57	0.000007	0.58	868.21	89.21	0.03
OldSmokyHill_3	6100	Max WS	312	1199.32	1211.6		1211.57	0.000007	0.57	861.20	86.63	0.03
OldSmokyHill_3	6000	Max WS	312	1199.22	1211.6		1211.57	0.000007	0.58	846.63	92.04	0.03
OldSmokyHill_3	5900	Max WS	309	1199.12	1211.6		1211.57	0.000006	0.54	916.60	101.85	0.03
OldSmokyHill_3	5800	Max WS	312	1199.02	1211.6		1211.57	0.000007	0.60	845.94	100.94	0.03
OldSmokyHill_3	5700	Max WS	312	1198.92	1211.6		1211.57	0.000007	0.58	856.87	92.33	0.03
OldSmokyHill_3	5600	Max WS	312	1196.42	1211.6		1211.57	0.000003	0.41	1102.96	109.63	0.02
OldSmokyHill_3	5500	Max WS	311	1195.72	1211.6		1211.57	0.000004	0.48	1048.25	108.71	0.02
OldSmokyHill_3	5400	Max WS	312	1195.72	1211.6		1211.57	0.000005	0.52	951.88	95.68	0.02
OldSmokyHill_3	5300	Max WS	311	1195.72	1211.6		1211.57	0.000003	0.43	958.45	96.88	0.02
OldSmokyHill_3	5200	Max WS	312	1195.72	1211.6		1211.57	0.000002	0.37	1016.18	97.97	0.02
OldSmokyHill_3	5100	Max WS	311	1195.72	1211.6		1211.57	0.000003	0.37	1002.05	103.70	0.02
OldSmokyHill_3	5000	Max WS	312	1195.72	1211.6		1211.57	0.000003	0.37	1006.78	102.96	0.02
OldSmokyHill_3	4900	Max WS	312	1198.22	1211.6		1211.56	0.000003	0.37	1008.40	102.30	0.02
OldSmokyHill_3	4800	Max WS	311	1198.32	1211.6		1211.57	0.000004	0.45	1056.16	116.19	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	310	1198.44	1211.6		1211.57	0.000006	0.55	937.19	105.78	0.03
OldSmokyHill_3	4600	Max WS	311	1198.52	1211.6		1211.56	0.000005	0.51	1013.25	115.20	0.03
OldSmokyHill_3	4500	Max WS	314	1198.62	1211.6		1211.56	0.000003	0.37	975.17	99.62	0.02
OldSmokyHill_3	4400	Max WS	327	1198.71	1211.6		1211.56	0.000004	0.43	933.89	111.82	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	374	1198.63	1211.6	1200.40	1211.56	0.000004	0.46	1016.26	106.26	0.02
OldSmokyHill_3	4278		Bridge									
OldSmokyHill_3	4200	Max WS	374	1198.65	1211.5		1211.54	0.000005	0.46	975.37	107.42	0.02
OldSmokyHill_3	4100	Max WS	406	1198.57	1211.5		1211.54	0.000005	0.47	1060.43	124.58	0.02
OldSmokyHill_3	4000	Max WS	707	1198.39	1211.5		1211.54	0.000014	0.84	1024.01	122.87	0.04
OldSmokyHill_3	3900	Max WS	708	1198.29	1211.5		1211.54	0.000016	0.91	997.03	112.74	0.05
OldSmokyHill_3	3800	Max WS	708	1195.72	1211.5		1211.53	0.000012	0.83	1021.14	98.91	0.04
OldSmokyHill_3	3700	Max WS	707	1195.72	1211.5		1211.53	0.000014	0.84	1032.52	99.20	0.04
OldSmokyHill_3	3600	Max WS	707	1195.72	1211.5		1211.53	0.000020	1.07	1055.05	104.61	0.05
OldSmokyHill_3	3500	Max WS	708	1195.72	1211.5		1211.53	0.000018	1.01	1082.30	101.31	0.05
OldSmokyHill_3	3400	Max WS	708	1198.22	1211.5		1211.53	0.000014	0.83	990.83	100.15	0.04
OldSmokyHill_3	3300	Max WS	707	1198.32	1211.5		1211.53	0.000016	0.90	923.31	94.02	0.05
OldSmokyHill_3	3200	Max WS	707	1198.39	1211.5		1211.53	0.000019	0.98	889.94	92.72	0.05
OldSmokyHill_3	3100	Max WS	707	1198.66	1211.5		1211.52	0.000029	1.20	898.84	104.22	0.06
OldSmokyHill_3	3000	Max WS	707	1198.34	1211.5		1211.52	0.000027	1.16	907.53	93.76	0.06
OldSmokyHill_3	2900	Max WS	708	1198.41	1211.5		1211.52	0.000033	1.28	934.39	104.20	0.06
OldSmokyHill_3	2800	Max WS	707	1198.34	1211.5		1211.51	0.000038	1.40	954.87	107.19	0.07
OldSmokyHill_3	2700	Max WS	707	1198.47	1211.5		1211.51	0.000033	1.31	938.99	104.27	0.06
OldSmokyHill_3	2600	Max WS	712	1198.50	1211.5		1211.51	0.000029	1.22	966.81	107.22	0.06
OldSmokyHill_3	2500	Max WS	712	1198.53	1211.5		1211.51	0.000044	1.49	823.92	109.90	0.07
OldSmokyHill_3	2400	Max WS	712	1198.93	1211.5	1201.90	1211.50	0.000026	1.13	872.06	106.64	0.06
OldSmokyHill_3	2345		Inl Struct									
OldSmokyHill_3	2300	Max WS	712	1198.50	1211.5		1211.48	0.000023	1.10	896.09	108.24	0.05
OldSmokyHill_3	2183	Max WS	712	1196.44	1211.5		1211.48	0.000028	1.27	668.33	106.96	0.06
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	712	1196.78	1207.7		1207.87	0.000205	3.00	237.54	90.86	0.16
OldSmokyHill_3	1900	Max WS	712	1198.47	1207.8		1207.84	0.000103	1.83	527.48	88.18	0.11
OldSmokyHill_3	1800	Max WS	712	1198.28	1207.8		1207.82	0.000065	1.40	628.17	89.63	0.09
OldSmokyHill_3	1700	Max WS	712	1198.12	1207.8		1207.82	0.000060	1.43	686.03	88.52	0.08

HEC-RAS Plan: 05-Alt3-USACE-2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	1600	Max WS	712	1198.25	1207.8		1207.81	0.000100	1.85	621.14	90.15	0.11
OldSmokyHill_3	1500	Max WS	712	1197.76	1207.8		1207.80	0.000072	1.59	649.60	93.56	0.09
OldSmokyHill_3	1400	Max WS	712	1197.87	1207.8		1207.79	0.000052	1.28	632.66	87.09	0.08
OldSmokyHill_3	1300	Max WS	712	1197.69	1207.7		1207.79	0.000133	2.07	438.04	71.15	0.12
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	712	1197.53	1207.7		1207.78	0.000129	2.09	410.67	73.12	0.12
OldSmokyHill_3	1100	Max WS	712	1197.72	1207.7		1207.76	0.000146	2.20	389.05	70.67	0.13
OldSmokyHill_3	1000	Max WS	712	1197.72	1207.7		1207.75	0.000162	2.29	366.41	66.56	0.13
OldSmokyHill_3	900	Max WS	712	1197.44	1207.7		1207.73	0.000180	2.49	356.87	69.47	0.14
OldSmokyHill_3	800	Max WS	712	1197.35	1207.6		1207.72	0.000160	2.37	379.18	74.31	0.14
OldSmokyHill_3	700	Max WS	712	1197.38	1207.6		1207.70	0.000166	2.45	373.96	73.11	0.14
OldSmokyHill_3	660	Max WS	722	1195.72	1207.6	1201.26	1207.69	0.000258	2.73	262.26	65.33	0.15
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	723	1194.52	1199.5	1200.32	1203.39	0.017251	15.81	45.72	12.07	1.26
OldSmokyHill_3	300	Max WS	722	1194.21	1198.4		1199.32	0.006063	7.87	97.71	32.48	0.72
OldSmokyHill_3	200	Max WS	722	1193.97	1197.7		1198.77	0.007925	8.49	89.90	31.47	0.81
OldSmokyHill_3	100	Max WS	722	1193.79	1197.3	1196.15	1197.32	0.001252	2.17	335.68	196.56	0.29

HEC-RAS Plan: 05-Alt3-USACE-01%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	36405	Max WS	0	1212.50	1220.6		1220.58	0.000000	0.00	609.44	145.79	0.00
OldSmokyHill_3	36394.74	Max WS	176	1213.50	1220.6	1214.39	1220.61	0.000010	0.45	452.38	105.16	0.03
OldSmokyHill_3	36393		Inl Struct									
OldSmokyHill_3	36392.76	Max WS	-309	1213.50	1220.6		1220.63	0.000030	-0.80	439.19	97.42	0.06
OldSmokyHill_3	36327	Max WS	147	1213.50	1220.8		1220.85	0.000006	0.37	478.85	101.85	0.02
OldSmokyHill_3	36269	Max WS	126	1205.97	1220.9		1220.94	0.000000	0.09	1493.26	157.24	0.00
OldSmokyHill_3	36150	Max WS	90	1205.38	1221.0		1221.03	0.000000	0.05	1980.28	182.41	0.00
OldSmokyHill_3	35948	Max WS	34	1204.53	1221.1		1221.11	0.000000	0.03	1363.47	139.71	0.00
OldSmokyHill_3	35900	Max WS	25	1212.00	1221.1		1221.13	0.000001	0.13	235.42	59.81	0.01
OldSmokyHill_3	35800	Max WS	13	1212.00	1221.2		1221.22	0.000000	0.06	239.91	55.31	0.00
OldSmokyHill_3	35770	Max WS	9	1209.00	1221.2	1209.30	1221.23	0.000000	0.02	475.00	57.12	0.00
OldSmokyHill_3	35764		Inl Struct									
OldSmokyHill_3	35756	Max WS	9	1210.00	1221.2		1221.23	0.000000	0.03	354.25	51.02	0.00
OldSmokyHill_3	35680	Max WS	0	1209.80	1221.3	1209.83	1221.25	0.000000	0.00	115.70	49.76	0.00
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-136	1209.50	1222.0		1222.05	0.000039	-1.43	95.22	87.91	0.07
OldSmokyHill_3	35300	Max WS	-136	1209.50	1222.0		1222.03	0.000002	-0.25	614.41	90.66	0.01
OldSmokyHill_3	35200	Max WS	-119	1209.50	1222.0		1222.03	0.000001	-0.22	619.98	90.47	0.01
OldSmokyHill_3	35100	Max WS	-119	1209.50	1222.0		1222.03	0.000001	-0.21	637.39	90.40	0.01
OldSmokyHill_3	35000	Max WS	-96	1210.30	1222.0		1222.03	0.000001	-0.16	682.03	93.16	0.01
OldSmokyHill_3	34900	Max WS	-96	1210.40	1222.0		1222.03	0.000001	-0.16	681.05	94.99	0.01
OldSmokyHill_3	34798	Max WS	-96	1210.50	1222.0		1222.03	0.000001	-0.16	685.93	97.22	0.01
OldSmokyHill_3	34701	Max WS	-96	1210.60	1222.0		1222.03	0.000001	-0.16	661.74	94.22	0.01
OldSmokyHill_3	34604	Max WS	-96	1210.70	1222.0		1222.03	0.000001	-0.16	668.80	97.12	0.01
OldSmokyHill_3	34499	Max WS	-96	1210.80	1222.0		1222.03	0.000001	-0.16	663.96	94.82	0.01
OldSmokyHill_3	34396	Max WS	-96	1210.90	1222.0		1222.03	0.000001	-0.16	664.52	97.73	0.01
OldSmokyHill_3	34306	Max WS	-96	1210.99	1222.0		1222.03	0.000001	-0.17	661.74	97.79	0.01
OldSmokyHill_3	34186	Max WS	-96	1211.11	1222.0		1222.03	0.000001	-0.19	632.15	179.24	0.01
OldSmokyHill_3	34100	Max WS	-96	1211.02	1222.0		1222.03	0.000001	-0.19	612.12	193.41	0.01
OldSmokyHill_3	34013	Max WS	-96	1210.93	1222.0		1222.03	0.000001	-0.20	725.57	211.84	0.01
OldSmokyHill_3	33965	Max WS	-96	1210.88	1222.0		1222.03	0.000001	-0.19	772.65	184.67	0.01
OldSmokyHill_3	33914	Max WS	-96	1210.83	1222.0		1222.03	0.000001	-0.17	916.78	150.84	0.01
OldSmokyHill_3	33833	Max WS	-81	1210.75	1222.0	1211.47	1222.03	0.000001	0.15	836.40	119.13	0.01
OldSmokyHill_3	33800		Inl Struct									
OldSmokyHill_3	33766	Max WS	-81	1210.68	1222.0		1222.03	0.000001	-0.14	826.04	109.32	0.01
OldSmokyHill_3	33673	Max WS	-81	1209.50	1222.0		1222.03	0.000000	-0.12	805.09	93.53	0.01
OldSmokyHill_3	33600	Max WS	-81	1209.50	1222.0		1222.03	0.000001	-0.15	675.47	82.80	0.01
OldSmokyHill_3	33500	Max WS	-81	1209.50	1222.0		1222.03	0.000000	-0.14	719.77	86.53	0.01
OldSmokyHill_3	33400	Max WS	-79	1209.50	1222.0		1222.03	0.000001	-0.15	683.31	86.51	0.01
OldSmokyHill_3	33300	Max WS	-71	1209.50	1222.0		1222.03	0.000000	-0.13	675.59	83.06	0.01
OldSmokyHill_3	33200	Max WS	-71	1209.50	1222.0		1222.03	0.000000	-0.13	692.53	85.74	0.01
OldSmokyHill_3	33100	Max WS	-71	1210.30	1222.0		1222.03	0.000000	-0.13	622.40	76.52	0.01
OldSmokyHill_3	33000	Max WS	-71	1210.40	1222.0		1222.03	0.000000	-0.13	655.58	83.03	0.01
OldSmokyHill_3	32900	Max WS	-72	1210.50	1222.0		1222.03	0.000000	-0.13	732.71	103.88	0.01
OldSmokyHill_3	32815	Max WS	55	1210.12	1222.0		1222.03	0.000000	0.08	852.03	144.20	0.00
OldSmokyHill_3	32773	Max WS	55	1211.25	1222.0		1222.03	0.000002	0.22	310.32	86.22	0.01
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	55	1211.25	1222.0		1222.03	0.000001	0.12	492.46	114.43	0.01
OldSmokyHill_3	32500	Max WS	53	1210.95	1222.0		1222.03	0.000001	0.17	552.14	86.27	0.01
OldSmokyHill_3	32400	Max WS	69	1210.85	1222.0		1222.03	0.000000	0.12	696.55	85.66	0.01
OldSmokyHill_3	32338	Max WS	69	1210.79	1222.0		1222.03	0.000001	0.14	621.59	79.81	0.01
OldSmokyHill_3	32300	Max WS	69	1210.75	1222.0		1222.03	0.000001	0.14	631.75	81.77	0.01
OldSmokyHill_3	32200	Max WS	69	1210.65	1222.0		1222.03	0.000000	0.12	727.18	90.09	0.01
OldSmokyHill_3	32100	Max WS	70	1210.55	1222.0		1222.03	0.000000	0.12	679.48	84.39	0.01
OldSmokyHill_3	31900	Max WS	69	1210.35	1222.0		1222.03	0.000000	0.14	586.26	72.46	0.01
OldSmokyHill_3	31800	Max WS	120	1210.25	1222.0		1222.03	0.000002	0.22	610.20	75.75	0.01
OldSmokyHill_3	31700	Max WS	122	1209.50	1222.0		1222.03	0.000002	0.25	632.07	80.95	0.01
OldSmokyHill_3	31600	Max WS	140	1209.50	1222.0		1222.03	0.000002	0.27	650.85	92.20	0.01
OldSmokyHill_3	31500	Max WS	139	1209.50	1222.0		1222.03	0.000002	0.27	627.83	110.00	0.01
OldSmokyHill_3	31400	Max WS	139	1209.80	1222.0		1222.02	0.000001	0.24	760.54	121.37	0.01
OldSmokyHill_3	31300	Max WS	139	1209.90	1222.0		1222.02	0.000001	0.24	769.49	109.80	0.01
OldSmokyHill_3	31200	Max WS	139	1210.00	1222.0		1222.02	0.000001	0.25	748.39	115.56	0.01
OldSmokyHill_3	31100	Max WS	142	1210.10	1222.0		1222.02	0.000002	0.26	723.39	96.68	0.01
OldSmokyHill_3	31000	Max WS	148	1210.20	1222.0		1222.02	0.000002	0.27	716.40	115.45	0.01
OldSmokyHill_3	30900	Max WS	148	1210.30	1222.0		1222.02	0.000002	0.28	726.72	102.99	0.01
OldSmokyHill_3	30800	Max WS	147	1210.40	1222.0		1222.02	0.000002	0.28	720.53	130.47	0.02
OldSmokyHill_3	30700	Max WS	148	1210.50	1222.0		1222.02	0.000002	0.28	688.61	83.31	0.02
OldSmokyHill_3	30651	Max WS	147	1210.55	1222.0		1222.02	0.000002	0.24	721.25	95.80	0.01
OldSmokyHill_3	30575	Max WS	148	1210.63	1222.0		1222.02	0.000002	0.29	721.41	124.64	0.02
OldSmokyHill_3	30500	Max WS	148	1210.70	1222.0		1222.02	0.000002	0.29	761.43	112.69	0.02
OldSmokyHill_3	30400	Max WS	147	1210.60	1222.0		1222.02	0.000002	0.28	732.86	101.23	0.02
OldSmokyHill_3	30300	Max WS	146	1210.50	1222.0		1222.02	0.000002	0.28	722.75	91.19	0.02
OldSmokyHill_3	30200	Max WS	146	1210.40	1222.0		1222.02	0.000002	0.27	775.32	108.23	0.01
OldSmokyHill_3	30100	Max WS	147	1210.30	1222.0		1222.02	0.000002	0.26	749.57	96.33	0.01
OldSmokyHill_3	29999	Max WS	148	1210.20	1222.0		1222.02	0.000002	0.27	772.79	119.90	0.01
OldSmokyHill_3	29899	Max WS	146	1210.10	1222.0		1222.02	0.000002	0.26	766.60	114.31	0.01
OldSmokyHill_3	29800	Max WS	151	1210.00	1222.0		1222.02	0.000002	0.25	817.61	118.69	0.01
OldSmokyHill_3	29704	Max WS	153	1209.90	1222.0		1222.02	0.000002	0.25	800.59	96.61	0.01

HEC-RAS Plan: 05-Alt3-USACE-01%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	29572	Max WS	150	1209.77	1222.0		1222.02	0.000002	0.25	776.34	128.23	0.01
OldSmokyHill_3	29466	Max WS	150	1209.66	1222.0		1222.02	0.000002	0.23	880.38	143.05	0.01
OldSmokyHill_3	29385	Max WS	1187	1209.50	1221.9		1221.99	0.000102	1.82	814.63	116.71	0.10
OldSmokyHill_3	29314	Max WS	1189	1209.50	1221.9		1221.99	0.000173	2.37	700.20	153.52	0.13
OldSmokyHill_3	29209	Max WS	1188	1209.50	1221.9		1221.97	0.000164	2.25	672.93	112.77	0.12
OldSmokyHill_3	29100	Max WS	1188	1209.50	1221.9		1221.95	0.000174	2.38	706.51	151.60	0.13
OldSmokyHill_3	28991	Max WS	1187	1209.50	1221.8		1221.93	0.000185	2.45	684.87	111.18	0.13
OldSmokyHill_3	28900	Max WS	1187	1210.12	1221.8		1221.91	0.000163	2.28	690.92	93.23	0.12
OldSmokyHill_3	28800	Max WS	1186	1210.22	1221.8		1221.89	0.000167	2.29	682.45	88.35	0.12
OldSmokyHill_3	28700	Max WS	1186	1210.32	1221.8		1221.88	0.000178	2.33	682.52	110.50	0.13
OldSmokyHill_3	28594	Max WS	1186	1210.43	1221.8		1221.86	0.000117	2.09	677.38	88.43	0.12
OldSmokyHill_3	28500	Max WS	1186	1210.52	1221.8		1221.85	0.000107	1.98	729.94	90.37	0.11
OldSmokyHill_3	28430	Max WS	1214	1210.34	1221.7	1215.42	1221.84	0.000496	3.18	519.87	81.46	0.18
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1205	1210.35	1221.2		1221.35	0.000517	3.46	587.10	90.66	0.20
OldSmokyHill_3	28200	Max WS	1205	1210.36	1221.2		1221.30	0.000191	2.29	693.93	89.87	0.13
OldSmokyHill_3	28100	Max WS	1211	1210.26	1221.2		1221.28	0.000185	2.27	721.66	94.33	0.13
OldSmokyHill_3	28000	Max WS	1210	1210.16	1221.2		1221.26	0.000192	2.37	710.94	91.89	0.13
OldSmokyHill_3	27900	Max WS	1210	1210.06	1221.2		1221.24	0.000188	2.34	700.08	88.78	0.13
OldSmokyHill_3	27800	Max WS	1209	1209.96	1221.1		1221.22	0.000186	2.34	681.34	84.78	0.13
OldSmokyHill_3	27700	Max WS	1208	1209.86	1221.1		1221.20	0.000120	2.07	695.87	89.50	0.12
OldSmokyHill_3	27600	Max WS	1208	1209.76	1221.1		1221.19	0.000110	2.00	678.93	85.64	0.11
OldSmokyHill_3	27500	Max WS	1221	1209.50	1221.1		1221.17	0.000126	2.02	671.78	88.67	0.12
OldSmokyHill_3	27400	Max WS	1221	1209.50	1221.1		1221.16	0.000114	1.91	690.42	88.54	0.11
OldSmokyHill_3	27300	Max WS	1221	1209.50	1221.1		1221.15	0.000246	2.63	685.71	94.18	0.15
OldSmokyHill_3	27200	Max WS	1219	1209.50	1221.1		1221.12	0.000133	2.07	653.55	84.93	0.12
OldSmokyHill_3	27100	Max WS	1224	1209.55	1221.0		1221.11	0.000133	2.27	691.76	93.34	0.12
OldSmokyHill_3	27000	Max WS	1225	1209.65	1221.0		1221.10	0.000107	1.93	700.12	101.51	0.11
OldSmokyHill_3	26900	Max WS	1223	1209.75	1221.0		1221.09	0.000095	1.82	742.80	116.12	0.10
OldSmokyHill_3	26800	Max WS	1224	1209.85	1221.0		1221.08	0.000101	1.87	744.62	125.60	0.11
OldSmokyHill_3	26700	Max WS	1227	1209.95	1221.0		1221.07	0.000134	2.16	669.56	115.68	0.12
OldSmokyHill_3	26600	Max WS	1226	1210.05	1221.0		1221.05	0.000144	2.26	645.56	85.02	0.13
OldSmokyHill_3	26522	Max WS	1216	1210.13	1220.9	1214.63	1221.05	0.000428	3.65	405.23	66.00	0.20
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1199	1210.19	1220.8		1220.98	0.000481	3.90	397.34	69.06	0.22
OldSmokyHill_3	26400	Max WS	1214	1210.25	1220.9		1220.92	0.000113	1.92	703.25	93.03	0.11
OldSmokyHill_3	26300	Max WS	1219	1210.35	1220.8		1220.91	0.000233	2.50	683.86	92.58	0.14
OldSmokyHill_3	26200	Max WS	1210	1210.45	1220.8		1220.89	0.000244	2.57	718.48	116.69	0.15
OldSmokyHill_3	26100	Max WS	1219	1210.55	1220.8		1220.86	0.000118	1.94	683.71	91.91	0.12
OldSmokyHill_3	26000	Max WS	1214	1210.45	1220.8		1220.85	0.000244	2.57	676.07	90.33	0.15
OldSmokyHill_3	25900	Max WS	1213	1210.35	1220.8		1220.82	0.000121	1.97	693.38	91.41	0.12
OldSmokyHill_3	25800	Max WS	1212	1210.25	1220.7		1220.81	0.000131	2.06	726.56	106.35	0.12
OldSmokyHill_3	25700	Max WS	1214	1210.15	1220.7		1220.79	0.000123	2.00	671.81	87.83	0.12
OldSmokyHill_3	25600	Max WS	1214	1210.05	1220.7		1220.78	0.000105	1.85	701.95	89.00	0.11
OldSmokyHill_3	25500	Max WS	1266	1209.95	1220.7		1220.77	0.000118	1.98	731.67	97.22	0.12
OldSmokyHill_3	25400	Max WS	1265	1209.85	1220.7		1220.76	0.000217	2.49	726.36	103.74	0.14
OldSmokyHill_3	25300	Max WS	1264	1209.75	1220.6		1220.74	0.000249	2.67	667.05	135.24	0.15
OldSmokyHill_3	25200	Max WS	1265	1209.50	1220.6		1220.71	0.000167	2.11	679.15	126.65	0.12
OldSmokyHill_3	25117	Max WS	1262	1208.41	1220.6	1213.27	1220.66	0.000865	2.11	733.05	143.90	0.11
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1221	1208.97	1220.4		1220.48	0.000349	3.05	516.21	86.22	0.17
OldSmokyHill_3	24900	Max WS	1231	1209.50	1220.4		1220.45	0.000129	1.95	700.44	97.93	0.12
OldSmokyHill_3	24800	Max WS	1222	1209.50	1220.4		1220.44	0.000152	2.18	636.15	90.72	0.13
OldSmokyHill_3	24700	Max WS	1234	1209.50	1220.4		1220.42	0.000121	1.91	696.02	93.64	0.12
OldSmokyHill_3	24600	Max WS	1227	1209.50	1220.4		1220.41	0.000100	1.79	757.14	99.31	0.11
OldSmokyHill_3	24500	Max WS	1218	1209.65	1220.3		1220.40	0.000120	1.96	694.43	92.20	0.12
OldSmokyHill_3	24400	Max WS	1220	1209.75	1220.3		1220.39	0.000109	1.87	701.23	88.72	0.11
OldSmokyHill_3	24300	Max WS	1220	1209.85	1220.3		1220.38	0.000114	1.90	691.37	88.46	0.11
OldSmokyHill_3	24200	Max WS	1213	1209.95	1220.3		1220.36	0.000120	1.94	684.85	90.83	0.12
OldSmokyHill_3	24100	Max WS	1210	1210.05	1220.3		1220.35	0.000129	2.03	656.21	86.09	0.12
OldSmokyHill_3	24000	Max WS	1213	1210.15	1220.3		1220.34	0.000123	1.98	690.24	92.15	0.12
OldSmokyHill_3	23900	Max WS	1211	1210.25	1220.3		1220.32	0.000123	1.96	682.94	94.55	0.12
OldSmokyHill_3	23800	Max WS	1229	1210.35	1220.2		1220.31	0.000132	2.04	664.07	106.01	0.12
OldSmokyHill_3	23700	Max WS	1227	1210.25	1220.2		1220.29	0.000132	2.04	666.15	92.39	0.12
OldSmokyHill_3	23600	Max WS	1223	1210.15	1220.2		1220.28	0.000127	2.00	668.91	90.49	0.12
OldSmokyHill_3	23500	Max WS	1224	1210.05	1220.2		1220.27	0.000115	1.89	699.22	93.24	0.11
OldSmokyHill_3	23362	Max WS	1234	1209.91	1220.2	1213.60	1220.25	0.000115	1.90	718.64	100.23	0.11
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1222	1209.75	1220.2		1220.21	0.000107	1.85	714.34	95.13	0.11
OldSmokyHill_3	23167	Max WS	1222	1209.72	1220.2		1220.21	0.000114	1.92	712.56	100.06	0.11
OldSmokyHill_3	23100	Max WS	1226	1209.50	1220.1		1220.20	0.000119	1.94	725.14	109.03	0.12
OldSmokyHill_3	23000	Max WS	1225	1209.50	1220.1		1220.19	0.000118	1.93	729.37	110.44	0.12
OldSmokyHill_3	22900	Max WS	1228	1209.50	1220.1		1220.18	0.000162	2.42	799.87	121.35	0.14
OldSmokyHill_3	22800	Max WS	1239	1209.55	1220.1		1220.16	0.000155	2.43	790.41	116.84	0.13
OldSmokyHill_3	22731	Max WS	1237	1209.62	1220.1		1220.15	0.000175	2.58	779.67	118.64	0.14
OldSmokyHill_3	22656	Max WS	1237	1209.70	1220.1	1213.27	1220.13	0.000119	1.98	714.78	104.97	0.12
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1235	1209.70	1220.1		1220.12	0.000117	1.96	716.85	108.28	0.12

HEC-RAS Plan: 05-Alt3-USACE-01%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	22578	Max WS	1239	1209.77	1220.1		1220.11	0.000109	1.88	746.01	118.81	0.11
OldSmokyHill_3	22500	Max WS	1235	1209.85	1220.0		1220.11	0.000179	2.58	728.72	130.57	0.14
OldSmokyHill_3	22400	Max WS	1233	1209.95	1220.0		1220.08	0.000207	1.82	682.54	163.46	0.14
OldSmokyHill_3	22300	Max WS	1228	1210.05	1220.0		1220.06	0.000162	1.76	724.29	185.66	0.13
OldSmokyHill_3	22200	Max WS	1233	1210.15	1220.0		1220.04	0.000121	1.61	815.38	212.58	0.11
OldSmokyHill_3	22100	Max WS	1224	1210.25	1220.0		1220.03	0.000109	1.81	804.83	204.09	0.11
OldSmokyHill_3	22000	Max WS	1222	1210.12	1220.0		1220.02	0.000127	1.97	730.55	166.89	0.12
OldSmokyHill_3	21900	Max WS	1206	1210.12	1219.9		1220.00	0.000158	2.22	661.06	112.06	0.13
OldSmokyHill_3	21799	Max WS	1191	1210.27	1219.9		1219.98	0.000181	2.37	647.79	121.51	0.14
OldSmokyHill_3	21722	Max WS	1185	1210.10	1219.9	1213.81	1219.97	0.000201	2.51	601.16	123.02	0.15
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1172	1210.10	1219.9		1219.95	0.000198	2.48	600.96	120.99	0.15
OldSmokyHill_3	21600	Max WS	1175	1210.31	1219.9		1219.93	0.000151	2.13	682.56	129.21	0.13
OldSmokyHill_3	21500	Max WS	1189	1210.12	1219.9		1219.91	0.000109	1.83	805.60	171.18	0.11
OldSmokyHill_3	21400	Max WS	1185	1209.93	1219.9		1219.90	0.000097	1.74	900.00	220.82	0.10
OldSmokyHill_3	21295	Max WS	1181	1209.93	1219.8		1219.89	0.000092	1.68	877.09	198.33	0.10
OldSmokyHill_3	21200	Max WS	1185	1209.82	1219.8		1219.88	0.000086	1.60	908.95	196.24	0.10
OldSmokyHill_3	21100	Max WS	1177	1209.83	1219.8		1219.87	0.000079	1.56	918.07	225.03	0.09
OldSmokyHill_3	20995	Max WS	1163	1210.03	1219.8		1219.86	0.000103	1.79	884.02	190.92	0.11
OldSmokyHill_3	20900	Max WS	1152	1209.74	1219.8		1219.85	0.000116	1.91	846.64	209.71	0.11
OldSmokyHill_3	20800	Max WS	1159	1209.69	1219.8		1219.83	0.000085	1.64	941.42	235.79	0.10
OldSmokyHill_3	20700	Max WS	1151	1209.43	1219.8		1219.82	0.000091	1.71	943.42	234.38	0.10
OldSmokyHill_3	20644	Max WS	1143	1209.47	1219.8		1219.82	0.000095	1.74	910.86	224.05	0.10
OldSmokyHill_3	20600	Max WS	1151	1209.50	1219.8		1219.81	0.000082	1.59	972.08	232.38	0.10
OldSmokyHill_3	20500	Max WS	1131	1209.49	1219.8		1219.80	0.000098	1.77	828.61	230.22	0.11
OldSmokyHill_3	20434	Max WS	1122	1209.28	1219.7		1219.79	0.000108	1.86	841.60	267.03	0.11
OldSmokyHill_3	20363	Max WS	1105	1209.34	1219.7	1213.11	1219.79	0.000147	2.18	599.28	272.23	0.13
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1109	1209.41	1219.7		1219.77	0.000131	2.07	662.16	267.95	0.12
OldSmokyHill_3	20300	Max WS	1118	1209.10	1219.7		1219.76	0.000052	1.35	1049.08	249.29	0.08
OldSmokyHill_3	20190	Max WS	1866	1209.10	1219.6		1219.72	0.000201	2.49	913.23	208.46	0.15
OldSmokyHill_3	20100	Max WS	1876	1209.16	1219.6		1219.70	0.000249	2.84	798.64	176.79	0.17
OldSmokyHill_3	20023	Max WS	1882	1209.05	1219.5		1219.68	0.000281	3.04	763.08	165.41	0.18
OldSmokyHill_3	19900	Max WS	1882	1209.06	1219.5		1219.65	0.000231	2.75	800.18	142.52	0.16
OldSmokyHill_3	19800	Max WS	1881	1208.97	1219.5		1219.63	0.000283	3.08	732.28	130.71	0.18
OldSmokyHill_3	19700	Max WS	1881	1208.92	1219.4		1219.59	0.000329	3.33	627.30	93.15	0.19
OldSmokyHill_3	19600	Max WS	1881	1208.86	1219.4		1219.56	0.000250	2.91	692.18	98.83	0.17
OldSmokyHill_3	19510	Max WS	1881	1208.72	1219.4	1212.75	1219.54	0.000191	2.57	788.59	102.62	0.15
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	1881	1208.72	1219.4		1219.53	0.000169	2.39	839.38	106.13	0.14
OldSmokyHill_3	19400	Max WS	1881	1208.53	1219.4		1219.52	0.000219	2.72	764.02	110.94	0.16
OldSmokyHill_3	19300	Max WS	1912	1208.28	1219.4		1219.49	0.000266	2.93	716.07	117.37	0.17
OldSmokyHill_3	19200	Max WS	1912	1208.22	1219.3		1219.46	0.000278	2.99	691.29	120.35	0.18
OldSmokyHill_3	19100	Max WS	1912	1208.22	1219.2		1219.45	0.000542	4.19	643.29	128.19	0.25
OldSmokyHill_3	19000	Max WS	1912	1208.09	1219.1		1219.41	0.000722	4.84	552.24	102.41	0.28
OldSmokyHill_3	18900	Max WS	1911	1208.03	1218.9		1219.36	0.000983	5.59	458.84	88.35	0.32
OldSmokyHill_3	18800	Max WS	1911	1207.66	1218.8		1219.26	0.000961	5.57	416.24	74.76	0.32
OldSmokyHill_3	18700	Max WS	1917	1207.83	1218.8		1219.15	0.000705	4.83	454.91	79.42	0.28
OldSmokyHill_3	18600	Max WS	1926	1207.62	1218.6		1219.08	0.000921	5.41	442.33	96.92	0.31
OldSmokyHill_3	18500	Max WS	1924	1207.70	1218.5		1218.98	0.000971	5.48	384.21	54.77	0.32
OldSmokyHill_3	18438	Max WS	1925	1207.53	1218.7	1212.93	1218.90	0.000418	3.71	599.51	86.05	0.22
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	1925	1207.50	1218.6		1218.74	0.000352	3.36	632.32	88.17	0.20
OldSmokyHill_3	18300	Max WS	1925	1207.75	1218.6		1218.71	0.000315	3.09	654.25	86.58	0.19
OldSmokyHill_3	18200	Max WS	1929	1207.43	1218.5		1218.68	0.000315	3.13	645.81	85.36	0.19
OldSmokyHill_3	18100	Max WS	1928	1207.42	1218.5		1218.65	0.000263	2.86	704.56	93.70	0.17
OldSmokyHill_3	18000	Max WS	1927	1207.16	1218.5		1218.62	0.000291	3.01	671.31	87.77	0.18
OldSmokyHill_3	17900	Max WS	1927	1207.10	1218.4		1218.59	0.000307	3.19	648.04	87.48	0.19
OldSmokyHill_3	17800	Max WS	1928	1206.51	1218.4		1218.56	0.000241	2.89	687.77	79.99	0.17
OldSmokyHill_3	17700	Max WS	1924	1206.52	1218.3		1218.53	0.000447	3.90	516.91	63.16	0.22
OldSmokyHill_3	17600	Max WS	2010	1206.23	1218.3		1218.47	0.000341	3.38	624.57	78.25	0.20
OldSmokyHill_3	17500	Max WS	2009	1206.44	1218.2		1218.44	0.000375	3.59	590.25	72.20	0.21
OldSmokyHill_3	17400	Max WS	2009	1206.06	1218.2		1218.40	0.000425	3.82	556.27	68.60	0.22
OldSmokyHill_3	17300	Max WS	2009	1205.78	1218.2		1218.36	0.000305	3.26	643.68	77.53	0.19
OldSmokyHill_3	17181	Max WS	2102	1204.48	1217.9	1212.85	1218.33	0.001023	5.57	561.73	88.30	0.30
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2102	1204.22	1216.9		1217.34	0.000940	5.59	502.29	72.99	0.30
OldSmokyHill_3	16923	Max WS	2102	1205.00	1217.0	1211.32	1217.28	0.001578	4.08	559.98	75.83	0.24
OldSmokyHill_3	16917		Inl Struct									
OldSmokyHill_3	16800	Max WS	2102	1205.21	1216.7		1217.15	0.001012	5.55	422.87	69.54	0.33
OldSmokyHill_3	16700	Max WS	2102	1204.84	1216.7	1211.70	1217.05	0.000780	4.99	481.39	78.71	0.29
OldSmokyHill_3	16653		Inl Struct									
OldSmokyHill_3	16600	Max WS	1950	1204.44	1215.6		1216.18	0.002135	6.25	349.08	87.41	0.46
OldSmokyHill_3	16500	Max WS	1954	1202.91	1215.8		1215.89	0.000126	2.37	928.22	115.15	0.12
OldSmokyHill_3	16400	Max WS	1986	1202.78	1215.8	1205.71	1215.87	0.000042	1.41	1484.36	143.71	0.07
OldSmokyHill_3	16356		Inl Struct									
OldSmokyHill_3	16300	Max WS	1985	1202.71	1215.8		1215.85	0.000123	2.31	981.46	118.29	0.12
OldSmokyHill_3	16200	Max WS	1984	1202.61	1215.7		1215.84	0.000151	2.57	899.11	112.31	0.13

HEC-RAS Plan: 05-Alt3-USACE-01%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	16100	Max WS	1982	1202.56	1215.7	1207.14	1215.82	0.000123	2.35	960.08	102.26	0.12
OldSmokyHill_3	16058		Inl Struct									
OldSmokyHill_3	16000	Max WS	1981	1202.51	1215.7		1215.81	0.000201	3.08	825.91	99.47	0.16
OldSmokyHill_3	15900	Max WS	1980	1202.34	1215.7		1215.80	0.000238	3.43	847.71	87.99	0.17
OldSmokyHill_3	15800	Max WS	1999	1202.44	1215.6	1207.91	1215.77	0.000282	3.67	709.19	85.34	0.19
OldSmokyHill_3	15743		Inl Struct									
OldSmokyHill_3	15700	Max WS	1997	1200.38	1215.6		1215.73	0.000228	3.62	812.72	79.46	0.17
OldSmokyHill_3	15635	Max WS	1994	1202.00	1215.5	1207.95	1215.74	0.000498	4.48	687.87	77.24	0.22
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	1990	1202.00	1215.5		1215.63	0.000343	3.71	929.03	107.09	0.18
OldSmokyHill_3	15400	Max WS	1992	1200.67	1215.5		1215.59	0.000164	3.14	956.81	87.46	0.15
OldSmokyHill_3	15300	Max WS	1992	1200.77	1215.4		1215.58	0.000182	3.31	900.68	84.04	0.15
OldSmokyHill_3	15200	Max WS	1993	1200.87	1215.4		1215.54	0.000162	3.03	979.82	126.75	0.14
OldSmokyHill_3	15100	Max WS	1994	1200.97	1215.4		1215.53	0.000163	3.03	1050.18	126.64	0.14
OldSmokyHill_3	15000	Max WS	1990	1200.87	1215.4		1215.51	0.000145	2.87	1095.17	130.12	0.14
OldSmokyHill_3	14900	Max WS	1992	1200.77	1215.4		1215.51	0.000170	3.20	1068.35	119.76	0.15
OldSmokyHill_3	14800	Max WS	1991	1200.67	1215.4		1215.49	0.000164	3.15	1078.12	117.90	0.15
OldSmokyHill_3	14700	Max WS	1997	1200.57	1215.3		1215.47	0.000162	3.14	1049.20	101.73	0.15
OldSmokyHill_3	14600	Max WS	1999	1200.47	1215.3		1215.46	0.000179	3.31	896.69	85.90	0.15
OldSmokyHill_3	14507	Max WS	2015	1201.00	1215.2	1207.99	1215.48	0.000601	5.07	811.50	91.08	0.24
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	2017	1201.00	1214.8		1214.98	0.000325	3.71	902.11	96.04	0.18
OldSmokyHill_3	14300	Max WS	2016	1200.17	1214.8		1214.95	0.000176	3.24	939.94	88.98	0.15
OldSmokyHill_3	14200	Max WS	2017	1200.07	1214.8		1214.93	0.000178	3.26	899.00	84.54	0.15
OldSmokyHill_3	14100	Max WS	2016	1199.97	1214.8		1214.91	0.000166	3.16	953.78	90.75	0.15
OldSmokyHill_3	14000	Max WS	2016	1197.97	1214.8		1214.89	0.000140	2.97	1020.26	92.11	0.14
OldSmokyHill_3	13900	Max WS	2017	1197.97	1214.8		1214.88	0.000132	2.82	998.46	90.79	0.13
OldSmokyHill_3	13800	Max WS	2015	1197.97	1214.8		1214.86	0.000126	2.72	981.00	95.44	0.13
OldSmokyHill_3	13700	Max WS	2016	1197.97	1214.8		1214.85	0.000104	2.48	1221.87	112.25	0.12
OldSmokyHill_3	13600	Max WS	2015	1197.97	1214.7		1214.84	0.000125	2.74	1071.39	99.46	0.13
OldSmokyHill_3	13500	Max WS	2016	1197.97	1214.7		1214.82	0.000112	2.57	1126.85	109.83	0.12
OldSmokyHill_3	13400	Max WS	2014	1199.47	1214.7		1214.82	0.000120	2.67	1104.68	107.88	0.12
OldSmokyHill_3	13300	Max WS	2016	1199.57	1214.7		1214.80	0.000120	2.63	1154.61	102.27	0.12
OldSmokyHill_3	13200	Max WS	2015	1199.67	1214.7		1214.79	0.000115	2.57	1041.11	97.21	0.12
OldSmokyHill_3	13100	Max WS	2136	1199.77	1214.6		1214.77	0.000156	3.01	970.15	90.04	0.14
OldSmokyHill_3	13000	Max WS	2148	1199.87	1214.6		1214.76	0.000170	3.16	997.14	100.76	0.15
OldSmokyHill_3	12900	Max WS	2148	1199.97	1214.6		1214.74	0.000165	3.07	1028.78	98.30	0.15
OldSmokyHill_3	12800	Max WS	2146	1200.07	1214.6		1214.72	0.000149	2.91	1005.06	92.39	0.14
OldSmokyHill_3	12700	Max WS	2145	1200.17	1214.6		1214.71	0.000177	3.18	976.77	89.20	0.15
OldSmokyHill_3	12600	Max WS	2144	1200.27	1214.5		1214.70	0.000211	3.51	1003.93	99.88	0.17
OldSmokyHill_3	12500	Max WS	2145	1200.17	1214.6		1214.67	0.000143	2.82	1035.85	97.95	0.14
OldSmokyHill_3	12400	Max WS	2153	1200.07	1214.5		1214.65	0.000137	2.77	1011.94	91.11	0.13
OldSmokyHill_3	12300	Max WS	2153	1199.97	1214.5		1214.64	0.000172	3.14	922.30	90.54	0.15
OldSmokyHill_3	12200	Max WS	2150	1199.87	1214.5		1214.63	0.000194	3.39	951.51	89.64	0.16
OldSmokyHill_3	12100	Max WS	2154	1199.77	1214.5		1214.62	0.000199	3.45	934.39	85.80	0.16
OldSmokyHill_3	12000	Max WS	2158	1199.67	1214.4		1214.59	0.000188	3.36	973.44	89.42	0.16
OldSmokyHill_3	11900	Max WS	2156	1197.80	1214.4		1214.57	0.000174	3.31	990.47	91.99	0.15
OldSmokyHill_3	11800	Max WS	2159	1197.80	1214.4		1214.56	0.000218	3.68	800.51	77.89	0.17
OldSmokyHill_3	11688	Max WS	2158	1197.80	1214.4		1214.53	0.000189	3.39	822.20	79.58	0.16
OldSmokyHill_3	11600	Max WS	2161	1197.80	1214.4		1214.52	0.000183	3.37	914.39	82.72	0.15
OldSmokyHill_3	11500	Max WS	2159	1197.80	1214.4		1214.48	0.000101	2.41	1065.97	94.65	0.11
OldSmokyHill_3	11400	Max WS	2164	1199.05	1214.4		1214.47	0.000096	2.40	1147.12	101.75	0.11
OldSmokyHill_3	11300	Max WS	2216	1199.15	1214.4		1214.47	0.000136	2.84	1025.88	92.67	0.13
OldSmokyHill_3	11200	Max WS	2216	1199.25	1214.3		1214.46	0.000180	3.31	980.02	88.75	0.15
OldSmokyHill_3	11100	Max WS	2211	1199.35	1214.3		1214.44	0.000195	3.37	760.56	82.27	0.16
OldSmokyHill_3	10956	Max WS	2229	1196.19	1214.3		1214.39	0.000062	1.82	1596.45	200.65	0.08
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	782	1195.60	1213.8		1213.76	0.000014	0.84	1337.45	165.08	0.04
OldSmokyHill_3	10500	Max WS	778	1199.95	1213.7		1213.76	0.000021	1.05	1095.51	111.05	0.05
OldSmokyHill_3	10400	Max WS	782	1200.05	1213.7		1213.76	0.000017	0.94	1084.49	114.39	0.05
OldSmokyHill_3	10335	Max WS	781	1199.99	1213.7	1202.74	1213.76	0.000018	0.99	1027.32	100.43	0.05
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	773	1199.95	1213.7		1213.75	0.000020	1.03	969.76	95.41	0.05
OldSmokyHill_3	10200	Max WS	776	1199.86	1213.7		1213.75	0.000016	0.92	1053.85	101.31	0.05
OldSmokyHill_3	10100	Max WS	776	1199.76	1213.7		1213.75	0.000016	0.94	985.20	94.75	0.05
OldSmokyHill_3	10000	Max WS	776	1199.66	1213.7		1213.75	0.000016	0.95	972.36	91.71	0.05
OldSmokyHill_3	9900	Max WS	774	1199.56	1213.7		1213.74	0.000017	0.97	969.25	96.14	0.05
OldSmokyHill_3	9800	Max WS	777	1199.46	1213.7		1213.74	0.000016	0.94	1017.27	97.48	0.05
OldSmokyHill_3	9700	Max WS	771	1199.36	1213.7		1213.74	0.000016	0.94	1034.62	101.88	0.05
OldSmokyHill_3	9600	Max WS	773	1199.26	1213.7		1213.74	0.000016	0.95	1038.80	97.63	0.05
OldSmokyHill_3	9500	Max WS	770	1199.16	1213.7		1213.74	0.000016	0.93	1002.29	93.12	0.04
OldSmokyHill_3	9400	Max WS	775	1199.06	1213.7		1213.74	0.000017	0.99	964.38	91.37	0.05
OldSmokyHill_3	9300	Max WS	773	1198.96	1213.7		1213.74	0.000017	0.97	988.00	92.00	0.05
OldSmokyHill_3	9200	Max WS	774	1198.86	1213.7		1213.73	0.000017	0.98	989.37	99.87	0.05
OldSmokyHill_3	9148	Max WS	778	1198.81	1213.7		1213.73	0.000017	0.97	958.59	92.02	0.05
OldSmokyHill_3	9100	Max WS	786	1198.76	1213.7		1213.73	0.000013	0.89	1057.12	95.22	0.04
OldSmokyHill_3	9000	Max WS	785	1198.66	1213.7		1213.73	0.000018	1.04	999.69	99.30	0.05
OldSmokyHill_3	8900	Max WS	780	1198.56	1213.7		1213.73	0.000023	1.20	944.04	92.59	0.06

HEC-RAS Plan: 05-Alt3-USACE-01%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	8800	Max WS	784	1198.46	1213.7		1213.73	0.000021	1.14	1044.00	100.46	0.05
OldSmokyHill_3	8668	Max WS	772	1198.33	1213.7	1201.71	1213.73	0.000046	1.58	910.27	102.63	0.07
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	779	1195.72	1213.7		1213.72	0.000017	1.05	1044.66	100.57	0.05
OldSmokyHill_3	8500	Max WS	780	1195.72	1213.7		1213.72	0.000018	1.08	1099.19	124.97	0.05
OldSmokyHill_3	8400	Max WS	774	1195.72	1213.7		1213.71	0.000018	1.08	1049.03	93.95	0.05
OldSmokyHill_3	8300	Max WS	777	1195.72	1213.7		1213.71	0.000012	0.89	1075.69	99.76	0.04
OldSmokyHill_3	8200	Max WS	774	1197.72	1213.7		1213.71	0.000016	1.03	1088.31	100.81	0.05
OldSmokyHill_3	8100	Max WS	772	1198.72	1213.7		1213.71	0.000015	0.91	1083.31	108.27	0.04
OldSmokyHill_3	8000	Max WS	774	1199.50	1213.7		1213.71	0.000014	0.89	1015.00	95.83	0.04
OldSmokyHill_3	7900	Max WS	773	1199.40	1213.7		1213.70	0.000016	0.95	1080.02	115.36	0.05
OldSmokyHill_3	7800	Max WS	769	1199.30	1213.7		1213.71	0.000022	1.15	1057.29	110.62	0.05
OldSmokyHill_3	7700	Max WS	771	1199.20	1213.7		1213.70	0.000027	1.27	1052.29	103.85	0.06
OldSmokyHill_3	7600	Max WS	771	1199.10	1213.7		1213.70	0.000015	0.93	1014.90	94.37	0.04
OldSmokyHill_3	7500	Max WS	769	1199.00	1213.7		1213.70	0.000022	1.15	1045.79	96.22	0.05
OldSmokyHill_3	7400	Max WS	769	1198.90	1213.7		1213.70	0.000021	1.13	1183.45	107.42	0.05
OldSmokyHill_3	7300	Max WS	769	1198.80	1213.7		1213.69	0.000021	1.13	1125.67	107.85	0.05
OldSmokyHill_3	7275		Lat Struct									
OldSmokyHill_3	7200	Max WS	730	1198.80	1213.7		1213.69	0.000019	1.08	1161.83	118.89	0.05
OldSmokyHill_3	7100	Max WS	355	1198.60	1213.7		1213.69	0.000002	0.38	1204.55	114.40	0.02
OldSmokyHill_3	7000	Max WS	358	1198.50	1213.7		1213.69	0.000004	0.46	1052.66	106.17	0.02
OldSmokyHill_3	6900	Max WS	358	1195.72	1213.7		1213.69	0.000003	0.46	1122.67	113.83	0.02
OldSmokyHill_3	6800	Max WS	359	1195.72	1213.7		1213.69	0.000004	0.50	1095.78	100.58	0.02
OldSmokyHill_3	6700	Max WS	358	1195.72	1213.7		1213.69	0.000004	0.51	1149.95	106.38	0.02
OldSmokyHill_3	6600	Max WS	356	1195.72	1213.7		1213.69	0.000003	0.45	1108.19	100.59	0.02
OldSmokyHill_3	6500	Max WS	357	1198.22	1213.7		1213.69	0.000004	0.49	1094.04	110.39	0.02
OldSmokyHill_3	6400	Max WS	357	1199.22	1213.7		1213.69	0.000005	0.54	1079.46	110.07	0.03
OldSmokyHill_3	6300	Max WS	357	1199.32	1213.7		1213.69	0.000005	0.53	1053.36	98.88	0.02
OldSmokyHill_3	6200	Max WS	358	1199.42	1213.7		1213.69	0.000005	0.56	1065.36	97.09	0.03
OldSmokyHill_3	6100	Max WS	357	1199.32	1213.7		1213.69	0.000005	0.55	1051.46	93.84	0.03
OldSmokyHill_3	6000	Max WS	358	1199.22	1213.7		1213.69	0.000005	0.56	1052.35	101.60	0.03
OldSmokyHill_3	5900	Max WS	357	1199.12	1213.7		1213.69	0.000004	0.52	1141.70	110.71	0.02
OldSmokyHill_3	5800	Max WS	358	1199.02	1213.7		1213.69	0.000005	0.57	1068.74	108.85	0.03
OldSmokyHill_3	5700	Max WS	357	1198.92	1213.7		1213.69	0.000005	0.56	1064.84	104.76	0.03
OldSmokyHill_3	5600	Max WS	357	1196.42	1213.7		1213.69	0.000002	0.40	1353.99	126.74	0.02
OldSmokyHill_3	5500	Max WS	355	1195.72	1213.7		1213.69	0.000003	0.47	1292.58	120.93	0.02
OldSmokyHill_3	5400	Max WS	357	1195.72	1213.7		1213.69	0.000004	0.51	1168.35	110.08	0.02
OldSmokyHill_3	5300	Max WS	357	1195.72	1213.7		1213.69	0.000003	0.43	1178.32	110.50	0.02
OldSmokyHill_3	5200	Max WS	357	1195.72	1213.7		1213.69	0.000002	0.36	1238.11	114.58	0.02
OldSmokyHill_3	5100	Max WS	356	1195.72	1213.7		1213.69	0.000002	0.36	1232.32	118.17	0.02
OldSmokyHill_3	5000	Max WS	356	1195.72	1213.7		1213.69	0.000002	0.36	1231.30	109.02	0.02
OldSmokyHill_3	4900	Max WS	357	1198.22	1213.7		1213.69	0.000002	0.36	1241.00	118.89	0.02
OldSmokyHill_3	4800	Max WS	357	1198.32	1213.7		1213.69	0.000003	0.43	1315.28	128.92	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	357	1198.44	1213.7		1213.69	0.000004	0.53	1191.40	126.15	0.02
OldSmokyHill_3	4600	Max WS	353	1198.52	1213.7		1213.69	0.000004	0.48	1263.72	121.47	0.02
OldSmokyHill_3	4500	Max WS	341	1198.62	1213.7		1213.69	0.000002	0.34	1218.74	118.16	0.02
OldSmokyHill_3	4400	Max WS	319	1198.71	1213.7		1213.69	0.000002	0.34	1176.17	116.73	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	283	1198.63	1213.7	1200.21	1213.69	0.000001	0.29	1246.30	110.38	0.01
OldSmokyHill_3	4278		Bridge									
OldSmokyHill_3	4200	Max WS	283	1198.65	1213.7		1213.68	0.000001	0.29	1215.29	118.29	0.01
OldSmokyHill_3	4100	Max WS	376	1198.57	1213.7		1213.68	0.000002	0.36	1352.84	143.45	0.02
OldSmokyHill_3	4000	Max WS	702	1198.39	1213.7		1213.68	0.000008	0.69	1311.34	147.07	0.03
OldSmokyHill_3	3900	Max WS	787	1198.29	1213.7		1213.67	0.000011	0.84	1250.28	128.06	0.04
OldSmokyHill_3	3800	Max WS	788	1195.72	1213.7		1213.67	0.000009	0.79	1243.98	111.07	0.04
OldSmokyHill_3	3700	Max WS	786	1195.72	1213.7		1213.67	0.000010	0.81	1274.30	164.04	0.04
OldSmokyHill_3	3600	Max WS	784	1195.72	1213.7		1213.67	0.000015	1.02	1301.96	150.02	0.04
OldSmokyHill_3	3500	Max WS	783	1195.72	1213.7		1213.67	0.000014	0.96	1319.25	146.97	0.04
OldSmokyHill_3	3400	Max WS	781	1198.22	1213.7		1213.67	0.000010	0.77	1232.10	151.20	0.04
OldSmokyHill_3	3300	Max WS	781	1198.32	1213.7		1213.67	0.000011	0.84	1149.92	162.29	0.04
OldSmokyHill_3	3200	Max WS	782	1198.39	1213.7		1213.67	0.000014	0.91	1147.60	179.68	0.04
OldSmokyHill_3	3100	Max WS	785	1198.66	1213.6		1213.67	0.000021	1.15	1209.87	181.33	0.05
OldSmokyHill_3	3000	Max WS	787	1198.34	1213.6		1213.67	0.000020	1.11	1139.47	137.65	0.05
OldSmokyHill_3	2900	Max WS	787	1198.41	1213.6		1213.66	0.000023	1.20	1167.79	114.29	0.06
OldSmokyHill_3	2800	Max WS	787	1198.34	1213.6		1213.66	0.000026	1.29	1194.69	115.55	0.06
OldSmokyHill_3	2700	Max WS	787	1198.47	1213.6		1213.65	0.000023	1.21	1171.01	111.55	0.06
OldSmokyHill_3	2600	Max WS	792	1198.50	1213.6		1213.65	0.000020	1.13	1204.28	113.99	0.05
OldSmokyHill_3	2500	Max WS	792	1198.53	1213.6		1213.65	0.000027	1.30	1075.80	124.27	0.06
OldSmokyHill_3	2400	Max WS	792	1198.93	1213.6	1202.06	1213.65	0.000016	1.00	1115.15	118.84	0.05
OldSmokyHill_3	2345		Inl Struct									
OldSmokyHill_3	2300	Max WS	792	1198.50	1213.6		1213.63	0.000015	0.98	1140.50	118.81	0.04
OldSmokyHill_3	2183	Max WS	792	1196.44	1213.6		1213.63	0.000020	1.19	786.11	119.53	0.05
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	792	1196.78	1209.0		1209.16	0.000175	2.98	265.47	97.19	0.15
OldSmokyHill_3	1900	Max WS	792	1198.47	1209.1		1209.12	0.000074	1.69	646.29	95.53	0.09
OldSmokyHill_3	1800	Max WS	792	1198.28	1209.1		1209.11	0.000048	1.33	745.90	92.80	0.08
OldSmokyHill_3	1700	Max WS	792	1198.12	1209.1		1209.11	0.000046	1.38	802.64	92.06	0.07

HEC-RAS Plan: 05-Alt3-USACE-01%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	1600	Max WS	792	1198.25	1209.1		1209.11	0.000077	1.77	742.82	97.41	0.10
OldSmokyHill_3	1500	Max WS	792	1197.76	1209.1		1209.10	0.000055	1.51	774.42	98.54	0.08
OldSmokyHill_3	1400	Max WS	792	1197.87	1209.1		1209.09	0.000039	1.23	748.86	92.25	0.07
OldSmokyHill_3	1300	Max WS	792	1197.69	1209.0		1209.08	0.000099	1.96	533.63	110.46	0.11
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	792	1197.53	1209.0		1209.08	0.000087	1.87	510.44	79.43	0.10
OldSmokyHill_3	1100	Max WS	792	1197.72	1209.0		1209.07	0.000098	1.98	487.12	78.01	0.11
OldSmokyHill_3	1000	Max WS	792	1197.72	1209.0		1209.06	0.000111	2.07	461.77	77.56	0.11
OldSmokyHill_3	900	Max WS	792	1197.44	1209.0		1209.05	0.000118	2.21	457.58	80.30	0.12
OldSmokyHill_3	800	Max WS	792	1197.35	1209.0		1209.03	0.000103	2.07	483.62	81.30	0.11
OldSmokyHill_3	700	Max WS	792	1197.38	1209.0		1209.02	0.000108	2.15	480.17	84.38	0.11
OldSmokyHill_3	660	Max WS	802	1195.72	1208.9	1201.51	1209.02	0.000199	2.61	301.60	80.37	0.13
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	805	1194.52	1201.5		1203.92	0.006897	12.54	64.47	13.68	0.85
OldSmokyHill_3	300	Max WS	69	1194.21	1201.2		1201.17	0.000007	0.39	200.45	41.23	0.03
OldSmokyHill_3	200	Max WS	82	1193.97	1201.1		1201.12	0.000008	0.43	209.10	37.90	0.03
OldSmokyHill_3	100	Max WS	81	1193.79	1201.1	1194.64	1201.10	0.000000	0.07	1167.49	221.83	0.01

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	36405	Max WS	0	1212.50	1215.5		1215.50	0.000000	0.00	119.62	49.72	0.00
OldSmokyHill_3	36394.74	Max WS	6	1213.50	1215.5	1213.60	1215.50	0.000001	0.07	83.74	48.75	0.01
OldSmokyHill_3	36393		Inl Struct									
OldSmokyHill_3	36392.76	Max WS	-296	1213.50	1216.5		1216.59	0.000821	-2.16	137.03	56.72	0.25
OldSmokyHill_3	36327	Max WS	-296	1213.50	1216.6		1216.64	0.000756	-2.14	138.41	54.23	0.24
OldSmokyHill_3	36269	Max WS	-296	1205.97	1216.6		1216.63	0.000004	-0.33	894.20	123.86	0.02
OldSmokyHill_3	36150	Max WS	-296	1205.38	1216.6		1216.63	0.000002	-0.24	1234.43	156.87	0.02
OldSmokyHill_3	35948	Max WS	-296	1204.53	1216.6		1216.63	0.000006	-0.37	805.79	113.65	0.02
OldSmokyHill_3	35900	Max WS	-296	1212.00	1216.6		1216.84	0.001855	-3.91	75.95	19.27	0.33
OldSmokyHill_3	35800	Max WS	-296	1212.00	1216.8		1216.99	0.001265	-3.40	87.71	22.08	0.28
OldSmokyHill_3	35770	Max WS	-296	1209.00	1216.9	1210.96	1216.97	0.000067	1.08	273.98	42.75	0.08
OldSmokyHill_3	35764		Inl Struct									
OldSmokyHill_3	35756	Max WS	-296	1210.00	1217.0		1217.00	0.000171	-1.63	181.87	30.75	0.11
OldSmokyHill_3	35680	Max WS	-296	1209.80	1217.3	1214.93	1218.11	0.013442	7.70	47.04	22.13	0.50
OldSmokyHill_3	35568		Inl Struct									
OldSmokyHill_3	35457	Max WS	-296	1209.50	1223.5		1223.58	0.000128	-2.79	106.24	93.80	0.13
OldSmokyHill_3	35300	Max WS	-296	1209.50	1223.5		1223.53	0.000004	-0.45	755.41	98.29	0.02
OldSmokyHill_3	35200	Max WS	-279	1209.50	1223.5		1223.53	0.000004	-0.42	760.02	97.54	0.02
OldSmokyHill_3	35100	Max WS	-279	1209.50	1223.5		1223.53	0.000004	-0.41	779.20	98.99	0.02
OldSmokyHill_3	35000	Max WS	-248	1210.30	1223.5		1223.53	0.000002	-0.34	826.52	100.39	0.02
OldSmokyHill_3	34900	Max WS	-248	1210.40	1223.5		1223.53	0.000002	-0.34	828.25	102.54	0.02
OldSmokyHill_3	34798	Max WS	-248	1210.50	1223.5		1223.53	0.000002	-0.34	837.16	105.01	0.02
OldSmokyHill_3	34701	Max WS	-248	1210.60	1223.5		1223.53	0.000003	-0.35	807.70	101.56	0.02
OldSmokyHill_3	34604	Max WS	-248	1210.70	1223.5		1223.53	0.000003	-0.35	820.55	105.68	0.02
OldSmokyHill_3	34499	Max WS	-248	1210.80	1223.5		1223.53	0.000003	-0.35	811.34	102.53	0.02
OldSmokyHill_3	34396	Max WS	-249	1210.90	1223.5		1223.53	0.000003	-0.35	816.29	105.19	0.02
OldSmokyHill_3	34306	Max WS	-249	1210.99	1223.5		1223.53	0.000003	-0.35	813.40	105.37	0.02
OldSmokyHill_3	34186	Max WS	-249	1211.11	1223.5		1223.53	0.000004	-0.41	775.10	206.03	0.02
OldSmokyHill_3	34100	Max WS	-249	1211.02	1223.5		1223.53	0.000004	-0.42	752.30	232.67	0.02
OldSmokyHill_3	34013	Max WS	-249	1210.93	1223.5		1223.53	0.000004	-0.42	1056.38	277.59	0.02
OldSmokyHill_3	33965	Max WS	-250	1210.88	1223.5		1223.53	0.000004	-0.41	1059.68	251.53	0.02
OldSmokyHill_3	33914	Max WS	-249	1210.83	1223.5		1223.53	0.000003	-0.37	1132.24	199.54	0.02
OldSmokyHill_3	33833	Max WS	-233	1210.75	1223.5	1212.17	1223.53	0.000003	0.36	1019.54	167.28	0.02
OldSmokyHill_3	33800		Inl Struct									
OldSmokyHill_3	33766	Max WS	-233	1210.68	1223.5		1223.53	0.000003	-0.36	993.61	153.04	0.02
OldSmokyHill_3	33673	Max WS	-234	1209.50	1223.5		1223.53	0.000002	-0.30	949.53	100.78	0.01
OldSmokyHill_3	33600	Max WS	-233	1209.50	1223.5		1223.53	0.000003	-0.37	802.95	87.96	0.02
OldSmokyHill_3	33500	Max WS	-234	1209.50	1223.5		1223.53	0.000002	-0.35	854.46	94.98	0.02
OldSmokyHill_3	33400	Max WS	-231	1209.50	1223.5		1223.53	0.000003	-0.37	818.67	94.94	0.02
OldSmokyHill_3	33300	Max WS	-218	1209.50	1223.5		1223.53	0.000003	-0.35	804.37	90.12	0.02
OldSmokyHill_3	33200	Max WS	-219	1209.50	1223.5		1223.53	0.000003	-0.35	825.71	94.24	0.02
OldSmokyHill_3	33100	Max WS	-217	1210.30	1223.5		1223.53	0.000003	-0.36	742.25	84.17	0.02
OldSmokyHill_3	33000	Max WS	-219	1210.40	1223.5		1223.53	0.000003	-0.36	785.97	92.91	0.02
OldSmokyHill_3	32900	Max WS	-219	1210.50	1223.5		1223.53	0.000003	-0.36	910.53	150.09	0.02
OldSmokyHill_3	32815	Max WS	-84	1210.12	1223.5		1223.53	0.000000	-0.11	1089.94	174.54	0.01
OldSmokyHill_3	32773	Max WS	-84	1211.25	1223.5		1223.53	0.000002	-0.28	395.73	109.81	0.02
OldSmokyHill_3	32706		Culvert									
OldSmokyHill_3	32610	Max WS	-87	1211.25	1223.5		1223.54	0.000001	-0.16	594.86	124.13	0.01
OldSmokyHill_3	32500	Max WS	-87	1210.95	1223.5		1223.54	0.000002	-0.23	701.08	132.57	0.01
OldSmokyHill_3	32400	Max WS	-59	1210.85	1223.5		1223.54	0.000000	-0.09	832.05	107.18	0.00
OldSmokyHill_3	32338	Max WS	-59	1210.79	1223.5		1223.54	0.000000	-0.11	748.59	95.83	0.01
OldSmokyHill_3	32300	Max WS	-58	1210.75	1223.5		1223.54	0.000000	-0.10	760.72	90.70	0.01
OldSmokyHill_3	32200	Max WS	-58	1210.65	1223.5		1223.54	0.000000	-0.09	867.39	115.40	0.00
OldSmokyHill_3	32100	Max WS	-59	1210.55	1223.5		1223.54	0.000000	-0.09	813.50	93.06	0.00
OldSmokyHill_3	31900	Max WS	-59	1210.35	1223.5		1223.54	0.000000	-0.10	712.36	143.67	0.01
OldSmokyHill_3	31800	Max WS	-4	1210.25	1223.5		1223.54	0.000000	-0.01	757.87	186.56	0.00
OldSmokyHill_3	31700	Max WS	0	1209.50	1223.5		1223.54	0.000000	0.00	785.02	158.55	0.00
OldSmokyHill_3	31600	Max WS	24	1209.50	1223.5		1223.54	0.000000	0.04	845.47	169.06	0.00
OldSmokyHill_3	31500	Max WS	23	1209.50	1223.5		1223.54	0.000000	0.04	845.91	198.75	0.00
OldSmokyHill_3	31400	Max WS	23	1209.80	1223.5		1223.54	0.000000	0.03	998.91	221.88	0.00
OldSmokyHill_3	31300	Max WS	22	1209.90	1223.5		1223.54	0.000000	0.03	987.85	200.78	0.00
OldSmokyHill_3	31200	Max WS	22	1210.00	1223.5		1223.54	0.000000	0.03	931.99	189.86	0.00
OldSmokyHill_3	31100	Max WS	27	1210.10	1223.5		1223.54	0.000000	0.04	946.30	199.88	0.00
OldSmokyHill_3	31000	Max WS	37	1210.20	1223.5		1223.54	0.000000	0.06	958.85	188.02	0.00
OldSmokyHill_3	30900	Max WS	36	1210.30	1223.5		1223.54	0.000000	0.06	923.00	188.37	0.00
OldSmokyHill_3	30800	Max WS	35	1210.40	1223.5		1223.54	0.000000	0.06	960.16	190.43	0.00
OldSmokyHill_3	30700	Max WS	34	1210.50	1223.5		1223.54	0.000000	0.06	875.18	174.52	0.00
OldSmokyHill_3	30651	Max WS	34	1210.55	1223.5		1223.54	0.000000	0.05	954.56	175.55	0.00
OldSmokyHill_3	30575	Max WS	34	1210.63	1223.5		1223.54	0.000000	0.06	947.11	184.58	0.00
OldSmokyHill_3	30500	Max WS	34	1210.70	1223.5		1223.54	0.000000	0.06	996.81	179.92	0.00
OldSmokyHill_3	30400	Max WS	33	1210.60	1223.5		1223.54	0.000000	0.06	939.33	160.90	0.00
OldSmokyHill_3	30300	Max WS	31	1210.50	1223.5		1223.54	0.000000	0.05	921.75	158.50	0.00
OldSmokyHill_3	30200	Max WS	31	1210.40	1223.5		1223.54	0.000000	0.05	1003.25	171.61	0.00
OldSmokyHill_3	30100	Max WS	30	1210.30	1223.5		1223.54	0.000000	0.05	943.68	152.66	0.00
OldSmokyHill_3	29999	Max WS	30	1210.20	1223.5		1223.54	0.000000	0.05	967.60	133.91	0.00
OldSmokyHill_3	29899	Max WS	30	1210.10	1223.5		1223.54	0.000000	0.05	1011.03	196.76	0.00
OldSmokyHill_3	29800	Max WS	37	1210.00	1223.5		1223.54	0.000000	0.05	1044.31	373.48	0.00
OldSmokyHill_3	29704	Max WS	34	1209.90	1223.5		1223.54	0.000000	0.05	1118.05	426.06	0.00

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	29572	Max WS	35	1209.77	1223.5		1223.53	0.000000	0.05	1073.64	410.99	0.00
OldSmokyHill_3	29466	Max WS	33	1209.66	1223.5		1223.53	0.000000	0.04	1208.93	451.98	0.00
OldSmokyHill_3	29385	Max WS	1563	1209.50	1223.5		1223.51	0.000112	2.08	1178.90	421.81	0.10
OldSmokyHill_3	29314	Max WS	1564	1209.50	1223.4		1223.52	0.000192	2.72	1061.75	389.27	0.14
OldSmokyHill_3	29209	Max WS	1563	1209.50	1223.4		1223.50	0.000176	2.55	985.11	335.67	0.13
OldSmokyHill_3	29100	Max WS	1563	1209.50	1223.4		1223.48	0.000191	2.71	1066.06	315.18	0.14
OldSmokyHill_3	28991	Max WS	1563	1209.50	1223.4		1223.46	0.000202	2.78	921.38	220.64	0.14
OldSmokyHill_3	28900	Max WS	1563	1210.12	1223.3		1223.44	0.000179	2.60	923.94	190.39	0.13
OldSmokyHill_3	28800	Max WS	1562	1210.22	1223.3		1223.42	0.000189	2.66	890.03	170.97	0.13
OldSmokyHill_3	28700	Max WS	1562	1210.32	1223.3		1223.40	0.000188	2.62	868.91	158.03	0.13
OldSmokyHill_3	28594	Max WS	1562	1210.43	1223.3		1223.38	0.000124	2.37	815.00	94.31	0.12
OldSmokyHill_3	28500	Max WS	1562	1210.52	1223.3		1223.37	0.000117	2.27	874.67	129.28	0.12
OldSmokyHill_3	28430	Max WS	1597	1210.34	1223.2	1216.37	1223.35	0.000531	3.49	655.47	123.23	0.19
OldSmokyHill_3	28352		Bridge									
OldSmokyHill_3	28275	Max WS	1593	1210.35	1222.7		1222.85	0.000532	3.88	732.05	120.17	0.21
OldSmokyHill_3	28200	Max WS	1592	1210.36	1222.7		1222.79	0.000204	2.60	848.22	142.46	0.14
OldSmokyHill_3	28100	Max WS	1601	1210.26	1222.7		1222.77	0.000200	2.59	888.09	122.34	0.14
OldSmokyHill_3	28000	Max WS	1600	1210.16	1222.7		1222.75	0.000214	2.74	851.11	109.18	0.14
OldSmokyHill_3	27900	Max WS	1601	1210.06	1222.6		1222.73	0.000208	2.70	837.15	104.02	0.14
OldSmokyHill_3	27800	Max WS	1600	1209.96	1222.6		1222.71	0.000205	2.68	817.86	106.57	0.14
OldSmokyHill_3	27700	Max WS	1601	1209.86	1222.6		1222.69	0.000130	2.37	841.56	139.43	0.13
OldSmokyHill_3	27600	Max WS	1600	1209.76	1222.6		1222.67	0.000119	2.29	816.70	134.05	0.12
OldSmokyHill_3	27500	Max WS	1616	1209.50	1222.6		1222.66	0.000132	2.29	810.33	140.53	0.12
OldSmokyHill_3	27400	Max WS	1616	1209.50	1222.6		1222.64	0.000119	2.16	842.99	142.44	0.12
OldSmokyHill_3	27300	Max WS	1616	1209.50	1222.5		1222.64	0.000263	2.98	829.17	137.63	0.16
OldSmokyHill_3	27200	Max WS	1615	1209.50	1222.5		1222.60	0.000140	2.35	794.53	138.62	0.13
OldSmokyHill_3	27100	Max WS	1623	1209.55	1222.5		1222.60	0.000145	2.59	830.73	147.37	0.13
OldSmokyHill_3	27000	Max WS	1623	1209.65	1222.5		1222.57	0.000116	2.21	834.99	169.63	0.12
OldSmokyHill_3	26900	Max WS	1623	1209.75	1222.5		1222.56	0.000103	2.08	881.02	150.78	0.11
OldSmokyHill_3	26800	Max WS	1623	1209.85	1222.5		1222.55	0.000110	2.15	906.82	165.29	0.12
OldSmokyHill_3	26700	Max WS	1629	1209.95	1222.5		1222.55	0.000148	2.50	844.01	198.53	0.13
OldSmokyHill_3	26600	Max WS	1629	1210.05	1222.4		1222.53	0.000158	2.60	784.12	143.50	0.14
OldSmokyHill_3	26522	Max WS	1629	1210.13	1222.3	1215.45	1222.55	0.000480	4.22	472.39	115.09	0.22
OldSmokyHill_3	26491		Bridge									
OldSmokyHill_3	26463	Max WS	1629	1210.19	1222.1		1222.38	0.000568	4.60	462.27	82.98	0.24
OldSmokyHill_3	26400	Max WS	1629	1210.25	1222.2		1222.30	0.000126	2.23	835.12	105.49	0.12
OldSmokyHill_3	26300	Max WS	1639	1210.35	1222.2		1222.30	0.000285	3.01	843.33	142.79	0.16
OldSmokyHill_3	26200	Max WS	1638	1210.45	1222.2		1222.27	0.000276	2.99	909.51	149.78	0.16
OldSmokyHill_3	26100	Max WS	1645	1210.55	1222.2		1222.23	0.000132	2.25	855.93	141.98	0.12
OldSmokyHill_3	26000	Max WS	1645	1210.45	1222.1		1222.22	0.000281	3.01	800.60	95.00	0.16
OldSmokyHill_3	25900	Max WS	1645	1210.35	1222.1		1222.19	0.000137	2.30	820.02	104.67	0.13
OldSmokyHill_3	25800	Max WS	1646	1210.25	1222.1		1222.18	0.000148	2.41	873.74	161.11	0.13
OldSmokyHill_3	25700	Max WS	1650	1210.15	1222.1		1222.16	0.000142	2.36	794.49	142.43	0.13
OldSmokyHill_3	25600	Max WS	1650	1210.05	1222.1		1222.15	0.000122	2.20	825.31	146.89	0.12
OldSmokyHill_3	25500	Max WS	1704	1209.95	1222.1		1222.13	0.000134	2.32	901.12	162.97	0.13
OldSmokyHill_3	25400	Max WS	1704	1209.85	1222.0		1222.13	0.000268	3.01	907.33	179.78	0.16
OldSmokyHill_3	25300	Max WS	1706	1209.75	1222.0		1222.11	0.000313	3.25	835.96	221.62	0.17
OldSmokyHill_3	25200	Max WS	1709	1209.50	1222.0		1222.06	0.000196	2.50	826.46	200.29	0.13
OldSmokyHill_3	25117	Max WS	1709	1208.41	1221.9	1213.86	1222.01	0.001222	2.71	890.15	219.19	0.14
OldSmokyHill_3	25047		Bridge									
OldSmokyHill_3	24980	Max WS	1709	1208.97	1221.7		1221.79	0.000399	3.53	630.17	163.48	0.19
OldSmokyHill_3	24900	Max WS	1709	1209.50	1221.7		1221.76	0.000154	2.35	835.99	179.89	0.13
OldSmokyHill_3	24800	Max WS	1709	1209.50	1221.6		1221.75	0.000187	2.64	758.58	179.34	0.15
OldSmokyHill_3	24700	Max WS	1717	1209.50	1221.6		1221.73	0.000146	2.30	821.89	158.06	0.13
OldSmokyHill_3	24600	Max WS	1718	1209.50	1221.6		1221.71	0.000124	2.18	893.89	162.26	0.12
OldSmokyHill_3	24500	Max WS	1720	1209.65	1221.6		1221.70	0.000151	2.41	819.04	127.52	0.13
OldSmokyHill_3	24400	Max WS	1720	1209.75	1221.6		1221.68	0.000138	2.30	816.40	93.16	0.13
OldSmokyHill_3	24300	Max WS	1720	1209.85	1221.6		1221.67	0.000143	2.33	807.56	95.42	0.13
OldSmokyHill_3	24200	Max WS	1720	1209.95	1221.6		1221.66	0.000153	2.40	803.91	99.33	0.13
OldSmokyHill_3	24100	Max WS	1720	1210.05	1221.5		1221.64	0.000168	2.52	781.15	122.60	0.14
OldSmokyHill_3	24000	Max WS	1723	1210.15	1221.5		1221.62	0.000159	2.46	816.96	110.80	0.14
OldSmokyHill_3	23900	Max WS	1723	1210.25	1221.5		1221.61	0.000157	2.42	813.54	113.25	0.14
OldSmokyHill_3	23800	Max WS	1744	1210.35	1221.5		1221.59	0.000166	2.50	825.62	141.46	0.14
OldSmokyHill_3	23700	Max WS	1744	1210.25	1221.5		1221.57	0.000168	2.52	791.97	104.79	0.14
OldSmokyHill_3	23600	Max WS	1744	1210.15	1221.5		1221.56	0.000163	2.48	785.76	99.75	0.14
OldSmokyHill_3	23500	Max WS	1744	1210.05	1221.5		1221.54	0.000147	2.34	817.89	97.20	0.13
OldSmokyHill_3	23362	Max WS	1751	1209.91	1221.4	1214.13	1221.52	0.000146	2.33	845.92	104.46	0.13
OldSmokyHill_3	23304		Bridge									
OldSmokyHill_3	23198	Max WS	1751	1209.75	1221.4		1221.47	0.000140	2.31	834.49	101.04	0.13
OldSmokyHill_3	23167	Max WS	1751	1209.72	1221.4		1221.47	0.000149	2.39	839.91	109.02	0.13
OldSmokyHill_3	23100	Max WS	1758	1209.50	1221.4		1221.46	0.000155	2.41	867.53	129.07	0.13
OldSmokyHill_3	23000	Max WS	1759	1209.50	1221.4		1221.44	0.000154	2.41	872.90	179.76	0.13
OldSmokyHill_3	22900	Max WS	1763	1209.50	1221.3		1221.43	0.000215	3.02	956.06	185.75	0.16
OldSmokyHill_3	22800	Max WS	1774	1209.55	1221.3		1221.42	0.000248	3.31	942.02	248.99	0.17
OldSmokyHill_3	22731	Max WS	1775	1209.62	1221.3		1221.41	0.000274	3.47	955.31	202.53	0.18
OldSmokyHill_3	22656	Max WS	1775	1209.70	1221.3	1213.89	1221.37	0.000160	2.50	866.38	166.43	0.14
OldSmokyHill_3	22648		Bridge									
OldSmokyHill_3	22634	Max WS	1774	1209.70	1221.2		1221.34	0.000158	2.47	860.39	147.71	0.14

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	22578	Max WS	1774	1209.77	1221.2		1221.33	0.000144	2.34	923.78	178.39	0.13
OldSmokyHill_3	22500	Max WS	1778	1209.85	1221.2		1221.34	0.000261	3.35	935.41	220.80	0.18
OldSmokyHill_3	22400	Max WS	1778	1209.95	1221.2		1221.29	0.000211	2.09	926.18	231.45	0.14
OldSmokyHill_3	22300	Max WS	1778	1210.05	1221.2		1221.27	0.000174	2.06	992.71	239.16	0.13
OldSmokyHill_3	22200	Max WS	1780	1210.15	1221.2		1221.25	0.000133	1.89	1091.47	240.08	0.12
OldSmokyHill_3	22100	Max WS	1781	1210.25	1221.2		1221.24	0.000131	2.17	1062.99	222.24	0.12
OldSmokyHill_3	22000	Max WS	1783	1210.12	1221.1		1221.23	0.000160	2.41	947.06	189.01	0.14
OldSmokyHill_3	21900	Max WS	1783	1210.12	1221.1		1221.22	0.000221	2.85	805.78	156.09	0.16
OldSmokyHill_3	21799	Max WS	1783	1210.27	1221.1		1221.20	0.000252	3.05	813.28	161.13	0.17
OldSmokyHill_3	21722	Max WS	1781	1210.10	1221.0	1214.67	1221.18	0.000278	3.21	759.08	148.50	0.18
OldSmokyHill_3	21714		Bridge									
OldSmokyHill_3	21705	Max WS	1778	1210.10	1221.0		1221.15	0.000280	3.20	753.63	145.87	0.18
OldSmokyHill_3	21600	Max WS	1780	1210.31	1221.0		1221.12	0.000212	2.75	845.07	151.22	0.16
OldSmokyHill_3	21500	Max WS	1793	1210.12	1221.0		1221.09	0.000149	2.32	1022.78	198.54	0.13
OldSmokyHill_3	21400	Max WS	1794	1209.93	1221.0		1221.08	0.000127	2.15	1187.81	277.09	0.12
OldSmokyHill_3	21295	Max WS	1793	1209.93	1221.0		1221.06	0.000123	2.11	1119.90	254.86	0.12
OldSmokyHill_3	21200	Max WS	1793	1209.82	1221.0		1221.05	0.000116	2.04	1162.36	309.68	0.12
OldSmokyHill_3	21100	Max WS	1794	1209.83	1221.0		1221.04	0.000111	2.02	1170.28	340.72	0.11
OldSmokyHill_3	20995	Max WS	1790	1210.03	1221.0		1221.03	0.000145	2.30	1122.03	240.55	0.13
OldSmokyHill_3	20900	Max WS	1791	1209.74	1220.9		1221.02	0.000160	2.44	1106.46	247.01	0.14
OldSmokyHill_3	20800	Max WS	1797	1209.69	1220.9		1221.00	0.000117	2.10	1237.92	280.56	0.12
OldSmokyHill_3	20700	Max WS	1795	1209.43	1220.9		1220.99	0.000127	2.19	1239.97	285.50	0.12
OldSmokyHill_3	20644	Max WS	1796	1209.47	1220.9		1220.98	0.000135	2.25	1210.20	287.44	0.13
OldSmokyHill_3	20600	Max WS	1795	1209.50	1220.9		1220.97	0.000116	2.06	1285.01	293.23	0.12
OldSmokyHill_3	20500	Max WS	1783	1209.49	1220.9		1220.96	0.000140	2.29	1144.21	313.73	0.13
OldSmokyHill_3	20434	Max WS	1781	1209.28	1220.9		1220.95	0.000148	2.37	1174.50	316.11	0.13
OldSmokyHill_3	20363	Max WS	1267	1209.34	1220.9	1213.35	1220.91	0.000107	2.02	939.72	318.06	0.11
OldSmokyHill_3	20352		Bridge									
OldSmokyHill_3	20343	Max WS	1262	1209.41	1220.8		1220.89	0.000094	1.90	995.56	311.41	0.11
OldSmokyHill_3	20300	Max WS	1387	1209.10	1220.9		1220.89	0.000049	1.41	1369.05	312.95	0.08
OldSmokyHill_3	20190	Max WS	2199	1209.10	1220.8		1220.87	0.000165	2.45	1196.79	269.61	0.14
OldSmokyHill_3	20100	Max WS	2204	1209.16	1220.8		1220.86	0.000206	2.80	1044.83	227.00	0.16
OldSmokyHill_3	20023	Max WS	2209	1209.05	1220.7		1220.85	0.000230	2.98	970.17	182.52	0.17
OldSmokyHill_3	19900	Max WS	2209	1209.06	1220.7		1220.82	0.000197	2.76	973.46	153.46	0.15
OldSmokyHill_3	19800	Max WS	2209	1208.97	1220.7		1220.80	0.000242	3.09	890.53	138.47	0.17
OldSmokyHill_3	19700	Max WS	2208	1208.92	1220.6		1220.78	0.000295	3.41	755.09	114.25	0.19
OldSmokyHill_3	19600	Max WS	2208	1208.86	1220.6		1220.74	0.000225	2.99	813.65	107.53	0.16
OldSmokyHill_3	19510	Max WS	2208	1208.72	1220.6	1213.07	1220.72	0.000174	2.66	913.70	111.32	0.14
OldSmokyHill_3	19481		Bridge									
OldSmokyHill_3	19452	Max WS	2209	1208.72	1220.6		1220.70	0.000155	2.48	967.19	113.99	0.14
OldSmokyHill_3	19400	Max WS	2208	1208.53	1220.6		1220.69	0.000198	2.80	903.14	126.36	0.15
OldSmokyHill_3	19300	Max WS	2233	1208.28	1220.5		1220.67	0.000232	2.98	860.77	127.18	0.17
OldSmokyHill_3	19200	Max WS	2233	1208.22	1220.5		1220.65	0.000242	3.03	842.50	132.68	0.17
OldSmokyHill_3	19100	Max WS	2232	1208.22	1220.4		1220.65	0.000448	4.14	804.10	137.73	0.23
OldSmokyHill_3	19000	Max WS	2230	1208.09	1220.3		1220.62	0.000608	4.83	694.48	125.13	0.26
OldSmokyHill_3	18900	Max WS	2230	1208.03	1220.2		1220.58	0.000822	5.55	585.03	114.02	0.30
OldSmokyHill_3	18800	Max WS	2230	1207.66	1220.0		1220.50	0.000817	5.58	533.10	111.16	0.30
OldSmokyHill_3	18700	Max WS	2234	1207.83	1220.0		1220.40	0.000602	4.85	592.39	131.51	0.26
OldSmokyHill_3	18600	Max WS	2241	1207.62	1219.9		1220.35	0.000748	5.32	583.45	120.53	0.29
OldSmokyHill_3	18500	Max WS	2241	1207.70	1219.8		1220.27	0.000839	5.57	460.45	73.78	0.31
OldSmokyHill_3	18438	Max WS	2241	1207.53	1220.0	1213.30	1220.18	0.000356	3.73	710.98	87.57	0.20
OldSmokyHill_3	18412		Bridge									
OldSmokyHill_3	18386	Max WS	2241	1207.50	1219.7		1219.90	0.000312	3.43	734.30	89.29	0.19
OldSmokyHill_3	18300	Max WS	2241	1207.75	1219.7		1219.87	0.000277	3.15	755.57	89.73	0.18
OldSmokyHill_3	18200	Max WS	2243	1207.43	1219.7		1219.84	0.000279	3.20	755.38	106.46	0.18
OldSmokyHill_3	18100	Max WS	2243	1207.42	1219.7		1219.81	0.000232	2.93	818.41	103.11	0.16
OldSmokyHill_3	18000	Max WS	2243	1207.16	1219.6		1219.79	0.000257	3.08	775.60	91.71	0.17
OldSmokyHill_3	17900	Max WS	2243	1207.10	1219.6		1219.76	0.000274	3.26	754.53	94.34	0.18
OldSmokyHill_3	17800	Max WS	2243	1206.51	1219.6		1219.74	0.000221	2.99	783.31	84.21	0.16
OldSmokyHill_3	17700	Max WS	2243	1206.52	1219.5		1219.71	0.000410	4.04	593.63	68.51	0.22
OldSmokyHill_3	17600	Max WS	2305	1206.23	1219.5		1219.66	0.000297	3.42	719.60	82.09	0.19
OldSmokyHill_3	17500	Max WS	2304	1206.44	1219.4		1219.63	0.000330	3.65	677.63	74.74	0.20
OldSmokyHill_3	17400	Max WS	2304	1206.06	1219.4		1219.60	0.000374	3.87	639.86	71.49	0.21
OldSmokyHill_3	17300	Max WS	2305	1205.78	1219.4		1219.56	0.000269	3.31	738.66	81.19	0.18
OldSmokyHill_3	17181	Max WS	2363	1204.48	1219.2	1213.37	1219.55	0.000825	5.38	675.23	92.23	0.27
OldSmokyHill_3	17052		Bridge									
OldSmokyHill_3	16929	Max WS	2360	1204.22	1218.3		1218.68	0.000745	5.40	608.08	79.27	0.27
OldSmokyHill_3	16923	Max WS	2362	1205.00	1218.4	1211.62	1218.63	0.001229	3.95	668.37	82.03	0.21
OldSmokyHill_3	16917		Inl Struct									
OldSmokyHill_3	16800	Max WS	2360	1205.21	1218.1		1218.55	0.000736	5.24	535.03	87.36	0.29
OldSmokyHill_3	16700	Max WS	2361	1204.84	1218.1	1212.03	1218.47	0.000569	4.71	606.15	91.45	0.26
OldSmokyHill_3	16653		Inl Struct									
OldSmokyHill_3	16600	Max WS	2354	1204.44	1217.9		1218.29	0.000961	5.24	533.02	101.52	0.32
OldSmokyHill_3	16500	Max WS	2359	1202.91	1218.1		1218.15	0.000099	2.34	1196.20	119.46	0.11
OldSmokyHill_3	16400	Max WS	2379	1202.78	1218.1	1205.98	1218.13	0.000034	1.41	1818.86	151.83	0.07
OldSmokyHill_3	16356		Inl Struct									
OldSmokyHill_3	16300	Max WS	2378	1202.71	1218.0		1218.12	0.000091	2.25	1265.81	131.98	0.11
OldSmokyHill_3	16200	Max WS	2373	1202.61	1218.0		1218.11	0.000111	2.49	1170.37	125.76	0.12

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	16100	Max WS	2376	1202.56	1218.0	1207.53	1218.10	0.000094	2.32	1196.64	105.67	0.11
OldSmokyHill_3	16058		Inl Struct									
OldSmokyHill_3	16000	Max WS	2370	1202.51	1218.0		1218.08	0.000150	3.00	1065.36	110.47	0.14
OldSmokyHill_3	15900	Max WS	2373	1202.34	1217.9		1218.08	0.000189	3.42	1056.24	97.15	0.16
OldSmokyHill_3	15800	Max WS	2384	1202.44	1217.9	1208.42	1218.06	0.000209	3.55	917.51	96.27	0.17
OldSmokyHill_3	15743		Inl Struct									
OldSmokyHill_3	15700	Max WS	2386	1200.38	1217.9		1218.02	0.000190	3.64	999.54	83.68	0.16
OldSmokyHill_3	15635	Max WS	2380	1202.00	1217.8	1208.58	1218.03	0.000383	4.37	875.03	85.10	0.20
OldSmokyHill_3	15566		Bridge									
OldSmokyHill_3	15502	Max WS	2380	1202.00	1217.8		1217.93	0.000260	3.59	1185.97	114.47	0.16
OldSmokyHill_3	15400	Max WS	2377	1200.67	1217.8		1217.90	0.000137	3.18	1164.53	93.27	0.14
OldSmokyHill_3	15300	Max WS	2379	1200.77	1217.7		1217.89	0.000151	3.33	1137.63	111.53	0.14
OldSmokyHill_3	15200	Max WS	2378	1200.87	1217.7		1217.84	0.000128	2.99	1395.45	236.56	0.13
OldSmokyHill_3	15100	Max WS	2381	1200.97	1217.7		1217.85	0.000127	2.97	1361.36	186.54	0.13
OldSmokyHill_3	15000	Max WS	2381	1200.87	1217.7		1217.83	0.000114	2.82	1409.03	138.58	0.12
OldSmokyHill_3	14900	Max WS	2377	1200.77	1217.7		1217.83	0.000137	3.18	1356.00	129.09	0.14
OldSmokyHill_3	14800	Max WS	2378	1200.67	1217.7		1217.81	0.000134	3.15	1359.89	126.96	0.14
OldSmokyHill_3	14700	Max WS	2384	1200.57	1217.7		1217.80	0.000139	3.21	1303.51	133.93	0.14
OldSmokyHill_3	14600	Max WS	2385	1200.47	1217.6		1217.79	0.000152	3.37	1112.24	104.16	0.15
OldSmokyHill_3	14507	Max WS	2402	1201.00	1217.6	1208.46	1217.82	0.000485	5.07	1044.15	114.10	0.22
OldSmokyHill_3	14427		Bridge									
OldSmokyHill_3	14349	Max WS	2404	1201.00	1217.2		1217.36	0.000253	3.65	1143.98	107.75	0.16
OldSmokyHill_3	14300	Max WS	2405	1200.17	1217.2		1217.34	0.000144	3.25	1162.43	97.30	0.14
OldSmokyHill_3	14200	Max WS	2403	1200.07	1217.2		1217.32	0.000148	3.31	1114.25	100.08	0.14
OldSmokyHill_3	14100	Max WS	2403	1199.97	1217.2		1217.31	0.000141	3.23	1227.02	146.07	0.14
OldSmokyHill_3	14000	Max WS	2400	1197.97	1217.2		1217.29	0.000123	3.07	1291.34	140.64	0.13
OldSmokyHill_3	13900	Max WS	2402	1197.97	1217.2		1217.27	0.000117	2.94	1312.05	186.84	0.13
OldSmokyHill_3	13800	Max WS	2401	1197.97	1217.2		1217.26	0.000103	2.73	1324.24	182.56	0.12
OldSmokyHill_3	13700	Max WS	2400	1197.97	1217.2		1217.24	0.000088	2.54	1597.60	212.68	0.11
OldSmokyHill_3	13600	Max WS	2398	1197.97	1217.1		1217.24	0.000112	2.87	1412.22	197.57	0.12
OldSmokyHill_3	13500	Max WS	2399	1197.97	1217.1		1217.22	0.000092	2.58	1482.96	207.76	0.11
OldSmokyHill_3	13400	Max WS	2397	1199.47	1217.1		1217.22	0.000099	2.68	1387.05	142.60	0.12
OldSmokyHill_3	13300	Max WS	2396	1199.57	1217.1		1217.20	0.000098	2.64	1426.89	150.31	0.11
OldSmokyHill_3	13200	Max WS	2395	1199.67	1217.1		1217.19	0.000093	2.57	1317.17	159.59	0.11
OldSmokyHill_3	13100	Max WS	1936	1199.77	1217.1		1217.14	0.000074	2.31	1219.52	139.97	0.10
OldSmokyHill_3	13000	Max WS	1941	1199.87	1217.1		1217.13	0.000078	2.39	1267.41	152.34	0.10
OldSmokyHill_3	12900	Max WS	1943	1199.97	1217.1		1217.13	0.000078	2.35	1289.11	125.11	0.10
OldSmokyHill_3	12800	Max WS	1940	1200.07	1217.0		1217.12	0.000070	2.22	1249.90	119.13	0.10
OldSmokyHill_3	12700	Max WS	1937	1200.17	1217.0		1217.11	0.000082	2.42	1208.61	101.01	0.11
OldSmokyHill_3	12600	Max WS	1937	1200.27	1217.0		1217.11	0.000095	2.63	1263.53	109.76	0.11
OldSmokyHill_3	12500	Max WS	1939	1200.17	1217.0		1217.09	0.000065	2.13	1295.52	112.60	0.09
OldSmokyHill_3	12400	Max WS	1943	1200.07	1217.0		1217.08	0.000063	2.11	1256.36	111.84	0.09
OldSmokyHill_3	12300	Max WS	1939	1199.97	1217.0		1217.08	0.000078	2.36	1168.43	106.57	0.10
OldSmokyHill_3	12200	Max WS	1940	1199.87	1217.0		1217.08	0.000089	2.57	1206.71	111.38	0.11
OldSmokyHill_3	12100	Max WS	1940	1199.77	1217.0		1217.07	0.000091	2.60	1161.18	93.58	0.11
OldSmokyHill_3	12000	Max WS	1943	1199.67	1217.0		1217.06	0.000085	2.52	1206.18	94.18	0.11
OldSmokyHill_3	11900	Max WS	1942	1197.80	1217.0		1217.05	0.000081	2.50	1238.15	106.13	0.11
OldSmokyHill_3	11800	Max WS	1942	1197.80	1216.9		1217.05	0.000100	2.77	1010.71	86.86	0.12
OldSmokyHill_3	11688	Max WS	1941	1197.80	1216.9		1217.03	0.000087	2.56	1043.28	96.10	0.11
OldSmokyHill_3	11600	Max WS	1940	1197.80	1216.9		1217.03	0.000085	2.55	1141.86	96.80	0.11
OldSmokyHill_3	11500	Max WS	1944	1197.80	1217.0		1217.01	0.000046	1.82	1319.70	105.83	0.08
OldSmokyHill_3	11400	Max WS	1941	1199.05	1217.0		1217.00	0.000044	1.81	1422.00	114.85	0.08
OldSmokyHill_3	11300	Max WS	2007	1199.15	1216.9		1217.00	0.000062	2.15	1277.30	106.49	0.09
OldSmokyHill_3	11200	Max WS	2000	1199.25	1216.9		1217.00	0.000084	2.52	1228.71	113.45	0.11
OldSmokyHill_3	11100	Max WS	1992	1199.35	1216.9		1216.99	0.000086	2.52	994.11	95.61	0.11
OldSmokyHill_3	10956	Max WS	2007	1196.19	1216.9		1216.96	0.000028	1.36	1932.35	209.00	0.06
OldSmokyHill_3	10836		Culvert									
OldSmokyHill_3	10708	Max WS	1073	1195.60	1215.7		1215.67	0.000017	1.00	1556.81	173.70	0.04
OldSmokyHill_3	10500	Max WS	1072	1199.95	1215.6		1215.66	0.000024	1.25	1318.13	124.20	0.06
OldSmokyHill_3	10400	Max WS	1073	1200.05	1215.6		1215.66	0.000019	1.10	1306.05	119.21	0.05
OldSmokyHill_3	10335	Max WS	1068	1199.99	1215.6	1203.15	1215.66	0.000021	1.16	1223.53	105.95	0.05
OldSmokyHill_3	10309		Bridge									
OldSmokyHill_3	10292	Max WS	1070	1199.95	1215.6		1215.65	0.000024	1.23	1156.32	101.72	0.06
OldSmokyHill_3	10200	Max WS	1065	1199.86	1215.6		1215.65	0.000019	1.09	1255.16	114.42	0.05
OldSmokyHill_3	10100	Max WS	1069	1199.76	1215.6		1215.65	0.000019	1.12	1175.02	107.95	0.05
OldSmokyHill_3	10000	Max WS	1068	1199.66	1215.6		1215.65	0.000020	1.13	1155.38	101.85	0.05
OldSmokyHill_3	9900	Max WS	1065	1199.56	1215.6		1215.65	0.000021	1.16	1162.39	108.16	0.05
OldSmokyHill_3	9800	Max WS	1061	1199.46	1215.6		1215.64	0.000019	1.11	1207.68	104.53	0.05
OldSmokyHill_3	9700	Max WS	1066	1199.36	1215.6		1215.64	0.000019	1.13	1238.31	115.24	0.05
OldSmokyHill_3	9600	Max WS	1062	1199.26	1215.6		1215.64	0.000019	1.13	1231.39	105.63	0.05
OldSmokyHill_3	9500	Max WS	1054	1199.16	1215.6		1215.64	0.000018	1.11	1185.07	100.15	0.05
OldSmokyHill_3	9400	Max WS	1060	1199.06	1215.6		1215.64	0.000021	1.18	1145.07	100.92	0.05
OldSmokyHill_3	9300	Max WS	1055	1198.96	1215.6		1215.64	0.000020	1.16	1175.72	111.11	0.05
OldSmokyHill_3	9200	Max WS	1054	1198.86	1215.6		1215.63	0.000020	1.16	1184.61	107.96	0.05
OldSmokyHill_3	9148	Max WS	1060	1198.81	1215.6		1215.63	0.000020	1.16	1146.00	115.09	0.05
OldSmokyHill_3	9100	Max WS	1072	1198.76	1215.6		1215.63	0.000016	1.07	1246.00	116.42	0.05
OldSmokyHill_3	9000	Max WS	1062	1198.66	1215.6		1215.63	0.000022	1.24	1217.36	142.19	0.05
OldSmokyHill_3	8900	Max WS	1061	1198.56	1215.6		1215.63	0.000029	1.44	1136.29	156.01	0.06

HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

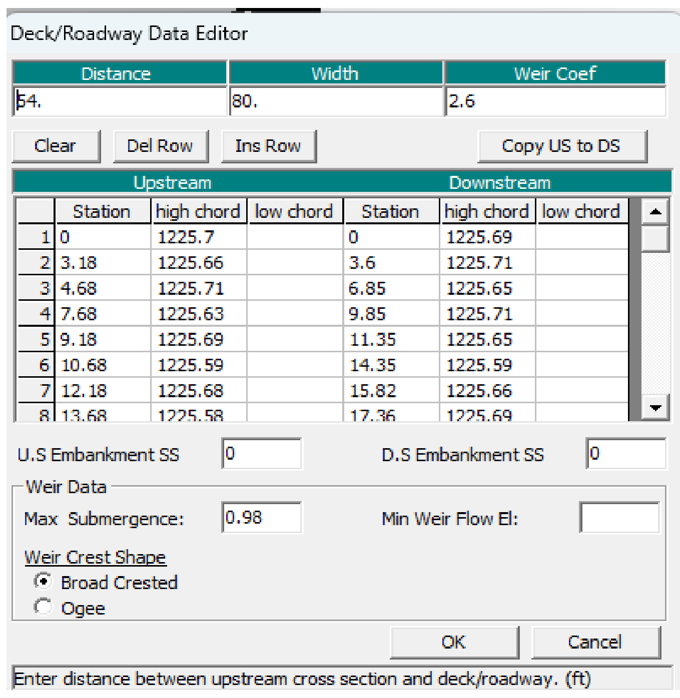
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	8800	Max WS	1064	1198.46	1215.6		1215.63	0.000027	1.40	1313.66	200.70	0.06
OldSmokyHill_3	8668	Max WS	1062	1198.33	1215.6	1202.49	1215.63	0.000054	1.86	1120.91	228.66	0.08
OldSmokyHill_3	8647		Bridge									
OldSmokyHill_3	8621	Max WS	1062	1195.72	1215.6		1215.61	0.000021	1.25	1236.99	228.16	0.05
OldSmokyHill_3	8500	Max WS	1060	1195.72	1215.6		1215.61	0.000023	1.31	1408.93	210.61	0.06
OldSmokyHill_3	8400	Max WS	1056	1195.72	1215.6		1215.60	0.000023	1.31	1237.45	113.94	0.06
OldSmokyHill_3	8300	Max WS	1056	1195.72	1215.6		1215.60	0.000015	1.06	1292.32	159.47	0.05
OldSmokyHill_3	8200	Max WS	1056	1197.72	1215.6		1215.60	0.000021	1.25	1334.89	184.95	0.05
OldSmokyHill_3	8100	Max WS	1057	1198.72	1215.6		1215.60	0.000018	1.10	1324.99	160.08	0.05
OldSmokyHill_3	8000	Max WS	1041	1199.50	1215.6		1215.59	0.000016	1.04	1220.23	117.23	0.05
OldSmokyHill_3	7900	Max WS	1046	1199.40	1215.6		1215.59	0.000019	1.13	1337.03	199.56	0.05
OldSmokyHill_3	7800	Max WS	1041	1199.30	1215.6		1215.59	0.000027	1.37	1290.47	143.01	0.06
OldSmokyHill_3	7700	Max WS	1035	1199.20	1215.6		1215.59	0.000031	1.49	1291.46	156.23	0.07
OldSmokyHill_3	7600	Max WS	1043	1199.10	1215.6		1215.59	0.000018	1.10	1201.27	118.12	0.05
OldSmokyHill_3	7500	Max WS	1038	1199.00	1215.6		1215.59	0.000027	1.39	1243.43	119.74	0.06
OldSmokyHill_3	7400	Max WS	1038	1198.90	1215.6		1215.58	0.000025	1.34	1395.03	118.35	0.06
OldSmokyHill_3	7300	Max WS	1030	1198.80	1215.6		1215.58	0.000024	1.33	1339.65	124.54	0.06
OldSmokyHill_3	7275		Lat Struct									
OldSmokyHill_3	7200	Max WS	985	1198.80	1215.6		1215.58	0.000023	1.29	1420.71	172.99	0.06
OldSmokyHill_3	7100	Max WS	480	1198.60	1215.6		1215.58	0.000003	0.45	1438.57	135.78	0.02
OldSmokyHill_3	7000	Max WS	483	1198.50	1215.6		1215.58	0.000004	0.54	1259.54	116.90	0.02
OldSmokyHill_3	6900	Max WS	484	1195.72	1215.6		1215.58	0.000004	0.55	1368.71	155.16	0.02
OldSmokyHill_3	6800	Max WS	483	1195.72	1215.6		1215.58	0.000005	0.60	1324.92	141.79	0.03
OldSmokyHill_3	6700	Max WS	484	1195.72	1215.6		1215.58	0.000005	0.61	1367.91	125.07	0.03
OldSmokyHill_3	6600	Max WS	484	1195.72	1215.6		1215.58	0.000004	0.55	1322.33	122.68	0.02
OldSmokyHill_3	6500	Max WS	485	1198.22	1215.6		1215.58	0.000005	0.58	1323.23	136.85	0.02
OldSmokyHill_3	6400	Max WS	485	1199.22	1215.6		1215.58	0.000006	0.65	1326.67	205.46	0.03
OldSmokyHill_3	6300	Max WS	482	1199.32	1215.6		1215.58	0.000006	0.64	1281.55	182.67	0.03
OldSmokyHill_3	6200	Max WS	484	1199.42	1215.6		1215.58	0.000006	0.66	1340.05	322.94	0.03
OldSmokyHill_3	6100	Max WS	484	1199.32	1215.6		1215.58	0.000007	0.68	1333.09	309.37	0.03
OldSmokyHill_3	6000	Max WS	478	1199.22	1215.6		1215.58	0.000006	0.67	1305.80	179.31	0.03
OldSmokyHill_3	5900	Max WS	477	1199.12	1215.6		1215.57	0.000005	0.62	1405.87	168.24	0.03
OldSmokyHill_3	5800	Max WS	483	1199.02	1215.6		1215.57	0.000007	0.70	1341.22	186.05	0.03
OldSmokyHill_3	5700	Max WS	478	1198.92	1215.6		1215.57	0.000006	0.66	1301.03	148.41	0.03
OldSmokyHill_3	5600	Max WS	483	1196.42	1215.6		1215.57	0.000003	0.48	1605.77	158.47	0.02
OldSmokyHill_3	5500	Max WS	481	1195.72	1215.6		1215.57	0.000004	0.57	1535.76	161.74	0.02
OldSmokyHill_3	5400	Max WS	479	1195.72	1215.6		1215.57	0.000005	0.61	1388.30	128.05	0.03
OldSmokyHill_3	5300	Max WS	482	1195.72	1215.6		1215.57	0.000003	0.50	1393.27	117.63	0.02
OldSmokyHill_3	5200	Max WS	481	1195.72	1215.6		1215.57	0.000002	0.43	1467.05	126.93	0.02
OldSmokyHill_3	5100	Max WS	482	1195.72	1215.6		1215.57	0.000002	0.43	1467.93	129.60	0.02
OldSmokyHill_3	5000	Max WS	480	1195.72	1215.6		1215.57	0.000002	0.43	1447.17	119.38	0.02
OldSmokyHill_3	4900	Max WS	480	1198.22	1215.6		1215.57	0.000002	0.42	1471.73	125.95	0.02
OldSmokyHill_3	4800	Max WS	480	1198.32	1215.6		1215.57	0.000003	0.51	1616.03	228.80	0.02
OldSmokyHill_3	4799		Lat Struct									
OldSmokyHill_3	4676	Max WS	473	1198.44	1215.6		1215.57	0.000005	0.63	1466.35	198.31	0.03
OldSmokyHill_3	4600	Max WS	469	1198.52	1215.6		1215.57	0.000004	0.57	1530.16	190.47	0.02
OldSmokyHill_3	4500	Max WS	443	1198.62	1215.6		1215.57	0.000002	0.38	1455.32	149.05	0.02
OldSmokyHill_3	4400	Max WS	397	1198.71	1215.6		1215.57	0.000002	0.37	1413.30	139.72	0.02
OldSmokyHill_3	4362		Lat Struct									
OldSmokyHill_3	4300	Max WS	314	1198.63	1215.6	1200.28	1215.57	0.000001	0.28	1475.45	145.68	0.01
OldSmokyHill_3	4278		Bridge									
OldSmokyHill_3	4200	Max WS	312	1198.65	1215.6		1215.56	0.000001	0.28	1476.76	167.50	0.01
OldSmokyHill_3	4100	Max WS	383	1198.57	1215.6		1215.56	0.000001	0.32	1655.86	173.60	0.01
OldSmokyHill_3	4000	Max WS	700	1198.39	1215.6		1215.56	0.000005	0.60	1612.36	165.90	0.03
OldSmokyHill_3	3900	Max WS	1011	1198.29	1215.5		1215.56	0.000012	0.95	1542.95	179.48	0.04
OldSmokyHill_3	3800	Max WS	1028	1195.72	1215.5		1215.56	0.000011	0.91	1563.98	190.81	0.04
OldSmokyHill_3	3700	Max WS	982	1195.72	1215.5		1215.56	0.000010	0.88	1600.68	175.08	0.04
OldSmokyHill_3	3600	Max WS	931	1195.72	1215.5		1215.56	0.000014	1.08	1599.89	161.20	0.04
OldSmokyHill_3	3500	Max WS	882	1195.72	1215.5		1215.56	0.000012	0.97	1605.52	153.00	0.04
OldSmokyHill_3	3400	Max WS	776	1198.22	1215.5		1215.56	0.000006	0.67	1534.65	163.19	0.03
OldSmokyHill_3	3300	Max WS	668	1198.32	1215.5		1215.56	0.000005	0.62	1476.56	176.13	0.03
OldSmokyHill_3	3200	Max WS	563	1198.39	1215.6		1215.56	0.000004	0.56	1491.49	183.06	0.02
OldSmokyHill_3	3100	Max WS	456	1198.66	1215.6		1215.56	0.000004	0.57	1587.60	229.28	0.02
OldSmokyHill_3	3000	Max WS	349	1198.34	1215.6		1215.56	0.000003	0.44	1555.30	289.46	0.02
OldSmokyHill_3	2900	Max WS	337	1198.41	1215.6		1215.56	0.000003	0.48	1482.53	232.17	0.02
OldSmokyHill_3	2800	Max WS	337	1198.34	1215.6		1215.56	0.000004	0.53	1519.68	235.88	0.02
OldSmokyHill_3	2700	Max WS	336	1198.47	1215.6		1215.56	0.000003	0.44	1514.94	233.54	0.02
OldSmokyHill_3	2600	Max WS	343	1198.50	1215.6		1215.55	0.000002	0.42	1520.82	197.88	0.02
OldSmokyHill_3	2500	Max WS	343	1198.53	1215.6		1215.55	0.000003	0.47	1328.68	139.65	0.02
OldSmokyHill_3	2400	Max WS	343	1198.93	1215.6	1200.98	1215.55	0.000002	0.36	1354.50	131.11	0.02
OldSmokyHill_3	2345		Inl Struct									
OldSmokyHill_3	2300	Max WS	343	1198.50	1215.5		1215.55	0.000002	0.36	1386.05	151.96	0.02
OldSmokyHill_3	2183	Max WS	343	1196.44	1215.5		1215.55	0.000003	0.45	891.95	180.96	0.02
OldSmokyHill_3	2100		Culvert									
OldSmokyHill_3	2026	Max WS	329	1196.78	1214.8		1214.76	0.000008	0.84	389.94	126.76	0.04
OldSmokyHill_3	1900	Max WS	330	1198.47	1214.8		1214.76	0.000002	0.38	1284.95	131.53	0.02
OldSmokyHill_3	1800	Max WS	330	1198.28	1214.8		1214.76	0.000002	0.34	1362.64	144.63	0.02
OldSmokyHill_3	1700	Max WS	330	1198.12	1214.8		1214.76	0.000002	0.36	1411.59	143.89	0.02

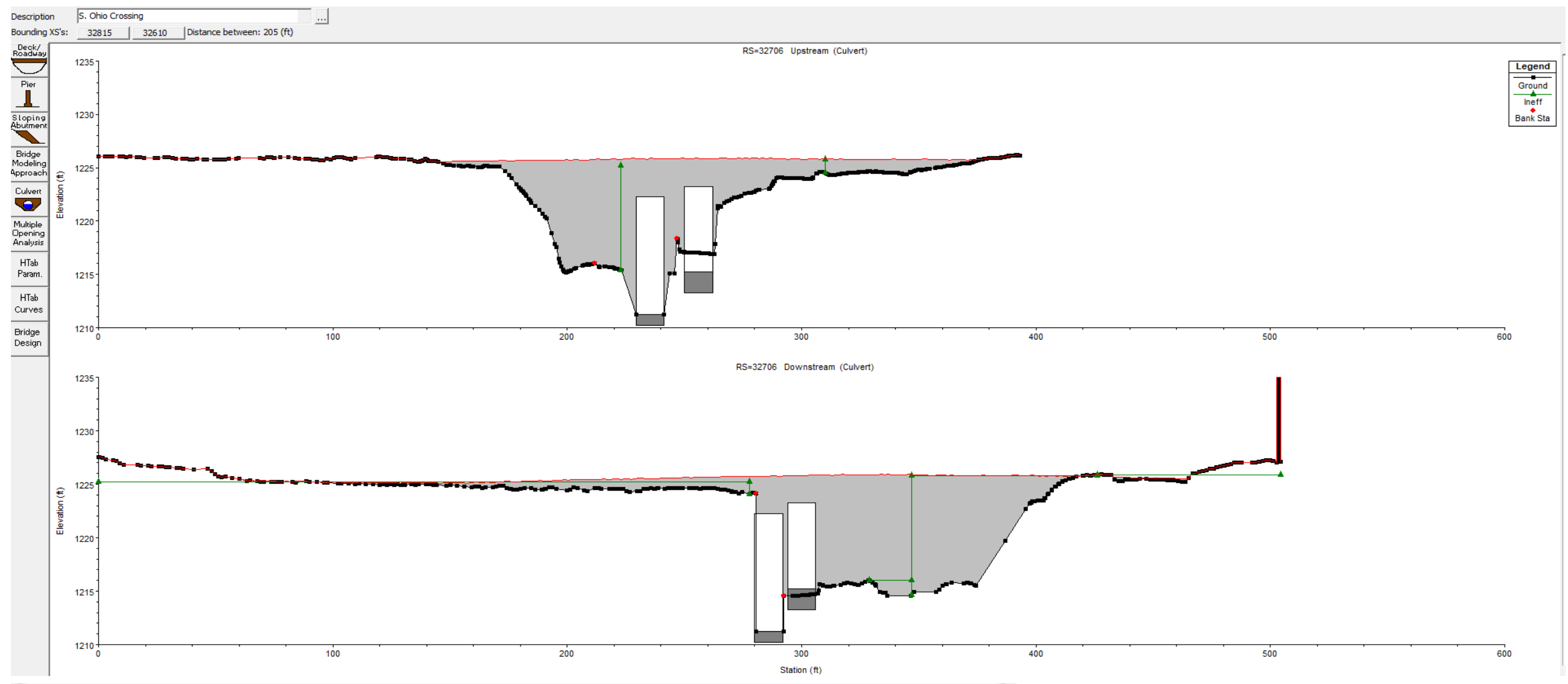
HEC-RAS Plan: 05-Alt3-USACE-0.2%AEP-PostTSPRefinements River: OldSmokyHill Reach: OldSmokyHill_3 Profile: Max WS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
OldSmokyHill_3	1600	Max WS	331	1198.25	1214.8		1214.76	0.000003	0.45	1449.06	187.65	0.02
OldSmokyHill_3	1500	Max WS	339	1197.76	1214.8		1214.76	0.000002	0.41	1488.86	178.54	0.02
OldSmokyHill_3	1400	Max WS	348	1197.87	1214.8		1214.76	0.000002	0.33	1374.30	135.02	0.01
OldSmokyHill_3	1300	Max WS	350	1197.69	1214.8		1214.76	0.000003	0.50	1041.26	249.69	0.02
OldSmokyHill_3	1202		Lat Struct									
OldSmokyHill_3	1200	Max WS	360	1197.53	1214.8		1214.76	0.000001	0.30	2041.43	401.38	0.01
OldSmokyHill_3	1100	Max WS	405	1197.72	1214.8		1214.76	0.000002	0.42	1813.38	516.11	0.02
OldSmokyHill_3	1000	Max WS	478	1197.72	1214.8		1214.76	0.000004	0.54	1729.05	533.93	0.02
OldSmokyHill_3	900	Max WS	572	1197.44	1214.8		1214.76	0.000007	0.72	1663.18	538.47	0.03
OldSmokyHill_3	800	Max WS	685	1197.35	1214.7		1214.75	0.000011	0.90	1606.42	531.48	0.04
OldSmokyHill_3	700	Max WS	787	1197.38	1214.7		1214.75	0.000016	1.11	1529.35	536.99	0.05
OldSmokyHill_3	660	Max WS	1056	1195.72	1214.7	1202.14	1214.77	0.000095	2.35	966.65	572.80	0.10
OldSmokyHill_3	508		Inl Struct									
OldSmokyHill_3	394	Max WS	1056	1194.52	1200.4	1201.97	1206.31	0.020925	19.50	54.19	12.49	1.43
OldSmokyHill_3	300	Max WS	1056	1194.21	1199.1		1200.38	0.006979	9.44	120.90	35.27	0.79
OldSmokyHill_3	200	Max WS	1056	1193.97	1198.2	1198.20	1199.86	0.009978	10.50	107.24	32.87	0.93
OldSmokyHill_3	100	Max WS	1056	1193.79	1197.7	1196.43	1197.78	0.001321	2.49	426.98	211.30	0.31

ATTACHMENT B – RAISE GRANT BRIDGE INFORMATION

1) South Ohio Street





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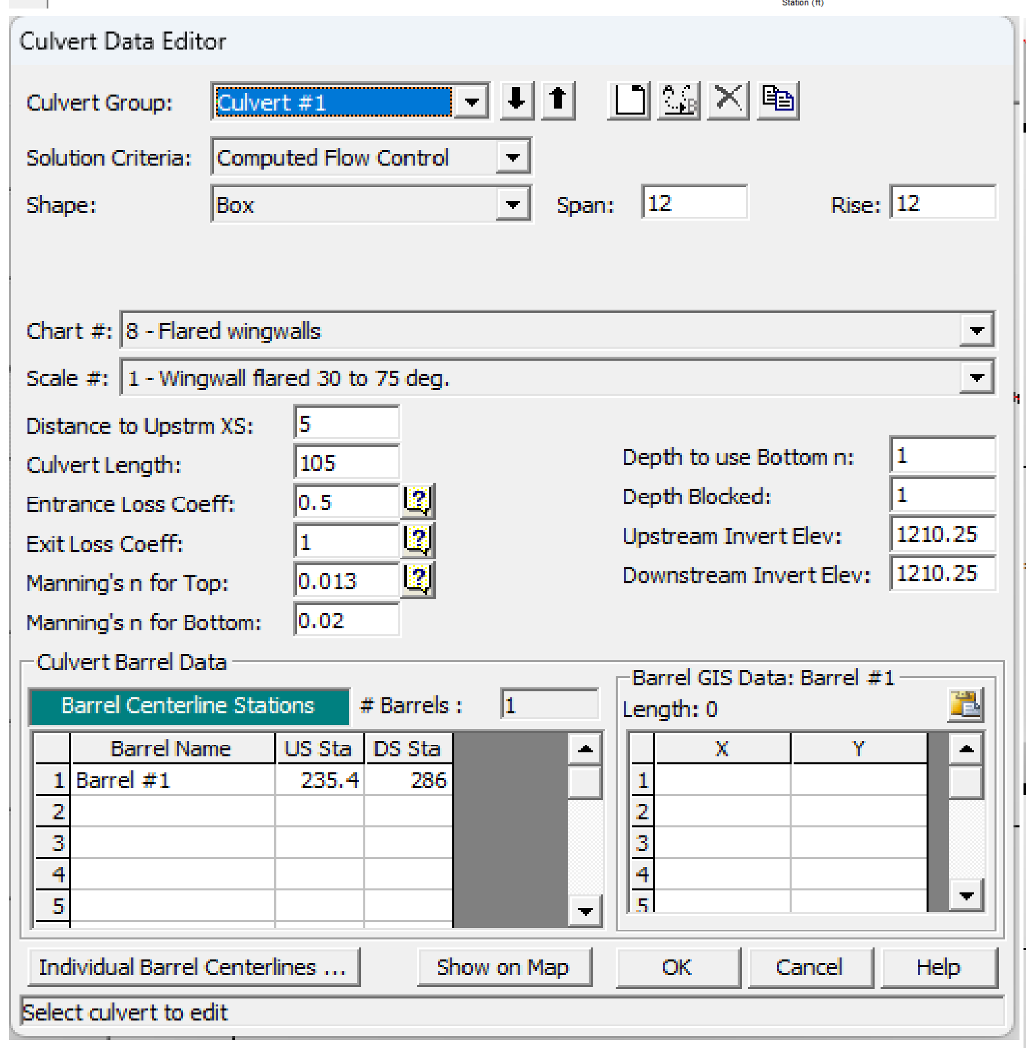
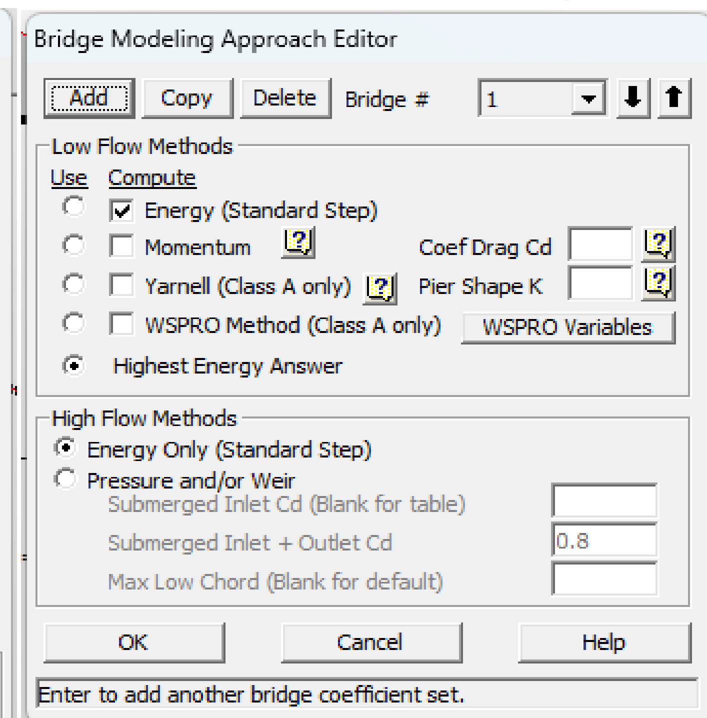
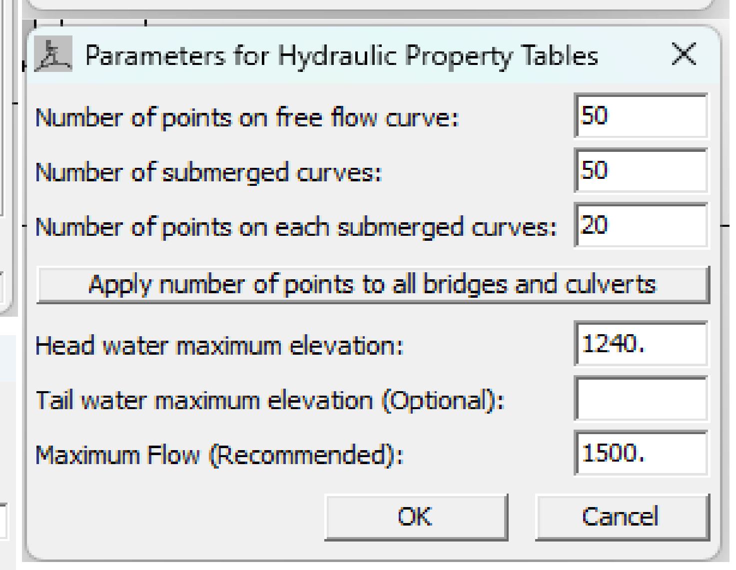
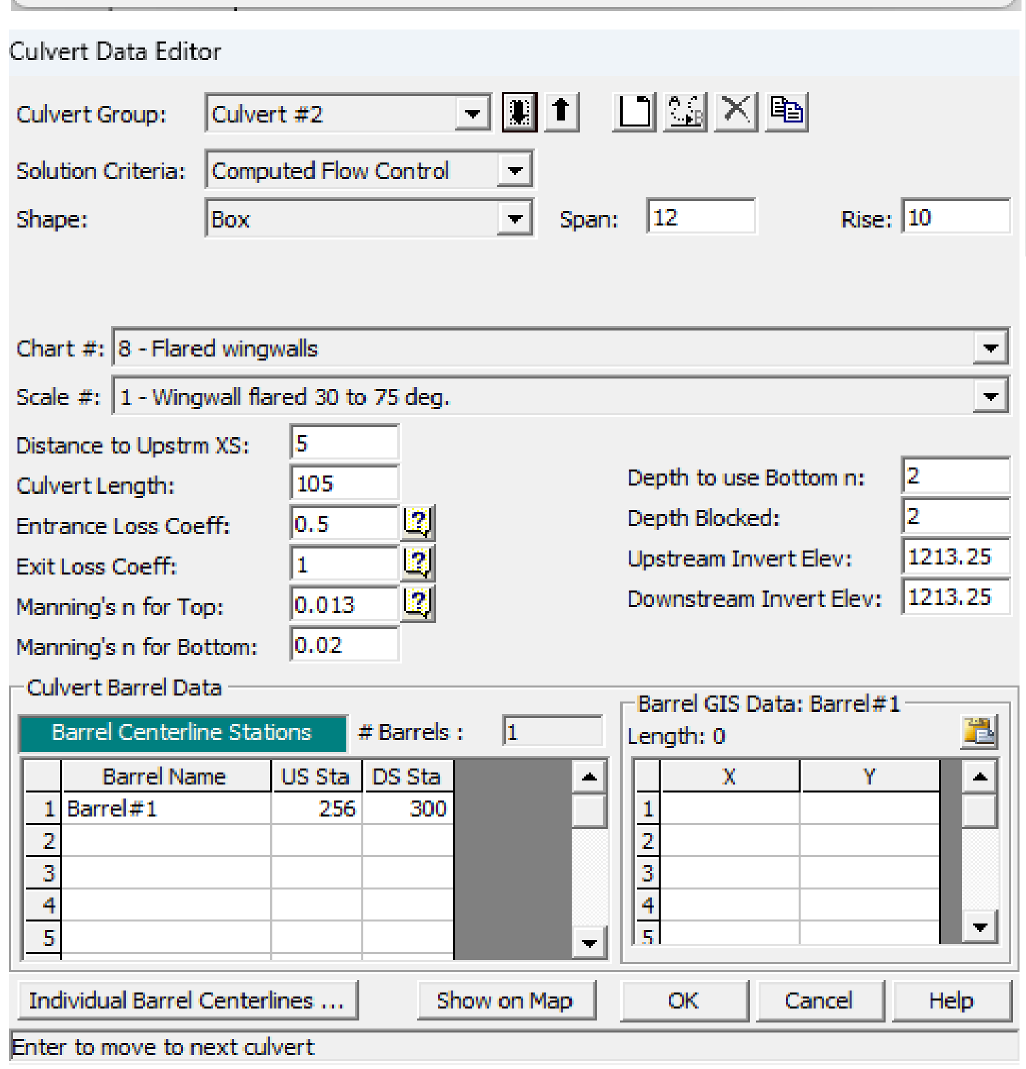
7.68	1225.63	9.85	1225.71
9.18	1225.69	11.35	1225.65
10.68	1225.59	14.35	1225.59
12.18	1225.68	15.82	1225.66
13.68	1225.58	17.36	1225.69
14.92	1225.65	18.96	1225.6
15.43	1225.65	20.36	1225.6
16.43	1225.61	21.86	1225.65
19.46	1225.6	23.36	1225.59
21.18	1225.54	24.62	1225.57
22.68	1225.65	26.36	1225.58
24.18	1225.62	29.72	1225.55
28.53	1225.62	30.48	1225.56
30.18	1225.59	32.36	1225.51
31.68	1225.59	33.86	1225.54
33.18	1225.53	35.36	1225.52
34.68	1225.56	36.86	1225.55
36.18	1225.53	38.36	1225.49
37.74	1225.56	39.86	1225.49
46.68	1225.56	41.36	1225.45
48.18	1225.53	42.86	1225.45
49.68	1225.56	44.36	1225.43
51.18	1225.56	45.86	1225.45
52.68	1225.53	47.36	1225.44
54.18	1225.56	50.36	1225.45
55.68	1225.5	53.37	1225.38
57.08	1225.53	54.87	1225.41
60.06	1225.47	56.37	1225.36
64.68	1225.47	57.87	1225.38
66.18	1225.5	59.37	1225.31
67.86	1225.5	60.87	1225.37
72.18	1225.44	62.37	1225.34
73.68	1225.46	63.87	1225.37
75.18	1225.46	65.37	1225.34
76.68	1225.43	66.87	1225.28
77.91	1225.45	68.37	1225.33
79.4	1225.43	69.66	1225.33
81.48	1225.45	73	1225.28
82.37	1225.41	74.47	1225.31
82.99	1225.42	77.4	1225.25
84.18	1225.46	78.88	1225.25
87.18	1225.41	80.41	1225.28
88.68	1225.48	81.95	1225.25
90.18	1225.41	83.37	1225.25
93.58	1225.47	84.87	1225.28
94.27	1225.45	87.87	1225.28
95.09	1225.44	89.37	1225.22
95.76	1225.45	90.88	1225.25
97.25	1225.43	92.38	1225.22
99.18	1225.46	93.88	1225.25
100.68	1225.45	96.88	1225.17
102.18	1225.41	99.88	1225.23
103.68	1225.45	101.38	1225.2
105.18	1225.46	105.88	1225.15
106.68	1225.4	108.88	1225.17
110.22	1225.46	110.38	1225.16
113.24	1225.44	111.88	1225.19
114.18	1225.46	113.38	1225.19
115.68	1225.53	114.88	1225.11
117.18	1225.46	116.38	1225.14
121.68	1225.49	117.88	1225.14
123.18	1225.52	119.38	1225.18
124.68	1225.46	120.88	1225.12
127.68	1225.5	122.38	1225.17









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136.68	1225.53	131.39	1225.16
138.18	1225.56	132.89	1225.12
141.88	1225.55	136.05	1225.12
144.85	1225.58	137.26	1225.15
147.18	1225.54	138.89	1225.12
148.68	1225.58	140.39	1225.15
150.18	1225.56	143.39	1225.16
151.68	1225.61	146.39	1225.1
153.18	1225.59	147.89	1225.16
154.68	1225.62	149.55	1225.13
156.75	1225.6	150.71	1225.16
159.18	1225.63	152.18	1225.13
160.68	1225.6	154.16	1225.14
165.18	1225.66	155.39	1225.16
167.17	1225.63	156.89	1225.08
168.18	1225.59	161.39	1225.2
172.68	1225.67	162.9	1225.18
175.26	1225.65	164.4	1225.13
180.56	1225.69	165.9	1225.19
181.68	1225.67	167.4	1225.18
183.18	1225.71	174.9	1225.27
183.54	1225.7	176.4	1225.22
184.33	1225.72	177.9	1225.2
185.84	1225.67	182.4	1225.3
187.68	1225.67	183.9	1225.28
189.18	1225.71	185.4	1225.32
190.68	1225.67	186.9	1225.31
193.68	1225.72	188.4	1225.37
195.18	1225.67	189.9	1225.32
196.68	1225.72	191.76	1225.32
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199.43	1225.79	194.4	1225.34
199.68	1225.8	196.16	1225.34
199.93	1225.79	197.17	1225.38
200.94	1225.71	198.9	1225.43
201.18	1225.7	200.41	1225.34
203.96	1225.75	201.91	1225.43
205.47	1225.73	203.41	1225.4
208.49	1225.73	207.91	1225.41
210.18	1225.76	212.29	1225.47
211.86	1225.76	213.91	1225.44
213.18	1225.84	215.41	1225.53
214.68	1225.78	216.91	1225.45
217.68	1225.78	218.41	1225.45
219.18	1225.84	219.91	1225.48
222.08	1225.78	221.75	1225.48
225.18	1225.84	222.55	1225.44
226.68	1225.81	222.91	1225.44
228.18	1225.88	224.83	1225.48
229.68	1225.82	225.91	1225.52
231.13	1225.84	227.41	1225.47
232.64	1225.84	228.91	1225.54
234.18	1225.78	230.41	1225.55
235.68	1225.91	234.91	1225.5
237.18	1225.84	236.42	1225.53
240.18	1225.84	237.92	1225.52
241.68	1225.81	240.92	1225.56
243.18	1225.84	242.42	1225.55
244.68	1225.81	243.92	1225.57
246.13	1225.87	245.42	1225.55
247.68	1225.87	247.48	1225.59
249.18	1225.9	248.94	1225.6
250.6	1225.85	249.41	1225.62
252.18	1225.82	251.87	1225.62
253.78	1225.85	252.48	1225.59
255.29	1225.9	253.34	1225.59
256.57	1225.85	254.01	1225.65
258.18	1225.82	254.42	1225.65
259.68	1225.85	255.92	1225.63
264.18	1225.85	257.42	1225.64
265.68	1225.9	258.92	1225.67
267.18	1225.88	260.42	1225.62
268.88	1225.87	261.92	1225.65
269.98	1225.83	264.92	1225.65
271.68	1225.82	266.42	1225.69
273.18	1225.88	270.92	1225.69
274.68	1225.85	272.42	1225.72
276.18	1225.89	273.99	1225.72
277.94	1225.87	275.33	1225.69
278.92	1225.89	278.6	1225.7
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281.9	1225.86	282.66	1225.73

283.39	1225.88	284.74	1225.73
285.18	1225.87	288.53	1225.78
286.68	1225.88	290.43	1225.76
288.18	1225.84	293.43	1225.79
290.02	1225.84	295.49	1225.77
290.84	1225.83	299.43	1225.83
291.53	1225.83	302.43	1225.8
292.68	1225.87	303.93	1225.84
294.18	1225.8	306.93	1225.88
295.68	1225.84	308.43	1225.84
298.68	1225.84	309.94	1225.86
300.18	1225.8	311.44	1225.86
302.1	1225.8	312.94	1225.8
303.18	1225.83	314.44	1225.86
304.68	1225.81	316.39	1225.88
306.18	1225.81	317.44	1225.91
307.68	1225.77	318.94	1225.89
309.18	1225.81	320.44	1225.9
310.68	1225.81	321.94	1225.87
312.18	1225.85	323.44	1225.9
315.18	1225.8	324.94	1225.85
316.68	1225.82	326.44	1225.9
318.18	1225.79	327.94	1225.9
321.18	1225.77	329.44	1225.88
322.68	1225.8	332.44	1225.88
324.18	1225.77	333.94	1225.91
325.68	1225.8	335.44	1225.84
327.18	1225.75	336.94	1225.91
328.68	1225.76	338.51	1225.88
330.18	1225.8	341.58	1225.87
337.68	1225.76	342.78	1225.85
339.18	1225.83	344.44	1225.88
340.68	1225.76	345.94	1225.94
343.68	1225.8	347.45	1225.86
346.68	1225.77	348.95	1225.88
349.68	1225.77	350.45	1225.85
352.68	1225.81	353.04	1225.84
354.18	1225.78	354.95	1225.8
357.19	1225.77	356.45	1225.82
358.69	1225.78	357.95	1225.88
360.19	1225.76	359.45	1225.84
361.69	1225.78	360.95	1225.89
363.19	1225.72	362.45	1225.82
364.69	1225.74	363.95	1225.85
367.69	1225.76	365.45	1225.81
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375.19	1225.77	380.45	1225.81
376.69	1225.77	381.95	1225.78
379.69	1225.69	383.46	1225.81
381.19	1225.72	387.96	1225.78
384.19	1225.69	390.96	1225.84
385.69	1225.71	393.82	1225.78
387.19	1225.67	396.96	1225.78
390.19	1225.7	398.46	1225.87
391.69	1225.68	399.96	1225.78
394.69	1225.67	401.42	1225.75
396.19	1225.62	402.89	1225.78
397.69	1225.63	404.36	1225.75
399.19	1225.59	405.96	1225.78
400.69	1225.63	407.29	1225.78
403.69	1225.63	407.64	1225.77
405.6	1225.65	408.96	1225.7
406.69	1225.63	410.46	1225.79
408.19	1225.57	411.96	1225.75
409.39	1225.59	414.96	1225.78
		416.46	1225.77
		417.96	1225.71
		419.46	1225.74
		420.97	1225.75
		422.47	1225.69
		423.97	1225.73
		425.47	1225.68
		426.97	1225.71
		428.47	1225.67
		429.97	1225.7
		432.97	1225.67
		435.97	1225.67
		437.47	1225.63
		438.97	1225.66
		441.01	1225.6
		446.47	1225.6
		447.97	1225.59
		449.47	1225.61

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452.47	1225.59
454.2	1225.56
458.48	1225.56
459.98	1225.5
462.98	1225.5
464.48	1225.53
467.48	1225.53
468.98	1225.5
470.48	1225.53
471.98	1225.5
473.48	1225.56
474.98	1225.51
476.2	1225.53
479.13	1225.52
483.98	1225.45
485.48	1225.47
486.98	1225.47
488.48	1225.44
492.99	1225.47
494.49	1225.44
496.72	1225.42
498.99	1225.45
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501.99	1225.46
503.49	1225.42
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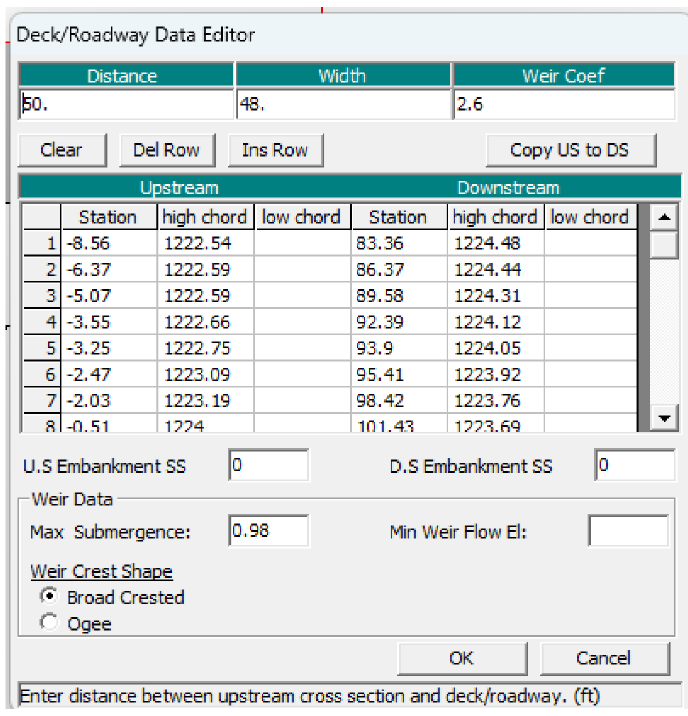
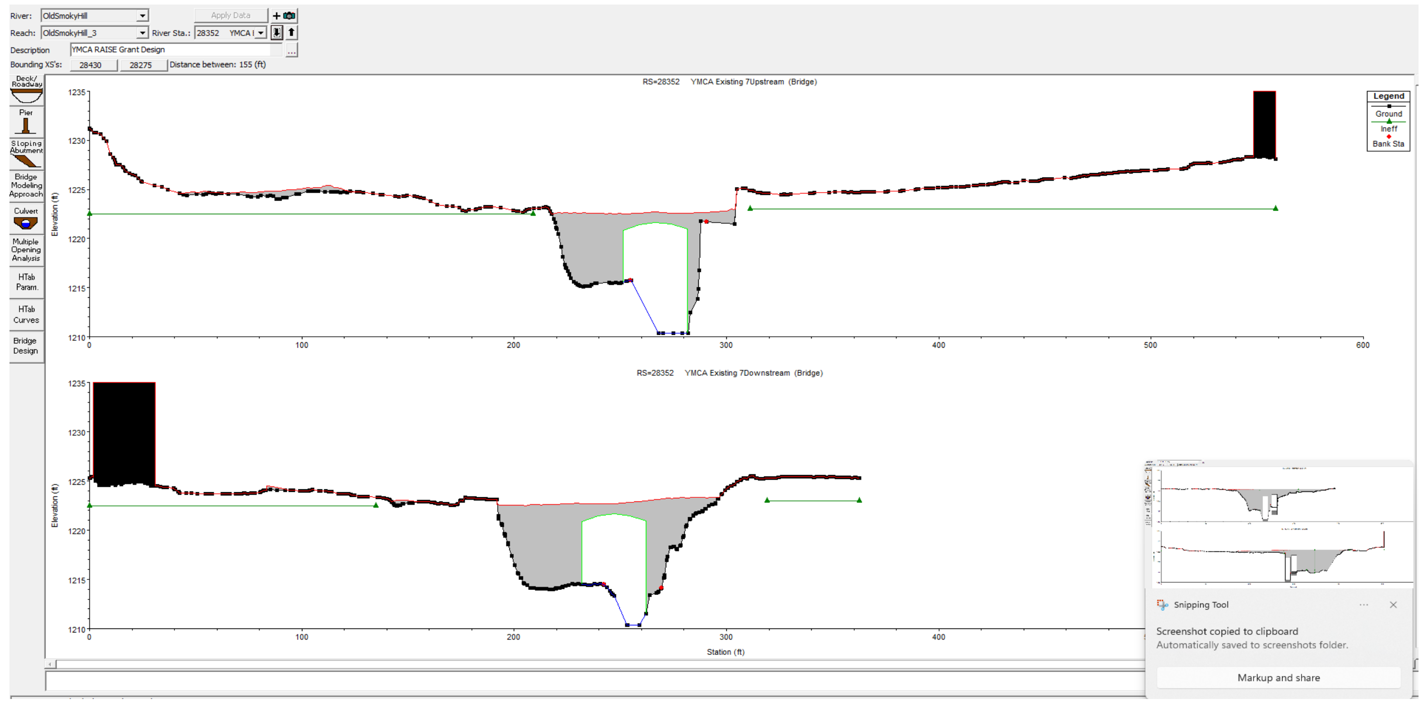
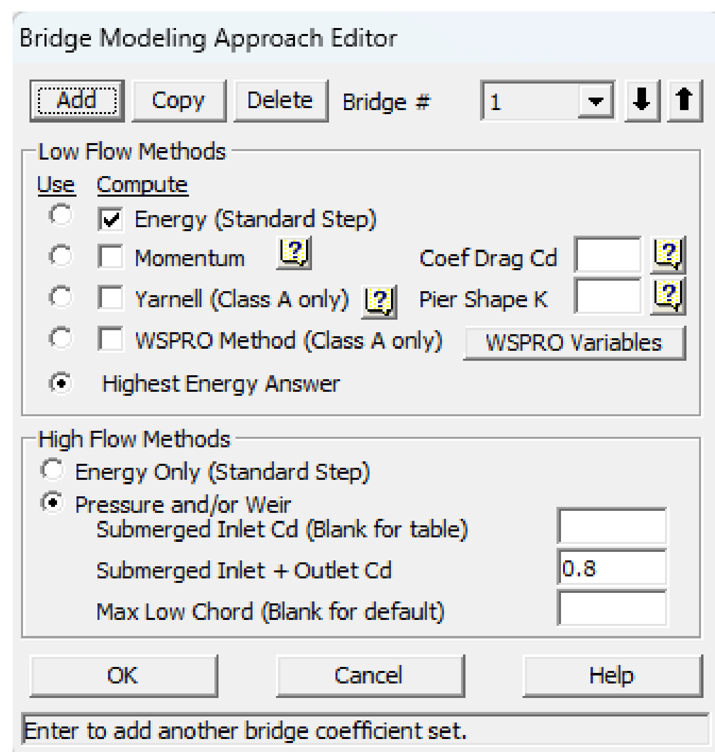
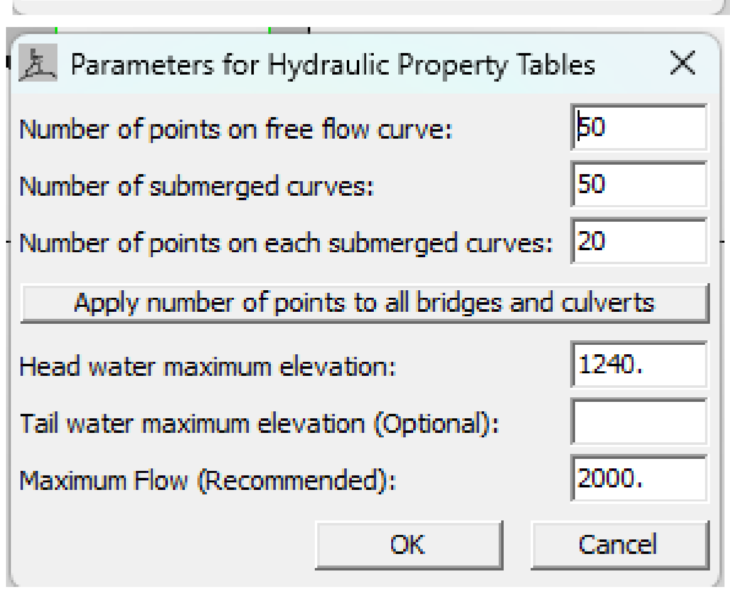
2) YMCA Drive









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-3.55	1222.66	92.39	1224.12
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-2.47	1223.09	95.41	1223.92
-2.03	1223.19	98.42	1223.76
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0.14	1224.24	102.94	1223.63
0.41	1224.38	104.44	1223.63
1.01	1224.64	106.14	1223.59
4.04	1224.69	107.52	1223.5
5.34	1224.63	108.9	1223.28
7.09	1224.59	110.47	1223.12
10.14	1224.59	111.66	1223.07
11.66	1224.56	113.04	1223.05
13.22	1224.59	116.49	1222.95
14.46	1224.57	118	1222.86
19.66	1224.68	121.01	1222.84
22.27	1224.69	122.52	1222.75
23.83	1224.66	124.03	1222.72
25.35	1224.66	125.53	1222.63
28.39	1224.71	131.56	1222.53
29.91	1224.66	133.06	1222.44
31.38	1224.69	135.11	1222.57
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34.48	1224.66	136.08	1222.61
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36	1224.64	139.09	1222.79
37.52	1224.58	141.06	1222.89
39.19	1224.56	144.77	1223.02
40.49	1224.56	146.62	1223.04
43.6	1224.63	148.13	1223.04
47	1224.66	149.63	1223.06
48.17	1224.73	151.14	1222.95
51.21	1224.65	154.15	1222.88
52.73	1224.78	155.81	1222.81
54.25	1224.82	157.19	1222.72
55.77	1224.77	158.67	1222.72
57.41	1224.66	161.68	1222.54
60.34	1224.65	163.19	1222.5
61.86	1224.61	164.7	1222.56
65.22	1224.6	170.72	1222.56
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69.12	1224.66	176.52	1222.51
72.51	1224.74	176.93	1222.52
74.03	1224.68	178.23	1222.62

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77.07	1224.67	181.23	1222.63	
78.59	1224.71	182.73	1222.59	
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86.41	1224.82	187.52	1222.57	
89.24	1224.86	188.43	1222.58	
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95.56	1224.95	194.38	1222.55	
96.84	1224.98	196.23	1222.55	
98.37	1225.05	197.73	1222.53	
99.89	1225.07	199.23	1222.56	
101.05	1225.11	200.73	1222.52	
101.67	1225.13	202.23	1222.56	
102.93	1225.22	203.73	1222.56	
104.27	1225.14	205.23	1222.48	
105.97	1225.19	208.23	1222.62	
108.17	1225.19	211.23	1222.59	
109.01	1225.21	212.73	1222.54	
109.47	1225.27	214.23	1222.61	
110.2	1225.31	215.73	1222.6	
110.54	1225.34	219.27	1222.62	
112.06	1225.41	220.23	1222.61	
113.58	1225.39	223.23	1222.71	
115.1	1225.16	224.73	1222.68	
116.62	1225.22	226.23	1222.67	
118.14	1225.12	227.73	1222.69	
119.66	1224.95	229.23	1222.74	
123.79	1224.75	232.01	1222.7	
125.75	1224.63	232.01	1222.7	1220.85
127.27	1224.6	239.51	1222.7	1221.44
128.79	1224.61	247.01	1222.7	1221.65
130.31	1224.56	254.51	1222.85	1221.48
131.6	1224.47	262.01	1223	1220.94
134.87	1224.33	262.01	1223	
138.11	1224.1	263.73	1223.07	
139.41	1224.06	265.23	1223.06	
142.48	1223.78	266.73	1223.12	
144.62	1223.75	268.23	1223.13	
147.22	1223.63	269.73	1223.19	
148.57	1223.63	272.73	1223.24	
150.09	1223.59	274.23	1223.21	
151.61	1223.54	275.73	1223.27	
152.43	1223.47	277.23	1223.28	
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159.6	1223	286.64	1223.32	
162.26	1222.86	287.33	1223.3	
165.3	1222.84	289.23	1223.32	
166.82	1222.75	290.73	1223.27	
168.34	1222.71	292.23	1223.34	
169.86	1222.63	294.89	1223.3	
175.93	1222.53	295.57	1223.31	
177.43	1222.44	296.4	1223.36	
179.05	1222.56	297.06	1223.36	
180.43	1222.6	298.54	1223.34	
181.93	1222.78	300.03	1223.29	
183.43	1222.78	300.94	1223.33	
184.93	1222.88	301.52	1223.33	
189.2	1223.02	303.01	1223.34	
193.64	1223.07	304.5	1223.33	
194.23	1223.05	305.73	1223.37	
195.43	1222.96	306.98	1223.35	
196.61	1222.92	308.96	1223.35	
198.43	1222.89	310.01	1223.37	
199.93	1222.83	311.73	1223.38	
201.43	1222.8	313.23	1223.3	
202.93	1222.7	316.23	1223.32	
205.51	1222.61	317.73	1223.28	
207.43	1222.49	319.23	1223.34	

208.93	1222.51	
210.43	1222.46	
211.93	1222.52	
213.43	1222.52	
214.93	1222.56	
216.43	1222.55	
217.93	1222.5	
220.94	1222.63	
222.44	1222.58	
223.94	1222.62	
226.94	1222.57	
228.44	1222.63	
229.94	1222.56	
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244.94	1222.54	
246.44	1222.51	
247.94	1222.51	
249.44	1222.54	
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251.44	1222.5	
251.44	1222.5	1220.85
258.94	1222.6	1221.44
266.44	1222.7	1221.65
273.94	1222.6	1221.48
281.44	1222.57	1220.94
281.44	1222.57	
282.44	1222.57	
283.94	1222.6	
285.44	1222.66	
286.81	1222.63	
288.44	1222.63	
289.94	1222.66	
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305.02	1223.03	
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315.24	1223.21	
317.16	1223.22	
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321.44	1223.26	
322.94	1223.31	
324.44	1223.28	
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337.49	1223.33	
341.94	1223.35	
344.9	1223.3	
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352.94	1223.33	
354.44	1223.3	
355.94	1223.31	

320.73	1223.34
322.23	1223.31
326.82	1223.32
328.16	1223.34
329.73	1223.34
331.23	1223.31
334.26	1223.31
335.73	1223.34
337.23	1223.28
338.73	1223.34
341.7	1223.34
344.73	1223.41
346.23	1223.37
347.73	1223.41
350.63	1223.35
352.3	1223.38

357.44	1223.26
358.94	1223.25
360.44	1223.28
361.94	1223.25
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381.45	1223.28
382.95	1223.29
384.45	1223.34
385.95	1223.32
387.45	1223.35
388.95	1223.31
390.45	1223.38
392.48	1223.35
394.95	1223.38
399.45	1223.33
401.98	1223.4
404.39	1223.41
405.88	1223.39
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411.05	1223.47
411.45	1223.48
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412.56	1223.45
414.45	1223.45
415.95	1223.5
417.45	1223.47
419.28	1223.5
421.95	1223.51
423.45	1223.53
425.24	1223.52
426.45	1223.48
427.95	1223.55
429.18	1223.53
435.45	1223.54
437.15	1223.51
438.45	1223.56
439.95	1223.5
441.45	1223.56
443.11	1223.57
444.45	1223.59
445.95	1223.56
447.31	1223.56
449.07	1223.57
451.95	1223.63
453.36	1223.6
454.95	1223.6
456.51	1223.63
462.45	1223.63
463.95	1223.66
465.45	1223.66
468.45	1223.72
469.95	1223.63
472.95	1223.69
475.95	1223.62
477.45	1223.66
480.34	1223.66
481.95	1223.62
486.45	1223.63
487.79	1223.68
490.95	1223.65
492.45	1223.71
495.45	1223.71
496.95	1223.69
498.45	1223.69
499.95	1223.71

501.45	1223.68
502.95	1223.72
505.95	1223.69
507.45	1223.71
508.95	1223.69
510.45	1223.69
511.95	1223.71
513.45	1223.71
514.95	1223.69
516.45	1223.71
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523.95	1223.74
525.45	1223.7
526.95	1223.74
528.45	1223.71
529.95	1223.76
532.46	1223.73
534.45	1223.74
535.95	1223.72
539.91	1223.75
546.45	1223.76
547.95	1223.75
549.45	1223.8
552.45	1223.83
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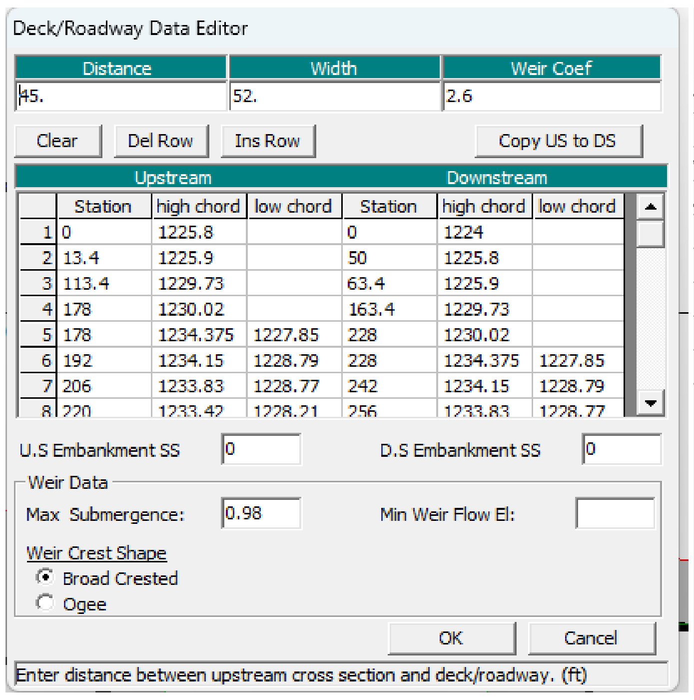
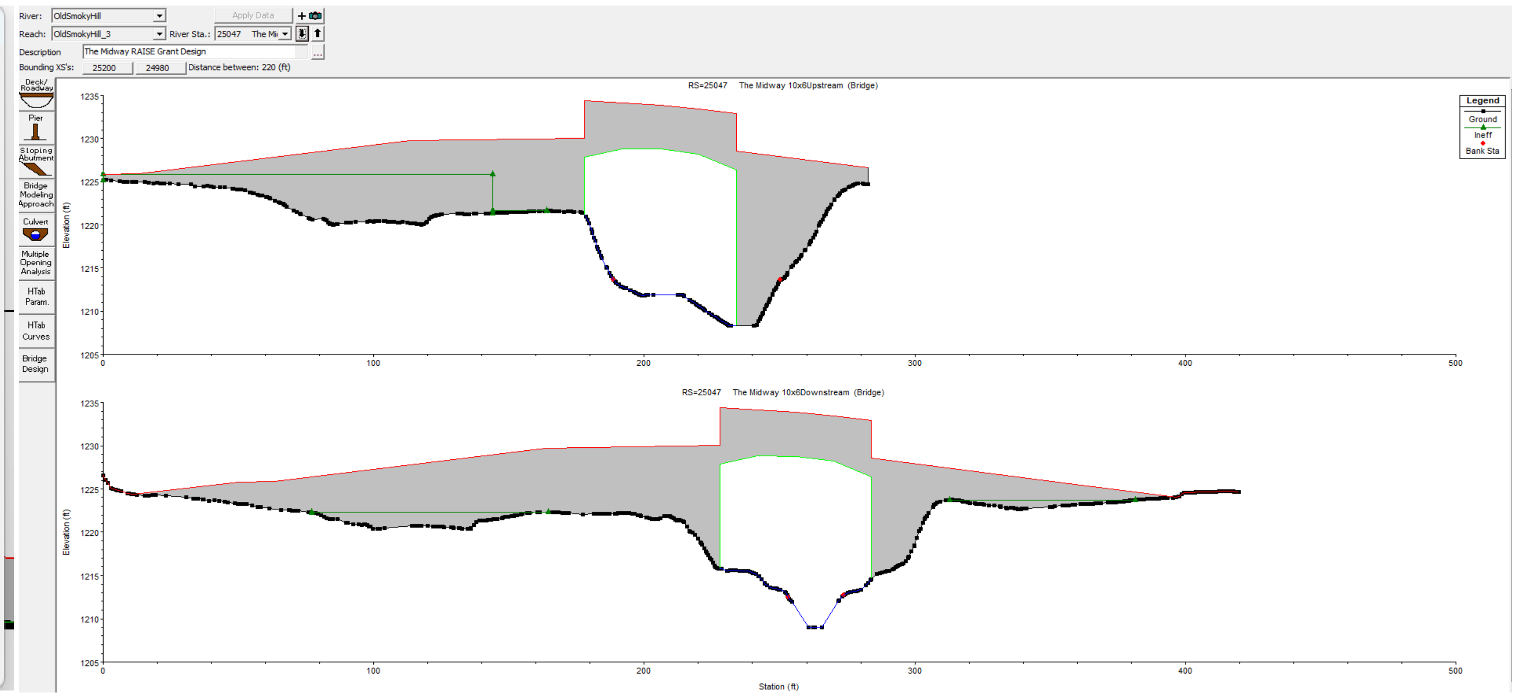
555.45	1223.83
557.78	1223.85
559.95	1223.84
562.16	1223.88

3) The Midway





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178	1234.375	1227.85	228	1230.02	
192	1234.15	1228.79	228	1234.375	1227.85
206	1233.83	1228.77	242	1234.15	1228.79
220	1233.42	1228.21	256	1233.83	1228.77
234	1232.9	1226.35	270	1233.42	1228.21
234	1228.56		284	1232.9	1226.35
313.6	1225.375		284	1228.56	
314.54	1221.76		363.6	1225.375	
315.73	1221.81		400.69	1223.87	
316.4	1221.79		402.66	1224.08	
317.45	1221.75		403.91	1224.19	
318.61	1221.84		404.51	1224.26	
319.17	1221.86		404.98	1224.29	
320.67	1221.88		405.63	1224.27	
321.91	1221.84		406.37	1224.23	
322.61	1221.86		407.13	1224.23	
324.12	1221.92		408.21	1224.28	
326.05	1221.84		409.31	1224.23	
327.77	1221.88				
329.87	1221.82				
331.83	1221.9				
334.03	1221.84				
336.37	1221.81				
337.34	1221.82				
339.07	1221.8				
341.53	1221.82				
343.25	1221.73				
343.95	1221.73				
344.97	1221.78				
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348.41	1221.69				
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352.77	1221.67				
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353.87	1221.62				
355.29	1221.68				
358.27	1221.61				
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374.8	1221.52				
377.01	1221.49				
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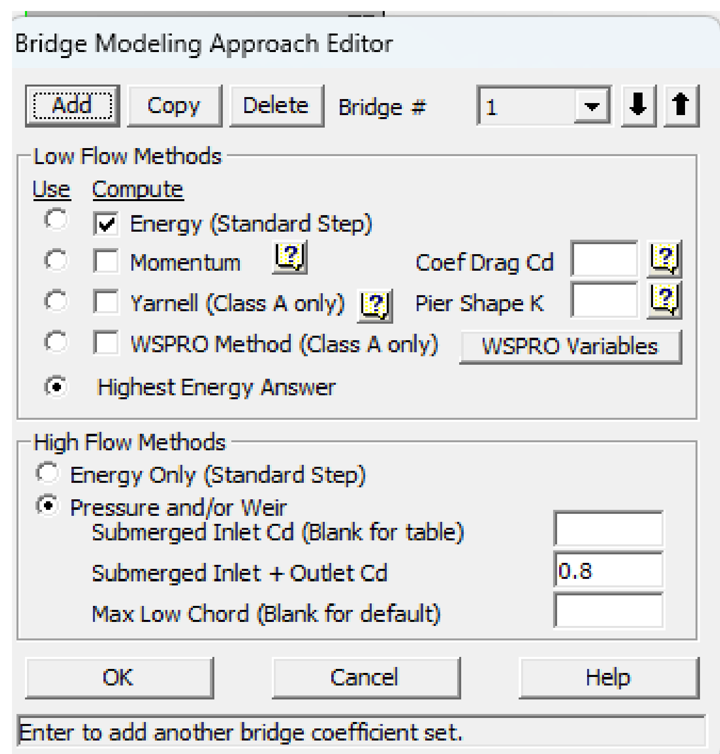

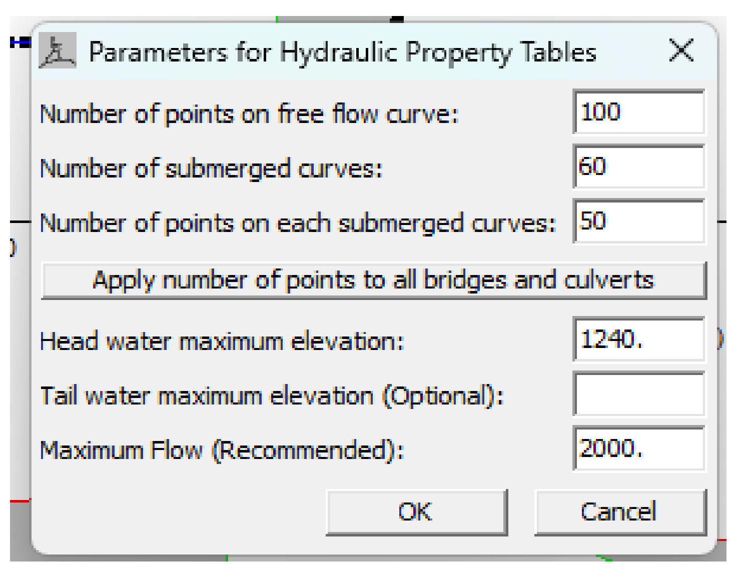

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392.43	1222.27
396.56	1222.41
398.28	1222.43
400	1222.46
401.72	1222.53
404.55	1222.53
405.66	1222.5
409.61	1222.59
412.27	1222.68
413.76	1222.77
414.47	1222.8
415.48	1222.8
416.67	1222.86
418.88	1222.91
419.98	1222.97
423.29	1223.06
425.79	1223.16
428.79	1223.23
429.9	1223.29
431.08	1223.31
432.67	1223.28
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437.83	1223.42
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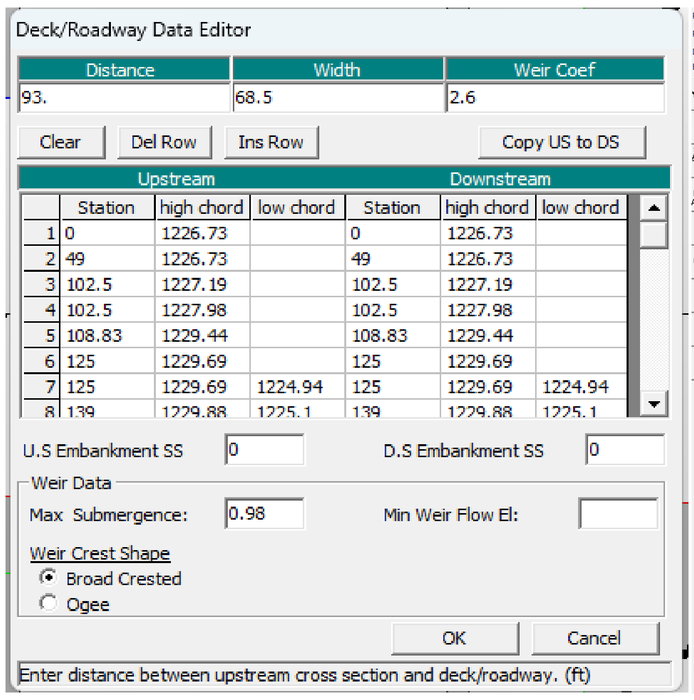
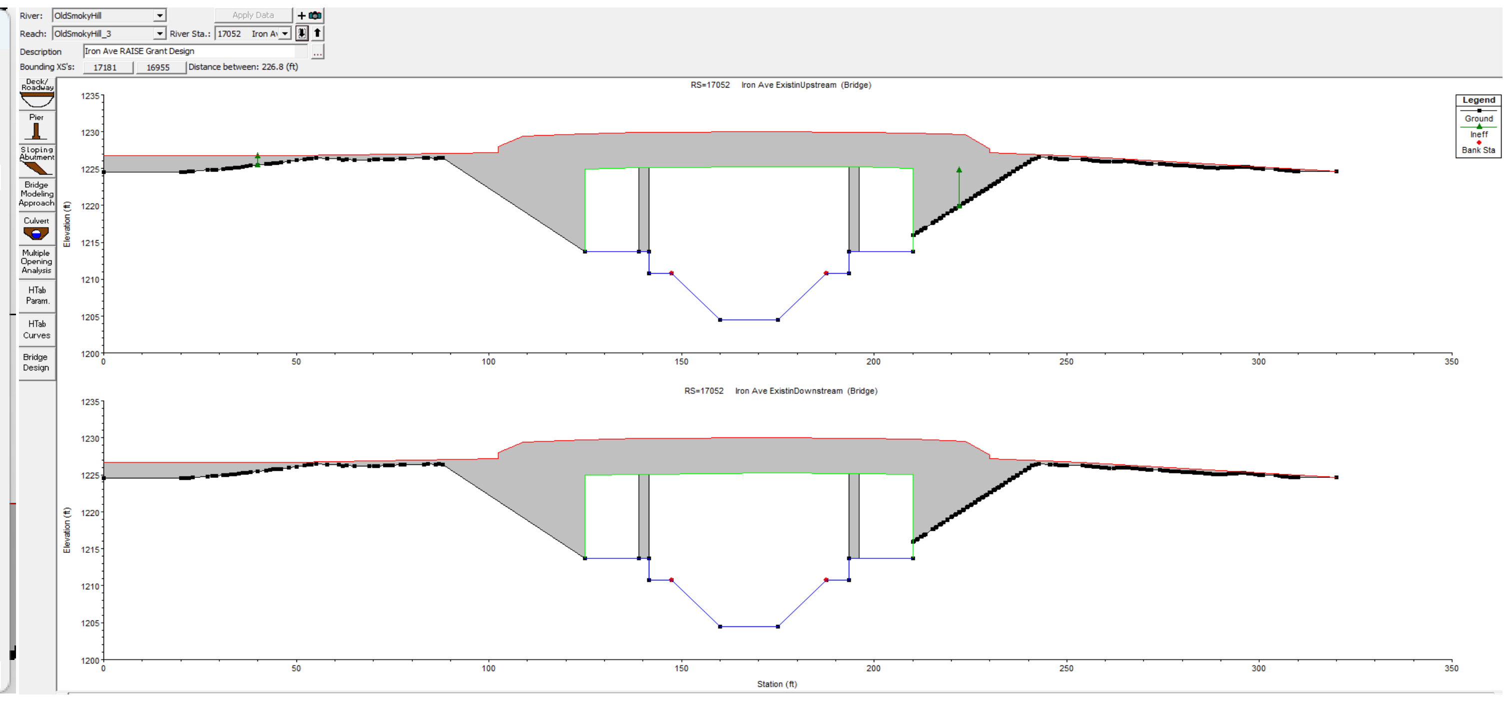
440.64	1223.43

4) Iron Avenue





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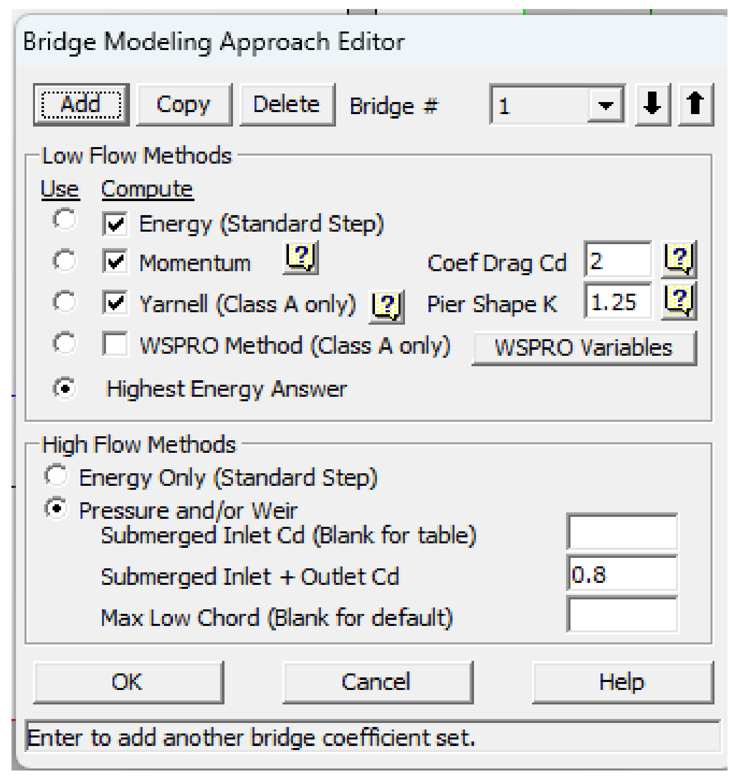
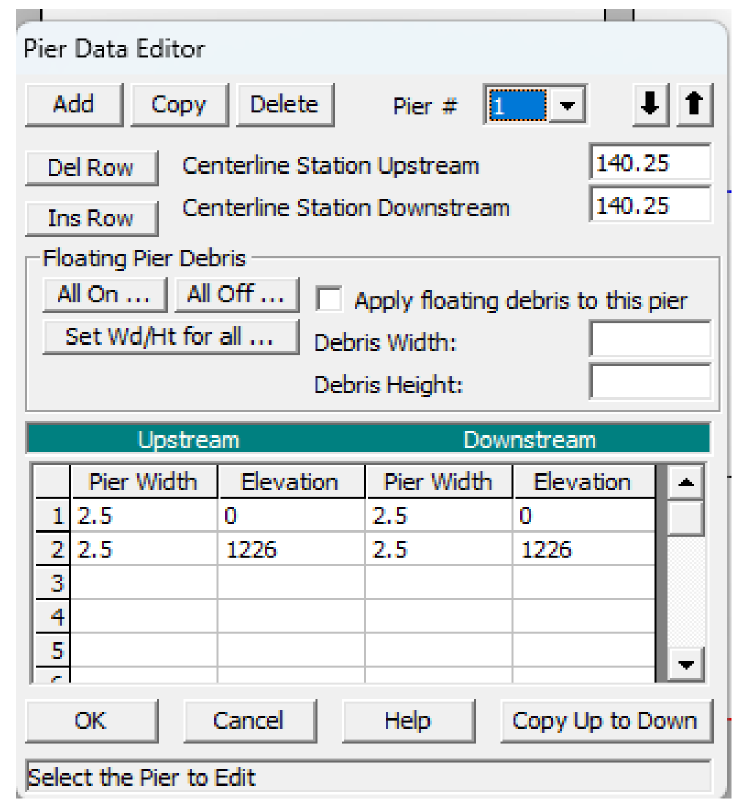
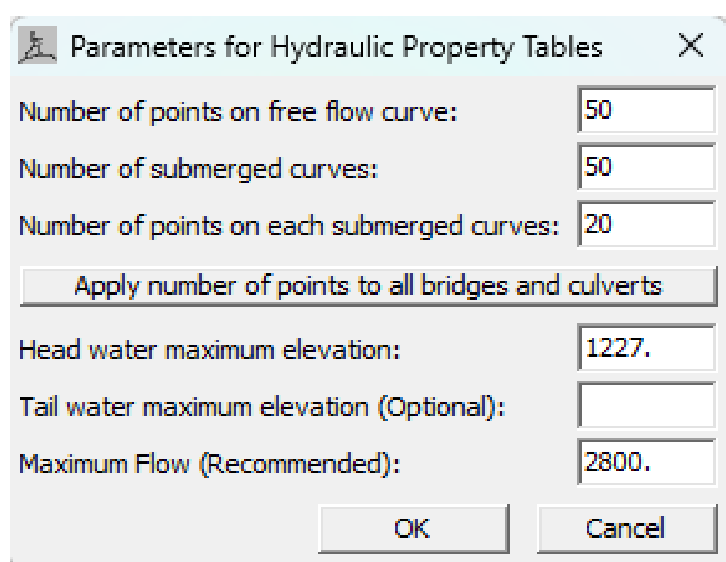
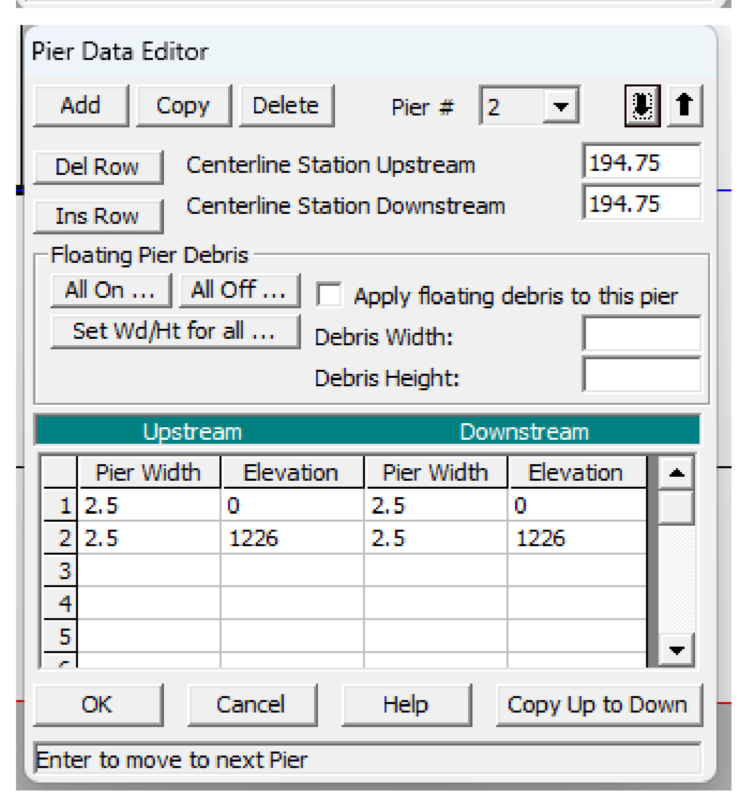
102.5	1227.98		102.5	1227.98	
108.83	1229.44		108.83	1229.44	
125	1229.69		125	1229.69	
125	1229.69	1224.94	125	1229.69	1224.94
139	1229.88	1225.1	139	1229.88	1225.1
141.5	1229.88	1225.1	141.5	1229.88	1225.1
174	1230.02	1225.27	174	1230.02	1225.27
193.5	1229.94	1225.19	193.5	1229.94	1225.19
196	1229.94	1225.19	196	1229.94	1225.19
210	1229.79	1225.04	210	1229.79	1225.04
210	1229.79		210	1229.79	
223.6	1229.56		223.6	1229.56	
230	1227.65		230	1227.65	
230	1227.17		230	1227.17	
253.4	1226.67		253.4	1226.67	
320	1224.66		320	1224.66	

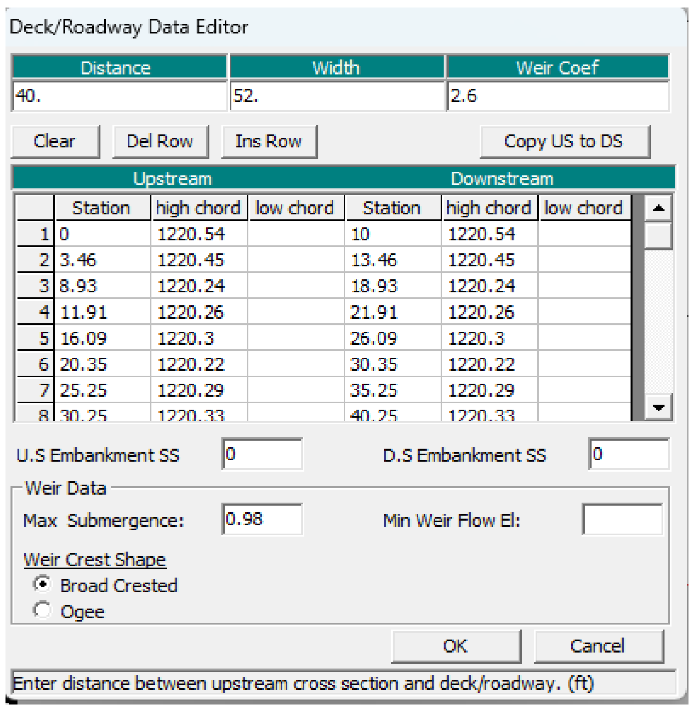


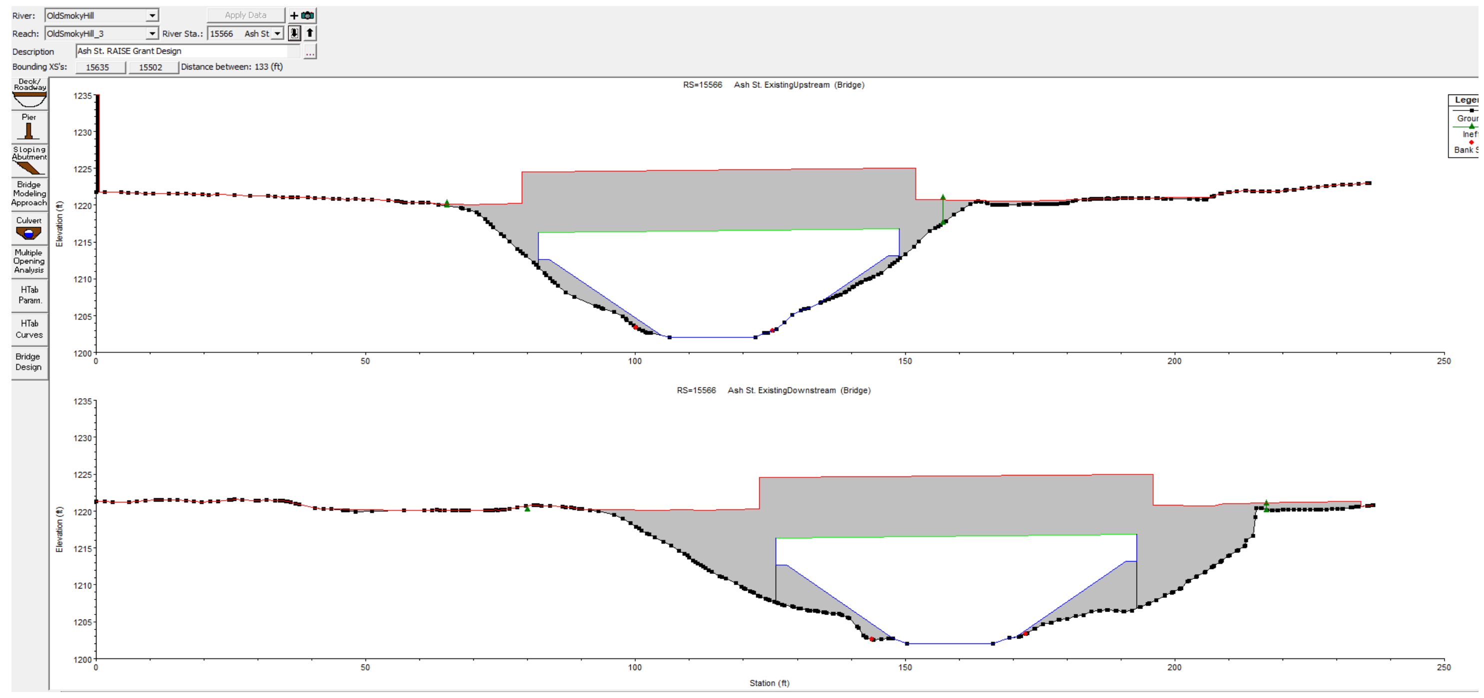






5) Ash Street





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8.93	1220.24		18.93	1220.24	
11.91	1220.26		21.91	1220.26	
16.09	1220.3		26.09	1220.3	
20.35	1220.22		30.35	1220.22	
25.25	1220.29		35.25	1220.29	
30.25	1220.33		40.25	1220.33	
39.74	1220.15		49.74	1220.15	
54.18	1219.95		64.18	1219.95	
61.51	1220.1		71.51	1220.1	
66.09	1220.15		76.09	1220.15	
67.86	1220.1		77.86	1220.1	
68.32	1220.06		86.25	1220.24	
78.9	1220.26		90.79	1220.23	
78.9	1224.53		95.8	1220.21	
82	1224.53		103.84	1220.07	
82	1224.53	1216.32	109.13	1220.17	
148.9	1224.98	1216.8	112.32	1220.06	
148.9	1224.98		122.9	1220.26	
152	1224.98		122.9	1224.53	
152	1220.78		126	1224.53	
163.1	1220.65		126	1224.53	1216.32
166.99	1220.55		192.9	1224.98	1216.8
172.53	1220.57		192.9	1224.98	
182.63	1220.73		196	1224.98	
186.47	1220.75		196	1220.78	
188.84	1220.81		207.1	1220.65	
195.92	1220.85		209.15	1221.04	
199.15	1221.04		218.8	1221.09	
208.8	1221.09		219.82	1221.16	
209.82	1221.16		223.63	1221.24	
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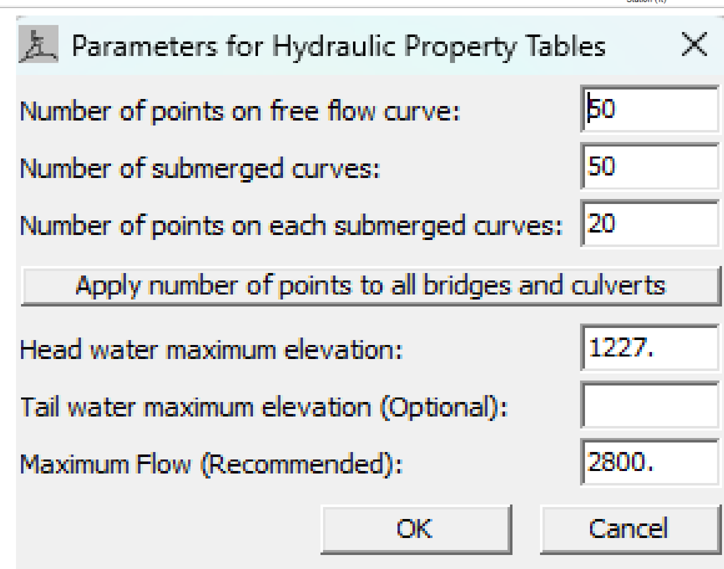
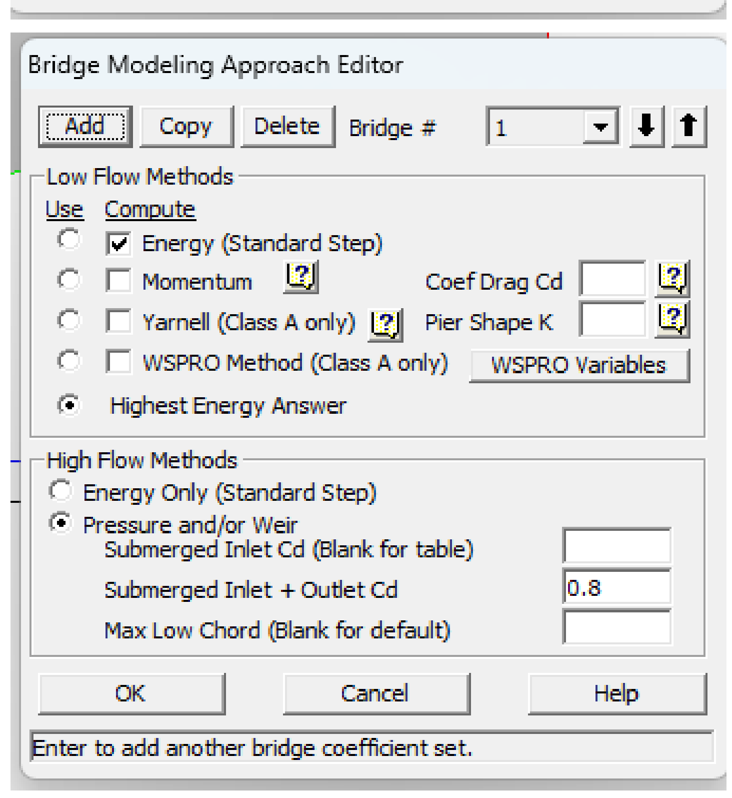
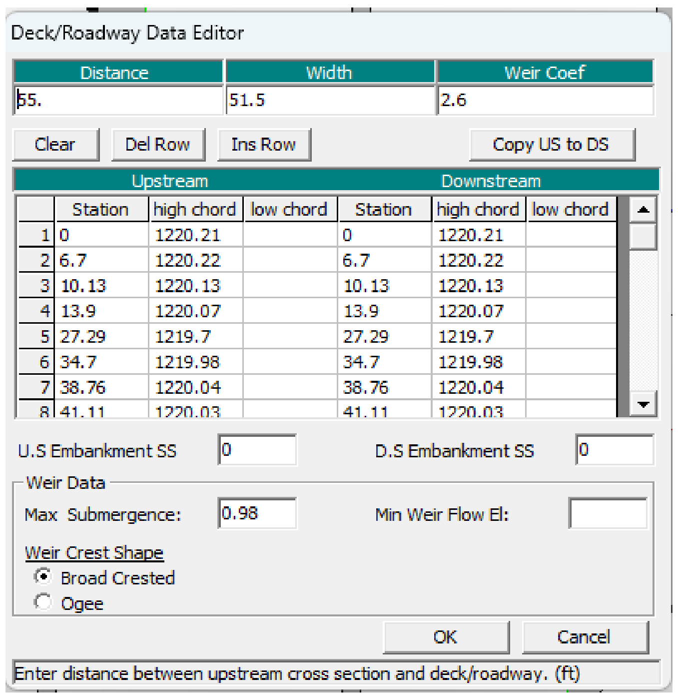
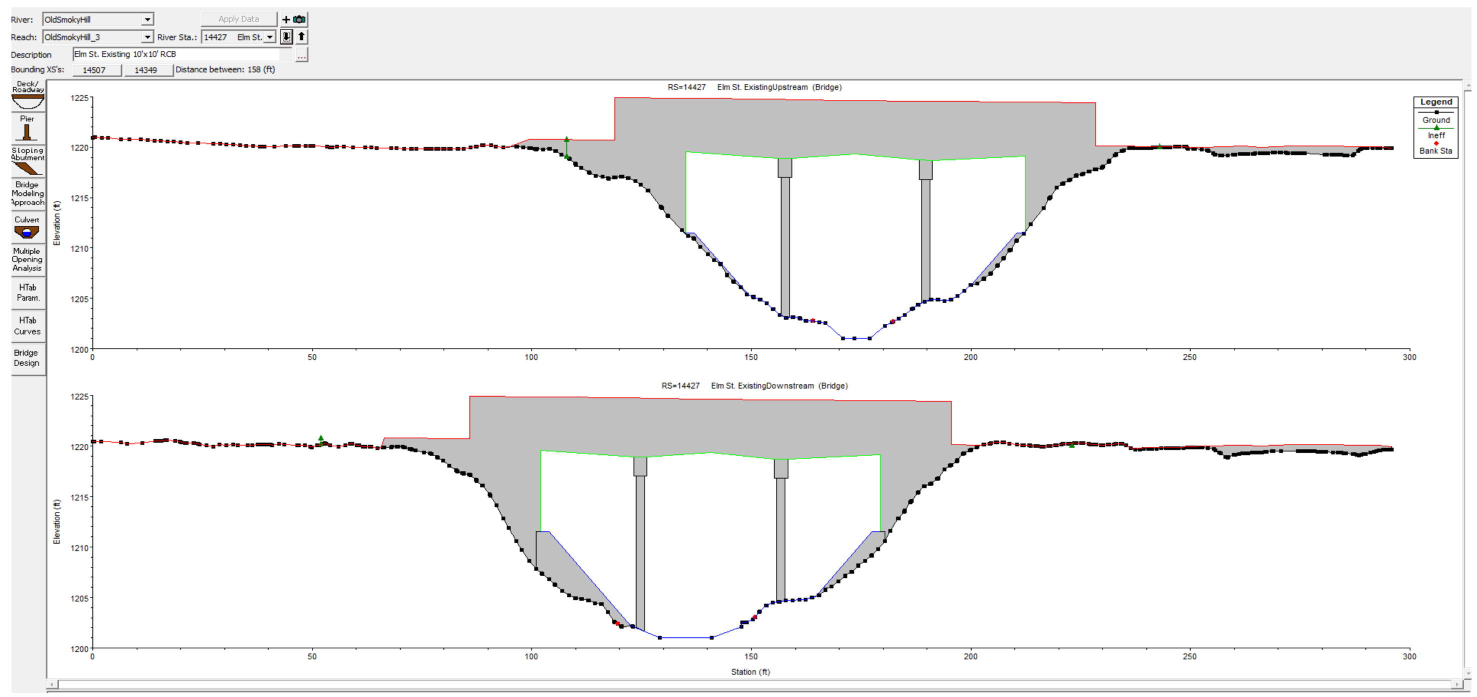


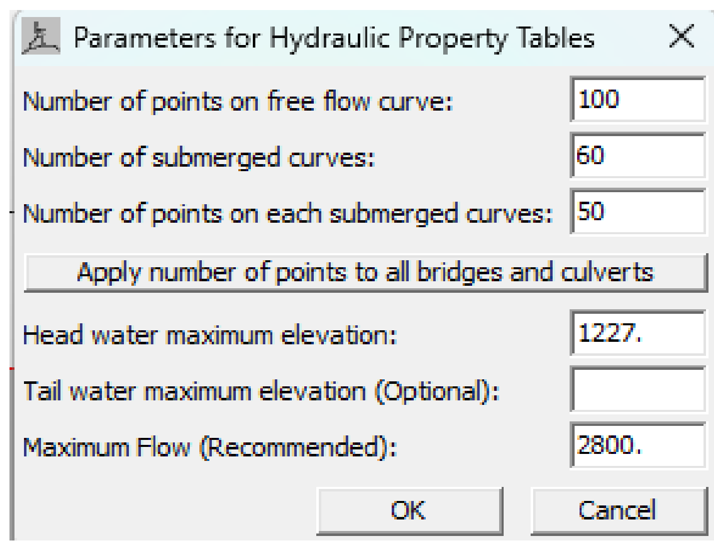


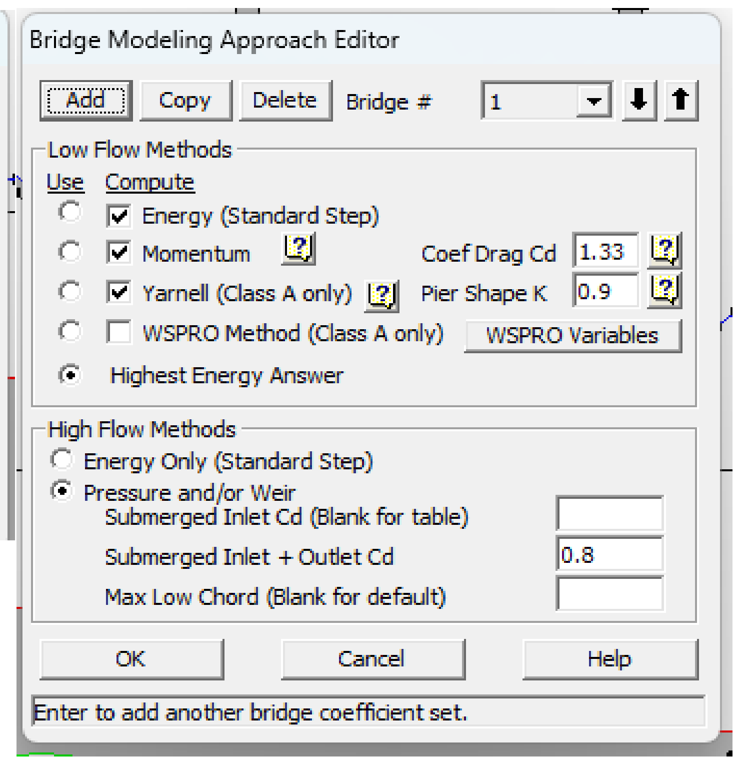
SLOPING ABUTMENT			
82	1212.64	126	1212.64
84	1212.64	128	1212.64
114	1197.64	158	1197.64
116.9	1198.15	160.9	1198.15
146.9	1213.15	190.9	1213.15
148.9	1213.15	192.9	1213.15

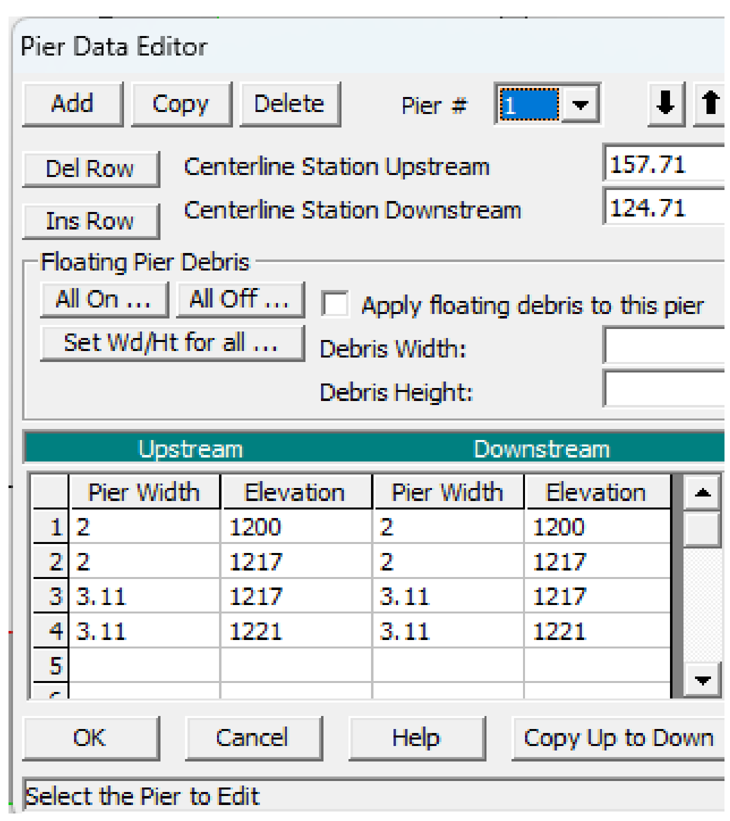
6) Elm Street

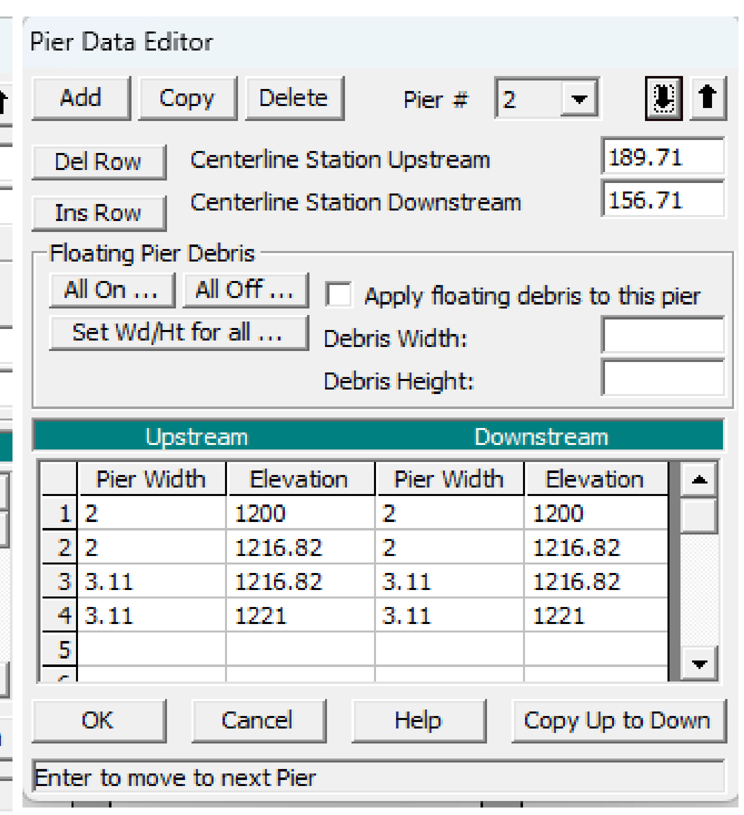












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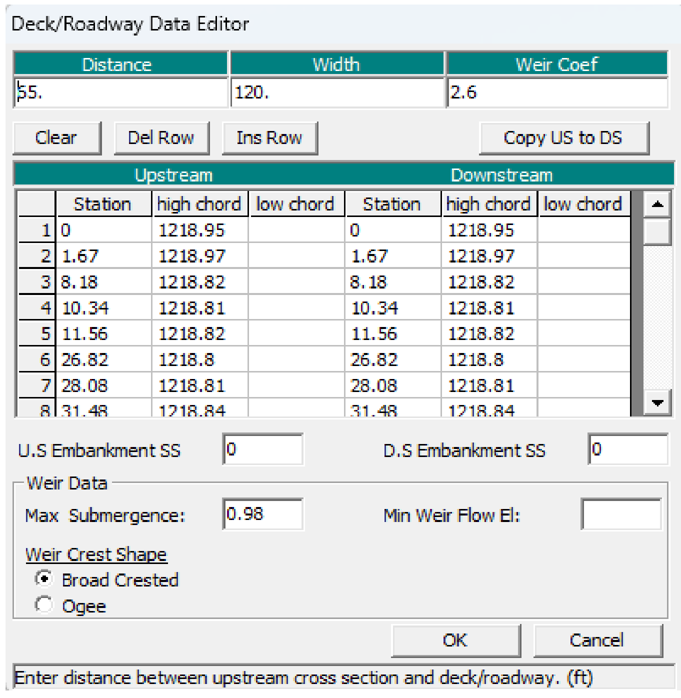
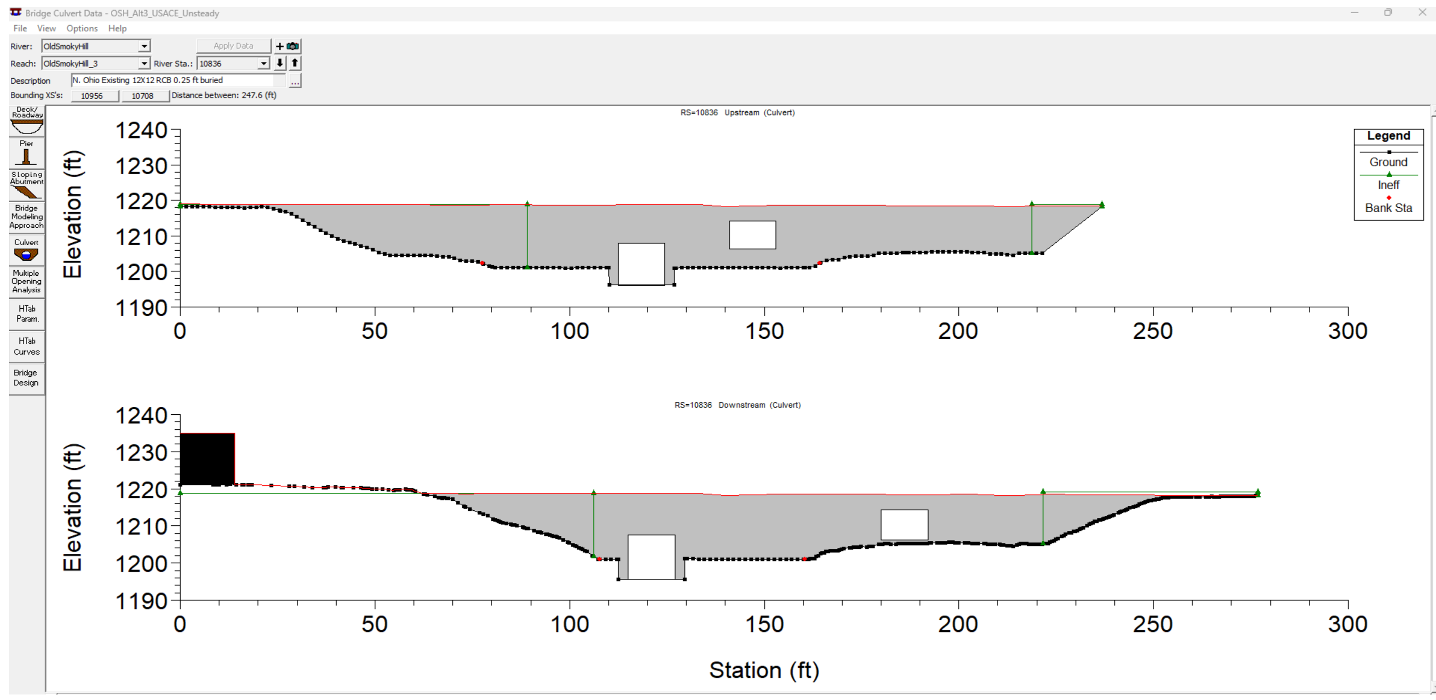
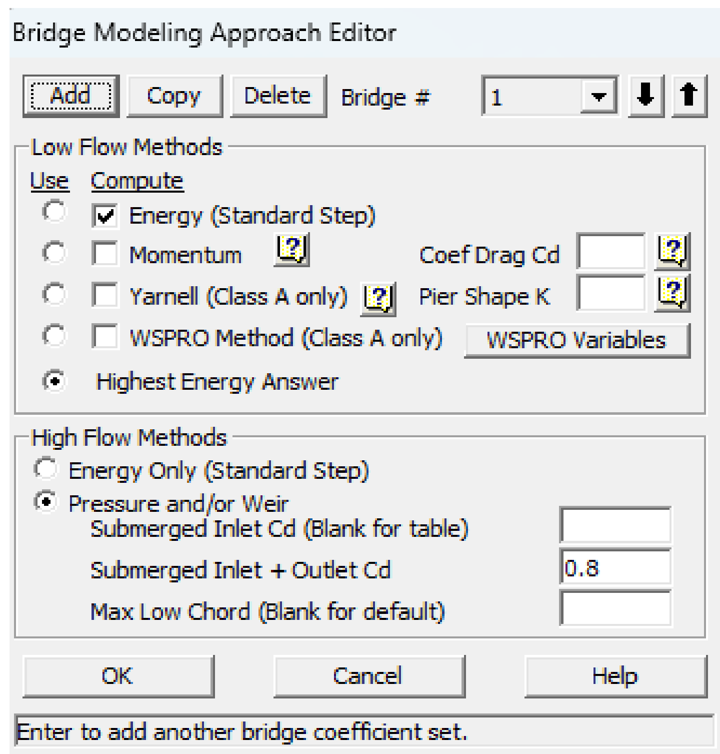
10.13	1220.13		10.13	1220.13	
13.9	1220.07		13.9	1220.07	
27.29	1219.7		27.29	1219.7	
34.7	1219.98		34.7	1219.98	
38.76	1220.04		38.76	1220.04	
41.11	1220.03		41.11	1220.03	
54.13	1219.86		54.13	1219.86	
54.99	1219.86		54.99	1219.86	
56.77	1219.79		56.77	1219.79	
65.57	1219.61		65.57	1219.61	
67.62	1219.61		66.35	1220.81	
80.77	1219.3		85.95	1220.71	
92.44	1219.59		85.95	1224.95	
99.35	1220.81		102	1224.87	
118.95	1220.71		102	1224.87	1219.54
118.95	1224.95		123.15	1224.76	1218.89
135	1224.87		126.26	1224.74	1218.88
135	1224.87	1219.54	140.71	1224.66	1219.33
156.15	1224.76	1218.89	155.15	1224.59	1218.72
159.26	1224.74	1218.88	158.259	1224.57	1218.71
173.71	1224.66	1219.33	179.41	1224.46	1219.13
188.15	1224.59	1218.72	179.41	1224.46	
191.259	1224.57	1218.71	195.46	1224.39	
212.41	1224.46	1219.13	195.46	1220.12	
212.41	1224.46		214.78	1220.02	
228.46	1224.39		217.2	1219.5	
228.46	1220.12		223.1	1219.71	
247.78	1220.02		231.87	1219.81	
253.12	1219.99		235.54	1219.8	
262.06	1220.1		242.48	1219.84	
265.98	1219.97		244.48	1219.83	
272.99	1220.13		246.87	1219.86	
277.15	1220.11		253.12	1219.99	
292.55	1220.08		262.06	1220.1	
292.64	1220.08		265.98	1219.97	
292.69	1220.07		272.99	1220.13	
292.71	1220.07		277.15	1220.11	
295.83	1219.92		292.55	1220.08	
			292.64	1220.08	
			292.69	1220.07	
			292.71	1220.07	
			295.83	1219.92	

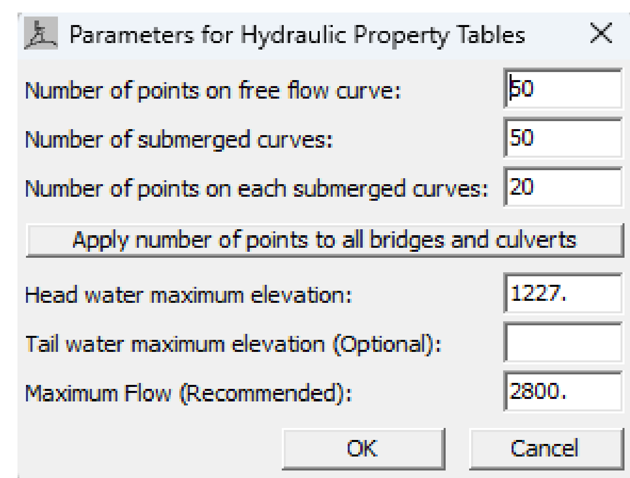
SLOPING ABUTMENT			
134	1211.5	101	1211.5
137	1211.5	104	1211.5
167	1196.5	134	1196.5
180.41	1196.5	147.41	1196.5
210.41	1211.5	177.41	1211.5
213.41	1211.5	180.41	1211.5

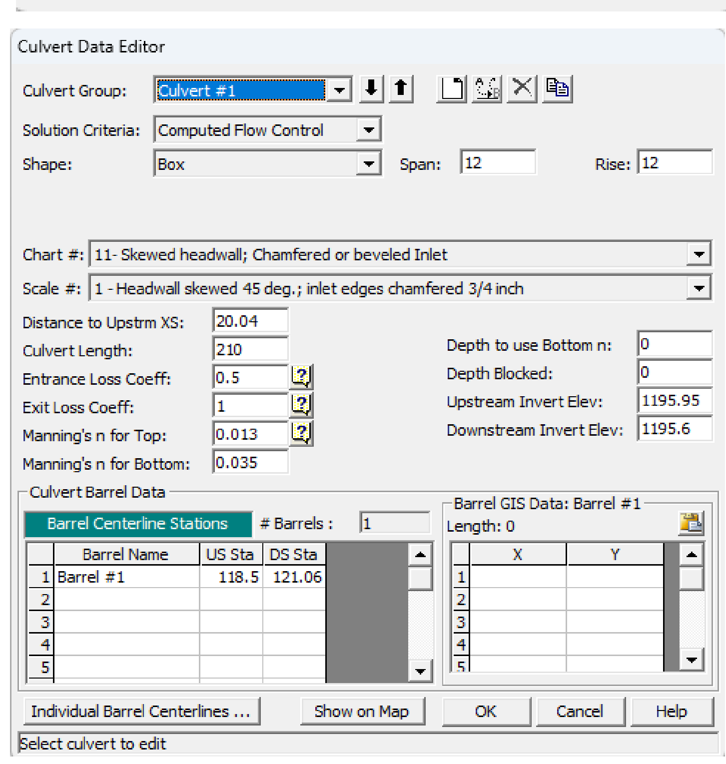
7) North Ohio Street

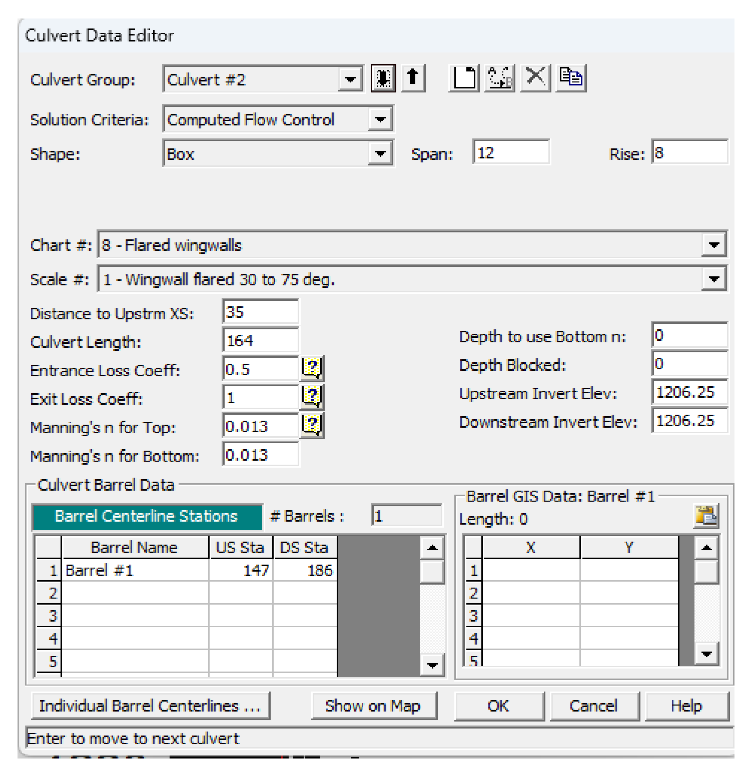












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1.67	1218.97	1.67	1218.97
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26.82	1218.8	26.82	1218.8
28.08	1218.81	28.08	1218.81
31.48	1218.84	31.48	1218.84
40.27	1218.88	40.27	1218.88
48.99	1218.84	48.99	1218.84
51.9	1218.83	51.9	1218.83
58.05	1218.78	58.05	1218.78
70.16	1218.71	70.16	1218.71
72.69	1218.66	72.69	1218.66
74.42	1218.66	74.42	1218.66
76.48	1218.68	76.48	1218.68
82.7	1218.84	82.7	1218.84
84.21	1218.84	84.21	1218.84
84.51	1218.85	84.51	1218.85
96.13	1218.67	96.13	1218.67
106.31	1218.7	106.31	1218.7
108.12	1218.69	108.12	1218.69
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133.29	1218.73	133.29	1218.73
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155.55	1218.64	155.55	1218.64
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185.35	1218.4	185.35	1218.4
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203.23	1218.52	203.23	1218.52
206.53	1218.47	206.53	1218.47
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240.64	1218.32	240.64	1218.32
260.03	1218.12	260.03	1218.12
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264.29	1218.18	264.29	1218.18
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297.31	1217.86	297.31	1217.86
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298.08	1217.86	298.08	1217.86
298.2	1217.86	298.2	1217.86

309.48	1217.9		309.48	1217.9
310.7	1217.89		310.7	1217.89
320.23	1217.97		320.23	1217.97
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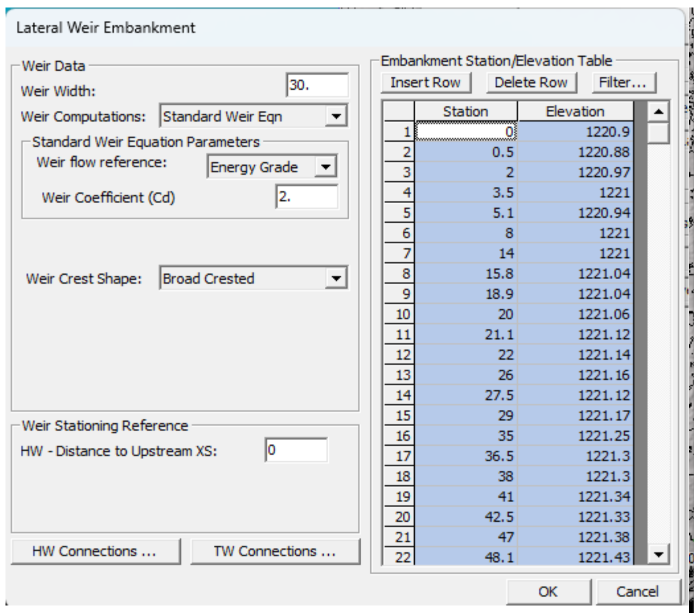
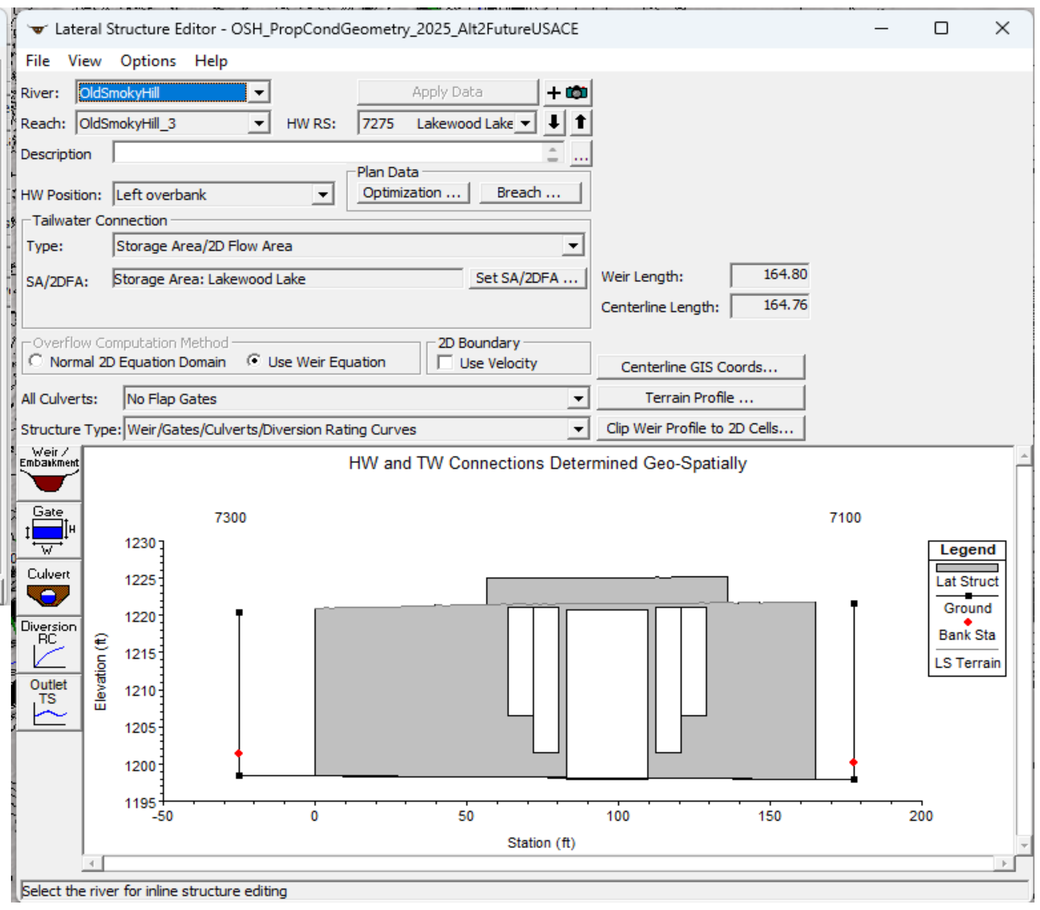
8) Lakewood Park





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14	1221
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18.9	1221.04
20	1221.06
21.1	1221.12
22	1221.14
26	1221.16
27.5	1221.12
29	1221.17
35	1221.25
36.5	1221.3
38	1221.3
41	1221.34
42.5	1221.33
47	1221.38
48.1	1221.43
48.5	1221.44
50.4	1221.46
51.2	1221.45
53	1221.44
54.8	1221.5
56.48	1221.5
56.48	1225
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60.5	1225
61.9	1225.03
62	1225.03
63.5	1225
66.5	1225.06
68	1225.06
68.1	1225.06
69.5	1225.03
71.2	1225
72.5	1225.03
73.9	1225
74	1225
74.2	1225.01
75.3	1225.05
75.5	1225.06
75.8	1225.05
77	1225
77.3	1225.01
78.5	1225.04
79.7	1225.06
80	1225.06
81.5	1225.09
81.9	1225.07
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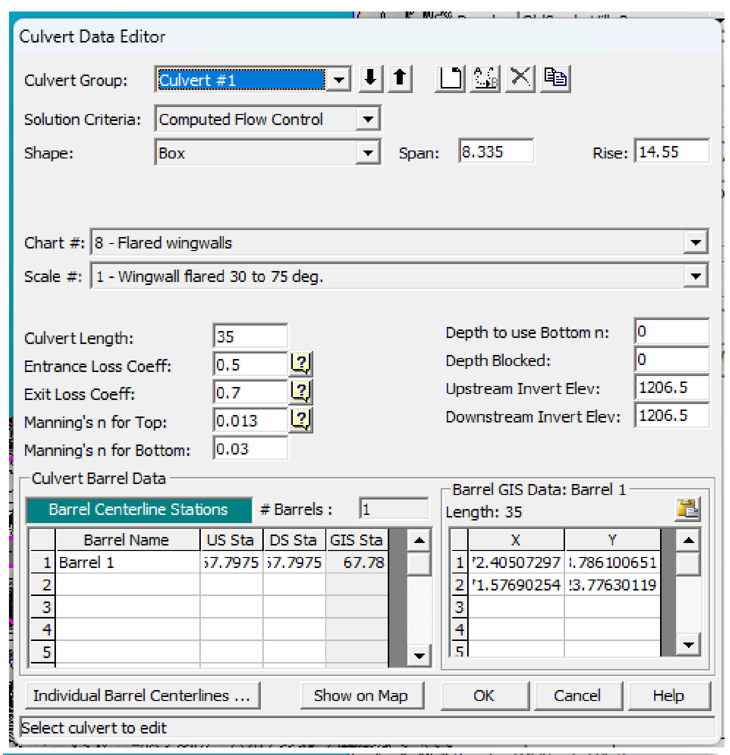

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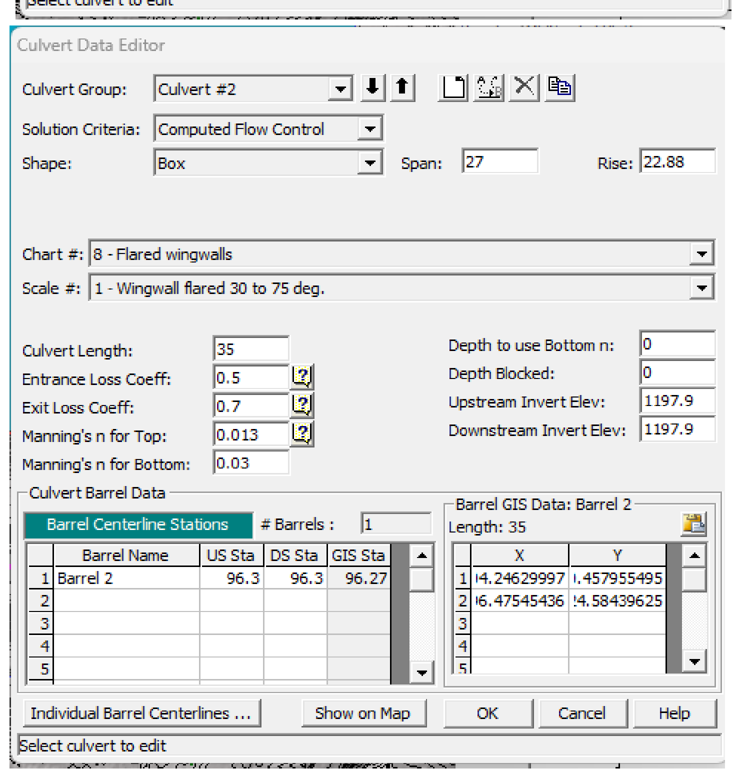
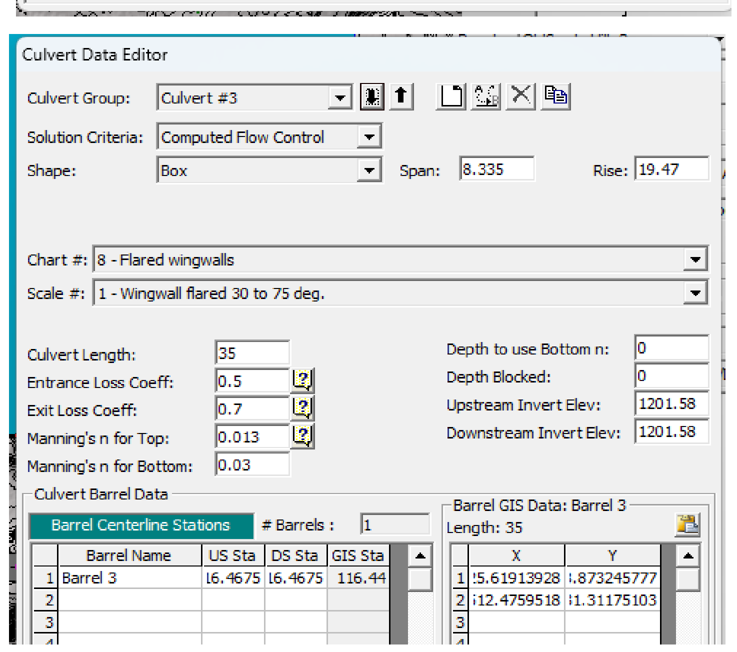
1430472	185723.8		



Barrel 2	96.3	96.3	96.27
1430504	185690.5		
1430496	185724.6		



Barrel 3	116.4675	116.4675	116.44
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1430512	185731.3		

90.5	1225.05
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96.6	1225.06
100.2	1225.08
100.9	1225.06
101.4	1225.04
101.6	1225.03
103.2	1225.08
103.7	1225.07
104.7	1225.06
107.1	1225.1
107.4	1225.09
108	1225.08
108.3	1225.08
108.9	1225.08
109.4	1225.09
109.6	1225.09
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112.9	1225.12
114	1225.06
114.5	1225.06
115.6	1225.09
116.1	1225.11
116.3	1225.1
118.6	1225.13
119.8	1225.13
120.9	1225.12
121.1	1225.13
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123.8	1225.16
124.2	1225.16
124.4	1225.16
124.8	1225.14
125.5	1225.13
125.8	1225.12
126.5	1225.15
126.7	1225.16
127.4	1225.18
127.8	1225.17
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129	1225.16
129.1	1225.16
129.2	1225.16
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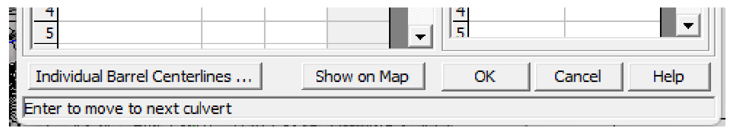

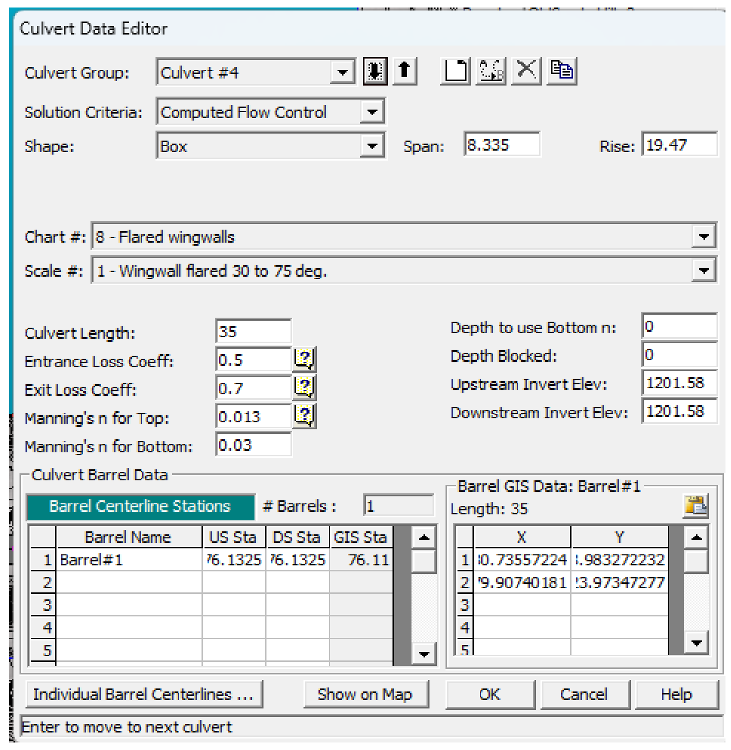

Barrel#1	76.1325	76.1325	76.11
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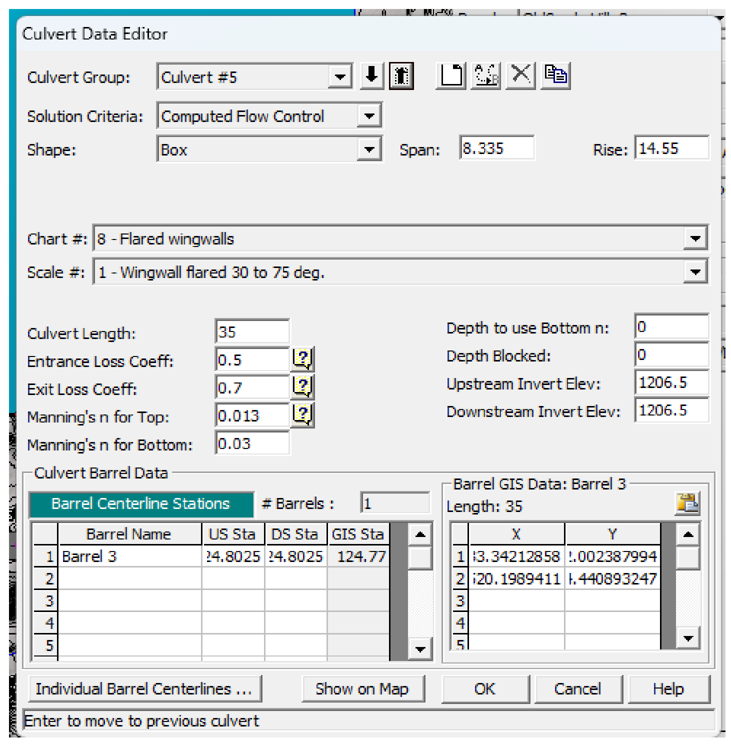

Barrel 3	124.8025	124.8025	124.77
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1430520	185734.4		

151.7	1221.76
152	1221.76
152.8	1221.73
153.2	1221.72
153.3	1221.72
153.7	1221.72
154.3	1221.71
155.5	1221.75
156.4	1221.75
156.6	1221.75
160.1	1221.74
160.8	1221.74
161.2	1221.74
161.4	1221.74
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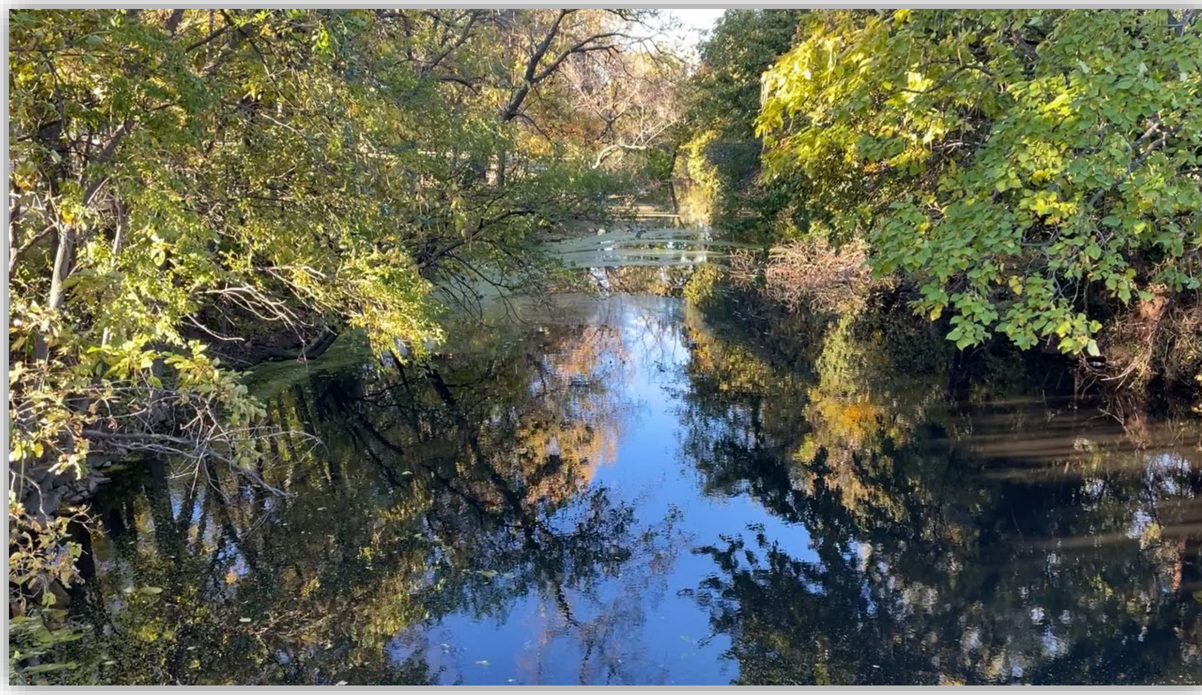
164.8	1221.75



Smoky Hill River GI Study
Salina, Kansas

Draft Integrated Feasibility Report and Environmental Assessment

Appendix B – Infrastructure and Installation Resilience

September 2025

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1. Introduction

1.1. Tier 1 Analysis of Vulnerability to Hydrological Change

This assessment is performed to highlight existing and future challenges facing the study area due to hydrological changes and is conducted in accordance with United States Army Corps of Engineers' (USACE) Engineering Construction Bulletin (ECB) 2018-14, revised 19 August 2024. The ECB is a guide for project planning with possible longer-term hydrological changes: for this evaluation, the focus is on vulnerabilities in the Lower Smoky Hill watershed (United States Geological Survey [USGS] Hydrologic Unit Code [HUC] 10260008). This assessment highlights risks due to existing and projected hydrology for the study area. Study background information can be found in the main feasibility report, and more general background information on potential change-driven risk can be found in ECB 2018-14.

1.2. Study Background

The Smoky Hill Ecosystem Restoration Study effort evaluates alternatives to reconnect an old Smoky Hill River channel and restore stream and aquatic habitat near Salina, Kansas. The project design life is 50 years. The recommended plan includes dredging to establish variable depth profiles, construction of a sediment forebay to reduce sediment loading, and construction of two weirs to manage water depth, achieving the project objectives provided below:

- Restore degraded in-stream aquatic and emergent wetland habitats within and surrounding the Old Channel during the 50-year period of analysis;
- Reestablish capacity in the Old Channel to convey appropriate flow rates throughout the year and during the 50-year period of analysis;
- Manage future Old Channel sedimentation during the 50-year period of analysis;
- Restore habitat connectivity for the 50-year period of analysis.

The objective of this assessment is to better understand observed present and projected future hydrological threats, vulnerabilities, and impacts specific to the study objectives for the Ecosystem Restoration business line and the recommended plan.

1.3. Project Site

The Smoky Hill River and this project study site (Figure 1) are located centrally within the State of Kansas in Salina, Kansas. Specifically, the project area includes 6.8 miles of disconnected channel and adjacent riparian zones within Salina, KS. The old channel inlet captures flow from the Smoky Hill River and travels downstream through Salina, draining through a federal levee outlet control and pump station, reconnecting to the main channel of the Smoky Hill River. Water sources into the disconnected channel occur from precipitation events within Salina and flow from the Smoky Hill River controlled by levee gates.

The drainage area on the Smoky Hill River at the Mentor, Kansas gage location, approximately 6 miles south of the project site, is 8,341 square miles. The immediate study area is located within the Hydrologic Unit Code 8 (HUC-8) Lower Smoky Hill watershed 10260008. Land use upstream of the site is primarily agricultural with pasture and row crop production. Land use adjacent to the disconnected channel and the immediate study area within Salina, Kansas is largely urban with residential neighborhoods and pockets of commercial zones and recreational areas. Within Salina, the Smoky Hill River has historically been manipulated to accommodate development and confine the floodplain, with recreational uses, such as golf courses and sports complexes, along the channel alignment. The project area is influenced by upstream regulation and is located downstream of the Kanopolis Reservoir. The Kanopolis Dam was constructed in 1948 and first reached multipurpose pool in July of 1948.

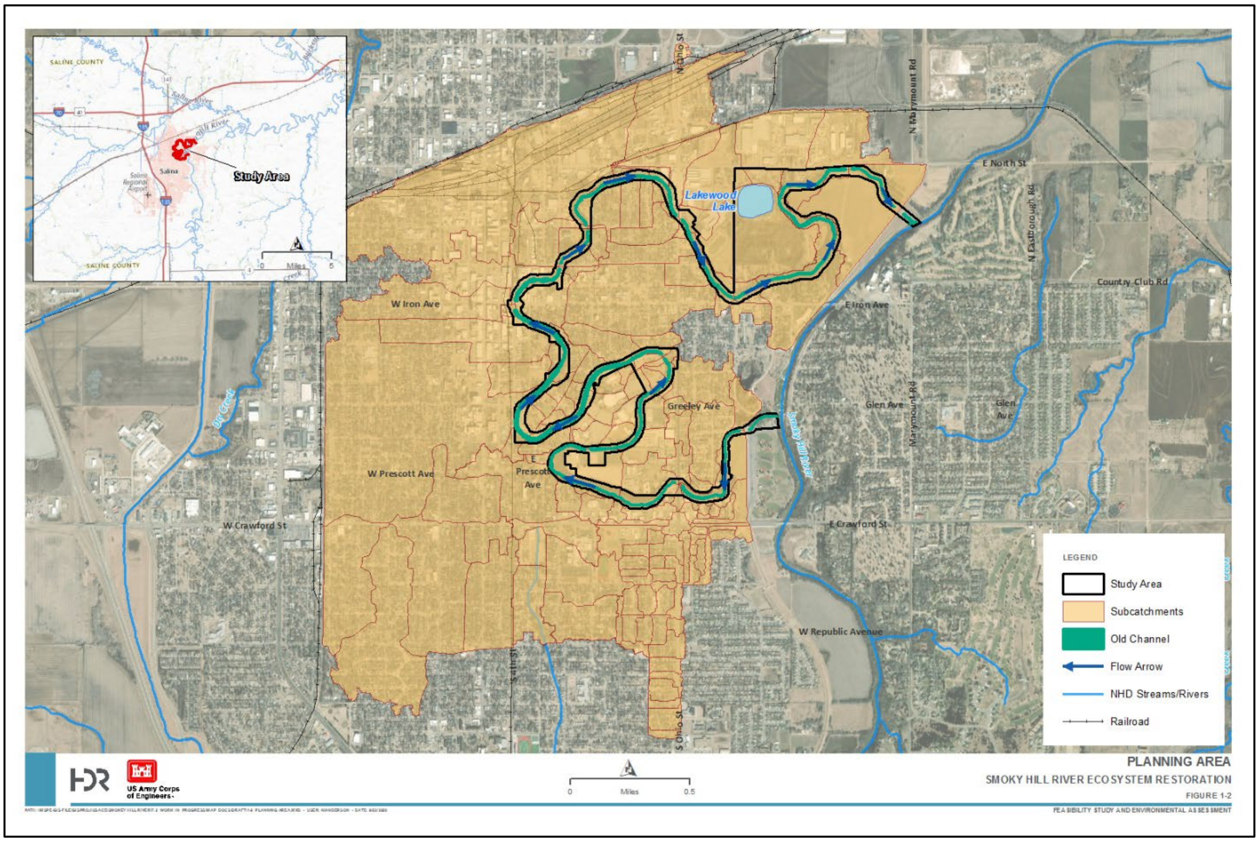


Figure 1. Smoky Hill Ecosystem Restoration Project Location

Historically, flood events within the watershed are characterized by large precipitation events coupled with wet antecedent moisture conditions. During the summer and fall, precipitation usually consists of short-duration thunderstorms with small high-intensity storm centers. Local and intense storms are frequent and can produce tributary overflows. Widespread general rains occur occasionally. Major and widespread storms are infrequent but are the cause of significant and historic floods along the major rivers. While snowfall is common, with the Smoky Hill watershed usually experiencing several snowfalls in the winter, the snowfall is typically not accumulative over several months and is not the primary contributor to flooding within the watershed. Annual precipitation across the Smoky Hill watershed varies from west to east. Based on normal annual precipitation data from 1991 to 2020, the annual precipitation varies from 18 to 23 inches in the west to 29 to 31 inches in the east (Kansas State University, 2024). Based on monthly normals from 1981 to 2010, maximum precipitation typically occurs in May with an average of 5.12 inches. Monthly temperatures vary throughout the year with average lows of 19℉ in January and average highs of 93℉ in July (U.S. Climate Data, 2025).

1.4. Relevant Hydrologic Variables

The key hydrologic related variables relevant to the study are streamflow, precipitation, and temperature. Available streamflow within the Smoky Hill River determines water availability within the oxbow. Variables like precipitation impact streamflow response and are also relevant to the study. Precipitation was considered for analysis because streamflow directly draining into the Smoky Hill River is driven by heavy precipitation events. Changes in temperature can also impact streamflow response especially if used to identify drought conditions. Streamflow was chosen as the primary hydrologic variable to analyze for this project because streamflow influences normal flow conditions through the channel restoration project, is the widest available data, and is tied to related trends such as precipitation and temperature.

2. Literature Review

Literature review for the project site on the Smoky Hill River includes a combination of sources to best discuss observed and projected trends at the Smoky Hill oxbow site in Salina, Kansas. The Smoky Hill Ecosystem Restoration project is located Salina, Kansas. For the purposes of this study, trends are assumed to follow Kansas statistically, as the watershed is part of the lower Smoky Hill River and is generally reflective of the landscape of the Great Plains region. References of this literature review include:

1. *Missouri River Flow Frequency Study – Yankton, South Dakota to Hermann, Missouri, Appendix J* (USACE, 2023). Report correlating to the overall Lower Missouri River System Study, focusing on trends for the mainstem Missouri River and systematic analysis of future project impacts. Smoky Hill River is in 2-digit HUC 10, the Missouri River Region.
2. *Fifth National Climate Assessment* (USGCRP, 2023). Report consolidating discussion of hydrology projections, including changes in temperature and precipitation, for specific regions. The project site is located in the Southern Great Plains region.
3. *NOAA National Centers for Environmental Information State Climate Summaries (NOAA, 2022).* State-level hydrology information collated for the NCA. Includes a historical record to 2020 and includes historical variations and trends as well as projected hydrology.
4. *USACE Water Resources Region 10: Missouri River* (USACE, 2015). Report focusing on regional summaries of peer-reviewed meteorological literature for 2-digit United States Geological Survey, hydrologic unit code (HUC) watersheds.
5. *USGS Flood Trends Report: Fragmented patterns of flood change across the United States* (Archfield, 2016). Assessment of trends in flood magnitudes and consistency within geographic regions of the United States. Regional trends were assessed in the frequency, duration, peak magnitude, and volume of flood events.
6. *Annual baseflow variations as influenced by climate variability and agricultural land use change in the Missouri River Basin* (Ahiablame et al., 2017). The study analyzed unregulated gages from (1951 to 2014) throughout the entire Missouri River Basin and examined observed records for statistically significant trends in precipitation and baseflow. Although located upstream of Salina, Kansas, two gage locations along the Smoky Hill River are included in this study and are representative of the project area.

These references summarize trends in historic temperature, precipitation, and streamflow records and provide an indication of future meteorology, based on the outputs from Global Circulation Models (GCMs)/Earth Systems Models (ESMs). For this assessment, background on observed and projected temperature and precipitation is provided as context for the impact they have on observed and projected streamflow.

In many areas, temperature, precipitation, and streamflow measurements have been taken since the late 1800s and provide insight into trends over the past century. GCMs are used in combination with different representative concentration pathways (RCPs) reflecting projected radiative forcings up to year 2100. Radiative forcings encompass the change in net radiative flux due to external drivers of hydrologic change, such as changes in carbon dioxide or land use/land cover. GCMs are used to approximate future temperature and precipitation. Projected temperature and precipitation time series can be transformed to regional and local scales (a process called downscaling). Downscaled time series can then be applied as inputs to macro-scale hydrologic models (Graham, Andreasson, and Carlsson, 2007).

Uncertainty is inherent to hydrological trend assessments due to the coarse spatial scale of the GCMs and the many inputs and assumptions required to create changed meteorological projections (USGCRP 2023). When applied, precipitation-runoff models introduce an additional layer of uncertainty. However, these methods represent the best available science to predict future hydrologic variables (e.g. precipitation, temperature, streamflow). It is best practice to use multiple GCMs when reviewing hydrological trends to understand how various model assumptions impact results (Gleckler et al., 2008).

2.1. Observed and Projected Trends

Literature review indicates that the Southern Great Plains region has experienced an increase in heavy precipitation since the 1950s. Winter temperatures have been rising, leading to more precipitation falling as rain rather than snow. Future projections under several global warming scenarios suggest a continued trend of increasing heavy precipitation events, higher temperatures, and increased probability of longer droughts. These changes are expected to increase annual runoff and increase the risk of flooding. Kansas has seen an above-average number of 2-inch extreme precipitation events since the 1960s which has likely already contributed to increased flood events in the magnitude of the 1993 and 2019 Missouri River floods. Circulation models, such as those from the NARCCAP and CMIP5, predict a wetter environment in the form of increased rainfall intensity, increasing the likelihood of flooding. Figure 2, developed with the *USACE Water Resources Region 10: Missouri River* report summarizes the consensus metrics of literature utilized in the hydrological analysis of the Missouri River basin (USACE, 2015).

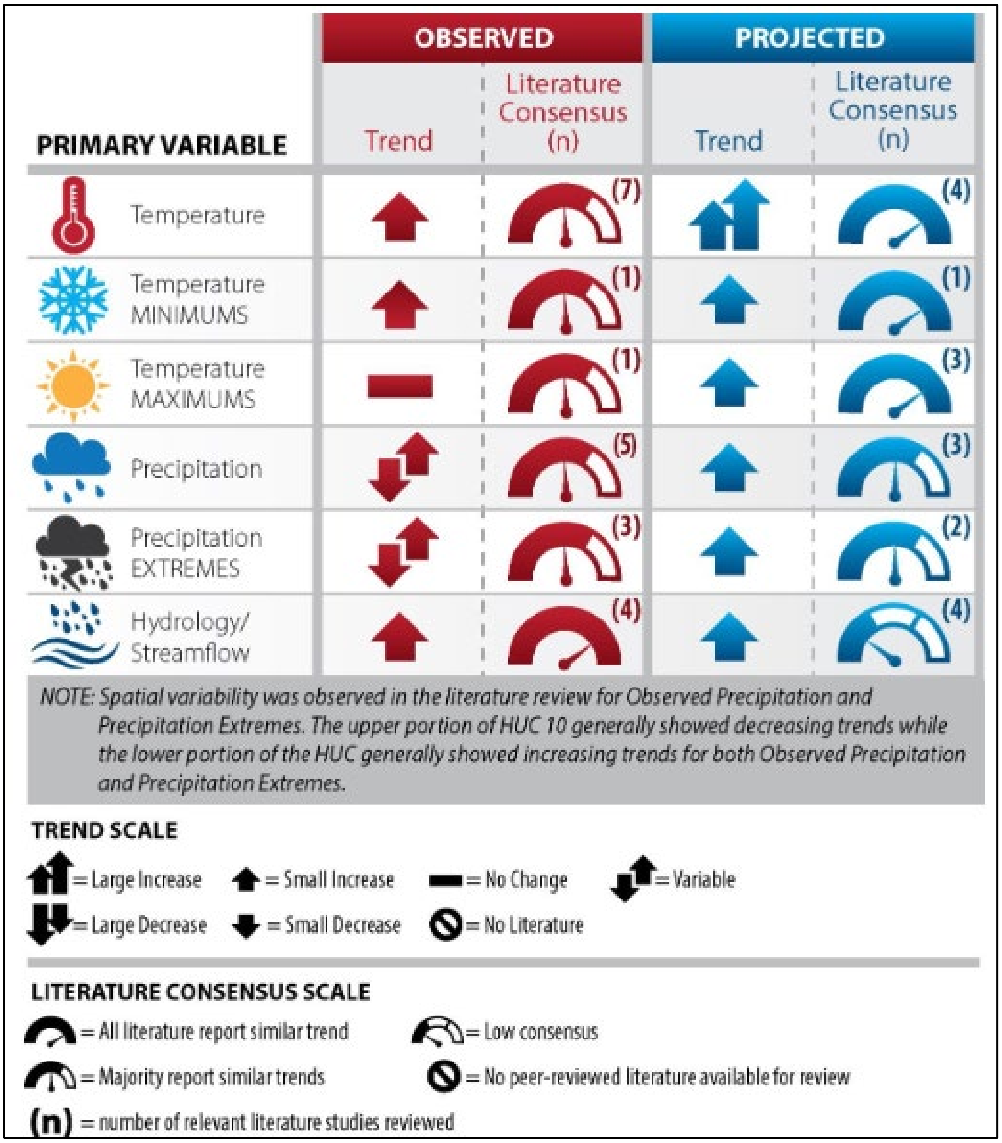


Figure 2. Observed and Projected Trends in Hydrology - HUC Region 10 (USACE 2015)

2.1.1. Temperature

Observed average temperatures in the Smoky Hill River basin have increased since the beginning of the 20th century, specifically warming in the winter and spring (NOAA, 2022). The most substantial upward shift is observed in minimum temperatures (USACE, 2015). There is also evidence of seasonal shifts, with spring occurring earlier in the year than in the past (USGCRP, 2023).

The projected changes in temperature worldwide represent a global average, with some regions expected to experience increases that are larger than this average. For every additional 1°C of global warming the temperature in the United States is projected to increase around 1.4°C. The continental United States is projected to be 2.4°C to 3.1°C warmer than the global average assuming an average global warming level of 2°C.

Shown in Figure 3, temperature changes would vary regionally, but would increase overall evapotranspiration demand at the project location (USGCRP, 2023).

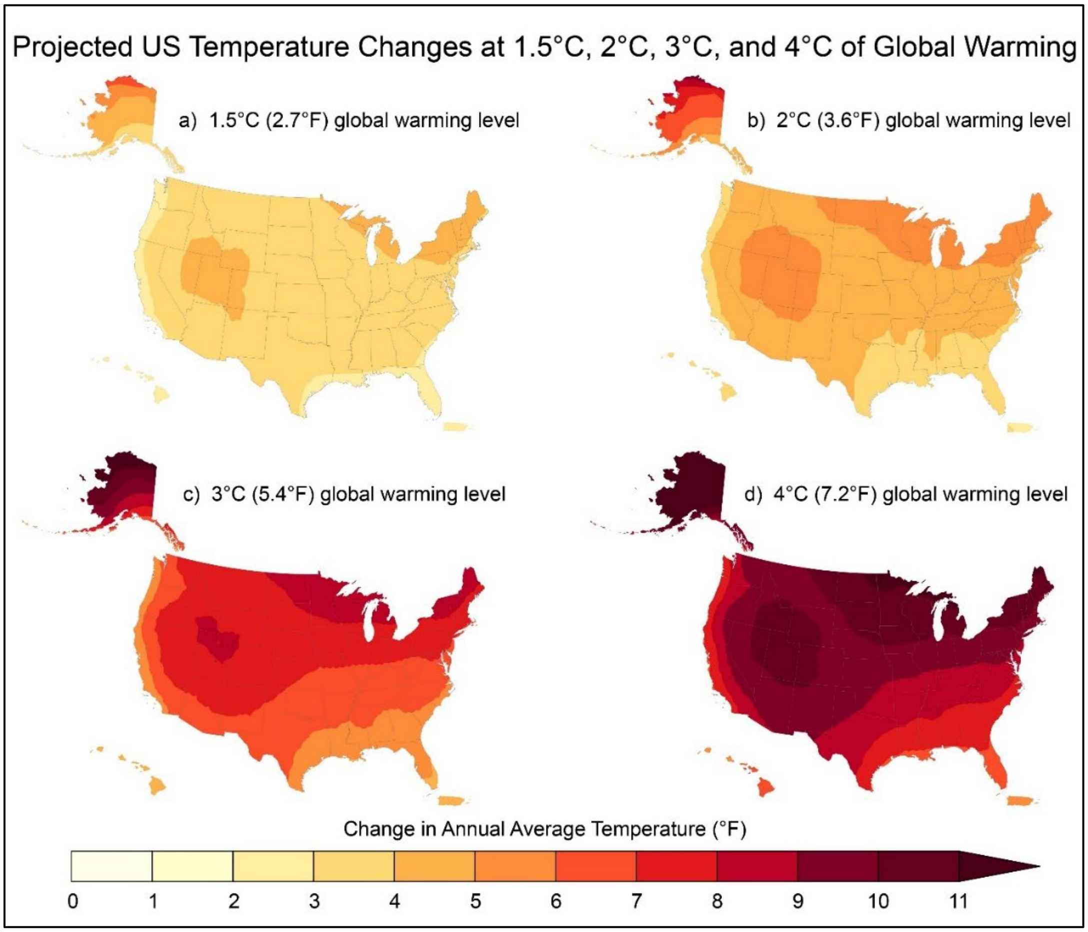


Figure 3. Predicted change in temperature over global average (USGCRP 2023)

2.1.2. Precipitation

Observed changes in precipitation are displayed in Figure 4. As seen in the figure, all metrics show an observed increase in heavy precipitation in the Southern Great Plains Region starting in the 1950s, driven by more frequent precipitation extremes, resulting in increases in river and stream flooding (USGCRP, 2023). Figure 5 depicts the projected changes in precipitation extremes relative to the 1991-2020 period, assuming 2°C average global warming. Increases in each metric for the Smoky Hill watershed indicate a continued trend of increasing extreme precipitation events, defined as the top 1% of heaviest precipitation events.

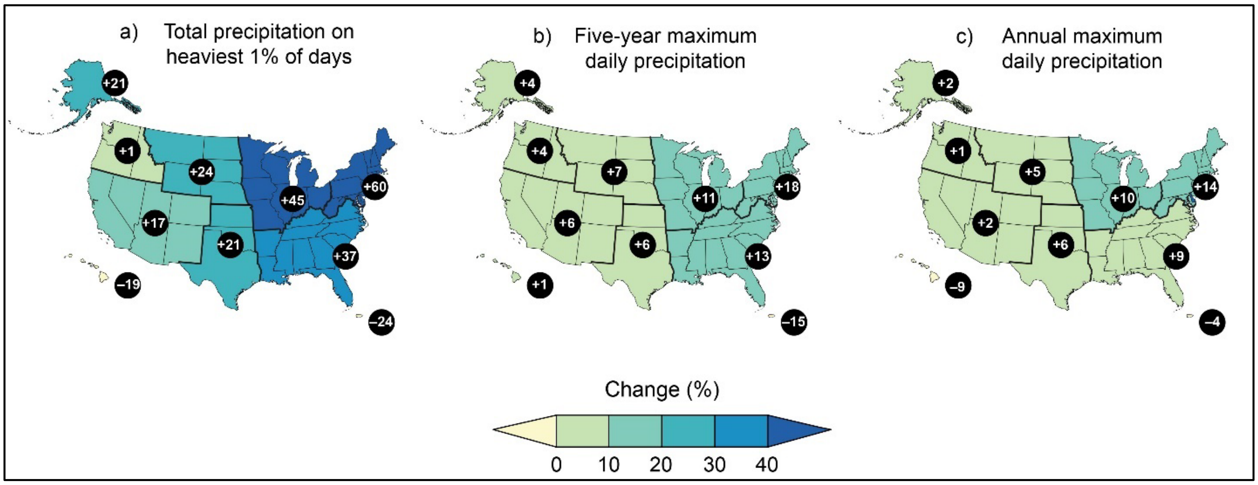


Figure 4. Observed Changes in the Frequency and Severity of Heavy Precipitation Events (USGCRP, 2023)

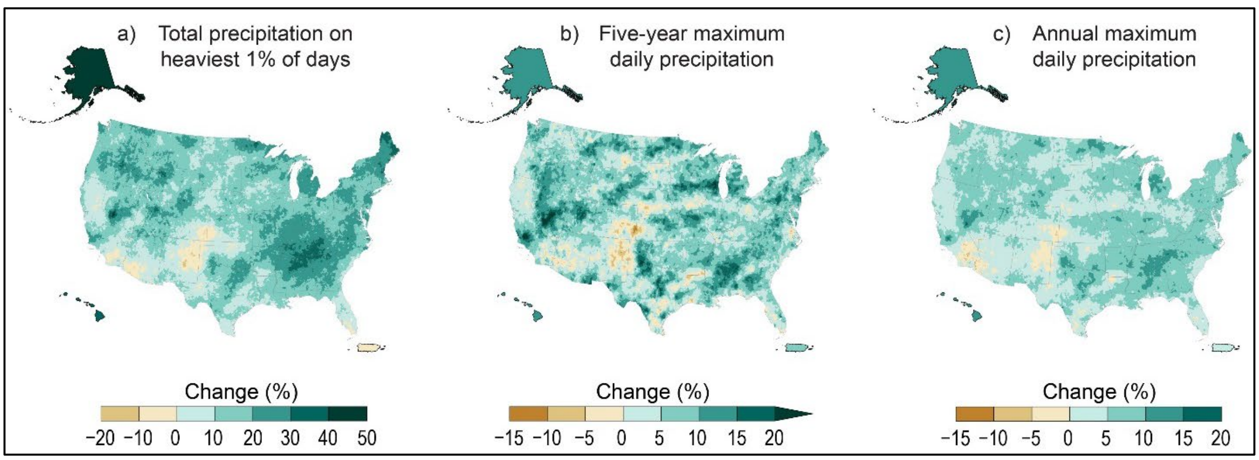


Figure 5. Projected Changes to Precipitation Extremes at 2°C of Global Warming (USGCRP, 2023)

Observed seasonal change in precipitation is depicted alongside changes in temperature in Figure 6. Much of the Southern Great Plains is shown to have increasing trends in annual precipitation for both winter and summer. Summer temperatures in this region on average remained the same or increased while winter temperatures have been increasing, leading to an overall increase of average annual temperature in Kansas. The increased average temperatures relate to a change, with precipitation falling more as rain than snow during the winter. Warming in summer temperatures creates less favorable antecedent moisture conditions with respect to drought that may negatively impact ecosystem restoration of aquatic habitat.

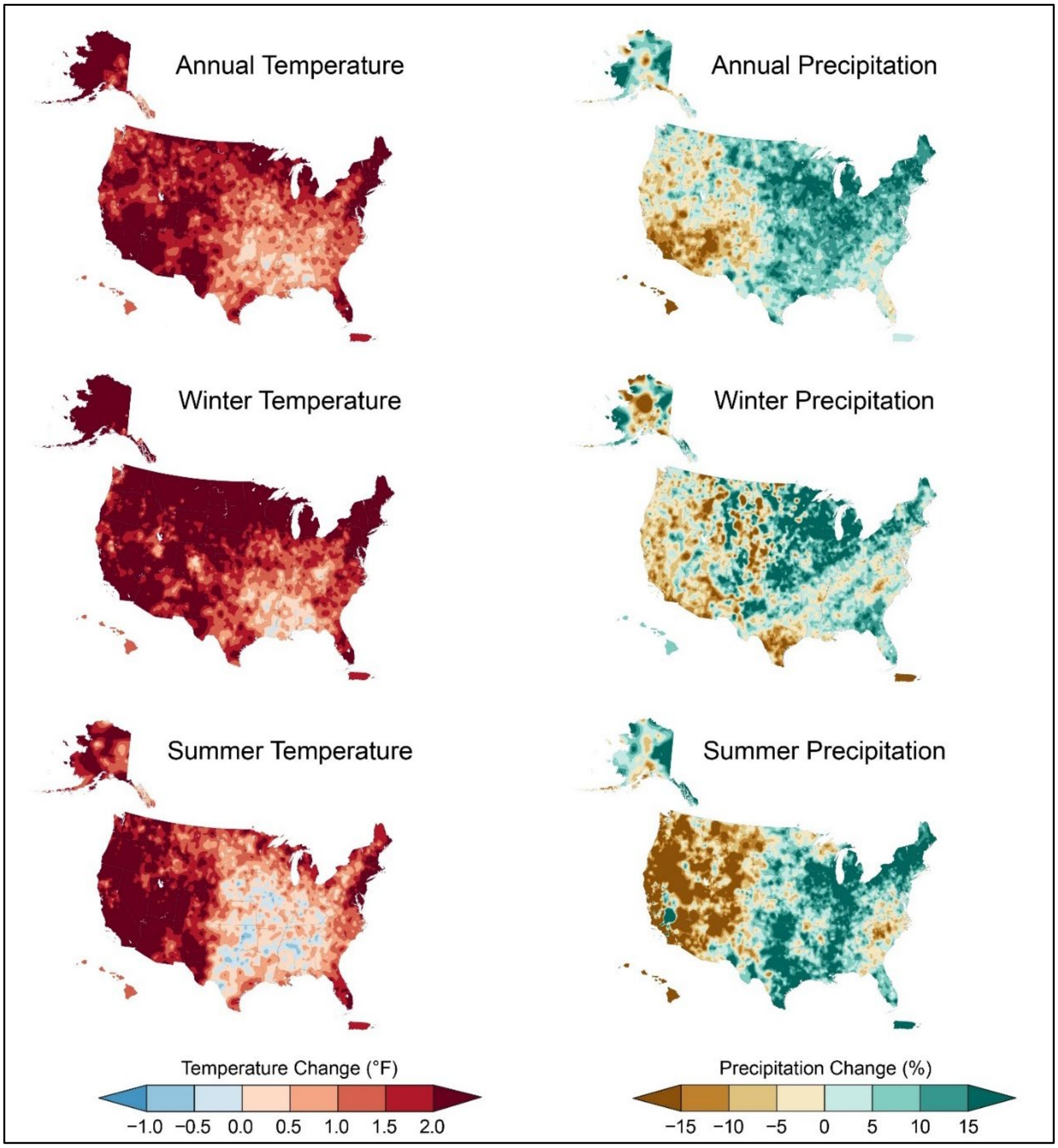


Figure 6. Observed Change in Annual, Winter, and Summer Temperature and Precipitation (USGCRP, 2023)

Changes in intensity of storm events and in soil moisture are projected to increase annual runoff totals over much of the country. Changes in runoff predicted by rising ambient temperatures can be seen in Figure 7 with central Kansas having an average projected increase in runoff of 0.0-0.1 inch annually. Runoff increases are likely to cause increased magnitude of flooding.

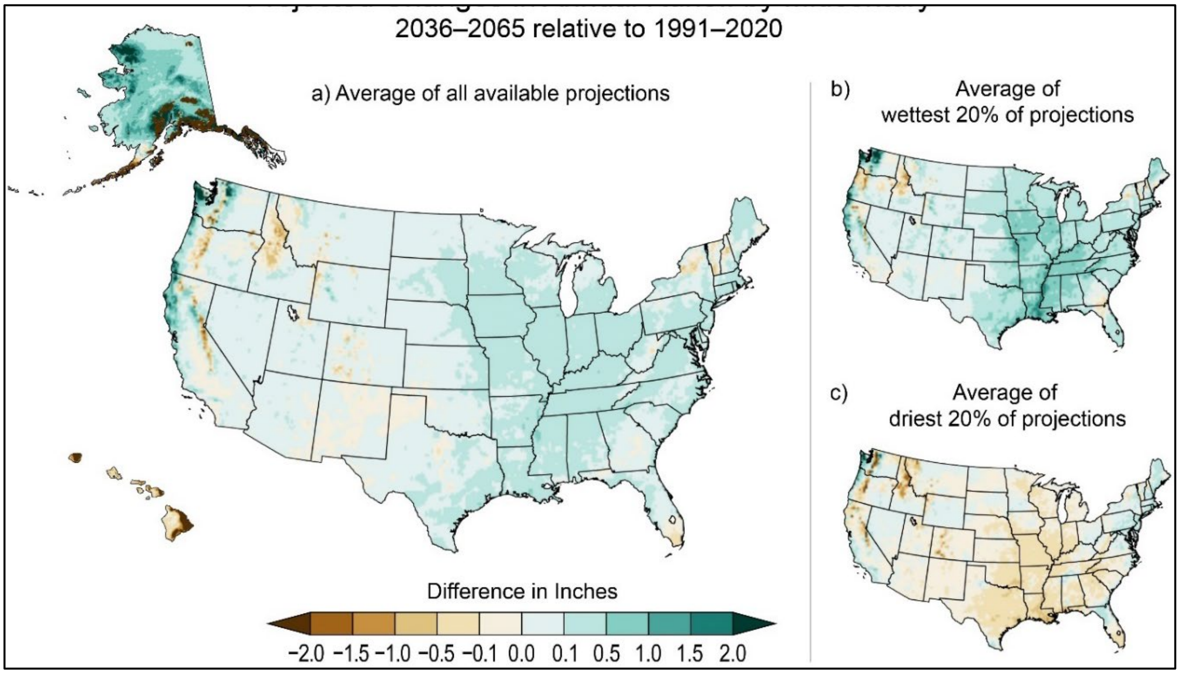


Figure 7. Projected Changes in Annual Runoff by Midcentury (USGCRP, 2023)

Increases in temperature could decrease the number of overall rainfall events. This is due to the Clasuius-Clapeyron relationship which states that for every 1°C increase in temperature water-holding capacity of the atmosphere increases by 7%. This also means that the intensity of rainfall events could increase. Many of the observed data in the NCA5 report comes from NOAA National Centers for Environmental Information (NCEI) which is broken up for state-level analysis. Figure 8 depicts the observed annual number of 2-inch extreme precipitation events between 1900-2020. Kansas is experiencing an above average amount of extreme precipitation occurrences compared to the historical averages, with an upward trend starting in the 1960s.

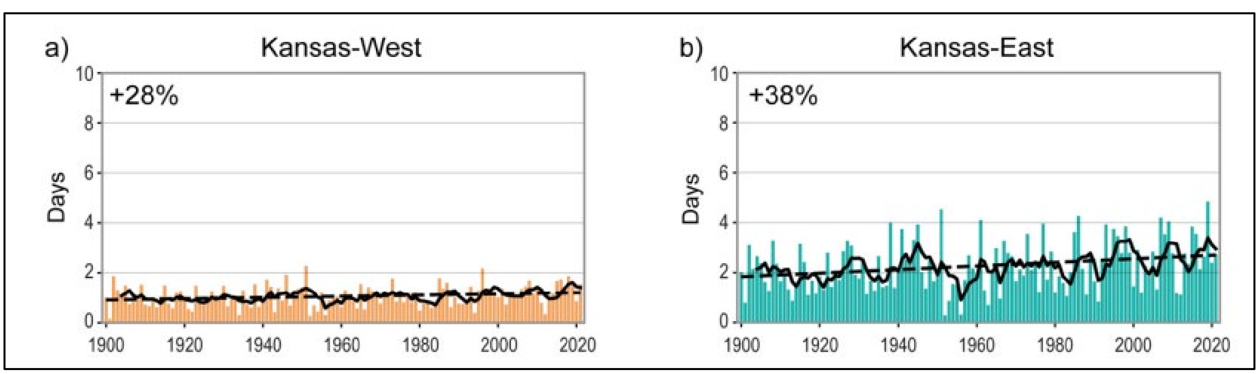


Figure 8. Observed Number of 2-inch Extreme Precipitation Events (USGCRP, 2023)

2.1.3. Streamflow

The USGS Flood Trends Report (Archfield, 2016) found that although changes in trends in the peak magnitude, frequency, duration, and volume of floods were observed at specific locations throughout the continental United States, there was not strong geographical cohesion between these site-specific observations. The report also noted that within a given region, changes within watersheds can vary greatly, even for watersheds within close geographic proximity. A significant negative frequency trend and significant positive trends related to duration and volume were identified in the Smoky Hill watershed as shown in Figure 9. However, positive trends were present in the greater Missouri River basin for duration and volume, while frequency displayed a negative trend.

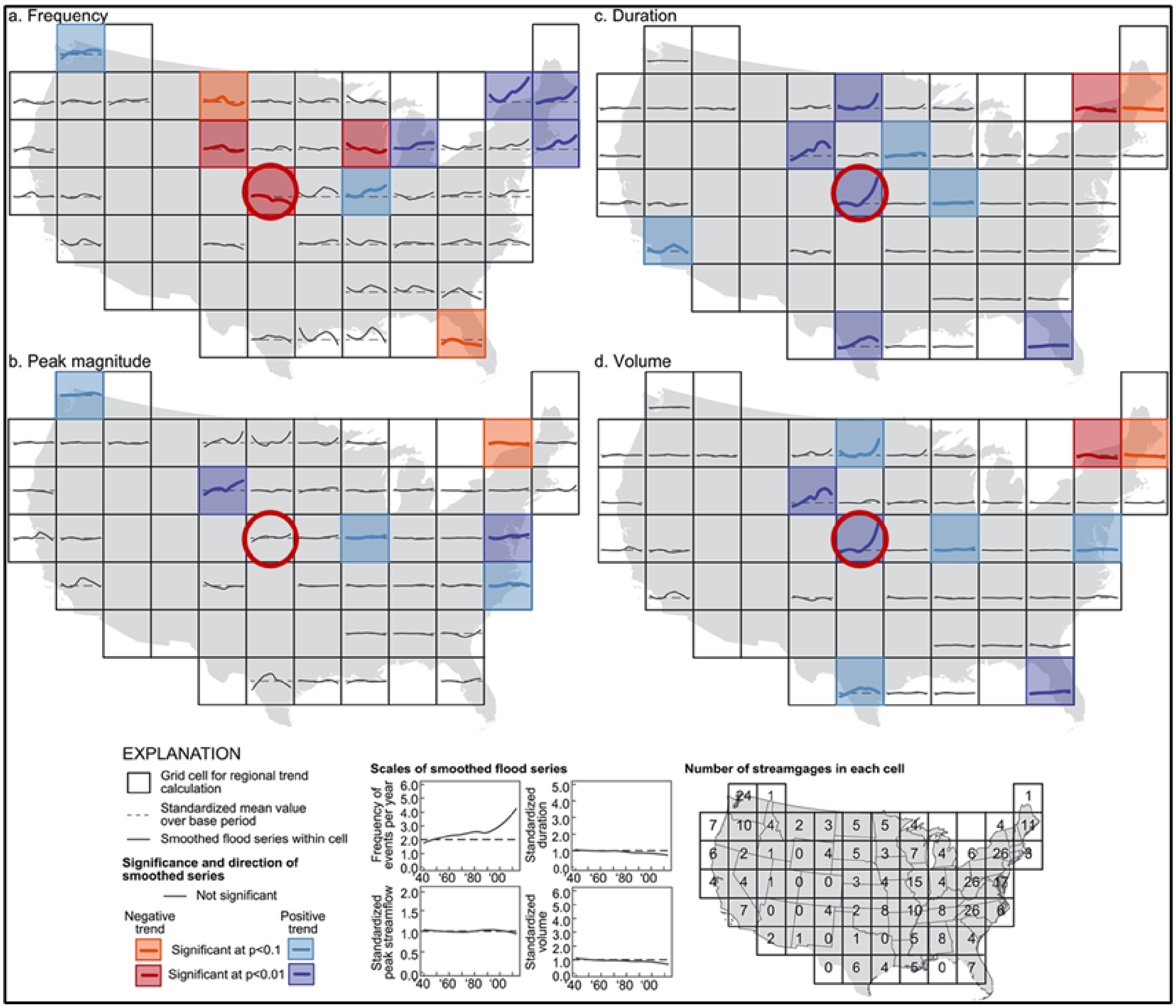


Figure 9. Regional changes in floods across the United States (1940-1969 vs 1970-2013) (Archfield, 2016)

Upward trends in Missouri River basin streamflow have been observed in the lower Missouri River basin and are likely attributed to changing hydrology (Hoerling et al., 2013; Conant et al., 2018). Future projections suggest variability in streamflow. Earlier snowmelt (not applicable to the Smoky Hill River) and increasingly wet springs are expected to increase daily maximum streamflow in the spring. Hotter summers with maintained to decreased seasonal precipitation suggest a decrease in summer streamflows and increased likelihood of drought (USGCRP, 2023).

In their review of data in the Smoky Hill River, Ahiablame et al. 2017 considered Mann-Kendall regression results showing trends of increasing precipitation in mm per 10 years, and baseflow as a percentage per 10-years (Figure 10). Statistically significant trends were identified related to precipitation and decreasing baseflow were identified for the Smoky Hill River basin which could be reflective of trends anticipated for the Smoky Hill River in Salina, Kansas.

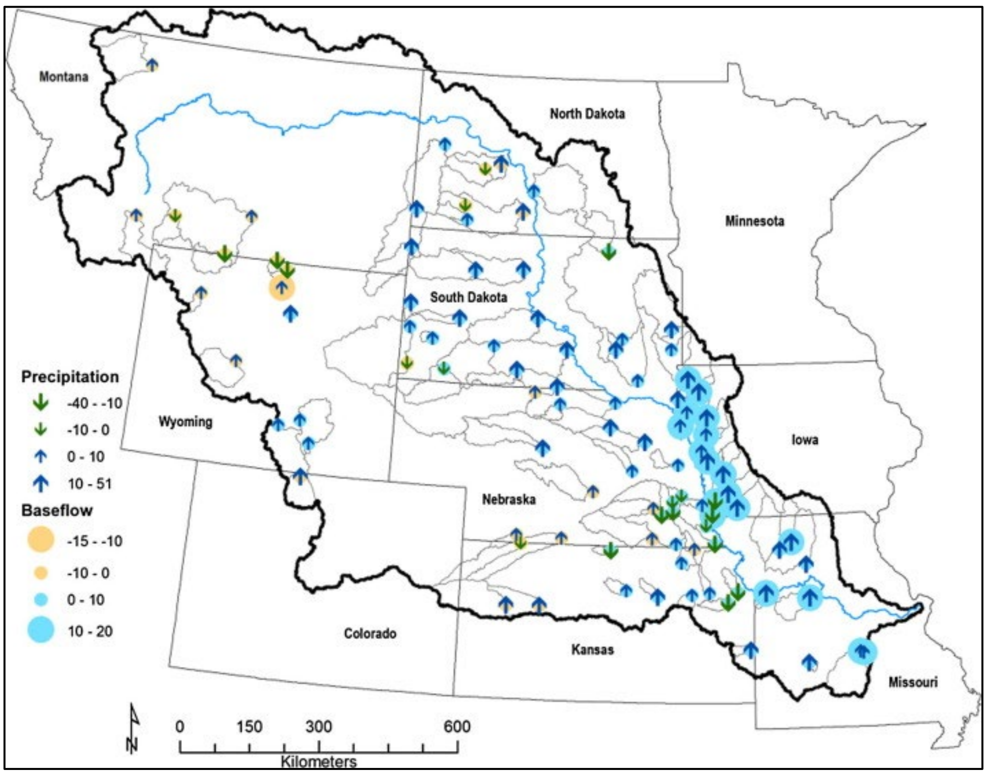


Figure 10. Slopes of Precipitation and Baseflow Trends in the Missouri River Basin. precipitation (mm/10-years), baseflow ((%)/10-years) (Ahiablame et al., 2017)

2.1.4. Summary

While the literature was conflicted in the projected peak magnitude, duration, and volume of extreme events the strongest consensus throughout the literature is that future conditions will favor increased flooding, increased drought frequency, and increased temperatures. This results in the potential of longer loadings, faster flows, increases in peak magnitude of flood events, increased water scarcity, and increased water temperatures. This would cause structural features such as the sediment forebay and weirs to experience higher velocities and more frequent inundation and overtopping which could incur greater long-term maintenance costs. Further increases in temperature and drought frequency may contribute to water scarcity and hotter water temperatures when hydraulically reconnecting the Smoky Hill River oxbow in Salina, Kansas, negatively impacting aquatic species.

3. Nonstationarity Detection and Trend Analysis

The assumption that hydrologic datasets are stationary (their statistical characteristics are unchanging) in time underlies many types of hydrologic analysis. Statistical tests can be used to test this assumption using the techniques outlined in Engineering Technical Letter (ETL) 1100-2-3 Guidance for Detection of Nonstationarities (2017). The USACE Time Series Toolbox (TST) is a web-based tool that enables the user to perform the statistical tests outlined the guidance. Both user uploaded time series data, as well as preloaded USGS annual peak discharge and stage datasets can be tested for nonstationarities and monotonic trends using the TST (Friedman et al., 2018; Olson et al., 2022).

For this evaluation, the TST is applied to annual instantaneous peak streamflow data collected by the USGS. An active Smoky Hill River streamflow gage exists upstream of Salina, Kansas near Mentor, Kansas. The USGS gage 06866500 is suitable for analysis with a continuous period of record of 77 years, spanning from 1948 to current day. The drainage area at the gage location is 8,341 square miles.

The Nonstationarity Detection Tool and the adopted default sensitivity parameters were used to assess the stationarity of the flow record for the USGS gage 06866500, located on the Smoky Hill River near Mentor, Kansas. The gage has recorded peaks in 1903, 1923-1932, 1935, and 1938, and a continuous period of record of annual peak discharge from 1948 to 2025. A period of record from 1949 to present day was selected for analysis to remove nonstationarities resulting from upstream reservoir construction. As shown in Figure 11, a strong nonstationarity was detected in 2000 and identified a decrease in mean streamflow. A strong nonstationarity is one that demonstrates a degree of consensus, robustness, and a significant increase or decrease in the same mean and/or variance. This nonstationarity was identified by multiple tests targeted at identifying a change in the mean, indicating consensus, and by multiple tests targeting changes in different statistical parameters, indicating robustness.

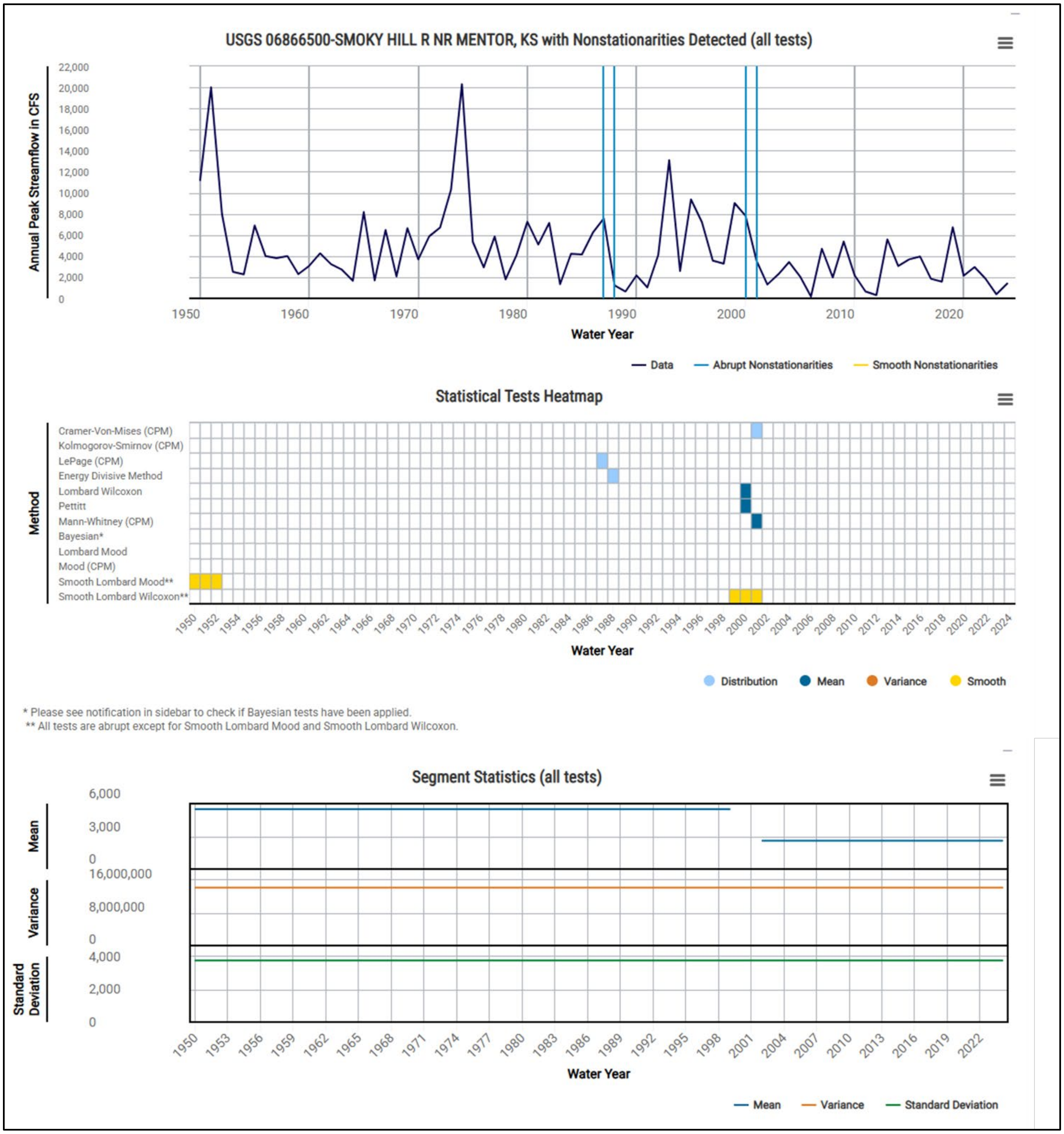


Figure 11. Time Series Toolbox Nonstationarity Detection Analysis of Peak Annual Discharge – Smoky Hill River near Mentor, Kansas, 1949 to 2024

This assessment evaluated monotonic trends using the t-test, Mann-Kendall, and Spearman Rank Order tests. A p-value threshold of 0.05 (<0.05 is considered statistically significant) was applied to evaluate whether trends detected are statistically significant. The analysis, shown in Figure 12, indicated statistically significant decreasing trends for the complete period of record from 1949 to 2024. The p-values associated with each test are summarized in Table 1.

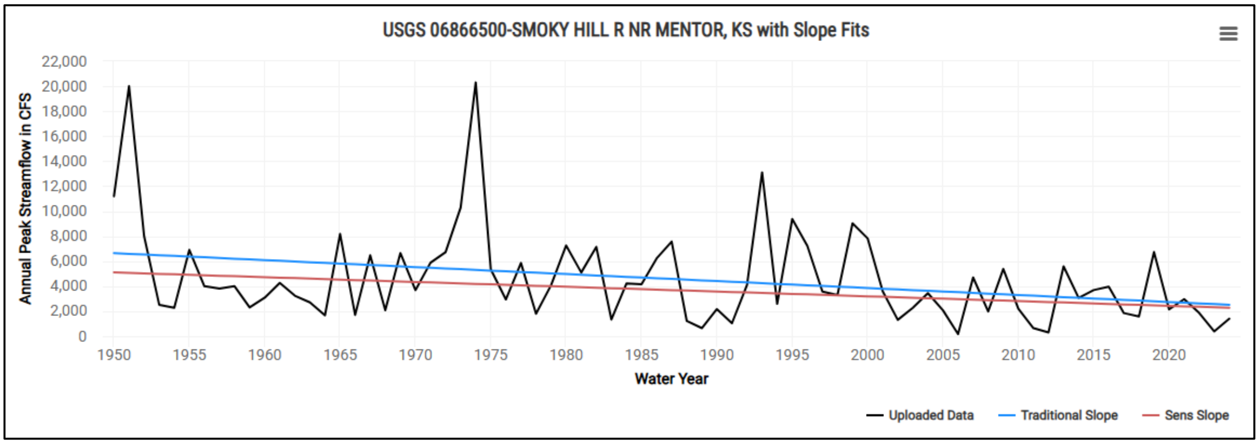


Figure 12. Trend Analysis of Annual Peak Streamflow of Smoky Hill River near Mentor, Kansas, 1949-2024

[t-Test, p value = 0.005; Mann-Kendall, p value = 0.003; Spearman Rank-Order, p value = 0.002]

Table 1. Summary of p-values for Monotonic Trend Analysis of Peak Annual Discharge of the Smoky Hill River near Mentor, KS, 1949-2024

Test Type / Period Analyzed	1949-2024	Conclusion
t-test	0.005	A statistically significant trend WAS detected.
Mann-Kendall Test	0.003	A statistically significant trend WAS detected.
Spearman Rank-Order Test	0.002	A statistically significant trend WAS detected.

Smoky Hill flows at the Mentor, Kansas gage cannot be analyzed using the assumption of stationarity for the period of record.

4. Comprehensive Hydrology Assessment Tool

The USACE Comprehensive Hydrology Assessment Tool (CHAT) was used to investigate potential future trends in streamflow for HUC 10260008, stream segment 10003715, shown in Figure 13. The CHAT displays various simulated, historical and projected future, streamflow, temperature, and precipitation outputs derived from 32 GCMs (Patel et al., 2020; USACE, 2023). The CHAT uses Coupled Model Intercomparison Project Phase 5 (CMIP5) GCM meteorological data outputs that have been statistically downscaled using the Localized Constructed Analogs (LOCA) method. GCMs rely on scenarios representing different pathways to a given atmospheric concentration of greenhouse gas (GHG, essentially carbon dioxide) emissions, referred to as representative concentration pathways (RCPs). RCPs describe the change in radiative forcing at the end of this century, as compared with pre-industrial conditions. Projected hydrological time series in the CHAT for 2006 to 2099 are produced using two future scenarios: RCP 4.5 (where CO_2 emissions stabilize by the end of the century) and RCP 8.5 (where CO_2 emissions continue to increase throughout the century). Simulated output representing the historic period of 1951 to 2005 is generated using a reconstitution of historic CO_2 emissions.

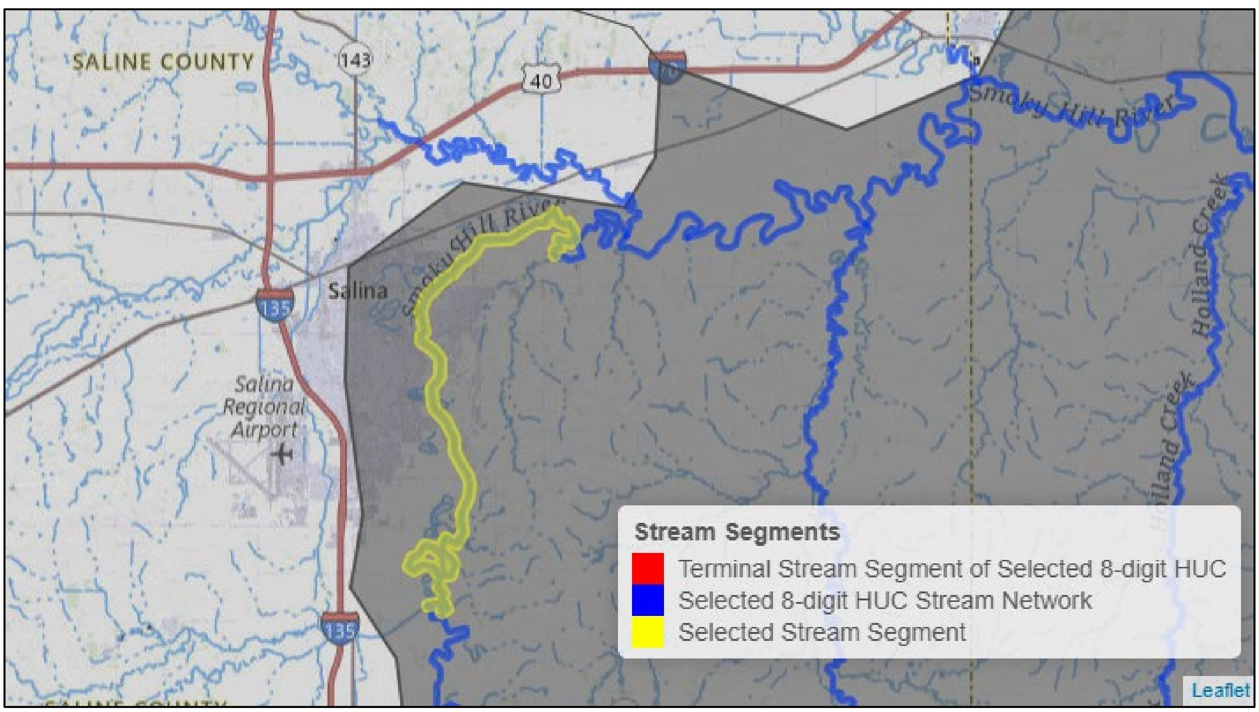


Figure 13. Stream Segment 10003715 Analyzed in the Comprehensive Hydrology Assessment Tool for HUC 10260008, Lower Smoky Hill

To analyze runoff, LOCA-downscaled GCM outputs are used to force an unregulated, Variable Infiltration Capacity (VIC) hydrologic model. Areal runoff from VIC is then routed through a stream network using mizuRoute. The VIC model outputs represent the daily in-channel routed runoff (i.e., streamflow) for each stream segment – valid at the stream segment endpoint. Since the runoff is routed, the streamflow value associated with each stream segment is a representation of the cumulative flow including all upstream runoff, as well as the local runoff contributions to that specific segment. Within the CHAT, output can be selected for the terminal stream segment (outlet) associated with a given 8-digit HUC watershed or for any given intermediate stream segment specific to a study location.

Figure 14 displays the range of projected annual maximum mean monthly streamflow, annual maximum 1-day precipitation, and annual mean 1-day temperature for the historic period (1951-2005) and future period (2006-2099) for the RCP 8.5 scenario. The figure also includes an indication of whether this agreement between GCMs in terms of the directionality of the change and whether the signal of change emerges from the historic variability. Within the annual maximum of mean monthly streamflow projections, no signal for change was detected for bot5h the mid-century and end-of-century epoch. Within the annual maximum 1-day precipitation projections, there is weak evidence of positive change for both the mid-century and end-of-century epochs. Within the annual mean 1-day temperature projections, robust evidence of positive change for both epochs was detected. The range of output is indicative of the uncertainty associated with projected, RCP-influenced streamflow and precipitation.

Projections were also run for the RCP 4.5 condition, which resulted in no signal for change in the annual maximum mean monthly streamflow projections for the mid-century epoch and end-of-century epoch. The annual maximum 1-day precipitation for the RCP 4.5 condition also resulted in no signal of change for the mid-century epoch and a weak positive change for the end-of-century epoch. Once again, robust evidence of positive change for both epochs was detected within the annual mean 1-day temperature projections.

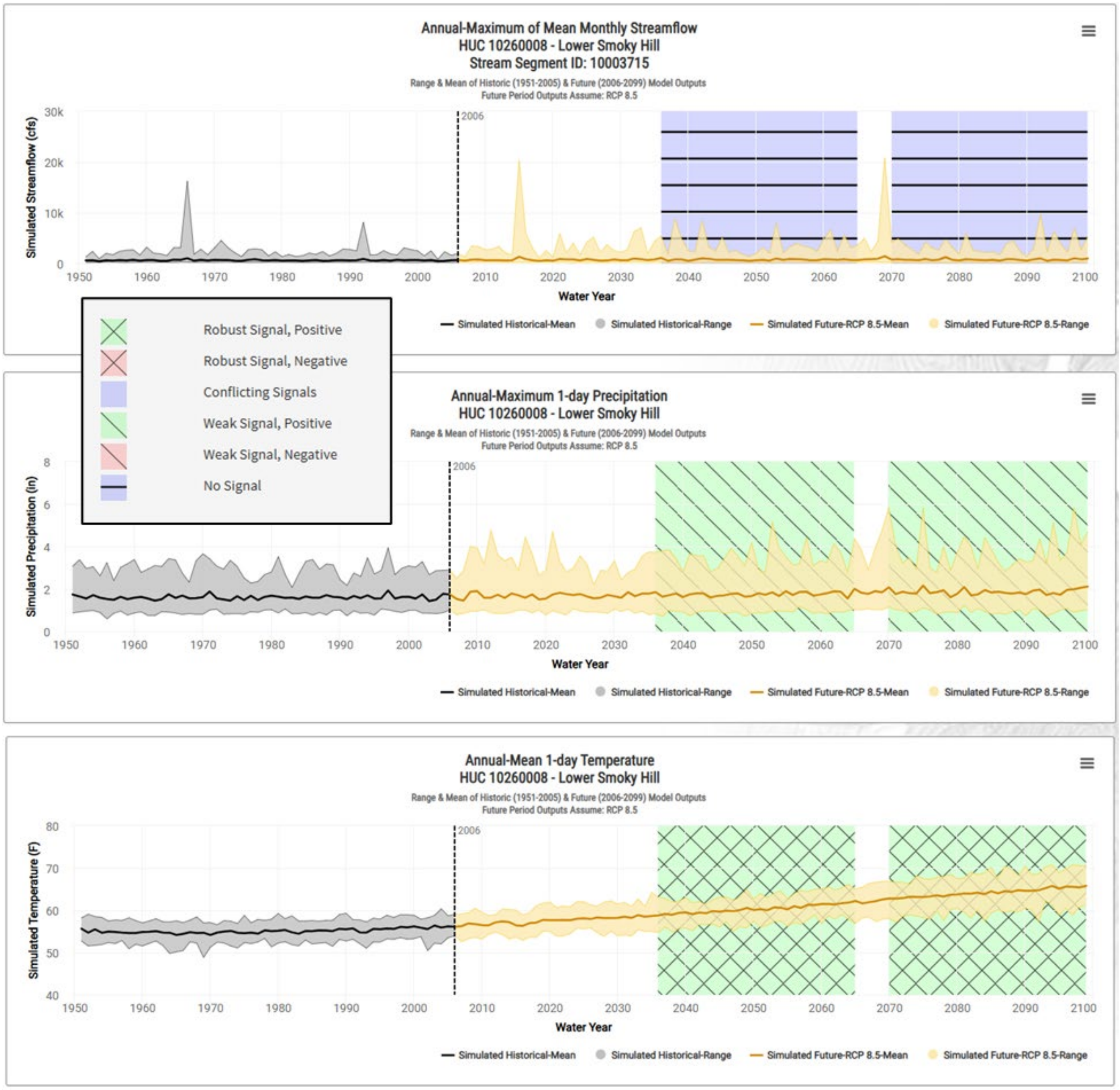


Figure 14. Robustness Metrics and Range of Annual-Maximum of Mean Monthly Streamflow, Annual Maximum 1-Day Precipitation, and Annual Mean 1-Day Temperature for HUC 10260008, Lower Smoky Hill

For the Lower Smoky Hill Watershed (HUC 10260008), trends in projected annual maximum monthly streamflow were evaluated using the t-Test, Mann-Kendall, and Spearman Rank-Order tests. All three statistical tests are applied using a 0.05 level of significance (p-values < 0.05 are considered statistically significant). The direction and magnitude of change in statistically significant trends were evaluated using the slope of the fitted linear regression.

The overall trends in the mean projected annual maximum monthly streamflow, 1-day precipitation, and 1-day temperature increased over time for the RCP 4.5 and RCP 8.5

conditions, as shown in Figure 15. Calculated p-values indicate statistically significant increasing trends for the future period condition for annual maximum mean monthly streamflow (RCP 4.5), annual maximum 1-day precipitation (RCP 4.5 and RCP 8.5), and annual mean 1-day temperature (RCP 4.5 and RCP 8.5). Historical trends are also not statistically significant for annual maximum of mean monthly streamflow, with a slight negative trend detected and annual maximum 1-day precipitation, with a slight increasing trend detected. The findings, summarized in Table 2 and Table 3, suggest there is potential for flood risk to increase in the future, especially in a condition where CO_2 production continues to increase, in the study area, as evidenced by increasing trends in mean monthly streamflow and annual maximum 1-day precipitation. The RCP 4.5 future trendline slope has a slope of 0.86 cfs a year, which equates to a 43 cfs change in the average of the 32 projections of annual mean streamflow over a 50-year period, an approximate 6.7% change. The RCP 8.5 future trendline has a slope of 0.80 cfs a year, which equates to a 40 cfs change in the average of the 32 projections of annual mean streamflow over a 50-year period, an approximate 6.3% change. Additionally, findings suggest there is potential for increasing drought frequency due to historic and future statistically significant increasing temperature trends (RCP 4.5 and RCP 8.5). All p-values for annual mean 1-day temperatures were less than 0.0001 with increasing slopes of 0.0225, 0.0482, and 0.1038 for historic, RCP 4.5, and RCP 8.5 scenarios.

Table 2. Trend Analysis of Average Model Output: Annual Maximum of Mean Monthly Streamflow

Statistical Test	Historic (1951–2005)	Future (2006–2099) RCP 4.5	Future (2006–2099) RCP 8.5
t-Test	P-value = 0.693; Not Statistically Significant (>0.05); Slope is -0.35 and slightly decreasing	P-value = 0.044; Statistically Significant (<0.05); Slope is 0.86 and slightly increasing	P-value = 0.212; Not Statistically Significant (>0.05); Slope is 0.80 and increasing
Mann-Kendall	P-value = 0.738; Not Statistically Significant (>0.05); Slope is -0.35 and slightly decreasing	P-value = 0.049; Statistically Significant (<0.05); Slope is 0.86 and increasing	P-value = 0.215; Not Statistically Significant (>0.05); Slope is 0.80 and increasing
Spearman Rank Order	P-value = 0.643; Not Statistically Significant (>0.05); Slope is -0.35 and slightly decreasing	P-value = 0.037; Statistically Significant (<0.05); Slope is 0.86 and increasing	P-value = 0.133; Not Statistically Significant (>0.05); Slope is 0.80 and increasing

Table 3. Trend Analysis of Average Model Output: Annual Maximum 1-Day Precipitation

Statistical Test	Historic (1951–2005)	Future (2006–2099) RCP 4.5	Future (2006–2099) RCP 8.5
t-Test	P-value = 0.538; Not Statistically Significant (>0.05); Slope is 0.0005 and slightly increasing.	P-value = <0.001; Statistically Significant (<0.05); Slope is 0.0014 and slightly increasing	P-value = <0.001; Statistically Significant (<0.05); Slope is 0.0029 and slightly increasing
Mann-Kendall	P-value = 0.722; Not Statistically Significant (>0.05); Slope is 0.0005 and slightly increasing.	P-value = <0.001; Statistically Significant (<0.05); Slope is 0.0014 and slightly increasing	P-value = <0.001; Statistically Significant (<0.05); Slope is 0.0029 and slightly increasing
Spearman Rank Order	P-value = 0.646; Not Statistically Significant (>0.05); Slope is 0.0005 and slightly increasing.	P-value = <0.001; Statistically Significant (<0.05); Slope is 0.0014 and slightly increasing	P-value = <0.001; Statistically Significant (<0.05); Slope is 0.0029 and slightly increasing

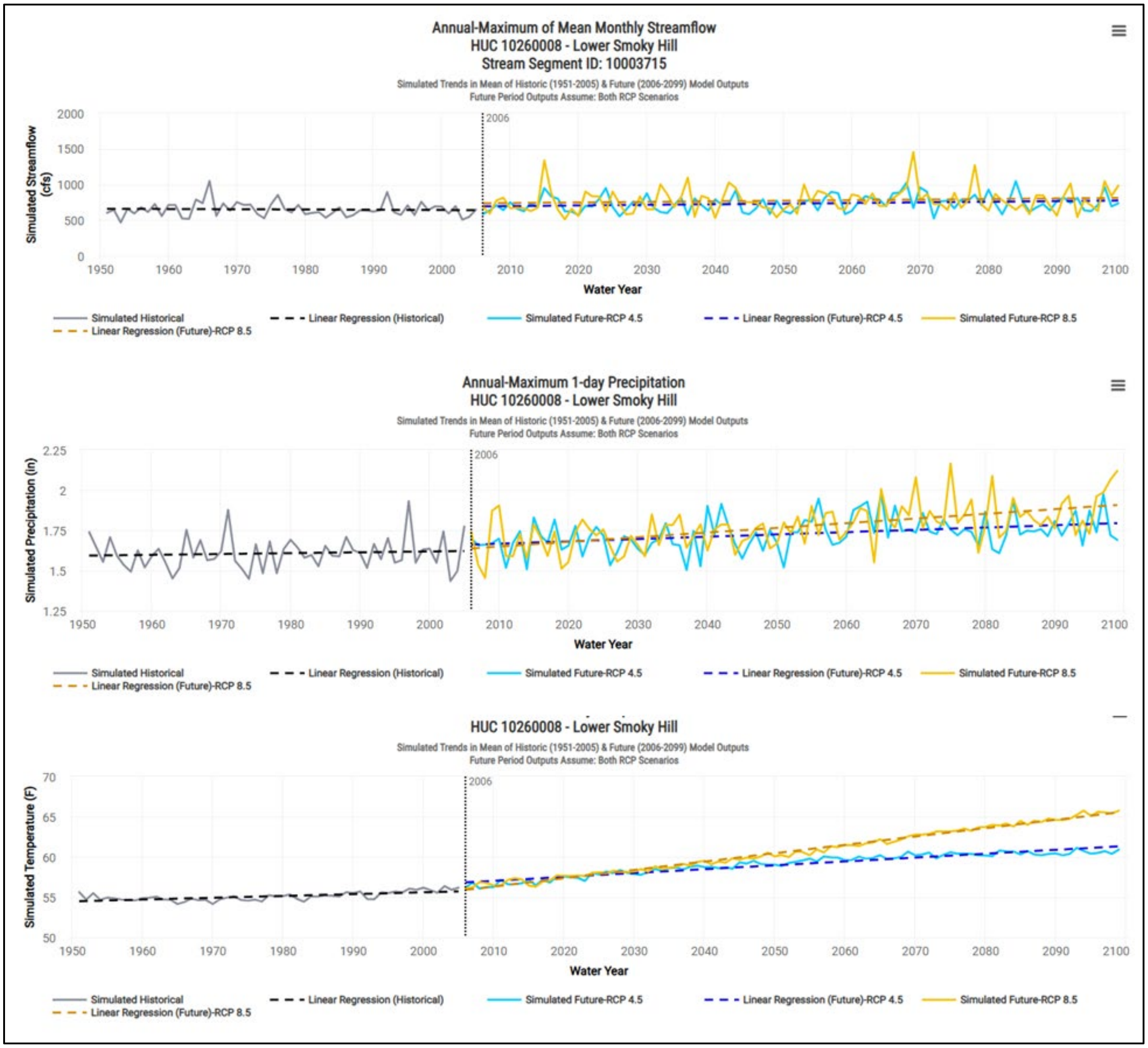


Figure 15. Trends in Mean Projected Annual Maximum Monthly Streamflow, Annual Maximum 1-Day Precipitation, and Annual Mean Temperature, HUC 10260008, Lower Smoky Hill

The CHAT provides streamflow and precipitation outputs analyzed comparatively by describing simulated changes in monthly and annual streamflow and precipitation between a baseline epoch (1976 to 2005) and two future epochs: 2035 to 2064 (mid-century) and 2075 to 2099 (end of century). The tool presents epoch-based monthly and annual change in streamflow and precipitation using boxplot visualizations. The monthly boxplots provide insight into the seasonality of changes in streamflow and precipitation over time. Figure 16 and Figure 17 present changes in epoch mean of simulated monthly mean streamflow for stream segment 10003715 in the Lower Smoky Hill watershed (HUC 10260008). For the stream segment of Smoky Hill River analyzed, it appears that for both emission scenarios and for both the mid-century and end-of-century epochs, flows are generally simulated to increase throughout most of the year, with reductions in overall flows through the hottest months including July and August. Increased change is most substantial for the winter and early spring months spanning December through May.

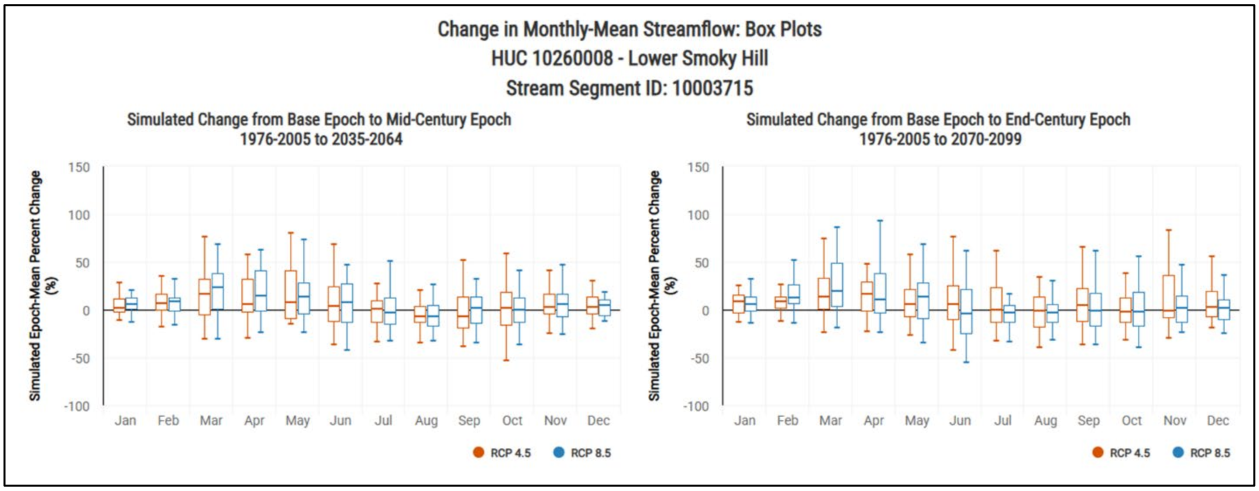


Figure 16. Change in Epoch Mean of Simulated Monthly Mean Streamflow – HUC 10260008, Stream Segment 10003715

When used to evaluate the change in the epoch mean of simulated annual mean streamflow, the CHAT calculates the median change from the base Epoch (1976 to 2005) to the mid-century epoch (2035 to 2064). The change in the epoch mean of simulated annual mean streamflow is 8 percent under the RCP 8.5 scenario. By the end-of-century epoch (2070 to 2099), the change relative to the base period under the RCP 8.5 scenario is 6 percent.

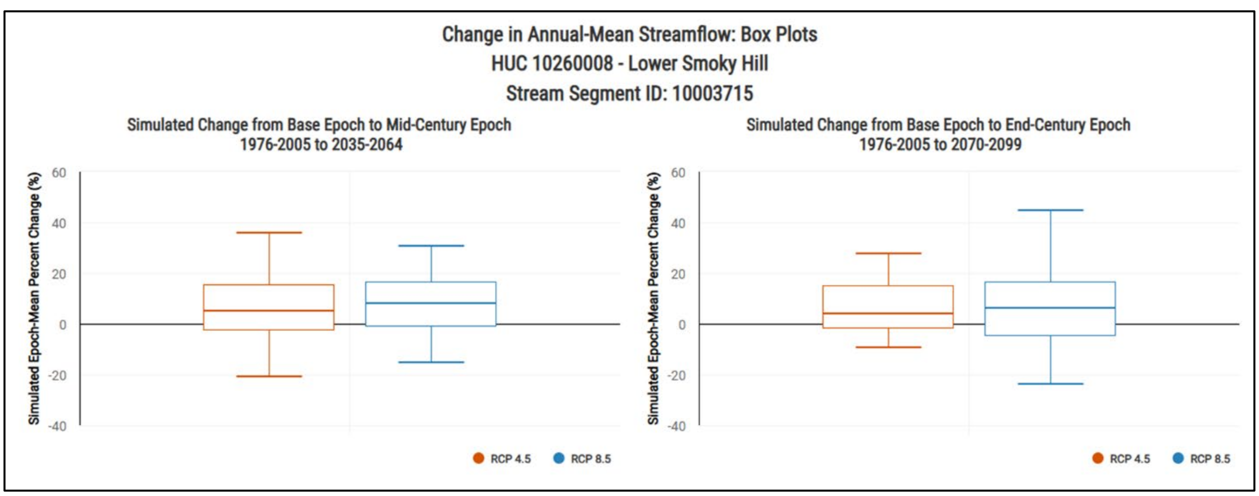


Figure 17. Change in Epoch Mean of Simulated Annual Mean Streamflow – HUC 10260008, Stream Segment 10003715

5. Screening Level Relative Vulnerability Assessment: Ecosystem Restoration

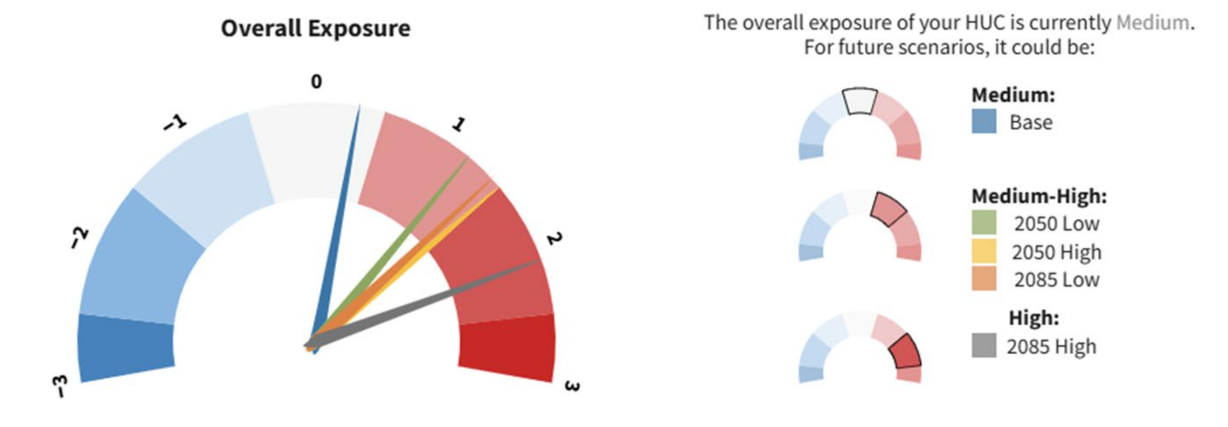
The USACE Civil Works Vulnerability Assessment Tool (CWVAT) facilitates a screening level, comparative evaluation of hazard exposure to projects for a selected USACE business line for an 8-digit HUC watershed relative to the other 8-digit HUC watersheds within the Continental United States (CONUS), Alaska, and Hawaii. The CWVAT computes and aggregates a series of indicator variables into an exposure score which shows how much the exposure to a hazard in one watershed differs from the median of all watersheds across the United States. The tool uses the CMIP5 GCM-based Bias Corrected, Spatially Disaggregated (BCSD) VIC dataset (2014) to define projected hydrologic and meteorologic inputs to the tool's z-scores.

The CWVAT offers hazard exposure scores and indicator variable values for two subsets of simulations: lower (future with moderate levels of change) and higher (future with higher levels of change). Hazard exposure scores are available for two 30-year futures epochs (centered on 2050 and 2085) and are calculated through a multi-step process. First, raw indicator values are calculated and normalized with respect to the median indicator across all watersheds. Hazard exposure scores are an average of the normalized indicators for a specific hazard that are then standardized to recenter the median value around zero. Total exposure scores are the sum of the hazard exposure scores standardized to recenter the median value around zero. The sign of an exposure score indicates if a project site and watershed are more or less vulnerable compared to the base historical period and the magnitude indicates by how much. The projected outputs incorporated into exposure scores contain considerable uncertainty. Some of this uncertainty is reflected by the differences in results for each of the subset-epoch combinations.

This assessment used the default, National Standards settings for the Ecosystem Restoration business line in the Lower Smoky Hill watershed, HUC 10260008. Overall exposure analysis, provided in Figure 18, indicates the project area is more exposed for all epochs and future scenarios than the typical watershed, ranging between medium to high and high exposure categories. This is a comparative evaluation and thus, does not imply that the watershed is not vulnerable to projected hydrological changes. Results indicate that for the select metrics incorporated into the tool, this watershed may be more vulnerable to projected changes relative to other watersheds.

Hazards influencing the Ecosystem Restoration business line include drought, energy demand, extreme temperature, historical extreme conditions, land degradation, riverine flooding, and wildfire. Dominant hazards and indicators contributing to total exposure for the watershed are provided in Table 4. In all future epochs and scenarios, extreme temperature contributes the most to the overall exposure of the watershed.

Indicators used to compute the extreme temperature hazard exposure score include: 5-day maximum temperature, days above 95° F, frost days, high heat days, and high heat index days. As shown in Table 4, the dominant indicator variables contributing to total exposure are high heat index days and days above 95° F. These two dominant indicators are related to increased temperatures which can negatively impact the ecosystem restoration business line. Specifically, increased temperatures can increase stress on vegetation and increase water temperatures, reducing habitat for cold water species. Additionally, increased temperatures can increase the risk of algal blooms which increase the risk of fish kills and negative impacts to targeted species.



Epoch-Scenario	Z-Score	Percentile	Change from Base	Change from 2050
Base	0.31	76%		
2050 Low	1.18	65%	0.87	
2050 High	1.49	68%	1.18	
2085 Low	1.42	67%	1.10	0.23
2085 High	2.10	64%	1.79	0.61

Figure 18. Exposure Overview – Lower Smoky Hill (HUC 10260008)

Table 4. CWVAT Output – HUC 10260008 Lower Smoky Hill

Subset and Epoch	Dominant Hazard	Hazard Exposure Z-Score	Hazard Exposure Change from Base (Change from 2050)	Dominant Indicator Contributing to Top Hazard	Dominant Indicator Z-Score	Dominant Indicator Change from Base (Change from 2050)
2050 Low	Extreme Temp	1.33	0.80	High Heat Index Days	1.39	0.64

Subset and Epoch	Dominant Hazard	Hazard Exposure Z-Score	Hazard Exposure Change from Base (Change from 2050)	Dominant Indicator Contributing to Top Hazard	Dominant Indicator Z-Score	Dominant Indicator Change from Base (Change from 2050)
2050 High	Extreme Temp	1.56	1.03	Days above 95̊F	1.59	1.00
2085 Low	Extreme Temp	1.61	1.08 (0.27)	Days above 95̊F	1.61	1.02 (0.25)
2085 High	Extreme Temp	2.48	1.96 (0.93)	Days above 95̊F	2.37	1.79 (0.79)

6. Resiliency to Dynamic Weather-Related Risk

A risk framework was applied to evaluate how dynamic weather-related (DWR) risks to project performance may change with time. As part of this process, risk sources, hazard likelihood, harms, consequence impacts, and an overall risk were evaluated for each project feature. Project features associated with the ecosystem restoration project include creation of variable depth pool and riffle structures, a sediment forebay, weirs, and wetland restoration. Recommended actions and resilience features were then considered to reduce and manage the relative risk for each project feature. Table 5 summarizes the risks associated with each project feature and recommended actions to manage risk.

The largest risk identified for the pool and riffle structures, sediment forebay, and weirs included increased streamflow and velocities resulting from projected increases in streamflow and precipitation. Increased streamflow and velocities may contribute to increased erosion and sedimentation within the channel leading to changes in stream habitat and increase the frequency of structure overtopping. While the likelihood of a trigger and hazard materializing is possible as indicated by increasing projected streamflow and precipitation trends, dredging is adaptable through maintenance and additional design features (sediment basin) were added to reduce sedimentation risk resulting from increased flows, reducing the overall likelihood to unlikely. A moderate impact rating was assigned due to potential increased erosion negatively impacting aquatic ecosystems. However, limited residual risk was identified as most flows from the Smoky Hill River are controlled via levee gates, providing measures to reduce streamflow into the old channel. Additionally, routine operation and maintenance for sediment removal and the inclusion of the sediment forebay can alleviate risks associated with increased streamflow and precipitation. Recommended actions include channel monitoring and maintenance.

Projected increases in temperature and increased drought frequency pose the greatest risk to wetland restoration measures. Increasing temperatures and drought frequency, may increase water temperatures and reduce water availability, stressing cool weather tolerant aquatic and vegetative species. The likelihood of a trigger and hazard materializing is highly likely, as indicated by statistically significant increasing projected temperature trends and medium to high extreme temperature hazard exposure. However, wetland management is adaptable through maintenance and additional design features, such as tree plantings to establish riparian zones for shade and decrease water temperatures, reducing the overall likelihood to possible. A major impact rating was assigned due to these environmental considerations. However, limited residual risk is anticipated due to design of pool structures that create pockets of deeper, cooler water, preservation of existing riparian zones, and acquisition of water rights to secure water availability from Kanopolis. Recommended actions include channel and riparian zone monitoring.

Table 5. DWR Risk Table

Project Feature	Trigger	Hazard and Hazard Likelihood	Harm	Overall Likelihood of Harm & Resilience Features	Max Impact Rating	Max Risk Score	Residual Risk	Evaluation	Recommended Actions to Maintain Acceptable Risk Level
Dredging (Pool and Riffle Structure)	Increased discharge and velocities	Future flood velocities may be higher than present	Erosion and sedimentation leading to changes in the stream habitat	Unlikely (2). Dredging is adaptable through O&M. Additional design features (sediment forebay) were added to reduce sedimentation risk resulting from increased flows	Moderate (3)	Low (6)	Limited residual risk. Flows entering the disconnected channel can be controlled with levee gate operation. Flows contributing from interior drainage can be stored within the channel and slowed with design features.	DWR risk adequately controlled through design and O&M	Monitor for changes in pools/riffles and potential sediment removal needs.
Sediment Forebay	Increased discharge and velocities	Future flood velocities may be higher than present	Erosion and sedimentation leading to changes in the stream habitat	Unlikely (2). Adaptable through O&M. Features are specifically designed for flooding and sedimentation risk	Moderate (3)	Low (6)	Limited residual risk. Structure is designed for flooding and routine O&M for sediment removal.	DWR risk adequately controlled through design and O&M	Monitor streamflow characteristics and continue to conduct periodic inspections to ensure design remains adequate and O&M needs are met
Weirs	Increased discharge and velocities	Future stormwater volumes may be larger than present	Weirs may be overtopped more frequently, resulting in more frequent flows and high velocities in the channel	Unlikely (2). Features are designed for frequent overtopping.	Moderate (3)	Low (6)	Limited residual risk due to design and performance history of existing weirs.	Risk controlled through design	Monitor streamflow characteristics and continue to conduct periodic inspections to ensure design remains adequate and O&M needs are met
Wetland Restoration	Increased temperatures	Future temperatures and drought conditions may be worse than present	Water temperatures may increase, negatively impacting aquatic species and drought conditions may reduce water availability.	Possible (3). Wetland management is adaptable through O&M and additional design features (increased riparian zones for shade) to reduce increased water temperatures	Major (4)	Moderate (12)	Limited risk due to design of pool structures that create pockets of deeper, cooler water. Additionally, construction and design does not remove existing riparian areas, allowing for earlier establishment of shade in the stream, reducing water temperatures.	Adequately controlled through water right acquisition and riparian zone preservation	Monitor for changes in pools/riffles and potential sediment removal needs. Additionally, monitor tree health and identify areas where future tree plantings may be needed.

7. Conclusions

The purpose of the Smoky Hill Ecosystem Restoration project is to restore aquatic and wetland habitats by reestablishing capacity in the old Smoky Hill River channel, managing sedimentation, and restoring habitat connectivity in Salina, Kansas. To determine how projected weather changes could cause future hydrologic and hydraulic differences due to changes in peak flows experienced within the watershed, this assessment reviewed historic hydrometeorological data, as well as projected hydrometeorological outputs. USACE tools were used to investigate how projected inputs may impact future streamflow, precipitation, and temperature in the Lower Smoky Hill watershed.

Overall, the resilience assessment indicates annual peak flows are not stationary on the Smoky Hill River near Mentor with statistically significant decreasing trends observed in the streamflow record during the 1949-2024 period. Future projections vary by season, with greater peak flows anticipated in spring and decreases in peak streamflow anticipated in warmer months. Projected changes may contribute to increased temperature and extreme precipitation in the region resulting in increased frequency in the occurrence of extreme storm events. Extreme departures from typical conditions, as projected, will also magnify periods of wet and dry weather resulting in longer more severe droughts and larger more extensive storms. This literature finding is further reinforced by computed trends in projected annual maximum mean monthly streamflow, annual maximum 1-day precipitation, and annual mean 1-day temperature where scenarios with continued growth in carbon dioxide emissions showed increasing trends. Statistically significant increasing trends were identified for projected precipitation and temperature variables.

Larger and more frequent storms may impact the Smoky Hill Ecosystem Restoration project by improving water availability for aquatic habitat. However, increased frequency of loading project features, may lead to higher maintenance costs. More extreme temperatures and extended periods of drought may increase water temperatures and reduce water availability, stressing cool weather tolerant aquatic and vegetative species. Project features associated with the ecosystem restoration project include creation of variable depth pool and riffle structures, a sediment forebay, weirs, and wetland restoration.

Table 5 indicates potential residual risk for ecosystem restoration project features due to the projected changes. The table also includes a qualitative rating of how likely those residual risks are to materialize and undermine project features resulting in continued ecosystem degradation within the study area. Examples of building resilience into the proposed project features include designing structures for frequent flooding and maintaining variable pool depths and riparian zones to provide protection from increased temperatures and worsening drought conditions.

This qualitative analysis supports the recommendation that the proposed project adequately addresses risks related to dynamic weather and changing hydrological conditions.

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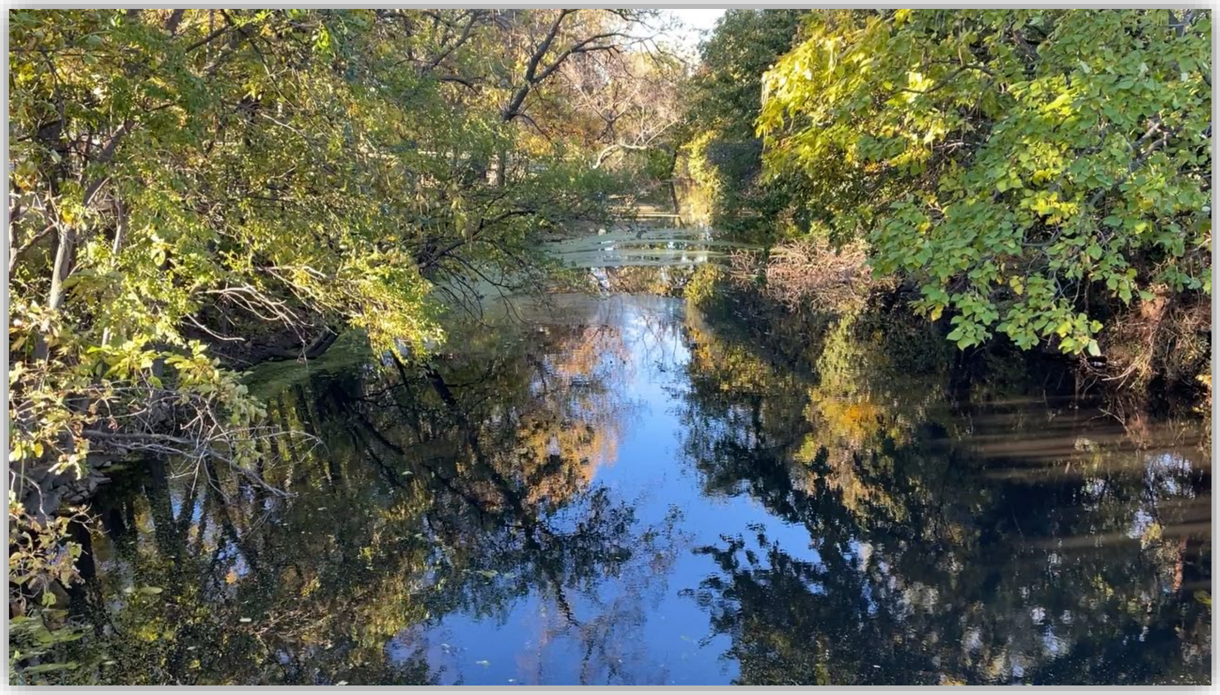
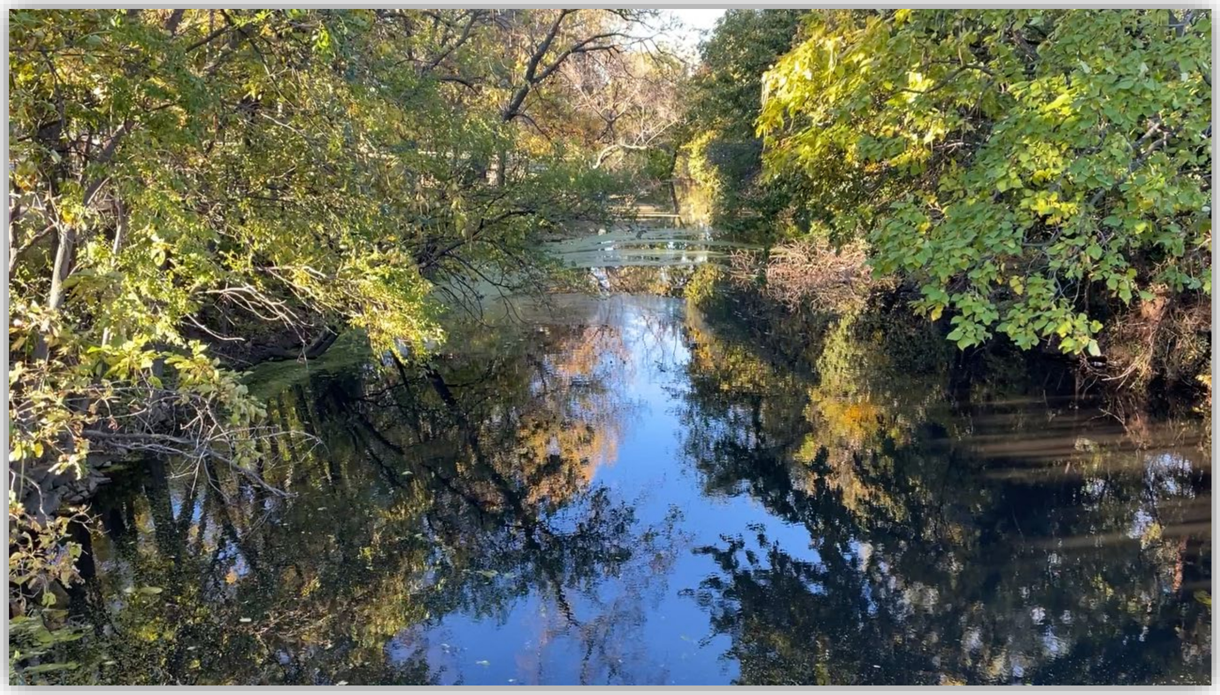


Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix C – Engineering

September 2025



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Appendix C1 – Alternatives

September 2025

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LIST OF FIGURES

1 PURPOSE

See the main report.

2 EXISTING CONDITIONS

The study area is located in the City of Salina, Kansas. The Smoky Hill River is located along the east side of salina flowing from south to north. A USACE Flood Risk Management (FRM) project, including a levee and cutoff channel, was completed in 1961. The project isolated the Old Channel from the Smoky Hill River and permanently diverted a significant volume of surface water away from the Old Channel, resulting in lost flow regimes and natural sediment transport functions. These changes have resulted in sediment aggradation, loss of high quality in-stream, wetland, and riparian corridor habitats, and the ability of the Old Channel to support native fish and wildlife communities.

2.1 Study Area

The project area, located in Saline County, Kansas, includes approximately 6.8 miles of remnant “Old Channel”, which flows through downtown Salina as well as adjacent riparian forest areas. The Old Channel inlet captures flow from the Smoky Hill River north of the Bill Burke Sports Complex. The Old Channel meanders west through downtown Salina, then turns back east through Lakewood Lake Park, then drains through a federal levee outlet control and pump station and re-connects to the Smoky Hill River south of East North Street.

3 SITE SELECTION AND PROJECT DEVELOPMENT

The City of Salina (local non-Federal Sponsor) and the surrounding public are interested in reestablishing flow, recreating stream habitat, and incorporating the rehabilitated stream into the larger downtown revitalization plan. Information on development of the project and alternatives can be found in Section 3.0 Plan Formulation and Evaluation of the main report.

3.1 Proposed Activities under Current Study

The project was originally authorized under Section 1135 of the Continuing Authorities Program (CAP). Due to cost estimates of the Tentatively Selected Plan (TSP) exceeding the CAP authority funding limits, the project was converted to a General Investigations (GI) program.

3.2 Issues and Other Information

The City of Salina has received a Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant from the US Department of Transportation. The grant would help the urban community move forward with modernization of roads, bridges, transit, and intermodal transportation in the downtown Salina area, making transportation safer, more accessible, affordable, and sustainable, and create greater incentives for people to use the downtown area. The modernization construction will be completed in 2029 to 2030. Therefore, USACE construction activities in the Old Channel should begin in 2027.

3.3 Channel Centerline

Two Centerlines are documented in this study. See the H&H Appendices for the centerline that follows the existing natural channel for analysis purposes. A design centerline developed in the CAP study along with the RAISE Grant design effort is also shown in the study documents.

Stationing referenced in this Engineering Appendix is the stationing along the design centerline developed in the CAP study.

The channel is distinguished into 2 reaches along the 6.8-mile-long channel. Reach 1 is the Southern portion of the Old Channel upstream of Western Star Mill Wier near Iron Avenue at approximate station 3013+40. Reach 2 is the northern portion of the Old Channel downstream of Western Star Mill Wier near Iron Avenue at approximate station 3013+40. The reaches are depicted in Figure 3-1.

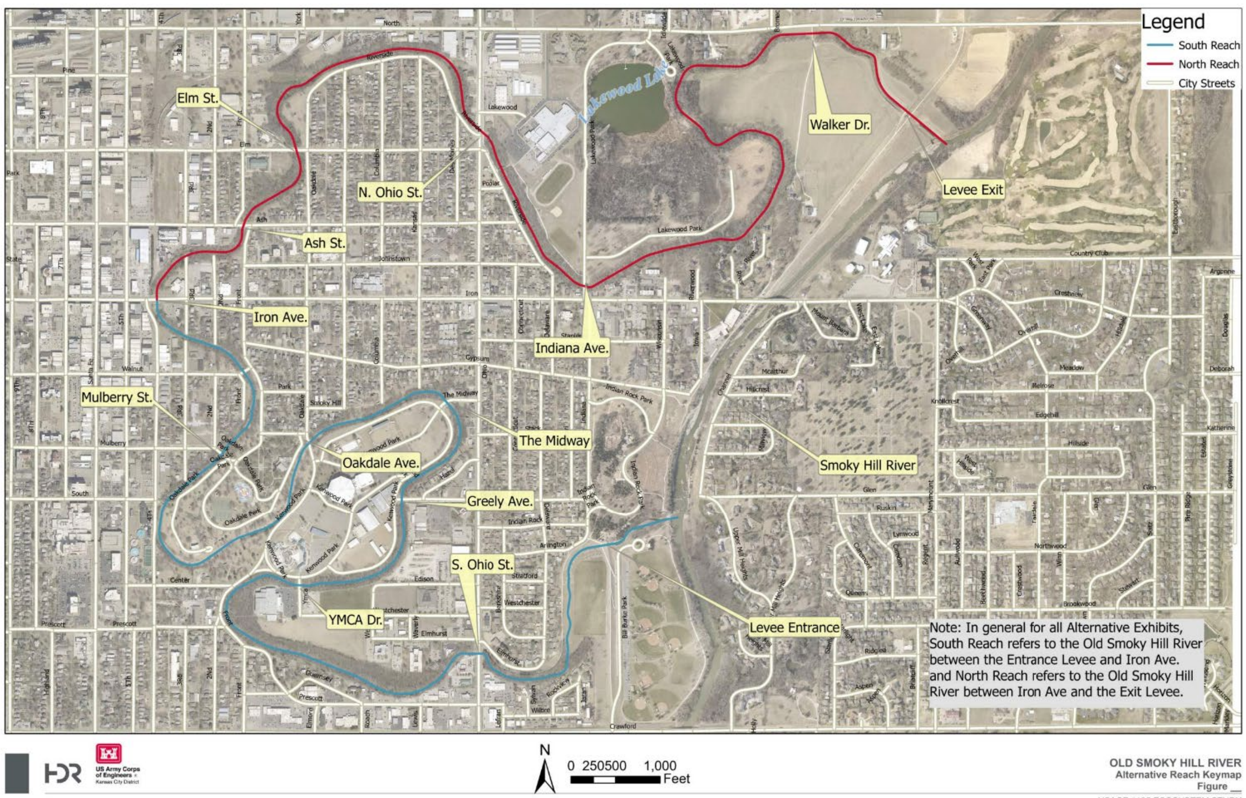


Figure 3-1. Old Smoky Hill River Reach Keymap

4 ALTERNATIVE COMPONENTS

The components described in this section are common to all the alternatives unless noted otherwise.

4.1 Entrance Works – Sediment Forebay

During the CAP study, a Technical Memo was written to describe the design requirements and propose design concept for the entrance works from the Smoky Hill River into the Old River Channel. See Appendix D Sediment Transport Assessment for the complete memorandum.

Concept Alternative 4 of the sedimentation forebay at the entrance to the Smoky Hill River channel was identified as the recommended alternative for this portion of the project. See Figure 4-1 for the sediment forebay plan included in alternatives A1 through A4.

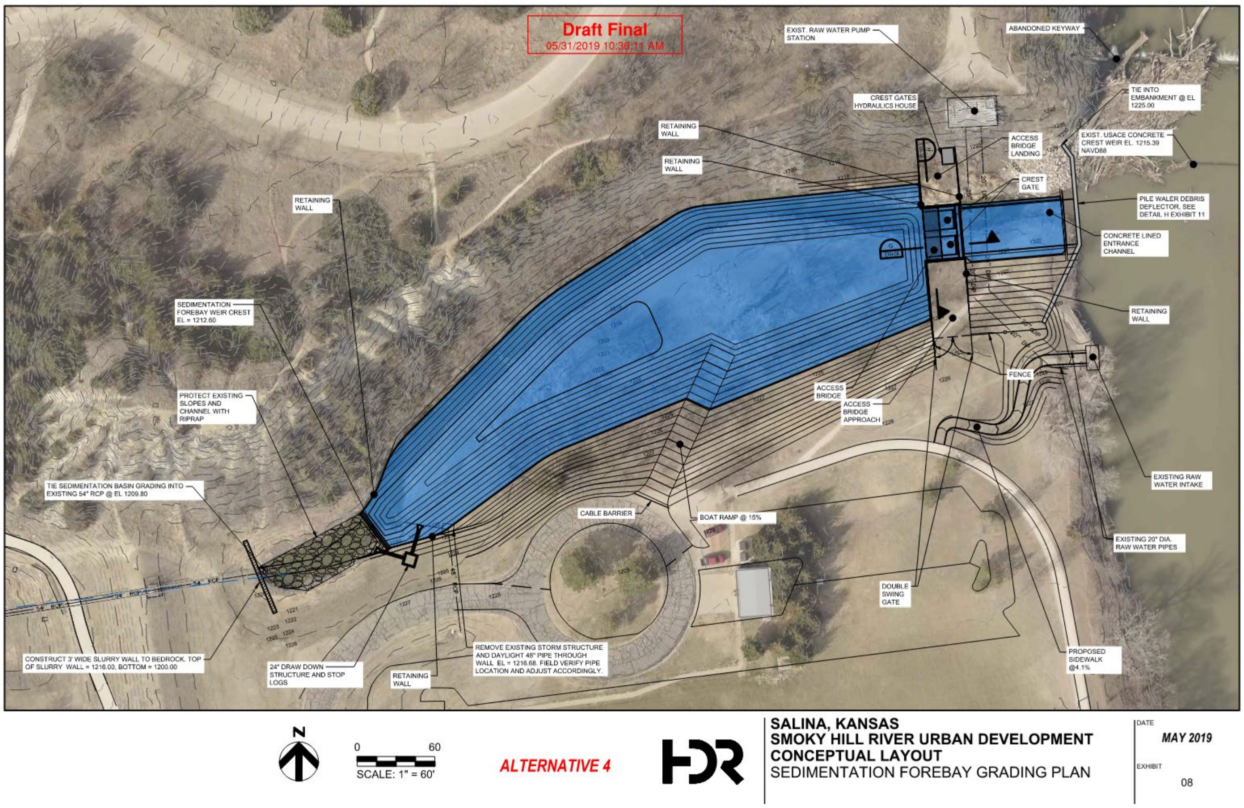


Figure 4-1. Sedimentation Forebay Selected Grading Plan

The Sediment Forebay includes an extensive inlet structure which includes crest gates, an access bridge, a concrete lined entrance channel, retaining walls and a debris deflector. Figure 4-2 shows the arrangement of the features. For more details refer to the drawings in Appendix C2.

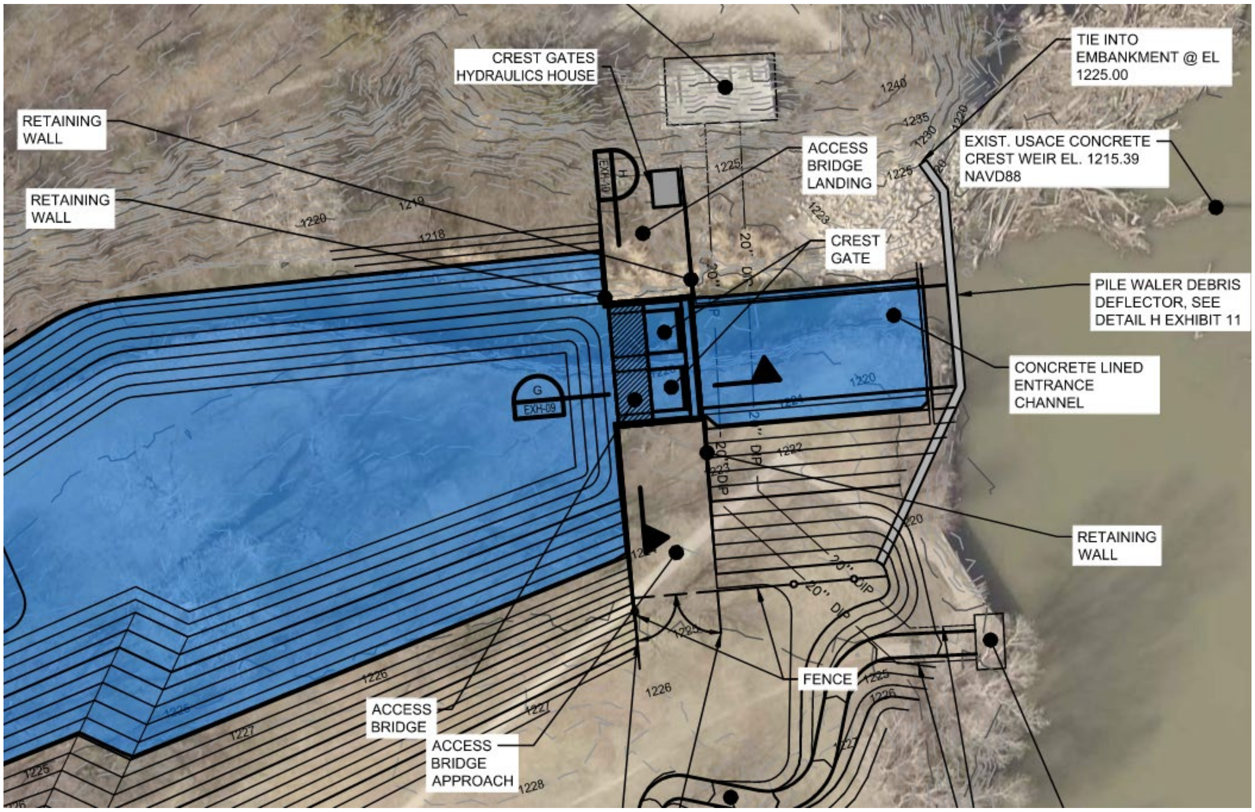


Figure 4-2. Sedimentation Forebay Inlet

4.2 Channel Dredging, Riffles, Pools and Wetland Shelves

Alternatives A2, A3 and A4 use the same typical sections to create a variable-depth profile consisting of glides, pools, riffles, and run habitats. Refer to the specific alternative plans and channel profile for applicability of the typical sections. Old channel typical riffle sections and pool sections applicable to Alternatives A2, A3 and A4 are shown in Figure 4-3 and Figure 4-4.

Pool sections are located halfway through bends to the end of the bend. Riffle sections are located at the section prior to the beginning of the bend. Glide sections are the transition from pool sections to riffle sections. Run sections are the transition from riffle sections to pool sections.

Typical old channel pool sections have a target depth of 4-6 feet with varying side slopes up to the existing grade. At inside bends, the slope up is 4:1, at outside bends, the slope up is 2:1 up to existing. Where wetland shelves occur, the bottom width of the pool sections is 1-foot to 5-feet. At all other locations in the channel the bottom width is 8-feet to 12-feet.

Typical riffle sections have a target depth of 3.25 feet deep with side slopes of 3:1 up to existing grade.

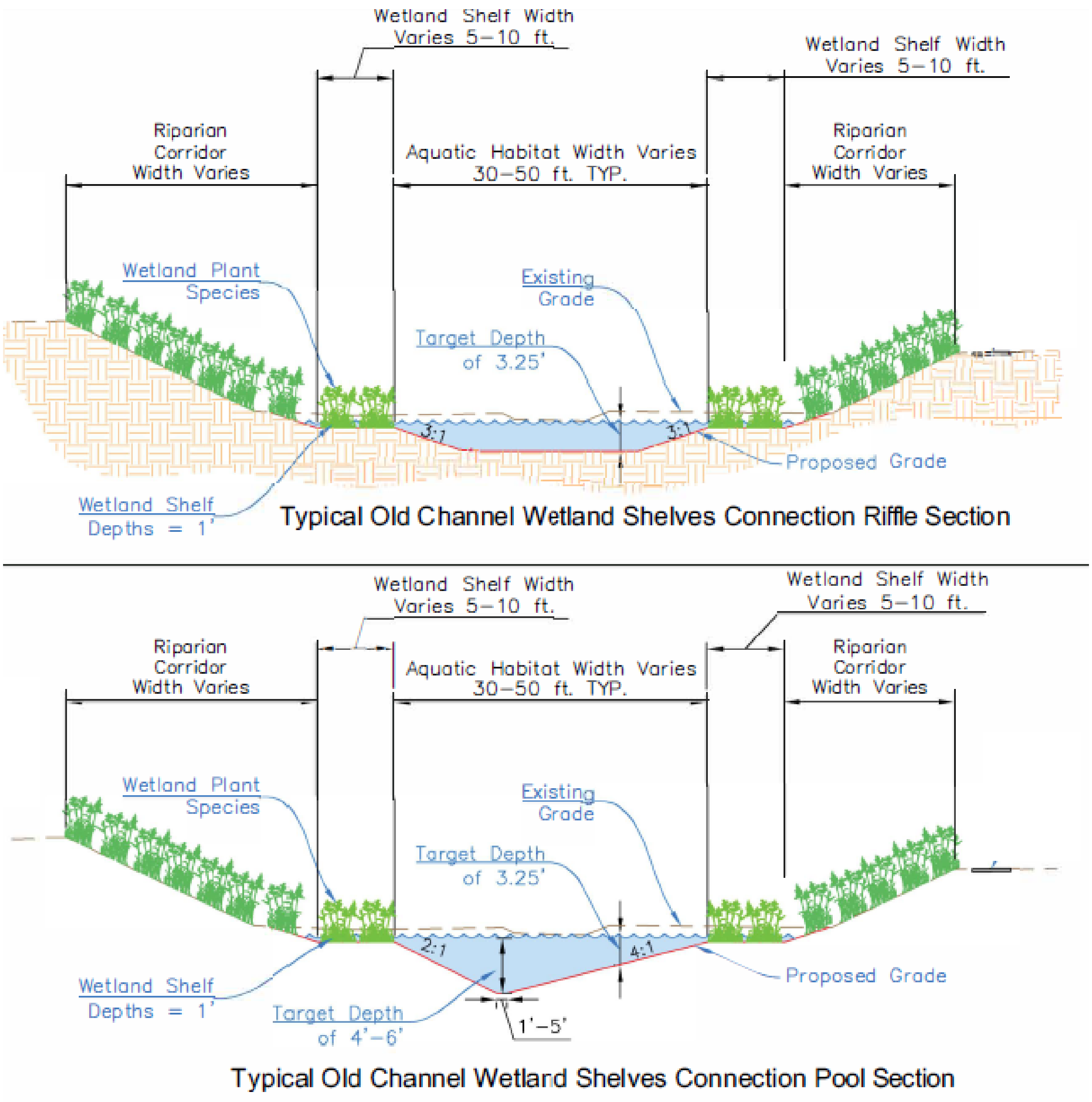


Figure 4-3: Alternatives A2, A3 and A4 Typical Sections with Wetland Shelves

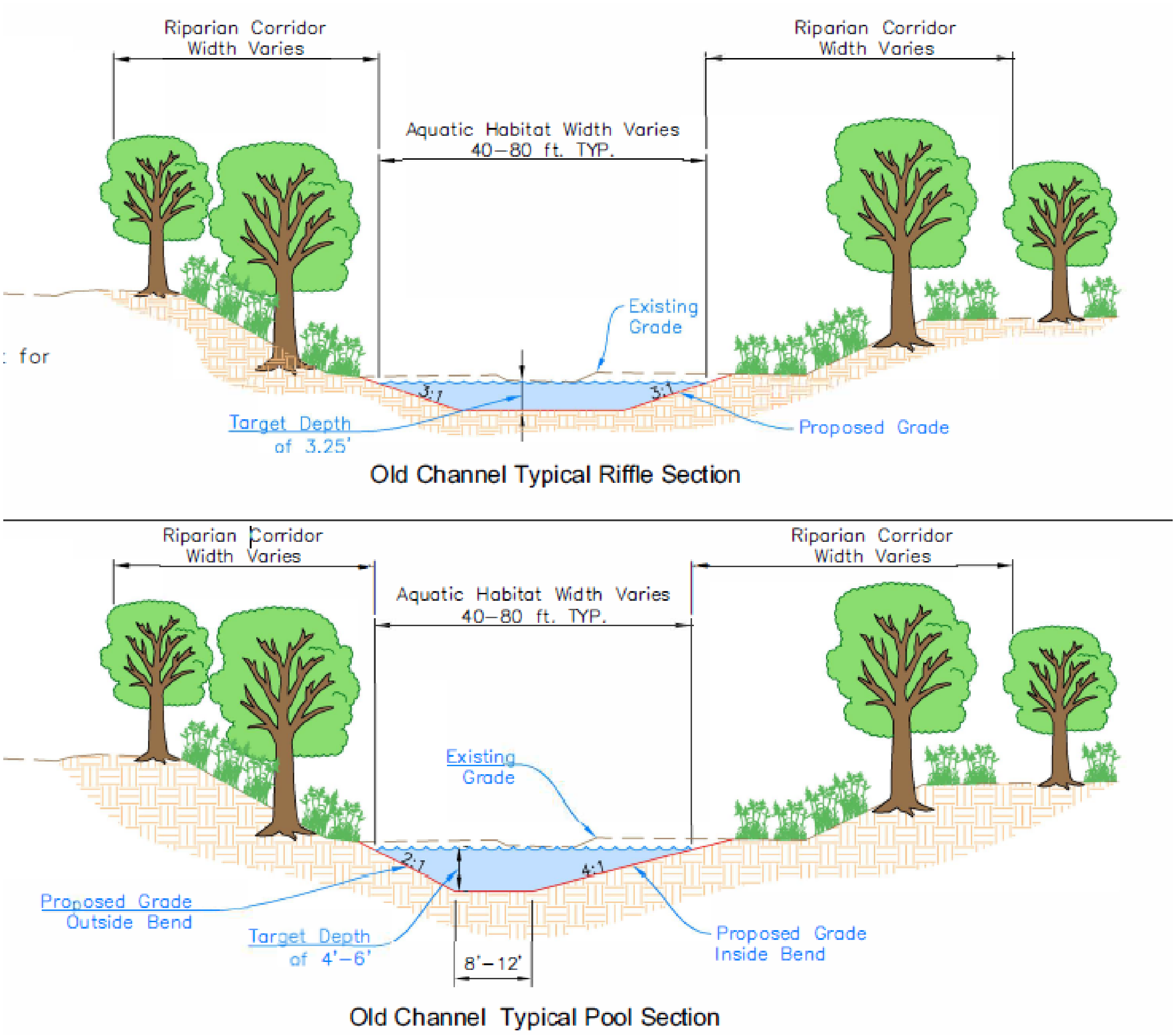


Figure 4-4. Alternative A2, A3 and A4 Old Channel Typical Sections

4.2.1 Channel Access

Access ramps down into the channel will be required to for construction activities. Access points are required for work between all bridges. Some access points may be located at the edge of the bridges, and some will be located at other areas where temporary access has minimal impact to the public and surrounding areas. The temporary access ramps will be restored at the end of construction.

4.3 Step Pools

Step pools are constructed in a stepwise fashion to allow fish and other aquatic life to move upstream through a series of submerged pools. Step pools are composed of channel-spanning pools and boulder or cobble steps with small slots between the larger rocks to allow fish to move from one pool to the next while still being submerged. This method does not rely on the ability of fish or other aquatic life to jump from one pool to the next. The pools are designed to convey flow all year round to ensure fish can pass each pool structure submerged. Step pools also allow safe public use of kayaks. Additional information is provided in Appendix C2 for rock riffle/pool structures.

4.4 Grade Control Structures

Grade control structures with stoplogs are required for multiple alternatives. The stoplog structure concept is provided in Figure 4-5 with additional information provided in Appendix C2. The new Lakewood Lake Habitat Wier is in Reach 2 near station 1020+00. The new Wetland Shelves Grade Control Structure is in Reach 1 near station 8007+80. The locations are shown in each alternative's plan.

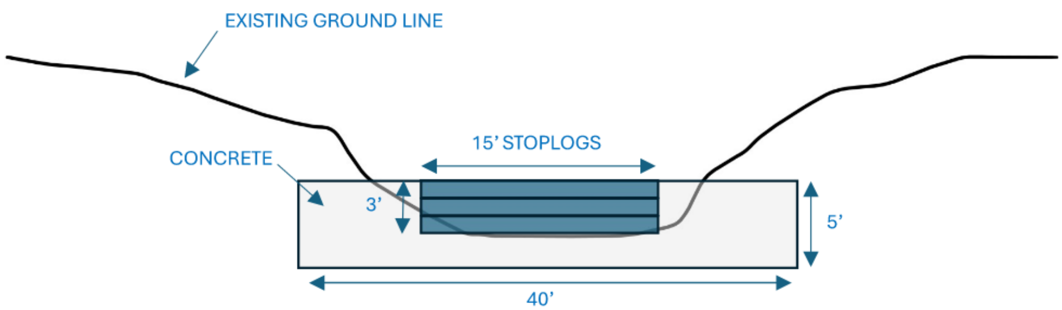


Figure 4-5. Typical Stoplog Structure for In-Channel

4.5 Remove Western Star Mill Weir and Replace with Step Pools

The Western Star Mill Weir (**Figure 4-6**) is to be removed and replaced with five step pools in Alternatives A1 through A4. The vertical portion of the weir will be removed and the concrete apron will remain in place. Refer to Appendix C2 for drawings.

Figure 4-6. Western Star Weir (to be removed)

4.6 Lakewood lake Restored Wetlands

During the CAP study, four alternatives of Lakewood Lake were evaluated with varying amounts of fill required to construct each. Lakewood Lake alternatives 1, 2 and 3 include a similar trail system each with increased amounts of fill being placed to create various wetland features. The trail configuration of Lakewood Lake alternative 4 is very extensive and requires more fill than alternatives 1, 2, and 3. See each of the alternative discussions below for more information.

4.6.1 Trails and Recreational Considerations

Each alternatives provides trail system through Lakewood Lake with a pedestrian bridge connection to be constructed under the RAISE grant by the City of Salina. The elevated trail system is to be constructed of fill material surfaced with mulch. The mulch will come from felled trees within the restored wetlands area.

Canoe and kayak discovery trails are planned in the restored wetland area of Lakewood Lake.

4.6.2 Culverts

Culverts through the trail systems will be installed to maintain flow connections to all the wetland areas.

4.7 Utilities

There are no known utilities impacted by the proposed work in this project. There are existing utilities that cross the channel but it is not anticipated that they will be impacted by construction activities. The team is gathering additional utility location information to evaluate further as the design progresses to increase our confidence in the assumptions we have made.

5 ALTERNATIVE A1

Alternative A1 involves dredging excess sediment from Reach 1 with a uniform trapezoidal section and pool habitat provided in Reach 2. Figure 5-1 though Figure 5-4 show the plan, profile and typical sections.

Figure 5-1. Alternative 1, Reach 1 – South Reach

Figure 5-2. Alternative A1, Reach 1 - North Reach

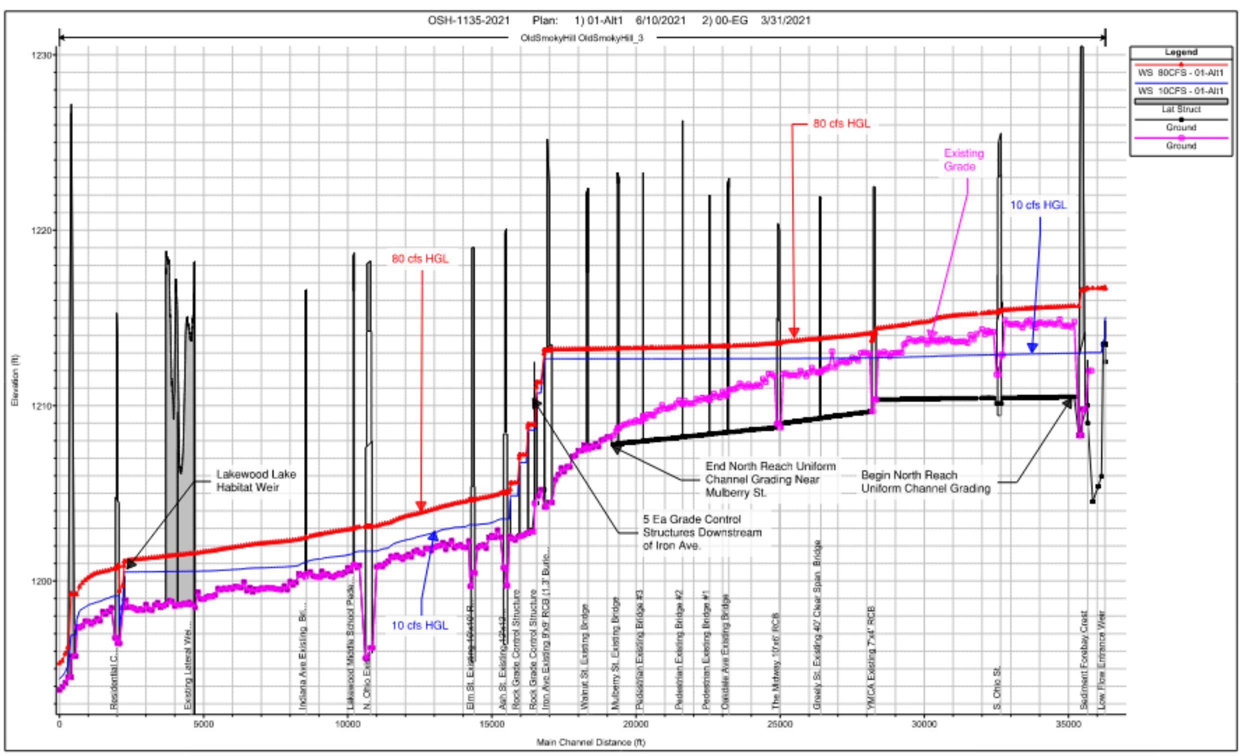


Figure 5-3. Alternative A1 Channel Profile

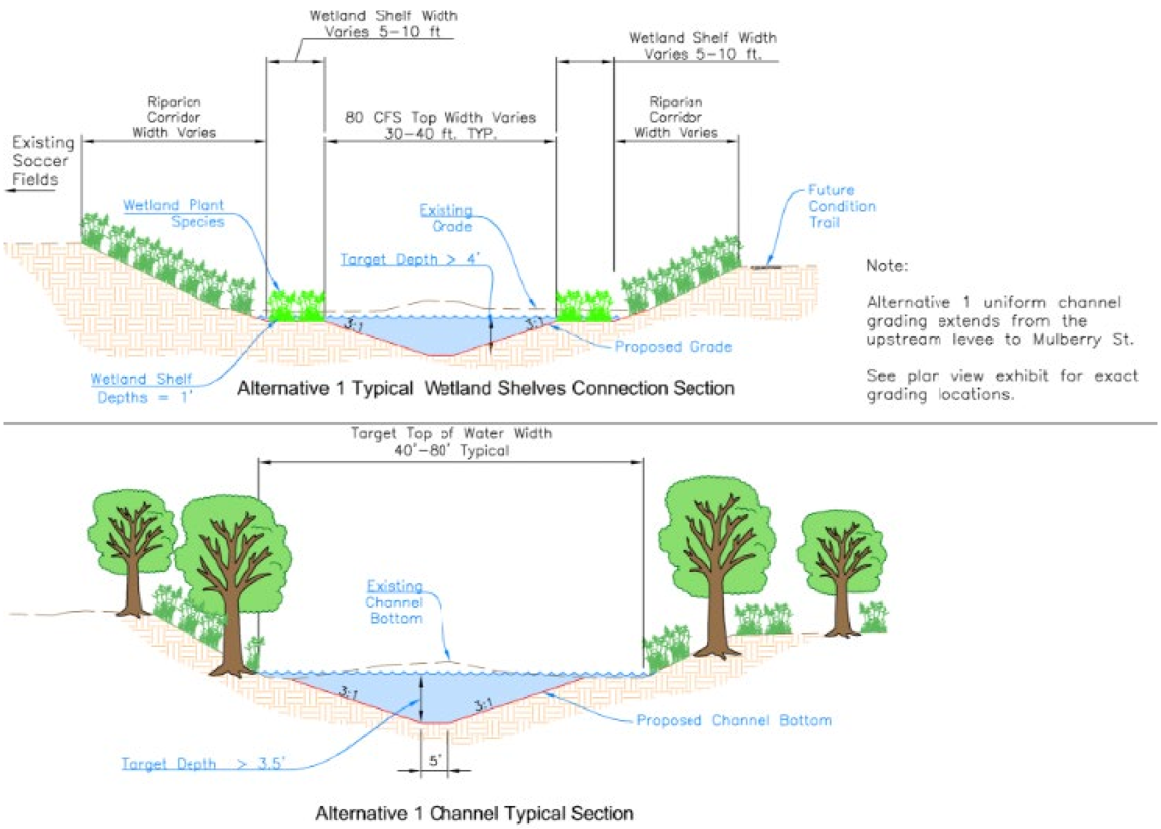


Figure 5-4. Alternative A1 Channel Sections

5.1 Entrance Works – Sediment Forebay

Alternative A2 includes the sediment forebay as shown in Section 4 of this appendix. Refer to Appendix C2 for more detailed drawings.

5.2 Grade Control Structures

Grade control structures with stoplogs as shown in paragraph 4.4 have been identified at two locations along the channel. The new Lakewood Lake Habitat Wier is in Reach 2 near station 1020+00. The new Wetland Shelves Grade Control Structure is in Reach 1 near station 8007+80.

5.3 Lakewood Lake Restored Wetlands

Restored wetlands at Lakewood Lake are supported by a system of added trails constructed from material hauled onsite. Refer to paragraph 4.6.

6 ALTERNATIVE A2

Alternative A2 involves dredging excess sediment from Reach 1 with a variable section to provide glides, pools, riffles and runs. Pool habitat is provided in Reach 2. Figure 6-1 through Figure 6-3 layout the features associated with Alternative A2. Refer to Section 4 for the typical sections.

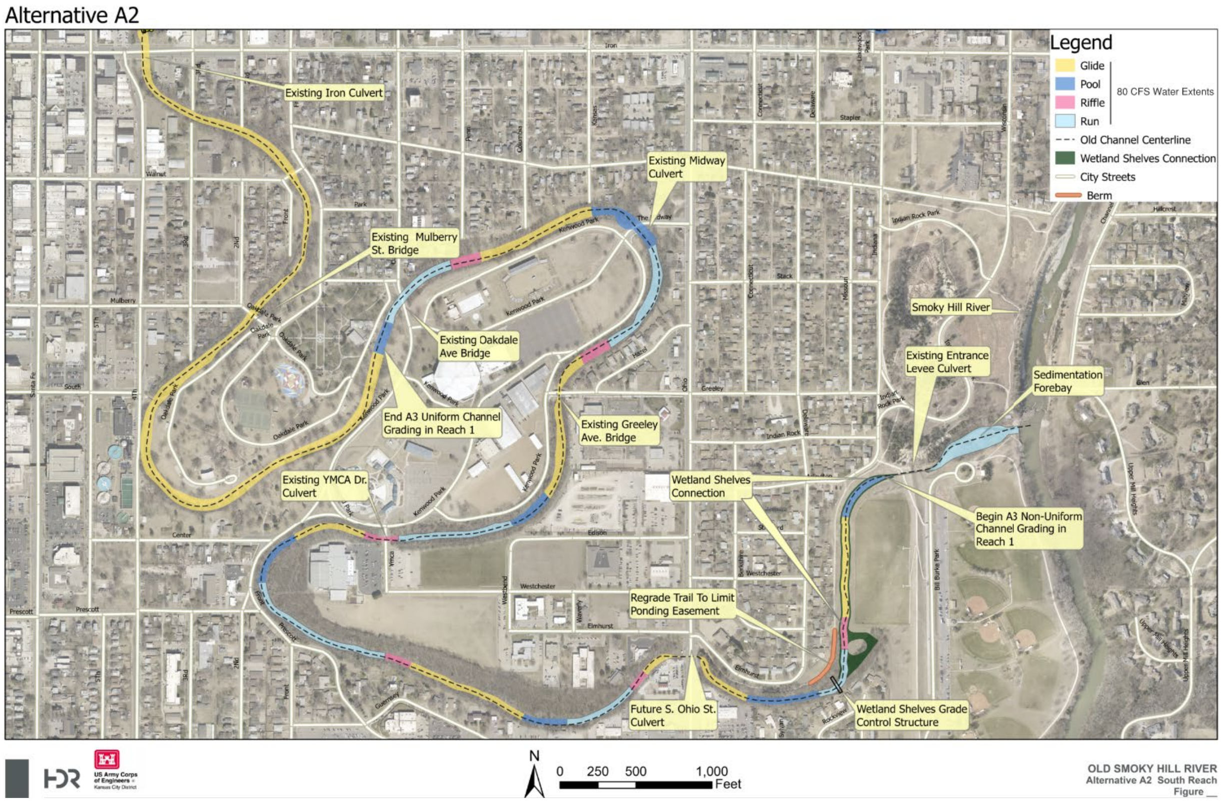


Figure 6-1. Alternative A2, Reach 1 – South Reach

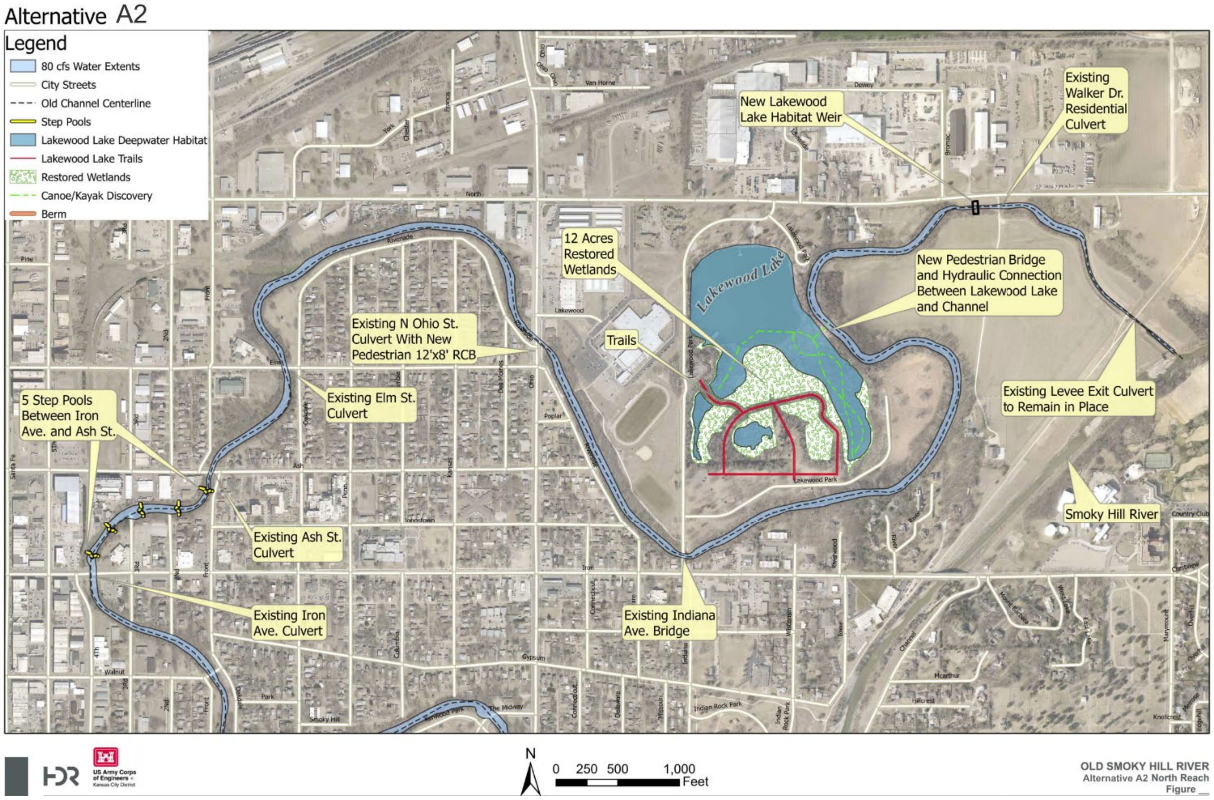


Figure 6-2. Alternative A2, Reach 2 - North Reach

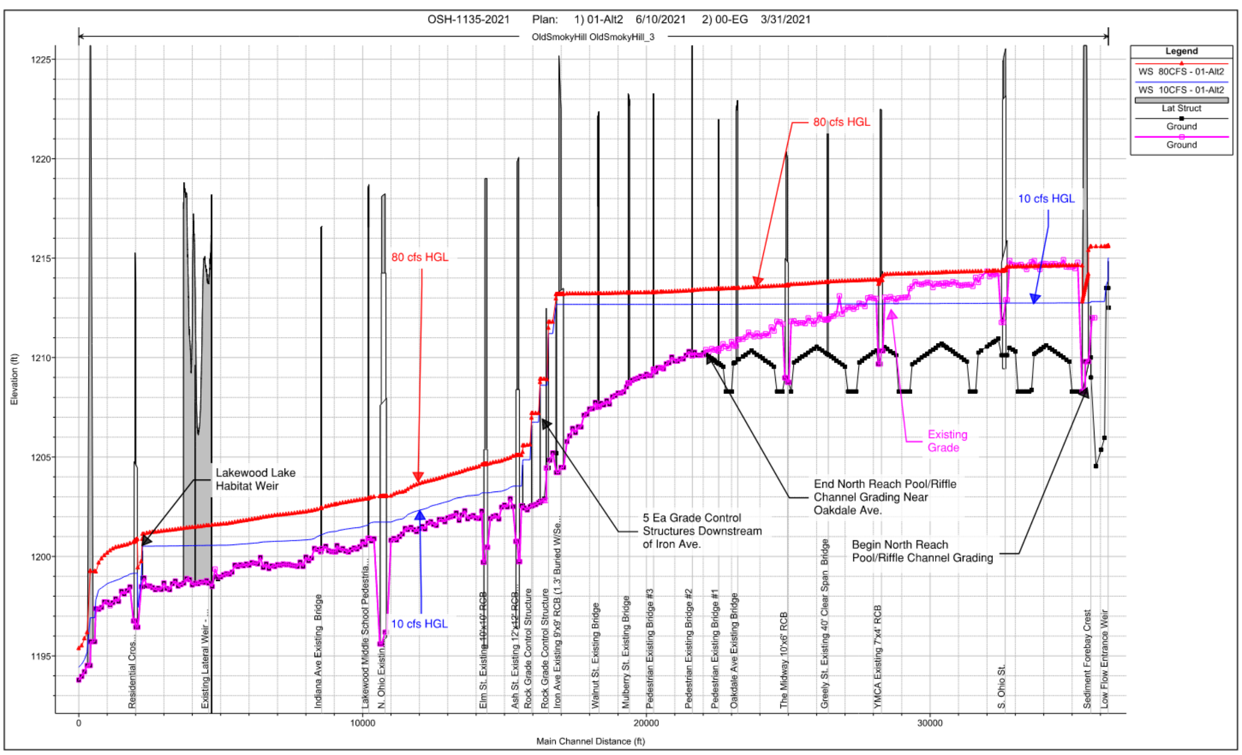


Figure 6-3. Alternative A2 Channel Profile

6.1 Entrance Works – Sediment Forebay

Alternative A2 includes the sediment forebay as shown in Section 4 of this appendix. Refer to Appendix C2 for more detailed drawings.

6.2 Channel Dredging, Riffles, Pools and Wetland Shelves

See paragraph 4.2 for the typical sections used for Alternative A2. The applicability of the typical sections are given in **Figure 6-1** through **Figure 6-3**.

6.3 Grade Control Structures

Grade control structures with stoplogs as shown in paragraph 4.4 have been identified at two locations along the channel. The new Lakewood Lake Habitat Wier is in Reach 2 near station 1020+00. The new Wetland Shelves Grade Control Structure is in Reach 1 near station 8007+80.

6.4 Lakewood lake Restored Wetlands

Restored wetlands at Lakewood Lake are supported by a system of added trails constructed from material hauled onsite. Refer to paragraph 4.6.

7 ALTERNATIVE A3

Alternative A3 involves dredging excess sediment from the Old Channel both in Reach 1 and Reach 2. See **Figure 7-1** through **Figure 7-3** for exhibits of the features associated with this alternative. Refer to Appendix C2 for Alternative A3 drawings.

Alternative A3

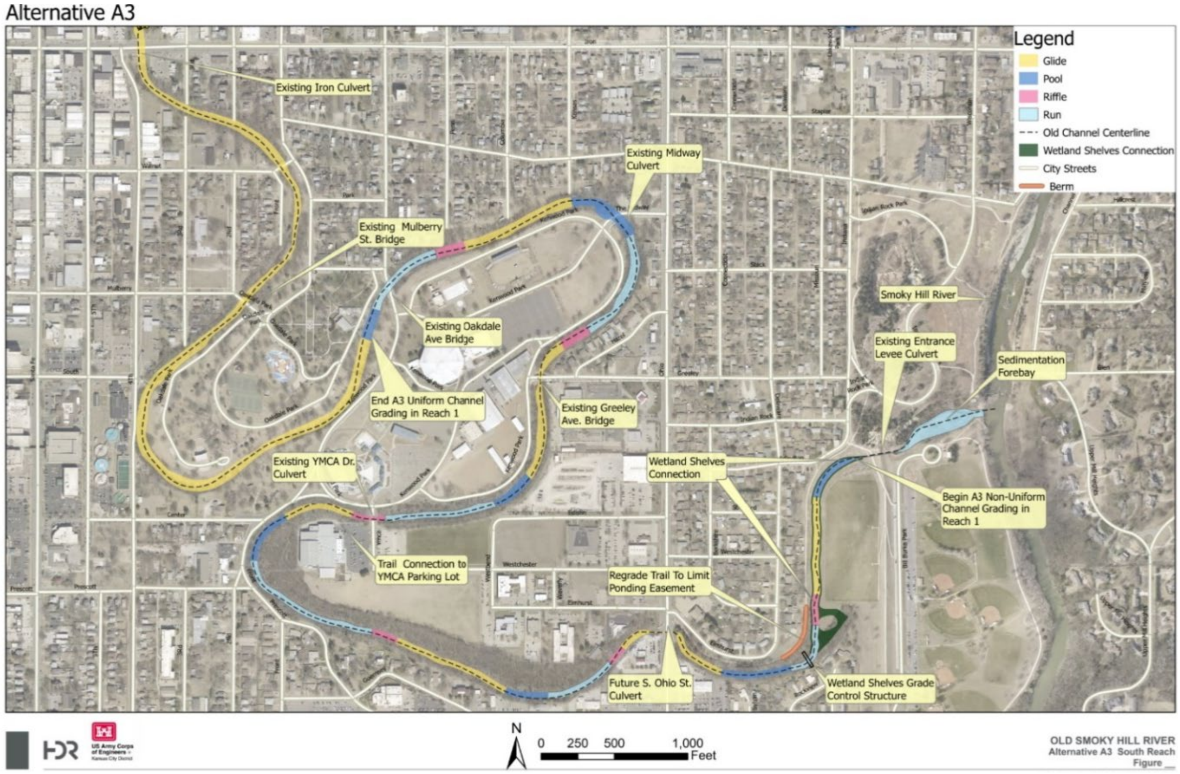


Figure 7-1. Alternative A3, Reach 1 – South Reach

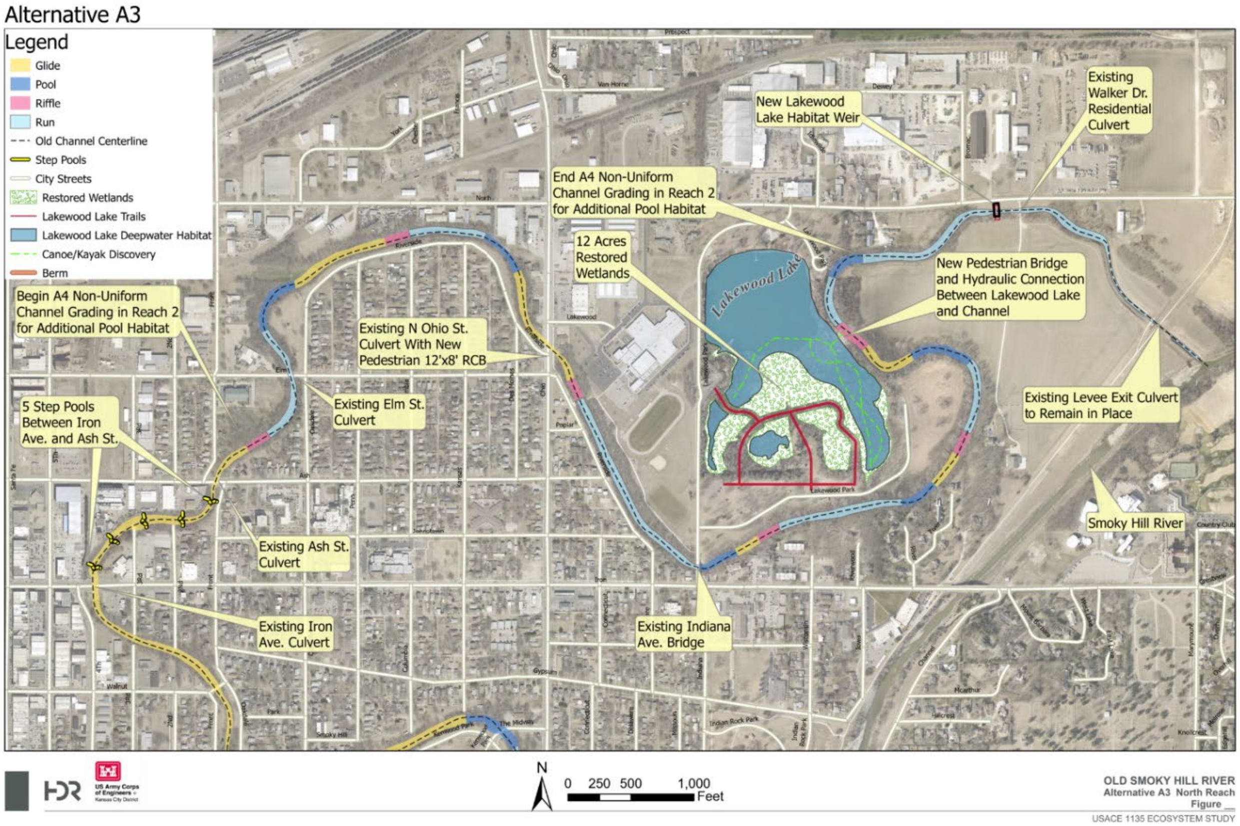


Figure 7-2. Alternative A3, Reach 2 - North Reach

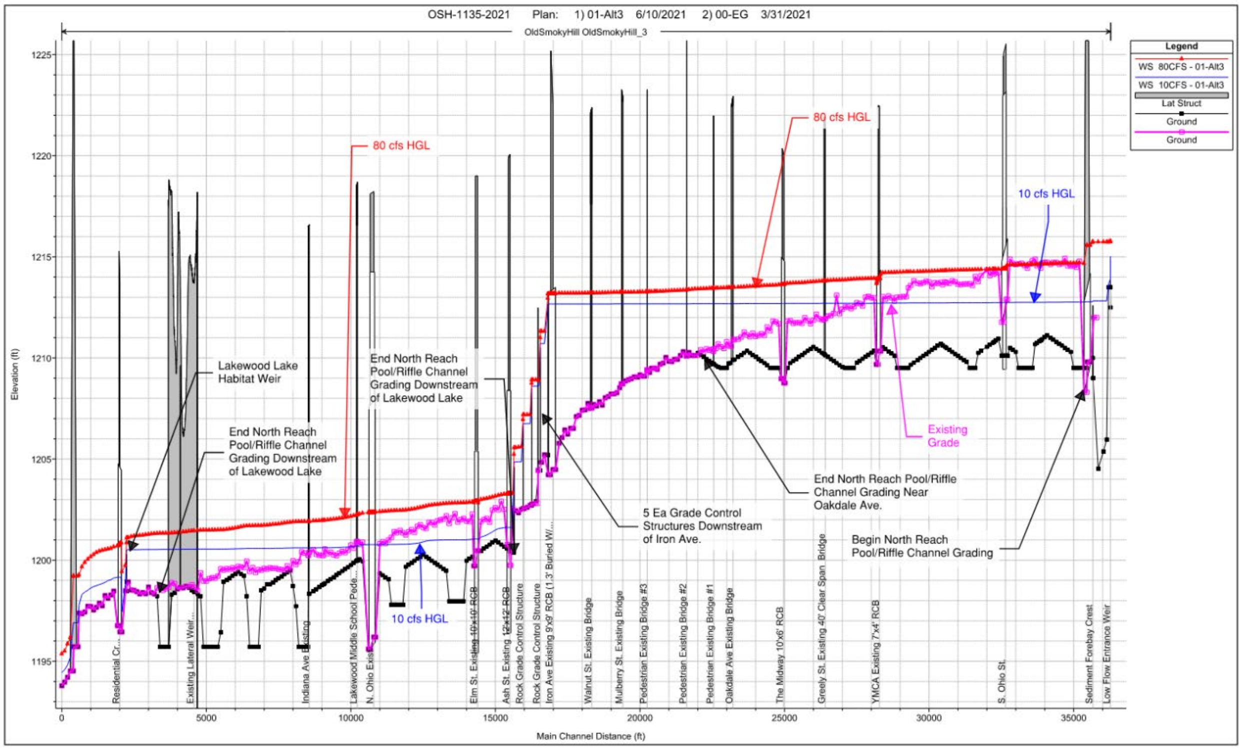


Figure 7-3. Alternative A3 Channel Profile

7.1 Entrance Works – Sediment Forebay

Alternative A2 includes the sediment forebay as shown in Section 4 of this appendix. Refer to Appendix C2 for more detailed drawings.

7.2 Channel Dredging, Riffles, Pools and Wetland Shelves

See paragraph 4.2 for the typical sections used for Alternative A3. The applicability of the typical sections are given in Figure 7-1 through Figure 7-3.

7.3 Grade Control Structures

Grade control structures with stoplogs as shown in paragraph 4.4 have been identified at two locations along the channel. The new Lakewood Lake Habitat Wier is in Reach 2 near station 1020+00. The new Wetland Shelves Grade Control Structure is in Reach 1 near station 8007+80.

7.4 Lakewood Lake Restored Wetlands

Restored wetlands at Lakewood Lake are supported by a system of added trails constructed from material hauled onsite. Refer to paragraph 4.6.

8 ALTERNATIVE A4

Alternative A4 contains the same entrance works and channel features in Alternative A3 with a more extensive trail system in the Lakewood Lake restored wetland area. Figure 8-1 shows the

Lakewood Lake for Alternative A4. Otherwise, refer to Alternative A3 for all channel and entrance work features.

Figure 8-1. Alternative A4, Reach 2 – North Reach

9 Real Estate

The Real Estate Plan (REP), in Appendix H, contains information regarding fee land, temporary easements, and permanent road easements for the project area. It addresses the construction period and the long-term operation and maintenance of the project.

10 Quantity Methodology

10.1 Earthwork Calculations

Three types of terrains were used to calculate the earthwork quantities: LiDAR generated, Civil 3D generated, and TIF generated. The existing terrain is LiDAR which was acquired, generated, and provided by the AE firm (HDR) in the form of a Civil 3D file. The proposed terrains for the Lakewood Lake Trails and Wetland Shelves Connection were generated in Civil 3D and provided by the AE firm in the form of a Civil 3D file. The proposed terrain for the channel work was created in HEC-RAS by the AE firm and provided in the form of a HEC-RAS Model; USACE-NWK then exported to a TIF file and generated a Civil 3D terrain using the TIF data. All terrains were then exported to a LandXML file and imported into OpenRoads Designer by USACE-NWK. Earthwork quantities were calculated in Civil 3D and OpenRoads Designer by creating a volume comparison where the existing terrain was compared to each proposed terrain. HEC-RAS was also used to calculate the earthwork quantity for the channel work to compare to the other calculated values.

11 RECOMMENDED POST-TSP REFINEMENT

11.1 Channel Profile

Evaluation and update to the proposed channel profile should occur to ensure it correctly correlates with the proposed locations of the glide, riffle, run and pool features.

11.2 Alternative 3 – Channel Cross Sections

During further development of the excavation required in the channel, the model should be updated to match the proposed typical cross sections for the glide, riffle, run and pool features.

11.3 Western Star Mill Area

A site visit post-TSP is necessary to better understand the area around the historic Western Star Mill area. There is an existing retaining wall where fill may be required after the removal of the mill. Gaining additional data about this area will provide more complete assumptions moving forward.

11.4 Grade Control Structures

Post-TSP analysis of the grade control structures will occur to determine adequacy of the footing depth and size. It will also be determined if downstream rock is necessary based on the final velocities and grades in the channel to prevent erosion.

12 OPERATIONS AND MAINTENANCE

The operations and maintenance of the completed project will ultimately fall to the non-federal sponsor, the City of Salina. Appendix K provides a feasibility-level summary of the O&M activities that would be anticipated during the lifetime of the constructed ecosystem restoration project. Refer to Appendix K Operations and Maintenance documentation.

13 REFERENCE LIST

Reference included may not be all inclusive but are meant to be a list of standards applicable to the project through construction completion.

13.1 USACE Engineering Manuals

Reference #	Title	Date
EM 1110-2-1413	Hydrologic Analysis of Interior Areas	24 Aug 2018
EM 1110-2-1416	River Hydraulics	15 Oct 1993
EM 1110-2-1417	Flood-Runoff Analysis	31 Aug 1994
EM 1110-2-1601	Hydraulic Design of Flood Control Channels	30 Jun 1994
EM 1110-1-1804	Geotechnical Investigations	01 Jan 2001

Reference #	Title	Date
EM 1110-2-1413	Hydrologic Analysis of Interior Areas	24 Aug 2018
EM 1110-2-1902	Slope Stability	31 Oct 2003
EM 1110-2-1906	Laboratory Soils Testing	20 Aug 1986
EM 1110-2-1913	Design and Construction of Levees	30 Apr 2000
EM 1110-2-2100	Stability Analysis of Concrete Structures	01 Dec 2005
EM 1110-2-2104	Strength Design for Reinforced Concrete Hydraulic Structures	30 Nov 2016
EM 1110-2-2504	Design of Sheet Pile Walls	31 Mar 1994
EM 1110-2-2902	Conduits, Culverts and Pipes	01 Dec 2020
EM 1110-2-2107	Design of Hydraulic Steel Structures	01 Aug 2022

13.2 USACE Engineering Regulations

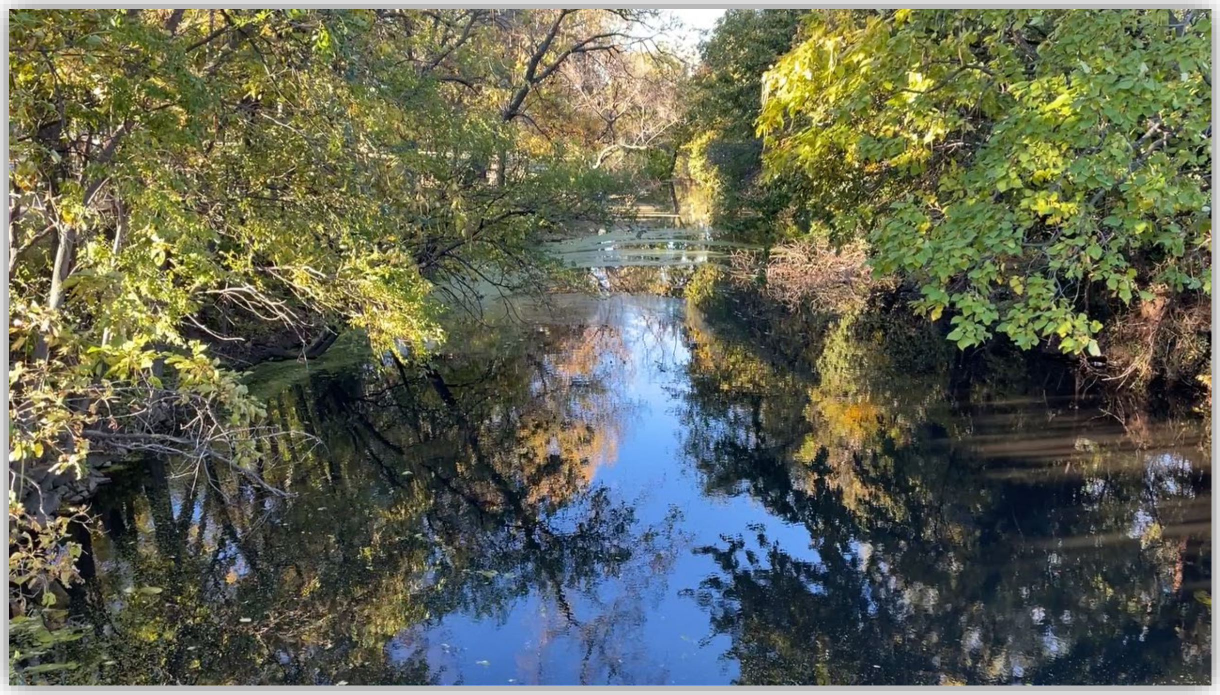
Reference #	Title	Date
ER 1110-1-1807	Drilling and Invasive Activities at Dams and Levees	01 Jun 2023

13.3 USACE Engineering and Construction Bulletin

Reference #	Title	Date
ECB 2017-2	Revision and Clarification of EM 1110-2-2100 and EM 1110-2-2502	27 Jan 2017

13.4 Other References

Reference Source	Title	Date
ASTM D2487-17	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soils Classification System)	25 Aug 2020



Smoky Hill River GI Study
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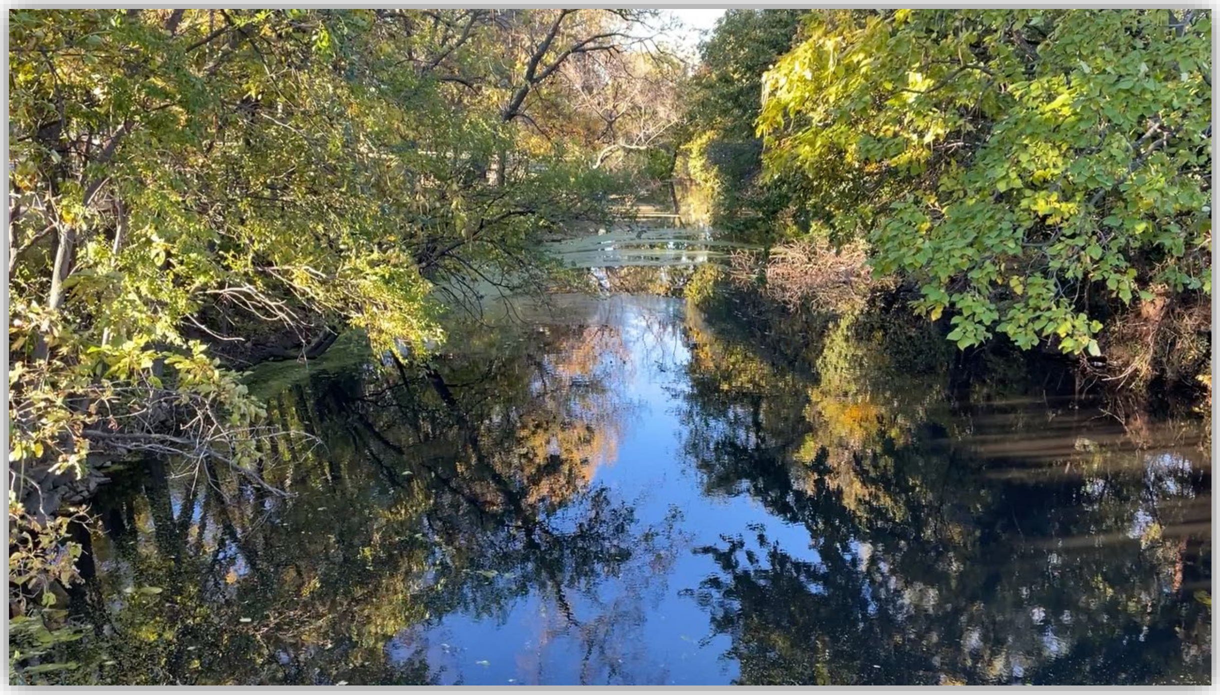
Appendix C2 – Alternate 3 Drawings

September 2025

US Army Corps of Engineers



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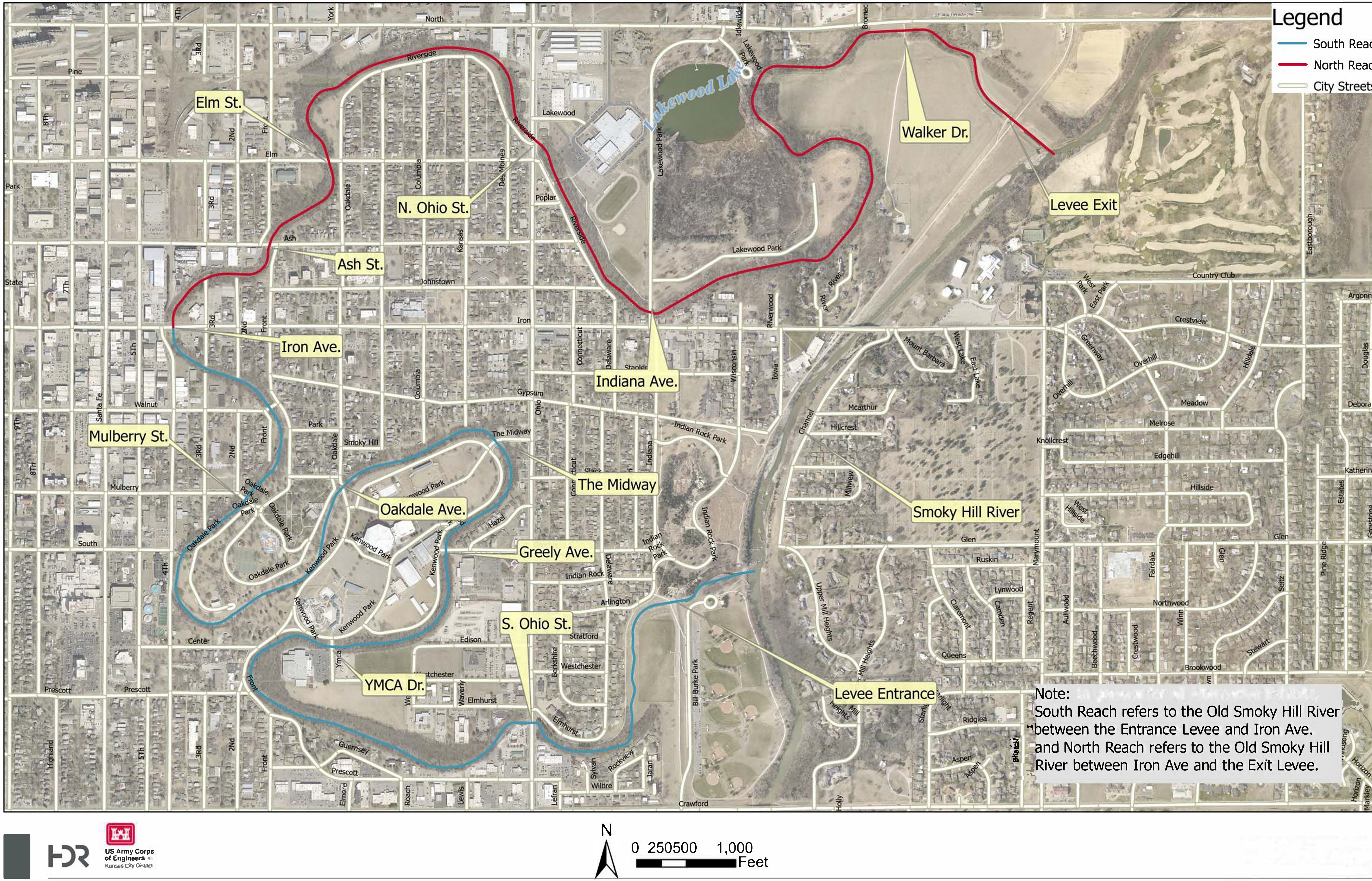
Appendix C2 – Alternate 3 Drawings

August 2025

City of Salina



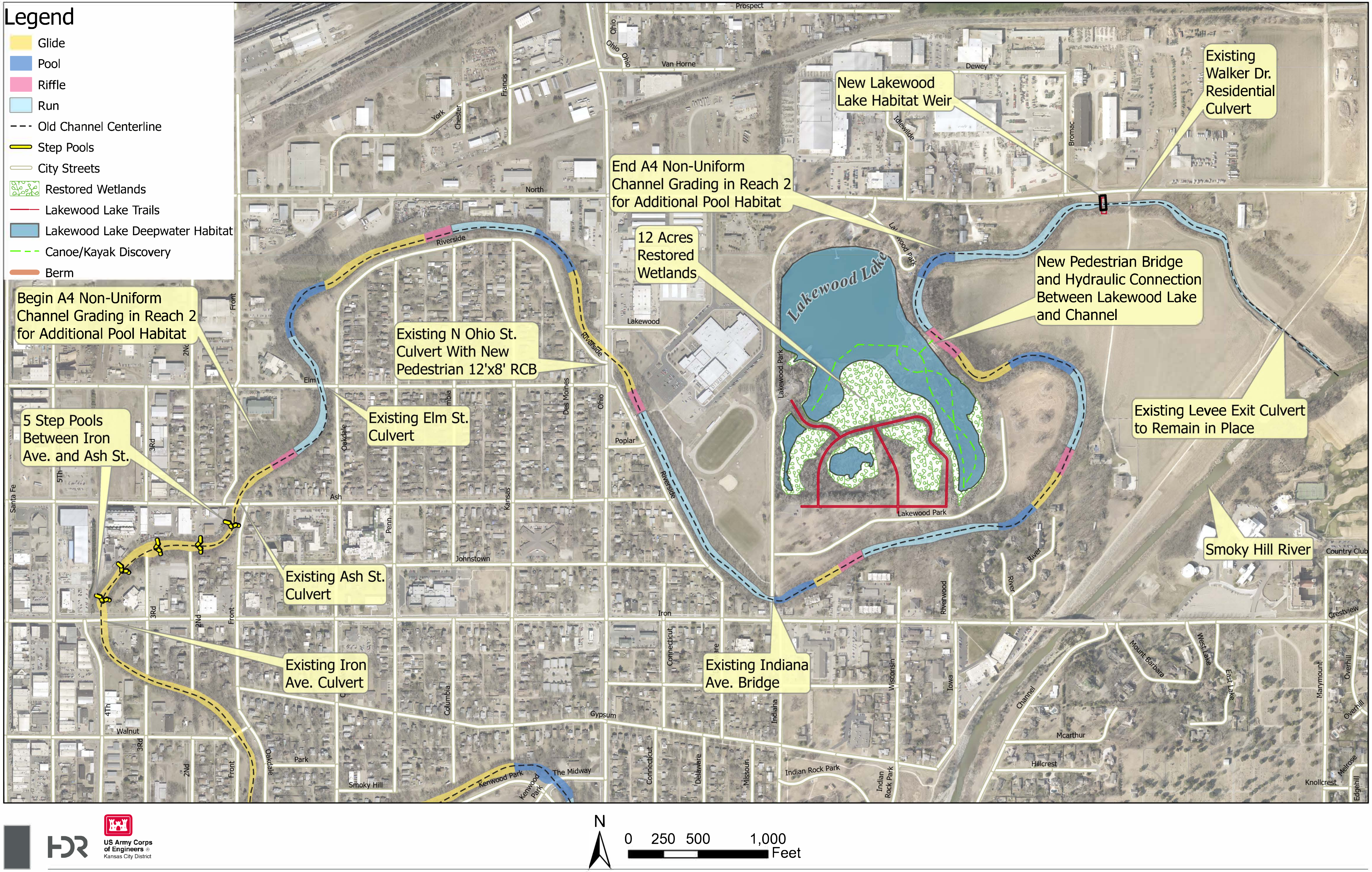
HDR

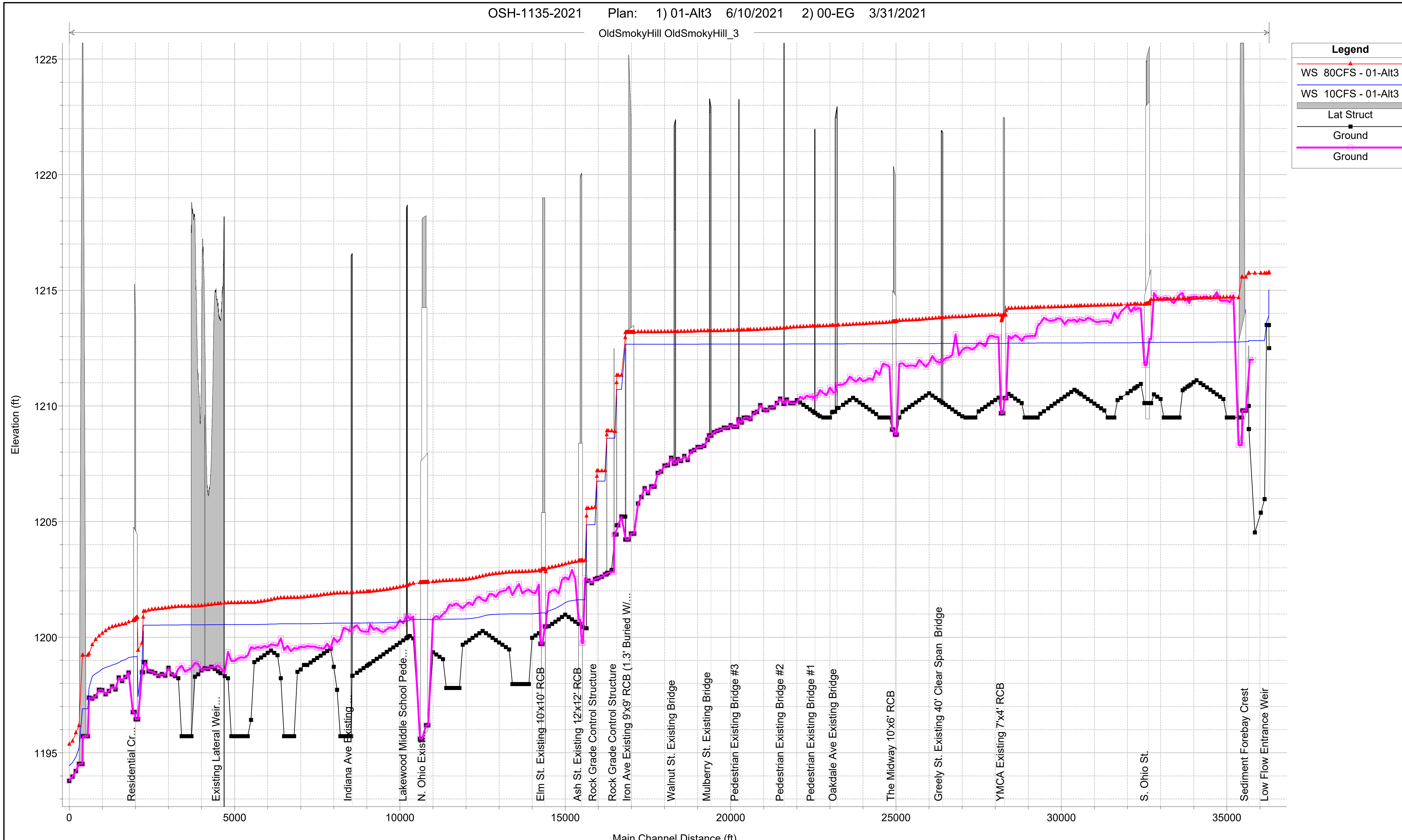
US Army Corps of Engineers
Kansas City District

Alternative A3

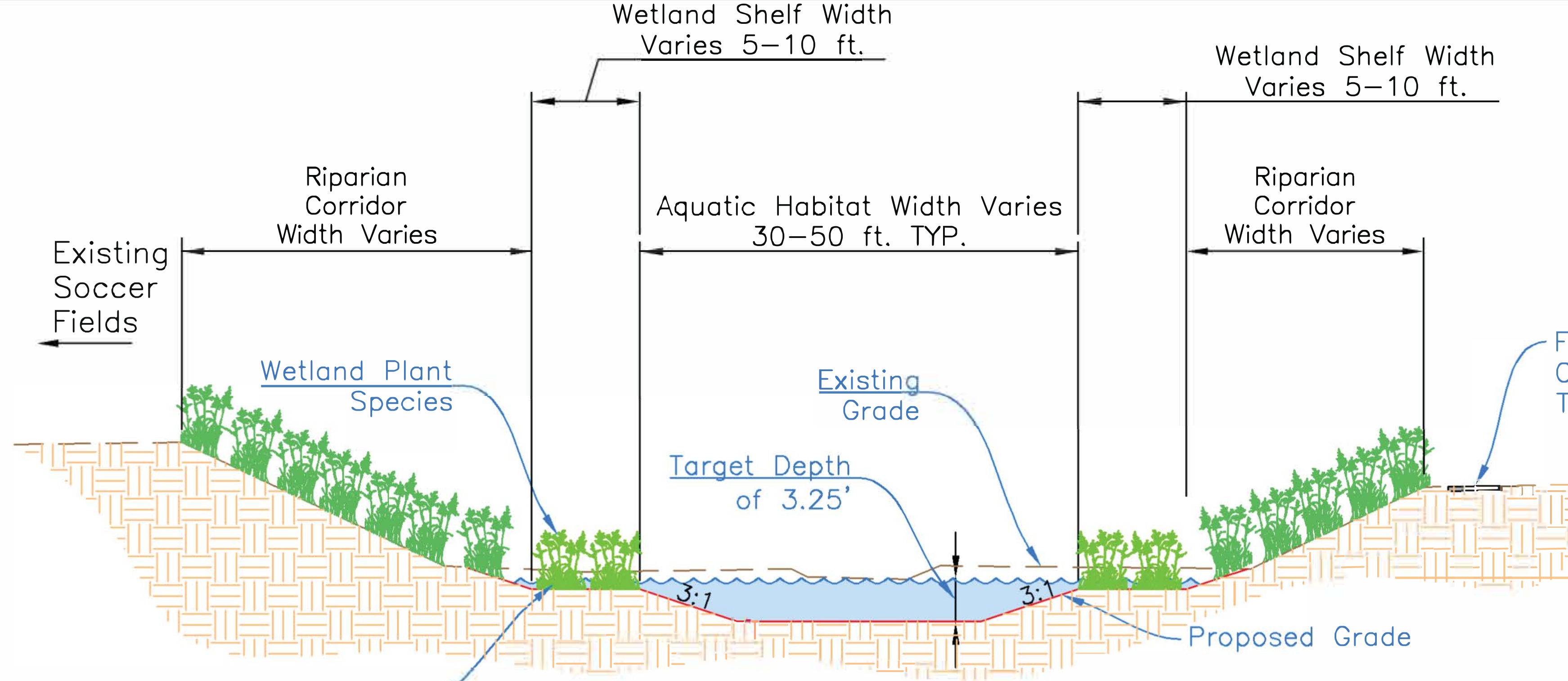
HDR
US Army Corps of Engineers
Kansas City District

Alternative A3





OSH-1135-2021 Plan: 1) 01-Alt3 6/10/2021 2) 00-EG 3/31/2021
OldSmokyHill OldSmokyHill_3
Legend
WS 80CFS - 01-Alt3
WS 10CFS - 01-Alt3
Lat Struct
Ground
Ground
Elevation (ft)
Main Channel Distance (ft)
Residential Cr...
Existing Lateral Weir...
Indiana Ave Existing...
Lakewood Middle School Pede...
N. Ohio Exist...
Elm St. Existing 10'x10' RCB
Ash St. Existing 12'x12' RCB
Rock Grade Control Structure
Rock Grade Control Structure
Iron Ave Existing 9'x9' RCB (1.3' Buried W/...
Walnut St. Existing Bridge
Mulberry St. Existing Bridge
Pedestrian Existing Bridge #3
Pedestrian Existing Bridge #2
Pedestrian Existing Bridge #1
Oakdale Ave Existing Bridge
The Midway 10'x6' RCB
Greely St. Existing 40' Clear Span Bridge
YMCA Existing 7'x4' RCB
S. Ohio St.
Sediment Forebay Crest
Low Flow Entrance Weir

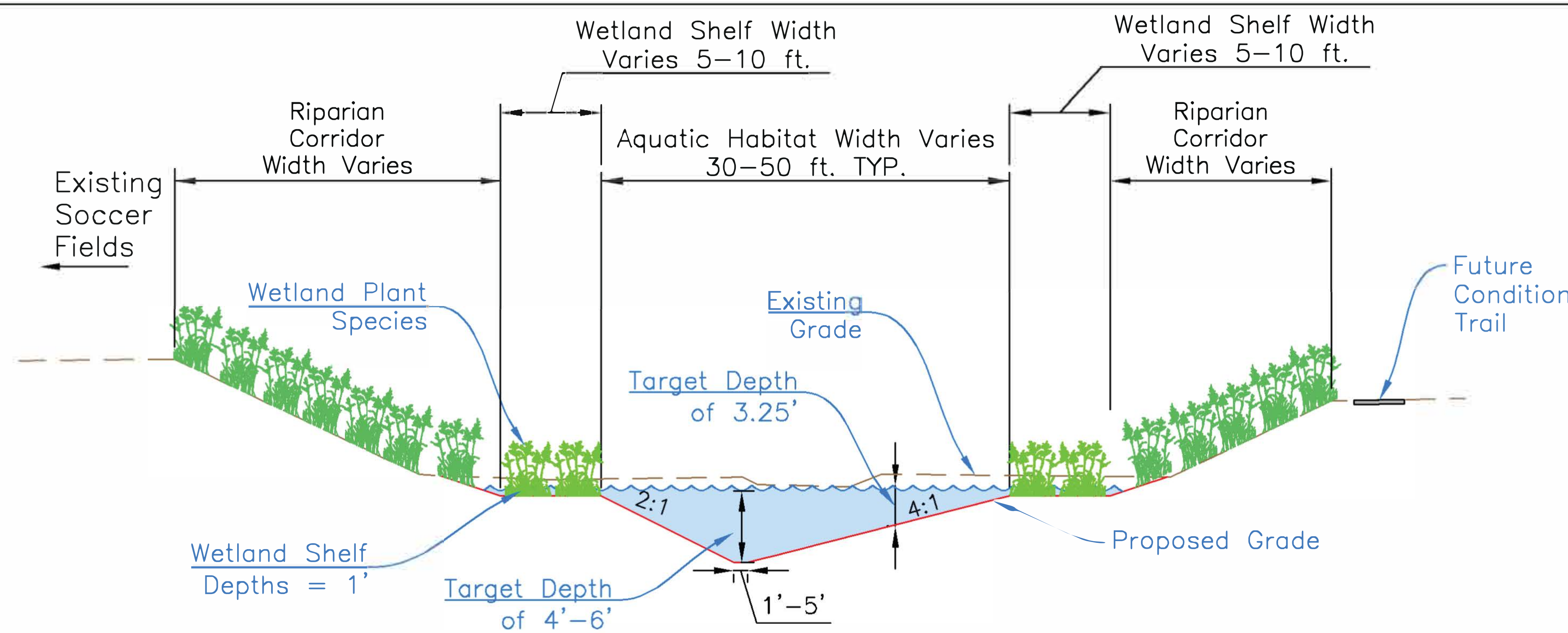


Typical Old Channel Wetland Shelves Connection Riffle Section

Note:

Alternative 3 pool and riffle channel grading extends from the upstream levee to Oakdale Ave. (South Reach) and Ash St. to Lakewood Lake (North Reach).

See plan view exhibit for exact grading locations.



Typical Old Channel Wetland Shelves Connection Pool Section

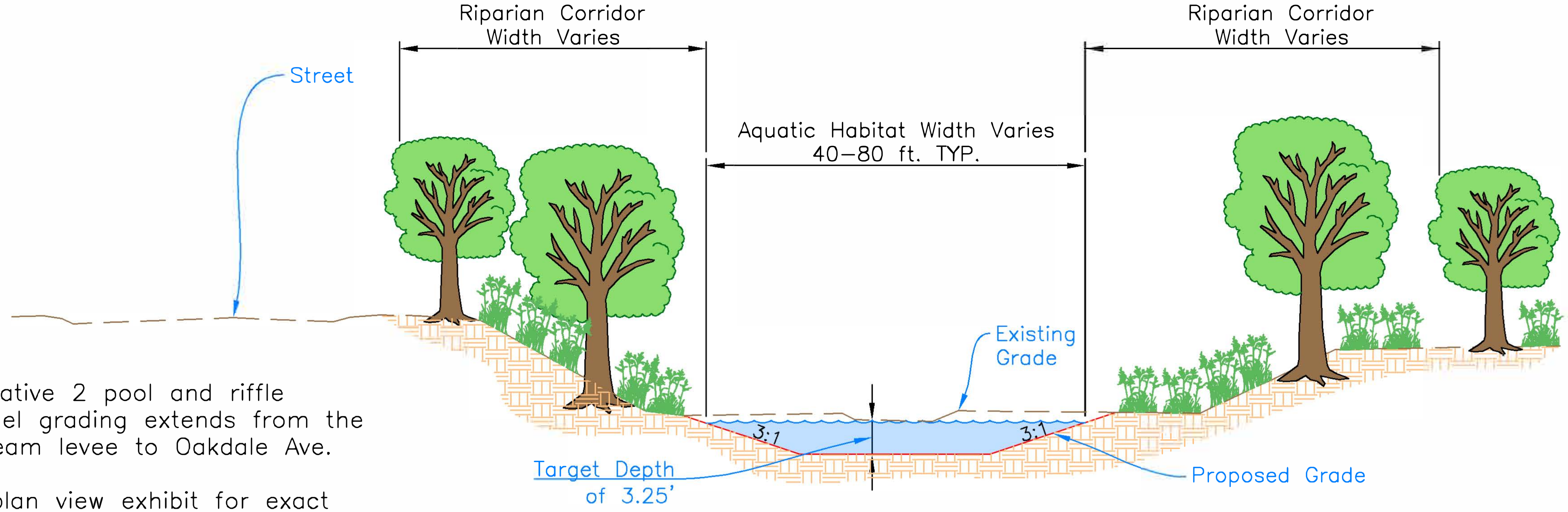
HDR

Alternative A3
Old Channel Typical Sections

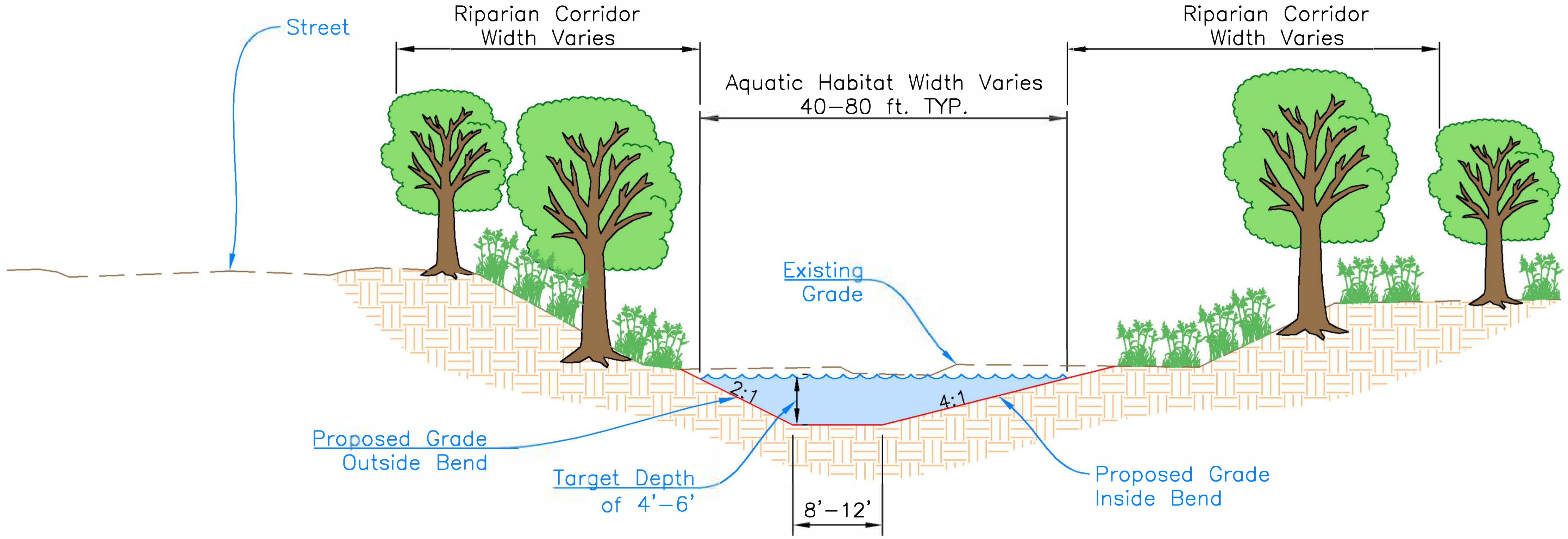
Note:

Alternative 2 pool and riffle channel grading extends from the upstream levee to Oakdale Ave.

See plan view exhibit for exact grading locations.



Old Channel Typical Riffle Section

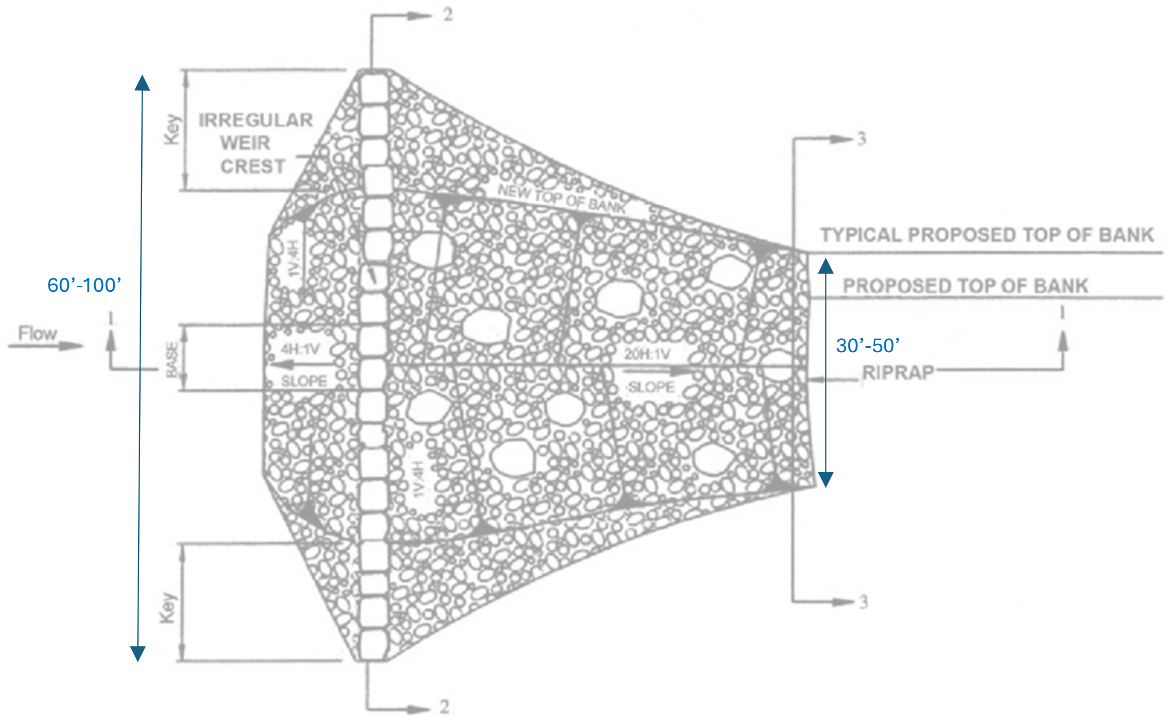


Old Channel Typical Pool Section

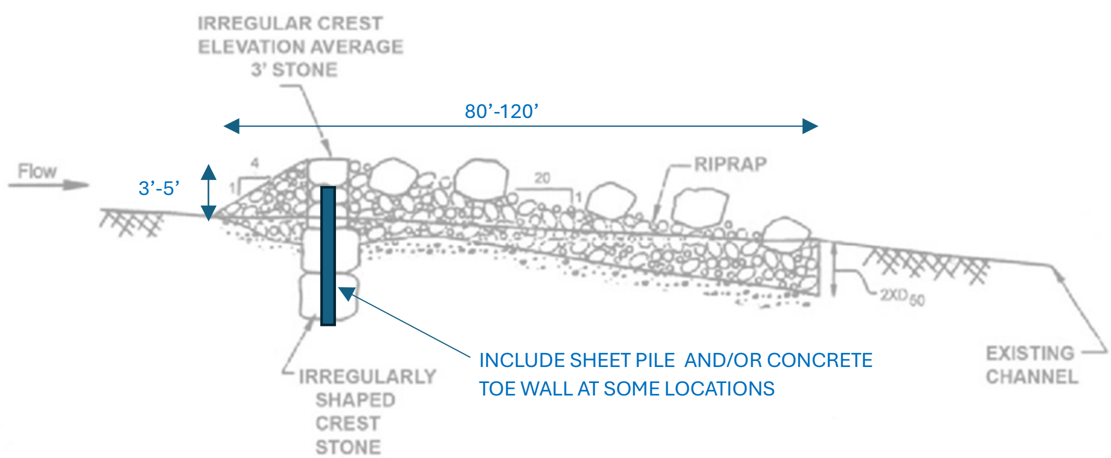
HDR

Alternative A2
Old Channel Typical Sections

ROCK RIFFLE/POOL STRUCTURES
(TYP.)



TYPICAL RIFFLE STUCTURE PLAN VIEW



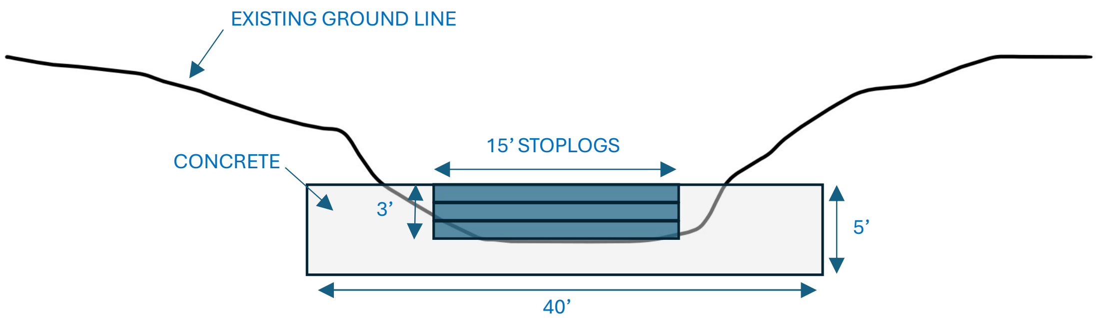
PROFILE VIEW

STOPLOG STRUCTURES

Stoplog structure may consist of the following components:

- Concrete sill at the base of the structure and concrete side walls
- Dimensions of concrete base and side walls to generally conform to stream channel
- Side channels or wall slots to receive, guide, and restrain the individual stoplogs
- Several horizontal stoplogs stacked vertically, likely aluminum, with dimensions/weight that facilitate periodic operation without heavy equipment or specialized lifting equipment
- Neoprene or rubber seals or gaskets at all interface points
- Rock riprap around periphery of concrete to transition to earthen, vegetated channel

Typical product info:
https://www.hydrogate.com/sites/hydrogate.com/files/uploads/media/stop_logs_brochure_folder_stop_logs_brochure-web.pdf



N

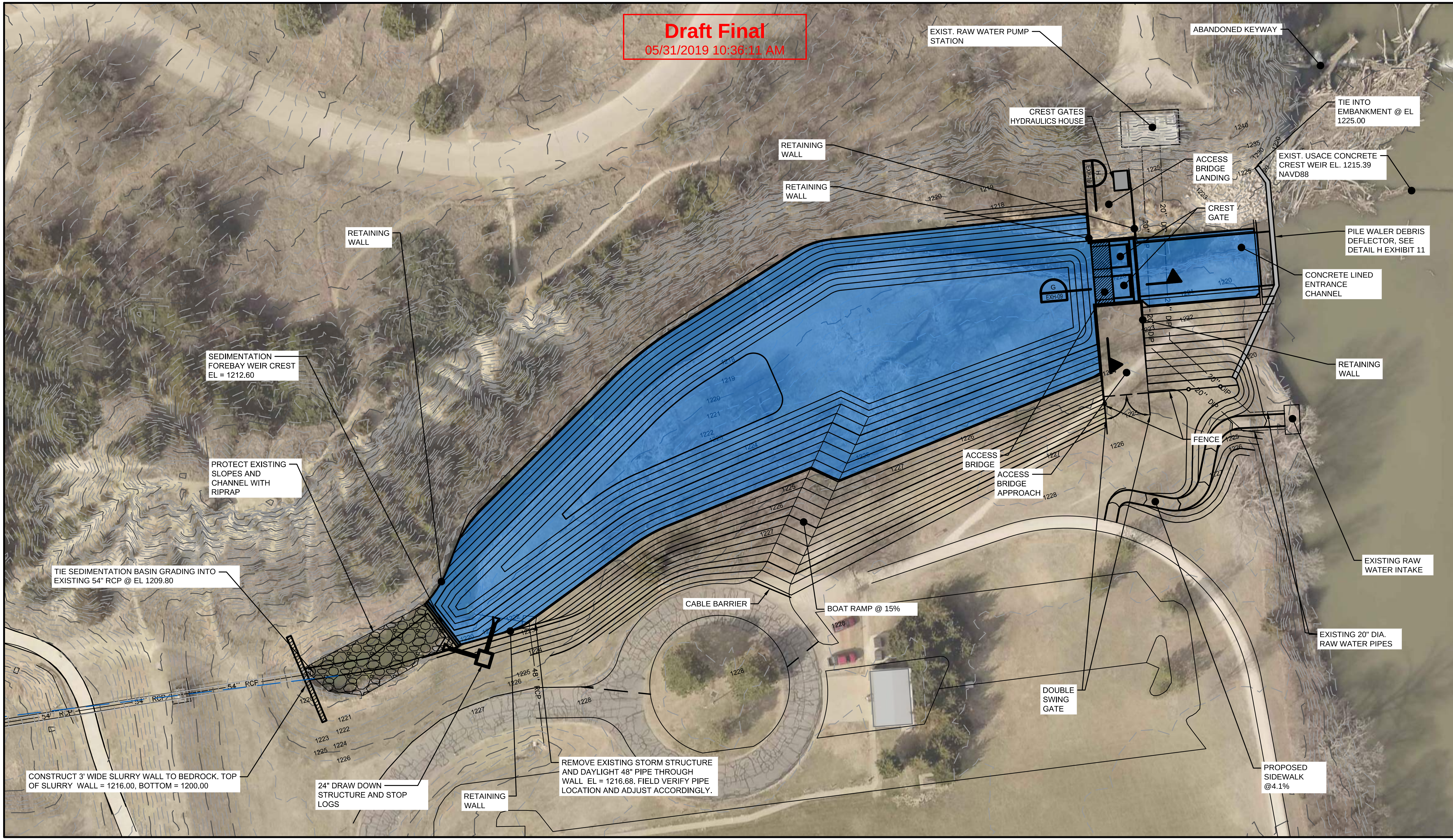
0 50

SCALE: 1" = 50'

SALINA, KANSAS
SMOKY HILL RIVER URBAN DEVELOPMENT
ENTRANCE WORKS
EXISTING FEATURES

DATE
MAY 2019

EXHIBIT
01



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0 60

SCALE: 1" = 60'

ALTERNATIVE 4

HDR

SALINA, KANSAS
SMOKY HILL RIVER URBAN DEVELOPMENT
CONCEPTUAL LAYOUT
SEDIMENTATION FOREBAY GRADING PLAN

DATE
MAY 2019

EXHIBIT
08

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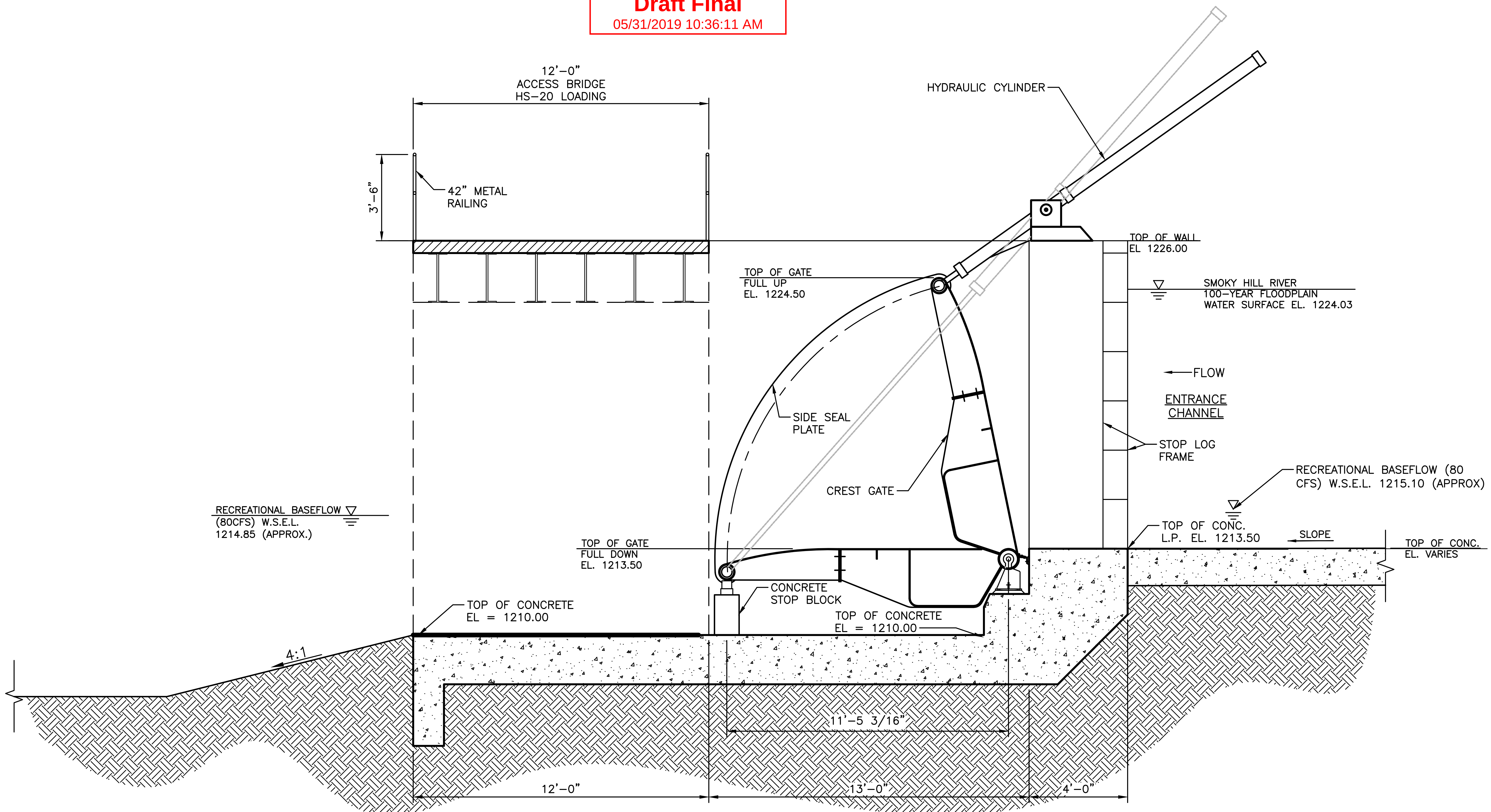


CRESTGATE SECTION

SCALE: 1/4" = 1'-0"

G
EXH-08

0 4
SCALE: 1/4" = 1'-0"

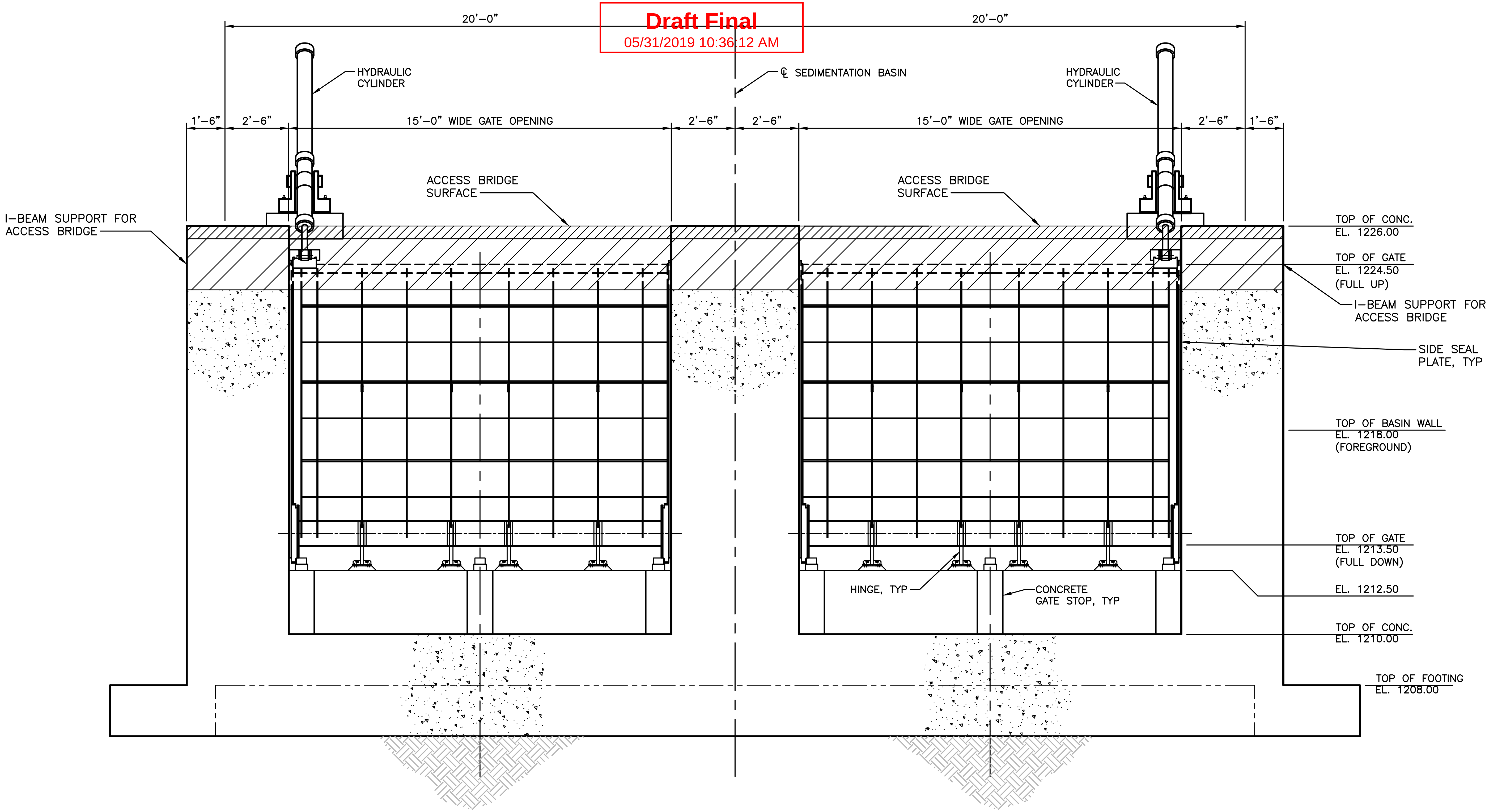
ALTERNATIVE 4

HDR

SALINA, KANSAS
SMOKY HILL RIVER URBAN DEVELOPMENT
CONCEPTUAL LAYOUT
CREST GATE SECTION

DATE
MAY 2019

EXHIBIT
09



CRESTGATE SECTION

SCALE: 1/4" = 1'-0"

H
EXH-08

0 4
SCALE: 1/4" = 1'-0"

ALTERNATIVE 4

SALINA, KANSAS
SMOKY HILL RIVER URBAN DEVELOPMENT
CONCEPTUAL LAYOUT
CREST GATE SECTION

DATE
MAY 2019

EXHIBIT
10

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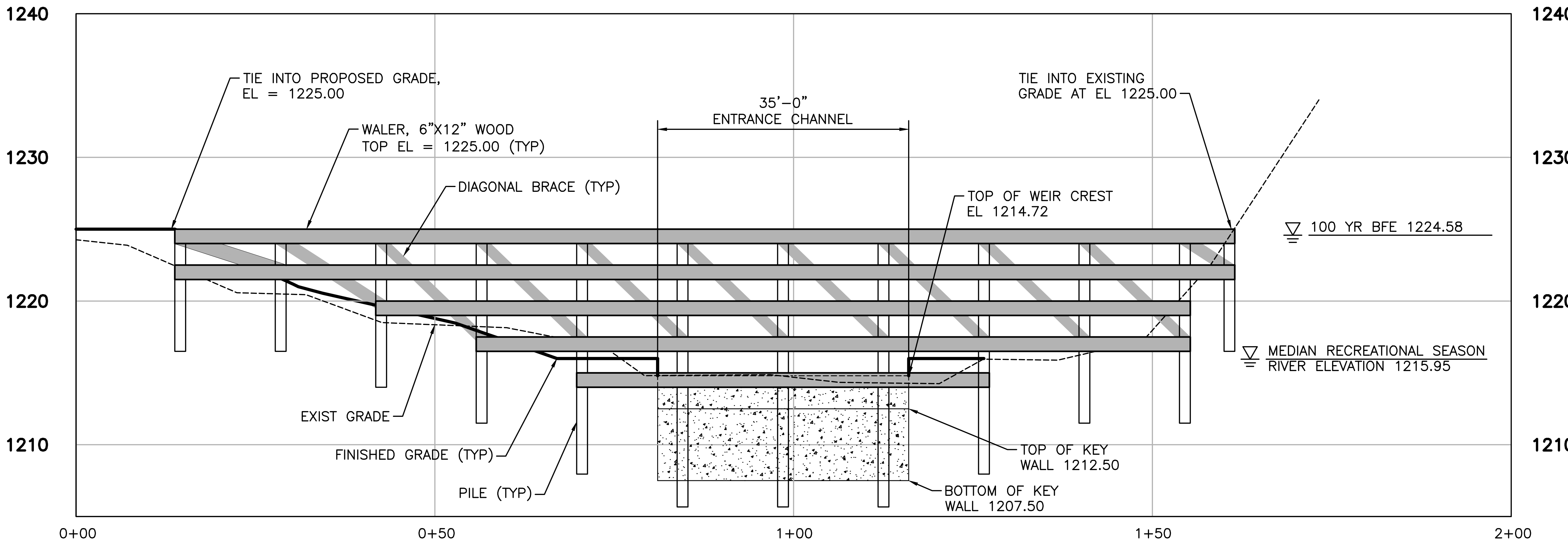


DEBRIS DEFLECTION WALL SECTION H EXH-08

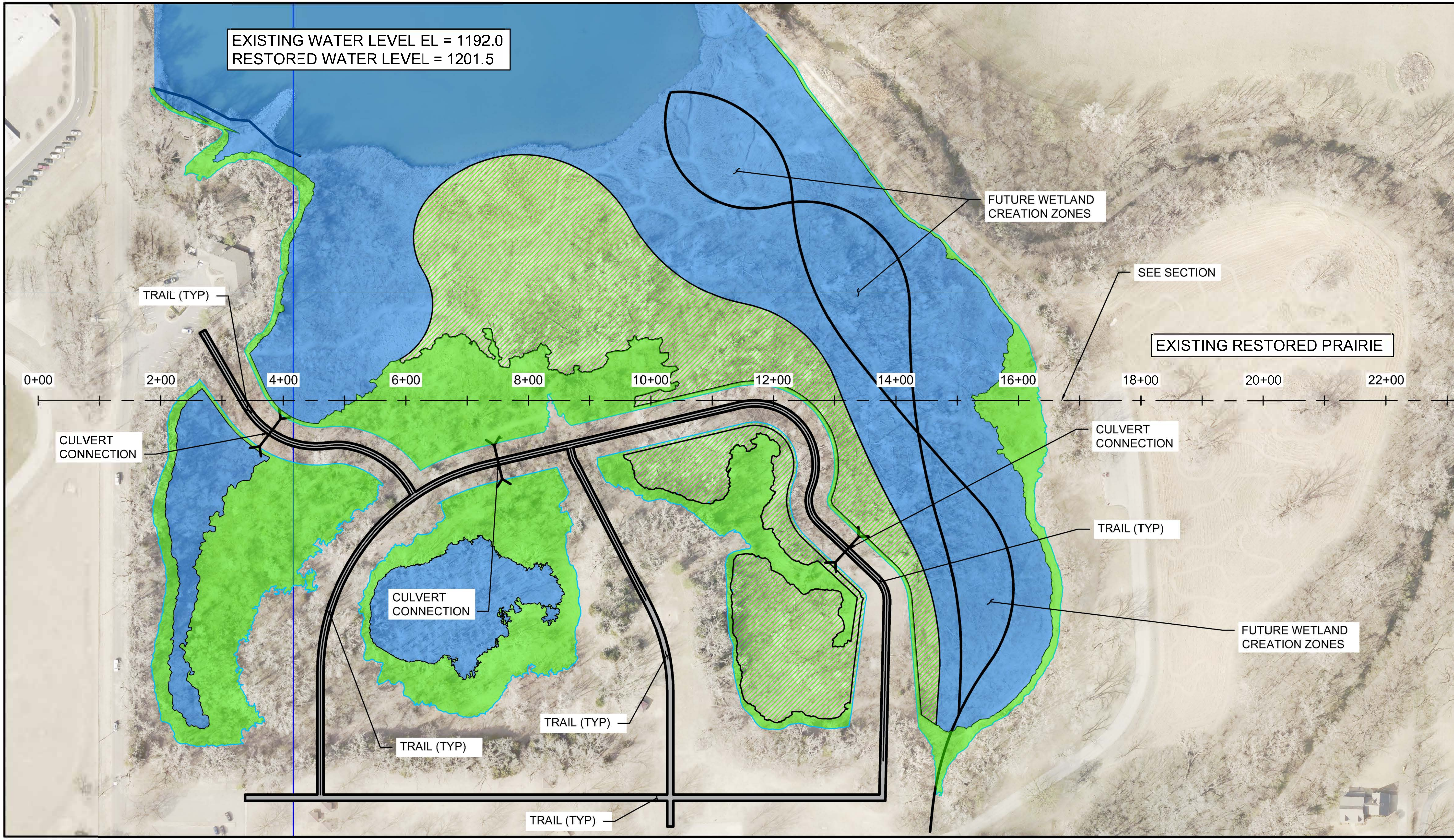
SCALE: HORIZ. 1/16" = 1'–0" , VERT. 1/8"=1'–0"

ALTERNATIVE 4

SALINA, KANSAS
SMOKY HILL RIVER URBAN DEVELOPMENT
CONCEPTUAL LAYOUT
DEBRIS DEFLECTION WALER WALL SECTION

DATE MAY 2019

EXHIBIT 11



DEEPWATER (>2FT.)

WETLAND (FILL)

WETLAND (RESTORED)

Note: This plan yields 12.0 acres of wetlands using approximately 47,000 CY

N W E S

0 150 300 Feet

HDR

Old Smoky Hill River
Lakewood Lake Alternative
Wetland Restoration Plan View Layout

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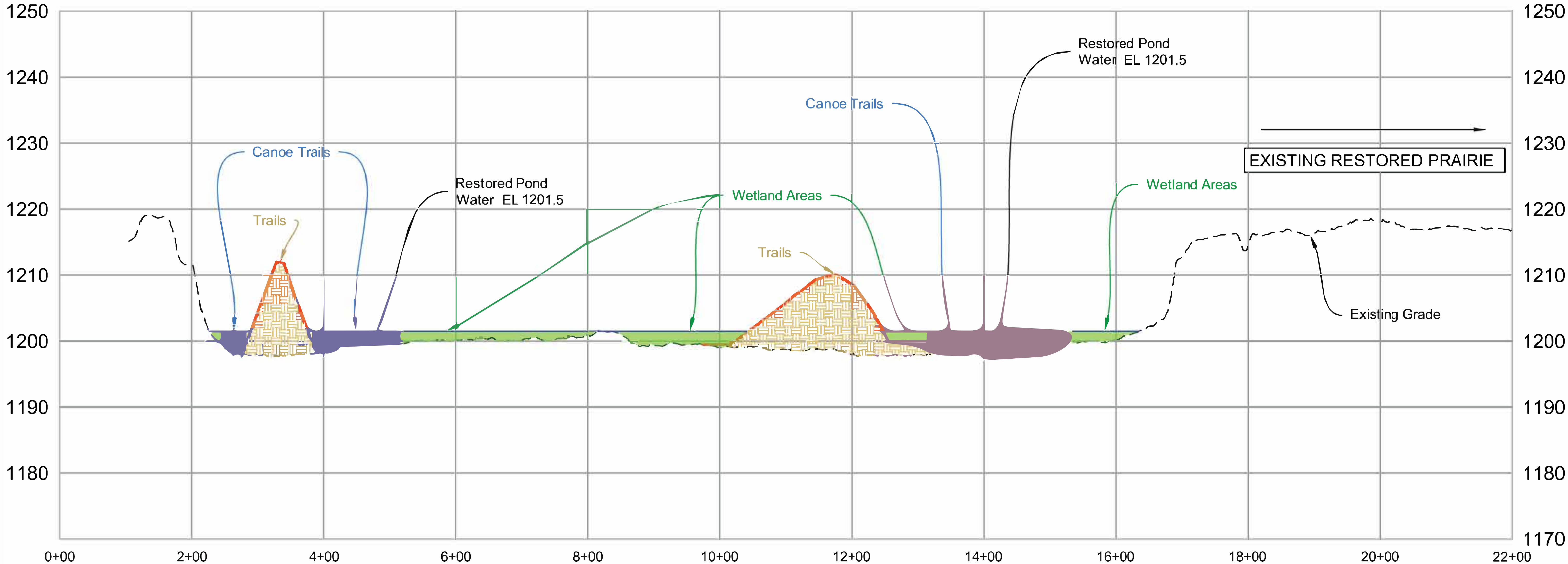

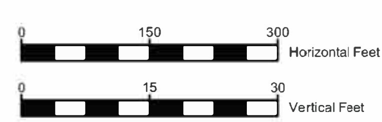

Old Smoky Hill River
Lakewood Lake Alternative
Wetland Restoration Section

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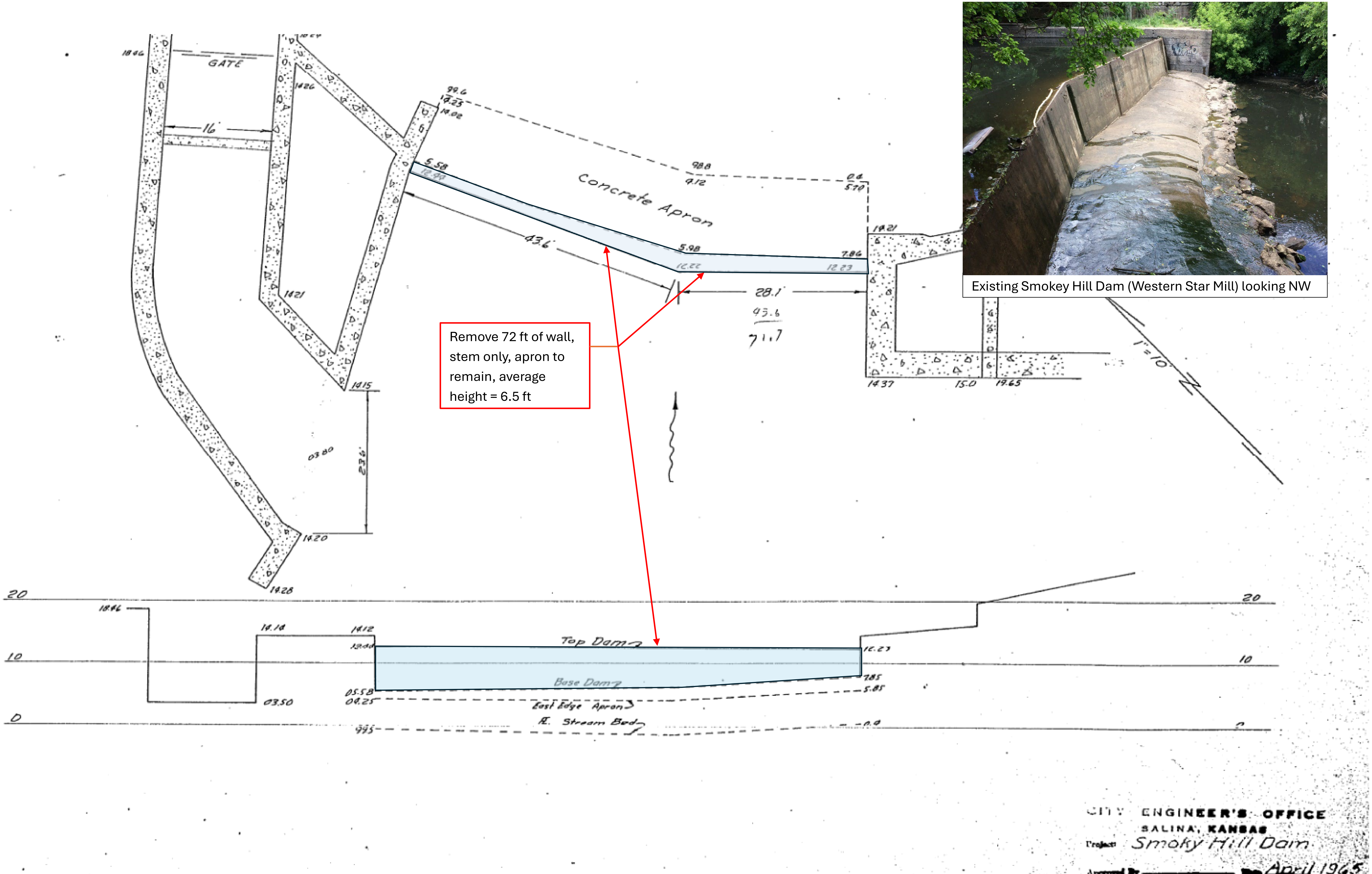
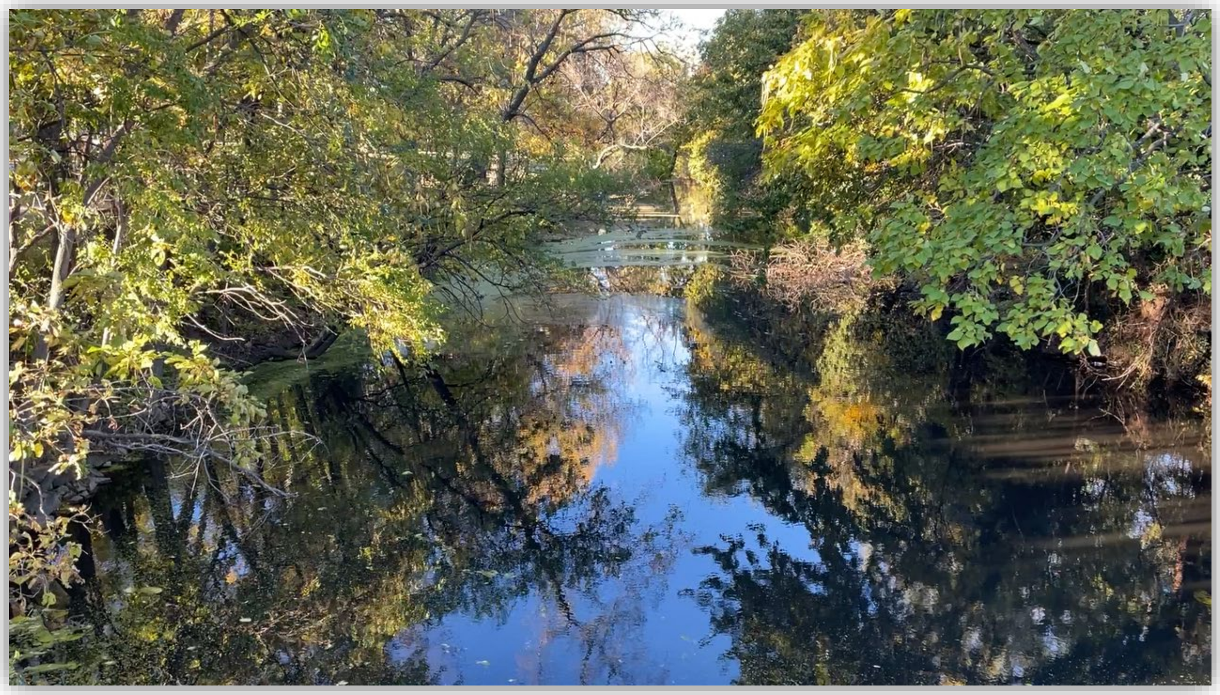


Existing Smokey Hill Dam (Western Star Mill) looking NW



Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix D – Sediment Transport Assessment

September 2025

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Table of Contents

List of Tables

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1. Introduction

The Smoky Hill River Renewal Master Plan was adopted by the City of Salina, Kansas (City), in 2010 and identifies the community's priorities and goals for the renewal of the Old Smoky Hill Channel through the center of Salina. The Old Smoky Hill Channel (herein referred to as Old Channel) represents the original river alignment through the City, prior to the construction of a flood control levee and bypass channel in the 1960s. The Old Channel presently has no sustained base flow and has accumulated large quantities of sediment and urban debris. The only surface water that currently reaches the Old Channel is from interior storm sewer discharge, which has intermittent and unpredictable flows.

Sediment loading into the Old Channel has been occurring for decades, causing extensive sedimentation in the upstream reaches of the channel, primarily upstream of the Western Star Mill Dam. There is not enough water flow in the channel to re-mobilize sediment to migrate it back to the Smoky Hill Cut-off Channel. Sedimentation has severely reduced the channel capacity and flow rates within the Old Channel and has degraded stream habitat features and overall function.

In 2019, the City's 2010 Smoky Hill River Renewal Master Plan was expanded on and revised. One goal of the Master Plan is to reconnect the community with the waterway by reintroducing flow to the Old Channel and developing the banks and adjacent areas for a variety of recreational, community and commercial uses. Lakewood Lake, located at the downstream end of the Old Channel, is currently cut off from low flow passage. The lake acts as a storage area during larger flood events when river levels get high enough to overflow into the lake. The Master Plan connects Lakewood Lake to the Old Channel and will function like a looped reach.

2. Purpose

The purpose of this technical memorandum is to present the sediment transport analysis and results for the Old Channel as part of the Smoky Hill River Aquatic Ecosystem Restoration Project (Project). Sediment analysis was conducted to evaluate the Old Channel under existing and proposed conditions, as well as evaluate the performance of the proposed sediment basin. The analysis was performed for both historical and expected future flow conditions.

The Sediment Impact Analysis Method (SIAM) was completed as part of the Project in order to estimate the incoming sediment load (mass and gradation) to the restoration reach and evaluate sediment deposition rates in the Old Channel for existing and proposed conditions. The existing analysis will establish baseline conditions for evaluating the effectiveness and potential operational and maintenance requirements of proposed alternatives in the Old Channel (Section 3 and 5). As part of the City's revised Master Plan, a proposed sediment forebay will be situated downstream of the Old Channel intake structure to provide a first line of defense for sediment capture before the diverted water is conveyed to the restoration reach. The sediment basin was evaluated with a mobile-bed sediment transport model to assess the performance of the proposed basin, evaluate maintenance requirements, and assess downstream impacts to the Old Channel (Section 4). Results from the mobile-bed sediment transport model inform the sediment loading for the SIAM model alternative conditions for the Old Channel.

Finally, the impact of the diversion of flow to the restoration reach was evaluated for the Smoky Hill Cut-off Channel using a mobile-bed sediment transport analysis (Section 6). Results were used to predict the long-term potential for scour along the Cut-off Channel.

A more refined evaluation of sediment loading contributing to the proposed sediment basin and Old Channel was conducted for the preferred alternative to provide refined results on system performance and to better define overall operation and maintenance requirements (Section 9).

3. Old Channel Sediment Transport Analysis for Existing Conditions

3.1 Methodology

Sedimentation analysis was conducted to inform alternatives development and operations and maintenance requirements for the proposed features. HDR's original approach was to develop full mobile-bed sediment transport models for both the Old Channel and Smoky Hill River Cut-off Channel (Figure 3-1). As the project progressed and field investigation was conducted, it was determined that a detailed mobile-bed sediment transport analysis would not be optimal for the Old Channel. This is due to its complex drainage characteristics (including 75 storm drain outfalls), slow moving water (with average flow velocity less than 1.5 ft/s), small sediment particle sizes (predominantly clayey-silt), and significant backwater conditions throughout the upper reach caused by the existing Western Star Mill weir (Figure 3-1). Therefore, it was decided that the sedimentation analysis would not likely be sensitive enough to perform detailed mobile-bed modeling in this reach. In addition, a sediment basin (see Figure 3-1 for proposed location) will be proposed with the project alternatives at the Old Channel inlet (east of the federal levee), which will further diminish model sensitivity downstream of the proposed sediment basin.

HDR performed a SIAM evaluation of the Old Channel using the HEC-RAS model constructed by HDR in 2018 (Figure 3-1) as part of the Smoky Hill River Renewal Project for the City of Salina, Kansas (City) as a starting point. This HEC-RAS model was updated as part of the current Project with 2020 topographic data. SIAM is a sediment budget tool that compares annualized sediment reach transport capacities to sediment supplies and indicates reaches of potential aggradation or degradation. It does not predict intermediate or final morphological patterns and does not update cross sections in time; however, it will predict average sedimentation trends that can be used to design/refine remediation efforts and screen the effectiveness of proposed alternatives. The annualized sediment load at the upper end of the SIAM reach (west of the federal levee) was assumed to be negligible for existing conditions since most of the river sediment deposits upstream (east) of the levee. Bed surface sediment samples along the Old Channel were collected by HDR and analyzed in the KAW Valley Engineering (KVE) geotechnical lab (KAW, 2020).

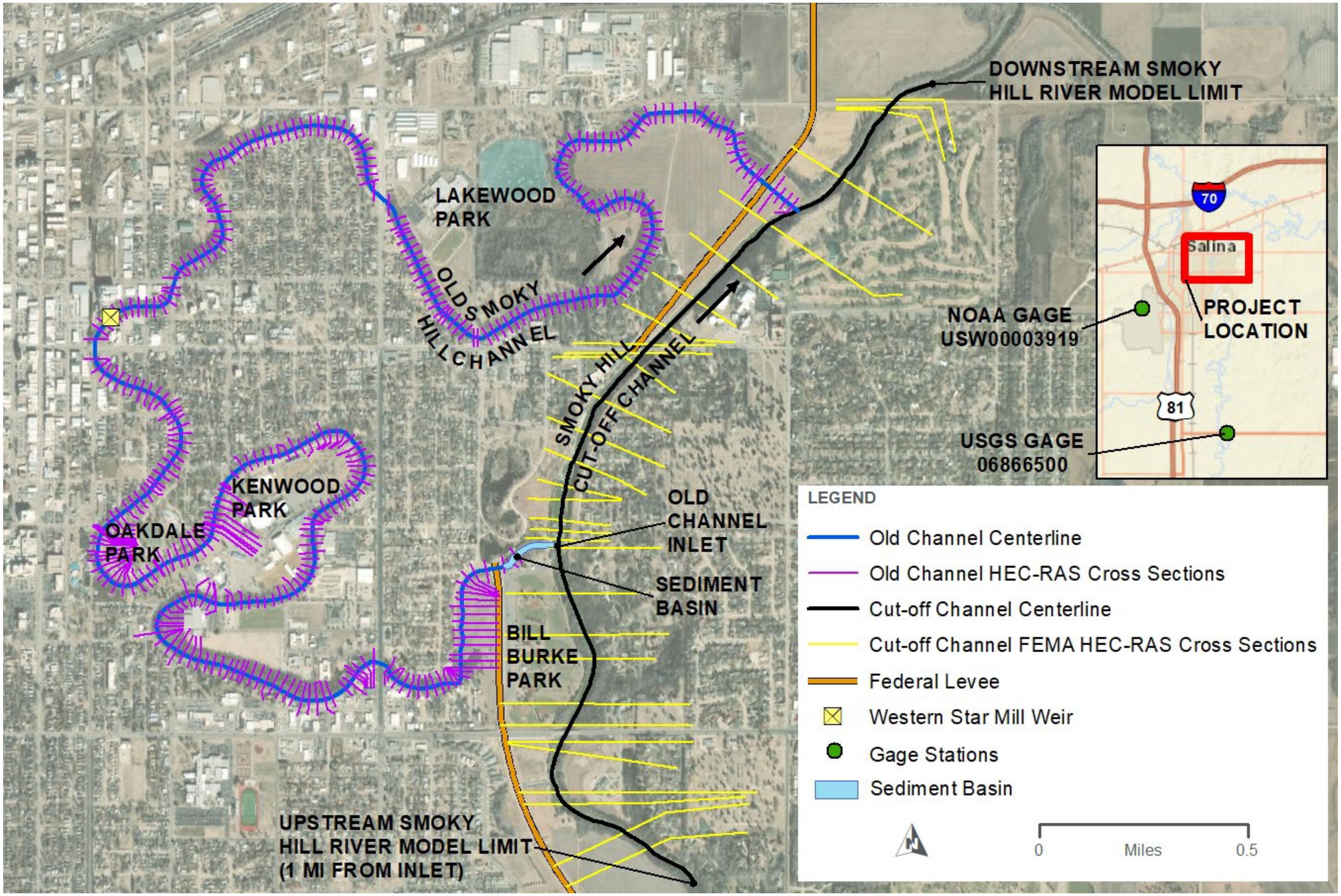


Figure 3-1. Schematic of Smoky Hill River Modeling System

3.2 Stormdrain Flow Duration Curves

Flow duration curves, representing annual flow rates versus duration of exceedance at selected locations along the Old Channel, were developed using the Stormwater Management Model (SWMM). These curves assisted in estimating interior drainage (stormdrain) inflow rates and suspended sediment loads for the SIAM model. The total contributing drainage area to the Old Channel from the City's storm sewer system is approximately 4.6 square miles.

A hydrologic model was previously developed (2018) for the City to simulate its interior drainage system using PCSWMM platform. The model included the City's major drainage components comprised of open channels, storage units, main culverts, diversion structures, and outfalls which flow into the Old Smoky Hill channel. Both hydrology and hydraulics were simulated using the SWMM engine to estimate flow rates via single event design storms. Sixty (60) years of rainfall data was downloaded from the Salina airport gauge station USW00003919 (Figure 3-1) for the period January 01, 1960, through December 31, 2019. Table 3-1 provides a summary of the obtained rainfall data.

Table 3-1. Summary of Rainfall 1960 – 2019 at Salina Airport Gage

	Total rainfall per year (inches)	Year
Maximum rainfall	58.08	1993
Average rainfall	29.50	N/A
Minimum rainfall	12.98	1996
Median	28.63	1962

A five-year period was selected for the continuous simulation to represent an average period of time with a heavy rainfall. The selected five-year period used for the analysis extends from January 1980 to December 1985 and is summarized in Table 3-2.

Table 3-2. Summary of Rainfall 1980 – 1985 at Salina Airport Gage

	Total rainfall per year (inches)
Maximum rainfall	39.42
Average rainfall	31.30
Minimum rainfall	20.38

Run time for an extended continuous simulation (5-10 years) would take days to obtain results; therefore, a portion of the model was extracted from the City-wide model for this analysis to reduce execution time. The model execution time for the extracted five-year duration was approximately 40 hours. Figure 3-2 illustrates a schematic of the extracted model and its tributary area. Figure 3-3 compares model results near the outfall into the Smoky River between the City-wide version and the extracted version using the 10-year design storm. The estimated peak flow using the City-wide version produced 752 cfs and the extracted version produced 754 cfs. This comparison validates the accuracy of the extracted model version.

The extracted model version was executed for the selected five-year period (1980 – 1985). Flow hydrographs and flow duration curves were developed at five representative locations: near the outfall, at the beginning of the stream, and at three locations in the middle. Refer to Figure 3-2 and Table 3-3 for location and description of each of the five representative locations. Table 3-3 provides a summary of estimated flows at each location, while Figure 3-4 shows duration curves at the five selected locations.

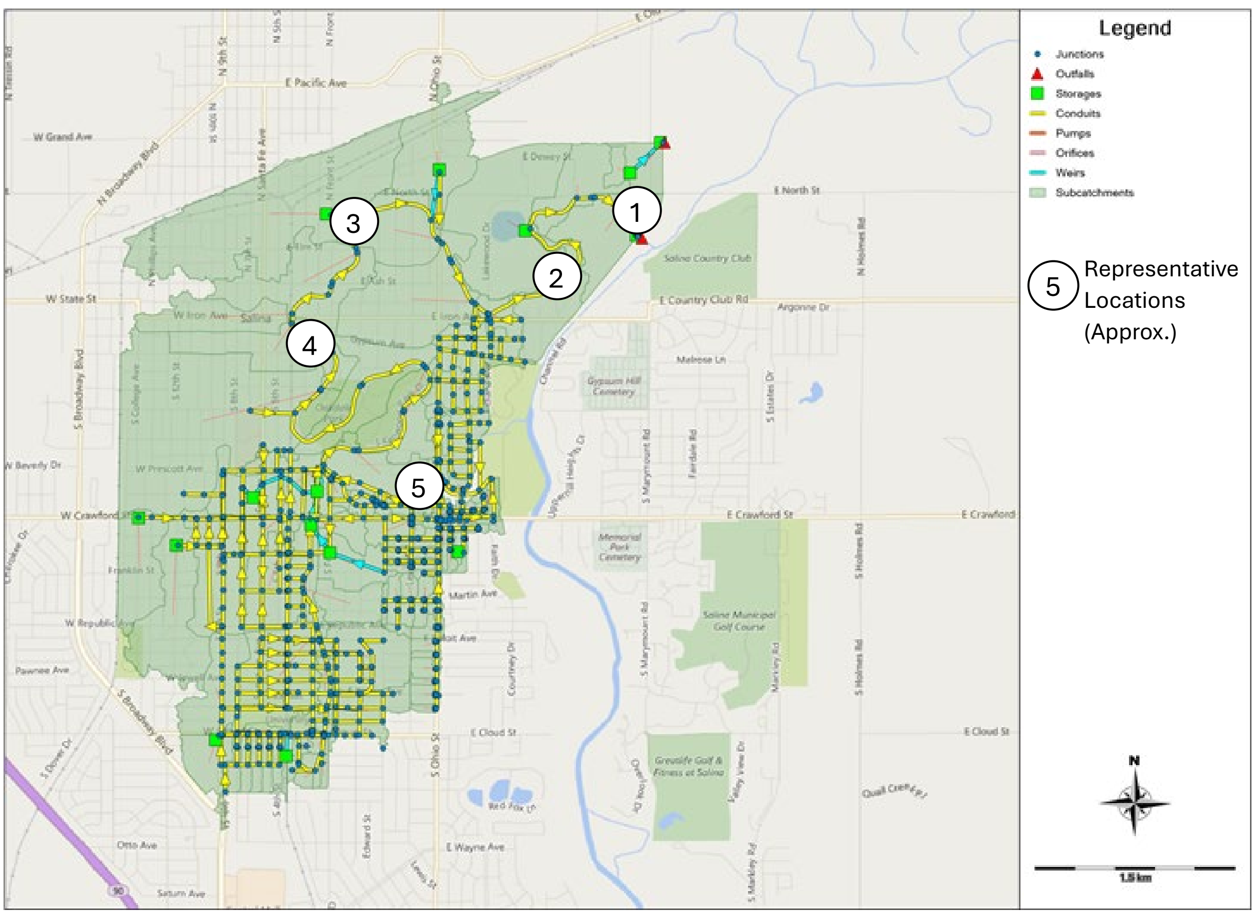


Figure 3-2. Schematic of Extracted SWMM Model

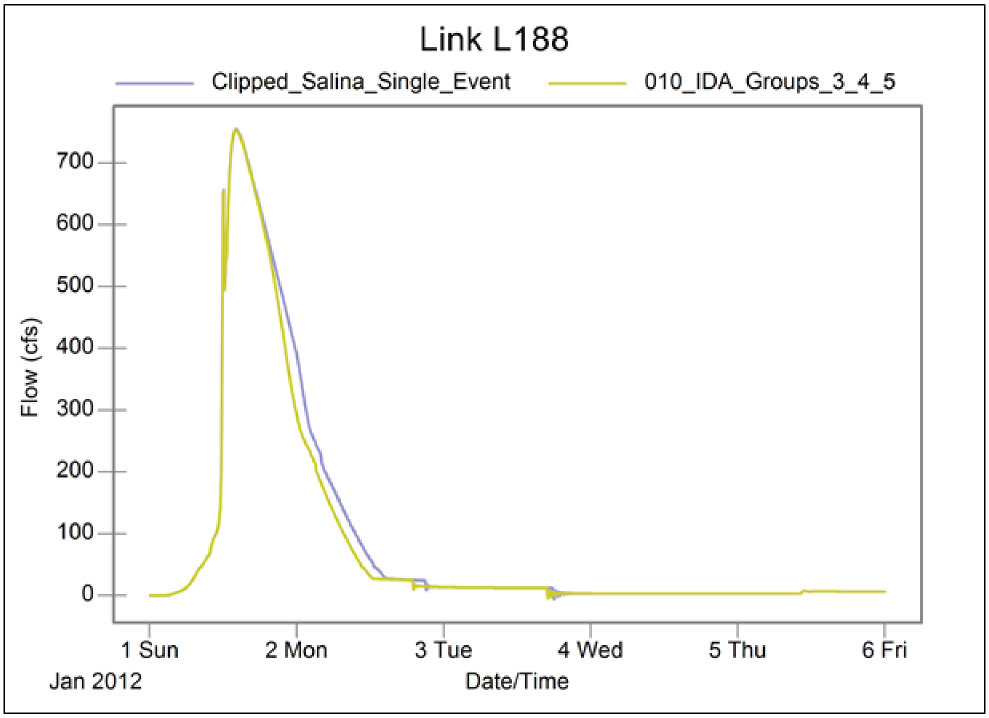


Figure 3-3. SWMM Results Comparison at Outfall Between City-Wide Model and Extracted Model

Table 3-3. Estimated Stormdrain Flows Using Five Years of Rainfall (1980 – 1985)

Location ID	Description	Total Flow Volume 5-year		Average Annual Total Flow Volume		Peak Flow
		ft^3	acre-ft	ft^3	acre-ft	cfs
1	Link L171 at outfall	1,154,000,000	26,492	230,800,000	5,298	427
2	Link 188 @ Upstream Lakewood	1,093,000,000	25,092	218,600,000	5,018	550
3	Link 160 @ Elm St & N. Oakdale Ave	832,200,000	19,105	166,440,000	3,821	420
4	Link 151 @ W. Walnut St	727,200,000	16,694	145,440,000	3,339	378
5	Transect L136 @ S. Ohio St	85,470,000	1,962	17,094,000	392	56

acre-ft = acre feet; cfs = cubic feet per second; ft^3 = cubic feet

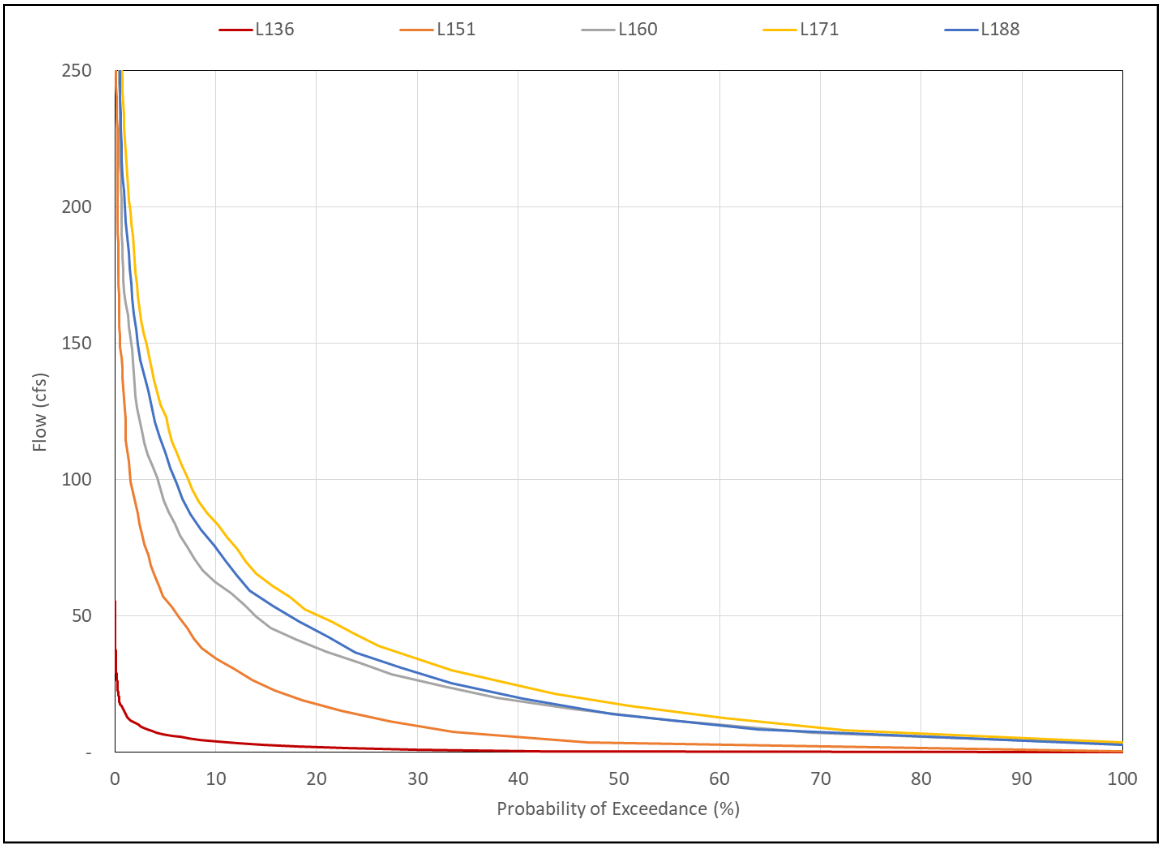


Figure 3-4. Stormdrain Flow Duration Curves for Selected Segments along Old Channel

Discretized flow values and corresponding annual durations along the SIAM sediment reaches in the Old Channel are shown in Table 3-4. The same discretized flow values were used for Sediment Reaches 1 and 2 since there was only a 6-percent difference between the total flow volumes summarized in Table 3-3; this difference was considered negligible in the final results so creating two separate flow duration curves was considered unnecessary.

Table 3-4. Discretized Annual Stormdrain Flow and Flow Duration in Old Channel

	SIAM Reach 7-8 (L136)		SIAM Reach 6 (L151)		SIAM Reach 4-5 (L160)		SIAM Reach 2 (L188)		SIAM Reach 1 (L171)	
	Flow (cfs)	Duration (day)	Flow (cfs)	Duration (day)	Flow (cfs)	Duration (day)	Flow (cfs)	Duration (day)	Flow (cfs)	Duration (day)
	0.3	54.5	2.0	57.3	9.5	33.2	10.2	37.8	10.2	37.8
	0.8	21.8	6.7	22.9	20.2	13.3	21.0	15.1	21.0	15.1
	1.6	10.9	13.7	11.5	32.5	6.6	36.3	7.6	36.3	7.6
	3.1	10.9	26.1	11.5	50.4	6.6	59.9	7.6	59.9	7.6
	5.4	5.4	45.4	5.7	76.7	3.3	92.5	3.8	92.5	3.8
	10.7	4.4	90.1	4.6	128.9	2.7	154.0	3.0	154.0	3.0
	35.4	1.1	249.8	1.1	292.1	0.7	372.1	0.8	372.1	0.8
	ANNUAL TOTALS									
DURATION (day)	109.0		114.6		66.4		75.7		75.7	
VOLUMES (acre-ft)	397.1		3319.8		3841.6		5047.9		5047.9	

3.3 Stormdrain Annual Sediment Load

Annual sediment load carried by the interior drainage (stormdrain) into the Old Channel was initially approximated using the average annual total flow volume (Table 3-3) and an estimated total suspended sediment (TSS) concentration of 67 milligrams per liter (mg/l) for assumed mixed land uses (Table 3-5), based on the Nationwide Urban Runoff Program report (US EPA, 1983). Sediment loads were converted to ton/year using a bulk sediment density of approximately 80 pounds per cubic foot (lb/ft^3), corresponding to a silt range sediment class.

Table 3-5. Median Event Mean Concentrations for Urban Land Uses

Pollutant	Units	Residential		Mixed		Commercial		Open/ Non-Urban	
		Median	COV	Median	COV	Median	COV	Median	COV
BOD	mg/l	10	0.41	7.8	0.52	9.3	0.31	--	--
COD	mg/l	73	0.55	65	0.58	57	0.39	40	0.78
TSS	mg/l	101	0.96	67	1.14	69	0.85	70	2.92
Total Lead	µg/l	144	0.75	114	1.35	104	0.68	30	1.52
Total Copper	µg/l	33	0.99	27	1.32	29	0.81	--	--
Total Zinc	µg/l	135	0.84	154	0.78	226	1.07	195	0.66
Total Kjeldahl Nitrogen	µg/l	1900	0.73	1288	0.50	1179	0.43	965	1.00
Nitrate + Nitrite	µg/l	736	0.83	558	0.67	572	0.48	543	0.91
Total Phosphorus	µg/l	383	0.69	263	0.75	201	0.67	121	1.66
Soluble Phosphorus	µg/l	143	0.46	56	0.75	80	0.71	26	2.11

COV: Coefficient of variation
Source: Nationwide Urban Runoff Program (US EPA 1983)

The estimated annual amounts of stormdrain sediment load carried into the Old Channel are shown in Table 3-6 (Incremental Sediment Load), along with the corresponding SIAM reaches where the load is discharged and the HEC-RAS river stations at the upstream end of the stormdrain link node.

Table 3-6. Annual Sediment Load Estimate in Stormdrains

Stormdrain Location	Annual Water Volume (ft3)	Cumulative Sediment Load (ton/year)	Incremental Sediment Load (ton/year)	SIAM Reach	HEC-RAS River Station
5 (L136)	17,094,000	45.8	45.8	7-8	32610
4 (L151)	145,440,000	389.8	344.0	6	18386
3 (L160)	166,440,000	446.1	56.3	4-5	14349
2 (L188)	218,600,000	585.8	139.8	2	7000
1 (L171)	230,800,000	618.5	32.7	1	1300

3.4 Bed Sediment Samples

Representative bed sediment samples in the Old Channel were collected by HDR in June 2020 and processed in the KVE geotechnical laboratory (KVE, 2020) by a sieve analysis (for grain sizes larger than 0.0625 mm) and hydrometer testing (for grain sizes smaller than 0.0625 mm). The locations of grab sediment samples are shown in Figure 3-5 along with the corresponding SIAM sediment reaches. The sediment gradation input data used in the SIAM model is shown in Table 3-7, with the majority of sediment sizes in the silt and clay range.

No sediment sample was collected downstream of the levee in the Old Channel (within Sediment Reach #0), so the bed gradation was artificially assigned with a D50 in the large cobble to small boulder range. This coarsening of the bed was needed to prevent unreasonably high erosion results along Sediment Reach #0. Significant erosion is not expected in this reach due to the existing riprap protection currently in place at the levee outfall.

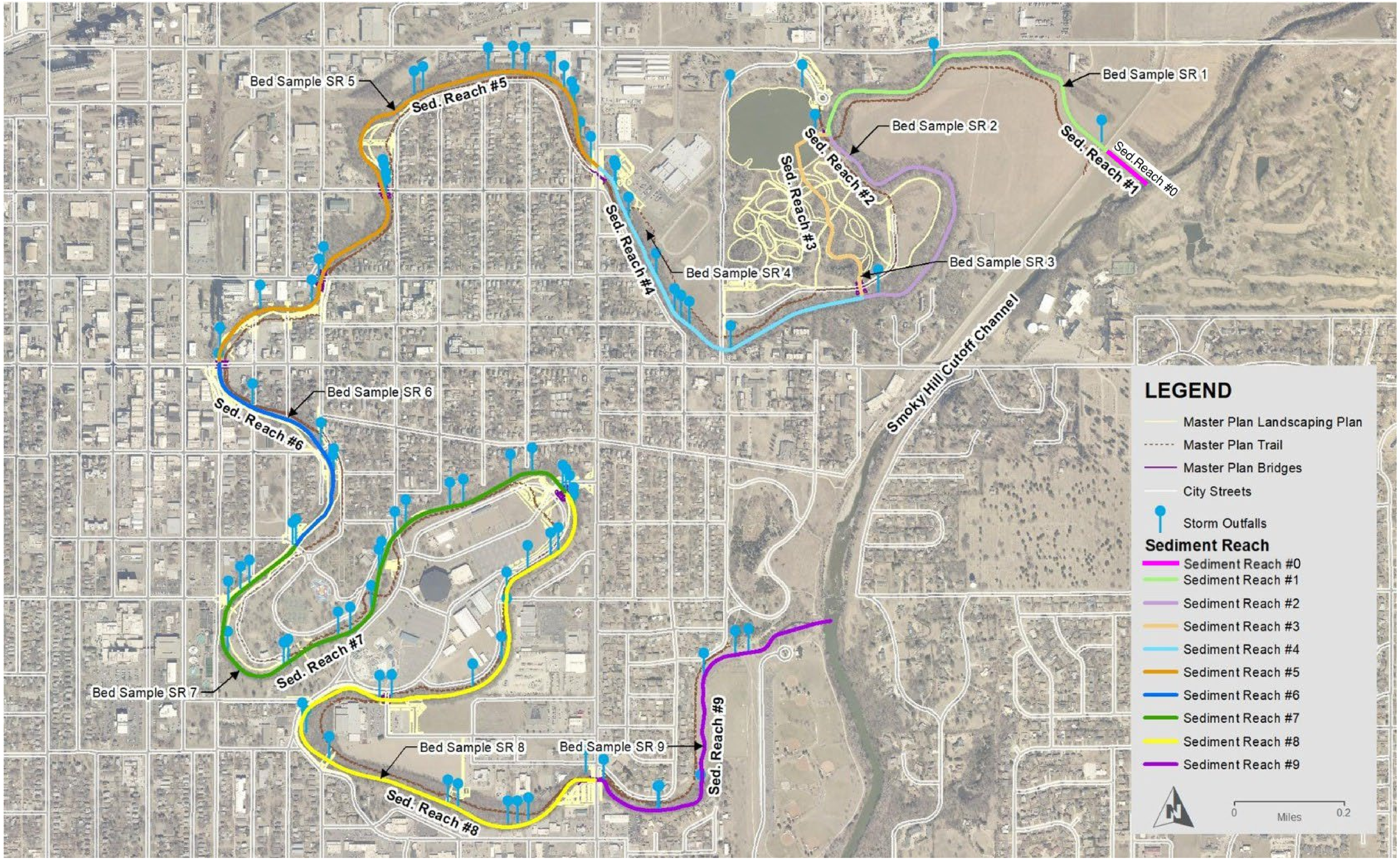


Figure 3-5. SIAM Sediment Reaches and Bed Sediment Sample Locations

Table 3-7. Old Channel Bed Gradation Data

Class	Class Description	D (mm)	Percent Finer in Sediment Reach (SR)							
			SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8
Clay	Clay	0.004	41	41	41	41	41	50	50	54
VFM	Very Fine Silt	0.008	54	54	54	54	54	51	63	63
FM	Fine Silt	0.016	65	65	65	65	65	52	73	73
MM	Medium Silt	0.032	70	90	90	90	73	53	90	90
CM	Coarse Silt	0.0625	76.4	91.3	96	96	83	53.8	99.5	95
VFS	Very Fine Sand	0.125	96.5	96.5	96.5	96.5	96.5	96.5	100	96
FS	Fine Sand	0.25	97.5	97.5	97.5	97.5	97.5	97.5	/	97.5
MS	Medium Sand	0.5	98.5	98.5	98.5	98.5	98.5	98.5	/	98.5
CS	Coarse Sand	1	99	99	99	99	99	99	/	99
VCS	Very Coarse Sand	2	100	100	100	100	100	100	/	100

Note: HEC-RAS terminology for sediment gradation classifies silt particles as ‘mud’. The HEC-RAS soil Class abbreviations (VFM, FM, MM, and CM) were maintained throughout this technical memorandum for consistency with HEC-RAS plotting and to avoid confusion with sand particles. The gradation used in Sediment Reach #0 was artificially set with a D50 in the large cobble to small boulder range.

3.5 SIAM Sediment Model Development and Validation

The baseline sediment budget model (SIAM) was constructed for the Old Channel based on the existing conditions HEC-RAS model developed by HDR (2018) as previously described. The SIAM geometry consists of ten sediment reaches to further evaluate sediment loading. The sediment reaches are shown in Figure 3-5 and summarized in Table 3-8, and generally coincide with roadway crossings and the Western Star Mill weir. Sediment Reach #3 is not considered in the existing model setup as it represents a looped Lakewood Park configuration that may be used in the future project phases. Similarly, Sediment Reach #9 is excluded from the baseline configuration because minor drainage entering this reach currently flows in the opposite direction (North) since the culvert at S. Ohio St. is blocked under existing conditions. Sediment Reach #0 was excluded from the sediment deposition calculations because it is located downstream of the levee and is assumed to have negligible sediment loading from local sources.

The mean annual sediment deposition for each sediment reach was estimated by comparing historic bed profiles. An average bed profile comparison plot, subdivided by the Western Star Mill weir, is provided in Figure 3-6 and Figure 3-7. The latest renovation to the Old Channel was completed in 1960-1961, with the construction of the flood control levee and installation of multiple drainage culverts. The construction of the levee has undoubtedly contributed to sedimentation in the Old Channel, and since the levee will remain in place for the foreseeable future, this was selected as an appropriate baseline condition for the deposition estimates. The Western Star Mill weir was constructed in the late 1800s and has likely also contributed to sediment deposition over the years; however, the levee was not built at that time, which would not be completely representative of conditions as they exist today. As such, the ground profile used as the baseline condition for the sediment deposition estimate was based on the 1960 data, following construction of the levee. The baseline 1960 profile was approximated from the best available data, which utilized known culvert invert elevations through the Old Channel and the Western Star Mill weir. The channel profile was roughly approximated from the flood control levee culvert at the inlet of the Old Channel downstream to the Western Star Mill weir, then tied into the culvert at Ash Street, and finally connected to the flood control levee culvert at the downstream end of the Old Channel. The existing conditions channel profile is based on 2017 survey data. The difference between the 2017 profile and the 1960 profile represents approximate sedimentation depths over a 57-year period, varying from approximately 0.5 ft to 6.7 feet over the time period. Refer to Figure 3-6 and Figure 3-7 for the historic bed profile of the Old Channel.

The average end area method was used to calculate the volume of sediment within each sediment reach, based on the depth from the profile plot and an average width for each sediment reach. The average width (reported in Table 3-8) was assumed as the average channel bottom width from the 2017 LiDAR data and was developed by averaging the bottom widths of the HEC-RAS cross sections within each sediment reach. Calculations were performed in 100-foot intervals. This calculated volume was then annualized, with the resulting average annual sediment depths for each sediment reach shown in Table 3-8. This information was used to calibrate the SIAM annual sediment load entering each sediment reach, which was initially estimated in Section 3.3 (Table 3-6).

Table 3-8. Sediment Deposition Rates from Historic Bed Profiles

Sediment Reach	Upstream HEC-RAS River Station	Downstream HEC-RAS River Station	Average Channel Width (ft)	Average Annual Sediment Deposition (ton/year)	Average Annual Sediment Deposition (inch/year)
1	4100	660	14.6	49.6	0.20
2	7100	4200	20.8	79.7	0.38
4	10708	7200	20.0	159.5	0.60
5	16929	10956	17.9	305.2	0.85
6	19452	17181	9.5	43.4	0.69
7	24980	19510	14.2	299.4	1.05
8	32610	25117	13.2	383.6	1.25

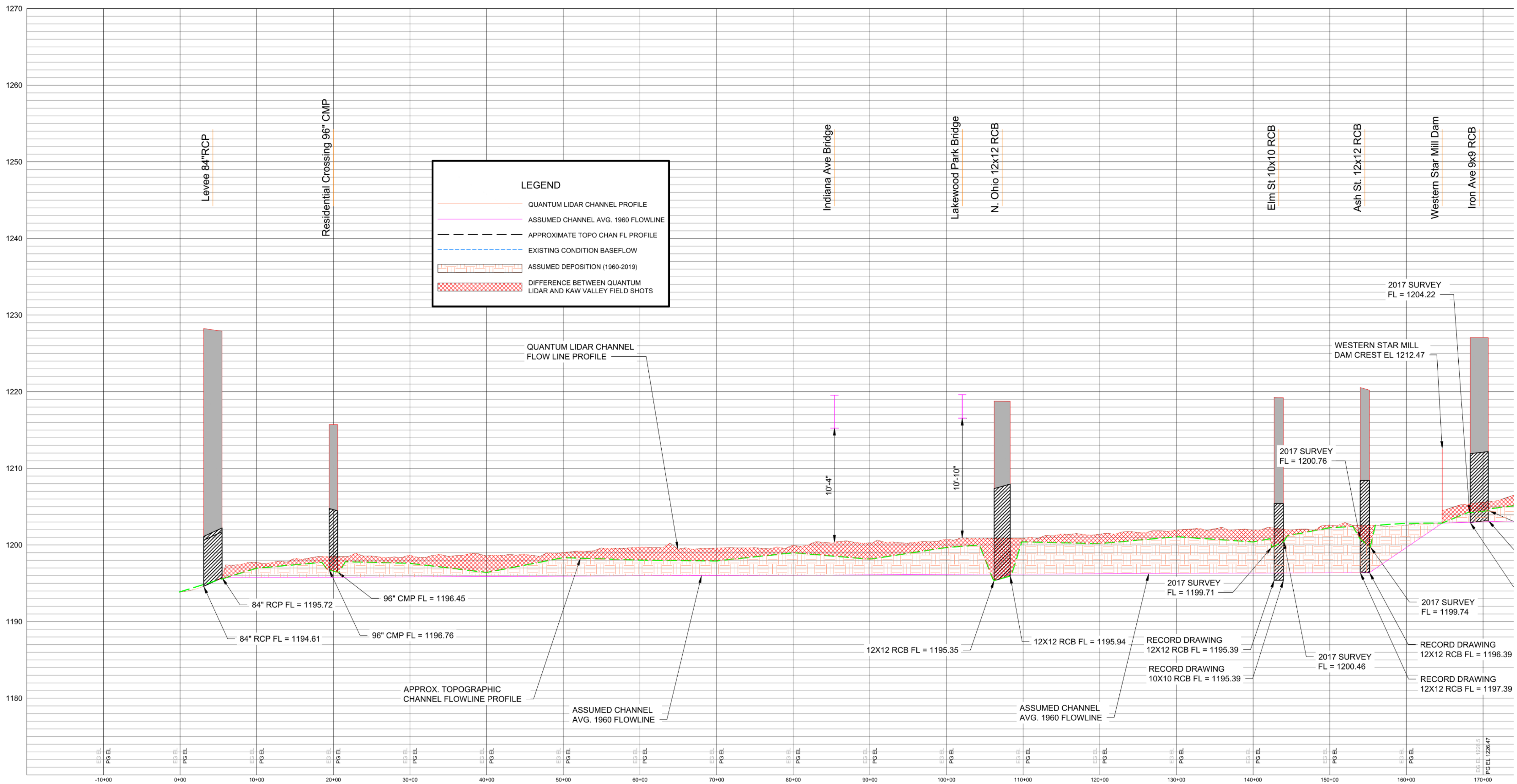


Figure 3-6. Old Channel Historic Plot, Downstream of Western Star Mill Weir

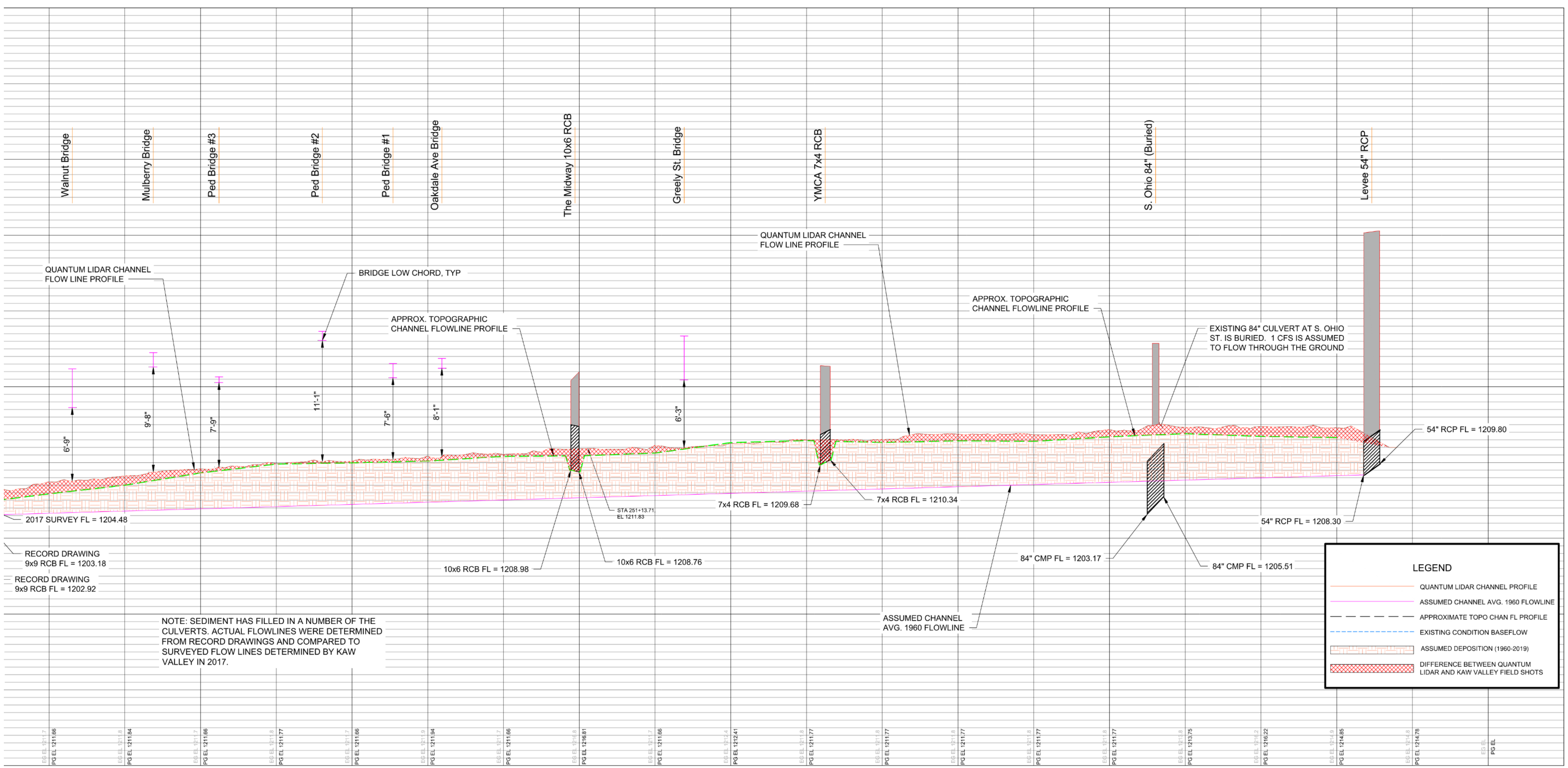


Figure 3-7. Old Channel Historic Plot, Upstream of Western Star Mill Weir

The Laursen (Copeland) sediment transport equation was selected because of its general applicability to fine-grain sized soil (less than 0.7 mm in diameter), however still presents a challenge for accurately representing cohesive soils. The wash load maximum class range was set to coarse silt (CM) to provide reasonable estimates of the reach sediment transport capacity (SIAM does not apply the standard transport equation to compute a mass balance for wash load material; instead, it automatically passes it through the sediment reach). Figure 3-8 shows the SIAM main window interface. Table 3-9 shows different load multipliers assigned to each sediment reach to match the predicted annual sediment deposition with the historically observed bed aggradation in the Old Channel. Table 3-10 provides a model validation with respect to annual sediment deposition estimated from the historical bed profile and as determined from the SIAM results for existing conditions.

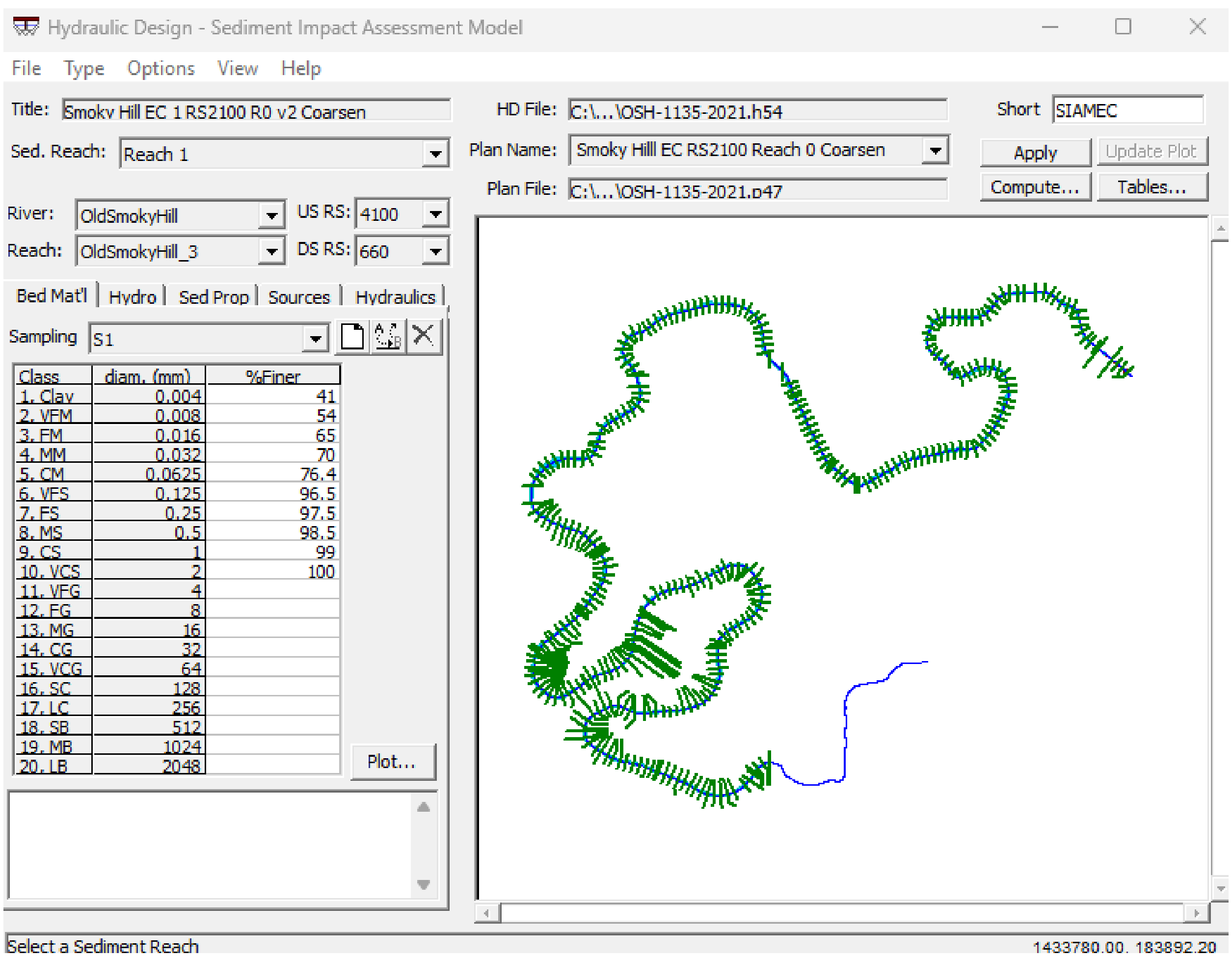


Figure 3-8. Old Channel SIAM Model in HEC-RAS

Table 3-9. Sediment Load Calibration Multipliers

Sediment Reach	Load Without Multiplier (tons/year)	Multiplier	Load With Multiplier (tons/year)
1	33	104.6	3,420
2	140	8.3	1,153
4	56	11.5	647
5	56	37.2	2,093
6	344	0.3	99
7	46	127.5	5,843
8	46	164.5	7,539
SUM	**721**	**/**	**20,796**

Table 3-10. Sediment Deposition Comparison (Model versus Historical Bed Profile)

Sediment Reach	Average Annual Sediment Deposition (ton/year)	
	Historical Profile Estimate	SIAM Model Results
1	49.6	49.7
2	79.7	79.6
4	159.5	160.0
5	305.2	306.0
6	43.5	44.3
7	299.4	293.0
8	383.6	378.0
SUM	1,321	1,311

The total annual sediment deposition in the Old Channel for existing conditions between Sediment Reach 1 and Sediment Reach 8 is calculated by summing the SIAM results shown in Table 3-10, which is estimated to be approximately 1,311 tons/year. Table 3-11 provides detailed sediment budget results as calculated by SIAM that include the sediment supply and sediment transport capacity (load) along each reach. The suspended load is calculated from the transport capacity for each reach given its hydraulic parameters and bed material. The bed supply is the total sediment load being supplied to each reach, including local lateral loads and the transported material being supplied from the adjacent upstream reach. Wash load is not included in the suspended load or bed supply. A visual summary of the sediment transport components into and out of the Old Channel and overall annual sediment budget is provided in Figure 3-9.

Table 3-11. Detailed Annual Sediment Budget

Sediment Reach	Local Supply (tons/year)	Suspended Load (tons/year)	Bed Supply (tons/year)	Wash Load (tons/year)	Sediment Balance (tons/year)
0	0	802	780	18,700	-22.1
1	3,420	780	830	18,700	49.7
2	1,153	22.3	102	16,100	79.6
4	647	1.51	161	15,000	160
5	2,093	51.3	357	14,500	306
6	99.1	1.48	45.8	12,800	44.3
7	5,843	0	293	12,700	293
8	7,539	0.0897	378	7,161	378
SUM	**20,794**	/	/	/	**1,289**

Note: Table generated from SIAM results; some values may result in rounding errors.

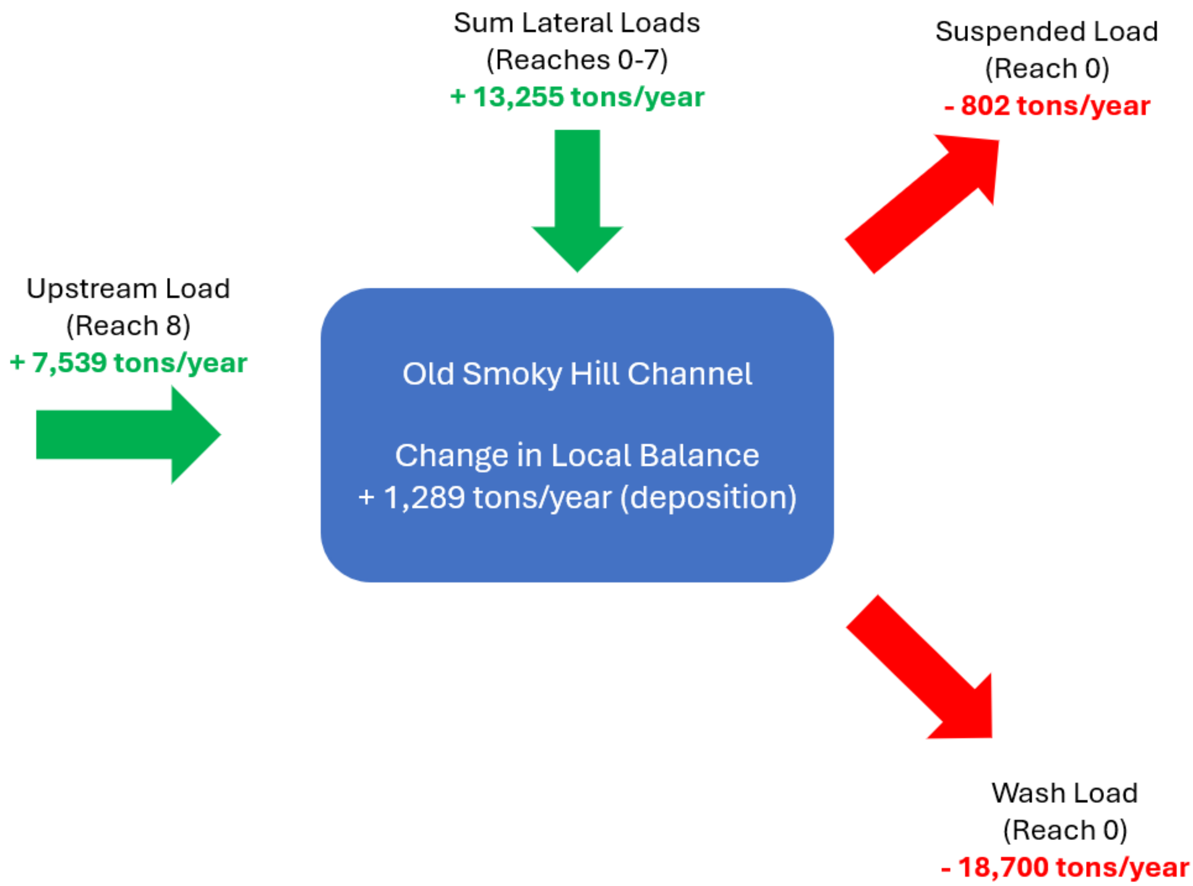


Figure 3-9. Annual Sediment Budget Diagram

3.6 SIAM Model Sensitivity

SIAM is a sediment budget tool which operates on an annual basis and does not account for a detailed seasonal distribution of modeling parameters, such as flow, water temperature or sediment load. Therefore, various input parameters were tested to evaluate the model's sensitivity within the expected range of values.

The impact of water temperature was tested within a reasonable seasonal variation (±20%). It was found that only the most downstream Reach 1 has relatively large sensitivity to temperature, which impacts the settling velocity of sediment particles through the viscosity of water. An average annual temperature of 65°F was ultimately selected for use in the model.

The SIAM wash load threshold was also tested. Typically, wash load is made up of grains that are not found in appreciable quantities in the channel bed. Wash load grains tend to be very small (mostly clay and silts, but also some fine sands) and therefore have a low settling velocity, being kept in suspension by the flow turbulence. The fine sediments that are in the wash load are generally smaller than 0.0625 mm. This wash load maximum class (corresponding to coarse silt CM) was selected as appropriate to reasonably match historical bed deposition during the sediment source calibration. A finer wash load threshold was tested and was found to produce more bed degradation (or less deposition). A coarser wash load threshold was tested on Reach 1 and was found to produce more deposition (Table 3-12).

Different sediment source (load) multipliers were applied to SIAM reaches as a calibration tool to match the predicted annual sediment deposition with the historically observed bed aggradation in the Old Channel. The calibration multipliers range from 0.3 to 170, depending on the reach. The highest values were specified for Reaches 7 and 8 in the upstream end and Reach 1 on the downstream end. Some sediment load from the river was historically entering the Old Channel through the culvert at S. Ohio St. (currently blocked under existing conditions), which likely contributes to higher calibration multipliers in the most upstream reaches. Using a coarser sediment supply load from interior drainage was found to produce lower calibration multipliers in each reach (coarser material deposits more and diminishes the need for larger load multipliers). Table 3-12 summarizes the calibration multipliers when coarsening the supply load at each sediment reach (shifting the load fractions up by two grain size classes so the D_{50} is within 0.032 mm to 0.0625 mm) and using a slightly coarser wash load threshold in Reach 1 (0.125 mm, corresponding to very find sand VFS). Based on the results in Table 3-12, the calibration multipliers are sensitive to grain size composition of the sediment load in interior drainage flow. Additional field measurements may provide better representation of the sediment load composition in this system.

Table 3-12. Sediment Load Calibration Multipliers Sensitivity

Sediment Reach	Original Load	Coarser Load	Coarser Load with Larger Wash Load Threshold in Reach 1
1	104.6	70.6	5.75
2	8.3	2.05	2.05
4	11.5	5.5	5.5
5	37.2	18.0	18.0
6	0.3	0.28	0.28
7	127.5	23.7	23.7
8	164.5	30.5	30.5

Reach 1 was found very sensitive to water temperature, which may contribute to one of the larger calibration multipliers of 104.6 needed in this reach. Also, the bed surface material recently collected in the Old Channel may underestimate sediment sizes historically carried by interior drainage, skewing the model results toward less deposition in multiple reaches (which required larger multipliers). Finally, the SIAM model flow duration curves were developed from only 5 years of simulated drainage flows (1980-1985), rather than a longer (more representative) period of record. All these factors may significantly influence the sediment load calibration process.

It is important to note that the SIAM model was developed mainly for the purpose of comparing various project alternatives (i.e. evaluating relative changes with respect to existing conditions and other alternatives), rather than providing absolute values of expected annual bed aggradation or degradation in the Old Channel. The impact of calibration coefficients is thereby minimized as they are identical for all the evaluated scenarios, providing more confidence in the alternative screening process.

4. Proposed Sediment Basin Analysis

As previously described, one of the Master Plan goals is to reconnect the community with the waterway by reintroducing flow to the Old Channel. The channel banks and adjacent areas in the Old Channel will be developed for a variety of recreational, community and commercial uses. As flow is re-introduced from the Smoky Hill Cut-off Channel to the Old Channel, so is the sediment that is transported by the diverted flows.

Consequently, as part of the proposed alternatives, a sediment basin is proposed downstream of the Old Channel intake structure to serve as a first line of defense for sediment capture before the diverted water is conveyed downstream to the restoration reach. The sediment basin was evaluated with a mobile-bed sediment transport model (HEC-RAS 5.0.7) to assess the performance of the proposed sediment basin, evaluate maintenance requirements, and assess downstream impacts to the Old Channel. Methodology, model development, and model results are presented herein. Results from this analysis are then used to inform sediment loading in the SIAM model to evaluate alternative conditions for the Old Channel, which is discussed in Section 5.

4.1 Methodology

HDR performed a detailed one-dimensional, mobile-bed sediment transport evaluation of the proposed sediment basin using HEC-RAS 5.0.7 sediment transport module as a modeling platform. The more detailed level of sediment analysis, as compared to SIAM, was utilized in this effort to capture the sediment basin bed evolution (where the cross sections are updated in time), allowing for prediction of intermediate and final morphological patterns in the system. Model results can then be used to evaluate the effectiveness of the proposed sediment basin, estimate a dredging schedule, approximate sediment loading within the proposed facility, as well as the sediment outflow leaving the sediment basin.

4.2 Model Development

The main inputs required for model development include channel geometry, quasi-unsteady flow data, bed material gradation, and sediment loading. These parameters, as well as other assumptions, are described in more detail in the subsequent sections.

4.2.1 Model Geometry

The model geometry for the sediment basin analysis was based on the HEC-RAS model developed for the Old Channel to evaluate proposed alternatives. Development of the downstream model geometry for each SIAM alternative is further described in Section 5. For purposes of analyzing the sediment basin, only a portion of the proposed model geometry was utilized with the upstream limit at the Old Channel intake structure, extending for a total length of approximately 2,200 feet downstream. The geometry extent is depicted in Figure 4-1 and the configuration of the proposed sediment basin is illustrated in Figure 4-2. Manning's roughness coefficients, channel configuration, and other geometry inputs remain unchanged from the proposed baseline model. The model profile is depicted in Figure 4-3.

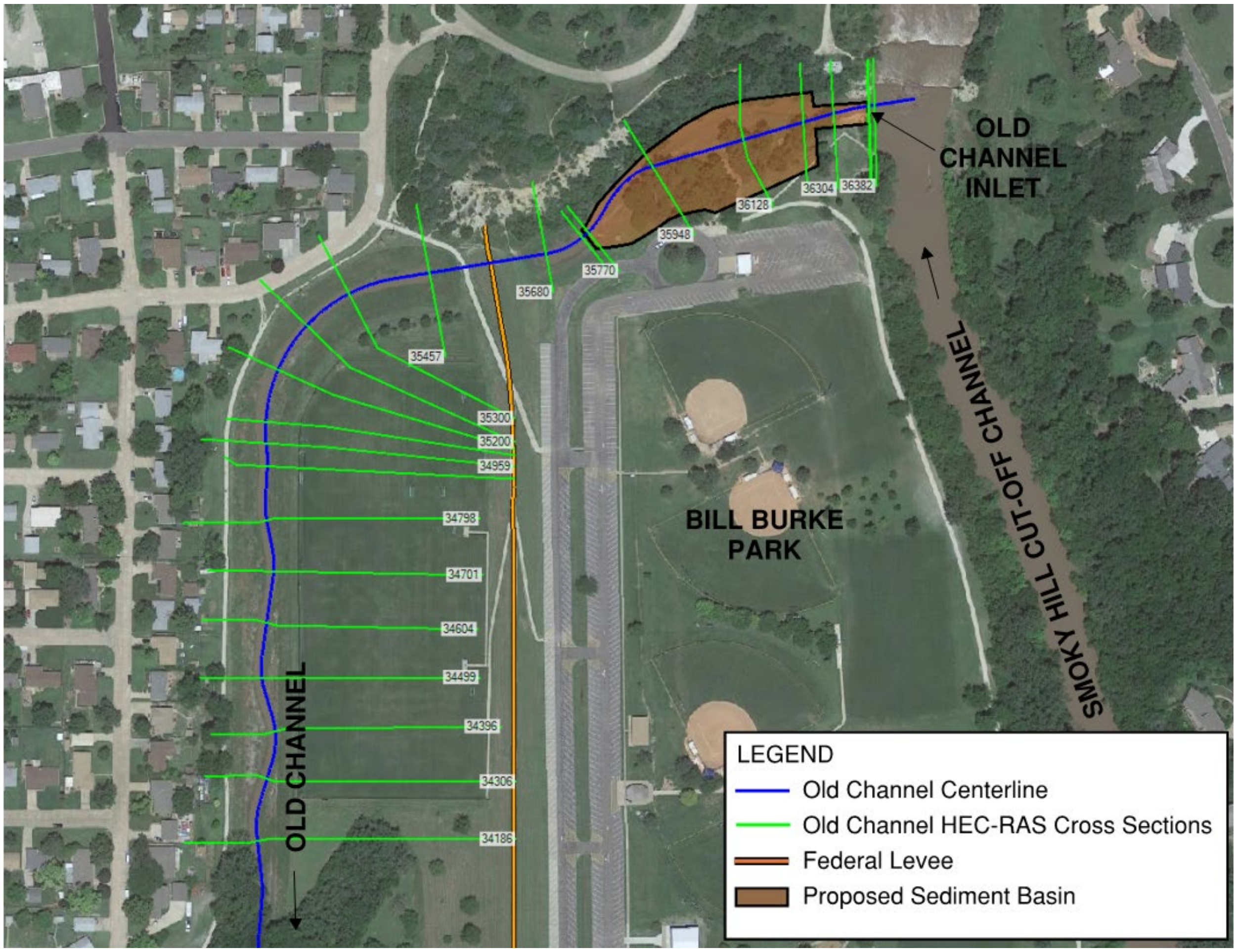


Figure 4-1. Schematic of Old Smoky Hill Proposed Sediment Basin HEC-RAS Model

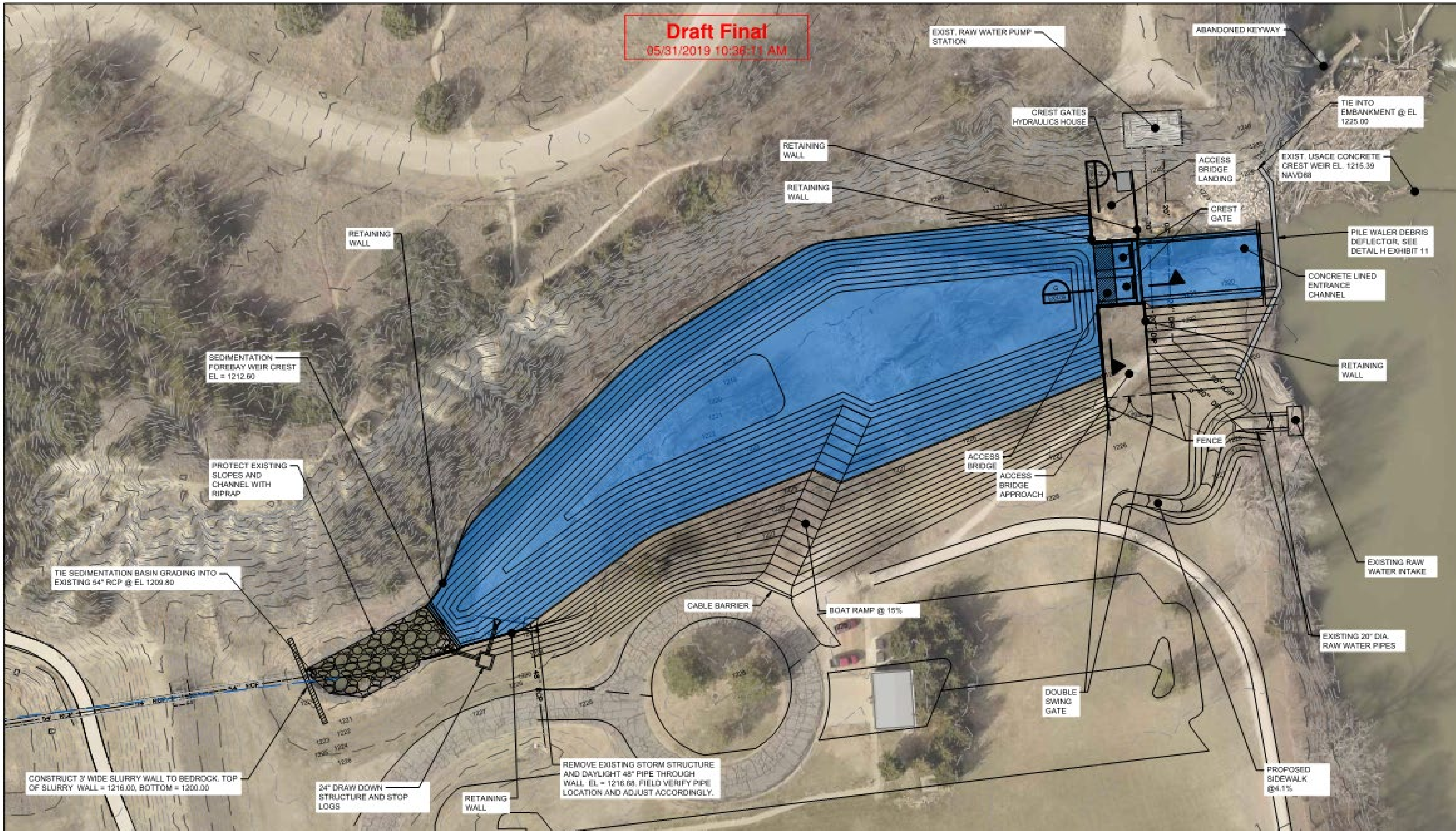


Figure 4-2. Proposed Sediment Basin at Old Channel Entrance

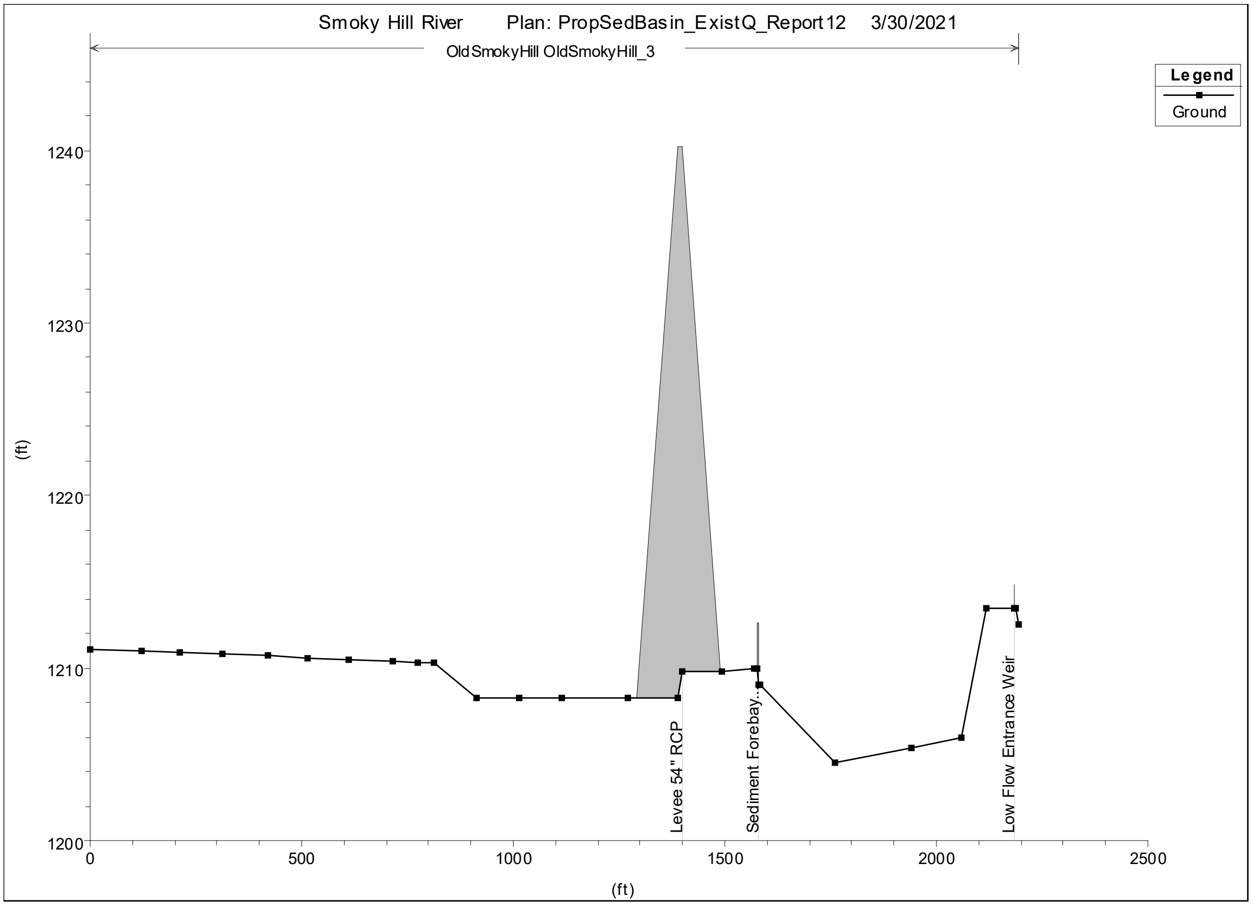


Figure 4-3. Proposed Sediment Basin HEC-RAS Model Bed Profile

4.2.2 Quasi-Unsteady Flow

The sediment transport model was evaluated under historical flows, as well as future flow conditions on the Smoky Hill Cut-off Channel for a 50-year duration.

Historical flow information was obtained from USGS Gage 06866500 (Figure 3-1) on the Smoky Hill River near Mentor, Kansas. Daily discharge data was obtained from 1968 to 2017, for a total of 50 years. Future daily flow information was provided by USACE via an output file from a HEC-ResSim model of Kanopolis Reservoir, as developed by USACE in 2021. The HEC-ResSim model was developed to estimate future hydrology conditions at the intake of the Old Channel based on the anticipated Kanopolis Reservoir operations. For purposes of this analysis, future daily discharge data was evaluated from 2050 to 2099.

The daily discharge data for existing and proposed flows represent daily averages along the Smoky Hill Cut-off Channel. The daily gage data was then adjusted in accordance with the water appropriation restrictions to determine how much water is potentially diverted to the Old Channel, and thus, routed through the proposed sediment basin. Per the Water Appropriation #47,510, water diversion is authorized only when flow in the Smoky Hill Cut-off Channel at the USGS Gage 06866500 near

Mentor, Kansas is equal to or greater than 40 cfs. In addition, a minimum of 30 cfs must remain in the Cut-off Channel to ensure that some volume of water remains. The water appropriation also includes seasonal diversion restrictions. Water diversion shall not exceed 80 cfs during warm months (May through September) or 10 cfs during winter months (October through April). Consequently, a pre-diversion flow of 110 cfs minimum is required during warm months to divert the entire 80 cfs. A breakdown of the diversion scenarios is presented in Table 4-1.

Table 4-1. Old Channel Flow Diversion Scenarios

Scenario	Smoky Hill Cut-off Channel Discharge	Discharge Diverted to Old Channel
1	Q_{river} = 39.99 cfs or less	Q_{div} = 0 cfs
2	Q_{river} = 40-110 cfs	$Q_{div} = Q_{river} - 30$ cfs not to exceed 80 cfs from May-Sept not to exceed 10 cfs from Oct-Apr
3	Q_{river} > 110 cfs	Q_{div} = 80 cfs (May-Sept) Q_{div} = 10 cfs (Oct-Apr)

For illustration purposes, the first three years of the future flow data was plotted in Figure 4-4, providing a comparison between the initial flow in the Smoky Hill Cut-off Channel, diverted flows to the Old Channel, and remaining flow in the Cut-off Channel less the diverted portion. The higher flows are cut off from the graphic to provide a zoomed in plot such that the diverted flows are visible.

Comparison of the historical and future flow data is provided in Table 4-2. Future discharges are anticipated to be larger than historical flows by an average of 10-17 percent based on the information provided (depending on if the estimate is from the average flow or median flow). Additionally, a side-by-side comparison of the existing and future diverted flows utilized in the sediment transport model is provided in Figure 4-5. While the individual graphics are not overly informative; presented side by side, it is evident that higher discharges are forecasted in the future, thus providing more frequent diversions to the Old Channel.

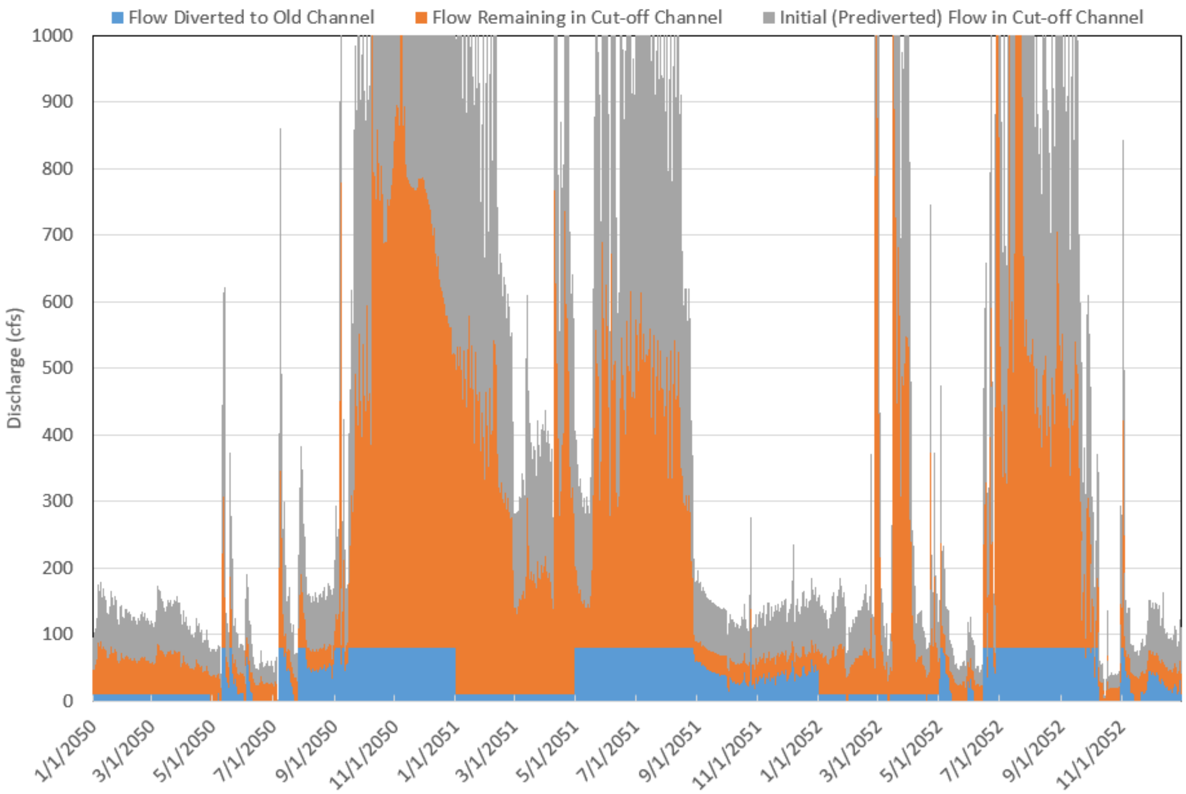


Figure 4-4. Old Channel Diversion and Cut-off Channel Flow Comparison for Portion of Future Flows

Table 4-2. Comparison Between Historical and Future Discharges in Smoky Hill Cut-off Channel and Diversion to Old Channel

Parameter	Smoky Hill Cut-off Channel (Pre-Diversion)		Diversion to Old Channel	
	Historical Flow (1968-2017)	Future Flow (2050-2099)	Historical Flow (1968-2017)	Future Flow (2050-2099)
Maximum Discharge (cfs)	18,500	24,219	80	80
Average Discharge (cfs)	353	391	31	40
Median Discharge (cfs)	119	139	10	20
Percentage of Total Pre-Diversion Flow	N/A	N/A	8.8%	10.2%

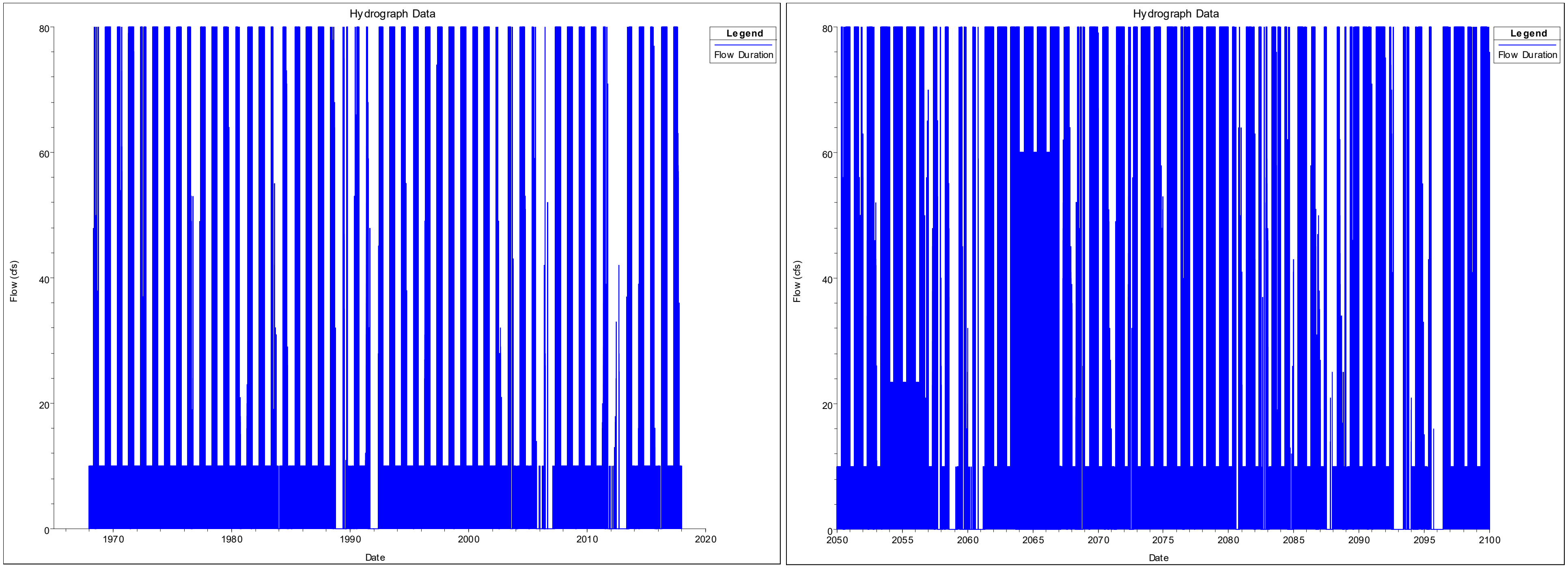


Figure 4-5. Comparison of Flow Series Hydrographs for Historical Flows (Left) and Future Flows (Right)

4.2.3 Sediment Loading

TSS and the corresponding flow rates were measured by HDR from six flow samples collected along the Smoky Hill Cut-off Channel (near the Old Channel inlet) on different days during 2018 (once a month from May until October). A regression equation for the TSS versus flow rate was developed (Figure 4-6), which was used to estimate the sediment basin inflow concentration (in mg/L) based on daily flows in the river. The daily TSS concentration was converted into ton/day using a bulk sediment density of 80 lb/ft^3, corresponding to a silt range sediment class.

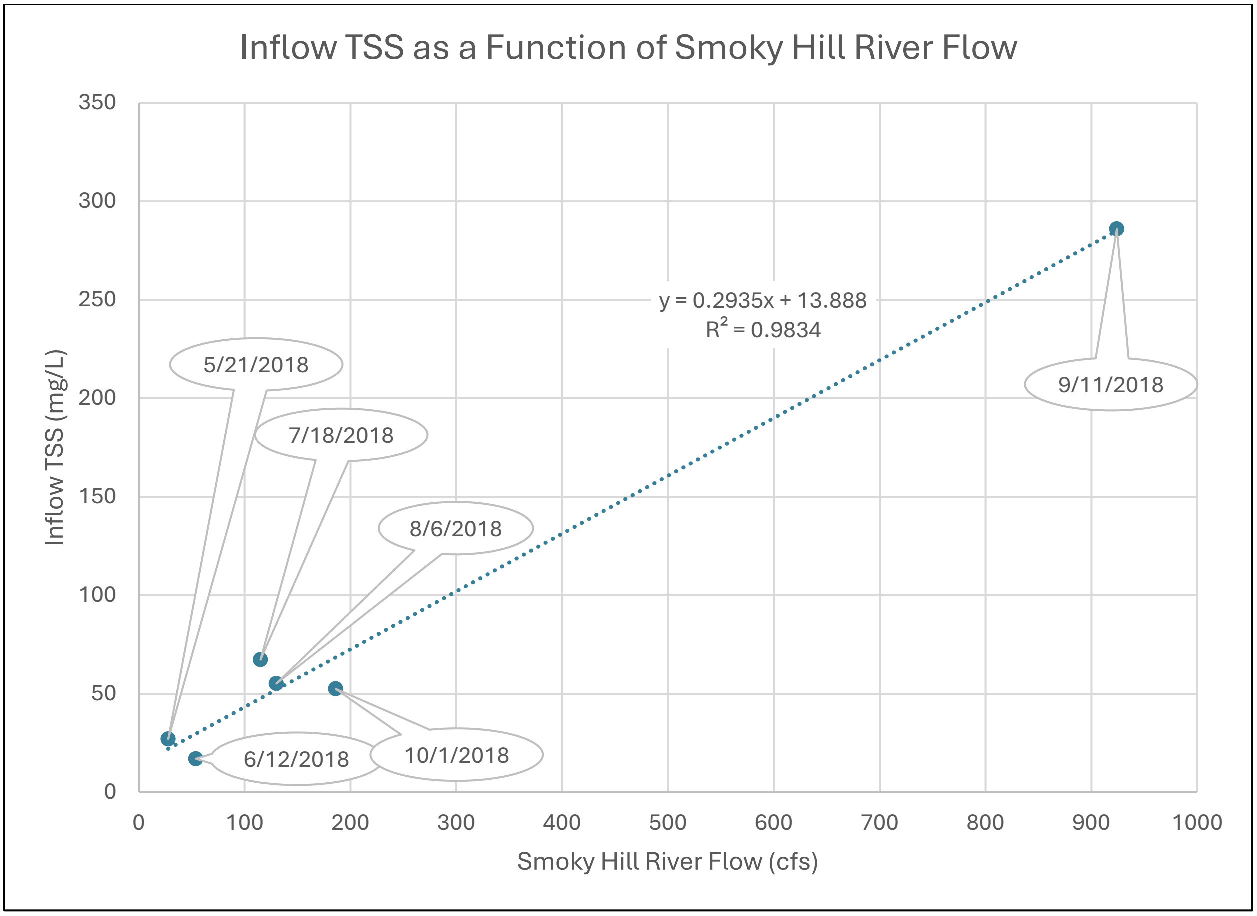


Figure 4-6. Inflow TSS as Function of Smoky Hill River Flow

Based on the linear regression equation for TSS (Figure 4-6), the TSS concentration for diverted flows was determined using the daily discharge data in the Smoky Hill Cut-off Channel (for both existing and future flows). It is noted that in linear regressions with small sample sizes (six data points), the coefficient of determination (R^2) can be highly unreliable and often biased, with deceptively high R^2 values and uncertain predictive performance. Sediment rating curves typically show data scatter particularly at low flows (Vanoni, 1975). The regression equation is missing TSS measurements for higher flows (greater than 1,000 cfs), which would typically exhibit some non-linear reduction in TSS; therefore, the TSS computed by the linear regression for higher flows results in a concentration that is higher than expected, providing a conservative estimate of sediment loading. While the analysis would benefit from more accurate TSS concentrations for a wider range of flows, the model input is based on the best available information at the time of the study. From the existing and future flow records, the flow in the Smoky Hill Cut-off Channel is greater than 1,000 cfs for approximately 10 percent of the simulation time period.

The gradation of the suspended sediment was obtained from hydrometer testing on site, which showed 95 percent clay/silt material. Sample SR8, located in the upstream portion of the channel provided a representative sample, The portion of material within each sediment class was obtained from the lab results (Kaw Valley Engineering Laboratory Test Results, June 2020) and is summarized in Table 4-3.

Table 4-3. Suspended Sediment Load Fractions

Class	Particle Size	Percent
Clay	0.002-0.004 mm	54%
Very Fine Silt (VFM)	0.004-0.008 mm	11%
Fine Silt (FM)	0.008-0.016 mm	9%
Medium Silt (MM)	0.016-0.032 mm	13%
Coarse Silt (CM)	0.032-0.0625 mm	8%
Very Fine Sand (VFS)	0.0625-0.125 mm	5%

The diverted inflow to the Old Channel occurs only when the Smoky Hill Cut-off Channel exceeds 40 cfs. As a result, there are some days in the simulation that do not experience any diversion of flow, as evident in the flow hydrographs in Figure 4-5. In order to provide a timely order of data within the model, all daily flows were entered into the sediment transport model, including those days with no diversion (a flow of 0.01 cfs was entered as a placeholder for days that do not have diversion).

4.2.4 Other Model Inputs

The downstream boundary condition was assumed as a rating curve, in which flows between 10 cfs and 80 cfs were associated with a corresponding water surface elevation from the models developed as part of Section 5. This provides a consistent correlation with simulated water surface elevations from the proposed alternative models.

Bed gradation in the sediment basin model was based on the USACE backwater sample (with more than 50 percent fines) from the Smoky Hill Cut-off Channel near diversion inlet to formally approximate sediment composition of bed material.

However, this approximation does not affect the modeling results as the sediment basin is mainly in depositional regime.

For purposes of the long-term sedimentation analysis, it was assumed that accumulated sediment within the proposed sediment basin would be completely removed when the basin was approximately half full, reaching an elevation of approximately 1209 ft. A dredging template was initiated at this time, which removes sediment and reverts it to its original configuration. Dredging operations were simulated for the four model cross sections located within the proposed sediment basin (Figure 4-1). The model simulation was performed using an iterative approach over the 50-year period to initiate dredging operations as needed. This allows for an estimate of the total dredging volume within the sediment basin over a 50-year period for both existing and future flow conditions.

4.3 Model Results

The sediment transport model captures bed profile changes over the course of the simulation, which allows for the prediction of sediment deposition in time. As an example, a profile plot from the model simulation with historical flows from January 1968 to October 1973 (just before a dredging operation commenced) is provided in Figure 4-7.

As expected, more frequent dredging is required during higher flow periods. On average, dredging is required every 2-7 years over the 50-year simulation, depending on the magnitude and duration of diverted flow. More frequent dredging is required under future flow conditions as compared to historical flows. This is also expected as future flows are anticipated to be greater than historical ones.

The HEC-RAS model reports the volume of dredged sediment over the evaluated 50-year simulation. Table 4-4 summarizes the dredged volume at each of the four HEC-RAS cross section located within the proposed basin, as well as the total cumulative volume under both historical and future flows. The total volume was then divided by 50 for an average annual accumulated sediment. A substantial increase in sediment accumulation (~35%) is observed for the future flows as compared to the historical ones. Note that this might be exaggerated by the suspended sediment loading utilized in the analysis, resulting in conservative concentrations for higher flow.

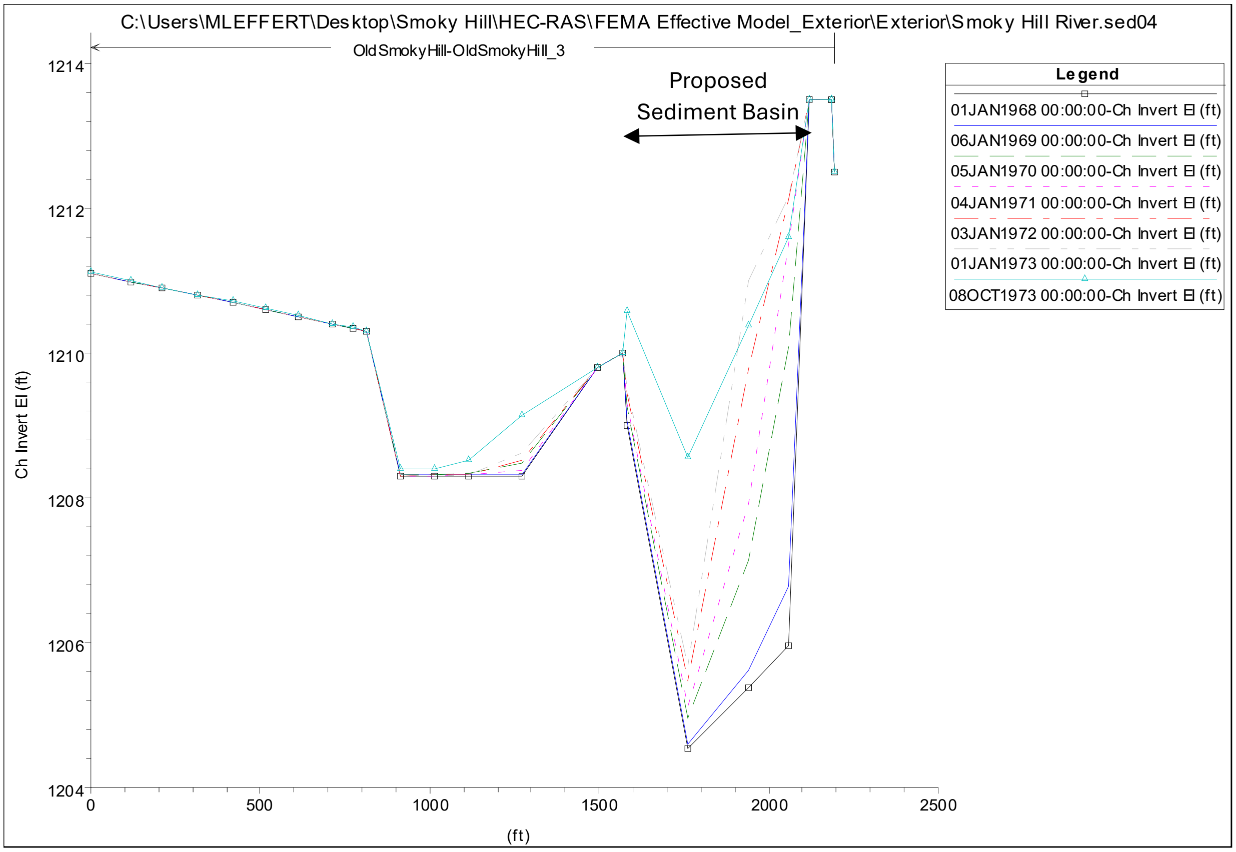


Figure 4-7. Example of Proposed Sediment Basin Profile Under Historical Flows from January 1968 to October 1973

Table 4-4. Summary of Dredged Sediment from Proposed Sediment Basin Under Historical and Future Flows

HEC-RAS River Station	Cumulative Dredged Sediment over 50-year Simulation	
	Historical Flows (ton)	Future Flows (ton)
36244	4,670	9,397
36128	36,644	50,930
35948	14,674	18,672
35770	3,346	4,381
Total Dredged Sediment (50-yrs)	59,335	83,381
Average Annual Dredged Sediment	1,187	1,668

The sediment basin trap efficiency is about 17 percent (Table 4-5) for both historical and future flows. The average annual sediment load released into the Old Channel downstream of the sediment basin (Reach 9) is about 6,850 ton/year for the future flows and about 5,000 ton/year for the historical flows.

Table 4-5. Trap Efficiency for Proposed Sediment Basin Under Historical and Future Flows

Cumulative over 50-year Simulation	Historical Flows	Future Flows
Mass In (ton)	301,481	412,533
Mass Out (ton)	249,417	342,502
Captured (ton)	52,064	70,031
Trap Efficiency (%)	17.3	17.0

5. Old Channel Sediment Analysis for Proposed Alternatives

5.1 Proposed Condition SIAM

The purpose of the proposed project alternatives is to restore the Old Channel by diverting some of the flow from the Smoky Hill Cut-off Channel into the Old Channel restoration reach (east of the federal levee). The diverted flow would first enter the intake structure and proposed sediment basin, which would control the amount of river flow and sediment inflow load through the Old Channel (west of the federal levee). The proposed alternatives reintroduce baseflow to the Old Channel through channel improvements and improved hydraulic structures with additional conveyance. The resulting improvements increase habitat and will provide a source for urban recreation.

Four different alternatives are proposed and analyzed using SIAM. Each alternative proposes unique geometric improvements to the baseline SIAM model, including changes to the cross-sectional shape and longitudinal bed slope. All of the proposed alternatives include culvert and bridge improvements and the addition of inline weirs that do not exist in the baseline conditions. The inline weirs represent either the proposed rock grade control structures or the proposed pool habitat weir (River Station 2390) for Lakewood Lake. The proposed condition SIAM models include future flows and corresponding sediment loads entering the Old Channel as a result of the anticipated Kanopolis Dam future operations by USACE. An additional SIAM model was also developed using the baseline geometry with future flows to evaluate potential impacts of increased flows and sediment loads under existing geometric conditions.

SIAM Reaches 0 through 8 for all scenarios utilize the same interior drainage and sediment inputs from the baseline condition SIAM model. Reach 9, which was not included in the baseline model, was added at the upstream end of the proposed condition models and the baseline with future flow model and extends from the federal levee upstream to the S. Ohio Street culvert crossing downstream. The additional SIAM inputs for Reach 9 and the future flow duration curves are described in more detail in the following sections.

5.2 Future Flow Duration Curves

Future flows in the Smoky Hill Cut-off Channel were provided by USACE over a 50-year daily record. The portion of this flow diverted into the Old Channel would be controlled by the inlet gates using the operation controls described in Section 4.2.2. These controls were used to determine the future daily inflows into Reach 9 over a 50-year record. Figure 5-1 shows the annualized future flow duration curve at Reach 9.

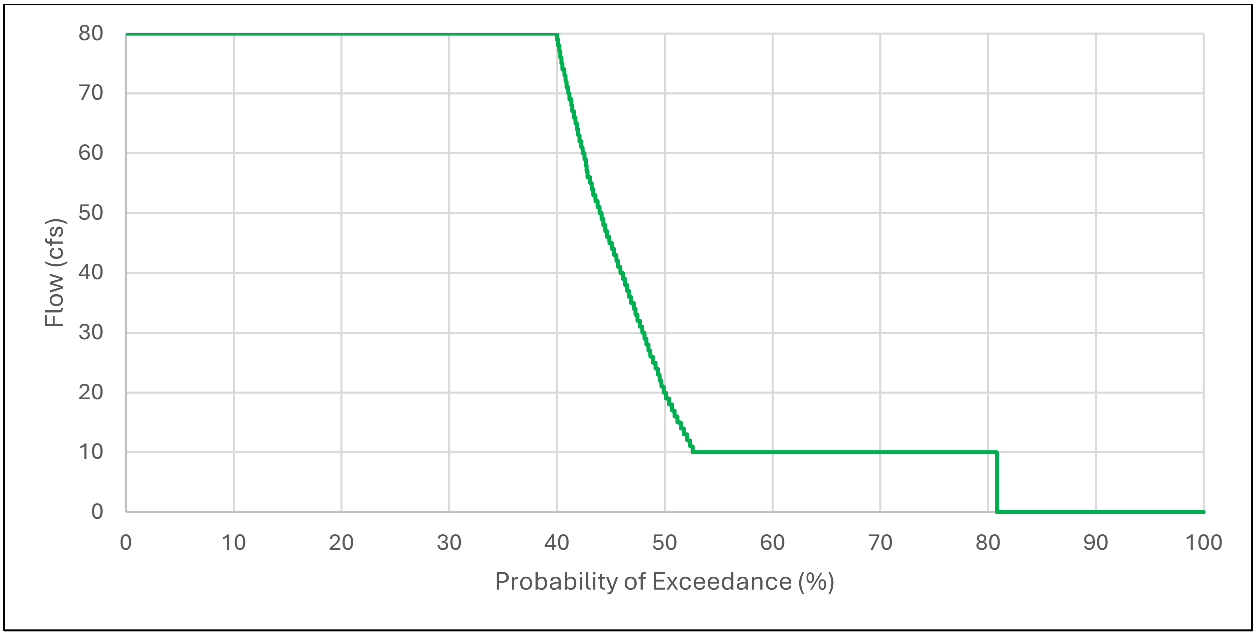


Figure 5-1. Future Flow Duration Curve for Reach 9

The discretized future flow values along Reach 9 were added to existing interior drainage flows along Reach 0 through Reach 8 from the baseline condition model (see Section 3.2). The resulting future flows along all the SIAM reaches were added into the HEC-RAS model as steady flow profiles (e.g., PF1, PF2, etc.), as shown in Table 5-1. The corresponding annual durations are shown in Table 5-2.

Table 5-1. SIAM Discretized Future Flows in Old Channel (cfs)

Profile	SIAM Reach 9	SIAM Reach 7-8	SIAM Reach 6	SIAM Reach 4-5	SIAM Reach 2	SIAM Reach 0-1
PF1	10.0	10.3	12.0	19.5	20.2	20.2
PF2	15.5	16.3	22.2	35.7	36.5	36.5
PF3	26.9	28.5	40.6	59.4	63.2	63.2
PF4	39.1	42.2	65.2	89.5	99.0	99.0
PF5	52.0	57.4	97.4	128.7	144.5	144.5
PF6	69.2	79.9	159.3	198.1	223.2	223.2
PF7	80.0	115.4	329.8	372.1	452.1	452.1

Table 5-2. SIAM Discretized Future Flow Durations (days)

Profile	SIAM Reach 9	SIAM Reach 7-8	SIAM Reach 6	SIAM Reach 4-5	SIAM Reach 2	SIAM Reach 0-1
PF1	103.0	54.5	57.3	33.2	37.8	37.8
PF2	9.9	21.8	22.9	13.3	15.1	15.1
PF3	9.0	10.9	11.5	6.6	7.6	7.6
PF4	9.0	10.9	11.5	6.6	7.6	7.6
PF5	9.0	5.5	5.7	3.3	3.8	3.8
PF6	9.0	4.4	4.6	2.7	3.0	3.0
PF7	146.0	1.1	1.1	0.7	0.8	0.8

5.3 Reach 9 Annual Sediment Load

The future daily sediment load not captured in the sediment basin was summed up over the 50-year flow record and then averaged to obtain an annual sediment load of 6,850 ton/year into Reach 9 (see Section 4.3). The grain size fractions in the load were assumed to have similar composition as sediment sample SR8 (see Section 3.4) which is closest to Reach 9. The annual sediment load composition in Reach 9 is summarized in Table 5-3.

Bed sediment sample SR8, shown in Table 3-7, was also used to characterize the most representative bed material in Reach 9 (bed sediment samples are described in more detail in Section 3.4).

Table 5-3. Reach 9 Annual Sediment Load for Future Flows

Particle Diameter (mm)	Annual Sediment Load (ton/year)
0.004	3,699
0.008	753
0.016	616
0.032	891
0.0625	548
0.125	343
Total	**6,850**

5.4 Proposed Conditions SIAM Results

The annual sediment budgets for each sediment reach are summarized in Table 5-4 (in ton/year) and Table 5-5 (in inch/year) for the baseline conditions, proposed alternative conditions, and the baseline with future flow conditions. Table 5-5 was developed for informational purposes only, distributing the volume of sediment throughout the total length of the reach, assuming an average channel configuration and depth. All the scenarios include calibrated local sediment load multipliers from Table 3-9, assuming the historical sediment supply rates (from interior drainage) project to future flow conditions.

Table 5-4. Annual Sediment Budget (ton/year)

Sediment Reach	Baseline w/ Historical Flows	Baseline w/ Future Flows	Alternative 1	Alternative 2	Alternative 3	Alternative 4
0	-22.1	-50.8	-383	-380	-628	-857
1	49.7	-405	-85.8	-85.8	136	362
2	79.6	64.8	73.5	73.5	94.9	97.4
4	160	262	254	254	154	145
5	306	214	229	230	333	342
6	44.3	31.1	25.3	24.2	23.7	23.7
7	293	299	294	293	293	293
8	378	373	379	378	379	378
9	N/A	342	341	342	342	342

Note: Negative values indicate bed degradation (erosion). Positive values indicate bed aggradation (deposition). All alternatives include future flows. The amount of erosion in Sediment Reach #0 is dependent on the bed gradation, which was artificially set to have a D50 in the large cobble to small boulder range. SIAM results for Sediment Reaches #1 through #9 are independent of the amount of erosion in Sediment Reach #0.

Table 5-5. Annual Sediment Budget (inch/year)

Sediment Reach	Baseline w/ Historical Flows	Baseline w/ Future Flows	Alternative 1	Alternative 2	Alternative 3	Alternative 4
0	N/A	N/A	N/A	N/A	N/A	N/A
1	0.2	-1.7	-0.4	-0.4	0.5	1.5
2	0.4	0.4	0.4	0.4	0.5	0.5
4	0.6	1.0	1.0	1.0	0.6	0.5
5	0.9	0.5	0.7	0.7	0.9	1.0
6	0.7	0.5	0.4	0.4	0.4	0.4
7	1.0	1.1	1.0	1.0	1.0	1.0
8	1.2	1.2	1.2	1.2	1.2	1.2
9	N/A	2.6	2.6	2.6	2.6	2.6

Note: Negative values indicate bed degradation (erosion). Positive values indicate bed aggradation (deposition). All alternatives include future flows. The amount of erosion in Sediment Reach #0 is dependent on the bed gradation, which was artificially set to have a D50 in the large cobble to small boulder range. SIAM results for Sediment Reaches #1 through #9 are independent of the amount of erosion in Sediment Reach #0.

The annual sediment budget computed by SIAM is a net difference between the sediment supply and the sediment transport capacity, calculated on a reach-by-reach basis. The sediment accounting excludes wash load, which is automatically passed through the system. An important indicator of sediment transport capacity in natural systems is the stream power, which is defined as the amount of energy in a stream that is available to transport sediment (stream power is conveniently expressed as a product of bed shear stress and average flow velocity); therefore, a higher stream power can be assumed to have a higher sediment transport capacity and may indicate a potential for bed scouring (or less sediment deposition). Conversely, a lower stream power may indicate a potential for sediment deposition (or less bed scouring). Table 5-4 shows that for upstream Reach 7 and Reach 8, there are minor differences in deposition between the baseline model (with historical flows/loads) and the five other models (with future flows/loads). Reach 9 was not modeled in the baseline conditions, but sediment deposition along this reach is virtually the same across all the other models. Figure 5-2 shows a profile of the Alternative 2 channel under the steady flow profile PF7. The existing Western Star Mill Weir at River Station 16574 (in the baseline geometry) and the proposed rock grade control structures beginning at River Station 16916 along Reach 5 create a backwater condition (see Figure 5-2) that reduces the upstream velocities to below 1 ft/s and keeps the transport capacities low, even with increased future flows. Also, in all the future flow scenarios, the added future load from the river (excluding wash load) is entirely deposited in Reach 9, with no increase in deposition farther downstream (in Reach 7 and Reach 8) when compared to baseline conditions.

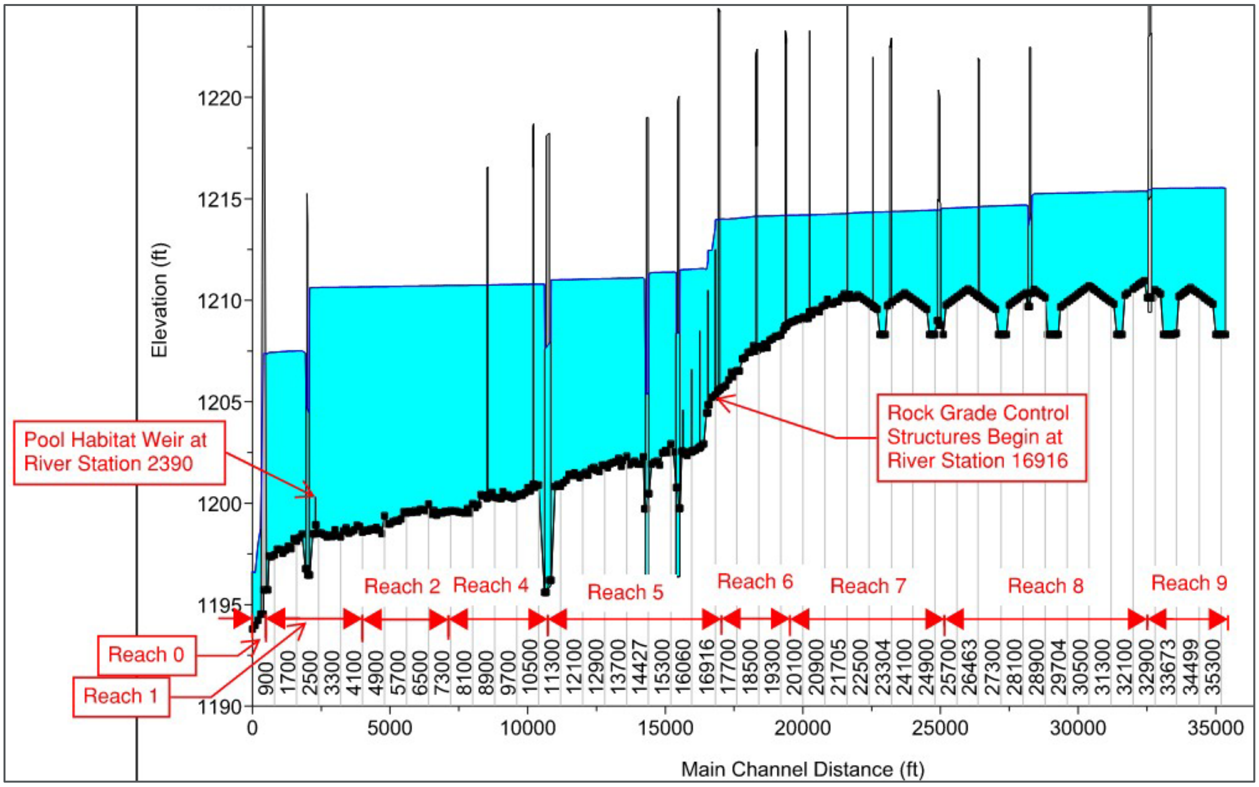


Figure 5-2. Alternative 2 Resulting Water Surface Profile for Flow Profile PF7 with Sediment Reaches

Reach 6 has an increased transport capacity in proposed conditions (due to larger future flows), but the sediment supply is the same, causing less deposition when compared to baseline conditions.

In Reach 5, the upstream sediment supply increases slightly due to increased transport capacity in Reach 6. For Alternative 1 and Alternative 2, the velocities are higher than in baseline conditions due to increased flows, resulting in an increased transport capacity and less deposition (i.e., increase in transport capacity is greater than the increase in sediment supply). However, for Alternative 3 and Alternative 4, the proposed improvements include channel widening, lowering the channel invert, and riffle-pool sequences that keep average velocities slightly lower than baseline conditions. Therefore, the transport capacities for Alternative 3 and Alternative 4 are slightly smaller than in baseline conditions, and the annual increase in sediment supply causes some increase in deposition.

In Reach 4, the transport capacity is nearly the same in all the scenarios with future flows. The existing 96-inch CMP culvert at the residential crossing in Reach 1 creates a backwater condition that reduces upstream velocities and keeps the transport capacities relatively low. For Alternative 1 and Alternative 2, the increased sediment load from Reach 5 is causing more deposition in Reach 4. However, for Alternative 3 and Alternative 4, there is a small decrease in transport capacity at

Reach 5 compared to baseline conditions (decreased by ~6 ton/year in Alternative 3 and decreased by ~16 ton/year in Alternative 4). These small changes are proportionally reflected in Reach 4.

Reach 2 has nearly the same sediment supply in all the scenarios, so the annual sediment budget is mostly dependent on the sediment transport capacity. For Alternative 1 and Alternative 2, the average velocities slightly increase with future flows, resulting in a slightly increased transport capacity and reduced deposition in Reach 2 compared to baseline conditions. However, for Alternative 3 and Alternative 4, the proposed riffle-pool features cause the average velocities to decrease compared to baseline conditions, thereby increasing the amount of deposition in Reach 2.

In Reach 1, the transport capacities for Alternative 1 and Alternative 2 are higher than in baseline conditions, resulting in increased erosion potential. This can be attributed to higher average velocities of increased future flows. Alternative 3 includes a riffle-pool feature upstream of the inline weir at River Station 2390, which reduces backwater velocities and causes annual deposition in Reach 1. Alternative 4 transport capacity reduces due to a higher inline weir at River Station 2390, causing more deposition in Reach 1.

There are no planned improvements along Reach 0, however, the SIAM results show that all scenarios with future flows result in increased erosion potential along Reach 0 compared to baseline conditions. This can be attributed to the increase in sediment transport capacity due to increased future flow rates in the proposed conditions. Existing erosion protection is currently in place at the levee outlet. It is recommended to continue to monitor the levee outlet conditions regularly as the proposed project is expected to result in slightly higher velocities and volumes exiting the levee culvert. Additional erosion protection can be installed as needed to address any emerging erosion concerns and provide for continued stability.

6. Smoky Hill Cut-Off Channel Sediment Transport Analysis

As the final step in the sediment transport assessment, it is important to evaluate the potential impacts of diverting water and sediment load from the Smoky Hill Cut-off Channel into the restoration reach. There is a possibility that too much sediment could be diverted, causing a sediment-starved condition within the downstream Smoky Hill Cut-off Channel. Under these circumstances, there is potential for increased bed scour in the Cut-off Channel, downstream of the diverted flow inlet.

To evaluate this condition, HDR performed a one-dimensional, mobile-bed sediment transport evaluation of the Smoky Hill Cut-off Channel using HEC-RAS 5.0.7. This sediment transport analysis allows the model to capture bed profile changes over time, predicting scour or deposition patterns within the system. Modeling results are used to evaluate the potential for scouring in the Cut-off Channel resulting from diversion of water to the restoration reach.

6.1 Model Development

The hydraulic model was developed using the FEMA effective model as a basis. The model was truncated near the diversion inlet, with the channel cross sections shortened on the western end such that they terminate at the federal levee. To improve model stability, a few cross sections from the effective model were removed. Refer to Figure 6-1 for a depiction of the model geometry utilized for the sediment transport analysis. All other aspects of the model geometry, including Manning's roughness coefficients, reach lengths, channel geometry, ineffective flow areas, etc. remain unchanged from the effective FEMA baseline model.

The sediment model was evaluated under historical flows, as well as future flows in the Smoky Hill Cut-off Channel for a duration of 50-years. Three hydrologic scenarios were evaluated as part of this analysis:

- Historical Flow Conditions (Historical flows without diversion)
- Future Flow Conditions (Future flows without diversion)
- Proposed Conditions with Future Flows (Future flows with diversion)

Existing daily discharge data (1968-2017) was obtained from USGS Gage 06866500 (see Figure 3-1) in the Smoky Hill River near Mentor, Kansas as previously described. Future flow information was obtained from a HEC-ResSim model of Kanopolis Reservoir, developed by USACE. For purposes of this analysis, future daily discharge data was evaluated from 2050 to 2099. Figure 4-5 provides a visual of the hydrographs used for the Historical Flow Conditions and Future Flow Conditions in the Smoky Hill Cut-off Channel. To evaluate the Proposed Conditions, a portion of the flow was diverted to the restoration reach using a lateral flow control. The diverted daily flows were developed in accordance with the water appropriations restrictions as described in Section 4.

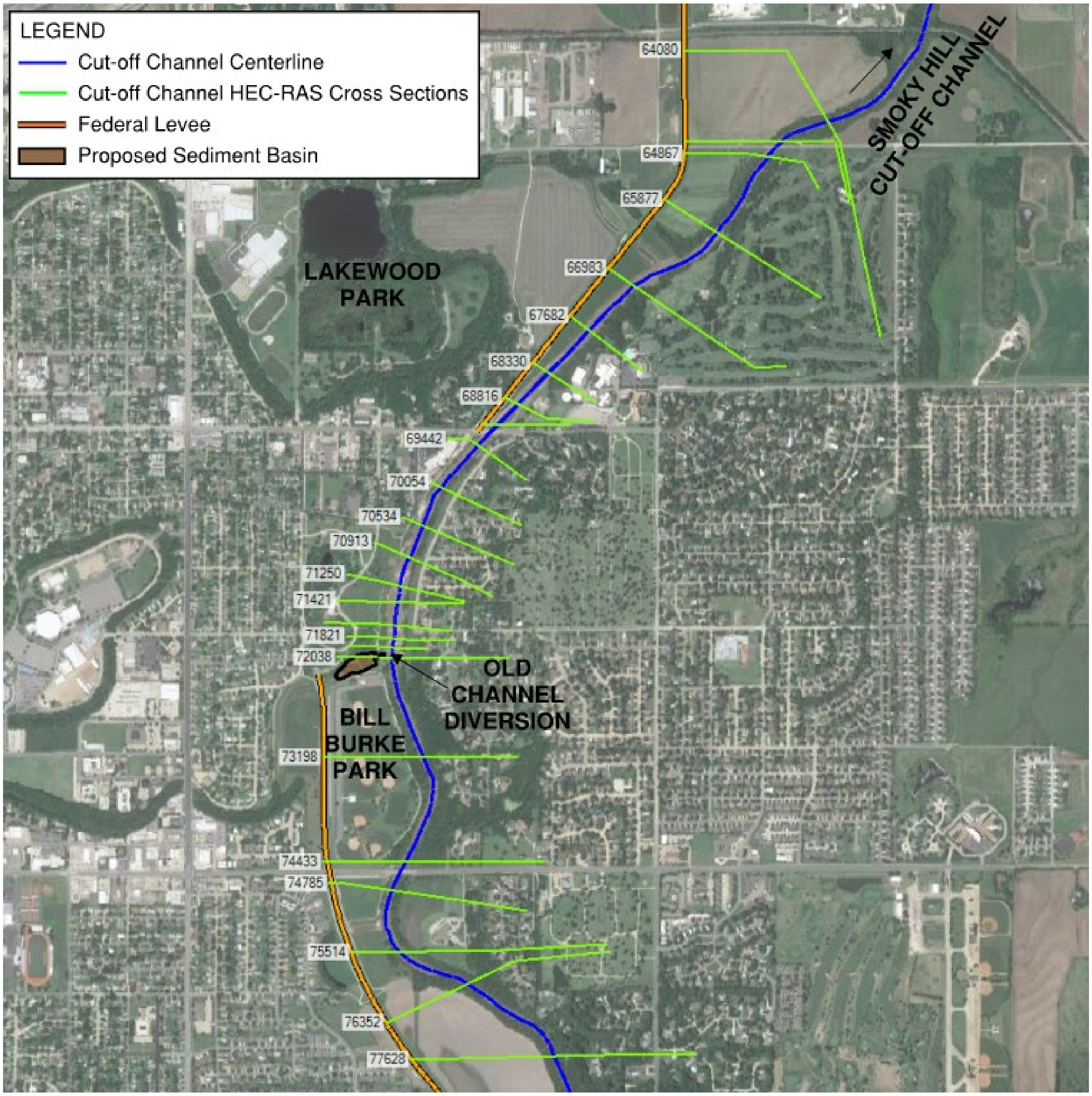


Figure 6-1. Schematic of Smoky Hill Cut-off Channel HEC-RAS Model Geometry

Representative bed sediment samples in the Smoky Hill Cut-off Channel were provided by USACE. The reach upstream of the USACE weir utilized the sample closest to the diversion inlet (approximately 0.5 miles upstream from the diversion) as shown in Table 6-1. This sample contains a fine sediment gradation (with a median grain size D_{50} in silt range), as a result of backwater conditions from the existing weir. Downstream of the diversion and existing weir, the bed material is coarser (D_{50} in medium sand range) and was based on the average of sediment samples provided by USACE.

Table 6-1. Smoky Hill River Cutoff-Channel Bed Gradation Data

CLASS	D (mm)	% Finer Bed Gradation (U/S of diversion)	% Finer Bed Gradation (D/S of diversion)
Clay	0.004	8.7	0.3
VFM	0.008	8.7	0.3
FM	0.016	20.5	0.6
MM	0.032	38.5	1.3
CM	0.0625	56.5	2.1
VFS	0.125	66.2	3.8
FS	0.25	76.4	11.2
MS	0.5	82.6	50.5
CS	1	87.7	90.6
VCS	2	92.5	94.9
VFG	4	95.8	96.8
FG	8	99.8	99.5
MG	16	100.0	100.0
CG	32	100.0	100.0

Based on the linear regression equation for TSS described in Section 4.2.3, the TSS concentration in the Smoky Hill Cut-off Channel was determined from daily discharge data (for both historical and future flows). As noted previously in Section 4.2.3, the regression equation is missing TSS measurements for higher flows (greater than 1,000 cfs), which would typically exhibit some non-linear reduction in TSS. For the purposes of this analysis, the upstream river load in the sediment transport model (at River Station 77628) was capped at 300 mg/L for all flows larger than 1,000 cfs, which seems to reasonably represent expected sediment concentration for higher flows.

The diversion sediment outflow was entered into the sediment transport model (at River Station 72038) using a rating curve with a defined diversion load. This setup does not allow the specification of daily values; therefore, there is no direct correlation between the diversion discharge and the river sediment load. In reality, the diversion load is based on the TSS concentration in the river which varies with its discharge. To maximize the Cut-off Channel scour potential downstream of the diversion inlet, it was assumed that the maximum sediment load (from the corresponding 50-year daily load record) is being diverted to the restoration reach for each flow between 10 cfs and 80 cfs (i.e., sediment load between 80 ton/day and

2,000 ton/day). The sediment load fractions from Table 4-3 were used, as described in Section 4.2.3.

6.2 Sediment Transport Model Results

The sediment transport model captures bed profile changes over the 50-year simulation period, which allows for the prediction of deposition and scour over time. Figure 6-2 shows the channel thalweg profile at the beginning of the simulation (Existing Channel Profile) and at the end of the 50-year simulation for the three evaluated scenarios. As expected, sediment deposition is predicted upstream of the existing USACE weir due to backwater effects. Model results indicate scour potential downstream of the weir under all scenarios (with or without diversion) for both flow conditions.

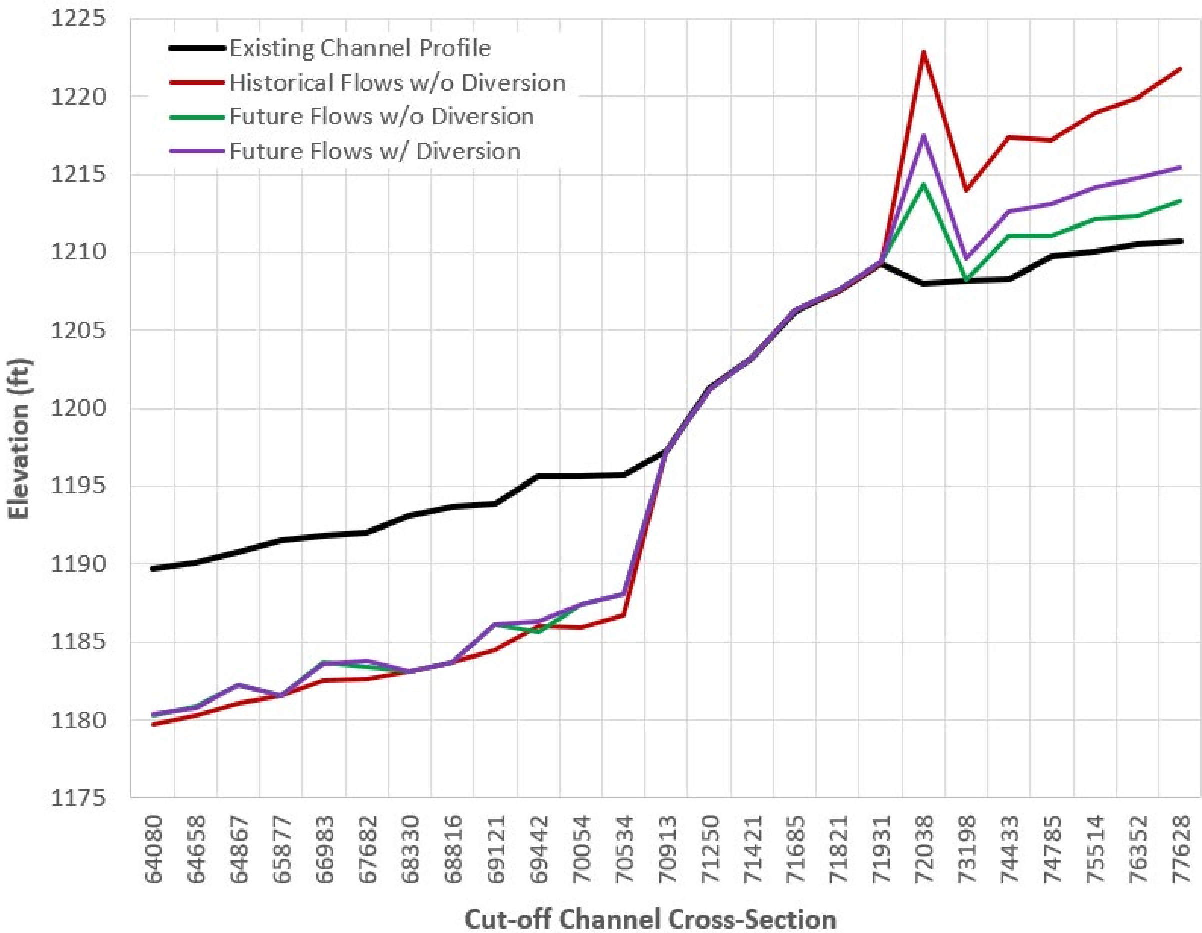


Figure 6-2. Smoky Hill Cut-off Channel Thalweg Profile

The resulting change in invert elevation, shown in Table 6-2 is provided for the three evaluated scenarios at the end of the 50-year simulation. The potential for scour is comparable under each scenario, indicating minor differences between future flow conditions (with and without flow diversion). Additionally, the future flows exhibit slightly less downstream scour potential (~1 ft less) compared to historical flows due to reduced backwater deposition, with more sediment transported downstream of the weir.

Table 6-2. Smoky Hill River Cutoff-Channel Invert Change after 50-year Simulation

HEC-RAS Cross Section	Historical Flow w/o Diversion (ft)	Future Flow w/o Diversion (ft)	Future Flow w/ Diversion (ft)
77628	11.0	2.7	4.8
76352	9.3	1.8	4.2
75514	8.9	2.1	4.1
74785	7.4	1.3	3.3
74433	9.1	2.8	4.4
73198	5.8	0.0	1.4
72038	14.8	6.4	9.5
71931	0.0	0.1	0.1
71821	0.0	0.1	0.1
71685	0.0	0.0	0.0
71421	0.0	0.0	0.0
71250	0.0	0.0	0.0
70913	0.0	0.0	0.0
70534	-9.0	-7.6	-7.6
70054	-9.7	-8.3	-8.3
69442	-9.6	-10.0	-9.3
69121	-9.3	-7.7	-7.7
68816	-10.0	-10.0	-10.0
68330	-10.0	-10.0	-10.0
67682	-9.3	-8.5	-8.2
66983	-9.3	-8.2	-8.3
65877	-10.0	-10.0	-10.0
64867	-9.7	-8.6	-8.5
64658	-9.8	-9.2	-9.2
64080	-10.0	-9.4	-9.4

Note: positive values indicate sediment deposition; negative values indicate scour.

7. Initial Modeling Findings

The annual sediment budget analysis was conducted using SIAM to evaluate the Old Channel under baseline and proposed conditions, for both historical and anticipated future flows. The analysis estimated the incoming sediment load to the restoration reach (from interior drainage and Smoky Hill Cut-off Channel) and evaluated annual deposition rates in the Old Channel for baseline and proposed alternative conditions. In all the proposed alternatives, the residual sediment load from the river (not captured in the proposed sediment basin) is predicted to entirely deposit in the most upstream Reach 9 (downstream of the sediment basin), with no increase in deposition farther downstream (in Reaches 7 and 8) when compared to baseline conditions (with historical flows). Comparing to baseline conditions, Reach 6 would experience about 45 percent less deposition for all the alternatives; Alternatives 1 and 2 would decrease annual deposition in Reach 5 (~25%), while Alternatives 3 and 4 would increase annual deposition in the same reach (~10%); Alternatives 1 and 2 would increase annual deposition in Reach 4 (~60%), while Alternatives 3 and 4 would be similar to baseline conditions in the same reach (less than 10%); Alternatives 1 and 2 are predicted to maintain similar levels of annual deposition in Reach 2 (less than 10%), while Alternatives 3 and 4 would increase annual deposition in the same reach (~20%); Alternatives 1 and 2 are showing erosional trend in Reach 1 since the transport capacities are higher than in baseline conditions; Alternative 3 and Alternative 4 significantly increase deposition in Reach 1 (> 200%) due to the addition of riffle-pool features; each alternative increases the erosion potential in Reach 0 due to the increased flow rates. Existing erosion protection is currently in place at the levee outlet (Reach 0), and additional erosion protection can be installed as needed.

In general, the maximum predicted sediment deposition for all the alternatives is approximately 1 inch/year, with the exception of Reach 9 (~2.6 inch/year). Reach 9 would need to be regularly maintained to remove excessive sediments not captured in the upstream sediment basin. Also, bed erosion protection would be suggested in Reach 1 for Alternatives 1 and 2. Additional analysis could be conducted in the design stage to identify erosion protection needs under the proposed channel configuration and compared to permissible shear stresses and velocities for various channel and vegetation materials. Velocities in the conceptual model appear to fall within the permissible shear limits for short grasses. Additionally, structures within Reach 1, such as the residential crossing and the proposed weir, serve as hardpoints within the channel, helping to reduce potential long term erosion.

The proposed sediment basin trap efficiency was found to be on the order of 17 percent. On average, basin dredging would be required every 2-7 years, depending on the magnitude and duration of diverted flows. More frequent dredging is predicted under future flow conditions as compared to historical flows. The average annual sediment diversion into the restoration reach downstream of the sediment basin (Reach 9) would be about 6,850 tons/year for anticipated future flows.

The geomorphic impact of the flow/sediment diversion on the Smoky Hill Cut-off Channel was evaluated through a mobile-bed sediment transport analysis. Results corroborate that proposed diversion does not increase the long-term scour potential in the Cut-off Channel downstream of the USACE inline weir.

8. Resuspension Analysis by Rouse Number to Verify SIAM Results

The SIAM results were further validated against critical shear velocity for the onset of significant resuspension (Rouse number or resuspension analysis) to verify depositional potential of fine sediments (silt and sand) for a given range of future flows in the Old Channel. This analysis was also used to assess the potential impact of increased future sediment load from Kanopolis Reservoir as determined by USACE (2019).

The Rouse number (R) is a non-dimensional number in fluid dynamics which is used to define a concentration profile of suspended sediment, and which also determines how sediment will be transported in a flowing fluid. It is a ratio between the sediment fall velocity v_s and the upwards turbulent velocity on the grain, as a product of the von Kármán constant κ and the bottom shear velocity u_* (Whipple, 2004):

$$R = \frac{v_s}{\kappa u_*},\ u_* = \sqrt{\frac{\tau}{\rho}},\ \ \tau = bed\ shear\ stress,\ \ \rho = 1.94\ \frac{slugs}{ft^3} = water\ density,\ \ \kappa = 0.41 \qquad (8\text{-}1)$$

The required Rouse numbers for sediment transport as bed load, suspended load, or wash load, are given in Table 8-1. The Rouse number value of 1.0 was used in this analysis as the cutoff for sediment resuspension (i.e., sediment load is considered suspended in the water column when R is less than or equal to 1; sediment deposits when R is greater than 1).

Table 8-1. Mode of Sediment Transport (Whipple, 2004)

Mode of Sediment Transport	Rouse Number
Bed Load	> 2.5
Suspended Load: 100% Suspended	> 0.8, < 1.2
Wash Load	< 0.8

Settling velocity v_s in this evaluation (Table 8-2) was calculated by the Cheng's (1997) formulation, depending on the particle diameter and kinematic viscosity of water.

Table 8-2. Settling Velocity of Fluid Particles per Cheng (1997)

Sediment Class	Particle Diameter D_{50} (mm)	Settling Velocity v_s (ft/s)*	Turbulent Velocity v_s/k (ft/s)
Clay	0.004	0.00003	0.00008
Very Fine Silt (VFM)	0.008	0.00014	0.00033
Fine Silt (FM)	0.016	0.00050	0.00122
Medium Silt (MM)	0.032	0.00210	0.00512
Coarse Silt (CM)	0.0625	0.00790	0.01927
Very Fine Sand (VFS)	0.125	0.02840	0.06927
Fine Sand (FS)	0.25	0.08510	0.20756
Medium Sand (MS)	0.5	0.19580	0.47756
Coarse Sand (CS)	1	0.36220	0.88341
Very Coarse Sand (VCS)	2	0.58820	1.43463
Very Fine Gravel (VFG)	4	0.89170	2.17488
Fine Gravel (FG)	8	1.30580	3.18488

*based on kinematic viscosity of $1.13 \cdot 10^{-5}$ ft^2/s for 65°F water

8.1 Alternative 2 Under Future Flows

The sediment resuspension (Rouse) analysis under future flows was performed for Alternative 2 using the same principles explained above. The HEC-RAS model was run with three steady flow profiles (PF1, PF4, and PF7 in Table 5-1) to capture the entire range of anticipated future flows. The smallest depositing sediment class (when $R > 1$) was determined in all sediment reaches based on their average shear velocity u_* for each flow profile. The summary of this analysis is shown in Table 8-3.

Table 8-3. Smallest Sediment Class Depositing in Alternative 2 for Future Flows

Sediment Reach	HEC-RAS Bounding River Stations		Sediment Class Depositing		
	Upstream	Downstream	PF1	PF4	PF7
1	4100	100	FS	FS	MS
2	7100	4200	FS	FS	MS
4	10708	7200	FS	FS	MS
5	16929	10956	FS	FS	MS
6	19452	17181	MS	MS	MS
7	24980	19510	FS	FS	FS
8	32610	25117	FS	FS	FS

Based on the Alternative 2 results in Table 8-3, the smallest sediment class depositing for the entire range of future flows in all reaches is fine sand (FS). Similar results were obtained for other alternatives and existing conditions. Consequently, the conveyance system of the Old Channel seems to be able to transport sediment sizes smaller than fine sand (D50 < 0.25 mm). However, this result varies from the collected bed sample data which would indicate possible deposition of clay and silt materials. The shear stresses and shear velocities estimated by the 1-D hydraulic model are not as accurate for estimating transport capacities for fine cohesive materials, which might explain some discrepancy between the bed sediment data and modeling results. It is also possible that the sediment samples may have been collected from backwater zones where the bed shear is not sufficient to generate enough vertical turbulence to keep the fines in suspension. Lastly, the settling velocity in the Rouse number definition for very fine particles may be driven by other processes in the system (e.g. flocculation or formation of clay colloids).

Currently, the proposed conditions SIAM models for the Old Channel (Section 5.1) include the assumption that bed samples collected in the field reflect the composition of future sediment load in storm drains. There are sediment classes larger than fine sand, which were predicted to deposit in the system (Section 5.4).

If the City continues to avoid using sand for winter street treatments, thereby preventing sandy material from entering storm drains and reaching the Old Channel in the future, it would significantly reduce (or eliminate) the amount of deposition predicted by SIAM models in Section 5.4. The proposed upstream sediment basin seems effective to capture riverine sediments in the sand range (larger than coarse silt), which would make the entire system less susceptible to future sediment deposition.

9. Refined Analysis for Tentatively Selected Plan

The analysis presented up to this point in the report was previously evaluated under a Continuing Authorities Program (CAP) Section 1135 Feasibility Study. The study was terminated prior to completion as the proposed alternatives exceed the Section 1135 cost limitation. While the study was not fully finalized, the 1135 CAP Study identified Alternative 2 as the Tentatively Selected Plan (TSP), which was endorsed by USACE during the TSP Milestone meeting in July 2022.

The sediment transport analysis was further developed for the TSP to provide more refined results on system performance and to better define overall operational and maintenance needs and associated costs with the sediment basin and channel improvements. The refined analysis for the TSP is presented herein within Section 9.

9.1 Proposed Sediment Basin Analysis

The proposed sediment basin offers the first line of defense to trap incoming sediment before the diverted water is conveyed to the TSP restoration reach. The sediment transport model for the sediment basin was rerun using a refined sediment inflow rating curve. Two rating curves were evaluated; one assuming Kanopolis Lake continues to trap sediment as it does today, and the other assuming the lake eventually fills with sediment and has zero sediment trapping capacity. Further evaluation of the sediment concentration distribution in a water column (Rouse analysis) was also conducted to examine how the vertical placement of the water intake structure might influence sediment loading into the sediment basin.

9.1.1 Modeling Methodology

The one-dimensional, mobile-bed sediment transport model for the proposed sediment basin, previously described in Section 4, was updated using HEC-RAS version 6.6 as part of this effort. The model results can then be used to evaluate the effectiveness of the basin, approximate sediment loading, estimate a dredging schedule, quantify sediment volume removed, and identify the outflow leaving the basin and entering the TSP restoration channel.

The channel geometry, geometric inputs, and sediment basin configuration (formerly described in Section 4.2.1) as well as the boundary conditions and bed material gradation in the sediment basin (described in Section 4.2.4) all remain unchanged from the previous analysis. Sediment loading inputs were revised as described in the next section.

The revised sediment transport model was run for future flow conditions for a 50-year duration (2050 to 2099). The quasi-unsteady flow data, based on future flow information previously provided from USACE in a HEC-ResSIM model and adjusted per the water appropriation restrictions described in Section 4.2.2, provide daily flows that will be diverted to the sediment basin and TSP restoration. The diverted flows remain unchanged from the previous analysis.

9.1.2 Sediment Loading

Sediment concentration and fraction data was revised as part of this effort and was developed for both the with- and without-trapping scenarios at Kanopolis Lake. The ‘With Kanopolis Lake Trapping’ condition represents conditions as they exist today, where Kanopolis Lake functions as a sedimentation basin and reduces sediment concentrations in downstream waters. The ‘Without Kanopolis Lake Trapping’ condition represents a potential future scenario where the lake fills with sediment and no longer has the capacity to trap additional sediment, allowing all incoming sediment to continue downstream. For purposes of this project, the ‘Without Kanopolis Lake Trapping’ scenario is considered the worst-case scenario, as heavy sediment loading is not anticipated from local tributaries between Kanopolis Lake and the project.

9.1.2.1 Sediment Loading 'With Kanopolis Lake Trapping'

The suspended sediment loading concentrations for the 'With Kanopolis Lake Trapping' scenario were updated herein to include a combination of USGS historic gage information and previously collected water samples along the Smoky Hill Cut-off Channel. The previously developed sediment rating curve was based only on the water samples, which represent a single year of data and capture a limited range of discharge conditions, creating uncertainty with the correlation. To supplement this data, suspended sediment concentration data from USGS Gage 06866500, located along the Smoky Hill River (Cut-off Channel) near Mentor, Kansas was incorporated. The available gage data spans between 1958 and 1981 and provides seven additional data points among a wider range of flows to support the development of a more robust rating curve. Table 9-1 provides a summary of the data from both sources and is arranged in ascending order of flow. The table reports date, suspended sediment concentration (TSS) and corresponding discharge.

Table 9-1. Refined Smoky Hill Cut-off Channel TSS Concentrations and Flow 'With Kanopolis Lake Trapping'

Date	TSS (mg/L)	Flow (cfs)	Source
5/21/2018	27	28	1135 Samples
6/12/2018	17	54	1135 Samples
7/18/2018	67	115	1135 Samples
8/6/2018	55	130	1135 Samples
10/1/2018	53	186	1135 Samples
3/10/1958	629	554	USGS Gage
7/20/1979	523	612	USGS Gage
* 8/24/1975	1610	674	USGS Gage
6/27/1960	520	902	USGS Gage
9/11/2018	286	924	1135 Samples
5/6/1976	1810	1060	USGS Gage
* 6/11/1981	4250	2080	USGS Gage
7/28/1958	2080	3440	USGS Gage

* Outlier data points

The gage data at Mentor includes data prior to and following construction of the federal levee. Both pre- and post-levee data was incorporated into the analysis as the levee system is not expected to have substantial impacts to overall sediment loading within the Smoky Hill Cut-off Channel. Two scenarios were evaluated, one with all of the USGS data points, and one with two data points excluded (identified in Table 9-1). These points appeared to be outliers when compared to adjacent values. The sediment concentrations for these two points exceeded the 'Without Kanopolis

Lake Trapping' scenario loading (further described in Section 9.1.2.2), which has been identified as the worst-case scenario and inclusion of such high concentrations appears overly conservative in this case.

Sediment data from USGS Gage 06865500 along the Smoky Hill Cut-off Channel at Langley, Kansas, just downstream of Kanopolis Lake, was also investigated for inclusion in this assessment. The data, however, does not demonstrate a strong correlation between discharge and suspended sediment concentration, therefore was not incorporated into the final analysis.

An updated regression equation for the TSS versus flow rate was developed for the 'With Kanopolis Lake Trapping' condition (one with outliers and one without outliers), which is used to estimate the sediment basin inflow concentration based on daily flows in the river. The dataset was divided into two regression equations to provide a better correlation to the data for lower and higher river flows (Figure 9-1 and Figure 9-2).

Similar to the discussion in Section 4.2.3, it is noted that in linear regressions with small sample sizes, the coefficient of determination (R^2) can be highly unreliable and often biased, with deceptively high R^2 values and uncertain predictive performance. Sediment rating curves typically show data scatter particularly at low flows (see Vanoni, 1975).

The linear regression equations were used to compute the total TSS concentration for diverted flows using the daily future discharge data. The daily TSS concentration was converted to tons/day sediment loading, for input into the HEC-RAS model, using a bulk sediment density of 80 lb/ft^3, which corresponds to a silt range sediment class.

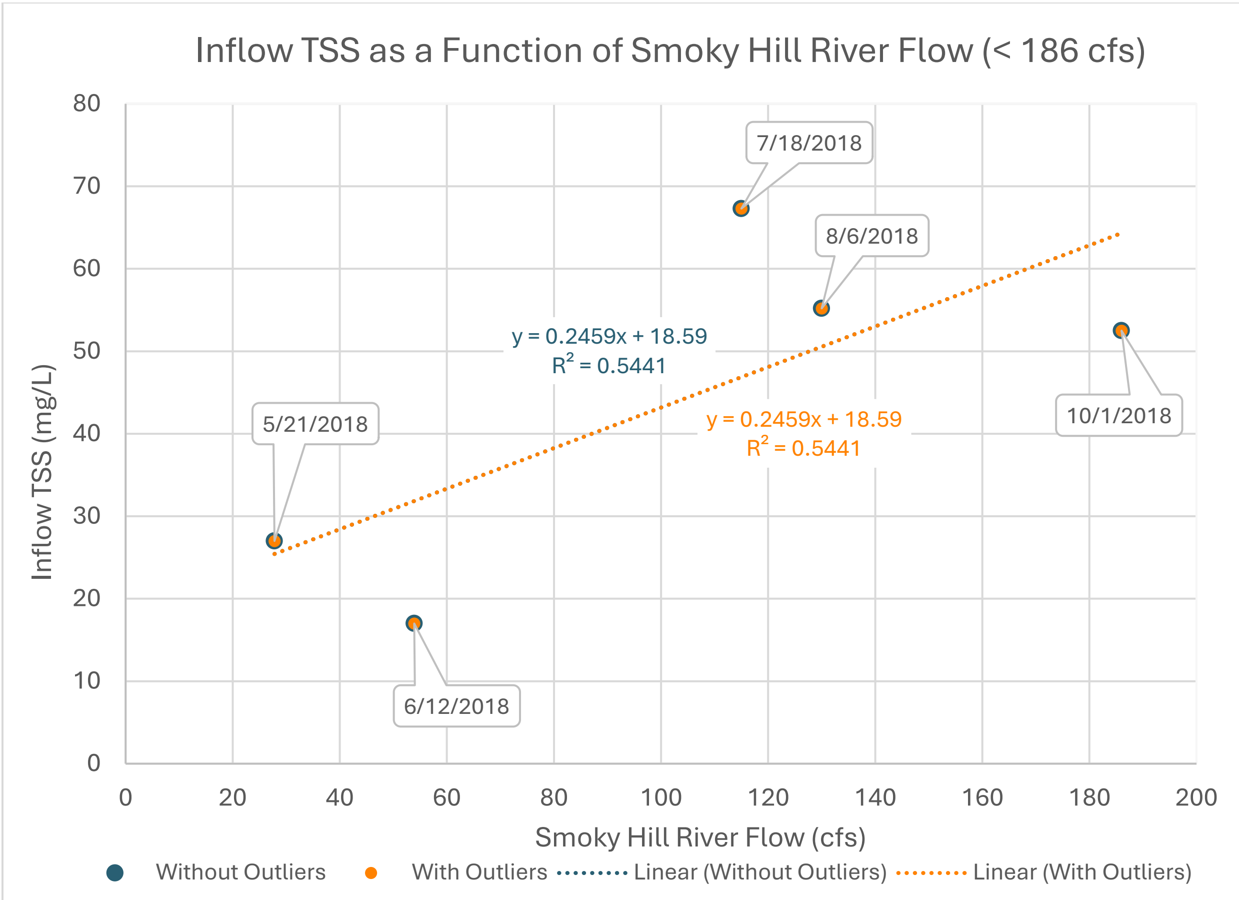


Figure 9-1. Revised Inflow TSS as Function of Smoky Hill River Flow 'With Kanopolis Lake Trapping' (Less than 186 cfs)

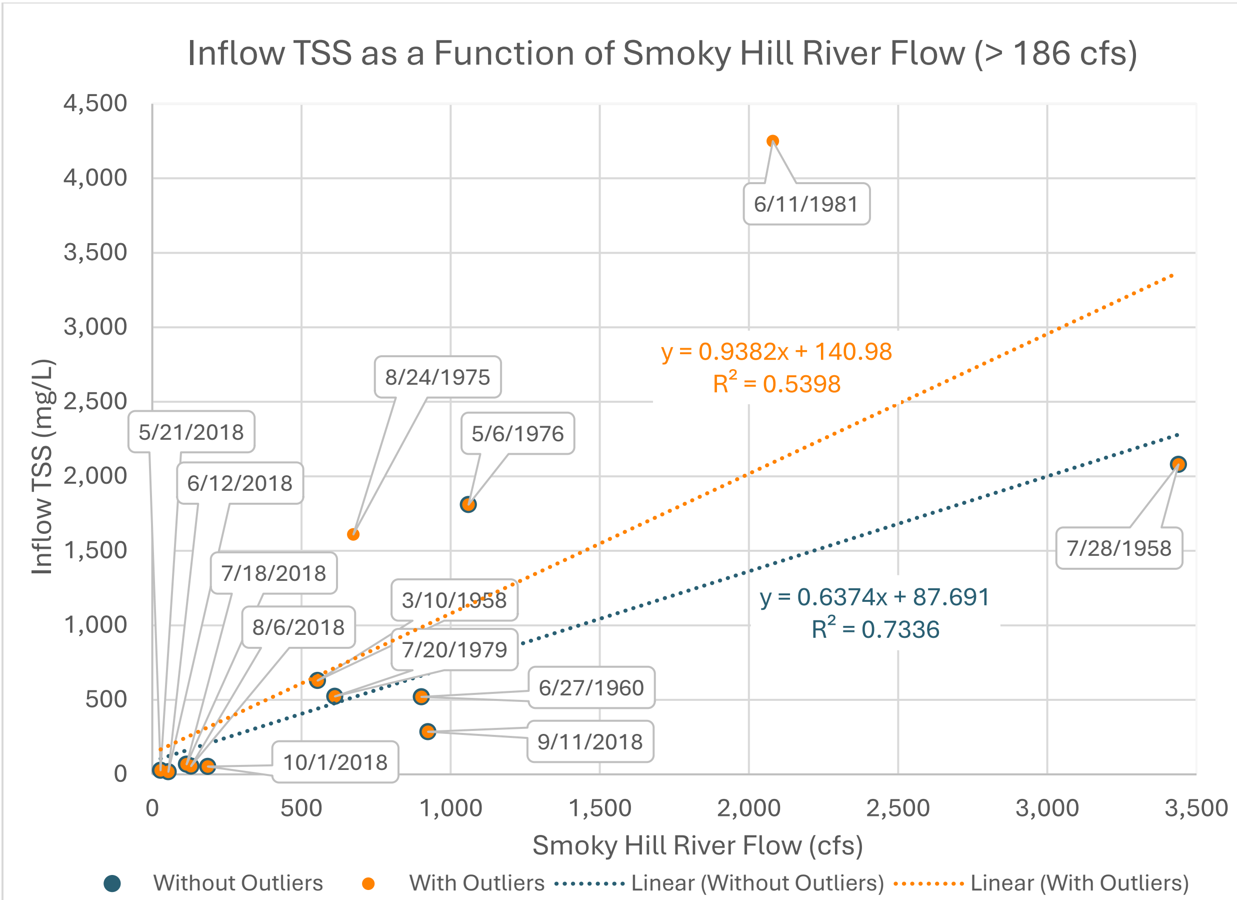


Figure 9-2. Revised Inflow TSS as Function of Smoky Hill River Flow 'With Kanopolis Lake Trapping' (Greater than 186 cfs)

The revised rating curve results in higher sediment loading than previously developed during the 1135 Study and generally reflects a reasonably conservative scenario. While the revised sediment rating curve provides more data points for a wider range of flows, creating an improved sediment relationship, the data still includes uncertainty with limited data points, removal of potential outliers, and an overall regression equation that is missing TSS measurements for larger rainfall events.

The composition of the suspended sediment was unchanged from the 1135 Study, which indicates 95 percent clay and silt material, with only 5 percent sand particles. The sediment load fractions used in the refined analysis are summarized in Table 4-3 and Table 9-3.

9.1.2.2 Sediment Loading 'Without Kanopolis Lake Trapping'

The suspended sediment load concentrations and fractions for the 'Without Kanopolis Lake Trapping' scenario were developed by USACE and provided in March 2025. This scenario represents a condition where sedimentation has reduced the available storage within Kanopolis Lake, deeming the Lake ineffective at collecting additional sediment, which results in all incoming sediment being transported downstream to the project area.

The dataset provided includes a range of flow conditions and corresponding sediment loading (reported in tons/day) along with the distribution of clay, silt, and sand particle fractions as shown in Table 9-2. Note that the corresponding TSS concentrations listed in Table 9-2 were calculated by HDR using the sediment load and flow data, assuming a bulk sediment density of 80 lb/ft^3.

Table 9-2. Smoky Hill Cut-off Channel TSS Concentrations and Flow 'Without Kanopolis Lake Trapping'

Flow (cfs)	Load (tons/day)	* TSS (mg/L)	% Clay	% Silt	% Sand
0.3	0.2	193	52.3	30.4	17.3
10	1	29	52.3	30.4	17.3
4,760	70,233	4269	48.0	28.4	23.6
10,000	109,810	3177	43.2	26.3	30.5
47,600	280,932	1708	43.2	26.3	30.5

* TSS concentration generated by HDR using a bulk sediment density of 80 lb/ft^3

Based on this data, the TSS and flow rate information was used to estimate the daily sediment concentrations within the Smoky Hill Cut-off Channel via linear interpolation. The total daily loading was then determined from the estimated sediment concentration and total diverted flows entering the sediment basin. The daily TSS concentration was converted to tons/day, for input into the HEC-RAS model, using a bulk sediment density of 80 lb/ft^3. As expected, the resulting sediment loading is higher than that previously developed during the 1135 Study and when compared to the 'With Kanopolis Lake Trapping' scenario.

There is also some uncertainty associated with the 'Without Kanopolis Lake Trapping' dataset. The data includes large gaps between discharges and although the total sediment loading increases with increasing discharge, the computed suspended sediment concentration decreases with higher flows. This is generally an atypical trend in natural systems; however, it may be partially explained if the system becomes supply-limited, particularly for fine bed materials during large flow events.

The suspended sediment composition was developed using the USACE-provided data summarized in Table 9-2. Per USACE direction, the 'Without Kanopolis Lake Trapping' scenario should assume a lesser sand fraction than reported in Table 9-2 as it will likely still drop out of suspension in Kanopolis Lake. As a result, it was assumed that the sand fraction would remain similar to that collected from the previous field samples as sand will continue to enter into the system downstream of the dam. The silt and clay percentages were adjusted to total 100 percent, effectively redistributing the sediment composition. After this adjustment, the overall distribution for each particle size, within each flow range, deviated by less than two percent from the average, supporting the use of a uniform sediment gradation across all flow regimes.

The data provided does not include a detailed breakdown of silt (mud) particle classification for input into the HEC-RAS sediment model; therefore, silt proportions from the previously collected suspended sediment samples were applied. Table 9-3 presents a comparison of sediment load fractions for the two trapping scenarios.

Table 9-3. Revised Suspended Sediment Load Fractions

Class	Particle Size	'With Kanopolis Lake Trapping' Percent	'Without Kanopolis Lake Trapping' Percent
Clay	0.002-0.004 mm	54%	60%
Very Fine Silt (VFM)	0.004-0.008 mm	11%	9%
Fine Silt (FM)	0.008-0.016 mm	9%	8%
Medium Silt (MM)	0.016-0.032 mm	13%	11%
Coarse Silt (CM)	0.032-0.0625 mm	8%	7%
Very Fine Sand (VFS)	0.0625-0.125 mm	5%	5%

9.1.3 Vertical Distribution of Sediment Concentration

Further evaluation of the sediment settling velocity and Rouse concentration distribution was conducted to examine the effects of the vertical placement of the water intake structure to the Old Channel and how that might influence sediment loading and sediment size entering the sediment basin.

HEC-RAS uses the Rouse (1937) approach to compute a vertical concentration distribution in some of the sediment transport modules. The same approach was applied here to approximately distribute average sediment concentrations throughout the water column and to determine a portion of sediment load that is transported above the intake weir into the sediment basin.

The Rouse approach compares the shear velocity (u_*) to the fall velocity (ω_s) in a dimensionless parameter called the Rouse Number:

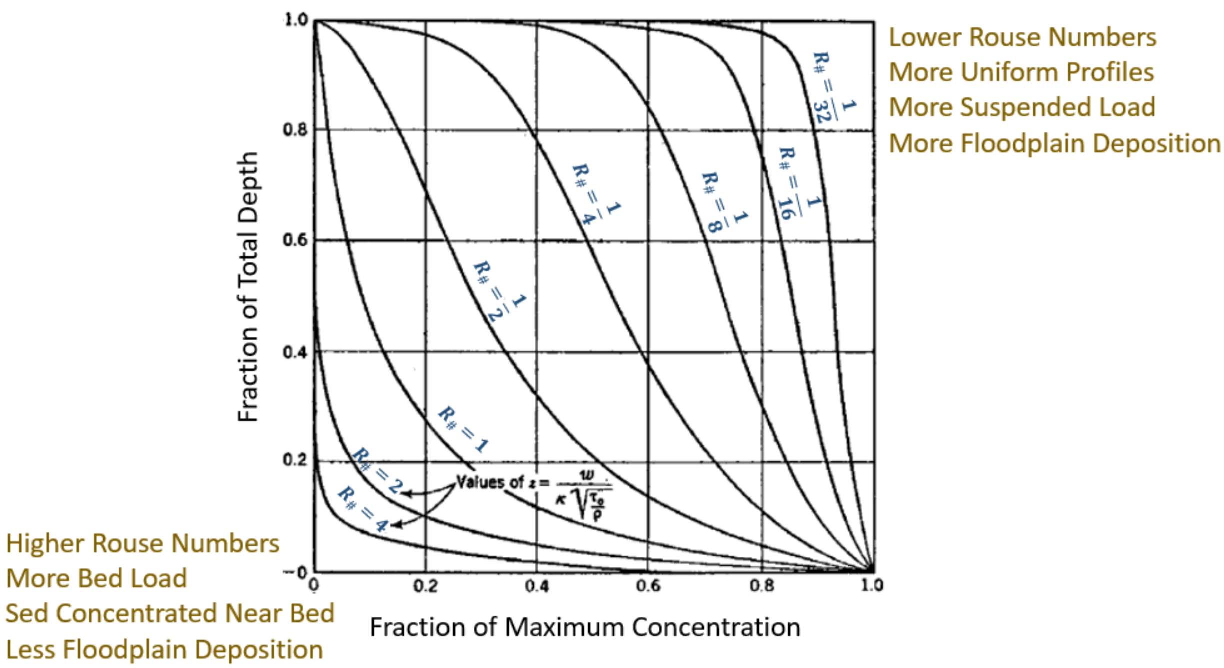
$$R_{\#} = \frac{\omega_s}{\kappa u_*} = \frac{\omega_s}{\kappa\sqrt{\tau/\rho}} \tag{9-1}$$

where k is the dimensionless von Karmen coefficient (~ 0.4) and u_* is the square root of the ratio between flow shear stress τ and fluid density ρ.

The smaller the Rouse Number is, the more uniform the vertical concentration profile is (i.e. concentrations near the surface are closer to concentrations near the bed). The larger the Rouse Number is, the more transport is concentrated near the bed. Rule of thumb approaches sometimes suggest that Rouse Numbers > 2.5 indicates that the grain class is primarily bedload, Rouse Numbers < 0.8 indicate wash load, and the zone between those two includes some combination of bed and suspended load. But the actual distributions are more continuous. In the analytical distribution for sediment concentration $C(y)$, the Rouse Number R becomes the power of a relationship between the computed depth (y), the total depth (D), and the "reference depth" (y_o) - a distance above the bed where a reference concentration (C_o) is measured or known:

$$C_i(y) = C_o\left[\left(\frac{D-y}{y}\right)\left(\frac{y_o}{D-y_o}\right)\right]^{\frac{\omega_i}{\kappa u_*}} \tag{9-2}$$

This generates the classic, unit concentration profiles presented in Figure 9-3 (each labeled with the associated Rouse number), plotted as a vertical fraction of the total depth and a horizontal fraction of the maximum concentration. A low Rouse Number indicates zones with more homogeneous concentration profiles and more suspended load that is almost uniformly distributed throughout the water column.



Source: HECRAS Sediment User's Manual

Figure 9-3. Unit Concentration Profile

Once the average concentration C_{avg} is known, it can be used to solve for the corresponding reference concentration C_o using the following integral:

$$C_{avg} = \frac{C_o}{b-a}\left(\frac{y_o}{D-y_o}\right)^R \int_a^b \left(\frac{D-x}{x}\right)^R dx \tag{9-3}$$

where *a* is the lower limit for the reference depth above bed (~ 0.05 *D*) and *b* is the total depth of the water column *D*. Once the reference concentration C_o is known, it can be used to determine the sediment concentration $C(y)$ at any depth *y* from equation (9-2).

Based on this methodology, the Rouse Number and concentration fraction was computed for each flow regime in the 'Without Kanopolis Lake Trapping' scenario for two particle sizes. Table 9-4 summarizes the concentration fraction for an average particle size, based on the geometric average and Table 9-5 for the largest very fine sand particle size.

Depending on particle size, results indicated relatively low Rouse numbers and a concentration fraction nearly 1.0 for the flows initially provided which indicates the concentration profile is generally uniform for the entire water column. As a result, the concentrations would not need to be reduced and the average concentrations utilized are appropriate under the modeled conditions.

Additional flow values were assessed (summarized in Table 9-4 and Table 9-5), which show some variation in concentration fraction. A sensitivity test was evaluated to assess the overall sediment loading with the resulting reduced concentration fractions as indicated per the Rouse analysis. The total daily average sediment concentration was reduced by only three percent and is not expected to have a large impact on the overall modeling results or operation and maintenance requirements.

Table 9-4. Rouse Concentration Distribution under Future Flow Conditions 'Without Kanopolis Lake Trapping' for Average Particle Size

Flow (Smoky Hill River), Q (cfs)	0.3	10	40	75	110	240	4760	10000	47600
Average particle size, d (mm)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Settling velocity, ω_s (ft/s)	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Shear stress, τ (lb/ft^2)	0.000001	0.000004	0.000061	0.000204	0.000424	0.001765	0.2303	0.616	3.388
Total depth, D (ft)	6.7	6.8	6.9	7.0	7.1	7.5	12.1	14.7	23.6
Depth, y (ft)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Reference depth (5% of D), y_o (ft)	0.34	0.34	0.35	0.35	0.36	0.38	0.61	0.74	1.18
Rouse number, R (/)	3.057	1.529	0.391	0.214	0.148	0.073	0.006	0.004	0.002
Reference concentration, C_o (mg/L)	416.4	416.4	416.4	416.4	416.4	416.4	416.4	416.4	416.4
Concentration, C (mg/L)	0.0	0.2	62.6	151.1	209.1	303.9	408.8	412.3	415.2
Concentration Fraction, C/C_o (/)	0.00	0.00	0.15	0.36	0.50	0.73	0.98	0.99	1.00

Note: The Reference Concentration, C_o was determined at the reference depth y_o and was computed by numerical integration of the Rouse function, assuming that the measured concentrations are a cross-sectional average.

Table 9-5. Rouse Concentration Distribution under Future Flow Conditions 'Without Kanopolis Lake Trapping' for Very Fine Sand Particle

Flow (Smoky Hill River), Q (cfs)	0.3	10	40	75	110	240	4760	10000	47600
VFS particle size, d (mm)	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Settling velocity, ω_s (ft/s)	0.0212	0.0212	0.0212	0.0212	0.0212	0.0212	0.0212	0.0212	0.0212
Shear stress, τ (lb/ft^2)	0.000001	0.000004	0.000061	0.000204	0.000424	0.001765	0.2303	0.616	3.388
Total depth, D (ft)	6.7	6.8	6.9	7.0	7.1	7.5	12.1	14.7	23.6
Depth, y (ft)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Reference depth (5% of D), y_o (ft)	0.34	0.34	0.35	0.35	0.36	0.38	0.61	0.74	1.18
Rouse number, R (/)	72.020	36.010	9.221	5.042	3.498	1.714	0.150	0.092	0.039
Reference concentration, C_o (mg/L)	416.4	416.4	416.4	416.4	416.4	416.4	416.4	416.4	416.4
Concentration, C (mg/L)	0.0	0.0	0.0	0.0	0.0	0.2	268.4	328.9	387.1
Concentration Fraction, C/C_o (/)	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.79	0.93

Note: The Reference Concentration, C_o was determined at the reference depth y_o and was computed by numerical integration of the Rouse function, assuming that the measured concentrations are a cross-sectional average.

9.1.4 Model Simulation, Results and Discussion

As sediment fills the proposed sediment basin to an elevation of approximately 1209 ft, a dredging template is initiated in which sediment is removed and is graded back to its original configuration. The model simulation was performed using an iterative approach for the entire 50-year time period and dredging operations were initiated as needed. The modeling results allow for the prediction of sediment deposition over time, capturing changes in the bed profile over the course of the simulation.

Due to increased sediment loading in the revised simulations under future flows conditions, more frequent dredging is anticipated for both the With and Without Kanopolis Lake Trapping conditions. Table 9-6 summarizes the modeling results for the 1135 Study and both Kanopolis Lake trapping scenarios. The 1135 Study model inputs were reprocessed using HEC-RAS version 6.6, to allow for direct comparison and to better align all modeling results using the same software version.

As reported in Table 9-6, the newly developed TSS rating curves indicate that projected future sediment loading of the proposed sediment basin is greater than that estimated in the original 1135 Study for future flow conditions. Approximate magnitudes of the total sediment loading compared to the original study, is 2.3, 3.4, and 2.8 times greater for the ‘With Kanopolis Lake Trapping’ (without and with USGS outliers) and ‘Without Kanopolis Lake Trapping’ scenarios, respectively.

In the ‘With Kanopolis Lake Trapping’ scenarios, including all USGS data points or without the two outliers previously discussed, more frequent dredging is required when compared to the previous analysis due to the increased sediment loading. It is important to note that the sediment load fractions remain unchanged and therefore do not contribute to the difference. On average, dredging will be needed every 1.1 to 1.7 years, depending on the TSS data used and the magnitude and duration of diverted flows. The average trapping efficiency for this scenario is approximately 18 percent, which is consistent with the values identified during the previous 1135 Study for future flow conditions.

The ‘Without Kanopolis Lake Trapping’ scenario results in the highest overall sediment loading to the proposed sediment basin compared to the previous study and the with trapping scenario where outliers were removed and also requires the most frequent dredging. The more conservative scenario where outliers were included in the With Kanopolis Lake Trapping results in the largest loading and most frequent maintenance. The average sediment basin trapping efficiency for this scenario is approximately 16 percent; slightly lower than the other scenarios likely due to the higher clay fraction in the suspended sediment composition. Looking at all scenarios and given the assumptions provided, dredging of the sediment basin is anticipated approximately every 1-2 years on average, depending on flow conditions.

Table 9-6: Summary of Refined Modeling Results for Proposed Sediment Basin for Future Flows (50-year Simulation)

Modeling Measure	1135 Study	With Kanopolis Lake Trapping Without Outliers	With Kanopolis Lake Trapping With Outliers	Without Kanopolis Lake Trapping
Total sediment loading to basin (tons)	490,370	1,130,670 (2.3 x 1135 Study)	1,670,645 (3.4 x 1135 Study)	1,383,890 (2.8 x 1135 Study)
Total number of dredging events	14	29	45	34
Approx. cleanout frequency	3.6 years	1.7 years	1.1 years	1.5 years
Total Cumulative Dredged Sediment (tons)	86,060	200,305	303,633	222,375
Average Annual Dredged Sediment (tons)	1,720	4,006	6,073	4,448
Average Trapping Efficiency	17%	18%	18%	16%

Future phases of this work could include additional analysis to explore the potential to extend the maintenance interval required by allowing greater sediment deposition in the sediment basin before dredging. The current assumption is to initiate a dredging event once the basin reaches approximately 50 percent capacity; however alternate scenarios could be evaluated to assess whether the frequency of maintenance could feasibly be extended without negatively impacting basin performance and increasing sediment loading downstream to the TSP restoration reach.

9.1.5 Sediment Particle Settling Velocity Comparison

The settling velocities for sediment transport capacity were further evaluated as part of this effort to assess the depositional potential of fine sediments (silt and clay particles). Settling velocities were computed for each particle class (based on the average particle size) using multiple formulation approaches, including Darby (2009), Cheng (1997), Van Rijn (1989), and Stokes (1851). The resulting settling velocities are provided in Table 9-7 and are compared to the settling velocity used in the HEC-RAS model (using Report 12) (HEC, 2021) to verify if the model is producing reasonable depositional rates.

Table 9-7: Settling Velocity (ft/s) of Sediment Particles for Range of Class Sizes

Particle Class	Clay	VFM	FM	MM	CM	VFS
Avg. Particle Diameter (mm)	0.003	0.006	0.012	0.024	0.047	0.094
HEC-RAS Model	0.000025	0.000100	0.000337	0.001472	0.005605	0.020664
Darby	0.000020	0.000074	0.000276	0.001022	0.003674	0.013405
Cheng	0.000019	0.000076	0.000303	0.001206	0.004595	0.016974
Van Rijn	0.000025	0.000102	0.000407	0.001627	0.006305	0.024821
Stokes	0.000025	0.000102	0.000407	0.001627	0.006305	0.024821

The settling velocities computed in the HEC-RAS sediment transport model are derived using the Report 12 methodology which uses similar curves as Van Rijn but utilizes an iterative solution to compute settling velocity and Reynolds number within acceptable tolerances. The velocity used within the model aligns closely with both the Van Rijn and Stokes approach. However, the more recently developed approaches of Darby and Cheng suggest that the model may be overestimating the level of sedimentation that might occur in the sediment basin. These approaches indicate that more particles will remain in suspension, suggesting potentially reduced sedimentation, less frequent dredging operations, and a less efficient sediment basin overall.

Additional sensitivity analysis during final design would be beneficial to better assess the sensitivity to various fall velocity methods.

9.2 Old Channel TSP Sediment Analysis

Results from the sediment transport modeling activities for the proposed sediment basin described above may be carried forward for use in informing the sediment transport along the Old Channel. The With and Without Kanopolis Lake Trapping scenarios could be routed through the previously developed SIAM (annual sediment budgeting) model for the Old Channel to evaluate sediment transport along the TSP restored channel. This annual sediment budgeting could be used to confirm sedimentation trends within the restoration reach based on the new sediment rating curve and to confirm sustainability and operational and maintenance expectations for the Project.

Substantive changes from the previous SIAM modeling results are not anticipated. Previous findings from the 1135 Study indicated effective transport of suspended sediment particles smaller than fine sand. Some potential residual sediment loading (not captured in the proposed sediment basin) may occur in the most upstream reach (Reach 9). All other downstream reaches along the TSP would not be expected to exhibit much sedimentation. Updated SIAM modeling results are not expected to significantly alter the conclusions of the previous 1135 Study regarding project performance or habitat benefits. SIAM analysis within the Old Channel should be further assessed during final engineering design based on the final channel configuration and structure replacements.

10. Conclusions

Sediment transport analysis was conducted to evaluate various channel improvement alternatives along the Old Smoky Hill Channel, as well as the proposed sediment basin at the upstream end of the reach. Approximate operation and maintenance dredging frequency were estimated for the sediment basin, which serves as the primary mechanism and first line of defense for removing sediment from diverted flows. Dredging within the sediment basin is anticipated every 1-2 years based on the current modeling assumptions and approach, depending on flow conditions and storm frequency.

Results from the approximate Rouse resuspension analysis suggest that suspended particle sizes finer than sand and coarse silt are likely to remain in suspension throughout the length of the Old Channel. Although sample data within the Old Channel bed does show some historic deposition of finer materials (e.g. clay and silt), such deposition may have occurred in response to the levee system and outfall culvert structure. These features have likely contributed to decreased channel velocities and resulting deposition of finer particles within the channel bed as the Old Channel reached a point of equilibrium since the time of levee construction.

It should also be noted that sediment transport equations available in HEC-RAS are not particularly accurate or well-suited for estimating transport capacities of fine materials. The relative evaluation of alternatives is still valid; however, there is still some uncertainty on the potential for future deposition. As such, while further evaluation of sediment transport, project features, and operation and maintenance requirements is recommended during future design phases, these factors are not expected to affect the feasibility determinations between the alternatives under consideration. Further evaluation of the selected alternative during future design phases should include consideration of refined operation and maintenance activities and costs.

In general, the project and related design features, including the proposed sedimentation basin, are intended to support long-term sustainability of ecosystem habitat and restoration functions. Combined with adaptive management and subsequent operations and maintenance activities, the dynamics of sediment transport (both aggradation and degradation) are expected to be fairly well balanced and supportive of natural processes within the region.

11. References

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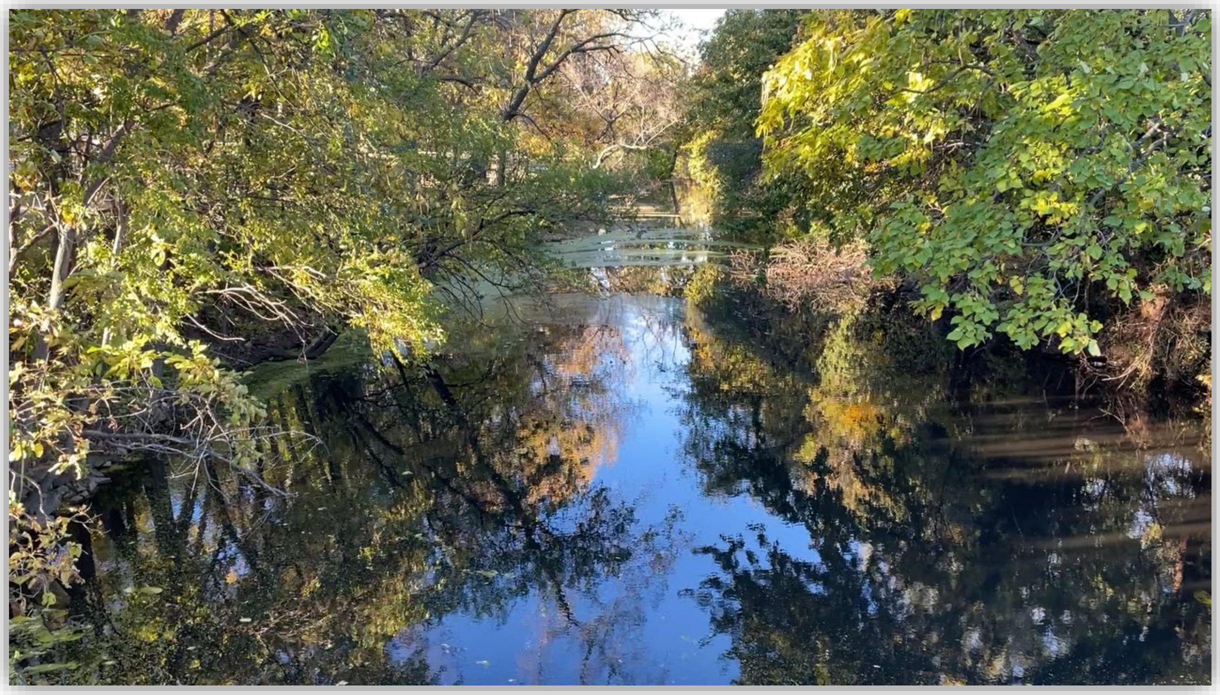

Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix E – Levee Safety Considerations

September 2025

City of Salina

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Attachment A	AMEC 2014 Geotechnical Study for Federal Emergency Management Agency (FEMA) Certification, Salina Levee System and B-01 Boring Log
Attachment B	Truncated version of KVE 2018 Revised Geotechnical Engineering Report Smoky Hill River Renewal Street and Pedestrian Bridges, Intake Structure and Basins, and Step Pools Report
Attachment C	GeoStudio Seepage Analysis Output
Attachment D	GeoStudio Slope Stability Output

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1 Introduction

This Levee Safety Considerations appendix presents a feasibility level summary to assess the proposed channel grading landward of the levee and the proposed sediment basin riverward of the levee for adverse impacts to the Salina Kansas Federal Levee System. Proposed features within 500 feet landward and 300 feet riverward of the levee centerline are included in this assessment.

The Salina Levee is comprised of 3.6 miles of locally funded and constructed levee and 18 miles of USACE funded and constructed levee. The Salina Levee design was considered final in 1958, and construction was completed in 1961. The proposed project is located near the inlet to the oxbow approximately 800 ft west of the Smoky Hill River where the levee crosses the oxbow (Figure 1-1). A plan view of the proposed channel grading and sediment basin extents are shown on Figure 1-2. The critical area, defined as 500 ft landward and 300 ft riverward of the levee centerline is also shown in Figure 1-2 along with the location of the analyzed cross section (discussed in Section 4.2). Flow from the Smoky Hill River will pass through the levee from the sediment basin to the graded channel via the existing 54-inch reinforced concrete pipe (RCP) inlet structure.

The purpose of this report is to complete levee seepage and stability analyses to characterize future condition levee performance during flood and drought conditions to understand any residual risks associated with the proposed project. This includes comparisons of existing (*future without project* - FWOP) and proposed (*with-project*) conditions.

Settlement, erosion potential, and interior drainage storage capacity related to impacts from the project will also be discussed in this report.

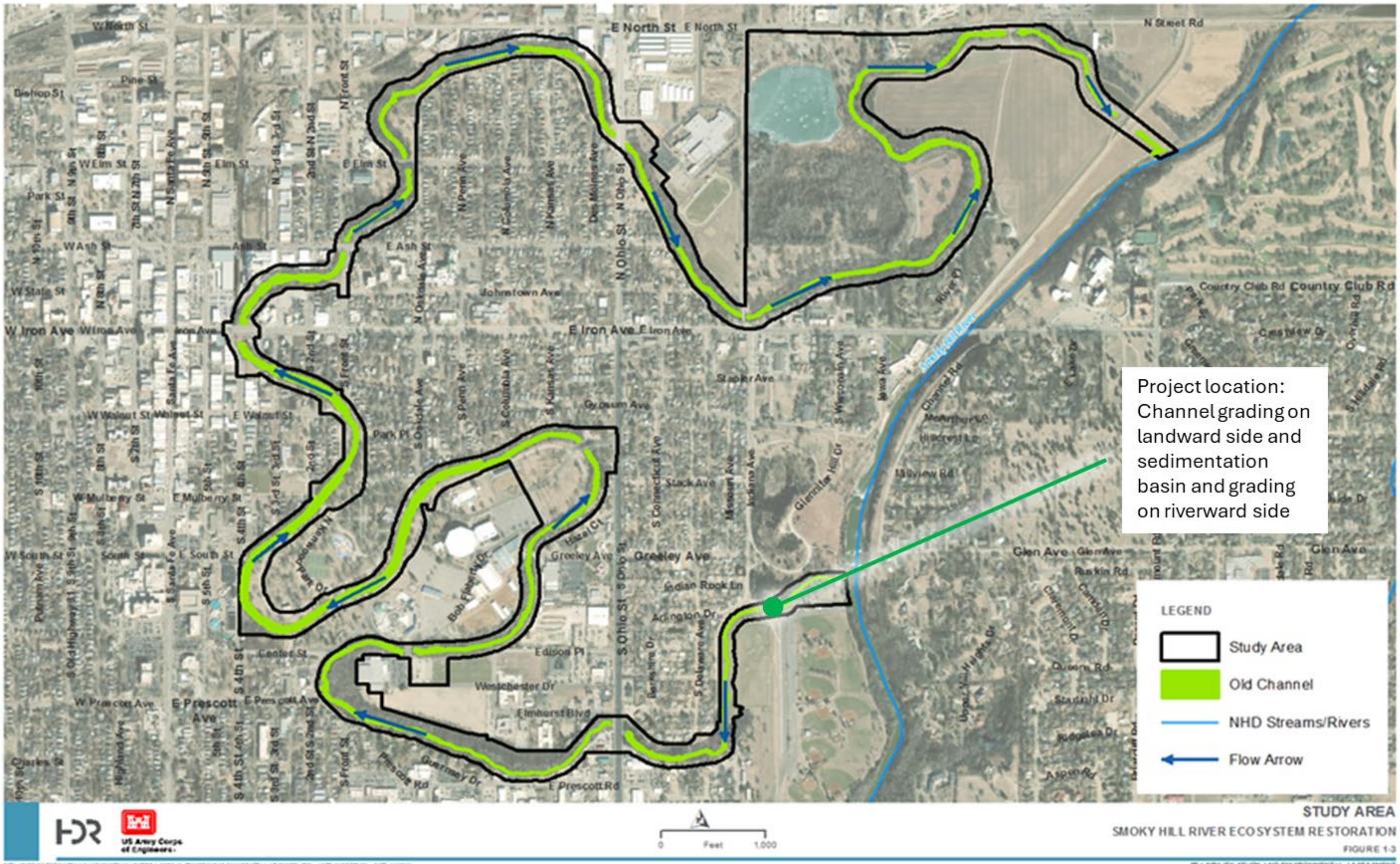


Figure 1-1. Project Location overview

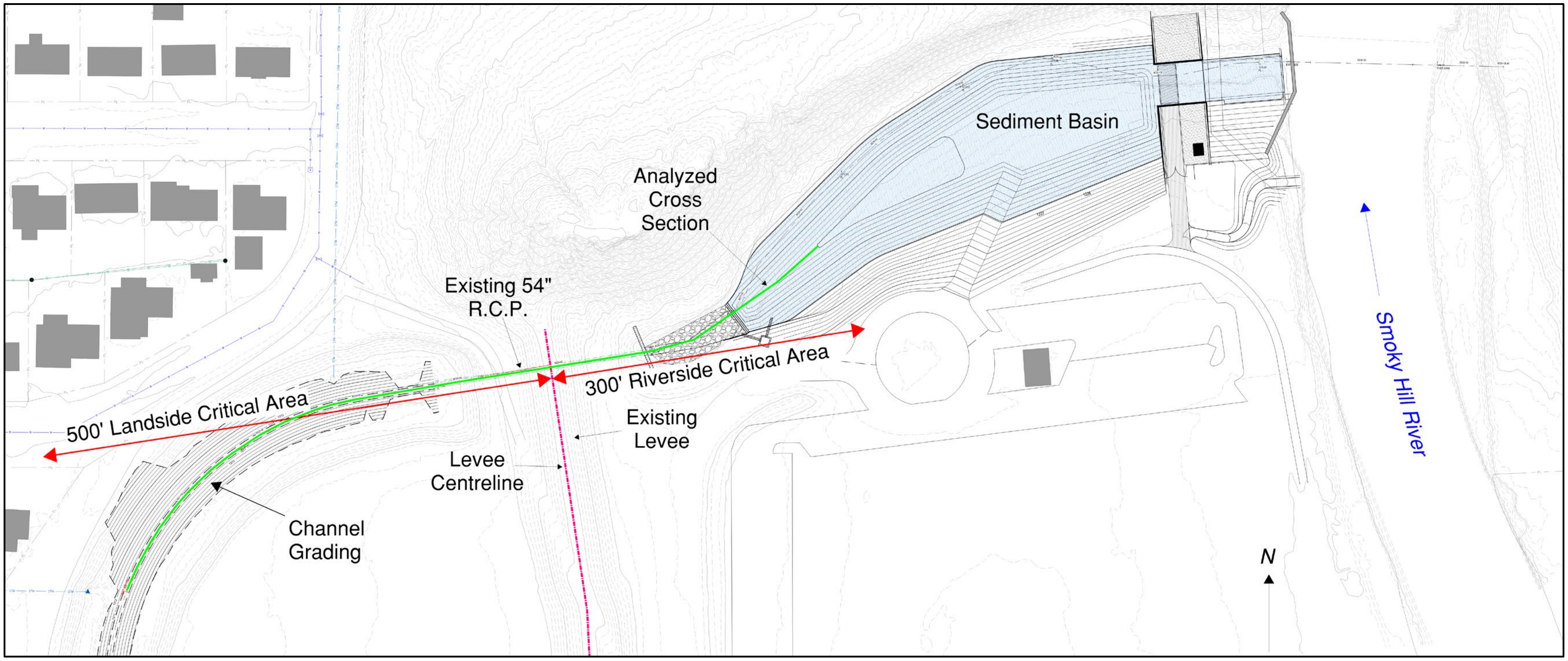


Figure 1-2. Plan view of Channel grading on landward side and sedimentation basin on the riverward side. Critical area dimensions and the location of the analyzed cross section are shown in this figure.

2 Site Description

According to the levee record drawings (U.S. Army Engineer District, Kansas City, February 1958) the system at the project site is at the transition of a diversion dam and levee system between Levee STA 0+00 to 2+00 in Section II. Figure 2-1 shows the record drawing of the levee at the inlet structure. The design elevations in the record drawings state that “elevations are referred to mean seal level, U.S.C & G.S., 1929 general adjustment”. The HDR topographic data of the site was developed from LiDAR in the NAVD88 datum. The levee elevations in the 1958 records were converted from NGVD29 to NAVD88. The vertical conversion for NGVD29 to NAVD88 at Salina is (FEMA 2018):

- **NGVD29 + 0.39 feet = NAVD88**

The 1958 record drawings show the following at the pipe crossing:

- The crest width is 10-feet with 3 horizontal to 1 vertical (3H:1V) upstream and downstream slopes.
- 25-foot-wide stability berms at elevation 1228.4 feet with 3H:1V slopes on the inlet and outlet side of the levee.
- The top of levee elevation is 1240.4 feet resulting in a levee height of 32 feet, measured from the outlet invert to the top of the levee.
- The levee embankment consists of impervious fill with a section of random fill on the landward side of the levee.
- The pipe consists of a 54” RCP.
- Bedrock is located under the levee and was excavated during construction. Figure 2-1 highlights the excavation line and the approximate top of bedrock prior to construction.

The LiDAR topographic data of the levee geometry at the project site is generally consistent with the 1958 record drawings.

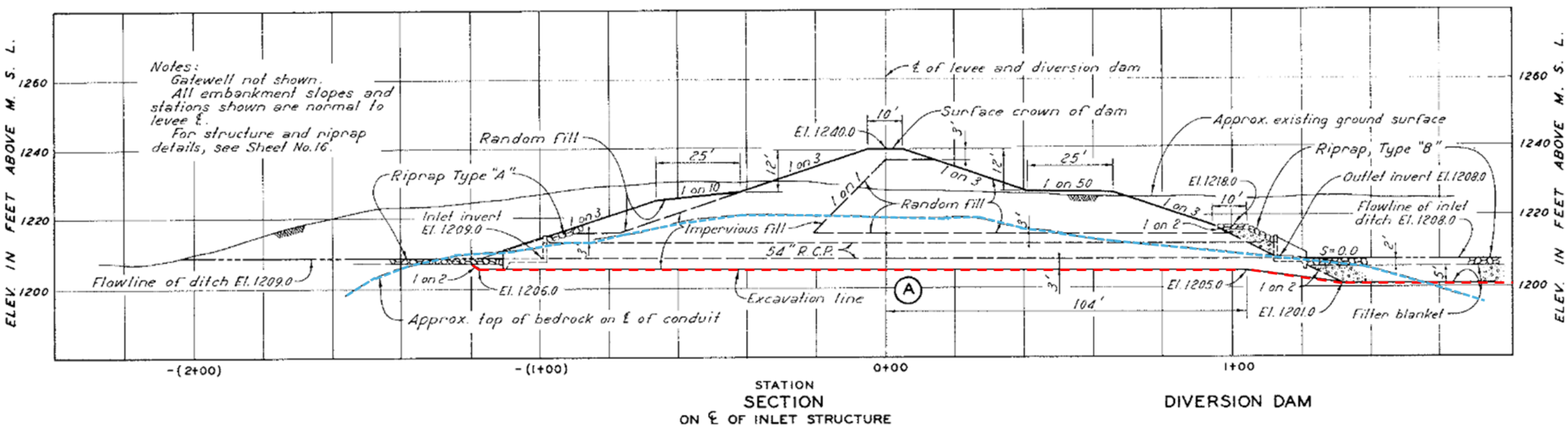


Figure 2-1. As-built cross section of the levee at the project location (U.S. Army Engineer District, Kansas City. February 1958)

3 Subsurface Conditions

3.1 Site Geology

Kansas Geological Survey (2011) mapping shows the project site is located in the area of the Alluvium and Terrace Valley Fill (Qal) and the Welington Formation (Pwe) (Figure 3-1).

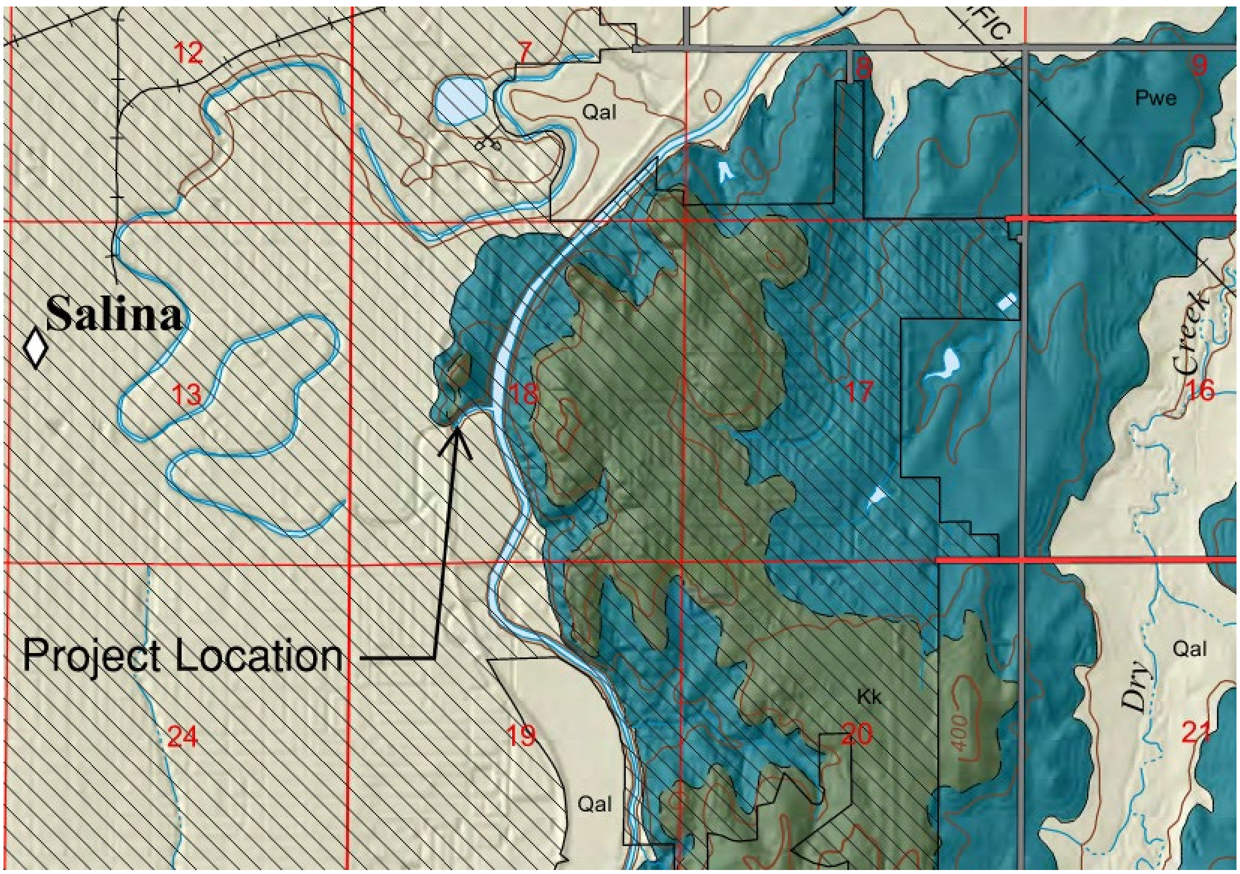


Figure 3-1. Project location on the Kansas Geologic Survey Map M-123, Surficial Geology of Saline County, 2011

The Alluvium and Terrace Valley Fill contains mostly clay, silt, sand, and gravel with the thickness of the alluvium up to approximately 60 ft (Kansas Geological Survey 2011). The Welington Formation is predominantly gray and bluish-grey shale with beds of gypsum, anhydrite, and argillaceous limestone (Kansas Geological Survey 2011).

The Kansas Geological Survey (2011) map includes a geologic cross section located approximately 1.7 miles to the south of the project site. Figure 3-2 shows the geologic cross section nearest the project site. The stratigraphy at the Smoky Hill River (which is labeled on the figure), shows approximately 30 feet of Alluvium and Terrace Valley Fill underlain by over 200 feet of the Welington Formation (shale).

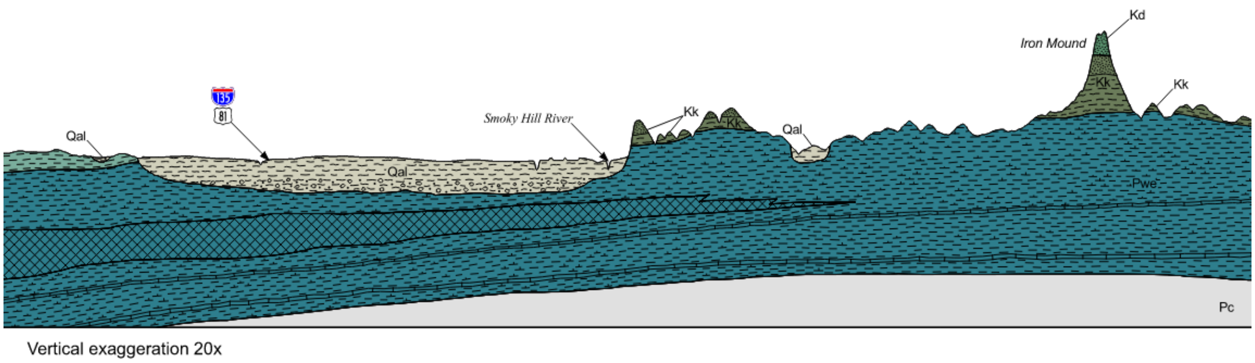


Figure 3-2. This Geologic cross section is located approximately 1.7 miles south of the project site. The Smoky Hill River is labeled on the figure. Source: Kansas Geologic Survey Map M-123, Surficial Geology of Saline County, 2011.

3.2 Subsurface Stratigraphy

Subsurface stratigraphy and soil parameters at the site were determined based on published geologic data (Kansas Geological Survey 2011) and soil information from previous geotechnical reports including:

- AMEC. Geotechnical Study for Federal Emergency Management Agency (FEMA) Certification., Salina Levee System. Salina, Kanas. January 2014.
- Kansas Geological Survey. Map M-123, Surficial Geology of Saline County, Kansas. 2011.
- Kaw Valley Engineering (KVE). Revised Geotechnical Engineering Report Smoky Hill River Renewal Street and Pedestrian Bridges, Intake Structure and Basins, and Step Pools, Salina, Kansas. February 27, 2018.
- U.S. Army Engineer District, Kansas City. Smoky Hill River, Salina, Kansas, Flood Control Project, Construction Plans for Channel Cutoff and Levee Section II. February 1958.

Five borings from the above reports are located near the project site and include one boring from the AMEC 2014 report, three borings from the 2018 KVE report, and one boring from the U.S. Army Engineer District, Kansas City 1958 record drawings. Figure 3-3 shows the location of the five borings on a Google Earth aerial. The AMEC 2014 boring was located using latitude and longitude coordinates from the boring log. The locations of the KVE 2018 borings were estimated using the map provided in the report (KVE 2018) because no latitude or longitude coordinates were provided. The location of the U.S. Army Engineer District, Kansas City 1958 boring was also estimated using the map provided in the report (U.S. Army Engineer District, Kansas City 1958) because no latitude or longitude coordinates were provided.

Figure 3-3. Google earth aerial showing the location of the AMEC 2014 boring, the three KVE 2018 borings, and the U.S. Army Engineer District, Kansas City boring from the 1958 record drawings.

The 2014 AMEC report includes one boring near the project site, B-01 (Figure 3-4). Note that the S-labeled locations on the map indicate a CPT site. B-01 goes through the levee approximately 250 ft south of the project site. B-01 consists of 16.5 feet of stiff to very stiff clay fill (embankment material) underlain by 12 feet of firm to stiff clay which is underlain by 10 feet of firm silt followed by 5 feet of very loose sand, returning to stiff clay where the boring was terminated at a depth of 45.5 feet. Attachment A contains the 2014 report and the boring log for B-01.

The 2014 AMEC study was in support of the Federal Emergency Management Agency (FEMA) levee certification process for the Salina Levee System. The report includes analysis to evaluate seepage into or through the levee embankment and foundation and the effect upon embankment and foundation stability. Embankment and subsurface soil engineering parameters were developed from laboratory analysis as well as estimates from published correlations or applicable USACE manuals and methods. The field investigation consisted of completing 68 soil test borings and 86 Cone Penetration Test (CPT) soundings along the length of the levee system.

Figure 3-4. AMEC 2011 boring B-01 near the project site (AMEC 2011). The S-labeled locations indicate CPT site.

The KVE 2018 report provides a boring location map (Figure 3-5) and the logs associated with those borings. Three borings were collected in the area of the sedimentation basin, which includes Intake-1, Sediment-1, and Sediment-2. All three borings generally show that bedrock was encountered between EL 1204.4 to EL 1207.5, between 13.8 to 19.5 feet below ground surface (BGS). The Sediment-2 and Sediment-1 boring, located within approximately 200 feet and 500 feet of the toe of diversion dam/levee respectively, consists of a mix of lean clay and silt layers above bedrock (shale). The Intake-1 boring generally consists of silt and silty sand above bedrock. Attachment B contains a truncated version of the KVE 2018 report.

Figure 3-5. KVE 2018 borings in the area of the proposed sediment basin (KVE 2018).

The U.S. Army Engineer District, Kansas City 1958 record drawings show one nearby boring, D-75, located approximately 200 ft south of the project site (Figure 3-6). The 1958 construction plans also show the stratigraphy of boring D-75 (Figure 3-7). D-75 consists of approximately 8 feet of lean clay underlain by 13 feet of silt, 1 foot of well graded sand, and ends after approximately 20 more feet of silt.

As mentioned in Section 2, the 1958 construction plans show a cross section through the levee at the project site (Figure 2-1). The cross section shows that bedrock is located under the levee and was excavated during construction.

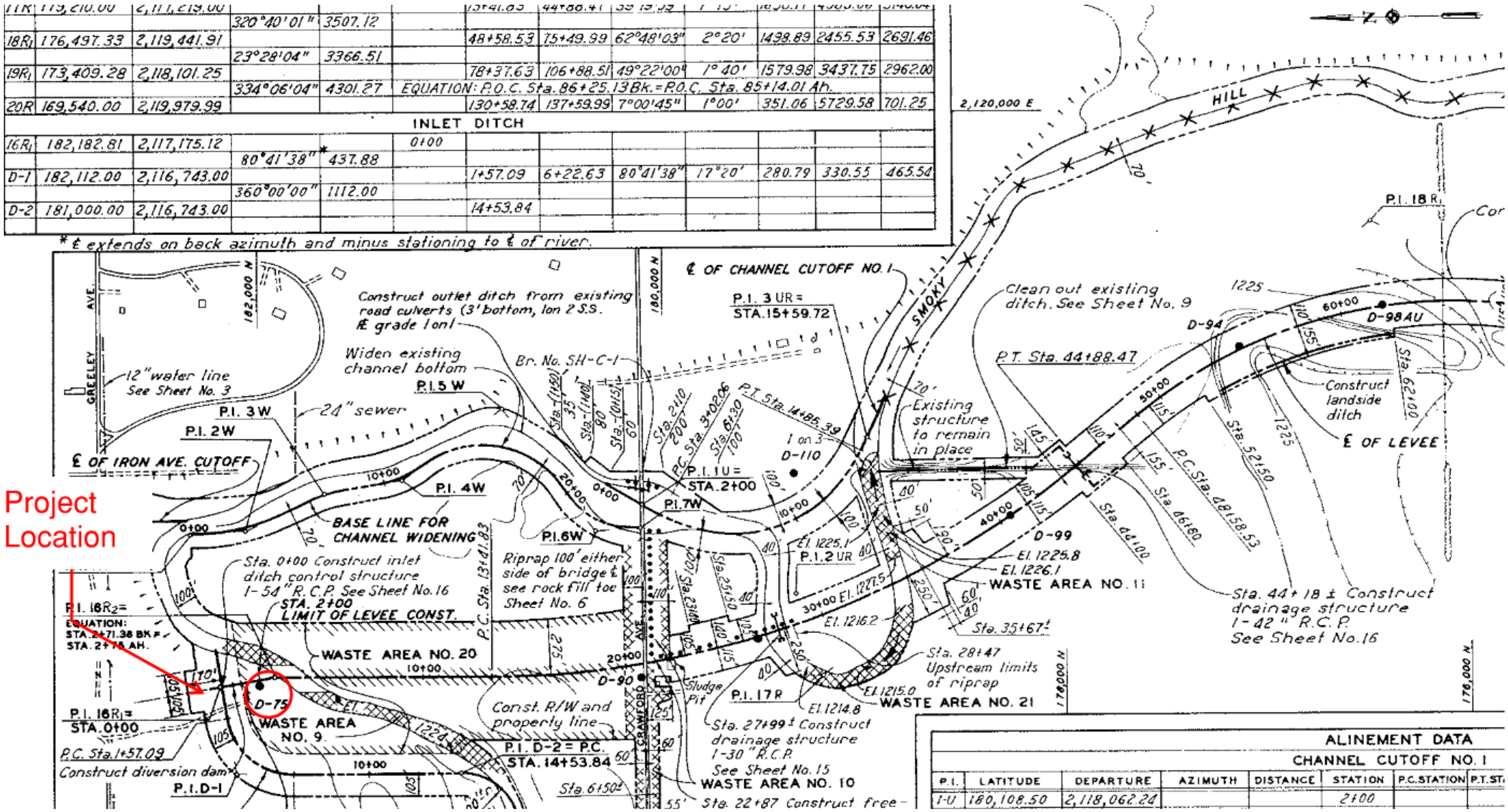


Figure 3-6. U.S. Army Engineer District, Kansas City boring D-75, near the project site (U.S. Army Engineer District, Kansas City 1958).

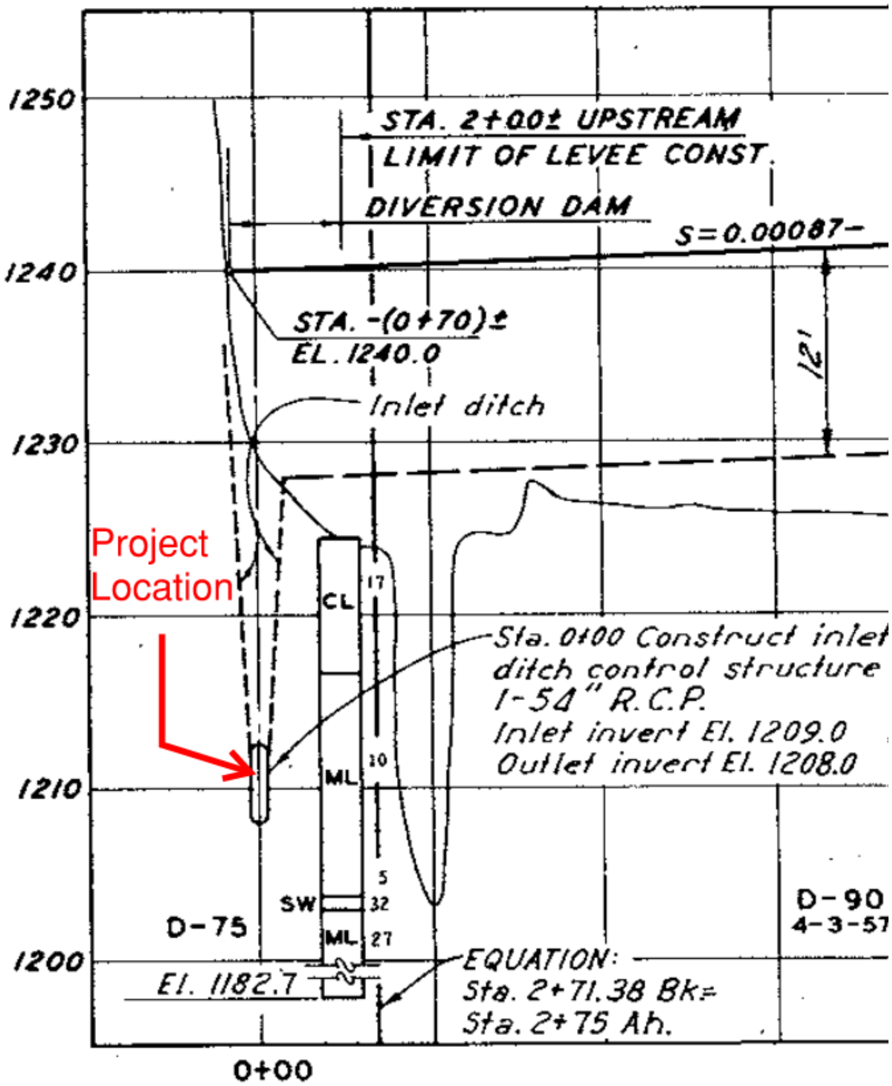


Figure 3-7. U.S. Army Engineer District, Kansas City boring D-75 subsurface information (U.S. Army Engineer District, Kansas City 1958).

Based on the published geologic data (Kansas Geological Survey 2011) and soil information from previous geotechnical reports discussed above, details of the soil units at the project site are described as follows:

- **Alluvium and Terrace Valley Fill:** Is a floodplain deposit associated with the Smoky Hill River (Kansas Geological Survey 2011). Based on the boring logs from previous geotechnical reports mentioned above, the main soil units in the project location associated with this formation include:
    - **Lean Clay (CL)** – This is an approximately 3 to 12-foot-thick, soft to very stiff, lean clay layer and is described in the borings as grey and brown in color. Atterberg limits testing performed on the lean clay includes liquid limit (LL) and plasticity index (PI) values ranging from 28 to 40 and from 8

to 22 respectively. Grain-size analyses testing resulted in percentages passing the number 200 sieve ranging from 79.4 to 97.4.

- **Soft Silt/Silty Clay (CL/ML)** – This 2 to 4-foot-thick, soft silt/clay layer is generally located under the lean clay layer and above the shale in the 2018 KVE borings. While this soft layer does not exist in the 2014 AMEC B-01 boring log, this soft layer is present other borings from the report.

- **Silt (ML)** – This silt layer is located above the shale and is intermixed with the other soil layers in the Alluvium and Terrace Valley Fill deposit. The layer is 1 to 10-feet-thick and is stiff to firm.

- **Sand/Silty Sand** - This sand layer is located above the shale and is intermixed with the other soil layers in the Alluvium and Terrace Valley Fill deposit. The layer is 1 to 5 feet thick and is very loose.

- **Welington Formation (Shale)** – This layer is present beneath the Alluvium and Terrace Valley Fill. 1958 construction drawings show the bedrock underneath the levee at the project site and the sediment basin borings show the shale as high as elevation 1204.5 feet. No shale was encountered in the AMEC 2014 boring or the U.S. Army Engineer District, Kansas City 1958 boring which terminated at elevations 1195 and 1183 feet respectively.

3.3 Groundwater

The groundwater readings for the sediment basin borings (KVE 2018) taken after completion were encountered at depths ranging from 6 to 10 feet BGS (elevations 1212.6 and 1212.5 feet respectively). B-01 recorded a water level reading during drilling at 42 feet BGS (elevation 1198.5 feet). Note that B-01 was drilled through the levee and is located approximately 250 ft south of the project site.

Because the clay soils present in the borings are relatively slow draining, considerable time may be required for static groundwater levels to be determined; as a result, the water level elevations reported on the boring logs may not represent actual groundwater conditions.

4 Geotechnical Analyses

The approach and technical basis for the geotechnical analyses conducted for the project, including seepage and slope stability are included within this section. The basis for parameter selection for each analysis is presented, followed by the results for each analysis. All elevations in the analysis cross section and in the text below are in NAVD88.

4.1 General Approach

Seepage and stability analyses were performed at the levee cross section at the project site for existing and proposed conditions in general accordance with EM 1110-2-1913, *Design and Construction of Levees* (USACE 2000). Flood elevation determination requirements are described in Section 4.3.

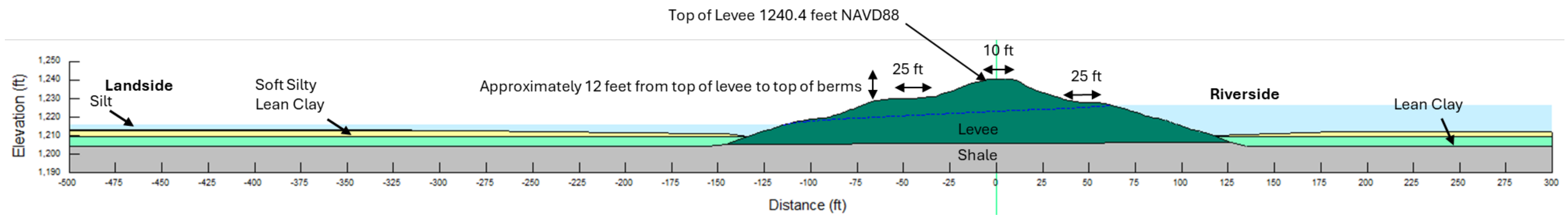
4.2 Analyzed Cross Section

4.2.1 Subsurface Stratigraphy

As described in Section 3.2 soil conditions at the site generally consist of lean clay, silt, and sand layers underlain by shale.

The subsurface stratigraphy from the Sediment 2 boring (KVE 2018) was selected for use in the seepage and slope stability analysis. This is due to the boring location being closest to the project site. The elevations of the shale noted in the levee cross section from the 1958 record drawings (Figure 2-1) were also used in the cross section and shale was modeled under the levee.

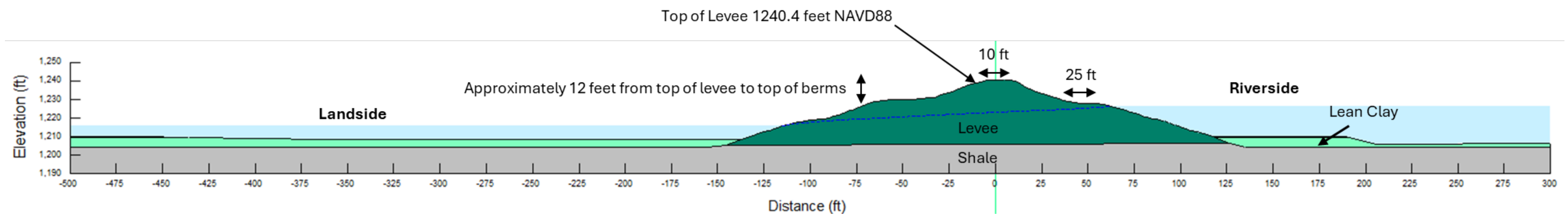
The subsurface stratigraphy from the Sediment 2 boring (modeled upstream and downstream of the levee) consists of 5.5 feet of lean clay, 1 foot of silt, 3 feet of soft silty clay, 5 feet of lean clay which is underlain by shale. The shale layer was extended approximately 5 feet deeper than the bottom of the boring. The cross section was taken just to the north of the culvert and includes the deepest part of the channel. The existing channel elevations were determined from KVE survey data. Figure 4-1 shows exiting conditions cross section and Figure 4-2 shows the proposed conditions cross section. The proposed cross section includes the excavated sediment basin on the riverside and the excavation of the channel grading on the landside. The plan view in Figure 1-2 shows the location of the analyzed cross section.



Notes: Side Slopes of levee and berms are approximately 3(H):1(V)

Due to the scale of the figure, the silt layer is hard to observe. It is 1-foot thick and is located above the soft silty lean clay layer.

Figure 4-1. Levee Cross Section Existing Conditions



Notes: Side Slopes of levee and berms are approximately 3(H):1(V)

Figure 4-2. Levee Cross Section Proposed Conditions

4.3 Seepage Analysis

The levee seepage analyses were performed using the SEEP/W module in the GeoStudio 2024.2.1 suite of software (version 24.2.1.28). SEEP/W uses the finite-element analysis technique to model water movement and pore water pressure (PWP) distribution within porous materials, such as soil and rock.

The levee cross section was evaluated with respect to exit gradients and uplift potential at the landside levee toe for the steady-state seepage conditions for the normal pool (Maximum Normal Storage) and flood surcharge pool.

Seepage analysis was evaluated per USACE EM 1110-2-1913 manual guidelines, which states the maximum allowable exit hydraulic gradient is limited to 0.5.

4.3.1 Seepage Model Boundary Conditions

Important elements for consideration in developing seepage models include model cross-section development, seepage parameter selection, and boundary condition selection. Seepage parameter selection is discussed in Section 4.5.1. Boundary conditions were applied to the model as follows:

- Riverside Full Flood Stage: Constant head boundary condition equivalent to the full flood stage along the riverside surface and levee slope below the full flood stage elevation. The 100-year flood stage elevation, equivalent to the base flood elevation, of 1,226.5 feet was selected for use as Full Flood Stage.

- Downstream: Potential seepage face review boundary condition along the levee crest, landside levee slope, and landside ground surface to the Base Flow Elevation.

4.4 Stability Analysis

Slope stability analyses were performed on the same analysis cross section evaluated for seepage. Slope stability shear strength parameter selection is summarized in Section 1.

The stability modeling was conducted using GeoStudio's SLOPE/W module, which uses the limit equilibrium approach to compute the Factor of Safety (FOS) of earth and rock slopes.

The following load cases were considered for stability analysis for existing and proposed conditions:

- Case I: Steady-State Seepage for Full Flood Stage (Base Flood Elevation)

- Case II: Steady-State Seepage for Drought Conditions

- Case III: Rapid Drawdown (Base Flood Elevation to Base Flow Elevation)

The PWP conditions for each stability model case are defined in Table 4-1

Table 4-1. Hydraulic Boundary Conditions for Loading Cases

Dam Loading Case		Stability Model Pore Water Pressure	Water Surface Elevation Riverside (feet) (NAVD88)	Water Surface Elevation Landside (feet) (NAVD88)
I	Full Flood Stage (Base Flood Elevation)	Parent Steady-state Seepage model	1,226.5	Base Flow Elevation: 1215.8 (existing conditions), 1215.6 (proposed conditions)
II	Drought Conditions	Piezometric line	1,215.4	1,215.4
III	Rapid Drawdown (Base Flood Elevation to Base Flow Elevation)	Piezometric lines	1,226.5 to 1215.8 (for existing conditions) 1,226.5 to 1215.6 (for proposed conditions)	Base Flow Elevation: 1215.8 (existing conditions), 1215.6 (proposed conditions)

No surcharge loads, such as vehicle or stockpile loads, were applied. The target FOS, as recommended by EM 1110-2-1913, as well as the slope analyzed for each loading case, is defined in Table 4-2. Because EM 1110-2-1913 does not have a recommended minimum FOS for drought conditions, a FOS of 1.4 was selected.

Table 4-2. Summary Recommended FOS for Slope Stability Modeling

Case	Description	Slope analyzed	USACE Recommended FOS
I	Full Flood Stage (Base Flood Elevation)	Riverside and Landside	1.4
II	Drought Conditions	Riverside and Landside	1.4[1]
III	Rapid Drawdown (Base Flood Elevation to Base Flow Elevation)	Riverside	1.2

[1] *FOS selected by HDR*

Spencer's 1967 method of analysis was used to calculate the FOS of the levee in the stability analysis. This method is considered an adequate limit equilibrium method because it satisfies conditions of static equilibrium and provides a FOS based on both force and moment equilibrium (Spencer 1967). Slip surfaces were defined using the entry-and-exit. The *optimize critical slip surface location* option was selected for each stability run. This option is used to seek a lower factor of safety value by incrementally altering portions of the previously solved critical slip surface.

Slip surfaces less than 3 feet deep were not considered as failing to meet criteria because they are indicative of localized sloughing failures which are a maintenance concern rather than a levee safety issue.

4.4.1 Case I: Steady State Seepage, Full Flood Stage (Base Flood Elevation)

Steady-state seepage conditions were utilized for Case I. For the flood loading, it is assumed that the duration of the flood is sufficient to establish steady-state seepage conditions through the levee embankment. The phreatic surfaces and PWPs calculated in the seepage analyses were used in the steady-state stability evaluations. Because steady-state seepage is a long-term condition, drained strengths were assigned to all soils, both coarse- and fine-grained.

For Case I, GeoStudio allows for integration of SEEP/W and SLOPE/W, such that the PWPs and phreatic surface computed in SEEP/W can be automatically imported and used in the SLOPE/W analysis. For cases where there is a differential head across the dam embankment, this approach allows for a more realistic stability analysis that can be obtained by estimating a phreatic surface. For any node on the ground surface line where the PWP is positive (i.e., surface ponding condition), SLOPE/W automatically computes the equivalent weight of the water above the ground surface.

4.4.2 Case II: Drought Conditions

This case represents the drought condition and was requested by the USACE in for this levee safety analysis. This analysis used one piezometric line defined at the drought elevation.

4.4.3 Case III: Rapid Drawdown (Base Flood Elevation to Base Flow Elevation)

This case represents the condition whereby a prolonged flood stage saturates at least the major part of the wet embankment portion and then falls faster than the soil can drain. This causes the development of excess pore water pressure which may result in the slope on the riverside of the embankment becoming unstable. Stability analysis was evaluated on the riverside. Rapid drawdown from the Base Flood Elevation to base flow elevation was analyzed.

Rapid drawdown was analyzed using the Duncan et al., 1990 method in GeoStudio (GEO-SLOPE International, Ltd., 2018). In this type of analysis two piezometric lines are defined to complete a staged rapid drawdown analysis. The higher piezometric line characterizes the pore-water pressure conditions prior to drawdown. The lower piezometric line characterizes the pore-water pressure conditions after drawdown.

GeoStudio (GEO-SLOPE International, Ltd., 2018) describes that the Duncan et al., 1990 method assures that the undrained strength, calculated prior to drawdown, does not exceed the drained strength calculated post drawdown. The analysis uses both drained and undrained strength input.

4.5 Determination of Engineering Parameters

The materials at the site were characterized based on published geologic data and soil information from previous geotechnical reports including (see Section 3.2 for details).

Soil parameters used in the geotechnical analyses were obtained from several sources and are summarized in Table 4-3 and Table 4-5 and in the following sections. In addition to the foundation soils, strength and seepage parameters were estimated the levee fill.

4.5.1 Seepage Parameters

The primary input parameters in the seepage analyses are hydraulic conductivity (or "permeability") and anisotropy (ratio of permeability in the horizontal and vertical directions) for the foundation soils, which is a function of soil classification, fines content, in situ density, and depositional history. Table 4-3 summarizes the design permeability values along with the other input parameters used in the seepage analysis.

The average of the two AMEC 2014 permeability test results were used for the selected permeability of the levee fill and the value is in line with recommended values for lean clay from typical values for compacted soils (NAVFAC 1986b). The levee fill in Boring B-01 (AMEC 2014) is described as firm to very stiff clay and the Amec 2014 geotechnical report describes the levee fill as consisting of a mixture of silt and clay with varying amounts of sand.

The average of the four AMEC 2014 permeability test results were used for the selected permeability of the native lean clay and the value is in line with recommended values for lean clay from USBR Design Standards (DS) 13-8 (USBR 2014).

The permeability of the 1-foot-thick silt layer and the 4-foot-thick soft silty clay layers were selected based on recommended values for natural soils from USBR Design Standards (DS) 13-8 (USBR 2014).

The permeability of the shale bedrock was selected based on Goodman 1989.

The geologic layers below the water table were modeled as *saturated only* because materials below the water table will always be saturated. The embankment fill material was modeled as *saturated/unsaturated*.

For materials modeled as *saturated only*, the saturated permeability value is the primary parameter used in modeling the material's seepage behavior. For *saturated/unsaturated* materials, however, additional parameters are required, namely the soil-water characteristic curve (SWCC) that provides the relationship of HC with the degree of saturation and the soil's ability to drain (matric suction).

The anisotropies of all soils were selected are based on published values (USBR 2014).

For this project, SWCCs were estimated using GeoStudio's SWCC estimating feature. The GeoStudio estimate is based on the modified Kovacs method developed by Aubertin et al. (2003), which allows the SWCC curve to be estimated based on the soil's grain size distribution (particularly the 10 and 60 percent passing grain size values), as well as the saturated volumetric water content and the coefficient of volume compressibility, m_v. The seepage model results are not sensitive to m_v. Generally, the results are identical for steady-state seepage analyses when using m_v values varying over orders of magnitude.

Table 4-3. SEEP/W Parameters

Materials	Material mode	Horizontal saturated permeability (kh) (cm/s)	Horizontal saturated permeability (kh) (ft/s)	Anisotropy (kv/kh)	Saturated Volumetric Water Content, Θ_s (ft^3/ft^3)	Residual Volumetric Water Content, Θ_r[1]
Lean Clay (CL) - Alluvium	Saturated Only	3.58E-06	1.17E-07	0.1	0.38	N/A
Silt (ML) - Alluvium	Saturated Only	1.00E-05	3.28E-07	0.25	0.43	N/A
Soft Silty Clay (CL) - Alluvium	Saturated Only	1.00E-05	3.28E-07	0.1	0.38	N/A
Existing and Proposed Embankment Fill Drained (CL-CL/ML)	Saturated/ Unsaturated	4.69E-06	1.54E-07	0.1	0.38	0.04
Shale	Saturated Only	1.00E-08	3.28E-10	0.25	0.33	N/A

1. N/A means that residual volumetric water content was not a required input because the soil/geologic unit was modeled as Saturated Only.

4.5.2 Slope Stability Parameters

This section describes the process used for evaluating the strength parameters for each of the materials in the analyzed cross section (Figure 4-1 and Figure 4-2) and discusses the drained and undrained strength values used in the levee evaluation.

As described in Section 4.4, the levee was evaluated for three conditions which are summarized in Table 4-4 along with applicable shear strength parameter conditions.

Slope stability parameters used in the geotechnical analysis were obtained from several sources and are summarized in Table 4-5 and in the in the following subsections.

Table 4-4. Shear Strength Parameter Applied to Stability Loading Cases

Stability loading case	Applicable shear strength parameters	
	Free-draining materials	Low-permeability materials
Full Flood Stage (Base Flood Elevation)	Effective stress parameters	Effective stress parameters
Drought Conditions	Effective stress parameters	Effective stress parameters
Rapid Drawdown (Base Flood Elevation to Base Flow Elevation)	Effective stress parameters	Staged analysis (both drained and undrained parameters applied)

4.5.2.1 Unit Weight

Moist unit weights for the levee fill and native lean clay were estimated using laboratory testing presented in the AMEC 2014 report. The moist unit weight for the shale was selected based on typical values from Goodman 1989. The moist unit weight for the silt and very soft silt layers were selected using typical values for soils (NAVFAC 1986a).

4.5.2.2 Drained Strengths

The drained strength for the levee fill and native lean clay were selected based on correlation with plasticity index results from the AMEC 2014 report (NAVFAC 1986a).

The drained strengths selected for the foundation silt and very soft silt were selected based on Table 8-1 from the Unified Facilities Criteria Soil Mechanics manual (UFC 2022).

The drained strength for the shale was selected based on Sabini et. all 2002.

4.5.2.3 Undrained Strengths

UFC Table 8-10 was used to select the undrained strength for the lean clay (UFC 2022).

The undrained strength for the proposed embankment fill was selected using typical values for compacted soils (NAVFAC 1986b).

Utilizing information from the 2014 AMEC report, the undrained strength selected for the very soft silt was c = 250 psf and phi = 0 degrees.

Table 4-5. SLOPE/W Parameters

Soil Layer	Moist Unit Weight (pcf)	Shear Strength Parameters			
		Undrained (End of Construction)		Drained (Effective) Stress Envelope	
		c	ϕ	c'	ϕ'
		(psf)	(deg)	(psf)	(deg)
Lean Clay (CL) - Alluvium	117	1000	0	0	30
Silt (ML) - Alluvium	116	N/A	N/A	0	30
Soft Silty Clay (CL) - Alluvium	110	250	0	0	25
Existing and Proposed Embankment Fill Drained (CL-CL/ML)	124	1000	0	0	30
Shale	140	N/A	N/A	100	27

5 Analysis Results and Recommendations

This section presents seepage and stability analysis results.

5.1 Seepage

The levee cross section was evaluated with respect to vertical exit gradients (y-gradient) at the levee toe for the steady-state seepage conditions at the base flood elevation.

Seepage outputs are provided in Attachment C, including sections contoured for total head and y-gradient. The seepage output from GeoStudio showing total head and Y-gradient contours at the landside toe for the proposed conditions model are shown in Figure 5-1 and Figure 5-2 respectively.

As mentioned in Section 4.3, seepage analysis was evaluated per USACE EM 1110-2-1913 manual guidelines, which states the maximum allowable exit hydraulic gradient is limited to 0.5. Seepage results demonstrate the exit gradient is less than the maximum allowable value of 0.5 at the toe of the levee satisfying seepage design requirements for this USACE condition for both existing and proposed conditions.

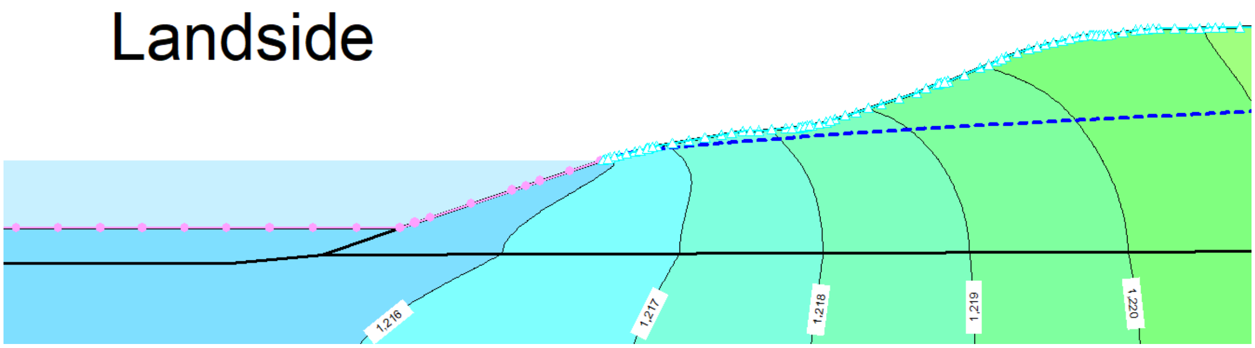


Figure 5-1. Total head contours at the landside toe for the proposed conditions model.

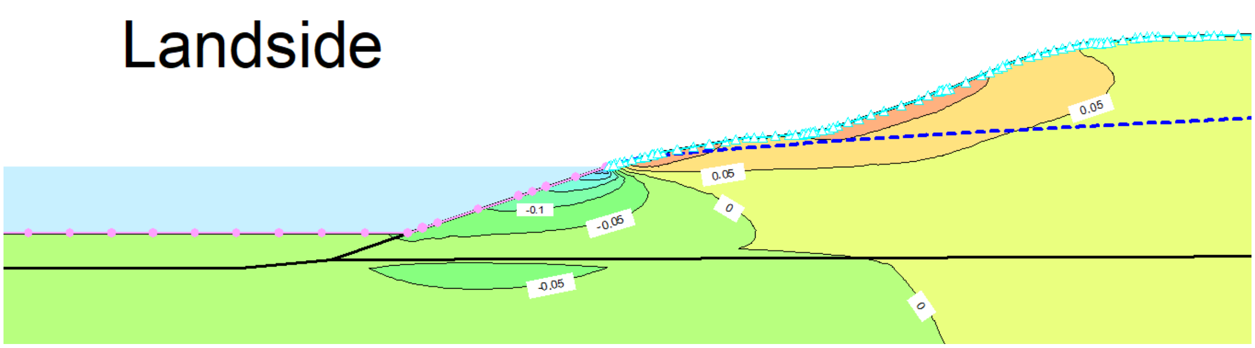


Figure 5-2. Y-Gradient contours at the landside toe for the proposed conditions model.

5.2 Stability

FOS results for the critical slip surfaces are presented in Table 5-1 for the proposed dam cross section based on the loading cases identified in Section 4.4 and the strength values defined in Section 1. Slope stability modeling outputs are provided in Attachment D.

The slope stability results demonstrate a FOS greater than or equal to the recommended FOS values (Table 5-1).

The geotechnical modeling indicates the levee slope stability FOS results are at or above recommended minimum values for all cases analyzed (Table 5-1). The proposed conditions results for Case II on the landside and Case III on the riverside show a 0.1 reduction in FOS from the existing conditions. This is likely due to the removal of soil near the inlet and outlet for the proposed channel excavation and sediment basin. Based on the results of the stability analysis, it is reasonable to conclude the proposed conditions appear to be feasible.

Table 5-1. Slope Stability Results

<table>
<tr><th colspan="2">Loading Case</th><th>Slope Analyzed</th><th>USACE Recommended Minimum Factor of Safety (EM 1110-2-1902)</th><th>Existing Conditions</th><th>Proposed Conditions</th></tr>
<tr><td rowspan="2">I</td><td rowspan="2">Full Flood Stage (Base Flood Elevation)</td><td>Landside</td><td rowspan="2">1.4</td><td>1.4</td><td>1.4</td></tr>
<tr><td>Riverside</td><td>2.0</td><td>2.0</td></tr>
<tr><td rowspan="2">II</td><td rowspan="2">Drought Conditions</td><td>Landside</td><td rowspan="2">1.4</td><td>1.8</td><td>1.7</td></tr>
<tr><td>Riverside</td><td>1.6</td><td>1.6</td></tr>
<tr><td>III</td><td>Rapid Drawdown (Base Flood Elevation to Base Flow Elevation)</td><td>Riverside</td><td>1.2</td><td>1.7</td><td>1.6</td></tr>
</table>

5.3 Settlement, Erosion Potential, and Interior Drainage Storage

Because no new loads will be added to the levee due to the proposed project (channel grading landward of the levee and the proposed sediment basin riverward of the levee), no settlement is expected at the project site.

In addition, based on the proposed project, no significant changes to erosion potential or interior drainage storage capacity are anticipated. For details on sediment transport, refer to the Sediment Transport Appendix.

5.4 Summary of Findings

The engineering evaluations demonstrate that proposed channel grading landward of the levee and the proposed sediment basin riverward of the levee will still meet USACE seepage and stability criteria.

6 Limitations

Recommendations and findings provided in this report are based on our limited existing subsurface explorations, limited laboratory tests, limited field observations, and review of record drawings (U.S. Army Engineer District, Kansas City, 1958). Soil conditions may vary between or beyond the points explored or observed. Groundwater conditions may vary from the conditions observed at the time of data collection. Information and recommendations presented in this report should not be used for other projects on this site, should not be extrapolated to other areas, and should not be used for projects in other locations without HDR's review and approval. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated.

HDR makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

The opinions, conclusions and results presented in this report are made in accordance with generally accepted principles and practices of the geotechnical engineering, geologic, and hydrogeologic professions. The conclusions and recommendations in this report are based on conditions of the project site at the time of this study. Human-induced or natural changes to the site could alter the analysis, findings, and recommendations contained here and could invalidate the analysis, findings, and recommendations. Site changes or advancements in scientific knowledge and engineering practices may affect the validity of this report. Consequently, a verification of validity by the signatory on this report may be required after the date of signature.

The analyses and recommendations submitted in this report are based in part on three subsurface borings, research and available literature, the results of field exploration and laboratory materials testing, and the results of engineering analysis. The nature and extent of variations across the site may not become evident until construction. If variations from the conditions documented in the geotechnical report are discovered prior to or during construction, it may be necessary to change some of the recommendations of this report. This investigation did not include assessment for the presence of potential environmental hazards or groundwater contamination, or the presence or absence of buried debris or structures.

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Attachment A

AMEC 2014 Geotechnical Study for Federal Emergency Management Agency (FEMA) Certification, Salina Levee System and B-01 Boring Log

GEOTECHNICAL STUDY FOR FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) CERTIFICATION

SALINA LEVEE SYSTEM
SALINA, KANSAS

Prepared for

The City of Salina
Salina, Kansas

Prepared by

AMEC Environment & Infrastructure, Inc.
Nashville, Tennessee
Topeka, Kansas

January 2014

AMEC FILE NO. 8-2750-00092

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1.0 INTRODUCTION

1.1 Why This Report Is Necessary

This report presents the results and conclusions of the geologic and geotechnical engineering study and evaluation performed by AMEC Environment & Infrastructure, Inc. (AMEC) for The City of Salina, Kansas. AMEC performed this study in support of the Federal Emergency Management Agency (FEMA) levee certification process for the Salina Levee System. This study generally conforms to FEMA guidance; United States Army Corps of Engineers (USACE) Engineering Circular (EC) 1110-2-6067 "*Certification of Levee Systems for the National Flood Insurance Program (NFIP),"* as applicable; and recognized industry standards.

The Code of Federal Regulations (CFR) Title 44 Section 65.10 (65.10) includes specific requirements relative to design and construction of levees for flood protection. According to the Section 65.10 Fact sheet, FEMA will only recognize "*…those levee systems that meet … minimum design, operation, and maintenance standards that are consistent with the level of protection sought through the comprehensive floodplain management criteria established by Section 60.3 of the NFIP regulations."* Section 65.10 describes the information FEMA requires to recognize that a levee system meets minimum design, operational, and maintenance standards that are consistent with providing protection from the base flood. FEMA defines the "base flood" as one that equals a flood having a 1-percent chance of occurrence in any given year. The levee owner/sponsor must supply this information to FEMA.

FEMA has established levee design criteria for levee freeboard, closures of penetrations through the levee, embankment (levee) protection, levee and foundation stability, settlement, interior drainage, and other design criteria. Additionally, FEMA requires Operations plans, including flood fighting, and Maintenance plans for the levees and their mechanical systems.

1.2 What Is Included In This Geotechnical Report

This geotechnical engineering report addresses CFR Title 44, Section 65.10, subsections (b) (4) embankment and foundation stability and (b) (5) settlement. The analyses evaluate seepage into or through the levee embankment and foundation and the effect upon embankment and foundation stability. The factors addressed in this report include:

- Embankment geometry and length of seepage path at critical locations;
- Embankment and foundation materials;
- Embankment strength characteristics;
- Other design factors affecting seepage (e.g., flood duration, drainage layers); and
- Other design factors affecting embankment and foundation stability (e.g., berms).

The report also includes analysis of the potential for, and magnitude of, future levee settlement.

1.3 What Is Not Included In This Geotechnical Report

This geotechnical report does not address certification tasks such as hydrologic analysis, hydraulic analysis, scour analysis, operations and maintenance manual review, electrical or mechanical aspects of the system, interior drainage analyses, evaluation of control structures, and evaluation of levee penetrations. These items are addressed in separate reports.

1.4 Non-Geotechnical Deficiencies

The hydrologic and hydraulic (H&H) analyses for FEMA certification indicated insufficient freeboard along portions of the levee. In these areas, the freeboard was increased by placing new fill along the levee crest. Prior to construction, we analyzed the proposed improvements' design from a geotechnical standpoint. We presented the results of our analyses in our Geotechnical Study for Levee Raising Project report, dated September 3, 2013. Section 6.7 of this report includes a summary of the analyses and construction performed for the levee raising project.

1.5 Previous Studies

AMEC previously completed a Phase I study for FEMA certification ("*City of Salina Phase I Levee Assessment and FEMA DFIRM Mapping Report*," dated February 1, 2010, file No 8275000059). The Phase I study included geotechnical concerns based upon a field levee walk performed on September 14 and 15, 2009. The findings and observations obtained during the Phase I assessment are summarized in Section 4.9.

2.0 FEMA 65.10 REQUIREMENTS

As part of FEMA's Map Modernization Program, it is the levee owner's or community's responsibility to provide data and documentation to show that a levee meets the requirements of Section 65.10 of the National Flood Insurance Program (NFIP) regulations. FEMA has separated the requirements of Section 65.10 into five categories:

- General criteria;
- Design criteria;
- Operations plans and criteria;
- Maintenance plans and criteria; and
- Certification requirements.

2.1 General Criteria

As mentioned above, FEMA will only recognize the levee systems that meet minimum design, operation, and maintenance standards that are consistent with the level of protection sought. Section 65.10 describes the types of information FEMA needs to recognize that a levee system provides protection to a Community from the base flood; that information must be supplied by the Community to FEMA. The FEMA review is solely to establish appropriate risk zone determination for NFIP maps.

2.2 Design Criteria

FEMA has established levee design criteria for levee freeboard, closures of penetrations through the levee, levee embankment protection, levee embankment and foundation stability, settlement, interior drainage, and other design criteria for the base flood event. The FEMA criteria evaluated as part of this geotechnical report are summarized in the following subsections.

2.2.1 Embankment and Foundation Stability

Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability.

The factors that shall be addressed in the analyses include:

- Depth of flooding;
- Duration of flooding;
- Embankment geometry and length of seepage path at critical locations;
- Embankment and foundation materials;

- Embankment compaction / consistency;
- Penetrations;
- Other design factors affecting seepage (e.g., drainage layers); and
- Other design factors affecting embankment and foundation stability (e.g., berms).

2.2.2 Settlement

Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum freeboard standards. This analysis must address:

- Embankment loads;
- Compressibility of embankment soils;
- Compressibility of foundation soils;
- Age of the levee system; and
- Construction compaction methods.

2.3 Certification

Data submitted to support that a given levee system complies with the requirements set forth above must be Certified by a Registered/Licensed Professional Engineer. Also, certified as-built plans of the levee must be submitted. Certifications are subject to the definition given in 44 CFR Section 65.2 of the NFIP regulations, as follows:

> *"§ 65.2 Definitions.*
> *(b) For the purpose of this part. A certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed or implied. Certification of data is a statement that the data is accurate to the best of the certifier's knowledge. Certification of analyses is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning.*
> *(c) For the purposes of this part, "reasonably safe from flooding" means base flood waters will not inundate the land or damage structures to be removed from the Special Flood Hazard Area* **(***SFHA***)** *and that any subsurface waters related to the base flood will not damage existing or proposed buildings."*

3.0 PURPOSE

The purposes of this geotechnical study were to evaluate the general soil conditions within the Salina Levee System and its foundation and to provide a geotechnical engineering evaluation of the stability of the levee system as well as an evaluation of seepage through and beneath the levees as a result of the base flood. The evaluation also included assessing the potential for and magnitude of future settlement. The geotechnical evaluation criteria used for the report is based on the requirements of FEMA 65.10 as outlined in Section 2.2.

3.1 Scope of Work

3.1.1 Geomorphology Review

The geomorphology review was performed to identify and map anomalous near-surface conditions (abandoned meanders, bars, etc.) created by past changes in watercourse and/or floodplain that could affect the integrity of the levee or its foundations.

3.1.2 Geotechnical Exploration

AMEC performed subsurface exploration to evaluate the subsurface conditions of the levee system. The current exploration program included conventional soil test borings using standard penetration tests (SPT) and cone penetration test (CPT) soundings. A more detailed discussion of the subsurface exploration is in Section 5.2 of this report.

3.1.3 Geotechnical Stability/ Seepage /Settlement Analyses

The stability and seepage assessments utilized existing data and data developed by this study to evaluate the slope and foundation stability of the subject system. We performed stability and seepage analyses at critical sections of the levee to evaluate foundation and embankment seepage and to develop the phreatic surfaces necessary to perform the various stability analyses. We performed slope stability analyses of levee embankments utilizing limit equilibrium stability analysis methods in accordance with the methodology outlined in USACE Engineering Manual (EM) 1110-2-1913 for existing levees. AMEC analyzed the critical cross sections for each of the following cases:

- Case A: Long term at normal stage (land and river side)
- Case B: Long term at base flood stage (land side)
- Case C: Sudden draw-down (river side)

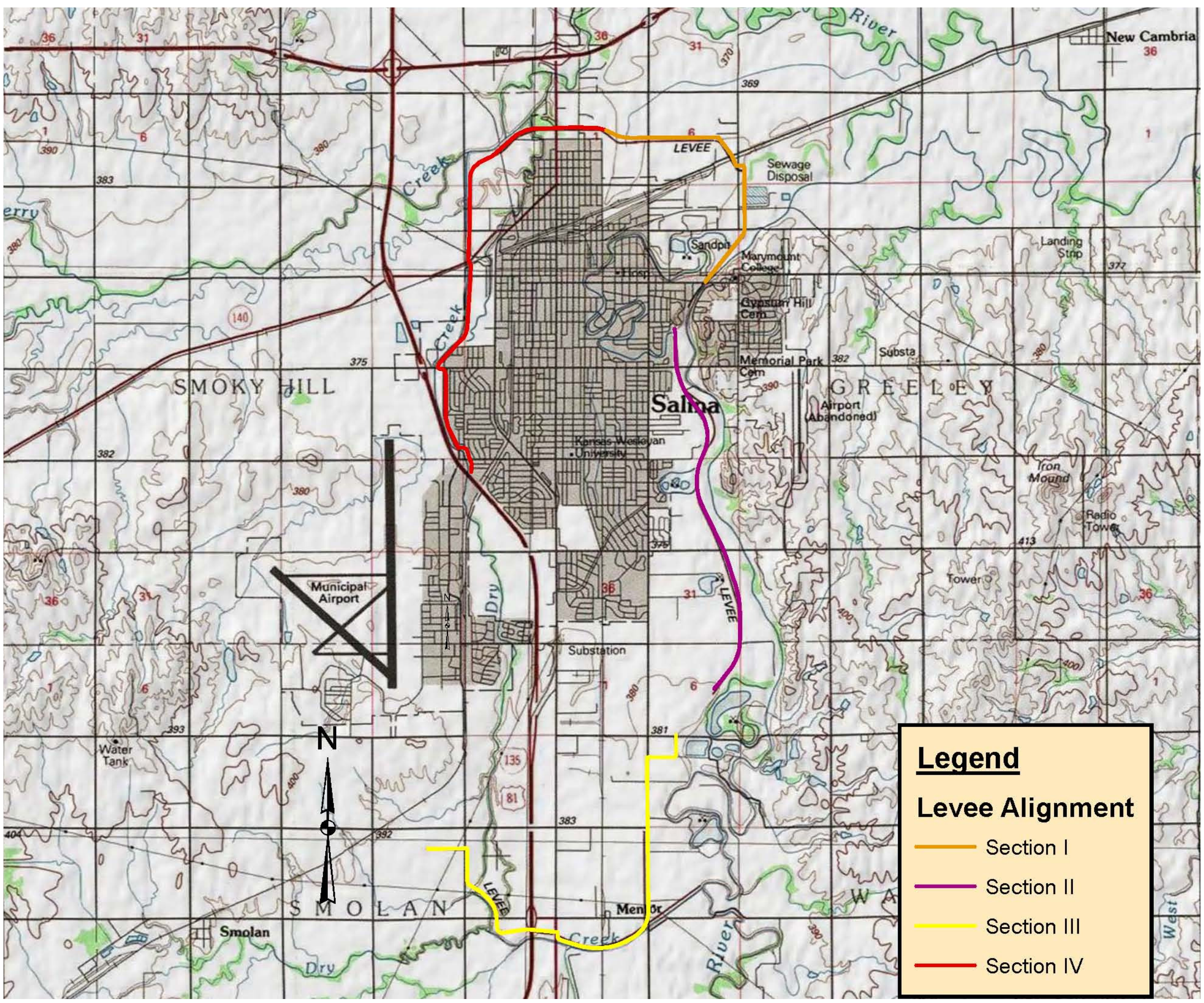
Additionally, AMEC evaluated critical earthen levee sections for potential settlement.

4.0 DESCRIPTION OF THE SALINA LEVEE SYSTEM

4.1 General

The City of Salina owns and operates the Salina Levee System, which is in Saline County, Kansas. The levee system is currently in the USACE Levee PL 84-99 program. The levee system provides protection from flood events on the Smoky Hill River, the Saline River, Dry Creek, and Mulberry Creek (see Figure 4-1 below and Site Plan in Attachment 1).

Figure 4-1 Map of Levees



Base Map Source: USGS Salina and Salina SW Quadrangle Maps

The Operation and Maintenance (O & M) Manual indicates that the USACE completed the construction of the Salina Levee System in June 1961. The USACE constructed the three levees in four sections (Sections I – IV) as shown in the above figure. Table 4-1 provides the limits and lengths for each levee section. We note that approximately one mile of levee embankment within Section IV was constructed by The City of Salina prior to USACE construction.

Table 4-1 Levee Sections

Levee Section*	Levee Name	Station		Length (miles)
		From	To	
I	North Levee	548+00	711+60	3.1
II	East Levee	-0+70	224+50	4.3
III	South Levee	259+00	545+00	5.4
IV	North Levee	1+00	19+42	5.3
		19+42**	96+90**	
		343+00	548+00	

* Levee Sections I and IV are both part of the North Levee.
** This reach was constructed by City of Salina and is not part of USACE program.

The combined length of the levee system is about 18 miles. The levees are composed of earthen embankments; no floodwalls are included in the system. Other features of the flood protection project include an improved channel for a portion of the Smoky Hill River, a diversion channel for Dry Creek, channel improvements for portions of Dry and Mulberry Creeks, 2 stormwater pumping plants, 8 sandbag gaps, and 23 drainage structures for removal of interior drainage.

The City of Salina is located near the confluences of the Saline and Smoky Hill Rivers. The Smoky Hill River flows in a northerly direction along the east side of Salina towards the mouth of the Saline River. The Saline River flows in an easterly direction along the north side of the city before emptying into the Smoky Hill River. Dry Creek and Mulberry Creek also flow along the perimeter of Salina. Dry Creek is a tributary of Mulberry Creek, which flows into the Saline River north of Salina.

4.2 Summary of Reviewed Documents

Documents reviewed for this study include the following tabulation of USACE and City documents:

Table 4-2 Background Documents

Document No.	Document Title	Document Description	No. Pages	Date
1	Design Memorandum No. 1	Design memorandum for flood protection project in Salina, Kansas	150	February 1958
2	Design Memorandum No. 2	Design memorandum for pumping plants in Salina, Kansas	29	July 1959
3	Operation and Maintenance Manual	O&M Manual for Salina's Flood Protection Project	136	1962
4	Record Drawings	As-built drawings for Sections I though IV of Salina's Flood Protection Project	79	1956 - 1959
5	Reconnaissance Report	USACE's Study on level of flood protection provided by flood control works	344	July 1997
6	Memorandum For Record	USACE's recommendations for repairing levee crest cracking between Station 451+00 and 485+34	8	September 2010
7	Sta 90+00 Holmquist.pdf	Multiple letters from USACE to City concerning relief wells at Sta. 90+00. Also includes relief well drawings.	16	1966 - 2008
8	Levee Crest Cracking	Memorandum from USACE that details cracking along north levee and provides repair recommendations	8	September 2010
9	Various E-mails	Multiple e-mail correspondences between USACE and City concerning levee cracking	N/A	2008 - 2011
10	City of Salina Phase I Levee Assessment and FEMA DFIRM Mapping Report	AMEC Phase 1 Report of Preliminary Levee Assessment	113	February 2010

4.3 Levee Embankments

The Salina Levee System consists of four sections of earthen levee averaging about 10 feet in height. The USACE documents indicate that the levee embankments were designed with a 10-foot wide crest and 3:1 (horizontal: vertical) riverside and landside slopes. The design also included stability berms strategically situated along the levee. Our field observations are consistent with the design geometry shown on the drawings. There are eight sand bag closures located along the levee system; four at roadway crossings and four at railroad crossings. The Record Drawings indicate that a concrete sill is located within the levee embankment beneath the railroad crossings. The sill is about 12 inches wide and extends to a depth of about 3 feet.

4.4 Flood Walls

No floodwalls are included in the levee system design.

4.5 Penetrations

The Salina Levee System includes 23 drainage pipes that penetrate the levee for interior drainage. A summary of the location and diameter of these structures is included in Table 4-3. Twenty-one of the structures are listed in the O & M Manual and Record Drawings, and two additional penetrations were observed during our Phase I site reconnaissance. Detailed inspection and analyses of the structures is beyond the scope of this geotechnical report. AMEC discusses these structures in detail in another, separate report.

Table 4-3 Levee Penetrations

No.	Levee	Station	Size	Type	Closure
1	East	0+00	54-inch	RCP	sluice gate
2	East	27+99	30-inch	RCP	sluice & flap gate
3	East	44+18	42-inch	RCP	sluice & flap gate
4	East	83+59.5	78-inch	RCP	sluice & flap gate
5	East	107+55	42-inch	RCP	sluice & flap gate
6	East	130+99	42-inch	RCP	sluice & flap gate
7	East	175+00	24-inch	RCP	sluice & flap gate
8	East	213+00	24-inch	RCP	sluice & flap gate
9	South	376+35	24-inch	RCP	sluice & flap gate
10	South	408+05	12-inch	CMP	flap gate
11	South	491+00	24-inch	RCP	sluice gate
12	North	58+65[(1)]	5-ft by 5-ft	RCB	sluice & flap gate
13	North	343+00[(1)]	78-inch	RCP	sluice & flap gate
14	North	364+33.5	78-inch	RCP	sluice & flap gate
15	North	506+92	78-inch	RCP	sluice & flap gate
16	North	547+60	24-inch	RCP	sluice & flap gate
17	North	562+30	42-inch	RCP	sluice & flap gate
18	North	574+92	24-inch	RCP	sluice & flap gate
19	North	614+05	24-inch	RCP	sluice & flap gate
20	North	626+40	24-inch	RCP	sluice & flap gate
21	North	631+80.5	36-inch	RCP	sluice & flap gate
22	North	661+37.5	24-inch	RCP	sluice & flap gate
23	North	685+50	78-inch	RCP	sluice & flap gate

(1) Drain not noted in O&M Manual or Record Drawings. Observed during site reconnaissance.

The Record Drawings indicate that 20 of the 21 listed penetrations were constructed with at least one seepage collar. Drainage pipes over 55 feet long have 2 seepage collars. The seepage collars consist of No. 12 gauge corrugated metal continuously connected to the perimeter of the pipes. The seepage collars extend to about 3 feet beyond the perimeter of the pipes. The CMP at Station 408+05 (South Levee) does not include a seepage collar. We are unaware if construction of the two drainage pipes not listed in the Record Drawings included a seepage collar(s).

4.6 Pump Stations

The Salina Levee System includes two pump stations for removal of interior surface drainage. The pump stations are located at Stations 506+92 and 685+50 along the North Levee. The pumping equipment is housed in operating houses at the landside toe of the levee. The operating houses are supported by reinforced concrete substructures (pumping pits) bearing on underlying alluvial soils. The pump stations are fed by gravity drains carrying runoff from nearby ponding areas. During low river stages, the gravity drains flow past the pump stations and under the levee to the creek/river. During high river stages, the drains' sluice gates are closed and flow is diverted into the pumping pits. The pumping equipment removes flow from the pump pit and discharges into the riverside gatewell. Detailed inspection and analyses of these structures is beyond the scope of this geotechnical report. The pump stations are discussed in more detail in other sections of the certification report.

4.7 Closures

The USACE Record Drawings indicates that there are eight sandbag closures for various road and railroad crossings. Table 4-4 provides the locations of these closures. As previously mentioned, the railroad closures include a concrete sill constructed within the embankment.

Table 4-4 Sandbag Closures

Location	Levee Section	Station
State Street	Section IV	402+17
Union Pacific R.R.	Section IV	409+47
W. Kansas Highway 140	Section IV	410+27
Kansas & Oklahoma R.R.	Section IV	415+97
North 9th Street	Section IV	520+22
E. Old Highway 40	Section I	627+00
Union Pacific R.R.	Section I	628+75
Union Pacific R.R.	Section I	660+95

4.8 Relief Wells

We observed three relief wells between Stations 92+00 and 95+00 during our site reconnaissance. These wells are not listed in either the Record Drawings or the O&M Manual. We reviewed the information provided by the City concerning the relief wells (Document No. 7). We understand that the relief wells were installed by the City in 1987 at the request of the USACE. The USACE requested the installation of the wells to reduce the water pressures in the area of an existing sand pit that is about 350 feet from the landside toe of the levee. The sand pit was apparently excavated in the 1960's, after levee construction. Excavation at the sand pit apparently stopped around 1970 and the pit was converted to a pond, which is now surrounded by residential properties.

The relief wells are located at about 150-foot spacing along the landside toe of the levee. The drawings indicated that the12-inch diameter wells consist of either 40 feet or 22 feet of casing, depending on location, and 10 feet of screen. The area surrounding the screen was backfilled with sand. The well boreholes extended at least two feet below the screen to contact a clay layer or bedrock at the bottom of the aquifer. The area between the bottom of the borehole and the casing was filled with a gravel pack. The relief wells discharge into manholes below the ground surface. The manholes are connected by 12-inch diameter manifold pipe that empties into a nearby drainage ditch.

The provided documents indicate that the relief wells were pump tested in 2008. We have not been provided with the details of the testing. However, a letter from the USACE dated May 14, 2008 indicates that the pump test results met the minimum 80% efficient requirements. The letter also states that reduced water pressures were observed in an observation well adjacent to the sand pit during the pump testing.

4.9 Phase I Levee Assessment

AMEC's Phase I study identified some areas of concern relative to geotechnical engineering aspects of the levees that include specific details of the corrective actions and recommendations.

- We observed some longitudinal cracking along the levee crest between approximate Stations 450+00 and 485+00. The USACE's September 2010 memorandum indicates that the levee crest through this reach was used as a haul road for a construction project in 2008. The observed cracking developed through this reach within several months after construction and after a two-week period where Salina received about six inches of rainfall. The USACE concluded that the cracking was caused from hauling along levee crest, which had experienced desiccation cracking prior to being used as a haul road. The USACE recommended removing the soils along the levee crest to a depth of two feet. The undercut subgrade was to be scarified to a depth of six inches and recompacted. The undercut soils could then be reused as fill to bring the levee embankment to the required finished grade. The provided e-mail correspondence between the City and the USACE indicates that the City completed these repairs during the summer of 2011. The USACE performed an inspection of the area in September 2011 and concluded that the repairs were in accordance with the USACE plans and specifications.
- We observed several utility pole and guy wire encroachments within the 15-foot exclusion zone landward from the toe of the levee. In some cases, the guy wires were penetrating the levee slope itself. In a storm event, it is possible that strong winds could cause the poles to rotate, fall, and pull out anchors, which may compromise the embankment stability. These encroachments are maintenance issues that do not affect certification from a geotechnical standpoint. However, the O

& M Manual should be updated to include inspection of these encroachment areas during flood events.

- We observed several animal burrows at isolated locations along the levee. We were unable to verify the extent of the burrows; however, they appear to penetrate relatively deep into the levee. The City should inspect the levees regularly and repair all animal burrows promptly. Animal burrows in areas with no signs of embankment distress should be backfilled with low-permeability impervious material or cementious grout. Animal burrows with signs of embankment stress surrounding a burrow may signify massive soil movement and require complete removal of the burrow by excavation. The excavation should be properly backfilled and compacted in a timely manner. Re-vegetate disturbed areas after compaction of the subgrade soil.
- We observed isolated woody vegetation within levee exclusion zone. These encroachments are maintenance issues that do not preclude certification from a geotechnical standpoint. However, we recommend removing the trees in accordance with USACE guidelines. In the meantime, The City should update the O & M Manual to include regular inspection of encroachment areas and removal of woody vegetation.

4.10 USACE's Reconnaissance Report

We reviewed the USACE's Reconnaissance Report (July 1997), which documented their flood damage reduction study for the City of Salina. The purpose of the study was to evaluate the level of flood protection for the existing flood control works at Salina. The study included hydraulic analysis, hydrologic analysis, geotechnical analysis, and a survey of the levee crest. The geotechnical analysis consisted of performing risk-based analyses to determine the geotechnical risk of levee failure. The USACE used subsurface and laboratory information from the Design Memorandum to assess the geotechnical uncertainties and probability distributions for a typical levee cross section. The USACE concluded that that the levee has a greater than 85% probability of withstanding water to a height equal to the levee crest. We note that the levee crest survey indicated that portions of the levee had experienced up to six inches of settlement since construction.

5.0 GEOTECHNICAL STUDY

AMEC performed field explorations and laboratory testing to gather data for the engineering analyses required by FEMA to demonstrate that seepage through the levee foundation and embankment will not jeopardize embankment or foundation stability.

5.1 Exploration Location Selection

AMEC chose exploration locations for the subsurface exploration to explore critical areas observed during Phase I of the certification program and our review of the historical documents. We also selected exploration locations between these critical areas to enhance the spatial distribution of information. During the historical data review, we noted that that the construction documents called for the removal of all meander deposits beneath the levee alignment. We selected some boring locations based upon apparent irregularities (or sag) in the levee crest that could indicate the presence of soft, compressible soils in the subsurface. In some cases, the depressed levee crests coincided with buried/abandoned river channel meanders that crossed the levee alignment; therefore, we selected some boring locations to evaluate the success of the meander deposit removal. We also explored areas where we observed sloughing and irregular levee geometry.

5.2 Field Explorations

AMEC conducted field exploration activities in 2011 to assess the geotechnical conditions of the study area. The exploration consisted of completing 68 soil test borings and 86 Cone Penetration Test (CPT) soundings. The Exploration Location Plans in Attachment 1 show the approximate exploration locations. We note that there was one planned boring (Boring B-45) and six planned soundings (Soundings, S-26, S-76, S-83, S-87, S-89, and S-90) that we could not perform due to access issues.

The borings and soundings were performed along either the levee crest, the landside toe, or the riverside toe. Exploration depths along the crest ranged from 15 to 55 feet in depth beneath the existing ground surface and averaged about 34 feet in depth. Each of the borings and soundings along the levee toe was terminated at a depth of about 20 feet.

AMEC's drilling subcontractor advanced the soil test borings using a combination of hollow-stem auger and wash boring techniques. The drillers sampled the soil using Standard Penetration Test (SPT) techniques in general compliance with ASTM D 1586. They also obtained undisturbed samples with a thin-walled sampler (ASTM D1587). After reaching the termination depth, the borings were backfilled with Bentonite-cement grout to near ground surface and topped with on-site soil material.

AMEC's CPT subcontractor performed the CPT soundings by pushing a probe with a cone tip through the soil at a constant rate in accordance with ASTM D 5778. Sensors in the probe measure tip resistance, friction, and pore pressures during advancement. We used the values obtained from these measurements to estimate soil type, strength, and other characteristics using CPeT-IT software by GeoLogismiki. Because the CPT soundings do not include obtaining soil samples, we correlated the soundings with the borings by performing a boring adjacent to about every fifth CPT sounding.

An experienced AMEC geologist supervised the exploration operations, logged the explorations, and prepared the samples for subsequent examination and laboratory testing. Where possible, AMEC visually classified earth materials the field in general accordance with the Unified Soil Classification System and ASTM D2488. We have included Boring Logs and CPT Logs in Attachment 2.

5.3 Laboratory Testing

AMEC obtained soil samples at intervals as shown on the logs and we tested selected specimens in our geotechnical laboratory. Soil classification tests included particle size analysis, specific gravity determination, moisture content determination, and Atterberg limits; engineering properties tests included direct shear, consolidation tests, and permeability tests. We have included laboratory test results in Attachment 3.

5.4 Surface and Subsurface Conditions

5.4.1 Surface Conditions

During our site visit, we observed that the surface of the levee embankment is vegetated with turf type grass. We note that portions of the levees' crest are covered with crushed stone gravel. The levee owners mowed most of the grassed surfaces on the levee embankments and adjoining grounds (within 15 feet of the levee) prior to the exploration. We judge the surface drainage of the levees to be good (crest surface slopes slightly downward from the centerline); we observed no wet areas, puddles, or water stained depressions on the levee during our exploration.

5.4.2 Subsurface Conditions

The borings initially encountered a thin veneer of topsoil and grass roots or crushed stone gravel, each averaging about six inches thick. Underlying the topsoil and/or crushed stone gravel, we encountered fill materials in the crest borings. We also encountered fill materials at six of the toe borings. The fill, which was used to construct the levees, extended to depths between 2½ feet and 35 feet beneath the existing ground surface. The fill had an average thickness of about 11 feet along crest and about 5 feet at the levee toe. The fill was generally composed of firm to stiff, silty clays and clayey silts. Beneath the fill interval and below the topsoil at the remaining toe borings, the borings generally encountered clay, silt, and sand alluvium to the boring termination depth. The clays and silts were generally firm to stiff in consistency with occasional very soft to soft layers. The sands were generally encountered beneath the clays and silts and were loose to medium dense.

AMEC's explorations detected, and the USACE record drawings confirm, a distinct lower permeability blanket of soil overlying a sand aquifer interval. The blanket materials consisted of silt, sandy silt, clay, and sandy clay. The alluvium also includes lenses and isolated intervals of silty sand within the blanket interval.

We advanced each of the borings and soundings to planned termination depths, except for Sounding S-1. This sounding encountered refusal at a depth of about 15 feet. We believe the refusal encountered at this sounding was due to rock fragments within the levee embankment fill and not due to the underlying bedrock surface. None of the other soundings or borings encountered refusal (the point where conventional augering or CPT techniques do not advance the hole).

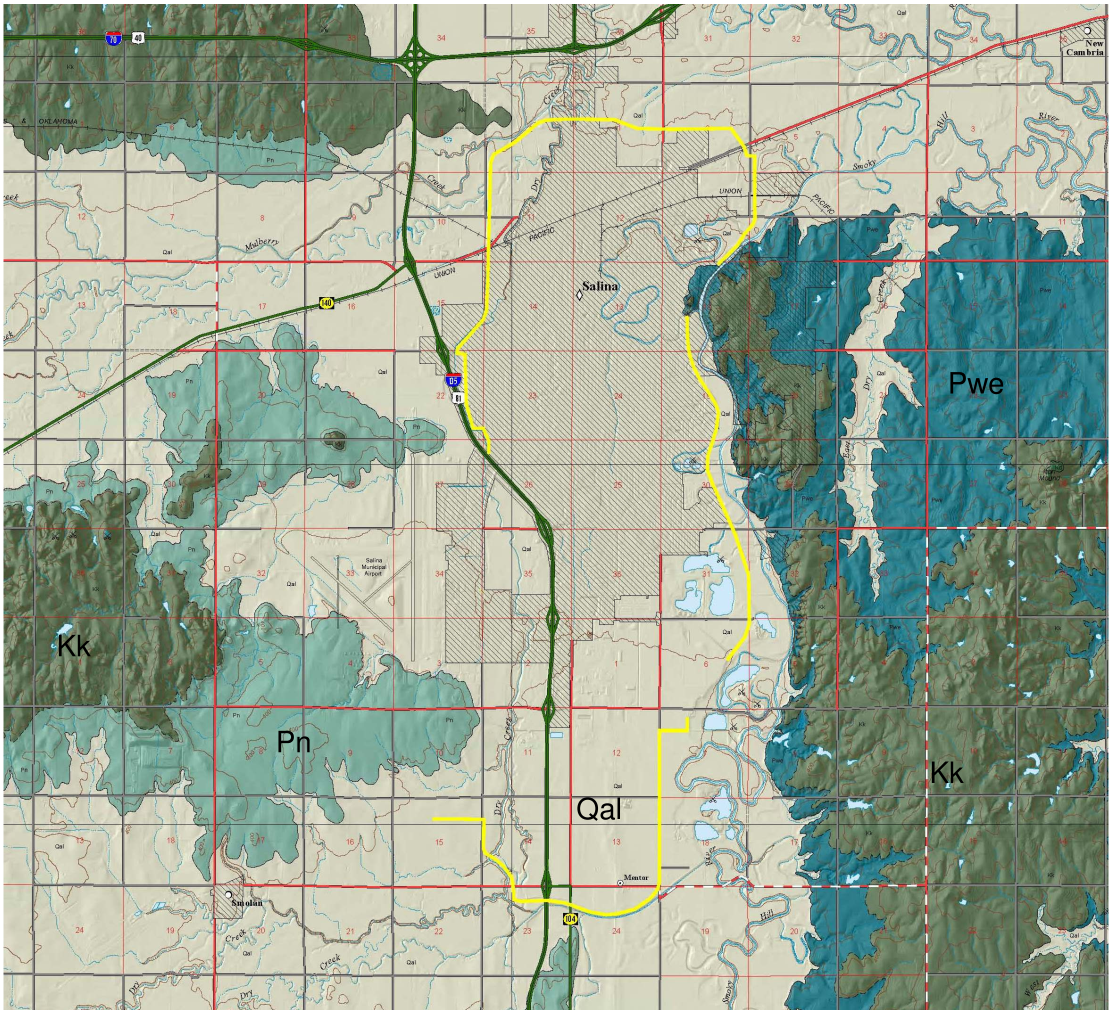
5.4.3 Groundwater Conditions

We detected groundwater at 24 of the 68 borings ranging from about 19 feet to about 42 feet below the existing ground surface (average of about 28 feet). We did not install monitoring wells nor allow time for water to accumulate in the borings for accurate groundwater readings. Therefore, the reader should consider the water level readings approximate. Furthermore, groundwater conditions vary depending upon seasonal changes and periods of drought or excess precipitation.

5.5 Geologic Setting

Publically available geologic literature shows that the Salina Levee System is founded on unconsolidated alluvial deposits that filled a shallow valley with low relief. Figure 5-1, is a geologic map of the project area in Salina.

Figure 5-1 Geologic Map



Legend
Qal – Alluvium or Terrace Valley Fill (tan)
Kk – Kiowa Formation (olive)
Pn – Ninnescah Shale (aqua)
Pwe– Wellington Formation (blue)
(From Surficial Geology of Saline County, Kansas Map, Kansas Geologic Survey Map M-123, 2011)

According to the Kansas Geological Survey, the Salina Levee System is underlain by undifferentiated floodplain alluvium (Qal). The referenced geologic map indicates that the floodplain deposits contain mostly clay, silt, sand, and gravel and is up to 60 feet thick. We presume that the Wellington Formation most likely lies beneath the alluvial deposits. According to the Kansas Geological Survey, the Permian-aged Wellington Formation consists primarily of gray and bluish-gray shale with beds of anhydrite, gypsum, and limestone.

6.0 GEOTECHNICAL ANALYSES

6.1 Selection of Critical Cross Sections

We divided the levee system into reaches with similar geometry and subsurface conditions. We then selected a cross section within each reach to represent a critical case scenario based upon the observed conditions. The critical aspects of the reach might include areas with the steepest slopes, highest slopes, narrowest portions of the levee, thinnest landside blanket, surficial anomalies, areas of scour or erosion, encroachments or impingements to flow, buried meanders, weak soil intervals, landside ditches, and inclusions of deleterious materials (wood, gravel beds, etc.). The table below summarizes the cross sections used in the analyses performed by AMEC.

Table 6-1 Critical Sections

<table>
<tr><th>Section No.</th><th>Critical Station</th><th>Levee</th><th colspan="2">Limits of Reach</th><th>Section No.</th><th>Critical Station</th><th>Levee</th><th colspan="2">Limits of Reach</th></tr>
<tr><td>1</td><td>64+00</td><td>East</td><td>-(0+70)</td><td>78+50</td><td>10</td><td>68+00</td><td>North</td><td>1+00</td><td>343+00</td></tr>
<tr><td>2</td><td>91+65</td><td>East</td><td>78+50</td><td>134+00</td><td>11</td><td>379+20</td><td>North</td><td>343+00</td><td>410+00</td></tr>
<tr><td>3</td><td>167+00</td><td>East</td><td>134+00</td><td>178+00</td><td>12</td><td>439+55</td><td>North</td><td>410+00</td><td>457+62</td></tr>
<tr><td>4</td><td>211+90</td><td>East</td><td>178+00</td><td>224+50</td><td>13</td><td>484+50</td><td>North</td><td>457+62</td><td>520+00</td></tr>
<tr><td>5</td><td>34+30</td><td>East</td><td colspan="2">Old meanders along east levee</td><td>14</td><td>544+80</td><td>North</td><td>520+00</td><td>600+00</td></tr>
<tr><td>6</td><td>338+40</td><td>South</td><td>259+00</td><td>375+00</td><td>15</td><td>665+55</td><td>North</td><td>600+00</td><td>690+00</td></tr>
<tr><td>7</td><td>447+40</td><td>South</td><td>375+00</td><td>452+00</td><td>16</td><td>696+80</td><td>North</td><td>690+00</td><td>711+60</td></tr>
<tr><td>8</td><td>491+30</td><td>South</td><td>452+00</td><td>493+00</td><td>17</td><td>685+50</td><td>North</td><td colspan="2">Smoky Hill Pumping Plant</td></tr>
<tr><td>9</td><td>494+50</td><td>South</td><td>493+00</td><td>545+00</td><td>--</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
</table>

For each of the critical sections, we estimated the subsurface conditions using the boring and CPT information from our subsurface exploration and the subsurface information provided in the Record Drawings.

6.2 Geomorphology

AMEC examined soil test boring results, historical documents, and maps and found no evidence within the interval explored that significant defects or anomalies remain from previously mapped meanders or bars created by past changes in watercourse and/or floodplain that could affect the integrity of the levee or its foundations.

6.3 Soil Engineering Parameters

Our findings from the exploration and laboratory work indicate that the soils used to construct the levees consisted of a mixture of silt and clay with varying amounts of sand. We also found these soils within the levee foundation. The soil consistency was slightly variable both between adjacent borings and vertically within a single boring. As noted in Section 5.4, some isolated borings encountered very soft to soft silts and clays within the levee foundation.

We derived engineering parameters for the soil intervals used in the seepage and stability analysis from laboratory analysis as well as estimates from published correlations or applicable USACE manuals and methods. We used the soil parameter values in Table 6-2 in our geotechnical analyses. We used laboratory testing for estimating the strength and hydraulic conductivity properties of embankment fill and clays. For sands, we used published correlations to estimate strength properties based on N-values, and we estimated hydraulic conductivity using D_{10} values and Figure 3-5b of EM 1110-2-1913. We used the data from our boring logs and CPT soundings to estimate the remaining soil parameters using published correlations.

In addition to the values indicated in the table below, we also used a ratio of vertical permeability to horizontal permeability of K-Ratio = 1 (k_{sat} horizontal is 1 times k_{sat} vertical) for the fill and alluvial soil at the site. To model seepage conditions within the levee and the underlying soils, it is necessary to estimate both the volumetric water storage capacity (volumetric water content versus soil suction) and the unsaturated hydraulic conductivity of these soils. The unsaturated hydraulic conductivity curves were estimated by the SEEP/W program based on typical water storage capacity curves and on methodology presented by Fredlund et al (1994).

Table 6-2 Soil Parameters

Soil Type	Moist Unit Weight, γ_m(pcf)	Friction Angle (°)		Cohesion (psf)	
		Effective, Φ'	Total, Φ	Effective, c'	Total, c
Embankment Fill (Clay and Silt, with occasional sandy clay/silt)	125	30	0	0	1000
Clay	120	30	0	50	500
Sandy Silt	120	30	0	0	500
Soft Silt/Clay	110	25	0	0	250
Silty Sand	120	30	30	0	0
Sand	120	33	33	0	0

Soil Type	Permeability, K_{sat} (cm/s)	Permeability, K_{sat} (ft/D)	Volumetric Content, Θ_s (ft^3/ft^3)
Embankment Fill (Clay and Silt, with occasional sandy clay/silt)	1×10^{-6}	2.83×10^{-6}	0.38
Clay	1×10^{-7}	2.83×10^{-4}	0.38
Sandy Silt	1×10^{-5}	2.83×10^{-2}	0.38
Soft Silt/Clay	1×10^{-5}	2.83×10^{-2}	0.38
Silty Sand	5×10^{-4}	1.42	0.51
Sand	5×10^{-2}	142	0.30

6.4 Seepage

We performed seepage analyses at the 17 critical sections using finite element methods. We performed the analyses using Geo-Slope International's Seep/W (version 7.21), a part of the GeoStudio 2007 suite of geotechnical software and in general accordance with the EM 1110-2-1913 *Design and Construction Levees*.

We initially evaluated the seepage characteristics of the critical sections using a steady state condition. For the steady state condition, the model assumes that the boundary conditions (i.e., floodwaters) have been in place for an infinite amount of time and will remain in that state in the future. Therefore, steady state analyses are generally highly conservative for levee embankments due to the relatively short flood duration. At three of our critical sections (Section Nos. 5, 8, and 17), our steady state analyses indicated excessive exit gradients at the bottom of ditches on the landside of the levee. However, the stage-duration hydrographs developed for the H & H study of this project indicate that the flood durations are relatively short for the Smoky Hill River and Dry Creek (less than one week). Therefore, we performed transient analyses at these sections to model flood stage versus time. Transient analysis models are more difficult to develop and take longer to analyze and interpret, but the results are generally considered more realistic. The transient models allow the water level to rise from normal stage to flood stage then recede to normal stage over a period of time. The time period of the analysis is subdivided into increments and the changes in phreatic surface, head, gradient, etc. are computed for each time period in each mesh element of the model. Our transient analyses, based on the provided hydrographs, indicate that seepage characteristics do not approach steady state conditions for the base flood event at the sections analyzed.

The steady state and transient models allowed seepage to pass through the entire cross section of the levee and its foundation soil. We reviewed total head contours beneath the ground surface to find the total head beneath the upper landside blanket of silt and clay materials. We then calculated the maximum exit gradient by dividing the total head loss at the levee toe by the height of the flow path (i.e., blanket thickness). The following equation was used to determine the vertical gradients:

$$i = \frac{\Delta H}{L}$$

where; i = vertical gradient, ΔH = total head loss, and L = height of flow path.

USACE's EM's allows a maximum exit gradient, $\boldsymbol{i_{max} = 0.50}$ to be used as acceptance criteria for seepage exiting the toe of the levees; that value corresponds to a factor of safety of about 1.6. Each of the modeled critical sections we selected produced maximum exit gradients less than 0.50. A summary of the seepage analyses results is included in Table 6-3. The seepage analyses results are included in Attachment 4.

Table 6-3 Seepage Results

Summary of Seepage Analyses			
Critical Section(1)	**Base Flood Elevation**(ft MSL)	**Levee Crest Elevation**(ft MSL)	**Exit Gradient** i_{max} (2)
1	1234	1244	0.33
2	1235.5	1244.5	0.14
3	1241	1248.5	0.14
4	1242.5	1551	0.02
5	1232.5	1243	0.33(3)
6	1255.5	1263.5	0.23
7	1266.5	1271.5	0.29
8	1266.5	1270.5	0.13(3)
9	1266.5	1271	<0.01
10	1230.5	1239	0.35
11	1229.5	1233	<0.01
12	1226.5	1231.5	<0.01
13	1225.5	1230.5	0.08
14	1216.5	1224	0.11
15	1216	1225.5	0.25
16	1217.5	1228	0.11
17	1217	1227	0.03(3)

(1) See Table 6-1 for critical section locations.
(2) Maximum exit gradient based upon seepage at landside toe of levee.
(3) Maximum exit gradient calculated from transient seepage analysis.

We note that the O&M Manual indicates that landside ponding is required in the approach channel of the Smoky Hill Pumping Plant. The required ponding elevation is elevation 1200 feet. We note that we considered this ponding elevation during completion of geotechnical analyses.

6.5 Slope Stability

We also performed slope stability analyses at the 17 critical sections mentioned in Section 6.1. We used Geo-Slope International's Slope/W (version 7.21), a part of the GeoStudio 2007 suite of geotechnical software, to analyze slope stability in general accordance with EM 1110-2-1913 and EM 1110-2-1902 *Slope Stability*. We used the Morgenstern-Price limit equilibrium method, which produces a circular failure surface, at each critical section. We then used the software to optimize each failure surface. We used EM 1110-2-1913 as criteria for minimum acceptable factor of safety for the existing levees (see Table 6-4).

Table 6-4 Slope Stability Requirements

Type of Slope	Applicable Stability Conditions and Required Factors of Safety		
	End-of-Construction	Long-Term Flood Stage	Sudden Drawdown[1]
Existing Levees	-N/A-	1.4	1.0 to 1.2
Other Embankments and dikes	1.3	1.4	1.0 to 1.2

AMEC analyzed a two-dimensional representation of the levee's critical cross sections. We analyzed three cases at each critical cross section of the levee. Initially, we analyzed the existing slope geometry landside and riverside at normal stage (Case A) to assess the validity of the soil strength parameters and geometry of the models. Then, we analyzed two critical cases (Cases B and C) to assess their compliance with the specified minimum acceptance criteria.

Case A represents the existing condition with no flood (normal stage). Case B represents the condition of the peak phreatic surface at the end of the base flood stage. Case C represents sudden drawdown from maximum base flood stage to normal stage. To analyze a sudden drawdown condition, we used the Staged Undrained Strength Method proposed by Duncan, Wright, and Wong (1990) per Geo-Slope's built-in procedure. We note that we used a minimum factor-of-safety of 1.0 for the sudden drawdown condition because of the short duration of the base flood event.

AMEC's slope stability analyses indicate that the levees exceed the required minimum required factor of safety at the critical sections. A summary of the slope stability analyses results is included in Table 6-5. The slope stability analyses results are included in Attachment 4.

[1] Sudden drawdown analyses. F. S. = 1.0 applies to stage levels prior to drawdown for conditions where these water levels are unlikely to persist for long periods preceding drawdown. F. S. = 1.2 applies to stage level, likely to persist for long periods prior to drawdown.

Table 6-5 Slope Stability Factors of Safety

Critical Section	Case A: *LT Normal Stage*		Case B: LT FS LS	Case C: SDD RS
	LS	*RS*		
Required	***1.4***	***1.4***	***1.4***	***1.0***
1	1.77	1.77	1.77	1.77
2	1.76	1.76	1.54	1.32
3	1.76	1.76	1.51	1.68
4	1.78	1.77	1.77	1.77
5	1.79	1.78	1.77	1.77
6	1.78	1.79	1.65	1.57
7	1.78	1.78	1.61	1.47
8	1.77	1.78	1.77	1.28
9	1.74	1.76	1.43	1.59
10	1.81	1.76	1.81	1.44
11	2.55	1.80	2.53	1.20
12	1.80	1.82	1.67	1.08
13	1.79	1.80	1.67	1.80
14	1.77	1.78	1.72	1.78
15	1.76	1.76	1.75	1.76
16	1.77	1.75	1.74	1.61
17	1.77	1.77	1.77	1.11

SDD - Sudden Drawdown; LT – Long Term;FS – Flood stage;
RS – Riverside; LS - Landside

6.6 Settlement

AMEC performed settlement analysis for this project following the procedures outlined in USACE Engineering Manual EM 1110-1-1904 Settlement Analysis.

The levees' foundation is predominantly composed of a blanket of clay and silt overlying a relatively thick sand aquifer. AMEC analyzed these materials for primary and secondary settlement due to the added load from the levee. Based upon the Boussinesq Method, AMEC estimated the total primary and secondary settlement of the clay blanket interval underlying the levee is about five inches with primary consolidation being essentially complete after about 21 years (the levee is currently more than 50 years old). Based upon the Schmertmann Method, AMEC estimated the total potential settlement of the sandy aquifer interval underlying the levee is less three inches. Therefore, we conclude that total settlement is about eight inches over the life of the levee. However, based upon published information, we consider settlement of sand to be immediate; therefore, settlement of the sand aquifer was complete by the end of construction in 1961. We project additional settlement over the next 10 years to be negligible.

6.7 Levee Raising Project

As mentioned in Section 1.4, the H&H analysis for FEMA certification indicated that two areas along the Salina Levee System did not meet freeboard requirements. Therefore, a levee raising project was performed to increase freeboard at two sites along the north levee. These two sites are between Sta. 382+85 and 408+90 and between Sta. 512+40 and 519+65 (total length is 3,330 feet). The freeboard increase was generally less than ½-foot, with a maximum increase of about 2 feet. The freeboard was increased by placing new fill along the levee crest. New fill was also placed along the landside and riverside slopes of the levee to maintain the levee's crest width at about 10 feet. The new fill slopes were constructed at 3H:1V.

As part of the project, we performed a geotechnical study to evaluate the general soil conditions within the project area and to provide geotechnical engineering evaluation of the stability of the embankment as a result of the planned construction. The evaluation also included assessing the potential for and magnitude of future settlement. For this study, we used the boring and laboratory testing information obtained from the FEMA certification study (Section 5.0). The slope stability and seepage analyses indicate that the levees exceed the required minimum factors of safety at the analyzed critical sections. Our settlement analysis indicated that less than one inch of settlement may occur within 10 years of construction due to placement of up to 2 feet of new fill. We presented more detailed results of our analyses in our Geotechnical Study for Levee Raising Project report, which is included in Attachment 6.

The levee raising project was constructed between September 2014 and October 2014. The construction project included performing field density tests to determine the soil's in-place density. The specifications required a density test for every 2,000 square feet of material placed, per lift. The contractor was to place the fill in lifts no greater than eight inches, loose. The fill was to be compacted to at least 95% of the maximum dry density as determined by the standard Proctor test and to within -1% and +2% of the optimum moisture content.

The City of Salina provided AMEC with in-place density test reports that were performed on the new embankment fill. The City perform 295 density tests using nuclear density gauge methods. The test reports indicated that 18 of the tests did not meet the required testing requirements. Seventeen of the tests did not meet the moisture content requirement and one test did not meet the density and moisture content requirements. Sixteen of the tests that did not meet the moisture content requirement were over/under by less than one percent. We believed that these test results are satisfactory for this project and did not require reworking and retesting. However, two of the tests, including the one that did not meet the density requirement, were over/under by more than one percent. The contractor reworked the areas where these tests were performed, and the compacted fill was retested. The retests met the moisture content and density requirements.

The field density testing results indicate 95% compaction or better at each of the test locations. Therefore, based on the field testing and our analysis, we believe that the fill materials placed for this project are suitable for embankment stability as analyzed during our stability analyses.

6.8 Summary of Findings

The findings of the geotechnical evaluation of the subject levee system are as follows:

Geomorphology: Based upon the soil test boring results, AMEC finds no evidence that significant defects or anomalies remain from previously mapped meanders or bars created by past changes in watercourse and/or floodplain that could affect the integrity of the levee or its foundations.

Seepage: The steady-state and transient seepage analyses that we performed at the 17 critical levee sections indicate that underseepage would not exceed an exit gradient of 0.5 at the landside toe for these sections during a base flood event.

Slope Stability: The stability analyses performed indicate that the critical sections of the levee embankments meet or exceed the minimum factors of safety criteria stipulated in EM-1110-2-1913 *Design and Construction of Levees*.

Settlement: We consider future potential settlement of the levee under static conditions to be negligible.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the geotechnical evaluation performed by AMEC, it is our opinion that there is reasonable certainty that the earthen embankments of the Salina Levee System meet the requirements of 44 CFR 65.10 with regard to embankment slope stability, seepage, and ground subsidence.

As previously mentioned in Section 4.9, we recommend that the O & M Manual be updated to include inspection of encroachment areas (trees, power poles, guy wires, houses, etc.). The inspections should note any evidence of deterioration, excessive seepage, and/or movement that might indicate failure, which could harm the levee embankment. We also recommend that the City remove trees within 15 feet of the levee's toe in accordance with USACE guidelines. We note that the tree removal is not required for certification but must be included in the O & M manual to maintain eligibility in the USACE's 84-99 program.

We note that the current Record Drawings and O & M Manual do not include any information regarding the relief wells located at Station 95+00 along the east levee. We recommend updating the Record Drawings to include as-built information for the wells and updating the O & M Manual to include regular maintenance procedures in accordance with USACE guidance.

We observed animal burrows within the levee embankments and adjacent areas during our exploration. We were unable to verify the extent of the burrows; however, they appear to penetrate relatively deep within the embankment. The burrows may provide seepage paths for floodwaters to migrate easily to the protected side of the levee. Therefore, we recommend that the City repair all existing animal burrows and continuously monitor the levees for additional burrows.

7.1 Report Limitations

AMEC bases this report upon the project and documents as described and the information obtained from the exploratory borings performed as referenced in this report. AMEC bases its findings, conclusions, and recommendations upon data obtained from a necessarily limited number of documents, observations, site visits, excavations, samples, and tests, including those performed by others. AMEC obtained such information only with respect to the specific locations that we explored. The explored locations may not completely define the subsurface conditions throughout the levee alignment. Differing geotechnical or geologic conditions can occur within small distances and under varying climatic conditions. Furthermore, changes in subsurface conditions can and do occur over time. The City must notify AMEC of any pertinent change in the project or field conditions. AMEC may reevaluate the conclusions and recommendations presented in this report if the City finds geotechnical conditions that differ from those described herein.

If the City plans to modify the existing levee substantially more than normal maintenance activities, they must allow AMEC to review the final design and remain involved during grading operations and foundation excavation phases of construction. If parties other than AMEC are engaged to provide construction observation services, then the City must provide documentation of construction activities and quality control to AMEC prior to certification.

AMEC prepared this report only for use by those parties named or described above. It may not contain sufficient information for other parties or other purposes. AMEC prepared the report in accordance with generally accepted geotechnical practices and makes no other warranties either express or implied, as to the professional advice or data included in it.

8.0 REFERENCES

a. Fredlund et al (1994) “Equations for the Soil-Water Characteristic Curve” Canadian Geotechnical Journal, Vol. 31.

b. US Army Corps of Engineers, Engineering and Design, Engineering Manual EM 1110-2-1902 – Slope Stability, dated 31 October 2003.

c. US Army Corps of Engineers, Engineering and Design, Engineering Manual EM 1110-1-1904 Settlement Analysis, dated September 30, 1990.

d. US Army Corps of Engineers, Engineering and Design, Engineering Manual EM 1110-2-1913 Design and Construction of Levees, dated 30 April 2000.

e. US Army Corps of Engineers, Engineering and Design, Engineering Manual ETL 1110-2-569 Design Guidance for Levee Underseepage, dated 1 May 2005.

f. American Association of State Highway and Transportation Officials, AASHTO, LRFD Bridge Design Specifications, 4th Edition, 2007, 2009 Interim Revisions.

amec

GEOTECHNICAL BRANCH
NASHVILLE, TENNESSEE

LOG OF BORING: B-01

PROJECT:	Salina Levee Phase II	DRILLER:	GSI, Inc.
PROJECT NO.:	8-275-0000-92	ON-SITE REP:	Jim Garnett, PG
BORING LOCATION:	97.58886 , 38.83213 2+70	DRY ON COMPLETION?	No
DATE:	3/19/2011	GROUND ELEVATION:	1240.5 (Estimated) FT.

	DEPTH		ELEV.	
REFUSAL DEPTH:		FT.		FT.
SAMPLED TO DEPTH:	45	FT.	1195.5	FT.
DEPTH TO TOP OF ROCK:		FT.		FT.
DEPTH WHERE CORING BEGAN:		FT.		FT.
FOOTAGE CORED (LF):		FT.		FT.
DEPTH TO BOTTOM OF HOLE:	45	FT.	1195.5	FT.

WATER LEVEL DATA (IF APPLICABLE)

INITIAL:	DEPTH	42	FT.
∇	ELEV.	1198.5	FT.
LDW AT:	DEPTH		FT.
LDW	ELEV.		FT.
AFTER 24 HRS:	DEPTH		FT.
▼	ELEV.		FT.

BORING ADVANCED BY: ☐ -POWER AUGERING ☑ -WASHBORING ☐ -OTHER: (________________)

STRATUM DEPTH FT	ELV	DEPTH FROM (FT.)	SAMPLE OR RUN #	SAMPLE TYPE	SPT VALUES 6"-6"-6"	N-N	LITHO	WATER	NOTES / PHOTO	STRATUM DESCRIPTION
0 --	1240.5	0	1	A/B						TOPSOIL,
-		0.5	2	SS	2-2-4	6				CLAY,DarkBrown,Firm,Moist,[FILL]
--										
-										
--		2	3	A/B						
2.5 -	1238	2.5	4	SS	6-9-10	19				-with Silt,Very Stiff,
--										
-										
--		4	5	A/B						
-										
5 --	1235.5	5	6	SS	6-9-11	20			Drier	-Very Stiff,
-										
--										
-		6.5	7	A/B						
--										
7.5 -	1233	7.5	8	ST						
--										
-										
--										
-		9.5	9	A/B						
10 --	1230.5	10	10	SS	4-6-7	13				-Stiff,
-										
--		11	11	SS						CLAY,DarkGray,Stiff,Moist,[FILL]
-		11.5	12	A/B						
--										
12.5 -	1228	12.5	13	SS	4-4-8	12				
--										
-										
--		14	14	A/B						
-										
15 --	1225.5	15	15	SS	4-5-7	12				
-										
--										
-		16.5	16	A/B						CLAY,DarkGray,Stiff,Moist,[ALLUVIUM]
--										
17.5 -	1223									
--										
-		18.5	17	SS	4-5-7	12				
--										
-										
20 --	1220.5	20	18	A/B						

REMARKS:

GEOTECHNICAL BRANCH
NASHVILLE, TENNESSEE

LOG OF BORING: B-01
SHEET 2 OF 3

PROJECT:	Salina Levee Phase II	DRILLER:	GSI, Inc.
PROJECT NO.:	8-275-0000-92	ON-SITE REP:	Jim Garnett, PG
BORING LOCATION:	97.58886 , 38.83213 2+70	DRY ON COMPLETION?	No
DATE:	3/19/2011	GROUND ELEVATION:	1240.5 (Estimated) FT.

REFUSAL DEPTH:	FT.	ELEV.	FT.	
SAMPLED TO DEPTH:	45 FT.	ELEV.	1195.5 FT.	
DEPTH TO TOP OF ROCK:	FT.	ELEV.	FT.	
DEPTH WHERE CORING BEGAN:	FT.	ELEV.	FT.	
FOOTAGE CORED (LF):	FT.	ELEV.	FT.	
DEPTH TO BOTTOM OF HOLE:	45 FT.	ELEV.	1195.5 FT.	

WATER LEVEL DATA (IF APPLICABLE)

INITIAL:	DEPTH	42	FT.
▽	ELEV.	1198.5	FT.
LDW AT:	DEPTH		FT.
LDW	ELEV.		FT.
AFTER 24 HRS:	DEPTH		FT.
▼	ELEV.		FT.

BORING ADVANCED BY: ☐ -POWER AUGERING ☑ -WASHBORING ☐ -OTHER: (____________)

STRATUM DEPTH FT	ELV	DEPTH FROM (FT.)	SAMPLE OR RUN #	SAMPLE TYPE	SPT N-VALUES 6"-6"-6"	N	LITHO	WATER	NOTES / PHOTO	STRATUM DESCRIPTION
22.5	1218									
		23.5	19	SS	2-4-4	**8**				-Firm,
25	1215.5	25	20	A/B						
27.5	1213									
		28.5	21	SS	2-3-3	**6**				SILT,with Clay,DarkGray,Firm,Moist,[ALLUVIUM]
30	1210.5	30	22	A/B						
32.5	1208									
		33.5	23	SS	3-3-3	**6**				
35	1205.5	35	24	A/B						
37.5	1203									
		38.5	25	SS	1-2-2	**4**				
		38.9	26	SS						SAND,with Gravel,LightBrown,Very Loose,Moist,[ALLUVIUM]
40	1200.5	40	27	A/B						

REMARKS:

amec

GEOTECHNICAL BRANCH NASHVILLE, TENNESSEE	LOG OF BORING: B-01 SHEET 3 OF 3

PROJECT:	Salina Levee Phase II	DRILLER:	GSI, Inc.
PROJECT NO.:	8-275-0000-92	ON-SITE REP:	Jim Garnett, PG
BORING LOCATION:	97.58886 , 38.83213 2+70	DRY ON COMPLETION?	No
DATE:	3/19/2011 GROUND ELEVATION: 1240.5 (Estimated) FT.		

REFUSAL DEPTH:		FT.	ELEV.		FT.
SAMPLED TO DEPTH:	45	FT.	ELEV.	1195.5	FT.
DEPTH TO TOP OF ROCK:		FT.	ELEV.		FT.
DEPTH WHERE CORING BEGAN:		FT.	ELEV.		FT.
FOOTAGE CORED (LF):		FT.	ELEV.		FT.
DEPTH TO BOTTOM OF HOLE:	45	FT.	ELEV.	1195.5	FT.

WATER LEVEL DATA (IF APPLICABLE)

INITIAL:	DEPTH	42	FT.
∇	ELEV.	1198.5	FT.
LDW AT:	DEPTH		FT.
LDW	ELEV.		FT.
AFTER 24 HRS:	DEPTH		FT.
▼	ELEV.		FT.

BORING ADVANCED BY: ☐ -POWER AUGERING ☑ -WASHBORING ☐ -OTHER: (______________)

STRATUM DEPTH	ELV FT	DEPTH FROM (FT.)	SAMPLE OR RUN #	SAMPLE TYPE	SPT N-VALUES 6"-6"-6"	N	LITHO	WATER	NOTES / PHOTO	STRATUM DESCRIPTION
--										
-										
--								∇		
42.5 -	1198									
--										
-		43.5	28	SS	5-7-9	**16**			Interbedded with sand/gravel	CLAY,DarkBrown,Very Stiff,Moist,[ALLUVIUM]
--										
-										
45 --	1195.5									

END OF BORING

REMARKS:

Attachment B

Truncated version of KVE 2018 Revised Geotechnical Engineering Report Smoky Hill River Renewal Street and Pedestrian Bridges, Intake Structure and Basins, and Step Pools Report

REVISED GEOTECHNICAL ENGINEERING REPORT
SMOKY HILL RIVER RENEWAL
STREET AND PEDESTRIAN BRIDGES, INTAKE STRUCTURE AND BASINS, AND STEP POOLS
SALINA, KANSAS

Prepared for:

CITY OF SALINA, KANSAS
300 West Ash Street
Salina, Kansas 67401

C/o
HDR ENGINEERING, INC.
3741 NE Troon Drive
Lee's Summit, Missouri 64064

Prepared by:

KAW VALLEY ENGINEERING, INC.
14700 West 114th Terrace
Lenexa, Kansas 66215

February 27, 2018

Project No. **E17G1693**

KAW VALLEY ENGINEERING, INC.

Office: 913.894.5150
Fax: 913.894.5977
Web: www.kveng.com
Address: 14700 W 114th Terrace
Lenexa, Kansas 66215

February 27, 2018 **E17G1693**

City of Salina, Kansas
300 West Ash Street
Salina, Kansas 67401

C/o Mr. Scott Brand
HDR Engineering, Inc.
3741 NE Troon Drive
Lee's Summit, Missouri 64064

RE: REVISED GEOTECHNICAL ENGINEERING REPORT
SMOKY HILL RIVER RENEWAL PROJECT
STREET AND PEDESTRIAN BRIDGES, INTAKE STRUCTURE AND BASINS, AND STEP POOLS
SALINA, KANSAS

Dear Mr. Brand:

This report presents the results of a subsurface exploration and geotechnical engineering analysis conducted for the Smoky Hill River Renewal Project in Salina, Kansas. The project includes six road bridges, a pedestrian bridge, an intake structure with adjoining sedimentation basins, and dam area and step pools.

The purpose of this study was to determine subsurface conditions at the areas of the proposed structures and step pools, to analyze these conditions as they relate to the proposed construction, and to provide foundation design recommendations. This Geotechnical Engineering Report was developed in general accordance with the guidelines presented in the KDOT Geotechnical Manual with regards to bridge foundation design.

We appreciate the opportunity to perform this work for you, and look forward to answering any questions or comments which may have been generated as a result of this assessment.

If you have any questions, please do not hesitate to contact us at (913) 894-5150.

Respectfully submitted,
Kaw Valley Engineering, Inc.

Jessica A. Nixon, P.E.
Geotechnical Engineer

Michael R. Osbourn, P.E.
Principal

MICHAEL R. OSBOURN
LICENSED
11676
2.27.18
KANSAS
PROFESSIONAL ENGINEER

drainage chimney should be backfilled with free draining granular material extending vertically above the drain line to within 2 feet of final grade. The remaining portion of the excavation should be backfilled with cohesive soils to minimize the infiltration of surface water. The granular section behind the wall should have a minimum width of 2 feet and should be encapsulated in a suitable filter fabric to minimize intrusion of fines. The use of a prefabricated drainage blanket on the retaining walls may also be considered to prevent hydrostatic loading. Drainage blankets should be installed in accordance with the manufacturer's recommendations.

If additional lateral support is required for design, passive resistance may be utilized for portions deeper than 3 feet. The passive resistance may be determined using K_p for the select material times the total unit weight of the soil.

During wall design, we recommend a minimum factor of safety of 1.5 for sliding and overturning resistance.

15.0 INTAKE AND SEDIMENTATION BASIN RECOMMENDATIONS

It is recommended that the sedimentation basins be supported by a structural slab or mat. Based upon a proposed bearing elevation of 1,201.5 feet, we recommend the sedimentation basin be founded entirely upon shale bedrock. Soil properties that the structural engineer may use for design of the slabs/mats are an allowable bearing capacity of 3,000 psf and a modulus of subgrade reaction of 125 pounds per cubic inch. The slabs/mats should be structurally reinforced to allow a minimum 10-foot unsupported span. Perimeter cut-off walls should be placed a minimum of 3 feet below the lowest adjacent exterior grade for frost protection.

Crest gate and additional support elements with higher bearing elevations should bear upon newly placed structural fill or shale bedrock. Due to the very soft soils above the bedrock, we recommend overexcavation of the insitu soils to the shale bedrock elevation and replacement with structural fill. Moderately weathered bedrock should be anticipated at an elevation of 1,204.5 feet. The overexcavation depth and replacement of unsuitable materials will have to be determined during the construction process. The allowable bearing capacity for structural fill as recommended is 2,000 psf.

Construction of the intake and sedimentation basin structures as well as the adjacent elements should require removal of the alluvial deposits to the hard shale surface. Due to wash out potentials, materials used for replacement structural fill should be of low permeability (soils with diameters less than 0.05 mm). These materials include silt, lean clay, and fat clay. One restriction to using these materials is that fat clay should be excluded from the top 12 inches of the structure and pavement subgrade. No granular materials such as sands or gravels should be included in the fill. If a granular base for the structures is desired, it should be composed of a well graded material such as KDOT AB-3.

All fill placed for these structures and pavements should consist of approved materials that are free of organic matter and debris. Fill should be placed in lifts having a maximum loose lift thickness of 8 inches. The fill should be compacted to a minimum of 95% of maximum density per standard Proctor (ASTM D698) with the moisture content within the range from 0 to +5 percent of optimum moisture content.

Where the fill intersects existing slopes and the existing grade is steeper than 5 (H) to 1(V), it is recommended that benches be established at regular intervals to provide a proper base for the new fill section. Benching of the slope provides interlocking between the new fill section and the existing slope and/or natural soils and facilitates compaction of the fill. Benches should be cut as the fill progresses and should have a maximum bench height of 2 feet.

Groundwater. With groundwater present in the test borings at this location at elevations ranging from 1,210 to 1,212.6 feet after 24 hours, conventional water pumps or other suitable methods may not be able to handle most water removal. Water bearing sands should be dewatered prior to excavation to prevent flowing sands and potential disturbance of the trench bottom. Dewatering methods such as well points may be necessary to dewater portions of the project during construction. In order to determine drawdown calculations for the dewatering system, the planned bearing elevation is to be approximately 10 feet lower than the static water level at the time of the exploration on November 28 and 29, 2017. We anticipate the silts and clays onsite to have permeabilities in the range of 10^{-6} to 10^{-7} centimeters per second.

It should be understood that the level of groundwater may fluctuate due to rainfall and other seasonal factors, and the water levels recorded represent conditions at the time of measurement only. The groundwater may or may not be present at the noted elevations or at higher elevations during construction or at other times during the life of the project.

The normal operation of the intake structure is anticipated to maintain a static water level above the mat/slab of approximately 10 feet. No buoyancy effect will occur during normal operations. If the groundwater level is rapidly drawn down, a short term buoyancy force may exist under portions of the mat/slab. The maximum buoyancy force would be dictated by the height of the adjacent wing walls which are designed to be approximately 10 feet tall. Therefore, a maximum buoyancy force of 750 pounds per square foot shall be used for the design of the mat/slab. The installation of relief valves within the mat/slab would mitigate the buoyancy forces.

16.0 STEP POOL OBSERVATIONS AND RECOMMENDATIONS

The current design includes removal of the upper 5 feet of the existing Western Star dam, placing fill downstream of the dam, and installing rock boulders to create 2-foot high drops into extended pools. The current plan view of the step pools is presented in Figure 2.

Depending on the permeability requirements, bentonite may be worked into the existing soils. Determination of bentonite quantities requires additional testing. A non-permeable geosynthetic may also be considered in lieu of reworking the existing soils.

17.0 CORROSIVITY POTENTIAL

Onsite soils classify as McCook silt loam and Lancaster loam. According to the Web Soil Survey, these soils have a low to moderate risk of corrosion to concrete. These soils also have a low risk of corrosion to steel. These characteristics indicate there is a low to moderate potential for future corrosion issues with the pile installation. Consequently, the use of appropriate protective coatings may be considered.

Additionally, the poor drainage conditions typically found in the floodplain area can add to the corrosion potential. Consequently, the use of chemical resistant concrete and appropriate protective coating or polyethylene encasing on utility lines may be considered for extended life. Recommendations for the concrete include a Shilstone type mix, a low water-cement ratio, epoxy coated reinforcing bar, and silica fume as a supplemental cementitious additive.

18.0 GENERALIZED DESIGN CONSIDERATIONS

The recommendations in this section do not supercede the previous site specific recommendations.

Site Preparation. Site preparation should commence with stripping of all vegetation, topsoil, and pavement from the construction areas. Stripping should extend a minimum of 5 feet beyond the structures footprints. Stripping depths will likely vary and should be adjusted to remove all vegetation and root systems. Soils removed during site stripping operations could be used for final site grading outside the proposed structure areas.

Following stripping and cutting to grade, the moisture content of the exposed soils should be evaluated. Depending on the in-situ moisture content of the exposed soils, moisture conditioning of the exposed grade may be required. The moisture content of the exposed grade should be adjusted to within the range recommended for structural fill, to allow the exposed material to be compacted to a minimum density of 95 percent of the material's maximum density as determined by the standard Proctor compaction procedure. Extremely wet or unstable areas that hamper compaction of the subgrade may require undercutting and replacement with structural fill or other stabilization techniques.

Following moisture conditioning of the exposed soils, it is recommended that the exposed grade be proofrolled to provide a more stable base for placement of structural fill and to assist in identifying soft or disturbed areas. Unsuitable areas identified by the proofrolling operation should be undercut and replaced with structural fill. Proofrolling can be accomplished through use of a fully-loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading. Following proofrolling, suitable structural fill should be placed to design grade as soon as practical to avoid moisture changes in the underlying soils. Care should be taken by the contractor during proofrolling and fill placement in order to not adversely influence the existing structures.

Where fill is being placed on a slope steeper than 5:1 (horizontal:vertical), the existing slope should be benched as fill placement progresses. These benches should be vertically stepped between 12 and 36 inches. Benches should be level, and wide enough to accommodate compaction and earth moving equipment. This procedure would better key the fill into the original slope and will facilitate compaction of the fill.

Subgrade preparation in the proposed pavement areas will not need to be as extensive as recommended for the structure areas. After stripping and/or cutting to grade, the exposed materials should also be moisture conditioned and proofrolled prior to paving. Any soft or unstable areas observed during proofrolling should be undercut and brought up to planned grade with structural fill.

Structural Fill. On-site soils are generally acceptable as general fill and backfill materials. All structural fill should consist of approved materials, free of organic matter and debris. Imported fill material should consist of low swell potential soils with a liquid limit less than 45 and a plasticity index between 10 and 25.

All fill should be placed in lifts having a maximum loose lift thickness of 8 inches, and should be compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D 698 (standard Proctor compaction). The moisture content of the fill at the time of compaction should be within a range of 1 percent below to 3 percent above optimum moisture content as defined by the standard Proctor compaction procedure. Moisture contents should be maintained within this range until completion of the floor slabs.

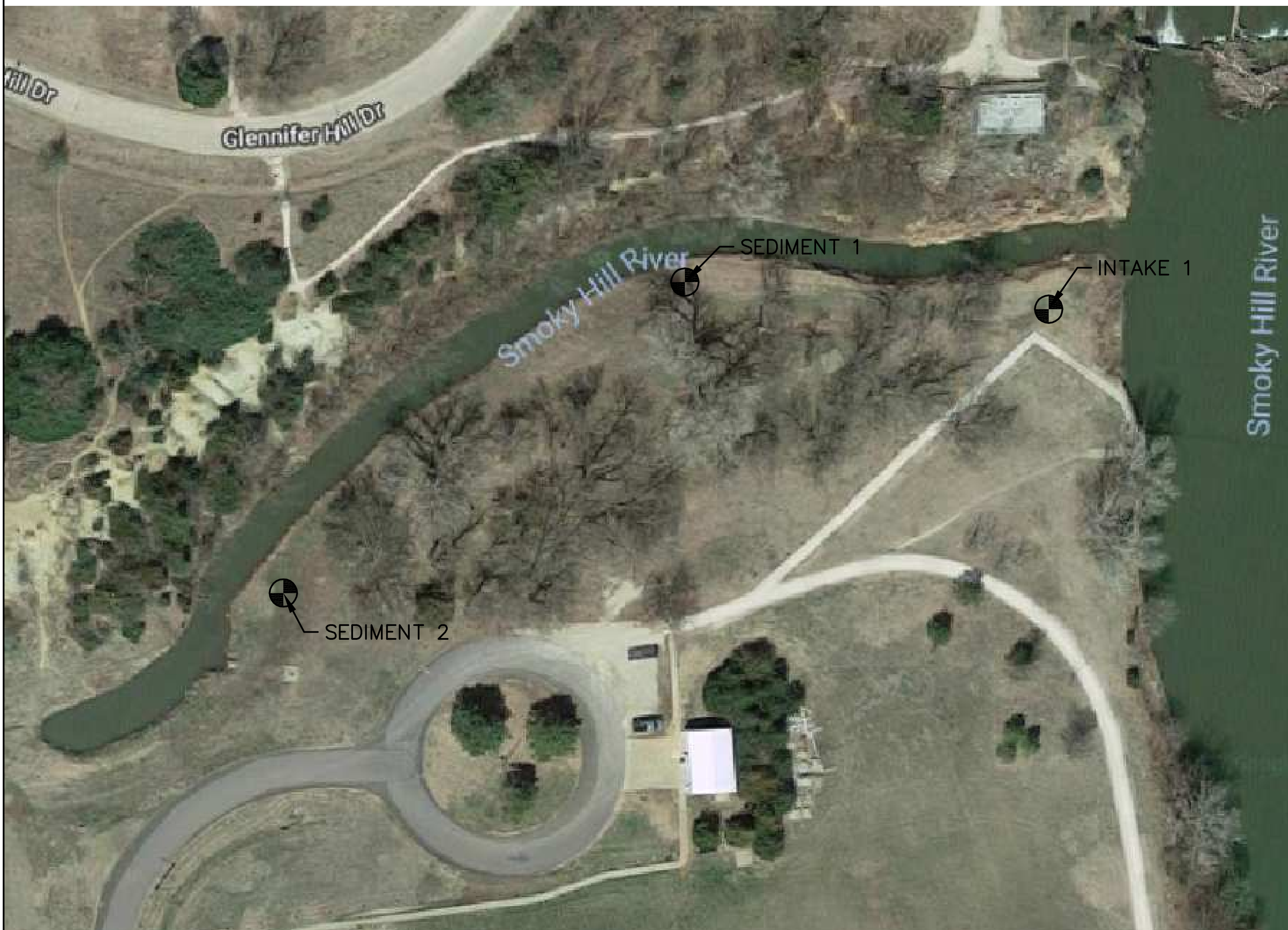
The geotechnical engineer should approve all fill material. Approval requires that a moisture-density relationship and Atterberg limits be performed for each proposed fill material prior to its placement.

All utility trenches should be backfilled with either on-site or imported fill material. Granular materials such as clean sand or gravel should not be used to bed utilities or backfill trenches unless the bottom of the trench is graded so that water flows away from the structure and pad areas.

Final slopes greater than 3:1 (horizontal:vertical) should not be used for ease of maintenance.

Continuous observation by the geotechnical engineer or his representative should be maintained during site preparation and compaction of all fill and backfill material.

Chemical Stabilization. In areas of high plastic soils, in order to reduce the effects of the medium to high swell potential, the on-site clays can be chemically stabilized using lime, cement, or fly ash, thereby removing the need to import low plastic fill soils. This recommendation may be utilized in areas where soil swelling needs to be minimized, i.e. floor slabs, walkways, and pavement areas. Following site stripping, stabilization should begin by



SITE PLAN AND APPROXIMATE BORING LOCATIONS

PLATE 8

NEW ENTRANCE WORKS FACILITY
BILL BURKE SPORTS COMPLEX
SALINA, KANSAS

KAW VALLEY ENGINEERING

APPROVED BY: JAN	NOT TO SCALE	E17G1693

LOG OF BORING INTAKE-1

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: HDR, Inc.
PROJECT: Smoky Hill River Renewal Project
NUMBER: E17G1693
LOCATION: Salina, Kansas

DATE(S) DRILLED: 11/29/17 - 11/29/17
DRILLING METHOD(S): HOLLOW STEM, NQ3
DRILL RIG: CME 55
DRILL RIG OPERATOR: Jeremy Webb
LOGGED BY: Kris Moore, RG

GROUNDWATER INFORMATION:
Water level prior to wash boring: 11.0'
Water level upon completion: 10.0'

SURFACE ELEVATION: 1222.5'

FIELD DATA / LABORATORY DATA

N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)
	14	11.2	24	17	7	101.6	1,630		
T = 5/3/2		19.1							
T = 2/1/2		23.8	25	21	4				
T = 0/0/0		33.5							
T = 0/0/0		47.2	43	19	24				
T = 0/0/0		47.1	40	17	23				
	0	15.8	39	20	19				
T = 38/24/25		21.2							
T = 7/17/37		17.0				113.6			
	6	17.0							
T = 36/37/50=3"									

BORING TERMINATED AT 27.8'

DESCRIPTION OF STRATUM

FILL: Gravel, concrete, clay
1219.5'
SILTY CLAY WITH SAND: Brown; loose; moist; fine grained; with rust laminations
1217.5'
SILT: Brown; soft; slightly moist to moist; with sand; with rust mottling in root holes
Becoming clayey from 7.0' to 8.5'
Becoming saturated at 8.0'
1213.5'
SILT: Brown; soft; moist; with black inclusion (possible coal fragments)
Becomes saturated at 9.3'
1209.5'
SILTY SAND: Dark gray; very loose; moist; fine to medium grained; well graded; with sandy lean clay
1207.5'
SHALE: Gray/blue; soft; moist; blocky; very highly to moderately weathered
1203.0'
SHALE: Gray to dark gray; hard; slightly weathered
Becomes less weathered and subfissile to black at 20.5'
1197.0'
SHALE: Dark gray to gray; hard; very silty with siltstone laminations; slightly weathered
1195.2'
Becomes maroon with gray and subfissle to blocky at 26.0'
1194.7'
SILTSTONE: Gray and maroon; hard; thin shale laminations throughout; fissile; slightly weathered

DEPTH (FT): 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial Conditions: Grass
Wash Bore Start Depth: 19.5'

LOG OF BORING SEDIMENT-1

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: HDR, Inc.
PROJECT: Smoky Hill River Renewal Project
NUMBER: E17G1693
LOCATION: Salina, Kansas

DATE(S) DRILLED: 11/28/17 - 11/28/17
DRILLING METHOD(S): HOLLOW STEM
DRILL RIG: CME 55
DRILL RIG OPERATOR: Jeremy Webb
LOGGED BY: Kris Moore, RG

GROUNDWATER INFORMATION:
Water level while drilling: 7.9'
Water level upon completion: 6.0'
Water level after 24 hours: 5.7'

SURFACE ELEVATION: 1218.6'

FIELD DATA		LABORATORY DATA								
DEPTH (FT)	N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)
1–3		14	13.9	29	23	6	97.9	1,945		
3–4.5	T = 2/2/2		29.3	40	21	19				
5–6.5	T = 0/0/0		36.2	32	21	11				
7–8.5	T = 0/0/0		54.3							
8.5–10	T = 1/2/1		45.3	37	15	22				
14–15	T = 2/11/50=5"		14.3							
18.5–20	T = 28/22/29		18.8	31	17	14				

BORING TERMINATED AT 20.0'

DESCRIPTION OF STRATUM

LEAN CLAY: Brown; firm; slightly moist; with silt	1217.6'
SILT: Light gray with rust mottling; stiff; slightly moist	1215.6'
LEAN CLAY: Brown; soft to firm; moist; with silt; rust mottling along root holes	1212.6'
SILT: Dark gray to brown; soft; very moist; with clay	1210.6'
LEAN CLAY WITH SAND: Brown; soft; saturated	1208.6'
SILTY SAND: Dark gray; very loose; saturated; fine grained; poorly graded	1204.8'
LIMESTONE: Tan; hard; fragmented; highly weathered	1204.6'
SHALE: Black; hard; fissile; moderately to slightly weathered Becoming dark gray at 14.5' Becoming subfissile to blocky at 18.5' With gray siltstone at 19.9'	1198.6'

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial Conditions: Grass

LOG OF BORING SEDIMENT-2

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: HDR, Inc.
PROJECT: Smoky Hill River Renewal Project
NUMBER: E17G1693
LOCATION: Salina, Kansas

DATE(S) DRILLED: 11/29/17 - 11/29/17
DRILLING METHOD(S): HOLLOW STEM
DRILL RIG: CME 55
DRILL RIG OPERATOR: Jeremy Webb
LOGGED BY: Kris Moore, RG

GROUNDWATER INFORMATION:
Water level while drilling: 13.7'
Water level upon completion: 9.7'
Water level after 24 hours: 8.5'

SURFACE ELEVATION: 1219.4'

FIELD DATA		LABORATORY DATA								
N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
										SILT: Light brown; stiff; dry; with roots (1218.9')
	14	12.9	28	20	8	105.0	2,275			LEAN CLAY: Brown; very stiff; slightly moist (1213.4')
T = 7/9/8		18.5								
T = 3/2/2		19.2	34	20	14					SILT: Brown; firm; moist; with clay; with rust mottling in root holes (1212.4')
T = 0/0/0										SILTY CLAY: Dark gray; soft; very moist (1209.4')
T = 0/4/2		51.9								LEAN CLAY: Dark gray; firm; very moist; with limestone fragments; trace fine to medium grained sand (1204.4')
T = 2/3/7		22.8								SHALE: Gray with light brown; silty; highly to moderately weathered (1200.9')
T = 46/50=1"		13.3								SHALE: Gray; hard; subfissile; silty; slightly weathered (1200.3')

Depth (FT) scale: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

BORING TERMINATED AT 19.1'

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial Conditions: Grass

BORING LOG REFERENCE LEGEND

DESCRIPTIVE SOIL CLASSIFICATION

Soil description is based on the Unified Soil Classification System as outlined in ASTM Designation D-2487. The Unified Soil Classification group symbol for soil descriptions shown on the boring logs corresponds with the group names listed below. The description includes soil constituents, consistency, relative density, color and any other appropriate descriptive terms. Geologic description of bedrock, when encountered, is also shown in the description column. Refer to the appropriate notes for bedrock classification.

Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name
GW	Well graded gravel	SW	Well graded sand	CL	Lean clay	CH	Fat clay
GP	Poorly graded gravel	SP	Poorly graded sand	ML	Silt	MH	Elastic silt
GM	Silty gravel	SM	Silty sand	OL	Organic clay Organic silt	OH	Organic clay Organic silt
GC	Clayey gravel	SC	Clayey sand			PT	Peat

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf

< 500	Very Soft
500 – 1,000	Soft
1,001 – 2,000	Firm
2,001 – 4,000	Stiff
4,001 – 8,000	Very Stiff
8,001 – 16,000	Hard
> 16,000	Very Hard

RELATIVE PROPORTIONS

Descriptive Term(s) (Components also Percent in Sample)	Sand & Gravel Percent of Dry Wt.	Fines Percent of Dry Wt.
Trace	< 15	<5
Some	15 – 29	5 - 12
Modifier	> 30	> 12

RELATIVE DENSITY OF COARSE-GRAINED SOILS

N - (blows/ft)	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50+	Very Dense

GRAIN SIZE TERMINOLOGY

Major Component	Size Range
Cobbles	12 in to 3 in
Gravel	3 in to #4 sieve
Sand	#4 to #200 sieve
Silt or Clay	Passing #200 sieve

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. In pervious soil the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with only short-term observation.

DEFINITIONS OF ABBREVIATIONS

CR – Core recovery, length of core recovered in each run compared to the length drilled expressed as percent
LL – Liquid limit of specimen
N – Number of blows to penetrate last 12 inches with 140-pound hammer in standard penetration test
Blow count reported for each 6-inch interval on logs
PL – Plastic limit of specimen
RQD – Rock quality designation, aggregate length of core pieces greater than 4 inches long, expressed as percent of length drilled
TW – Thin walled tube
SS – Standard penetration test
NQ2 – 2 inches diameter core
CFA – Continuous flight augers
HSA – Hollow stem augers
EOB – End of boring

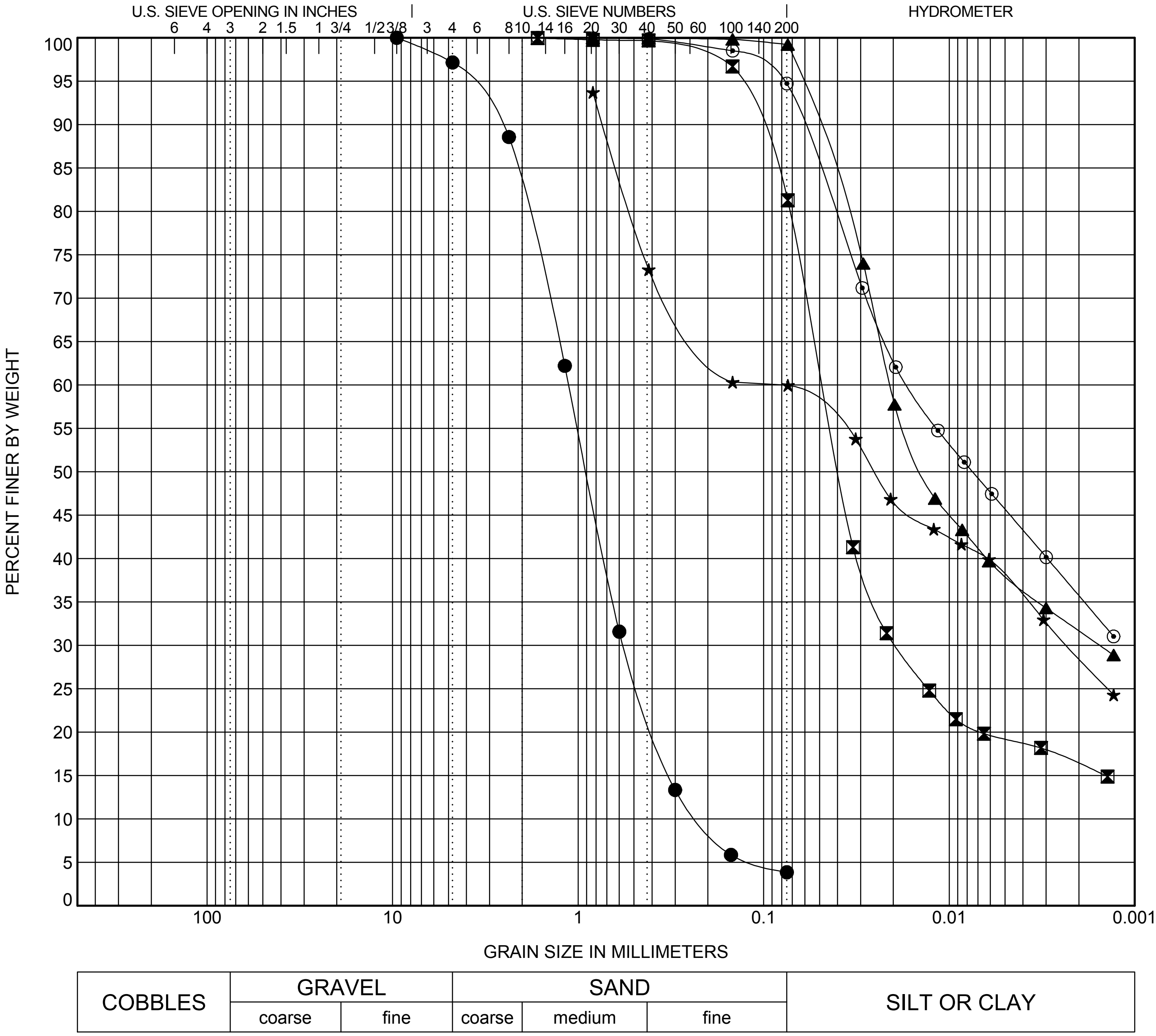
KAW VALLEY ENGINEERING

Kaw Valley Engineering
14700 W 114th Terrace
66215
Telephone: 913-894-5150
Fax: 913-894-5977

GRAIN SIZE DISTRIBUTION

CLIENT HDR, Inc. **PROJECT NAME** Smoky Hill River Renewal Project

PROJECT NUMBER E17G1693 **PROJECT LOCATION** Salina, Kansas



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	ELM-2	68.5	**POORLY GRADED SAND(SP)**				1.29	5.10
⧗	INTAKE-1	5.0	**SILTY CLAY with SAND(CL-ML)**	25	21	4		
▲	INTAKE-1	8.5	**LEAN CLAY(CL)**	43	19	24		
★	INTAKE-1	13.5	**SANDY LEAN CLAY(CL)**	40	17	23		
⊙	IRON-1	6.0	**LEAN CLAY(CL)**	42	16	26		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	ELM-2	68.5	9.5	1.124	0.565	0.22	2.8	93.3	3.8	
⧗	INTAKE-1	5.0	1.651	0.048	0.019			18.4	62.4	19.2
▲	INTAKE-1	8.5	0.833	0.021	0.002			0.7	61.0	38.2
★	INTAKE-1	13.5	0.833	0.081	0.002			33.8	22.1	37.9
⊙	IRON-1	6.0	1.651	0.017			0.0	5.3	49.1	45.7

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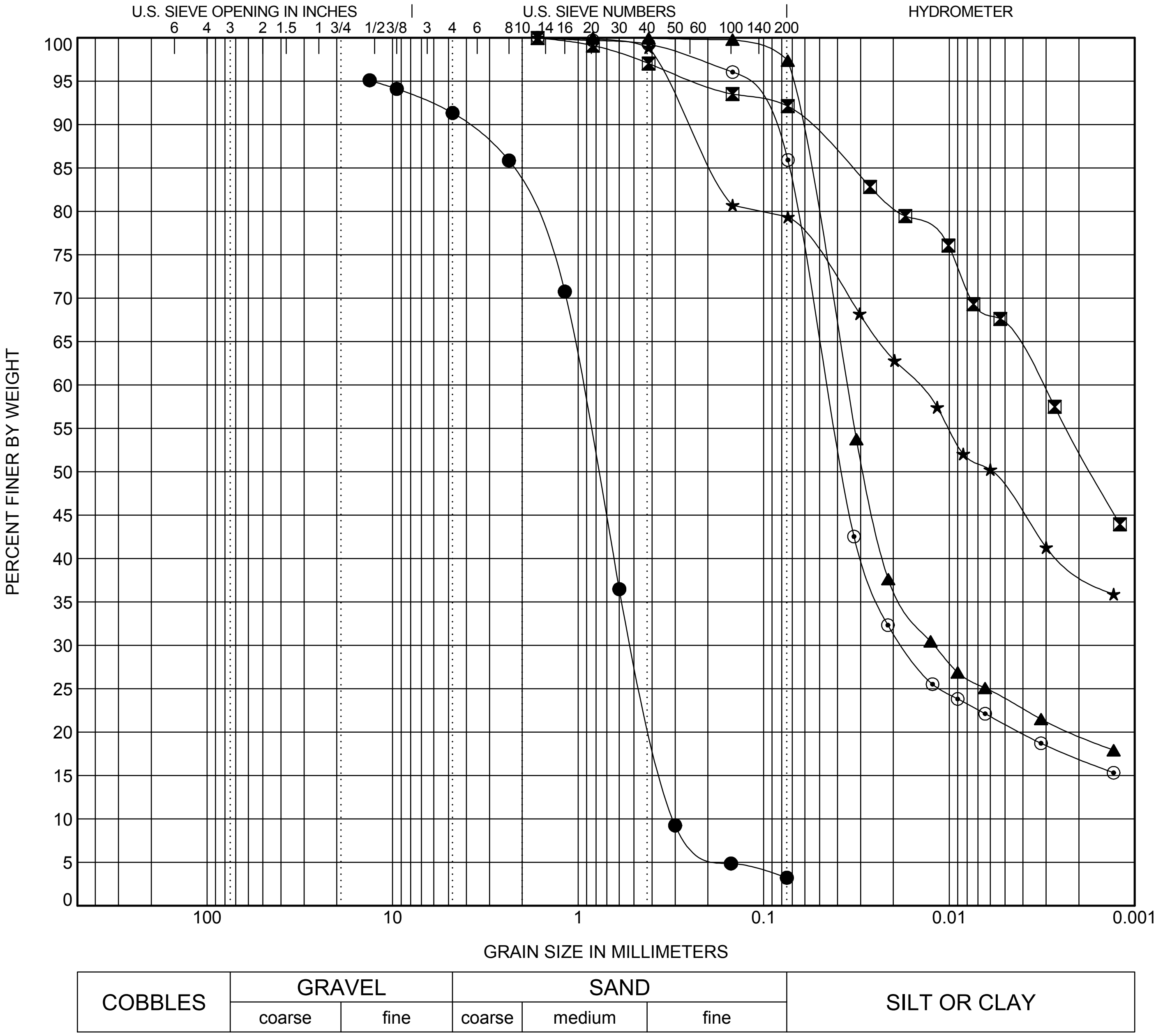
GRAIN SIZE DISTRIBUTION

CLIENT HDR, Inc. **PROJECT NAME** Smoky Hill River Renewal Project

PROJECT NUMBER E17G1693 **PROJECT LOCATION** Salina, Kansas



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	OHIO-2	48.5	**POORLY GRADED SAND(SP)**				0.89	3.12
⧗	SEDIMENT-1	1.0	**SILT(ML)**	29	23	6		
▲	SEDIMENT-1	5.0	**LEAN CLAY(CL)**	32	21	11		
★	SEDIMENT-1	8.5	**LEAN CLAY with SAND(CL)**	37	15	22		
⊙	SEDIMENT-2	1.0	**LEAN CLAY(CL)**	28	20	8		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	OHIO-2	48.5	13.3	0.954	0.509	0.306	3.8	88.1	3.2	
⧗	SEDIMENT-1	1.0	1.651	0.003				7.8	25.4	66.7
▲	SEDIMENT-1	5.0	0.833	0.036	0.012		0.0	2.6	73.6	23.8
★	SEDIMENT-1	8.5	1.651	0.015			0.0	20.6	31.5	47.9
⊙	SEDIMENT-2	1.0	1.651	0.045	0.018		0.0	13.9	65.2	20.9

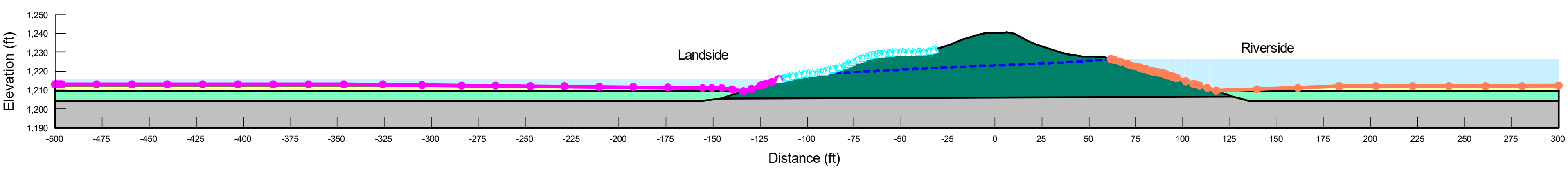
GRAIN SIZE E17G1693_R2_SMOKY_HILL_RIVER_PROS_SALINA_KS.GPJ GINT US LAB.GDT 1/18/18

Attachment C

GeoStudio Seepage Analysis Results

Color	Name	Hydraulic Material Model	Sat Kx (ft/sec)	Volumetric Water Content	Compressibility (/psf)	Ky'/Kx' Ratio	Vol. WC. Function	K-Function
	Lean Clay	Saturated Only	1.17e-07	0.38	4.7e-07	0.1		
	Levee Fill	Saturated / Unsaturated				0.1	Levee Fill	Levee Fill
	Shale	Saturated Only	3.28e-10	0.33	4.7e-07	0.25		
	Silt	Saturated Only	3.28e-07	0.43	4.7e-07	0.25		
	Soft Silty Lean Clay	Saturated Only	3.28e-07	0.38	4.7e-07	0.1		

Color	Name	Category	Kind	Parameters
	Base Flood 1226.5 feet	Hydraulic	Water Total Head	1,226.5 ft
	Base Flow Existing 1215.8 feet	Hydraulic	Water Total Head	1,215.8 ft
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/sec



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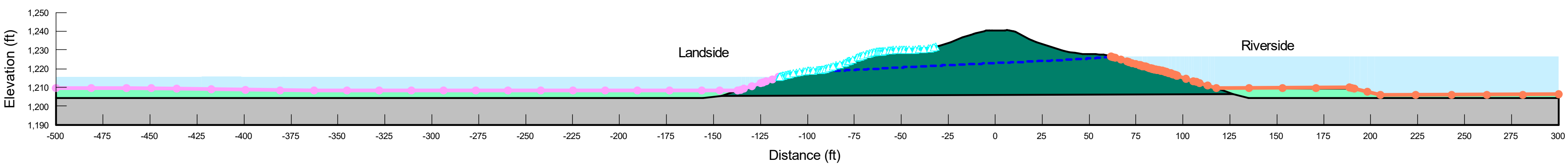
City of Salina

Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Existing - Steady-State Seepage Full Flood Stage		
	Scale: 1:1,005	

Color	Name	Hydraulic Material Model	Sat Kx (ft/sec)	Volumetric Water Content	Compressibility (/psf)	Ky'/Kx' Ratio	Vol. WC. Function	K-Function
	Lean Clay	Saturated Only	1.17e-07	0.38	4.7e-07	0.1		
	Levee Fill	Saturated / Unsaturated				0.1	Levee Fill	Levee Fill
	Shale	Saturated Only	3.28e-10	0.33	4.7e-07	0.25		
	Soft Silty Lean Clay	Saturated Only	3.28e-07	0.38	4.7e-07	0.1		

Color	Name	Category	Kind	Parameters
	Base Flood 1226.5 feet	Hydraulic	Water Total Head	1,226.5 ft
	Base Flow Proposed 1215.6 feet	Hydraulic	Water Total Head	1,215.6 ft
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/sec



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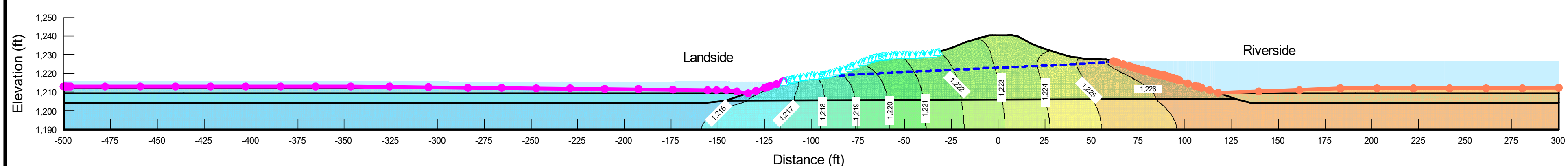
City of Salina

Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Proposed - Steady-State Seepage Full Flood Stage		
	Scale: 1:1,005	

Color	Name	Hydraulic Material Model	Sat Kx (ft/sec)	Volumetric Water Content	Compressibility (/psf)	Ky'/Kx' Ratio	Vol. WC. Function	K-Function
	Lean Clay	Saturated Only	1.17e-07	0.38	4.7e-07	0.1		
	Levee Fill	Saturated / Unsaturated				0.1	Levee Fill	Levee Fill
	Shale	Saturated Only	3.28e-10	0.33	4.7e-07	0.25		
	Silt	Saturated Only	3.28e-07	0.43	4.7e-07	0.25		
	Soft Silty Lean Clay	Saturated Only	3.28e-07	0.38	4.7e-07	0.1		

Color	Name	Category	Kind	Parameters
	Base Flood 1226.5 feet	Hydraulic	Water Total Head	1,226.5 ft
	Base Flow Existing 1215.8 feet	Hydraulic	Water Total Head	1,215.8 ft
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/sec



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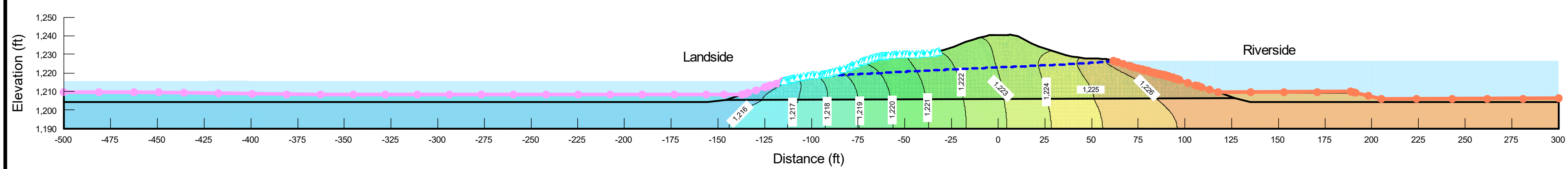
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Existing - Steady-State Seepage Full Flood Stage		
	Scale: 1:1,005	

Color	Name	Hydraulic Material Model	Sat Kx (ft/sec)	Volumetric Water Content	Compressibility (/psf)	Ky'/Kx' Ratio	Vol. WC. Function	K-Function
	Lean Clay	Saturated Only	1.17e-07	0.38	4.7e-07	0.1		
	Levee Fill	Saturated / Unsaturated				0.1	Levee Fill	Levee Fill
	Shale	Saturated Only	3.28e-10	0.33	4.7e-07	0.25		
	Soft Silty Lean Clay	Saturated Only	3.28e-07	0.38	4.7e-07	0.1		

Color	Name	Category	Kind	Parameters
	Base Flood 1226.5 feet	Hydraulic	Water Total Head	1,226.5 ft
	Base Flow Proposed 1215.6 feet	Hydraulic	Water Total Head	1,215.6 ft
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/sec



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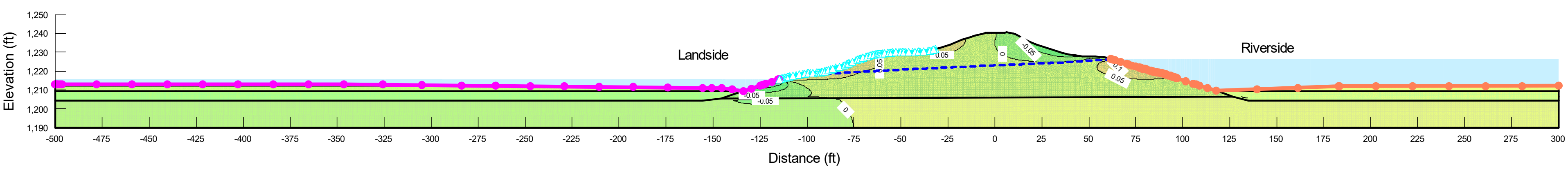
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Proposed - Steady-State Seepage Full Flood Stage		
	Scale: 1:1,005	

Color	Name	Hydraulic Material Model	Sat Kx (ft/sec)	Volumetric Water Content	Compressibility (/psf)	Ky'/Kx' Ratio	Vol. WC. Function	K-Function
	Lean Clay	Saturated Only	1.17e-07	0.38	4.7e-07	0.1		
	Levee Fill	Saturated / Unsaturated				0.1	Levee Fill	Levee Fill
	Shale	Saturated Only	3.28e-10	0.33	4.7e-07	0.25		
	Silt	Saturated Only	3.28e-07	0.43	4.7e-07	0.25		
	Soft Silty Lean Clay	Saturated Only	3.28e-07	0.38	4.7e-07	0.1		

Color	Name	Category	Kind	Parameters
	Base Flood 1226.5 feet	Hydraulic	Water Total Head	1,226.5 ft
	Base Flow Existing 1215.8 feet	Hydraulic	Water Total Head	1,215.8 ft
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/sec



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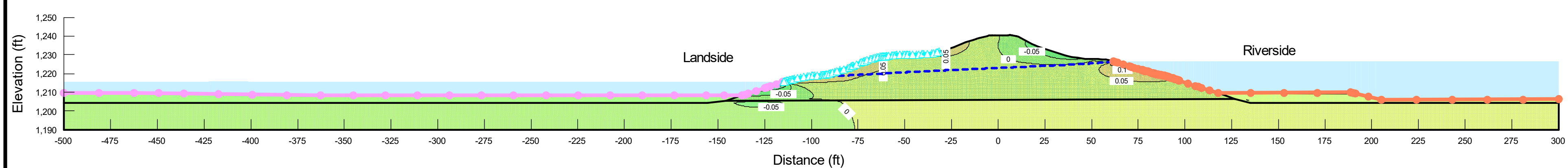
City of Salina

Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Existing - Steady-State Seepage Full Flood Stage		
	Scale: 1:1,005	

Color	Name	Hydraulic Material Model	Sat Kx (ft/sec)	Volumetric Water Content	Compressibility (/psf)	Ky'/Kx' Ratio	Vol. WC. Function	K-Function
	Lean Clay	Saturated Only	1.17e-07	0.38	4.7e-07	0.1		
	Levee Fill	Saturated / Unsaturated				0.1	Levee Fill	Levee Fill
	Shale	Saturated Only	3.28e-10	0.33	4.7e-07	0.25		
	Soft Silty Lean Clay	Saturated Only	3.28e-07	0.38	4.7e-07	0.1		

Color	Name	Category	Kind	Parameters
	Base Flood 1226.5 feet	Hydraulic	Water Total Head	1,226.5 ft
	Base Flow Proposed 1215.6 feet	Hydraulic	Water Total Head	1,215.6 ft
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/sec



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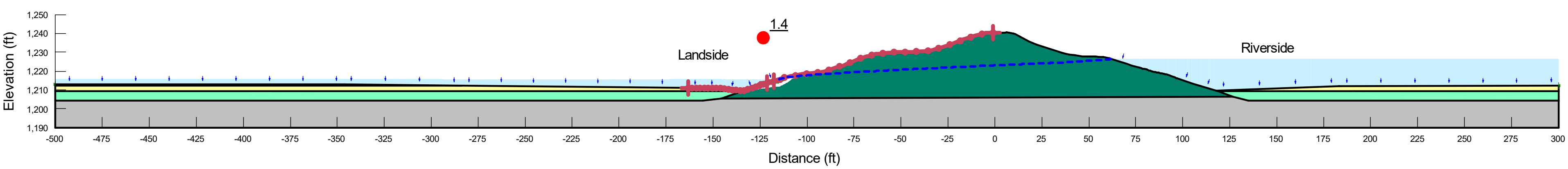
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Proposed - Steady-State Seepage Full Flood Stage		
	Scale: 1:1,005	

Attachment D

GeoStudio Slope Stability Analysis Results

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Lean Clay	Mohr-Coulomb	117	0	30
	Levee Fill	Mohr-Coulomb	124	0	30
	Shale	Mohr-Coulomb	140	100	27
	Silt	Mohr-Coulomb	116	30	0
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25



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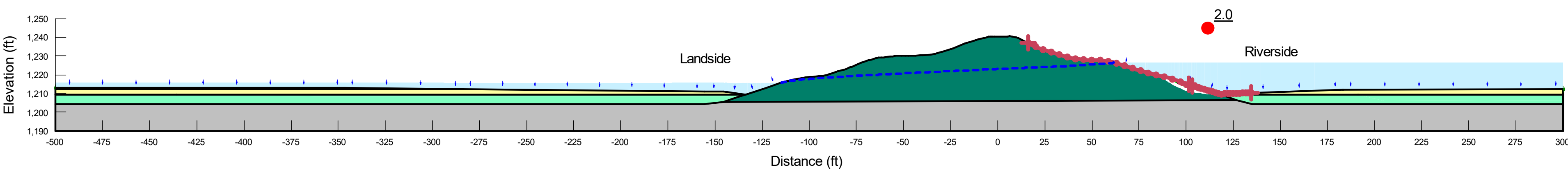
City of Salina

Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Existing - SSS Full Flood Stage, Slope Stability - Landside		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Lean Clay	Mohr-Coulomb	117	0	30
	Levee Fill	Mohr-Coulomb	124	0	30
	Shale	Mohr-Coulomb	140	100	27
	Silt	Mohr-Coulomb	116	30	0
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25



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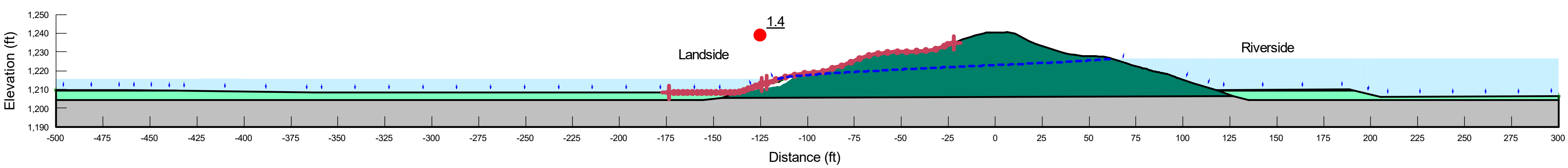
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Existing - SSS Full Flood Stage, Slope Stability - Riverside		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Lean Clay	Mohr-Coulomb	117	0	30
	Levee Fill	Mohr-Coulomb	124	0	30
	Shale	Mohr-Coulomb	140	100	27
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25



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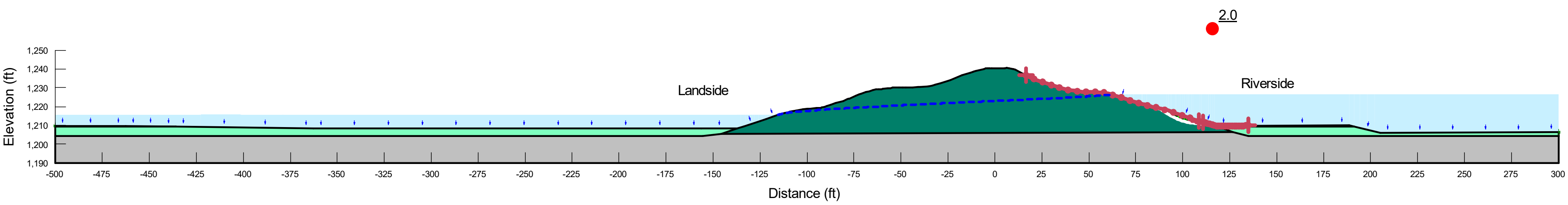
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case I Proposed - SSS Full Flood Stage, Slope Stability - Landside		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Lean Clay	Mohr-Coulomb	117	0	30
	Levee Fill	Mohr-Coulomb	124	0	30
	Shale	Mohr-Coulomb	140	100	27
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25



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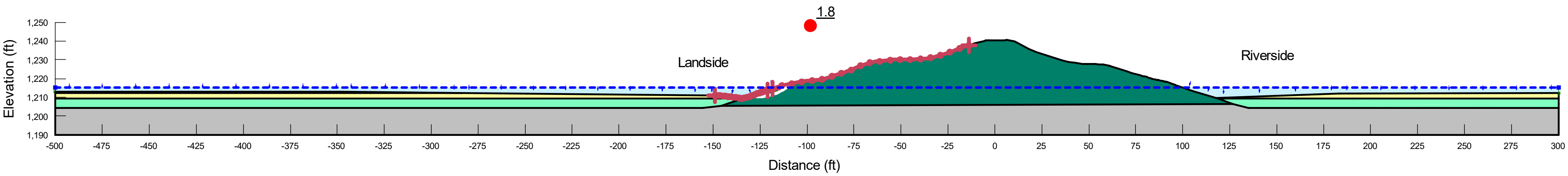
Salina Inlet		Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28		Checked: GB	Date:04/23/2025
Case I Proposed - SSS Full Flood Stage, Slope Stability - Riverside			
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes		Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Lean Clay	Mohr-Coulomb	117	0	30	1
	Levee Fill	Mohr-Coulomb	124	0	30	1
	Shale	Mohr-Coulomb	140	100	27	1
	Silt	Mohr-Coulomb	116	30	0	1
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25	1



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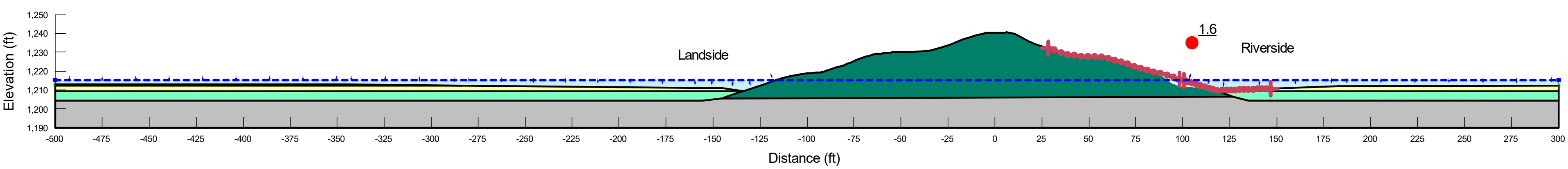
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case II Existing - Drought Conditions, Slope Stability - Landside		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Lean Clay	Mohr-Coulomb	117	0	30	1
	Levee Fill	Mohr-Coulomb	124	0	30	1
	Shale	Mohr-Coulomb	140	100	27	1
	Silt	Mohr-Coulomb	116	30	0	1
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25	1



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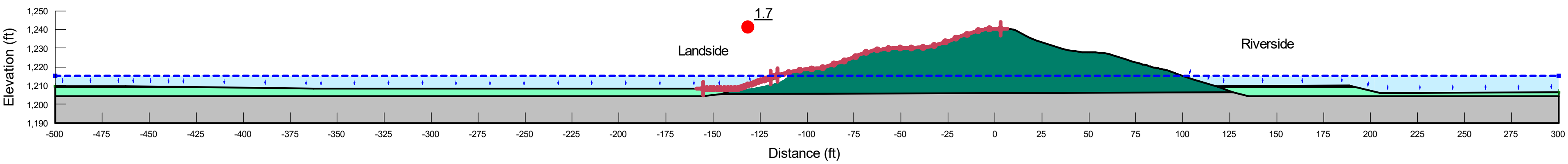
City of Salina

Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case II Existing - Drought Conditions, Slope Stability - Riverside		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Lean Clay	Mohr-Coulomb	117	0	30	1
	Levee Fill	Mohr-Coulomb	124	0	30	1
	Shale	Mohr-Coulomb	140	100	27	1
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25	1



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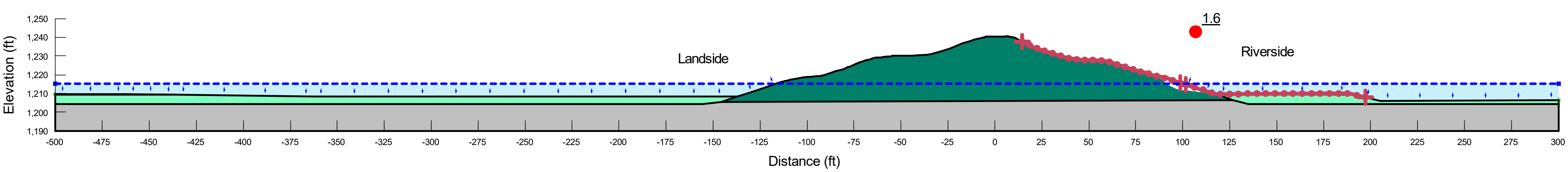
City of Salina		Salina Inlet	Computed: KB	Date:04/23/2025
		Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
		Case II Proposed - Drought Conditions, Slope Stability - Landside		
		Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Lean Clay	Mohr-Coulomb	117	0	30	1
	Levee Fill	Mohr-Coulomb	124	0	30	1
	Shale	Mohr-Coulomb	140	100	27	1
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25	1



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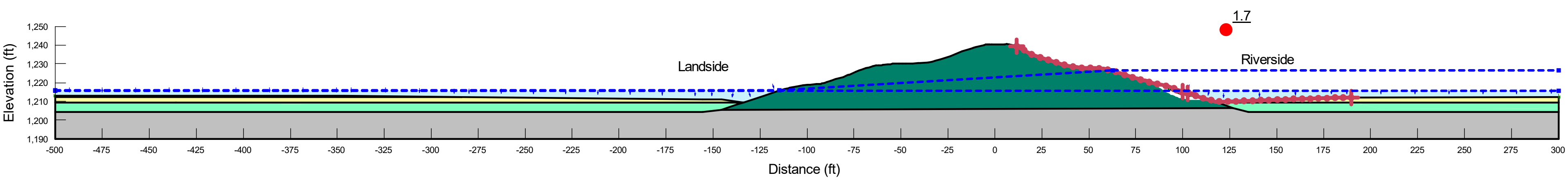
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case II Proposed - Drought Conditions, Slope Stability - Riverside		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion R (psf)	Phi R (°)	Piezometric Surface	Piezometric Surface After Drawdown
	Lean Clay	Mohr-Coulomb	117	0	30	1,000	0	1	1
	Levee Fill	Mohr-Coulomb	124	0	30	1,000	0	1	1
	Shale	Mohr-Coulomb	140	100	27	0	0	1	1
	Silt	Mohr-Coulomb	116	30	0	0	0	1	1
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25	250	0	1	1



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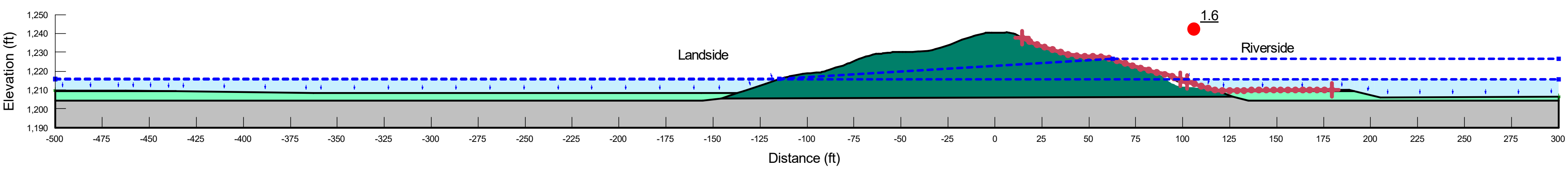
Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case III Existing - Rapid Drawdown, Slope Stability		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

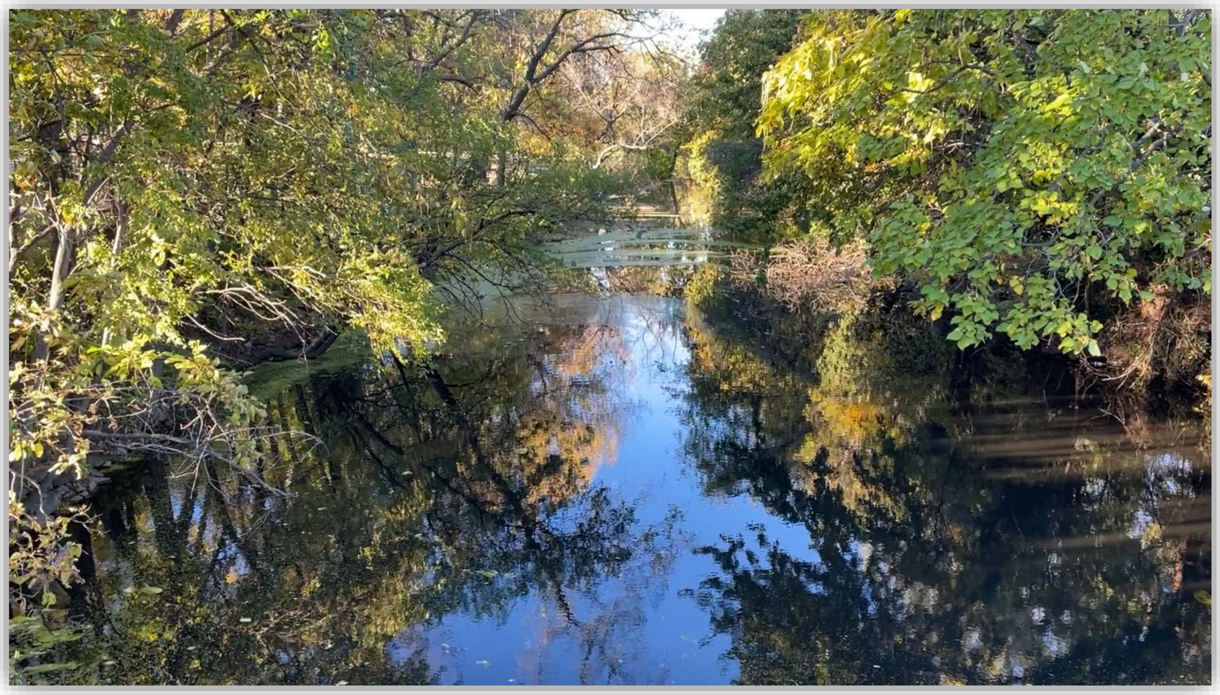
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion R (psf)	Phi R (°)	Piezometric Surface	Piezometric Surface After Drawdown
	Lean Clay	Mohr-Coulomb	117	0	30	1,000	0	1	1
	Levee Fill	Mohr-Coulomb	124	0	30	1,000	0	1	1
	Shale	Mohr-Coulomb	140	100	27	0	0	1	1
	Soft Silty Lean Clay	Mohr-Coulomb	110	0	25	250	0	1	1



C:\Users\kberg\Desktop\Salina\Inlet\Salina Inlet V2.gsz

Salina Inlet	Computed: KB	Date:04/23/2025
Product Version: 24.2.1.28	Checked: GB	Date:04/23/2025
Case III Proposed - Rapid Drawdown, Slope Stability		
Kind: SLOPE/W, Optimize Critical Slip Surface Location: Yes	Scale: 1:1,005	

US Army Corps of Engineers



Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix F – Environmental

September 2025

City of Salina

APPENDIX F – ENVIRONMENTAL
F1 - HABITAT MODELLING

US Army Corps
of Engineers ®
Kansas City District

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1.0 INTRODUCTION

This appendix provides the documentation of the habitat evaluation and quantification process that was conducted to evaluate the benefits and impacts of various alternatives for the Smoky Hill River Aquatic Ecosystem Restoration Study. During the development of feasibility reports, the environmental effects of each alternative evaluated in detail by the U.S. Army Corps of Engineers (USACE) must be captured and quantified to better compare the alternatives, and if necessary, determine any compensatory mitigation that may be required.

One method to evaluate the environmental impacts of alternatives is the Habitat Evaluation Procedure (HEP). HEP was developed by the U.S. Fish and Wildlife Service (USFWS) and evaluates the quality and quantity of available habitat for selected wildlife species or groups of species. HEP provides information for two general types of wildlife habitat comparisons. One, the relative value of different areas at the same point in time, and two, the relative value of the same area at future points in time. By combining these two types of comparisons, the impact of proposed land and water use changes on wildlife habitat can be quantified. HEP describes relative habitat value for selected wildlife species as a Habitat Suitability Index (HSI) with a value ranging from 0.0 (unsuitable) to 1.0 (optimal). This value is multiplied by the area of available habitat to obtain Habitat Units (HUs). To calculate habitat value over a period of time, such as a 50-year period of analysis, HUs are averaged on a yearly basis to provide Average Annual Habitat Units (AAHU). The project delivery team used the quantity and quality of the habitat jointly, in the form of habitat units, to measure benefits provided by ecosystem restoration at potential project sites. The following sections describe how the project delivery team (PDT) quantified habitats and determined the quality of the habitat with and without project features.

Early in the study, the PDT developed a conceptual ecological model (Figure 1-1) to further define the problems in the study area and to visualize and explain the interactions between the primary drivers of ecological degradation in the Project area, the intermediate outcomes, and the ultimate consequences. The conceptual model aided the identification of resource problems, opportunities and constraints, development of study objectives and potential measures as well as helped identify habitat types that could be used to quantify potential project benefits. This procedure also helped in identifying which ecological models to use for this study.

In-stream aquatic benefits and wetland benefits were quantified through the use of habitat suitability index models for instream and wetland habitat. Instream habitat was assessed using the Qualitative Habitat Evaluation Index (QHEI; Ohio EPA, 2006). Wetland habitat was assessed using the Dabbling Duck Migration Model (USACE, 2013). These models are both regionally certified.

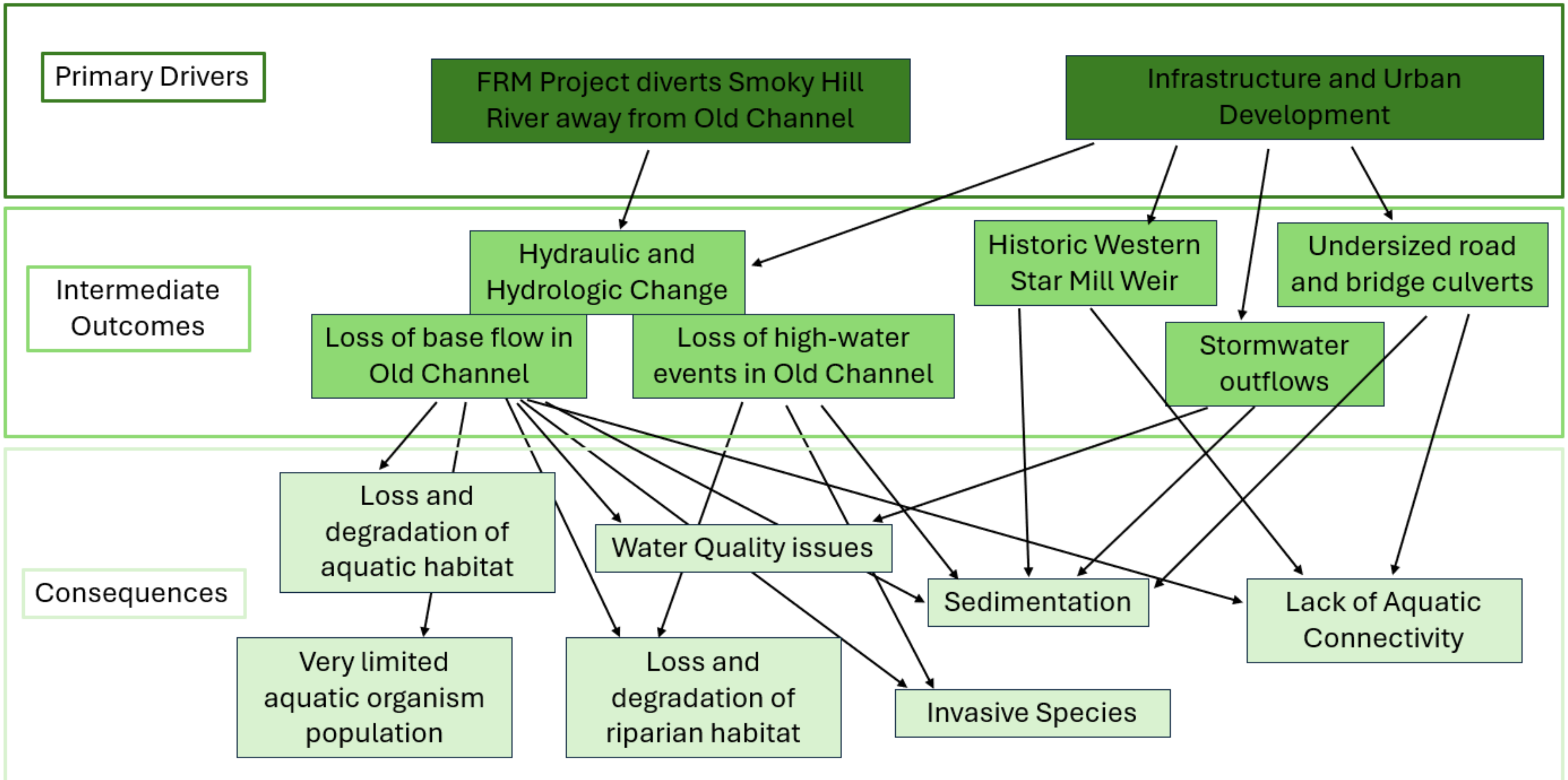

Figure 1-1: Conceptual Ecological Model for the Smoky Hill Aquatic Ecosystem Restoration Study

2.0 General Habitat Quality Assessment

The methodology utilized for evaluating benefits to aquatic and terrestrial habitat incorporates the Habitat Evaluation Procedures (HEP) format, which was developed by the USFWS. HEP is a habitat-based evaluation methodology used in project planning. The procedure documents the quality and quantity of available habitat for selected fish and wildlife species. The qualitative component of the analysis is known as the habitat suitability index (HSI) and is rated on a 0.0 to 1.0 scale, with higher values indicating better habitat for that species.

The HSI for a particular habitat type is determined by selecting values that reflect present and future project area conditions from a series of abiotic and biotic metrics. Each value corresponds to a suitability index for each species. Future values are determined using management plans, historical conditions and best professional judgment. The quantitative component is the number of acres of the habitat being evaluated. The standard unit of measure from the calculated qualitative and quantitative values, the habitat unit (HU), is calculated using the formula (HSI × Acres = HUs). Habitat units are calculated for specific target years to forecast changes in habitat values over the life of the project with- and without-project conditions.

For the purpose of planning, design and impact analysis, the period of analysis was established as 50 years. The period of analysis was determined to be 50 years based on the prediction that some future without project conditions would occur within that time interval and that some project features (e.g., development of key ecological processes needed to restore ecosystem structure and function) would need a longer period of time to reach maximum benefits; and the accrual of benefits was predicted to level off after 50 years. To facilitate comparison, target years were established at 0 (existing conditions), 10, 25, and 50 years. When HSI scores are not available for each year of analysis, a formula that requires only target year HSI and area estimates it used (USFWS, Habitat Evaluation Procedures, 1980). This formula is:

$$\int_0^T HU\,dt = (T_2 - T_1)\,X\left[\left(\frac{A_1H_1 + A_2H_2}{3}\right) + \left(\frac{A_2H_1 + A_1H_2}{6}\right)\right]$$

Where:

$\int_0^T HU\,dt$ = *Cumulative HUs*

T_1 = first target year of time interval
T_2 = last target year of time interval
A_1 = area of available habitat at beginning of time interval
A_2 = area of available habitat at end of time interval
H_1 = habitat suitability index at the beginning of time interval
H_2 = habitat suitability index at the end of time interval

3 and 6= constants derived from integration of HSI × Area for the interval between any two target years

This formula was developed to precisely calculate cumulative HUs when either HSI, or area, or both change over a time interval, which is common when dealing with the unpredictable fluctuations found in nature. Habitat Unit gains or losses are annualized by summing the cumulative HUs calculated using the above equation across all target years in the period of analysis and dividing the total (cumulative HUs) by the number of years in the life of the project (i.e., 50 years). This calculation results in the Average Annual Habitat Units (AAHUs) (USFWS 1980). The calculation of the HUs and AAHUs were completed in a Microsoft Excel spreadsheet for each model containing the formula above.

The benefits of each proposed project feature (net AAHUs) are then determined by calculating the difference in AAHUs between the with-project benefits and the without-project benefits. The effects of various habitat improvement feature combinations (alternatives) can then be evaluated by comparing the net AAHUs and their associated costs for each alternative considered.

3.0 Habitat Delineation

3.1. In-stream Aquatic Habitat

The Old Channel of the Smoky Hill River was defined using LiDAR. LiDAR of the Old Channel area was viewed at 1:1,500 scale in ArcGIS Pro. A polyline was drawn for both left and right banks from the confluence with the Smoky Hill River on both the upstream and the downstream site of the Old Channel. The elevation change from the steep banks was used as the dividing line between aquatic and riparian habitat. A polygon was created between the bank lines to get the area of the in-stream aquatic habitat.

Figure 3-1: Example LiDAR section of the Old Channel, viewed at 1:1,500 in ArcGIS Pro, with banklines drawn in red.

3.2. WETLAND HABITAT

The wetland habitat was defined using the conceptual drawings and modeled acreages prepared by the original contractor for the project (HDR Engineering).

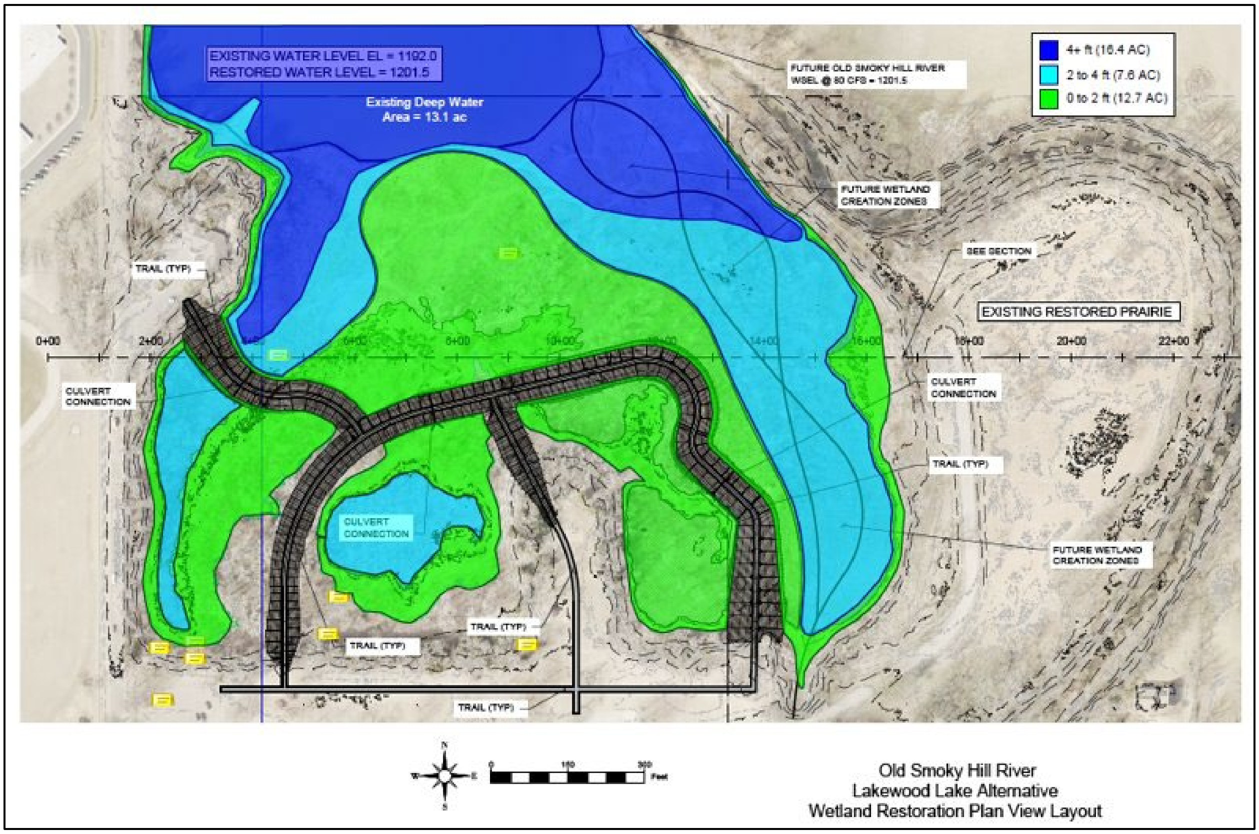

Figure 3-2: Wetland Acreages for Alternatives 1, 2 and 3

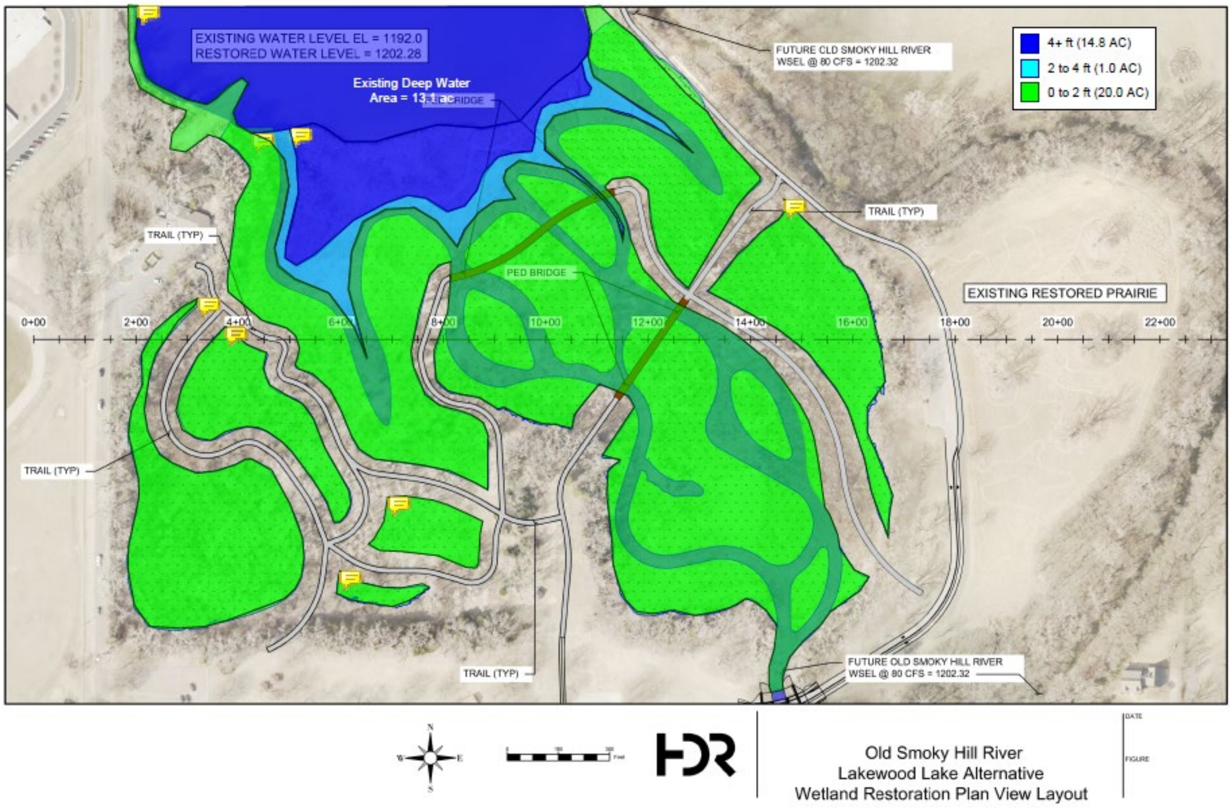

Figure 3-3: Wetland acreages for Alternative 4

4.0 HABITAT MODELS

4.1. QHEI

The Qualitative Habitat Evaluation Index (QHEI) is a model that quantifies the ecological value of in-stream habitat. This model was used to assess potential effects to in-stream habitat. The QHEI model was originally developed by the Ohio Environmental Protection Agency (EPA) and subsequently updated as data was collected (Ohio EPA 2006). It is an index of macro-habitat quality of streams in Ohio and associated ecoregions. The QHEI is a rapid, index-based, community-focused, ecological assessment designed to provide a measure of the habitat that generally corresponds to those physical factors that affect fish communities, and which are generally important to other aquatic life (e.g., invertebrates). The model provides a macro-scale approach, used to measure emergent properties of habitat (e.g., sinuosity, pool/riffle development, bank erosion) rather than the individual factors which shape these characters (e.g., current velocity, depth). The QHEI methodology is applicable to stream restoration and restoration of fish passage for small- to medium watersheds and stream communities.

Calculation of the index is based on field observations and scoring of reach-scale habitat metrics, which describe attributes of the physical habitat that may be important in explaining composition of fish communities in streams, and the presence or absence of species (Ohio Environmental Protection Agency [Ohio EPA] 1989). The five metrics include:

- **Substrate type and quality** – points are awarded to locations with diverse, high quality substrate types. Includes: best substrate types, origin, quality, and embeddedness.
- **Instream Cover** – scores the presence of cover types and overall instream cover.
- **Channel Morphology** – emphasizes the quality of stream channel as it relates to the creation and stability of macrohabitats. Includes: sinuosity, development, channelization, and stability.
- **Riparian Zone and Bank Erosion** – emphasizes quality of the riparian buffer zone and floodplain vegetation. Each streambank is scored separately and then averaged to determine the component value (the average of each streambank). Includes: erosion, riparian width, and floodplain quality.
- **Pool/Glide and Riffle-Run Quality** – the quality of pool, glide, and/or riffle-run habitats is emphasized in this metric. Includes maximum depth (pools), channel width, current velocity, riffle depth, run depth, riffle/run substrate, and riffle/run embeddedness.

The metrics are individually scored and then summed to provide the total QHEI location score. The highest scores are assigned to the parameters that have been shown to be correlated with streams that have high biological diversity and integrity, with a maximum score of 90. Progressively lower scores are assigned to less desirable habitat features (Rankin 1989).

In May of 2020, the USACE Ecosystem Restoration Center of Expertise (ECO-PCX) approved the QHEI model for regional use in Kansas and Nebraska streams in the High

Plains, Southwestern Tablelands, Central Great Plains, Flint Hills, Cross Timbers, Ozark Highlands, and Western Corn Belt Plains Level III Ecoregions (USACE 2020). Appropriate modifications were made to the model metric scoring to better reflect general stream conditions in the States of Kansas and Nebraska.

Stream data from the Old Channel was collected from a combination of sources including a site visit in 2019. During the site visit, photographs were taken characterize in and along the Old Channel at representative sample points substrate, instream cover, channel morphology, pool/glide, riffle/run, and riparian corridor composition. Desktop GIS and engineering analysis was used (when needed) to characterize flow regime, channel morphology and riparian habitat width.

Scoring of QHEI habitat variables for alternatives was done by scoring Reach 1 separately from Reach 2. Environmental outputs, quantified as habitat units (HUs), were calculated by multiplying the acres of in-stream habitat in each alternative by the QHEI score as follows:

AREA x QHEI HABITAT SCORE = HABITAT UNIT (HU)

HUs were calculated for select time series years (0 year, 10 years, 25 years, 50 years) for the FWOP and FWP conditions, and annualized over the life of the Project (50 years) to derive average annual habitat units (AAHUs). Estimating HUs and AAHUs is essential for evaluating Project alternatives, and paired with costs, these metrics serve as the basis for selecting and justifying a Tentatively Selected Plan.

4.1.1. Model and Variable Assumptions

Reach 1 and Reach 2 of the Old Channel were modeled, including both the FWOP (Future without Project) alternative and all FWP (Future with Project) alternatives.

- A series of TYs within this 50-year setting were developed including TY0 (baseline conditions), TY10 (project installation, initial establishment), TY25 (majority of project establishment), and TY50 (full project establishment, full period of analysis).
- In the FWOP condition (the No Action Alternative) the HSI score was low and declined through the 50-year period of analysis. Over the 50-year period, the Old Channel would remain sedimented in, with limited water availability. Additionally, invasive species would continue to spread through the area and choke out native species.
- Substrate type and quality did not vary over the 50-year period. The FWOP condition is silt, with Heavy silt cover and Extensive embeddedness. For all action alternatives, Substrate type and quality improves at Year 10, after construction, then remains the same for the rest of the 50-year period. Alts 2, 3 and 4 have higher Substrate scores than Alt 1, because the riffle-pool-run sequences will add some rocks to the channel to maintain riffles. The uniform trapezoidal shape of Alt 1 does not include any additional rock habitat.
- Instream Cover declines over time in the FWOP condition, as large native trees die and are replaced by invasive shrubs. For all action alternatives, instream cover increases at Year 10, after construction, then continues to increase through the rest of the 50-year period. For Alt 1, all metrics improve with the return of water to the

channel, but there is no vegetation restoration in this alternative, so the gains are minor. For Alts 2, 3 and 4, Instream cover improves to a greater degree. Alternative 4 is differentiated from Alternative 3 through deeper pools in Reach 1, which affect this variable.

- Channel Morphology remains the same over time in the FWOP condition. For all action alternatives, at TY10, Channel Morphology improves and then remains the same for the rest of the 50 year period. Channelization goes to Recovering, and Stability goes to High.
- Bank Erosion and Riparian Zone remains the same over time in the FWOP condition. This variable also remains the same for the action alternatives. There is minimal erosion now (due to no water) and erosion is not expected after the channel is reconfigured and flow returns to the Old Channel. The land use in the floodplain is not expected to change, so these variables remain the same for all alternatives.
- Pool/Glide and Riffle-Run Quality remains the same (non-existent) over time in the FWOP condition. There are no riffles in Alternative 1, so the variable remains the same over time. In Alternatives 2, 3, and 4, riffles are planned, so the variable increases at TY10 and then remains the same for the rest of the 50-year period.
- Many of the measures used for each reach and alternative are the same. The following matrix was developed to keep the habitat modelling consistent. Alternative 2, Reach 1 (A2R1), A3R1, A3R2 and A4R2 have the exact same attributes. A4R1

	Alternative			
	A1R1	A2R1	A3R1	A4R1
	Uniform trapezoidal channel dredging.	Channel dredging - Variable (glide/pool/riffle/run)	Channel dredging - Variable (glide/pool/riffle/run)	Channel dredging - Variable + 1 foot (glide/pool/riffle/run)
	Bottom: 5 ft width	Bottom: 8-12 ft width	Bottom: 8-12 ft width	Bottom: 8-12 ft width
	Top: 30-50 ft @ 60 cfs	Top: 30-50 ft @ 80 cfs	Top: 30-50 ft @ 80 cfs	Top: 30-50 ft @ 80 cfs
	Depth: 3.25 ft	Depth: Pool 4-6 ft Riffle: 3.25 ft Glide/run: 3-4 ft	Depth: Pool 4-6 ft Riffle: 3.25 ft Glide/run: 3-4 ft	Depth: Pool 5-7 ft Riffle: 4.25 ft Glide/run: 4-5 ft
Reach	A1R2	A2R2	A3R2	A4R2
	No dredging	No dredging	Channel dredging - Variable (glide/pool/riffle/run)	Channel dredging - Variable (glide/pool/riffle/run)
	2 ft habitat weir	2 ft habitat weir	2 ft habitat weir	2 ft habitat weir
	Bottom: ~20 ft	Bottom: ~20ft	Bottom: 8-12 ft width	Bottom: 8-12 ft width
	Top: 40-80 ft @ 60 cfs	Top: 40-80 ft @ 80 cfs	Top: 30-50 ft @ 80 cfs	Top: 30-50 ft @ 80 cfs
	Depth: 2 ft	Depth: 2 ft	Depth: Pool 4-6 ft Riffle: 3.25 ft Glide/run: 3-4 ft	Depth: Pool 4-6 ft Riffle: 3.25 ft Glide/run: 3-4 ft

Figure 4-1: Matrix used to guide QHEI modeling consistency.

4.1.2. Model Results

Table 4-1: QHEI Modelling results – Reach 1

Restoration Alternative/ Measure	Condition	TY	Year Interval	HSI	Acres	HU at TY	Interval HUs	Cumulative HUs	AAHUs	Net AAHUs
A0 - No Action	FWOP	0	0	0.17	34.68	5.78		251.4	5.0	0
A0 - No Action	FWOP	10	10	0.17	34.68	5.78	57.80	251.4	5.0	0
A0 - No Action	FWOP	25	15	0.13	34.68	4.62	78.03	251.4	5.0	0
A0 - No Action	FWOP	50	25	0.13	34.68	4.62	115.60	251.4	5.0	0
A1 -	FWP	0	0	0.17	34.68	5.78		799.6	16.0	
A1 -	FWP	10	10	0.46	34.68	15.80	107.89	799.6	16.0	
A1 -	FWP	25	15	0.50	34.68	17.34	248.54	799.6	16.0	
A1 -	FWP	50	25	0.52	34.68	18.11	443.13	799.6	16.0	
A2 -	FWP	0	0	0.17	34.68	5.78		1185.9	23.7	
A2 -	FWP	10	10	0.70	34.68	24.28	150.28	1185.9	23.7	
A2 -	FWP	25	15	0.74	34.68	25.82	375.70	1185.9	23.7	
A2 -	FWP	50	25	0.78	34.68	26.97	659.88	1185.9	23.7	
A3 -	FWP	0	0	0.17	34.68	5.78		1185.9	23.7	
A3 -	FWP	10	10	0.72	34.68	24.28	150.28	1185.9	23.7	
A3 -	FWP	25	15	0.77	34.68	25.82	375.70	1185.9	23.7	
A3 -	FWP	50	25	0.78	34.68	26.97	659.88	1185.9	23.7	
A4 -	FWP	0	0	0.17	34.68	5.78		1210.9	24.2	
A4 -	FWP	10	10	0.72	34.68	25.05	154.13	1210.9	24.2	
A4 -	FWP	25	15	0.77	34.68	26.59	387.26	1210.9	24.2	
A4 -	FWP	50	25	0.78	34.68	26.97	669.52	1210.9	24.2	

Table 4-2: QHEI Modeling Results – Reach 2

Restoration Alternative	Condition	TY	Year Interval	HSI	Acres	HU at TY	Interval HUs	Cumulative HUs	AAHUs	Net AAHUs
A0 - No Action	FWOP	0	0	0.17	31.92	5.32		231.4	4.6	0
A0 - No Action	FWOP	10	10	0.17	31.92	5.32	53.20	231.4	4.6	0
A0 - No Action	FWOP	25	15	0.13	31.92	4.26	71.82	231.4	4.6	0
A0 - No Action	FWOP	50	25	0.13	31.92	4.26	106.40	231.4	4.6	0
A1 -	FWP	0	0	0.17	31.92	5.32		672.1	13.4	
A1 -	FWP	10	10	0.41	31.92	13.12	92.21	672.1	13.4	
A1 -	FWP	25	15	0.46	31.92	14.54	207.48	672.1	13.4	
A1 -	FWP	50	25	0.48	31.92	15.25	372.40	672.1	13.4	
A2 -	FWP	0	0	0.17	31.92	5.32		672.1	13.4	
A2 -	FWP	10	10	0.41	31.92	13.12	92.21	672.1	13.4	
A2 -	FWP	25	15	0.46	31.92	14.54	207.48	672.1	13.4	
A2 -	FWP	50	25	0.48	31.92	15.25	372.40	672.1	13.4	
A3 -	FWP	0	0	0.17	31.92	5.32		1075.5	21.5	
A3 -	FWP	10	10	0.69	31.92	21.99	136.55	1075.5	21.5	
A3 -	FWP	25	15	0.73	31.92	23.41	340.48	1075.5	21.5	
A3 -	FWP	50	25	0.77	31.92	24.47	598.50	1075.5	21.5	
A4 -	FWP	0	0	0.17	31.92	5.32		1075.5	21.5	
A4 -	FWP	10	10	0.69	31.92	21.99	136.55	1075.5	21.5	
A4 -	FWP	25	15	0.73	31.92	23.41	340.48	1075.5	21.5	
A4 -	FWP	50	25	0.77	31.92	24.47	598.50	1075.5	21.5	

Table 4-3: QHEI Modeling Results – Reach 1 and 2 Combined

Restoration Alternative	Condition	Cumulative AAHUs	Net AAHUs
A0 – No Action	FWOP	9.7	0
A1 -	FWP	29.4	19.8
A2 -	FWP	37.2	27.5
A3 -	FWP	45.2	35.6
A4 -	FWP	45.7	36.1

4.2. DABBLING DUCK

To model the wetland ecological benefits at Lakewood Lake, the Dabbling Duck Migration Model for the Upper Mississippi River was used to assess potential changes in emergent wetland habitat, as well as changes in deepwater lentic habitat in Lakewood Lake. The model, which was originally reviewed and certified by USACE in 2013, was developed to evaluate the quality of fall migration habitat in large riverine areas and their associated backwaters for a wide variety of dabbling duck species. The model was originally developed for the Upper Mississippi River, but a range expansion was approved in April 2025, and the model is now certified for regional use in the Central Flyway. Range expansion documentation and certification is included at the end of this Appendix, in Section 6.0 Documentation.

The duck species represented in the model include mallard (*Anas platyrhynchosa*), gadwall (*Anas strepera*), pintail (*Anas acuta*), blue-winged teal (*Anas discors*), green-winged teal (*Anas crecca*), wigeon (*Anas Americana*), and wood duck (*Aix sponsa*). The Dabbling Duck model obtains a final habitat suitability index (HSI) score from 0.0 to 1.0 to determine the "quality" score for emergent wetland habitat based on a suite of variables that can be measured and assessed. The area of available habitat was assessed using design information and GIS aerial photography to determine proposed quantities (acres) of emergent wetland habitat. Model variables (V) for the Dabbling Duck Migration Model are included below.

- **V1 – Wetland Distance to Bottomland Hardwoods, Species Composition and Water Availability.** Higher scores given to areas close to hardwood woodlands, as some species of dabbling duck will feed in woodlands during migration. The presence of mast producing species (such as oaks) provide high quality food resources, especially pin oaks, which produce small acorns preferred by ducks. Areas with consistent water availability are scored higher as well.
- **V2 – Distance of Wetlands to Cropland and Cropland Practices.** Agricultural grains can provide a high energy food source for ducks during migration. Higher scores are given to areas close to croplands, with agricultural harvest practices that leave some grain in the fields.
- **V3 – Percent of Wetland Habitat with Water Depth 4-18 inches in Fall.** This depth is optimum foraging depth for dabbling ducks. Higher scores are given to areas with more optimum foraging habitat. Areas with >90% optimum depth receive the highest score.
- **V4 – Percent of Wetland Habitat with Water Depth < 4 inches in Fall.** Sandflats/mudflats are heavily used by dabbling ducks. In addition to providing loafing areas to conserve energy, these shallow areas also allow for the development of emergent vegetation adding diversity to food availability. Highest scores are given to areas where 15-25% of the area is shallow water habitat.
- **V5 – Percent of Wetland Habitat with Open Water.** For habitat value, areas with an interspersed mix of open water and vegetation are more valuable than entirely vegetated or entirely open areas. Highest scores are given to areas with a 50/50 mix of open water and vegetation.

- **V6 – Plant Community Diversity.** High quality habitat has a diverse assemblage of preferred food plants, compared to monotypic stand of one species. This diversity also maintains high quality food habitat as conditions change from year to year and different plant species dominate. Highest scores are given to areas with high plant diversity, with greater than 6 food plant species being the best habitat possible.
- **V7a – Do Vegetative Beds Cover < 20% of the Evaluation Area?**
- **V7b – Percent Coverage of Wetland Vegetative Beds with Important Food Plants.** These variables address the percent of vegetation of the area that contains preferred food plants for dabbling ducks. Important food plants include bidens, chufa, coontail, cutgrass, duckweeds, pondweeds, etc. Important food plants may be present outside of the area of optimal water depths, so the optimum for percent area of food species is greater than the optimum for percent area of ideal water depths.
- **V8 – Percent of the Wetland Area Containing Loafing Structures.** Loafing sites/structures allow dabbling ducks to rest and conserve energy, so areas with more loafing structures are higher quality. Sandflats/mudflats, tree stumps, low islands and clumps of vegetation are all considered loafing structures.
- **V9 – Percent of the Wetland Area with Structure to Provide Thermal Protection.** Protection of the area from prevailing winds is an important factor in allowing dabbling ducks to conserve energy. Protected shorelines, coves, backwater wetlands, large stands of vegetation or islands can all provide the necessary thermal protection. Need for these structures is intermittent, so highest scores are given to locations with greater than 5% thermal protection.
- **V10 – Disturbance in the Fall.** Human disturbance in an area lowers the value of an area as migration habitat. Disturbance limits feeding opportunities and forces the birds to expend energy in avoidance activity. Hunting, bird-watching, research and other human activities can all cause disturbance. Highest scores are given to areas closed to all human activity.
- **V11 – Presence of Visual Barriers.** Secure resting areas are important to migrating waterfowl. Dabbling ducks may be disturbed by human intrusion like hunting or fishing, causing them to leave the area and expend energy. The presence of visual barriers may increase their tolerance for disturbance by eliminating visual cues, or decrease the distance that they move once disturbed, conserving energy.

The metrics are individually scored and then combined to provide the total HSI score for the location. Environmental outputs, quantified as habitat units (HUs), were calculated by multiplying the acres of in-stream habitat in each alternative by the Dabbling Duck HSI score as follows:

AREA x Dabbling Duck HSI SCORE = HABITAT UNIT (HU)

HUs were calculated for select time series years (0 year, 2 years, 10 years, 50 years) for the FWOP and FWP conditions, and annualized over the life of the Project (50 years) to derive average annual habitat units (AAHUs). Estimating HUs and AAHUs is essential for evaluating Project alternatives, and paired with costs, these metrics serve as the basis for selecting and justifying a Tentatively Selected Plan.

Year 0 for each Alternative is the existing condition, before any construction has begun. Year 0 in each Alternative is equivalent to the No Action Alternative. Year 2 is after construction is completed, and plants have begun filling in and maturing. Year 10 is after there have been several years to capture the habitat benefits from plant establishment and maturing vegetation. HSI scores increased over time for all alternatives, as the vegetation is expected to fill in and the diversity of plant species increases as more species have a chance to colonize the area. This increase in plant maturity and diversity provides increased loafing structures, thermal protection, and visual barriers, benefits of which were accounted for at Year 10. The period of analysis of most civil works projects is 50-years, so Year 50 was chosen to capture the theoretical end point of the project. The project is expected to continue operations and benefit the area for much longer than 50 years, but the period of analysis ends at Year 50.

4.2.1. Model and Variable Assumptions

Each wetland restoration alternative was modeled, including both the FWOP (Future without Project) alternative and all FWP (Future with Project) alternatives.

- A series of TYs within this 50-year setting were developed including TY0 (baseline conditions), TY10 (project installation, initial establishment), TY25 (majority of project establishment), and TY50 (full project establishment, full period of analysis).
- In the FWOP condition (the No Action Alternative) the HSI score remained low and unchanged through the 50-year period of analysis. The existing wetland areas will remain in low quality wetland habitat, with the same problems of water availability, minimal diversity, and invasive species establishment.
- V1 - Distance to bottomland hardwood forest remains the same in the FWOP condition. For all action alternatives, this variable improves at Year 2 and then remains the same.
- V2 - Distance to cropland remains the same over time in the FWOP condition. For all action alternatives, distance to cropland is the same as the FWOP condition, and remains the same. There will be no changes to land use in the larger area outside of the restored wetlands.
- V3, V4 and V5 (Water Depth 4-18 inches, Water depth <4 inches, and Percent Open Water) do not vary over time for the FWOP or action alternatives. For action alternatives, these variables change after construction at Year 2, and then remain the same over the rest of the 50-year period.
- V7a – Do vegetative beds cover <20% of the evaluation remains the same over time in the FWOP alternative. For all action alternatives, this condition improves at TY2 (increases over 20%) and then remains the same over time.
- V7b and V8 (Important food plant coverage, percent of the area containing loafing structures) remains the same over time in the FWOP condition. For all action alternatives, these variables improve at TY2, and then continue to improve over time as the vegetation community develops and continues to fill in.

- V9 – Structure to provide thermal protection remains the same over time in the FWOP condition. For action alternatives, this variable improves after construction at TY2, remains the same at TY10, and then increases at TY50. These would be larger vegetation (trees, large dead logs) that would take longer to develop.
- V10 – disturbance in the Fall is the same for both the FWOP and action alternatives, and remains the same over time. The land use in the area would not substantially change – the area is currently used as parkland, and after restoration, the use for public recreation would continue.
- V11 – Visual barriers remain the same over time in the FWOP condition. For action alternatives, this variable improves after construction at TY2, and then remains the same over time. Alternative 4 has a slightly higher visual barrier condition, from the more complex trail system and more vegetation establishment.
- For the wetlands, alternatives 1, 2 and 3 are identical. Alternative 4 has a different configuration of shallow water and deep water habitat. The major differences in modelling between these two different alternatives is V3, V4, V7b and V8. The different configuration of depth results in V3 and V4 being different, with Alternative 4 designed with more shallow water habitat. V7b and V8 are different in Alt 4 as well – the increase shallow water habitat is likely to lead to more vegetation growth and establishment.

4.2.2. MODEL RESULTS

Table 4-4: Dabbling Duck Model Results

Restoration Alternative/ Measure	Condition	TY	Year Interval	HSI	Acres	HU at TY	Interval HUs	Cumulative HUs	AAHUs	Net AAHUs
A0 - No Action	FWOP	0	0	0.34	14	4.69		234.7	4.7	0
A0 - No Action	FWOP	10	10	0.34	14	4.69	9.39	234.7	4.7	0
A0 - No Action	FWOP	25	15	0.34	14	4.69	37.55	234.7	4.7	0
A0 - No Action	FWOP	50	25	0.34	14	4.69	187.76	234.7	4.7	0
A1 -	FWP	0	0	0.34	36.7	12.31		1292.5	25.8	21.2
A1 -	FWP	10	10	0.62	36.7	22.88	35.19	1292.5	25.8	21.2
A1 -	FWP	25	15	0.71	36.7	25.91	195.16	1292.5	25.8	21.2
A1 -	FWP	50	25	0.74	36.7	27.20	1062.14	1292.5	25.8	21.2
A2 -	FWP	0	0	0.34	36.7	12.31		1292.5	25.8	21.2
A2 -	FWP	10	10	0.62	36.7	22.88	35.19	1292.5	25.8	21.2
A2 -	FWP	25	15	0.71	36.7	25.91	195.16	1292.5	25.8	21.2
A2 -	FWP	50	25	0.74	36.7	27.20	1062.14	1292.5	25.8	21.2
A3 -	FWP	0	0	0.34	36.7	12.31		1292.5	25.8	21.2
A3 -	FWP	10	10	0.62	36.7	22.88	35.19	1292.5	25.8	21.2
A3 -	FWP	25	15	0.71	36.7	25.91	195.16	1292.5	25.8	21.2
A3 -	FWP	50	25	0.74	36.7	27.20	1062.14	1292.5	25.8	21.2
A4 -	FWP	0	0	0.34	35.8	12.00		1350.1	27.0	22.3
A4 -	FWP	10	10	0.62	35.8	22.32	34.33	1350.1	27.0	22.3
A4 -	FWP	25	15	0.74	35.8	26.53	195.43	1350.1	27.0	22.3
A4 -	FWP	50	25	0.82	35.8	29.48	1120.33	1350.1	27.0	22.3

4.3. COMBINED MODELLING RESULTS

Table 4-5: QHEI and Dabbling Duck Combined Net AAHUs

Restoration Alternative	Condition	Net AAHUs
A0 – No Action	FWOP	0
A1 -	FWP	41.0
A2 -	FWP	48.7
A3 -	FWP	56.8
A4 -	FWP	58.4

5.0 LITERATURE CITED

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6.0 DOCUMENTATION

[placeholder. Merge Certification, range expansion memo , and field data sheets in PDF version]

Appendix F2 –
Monitoring and Adaptive Management

US Army Corps
of Engineers ®
Kansas City District

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1.0 Project Overview

The tentatively selected plan (TSP) is intended to reconnect and restore water flows within the Old Channel and adjacent wetland areas to promote and maintain a self-sustaining aquatic ecosystem. The key features of the TSP that would be monitored includes habitat quality/quantity associated with riffle/pool/run sequences and future sedimentation in the Old Channel.

There are uncertainties related to the physical and/or biological performance of these measures that could affect the ability to meet the project goals and objectives. There is always a risk of poor performance when changing stream hydraulics, planting vegetation, or restoring wetlands, due to engineering challenges, local site conditions, and weather patterns after planting. These measures would be monitored following project construction to inform decision-makers whether 1) The project is meeting performance measures and should continue as implemented 2) The project is not meeting performance measures and should be adjusted, or 3) The project has met success criteria and no further monitoring for ecological performance is needed.

USACE Implementation Guidance for Section 1161 (Monitoring Ecosystem Restoration) of the Water Resources Development Act of 2016, and Section 2036 (Mitigation for Fish and Wildlife and Wetlands Losses) of the Water Resources Development Act of 2007 require monitoring sufficient to evaluate ecosystem restoration and mitigation success. USACE is required to consider adaptive management (or contingency plans) for ecosystem restoration projects and mitigation projects because they often involve uncertainty that can be reduced through an adaptive management approach. For this project, adaptive management is an appropriate management strategy because there is: 1) uncertainty regarding the outcome of the management measures, 2) an ability to monitor and evaluate the system response to management measures, 3) capacity to learn from monitoring, and 4) the ability to apply a decision to change management if needed.

2.0 Objectives and Design

An important part of the monitoring and adaptive management plan is the translation of the management goals and objectives from the planning process into specific performance measures (sometimes called metrics), success criteria (sometimes called targets), and decision triggers (triggers for implementing a contingency plan or other decision). During development of the monitoring and adaptive management plan the team worked from the planning study conceptual model(s) and impact/benefit assessments to define the physical, chemical, biological, and ecological criteria that would be monitored to assess project performance.

The monitoring design for this project includes the minimum actions necessary to evaluate success of the implemented ecosystem restoration measures. It focuses on the performance measures of the project objectives to determine success. Each relevant objective and the associated performance measures are described below along with information required by USACE guidance.

Monitoring would continue until project success criteria are met. Monitoring would be cost-shared between USACE and the non-Federal Sponsor for up to 10 years after construction is complete. Any additional monitoring beyond 10 years would be a non-Federal responsibility.

Pre-construction data would be used to inform baseline conditions. Post-construction data would be used to inform adequacy of dredging, effectiveness of riffle, pool, and run features, and establishment of reliable flow in the Old Channel.

The following have been developed for this monitoring and adaptive management plan:

2.1 Objective: Restore degraded in-stream aquatic habitat in the Old Channel during the 50-year period of analysis

2.1.1 Performance Measure

1. Assess Old Channel flow capacity.
2. Assess habitat quality and availability in riffle, pool, and run features.

2.1.2 Success Criteria

1. Old Channel maintains 40-80 cfs flows from May to September, approximately 150 days per year.
2. Old Channel maintains at least 10-40 cfs flows from October to April, approximately 240 days per year.
3. During extreme drought conditions, the Old Channel maintains less than 10 cfs flows for no more than approximately 30 days per year.
4. Riffle pool run sequences provide aquatic habitat. Riffle depths should be between 1-4 feet, Pool depths should be between 4 – 7 feet.

2.1.3 Monitoring Design, Duration, and Periodicity

1. Install and monitor flow gauges in the Old Channel to assess daily, monthly, and/or yearly flow averages.
2. Conduct a pre-construction survey, then surveys at select riffle, pool, and run sites at Years 1, 3, 5, 7, and 9 post-construction to monitor habitat depths, area, and use by fish and aquatic organisms. Photo documentation would be used to examine the riffle, pool, and run features over time. Monitor aquatic macroinvertebrate colonization at various stream features, note other aquatic organism presence/absence. Make qualitative observations of fisheries in the Old Channel to determine diversity and abundance of fish species.

2.1.4 Decision Trigger

1. Less than 10 cfs baseflow in the Old Channel under normal flow conditions for more than 10 consecutive days or more than 30 days per season.
2. Riffle pool run sequences are not defined, are not providing suitable habitat for aquatic organisms

2.1.5 Contingency Measure(s)

1. If Smoky Hill River flows are available and success criteria are not being met; increase flows through the sediment forebay to maximize available flow in the Old Channel and riffle, pool, and run habitat depths.
2. If Smoky Hill River flows are not available and success criteria are not being met; adjust the two weir features to increase depths and habitat area within the Old Channel.
3. Adjust riffle, pool, and run physical features (length, width, depth, amount of rock, bank slope, etc.) if needed to better maintain habitat features and natural transitions between habitat types.

2.1.6 Costs, Responsibilities, and Closeout

1. USACE estimates that monitoring for instream aquatic habitat would cost up to $213,000 over a ten-year period.
2. USACE and the non-federal sponsor would share monitoring and adaptive management responsibilities for the 10-year monitoring period. This is a cost shared responsibility, but it is likely that USACE staff members would be performing the site visits and surveys.
3. Monitoring reports would be prepared by USACE after every monitoring visit and results shared with the non-federal sponsor. Monitoring requirements for this activity would be completed following the last post-construction site visit and survey.

2.2 Objective: Restore degraded wetland habitat in the Lakewood Lake area (and create wetland shelves in the Old Channel) during the 50-year period of analysis

2.2.1 Performance Measure

1. Assess Lakewood Lake and Wetland Shelf hydrology and hydric indicators
2. Assess Lakewood Lake and Wetland Shelf plant communities

2.2.2 Success Criteria

1. Wetlands have a reliable water supply and show evidence of wetland hydrology criteria based on the 1987 Corps of Engineers Wetland Delineation Manual and the Great Plains Region Supplement within 5 years of construction completion. The Lakewood Lake area should be about 20 acres of wetland (with an additional 13 acres of open water), while the wetland shelves in the Old Channel should have about 1.7 acres of wetland.
2. Wetlands meet the hydric vegetation criteria in the 1987 Corps of Engineers Wetland Delineation Manual and Great Plains Region Supplement. There should be >50% wetland vegetation dominance in wetland areas (plant species are rated obligate (OBL), facultative wet (FACW) or facultative (FAC)) in USACE Wetland Delineation Manual.
3. Noxious weeds and invasive species will comprise no more than 10% of the absolute percent cover in the wetland area, with no individual colony comprising more than 5% of the percent cover.

2.2.3 Monitoring Design, Duration, and Periodicity

1. Wetland Hydrology – Preconstruction site visit, then establish wetland hydrology sampling sites post construction with installation of piezometers to monitor water levels. Piezometers should be monitored seasonally for the first year, then at Years 3, 5, 7, and 9. On-site surveys would include photo points, visual inspection for hydrology indicators, soil samples, and water level results.
2. Wetland Community – Preconstruction survey, then surveys post construction in Years 1, 3, 5, 7, and 9 to establish sampling points and collect data on vegetation (wetland plant community composition, # of species, native vs invasive, % vegetation coverage), and soils present. Surveys would include photos, inspections for invasive species, hydric indicator surveys for a simplified wetland delineation, and identification of wetland versus upland species.

2.2.4 Decision Trigger

1. Wetlands are not maintaining sufficient water supply and depth to develop wetland hydrology and hydric characteristics.
2. Hydric vegetation is below 50% of vegetation in the wetland area.
3. Excessive establishment of invasive species (>10% of vegetation cover in the area.)

2.2.5 Contingency Measure(s)

1. Coordinate with the USACE Lewisville Aquatic Ecosystem Restoration Facility (LAERF) for initial plantings followed by additional replacement plantings.

2. Coordinate with LAERF for manual and/or herbicide removal of invasive species followed by additional native plantings.

3. Adjust sediment forebay and/or habitat weirs to increase flows and wetland depths to modify wetland depth/area targets.

4. Modifications to wetland contour depths or extents to improve flow or conditions necessary to improve hydrophytic vegetation growth and survival.

2.2.6 Costs, Responsibilities, and Closeout

1. The USACE estimates that monitoring of the Wetland Shelves and Lakewood Lake Wetlands would cost $250,000 over a ten-year period.

2. Monitoring and adaptive management would continue until project success criteria are met. Monitoring and adaptive management would be cost-shared between USACE and the non-Federal Sponsor for 10 years after construction is complete. Any additional monitoring and adaptive management beyond 10 years would be a non-Federal responsibility.

3. Monitoring reports would be prepared by USACE after every monitoring visit and results shared with the non-Federal Sponsor. Monitoring and adaptive management requirements for this activity would be completed following the last post-construction site visit and survey.

2.3 Objective: Manage Old Channel sedimentation during the 50-year period of analysis

2.3.1 Performance Measure

1. Assess sediment loads and deposition from Smoky Hill River flows into the sediment forebay and within the Old Channel.

2.3.2 Success Criteria

1. Newly constructed sediment forebay should retain sediment from the Smoky Hill River to decrease the sediment load in the Old Channel.

2.3.3 Monitoring Design, Duration, and Periodicity

1. Settleable solids tests (using Imhoff cones) at several locations in the Old Channel in conjunction with permanent sediment deposition depth benchmarks/gages established in the channel bottom and near stormwater outfalls. Monitor these gages, along with photo points, at Years 1, 3, 5, 7, 9.

2. Monitoring of sediment forebay sediment levels annually to determine when clean out is needed and if the sediment forebay is functioning as designed, and to determine clean-out timeframes.

2.3.4 Decision Trigger

1. Sedimentation in Old Channel is inhibiting natural habitat functions of riffle, pool, run sequences.

2. Identification of head-cutting, streambank erosion, or similar erosion processes.

2.3.5 Contingency Measure(s)

1. If sedimentation is due to inflows from the Smoky Hill River, reevaluate the operation and function of the sediment forebay and/or in-channel weirs; increase/decrease the number of sediment forebay clean-outs, increase/decrease forebay inflows, adjust weir levels.

2. If excessive sedimentation or debris is occurring from the 75 City outfall structures, coordinate with the non-Federal Sponsor to implement additional storm outfall best management practices.

3. Address stream/streambank erosion processes with rock replacement measures, forebay/weir adjustments, or local outfall modifications.

2.2.6 Costs, Responsibilities, and Closeout

1. The USACE estimates that monitoring of sedimentation would cost $100,000 over a ten-year period.

2. Monitoring and adaptive management would continue until project success criteria are met. Monitoring and adaptive management would be cost-shared between USACE and the non-Federal Sponsor for 10 years after construction is complete. Any additional monitoring and adaptive management beyond 10 years would be a non-Federal responsibility.

3. Monitoring reports would be prepared by USACE after every monitoring visit and results shared with the non-Federal Sponsor. Monitoring and adaptive management requirements for this activity would be completed following the last post-construction site visit and survey.

2.4 Objective: Restore habitat connectivity for the 50-year period of analysis

2.4.1 Performance Measure

1. Assess channel and/or wetland connectivity issues from potential future sedimentation, debris jams, inadequate flows, or constructed project features. Key locations include, the Western Star Mill Weir step pools, the two habitat weirs, the Lakewood Lake wetland location, and at the outflow site from the Old Channel to the Smoky Hill River.

2.4.2 Success Criteria

1. Western Star Mill Weir no longer operates as a barrier to aquatic species passage. Step pool slopes and distances between steps do not inhibit aquatic species passage.

2. The two weir locations do not inhibit aquatic species passage.

3. Lakewood Lake wetland area is connected to the Old Channel and Lakewood Lake at inlet and outlet locations.

4. Aquatic species can migrate to the Smoky Hill River at the Old Channel outlet.

2.4.3 Monitoring Design, Duration, and Periodicity

1. Pre-construction site surveys at the proposed passage locations.

2. Post construction site surveys at each key location at Years 1, 3, 5, 7, and 9 to monitor flow conveyance and potential obstructions.

3. Monitoring of water flow in the Old Channel is also covered under Objective 1. Photos and slope measurements would be taken at each site visit at each feature to monitor riprap movement, slope changes, and flow connectivity to ensure that the features are not serving as a barrier to aquatic organism passage.

2.4.4 Decision Trigger

1. Faulty feature design, flooding, sedimentation, debris accumulation, erosion or inadequate flows has created barriers to connectivity and aquatic species passage.

2.4.5 Contingency Measure(s)

1. Add or remove riprap to reestablish gradient sufficient for aquatic organism passage within the Old Channel.

2. Adjust flows from sediment forebay and/or at weir locations to modify flows and depths that increase/decrease inundation of Wetland Shelves or Lakewood Lake wetland contours.

2.2.6 Costs, Responsibilities, and Closeout

1. The USACE estimates that monitoring of connectivity sites would cost $50,000 over a ten-year period.

2. Monitoring and adaptive management would continue until project success criteria are met. Monitoring and adaptive management would be cost-shared between USACE and the non-Federal Sponsor for 10 years after construction is complete. Any additional monitoring and adaptive management beyond 10 years would be a non-Federal responsibility.

3. Monitoring reports would be prepared by USACE after every monitoring visit and results shared with the non-Federal Sponsor. Monitoring and adaptive management requirements for this activity would be completed following the last post-construction site visit and survey.

3.0 Assessment

Evaluating the monitoring data includes a comparison of the results of the monitoring effort compared to predictions made in the planning process and success criteria.

The data collected to evaluate changes and success post-construction would be qualitatively and quantitatively compared to pre-construction data and decision triggers.

Qualitatively, visual inspection of riffle, run, and pool structures, sediment depth markers, and aerial imagery would be used to assess the success of dredging/sedimentation activities. Community structure of planted areas and hydric conditions of wetland areas would also be assessed qualitatively to determine if they are adequately like reference sites. Quantitative stream connectivity changes from removal of the Western Star Mill Weir would be assessed to ensure increased aquatic connectivity in the Old Channel.

For each year with monitoring activities, the USACE would prepare a report documenting the data collected during monitoring. The report would identify which restoration activities have met their respective success criteria, and which have not. For restorations that have not met their success criteria, the report would assess the progress that has been made to meet them. The report would evaluate if any contingency measures are necessary and would identify which measures are recommended for implementation. The USACE would provide this report to managers, decision makers, and stakeholders for discussion and consideration before the decision to implement contingency measures is made.

4.0 Decision Making

This section describes the process whereby the results from monitoring, surveys, and site assessment would be used to make decisions concerning future project management decisions. Primary components of the decision-making process include decisions to be made, decision making responsibilities, how the decision-making group operates, how they report their decisions, and the required timing of decisions in order for potential adjustments to be effective. These components are described in Table 1.

Table 1: Decision-Making Framework.

Decisions to be Made	Implement contingency measures
Decision Responsibility	Project Delivery Team (PDT) and Non-Federal Sponsor
Operation of Decision-Making Group	Virtual meeting would be called to discuss conditions and contingency measures
Reporting of Decisions	Decision would be documented in a Memorandum for Record (MFR).
Required Timing for Decisions	Within 1 month

Once the results of monitoring have been assessed and evaluated, the Project Delivery Team (PDT) and non-Federal sponsor can decide to: (1) continue the action with no adjustments because performance measures indicate a favorable trajectory, (2) adjust using a contingency plan, may reformulate the plan revisiting the planning process, or (3) decide the action is successful and complete based on meeting success criteria.

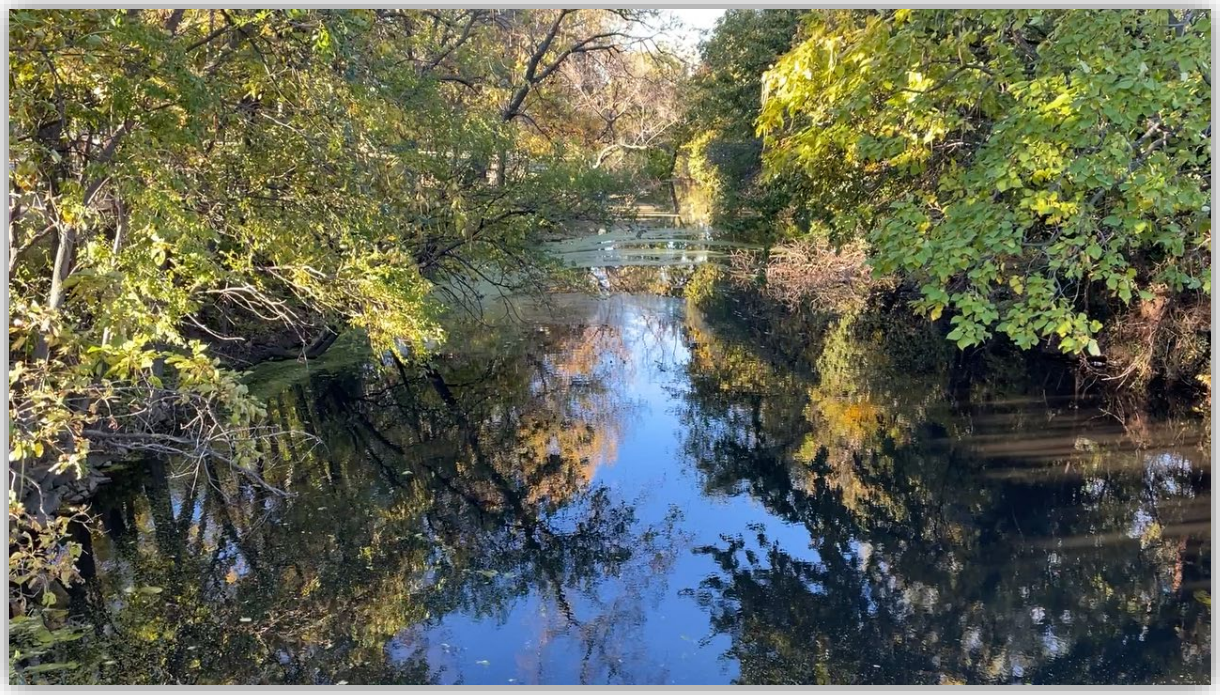
5.0 Contingency Plan

To address potential problems with project features, the USACE has identified some potential modifications or different measures that could be implemented. The below table includes a description of potential contingency measures, under what circumstances they would be implemented, an estimated cost for implementation, and identifies responsibilities (Table 6.1). If the Decision-Making Group determines there would be no cost-appropriate adaptive management actions that would resolve a failure of this project to meet an objective, an After-Action Review (AAR) would be conducted to determine the reasons for this project not meeting this objective, to include suggestions on how to prevent this failure from occurring on similar projects in the future. These cost estimates are preliminary and would be refined and updated during Design.

Table 6.1. Potential Contingency Measures (Adaptive Management)

Contingency Measure	Decision Trigger	Cost Estimate	Responsible Party
Increase flows through the sediment forebay to maximize available flow in the Old Channel and riffle, pool, and run habitat depths. Adjust habitat weirs to increase depth with available water	Recreational and non-recreational seasonal flows not as projected Less than 10 cfs baseflow in the Old Channel under normal flow conditions during the recreation season for more than 10 consecutive days or more than 30 days per season.	$5,000	Cost Shared
Adjust rifle, pool, run features – dredge out pool sections, add more rock to riffle features Coordinate with Sponsor for any additional storm water outfall sedimentation concerns	Riffle, pool run features are not functioning as intended On-site habitat assessments determine the need for changes to flows, habitat depth, or extents Excessive sedimentation is filling in pools, erosion or high flows modified the riffle pool runs so they are not defined aquatic habitats	10% of Construction cost, one time	Cost Shared
Reshape and slope the bank, add additional erosion prevention features – woody	Increased flow in Old Channel causes excessive erosion	$100,000	Cost Shared

Contingency Measure	Decision Trigger	Cost Estimate	Responsible Party
debris, rock at the most vulnerable spots	Riffle, pool, run features cause excessive bank erosion		
Adjust wetland topography, plantings (additional or different wetland plants) at wetland shelves or Lakewood Lake wetlands. Perform invasive species control.	Wetlands are not maintaining at least 50% hydrophytic species (OBL, FACW or FAC), wetlands not maintaining hydric indicators	20% of wetland planting cost	Cost Shared
Modify step pool structures or habitat weirs – add or remove riprap, adjust gradient.	Step pool structure not working as intended. Habitat weir not working as intended. Rip/rap movement or eroded gradient has altered fish passage	25% of Construction Cost, one time	Cost Shared



Smoky Hill River GI Study

Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix G – Hazardous, Toxic and Radioactive Waste Investigation

September 2025

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Tables

Figures

Attachments

Abbreviations and Acronyms

AAI	All Appropriate Inquiry
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
AUL	Activity Use Limitation
BER	Business Environmental Risk
COC	Contaminants of Concern
CFR	Code of Federal Regulations
CREC	Controlled REC
DEM	Digital Elevation Model
EDR	Environmental Data Resources, Inc.
ERNS	Emergency Response Notification System
ERS	Eligible Response Site
ESA	Environmental Site Assessment
FUDS	Formerly Used Defense Sites
HDR	HDR Engineering, Inc.
HREC	Historical REC
HRH	High Range Hydrocarbons
ICIS	Integrated Compliance Information System
KDHE	Kansas Department of Health and Environment
MCL	Maximum Contaminant Level
MRH	Mid Range Hydrocarbons
NFA	No Further Action
NPL	National Priorities List
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethylene/perchloroethylene
PFAS	Per- and Polyfluoroalkyl Substances
PFOA	perfluorooctanoic acids
PFOS	perfluorooctanesulfonic acid
PRP	Potentially Responsible Parties
RCRA	Resource Conservation and Recovery Act
REC	Recognized Environmental Condition
ROD	Records of Decision

ROW	Right of Way
RSK	Risk-based Cleanup Standards
SEMS	Superfund Enterprise Management System
SHWS	State Hazardous Waste Site
SWF	Solid Waste Facilities
TCE	Trichloroethylene
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UST	Underground Storage Tank
VOCs	Volatile Organic Compounds
VSQG	Very Small Quantity Generator

Glossary of Databases Identified by EDR

AIRS - A listing of Air Pollution Control Division permits and emissions data.

AST - Aboveground storage tank locations.

BIOSOLIDS - The data reflects compliance information about facilities in the biosolids program.

CITY DUMPS – City Dump Listing. The City Dump Cleanup Program provides funds to cities or counties for the repair of old, unused municipal dump sites. These sites primarily operated between the 1940s and the 1970s before many counties had landfills and prior to the current regulations for solid waste disposal.

CONSENT - Superfund (CERCLA) Consent Decrees. Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

ECHO - ECHO provides integrated compliance and enforcement information for about 800,000 regulated facilities nationwide.

EDR Hist Auto – EDR Historical Auto Stations. EDR search of national collections of business directories and listings of potential gas station/fill station/service station sites, including gas, gas station, gasoline station, filling station, auto, automobile repair, auto service station, and service station records.

E MANIFEST - USEPA established a national system for tracking hazardous waste shipments electronically. This system, known as E-Manifest, will modernize the nation's cradle-to-grave hazardous waste tracking process while saving valuable time, resources, and dollars for industry and states.

ERNS - Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

FINDS – Facility Index System/Facility Registry System. Contains both facility information and "pointers" to other sources that contain more detail.

FUDS - Formerly Used Defense Sites. The listing includes locations of Formerly Used Defense Sites properties where the US Army Corps of Engineers is actively working or will take necessary cleanup actions.

ICIS - The Integrated Compliance Information System (ICIS) supports the information needs of the national enforcement and compliance program as well as the unique needs of the National Pollutant Discharge Elimination System (NPDES) program.

KEIMS – Kansas Environmental Information Management System. The Kansas Department of Health and Environment (KDHE) Bureau of Environmental Remediation (BER) uses a web-based database management system to track information about identified contaminated sites in the State of Kansas.

LIENS 2 - CERCLA Lien Information. A Federal CERCLA ('Superfund') lien can exist by operation of law at any site or property at which USEPA has spent Superfund monies. These monies are spent to investigate and address releases and threatened releases of contamination. CERCLIS provides information as to the identity of these sites and properties.

LUST – Leaking Underground Storage Tank Incident Reports.

NPL - National Priority List - National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by USEPA's Environmental Photographic Interpretation Center (EPIC) and regional USEPA offices.

PFAS – PFAS Inventory Report. The KDHE is taking steps to address PFAS in drinking water through a joint investigation conducted by the Bureau of Environmental Remediation and the Bureau of Water. This investigation includes development of a statewide inventory and prioritization of potential PFAS sources, which will be used to develop a public water supply monitoring program.

PRP - Potentially Responsible Parties. A listing of verified Potentially Responsible Parties

RCRA NONGEN / NLR - RCRA - Non-Generators / No Longer Regulated. RCRAInfo is USEPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Non-Generators do not presently generate hazardous waste.

RCRA SQG - RCRAInfo is USEPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Small quantity generators (SQGs) generate between 100 kg and 1,000 kg of hazardous waste per month.

RCRA VSQG - Very Small Quantity Generators (Formerly Conditionally Exempt Small Quantity Generators) RCRAInfo is USEPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Very small quantity generators (VSQGs) generate less than 100 kg of hazardous waste, or less than 1 kg of acutely hazardous waste per month.

ROD - Records of Decision - ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

SEMS - Superfund Enterprise Management System - SEMS tracks hazardous waste sites, potentially hazardous waste sites, and remedial activities performed in support of USEPA's Superfund Program across the United States. The list was formerly known as CERCLIS, renamed to SEMS by the USEPA in 2015. The list contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies, and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This dataset also contains sites which are either proposed to or on the National Priorities List (NPL) and the sites which are in the screening and assessment phase for possible inclusion on the NPL.

SEMS-ARCHIVE - (Superfund Enterprise Management System Archive) tracks sites that have no further interest under the Federal Superfund Program based on available information. The list was formerly known as the CERCLIS-NFRAP, renamed to SEMS ARCHIVE by the USEPA in 2015. USEPA may perform a minimal level of assessment work at a site while it is archived if site conditions change and/or new information becomes available. Archived sites have been removed and archived from the inventory of SEMS sites. Archived status indicates that, to the best of USEPA's knowledge, assessment at a site has been completed and that USEPA has determined no further steps will be taken to list the site on the National Priorities List (NPL), unless information indicates this decision was not appropriate or other considerations require a recommendation for listing at a later time. The decision does not necessarily mean that there is no hazard associated with a given site; it only means that. based upon available information, the location is not judged to be potential NPL site.

SHWF - A listing from the Solid Waste Information System, which is used to help administer the various programs of our solid waste and materials management program. It includes a wide variety of types of facilities and sites, and includes information obtained over several decades and numerous legacy data systems.

SHWS - Hazardous Sites Cleanup Act Site List - The Hazardous Sites Cleanup Act Site List includes sites listed on PA Priority List, sites delisted from PA Priority List, Interim Response Completed sites, and Sites Being Studied or Response Being Planned.

SPILLS - State reported spills.

SWF/LF - Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

US AIRS - The database is a sub-system of Aerometric Information Retrieval System (AIRS). AFS contains compliance data on air pollution point sources regulated by the USEPA and/or state and local air regulatory agencies. This information comes from source reports by various stationary sources of air pollution, such as electric power plants, steel mills, factories, and universities, and provides information about the air pollutants they produce. Action, air program, air program pollutant, and general level plant data. It is used to track emissions and compliance data from industrial plants.

US ENG CONTROLS - Engineering Controls Sites List - A listing of sites with engineering controls in place. Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or affect human health.

US INST CONTROLS - Institutional Controls Sites List - A listing of sites with institutional controls in place. Institutional controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on site. Deed restrictions are generally required as part of the institutional controls.

UST – Registered Underground Storage Tanks.

UST FINDER – EPA developed UST Finder, a web map application containing a comprehensive, state-sourced national map of underground storage tank (UST) and leaking UST (LUST) data. It provides attributes and locations of active and closed USTs, UST facilities, and LUST sites from states and from Tribal lands and US territories.

UST FINDER RELEASE - UST Finder Releases Database. US EPA's UST Finder data is a national composite of leaking underground storage tanks. This data contains information about, and locations of, leaking underground storage tanks.

Executive Summary

HDR Engineering. Inc. (HDR) has conducted a Hazardous, Toxic and Radioactive Waste (HTRW) evaluation of the Smoky Hill River Ecosystem Restoration Project site located in Salina, Kansas for the United States Army Corps of Engineers (USACE). This HTRW Investigation report is intended for inclusion in the Draft Integrated General Investigation Feasibility Study and Environmental Assessment.

The property, referenced herein as the Subject Property, is defined as a 6.8-mile-long corridor, consisting of approximately 280 acres in the City of Salina, Saline County, Kansas. The Subject Property is located west of the Smoky Hill River across from the Salina Country Club and following the Old Channel of the Smoky Hill River south to its southern terminus with the Smoky Hill River, between Indian Rock Park to the north and Bill Burke Sports Complex to the south. The Public Land Survey System location is in the Southeast Quarter of Sections 07, 12, 13, and 18, Township 14 South, Range 2 West of the 6th Principal Meridian. Please refer to the Project Location and Site Detail Maps (Figures 1 and 2, respectively) for further site location detail.

HDR performed the HTRW Investigation in substantial conformance with the scope and limitations in ASTM Practice E1527-21. Any exceptions to, or deletions from, this practice are described in Section 1.6 of this report.

The Subject Property is located along the Old Channel of the Smoky Hill River. Seventeen listings were identified from the EDR database search within the Subject Property boundary. Parcels within or partially within the Subject Property were listed on multiple databases, under multiple site names. The majority of the database listings were associated with privately owned properties intersected by the Subject Property, although several properties are currently or previously owned by the City of Salina.

Findings and Opinions

HDR has reviewed the stated data sources, which are part of the ASTM E 1527-21 assessment protocol. Based upon the review of the data, HDR has developed the following professional opinions regarding Recognized Environmental Conditions (RECs), Historical RECs (HRECs), and/or Controlled RECs (CRECs).

- The **Central Garage (418 E Ash Street)** property lies partially within the western portion of the Subject Property, just south of E Ash Street and is currently occupied by Salina Public Works Garage. One LUST record was found for the property from a gasoline release of an unknown amount from a UST on 11/12/1992. Subsequent contamination assessments revealed that groundwater contamination was present, with an undetermined lateral extent of contamination. The tank was immediately taken out of service (and removed three days later), but an NFA letter was not found, and the site status remains listed as “monitor.” Due to lack of details on closure of the site, and since the site status remains listed as “monitor,” this site is considered a REC for the Subject Property.

- The **Kenison, Inc (920 E North Street)** property lies partially within the northern portion of the Subject Property, just south of E North Street. Soil testing and removal of impacted soils/waters was completed following a spill of transformer oil in 2013. This site is considered an HREC for the Subject Property.

- The **Land Pride S4/Turbine Specialties, Salina/Turbine Specialties, Inc. (1030 E North Street)** property is bisected by the Subject Property. No contaminants were found following a LUST incident in 1990, and No Further Action was deemed necessary. This site is considered an HREC for the Subject Property.

- The **ADM Milling Company (Ash & 3rd Street)** is crossed by the Subject Property. No further action was deemed necessary for the 1990 LUST incident at this site. This site is considered an HREC for the Subject Property.

- The southeastern corner of the **Star A Insurance/Super Wash & Detail (156 N 5th Street)** property is crossed by the Subject Property. An abandoned UST was identified during installation of a groundwater monitoring well for an investigation at a nearby site, with an odor noted in the soil. No further action was deemed necessary for the 2006 LUST incident at this site. This site is considered an HREC for the Subject Property.

- The **City of Salina/Oakdale Park Maintenance/City Offices/Knox Pit & Plant (730 Oakdale Park)** property is crossed by the Subject Property on the northwest, southwest, and eastern perimeters of the park. A LUST record for the site reports that small areas of diesel and gasoline contamination were identified in soils around fill tubes during the removal of two 500-gallon USTs in 1992. The contamination around the fill tubes did not exceed one foot in diameter. Slight odor/staining was observed. Due to the limited area of contamination, the case was closed, and no further action was deemed necessary.

  A MINES MRDS record for the site was also found, detailing a sand and gravel mine noted on the site in 1983. No further details on mining activities or dates of operation were found. Historical aerials do not depict any indication of gravel mining activities within the park. This site is not considered a REC for the Subject.

- The **616 E North Street** property is adjacent to the northwest and upgradient from the Subject Property. This site was listed as a REC in a previous investigation. A Phase II ESA was completed for the site in 2014. Tetrachloroethylene (PCE) was detected in the groundwater at the site and south of the building. A subsequent investigation completed in 2015 found additional tetrachloroethylene was found along the southern boundary of the property. Deep groundwater sampling was conducted in 2018, which did not detect any contamination. Six permanent groundwater monitoring wells were installed in 2019; semi-annual groundwater monitoring has been conducted since the installation. The most recent results noted in the EDR database were from March 2020, which found elevated PCE levels at or above the USEPA Maximum Contaminant Level (MCL) in two wells on the site, at 14.9 and 23.1 micrograms per liter (µg/L). This site was listed as a REC in a previous investigation. Due to continued groundwater monitoring at the site, and recent (2020) contaminants found during the monitoring, this site is considered a REC for the Subject Property.

- The **412 E. Ash** property lies partially within the western portion of the Subject Property. The City of Salina Public Works began developing the property in January 2024 to build a new sanitation truck storage facility. During the excavation process, a suspicious material was found. A subsequent Limited Site Investigation was completed in April 2024 that identified hazardous materials within the soil at levels exceeding the residential RKSs for Kansas. The Kansas Department of Health and Environment (KDHE) approved a voluntary clean-up plan for the city in July 2025, but no additional testing has taken place, and the clean-up plan has not started. Due to pending clean-up efforts, this site is considered a REC for the Subject Property.
- The remaining listings within and adjacent to the Subject Property are not considered RECs due to distance, hydraulic gradient, geology, regulatory, or clean-up status of the properties.

Conclusions

Based upon the above-detailed Findings and Opinions, HDR concludes that RECs have been identified for the proposed USACE ecosystem restoration project for the Old Channel of the Smoky Hill River, as enumerated in the Findings and Opinions section above. The following statement is required by ASTM E 1527-21 as a positive declaration of whether RECs were found:

- *HDR has performed a Phase I ESA in conformance with the scope and limitations of ASTM E 1527-21 for* the proposed USACE ecosystem restoration project for the Old Channel of the Smoky Hill River in *Salina, Saline County, Kansas. Any exceptions to, or deletions from, these practices are described in previous sections of this report. This report has revealed indication of RECs in connection with the Subject Property.*

Recommendations

Recommendations included in this report were developed through the investigative procedures described in the Scope of Services, Significant Assumptions, and Limitations sections of this report. These findings should be reviewed within the context of the limitations provided in the Limitations section.

Based upon the identification of RECs for the Subject Property, HDR makes the following recommendations.

Recommendation 1

HDR recommends a Phase II evaluation of soil and groundwater at REC locations where previous soil investigations have not occurred or institutional controls do not exist.

Recommendation 2

For locations where previous investigations have been conducted and/or institutional controls are in place, HDR recommends the development of a soil management plan.

Recommendation 3

HDR recommends that the USACE consider the “shelf life” of Phase I documents in determining risk. ASTM E 1527-13: 4.6 states that a conforming “Phase I” report is valid for a period of 180 days and may be updated during the 180 days to 1-year timeframe. The report is valid for use in any of the CERCLA defenses ONLY if it is updated within this time frame. If greater than one year passes from the final report date, the Phase I effort would need to be repeated to remain in compliance with ASTM and the “All Appropriate Inquiry” protection.

1 INTRODUCTION

1.1 Purpose

The purpose of this report is to discuss the hazardous, toxic, and radioactive waste (HTRW) Investigation for the Smoky Hill River Ecosystem Restoration Project (Subject Property). This report identifies both HTRW and non-HTRW environmental issues and presents appropriate measures to resolve these issues. This HTRW Investigation report is intended for inclusion in the Draft Integrated General Investigation Feasibility Study and Environmental Assessment. The methods used in performing the investigation are described in detail. Conclusions and recommendations regarding potential impacts due to HTRW and non-HTRW issues associated with the Subject Property are provided.

1.2 Authority

Engineer Regulation (ER) 1165-2-132, Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects requires that a site investigation be conducted as early as possible to identify and evaluate potential HTRW concerns. According to ER 1165-2-132, non-HTRW issues that do not comply with the federal, state, and local regulations should be discussed in the HTRW investigation along with HTRW concerns.

The HTRW investigation presented in this report was conducted during the feasibility phase of the Subject Property. This report was performed at the level of detail required and relies on existing information, observations made through database research, aerial photographs, topographic maps, and historical document review. As stated in the ER 1165-2-132 if an initial assessment indicates the potential for HTRW an analysis like a Feasibility Study should be conducted prior to proceeding with the project design. Because there is the potential for HTRW in the study area this analysis is being conducted as part of the Smoky Hill River Ecosystem Restoration feasibility study.

1.3 Hazardous, Toxic and Radioactive Waste

This investigation identifies potential HTRW concerns and discusses resolution and/or provides recommendations regarding the HTRW identified according to the procedures outlined in ER 1165-2-132.

1.3.1 Non-Hazardous, Toxic and Radioactive Waste

According to ER 1165-2-132, non-HTRW environmental issues that do not comply with federal, state, and local regulations should be discussed in the HTRW investigation along with HTRW. For example, solid waste is a non-HTRW issue considered. Petroleum releases from Leaking Underground Storage Tanks (LUSTs) are not considered HTRW but are regulated under the Kansas Administrative Regulations (K.A.R.) 28-44-12 *et seq* and Kansas Storage Tanks Act (Kansas Statutes Annotated [K.S.A.] 65-34, 100 *et seq*. Petroleum Storage Tanks). These sites have the potential to impose environmental hazards. Non-HTRW issues identified during the investigation are also discussed in this report, along with resolutions and/or recommendations for resolution.

1.4 Guidance

Supplemental guidance was provided by the American Society for Testing of Materials (ASTM) Standard Practice for Environmental Assessments: Phase I Environmental Site Assessment Process (Designation: E 1527-21). The purpose of this guidance is to define good commercial and customary practice in the United States for conducting an environmental site assessment of a parcel of real estate with respect to the range of contaminants within the scope of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 U.S.C. 9601) and petroleum products. These standards include a records review, site visit, and report preparation. This report followed many of the ASTM E 1527-21 guidelines but not to the same level of detail described by the ASTM E 1527-21 guidance. The goal of this HTRW report is to identify recognized environmental conditions (RECs) on a property.

ASTM Practice E 1527-21 defines the following categories of recognized environmental condition (REC):

REC:
The presence or likely presence of any hazardous substances or petroleum products in, on, or at a property: (1) due to release to the environment; (2) under conditions indicative of a release to the environment; or (3) under conditions that pose a material threat of a future release to the environment. De minimis conditions are not recognized environmental conditions (see definition below).

ASTM E 1527-21 defines release as a release of any hazardous substance or petroleum product shall have the same meaning as the definition of “release” under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 42 U.S.C. § 9601(22)).

Historical REC (HREC):
A past release of any hazardous substances or petroleum products that has occurred in connection with the property and has been addressed to the satisfaction of the applicable regulatory authority or meeting unrestricted use criteria established by a regulatory authority. The property is not subject to any required controls (for example, property use restrictions, activity and use limitations, institutional controls, or engineering controls).

Controlled REC (CREC):
A recognized environmental condition resulting from a past release of hazardous substances or petroleum products that has been addressed to the satisfaction of the applicable regulatory authority (for example, as documented by the issuance of a No Further Action [NFA] letter or equivalent, or meeting risk-based criteria established by the

regulatory authority). Hazardous substances or petroleum products are allowed to remain in place, subject to the implementation of required controls (for example, property use restrictions, activity and use limitations, institutional controls, or engineering controls).

Additional conditions that are not included under the definitions of a REC, but are defined by ASTM Practice E 1527-21 include:

De minimis:
A condition that generally does not present a threat to human health or the environment, and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Conditions determined to be de minimis conditions are not RECs, historical RECs, nor CRECs.

1.5 Laws and Regulations

1.5.1 Federal

The definition of HTRW according to ER 1165-2-132, page 1, paragraph 4(a) is as follows:

Except for dredged material and sediments beneath navigable waters proposed for dredging, for purposes of this guidance, HTRW includes any material listed as a "hazardous substance" under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq (CERCLA). (See 42 U.S.C. 9601(14).) Hazardous substances regulated under CERCLA include "hazardous wastes" under Sec. 3001 of the Resource Conservation and Recovery Act, 42 U.S.C. 6921 et sq.; "hazardous substances" identified under Section 311 of the Clean Air Act, 33 U.S.C. 1321, "toxic pollutants" designated under Section 307 of the Clean Water Act, 33 U.S.C. 1317, " hazardous air pollutants" designated under Section 112 of the Clean Air Act, 42 U.S.C. 7412; and "imminently hazardous chemical substances or mixtures" on which EPA has taken action under Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606; these do not include petroleum or natural gas unless already included in the above categories. (See 42 U.S.C> 9601(14).)

As stated in 42 U.S.C. 9601(14), the definition of hazardous substance does not include petroleum, including crude oil or any fraction thereof, which is not otherwise specifically listed or designated as a hazardous substance, nor does the term include natural gas, natural gas liquids, liquified natural gas, or synthetic gas usable for fuel. Underground Storage Tanks (USTs) are federally regulated under 40 CFR Part 280, which includes technical standards and corrective action requirements for owner and operators of USTs.

1.5.2 State

The Kansas State regulations were examined to determine which regulations governed the state specific hazardous waste disposal, release, and cleanup requirements. The State of Kansas regulates underground storage tanks (USTs) under Kansas Administrative Regulations (K.A.R) 28-44-12 through K.A.R. 28-44-27 (authorized by and implementing K.S.A. 1989 Supp. 65-34, 105, effective Nov. 26, 1990). The regulations adopt by reference the rules and regulations to standards, procedures, or requirements of 40 CFR part 280, including any notes and appendices associated therewith, unless otherwise specifically stated in the regulations. The Kansas Department of Health and Environment (KDHE) – Bureau of Environmental Remediation also regulates the storage of petroleum and other hazardous chemicals in accordance with the Energy Policy Act of 2005. Owners and operators or petroleum or hazardous substance USTs must comply with the requirements of K.A.R. 28-44-17 except for USTs excluded under K.A.R. 28-44-18. Release detection, monitoring and reporting requirements are defined by K.A.R. 28-44-23 through K.A.R. 28-44-25.

Similarly, the State of Kansas regulates above ground storage tanks (ASTs) under K.A.R. 28-44-28 through K.A.R. 28-44-29 (authorized by and implementing K.S.A. 65-34, parts 104, 105 and 106, effective Nov. 22, 1993). The Kansas Department of Health and Environment – Bureau of Environmental Remediation is responsible for regulating releases from ASTs as defined in the Kansas Storage Tank Act

1.6 Scope Of Services, Significant Assumptions, and Limitations

1.6.1 Scope of Services

HDR conducted this HTRW for the Subject Property in substantial compliance with ASTM Practice E 1521-21. The methodologies within this ASTM guidance are utilized to identify RECs associated with the Subject Property and included the following tasks.

- Provide a general description of the Subject Property.
- Review reasonably ascertainable and reviewable regulatory information published by federal, state, local, and tribal environmental agencies pertaining to the Subject Property (Section 4.0 in total).
- Review historical data sources for the Subject Property, including aerial photographs and topographic maps.
- Conduct an area reconnaissance and an environmental review—including a visual review of adjoining properties—with a focus on indications of HTRW, petroleum products, polychlorinated biphenyls (PCBs), wells, storage tanks, solid waste disposal pits and sumps, and utilities.
- Prepare a written report of methods, findings, opinions, and conclusions.

Investigative areas not included in the standard ASTM ESA scope include: asbestos, lead-based paint, lead in drinking water, radon or urea formaldehyde, wetland issues, regulatory compliance, cultural and historic resources, industrial hygiene, health and safety, ecological resources, endangered species, and high voltage power lines.

Indoor air quality from sources such as mold and asbestos are not included in the ASTM standard except to the extent that indoor air impacts are related to Superfund release and/or caused by releases of hazardous substances into subsurface soil or groundwater (vapor intrusion).

The potential for vapor encroachment or intrusion into structures in the Subject Property are assessed from onsite or offsite sources, based on the experience of the Environmental Professional. State and national policies and standards relevant to vapor intrusion are in flux, and subject to change.

The scope of services for ESA projects also does not include the completion of soil borings, the installation of groundwater monitoring wells, or the collection of soil or groundwater samples.

1.6.2 Significant Assumptions

HDR has made certain assumptions in preparing the scope of this assessment:

- Data gathered from public information sources (i.e., libraries or public regulatory agencies) are accurate and reliable.
- Site operations reflect site conditions relative to potential releases, and no intentional concealment of environmental conditions or releases has occurred.
- Published geologic information and site observations made by the environmental professional are used to estimate likely contaminant migration pathways in the subsurface. These estimates by the environmental professional are limited in accuracy and are generally cross-referenced with existing information about similar sites and environmental releases in the area, if available.
- Regulatory information is limited to sites identified after the late 1980s, because reliable records were not kept by regulatory agencies prior to that time frame.

The site history review, review of practically reviewable federal and state environmental records, site reconnaissance, and findings and conclusions presented in this report are based on the procedures described in ASTM Practice E 1527-21, informal discussions with various agencies, a review of the available literature cited in this report, conditions noted at the time of this HTRW Investigation, and HDR's interpretation of the information obtained as part of this HTRW Investigation. The findings and conclusions are limited to the specific project and properties described in this report, and by the accuracy and completeness of the information provided by others.

An ESA cannot entirely eliminate uncertainty regarding the potential for RECs. Conducting this assessment is intended to reduce, but not eliminate, uncertainty regarding the potential for RECs in connection with a Subject Property within reasonable limits of time and cost. In conducting its services, HDR used a degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same locality. This HTRW Investigation generally conforms to the level of documentation required in ASTM Practice E 1527-21. However, HDR did not conduct interviews and may omit discussion of certain records, i.e., sources deemed, in HDR's professional opinion, to be inapplicable, or of limited value, to the specific needs of the client.

1.7 Reliance

This HTRW Investigation report was completed by HDR for the Smoky Hill River Ecosystem Restoration Project to inform the ecosystem restoration project development team and decision makers of any HTRW risks. Use of this report by any other party will be at that party's sole risk. HDR accepts no liability for the use or reliance on this report by any other party.

2 Site Description

2.1 Location

The property, referenced herein as the Subject Property, is defined as a 6.8-mile-long corridor, consisting of approximately 280 acres in the City of Salina, Saline County, Kansas. The Subject Property is located west of the Smoky Hill River across from the Salina Country Club and following the Old Channel of the Smoky Hill River south to its southern terminus with the Smoky Hill River, between Indian Rock Park to the north and Bill Burke Sports Complex to the south. The Public Land Survey System location is in the Southeast Quarter of Sections 07, 12, 13, and 18, Township 14 South, Range 2 West of the 6th Principal Meridian.

Please refer to the Project Location and Site Detail Maps (Figures 1 and 2, respectively) for further site location detail.

2.2 Site and Vicinity Description

The Subject Property follows the original river alignment through the City of Salina. The river was diverted in 1961 as part of the Federal Flood Control project for the Smoky Hill River. The Subject Property is surrounded by commercial, residential, and recreational properties, and multiple roads and utilities intersect the Subject Property. The northern portion of the Subject Property encompasses Lakewood Lake Park. The Subject Property then turns southwest at Riverside Park and winds through residential and commercial areas of Salina, passing Oakdale Park, Indian Rock State Park, and the Bill Burke Sprots Complex on the southern end. The Salina Water Treatment Plant lies across from the Old Channel towards the southern end of the Subject Property.

2.3 Current Site Use

The Subject Property captures flow from the Smoky Hill Cutoff Channel near Bill Burke Sports Complex and flows north and east to drain through a federal levee outlet control/pump station back into the Smoky Hill Cutoff Channel. An effort is being made to restore and establish wetlands and riparian vegetation along the corridor, through the Smoky Hill River Ecosystem Restoration Project, which includes this HTRW investigation. The City of Salina owns a large portion of the Subject Property, while the remaining parcels are privately owned.

2.4 Description of Structure, Roads, and Other Site Improvements

The Subject Property is located within the Old Channel of the Smoky Hill River, owned by the City of Salina and other private individuals. It is surrounded by residential, commercial, and recreational properties, including Lakewood Lake Park, Riverside Park, Oakdale Park, Indian Rock State Park, and the Bill Burke Sports Complex.

The Subject Property is accessed by multiple streets throughout.

2.5 Topography

The United States Geological Survey (USGS) 7.5' Digital Elevation Model (DEM) indicates that the Subject Property is located at an elevation of approximately 1,250 feet above sea level.

Topographic gradient at the Subject Property is generally flat, surface water travels northeast across the Subject Property towards the Smoky River. Groundwater typically follows topographic gradient towards areas of discharge, commonly surface waters; therefore, groundwater is estimated to travel east towards the Smoky River.

2.6 Area Geology and Hydrogeology

The project area is underlain by the late Pleistocene and Holocene Alluvium and Terrace Valley Fill. The alluvium consists of clay, silt, sand, gravel, and other unconsolidated materials deposited by the Smoky Hill River and is up to 60 feet thick. Groundwater within the Subject Property and City of Salina comes from Holocene terraces and alluvial valley fills deposited in the Smoky Hill River valley. Groundwater deposits make up most of the drinking water throughout Salina, which is primarily sourced through shallow wells.

Soil data was obtained from the United States Department of Agriculture (USDA) Web Soil Survey, as seen in **Table 1** below. Soils within the Subject Property are well drained and have predominately low runoff classes. The depth to water table throughout the Subject Property is greater than 80 inches.

Table 1: Soils within the Subject Property

Map Unit Symbol	Map Unit Name	Hydric (Y/N)	Depth to Water Table	Drainage Class	Runoff Class	Acres	Percentage
2347	McCook silt loam, rarely flooded	N	>80 inches	Well Drained	Low	233.3	83.2%
2375	Roxbury silt loam, rarely flooded	N	>80 inches	Well Drained	Very Low	8.9	3.2%
9989	Orthents, clayey	N	>80 inches	Well Drained	High	26.0	9.3%
9999	Water	-	-	-	-	12.0	4.3%

Figure 1. Project Location Map

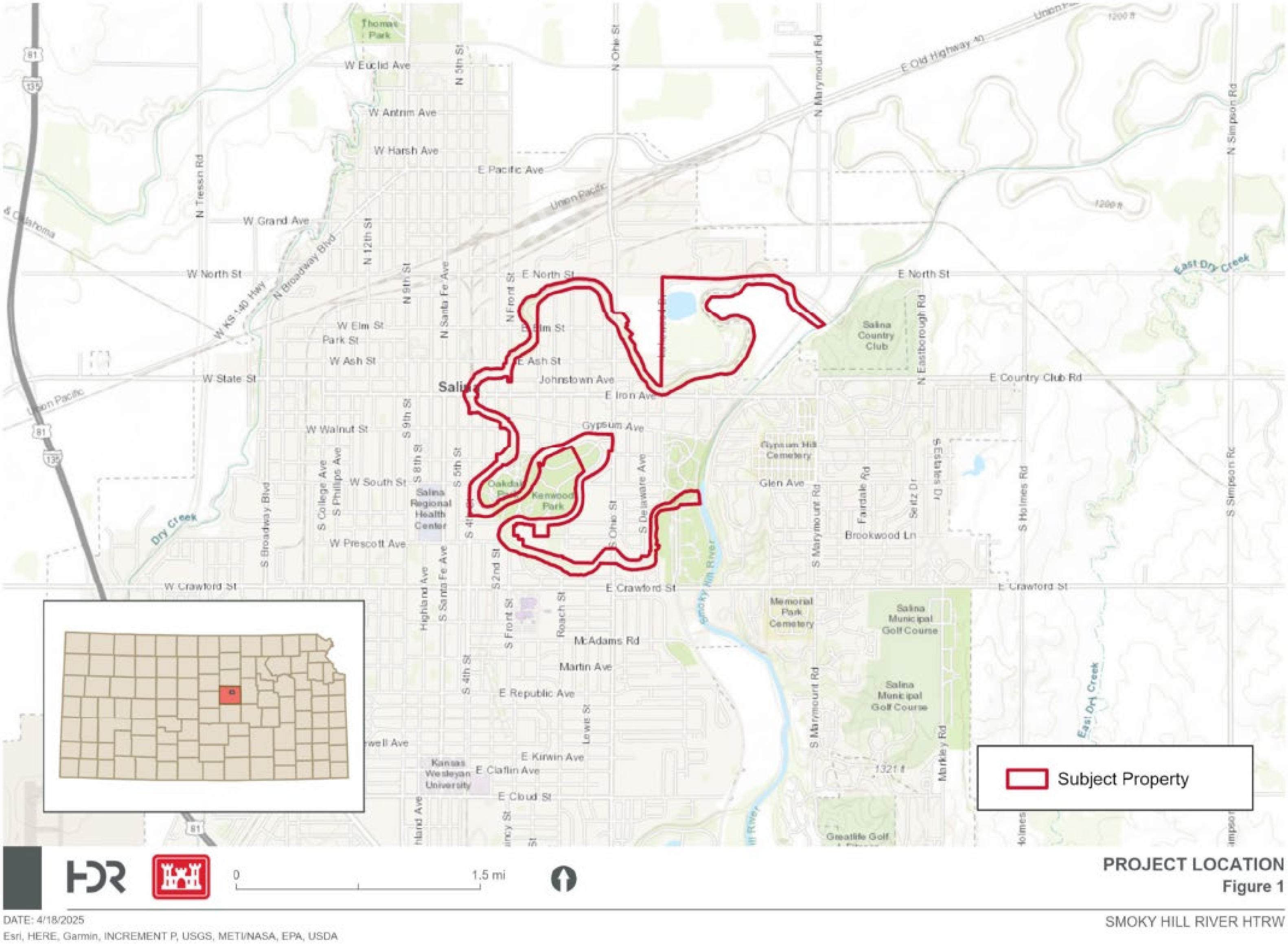
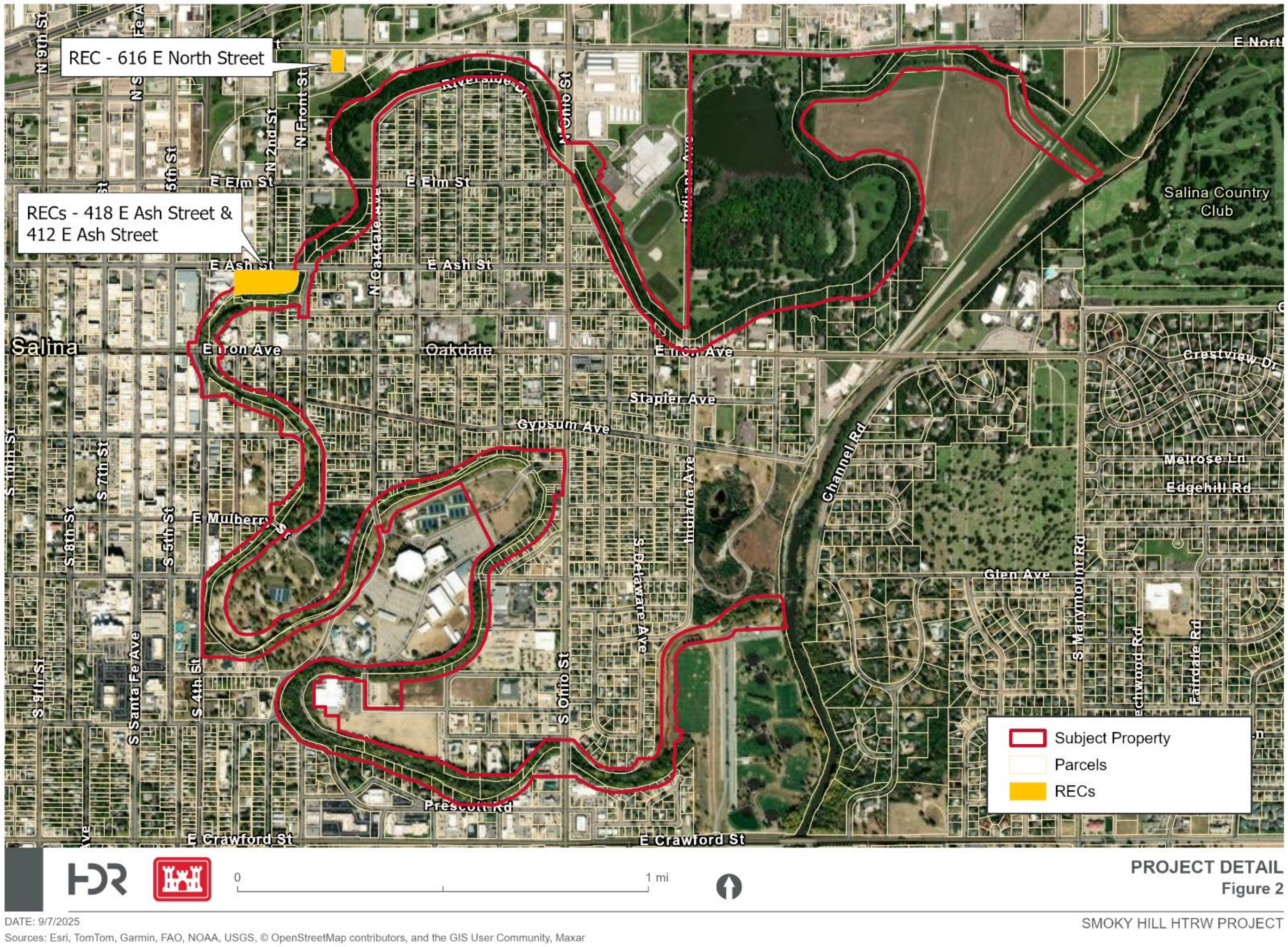


Figure 2. Project Detail Map



3 Environmental Records Review

3.1 Governmental Database Search Results

HDR contracted Environmental Data Resources, Inc. (EDR) to complete a database search of federal, state, and tribal environmental records for the project area. EDR performed a computerized environmental information database search on March 31, 2025. The databases searched included federal, state, local, tribal, and EDR proprietary databases as defined by ASTM Practice E1527-21, plus EDR proprietary databases as research aids. A complete copy of the EDR environmental database report is included in Appendix A.

Seventeen listings were identified from the EDR search within the Subject Property boundary. Parcels within or partially within the Subject Property were listed on multiple databases, under multiple site names. The databases include KEIMS, RCRA NonGen/NLR, FINDS, ECHO, SPILLS, PFAS, ECHO, RCRA-VSQG, E MANIFEST, LUST, UST, AST, UST FINDER, UST FINDER RELEASE, and CITY DUMPS databases. The majority of these database listings are associated with privately owned properties intersected by the Subject Property, although several properties are currently or previously owned by the City of Salina.

- **Kenison, Inc** (920 E North Street) – This site is located partially within the northern portion of the Subject Property, just south of E North Street, and is listed in the RCRA NonGen/NLR, FINDS, ECHO, KEIMS, and SPILLS databases.
    - No violations were found regarding the RCRA NonGEN, FINDS, ECHO, or KEIMS records within the last 10 years.
    - One SPILLS record was found for a spill of transformer oil caused by a pole mounted transformer falling during a storm on 7/11/2013. Soil testing was completed and impacted soils/waters were removed. No further action was deemed necessary, and the incident was closed on 8/7/2013.

- **Vans Conoco Service & Parking** (316 E Iron Avenue) – This site is located partially within the western portion of the Subject Property, near the intersection of E Iron Avenue and S 4th Street and is listed in the EDR Hist Auto database.
    - One record notes the gas station as present in 1969. No UST, AST, LUST, or SPILLS records are associated with the listing, and the property is now occupied by a Burger King.

- **City of Salina #14** (085-SAL#14) (505 E Walnut Street) – This site is located partially within the Subject Property just north of E Walnut Street and is listed on the City Dumps database.

- The property possessed a D-dump permit type and is now closed. The City Dump record notes that post-closure care was completed prior to closure. The site is currently a vacant lot.

- **Central Garage** (418 E Ash Street) – This site is located partially within the western portion of the Subject Property, just south of E Ash Street, and is listed in the KEIMS, LUST, UST, AST, RCRA NonGen/NLR, FINDS, ECHO, UST Finder, and UST Finder Release databases. The property is currently occupied by Salina Public Works Garage.
  - No RCRA NonGen/NLR, FINDS, ECHO, or KEIMS violations were found were found within the last 10 years.
  - Two USTs and one AST were listed for the property. Both USTs were 3,000 gallons and held gasoline; both are permanently out of use and were removed 11/15/1992. The 447-gallon AST holds used oil and is currently in use.
  - One LUST record was found for the property from a gasoline release of an unknown amount from a UST on 11/12/1992. Subsequent contamination assessments revealed that groundwater contamination was present, with an undetermined lateral extent of contamination. The tank was immediately taken out of service (and removed three days later), but an NFA letter was not found, and the site status remains listed as "monitor."

- **Land Pride S4/Turbine Specialties, Salina/Turbine Specialties, Inc.** (1030 E North Street) – This site is bisected by the Subject Property and is listed in the RCRA-VSQG, KEIMS, LUST, and UST Finder Release databases.
  - No RCRA violations were found within the last 10 years.
  - The LUST, KEIMS, and UST Finder Release records pertained to a 10,000-gallon tank operated by Turbine Specialties. A leak was reported on 1/19/1990. The tank was subsequently filled in place and soil samples from the east side of the tank were tested. No contaminants were detected. The UST Finder Release database notes No Further Action is required.

- **DRS Weber-Palmer & Macy** (338 N Front Street) – The eastern edge of this site is crossed by the Subject Property. The site is listed RCRA-VSQG, FINDS, ECHO, and E Manifest databases.
  - Three RCRA violations were noted between 2007 and 2018; all have since been returned to compliance.

- **Mercury Comcare of Salina, KS** (617 E Elm) – The eastern edge of this site is crossed by the Subject Property. The site is listed in the SEMS-Archive database.

  - The site was listed in the SEMS-Archive database in 2008. The site is not on the NPL and is classified as a Removal Site Only (no site assessment work needed).

- **City of Salina #15 (085-SAL#15)** (Elm & Front Streets) – This site is bisected by the Subject Property and is listed in the SEMS-Archive, KEIMS, and City Dumps databases.
  - The property possessed a D-dump permit type and is now closed. The City Dump record notes that post-closure care was completed prior to closure. The site is currently occupied by a senior living facility.
  - The site was listed in the SEMS-Archive database in 2001. The site is classified as a not qualifying for the NPL based on existing information.

- **ADM Milling Company** (Ash & 3rd Street) – The southern perimeter of this site is crossed by the Subject Property. The site is listed in the LUST and UST Finder Release databases.
  - The LUST incident was reported on 5/5/1990 while the UST was being removed from the site. No information on the type or amount of release was found. The UST Finder Release record states no further action required.

- **Star A Insurance/Super Wash & Detail** (156 N 5th Street) – The southeastern corner of this site is crossed by the Subject Property. The site is listed in the KEIMS, LUST, UST, UST Finder, and UST Finder Release databases.
  - The LUST incident was discovered while drilling for installation of a monitoring well for a nearby site (Former Bus Depot). A 4-foot abandoned tank was discovered, and the surrounding soil was noted to have an odor. The tank was removed in 2006 and the UST Finder Release database notes that no further action is required.
  - Two other 110-gallon gasoline USTs were removed from the property in 1998.

- **ADM Western Star Mill** (124 N 4th Street) – The eastern perimeter of this site is crossed by the Subject Property. The site is listed in the FINDS, ECHO, and E Manifest databases.
  - No violations were found in these databases for the last 10 years.

- **Roland Bird** (127 S 4th Street) – This site lies within the western boundary of the Subject Property and is listed in the KEIMS, RCRA-VSQG, FINDS, and ECHO databases.
  - No violations were found in these databases for the last 10 years.

- **City of Salina/Oakdale Park Maintenance/City Offices/Knox Pit & Plant** (730 Oakdale Park) – This site is crossed by the Subject Property on the northwest, southwest, and eastern perimeters of the park. The site is listed in the KEIMS, LUST, RCRA NonGen/NLR, FINDS, ECHO, MINES MRDS, UST, and AST databases.
    - The LUST record pertains to a gasoline/diesel release on 10/31/1992 from a 500-gallon UST. A secondary UST was also present on the site at the time. Both UST were removed, and the surrounding area was investigated for contamination. Small areas of contamination were present around the fill tubes, but did not exceed one foot in diameter. Slight odor/staining was observed. Due to the limited area of contamination, the case was closed, and no further action was deemed necessary.
    - One 1,000-gallon diesel AST was listed for the site. The tank is still in use.
    - No RCRA NonGen/NLR, FINDS, or ECHO violations were found for the last 10 years.
    - The MINES MRDS record details a sand and gravel mine was noted on the site in 1983. No further details on mine activities or dates of operation were found.

- **Tagues Auto Service, Inc.** (833 E Prescott) – This site is bisected by the Subject Property and is listed in the RCRA-VSQG, FINDS, ECHO, and KEIMS databases.
    - No violations were found for the last 10 years.

- **Bennett Autoplex, Inc.** (651 S Ohio) – The northeast corner of this site is crossed by the Subject Property. The site is listed in the RCRA-VSQG, FINDS, and ECHO databases.
    - Two violations were reported in 2001 and were returned to compliance on 9/24/2001. No violations were found for the last 10 years.

- **Salina Journal, Inc.** (333 S 4th Street) – The southeast corner of this site is crossed by the Subject Property. The site is listed in the RCRA NonGen/NLR, FINDS, ECHO, and E Manifest databases.
    - One RCRA violation was found from 2020. The site was returned to compliance on 7/7/2020 and no subsequent violations were found.

HDR also reviewed the listings adjacent to the Subject Property. Listings or sites that were identified by EDR as a potential concern to the Subject Property are described in further detail in the following bullets. The remaining listings were not of concern to the Subject Property based on factors such as distance, hydraulic gradient, geology, or clean-up status. Four sites of potential concern to the Subject Property were identified in the radius report.

- **Research Chemical Company/McShares, Inc./Research Products Company/Dewey Avenue Site** (1835 E North Street) – This site is located adjacent, approximately 79 feet, to the north of the Subject Property, across E North Street, downgradient from the Subject Property. The site is listed in the SHWS, INST Controls, KEIMS, UST Finder, UST Finder Release, LUST, UST, AST, RCRA-VSQG, FINDS, and E Manifest databases. The property is currently occupied by Repco, a food products supplier.
    - The UST, LUST, UST Finder Release, and UST Finder records detail the removal of a 12,000-gallon emergency diesel tank and lines on 3/1/1990. No contamination was found surrounding the tank except for minor amounts where the product line was cut. The incident has been closed, and no further action is required.
    - The SHWS and INST Controls records pertain to a release of carbon tetrachloride and chloroform found in water sampling conducted in 1992 at an industrial well at the Wyatt Foundry. The release was traced back to the Research Chemical Company and further testing revealed additional VOCs in area groundwater. A Comprehensive Investigation and Corrective Action Study was approved for the site in 1998. In 1999 and 2000, ethylene dibromide and 1,2-dichloroethane were detected in residential wells approximately 1 mile downgradient (north) of the site. Further investigations were completed between 1998-2004 to determine the extent of contamination, and a permanent monitoring well network was installed in 2006. A Soil Vapor Extraction system was installed in 2010 but was subsequently shut down in 2015 due to equipment failure. A new system has not yet been installed. Land use restrictions for the site include no addition of subsurface structures to existing buildings, no public or residential uses, the preservation of survey markers and/or monitoring stations, and construction restrictions.
    - Two 5,000-gallon ASTs (empty) are temporarily out of service as of 12/17/2019, pending tank registrations.
    - Multiple RCRA-VSQC violations were found, occurring between 1992 and 2015. All have since been returned to compliance.

- **Salina Wrecker Service, Inc/Salina Wrecker Service & Transport, Inc.** (850 E North Street) – This site is located adjacent, approximately 79 feet, to the northern perimeter of the Subject Property, downgradient, and is listed in the EDR Hist Auto, RCRA-VSQG, FINDS databases.
    - The property is listed in the EDR Hist Auto database for 1991-1995.
    - No RCRA or FINDS violations were found within the last 10 years.

- **616 E North Street** – This site is located adjacent, approximately 346 feet, to the northwest of the Subject Property, upgradient, and is listed on the KEIMS, SHWS, SEMS-Archive, and VCP databases.
  - A Phase II ESA was completed for the site in 2014. Tetrachloroethylene was detected in the groundwater at the site and south of the building. A subsequent investigation completed in 2015 found additional tetrachloroethylene was found along the southern boundary of the property. Deep groundwater sampling was conducted in 2018, which did not detect any contamination. Six permanent groundwater monitoring wells were installed in 2019; semi-annual groundwater monitoring has been conducted since the installation. The most recent results noted in the EDR database were from March 2020, which found elevated tetrachloroethylene levels in two wells on the site.
  - The site is not on the NPL and was found to not qualify for the NPL.

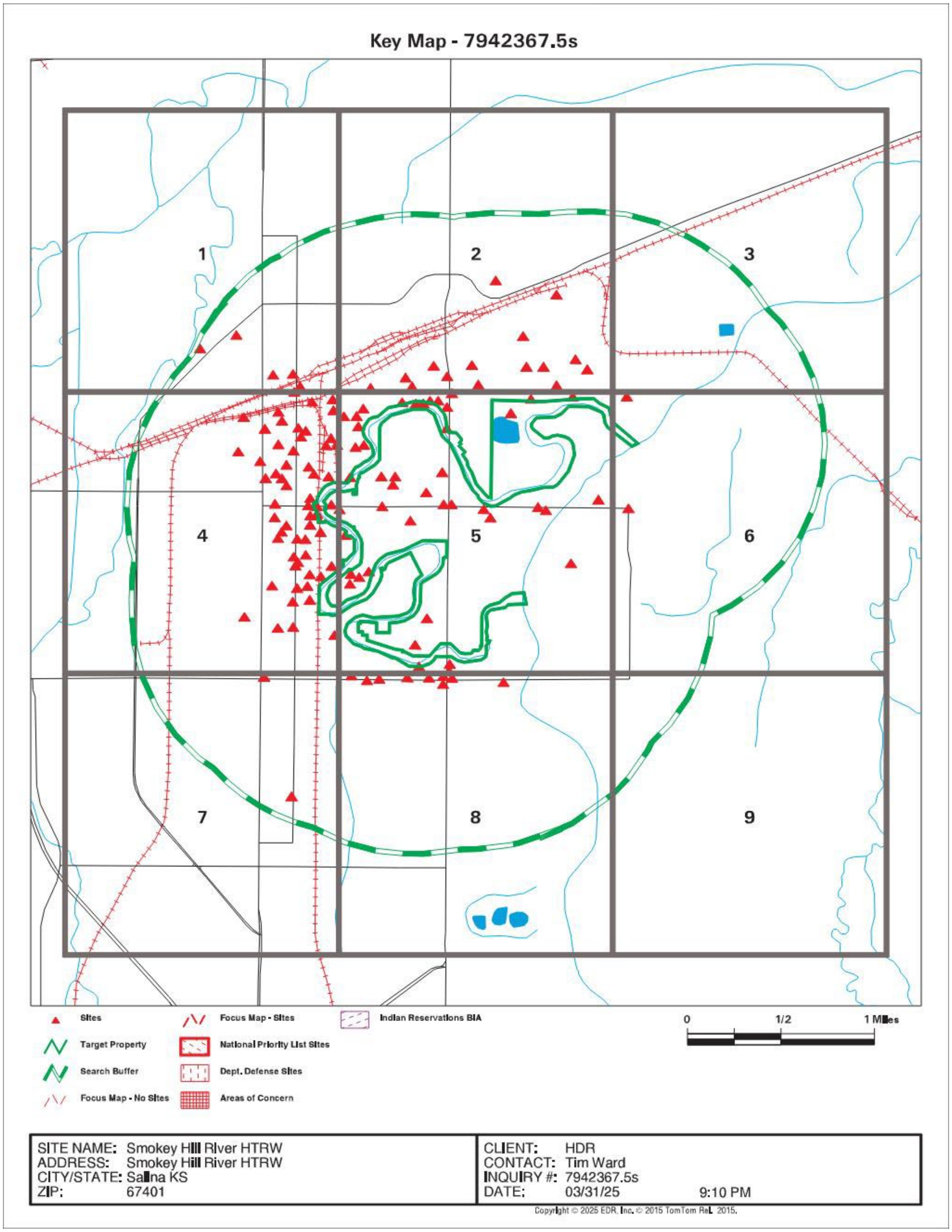
- **Salina PWS/City of Salina Water Treatment/Salina WTP** (401 S 5th Street) – This site is adjacent, approximately 256 feet, to the western perimeter of the Subject Property, upgradient. An in-use railroad track lies between the Subject Property and this site. The site is listed in the SEMS-Archive, KEIMS, SHWS, Tier 2, RCRA NonGen/NLR, FINDS, and ECHO databases.
  - The site is not on the NPL and does not qualify for listing.
  - VOC contamination of groundwater was found in 1988. After subsequent site investigations were completed, a packed tower-air stripped was installed at the plant in July 2002, using funding from the UST and Drycleaner programs. The system treats all the PWS wells in the City of Salina.
  - No RCRA violations were found.

Fifty-two orphan sites (sites without enough information to be mapped) were identified in the environmental database report. All but four of these sites were likely outside the search radius based on the limited information provided. The four adjacent orphan sites are discussed below:

- Kenwood Cover Aquatic Park (701 Kenwood Park Drive) – The Subject Property crosses this site to the north, south, east, and northwest. The site is listed on the AST database. One in-use sodium hypochlorite AST is registered to the property.
- The remaining three orphan site listings were listed in the FTTS, HIST FTTS, FINDS, and/or E Manifest databases. No violations were noted, and these properties are not considered a concern to the Subject Property.

****Definitions for the databases listings and acronyms above can be found in the List of Acronyms and Glossary of Databases Identified by EDR in the beginning of this report.***

Figure 3. Governmental Database Search Results



4 Historical Use Information

The objective of reviewing historical use information is to develop a history of previous land uses at and in the vicinity of the Subject Property, and to assess these uses for potential hazardous materials impacts that may affect the Subject Property. HDR reviewed those historical sources that were reasonably ascertainable and likely to provide useful information, as defined by the ASTM standard.

4.1 Historical Aerial Photographs

Historical aerial photographs are valuable for the environmental assessor to review features of the Subject Property and surrounding properties over a long period of time.

HDR reviewed historical aerial photographs (Appendix B) for the following years: 1954, 1972, 1977, 1981, 1985, 1991, 1997, 2003, 2006, 2010, 2014, and 2019.

Table 2: Historical Aerial Photograph Review Summary – Subject Property

Year(s)	Subject Property Description
1954	Residential and commercial development is visible in and around the Subject Property. The sandpit is visible in the current location of Lakewood Park Lake.
1972	The Smoky Hill diversion channel is visible beginning in 1972. The sandpit appears to have been filled in with water.
1977	Lakewood Park (adjacent to the Lake) appears to have been built up.
1981	No visible changes to the Subject Property.
1985	No visible changes to the Subject Property.
1991	Development of trails within Lakewood Park is visible beginning in 1991.
1997-2019	No visible changes to the Subject Property.

Table 3: Historical Aerial Photograph Review Summary – Adjacent Properties

Year(s)	Adjacent Property Description
1954	Residential and commercial development is visible in and around the Subject Property.
1972-1981	No visible changes to properties adjacent to the Subject Property.
1985	Additional residential and commercial development visible adjacent to the southern portion of the Subject Property.
1991	Vehicles and debris were visible on the 616 E North Street property beginning in 1991.
1997	Additional residential and commercial development visible adjacent to the southern portion of the Subject Property.
2003	Additional residential and commercial development visible adjacent to the northern portion of the Subject Property.
2006-2019	No visible changes to properties adjacent to the Subject Property.

4.2 Historical Topographic Maps

Historical topographic maps provide an overview of the area relative to potential previous land uses. HDR reviewed historical topographic maps of the Project Area provided by EDR.

The USGS 7.5-minute series topographic maps for Salina, Kansas were reviewed for 1955, 1978, 2012, 2015, 2018, and 2022. The USGS 30-minute series topographic maps for Salina, Kansas were reviewed for 1892, and 1942. Copies of the maps are provided in Appendix C. These maps served to augment information that was gathered in the historic aerial photograph review.

Table 4: Historical Topographic Map Review Summary – Subject Property

Year(s)	Subject Property Description
1892	The 1892 topographic map shows the original Smoky Hill River channel.
1942	No changes to the Subject Property
1955	The sandpit (current location of Lakewood Park Lake) is noted on the 1955 topographic map.
1978	The realignment of the Smoky Hill River is visible to the east of the Subject Property beginning in the 1978 topographic map.
2012	Lakewood Lake Park is visible, and the sandpit notation has been removed.
2015	No visible changes to the Subject Property.
2018	No visible changes to the Subject Property.
2022	No visible changes Property.

Table 5: Historical Topographic Map Review Summary – Adjacent Properties

Year(s)	Adjacent Property Description
1892	Urban development is visible to the west of the Subject Property. Minor development is visible to the east.
1942	No visible changes to adjacent properties.
1955	Oil wells to the west of Lakewood Park Lake are noted on the 1955 topographic map. Oakdale Park is visible.
1978	The oil wells and sandpit are still visible. Additional development west of the diverted Smoky Hill River and adjacent to the southern end of the Subject Property is present.
2012	Lakewood Lake Park is visible, and the oil wells notations have been removed.
2015	No visible changes to adjacent properties.
2018	No visible changes to adjacent properties.
2022	No visible changes to adjacent properties.

5 Previous Investigations

A previous HTRW and Non-HTRW investigation was completed for the Subject Property in 2020. The previous investigation identified 13 RECs within the EDR search radius, including two adjacent properties (307 E. Walnut and 418 E. Ash Street) and one property approximately 300 feet northwest of the Subject Property (616 E. North Street):

- **307 E. Walnut** – This property is currently occupied by Heritage Real Estate Advisors and was listed as a REC in the previous investigation due to unresolved LUST records from a 1994 release. The previous investigation found that a prior owner of the site applied to the Trust Fund, but there remain no records on incident closure or the limits of contamination at the site.

- **418 E. Ash Street** – This property is owned by the Salina Public Works Garage and was listed as a REC in the previous investigation due to a previous LUST incident that required continued monitoring for groundwater contamination.

- **616 E. North Street** – The property is currently occupied by Midwest Commercial Laundry Equipment and was listed as a REC in the previous investigation due to SHWS records of soil and groundwater contamination. The previous investigation reported the presence of monitoring wells on the property.

The City of Salina Public Works began developing the property at **412 E. Ash Street** (directly adjacent to the 418 E Ash Street property owned by the Salina Public Works Garage) in January 2024 to build a new sanitation truck storage facility. During the excavation process, a suspicious material was found. A subsequent Limited Site Investigation was completed in April 2024 that identified RCRA metals, Total Petroleum Hydrocarbons (TPH), High Range Hydrocarbons (HRH), Mid Range Hydrocarbons (MRH), and Polycyclic Aromatic Hydrocarbons (PAHs) within the soil at levels exceeding the residential Risk-based Cleanup Standards for Kansas (RSKs).

In July 2025, KDHE approved a voluntary clean-up plan for the city to clean up and dispose of the small amount of the hazardous waste found on the site. No additional testing has taken place, and the clean-up plan has not started.

6 Site Reconnaissance

HDR visited the Subject Property and surrounding properties and conducted a site reconnaissance on April 7, 2025. The site reconnaissance consisted of pedestrian and vehicle surveys from publicly accessible areas and/or local roadways. Due to the presence of physical barriers, dense vegetation, and private properties, it was not reasonable ascertainable to inspect the entirety of the Subject Property or adjacent properties. Site and adjacent property reconnaissance photographs are provided in **Appendix C**.

6.1 General Site Observations

HDR encountered multiple signs indicating utilities on the property. Multiple fiber optic lines, sewer infrastructure lines, and overhead power lines were found in or adjacent to the Subject Property. Overhead transmission lines (associated with the substation adjacent to the northern terminus of the Subject Property) bisected the northern edge of the Subject Property. Pole-mounted transformers were present within and in the vicinity of the Subject Property.

6.1.1 Site Observations of Note

De minimis conditions (primarily trash washed into the Old Channel) were present in various locations throughout the Subject Property. No leaks or stains on pole mounted transformers within the Subject Property were observed. No sheens were noted on the river.

6.2 General Adjacent Property Observations

Adjacent properties included commercial, residential, and recreational properties. Adjacent properties were generally well-kept. Various de minis conditions were noted on several residential properties adjacent to the Subject Property.

6.2.1 Adjacent Property Observations of Note

An electrical substation was adjacent to the northern terminus of the Subject Property. ASTs were noted on the Great Plains Trucking property, north E North Street. Secondary containment was present around the tanks, and no stains or spills were visible from the public Right-of-Way (ROW). The Salina Wrecker Service (850 E North Street) property contained multiple old vehicles throughout. No stains or spills were visible from the public ROW. ASTs were noted on the Salina Sanitation Department (418 E Ash Street) property (a former REC location from the previous investigation). Secondary containment was present around the tanks, and no stains or spills were visible from the public ROW. Vehicles and debris noted in aerials on the 616 E North Street property were not visible from the public ROW.

7 Findings, Opinions and Conclusions

HDR has conducted an HTRW Investigation/Phase I ESA to determine if HTRW and non-HTRW RECs located within the Subject Property boundaries or adjacent to the Subject Property will impact the implementation of the proposed USACE ecosystem restoration project for the Old Channel of the Smoky Hill River in Salina, Kansas. This HTRW Investigation report is intended for inclusion in the Draft Integrated General Investigation Feasibility Study and Environmental Assessment.

The Phase I ESA was performed in accordance with the scope and limitations of ASTM Practice E 1527-21. Any exceptions to, or deletions from, this practice are described previously in this report. Included in this Phase I ESA are a summary of the site reconnaissance conducted on April 7, 2025, the review of the environmental database search report, historical data sources and other records, and interviews with available personnel knowledgeable about the Subject Property.

7.1 Findings and Opinions

HDR has reviewed the stated data sources, which are part of the ASTM E 1527-21 assessment protocol. Based upon the review of the data, HDR has developed the following professional opinions regarding Recognized Environmental Conditions (RECs), Historical RECs (HRECs), and/or Controlled RECs (CRECs).

- The **Central Garage (418 E Ash Street)** property lies partially within the western portion of the Subject Property, just south of E Ash Street and is currently occupied by Salina Public Works Garage. One LUST record was found for the property from a gasoline release of an unknown amount from a UST on 11/12/1992. Subsequent contamination assessments revealed that groundwater contamination was present, with an undetermined lateral extent of contamination. The tank was immediately taken out of service (and removed three days later), but an NFA letter was not found, and the site status remains listed as “monitor.” Due to lack of details on closure of the site, and since the site status remains listed as “monitor,” this site is considered a REC for the Subject Property.

- The **Kenison, Inc (920 E North Street)** property lies partially within the northern portion of the Subject Property, just south of E North Street. Soil testing and removal of impacted soils/waters was completed following a spill of transformer oil in 2013. This site is considered an HREC for the Subject Property.

- The **Land Pride S4/Turbine Specialties, Salina/Turbine Specialties, Inc. (1030 E North Street)** property is bisected by the Subject Property. No contaminants were found following a LUST incident in 1990, and No Further Action was deemed necessary. This site is considered an HREC for the Subject Property.

- The **ADM Milling Company (Ash & 3rd Street)** is crossed by the Subject Property. No further action was deemed necessary for the 1990 LUST incident at this site. This site is considered an HREC for the Subject Property.

- The southeastern corner of the **Star A Insurance/Super Wash & Detail (156 N 5th Street)** property is crossed by the Subject Property. An abandoned UST was identified during installation of a groundwater monitoring well for an investigation at a nearby site, with an odor noted in the soil. No further action was deemed necessary for the 2006 LUST incident at this site. This site is considered an HREC for the Subject Property.

- The **City of Salina/Oakdale Park Maintenance/City Offices/Knox Pit & Plant (730 Oakdale Park)** property is crossed by the Subject Property on the northwest, southwest, and eastern perimeters of the park. A LUST record for the site reports that small areas of diesel and gasoline contamination were identified in soils around fill tubes during the removal of two 500-gallon USTs in 1992. The contamination around the fill tubes did not exceed one foot in diameter. Slight odor/staining was observed. Due to the limited area of contamination, the case was closed, and no further action was deemed necessary.

  A MINES MRDS record for the site was also found, detailing a sand and gravel mine noted on the site in 1983. No further details on mining activities or dates of operation were found. Historical aerials do not depict any indication of gravel mining activities within the park. This site is not considered a REC for the Subject.

- The **616 E North Street** property is adjacent to the northwest and upgradient from the Subject Property. This site was listed as a REC in a previous investigation. A Phase II ESA was completed for the site in 2014. Tetrachloroethylene (PCE) was detected in the groundwater at the site and south of the building. A subsequent investigation completed in 2015 found additional tetrachloroethylene contamination along the southern boundary of the property. Deep groundwater sampling was conducted in 2018, which did not detect any contamination. Six permanent groundwater monitoring wells were installed in 2019; semi-annual groundwater monitoring has been conducted since the installation. The most recent results noted in the EDR database were from March 2020, which found elevated PCE levels at or above the USEPA Maximum Contaminant Level (MCL) in two wells on the site, at 14.9 and 23.1 micrograms per liter (µg/L). This site was listed as a REC in a previous investigation. Due to continued groundwater monitoring at the site, and recent (2020) contaminants found during the monitoring, this site is considered a REC for the Subject Property.

- The **412 E. Ash** property lies partially within the western portion of the Subject Property. The City of Salina Public Works began developing the property in January 2024 to build a new sanitation truck storage facility. During the excavation process, a suspicious material was found. A subsequent Limited Site Investigation was completed in April 2024 that identified hazardous materials within the soil at levels exceeding the residential RKSs for Kansas. KDHE approved a voluntary clean-up plan for the city in July 2025, but no additional testing has taken place, and the clean-up plan has not started. Due to pending clean-up efforts, this site is considered a REC for the Subject Property.

- The remaining listings within and adjacent to the Subject Property are not considered RECs due to distance, hydraulic gradient, geology, regulatory, or clean-up status of the properties.

7.2 Conclusions

Based upon the above-detailed Findings and Opinions, HDR concludes that RECs have been identified for the proposed USACE ecosystem restoration project for the Old Channel of the Smoky Hill River, as enumerated in the Findings section above. The following statement is required by ASTM E 1527-21 as a positive declaration of whether RECs were found:

- *HDR has performed a Phase I ESA in conformance with the scope and limitations of ASTM E 1527-21 for* the proposed USACE ecosystem restoration project for the Old Channel of the Smoky Hill River in *Salina, Saline County, Kansas. Any exceptions to or deletions from these practices are described in previous sections of this report. This report has revealed indication of RECs in connection with the Subject Property.*

8 Recommendations

Recommendations included in this report were developed through the investigative procedures described in the Scope of Services, Significant Assumptions, and Limitations sections of this report. These findings should be reviewed within the context of the limitations provided in the Limitations section.

Based upon the identification of RECs for the Subject Property, HDR makes the following recommendations.

Recommendation 1

HDR recommends a Phase II evaluation of soil at REC locations where previous soil investigations have not occurred or institutional controls do not exist.

Recommendation 2

For locations where previous investigations have been conducted and/or institutional controls are in place, HDR recommends the development of a soil management plan.

Recommendation 3

HDR recommends that the USACE consider the “shelf life” of Phase I documents in determining risk. ASTM E 1527-13: 4.6 states that a conforming “Phase I” report is valid for a period of 180 days, and may be updated during the 180 days to 1-year timeframe. The report is valid for use in any of the CERCLA defenses ONLY if it is updated within this time frame. If greater than one year passes from the final report date, the Phase I effort would need to be repeated to remain in compliance with ASTM and the “All Appropriate Inquiry” protection.

9 Qualifications of Environmental Professionals

Signatures and Qualifications

We declare that, to the best of our professional knowledge and belief, we meet the definition of environmental professional as defined in Section 312.10 of 40 Code of Federal Regulations [C.F.R.] Part 312.

We have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the Project Area. We have developed and performed the all appropriate inquires in conformance with standards and practices set forth in 40 CFR Part 312.

Report Author
Hannah Hedinger
Environmental Scientist

Quality Control / Quality Assurance
Todd Wilson
Chemist

Qualifications of Environmental Professionals

This Phase I ESA was performed by the following HDR personnel.

Ms. Hannah Hedinger is an environmental scientist with expertise in biological, ecological, and permitting services for environmental and natural resource projects. She has expertise in threatened and endangered species habitat assessments, wetland delineations, Phase I & II Environmental Site Assessments (ESAs), NEPA compliance, environmental permitting, and GIS data analysis.

Quality Assurance / Quality Control was performed by the following HDR Personnel.

Mr. Todd Wilson is a qualified environmental professional, as defined by ASTM Practice E1527-21, with over 33 years of experience in environmental site assessment and remediation. Todd has experience providing advice on complex chemistry problems arising at, and management of, hazardous toxic and radioactive waste (HTRW) sites across the country, as well as advising on or performing chemical sampling, testing, and analysis of wastes. He recommends appropriate disposal, treatment, or processing requirements of materials based on the chemical properties of the waste to ensure compliance with all applicable laws and regulations, and investigates, analyzes, directs, and manages investigations of site operations to determine the presence and concentration of toxic and hazardous chemicals. Mr. Wilson also reviews sampling, testing, and analysis of reports to verify the accuracy and adequacy of the data; and to ensure compliance with contract requirements and conformance with accepted procedures to all applicable laws and regulations.

10 References

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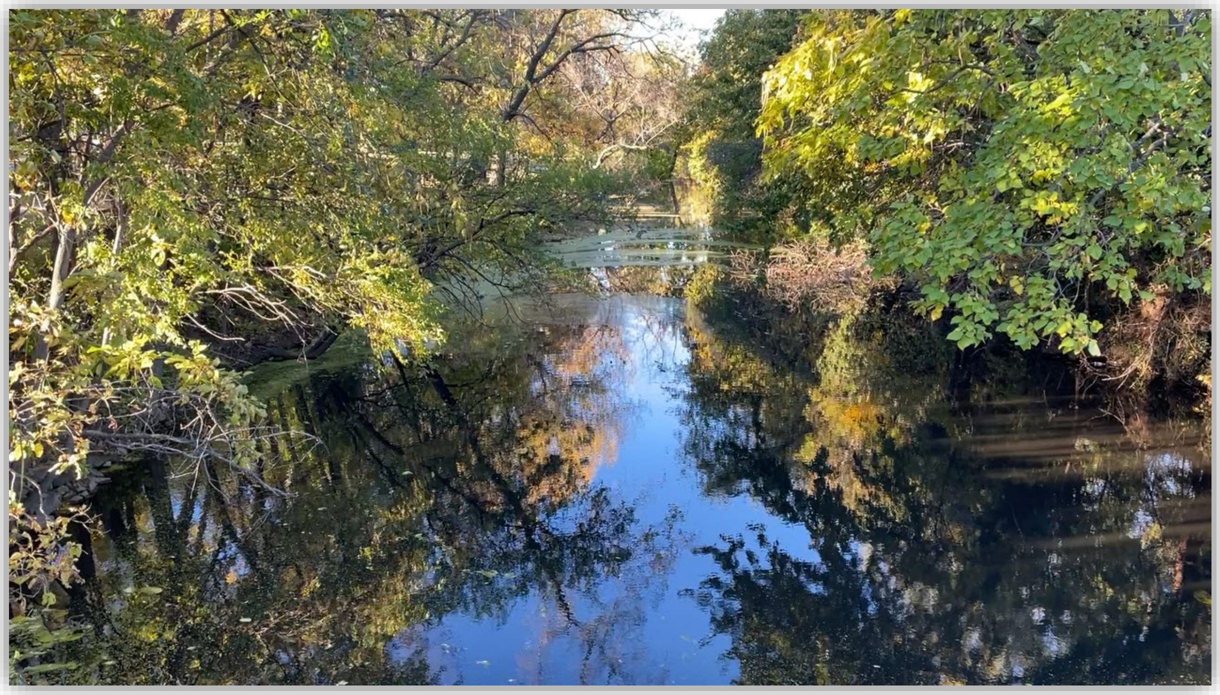


Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix H – Real Estate Plan

September 2025

City of Salina

REAL ESTATE PLAN
SMOKY HILL RIVER GI STUDY
ECOSYSTEM RESTORATION
SALINE COUNTY, KANSAS

1. Purpose: This Real Estate Plan (REP) was developed in support of the Feasibility Report for the Smoky Hill River Aquatic Ecosystem Restoration Project ("Project") under authority of Section 216 of the Flood Control Act of 1970, Public Law (P.L.) 91-611, December 31, 1970, as amended, and in accordance with Engineer Regulation (ER) 405-1-12, Chapter 12, paragraph 12-16 dated 1 May 1998. The purpose of this REP is to include information on any real estate activities that may be involved for the Project. In partnership with the City of Salina as the non-Federal sponsor ("NFS"), the Study was conducted along the "Old Channel" of the Smoky Hill River, in Salina, Kansas. The total project costs will be cost-shared, 65% Federal and 35% non-Federal. The Project Area includes approximately 6.8 miles of the Old Channel corridor throughout urban areas of Salina, as well as an adjacent riparian forest component. The Old Channel inlet captures flow from the Smoky Hill River and winds its way through downtown Salina, before exiting at a federal levee outlet control structure and pump station and then re-connecting to the main channel of the Smoky Hill River.

The purpose of the Project is to restore aquatic habitat functions and features within and near the Old Channel that were lost as a result of the 1961 Flood Risk Management (FRM) Project. Along with restoration of the aquatic habitat functions and features, there are also opportunities to restore the limited riparian forest along the Old Channel, create new off-channel emergent wetland habitat, and enhance deep-water habitat availability in Lakewood Lake. The restored habitats are intended to benefit native plants and animals to the greatest extent practicable within the urbanized watershed.

The Tentatively Selected Plan ("TSP") is Alternative A3 which proposes dredging, including forming variable depth profiles with pools, riffles, runs and glides. In addition, the TSP will produce ecological restoration impacts throughout the Reaches 1 and 2 of the Old Channel by creating diversity of habitats beneficial to aquatic organisms and other wildlife. The stream reconfiguration will restore gravity flows and sediment transport functions within the Old Channel. Furthermore, the replacement of the Western Star Mill Weir with five step-pool features would help establish and maintain a more natural flow regime, provide habitat diversity, and reconnect the Old Channel hydraulically and hydrologically to the main channel. To support aquatic organisms and wetland shelves and to help regulate flow and maintain sufficient water depth, weirs near the downstream and upstream ends of the Old Channel will be installed. Similarly, the Project would reconnect the wetlands around Lakewood Lake with the Old Channel, restoring hydrologic and ecological connections.

2. Description of Lands, Easements, Rights of Way, Relocation and Disposal (LERRD): This project will be constructed on approximately 181.45 acres of publicly and privately owned land. This includes 180.22 acres of Fee lands, 0.15 acres for a Road Easements, and 1.08 acres for Temporary Work area Easements for construction staging. All adaptive management and future operation and maintenance will be performed within Fee areas. The Project footprint spans across 94 privately owned parcels and 21 NFS owned parcels.

The disposal site for all excess grading material would be on-site near the south side of Lakewood Lake and re-used for wetlands restoration/creation. Soil would be spread out in areas demarcated on the construction plans.

FEE. The fee simple title to (the land described in Schedule A) (Tracts Nos. , and ____). Subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

ROAD EASEMENT. A temporary easement and right of way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the location, construction, operation, maintenance, alteration replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right of way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right of way as access to their adjoining land at the locations indicated in Schedule B); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT. A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Table 1. Real Estate Required for Smoky Hill River GI Study

Standard Estate Type	Ownership Type	Number of Parcels Impacted	Acreage	Cost
Fee	Private	94	25.89	$1,653,189.12
	NFS	21	154.33	$5,336,535.60

Standard Estate Type	Ownership Type	Number of Parcels Impacted	Acreage	Cost
Road Easement	Private	1	0.15	$9,801.00
Temporary Work Area Easement	Private	1	0.47	$12,283.92
	NFS	2	0.61	$1,062.86

3. LERRD Owned by Non-Federal Sponsor: This paragraph assumes that the NFS will provide the required real estate for project features located within its boundaries. Based on planning assumptions, the NFS is expected to contribute land either in fee or through easements. The NFS is anticipated to provide 154.33 acres in Fee and 0.61 acres in Temporary Work Area Easements.

4. **Non-Standard Estates:** No non-standard estates will be proposed for this project area.

5. Existing Federal Project in Area: In 1951, a reported 0.2 percent annual exceedance probability (AEP) flood affected more than 50 percent of the City of Salina's residential and commercial areas. As a result of the economic and social losses, state and federal funding was used to implement a Flood Risk Management project. The project reduced flow through downtown Salina by creating an excavated 1.1-mile channel (cut-off channel) and building an associated federal levee system. These management features constitute the Salina Kansas Federal Flood Risk Management (FRM) Project, which was constructed by the US Army Corps of Engineers (USACE) and was completed in 1961. It is operated and maintained by the City of Salina and has decreased flood risk for the entire city. The NFS was contacted to obtain real estate limits of the Salina Kansas Federal FRM Project. Once documentation has been received, pertinent information will be incorporated into the report. If no other options prove viable, information will be made available in the Preconstruction Engineering and Design Phase (PED) when the NFS completes the title search and boundary survey.

6. Federally Owned Land in Project Area: There is no federally owned land within the Project Area.

7. Navigational Servitude: Navigational Servitude will not be utilized for this project.

8. Real Estate Maps: A map of the proposed project areas is attached as Exhibits “A”.

9. Flooding Induced by Project: Preliminary hydraulic modeling indicates that there will be project features impacted by increased water surface elevations. However, additional modeling will need to be conducted by H&H with the outputs of those analyses used to determine the necessary property interests to be acquired. The affected lands, as stated above, are subject to change based on the additional water surface modelling to be conducted prior to completion of this feasibility report.

10. Baseline Cost Estimate on Acquisition of LERRD: Estimated Land value for the Project is from a Real Estate Cost Estimate prepared on May 7, 2025, by a Certified General Review Appraiser. USACE RE prepared an estimate for LERRD Administrative costs, including administrative services, contracting appraisals, review appraisal(s), and other acquisition costs.

TABLE 10.1 - Baseline Cost Estimate	
Type of Costs	Total Costs
Land Acquisition Costs	
Fee	$6,989,724.72
Road Easement	$9,801.00
Temporary Work Area Easement	$13,346.78
20% Contingency	$1,402,574.50
Total Real Estate Land Cost w/Contingency	$8,415,447.00
LERRD Administrative Costs	
Incidental Cost (NFS)	$1,550,100.00
Federal Incidental Costs (not LERRD creditable)	$322,000.00
15% Contingency	$280,815.00
Total LERRD Administrative Costs	$2,152,915.00
Total LERRDS Costs	$10,568,362.00
Total Creditable LERRDS Costs (excludes Federal Incidental Cost plus 15% Contingency)	**$10,198,062.00**

*The Creditable LERRDS total shown does not include federal incidental costs

11. Relocation Assistance (P.L. 91-646): There are no displaced persons, businesses, or farms entitled to relocation assistance as defined in the uniform Relocation Assistance and Real Property Acquisitions Policies Act of 1948, as amended (Public Law 91-646) necessary for this project.

12. Mineral Activity Impacted Present/Future: There is no current or anticipated mineral activity or timber value impact in the vicinity of the proposed project.

13. Assessment of Non-Federal Sponsor Legal Capability: Assessment of non-Federal sponsor’s Real Estate Acquisition Capability Checklist was sent to the NFS in August 2025. Once it is returned it will be attached to report and signed by the Real Estate Chief prior to the final report.

14. Zoning Ordinances Considered in Support of LERRD Requirements: There are no zoning ordinances in place or proposed in connection with the project.

15. Acquisition Schedule: The NFS is responsible for acquiring real property interests required for the project. A time frame for land acquisitions has been outlined for the area of interest and coordinated with the Sponsor. The following are proposed duration milestones for the acquisition 115 parcels estimated by USACE-RE:

Mapping & Survey	8 months
Obtain Title & Appraisals	8 months
Appraisal Review	6 months
Negotiations	12 months
Final Title & Closing	4 months

Mapping & Survey and Obtaining Title & Appraisals steps will run concurrently. Estimated time for acquisition is 30 months. If condemnation is required, it will add an estimated 24 months to the schedule.

16. Facility/Utility Relocation: The preliminary project design, for which this report has been drafted, indicates that no facility or utility relocations will be required for this project.

“ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN, OR ELSEWHERE IN THIS PROJECT REPORT, THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY’S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES.”

17. Impact of Hazardous, Toxic and Radioactive Waste (HTRW): HDR Engineering, Inc. (HDR) conducted HTRW and non-HTRW investigations to identify any potential HTRW sites, including soil, surface water, and groundwater contamination pathways that could be affected by Project construction. Two (2) recognized environmental condition (REC) sites were identified due to ongoing contamination or no closure documentation. The remaining sites were identified as Historical RECs, where contamination had occurred but was resolved.

Central Garage (418 E Ash Street) partially overlaps the Project area and experienced a gasoline release from an underground storage tank in 1992, resulting in groundwater contamination with undetermined extent. The site status remains "monitor" with no closure documentation found, making it a REC. 616 E North Street is adjacent to and upgradient from the Project area, with tetrachloroethylene (PCE) contamination detected in groundwater during multiple investigations from 2014-2020. Recent 2020 monitoring found elevated PCE levels above U.S. Environmental Protection Agency (EPA) maximum contaminant levels in two wells, maintaining its status as a REC due to ongoing contamination.

Based upon the identification of RECs for the Project area, recommendations were made by HDR to further evaluate the area. HDR recommends a Phase II evaluation of soil and groundwater at REC locations where previous soil investigations have not occurred, or institutional controls do not exist. For locations where previous investigations have been conducted and/or institutional controls are in place, HDR recommends the development of a soil management plan. It is the responsibility of the NFS to provide uncontaminated land for project use. For detailed information and the full list of identified sites, see Appendix G – Hazardous, Toxic and Radioactive Waste Investigation of the Feasibility Report.

18. Opposition/Support of Project by Local Landowners: The rehabilitation of Smoky Hill River is generally seen by the NFS, public, and stakeholders as a critical piece of ongoing efforts to revitalize the downtown area of Salina. In 2010, the NFS approved the Smoky Hill River Master Plan (Master Plan) after soliciting public input. The intent of the Master Plan was to identify appropriate planning, design and preliminary engineering responses to the specific opportunities associated with the restoration and redevelopment of the Old Channel area of the Smoky Hill River. This effort indicated that the NFS and public strongly supported restoring the Old Channel. In 2016, the City of Salina voted to increase and allocate a portion of its sales tax to support the renewal of Smoky Hill River for the next twenty (20) years.

The U.S. Fish and Wildlife Service, Kansas Ecological Services Field Office encourages the restoration of altered or degraded watersheds to support conservation of native fish communities. The Kansas Department of Wildlife, Parks and Tourism generally supports efforts to restore aquatic habitats and habitat connectivity. Friends of the River—a public advocacy group—advocates, communicates and educates for the good of Smoky Hill River and is strongly in support of this study. Smoky Hill Museum and Friends of the River agreed to be invited signatories for the Project. Along with the Pawnee Nation, they have expressed interest in participating in mitigation consultation of the Western Star Mill Weir. While the consultation is expected to result in a Memorandum of Agreement, formal consultation has not yet begun beyond the identification of interested parties.

19. Notification to Non-Federal Sponsor of Risk and Early Acquisition of LERRD: The NFS will be made aware of the risks associated with acquiring land before the execution of the PPA and a risk letter will be prepared and sent to the NFS in August 2025.

20. Other Real Estate Issues: In 2024, the NFS received a USDOT Rebuilding American Infrastructure with Sustainability and Equity grant (“RAISE”) grant. The RAISE grant will help the NFS modernize infrastructure in the downtown Salina area, including bridge and culvert work that will improve Old Channel flow, consequently reducing sedimentation, and complementing the aquatic ecosystem restoration efforts of this Project. It is critical to coordinate all phases on the Project (feasibility, design, and construction) with the RAISE grant project to ensure that this Project’s construction activities occur after city’s construction has been completed. The footprints of the two projects do overlap; however, the NFS is not using USDOT funding to acquire lands in those areas so the acquisitions will be LERRD creditable.

The potential for induced flooding presents key real estate considerations, particularly regarding the extent of impacts and necessary mitigation measures.

Preliminary hydraulic modeling indicates that project features will impact water surfaces at various events, including the 2%, 1% and 0.2% Annual Exceedance Probability (AEP) events. In each event, induced impacts were identified on the northern section of river with all three events spreading to surround Lakewood Lake. The 2% AEP event future with project (FWP) water surface elevation (WSE) is a maximum of 6 inches higher than the future without project (FWOP) WSE, with the total induced impacts area being approximately 0.67 acre. The 1% AEP FWP WSE is a maximum of 3.6 inches higher than the FWOP WSE, with the total induced impacts area being approximately 1.30 acres. The 0.2% FWP WSE is a maximum of 2.4 inches higher than the FWOP WSE, with the total induced impacts area being approximately 1.49 acres. There are some locations in the southern section of river where the FWP inundation extents appear larger than the FWOP inundation extents due to slight changes resulting from the channel excavation or new flow paths under bridges, however upon further review these areas were determined to be invalid and are consequences of the hydraulic model limitations.

For the final report, the project recommendations will fully account for all actions necessary to mitigate or compensate for adverse impacts due to flooding. See Appendix A2 for discussion regarding the analysis of induced flooding impacts.

REAL ESTATE PLAN
SMOKY HILL RIVER GI STUDY
ECOSYSTEM RESTORATION
SALINE COUNTY, KANSAS

PROJECT MAPS

EXHIBIT A – Project Location Map

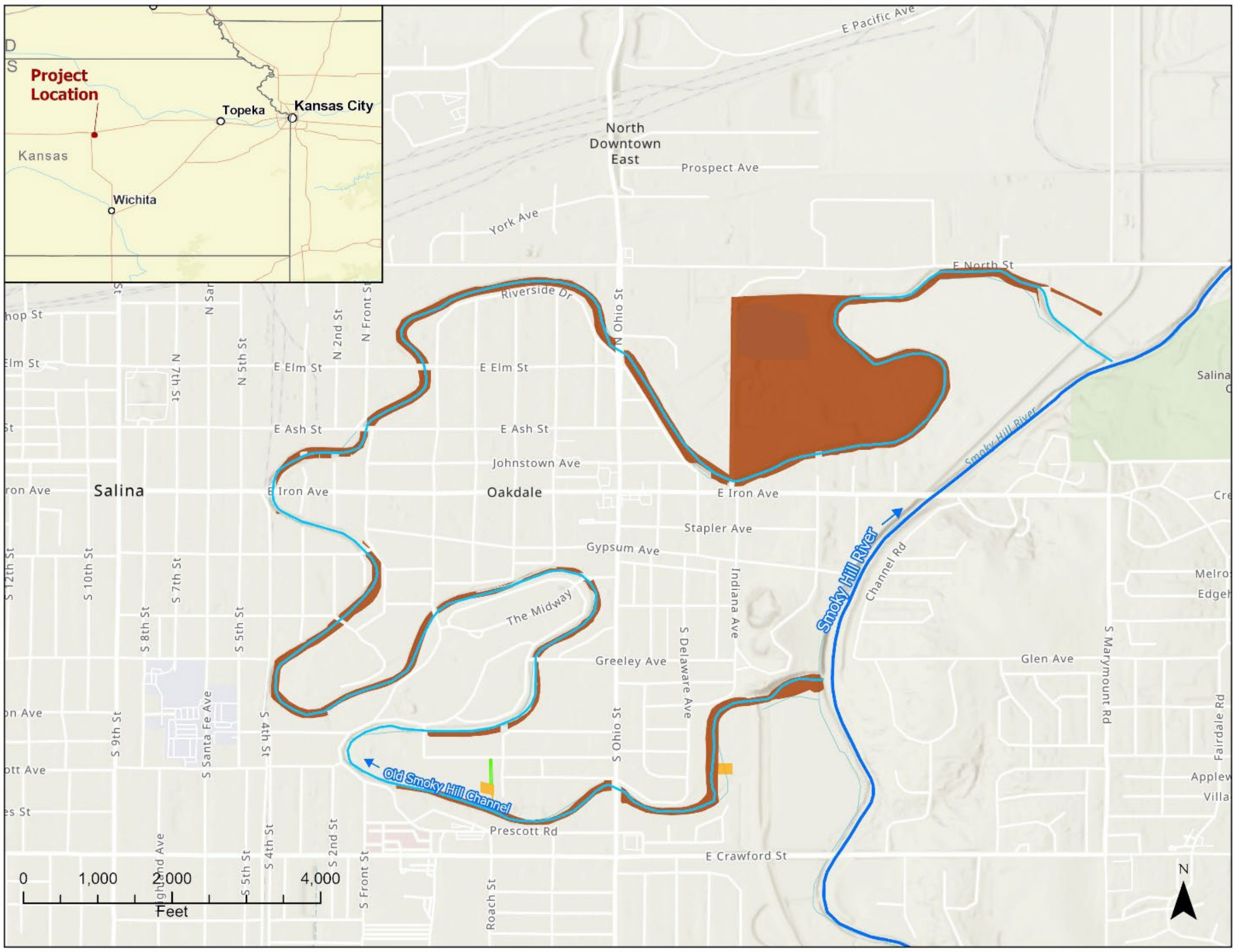
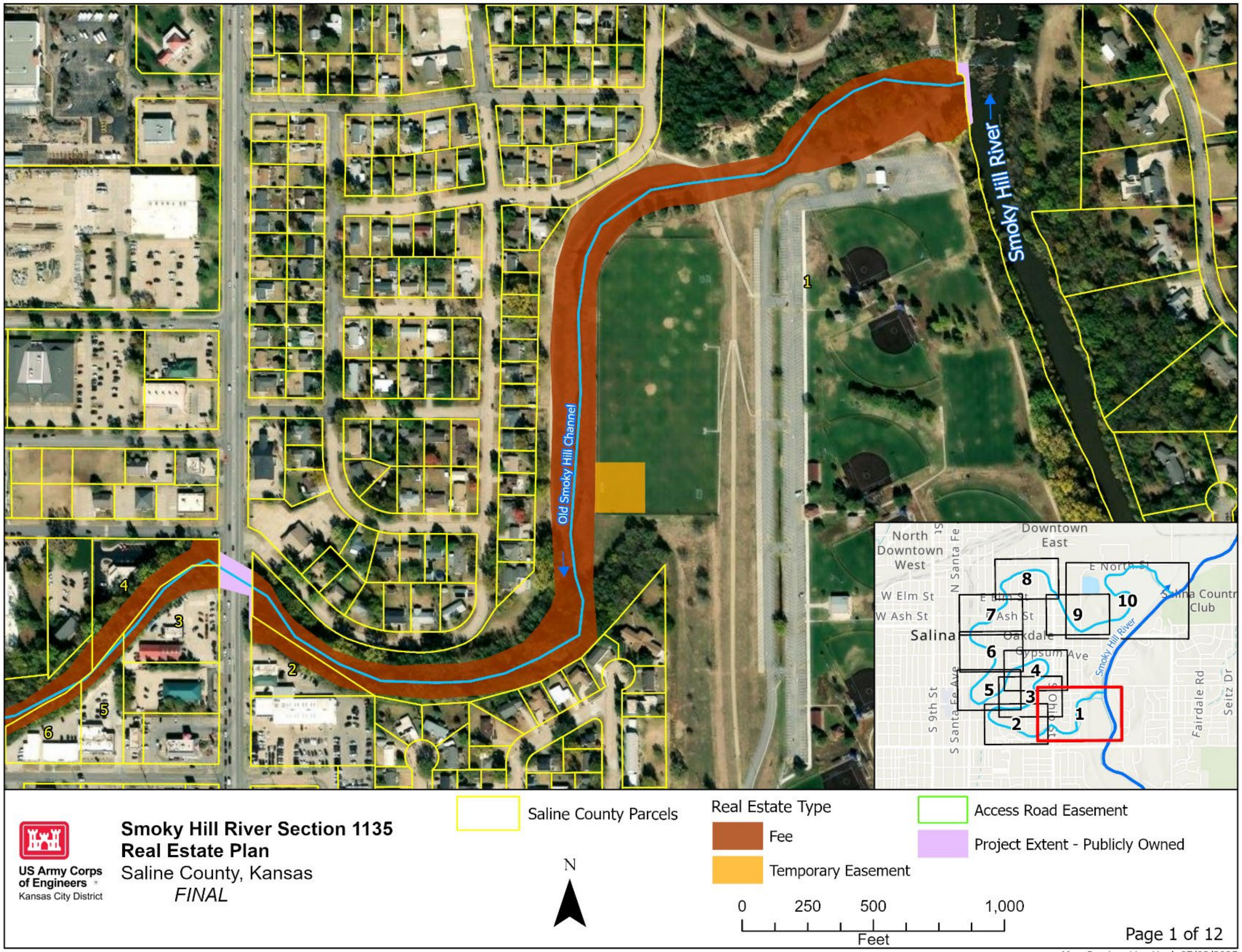


EXHIBIT A-1 - Real Estate Maps



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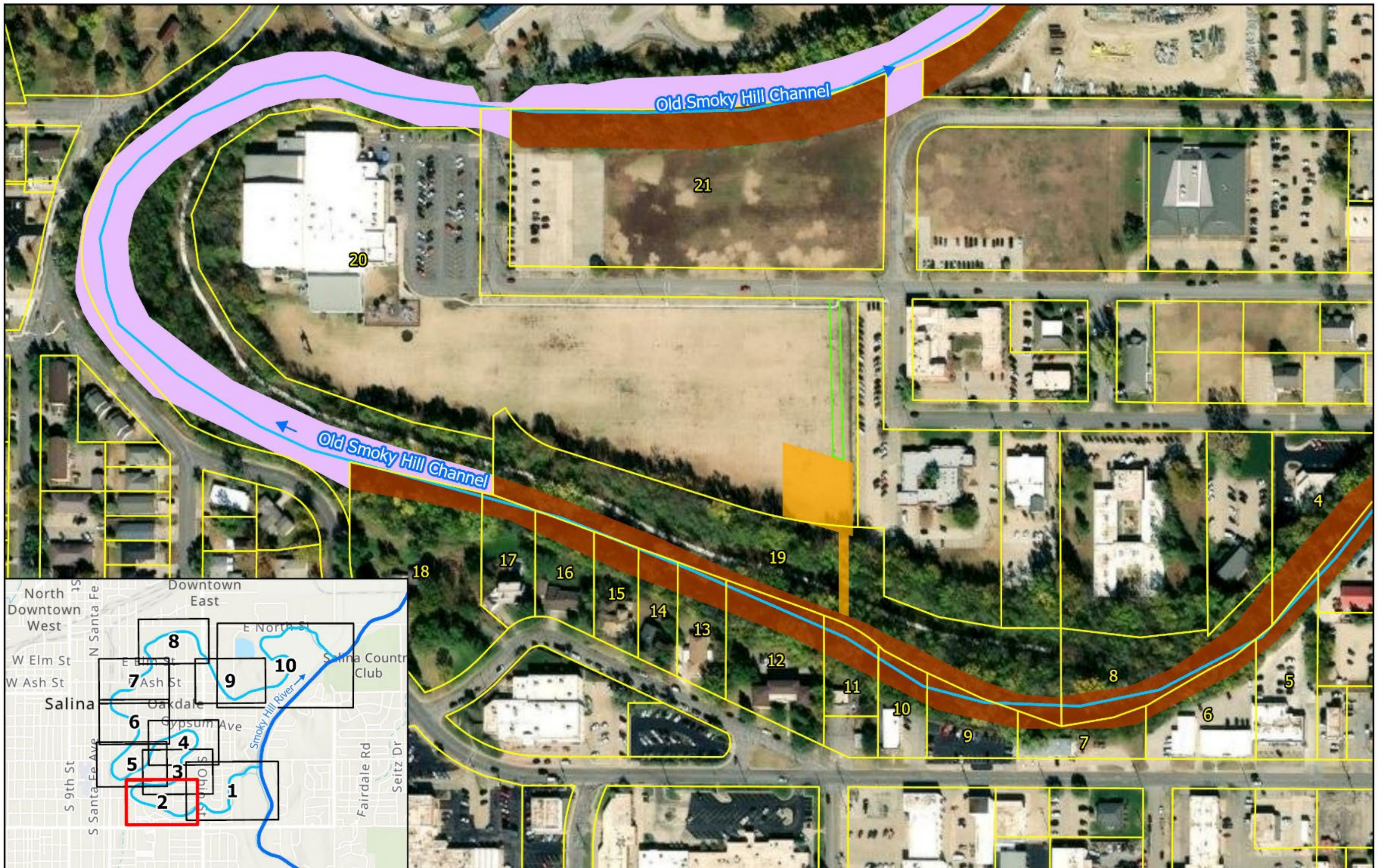


US Army Corps of Engineers
Kansas City District

Smoky Hill River Section 1135
Real Estate Plan
Saline County, Kansas
FINAL

Saline County Parcels

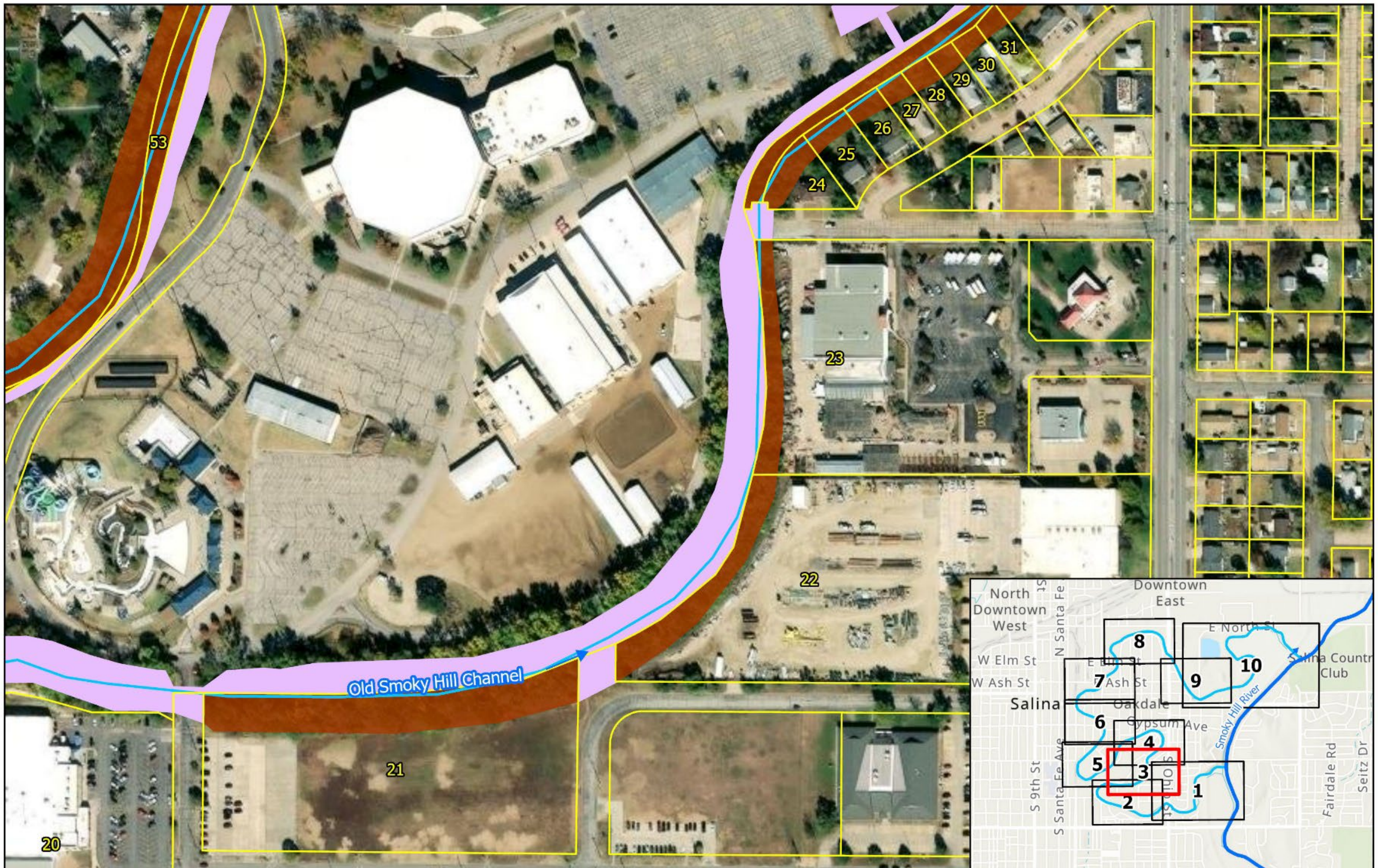
Real Estate Type
Fee
Temporary Easement

Access Road Easement
Project Extent - Publicly Owned

N

0 250 500 1,000
Feet

Map Creator: Lisa Hook 07/03/2025



US Army Corps of Engineers
Kansas City District

Smoky Hill River Section 1135
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Saline County, Kansas
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Saline County Parcels

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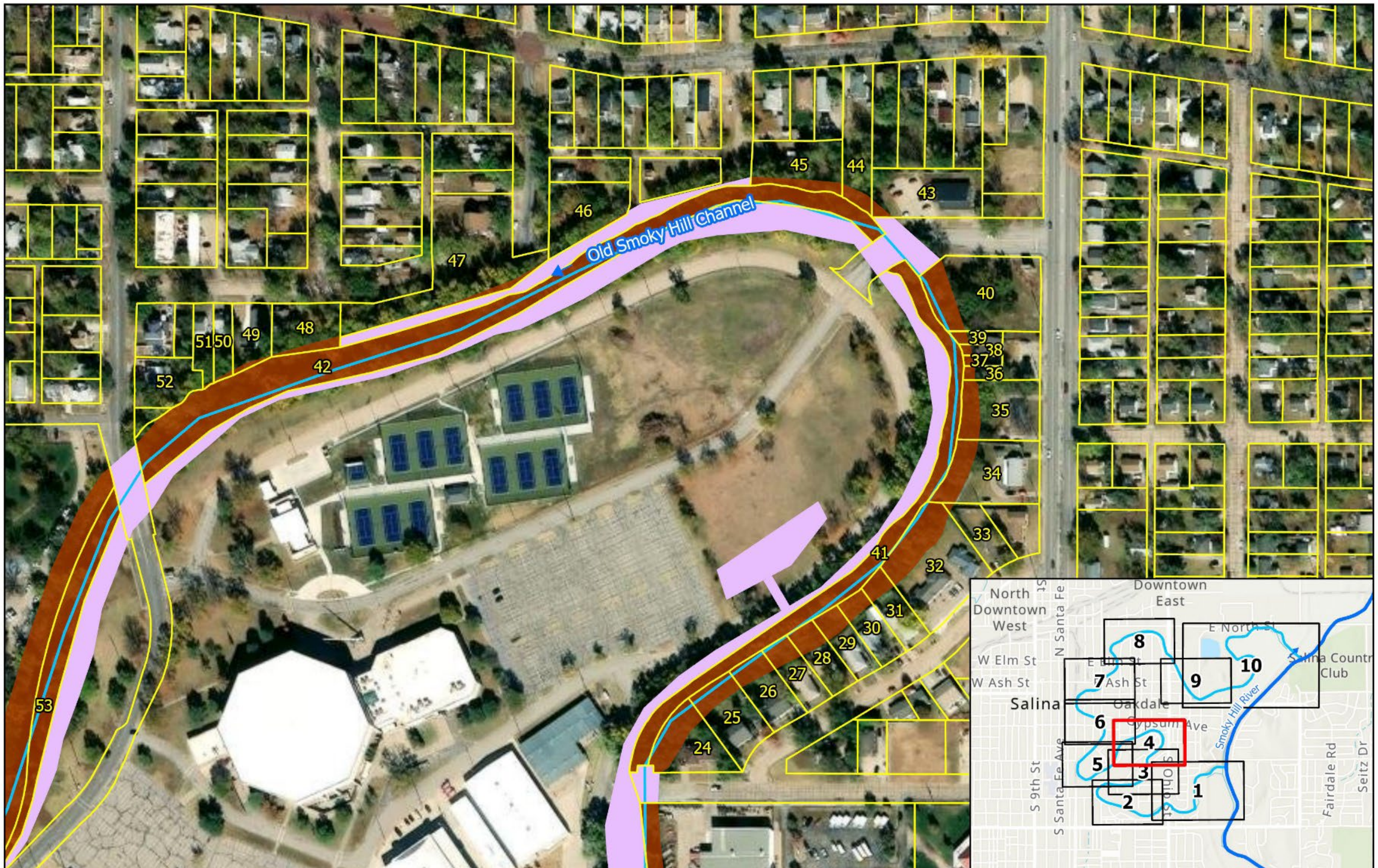

US Army Corps of Engineers
Kansas City District

Smoky Hill River Section 1135
Real Estate Plan
Saline County, Kansas
FINAL

Saline County Parcels

Real Estate Type
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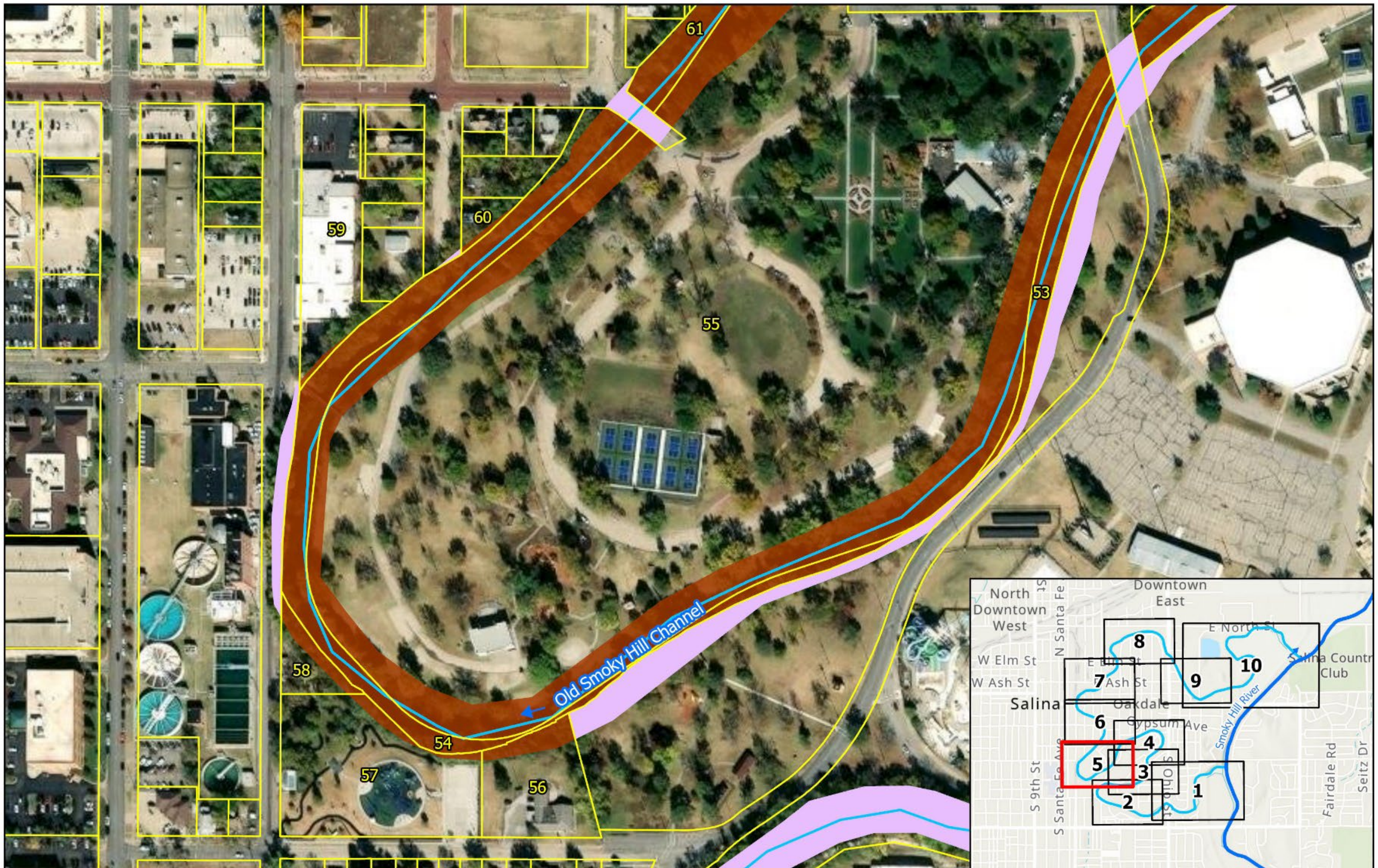

US Army Corps of Engineers
Kansas City District

Smoky Hill River Section 1135
Real Estate Plan
Saline County, Kansas
FINAL

Saline County Parcels

Real Estate Type
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- Temporary Easement

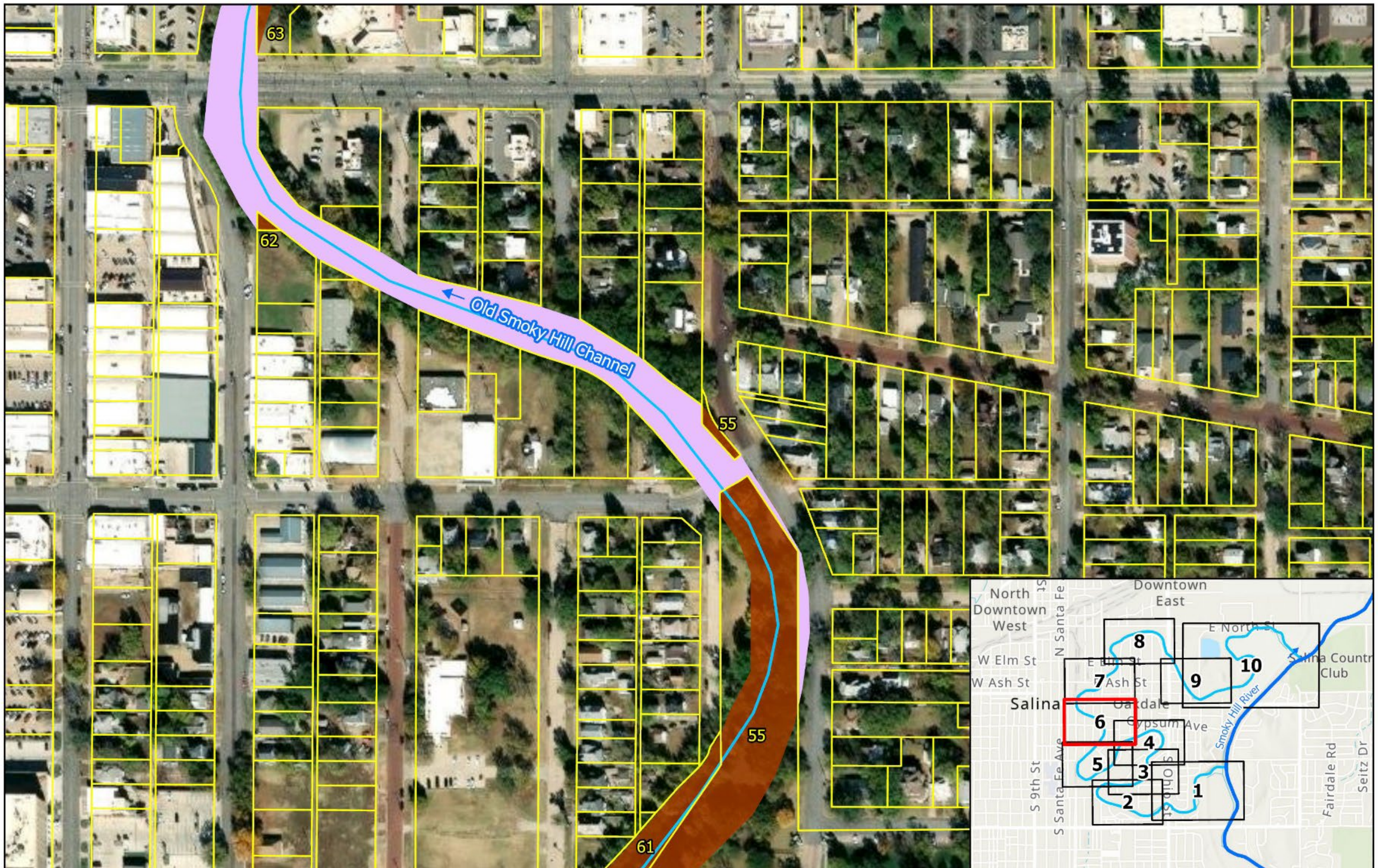
Access Road Easement

Project Extent - Publicly Owned

N

0 250 500 1,000
Feet

Map Creator: Lisa Hook 07/03/2025



Smoky Hill River Section 1135
Real Estate Plan
Saline County, Kansas
FINAL

US Army Corps of Engineers
Kansas City District

Saline County Parcels

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0 250 500 1,000
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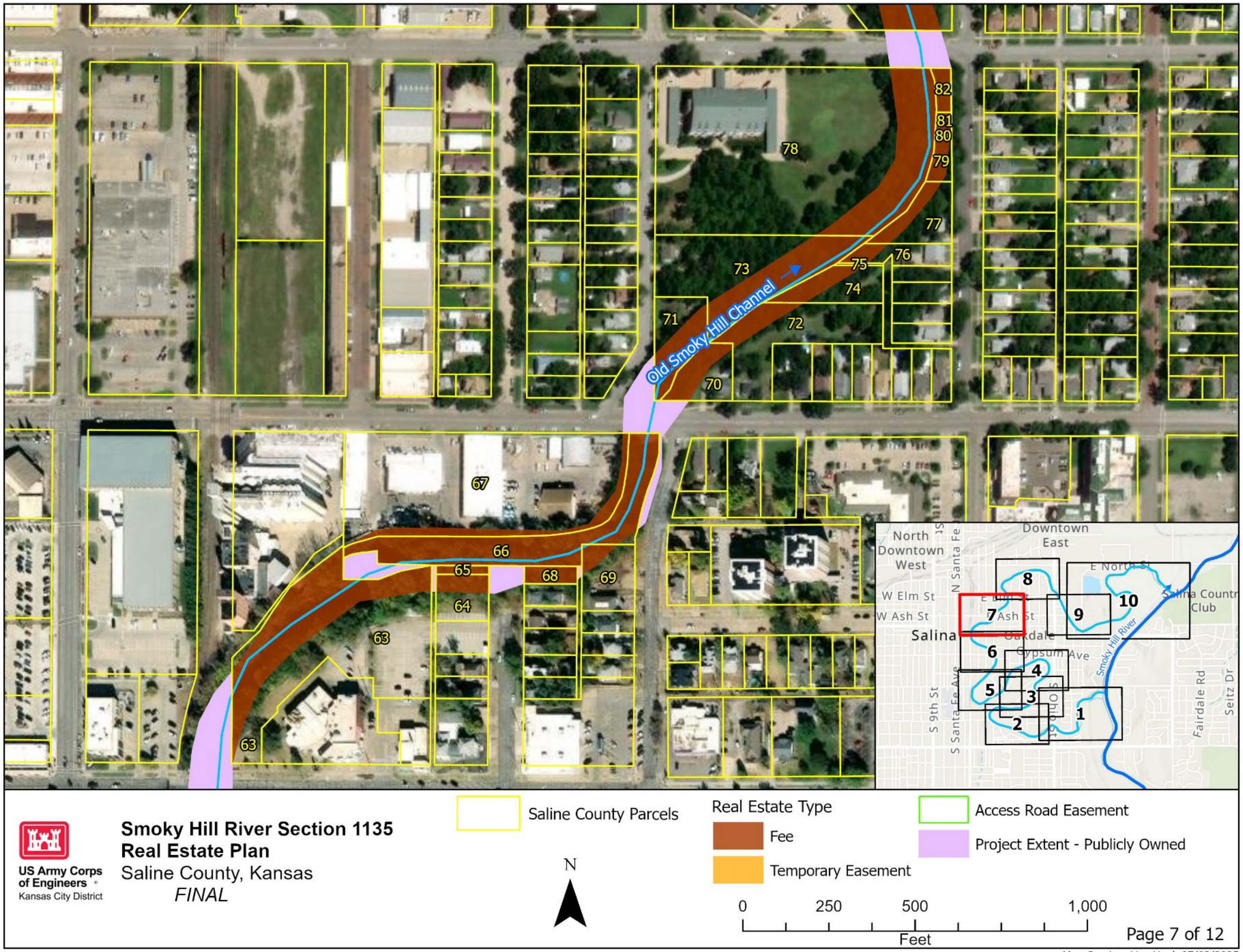

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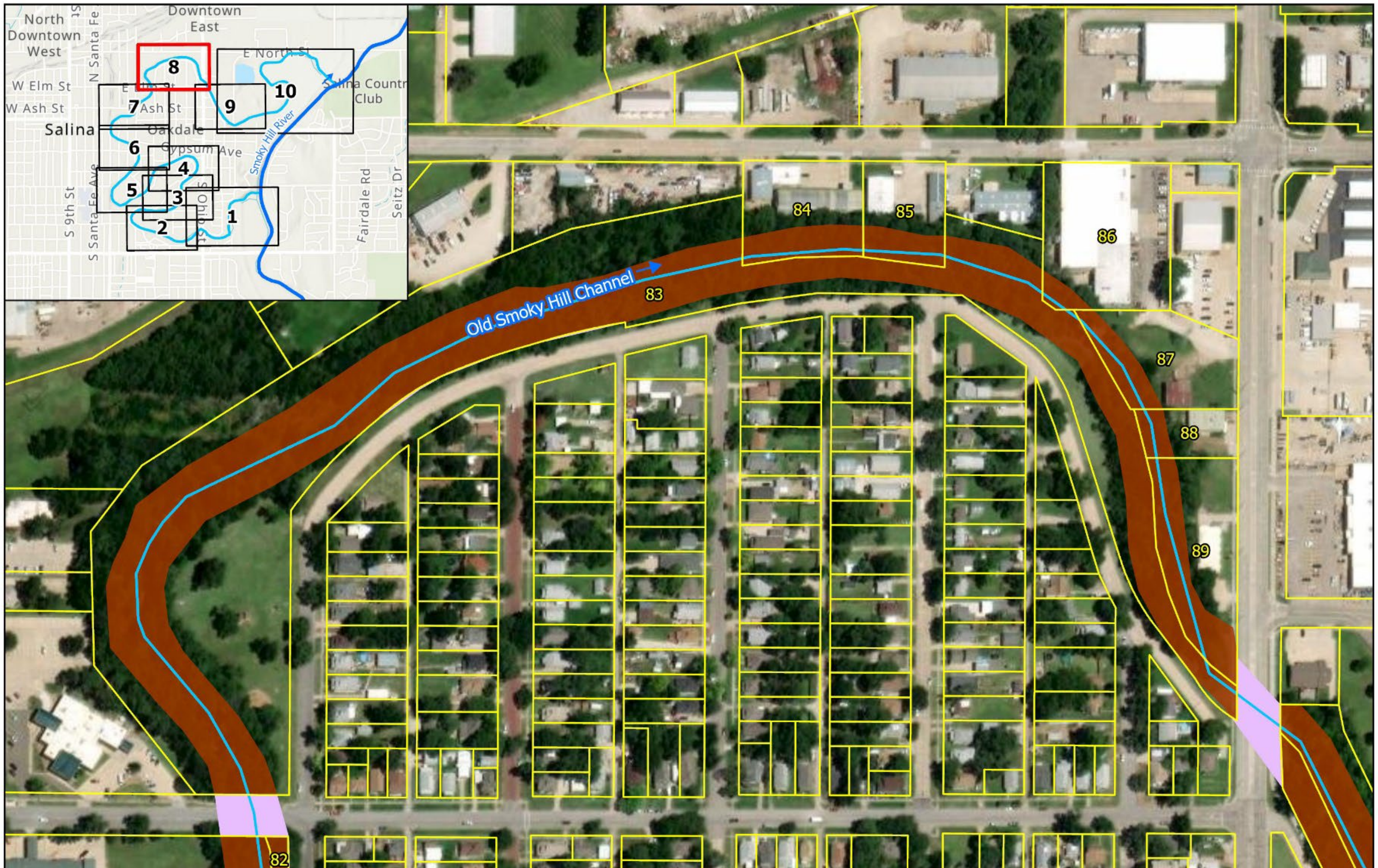

Smoky Hill River Section 1135
Real Estate Plan
Saline County, Kansas
FINAL

US Army Corps of Engineers
Kansas City District

Saline County Parcels

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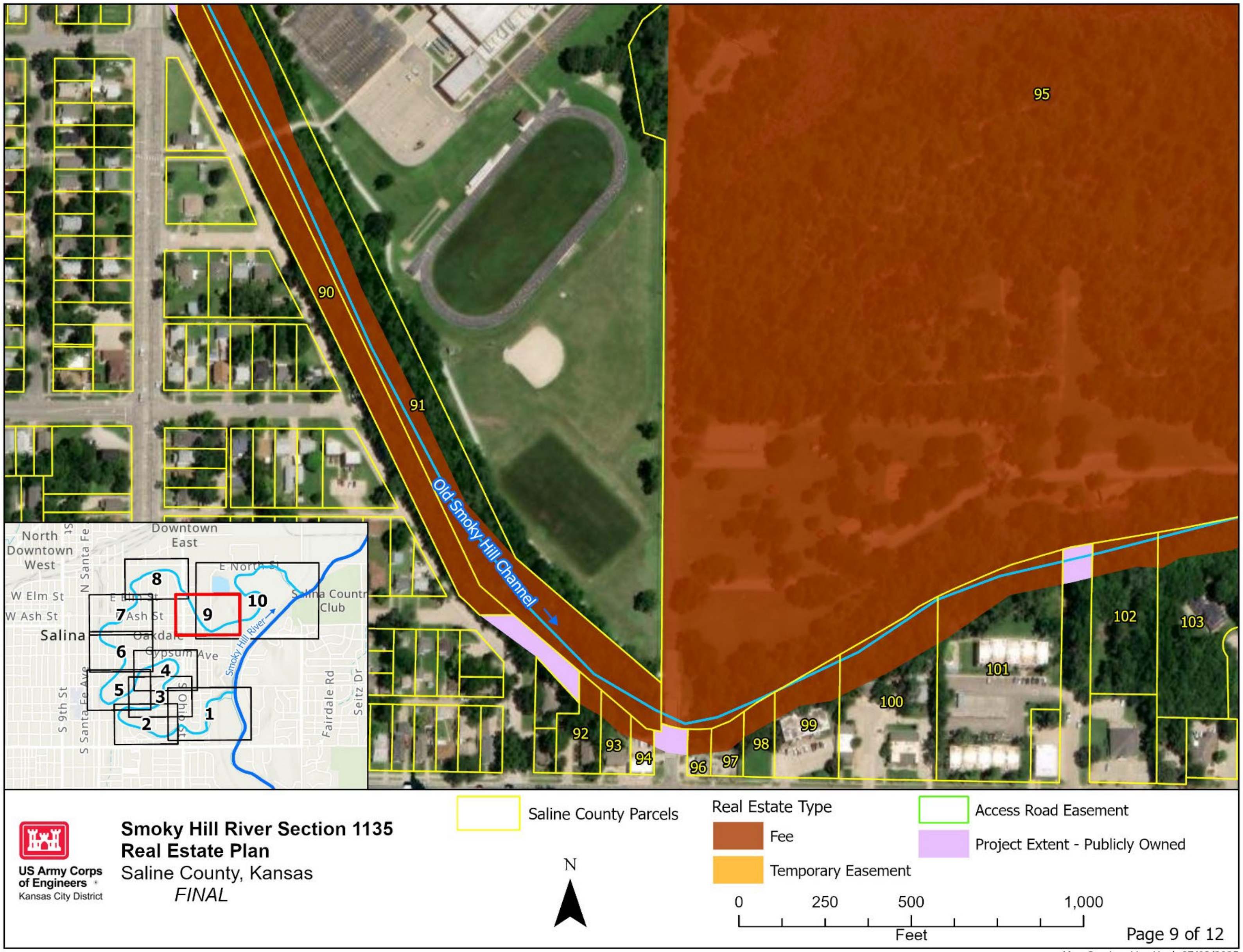

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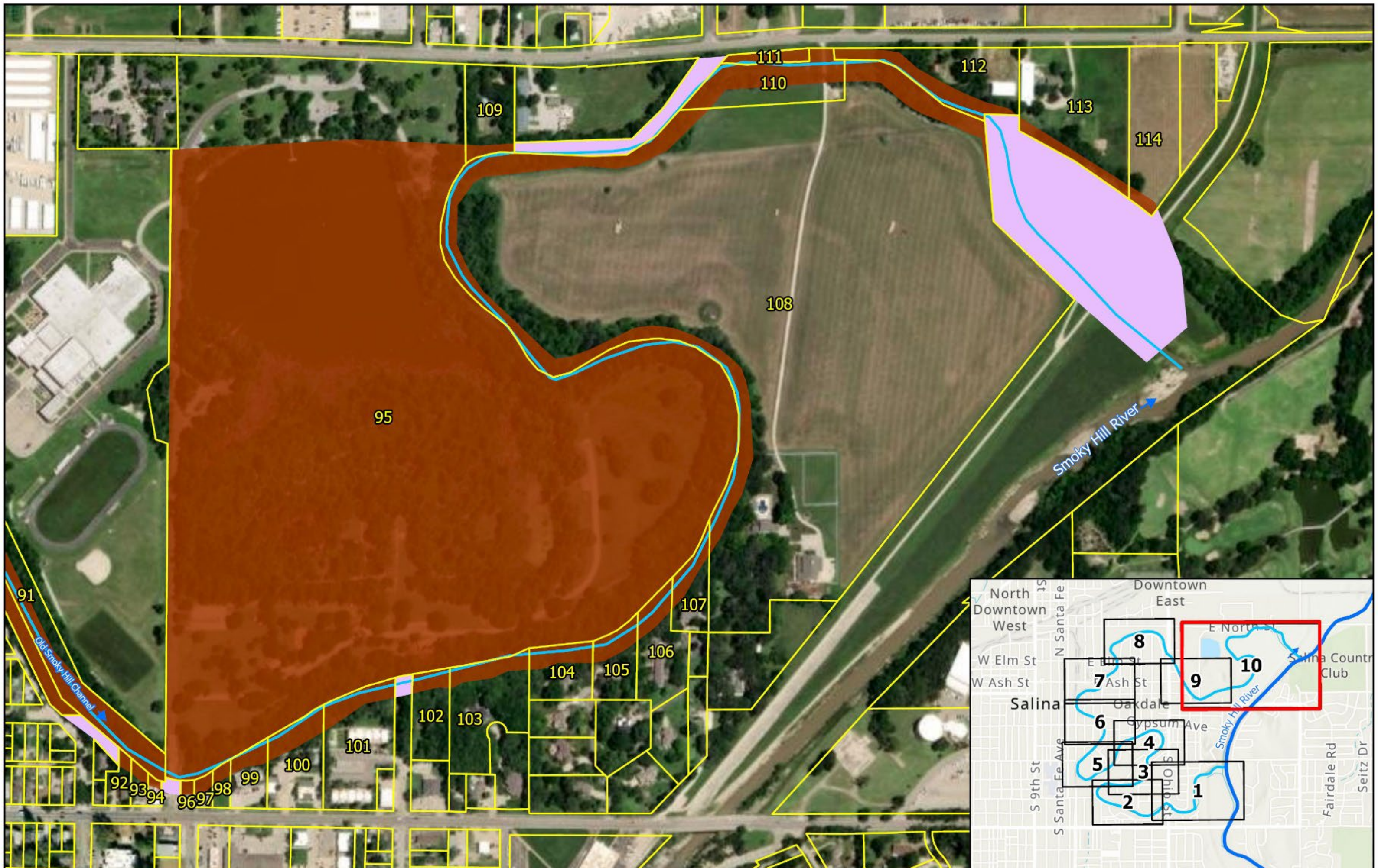

US Army Corps of Engineers
Kansas City District

Smoky Hill River Section 1135
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Saline County, Kansas
FINAL

Saline County Parcels

Real Estate Type
Fee
Temporary Easement
Access Road Easement
Project Extent - Publicly Owned

N

0 500 1,000 2,000
Feet

Map Creator: Lisa Hook 07/03/2025

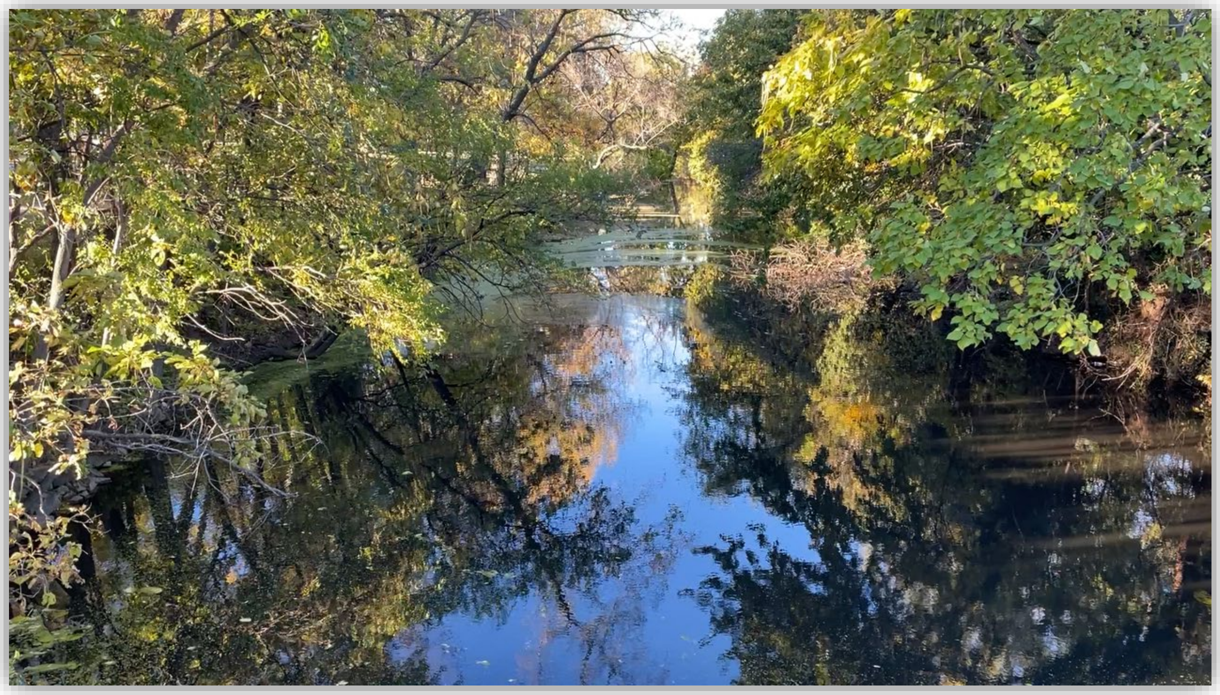
REAL ESTATE PLAN
SMOKY HILL RIVER GI STUDY
ECOSYSTEM RESTORATION
SALINE COUNTY, KANSAS

PROJECT MAPS

EXHIBIT B – NFS Capability Checklist

To be added once completed by NFS and will be signed by RE Chief prior to Final Report

US Army Corps of Engineers



Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix I – Economics

September 2025

City of Salina

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List of Figures

List of Tables

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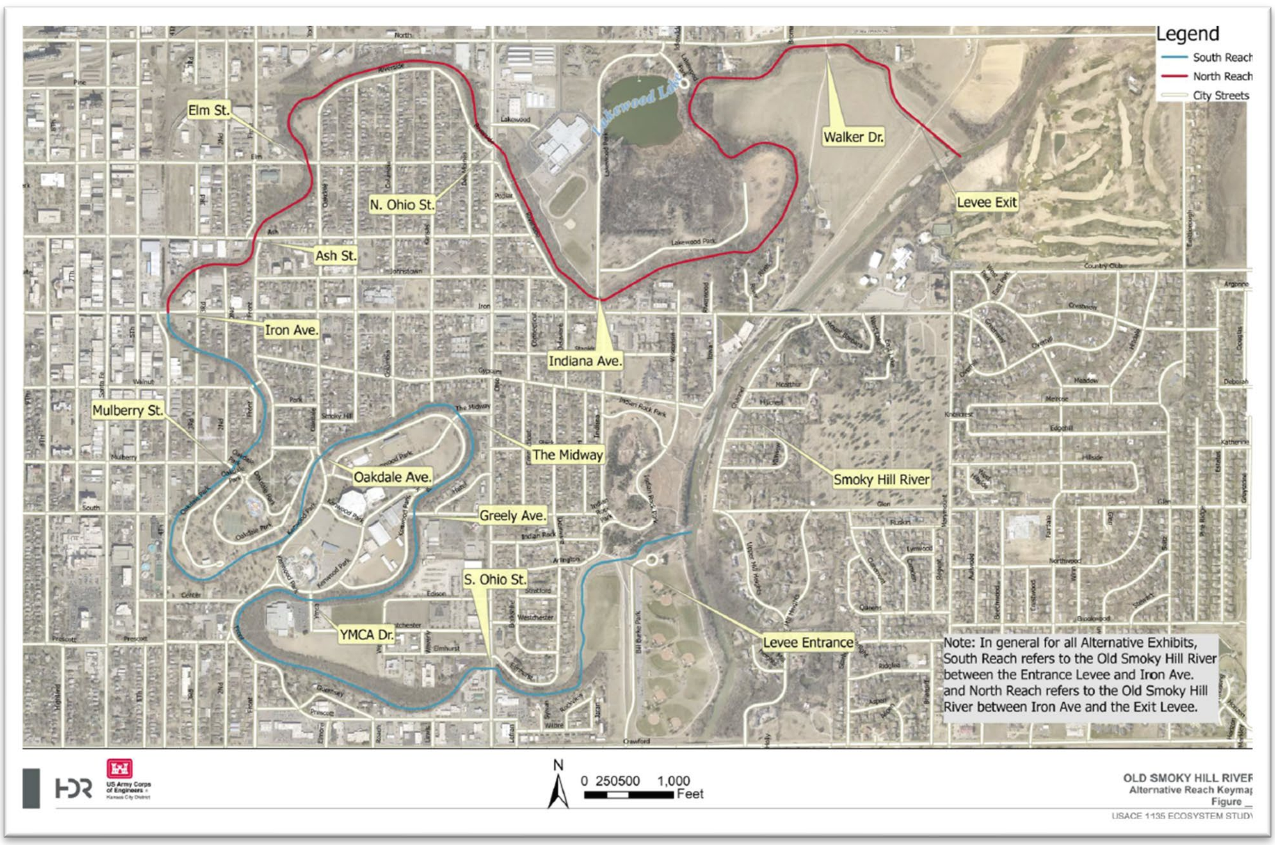
1 - Study Area

1.1 Areas of Consideration

The study area is located in northern Salina, Kansas, near Mission Trail (Figure 1). The Smoky Hill River used to meander throughout northern Salina. Channel straightening and a pair of cutoff levees rerouted the Smoky Hill River to flow more to the northeast, which isolated about seven miles of the original channel, and Lakewood Lake. Aquatic conditions in the channel as well as riparian conditions adjacent to the older channel and surrounding Lakewood Lake have subsequently deteriorated, which serves as the rationale for this investigation. See Section 1.0 of the Main Report for additional details.

Figure 1-1 – Study area location



2 - Plan Formulation and Ecosystem Restoration Analysis

2.1 Plan Formulation and Alternative Development

An alternative plan consists of a system of structural and/or non-structural measures, strategies, or programs formulated to meet, fully or partially, the identified study planning objectives subject to planning constraints. A management measure is a feature or an activity that can be implemented at a specific geographic site to address one or more planning objective. Management measures are the building blocks of alternative plans.

Restoration measures to enact the proposed improvements for this project include a) channel dredging of varying configurations (e.g. glide, pool, riffle, run), b) additional pool habitats, c) sediment forebay structures, d) riparian habitat development along the Old Channel, e) removal of deteriorated weir and replacement with step pools, and f) riparian habitat development at Lakewood Lake. Alternative plans for habitat restoration include one or more of the above measures. More detailed information regarding the plan formulation process can be found in the Main Report, Section 3.0 Plan Formulation and Evaluation. Table 1 summarizes each of the restoration alternatives used in this study. Locations of those measures are displayed in Figure 2. Due to the combinability and dependencies amongst the measures, the project delivery team (PDT) combined the measures into alternatives to ensure that all alternatives would be successful in achieving the project goals and objectives. Therefore, individual measures were not entered into the USACE Institute for Water Resources (IWR) Planning Suite (IWR-Plan) II, version 2.0.9.35 (Certified May 2018). Instead, the already combined measures, now referred to as alternatives were entered into IWR Planning Suite, including the No Action Alternative. Alternatives 1 and 2 are similar; however, in Reach 1, Alternative 2 creates a variable section and depth profile as opposed to a uniform trapezoidal channel. Alternatives 3 is proposing to dredge Reach 2 to an average depth of four to six feet, while Alternative 4 would have additional dredging to create an average depth of five to seven feet. Alternative 4 is also proposing a different configuration of the wetland and Lake Wood Lake. IWR-Plan Decision Support Software assists with the formulation and comparison of alternative plans by conducting cost effectiveness and incremental cost analyses, identifying the plans which are the best financial investments, and displaying the effects of each plan on a range of decision variables.

Table 2-1 – Alternatives and their description

Alternative No.	Restoration Measures Combination
A0 (No Action)	N/A
A1 (Base Alternative – Restore Base Flow)	• Channel Dredging Reach 1 – Uniform Trapezoidal Section and Profile • Pool Habitat Reach 2 - created by installation of a 2 ft weir • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves[1] • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake –Connected Wetland

Alternative No.	Restoration Measures Combination
A2	• Channel Dredging Reach 1 – Variable Section and Depth Profile (Pool/Riffle/Run) • Pool Habitat Reach 2 - created by installation of a 2 ft weir • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves[1] • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake –Connected Wetland
A3	• Channel Dredging Reaches 1 and 2 – Variable Depth Profile (Pool/Riffle/Run) • Pool Habitat Reach 2 - average depth of 4 – 6 ft • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves[1] • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake –Connected Wetland
A4	• Channel Dredging Reach 1 and 2– Variable Depth Profile (DeeperPool/Riffle/Run) • Pool Habitat Reach 2 - average depth of 5 – 7 ft • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves[1] • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake –Connected Wetland with different configuration

[1] Old Channel Connected Wetland Shelves cost considered part of stream riparian zone variable evaluated in QHEI; therefore, shelve costs are included with stream costs.

Figure 2-1 – Measures and their location (southern portion)

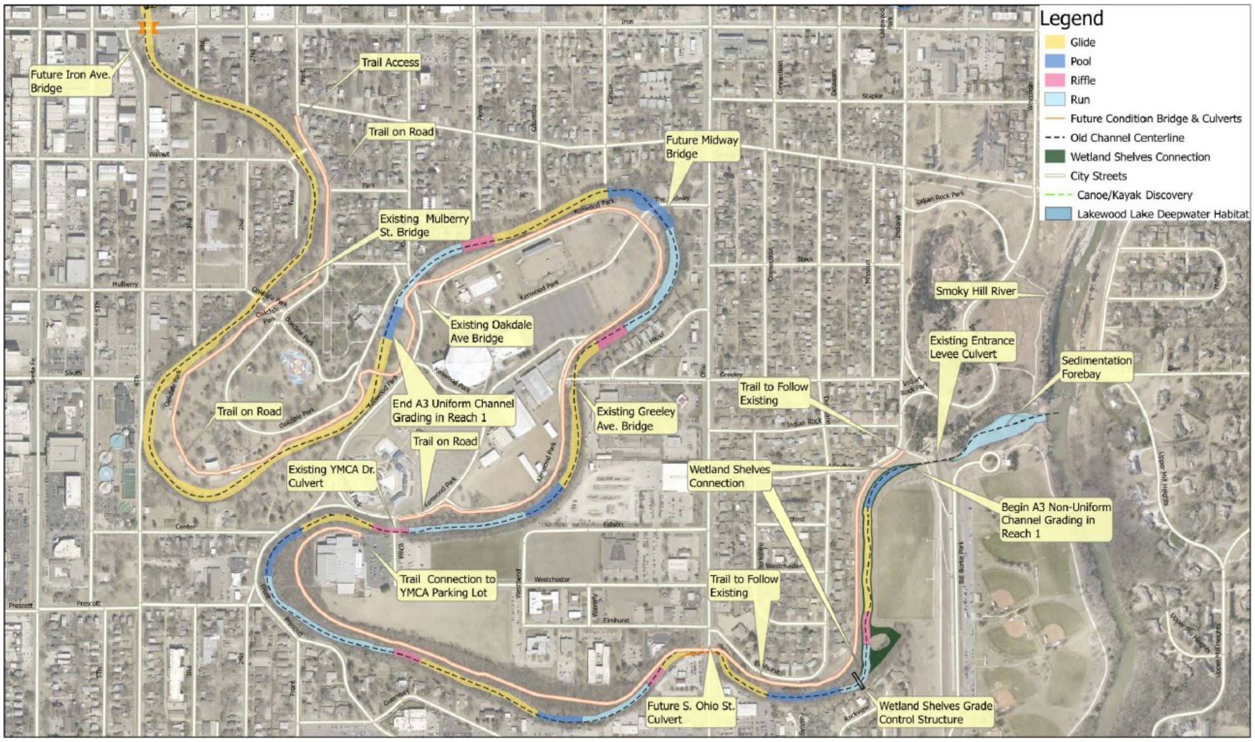
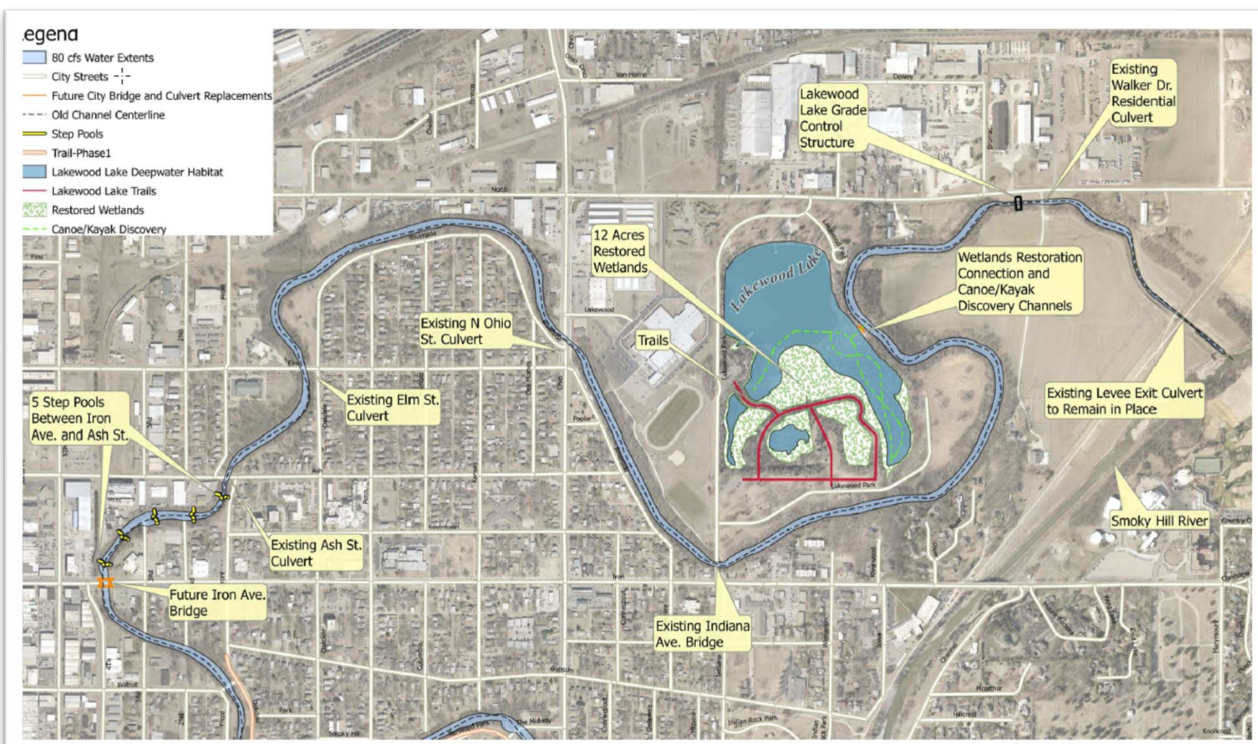


Figure 2-2 - Measures and their location (northern portion)



2.2 Ecosystem Restoration Analysis Introduction

United States Army Corps of Engineers (USACE) policy, presented in Engineer Regulation 1105-2-103, *Planning Guidance Notebook*, requires that potential ecosystem restoration projects be analyzed for cost effectiveness and incremental benefits gained from various restoration alternatives or plans. Benefits are represented with net average annual habitat units (AAHUs), calculated by PDT biologists. It is important to note that benefits are represented by *net* AAHUs because there is a value the habitat is expected to maintain or degrade to over the course of the project life under the future without project (FWOP) condition if nothing is done. Net AAHUs represent the difference between this value and the gross AAHUs of the habitat conditions under the proposed alternative. There were two habitat models used for the Smoky Hill study, the Qualitative Habitat Evaluation Index (QHEI) model to project habitat lift in the channel where water will now be flowing and the Dabbling Duck model to project habitat lift in the improved wetland area at Lakeland Lake. Additional information regarding the habitat modeling can be found in Appendix F, Environmental. The plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, is selected and identified as the National Ecosystem Restoration (NER) Plan.

Cost Effective/Incremental Cost Analysis (CE/ICA) is the technique used by the USACE to develop cost-effective restoration projects. Analysis of cost effectiveness, in general, compares the relative costs and benefits of alternative plans. The most efficient plans that provide the greatest increase in output for the least increase in cost are called the best buys. The Tentatively Selected Plan is usually chosen from among the best buy plans after the PDT has carefully considered the relative costs and benefits of these plans and determined that the incremental costs associated with additional habitat outputs are justified.

Specifically, cost-effectiveness analysis compares the costs and expected environmental outputs among various plans. If different plans can produce the same level of output, only the least expensive (least-cost) choice makes economic sense for that level of output; economically *inefficient* alternative plans can be eliminated from further consideration. Similarly, if one alternative plan can produce a greater level of output for the same or less cost than others (cost-effective), only the greater output choice makes economic sense; economically *ineffective* plans can be eliminated. After elimination of inefficient and ineffective alternative plans, there remain several least-cost, cost-effective plans offering a range of output values from which to identify the means of meeting the ecosystem restoration objective. This process is done using the Institute for Water Resources (IWR) Planning Suite II 2.0.9.36 software.

IWR Planning Suite requires the inputs several measures, each with its own costs and benefits. These costs and benefits are provided in the form of annual costs and net AAHUs. The process for calculating annual costs consists of gathering project first costs for construction, planning, engineering, and design (PED), real estate (RE), construction management, contingency. The sum of these costs makes up the total capital costs. Then interest during construction (IDC) is calculated on the total capital costs according to when components of the capital cost will be expended during project implementation and uses the Fiscal Year 2025 (FY2025) interest rate of 3%. The IDC is then added to the total capital costs to get the total investment costs. The total investment cost is annualized using the FY25 interest rate of 3% over the project life of 50 years.

Most federal agencies use annualized output values to display benefits and costs, and ecosystem restoration analyses should provide data that can be directly compared to the traditional benefit/cost analysis. Because habitat value is difficult to express in monetary terms, the cost effectiveness of project features is measured in habitat units (HU). HUs are the product of the amount and value of the habitat. HUs are calculated by summing HUs across all years in the period of analysis. The results of this calculation are referred to as average annual habitat units (AAHU) and can be expressed mathematically. Using AAHU as metric, plans can be compared over time based on the forecast conditions. In this way, it is possible to quantify a change in habitat by implementing the project and evaluate whether that change is cost effective. There were two habitat models used for the Smoky Hill study, the Qualitative Habitat Evaluation Index (QHEI) model to project habitat lift in the channel where water will now be flowing and the Dabbling Duck model to project habitat lift in the improved wetland area at Lakeland Lake. Additional information regarding the modeling can be found in Appendix F, Environmental.

Table 2 presents the outputs, costs, and marginal outputs necessary to conduct the cost effectiveness analysis. This study originally began as a Section 1135 Continuing Authorities Program (CAP) project. Costs for alternatives were developed in 2022, using the Fiscal Year FY2022 price level. At that point the project delivery team (PDT), realized that the total project cost would exceed the CAP cost threshold, and the project waited to begin as a General Investigations (GI) project. To keep the schedule, a risk informed decision was made to use the same costs developed in FY2022 and escalate the costs to FY2025 by cost engineering. This resulted in an escalation of 7.49% to the total construction cost. The decision was made to not escalate Real Estate costs from the original cost estimate. Project installation costs were amortized over a 50-year project life using the FY2025 discount rate of 3.0%. The original cost estimate included recreation features for each alternative, which have been removed and are not included in the total project costs displayed in Table 2-2. The recreation costs for Alternatives A1 thru A3 were approximately $100,000 and the recreation cost for Alternative A4 was approximately $830,000. The sponsor plans to implement these features separately, but in conjunction with the project. Contingency was applied on a sliding scale based on the risk of excavating and placing all dredged material to create the requisite wetlands for each alternative. Each Alternative is proposing to dredge more material from the channel. The following construction contingencies were applied: A1-25%; A2-28%; A3-33%; A4-38%. Monitoring and adaptive management costs were added after the total project cost plus escalation. Additional information regarding the development of the monitoring and adaptive management costs are in Appendix G2, Monitoring and Adaptive Management. IDC was calculated for each alternative and assumed a three-year timeframe for construction with real estate acquisition and planning, engineering and design (PED) occurring in Year 1 and construction spanning over Years 2 and 3. Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs were calculated as 0.5% of construction costs based off the total project costs including escalation. There is also an annual $100,000 included as a separate line item for OMRR&R to capture the maintenance work required to clear the sedimentation basins annually.

Table 2-2 – Alternative Costs

	Alt A1	Alt A2	Alt A3	Alt A4
Mobilization and Utility Relocation	$877,081	$913,444	$1,000,464	$1,011,298
Construction	$5,169,571	$5,654,411	$6,814,670	$6,959,122
Construction Contingency	$1,511,663	$1,838,999	$2,578,994	$3,028,759
Sub-Total Construction Costs	$7,558,315	$8,406,854	$10,394,128	$10,999,179
Real Estate Costs (LERRDS)	$2,000,000	$2,000,000	$2,000,000	$2,000,000
PED	$1,632,596	$1,773,321	$2,110,086	$2,152,013
Construction Management	$604,665	$656,785	$781,513	$797,042
Total Construction Costs	**$11,795,576**	**$12,836,961**	**$15,285,728**	**$15,948,235**
Total Construction Cost with 7.49% Escalation applied	**$12,679,065**	**$13,798,449**	**$16,430,629**	**$17,142,757**
Total Capital Costs	$13,169,065	$14,400,355	$17,268,441	$18,009,371
Adaptive Mgmt and Monitoring	$490,000	$601,906	$837,812	$866,614
Interest During Construction	$487,000	$516,000	$585,000	$593,839
Total Investment Costs	$13,656,065	$14,916,355	$17,853,441	$18,603,210
Interest and Amortization Factor	0.03887	0.03887	0.03887	0.03887
Annualized Costs	$530,811	$579,799	$693,963	$723,107
Annual OMRR&R Costs (0.5% of Sub-Total of Construction Costs)	$63,395	$68,992	$82,153	$85,714

	Alt A1	Alt A2	Alt A3	Alt A4
Annual Sedimentation Basin Clearing	$100,000	$100,000	$100,000	$100,000
Total OMRR&R	$163,395	$168,992	$182,153	$185,714
Total Annual Costs Rounded	**$694,000**	**$749,000**	**$876,000**	**$909,000**
Total Net AAHUs	**41**	**48.7**	**56.8**	**58.4**
Average Annual Cost/AAHU	**$16,932**	**$15,376**	**$15,425**	**$15,562**

FY25 Price Level; Federal Discount Rate of 3.0%; Period of Analysis of 50 years; discrepancies in totals due to rounding.

2.2.1 Combinability and Dependability

Combinability and dependency are two types of relationships used in the CE/ICA analysis. In a typical USACE study, management measures may or may not be mutually exclusive, and it is the property of combinability that allows planners to mix and match measures into different plans. Conversely, some measures may preclude others, and this will limit the ability to mix and match the measures. In consideration of combinability, two measures might be mutually exclusive because of:

- Location, where two different measures cannot occupy the same space at the same time.
- Function, where two different measures may work against one another.

In addition to being combinable, many measures may be dependent on other measures in order to be implemented. Dependency relationships between two measures may exist for several reasons, including:

- Necessary to function.
- Reduce risk or uncertainty.
- Improve performance.

In this analysis, all measures were relatively dependent All alternatives share common measures, with the distinguishing characteristic between them being the configuration of the Old Channel.

2.2.2 Plan Generation and Cost-Effectiveness

Within the IWR-Planning Suite, and once a planning study comprised of variables, outputs, and attributes has been defined with the plan editor, the plan generation module is used to populate a new planning set with plan alternatives. The IWR-Planning

Suite displays generated planning sets with the information needed to assist planners to manage the plans and keep the plans in context. Due to the planning process for this particular study, the plan were pre-generated by the PDT: A1; A2; A3; and A4.

The cost effectiveness analysis uses the information in Table 2-2, above. There are four different action alternatives available. Each of the alternatives represent a competing use for land compared to the other alternatives and are thus non-combinable. Each alternative is largely comprised of similar measures, with the notable distinction being the configuration of the redesigned Old Channel.

This analysis looks at the Net Average Annual Habitat Unit (AAHU) output as a desirable output of the ecosystem restoration efforts. The benefit stream for all the measures was calculated over a 50-year project life, summed, and then averaged over that period of analysis. Finally, where the existing condition is assigned a value for a given alternative, that measure’s output score in the existing condition is removed from the output score with project to compute only the marginal benefits of performing a specific alternative in the cost effectiveness analysis.

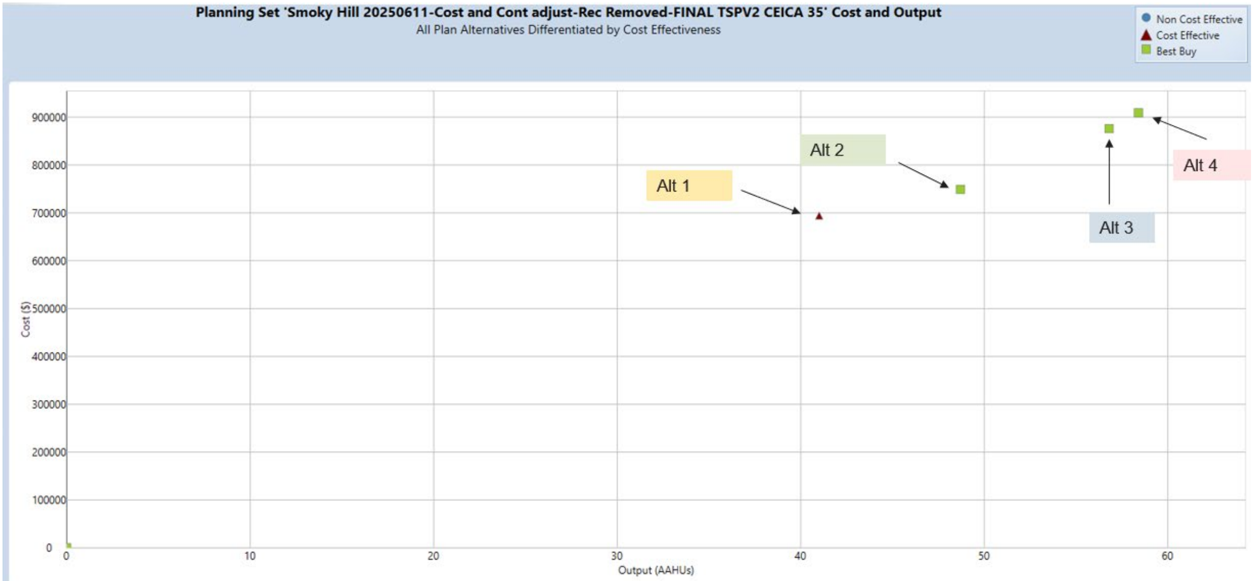
Using the nomenclature, Total Average Annual Costs and Net Average Annual Habitat Units from Table 2-2 were used to evaluate the cost-effectiveness of the four plans. The analysis showed that Alternative 1 is deemed cost-effective. The cost-effective and best buy plans from the cost effectiveness analysis are presented in Table 2-3 and Figure 2-3.

Table 2-3 –Cost Effectiveness Analysis

Plan Name	Total Annual Cost	Output Value (Total Net AAHUs)	Cost Effective/Best Buy
Alternative A1	$694,000	41	Cost Effective
No Action	$0.00	0	Best Buy
Alternative A2	$749,000	48.7	Best Buy
Alternative A3	$876,000	56.8	Best Buy
Alternative A4	$909,000	58.4	Best Buy

October 2025 Price Level, 50-year period of analysis, FY25 Discount Rate of 3.0%

Figure 2-3 – Cost-Effectiveness Scatter Plot



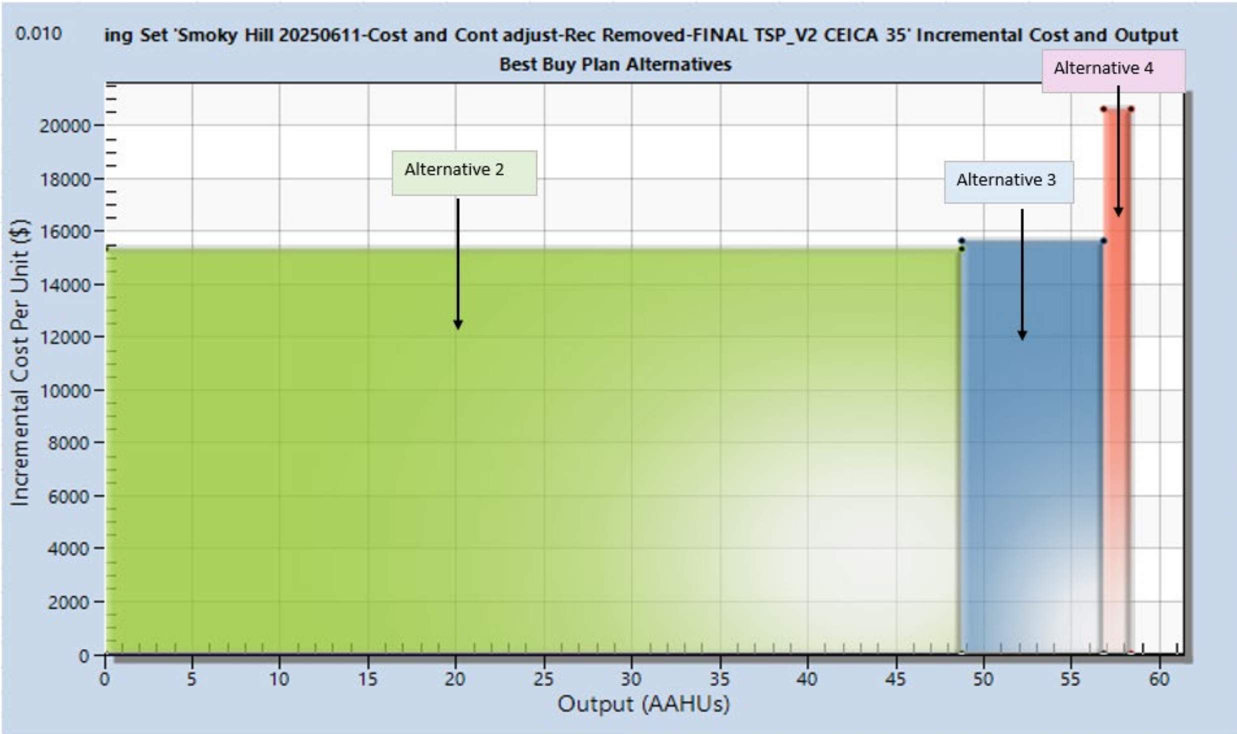
2.2.3 Incremental Cost Analysis

An incremental cost analysis was performed on the best buy alternatives to capture the marginal utility for each additional restoration feature. The most efficient plans that provide the greatest increase in output for the least increase in cost are called the best buys. The least expensive best buy, which meets the restoration objective, is usually chosen as the national ecosystem restoration (NER) plan depending on the scarcity of the resource. Alternative 1 was only a cost-effective plan. The No Action, Alternative 2, Alternative 3, and Alternative 4 are all considered best buy plans. Alternative 2 has an incremental cost per incremental output of $15,380; Alternative 3 provides an incremental cost per incremental output of $15,679; and Alternative A4 provides an incremental cost per incremental output of $20,625. The best buy plan cost and output details are summarized in Table 2-4 and depicted in the bar graph in Figure 2-4.

Table 2-4. Best Buy Plans Comparison

Plan Name	Total Project Cost	Total Annual Cost	Incremental Cost	Output (Net AAHUs)	Incremental Output	Incremental Cost/ Incremental Output	Cost Effective
No Action Plan	$0	$0	$0	0	$-	$-	Best Buy
A2	$14.9M	$749,000	$749,000	48.7	48.7	$15,380	Best Buy
A3	$17.9M	$876,000	$127,000	56.8	8.1	$15,679	Best Buy
A4	$18.6M	$909,000	$33,000	58.4	1.6	$20,625	Best Buy

Figure 2-4. Best Buy Plan Bar Graph



2.2.4 Identification of the NER Plan

Alternative 3 was identified as the NER Plan being that it is the plan that it "maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, is selected and identified as the NER Plan" (Engineer Regulation 1105-2-103, *Policy for Conducting Civil Works Planning Studies)*. Alternative 3 is preferred to Alternatives 2 and 4 because Alternative 3 provides additional benefits to Reach 2 that are not achieved in Alternative 2. Alternative 3 provides an additional 8.1 AAHU above Alternative 2 with an incremental cost of $15,679 per incremental AAHU. Alternative 4's additional 1.6 AAHU with an incremental cost of $20,625 per unit is deemed "not worth it" for its minimal habitat lift and higher cost.

2.3 Comprehensive Benefits Analysis

The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (March 10, 1983) establishes four accounts to facilitate the evaluation and display of effects of alternative plans. The four accounts are the National Economic Development Account (NED), the Environmental Quality (EQ) and National Ecosystem Restoration Account (NER), the Regional Economic Account (RED), and the Other Social Effects Account (OSE). They are described in ER 1105-2-103, Policy for Conducting Civil Works Planning Studies. The evaluation of the alternatives against those accounts follows:

2.3.1 National Economic Development

As defined in the Planning Guidance Notebook, ER-1105-2-103, NED contributions are increases in the net value of the national output of goods and services, expressed in monetary units. NED contributions are the direct net benefits that accrue in the planning area and the rest of the Nation, including the net value of both marketed goods and services and goods and services that are not marketed. Traditionally, NED benefits are associated with flood risk management and navigation studies where the costs and benefits of implementing an alternative are assessed relative to flooding of property, emergency flood costs, and transport of commodities. For this project, the only aspect contributing to the NED account are recreation benefits. These are ancillary benefits that are not quantified but are assumed to materialize for people who choose to visit and recreate in the improved ecosystems of the Smoky Hill River and the Lake Wood Lake wetland area. There would be no additional recreation benefits under the No Action alternative; recreation benefits would slightly improve under Alternatives A1 and A2, moderately improve under Alternative A3 and more greatly improve under Alternative A4 because of the additional trail system in the wetland area.

2.3.2 National Ecosystem Restoration and Environmental Quality

As defined in ER-1105-2-103, ecosystem restoration is one of the primary missions of the USACE Civil Works Program. For ecosystem restoration focused projects, like this project, the USACE objective is to contribute to National Ecosystem Restoration (NER). This contribution is measured in increases to the net quantity or quality of desired resources and expressed quantitively in physical units or indexes (but not monetary units). The selection of a plan as the NER Plan indicates that the plan reasonably maximizes ecosystem restoration benefits compared to costs and is consistent with the Federal objective of contributing to NER.

The Environmental Quality (EQ) account considers broader effects on significant natural and cultural resources, while the NER evaluation more narrowly measures non-monetary benefits to habitat resulting from ecosystem restoration. An effect on EQ resources occurs whenever estimates of future with and future without plan conditions of the resource are different.

Specifically, the EQ account encompasses:

- Ecological attributes, defined in the ER – 1105-2-103 as components of the environment and the interactions among all its living and nonliving components that sustain dynamic, diverse, and viable ecosystems.
- Cultural attributes, defined as evidence of past and present habitat that can be used to reconstruct or preserve human lifeways.
- Aesthetic attributes, defined as perceptual stimuli that provide diverse and pleasant surroundings for human enjoyment and appreciation.

For the NER evaluation, AAHUs were generated for each alternative, using the USACE approved Qualitative Habitat Evaluation Index (QHEI) model and the Dabbling Duck model. These models are discussed in more detail in the main report and in Appendix G1 – Habitat Modelling. The Smoky Hill Ecosystem Restoration project is a single purpose ecosystem restoration study, meaning that the plans were formulated and evaluated in terms of their net contributions to increase in ecosystem value (NER outputs).

Currently, the Old Channel is filled with sediment, to the point where any flows in the channel that are greatly reduced and in adequate to transport sediment. The lack of flow and sediment has an adverse impact on the amount and quality of instream habitat. Additionally, the Western Star Mill Weir limits connectivity in the river for aquatic organisms. By establishing a more natural variable depth profile, removing the Western Star Mill Weir, and minimizing future sedimentation the construction of a sediment forebay and natural gravitational flow, the proposed measures would have a substantial positive impact on the on the habitat quality along the Old Channel.

The No Action Alternative does not improve the ecological resources in the project area and allows the resources to continue to degrade. There would be no benefit to aquatic species, water quality, and no aesthetic benefits. This alternative generates 0 Net AAHUs that is used as a baseline against which all other alternatives are to be compared.

Alternative A2 would restore a variable depth pool profile (including pools, riffles, runs, and glides) to Reach 1 (from the intake at the Smoky Hill up to the Western Star Mill Weir) through dredging and construction of in-stream features. Flow capacity would be improved by the establishment of the more natural channel design along with the construction of a sediment forebay. The forebay will minimize continued sedimentation, contributing to maintaining appropriate flow rates. Replacing the Western Star Mill Weir with 5 step-pool features will provide habitat connectivity between Reaches 1 and 2 and create in-stream habitat that will be beneficial to aquatic organisms and wildlife. Installations of weirs near the downstream end of the Old Channel and at Walker Drive near the downstream end of Reach 2 would help manage and maintain beneficial depths in both Reach 1 and Reach 2. Alternative A2 generates 48.7 AAHUs.

In addition to the features of Alternative A2, Alternative A3 would include dredging and the establishment of a variable depth pool (including pools, riffles, runs, and glides) in Reach 2. This would add in-stream habitat along the full 6.8 miles of the Old Channel. The wetlands around Lakewood Like will be configured with slight differences to the depth and extent than those in Alternative A2. Alternative A3 generates 56.8 net AAHUs.

Alternative A4 would be differentiated from Alternative A3 by pools with an overall greater average depth and a wetland complex around Lakewood Lake with a more extensive network of trails and marginally different depth and extent configuration. Alternative 4 generates 58.4 AAHUs.

All four Action Alternatives are similar in their effects and would provide substantial benefits to aquatic habitat in the Old Channel, including establishing varied habitat, minimizing sedimentation, and restoring aquatic connectivity. Other benefits would be achieved by reestablishing hydraulic connectivity between the Old Channel and wetlands around Lakewood Lake along with creation of wetland habitat. The additional dredging and installation of in-stream features in Alternatives A3 and A4 potentially lead to increased ecological benefits through increased depth and diversity of habitats.

The removal of Western Star Mill Weir and its replacement with 5 step pool features is part of each action alternative. USACE is working with the city and appropriate stakeholders to develop a Memorandum of Agreement to mitigate for its removal. Additionally, a Programmatic Agreement is being drafted and the project will go through the National Historic Preservation Act 106 process should any cultural resources be found during survey prior to construction.

All the plans have similar outputs, as shown by the AAHUs generated, which have a range of 41.0 AAHUs to 58.4 AAHUs. The configuration of in-stream features, variable depth profile, and wetland habitat vary between alternatives, but the environmental benefit is functionally the same between alternatives.

Overall, Alternative A3, which generates 56.8 net AAHUs, was selected as the NER plan. The feasibility study team, with support from the Local Sponsor, concluded that Alternative A3 has the best balance of cost and ecosystem benefits of all the alternatives. The increase from Alternative A3 provides 8.1 net AAHUs more than Alternative A2 with an incremental cost per unit of $15,679, $299 per incremental unit cost more than Alternative A2 and an incremental cost per incremental output of $1,936. Alternative A4 only provides an additional 1.6 net AAHUs, which is an additional $20,625 incremental cost per unit and $12,891 incremental cost per incremental output, which is the highest of all the alternatives. Alternative A3 represents the best balance of maximizing ecosystem benefits by restoring in-stream habitat, connectivity, and flow and preventing sedimentation at a cost that is reasonable.

Table 2-5. National Ecosystem Restoration (NER) and Environmental Quality Identified Benefits

Alternatives	Total Project Cost	Incremental Costs per Unit	NET AHUUS/ Incremental Output	Incremental Cost/ Incremental Output	Water Quality, Quantity, and Timing
No Action	-	-	-	-	Does not provide any water quality, quantity, or timing benefits
Alternative A1	$13,7M	-	41.0 / --	-	Moderate amounts of Benefits to Quality, Quantity, and Timing
Alternative A2	$14,9M	$749,000	48.7 / 48.7	15,380	High amounts of Benefits to Quality, Quantity, and Timing
Alternative A3	$17,9M	$127,000	56.8 / 8.1	$15,679	Very High amounts of

Alternatives	Total Project Cost	Incremental Costs per Unit	NET AHUUS/ Incremental Output	Incremental Cost/ Incremental Output	Water Quality, Quantity, and Timing
					Benefits to Quality, Quantity, and Timing
Alternative A4	$18,6M	$33,000	58.4 / 1.6	$20,625	Very High amounts of Benefits to Quality, Quantity, and Timing

2.3.3 Regional Economic Development

The RED account includes a description and assessment of the changes in regional economic activity that would occur under the alternatives, including changes in jobs, income, economic output, and population (ER 1105-2-103).

Construction of the project features would likely be awarded to a local contractor, generating more jobs and income in the local community that varies proportionally with the amount of construction work per alternative. The construction costs cited below are for construction of the project only, they do not include other elements of the Total Project Cost because construction costs would have the most direct effect on the regional economy of the area. The No Action Alternative would not provide any construction benefits to the local economy. Alternative A2 has the lowest construction cost as it does not include any dredging or channel depth profile work in Reach 2 and has the fewest number of features. The remaining alternatives (A2 thru A4) are incrementally more expensive plans with more constructed features. These plans could contribute slightly more to the regional economy during construction than Alternative A2. USACE's Regional Economic System (RECONS) analysis was performed on the three action alternatives to find the regional impact of localized spending and jobs. The results of the RECONS analysis are shown in Table 2-6**.**

Table 2-6. Regional Economic System (RECONS) Results

	Alt A1	Alt A2	Alt A3	Alt A4
Local Capture	$6,390,304	$7,107,716	$8,787,890	$9,299,441
Jobs (in Full-Time Equivalence)	87.1	96.9	119.8	126.8

*FY2028 dollars

In addition to the benefits to the regional economy generated during construction, increases in recreational use could also benefit the local economy. All three action alternatives would provide passive and active recreation opportunities with improved habitat to fish and wildlife species, and increased access to the reiver and wetlands for watercraft. This has been labeled as “RED 2: Tourism and Economic Opportunities” The local economy would benefit from this through increased spending by recreationists on gas, hotels, and other goods and services provided in the downtown area leading to increased regional economic development in the immediate area. Any increase in tourism and recreation could be small depending on the alternative. It would vary from moderate increases in tourism and economic opportunity to very high depending on actions taken within each alternative. Though it is clear the “No Action” alternative would not generate an increase local tourism nor regional spending.

In the Array of Alternatives, the “No Action” alternative does not lead to improvements to the health and safety of users in the area through safe navigation. This alternative does not increase for community attraction to the existing leisure and recreational opportunities in the project area. This alternative also does not and does not improve social vulnerability and resilience. It does not address current or future sedimentation of the Old Channel and provides no in-stream habitat improvement or connectivity for the local region.

Alternative 1 produces many positive benefits when compared to the “No Action” alternative. Through using the RECONS software, the local capture showed there was 87.1 jobs created, and the revenue brought into the area was $6,390,304. There is also a moderate number of benefits created from the increase in tourism as well as the local economic opportunity.

Alternative 2 produces more positive benefits when compared to Alternative 1. Through using the RECONS software, the local capture showed there was 96.6 jobs created, and the revenue brought into the area was $7,107,716. There is also a high number of benefits created from the increase in tourism as well as the local economic opportunity.

Alternative 3 produces more positive benefits when compared to Alternative 1. Through using the RECONS software, the local capture showed there was 119.8 jobs created, and the revenue brought into the area was $8,787,890. There is also a high number of benefits created from the increase in tourism as well as the local economic opportunity.

Alternative 4 produces the most positive benefits when compared to the other alternatives. Through using the RECONS software, the local capture showed there was 126.4 jobs created, and the revenue brought into the area was around $9,299,441. There is also a moderate number of benefits created from the increase in tourism as well as the local economic opportunity.

Table 2-7. Regional Economic Development Identified Benefits

Alternatives	RED1: RECONS Results (FY 2028)	RED 2: Tourism and Economic Opportunity
No Action	Does not provide any increased benefits to the regional economy.	Does not provide any increased tourism or new economic opportunity
Alternative A1	Local Capture: $6,390,304 Jobs **(in Full-Time Equivalence)**: 87.1	Moderate number of benefits from tourism along with increases in Local Economic opportunity
Alternative A2	Local Capture: $$7,107,716 Jobs **(in Full-Time Equivalence)**: 96.6	High number of benefits from tourism along with increases in Local Economic opportunity
Alternative A3	Local Capture: $8,787,890 Jobs **(in Full-Time Equivalence)**: 119.8	Very high number of benefits from tourism along with increases in Local Economic opportunity
Alternative A4	Local Capture: $9,299,441. Jobs **(in Full-Time Equivalence)**: 126.4	Very high number of benefits from tourism along with increases in Local Economic opportunity

2.3.4 Other Social Effects

As defined in ER 1105-2-103, the Other Social Effects account includes plan effects on social aspects such as community impacts, public health and safety, access to critical infrastructure, displacement, energy conservation, and others social factors. The Institute for Water Resources publication Other Social Effects: A Primer (Section II, Table 1) further defines these categories as health, safety, social vulnerability, resilience, economic vitality, social connectedness, identity, recovery, participation, and leisure and recreation. All these categories help to understand the importance of their impacts within the local communities.

For this ecosystem restoration project, the categories that focused on revolved around public health and safety, local recreation, and social vulnerability within the area. Each of these categories were relevant to this specific project. The OSE categories considered for this project were “Life Safety, Visual Aesthetics, Local Recreation, Local Community Support, and Identity.” Since there were no changes to incremental risk with the federal levee system and only a minimal amount of water being reintroduced into the channel, none of the alternatives, including the “No Action” alternative would negatively impact life safety. Therefore, it was not incorporated as an evaluation criteria. Visual aesthetics and local recreation, community support and identity incorporated since they were identified as important pillars in the local community’s culture and cohesion. These categories were picked because it was important to understand how improved recreational spaces and areas could lead to improvements in local life within the community. Especially in urban communities where access to recreational services and areas could be limited. This shows the significant role that these areas can play in promoting improvements to health, as well as drawing more members of the community to these specific areas.

In the Array of Alternatives, the “No Action” alternative does not lead to improvements to the health and safety of users in the area through safe navigation. This alternative does not increase for community attraction to the existing leisure and recreational opportunities in the project area. This alternative also does not and does not improve social vulnerability and resilience. It does not address current or future sedimentation of the Old Channel and provides no in-stream habitat improvement or connectivity for the local region.

Alternative 1 sees moderate improvements throughout the two “Other Social Effects” categories. With implementation of this alternative there are significant improvements to the local community aesthetics of the area. This could lead to people being interested in exploring these places. Due to the increased usage from the local community, there could be improvements to mental and physical health. However, with Alternative A1, there are less recreational options and visual enhancements as compared to Alternative A2, Alternative A3, and Alternative A4.

Alternative a2 sees a high number of positive benefits in the two “Other Social Effects” categories. With implementation of this alternative, there is significant improvement to the visual aesthetics of this area. This could lead to more people being interested in exploring the recreational areas within the study. Due to the increased usage from the local community, there could be improvements to mental and physical health, which would benefit a moderate number of people. In this alternative due to the higher number of visitors, there would potentially be more engagement and support for local shops. However, with Alternative A2, there are still less recreational options and visual enhancements as compared the Alternative A3, and Alternative A4.

Alternative A3 has a very high number of positive benefits in the two “Other Social Effects” categories. With implementation of this alternative, there is a significant improvement to the visual aesthetics of this area. This could lead to more people being interested in exploring the recreational areas within the study. This is due to creating more areas for visual aesthetics as well as recreation as compared to Alterantives A1 and A2. Because the area is more visually appealing, that could lead to an increased usage from the local community, and even more river centered events. There would potentially be more engagement and support for local shops, as well as, improvements to mental and physical health. However, with Alternative A3, there are still less recreational options and visual enhancements Alternative A4.

Alternative A4 provides the highest number of positive benefits in the two "Other Social Effects" categories. With implementation of this alternative, there is a significant improvement to the visual aesthetics of this area. This could lead to more people being interested in exploring the recreational areas within the study. This is due to creating more areas for visual aesthetics as well as an expanded trail system at Lakewood Lake wetlands recreation. Because of these enhancements, it could lead to an increase of usage from the local community, as well as holding more river centered events. There would potentially be more engagement and support for local shops, as well as, improvements to mental and physical health over and above what the other alternatives provide.

Table 2-8. Other Social Effects Identified Benefits

Alternatives	Visual Aesthetics and Access to Local Recreation	Improved Community Identity	Community Support
No Action	No new nor additional improvements	Community Identity is not improved	No Improvements to mental health within the community, nor physical health
Alternative A1	Enhanced visual Aesthetics but leases recreations	Due to improved recreation, community Identity is improved.	Improvements to mental health within the community, nor physical health
Alternative A2	Larger dedicated area allows for more enhanced visual aesthetics experience but leases recreations	Due to improved recreation, community Identity is improved.	Larger improvements to mental and physical health within the community
Alternative A3	Larger dedicated area allows for more enhanced visual aesthetics experience but leases recreations	Due to improved recreation, community Identity is substantial improved.	Larger improvements to mental and physical health within the community
Alternative A4	The largest dedicated area allows for more enhanced visual	Due to improved recreation, community	Largest improvements to mental and physical

Alternatives	Visual Aesthetics and Access to Local Recreation	Improved Community Identity	Community Support
	aesthetics experience but leases recreations	Identity is substantial improved.	health within the community

2.3.5 Comprehensive Benefits Summary

From the completed analysis, positive identified benefits were obtained from the four accounts and put into a comprehensive table. The four accounts are the NED, NER/EQ, RED, and OSE. This table was created by combing the four previous section's analysis. Each account and each screening criterion display the identified benefits for each alternative as compared to the "No Action". The alternatives and criterion are assigned ratings of "VERY LOW, LOW, Not Applicable (N/A), MEDIUM (MED), HIGH, and VERY HIGH." This comparison is important because it gives the PDT a way to understand how all the accounts collectively can be evaluated to identify a comprehensive benefits plan.

The No Action alternative leads to no positive benefits within the comprehensive benefits table. There are no positive benefits (or no change from the existing/FWOP condition) in the NED, NER/EQ, RED, nor OSE accounts.

Alternative A1, has the lowest contributions to all four accounts due to the Old Channel configuration and lower amount of changes to the Lake Wood Lake wetland area. Alternative A2, had a higher amount of benefits as compared to the No Action alternative and was also a best buy plan. Alternatives A3 and A4 had the most notable changes to the four accounts. The main difference was in the NER/EQ account. Alternative A3 provided a considerable increase in AAHUs (56.8 net AAHUs) or 8.1 additional net AAHUs with an incremental cost of $127,000 and an incremental cost per incremental output of $15,679, at a reasonable cost. Alternative A4, while also a best buy plan only contributed an additional 1.6 AAHUs, but at an increased incremental cost of $33,000 and the highest incremental cost per incremental output of $20,625.

Table 2-9. Comprehensive Benefits Summary

Score	Ranking of Benefits
VERY LOW	**Very Low amount of identified benefits compared to the existing conditions**
LOW	**Low amount of identified benefits compared to the existing conditions**
N/A	**Not Applicable/Existing Conditions**
MED	**Moderate amount of identified benefits compared to the existing conditions**
HIGH	**High amount of identified benefits compared to the existing conditions**
VERY HIGH	**Very High amount of identified benefits compared to the existing conditions**

Score	Ranking of Benefits	NED	NER/EQ					RED		OSE	
		NED 1: Recreation Benefits	**Project First Cost**	**Average Annual Cost per Net AAHU:**	**Incremental Cost per Incremental Output**	**Net AAHUS**	**Water Quality, Quantity, and Timing**	**RED 1: RECONS**	**RED 2: Tourism and Economics Opportunities**	**OSE 1: Visual Aesthetics and Local Recreation**	**OSE 2: Community Identity and Support**
No Action		-	-	-	-	-	Does not provide any water quality, quantity, or timing benefits	Does not provide any increased benefits to the regional economy.	Does not provide any increased tourism or new economic opportunity.	No new or additional benefits provided.	No new or additional benefits provided.
A1	Channel Dredging Reach 1 – Uniform Trapezoidal; Pool Habitat Reach 2; Lakewood Lake Wetlands; Remove Western Star Mill	Moderate amount of in-channel recreation benefits	$13.7 M	$17,000	-+	41.0	Moderate amounts of Benefits to Quality + Quantity + Timing	Local Capture: $6,390,304 Jobs: 87.1	Moderate number of benefits from tourism along with increases in Local Economic opportunity	Enhanced visual aesthetics but less recreational opportunities than Alts 2-4.	Health Benefits + Increased Usage
A2	Channel Dredging Reach 1 – Variable Depth Profile; Pool Habitat Reach 2; Lakewood Lake Wetlands; Remove Western Star Mill	Moderate amount of in-channel recreation benefits	$14.9 M	$15,380	$15,380	48.7	High amounts of Benefits to Quality ++ Quantity ++ Timing ++	Local Capture: $7,107,716 Jobs: 96.6	High number of benefits from tourism along with increases in Local Economic opportunity	Enhanced visual aesthetics + recreational opportunities.	Health Benefits + Increased Usage + Local engagement with shops + More Access

Score	Ranking of Benefits	NED	NER/EQ					RED		OSE	
VERY LOW	Very Low amount of identified benefits compared to the existing conditions	NED 1: Recreation Benefits	Project First Cost	Average Annual Cost per Net AAHU:	Incremental Cost per Incremental Output	Net AAHUS	Water Quality, Quantity, and Timing	RED 1: RECONS	RED 2: Tourism and Economics Opportunities	OSE 1: Visual Aesthetics and Local Recreation	OSE 2: Community Identity and Support
LOW	Low amount of identified benefits compared to the existing conditions										
N/A	Not Applicable/Existing Conditions										
MED	Moderate amount of identified benefits compared to the existing conditions										
HIGH	High amount of identified benefits compared to the existing conditions										
VERY HIGH	Very High amount of identified benefits compared to the existing conditions										
A3	Channel Dredging Reach 1 and 2 – Variable Depth Profile; Pool Habitat Reach 2; Lakewood Lake Wetlands; Remove Western Star Mill	High amount of in-channel benefits for recreation	$17.9 M	$15,425	$15,679	56.8	Very High amounts of Benefits to Quality +++ Quantity +++ Timing +++	Local Capture: $8,787,890 Jobs: 119.8	Very high number of benefits from tourism along with increases in Local Economic opportunity	Larger area for enhanced visual aesthetics and recreation opportunities.	for local community
A4	Channel Dredging Reach 1 and 2 – Variable Depth Profile (Deeper Pools); Pool Habitat Reach 2; Lakewood Lake Wetlands; Remove Western Star Mill	High amount of in-channel benefits for recreation	$18.6 M	$15,560	$20,625	58.4	Very High amounts of Benefits to Quality +++ Quantity +++ Timing +++	Local Capture: $9,299,441 Jobs: 126.4	Very high number of benefits from tourism along with increases in Local Economic opportunity	Enhanced aesthetics + increased recreational opportunities. More expanded trail system at Lakewood Lake wetlands.	

2.4 Summary of Findings

2.4.1 Identification of the Tentatively Selected Plan and Comprehensive Benefits Plan

Alternative A3 is identified as the NER plan and the Tentatively Selected Plan as well as the Comprehensive Benefits Plan. Alternative A3 meets all the project objectives outlined in the main report:

- Restore Old Channel's capacity to convey variable base flows.
- Reduce or prevent future Old Channel sedimentation.
- Restore in-stream aquatic habitat functions and feature in the Old Channel.
- Restore and create supporting habitat functions, which are hydraulically connected to the Old Channel.

The study team believes that Alternative A3 is necessary to achieve the objective of restoring in-stream aquatic habitat functions in both Reach 1 and Reach 2 and, given that is also a cost-effective and best buy plan and also has national and regional significance as described in Section 1.9 of the Main Report. The PDT believes that channel modifications to provide variable aquatic features, such as glides, pools, riffles and runs, is necessary to ensure project success. Alternative A3 provides an additional 8.1 AAHU above Alternative A2, with an incremental cost of $15,679 per incremental AAHU. Alternative A4 provides additional depth in the channel and a different wetland configuration. Alternative A4's additional 1.6 AAHU with an incremental cost of $20,625 per unit is deemed "not worth It" for its minimal habitat lift and higher cost. It will provide a boost to 66.6 habitat acres in-channel and create 1.7 acres of wetlands within the Old Channel, while also boosting the habitat within the 36 acres of wetlands at Lake Wood Lake.

Alternative A3 is the comprehensive benefits plan because it reasonably maximizes benefits under the NED, EQ/NER, RED and OSE accounts as compared to the other alternatives Alternative A3 will provide a short-term construction boost to the regional economy as well as provide opportunities for recreation, additional tourism and a more aesthetically pleasing riverbed.

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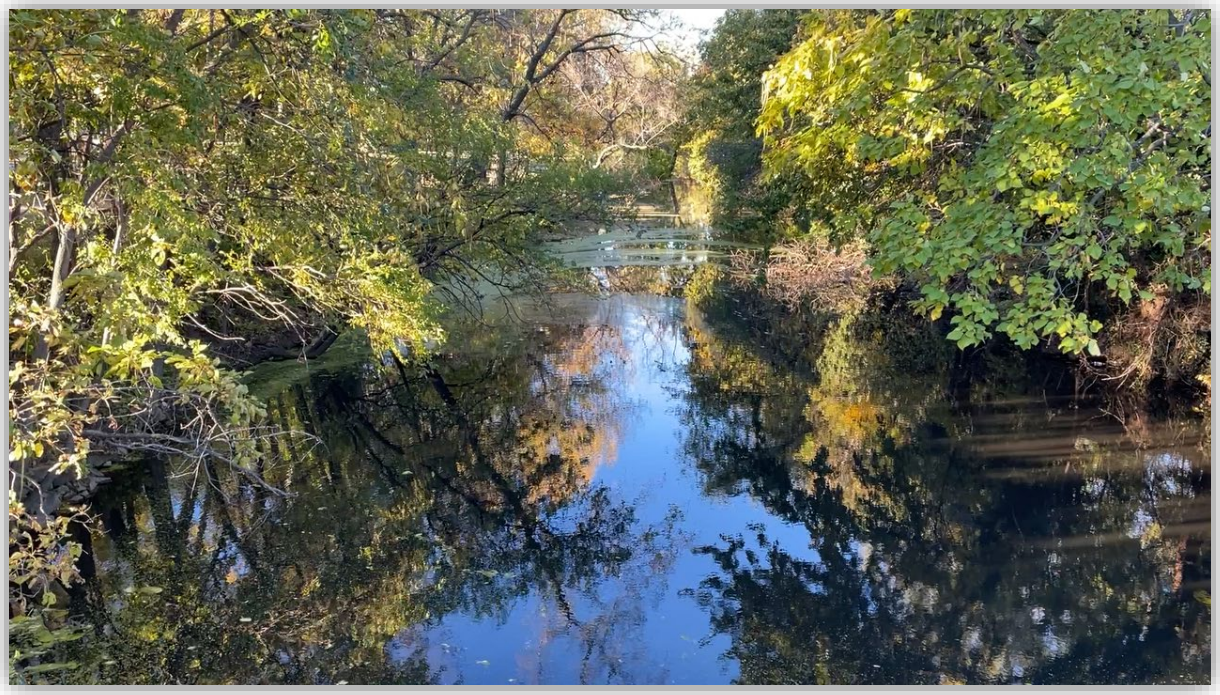

Smoky Hill River GI Study

Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix J – Public and Agency Involvement

September 2025

City of Salina

Exhibit A. Public Meetings

Smoky Hill River GI Study
Draft Integrated Feasibility Report and Environmental Assessment

September 2025

U.S. Army Corps of Engineers
Kansas City District

KANSAS CITY DISTRICT PRESENTATION OF SALINA RIVER SECTION 1135

Damon Slaughter
Program Manager | Project Manager
1 November 2021

US Army Corps of Engineers ®

CONTINUING AUTHORITIES PROGRAM (CAP)

Section 14 of the Flood Control Act of 1946 Streambank (Erosion) Protection

Section 205 of the Flood Control Act of 1948
Flood Risk Management

Section 206 of the WRDA of 1996
Aquatic Ecosystem Restoration

Section 1135 of the WRDA of 1986
Modifications for the Benefit of the Environment

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CONTINUING AUTHORITIES PROGRAM (CAP) PROJECT PHASES & DURATION

	Feasibility	Design	Construction	O&M
Typical Duration	1 - 3 Years	1 - 2 Years	1 - 3 Years	Life of Project
Federal Share of Costs	50%	65% or 75%		0%
Federal Per Project Limit		**$5,000,000** **$10,000,000**		$0

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FCSA = Feasibility Cost Share Agreement

PPA = Project Partnership Agreement

SMOKY HILL RIVER SECTION 1135

Problems
Opportunities
Objectives
Constraints

Measures
Alternatives
Costs
FWP

NER | LPP
TSP

REP
Cost Estimate

MDM

NWD Review
And Approval

Design

Jan 22	6 Months	2 Months	2 Month	12- 18 Months	24 Months

Environmental
Models
CE-ICA

Existing Conditions
FWOP

Refine TSP

DQC

ATR
Public Meeting

PPA

Construction

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SMOKY HILL RIVER SECTION 1135

	Alternative 1	Alternative 2
CE-ICA	Cost Effective	Best Buy | NER
Escalated Project Cost	**$13,797,000**	**$14,790,000**
75% Federal	$10,348,000	$11,093,000
25% Non-Federal	$3,449,000	$3,698,000
FED Feasibility Costs	$450,000	$450,000
Estimated Total FED	$10,798,000 | 8%	$11,543,000 | 15%
FED DI Costs	$9,550,000	$9,550,000
NFED Costs	**$4,247,000**	**$5,240,000**
LERRD	$2,586,000	$2,586,000
NFED Cash	$1,661,000	$2,655,000
Escalated Project Cost	**$13,797,000**	**$14,790,000**
Federal	$9,550,000 | 69%	$9,550,000 | 65%
Non-Federal	$4,247,000 | 31%	$5,240,000 | 35%

- CE-ICA
- NER | LPP
- Per Project Limit | Waiver Authority
  - $10,000,000
  - 25% NWD | 50% HQ USACE
- NFED Costs = LERRD + Cash + WIK
- Current Hold on Project Partnership Agreements
- WRDA 2022
  - Authorization vs Appropriation
  - Possible PPL increase
- Energy and Water Appropriations Bill (CRA)
- Bipartisan Infrastructure Bill (AJA)
- Supplemental
- Cost Increases | Modifications

SMOKY HILL RIVER SECTION 1135

- Select NER/LPP submit to NWD for approval up to 25% over Fed PPL. Currently on PPA Hold.
- Select NER/LPP wait for BID/AJA to increase CAP Program/Project funding. Currently on PPA Hold.
- Select NER/LPP wait for WRDA to increase the CAP limit (Dec 22). Currently on PPA Hold.
- Reduce project scope/cost. Additional Feasibility cost, reduce PPL in DI.
- WIK
    - Sponsor provides pilot channel—changes existing conditions. Additional Feasibility cost, reduce PPL in DI.
- Terminate the project.
    - Convert the Study from 1135 to 206. Limited support.
    - Convert the Study to the GI Program. Additional feasibility cost and delay while waiting authorization.

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SMOKY HILL RIVER SECTION 1135

- Feasibility
  - Schedule | Cost
  - LPP
    - Waiver
  - PPL
    - Waiver
      - BID
      - WRDA 2022

- Design and Implementation
  - PPA Hold
    - Energy and Water Development
    - Supplemental
    - Bipartisan Infrastructure Deal
      - Timing
  - Cost Increases
    - Sponsor Burden

Questions

SMOKY HILL RIVER SECTION 1135

- CAP-Continuing Authority Program
- WRDA-Water Resource Development Act
- O&M-Operations and Maintenance
- FCSA-Feasibility Cost Share Agreement
- PPA-Project Partnership Agreement
- FWOP-Future Without Project
- FWP-Future With Project
- CE-ICA-Cost Effective Incremental Cost Analysis
- NER-Nation Ecosystem Restoration
- LPP-Locally Preferred Plan
- TSP-Tentatively Selected Plan
- REP-Real Estate Plan
- DQC-District Quality Control
- MSC-Major Subordinate Command
- MDM-MSC Design Meeting
- ATR-Agency Technical Review
- NWD-Northwest District
- Fed-Federal
- NFED-Non-Federal
- DI-Design and Implementation
- HQ USACE-Head Quarters United States Corps of Engineers
- LERRD-Lands, Easements, Right of Ways, Relocations Disposal
- WIK-Work In Kind
- CRA-Continuing Resolution Authority
- BID-Bipartisan Infrastructure Bill
- AJA- American Jobs Act
- PPL-Per Project Limit

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Exhibit B. Interagency Coordination

Smoky Hill River GI Study
Draft Integrated Feasibility Report and Environmental Assessment

September 2025

U.S. Army Corps of Engineers
Kansas City District

SMOKY HILL RIVER AQUATIC ECOSYSTEM RESTORATION STUDY

Interagency Meeting

04 October 2024

Katharine Lynch, Environmental Resources
Laura Totten, Project Manager
Gina Powell, Archaeologist/Tribal Liaison

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OVERVIEW

Authorization

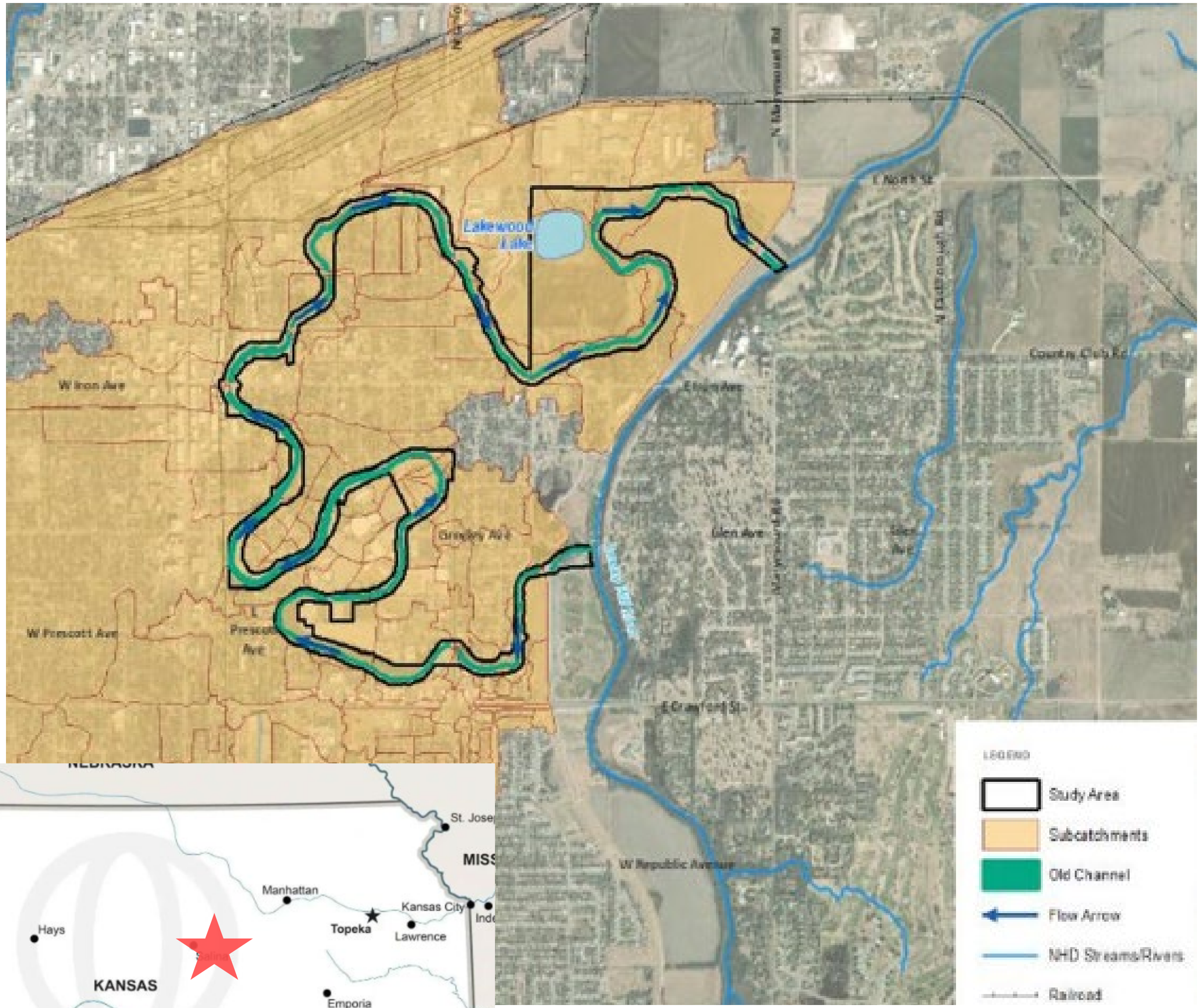
Authorized under Section 216 of the Flood Control Act of 1970, P.L. 91-611, Dec. 31, 1970

Non-Federal Sponsor

City of Salina, Kansas

Study Area

– Salina, KS in Central Kansas
– 6.8 miles of Old Channel through Salina
– Adjacent riparian forest and urban areas



BACKGROUND AND HISTORY

- In 1951, a reported 500-year flood affected more than 50% of the City of Salina's residential and commercial areas, after which USACE conducted a Flood Risk Management (FRM) study

- The FRM project was completed in 1961 and channelized the Smoky Hill River and created a levee system

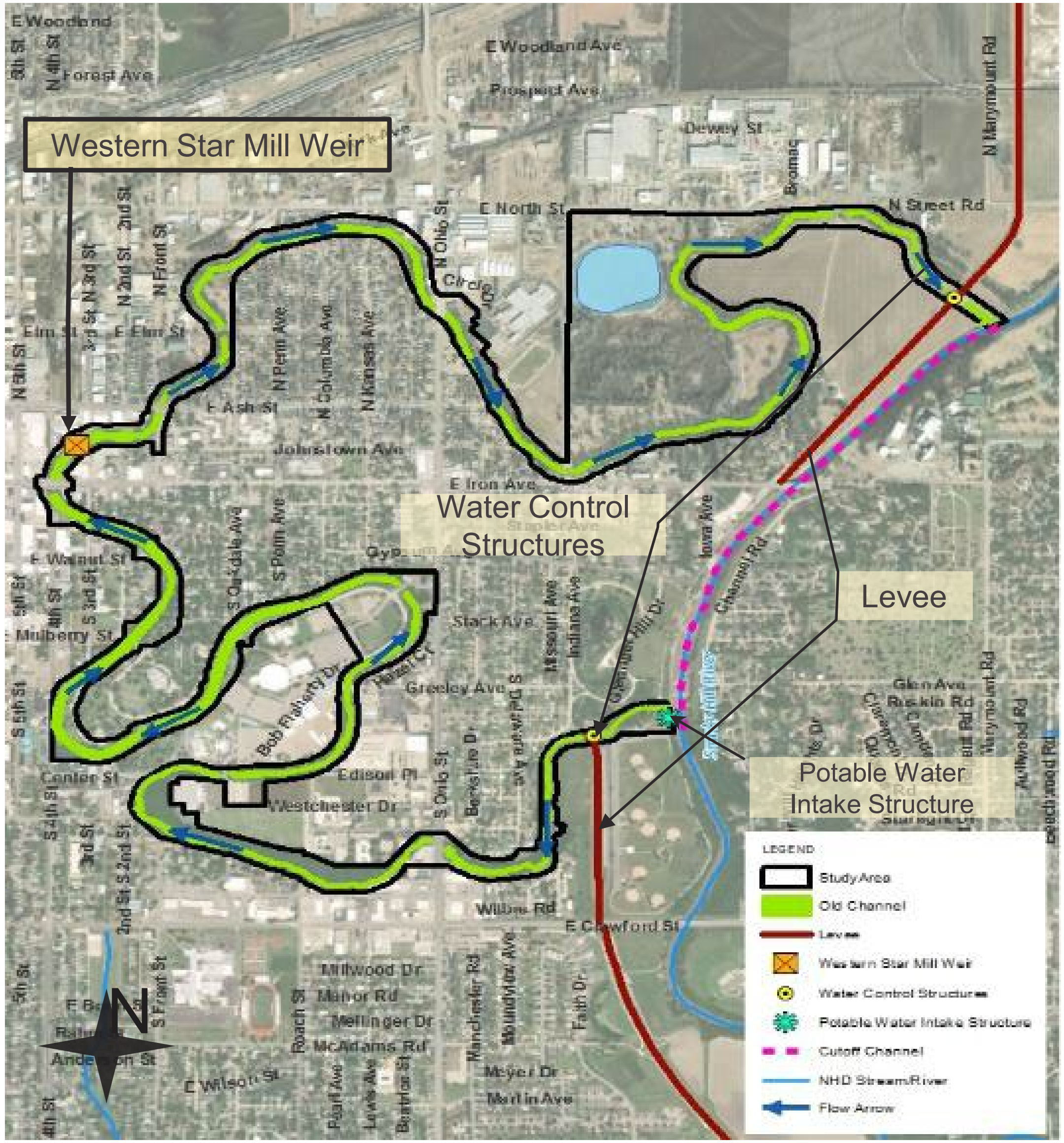
- This permanently diverted most surface water away from the Old Channel, causing a loss of natural flow regime and sediment transport.

- This loss of natural flow resulted in sediment aggradation, loss of high quality in-stream aquatic habitats, loss of wetlands, and decreased ability of the Old Channel to support native fish and wildlife communities.

CAP 1135 TO GENERAL INVESTIGATION

- Continuing Authorities Program (CAP) 1135 Study was initiated in 2018 with the City of Salina
- Ecosystem Restoration project looking to restore aquatic habitat functions and features within and near the Old Channel that were lost resulting from the FRM project.
- After developing measures and alternatives, it was determined the project would exceed the scope of a CAP 1135 ($10 million dollar projects, of limited size, scope and complexity)
- 1135 project placed on hold in 2022 and other options explored
- Study was converted to a General Investigation study (specifically authorized) and initiated in 2024.

STUDY AREA: SMOKY HILL RIVER, SALINA, KANSAS



- Fully-developed, urbanized area, with a combination of high density residential, commercial, and recreational land uses
- Portion of the Study Area is owned by the City of Salina, KS; Privately owned (55 parcels on 26 ac) will require acquisition or easement
- FRM project diverted 6.8 river miles with a 1.1 mile cutoff channel, built a levee
- Western Star Mill Weir acts as a sediment trap
- Lakewood Lake – disconnected from channel

PROBLEMS – LOSS OF NATURAL FLOW REGIME

- Diversion of the Smoky Hill River into the cut-off channel resulted in loss of a natural flow regime and sediment transport function in the old channel.

- Previously, Old Channel would have received runoff from 8,341 square mile drainage, contributing 80,000 acre-ft of water annually.

- Now, Old Channel receives runoff from a 4.6 square mile urban drainage that contributes 6,300 acre-feet of runoff.

- Not sufficient for maintaining quality aquatic and riparian habitat

PROBLEMS – SEDIMENTATION IN OLD CHANNEL

- After the channel cut-off was constructed, reduced flow in the Old Channel caused sedimentation, which further reduced channel capacity and flow rates

- Not enough water flow to re-mobilize sediment, and Old Channel has a very mild slope – easy for sediment to deposit with low flows

- Sedimentation has degraded stream habitat function and features, including loss of stream flow area, loss of stream depth, and loss of riffle/pool sequences.

- Sediment deposition upstream of the weir is ~7 feet deep

PROBLEMS – LOSS OF QUALITY HABITAT & CONNECTIVITY

- Aquatic, wetland, riparian habitat features degraded or eliminated by loss of flow and sedimentation

- Floodplain encroachment and development

- Loss of riparian forest and off-channel emergent wetland habitats

- Currently limited connectivity between wetlands and Lakewood Lake and Old Channel

- Loss of aquatic passage

OPPORTUNITIES

- Restore Old Channel capacity
- Restore and / or create wetland and in-stream aquatic habitat features
- Manage sedimentation
- Restore supporting aquatic habitat connectivity and species life movement functions
- Restore floodplain habitat and functionality
- Stabilize stream banks
- Support incidental water quality improvements
- Support incidental passive recreational opportunities
- Complement other Local Sponsor renewal development plans and activities

STUDY OBJECTIVES

- Restore degraded in-stream aquatic and emergent wetland habitats within and surrounding the Old Channel during the 50-year period of analysis;
- Reestablish capacity in the Old Channel to convey appropriate flow rates throughout the year during the 50-year period of analysis;
- Manage future Old Channel sedimentation during the 50-year period of analysis;
- Restore habitat connectivity for the 50-year period of analysis.

PLANNING CONSTRAINTS & CONSIDERATIONS

- Avoid unduly disrupting or modifying local transportation systems
- Avoid adverse effects to existing FRM project
- Avoid adverse flooding effects
- Coordinate with City’s RAISE Grant
- Inclusion of project construction phase into WRDA 2026
- City purchase of water storage from Kanopolis Reservoir to support downstream flows during periods of extreme drought

FUTURE WITHOUT PROJECT CONDITIONS

- Continued lack of flow within the Old Channel from FRM project
- Continued sediment deposition within the Old Channel
- Emergent wetland and in-stream aquatic habitat quality and quantity will continue to be low
- Climate change – regional analyses indicate that future weather patterns will be more variable resulting in the potential for more extreme droughts and precipitation events

PLAN FORMULATION

Measures and Alternatives

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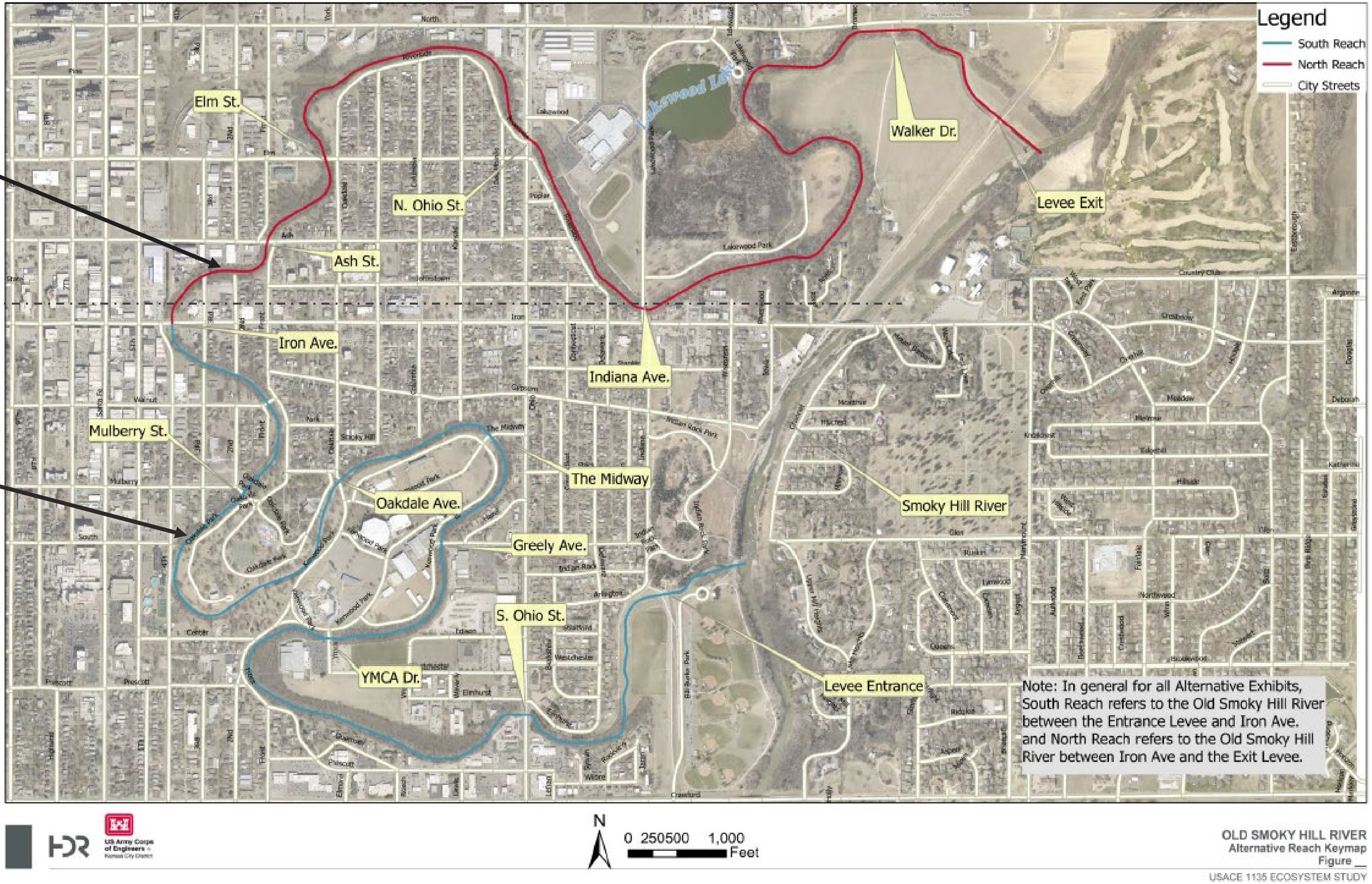
RIVER REACHES

Reach 2 – Northern Section of River

Reach 1 – Southern Section of River



RESTORATION MEASURES CONSIDERED – 1/3

Measure	Name of Measure	Description
1	Channel Dredging Reach 1	Dredging the channel in Reach 1 to create a uniform trapezoidal section and profile. Would restore gravity-based flow conveyance.
2	Channel Dredging Reach 1	Dredging the channel in Reach 1 to create a variable depth profile (Glide/Pool/Riffle/Run sequences). Would restore gravity-based flow conveyance.
3	Channel Dredging Reaches 1 & 2	Dredging the channel in Reach 1 and Reach 2 to create a variable depth profile (Glide/Pool/Riffle/Run sequences). Would restore gravity-based flow conveyance.
4	Channel Dredging Reaches 1 & 2	Dredging the channel in Reach 1 and Reach 2 to create a variable depth profile (Glide/Pool/Riffle/Run sequences), with deeperpo9ols in Reach 1. Would restore gravity-based flow conveyance.
5	Channel Dredging in Reaches 1 & 2 to Original Channel Depth	Dredging the channel in Reach 1 and Reach 2 to the original channel depth. Would lower channel bed 10-11 feet over 6.8 miles. Streambank grading would be required.

RESTORATION MEASURES CONSIDERED – 2/3

Measure	Name of Measure	Description
6	Old Channel Substrate Enhancement	Measure would be combined with a dredging measure. Would add more diverse substrate (gravel, cobbles, etc.) the channel after dredging to enhance aquatic habitat.
7	Pool Habitat	Construct a habitat weir (2 ft tall) in Reach 2 to create and maintain pool habitat (4' – 6') in Reach 2.
8	Sediment Capture	Construct a sediment forebay near the intake structure in the old channel. Design to slow incoming water and settle sediments. Would need to be dredged.
9	Old Channel Connected Wetlands	Construct 1.7 acres of connected wetland shelves within the Old Channel.

RESTORATION MEASURES CONSIDERED – 3/3

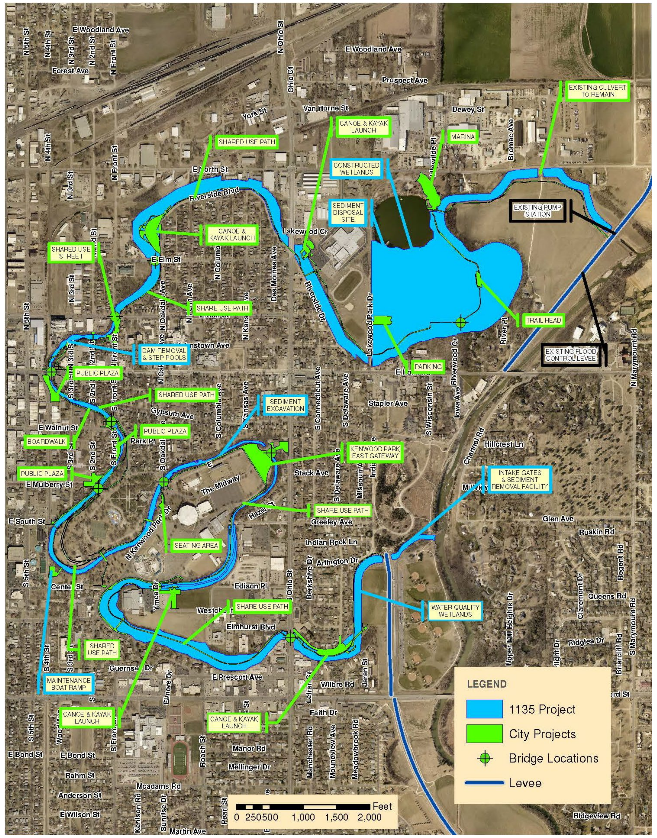
Measure	Name of Measure	Description
10	Renovate Western Star Mill Weir	Weir constructed in the early 1900's is in declining conditions. This measure would repair the weir to prevent an unexpected failure.
11	Remove Western Star Mill Weir	Remove the weir, and do some minor channel reshaping and rock placement to moderate the slope difference.
12	Remove and Replace Western Star Mill with Step Pools	Remove the weir and replace with 5 step pools that would moderate the slope difference and allow for aquatic and recreational passage.
13	New Main Channel Alignment	Create a new channel alignment connected to the cut-off channel for aquatic connectivity and passage.
14	Restore/Create Wetland Habitat in Lakewood Lake	Would restore/create about 20 acres of wetlands. Dredged sediment from Old Channel would be placed into Lakewood Lake and formed into emergent wetlands.
15	Riparian Habitat Restoration Along the Old Channel	Invasive species removal, tree plantings, forest management along the riparian corridor.

MEASURES – NOT CARRIED FORWARD

Measure	Name for Measure	Description/Reason for not being retained
5	Channel Dredging in Reaches 1 & 2 to Original Channel Depth	Cost prohibitive, significant bank sloping to accommodate lower channel bottom would add real estate constraints
6	Old Channel Substrate Enhancement	Difficult to maintain, not sustainable
10	Renovate Western Star Mill Weir	Does not address connectivity or habitat restoration.
11	Remove Western Star Mill Weir	Increases risk of stream instability, erosion and headcutting. The steep gradient with weir removal does not facilitate aquatic passage.
13	New Main Channel Alignment	Major community disruption, very high cost, no land available.
15	Riparian Habitat Restoration Along the Old Channel	Cost prohibitive; City will manage separately; not needed for a complete project

MEASURES SUMMARY – MEASURES CARRIED FORWARD

Measure	Name of Measure	Description
1	Channel Dredging Reach 1	Uniform Trapezoidal Section and Profile
2	Channel Dredging Reach 1	Variable Depth Profile (Glide/Pool/Riffle/Run)
3	Channel Dredging Reaches 1 & 2	Variable Depth Profile (Glide/Pool/Riffle/Run)
4	Channel Dredging Reaches 1 and 2	Variable Depth Profile (Glide/Deeper Pool/Riffle/Run)
7	Pool Habitat	Additional Pool Habitat (Reach 2)
8	Sediment Capture	Sediment Forebay (Inlet Area)
9	Old Channel Connected Wetlands	Construct 1.7 acres of connected wetland shelves within the Old Channel.
12	Western Star Mill Treatment	Remove and Replace Western Star Mill with Step Pools
14	Wetland Habitat	Restore/Create Wetland Habitat in Lakewood Lake



ALTERNATIVE FORMULATION

Measures carried forward were combined into complete alternatives that could address project goals and objectives and not violate constraints.

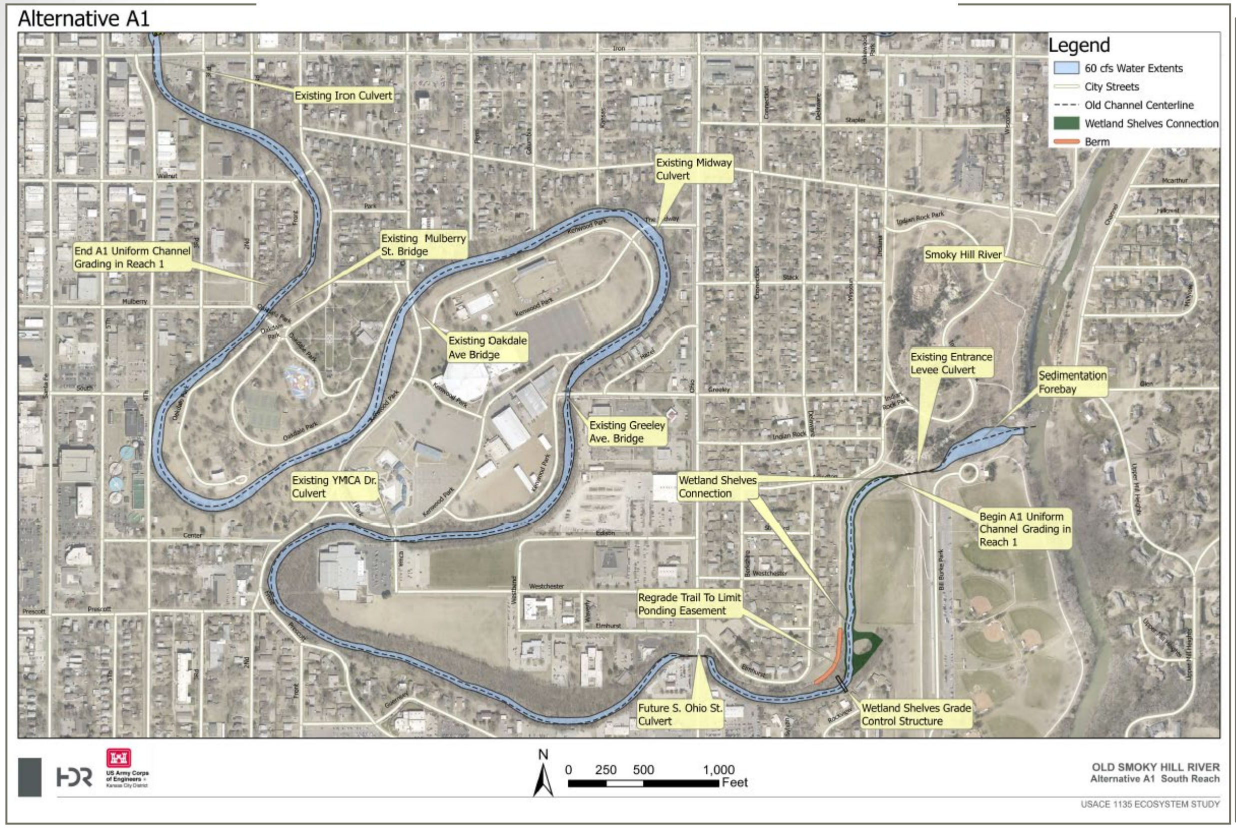
Focused on combining stream restoration measures with Lakewood Lake measures to lead to a healthy ecosystem with a functioning stream and wetlands.

ALTERNATIVES ARRAY

Alternative	Restoration Measures Combination	Habitat Type	Habitat Acres	Cumulative AAHUs	Net AAHUs
A0 (No Action)	N/A	Stream Wetland	27.0 36.7	0.3 4.7	NA
A1	• Channel Dredging Reach 1 – Uniform Trapezoidal Section and Profile • Pool Habitat Reach 2 – created by installation of a 2 ft weir • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake – Connected Wetland	Stream Stream Stream Stream Stream Wetland	27.0 36.7	10.4 25.8	9.2 21.2
A2	• Channel Dredging Reach 1 – Variable Section and Depth Profile (Pool-Riffle-Run) • Pool Habitat Reach 2 – created by installation of a 2 ft weir • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake – Connected Wetland	Stream Stream Stream Stream Stream Wetland	27.0 36.7	11.5 25.8	11.3 21.2
A3	• Channel Dredging Reaches 1 and 2 – Variable Depth Profile (Pool-Riffle-Run) • Pool Habitat Reach 2 – average depth of 4 – 6 ft • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake – Connected Wetland	Stream Stream Stream Stream Stream Wetland	27.0 35.8	11.5 27.0	13.9 22.3
A4	• Channel Dredging Reaches 1 and 2 – Variable Depth Profile (Deeper Pool/Riffle/Run) • Pool Habitat Reach 2 – average depth of 4- 6 ft • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lake Wood Lake –Connected Wetland	Stream Stream Stream Stream Stream Wetland	27.0 35.8	11.6 27.0	14.1 22.3

PLAN VIEW MEASURES – REACH 1

Alternative 1



Alternatives 2, 3, 4

Alternative	Bottom width	Top of water @80cfs	Riffle Depth	Pool Depth
1	5 ft	30 - 50 ft	3.25 ft (uniform bed)	X
2	8 - 12 ft	30 - 50 ft	3.25 ft (variable)	4 -6 ft
3	8 - 12 ft	30 - 50 ft	3.25 ft (variable)	4 -6 ft
4	8 - 12 ft	30 - 50 ft	3.25 ft (variable)	5 -7 ft

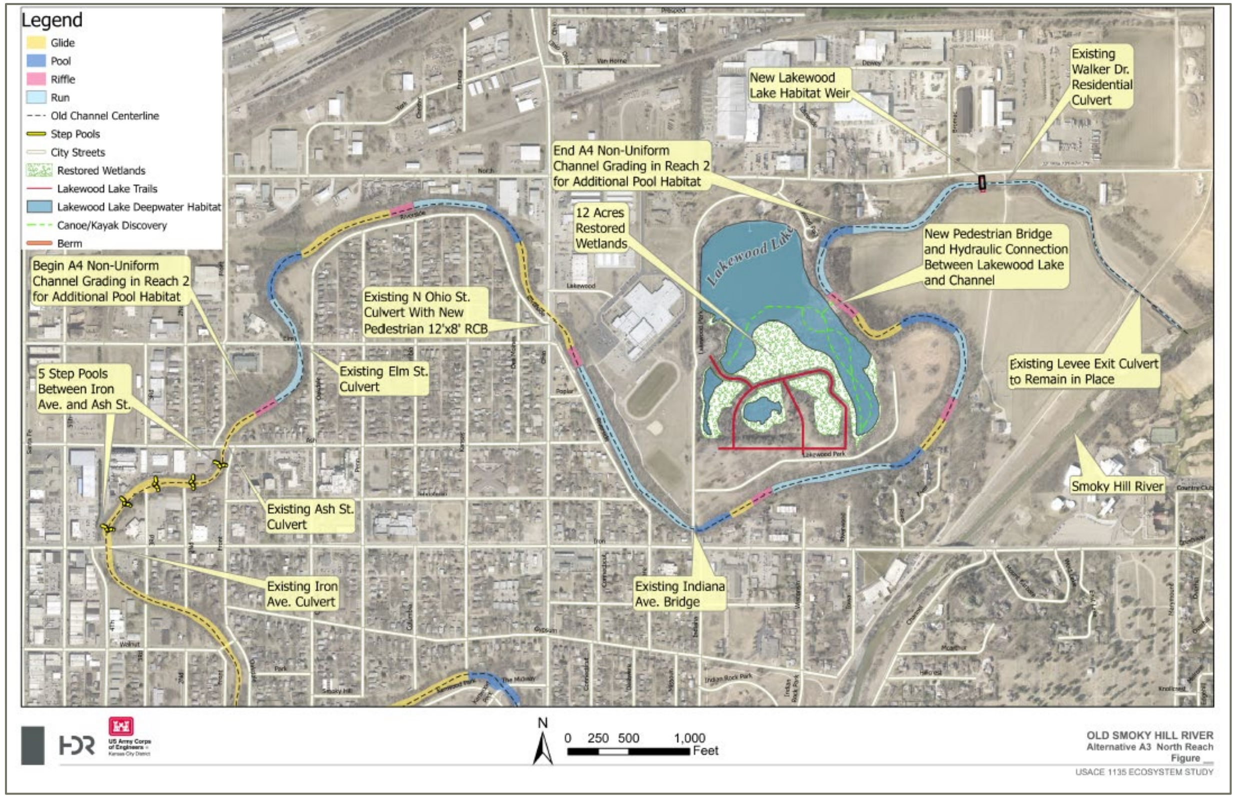
Alt.	Total Dredged (cu yds)
1	42,065
2	63,027
3	105,914
4	107,390

Note: Sediment removal includes S. Ohio St. Culvert, and both reaches

PLAN VIEW MEASURES – REACH 2

Alternatives 1 and 2

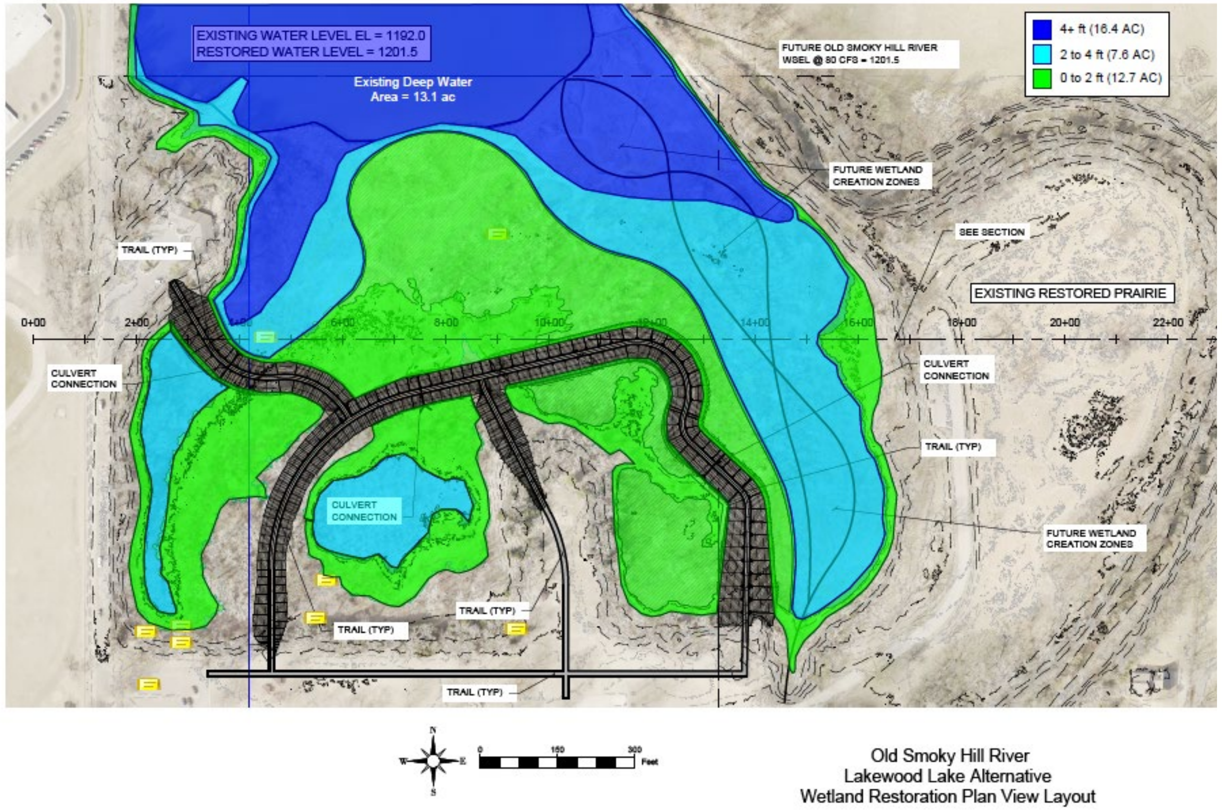
Alternatives 3 and 4



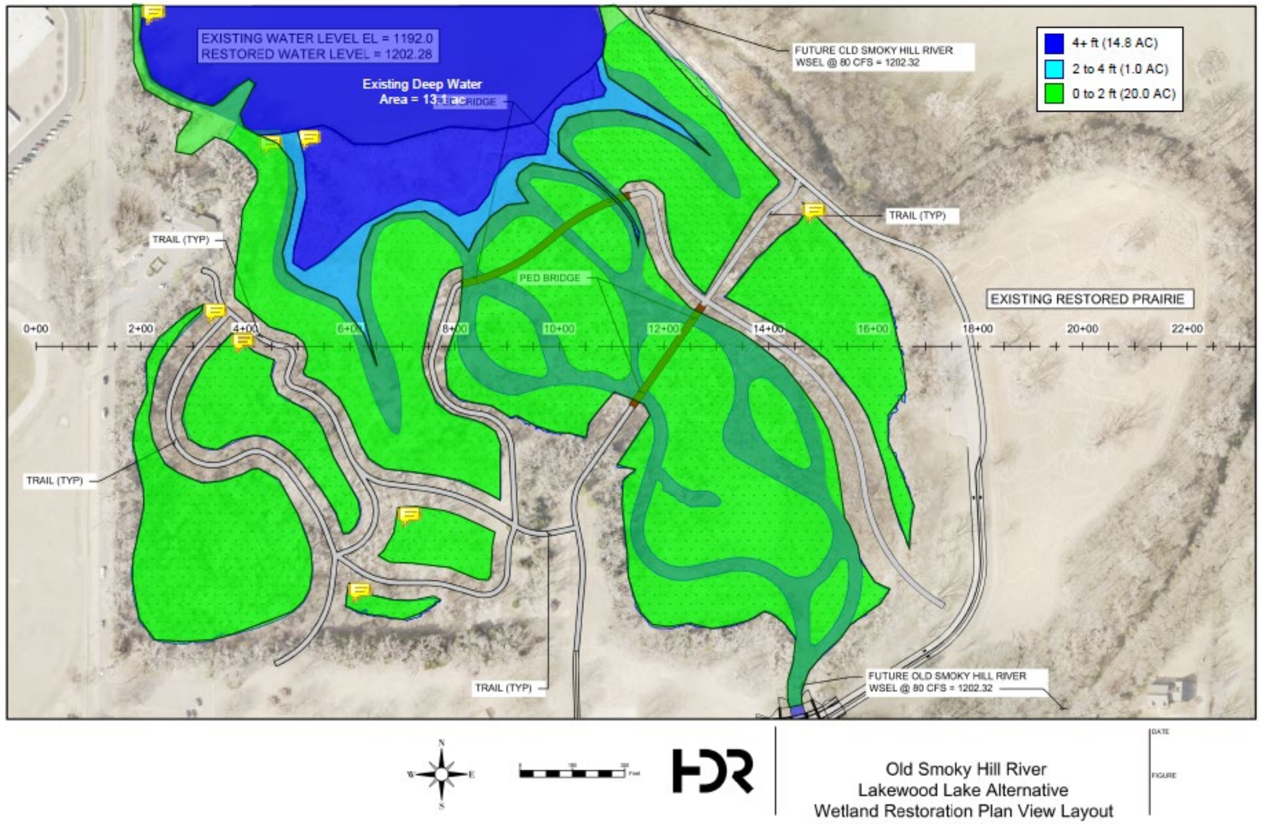
Alternative	Bottom width	Top of water @80cfs	Target Depth Riffle	Pool Depth
1	3 ft	X	X	X
2	3 ft	X	X	X
3	8 - 12 ft	30 - 50 ft	3.25	4 - 6 ft
4	8 - 12 ft	30 - 50 ft	3.25	4 - 6 ft

WETLAND RESTORATION- CONCEPTUAL PLAN DESIGN

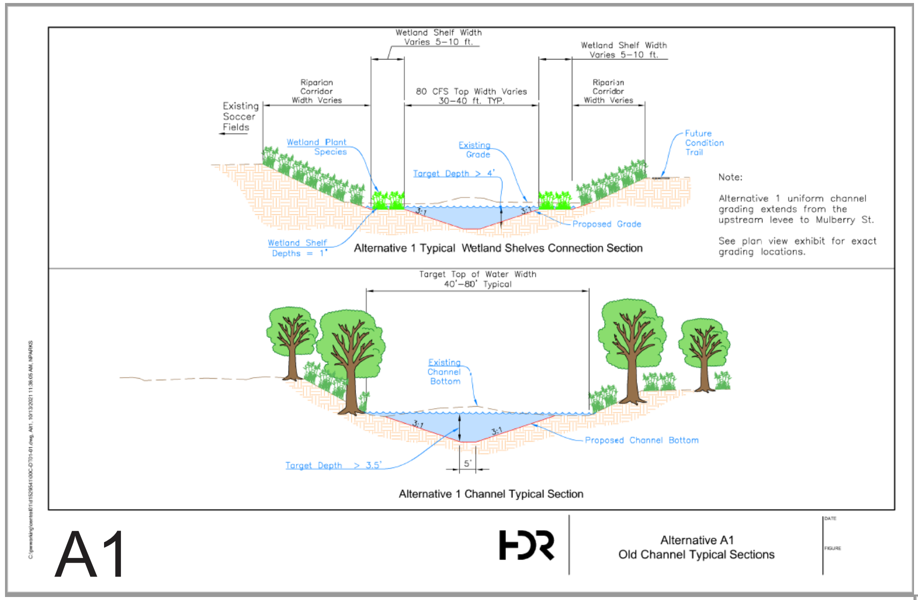
Alternatives 1 and 2

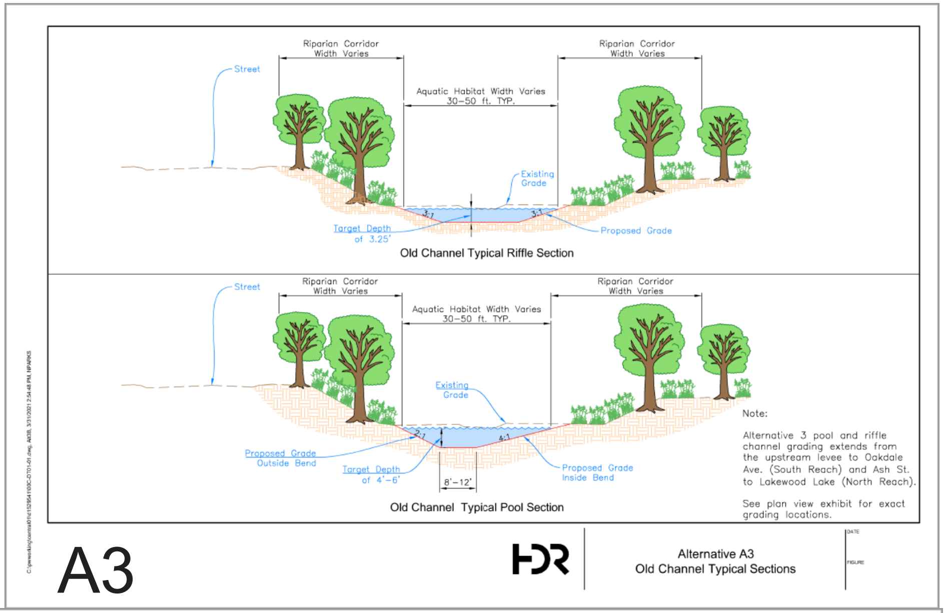


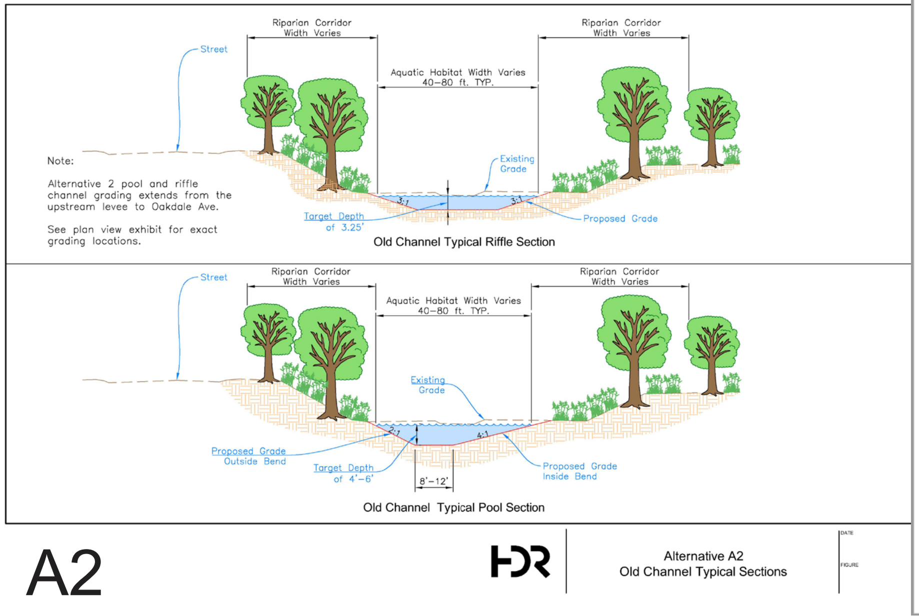
Alternatives 3 and 4

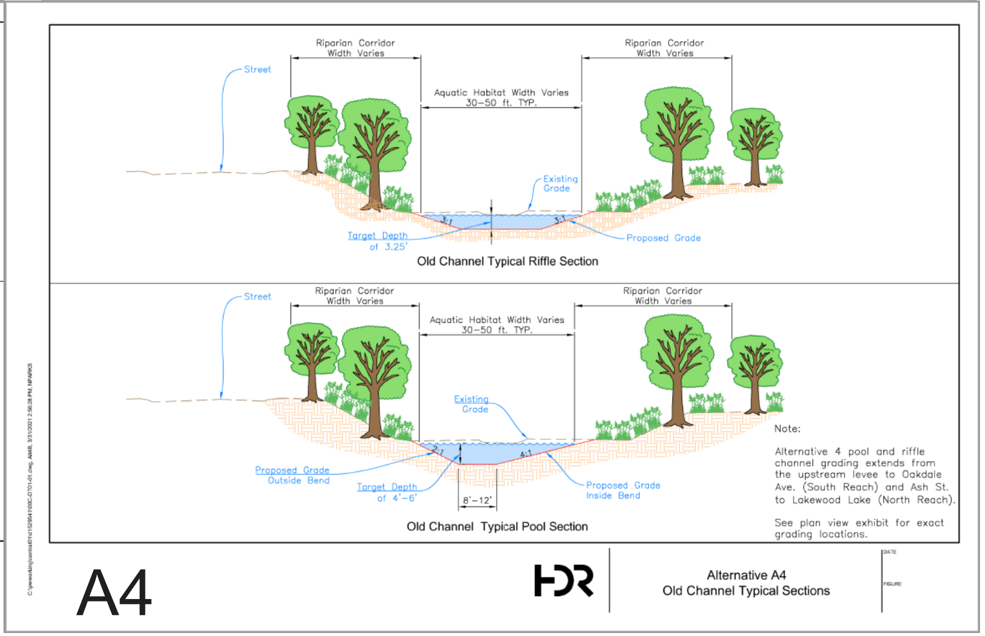


CHANNEL CROSS SECTIONS – ALL 4 ALTERNATIVES









ENVIRONMENTAL COMPLIANCE APPROACH

U.S. ARMY

US Army Corps of Engineers®

RECOMMENDED SCHEDULE

Milestone	Scheduled Date
FCSA Execution	15 JUL 2024
Alternatives Milestone	9 OCT 2024
Vertical Team Alignment Memorandum	1 DEC 2024
Tentatively Selected Plan	15 DEC 2024
Draft Report to Public	1 MAR 2025
Agency Decision Milestone	31 JUL 2025
Final Report Transmittal	30 DEC 2025
State & Agency Briefing	30 MAR 2026
Chief's Report	30 JUN 2026

COOPERATING & PARTICIPATING AGENCIES

- EPA and USFWS will be invited to serve as Cooperating Agencies
- All other relevant agencies will be invited to be participating agencies
- USACE will consider any requests from agencies or Tribes to be Cooperating agencies

TRIBAL NATIONS

- Initial consultation letters (for 1135 project) were sent to listed tribes
- Re-engaging for consultation for the GI study

- Absentee Shawnee Tribe
- Cheyenne and Arapaho Tribes
- Delaware Tribe of Indians
- Iowa Tribe of Kansas and Nebraska
- Kaw Nation
- Osage Nation
- Pawnee Nation of Oklahoma
- Prairie Band Potawatomie Nation
- Sac and Fox Nation of Missouri in Kansas and Nabraska
- Shawnee Tribe
- Whichita and Affiliated Tribes

NATIONAL ENVIRONMENTAL POLICY ACT

Environmental Assessment will be prepared with Integrated Feasibility Report

Key Dates

- February 2025 – Cooperating Agency Review of Preliminary Draft (if needed)
- March 2025 – Public and Agency Review of Draft Feasibility Report and EA/Public Meeting(s)
- April 2025 – Comments due on Draft Report/EA

ENDANGERED SPECIES ACT

Section 7 consultation re-initiated, with species list from IPaC

- Whooping Crane (endangered)
- Monarch Butterfly (candidate)

No critical habitat for either species in the project area

FISH AND WILDLIFE COORDINATION ACT

Coordinated with USFWS in 2020 for the 1135 study

- No concerns from USFWS at that time

Re-engaging with USFWS for FWCA on GI study

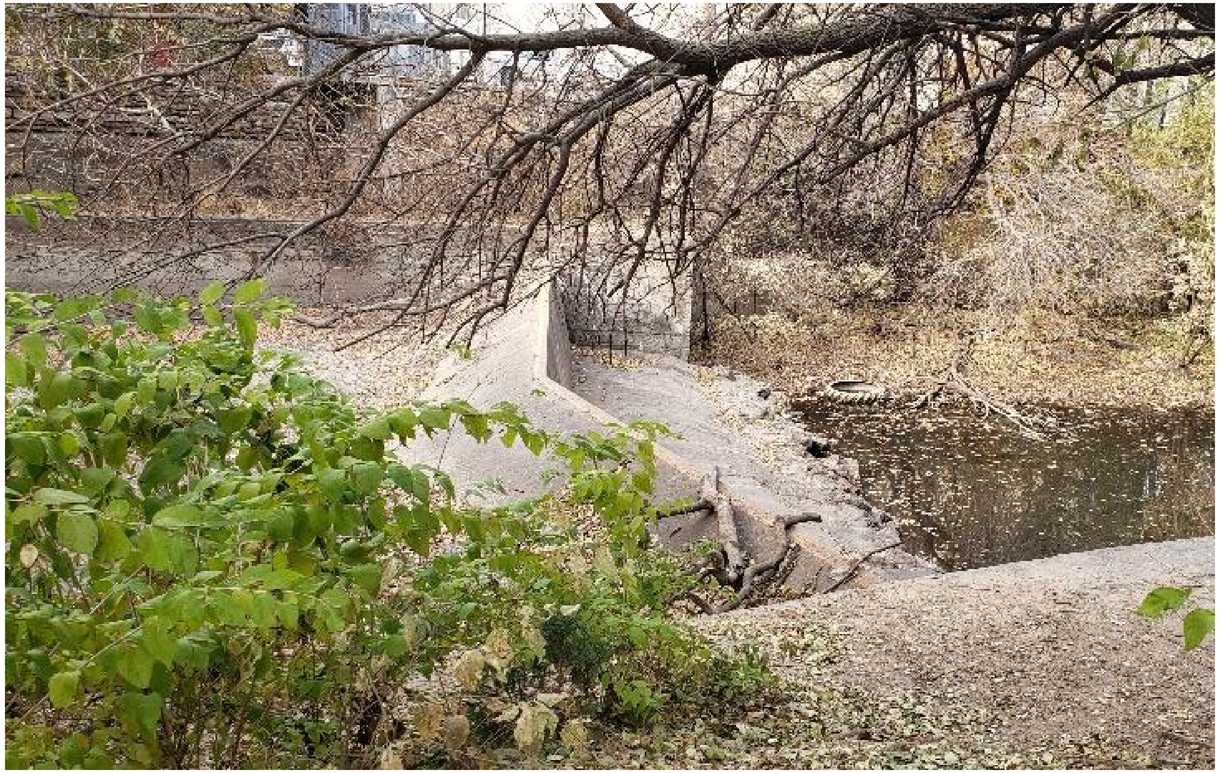
- Scope of USFWS involvement to be determined (PAL or FWCAR)

CLEAN WATER ACT

CWA Section 404

- Nationwide Permit 27 and associated general permit conditions
- Will fulfill 401 permit conditions for Kansas

NATIONAL HISTORIC PRESERVATION ACT – SECTION 106 PROCESS



Compliance with the National Historic Preservation Act (NHPA) is underway.

Re-engaged with the Kansas SHPO

Area of Potential Effect is being identified and researched. Expected archaeological survey in 2025.

Western Star Mill Weir is considered eligible for the Historic Register. MOA needed for removal of Western Star Mill Weir

QUESTIONS?

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, KANSAS CITY DISTRICT
601 E. 12TH STREET, 635 FEDERAL BLDG
KANSAS CITY, MO 64106-2824

CENWK-PMP-R (ARIMS)

Ms. Meg McCollister
Regional Administrator
Environmental Protection Agency
11201 Renner Boulevard
Lenexa, KS 66219

The U.S. Army Corps of Engineers (Corps), Kansas City District, is initiating a Feasibility Study with Integrated Environmental Document pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, for the proposed Smoky Hill Ecosystem Restoration Feasibility Study. The study will investigate implementation of aquatic ecosystem restoration measures in the old Channel of the Smoky Hill River, in downtown Salina, Kansas. The non-Federal sponsor is the City of Salina, Kansas.

Your agency has been identified as an agency that may have an interest in the proposed project based on your jurisdiction by law and/or special expertise. As the lead Federal agency under NEPA, we invite you to be a cooperating agency with the Corps in the development of the environmental document. Your designation as a cooperating agency does not imply you support the proposed project, nor does it diminish or otherwise modify your agency's independent statutory obligations and responsibilities under applicable federal laws, regulations, and Executive Orders.

In accordance with the Council on Environmental Quality (CEQ) 2020 implementing regulations for NEPA (40 C.F.R. § 1501.8), the Corps requests, as the lead agency, your assistance and participation in the NEPA process in the following ways:

a. Participate in the scoping process (as described in 40 C.F.R. § 1501.9).

b. Assist in developing information and preparing environmental analyses, including portions of the environmental impact statement or environmental assessment concerning which the cooperating agency has special expertise.

c. Actively participate as part of the interdisciplinary team.

d. Provide comments and limit its comments to those matters for which it has jurisdiction by law or special expertise with respect to any environmental issue consistent with 40 C.F.R. § 1503.2.

e. To the maximum extent practicable, jointly issue environmental documents with the lead agency.

Please provide your written acceptance or declination of this invitation on or before **31 January 2025.** Should you decline to accept our invitation to be a cooperating agency, we advise that you provide a copy of your response to CEQ as specified at 40 C.F.R. § 1501.8. We look forward to working with your agency on the preparation of the environmental document.

If you have any questions or would like to discuss in more detail the project or our agencies' respective roles and responsibilities during the preparation of the Feasibility Study with Integrated Environmental Document, please contact Ms. Laura Totten, Project Manager at (816-868-2530) or Ms. Katharine Lynch, Environmental Resources Specialist at (816-389-3901).

Sincerely,

Todd Gemeinhardt

Todd R. Gemeinhardt
Chief, Planning Branch
U.S. Army Corps of Engineers
Kansas City District

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, KANSAS CITY DISTRICT
601 E. 12TH STREET, 635 FEDERAL BLDG
KANSAS CITY, MO 64106-2824

Mr. Matt Hogan
Regional Director
U.S. Fish and Wildlife Service, Mountain-Prairie Region
1 Denver Federal Center
Building 25 – Room 1911
Denver, Co, 80225

The U.S. Army Corps of Engineers (Corps), Kansas City District, is initiating a Feasibility Study with Integrated Environmental Document pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, for the proposed Smoky Hill Ecosystem Restoration Feasibility Study. The study will investigate implementation of aquatic ecosystem restoration measures in the old Channel of the Smoky Hill River, in downtown Salina, Kansas. The non-Federal sponsor is the City of Salina, Kansas.

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Sincerely,

Todd Gemeinhardt

Todd R. Gemeinhardt
Chief, Planning Branch
U.S. Army Corps of Engineers
Kansas City District

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mountain-Prairie Region
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, Kansas 66502

IN REPLY REFER TO:
FWS/R6/

January 31, 2025

Todd R. Gemeinhardt
Chief, Planning Branch
USACE, Kansas City District

RE: Smoky Hill Ecosystem Restoration Feasibility Study

Dear Mr. Gemeinhardt,

The U.S. Army Corps of Engineers (Corps), Kansas City District, is initiating a Feasibility Study with Integrated Environmental Document pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, for the proposed Smoky Hill Ecosystem Restoration Feasibility Study. The study will investigate implementation of aquatic ecosystem restoration measures in the old Channel of the Smoky Hill River, in downtown Salina. The non-Federal sponsor is the City of Salina, Kansas.

This letter is in response to your invitation to be a cooperating agency with the Corps in the development of the environmental document.

The Service has various statutory authorities and responsibilities, including those under NEPA; the Endangered Species Act of 1973, as amended; the Fish and Wildlife Coordination Act (l6 U.S.C. 661 et. seq.); and for certain resources under section 4(f) of the Department of Transportation Act of 1966. Participating agency status neither enlarges nor diminishes the decision-making authority of any agency involved in the NEPA process (CEQ memorandum of January 30, 2002).

The intent of the NEPA and sections 1501.6 and 1508.5 of the Council on Environmental Quality (CEQ) regulations implementing NEPA (reiterated in the CEQ memorandum of January 30, 2002) that the Federal official responsible for making any detailed statement (environmental document) shall early in the NEPA process begin coordinating with any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative); and

That no Service lands or lands funded under various Service grant programs are potentially involved in the project, but that, as detailed in Appendix II to the CEQ NEPA regulations, the Service does possess special expertise with respect to the protection of federally threatened and endangered species and their critical habitats, migratory birds, floodplains, wetlands, and other fish and wildlife resources.

We regret that at this time, other program commitments and limitations preclude cooperating agency involvement, or the degree of involvement requested in the action that is the subject of the environmental document. However, we would accept participating agency status with the understanding that:

> The Service will participate to the extent that limited staffing and budgets allow and commensurate with the potential impacts of the project on resources within the interests of the Service. If additional workload is anticipated because of participating agency status, we will request funding support from the Corps.
>
> The Service's acceptance of participating agency status does not necessarily imply endorsement or support of the project or of a particular alternative. The intent of the Service's acceptance of participating agency status, is to ensure that significant environmental issues are identified as early as possible in the planning process and that throughout the multiple stages of the planning process, decisionmakers have the environmental information necessary to make informed and timely decisions.

We look forward to working as a participating agency on this ecosystem restoration project. If you have any questions, please contact Michele McNulty, Fish and Wildlife Biologist at michele_mcnulty@fws.gov.

Sincerely,

Jason Luginbill
Field Supervisor

From: Hofmeier, Jordan [KDWPT] <Jordan.Hofmeier@KS.GOV>
Sent: Monday, February 10, 2020 2:37 PM
To: jpolak@habitatarchitects.net
Subject: KDWPT Review: Smoky Hill River Ecosystem Restoration feasibility study, SA Co. (Track #20200058)

Dear Mr. Polak,

We have reviewed the information for the proposed Smoky Hill River Ecosystem Restoration feasibility study in Saline County, KS. The project was reviewed for potential impacts on crucial wildlife habitats, current state-listed threatened and endangered species and species in need of conservation, and Kansas Department of Wildlife, Parks, and Tourism managed areas for which this agency has administrative authority.

KDWPT generally supports efforts to restore aquatic habitats and habitat connectivity, and we provide the following comments and general recommendations, when applicable:

- **Use principles of Natural Channel Design for stream restoration efforts.**
- **Implement soft-armoring techniques for streambank stabilization such as rootwad revetments and/or willow stakes.**
- **Stabilization projects should be keyed into existing stable points in the streambank at the up- and downstream extents to reduce the risk of flanking and failure.**
- **Erosion control blankets can pose impacts for reptiles and amphibians by ensnaring and entrapping individuals moving over/through the mesh. We recommend using compost, mulch, or biodegradable/natural fiber blankets (coconut/coir fiber is common) as potential alternatives to plastic erosion control blankets. Such alternatives can also promote the growth of vegetation further improving bank stability. Though less preferable than the aforementioned options, loose-weave mesh is also acceptable, specifically types with weaves that are not welded at the intersections that would allow the opening to expand if an animal attempts to pass through.**
- **The construction and removal of soil coffer dams is likely to increase sedimentation in the stream, which could impact several aquatic species. Soil coffer dams also have the potential to be eroded or destroyed during high flow events. If coffer dams are used, we recommend using portable or inflatable coffer dams. We also recommend seining**

areas between coffer dams to remove fish prior to pumping water out of the area. Fish should be released in flowing water downstream of the construction site.

- **Avoid the introduction of invasive species, aquatic or terrestrial, during construction. All equipment should be thoroughly inspected and cleaned of mud, plant material, or other debris and cleaned with pressurized hot water or allowed to dry for 5 days prior to contacting any other Waters of the U.S. to prevent transporting invasive species. Invasive species in the riparian area should be controlled during construction until native vegetation is established.**

- **Avoid or minimize all bank or instream activity, particularly during general fish spawning season (March 1 – Aug. 31).**

- **Implement and maintain standard erosion-control Best-Management-Practices during all aspects of construction by installing sediment barriers (wattles, filter logs, rock ditch checks, mulching, or any combination of these) across the entire construction area to prevent sediment and spoil from entering aquatic systems. Barriers should be maintained at high functioning capacity until construction is completed and vegetation is established. For more information, go to:** http://www.kdheks.gov/stormwater/#construct

- **Reseed disturbed areas with native warm-season grasses, forbs, and trees.**

As there are no specific restoration plans at this time, this review is preliminary and does not provide automatic clearance for this project. At this time, there is no state Designated Critical Habitat in the vicinity of the project and there are no anticipated impacts to state listed species. Since the Department's recreational land obligations and the State's species listings periodically change, if construction has not started within one year of this date, or if design changes are made in the project plans, the project sponsor must contact this office to verify continued applicability of this assessment report. For our purposes, we consider construction started when advertisements for bids are distributed.

Permits or reviews may be required from other regulatory agencies including but not limited to: Kansas Dept. of Agriculture - Division of Water Resources, Kansas Dept. of Health and Environment, U.S. Army Corps of Engineers, U.S. Fish & Wildlife Service, etc. You should verify this yourself.

Please consider this email our official review for this project. Thank you for the opportunity to provide these comments and recommendations. Please let me know if you have any questions or concerns about the preceding information.

Please direct all review materials electronically to KDWPT.ess@ks.gov *to streamline the review process for all parties.*

JH

Jordan Hofmeier

Aquatic Ecologist, Ecological Services

Kansas Dept. of Wildlife, Parks, & Tourism

512 SE 25th Ave, Pratt, KS 67124

Office: (620) 672-0798

Cell: (785) 249-0874

Fax: (620) 672-2972

jordan.hofmeier@ks.gov

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, KS 66502-2801
Phone: (785) 539-3474 Fax: (785) 539-8567

In Reply Refer To: 06/04/2025 18:51:44 UTC
Project Code: 2025-0000217
Project Name: Smoky Hill Ecosystem Restoration

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see https://www.fws.gov/program/migratory-bird-permit/what-we-do.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see https://www.fws.gov/library/collections/threats-birds.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/partner/council-conservation-migratory-birds.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, KS 66502-2801
(785) 539-3474

PROJECT SUMMARY

Project Code: 2025-0000217
Project Name: Smoky Hill Ecosystem Restoration
Project Type: Restoration / Enhancement of Waterbody
Project Description: aquatic habitat restoration in Old Channel and wetlands near Lakewood Lake
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@38.8383834,-97.60353763942578,14z

Counties: Saline County, Kansas

ENDANGERED SPECIES ACT SPECIES

There is a total of 2 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

---

1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

BIRDS

NAME	STATUS
Whooping Crane *Grus americana* Population: Wherever found, except where listed as an experimental population There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/758	Endangered

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* There is **proposed** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/9743	Proposed Threatened

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

IPAC USER CONTACT INFORMATION

Agency: Army Corps of Engineers
Name: Katharine Lynch
Address: 601 E 12th St
City: Kansas City
State: MO
Zip: 64106
Email katharine.e.lynch@usace.army.mil
Phone: 8166484519

From: Thornton, Christopher J <christopher_thornton@fws.gov>
Sent: Thursday, March 26, 2020 3:21 PM
To: jpolak@habitatarchitects.net
Cc: Yapp, Cheryl <cheryl_yapp@fws.gov>; Luginbill, Jason S <jason_luginbill@fws.gov>
Subject: 2020-CPA-0109 Smoky Hill River Ecosystem Restoration Integrated Section 1135 Feasibility and EA

Dear Mr. Polak:

We have reviewed your letter dated January 9, 2020 requesting our review of a feasibility study involving the potential of restoring the former alignment of the Smoky Hill River near Salina Kansas. We reviewed your proposal for potential effects to any federally listed threatened or endangered species, critical habitats, or species of conservation concern, and we currently have no concerns with regard to any of these federal trust resources. The Kansas Ecological Services Field Office and the USFWS overall encourages the restoration of altered and degraded watersheds to support the conservation of native fish communities. Restoration of watershed "connectivity features" can provide vital aquatic organism passage (AOP) that supports native fish reproduction and survival, as well as contributing to genetic diversity and resilience.

Thank you for the opportunity to provide review and comment and please consider this our official response to your request.
Please direct any questions to Chris Thornton at 785-539-3474 x 102 or 912-294-7182.

Telework contact: 912-294-7182

Chris Thornton
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan Kansas 66502
Office: (785) 539-3474 X 102

Exhibit C. Tribal and Cultural Coordination

Smoky Hill River GI Study
Draft Integrated Feasibility Report and Environmental Assessment

September 2025

U.S. Army Corps of Engineers
Kansas City District

6425 SW 6th Avenue
Topeka, KS 66615

Kansas

phone: 785-272-8681
fax: 785-272-8682
cultural_resources@kshs.org

Kansas Historical Society

Governor Laura Kelly
Jennie Chinn, Executive Director

KSR&C No. 19-10-126
November 8, 2019

Gina Powell
U.S. Army Corps of Engineers
Via E-Mail

RE: Section 1135 Ecosystem Restoration
Old Smoky Hill River Channel, Salina
Saline County

Dear Dr. Powell:

The Kansas State Historic Preservation Office has reviewed your letter and attached documentation regarding above-referenced project dated October 23, 2019. As we understand it, the project will involve restoration of water flow (and associated floodplain habitat) within the old Smoky Hill River channel in downtown Salina. As there will be related developments along the channel, there is potential for impacts to both archeological and architectural resources.

As you noted, virtually none of the proposed project area has seen any archeological survey. Since there is clear precedent for intact archeological sites on the Smoky Hill flood plain both upstream and downstream of Salina, we agree that survey of the project area is warranted. We also agree that such investigations should be targeted, given the documented level of disturbance in some areas.

We agree that architectural resources will need to be evaluated as well. Our staff members have reviewed the documentation for the Western Star Mill Dam. We will need to see additional photos of the dam as it currently exists in order to evaluate its eligibility for listing in the National Register of Historic Places. Impacts to other nearby architectural resources will need to be evaluated once the final project boundaries have been established.

This information is provided at your request to assist you in identifying historic properties, as specified in 36 CFR 800 for Section 106 consultation procedures. We look forward to working with you as the project progresses. If you have questions or need additional information regarding these comments, please contact Tim Weston at 785-272-8681 (ext. 214) or Lauren Jones at 785-272-8681 ext. 225. Please refer to the Kansas Review & Compliance number (KSR&C#) above on all future correspondence relating to this project.

Sincerely,

Jennie Chinn
Executive Director and
State Historic Preservation Officer

Patrick Zollner

Patrick Zollner
Deputy State Historic Preservation Officer

From: Main, Austin [KSHS]
To: Powell, Gina S CIV USARMY CENWK (USA); Lerman, Seth A CIV USARMY CENWK (USA)
Cc: Meade, Timothy M CIV USARMY CENWK (USA); Zollner, Patrick [KSHS]
Subject: [URL Verdict: Neutral][Non-DoD Source] RE: Smoky Hill River, Western Star dam
Date: Friday, May 20, 2022 12:30:02 PM

Gina & Seth,

Thank you for meeting with Patrick and I today to discuss the project. It seemed very productive on both ends, and you've done a great job with this write-up. Once those details are ironed out about the access roads in the project area, we can discuss the archaeological component further.

Best,

Austin

Austin Main, MA

SHPO Archeologist

Kansas Historical Society

6425 SW 6th Avenue

Topeka, KS 66615-1099

785-272-8681 x228

Austin.Main@ks.gov

Your Stores | Our History

From: Powell, Gina S CIV USARMY CENWK (USA) <Gina.S.Powell@usace.army.mil>
Sent: Friday, May 20, 2022 11:36 AM
To: Lerman, Seth A CIV USARMY CENWK (USA) <Seth.A.Lerman@usace.army.mil>; Main, Austin [KSHS] <Austin.Main@ks.gov>
Cc: Meade, Timothy M CIV USARMY CENWK (USA) <Timothy.M.Meade@usace.army.mil>; Zollner, Patrick [KSHS] <Patrick.Zollner@ks.gov>
Subject: Smoky Hill River, Western Star dam

A follow up from today's meeting for my own clarity:

Attendees: Seth Lerman, USACE PM; Austin Main, SHPO archaeology reviewer; Patrick Zolner, acting SHPO (?), and Gina Powell, USACE archeologist

After several technical difficulties, the four of us met over Zoom to discuss the NRHP status of the dam.

I sent a letter to the KS SHPO in 2019 thinking that the dam was not eligible since it was a concrete thing from the 1960s that was a replacement for the original 19th century dam. It was old enough, but I thought (mistakenly) that it was not unique. SHPO asked for additional information.

I sent more photos to KHRI.org but that did not answer the question if it was eligible so Austin asked for a meeting.

Today, Patrick explained that although the dam is not in good shape, it is actually pretty rare in Kansas. He cited the Bowersock Power dam in Lawrence (https://www.bowersockpower.com/about/our-history), a concrete dam that is considered eligible.

For these two reasons, the KS SHPO considers the Western Star dam potentially eligible. Barring a survey of concrete dams in the state of Kansas to disprove this assertion, Gina agreed that the dam is potentially eligible.

Patrick offered resources, namely Susan Hawksworth, the director of the Smoky Hill Museum in Salina (susan.hawksworth@salina.org). She would probably want to be a consulting party to a future MOA, and would have suggestions for others. The Friends of the River and relevant Tribes will also be contacted. Signatories are thought to be the City of Salina, the KS SHPO, and USACE.

Regarding the MOA and mitigation, Patrick noted that the SHPO was hoping for a small-scale mitigation of the dam, such as an overlook and interpretative signs or displays at the site. This is all yet to be determined through consultation. He also said that there are historians in Salina that would meet the minimum requirements to draft interpretive materials.

Austin brought up the archeological component of the project and we discussed that the city was working on the details of access to the channel for dredging and the design of the wetlands using dredge material.

Gina's next steps:

Write a new letter for SHPO re: the above .

Reach out to local interested parties.

Find out the City's plan for removing the dam and what other associated structures? The mill race/flood gates, the stone wall?

Eventually, we will continue consultation, start drafting the MOA, invite the ACHP, etc. etc.

It was nice to see everyone today! Let me know if I'm off base somewhere.

Gina

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, KANSAS CITY DISTRICT
601 E. 12TH STREET, 635 FEDERAL BLDG
KANSAS CITY, MO 64106-2824

June 6, 2022

SUBJECT: Western Star Weir adverse effect mitigation MOA

Mr. Matt Reed, THPO
Pawnee Nation
P.O. Box 470
Pawnee, OK 74058-0470

Dear Mr. Reed,

As part of the project to restore water flow of the old Smoky Hill channel in the City of Salina, Saline County, Kansas, the U.S. Army Corps of Engineers, Kansas City District (USACE) and the City of Salina are planning to alter the Western Star dam, a structure eligible for the National Register of Historic Places (NRHP). This letter continues consultation for the project under Section 106 of the National Historic Preservation Act that was initiated with your Tribe in October 2019. Specifically, this letter is an invitation to participate in the development of a Memorandum of Agreement (MOA) regarding the mitigation of the adverse impact to the dam. Additional consultation will occur after plans are developed for the rest of the channel and Areas of Potential Effect are determined.

The proposed project includes the demolition of the sluice gates and the top foot of the concrete dam in order to repurpose the structure into a portion of step pools. All of these structures are owned by the City of Salina. The existing stone walls on the western side of the channel belong to ADM Milling Company and are not part of the project.

The Western Star Mill dam is located on the Smoky Hill River adjacent to Founder's Park, the place where the founders of Salina—William A. Phillips, Alexander M. Campbell, and James Muir—marked out the townsite and a ferry crossing in 1858. The park commemorates these events and the importance of milling to Salina's commercial development.

Cutler (1888) mentions several mills in Salina but the grist mill built by C.R. Underwood in 1867 on the Smoky, which was operated by both steam and water power, is probably the Western Star Mill. Mills and most of the businesses of this era were spurred by the arrival of the Kansas Pacific Railroad. It was not until then that Kansas' copious hard wheat crop could be turned into flour and exported by rail.

The dam was strengthened and elevated in 1873 and then purchased by the Western Star Milling Company in 1925. In 1960, after the severe flood of 1951, USACE built a by-pass channel and flood control levee on the Smoky Hill River. This flood control project diverted the river flows away from the Western Star Mill dam site and only stormwater drainage from approximately five square miles routinely flows through the site. In 1967, after the flood control by-pass channel was built, the Western Star Dam was rehabilitated and concrete faced, and the sluice gates were installed.

In May 2022, in a meeting with the Kansas SHPO, USACE agreed that due to the relative rarity of concrete dams in Kansas, the Western Star Dam was eligible for the NRHP. As such, an MOA outlining actions for mitigation for the adverse effect must be undertaken.

Thank you for your consideration in this matter. If you have any questions or have need of further information, please contact Dr. Gina Powell, by email at Gina.S.Powell@usace.army.mil or by phone at (816) 389-2320. We respectfully request that you let us know if you wish to participate as an invited signatory by July 11, 2022.

Sincerely,

Gina Powell

Dr. Gina Powell
Archeologist

References

Cutler, William G.
1883 *History of the State of Kansas*. A. T., Chicago, IL.
https://www.kancoll.org/books/cutler/saline/saline-co-p1.html#TOC

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, KANSAS CITY DISTRICT
635 FEDERAL BUILDING
601 E. 12TH STREET
KANSAS CITY, MISSOURI 64106-2824

August 1, 2022

CENWK-PMP-C
Communication and Review Section, Planning Branch

Mr. Patrick Zolner
Acting Kansas State Historic Preservation Office
Kansas Historical Society
Topeka, Kansas

SUBJECT: Cancellation of Section 1135 Project, Smoky Hill River. KSR&C No.19-10-126

Dear Mr. Zolner:

This letter continues consultation for a project under Section 106 of the National Historic Preservation Act as part of KSR&C No.19-10-126, the proposed Section 1135 Ecosystem Restoration Project along the Smoky Hill River channel in Salina, Kansas, by the U.S. Corps of Engineers, Kansas City District (USACE) in cooperation with the City of Salina. This letter is to inform your office that the Section 1135 Project has been cancelled but is anticipated to become a General Investigation study in the future. At that time, we will continue our investigations and consultation.

If you have any questions or have need of further information please contact Gina Powell, USACE Kansas City Archeologist, at Gina.S.Powell@usace.army.mil or at (816) 389-2320.

Sincerely,

Gina Powell

Dr. Gina S. Powell
Archeologist

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, KANSAS CITY DISTRICT
601 E. 12TH STREET, 635 FEDERAL BLDG
KANSAS CITY, MO 64106-2824

October 11, 2024

Planning Branch

Mr. Patrick Zolner
Kansas State Historic Preservation Officer
Kansas Historical Society
6425 SW 6th Avenue
Topeka, KS 66615-1099

SUBJECT: General Investigation Study, Smoky Hill River, Salina, Saline County, Kansas. USACE P2 No. 507961, previous SHPO No. 19-10-126

Dear Mr. Zolner,

In October 2019, the U.S. Corps of Engineers, Kansas City District (USACE) initiated consultation with your office under Section 106 of the National Historic Preservation Act regarding a proposed Section 1135 Ecosystem Restoration Project along the Smoky Hill River channel in Salina, Kansas in cooperation with the City of Salina. At that time, the project was in the early planning stages and specific project plans had not been developed. Since then there have been several updates and changes to the project so we are re-initiating consultation. This letter is to update you on the progress of the study and to invite your participation in the development of a Programmatic Agreement (PA) that USACE is developing to meet our obligations under the National Historic Preservation Act.

The project has been converted from a Section 1135 Ecosystem Restoration Project to a General Investigation (GI Study) but the project area remains the same and the array of alternatives developed during the Section 1135 study remain the same. Actions include restoring water to the old channel; a levee entrance sediment forebay; dredging parts of the old channel; channel shaping; bank stability and vegetation; demolition and replacement of the Western Star Mill dam by a series of five step pools; old channel-connected wetland shelves; and develop Lake Wood (a former sand quarry) into a connected wetland. The City of Salina would be responsible for the other actions, such as bridges, parks, and overlooks.

At present, there is one archeological site recorded in or near the project area: 14SA471, “27 Indian Rock Battle Site,” recorded on a hill in the center of Indian Rock Lake Park. It is the reported location of an 1857 battle between Eastern displaced Tribes and local Central Plains Tribes. The site, as currently defined, should not be impacted by the project. Survey will be conducted within the planned sediment forebay planned for that area at the base of the hill where the site is located.

There are five documents included with this letter. The first is a map of the project area that shows the existing cultural resources and surveys and the second is a preliminary map of the APE in relation to cultural resources. The third attachment is a summary document of the recorded cultural resources and surveys that had prepared for the feasibility study. The fourth attachment is a newspaper article regarding the Indian Rock Battle Site. Finally is an excerpt from the Alternative Milestone meeting held for agencies on October 4, 2024.

The Western Star Dam has been determined eligible for the National Register of Historic Places (NRHP) and consultation with your office and other parties was initiated in June 2022 to create the Memorandum of Agreement that would result in mitigation for the potential removal of the dam.

We will be developing a draft PA in the near future which will be forwarded to all consulting parties for review and comment. We will also schedule a virtual meeting in the near future to kick off the PA and discuss the project and alternatives.

Please contact me at (816) 389-2320 or Gina.S.Powell@usace.army.mil if you have any questions or need additional information.

Sincerely,

Gina Powell

Dr. Gina Powell
Archeologist

Attachments
1. Map of the project area and known cultural resources (below).
2. Preliminary Areas of Potential Effect in relation to known cultural resources (below).
3. Summary of the recorded cultural resources and surveys.
4. Newspaper article regarding the Indian Rock Battle Site.
5. Excerpt of AMM presentation showing maps and tables of the alternative measures.

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, KANSAS CITY DISTRICT
601 E. 12TH STREET, 635 FEDERAL BLDG
KANSAS CITY, MO 64106-2824

October 11, 2024

Planning Branch

Mr. Matt Reed
Historic Preservation Officer
Pawnee Nation of Oklahoma
P.O. Box 470
Pawnee, OK 74058-0470

SUBJECT: General Investigation Study, Smoky Hill River, Salina, Saline County, Kansas. USACE P2 No. 507961

Dear Mr. Reed,

In October 2019, the U.S. Corps of Engineers, Kansas City District (USACE) initiated consultation with your Tribe under Section 106 of the National Historic Preservation Act regarding a proposed Section 1135 Ecosystem Restoration Project along the Smoky Hill River channel in Salina, Kansas in cooperation with the City of Salina. At that time, the project was in the early planning stages and specific project plans had not been developed. Since then there have been several updates and changes to the project so we are re-initiating consultation. This letter is to update you on the progress of the study and to invite your participation in the development of a Programmatic Agreement (PA) that USACE is developing to meet our obligations under the National Historic Preservation Act.

The project has been converted from a Section 1135 Ecosystem Restoration Project to a General Investigation (GI Study) but the project area remains the same and the array of alternatives developed during the Section 1135 study remain the same. Actions include restoring water to the old channel; a levee entrance sediment forebay; dredging parts of the old channel; channel shaping; bank stability and vegetation; demolition and replacement of the Western Star Mill dam by a series of five step pools; old channel-connected wetland shelves; and develop Lake Wood (a former sand quarry) into a connected wetland. The City of Salina would be responsible for the other actions, such as bridges, parks, and overlooks.

At present, there is only one archeological site recorded in or near the project area: 14SA471, “27 Indian Rock Battle Site,” recorded on a hill in the center of Indian Rock Lake Park. It is the reported location of an 1857 battle between Eastern displaced Tribes and local Central Plains Tribes. The site, as currently defined, should not be impacted by the project. Survey will be conducted within the planned sediment forebay planned for that area at the base of the hill where the site is located. If your Tribe has information they would like to share on the battle or the site, we could incorporate into the report and considerations of effect.

There are five documents included with this letter. The first is a map of the project area that shows the existing cultural resources and surveys and the second is a preliminary map of the APE in relation to cultural resources. The third attachment is a summary document of the recorded cultural resources and surveys that had prepared for the feasibility study. The fourth attachment is a newspaper article regarding the Indian Rock Battle Site. Finally is an excerpt from the Alternative Milestone meeting held for agencies on October 4, 2024.

The Western Star Dam has been determined eligible for the National Register of Historic Places (NRHP) and consultation with your Tribe and other parties was initiated in June 2022 to create the Memorandum of Agreement that would result in mitigation for the potential removal of the dam.

We will be developing a draft PA in the near future which will be forwarded to all consulting parties for review and comment. We will also schedule a virtual meeting in the near future to kick off the PA and discuss the project and alternatives.

Should your Tribe have information on this or any other cultural resource that may be affected by the proposed project of which we may be unaware, we would take such information into account for our final determination of effect. Please contact me at (816) 389-2320 or Gina.S.Powell@usace.army.mil if you have any questions or need additional information. We respectfully request that you provide any input or information your Tribal Government may have by November 21, 2024.

Sincerely,

Gina Powell

Dr. Gina Powell
Archeologist

Attachments
1. Map of the project area and known cultural resources (below).
2. Preliminary Areas of Potential Effect in relation to known cultural resources (below).
3. Summary of the recorded cultural resources and surveys.
4. Newspaper article regarding the Indian Rock Battle Site.
5. Excerpt of AMM presentation showing maps and tables of the alternative measures.

Tribe-GI initiation letter

Absentee Shawnee
Cheyenne & Arapaho Tribes
Delaware Tribe of Indians
Eastern Shawnee
Iowa of Kansas and Nebraska
Kaw Nation
Osage Nation
Pawnee Nation
Prairie Band of Pottawatomie
Sac and Fox of Missouri in KS and NE
Wichita
Kiowa
Comanche Nation
Lower Brule Sioux Tribe
Oglala Sioux Tribe
Rosebud Sioux Tribe
Sac & Fox Miss in Iowa
Santee Sioux Tribe
Standing Rock Sioux Tribe
Yankton Sioux Tribe

[Non-DoD Source] RE: USACE General Investigation Study, Smoky Hill River, Saline County...

Joseph Reed <jreed@pawneenation.org>
To Powell, Gina S CIV USARMY CENWK (USA)

Mon 12/2/2024 11:51 AM

Follow up. Start by Monday, December 2, 2024. Due by Monday, December 2, 2024.
You replied to this message on 12/2/2024 11:58 AM.

Nawa,

I want us to stay involved with this project. My greatest concern is with the wealth of Smoky Hill phase sites and non-specific Prehistoric sites in the area. The closest site is noted in your paperwork. With the amount of ground disturbance that might occur, I want to make sure that we know what's going on.

Nawa iri,

Matt R

Kukâkû'ut

Matt Reed

Tribal Historic Preservation Officer

Phone: (918) 762- 2180

Email:jreed@pawneenation.org

881 Little Dee Drive

Pawnee, OK 74058

www.PawneeNation.org

From: Powell, Gina S CIV USARMY CENWK (USA) <Gina.S.Powell@usace.army.mil>

[Non-DoD Source] RE: Smoky Hill River PA consultation

BM
Benjamin M. Bressoud <benjamin.bressoud@osagenation-nsr
To Powell, Gina S CIV USARMY CENWK (USA)

Reply | Reply All | Forward | ...

Mon 12/23/2024 8:39 AM

Follow up. Start by Monday, December 23, 2024. Due by Monday, December 23, 2024.
You replied to this message on 12/23/2024 10:13 AM.

Hi Gina,

Yes, we will not be participating in this PA. Thanks for the reminder though! Our email systems were down for a while, so I haven't been able to get back to things quickly until now.

Have a good holiday season!

-Ben

[Non-DoD Source] RE: KC S R&C No. 24-10-075 Smoky Hill River PA

SB

Shelby Beltz [KSHS] <Shelby.Beltz@ks.gov>
To Powell, Gina S CIV USARMY CENWK (USA)

Reply | Reply All | Forward

Tue 12/17/2024 1:41 PM

Follow up. Start by Wednesday, December 18, 2024. Due by Wednesday, December 18, 2024.
You replied to this message on 12/19/2024 10:47 AM.

Hi Gina,

I apologize for dropping the bucket on this one and the delay in response to this correspondence. Yes, our office is interested in participating in the review of this project and the draft PA.

Best,

Shelby Beltz
SHPO Archeologist
Kansas Historical Society
6425 SW 6th Avenue
Topeka KS 66615-1099
785-272-8681 x219
Shelby.Beltz@ks.gov

From: Jane
To: Powell, Gina S CIV USARMY CENWK (US)
Subject: RE: [Non-DoD Source] RE: Consultation partner for the Smoky Hill River project
Date: Tuesday, November 3, 2020 11:58:00 AM

Gina,

Yes, that is true. We realize the value of letting the river be more friendly to fish and also boating.

I am sorry to see a piece of history go, but we believe it will be for the greater good.

Thanks,

Jane Anderson
Executive Director
Friends of the River Foundation
159 S. 4th St
PO Box 953
Salina, KS 67402-0953
(785)493-8491
Blockedwww.smokyhillriver.org

From: Powell, Gina S CIV USARMY CENWK (US) <Gina.S.Powell@usace.army.mil>
Sent: Tuesday, November 3, 2020 9:25 AM
To: Jane <janea@smokyhillriver.org>
Subject: RE: [Non-DoD Source] RE: Consultation partner for the Smoky Hill River project

Jane,
I was told I do not have to send you an "official" letter-this conversation will act as the notice.

I was told that your organization is not against getting rid of or altering the Western Star dam. Is that true? We would take your opinion into account when making a determination and SHPO would also consider it.

Gina

From: Jane <janea@smokyhillriver.org>
Sent: Tuesday, November 3, 2020 1:21 PM
To: Powell, Gina S CIV USARMY CENWK (US) <Gina.S.Powell@usace.army.mil>
Subject: [Non-DoD Source] RE: Consultation partner for the Smoky Hill River project

Gina,

Yes, we would appreciate being consulted. I have been able to research through the library and the Smoky Hill Museum for information that HDR Eric Dove was looking for the Corps of Engineers fairly recently. If I can help you let me know.

I am so glad that the video and old pictures helped you.

Thanks again,

Jane Anderson
Executive Director
Friends of the River Foundation
159 S. 4th St
PO Box 953
Salina, KS 67402-0953
(785)493-8491
BlockedBlockedwww.smokyhillriver.org

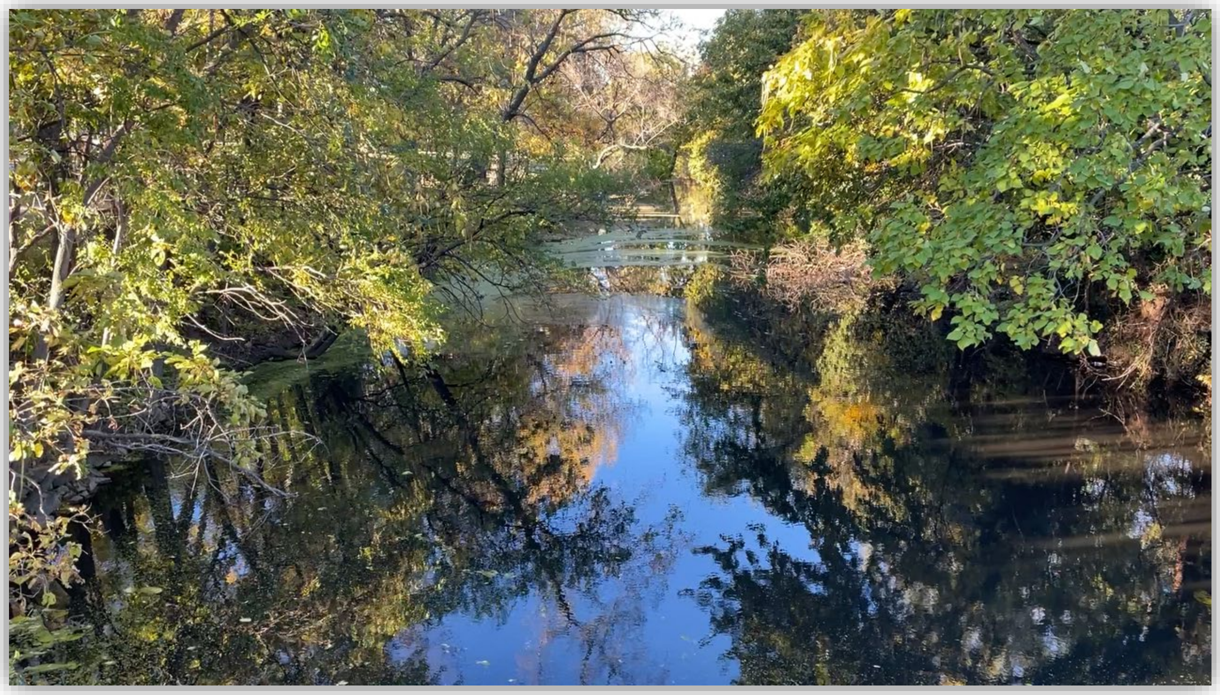
From: Powell, Gina S CIV USARMY CENWK (US) <Gina.S.Powell@usace.army.mil>
Sent: Monday, November 2, 2020 1:17 PM
To: friends@smokyhillriver.org
Subject: Consultation partner for the Smoky Hill River project

Dear Ms. Anderson,
I got your name from Tim Fobes after I talked to Martha Tasker about the Western Star Mill dam. I came out and took some pictures of it to start working with the Kansas State Historic Preservation Office (SHPO) on whether it is eligible for the National Register in case it is to be altered or removed. I assume you would like to be involved in this consultation and the rest of the project. The federal agency has the responsibility of consulting with the Kansas SHPO, Native American Tribes, and other interested parties. Your group is the definition of an interested party. I will send you an official letter via email to get the consultation ball rolling.

Your group is so knowledgeable about the river and its history! I looked over your website and YouTube film and it showed me a lot more information than I was able to find online in other places.

Sincerely,

Dr. Gina S. Powell, Archeologist
U.S. Army Corps of Engineers, Kansas City District
601 E. 12th Street
Kansas City, MO 64106
Phone: 816-389-2320



Smoky Hill River GI Study

Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix K – Operations and Maintenance

September 2025

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Table of Contents

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1. Project Background

1.1 Introduction

This Operations and Maintenance (O&M) appendix presents a feasibility-level summary of the O&M activities that would be anticipated during the lifetime of the constructed ecosystem restoration project, along with rough order of magnitude costs for these activities.

A detailed O&M manual for the constructed project would be developed during the Preconstruction Engineering and Design (PED) phase of the project and completed during construction. As the non-federal project sponsor, the City of Salina would be responsible for the operations, maintenance, repair, replacement and rehabilitation (OMRR&R) of the project after construction completion.

In addition to O&M activities, it is noted that there will also be a Monitoring and Adaptive Management Plan (MAM) as required by USACE guidance. The MAM includes a plan for monitoring ecological success, along with adaptive management activities needed to provide for project performance. Implementation of the MAM plan, when combined with the O&M activities described herein, will form the overall strategy for driving the project towards successful outcomes over the life of the project.

This O&M appendix is primarily intended to outline the anticipated activities in support of the ecosystem restoration project. O&M activities for the federal levee and related flood risk management are expected to continue.

1.2 Project Purpose

The purpose of the Project is to restore aquatic habitat functions and features within and near the Old Smoky Hill channel that were affected by the federal Flood Risk Management Project. The purpose is also to identify a plan that contributes to the National Ecosystem Restoration (NER) objective, reverses ecosystem degradation trends, and achieves ecosystem lift by increasing the net quantity and quality of desired ecosystem resources. The Project is needed because without intervention, the aquatic ecosystem functions associated with the Old Channel's aquatic habitats will continue to degrade and become unavailable to local, regional, and migratory species.

The Project implementation and features are intended to support long-term sustainability of ecosystem restoration functions. It is recognized that some degree of OMRR&R will be necessary over the project lifetime.

1.3 Plan Formulation and Management Measures

In accordance with applicable USACE planning guidance, a wide array of management measures were considered during the plan formulation process. The management measures included various actions that could be implemented as part of an overall project plan to effectively restore the aquatic habitat functionality along the Old Smoky Hill channel. Management measures included such activities:

- Restoring base flows to the Old Smoky Hill channel to facilitate aquatic habitat
- Dredging of excess, historical sediment that has accumulated within the Old Smoky Hill channel
- Removal of channel obstructions such as low-head dams, clogged culverts, and other structures that are not conducive to sustainable aquatic habitat conditions
- Construction of in-stream channel measures such as riffle/pool sequences
- Construction of a sedimentation basin at the entrance to the restored channel
- Development of wetland areas adjacent to the Old Smoky Hill channel
- Development of hydraulic connections to deep water aquatic habitat in Lakewood Lake
- Riparian habitat restoration along the project corridor through revegetation with native seeding and natural recruitment of woody vegetation over time

1.4 Restoration Alternatives

Through the plan formulation process, the various management measures listed above were combined and arrayed across different areas and scales along the project area. In addition to the no-action alternative, four (4) restoration alternatives were formulated and carried forward as alternatives into the final planning array.

Table 1. Alternatives, Final Array

Alternative No.	Restoration Measures Combination
A0 (No Action)	N/A
A1	• Channel Dredging Reach 1 – Uniform Trapezoidal Section and Profile • Pool Habitat Reach 2 • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lakewood Lake – Connected Wetland

Alternative No.	Restoration Measures Combination
A2	• Channel Dredging Reach 1 – Variable Section and Depth Profile (Glide/Pool/Riffle/Run) • Pool Habitat Reach 2 • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lakewood Lake – Connected Wetland
A3	• Channel Dredging Reaches 1 and 2 – Variable Depth Profile (Glide/Pool/Riffle/Run) • Pool Habitat Reach 2 • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lakewood Lake – Connected Wetland
A4	• Channel Dredging Reach 1 – Variable Depth Profile (Glide/Deeper Pool/Riffle/Run) • Pool Habitat Reach 2 • Sediment Forebay (Inlet Area) • Old Channel Connected Wetland Shelves • Remove and Replace Western Star Mill Weir with Five Step Pools • Lakewood Lake – Connected Wetland

2. O&M Activities

The non-federal sponsor is responsible for all long-term project OMRR&R following project construction and acceptance. There are some actions that may be needed following initial construction, and during the adaptive management project timeframe (typically 10 years following construction), to be further defined as the project advances toward PED. Such actions could include periodic monitoring and inspections, review of sedimentation basin effectiveness, vegetation establishment, and overall ecosystem restoration performance along the Old Smoky Hill riparian corridor.

A primary goal or consideration of the Project feasibility study has been to formulate alternatives and recommendations that are generally sustainable, with reasonable O&M costs that the non-federal sponsor would assume. This section identifies and includes the major O&M actions anticipated at this stage in the feasibility study process. Note that the O&M activities may be adjusted and refined during the project development process, with subsequent changes that may become apparent during the initial monitoring and adaptive management timeframe.

2.1 Operations Activities

Operational activities are those actions that may be needed to manage inflows to the restored channel, facilitate water delivery through the Project area, manage sediment transport through the system, maximize habitat quality, or to minimize project-related risks. In addition to operational actions, periodic inspections should also be scheduled and conducted to monitor project performance and identify maintenance needs. Below is a summary list of anticipated operational activities:

<u>Intake Structure, Levee Structure and Sluice Gate Operation</u>. The Project will rely on source water from a surface water right appropriation from the Kansas Department of Agriculture - Division of Water Resources (DWR) approved in May 2011 under Water Appropriation # 47,5101. There is an existing sluice gate at 54" levee outfall structure which, left open, allows surface water diversion from the Smoky Hill River to the Old Smoky Hill channel. Operation of this sluice gate is intended to continue in accordance with the flood risk management purposes of the levee unit, and as required by the O&M manual for the levee unit.

<u>Intake Structure, Bottom-Hinged Crest Gate</u>. This Project includes a bottom-hinged crest gate just upstream of the intake structure to divert water from the top of the water column. The intake structure and crest gate are located approximately 580 feet upstream of the existing 54" levee outfall structure in Bill Burke Park. This feature is intended to help manage water quality by minimizing turbidity and sediment delivery to the restored channel. The crest gate will be automated with manual override. The automated crest gate does not replace the flood control operation of the existing 54" levee outfall structure. The automated crest gate will be hydraulically actuated or have electric motor actuators. Operations will consist of periodic monitoring, control adjustments to optimize performance, and manual gate operation when automated control systems are not in service.

<u>Water Level Controls Adjustment</u>. Along the restored Old Smoky Hill channel, there may be opportunities to periodically review and adjust water level controls. These adjustments could help optimize performance of the habitat restoration and baseflow water levels. The Project includes an in-stream stoplog feature downstream of Lakewood Lake along the channel, and this feature could be adjusted if warranted during periodic inspections.

<u>Periodic Inspections</u>. As a nature-based, restored ecosystem, the Project is intended to be generally sustainable. Periodic inspections will be necessary to visually observe conditions and identify maintenance requirements, operational changes, or other activities necessary to sustain ecosystem functions. Specific items and locations to be inspected include the following:

- Intake structure and gate at the upstream terminus of the Project

- Riparian vegetation along the entire Project length
- Water levels and flow conditions along the entire Project length
- Water quality, debris, and suitable construction access along the entire Project length
- Sediment conditions and restored channel substrate along the entire Project length
- Stormwater outfall structures along the entire Project length
- Water connectivity between Lakewood Lake and the restored channel
- Rock riffles, pools, and other habitat structures along the entire Project length

Post-Flood Inspections. Flooding conditions can arise from multiple sources, including interior drainage from local stormwater outfalls and from Smoky Hill River backwater through the federal levee. Following significant flood events, inspections of the items listed above and general surrounding conditions should be conducted to observe conditions, identify maintenance and repairs, and potential changes to future flood operations and response.

2.2 Maintenance Activities

These are activities required to maintain the intended habitat functionality and restored ecosystem along the Project. Such maintenance actions will be further defined during subsequent design activities, and throughout the adaptive management timeline. Specific maintenance items will also be identified and scheduled as part of the operations and inspections noted above. Maintenance items can also include repairs, replacement, and rehabilitation. Below is a summary list of anticipated maintenance activities:

Sedimentation Basin Dredging and Disposal. The Project includes a sedimentation basin at the upstream terminus, situated between the intake structure gate and the levee. This basin is intended to capture sediment prior to water delivery to the restored channel. The sediment basin is an unlined excavated area with a boat ramp which will allow access using a small hydraulic dredge. The basin relies on gravity-settling of primarily coarse-grained materials including gravels and sands, with some silt materials as well. There is six vertical feet of storage (representing about 5,000 cubic yards) and the anticipated cleanout interval is approximately once every 1 ½ to 2 years. Sediment removal is anticipated to occur through mechanical dredging and excavation. The accumulated sediment would be hydraulically pumped into geotextile tubes on trailers. Once the geotextile tube is full and dewatered, the sediment would be either hauled or loaded into dump trucks for suitable disposal offsite. Sediment is not expected to be contaminated or require specialized handling.

Vegetation Management. Restored ecosystem function provided by the Project will include revegetation using native plantings. Vegetation management will be required to control invasive species, manage woody growth, and support a vibrant and diverse habitat. Maintenance may require physical removal of unwanted growth, selective use of approved herbicides, and other techniques to encourage establishment of desired species along the restored channel and riparian corridor.

<u>Erosion Control</u>. In general, the restored channel has a relatively flat slope and is not expected to exhibit highly erosive velocities. There may be localized areas at rock riffles, stormwater outfalls, or other conditions may exhibit erosion. These areas may require periodic restoration with suitable rock materials and/or selective vegetation.

<u>Re-establishment of Damaged/Deteriorated Structures</u>. The Project includes aquatic habitat restoration features including rock riffles, pools, and other channel stabilization measures. These structures may periodically require repairs, rehabilitation, or replacement as noted during inspections.

<u>Debris Clearing</u>. Periodic debris clearing may be required at the entrance works and intake structure, along the Project length, and at the levee outfall back to the Smoky Hill River. Materials may include woody debris, trash, or other items that may affect project performance.

Native materials may be allowed to remain in the system or transported downstream along the river, while trash and other objectionable items should be removed and disposed.

<u>Access Routes</u>. The Project design will include routes to facilitate equipment access for maintenance. These access routes may require periodic maintenance including removal of excessive vegetation growth, resurfacing, and clearing of obstructions to maintenance vehicles and equipment.

<u>Gate Lubrication and Maintenance</u>. The bottom-hinged intake gate mechanism will require periodic lubrication, operation, and maintenance to prevent rusted or deteriorated conditions. Replacement of worn parts/materials may be required to improve reliability and functionality.

<u>Sediment Removal Along the Restored Channel</u>. The intent of the Project is for the restored channel to be sustainable. Frequent disturbance of the restored channel for sediment removal is not desirable. The sedimentation basin will capture coarse-grained materials and some silts, while the suspended silts and clays are expected to remain suspended and continue transport through the Project and be returned to the Smoky Hill River at the levee outfall. Although some sediment deposition may occur along the Project, such locations are expected to be minimal and acceptable for aquatic habitat. Sediment removal could be performed at limited spot locations

as needed. Preliminary sediment transport analysis indicates that the vast majority of the restored channel length (>90%) is expected to be fairly well balanced and supportive of natural processes. Some periodic sediment removal could be anticipated in the 0.5 mile section upstream of S. Ohio Street (Reach 9 as reported in Sediment Transport Appendix). Subject to adaptive management considerations, it is possible that accumulated sediment in this upstream area may reach a point of equilibrium over a number of years with natural succession of suitable habitat conditions.

<u>Stormwater Outfalls</u>. There are approximately 75 existing stormwater outfalls that eventually discharge surface runoff towards the restored channel. These outfalls may contribute sediment and debris including sand and salt from winter road treatments. Stormwater management opportunities through various best management practices (BMPs) will be considered during further design activities, with the intent to focus on cost-effective approaches that minimize O&M requirements and are commensurate with ongoing public works functions.

3. O&M Costs

The O&M activities presented herein are feasibility-level and are to be further developed during the PED phase of the project when the detailed O&M manual is prepared. As the non-federal project sponsor, the City of Salina would be responsible for the operations, maintenance, repair, replacement and rehabilitation (OMRR&R) of the project after construction completion. Rough order of magnitude costs have been developed for each of the final array alternatives. The O&M activities that are anticipated for each of the alternatives are very similar, and the associated annual costs are commensurate with this similarity.

The O&M activities and associated costs of the selected plan will be further developed and refined as the project advances into the PED phase and through continued coordination with the City.

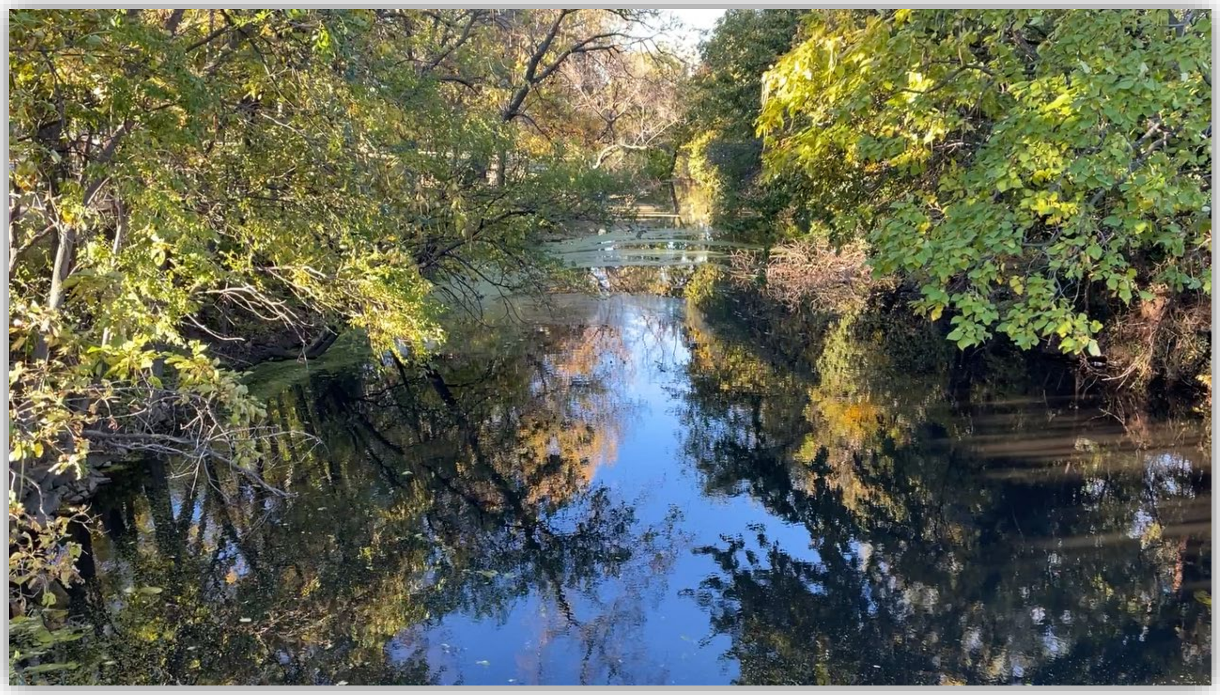
Based on review of over twenty civil works ecosystem restoration projects, annual O&M costs are typically in the range of 0.1% to 0.5% of initial capital construction costs. For the purposes of this rough order of magnitude estimate, the values shown below are based on 0.5% of the initial costs, plus an additional annualized cost for the sedimentation basin cleanout. The sedimentation basin cleanout activity may be considered atypical for most ecosystem restoration projects, so this cost was captured separately and is based on periodic cleanout every 1 ½ years. Although it may not be necessary, costs have also been included for up to three sediment cleanout actions and revegetation costs in Reach 9.

Table 2. Annual O&M Costs, Rough Order of Magnitude

Cost Component	Alternative A1	Alternative A2	Alternative A3	Alternative A4
Initial Capital Construction Cost[1]	$13,476,983	$14,436,389	$17,310,827	$18,997,673
Annual O&M Cost (0.5%)[2]	$70,000	$75,000	$90,000	$95,000
Annualized Sedimentation Basin O&M	$200,000	$200,000	$200,000	$200,000
Annualized Sediment Removal, Reach 9	$10,000	$10,000	$10,000	$10,000
Total Annual O&M Cost	$280,000	$285,000	$300,000	$305,000

[1]Costs obtained from USACE MFR dated March 24, 2025

[2]Rounded, Rough Order of Magnitude costs



Smoky Hill River GI Study
Salina, Kansas

Draft Feasibility Report and Integrated Environmental Assessment

Appendix L – Cultural Resources

September 2025

PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; THE CERTIFIED LOCAL GOVERNMENT OF SALINA; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS

List of Contents

WHEREAS, the U.S. Army Corps of Engineers, Kansas City District (USACE) is partnering with the City of Salina (the City), Kansas on the Smoky Hill River Restoration General Investigation Study (the Study) authorized under Section 216 of the Flood Control Act of 1970 which, if implemented, will result in a Project that will restore flow to the old channel, recreating stream habitat, incorporating the rehabilitated stream into the larger downtown revitalization; and

WHEREAS, the geographic scope of the Study in the state of Kansas includes approximately 6.8 miles of the "old channel" of the Smoky Hill (Attachment A) through downtown Salina and adjacent riparian forest areas; and

WHEREAS, the general area of potential effects (APE) for the Study, as defined in Attachment A, includes City-owned and privately owned lands within the immediate areas of the old channel and Lakewood Lake; the tentatively selected plan (TSP; Attachment B) suggested an array of actions that will be further refined in the Design Phase of the project; those locations that have not yet been fully determined will require a specific APE to be determined prior to project implementation; and

WHEREAS, USACE, as a Federal agency, is required to comply with Section 106 of the National Historic Preservation Act (NHPA), as amended (54 U.S.C. § 306108) and its implementing regulations, "Protection of Historic Properties," codified in 36 CFR § 800; and,

WHEREAS, USACE has determined that the decision to construct a Project resulting from this Study is an undertaking that has the potential to affect historic properties included in or eligible for inclusion in the National Register of Historic Places (NRHP) as defined under 36 CFR § 800.16(y); and,

WHEREAS, in accordance with 36 C.F.R. §§ 800.4(b)(2) and 800.5(a)(3), USACE has elected to conduct identification and evaluation of historic properties, and for application of the criteria of adverse effect and, as appropriate, resolution of adverse effects, respectively, to the design phase of the project because the scope of the undertakings make it unreasonable to identify historic properties or determine the effects of undertakings at this time; and

WHEREAS, 36 C.F.R. § 800.14 allows USACE to negotiate a programmatic agreement (PA) to govern the implementation of a particular program or the resolution of adverse effects from complex project situations; and

WHEREAS, the undertakings are subject to environmental review under the National Environmental Policy Act (NEPA) and other environmental laws; and,

WHEREAS, in this PA, "Signatories," "Invited Signatories," and "Concurring Parties" are defined in 36 C.F.R. § 800.6(c) and in Attachment C; and

WHEREAS, in accordance with 36 C.F.R. § 800.6(a)(1)(i)(C), the Advisory Council on Historic Preservation (ACHP) has been provided the required documentation and invited to participate as a signatory to this PA, and has declined to participate in a letter dated November 13, 2024; and

WHEREAS, the USACE has consulted with the Kansas State Historic Preservation Officer (SHPO) on the development of this PA, and the SHPO is a signatory to this PA; and

WHEREAS, USACE has consulted with the City of Salina (the City) on the development of this PA, and the City is a signatory to this PA; and

WHEREAS, USACE in accordance with 36 CFR § 800.2(c)(2)(ii), 800.3(f)(2), and 800.14(b)(2), the USACE, in a letter dated October 11, 2024, initiated consultation with 20 Federally recognized Indian tribes (Attachment D) that may ascribe religious or cultural significance to historic properties that have the potential to be affected by the Project undertakings and need to be consulted about the identification and assessment of effects on historic properties, to consult on the development of this PA, and these tribes are listed in Attachment D; and

WHEREAS, of those Indian Tribes invited to participate, the Pawnee Nation has chosen to participate in Section 106 consultation in accordance with 36 C.F.R. 800.2 and 800.6 as an invited signatory; and

WHEREAS, the Friends of the River Foundation (Friends of the River) were invited to participate and replied in an email dated December 6, 2024 and have chosen to participate as an invited signatory; and

WHEREAS, the Smoky Hill Museum (Museum) was invited to participate and replied in an email dated January 10, 2025 and have chosen to participate as an invited signatory; and

WHEREAS, the Certified Local Government/Preservation Commission (CLG) of Salina was invited to participate in an email dated January 28, 2025 and a response was received from the Planning and Zoning Administrator for the City of Salina, on February 27, 2025; and

WHEREAS, USACE provided opportunities for public review and comment on this PA by publishing online information, including a Public Notice posted on December 11, 2024 for this PA, and received no comments but will continue to engage the public, as appropriate, during Section 106 review of the Study under the terms of this PA; and,

NOW THEREFORE, USACE**,** SHPO, the City (Signatories), the Pawnee Nation, Smoky Hill Museum, and Friends of the River (Invited Signatories) agree that the undertaking shall be implemented in accordance with the following stipulations in order to take into account the effect of the undertaking on historic properties.

STIPULATIONS

I. SCOPE AND APPLICABILITY

A. This PA shall apply to all undertakings to implement the Project being studied through the Smoky Hill River Restoration General Investigation Study that have the potential to cause effects to historic properties per 36 C.F.R. §§ 800.3 (a) and require Section 106 review after the execution of this PA, and are not otherwise already covered by a separate memorandum of agreement (MOA) or PA.

B. All undertakings to which this PA is applicable shall be reviewed in accordance with the stipulations in this PA.

C. USACE shall identify and consult with the appropriate SHPO, Indian Tribes, and other appropriate Consulting Parties for the Study's undertakings (collectively "Consulting Parties") as defined below:

1. The Kansas SHPO, Signatory
2. The City of Salina, Signatory
3. Pawnee Nation, Invited Signatory
4. Friends of the River, Invited Signatory
5. Smoky Hill Museum, Invited Signatory
6. The Certified Local Government of Salina, Invited Signatory
7. Additional consulting parties with a demonstrated interest including but not limited to local preservation organizations that may be affected by the Study undertaking.

D. As contacts and consultation interests may change over time, USACE will maintain an updated list of Consulting Party points of contact. The contact list for Consulting Parties at the time of execution of this PA is provided in Attachment E.

1. The Consulting Parties will each designate a primary and secondary point of contact. The primary contact is the contact to which all initial and formal correspondence is sent. If the individual designated as the primary point of contact is not available, communications shall be directed to the secondary contact.
2. Consulting Parties to this PA shall provide all parties to the PA with the phone numbers, email addresses, and mailing addresses for the primary and secondary contacts (Attachment E). Similarly, when a point of contact changes, all Signatories and Invited Signatories shall be notified in writing (hardcopy or email) within thirty (30) business days of the change. Such changes shall not require an amendment to this PA.

E. USACE shall seek ways to identify and preserve historic properties through design measures, and to avoid, minimize, or mitigate any adverse effects on historic properties, listed on or eligible for inclusion in the NRHP under Section 106 of the NHPA. USACE shall also attempt to protect burials, cemeteries, or sites likely to contain human remains/artifacts and objects associated with interments or religious activities, and provide this information, studies, and/or reports to the Consulting Parties through the implementation of historic property surveys and testing, and the treatment of historic properties.

F. USACE shall achieve compliance with all relevant terms of this PA prior to initiating physical construction or construction related on site activities such as staging areas, access roads, and other areas of ground disturbance.

II. STANDARDS

A. All cultural resource investigations, reporting, and documentation including site identification, NRHP eligibility evaluations and, as appropriate, mitigation measures for adverse effects to historic properties required under the terms of this PA will be carried out by or under the direct supervision of appropriate professional(s) or by contractors who meet, at a minimum, the Secretary of the Interior's Historic Preservation Professional Qualification Standards (48 FR 44716, September 29, 1983).

B. In developing scopes of work for identification, evaluation studies, treatment measures, and stewardship activities required under the terms of this PA, USACE will take into account the following guidance, as appropriate:

1. ACHP's guidance on conducting archaeology under Section 106 (2009);
2. ACHP's Policy Statement Regarding the Treatment of Burial Sites, Human Remains and Funerary Objects (2023);
3. Kansas State Unmarked Burial Statutes and Regulations K.S.A.75-2741 through 75-2754;
4. Guidance from the Kansas SHPO (Available on their website at https://www.kansashistory.gov/p/shpo-s-guide-to-archeological-survey-assessment-reports/15783).
5. Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44716-42, September 29, 1983); and
6. ACHP Policy Statement on Indigenous Knowledge and Historic Preservation (2024).

III. CONFIDENTIALITY

USACE shall seek and consider the views of the public and Indian Tribes in a manner that reflects the nature of the Study undertakings and their effects on historic properties following procedures pursuant to 36 CFR § 800.2(d). USACE will keep the nature and location of archeological sites and other cultural resource sites covered by this PA confidential pursuant to 36 C.F.R. § 800.11(c), Section 304 of the NHPA (54 U.S.C. 307103); Section 9 of the

Archaeological Resources Protection Act (16 U.S.C. 470hh); and Section 552(b) of the Freedom of Information Act (5 U.S.C. 552) and applicable state laws.

IV. UNDERTAKING REVIEW PROCESS

A. USACE INTERNAL REVIEW PROCESS

1. USACE will identify all Study projects, actions, and activities to determine if they are applicable Study undertakings as described in Stipulation I.A.
2. In the earliest stages of development of the Study's design-phase planned undertakings (project undertakings), USACE shall assign a SOI-qualified staff member to ensure cultural resources and historic properties are identified and considered in the USACE planning process.
3. USACE shall further refine the Area of Potential Effect (APE) for the project undertakings in the development of the Tentatively Selected Plan, as defined in Attachment B, and carry out initial efforts to identify historic properties and initiate an assessment of the undertaking's potential effects to historic properties.
4. Before the selection of the project undertakings, USACE shall complete initial background research of the study area to include reviewing available investigations and consulting with the Kansas state historic preservation databases and/or inventories to determine and direct adequate survey coverage for historic, architectural, and archeological properties.
5. At any given time during the development of the Design Plan for a project undertaking, USACE may seek input from the Consulting Parties as appropriate.

B. DEFINE AND DOCUMENT THE AREA OF POTENTIAL EFFECTS

1. USACE shall identify and document the APE, as defined in Attachment C, appropriate to the scope and scale of the Design Plan, for project undertakings as identified through Stipulation IV.A. The APE information will include but is not limited to, the following:
    a. The vertical and horizontal extents (i.e., breadth and depth), if available, of all construction activities required to complete the project undertaking, including staging areas, access routes, borrow areas, and areas of anticipated erosion.
    b. Areas outside of the construction areas of the project undertaking where the undertaking's potential direct, indirect, or cumulative effects to historic properties may be reasonably anticipated and will include areas of auditory and visual effects.
2. USACE will provide the Consulting Parties an electronic copy of the APE documentation and results of the USACE background review as described in Stipulation IV.A via e-mail for a 30-business day review period.
3. USACE is responsible for defining and documenting a final APE, including any modification to the APE resulting from a change in scope and scale of the Recommended Plans, for project undertakings.

4. USACE will provide the APE and results of the background research to the archeological contractor hired to perform the field survey, analysis, and documentation of the survey results and recommendations.

C. HISTORIC PROPERTY IDENTIFICATION

1. USACE will hire or will task a contractor to hire an archeologist (qualified per Stipulation IIA) to complete and document historic property identification efforts and NRHP-eligibility recommendations for all properties within the APE for the project undertaking prior as follows.
2. The archeologist shall complete a literature review of the APE where not adequate in the background review provided by USACE.
   a. The literature review shall include consulting the Kansas state historic inventory and archeological site files, previous survey reports, historic contexts, and other pertinent documents of the appropriate state for information on previously developed historic contexts, recorded historic properties, and previously surveyed areas.
   b. USACE, using information and documentation compiled by the archeologist, will determine adequacy of existing documentation and determine the scope of any additional research or surveys within the project undertaking's APE, including the need for additional historic context development and/or re-evaluation of any previously identified historic properties or properties previously determined to be eligible for listing on the NRHP.
   c. USACE shall provide the Consulting Parties the results of the literature review, including cultural resource reports, maps, and pertinent documents for a review and comment period of 30 business days prior to the initiation of archeological fieldwork. Submissions will conform to the requirements of each applicable Consulting Party in accordance with Stipulation IIB).
3. In consultation with the Consulting Parties, archeological surveys may appropriately exclude land shown to be recently accreted or disturbed to an extent that it is unlikely that intact cultural resources would be present in the area.
   a. Documentation for excluding such land will be provided to Consulting Parties in advance of the cultural resource survey report.
   b. If a Consulting Party disagrees with the determination on lands that are excluded from survey, USACE shall consult with the Consulting Party for no more than 30 business days to reach resolution.
   c. If resolution cannot be reached, USACE shall follow the dispute resolution procedures in Stipulation IX.
4. Following consultation on the literature review results, the contractor will also take appropriate measures necessary to identify and record historic properties through historic property surveys and testing within the APE. USACE shall ensure that:

a. All state survey guidelines and testing are followed.
b. All properties will be recorded meeting or exceeding minimum criteria for recordation, such as buildings, structures, objects, linear resources, landscapes, districts, Traditional Cultural Properties/Places, archeological/historical sites, and burial sites.
c. Recordation of structures, buildings, objects, districts, and sites shall be prepared using the appropriate Kansas state recordation forms and processes.

5. Pursuant to 36 CFR § 800.4(a)(4), historic property identification efforts shall include USACE contacting the Tribal Historic Preservation Offices (THPOs), or other appropriate Tribal representative of Indian Tribes for the project undertaking, to assist in identifying properties within the APE, which may be of religious and cultural significance and may be eligible for listing on the NRHP.
6. USACE shall ensure that all surveys and field studies are conducted in a manner consistent with the Secretary of the Interior's Standards and Guidelines for Identification and Evaluation; see Stipulation II.B.
7. USACE shall ensure that the results of these identification efforts, including reports and supporting documentation, are prepared in accordance with Stipulation II.B.
8. In consultation with Consulting Parties, USACE shall evaluate the contractor's cultural resources report for its methodological completeness to ensure that cultural resources that are within the APE of the project undertaking areas are evaluated for eligibility for the NRHP pursuant to NRHP criteria (36 C.F.R. Part 60.4).
9. USACE shall provide the Consulting Parties appropriate site identification effort documentation, NRHP determinations, and effects determination for a review period of 30 business days. If no comment is received, USACE will assume that the Consulting Parties have no objection to the reports.

D. ASSESSMENT OF EFFECTS TO HISTORIC PROPERTIES—USACE shall assess potential adverse effects caused by the project undertaking on all identified historic properties within the APE. This assessment shall include consideration of all direct, indirect, and cumulative effects caused by the project undertaking, and shall use the criteria of adverse effects (36 CFR § 800.5(a)(1)). USACE shall make one of the following findings as a result of its historic property identification efforts:

1. "No Historic Properties Affected."
   a. If USACE finds that either there are no historic properties identified within the APE or there are historic properties within the APE and the project undertaking will have no effect upon them as defined in 36 CFR § 800.16(i) then the USACE shall make a "No Historic Properties Affected" finding and provide this finding, along with supporting documentation, in accordance with 36 CFR § 800.11(d), to the Consulting Parties.
   b. For project undertakings with a finding of "No Historic Properties Affected,"

USACE shall provide the Consulting Parties information including the following for a 30 business day review and comment period:

(1) A full description of the project undertaking, to include anticipated depth and amount of ground disturbance, as well as above-ground impacts.

(2) An APE map and narrative description of the APE for the project undertaking.

(3) A description of the steps taken, and justification for the level of effort, to identify historic properties within the APE.

(4) Results of historic property identification efforts completed by the contractor, including an appropriate level of documentation, to include reports, forms, evaluations, eligibility recommendations, or other documents supporting USACE's NRHP eligibility determinations.

(5) Any photos, additional maps, images, or plans, as appropriate.

(6) A stated finding of "No Historic Properties Affected" for the project undertaking and request for comment on said finding from Consulting Parties.

c. USACE shall take any comments received from Consulting Parties into consideration and will notify the other Consulting Parties of these concerns and the USACE response to them. Any objections to this historic property determination will be addressed by USACE in accordance with Stipulation IV.D.1.f, below.

d. Consulting Parties shall provide a response to a USACE finding within 30 business days of receipt of a fully documented "No Historic Properties Affected" finding. If no comments or requests for an extension are received from the Consulting Parties within the 30-business day review period, USACE will assume they have no objection with the finding.

e. If Consulting Parties have no objection with the "No Historic Properties Affected" finding for a project undertaking, USACE has no further obligations under this Stipulation.

f. If a Consulting Party objects to the finding of "No Historic Properties Affected" due to identification efforts, finding of effect, or both within the 30-business day review period, USACE shall notify all Consulting Parties and consult with the objecting party, to attempt to resolve concerns as identified by the objecting party.

(1) USACE may, based on comments received from Consulting Parties, revise its finding of "No Historic Properties Affected." If USACE revises its finding to a different finding for the project undertaking, then the USACE shall continue consultation pursuant to the appropriate stipulation

(2) If at the end of the 30-business day review period, or agreed-to specified time, the objecting Consulting Party(ies) concur or have no objection with the finding of "No Historic Properties Affected," USACE shall document

this response, and USACE has no further obligations for the project undertaking under this stipulation.

(3) If at the end of the 30-business day review period, or agreed to specified time, the Consulting Party(ies) object to the finding of "No Historic Properties Affected" and the USACE has not altered its effects determination, USACE shall seek the ACHP's opinion in accordance with 36 C.F.R. § 800.4(d)(ii-v).

(4) If there is a disagreement between USACE and a SHPO regarding NRHP eligibility of a property after consultation between consulting parties, USACE will forward the determination to the Keeper of the NRHP, pursuant 36 CFR § 800.4(c)(2), for a formal determination of eligibility. If an Indian tribe that attaches religious and cultural significance to a property off tribal lands does not agree with USACE's determination eligibility, following consultation with USACE, it may ask the ACHP to request the agency official to obtain a determination of eligibility from the Keeper..

2. "No Adverse Effect to Historic Properties."

a. If USACE determines that historic properties present in the APE will be affected by a project undertaking but the characteristics of the historic properties that qualify the properties for inclusion in the NRHP are not diminished or altered, then USACE shall make a "No Adverse Effect to Historic Properties" finding and provide this finding, along with supporting documentation, in accordance with 36 CFR § 800.11(e), to the Consulting Parties for review and comment.

b. For project undertakings with a finding of "No Adverse Effect to Historic Properties," USACE shall provide the Consulting Parties with the following for a 30 business day review and comment period:

(1) A full description of the project undertaking, to include anticipated depth and amount of ground disturbance, as well as above-ground impacts.

(2) An APE map and narrative description of the APE for the Study undertaking.

(3) A description of the steps taken, and justification for the level of effort, to identify historic properties within the APE.

(4) Results of historic property identification efforts completed by the contractor, including an appropriate level of documentation to include reports, forms, evaluations, eligibility recommendations, or other documents supporting USACE's NRHP eligibility determinations.

(5) Any photos, additional maps, images, or plans, as appropriate.

(6) A description of the affected historic properties including information on the characteristics that qualify them for the NRHP.

(7) A description of the undertaking's potential effects on the identified

historic properties and explanation of why the criteria of adverse effect were found inapplicable.

(8) A stated finding of "No Adverse Effect to Historic Properties" for the project undertaking and request for comment for said finding from Consulting Parties.

c. USACE shall take any comments received from Consulting Parties into consideration and will notify the other Consulting Parties of these concerns and the USACE response to them. Any objections to this historic property determination will be addressed by USACE in accordance with Stipulation IV.D.2.f below.

d. Consulting Parties shall provide a response to a USACE finding within 30 business days of fully documented "No Adverse Effect to Historic Properties" finding. If no comments or requests for an extension are received from the Consulting Parties within the 30-business day review period, USACE will assume they have no objection with the finding.

e. If Consulting Parties have no objection with the "No Adverse Effect to Historic Properties" finding for a project undertaking, USACE has no further obligations under this Stipulation.

f. If a Consulting Party objects to the finding of "No Adverse Effect to Historic Properties," USACE shall notify all Consulting Parties and consult with the objecting party (ies), for no more than a total of 30 business days, upon receipt of the notification of non-concurrence to attempt to resolve concerns as identified by the objecting party.

(1) USACE may, based on the comments provided by Consulting Parties, revise its finding of "No Adverse Effect to Historic Properties." If USACE revises its finding to a different finding for the Study undertaking, then the USACE shall continue consultation pursuant to the appropriate stipulation.

(2) If at the end of the 30 business day review period, or an agreed to specified time, the objecting party(ies) concur with the finding of "No Adverse Effect to Historic Properties," USACE shall document this concurrence, and USACE has no further obligations under this stipulation for the specific Study undertaking.

(3) If at the end of the 30 business day review period or agreed-to specified time, the Consulting Party(ies) continue to object to the finding of "No Adverse Effect to Historic Properties," and USACE has not altered its effects determination, USACE shall seek ACHP's opinion in accordance with 36 C.F.R. § 800.5(c)(2).

3. "Adverse Effect to Historic Properties."

a. If USACE determines that historic properties present in the APE will be affected by the project undertaking and the characteristics of the historic properties that qualify them for inclusion will be diminished or altered, then

USACE shall make an "Adverse Effect to Historic Properties" finding and provide this finding, along with supporting documentation, in accordance with 36 CFR § 800.11(e), to the Consulting Parties for review and comment.

b. A project undertaking with a finding of "Adverse Effect to Historic Properties," USACE shall provide the Consulting Parties with the following for a 30 business day review and comment period:
   (1) A full description of the Study undertaking, to include anticipated depth and amount of ground disturbance, as well as above-ground impacts.
   (2) An APE map and narrative description of the project undertaking.
   (3) A description of the steps taken, and justification for the level of effort, to identify historic properties within the APE.
   (4) Results of historic property identification efforts completed by the contractor, including an appropriate level to include reports, forms, evaluations, eligibility recommendations, or other documents of documentation supporting USACE's NRHP eligibility determinations.
   (5) Any photos, additional maps, images, or plans, as appropriate.
   (6) A description of the affected historic properties including information on the characteristics that qualify them for the NRHP.
   (7) A description of the project undertaking's potential effects on the historic properties and an explanation of why the criteria of adverse effect were found applicable or inapplicable.
   (8) A stated finding of "Adverse Effect to Historic Properties" and request for comment for said finding from the Consulting Party(ies).

c. USACE shall take any comments received from Consulting Parties into consideration and will notify the other Consulting Parties of these concerns and the USACE response to them. Any objections to this historic property determination will be addressed by USACE in accordance with Stipulation IV.D.3.f below.

d. Consulting Parties shall provide a response to a USACE finding within 30 business days of fully documented "Adverse Effect to Historic Properties" finding. If no comments or requests for an extension are received from the Consulting Parties within the 30-business day review period, USACE will assume they have no objection with the finding.

e. If Consulting Parties have no objection with the "Adverse Effect to Historic Properties" finding for a project undertaking, then USACE shall follow Stipulation IV.E.

E. RESOLUTION OF ADVERSE EFFECTS

   1. USACE shall notify the Consulting Parties and the public on a finding of "Adverse Effect to Historic Properties" for a project undertaking using the following process:

a. For public awareness, per Stipulation III (Confidentiality), USACE shall post a notice of the "Adverse Effect to Historic Properties" finding on the official Kansas City District USACE website, as appropriate, to include a description of the project undertaking, a list of identified historic properties, the explanation for the finding of adverse effects, steps taken or considered by USACE to avoid or minimize the adverse effects, any Consulting Party comments received by USACE regarding the Study undertaking, and an invitation to provide written comment within 30-business days of posting to the website.
b. USACE shall take any comments received from the Consulting Parties into consideration before concluding the consultation and will notify the Consulting Parties of any concerns and USACE response to those concerns.

2. Following the review as outlined in Stipulation IV.E.1, USACE shall consult with the Consulting Parties to determine appropriate avoidance, minimization, and/or mitigation measures to resolve the adverse effect. USACE shall offer to facilitate a consultation meeting, to include Consulting Parties, within 30-business days after notification of an adverse effect finding, to discuss project undertaking alternatives to avoid, minimize, or mitigate the adverse effects, and may schedule additional meetings at its discretion.
3. If through consultation with Consulting Parties, USACE modifies the project undertaking to avoid adverse effects to historic properties within the APE, USACE shall document the alternatives and procedures utilized to eliminate the adverse effects of the proposed undertaking resulting in a revised finding of "No Adverse Effect to Historic Properties," which must receive concurrence or non-objection from the Consulting Parties. Once concurrence or non-objection is achieved, USACE has no further obligations under this stipulation for the specific undertaking.
4. If through consultation with the Consulting Parties, USACE reaches agreement to appropriately resolve the adverse effects through minimization and/or mitigation measures then the measures agreed to by USACE and the Consulting Parties shall be specified in a Memorandum of Agreement (MOA) developed and executed for the Study undertaking in accordance with 36 CFR § 800.6(b)(1) and 800.6(c) and filed by USACE with the ACHP upon execution.

V. TREATMENT OF HUMAN REMAINS AND ITEMS OF RELIGIOUS AND CULTURAL IMPORTANCE

A. USACE shall follow ACHP, State, and Tribal policy and guidance for human remains, funerary objects, sacred objects, or objects of cultural patrimony as listed in Stipulation IIB.

B. Under this PA, no investigative surveys or construction activities will be planned to knowingly disturb human remains, funerary objects, sacred objects, or objects of cultural patrimony. If any potential unmarked human burials or skeletal remains are encountered during construction activities, all ground-disturbing activities will cease within 300 feet. Should any potential findings be made, field personnel will follow instructions provided by USACE for each project to initiate identification, evaluation, and consultation efforts as outlined below.

C. If suspected human remains, funerary objects, sacred objects, or objects of cultural patrimony are encountered during field investigations, laboratory work, or during construction activities, USACE shall comply with the provisions below based on the nature of the land ownership at the time remains or objects are encountered.

1. USACE shall immediately notify appropriate law enforcement, appropriate medical examiner or coroner, applicable SHPO, Consulting Tribes, Kansas State Archaeologist, and landowner within twenty-four (24) hours, or as soon as otherwise practicable, via email or telephone.
2. USACE shall require that all work will immediately cease within a 300-foot radius from the point of discovery and require that the contractor secure the area by placing pin flags within the work area radius around the discovery.
3. USACE shall implement measures to protect the discovery from looting and vandalism. Any human remains or other items in the immediate vicinity of the discovery must not be removed or otherwise disturbed. Human remains must be covered with canvas or other natural material. Should the situation be appropriate, plastic tarping may be used on top of natural materials for protection.
4. Following other appropriate measures directed by USACE to protect the discovery from further disturbance. USACE shall consult with the Consulting Parties regarding additional steps to be followed. All human remains, regardless of ancestry, will be treated with dignity and respect.
5. If the human remains, funerary objects, sacred objects, or objects of cultural patrimony appear to be Native American, USACE will comply with all applicable federal, tribal, and state burial laws and ordinances.
6. USACE shall notify appropriate authorities and follow Kansas Unmarked Burial Sites Statute and Regulations K.S.A. 75-2741 through 75-275.
7. Measures to protect the human remains and any associated artifact(s) will remain in effect until an appropriate treatment plan for the discovery (if applicable) has been completed for the remains and associated artifacts.
8. USACE shall consider redesign of project undertakings to avoid effects to human remains and any associated artifacts(s). Work will not resume work in the vicinity of the find until the USACE has granted clearance to do so.
9. Where suspected burial sites in the absence of human remains are encountered, the USACE or its contractor will comply, as applicable, with the Kansas Unmarked Burial Sites Statute and Regulations K.S.A. 75-2741 through 75-2754.

VI. REPORTS

USACE shall ensure that all reports and other documents resulting from the actions pursuant to this PA will be provided in a format acceptable to the Consulting Parties. USACE will ensure that all such reports (e.g., identification surveys, evaluation reports, treatment plans, and data recovery reports) meet or exceed the Department of the Interior's Format Standards for Final Reports of Data Recovery (42 FR 5377-79) and the standards identified in Stipulation II.B.

VII. CURATION

A. It is USACE policy that archeological items and materials, not associated with human remains or burials, recovered from lands other than USACE fee-title, are the property of the respective landowner including private, state, federal, and other locally owned lands.

1. The collection of artifacts during survey on private property will be discouraged except in exceptional cases and with written permission from the landowner.
2. Collection of artifacts on city-owned property may occur, in consultation with the City and Smoky Hill Museum, and will be curated by the Smoky Hill Museum (specifically, Ms. Jennifer Toelle), after analysis.
3. In-field analysis and photographs should be substituted for artifact collection.

B. All records and materials resulting from the actions required by this PA shall be curated to the extent provided by law in accordance with 36 CFR Part 79, Curation of Federally Owned or Administered Archeological Collections, except those materials identified as Native American human remains and items associated with Native American burials, which would be subject to Stipulation V.

C. Subject to Stipulation VII and consistent with the USACE's property interest, USACE or its contractors, in accordance with 36 CFR Part 79, will maintain all archeological items and materials collected until any specified analyses and reviews are complete. Then they will be returned to the landowner.

VIII. PROVISIONS FOR POST-REVIEW DISCOVERIES

A. The following procedures shall be used in the event that new historic properties are discovered or new effects to historic properties occur during the construction or maintenance activities. The procedures below are intended to ensure that the undertaking is in full compliance with all applicable federal and state laws and regulations, including Section 106 of the NHPA. Contracting officer will contact USACE will inform all construction contractors and appropriate personnel of the following procedures.

1. All work within a 300-foot radius must stop immediately. USACE will notify the Consulting Parties, pursuant to 36 C.F.R. § 800.13 as well as any other affected party, of the discovery, and implement interim measures to protect the discovery from looting and vandalism. Construction may continue outside the 300-foot radius. Within forty-eight (48) hours of receipt of notification of the discovery or

as soon as practicable, the Kansas City District Tribal Liaison and archeologist shall:

a. inspect the work site to determine the extent of the discovery and ensure that work activities have halted within the 300-foot radius buffer zone;
b. clearly mark the area of the discovery;
c. implement additional measures, as appropriate, to protect the discovery from looting and vandalism; and
d. provide an initial assessment of the site's condition and NRHP eligibility to the Consulting Parties.

2. The Consulting Parties will have seven (7) business days following notification to concur or disagree with USACE's determination of the NRHP eligibility of the discovery.
3. If USACE determines that the cultural resource site or artifact is or may be eligible for the NRHP, USACE will consult with the Consulting Parties regarding appropriate measures for site treatment pursuant to 36 C.F.R. § 800.6(a). Consulting Parties will have seven (7) business days to provide their objections or concurrence on the proposed actions. These measures may include:
   a. A formal archeological evaluation of the site or resource.
   b. Invitation to Consulting Parties to visit the site.
   c. Exploration of potential alternatives to avoid the site.
   d. Preparation and implementation of a treatment plan by USACE in consultation and concurrence or non-objection with Consulting Parties.
4. If USACE, after consultation with Consulting Parties, determines the site is either an isolated find, completely disturbed by construction activities, or will not be further disturbed by construction activities, construction may resume within the 300-foot radius buffer zone.

B. In the event that human remains, funerary objects, sacred objects, and objects of cultural patrimony are encountered during construction or maintenance activities, USACE will follow all procedures as described in Stipulation V.

IX. DISPUTE RESOLUTION

A. Should a Consulting Party to this PA object at any time to any proposed Study undertakings or the manner in which the terms of this PA are implemented, USACE shall consult with such party to resolve the objection. If USACE determines that such objection cannot be resolved, USACE will forward all documentation relevant to the dispute, including USACE's proposed resolution, to the ACHP.

1. The ACHP shall provide USACE with its advice on the resolution of the objection within 30-business days of receiving adequate documentation. Prior to reaching a final decision on the dispute, USACE shall prepare a written response that takes into account any timely advice or comments regarding the dispute from the ACHP

and other Consulting Parties and provide them with a copy of this written response. USACE will then proceed according to its final decision.

2. If the ACHP does not provide its advice regarding the dispute within the thirty 30-business day comment period, USACE may make a final decision on the dispute and proceed accordingly. Prior to reaching such a final decision, USACE shall prepare a written response that takes into account any timely comments regarding the dispute from the Consulting Parties and provide them and the ACHP with a copy of such written response.

B. It is USACE's responsibility to carry out all other actions subject to the terms of this PA that are not the subject of the dispute remain unchanged.

X. SEVERABILITY

A. If any section, subsection, paragraph, sentence, clause, or phrase in this PA, for any reason, is held to be unconstitutional or invalid or ineffective, such decision shall not affect the validity or effectiveness of the remaining portions of this PA.

B. If any section, subsection, paragraph, sentence, clause, or phrase in this PA, for any reason, is held to be unconstitutional or invalid or ineffective, the Consulting Parties shall consult to determine whether an amendment to this PA is needed.

XI. TERMINATION

A. If any signatory or invited signatory to this PA determines that its terms will not or cannot be carried out, that party shall immediately consult with the other signatories to attempt to develop an amendment per Stipulation XII, below. If within 30 business days (or another time period agreed to by all signatories) an amendment cannot be reached, any signatory or invited signatory may terminate the PA upon written notification to the other signatories.

B. Once the PA is terminated, and prior to work continuing on Study undertakings covered by the PA, USACE must either (a) execute a new PA pursuant to 36 CFR § 800.14 or comply with 36 CFR part 800.4 through part 800.6 for all Study undertakings that would otherwise be reviewed under this PA. USACE shall notify the Consulting Parties as to the course of action it will pursue.

XII. AMENDMENTS

Any Signatories or Invited Signatories to this PA may at any time propose amendments, whereupon all Signatories and Invited Signatories shall consult to consider such amendment for no more than ninety (90) days. An amendment will be effective on the date a copy signed by all Signatories and Invited Signatories is filed with the ACHP.

XIII. PERIODIC REVIEW

A. USACE will provide the Consulting Parties evidence of compliance with this PA in project undertaking-specific annual reports pursuant to NEPA and Section 106 of the NHPA. This documentation shall contain the name of the project undertaking, historic properties identified, determinations of effect, avoidance procedures, and level of investigation and/or mitigation conducted with titles of all reports related to such investigation and/or mitigation which have been completed. USACE will submit the annual report on or before December 31 of each year following execution of the PA for the duration of the PA.

B. The PA shall expire ten (10) years from the date of the last signature. Five years after the execution of the PA, Consulting Parties will be invited to a virtual meeting to determine if the PA is working as intended. One (1) year prior to the expiration of the PA, the Consulting Parties shall review the PA in order to determine whether it should be reissued or allowed to expire. If the PA requires reissue, USACE shall consult with the Consulting Parties, as well as amend the PA in order to ensure compliance with the most current version of the Federal regulations implementing the NHPA.

XIV. ANTI-DEFICIENCY PROVISION

USACE's obligations under this PA are subject to the availability of appropriated funds, and the stipulations of this PA are subject to the provisions of the Anti-Deficiency Act. USACE shall make reasonable and good faith efforts to secure the necessary funds to implement this PA in its entirety. If compliance with the Anti-Deficiency Act alters or impairs USACE' ability to implement the stipulations of this PA, USACE shall consult in accordance with the amendment procedures found at Stipulation XII and termination procedures found at Stipulation XI.

XV. COMMUNICATION

USACE will provide the Consulting Parties with public meeting announcements, special releases, and notifications of the availability of report(s); comments received by USACE will be taken into account in finalizing plans for each undertaking.

XVI. EXECUTION AND IMPLEMENTATION

A. Nothing in this PA is intended to prevent USACE from consulting more frequently with the Consulting Parties concerning any questions that may arise or on the progress of any actions falling under or executed by this PA.

B. This PA may be executed in counterparts. Executed in counterparts means each party signs their own separate duplicate copy of the PA, rather than signing together on the same page of the same document.

C. Each party agrees a person may execute this document by electronic symbol or process attached to or logically associated with the document, with an intent to sign the document and by a method that must include a feature to verify the identity of the signer and the authenticity of the document, commonly referred to as verified electronic signature. Each party further agrees to accept in-person signature with ink for such party who agrees but does not wish to or have access to adequate technology to sign electronically.

D. Execution of this PA by USACE, Kansas SHPO, and the City and implementation of its terms evidence that USACE has taken into account the effects of the undertakings on historic properties and afforded the ACHP an opportunity to comment.

**PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS**

SIGNATORY

U.S. ARMY CORPS OF ENGINEERS, KANSAS CITY DISTRICT

BY: ____Date: ___________________

Andrew T. Niewohner

Colonel, Corps of Engineers

District Commander

**PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS**

SIGNATORY

KANSAS STATE HISTORIC PRESERVATION OFFICE

BY: ____Date: ___________________

Mr. Patrick Zollner, Executive Director

Kansas Historical Society

PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS

SIGNATORY

CITY OF SALINA

BY: ____Date: __________________

Martha Tasker

Director of Utilities

PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS

INVITED SIGNATORY

THE PAWNEE NATION OF OKLAHOMA

BY: ____Date: ____________________

Misty Nuttle

President, Pawnee Business Council

**PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS**

INVITED SIGNATORY

FRIENDS OF THE RIVER FOUNDATION

BY: ____Date: ____________________

Brad Stuewe

Board President

PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS

INVITED SIGNATORY

SMOKY HILL MUSEUM

BY: ____Date: __________________

Susan Hawksworth

Museum Director

PROGRAMMATIC AGREEMENT
AMONG THE
U.S. ARMY CORPS OF ENGINEERS;
KANSAS STATE HISTORIC PRESERVATION OFFICE;
CITY OF SALINA; FRIENDS OF THE RIVER; SMOKY HILL MUSEUM; AND THE PAWNEE NATION
REGARDING
THE SMOKY HILL RIVER GENERAL INVESTIGATION STUDY, SALINA, KANSAS

INVITED SIGNATORY

SALINA CERTIFIED LOCAL GOVERNMENT

BY: ____Date: __________________

Dean Andrew

Planning and Zoning Administrator

Figures and Maps

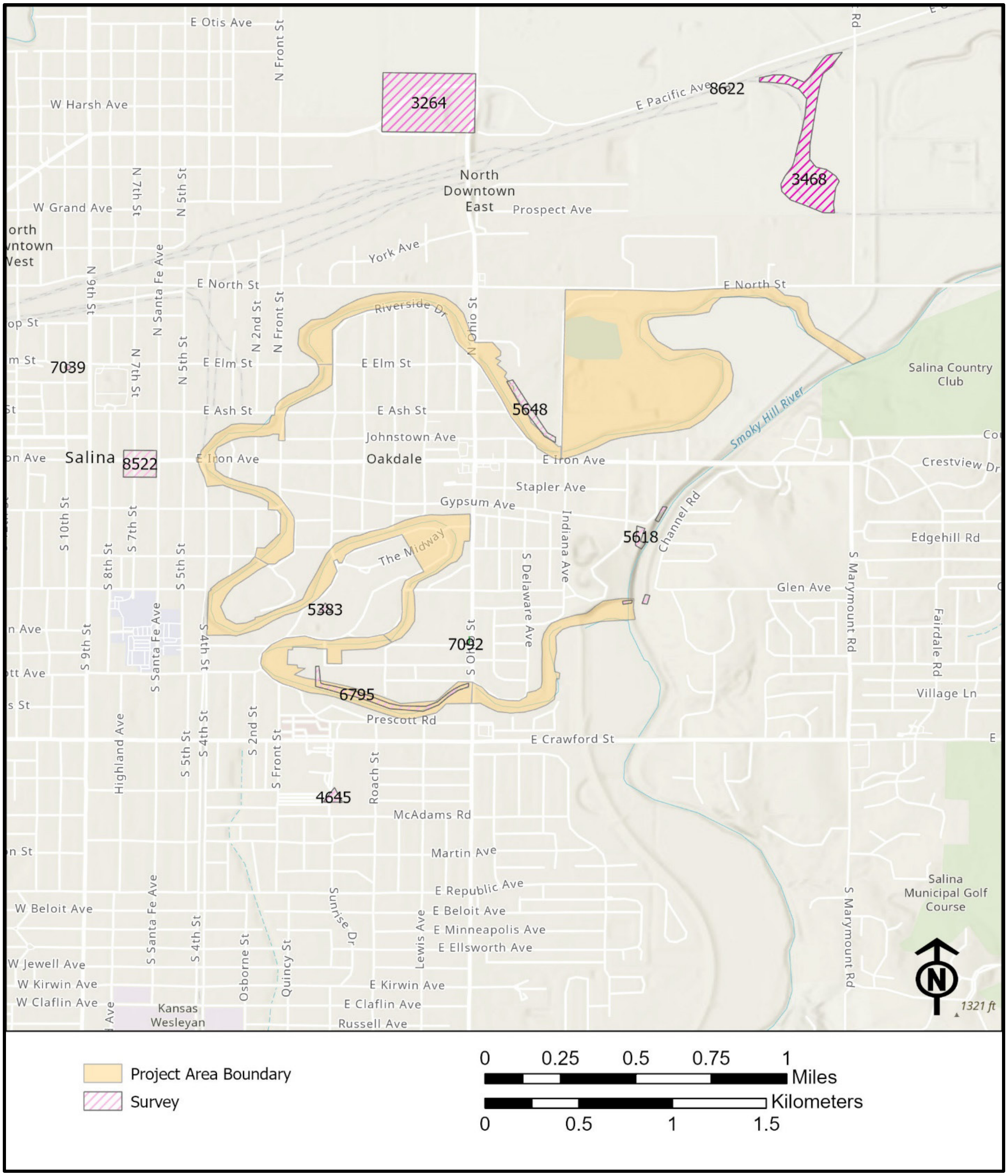


Figure 1. Map showing project area and previous cultural resources surveys. Surveys are marked with their Kansas SHPO reference numbers. Archeological site locations are not shown in public documents.

Figure 2. Lakewood Park Bridge.

Figure 3. Stone wall at the end of 3rd Street, view is to the northeast.

Figure 4. Close-up of downtown Salina showing recorded architectural resources close to project area.

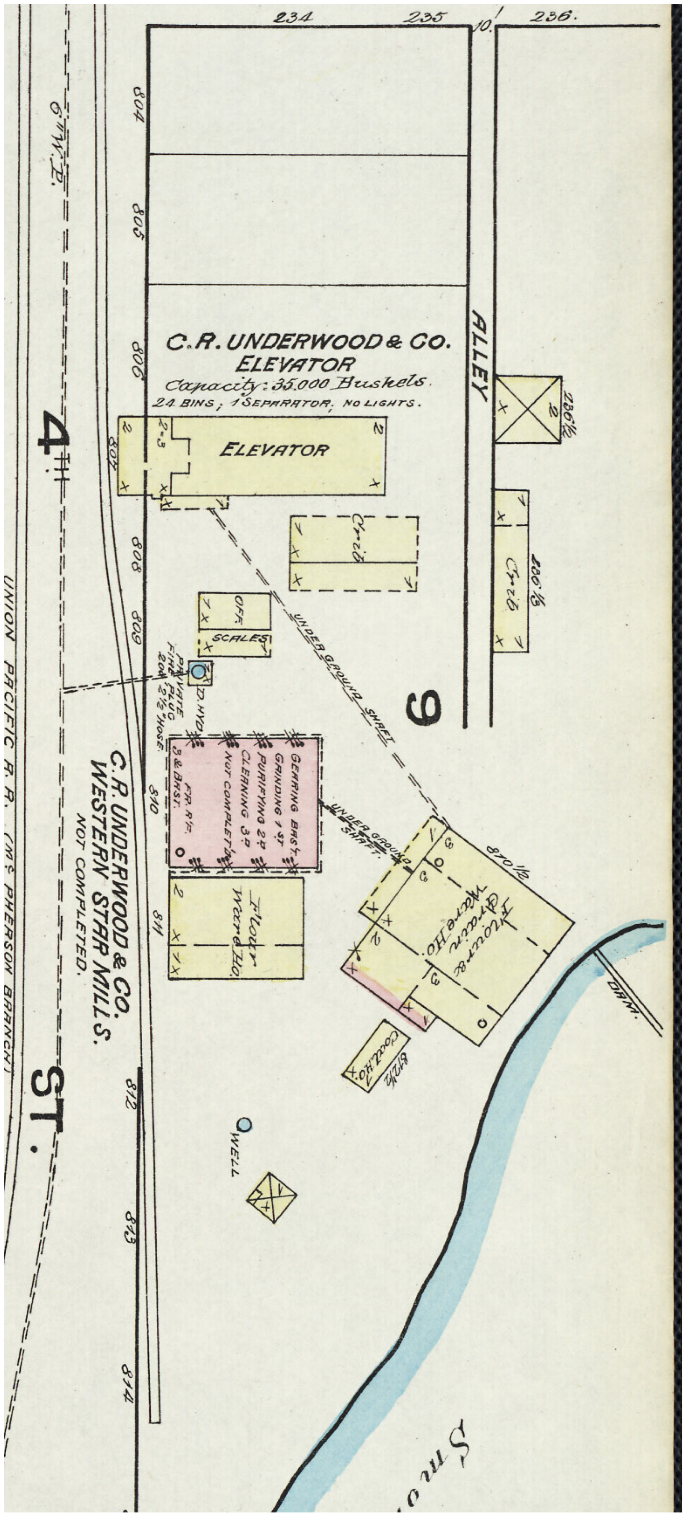


Figure 5. Excerpt from 1884 Sanborn Fire Insurance map showing the Western Star Mills (not completed) owned by C.R. Underwood and Co.

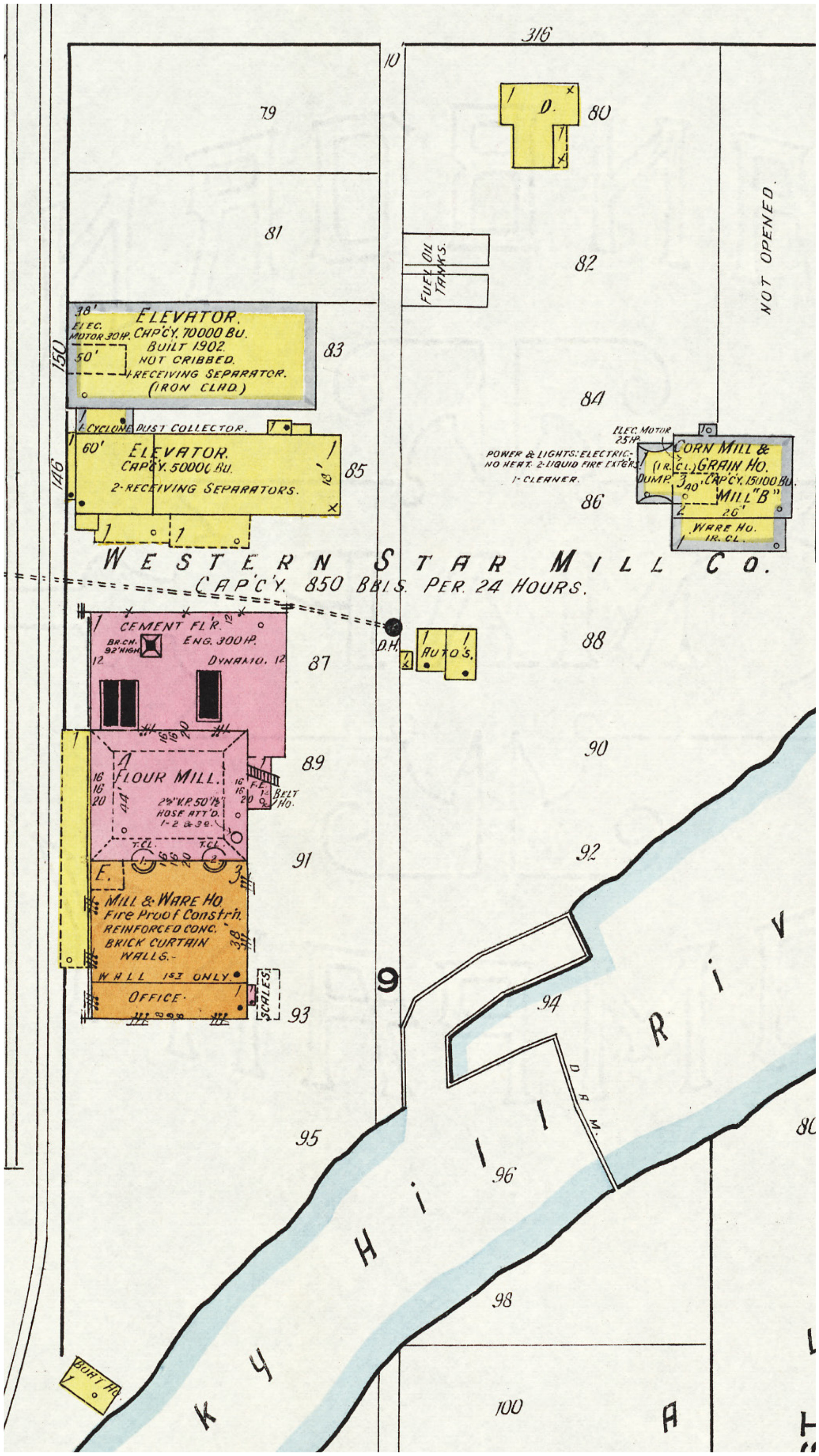


Figure 6. Excerpt from 1917 Sanborn Fire Insurance map showing the Western Star Mill Co. and dam.

Figure 7. Western Star Mill and Dam between 1920 and 1929. View is to the northwest. Photograph courtesy of Kansas Historical Society.

Figure 8. Existing Western Star Mill Dam, looking southwest, dated October 2020.

Figure 9. The existing retaining wall at the west abutment of the Western Star Mill Dam. View is to the west, dated Nov 2016.

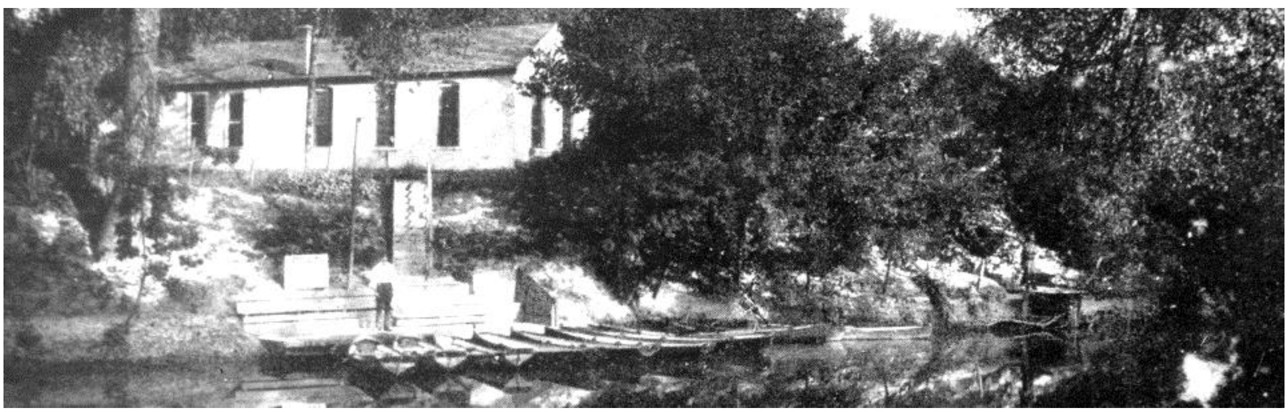


Figure 10. Commercial boat dock on the old Smoky Hill River channel, date unknown. The location is south of the pedestrian bridge at South Street.