US Army Corps
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Walla Walla District

BARBER POOL SECTION 1135 ECOSYSTEM RESTORATION

DRAFT INTEGRATED FEASIBLITY REPORT AND ENVIRONMENTAL ASSESSMENT

APPENDIX A, HYDROLOGY AND HYDRAULICS

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BARBER POOL SECTION 1135 ECOSYSTEM RESTORATION
ADA COUNTY, IDAHO
DRAFT INTEGRATED FEASIBILITY REPORT
AND ENVIRONMENTAL ASSESSMENT

APPENDIX A, HYDROLOGY AND HYDRAULICS

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	**Definition**
2D	two-dimensional
AEP	annual exceedance probability
dss	Data Storage System (file)
FCD	Flood Control District
FR/EA	Feasibility Report/Environmental Assessment
FWOP	Future without Project
FWP	Future with Project
HEC-RAS	Hydrologic Engineering Center-River Analysis System
HEC-DSSVue	Hydrologic Engineering Center-Data Storage System Visual Utility Engine
lidar	Light Detection and Ranging
Q	discharge feet^3/second
SA/2D	Storage Area / two dimensional
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers
WSE	water surface elevation

SECTION 1 - INTRODUCTION

1.1 BACKGROUND

The U.S. Army Corps of Engineers (USACE), Boise State University, and members of the Barber Pool Action Committee completed prior studies related to river hydraulics, groundwater levels and their seasonal fluctuation, sediment transport, and other topics along the Boise River. Barber Pool falls within the domain of the Boise River Flood Control District Ten (FCD 10) Two-Dimensional (2D) Hydrologic Engineering Center-River Analysis System (HEC-RAS) model prepared in 2021 that extends from Lucky Peak Dam (Lucky Peak) down to the confluence with the Snake River. The Boise reach of the FCD 10 study encompassed the Barber Pool study area. A portion of the FCD 10 model served as the starting point for the Barber Pool study. Given the focus on a smaller geographic region and the priority on water surface elevation (WSE) in the Barber Pool area, adjustments were made to set the stage for restoration measure analysis, as described below. The general objective is floodplain reconnection, riparian habitat enhancement, and fish habitat improvement. This appendix to the Barber Pool Section 1135 Integrated Feasibility Report and Environmental Assessment (FR/EA) describes how the existing FCD 10 hydraulic model was customized to inform Barber Pool ecosystem restoration discussions.

Located upstream of any municipal inputs, the Barber Pool reach has relatively high water quality and is upstream of all but a few irrigation diversions. In 1904, Barber Dam was the first on the Boise River. It is near the mouth of the canyon and many cubic yards of sediment deposited over the years. Lucky Peak, Arrowrock, Anderson Ranch Dams and the New York Canal diversion were built 1955, 1950, 1915, and 1908 respectively, and restricted sediment supply to Barber Pool. The current condition of the pool is a combination of the early sediment deposits, subsequent spillway crest elevation changes, and flow regulation. In the 1980s, the crest was lowered approximately 8 feet, lowering the river’s access to much of what had become the floodplain on the south bank of the river.

SECTION 2 - HYDROLOGY

2.1 FLOOD EVENT MAGNITUDES

Flow in Barber Pool was calculated as the difference between Lucky Peak outflow and New York Canal Diversion. The two gauged flows were determined using time series data from USACE Northwest Division Dataquery 2.0 (https://www.nwd-wc.usace.army.mil/dd/common/dataquery/www/). Time series data for Lucky Peak Outflow and New York Canal inflow were imported and differenced in HEC-Data Storage System Visual Utility Engine (HEC-DSSVue). The resulting period of record is approximately 18 years, and is shown in Figure 1. The water budget of the study area was dominated by Lucky Peak outflow, the New York Canal diversion, and outflow downstream from Barber Dam. Other inflows and outflows were not included. The Penitentiary Canal, for example, diverts from the north bank across from the New York Canal diversion but was disregarded in this study given its relatively small flow magnitude (maximum 20 cfs). New York Canal leakage through the canal embankment and blocked gate on the southern domain boundary was also disregarded partly because measures were concentrated along the main channel, not in the wetlands or open space influenced by this seepage.

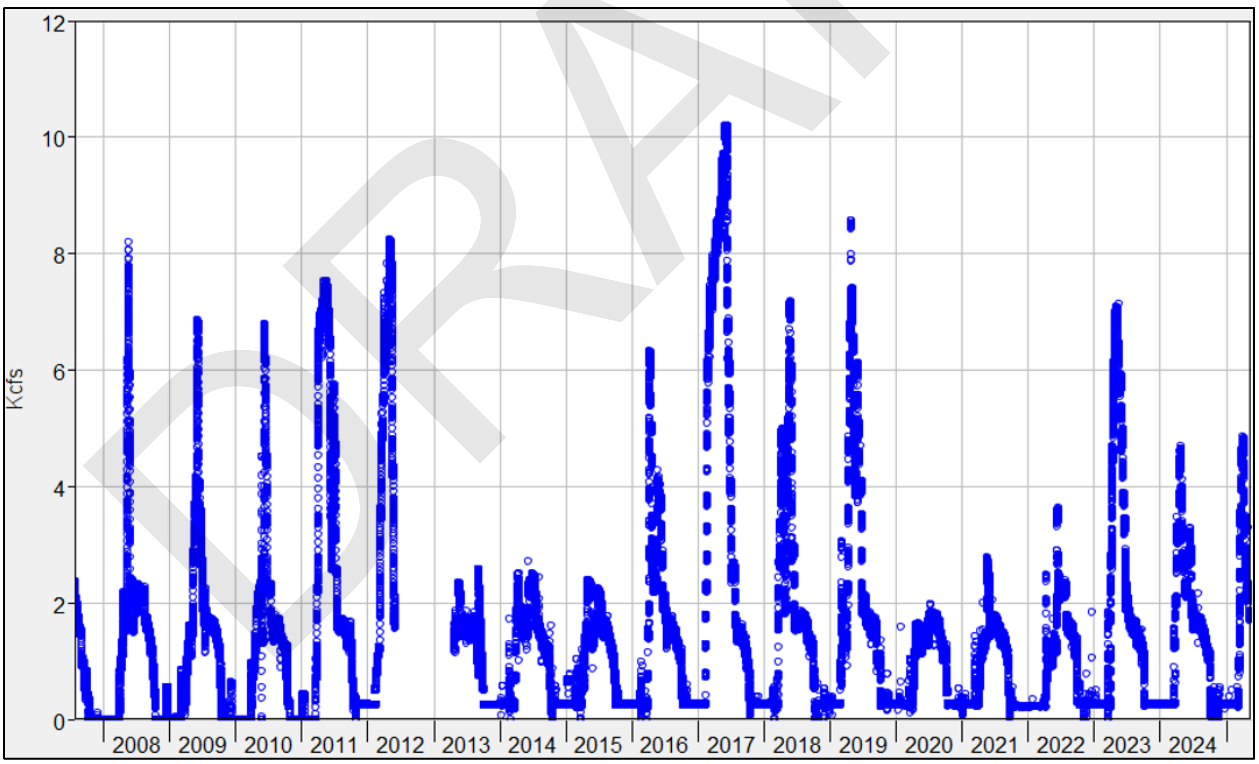

Figure 1. Calculated Flow at Barber Pool. Difference of Lucky Peak Outflow and the New York Canal Inflow after conversion to 15-Minute Time Series

Key flow magnitudes were extracted from the flow data: wintertime flow at 250 cfs, typical summer flows at 1,600 cfs, high but common flow magnitude at 4,000 cfs, and rarer but still fairly frequently occurring flow of 6,500 cfs. Higher flows (1% and 0.2% Annual Exceedance Probability [AEP] flows) were adopted from the Glenwood Gauge flow frequency curve designed by USACE in 2020 and used for the FCD 10 work (see Plate 1 at the end of Section 4). Flows modeled in this study are presented in Table 1.

Table 1. Flow Magnitudes

Flow Scenario Descriptor	Flow Magnitude (cfs)
Winter	250
Irrigation	1,600
Typical High	4,000
31% AEP	6,500
1% AEP*	16,600
0.2% AEP*	35,000

* Adopted from the Annual Regulated Peak Discharge Frequency Curve at Glenwood Bridge, May 2020

Annual peak flow magnitudes were extracted from the Barber Pool time series and a Bulletin 17c analysis was performed using HEC-Statistical Software Package (SSP) v2.3. This analysis used station skew with the low outlier threshold overridden at 100 cfs. Other settings were default. The resulting flow frequency curve fits poorly (Figure 2) and may benefit from a mixed population analysis. Nevertheless, the analysis was retained as support for classifying the 6,500-cfs flow magnitude as a return magnitude of 3.2 years. This local flow frequency analysis associates a slightly higher AEP with the 6,500-cfs flow magnitude than the Glenwood Gauge estimate of 3.8-year return interval. A simple tally of the number of times flow in the Barber Pool area exceeded 6,500 cfs in the last 13 years (see Figure 1) reveals exceedance four times, which agrees with the 3.2-year return interval estimate.

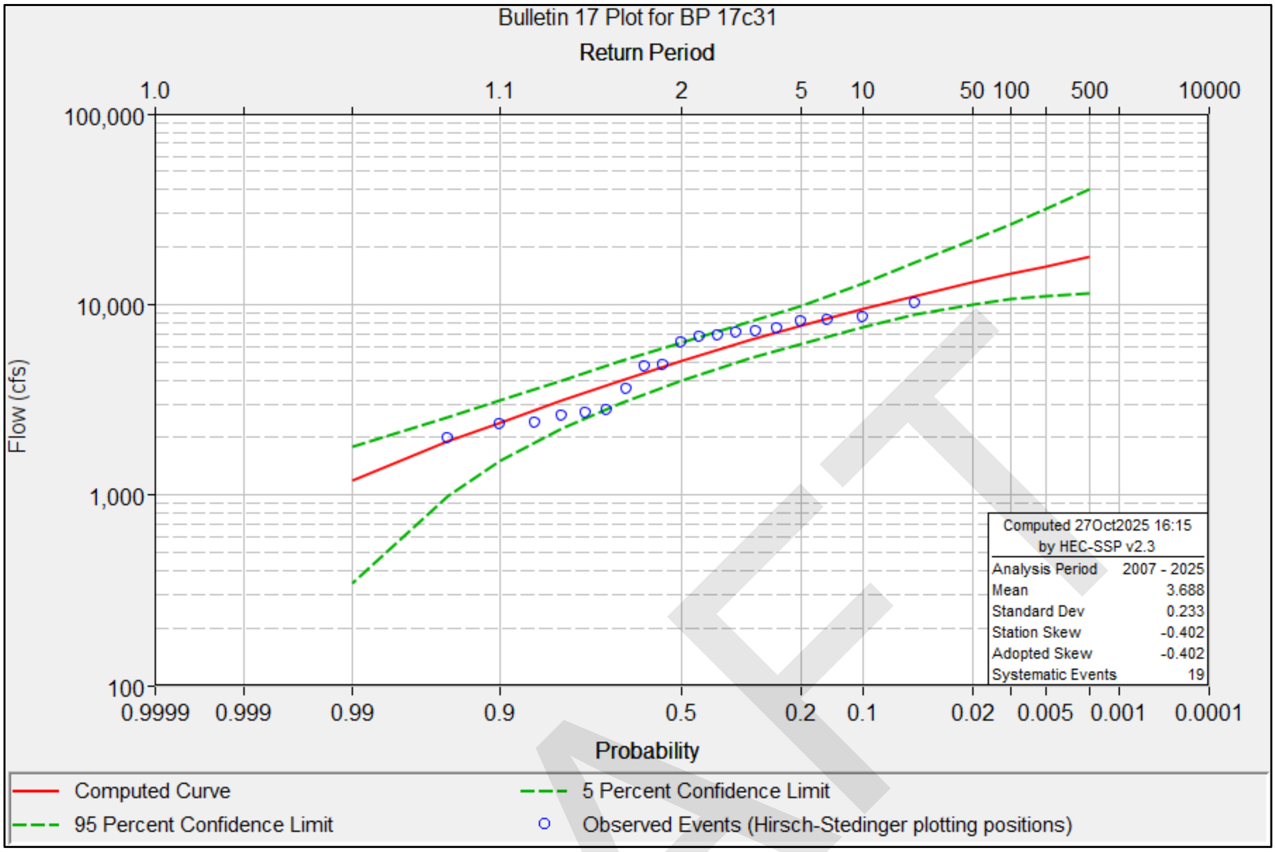

Figure 2. Flow Frequency Based on Lucky Peak Outflow - New York Canal Diversion Peaks Extracted from the Time Series Shown in Figure 1

SECTION 3 - HYDRAULICS

The Barber Pool study builds on the FCD 10 hydraulic modeling completed in September 2021 as part of a Planning Assistance to States project. Portions of this appendix were taken from that final report.

3.1 TERRAIN

Terrain data was obtained by FCD 10 through a contract with Quantum Spatial and provided to USACE. The terrain grid has a 3-foot cell size and is based on green light detection and ranging (lidar) collected November 6–11, 2019. In their lidar report, Quantum Spatial specifies absolute vertical accuracy in the non-vegetated areas at 0.15’, a vegetated vertical accuracy of 0.25’, and bathymetric vertical accuracy of 0.41’ for fully submerged with wetted edge accuracy at 0.60’.

The study terrain has buildings and tree canopy removed (bare earth). In the Barber Pool study area, the Highway 21 bridge was removed during lidar surface generation and no manual edits were necessary. Areas too deep for the green lidar were interpolated by USACE geospatial specialist to create a continuous terrain surface. One such area is immediately upstream from the Barber Dam powerhouse. The interpolation appeared to artificially raise the bed in this area, so the decision was made to lower this 0.12-acre area to the elevation of the upstream perimeter to better match field conditions as reported by personal communication with the Barber Dam operator. The modified terrain was used in the Future Without Project (FWOP) scenario. This terrain simplification near the powerhouse is displayed in Figure 3. Field verification would reduce uncertainty associated with this modification. Terrain, as is typical with 2D models, was a major contributor to model uncertainty.

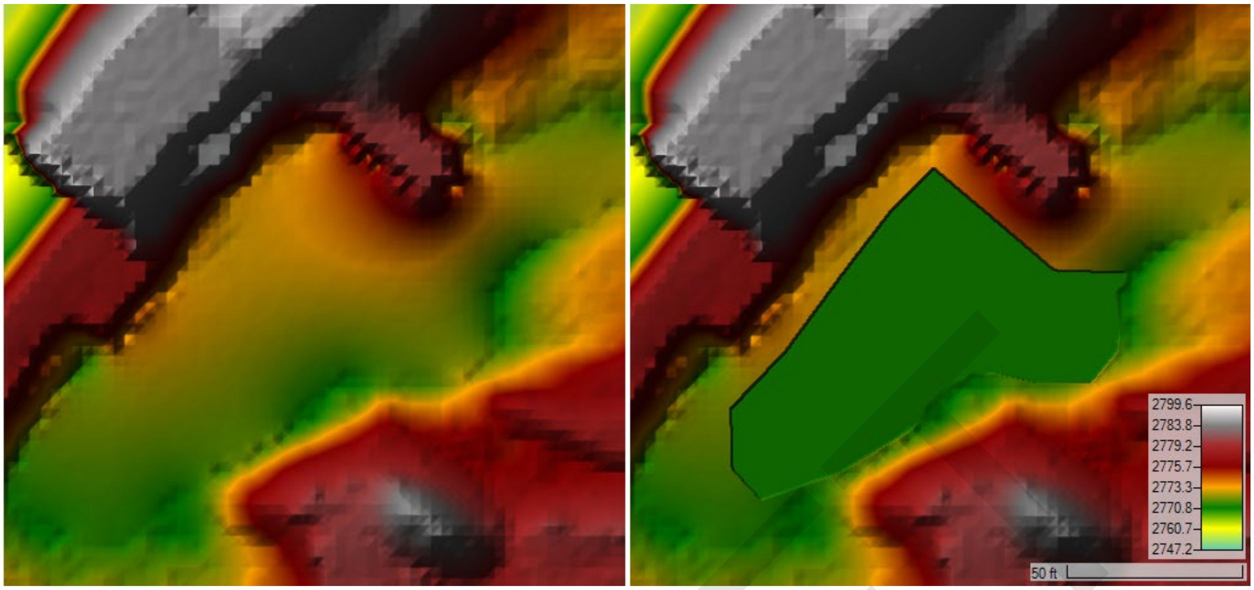

Figure 3. Terrain Simplification upstream from Barber Dam Powerhouse to Lower 0.1-acre Interpolated Area to the Elevation of Upstream Perimeter

3.2 HEC-RAS 2D MODEL

The Barber Pool RAS model was created by adapting the FCD 10 model to a smaller domain. Adjustments were made to the geometry, specifically the mesh, to capture landscape detail relevant to the Barber Pool ecosystem restoration study.

The model consists of a FWOP scenario with baseline terrain, a calibration scenario, and a Future With Project (FWP) scenario with modified terrain according to a selected set of proposed restoration measures. Each plan has associated geometries, terrains, and flow files, as presented in Table 2.

Table 2. HEC_RAS Plans and Associated Files

no.	Plan	pXX	Geometry	gXX	Flow	uXX	Terrain	Manning's n
1	1600cfs_OG_calibration check	03	Boise Reach_imported	15	BarberQ_1600cfs	34	BarberFWOP.PHLowered	Manning's n
2	4000cfs_OG_calibration check	04	"	"	BarberQ_4000cfs	20	"	"
3	6500cfs_OG_calibration check	47	"	"	BarberQ_6500cfs	28	"	"
4	250cfs_fwop1WD	32	BP1wd_fwop	10	BarberQ_250cfs1WD	7	"	"
5	6500cfs_fwop1WD	33	"	"	BarberQ_6500cfs1WD	8	"	"
6	1600cfs_fwop1WD	34	"	"	BarberQ_1600cfs1WD	10	"	"
7	4000cfs_fwop1WD	35	"	"	BarberQ_4000cfs1WD	9	"	"
8	250cfsTSP	36	TSP	11	BarberQ_250cfs1WD	7	TSPterrain	Manning's n TSP
9	1600cfsTSP	37	"	"	BarberQ_1600cfs1WD	10	"	"
10	4000cfsTSP	38	"	"	BarberQ_4000cfs1WD	9	"	"
11	6500cfsTSP	39	"	"	BarberQ_6500cfs1WD	8	"	"
12	2017calibration	40	BP1wd_fwop	10	2017_9600cfs	13	BarberFWOP.PHLowered	Manning's n
13	16600cfsTSP	41	TSP	11	16600cfs	11	TSPterrain	Manning's n TSP
14	65000cfsTSP	42	TSP	11	35000cfs	12	TSPterrain	Manning's n TSP
15	16600cfs_fwop1WD	43	BP1wd_fwop	10	16600	11	BarberFWOP.PHLowered	Manning's n
16	35000cfs_fwop1WD	44	"	"	35000cfs	12	"	"
17	4000cfs_fwop_highn	45	fwop_highn	12	BarberQ_4000cfs1WD	9	"	"
18	4000cfs_fwop_lown	46	fwop_lown	13	BarberQ_4000cfs1WD	9	"	"

3.2.1 Boundary Conditions and Hydrologic Input

Model flow rates through the Barber Pool reach were achieved by scaling a stepped hydrograph to meet the desired peak flow magnitude, this reflects the regulated hydrologic context of the study area. Flow data for the HEC-RAS model comes from the HEC-DSS Barber Pool file discussed in section 2.1.

The downstream boundary condition was defined as normal depth far enough downstream from the area of interest to minimize influence. The crest of the dam was not used as the downstream domain boundary because pool WSE depends on flow over and through the dam and is critical to proposed restoration measures located within the upstream area of dam influence.

3.2.2 Calibration

Model calibration was checked in two ways: against the 2017 high flow aerial imagery captured May 22, 2017, and by comparing model results against those produced by running the same flows in the original, calibrated FCD 10 model geometry.

Visual comparison with the 2017 aerial imagery illustrates adequate calibration. Figure 4 shows this comparison near the dam, validating the choice of how to represent the dam in the model (described below in section 3.2.5 Barber Dam Geometry). It is noteworthy that the model slightly overestimates inundation near the dam. Imagery was flown May 22, but the peak for the event occurred a few days later, on May 29. High flow after the imagery was obtained was very likely bed-shaping, scouring from the large, historic repository of aggraded sediment and redepositing closer to the dam. The 2019 lidar flight reflects the condition of the bed after the peak flows in 2017 and high flows in subsequent years. In summary, when compared with the inundation boundary produced by the 2019 lidar, the 2017 imagery represents an earlier bathymetry with a correspondingly different inundation boundary. Figure 5 below, is further upstream. The area shown encompasses most of the proposed measures subsequently described and further demonstrates good model calibration

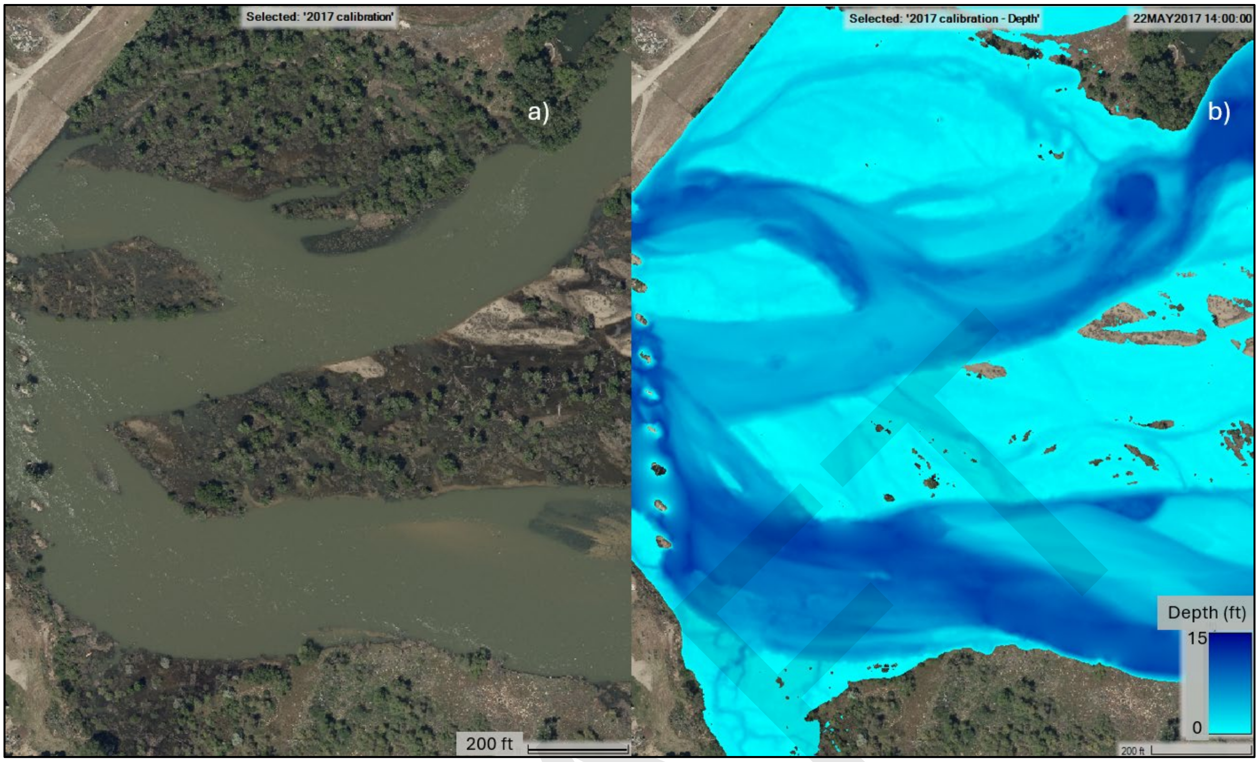

Figure 4. 2017 High Flow Aerial Imagery Comparison against the Modeled Flow Depth

This figure shows slightly more inundation predicted than actual, although shallow water is more apparent in the model than in the photo.

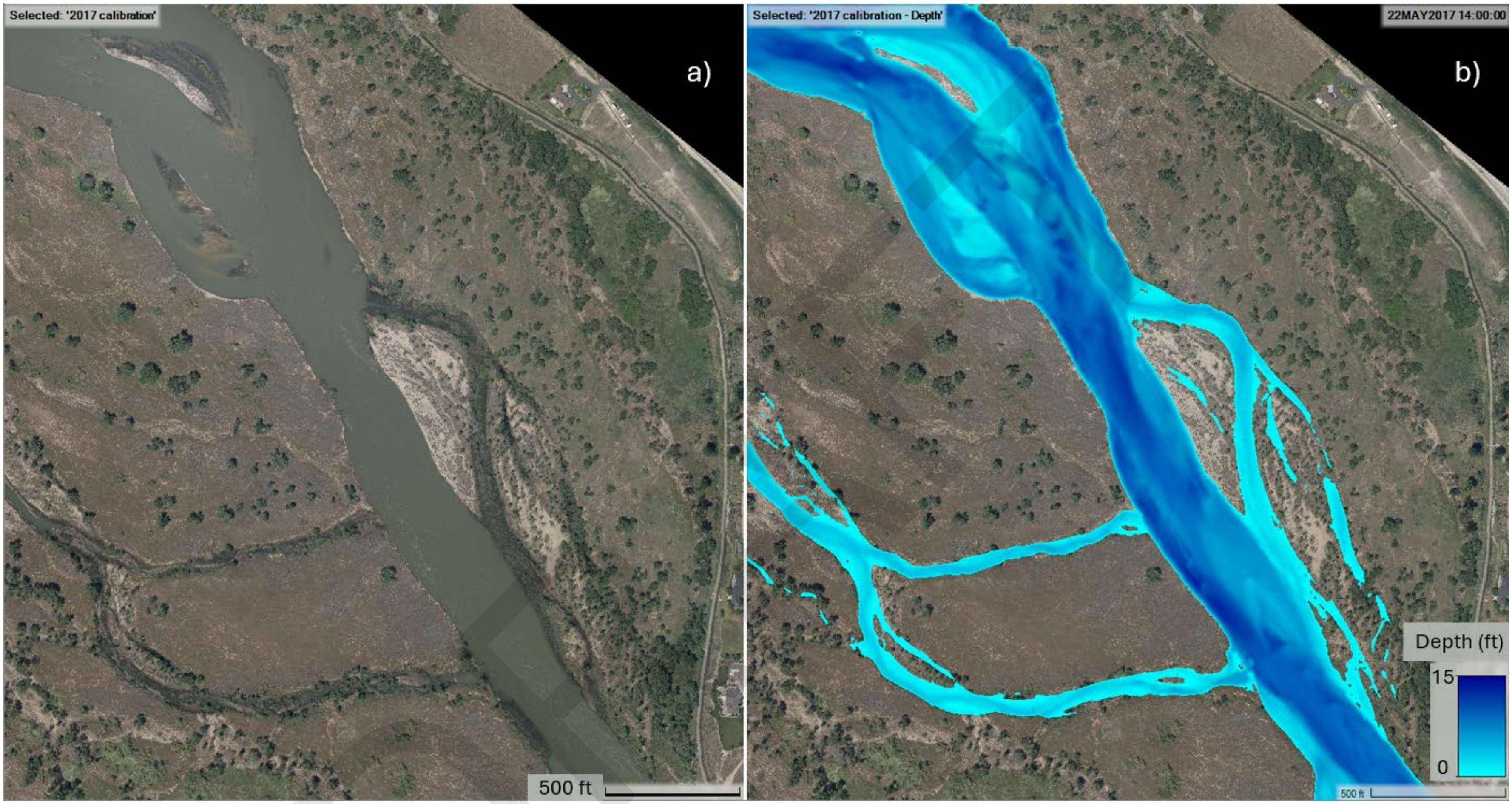

Figure 5. Fair Agreement between Modeled Inundation and Aerial Imagery Flown during a High Flow Event May 22, 2017, with Flow Magnitude 9,474 cfs

3.2.3 Model Uncertainty

Model uncertainty stems from a variety of factors including the terrain, Manning's n roughness values, and the decisions made when creating the model geometry.

For this model, the priority in accuracy was the active channel and riparian and wetland areas close to the active channel. Although less emphasis was placed on the inundation in the overbanks far from the channel, Manning's n uncertainty was quantified by varying the roughness values ±10% for the entire model domain. A higher Manning's n value means greater roughness and more flow impedance. A flow magnitude associated with floodplain reconnection given our proposed measures, 4,000 cfs, was selected to test model sensitivity to the Manning's n value. Water surface elevations along the river centerline varied on average 0.17 feet above and below the calibrated WSE for the high and low Manning's n values. Figure 6 shows the longitudinal WSE profile from this sensitivity analysis. As velocity decreases closer to the dam, the roughness values are less influential and spillway elevation dominates WSE values.

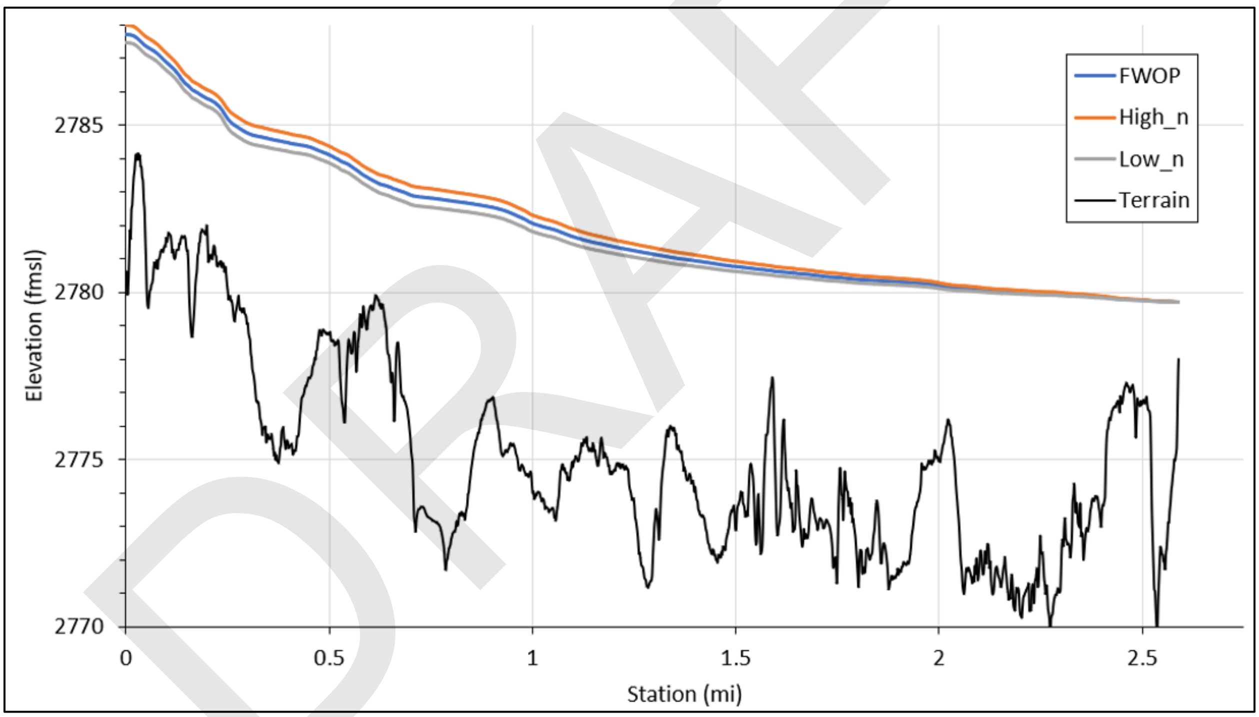

Figure 6. WSE Longitudinal Profiles Output from Various Roughness Definition Starting at the New York Canal Diversion and Extending down to the Barber Dam Spillway Crest

Computational geometry uncertainty is considered here qualitatively. The HEC-RAS computational approach allows flow to jump from one mesh cell to another, depending on relative minimum terrain elevations at the cell edges. This can happen despite the presence of a flow path between the low elevations. Depending on mesh resolution, this can place water in the landscape where it would not in reality exist. This potential inaccuracy is balanced by the assumption of an impervious bed, with no accounting for seepage, hyporheic flow (e.g., through gravel bars), or groundwater movement. Interpretation of results should account for these limitations.

Wetlands thick with aquatic macrophytes that occupy most or all of the water column are interpreted in the lidar as solid ground. Accurate wetland and marsh bathymetry would improve the model. Accounting for hyporheic flow would also improve the model, especially given the somewhat unconsolidated sediment deposit comprising most of the study area. Given the history of the large sediment deposit comprising much of the Barber Pool area it is reasonable to assume no strong or extensive impervious layers in the overbank substrate block groundwater / surface water interaction. Piezometer data collected by local scientists and consulted while developing measures confirms a response of piezometers near the New York Canal to presence of water in, and hence leakage from, this canal on the southern edge of the model domain. Similar hyporheic flow is likely throughout the study area.

3.2.4 Mesh Development

The mesh reflects the legacy of the Boise reach of the FCD 10 models. This legacy includes a background overbank mesh resolution of 80 feet. Along the main channel and in most of the study area the mesh is refined to 20 feet. Breaklines were defined along the center of the Boise River channel and significant riverbed as well as overbank elevated features. Mesh for the calibrated, FWOP, and FWP scenarios are identical.

3.2.5 Barber Dam Geometry

One significant change from the original FCD 10 model is the treatment of Barber Dam. The FCD 10 model has a breakline defined along the crest. With a smaller geographic focus and priority on the WSE in Barber Pool, the dam was converted to a Storage Area (SA)/2D structure. For the spillway crest, this change allowed precise crest elevation definition, and the weir equation could be selected to calculate flow over the spillway rather than the normal 2D equations. Furthermore, using a SA/2D structure shown in Figure 7 and Figure 9 allowed routing through the powerhouse, which locally effected WSE.

Communication with the primary operator at Barber Dam helped confirm crest elevation and other dam geometry details, as well as dam operation. According to the dam operator, the operation strategy is different during the irrigation season than the off-season. During irrigation season (assumed to be April–October), half of the incoming flow is routed through the powerhouse until the powerhouse reaches its capacity at 2,200 cfs. In the off-season, all incoming flow is routed through the powerhouse until it reaches capacity. Remaining discharge flows over the spillway. Accordingly, a rule for this dam operation was defined in the unsteady flow file for the SA/2D connection, governing flow through the powerhouse in response to discharge across a reference transect just upstream of the dam. In the rule code, the month in the flow time series was checked and flow routed accordingly. Discharge across the reference transect triggered changes in flow through the powerhouse, and the spillway was left to passively accommodate remaining flow not routed through the powerhouse.

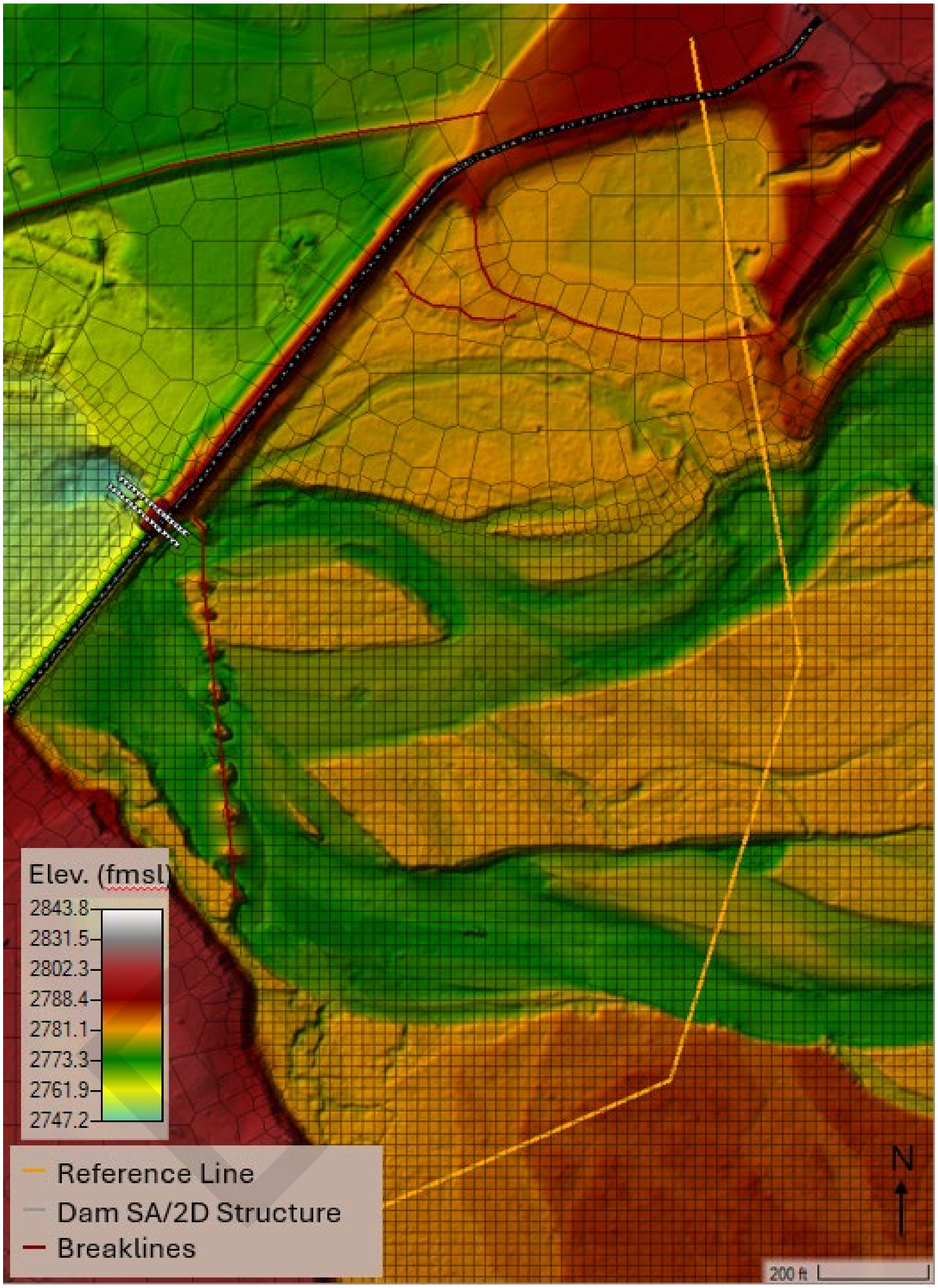

Figure 7. Barber Dam SA/2D Structure with Upstream Reference Line

Note the gates are simply for visualization, orifice flow calculation through them is overridden by the rule defined in the unsteady flow file for the SA/2D structure.

The location of the powerhouse outflow from the SA/2D structure was manually set in the powerhouse tailrace. Gate geometry on the upstream face of the powerhouse is not known. As-built drawings of the spillway crest and upstream powerhouse face were requested but not provided at the time of this documentation. It should be noted the gates are present only for visualization. Typically, orifice flow would be used to calculate flow through gates but is overridden in this case by the rule defining flow through the powerhouse. The spillway crest is not horizontal. Lidar captures the crest fairly well, but to create a smoother crest, the station elevation data were extracted in RAS Mapper. A smooth spline fit was developed in Matlab's Curve Fitting Toolbox (Figure 8), and points were copied back into the RAS geometry editor.

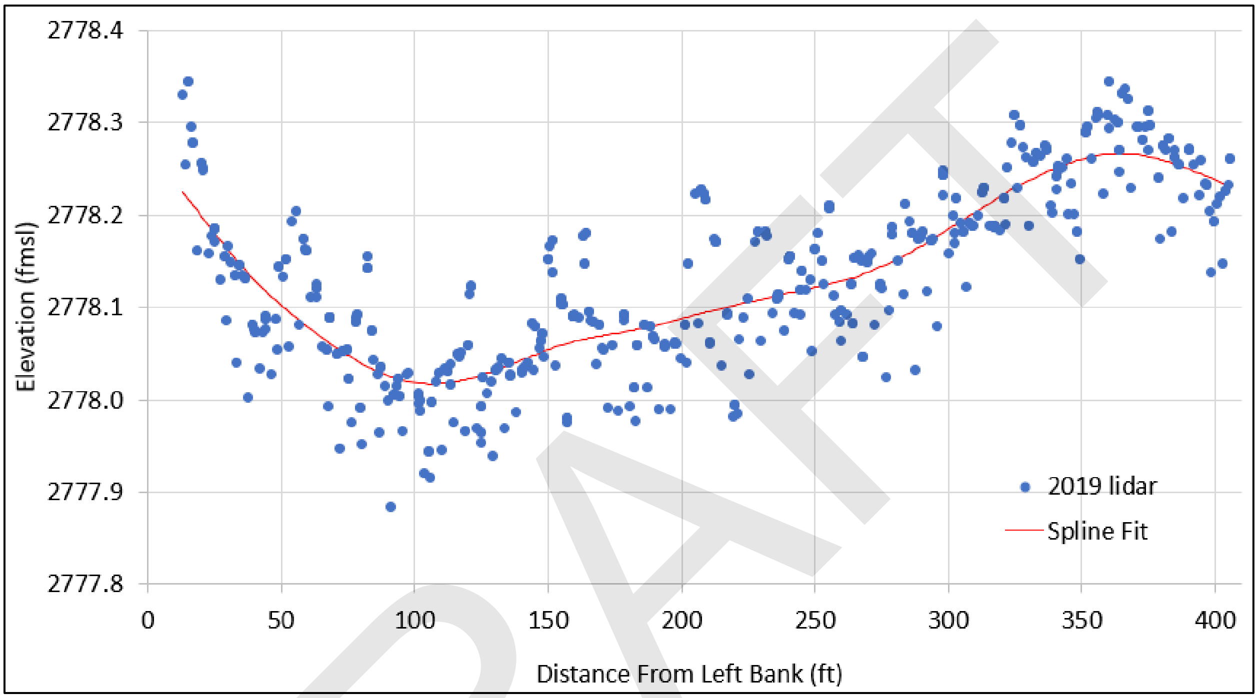

Figure 8. Barber Dam Spillway Crest Station Elevation Data Was Based on a Spline Fit to the 2019 Lidar

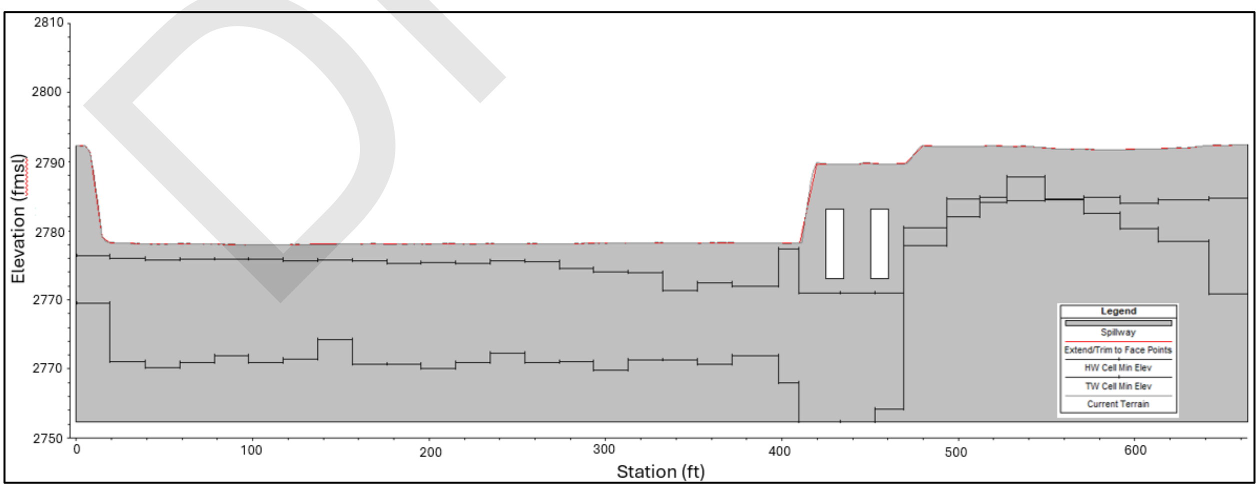

Figure 9. Barber Dam Geometry as Represented in the HEC-RAS Model

Gate geometry is included simply for visualization; flow through powerhouse is defined by an unsteady flow file rule as described in the text.

3.2.6 Future without Project Conditions

Unedited lidar terrain was used in all locations except for the area upstream from the powerhouse where an adjustment was made to the bathymetric interpolation, as noted above in Section 3.1. Although the only change between FWOP and FWP in this study is in the terrain, two other characteristics of the FWOP condition of the study area are noteworthy: sediment dynamics and regulated hydrology. These are discussed below in Section 4.4.

3.2.7 Future with Project Conditions

The full list of restoration measures and their descriptions are provided in the FR/EA. A truncated list includes:

- laying back a 600-foot section of a steep sandy bank
- repurposing excavated sediment to create terraces and narrow a portion of the over widened reach nearer the dam,
- excavation for wetlands and sloughs
- bank stabilization

Biological components are incorporated in all these restoration measures for habitat enhancement (e.g., large woody material placement). Each measure requiring excavation or fill was imposed on the lidar terrain by cloning the terrain in RAS Mapper and introducing terrain modifications. Calibration regions were defined for each measure to override the base Manning's n values for the footprint of the measure.

One consideration of note for the FWP condition is the impervious bed assumption built in to HEC-RAS and discussed above in Section 3.2.3. An example of this is the proposed side channel within what is termed Main Channel Complexity 1. The longitudinal profile showing WSEs is shown in Figure 11, and the location of this profile line along the proposed side channel is shown in Figure 12. The 250 cfs WSE line should extend through the "impervious" terrain line according to inundated wetland connection observed by walking the site in the field.

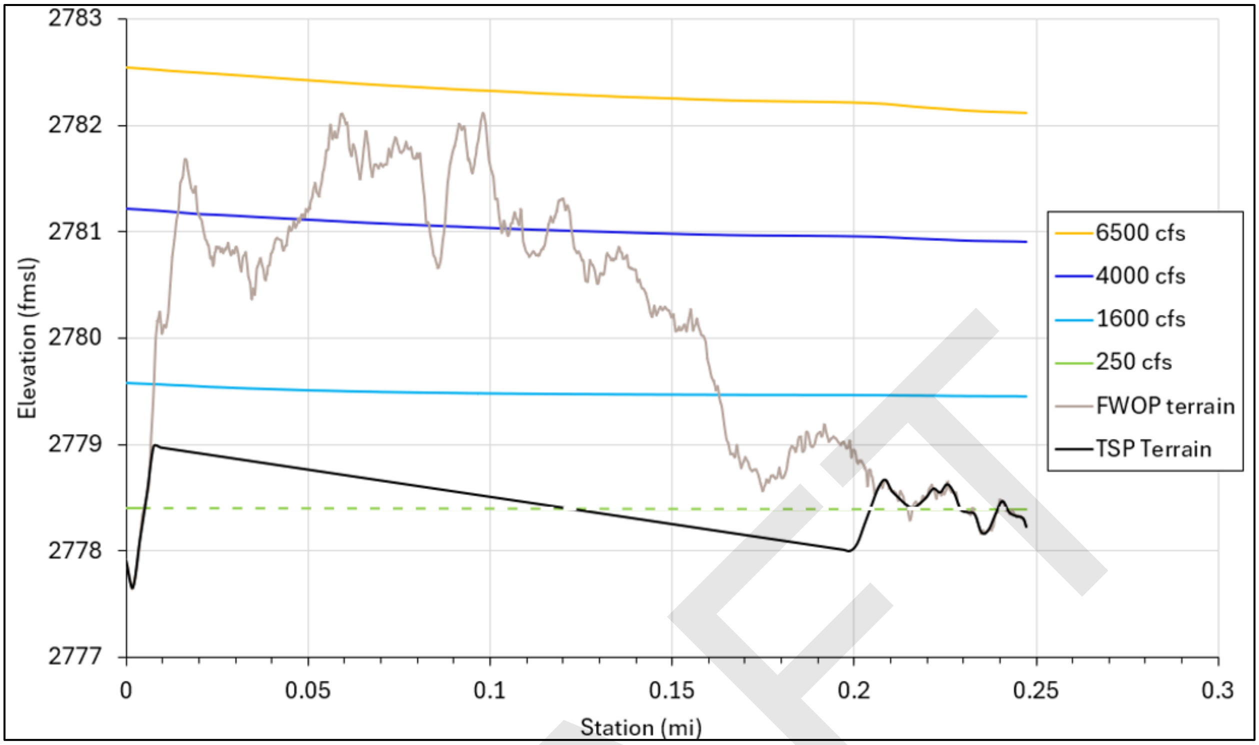

Figure 10. Longitudinal Profile of a Proposed Side Channel in Main Channel Complexity 1 (See Main Report for Description) Intended to be Active in Typical Summer Flow (1600 cfs) but Not during Winter (250 cfs)

The dashed line in Figure 10 depicts the more realistic 250 cfs WSE. The segments of solid green line at the upstream and downstream ends of the 250 cfs WSE are the HEC-RAS result that stops at the impervious terrain surface. This limited extent does not agree with greater extent of the wetland observed in the field and as flow permeates thick marsh vegetation and shallow groundwater depicted by the dashed line in Figure 10.

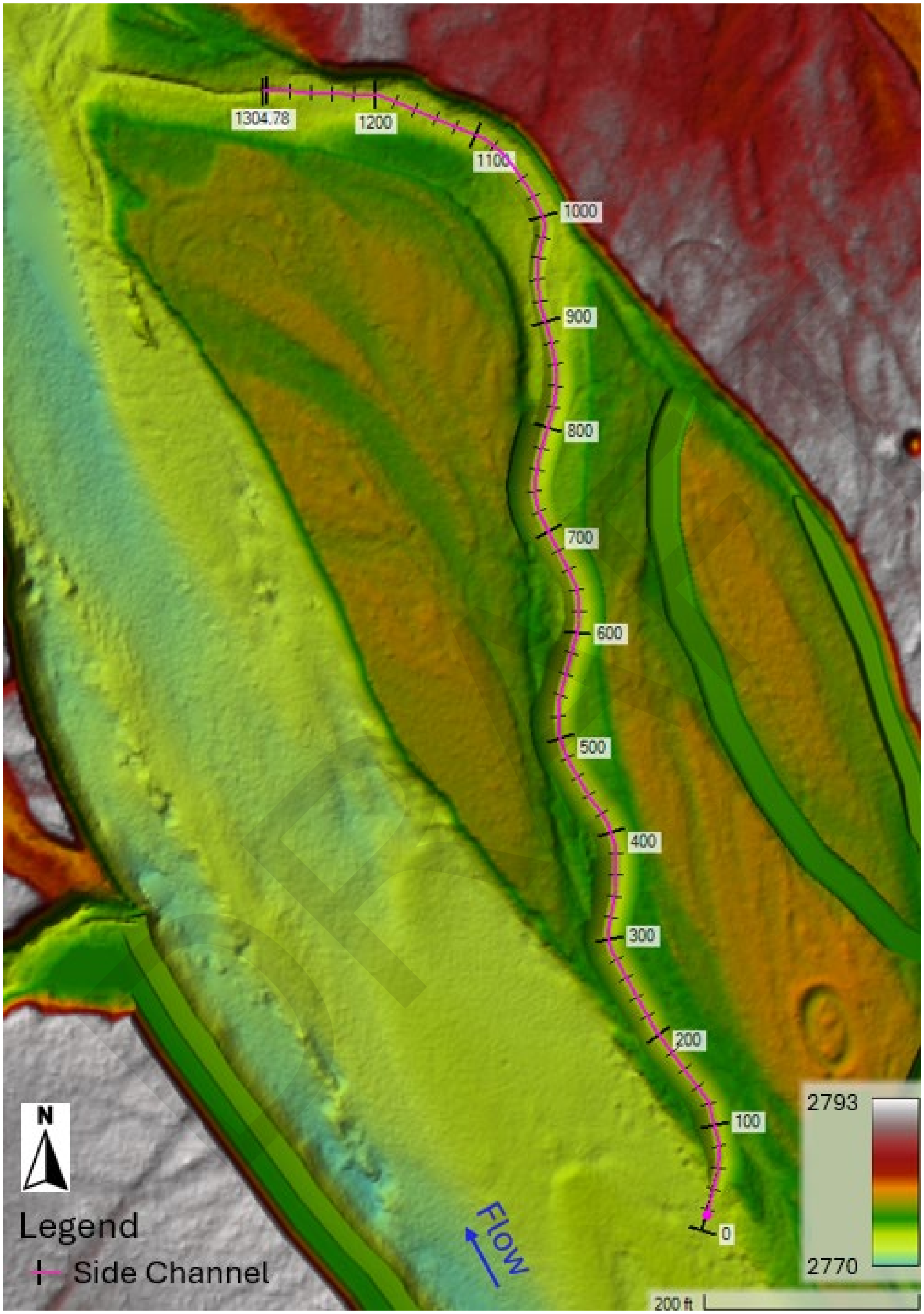

Figure 11. Proposed Side Channel on the Right Bank in Main Channel Complexity 1 Corresponding to the Longitudinal WSE Profile Shown in Figure 10.

3.2.8 Induced Flooding

In compliance with EM 1110-2-1150, flooding induced by the proposed treatments has been analyzed. This analysis primarily focused on the difference between the FWOP and FWP inundation footprints as an indicator of areas influenced by the project. In addition to inundation footprint the velocity and depth of flow was considered. Duration was not considered because of the regulated nature of the Boise River in the Barber Pool area a few miles downstream from Lucky Peak Dam. High flow duration in Barber Pool is controlled by Lucky Peak Dam outflow, which holds steady for long periods of time and was simulated with a stepped hydrograph.

3.2.8.1 Post-Processing Model Output for Induced Flooding Analysis

The inundation boundary difference analysis was conducted primarily in ArcGIS Pro after exporting the raw inundation boundaries for each flow magnitude. The FWP inundation boundary (IB) was clipped by the FWOP IB to isolate areas wetted by the FWP but not by the FWOP scenarios. The resulting areas are hereafter referred to as induced flooding polygons.

The induced flooding polygons were post-processed to remove computational and rendering artifacts. These artifacts are a result of the number of significant digits generated through the lidar data processing, and reflect an accuracy greater than the reliability of the data. A threshold depth of 0.01 ft was chosen for screening inundation polygons. Below this resolution, in the thousandths of a foot, reported values reflect computational processes (rounding, rendering, and interpolation within the RAS computation and rendering engines) rather than realistic accuracy. Depth differences greater than 0.01 ft were considered when evaluating the induced flooding, although this depth difference threshold is independent from the vertical uncertainty in both the lidar and modeling, which is discussed below.

Induced flooding was spatially analyzed in two ways: using the inundation polygons generated in RAS, and using depth rasters exported from RAS at the resolution of the underlying lidar. These two spatial model outputs were used together to analyze areas of induced flooding. Inundation polygons rely on interpolation and smoothing to represent the boundary between computational mesh cells. Raster generation also relies on interpolation, but the depth rasters reflect the resolution of the RAS depth computations more appropriately than the smoothed inundation boundaries. The Extract by Mask tool was employed in ArcGIS Pro to remove the FWOP raster cells from the FWP rasters. The remaining cells (hereafter referred to as induced flooding raster cells) were overlaid on the induced flooding polygons. Induced flooding polygons were eliminated if they were not proximal to any induced flooding raster cells at least 0.01 ft deep. Figure 12 illustrates this process for a portion of the 4,000 cfs induced flooding polygons. In this figure, green squares are induced depth raster cells with depth greater than 0.01 ft; red cells reflect depths less than 0.01 ft. If an induced flooding polygon intersected or was proximal to any green squares the induced flooding polygon was retained.

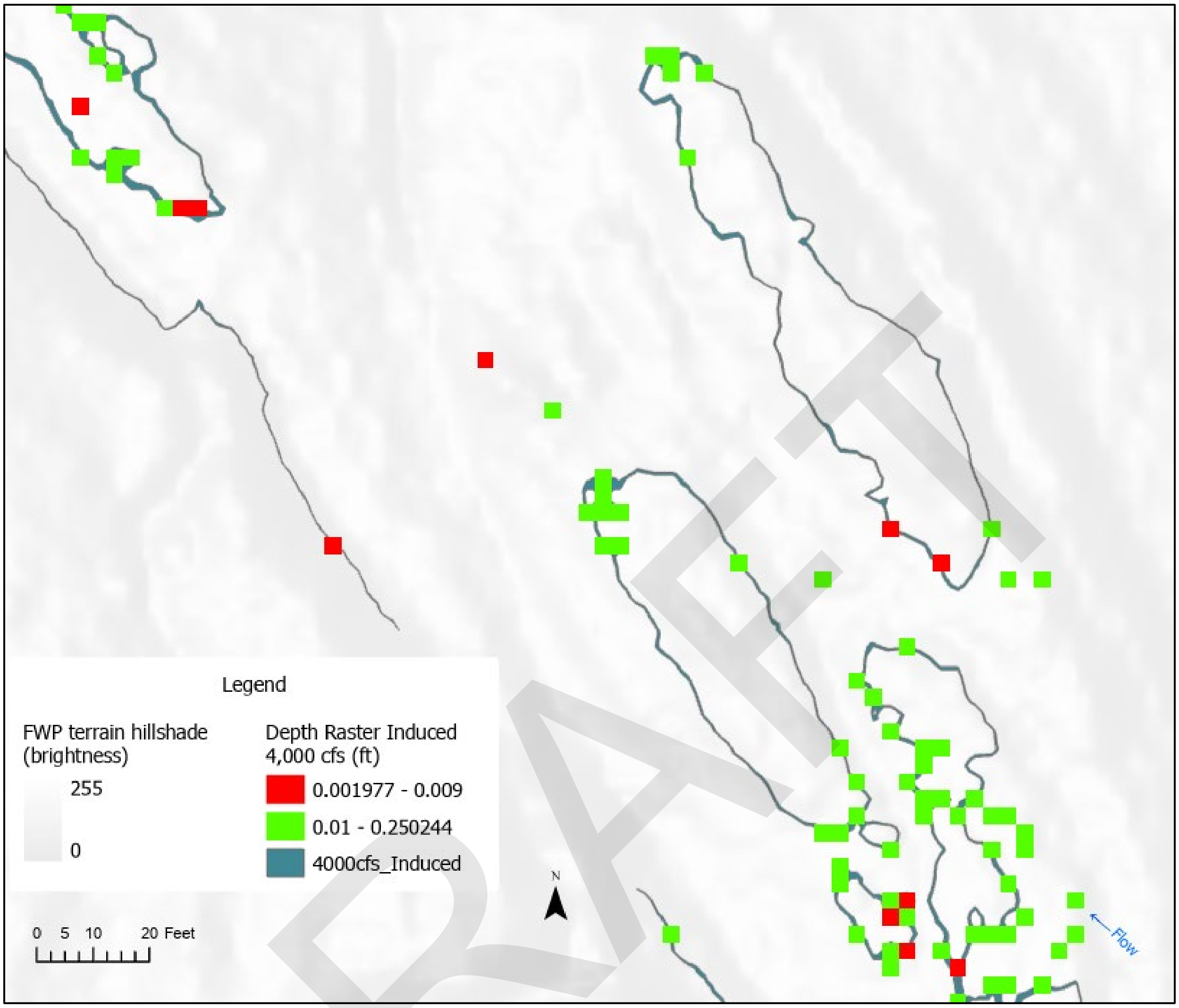

Figure 12. Depth Rasters and Induced Flooding Polygons Were Used to Evaluate Induced Flooding Polygons

Induced flooding post-processing criteria further considered mesh resolution and rendering in RAS Mapper. As flow descends the Barber Dam spillway it was rendered into angular polygons by the RAS Mapper rendering engine as shown in Figure 13. This depiction of the inundation was inaccurate and could not validly be used as a basis for evidence of an expanded footprint or depth induced by the proposed project measures. Rather than refining the mesh resolution, the artificial triangles were not included in the induced flooding analysis. In addition, isolated and disconnected pockets of inundation less than 10 ft^2 were removed from the induced flooding polygons as these are likely a result of computational mesh resolution and modeling artifacts.

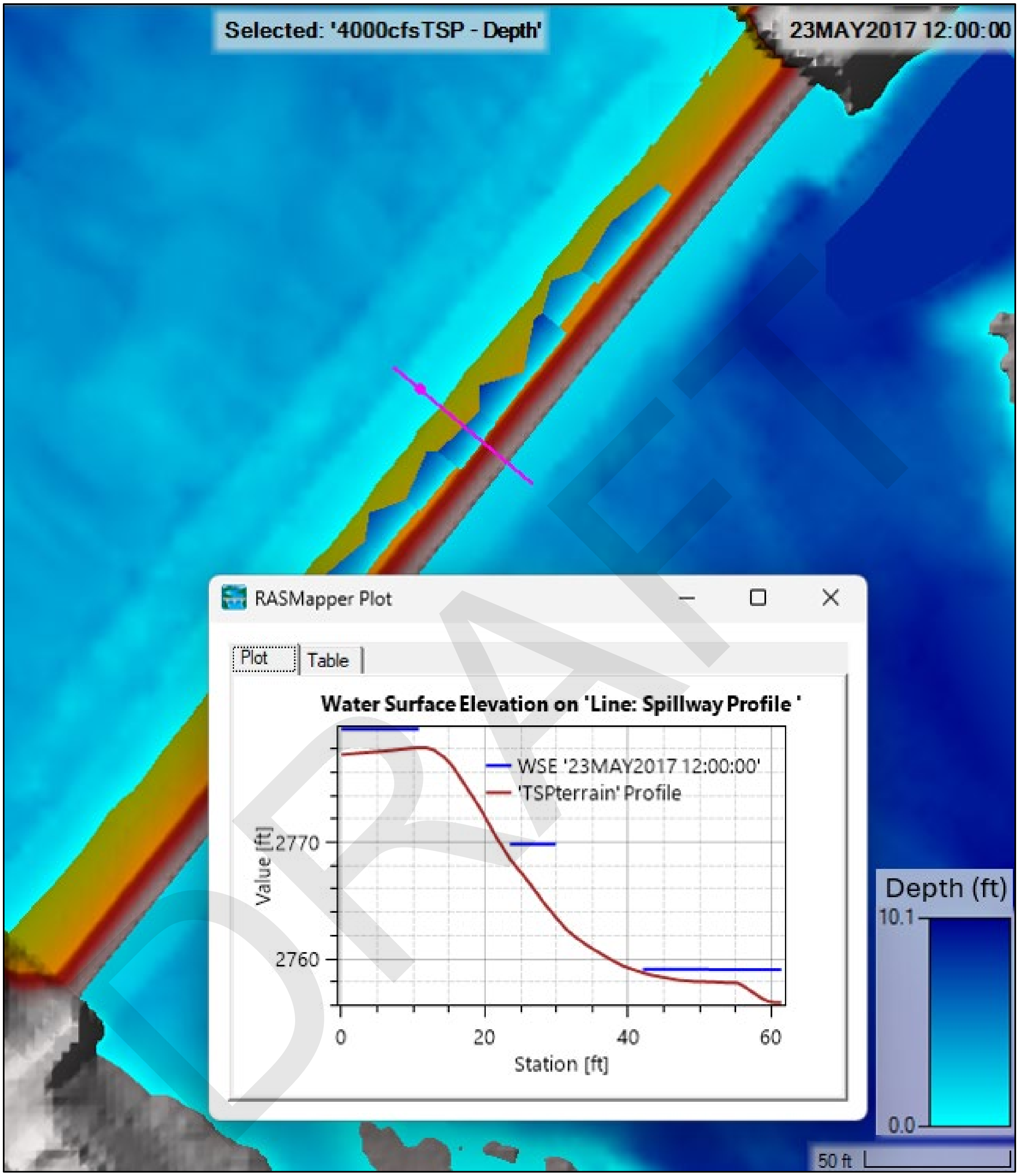

Figure 13. An Example of RAS Mapper Rendering on the Barber Dam Spillway Not Included in the Induced Flooding Analysis

In Figure 13 the inset plot is the WSE and terrain along the pink line crossing the spillway, which was drawn from the forebay over the spillway to the tailrace. The water occurring at elevation 2770 ft in the inset is an example of unrealistic inundation that was removed during post-processing.

The total area of induced flooding was determined for the tentatively selected plan (TSP). Acres of induced flooding for the various flows analyzed are shown below in Table 3. Induced flooding polygons for the various flows used in the analysis are included as figures at the end of this document.

Table 3. Induced Flooding Inundation Area Increase for the TSP

Return Interval (yr)	Q (cfs)	Inundation Area Increase* (ac)
0.33 (winter)	250	0
0.67 (summer)	1,600	0.39
approx. 1.5	4,000	1.38
3 – 5	6,500	2.04
100	16,600	0.58
500	35,000	0.08

* FWP inundation area compared against FWOP inundation area

Larger events are not considered in this study because of the highly regulated context of the study area. Upstream from the study area are three large dams with irrigation and flood control as their primary functions. The 0.2% AEP event, at 35,000 cfs, is associated with the downstream dam (Lucky Peak) running with all outlets at full capacity, which operationally would be considered for a dam safety measure. The 1% AEP event, at 16,600 cfs, is also less meaningful to the intent and context of this Barber Pool Ecosystem Restoration project. Connection of side channels desired at lower flows occurs naturally at the 1% AEP and the effect of proposed restoration measures along the banks of the main channel is washed out by the increased flow volume of the extremely large events.

As the Inundation Area Increase in Table 3 shows, proposed restoration measures are significant for lower, more common flow events selected for project design (250 cfs, 1,600 cfs, 4,000 cfs, 6,500 cfs). Figure 14 illustrates induced flooding for 6,500 cfs which was the peak design flow and exhibited the largest amount of inundation area increase.

3.2.8.2 Model Uncertainty Related to Induced Flooding

Two sources of uncertainty that were not included in the post-processing procedure for induced flooding are the terrain and geometry mesh resolution. Terrain data was obtained by FCD 10 through a contract with Quantum Spatial and provided to USACE. The terrain grid has a 3-foot cell size and is based on green lidar collected November 6-11, 2019. In the lidar report Quantum Spatial specifies absolute vertical accuracy in the non-vegetated areas at 0.153', a vegetated vertical accuracy of 0.253', and bathymetric vertical accuracy of 0.411' for fully submerged with wetted edge accuracy at 0.599'. The green lidar, which is water-penetrating, was not able to capture the deeper pools and the USACE GIS team interpolated surfaces to create a cohesive surface for RAS modeling. Terrain was a major contributor to model uncertainty, though this level of uncertainty was not used as screening criterion for induced flooding when assessing the technical validity of the data shared with the team. Another source of uncertainty is the RAS model geometry. Mesh grid lines capture the terrain and incorporate terrain elevations into the flow computations. The model only recognizes elevations intersected by the mesh boundary lines. The uncertainty associated with model geometry is not included in the post-processing procedure for induced flooding.

Induced flooding polygons are appended in Plates 1 - 5. Note that there was no induced flooding for the lowest design flow, 250 cfs, so no plate is included for this scenario.

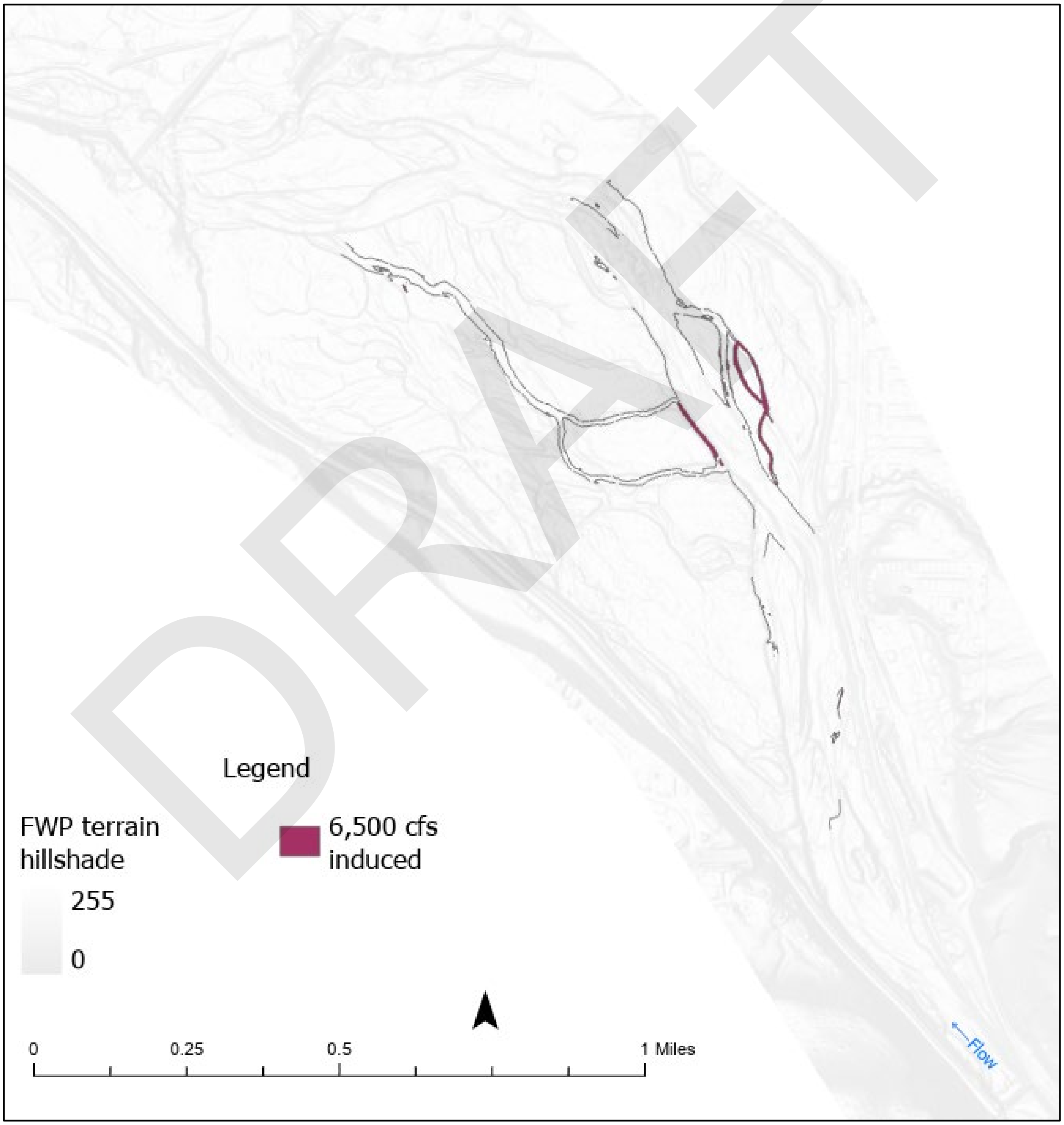

Figure 14. Induced Flooding Polygons for the TSP at 6,500 cfs

SECTION 4 - GEOMORPHOLOGY

4.1 HISTORICAL CONTEXT

Historically the Boise River Floodplain had large expanses of cottonwoods and given cottonwood germination requirements, it is likely that the floodplain experienced frequent flood disturbance. One driver of the river morphology of the past was large woody material. Historically (>150 years ago) there were more side channels, split flows, sloughs, and alcoves, apparent today as relic channel scars in the existing topography.

Before it became highly regulated, the Boise River underwent periodic flooding that shaped the river corridor. The dams (including Barber Dam) have generally starved the lower Boise reach of bedload material that drove many of the historic geomorphic processes. Historic accounts and maps indicate the channel was primarily single threaded with several islands near the cities of Boise and Eagle (Richardson and Guilinger, 2015). Evidence from gravel pits throughout the lower Boise River valley in support of the “alluvial” classification, meaning the river flowed over sediment of its own deposition, not over bedrock, so it dynamically scoured and deposited its bed. Currently, the banks of the Boise River are generally sand and silt, representing historic floodplain deposition overlying coarser gravels and cobbles. As a reference, the 2015 Geomorphic assessment cites low flow as 300 cfs and approximate bankfull flow at 7,000 cfs. Flow regulation reduced channel discharge from commonly exceeding 10,000 cfs to a maximum target of 7,000 cfs (currently 6,500 cfs). Regulated peak flows, sediment starvation, and channelization have resulted in a relatively homogenous and geomorphically static river (Richardson and Guilinger, 2015).

4.2 GENERAL CHANNEL CHARACTERISTICS

The longitudinal profile of the riverbed shows a slope break approximately 1.7 miles upstream from Barber Dam (Figure 14). Visually fitting a line to the “Background” slope (0.002 feet/foot) and the “Barber Pool” slope (0.0004 feet/foot) shows a background slope five times steeper than the slope within the impoundment. This could reflect, in part, natural phenomena not accounted for in this study but appears to predominantly be a legacy of the last 100 years of impoundment by Barber Dam.

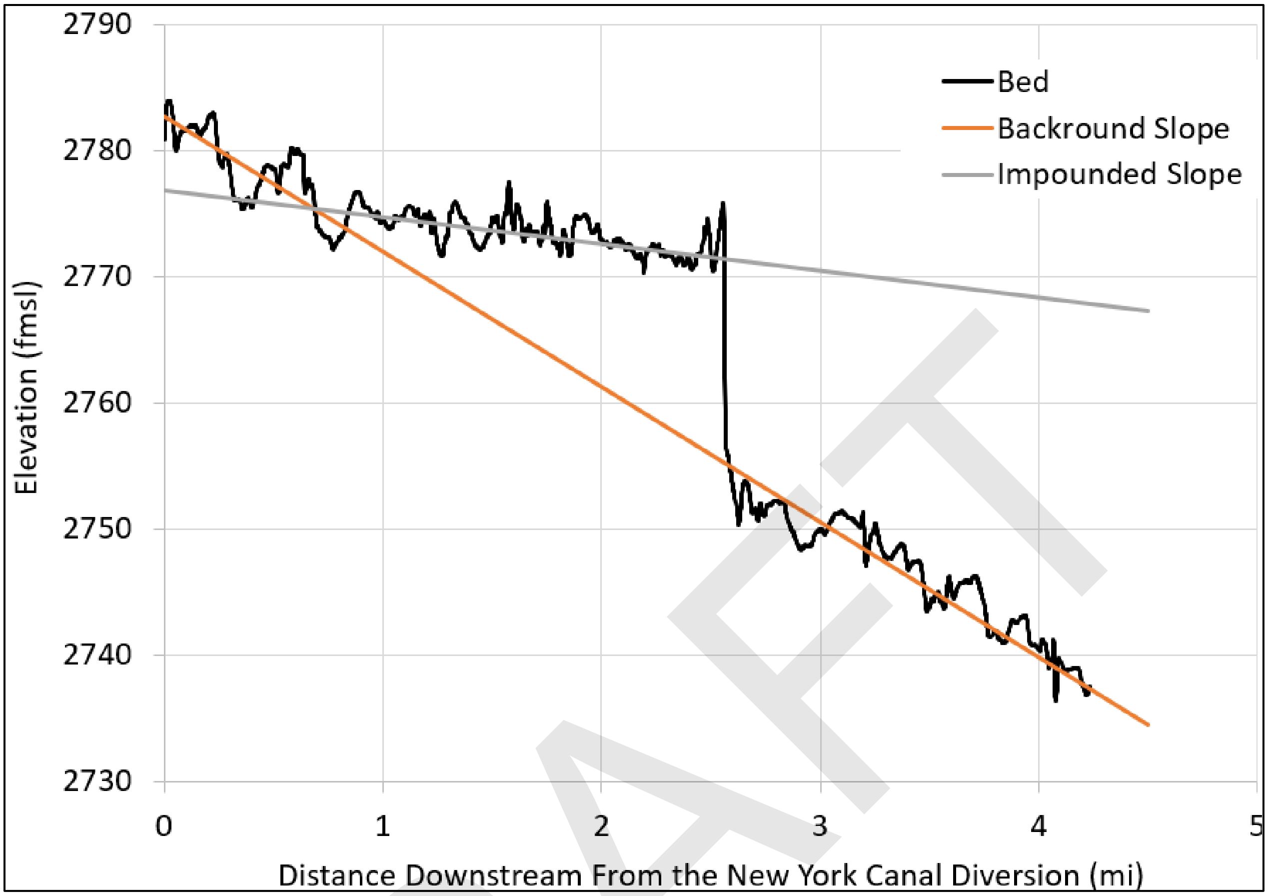

Figure 15. Longitudinal Profile of the Main Channel from 2019 Lidar Showing a Slope Break Approximately 1.7 Miles Upstream from Barber Dam.
Lines are fitted visually.

The water surface elevation shows a slope lessening as one progresses through the study area toward the dam, which is more pronounced for the lower flow magnitudes (Figure 15). This lack of slope constrains introduction of flowing side channels near the dam, but presence of a stable, more gradual slope allows for slough, wetland, and riparian corridor creation and enhancement connected to correspondingly higher groundwater in the affected area. In-channel fish habitat is constrained to slower velocities and/or less velocity heterogeneity in the lower slope reach. While opportunities for habitat enhancement are present, from a river hydraulics or river morphology point of view, true restoration to a pre-dam condition would involve restoring this reach to the background slope. Given upstream regulation and the mismatch between the background river morphology and the current regulated hydrology, priority is given to habitat enhancement within the constraints of the Barber Dam impoundment.

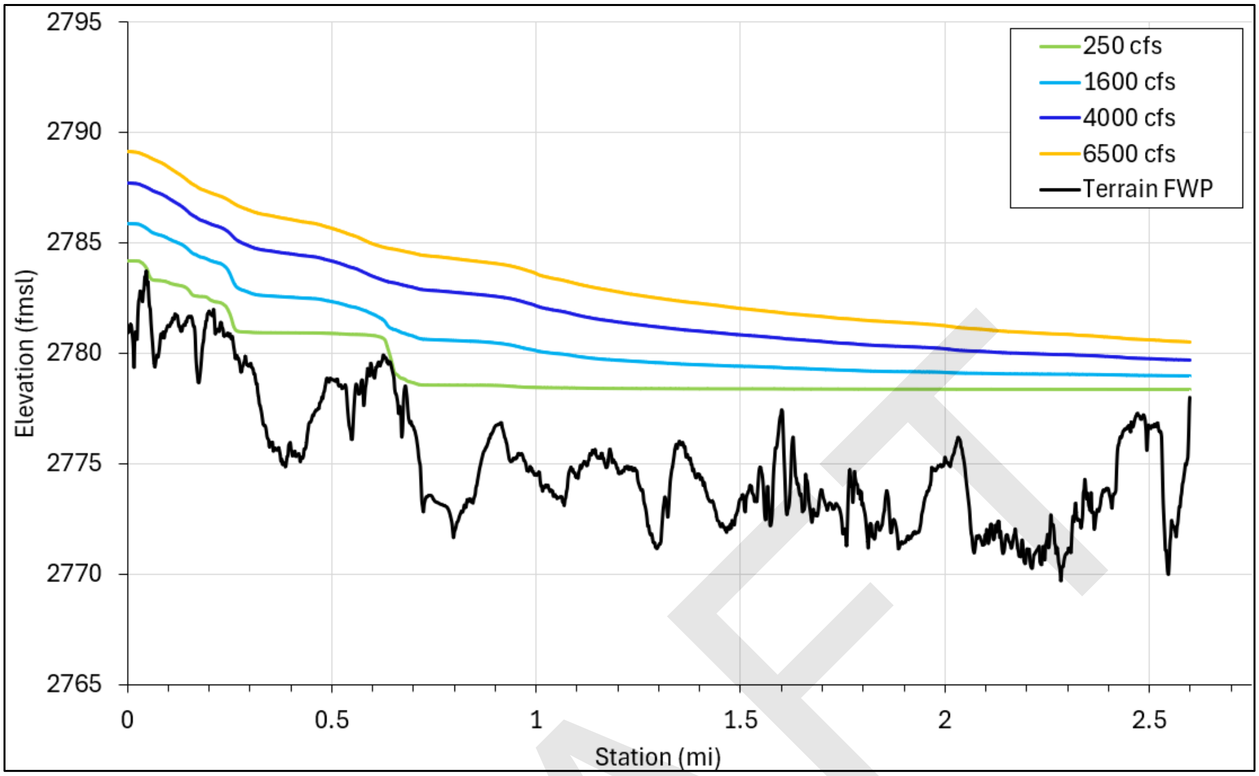

Figure 16. Modeled Water Surface Elevation Profiles Illustrating the Area of Impoundment Influence Change with River Discharge

Aerial view of the project area reveals sediment deposits on alternating banks (e.g., a bar or low elevation terrace) paired with one or more side channels on the inside of the main channel bends. Center points of depositional areas on the inside of bends are separated by an average of 0.3 miles, with decreasing size and separation distance nearer the dam (Figure 16). Proposed measures help to establish the two downstream instances of this pattern. Details of the enhancement may change, but the proposed measures are designed to persist and provide benefit regardless of changes to the dam crest elevation.

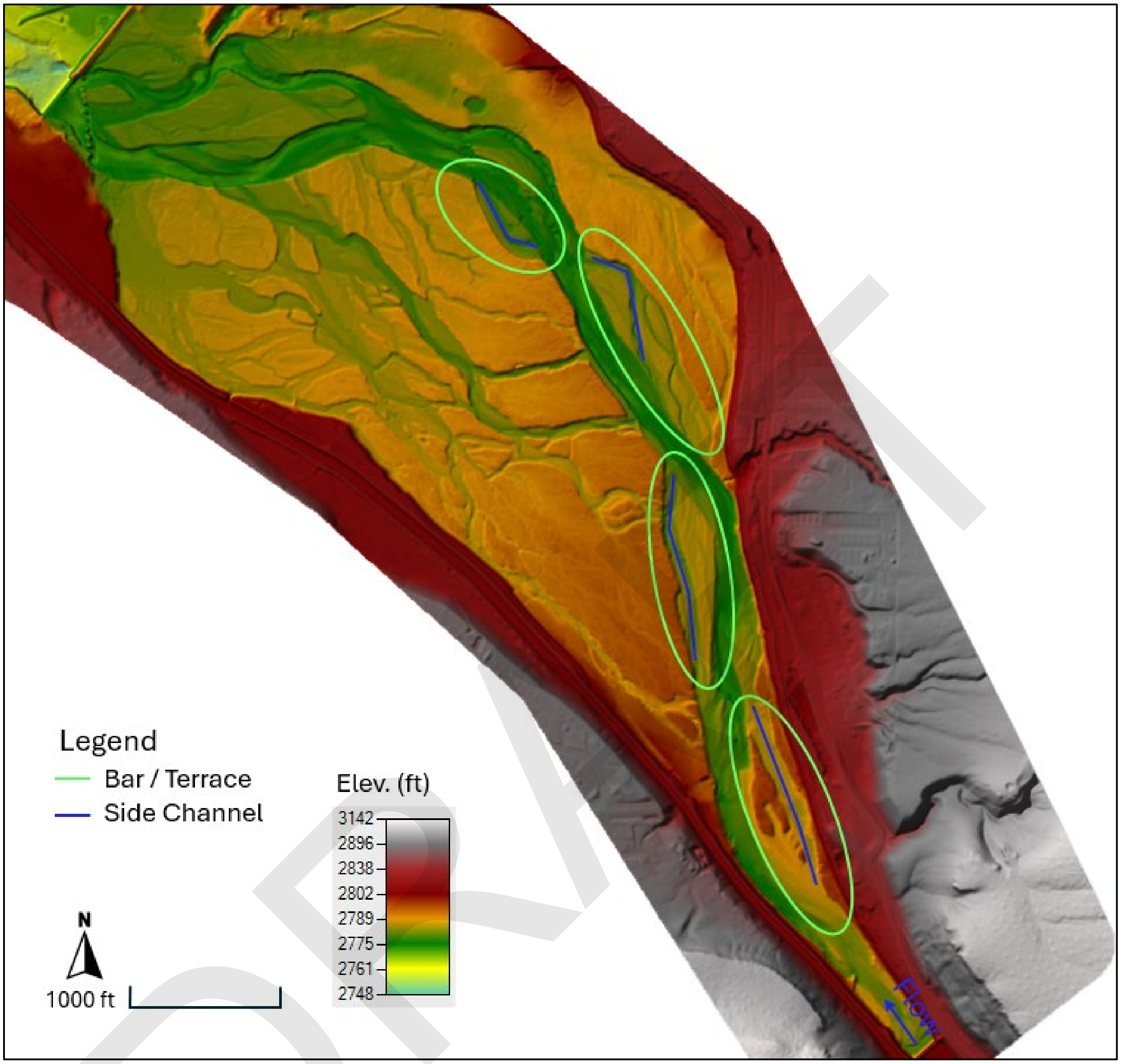

Figure 17. Barber Pool 2019 Lidar with Measures Present in the Landscape Illustrating the Pattern of Alternating Sediment Deposits Paired with Side Channels until within Approximately 1 Mile of the Dam

4.3 SEDIMENT

4.3.1 Grain Size Classification and Comparison with Historic Condition

In the Barber Pool area, the layer of sediment overlying the coarser gravels and cobbles is likely much thicker than other areas due to Barber Dam's early construction relative to the other impoundments.

Reach 1 of the Richardson and Guilinger (2015) report is the Barber Pool study area. Here they report an overwidened channel with a width to depth ratio of 45 (representative bankfull channel divided by average channel depth). They also quantify bed composition as predominantly sand with a low amount of bed armoring.

Based on multiple days spent in the field at the study area, it is clear that general characteristics have qualitatively changed little since the geomorphic assessment in 2015, despite the high flow event in 2017.

4.4 RELATED RESTORATION OPPORTUNITIES ON THE BOISE RIVER

Sediment transport patterns are dampened with the regulated hydrology and the channel has been relatively stable for many years. This FWOP condition contrasts a natural river system with dynamic scour and deposition patterns. Figure 10 depicts three example years showing regulated and unregulated hydrograph differences. Higher peaks and a quicker receding limb characterize the natural, unregulated flow. Outflow from Lucky Peak does not currently mimic a natural timing nor shape of seasonal snowmelt runoff in a natural system. Currently, river flow is reduced by steps of 100–500 cubic feet per second (cfs) that suddenly lower WSE. Smaller, more frequent steps would more closely mimic a natural receding hydrograph and allow aquatic and riparian biota more opportunity to respond to a gradually receding flow and WSE.

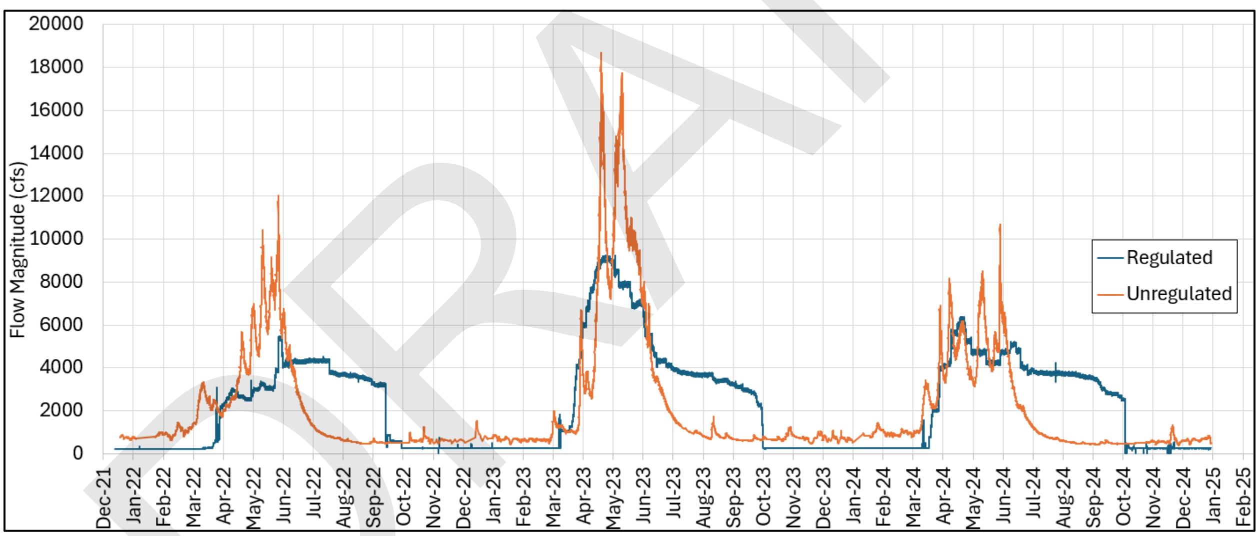

Figure 18. The Sum of Upstream Gauges (Mores Creek, the North, Middle and South Forks of the Boise River) Representing the Unregulated Flow Expected at Barber Pool Overlaying the Difference Between Lucky Peak Outflow and the New York Canal Flow Magnitude Representing Regulated Flow at Barber Pool

Another noteworthy restoration or habitat improvement that has not been made yet, and that is outside the scope of this study, is fish passage and fish screens at Barber Dam. Survival over and through Barber Dam is unknown, but given studies at other hydroelectric dams one can assume similarity. Screening the powerhouse penstocks and providing some safer downstream and upstream pathway past the dam would complement the upstream restoration measures discussed in this document.

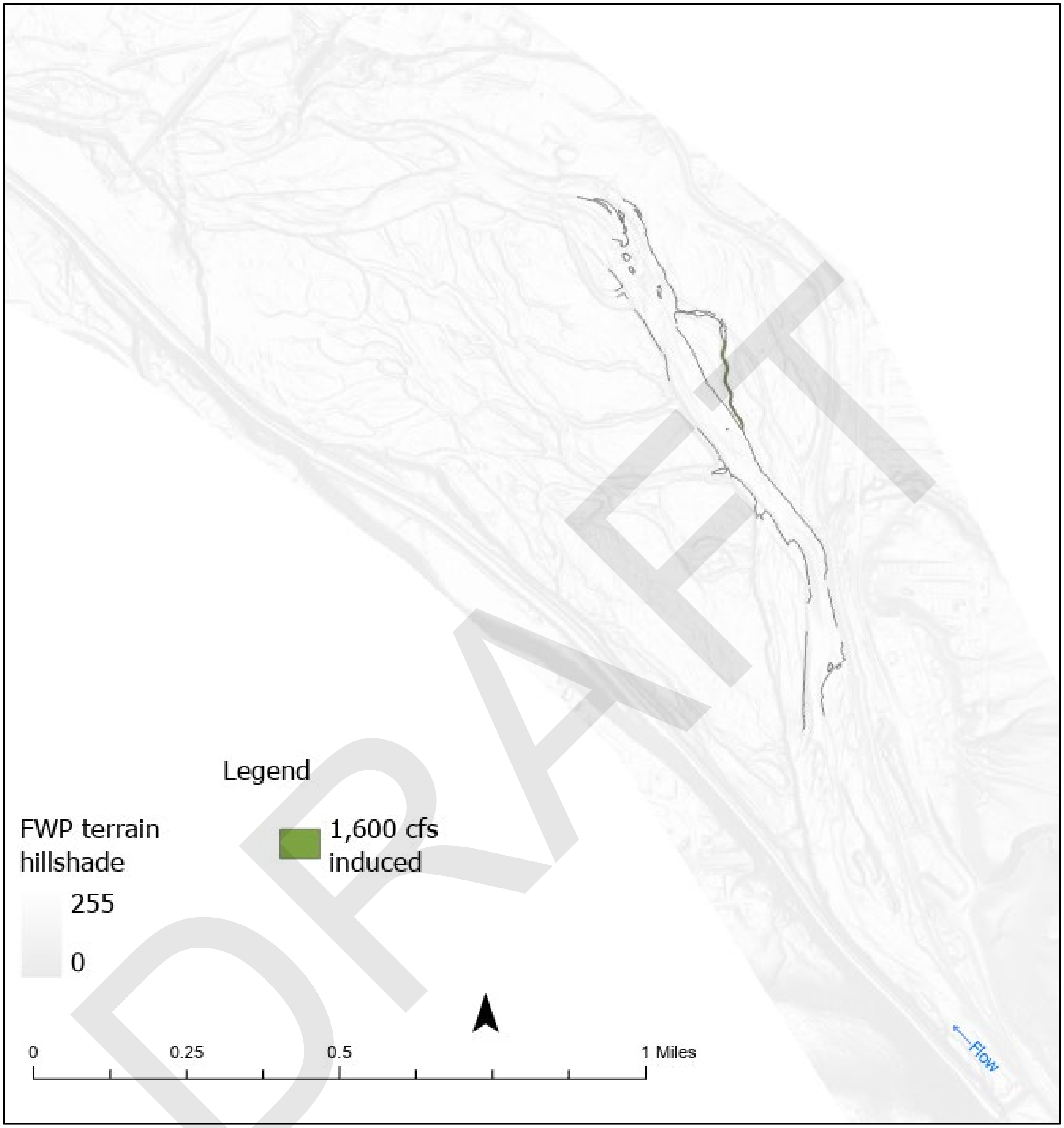

Plate 1. Induced Flooding Polygons for the TSP at 1,600 cfs

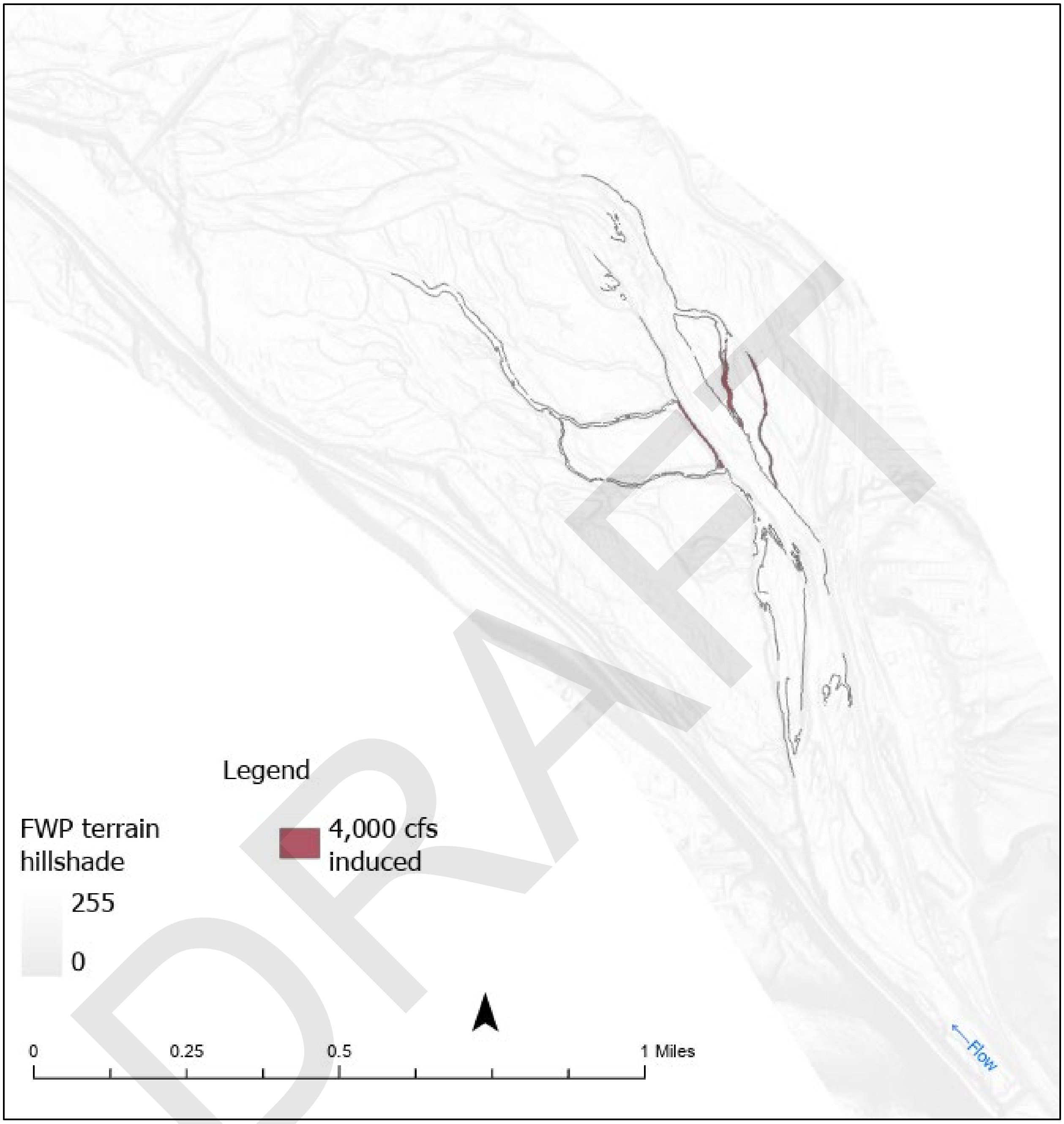

Plate 2. Induced Flooding Polygons for the TSP at 4,000 cfs

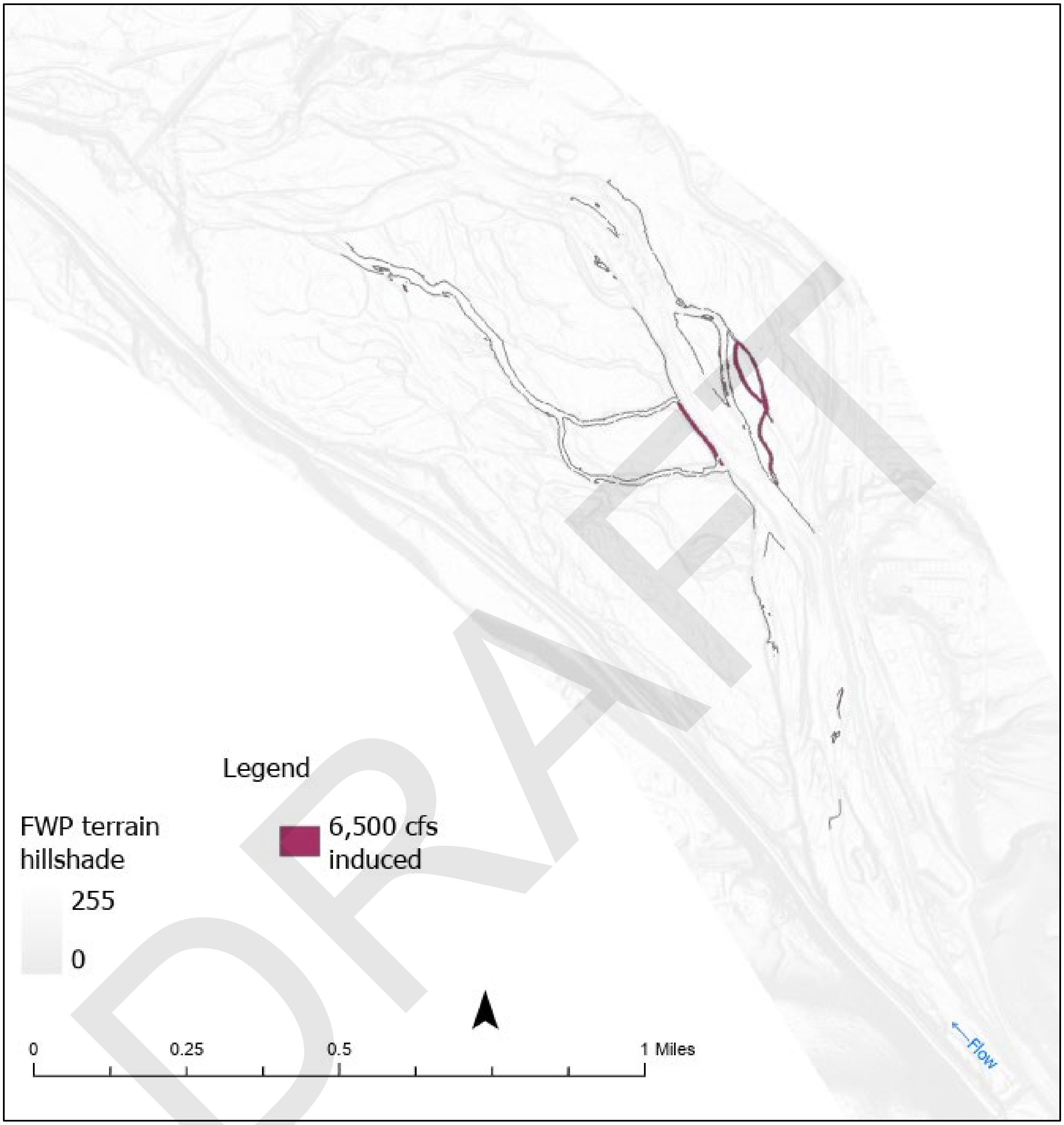

Plate 3. Induced Flooding Polygons for the TSP at 6,500 cfs

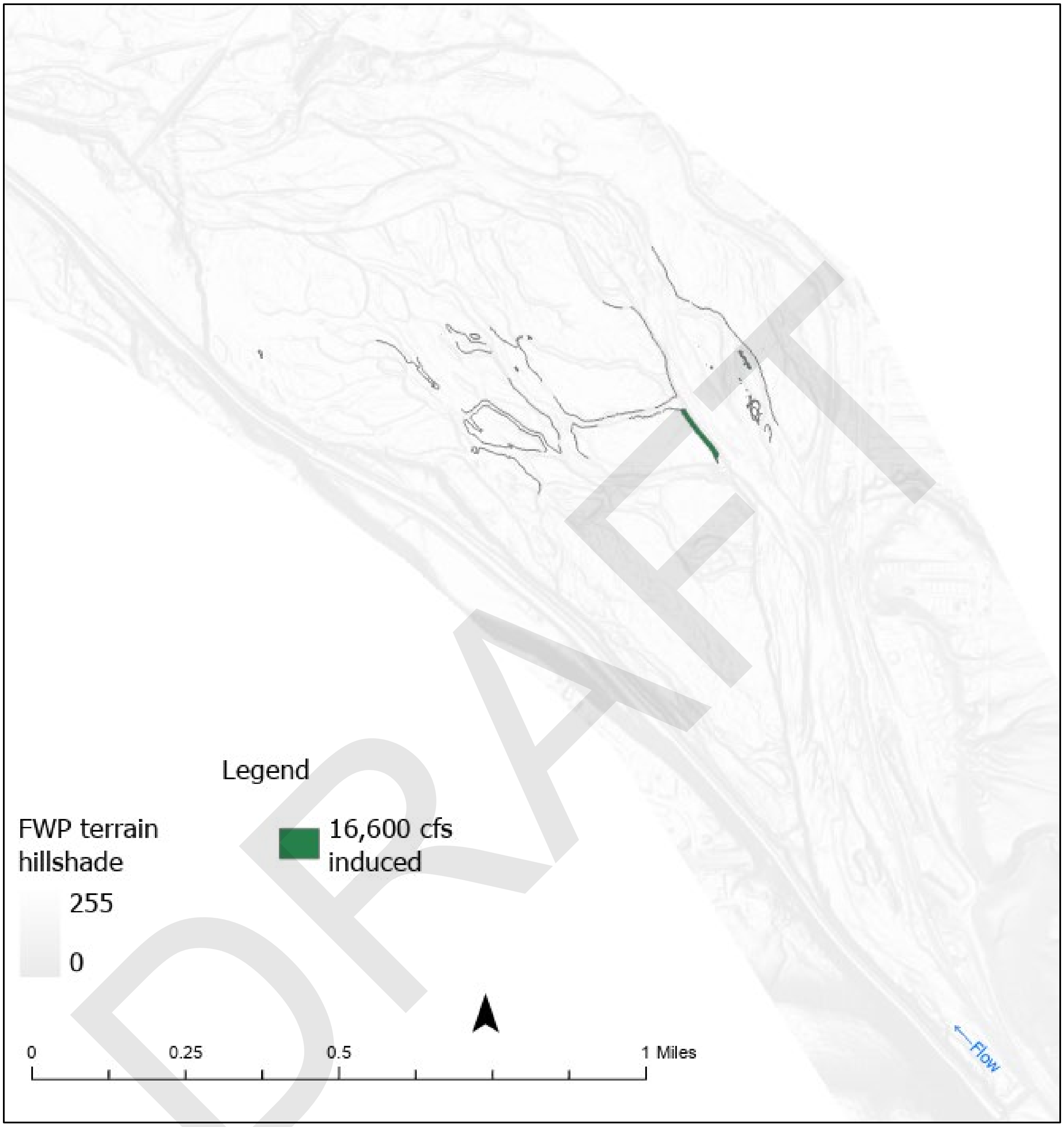

Plate 4. Induced Flooding Polygons for the TSP at 16,600 cfs

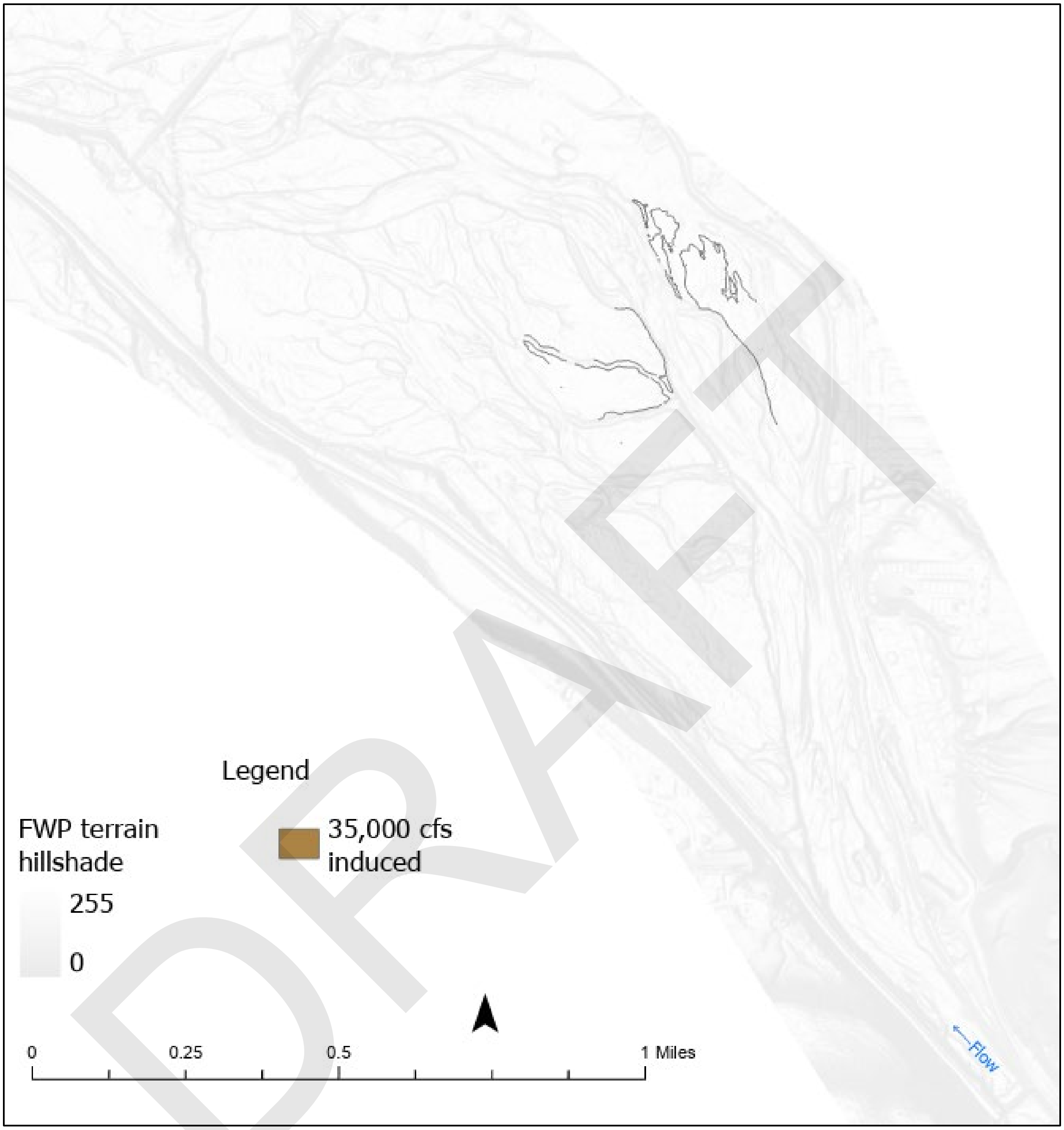

Plate 5. Induced Flooding Polygons for the TSP at 35,000 cfs

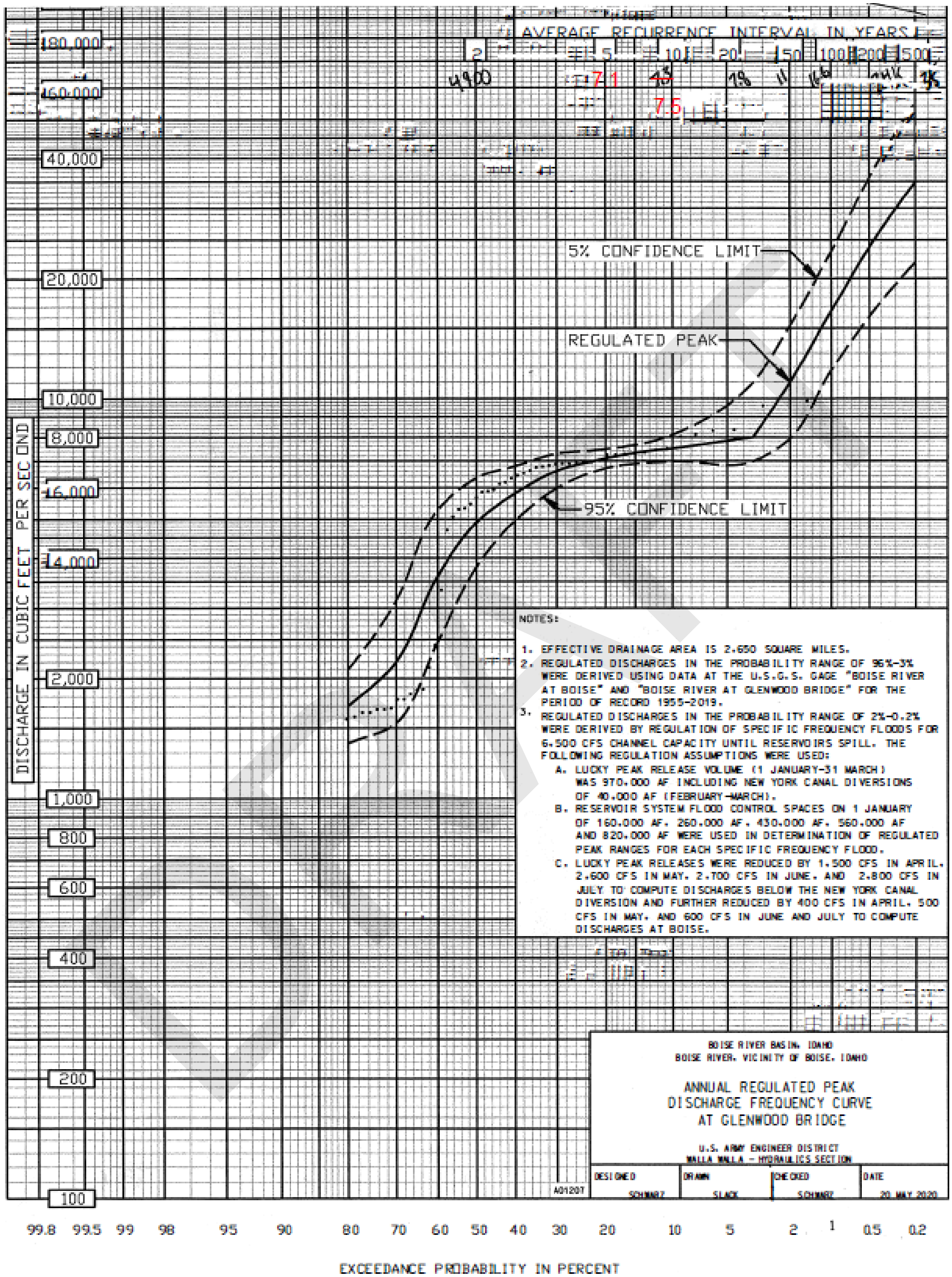

Plate 6. Annual Regulated Peak Discharge Frequency Curve at Glenwood Bridge, USACE 2020

SECTION 5 - REFERENCES

1. U.S. Army Corps of Engineers Walla Walla District. September 2021. Boise River 2D Model and Mapping Ada and Canyon Counties, Idaho; Section 22 – Planning Assistance to States; Project Partner: Boise River Flood Control District 10.

2. 2015 HEC-RAS 2D Sediment User Manual https://www.hec.usace.army.mil/confluence/rasdocs/h2sd/ras2dsed/6.6/sediment-data/2d-options

3. Richardson, R., Guilinger, J., Geomorphic Assessment of the Lower Boise River, Idaho, Feb 2015, prepared for the Boise River Enhancement Network.