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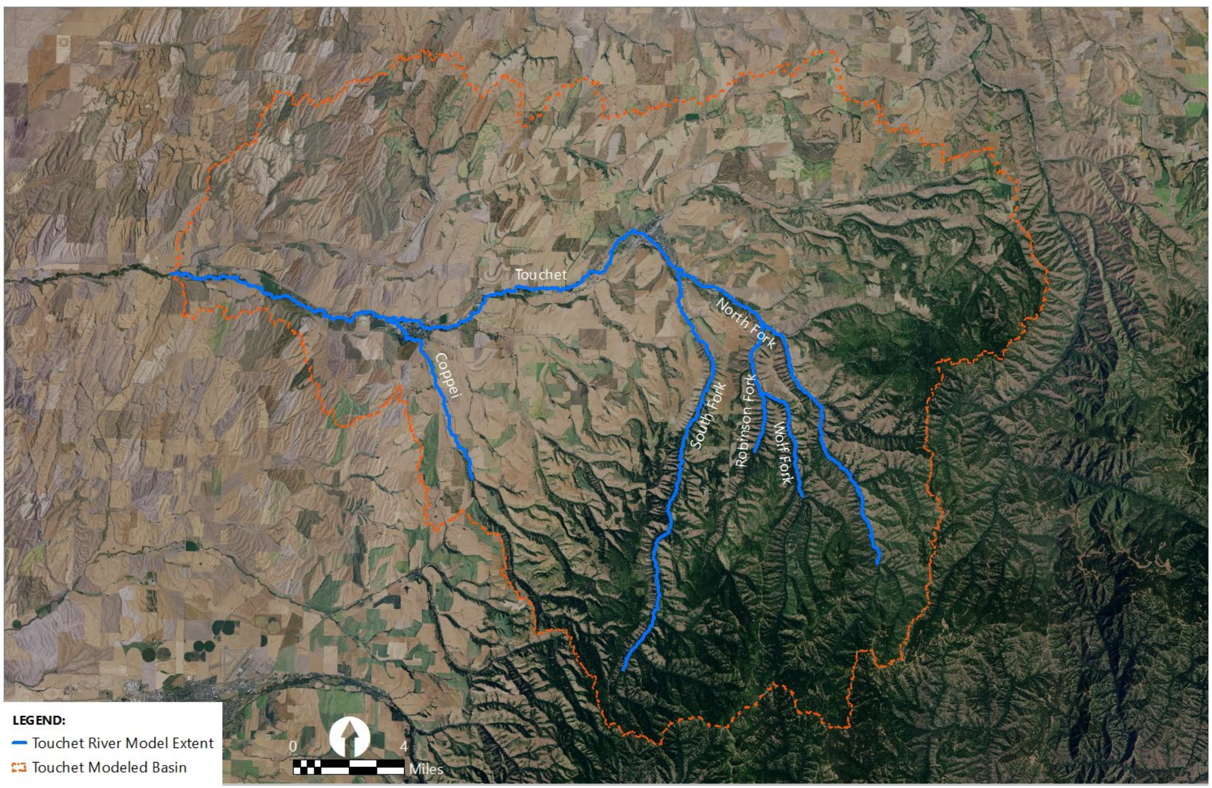
Appendix D
Hydraulic Modeling

1.1 Hydraulic Model Overview

A 1D hydraulic model was developed using U.S. Army Corps of Engineers (USACE) HEC-RAS 5.0.7 for this assessment. The hydraulic model includes the mainstem Touchet River upstream of Waitsburg, the North, South, Wolf, and Robinson forks of the Touchet River, and Coppei Creek. The extent of the model is shown in Figure D-1.

Figure D-1
Touchet River Model Extent



The model contains peak flow data for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year floods. The flow data for the mainstem and all the tributaries were determined using the U.S. Geological Survey (USGS) StreamStats database (USGS 2019a). The flow data for the 1-year flood were developed using a regression equation using the 2- to 100-year floods (see Appendix C, Hydrologic Analysis Methods and Results). The inundated area for the 2- and 5-year floods was used as the basis for a basin-wide floodplain connectivity analysis prioritizing the removal and setback of levees and other confining structures. The 1-year inundated area was used as the basis for the Standardized Complexity

Evaluation (SCE), which uses metrics of sinuosity, island count, and island perimeter to calculate complexity. Finally, the 2-year flow values were used in the excess transport capacity analysis to quantify variations in shear stress in the basin. While the larger return intervals including the 50- and 100-year flood were generated for conceptual purposes, their accuracy is limited by the lack of hydrologic data and the fact that the model was constructed using hydrologic regressions.

1.2 Hydraulic Model Development

1.2.1 Model Data

1.2.1.1 LiDAR Data

The original Light Detection and Ranging (LiDAR) dataset for the Touchet River was collected from March 31 to April 14, 2010, by Watershed Sciences, Inc. (WS 2010). This aerial survey produced near-infrared (NIR) LiDAR data for 15,159 acres of the mainstem, North, Wolf, and Robinson forks and 1,886 acres of data for the South Fork Touchet River (WS 2010). Digital elevation models produced by WS were resolved to 0.5 meter and have an assessed vertical accuracy of approximately 11 centimeters. This dataset was ultimately not used for the model because new data of comparable accuracy from 2018 became available.

The 1D model is based on a LiDAR dataset gathered by Quantum Spatial, Inc. (QSI) in late 2017 and early 2018 (QSI 2018). The QSI aerial survey gathered standard NIR LiDAR data for 1.85 million acres across Garfield, Columbia, and Walla Walla counties (QSI 2018). The LiDAR data did not incorporate bathymetry, and hydro-flattening was executed to smooth the surfaces of ponds, lakes, and rivers wider than 100 feet (QSI 2018). Digital elevation models produced by QSI were resolved to 3 feet (approximately 0.9 meter) and have an assessed vertical accuracy of approximately 0.253 foot (approximately 8 centimeters) based on the LiDAR report published by QSI (QSI 2018).

1.2.1.2 Manning's N Data

A land use dataset spanning the entire United States was downloaded into HEC-RAS to inform Manning's n values for the model cross sections (USGS 2014). Horizontal variation in Manning's n values within cross sections was based on this USGS land use dataset as well as satellite imagery. Another set of values categorizing Manning's n for each land type was consulted to help determine a standard for Manning's n values. This dataset comes from Manning's n estimates by land type in Kansas (Janssen 2016). The Manning's n values used for this model were consistent with previous assessments on the Tucannon River and are shown in Table D-1.

Table D-1
Standard Manning's n Values

Land Cover Type	Manning's n Value
River Channel	0.04
Agricultural Field	0.045
Developed-Low Intensity, Shrub/Scrub	0.06
Developed-Medium Intensity	0.08
Developed-High Intensity, Evergreen Forest, Deciduous Forest	0.1

1.2.1.3 Hydrology Data

Hydrology data for the model were entirely derived from regressions in the USGS StreamStats database (USGS 2019a). Discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year flood events were included in the model. Two stream gages on the mainstem and North Fork provided continuous data via USGS from 1924 to 1989 and 1941 to 1968, respectively (USGS 2019b). The same gages had data available through the Washington State Department of Ecology dating back to 2007 and 2002, respectively. This non-continuous set of hydrology data was considered insufficient to determine flood recurrence intervals, and the decision was made to pursue an entirely regression-based approach to model hydrology. For more information on development of model hydrology, see Appendix C, Hydrologic Analysis Methods and Results.

1.2.2 Model Setup

1.2.2.1 Model Extent

The Touchet 1D hydraulic model included the section of the mainstem Touchet River from the Highway 125 bridge in Prescott to the confluence of the North and South forks. It also included Coppei Creek from its forks to its mouth, the North Fork downstream of Spangler Creek, the Wolf Fork downstream of Coates Creek, 2.5 miles of the Robinson Fork, and 18.22 miles of the South Fork. Model extents were initially constrained by the LiDAR dataset from WS (WS 2010). The model was expanded upon receiving the tri-county 2018 LiDAR data. Coppei Creek was added to the model, as were upstream portions of the North, Wolf, and Robinson forks and the mainstem reach from Waitsburg to Prescott. The extensions up the forks were roughly aligned with assumed fish use extents. Patit Creek was not included in the model because significant incision undermines the effectiveness of a floodplain connectivity analysis on Patit Creek.

1.2.2.2 Model Geometry

The first step in model geometry development was manually delineating channel centerlines and approximate bank lines using both satellite imagery and LiDAR data for guidance. Next, cross sections were generated in intervals of 660 feet or 1/8 mile. 1/8-mile intervals were considered sufficiently spaced to develop the backbone of the model, and additional cross sections were manually added at confluences, islands, and sections of high complexity to further resolve the model. Elevations for the cross sections were cut directly from the terrain derived from the 2018 LiDAR dataset (QSI 2018). Manning's n data were manually entered for each cross section using the land cover dataset (USGS 2014) and satellite imagery for guidance and conforming to the standards listed in Table D-1.

Levees and channel confining structures were abundant in the Touchet basin. The levee function in HEC-RAS was used to model USACE levees such as the levees in Dayton and Waitsburg as well as major roads alongside the river that act as continuous levees. This function prevented flow from appearing behind these structures unless the water surface elevation overtopped the levee. Smaller or non-continuous levees were modeled using the ineffective flow function in HEC-RAS. This omitted these inundated areas from flow velocity calculations unless they were overtopped. This two-part approach to levee modeling accurately models the function of major levees through the cities but depicts the potential floodplain connectivity that would be restored if minor levees are removed.

1.2.3 Model Results

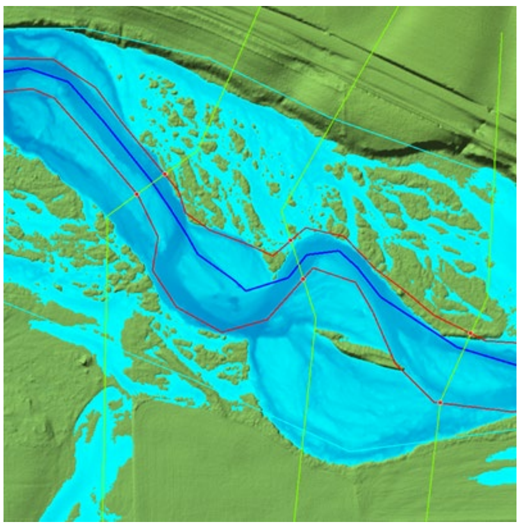
The model produces results for water depth, velocity, inundation extent, water surface elevation, and shear stress. The modeled inundation extents were used as inputs for floodplain connectivity and complexity indices. Specifically, the 2-year and 5-year inundation extents were used as inputs to the connectivity analysis while the 1-year inundation extent was used for the complexity analysis. The modeled shear stress was used as an input for the excess transport capacity analysis. Model results for flood events greater than the 5-year event are available but should not be used for anything except general predictions due to uncertainty in the regression equations used to build the model's hydrology.

1.2.4 Model QA/QC

Quality assurance/quality control (QA/QC) tasks included checking the model results for stream continuity as well as confirming flow patterns and confining structures with field observations. In 1D model results, high points between cross sections may cause a discontinuity in the river. Addition of more closely spaced cross sections in these areas provides HEC-RAS a shorter distance to calculate slope, helping to eliminate these false discontinuities. In addition, inundated areas behind natural and manmade levees may appear isolated from the river. These areas were checked to ensure proper connection to the main flow. If model results revealed gaps in levees, these levees were changed to ineffective flow areas to allow water to inundate the areas behind them. Lastly, island complexes forming multiple side channels were QC'ed. For certain flows, side channels appear to be disconnected, but addition of more cross sections provides enough resolution to render these side channels continuous.

Field work in July and August 2019 also provided an opportunity to confirm model results. Anchor QEA field staff surveyed the Touchet River and its tributaries from July 29 to August 2, 2019, and from August 12 to 16, 2019. The field survey included the entire section of the mainstem from Dayton to Prescott as well as portions of the forks and Coppei and Patit creeks. Field observations were useful in confirming the locations of levees and confining structures, determining the current flow split in side channels, and observing any recent avulsions. One inconsistency noted between the model and current conditions is shown in Figure D-2. The model indicates the left channel is the main channel, but the field visit revealed a recent avulsion to the narrow right channel. Ground truthing the model in the field was invaluable to the modeling process.

Figure D-2
Discrepancy Between Model and Observations, Avulsion Below Waitsburg



Left: The channel flows from right (upstream) to left (downstream) in this image. The annotated river centerline in dark blue traces the new path of the river through a narrow right channel resulting from a recent neck avulsion. However, the modeled river depth indicates the left channel is the main channel. Right: During the field visit, the view from upstream of the avulsion looking downstream shows the new narrow main channel on river right.

1.3 References

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