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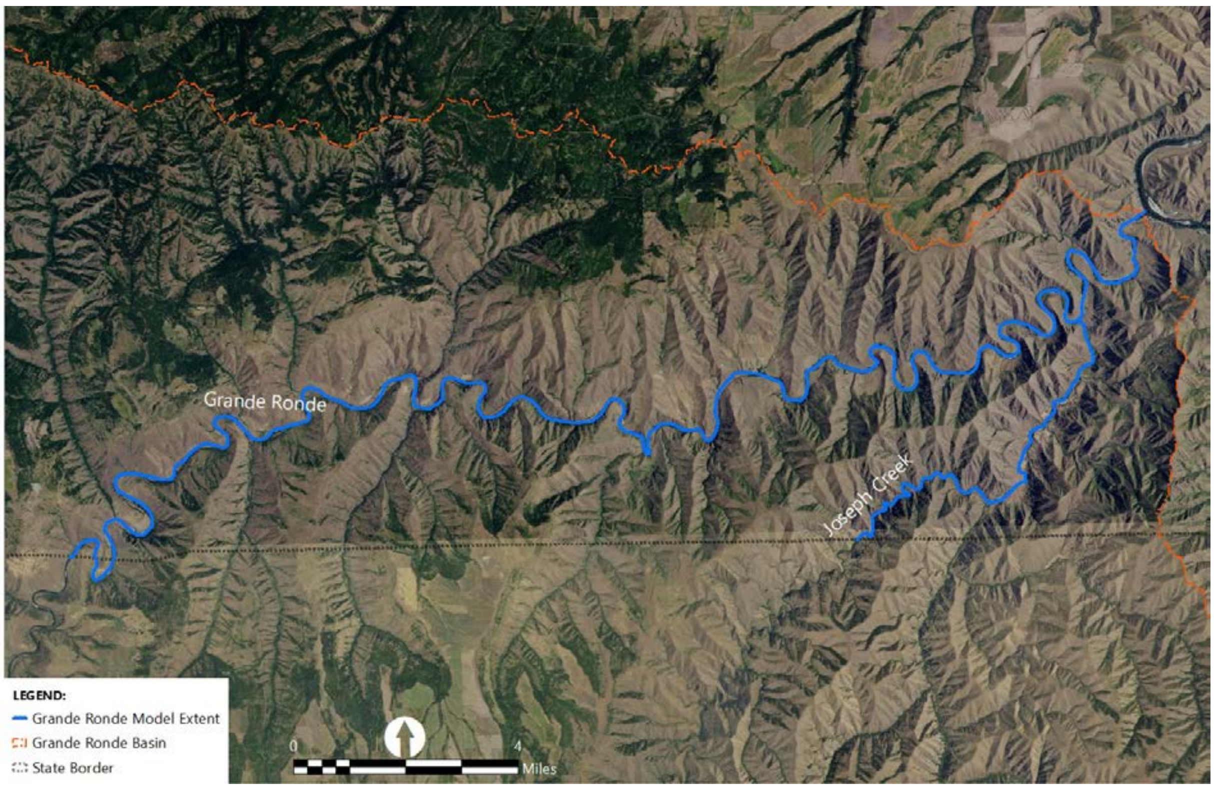
Appendix B
Hydraulic Modeling

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 portion of the Grande Ronde River and its major tributary, Joseph Creek, within Washington State. The extent of the model is shown in Figure B-1.

Figure B-1
Grande Ronde Model Extent



The model contains peak flow data for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year floods as well as summer and winter low-flow profiles. The flow data for the mainstem Grande Ronde River were determined from the U.S. Geological Survey (USGS) gage at Troy, Oregon, with daily data dating back to water year 1945 (USGS 2019a). Flows for the tributaries were estimated using regressions from the USGS StreamStats database (USGS 2019b). Comparisons between the 1-, 5-, and 10-year inundated areas were used to assess floodplain connectivity in the mainstem and Joseph Creek as well as prioritize restoration sites in the mainstem.

1.2 Hydraulic Model Development

1.2.1 Model Data

1.2.1.1 LiDAR Data

The 1D model is based on a topobathymetric Light Detection and Ranging (LiDAR) dataset gathered by Quantum Spatial, Inc. (QSI) in November 2018 (QSI 2019). The QSI aerial survey included green wavelength bathymetric data for the mainstem Grande Ronde River and Joseph Creek, while near-infrared (NIR) data were gathered for reaches of the tributaries Buford, Rattlesnake, Cottonwood, and Cougar creeks (QSI 2019). The green wavelength data penetrate the water column and can resolve the bed depending on water depth, while NIR data do not penetrate the water surface. Only the areas with topobathymetric data were incorporated into the 1D HEC-RAS model. Flows ranged from 694 to 917 cubic feet per second at the USGS gage in Troy during the week of LiDAR collection (QSI 2019; USGS 2019a).

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 B-1.

Table B-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 mainstem were derived from USGS gage data, and hydrology data for the tributaries were determined with regressions from the USGS StreamStats database (USGS 2019a, 2019b). The record of the USGS gage 13333000 at Troy, Oregon, contains daily data and annual peak flow data from water year 1945 to present (USGS 2019a). The yearly peak flow dataset was analyzed using a Log-Pearson Type III distribution to estimate 2- to 100-year flood recurrence intervals for the mainstem Grande Ronde River. Summer and winter low-flow profiles for the mainstem were created using monthly average flows for August to October and December to February, respectively (USGS 2019a). Peak flow recurrence intervals for the tributaries were calculated using regressions from USGS StreamStats in Washington, while summer and winter low-flow profiles were developed using StreamStats in Oregon for the August to October and December to February 50% flow duration statistics (USGS 2019b). For both the tributaries and the mainstem, 1-year floods were estimated using curve interpolation from the 2- to 100-year floods. For all flow profiles, tributary flows were manually added at the cross section immediately downstream of the tributary. For more information on development of model hydrology, see Appendix A, Hydrologic Analysis Methods and Results.

1.2.2 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 for both the mainstem and Joseph Creek. 1/8-mile intervals were considered sufficiently spaced to develop the backbone of the model, and additional cross sections were manually added in sections of high complexity or near islands to further resolve the model. Elevations for the cross sections were cut directly from the terrain derived from the topobathymetric LiDAR (QSI 2019), providing accurate bathymetric and floodplain elevations for the model. Manning's n data were manually entered for each cross section using the land cover data set (USGS 2014) and satellite imagery for guidance and conforming to the standards listed in Table B-1. There were few manmade levees in the Grande Ronde system besides roads. Inundated areas behind roads were modeled as ineffective flow areas, omitting them from flow velocity calculations.

1.2.3 Model Results

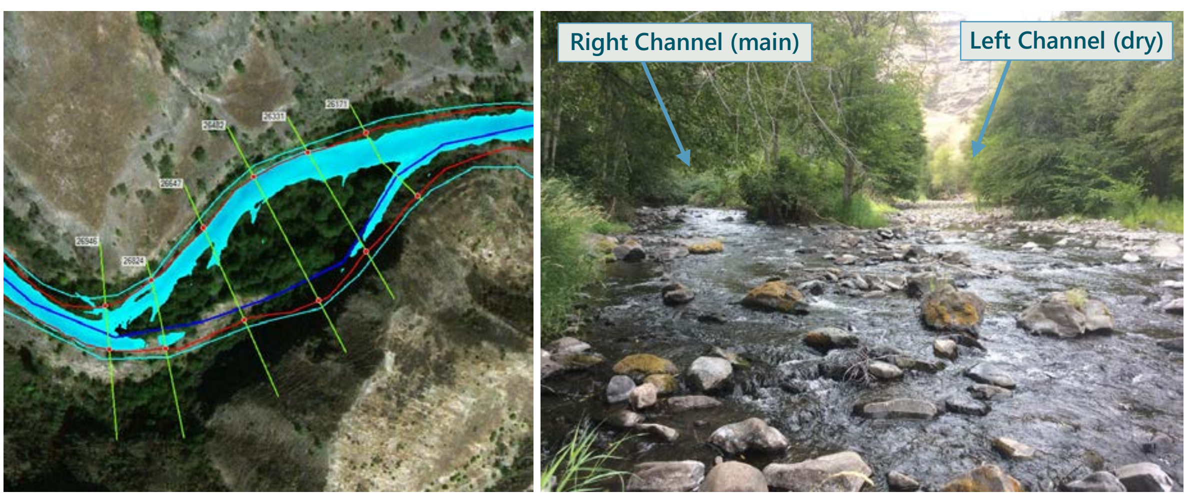
The model produces results for water depth, velocity, inundation extent, water surface elevation, and shear stress. The modeled inundation extents at different recurrence intervals were used as inputs for channel complexity and connectivity analyses on the mainstem and tributaries. The difference between the 1-, 5-, and 10-year floods was used to assess connectivity potential in the Joseph Creek prioritization. Differences between floods from the 1-year to the 25-year flood were used to evaluate areas of potential floodplain connectivity in the mainstem and to locate specific restoration sites.

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 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. 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.

Water depth and side channel connection were also checked following the site visit from August 26 to 29, 2019. Anchor QEA field staff walked and rafted the entire section of the mainstem Grande Ronde River included in the model, as well as sections of Joseph Creek and lower reaches of the tributary creeks to the mainstem and Joseph Creek. The field survey was conducted during the lowest summer flow conditions, providing an opportunity to QC the summer low-flow profile. Field observations were used to QC water levels in the tributary and mainstem and to confirm side channel connectivity. One inconsistency between the model and observations was observed in Joseph Creek, indicating either an avulsion since the LiDAR was gathered in November 2018 or an error in the model. The noted discrepancy is shown in Figure B-2. The model indicates the left channel is the main channel, but the field visit revealed that the left channel was dry during low flow. Ground truthing the model in the field was invaluable to the modeling process.

Figure B-2
Discrepancy Between Model and Observations, Joseph Creek Side Channel



Left: Joseph Creek flows from left (upstream) to right (downstream) in this image. The modeled split flow reach indicates the left channel is the main channel (as indicated by the light blue water depth output). Right: During the field visit, the view from downstream of the split looking upstream shows that the left channel is dry at low flow and the right channel is the main channel. Photograph credit: Tom Hutchison, August 29, 2019.

1.3 References

Janssen, C., 2016. Manning's n Values for Various Land Covers To Use for Dam Breach Analyses by NRCS in Kansas. Available at: https://www.wcc.nrcs.usda.gov/ftpref/wntsc/H&H/HecRAS/NEDC/lectures/docs/Manning%92s%20n-values%20for%20Kansas%20Dam%20Breach%20Analyses%20-%20Adopted%20071216.pdf.

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