US Army Corps
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Walla Walla District

LITTLE WOOD, GOODING, IDAHO

DRAFT INTEGRATED LETTER REPORT AND ENVIRONMENTAL ASSESSMENT

APPENDIX C, HYDROLOGY AND HYDRAULICS CALCULATIONS

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ACRONYMS AND ABBREVIATIONS

cfs	cubic feet per second
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
USACE	U.S. Army Corps of Engineers

1 BACKGROUND

To support the feasibility study of the Little Wood River through Gooding, Idaho, some analysis of the current and future without-project conditions will be required. Additionally, some examination of future with-project conditions is necessary. While this project may be able to provide the *potential* for large-scale flood risk reduction, most of the flood risk reduction provided will be very localized.

Gooding has experienced localized flooding, especially in the winter, due to ice jams. The deteriorating nature of the existing wall is causing it to fail in places, which places debris into the channel. This debris becomes a likely site for ice jams to form, and if big enough, may cause local flooding on its own during high flows. The current bridges cause constrictions, which also make them likely candidates for ice jams.

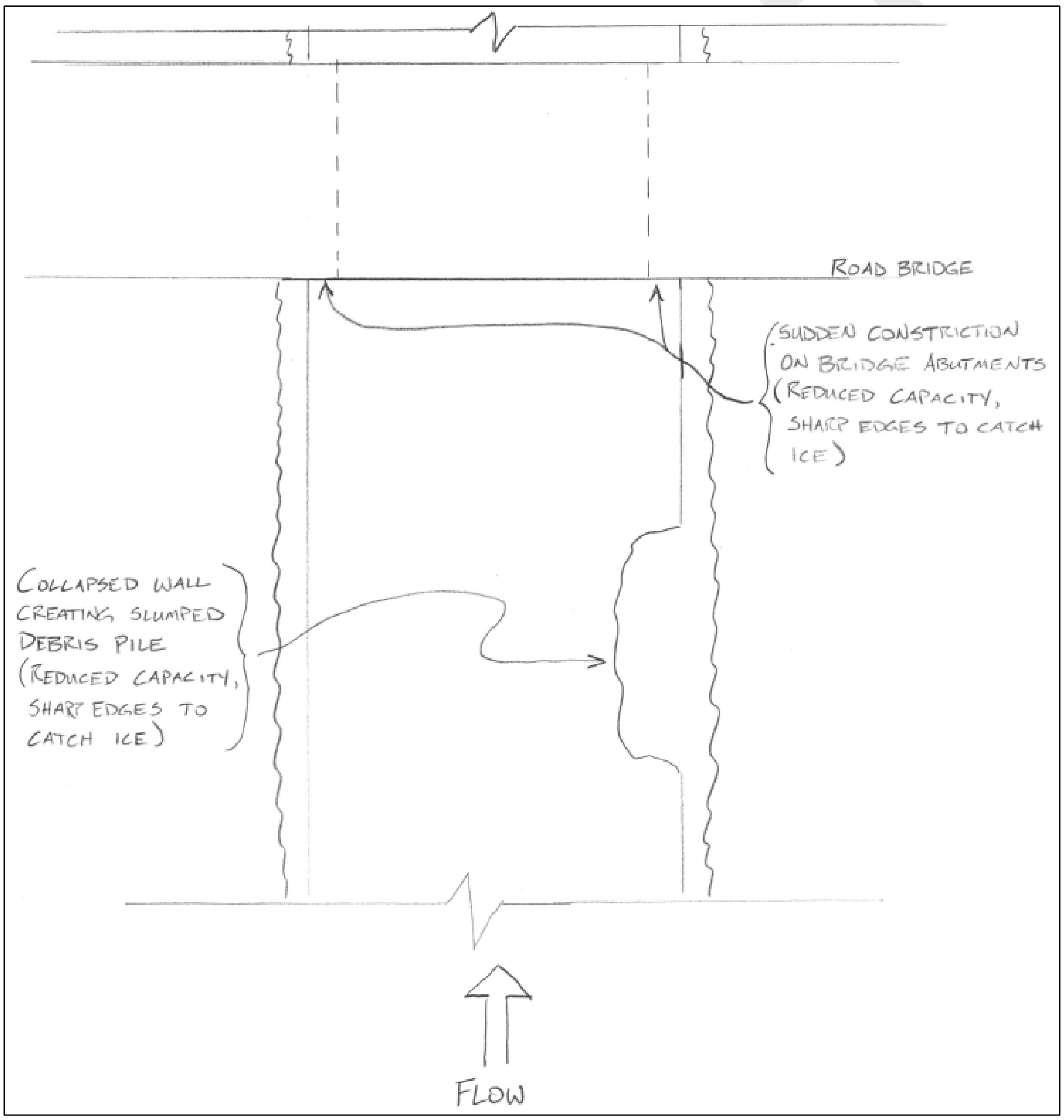

Figure 1. Ice Jam/Local Flooding Potential

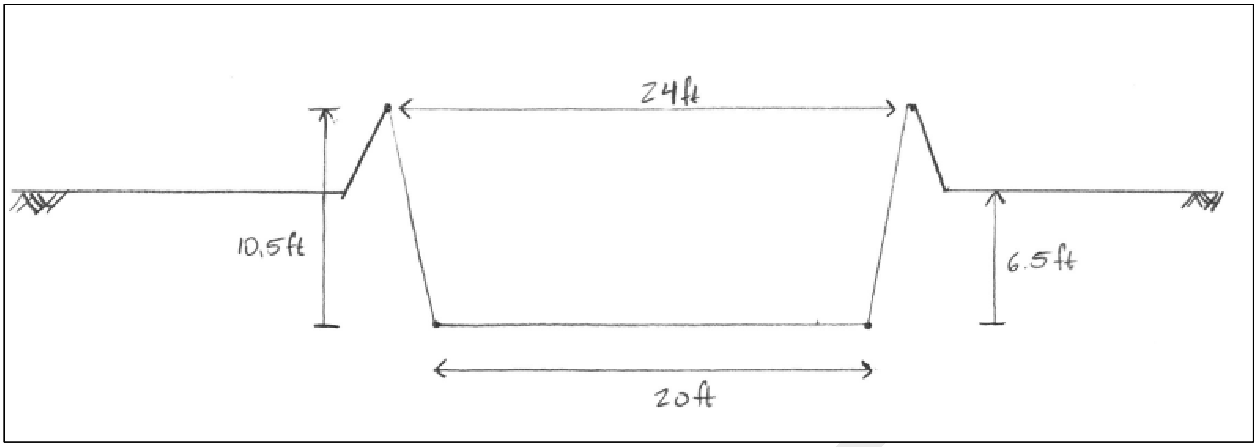

Figure 2. Typical Channel Cross Section

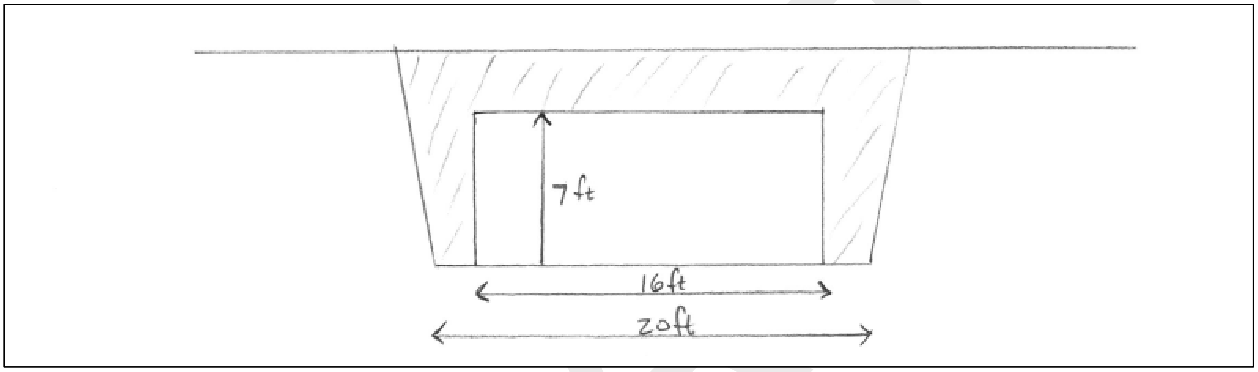

Figure 3. Typical Two-Lane Bridge Crossing Channel Section

2 CALCULATIONS

2.1 Manning's Equation

$$Q = \frac{1.49}{n} AR^{2/3} {S_0}^{1/2}$$

Manning's Equation can be solved iteratively or through tables to determine the normal depth (y_n) expected from a particular flow, slope, and roughness. That will be the basis largely qualitative analysis.

2.2 Assumptions

Some reasonable assumptions can be carried forward from the City of Gooding Flood Insurance Study (FIS) (FEMA 1985).

The FIS states that the slope of the river in the study area is 6.7 feet (ft) of drop per mile:

$$S_0 = \frac{6.7}{5280} = 0.0013$$

Inside the model, it seemed like the slope was closer to 0.0025 in the built-up section through town.

For flow, the 10 percent AEP is used.

$$Q = 375\ cfs$$

(cfs = cubic feet per second)

Manning's *n* in the study was set at *n* = 0.039 in the channel. Chow (1959) gives a range of 0.023 < *n* < 0.035 for "dry rubble masonry" lining a channel. For "gravel bottom with sides of dry rubble or riprap," Chow suggests 0.23 < n < 0.036. The FIS value is above these ranges, perhaps better representing the actual degraded conditions.

3 COMPARISONS

3.1 Comparison 1: Typical Section without- and with-Project Conditions

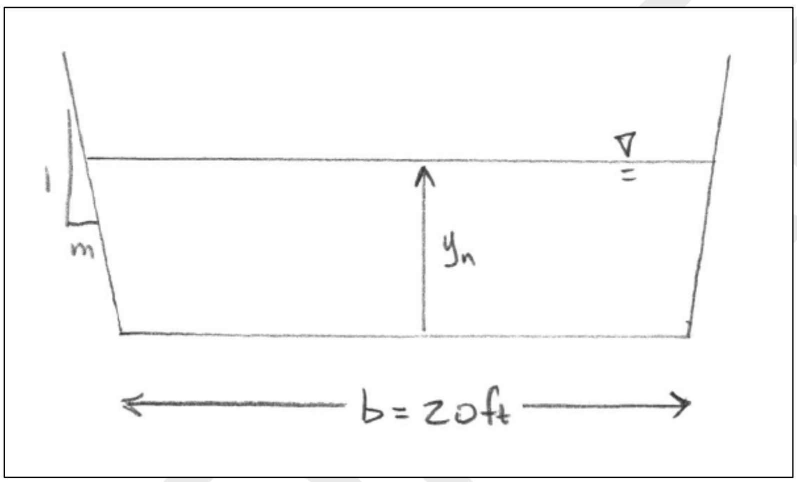

Figure 4. Typical Section Comparison

<u>Without-Project Values</u>

$m = \frac{2}{10} = 0.2$

$n = 0.039$

Using Table B-1 from Jain (2001), Normal Depth in Trapezoidal Channels

$$\frac{n\,Q}{1.49\left(b^{8/3} S_0{}^{1/2}\right)} = \frac{0.039\ (375)}{1.49\ (20)^{8/3}(0.0025)^{1/2}} = 0.0667$$

(m = 0.5)

$$0.0667 \rightarrow {}^{y_n}\!/_{b} = 0.21$$

$$0.21\ (20) = y_n = 4.2\ feet$$

<u>With-Project Values</u>:

m = 0.2

n = 0.017 (concrete)

$$\frac{n\,Q}{1.49\,\left(b^{8/3}\,S_0^{\ 1/2}\right)} = \frac{0.017\ (375)}{1.49\ (20)^{8/3}(0.0025)^{1/2}} = 0.0290$$

$$0.0403 \rightarrow {}^{y_n}\!/_{b} = 0.10$$

$$0.10\ (20) = y_n = 2.0\ ft$$

All other things being equal, a vast reduction of roughness in the channel will lower the normal depth of a given flow rate. This also means capacity should be increased. Working backwards through the table using the lower *n* value, what capacity would be available at y_n = 4.2 ft?

$$^{4.2\ ft}\!/_{20\ ft} = 0.21 \rightarrow 0.0667 = \frac{n\,Q}{1.49\ b^{8/3}\ S_0^{\ 1/2}}$$

$$\frac{0.0667\ (1.49)\ (20)^{8/3}(0.0025)^{1/2}}{0.017} = Q = 860\ cfs$$

3.2 Comparison 2: Bridge Section without- and with-Project Conditions

There are some assumptions built into these comparisons. No attempt to examine backwater effects from current bridge crossings will be made. Only capacity at the bridge section will be examined.

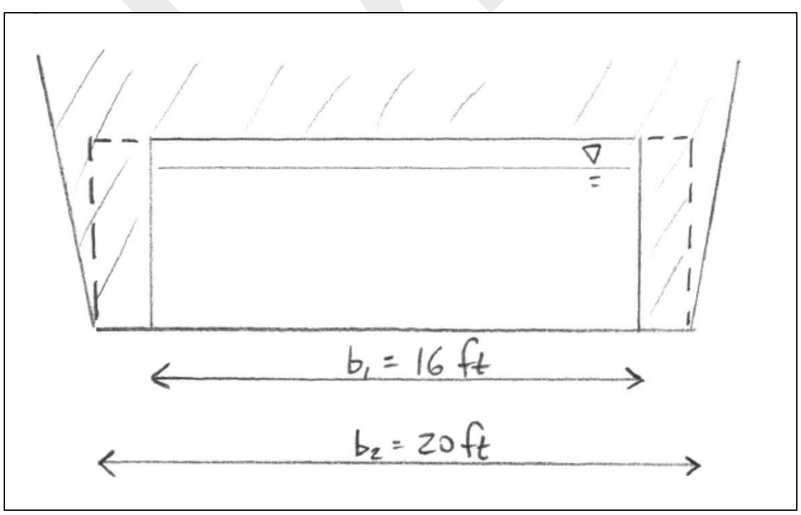

Figure 5. Bridge Section Comparison 2

Without Project Values

m = 0

n = 0.020 (older concrete)

Using Table B-1 from Jain (2001), Normal Depth in Trapezoidal Channels

$$\frac{n\,Q}{1.49\,b^{8/3}S_0^{\;1/2}} = \frac{0.020\,(375)}{1.49\,(16)^{8/3}(0.0025)^{1/2}} = 0.0619$$

(*m* = 0)

$$0.0619 \rightarrow {}^{y_n}/_{b_1} = 0.21$$
$$0.21\,(16) = y_n = 3.36\,ft$$

With Project Values

m = 0

n = 0.017 (concrete)

Using Table B-1 from Jain (2001), Normal Depth in Trapezoidal Channels

$$\frac{n\,Q}{1.49\,b^{8/3}\,S_0^{\;1/2}} = \frac{0.017\,(375)}{1.49\,(20)^{8/3}(0.0025)^{1/2}} = 0.029$$

(*m* = 0)

$$0.029 \rightarrow {}^{y_n}/_{b_2} = 0.13$$
$$0.13\,(20) = y_n = 2.6\,ft$$

What capacity might a new bridge section have? $y_n = 3.36\,ft$

$${}^{y_n}/_{b_2} = {}^{3.36}/_{20} = 0.168 \rightarrow 0.043 = \frac{n\,Q}{1.49\,b_2^{\;8/3}\,S_0^{\;1/2}}$$

$$\frac{0.043\,(1.49)(20)^{8/3}(0.0025)^{1/2}}{0.017} = Q = 555\,cfs$$

3.3 Comparison 3: Slumped/Failed Wall Section without- and with-Project

An assumption is made here about a general shape and size of a slumped/failed wall. No attempt to identify any 3D hydraulic effects of the failed wall is made. Only capacity of the section is examined.

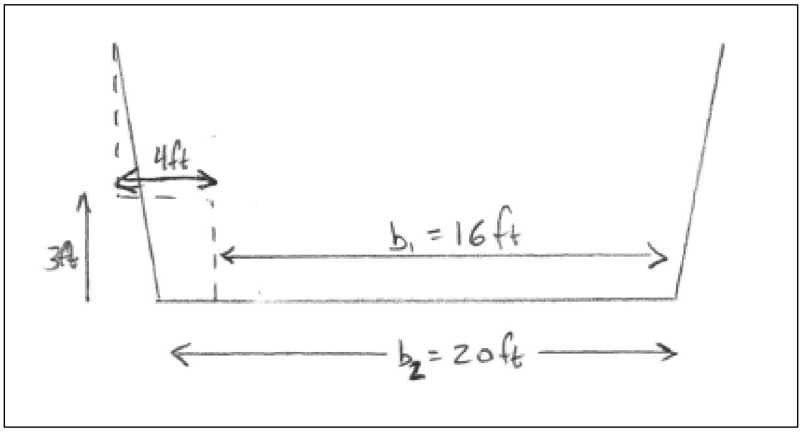

Figure 6. Slumped/Failed Section Comparison

<u>Without-Project Values</u>

n = 0.039

Simplifying assumption: Assume both sides are vertical (*m* = 0). Up to *y* = 4ft, *b*=16ft. Using Table B-1 from Jain (2001).

$$\frac{n\,Q}{1.49\,b^{8/3}S_0^{\,1/2}} = \frac{0.039\,(375)}{1.49\,(16)^{8/3}(0.0025)^{1/2}} = 0.121$$

(*m* = 0)

$$0.121 \;\rightarrow\; {}^{y_n}\!/_{b_1} = 0.30$$
$$0.30\,(16) = y_n = 4.8\,ft$$

This is an over-simplification; the real expected y_n will be less than 4.8 ft for a section like this. However, compare this result to those in Section 3.1 The slumped wall raises the expected y_n from 4.2 ft. The rebuilt section would drop the expected y_n to around 2.0 ft.

4 CONCLUSION

These are all very rough estimates, looking at individual elements of sections without- and with-project conditions. This exercise illustrates that significant improvements in conveyance capacity will occur with this project. It very likely won't be enough to reduce overall flood risk for the City of Gooding, but it is a significant step in the right direction. More importantly, removing the sudden constrictions at bridges and the slumping failed walls will greatly reduce the potential for ice jams to form. When combined with the capacity improvement from this project, the *localized* flood risks from ice jams and other snags will be meaningfully reduced.

5 SOURCES

Chow, V.T. 1959. Open Channel Hydraulics. McGraw Hill

FEMA (Federal Emergency Management Agency). 1985. Flood Insurance Study, City of Gooding, Idaho.

Jain, S. C. 2001. Open Channel Flow. John Wiley & Sons, Inc.