US Army Corps of Engineers ®
Walla Walla District

OWYHEE RIVER ECOSYSTEM RESTORATION

Draft Feasibility Report with
Integrated Environmental Assessment

Appendix A

Hydrology and Hydraulics

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List of Acronyms

Acronym	Description
BIA	U.S. Bureau of Indian Affairs
CAP	USACE Capital Authorities Program
CDD	China Diversion Dam
cfs	Cubic feet per second
DVIP	Duck Valley Irrigation Project
HUC	Hydrologic Unit Code
IQR	Inner Quartile Range (25^{th} to 75^{th} percentiles of a distribution)
ITRC	Irrigation Training and Research Center
Q	Shorthand for hydraulic flow in units of volume per time
SPT	Shoshone-Paiute Tribes of the Duck Valley Indian Reservation
SWL	Static Water Level
USACE	US Army Corps of Engineers
USBR	US Bureau of Reclamation
USGS	US Geological Survey

1 Introduction

Appendix A summarizes the baseline hydrology and hydraulics and related physical riverine conditions for the Owyhee River downstream of the China Diversion Dam near Owyhee, Nevada. This feasibility study and proposed project is proceeding under the USACE Continuing Authorities Program (CAP) Section 206 and is evaluating the ecosystem restoration on two sites just north of the state line to improve degraded aquatic and riparian habitat. As per ER-1105-2-100, the scope of this task was limited to an assessment of existing baseline conditions to inform the CAP§206 feasibility study.

Three key takeaways from this H&H assessment are that:

1) Hydrologic inflows to the project reach are directly affected by upstream irrigation diversions that generate notable periods of very low baseflow and do eventually dewater the channel during a significant portion of each summer.

2) Annual flood events typically occur prior to the irrigation season and are predominately routed through a historic straightened channel with a nominal top width of <100 feet and depth of 2-3+ feet. Despite the straightened reach, at Sites #3 and #4, annual floods as low as the 50% AEP (2-year return period) activate relic side channels, flanking of deprecated alluvial levees.

3) The design and implementation of proposed restoration measures will need to be effective, and stable over a wide range of flows from very low baseflows to flashy overbank flood events. From the perspective of hydrologic resilience, measures (e.g.: channel/floodplain grading, in-stream structures, beaver-dam-analogs, etc.) should be designed for a stage progressive response with re-activated side channels sized to inundate overbanks and refill wetlands at median flows <50 cfs during late winter / early spring before the pre-irrigation season begins in March. Capturing early spring flows and the subsequent brief May freshet, will be essential to recharge local groundwater as a hedge against abrupt dewatering of the river channel in June followed by multiple months without measurable surface water inflows.

Effective restoration of both aquatic and riparian ecosystem function will need to account for a regulated hydrograph where Owyhee River flows below the China Diversion Dam can drop abruptly with the start of the irrigation season (around the April/May timeframe) with the reach rapidly dewatering to zero inflow typically by June until the end of the water year. Proposed measures to develop a riparian corridor by reconnecting relic side channels and constructing wetlands in adjacent overbanks should be designed with progressive grading to maximize volume capture of the spring freshet before May, increase roughness and sustain riparian processes.

Live riparian vegetation components of the proposed ecosystem restoration will be the essential "glue" necessary to improve project durability and should be strategically integrated into banklines and low benches, side channel inlets/outlets. It will be critical for the revegetation rooting depths to be installed such that they extend much deeper than proposed channel and wetland inverts (recommend >3 feet below finished grade) to intercept irrigation return groundwater to provide resilience during the 4+ month period (June through September) when the reach is dewatered.

During the subsequent PED phase for the preferred alternative, hydraulic modeling and design analysis will be necessary to optimize site specific design parameters including: final alignment planform, hydraulic geometry, slope transitions, detailed structure layout, and stability criteria for higher energy flood events.

Integrated restoration measures should be designed to optimize hydraulic performance for both stability and ecologic resilience. Key components of proposed structural and grading measures should be designed to remain stable at the 1% AEP of ~4500 cfs with design criteria and countermeasures that account for localized hydraulic conditions to address known modes of failure including: impingement, overtopping, tear-out, break-apart, and scour.

2 Hydrology

The Owyhee River catchment above China Diversion Dam is located in north-central Nevada within the Semiarid Uplands (Level IV ecoregion 80J) of the Northern Basin and Range Level III ecoregion. Fed by the Independence Mountains of the upper Owyhee subbasin (HUC 17050104) on Humboldt–Toiyabe National Forest lands north of Elko, Nevada, runoff from the upper Owyhee basin is stored in Wild Horse Reservoir (USGS#13174000) which is part of the larger Duck Valley Irrigation Project (DVIP) as detailed in Section 2.1 below. Land cover is predominately shrub/scrub and herbaceous with common species such as Mountain big sagebrush and grasses such as Idaho fescue respectively. With a low forested area less than 3%, the woodland zone is occupied by mountain brush and scattered aspen groves with limited juniper woodland.

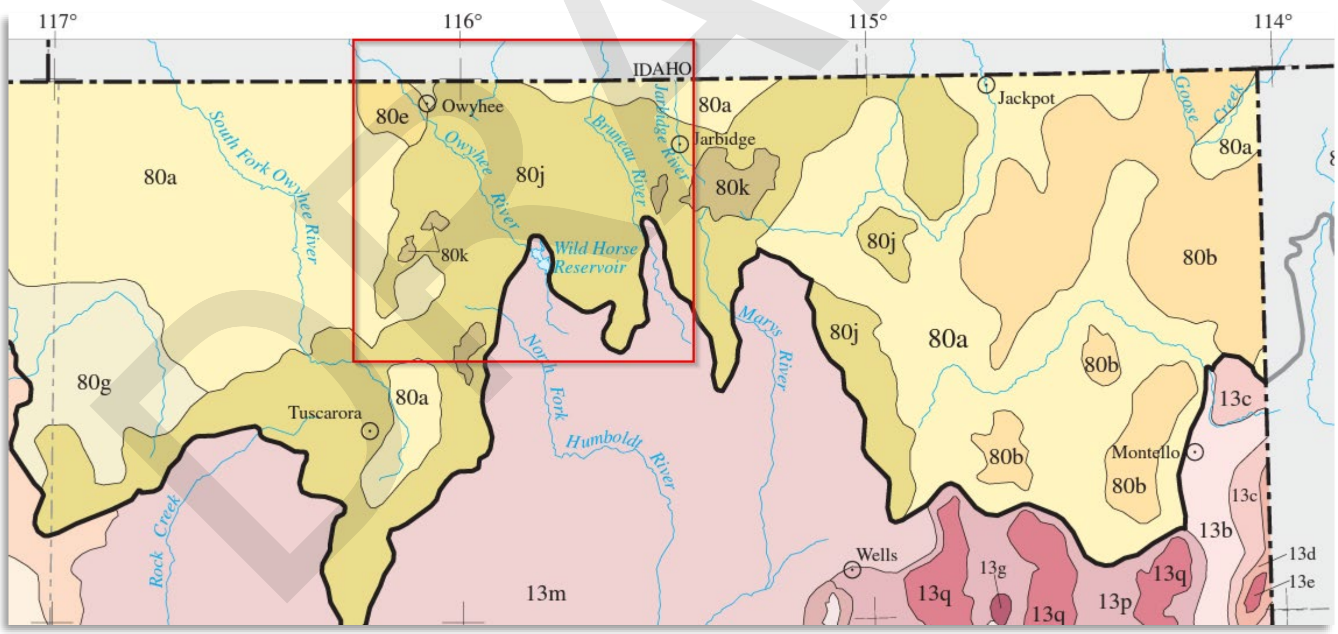

Figure 2-1. Ecoregions of Northern Nevada. (EPA 2016). Red box outlines the Owyhee River catchment considered for feasibility.

The study reach for the Owyhee River below China Diversion Dam (HUC 170501040701) is a fourth order stream located on the Shoshone-Paiute Tribes Duck Valley Reservation in north-central Nevada and south-central Idaho with a drainage area of approximately 458 square miles (Figure 2-2)

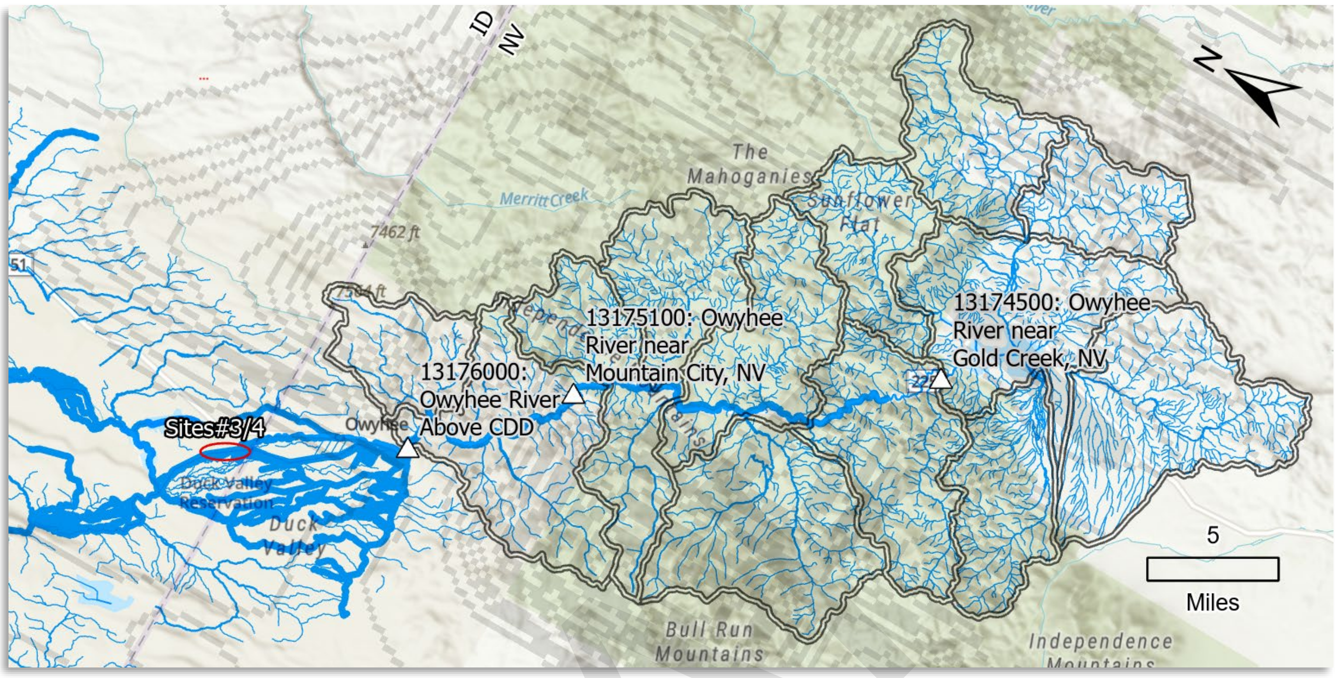

Figure 2-2. Owyhee River Watershed (HUC 17050104). *Flow paths in blue. Triangles represent USGS streamflow gaging stations. Polygons represent HUC12 catchments above CDD*

Table 2-1. Summary of Owyhee River above China Diversion Dam Gage-basin Characteristics

Station	**13176000**	**13175100**	**13174500**
Parameter	**Above CDD**	**Near Mtn City**	**Near Gold Creek**
Mean basin elevation	6,660 feet	6,684 feet	6,710 feet
Max basin elevation	9,107 feet	9,107 feet	8,858 feet
Basin relief	3,677 feet	3,546 feet	2,668 feet
Mean basin slope	23.2%	22.6%	17.4%
Percent area with slopes > 30%	30.9%	25.5%	8.8%
Mean Basin Aspect	East (89°)	East (84°)	Northeast (53°)
% Forested area	2.4%	1.3%	0.8%
% Shrub/Scrub Area	54%	51%	64%
% Herbaceous Area	41%	45%	32%
PRISM 30-year precipitation normals for 1991 to 2020	Min: 12.7 in Mean: 18.7 in σ: 4.5 in Max: 35.9 in	Min: 12.7 in Mean: 18.5 in σ: 4.4 in Max: 35.9 in	Min: 12.7 in Mean: 17.0 in σ: 3.0 in Max: 29.6 in

2.1 Duck Valley Irrigation Project

Originally constructed in 1937 as a reported CCC project, Wild Horse Dam was replaced in 1969 with a new concrete single-arch dam constructed by USBR for BIA that roughly doubled the storage capacity with a height of 87 feet and a length of 458 feet. Wild Horse Reservoir has a median annual storage of approximately 44 kaf with an inner quartile range between ~28 kaf and ~57 kaf. The annual storage fluctuation averages ~28 kaf. Downstream of Wild Horse Reservoir, the Owyhee River flows ~27 river miles through the Duck Valley Reservation to the China Diversion Dam (USGS#13176000).

Figure 2-3. Wild Horse Reservoir in Elko County, NV. *Left: Wild Horse Dam, Right: Wild Horse Reservoir. Source: Wikimedia Commons.*

Downstream water rights to the Wildhorse Reservoir waters are held by various entities, including the Duck Valley Indian Reservation and other water users with legally recognized water rights. The Duck Valley Indian Reservation leases water from BIA who retains administration and ownership of Wildhorse Reservoir. Originally constructed in 1937 and rehabilitated in 1982 by USBR, the China Diversion Dam is a small run-of-river regulation project that diverts Owyhee River inflows into two primary conveyances of the DVIP; to the North, the Agency Canal system routes irrigation flows to Mountain View Lake while to the south, the Highline Canal system routes irrigation flows to Sheep Creek Reservoir. Both the Agency and Highline canals include lateral turnouts to supply irrigation water to the Duck Valley through a branched system of canals as depicted in Figure 2-5.

A prior engineering assessment (DOWL-HKM 2009) documents that the maximum diversion capacity at the CDD is 255 cfs to the Highline Canal, and 100 cfs to the Agency Canal for a combined diversion of 355 cfs. That report notes that a typical high operation diversion is 180 cfs with 150 cfs to the Highline Canal and 30 cfs to the Agency Canal. However, SPT clarified for this study that the DVIP is operated at maximum diversion capacity whenever possible in accordance with The Shoshone Paiute Tribes Water Code (adopted 3/16/2012) as detailed further in Section 2.2.7. Any additional inflows to the CDD above 355 cfs are not diverted, and spill through the diversion structure, flowing North through a channelized conveyance reach of the Owyhee River. As detailed further herein, seasonal irrigation diversions frequently equal inflows to the CDD effectively dewatering the downstream reach in the summer.

Figure 2-4. Original China Diversion Dam, May 2022. *Left: looking upstream, Right: looking downstream.*

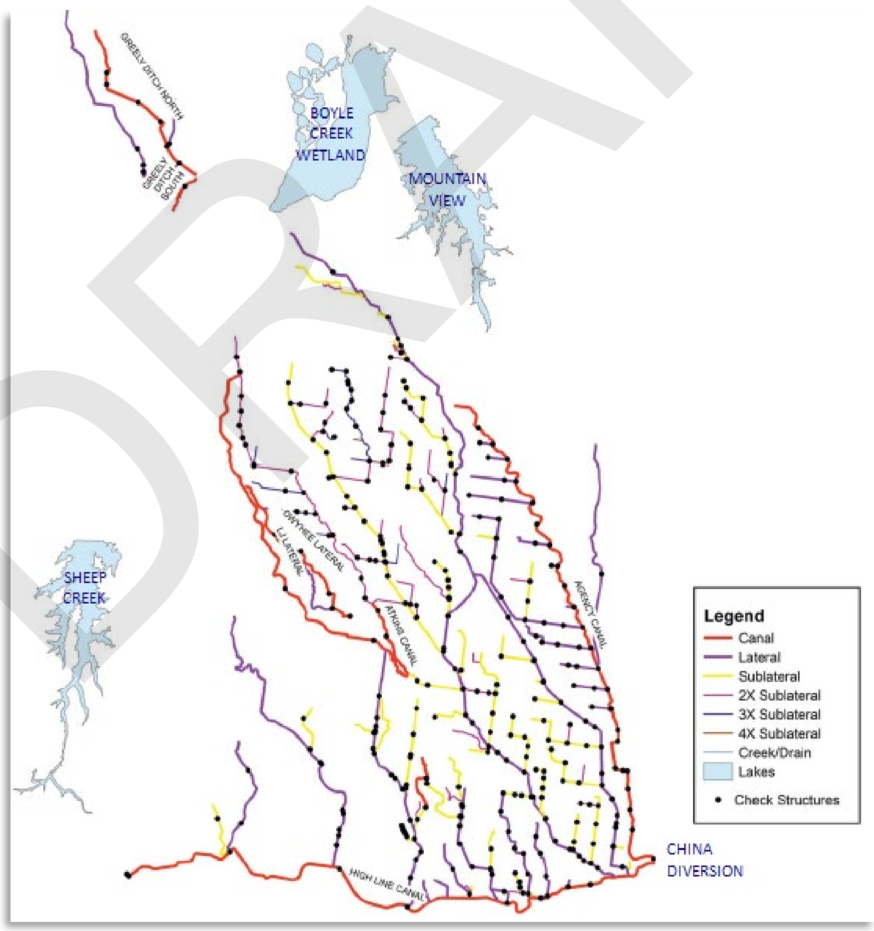

Figure 2-5. Schematic of DVIP irrigation system below the China Diversion. Source: ITRC 2017.

The DVIP is incrementally investing in modernizing the irrigation system, informed by a 2017 plan developed by the Irrigation Training and Research Center (ITRC). The modernization plan is intended to provide more efficient delivery and use of irrigation water, by focusing on water management and operational changes. Irrigation system improvements include converting some surface laterals into closed conduits, improved turnout gates, and canal water level controls. Only minimal canal lining was recommended. Recommended upstream reservoir improvements include the construction of a buffering re-regulation reservoir immediately upstream of CDD combined with remote operation of the Wild Horse Dam gates to utilize the Wild Horse Reservoir water more efficiently. Recommended downstream reservoir improvements include a reservoir control structure and pump station at Blue Creek Reservoir/Wetland to capture irrigation return flows from Duck Valley and augment Mountain View Reservoir storage.

The recommended CDD upgrades were designed and constructed in 2023. The upgraded diversion constructed a small (~170 acre-foot) run-of-river re-regulation reservoir with ~59 acre-feet of operational range to assist the DVIP in managing flow lag time between Wildhorse Reservoir and the CDD during the irrigation season. In addition, the diversion structure and mechanical appurtenances were upgraded to improve operational flexibility. This increased storage capacity and operational flexibility may provide future capacity for flow shaping to increase flow duration in Owyhee River downstream of the diversion, and reduce the number of days that the reach is seasonally dewatered.

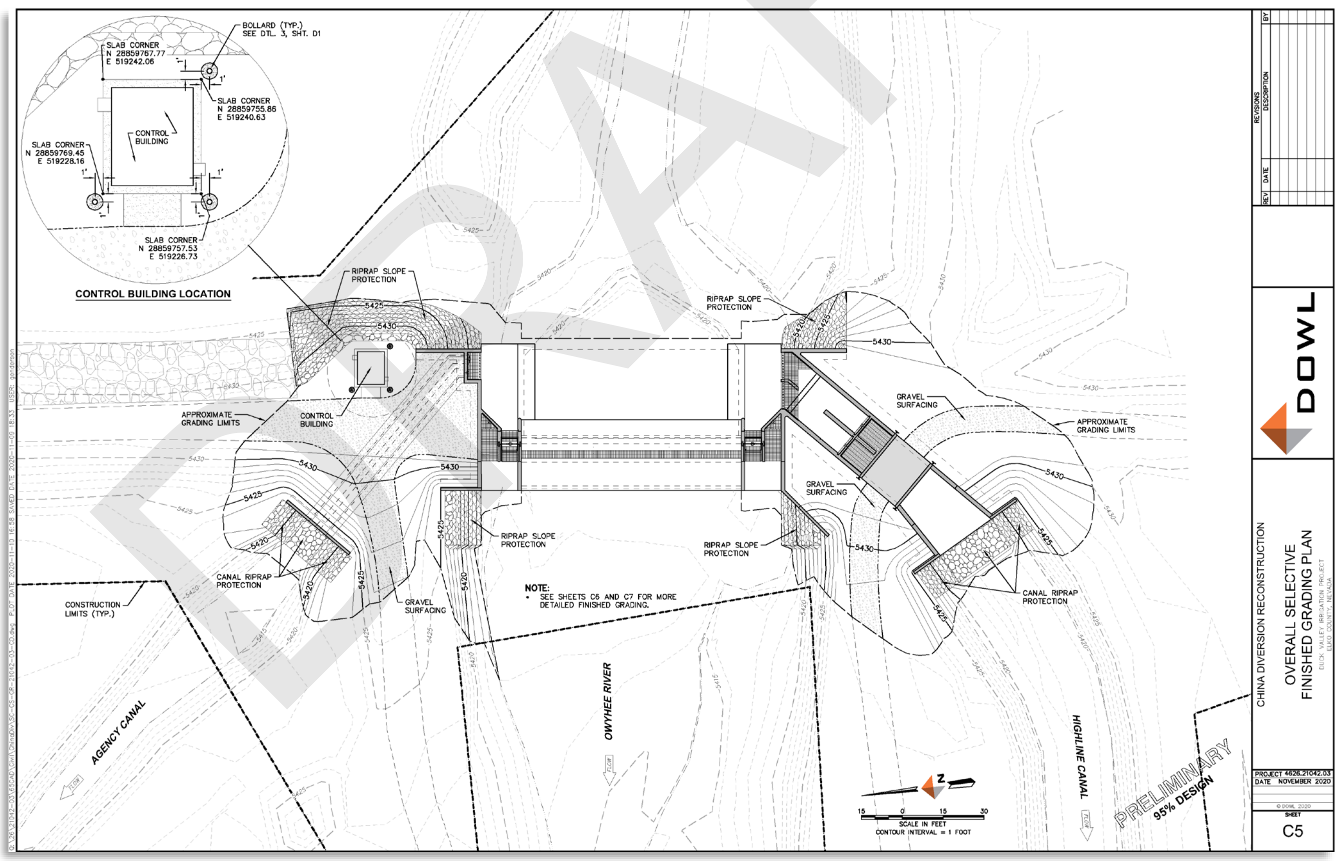

Figure 2-6. Example Grading Plan from the Preliminary 95% Design Plans to upgrade the CDD. Source: DOWL-HKM, November 2020. Note that Flow direction is from top to bottom.

Figure 2-7. Reconstructed China Diversion Dam, March 2024. *Left: looking upstream, Right: looking downstream.*

2.2 Flow Regime

Stream flow patterns in the Owyhee River above the China Diversion dam are characterized by a seasonal snowmelt driven freshet of the basin upper elevations during late winter or early spring (February to May) that are used to refill Wild Horse Reservoir which support the Duck Valley Irrigation Project (DVIP) throughout the summer irrigation season. Between Wild Horse Reservoir and the China Diversion dam, the Owyhee River flows ~27 river miles, gaining an additional ~249 square miles of drainage area from local inflows for a total drainage area of ~458 square miles. At the upstream (south) end of the Duck Valley, the China Diversion dam diverts flows into both the Agency (north branch) and Highline (south branch) Canals, and any remaining flow spills back into the Owyhee River, flowing north through the Duck Valley for approximately seven river miles to the feasibility study area reach for Sites #3 and #4. Downstream of the study reach, the Owyhee River valley flows for approximately another 2.5 river miles, gradually rejoining flow from other relic meanders in a wetland complex upstream of Blue Creek reservoir.

2.2.1 <u>Stream Gages</u>

This section includes summary plots of seasonal quantiles for the available period of record for three gages. Each plot represents the available period of record, with the solid bold line representing the median; the inter-quartile-range and other quantiles are shaded or identified as enumerated in the legends.

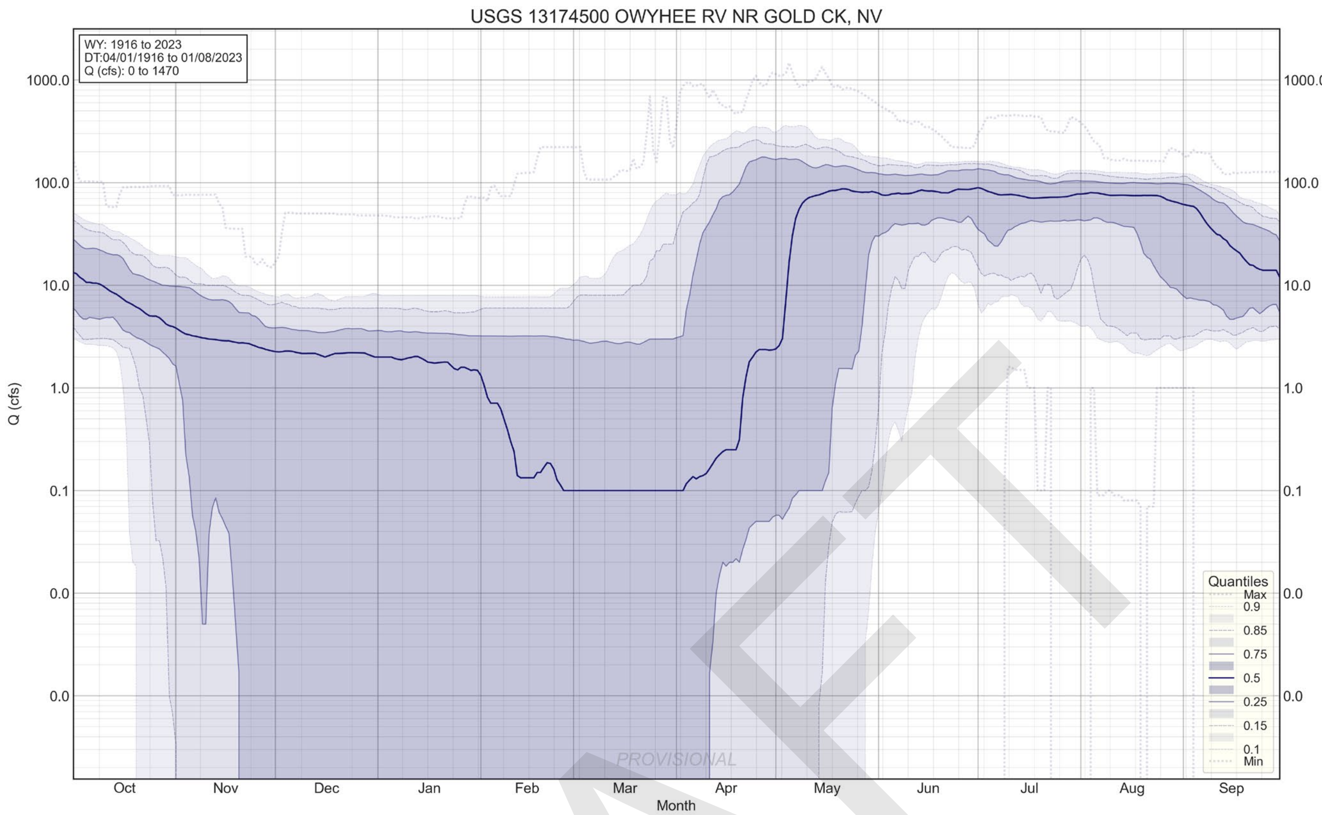

Figure 2-8. Seasonal flow at USGS 13174500 Owyhee River near Gold Creek , NV downstream of Wild Horse Reservoir.

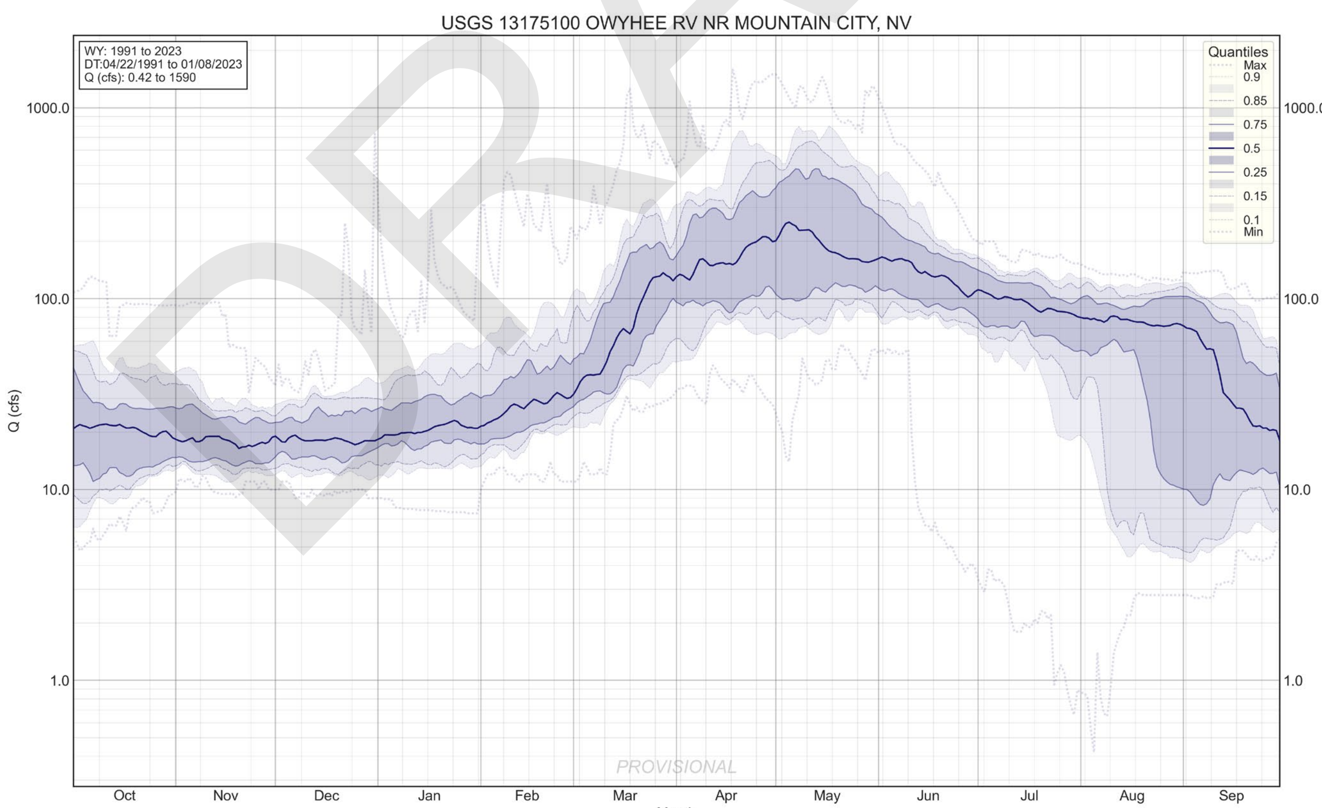

Figure 2-9. Seasonal flow at USGS 13175100 Owyhee River near Mountain City, NV.

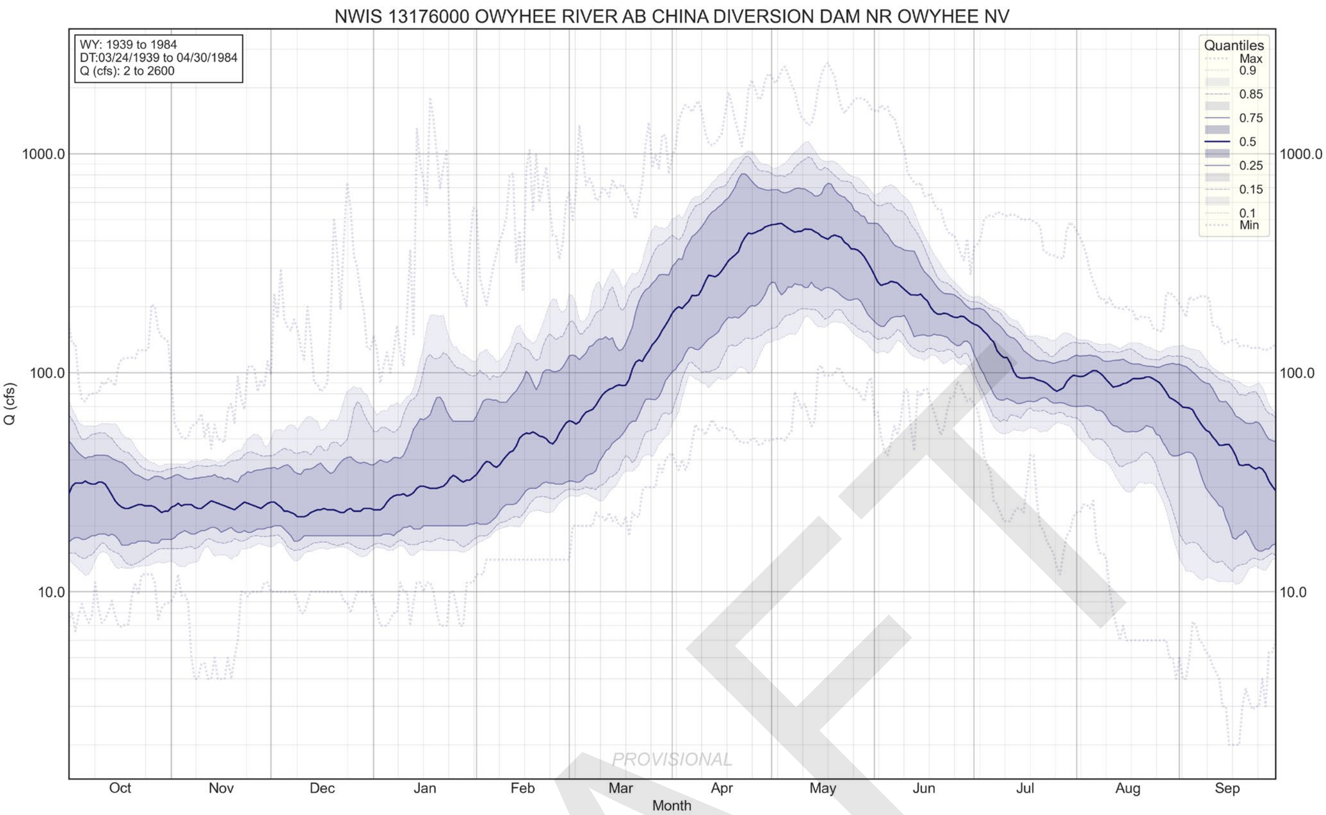

Figure 2-10. Historical seasonal flow at USGS 13176000 Owyhee River above China Diversion Dam.

2.2.2 Measured Flow Comparisons

Inflows to the China Diversion Dam were historically measured at USGS gage#13176000 (Owyhee River above CDD) which includes ~44 years of measured stage and flows between water years 1940 and 1984 before being discontinued. Ideally this gage could be used to represent current inflows to the CDD, however having been discontinued for nearly forty years, a comparison with more current measured data was considered. The next available Owyhee River gage with current data is located approximately eleven river miles upstream near Mountain City, NV (USGS#13175100) with a flow record from water year 1991 to 1994 and 1998 to present. Data gaps within the available periods of record, where neither gage has data, are present in water years 1984-1990, 1995-1997.

A comparison of these two gages (Figure 2-11) depicts an approximate 50% difference in mean daily flow magnitude which is larger than the difference in contributing drainage area. The difference in catchment area between the Near Mountain City gage (#13175100) and the Above China Diversion gage (#13176000) is ~17% (458/391 mi^2), with the additional 67mi^2 of drainage area contributed predominately from the Fawn Creek (HUC#170501040304 @ 70%) and Skull Creek (HUC#170501040303 @ 30%) subbasins which drain the northwest flanks of the Independence Mountains as depicted in Figure 2-2.

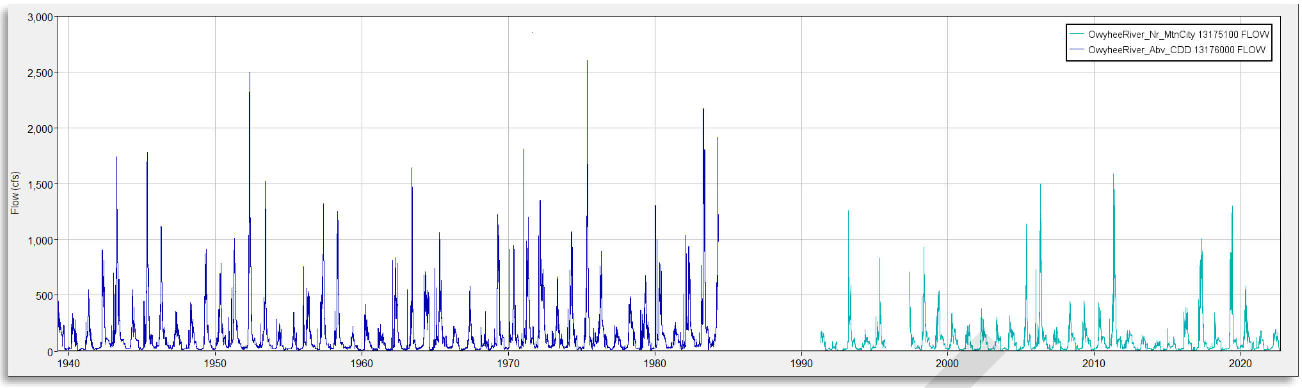

Figure 2-11. Owyhee River mean daily flow values. Blue data depicts historical site above CDD (#13176000) & cyan data is the currently active gage site near Mountain City (#13175100). *Note ~50% difference in seasonal flow magnitudes.*

Because the two Owyhee River flow records did not overlap in time, a generalized comparison between the flow duration exceedance distributions (Figure 2-12) was evaluated. One notable observation between the two gage site records is that the historical flow magnitude at the downstream site (above CDD) is consistently higher (mean ~52%, median~46%, standard deviation ~24%) than the current upstream gage site near Mountain City, NV (Figure 2-13) with the largest ratios present at low baseflows < 10 cfs as would be expected.

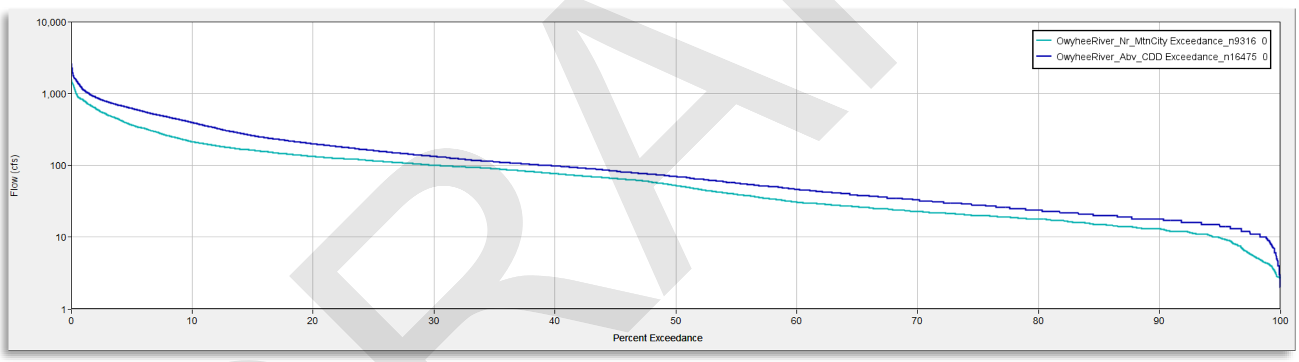

Figure 2-12. Owyhee River mean daily flow duration exceedance. Blue data depicts historical site above CDD (#13176000) & cyan data is the currently active gage site near Mountain City (#13175100). Note that y-Scale is log10 based.

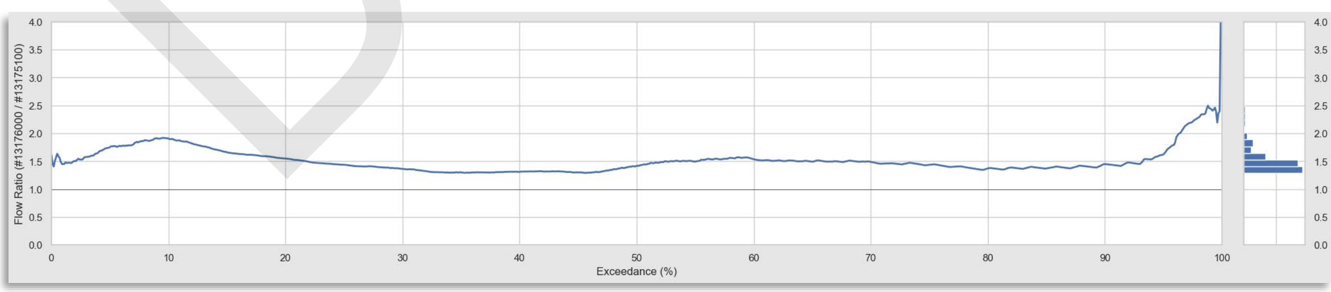

Figure 2-13. Owyhee River flow exceedance ratio between gages. (Above CDD / Near Mtn City)

2.2.3 Wildhorse Reservoir Storage

Considering that the average ~52% increase between flow rate exceedance for historical flows at the China Diversion is nearly three times larger than the 17% increase in contributing drainage area relative to Mountain City, the influence of upstream regulation was evaluated. Annualized water year volumes for Wildhorse Reservoir storage and outflows to the Owyhee River near Gold Creek are plotted in Figure 2-14. Prior to Wildhorse Reservoir upgrades completed at the end of water year 1969 (see section 2.1), annual outflow volumes from Wildhorse Reservoir would regularly exceed the maximum storage capacity of ~35 kaf, indicative of more passthrough (unregulated) flow for those years. Further, for lower yield water years, the reservoir storage frequently dropped to near-zero levels. In the hydroperiod following reservoir upgrades, outflow volumes for water years 1970 through 1984 generally trended higher than the seasonal storage fluctuation, indicative of multiple wetter years that provided a higher amount of carryover storage for the following season. In the last-20-year hydroperiod, the Owyhee River outflow volume has trended closer to the annual water year storage fluctuation, while the carryover storage capacity has typically been held at or above 5 kaf.

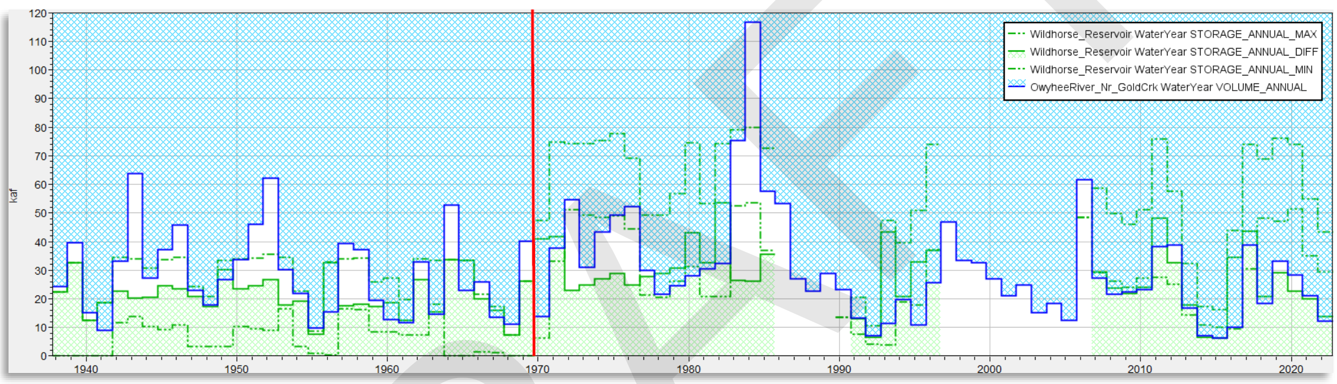

Figure 2-14. Comparison of annual volume storage and outflow at Wildhorse Reservoir.

Timeseries of reservoir outflows to the Owyhee River near Gold Creek (gage#13174500) were split to coincide with the period of record for the above CDD gage (#13176000: 01-Oct-1970 to 29-Apr-1984) and the near Mountain City gage (#13175100: 21-Apr-1991 to 06-Nov-2022). As illustrated in Figures 2-14 and 2-15, the frequency difference of reservoir outflows near Gold Creek, exhibits a similar distribution trend as the comparison between the above CDD and the near Mountain City gages. This suggests that the trend of statistically larger flows measured for the above CDD gage can be attributed in part to upstream hydroregulation at Wildhorse Reservoir.

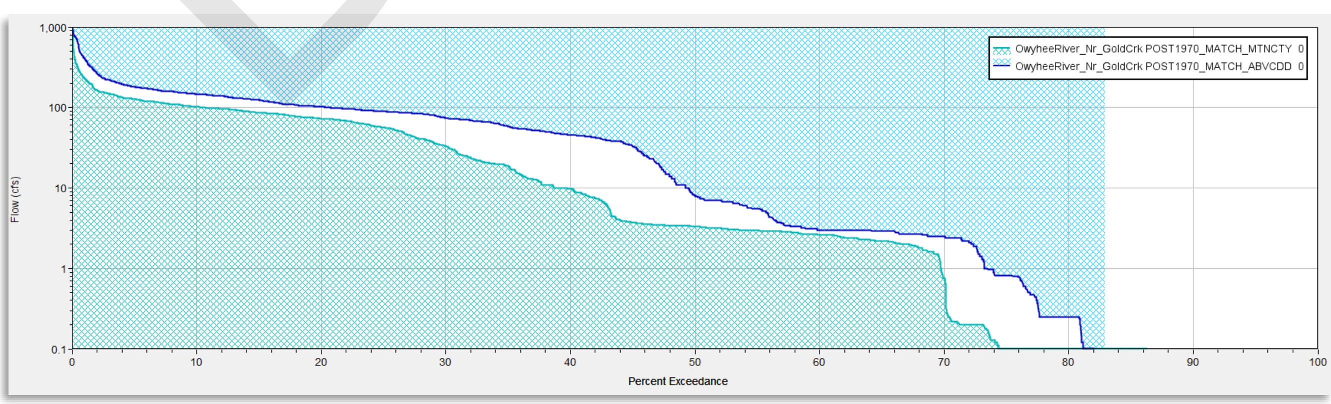

Figure 2-15. Owyhee River mean daily flow duration exceedance measured near Gold Creek after WY1970. *Blue curve depicts historical hydroperiod (1970-1984) that coincides with measurements above CDD (#13176000) & cyan curve represents the current hydroperiod (1991-2002) that coincides with measurements near Mountain City (#13175100). Note that y-Scale is log10 based.*

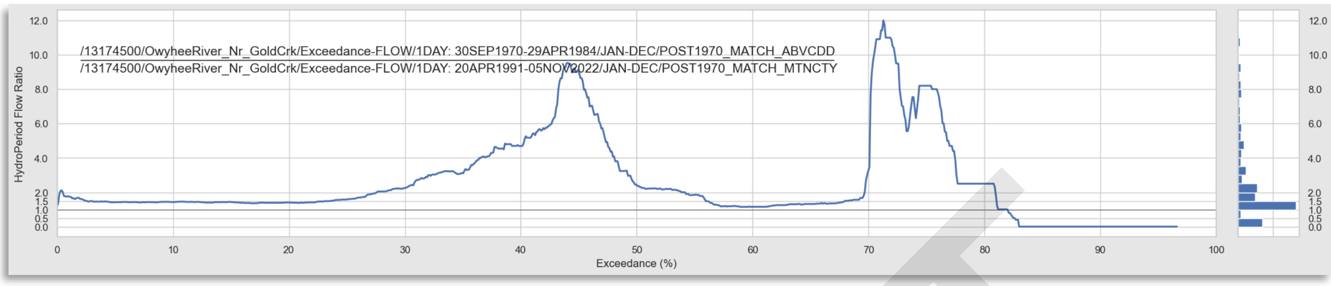

Figure 2-16. Owyhee River near Gold Creek Station#13174500. Flow exceedance ratio between coincident hydroperiods with downstream gages. (Hydroperiods are: Above CDD / Near Mountain City)

2.2.4 Volumetric Yield Comparisons

A comparison of volumetric yield between gage subbasins was also made to evaluate inflows to CDD. The first baseline gage (#13174500 Owyhee River near Gold Creek) is approximately sixteen river miles upstream of Mountain City and represents regulated outflows from Wild Horse reservoir. The second baseline gage, #13161500 Bruneau River at Rowland, NV is located about seventeen miles northeast of Mountain City, and also drains the north flank of the Independence Mountains (HUC#17050102). As an active gage with a relatively long period of record (55 years), and a similar drainage area to the Owyhee River near Mountain City gage (382 square miles) it was selected for comparison of unregulated flow and volume trends within the same physiographic region.

As illustrated in Figure 2-17 below, the annual volumetric yield rates in acre-feet/square mile trend consistently between gages across wet and dry cycles within the period of record. Average volumetric yield rates at the upstream baseline near Gold Creek were ~144 acre-feet/mi^2, with the next gage downstream near Mountain City averaging ~181 acre-feet/mi^2 (a ~25% increase), and the above China Diversion gage averaging ~235 acre-feet/mi^2 (an additional ~30% increase relative to Mountain City gage).

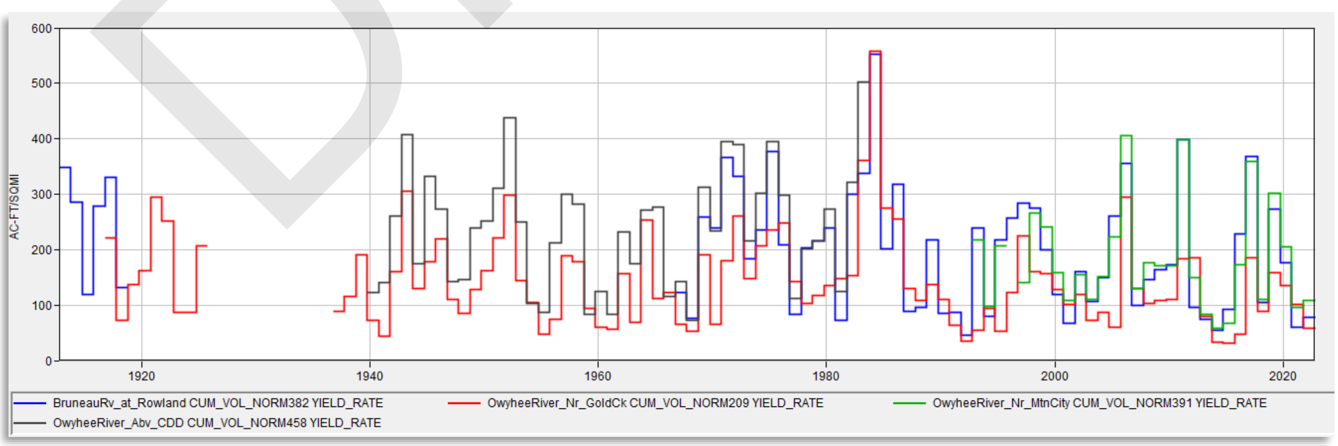

Figure 2-17. Owyhee River water year volumetric yield rates in ac-ft/mi^2 at three gages between China Diversion dam and Wild Horse reservoir, and a fourth reference gage on the Bruneau River.

Two notable trends are that annual volumetric yield rates at the near Mountain City and Bruneau River gages were generally similar over most of the coincident record (1996 to 2022), and that historical yield trends at the Above CDD gage were consistently higher than the near Gold Creek gage and also the Bruneau River gage. A similar trend is also evident in Figure 2-18 that depicts the annual volumetric yield rate exceedance curves of the four regional gages. This suggests that the Wildhorse Reservoir hydroregulation (see Section 2.2.3) during the data collection period above China Diversion Dam (01-Oct-1970 to 29-Apr-1984) increased the inflows to CDD during that period above regional volume normals of the last thirty-year hydroperiod.

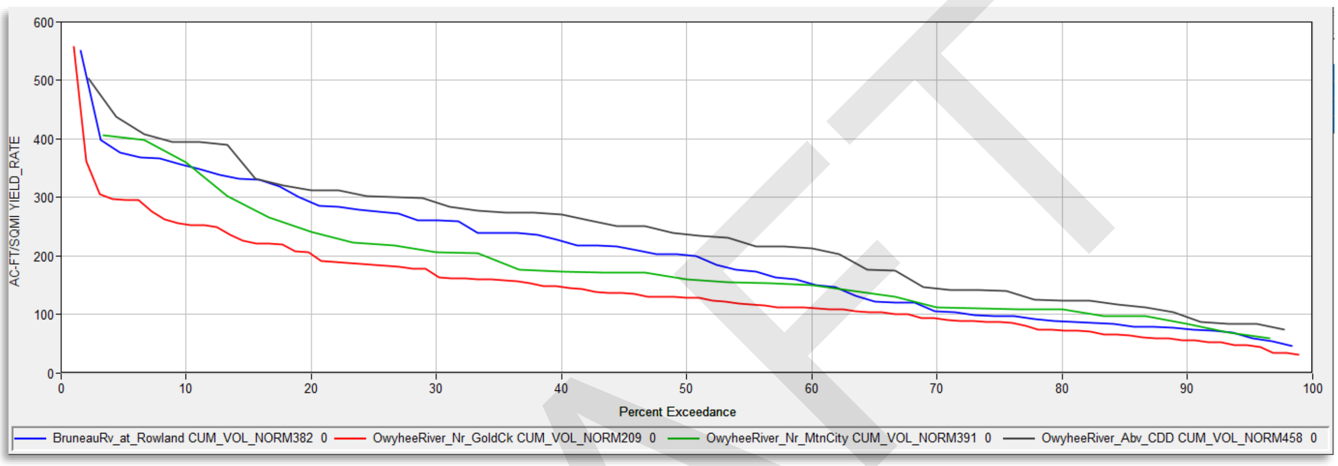

Figure 2-18. Annual volumetric yield rate exceedance curves at four regional gages.

2.2.5 Precipitation Distributions

A cursory check of the 30-year precipitation normals was also conducted to identify trends that relate to the relatively higher historical flows measured above CDD. The 800meter resolution PRISM group grids of 30-year precipitation normals for the 1991-2020 period were analyzed for contributing subbasins to the three gages. As depicted in Figure 2-19, the cumulative fraction catchment area of precipitation normals was notably lower for the headwater gage near Gold Creek (#13174500), and that the spatial distributions were similar for the above China Diversion and near Mountain City catchments. This does support using the currently active near Mountain City gage as a representative surrogate for current inflows to CDD once corrected for area.

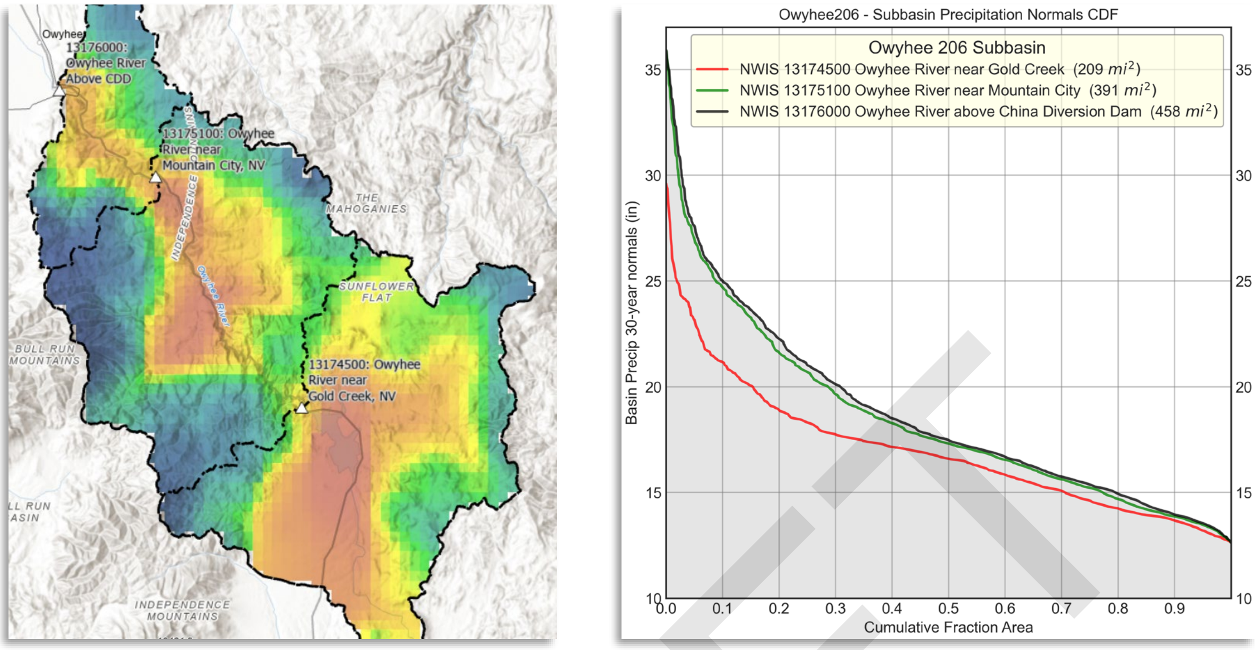

Figure 2-19. PRISM 30-year Precipitation Normals for 1991-2020. Left: subbasin distribution. Right: subbasin exceedance.

2.2.6 Basin Hypsometry

A final cursory check for potential orographic effects to explain the larger historic inflows to CDD, the hypsometric distributions were evaluated for the Owyhee gage sub-catchments. As plotted in Figure 2-20, the basin elevation hypsometric distributions were found to be very similar for both the Mountain City and above CDD gage locations, with some divergence for the near Gold Creek gage. This suggests that elevation effects would not be a contributor to the higher measured historical flows for the above CDD gage. This further supports the approach of areal upscaling the currently active near Mountain City gage to develop a synthetic flow hindcast as discussed in the Section 2.2.7 below.

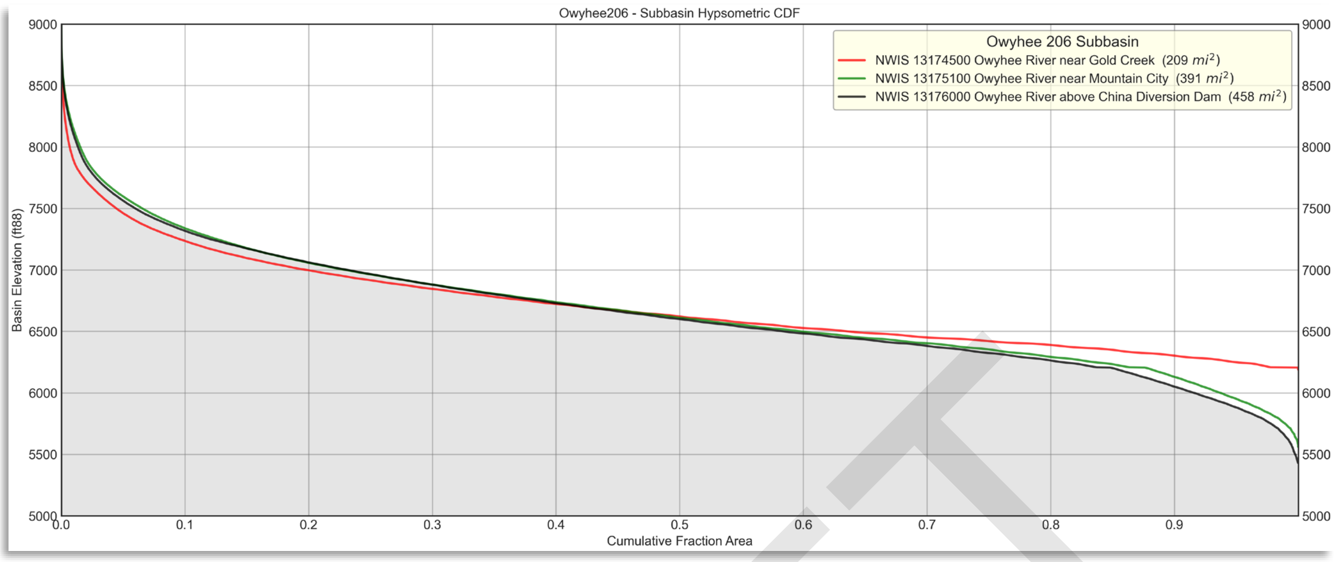

Figure 2-20. Owyhee River gage basins hypsometric curves of elevation fraction area.

2.2.7 <u>Synthetic Hindcast</u>

For this feasibility study, the active stream gage on the Owyhee River near Mountain City (USGS #13175100) is considered the best available recent record of the last thirty-year hydroperiod to quantify flows generated in the upper Owyhee Basin, representing the seasonal hydroregulation from Wild Horse Reservoir and lateral inflows above that point. As detailed in Section 2.2 historical changes in hydroregulation have established the current hydroperiod (last 50-year) flow regime, within which hydroregulation for the last 30-years was notably different from the first 20-years.

As previously discussed in Section 2.2, the increased historical flows at CDD are suspected to be predominately attributed to historical changes in upstream regulation at Wildhorse Reservoir spanning in water year 1970 to 1995. Downstream of Gold Creek, the additional catchment helps to balance the flow regime. No additional trends in physical watershed characteristics or precipitation normals were attributed to the higher historical inflows to CDD. Assuming continuity in watershed response, the additional catchment area of ~17% was used as the sole factor for areal scaling the near Mountain City flows to the above China Diversion Dam inflows. These synthetic flows, developed by scaling up Mountain City flows by 17%, were assigned station Syn#13176000 for this study. The feasibility study-area sites #3 and #4 are located approximately seven river miles north of the China Diversion, just north of the Idaho-Nevada state line. Residual flow below the China diversion follows a predominately entrenched conveyance that trends down-gradient through the Duck Valley alluvial fan towards the Blue Creek wetland/reservoir.

To characterize the baseline flow regime for the ecosystem restoration feasibility study sites #3 and #4, Owyhee River estimates of residual flow below the China Diversion Dam were synthesized by subtracting the Agency (north branch) and Highline (south branch) Canals from the synthetic in-flows. Ideally, timeseries records of CDD irrigation withdrawals magnitude and operational timing would provide a sound basis for computing residual flows below CDD. Unfortunately, SPT/DVIP was not able to provide gaged measurements of irrigation out-flows or residual over-flows at CDD. As such, seasonal flows below CDD were synthesized by applying a generalized DVIP operations ruleset as recommended by SPT between FY22 and FY23 and assigned synthetic station number #13176101 for this feasibility study.

As of July 2023, the following general information was used by NWW-ECH to synthesize flows below China Diversion Dam for representative flow at feasibility sites #3 and #4.

1. The pre-irrigation season is from 01-March to 15-April. During this time, if Wild Horse Reservoir is spilling water in excess of its capacity, and/or during the Owyhee River annual spring run-off, the DVIP will divert Owyhee River water at the China Diversion and deliver it to irrigators. The regular irrigation season starts 01-April and extends through 31-October and frequently diverts all of the Owyhee River inflows into the two canal systems. There is no minimum baseflow requirement for the Owyhee River downstream of CDD.

2. Per Dowl-HKM 2021, a typical high-flow diversion operation totals 180cfs (30cfs and 150cfs at the Agency and Highline canals respectively). However, based on guidance from SPT, starting 01-March the DVIP system is operated to divert all inflows to the China Diversion up to the maximum canal capacity of 355 cfs (255 cfs to the Highline, and 100cfs to the Agency canals respectively) which continues through the end of the irrigation season, 31-October. This doubled diversion amount significantly shifts the exceedance curve for overflows downstream of CDD and is this best available information as of July 2023.

3. During the irrigation season, excess inflows exceeding 355 cfs spill into the Owyhee River downstream of CDD. This seasonally occurs during the spring freshet, typically April/May, after which time the Owyhee River is dewatered through the end of the irrigation season as historical/current operations did/do not provide a base flow allocation. Outside of the irrigation season, 01-November to 01-March, Owyhee River inflows pass downstream of CDD and represent the longest duration for potential groundwater recharge with stage progressive features that operate over a seasonal IQR of ~10-60cfs and a median of ~50cfs.

4. No information was available regarding measurable surface water inflows in the seven miles between the CDD and feasibility project sites #3 and #4. Groundwater irrigation returns to the Owyhee River downstream of the CDD are seasonally present, gradually gaining as the river valley trends north down the alluvial fan. At Site #4, the Agency Canal lateral returns to the Owyhee River, after passing ~2,000 acres of flood irrigated lands over eight miles downstream from the CDD. As of July 2023, the reaches and magnitude of irrigation return flows upstream of project sites #3 and #4 remain unquantified and were not considered further for synthesizing flows for the feasibility study. Assuming that the magnitude of such groundwater return flows would be relatively low, the potential effect would be beneficial as it would extend the low flow exceedance tails into the summer irrigation season, potentially delaying dewatering of the system. Lateral recharge <2 cfs/mile would likely not actively convey in the ~70' wide plane bed channel. However, lateral groundwater recharge >5cfs/mile could be used to sustain baseflow in measures with reactivated side channels. A final note regarding ground water is that downstream of Site #3 the tapering alluvial fan intercepts the static ground water level, downstream of which groundwater irrigation returns significantly re-enter the Owyhee River from various non-point sources over ~2 river miles before flowing into the Blue Creek wetland complex.

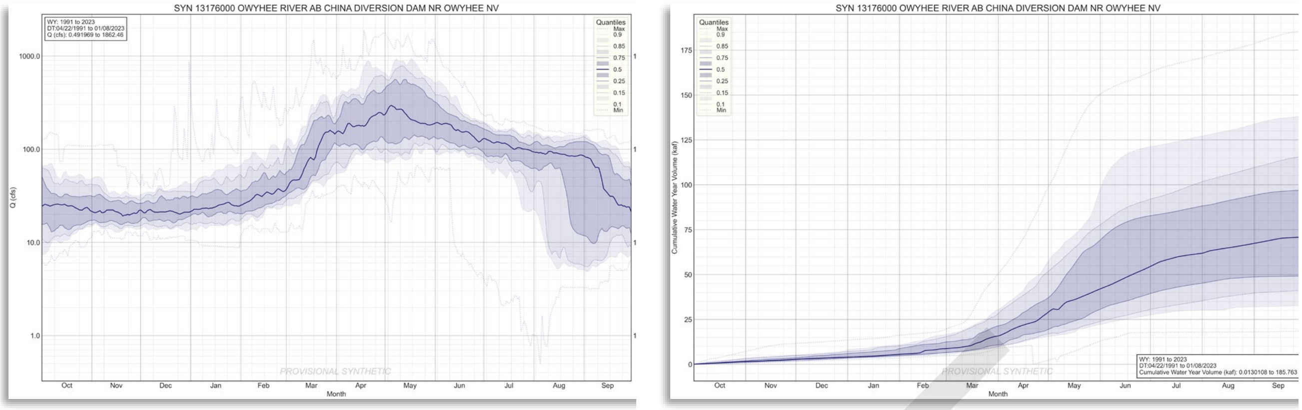

Figure 2-21. Owyhee River. Synthetic inflows to CDD. *Left: Flow Rate, Right: Cumulative Volume inflows.*

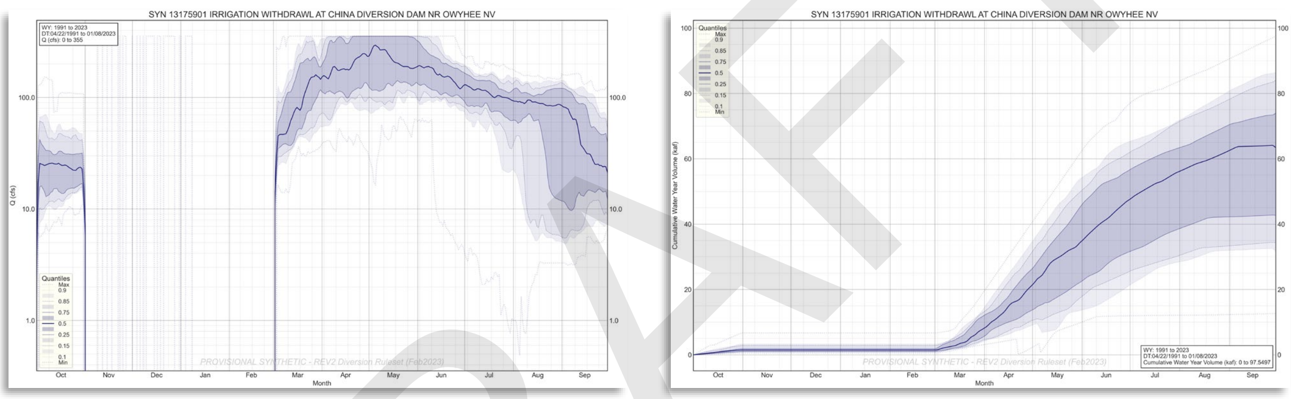

Figure 2-22. Owyhee River. Synthetic irrigation withdrawals at CDD. based on SPT rev2 ruleset *Left: Flow Rate, Right: Cumulative Volume withdrawn. Note abrupt transition starting 01-Mar to max withdrawal.*

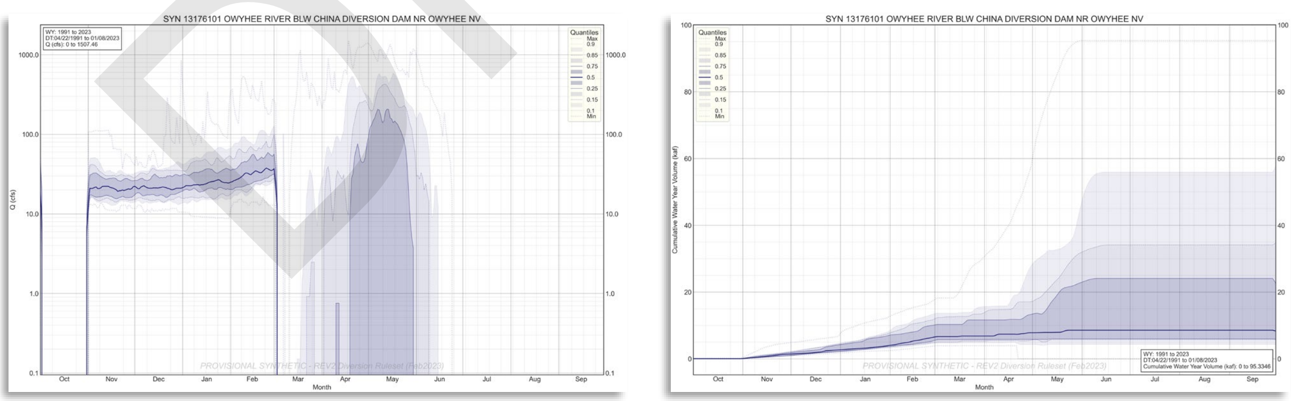

Figure 2-23. Owyhee River. Synthetic flows downstream of CDD. *Left: Flow Rate, Right: Cumulative Volume flowing into the project reach. Note winter hydroperiod abruptly transitioning starting 01-Mar followed by May freshet and summer dewatering.*

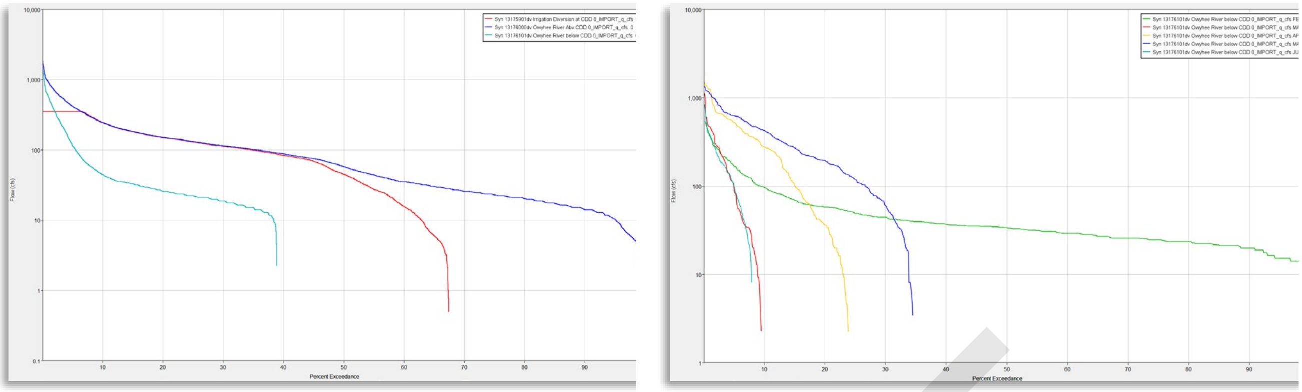

Figure 2-24. Owyhee River at China Diversion. Flow Exceedance Curves. *Left: Annual, Right: Monthly*

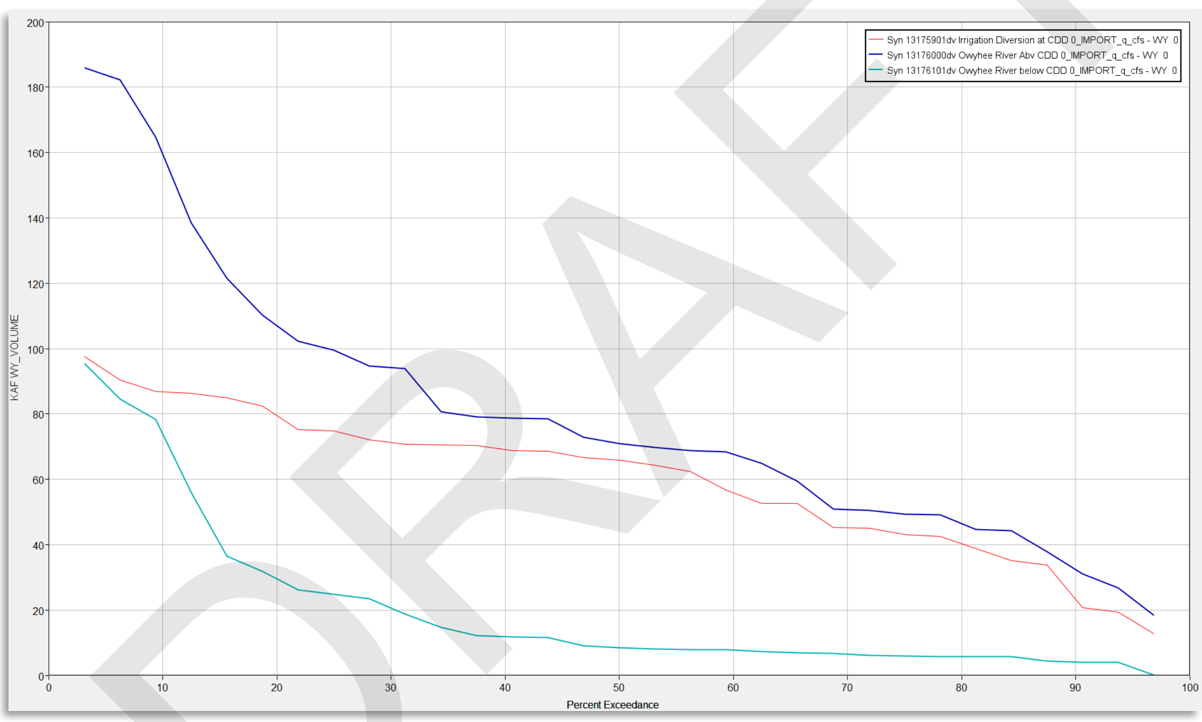

Figure 2-25. Owyhee River at China Diversion. Annual Volume Exceedance Curves for Inflows, irrigation diversion, and overflows.

2.3 Flood Regime

2.3.1 Peak Flows

Annual peak flood flows on the Owyhee River upstream of China Diversion Dam are driven by both snowmelt and precipitation events, typically in the spring between April and June, and can occur after the start of the DVIP irrigation season. Annual flood peaks have been measured at multiple gaging stations, with equivalent truncated period of records to the mean daily flow values discussed in Section 2.2. The most common month for flooding on the Owyhee is May when winter snow melts quickly with warming seasonal temperatures. Early spring floods in March represent ~5% of the peak flow record, with ~11% summer floods (July through September), and ~11% winter floods (November through February) which is likely indicative of a mixed population weighted to the tails. USGS WSP 2433 (USGS 1997) notes that snowmelt followed by ground freezing and subsequent rainfall has caused large floods in northern Nevada and southern Idaho. Coincident with trends in the mean daily flow record, historical peak flows gaged above China Diversion Dam (#13176000) were notably larger than current peak flow records for the active gage near Mountain City (#13175100) as illustrated in Figure 2-26. As previously discussed in Section 2.2, this difference is predominately attributed to historical changes in upstream regulation at Wildhorse Reservoir after 1969, with an additional ~17% increase in drainage area between Mountain City and CDD.

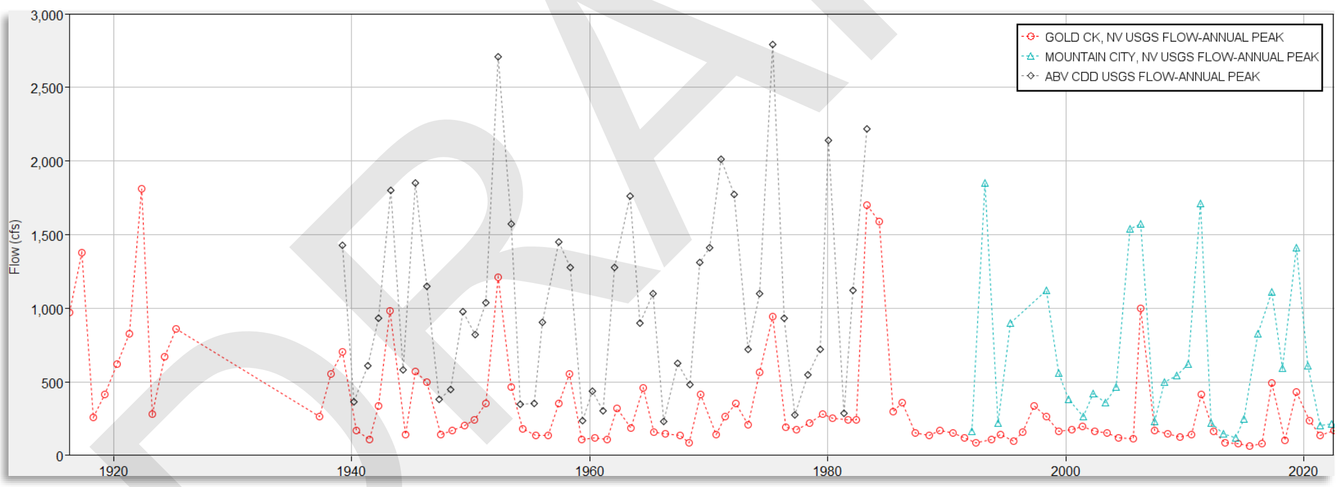

Figure 2-26 Summary Plot of Owyhee River Annual Peak Flows.

2.3.2 Flood Frequency

Considering that Wild Horse reservoir is not operated for flood control, a provisional evaluation of flood frequency inflows to the China Diversion was completed using Bulletin 17C methods with the expected moments algorithm (USGS 2019) using HEC-SSP version 2.3 (USACE 2023). Flood frequency curves were computed from 45 historic peak flows above CDD (#13176000) as well as 30 peak flows measured at the active gage near Mountain City (#13175100). There are currently no detailed skew studies for the upper Owyhee, and thus the regional skew of -0.1 and MSE 0.302 from Plate I of Bulletin 17B, was used to weight the station skew. The adopted skews at the two stations were -0.22 and -0.016 respectively. As depicted in Figure 2-27, the computed flood frequencies at both Stations were nearly equal at an AEP of 0.002, then continue to diverge with increasing probability.

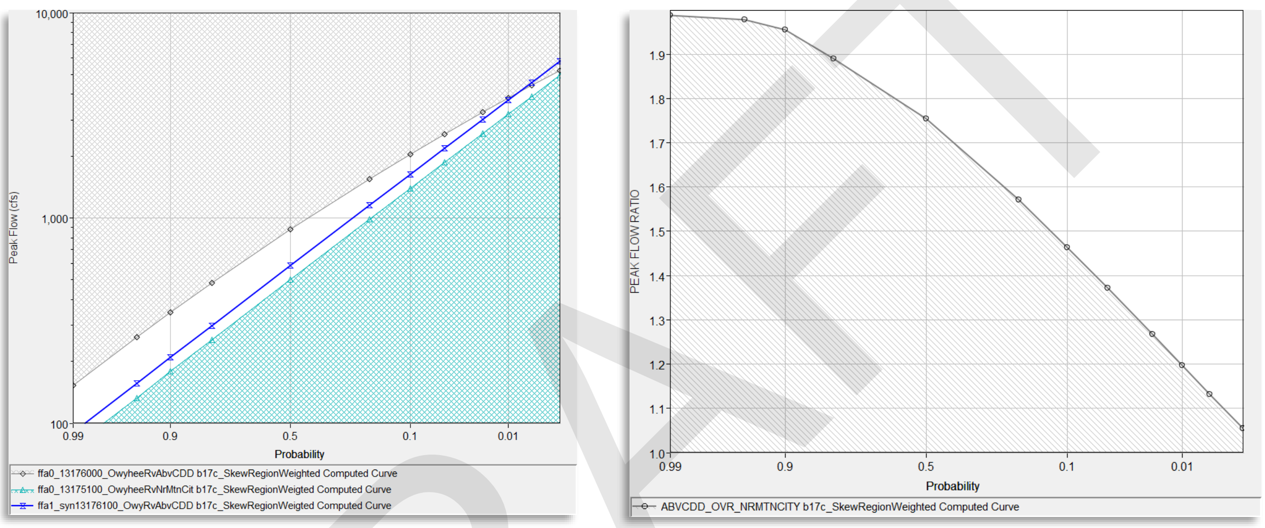

Figure 2-27. Comparison plots of Bulletin 17c frequency curves. *Left: Computed curve peak flows. Right: Peak Flow Ratio.*

As previously evaluated in Section 2.2, the flow difference between the above CDD historical gage (#13176000) and the near Mountain City active gage (#13175100) is anomalously larger than the additional 17% catchment area and likely resulted from hydroregulation operations at Wildhorse Reservoir during that period. This same anomaly is present in the annual flood peaks and he historical measured flood peaks are not considered representative of the last 30-year hydroperiod.

Equivalent to the synthetic hindcast discussed in Section 2.2.7, an areal scaling approach was used to synthesize peak inflows to CDD that would be representative of the last 30-year hydroperiod. Peak Flows from the near Mountain City Gage (#13175100) were scaled by ~117% and used to compute a synthetic Bulletin 17C flood frequency curve for station Syn#13176000. As plotted in Figure 2-27, the Log Pearson Type III distribution provided a good fit across the range of measured flood peaks. This suggests that upstream regulation effects from Wildhorse Reservoir are minimal for seasonal flood peaks, and the risk associated with regulation uncertainty can be captured by using the 17C expected probability curve versus, pursuing more detailed hydrologic analyses. Per ER 1105-2-101, to account for uncertainty in the scaled peak flow record, adoption of the expected probability curve is recommended to establish design flood criteria for the proposed restoration project and support related risk informed decision making. The values are presented in Table 2-2 below and plotted in Figure 2-28.

Table 2-2. Provisional Peak flow Frequency Values for Syn#13176000 – Owyhee River above CDD.

Frequency Curve for: OWYHEE RV-SYN13176100_ABV_CDD-FLOW-ANNUAL PEAK

Percent Chance Exceedance	Computed Curve Flow in cfs	Expected Prob. Flow in cfs	Variance Log (EMA)	Confidence Limits Flow in cfs	
				0.05	0.95
0.2	5803	9196	0.040574	17880	3350
0.5	4569	6085	0.029412	11709	2839
1.0	3750	4533	0.022415	8396	2456
2.0	3021	3408	0.016637	5936	2077
5.0	2183	2326	0.010805	3646	1586
10.0	1635	1694	0.0076975	2450	1226
20.0	1151	1172	0.0056338	1583	883
50.0	587	586	0.0044140	760	452
80.0	298	293	0.0052463	389	216
90.0	209	202	0.0069409	280	139
95.0	156	147	0.0095648	215	92
99.0	90	75	0.019512	138	39

Distribution Parameters

Parameter	Value
Mean	2.767475
Standard Dev	0.348481
Station Skew	0.034882
Regional Skew	-0.100000
Weighted Skew	-0.016104
Adopted Skew	-0.016104
EMA Estimate of MSE (G at-site)	0.169
Grubbs-Beck Critical Value	0.000

Events

Event	Number
Historic Events	0
High Outliers	
Low Outliers and Zero Flows	0
Missing Flows	2
Systematic Events	30
Historic Period	32
Equivalent Record Length (years)	33.437

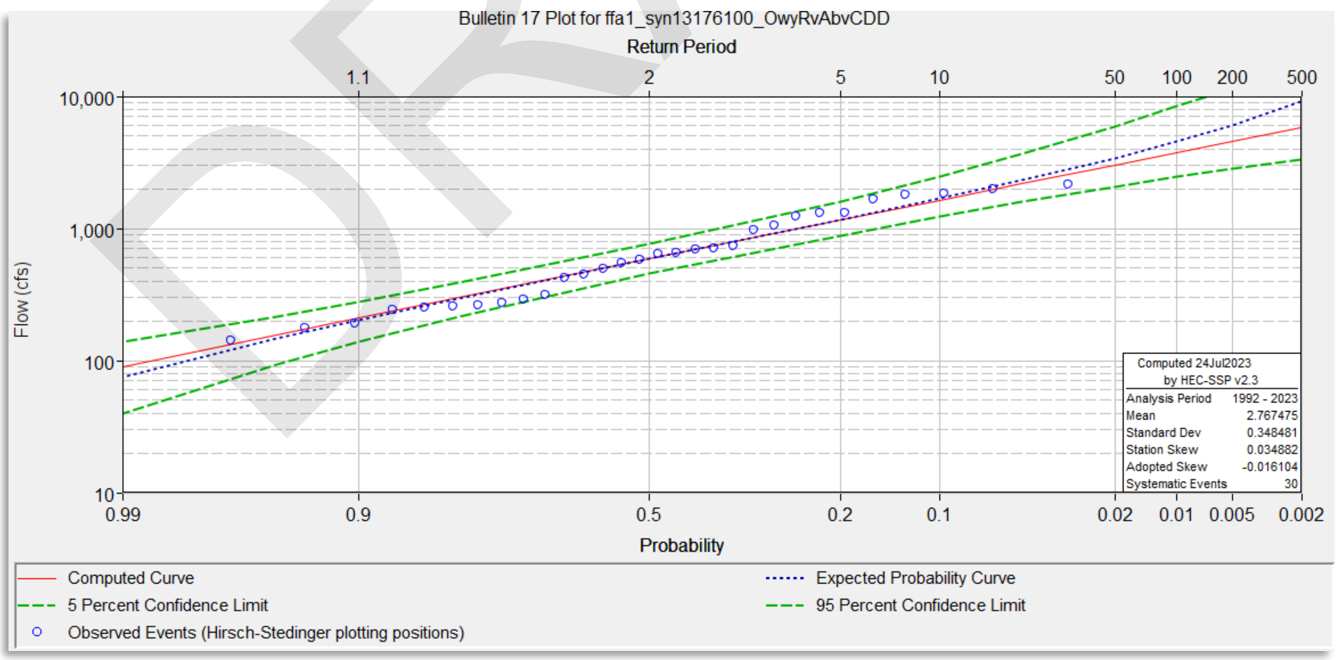

Figure 2-28. Provisional Peak Regulated Flow Frequency curves for Owyhee River above CDD. (Syn#13176000)

3 Hydraulics

3.1 Owyhee River Configuration

The China Diversion Dam is situated at the head of a low gradient alluvial fan at the upstream end of the Duck Valley (Section 2.1). Downstream of this diversion, any remaining flow that is not diverted for irrigation, flows north at a nominal slope of <5 feet per mile for seven miles towards sites #3 and#4 through a channelized reach with a nominal width of ~75 feet (Figure 3-1). Both proposed restoration sites are located in Idaho, just north of the state line. This reach of the Owyhee River was historically braided, and relic channels and side channels are prolific throughout the system. However, with the development of the Duck Valley Irrigation Project, the Owyhee River was straightened and integrated with various laterals and sub-laterals to convey irrigation water for predominately flood irrigation methods. This modified reach of the Owyhee is now relatively incised, sitting at a lower base level than the historic system.

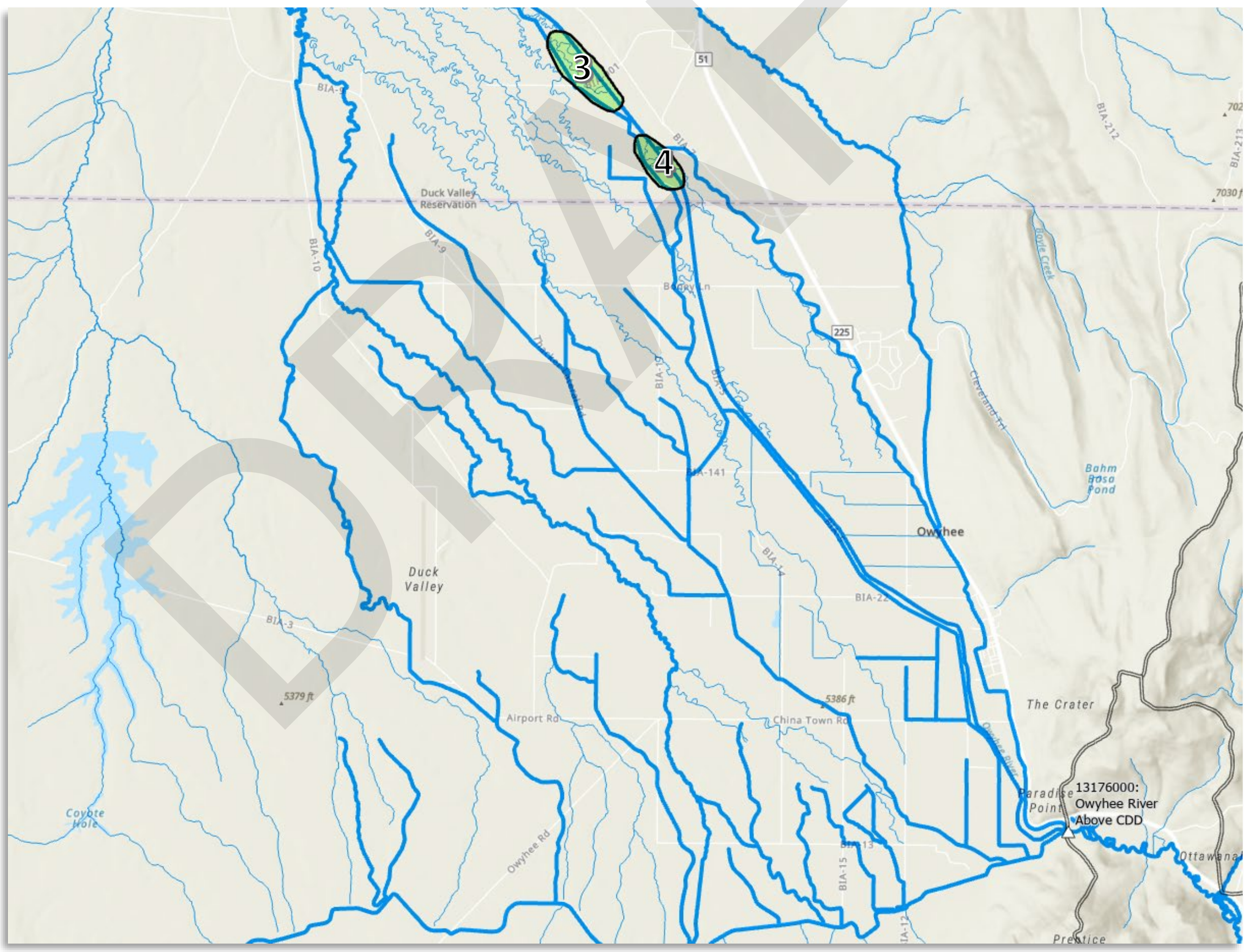

Figure 3-1. Owyhee River in Duck Valley downstream of China Diversion Dam; *Irrigation conveyances depicted in blue.*

3.2 Hydraulic Model Development

To assess hydraulic conditions in the Owyhee River downstream of the China Diversion, two-dimensional depth-averaged planning level models were developed using HEC-RAS version 6.4.

The first hydraulic model was used to evaluate flow partitioning upstream of the restoration project sites. It encompassed ~13 square miles of the eastern side of the Duck Valley, extending from the China Diversion at the south end for ~10 miles to the Blue Creek delta at the north end. This valley model included ~135k cells with a nominal cell size of 10 feet in the channel corridor transitioning to 100-foot cells in the floodplain overbanks on the alluvial fan.

The second hydraulic model focused on the two restoration project sites (#3 and #4), spanning from Boney Lane upstream in Nevada for approximately three river miles, past National Guard Road (BIA-901) to the north into Idaho. The eastern boundary of the project model followed the morphologic edge between the Owyhee River floodplain and higher terraced ground. The project model western boundary was extended up to 1 mile past the main canal road alignment that bisects the historic floodplain of the Owyhee River to allow overbank flows to leave the domain under normal depth conditions. The project model included ~600k cells with a nominal cell size of 3-5 feet in the channel transitioning to 25-foot cells for the floodplain overbanks.

Baseline terrain for both models utilized the hydro-flattened bare-earth LiDAR grids collected April 2017 (Quantum Spatial 2017) on the NAVD88 vertical datum. Variable roughness coefficients were mapped to bankfull depth based on observed field conditions, recommendations contained in publications RMRS-GTR-323 and FHWA-NHI-01-004, and a comparison with similar streams documented in USGS Water Supply Paper 1849.

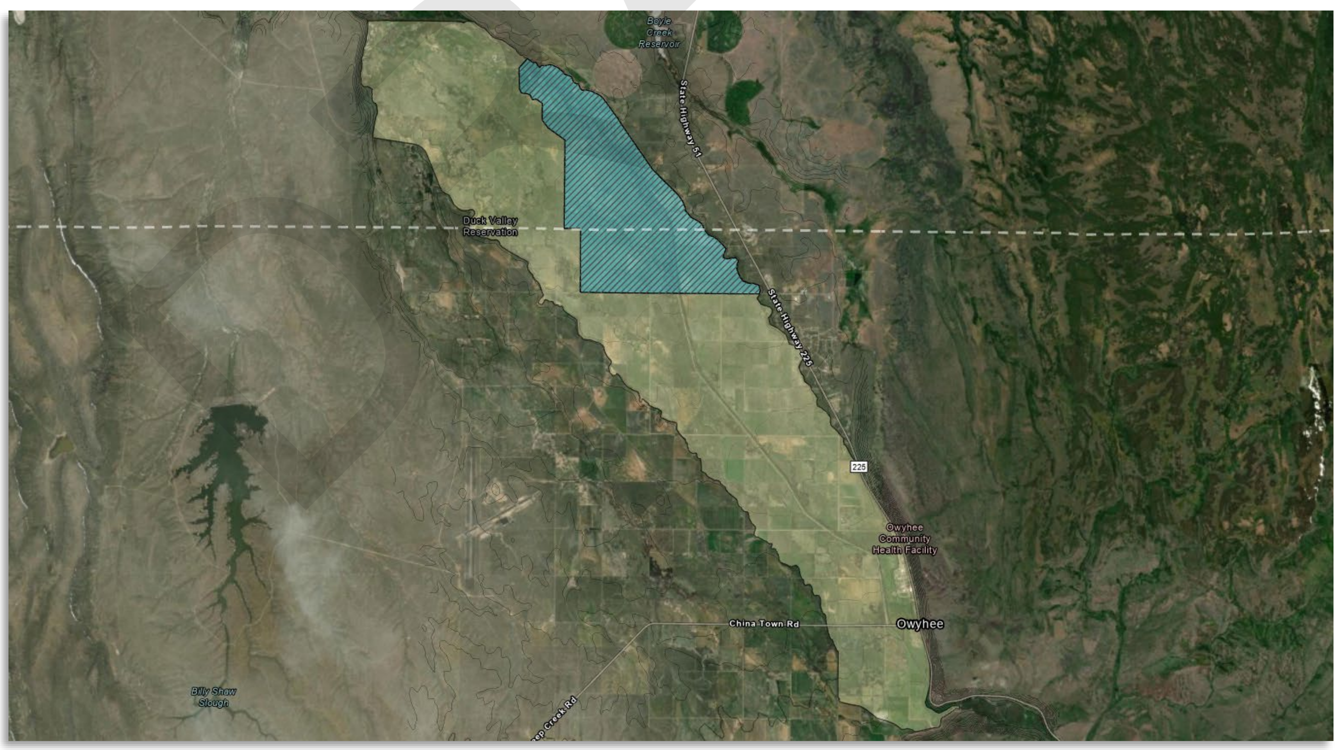

Figure 3-2. Hydraulic model boundaries for the Duck Valley model (yellow) and the restoration site model (blue). Flow is from bottom (south) to top (north) with left overbank flow towards the northwest.

3.3 Owyhee River Baseline

3.3.1 Duck Valley Flooding

As discussed in section 2.3.1, flooding on the Owyhee River most frequently occurs in the months of April and May, with occasional rain-on-snow events during winter months (December through March). In the reach below the China Diversion Dam, the main river channel follows a straightened and re-graded conveyance with a nominal top width of 75 to 100 feet and plane-bed depth of ~2-3+ feet (relative to the adjacent floodplain grade). Intermittent levees constructed from what appears to be predominately native small cobble (3" minus) alluvium are present both sides of the channel, extending an up to 6 feet above the bankfull floodplain profile. Within the modeled study reach for restoration sites #3 and #4, the levees are discontinuous, with various low/slumped areas, and breaches at inlets to overbank side channels and swales. As the conveyance channel flows north down the alluvial fan, the degree of entrenchment lessens, and the channel eventually reconnects with the floodplain north of Site#3 around an elevation of 5310 feet NAVD88.

Below the China Diversion, flows begin to leave the straightened and leveed Owyhee River conveyance channel starting around 1000 cfs (~5 year return period). As illustrated in Figure 3-3 below, flood waters that leave the conveyance channel travel as sheet flow down the alluvial fan where they are intersected by non-levee road embankments that detain flows. Downstream of the diversion ~3.5 miles, the left floodplain transitions from cultivated to a more naturalized floodplain with notable relic side channels. Increased duration and flow both increase the impounded depths, progressively activating relic swales and side channels with depths up to 5 feet and flows that generally trend to the northwest, away from the main Owyhee River conveyance and project sites. The right floodplain remains predominately cultivated and stepped where overland flows travel as sheet flow with up to 2 feet of impounded depth at road crossings and graded irrigation returns.

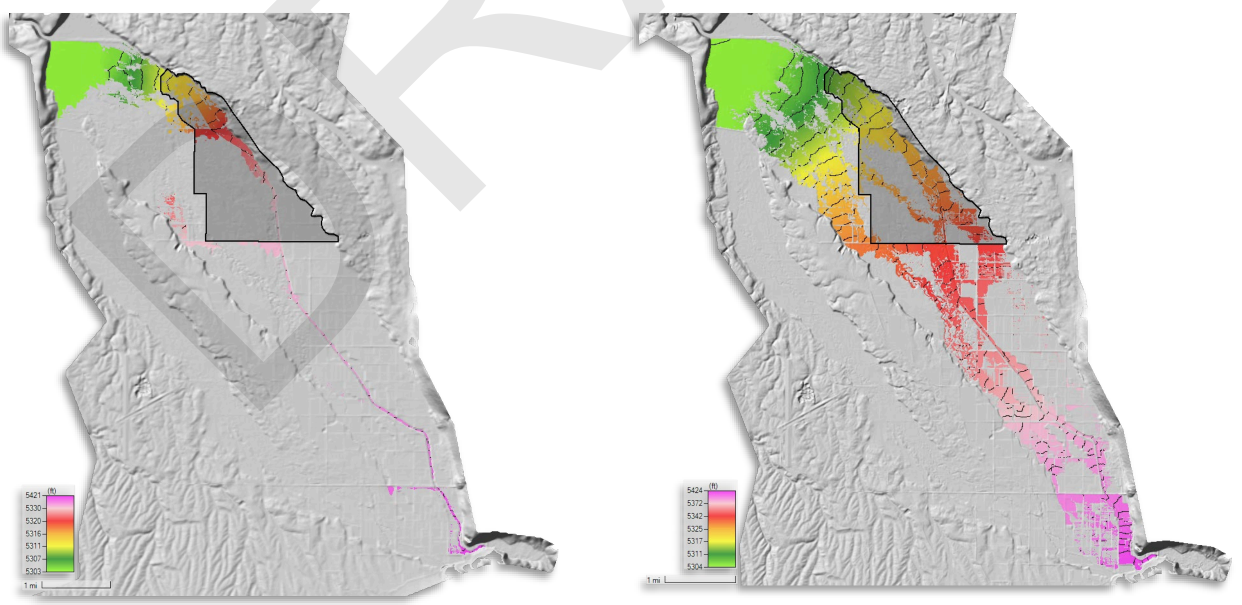

Figure 3-3. Simulated water surface elevations in the Owyhee River below China Diversion. *Left: 20% AEP peak flow (5-year-return-period) of 1172 cfs. Right: 1% AEP peak flow (100-year-return period) of 4533 cfs. Contour interval is 2 feet. Flow is from south (bottom) to north (top). Shaded area depicts the project model domain.*

As plotted in Figure 3-4, the water surface slopes for flood profiles in the Owyhee River below the diversion, track with the main channel slope averaging between 14 and 18 feet per mile.

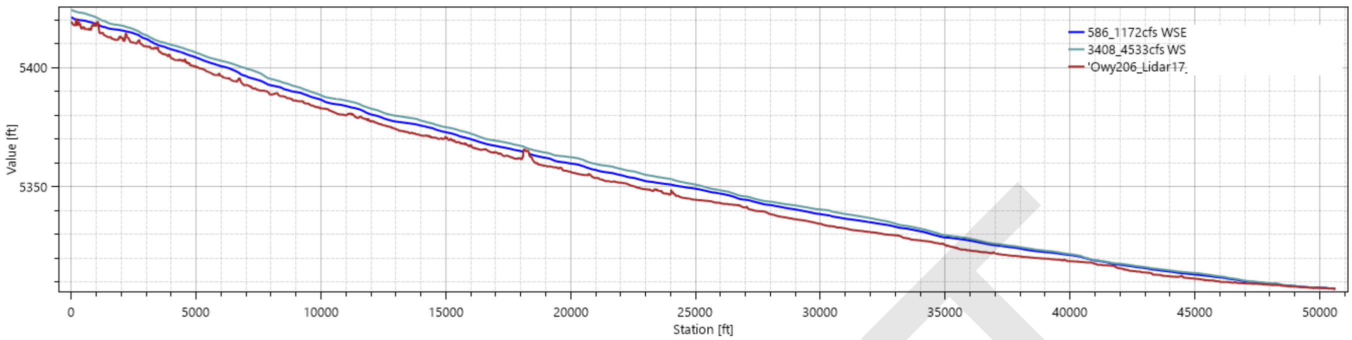

Figure 3-4. Simulated water surface elevation profile for Owyhee River below China Diversion. *Cyan: 20% AEP peak flow (5-year-return-period) of 1172 cfs. Blue: 1% AEP peak flow (100-year-return period) of 4533 cfs.* Maroon: Channel elevation (2017 lidar).

Flow partitioning to the project site increases with Owyhee River inflows. For the 20% AEP (5-year return period), flow is just starting to leave the Owyhee River conveyance upstream of Boney Lane, filling relic channels up to 2 feet after 48 hours. Overbank flooding upstream of the project study area is mapped in Figure 3-5 below for the 1% AEP peak flow of 4533cfs with simulated flood depths upstream of Boney Lane up to 5 feet in relic side channels that route water to the northwest out of the system.

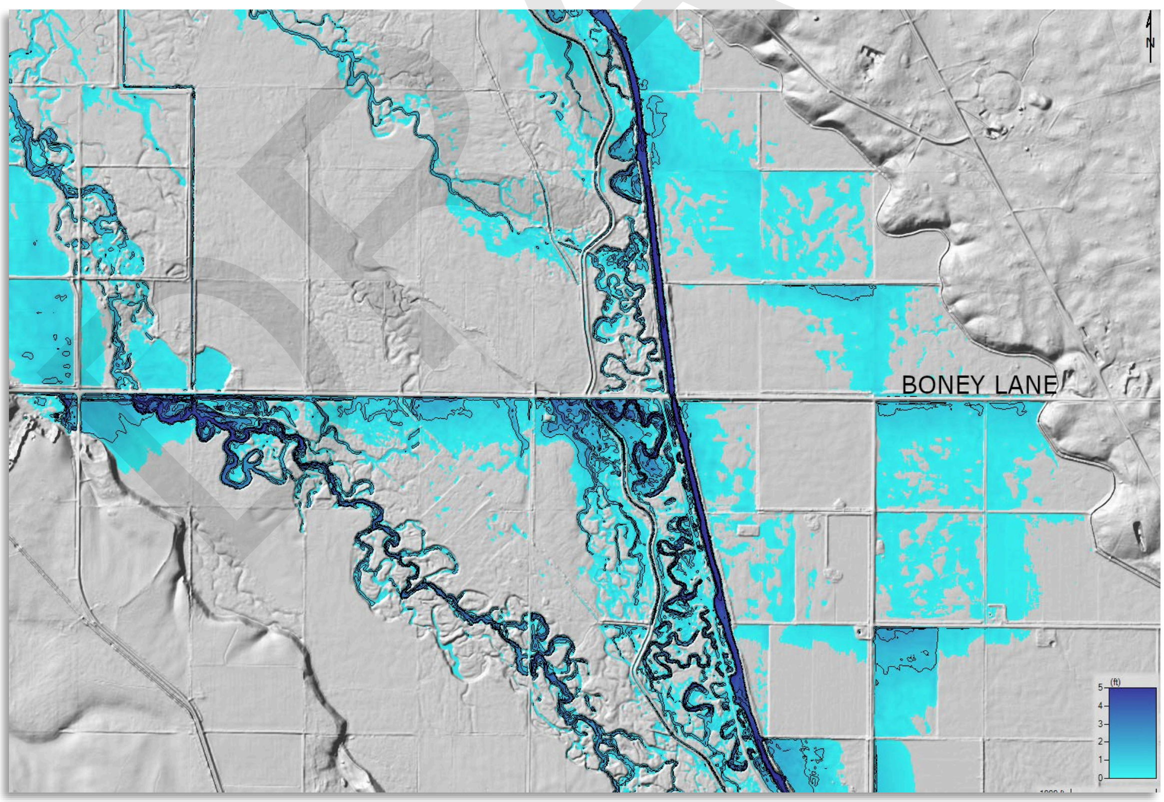

Figure 3-5. Simulated depth upstream of project sites *for the* 1% AEP peak flow (100-year-return period) of 4533 cfs. Contour interval is 1 foot. Flow is from south (bottom) to north (top).

Table 3-1. Flow Partitioning between China Diversion and project sites.

AEP (%)	RP (year)	Flow below CDD (cfs)	Flow loss above project (%)	Flow into project (cfs)
95	1.1	147	0	147
50	2	586	0	586
20	5	1172	2	1146
10	10	1694	10	1530
5	20	2326	16	1963
2	50	3408	30	2400
1	100	4533	40	2698

3.3.2 Project Site Flooding

As discussed in section 3.3.3, upstream Site #4 is more incised in the alluvial fan than Site #3, with overbank side channels not activating until flows exceed ~200 cfs to ~500 cfs which is still less than a 50% AEP flood event. At the 50% AEP, side channels on the downstream end of Site #4 begin to overtop. Conversely, at the upstream end of Site #4, side channel flow does not overtop until the 10% AEP (Figure 3-7). While flooding can impact agricultural operations, neither of the two project sites contain flood prone structures of concern.

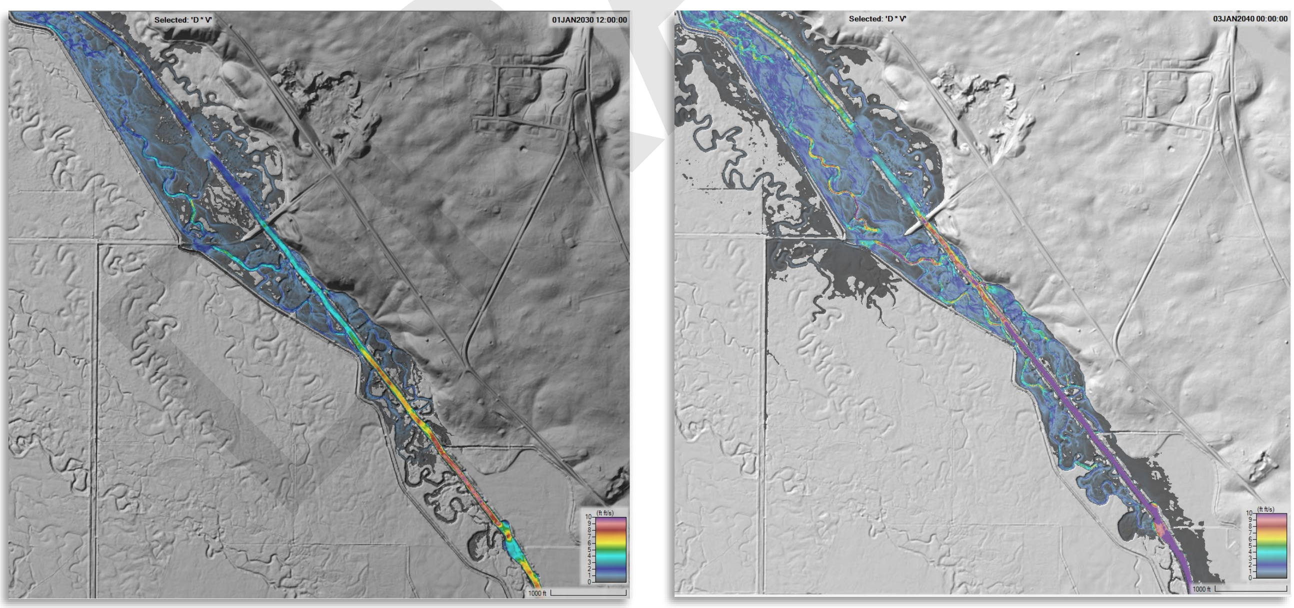

Figure 3-6. Simulated unit conveyance at Sites #3 & #4. *Left: 50% AEP peak flow (2-year-return-period) of 586 cfs, Right: 10% AEP peak flow (10-year-return-period) project inflow of 1530cfs. Conveyance range: 0-10 + cfs/ft. Note the incised straightened conveyance channel and active relic meanders on both sides of the channel. Note decreasing incision to the north.*

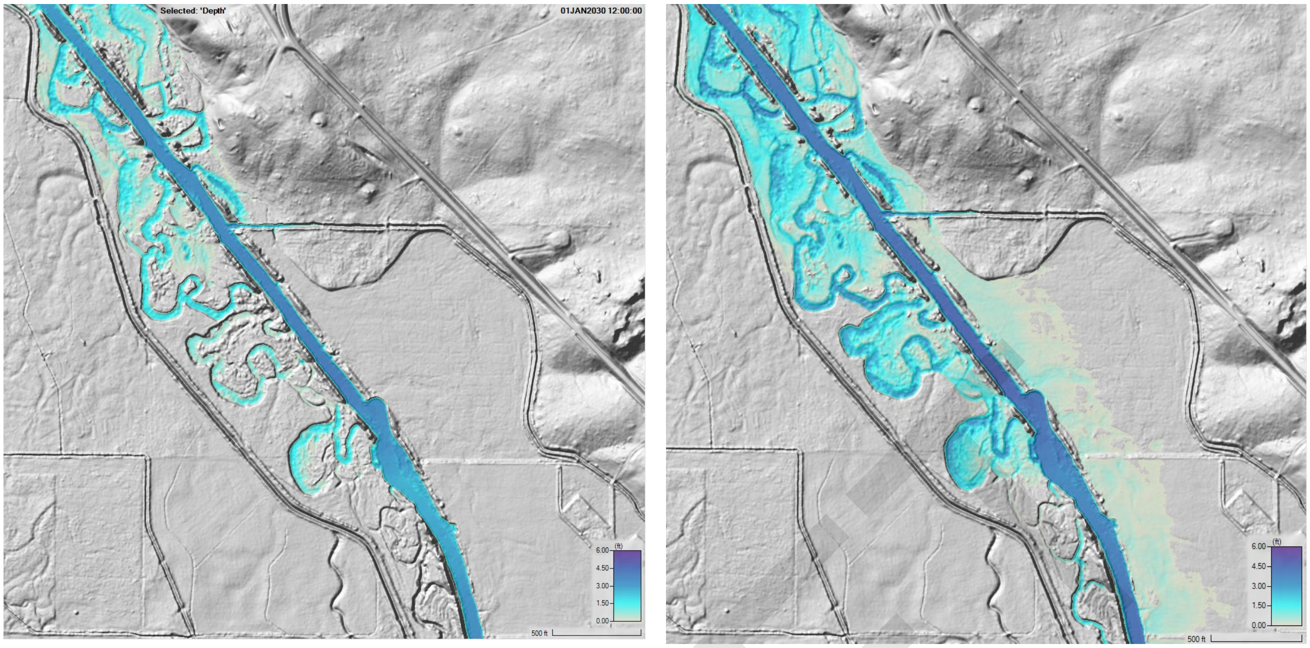

Figure 3-7. Simulated depth at Site #4. *Left: 50% AEP peak flow (2-year-return-period) of 586 cfs, Right: 10% AEP peak flow (10-year-return-period) project inflow of 1530 cfs. Depth range: 0-6 feet*

A half mile north of Site #4, within the south half of Site #3 upstream of National Guard Road, low overbank side channels begin to activate at much lower flows of ~25 to ~75 cfs as mapped in Figure 3-8. Low bankfull surfaces and swales adjacent to the side channels begin to inundate for main channel flows exceeding ~100cfs, and higher terrace level swales at main channel flows of ~200cfs. The National Guard Road culvert crossing also overtops the west approach for main channel flows > 100 cfs.

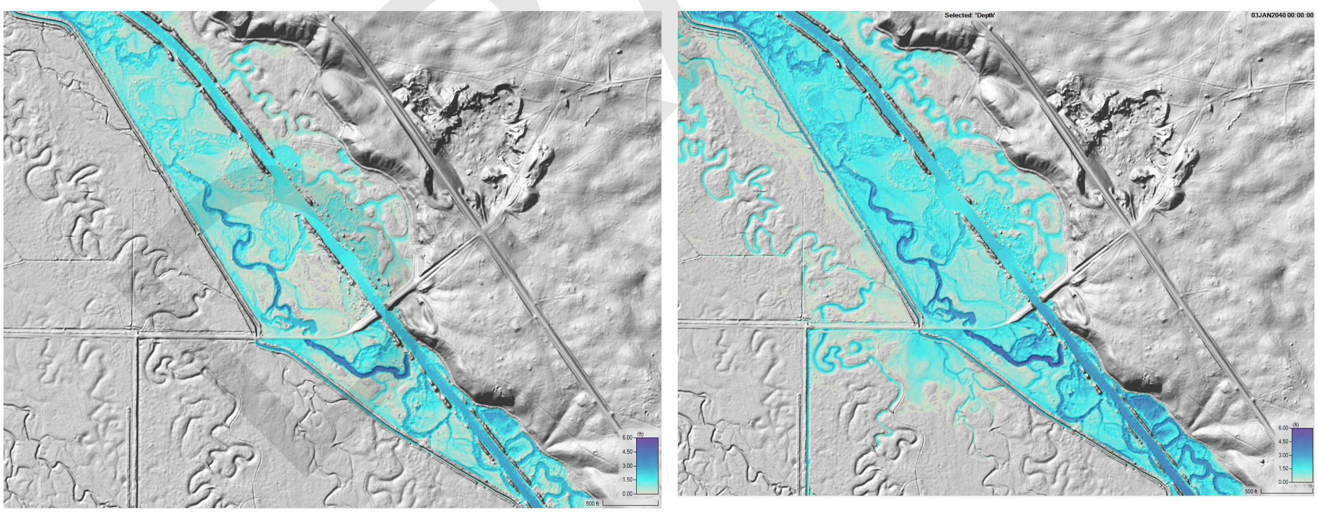

Figure 3-8. Simulated depth at Site #3. *Left: 50% AEP peak flow (2-year-return-period) of 586 cfs, Right: 10% AEP peak flow (10-year-return-period) project inflow of 1530 cfs. Depth range: 0-6 feet. Note sheet flow over topping culvert in west approach to National Guard bridge.*

3.3.3 Flow Inundation Thresholds

Baseline hydraulic conditions at sites #3 and #4 were developed by simulating a range of index flows defining the flow exceedance curve for the Owyhee River below CDD (Syn#13176101). These synthetic flows are based on multiple tiered assumptions as detailed in Section 2.2.7. In addition, simulations of select flood events were also completed to evaluate system response.

Hydraulic results were used to derive the minimum flow threshold to exceed a corresponding minimum depth threshold of 0.1 feet. As depicted in Figure 3-9, for low flows, all the flow is contained within the main straightened and leveed river channel. About a quarter mile downstream of the National Guard Road (BIA-901) crossing, there is an area of multiple low side channels that frequently activate for low flows less than 10 cfs. This flow drains to the southwest into a hydraulically connected relic side channel adjacent to the west canal road. At the north end of Site #3, there are some additional low elevation side channels begin to activate at the next low flow tier of ~25cfs. On the upstream side of the National Guard Road crossing (BIA-901), the upstream extent of that side channel does not activate until flows reach ~75cfs. Further upstream on Site #4, the existing straightened channel is more incised into the alluvial fan, with a couple of the relic side activating around 200 cfs, although most of Site #4 does not convey overbank flow until inflows exceed 400 cfs. These threshold flows were remapped with the exceedance frequency curve presented in Figure 2-24 for Syn#13176101 as presented in Figures 3-4 and 3-6 for Site #3 and Site #4 respectively.

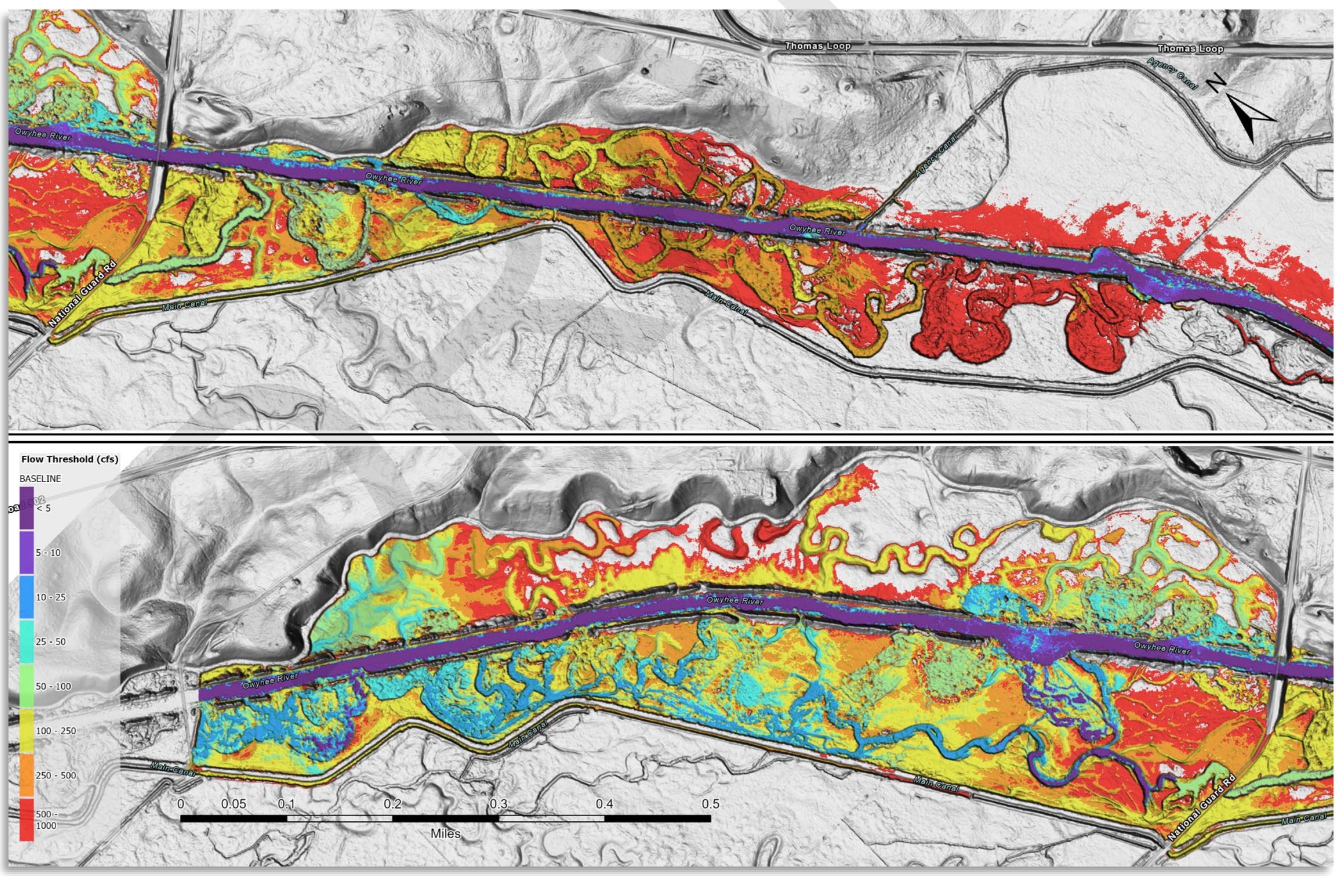

Figure 3-9. Baseline flow inundation thresholds at Sites #3 and #4 in cfs. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left).*

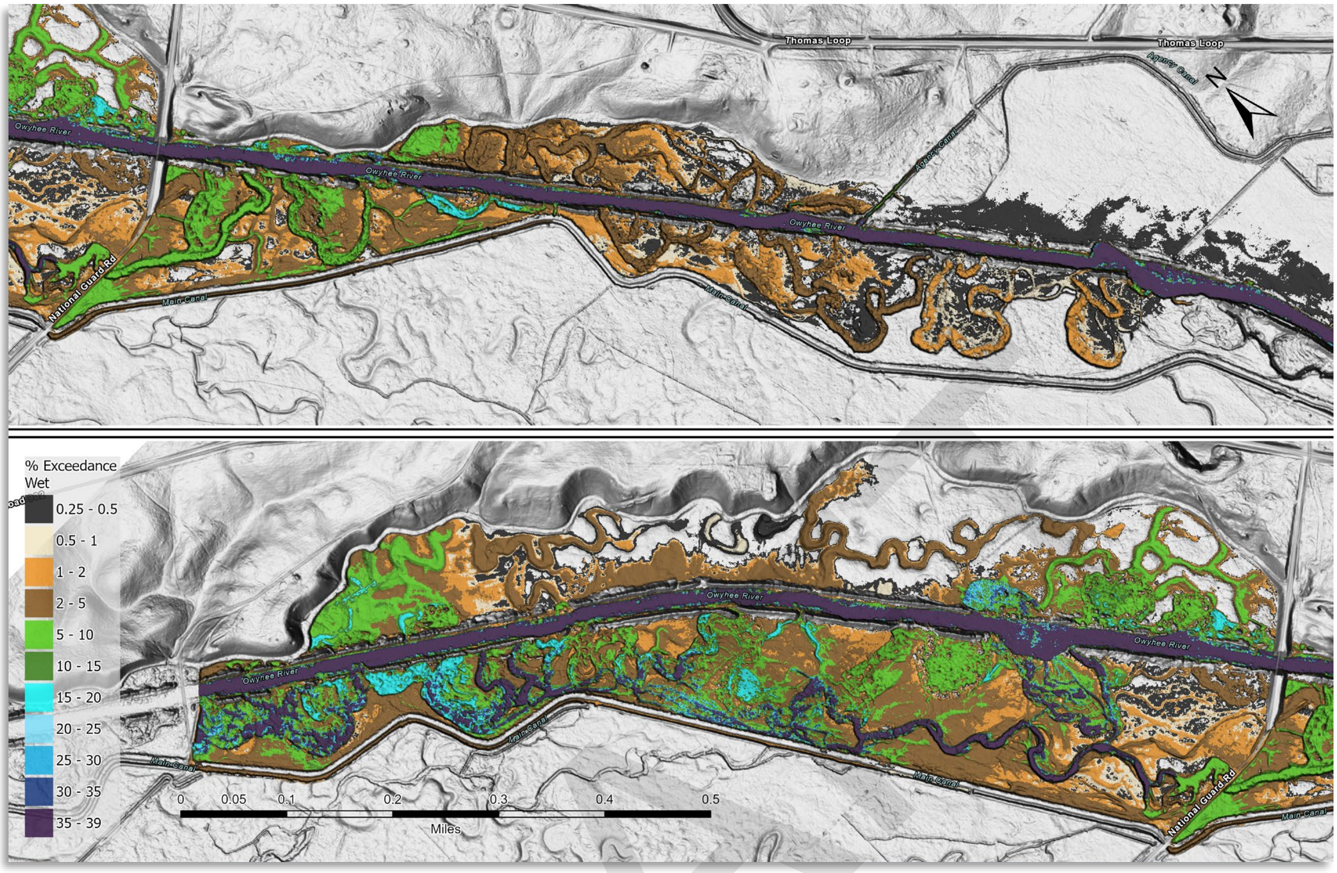

Figure 3-10. Baseline mean daily flow threshold exceedance per curve in Figure 2-23. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left). Note main straightened conveyance channel and lower exceedance thresholds in Site#4 side channels relative to Site #3.*

At Site #3, the hydraulic capacity of the 36” corrugated metal pipe culvert west of the National Guard Road bridge (BIA-901) was evaluated using FHWA HY-8 version 7.60. As illustrated in Figure 3-11 below, the maximum capacity of the existing 36” CMP is ~100 cfs at the National Guard Road overtopping elevation of ~5230 feet. For a bankfull depth of ~2 feet in the upstream approach side channel, the nominal culvert capacity is ~30 cfs. Due to this limited capacity, flows begin to overtop the west approach of the National Guard Road when flows exceed ~100 cfs.

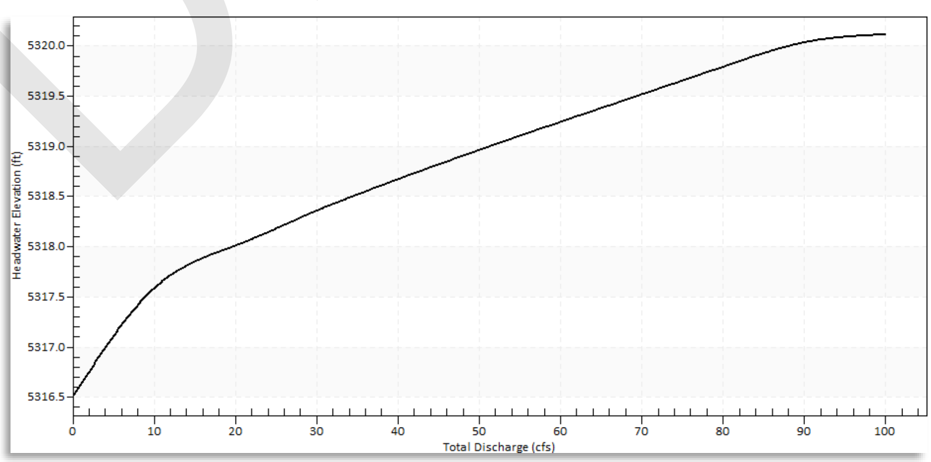

Figure 3-11. Rating curve for existing 36” culvert at National Guard Road at Site 3.

3.4 Owyhee River TSP

As of May 2024, the tentatively selected plan (TSP) for the Section 206 project is Alternative #6 with proposed grading changes to both sites #3 and #4. Alternative #6 includes lowering most berms on the left side of the Owyhee River conveyance down to the historical bankfull floodplain elevation with select notching of side channel inlets to extend the activated flow range down towards baseflows as detailed in Appendix H. Spoils from lowering the berms will be graded into the Owyhee River conveyance to raise the base level so that side channels remain active at low flows while the main channel conveyance capacity is maintained for routing larger flood flows when they occur. The channel fill is intended to raise the base level and reconnect the floodplain on the left side of the channel. Some of the right overbank areas in both sites are currently flood prone and will remain so under the TSP with increased frequency.

The initially proposed cross section shape for the Owyhee River conveyance includes a simple fill bench with a baseflow channel skewed to the left side to route flows into left overbank side channels. Mild slopes and smooth transitions in the vertical profile were used to minimize the need for extensive vertical grade control as detailed in Section 3.4.3. Site#3 has an average fill depth of ~1.5 feet and side channel notch depth of ~0.5 feet to match existing grade. Because Site #4 is more incised into the alluvial fan than Site #3, the fill depths are slightly larger, averaging up to ~3 feet with side channel notch depths of ~1 foot to tie into the historical floodplain grade. Excess fill from Site#3 berm lowering can be used to supplement Site#4 channel fill shortfall such that they balance across both projects.

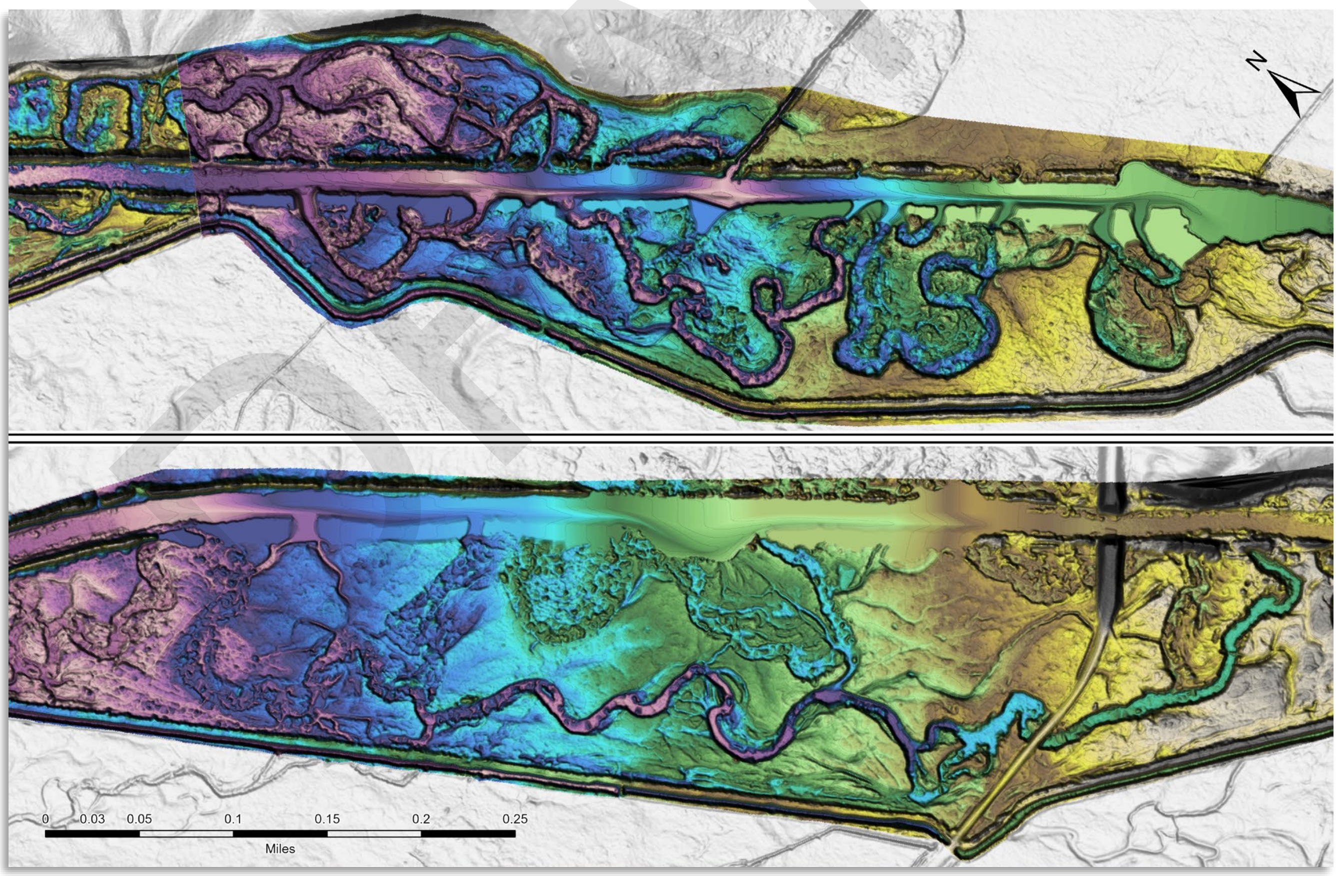

Figure 3-12. TSP Project Terrain. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left).*

3.4.1 TSP Project Flooding

Assessment of the TSP for larger floods was evaluated using the detailed project model with revised terrain representing the lines and grades for the proposed changes. As illustrated in Figure 3-13, under the TSP, floodplain reactivation reduces conveyance in the main channel. This effect is more pronounced at Site#4 compared to Site#3, due to the degree of entrenchment.

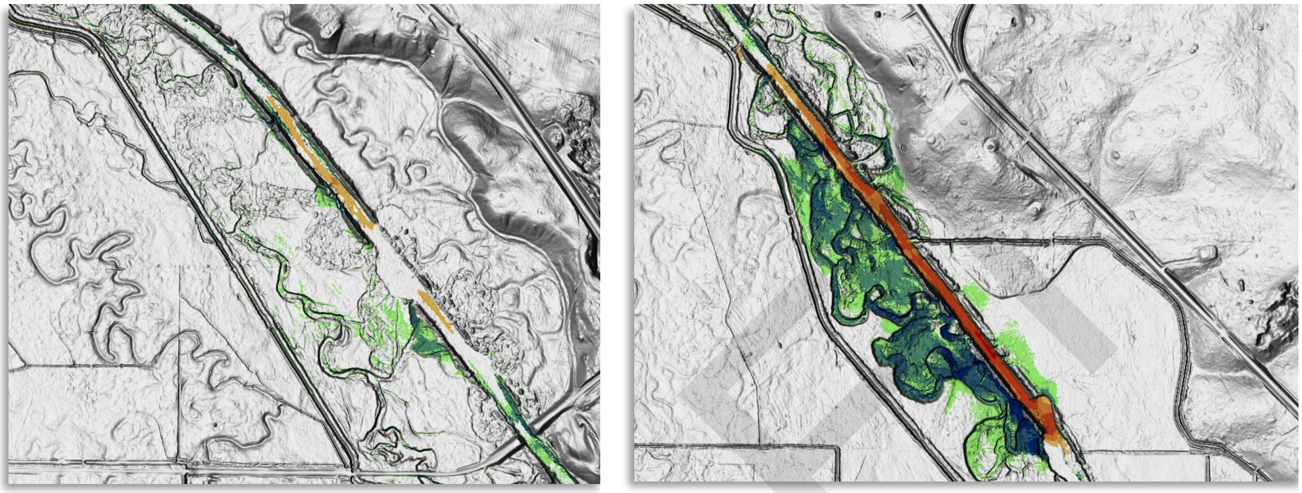

Figure 3-13. Change in conveyance between TSP and baseline conditions for 1% AEP (100-year return period) project inflow of 2698 cfs. Left: Site#3. Right: Site#4. Yellow-Red colors represent a decrease and Green-Blue colors represent an increase.

Considering the TSP is an overbanking floodplain reactivation alternative, maintaining a zero-rise condition is impractical and is not an NFIP regulatory requirement for this project. However, because the Owyhee River floodplain is already activated at the 1% AEP, the net change was minimal. As plotted in Figure 3-14, the change in the Owyhee River 1% AEP water surface profile between the TSP and baseline conditions varied between -0.4 and 0.25 feet. This variation depends on the overbank flow patterns and corresponding conveyance capacity. Site#4 had the largest water surface drop associated with the berm notches that activate larger side channels that draw water to the west. At Site#3, the largest rise was downstream of the National Guard Road, coincident with fill that bulked flows up to the berm overtopping elevation. The downstream end of Site#3 is less entrenched where side channels are more active which results in less overall rise.

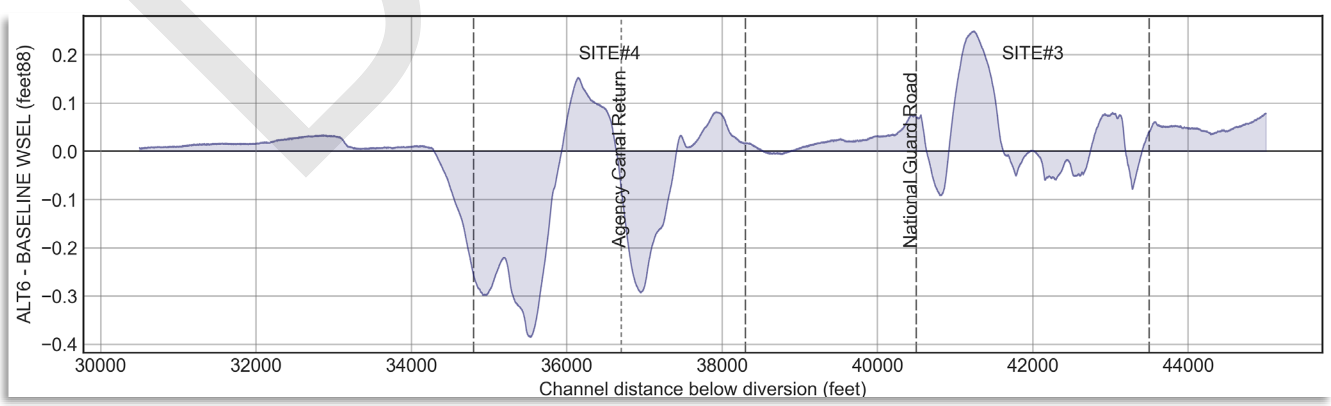

Figure 3-14. Water surface profile difference for TSP versus baseline conditions for the 1% AEP (100-year return period) project inflow of 2698 cfs.

3.4.2 TSP Flow Inundation Thresholds

The same approach used to assess baseline flow inundation frequency (Section 3.3.3) was used to assess the performance of the TSP. The project model was first updated with revised terrain representing the lines and grades for the proposed changes. A range of index flows that discretize the mean daily flow exceedance curve for the Owyhee River below CDD (Syn#13176101) were then simulated to a steady-state condition. The minimum flow threshold needed to exceed a corresponding minimum depth threshold of 0.1 feet was interpolated from the hydraulic results and transformed to the regulated flow exceedance curves below the China Diversion. The relative shift was more pronounced at Site#4 compared to Site#3 due to the degree of entrenchment and graded notches at side channel inlets. For Site#3, the side channel depth and corresponding wetted area increased.

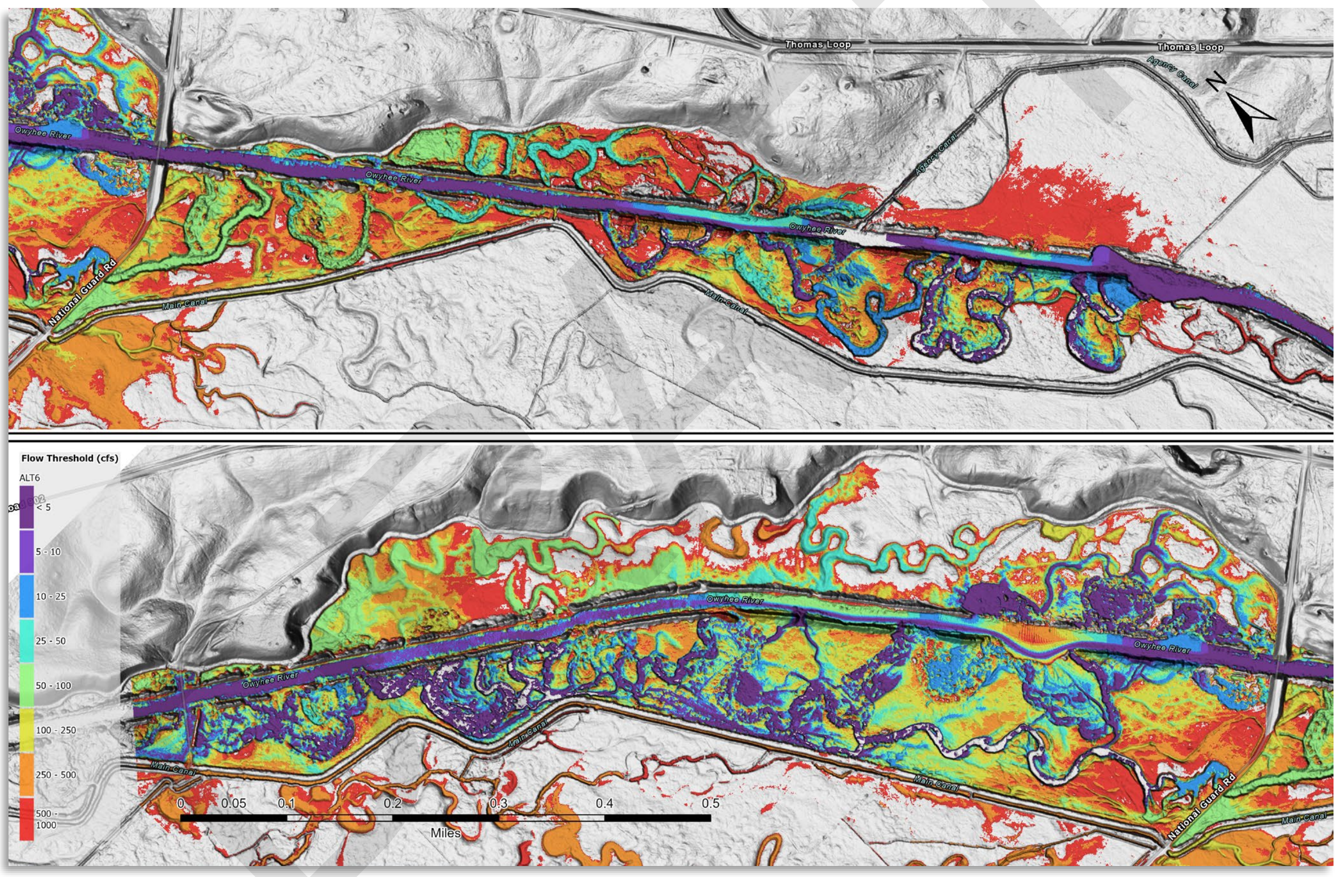

Figure 3-15. TSP flow inundation thresholds at Sites #3 and #4 in cfs. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left)*

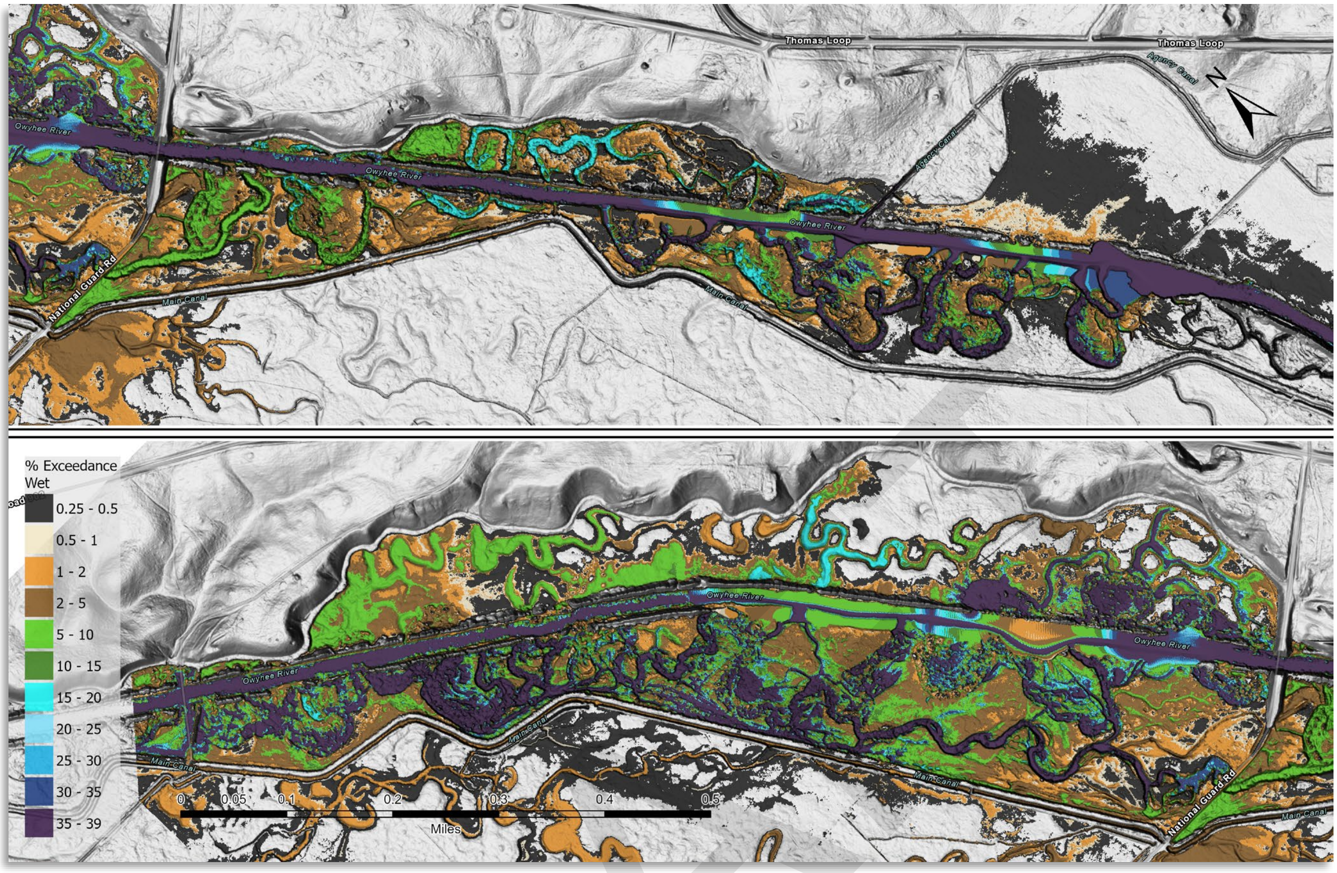

Figure 3-16. TSP. Mean daily flow threshold exceedance per curve in Figure 2-23. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left). Note dominant straightened conveyance channel and lower exceedance thresholds in Site#4 side channels relative to Site #3.*

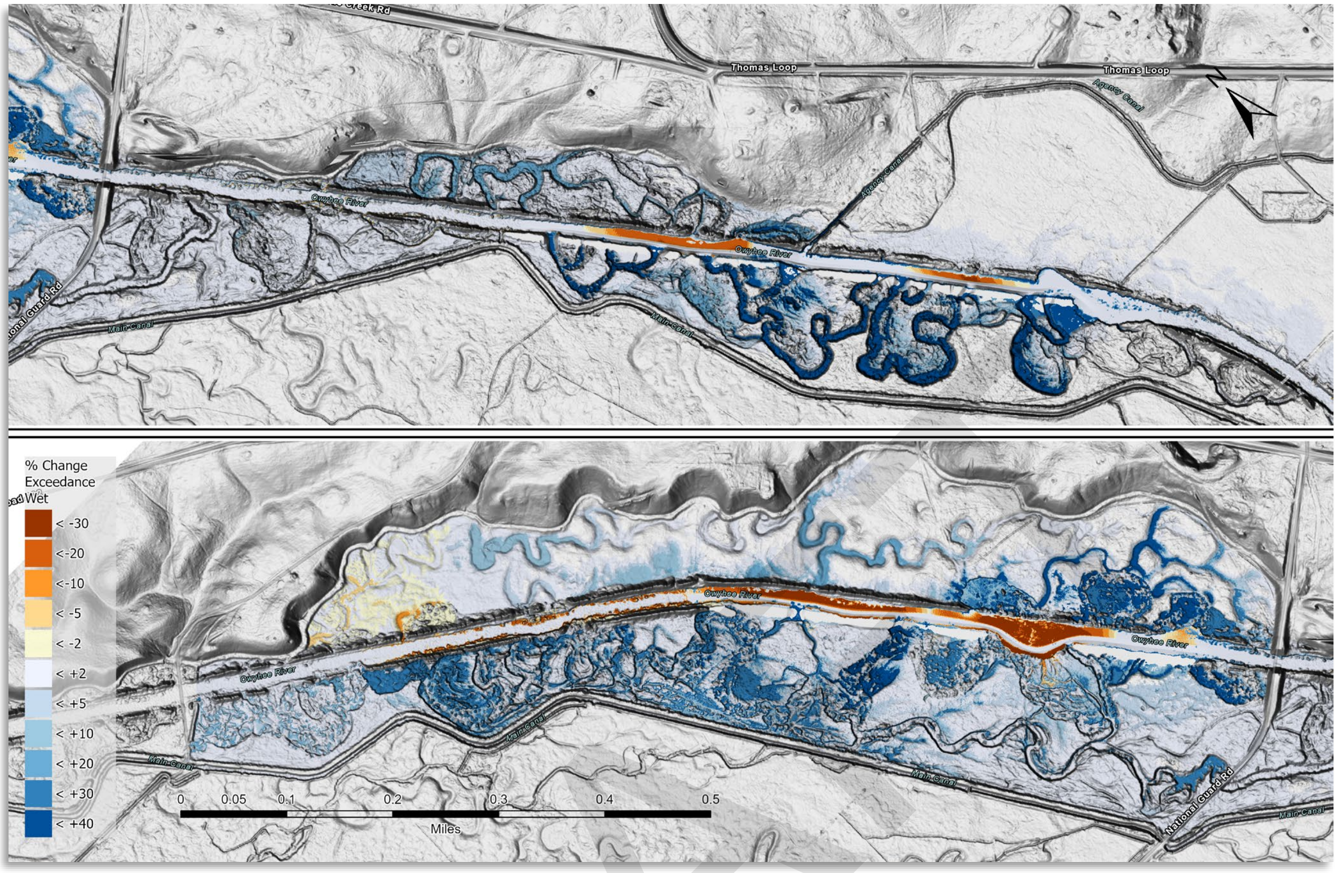

Figure 3-17. Change in Mean daily flow threshold exceedance for TSP relative to baseline. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left). Blue areas indicate increased inundation frequency. Orange areas indicate decreased inundation frequency.*

3.4.3 TSP Channel Stability

Although a Stage 1 channel stability assessment was beyond the scope of this CAP§206 feasibility study, a provisional cursory evaluation of the TSP was completed. Hydraulic modeling results were used to compute the critical sediment size via the Shields (1936) competence-based approach whereby grain mobility is a force balance between applied and resisting forces. For gradually varying flow in an alluvial channel, the applied force results from the hydrodynamics of the flow while the resisting force is related to the submerged weight of a non-cohesive sediment grain. The critical sediment size represents the upper bound for incipient bedload transport, whereby finer grain sizes would also be mobile, and coarser grain sizes would not. Coarse bedload sediments typically move in lagged pulses along the channel bed as a function of tractive force at transport rates significantly lower than those for fines. An important distinction to note is that this is a threshold measure of hydraulic capacity to move a sediment size. If that size is not present in the incoming upstream sediment supply or cannot be eroded from the channel bed or banks, then it would not be in transport despite sufficient hydraulic capacity to move it.

Figure 3-18 illustrates that for a bankfull flow of ~100cfs, most of the flow is still conveyed in the main channel with select side channels starting to activate with depths up to 2 feet. At this flow, the mobile sediment size in the main channel varies from coarse sand (*brown shades*) to fine gravel (*green shades*), with left overbanks mobilizing sand and some side channel segments starting to mobilize fine gravel (8mm = 0.31in).

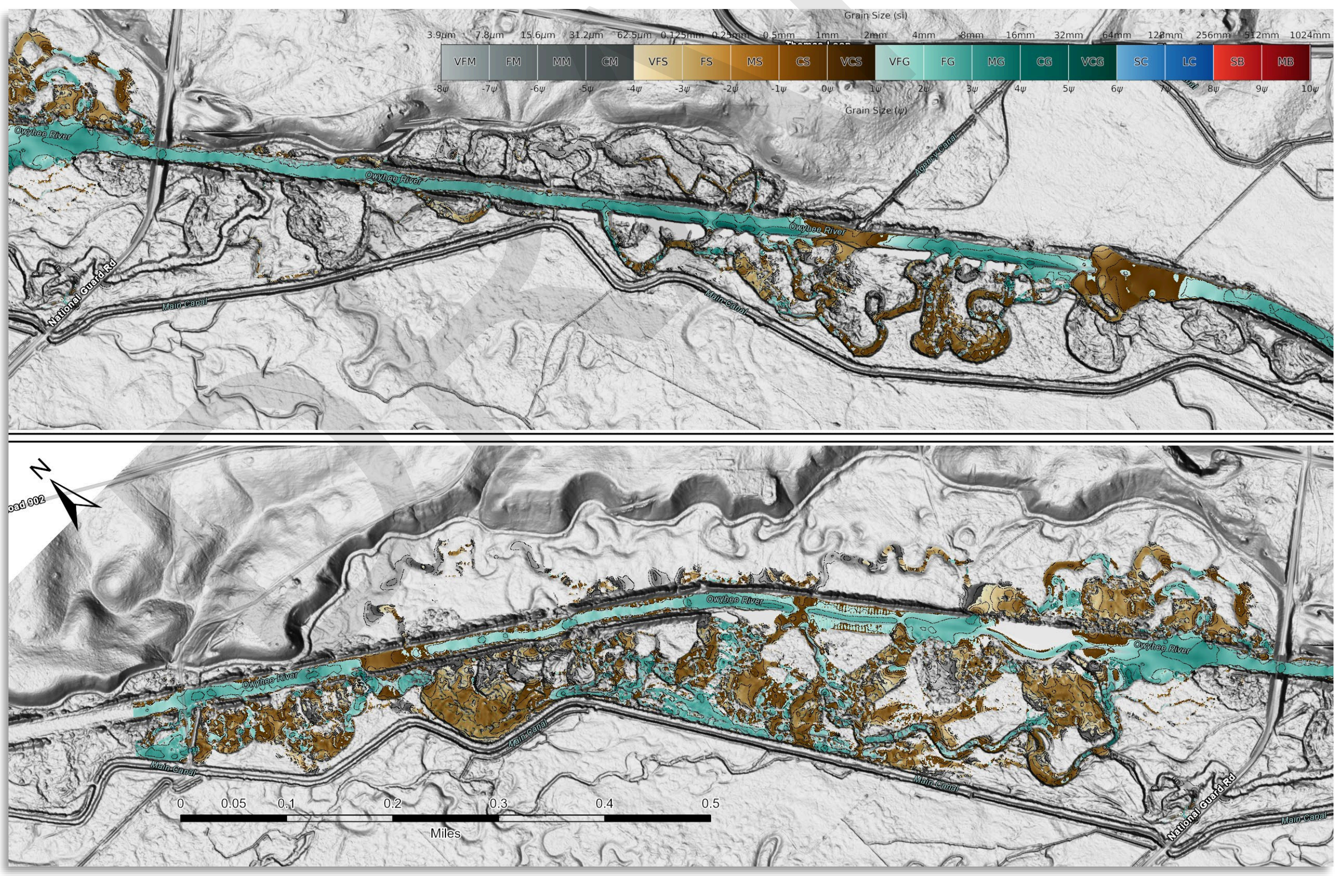

Figure 3-18. TSP. Shields Mobile Particle Size for ~ bankfull flow (100cfs inflow) and τ^*=0.047. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left). Sands are shades of brown, and gravels are shades of green with 1 ψ contour interval.*

Figure 3-19, depicts the mobile sediment size for the 2-year return period of ~586cfs. At this flow, the floodplain is partially activated with main and side channel depths up to 3 feet, and shallow overbank flow < 1 foot. With ~6x more flow than bankfull, the mobile particle size in the main channel increased by ~2-3 grain sizes from fine gravel to very coarse gravel (64mm = 2.5”). For the 100-year return period of 2698cfs project inflow, the floodplain is a fully active conveyance with main channel slopes averaging ~0.005 ft/ft, and side channel slopes on the alluvial fan <0.02 ft/ft. Main and side channel flow depths are <5 feet and overbank flow depths average ~2 feet. At this flow magnitude, the main channel velocity upstream of site #4 averages > 6 feet/second which is dampened to ~3 feet/second as the flow transitions into site #4 with more floodplain access. Figure 3-20, illustrates that the mobile sediment size in the main channel under these flow conditions remains predominately the same as the 2-year (very coarse gravel) with fine to medium gravel being mobilized in the overbanks. Upstream of site #4, the mobile particle size in the main channel is small and large cobble which transitions back to coarse gravels through the project. Within the project extents, limited cobble mobilization would be expected except for the flow constriction at the National Guard Road crossing and select areas of depths >5 feet.

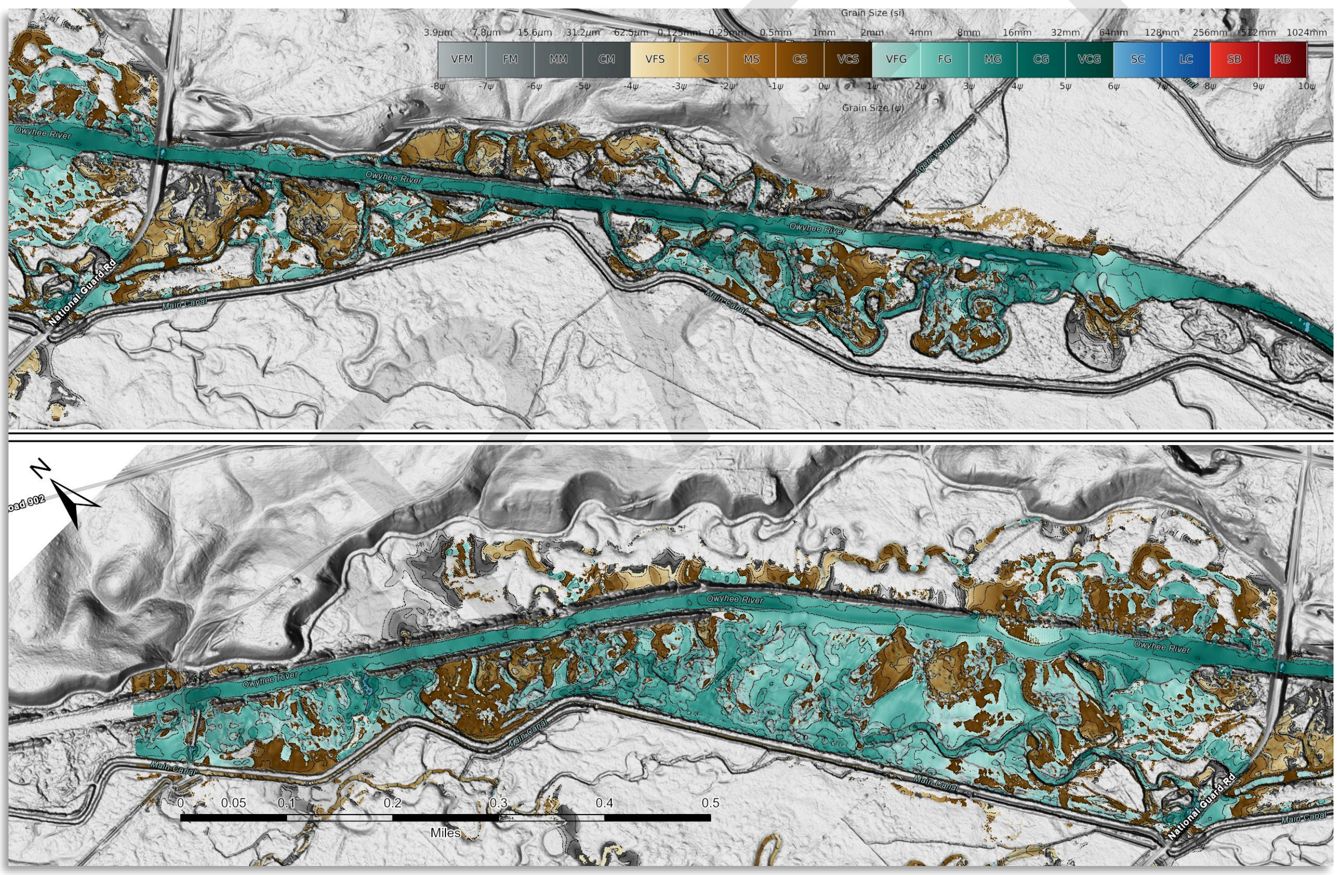

Figure 3-19. TSP. Shields Mobile Particle Size for 50% AEP (586cfs inflow) and τ*=0.047. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left). Sands are shades of brown, and gravels are shades of green with 1 ψ contour interval.*

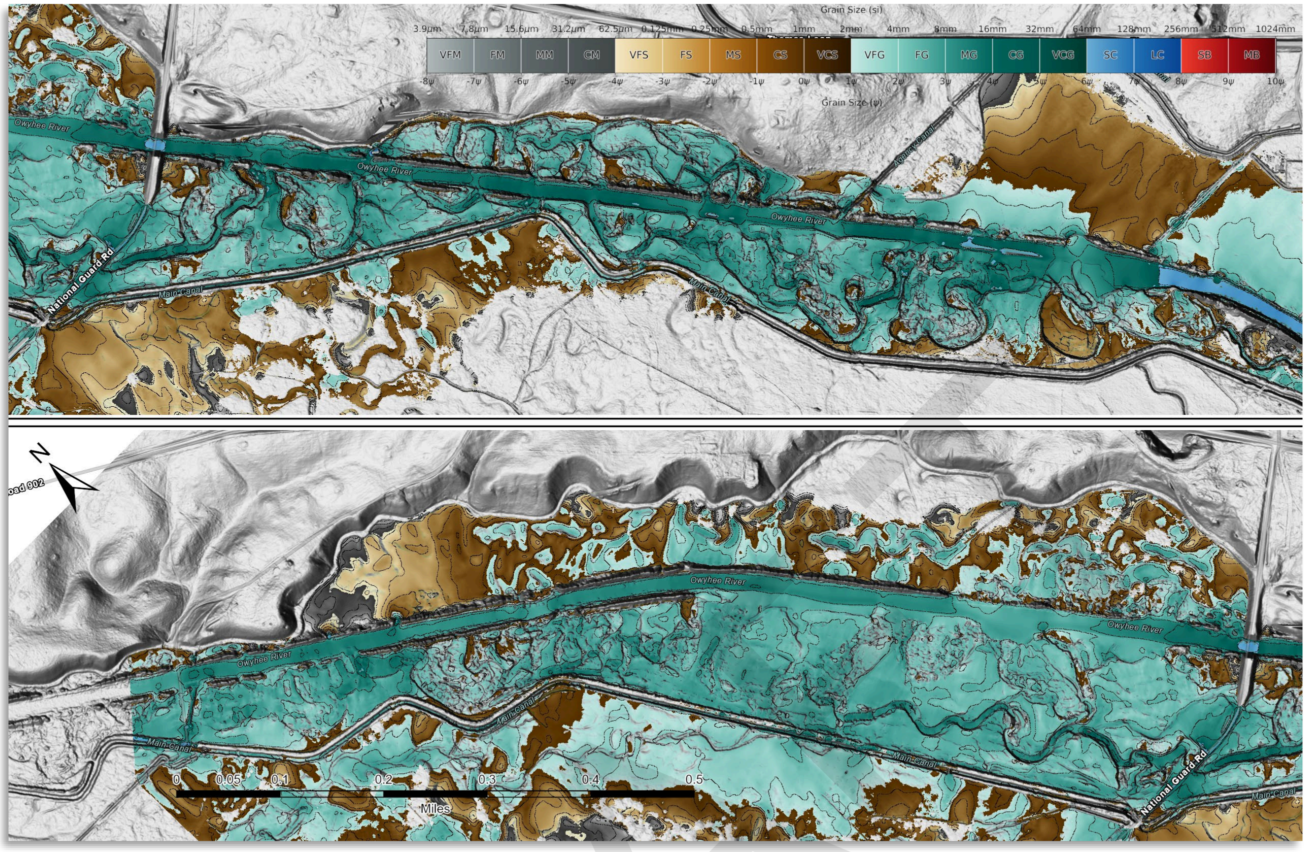

Figure 3-20. TSP. Shields Mobile Particle Size for 1% AEP (2698cfs inflow) and τ^*=0.047. *Top: Site#4. Bottom: Site#3. Flow is towards the northwest (from right to left). Sands are shades of brown, and gravels are shades of green with 1 ψ contour interval.*

Based on the currently available information, this cursory assessment provisionally indicates that channel stability for the TSP is not expected to be a significant project risk. Relative to baseline conditions, the TSP raises the overall base level and modifies channel slopes which activates the floodplain, changes flow paths, and reduces flow and stress on the main channel conveyance. During large floods, the project is expected to function closer to historical conditions which was a braided system on an alluvial fan in dynamic equilibrium with the valley slope and parent material. Both project sites are still constrained by the road to the west which eventually overtops. Considering the alluvial fan trends northwest, this could be alleviated with the installation floodplain culverts. As flows increase past bankfull, side channels activate with average initial slopes up to ~0.02 ft/ft and some localized overbank discontinuities up to 0.05 ft/ft. Once the side channels are activated with a minimum depth of 1 foot, energy grade slopes gradually flatten with increasing conveyance as the side channel overbanks deepen. It is expected that side channel inlet/outlet slopes will equilibrate during the first 5 to 10 year project burn in period which should be monitored per adaptive management plan. Both project sites could accommodate some lateral adjustments with main channel subsections dewatered up to a threshold flow if desired.

During PED, test pit data should be collected to determine the grain size distribution of both the subgrade alluvial channel framework material and berm core material to be used for channel fill to validate channel stability considerations. In addition, the PDT should assess where to hold grade in the main channel and select side channel inlets/outlets as appropriate. Discussion of potential vertical grade control countermeasures to reduce future risk of down cutting is discussed in Section 6.2 of the report.

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