PUBLIC VERSION

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VA103-640/1-6

KLAMATH RIVER RENEWAL PROJECT
60% DESIGN REPORT

Rev	Description	Date
0	Issued in Final	February 7, 2020

Knight Piésold CONSULTING

res

EXECUTIVE SUMMARY

The Klamath River Renewal Project involves the removal of four hydroelectric facilities on the upper Klamath River basin to restore natural flow and volitional fish passage through the former dam and reservoir reaches. These facilities are J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate. The Project also includes demolition of existing and development of new recreation sites, related work for roads, bridges, and culverts for construction and/or permanent use, and habitat restoration of the former facilities and reservoirs.

The 60% Design is built upon the concepts presented in the 30% Design Report. Extensive design analyses and collaboration of the multi-disciplinary Project Team throughout the 60% Design phase have targeted reduced costs and construction risks.

Each hydropower facility removal can be categorized into three general time periods:

- Pre-drawdown works: the period wherein temporary access, dam and tunnel modifications are constructed to facilitate reservoir drawdown;
- Drawdown: the period wherein reservoirs are emptied to facilitate dam removal works; and
- Post-drawdown works: the period when dam and other hydropower facility infrastructure is deconstructed and the volitional fish passage channels are established.

[redacted]

Various roads, bridges, and culverts improvements will be completed to support construction and long-term access in and around the former dams and reservoirs. Where possible, temporary bridges and structures have been used to limit disturbances to public infrastructure.

Six recreation sites are included in the 60% Design:

- Pioneer Park West Day Use Site
- Below J.C. Boyle Dam Day Use Site
- Copco Valley Day Use Site
- Copco No. 2 Powerhouse Day Use Site
- Camp Creek Day Use Site
- Iron Gate hatchery Day Use Site

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ABBREVIATIONS

BMP	best management practice
CFD	computational fluid dynamics
cfs	cubic feet per second
DAC	depth area curve
DCD	Design Completion Documents
El.	elevation
ft	feet, foot
HPU	hydraulic power unit
HVAC	heating, ventilation, and air conditioning
Kiewit	Kiewit Infrastructure West
KP	Knight Piésold Ltd
KRRC	Klamath River Renewal Corporation
KRRP	Klamath River Renewal Project (the Project)
kV	kilovolt
PacifiCorp	PacifiCorp Energy
PFMA	Probable Failure Modes Analysis
RES	Resource Environmental Solutions
RM	River mile

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This 60% Design Report is one of the key interim technical documents developed for the Klamath River Renewal Corporation (KRRC), for the purposes of implementing the Klamath River Renewal Project (KRRP). The report has been prepared by Knight Piésold (KP) and Resource Environmental Solutions (RES), with input from Kiewit Infrastructure West (Kiewit) and other engineering, construction, and environmental professionals. Collectively, these parties are referred to as the Project Team.

The Project involves the removal of four hydroelectric developments and appurtenant facilities located on the upper basin of the Klamath River. The purpose of the Project is to achieve a free-flowing condition and volitional fish passage through the former dam and reservoir reaches. The term "Project" as used in this report refers to the design, construction, demolition, and restoration components of the work.

The four hydropower facilities to be decommissioned in the Project, from upstream to downstream, are J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate. The Project also encompasses dam and tunnel modifications, construction and permanent access roads, bridges and culverts, recreational facility removal and improvement, and channel and floodplain restoration.

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1.2 DESIGN CRITERIA

This report is a focused design document that should be read in conjunction with the design criteria provided in Appendix A. The appendix is subdivided as shown in Table 1.1.

Table 1.1 Appendix A List and Description

Appendix	Description
A1	Project Notation, Units, and Conversion
A2	Mapping, Surveys, and Site Controls
A3	Geological Setting
A4	Geomorphology
A5	Seismicity
A6	Climate
A7	Hydrology
A8	Work Restrictions
A9	Diversion Tunnel Improvements and Work Platforms
A10	Reservoir Drawdown
A11	Auxiliary Equipment Installation and Removal
A12	Embankment Dam Removal
A13	Concrete Dam and Structures Removal
A14	Roads, Bridges, and Culverts
A15	Electrical
A16	Material Disposal
A17	Recreation Sites
A18	Site Restoration

1.3 APPENDICES

Table 1.2 provides a list and description of the appendices provided with this report.

Table 1.2 Appendix List and Description

Appendix	Description
A	Design Criteria
B	J.C. Boyle Design Details
C	Copco No. 1 Design Details
D	Copco No. 2 Design Details
E	Iron Gate Design Details
F	Roads, Bridges, and Culverts Design Details
G	Reservoir Drawdown Model
H	Reference Reach Cross Sections and Figures
I	Profiles of Key Tributaries
J	Seed Collection Areas
K	Seed Collection Data Sheets
L	Invasive Exotic Vegetation
M	Large Wood Stability Calculations
N	Permit Conditions
O	BLM Comments on Definite Plan
P	Project Implementation Schedule
Q	Erosion and Sediment Control
R	Electrical

1.4 DRAWINGS AND SPECIFICATIONS

This report refers to the 60% Design Drawings and Project Technical Specifications which, in combination with this report and the Cost Model, form the 60% Design Completion Documents (DCD). These additional documents are issued separately from this report.

Drawing lists for J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate are provided in Sections 2.1.2, 3.1.2, 4.1.2, and 5.1.2, respectively. Drawing lists for roads, bridges and culverts, recreation sites, and site restoration are presented in Sections 6, 7, and 8, respectively.

1.5 EROSION AND SEDIMENT CONTROL

The construction and removal works required for the Project will be conducted in a manner that provides environmental protection and best management practices (BMP) for erosion and sediment control. Appendix Q provides the erosion and sediment control design measures for each Project area.

1.6 ELECTRICAL

The Project encompasses various electrical components including the decommissioning and reconnection of transmission lines and the removal and disposal of electrical infrastructure. Appendix R provides a description of the electrical works required for the Project.

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

SECTION 2.0 J.C. BOYLE HYDROPOWER FACILITY REMOVAL

PAGES 4 TO 15

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

SECTION 3.0 COPCO NO. 1 HYDROPOWER FACILITY REMOVAL

PAGES 16 TO 27

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

SECTION 4.0 COPCO NO. 2 HYDROPOWER FACILITY REMOVAL

PAGES 28 TO 35

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

SECTION 5.0 IRON GATE HYDROPOWER FACILITY REMOVAL

PAGES 36 TO 45

6.0 ROADS, BRIDGES, AND CULVERTS

6.1 GENERAL

The scope of work for roads, bridges and culverts consists of two components:

- Mitigation of drawdown effects on permanent bridge and culvert crossings
- Construction access improvements: roads, bridges, and culverts

Reservoir drawdown will potentially affect certain bridges and culverts located on reservoir tributaries by initiating tributary channel incision and headcutting, which could undermine abutments or outlets. Impassable fish barriers could be created where an upstream migrating headcut intersects a crossing-related hard point (i.e. culvert outlet).

The following bridges and culverts have been assessed for drawdown effects and the following mitigation/ designs are in development:

- Camp Creek culvert: to be replaced by a bridge
- Scotch Creek culvert: to be replaced by a bridge
- Jenny Creek bridge: channel erosion mitigation to be installed (pending review and approval from Siskiyou County)
- Spencer and Copco bridges: no mitigation designed at this time; monitor post-drawdown
- Several culverts: no mitigation designed at this time; monitor post-drawdown

Construction access improvements are required where existing roads and bridges are not sufficient to handle construction equipment dimensions or loads, or to create new access to certain areas that do not have access now.

The planned construction access improvements are summarized below:

- Temporary single span overlay bridge spans on existing bridges to meet construction load requirements:
    - Fall Creek Bridge
    - Dry Creek Bridge

[redacted]

- Improvement of public roads and culverts, as needed, leaving them in equal or better condition after Project implementation than they are at present:
    - Copco Road
- Local construction access – J.C. Boyle:
    - Road realignment: at scour hole
    - Road reactivation: lower penstock access road
- Local construction access – Copco No. 1:
    - Road improvement: Right Bank access from Copco Road down to Copco No. 1 Powerhouse
    - [redacted]
- Local construction access – Copco No. 2:

  - New road: Right Bank access to downstream of Copco No. 2 Dam
  - Road improvement: Left Bank utility corridor leading toward Copco No. 2 Dam
- Local construction access – Iron Gate:
  - New road: Right Bank access to Iron Gate Dam low-level tunnel outlet
  - [redacted]

The drawings list for the drawdown-affected bridges and culverts, and for the construction access improvements other than local construction access, are presented in Table 6.1. Local construction access improvements at the four hydropower facilities are addressed in the applicable facility sections and drawing sets (see Sections 2 through 5 of this report).

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7.0 RECREATION SITES

7.1 INTRODUCTION

The design program for the recreation sites focused on producing site designs that maintain a natural, largely undeveloped feel and improve the visitor's experience within the context of the resource setting while protecting sensitive cultural resources and enhancing ecological resources. The potential recreation sites support improved recreation programs and improve access to the river. Careful consideration has been given to the existing natural character of the area during site design, including restoration and enhancement of the natural features whenever possible. Site design has accounted for issues affecting potential recreation activities, such as river hydrology and gradient and potential safety hazards related to access.

To reduce potential impacts to habitat and vegetation, site designs were developed that limited the clearing of mature vegetation as much as possible and potential site amenities and features would be field fit to reduce site disturbance. It is anticipated that construction of the potential recreation sites would be done in coordination with vegetation management guidelines, invasive non-native plant prevention and control measures, revegetation measures, and project demolition actions as outlined in the Surrender Order and related plans.

The recreation site locations were chosen based on the predicted results of Project implementation and return of the river system back to its original alignment. Consideration was given to slope and gradient of the river channel, the relationship of the site to potential whitewater boating runs, and the site's potential to support development of infrastructure to enhance recreation experiences within specific setting characteristics for day use recreation, whitewater boating access, and fishing. Sites were also vetted for their viability by stakeholders and ability to accommodate assumed levels of use.

The following design principles were considered in site planning and design of the river access sites to understand how the river is being used and by whom.

- System and Location: the location, geomorphology, and physical characteristics of a site within the continuum of the river system.
- Landscape Setting: the site-specific features as well as the site conditions characterized as natural, enhanced, or constructed and the site-specific features that define setting.
- Temporal Dependence: the seasonal nature of on-site activities and how variability of water levels may affect timing and types of uses.
- Frequency: when and how often activities occur at a site and how that site activity integrates or impacts the biological setting and natural resources.
- Density: the number of individuals who will use a site and the site's spatial constraints that define how well desired uses can be accommodated.
- Use Type and Challenge Level: the activity types and challenge levels occurring at the site.
- Management: the needs and challenges available to support resource managers in operations and maintenance activities.
- Scenic Integrity: protection of aesthetic resources through thoughtful design.

In addition to the design principles described above, the KRRC developed a set of program objectives to guide the configuration of each site. The program objectives for the recreation sites are:

- Conserve, protect, and enhance habitat.
- Avoid/reduce user conflicts between boat ramp, trails crossings, parking and general day use activities.
- Provide designated launching areas.
- Offer group staging areas for commercial operators and private groups.
- Provide adequate waste facilities.
- Support the health, safety and welfare of the visitor.
- Provide opportunities for interpretation and education information.
- Provide additional vegetation enhancements.
- Provide opportunities for day use/picnicking.
- Improve fishing access.
- Provide pedestrian circulation paths that take advantage of scenic viewing areas.
- Provide universal accessibility to the river along paths where feasible.
- Plan and schedule all work to be consistent with other applicable plans under the Surrender Order and in coordination with other working groups (i.e., Restoration, Cultural Resources, Engineering, etc.).

7.2 GENERAL GUIDANCE

Concepts for each site presented in the Draft Klamath River Recreation Facilities Plan (Recreation Plan) provided by the KRRC in September 2019 were used as a starting point for development of the site designs. Site concepts were refined following value engineering meetings, design team site visits, and constraints identified during review of additional survey data collected at non-inundated sites. Updates to the site layouts were also provided to the Design Team to keep the proposed sites within Parcel B land and FERC project boundaries.

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7.2.1 STANDARD SPECIFICATIONS

Technical specifications were prepared using Construction Specifications Institute MasterFormat® numbers and titles and included input for the following divisions:

- Division 01 – General Requirements
- Division 02 – Existing Conditions
- Division 03 – Concrete
- Division 05 – Metals
- Division 12 – Furnishings
- Division 31 – Earthwork
- Division 32 – Exterior Improvements
- Division 33 – Utilities

7.2.2 COORDINATE SYSTEM AND DATUM

The coordinate system and datum used consists of the HARN/CA California State Planes, Zone I, US Foot and the North American Vertical Datum 1988.

7.3 DESIGN CRITERIA

The recreation sites were designed following the criteria presented in the 30% Design Criteria Document submitted to the KRRC by Knight Piésold on October 18, 2019.

7.4 DESIGN SUMMARY

7.4.1 ROAD DESIGN

Roadways and parking lot areas for each recreation site were originally presented as paved areas in the concepts shown in the latest Recreation Plan. Following value engineering meetings, and with input from the KRRC, roads and parking lot areas were designed as gravel roads. Changes in the roadway alignments and parking lot layouts were also necessary to comply with the project Design Criteria and make the improvements constructible.

7.4.1.1 ROAD GEOMETRY AND ALIGNMENT

7.4.1.1.1 Horizontal Layout

The horizontal alignment of proposed roads was developed to accommodate two-way travel with minimum turn radii of 100 feet for fire access roads, 50 feet for other roads, and a road speed limit of 15 mph. Additionally, sites with fire access require a 120-foot diameter turnaround area. Sight distance equal to at minimum the calculated stopping sight distance is provided in the layout shown on the plans. Road horizontal curve and stopping sight distance calculations are presented in Appendix A17. Sizing and layout for each parking lot facility was originally provided in the concepts shown in the Recreation Plan and modified to accommodate constructability at each site.

7.4.1.1.2 Vertical Alignment and Grade

Road vertical grades were maintained at or less than 8% for fire access roads and less than 12% for other roads. Flattening of access roads was also provided ahead of curves and, as was specified above, a maximum vertical grade through a turn of 8% is provided in the current road configuration. Minimum crest and sag vertical curve calculations are presented in Appendix A17.

7.4.1.1.3 Road Embankment

Construction of road embankments will be required as shown in the plans for access to the recreation site. The embankments will be constructed of locally available fill materials available at each site. Slopes will be constructed at 3H:1V and were selected as typical slopes for stable fills. Slope stability analyses have not been performed but are recommended for a future design stage.

The traveled way width per lane was set at 12 feet, meeting fire access requirements for access roads. Localized widening around curves was accommodated where feasible. Two-foot shoulders are also provided along with minimum 2% cross slopes to facilitate drainage off the traveled way.

Fill that is used to achieve final subgrade elevations should be placed in lifts less than 8 inches, moisture-conditioned to within 3 percent of optimum moisture content for sands and between 1 percent below optimum and 3 percent above optimum moisture content for clays, and compacted to least 95 percent of standard Proctor maximum dry density (AASHTO T99). If soft or unstable soils are encountered below the proposed road section, the soft or unstable soils should be removed and replaced with additional granular soils.

7.4.1.2 PAVEMENT DESIGN AND CONSTRUCTION

7.4.1.2.1 Subgrade

A geotechnical investigation was not performed, and little soil information is known about the sites. Therefore, subgrade soils at each site were assumed to be classified as A-6, according to the AASHTO classification system, which are typically described as poor subgrade soils. A resilient modulus of 3,700 psi was derived from Figure 4.1 and Table 4.3 in AASHTO's 1993 Guide for Design of Pavement Structures for this type of soil. Region V and a Poor Roadbed was selected to attain the value for the resilient modulus for use in pavement design.

7.4.1.2.2 Traffic

Current traffic counts or future traffic forecasts were not included in the latest Recreation Plan for the proposed recreation sites. Traffic counts obtained by PacifiCorp in 2014 and populated in the Federal Energy Regulatory Commission Form 80 Recreation Report were used to estimate the amount of future traffic at the proposed recreation sites. The data showed that approximately 11,900 recreational visits to the Iron Gate Reservoir area were made in 2014. For purposes of developing an 18-kip Equivalent Single Axle Load (ESAL) count, it was assumed that 2 visitors per vehicle arrived at the site. It was also assumed that 95 percent of the vehicles were passenger vehicles and 5 percent were buses. Load equivalency factors for passenger vehicles and buses of 0.0008 and 0.68, respectively, were selected.

An ESAL count over a 20-year design life of less than 30,000 is obtained with this criteria and meets the traffic volume criteria of a low volume aggregate-surfaced road per section 4.2.3 of AASHTO's 1993 *Guide for Design of Pavement Structures.*

7.4.1.2.3 Pavement Design

Based on the ESAL stated above (Low Volume), the assumed poor subgrade resilient modulus, and the Region V U.S. Climatic Region, a pavement section of 8 inches was selected from Table 4.10 of AASHTO's 1993 *Guide for Design of Pavement Structures* for the recreational sites.

A summary of the pavement design input parameters is provided in Table 7.2 below.

Table 7.2 Design Pavement Section Thickness

Roadway	Gravel Road Pavement Aggregate Base (inches)
KRRP Recreation Sites – Access Roads and Parking Lots	**8**

Surface aggregate road base meeting requirements of Caltrans Class 3 Aggregate Base, 3/4-inch maximum is recommended for the proposed road sections and parking lot areas.

7.4.2 DRAINAGE

The purpose of this report is to present the proposed storm drainage improvements for the recreation site development at Copco Valley and Camp Creek sites. Drainage at Pioneer Park West, Moonshine Falls, Copco No. 2, and Iron Gate sites will be handled via sheet flow, as no major drainage paths cross through the proposed sites. Copco No. 2 has an existing culvert that manages runoff through the site that will remain as part of the new site. This report examines the undeveloped flow patterns of off-site and on-site drainage and the proposed stormwater structures designed to convey the drainage through the Copco Valley and Camp Creek recreation sites.

7.4.2.1 LOCATION AND EXISTING CONDITIONS

The Copco Valley recreation site is located on an approximately 10-acre parcel located nearly 2 miles south of the California-Oregon border. The existing site for Copco Valley consists only of a gravel access road. The remainder of the proposed site is on land currently inundated by Copco Lake. Therefore, there is no existing drainage plan in this area. The bathymetry of the lakebed in combination with survey data acts as the existing conditions for this site.

The proposed location for Camp Creek is a 3.5-acre area currently inundated by Iron Gate Reservoir. There is an existing dirt and gravel access road connecting Copco road to the reservoir where the Camp Creek site is proposed. The existing access road does not meet required turn radius or grade. The site is located downstream of the existing Copco No. 2 Powerhouse facility.

A vicinity map for both sites has been provided in Appendix A17.3. The historic drainage paths for both sites are attached to this report as Appendix A17.3.

7.4.2.2 PROPOSED DEVELOPMENT

The proposed layout for the Copco Valley recreation site falls partially within the existing Copco Lake extents. The site is designed based on bathymetric contours that show the historic river channel located within the reservoir's footprint. The site's proposed plan contains a 2-lane boat ramp with river access, numerous day-use picnic sites, and a gravel parking lot. Three major drainage paths are run through or adjacent to the proposed site based on the lakebed bathymetry. A combination of grading, culverts, and sheet flow will guide the runoff to the historic river channel. No runoff will be retained in the site, as runoff and time of concentration does not increase significantly for post-developed conditions. The proposed site contains little to no impervious area, therefore the difference between pre-developed and post-developed runoff is minimal. Copco Valley consequently does not require post-developed drainage runoff analysis. The proposed drainage plan for Copco Valley has been attached to this report as Appendix A17.3.

The proposed layout for Camp Creek is nearly 26,500 square feet (0.6 acres). The site contains a small gravel parking lot, vault toilet, and a gravel walking trail winding down to the Klamath River. With the small increase in gravel area in the proposed site, the difference between pre-developed and post-developed runoff is minimal. Therefore, post-developed drainage was not documented for the Camp Creek recreation site.

7.4.2.3 DRAINAGE BASINS AND SUB BASINS

Drainage for the recreation sites required watershed and subbasin analysis to determine where historic drainage paths occur. The goal for each site was to minimize drainage structures while also using minimal grading. Using only sheet flow over the parking and access roads was applicable for Pioneer Park, Moonshine Falls, and Iron Gate. These sites have no proposed culverts or other drainage mechanisms, as runoff does not significantly impact the sites at any locations. Copco No. 2 Powerhouse will utilize sheet flow as well as existing culverts to drain the site. Copco Valley and Camp Creek both require drainage mechanisms where major runoff paths cross proposed roads or paths. The runoff produced uphill of Copco Valley requires a series of culverts and a riprap-lined channel to guide the flow through the site and down to the Klamath River. At Camp Creek, there are two major drainage paths that cross the proposed gravel walking trail leading to the river. Both locations will transition from the surface course to riprap surfacing, which will allow runoff to flow over the trails at these points.

7.4.2.3.1 Major Basin Description

The proposed site for Copco Valley is located in rural Siskiyou County and is surrounded mostly by undeveloped short grass and wooded cover. According to the Web Soil Survey of Siskiyou County, site soils are primarily stony loam and very stony clay throughout the Copco Valley site tributary watershed basins. Site soils for the Camp Creek project site and tributary watershed areas are primarily stony clay. A detailed soil survey report has been provided in Appendix A17.3 for Copco Valley and Camp Creek. The soil types within both project sites are predominantly hydrologic soil group D, with a high runoff potential.

7.4.2.3.2 Historic Drainage Patterns

For both Copco Valley and Camp Creek, site rainfall depth information was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 6, Version 2, Precipitation-Frequency Atlas of the United States (2013). The current NOAA data was used to determine point rainfall data. Rainfall data is presented in Appendix A17.3.

The time of concentration for each Basin and the historic runoff coefficients are determined for each site soil type using the methods detailed in the California Department of Transportation Highway Design Manual and the Water Resources Engineering Manual, Rational Method Design (2005). Because the areas of proposed development are less than 160 acres and without impervious areas, the Rational Method was used to analyze the historic peak flows. A Historic Drainage Plan is enclosed with this report as Appendix A17.3.

Copco Valley

There are three basins that drain 236 acres of runoff through the project site and feed into Copco Lake. The area currently underwater will continue these drainage paths once the reservoir is drawdown. The bathymetric data in the area indicates that there are three subbasins, each with a drainage path that passes through the proposed site.

Historic peak flows for the 25-year storm events for the proposed developments have been provided in Table 7.3 below.

Table 7.3 Copco Valley Historic Peak Flows

Basin ID	Area (acres)	Peak Flow 25 Year (cfs)
A1	68.0	118
A2	145.6	253
A3	23.4	41

For Copco Valley, Basin A is divided into 3 subbasins. The runoff produced by the addition of gravel area will not be detained on the site. The runoff will be guided through a series of culverts and a riprap lined channel until the flow reaches the outlet, the Klamath River. The runoff produced by subbasin A1 does not cross the site at any major locations, except for a low point near the outlet. A small amount of grading work will be done to guide the drainage away from the site and into the river at this location. The runoff from subbasin A2 runs through the center of the proposed site and passes under the road leading into the parking area twice. At each location, three culverts will convey flow under the roadway. There will be a riprap-lined channel to convey the runoff flow from the to culvert, and then continuing down to the Klamath River. Subbasin A3 produces runoff that is mainly sheet flow and does not impact the proposed site.

Camp Creek

Drainage for the Camp Creek recreation site is divided into three subbasins (B1, B2, and B3). Based on bathymetry, both subbasin B1 and B2 have a drainage path that crosses the gravel path each at one unique point. In order to prevent erosion of the trail, riprap surfacing will be installed at these locations to allow runoff to flow over the trail. A trail water crossing is more economical than a culvert for this site, as the hiking trail is natural and is expected to experience minimal use. The typical detail used for reference is Section 913- Riprap Surfacing of the U.S. Forest Service Standard Trail Plans and Specifications, drawing number STD_913-50-01. Subbasin B3 does not drain across the site. Therefore, the runoff from subbasin B3 will drain directly into the Klamath River.

Historic peak flows for the 25-year storm events for the proposed developments have been provided in Table 7.4 below.

Table 7.4 Camp Creek Historic Peak Flows

Basin ID	Area (acres)	Peak Flow 25 Year (cfs)
B1	33.5	53
B2	38.9	62
B3	21.1	33

7.4.2.4 DRAINAGE DESIGN CRITERIA

This report is prepared in compliance with California Department of Transportation. Based on this criterion, a 25-year storm is used when evaluating runoff for the proposed recreation sites. For drainage basins less than 160 acres in area, which includes the on-site and off-site basins, the Rational Method was used in stormwater runoff calculations.

Rainfall Data: Data for the 24-hour storm event was collected using the NOAA Atlas 14, Volume 6, Version 2, Point Precipitation-Frequency Atlas of the United States.

Pipe and Culvert Sizing: Site storm infrastructure capacities have been evaluated using Manning's Equation and in accordance with the U.S. Forest Service Road Preconstruction Handbook. The culverts on site are sized to convey the 25-year storm event and shall not be less than 18 inches in diameter. Erosion control devices will be provided at all culvert and swale outlets to protect against downstream erosion. Culvert sizes were determined using HY-8 software. All culverts utilized at Copco Valley recreation site will follow the Flared End Section detail D94A from Caltrans 2018 Standard Plans. The RCP culverts will require two feet of cover minimum, except under roads where the minimum increases to 3 feet. Pipe sizing calculations have been provided in Appendix A17.3.

In accordance with the California Department of Transportation Highway Design Manual, channel design for the riprap-lined drainage channel in the Copco Valley recreation site was designed using a 25-yr, 24-hour storm channel capacity for a uniform trapezoidal section. The channel is designed to convey the 25-year storm event that passes through a culvert running under the road embankment. The shear stress resulting from the 25-year flow was calculated and an appropriate slope protection was chosen to line the channel.

Riprap Design: Riprap will be placed within the channel running through Copco Valley, lining the ditch to the east of the Copco Valley site, and at all trail drainage crossings in Camp Creek. Riprap design follows the requirements outlined in California Department of Transportation Highway Design Manual and the Design Hydrology and Sedimentology for Small Catchments manual. From this manual, facing riprap will provide the necessary protection against shear stress and velocity for the channel. Detailed riprap calculations have been provided in Appendix A17.3.

7.4.3 BOAT RAMP DESIGN

Boat ramp facilities are provided to accommodate anticipated whitewater rafting and fishing recreation activities. Criteria provided by the Oregon Marine Conservation Board for recreational boating facilities was used in establishing the vertical and horizontal alignment, dimensions, and surfacing for the boat ramps. Boat ramp toe elevations were set at the transition of riverbank and river bottom while the top of ramp was set based on the topography of the floodplain bench above the riverbank at each site. Approximate river flow recurrence intervals at each boat ramp location are shown in Table 7.5 below. Recurrence intervals were obtained from the USBR HEC-RAS 1-D model of the Klamath River. The model was run showing existing conditions as cross section geometry matched bathymetry elevations used for the design of the sites is presented in Table 7.5 below.

Table 7.5 Approximate River Flow Recurrence Intervals at Boat Ramp Locations and Features

Site	Recurrence Interval
Pioneer Park Toe	<2-year
Pioneer Park Top	>500-year
Copco Valley Toe	<2-year
Copco Valley Top	>500-year
Iron Gate Toe	<2-year
Iron Gate Top	200-500 year

7.4.4 PRECAST CONCRETE RESTROOM FACILITIES

A precast vault toilet restroom system meeting requirements of ASTM C913 – Standard Specification for Precast Concrete Water and Wastewater Structures and ASTM C1227 – Standard Specification for Precast Concrete Septic Tanks has been specified for installation at each recreation site.

7.4.5 EROSION AND SEDIMENT CONTROL

7.4.5.1 PERIMETER CONTROLS

Sediment control best management practices (BMPs) are always required at appropriate locations along the site perimeter during active construction. The discharger is responsible for ensuring that adequate sediment control devices are available to prevent sediment discharges at the downgradient perimeter of the project site. The following sediment control BMPs may be implemented on this project:

- Silt Fence. Silt fence can be used where runoff occurs in the form of sheet and rill erosion to detain sediment-laden water.
- Fiber Rolls. Fiber rolls will be installed around the perimeter of the site to minimize the amount of sediment that discharges from the site.
- Gravel Bag Berm. Gravel bags can pond sheet flow runoff, allowing sediment to settle out, and release runoff slowly as sheet flow, preventing erosion.

7.4.5.2 SLOPE PROTECTION

Slope protection BMPs will be required where exposed slopes have not yet been stabilized with vegetation. The following sediment control BMPs may be implemented on this project:

- Check Dams. Check dams reduce the effective slope thereby reducing the velocity of flowing water, allowing sediment to settle and reducing erosion. Gravel bags can be stacked to form check dams along v-ditches.
- Fiber Rolls. Fiber rolls may be installed at the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
- Straw Mulch. Portions of the site that will remain undisturbed during the wet season will be mulched to prevent sediment migration.
- Erosion Control Blankets. Erosion control blankets will be installed on fill or cut slopes that are 3:1 or steeper to reduce sediment migration and assist with vegetation establishment.

7.4.5.3 VEHICLE TRACKING

The following BMPs have been selected to reduce sediment tracking from the construction site onto private or public roads:

- Stabilized Construction Entrance. Stabilized construction entrances will be constructed to limit the amount of sediment that is tracked on to public roadways from the site.
- Stabilized Construction Roadway.
- Entrance/Outlet Tire Wash.

7.4.5.4 DUST CONTROL

The following BMPs have been selected to control dust from the construction site:

- Wind Erosion Control. Dust control practices via watering or temporary seeding will be implemented as necessary.

7.4.6 LANDSCAPE IMPROVEMENTS

7.4.6.1 ENTRY TREATMENTS

To enhance and identify entries to the recreation areas, entry signs and native plantings that offer interest are to be installed in key intersection locations. Consideration to visibility dictates that some signs will have double sided messaging and all plantings will be no higher than 30” within a visibility triangle on either side of the intersection.

Signage style to reflect the simplicity of other recreation furnishings. Low maintenance materials such as stone veneers for the bases and concrete body of the signs to be used.

Plantings to be native plantings derived from the restoration list of approved locally available plantings. Interest to be created with foliage or flower color and differing textures.

7.4.6.2 INTERIOR PLANTING

A seed mix of native plantings will be used to repair damaged areas within the recreation day use sites. Limited use of ground covers and shrubs of native varieties will be used to identify and separate parking areas from roadways and walkways and to provide shade in the parking areas. Seed mix and planting species were coordinated directly with the restoration design team.

7.4.6.3 FURNISHINGS

Picnic tables and benches will be provided at each of the three recreation areas. Picnic tables and benches are to be prefabricated from concrete for durability and vandalism resistance. All tables and benches meet ADA standards and requirements. Kiosks will be utilized in focal locations at each site and each one will allow a variety of information to be posted.

7.4.6.4 SIGNAGE

Signage programs are seen as a method to organize sites and provide the circulation system for cars, trailers and pedestrians. The signage program at each recreation site will employ a hierarchy of signs as tools to implement the safety plan.

Entry signs, ADA signage, directional, informational signs and park regulation and warning signs will be located within each recreation area. Many of the directional and locational signs will be simple pole signs with metal placard areas with messages in large letters. ADA signage will conform to the highest standards and requirements. Entry signs strategically placed will help drivers on the winding roads find their destination and be able to make turns into each site safely.

7.4.6.5 TREE PROTECTION

Preservation of trees within the work areas is a priority of the project, especially those native and larger trees that will continue to provide character, shade and contribute to habitat and overall ecosystem health. Trees within work areas will have a Tree Protective Zone defined by construction fencing. Requirements to avoid grading or use of the space as a lay down or storage area will add to the survivability of this resource.

8.0 SITE RESTORATION

8.1 RESTORATION SUMMARY

The primary habitat restoration actions for the reservoirs will be 1) reservoir drawdown, 2) sediment evacuation, and 3) dam removal. Additional restoration actions will be performed as needed to provide volitional fish passage, selectively stabilize residual sediments, and encourage native plant establishment. In addition, supplemental restoration actions will be taken to enhance aquatic habitat as feasible. The major restoration actions undertaken within the former reservoir footprints will include:

- Implementing measures to encourage sediment evacuation during drawdown.
- Reconstructing a geomorphically-appropriate channel through the former dam footprints.
- Selective post-drawdown grading of mainstem near-channel areas and key tributaries as needed to provide volitional fish passage, remove large, unstable residual sediment deposits, and, where cost-effective and feasible, improve hydrologic connectivity to off-channel and floodplain areas to establish and sustain native riparian vegetation and enhance aquatic habitat.
- Installing large wood and boulder clusters to enhance habitat.
- Installing willow baffles to provide floodplain roughness and to encourage vegetation establishment and selectively stabilize sediments.
- Revegetating formerly inundated areas primarily through seeding to slow erosion and re-establish native plant communities.
- Selectively planting and irrigating locally salvaged and/or nursery-sourced plants, including wetland sod, willow cuttings, bareroot trees, and shrubs and acorns.
- Controlling high priority invasive exotic vegetation (IEV) prior to, during, and following construction where cost-effective and feasible.
- Fencing select locations to protect restored reservoir areas from trampling and herbivory by cattle and wild horses.

Restoration actions will be focused on the mainstem of the Klamath River and high-priority tributaries and natural springs. The main physical constraints limiting the extent of restoration actions are difficult construction access and presence of culturally sensitive resources.

The application of most of the above restoration actions depends on the distribution and amount of residual sediment following drawdown in each of the reservoirs. However, both the location and thickness of residual sediment remaining in the reservoirs following drawdown is uncertain. Residual sediment will vary, primarily depending upon river flows during drawdown and, to a lesser degree, by the effectiveness of supplemental sediment evacuation methods.

The reservoir restoration is designed to be flexible and adaptable to (a) address actual field conditions following drawdown, (b) target actions on priority restoration areas, and (c) work within available project funding. Certain habitat enhancement actions may be reduced or eliminated if needed based on these considerations.

This report section presents the design basis for restoration of the Copco 1, Iron Gate, and J.C. Boyle reservoirs following dam removal. We first present the process for selecting restoration priority areas and then provide more detailed design basis for each restoration action. [redacted]

[redacted]

8.2 RESTORATION PRIORITIES AND ACTIONS

Appendix H of the Definite Plan provided a foundation and framework for translating restoration goals and objectives into restoration priorities and actions based on anticipated site conditions and ecological functions. Both pre-dam and anticipated post-dam conditions presented in Appendix H were used to identify restoration opportunities and constraints and develop restoration priorities. Appendix H was reviewed to understand the full suite of restoration areas and to develop a basis for refining specific actions and assumptions to accomplish the restoration.

Restoration areas and actions identified in the Definite Plan were refined and prioritized based on the following three steps, described further below:

- **Step 1:** Developed general restoration priorities.
- **Step 2:** Applied the restoration priorities to each reservoir to identify restoration areas.
- **Step 3:** Identified specific restoration elements/actions to be implemented at each area.

Table 8.1 below provides the restoration drawing list.

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8.2.1 STEP 1: RESTORATION PRIORITIES

Restoration priorities are driven by the primary project goals of volitional fish passage, residual sediment stabilization, native plant establishment, and the secondary goal of enhancing native fish habitat. We also considered the challenging natural environment for plant establishment, including variable soil quality, low rainfall, high summer temperatures, and competition from invasive species. From this, we identified the following four restoration priorities with the intent of leveraging natural water sources as much as possible.

8.2.1.1 1ST PRIORITY – KLAMATH RIVER

The highest project priority is providing volitional fish passage on the Klamath River. Mainstem habitat connectivity is important for re-establishing natural distributions of anadromous salmonids and Pacific lamprey in the Klamath River Basin. Specific restoration actions include reconstructing a fish-passable and geomorphically appropriate channel through the footprint of the former dams. In addition, any anthropogenic structures in the river channel, either known or uncovered post-drawdown, will be removed.

In addition to these required actions, additional measures may be taken to opportunistically encourage floodplain benches and channel complexity where post-drawdown conditions, access, time, and budget allow. Generally, the restoration approach for the Klamath River is to restore natural processes so the river and its habitats can recover without significant intervention (process-based restoration).

8.2.1.2 2ND PRIORITY - PERENNIAL TRIBUTARIES

The secondary priority is perennial tributaries, particularly at the tributary mouths and where tributaries have formed deltas around the reservoir rim. Tributaries and tributary mouths tend to be highly used habitats by anadromous salmonids and Pacific lamprey. Tributaries can support several life stages necessary for anadromous salmonids to complete their life history, including spawning, egg incubation, juvenile rearing, and overwintering. Tributary mouths provide habitats for anadromous salmonids originating in the tributary, as well as adults and juveniles during migration and rearing. Because tributaries are expected to have lower suspended sediment loads than the mainstem as it adjusts to its restored condition, tributary mouths may also be particularly important refugia habitat for salmonids and Pacific lamprey in the first few years following drawdown.

One required restoration action is to provide mainstem connectivity for all fish-bearing tributaries. In addition, measures will be taken to enhance potential spawning, rearing and overwintering habitat as access and budget allow.

8.2.1.3 3RD PRIORITY – NATURAL SPRINGS

Given the challenging climatic conditions, restoration actions will target natural springs and seeps. These water sources can be leveraged to create wetlands, add channel complexity by supporting spring-fed alcoves or side channels, and widen riparian areas. Appropriate planting and focused, minor grading can add complexity and connectivity to ecosystems associated with the river. The expanded and revegetated areas serve as seed source for passive restoration in adjacent areas, provide critical functions in terms of refugia and foraging for terrestrial species, and improve potential biological productivity for a range of species including aquatic organisms.

8.2.1.4 4TH PRIORITY - INTERMITTENT TRIBUTARIES

While perennial tributaries are the highest priority, there are select intermittent tributaries that may provide non-natal juvenile rearing refuge habitat. Restoration actions will focus on connectivity at the mainstem confluence of the larger intermittent tributaries to provide expanded habitat and/or increased biological productivity.

8.2.2 STEP 2: RESTORATION AREAS

These priorities were applied to each reservoir to identify restoration areas. The resulting areas are those with the greatest opportunity to enhance habitat value through direct actions, such as grading and installing enhancement features. Areas outside of restoration areas will be restored more passively, primarily through native seeding and selective planting.

We understand that the restoration opportunity areas presented in the Definite Plan are considered the maximum potential extent of restoration and that further screening and refinement was anticipated during the design-build process (Scott Wright, pers. comm). River Design Group (RDG) conducted a screening process to select the areas shown in the Definite Plan (Figures 5-1, 5-4 and 5-7). The process began with identifying the full range of restoration opportunities, then eliminating areas or reducing their size by evaluating them against several factors (S. Wright, pers. comm), including:

- Difficult construction access and other constructability concerns
- Appropriate geomorphology to support target feature/habitat type
- Safety concerns regarding slope/geotechnical stability
- Tributary drainage areas, habitat availability and flow
- Potential presence of sensitive cultural resources

The RES Team evaluated and further refined these areas based on restoration priorities listed above, field observations and desktop assessments. Our evaluation resulted in further prioritizing the restoration opportunities identified in the Definite Plan. Generally, perennial and/or historically fish-bearing tributaries were given high priority. A more thorough description of the process for prioritizing the numerous tributaries for each reservoir is provided in Section 8.11.1 below.

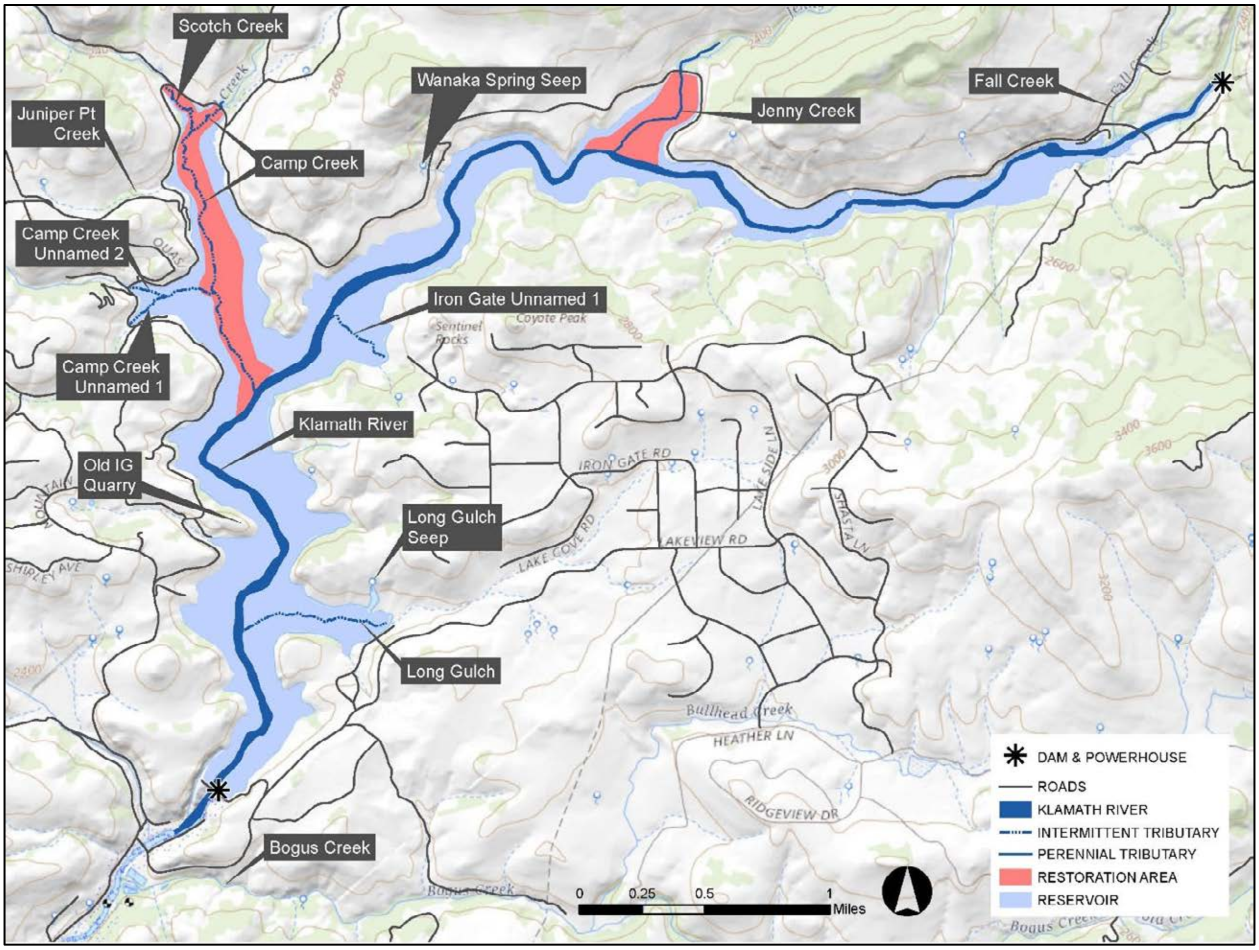
8.2.2.1 IRON GATE

The Iron Gate Reservoir is located in a relatively confined valley with little to no pre-dam floodplain connectivity, so restoration opportunities are primarily focused on the larger tributary confluences. The four main restoration areas on Iron Gate are listed below and shown schematically in Figure 8.1.

1. Klamath River - Narrow canyon limits opportunities to reconnect the river to adjacent habitats.
2. Jenny Creek - Perennial, fish-bearing stream (Definite Plan Site 3).
3. Camp Creek Complex (Dutch, Camp and Scotch creeks) - Intermittent fish-bearing stream (Definite Plan Site 2); target confluences with Scotch Creek, unnamed tributary and the mainstem.
4. Wanaka Springs - natural springs to receive wetland planting.

Comparison to the Definite Plan: The two tributaries listed above are identified for active grading in the Definite Plan (Figure 5.7). The Definite Plan also included Iron Gate’s Unnamed Tributary 1 and Long Gulch (Definite Plan Site 1), which are considered low priority for restoration. Wanaka Springs is not included in the Definite Plan but has been included above; consistent with approach of prioritizing natural wetlands and seeps.

Fall Creek, at the upstream end of the Iron Gate Reservoir, and Bogus Creek, located downstream of Iron Gate dam, were not included in the Definite Plan and therefore not considered high priority restoration areas. However, regulatory agencies have noted that mainstem connectivity at these tributary confluences is important. The mouths of these creeks will be monitored following drawdown, and residual sediment will be removed as needed for fish passage.



NOTES:

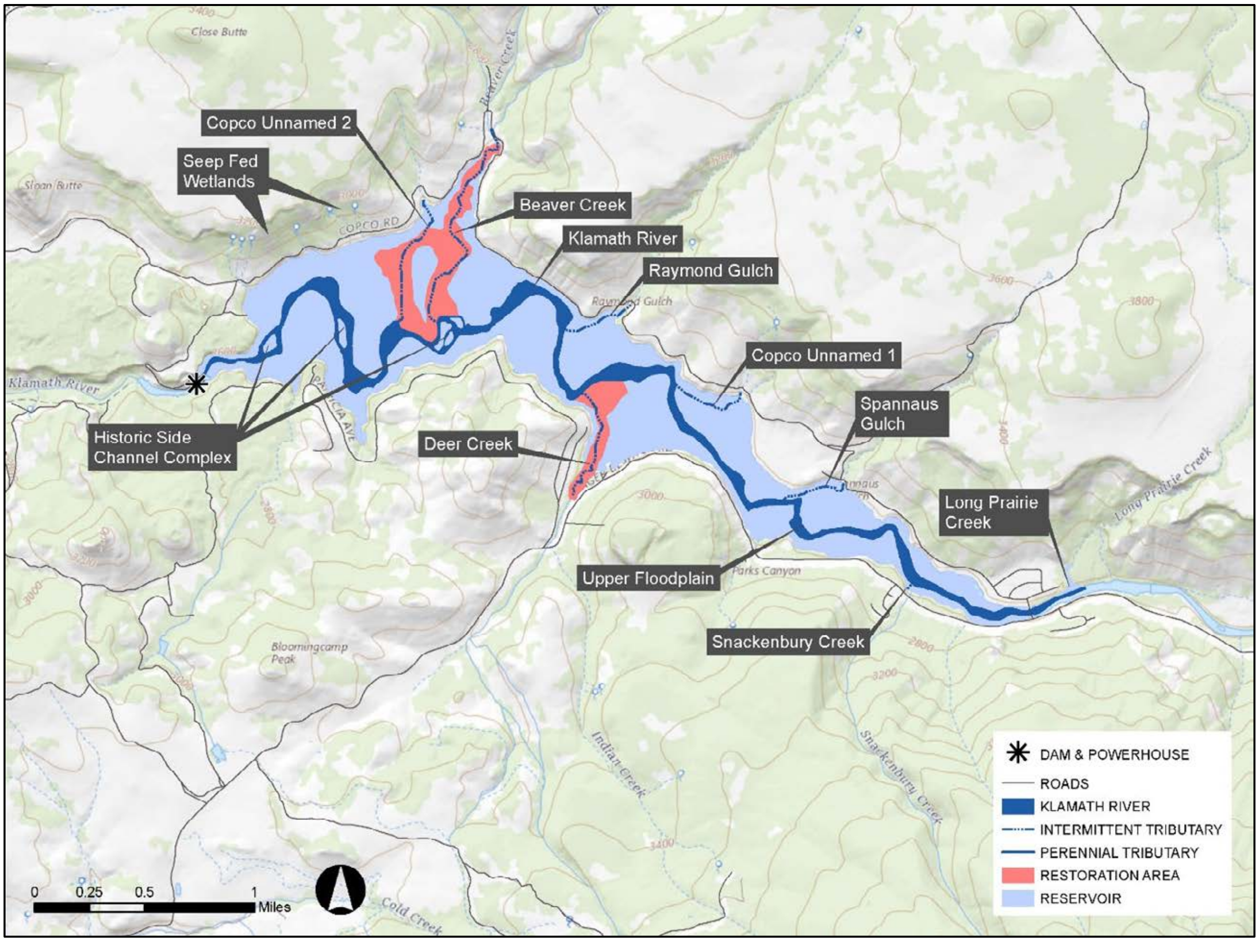
1. SOURCE: ESRI, USGS.

Figure 8.1 Iron Gate Reservoir Restoration Areas

8.2.2.2 COPCO 1

Copco 1 Reservoir is considered to be the reservoir with the highest restoration potential based on its wider, less confined valley and meandering mainstem. Copco 1 has restoration opportunity areas along the mainstem as well as key tributaries. The three main restoration areas on Copco 1, as shown schematically in Figure 8.2, are:

1. Beaver Creek Complex- Intermittent stream with historic fish presence (Definite Plan Site 2); includes downstream end of Unnamed Copco 2.
2. Deer/Indian Creek - Intermittent stream with historic fish presence.
3. Spring-fed floodplain/wetland complex –natural springs to receive wetland planting.



NOTES:

1. SOURCE: ESRI, USGS.

Figure 8.2 Copco Reservoir Restoration Areas

Comparison to the Definite Plan: One of the six sites identified for active grading in the Definite Plan for Copco 1, Site 2, is included in the above priorities. Definite Plan Site 1, the historic side channel complex on the mainstem, is a focus area for assisted sediment evacuation during drawdown. Definite Plan Sites 3 through 6 are considered lower priority, and therefore will not be targeted for restoration actions. In addition, the following intermittent tributaries identified in the Definite Plan (Figure 5.4), are considered low priority:

- Raymond Gulch
- Unnamed Copco 1 Tributary
- Spannaus Gulch
- Snackenbury Creek
- Unnamed Copco 1 Tributary

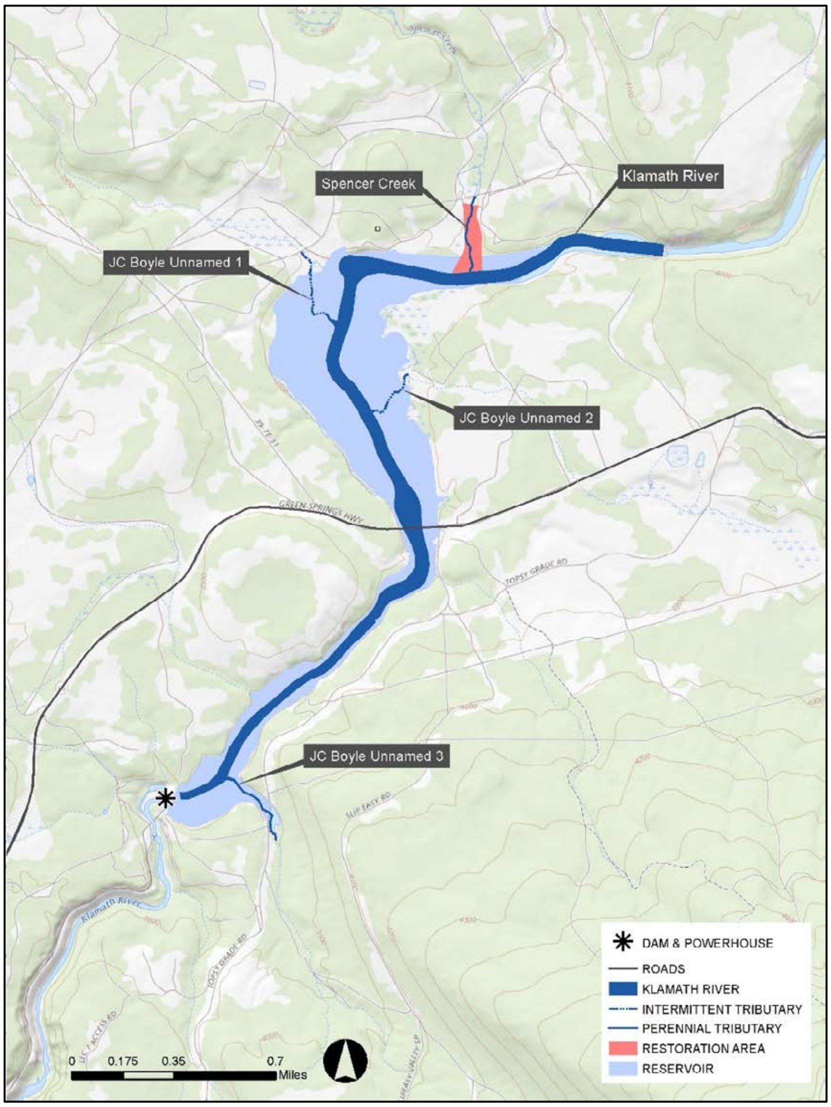
We have also added Long Prairie Creek at the upstream end of Copco 1 as a low priority tributary, even though it was not included in the Definite Plan.

8.2.2.3 J.C. BOYLE

While the lower reach of J.C. Boyle is confined, the less confined upper reach presents more restoration opportunity. However, given the relatively low sediment deposition in JC Boyle, little intervention is anticipated to be needed to reconnect with Klamath River with adjacent habitats. Therefore, the restoration area in J.C. Boyle, as shown schematically in Figure 8.3, is:

1. Spencer Creek - Fish-bearing, perennial stream

Comparison to the Definite Plan: Spencer Creek was identified for restoration actions in the Definite Plan (Figure 5.1). The three unnamed tributaries, which were identified for active grading in the Definite Plan (Sites 1 to 3) are considered low priority.



NOTES:
1. SOURCE: ESRI, USGS.

Figure 8.3 J.C. Boyle Reservoir Restoration Areas

8.2.3 STEP 3: RESTORATION ACTIONS

The restoration approach and recommended actions have been identified for each restoration area. We started with the same general approach for the four priorities: mainstem, high priority (perennial and/or historically fish-bearing) tributaries, wetlands and low priority tributaries. We then tailored the approach as needed to address site-specific considerations for each reservoir and area. General restoration approaches are described below, followed by a summary table of specific restoration actions at each site.

8.2.3.1 KLAMATH RIVER

There are three main restoration actions envisioned for the mainstem of the Klamath River throughout the former reservoirs. The required restoration actions include:

Provide fish passage through dam footprints by reconstructing geomorphically appropriate, natural channel for aquatic passage.

- Perform select grading as needed to:
  - Provide fish passage.
  - Stabilize un-evacuated sediment at vulnerable high-sediment-yield locations.
- Seed all channel banks with riparian/wetland bank plant communities.
- Plant wetland and riparian vegetation (either transplanted or nursery stock), as practical and appropriate.

In addition, the following elective restoration actions to enhance habitat will be implemented:

- Perform select grading to:
  - Provide connectivity to wetland complexes that emerge post-drawdown.
  - Enhance side channel connectivity in former Copco 1 Reservoir.
  - Excavate riparian benches at unnaturally high channel banks to facilitate plant establishment.

8.2.3.2 HIGH PRIORITY TRIBUTARIES

The following required restoration actions will be taken on the high priority tributaries considered to have the greatest fish habitat potential:

- Perform select grading as needed to:
  - Remove unnatural, erosion-resistant deposits that create fish passage barriers (such as the coarse delta deposits at Jenny Creek and the Camp Creek complex).
  - Stabilize un-evacuated sediment at vulnerable high-sediment-yield locations.
- Seed all channel banks with riparian/wetland bank plant communities.
- Plant wetland and riparian vegetation (either transplanted or nursery stock), as practical and appropriate.
- As a contingency measure, install enhanced channel bed materials (gravel, cobble and/or boulders) where needed to create fish passable channel.

The following additional restoration actions to enhance habitat value will also be implemented:

- Perform select grading to enhance wetland and/or floodplain connectivity.
- Install large wood to provide in-channel habitat enhancement and/or in-channel hydraulic complexity.

- Install willow baffles at select locations on the overbanks to encourage sediment deposition and reduce erosion.
- Install boulder clusters (three to twenty boulders per cluster) to increase in-channel habitat and hydraulic complexity.

Restoration actions will generally start at the mainstem and work upstream. In some cases, a “nodal approach” may be appropriate given uncertainty/opportunities associated with post drawdown sediment conditions.

8.2.3.3 WETLANDS

Restoration actions may occur at potential wetland locations that are connected to or isolated from the adjacent channel. The following optional restoration actions may be implemented to enhance and/or recreate wetlands as budget allows:

- Transplant salvageable wetland vegetation, as practical and appropriate.
- Establish riparian/wetland vegetation in wetted areas.
- Perform grading to develop/enhance saturated slope/connected backwater wetland features.

8.2.3.4 LOW PRIORITY TRIBUTARIES

In addition to the high priority areas listed above, we have identified twelve (12) of the largest tributaries to receive limited restoration actions. These lower priority tributaries, listed below in Section 8.2.3.5, will receive the following restoration actions:

- Target for assisted sediment evacuation as time and budget allows.
- Seed channel banks with riparian/wetland bank plant communities.
- Plant wetland and riparian vegetation (either transplanted or nursery stock), as practical and appropriate.
- As a contingency measure, remove residual sediment from the mainstem confluence only as needed for connectivity (either through assisted evacuation during drawdown or mechanical excavation post-drawdown).

8.2.3.5 SPECIFIC RESTORATION ACTIONS BY AREA

Table 8.2 below summarizes the proposed restoration actions for each restoration area within the three former reservoirs. All potential actions for each area are listed below, with the understanding that some of these actions may be reduced or eliminated due to cost, construction feasibility and/or lack of need depending on post-drawdown conditions.

The actions are summarized in Table 8.2 by the following general categories:

- Active sediment evacuation methods during drawdown
- Selective grading
- Habitat enhancement features
- Riparian planting
- Other site-specific measures

Table 8.2 Summary of Restoration Actions by Area

Restoration Area	Assisted Sediment Evacuation during Drawdown	Selective Grading	Habitat Enhancement Features (number/locations will vary)	Riparian Planting (average width)	Other
IRON GATE RESERVOIR					
Klamath River		Stabilize unnatural sediment deposits, as needed		50-ft wide along mainstem	Fish passable channel at dam;
Jenny Creek	Focus Area	Excavate delta at reservoir rim	Large wood, willow baffles, boulder clusters	30-ft wide	
Camp Creek Complex (Includes Dutch, Scotch creeks and Unnamed Camp 1 and 2)	Focus Area	Excavate delta at reservoir rim; selectively along channel length	Large wood, willow baffles, boulder clusters	30-ft wide	
Wanaka Springs					Wetland planting
Long Gulch				30-ft wide	Remove remnant crossing; Wetland planting at seep
COPCO 1 RESERVOIR					
Klamath River (entire length)		Stabilize unnatural sediment deposits, as needed;		50-ft wide along mainstem	Fish passable channel at dam
Klamath River - Historic Sides Channel Complex	Focus Area	Spot grading to reconnect side channel		50-ft wide along mainstem	
Spring-fed Wetlands					Wetland planting
Beaver Creek	Focus Area	Spot grading along entire reach for connectivity	Large wood, willow baffles, boulder clusters	30-ft wide	
Deer Creek	Focus Area	Spot grading along entire reach for connectivity	Large wood, willow baffles, boulder clusters	30-ft wide	
JC BOYLE RESERVOIR					
Klamath River (entire length)		Stabilize unnatural sediment deposits, as needed		50-ft wide along mainstem	Fish passable channel at dam; remove former crossing
Spencer Creek	Focus Area		Large wood, willow baffles, boulder clusters	30-ft wide	

Table 8.2 only lists restoration actions primarily focused on enhancing aquatic habitats. Other actions to enhance upland habitats within the reservoir footprints include seeding, planting, irrigation and associated exclusion fencing and IEV management activities, as described in Section 8.7.

In addition to the sites listed above, low priority tributaries will receive riparian seeding/planting and be graded if needed for mainstem connectivity. These twelve (12) low priority tributaries are:

- Iron Gate Reservoir – Long Gulch, Unnamed Iron Gate Tributary 1, Fall Creek

- Copco 1 Reservoir - Raymond Gulch, Unnamed Copco 1 Tributary, Spannaus Gulch, Snackenbury Creek, Unnamed Copco 2 Tributary and Long Prairie Creek
- JC Boyle Reservoir - Unnamed JC Boyle tributaries 1, 2, and 3

In addition, Fall and Bogus creeks located in the vicinity of Iron Gate Reservoir may be graded if needed as a contingency measure (for connectivity at the confluence only).

8.2.4 FUTURE DESIGN ADJUSTMENTS

The location and extent of the proposed restoration actions listed in Table 8.2 will be refined both during the subsequent post-drawdown design phases, and again during construction, as necessary, to adapt to on-the-ground conditions. Future refinements may include reducing the extent of optional restoration actions.

These adjustments will be guided by the following main factors:

- The actual location and thickness of residual sediment remaining in the reservoirs following drawdown is uncertain and will vary.
- Construction accessibility, as assessed during subsequent design phases, and re-evaluated based on post-drawdown conditions.
- Presence of culturally sensitive resources as currently identified by local tribes and adjusted during implementation based on any inadvertent discoveries.

Design adjustments will include determining the following:

- Exact location, volume and function of grading, as described further in Section 8.4.
- Location of large wood and other habitat enhancement features at each restoration area, based primarily on the channel morphology that emerges.
- Width of the riparian planting based primarily on channel bank topography and proximity to the low flow channel, per Section 8.5.
- Whether and where to install enhanced channel bed materials and/or step grade controls for fish passage on high priority tributaries.

8.3 FISH PASSAGE

Habitat restoration following dam removal is focused on the following target fish species: Coho salmon, fall-run and spring-run Chinook salmon, winter-run and summer-run steelhead, redband trout, and Pacific lamprey. Note that Coho salmon in the Klamath are part of the Southern Oregon Northern Central California (SONCC) Distinct Population Segment which is listed as threatened under the Endangered Species Act (ESA). These target species are expected to expand their distributions into the habitats made accessible through the restoration action. Design criteria for salmonids and Pacific lamprey are considered to be protective of habitats required by other native fish in the river. This includes ESA-listed bull trout who are concentrated in the Upper Klamath, as well as the non-larval life stages of Klamath largescale suckers and Klamath smallscale suckers. Other ESA-listed fish species, such as shortnose suckers and Lost River suckers, are not expected to have suitable habitat in the project area following restoration due to their reliance on warm, slow-moving waters or lakes.

Volitional fish passage for adults and juveniles is a primary project goal. This section describes the design criteria for volitional fish passage, which will apply to the mainstem of the Klamath River, as well as key tributaries (defined in Section 8.2.2 above). Design criteria are discussed by the following potential fish passage barriers that may occur in the Project Area now or following dam removal:

- Remnant anthropogenic structures within the former reservoir footprints, including temporary coffer dams, former crossings, etc.
- Steep headcuts (near vertical drops) in residual sediment (post-dam deposits not fully evacuated during drawdown).
- Sustained steep reaches controlled by “natural” channel bed forms.

The first two types of barriers will be addressed as described below. The third type, fish passage barriers due to channel bed form, are considered a “natural” condition that does not require corrective actions. The potential presence of natural fish passage barriers was considered during prioritization of the tributaries, as described in Section 8.11.

8.3.1 ANTHROPOGENIC STRUCTURES

Anthropogenic structures that impede fish passage are required to be removed from the mainstem and tributaries, including the dams, associated infrastructure (e.g., temporary coffer dams), former road crossings and other currently known and unknown obstructions. Exposed anthropogenic structures will be removed down to a depth equal to or below the estimated scour depth. Removal depth shall consider the potential for structures to be exposed in the future due to local or reach-scale channel bed adjustments. The design basis for removal depths for each dam and related infrastructure is described in Section 8.10.3 below.

Table 6-6 of Appendix H of the Definite Plan (KRRC, 2018a) states a design criterion of no unnatural jump barriers exceeding 6 inches. This design criterion is considered appropriate for any new or existing tributary crossings (e.g. culverts or bridges) and other human built structures.

8.3.2 HEADCUTS IN RESIDUAL SEDIMENT

The design criterion of no unnatural channel headcuts exceeding 6 inches (Table 6-6 of Appendix H of the Definite Plan) is understood to apply to human built structures and obstructions, rather than temporary channel headcuts. In this section, we propose a process for evaluating whether temporary headcuts are a barrier to fish migration and describe measures to address if they are deemed to be fish passage barriers.

Discontinuities in the channel bed due to uneven evacuation of sediments may lead to temporary headcuts that could act as an impediment to fish migration. Depending on the nature of the residual sediment and subsequent flows experienced, such headcuts may be short-lived and/or not likely to pose a sustained threat to fish passage or long-term habitat function.

We propose the following process for identifying and addressing residual reservoir sediment headcuts[1] that may be fish passage barriers:

1. Monitor during and after drawdown to identify localized residual reservoir sediment accumulations within or directly upstream of the former reservoir footprint that may pose a threat to fish migration.

[1] Headcuts due to factors beyond dam removal (i.e. naturally occurring sediment loads due to fire or storms) will not be removed.

2. Identify vertical headcuts likely resulting in a water surface elevation drop greater than 6 inches[2] in the mainstem and fish-bearing tributaries.
3. Evaluate identified headcuts to:
   - Determine whether the headcut is in residual sediment or pre-dam channel bed (i.e. pre-existing natural headcut not a result of the project).
   - Estimate the erodibility of residual sediment.
   - Assess whether there is likely fish passage around the headcut.
4. Take active measures to address headcuts that meet the following criteria:
   - Are located in erosion-resistant deposits of residual sediment and/or.
   - Pose an immediate threat to fish passage given lack of alternate fish passage route.
5. During future monitoring, revisit identified headcuts not requiring active measures (per step 4) to monitor headcut adjustment and re-evaluate need to take active measures.

Active measures to address fish passage will vary but will likely include hand tools or mechanical removal using land-based equipment. These thresholds for taking action and additional fish passage evaluation are informed by the summary of potential fish passage criteria presented in Table 8.3 below.

Table 8.3 Summary of Potential Fish Passage Criteria

<table>
<tr><th>Potential Design Criteria</th><th>Source</th><th>Comments</th></tr>
<tr><td colspan="3">Jump Height</td></tr>
<tr><td>Maximum hydraulic jumps of 6 inches. Evaluate over a flow range defined by 1% and 50% exceedance flows (high design flow and low design flow, respectively)</td><td>Criteria based on CDFG 2004, Oregon Administrative Rules (OAR) 635-412-0035(2)(d), and NMFS (2019</td><td>This criterion is intended for monitoring to identify headcuts where fish passage may be impeded</td></tr>
<tr><td>Approach pool downstream of area requiring a vertical leap should be 1.5 times the stream depth, or a minimum of 2 feet deep, whichever is deeper</td><td>Criteria in NMFS (2019) for anadromous adult salmon</td><td></td></tr>
<tr><td colspan="3">Maximum Velocity</td></tr>
<tr><td>Anadromous Adult Salmon:
<table>
<tr><td>Reach Length (ft)</td><td>Max Velocity (ft/sec)</td></tr>
<tr><td><60</td><td>6</td></tr>
<tr><td>60-100</td><td>5</td></tr>
<tr><td>100-200</td><td>4</td></tr>
<tr><td>200-300</td><td>3</td></tr>
<tr><td>>300</td><td>2</td></tr>
</table></td><td>Criteria in CDFG (2004), and NMFS (2019) for anadromous adult salmon.</td><td>Considering lamprey, criteria are consistent with USFWS (2010) document citing research by Mesa et al. 2003 that flows greater than 5 to 6 ft/sec are difficult for Pacific lamprey to move against.</td></tr>
<tr><td colspan="3">Exceedance Flows</td></tr>
</table>

[2] NMFS (2019) *Guidelines for salmonid passage at stream crossings addendum* standards allow for juvenile jump heights of 12 inches. Following the drawdown year, in coordination with NMFS and CDFW, the residual dam sediment headcut threshold for the California portion of the Project will be adjusted from 6 inches to 12 inches. A similar monitoring adjustment will be made to the Oregon portion if agreed to by NMFS and ODFW.

Potential Design Criteria	Source	Comments
For anadromous adult salmon, fish passage conditions should be evaluated at the 1% exceedance flow and the 50% exceedance flow as the upper and low fish passage design flows, respectively. For juvenile salmon, fish passage conditions should be evaluated at the 10%	Criteria in CDFG (2004)	NMFS (2019) criteria matches the California criteria.
Unimpeded fish passage should be provided between 5% to 95% exceedance flows, excluding days with no flow	OAR 635-412-0005(26) and (30)	

8.3.3 NATURAL CHANNEL GRADIENTS

Channel gradients may present a natural barrier to upstream fish passage. Sustained channel gradients exceeding eight to ten percent over long distances (1,000 feet or more) are considered natural barriers to anadromous fish passage (CDFG 2004). Evaluation of potential natural fish passage barriers on the largest tributaries is provided in Section 8.11.1.2.

8.4 GRADING APPROACH

One project element with significant variability is the extent of active grading (balanced on-site cut and fill) that will be undertaken during construction. The extent that active grading is needed for tributary connectivity and habitat enhancement will depend on the location and thickness of residual sediment remaining in the reservoirs following drawdown. The amount of residual sediment is uncertain and will vary depending upon river flows during drawdown primarily, and to a lesser degree, by the effectiveness of assisted sediment evacuation methods during the drawdown window of January 1 to March 15 of the drawdown year.

While there is high uncertainty, there is still a need to approximate post-drawdown topography to estimate active grading locations and calculate preliminary earthwork volumes. The process for estimating and adjusting earthwork volumes is summarized below and described in the following sections:

1. Identify available topobathymetric data for existing and historic conditions
2. Estimate post-drawdown topography
3. Calculate potential earthwork volumes for mechanical grading
4. Describe how grading locations and volumes will be adjusted post-drawdown

8.4.1 AVAILABLE TOPOBATHYMETRIC DATA

Surface information provided to the Project Company included historic reservoir topography (i.e. pre-dam topography) and topo-bathymetric surfaces collected in 2018.

8.4.1.1 HISTORIC RESERVOIR BATHYMETRIC SURFACES

Historic reservoir bathymetric surfaces were provided digitally as a Tagged Image Format (TIF) file. The surfaces were generated by AECOM by first digitizing historic maps provided by the Bureau of Reclamation.

The Iron Gate digitized drawings are dated January 29, 1957; Copco Reservoir drawings dated Aug. 12, 1940; and J.C. Boyle Reservoir drawings dated March 30, 1963.

The digitized drawings were converted to a TIF raster file format and contours were modified using ArcGIS "Spatial Adjustment" toolset to align the contours with the geomorphology visible within in 2018 topo/bathymetric survey and 2010 LiDAR data. Additionally, manual updates to the historic surface were made using breaklines to estimate channel geometry having an assumed top and bottom of bank locations separated 10 feet horizontally and 10 feet vertically (1H:1V slope). The channel thalweg was set 2 feet below the assumed bottom of bank elevation. Additional GIS processing was performed to compile the adjusted contours and breaklines using the ArcGIS "Natural Neighbor" interpolation tool with cell sizes set to 10 feet.

8.4.1.2 2002/2010 TOPOBATHYMETRIC SURFACES

AECOM provided as a file geodatabase raster comprising the 2002 bathymetry data for each reservoir. The file metadata included the following source information:

The bathymetric data was generated by the interpolation of contours into a 2-foot cell-size surface. The source of the bathymetric data is J.C. Headwaters, Inc., J.M. Eilers and C.P. Gubala (Eilers and Gubala 2003).

The bathymetry was available only as contours; the original hydroacoustic sounding data was not available. Because the contour data are a derivative, the surface generated from the contours is not as accurate as using the primary sounding data. This surface was generated to conform with the surface generated from the 2010 Light Detection and Ranging (LiDAR) survey so that it could be seamlessly included with the 2010 LiDAR survey either in a mosaic dataset or in the generation of a static raster surface by merging. The 2-foot cell size was determined by determining the mean point spacing of the native LiDAR LAS files. Watershed Sciences, Inc. (WS) collected LiDAR data of the Klamath River and associated riparian zones from Klamath Falls, Oregon to Happy Camp, California for Woolpert, Inc.

8.4.1.3 2018 TOPO/BATHYMETRIC SURFACES

The 2018 topographic and reservoir bathymetric surveys were completed and provided on external hard drive by GMA Hydrology (GMA). The surfaces generated from the GMA survey were provided in tiled raster floating-point file (.FLT) format with spatial reference set to North American Datum of 1983 (NAD83) 2011/ Urchin Tracking Module (UTM) zone 10N, projection Transverse Mercator. Combined surfaces were provided for Copco 1 and Iron Gate set to NAD1983 High Accuracy Reference Network (HARN) State Plane California I spatial reference. A combined surface for JC Boyle was created from the provided tiled raster data. The 2018 bathymetry data supersedes the 2002/2010 bathymetry data due to it being the most current data created from one known source with no digitization.

8.4.2 ESTIMATED POST-DRAWDOWN TOPOGRAPHY

An assumed post-drawdown reservoir surface will be largely influenced by the information in the surfaces provided as well as the sediment material properties. Initial comparisons between the surfaces provided indicate that the historic surfaces do not provide a reasonable indication of anticipated post-drawdown conditions across the entire footprint of the existing reservoirs. Areas within the floodplains of all three reservoirs showed that historic conditions represented were higher in elevation than the 2018 bathymetric surface. The historic mainstem Klamath River channel was also higher in elevation than the 2018 bathymetric surface within the J.C. Boyle Reservoir. These surfaces were also compared to the terrain file used in the AECOM 2D Hydrologic Engineering Center's River Analysis System (HEC-RAS) reservoir model. The geometry contained within the AECOM HEC-RAS model suggests that it was developed based upon the historic bathymetry surface.

8.4.2.1 KLAMATH RIVER

Modification of the 2018 topo/bathymetric surface, using the historic surface as a reference for pre-dam mainstem Klamath River conditions, is the preferred method of estimating post-drawdown conditions in the footprint of the historic channel.

It is assumed that the mainstem Klamath River and all perennial tributaries may evacuate the majority of sediment accumulated within their historic bankfull channels. The post drawdown alignment, profile, and extents of the mainstem Klamath River for Iron Gate and Copco Reservoirs are assumed to be approximately equivalent to the conditions represented in the historic surface. The historic surface does not appear to be sufficient for estimating post-drawdown channel conditions in J.C. Boyle because much of the surface is at a higher elevation than the 2018 bathymetry data. To represent the pre-dam conditions of the mainstem Klamath River in the J.C. Boyle Reservoir, a historic channel profile was estimated using the 2018 bathymetry within the reservoir and below the dam. A typical bankfull channel was estimated from existing conditions within the reservoir and extrapolated along the historic alignment and determined profile. See Section 8.4.3 for an overview of bankfull cross-section area calculations.

For sediment that is not mobilized and remains in place, an angle of repose for exposed sediments above the bankfull channel of the mainstem Klamath River and its tributaries was assumed to be 10H:1V. The historic channel surface may extend at this slope to a point where it daylights with the 2018 bathymetry. In areas where the slope does not daylight, primarily in entrenched reaches of the Klamath River and tributaries, the approximate adjacent slope can be extended to the edge of the bankfull channel.

[redacted]

8.4.3 ESTIMATED EARTHWORK VOLUMES

Grading is currently proposed for high priority tributaries and will be conducted on an as-needed basis at low priority tributaries and elective habitat enhancement areas. The objective for this section is to describe the methods used to calculate earthwork volumes and to present the results of those calculations.

Sediment earthwork volumes were estimated for all the high priority tributaries. Estimates were made for channel, floodplain, and deltaic sediment deposits. Spencer Creek was assumed to have negligible sediment deposition within the restoration boundary and earthwork volumes were only estimated for the delta. Estimating sediment earthwork volumes relied on a 2011 Bureau of Reclamation report that estimated sediment depths across the entire inundated area of each reservoir. These sediment depths were based on past sediment core data collected by others and sediment core data collected by the USBR 2011 report. The published sediment depth isolines were digitized to develop a sediment depth digital elevation model (USBR, 2011a).

8.4.3.1 CHANNEL SEDIMENT VOLUME

The channel volume estimates include the total estimated sediment depth (no shrinkage factor applied) along the anticipated channel alignment, within the top of banks, and assumes a vertical cut from the top of banks. The channel alignment was drawn following the path of least resistance based on the 2018 bathymetry data.

8.4.3.2 FLOODPLAIN SEDIMENT VOLUME

The floodplain sediment volume includes the total sediment accumulation from the top of bank to the extent of the flood-prone area for both banks. It was assumed that the sediment will be graded 3H:1V along the flood-prone area fringe to tie-in to the top of the post-drawdown topography. The tie-in location is the extent of the flood-prone area. The flood-prone area was determined for each tributary by calculating the intersection of two times the max channel depth with the pre-impoundment surface along the length of the channel alignment.

8.4.3.3 DELTA DEPOSITS

Earthwork volumes for backwater delta formations were estimated for Camp/Scotch, Jenny, and Spencer Creek. These tributaries were selected because they were previously identified as having the greatest risk for incision due to significant delta deposits. See Section 8.11.1.1 of this report for more detailed information about the risk of incision and the selection of tributaries. They were also recognized for their potential to provide important fish habitat as well as for their ability to deliver beneficial sediment to the mainstream Klamath River (GMA, 2003).

Delta earthwork volumes were calculated for these reaches by 1) identifying the downstream extent of the delta, 2) identifying the location and elevation of the upstream tie in point, and 3) connecting the channel between the points. The delta earthwork volumes were based on 2018 bathymetric data and stable channel dimensions. In the case of Camp/Scotch and Jenny Creek, the upstream tie-in was based on the channel invert elevations for newly designed bridges. No such tie-ins were available for Spencer Creek so upstream end points were selected using professional judgement.

Stable channel dimensions were calculated by first determining the cross-sectional area for all five tributaries by applying the concept of a regional curve following methodology presented in Rosgen (1996).

A regional curve is a regression of the relation of bankfull-channel dimensions and bankfull discharge to drainage area and provides estimated bankfull-channel dimensions and streamflow for the channel when drainage area is known (Rosgen 1996). A predictive relationship between cross-sectional area and drainage area was derived using data from upper Camp Creek (upstream of Scotch Creek confluence). This equation was then used to calculate cross-sectional area at each of the five tributaries. Lastly, channel width was calculated from the cross-sectional area by assuming an average width to depth ratio of 20. Earthwork volume was then calculated by multiplying the stable channel width by the length of the channel intersecting the deposit and the thickness of the deposit.

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[redacted]

[redacted]

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1. [redacted]

8.4.4 GRADING ADJUSTMENTS AFTER DRAWDOWN

Once drawdown occurs, the exposed former reservoir bottom will be surveyed to develop more detailed grading plans. While the total earthwork volume will not likely exceed the volume calculated as described above, the actual location of grading may differ. Grading is currently proposed for high priority tributaries and will be conducted on an as-needed basis at low priority tributaries and elective habitat enhancement areas. The primary objectives will be to 1) provide volitional fish passage (Section 8.2.1) and 2) stabilize un-evacuated sediment at vulnerable high-sediment yield locations (Section 8.9).

Earthwork areas and estimated sediment removal quantities for the five high priority tributaries are detailed above in 8.4.3. An additional 200,000 cubic yards was included in the total amount of earthwork to account for potential work at twelve low priority tributary confluences and/or grading along the mainstem to stabilize unstable sediment deposits. Grading at low priority tributaries may occur to enable volitional fish passage and to account for potential earthwork to stabilize unstable sediment wedges located throughout each reservoir.

Elective grading, up to total earthwork volume, may also occur for habitat enhancement. Potential work may include:

- Enhance side channel connectivity in former Copco 1 Reservoir.
- Excavate floodplain benches at unnaturally high channel banks to facilitate riparian plant establishment, (guided by elevation relationships described in Section 8.5).
- Perform select grading to enhance wetland and/or floodplain connectivity.

Excavated material will be disposed onsite depending on site location and accessibility. It will be placed and spread in nearby uplands above the Q5 water surface elevation (WSE), and preferably above the Q100 WSE. Where feasible, the disposed sediment will be placed on the rocky wake zone.

8.5 HYDROLOGIC CONNECTIVITY

The RES Team characterized the vertical distribution of different vegetation types with respect to water surface elevation (WSE). These relationships were used to estimate the elevation range where riparian vegetation can be expected to establish along the low flow channel. These relationships were primarily applied to determine the width of riparian plantings along the mainstem and tributaries. In some cases, these relationships may be used to guide grading to stabilize oversteepened channel banks in a manner that also facilitates riparian vegetation establishment.

8.5.1 METHODOLOGY

These recommendations are based on field observations, limited transect surveys and desktop analyses by RES team member Environmental Science Associates, Inc. (ESA). ESA surveyed six cross sections along the Klamath River mainstem as well as one site each at Jenny and Camp Creek. Cross sections were selected after a field reconnaissance, to be representative of typical conditions in the respective reaches. Three sites were in the Klamath River between J.C. Boyle and Copco 2 reservoirs, and three were downstream of Iron gate reservoir. Cross sections and location map are presented in Appendix H. At each cross section a transect was surveyed from the edge of the water line up the bank of the river, noting the upper and limits of different species.

Field measurements were taken under summer low flow conditions (approximately 1,100 cfs). The cross sections did not extend below the water level but were spatially referenced and mapped onto with nearby cross sections from the USBR 1D hydraulic model. This mapping allowed the vegetation elevations to be roughly correlated with flows for different recurrence intervals. As shown in Appendix H, the Q2 and Q5 WSEs are compared to select vegetation limits. The field measurements were supplemented by aerial photo and elevation analysis along the Klamath River using Google Earth. Riparian trees and herbaceous covers were identified, and the underlying elevations compared with the low flow WSE.

8.5.2 RESULTS

As shown in Appendix H, the various tree species observed and mapped varies by cross-section. In addition, the elevation of specific tree species relative to WSE varies by cross-section, but some general correlations were observed. For example, the upper limit of willows and cottonwood was approximately 2 to 4 feet above the summer low flow WSE (1,100 cfs). The lower limit of oaks extended down to roughly 6 to 10 feet above flow low WSE. In general, various riparian species were observed at or near [redacted] 7,400 cfs.

These results were used to develop the following relationships between vegetation communities and inundation frequency:

- The riparian vegetation zone extends from base flow up to approximately the Q2 WSE.
- Riparian species within this planting zone will transition from wetter to drier species with increased bank height.
- Generally, wetter riparian species (e.g. willows, dogwood, etc.) will occur in the lower channel banks, up to approximately 5 feet above the low-flow WSE.
- Drier riparian species (e.g. ash, alder, etc.) will be planted in the upper elevations, from approximately 5 to 15 feet above the low flow WSE.

The estimated average planted width for cost estimating purposes is 50 feet for the main stem Klamath and 30 feet for tributaries. The actual width will be determined in response to post-drawdown topography and to avoid existing wetland and riparian vegetation. In reaches with oversteepened banks, the channel banks may be lowered and/or laid back to create gradually-sloped channel banks (3H:1V, or flatter) up to 15 feet above the low flow WSE.

8.6 PLANTING APPROACH

The proposed species to be planted will be based in part upon on the vegetation cover types documented in the 2004 Final Technical Terrestrial Resources Report (PacifiCorp, 2004). The species selection will be informed by the vegetation cover types and species identified in the report but will be simplified based on plant material availability, installation logistics and species ability to tolerate clay sediments. The vegetation cover types referenced for each of the revegetation planting zones are identified in Section 8.12, Planting Methods.

To refine the planting zones, we reviewed mapping of historic vegetation cover types within the reservoir footprints as well as present day cover types surrounding the reservoirs. This information was cross checked against high-resolution aerial photography and informed by site visits to observe plant community composition and spatial distribution on the ground. This exercise informed the planting design approach and methods proposed in the planting zones.

8.6.1 CONCEPTUAL APPROACH TO REVEGETATION

The broad planting zones (wetland, riparian and upland/floodplain) provide a spatial organizing framework for restoration activities on the ground post-drawdown. The approach to revegetation within the defined zones, regarding densities and spatial distribution, is based upon the documentation of vegetation cover type conditions, aerial photo interpretation and field observations with the goal of setting a trajectory toward the establishment of native vegetation. Post-drawdown soil conditions will be highly variable and cannot be accurately predicted. Clay content in residual sediment will range from 30 to 78 percent with depths from several feet to just a few inches. Sediment conditions could result in novel plant communities that differ from surrounding vegetation communities. Many species in surrounding communities may not be well adapted to clay sediments. Allowing flexibility is therefore essential.

The design approach is guided by the following framework:

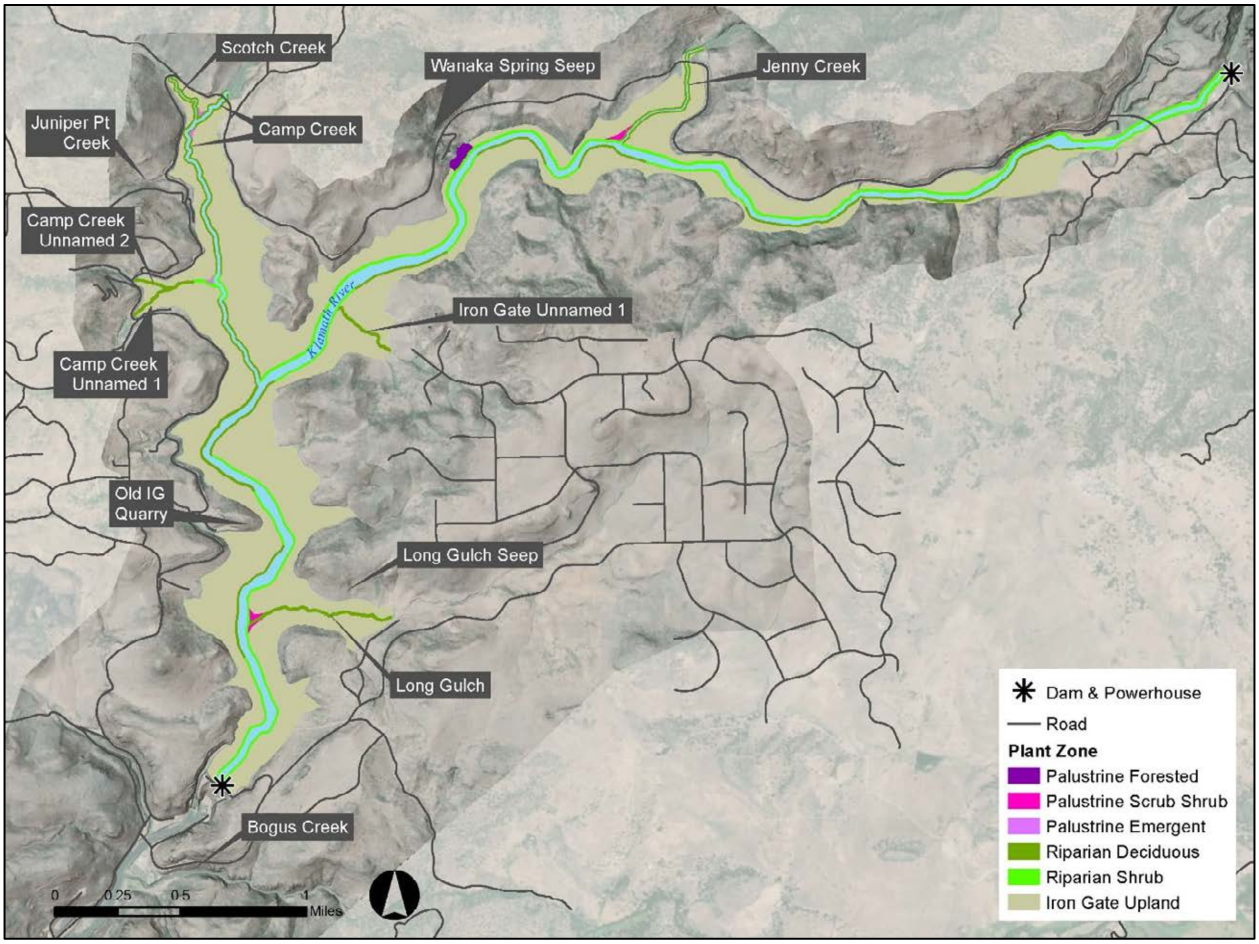
- Develop an additive layering system within each broad community type that sets a matrix condition with seed and then builds upon that with supplemental woody species plantings where appropriate.
- Provide flexibility for the contractor to respond to unfolding field conditions and subtleties in the landscape such as remnant wetland/riparian vegetation, post-drawdown soil conditions, microtopography, soil moisture, seeps, rocky areas, and drainages within each planting zone.
- Create a tool that will support revegetation post drawdown as well as short- and long-term adaptive management efforts.
- Use inexpensive and robust plant material in the form of seed, cuttings, and bareroot stock that are easily transported, establish well in difficult restoration conditions, cost much less per plant than container plants, and reduce the likelihood of spreading pathogens such as phytophthora.
- Use traditional restoration bareroot plant spacing with modifications to accommodate the large spatial scale of this project. These modifications include reducing the density, or widening the spacing, to allow more overall area to be planted for the available budget. (For example, where traditional restoration planting may call for shrub spacing at four to six feet on-center, we are proposing ten feet on-center.)
- Use existing adjacent vegetation cover types and post-drawdown topography and soil conditions to guide revegetation efforts.
- Allow for modifications to planting densities within an area while adhering to the total quantity of plant material being installed and managed to better mimic the subtle changes in densities across communities and the strata (tree, shrub, groundcover) within those communities.
- Incorporate salvage wetland vegetation (sod, plugs or woody vegetation) opportunistically.

8.6.1.1 60-PERCENT DESIGN APPROACH

At 60 percent design, the planting zones provide a starting point for refinement post drawdown during implementation.

To generate the 60 percent design cost estimate, we have developed a simple additive planting matrix for each of the major planting zones (riparian, wetland and upland/floodplain). These matrices are described in detail in Section 8.12, Planting Methods.

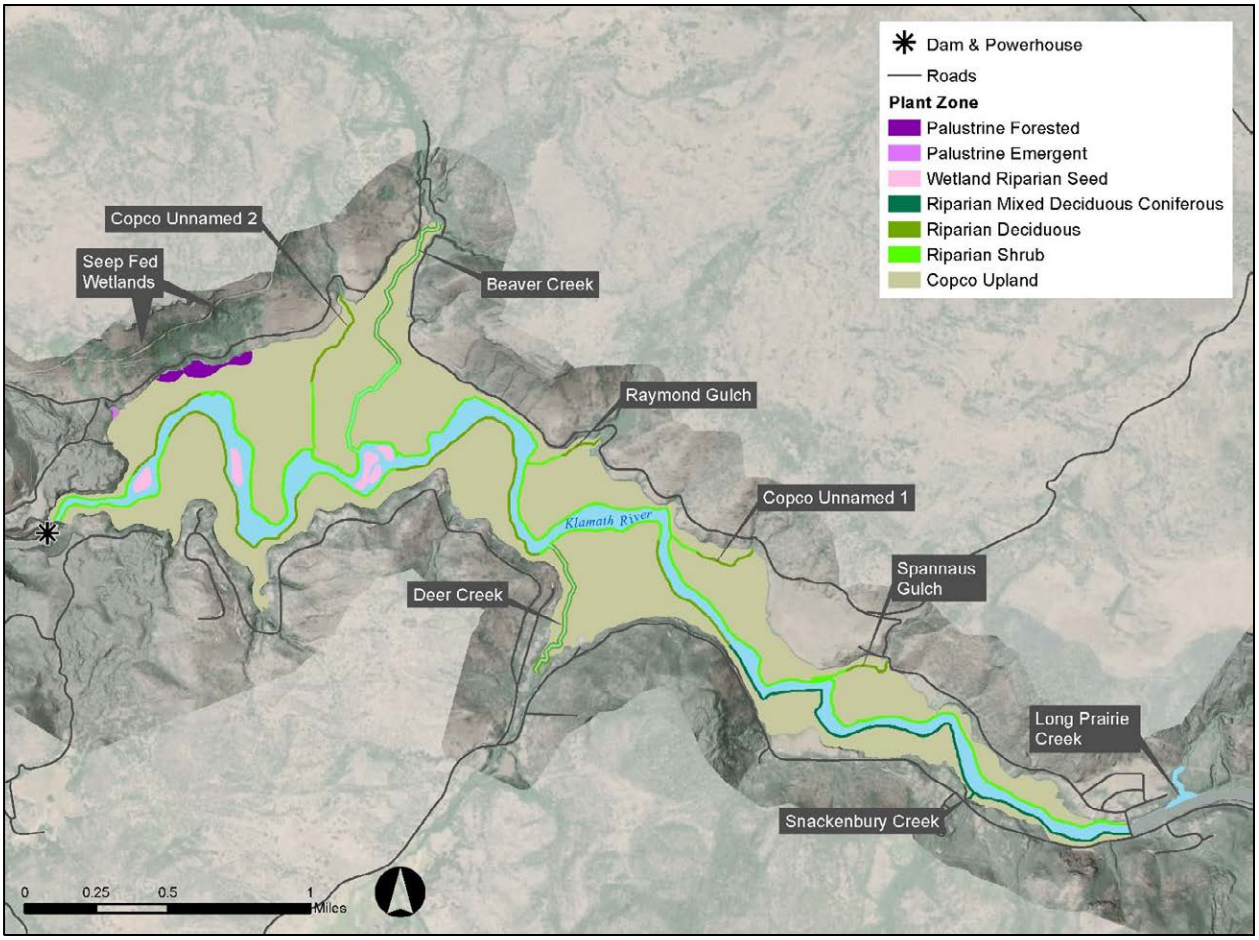
[redacted]



NOTES:

1. SOURCE: ESRI, USGS.

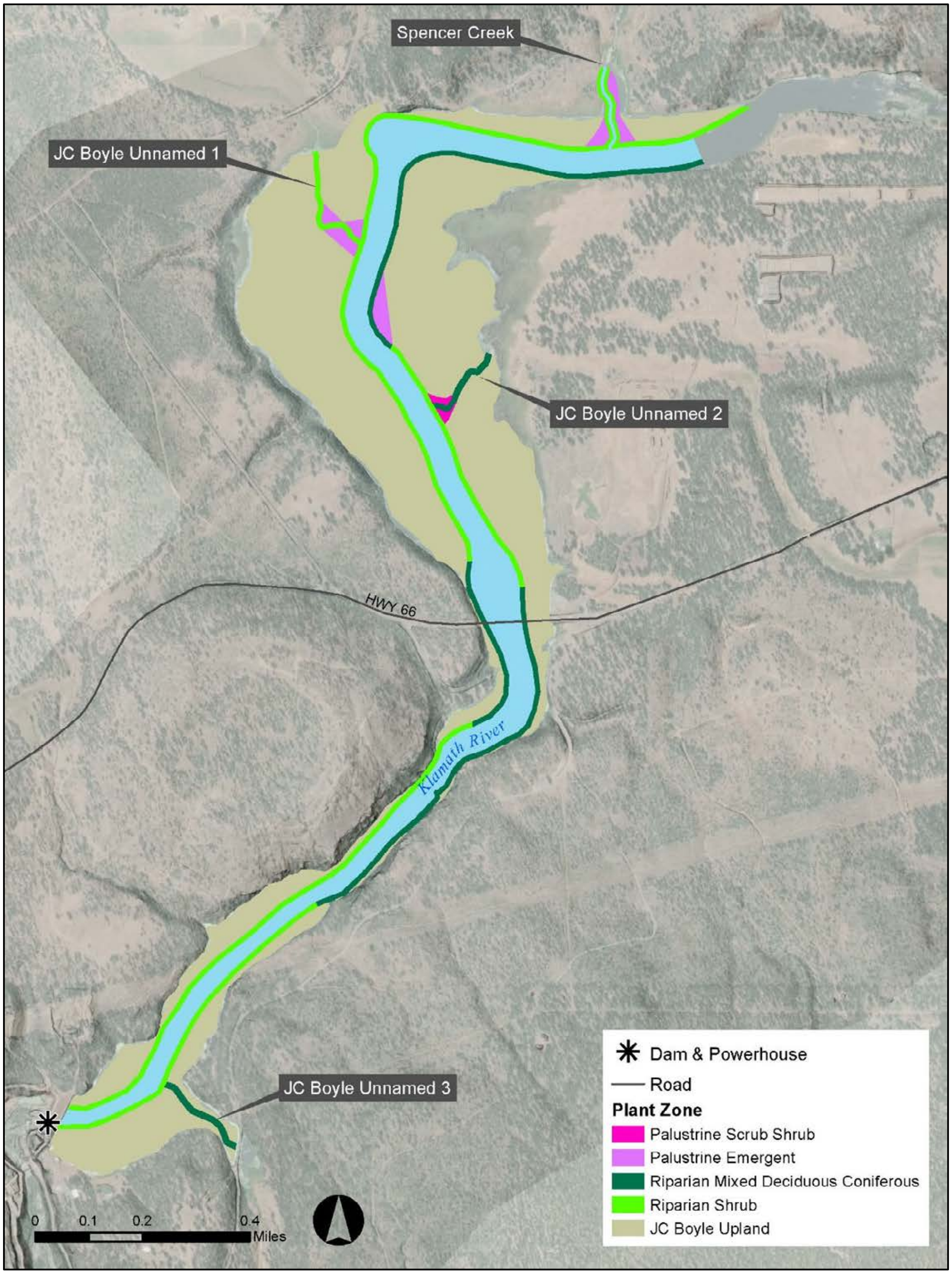
Figure 8.4 Planting Zones: Iron Gate



NOTES:

1. SOURCE: ESRI, USGS.

Figure 8.5 Planting Zones: Copco



NOTES:

1. SOURCE: ESRI, USGS.

Figure 8.6 Planting Zones: J.C. Boyle

8.6.2 SEED PROPAGATION AND IMPLEMENTATION

The RES Team supports, with some modifications, the overall seeding approach described in Section 4.13.2, Appendix 4, of the KRRC Project Agreement. This plan proposes the application of pioneer seed mixes as soon as practicable following drawdown while the sediment and remaining soil is holding moisture. During the following late winter/early spring, over-seeding diversity mixes are proposed to add to species diversity. Seed will be broadcast by hand, from helicopters and/or other mechanical seeding methods (i.e. All-Terrain Vehicle mounted seeders) in areas difficult to access on foot.

AECOM initiated seed increase contracts in 2018 with BFI Native Seeds in Moses Lake, Washington and S&S Seeds in Carpinteria, California. The estimated seed to be produced from those existing contracts is the foundation for the pioneer seed mixes. New contracts will be pursued in 2019, 2020, and 20221 to boost species diversity in the seed mixes and to reach the quantities needed for the project. Some of the species proposed for the seed mixes will be wild-collected seed only, particularly species that do not perform well in seed increase fields (i.e. *Lupinus argenteus* and wetland species, as per BFI and Hedgerow Farms consultations).

8.6.2.1 EXISTING SEED CONTRACTS

Existing seed increase contracts with BFI Native Seeds and S&S Seeds are anticipated to produce 32,000 pounds of seed (Table 8.5). Many of the species in production have very small seed with millions of seeds per pound. As a result, the seed anticipated to be produced in the existing contracts will be sufficient to seed 2,773 acres at 80 seeds per square foot (Table 8.6). This estimate of total seeds does not include two species in production (*Juncus balticus* and *Rumex transitorius*) because no estimates of seeds per pound were available for this analysis. Seed collected in 2018 and 2019 not used for seed increase fields are being stored for future use at two facilities; Pacific Coast Seed in Tracy, California (PCS) and Hedgerow Farms in Winters, California (HRF). Stored seed will be directly added to seed mixes to boost diversity.

Table 8.5 Estimated Seed Production from Existing BFI and S&S Contract

Species	Common Name	Existing Contract	Low end seeds/lb	lbs anticipated	Total seeds
Achillea millefolium	common yarrow	BFI	2,790,000	600	1,674,000,000
Artemesia douglasiana	mugwort	BFI	340,000	200	68,000,000
Bromus carinatus	California brome	BFI	80,000	13,921	1,113,680,000
Drymocallis glandulosa	Sticky cinqufoil	BFI	1,135,000	22	24,970,000
Elymus cinereus	Great Basin wild rye	BFI	130,000	1,725	224,250,000
Elymus elymoides	squirreltail	BFI	181,200	5,414	981,016,800
Elymus glaucus	blue wildrye	BFI	110,000	3,600	396,000,000
Elymus triticoides	Creeping wild rye	BFI	51,000	140	7,140,000
Euthamia occidentalis	western goldenrod	BFI	2,500,000	420	1,050,000,000
Festuca idahoensis	Idaho fescue	BFI	450,000	2,166	974,700,000
Juncus balticus	Baltic rush	BFI	unavailable	720	unavailable
Penstemon roezlii	Rozel's penstemon	BFI	650,000	448	291,200,000
Poa secunda	Sandberg's bluegrass	BFI	912,500	1,084	989,150,000

Species	Common Name	Existing Contract	Low end seeds/lb	lbs anticipated	Total seeds
Solidago elongata	Cascade goldenrod	BFI	4,600,000	370	1,702,000,000
Grindelia camporum	Gumplant	S&S	132,000	681	89,892,000
Rumex transitorius	willow dock	S&S	unavailable	177	unavailable
Trichostema lanceolata	vinegarweed	S&S	126,400	604	76,345,600
Totals				**32,292**	**9,662,344,400**

NOTES:

1. ESTIMATED SEED PRODUCTION IS BASED ON POUNDS OF SEED ANTICIPATED (BFI AND S&S ESTIMATES) MULTIPLIED BY SEEDS PER POUND FOR EACH SPECIES. THE SEEDS PER POUND IS BASED ON LOW-END ESTIMATES AVAILABLE IN THE LITERATURE.

Table 8.6 Seed and Acreage Calculations

Seeds per sq ft	Seeds per acre (80*43,560 sq ft)	Total seed available	Total acres (Total seed/seed per acre)
80	3,484,800	9,662,344,400	2,772.7

NOTES:

1. CALCULATIONS ARE BASED ON EXISTING CONTRACTS.

8.6.2.2 NEW SEED CONTRACTS

New seed increase contracts and wild collections will be designed to add species needed for the pioneer and diversity seed mixes and produce enough seed to plant an additional approximately 900 acres, bringing the total seed available for this project to plant over 3,600 acres. This will allow for seeding the reservoirs twice with additional seed available to seed areas outside the former reservoirs that are impacted by deconstruction activities (Recreation areas, JC Boyle canal removal, etc). The species required for the pioneer seed mixes are not all in production and require new seed collection and propagation for nine species (Table 8.7). Of those nine species, four have sufficient seed to initiate new seed increase fields in the winter of 2019-2020. One annual species, *Lupinus microcarpus,* has a small amount of seed available to begin small-scale seed increase with the goal of producing enough seed in 2020 to plant a minimum 1-acre seed increase field. The remaining four species needed for the pioneer seed mixes will be collected in 2020 for propagation in 2021-2022. One species, *Lupinus argenteus,* does not perform well in seed increase fields (BFI and HFR, personal communication) and will be wild collected and stored for use in the pioneer upland mix. Additional contracts will be pursued for species needed for the diversity seed mixes and will depend on seed available for collection in 2020-2021. New contracts will be pursued with the most cost-effective facilities including BFI Native Seeds, Hedgerow Farms and Corvallis Plant Material Center.

Table 8.7 Seed Designated for Pioneer Seed Mixes

Species	Common Name	Seed Status	Propagation Plan
Agrostis exarata	spike bentgrass	Collect in 2020	Contract 2021-2022
Croton setiger	turkey mullein	Seed collected 2019	Contract 2020 & 2021
Deschampsia caespitosa	tufted hairgrass	Seed collected 2019	Contract 2020-2021
Deschampsia elongata	slender hairgrass	Collect in 2020	Contract 2021
Elymus spicata	blue bunch wheat grass	Collect in 2020	Contract 2021-2022
Eriophyllum lanatum	Wooly sunflower	Seed collected 2019	Contract 2020-2021
Hordeum brachyantherum ssp. brachyantherum	meadow barley	Seed collected 2019	Contract 2020-2021
Lupinus argenteus	silvery lupine	Collect in 2020-2022	Wild collect only
Lupinus microcarpus	chick lupine	1 lb 2019 (AECOM)	Contract 2020-2021

8.6.2.3 PIONEER SEED MIXES

Two pioneer mixes will be applied, one for upland areas and one for wetland/riparian areas. The primary function of the pioneer mixes is to break apart the soil crust, begin the development of a more complex soil structure, create pore space for precipitation penetration, support development of the soil microbial ecosystem, and create cover over the soil to prevent erosion and support future plantings. The KRRC pioneer mix design criteria call for up to seven forb species and at least four grass-like species. The RES Team proposes using eleven forb species (including two legumes) and six grass species in the pioneer upland mix and six forbs and eight grass-like species in the pioneer riparian/wetland seed mix. The proposed pioneer seed mixes are included in the drawings (Sheet R0806). Both pioneer seed mixes will be sown immediately after reservoir drawdown before the sediments dry out. Seeds will be applied at a rate of 80 seeds per square foot, per Sheet R0806. Actual seed mix species composition, including species percentages, will be determined during final design and will be based on the results of seed collection and yield increase activities.

8.6.2.4 DIVERSITY SEED MIXES

The proposed over-seeding diversity mixes will be divided into two mixes, a wetland/riparian mix and upland mix. They will include many of the same species in the pioneer mixes but will be supplemented with seed from increase fields established in 2020 and collected in the wild (Table 8.8 and Table 8.9). The diversity seed applied at a given reservoir will be tailored to include species local to that reservoir. These mixes will incorporate more perennial, forb and woody species as well as additional sedge and rush species for the riparian/wetland zones. Culturally valuable species to local Native American Tribes will also be included, such as *Lomatium* sp. and Yampah plants (i.e. *Perideridia bolanderi*). The diversity mixes will be seeded in the fall of 2022 and early spring of 2023, depending on species availability from seed increase fields and weather conditions. When the application window for these two mixes approaches, the landscape will have had at least one season to respond to the drawdown and managers will be able to identify pioneer seed success and failures, natural regeneration patterns and emerging habitat zones for appropriate application locations. This will allow for a more strategic (i.e. adjust seeds per square foot as needed) and successful application of seed mixes that are more expensive and in limited supply. Areas identified with dense vegetation that is not native or has low diversity may be prepped prior to seeding to ensure open ground and sunlight are available. Surface preparations will include tilling or other surface roughening and/or mowing tall vegetation.

Table 8.8 Potential Species for the Riparian/Wetland Diversity Seed Mix

Species	Common name	Lifeform	Seed Status
Acmispon americanus	Spanish lotus	Annual forb	Stored (PCS)
Bidens frondosa	Devil's beggarticks	Annual forb	Stored (HRF, PCS)
Carex nebrascensis	Nebraska sedge	Perennial sedge	Stored (PCS)
Carex praegracilis	clustered field sedge	Perennial sedge	Stored (PCS)
Carex simulata	short beaked sedge	Perennial sedge	Stored (PCS)
Deschampsia danthonoides	annual hairgrass	Annual grass	Stored (HRF)
Erythranthe guttata	yellow monkey flower	Annual/Perennial forb	To be collected
Hordeum depressum	Alkali barley	Annual grass	To be collected
Juncus occidentalis	western rush	Perennial rush	Stored (HRF)
Kyhosia bolanderi	Bolander's tarweed	Perennial forb	To be collected
Muhlenbergia richardsonis	mat muhly	Perennial grass	To be collected
Paspalum distichum	knotgrass	Perennial grass	To be collected
Persicaria amphibia	water smartweed	Perennial forb	Stored (PCS)
Sidalcea oregana	Oregon checkermallow	Perennial forb	To be collected
Stipa lemmonii	Lemmon's needlegrass	Perennial grass	Stored (HRF)
Trifolium willdenovii	Tomcat clover	Annual forb	To be collected
Xanthium strumarium	cocklebur	Annual forb	Stored (HRF, PCS)

NOTES:

1. THE RIPARIAN/WETLAND DIVERSITY MIX WILL ALSO INCLUDE SPECIES FROM THE RIPARIAN/WETLAND PIONEER SEED MIX DEPENDING ON AVAILABILITY. SMALL AMOUNTS OF SEED ARE CURRENTLY STORED AT TWO FACILITIES, HEDGEROW FARMS IN WINTERS, CA (HRF) AND PACIFIC COAST SEED IN TRACY, CA (PCS).
2. THE APPLICATION RATE AND SEED MIX COMPOSITION WILL BE DETERMINED FOLLOWING DRAWDOWN BASED ON RESERVOIR POST-DRAWDOWN CONDITIONS

Table 8.9 Potential Species for the Upland Diversity Seed Mix

Species	Common name	Lifeform	Seed Status
Amsinckia menziesii	Menzies' fiddleneck	Annual forb	To be collected
Acmispon americanus	Spanish lotus	Annual forb	Stored (PCS)
Angelica arguta	Lyall's angelica	Perennial forb	To be collected
Artemisia tridentata	big sagebrush	Shrub	Stored (PCS)
Danthonia californica	California oatgrass	Perennial grass	To be collected
Ericameria nauseosa	Rabbitbrush	Shrub	Stored (HRF, PCS)
Festuca microstachys	small fescue	Annual grass	To be collected
Grindelia nana	Idaho gumweed	Perennial forb	To be collected
Koeleria macrantha	June grass	Perennial grass	To be collected
Lomatium macrocarpum	bigseed biscuitroot	Perennial forb	To be collected
Lomatium nudicaule	barestem biscuitroot	Perennial forb	To be collected
Lomatium triternatum	nineleaf biscuitroot	Perennial forb	To be collected
Monardella odoratissima	mountain mondardella	Perennial forb	To be collected
Penstemon deustus	rock penstemon	Perennial forb	To be collected
Perideridia bolanderi	Bolander's yampah	Perennial forb	To be collected
Phacelia heterophylla var *virgata*	varied leaf phacelia	Perennial forb	To be collected
Poa secunda	Sandberg's bluegrass	Perennial grass	To be collected
Stipa lemmonii	Lemmon's needlegrass	Perennial grass	Stored (HRF)
Stipa occidentalis	western needlegrass	Perennial grass	To be collected

NOTES:

1. THE UPLAND DIVERSITY MIX WILL ALSO INCLUDE SPECIES FROM THE UPLAND PIONEER SEED MIX DEPENDING ON AVAILABILITY.
2. THE APPLICATION RATE AND SEED MIX COMPOSITION WILL BE DETERMINED FOLLOWING DRAWDOWN BASED ON RESERVOIR POST-DRAWDOWN CONDITIONS

8.6.2.5 ADAPTIVE MANAGEMENT OF SEED MIXES

The species in the diversity mix, particularly the annual species, may be added to the pioneer seed mixes if sufficient seed is available for the winter 2022 seeding. Further refinement of species mixes by reservoir may occur and may include species not identified in this report. Seed mixes for areas outside of the reservoirs (i.e. the IEV treated areas requiring revegetation) will resemble the upland seed mix but will be refined for each area as needed.

8.6.3 MULCHING

Where application is feasible, we propose using native straw mulch or sterile wheat mulch as a seeding mulch on bare soils and exposed sediment. KRRC's outdoor seed germination tests found the straw mulch greatly improved germination and survival of seedlings (RFI RES-08). The study suggested that the mulch served two key purposes: it retained surface soil moisture and it offered the seedlings some thermal protection from below-freezing nighttime temperatures.

Straw mulch is commonly used to aid in germination and protect exposed soils in many types of seeding and erosion control applications. The risk of applying straw mulch is that the straw may contain unwanted weed seeds. We propose that native straw mulch is procured in advance and can be monitored prior to harvest and tested after harvest for the presence of weed seeds. We propose that the native straw mulch or sterile wheat straw mulch be applied with the pioneer seed mix after drawdown in select areas. During subsequent years the widespread use of straw mulch will not be necessary. Straw mulch can be used as an adaptive management technique in areas that show poor coverage and require reseeding.

The use of other types of mulch such as wood chips or shavings, and pine needle shavings, are also being tested and considered for use during the initial seeding and for adaptive management of strategic locations.

8.6.4 UNCERTAINTIES

The revegetation effort faces the following uncertainties that could present challenges to a successful outcome.

- Construction budget constraints will limit irrigation extents, limit the amount of plants and seed that can be installed, and limit long-term management actions.
- Construction access constraints include: the remaining reservoir sediments and their inability to support construction and agricultural equipment, private land limiting access options, steep topography limiting access to certain areas, and the overall spatial area that requires treatment, management, and irrigation.
- Harsh environmental conditions that create uncertainty for plant establishment include freezing temperatures during the wet season, reservoir sediment structure and crust, sharply limited seasonal precipitation patterns, domestic livestock grazing, wildlife herbivory, and the widespread IEV presence on surrounding lands.

8.6.5 PLANT MATERIAL SOURCES

This section describes the methods for:

- Native plant seed collection, propagation and storage
- Native plant material collection and propagation
- Pole cutting collection and storage
- Native riparian plant preservation in place during drawdown, salvage, and relocation

In addition, the RES Team will develop a detailed schedule for collection, propagation and storage of all native plant materials and mapping existing wetland and riparian plant locations appropriate for salvage activities during drawdown.

8.6.5.1 SEED COLLECTION, PROPAGATION AND STORAGE

1. Site Selection: For each target species, collection sites have been and will continue to be located using guidelines that ensure a representative sample of genetic variation is obtained. AECOM has already done much of the necessary work to identify suitable collection sites within the Klamath Basin for 2018 but additional work is necessary for 2020 and 2021 collection seasons. The specific number and distribution of collection sites will vary according to size, density, continuity of populations, and biology of the species sampled, as well as the desired quantity of seed to be obtained. The RES Team is employing methods for collection as described in Appendix 4 of the Definite Plan throughout the project collection areas. Collection areas and landowners are depicted in Appendix J.

2. Collection Methods: Seed collection methods vary depending on the species. Grass seed is harvested by stripping or shaking it off the stem, or by clipping the stem with scissors or small scythes just below the spikelet. Shrub seed is picked or lightly beaten or shaken, using a tarp to catch the falling seed. For species that dehisce explosively, the entire inflorescence may be cut prior to maturity and allowed to dry in mesh or paper bags, or under netting. Ladders or tree climbing using professional arborists may be required for collecting seed from taller shrubs and trees, or plants can be lightly pruned with telescoping pole pruners. For large-scale harvesting, specialty equipment and machines may be necessary where appropriate. Mechanical collection requires coordination with agencies and landowners to allow for such activity. Collections will be conducted in a manner that does not damage existing vegetation or other resources. At least 50 percent of the seed crop at a given site is left intact to allow for natural recruitment and regeneration of the native population. Close monitoring will be conducted to match the timing of seed collection to the distribution of seed maturation. Multiple trips to a site may be required for determining when the seed is mature and for collecting. Collecting at multiple times throughout the maturation period can help prevent inadvertent selection for early or late maturing genotypes. Seed will be collected using the protocols described in Appendix A18 of the Design Criteria Report. Field data sheets (Appendix K) will be used to document seed collections.
3. Seed Storage: Seed will be collected and stored in such a way as to ensure its viability. Overheating can kill seeds, and excessive heat and temperature fluctuations should be avoided. High moisture content during storage can also cause seed damage and loss of viability due to molds. The 100 rule of thumb, where the sum of temperature (degrees F) and relative humidity (%) does not exceed 100, will be employed. Seed collected in 2018 and 2019 that was not used for seed increase fields is currently being stored by Pacific Coast Seed in Tracy, CA and Hedgerow Farms in Winters, CA.
4. Native Seed Propagation: The RES Team will contract with as many nurseries as necessary to achieve the target seed rates for all species. Seed from eleven species collected in 2018 and an additional six species collected by commercial producers in the upper Klamath Basin are currently being grown at BFI Native Seed in eastern Washington and S&S Seed in California in seed increase fields expected to produce over 32,000 lbs of seed. Seed collected in 2019 will also be sent to propagation nurseries, cleaned and tested for viability. New seed increase fields from species not yet in production will be sown in the winter/early spring of 2020. The remaining wild collected seed will be stored for use in the diversity seed mix in upland and riparian lands exposed after dam removal.

8.6.5.2 NATIVE BAREROOT PLANTS

1. Bareroot material (trees, shrubs and herbaceous) may be propagated to add diversity and structure in seeded areas. The woody species that are the primary components of the surrounding existing plant communities and are tolerant of clay soils will be prioritized for propagation. Provisional species lists are included in Section 8.12, Planting Methods.
2. The RES Team will contract for the propagation of bareroot woody species as necessary to achieve target planting densities outlined in this plan. Seed from woody species will be collected and sent to the bareroot propagator to ensure appropriate genetic integrity. Bareroot propagation requires one to two years, depending on the species. Many species are ready after one growing season and are shipped in late winter. The first round of bareroot plants will be ready to plant immediately after dam removal, maximizing survival rates in the moist sediments. Bareroot materials will be stored temporarily at facilities close to the dams (location TBD). Plants will be removed from shipping bags and stored in

mulch piles to keep the root systems moist until planting. Bareroots will not be stored for longer than six weeks.

3. Bareroot plant materials will be tested for Phytophthora species detrimental to native plant communities. A minimum of 5 percent of all bareroot material will be tested. Any detrimental Phytophthora species detected will result in removal of all plants of that species (from the same nursery) from the project. Testing methods to be determined.

8.6.5.3 POLE CUTTING AND LIVE STAKE CUTTING COLLECTION AND STORAGE

1. Pole cuttings are required to plant the large wood features, willow baffles, mixed willow clusters, and cottonwood clusters as indicted on the revegetation design sheets. Pole planting should occur after November 20, when plants are dormant.
2. Live black cottonwood and willow pole cuttings will be primarily collected after leaves have fallen from donor plants; however, due to construction scheduling and the amount of pole cuttings required for each project area, pole collection may occur earlier. Pole cuttings will be collected as close to complete dormancy as feasible. Pole cuttings will be collected from an equal amount of male and female donor plants. Pole cuttings may be collected from a nursery, from plants growing along the river, logs, stumps, or other horticultural methods that produce hardwood poles of the desired species, sex, lengths, and diameter.
3. Pole cutting diameter is a good proxy of the amount energy reserves stored in the cutting and desiccation vulnerability. Smaller diameter poles need more poles installed in each planting to ensure that one pole survives, whereas larger diameter poles require fewer poles per planting to ensure survival. Live hardwood pole diameters at the largest end should be 1-1/2-inch minimum and 3-inch maximum. Live hardwood pole lengths should be 10 foot minimum.
4. After collection, the smaller diameter end of each hardwood pole should be color coded with latex paint to indicate plant species, pole direction, and to facilitate layout. Poles could be color coded for simple speciation.
5. After pole cuttings are color coded, they will be bundled into groups of 25 and soaked. Each bundle will be prepared with a mixture of diameter ranges and an equal number of male and female poles. Individual bundles will be labeled with an aluminum tag that may indicate the collectors(s), species, number of males and female poles (if possible), date and location of collection, the date soaking began and ended, and a unique ID number for tracking the survivorship of poles from each bundle after installation. Poles will be soaked for ⅔ their length for no more than 16 days and no less than 7 days before planting.
6. Pole cuttings may need to be stored if they cannot be installed immediately after soaking. Storage may include placing poles in cold storage after soaking. Bundles of pole cuttings should be placed in cold storage for the minimum period necessary. If cold storage is required, the poles would be collected, soaked for 9 to 10 days, and stored at 5ºC until planting. After the poles have been removed from cold storage, they should be soaked for another four to five days to complete soaking and ensure hydration before and after storage.
7. Pole cuttings will be delivered to the revegetation site in tagged bundles of 25 poles. Delivery to the jobsite from storage needs to be carefully coordinated to ensure that pole cuttings do not dry out. The

best assurance would be to deliver to the site no more poles than can be planted within 24 hours after removal from storage. If daily average air temperatures exceed 27ºC, on-site poles can be temporarily stored in the shade under wet burlap sacks. Poles that are not used in a day should be wrapped in wet burlap sacks and stored in a cool location until the next planting day.

8. Live-stake cuttings will be used for direct staking into riparian and wetland areas that do not require heavy equipment for planting, Live-stake cutting diameters should be ¼ inch minimum and 1 inch maximum. Cutting lengths should be a minimum of 48-inches. Management and storage of live-stake cuttings will follow the same methods as for pole cuttings described above.

8.6.5.4 NATIVE PLANT SALVAGE

Native Wetland/Riparian Plant Salvage (sod, plugs or woody vegetation): Native plant salvage and relocation will occur during drawdown to remove vegetation that is currently around the reservoir rim and installed immediately to newly exposed wetlands or riparian areas.

8.6.6 IRRIGATION

Irrigation systems will be installed in the riparian areas of Irongate (109 acres) and Copco (98 acres) to increase likelihood of seeding success, facilitate establishment of native vegetation, and promote stabilization of the floodplain of the Klamath River and its tributaries within the project area post-draw down. Additional areas will receive supplemental irrigation, with primary focus on south facing slopes with lower soil moisture, as needed to meet vegetative success criteria and achieve sediment stabilization. The system will be installed in May of 2022 and will be maintained and operated during the first growing season until October of 2022. Large scale irrigation is not currently anticipated for any parts of the project area after the draw down year.

8.6.7 FENCING

Strategic uses of temporary fencing are proposed to prevent browsing of newly planted vegetation. The use of fencing is constrained by cost, construction access, and flooding. We propose creating exclusion zones around each of the proposed restoration areas instead of protecting individual plants with tubes. The fencing is intended to exclude cows and horses. Taller fencing will be needed to protect against deer and other native herbivores if herbivory becomes a management problem. Taller fencing is not proposed at this time but will be investigated as an adaptive management practice if unacceptable levels of herbivory by deer are observed during monitoring events.

8.6.8 PERFORMANCE CRITERIA FOR PLANTING AND SEEDING

The performance criteria proposed are designed to capture the success of seeding (species richness, vegetation cover) and the establishment of trees and shrubs measured by estimating density of stems per acre (which will include naturally occurring plants). These criteria are tailored for the unique conditions associated with dam removal. Dam removal in the Klamath will expose a landscape covered in fine sediments that have accumulated over the last 50-100 years. These sediments contain only a minor seed bank and the dewatered reservoirs will undergo primary succession, supplemented by the proposed seeding and planting activities. Natural primary succession is a relatively rare and lengthy process. Other examples of primary succession are volcanic eruptions (i.e. Mt. St Helens), glacier retreats (Walker & del Moral 2003), and other large dam removal projects (Auble et al. 2007). A primary driver of succession is environment, making each instance of primary succession unique. The Klamath Project will respond in ways that are difficult to predict because of the unique environmental conditions. The first few years will be quite different from target reference communities and success criteria should reflect these challenges.

The areas exposed by Klamath Dam removal are large and diverse. Draining the reservoirs will expose upland areas (87 percent of acreage) and riparian areas (13 percent). The vegetation response to these landforms will be different as a result of water availability and management actions. The riparian areas are a priority for restoration and may be irrigated. Because of the expected differences in vegetation response, some criteria will be tailored to landform.

Revegetation of the reservoirs that will be exposed by the removal of four Klamath River dams will be achieved by a combination of IEV management, seeding native herbaceous and woody species, planting bareroot trees and shrubs and natural recruitment of vegetation. The use of irrigation in the Iron Gate and Copco newly established riparian areas and strategically placed fencing are planned for high priority restoration areas around tributaries and riparian areas along the main channel of the Klamath River. Detailed revegetation plans are presented in the previous section (8.6.6) and in the following section (8.6.7).

The first two years post-dam removal (2022-2023) are critical to vegetation establishment as a blank canvas will be unearthed providing opportunity for primary succession and establishment of the surrounding vegetative communities. This period (2022 to 2023) is defined as Year Zero, the year when the restoration area transforms from a lake system to a riverine system and following re-seeding and planting. The areas that will be unearthed as a result of reservoir drawdown and dam removal cover a large geographic area with diverse substrate. Draining the reservoirs will expose upland areas (approximately 87 percent of the restoration acreage) and riparian areas (approximately 13 percent of the restoration acreage). Additionally, deep layers of fine sediments accumulated over several decades, within the reservoir footprints will be exposed.

8.6.8.1 DETERMINING REVEGETATION SUCCESS

Success criteria for the project provide targets to determine the progression of vegetation development in the reservoirs with the goal of creating viable self-sustaining native plant communities in riparian and upland habitats. Annual monitoring of the restoration areas will determine if revegetation is progressing along the goals of the prescribed success criteria and if adaptive management should be implemented. A five-year maintenance period (2024-2028) is prescribed post-construction during which time restored vegetation in the riparian and upland areas will be monitored quantitatively and adaptive management will be used to promote success of the restoration sites.

These criteria were developed out of previous dam removal monitoring programs and provide metrics which can be quantifiably measured efficiently. These criteria establish targets for which to report restoration progress and are separated into upland and riparian/wetland criteria. In both landforms, success criteria are established for species richness, vegetation cover, tree and shrub density, and exotic vegetation frequency.

Success criteria will be assessed using quantitative monitoring methods. Randomly distributed permanent plots will be established in all three reservoirs and monitored annually beginning in 2024 (Year 1) after implementation is complete and re-surveyed annually until 2028 (Year 5). These data will be used to adaptively manage the project and determine if the success criteria are being met. If criteria are not meeting targets, remedial actions may be needed. These criteria are defined in Table 3.1 of the Restoration Design Criteria (Appendix A18):

> The success criteria will be monitored using quantitative vegetation surveys in permanent plots randomly located with the reservoir footprints and stratified by landform (upland or riparian/wetland) and treatment (i.e. seeded only, planted and seeded or unmanaged). Each plot will be monitored using methods to capture the four success criteria.

The observational setup at each location consists of two elements, a 65-foot line-intercept transect and a 16-foot by 32-foot plot (larger plots will be required in uplands and dimensions may differ in wetland/riparian areas). Bare-ground, cover of woody plants, and the total cover of herbaceous plants will be measured along the line-intercept transect. All distinct plants within each plot will be identified to species and all trees and shrubs will be counted - by species. A minimum of four, 3-foot square quadrats within each plot will be sampled for rooted IEV frequency. Plots will be surveyed late spring or early summer, annually, to ensure annual species are captured during their peak bloom/abundance period.

8.6.8.2 VEGETATION COVER

The vegetation cover criterion will be determined through direct comparison to observed vegetative cover in reference[3] communities. Vegetation cover is expected to be slow to reach targets because primary successional surfaces devoid of vegetation take time to develop. In riparian/wetland areas, primary succession can result in rapid cover of vegetation which can be accelerated by irrigation. We expect upland areas that are not irrigated to develop slowly. For example, we do not expect oak trees to develop significant cover in only seven years. We do expect a progression of increasing cover annually after year 1. Table 8.10 below defines vegetative cover success criteria.

Table 8.10 Vegetation Cover Success Criteria

Habitat	Year 1	Year 2	Year 3	Year 4	Year 5
Upland	15%	25%	45%	60%	80%
Riparian	50%	60%	70%	80%	90%

8.6.8.3 SPECIES RICHNESS CRITERIA

Species richness measures the total number of species present in a given area. Species richness provides a general idea of how many different species are colonizing the sites and can be measured quickly and affordably on a large scale. Alternatively, species diversity can be time consuming to measure and can be prone to subjectivity as surveyors tend to view ocular cover measurements differently.

Primary successional communities tend to start with low species richness relative to surrounding plant communities but increase quickly in the first few years because competition is low and bare ground is abundant. Species richness is sometimes a preferable metric to species diversity because weedy annuals, abundant in early successional communities, tend to skew diversity metrics to suggest low diversity when in fact many long-lived, slow growing species are present in considerable numbers but are low in cover the first few years. These long-lived species are important to ecosystem development and provide significant species richness to early successional communities that will, in the long run, result in high species diversity.

[3] Reference sites to be determined by Year Zero.

High species richness is also important in restoration because it correlates with high ecosystem resilience and sustainability (Walker et al. 1999, Halofsky and Peterson 2016).

Species richness will be determined through direct comparison to observed species richness in reference[4] communities. Over time, we expect species richness to increase as a result of planting and natural recruitment. Moist riparian habitats are expected to develop more rapidly than drier upland habitats. Riparian habitats will be immediately connected to intact upstream riparian communities that provide moisture, seed and vegetative propagules critical to habitat development. Table 8.11 below defines species richness success criteria.

Table 8.11 Species Richness Success Criteria

Habitat	Year 1	Year 2	Year 3	Year 4	Year 5
Upland	50%	55%	60%	65%	70%
Riparian	50%	60%	70%	80%	90%

8.6.8.4 TREE AND SHRUB DENSITY

Trees and shrubs provide important structural features in upland and riparian habitats. Target densities will be achieved by planting bare root plants, seeding (i.e *Ericameria nauseosa* and *Quercus* species) and natural recruitment from surrounding seed sources. We will not differentiate between natural and planted trees and shrubs; all woody plants present in the plots will be treated equally. This data will allow us to assess species performance in the sediments so that we can focus maintenance activities on planting species that exhibit tolerance to the unique environmental conditions. This data also provides a species diversity metric for woody plants.

Tree and shrub density will be based on a percentage of densities observed in reference[5] plant communities. We expect riparian areas to support densities close to reference conditions more quickly than in drier upland sites. Table 8.12 below defines tree and shrub success criteria.

Table 8.12 Tree and Shrub Density Success Criteria

Habitat	Year 1	Year 2	Year 3	Year 4	Year 5
Upland	50%	55%	60%	65%	70%
Riparian	50%	60%	70%	80%	90%

8.6.8.5 REFERENCE COMMUNITIES

Upland and riparian reference sites will be established by Year Zero to identify suitable sites for comparison with temporal conditions in the restoration site. Due to the uniqueness of the newly formed communities within the reservoir footprints, control plots located within the reservoir footprints will be used to assess restoration success of the reservoir footprints. Control plots will not be seeded or planted in order to observe natural succession as previously deeply buried sediments will create unique substrate quite different from adjacent ecosystems, resulting in a lack of comparable sites for reference. The success criteria account for these unique conditions and focus on vegetation characteristics less likely to significantly differ from

[4] Reference communities will be determined by Year Zero.
[5] Reference communities will be determined by Year Zero.

adjacent plant communities as the newly available substrate will likely differ significantly from adjacent, mature plant communities.

Naturally occurring species will not be considered separately in the data. Initial reconnaissance to identify potentially suitable upland and riparian reference sites will occur in the spring and summer of 2020. Results of reconnaissance surveys may also serve to establish baseline criteria for monitoring. Multiple plant communities in the uplands adjacent to reservoirs and within tributary and mainstem riparian habitats will be sampled.

Qualitative monitoring will begin after dam removal (summer 2022, Year Zero). Qualitative monitoring will include regular site inspections of all plantings and seeded areas conducted by professional botanists and ecologists. Qualitative inspections will allow for in-season adaptive management of vegetation and inform project managers of the progress of vegetation development. All landscape scale photo points will be established by 2022 which includes establishing locations, georeferencing points, and taking photos. Photo points will be monitored annually through 2028, at the end of the prescribed monitoring period.

8.6.8.6 REMEDIAL ACTIONS

If the monitoring data determined that the success criteria outlined above are not being met, the following actions will be taken:

1. Determine the cause of the problem. Appropriate staff, including, but not limited to, restoration ecologists, botanists, soil scientists, hydrologists, geomorphologists will assess environmental conditions and submit a report to project management.
2. Success criteria will be re-evaluated by comparing plot data to control sites. Results will be summarized and submitted to the appropriate regulatory agencies for review.
3. If necessary, remedial measures based on problem determination will be proposed and submitted to the regulatory agencies for approval prior to implementation.
4. Remedial actions implemented will be monitored to determine if they are successful.

8.6.8.7 MAINTENANCE ACTIVITIES

The maintenance period begins in Year 3 post dam removal. Data from the first two years will be used to develop the five-year maintenance plan. Maintenance will focus on ensuring success criteria are met and IEV species are managed within the reservoir footprints using the following options to ensure successful revegetation during the maintenance period including 1) re-seeding, 2) re-planting, 3) irrigation, and 4) IEV control.

1. **Re-seeding:** Areas that are not performing up to standard (i.e. low cover, low richness or high IEV abundance) may need to be re-seeded with species proven to succeed in the unique environmental conditions (fine sediments). Data from control plants and managed sites will be used to determine species patterns that are successful, and seed may be wild-collected to sow into trouble sites. No new seed increase contracts will be pursued during the maintenance period. However, we may be able to obtain genetically appropriate native species commercially (see section 8.6.5.1).
2. **Plant Replacement:** Replanting may be considered if tree and stem densities are not meeting the target numbers defined in the success criteria. Species selected for re-planting will be based on native species proved to tolerate the unique environmental conditions in the reservoir footprints based on data collected in the first 2 years.

3. **Irrigation:** Irrigation may a remedial action at sites that need to be re-planted or re-seeded. Location and irrigation methodology will be determined as needed during the maintenance period.
4. **IEV Management:** The management of all IEV species is critical to successful revegetation. A long-term IEV management plan will be developed after year 2 to re-evaluate species priorities and population patterns based on the first two years (Appendix L).

8.7 INVASIVE EXOTIC VEGETATION

Dam removal will create large areas devoid of vegetation, providing opportunities for exotic plant species to colonize and attain dominance. Post-drawdown reservoir footprints are particularly susceptible to invasion by exotic plants. If left unchecked, invasive species establishing in the former reservoir areas will degrade potential salmon habitat by dispersing propagules (seeds, rhizomes) downstream. Managing invasive exotic vegetation will be a concern at all three reservoir areas. Iron Gate, and to some extent Copco No. 1, will be particularly challenging with the most aggressive and widespread existing IEV coverage adjacent to the project boundaries.

The presence of IEV in the lower Klamath River watershed was documented by PacifiCorp in 2002-2003 (PacifiCorp 2004) and then revisited by KRRC biologists in 2017 and 2018 (KRRC 2018). A prioritized target list of fifty-three invasive species was developed by KRRC and was modified by the contractor to reflect 2019 agency ratings (Table 8.8). The priority list will be adaptively managed as conditions on-the-ground and agency priorities change. Of the 53 species of concern identified on the priority list, only 23 were present in the latest survey by AECOM (2019). The 2019 survey was used to define treatment strategies. There are two primary strategies for IEV treatment, eradication and containment. Strategies were determined for each species and were based on abundance on the landscape and the cost-effectiveness of treatments. Treatments will be adaptively managed through a robust quantitative monitoring program.

Treatments will require a combination of methods including mechanical (grubbing, mowing) and chemical. Chemical treatments will be minimized and used only on species that are not effectively treated mechanically. Only herbicides that are pre-approved by all appropriate agencies will be utilized. Treatments will require a multi-year approach to ensure containment or eradication goals are achieved.

The full IEV management plan is provided in Appendix L. The IEV management plan covers pre-dam removal (2020-2021) and the dam removal and restoration phase (2022-2023). The post restoration period from 2023-2028 will be managed under a long term IEV Management Plan to be produced in 2023 and based on the status of IEV abundance in 2023.

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8.9 RESIDUAL SEDIMENT STABILIZATION

Uneven sediment evacuation and erosion is expected in the mainstem of the Klamath River and throughout the former reservoir footprint. Some slumping and erosion of residual sediment on the floodplain and uplands is anticipated for the first few years following drawdown. Over time, the stability of the surficial slopes is expected to improve as groundwater elevations decrease and surface vegetation develops root structure, adding strength and further reducing groundwater through evapotranspiration.

Following drawdown, however, a detailed review will be undertaken to identify locations where stabilization of residual sediments on these slopes might be appropriate. The main reason for actively stabilizing sediments where sediment slopes appear unstable is to reduce the risk of delivering large volume to sediment directly into a tributary channel or the Klamath River such that it may block fish passage in the future or severely degrade habitat quality. Preventive measures that may be taken to stabilize unstable sediment deposits include:

- Grading – Laying back slopes of significant sediment deposits to more stable angle.
- Bank Protection – Strategic vegetation planting coupled with temporary erosion control blanket may be installed to increase resistance to surficial erosion and geotechnical processes that may make the sediments unstable.
- Following initial stabilization, the site should be monitored for signs of local slope failures. Local slumping may be triggered by groundwater flow or toe erosion from the migration of the river channel. Active slope failures shall be evaluated by a geotechnical engineer to recommend remedial measures.

8.10 KLAMATH RIVER

Under this section, we first describe how the Klamath River is expected to respond and evolve in the first few years after drawdown, which serves as the basis for recommended restoration actions. Specific actions along the mainstem of the Klamath River, including how the channel will be reconstructed at each of the removed dams, is then presented.

8.10.1 ANTICIPATED CHANNEL EVOLUTION

The anticipated channel evolution of the Klamath River is driven by its pre-dam nature as a highly resistant boundary channel now filled with relatively low thicknesses of highly erodible reservoir sediment. As described in KRRC 2018a and other studies, much of the pre-dam mainstem Klamath River within the Project area was highly erosion resistant and sediment-supply-limited: mostly a mixture of bedrock, cobble or boulder channel in the canyon reaches (downstream reach of J.C. Boyle, upstream reach of Copco No. 1, both reaches of Iron Gate). The upstream reach of J.C. Boyle and downstream reach of Copco No. 1 are more alluvial in nature, and the mainstem here is believed to be made up of gravels and sands. By contrast to the pre-dam channel, the post-dam sediments that currently fill the Klamath River channel have been characterized as relatively thin layers of fine, erodible sediment. Reservoir sediment is mostly 2 to 10 feet thick, approximately 85 percent silt, clay and organic material, with the remainder mostly sand (US Bureau of Reclamation, USBR 2011a).

8.10.1.1 IMMEDIATELY AFTER DRAWDOWN

Owing to the fine grained and easily erodible nature of the reservoir sediments, it is expected (see USBR 2011a) that during drawdown a large amount of the fine reservoir sediment will be mobilized and washed out of the Project area, exposing the more resistant historic channel. Depending on whether it is a dry, average or wet winter and spring during and immediately after drawdown, between 41, 50, and 65 percent of the post-dam sediment respectively is expected to be washed out of the Project area within the first year of the project, with most of that transport occurring during the initial drawdown period in January through March. Silt, clay and organics are expected to be preferentially mobilized during drawdown, leaving behind a greater proportion of sand (estimated to be 30 to 50 percent of the residual sediment post drawdown, USBR 2011a). In the canyon reaches the distinction between historic channel and residual reservoir sediment should be very clear (silt/sand overlying bedrock/boulder/cobble beds), and the residual sediment is expected to wash out over the next few years. In the alluvial reaches the distinction between native and reservoir sediment may be less sharp, but in general the historic bed is expected to be fairly well defined with localized pockets of residual reservoir sand. Differential erosion of sediment pockets may lead to temporary headcuts that are a barrier to fish migration. Active removal of reservoir sediment from the mainstem Klamath River is not anticipated to be a widespread activity, since it is not expected that sedimentation will be long-lived or pose a threat to fish passage or long-term habitat function. The mainstem will be monitored during and after drawdown in case localized sediment accumulations pose a threat to fish migration. Erosion-resistant deposits of residual sediment that are deemed immediate fish passage barriers will be monitored and addressed as described in Section 8.3.

Channel bank stability and lateral planform stability are expected to vary between canyon and alluvial reaches. In the alluvial reaches, pre-dam photos show that the floodplains had narrow and discontinuous riparian corridors, potentially due to grazing pressure as well as limited moisture availability away from the river edge. Though sparse, the riparian corridor likely provided some bank stability along alluvial sections of the river. Immediately after drawdown any banks that are exposed by washing away of fine reservoir sediment will be un-vegetated. We might anticipate accelerated bank erosion in these areas immediately following drawdown, before vegetation becomes established. In the canyon reaches the initial absence of vegetation will likely make little difference to bank erodibility, which is expected to be controlled by the resistance of coarse colluvial sediment (boulders and cobbles) along the channel margins.

8.10.1.2 ONE TO FIVE YEARS POST-DAM REMOVAL

Sediment transport modeling by USBR (2011a) showed that the residual, sandier, one to two thirds of the reservoir sediment that was left after the first year following reservoir drawdown would likely require about a two-year flow event to mobilize it. Thus, within one to five years following dam removal we would expect to see most of the reservoir sediment transported out of the Project area, leaving a mainstem form that closely resembles the historic condition. It is possible that sediment evacuation from the mainstem Klamath will occur unevenly and create temporary local headcuts where downstream sediment erodes but upstream sediment is more persistent. Such headcuts will be monitored and addressed as described in Section 8.3.

Alluvial reaches could experience some accelerated bank erosion in the first one to five years as riparian vegetation becomes established. Minor channel widening could occur associated with bank erosion. As vegetation becomes established in the first one to five years, bank stability will increase and widened sections of channel could potentially narrow again due to vegetation encroachment. Because most of the Project site is not believed to be highly susceptible to bank erosion, and because riparian vegetation is expected to recover over the first few years of the Project, we do not anticipate active bank stabilization unless there are specific threats to infrastructure or critical habitat elements.

8.10.1.3 CONCLUSIONS

Drawdown will mobilize and reorganize a tremendous amount of material including the sediment that has been unnaturally trapped by the dams as well as native material moved by the magnitude and duration of the drawdown flows. It will take several seasons of normal low and high flows for this material to reach natural equilibrium. During this period, changes are expected to occur in the channel and along the channel margins. Because this is part of the natural process of channel evolution to reach an equilibrium state, direct interventions will only be implemented as needed to meet project requirements of (a) volitional fish passage and (b) sediment stabilization. The design basis for fish passage is presented in Section 8.3, Fish Passage and sediment stabilization is discussed in Section 9.9, Residual Sediment Stabilization.

Similarly, bank erosion and deposition are expected as part of natural channel evolution, and riparian vegetation is expected to recover over the first few years of the Project. Therefore, we do not anticipate active bank stabilization unless there are specific threats to infrastructure.

8.10.2 PROPOSED RESTORATION ACTIONS AND ELEMENTS

This section describes proposed restoration actions that will be utilized along the Klamath River to encourage reestablishment of natural processes. The main restoration actions are selective grading and planting. The location and quantity of the restoration actions will be guided by assessment of the post drawdown conditions, channel features and characteristics.

8.10.2.1 MID-CHANNEL ISLANDS

Mid-channel islands exist on the Klamath River within and near the project reach. These island features were recently observed in the field and have also been previously documented in a number of instances (Ayers, 1999; USBR, 2012; Definite Plan). Based on field observations, these islands are often comprised of coarse material (e.g., large cobbles and boulders), tend to be semi- to well-vegetated, and appear to persistent over time and not be particularly dynamic features. In the historic reach of the Klamath River within the Copco 1 Reservoir, USBR (2012) noted the presence of a greater number of vegetated islands, some abandoned channel meanders, and wetland or floodplain environments; most surfaces in the reach were less than 5 feet above the river channel based on historical topography. These mid-channel islands appear to be the result of river avulsions over point bars or older floodplain surfaces, or through deltas at tributary confluences.

Using existing aerial imagery, the Project Team systematically identified mid-channel islands and additional areas of obvious split flow for two sections of the Klamath River (from Copco 1 to approximately 6 miles upstream, and from Iron Gate Dam to the confluence of the Shasta River). Nine Islands were observed upstream of Copco Lake, while fifteen islands were observed downstream of Iron Gate Dam. Table 8.14 provides a summary of the islands' geometric attributes for each respective river section for reference. Volume and height information was derived from existing topographic data. The island features observed upstream of Copco 1 were considerably larger than the island features observed downstream of Iron Gate Dam. Islands seem prevalent throughout the river and a majority of the islands identified upstream of Copco Lake can be seen in aerial imagery dated as early as 1953. Where possible, remnant mid-channel islands in Copco 1 reservoir will be passively restored through sediment evacuation during drawdown.

Table 8.14 Average Geometric Characteristics of Island Features

River Section	Average Area[1] (acres)	Average Max Protruding Height (feet)[1,2]	Average Longitudinal Length[1] (feet)	Average Max Width (feet)
US of Copco #1 Lake	1.2	8.8	474	145
DS of Iron Gate Dam	0.5	4.0	294	86

NOTES:

1. GEOMETRIC MEASUREMENTS WERE DETERMINED FROM AERIAL IMAGERY AND DEMS WITH A RANGE OF DISCHARGE OF 881 – 1080 CFS AT USGS 11516530 BELOW IRON GATE DAM.
2. HEIGHT IS THE DIFFERENCE BETWEEN THE MAX HEIGHT OF THE ISLAND'S LONGITUDINAL PROFILE AND THE DS WSE.

8.10.2.2 SELECTIVE GRADING

Selective grading along the Klamath River will be undertaken on the channel margin and at confluences of priority tributaries to augment sediment evacuation and improve river-floodplain connectivity. As noted in Section 8.2.1.1, select, localized grading will occur along the mainstem only as needed to provide fish passage, and stabilize un-evacuated sediment at vulnerable high-sediment-yield locations. In addition, if budget allows additional optional grading may occur at select locations to:

1. Provide connectivity to wetland complexes that emerge post-drawdown.
2. Enhance side channel connectivity in former Copco 1 Reservoir.
3. Create riparian benches at unnaturally high channel banks to facilitate plant establishment.

USBR (2012) noted the presence of a greater number of vegetated islands, some abandoned channel meanders, and wetland or floodplain environments prior to construction of the dams. The downstream reach of the Copco 1, with its broader, less confined alluvial valley has the highest potential for side channels and mid-channel islands to re-emerge. For the most part, optional grading along the mainstem will only occur in Copco 1 where minor grading could re-establish and/or reconnect secondary channels.

Other selective grading areas will be determined based on opportunities to effectively enhance and expand riparian conditions. Well-connected floodplains and channel terraces are needed to support the dynamic fluvial processes that are the basis for natural regeneration of riparian vegetation. As described in Section 8.5, existing riparian vegetation along the mainstem is typically located within a vertical band ranging up to approximately 15 feet above summertime base flows. If budget allows, select areas with unnaturally high channel banks would be lowered to help establish narrow terraces approximately 8 to 15-feet above the channel and up to 30-feet wide.

8.10.2.3 PLANTING

The Klamath River channel margins will be planted as feasible with riparian plant communities as described in more detail in Section 8.12.

8.10.2.4 LARGE WOOD

Large wood structures will be installed along channel margin and floodplains at key tributaries within the reservoir boundary. Additional large wood will be placed along the mainstem at the tributary confluences. More information on design approach and design criteria for large wood is provided in Section 8.11.2.2 below.

8.10.3 FORMER DAM FOOTPRINT RIVER RECONSTRUCTION

A key design consideration is providing volitional fish passage through the footprints of the former dam sites. The channel will be appropriately sized and designed to account for immediate conditions, as well as future potential for incision (i.e., bed lowering) and lateral thalweg shifting as bed material shifts in response to high flow events. Incision at the former dam site(s) could cause the formation of a head-cut and/or expose buried, structural components of the dam. Below we summarize our basis and preliminary recommendations for (as necessary) excavation depths, backfill depths and material, equilibrium bed profiles, and general channel geometry. In developing our design basis, we reviewed numerous documents, including the Definite Plan and Appendices, the Preliminary Design Drawings (REF-05), and historic design drawings (REF-01) and photographs (REF-02), and pre-dam topography (REF-03).

Regarding incision potential, we adopt the concept of an equilibrium slope to assess how the channel gradient might evolve. The equilibrium slope is the slope at which the shear stress acting on the bed equals or slightly exceeds the critical shear stress needed to initiate sediment motion. In natural, coarse-bedded rivers, the stable ratio of the shear stress acting on the bed to the critical shear stress for motion generally falls within the range of 1.2 to 1.6 for flows near a bankfull discharge (Palucis and Lamb, 2017, Mueller et.al., 2015, Parker et. al., 2007). Work specific to the Klamath River suggests the ratio may be 1.3 in the project area (USBR, 2011). In systems or reaches with low sediment supplies the stable ratio may be closer to 1.0 (or lower) (i.e., a "threshold" channel). These shear stress ratios are typically in reference to the D50, however in systems with relatively low sediment supply and/or coarse beds (e.g., mostly cobbles and small boulders) using the D84 may be more appropriate. In general, the equilibrium slope method requires 1) determining an appropriate critical shear stress and 2) calculating a channel slope based upon an assumed relation between channel hydraulics and a stable bed slope. Determination of the critical shear stress is dependent upon an assumed grain size or grain size distribution. For the subsequent channel slope calculation, an average flow depth value is required.

This approach is best applied to graded, or self-formed, alluvial channels, and in cases where the sediment supply is low or other controls over channel gradient are present (e.g., bedrock) will likely produce a lower equilibrium slope. However, for our purposes we consider this method appropriately conservative for assessing reach-scale channel adjustment. The work of others has shown that, for example, critical shear stress increases with channel slope and the underlying explanation is that the process variables that control the channel bed state covary with slope for most natural rivers (e.g., Lamb et al., 2008; Palucis and Lamb, 2017); the referenced studies are based on rivers with slopes up to 10-percent and greater.

8.10.3.1 J.C. BOYLE

Just upstream of J.C. Boyle Dam, the historic Klamath River steepened significantly as it began to enter the basalt, cliff-lined canyon that contains the river for miles downstream (PWA 2009). At the location of the J.C. Boyle Dam the historical channel widens somewhat compared to the narrower valley just upstream. The area of the dam, as with the upstream area, has significant exposures of bedrock and most in-channel sediment visible in photos is boulder- or cobble-sized (Definite Plan). The J.C. Boyle Dam is founded on basalt bedrock and, thus, the potential for short- or long-term channel adjustment at this location after dam removal is limited.

Excavation depths at J.C. Boyle during dam removal will generally go down to bedrock and exposed or very shallow bedrock exists upstream and downstream of the dam site. These bedrock exposures provide natural grade control that will limit the risk of channel incision compared to a channel formed in alluvium, so an equilibrium slope with respect to assessing vertical adjustment potential was not used. Finished grade bed elevations will generally extend to bedrock. [redacted] he stable bed slope and range of bankfull and bottom widths are based upon reference reaches presented by Graham Matthews & Associates (2003) and review of historic topography (REF-03) and drawings (REF-01). Further, stable geometries are also presented based upon the quasi-universal, gravel-bed river relationships developed by Parker *et al.* (2007). These metrics help to guide assumed excavation and grading extents, but the ultimate channel geometry is this location will be largely controlled, laterally and vertically, by exposed or shallow bedrock and the relatively steep natural slopes.

Table 8.15 Assumptions for Channel Within Dam Footprints.

Dam Removal Site	Dam Removal Elevation (feet NAVD88)	Assumed Equilibrium Slope for Vertical Adjustment (ft/ft)	Reconstructed Channel Geometry			Parker et al (2007) Hydraulic Geometry (for reference only)	
			Bed Slope (ft/ft)	Channel Width (Q2-Q5) (feet)	Channel Depth (Q2-Q5) (feet)	Channel Width (Q2-Q5) (feet)	Channel Depth (Q2-Q5) (feet)
J.C. Boyle	Varies (to bedrock)	N/A	0.017-0.025[1]	133-138	4.9-5.3	123-134	6.6-7.1
Copco 1	2,472.1	0.011	0.011-0.016	103-107	7.1-8.2	129-147	6.6-7.4
Copco 2	2,453.3	0.011	0.011-0.02	131-139	5.6-6.4	123-140	6.6-7.1
Iron Gate	Varies (to bedrock)	N/A	0.0027[2]	150-170	7.5-8.5	159-181	6.7-7.5

NOTES:
1. HIGH FLOW AND LOW FLOW SLOPE, RESPECTIVELY.
2. BASED ON HISTORIC DRAWING (REF-01) AND HISTORIC TOPOGRAPHY (REF-03).

8.10.3.2 COPCO 1 & 2

Copco 1 Reservoir is located at a topographic transition on the inundated Klamath River, whereby roughly the upper 80 percent of the reservoir is sitting atop a formerly lower-gradient, wider-valley reach of river, with the downstream portion of the reservoir, and dam site, atop a reach of river confined by very steep, basalt-derived cliffs (PWA 2009). This change in river valley constriction (from open to narrow), marks the entrance to a steeper canyon section. In this section, the Copco 1 dam overlies an ancient canyon filled with an unconsolidated mass of boulders, gravel, sand, and other detritus, extending approximately 100 feet below the pre-dam channel bed (REF-01). Copco 2 is approximately 1,715 feet downstream of Copco 1, and is within a steeper section of the narrow bedrock canyon that begins just upstream of Copco 1. However, Copco 2 is not underlain to the same extent or with same material as Copco 1; historic drawings (REF-01) indicate that bedrock may be 20 to 30 feet below the streambed.

Copco Dams 1 and 2 are founded on concrete installed below the grade of the riverbed at the time of construction. An important objective of the Project is to remove this foundation concrete to an adequate depth such that, given uncertainties in future physical processes and conditions, the risk of eventually exposing what concrete remains would be reduced. To estimate the dam foundation excavation depth, we followed the following general approach:

- Confirm the grade control downstream of Copco 2
- Use a stable bed slope analysis to assess adjustment potential
- Add a factor of safety to account for potential, localized scour

The excavation depths are based on an assumed grade control downstream of the dams, and consistent assumptions for the equilibrium channel slope and scour depth/factor of safety. We use both a quantitative analysis as well as historical and existing data and observations.

As described in detail in the *Existing Conditions Assessment Report* (KP 2019b), there is a steep, boulder/step-pool reach beginning approximately 525 feet downstream of Copco 2 and extending for another approximately 450 feet. This reach exhibits a very uniform average slope and is characterized by a highly structured bed with large, imbricated boulders (generally between 3 to 5 feet in diameter) forming the steps. The boulder/step-pool reach appears to have been in existence for at least over half a century (e.g. river alignment and adjacent hillslope appear unchanged in 1953 aerial photos) and has withstood several large events during this time, including the apparent flood of record for the Klamath River (1965) based on over 150 years of flow data. This reach has a low potential for incision and, based on field observations and other empirical data, the top of the step pool reach, at elevation of 2,455 feet (NAVD88), is considered the grade control point for the reach upstream that includes Copco 1. Since dam removal will generally not increase the hydraulic forces of high flows events, or negatively affect sediment supply, there is no reason to believe the boulder/step-pool reach will be less stable in the future than it has been over the last half-century or more. Equilibrium slope is used to estimate the future streambed elevation at both the Copco 1 and 2 dam sites based on extending this slope upstream from the assumed grade control point.

8.10.3.2.1 Particle Size for Critical Shear Stress

Quantitative estimates of particle sizes and distributions are generally limited to those presented by PacifiCorp (2004) and those summarized by USBR (2011) (the latter reference includes the PacifiCorp data as well data collected by the USBR, USGS and Ayers Associates). Data collected within the Copco 2 Bypass Reach (or “Ward’s Canyon”) are presented in PacifiCorp (2004) (Figure 8.7 D_{50} and D_{84} particle size dimensions are in mm).

Figure 8.1 Copco 2 Bypass Reach Sediment Data (PacifiCorp, 2004; annotations added)

Copco No. II Bypass Reach

Pebble Count Summary

“average”

Reach Name	River Mile	D_{50}	D_{84}	Geomorphic Feature	Location
Copco 2 Bypass	197.7	132	344.9	Channel	On RB near XS1
Copco 2 Bypass	197.7	175.6	344.4	Channel	In main channel near XS1
Copco 2 Bypass	197.7	252.3	548.3	Fossilized Bar	On Bar near XS1
Copco 2 Bypass	197.2	85.7	148.2	Currently mobile bar	Currently mobile bar. Approximately 0.5 miles DS of Copco 2 Bypass site

“max”

We used an average estimate derived from the two channel samples, and we used a maximum estimated derived from the “fossilized bar” sample (assuming the latter reflects a completely armored condition, the sizes of which may be most reflective of the framework channel bed material throughout the reach of interest, i.e., roughly between Copco 1 and 2). These grain size characteristics are generally consistent with data presented by multiple entities and spanning the Klamath River between Iron Gate and JC Boyle (Figure 8.8).

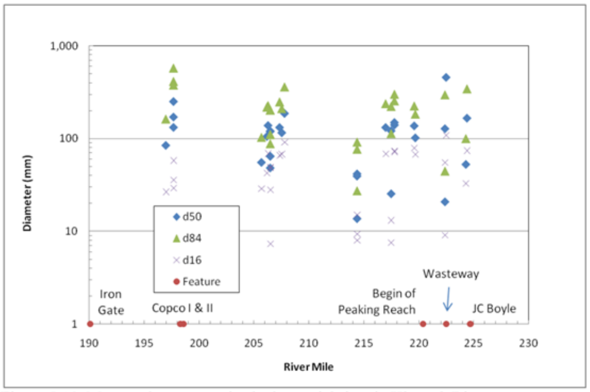

Figure 5-18. Measured representative bed material sizes in Klamath River downstream of J.C. Boyle and Upstream of Iron Gate reservoirs (PacifiCorp, 2004b).

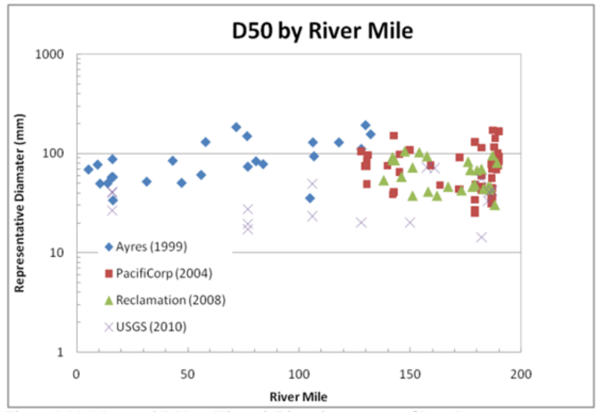

Figure 5-20. Measured D50 on Klamath River downstream of Iron Gate Reservoir.

Figure 8.2 Sediment Data Presented in USBR (2011)

8.10.3.2.2 Depth of Flow (Hydraulic Radius)

There is no model or reliable reach-scale topography from which to derive hydraulic parameters for the pre-dam condition in the reach of interest. We used an average hydraulic radius of 6.07 feet. This estimate was derived from 1) the average hydraulic radius (at 8,000 cfs) from the USBR HECRAS 1D model over the upstream part of the Copco 2 bypass reach and 2) an at-a-station hydraulic analysis of the historic cross-section at the Copco 2 dam for the BiOp Q2 flow (7,200 cfs).

8.10.3.2.3 Critical Shear and Equilibrium Slope Estimates

The critical (or reference) shear stress for the D_{50} and D_{84} was calculated using the method of Wilcock and Crowe (2003). This method accounts for the effect that smaller particles may have upon increasing the mobility of larger particles. The critical shear stress was also derived using the relationship of Lamb et al. (2008), who demonstrated that the critical shear stress increases with bed slope. The range of estimates is summarized in Table 8.16.

Table 8.16 Equilibrium Slope Estimates

Sediment Size Used	Method	Bankfull Shear/Critical Shear	Eq. Slope (ft/ft)	Relative to other Slopes
Avg **D50**	Lamb et al. (2008)	1.3	0.0084	“low end”
Avg **D84**/D50	WC (2003)	1.3	0.0093	
Max **D50**	WC (2003)	1.3	0.0105	“middle”
Max **D84**/D50	WC (2003)	1.0	0.0114	
Max **D50**	Lamb et al. (2008)	1.3	0.0137	“high end”
Max **D84**/D50	WC (2003)	1.3	0.0148	

NOTES:

1. WC = WILCOCK AND CROWE (2003)
2. RATIO OF 1.0 USED BECAUSE MAXIMUM D84 IS USED, THUS ASSUMING AN ARMORED STATE AND/OR LOW SEDIMENT SUPPLY.

The range of slope estimates presented above reflects, to some extent, the uncertainty in and sensitivity to the parameters for calculating channel adjustment (regardless of methodology) as well as, indirectly, the inherently stochastic nature of sediment transport processes and subsequent channel adjustment. However, historic drawing G-3444 (Figure 8.9) depicts a reach-scale bed slope of approximately 0.011 for the pre-dam channel bed between Copco 1 and 2, and this slope is consistent with our mid-to-low estimates presented above. Thus 0.011 was selected as the equilibrium slope with which to calculate and account for the potential reach-scale, systemic adjustment of the channel bed. Projecting the equilibrium slope upstream from the assumed grade control point results in an assumed potential incision depth at Copco 2 of 1.2 feet, and of 6.9 feet at Copco 1. Figure 8.10 shows the range of equilibrium slopes along with a 2018 long profile of the Klamath River and reservoirs in the vicinity of Copco 1 and 2.

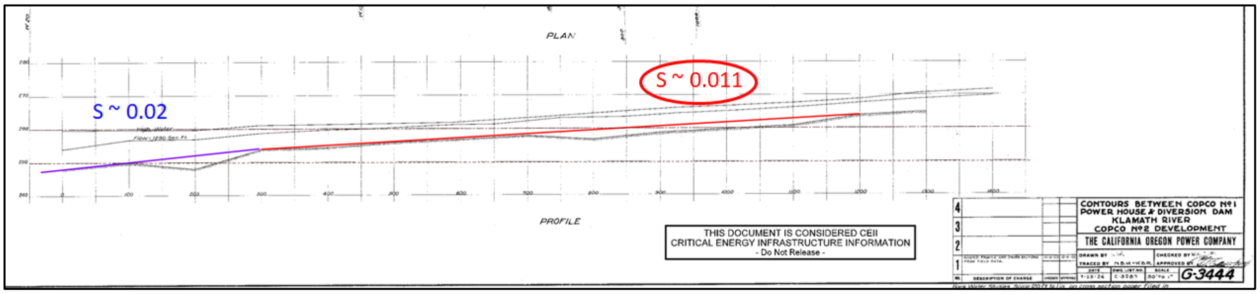

Figure 8.3 Historic Copco 2 Drawing G-3444 (annotations added)

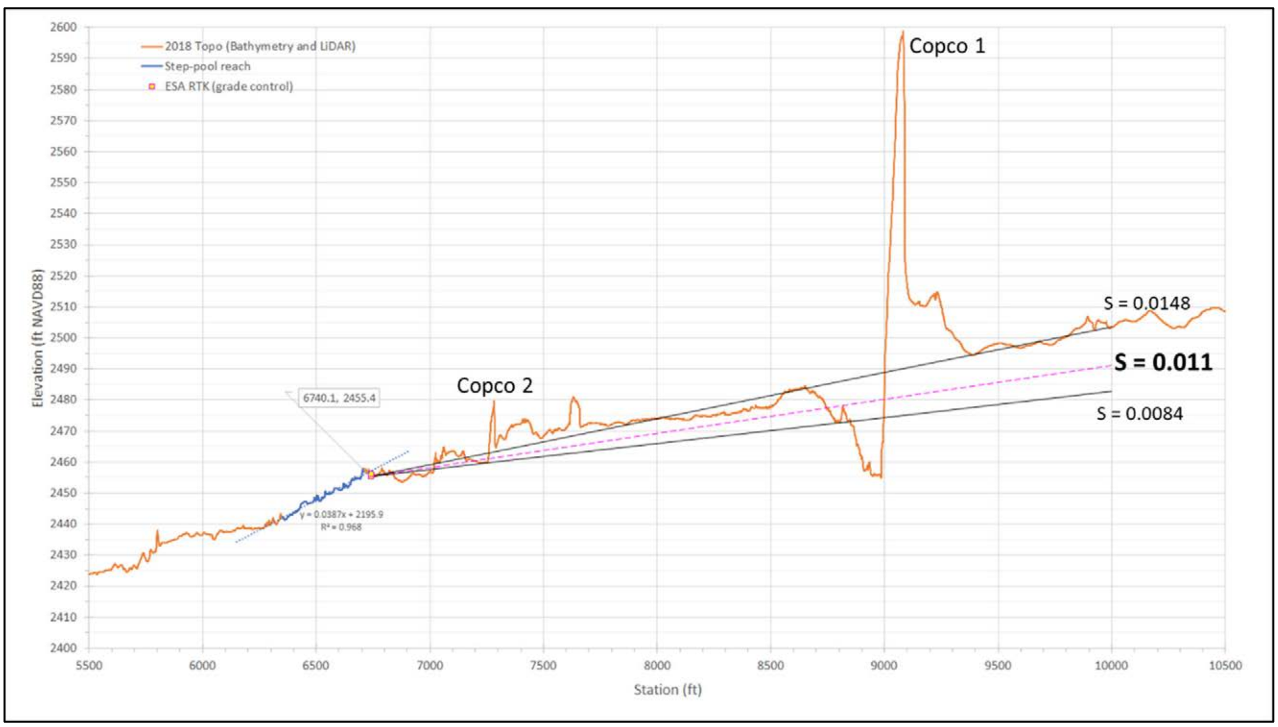

Figure 8.4 Equilibrium Slope Projections at Copco 1 and 2

The existing and historic slope in the reach beginning just upstream of Copco 1 and extending well downstream of Copco 2 (or "Ward's Canyon") was, on average, likely steeper than the estimated equilibrium gradient used here. Average slope estimates of this reach range from 0.013 to 0.019 (Graham Matthews & Associates, 2003; PacifiCorp, 2004), suggesting that the 0.011 assumed slope may be conservative with respect to projecting a slope upstream for channel adjustment. However, the direct influence of bedrock control and the canyon reach itself on adjustment potential is uncertain, and the historic channel gradients through this area likely varied based on localized controls. Historic and existing topography suggest that, respectively, the historic slope at the entrance to "Ward's Canyon" was just over 0.009, and the existing bed slope just downstream of the boulder/step-pool reach is also just over 0.009. Further, the equilibrium slope is also based upon existing sediment gradation information. If the overall particle size distribution changes in the future and, for example, becomes finer as a result of dam removal upstream, the reach slope could adjust to a lower gradient.

8.10.3.2.4 Scour Depth

The potential scour depth serves as an estimate of additional erosion below equilibrium channel slope due to local- or reach-scale scour. It can be thought of as the additional depth of potential incision due to local hydraulics (e.g., a debris jam or other obstruction forcing jet flow) and/or an abrupt decrease in the supply of sediment. Using the method described in NRCS (2007), the range of scour depth estimates were based on the Q100 event (BiOp flows) and the average D_{50} and D_{84} as well as the maximum D_{50} and D_{84} (from Figure 8.10 above and Table 8.16). The D_{84} sizes used fall into the boulder size class. The hydraulic parameters were derived as described above (except for the Q100) or as noted in Table 8.17. The calculated scour depths were cross-checked against field measurements of pool depths from the reference reach data (4 to 9 feet maximum depth; PacifiCorp, 2004) and recent field observations in October of 2019 (greater than 7 feet), though neither of these necessarily account for the deepest pools. These calculated and empirical values generally corroborate the calculated scour depths of 5.8 to 7.5 feet presented in previous work (KRRC, 2018a). Given the associated uncertainty, the higher end of our scour depth estimates was considered most appropriate; we assume a potential scour depth of 8 feet at both Copco 1 and Copco 2.

Table 8.17 Scour Estimates (ft.)

	Copco 2	***Copco 1***
	At-a-Station	***At-a-Station***
	Historic XS	***Historic XS***
	(n=0.06*, S=0.011)	***(n=0.06*, S=0.011)***
D50/D84 Max	5.4	7.8

NOTES:

1. FROM TABLE 6.7-13 IN PACIFICORP ENERGY INC. (PACIFICORP), 2004. FINAL TECHNICAL REPORT, KLAMATH HYDROELECTRIC PROJECT (FERC PROJECT NO. 2082), WATER RESOURCES. VERSION: FEBRUARY 2004.

8.10.3.2.5 Excavation Depth Copco 1

Based on the above analysis, the concrete in river channel will be removed down to elevation 2,472.1 feet (+/-) NAVD88. This preliminary estimate is approximately 14.9 feet below a pre-dam channel bed elevation of approximately 2,487 feet NAVD88, and is based on the following:

- Future incision – 6.9 feet (based on projecting an equilibrium slope of 0.011 from downstream grade control at elevation 2,455.4 feet NAVD88)
- Scour depth/safety factor – 8 feet (based on BiOp 100-year flow and parameters described above, and field observation)

These recommendations are preliminary and subject to revision prior to the 90 percent design completion documents.

Concrete will be removed to the full channel width [as shown on the channel profile on Sheet C-176 of the Definite Plan Drawings (REF-05)], and the former dam footprint will be backfilled up to or above the pre-dam channel bed elevation. The scour hole downstream of the Copco 1 will also be backfilled to approximately 8 feet below the average thalweg grade elevation to support the formation of a constriction pool where the canyon narrows. Sizing of back-filled material is described below in 8.10.3.2.6.

8.10.3.2.6 Excavation Depth Copco 2

The concrete in river channel will be removed down to elevation 2,453.3 feet (+/-) NAVD88, which is approximately 9.2 feet below the pre-dam channel bed elevation and is based on the following:

- Future incision – up to 1.2 feet (based on projecting an equilibrium slope from downstream grade control at el. 2,455 NAVD88)
- Scour depth/safety factor – 8 feet (based on BiOp 100-year flow and parameters described above, and field observation)

These recommendations are preliminary and subject to revision prior to the 90 percent design completion documents.

Concrete will be removed to span the approximately 150-foot channel width (lateral removal extent likely to be up to 200 feet, with bank slope grading), and the former dam footprint will be backfilled up to or above the pre-dam channel bed elevation. Sizing of back-filled material is described below in 8.10.3.2.7.

8.10.3.2.7 Bed Mix Sizing for Copco 1 and 2

Following the removal of Copco 1 and 2, it will be necessary to replace the excavated concrete foundations with a mixture of cobble and boulders from the top of the remaining concrete up to the approximate pre-dam bed elevation. Given the lack of specific particle sizing information collected from the bed prior to constructing the dams, it is necessary to utilize other means to determine the appropriate D_{50} for channel reconstruction. We have consulted other data sources including pebble count data collected downstream of Copco 2 in the bypass reach, unscaled photographs of bed material being excavated for the construction of the Copco 1 dam foundation, and computed nominal depths using U.S. Army Corps of Engineers EM 1110-2-1601 Riprap Design manual.

Data provided by PacifiCorp (2004) indicates a D_{50} of 252mm (10 inches) and a D_{84} of 548mm (22 inches) for the bar. Previous geomorphic studies performed by Stantec on gravel/cobble/boulder systems have revealed the D_{84} of bar features is approximately the D_{50} of bed features at riffle (hydraulic control) points. In an historical photo showing the bed material excavated from the Copco 1 dam footprint, the size of the material shown in the photo appears to be a mix of boulders ranging from 2-3 feet across the median axis. Given this is the material that ostensibly comprised the bed before the dam, it is reasonable to expect material of a similar size to be appropriate for reconstructing the bed after the dams have been removed.

Based on these findings, it is recommended that a bed mix with a D_{50} of 24 inches will be used to reconstruct the bed at Copco 1 and 2. However, we strongly recommend supplementing the bed mix with several large 4-foot to 6-foot boulders placed in clusters to provide holding cover/flow shadows for migrating fish given the narrow nature of the channel, particularly in the immediate vicinity of the downstream limits of Copco 1.

8.10.3.3 IRON GATE

Based on limited historic photos (REF-02) and drawings (REF-01), the historic Klamath River at the Iron Gate Dam site exhibited run morphology and a channel that was constrained laterally by steep hillslopes or canyon walls. Bedrock was exposed at and very near the surface in the Klamath River bed at the Iron Gate Dam site (REF-01; REF-02). At the dam footprint, given the bedrock control and limited sediment accumulation (USBR, 2012), the channel is expected to rapidly revert back to the original geometry and morphology over a relatively short period.

Similar to J.C. Boyle, excavation depths at Iron Gate will generally go down to bedrock, and an equilibrium slope with respect to assessing vertical adjustment was not used. [redacted]

For Iron Gate, the stable slope estimate is based upon historic topography as well as geometry from the USBR (2012) HEC-RAS 1D model (which included surveyed river sections downstream of Iron Gate Dam). The bed elevation of the Klamath River was bedrock-controlled at this location, and this may account for the relatively flatter slope estimate in this location compared to downstream. For example, all reaches downstream of this point generally have an average slope of 0.003 (feet/feet) (PacifiCorp, 2004). These metrics help to guide assumed excavation and grading extents, but the ultimate channel geometry at this location will be largely controlled, laterally and vertically, by exposed or shallow bedrock.

8.11 MAJOR TRIBUTARIES AND CONFLUENCES

Under this section, we first describe how various tributaries to the three reservoirs have been prioritized for restoration actions. We then discuss the specific restoration actions for the tributaries, including grading, large wood and riparian planting.

8.11.1 PRIORITIZATION OF TRIBUTARIES

The five (5) high priority tributaries and/or tributary complexes identified as Restoration Areas in Section 8.2.2 were selected based on the following factors:

- Watershed size and flow regime (perennial or intermittent)
- Historic presence of salmon and/or steelhead
- Potential future incisions risk
- Channel type, including presence of suitable spawning and rearing habitat and/or natural fish passage barriers

These five tributaries are considered to have the highest potential to support target fish species based on the factors above. We identified these tributaries by evaluating and prioritizing the ten (10) largest tributaries identified in the Definite Plan. (Note that Long Gulch, which only has a 1.4 square mile watershed area but has features of interest (e.g. historic crossings and seep, was also included.) Below we present the analysis for future incision risk and channel slope analysis, followed by a brief discussion of each tributary.

8.11.1.1 TRIBUTARY INCISION RISK ASSESSMENT

Differential incision is a potential fish passage risk for tributary channels that have developed sedimentary deltas at the reservoir rim. Preferential erosion of the finer, unvegetated sediment below the reservoir level but not the coarser, well vegetated sediment deposited above the water line could result in headcuts that form barriers to fish migration, as well as degraded, deeply incised channels that offer limited fish habitat benefit. This incision risk was previously studied (GMA, 2003) for the four tributaries considered especially important either for potential fisheries or for sediment delivery to the mainstem of the Klamath River: Scotch, Camp/Dutch, and Jenny Creeks on Iron Gate, and Spencer Creek on J.C. Boyle. The study included surveying the above and below reservoir portions of the deltas that formed when each tributary was inundated and comparing them with the pre-dam topography (estimated using historic maps). Based on these comparisons it appears that the existing channels in Scotch Creek and Camp/Dutch Creek are up to 16 feet higher than the historic channels due to sediment that has been deposited in the alluvial fans The difference in channel elevation for the deltas at Jenny and Spencer Creeks, while smaller at 2 to 4 feet deep, could still present an incision risk.

Above the reservoir level, the delta sediment is quite coarse and well vegetated, creating a relatively erosion-resistant surface. Below the reservoir level, the alluvial fan sediment is unvegetated and, while coarser than the sediment in the main body of the reservoirs, is likely finer and more erodible than the material immediately upstream. Hence, a possible condition soon after the reservoirs are drawn down is for tributary channels with thick alluvial deposits such as Scotch and Camp/Dutch Creeks to incise in the finer sediment immediately below reservoir level and then for incision to be arrested by the coarser sediment or road crossings upstream. This may create the potential for “hanging” tributaries with knickpoints (which could be potential fish passage barriers) at the transitions between incision and bed stability.

It appears that the GMA study was focused on the tributaries where incision was most likely to be a risk. The remaining tributaries do not appear to have deposited deltas as thick as Scotch, Camp and Dutch Creeks, and hence are assumed to have a lower risk of headcuts developing.

The recommended design approach for Scotch, Camp, Dutch and Jenny Creeks is to actively remove sediment from the deltas during and after drawdown, including some coarse delta sediment that is now above the reservoir water level. Spencer Creek is not included in this approach because of its thinner sediment and because of culturally sensitive sites that constrain excavation. The goal of sediment removal in this area is to prevent partial incision from creating headcuts that impede fish migration, as well as to restore a wider floodplain along the tributaries than would otherwise emerge, with side slopes that are gentle enough to support planting of riparian trees. The channel invert will be excavated down to the historic invert, assuming that this is identifiable as the boundary between overlying gravel and sand and underlying boulders and cobble. Sediment removal may be achieved by hydraulic methods during drawdown (e.g. jetting, boat waking) or by earth moving equipment following drawdown.

8.11.1.2 CHANNEL TYPE & FISH PASSAGE ANALYSIS

The RES Team reviewed prior documentation of the 16 tributaries identified in the Definite Plan. Of these, eleven tributaries with either fish habitat potential or larger watersheds were further analyzed to assess channel slope, from which potential natural fish passage barriers and habitat type were inferred. [Note that the following six tributaries from the Definite Plan were not included in the slope analysis due to their smaller watershed size (less than 3 square miles): Unnamed Iron Gate 1, Spannaus Gulch, Raymond Gulch, Unnamed Copco 1, Snackenbury Creek, and Unnamed J.C. Boyle 1].

Channel slope was used to infer channel bedform using the Montgomery-Buffington classification scheme (2013). We recognize that parameters in addition to slope are used to classify channels in the Montgomery – Buffington scheme, and that in a sediment-limited watershed channel type may shift towards steeper classes than those indicated using slope alone, but this method provided an efficient desktop method to quickly evaluate a large length of tributaries. The calculated slopes were also used to evaluate whether the tributary slopes likely constituted natural barriers for fish passage, and this was cross-referenced against field notes and a literature review of historic fish presence.

Stantec provided station-elevation data for key tributaries from the estimated post-drawdown surface to just above the current water line of each reservoir. These were tied into profiles cut from 2013 USGS DEMs for the upstream portion of key tributaries. These datasets were resampled at uniform 25-foot intervals to calculate gradients for the Montgomery-Buffington classification.

Table 8.18 shows the different slopes used to assign Montgomery-Buffington channel type, overlain with a compilation of published gradient limits on fish passage for various salmonid species (recognizing that fish passage limitations are naturally variable and affected by other factors such as the length and hydraulic properties of the reach in question).

Table 8.18 Montgomery-Buffington Stream Classification and Fish Passage Criteria

<table>
<tr><th>Bed slope</th><th>Channel Type (Montgomery-Buffington)</th><th>Limits of Coho and Chinook salmon usage</th><th>Limits of adult steelhead usage</th></tr>
<tr><td><0.1%</td><td>Regime</td><td rowspan="4">0-7% usable for migration, spawning and rearing [A]</td><td rowspan="5">0-12% usable for migration, spawning and rearing [A]</td></tr>
<tr><td>0.1- 2%</td><td>Riffle-pool</td></tr>
<tr><td>1- 2%</td><td>Riffle-pool to plane-bed overlap</td></tr>
<tr><td>1- 3%</td><td>Plane-bed</td></tr>
<tr><td>3-10%</td><td>Step- pool</td><td>>8% to 10% gradients for more than 1,000 feet are natural barriers to migration[B]
Gradients from 7-16% are potentially passable [A]</td></tr>
<tr><td>10-30%</td><td>Cascade</td><td>>16% for more than 525 feet are natural barriers to migration[A]
>20% for >30 feet are also impassable[C]</td><td>12-20% used for migration but not rearing/spawning. >20% for more than 525 feet are natural barriers to migration [A]</td></tr>
<tr><td>>30%</td><td>Colluvial</td><td>Impassable</td><td>Impassable</td></tr>
</table>

SOURCES:

1. WASHINGTON DEPARTMENT OF FISH AND WILDLIFE (WDFW): FISH PASSAGE INVENTORY, ASSESSMENT, AND PRIORITIZATION MANUAL (WDFW, 2019).
2. CALIFORNIA DEPARTMENT OF FISH AND GAME (CDFG): CALIFORNIA SALMONID STREAM HABITAT RESTORATION MANUAL, SECTION IX (CDFG 2004).
3. OREGON DEPARTMENT OF FORESTRY (ODF) RULES: CITED IN "INVENTORY OF BARRIERS TO FISH PASSAGE IN CALIFORNIA'S COASTAL WATERSHEDS" (COASTAL CONSERVANCY, 2004; PAGE 1 APPENDIX A).

Most published limits of salmonid migration fall within the cascade class. While short, 30-foot segments of greater than 20 percent slope are considered impassable, the topographic data were not of fine enough resolution to allow for analysis on that scale. Instead, the following discussion and profiles in Appendix I consider a reach impassable if the stream slope is greater than 16 percent on average for a length of 525 feet. The data were smoothed by taking a moving average of slope values over a sliding window of 525 feet. This analytical approach was supplemented with field notes and literature review. The results are summarized in Table 8.18.

8.11.1.3 PRIORITIZATION SUMMARY

A summary of tributary characteristics, results of analyses discussed above, and the final prioritization of the eleven largest tributaries is presented in Table 8.19, followed by a brief discussion of each. Based on this analysis, each tributary was classified as high or low priority for restoration actions, defined as follows:

- **High Priority:** Restoration activities planned along the tributary to remove reservoir sediment, facilitate fish passage and/or enhance habitat.
- **Low Priority:** Only intervention planned is minor grading at the mainstem confluence if needed for connectivity.

Note that there are six additional tributaries identified in the Definite Plan that are not listed in Table 8.19 due to their smaller watershed size [less than three (3) square miles]. However, because they were included in the Definite Plan, these six tributaries are also considered low priority: Unnamed Iron Gate 1, Spannaus Gulch, Raymond Gulch, unnamed Copco 1, Snackenbury Creek and unnamed J.C. Boyle 1.

Table 8.19 Characteristics of Key Tributaries

Tributary	Reservoir	Approx. Watershed Area (acres)[1]	Q2 (cfs)[1]	Flow Regime	Historical Fish Presence[2]	Limit of Anadromy[11]	Potential Barrier	Incision Potential at Reservoir Rim	Priority
Spencer Creek	J.C. Boyle	54,500	N/A	Perennial[3]	Chinook salmon, Coho salmon, Pacific lamprey, steelhead trout	None	N/A	No	High
Unnamed Tributary JC03	J.C. Boyle	8,000	N/A	Perennial, TBD[4]	N/A	RM 8.6	Steep gradient	N/A	Low
Unnamed Tributary JC02	J.C. Boyle	3,300	N/A	Unknown	N/A	RM 3.6	Steep gradient	N/A	Low
Long Prairie Creek	Copco 1	26,600	187	Perennial, TBD[4]	N/A	RM 0.2	Steep gradient	N/A	Low
Deer/Indian Creek	Copco 1	4,600	68.2	Intermittent[3]	Coho salmon[9]	RM 4.1 on Deer Creek RM 1.0 on Indian Creek	Steep gradient	N/A	High
Beaver Creek	Copco 1	3,600	42.2	Intermittent[3]	Coho salmon[9]	RM 1.5	Steep gradient	N/A	High
Jenny Creek	Iron Gate	134,700	927 (1,400[10])	Perennial[3]	Chinook salmon, Coho salmon	RM 0-1 at low flows	Falls[5]	Yes	High
Dutch/ Camp Creek	Iron Gate	12,700	126	Intermittent[8]	Chinook salmon, Coho salmon[9], steelhead trout	RM 6.6 on Camp Creek None on Dutch Creek	Steep gradient	Yes	High
Scotch Creek	Iron Gate	11,500	115	Intermittent[6]	Steelhead trout	RM 5.0	Steep gradient	Yes	High
Fall Creek	Iron Gate	9,600	82.2	Perennial[3]	Chinook salmon, Coho salmon, Pacific lamprey, steelhead trout	RM 0.1 RM 1.0	Culvert[6] Steep gradient	N/A	Low
Long Gulch	Iron Gate	900	11.1	Intermittent[7]	N/A	RM 2.6	Steep gradient	N/A	Low

NOTES:
1. USGS 2019.
2. HAMILTON 2005, UNLESS OTHERWISE NOTED
3. USDOI AND NMFS 2007.
4. CONFIRM SOURCE FOR NEXT SUBMITTAL (ECAR).
5. RDG 2018.
6. RDG 2019, FISH PASSAGE STRUCTURE INVENTORY.
7. PWA 2009.
8. INTERMITTENT ACCORDING TO USDOI AND NMFS 2007 AND RECENT FIELD OBSERVATION (OCTOBER 2019); PERENNIAL ACCORDING TO PWA 2009.
9. BROWNELL 1999
10. Q2 FOR JENNY CREEK ESTIMATED AS 1400 CFS BASED ON PRELIMINARY ANALYSIS BY KP (DCR, APPENDIX B, TABLE 4.1)
11. RM = RIVER MILE AS MEASURED UPSTREAM FROM ESTIMATED MAINSTEM CONFLUENCE
12. THE FOLLOWING TRIBUTARIES WITH WATERSHED AREAS LESS THAN 3 SQUARE MILES WERE NOT ANALYZED: UNNAMED IRON GATE 1, SPANNAUS GULCH, RAYMOND GULCH, UNNAMED COPCO 1, SNACKENBURY CREEK AND UNNAMED J.C. BOYLE 1.

8.11.1.3.1 Spencer Creek

Spencer Creek extends for approximately 13 miles above the confluence with the mainstem Klamath River and is perennial. No stretches within the longitudinal profile exceed the gradient and length for natural fish passage barriers. With the exception of a short stretch of step-pools in the first mile of the creek, the lower 6 miles are characterized primarily by riffle-pool bedforms. After that, the creek's slope steepens, and the estimated channel type becomes primarily step-pool. Currently, Spencer Creek is wide and shallow with episodically connected side channels, but historic photographs suggest it was deeper, sinuous, and densely vegetated (PWA 2009).

Fall run Chinook salmon and steelhead trout were present on Spencer Creek prior to dam construction (Hamilton 2005). The upstream limit for Coho salmon and Pacific lamprey is believed to have extended at least to Spencer Creek, which has suitable habitat for Coho salmon (Hamilton 2005, USDOI and NMFS 2007, NMFS 2014). Additionally, Huntington (2006) suggests that approximately 13 miles of Spencer Creek are "potential anadromous fish habitat." Based on this analysis, Spencer Creek is considered a high priority tributary.

8.11.1.3.2 Unnamed Tributary JC03

Tributary JC03 is 8.6 miles long and confluences with the Klamath River towards the upstream end of J.C. Boyle Reservoir and is believed to be perennial. The first four miles of JC03 are estimated to be of the riffle-pool bedform except for a half mile of step-pools after RM1. After RM4, the tributary is primarily characterized by step-pools with short stretches of plane-bed/riffle-pool and cascades. The headwaters of JC03 are a fish passage barrier under the gradient and length criteria. Additionally, this tributary was likely too small to have supported fish habitat (PWA 2009). Based on this analysis, JC03 is considered a low priority tributary.

8.11.1.3.3 Unnamed Tributary JC02

Tributary JC02 extends for 4.4 miles from the middle of the J.C. Boyle Reservoir. The first two miles are characterized primarily by estimated riffle-pool bedform and the upper two miles by step-pools transitioning to cascades. The gradient meets the length scale requirement to be classified as a fish passage barrier at RM 3.6. Additionally, this tributary was likely too small to have supported fish habitat (PWA 2009). Based on this analysis, JC02 is considered a low priority tributary.

8.11.1.3.4 Long Prairie Creek

Although Long Prairie Creek is believed to be perennial and stretches for 19 miles above its confluence with the Klamath River at the current upstream end of the Copco Reservoir, most of its length is unreachable for anadromous fish, due to steep reach that is likely to be a natural passage barrier at RM 0.2. Based on this analysis, Long Prairie Creek is considered a low priority tributary.

8.11.1.3.5 Deer/Indian Creek

The Deer/Indian Creek complex extends from the southern side of the Copco Reservoir and is intermittent. Deer Creek is 6.9 miles long, and the 3.4-mile long Indian Creek flows into Deer Creek 0.2 miles upstream of the latter's confluence with the Klamath. Both creeks are characterized primarily by estimated step-pool and cascade bedforms. Deer Creek has a natural passage barrier at RM 4.1 and Indian Creek has one 0.9 miles above its confluence with Deer Creek.

Coho salmon (including spawning adults and naturally-spawned juveniles) have been documented in Indian Creek (Brown and Moyle 1991; Brownell 1999), which was also identified as being one of the "highest potential" streams for the restoration of summer migratory habitat, summer rearing habitat, and winter rearing habitat (NMFS 2014). Based on this analysis, Deer Creek is considered a high priority tributary and Indian Creek is considered a low priority tributary.

8.11.1.3.6 Beaver Creek

Beaver Creek consists of a three-mile intermittent mainstem with east and west forks. A natural barrier occurs at RM 1.5 of the mainstem. The lower mile of the creek coming up from the Klamath River is characterized primarily by riffle-pool bedform, which transitions into cascades and step-pools for about a half mile before the passage barrier. Coho salmon (including juveniles) have been documented in Beaver Creek (Brownell 1999), which may contain refugia areas (NMFS 2014). Additionally, the forks of the Beaver Basin may have been steelhead or salmon habitat (PWA 2009; USDOI and NMFS 2007). Based on this analysis, Beaver Creek is considered a high priority tributary.

8.11.1.3.7 Jenny Creek

The longest of the studied tributaries, Jenny Creek is perennial and extends for 22.3 miles upstream of its confluence with Iron Gate Reservoir. The lower 3.5 miles are primarily of estimated step-pool bedforms, and the next 16 miles upstream are at a gentler slope before the gradient steepens again towards the headwaters.

Though Jenny Creek does not have reaches that meet the length and gradient criteria for a natural passage barrier as described above, field notes indicate that falls located two miles from the current reservoir limit are a natural passage barrier (RDG 2018b). In addition, a series of cascades in the first mile upstream from the current reservoir limit may be an obstacle at low flow conditions (RDG 2018b). Spawning habitat may be limited, as the visible substrate consisted mostly of boulders (RDG 2018b). However, according to PWA (2009), of the studied creeks, Jenny Creek has the greatest potential to provide quality anadromous fish habitat. More specifically, Jenny Creek contains suitable rearing habitat for Coho (USDOI and NMFS 2007), and about one mile of the creek is considered "accessible habitat" to Pacific lamprey (Hamilton 2010, as cited in Close 2010). Based on this analysis, Jenny Creek was considered a high priority tributary.

8.11.1.3.8 Dutch/Camp Creek

Dutch and Camp Creek are intermittent according to USDOI and NMFS 2007 (and consistent with recent field observations). Camp Creek is characterized by multiple channels and developed riparian vegetation at its mouth, transitioning to riffle-pool and plane-bed bedform for the lower 1.5 miles. Moving upstream, the bedform then becomes considerably more varied, spanning all classes from regime to cascade until its upstream extent at RM 8.6. The Dutch-Camp Creek confluence occurs at Camp Creek RM 1.3. Dutch Creek extends for about 3.7 miles upstream of the confluence and varies in classification largely between riffle-pool and step-pool.

It is documented to have been habitat for steelhead trout and Chinook salmon (Hamilton 2005, Hamilton 2016). Coho salmon have also been observed in Camp Creek, which is believed to provide natal rearing habitat (NMFS 2014). In fact, along with Fall Creek and Jenny Creek, the Camp/Dutch complex is named in the PWA study (2009) as one of the three tributaries to Iron Gate that may have provided "high quality" salmonid habitat, in this case particularly for spawning and non-natal rearing.

It is currently unknown whether the culvert under the road near Iron Gate Reservoir is passable (RDG 2019). This culvert is being replaced with a larger, fish passable crossing as described in Section 6.2.

Based on this analysis, Camp/Dutch Creek was considered a high priority tributary.

8.11.1.3.9 Scotch Creek

Scotch Creek is an intermittent stream that empties into the current Iron Gate Reservoir at a cove on the northern side near the mouth of the Camp/Dutch Creek complex. Scotch Creek is 8.4 miles long and flows into the post-dam course of Camp Creek approximately 1.2 miles upstream of where Camp confluences with the Klamath River mainstem. The slope analysis for Scotch Creek suggests no one bedform type is dominant in the lower 3 miles of the creek. The upper 6 miles consist mostly have step-pools with cascades toward the headwaters; a natural passage barrier occurs at RM 5.0. Historically, steelhead trout were observed in Scotch Creek (Hamilton 2005). It may also be suitable rearing habitat for Coho salmon (USDOI and NMFS 2007).

However, it is also currently unknown whether the culvert under the road near Iron Gate Reservoir is passable (RDG 2019). This culvert is being replaced with a larger, fish passable crossing as described in Section 6.2. Based on this analysis, and due to its connectivity with Camp and Dutch Creeks, Scotch Creek was considered a high priority tributary.

8.11.1.3.10 Long Gulch

Long Gulch is 2.8 miles long and flows into the eastern side of Iron Gate Reservoir. It is comprised primarily of estimated step-pool bedform through the first 2.8 miles, after which it rises steeply. An existing culvert presents an unnatural fish passage barrier at approximately at RM 0.7 (450 feet upstream of the reservoir rim). In addition, a natural passage barrier based on length and gradient criteria is located at RM 2.6. Currently, Long Gulch suffers from high turbidity and poor water quality due to cattle grazing (PWA 2009). There is an existing wetland seep along the north bank of Long Gulch that currently daylights into the Iron Gate reservoir; this wetland should be re-connected to Long Gulch following drawdown. Long Gulch also contain two historic crossings that will be removed within the reservoir area. Based on this analysis, Long Gulch was considered a low priority tributary, that will receive select structure removal actions.

8.11.1.3.11 Fall Creek

Fall Creek is located approximately 10.5 miles upstream of Iron Gate Dam and flows into the Klamath River from the north. Fall Creek's watershed is 15 square miles (USGS 2019) and discharges into the upstream, north side of Iron Gate Reservoir. Fall Creek's flow is perennial (USDOI and NMFS 2007). Fall Creek has a moderately steep to steep gradient for approximately its first mile and a steep gradient for the next approximately one-and-a-half miles. A culvert 100 feet upstream of the mouth may be a passage barrier (particularly for juvenile fish), though there has not been a formal assessment (RDG 2018a). Approximately one mile upstream of the mouth, the steep, natural falls represent the upper limit of passage for all fish life stages. The Draft EIR for the Lower Klamath Project License Surrender further identified Fall Creek as one of four "primary tributary habitat[s] available for salmonids," along with Jenny, Shovel, and Spencer Creeks (SWRCB 2018). Coho spawning was observed in Fall Creek in the past (USDOI and NMFS 2007), and about 1.2 miles of the creek were identified as "accessible habitat" for Pacific lamprey (Hamilton 2010, as cited in Close 2010).

The Fall Creek Hatchery is located on Fall Creek approximately 2000 feet upstream of the confluence with the Klamath River. Fish rearing and production at Fall Creek Hatchery ceased in 2003 (KRRC 2018a). However, KRRC plans to rehabilitate the Fall Creek Hatchery as part of the Klamath River Renewal Project. (Note that improvements to the Fall Creek hatchery are currently outside the scope of work of the Design-Build Team.)

Although Fall Creek was not included in the Definite Plan, it is included in this analysis because the Fall Creek Hatchery will become operational in the near future. Fall Creek is considered a low priority tributary, and restoration actions would be limited to providing connectivity at its confluence with the Klamath River.

8.11.2 PROPOSED RESTORATION ACTIONS

This section describes proposed restoration actions and elements that will be utilized to enhance and/or encourage reestablishment of natural processes and habitat features within priority tributaries. Specifically, restoration actions will focus on enhancing and supporting conditions for fish passage and re-establishing nodes of resilient riparian areas that will serve to support the passive expansion of habitats. The location and quantity of the restoration actions will be guided by assessment of the post drawdown conditions, channel features and characteristics.

8.11.2.1 SELECTIVE GRADING

The expanded and connected tributary confluences at the mainstem channel will allow for a range of dynamic geomorphic processes to support resilient habitat structure and fish passage conditions. Select grading will be performed as needed to:

- Remove unnatural, erosion-resistant deposits that create fish passage barriers (such as the coarse delta deposits at Jenny Creek and the Camp Creek complex)
- Stabilize un-evacuated sediment at vulnerable high-sediment-yield locations

In addition, if budget allows, additional optional grading may occur at select locations to enhance wetland and/or floodplain connectivity.

On the perennial tributaries, the existing riparian vegetation is typically located within a vertical band ranging from 1 foot to 6 feet above the channel invert; this serves as a basis for selective grading actions on the priority tributaries. In addition, selective grading may be used to lay back tributary channel banks (for example, 3H:1V slopes on alternating banks) opportunistically to mimic reference channel geometries and support revegetation. Areas for selective bank grading will be identified and prioritized based on location of other restoration actions.

8.11.2.2 LARGE WOOD FEATURES

Large wood habitat features will be introduced in key tributaries primarily to create and support microhabitats for salmonid species. Large wood features provide both short-term and long-term habitat enhancement for fish and other aquatic species and provide hydraulic variability and complexity for in-channel areas and floodplains. Relatively simple large wood features will be installed along high priority tributaries for two main functions:

- In-channel habitat enhancement that will provide cover, shade, velocity refuge, and foraging areas for fish and other aquatic species.

- In-channel hydraulic complexity, including connectivity with floodplains, providing roughness, and flow steering to enhance and encourage volitional fish passage.

8.11.2.2.1 Large Wood Design

Large wood feature design and implementation for the project will emulate natural river processes to allow all wood to be dynamic and provide long-term complexity. Each large wood feature will be strategically placed based on post-drawdown topographic and hydraulic conditions. No artificial anchoring will be used to ballast wood elements. The 60 percent design is based on anticipated geomorphic evolution at each site and is represented as total wood elements per proposed restoration area. Cultural resources will be evaluated and considered for specific wood design locations and any ground placement during implementation activities will be coordinated with cultural specialists or on-site tribal monitors.

The typical large wood habitat features will be primarily focused at tributary areas and will consist of several rootwad logs or trees placed in strategic arrangements or complexes. Large wood will be implemented using a combination of ground and aerial helicopter methods based on the specific location and post drawdown conditions. Wood will be installed at various orientations depending on function and may be clustered to increase complexity. Rootwads are an important component of the structure and when submerged provide complex cover for juvenile salmonids as well as locations for macroinvertebrates and other food sources to reside. The placement and orientation of multiple structures can be used to create areas of flow constriction, direct or turn flow, and to induce scour.

The basic design parameters for large wood structures are listed in Table 8.20. The exact design, architecture, placement locations, and material characteristics for each structure will be determined based on actual topographic field conditions after the reservoir drawdown phase.

Table 8.20 Large Wood Features

Placement Type	Type of Wood	Dimensions	Ballast Method
Ground Based Placement	Rootwad logs	12-24" Dia. 35-50-foot length	natural earth materials or dug into existing bank
Aerial Helicopter Placement	Full Length trees	18-30" Dia. 50-100 foot in length	None

8.11.2.2.2 Large Wood Stability

Mobility is defined here as displacement of placed wood by buoyant and hydrodynamic forces. Tolerances for mobility depend on the risk associated with relocation of materials. Factors of safety and other design criteria were derived from guidance from USBR's Large Woody Material Risk Based Design Guidelines, (USBR 2014). The criteria for resistance to movement is expressed as a combination of target design floods and associated factor of safety. Large wood stability calculations can be found in Appendix M.

There are two main risk considerations for large wood - public safety and property protection. The main public safety concern for the Project Area is boater safety, as the Klamath River will be used for whitewater kayaking, rafting and fishing. While this use will be focused on the mainstem of the Klamath River, rather than the tributaries where LW will be located, the Project area is preliminarily categorized as a relatively low public safety risk. This risk factor was based on hydraulic modeling and risk assessment of the primary tributaries and their interaction with the mainstem Klamath River. Hydraulic conditions for both the 10-year and 25-year event were evaluated. Once the data and output were compared to the Risk-Based Guidelines

(USBR 2014) it was determined that the appropriate category is Low for public safety. In addition, the risk of property damage for the Project area is also considered to be relatively low based on:

- Limited number of in-channel structures following dam removal, including existing bridges and future recreational boat docks.
- Limited number of structures located in the floodplain immediately downstream of the dams.
- Future land use of former reservoirs as open space.

The minimum factor of safety and design storm event for large wood stability were selected based on the values recommended by the USBR (2014) – reproduced in Table 8.21 below.

Table 8.21 Minimum Recommended Factors of Safety from USBR (2014)

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	Factor of Safety		
			Sliding	Buoyancy	Rotation and Overturning
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

SOURCE:
1. TABLE 4, LARGE WOODY MATERIAL RISK BASED DESIGN GUIDELINES, (USBR, 2014).

Due to the location of the wood placement in the reservoir areas and risk assessment, the recommended design storm event for large wood stability is the 10-year event (highlighted in green in Table 8.21). The risk level will be categorized as Low for public safety and therefore design factor of safety will be for the 10-year storm event as follows:

- Sliding – 1.25
- Buoyancy – 1.5
- Rotation & Overturning – 1.25

Preliminary stability calculations based on anticipated drawdown characteristics can be found in Appendix M. Large wood habitat features will be designed to the factor of safety specifications for the 10-year design storm event but will be highly dependent on geomorphic evolution trajectory during post-dam removal topography and corresponding hydraulic conditions. Design information based on actual post-drawdown conditions will need to be re-evaluated and refined to finalize large wood stability calculations. Although, it is important to note that under larger storm events, the habitat elements may be subject to movement and may shift within the tributary corridor and reservoir area, much like current natural wood movement and ecological processes.

8.11.2.2.3 Large Wood Placement

Large wood features will be placed at high-priority tributaries, particularly focused on the mainstem confluences and adjacent floodplain or off-channel wetlands. The location and density of large wood features will be based on post-drawdown topographic and hydraulic conditions. Onsite field representatives will determine exact geographic locality, arrangement, and architecture of each large wood complex during implementation. The density will be based on field observations and will be consistent with the Southern Oregon Northern California Coast (SONCC) Coho Salmon Recovery Plan (NMFS, 2014).

8.11.2.3 OTHER HABITAT ENHANCEMENT FEATURES

In addition to large wood, willow baffles and boulder clusters will be installed along the high priority tributaries. Both features are detailed on Sheet R0804 of the design drawings. Willow baffles are live roughness elements installed on the floodplain to reduce flow velocities and trap fine sediment. Willow baffles are proposed as short-term measures to help stabilize newly exposed channel overbank areas until riparian revegetation establishes. Willow baffles are 'hedges' of willow poles planted perpendicular to the flow direction. The poles are planted densely in trenches that are back-filled with soil and small rock, to provide some initial resistance to flow. Willow baffles will be approximately 15 to 30 feet long and should be spaced between 60 to 120 feet apart adjacent to the channel.

Small clusters of locally sourced, oversized boulders (approximately 2 to 6 feet in diameter) will also be installed at select locations along high priority tributaries to enhance habitat. The number and size of boulders will vary depending on location and function. Clusters of three to 10 boulders can be used to break up high flow fields, encourage site scale sediment sorting and provide resting for migrating adults. Generally, boulder clusters will be located with intent of preserving existing riffles, or in predicted high velocity areas to provide velocity shelter. Denser boulder fields (up to 12 boulders, depending on tributary size) may be installed adjacent to near-channel wetlands to locally elevate water levels and enhance connectivity.

Boulder clusters will be placed using land-based equipment in readily accessible areas. For the tributaries, boulders will be 2- to 4-foot diameter sourced onsite. Boulder placement will be staggered downstream, with adequate spacing between boulders to allow flow-through.

8.11.2.4 CONTINGENCY MEASURES FOR FISH PASSAGE

The 60 Percent Drawings include certain design details that may be used as contingency measures to address potential fish passage barriers that cannot be addressed through sediment removal. As described in Section 8.3, volitional fish passage may be restricted by:

- Remnant anthropogenic structures (e.g., former crossings, abandoned structures, etc.)
- Steep headcuts in residual sediment
- Natural channel bed forms

Anthropogenic structures are addressed in section 8.3.1 and natural channel bed forms do not require corrective actions. The potential for residual sediment to pose a barrier to fish passage varies from location to location. For example, prior work (GMA 2003) suggests that the existing channels in Scotch Creek and Camp/Dutch Creek are up to 16 feet higher than the historic channels due to sediment that has been deposited in the alluvial fans. In contrast, the difference in channel elevation for the deltas at Jenny and Spencer Creeks is smaller (2 to 4 feet) but could still present an incision risk. Sites will be assessed by a fisheries biologist and a restoration engineer. Remedies, if needed, will be prescribed on an individual basis. Anticipated grading volumes are presented in Section 8.4.4.

In cases where barriers exist, sediment will be removed and the channel will be excavated down to the historic invert, provided this feature is detectable in the field. The newly constructed channel must conform to previously discussed conventions in order to provide fish passage. It is generally desirable for channel slope to be less than 12 percent, but higher slopes are permissible as described in Table 8.18. Longitudinal profiles suggest that very steep slopes are present at the confluence with the Klamath River and Camp Creek (R4724), Beaver Creek (R2712), and Jenny Creek (R4721). The terminus of the deltaic deposit on Jenny Creek may also be very steep is currently targeted for grading (R4720). Jump height, channel velocity, and seasonally appropriate depth of flow are all elements of fish friendly channels and must figure into the post-drawdown channel dimensions (Table 8.3). Fringe roughness is another strategy to help facilitate fish passage.

To accomplish these objectives, the constructed channels will conform to potential restoration types and are classified by bed mix augmentation strategy as follows:

- Type I: In-situ material with no augmentation
- Type II: In situ material with cobble/boulder augmentation
- Type III: In-situ material with precise machine-placed cobble/boulder augmentation

Type I channels will be used primarily in locations where barriers are absent, where in-situ material is available for construction, or where sediment removal is the only action necessary to provide volitional fish passage. Steep channels where measured bed material size is inadequate to withstand anticipated hydraulic forces such that head cuts and fish passage barriers may form will use Type III precise machine-placed boulder/cobble bed mix and will be used to maintain grade control. This approach will likely be utilized at confluences and discrete sections of channel where the slope exceeds 4% and requires specific actions by the operator to place boulders and cobble in a desired manner. The circumstance between these two scenarios will utilize a Type II approach, which provides bed material augmentation without precise machine-placed grade control. In this case, general mixing of larger material with the in-situ bed material will occur. The sizes of the bed mixes will be determined on a case-by-case basis based on the size of in-situ material and probable hydraulic shear stresses. All gradations are subject to change based on in-situ material present following drawdown as well as other localized geomorphic processes that may be influencing bed gradation and/or bed facet type. The alignment and profile of the channel may need field adjustment and may require excavation below pre-dam ground elevations for placement of augmented bed mix within the channel footprint only.

Finally, it is important to note that much about the post-drawdown condition remains poorly understood. In some cases, absent, inadequate, or contradictory data sets limit our understanding of the project area topography. This section provides an overview of proposed actions based on our understanding of anticipated conditions. However, site circumstances may dictate actions that have not yet been contemplated.

8.11.2.5 PLANTING

The tributaries and confluences will be planted as feasible with riparian, and more opportunistically wetland, plants as described in detail in Section 8.12.

8.12 PLANTING METHODS

This section identifies the proposed planting methods for each of the proposed planting zones, as shown on Figures 8.4 to 8.6. The key plant species within these zones are described in detail in the Existing

Conditions Assessment Report (ECAR 2019). Table 8.22 cross-walks the proposed planting zones with the planting zones identified in Appendix H of the Definite Plan.

Table 8.22 Summary of Definite Plan Planting Zones

Revised 60% Planting Zones	Definite Plan Planting Zones
Wetland	Emergent Wetland
Riparian	Bank Wetland & Bank Riparian
Upland / Floodplain	Uplands Below Rocky Wake Zone & Floodplain Riparian

The following sections describe each planting zone and include a table of reference plant communities for each zone and a table that summarizes proposed revegetation sequence and methods for each planting zone.

The Revegetation Methods tables sequence revegetation actions in numerical order. These actions begin with the most common uniform treatments. Subsequent actions build on earlier actions and are more targeted.

The first revegetation action is common across the three-reservoir drawdown areas.

- Seed: pioneer upland mix with straw mulch
- Seed: pioneer wetland/riparian mix with straw mulch
- Selectively supplement areas seeded with pioneer wetland/riparian mix by adding saltgrass plugs and milkweed rhizomes

The second revegetation action is common across the three-reservoir drawdown areas with two different upland mixes.

- Seed: wetland/riparian diversity mix (one mix for all reservoirs with some site-specific additions)
- Seed: upland diversity mix (one mix for all reservoirs with some site-specific additions)

Subsequent revegetation actions are specific to the Planting Zone.

- For the Riparian Zone types these actions include:
  - Cuttings (¼ to 1-inch diameter)
  - Pole Cuttings (1-1/2 to 3-inch diameter)
  - Bareroot shrubs
  - Bareroot trees
  - Salvaged wetland/riparian woody species
  - Salvaged wetland/riparian sod
- For the Wetland Zone types these actions include:
  - Herbaceous bareroot
  - Sod transplant
  - Cuttings
  - Pole cuttings
  - Bareroot shrubs
  - Bareroot trees
  - Salvaged wetland/riparian woody species

  - o Salvaged wetland/riparian sod
- For the Upland/Floodplain Zone these actions include:
  - o Bareroot shrubs all reservoirs
  - o Bareroot trees all reservoirs

Mid-channel islands are anticipated at Copco. Access to these areas may be difficult post drawdown so the RES Team proposes seeding them with either the upland or wetland/riparian mix depending upon elevation above channel. Additional planting may be added where access is possible.

In all planting zones, it is anticipated not that 100 percent of the pre-impoundment ground surface would be suitable for vegetation establishment. For example, areas underlain by bedrock, talus, or scree with only a thin veneer of reservoir sediments are not likely to support vegetation activities. Prior to impoundment, these areas likely supported sparse to no vegetation, so it would be unrealistic to expect that vegetation could be established after the reservoirs are drawn down. These areas will be identified in the field post-drawdown and will receive a modified revegetation approach, or no attempt will be made to force revegetation.

8.12.1 RIPARIAN

The plant species proposed to be planted in the riparian zone along the mainstem channel margin of the Klamath River, along perennial tributaries and locally at intermittent and perennial confluences will include species from the existing cover types shown in Table 8.23.

Table 8.23 Reference for Proposed Riparian Planting

Location	Vegetation Cover Types (PacifiCorp 2004)
J.C. Boyle	Riparian Mixed Deciduous-Coniferous Riparian Shrub
Copco No. 1	Riparian Mixed Deciduous-Coniferous Riparian Deciduous Riparian Shrub
Iron Gate	Riparian Deciduous Riparian Shrub

For the purposes of 60 percent design costing, the RES Team is proposing an average 50-foot wide planted riparian corridor along both sides of the mainstem and an average 30-foot planted riparian corridor along both sides of tributary channels. Riparian vegetation is proposed up to the edge of the reservoir footprint. Reservoir independent wetland and riparian vegetation has been documented along the reservoir margins. This vegetation will be protected in place to the maximum extent practicable.

Widths will be adjusted during construction to better fit actual post drawdown channel bank topography and selective grading relative to adjacent water surface elevations. Species distribution in these areas will be refined based on land surface elevation and hydrologic connectivity described in Section 8.5.

These riparian areas will be planted with a mix of seed, cuttings, pole cuttings, salvaged plants and bareroot material. The revegetation methods for each of the proposed communities is shown in Table 8.24.

Table 8.24 Riparian Revegetation Methods

Planting Zone	Installation Methods
Riparian Shrub	1. Seed: pioneer riparian/wetland mix with straw mulch 2. Seed: riparian/wetland diversity mix 3. Cuttings (10’ o.c., 25% of area) 4. Bareroot shrubs (10’ o.c., 25% of area)
Riparian Deciduous & Riparian Mixed Deciduous Coniferous	1. Seed: pioneer riparian/wetland mix with straw mulch 2. Seed: riparian/wetland diversity mix 3. Cuttings (10’ o.c., 25% of area) 4. Bareroot shrubs (10’ o.c., 10% of area) 5. Pole Cuttings (40’ o.c., 25% of area) 6. Bareroot trees (40’ o.c., 10% of area)

The woody species prioritized for propagation and/or collection for riparian planting are summarized in Table 8.25, Table 8.26, and Table 8.27. Actual planting mix species composition, including species percentages, will be determined during final design and will be based on the results of seed collection and grow-out activities.

Table 8.25 Riparian Shrub

Scientific Name	Common Name	Strata
Alnus rhombifolia	white alder	Tree Layer
Fraxinus latifolia	Oregon ash	Tree Layer
Salix exigua	coyote willow	Tree Layer
Salix lasiolepis	arroyo willow	Tree Layer
Prunus virginiana	chokecherry	Tree Layer
Cornus glabrata	smooth dogwood	Shrub Layer
Philadelphus lewisii	mock orange	Shrub layer
Sambucus nigra	blue elderberry	Shrub Layer
Spiraea douglasii	rose spirea	Shrub Layer
Symphoricarpos albus	common snowberry	Shrub Layer

Table 8.26 Riparian Deciduous

Scientific Name	Common Name	Strata
Alnus rhombifolia	white alder	Tree Layer
Betula occidentalis	water birch	Tree Layer
Fraxinus latifolia	Oregon ash	Tree Layer
Quercus garryana	Oregon white oak	Tree Layer
Salix exigua	coyote willow	Tree Layer
Salix lasiolepis	arroyo willow	Tree Layer
Salix lucida ssp. Lasiandra	shining willow	Tree Layer
Cornus glabrata	smooth dogwood	Shrub Layer
Rhus trilobata	skunkbush sumac	Shrub Layer

Table 8.27 Riparian Mixed Deciduous-Coniferous

Scientific Name	Common Name	Strata
Alnus rhombifolia	white alder	Tree Layer
Amelanchier alnifolia	western serviceberry	Tree Layer
Betula occidentalis	water birch	Tree Layer
Fraxinus latifolia	Oregon ash	Tree Layer
Pinus ponderosa	ponderosa pine	Tree Layer
Pseudotsuga menziesii	Douglas-fir	Tree Layer
Salix exigu	coyote willow	Tree Layer
Salix lasiolepis	arroyo willow	Tree Layer
Berberis aquifolium	Oregon grape	Shrub Layer
Physocarpus capitatus	ninebark	Shrub Layer
Spiraea douglasii	rose spirea	Shrub Layer
Symphoricarpos albus	common snowberry	Shrub Layer

8.12.2 WETLANDS

The plant species proposed to be planted in the wetland areas include species from the existing cover types shown in Table 8.28.

Table 8.28 Reference for Wetland Planting

Location	Vegetation Cover Types (PacifiCorp 2004)
J.C. Boyle	Palustrine Emergent Wetland Palustrine Shrub-Scrub Wetland
Copco No. 1 and Iron Gate	Palustrine Emergent Wetland Palustrine Shrub-Scrub Wetland Palustrine Forested Wetland

Wetland areas are proposed to be planted with a mix of seed, salvaged sod, cuttings, pole cuttings, salvaged plants and bareroot material. The revegetation methods for each of the proposed communities is shown in Table 8.29.

Table 8.29 Wetland Revegetation Methods

Planting Zone	Installation Methods
Palustrine Emergent Wetland	1. Seed: pioneer riparian/wetland mix with straw mulch 2. Seed: riparian/wetland diversity mix 3. Bareroot herbaceous (4’ o.c., 25% of area) 4. Sod transplant (10% of area)
Palustrine Shrub-Scrub Wetland	1. Seed: pioneer riparian/wetland mix with straw mulch 2. Seed: riparian/wetland diversity mix 3. Bareroot herbaceous (4’ o.c., 20% of area) 5. Cuttings (10’ o.c., 20% of area) 6. Bareroot shrubs (10’ o.c., 20% of area)
Palustrine Forested Wetland	1. Seed: pioneer riparian/wetland mix with straw mulch 2. Seed: riparian/wetland diversity mix 3. Bareroot herbaceous (4’ o.c., 20% of area) 5. Cuttings (10’ o.c., 10% of area) 6. Bareroot shrubs (10’ o.c., 10% of area) 7. Pole Cuttings (40’ o.c., 10% of area) 8. Bareroot trees (40’ o.c., 10% of area)

The woody species prioritized for propagation and/or collection for wetland planting are summarized in Table 8.30, Table 8.31, and Table 8.32. Actual planting mix species composition, including species percentages, will be determined during final design and will be based on the results of seed collection and grow-out activities.

Table 8.30 Palustrine Emergent Wetland

Tree and shrub species are not proposed for this planting zone.

Table 8.31 Palustrine Scrub-Shrub Wetland

Scientific Name	Common Name	Strata
Fraxinus latifolia	Oregon ash	Tree Layer
Prunus virginiana	chokecherry	Tree Layer
Quercus garryana	Oregon white oak	Tree Layer
Salix exigua	coyote willow	Tree Layer
Salix lasiolepis	arroyo willow	Tree Layer
Salix lucida ssp. Lasiandra	shining willow	Tree Layer
Chrysothamnus nauseosus	gray rabbitbrush	Shrub Layer
Cornus sericea	red-osier dogwood	Shrub Layer
Philadelphus lewisii	Lewis’ mock orange	Shrub Layer
Rhus trilobata	skunkbush sumac	Shrub Layer
Spiraea douglasii	rose spirea	Shrub Layer

Table 8.32 Palustrine Forested Wetland

Scientific Name	Common Name	Strata
Acer macrophyllum	bigleaf maple	Tree Layer
Alnus rhombifolia	white alder	Tree Layer
Fraxinus latifolia	Oregon ash	Tree Layer
Quercus garryana	Oregon white oak	Tree Layer
Salix exigua	coyote willow	Tree Layer
Salix lasiolepis	arroyo willow	Tree Layer
Salix lucida ssp. Lasiandra	shining willow	Tree Layer
Berberis aquifolium	Oregon grape	Shrub Layer
Cornus glabrata	smooth dogwood	Shrub Layer
Rhus trilobata	skunkbush sumac	Shrub Layer

8.12.3 FLOODPLAIN

With additional analysis and field observations we have a better understanding of the site conditions constraining the development of riparian floodplain forest on the Klamath River. The channel is confined in narrow steep valleys for much of its length, which limits the number of wide floodplain areas. In addition, the Klamath Irrigation Project will remain in place limiting peak flows and high-flow durations downstream in the restored reservoir areas. Combined, these factors greatly limit the area, depth, frequency and duration of inundation adjacent to the Klamath River. In areas where these conditions combine to support water-dependent vegetation revegetation will favor riparian or other wetland plant communities. Areas without adequate hydrology will be treated as uplands.

8.12.4 UPLANDS

The plant species proposed to be planted in the upland zones include species from the cover types shown in Table 8.33.

Table 8.33 Reference for Upland/ Floodplain Planting

Location	Vegetation Cover Types (PacifiCorp 2004)
J.C. Boyle	Klamath Mixed Conifer Ponderosa Pine Sagebrush Mixed Chaparral Perennial Grasslands
Copco No. 1	Montane Hardwood Oak Montane Hardwood Oak-Conifer Montane Hardwood Oak-Juniper Juniper Woodland Klamath Mixed Conifer Mixed Chaparral Perennial Grasslands

Location	Vegetation Cover Types (PacifiCorp 2004)
Iron Gate	Montane Hardwood Oak Montane Hardwood Oak-Juniper Juniper Woodland Mixed Chaparral Perennial Grasslands

Planting of all upland areas extending out to the footprint of the reservoirs is proposed. The areas will be planted with a mix of seed and bareroot material. The spacing and percent of area planted for the woody species below is intended to provide an overall planting cost for the project. Planting density and percent cover can be locally increased or decreased post drawdown to better fit site-specific topography and underlying substrate. For example, currently inundated reservoir areas that are presently underlain by bedrock, talus, or scree with only a thin veneer of reservoir sediments are likely not suitable for establishment of vegetation. The revegetation methods for each of the proposed communities is shown in Table 8.34 and Table 8.35.

Table 8.34 Upland / Floodplain Revegetation Methods Iron Gate and Copco

Planting Zone	Installation Methods
Upland / Floodplain	1. Seed: pioneer upland mix with straw mulch 2. Seed: upland diversity mix 3. Bareroot shrubs (10’ o.c., 25% of area) 4. Bareroot trees (80’ o.c., 50% area)

Table 8.35 Upland Revegetation Methods J.C. Boyle

Planting Zone	Installation Methods
Upland / Floodplain	1. Seed: pioneer upland mix with straw mulch 2. Seed: upland diversity mix 3. Bareroot shrubs (10’ o.c., 25% of area) 4. Bareroot trees (40’ o.c., 75% of area)

The woody species prioritized for propagation and/or collection for upland/floodplain planting are summarized in Table 8.36, Table 8.37, and Table 8.38. Actual planting mix species composition, including species percentages, will be determined during final design and will be based on the results of seed collection and grow-out activities.

Table 8.36 Iron Gate Upland

Scientific Name	Common Name	Strata
Amelanchier alnifolia	western serviceberry	Tree Layer
Juniperus occidentalis	western juniper	Tree Layer
Prunus emarginata	bitter cherry	Tree Layer
Prunus subcordata	Klamath plum	Tree Layer
Quercus garryana	Oregon white oak	Tree Layer
Quercus kelloggii	California black oak	Tree Layer

Scientific Name	Common Name	Strata
Berberis aquifolium	Oregon grape	Shrub Layer
Ceanothus cuneatus	buckbrush	Shrub Layer
Ceanothus integerrimus	deerbrush	Shrub Layer
Cercocarpus betuloides	birchleaf mountain mahogany	Shrub Layer
Cornus glabrata	smooth dogwood	Shrub Layer
Lonicera interrupta	chaparral honeysuckle	Shrub Layer
Philadelphus lewisii	Lewis' mock orange	Shrub Layer
Purshia tridentata	antelope bitterbrush	Shrub Layer
Rhus trilobata	skunkbush sumac	Shrub Layer
Ribes velutinum	desert gooseberry	Shrub Layer
Rosa woodsia	wood rose	Shrub Layer
Sambucus nigra	blue elderberry	Shrub Layer
Symphoricarpos albus	common snowberry	Shrub Layer

Table 8.37 Copco Upland

Scientific Name	Common Name	Strata
Acer macrophyllum	bigleaf maple	Tree Layer
Amelanchier alnifolia	western serviceberry	Tree Layer
Calocedrus decurrens	incense cedar	Tree Layer
Juniperus occidentalis	western juniper	Tree Layer
Prunus emarginata	bitter cherry	Tree Layer
Prunus subcordata	Klamath plum	Tree Layer
Quercus garryana	Oregon white oak	Tree Layer
Quercus kelloggii	California black oak	Tree Layer
Berberis aquifolium	Oregon grape	Shrub Layer
Ceanothus cuneatus	buckbrush	Shrub Layer
Ceanothus integerrimus	deerbrush	Shrub Layer
Cercocarpus betuloides	birchleaf mountain mahogany	Shrub Layer
Cornus glabrata	smooth dogwood	Shrub Layer
Lonicera interrupta	chaparral honeysuckle	Shrub Layer
Philadelphus lewisii	Lewis' mock orange	Shrub Layer
Rhus trilobata	skunkbush sumac	Shrub Layer
Ribes velutinum	desert gooseberry	Shrub Layer
Rosa woodsia	wood rose	Shrub Layer
Sambucus nigra	Blue elderberry	Shrub Layer
Symphoricarpos albus	common snowberry	Shrub Layer
Purshia tridentata	antelope bitterbrush	Shrub Layer

Table 8.38 J.C. Boyle Upland

Scientific Name	Common Name	Strata
Amelanchier alnifolia	western serviceberry	Tree Layer
Pinus ponderosa	ponderosa pine	Tree Layer
Prunus subcordata	Klamath plum	Tree Layer
Prunus virginiana	chokecherry	Tree Layer
Pseudotsuga menziesii	Douglas-fir	Tree Layer
Quercus garryana	Oregon white oak	Tree Layer
Arctostaphylos patula	greenleaf manzanita	Shrub Layer
Artemisia tridentata	big sagebrush	Shrub Layer
Berberis aquifolium	Oregon grape	Shrub Layer
Ceanothus cuneatus	buckbrush	Shrub Layer
Ceanothus integerrimus	deerbrush	Shrub Layer
Cercocarpus betuloides	birchleaf mountain mahogany	Shrub Layer
Chrysothamnus nauseosus	gray rabbitbrush	Shrub Layer
Ericameria linearifoli	linear–leaf ericameria	Shrub Layer
Philadelphus lewisii	Lewis' mock orange	Shrub Layer
Purshia tridentata	antelope bitterbrush	Shrub Layer
Rhus trilobata	skunkbush sumac	Shrub Layer
Ribes velutinum	desert gooseberry	Shrub Layer
Rosa gymnocarpa	dwarf rose	Shrub Layer
Symphoricarpos albus	common snowberry	Shrub Layer

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

SECTION 9.0 COMPLIANCE WITH REGULATORY AND KRRC REQUIREMENTS

PAGES 138 TO 162

10.0 LIMITATIONS

This report was prepared by the Project Team (Kiewit Infrastructure West Co., Knight Piésold, Environmental Science Associates, Stantec, Resource Environmental Solutions, Camas) for the account of the Klamath River Renewal Corporation. Report content reflects the Project Team's best judgement based on the information reviewed at the time of preparation. Any use a third party makes of this report, or any reliance on or decisions made based on it is the responsibility of such third parties. The Project Team accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. Any reproductions of this report are uncontrolled and might not be the most recent revision.

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12.0 CERTIFICATION

This report is the product of a collaborative effort by several authors and reviewers from the Project Team (Kiewit Infrastructure West Co., Knight Piésold, Resource Environmental Solutions, Environmental Science Associates, Stantec, Camas).

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APPENDIX A

Design Criteria

APPENDIX A1

Project Notation, Units, and Conversion

(Pages A1-1 to A1-2)

APPENDIX A1
PROJECT NOTATION, UNITS, AND CONVERSION

1.0 PROJECT NOTATION

1.1 STANDARD UNITS

The standard units for the design of the project will be the following US Customary Units:

- Length: inch (in), feet (ft) and mile (mi)
- Area: acres
- Volume (reservoir): acre-feet (acre-ft)
- Volume (fluid): US gallons, million US gallons (gal, Mgal)
- Volume (concrete, earthfill): cubic yard (yd3)
- Mass: pound (lb), short tons (tons)
- Density: pounds per cubic foot (pcf)
- Pressure: pound-force per square foot (psf)
- Temperature: degrees Fahrenheit (°F)
- Power: horsepower (hp)
- Flow rate: cubic foot per second (cfs), cubic foot per minute (cfm) gallons per minute (gpm)

1.2 CONVERSIONS TO OTHER US CUSTOMARY UNITS

Other US Customary Units will also be used for preparation of the design. These units and conversion factors from the standard units (unless otherwise indicated) will be the following:

- Length: 1 ft = 12 inches (in)
- Length: 1 yard (yd.) = 3 ft
- Length: 1 mile (mi) = 5,280 ft
- Area: 1 acre = 43,560 square feet (sq. ft)
- Volume: 1 acre-ft = 43,560 cubic feet (ft^3)
- Volume: 1 acre-ft = 1,613 cubic yards (yd^3)
- Fluid volume: 1 Mgal = 1,000,000 gallons (gal)
- Mass: 1 ton = 2,000 pounds (lbs)
- Density: 1 short ton per cubic yard ($tons/yd^3$) = 74 pcf
- Pressure: 1 pound-force per square inch (psi) = 144 psf
- Pressure: 1 kilopound per square inch (ksi) = 1,000 psi

1.3 CONVERSIONS TO INTERNATIONAL SYSTEM OF UNITS (SI)

Typical conversion factors to the International System of Units (SI) from the standard units for the project are the following:

- Length: 1 ft = 0.305 meters (m)
- Length: 1 yd. = 0.914 m

- Length: 1 mi = 1.61 kilometers (km)
- Diameter: 1 in = 25.4 millimeters (mm)
- Area: 1 acre = 4,047 square meters (m^2)
- Area: 1 acre = 0.405 hectare (ha)
- Volume: 1 acre-ft = 1,233 cubic meters (m^3)
- Volume: 1 yd^3 = 0.765 m^3
- Volume: 1 ft^3 = 0.028 m^3
- Fluid volume: 1 gal = 3.785 litres (L)
- Fluid volume: 1 Mgal = 3,785 m^3
- Mass: 1 ton = 907 kilograms (kg)
- Mass: 1 ton = 0.907 tonnes (t)
- Density: 1 pcf = 16 kilograms per cubic meter (kg/m^3)
- Density: 1 pcf = 0.016 tonnes per cubic meter (t/m^3)
- Density: 1 $tons/yd^3$ = 1.19 tonnes per cubic meter (t/m^3)
- Pressure: 1 psf = 0.048 kilopascal (kPa)
- Pressure: 1 psi = 6.89 kilopascal (kPa)
- Power: 1 hp = 746 watts (W)
- Flow rate: 1 gpm = 0.227 cubic meters per hour (m^3/hr)
- Flow rate: 1 gpm = 0.063 litres per second (L/s)

APPENDIX A2

Mapping, Surveys, and Site Controls

(Page A2-1)

APPENDIX A2
MAPPING, SURVEYS, AND SITE CONTROLS

1.0 OVERVIEW

Project area mapping to document the existing site conditions across the project site was undertaken by the US Department of the Interior (USDOI) in 2009. LiDAR and 3D breaklines for approximately 170 miles on the Klamath River from Link River Dam, OR to the confluence with Elk Creek south of Happy Camp, CA, and surveys along with above and in-water cross-sections at each of nine bridges, were included in the study area (USDOI, 2010). The map projection for the project is as follows:

- Projection: California State Plane:
  - Zone: 1
  - Fipszone: 0401
  - Vertical Datum: NAVD 1988
  - Horizontal Datum: NAD83
  - Unit: Feet

Site control will be established and verified by the Contractor. Scale factors will be established for the entire site for use in ground to UTM coordinate conversions if required.

Survey control will be established through surveyed benchmarks across the site. Benchmarks are expected to be established at the intake locations, along the penstock routes and at the powerhouse & switchyard locations. Benchmarks will also be established along the transmission line alignments and at major bridge and road crossings.

The Contractor will establish any other control points and benchmarks necessary to set out and construct the Works.

2.0 REFERENCES

US Department of the Interior, Bureau of Reclamation (USDOI), 2010. *Klamath River Dams Project Geospatial Base Map Data Dictionary.* Denver, Technical Service Center, Environmental Services Division Colorado, USA.

APPENDIX A3

Geological Setting

(Pages A3-1 to A3-2)

APPENDIX A3
GEOLOGICAL SETTING

1.0 GENERAL

The Klamath River traverses multiple physiogeographic provinces starting in the Basin and Range Province of Oregon, traversing the High and Western Cascades, Klamath Mountains Province and the Coastal Ranges of northern California, and reaching the Pacific Ocean at Requa, 16 miles south of Crescent City. The Project area is predominantly contained in the Western and High Cascades. The Klamath River pre-dates the formation of the Cascade Mountain Range and maintained a relatively similar course through the mountain building events.

The bedrock of the Project Area comprises volcanic rocks (up to 45 million years old) and includes basalt and andesite lava flows, tuffs, tuff-breccias and volcaniclastic sandstone. The volcanic rocks are intruded by numerous dikes and plugs of andesite, rhyolite, and basalt. Many of the volcanoes associated with the Western Cascades have since eroded, but large shield volcanoes and vents of the High Cascades remain and are still active in present times.

Large deposits of coarse alluvium were deposited along the Klamath River during the period of the last glaciation when the river had a higher discharge. Lacustrine deposits were laid down in former temporary lakes that were created at the present-day sites of the Copco I and J.C. Boyle Reservoirs when the Klamath River was temporarily ‘dammed’ by volcanic activity.

2.0 J.C. BOYLE HEF

The topography in the area of the J.C. Boyle HEF is predominantly a low-gradient bowl with gently rolling terrain. The steepest topography exists in the river canyons upstream and downstream of the reservoir. All the bedrock units in the area are estimated to be younger than 5 Ma and associated with High Cascades volcanism from large stratovolcanic complexes and smaller shield volcanoes and vents; these are typically basaltic flows interlayered with volcaniclastics and hydrovolcanic deposits, leading to highly complex geology from a large variety of sources.

Faulting is very prominent in the J.C. Boyle Reservoir area and appears to be associated with extensional tectonics of the Basin and Range Province that began approximately 1.5 to 2.0 Ma ago. The bowl topography of the reservoir area likely formed as a dropped-down basin. At least one fault splay is predicted to extend into the dam area (PanGEO, 2008).

The surficial deposits at the reservoir comprise lacustrine deposits as well as river alluvium and local colluvial deposits. The lacustrine deposits comprise older sediments that were laid down in a former lake that was created when the river was temporarily ‘dammed’ by volcanic activity and recent sediments, which were deposited within the reservoir.

3.0 COPCO NO. 1 AND COPCO NO. 2 HEF’S

The area surrounding the Copco No. 1 and Copco No. 2 reservoirs is characterized by hillsides comprised of low gradient lava flows from surrounding shield volcanoes. The Copco Basalt (0.14 Ma) makes up the vertical upper walls of the canyon in the vicinity of the dam site. The Copco Basalt was created by volcanic flows from vents on both sides of the river, which led to damming of the river and the formation of a lake in the same area as the present-day reservoir. The Western Cascades Volcanics underlie most of the slopes on the shoreline of the reservoir. This unit comprises andesite with interstratified tuff-breccia, volcaniclastic sandstone and tuffs.

Small faults that have been historically mapped in the area of the Copco I and II HEF's typically trend west to northwest south of the river. Limited structural mapping of faults north of the river shows a northward trend.

The surficial deposits at the Copco I Reservoir comprise lacustrine deposits as well as river alluvium and local colluvial deposits. The lacustrine deposits mainly comprise sediments that were laid down in a former lake that was created when the river was temporarily 'dammed' by volcanic activity. Fine sediments, comprising silts and diatomite (siliceous skeletal remains of diatoms) were deposited in the lake. The formation of the lake resulted in fluvial terraces and fans developing further still from the contemporary course of the river. Recent lacustrine deposits have accumulated within the reservoir since its construction. Colluvium occurs locally around the shoreline of the Copco II Reservoir.

Natural groundwater springs can be observed and typically exist in the tuffaceous layers between impermeable lava flows and along lithological contacts. The rapidly cooled more porous lava flow tops and bottoms are common aquifers in the region.

4.0 IRON GATE HEF

The Iron Gate Dam and its reservoir lie entirely within the Western Cascades Geologic Province. The bedrock around the shoreline comprises andesite and basalt with volcanic breccia, tuff, tuffaceous siltstones and sandstones. The Western cascades strata dip gently towards the east. Surficial deposits around the reservoir shoreline include colluvium and local alluvial deposits at drainage line intersections.

Natural springs are also found in numerous locations on the valley slopes surrounding the Iron Gate Reservoir.

5.0 REFERENCES

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APPENDIX A4

Geomorphology

(Pages A4-1 to A4-4)

APPENDIX A4 GEOMORPHOLOGY

Evidence for the geomorphic character of the Klamath River through the Project area comes from historic aerial and oblique photos that predate the dams, maps, and the bathymetric surface. Additional characterization has been performed by PacifiCorp (2004), Graham Matthews and Associates, AECOM, River Design Group and others.

The Klamath River is almost entirely a single thread channel in the Project area. The exposed reaches between the reservoirs are mostly classified as Rosgen type Bc (gentle slopes, low meander widths, and a moderately entrenched active channel with little floodplain), C (slightly entrenched in well-developed floodplains with pool-riffle bedform morphology) and F channels (entrenched, meandering channels and are typically deeply incised in valleys of relatively low relief containing highly erodible materials) (PacifiCorp, 2004). The mainstem is mostly relatively low sinuosity (less than 1.2).

Under the Montgomery-Buffington (Buffington and Montgomery, 2013) classification scheme the exposed channel reaches of the Project area are a combination of bedrock, cascade (especially in the steeper reaches around J.C. Boyle reservoir), plane bed (especially the J.C. Boyle bypass and peaking reaches), and riffle-pool (mostly around Iron Gate Reservoir). Bedrock and cascade reaches are considered to be transport reaches and are not expected to store much finer (e.g. gravel sized) sediment. Plane bed and, especially, rifle-pool reaches can potentially store alluvial sediment if it is delivered to them from upstream.

1.0 J.C. BOYLE

As described in KRRC (2018), the J. C. Boyle Reservoir is characterized by two main reaches: the upstream reach and the (lower) canyon reach. The upstream reach, which extends from the Highway 66 Bridge to the upstream extent of J.C. Boyle Reservoir (USGS RM 231 to 233), is a wide, low relief reach that lies between the (lower) canyon reach and the narrow bedrock canyon (Keno Canyon) upstream of RM 233. This reach is mostly alluvial (with the exception of a bedrock control approximately 1,000 feet upstream of RM 232) and was historically supplied by sediment from the tributary alluvial fans. Spencer Creek had a large alluvial fan and possibly a narrow floodplain on the edge of the alluvial fan. Spencer Creek was multi-threaded near its confluence with the Klamath River in 1952 (pre-dam) and likely supported wetlands. A large, semi-vegetated mid-channel bar in the mainstem river existed upstream of the Highway 66 Bridge in a 1952 photo. During high flows, the river actively modified its channel and floodplain and much of the current reservoir was shallowly flooded (KRRC, 2018). Sampling of post-dam sediment in the reservoir indicates that this reach has typically less than 4 feet of mostly sandy aggraded sediment (55% sand, 25% silt, 20% clay) with the majority of it in the old river channel, with a 1,000-foot sub-reach around RM 231 where sediment depths are around 8-10 feet and spread beyond the old river channel. The upper reach is one of the few areas within the Project area where active floodplain and channel bar formation appear to have occurred in pre-dam conditions, making this a reach where there is potential for restoration of channel-floodplain connectivity and complex aquatic and riparian habitat. The 2-year floodplain extends up to 800 feet at its widest point, and the 100-year floodplain extends 1,700 feet.

The (lower) canyon reach extends from J.C. Boyle Dam upstream to the Highway 66 Bridge (USGS RM 230-231). Prior to the construction of the dam, this reach was a deep, narrow valley which had incised multiple tens to hundreds of feet into the volcanic bedrock, forming a confined bedrock canyon with limited space for sediment storage. The channel form in this reach was a mix of cobble, boulder and bedrock, and likely characterized by plane-bed and broadly stepped morphology. Post-dam sediment in this reach is finer than in the upstream reach: 90% silt or clay. [redacted] The confinement of this reach is demonstrated by the relative lack of expansion between the modeled width of the channel, 2-year and 100-year flow surfaces, which are 100-200 feet wide in most of the reach (KRRC, 2018).

2.0 COPCO NO. 1

Copco 1 Reservoir (Copco 1) is located at a topographic transition on the inundated Klamath River, whereby roughly the upper 80 percent of the reservoir is sitting atop a formerly lower-gradient, wider-valley reach of river, with the downstream portion of the reservoir, and dam site, atop a reach of river confined by very steep, basalt-derived cliffs (PWA, 2009). Copco 1 is geologically and topographically distinct from J.C. Boyle and Iron Gate Reservoirs due to the flat valley floor created by ancient diatomite deposits in the upstream sections. Pre-dam, the Klamath River in Copco 1 was a sinuous, generally single-thread (except where split by bedrock islands) channel inset into diatomite. The pre-dam channel was actively eroding through the fine-grained, erosion-resistant diatomite both laterally and vertically, leaving gradual slopes with alluvium on the inside of meander bends and steep to vertical bluffs of diatomite sometimes ten or more feet in height on the outside of meander bends up to RM 205. The diatomite formed vertical bluffs on the outside of many meanders: due to the porous but slow-draining nature of the rock these bluffs are considered susceptible to land sliding during rapid reservoir drawdown, creating a constraint on the rate at which Copco 1 can be drained. Side channels, remnant meanders, and swales in the pre-dam topography all indicate that the river was actively modifying its floodplain, although point bars were not noted in historical records and the degree of alluviation is uncertain. Copco 1 is also distinct in that it has trapped the most sediment as a percentage of its volume (14.6%), likely due to a combination of it being in an area with substantial topographic relief, a high trapping efficiency, and being behind the oldest dam (completed in 1922) in the system.

Copco 1 was divided into an upstream and downstream reach by KRRC (2018). The upstream reach extends from RM205 to 208 and is more confined than the downstream reach, with a low sinuosity channel and moderate width 100-year floodplain (typically 300-500 feet wide). Post-dam sediment deposits in the upstream reach are shallower but coarser than the downstream reach, with 25% sand, 45% silt and 30% clay underlain by (assumed to be pre-dam) fluvial deposits of sand with traces of gravel. In the downstream reach (from Copco Dam below RM202 to RM205) the pre-dam river had created a wider floodplain in the diatomite and has a much more sinuous planform as well as meander cut-offs and other alluvial features. Hydraulic modeling shows several narrow areas where the 2-year flow is 100-200 feet wider than the channel flow (indicating frequently active floodplain) as well as several areas where the 100-year floodplain is 500-800 feet wide (KRRC, 2018). Post-dam sediments are finer than upstream, with 55% clay, 45% silt and 10% sand, [redacted].

Though the Copco 1 downstream reach is generally wider, the downstream end (approximately the downstream 1000 feet of the inundated reservoir) of this reach marks the entrance to a steeper canyon section, whereby the pre-dam channel becomes confined by very steep, basalt-derived cliffs (PWA, 2009).

In this section the Copco 1 dam overlies an ancient canyon filled with an unconsolidated mass of boulders, gravel, sand, and other detritus, extending approximately 100 feet below the pre-dam channel bed.

3.0 COPCO NO. 2

Copco No. 2 (Copco 2) dam is approximately 1,715 feet downstream of Copco 1 and within a steeper section of the narrow bedrock canyon that begins just upstream of Copco 1 (however, Copco 2 is not underlain with material to the same extent or depth as Copco 1). Copco 2 dam diverts most of the flow of the river via a flume and tunnels around a canyon section of the Klamath River (referred to as the Copco 2 Bypass Reach). Copco 2 reservoir is very narrow, only approximately 2,000 feet long, and has a storage volume of only 70 acre-feet, so it is therefore small in comparison to the other reservoirs in the project.

PacifiCorp 2004 (Appendix 6A) includes a reference reach approximately 3,000 feet downstream of Copco 2 dam. The bankfull channel width is unclear from the cross sections but appear to be in the order of 70-90 feet and bed materials had a D50 of 85-252 mm. Existing and historic channel slopes in the Copco 2 Bypass Reach are relatively steep and generally range from 1 to 3 percent.

There is a steep, boulder/step-pool reach beginning approximately 600 feet downstream of Copco 2 and extending for another approximately 400 feet. The top of this step pool reach has low erosion potential and will likely control grades upstream. This reach is organized into a series of step-pool formations controlled by jams of very large to huge boulders. The supply of boulders to this reach appears, for the most part, to be the talus slope on the north side of the channel; the talus slope extent is roughly coincident with the extent of the steep, boulder/step-pool reach. Based on field observations and other empirical data, the top of the step pool reach, is considered a grade control point. The step-pool reach appears to have been in existence for many decades (e.g. present in 1953 aerial photos) and has withstood several large events during this time, including the apparent flood of record for the Klamath River based on over 150 years of flow data on the lower river.

4.0 IRON GATE

As described in KRRC (2018), prior to dam construction the river had low to moderate sinuosity and was mostly a single–thread channel. It was located in a narrow canyon incised into bedrock. Longitudinally, the Iron Gate reach was relatively uniform except where locally influenced by tributary sediment delivery. The channel bottom includes bedrock exposures with boulders deposited by hillslope mass movement processes which formed rapids, as well as more alluvial reaches influenced by sediment delivered from the larger tributary alluvial fans.

The Iron Gate Reservoir area can be divided into two reaches, the upstream reach (from the upstream end of the reservoir down to the Mirror Arm/Camp Creek confluence near RM 195) and the downstream reach (upstream of the Mirror Arm/Camp Creek confluence near RM 195 to Iron Gate Dam). The upstream reach was topographically confined and had a narrow floodplain and channel (typically 10-200 feet wide), with little difference between the 2-year and 100-year floodplain widths (KRRC, 2018). In pre-dam photos the upstream reach largely lacked in-channel geomorphic features with the exception of those at the Jenny Creek confluence, which likely contributed considerable amounts of sediment (USBR, 2010). Downstream of the Fall Creek confluence and near RM 199, the bottom of the valley widened and there were mapped terraces and alluvial fans (USBR, 2011). [redacted]

[redacted]

The downstream reach is slightly less confined than upstream, with a 300-600-foot-wide 100-year floodplain between RM 193.6 and 195, and historic aerial photos show a number of alluvial terraces, fans, floodplain areas and unvegetated bars in the channel downstream of the Camp Creek confluence, with its large alluvial fan. The 100-year floodplain tapers down to a confined canyon for the half mile above the dam, and historic photos show that the channel was very disrupted in this sub-reach during dam construction, with coffer dams and construction roads. Post-dam sediment in the downstream reach is finer than upstream, with 60% clay, 25% silt and 15% sand.

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APPENDIX A5

Seismicity

(Pages A5-1 to A5-2)

APPENDIX A5
SEISMICITY

1.0 DESIGN PARAMETERS FOR TEMPORARY STRUCTURES

A standard and guideline review of DSOD, the California Water Code, Caltrans, USACE, ASCE, FEMA, FERC, USBR, and Uniform Building Code documents did not yield clear design criteria for the seismic design of temporary structures. KP has also reviewed the latest Supporting Technical Information Documents (STIDs) provided by PacifiCorp as they pertain to geology and seismicity at J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate. It was determined from these documents that the site-specific ground motion parameters for permanent structures were developed by Kleinfelder West Inc. (Kleinfelder) and Black & Veatch using the 2002 United States Geological Survey (USGS) database. The seismic design parameters presented in this appendix have been determined using the updated USGS seismic hazard database in conjunction with a design life equal to or less than one year. The current data provided by the USGS seismic hazard database is based on the 2014 model which incorporates the latest ground motion prediction models for shallow crustal earthquakes (known as the Next Generation Attenuation Models).

The probability of exceedance for the OBE and MDE events were assessed to quantify the risk associated with structures having a design life of 1 year. The probability of exceedance was calculated using the following equation:

$$Q = 1 - e^{-L/T}$$

Where: Q = probability of exceedance

L = design life (years)

T = return period (years)

The resulting probabilities of exceedance are as-follows:

- OBE (1/475-year event): 0.2% probability of exceedance
- MDE (1/2475-year event): 0.04% probability of exceedance

The OBE event was selected for the design of temporary structures having a design life of one year or less. The spectral accelerations corresponding to the OBE event at each site are presented with the OBE PGAs in Table 1.1.

Table 1.1 Selected Seismic Design Parameters for Temporary Structures at Each Site

Site	Return Period (years)	2014 USGS[1] PGA (g)	2014 USGS[1] Sa (0.2 s)	2014 USGS[1] Sa (1.0 s)
J.C. Boyle	475	0.17	0.39	0.14
Copco No. 1	475	0.12	0.26	0.10
Copco No. 2	475	0.12	0.26	0.10
Iron Gate	475	0.11	0.25	0.10

NOTES:

1. PGA AND SPECTRAL ACCELERATION VALUES TAKEN FROM THE USGS UNIFIED HAZARD TOOL DABATASE (USGS).

2.0 REFERENCES

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APPENDIX A6

Climate

(Pages A6-1 to A6-8)

APPENDIX A6
CLIMATE

1.0 OVERVIEW

The Project sites are located in predominantly rural areas of southern Oregon and northern California, along the riparian corridors of the Klamath River and its tributaries. The local climate is characterized by cool, wet winters and warm, dry summers. Cold air temperatures generally occur from November through March and warmer air temperatures and drier conditions occur from April through October with summer air temperatures highest in July, August, and September. The summers are dry with occasional isolated thunderstorms from July to September (Oregon Watershed Enhancement Manual, 2001).

The area is characterized by varying precipitation with a drier climate near Klamath Falls, Oregon and a wetter climate in northern California. Most precipitation occurs in the winter months of November, December and January (Oregon Watershed Enhancement Manual, 2001). Due to generally high elevations, the upper plateau has cool temperatures and receives a substantial amount of snow, which accumulates into moderately deep snowpack (Oregon Watershed Enhancement Manual, 2001). At its higher elevations (above 5,000 feet), the Klamath Basin receives rain and snow during the late fall through to spring.

2.0 AVAILABLE DATA

The National Oceanic and Atmospheric Administration (NOAA) operate several cooperative climate stations in the region. The regional climate datasets most relevant to the Project sites are:

- Keno, Oregon: NCEI COOP #354403 (6 miles from J.C. Boyle facility)
- Copco Dam No. 1, California: NCEI COOP #041990 (located at Copco No. 1 facility)

The location of the regional climate stations and the Project sites are shown on Figure 2.1.

Figure 2.1 Regional Climate Station Locations and Project Locations

2.1 TEMPERATURE

Data from the regional climate station within the closest proximity to each site was selected to represent the temperatures at that Project site. Available temperature data for the regional climate stations are presented in Table 2.1. The mean annual air temperature range is 44°F to 52°F between Keno, Oregon climate stations and Copco Dam No. 1, California. The months with the highest mean temperatures for the stations are July through September with maximum monthly mean temperatures ranging between 68°F and 75°F. The lowest minimum monthly mean temperatures are in January and December ranging between 29°F and 36°F.

Table 2.1 Measured Regional Temperature Data Summary

Station Details[1]	Unit	Keno, OR	Copco Dam No. 1, CA
Station Number	-	35-4403	04-1990
Latitude	° ' "	42° 7' 46.92" N	41° 58' 46.92" N
Longitude	° ' "	121° 55' 46.92" W	122° 20' 16.08" W
Elevation	ft	4,116	2,703
Distance from Site			
Nearest Project Site(s)	-	J.C. Boyle	Copco No. 1, Copco No. 2, Iron Gate
Distance from Site	mi	6.2	6.0 from Iron Gate
Period of Record[2]	-	1927-2019	1959-2019
Measured Values[3, 4]			
Mean Annual	°F	44.4	52.1
Mean Annual High	°F	58.5	65.7
Mean Annual Low	°F	29.1	38.6
Maximum Monthly Mean	°F	68.4	75.3
Minimum Monthly Mean	°F	29.0	35.9
Maximum Recorded Daily	°F	103	115
Minimum Recorded Daily	°F	-20	-2

NOTES:

1. DATA OBTAINED FROM NOAA ATLAS 14 – PRECIPITATION-FREQUENCY ATLAS OF THE UNITED STATES (2014).
2. THE PERIOD OF RECORD IDENTIFIES WHEN THE FIRST AND LAST MEASUREMENTS WERE TAKEN AND DOES NOT REPRESENT A CONTINUOUS PERIOD OF DATA COLLECTION.
3. MEASURED TEMPERATURE VALUES OBTAINED FROM NOAA REGIONAL CLIMATE CENTERS (ACIS, 2015).
4. MEASURED TEMPERATURE VALUES REPRESENT RECORDED DATA ONLY.

2.2 PRECIPITATION

Precipitation values for the project sites were derived in a similar manner to the temperature values, with the nearest regional climate station data providing the representative values for each specific project site. The wettest months are November through January. The proportion of precipitation falling as snow is directly correlated to temperature, which varies with each location within the Project region. In the upper watershed, snow is the primary form of precipitation for elevations above 5,000 feet.

The maximum daily rainfall range observed (recorded) at the regional climate stations is 3.0 inches and 6.0 inches for the Copco Dam No. 1 and Keno climate stations, respectively. The daily rainfall was converted to an equivalent 24-hr rainfall using a standard factor of 1.13 (Hershfield, 1961) resulting in maximum 24-hr rainfall of 3.4 inches to 6.8 inches for the Copco Dam No. 1 and Keno climate stations, respectively. The precipitation values are summarized in Table 2.2.

Table 2.2 Measured Regional Precipitation Summary[1, 2]

	Unit	Keno, OR	Copco Dam No. 1, CA
Period of Record[3]	-	1927-2019	1959-2019
Mean Annual Precipitation	in.	18.6	19.7
Mean Total Annual Rainfall	in.	13.4	18.0
Percentage of Annual Precipitation as Rain	%	72%	91%
Mean Total Annual Snowfall	in.	51.5	16.8
Mean Total Annual SWE[4]	in.	5.1	1.7
Maximum Recorded 24-hour Precipitation[5]	in.	6.8	3.4

NOTES:

1. DATA OBTAINED FROM NOAA REGIONAL CLIMATE CENTERS (ACIS, 2015).
2. MEASURED PRECIPITATION VALUES REPRESENT RECORDED DATA ONLY.
3. THE PERIOD OF RECORD IDENTIFIES WHEN THE FIRST AND LAST MEASUREMENTS WERE TAKEN AND DOES NOT REPRESENT A CONTINUOUS PERIOD OF DATA COLLECTION.
4. SWE – SNOW WATER EQUIVALENT. VALUES DETERMINED ASSUMING SNOW WATER EQUIVALENCY CONVERSION FACTOR OF 0.1 (NRCS).
5. MAXIMUM RECORDED 24-HOUR PRECIPITATION WAS DETERMINED BY APPLYING A 1.13 FACTOR (HERSHFIELD, 1961) TO THE MAXIMUM RECORDED DAILY PRECIPITATION.

The intensity duration frequency (IDF) data for the Copco Dam No. 1 climate station were provided by NOAA's Precipitation Frequency Data Server (NOAA, 2017). NOAA provides data for recurrence periods from 1 to 1,000 years with durations ranging from 5 minutes to 60 days. The IDF data for the Copco Dam No. 1 climate station is tabulated in Table 2.3 and are representative of the Copco No. 1, Copco No. 2, and Iron Gate Project Sites.

Table 2.3 IDF Data for Copco Dam No. 1 Climate Station (inches)

Duration	Recurrence Interval (yrs)									
	1-yr	2-yrs	5-yrs	10-yrs	25-yrs	50-yrs	100-yrs	200-yrs	500-yrs	1,000-yrs
5-min	0.10	0.14	0.20	0.24	0.31	0.36	0.41	0.47	0.62	0.77
10-min	0.15	0.20	0.28	0.35	0.44	0.51	0.59	0.68	0.89	1.10
15-min	0.18	0.25	0.34	0.42	0.53	0.62	0.72	0.82	1.07	1.33
30-min	0.24	0.33	0.45	0.55	0.70	0.82	0.95	1.09	1.42	1.76
60-min	0.32	0.44	0.60	0.74	0.94	1.10	1.27	1.46	1.91[1]	2.36[1]
2-hr	0.45	0.59	0.77	0.92	1.13	1.30	1.47	1.65	1.93[1]	2.38[1]
3-hr	0.55	0.70	0.90	1.07	1.30	1.47	1.65	1.84	2.09	2.41
6-hr	0.79	0.98	1.23	1.43	1.70	1.91	2.12	2.34	2.63	2.85
12-hr	1.10	1.36	1.70	1.98	2.36	2.66	2.96	3.26	3.68	4.01
24-hr	1.57	1.96	2.47	2.90	3.50	3.98	4.47	4.99	5.70	6.28
2-day	1.98	2.50	3.20	3.78	4.61	5.26	5.94	6.67	7.68	8.50
3-day	2.29	2.91	3.76	4.46	5.46	6.24	7.07	7.94	9.16	10.10
4-day	2.48	3.18	4.11	4.89	5.97	6.83	7.71	8.65	9.95	11.00
7-day	2.90	3.73	4.81	5.69	6.90	7.83	8.78	9.77	11.10	12.10
10-day	3.22	4.15	5.34	6.31	7.61	8.59	9.59	10.60	12.00	13.00
20-day	4.16	5.40	6.98	8.22	9.86	11.10	12.30	13.50	15.10	16.30
30-day	5.07	6.61	8.53	10.00	12.00	13.40	14.90	16.30	18.10	19.50
45-day	6.42	8.36	10.80	12.60	15.10	16.80	18.50	20.20	22.40	24.00
60-day	7.56	9.80	12.60	14.70	17.40	19.40	21.30	23.20	25.60	27.40

NOTES:

1. THE 500-YR AND 1,000-YR 60-MIN AND 2-HR VALUES WERE FLAGGED AS POTENTIALLY ERRONEOUS DUE TO MINIMAL INCREASE IN RAINFALL WITH INCREASE IN STORM DURATION.
2. IDF DATA TAKEN FROM NOAA'S PRECIPITATION FREQUENCY DATA SERVER (NOAA, 2017).

The IDF curves for the Keno climate station were determined using information provided by the Oregon Department of Transportation (ODOT) and supplemented by data available through the Western Regional Climate Center (WRCC). Intensity Duration Recurrence (IDR) information is dictated by the Oregon Rainfall IDR Curve Zone Map as stipulated in the ODOT Hydraulics Manual (ODOT, 2014). The Rainfall IDR Curve Zone Map is shown in Figure 2.2.

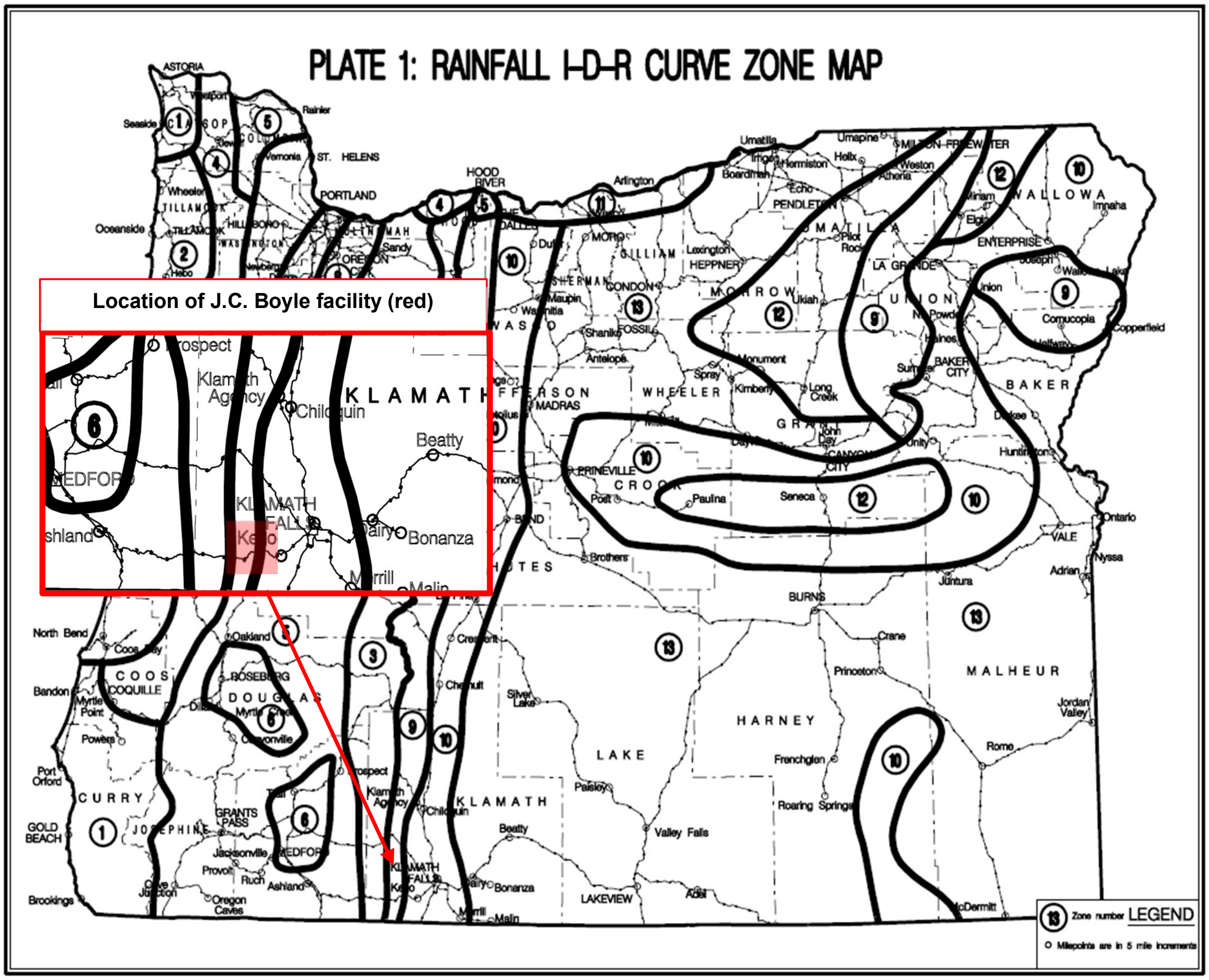

Figure 2.2 ODOT Rainfall IDR Curve Zone Map and Approximate Location of J.C. Boyle (ODOT, 2014)

The zoning map is used to identify which IDR data should be applied to a site. Zone 9 has been selected as representative of the IDR data for the J.C. Boyle project site based on the site location. The IDR rainfall intensity data for Zone 9 is tabulated in Table 2.4.

Table 2.4 IDR Data for Oregon Zone 9 (inches)

Duration	Recurrence Interval (yrs)					
	2-yrs	5- yrs	10-yrs	25-yrs	50-yrs	100-yrs
5-min	0.13	0.18	0.21	0.25	0.29	0.34
10-min	0.19	0.28	0.33	0.40	0.44	0.52
15-min	0.25	0.35	0.41	0.50	0.58	0.66
30-min	0.34	0.48	0.58	0.70	0.80	0.90
60-min	0.44	0.64	0.73	0.88	1.05	1.15
2-hr	0.58	0.82	0.90	1.04	1.20	1.38
3-hr	0.72	0.96	1.08	1.23	1.38	1.59
6-hr	1.02	1.32	1.50	1.62	1.80	2.04
24-hr	2.00	2.50	2.80	3.20	3.80	4.00

NOTES:

1. DATA FOR RECURRENCE PERIODS FROM 2 TO 100 YEARS WITH DURATIONS RANGING FROM 5 MINUTES TO 6 HOURS PROVIDED BY ODOT (ODOT, 2014).
2. 24-HOUR DURATION EVENT DATA PROVIDED BY WRCC PRECIPITATION FREQUENCY MAPS PUBLISHED IN NOAA ATLAS 2 AND REPRESENTS THE IDF DATA FOR THE WHOLE STATE OF OREGON (WRCC, 1973).

2.3 WIND

Regional wind data was not available for the Copco Dam No. 1 and Keno climate stations at the time of the preparation of this report. Wind is a design parameter required for the design of bridges and piers. The American Association of State Highway and Transportation Officials (AASHTO) requires a wind velocity at 30 ft (V_{30}) above low ground/above design water level and recommends the adoption of V_{30} = 100 mph in the absence of site-specific wind data (AASHTO, 2012). This value has been adopted for the 30% design. Alternative wind velocities may be considered to evaluate freeboard requirements specific to wave run-up and set-up considerations.

3.0 REFERENCES

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APPENDIX A7

Hydrology

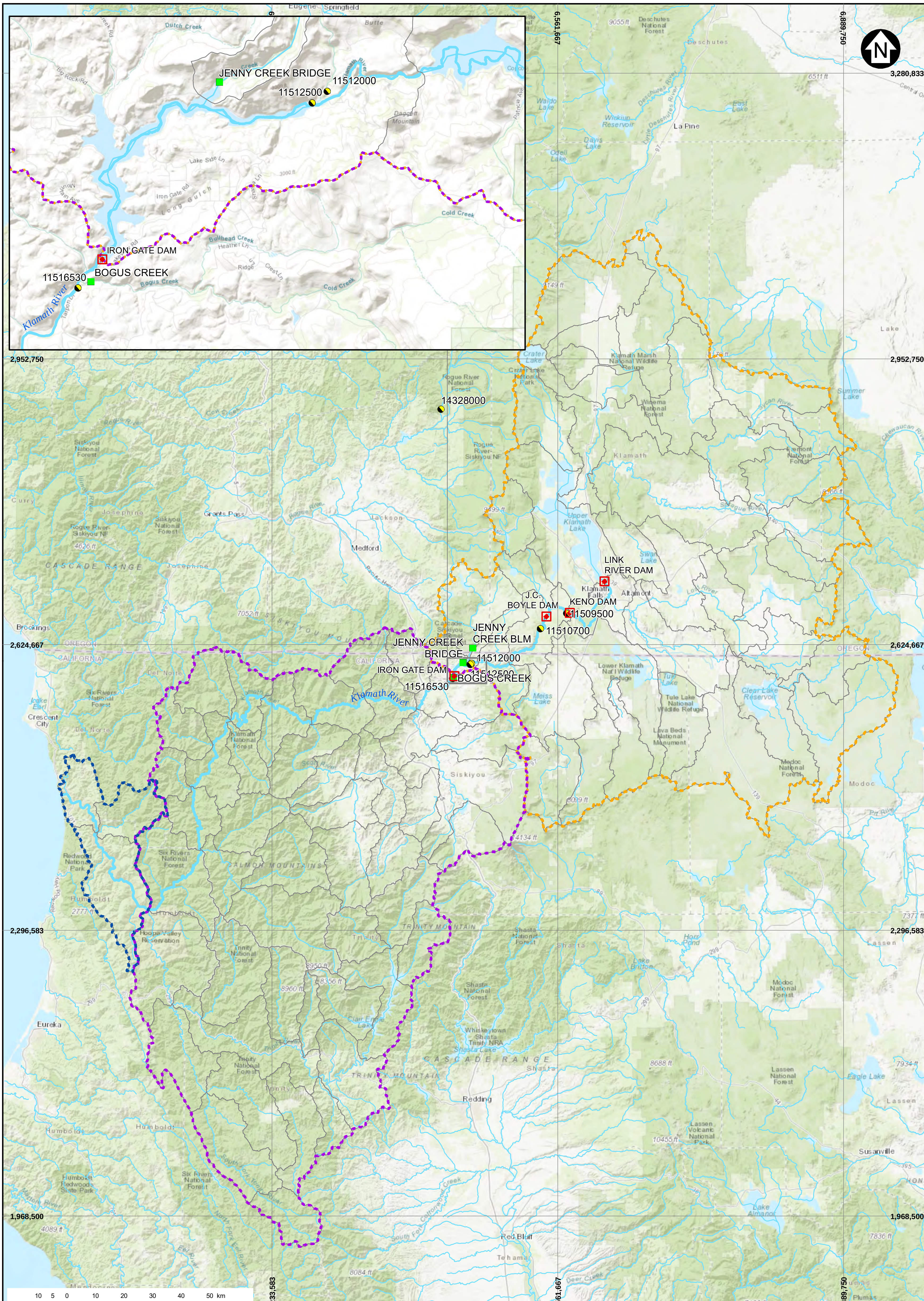
(Pages A7-1 to A7-33)

APPENDIX A7
HYDROLOGY

1.0 WATERSHED DESCRIPTION

The Klamath River originates at the outlet of Upper Klamath Lake in southern Oregon and flows approximately 250 miles southwest through the Cascade Mountains of southern Oregon and northern California to the Pacific Ocean. The Upper Klamath Basin has five main lakes: Crater Lake, Upper Klamath Lake, Lower Klamath Lake, Clear Lake, and Tule Lake. The Upper Klamath Basin also contains all the hydroelectric developments on the Klamath River, including the Klamath River Renewal Project (KRRP) sites. The Middle Klamath Basin extends 150-miles from Iron Gate Dam downstream to the Trinity River confluence, and its tributaries include the Shasta, Scott, and Salmon Rivers. The Lower Klamath Basin starts at the Trinity River confluence and extends 43 miles downstream to the Pacific Ocean.

The Upper Klamath Basin has broad valleys shaped by volcanoes and active faulting. The fault-bounded valleys contain all the large, natural lakes and large wetlands of the Klamath Basin. The Klamath River flows through mountainous terrain from J.C. Boyle Dam to Iron Gate Dam. Downstream of Iron Gate Dam, and for most of the river's length to the Pacific Ocean, the river maintains a relatively steep, high-energy channel (NRC, 2004). A map of the reach containing the four PacifiCorp dams being analyzed for removal is given on Figure 1.1.



LEGEND:

- ADDITIONAL HYDROLOGY STATION
- USGS STATION
- DAM LOCATION
- KLAMATH RIVER
- LOWER KLAMATH BASIN
- MIDDLE KLAMATH BASIN
- UPPER KLAMATH BASIN
- SUB-CATCHMENT

NOTES:

1. BASE MAP: ESRI ONLINE TOPOGRAPHIC MAP.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 2011 STATEPLANE CALIFORNIA I FIPS 0401 FT US.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,250,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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PUBLIC VERSION

KIEWIT INFRASTRUCTURE WEST CO.

KLAMATH RIVER RENEWAL PROJECT

KLAMATH WATERSHED BASIN

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-640/1	6

FIGURE 1.1 REV 0

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2.0 AVERAGE MONTHLY FLOW CONDITIONS

The US Bureau of Reclamation (USBR) stores, diverts, and conveys the waters of the Klamath and Lost Rivers to serve authorized Klamath Irrigation Project (Irrigation Project) purposes. The Bureau is required to meet contractual obligations in compliance with state and federal laws and to carry out the activities necessary to maintain the Project and ensure its proper long-term functioning and operation. To evaluate the potential effects of the continued operation of the Klamath Irrigation Project on species listed as threatened or endangered under the Endangered Species Act (ESA), biological assessments have been prepared pursuant to Section 7(a)(2) of the ESA of 1973, as amended, (16 United States Code [USC.] § 1531 et seq.).

Several Section 7 Consultations and Biological Opinions (BiOp's) have governed the operation of Upper Klamath Lake (UKL) and the USBR's Irrigation Project since the 1990's (USBR, 2012). The consultations involve the National Marine Fisheries Service (NMFS), also known as NOAA Fisheries, as well as the US Fish and Wildlife Service (FWS) and the USBR. The USBR currently meets its obligations under the ESA by operating the Irrigation Project in accordance with the latest FWS and NMFS BiOp, dated March 29, 2019. This BiOp is based on information provided in the USBR's Final Biological Assessment (USBR, 2018) and is effective April 1, 2019 through March 31, 2029. The latest BiOp operating conditions will govern the Klamath River during the dam removal and reclamation activities of the KRRP.

The KBPM incorporates the 2019 BiOp operating conditions and models the Klamath River flows. The USBR uses results generated by the Water Resources Integrated Modeling System (WRIMS) to identify the Klamath River and Upper Klamath Lake hydrographs that are likely to occur as a result of implementing the proposed operations across the full range of reasonably foreseeable annual precipitation and hydrologic patterns. WRIMS is a generalized water resources modeling system for evaluating operational alternatives of large, complex river basins. USBR has developed a WRIMS model specific to the Klamath Basin, which is referred to as the Klamath Basin Planning Model (KBPM). WRIMS is used to estimate mainstem Klamath River flows at the Keno and Iron Gate Dam facilities. While the KSPM captures the hydrology under the full range of conditions, the unique sequencing and patterns of climatological and hydrological events that will occur in the future cannot be predicted.

Thirty-six years (October 1980-November 2016) of daily average flows for the Keno and Iron Gate facilities, modeled using the Klamath Basin Planning Model, are available, as provided to Stillwater Sciences by the USBR Klamath Falls office (AECOM, 2019). These daily flows were used to calculate the monthly average flow conditions for each of the four KRRP sites. The Keno values were prorated by the ratio of the respective drainage areas to generate values for J.C. Boyle. The Iron Gate values were prorated by drainage area to generate values for Copco No. 1, which were also used for Copco No. 2 since those two facilities are very proximate. It is common practice to use ratios of drainage area to translate flows at one location to flows at another, particularly for locations on the same river system (Maidment, 1993). The monthly average flows are shown in Table 2.1 and on Figure 2.1 for each facility.

Table 2.1 Monthly Average Flows at Project Sites

Facility	J.C. Boyle[2]	Copco No. 1[2,3]	Iron Gate[1]
Drainage Area (mi²)	4,080	4,370	4,630
Month	Monthly Average Flow (cfs)		
January	1,500	1,910	2,030
February	1,900	2,360	2,500
March	2,800	3,230	3,430
April	2,370	2,790	2,950
May	1,760	2,110	2,230
June	1,140	1,420	1,500
July	750	990	1,050
August	760	980	1,040
September	800	1,030	1,090
October	850	1,100	1,170
November	960	1,230	1,310
December	1,110	1,490	1,580
Average Annual Flow (cfs)	1,390	1,710	1,820
Average Annual Unit Flow (cfs/mi²)	0.34	0.39	0.39

NOTES:

1. 2019 BIOLOGICAL OPINION FLOWS (AECOM, 2019) WERE USED AS REPRESENTATIVE OF INCOMING FLOWS TO THE FACILITY. BASED ON THE PERIOD OF RECORD FROM 1980 - 2016.
2. FLOWS CALCULATED USING THE RATIO OF THE RESPECTIVE DRAINAGES AREAS. J.C. BOYLE FLOWS WERE PRORATED FROM THE 2019 BIOLOGICAL OPINION FLOWS FOR THE KENO FACILITY. COPCO NO. 1 FLOWS WERE PRORATED FROM THE 2019 BIOLOGICAL OPINION FLOWS FOR THE IRON GATE FACILITY.
3. MONTHLY AVERAGE FLOWS FOR COPCO NO. 1 ARE USED AS REPRESENTATIVE OF THE MONTHLY AVERAGE FLOWS FOR COPCO NO. 2.

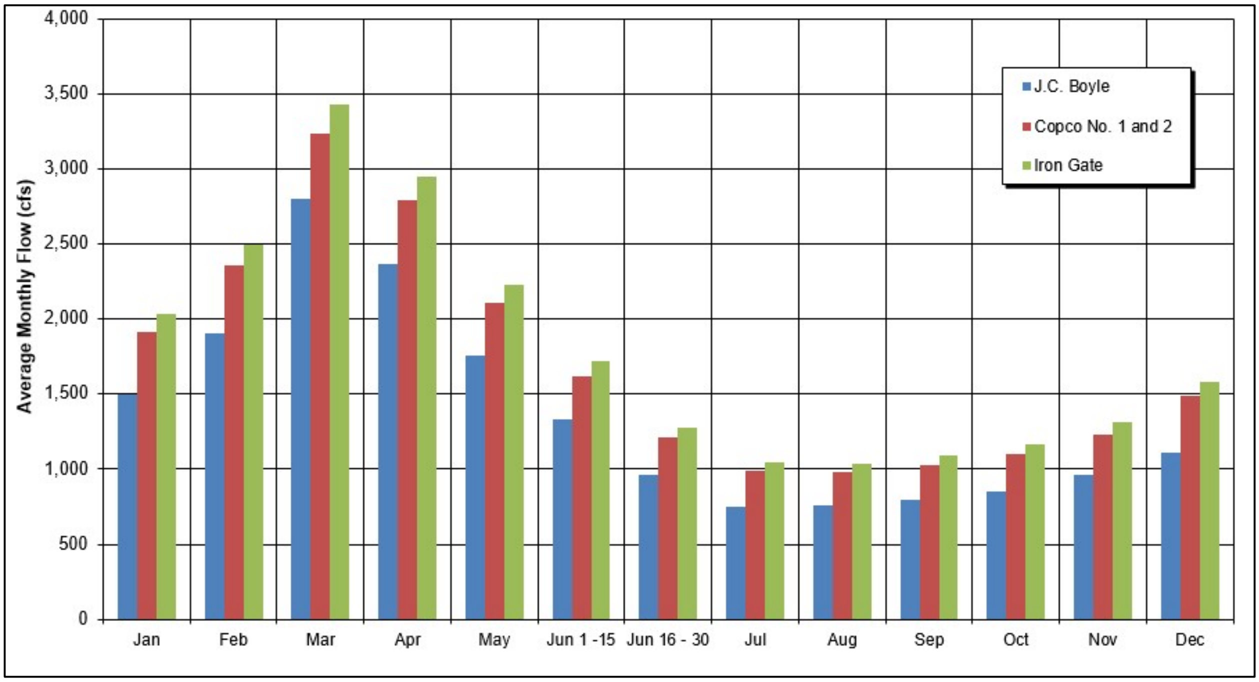

Figure 2.1 Monthly Average Flows at Project Sites

The annual patterns of streamflows apparent in the above hydrographs are characterized by high flows in the spring (March and April) due to spring snowmelt runoff (freshet), lower flows in mid-summer to late fall (July through October) due to reduced precipitation during the summer months, and flows increasing throughout the winter months (November through February) due to progressively increasing precipitation (which falls as snow in the upper elevations and rain in the lower elevations).

3.0 PEAK FLOODS

3.1 ANNUAL PEAK FLOODS

3.1.1 HISTORIC USGS DATA

Various return period design flood estimates are required for design purposes. The United States Geological Survey (USGS) operates several stream gages on the Klamath River and within proximity of the Project area. These regional hydrology stations have been used to develop design flood flows for the various facilities within the project area. The station details of the regional datasets most relevant to the KRRP are provided in Table 3.1.

Table 3.1 USGS Regional Streamflow Gaging Stations

USGS Gaging Station No.	Station Name	Drainage Area (mi²)	Longitude	Latitude	Period of Record
11509500	Klamath River at Keno, OR	3,920	42°08’00”	121°57’40”	1905-1913 1930-2017
11510700	Klamath River below John C. Boyle Power Plant near Keno, OR	4,080	42°05’05”	122°04’20”	1959-2017
11512500	Klamath River below Fall Creek near Copco, CA	4,370	41°58’20”	122°22’05”	1923-1961
11516530	Klamath River below Iron Gate Dam, CA	4,630	41°55’41”	122°26’35”	1960-2017

Annual peak flow data are available to be downloaded and used directly through the United States Army Corps of Engineers’ HEC-SSP software (V2.1) for USGS stations. Flood frequency analyses were performed on the regional stations' annual peak flow data using the HEC-SSP software, following the Bulletin 17B method for Log-Pearson Type III distributions (USGS, 1982). This included an analysis of the Keno gage data, although these results were used only for comparison purposes and are not presented in this report.

As described in the Definite Plan (KRRC, 2018), KRRC assessed the plots of the flood-frequency curves to determine if there was a low flow threshold below which flows did not fit the distribution. They found that the data visually fit within the 95 percent confidence limit of the distribution for all locations except J.C. Boyle. Accordingly, they marked the J.C. Boyle data below 3,400 cfs as low flow outlier values and then followed the Bulletin 17B procedures to adjust the flood probabilities to account for these low outliers. This same methodology was followed for this updated peak flow analysis.

The time period used for the peak flow analysis is from 1960 onwards. The records for the J.C. Boyle and Iron Gate Dam gages begin after 1960 and account for the effects of the majority of the reservoirs within the Klamath River basin, and also include the well-known flood of record for the Klamath region, which occurred in December 1964. Copco No. 1 only has a peak flow record for the period of 1923 to 1961, which is outside the selected period of analysis. Accordingly, the return period peak flows for Copco No. 1 were calculated by scaling the flood flows at J.C. Boyle according to the methodology described in “Estimation of Peak discharges for Rural, Unregulated streams in Western Oregon” (USGS, 2005).

3.1.2 2019 BIOLOGICAL OPINION DATA

The 2019 BiOp flows (AECOM, 2019) are comprised of thirty-six years (1980-2016) of daily flows for both the Keno and Iron Gate hydroelectric facilities. These daily flows were used to estimate the peak floods for the KRRP hydroelectric facilities. The daily flows were converted to instantaneous peak floods using conversion factors that were calculated by comparing the annual maximum instantaneous flows to the corresponding daily flows using data available from USGS operated stream gages located downstream of J.C. Boyle (11510700, Klamath River BLW John C Boyle Powerplant, Nr Keno OR) and downstream of Iron Gate Dam (11516530, Klamath River below Iron Gate Dam, CA). In general, the comparisons indicate that the annual maximum instantaneous floods are approximately 10% higher than the daily flows for the same day. Conversion factors of 1.10 and 1.12 were used to adjust the available 2019 BiOp daily flows into instantaneous peak floods for the J.C. Boyle and Iron Gate data, respectively.

Flood frequency analyses were performed on the 2019 BiOp annual peak flood data for the Keno and Iron Gate facilities using the United States Army Corps of Engineers' (USACE) HEC-SSP software (V2.1), following the Bulletin 17B method for Log-Pearson Type III distributions (USGS, 1982). The J.C. Boyle and the Copco No. 1 annual peak floods were calculated using the methodology described in "Estimation of Peak discharges for Rural, Unregulated streams in Western Oregon" (USGS, 2005), based on the annual BiOp flood frequency results for the Keno and Iron Gate facilities and the respective drainage areas.

The peak flood results from the Iron Gate facility were used in preference to those at the Keno facility to estimate flood values at the Copco No. 1 facility because the Iron Gate flows demonstrate proportionally greater flood flows than the Keno flows and therefore better represent the effects of the relatively large peak flow contributions from the largely unregulated tributary creeks and rivers that inflow between Keno and Copco No. 1.

3.1.3 ANNUAL PEAK FLOOD RESULTS

The historic USGS data and the 2019 BiOp data were both used to estimate annual return period floods at the Klamath River hydroelectric facilities. The flood values selected as the recommended design values are the maximum calculated values, as shown in Table 3.2. The annual return period floods at Copco No. 1 are used as representative of the annual return period floods for Copco No. 2.

Table 3.2 Annual Peak Floods

Location	Drainage Area (mi²)	Annual Percent Probable Flood (cfs)							
		50%	20%	10%	5%	2%	1%	0.50%	0.20%
Historic USGS Data[1]									
J.C. Boyle[2]	4,080	5,300	8,500	10,300	11,700	13,300	14,200	15,000	15,800
Copco No. 1	4,370	5,600	10,300	14,000	18,200	24,200	29,400	35,000	43,200
Iron Gate	4,630	5,900	10,900	14,900	19,300	25,700	31,200	37,100	45,800
2019 Biological Opinion Data[3]									
J.C. Boyle[4]	4,080	7,000	8,400	9,500	10,400	11,800	12,900	14,100	15,600
Copco No. 1[4]	4,370	7,100	9,400	11,500	14,000	17,800	21,300	25,500	32,100
Iron Gate	4,630	7,500	10,000	12,200	14,800	18,900	22,600	27,000	34,100
Recommended Design Values									
J.C. Boyle	4,080	7,000	8,500	10,300	11,700	13,300	14,200	15,000	15,800
Copco No. 1	4,370	7,100	10,300	14,000	18,200	24,200	29,400	35,000	43,200
Iron Gate	4,630	7,500	10,900	14,900	19,300	25,700	31,200	37,100	45,800

NOTES:

1. PERIOD OF ANALYSIS IS 1960 - 2017. J.C. BOYLE RESULTS ARE BASED ON USGS GAGING STATION 11510700 FLOW DATA. IRON GATE RESULTS ARE BASED ON USGS GAGING STATION 11516530 FLOW DATA. COPCO NO.1 RESULTS ARE CALCULATED BASED ON IRON GATE RESULTS USING METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).
2. FLOWS BELOW 3,400 CFS WERE CENSORED AS LOW FLOW OUTLIERS DUE TO THE INFLUENCE OF UPSTREAM LINK RIVER DAM.
3. PERIOD OF ANALYSIS IS 1980 - 2016. 2019 BIOLOGICAL OPINION FLOWS ARE BASED ON THE KENO DAM LOCATION AND THE IRON GATE DAM LOCATION (USGS GAGING STATION 11516530).
4. J.C. BOYLE AND COPCO NO. 1 RESULTS ARE CALCULATED BASED ON KENO AND IRON GATE RESULTS, RESPECTIVELY, USING METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).

As per the methodology described in Section 3.1.2, the 2019 BiOp data were also used to estimate the annual peak floods at the Klamath River hydroelectric facilities that have high probabilities of exceedance, as shown in Table 3.3. For example, the 80% value has an 80% chance of being exceeded in any year. The annual percent probable floods at Copco No. 1 are used as representative of the annual percent probable floods for Copco No. 2.

Table 3.3 Flows with High Probabilities of Exceedance

Location	Drainage Area (mi²)	Annual Probability of Exceedance Flows (cfs)		
		99.9%	80.0%	66.7%
J.C. Boyle[1]	4,080	4,600	5,900	6,400
Copco No. 1[2]	4,370	5,200	5,900	6,400
Iron Gate	4,630	5,500	6,300	6,800

NOTES:

1. CALCULATED BASED ON KENO RESULTS (USING 2019 BIOP FLOWS) USING METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).
2. CALCULATED BASED ON IRON GATE RESULTS (USING 2019 BIOP FLOWS) USING METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).

The annual hydrograph indicates that the highest sustained flows typically occur in March during spring runoff, but the largest peak flood events generally occur in December and January as a result of rain on snow events. The peak floods at Iron Gate are substantially greater than the peak floods at J.C. Boyle due to the tributary flows that enter the Klamath River between the two facilities, and most notably the flows from Jenny Creek. Jenny Creek contributes a large amount to the flow during the winter and spring months and is the largest single tributary between the Keno and Iron Gate facilities.

3.2 PEAK FLOODS FOR MONTHLY TIME PERIODS

A flood frequency analysis was performed for monthly periods to better define the risk of flooding events occurring during the embankment dam removal period. The flood frequency analysis used to determine monthly return period peak flows was the same as that used for the annual return period flows, as described in previous sections. The data indicate that the areal extent of freshet snowmelt contributing to peak flows diminishes greatly in the second half of June, and therefore the month of June was divided into two periods for peak flow analysis purposes: June 1 to June 15 and June 16 to June 30.

3.2.1 HISTORIC USGS DATA

Daily data for the USGS stations (J.C. Boyle and Iron Gate Dam) were used to calculate the monthly peak floods. Daily discharge data are available to be downloaded through the USGS Current Conditions for the Nation website (https://waterdata.usgs.gov/nwis/uv). Daily discharge data from January 1960 up until the most recent data available were used for the monthly flood frequency analyses.

The Iron Gate data source was USGS station 11516530. The J.C. Boyle data source was USGS station 11510770 and flows below 3400 cfs were treated as low flow outliers due to the influence of upstream activity. The daily flows of both datasets were converted to equivalent instantaneous 24-hr floods using the conversion factors developed for each site during the annual flood frequency analysis discussed above. It is recognized that the instantaneous to daily ratios would tend to vary monthly depending on the source of the flood flows and the amount of upstream flow regulation, but instantaneous peak flows are not available on a monthly basis and the regulation from upstream reservoirs would tend to limit the size of the ratios to less than the annual peak ratios, so use of annual ratios results in reasonably conservative instantaneous peak flow estimates. A flood frequency analysis was performed on these monthly peak flows using the United States Army Corps of Engineers' HEC-SSP software (V2.1), following the Bulletin 17B method for

Log-Pearson Type III distributions (USGS, 1982). The monthly peak floods at the remaining station (Copco No. 1) were calculated using non-linear proration with Iron Gate using methodology described in “Estimation of Peak Discharges for Rural, Unregulated Streams in Western Oregon” (USGS 2005). Table 3.5 provides the flood frequency results for the specified time periods.

It should be noted that the historic USGS flows are influenced by the operation of the reservoirs on the Klamath River and are, therefore, regulated. The regulation makes it possible for peak flows to be higher at J.C. Boyle than at Iron Gate.

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TABLE 3.4

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KLAMATH RIVER RENEWAL PROJECT

PEAK FLOODS FOR SPECIFIED TIME PERIOD
USING HISTORIC USGS GAGE DATA

Location	Drainage Area (mi²)	Month	Instantaneous Peak Floods for Specified Time Period (cfs)							
			50% Probable Flood	20% Probable Flood	10% Probable Flood	5% Probable Flood	2% Probable Flood	1% Probable Flood	0.5% Probable Flood	0.2% Probable Flood
J.C. Boyle[1]	4,080	Jan	2,600	4,400	6,000	8,000	11,100	14,000	17,500	23,200
		Feb	2,700	4,900	6,900	9,200	13,000	16,400	20,400	26,800
		Mar	3,500	6,300	8,500	10,900	14,400	17,300	20,400	25,000
		Apr	3,400	5,700	7,400	9,200	11,600	13,600	15,700	18,600
		May	2,600	4,300	5,500	6,800	8,500	9,900	11,300	13,400
		Jun 1 - 15	1,500	2,400	3,200	4,200	5,800	7,300	9,100	12,100
		Jun 16 - 30	1,200	1,700	2,200	2,700	3,400	4,100	4,800	5,900
		Jul	1,100	1,400	1,700	2,100	2,700	3,100	3,700	4,600
		Aug	1,400	1,500	1,600	1,700	1,800	1,800	1,800	1,900
		Sep	1,500	1,900	2,200	2,500	2,800	3,000	3,200	3,600
		Oct	1,800	2,400	2,900	3,400	4,000	4,600	5,200	6,000
		Nov	2,000	2,900	3,600	4,300	5,300	6,200	7,100	8,400
		Dec	2,500	3,900	5,100	6,300	8,200	9,900	11,700	14,400
Copco No. 1[2]	4,370	Jan	3,000	5,800	8,400	11,800	17,600	23,400	30,500	42,800
		Feb	3,000	5,800	8,400	11,800	17,600	23,400	30,500	42,800
		Mar	4,100	7,400	10,200	13,000	17,100	20,500	23,900	29,000
		Apr	3,600	6,500	8,900	11,100	14,400	17,000	19,700	23,400
		May	2,600	4,500	5,900	7,400	9,400	11,000	12,700	15,100
		Jun 1 - 15	1,500	2,500	3,400	4,500	6,400	8,200	10,500	14,100
		Jun 16 - 30	1,200	1,800	2,200	2,700	3,500	4,100	4,900	6,100
		Jul	900	1,300	1,600	2,000	2,600	3,200	3,900	5,100
		Aug	1,100	1,300	1,500	1,600	1,800	2,000	2,100	2,400
		Sep	1,400	1,700	1,900	2,100	2,400	2,500	2,600	2,900
		Oct	1,500	2,300	2,700	3,400	4,400	5,300	6,300	7,900
		Nov	2,000	3,100	4,000	4,900	6,400	7,600	9,000	11,100
		Dec	2,500	5,000	7,400	10,700	16,600	22,600	30,500	44,800
Iron Gate[3]	4,630	Jan	3,200	6,100	8,900	12,500	18,700	24,800	32,400	45,400
		Feb	3,200	6,100	8,900	12,500	18,700	24,800	32,400	45,400
		Mar	4,300	7,900	10,800	13,800	18,100	21,700	25,400	30,800
		Apr	3,800	6,900	9,400	11,800	15,300	18,000	20,900	24,800
		May	2,800	4,800	6,300	7,900	10,000	11,700	13,500	16,000
		Jun 1 - 15	1,600	2,600	3,600	4,800	6,800	8,700	11,100	15,000
		Jun 16 - 30	1,300	1,900	2,300	2,900	3,700	4,400	5,200	6,500
		Jul	1,000	1,400	1,700	2,100	2,800	3,400	4,100	5,400
		Aug	1,200	1,400	1,600	1,700	1,900	2,100	2,200	2,500
		Sep	1,500	1,800	2,000	2,200	2,500	2,600	2,800	3,100
		Oct	1,600	2,400	2,900	3,600	4,700	5,600	6,700	8,400
		Nov	2,100	3,300	4,200	5,200	6,800	8,100	9,500	11,800
		Dec	2,700	5,300	7,900	11,300	17,600	24,000	32,400	47,500

M:\1\03\00640\01\A\Data\Task 0700 - 60% Design\08 - Hydrology\Flood Frequency Analysis\[Flood Frequency Analysis - Monthly.xlsm]Table - Monthly_USGS

NOTES:

1. DATA SOURCE USGS STATION 11510770 "KLAMATH RIVER BLW JOHN C.BOYLE PWRPLNT, NR KENO,OR", PERIOD OF RECORD 1959 TO 2019. PERIOD OF RECORD USED IN ANALYSIS 1960 TO 2019 TO COINCIDE WITH THE IRON GATE PERIOD OF RECORD. FLOWS BELOW 3,400 cfs WERE CENSORED LOW FLOW OUTLIERS DUE TO THE INFLUENCE OF UPSTREAM DAM ACTIVITIES.
2. CALCULATED USING NON-LINEAR PRORATION WITH IRON GATE USING METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).
3. DATA SOURCE USGS STATION 11516530 "KLAMATH R BL IRON GATE DAM CA", PERIOD OF RECORD 1960 TO 2019. PERIOD OF RECORD USED IN ANALYSIS 1960 TO 2019.
4. ANALYSIS USES HISTORIC USGS GAGE DATA. THESE FLOWS ARE INFLUENCED BY THE OPERATION OF THE RESERVOIRS ON THE KLAMATH RIVER AND ARE, THEREFORE, REGULATED. THE REGULATION MAKES IT POSSIBLE FOR PEAK FLOWS TO BE HIGHER AT J.C. BOYLE THAN AT IRON GATE.
5. THE DATA INDICATE THAT THERE IS A TRANSITION IN THE HYDROLOGY IN THE MIDDLE OF JUNE FROM FRESHET TO LOWER SUMMER FLOWS. FOR ANALYSIS PURPOSES THE MONTH OF JUNE HAS BEEN DIVIDED INTO TWO PERIODS: JUNE 1 TO 15 AND JUNE 16 TO 30.

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3.2.2 2019 BIOLOGICAL OPINION DATA

The 2019 BiOp daily flows for the Keno and Iron Gate facilities were used to estimate the monthly peak floods for the KRRP hydroelectric facilities. The peak daily flow in each specified time period was determined and converted to an instantaneous peak flow using the conversion factor of 1.10. A flood frequency analysis was performed on these peak floods using the USACE HEC-SSP software (V2.1), following the Bulletin 17B method for Log-Pearson Type III distributions (USGS, 1982).

The peak flows for specified time periods at J.C. Boyle and Copco No. 1 were calculated using the methodology described in USGS (2005), based on the results for the Keno and Iron Gate facilities, respectively for J.C. Boyle and Copco No. 1. The return period floods for specified periods at Copco No. 1 are used as representative for Copco No. 2. Table 3.5 provides the flood frequency results for the specified time periods.

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TABLE 3.5

KIEWIT INFRASTRUCTURE WEST CO.
KLAMATH RIVER RENEWAL PROJECT

PEAK FLOODS FOR SPECIFIED TIME PERIOD
USING 2019 BIOLOGICAL OPINION DATA[1]

Location	Drainage Area (mi²)	Month	Instantaneous Peak Floods for Specified Time Period (cfs)							
			50% Probable Flood	20% Probable Flood	10% Probable Flood	5% Probable Flood	2% Probable Flood	1% Probable Flood	0.5% Probable Flood	0.2% Probable Flood
		Jan	2,000	3,700	5,400	7,400	10,600	13,700	17,400	23,500
		Feb	2,200	4,500	6,700	9,300	13,700	18,000	23,100	31,600
		Mar	6,000	7,700	8,400	8,900	9,200	9,400	9,500	9,600
		Apr	4,300	6,400	7,800	9,000	10,500	11,600	12,700	14,000
		May	2,800	3,900	4,700	5,500	6,500	7,300	8,100	9,200
		Jun 1 - 15	2,000	2,800	3,400	4,000	4,900	5,500	6,200	7,100
Keno[2]	3,920	Jun 16 - 30	1,500	2,100	2,400	2,800	3,400	3,800	4,200	4,800
		Jul	1,300	1,600	1,800	1,900	2,000	2,100	2,200	2,300
		Aug	1,300	1,600	1,800	1,900	2,000	2,100	2,200	2,300
		Sep	1,000	1,100	1,200	1,200	1,300	1,300	1,400	1,400
		Oct	1,000	1,200	1,400	1,800	2,400	3,000	3,800	5,300
		Nov	1,200	1,900	2,600	3,500	5,000	6,600	8,700	12,400
		Dec	1,800	3,200	4,400	5,800	8,000	10,100	12,500	16,300
		Jan	2,100	3,900	5,600	7,700	11,000	14,300	18,100	24,500
		Feb	2,300	4,700	7,000	9,700	14,300	18,800	24,100	32,900
		Mar	6,300	8,000	8,800	9,300	9,600	9,800	9,900	10,000
		Apr	4,500	6,700	8,100	9,400	10,900	12,100	13,200	14,600
		May	2,800	4,100	4,900	5,700	6,800	7,600	8,500	9,600
		Jun 1 - 15	2,000	2,800	3,500	4,200	5,100	5,700	6,500	7,400
J.C. Boyle[3]	4,080	Jun 16 - 30	1,600	2,100	2,500	2,800	3,400	3,900	4,300	4,800
		Jul	1,400	1,700	1,800	2,000	2,100	2,200	2,300	2,400
		Aug	1,400	1,700	1,800	2,000	2,100	2,200	2,300	2,400
		Sep	1,000	1,100	1,200	1,200	1,300	1,400	1,500	1,500
		Oct	1,000	1,200	1,500	1,800	2,500	3,100	3,900	5,400
		Nov	1,300	2,000	2,700	3,600	5,200	6,800	9,000	12,600
		Dec	1,900	3,300	4,600	6,000	8,300	10,500	13,000	17,000
		Jan	2,400	4,500	6,800	9,600	14,600	19,700	26,300	37,800
		Feb	2,900	5,800	8,500	11,800	17,400	22,800	29,500	40,700
		Mar	6,500	8,500	9,200	9,800	10,200	10,400	10,600	10,700
		Apr	4,600	7,000	8,600	10,000	11,900	13,200	14,500	16,200
		May	2,900	4,200	5,300	6,300	7,800	9,000	10,400	12,200
		Jun 1 - 15	2,100	2,900	3,600	4,300	5,400	6,300	7,400	9,000
Copco No. 1[4]	4,370	Jun 16 - 30	1,700	2,200	2,600	2,900	3,400	3,900	4,300	4,900
		Jul	1,500	1,800	1,900	2,100	2,200	2,300	2,400	2,500
		Aug	1,500	1,800	1,900	2,100	2,200	2,400	2,500	2,500
		Sep	1,100	1,200	1,300	1,300	1,400	1,500	1,500	1,600
		Oct	1,100	1,300	1,600	1,900	2,600	3,200	4,000	5,500
		Nov	1,400	2,100	2,800	3,700	5,300	6,900	9,100	12,800
		Dec	2,000	3,800	5,700	8,100	12,400	17,100	22,900	33,400
		Jan	2,500	4,800	7,200	10,200	15,500	20,900	27,900	40,100
		Feb	3,100	6,100	9,000	12,500	18,500	24,200	31,300	43,200
		Mar	6,900	9,000	9,800	10,400	10,800	11,000	11,200	11,300
		Apr	4,800	7,400	9,100	10,600	12,600	14,000	15,400	17,200
		May	3,000	4,500	5,600	6,700	8,300	9,600	11,000	12,900
		Jun 1 - 15	2,200	3,000	3,700	4,500	5,700	6,700	7,800	9,500
Iron Gate[5]	4,630	Jun 16 - 30	1,800	2,300	2,700	3,000	3,500	4,000	4,400	5,000
		Jul	1,600	1,900	2,000	2,200	2,300	2,400	2,500	2,600
		Aug	1,600	1,900	2,000	2,200	2,300	2,500	2,600	2,700
		Sep	1,200	1,300	1,400	1,400	1,500	1,600	1,600	1,700
		Oct	1,200	1,400	1,700	2,000	2,700	3,300	4,100	5,600
		Nov	1,500	2,200	2,900	3,900	5,500	7,100	9,300	13,000
		Dec	2,100	4,000	6,000	8,600	13,200	18,100	24,300	35,400

M:\1\03\00640\01\A\Data\Task 0700 - 60% Design\08 - Hydrology\Flood Frequency Analysis\[Flood Frequency Analysis - Monthly.xlsm]Table - Monthly_2019BiOp

NOTES:

1. 2019 BIOLOGICAL OPINION FLOWS (AECOM, 2019) WERE PROVIDED FOR THE PERIOD FROM 1981 TO 2016. FLOWS WERE PROVIDED AT KENO (USGS GAGE 11509500) AND IRON GATE (USGS GAGE 11516530).
2. CALCULATED USING 2019 BIOP FLOWS AT KENO. A FACTOR OF 1.10 WAS APPLIED TO ADJUST DAILY AVERAGE FLOW TO DAILY PEAK FLOW.
3. CALCULATED USING NON-LINEAR AREA PRORATION WITH 2019 BIOP FLOWS AT KENO USING METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).
4. CALCULATED USING NON-LINEAR AREA PRORATION WITH 2019 BIOP FLOWS AT IRON GATE USING METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).
5. CALCULATED USING 2019 BIOP FLOWS AT IRON GATE. A FACTOR OF 1.12 WAS APPLIED TO ADJUST DAILY AVERAGE FLOW TO DAILY PEAK FLOW.

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3.2.3 MONTHLY PEAK FLOOD RESULTS

The Historic USGS data and 2019 BiOp data were both used to determine the monthly peak flows at the Klamath River reservoirs. The flood values selected as the recommended design values are the maximum calculated values, as shown in Table 3.6. The monthly return period floods at Copco No. 1 are used as representative of the monthly return period floods for Copco No. 2.

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TABLE 3.6

KIEWIT INFRASTRUCTURE WEST CO.
KLAMATH RIVER RENEWAL PROJECT

RECOMMENDED DESIGN VALUES OF OF MONTHLY PEAK FLOODS

Location	Drainage Area (mi²)	Month	Instantaneous Peak Floods for Specified Time Period (cfs)							
			50% Probable Flood	20% Probable Flood	10% Probable Flood	5% Probable Flood	2% Probable Flood	1% Probable Flood	0.5% Probable Flood	0.2% Probable Flood
J.C. Boyle	4,080	Jan	2,600	4,400	6,000	8,000	11,100	14,300	18,100	24,500
		Feb	2,700	4,900	7,000	9,700	14,300	18,800	24,100	32,900
		Mar	6,300	8,000	8,800	10,900	14,400	17,300	20,400	25,000
		Apr	4,500	6,700	8,100	9,400	11,600	13,600	15,700	18,600
		May	2,800	4,300	5,500	6,800	8,500	9,900	11,300	13,400
		Jun 1 - 15	2,000	2,800	3,500	4,200	5,800	7,300	9,100	12,100
		Jun 16 - 30	1,600	2,100	2,500	2,800	3,400	4,100	4,800	5,900
		Jul	1,400	1,700	1,800	2,100	2,700	3,100	3,700	4,600
		Aug	1,400	1,700	1,800	2,000	2,100	2,200	2,300	2,400
		Sep	1,500	1,900	2,200	2,500	2,800	3,000	3,200	3,600
		Oct	1,800	2,400	2,900	3,400	4,000	4,600	5,200	6,000
		Nov	2,000	2,900	3,600	4,300	5,300	6,800	9,000	12,600
		Dec	2,500	3,900	5,100	6,300	8,300	10,500	13,000	17,000
Copco No. 1	4,370	Jan	3,000	5,800	8,400	11,800	17,600	23,400	30,500	42,800
		Feb	3,000	5,800	8,500	11,800	17,600	23,400	30,500	42,800
		Mar	6,500	8,500	10,200	13,000	17,100	20,500	23,900	29,000
		Apr	4,600	7,000	8,900	11,100	14,400	17,000	19,700	23,400
		May	2,900	4,500	5,900	7,400	9,400	11,000	12,700	15,100
		Jun 1 - 15	2,100	2,900	3,600	4,500	6,400	8,200	10,500	14,100
		Jun 16 - 30	1,700	2,200	2,600	2,900	3,500	4,100	4,900	6,100
		Jul	1,500	1,800	1,900	2,100	2,600	3,200	3,900	5,100
		Aug	1,500	1,800	1,900	2,100	2,200	2,400	2,500	2,500
		Sep	1,400	1,700	1,900	2,100	2,400	2,500	2,600	2,900
		Oct	1,500	2,300	2,700	3,400	4,400	5,300	6,300	7,900
		Nov	2,000	3,100	4,000	4,900	6,400	7,600	9,100	12,800
		Dec	2,500	5,000	7,400	10,700	16,600	22,600	30,500	44,800
Iron Gate	4,630	Jan	3,200	6,100	8,900	12,500	18,700	24,800	32,400	45,400
		Feb	3,200	6,100	9,000	12,500	18,700	24,800	32,400	45,400
		Mar	6,900	9,000	10,800	13,800	18,100	21,700	25,400	30,800
		Apr	4,800	7,400	9,400	11,800	15,300	18,000	20,900	24,800
		May	3,000	4,800	6,300	7,900	10,000	11,700	13,500	16,000
		Jun 1 - 15	2,200	3,000	3,700	4,800	6,800	8,700	11,100	15,000
		Jun 16 - 30	1,800	2,300	2,700	3,000	3,700	4,400	5,200	6,500
		Jul	1,600	1,900	2,000	2,200	2,800	3,400	4,100	5,400
		Aug	1,600	1,900	2,000	2,200	2,300	2,500	2,600	2,700
		Sep	1,500	1,800	2,000	2,200	2,500	2,600	2,800	3,100
		Oct	1,600	2,400	2,900	3,600	4,700	5,600	6,700	8,400
		Nov	2,100	3,300	4,200	5,200	6,800	8,100	9,500	13,000
		Dec	2,700	5,300	7,900	11,300	17,600	24,000	32,400	47,500

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NOTES:

1. RECOMMENDED DESIGN VALUES ARE BASED ON THE MAXIMUM VALUES BETWEEN THE ANALYSIS COMPLETED USING THE HISTORIC USGS GAGE DATA AND THE 2019 BIOP FLOW DATA.

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Overall, the results show that for the J.C. Boyle facility, the peak flood results for specified time periods decrease progressively from April through to September, with a substantial decrease in September. The peak flood results then increase from October through to December. For the Copco No. 1 and Iron Gate facilities, the peak flood results for specified time periods also decrease from April through to August, but the higher percent probable floods continue decreasing or remain constant in September, while the lower percent probable floods increase again in September.

When considering the application of the monthly peak floods in relation to deconstruction activities, embankment dam removal periods, or instream works, the designer/contractor should consider the time period that the work will take place or the time period that the structure will remain in place. The designer/contractor should select the highest peak flow value within the time period that the work and/or structure will occur. If this time period is a year or longer or occurs during the winter period, it is recommended that the designer use the annual peak flood results and not the monthly peak flood results for design purposes as these would better represent the peak floods that have a possibility of occurring over the lifetime of the activity or structure.

4.0 ANNUAL DAILY FLOW DURATION

Daily flow duration curves show the percentage of time that an inflow is likely to equal or exceed a specified flow value on an annual basis. The flow duration curves for the KRRP hydroelectric facilities were created with the following inputs:

- Developed using the 2019 Biological Opinion Flows (2019 BiOps) provided by USBR (2018).
- 2019 BiOps for USGS gage 11509500 Klamath River at Keno, OR were linearly prorated by drainage area to generate values for the J.C. Boyle facility.
- 2019 BiOps for USGS gage 11516530 Klamath River below Iron Gate Dam, CA were used for the Iron Gate Dam facility and were linearly prorated by drainage area to generate values for the Copco No. 1 facility. The flows for the Copco No. 1 facility were used for the Copco No. 2 facility.

The annual and monthly daily flow duration curves based on the 2019 BiOp flows are shown below in Table 4.1 to Table 4.4 and on Figures 4.1 to 4.4 for each of the KRRP facilities.

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TABLE 4.1

KIEWIT INFRASTRUCTURE WEST CO.
KLAMATH RIVER RENEWAL PROJECT

FLOW DURATION FLOWS BASED ON 2019 BI OP FLOWS
ANNUAL

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% of Time Equaled or Exceeded	Discharge (cfs)			
	Keno	J.C. Boyle	Copco No. 1	Iron Gate Dam
99%	300	320	850	900
95%	500	530	850	900
90%	570	590	900	950
80%	640	660	940	1,000
75%	660	690	940	1,000
70%	690	720	970	1,030
60%	760	790	1,050	1,110
50%	820	860	1,110	1,180
40%	920	950	1,250	1,320
30%	1,130	1,170	1,540	1,630
25%	1,400	1,460	1,780	1,880
20%	1,770	1,840	2,210	2,340
10%	2,860	2,980	3,430	3,630
5%	4,140	4,310	4,780	5,060
1%	6,680	6,960	7,630	8,080

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NOTES:

1. KENO AND IRON GATE DAM FLOWS BASED ON TE 2019 BIOP AVERAGE DAILY FLOWS.
2. J.C. BOYLE FLOWS ARE CALCULATED USING LINEAR AREA PRORATION WITH THE KENO 2019 BIOP FLOWS.
3. COPCO NO. 1 FLOWS ARE CALCULATED USING LINEAR AREA PRORATION WITH THE IRON GATE DAM 2019 BIOP FLOWS.

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TABLE 4.2

KIEWIT INFRASTRUCTURE WEST CO.
KLAMATH RIVER RENEWAL PROJECT

FLOW DURATION FLOWS BASED ON 2019 BI OP FLOWS
MONTHLY - J.C. BOYLE

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% of Time Equaled or Exceeded	Discharge (cfs)														
	Monthly														Annual
	Jan	Feb	Mar	Apr	May	Jun	Jun 1 - 15	Jun 16 - 30	Jul	Aug	Sep	Oct	Nov	Dec	
99%	360	440	290	230	190	230	210	250	460	460	440	240	440	420	320
95%	470	510	550	770	740	620	630	600	560	550	630	560	570	490	530
90%	520	540	690	890	860	680	750	670	600	590	670	670	610	520	590
80%	580	600	1,060	1,000	940	750	800	710	640	620	700	730	660	570	660
75%	600	630	1,220	1,040	980	770	820	730	670	630	720	750	680	590	720
70%	620	650	1,440	1,120	1,030	790	860	750	680	650	740	770	700	610	720
60%	660	720	1,800	1,450	1,140	840	940	780	720	670	770	800	740	650	790
50%	720	940	2,220	1,870	1,410	920	1,020	820	750	700	790	830	800	680	860
40%	970	1,580	2,650	2,330	1,720	990	1,140	890	780	740	820	860	870	740	950
30%	1,530	2,220	3,350	2,840	2,110	1,120	1,400	970	810	790	860	890	930	970	1,170
25%	1,850	2,540	3,880	3,390	2,330	1,260	1,600	1,020	830	810	880	910	970	1,240	1,840
20%	2,160	2,980	4,770	3,790	2,530	1,450	1,930	1,080	850	850	910	950	1,030	1,530	1,840
10%	3,500	4,320	5,840	4,920	3,180	2,110	2,480	1,500	910	1,000	950	1,040	1,290	2,350	2,980
5%	4,870	6,010	6,660	5,670	3,870	2,540	2,870	1,800	970	1,360	1,000	1,150	2,210	3,250	4,310
1%	8,280	8,880	8,560	6,860	5,290	3,610	4,330	2,580	1,060	1,560	1,070	2,700	3,840	5,640	6,960

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NOTES:

1. J.C. BOYLE FLOWS ARE CALCULATED USING LINEAR AREA PRORATION WITH THE KENO 2019 BIOP FLOWS.

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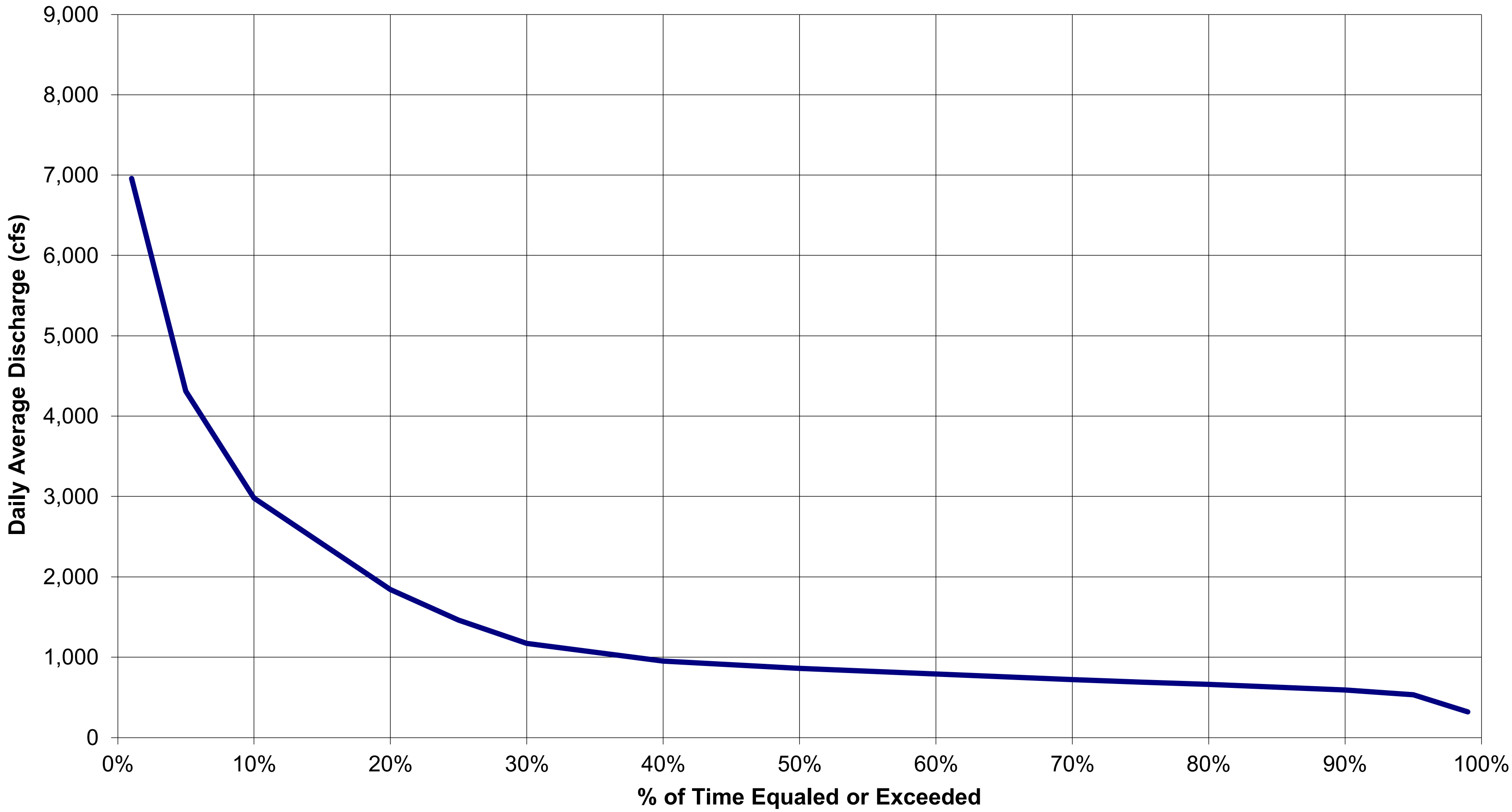

NOTES:
1.J.C. BOYLE FLOWS ARE CALCULATED USING LINEAR AREA PRORATION WITH THE KENO 2019 BIOP FLOWS.

KIEWIT INFRASTRUCTURE WEST CO.

KLAMATH RIVER RENEWAL PROJECT

J.C. BOYLE
ANNUAL FLOW DURATION CURVE

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P/A NO. VA103-640/1

REF. NO. 6

FIGURE 4.1

REV 0

0	07FEB'20	ISSUED WITH REPORT	AS	ELK
REV	DATE	DESCRIPTION	PREP'D	RVW'D

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PUBLIC VERSION

TABLE 4.3

KIEWIT INFRASTRUCTURE WEST CO.
KLAMATH RIVER RENEWAL PROJECT

FLOW DURATION FLOWS BASED ON 2019 BI OP FLOWS
MONTHLY - COPCO NO. 1

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% of Time Equaled or Exceeded	Discharge (cfs)														
	Monthly														Annual
	Jan	Feb	Mar	Apr	May	Jun	Jun 1 to 15	Jun 16 to 30	Jul	Aug	Sep	Oct	Nov	Dec	
99%	900	900	940	1,250	1,110	970	970	960	850	850	940	940	940	900	850
95%	900	900	940	1,250	1,110	970	970	970	850	850	940	940	940	900	850
90%	900	900	1,080	1,250	1,110	970	970	970	850	850	940	940	940	900	900
80%	900	900	1,520	1,280	1,240	970	1,040	970	850	850	940	940	940	900	940
75%	900	940	1,630	1,410	1,290	970	1,080	970	870	850	940	980	940	900	940
70%	900	990	1,800	1,540	1,350	1,010	1,130	970	900	850	940	1,000	940	900	970
60%	970	1,120	2,210	1,810	1,430	1,090	1,200	990	940	850	940	1,030	960	900	1,050
50%	1,120	1,390	2,640	2,230	1,700	1,160	1,300	1,050	980	890	1,010	1,070	1,050	930	1,110
40%	1,420	1,980	3,120	2,780	2,080	1,230	1,480	1,120	1,000	960	1,080	1,090	1,140	1,060	1,250
30%	1,930	2,570	3,850	3,320	2,470	1,470	1,660	1,190	1,060	1,040	1,100	1,120	1,160	1,440	1,540
25%	2,280	2,920	4,430	3,920	2,700	1,580	1,840	1,230	1,060	1,050	1,100	1,130	1,240	1,600	1,780
20%	2,580	3,400	5,200	4,270	2,940	1,700	2,140	1,410	1,090	1,060	1,130	1,180	1,300	1,860	2,210
10%	3,980	4,820	6,080	5,260	3,620	2,300	2,830	1,770	1,160	1,110	1,160	1,250	1,550	2,800	3,430
5%	5,340	6,980	7,110	5,750	4,250	2,850	3,250	2,050	1,180	1,460	1,160	1,350	2,440	4,020	4,780
1%	9,070	10,460	8,920	7,220	5,430	3,930	4,560	2,780	1,260	1,600	1,190	2,670	3,950	6,770	7,630

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NOTES:

1. COPCO NO. 1 FLOWS ARE CALCULATED USING LINEAR AREA PRORATION WITH THE IRON GATE DAM 2019 BIOP FLOWS.

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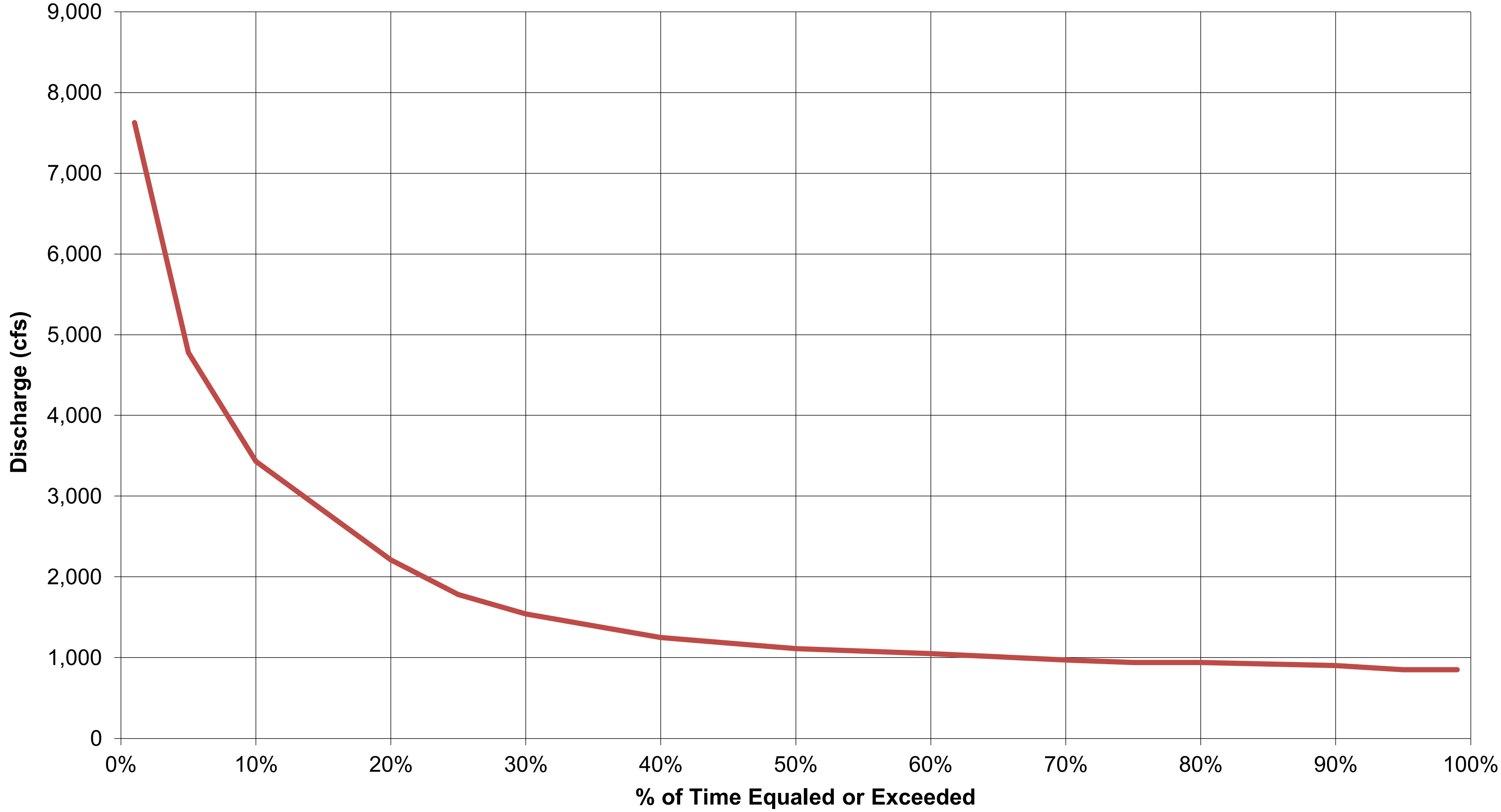
REV	DATE	DESCRIPTION	PREP'D	RVW'D

PUBLIC VERSION



NOTES:
1.IRON GATE DAM FLOWS BASED ON THE 2019 BIOP AVERAGE DAILY FLOWS.
2.COPCO NO. 1 FLOWS ARE CALCULATED USING LINEAR AREA PRORATION BY RATIO OF DRAINAGE AREAS WITH THE IRON GATE DAM 2019 BIOP FLOWS.

0	07FEB'20	ISSUED WITH REPORT	AS	ELK
REV	DATE	DESCRIPTION	PREP'D	RVW'D

KIEWIT INFRASTRUCTURE WEST CO.

KLAMATH RIVER RENEWAL PROJECT

COPCO NO. 1
ANNUAL FLOW DURATION CURVE

Knight Piésold CONSULTING

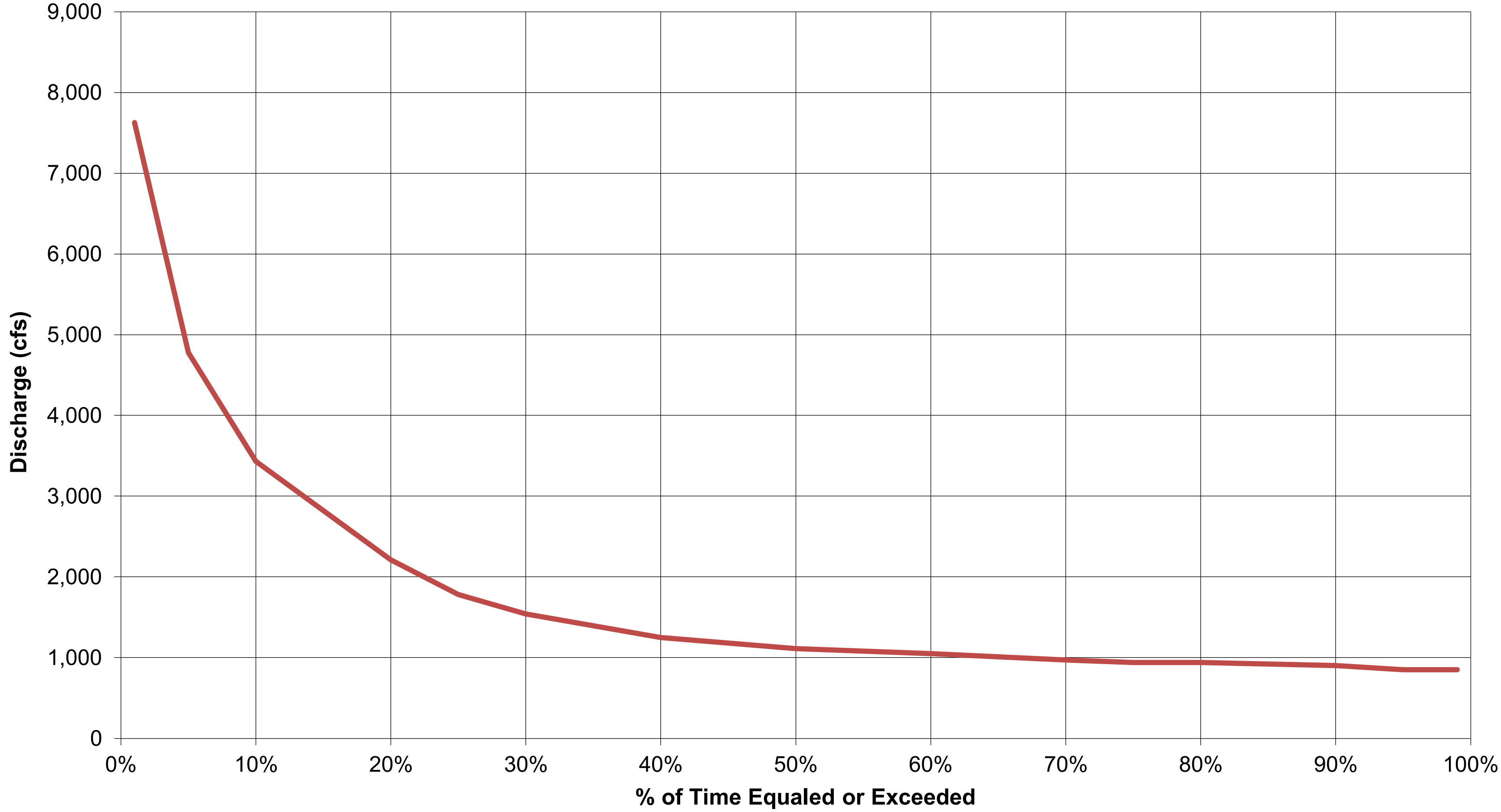
P/A NO. VA103-640/1

REF. NO. 6

FIGURE 4.2

REV 0

PUBLIC VERSION



NOTES:
1.IRON GATE DAM FLOWS BASED ON TE 2019 BIOP AVERAGE DAILY FLOWS.
2.COPCO NO. 1 FLOWS ARE CALCULATED USING LINEAR AREA PRORATION WITH THE IRON GATE DAM 2019 BIOP FLOWS.

0	07FEB'20	ISSUED WITH REPORT	AS	ELK
REV	DATE	DESCRIPTION	PREP'D	RVW'D

KIEWIT INFRASTRUCTURE WEST CO.

KLAMATH RIVER RENEWAL PROJECT

COPCO NO. 2
ANNUAL FLOW DURATION CURVE

Knight Piésold CONSULTING

P/A NO. VA103-640/1

REF. NO. 6

FIGURE 4.3

REV 0

PUBLIC VERSION

TABLE 4.4

KIEWIT INFRASTRUCTURE WEST CO.
KLAMATH RIVER RENEWAL PROJECT

FLOW DURATION FLOWS BASED ON 2019 BI OP FLOWS
MONTHLY - IRON GATE DAM

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% of Time Equaled or Exceeded	Discharge (cfs)														
	Monthly														Annual
	Jan	Feb	Mar	Apr	May	Jun	Jun 1 to 15	Jun 16 to 30	Jul	Aug	Sep	Oct	Nov	Dec	
99%	950	950	1,000	1,330	1,180	1,020	1,030	1,020	900	900	1,000	1,000	1,000	950	900
95%	950	950	1,000	1,330	1,180	1,030	1,030	1,030	900	900	1,000	1,000	1,000	950	900
90%	950	950	1,150	1,330	1,180	1,030	1,030	1,030	900	900	1,000	1,000	1,000	950	950
80%	950	950	1,610	1,360	1,320	1,030	1,100	1,030	900	900	1,000	1,000	1,000	950	1,000
75%	950	1,000	1,730	1,500	1,370	1,030	1,150	1,030	920	900	1,000	1,040	1,000	950	1,000
70%	950	1,050	1,910	1,640	1,430	1,070	1,190	1,030	950	900	1,000	1,060	1,000	950	1,030
60%	1,030	1,180	2,340	1,920	1,520	1,150	1,270	1,050	1,000	900	1,000	1,100	1,020	950	1,110
50%	1,180	1,470	2,800	2,360	1,810	1,230	1,380	1,110	1,040	940	1,070	1,130	1,110	980	1,180
40%	1,500	2,090	3,310	2,950	2,200	1,310	1,570	1,180	1,060	1,020	1,140	1,150	1,210	1,120	1,320
30%	2,040	2,730	4,080	3,520	2,620	1,550	1,760	1,260	1,120	1,100	1,160	1,180	1,230	1,520	1,630
25%	2,420	3,100	4,700	4,150	2,860	1,670	1,950	1,300	1,120	1,110	1,170	1,200	1,320	1,700	1,880
20%	2,730	3,600	5,510	4,530	3,110	1,800	2,270	1,490	1,160	1,130	1,200	1,250	1,380	1,970	2,340
10%	4,220	5,110	6,450	5,570	3,840	2,440	2,990	1,870	1,230	1,180	1,230	1,330	1,640	2,960	3,630
5%	5,650	7,390	7,530	6,090	4,500	3,020	3,440	2,180	1,250	1,550	1,230	1,430	2,580	4,260	5,060
1%	9,600	11,080	9,450	7,650	5,760	4,160	4,830	2,950	1,340	1,700	1,260	2,830	4,190	7,170	8,080

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NOTES:

1. IRON GATE DAM FLOWS BASED ON TE 2019 BIOP AVERAGE DAILY FLOWS.

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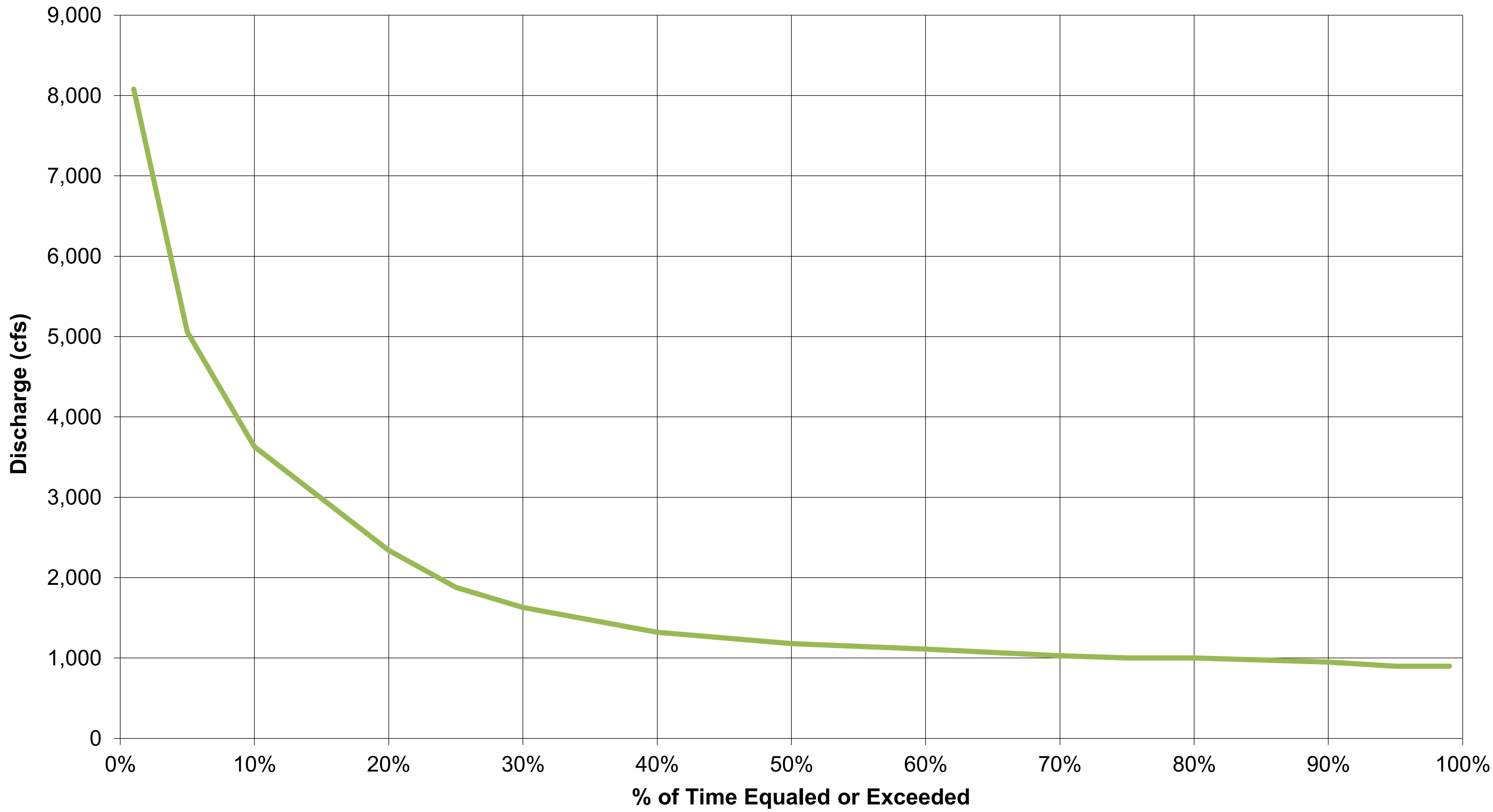

NOTES:
1.IRON GATE DAM FLOWS BASED ON TE 2019 BIOP AVERAGE DAILY FLOWS.

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KIEWIT INFRASTRUCTURE WEST CO.

KLAMATH RIVER RENEWAL PROJECT

IRON GATE DAM
ANNUAL FLOW DURATION CURVE

Knight Piésold CONSULTING

P/A NO. VA103-640/1

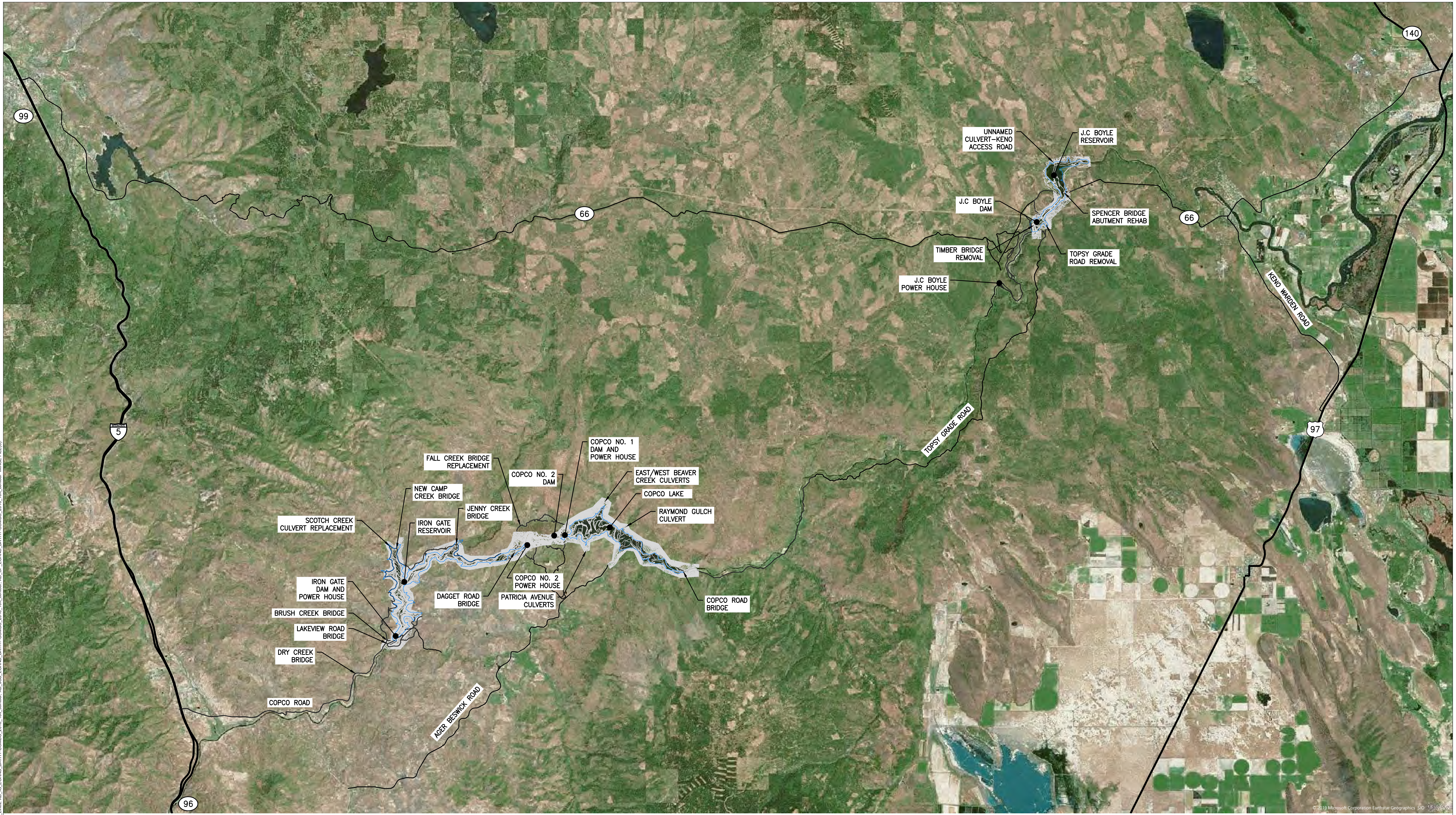
REF. NO. 6

FIGURE 4.4

REV 0

5.0 TRIBUTARY FLOWS

Located within the KRRP area are various roads, bridges, and culvert structures. The locations of road, bridge, and culvert sites identified for improvement, monitoring, or construction purposes are identified on Figure 5.1 along with the location of the four KRRP facilities.



PLAN
1"= 7500'

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HORIZ 1" =7500', VERT 1" = 7500'

KIEWIT INFRASTRUCTURE WEST CO.

KLAMATH RIVER RENEWAL PROJECT

PROJECT VICINITY AND ACCESS KEY PLAN

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-640/1	6

FIGURE 5.1	REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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SAVED: M:\1\03\00640\01\A\Acad\FIGS\B02, 2/6/2020 9:01:25 AM , WLAHODA PRINTED: 2/6/2020 9:01:36 AM, Key Plan, WLAHODA ACAD VERSION: 23.0S (LMS TECH)
XREF FILE(S): XC-Klamath Access Routes; X_Klamath_Access_Rd_Lines; XD_IG_EGRND_BATHY-COMBO_2018_10ft_contour; XD_JCB_EGRND_BATHY-COMBO_2018_10ft_contour; XD_CP_EGRND_BATHY-COMBO_2018_10ft_contour IMAGE FILE(S):

The primary design goal for the roads, bridges, and culverts component of the KRRP is to modify the existing transport infrastructure to accommodate safe construction access throughout the KRRP site and to maintain existing public access during all stages of the project, from initial construction through to final removal of the hydroelectric facilities, and subsequent restoration. In order to facilitate this transportation design goal, design flood estimates for ungaged locations within the KRRP area are required.

Most of the transportation points of interest (POIs) are located on tributaries to the Klamath River, with the remaining POIs located directly on the Klamath River. In order to estimate the peak design floods at the ungaged locations, it was necessary to characterize the tributary flows within the Klamath Basin between the J.C. Boyle and Iron Gate facilities. The Jenny Creek tributary represents a significant portion of the incoming flows between the J.C. Boyle and the Iron Gate facilities. While Jenny Creek does have irrigation diversions and the flows are therefore somewhat regulated, this regulation effect is much smaller than that caused by the reservoirs on the mainstem of the Klamath River, and likely has little impact on the highest peak flows.

Many of the other larger tributary streams to the Klamath River are also regulated with irrigation structures, but as with Jenny Creek, the effects of this regulation on the largest peak flows is likely quite limited. Accordingly, the return period peak design flows calculated for all tributary streams are based on flow records for unregulated streams.

5.1 JENNY CREEK TRIBUTARY

Jenny Creek is a tributary to the Klamath River that discharges into the Iron Gate reservoir. The flow at Jenny Creek represents a significant portion of the tributary inflows into the Klamath River between the J.C. Boyle and Iron Gate facilities. There is an inactive USGS hydrology station located at the outlet of Jenny Creek (USGS Station JENNY C NR COPCO CA, 11516500); however, peak flow data for this gage are only available from 1923 to 1928, and the quality of the data from almost a century ago is uncertain. This station has a drainage area of 205 mi^2 (210 mi^2 using USGS Streamstats), and the records indicate annual peak flows ranging from 420 cfs to 1960 cfs, with a six-year average of 1002 cfs. Relative to peak flows recorded at other creeks in the region, these values seem to be very low.

The Bureau of Land Management (BLM) has a hydrology gage on Jenny Creek (located below Spring Creek at UTM 10T 0553140 / 4652570 (Lat/Long: 42.02335, -122.35817) with a drainage area of approximately 195 mi^2. BLM provided KP with daily flow and annual peak flow data from this gage for the period of 1998 to 2018, noting that the rating curve may no longer be applicable and may require updating. The information for this gage has not undergone QA/QC procedures and is therefore subject to change. KP has submitted a request for Information (RFI) to obtain additional information regarding the BLM Jenny Creek gage from PacifiCorp. Nonetheless, the data are believed to be the best Jenny Creek specific flow data currently available, and as such, KP completed hydrologic analyses using these data.

5.1.1 AVERAGE MONTHLY FLOW

Using the BLM flow record, the average monthly flows for Jenny Creek at the Jenny Creek Bridge were calculated, as presented in Table 5.1 and on Figure 5.2. As the BLM gage is a distance upstream from the bridge, this calculation involved prorating the BLM gage flow values by the ratio of drainage areas for the two sites, 210 mi^2/195 mi^2.

Table 5.1 Monthly Average Flow for Jenny Creek at Jenny Creek Bridge (Preliminary)

Month	Monthly Average Flow (cfs)
January	121
February	181
March	305
April	225
May	136
June	41
July	16
August	15
September	16
October	19
November	29
December	87

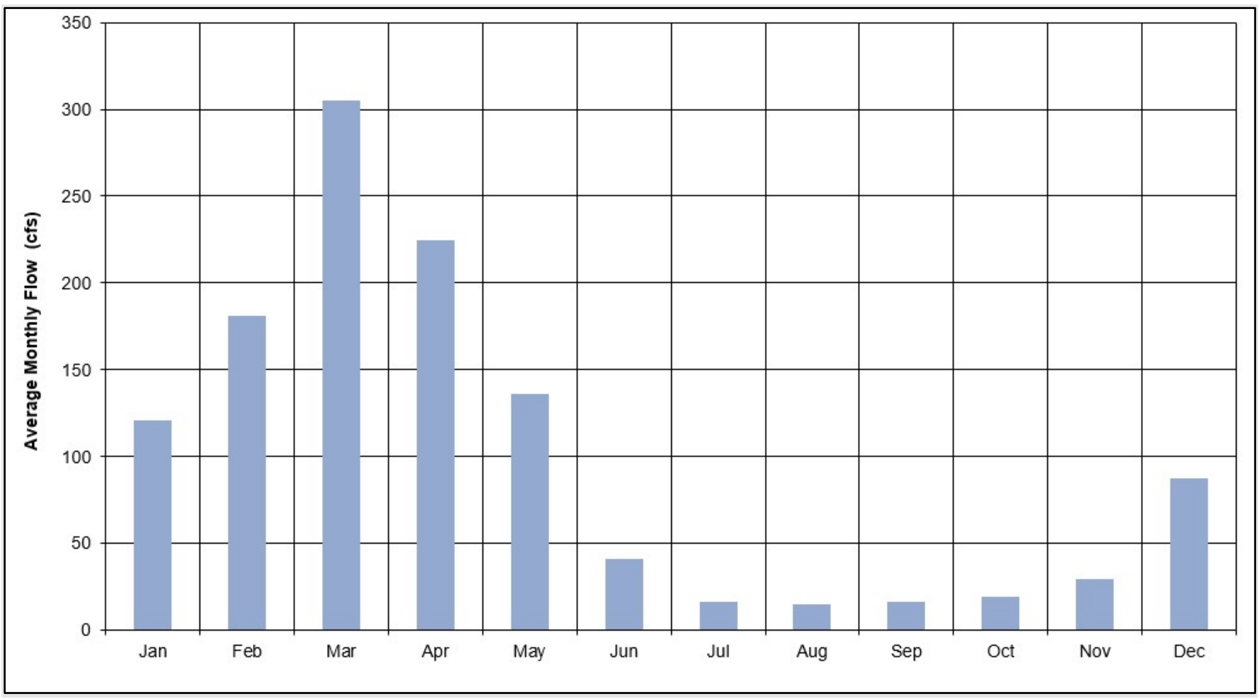

Figure 5.2 Monthly Average Flow for Jenny Creek at Jenny Creek Bridge (Preliminary)

5.1.2 ANNUAL PEAK FLOOD

A summary of the available stream gage data used by KP for the regional hydrology assessment is provided in Table 5.2 below, and the station locations are shown on Figure 5.3.

Table 5.2 Summary of Streamflow Gage Records

Gage	Gage Operator/ Number	Basin Area (mi^2)	Period of Record	Notes
Klamath Tributary near Keno, OR	USGS 11509400	1.02	1964-1981	Annual peak flow estimates only. Includes the 1964 flood.
Fall Creek at Copco CA	USGS 11512000	14.6	1928 - 1959	Peak streamflow available. Does not include 1964 flood.
Fall Creek at Copco CA	PacifiCorp	14.6	2015 - 2017	Hourly data available. Not QA/QC'd. Does not include 1964 flood.
Bogus Creek	PacifiCorp	53.7	2014 - 2018	15-minute data available. Not QA/QC'd. Does not include 1964 flood.
Jenny Creek	BLM	195	1998 - 2018	15-minute data available. Not QA/QC'd. Does not include 1964 flood.
Rogue River above Prospect, OR	USGS 14328000	312	1909 – 2017	15-minute data available. Includes 1964 flood record.

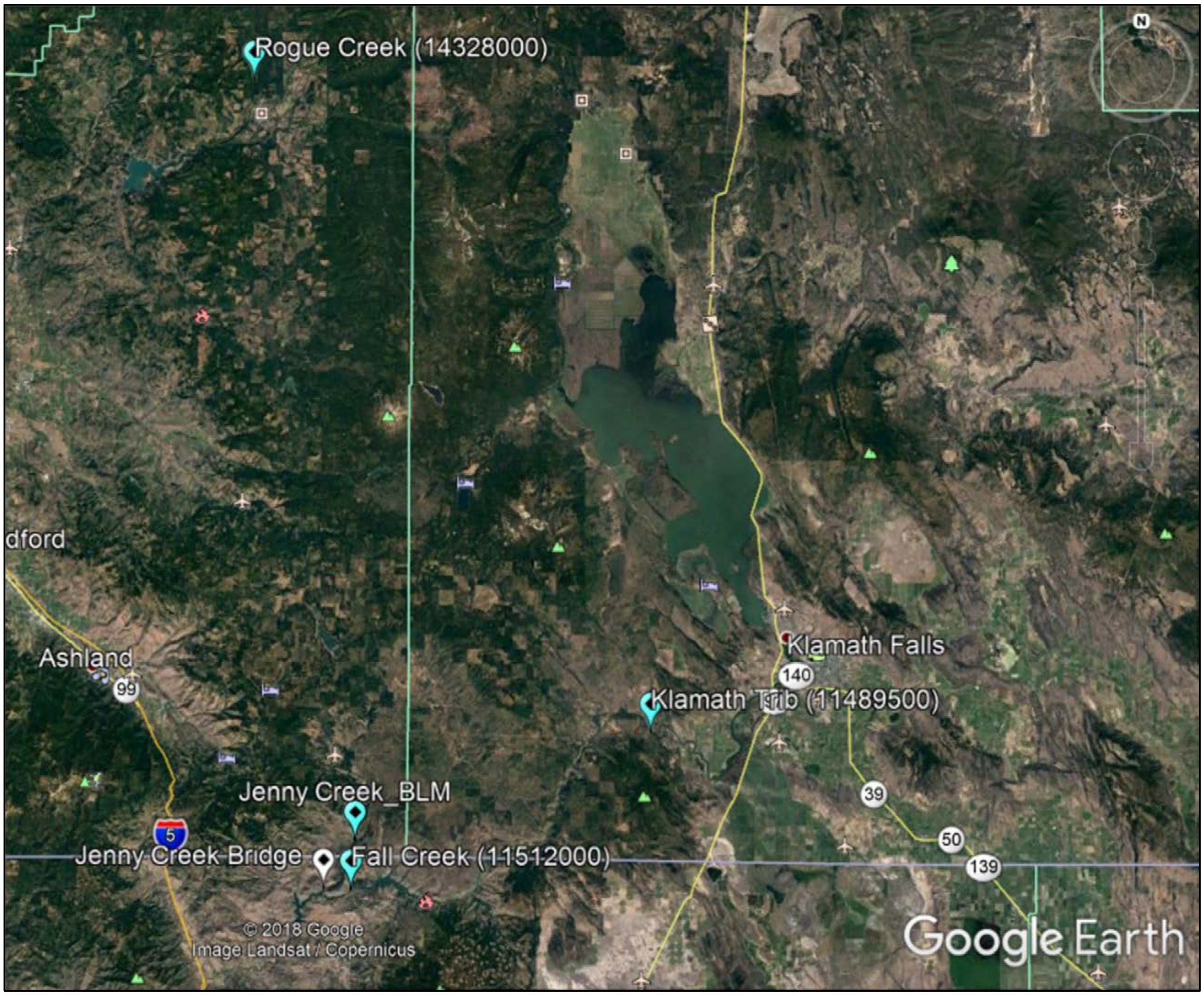

Figure 5.3 Regional Streamflow Gage Locations

A regional flow assessment was performed on available peak flow data for the USGS stream gages listed in Table 5.2. The characteristics of the gaged basins as well as the lengths of available streamflow records were considered when determining the suitability of a gage for estimating flood flows for Jenny Creek. The PacifiCorp gages on Bogus Creek and Fall Creek were excluded due to insufficient stream gage data for the analysis. The USGS gage data for Fall Creek at Copco and the Klamath Tributary near Keno were excluded because their drainage areas are outside of the range of 0.50 to 1.50 times the size of Jenny Creek drainage area, as recommended by the USGS (2005). Data for the USGS stream gage on Rogue River above Prospect (gage number 14328000) were selected as the most appropriate dataset for calculating return period peak flows for Jenny Creek because of the similarity of Rogue Creek's watershed to Jenny Creek's, in terms of drainage area and mean basin elevation. In addition, Rogue Creek has a lengthy period of record, which dates from 1909 to 2017, and includes 1964 when the well-known flood of record for the Klamath region occurred.

A flood frequency analysis was completed for the entire period of record for the Rogue River using the USACE HEC-SSP software (V2.1), following the Bulletin 17B method for the Log-Pearson Type III distribution (USGS, 1982). The Rogue River flood frequency results were then transposed using non-linear area proration to calculate the peak flood flows for Jenny Creek at the bridge (USGS, 2005). A scaling exponent of 1.0 was used for the transposition, as recommended in USGS (2005).

A flood frequency analysis was also performed on the BLM Jenny Creek annual peak flood data using the USACE HEC-SSP software (V2.1), following the Bulletin 17B method for the Log-Pearson Type III distribution (USGS, 1982). The calculated peak flood values were non-linearly prorated to the Jenny Creek bridge location using the methods outlined in USGS (2005) and a scaling exponent of 1.0.

The flood frequency analysis results based on both the USGS Rogue River and the BLM Jenny Creek datasets are presented in Table 5.3.

Table 5.3 Flood Frequency Analysis for Jenny Creek Bridge

Percent Probable Flood	Return Period	Jenny Creek Bridge Peak Floods (cfs)	
		Design Values - Prorated from Rogue River USGS gage, 1909 - 2017	Prorated from Jenny Creek BLM gage, 1998 - 2017
50%	2 Year	3,100	1,400
20%	5 Year	5,000	2,700
10%	10 Year	6,500	4,000
5%	20 Year	8,000	5,500
2%	50 Year	10,100	8,000
1%	100 Year	11,900	10,400
0.5%	200 Year	13,900	13,200
0.2%	500 Year	16,600	17,700

For the lower return periods, the Rogue River based values are higher, but at the higher return periods that are typically used for the design of hydraulic structures, the two sets of values agree very strongly.

5.2 TRIBUTARY PEAK FLOODS

Design flood estimates for ungauged locations for road, bridge, and culvert crossings within the KRRP area were determined by scaling regional peak flows according to the crossing location.

For ungaged locations located on the Klamath River, the annual peak floods were determined based on the design flood estimates from the closest appropriate dam facility, which were linearly prorated by the ratio of the respective drainage areas to the location of interest.

For ungaged locations on tributary streams of the Klamath River, the annual peak floods were calculated based on the annual peak flood values for the USGS gage on Fall Creek (gage number 11512000) using non-linear drainage area proration. The Fall Creek stream gage data were selected for the analysis based on drainage area size and mean basin elevation, which are generally representative of the watersheds pertaining to the majority of the POI’s that are located on smaller tributaries to the Klamath River. In addition, the Fall Creek record length is reasonably long, at 32 years, and though it is quite old, dating from 1928 to 1959, it is the most appropriate record available.

A flood frequency analysis was performed on the Fall Creek annual peak flood data using the USACE HEC-SSP software (V2.1), following the Bulletin 17B method for the Log-Pearson Type III distribution (USGS, 1982). The calculated peak floods were then non-linearly prorated to the POI locations. The scaling exponent for drainage area was investigated to determine the appropriate value to use for the smaller drainage areas of the POIs. A regional analysis based on Cathcart (2001) indicates a much flatter sloped drainage area scaling exponent of 0.32 for drainage areas less than 50 km² (approximately 19 mi²); however, this value is calculated based on a limited number of data points and is therefore likely subject to sampling error. A review of the various USGS regional regression equations for determining peak floods for Oregon and California for the Klamath region indicates scaling exponents ranging from 0.5 to 1.0, although most of the values tend to be towards the upper end of the range, and therefore a value of 0.9 was selected for design purposes.

Preliminary design flood values estimated for roads, bridges, and culverts are provided on a site-by-site basis in Table 5.4.

Table 5.4 Annual Peak Floods for Roads, Bridges, and Culvert Structures

Location	Drainage Area (mi²)	Annual Percent Probable Flood (cfs)[6]						
		50%	10%	5%	2%	1%	0.5%	0.2%
Scotch Creek Culvert[1]	17.9	170	450	600	850	1,070	1,320	1,710
New Camp Creek Bridge[1]	19.8	180	490	660	930	1,170	1,440	1,870
Jenny Creek Bridge	210	1,400	4,000	5,500	8,000	10,300	13,100	17,700
Timber Bridge Removal[2,3]	4,080	7,000	10,300	11,700	13,300	14,200	15,000	15,800
East/West Beaver Culverts[1]	5.6	60	160	210	300	370	460	600
Raymond Gultch Culvert[1]	2.5	28	80	103	140	180	220	291
Patricia Avenue Culverts[1]	0.4	5	15	20	28	35	43	56
Copco Road Bridge[2,3]	4,340	7,100	13,900	18,100	24,000	29,200	34,800	42,900
Unnamed Culvert Keno Access Road[1]	12.2	120	320	430	600	750	930	1,210
Spencer Bridge[2,3]	4,050	6,900	10,200	11,600	13,200	14,100	14,900	15,700
Topsy Grade Road Culvert[1]	2.2	30	70	90	130	160	200	260
Dagget Road Bridge[2,3,4]	4,370	7,100	14,000	18,200	24,200	29,400	35,000	43,200
Fall Creek Bridge[1]	12.2	120	320	430	600	750	930	1,210
Brush Creek Bridge[1]	5.0	50	140	190	270	340	420	540
Lakeview Road Bridge[2,3,5]	4,630	7,500	14,900	19,300	25,700	31,200	37,100	45,800
Dry Creek Bridge[1]	8.9	90	240	320	450	570	700	910

NOTES:

1. VALUES ARE CALCULATED BASED ON FALL CREEK ANNUAL PEAK FLOOD RESULTS USING NON-LINEAR DRAINAGE AREA PRORATION WITH A SCALING FACTOR OF 0.9, FOLLOWING THE METHODOLOGY DESCRIBED IN "ESTIMATION OF PEAK DISCHARGES FOR RURAL, UNREGULATED STREAMS IN WESTERN OREGON" (USGS, 2005).
2. VALUES ARE BASED ON ANNUAL PEAK FLOOD RESULTS FROM THE CLOSEST APPROPRIATE DAM FACILITY, WHICH WERE LINEARLY PRORATED BY THE RATIO OF THE RESPECTIVE DRAINAGE AREAS.
3. THE SITE IS LOCATED ON THE KLAMATH RIVER AND THEREFORE THE FLOW DATA ARE REGULATED.
4. THE DRAINAGE AREA OF THE COPCO NO. 1 FACILITY WAS USED FOR THE DRAINAGE AREA OF POINT OF INTEREST.
5. THE DRAINAGE AREA OF THE IRON GATE FACILITY WAS USED FOR THE DRAINAGE AREA OF POINT OF INTEREST.
6. THE FLOOD VALUES ARE PRELIMINARY AND ARE EXPECTED TO BE UPDATED FOR 90% DESIGN COMPLETION DOCUMENTS. ADDITIONAL TRIBUTARY HYDROLOGY DATA HAVE BEEN REQUESTED FROM BLM, PACIFICORP, AND AECOM.

6.0 REFERENCES

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CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

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APPENDIX A8 Work Restrictions - Design Criteria

PAGE A8-1

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

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APPENDIX A9 Diversion Tunnel Improvements and Work Platforms - Design Criteria

PAGE A9-1

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

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APPENDIX A10 Reservoir Drawdown - Design Criteria

PAGE A10-1

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

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APPENDIX A11 Auxiliary Equipment Installation and Removal - Design Criteria

PAGE A11-1

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

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APPENDIX A12 Embankment Dam Removal - Design Criteria

PAGE A12-1

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APPENDIX A13 Concrete Dam and Structure Removal - Design Criteria

PAGE A13-1 to A13-2

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APPENDIX A14 Roads, Bridges, and Culverts - Design Criteria

PAGE A14-1 to A14-9

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APPENDIX A15 Obsolete

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APPENDIX A16 Material Disposal - Design Criteria

PAGE A16-1 to A16-2

APPENDIX A17

Recreation Sites

Appendix A17.1 Recreation Sites – Design Criteria
Appendix A17.2 Road Design Calculations
Appendix A17.3 Recreation Sites – Figures and Supporting Information

Appendix A17.1

Recreation Sites – Design Criteria

(Pages A17.1-1 to A17.1-6)

APPENDIX A-17 RECREATION SITES DESIGN CRITERIA

1.0 DESIGN CRITERIA

The tables below outline the primary design criteria and have been developed for use by the Design-Build Team to achieve the goals and objectives previously discussed. The tables are organized by feature, criteria and remarks/reference.

Table 1-1
Layout and Civil Design Criteria

Feature	Criteria	Remarks/Reference
1. Access Road and Parking Areas		
a. Traffic Level of Service	Level of Service H, Less than 400 ADT	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design
b. Surfacing	Road Base	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design. AASHTO Guide for Design of Pavement Structures
c. Pavement Thickness	8 inches min.	AASHTO Guide for Design of Pavement Structures
d. Design Lifespan	20-year	AASHTO Guide for Design of Pavement Structures
e. Width	12-foot min. 2-foot shoulders	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design
f. Design Vehicle	Large Recreation Vehicle	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design
g. Design Speed	15 mph	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design
h. Vertical Grade	8% max. for fire access roads 12% max for other access roads	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design NFPA 1142 Standard on Water Supplies for Suburban and Rural Fire Fighting
i. Curve Radius	100 feet min. for fire access roads 50 feet min for other roads	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design NFPA 1142 Standard on Water Supplies for Suburban and Rural Fire Fighting
j. Turnaround Diameter	120-feet min. for fire access sites	NFPA 1142 Standard on Water Supplies for Suburban and Rural Fire Fighting
k. Drainage Requirements	Low volume, rural, 25-yr peak discharge (Q_{25})	California Department of Transportation (CALTRANS) Highway Design Manual, Chapter 830

l. Parking Lane Width	10 feet min. ADA 10 feet lane w/ 4' extension striping	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design
m. Temporary Access Roads	Design Build Contractor to meet applicable environmental and safety requirements	NRS Forest Service- Forest Road Construction and Maintenance Manual
2. Drainage Improvements		
a. Design Storm	Low volume, rural, 25-yr peak discharge (Q_{25})	California Department of Transportation (CALTRANS) Highway Design Manual, Chapter 830
b. Minimum Culvert/Storm Pipe Size	18" min.	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design
c. Stormwater Management	BMP selection based on site conditions – perimeter and local erosion control, dust control, concrete washout	USFS Road Preconstruction Handbook, 7709.56, Chapter 40 – Design
3. Boat Ramps		
a. Elevation Requirements	Top – dictated by local topography or ordinary high-water line Toe – transition in riverbank and river-bottom slope or low water line	USFS FSH 2309.13 Recreation Site Handbook Oregon State Marine Board, Design Guidelines for Recreational Boating Facilities
b. Grade	12%-15% overall	USFS FSH 2309.13 Recreation Site Handbook Oregon State Marine Board, Design Guidelines for Recreational Boating Facilities
c. Cross Slope	2% max	Oregon State Marine Board, Design Guidelines for Recreational Boating Facilities
d. Width	15 feet min. per lane 20 feet for single lane ramp	USFS FSH 2309.13 Recreation Site Handbook Oregon State Marine Board, Design Guidelines for Recreational Boating Facilities
e. Surfacing	Concrete, surfacing for boat ramp should meet OSMB requirements for v-groove finish	USFS FSH 2309.13 Recreation Site Handbook, Oregon State Marine Board, Design Guidelines for Recreational Boating Facilities
f. Scour		US FHWA HEC-18 and US FHWA HEC-23
4. ADA Accessibility		
a. Grades and dimensions	8.3% max. Outdoor recreation access route-50' resting intervals when slope length interval is 30'-60'. Passing spaces every 200 LF. Stairs not allowed. No	US Forest Service Outdoor Recreation Accessibility Guidelines (2013) and the USFS Accessibility Guidebook for Outdoor Recreation and Trails

	protrusions between 27 and 80”. Protrusions above travel surface- 4” max.	
b. Access Walk Width	48” Minimum with 32” clear passage through and around any obstacles and 60” diameter turning area.	US Forest Service Outdoor Recreation Accessibility Guidelines (2013) and the USFS Accessibility Guidebook for Outdoor Recreation and Trails
c. Surfacing	Stable, slip-resistant, and firm surface resisting deformation by indentations is to be provided either with native soil or soil stabilizer. Surfacing may include compacted rock or asphalt.	US Forest Service Outdoor Recreation Accessibility Guidelines (2013) and the USFS Accessibility Guidebook for Outdoor Recreation and Trails
5. Hiking/River Trails		
a. Surfacing	Varies-Accessible trails to be stabilized soil, crushed rock, DG, ½” rock, compacted 3-4” rock.	
b. Width	48” clear min.	USFS FSH 2309.13 Recreation Site Handbook
c. Grade	8.3% max. for ADA accessible trails. Outdoor recreation access route-50’ resting intervals when slope length interval is 30’-60”. Passing spaces every 200 LF. Stairs not allowed. No protrusions between 27 and 80”. Protrusions above travel surface- 4” max allowed. Edge protection required on ADA routes-3” high. Cross Slope: 2% min., 5% max.	Chapter 10 ABAAG, ABAAS, USFS Trail Accessibility Guidelines, USFS Outdoor Recreation Accessibility Guidelines
d. Accessibility requirements	Accessibility limits to be provided where feasible. At minimum, accessible parking spots and pathway to vault toilet to be graded to meet accessibility requirements.	
e. Signage	Trail signs need to include length of trail, surface type, portion that is accessible, width, and slope data	Oregon Sites – Oregon State Parks and Recreation California Sites – California State Parks
6. Outdoor Facilities		
a. Recreation / Picnic Furnishings	Furnishings to meet ADA requirements.	Oregon Sites – Oregon State Parks and Recreation

		California Sites – California State Parks
7. Signage		
a. Dimension	Per managing agency design guidelines.	USFS FSH 2309.13 Recreation Site Handbook
b. Location	Per managing agency design guidelines.	USFS FSH 2309.13 Recreation Site Handbook
c. Accessible Parking Stalls	Signs per Federal and Oregon and California State Standards.	ABAAS and US Forest Service Outdoor Recreation Accessibility Guidelines (2013) and the USFS Accessibility Guidebook for Outdoor Recreation and Trails

Table 1-2
Geotechnical Criteria

Feature/Issue	Criteria	Remarks/Reference
1. Boat Ramps		
a. Foundation Parameters	TBD. Based on data in the Geotechnical Data Report.	USACE EM 1110-1-1905, Bearing Capacity of Soils. USACE EM 1110-1-2908, Rock Foundations.
2. Boat Slides		
a. Foundation Parameters	TBD. Based on data in the Geotechnical Data Report.	USACE EM 1110-1-1905, Bearing Capacity of Soils. USACE EM 1110-1-2908, Rock Foundations.
3. Earthwork/Bank Stabilization		
a. Maximum Slope Grade	TBD. Based on data in the Geotechnical Data Report.	
b. Factors of Safety for Slope Stability	End of Construction – FS=1.5 Pseudostatic – FS>1.0	USACE EM 1110-2-1902, Slope Stability
4. Angler Box		
a. Foundation Parameters	TBD. Based on data in the Geotechnical Data Report.	USACE EM 1110-1-1905, Bearing Capacity of Soils. USACE EM 1110-1-2908, Rock Foundations.

Table 1-3
Seismic Load Criteria

Feature/Issue	Criteria	Remarks/Reference
1. Ground Motion Parameters		
a. Site-Specific Parameters and time histories	Site specific	USGS Earthquake Hazards Program, Unified Hazard Tool

2.0 REFERENCES

American Association of State Highway and Transportation Offices, AASHTO (1993). *Guide for Design of Pavement Structures.* Part II.

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APPENDIX A17.2 Road Design Calculations

PAGE A17.2-1 to A17.2-3

Appendix A17.3

Recreation Sites – Figures and Supporting Information

(Pages A17.3-1 to A17.3-57)

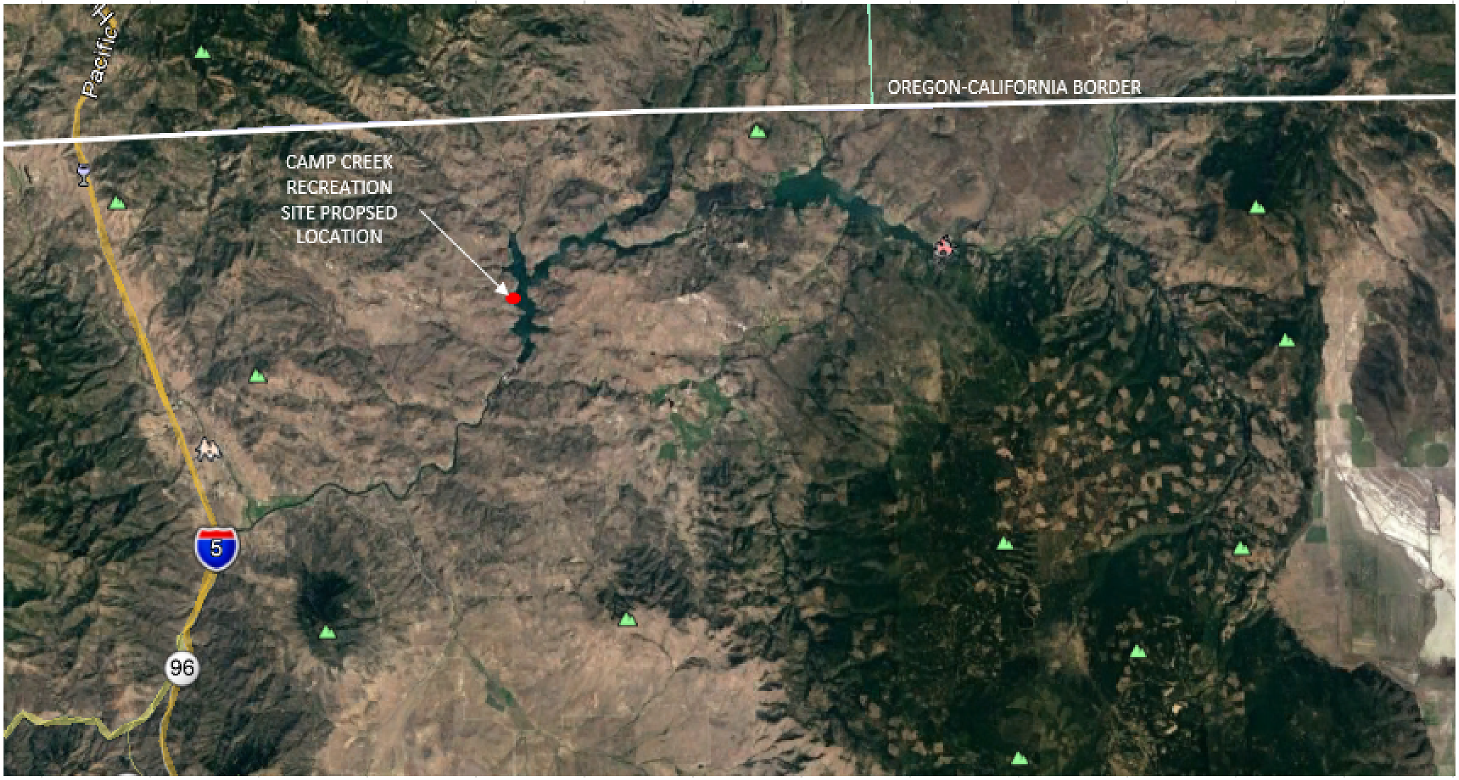
APPENDIX A17-A- FIGURES

APPENDIX A17-A1

VICINITY MAP

Copco Valley Vicinity Maps

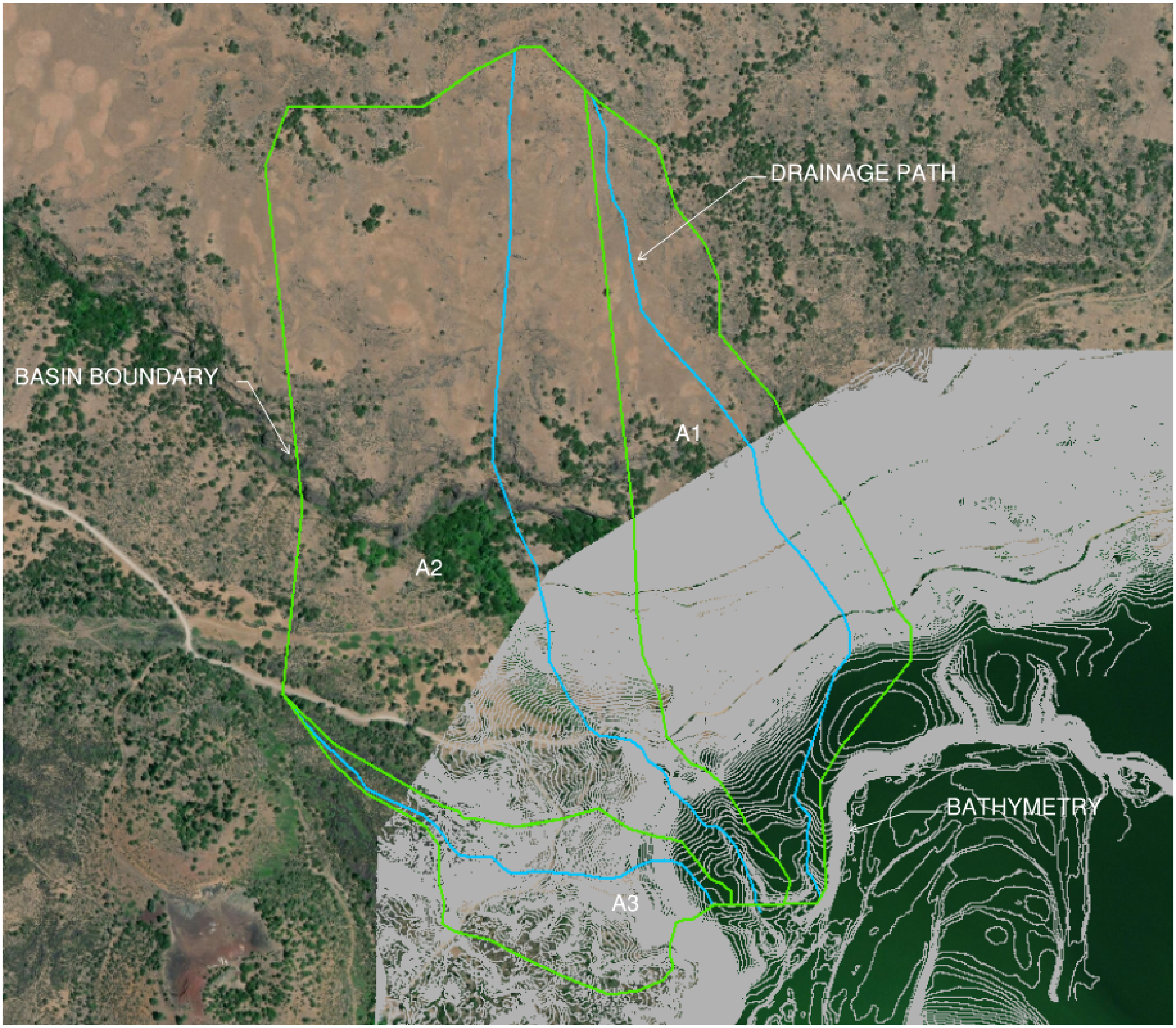
Camp Creek Vicinity Maps



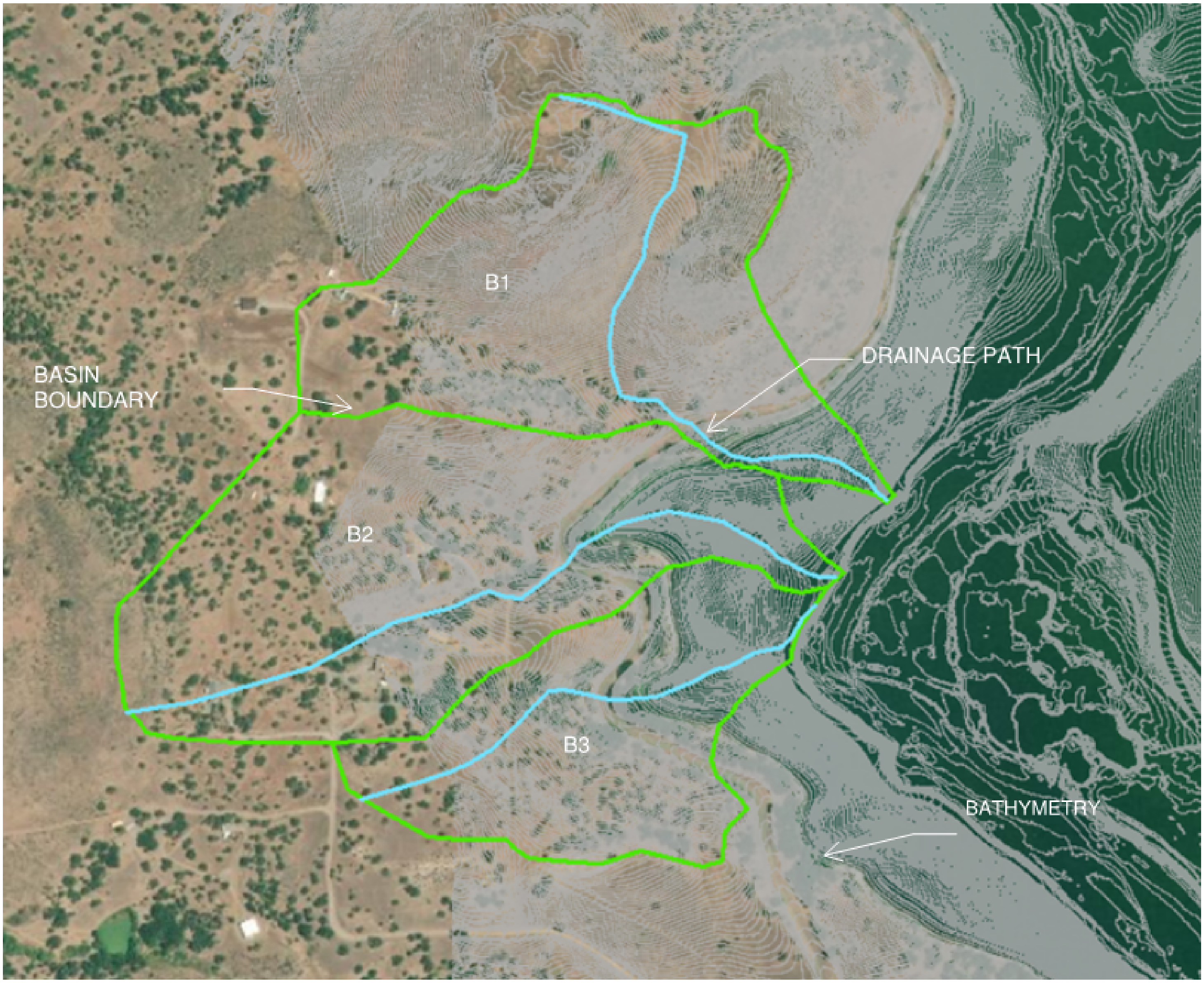
APPENDIX A17-A2

HISTORIC DRAINAGE PATH

Copco Valley Drainage Paths



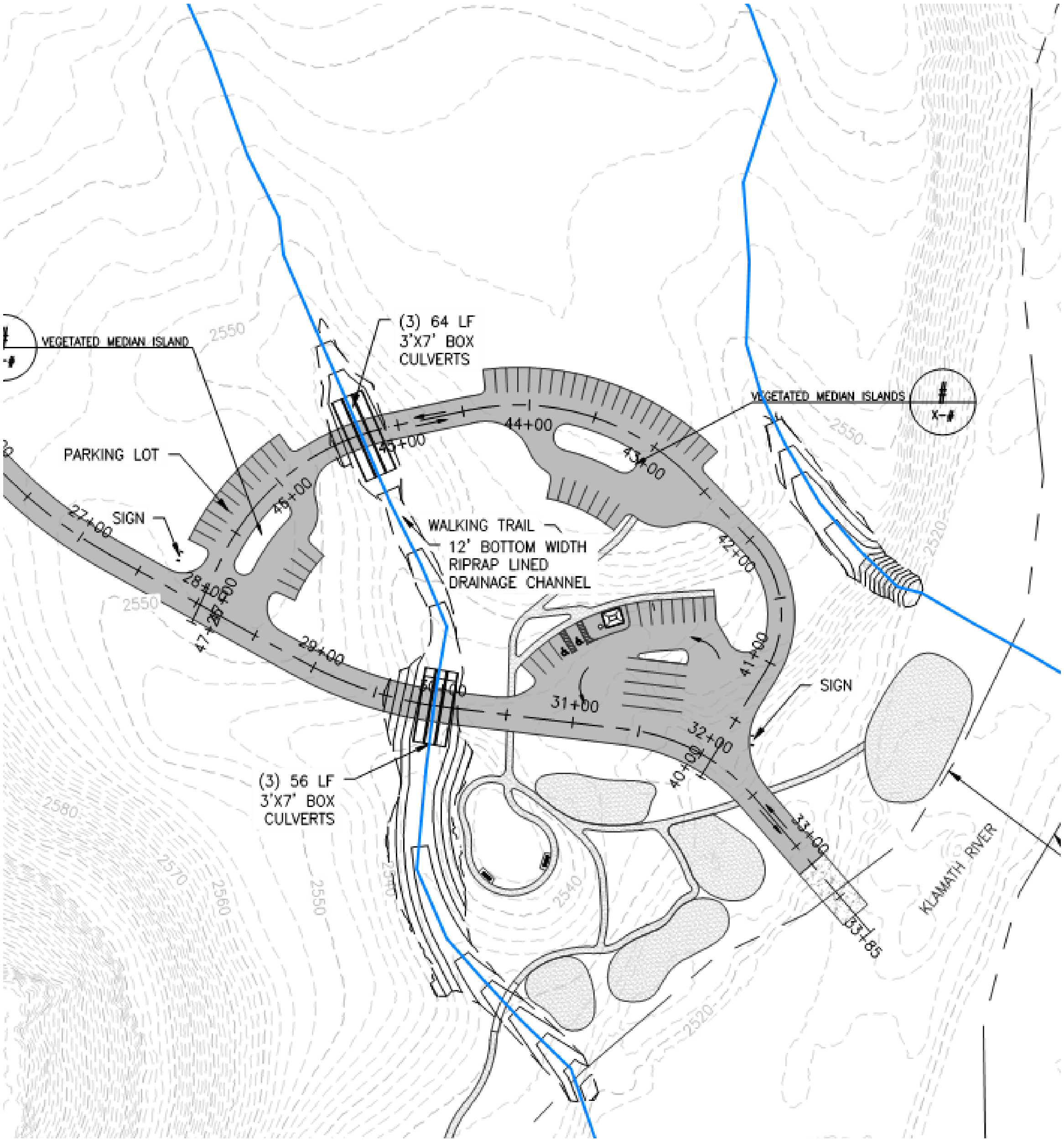
Camp Creek Drainage Paths



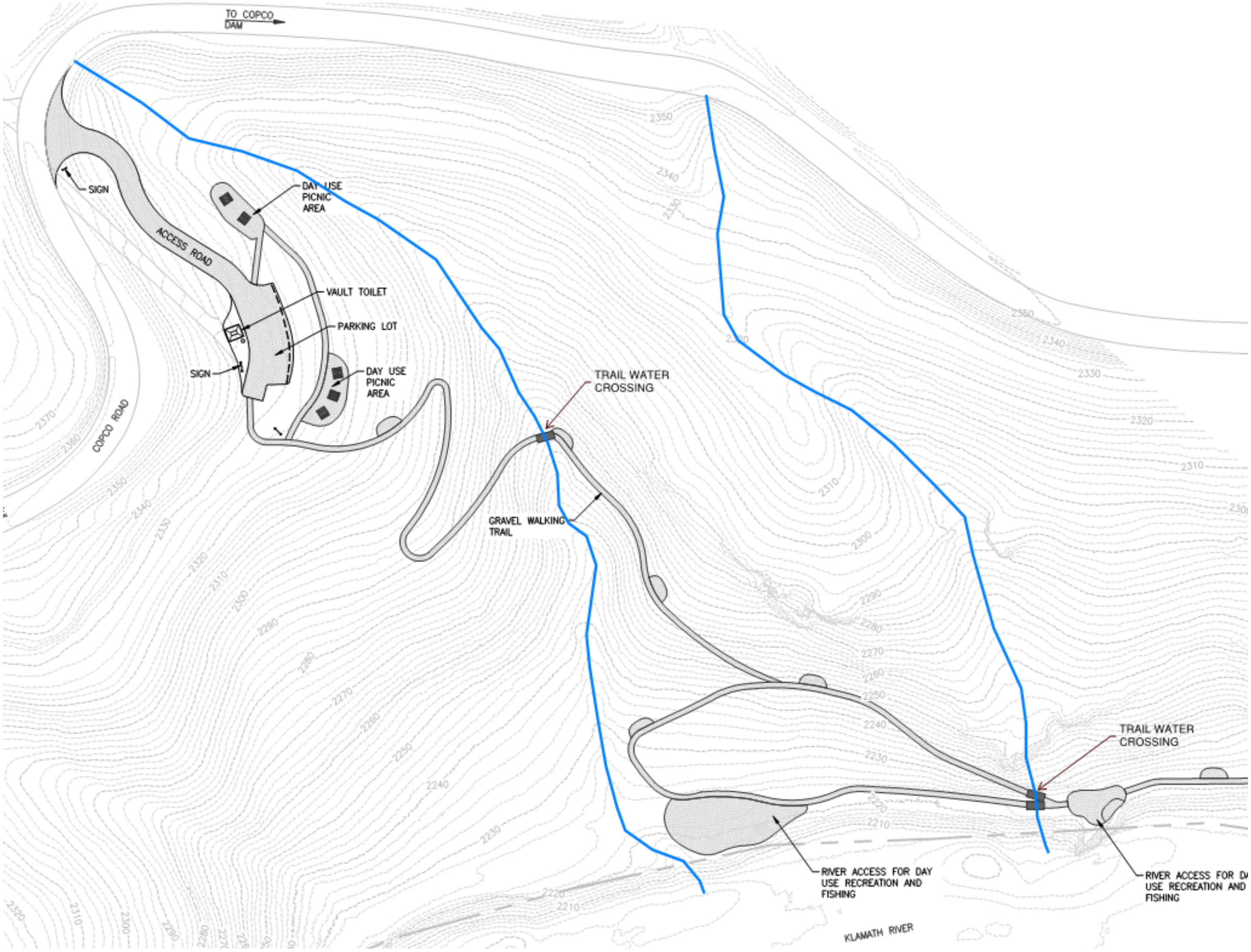
APPENDIX A17-A3

DEVELOPED DRAINAGE PLAN

COPCO VALLEY PROPOSED DRAINAGE PLAN



CAMP CREEK PROPOSED DRAINAGE PLAN



APPENDIX A17-B- SITE DATA

APPENDIX A17-B1

NRCS SITE SOIL SURVEY REPORT

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Siskiyou County, California, Central Part

Klamath River Renewal Recreation Sites

PREFACE

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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CONTENTS

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

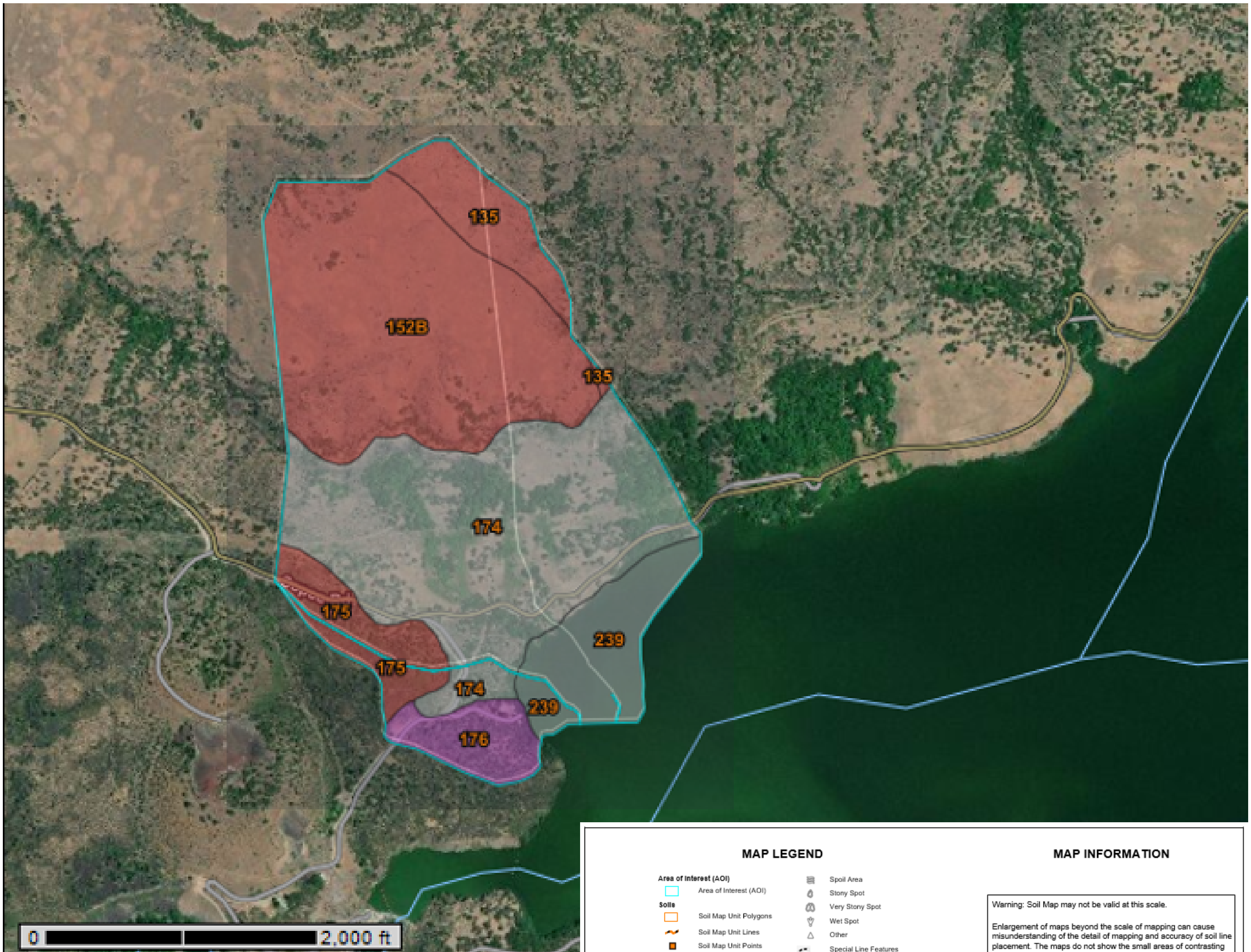
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

SOIL MAP

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Copco Valley Custom Soil Resource Report
Hydrologic Soil Group Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

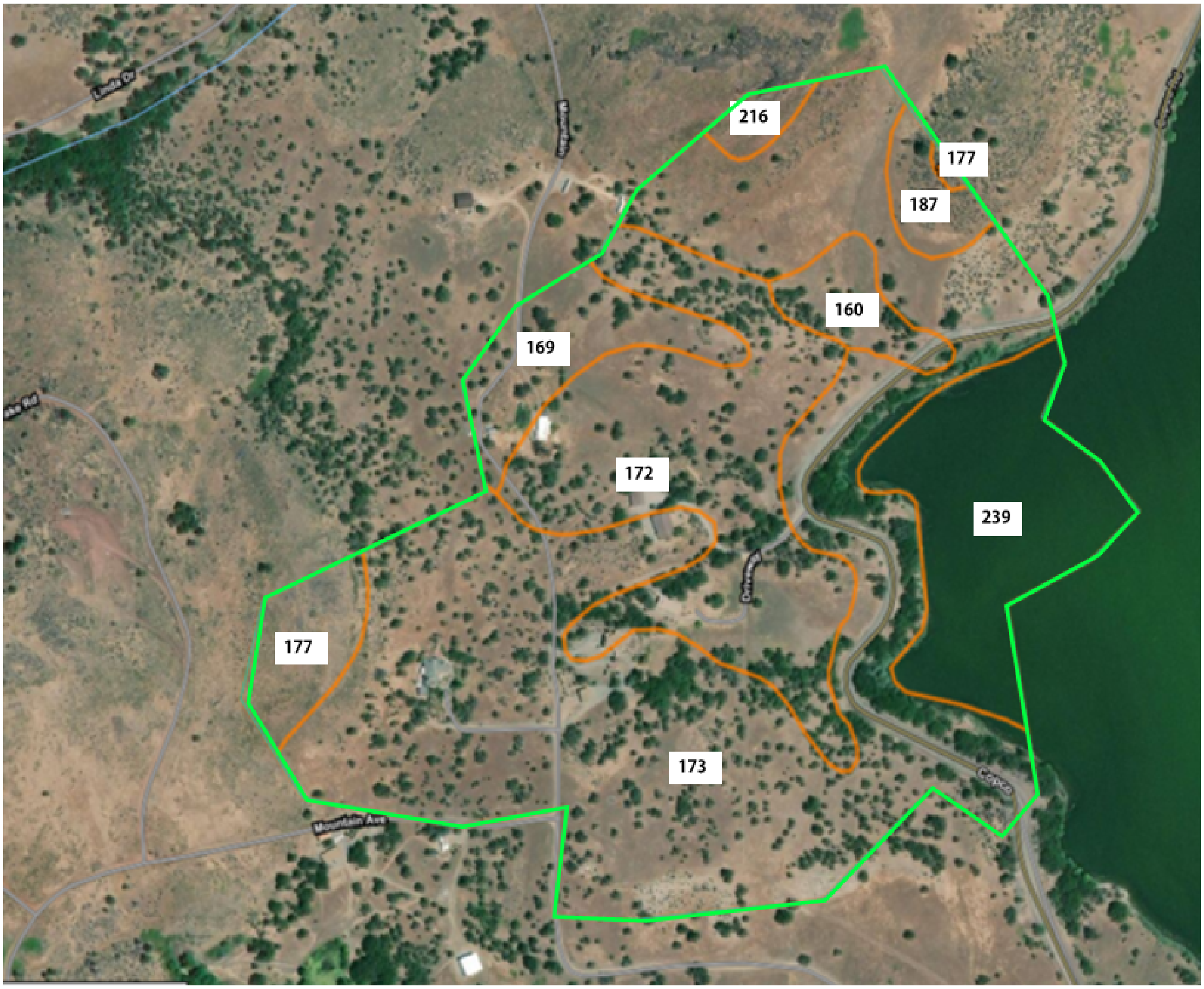
Soil Survey Area: Siskiyou County, California, Central Part
Survey Area Data: Version 11, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Camp Creek Custom Soil Resource Report

Hydrologic Soil Group Map



Map Unit Legend

Copco Valley			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
135	Deven-Rubble land complex, 0-30% slopes	14.5	6.1%
152B	Randcore-Shoat complex, 0-5% slopes	84.5	35.7%
174	Lassen-Rock outcrop-Kuck complex, 2-50% slopes	89.8	37.9%
175	Lava Flows	14.6	6.1%
176	Laval flows- Xerorthents complex, 0-50% slopes	11.3	4.8%
239	Water	22.3	9.4%
Totals for Area of Interest		**236.8**	**100.0%**

Camp Creek			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
160	Jenny clay, 2 to 15 percent slopes	2.3	2.6%
169	Lassen clay, 2 to 9 percent slopes Lassen clay, 2 to 9 percent slopes	4.5	5.0%
172	Lassen-Kuck complex, 15 to 50 percent slopes	17.4	19.7%
173	Lassen-Kuck complex, stony, 2 to 50 percent slopes	48.5	54.7%
177	Lithic Haploxerolls-Rock outcrop complex, 0 to 65 percent slopes*	3	3.4%
187	Mary stony loam, 2 to 50 percent slopes	1.7	1.9%
216	Rock outcrop	0.9	1.0%
239	Water	10.4	11.7%
Totals for Area of Interest		**88.7**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha- Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation

Siskiyou County, California, Central Part

Copco Valley

135—Deven-Rubble land complex, 0 to 30 percent slopes

Map Unit Setting

National map unit symbol: hdnw
Elevation: 3,500 to 4,000 feet
Mean annual precipitation: 16 inches
Mean annual air temperature: 48 degrees F
Frost-free period: 125 days
Farmland classification: Not prime farmland

Map Unit Composition

Deven and similar soils: 40 percent
Rubble land: 35 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Deven

Setting

Landform: Plateaus
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Upper third of mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from andesite

Typical profile

H1 - 0 to 5 inches: loam
H2 - 5 to 17 inches: clay loam, clay
H2 - 5 to 17 inches: unweathered bedrock
H3 - 17 to 21 inches:

Properties and qualities

Slope: 0 to 30 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: SHALLOW LOAMY (R022XD063CA)
Hydric soil rating: No

Description of Rubble Land

Setting

Landform: Plateaus
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Upper third of mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Igneous rock

Typical profile
H1 - 0 to 60 inches: fragmental material
Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: A
Hydric soil rating: No
Minor Components
Unnamed
Percent of map unit: 10 percent
Hydric soil rating: No
Kuck
Percent of map unit: 5 percent
Hydric soil rating: No
Pinehurst variant
Percent of map unit: 5 percent
Hydric soil rating: No
Rock outcrop
Percent of map unit: 5 percent
Hydric soil rating: No

152B—Randcore-Shoat complex, 0 to 5 percent slopes

Map Unit Setting
National map unit symbol: rwyp
Elevation: 2,000 to 6,000 feet
Mean annual precipitation: 12 to 35 inches
Mean annual air temperature: 45 to 52 degrees F
Frost-free period: 50 to 150 days
Farmland classification: Not prime farmland
Map Unit Composition
Randcore and similar soils: 60 percent
Shoat and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.
Description of Randcore
Setting
Landform: Plateaus
Landform position (two-dimensional): Backslope, summit
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess derived from volcanic rock
Typical profile
H1 - 0 to 1 inches: extremely stony loam
H2 - 1 to 6 inches: loam
H3 - 6 to 16 inches: unweathered bedrock
Properties and qualities
Slope: 0 to 5 percent
Percent of area covered with surface fragments: 40.0 percent
Depth to restrictive feature: 4 to 10 inches to lithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: Very low (about 0.8 inches)
Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: BISCUIT-SCABLAND (SCABLAND) 18-26 PZ (R005XY008OR)
Hydric soil rating: No
Description of Shoat
Setting
Landform: Plateaus
Landform position (two-dimensional): Backslope, summit
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess derived from volcanic rock
Typical profile
H1 - 0 to 4 inches: loam
H2 - 4 to 24 inches: loam
H3 - 24 to 34 inches: unweathered bedrock
Properties and qualities
Slope: 0 to 5 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)
Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: BISCUIT-SCABLAND (BISCUIT) 18-26 PZ (R005XY006OR)
Hydric soil rating: No
Minor Components
Lorella
Percent of map unit: 2 percent
Ecological site: DROUGHTY SLOPES 20-30PZ (R005XA020OR)
Hydric soil rating: No
Paragon
Percent of map unit: 1 percent
Ecological site: LOAMY SLOPES 18-24 PZ (R005XA034OR)
Hydric soil rating: No
Randcore, >5%
Percent of map unit: 1 percent
Ecological site: BISCUIT-SCABLAND (SCABLAND) 18-26 PZ (R005XA008OR)
Hydric soil rating: No
Rock outcrop
Percent of map unit: 1 percent
Hydric soil rating: No
Unnamed, wet spots & marsh
Percent of map unit: 1 percent
Landform: Mountains
Hydric soil rating: Yes
Skookum

Percent of map unit: 1 percent
Ecological site: DROUGHTY SLOPES 20-30PZ (R005XA020OR)
Hydric soil rating: No
Shoatc, 10-20 c
Percent of map unit: 1 percent
Ecological site: BISCUIT-SCABLAND (BISCUIT) 18-26 PZ (R005XA006OR)
Hydric soil rating: No
Shoat, >40 c
Percent of map unit: 1 percent
Ecological site: BISCUIT-SCABLAND (BISCUIT) 18-26 PZ (R005XA006OR)
Hydric soil rating: No
Shoat, >5%
Percent of map unit: 1 percent
Ecological site: BISCUIT-SCABLAND (BISCUIT) 18-26 PZ (R005XA006OR)
Hydric soil rating: No

174—Lassen-Rock outcrop-Kuck complex, 2 to 50 percent slopes

Map Unit Setting
National map unit symbol: hdq4
Elevation: 2,500 to 4,500 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 110 to 140 days
Farmland classification: Not prime farmland
Map Unit Composition
Lassen and similar soils: 25 percent
Rock outcrop: 20 percent
Kuck and similar soils: 15 percent
Minor components: 38 percent
Estimates are based on observations, descriptions, and transects of the mapunit.
Description of Lassen
Setting
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Residuum weathered from igneous rock
Typical profile
H1 - 0 to 9 inches: very stony clay
H2 - 9 to 28 inches: cobbly clay, cobbly clay loam
H2 - 9 to 28 inches: unweathered bedrock
H3 - 28 to 32 inches:
Properties and qualities
Slope: 2 to 50 percent
Percent of area covered with surface fragments: 35.0 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: STONY CLAY (R022XD067CA)
Hydric soil rating: No
Description of Rock Outcrop
Setting
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from igneous rock
Typical profile
H1 - 0 to 4 inches: unweathered bedrock
Properties and qualities
Slope: 2 to 50 percent
Depth to restrictive feature: 0 to 4 inches to lithic bedrock
Natural drainage class: Excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No
Description of Kuck
Setting
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Residuum weathered from igneous rock
Typical profile
H1 - 0 to 6 inches: very stony clay loam
H2 - 6 to 20 inches: stony clay loam, stony silty clay loam, stony clay
H2 - 6 to 20 inches: stony clay loam
H2 - 6 to 20 inches: weathered bedrock
H3 - 20 to 32 inches:
H4 - 32 to 36 inches:
Properties and qualities
Slope: 2 to 50 percent
Percent of area covered with surface fragments: 35.0 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.3 inches)
Interpretive groups
Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: STONY CLAY (R022XD067CA)
Hydric soil rating: No
Minor Components
Montague
Percent of map unit: 14 percent
Hydric soil rating: No
Unnamed
Percent of map unit: 14 percent
Hydric soil rating: No
Jenny
Percent of map unit: 10 percent
Hydric soil rating: No

175—Lava flows

Map Unit Composition
Lava flows: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.
Description of Lava Flows
Setting
Landform: Lava fields
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pahoehoe lava
Typical profile
H1 - 0 to 60 inches: fragmental material
Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D
Hydric soil rating: No
Minor Components
Mart
Percent of map unit: 5 percent
Hydric soil rating: No
Jilson
Percent of map unit: 5 percent
Hydric soil rating: No
Unnamed
Percent of map unit: 5 percent
Hydric soil rating: No

176—Lava flows-Xerorthents complex, 0 to 50 percent slopes*

Map Unit Setting
National map unit symbol: hdq6
Elevation: 3,000 to 8,500 feet
Mean annual precipitation: 20 to 45 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 60 to 125 days
Farmland classification: Not prime farmland
Map Unit Composition

Lava flows: 40 percent
Xerorthents and similar soils: 30 percent
Minor components: 29 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows

Setting

Landform: Lava fields
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Pahoehoe lava

Typical profile

H1 - 0 to 60 inches: fragmental material

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: A
Hydric soil rating: No

Description of Xerorthents

Setting

Landform: Mountains
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Residuum weathered from andesite and/or residuum weathered from basalt

Typical profile

H1 - 0 to 15 inches: variable
2 - 15 to 25 inches: bedrock

Properties and qualities

Slope: 0 to 50 percent
Percent of area covered with surface fragments: 2.0 percent
Depth to restrictive feature: 8 to 40 inches to lithic bedrock
Natural drainage class: Excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.06 to 20.12 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 14 percent
Hydric soil rating: No

Rubble land

Percent of map unit: 10 percent
Hydric soil rating: No

Riverwash

Percent of map unit: 5 percent
Landform: Drainageways

Hydric soil rating: Yes

Camp Creek

160—Jenny clay, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: hdpp
Elevation: 2,500 to 5,000 feet
Mean annual precipitation: 12 to 15 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 110 to 140 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Jenny and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Jenny

Setting

Landform: Terraces
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from igneous rock

Typical profile

H1 - 0 to 16 inches: clay
H2 - 16 to 23 inches: clay, silty clay
H2 - 16 to 23 inches: stratified loam to clay
H3 - 23 to 60 inches:

Properties and qualities

Slope: 2 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 25 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: High (about 10.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: CLAYEY (R022XD065CA)
Hydric soil rating: No

Minor Components

Kuck

Percent of map unit: 5 percent
Hydric soil rating: No

Lassen

Percent of map unit: 5 percent
Hydric soil rating: No

Medford

Percent of map unit: 3 percent
Hydric soil rating: No

Unamed

Percent of map unit: 2 percent

Landform: Drainageways
Hydric soil rating: Yes

169—Lassen clay, 2 to 9 percent slopes

Map Unit Setting

National map unit symbol: hdpz
Elevation: 2,000 to 4,500 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 110 to 140 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Lassen and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lassen

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from igneous rock

Typical profile

H1 - 0 to 9 inches: clay
H2 - 9 to 26 inches: clay loam, clay
H2 - 9 to 26 inches: gravelly clay loam, gravelly clay
H3 - 26 to 28 inches: unweathered bedrock
H3 - 26 to 28 inches:
H4 - 28 to 32 inches:

Properties and qualities

Slope: 2 to 9 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: CLAYEY (R022XD065CA)

Hydric soil rating: No

Minor Components

Jenny

Percent of map unit: 8 percent
Hydric soil rating: No

Lassen

Percent of map unit: 5 percent
Hydric soil rating: No

Unnamed

Percent of map unit: 2 percent

Landform: Drainageways

Hydric soil rating: Yes

172—Lassen-Kuck complex, 15 to 50 percent slopes

Map Unit Setting

National map unit symbol: hdq2
Elevation: 2,500 to 4,500 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 110 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Lassen and similar soils: 45 percent
Kuck and similar soils: 20 percent
Minor components: 35 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lassen

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave, linear
Across-slope shape: Convex, linear
Parent material: Residuum weathered from igneous rock

Typical profile

H1 - 0 to 9 inches: clay
H2 - 9 to 26 inches: clay loam, clay
H2 - 9 to 26 inches: gravelly clay loam, gravelly clay
H3 - 26 to 28 inches: unweathered bedrock
H3 - 26 to 28 inches:
H4 - 28 to 32 inches:

Properties and qualities

Slope: 15 to 50 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: CLAYEY (R022XD065CA)
Hydric soil rating: No

Description of Kuck

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Residuum weathered from igneous rock

Typical profile

H1 - 0 to 6 inches: clay loam
H2 - 6 to 20 inches: clay loam, silty clay loam, clay
H2 - 6 to 20 inches: gravelly clay loam
H2 - 6 to 20 inches: weathered bedrock
H3 - 20 to 32 inches:
H4 - 32 to 36 inches:

Properties and qualities

Slope: 15 to 50 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: CLAYEY (R022XD065CA)
Hydric soil rating: No

Minor Components

Montague

Percent of map unit: 20 percent

Hydric soil rating: No

Rock outcrop

Percent of map unit: 15 percent
Hydric soil rating: No

173—Lassen-Kuck complex, stony, 2 to 50 percent slopes

Map Unit Setting

National map unit symbol: hdq3
Elevation: 2,500 to 4,500 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 110 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Lassen and similar soils: 35 percent
Kuck and similar soils: 25 percent
Minor components: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lassen

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave, linear
Across-slope shape: Convex, linear
Parent material: Residuum weathered from igneous rock

Typical profile

H1 - 0 to 9 inches: stony clay
H2 - 9 to 28 inches: cobbly clay, cobbly clay loam
H2 - 9 to 28 inches: unweathered bedrock
H3 - 28 to 32 inches:

Properties and qualities

Slope: 2 to 50 percent
Percent of area covered with surface fragments: 2.0 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: D
Ecological site: STONY CLAY (R022XD067CA)
Hydric soil rating: No

Description of Kuck

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Residuum weathered from igneous rock

Typical profile

H1 - 0 to 6 inches: stony clay loam
H2 - 6 to 20 inches: stony clay loam, stony silty clay loam, stony clay
H2 - 6 to 20 inches: stony clay loam
H2 - 6 to 20 inches: weathered bedrock
H3 - 20 to 32 inches:
H4 - 32 to 36 inches:

Properties and qualities

Slope: 2 to 50 percent
Percent of area covered with surface fragments: 2.0 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: STONY CLAY (R022XD067CA)
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 20 percent
Landform: Mountains
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Upper third of mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Rock outcrop

Percent of map unit: 10 percent
Hydric soil rating: No

Montague

Percent of map unit: 5 percent
Hydric soil rating: No

Jenny

Percent of map unit: 5 percent
Hydric soil rating: No

177—Lithic Haploxerolls-Rock outcrop complex, 0 to 65 percent slopes*

Map Unit Setting

National map unit symbol: hdq7
Elevation: 2,000 to 6,000 feet
Mean annual precipitation: 20 to 50 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 60 to 125 days
Farmland classification: Not prime farmland

Map Unit Composition

Lithic haploxerolls, very stony loam, and similar soils: 40 percent
Rock outcrop: 30 percent
Minor components: 29 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lithic Haploxerolls, Very Stony Loam

Setting

Landform: Mountains
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Residuum weathered from igneous and metamorphic rock

Typical profile

H1 - 0 to 3 inches: very stony sandy loam
H2 - 3 to 10 inches: extremely stony sandy loam, very stony sandy loam, very cobbly sandy loam
H2 - 3 to 10 inches: unweathered bedrock
H2 - 3 to 10 inches:
H3 - 10 to 10 inches:

Properties and qualities

Slope: 0 to 65 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 1.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountains
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Igneous and metamorphic rock

Typical profile

H1 - 0 to 10 inches: unweathered bedrock

Properties and qualities

Slope: 0 to 65 percent
Depth to restrictive feature: 0 to 4 inches to lithic bedrock
Natural drainage class: Excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 14 percent
Hydric soil rating: No

Rubble land

Percent of map unit: 10 percent
Hydric soil rating: No

Riverwash

Percent of map unit: 5 percent
Landform: Drainageways
Hydric soil rating: Yes

187—MARY STONY LOAM, 2 TO 50 PERCENT SLOPES

MAP UNIT SETTING

National map unit symbol: hdqk
Elevation: 2,500 to 4,500 feet
Mean annual precipitation: 18 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 110 to 140 days
Farmland classification: Not prime farmland

MAP UNIT COMPOSITION

Mary and similar soils: 80 percent

Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

DESCRIPTION OF MARY

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from igneous rock

Typical profile

H1 - 0 to 10 inches: stony loam
H2 - 10 to 24 inches: loam, clay loam
H2 - 10 to 24 inches: sandy clay loam
H3 - 24 to 28 inches: unweathered bedrock
H4 - 28 to 32 inches:

Properties and qualities

Slope: 2 to 50 percent
Percent of area covered with surface fragments: 2.0 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: STONY LOAM (R022XD068CA)
Hydric soil rating: No

MINOR COMPONENTS

Hilt

Percent of map unit: 5 percent
Hydric soil rating: No

Terwilliger

Percent of map unit: 5 percent
Hydric soil rating: No

Rock outcrop

Percent of map unit: 5 percent
Hydric soil rating: No

APPENDIX A17-B2

NOAA SITE RAINFALL DATA

COPCO VALLEY

NOAA Atlas 14, Volume 6, Version 2
Location name: Hornbrook, California, USA*
Latitude: 41.9849°, Longitude: -122.3312°
Elevation: 2643.29 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.103 (0.089-0.121)	0.142 (0.122-0.166)	0.195 (0.168-0.230)	0.241 (0.205-0.286)	0.306 (0.251-0.377)	0.358 (0.286-0.453)	0.414 (0.322-0.538)	0.473 (0.356-0.635)	0.621 (0.445-0.874)	0.767 (0.529-1.12)
10-min	0.148 (0.128-0.173)	0.203 (0.176-0.238)	0.280 (0.241-0.329)	0.345 (0.294-0.410)	0.438 (0.359-0.541)	0.514 (0.411-0.649)	0.593 (0.461-0.771)	0.678 (0.511-0.911)	0.890 (0.639-1.25)	1.10 (0.758-1.61)
15-min	0.179 (0.154-0.209)	0.246 (0.212-0.288)	0.339 (0.291-0.398)	0.418 (0.356-0.495)	0.530 (0.434-0.654)	0.621 (0.497-0.785)	0.717 (0.557-0.932)	0.821 (0.617-1.10)	1.08 (0.772-1.52)	1.33 (0.917-1.95)
30-min	0.237 (0.205-0.277)	0.326 (0.281-0.382)	0.449 (0.386-0.527)	0.553 (0.471-0.656)	0.702 (0.575-0.866)	0.823 (0.658-1.04)	0.950 (0.738-1.24)	1.09 (0.818-1.46)	1.43 (1.02-2.01)	1.76 (1.21-2.58)
60-min	0.318 (0.275-0.372)	0.438 (0.378-0.513)	0.603 (0.518-0.708)	0.743 (0.633-0.881)	0.943 (0.773-1.16)	1.11 (0.884-1.40)	1.28 (0.992-1.66)	1.46 (1.10-1.96)	1.92 (1.37-2.70)	2.37 (1.63-3.46)
2-hr	0.449 (0.388-0.525)	0.587 (0.506-0.687)	0.771 (0.663-0.906)	0.924 (0.787-1.10)	1.14 (0.931-1.40)	1.30 (1.04-1.65)	1.47 (1.15-1.92)	1.65 (1.24-2.22)	1.93 (1.39-2.72)	2.39 (1.65-3.50)
3-hr	0.550 (0.475-0.643)	0.703 (0.607-0.823)	0.905 (0.779-1.06)	1.07 (0.912-1.27)	1.30 (1.06-1.60)	1.47 (1.18-1.86)	1.65 (1.29-2.15)	1.84 (1.39-2.47)	2.10 (1.50-2.95)	2.41 (1.66-3.53)
6-hr	0.787 (0.680-0.921)	0.981 (0.846-1.15)	1.23 (1.06-1.45)	1.43 (1.22-1.70)	1.71 (1.40-2.11)	1.92 (1.53-2.42)	2.13 (1.65-2.76)	2.34 (1.76-3.15)	2.63 (1.89-3.71)	2.86 (1.97-4.18)
12-hr	1.10 (0.953-1.29)	1.36 (1.18-1.60)	1.71 (1.47-2.01)	1.99 (1.69-2.36)	2.37 (1.94-2.92)	2.66 (2.13-3.36)	2.96 (2.30-3.85)	3.27 (2.46-4.39)	3.69 (2.65-5.20)	4.02 (2.77-5.89)
24-hr	1.58 (1.41-1.80)	1.96 (1.75-2.24)	2.48 (2.21-2.84)	2.91 (2.58-3.36)	3.51 (3.02-4.17)	3.99 (3.36-4.83)	4.48 (3.70-5.54)	5.00 (4.02-6.34)	5.72 (4.43-7.53)	6.29 (4.72-8.55)
2-day	1.99 (1.78-2.27)	2.50 (2.24-2.86)	3.20 (2.86-3.67)	3.79 (3.36-4.37)	4.62 (3.97-5.48)	5.27 (4.45-6.38)	5.96 (4.92-7.37)	6.69 (5.38-8.48)	7.71 (5.97-10.2)	8.53 (6.40-11.6)
3-day	2.30 (2.05-2.62)	2.92 (2.61-3.33)	3.77 (3.36-4.31)	4.47 (3.96-5.16)	5.47 (4.70-6.50)	6.26 (5.28-7.58)	7.09 (5.85-8.77)	7.96 (6.40-10.1)	9.19 (7.12-12.1)	10.2 (7.63-13.8)
4-day	2.49 (2.23-2.84)	3.19 (2.85-3.64)	4.12 (3.67-4.71)	4.90 (4.34-5.65)	5.99 (5.14-7.11)	6.84 (5.77-8.28)	7.74 (6.38-9.57)	8.67 (6.98-11.0)	9.98 (7.73-13.1)	11.0 (8.27-15.0)
7-day	2.91 (2.61-3.32)	3.74 (3.34-4.27)	4.82 (4.30-5.52)	5.71 (5.05-6.58)	6.92 (5.95-8.22)	7.85 (6.62-9.50)	8.81 (7.26-10.9)	9.79 (7.88-12.4)	11.1 (8.63-14.7)	12.2 (9.15-16.6)
10-day	3.23 (2.89-3.69)	4.16 (3.72-4.75)	5.36 (4.78-6.13)	6.32 (5.60-7.29)	7.62 (6.55-9.05)	8.61 (7.26-10.4)	9.61 (7.93-11.9)	10.6 (8.55-13.5)	12.0 (9.30-15.8)	13.1 (9.81-17.8)
20-day	4.17 (3.73-4.76)	5.42 (4.84-6.19)	7.00 (6.24-8.01)	8.24 (7.30-9.50)	9.88 (8.49-11.7)	11.1 (9.36-13.4)	12.3 (10.2-15.2)	13.5 (10.9-17.1)	15.1 (11.7-19.9)	16.3 (12.2-22.2)
30-day	5.08 (4.55-5.80)	6.63 (5.92-7.56)	8.56 (7.63-9.79)	10.1 (8.91-11.6)	12.0 (10.3-14.3)	13.5 (11.4-16.3)	14.9 (12.3-18.4)	16.3 (13.1-20.7)	18.1 (14.0-23.9)	19.5 (14.6-26.5)
45-day	6.44 (5.76-7.34)	8.39 (7.50-9.57)	10.8 (9.63-12.4)	12.7 (11.2-14.6)	15.1 (13.0-17.9)	16.8 (14.2-20.4)	18.5 (15.3-22.9)	20.2 (16.3-25.7)	22.4 (17.4-29.5)	24.0 (18.0-32.6)
60-day	7.58 (6.78-8.64)	9.83 (8.79-11.2)	12.6 (11.2-14.4)	14.7 (13.1-17.0)	17.5 (15.0-20.8)	19.5 (16.4-23.5)	21.4 (17.6-26.4)	23.3 (18.7-29.5)	25.7 (19.9-33.8)	27.4 (20.6-37.3)

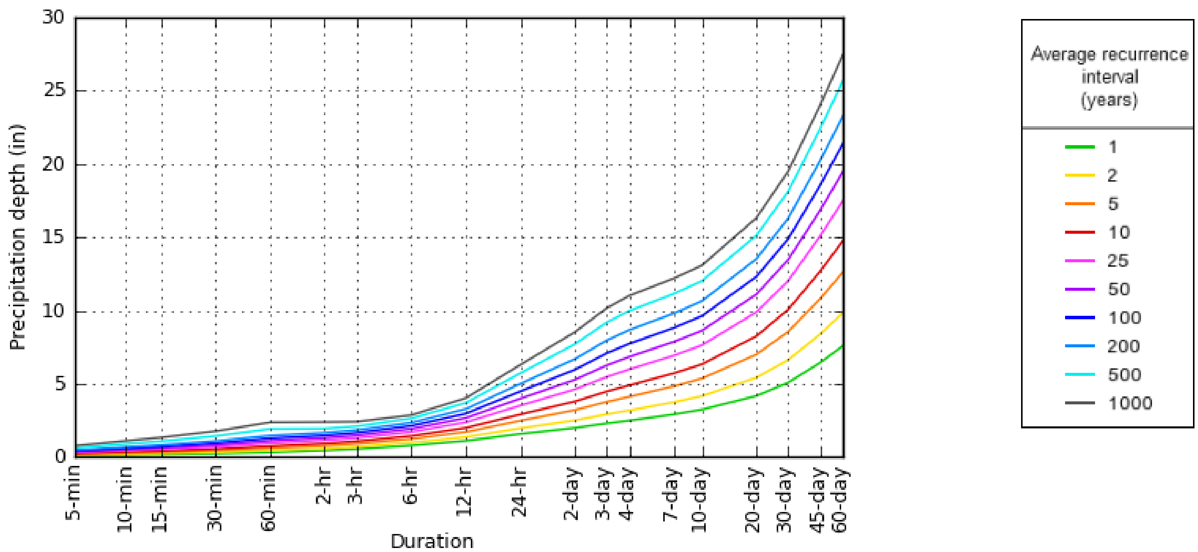
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

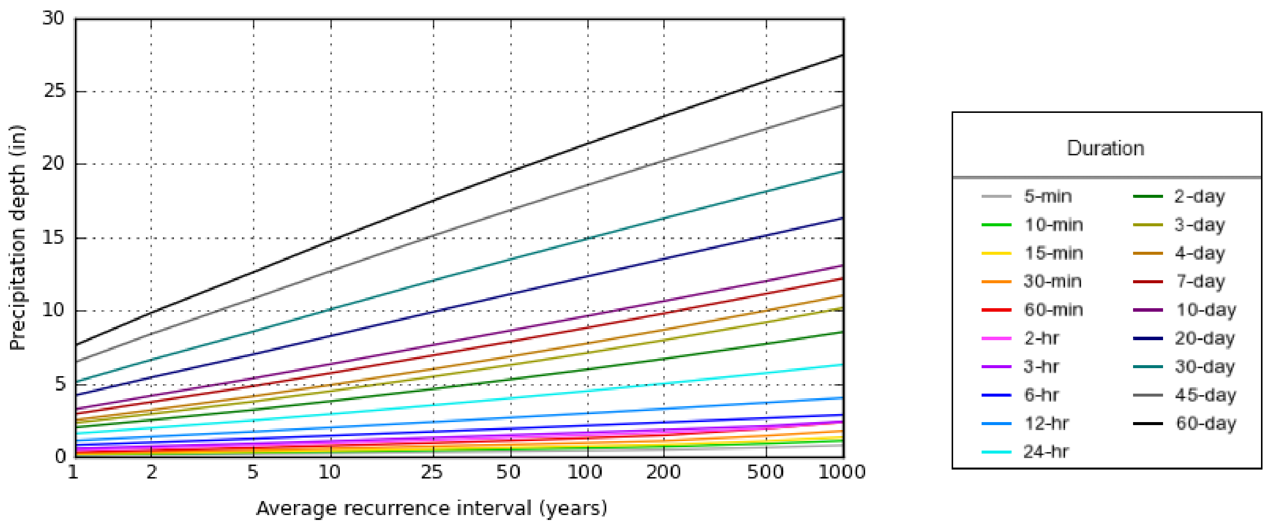
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

COPCO VALLEY

PF graphical





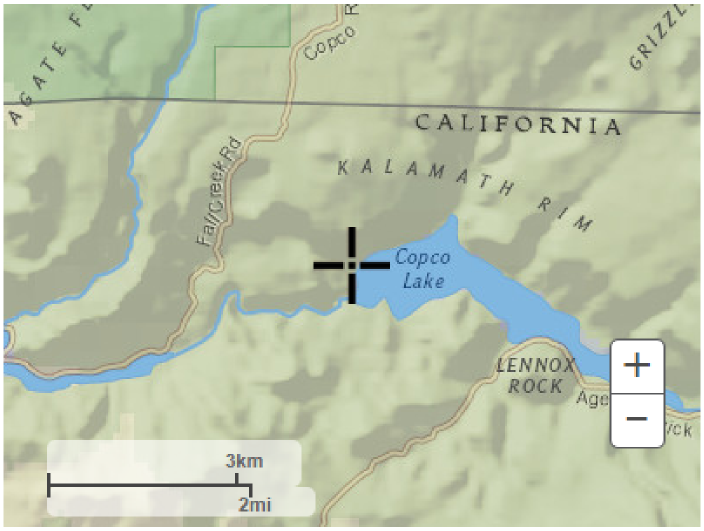
NOAA Atlas 14, Volume 6, Version 2

Created (GMT): Wed Oct 16 19:56:39 2019

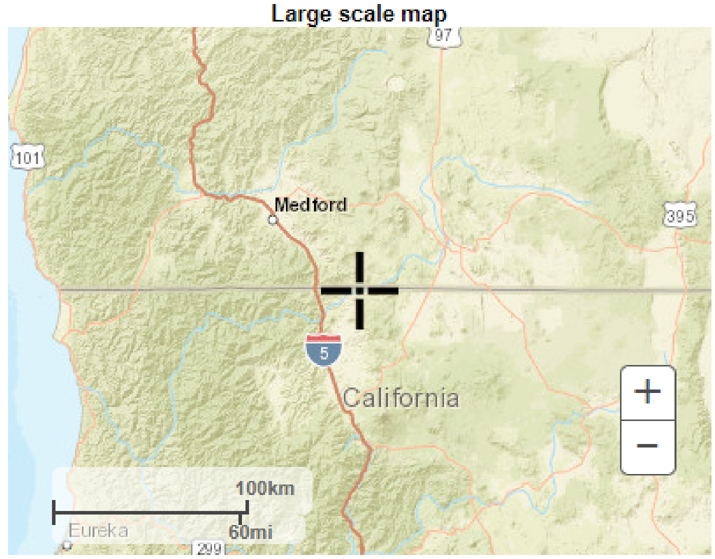
COPCO VALLEY

Maps and Aerials

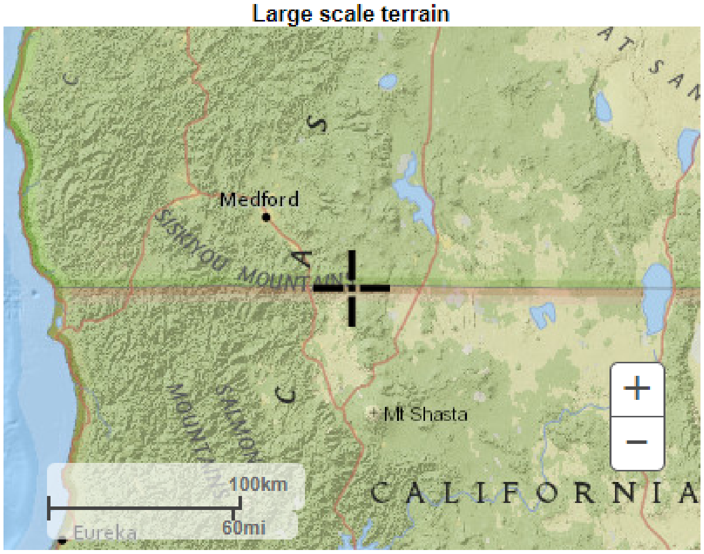
Small scale terrain



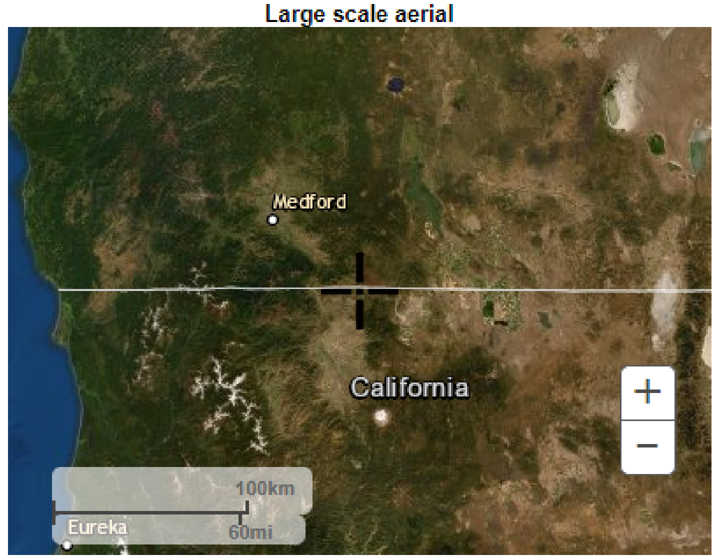
Large scale map



Large scale terrain



Large scale aerial



CAMP CREEK

NOAA Atlas 14, Volume 6, Version 2
Location name: Hornbrook, California, USA*
Latitude: 41.9849°, Longitude: -122.3312°
Elevation: 2643.29 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.102 (0.088-0.119)	0.137 (0.118-0.160)	0.185 (0.159-0.217)	0.225 (0.192-0.267)	0.282 (0.231-0.348)	0.329 (0.263-0.415)	0.377 (0.293-0.490)	0.429 (0.323-0.576)	0.517 (0.371-0.728)	0.625 (0.431-0.915)
10-min	0.146 (0.126-0.171)	0.196 (0.169-0.229)	0.264 (0.227-0.311)	0.322 (0.275-0.382)	0.405 (0.332-0.499)	0.471 (0.377-0.595)	0.541 (0.421-0.703)	0.615 (0.463-0.826)	0.741 (0.532-1.04)	0.896 (0.618-1.31)
15-min	0.177 (0.153-0.207)	0.237 (0.204-0.278)	0.320 (0.275-0.376)	0.390 (0.332-0.462)	0.490 (0.401-0.604)	0.570 (0.456-0.720)	0.654 (0.509-0.850)	0.744 (0.560-0.999)	0.896 (0.643-1.26)	1.08 (0.748-1.59)
30-min	0.232 (0.201-0.272)	0.312 (0.269-0.365)	0.421 (0.362-0.494)	0.513 (0.437-0.608)	0.644 (0.527-0.794)	0.749 (0.599-0.946)	0.860 (0.669-1.12)	0.978 (0.736-1.31)	1.18 (0.846-1.66)	1.43 (0.983-2.09)
60-min	0.309 (0.267-0.361)	0.414 (0.357-0.485)	0.558 (0.480-0.656)	0.681 (0.580-0.807)	0.855 (0.700-1.05)	0.995 (0.795-1.26)	1.14 (0.888-1.48)	1.30 (0.978-1.74)	1.57 (1.12-2.20)	1.89 (1.31-2.77)
2-hr	0.428 (0.369-0.500)	0.548 (0.473-0.642)	0.710 (0.611-0.834)	0.845 (0.719-1.00)	1.03 (0.845-1.27)	1.18 (0.942-1.49)	1.33 (1.03-1.73)	1.49 (1.12-2.00)	1.70 (1.22-2.40)	1.91 (1.32-2.80)
3-hr	0.518 (0.448-0.606)	0.652 (0.563-0.764)	0.830 (0.713-0.975)	0.976 (0.831-1.16)	1.18 (0.965-1.45)	1.34 (1.07-1.69)	1.50 (1.16-1.94)	1.66 (1.25-2.23)	1.89 (1.35-2.65)	2.06 (1.42-3.01)
6-hr	0.724 (0.626-0.847)	0.892 (0.770-1.05)	1.11 (0.956-1.31)	1.29 (1.10-1.53)	1.53 (1.26-1.89)	1.72 (1.37-2.17)	1.90 (1.48-2.47)	2.09 (1.58-2.81)	2.35 (1.69-3.31)	2.54 (1.75-3.72)
12-hr	0.988 (0.854-1.16)	1.23 (1.06-1.44)	1.54 (1.32-1.81)	1.79 (1.52-2.12)	2.13 (1.74-2.62)	2.39 (1.91-3.02)	2.65 (2.06-3.44)	2.91 (2.19-3.91)	3.26 (2.34-4.59)	3.53 (2.43-5.16)
24-hr	1.39 (1.24-1.58)	1.76 (1.57-2.01)	2.24 (2.00-2.57)	2.64 (2.33-3.04)	3.17 (2.72-3.77)	3.58 (3.02-4.34)	3.99 (3.29-4.94)	4.42 (3.55-5.61)	4.99 (3.86-6.57)	5.42 (4.07-7.38)
2-day	1.72 (1.54-1.96)	2.23 (1.99-2.54)	2.89 (2.57-3.31)	3.42 (3.03-3.95)	4.14 (3.55-4.92)	4.69 (3.95-5.68)	5.24 (4.32-6.49)	5.81 (4.67-7.37)	6.57 (5.08-8.66)	7.15 (5.36-9.72)
3-day	1.96 (1.76-2.24)	2.57 (2.30-2.94)	3.37 (3.00-3.85)	4.00 (3.54-4.62)	4.86 (4.17-5.77)	5.50 (4.64-6.66)	6.15 (5.07-7.62)	6.82 (5.48-8.66)	7.71 (5.97-10.2)	8.39 (6.29-11.4)
4-day	2.13 (1.90-2.43)	2.80 (2.50-3.20)	3.67 (3.27-4.21)	4.37 (3.87-5.05)	5.30 (4.55-6.30)	6.01 (5.06-7.27)	6.71 (5.53-8.31)	7.42 (5.97-9.43)	8.37 (6.48-11.0)	9.09 (6.82-12.4)
7-day	2.47 (2.20-2.81)	3.23 (2.89-3.69)	4.22 (3.76-4.84)	5.01 (4.43-5.78)	6.05 (5.19-7.19)	6.82 (5.75-8.26)	7.58 (6.25-9.39)	8.34 (6.70-10.6)	9.33 (7.22-12.3)	10.1 (7.54-13.7)
10-day	2.70 (2.41-3.08)	3.53 (3.15-4.03)	4.61 (4.10-5.27)	5.46 (4.83-6.30)	6.58 (5.65-7.82)	7.40 (6.24-8.97)	8.21 (6.77-10.2)	9.01 (7.24-11.4)	10.0 (7.77-13.2)	10.8 (8.09-14.7)
20-day	3.42 (3.06-3.90)	4.51 (4.03-5.15)	5.91 (5.26-6.76)	7.00 (6.20-8.08)	8.45 (7.25-10.0)	9.51 (8.01-11.5)	10.5 (8.69-13.0)	11.5 (9.28-14.7)	12.8 (9.92-16.9)	13.7 (10.3-18.7)
30-day	4.05 (3.62-4.62)	5.36 (4.79-6.12)	7.03 (6.27-8.06)	8.35 (7.39-9.64)	10.1 (8.66-12.0)	11.4 (9.57-13.8)	12.6 (10.4-15.6)	13.8 (11.1-17.5)	15.3 (11.8-20.1)	16.3 (12.2-22.2)
45-day	5.06 (4.53-5.78)	6.70 (5.98-7.66)	8.78 (7.82-10.1)	10.4 (9.22-12.0)	12.6 (10.8-14.9)	14.2 (11.9-17.2)	15.7 (12.9-19.4)	17.2 (13.8-21.8)	19.0 (14.7-25.1)	20.3 (15.2-27.6)
60-day	5.95 (5.32-6.79)	7.84 (7.00-8.95)	10.2 (9.12-11.7)	12.1 (10.7-14.0)	14.6 (12.5-17.4)	16.4 (13.8-19.9)	18.2 (15.0-22.5)	19.9 (16.0-25.2)	22.0 (17.0-29.0)	23.4 (17.6-31.9)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

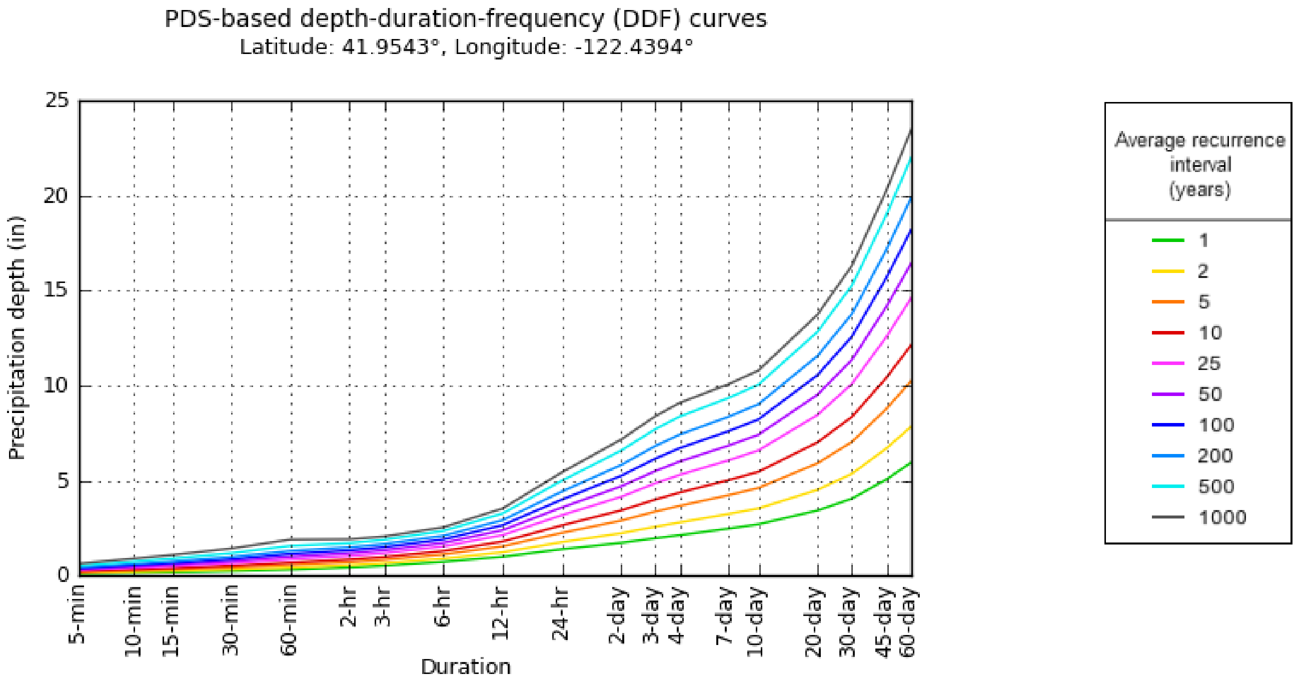
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

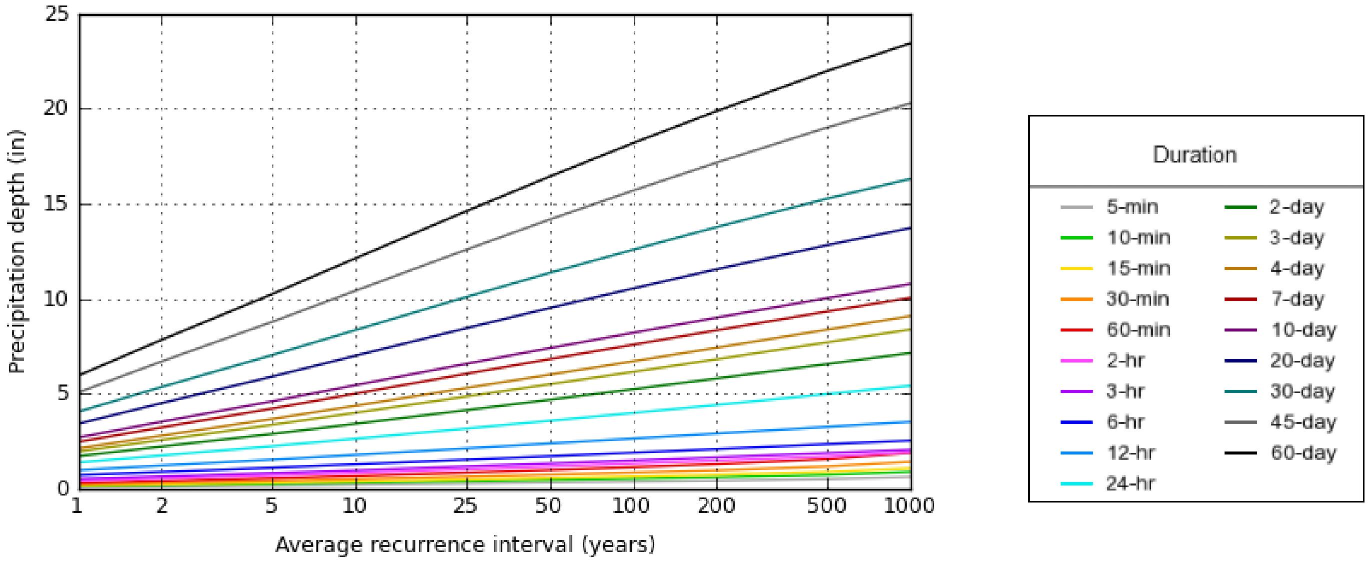
Please refer to NOAA Atlas 14 document for more information.

Back to Top

CAMP CREEK

PF graphical

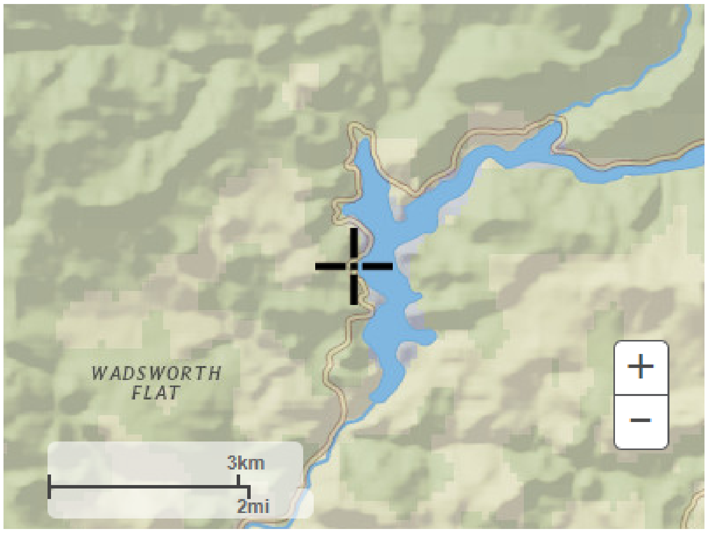




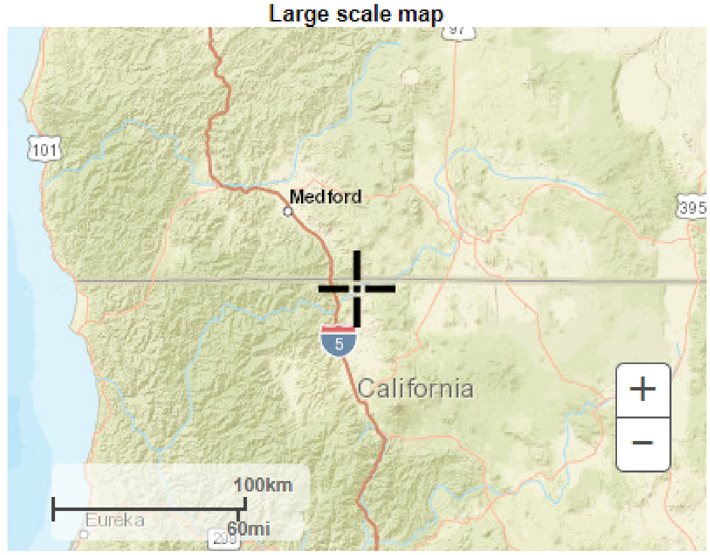
CAMP CREEK

Maps and Aerials

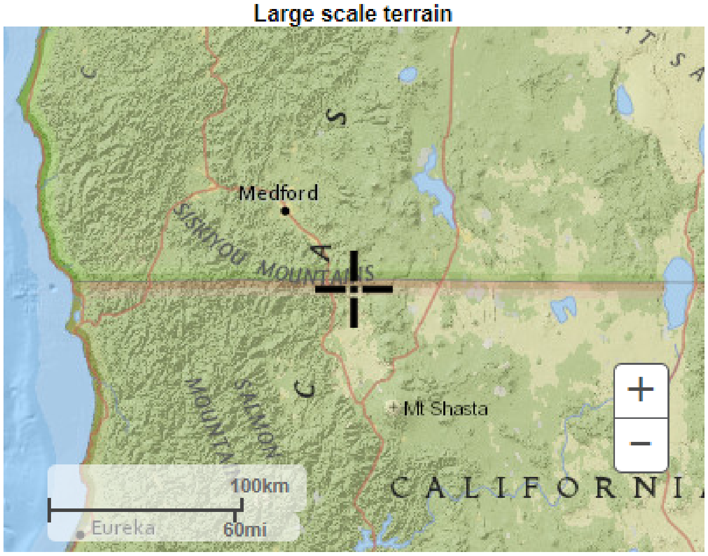
Small scale terrain



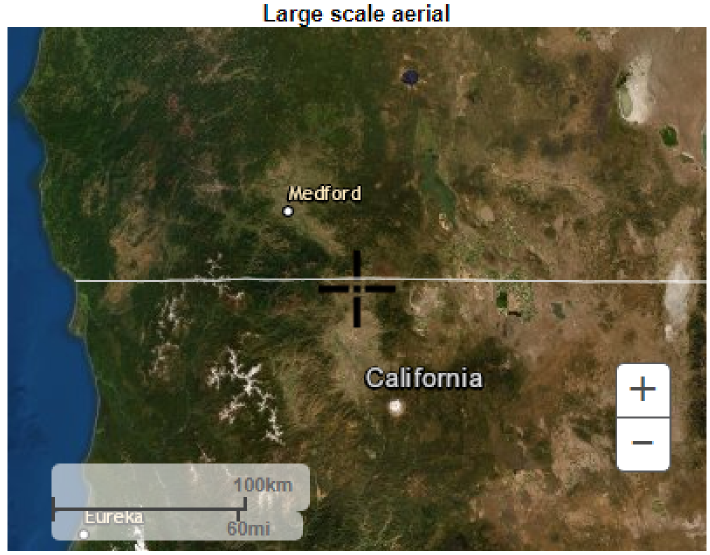
Large scale map



Large scale terrain



Large scale aerial



APPENDIX A17-B3

HISTORIC RUNOFF CALCULATIONS

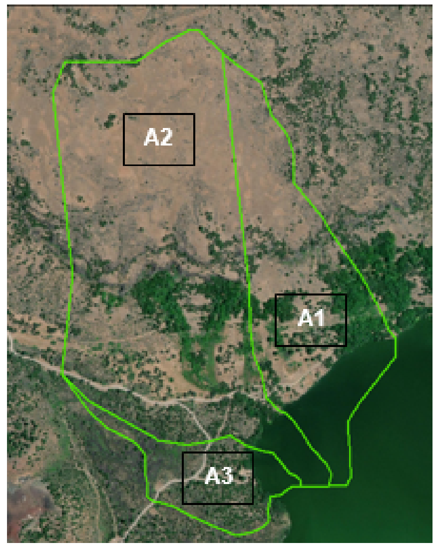
Copco Valley

Historic Runoff Calculations

Watershed ID	Area (acres)	Runoff Coefficient, C	Time of Conc. (min)	Time of Conc. (hr)	Point Rainfall Depth 25-yr, 1-hr (in)	Rainfall Intensity, I (in/hr)	Q (cfs)
A1	68	0.4	9.6	0.16	0.943	4.3	118.2
A2	146	0.4	10.2	0.17	0.943	4.3	252.7
A3	23	0.4	9.6	0.16	0.943	4.3	40.6

Basin Hydrologic Soil Types

Basin A1	Area (acres)	% Total Area
Soil Type A	3.5	5.15%
Soil Type B	0.0	0.00%
Soil Type C	4.5	6.62%
Soil Type D	60.0	88.24%
Soil Type E	0.0	0.00%
	68	**100.00%**



Basin A2	Area (acres)	% Total Area
Soil Type A	4.5	3.08%
Soil Type B	0.0	0.00%
Soil Type C	23.5	16.10%
Soil Type D	118.0	80.82%
Soil Type E	0	0.00%
	146	**100.00%**

Basin A3	Area (acres)	% Total Area
Soil Type A	7	28.26%
Soil Type B	0	0.00%
Soil Type C	0	0.00%
Soil Type D	17	71.74%
Soil Type E	0	0.00%
	23	**100.00%**

Notes:
Runoff coefficient not calculated per the *Urban Storm Drainage Criteria Manual, Volume 1, Ch. 5,* as there is little no impervious area in the watershed. Coefficients were pulled from Table 15.2.3 *Runoff Coefficients for Use in Rational Method.*

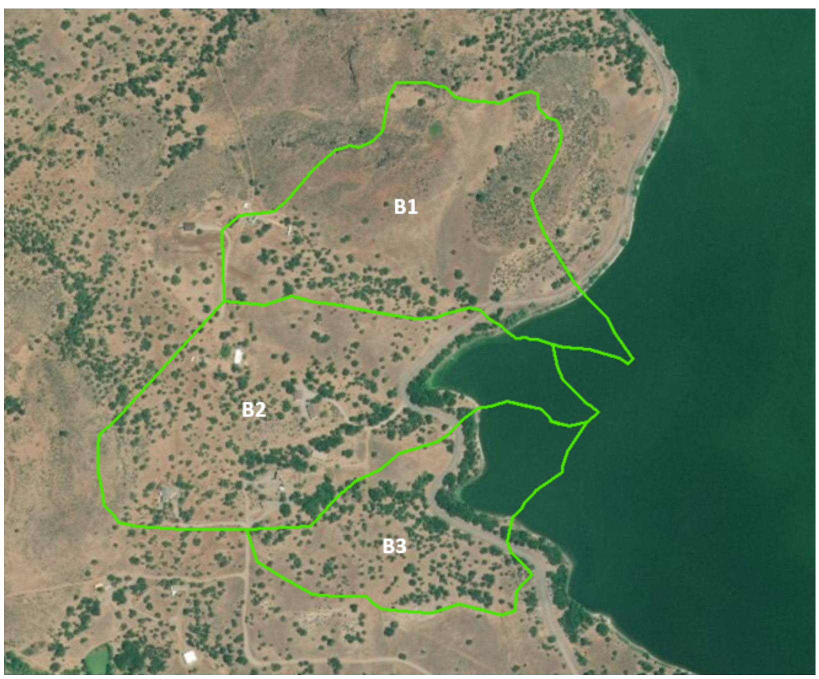
Equations:

Time of Concentration	Rainfall Intensity	Discharge
Tt1 = [0.007(nL)0.8]/[sqrt(P2) S0.4] Tt2 = L / 3600V Tc = Tt1 + Tt2 -where Tt1 is sheet flow and Tt2 is shallow concentrated flow	I = (28.5*P1) / (10+Tc)^0.786 -where P1 is the 25 yr, 1-hr point rainfall depth -Tc is Time of Concentration	Q = CIA -where Q is flow -C is the Runoff Coefficient

Camp Creek
Historic Runoff Calculations

Watershed ID	Area (acres)	Runoff Coefficient, C	Time of Conc. (min)	Time of Conc. (hr)	Point Rainfall Depth 25-yr, 1-hr (in)	Rainfall Intensity, I (in/hr)	Q (cfs)
B1	33.5	0.4	6	0.1	0.86	4.0	53.0
B2	38.9	0.4	6.6	0.11	0.86	4.0	61.6
B3	21.1	0.4	6.6	0.11	0.85	3.9	33.1

Entire Basin	Area (acres)	% Total Area
Soil Type A	0	0.00%
Soil Type B	0	0.00%
Soil Type C	4	4.30%
Soil Type D	89	95.70%
Soil Type E	0	0.00%
	93	**100.00%**



Notes:
Runoff coefficient not calculated per the *Urban Storm Drainage Criteria Manual, Volume 1, Ch. 5,* as there is little no impervious area in the watershed. Coefficients were pulled from Table 15.2.3 *Runoff Coefficients for Use in Rational Method.*

Equations:

Time of Concentration	Rainfall Intensity	Discharge
Tt1 = [0.007(nL)0.8]/[sqrt(P2) S0.4] Tt2 = L / 3600V Tc = Tt1 + Tt2 -where Tt1 is sheet flow and Tt2 is shallow concentrated flow	I = (28.5*P1) / (10+Tc)^0.786 -where P1 is the 25 yr, 1-hr point rainfall depth -Tc is Time of Concentration	Q = CIA -where Q is flow -C is the Runoff Coefficient

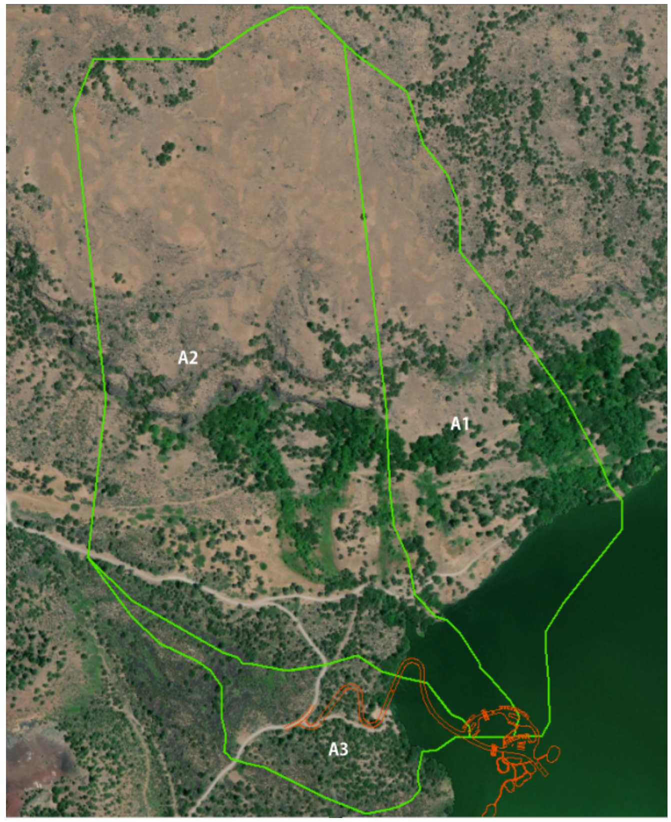
APPENDIX A17-C1

PIPE AND CULVERT SIZING CALCULATIONS

Copco Valley

Culvert Sizing Calculations Summary

Basin	Drainage Area	Flow	Culvert ID	Culvert Shape	Size	Length	No. of Barrels
A2	146 acres	254.5 cfs	A2 Culvert 1	Concrete Box	3' x 7'	64 '	3
			A2 Culvert 2	Concrete Box	3' x 7'	56'	3



Notes:

1. Drainage from basin A1 drains away from the proposed site location. No drainage measures will be taken for this basin.
2. Drainage from A2 crosses the proposed site at one focal location. No subbasins for A2 need to be delineated.
3. Drainage from A3 drains along the road and sheet flows into the historical river channel. No drainage measures will be taken for this basin.

Culvert 1:

Geometry	
Inlet Elevation:	2543.19 ft
Outlet Elevation:	2542.20 ft
Culvert Length:	64.01 ft
Culvert Slope:	0.0155

Culvert 2:

Geometry	
Inlet Elevation:	2536.10 ft
Outlet Elevation:	2535.23 ft
Culvert Length:	56.01 ft
Culvert Slope:	0.0155

Data Results from HY-8 Culvert Analysis: Copco Valley

Copco Valley Culvert 1 (Upstream Triple Barrel Culvert)										
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0	0	2543.19	0	0	0	0	0	0	0	0
30	30	2543.86	0.67	-0.56	0.23	0.4	0.25	0.42	5.71	5.32
60	60	2544.26	1.07	-0.33	0.37	0.63	0.39	0.64	7.33	6.78
90	90	2544.59	1.4	-0.11	0.48	0.83	0.51	0.8	8.34	7.77
120	120	2544.88	1.69	0.11	0.58	1	0.63	0.95	9.07	8.54
150	150	2545.15	1.96	0.33	0.67	1.17	0.75	1.07	9.59	9.18
180	180	2545.4	2.21	0.55	0.76	1.32	0.85	1.19	10.08	9.72
210	210	2545.64	2.45	0.77	0.84	1.46	0.95	1.3	10.52	10.2
240	240	2545.87	2.68	1	0.91	1.59	1.05	1.4	10.89	10.63
260	260	2546.02	2.83	1.16	0.96	1.68	1.12	1.46	11.1	10.89
300	300	2546.32	3.13	1.48	1.06	1.85	1.24	1.58	11.51	11.37

Copco Valley Culvert 2 (Downstream Triple Barrel Culvert)										
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0	0	2536.1	0	0	0	0	0	0	0	0
30	30	2536.77	0.67	-0.44	0.23	0.4	0.25	0.42	5.7	5.32
60	60	2537.17	1.07	-0.21	0.37	0.63	0.39	0.64	7.29	6.78
90	90	2537.5	1.4	0.01	0.48	0.83	0.52	0.8	8.26	7.77
120	120	2537.79	1.69	0.23	0.58	1	0.64	0.95	8.96	8.54
150	150	2538.06	1.96	0.45	0.67	1.17	0.75	1.07	9.47	9.18
180	180	2538.31	2.21	0.66	0.75	1.32	0.86	1.19	9.96	9.72
210	210	2538.55	2.45	0.89	0.84	1.46	0.96	1.3	10.37	10.2
240	240	2538.78	2.68	1.11	0.91	1.59	1.07	1.4	10.7	10.63
260	260	2538.93	2.83	1.27	0.96	1.68	1.13	1.46	10.94	10.89
300	300	2539.23	3.13	1.59	1.06	1.85	1.26	1.58	11.33	11.37

APPENDIX A17-C2

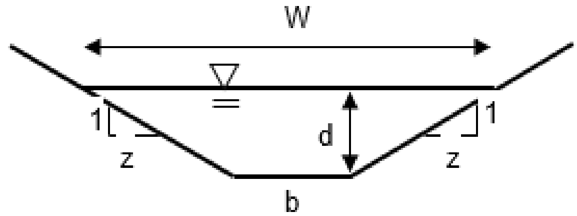
DRAINAGE CHANNEL SIZING AND SHEAR STRESS CALCULATIONS

Copco Valley Riprap Channel

25-year, 24-hour Channel Capacity & Depth Calculations

Riprap Channel through A2

Channel Sketch



Channel Section 1

1. Uniform (Symmetrical) Trapezoidal Section

Input Data:

Manning's "n" value	0.033	
Longitudinal Slope - S_o	0.050	ft/ft
Design Discharge - Q	260.0	ft^3/s - cfs

Channel Geometry Data:

Bottom Width(s)

b_1 or b	12	feet

Side Slope(s)

z_1 or z	3.0	z H:1V

Governing Geometry Equations

$$W = b + 2dz$$

$$A = bd + zd^2$$

$$W_p = b + 2d\sqrt{z^2 + 1}$$

Output Data:

Calculated Flow Depth - d	**1.50**	feet
Calculated Top Width - W	**30.00**	feet
Calculated Area - A	24.75	ft^2
Calc. Wetted Perimeter - Wp	21.49	feet
Calc. Hydr. Radius - R	1.15	feet
Calculated Discharge - Q'	274.58	ft^3/s - cfs
Convergence	14.58	ft^3/s - cfs
Calculated Velocity	**11.09**	ft / s
Calculated Shear Stress - τ_d	**4.68**	lb / ft^2

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S_o^{\frac{1}{2}} \qquad R = \frac{A}{W_p}$$

$$\tau_d = \gamma d S \qquad V = \frac{Q}{A}$$

Note: The calculated top width includes an additional 1.5 feet of depth for freeboard and the riprap thickness lining the channel. Therefore, the total width of the channel is 30 feet when considering the 3:1 side slope. The Mannings "n" value was referenced from "Open Channel Hydraulics" by Ven Te Chow, PhD. Table 5-6 lists a Manning's "n" value of 0.033 for a riprap lined channel.

Riprap Sizing Using FHA Procedure

$$d_{max} = \frac{5 D_{50}}{\gamma S_o}$$

$$D_{50} = \frac{d \gamma S_o}{5}$$

Anticipated Flow Depth - d	**1.50**	feet
Channel Slope - So	**0.05**	ft/ft
Calculated D_{50}	**0.94**	feet
Blanket Thickness-T (1.5*D50)	**1.40**	feet

Copco Valley Channel Riprap Design:

According to California Highway Design Manual, the following materials can be applied to lined channels. Facing Rock Slope Protection, or Class (3) Riprap, provides permissible shear stress, velocity, and D50 values that protect against the calculated values for the channel in Copco Valley. See tables below:

Table 865.2(2) (con't.)
Permissible Shear and Velocity for Selected Lining Materials

Boundary Category	Boundary Type	Permissible Shear Stress (lb/ft^2)	Permissible Velocity (ft/s)
Rolled Erosion Control Products (RECPs)			
Temporary Degradable Erosion Control Blankets (ECBs)	Single net straw	1.65	3
	Double net coconut/straw blend	1.75	6
	Double net shredded wood	1.75	6
Open Weave Textile (OWT)	Jute	0.45	2.5
	Coconut fiber	2.25	4
	Vegetated coconut fiber	8	9.5
	Straw with net	1.65	3
Non Degradable Turf Reinforcement Mats (TRMs)	Unvegetated	3	7
	Partially established	6.0	12
	Fully vegetated	8.00	12
Rock Slope Protection, Cellular Confinement and Concrete			
Rock Slope Protection	Small-Rock Slope Protection (4-inch Thick Layer)	0.8	6
	Small-Rock Slope Protection (7-inch Thick Layer)	2	8
	No. 2	2.5	10
	Facing	5	12

RSP Class	D_{50} Size[1]	D_{50} Weight
	inches	pounds
8 Ton	71	17600
4 Ton	56	8800
2 Ton	45	4400
1 Ton	36	2200
1/2 Ton	28	1100
1/4 Ton	23	550
Light	16	200
Facing	12	75
Backing No 1	12	75

Camp Creek Riprap Design:

- -

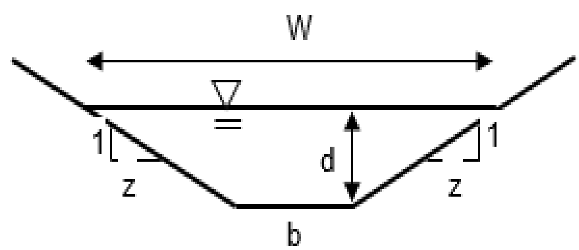
25-year, 24-hour Channel Capacity & Depth Calculations

Riprap Channel through A2

Channel Sketch

Channel Section 1

1. Uniform (Symmetrical) Trapezoidal Section



Input Data:

Manning's "n" value	0.06	
Longitudinal Slope - S_o	0.2	ft/ft
Design Discharge - Q	62.0	ft^3/s - cfs

Channel Geometry Data:

Bottom Width(s)

b_1 or b	20	feet

Side Slope(s)

z_1 or z	5.0	z H:1V

$$W = b + 2dz$$

$$A = bd + zd^2$$

$$W_p = b + 2d\sqrt{z^2 + 1}$$

Output Data:

Calculated Flow Depth - d	**0.50**	feet
Calculated Top Width - W	**25.00**	feet
Calculated Area - A	11.25	ft^2
Calc. Wetted Perimeter - Wp	25.10	feet
Calc. Hydr. Radius - R	0.45	feet
Calculated Discharge - Q'	73.18	ft^3/s - cfs
Convergence	11.18	ft^3/s - cfs
Calculated Velocity	**6.50**	ft / s
Calculated Shear Stress - τ_d	**6.24**	lb / ft^2

$$\boxed{Q = \frac{1.49}{n} A R^{\frac{2}{3}} S_o^{\frac{1}{2}} \qquad R = \frac{A}{W_p} \qquad \tau_d = \gamma d S \qquad V = \frac{Q}{A}}$$

Riprap Sizing Using FHA Procedure:

$$d_{max} = \frac{5\,D_{50}}{\gamma\,S_o}$$

$$D_{50} = \frac{d\,\gamma\,S_o}{5}$$

Anticipated Flow Depth - d	**0.50**	feet
Channel Slope - So	**0.20**	ft/ft
Calculated D_{50}	**1.25**	feet
Blanket Thickness-T (1.5 * D50)	**1.87**	feet

APPENDIX A18

Site Restoration

(Pages A18-1 to A18-17)

APPENDIX A18
SITE RESTORATION

1.0 RESTORATION GOALS AND OBJECTIVES

The primary restoration-related goals as defined in Appendix H of the Definite Plan (Chapter 2, Goals and Objectives and Chapter 6, Monitoring and Management) are:

- Restore volitional fish passage in main stem and tributaries to natural conditions.
- Allow natural erosion and transport of reservoir sediment and dispersal into the ocean.
- Stabilize remaining reservoir sediments.
- Restore natural ecosystem processes by:
    - Establishing native vegetation cover.
    - Minimizing invasive exotic vegetation.
- Maximize reservoir area restoration for ecological uplift, *within project constraints*.
- Implement process-based river and tributary restoration actions where applicable *and feasible.*

Modifications to Appendix H goals are noted in italics. We have added qualifiers to the stated project goals maximizing ecological uplift and implementing process-based restoration actions to acknowledge the various site constraints that limit the extent and location of restoration actions taken. Major constraints on restoration actions include:

- Unknown hydrologic conditions (timing and magnitude of storm events) during drawdown period
- Unknown soil conditions after drawdown period
- Limited construction access
- Fixed construction funding
- Known and potential cultural resource sites

Based on these goals, the objective for each restoration component were developed.

Table 1.1 Reservoir Restoration Objectives

Feature/Habitat Type	Objectives	Timeframe after Drawdown	
		Short-term (0-2 years)	Long-term (2+ years)
Klamath River	Restore volitional fish passage to natural conditions.	X	X
	Re-establish geomorphically-appropriate channel through dam removal extents.	X	X
	Encourage the prevalence of large wood to emulate historic conditions.		X
	Encourage formation of off-channel habitat for summer rearing habitat similar to historic conditions where feasible.	X	X
	Provide juvenile fish rearing and overwintering habitat where feasible.	X	X
	Allow natural river processes, including channel migration	X	X
Sediment Stabilization	Limit channel migration and slope instability that could threaten structures and/or release significant sediment volume downstream.	X	X
Major Tributaries	Restore volitional fish passage to natural conditions.	X	X
	Provide juvenile fish rearing and overwintering habitat.	X	X
	Allow natural river processes, including channel migration.	X	X
	Encourage accumulation of large wood for fish cover.		X
	Allow for channel bed adjustment without creating fish passage barrier at road crossings.	X	X
Emergent Wetlands	Leverage post-drawdown conditions to re-establish emergent wetland plant communities where hydrogeomorphic processes are present.	X	X
Floodplain	Leverage post-drawdown conditions to re-establish flood-reliant plant communities where flood processes are present.		X
Uplands	Re-establish patches of a range of location-appropriate native plant communities to serve as seed sources for natural community expansion.		X

2.0 RESTORATION FAILURE MODES

The following section describes potential project failure modes and mitigation actions to address potential failure modes. The following is a list of project failure modes that will be addressed by the mitigation contractor both through restoration design and during restoration implementation. This list might not be all inclusive, as circumstances could arise following draw-down that are unexpected. This list also assumes that the existing project components (dams, powerhouses, transmission lines, etc.) are removed in their entirety with the resulting river channel cross sections at the previous dam locations capable of allowing volitional fish passage. The list has been further divided into categories based on the three primary project restoration goals.

2.1 VOLITIONAL FISH PASSAGE AND FREE-FLOWING RIVER CONDITION

1. Inadequate sediment evacuation results in fish passage barrier on main river channel or fish-bearing tributaries.
    a. Problem Statement – Sediment evacuation from the Klamath River main channel and tributaries is expected to occur during the drawdown of the reservoirs, by scour of natural river flows, as the reservoir water surface elevation is lowered. The Definite Plan, as well as the restoration design, assume that the vast majority of sediment will be transported through the dam outlets during drawdown, and additional sediment removal will occur through the return of the natural river flow regime after the dams are removed.
    b. Failure Mode Mitigation – If complete sediment evacuation from the main channel is not achieved during the drawdown process or by natural flows post-dam removal, and a fish passage barrier in the form of a sediment plug or large wood accumulation (or a combination thereof) occurs, the blockage will be physically removed using appropriate methods (e.g., excavator, hydrojetting) depending on the extent and location of the blockage.
2. Geotechnical failure of soil and/or geologic material into the main river channel or fish-bearing tributaries post-drawdown.
    a. Problem Statement – Geotechnical failure of the riverbanks or adjacent canyon walls has the potential to create fish passage blockages in the Klamath River main channel and tributaries post-drawdown.
    b. Failure Mode Mitigation – If geotechnical failures occur post-drawdown and create fish passage barriers, the blockages will be physically removed using appropriate methods (excavator, blasting, or a combination of excavation and blasting) depending on the extent and location of the blockage.
3. Man-made dams, bridges or other infrastructure results in fish passage barriers.
    a. Problem Statement – Based on a review of historical maps, historical aerial photographs and bathymetry survey data, there are structures within the reservoirs that have the potential to create fish passage barriers after the dams are drawn down. In addition, there are bridge and culvert crossings across tributary channels that will remain post-drawdown that may create fish passage barriers.
    b. Failure Mode Mitigation – All submerged manmade structures within the existing reservoir footprints will be removed post-drawdown to eliminate the possibility that they create fish passage barriers. Bridge and culvert tributary crossings that are proposed to remain in place post-drawdown are being reviewed by Knight Piésold and the restoration team to evaluate the potential for fish passage barriers. If crossings are anticipated to be fish passage barriers post-drawdown, plans will be developed to re-configure the crossings to allow volitional fish passage. If a situation arises where a bridge or culvert creates an unexpected fish passage barrier post drawdown, plans will be developed and implemented to reconfigure the crossing to allow passage.
4. Woody debris blockages at remaining bridges results in fish passage barrier

a. Problem Statement – There is a potential for woody debris to accumulate on the upstream sides of bridges and culverts remaining on the Klamath River and tributaries following drawdown and dam removal.
b. Failure Mode Mitigation – Fish passage blockages that result from wood accumulation at the upstream sides of Klamath River and tributary bridges and culverts will be physical removed as part of road and highway maintenance activities.

2.2 SEDIMENT STABILIZATION (AVOID OR MINIMIZE DOWNSTREAM IMPACTS)

1. Sediment delivery downstream (caused by suboptimal sediment removal from floodplain and tributary sediment, landslides, road runoff, etc.) following the initial drawdown is greater than anticipated, resulting in a greater than anticipated impact on native fish populations. The “failure mode mitigation actions” described below include operational steps to be taken if sediment delivery is greater than anticipated. The regulatory permits authorizing the removal of the dam will, to the greatest extent possible, describe the mitigation actions that may be required by the regulators if sediment has a greater than anticipated impact on native fish populations. The relevant regulatory discussions are ongoing.
   a. Problem Statement
      - The Definite Plan states that approximately 50 percent of the total amount of sediment accumulated behind the dams will be removed during initial drawdown activities by natural river and tributary flows, depending on background flow conditions in the Klamath River and tributaries during the drawdown period, based on studies conducted by USBR in 2011. The remaining 50 percent of sediment has the potential to erode during subsequent rainfall and runoff events, contributing to greater than anticipated sediment delivery to the Klamath River post-drawdown.
      - Landslides other geotechnical failure of riverbanks, tributary streambanks, and adjacent canyon walls also has the potential to contribute sediment to downstream river reaches post-drawdown.
      - Road runoff from temporary construction access roads and/or permanent dirt and gravel roadways around the reservoirs has the potential to contribute to greater than anticipated sediment delivery post-drawdown.
   b. Failure Mode Mitigation
      - Excess sediment attributed to erosion of reservoir sediments post-drawdown will be mitigated through multiple approaches. First, during drawdown, activities (water jetting, long-reach excavators, wake wash, etc.) will take place to mechanically promote the removal of reservoir sediments from the river channel, tributary channels, and floodplain areas. This will reduce the amount of sediment available for erosion and transport to downstream reaches during subsequent rainfall and runoff events. Second, vegetation will be established via aerial seeding of pioneer species on remaining reservoir sediments as soon as possible following completion of drawdown activities. Mulch will be spread on exposed sediment in floodplain restoration areas. As described in the Definite Plan, vegetation establishment of reservoir sediments is expected to reduce erosion by approximately 33 percent, and mulch application by 99 percent, based on studies of sediment stabilization for the Elwha Dam removal conducted by Ellen Mussman in 2008.

- Landslides and geotechnical failures of riverbanks, tributary streambanks and adjacent canyon walls is expected to occur post drawdown. While this is a relatively natural process, the amount of sediment expected to be contributed to the river from landslides and other geotechnical failures is unknown and difficult to estimate. First, the maximum rate of reservoir drawdown (maximum 5 feet per day) has been proposed to reduce destabilization of the reservoir rim. Second, channel grading activities that will take place along portions of the Klamath River and tributary channels will reconfigure river and streambanks to stable configurations that will reduce the likelihood of landslides and other geotechnical failures. Third, the establishment of vegetation and placement of mulch on reservoir sediments will help regulate sediment moisture content fluctuations, which will promote stability.
- Best management practices will be applied to temporary construction access roads and permanent gravel roadways (in locations where permanent roadway improvements have been identified). Temporary construction access roads will be constructed in locations that will minimize roadway gradient to reduce high-velocity roadway runoff and subsequent filling. Construction road placemat will also avoid erosion-sensitive areas such as existing drainage pathways. Where temporary construction roads must pass over existing drainage pathways, culvert pipes will be placed or temporary low-water crossing improvements will be made to reduce potential erosion of the road surface. Mulch will be placed on temporary construction road surfaces to protect underlying sediment to reduce erosion and sediment runoff from road surfaces. Where needed, road drainage will be configured in a manner to reduce flow accumulation, velocity, and subsequent erosion. In areas where improvements will be made to permanent dirt and gravel roadways, proposed drainage improvements will be configured in a manner to reduce flow accumulation, velocity, and subsequent erosion. Temporary construction access roads and permanent dirt and gravel roads will be maintained during construction to reduce sediment runoff. Maintenance activities could include installation and maintenance of silt fences, adding or replacing mulch, regrading, or improvements to drainage features. Post-construction, temporary access roads will be removed and restored via ripping to break up compacted soil and seeded to promote vegetation establishment. Following vegetation establishment, erosion protection measures such as silt fences will be removed. Post-construction, permanent dirt and gravel roads will be restored to their pre-construction condition and maintenance obligations will be taken over by the local authority.

2.3 NATIVE PLANT ESTABLISHMENT (REMEDIATION AND RESTORATION, INCLUDING PREVIOUSLY INUNDATED LANDS)

1. Reservoir areas are dominated by invasive, non-native plants.
   a. Problem Statement – Post-drawdown, non-native and/or invasive species might become established in reservoir sediment and outcompete native and/or desired species.
   b. Prior to implementation of invasive exotic vegetation (IEV) management, establish an IEV prioritization plan collaboratively with regulatory agencies. Some non-native species are naturalized and are not aggressive and/or displace native species. We recognize that some species are beyond reasonable control, but others are aggressive and displace native species. The primary focus of IEV control efforts should be on the highly invasive and aggressive species that displace native species (Himalayan blackberry, Medusa Head, reed canary grass, yellow start thistle, teasel, hoary cress, dyer's woad, etc.).If, during vegetation monitoring events, non-native and/or invasive

species are observed to be occurring in higher than acceptable concentrations, non-native/invasive species control measures will be undertaken. These activities will primarily take the form of mowing and hand weeding. Herbicide application might also need to be conducted to control non-native and invasive species and will need to be discussed with KRRC and approved by the resource agencies and the native American tribes' representatives as discussed in the Performance Criteria.

2. Seed and plantings do not establish due to poor soil conditions, lack of large-scale irrigation, and/or trampling or herbivory by livestock or wildlife.
   a. Problem Statement – The Definite Plan Reservoir Area Management Plan discuses potential issues related to vegetation establishment post-drawdown. These include soil acidity, high clay content, high shrink-swell potential, high organic content, no soil structure, high risk of compaction, arid climate, and herbivory by livestock and/or wildlife.
   b. Failure Mode Mitigation
      - Establish realistic vegetation survival and cover performance criteria with regulatory agencies prior to construction.
      - Pioneer species will be aerially seeded post-drawdown in order to develop soil structure, facilitate the conversion of sterile sediment into production topsoil for native vegetation through the reintroduction of soil microorganisms. Micro-organisms can be additionally introduced via mulch that will be used to protect pioneer seeded areas, and via mycorrhizal inoculation of the seed bank. The intent is to aerially seed pioneer species as soon after soils are exposed as possible to give seeds an opportunity to embed and germinate before the exposed reservoir sediments dry out and harden.
      - Irrigation systems will be installed and maintained as needed in key selected bank and floodplain riparian areas at each reservoir site and might be installed in other floodplain riparian and upland areas to promote vegetation establishment. Additional irrigation systems might be installed and maintained to promote vegetation established in other sensitive areas as needed and as access allows.
      - In areas of poor seed germination and vegetation establishment following the initial seed and mulch application, soil preparation activities might be needed to prepare the seed bed prior to re-seeding. Temporary irrigation might also be beneficial to vegetation establishment in these areas.
      - Cattle are expected to be excluded from floodplain restoration areas to eliminate the threat of livestock overgrazing and trampling. Herbivory by wildlife is not expected to pose a large enough threat to vegetation establishment to warrant mitigation measures. Re-plantings may be necessary depending on the cost of fencing and other cattle exclusion measures.
3. Plants are infected with phytophthora or another malady.
   a. Problem Statement –Phytophthora is a genus of water molds that includes (among 500 others) about 25 aggressive, non-native species such as *P. ramorum* (sudden oak death), *P. tentaculata*, *P. cactorum*, *P. cinnamomi* and others that spread actively via motile spores through water and moist soil. They can cause devastating losses of native plants of almost all species and genera. They are not killed by any known fungicides, however, they can only be suppressed to reactivate later. If phytophthora are introduced through transplanted restoration plantings, they can quickly spread to adjacent native vegetation.
   b. Failure Mode Mitigation – Containerized plants will not be permitted for restoration plantings. All bare root stock will be sourced from phytophthora-free nurseries. Other planting materials (willow

stakes and poles) will be sourced from on site or from phytophthora free suppliers. A disinfection procedure for equipment and worker boots shall be developed and applied to further reduce the potential for site contamination.

4. Insufficient native seed is collected and propagated in advance of construction.
   a. Problem Statement – The success of individual seed collection activities is measured by the quantity of seed collected and propagated. The quantity of seed collected and propagated is directly related to the quantity of seeds produced by target species. Seed production during any given year is variable and based on natural seed production cycles for hard mast trees, as well as climate conditions during the year while seed development is occurring. Given this natural variably in annual seed production, it is possible that seed collection and propagation goals might not be reached during initial collection events.
   b. Failure Mode Mitigation - Seed collection efforts will be ongoing through the extended pre-construction schedule (through end of 2021), which should allow for the collection of a sufficient quantity of seed. If necessary, additional seed collection efforts will take place in years immediately following drawdown to supplement native seed plantings. Seed collection efforts will prioritize those plants that show high success in clay soils. Seed collection success will directly impact the amount of seed that can be propagated. See propagation is required to produce the volume of seed that will be required to perform revegetation efforts. Native seed propagation is underway and should continue as long a necessary to produce the quantity of see necessary for successful restoration.

3.0 DESIGN CRITERIA

The removal of four significant dams along the Klamath River poses an unprecedented opportunity to restore critical habitat functions. Given the scale of the project and the possible modes of failure outlined in Section 2.0, Restoration Failure Modes, design criteria have been established. In addition to the complexities of a large infrastructure project, the riverine ecological system being restored is, by definition, dynamic and constantly undergoing change. Therefore, restoration at this scale is intended to establish a trajectory for the natural processes that will result in desired habitat outcomes over various time scales. For example, adequate fish passage might be anticipated relatively quickly, while mature upland forest could take decades. Keeping this dichotomy in mind, the design criteria described below aim to serve two purposes. First, they provide specific targets for setting the proper ecological trajectory in order to achieve the project's stated goals and objectives. Second, they provide a framework by which to measure ecosystem function as the site evolves. For example, many of these measurable design criteria can be immediately designed for (e.g., placing large wood to create microhabitats), but many of them will need to be re-visited in an adaptive manner once the project is underway (e.g., examining soil conditions for revegetation areas).

The restoration design criteria presented below are intended to more fully develop the criteria for engineered habitat features and grading-related activities. They are organized by the following major geomorphic features and/or habitat types:

- Sediment Stability
- Klamath River
- Major Tributaries
- Wetlands
- Seeding

- Plant Communities and Methods
- Invasive Exotic Vegetation (IEV)
- Irrigation
- Fencing
- Establishment, Maintenance and Monitoring

The various design criteria were subdivided into more specific items or features as presented below. The table includes design criteria for the following sections of Appendix 4 of the Project Agreement:

4.12 Engineered Habitat Features
4.13 Plant Materials
4.14 Invasive Exotic Vegetation Removal
4.15 Habitat Restoration
4.16 Irrigation
4.17 Plant Establishment and Maintenance
4.18 Plant Monitoring

Given the amount of uncertainty around the extent, methods, and target plant communities associated with the proposed revegetation, and related activities such as IEV management and irrigation, much of the design criteria are preliminary and subject to refinement during final Design.

Table 3.1 Reservoir Restoration Design Criteria

Feature	Criteria	Remarks	Reference
RESERVOIR			
Sediment Stability			
Locations	Active stabilization measures only taken to stabilize significant unnatural sediment deposits	Dynamic bank erosion and deposition considered part of process-based restoration	60% Design Report, Section 8
Design storm event for bank stabilization	25- to 100-year event – infrastructure protection	Appropriate design storm event to be selected based on potential risk.	60% Design Report, Section 8
KLAMATH RIVER & MAJOR TRIBUTARIES			
Fish Passage			
Manmade Structures	No protrusion above channel bed.		App 4: 4.12.2.1 (b) Definite Plan, Appendix H
New or Existing Culverts	No hydraulic jumps greater than 6 inches.	As appropriate on fish-bearing streams	Definite Plan, Appendix H, Table 6-6
Headcuts in Residual Sediment	Evaluate all headcuts 6 inches or greater.		60% Design Report, Section 8

Feature	Criteria	Remarks	Reference
Reconstructed Channel at Dam Removal Footprint			
JC Boyle	Bedrock-controlled channel		60% Design Report, Section 8 App 4: 4.12.2.1 (d)
Copco 1	Reconstructed channel (ESM with shelter boulders on coarse subgrade)		60% Design Report, Section 8 App 4: 4.12.2.1 (d)
Copco 2	Reconstructed channel (ESM with shelter boulders on coarse subgrade)		60% Design Report, Section 8 App 4: 4.12.2.1 (d)
Iron Gate Channel	Bedrock-controlled channel	Assume some ESM and/or boulder placement to enhance fish passage (to be verified)	60% Design Report, Section 8 App 4: 4.12.2.1 (d)
Riparian Channel Margin			
Hydrologic Connectivity	Up to15 vertical feet above summertime base flow (1100 cfs)		60% Design Report, Section 8
Width (along channel margin)	15 to 50 feet	Assumed approximately 30 feet along tributaries and 50 feet on Klamath River for 60% Design	60% Design Report, Section 8
Large Wood			
Functions	In-channel habitat complexity Flow diversion/dispersion		60% Design Report, Section 8
Location	High priority tributaries Adjacent to emergent wetlands		60% Design Report, Section 8 App 4: 4.12.2.2 (b)
Type and size	35-50-foot rootwad logs (Ground Placed) and 50 to 100-foot full length trees (Helicopter Placed)	Exact log sizing to be determined. 12-inch diameter minimum.	60% Design Report, Section 8 App 4: 4.12.2.2 (a)
Density	Determined by post draw down topography. Average of 2 logs placed every 42 feet of tributary length		
Stability Mechanisms	Stability from portion of log projected above flow Embedment into streambank or floodplain surface		60% Design Report, Section 8 Large Woody Material - Risk Based Design Guidelines, (USBR,2014)
Stability factor of safety	Sliding – 1.25 Buoyancy – 1.5 Rotation & Overturning – 1.25	Recommendation for low public safety risk and high property damage risk.	60% Design Report, Section 8 Table 4, Large Woody Material - Risk Based Design Guidelines, (USBR,2014) App 4: 4.12.2.2 (c),(d)
Design storm event for stability	10-year event		

Feature	Criteria	Remarks	Reference
WETLANDS			
Near-channel Wetlands	Hydrologic connection up to approximately 5 vertical feet above summertime base flow (1100 cfs)		60% Design Report, Section 8 App 4: 4.12.2.2 (e)
Natural springs/seeps	Hydrologic connection varies; determined as observed post drawdown	Subject to refinement at Final Design	60% Design Report, Section 8 App 4: 4.12.2.2 (e)
SEEDING			
General			
General	Sourced from Upper Klamath and Lost River Watersheds at elevations 1,800-4,300 feet No more than 4 generations removed from wild parent seed except for rapidly reproducing species	Existing contracts will provide most of the seed needed. New contracts are being developed to boost diversity and quantities.	60% Design Report, Section 8 App 4: 4.13.2.1 (a) App 4: 4.13.2.1 (c)
Pioneer Seeding			
Timing	Applied during drawdown, as soon as practicable on wet soils		60% Design Report, Section 8 App 4: 4.13.2.1 (f),(g)
Commercially sourced non-native sterile seed	May exceed 5% of seed count by seed count depending on future seed collection success	5% maximum per App 4	App 4: 4.13.2.1 (b) App 4: 4.13.2.2 (d)
Number of seed mixes	Two mixes: one upland pioneer seed mix and one riparian/wetland seed mix		60% Design Report, Section 8 App 4: 4.13.2.1 (f) App 4: 4.15.2.1 (e), (f)
Seed Mix	Species diversity Includes 14-17 native plant species Includes legume species, 6-7 grasses, and 6-11 forbs		60% Design Report, Section 8 App 4: 4.13.2.1 (h),(k) App 4: 4.13.2.2 (d) App 4: 4.15.2.1 (g) App 4: 4.15.2.2 (a)
Minimum Supply	7,889,587,200 seeds will be available by Dec 31 before drawdown	3,484,800 seeds per acre for the entire 2,264 acres	60% Design Report, Section 8 App 4: 4.13.2.1 (j)
Rate	Proposed application rate: Min. 80 seeds/sf		60% Design Report, Section 8 App 4: 4.13.2.1 (f) App 4: 4.15.2.1 (c)
Over-Seeding			
Timing	Applied in fall or early spring after drawdown		App 4: 4.15.2.1 (f)
Commercially sourced non-native sterile seed	Not recommended or needed due to anticipated collection and propagation of sufficient quantities	None	App 4: 4.13.2.2 (d)

Feature	Criteria	Remarks	Reference
Number of seed mixes	Two mixes: Wetland/riparian diversity mix Upland diversity mix (may include two mixes (high and low elevation reservoirs) To be developed based on seed availability, reference sites and performance in plots		App 4: 4.15.2.1 (f)
Seed Mix	Species diversity Minimum 15 native plant species	To be further adapted and developed based on Appendix H and soil test plot results.	App 4: 4.13.2.1 (i),(j) App 4:4.13.2.2 (d), (f) App 4: 4.15.2.1 (h) App 4: 4.15.2.2 (b)
Minimum Supply	7,889,587,200 seeds will be available by the first fall or spring following dam removal.	3,484,800 seeds per acre for the entire 2,264 acres	App 4: 4.13.2.1 (j)
Rate	To be determined based on monitoring results from the first growing season.	Minimum 50 seeds/sf	App 4: 4.13.2.1 (f) App 4: 4.15.2.1 (c)
Site Preparation	Do not over-compact surface soils. Use low ground pressure equipment, where possible. Decompact (e.g. cross rip) surfaces compacted to 85% RC or greater in areas not dominated by clay. Mow or till areas of dense vegetation that is exotic or lacking diversity to open ground for successful germination	App 4 proposes 80% RC	App 4: 4.15.2.2 (j) App 4: 4.15.2.1 (b) App 4: 4.15.2.1 (i).
Mycorrhizal inoculant rate	To be determined based on spore counts in sediments	Sediment samples needed for testing	App 4: 4.15.2.2 (c)
PLANT COMMUNITIES AND REVEGETATION METHODS			
General			
Planting Zones	Zones based on hydro-geomorphic process: Wetland Riparian Upland / Floodplain	Differs from five planting zones per App 4: 4.13.2.1 (d) & Bank Riparian and Floodplain Riparian have been combined.	60% Design Report, Section 8 App 4: 4.15.2.1 (c)
Reference Sites	To be determined		App 4: 4.13.2.2 (f) App 4: 4.15.2.2 (h)
Wetland Vegetation Reference Cover Types			
J.C. Boyle	Palustrine Emergent Wetland Palustrine Shrub-Scrub Wetland	Given wetland dependency on hydrology, ability to plant these will be largely reliant on post drawdown conditions.	PacifiCorp, 2004 App 4: 4.15.2.1 (d)

Feature	Criteria	Remarks	Reference
Copco No. 1	Palustrine Emergent Wetland	Given wetland dependency on hydrology, ability to plant these will be largely reliant on post drawdown conditions.	PacifiCorp, 2004 App 4: 4.15.2.1 (d)
Iron Gate	Palustrine Emergent Wetland Palustrine Shrub-Scrub Wetland Palustrine Forested Wetland	Given wetland dependency on hydrology, ability to plant these will be largely reliant on post drawdown conditions.	App 4: 4.15.2.1 (d)
Maximum Plant Densities by Wetland Vegetation Cover Types (subject to reduction if needed due to cost)			
Palustrine Emergent Wetland	Herbaceous bareroot/plugs (4’ o.c., 25% of area) Sod transplant (10% of area)	1 salvaged transplant every 40 sf per App 4	60% Design Report, Section 8 App 4: 4.15.2.1(j) App 4: 4.15.2.2 (h)
Palustrine Shrub-Scrub Wetland	Herbaceous bareroot/plugs (4’ o.c., 20% of area) Cuttings (10’ o.c., 20% of area) Bareroot shrubs (10’ o.c., 20% of area)	1 salvaged transplant and 5 pole cuttings every 100 sf per App 4	60% Design Report, Section 8 App 4: 4.15.2.1(j) App 4: 4.15.2.2 (h)
Palustrine Forested Wetland	Herbaceous bareroot/plugs (4’ o.c., 20% of area) Cuttings (10’ o.c., 10% of area) Bareroot shrubs (10’ o.c., 10% of area) Pole Cuttings (40’ o.c., 10% of area) Bareroot trees (40’ o.c., 10% of area)	1 salvaged transplant and 5 pole cuttings every 100 sf per App 4	60% Design Report, Section 8 App 4:4.15.2.1(k) App 4: 4.15.2.2 (h)
Wetland Planting Requirements			
Salvaged plant material	Existing wetland vegetation at waterline as feasible	May be limited due to availability of saturated low-slope areas post drawdown. Greatest potential at JC Boyle	60% Design Report, Section 8 App 4: 4.13.2.1 (n) App 4: 4.15.2.1 (p)
Timing	Salvage when plants are dormant; transplant as early after drawdown as feasible		App 4: 4.13.2.1.(o) App 4: 4.15.2.1.(q)
Site Restoration	Reseed source areas		App 4: 4.13.2.1.(p)
Riparian Vegetation Reference Cover Types			
J.C. Boyle	Riparian Mixed Riparian Shrub		PacifiCorp, 2004 App 4: 4.15.2.1 (d)
Copco No. 1	Riparian Mixed Riparian Deciduous Riparian Shrub		PacifiCorp, 2004 App 4: 4.15.2.1 (d)
Iron Gate	Riparian Deciduous Riparian Shrub		PacifiCorp, 2004 App 4: 4.15.2.1 (d)

Feature	Criteria	Remarks	Reference
Maximum Plant Densities by Riparian Vegetation Cover Types (subject to reduction if needed due to cost)			
Riparian Shrub	Cuttings (10' o.c., 25% of area) Bareroot shrubs (10' o.c., 25% of area)		60% Design Report, Section 8 App 4: 4.13.2.2 (e) App 4: 4.15.2.2 (h)
Riparian Deciduous & Riparian Mixed	Cuttings (10' o.c., 25% of area) Bareroot shrubs (10' o.c., 10% of area) Pole Cuttings (40' o.c., 25% of area) Bareroot trees (40' o.c., 10% of area)	1 salvaged transplant and 5 pole cuttings every 100 sf per App 4 1 pole cutting and 1 seeded woody plan every 100 sf per App 4	60% Design Report, Section 8 App 4: 4.15.2.1 (l) App 4: 4.15.2.1 (m) App 4: 4.13.2.2 (e) App 4: 4.15.2.1 (n) App 4: 4.15.2.2 (h)
Riparian Planting Requirements			
Salvaged plant material	Existing riparian plants at waterline as feasible		App 4: 4.13.2.1 (n) App 4: 4.15.2.1 (p)
Pole Cuttings.	Remove no more than 30% of host plant. Do not harm existing plants.		App 4: 4.13.2.1 (l), (m)
Timing	Salvage when plants are dormant; transplant as early after drawdown as feasible		App 4: 4.13.2.1 (o) App 4: 4.15.2.1 (q)
Site Restoration	Reseed source areas if necessary		App 4: 4.13.2.1 (p)
Upland / Floodplain Vegetation Reference Cover Types			
J.C. Boyle	Klamath Mixed Conifer Ponderosa Pine Sagebrush Mixed Chaparral Perennial Grasslands		PacifiCorp, 2004 App 4: 4.15.2.1 (d) App 4: 4.15.2.2 (h)
Copco No. 1	Montane Hardwood Oak Montane Hardwood Oak-Conifer Montane Hardwood Oak-Juniper Juniper Woodland Klamath Mixed Conifer Mixed Chaparral Perennial Grasslands		PacifiCorp, 2004 App 4: 4.15.2.1 (d) App 4: 4.15.2.2 (h)
Iron Gate	Montane Hardwood Oak Montane Hardwood Oak-Juniper Juniper Woodland Mixed Chaparral Perennial Grasslands		PacifiCorp, 2004 App 4: 4.15.2.1 (d) App 4: 4.15.2.2 (h)

Feature	Criteria	Remarks	Reference
Maximum Plant Densities by Upland/Floodplain Vegetation Cover Types (subject to reduction if needed due to cost)			
Upland/ Floodplain Iron gate/ Copco	Bareroot shrubs (10’ o.c., 25% of area) Bareroot trees (80’ o.c., 50% of area)		60% Design Report, Section 8 App 4: 4.13.2.2 (e) App 4: 4.15.2.2 (h)
Upland/ Floodplain J. C. Boyle	Bareroot shrubs (10’ o.c., 25% of area) Bareroot trees (40’ o.c., 75% of area)	2 seeded trees and 2 seeded shrubs per acre per App 4	60% Design Report, Section 8 App 4: 4.15.2.1 (o) App 4: 4.15.2.2 (h) App 4: 4.13.2.2 (e)
Invasive Exotic Vegetation (IEV) Removal			
Allowable methods	Physical (preferred) Biological (upon approval) Chemical (upon approval)		App 4: 4.14.2.1 (b), (c), (d) App 4: 4.14.2.2 (c)
Duration	Begin spring 2020, immediately prior to dam removal. Shift to reservoir areas during drawdown. Monitor for 5 years.		App 4: 4.14.2.1 (f), (i), (j)
Other Removal Criteria	Using standard of practice Supervised by qualified foreman Protective of surrounding ecosystem Remove entire root system to min 18-inch depth, as appropriate (where needed and applicable).		App 4: 4.14.2.1 (k) App 4: 4.14.2.1 (k) App 4: 4.14.2.1 (a) App 4: 4.14.2.1 (l)
Disposal Locations	To be determined.		App 4: 4.14.2.2 (a)
Performance Criteria			
By Dec 31, prior to drawdown (areas above OHWM)	High priority IEV species: less than 3% cover within 500 ft of reservoir rim. Medium priority species: less than 10% cover within 500 ft of reservoir rim.	Priority levels to be updated with agencies and Cal-IPC ratings in addition to proposed new criteria	App 4: 4.14.2.1 (e)
Conclusion of Maintenance period	High priority IEV species: less than 1% cover within currently inundated lands Medium & low priority IEV species: less than average cover of two reference sites		App 4: 4.14.2.1 (g), (h)
Priority rating of IEV species	Based on agency ratings and control feasibility.		App 4: 4.14.2.2 (b)
IRRIGATION			
Riparian	Overhead spray, full coverage at Iron Gate and Copco		App 4: 4.16.2.1 (a)
Upland	If-needed Biodegradable cocoons Intermittently irrigate with temporary system (e.g. Rain- for-Rent) if low water at time of germination (in drought, etc.)		App 4: 4.16.2.1 (i) App 4: 4.16.2.1 (d)

<table>
<tr><th>Feature</th><th>Criteria</th><th>Remarks</th><th>Reference</th></tr>
<tr><td>Irrigation System requirements</td><td>7-year min design life
Size to minimize erosion
Pipe velocities 5 feet/s max
Thrust blocks at direction changes
Drainage valves at low points
Removable for high flow events</td><td></td><td>App 4: 4.16.2.1 (c)
App 4: 4.16.2.1 (e)
App 4: 4.16.2.1 (g)
App 4: 4.16.2.1 (h)
App 4: 4.16.2.1 (m)
App 4: 4.16.2.1 (n)</td></tr>
<tr><td>Pump requirements</td><td>House gas-powered pumps in spill containment basins
Fish screen on any river pump intake</td><td></td><td>App 4: 4.16.2.1 (k)
App 4: 4.16.2.1 (l)</td></tr>
<tr><td>Design Parameters</td><td>Min evapotranspiration coefficient for riparian – 0.6
Min irrigation efficiency coefficient – 0.8</td><td></td><td>App 4: 4.16.2.1 (f)
App 4: 4.16.2.2 (c), (d)</td></tr>
<tr><td>Frequency</td><td>Proposed Criteria:
<table>
<tr><th rowspan="2">Month</th><th colspan="3">Min Weekly Application</th></tr>
<tr><th>Y0</th><th>Y1-3</th><th>Y4-5</th></tr>
<tr><td>April</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>May</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td>June</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>July</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td>Aug</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Sept</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Oct</td><td>2</td><td>1</td><td>0</td></tr>
</table></td><td></td><td>App 4: 4.16.2.1 (o)</td></tr>
<tr><td>Quantity of water</td><td>Proposed criteria:
<table>
<tr><th>Month</th><th>Min gal/acre</th><th>Min in/month</th></tr>
<tr><td>April</td><td>59,000</td><td>2.2</td></tr>
<tr><td>May</td><td>83,000</td><td>3.1</td></tr>
<tr><td>June</td><td>124,000</td><td>4.6</td></tr>
<tr><td>July</td><td>151,000</td><td>5.6</td></tr>
<tr><td>Aug</td><td>126,000</td><td>4.7</td></tr>
<tr><td>Sept</td><td>83,000</td><td>3.1</td></tr>
<tr><td>Oct</td><td>35,000</td><td>1.3</td></tr>
</table></td><td></td><td>App 4: 4.16.2.1 (p)</td></tr>
<tr><td>Winter Months</td><td>If < 0.5 in precipitation in any week, deliver 0.25 in/acre of water per week.</td><td></td><td>App 4: 4.16.2.1 (q)</td></tr>
<tr><td>Timing</td><td>Between 5am and 10am, as practical</td><td></td><td>App 4: 4.16.2.1 (r)</td></tr>
<tr><th colspan="4">FENCING AND PROTECTION</th></tr>
<tr><td>Herbivory Protection</td><td>Type to be determined and installed if unacceptable levels of herbivory by native species is observed during monitoring and maintenance period</td><td></td><td>60% Design Report, Section 8
App 4: 4.15.2.2 (i), (k)
App 4: 4.17.2.1 (d)</td></tr>
</table>

<table>
<tr><th>Feature</th><th>Criteria</th><th>Remarks</th><th>Reference</th></tr>
<tr><td>Cattle exclusion</td><td>Cattle exclusion fence to be installed around restoration areas</td><td></td><td>60% Design Report, Section 8
App 4: 4.15.2.2 (m), (n)
App 4: 4.17.2.1 (g)</td></tr>
<tr><td>Other protection</td><td>Protect all existing native vegetation, particularly special status species if presence confirmed at restoration sites</td><td></td><td>App 4: 4.15.2.1 (a), (s)</td></tr>
<tr><td colspan="4">PLANT ESTABLISHMENT, MAINTENANCE, AND MONITORING</td></tr>
<tr><td>Duration</td><td>2 years after acceptance of installation</td><td></td><td>App 4: 4.17.2.1 (a)</td></tr>
<tr><td>Plant replacement</td><td>Criteria for replacement and adaptive management under development</td><td></td><td>App 4: 4.17.2.1 (f)
App 4: 4.17.2.2 (a)</td></tr>
<tr><td>Reseeding</td><td>If no germination of seeded species reseed as soon as viable (fall, spring).</td><td></td><td>App 4: 4.17.2.1 (b)
App 4: 4.15.2.2 (d)</td></tr>
<tr><td>Upland Performance Criteria</td><td>Proposed Criteria:
<table>
<tr><td rowspan="2"></td><td>Y1</td><td>Y2</td><td>Y3</td><td>Y4</td><td>Y5</td></tr>
<tr><td colspan="5">% of Reference Sites</td></tr>
<tr><td>Richness</td><td>50</td><td>55</td><td>60</td><td>65</td><td>70</td></tr>
<tr><td>Tree and shrub density</td><td>50</td><td>55</td><td>60</td><td>65</td><td>70</td></tr>
<tr><td></td><td colspan="3">Mean % Cover</td><td colspan="2">% reference sites</td></tr>
<tr><td>Vegetation Cover</td><td>15</td><td>25</td><td>45</td><td>60</td><td>80</td></tr>
</table></td><td>Differs from App 4</td><td></td></tr>
<tr><td>Riparian performance criteria for irrigated sites</td><td>Proposed Criteria:
<table>
<tr><td rowspan="2"></td><td>Y1</td><td>Y2</td><td>Y3</td><td>Y4</td><td>Y5</td></tr>
<tr><td colspan="5">% of Reference Sites</td></tr>
<tr><td>Richness</td><td>50</td><td>60</td><td>70</td><td>80</td><td>90</td></tr>
<tr><td>Tree and shrub density</td><td>50</td><td>60</td><td>70</td><td>80</td><td>90</td></tr>
<tr><td>Vegetation Cover</td><td>50</td><td>60</td><td>70</td><td>80</td><td>90</td></tr>
</table></td><td>Differs from App 4</td><td></td></tr>
<tr><td>Naturally recruited native woody species</td><td>Counted as 100% survival</td><td>Differs from App 4</td><td>App 4: 4.17.2.1 (c)
App 4: 4.18.2.1 (a)</td></tr>
</table>

4.0 REFERENCES

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CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX B J.C. Boyle

PAGE B1-1 to B3-5

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX C Copco No. 1

PAGE C1-1 to C3-6

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX D Copco No. 2

PAGE D1-1 to D3-5

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

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APPENDIX E Iron Gate

PAGE E1-1 to E4-4

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX F Roads, Bridges, and Culverts

PAGE F1-1 to F4.2-41

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX G Drawdown Modeling

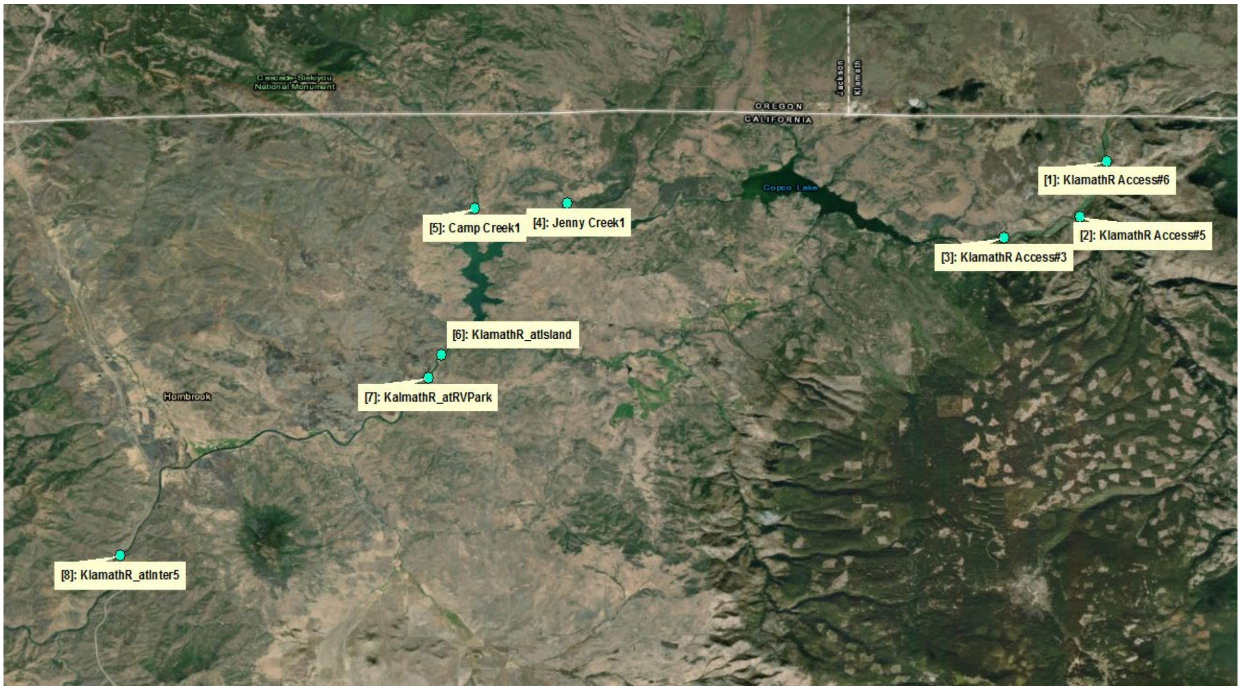
PAGE G1 to G-86

APPENDIX H

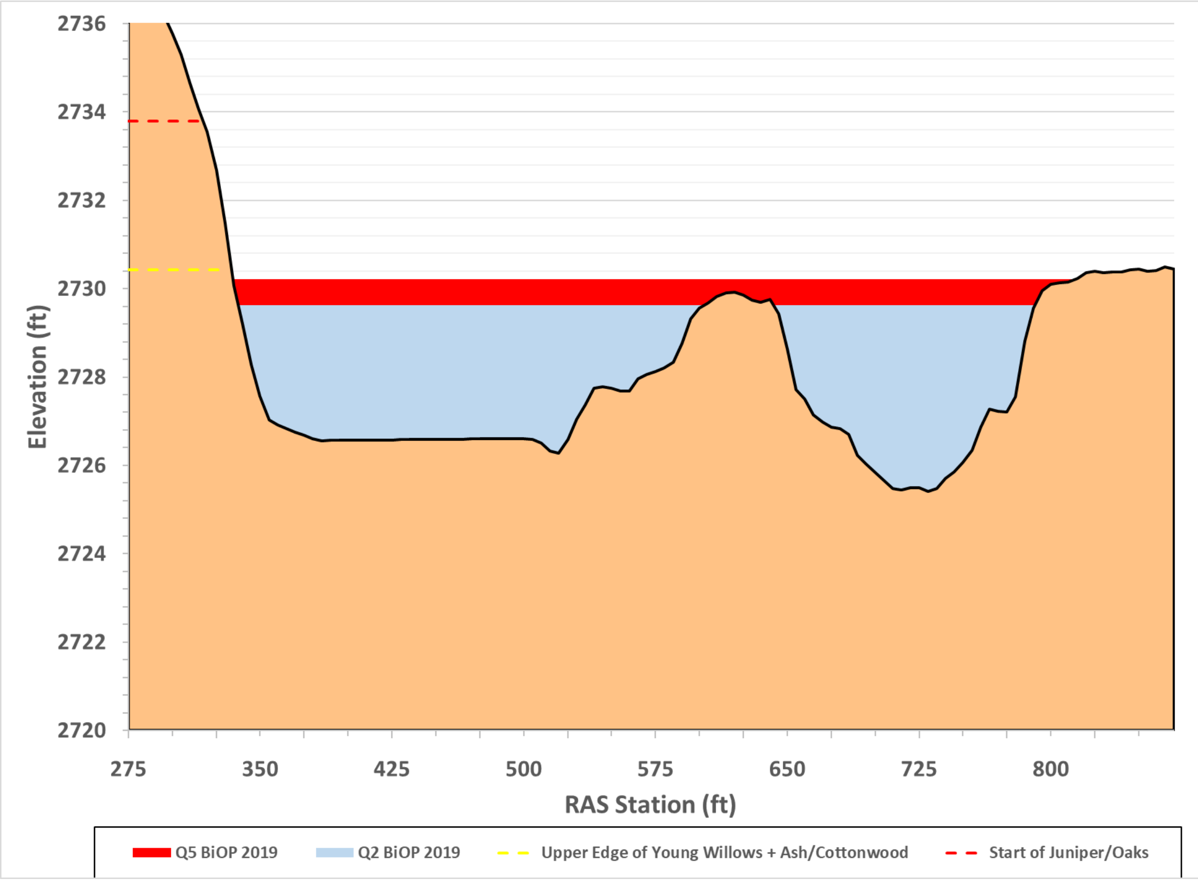
Reference Reach Cross Sections

(Pages H-1 to H-4)

APPENDIX H Hydrologic connectivity cross sections



Reference reach locations



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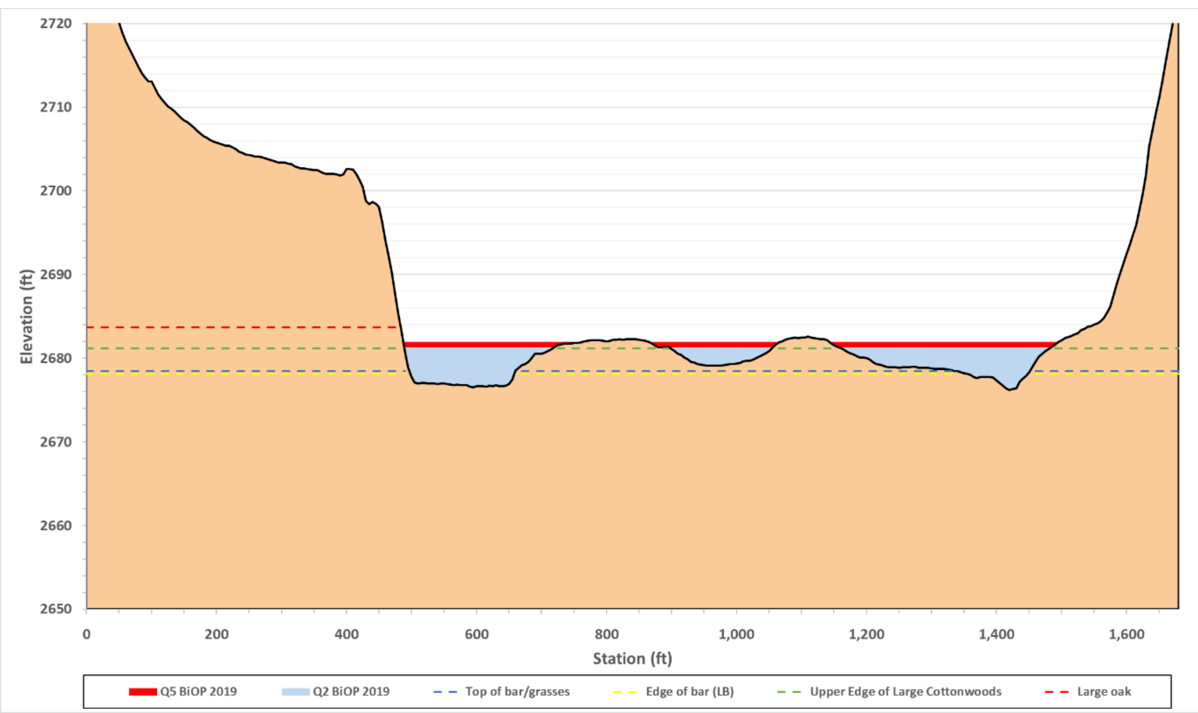

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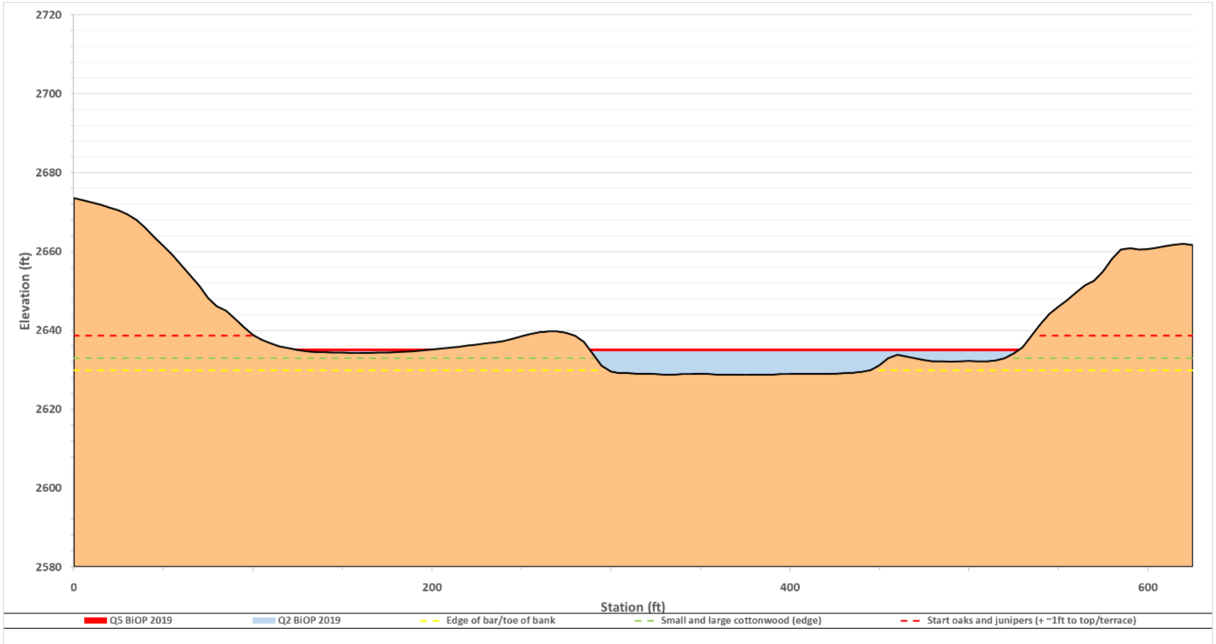

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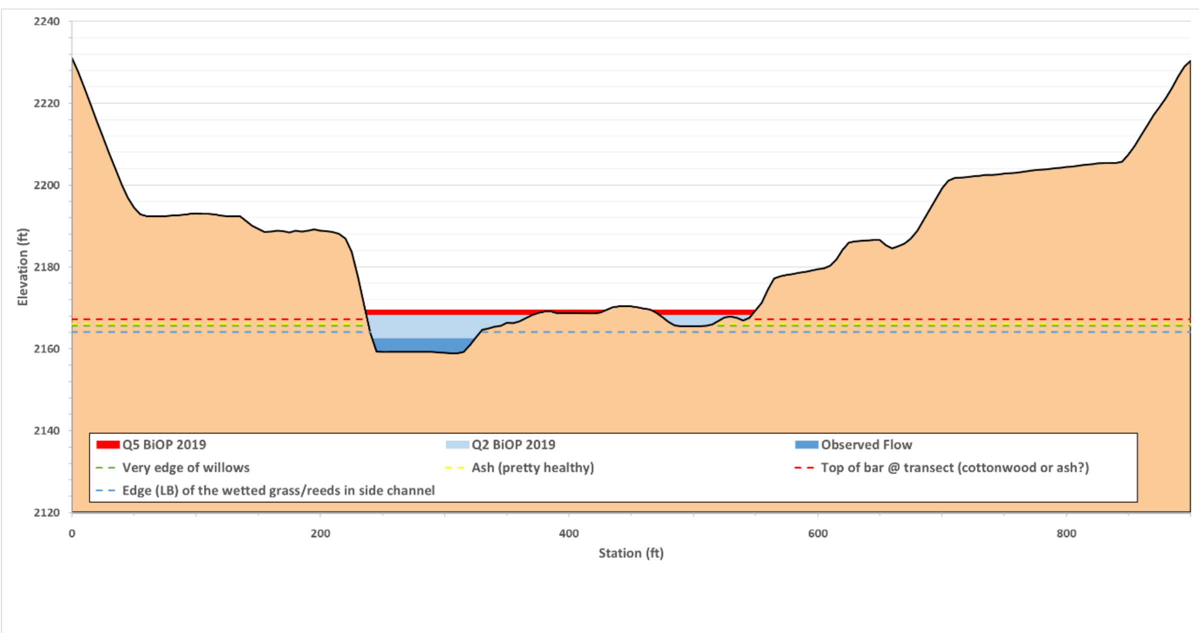
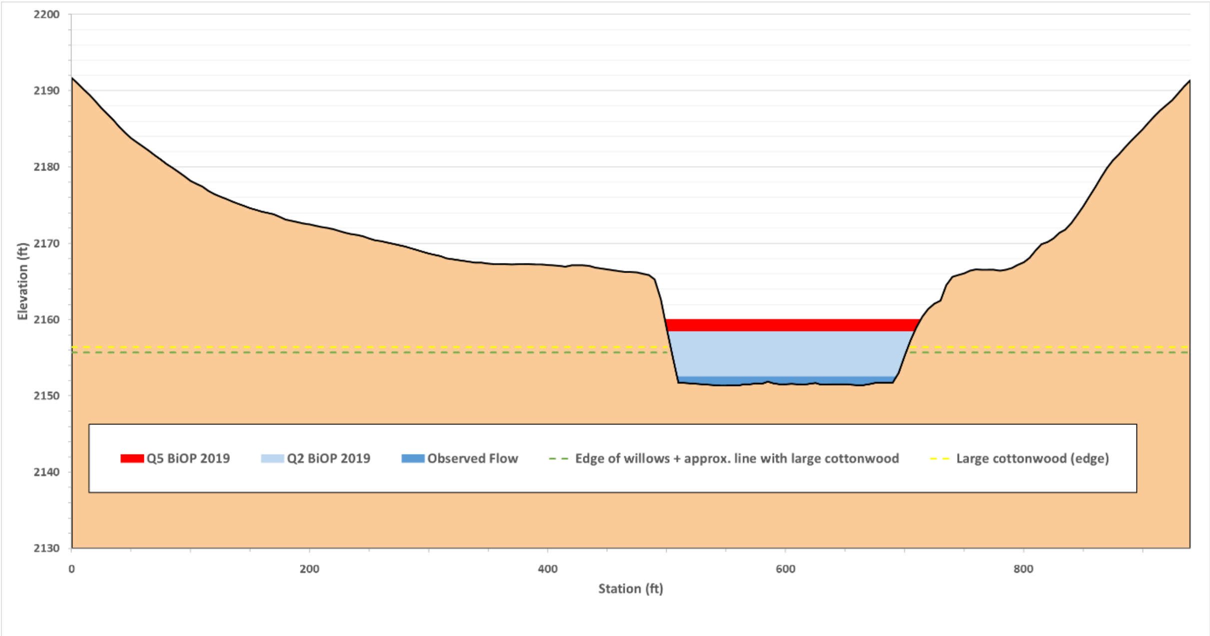
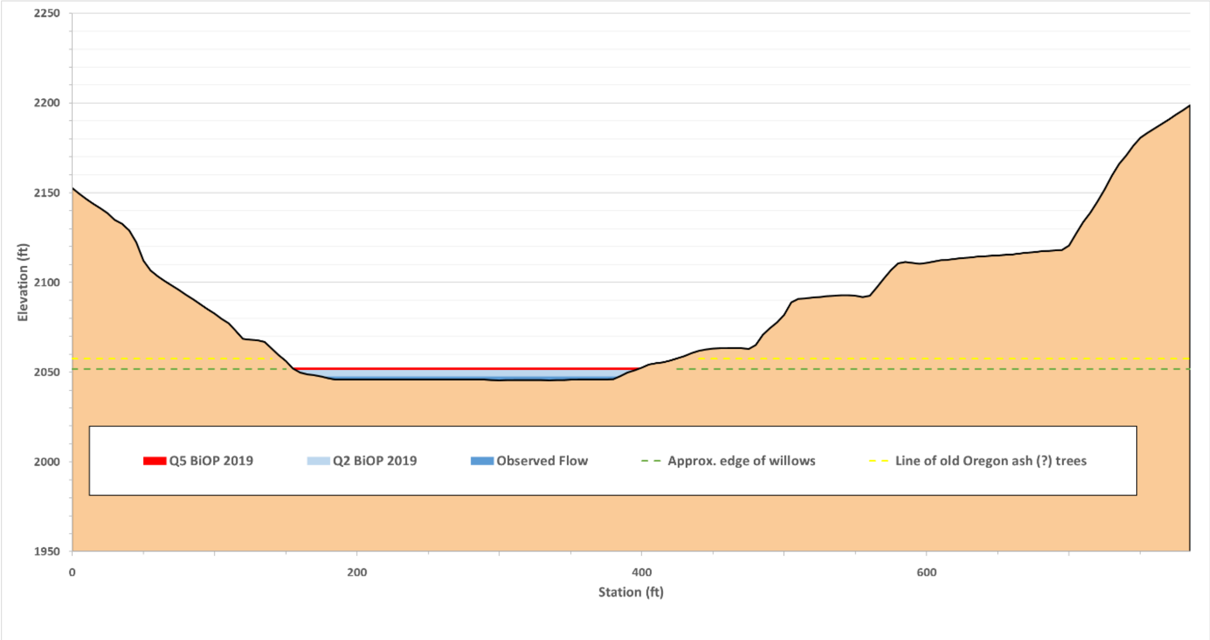


Klamath at Island below Iron Gate



Klamath at RV Park below Iron Gate



Klamath at I-5

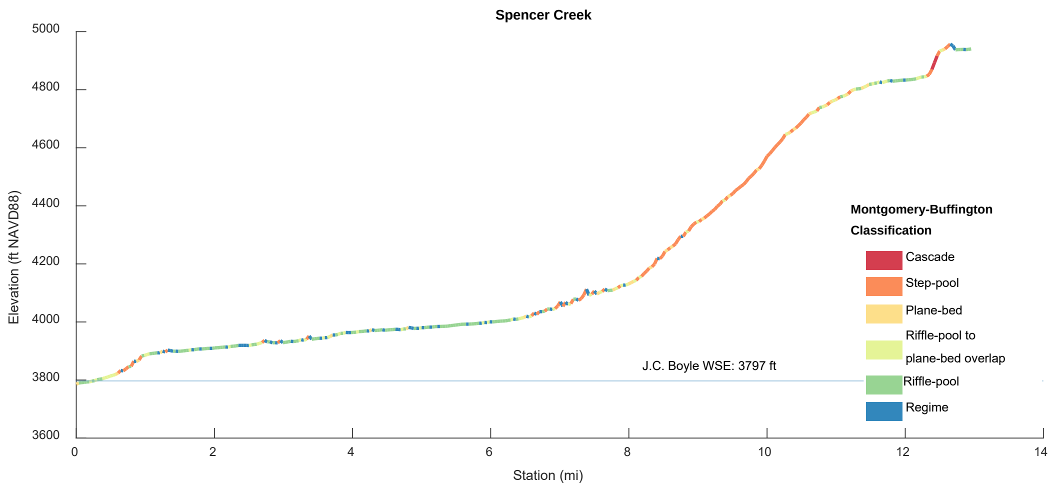
APPENDIX I

Tributary Profiles

(Pages I-1 to I-7)

APPENDIX I: LONGITUDINAL PROFILES OF KEY TRIBUTARIES

Spencer Creek



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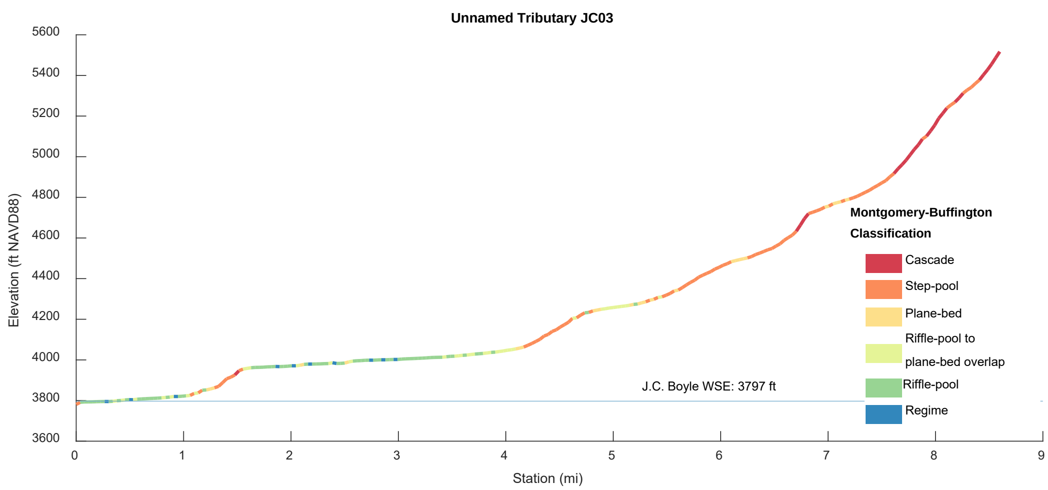

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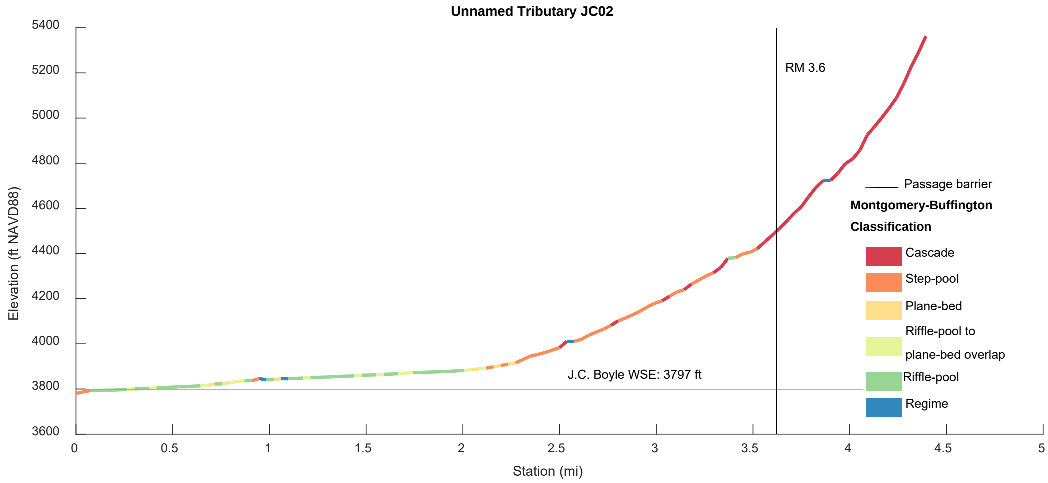
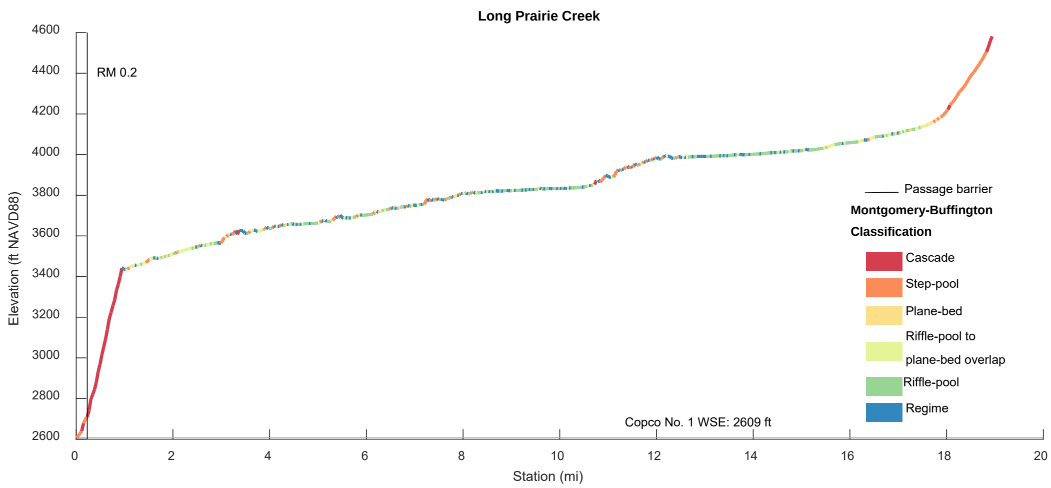
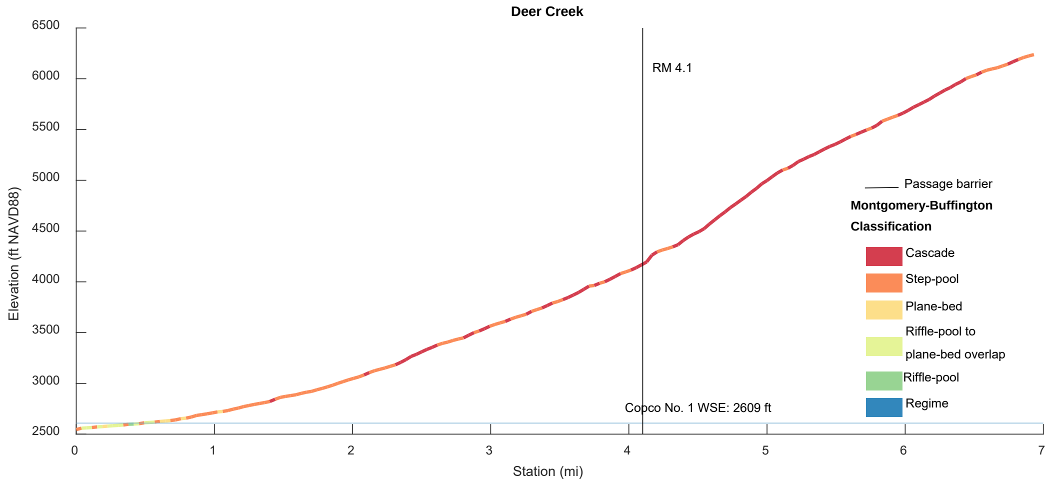
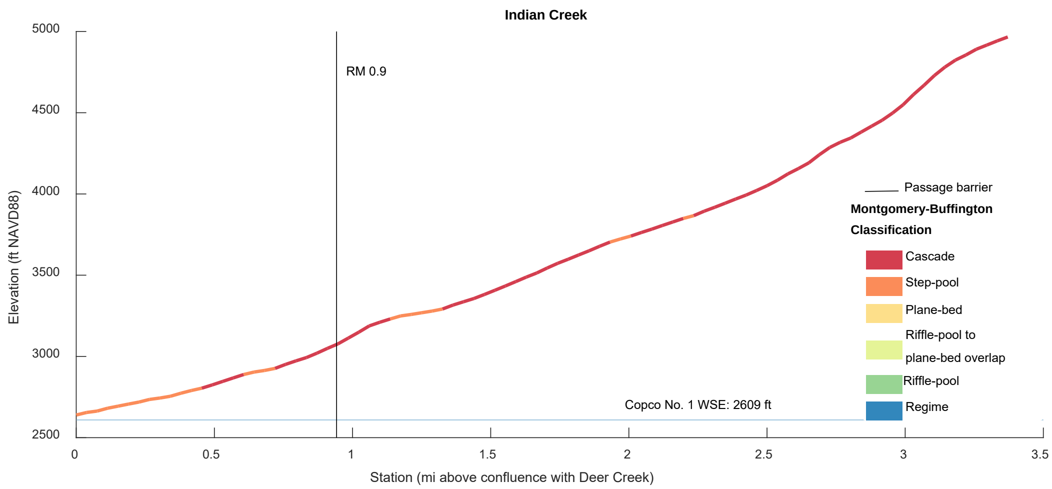


Long Prairie Creek

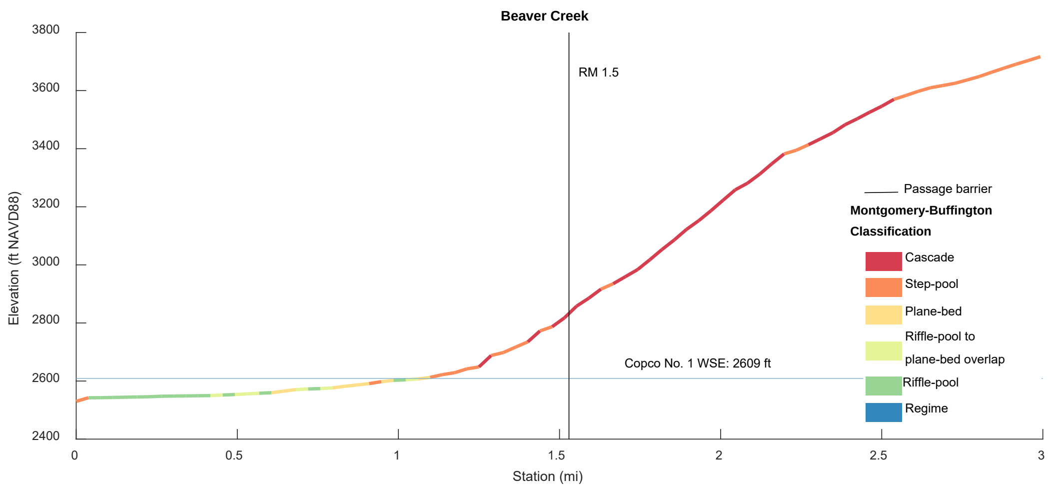


Deer/Indian Creek

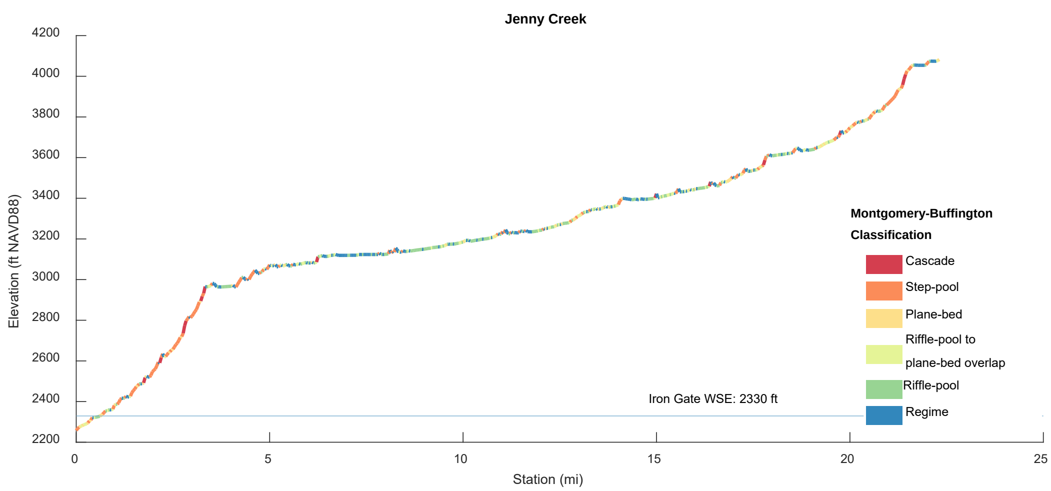




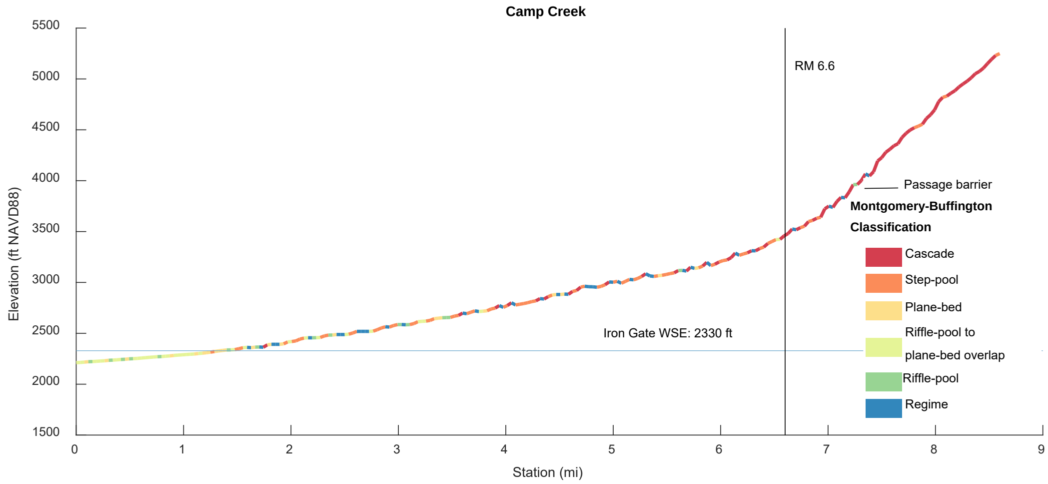
Beaver Creek

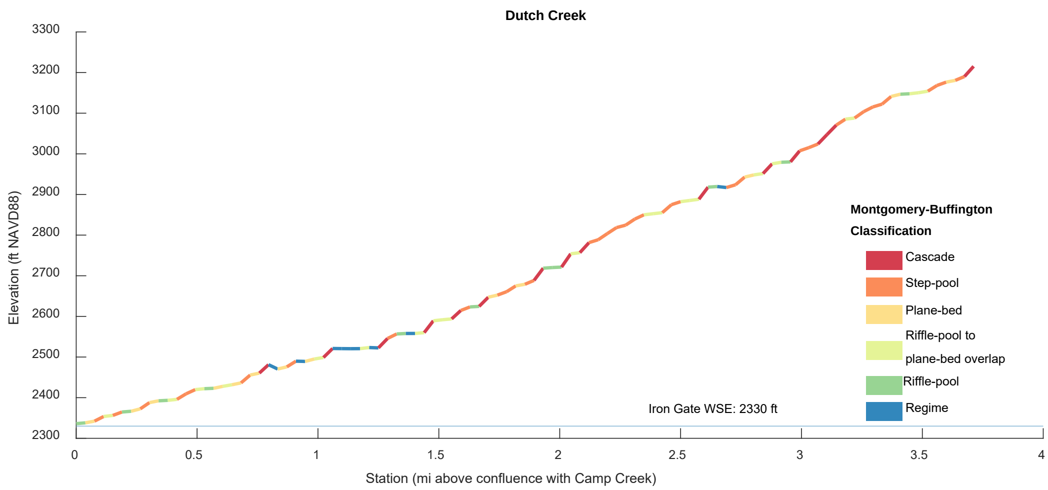


Jenny Creek

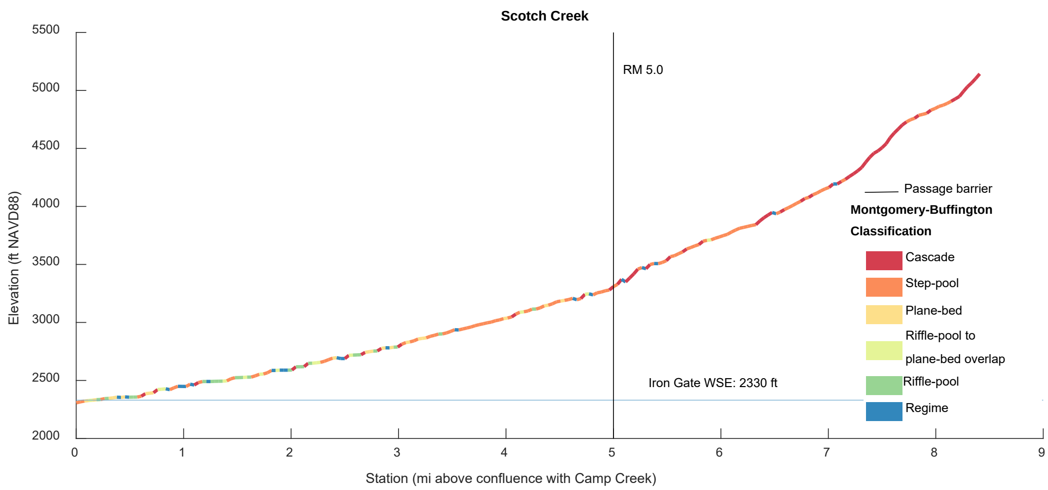


Dutch/Camp Creek

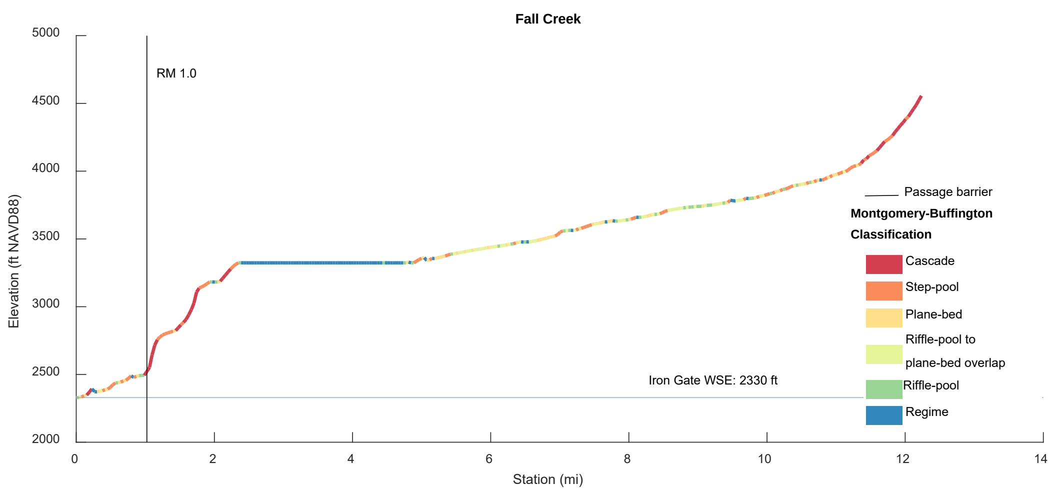




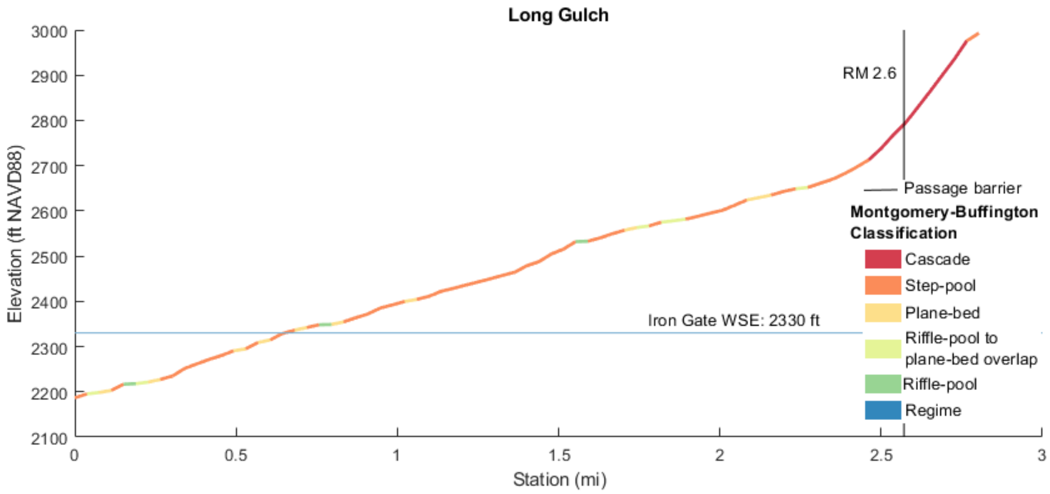
Scotch Creek



Fall Creek



Long Gulch



Long Gulch
RM 2.6
Iron Gate WSE: 2330 ft
Passage barrier
Montgomery-Buffington Classification
Cascade
Step-pool
Plane-bed
Riffle-pool to plane-bed overlap
Riffle-pool
Regime
Elevation (ft NAVD88)
Station (mi)
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
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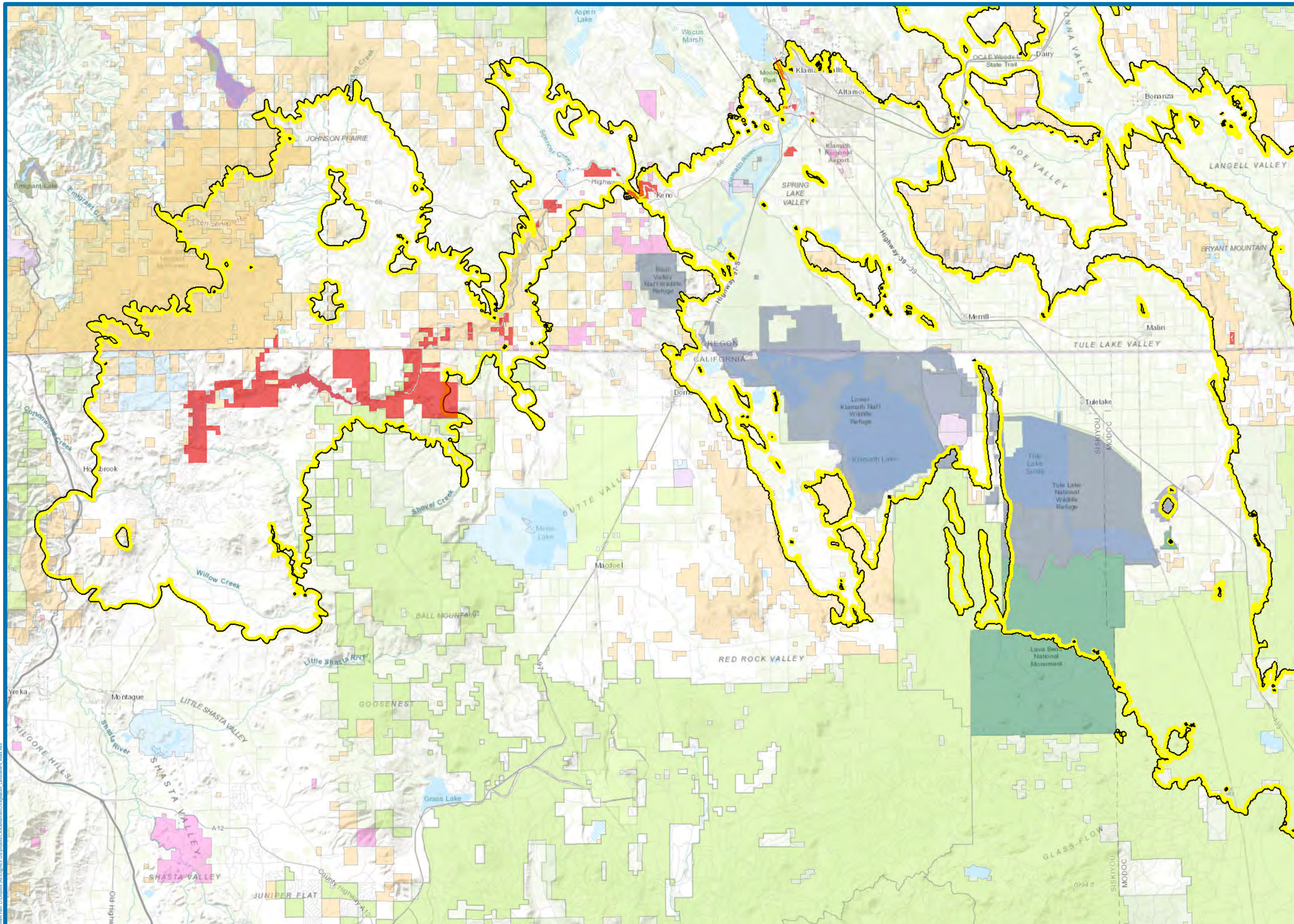
APPENDIX J

Seed Collection Areas

(Pages J-1 to J-40)

PUBLIC VERSION



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SEED COLLECTION SURVEY

PROPERTY OVERVIEW MAP

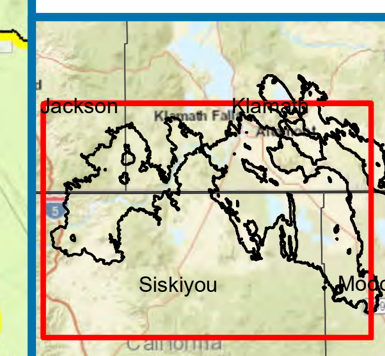
Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Index Map

LEGEND

- Seed Collection Study Area
- PacifiCorp Parcels

Ownership - Public Agency

- Other
- Bureau of Land Management
- National Park Service
- Forest Service
- U.S. Fish & Wildlife Service
- State Fish and Wildlife
- Bureau of Reclamation
- City Land
- County Land
- Natural Resources Conservation Service



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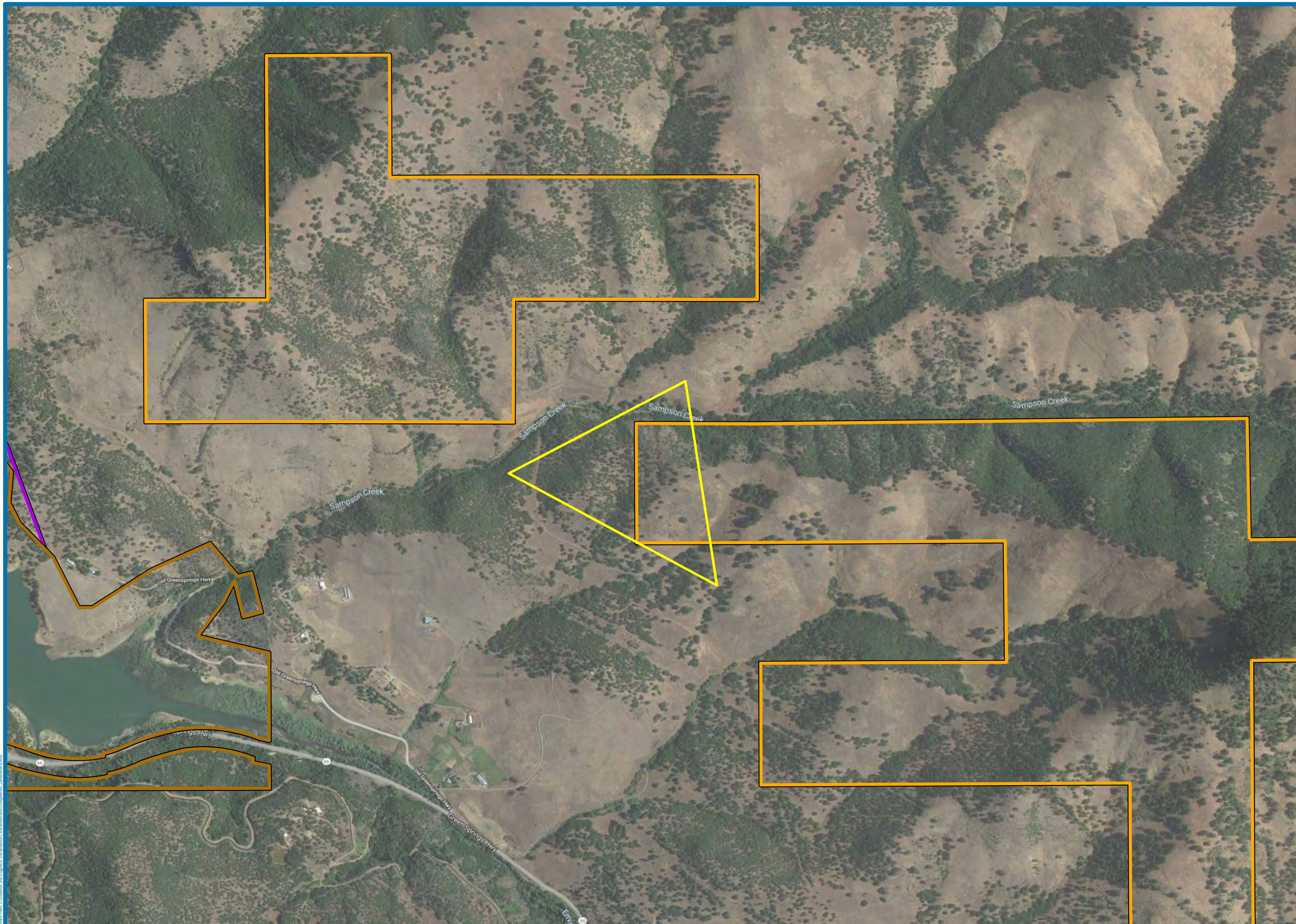

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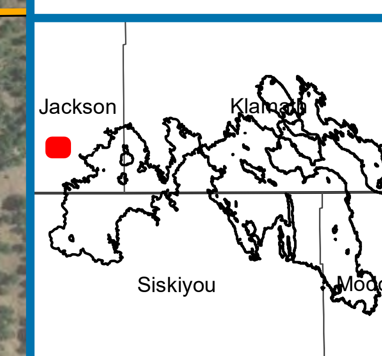
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 1 of 39

LEGEND

- Seed Collection Polygon
- Bureau of Land Management
- Bureau of Reclamation
- County Land



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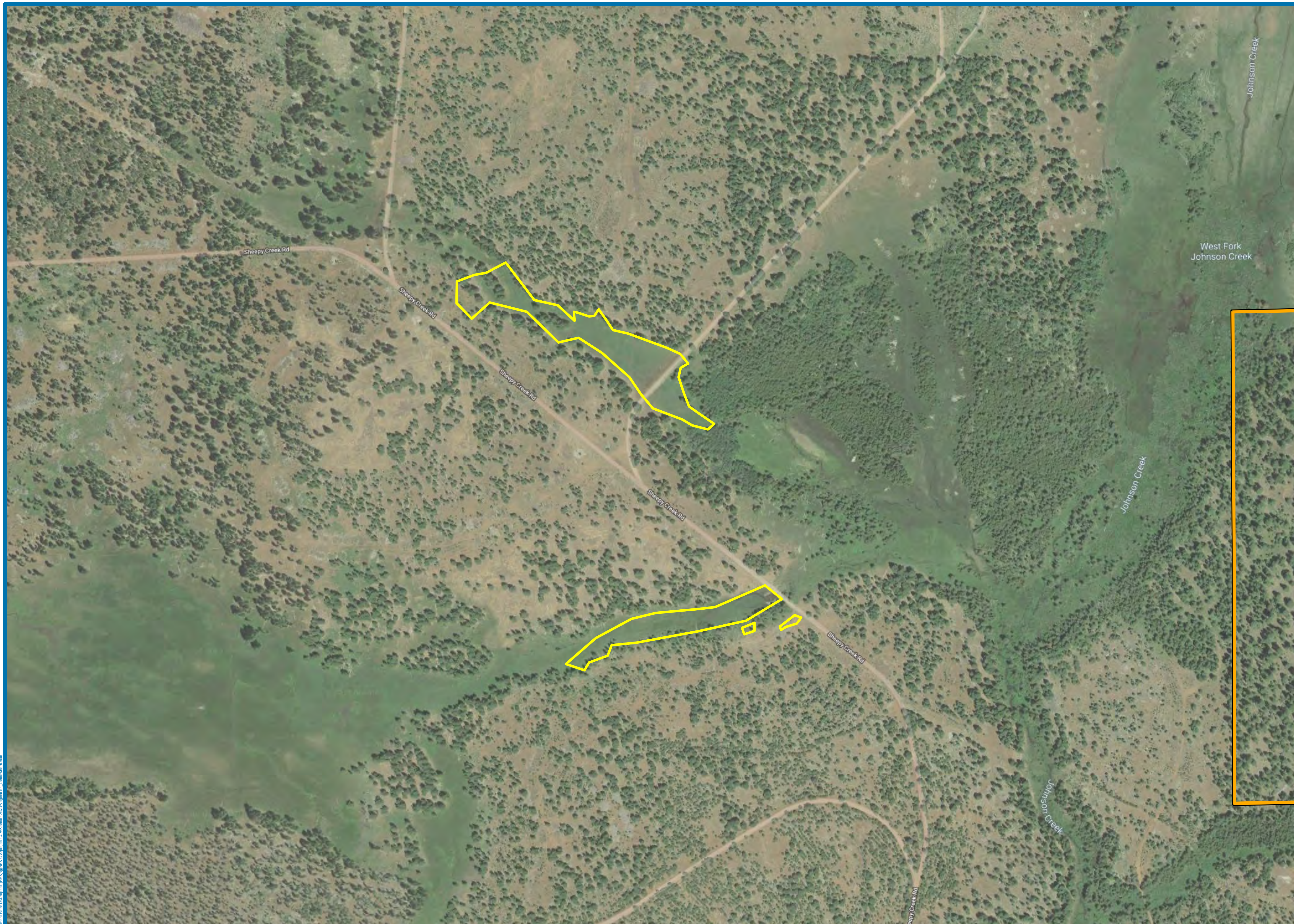

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 2 of 39

LEGEND

- Seed Collection Polygon
- Bureau of Land Management

REFERENCE

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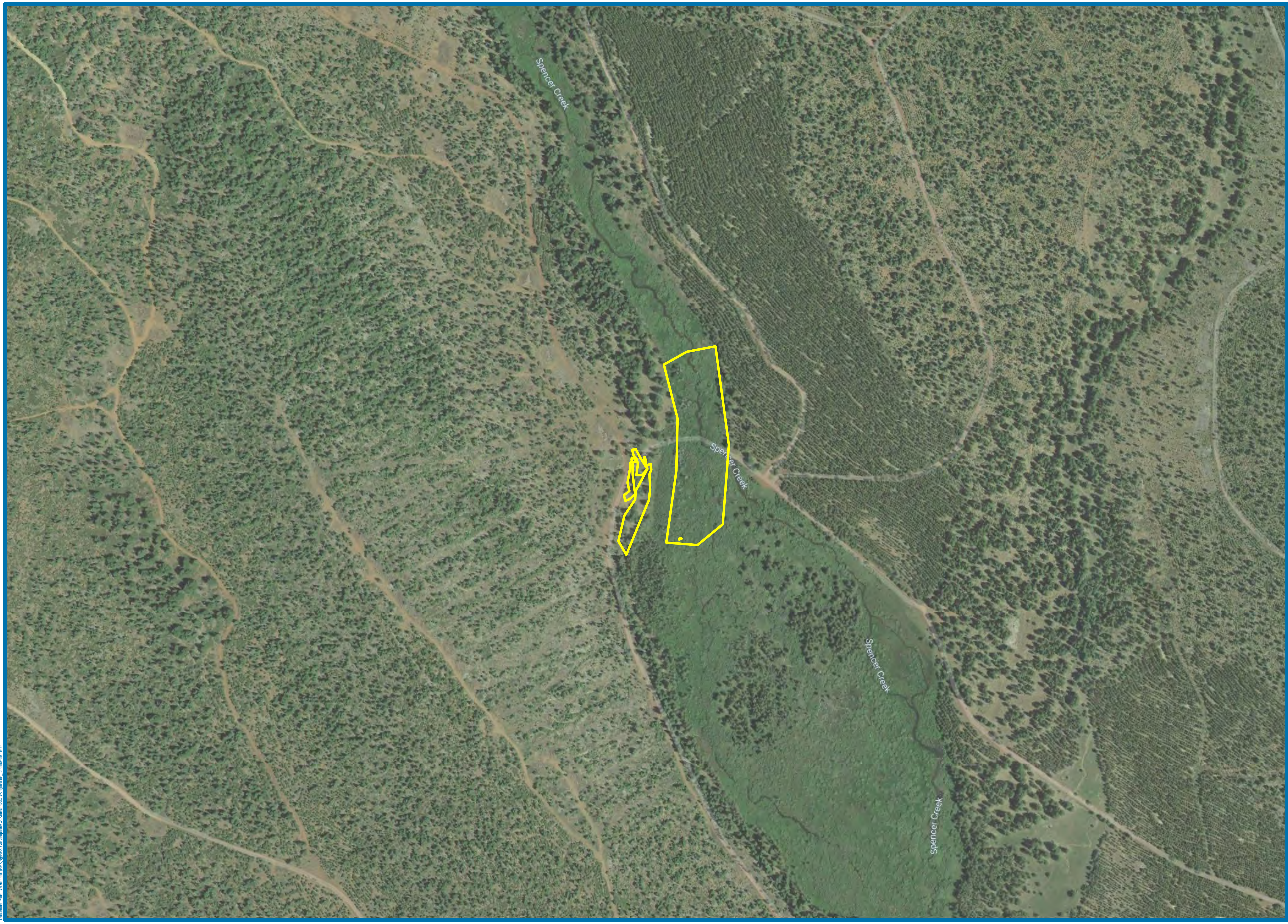

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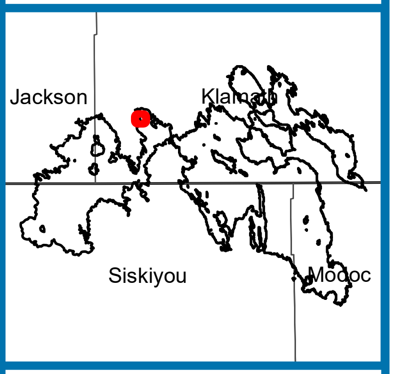
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 3 of 39

LEGEND

Seed Collection Polygon



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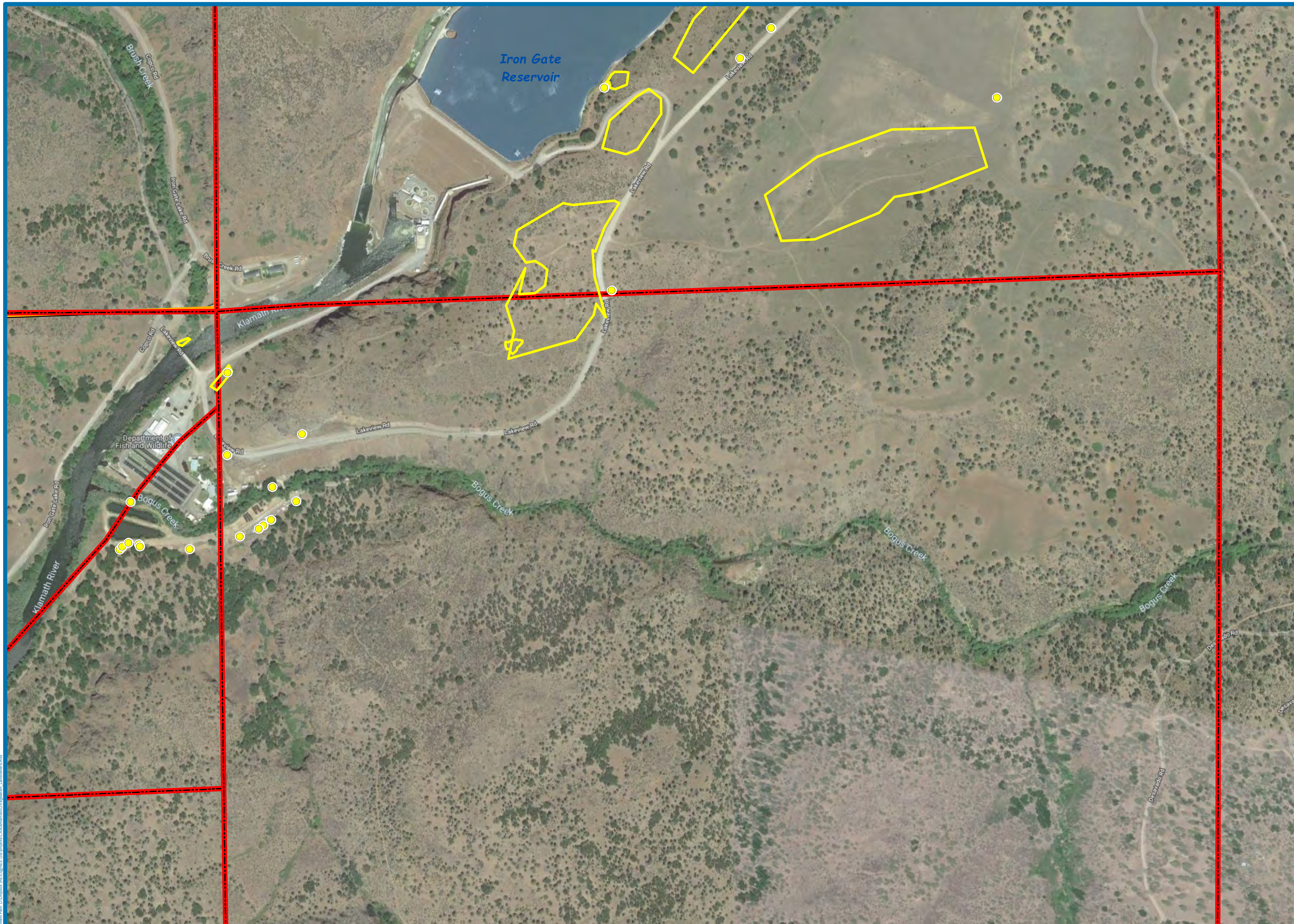

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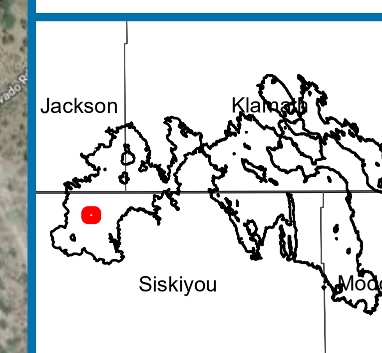
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 4 of 39

LEGEND

- Seed Collection Point
- Seed Collection
- PacifiCorp Parcels
- Bureau of Land



REFERENCE

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2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM


Iron Gate Reservoir
Long Gulch
Mountain Ave
Copco Rd
Iron Gate Lake Rd
Lakeview Rd
Brush Cr
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SEED COLLECTION SURVEY
Date: 8/22/2019
Drawn by: BRG
Checked by: GS
Page 5 of 39
LEGEND
Seed Collection Point
Seed Collection Polygon
PacifiCorp Parcels
Bureau of Land
Jackson
Klamath
Siskiyou
Modoc
REFERENCE
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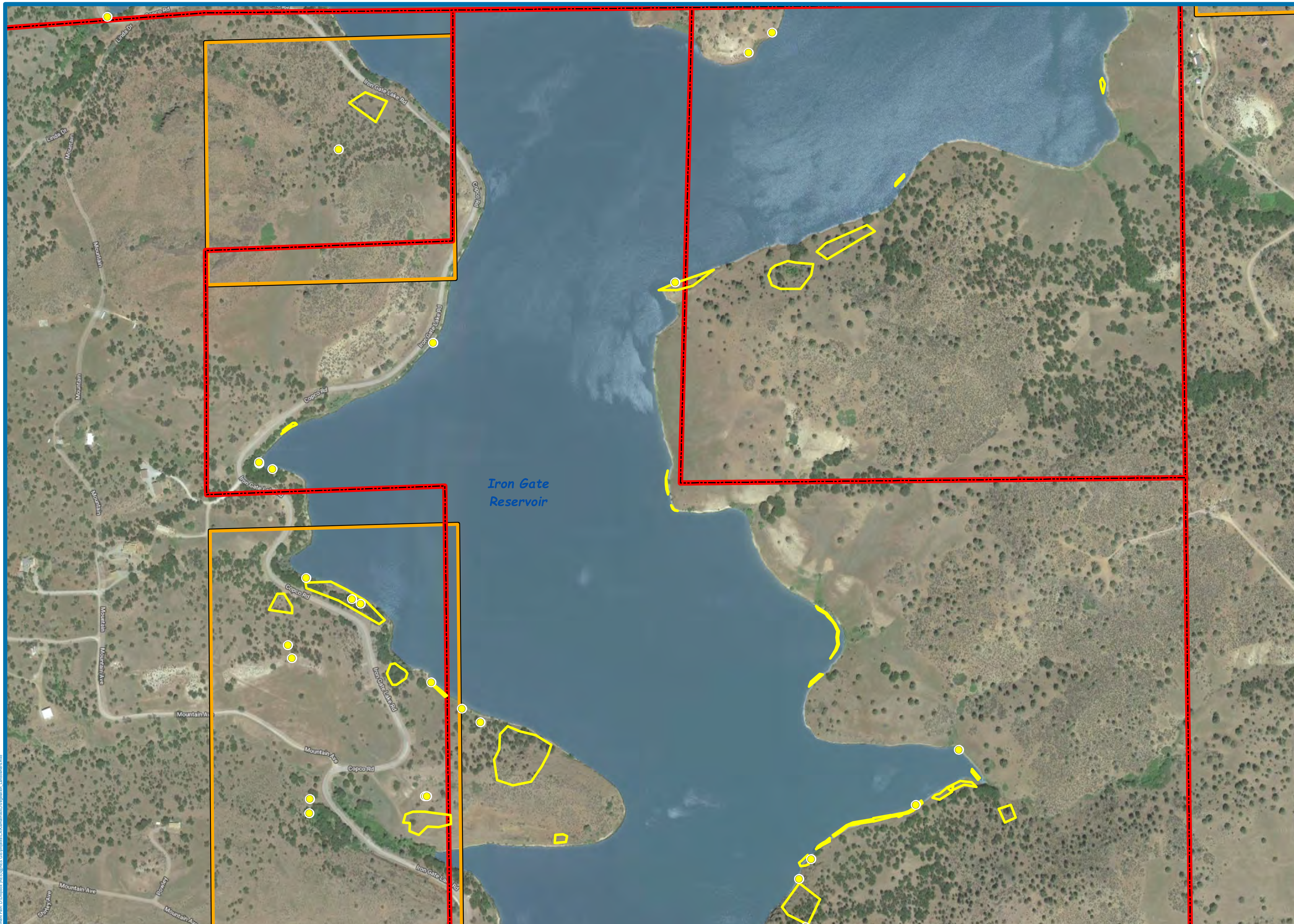

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 6 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land

REFERENCE

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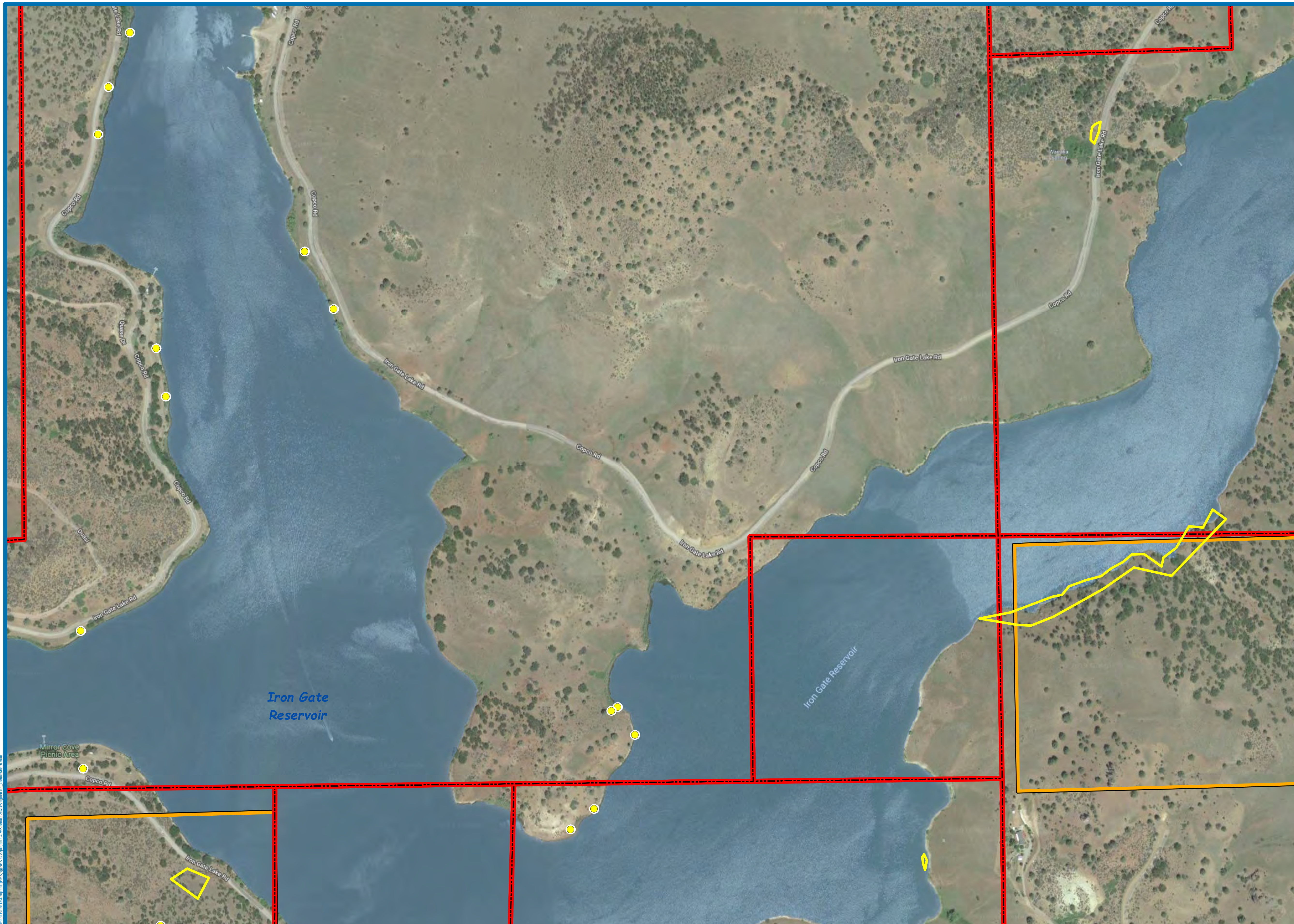

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 7 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land

REFERENCE

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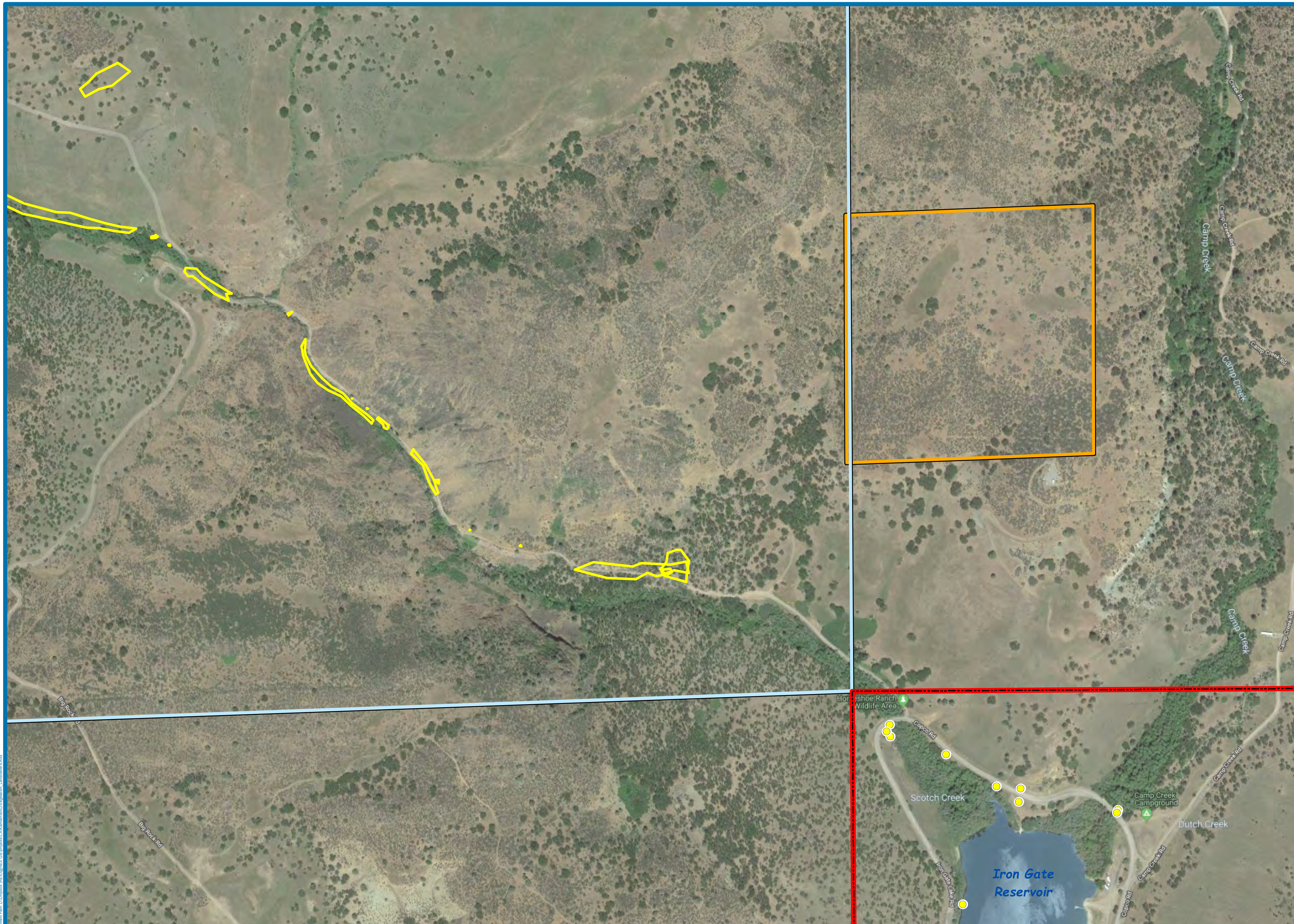

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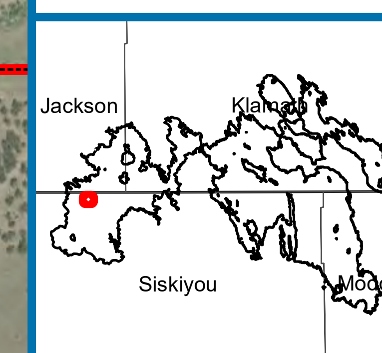
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 8 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land
- State Fish and Wildlife



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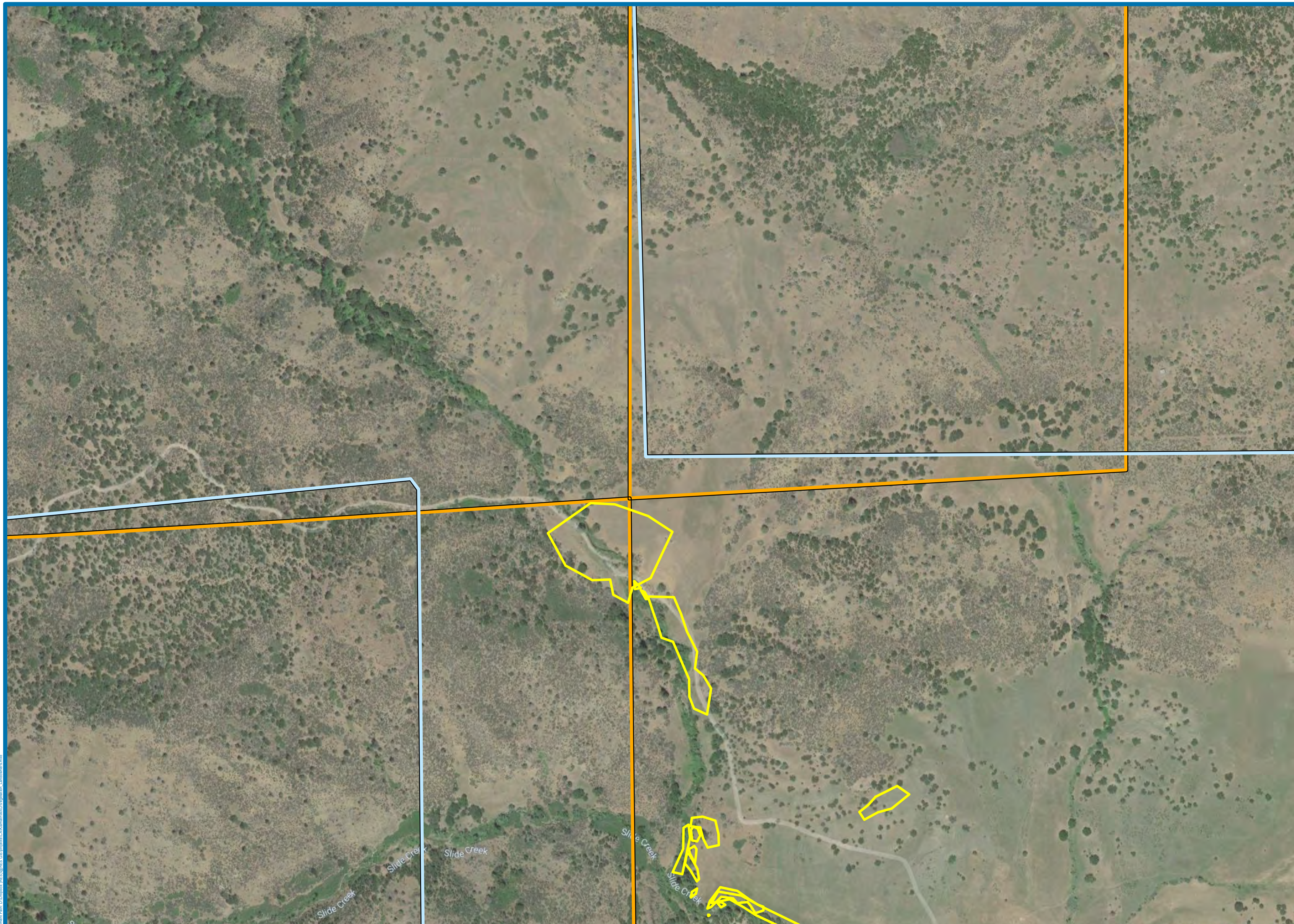

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 9 of 39

LEGEND

- Seed Collection Polygon
- Bureau of Land
- State Fish and Wildlife

REFERENCE

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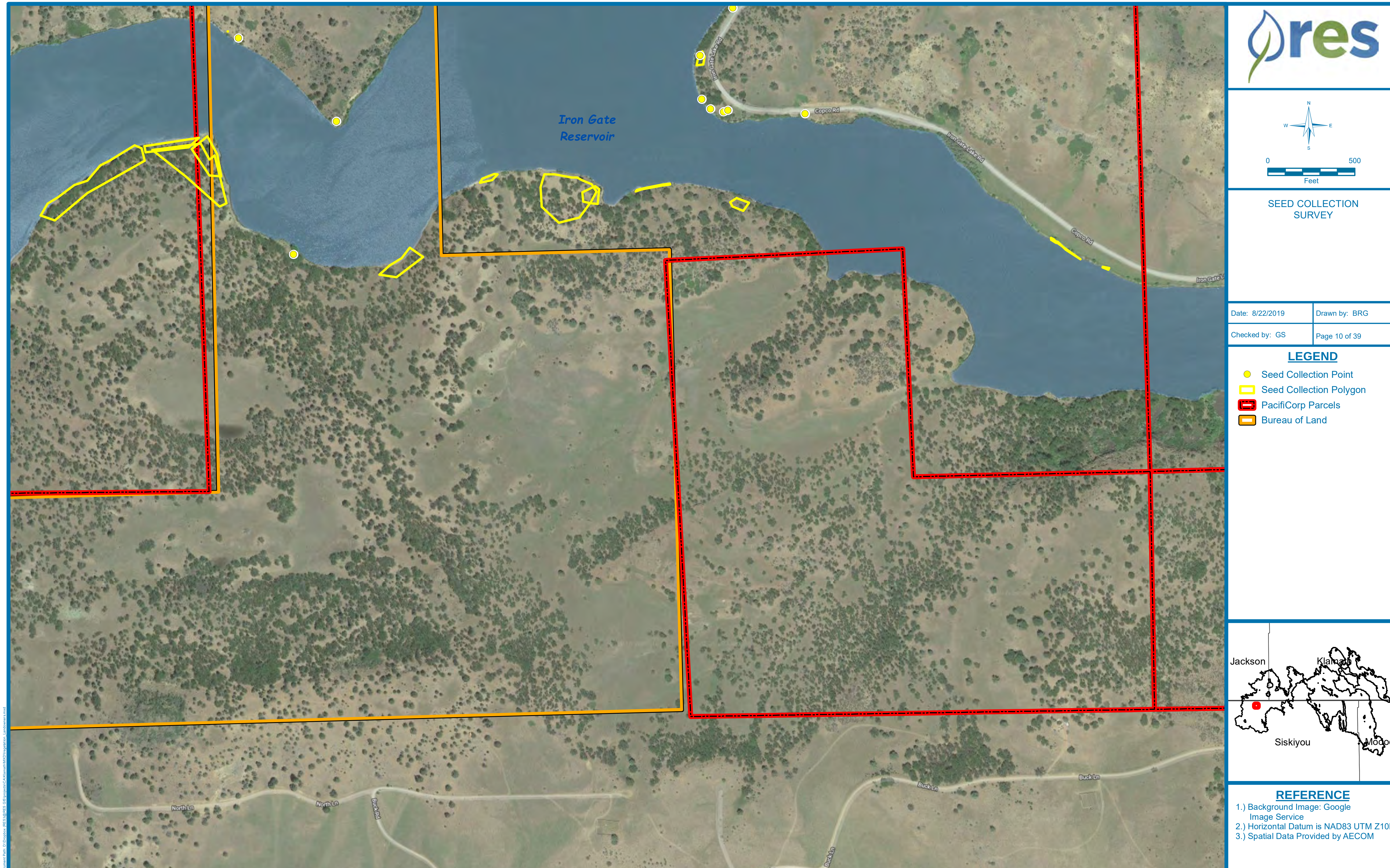

Iron Gate Reservoir
Iron Gate Lake Rd
Copco Rd
North Ln
Buck Rd
Buck Ln
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SEED COLLECTION SURVEY
Date: 8/22/2019
Drawn by: BRG
Checked by: GS
Page 10 of 39
LEGEND
Seed Collection Point
Seed Collection Polygon
PacifiCorp Parcels
Bureau of Land
Jackson
Klamath
Siskiyou
Modoc
REFERENCE
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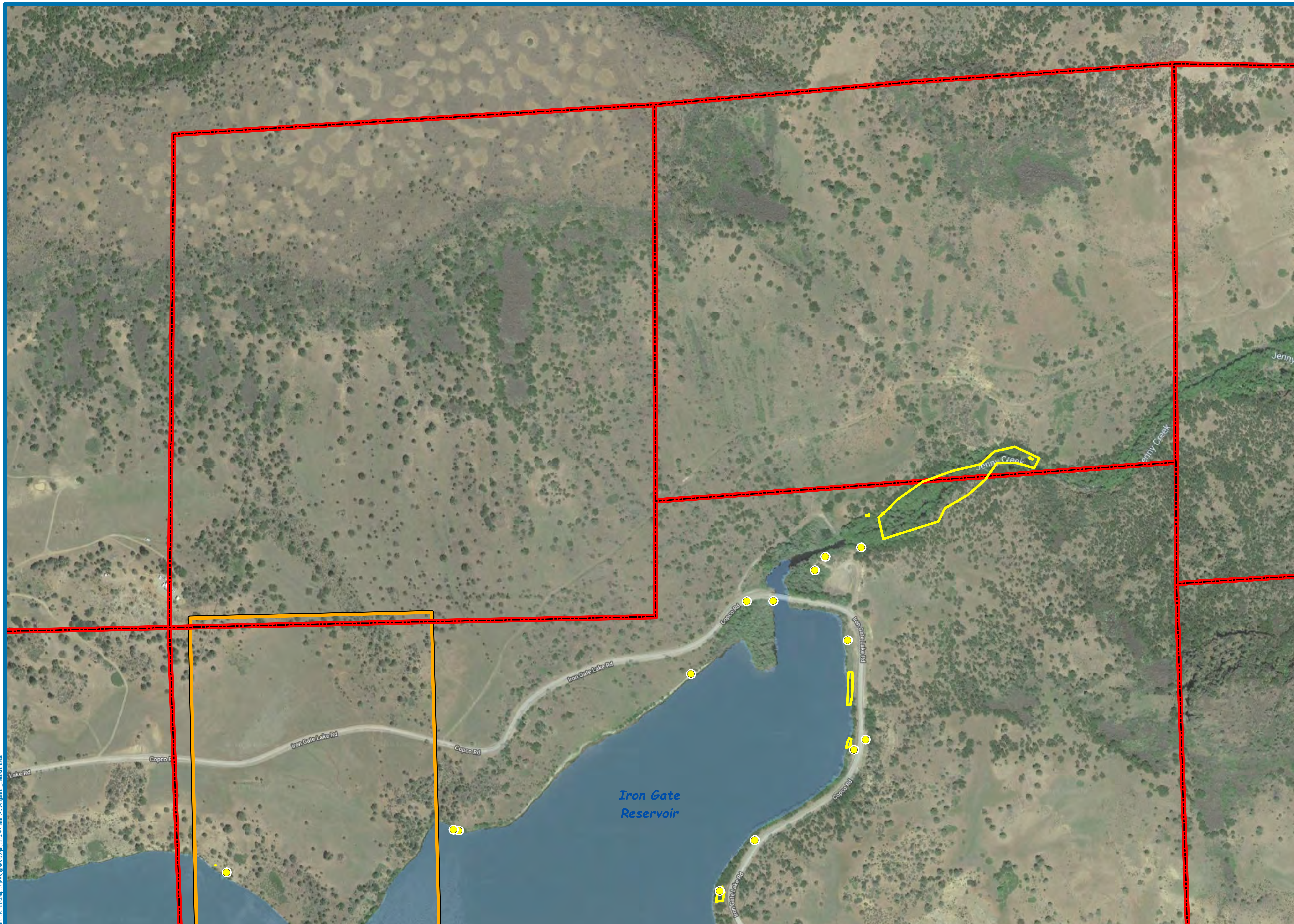

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 11 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land

REFERENCE

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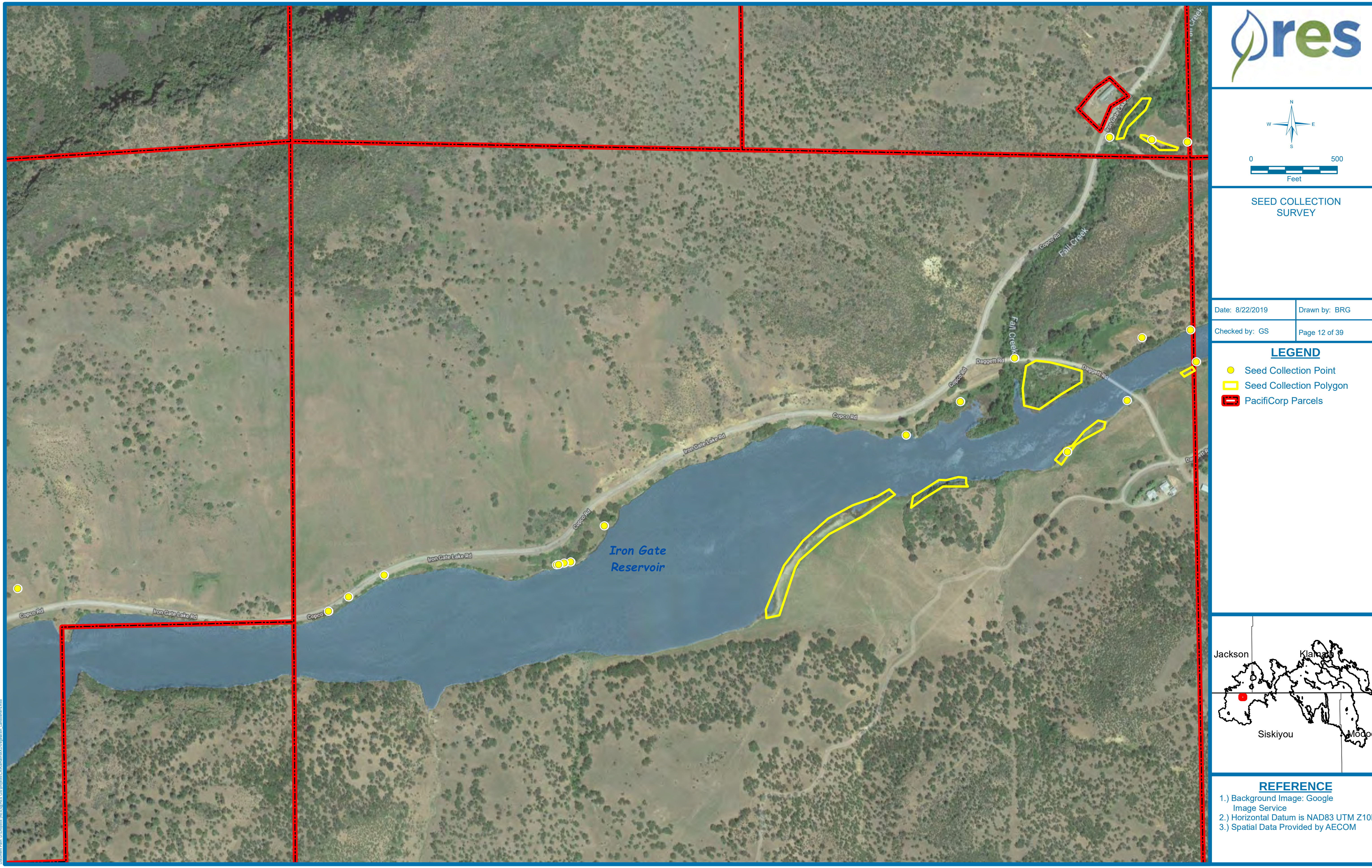
Iron Gate Reservoir
Copco Rd
Iron Gate Lake Rd
Daggett Rd
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SEED COLLECTION SURVEY
Date: 8/22/2019
Drawn by: BRG
Checked by: GS
Page 12 of 39
LEGEND
Seed Collection Point
Seed Collection Polygon
PacifiCorp Parcels
Jackson
Klamath
Siskiyou
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REFERENCE
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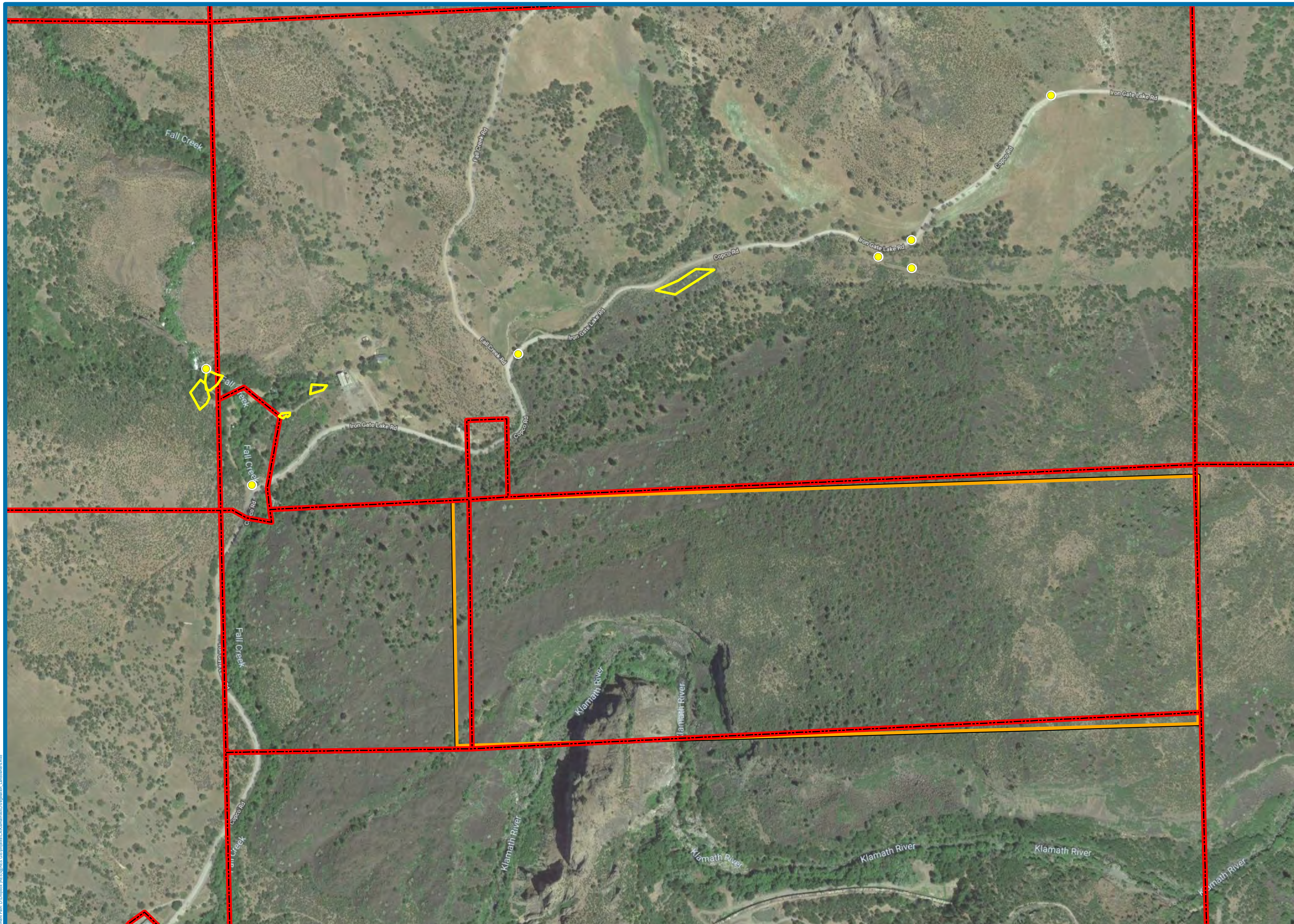

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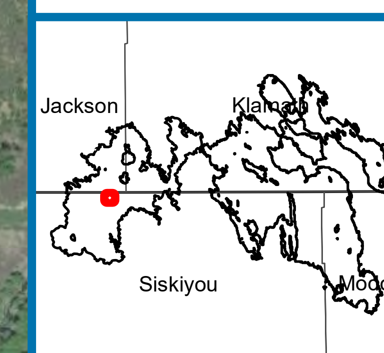
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 13 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land Management



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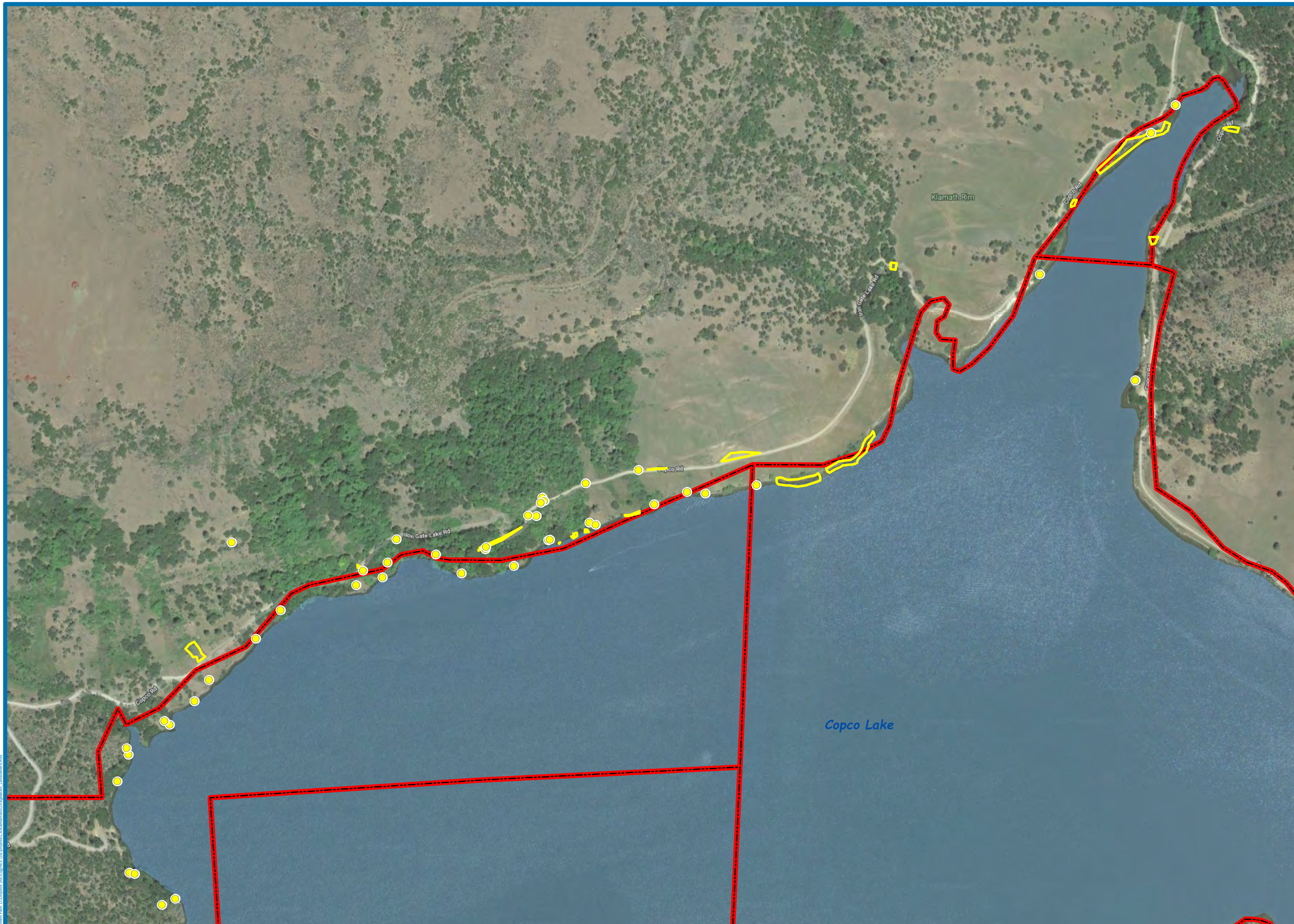

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 14 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels

REFERENCE

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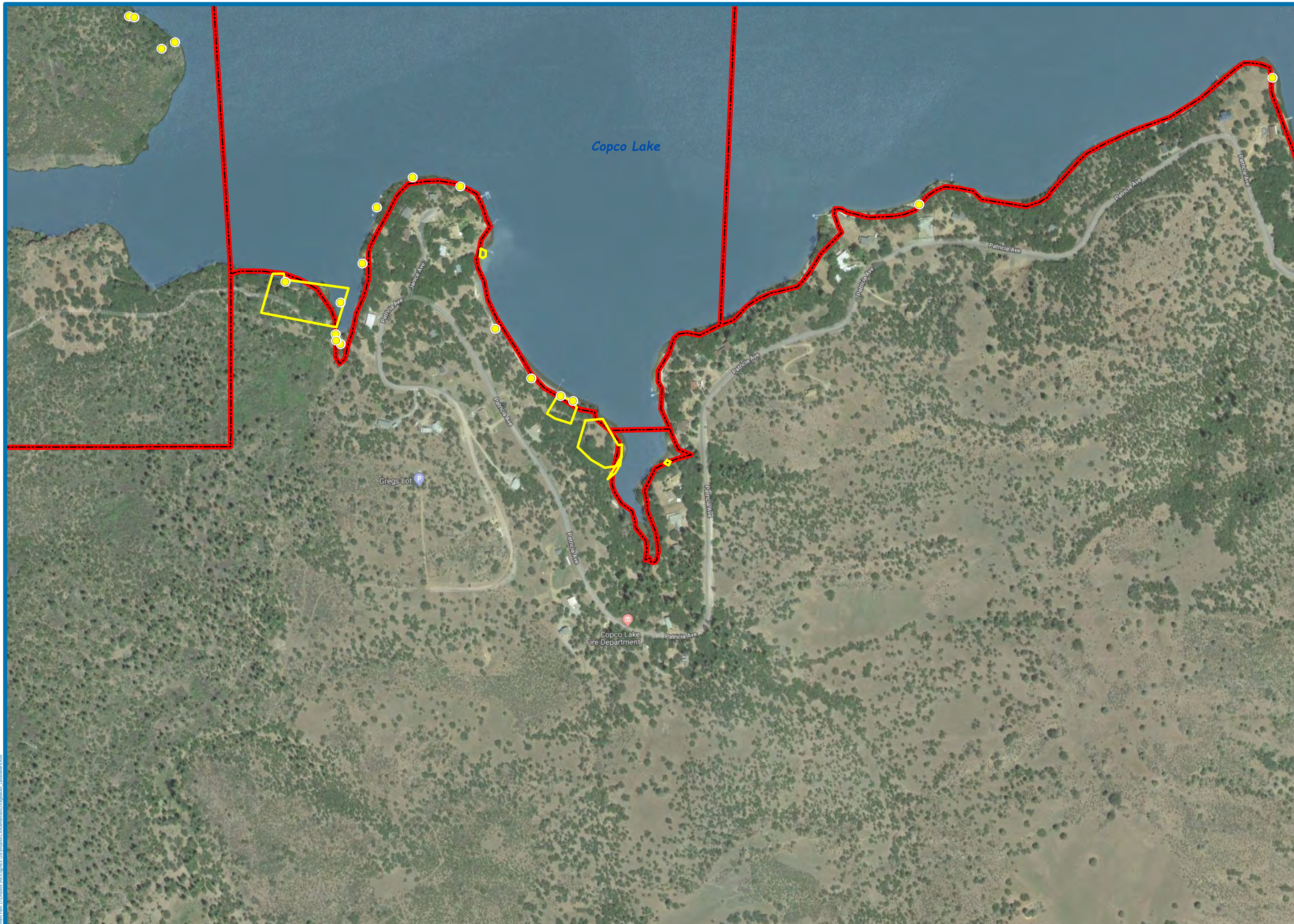

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 15 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 16 of 39

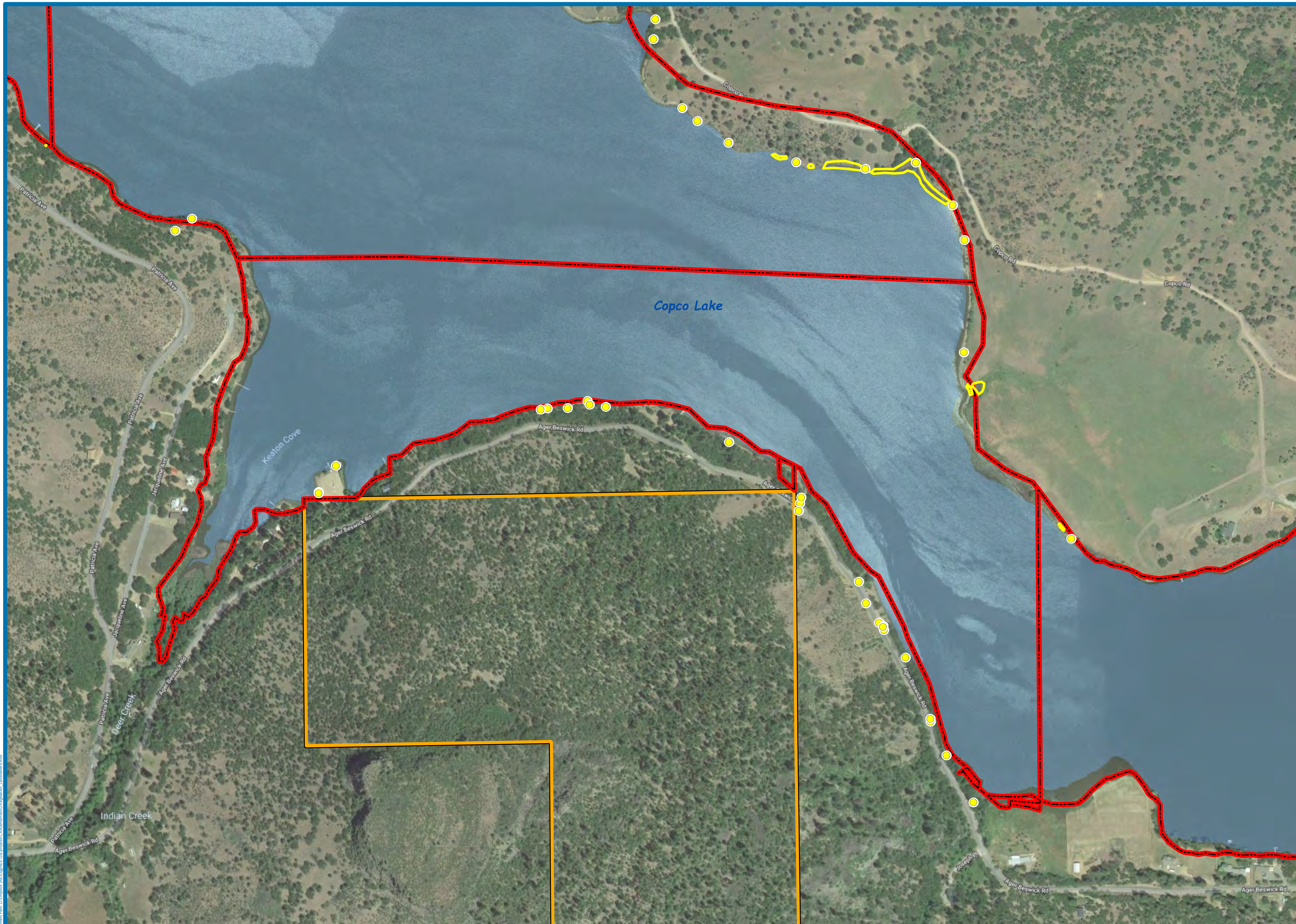
LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

PUBLIC VERSION



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SEED COLLECTION SURVEY

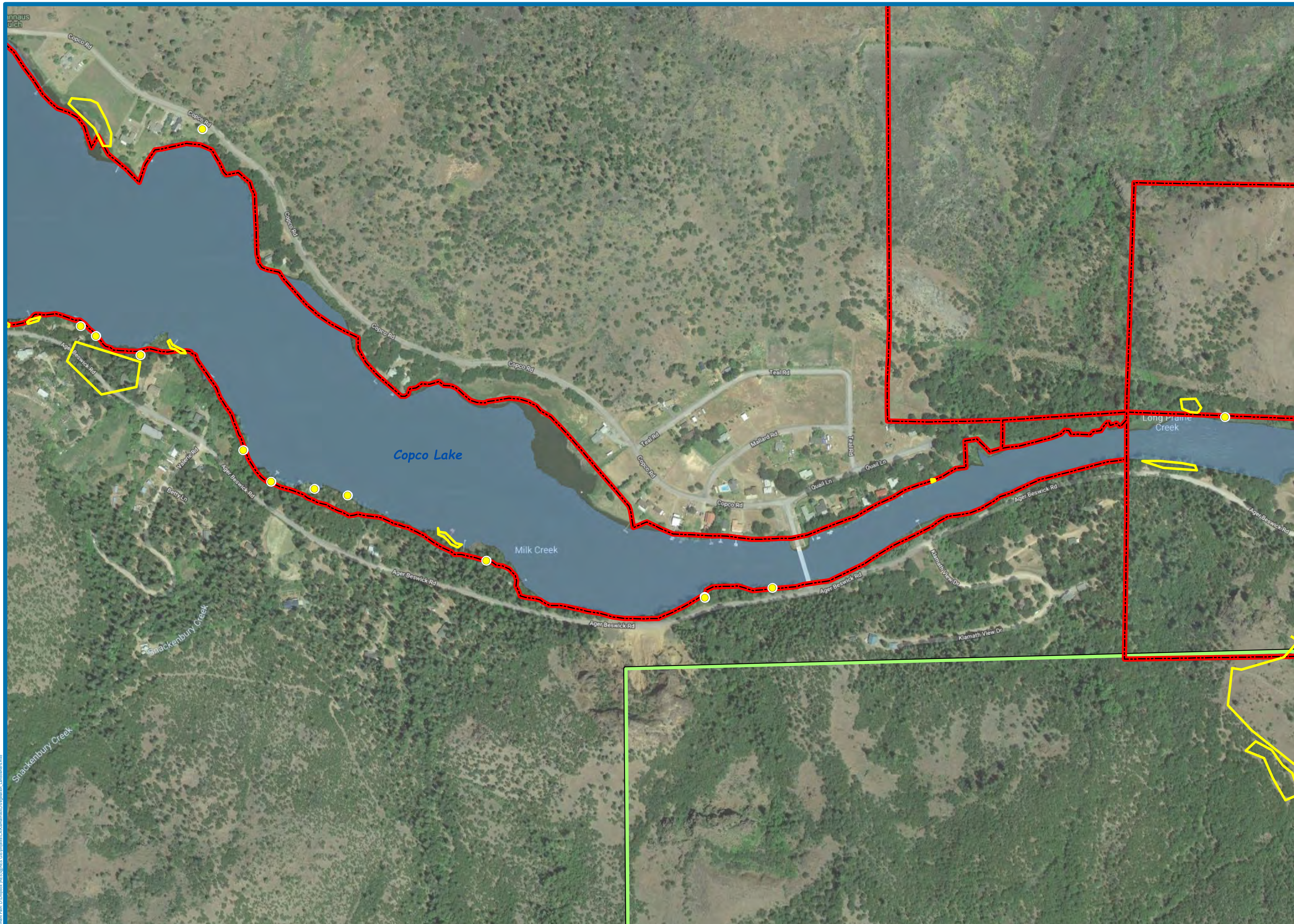
Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 17 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land Management

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM



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SEED COLLECTION SURVEY

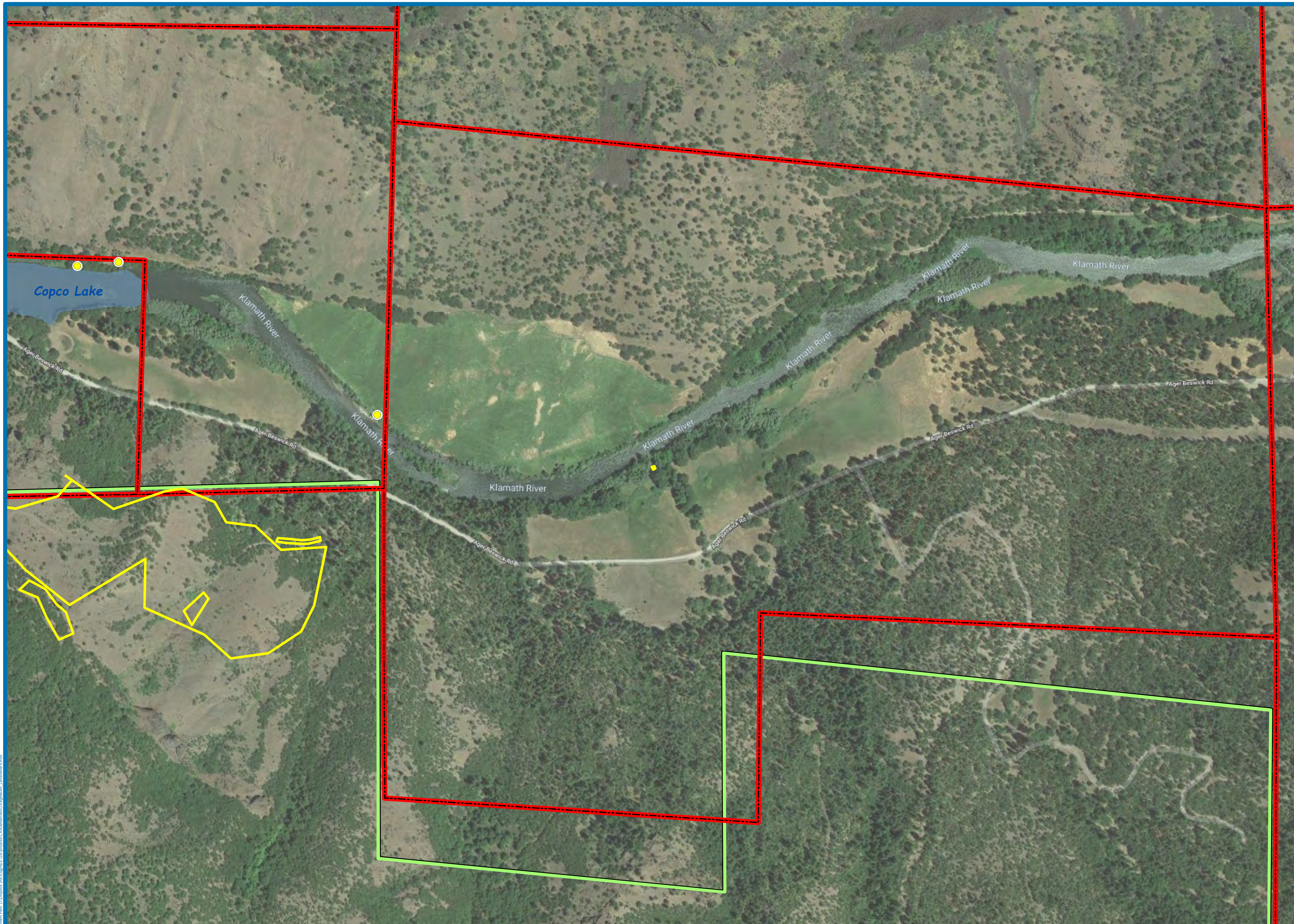
Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 18 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Forest Service

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM



SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 19 of 39

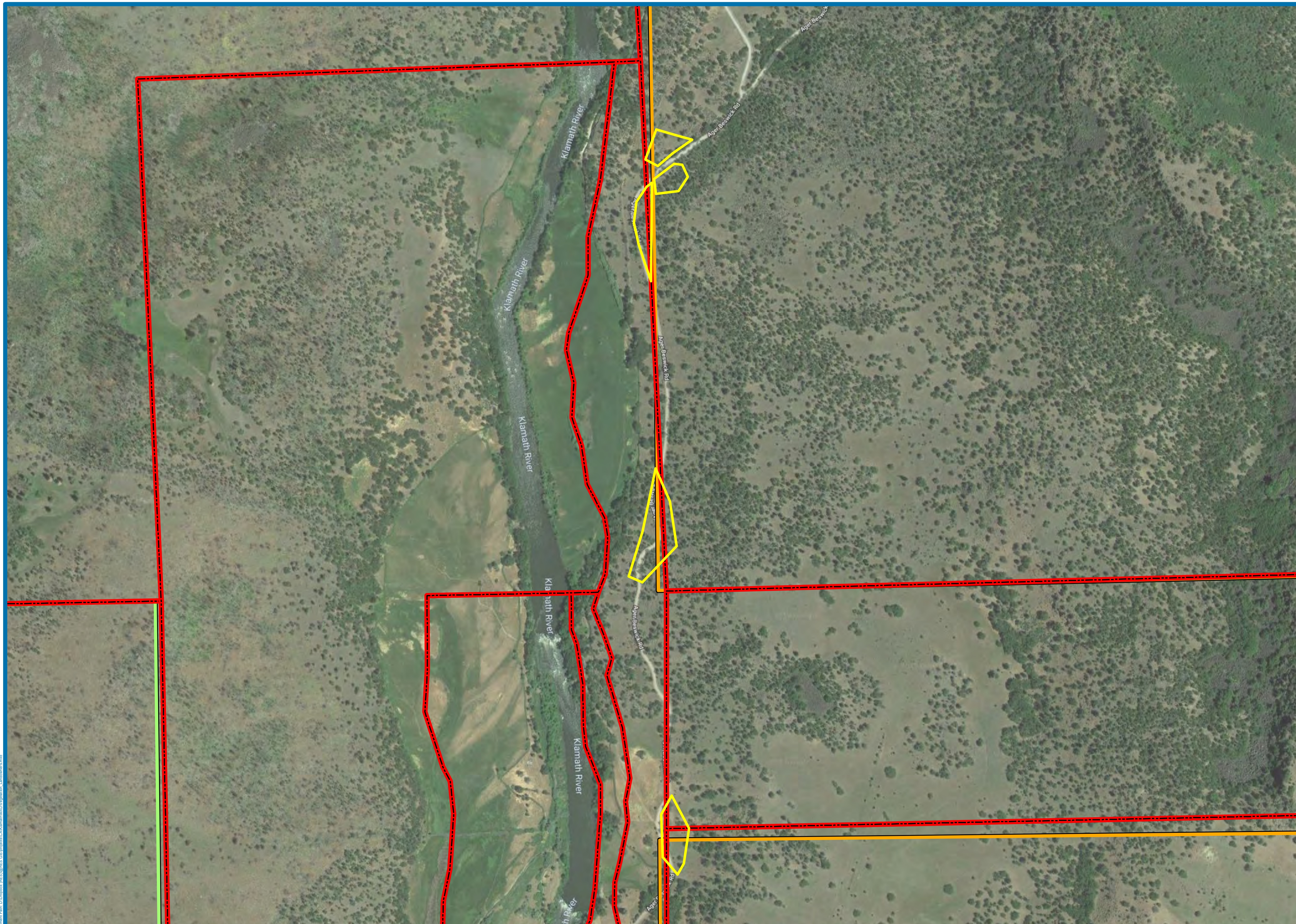
LEGEND

- Seed Collection Point
- Seed Collection
- PacifiCorp Parcels
- Forest Service

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

PUBLIC VERSION



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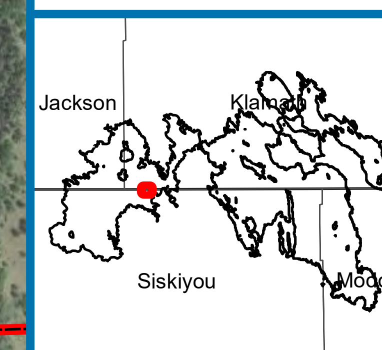
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 20 of 39

LEGEND

- Seed Collection
- PacifiCorp Parcels
- Bureau of Land
- Forest Service



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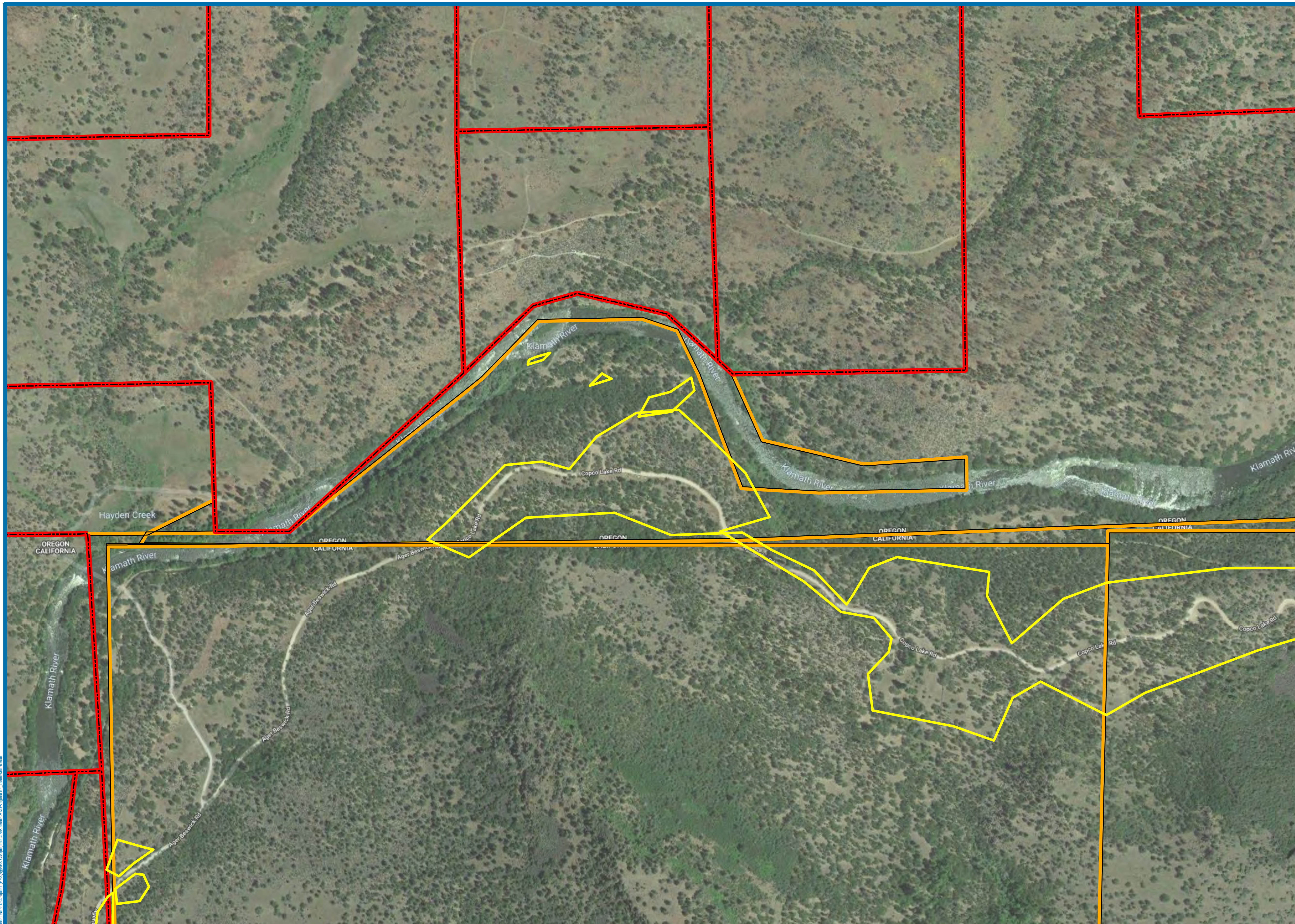
3.) Spatial Data Provided by AECOM



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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 21 of 39

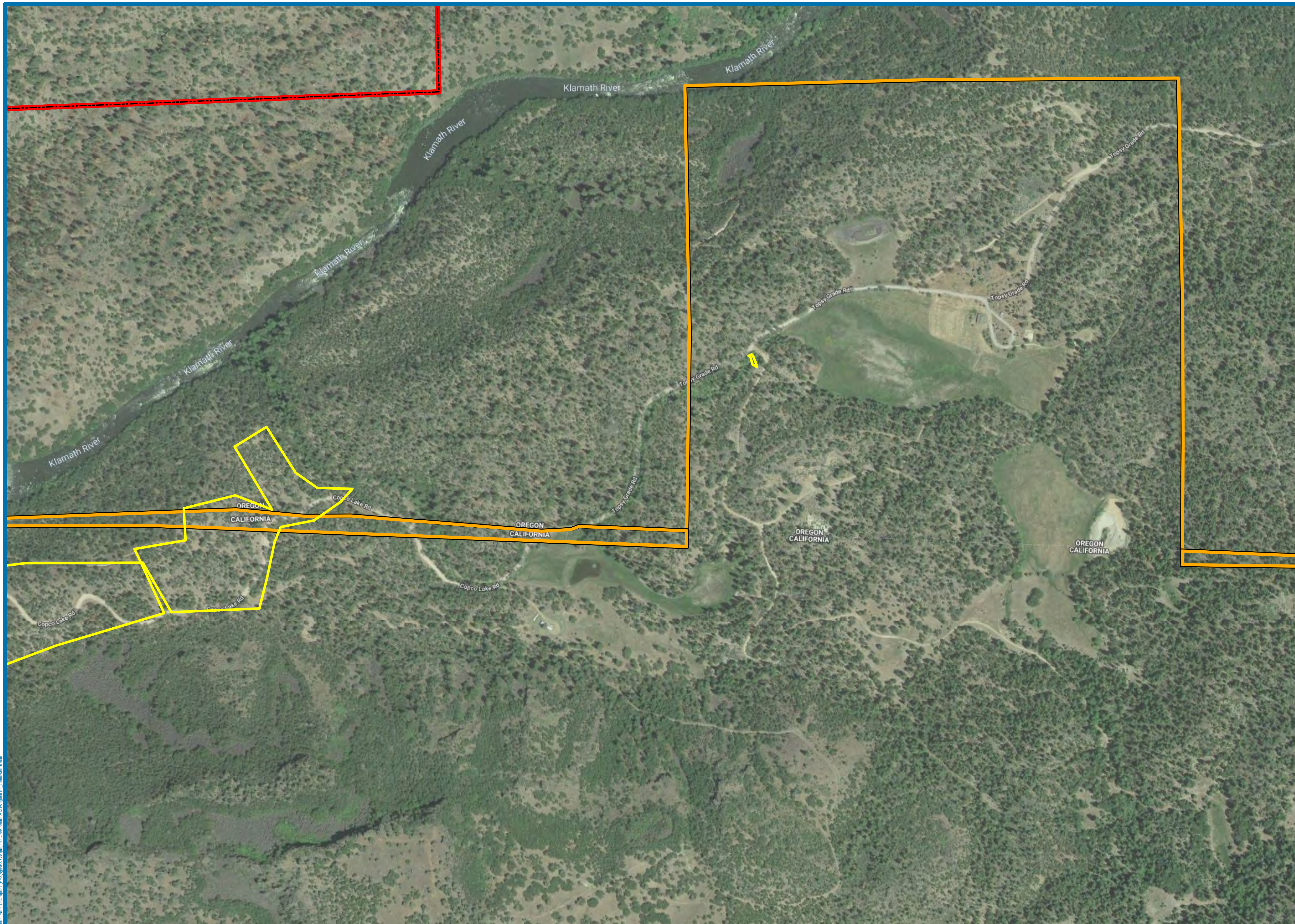
LEGEND

- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

PUBLIC VERSION



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SEED COLLECTION SURVEY

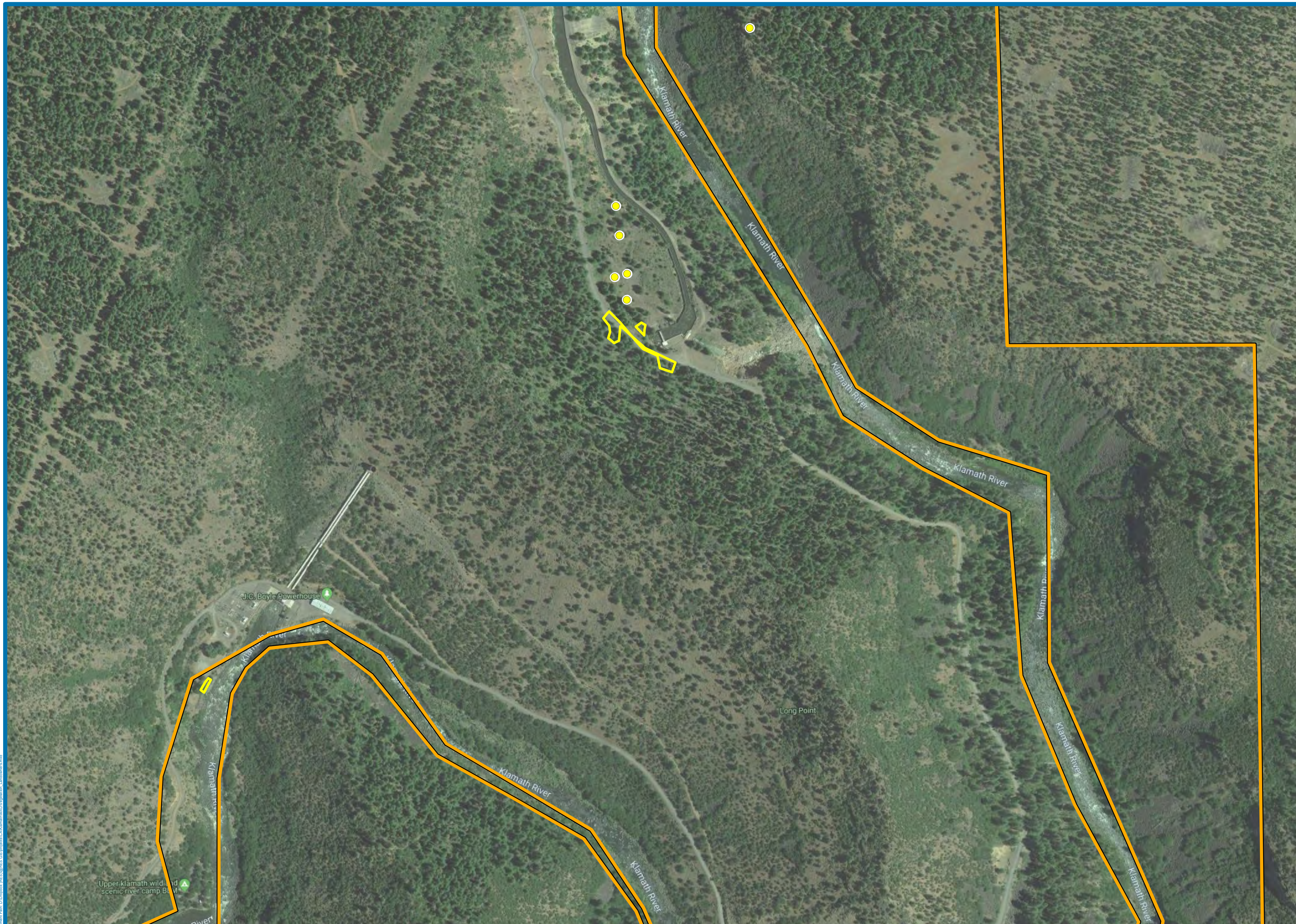
Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 22 of 39

LEGEND

- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM



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SEED COLLECTION SURVEY

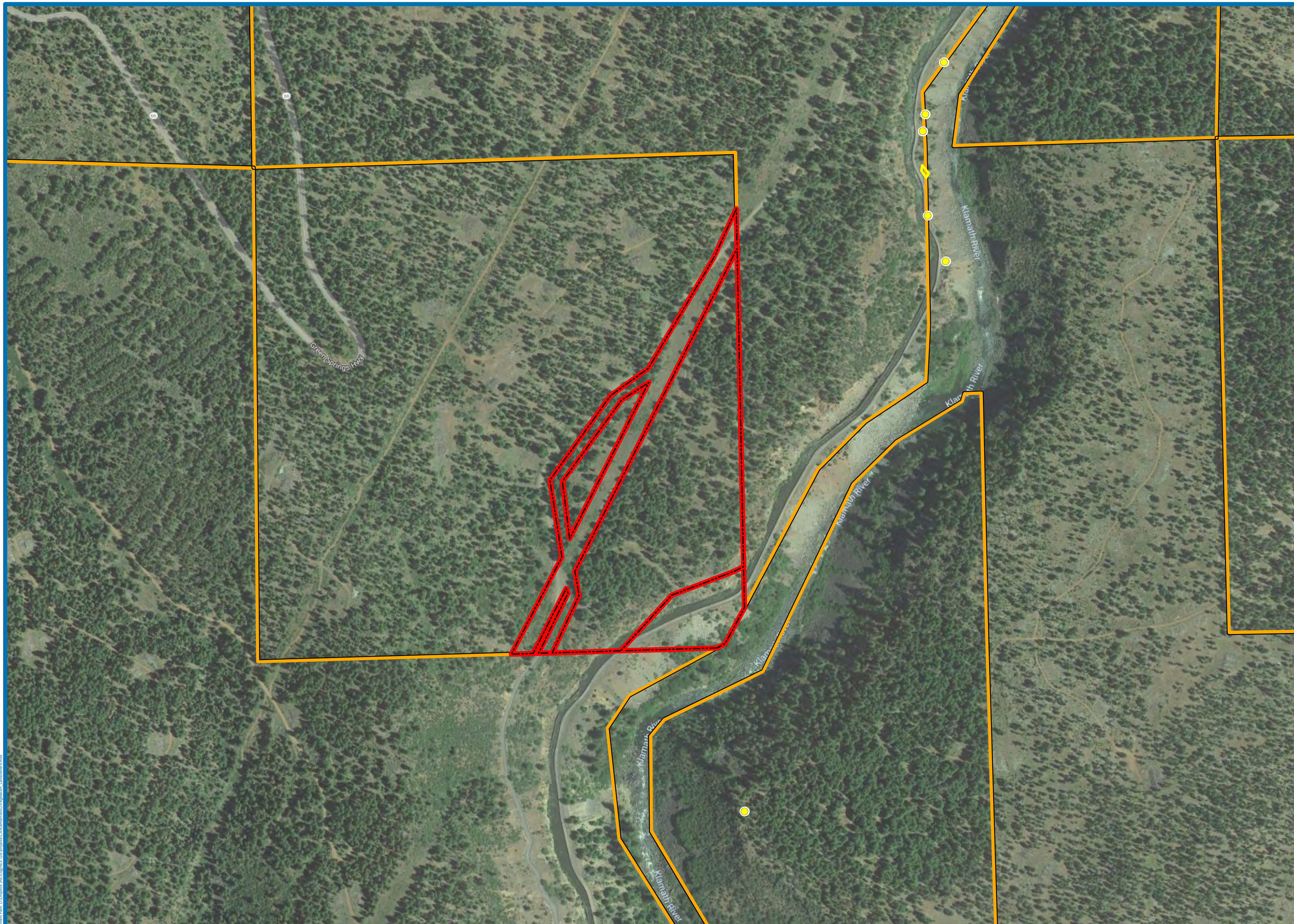
Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 23 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- Bureau of Land

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM



SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 24 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land

REFERENCE

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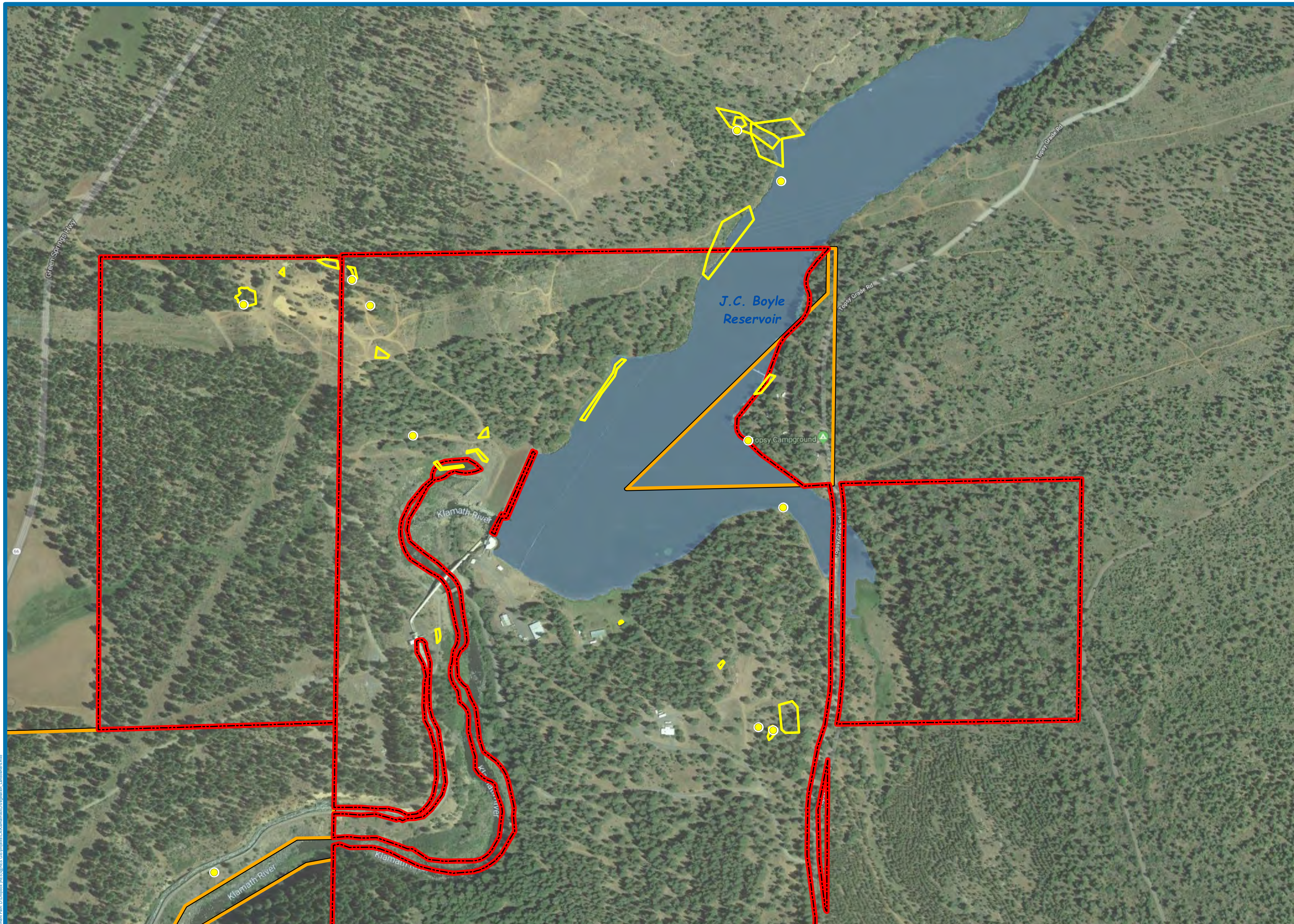
3.) Spatial Data Provided by AECOM

PUBLIC VERSION



SEED COLLECTION SURVEY

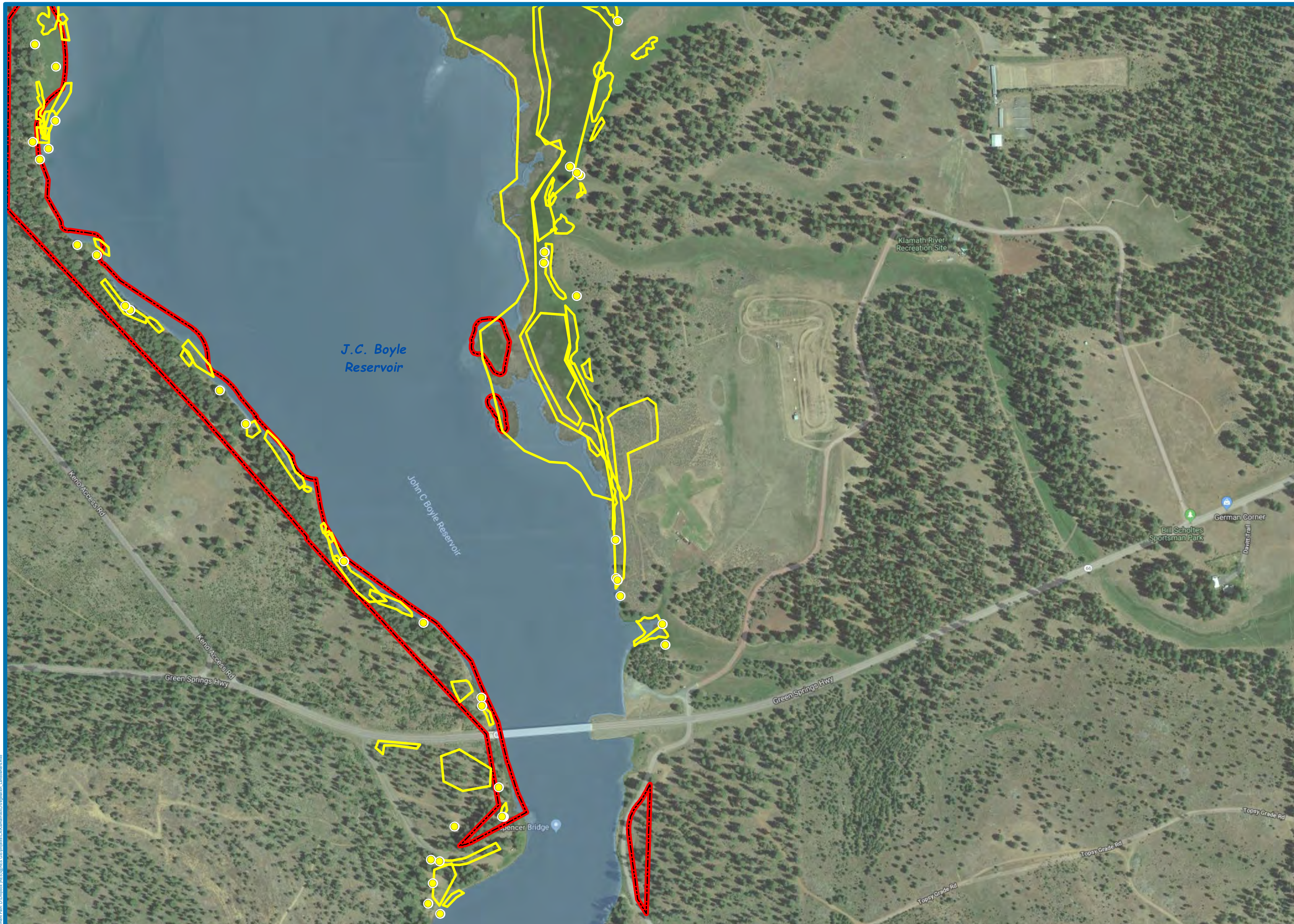
Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 25 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Bureau of Land

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM



SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 26 of 39

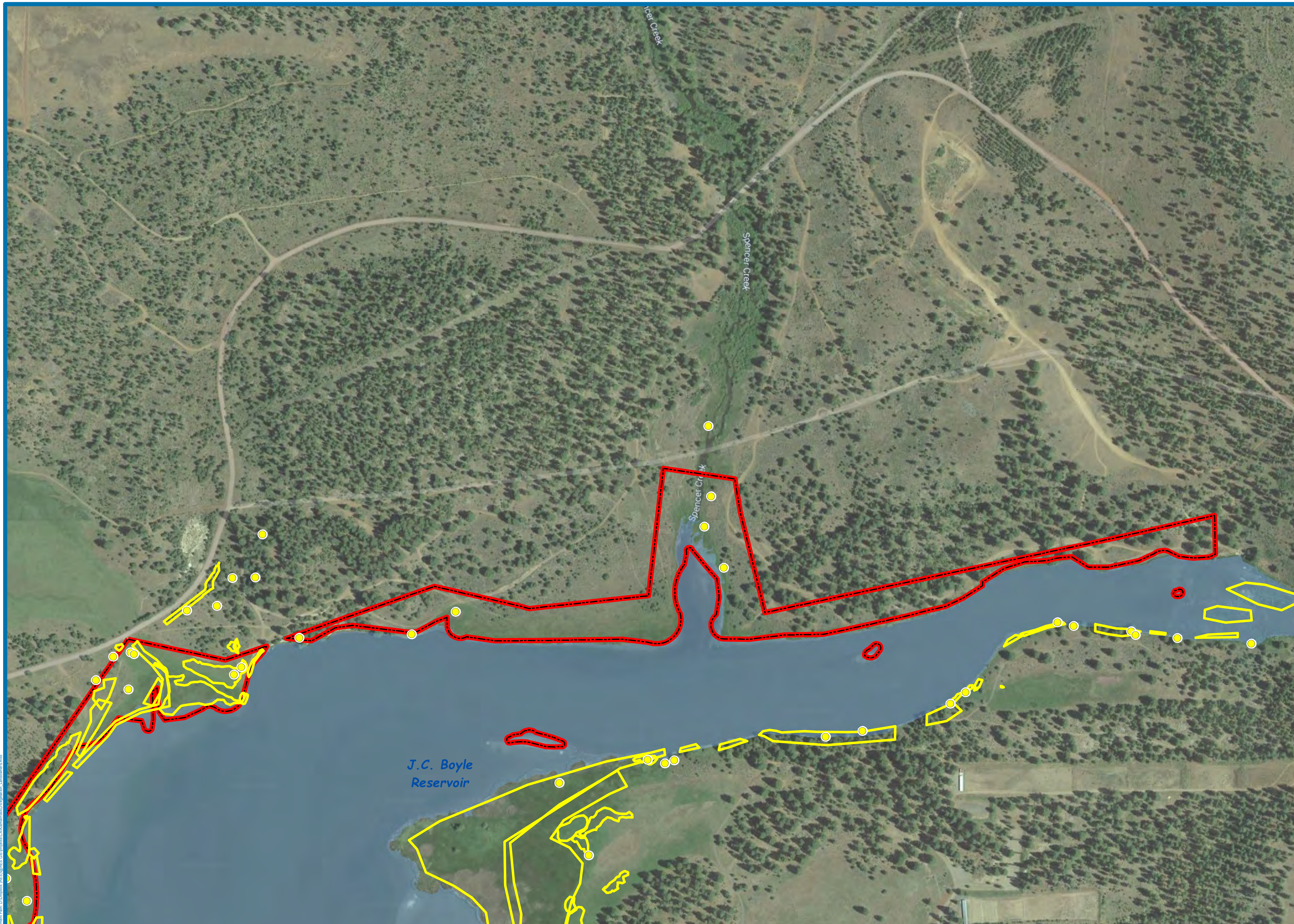
LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels
- Other

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

PUBLIC VERSION



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SEED COLLECTION SURVEY

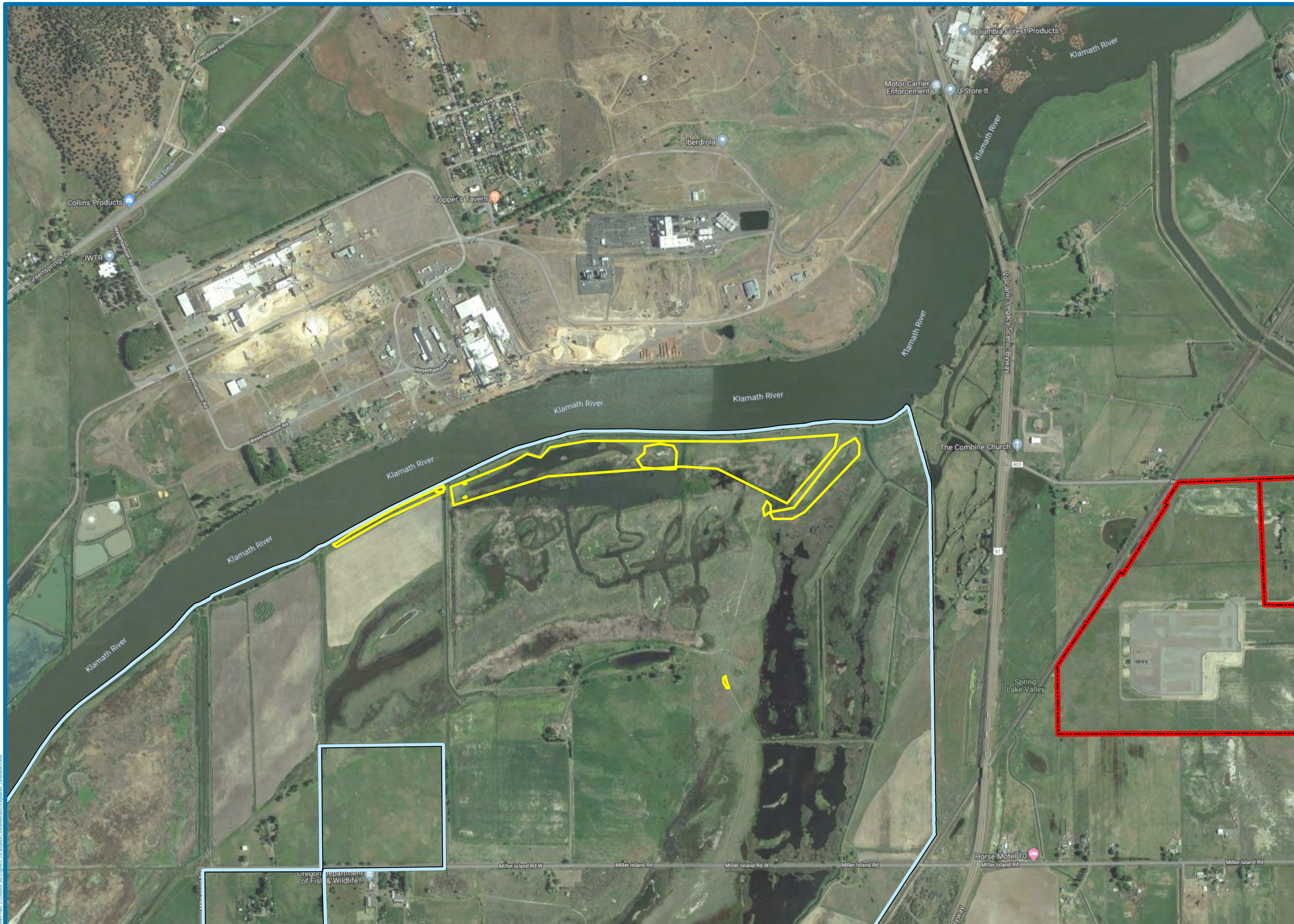
Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 27 of 39

LEGEND

- Seed Collection Point
- Seed Collection Polygon
- PacifiCorp Parcels

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM



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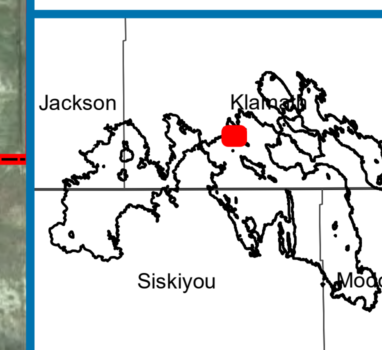
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 28 of 39

LEGEND

- Seed Collection Polygon
- PacifiCorp Parcels
- U.S. Fish & Wildlife Service
- State Fish and Wildlife



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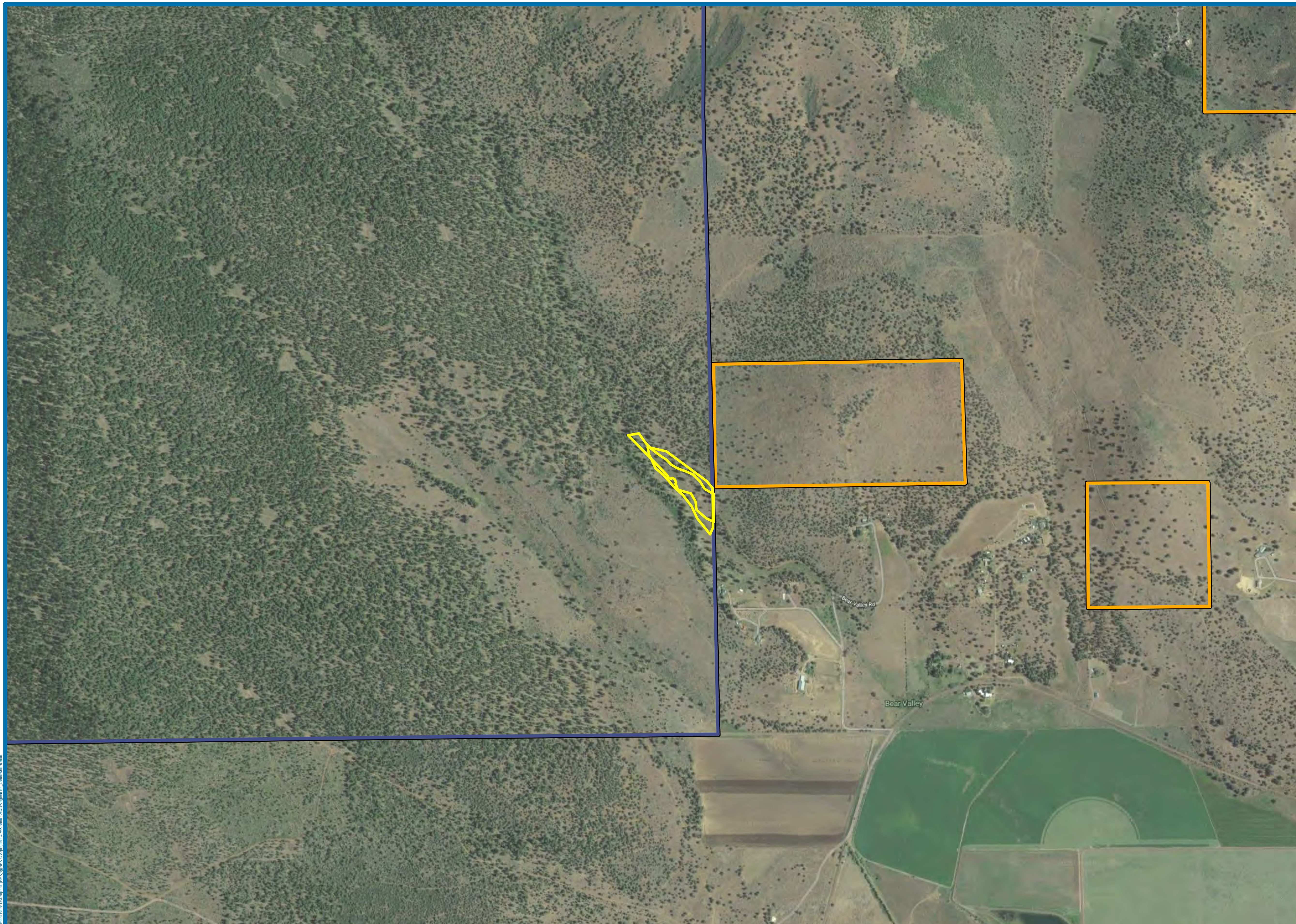
PUBLIC VERSION



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SEED COLLECTION
SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 29 of 39

LEGEND

Seed Collection Polygon
Bureau of Land Management
U.S. Fish & Wildlife Service

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

res

SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 30 of 39

LEGEND

- Seed Collection Polygon
- U.S. Fish & Wildlife Service

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

PUBLIC VERSION

SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 31 of 39

LEGEND

- Seed Collection Polygon
- Bureau of Land
- U.S. Fish & Wildlife

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

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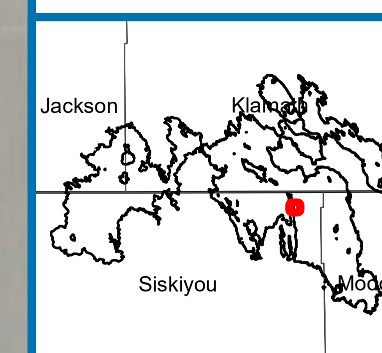
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 32 of 39

LEGEND

- Seed Collection Polygon
- U.S. Fish & Wildlife Service
- State Fish and Wildlife



REFERENCE

1.) Background Image: Google Image Service
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3.) Spatial Data Provided by AECOM

PUBLIC VERSION

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 33 of 39

LEGEND

- Seed Collection Polygon
- U.S. Fish & Wildlife Service

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

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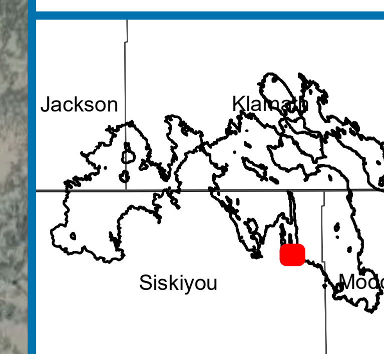
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 34 of 39

LEGEND

- Seed Collection Polygon
- National Park Service
- Forest Service



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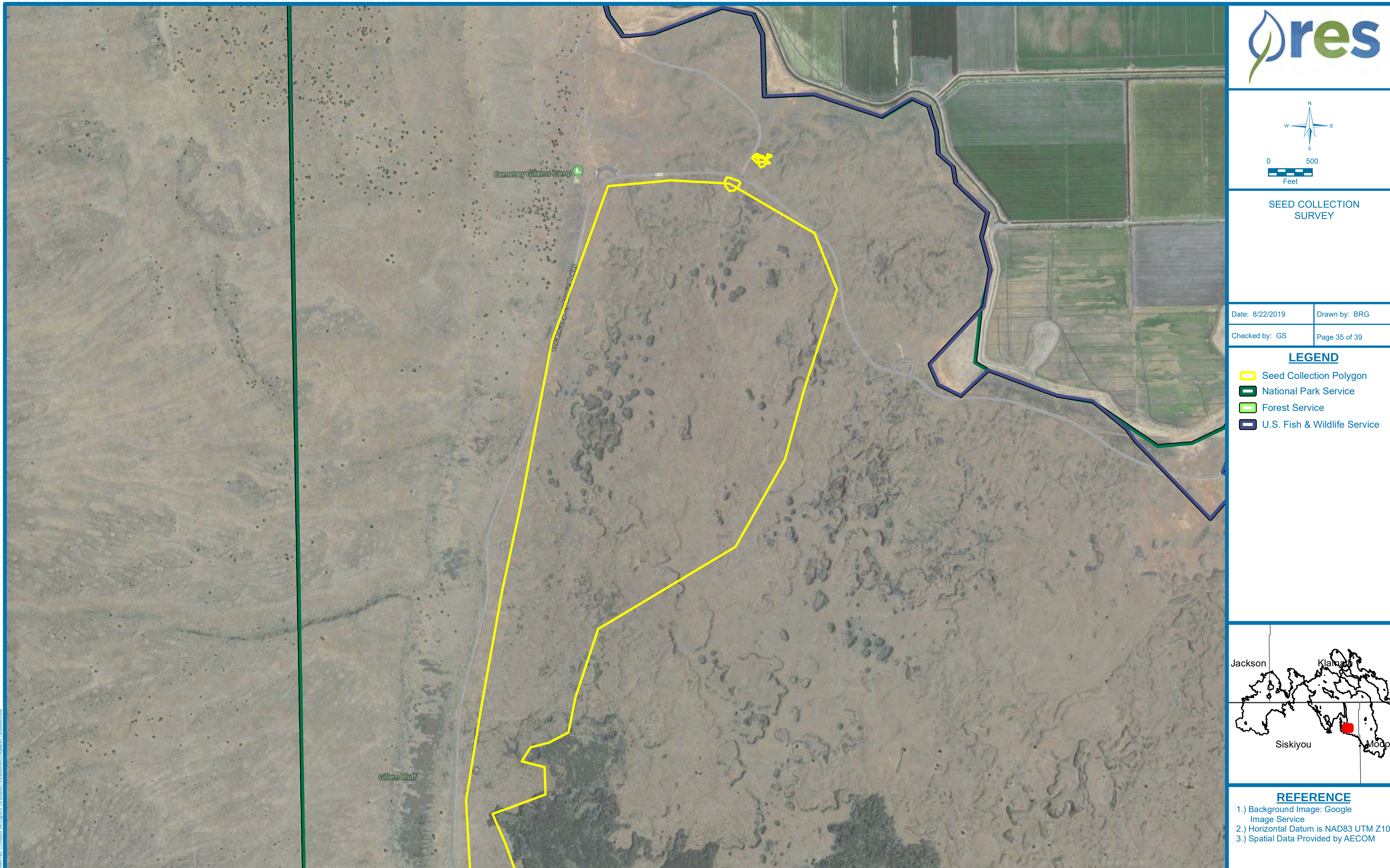

SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 35 of 39

LEGEND

- Seed Collection Polygon
- National Park Service
- Forest Service
- U.S. Fish & Wildlife Service

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

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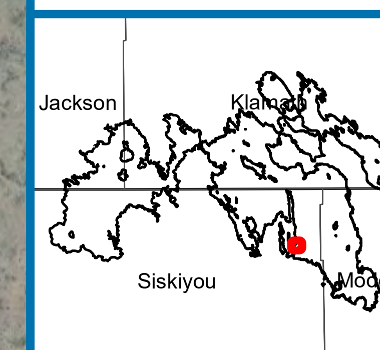
SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 36 of 39

LEGEND

Seed Collection Polygon
National Park Service



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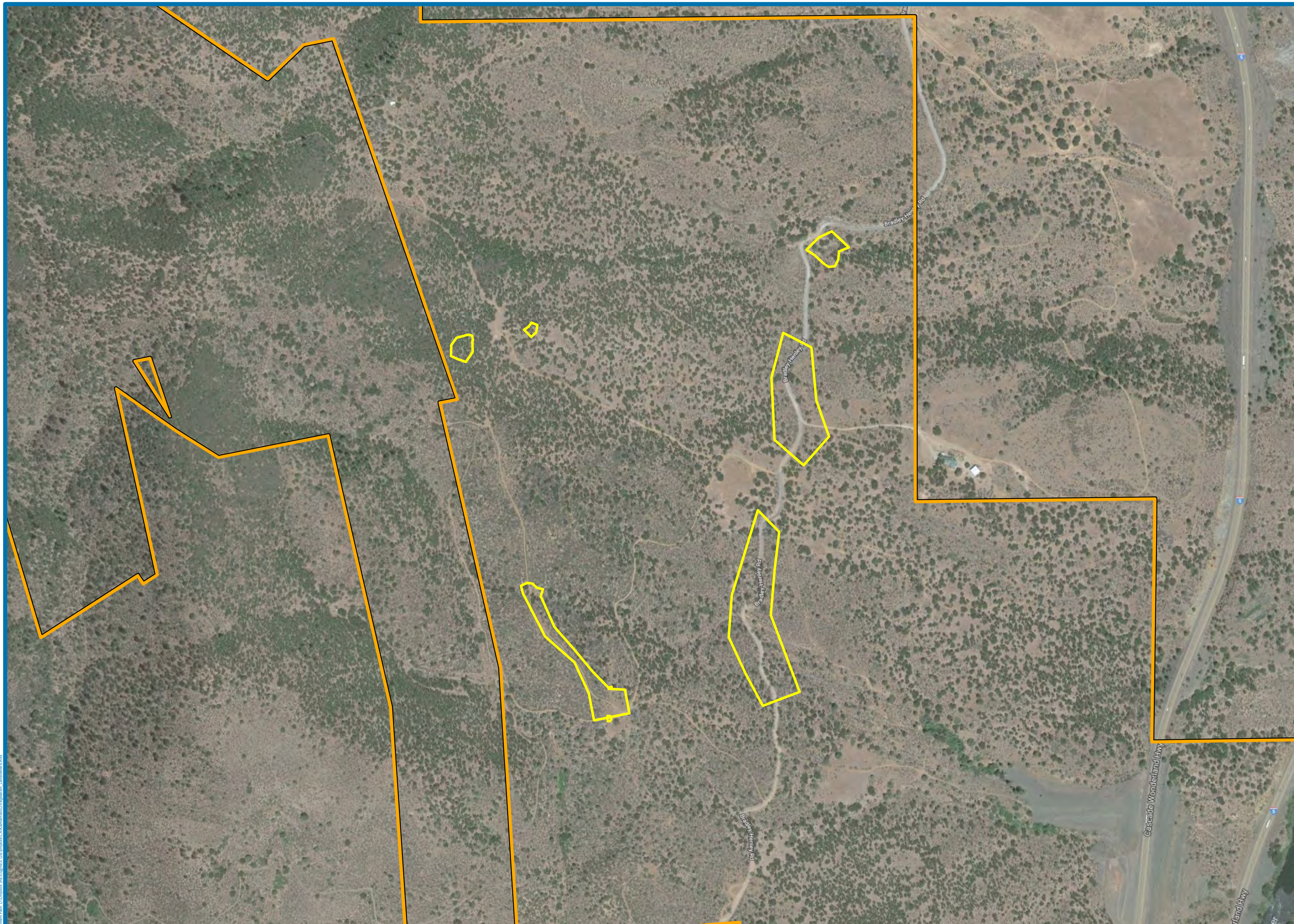

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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 37 of 39

LEGEND

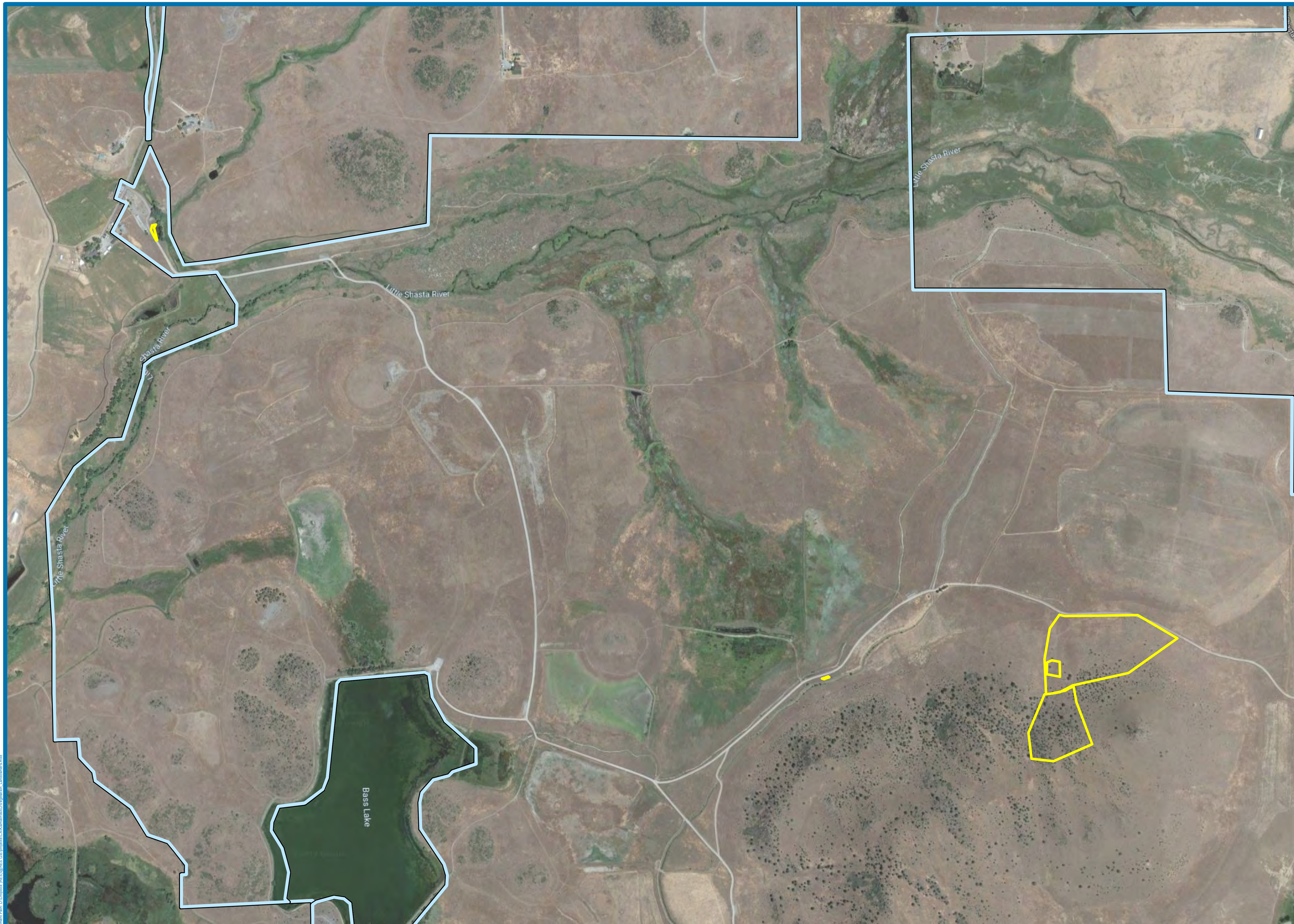
Seed Collection Polygon

Bureau of Land Management

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

PUBLIC VERSION



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SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 38 of 39

LEGEND

- Seed Collection Polygon
- State Fish and Wildlife

Jackson
Klamath
Siskiyou
Modoc

REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

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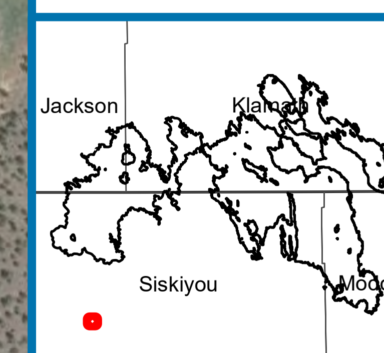
Feet

SEED COLLECTION SURVEY

Date: 8/22/2019	Drawn by: BRG
Checked by: GS	Page 39 of 39

LEGEND

Seed Collection Polygon
Other



REFERENCE

1.) Background Image: Google Image Service
2.) Horizontal Datum is NAD83 UTM Z10N.
3.) Spatial Data Provided by AECOM

APPENDIX K

Seed Collection Data Sheets

(Pages K-1 to K-2)

Native Seed Collection Field Data Sheet

Seed Lot:		**Genus:**	
Date Collected:		**Species:**	
Field Material Weight:		**Common Name:**	
Collection Site :		**Latitude:** (four decimal points)	
State/County:		**Longitude:** (four decimal points)	
Nearest Town:		**Elevation:**	
Nearest Road:		**Collection Radius:**	

Seed Crop Quantity: (circle)	**Risk of Seed Lot Weed Contamination:** (circle)
Heavy Medium Light	High Moderate Low
Seed Crop Timing: (circle)	**Risk of Seed Lot Insect/Fungal Contamination:** (circle)
Early Peak Late	High Moderate Low
Parent Plant Origin: (circle and indicate % ea. to add up to 100%)	**Number of Plants Available for Collection at this Site:** (circle)
Wild Native Vegetation Stand: Previously Planted or 2nd Growth: Seeded Pasture Farm or Field:	<10 10-20 21-50 51-100 101-200 >200
Parent Plant General Abundance: (circle)	**Number of Plants Collected from at this Site:** (circle)
Dominant Abundant Common Uncommon Rare Solitary	<10 10-20 21-50 51-100 101-200 >200
Collection Site Aspect: (circle and indicate % ea. to add up to 100%)	**Coll. Site Habitat:** (circle and indicate % ea. to add up to 100%)
N NE E SE S SW W NW W	aquatic wetland streambank upland hilltop
Collection Site Light: (circle and indicate % ea. to add up to 100%)	**Coll. Site Topography:** (circle and indicate % ea. to add up to 100%)
full sun partial shade shade varies	depression flat lower slope middle slope upper slope variable
Collection Site Soil: (circle and indicate % ea. to add up to 100%)	**Collection Site Geology:** (describe, use add'l space in remarks)
organic clayey silty sandy gravelly rocky varies	
Voucher Specimen: (circle and describe in remarks)	**Photos Taken of:** (circle and describe in remarks)
pressed in ziploc bag other	Collection Area Parent Plants Habitat
Remarks about Vouchers:	**Remarks about Photographs:**
Collector: (pring name)	**Signature:**

Native Seed Storage and Dispatch Data Sheet

Accession Number:		Genus:	
Date Collected:		Species:	
Net Weight:		Common Name:	
Collectinon Site:		Latitude:	
State/County:		Longitude:	
Nearest Town:		Elevation:	

Mean Annual Rainfall:	Mean Annual Days of Frost:
Average Daily Maximum Temperature:	Nearest CIMIS Station:
Average Daily Minimimum Temperature:	Plant Form:
Seedlot Owners:	Collector:
Parent Plant General Abundance: (circle)	Number of Plants Collected from at this Site: (pls, circle)
Dominant Abundant Common Uncommon Rare Solitary	<10 10-20 21-50 51-100 101-200 >200
Collection Site Aspect(s): (circle and indicate % ea. to add up to 100%)	Collection Site Habitat: (circle and indicate % ea. to add up to 100%)
( )=100%	( )=100%
N NE E SE S SW W NW W	aquatic wetland streambank upland hilltop
Collection Site Light: (circle and indicate % ea. to add up to 100%)	Collection Site Topography: (circle and indicate % ea. to add up to 100%)
( )=100%	( )=100%
full sun partial shade shade	depression flat lower slope middle slope upper slope
Collection Site Soil: (circle and indicate % ea. to add up to 100%)	Collection Site Geology: (describe)
( )=100%	
organic clayey silty sandy gravelly rocky	

Storage Summary:

Seeds per lb:		Seed Quality:		
Storage Container:		Pests:		
Storage Location:		Pest Control:		

Germination Test

Date:	Test:	PLS %	Comments:	Tested by:

Dispatch

Date:	Seed Amount out: [lb]	Released by: (type first/last name)	Signature:	Project/Task:	Remaining Stock: [lb]

APPENDIX L

Invasive Exotic Vegetation

(Pages L-1 to L-26)

APPENDIX L - INVASIVE EXOTIC VEGETATION

1.1 INTRODUCTION

Dam removal will create large areas devoid of vegetation, providing opportunities for exotic plant species to colonize and attain dominance. Post-drawdown reservoir footprints are particularly susceptible to invasion by exotic plants. If left unchecked, invasive species establishing in the former reservoir areas will degrade potential salmon habitat by dispersing propagules (seeds, rhizomes) downstream. Managing invasive exotic vegetation will be a concern at all three reservoir areas. Iron gate, and to some extent Copco No. 1, will be particularly challenging with the most aggressive and widespread existing Invasive Exotic Vegetation (IEV) coverage adjacent to the project boundaries. Existing IEV coverage ranges from 16.3 percent at J.C. Boyle, to 18.6 percent at Copco No. 1, to 74.7 percent at Iron Gate. This management plan presents treatment proposals, monitoring goals and a management timeline beginning before dam removal (spring 2020) and extending two years after dam removal (2023). A long-term IEV management and monitoring plan will be developed in 2023 to reflect on-the-ground conditions and lessons learned and will cover the entire LTC period (2023-2028).

The implementation of IEV management will consist of the following basic elements:

1. **Prioritize IEV Species for Treatments**. The initial prioritization offered here is preliminary. Further surveys and changing patterns of IEV on the landscape require an adaptive management approach to prioritization that will be reviewed annually.
2. **IEV Monitoring**. Annual IEV monitoring will consist of two elements: geo-spatial monitoring and plot-based quantitative surveys of treatment effects.
3. **IEV Treatments**. The initial treatment proposals provide here are preliminary. Treatment effects are known to vary by location. Methods and chemicals may change over the course of the project based on data from plot-based surveys of treatment effects.

Management of IEV will be directed through annual reports and plans. These are:

1. **Annual IEV Action Plan**. The Action Plan will be based on the data from previous years and will re-prioritize locations and species and re-assess treatments based on past results. It will also direct monitoring plans (methodologies, locations etc.) for the each growing seasons.
2. **Annual IEV Assessment Report**. The Assessment Reports will summarize all treatments and include locations of treatments, treatment methodology (including chemicals used, quantities, locations etc.) and treatment effects based on plot surveys. It will also summarize location data from the geo-spatial mapping surveys.

The presence of IEV in the lower Klamath River watershed was documented by PacifiCorp in 2002-2003 (PacifiCorp 2004) and then revisited by KRRC biologists in 2017, 2018 (KRRC 2018) and 2019. A prioritized target list of invasive species was developed by KRRC. Tables listing the IEV species found in the study area and their percent cover by species are found in Appendix H of the Definite Plan. AECOM mapped invasive exotic vegetation at each reservoir and mainstem Klamath River. Data primarily from the 2019 AECOM survey were used to identify target species and determine the extent of control efforts during Project activities.

At the J.C. Boyle reservoir uplands, the five most common IEV species include, in order of total acres: cheatgrass, teasel, reed canary grass, medusa head, and yellow star-thistle. Moving downstream, to the Copco No. 1 reservoir, the warmer, drier conditions and surrounding land uses support a different proportion of IEV species with the top five in order of acreage being: yellow star-thistle, medusa head, Himalayan blackberry, reed canary grass, and teasel. The Iron Gate area is most affected by yellow star-thistle, with almost one hundred acres impacted. The top five IEV species at Iron Gate include: yellow star-thistle, medusa head, teasel, cheatgrass, and Himalayan blackberry.

1.2 INVASIVE SPECIES IDENTIFICATION AND PRIORITIZATION

IEV, often referred to as noxious weeds by State and County authorities, are defined as exotic species capable of diverting or arresting native plant succession, damaging or altering essential ecological processes or causing harm to local economies or human health. The KRRC priority list of IEV species identified in the Definite Plan (Table 5-4) was based on a comprehensive review of six sources; California Department of Food and Agriculture's (CPFA) Noxious weed list, California Invasive Plant Council's (Cal-IPC) Plant Inventory, Oregon Department of Agriculture's (ODA) Noxious Weed List, U.S. Forest Service (USFS-KNF), Klamath National Forest Noxious Weed and Non-native Invasive Plant List and County noxious weed lists (Siskiyou, CA and Klamath, OR). The KRRC list was the basis for the final IEV list of target species.

KRRC identified four criteria used to determine IEV priorities. They were IEV species with the greatest potential to "(1) spread quickly, (2) take over extensive areas, (3) compete for resources with native species, and (4) cause any other environmental damage." efforts. The 2018 priority determination was based on the number of agencies ranking each species as a high priority for treatment. Species with at least two high priority ratings from the agencies were ranked as high priority for this project. The IEV priority list from the Definite Plan was updated to reflect 2019 agency ratings (using the six sources identified above). Only four species changed rankings from 2018 to 2019 and are highlighted in Table L-1. Three species had an increase in the number of high priority agency rankings in 2019 and remain a high priority for control. *Dipsacus fullonum* was downgraded to zero agencies with a high priority ranking. However, we will keep this species ranked as a medium priority for the project.

The priority list is not 'final'; it will be adaptively managed through an annual review for each phase of project implementation (pre-dam removal period through implementation and the monitoring period) to ensure the priority list reflects changing federal, state and county priorities and patterns of IEV as they appear on or are removed from the landscape.

Table L-1 Invasive exotic vegetation (IEV) ratings and basis for prioritizing management before, during and after Klamath dam removal. Highlighted rows reflect a change in the number of agencies that ranked it as a highest priority for control from 2018 to 2019.

Scientific Name	Common Name	# of agencies (2018)	# of agencies (2019)	2018 Priority
Chondrilla juncea	skeleton weed	5	5	High
Centaurea diffusa	diffuse knapweed	4	4	High
Centaurea virgata ssp. squar	squarrose knapweed	4	4	High
Euphorbia esula	leafy spurge	4	4	High
Onopordum acanthium	Scotch thistle	4	4	High
Onopordum tauricum	Taurian thistle	2	4	High
Acroptilon repens	Russian knapweed	3	3	High
Carduus acanthoides	plumeless thistle	3	3	High
Carduus nutans	musk thistle	2	3	High
Centaurea stoebe ssp. micr	spotted knapweed	3	3	High
Cytisus scoparius	Scotch broom	3	3	High
Lepidium latifolium	perennial pepperweed	3	3	High
Linaria dalmatica	Dalmatian toadflax	2	3	High
Lythrum salicaria	purple loosestrife	3	3	High
Fallopia japonica	Japanese knotweed	2	2	High
Sonchus arvensis	filed sowthistle	2	2	High
Tamarix parviflora	small-flower tamarisk	2	2	High
Anchus officinalis	Alkanet	1	1	Medium
Bromus madritensis ssp. *rubens*	foxtail brome	1	1	Medium
Bromus tectorum	Cheatgrass	1	1	Medium
Centaurea solstitialis	yellow starthistle	1	1	Medium
Cirsium ochrocentrum	Beaumont thistle	1	1	Medium
Convolvulus arvensis	field bindweed	1	1	Medium
Crupina vulgaris	bearded creeper	1	1	Medium
Dipsacus fullonum	Teasel	1	0	Medium
Elymus caput-medusae	Medusahead	1	1	Medium
Foeniculum vulgare	Fennel	1	1	Medium
Halogeton glomeratus	Saltlover	1	1	Medium
Isatis tinctoria	dyer's woad	1	1	Medium
Linaria vulgaris	butter-and-eggs	1	1	Medium
Phalaris arundinacea	reed canarygrass	1	1	Medium
Rubus armeniacus	Himalayan blackberry	1	1	Medium

Scientific Name	Common Name	# of agencies (2018)	# of agencies (2019)	2018 Priority
Salvia aethiopis	Mediterranean sage	1	1	Medium
Tribulus terrestris	puncture vine	1	1	Medium
Xanthium spinosum	spiny clotbur	1	1	Medium
Aegilops cylindrica	Goatgrass	0	0	Low
Avena barbata	slender oat	0	0	Low
Brassica nigra	black mustard	0	0	Low
Bromus diandrus	ripgut grass	0	0	Low
Cirsium arvense	Canada thistle	0	0	Low
Cirsium vulgare	bull thistle	0	0	Low
Conium maculatum	poison hemlock	0	0	Low
Festuca arundinacea	tall fescue	0	0	Low
Hirschfeldia incana	summer mustard	0	0	Low
Hordeum murinum	foxtail barley	0	0	Low
Hypericum perforatum	St. John's wort	0	0	Low
Lepidium draba	hoary cress	0	0	Low
Leucanthemum vulgare	oxeye daisy	0	0	Low
Marrubium vulgare	white horehound	0	0	Low
Mentha pulegium	Pennyroyal	0	0	Low
Persicaria wallichii	Himalayan knotweed	0	0	Low
Rumex acetosella	common sheep sorrel	0	0	Low
Torilis arvensis	field hedge parsley	0	0	Low

1.3 TREATMENT PRIORITIZATION

The IEV ratings was further evaluated for treatment prioritization by adding two criteria: (1) abundance in the immediate area and (2) control opportunities. Abundance of IEV species was based on the number of GIS point and polygon observations from the AECOM surveys conducted in May 2019. The AECOM 2019 survey recorded 906 observations (442 GIS points and 464 GIS polygons). The data is a preliminary assessment of abundance. Further mapping and adjustments to priorities will be required.

Control opportunities are broken down into 1) eradication and 2) containment (Brusati *et al.* 2011). Eradication is defined as the "complete removal of an infestation, possible where smaller infestations occur isolated from other infestations" (Brusati *et al.* 2011). Opportunity for eradication of a species is considered high if the 2019 observations were low (0-25). Invasive species low in abundance offer the most cost-effective opportunities for successfully eradication prior to dam removal. Species high in abundance (75 or more observations) were rated as having a 'low' opportunity for eradication. Opportunity for eradication of species with observations between 26-74 is considered 'moderate.' Containment is defined as "limiting spread from larger infested areas. Strategic [containment] potential depends on the geography of the infestation, how isolated it is, and the suitability of adjoining areas" (Brusati *et al.* 2011). Our containment ratings are based on the feasibility for the species with high or moderate abundance to be isolated from the newly exposed lands after reservoir drawdown to prevent rapid encroachment. IEV species that were not abundant but are considered a high priority by federal, state and local authorities will be considered the highest priority for control and eradication. Species ranked high or moderate in Table 8.7 are prioritized over species ranked low.

The 2019 survey observed 23 of the 53 possible IEV species within the project area. These 23 species were ranked based on control opportunities (Table L-2a).

Table L-2a. Target IEV species for control before, during and after dam removal.

Scientific Name	Common Name	2018 Priority	2019 total obs	Control Opportunity	
				Eradication	Containment
Onopordum acanthium	Scotch thistle	High	2	High	-
Centaurea diffusa	diffuse knapweed	High	1	High	-
Acroptilon repens	Russian knapweed	High	1	High	-
Linaria dalmatica	Dalmatian toadflax	High	1	High	-
Isatis tinctoria	dyer's woad	Medium	1	High	-
Bromus madritensis ssp. *rubens*	foxtail brome	Medium	4	High	-
Foeniculum vulgare	fennel	Medium	2	High	-
Xanthium spinosum	spiny clotbur	Medium	1	High	-
Rubus armeniacus	Himalayan blackberry	Medium	54	Moderate	Moderate
Bromus tectorum	cheatgrass	Medium	185	Low	High
Centaurea solstitialis	yellow starthistle	Medium	107	Low	High
Dipsacus fullonum	teasel	Medium	161	Low	High
Elymus caput-medusae	medusahead	Medium	96	Low	High
Phalaris arundinacea	reed canarygrass	Medium	100	Low	Low
Low Priority Species					
Brassica nigra	black mustard	Low	4	High	-
Bromus diandrus	ripgut grass	Low	4	High	-
Cirsium arvense	Canada thistle	Low	5	High	-
Conium maculatum	poison hemlock	Low	9	High	-
Festuca arundinacea	tall fescue	Low	9	High	-
Hypericum perforatum	St. John's wort	Low	2	High	-
Lepidium draba	hoary cress	Low	53	Moderate	Low

Scientific Name	Common Name	2018 Priority	2019 total obs	Control Opportunity	
				Eradication	Containment
Cirsium vulgare	bull thistle	Low	93	Low	Low

Eradication opportunities are high for eight high-to-moderate priority species due to the low numbers of observations. Species ranked as having a 'high' opportunity for containment were species located directly above the reservoirs that can be cost-effectively contained by repeat mowing to minimize flowering and seeding before and during reservoir restoration operations. Opportunities to contain species with high abundance along waterways (riverbanks and creeks) are low because propagule dispersal from waterways outside of the project area will continuously impact riparian areas despite localized control efforts. These species will be prioritised for treatment within the reservoir footprints during restoration implementation to minimize invasions and allow native species to obtain dominance. Species that were ranked 'low' priority in Table L-2a will be opportunistically managed based on control opportunities. The 30 species not observed near the project areas in 2019 remain on a 'watch list' with a high opportunity for eradication if they appear in future surveys of the watershed (Table L-2b). For example, they will be removed or contained when encountered during management of other higher priority species.

Table L-2b. Watch list of IEV species not observed in the 2019 AECOM survey that remain a priority for control.

Scientific Name	Common Name	2018 Priority
Centaurea virgata ssp. *squar*	squarrose knapweed	High
Euphorbia esula	leafy spurge	High
Onopordum tauricum	Taurian thistle	High
Carduus acanthoides	plumeless thistle	High
Carduus nutans	musk thistle	High
Centaurea stoebe ssp. micr	spotted knapweed	High
Cytisus scoparius	Scotch broom	High
Lepidium latifolium	perennial pepperweed	High
Lythrum salicaria	purple loosestrife	High
Fallopia japonica	Japanese knotweed	High
Sonchus arvensis	filed sowthistle	High
Tamarix parviflora	small-flower tamarisk	High
Anchus officinalis	alkanet	Medium
Cirsium ochrocentrum	Beaumont thistle	Medium
Convolvulus arvensis	field bindweed	Medium
Crupina vulgaris	bearded creeper	Medium
Halogeton glomeratus	saltlover	Medium
Linaria vulgaris	butter-and-eggs	Medium
Salvia aethiopis	Mediterranean sage	Medium

Scientific Name	Common Name	2018 Priority
Tribulus terrestris	puncture vine	Medium
Aegilops cylindrica	goatgrass	Low
Avena barbata	slender oat	Low
Hirschfeldia incana	summer mustard	Low
Hordeum murinum	foxtail barley	Low
Leucanthemum vulgare	oxeye daisy	Low
Marrubium vulgare	white horehound	Low
Mentha pulegium	pennyroyal	Low
Persicaria wallichii	Himalayan knotweed	Low
Rumex acetosella	common sheep sorrel	Low
Torilis arvensis	field hedge parsley	Low

1.4 IEV CONTROL

IEV treatment will begin during pre-drawdown site preparation activities (early spring 2020), continue through demolition, and extend two to three years post-drawdown and into the monitoring period. Although total eradication or prevention of IEV in the reservoirs is not possible, the strategy will be to minimize IEV presence during the crucial plant establishment phase, providing desirable native vegetation a competitive advantage for several years. Control of IEV will extend for five years after 2023 and treatment methods for that period will be defined in the long-term IEV management plan

Strategies for controlling IEV will differ for each revegetation period. Prior to dam removal, beginning in the spring of 2020, restoration staff will work at the watershed scale to eradicate and contain established populations to limit the opportunity for propagules to disperse into the dewatered reservoirs (Von Holle and Simberloff 2005). Highest priority sites for IEV control will be the future access points and staging areas. We will establish a 50-100-ft buffer around all future staging areas. This buffer will be eradicated of all IEV species and maintained IEV-free during the lifespan of these temporary access sites. During demolition, work at the watershed scale will continue but the priority will shift to evaluating and eradicating pioneering populations of IEV in the newly exposed areas. After dam removal, efforts will focus on preventing introductions of IEV by initiating an Early Detection and Rapid Response (EDRR) program in the exposed reservoirs. Eradicating pioneering populations within the reservoirs will be the highest priority during and after dam removal (Moody and Mack 1988). Preventing inadvertent introductions of IEV can be achieved by focusing management around roads and access points to the reservoirs. New trails and roads established in the dewatered reservoirs will be major pathways for moving invasive plants (seeds/roots). Therefore, we will maintain a 50-foot buffer free of IEV around access trails and roads during and after dam demolition.

Control efforts will begin in the early spring of 2020. Mowing is considered an effective containment strategy for the most abundant IEV species (*Bromus tectorum, Centaurea solstitialis, Dipsacus follunum* and *Elymus caput-medusae*) (DiTomaso *et al.* 2013). For this to be effective, mowing must be repeated 2-3 times during the growing season for three or more years to be effective (DiTomaso *et al.* 2013). A buffer of 50-100 ft mowed regularly should prevent seed dispersal into the reservoirs after drawdown because these species all disperse seed short distances in the wind (DiTomaso *et al.* 2013). Wildlife will disperse seed long distances from the unmanaged areas into fenced and unfenced exposed reservoir areas by tracking seed on their hooves and paws. The EDRR program will be designed to eradicate IEV populations originating from seed tracked into the area.

1.4.1 PROPOSED CONTROL METHODS

We will employ a variety of methods to control IEV species. Invasive exotic vegetation identified in the project area were individually evaluated to determine effective control methods using federal, state and local recommendations (i.e. California Invasive Plant Council Management guidelines). The following control methods are proposed to be utilized for invasive exotic vegetation control:

1. Grubbing (hand pulling) is effective for controlling small IEV infestations, emerging infestations or infestations at the fringes of a large patch. Grubbing (hand pulling) is typically more effective on annual species and species that are not rhizomatous but can be used for perennial species if the populations are small and/or young. Grubbing will be done with hand tools such as Pulaskis, shovels or other digging tools. Efforts will be made to minimize soil disturbance when possible. Large patches of *Rubus armeniacus* may be grubbed using large equipment (i.e. excavators) during construction activities when possible.

2. Mowing or cutting (using weed trimmers, mowers) for invasive annuals will be employed as a containment strategy to reduce seed production in biennials and perennials, exhaust the nutrient reserves, and reduce plant vigor, as well as decrease the buildup of thatch. This method will only be employed in areas with extensive, near-monoculture stands of IEV to avoid mowing native species. The time of year is important when implementing these techniques and depending on the target species treatments should be carried out to allow native species to be the first to re-sprout after a mowing event. Species targeted for this method include yellow starthistle, medusahead and other early spring herbaceous IEV that are abundant along the rim of the reservoirs, particularly Iron Gate. Mowing will be accomplished primarily with string trimmers. Large rocks, steep terrain and other features on the landscape preclude the effective use of tractor-based mowers. Trimmers can handle the terrain better and presents less risk of sparking wildfire. Trimmers will also allow for the preservation of important native species such as *Lupinus argenteus* and woody shrubs within the mowed area, providing residual vegetation capable of seeding into the mowed areas.

3. Solarization may be used only in areas where there are small patches of invasive vegetation (i.e. reed canarygrass). Solarization will be accomplished using thick, non-translucent black plastic or other heavy duty weed fabric capable of smothering a population and blocking all sunlight.

4. Herbicides will be used for species that are not suited to mechanical removal techniques. Only herbicides that have been approved for use by the BLM, California Department of Fish

and Wildlife (CDFW), Oregon Department of Fish and Wildlife (ODFW), Regional Water Quality Control Board (RWQCB), US Fish and Wildlife Service (USFWS) and NMFS in both California and Oregon and the KRRC and Native American Tribes will be considered. Herbicides are applied in fall, winter, and early spring, and are rotated when possible to reduce herbicide resistance. Spot spraying, the primary method we will employ on this project, is used for species-specific control. All herbicides are applied according to label specifications and by a California Licensed Qualified Applicator and approved by the EPA.

Additional IEV control methods that may be employed include:

5. Tilling and disking is an agricultural weed eradication method in solid stands of invasive species, in order to disrupt and bury the plant or to separate the root from the plant after soil dries out to have the largest impact. This method will be employed only in level heavily infested areas where erosion is not a concern and culturally significant resources are not expected. If used, seeding of pioneer as well as native species will follow the tilling/disc event to promote native growth to outcompete the invasive species. This method will be best employed on areas outside the reservoirs that are impacted by deconstruction activities.
6. Grazing may be used for control of invasive vegetation palatable for cattle, sheep and goats and the timing, quantity and will select the type of livestock to address different invasive species.

1.4.2 DISPOSAL

Dispose of all IEV removed from the Project site in accordance with all federal, state, and local law.

1.4.3 BEST MANAGEMENT PRACTICES

The following methods will be employed to stop the spread of invasive species during removal efforts:

- Maintain 50 ft wide buffer free of IEV species around access roads and trails.
- Thoroughly clean clothing and gear following site visits.
- Check clothing and gear for soil, seeds, and plant materials.
- Inspect and clean equipment upon entering and exiting the project site.
- Inspect and clean vehicles upon entering and exiting the project site.
- Train staff, including contractors, on weed identification and methods to avoid the unintentional spread of invasive plants.
- Manage vegetation using methods that reduce the spread of invasive species and encourage desirable vegetation.

1.4.4 HERBICIDE APPLICATION

Herbicide will only be used to control species not suited to mechanical removal methods. Application timing and locations will be designed to minimize chemical contamination of waterways. When necessary, populations that are close to water will be treated with AquaNeat, the only herbicide identified for use on IEV near water. AquaNeat is an herbicide designed for use in aquatic environments and is approved by the EPA for use in or near water.

All herbicides proposed will be approved for use by the BLM, California Department of Fish and Wildlife (CDFW), Oregon Department of Fish and Wildlife (ODFW), Regional Water Quality Control Board (RWQCB), U.S. Fish and Wildlife Service (USFWS) and NMFS in both California and Oregon. Herbicides that are approved for use will be applied using ground crews and backpack sprayers. Foliar and stump-cut treatments will be the primary method of application. No helicopter or other mechanical sprayers will be used on the project. A detailed herbicide application log will be completed for all applications and submitted annually to project management. The log will include product and rate of application, weather conditions, applicator name, date and location of treatments. All IEV crew leaders will be certified to apply herbicides in Oregon and California and will always be on-site during herbicide use. Certification will be in the category of herbicide applications related to the project including but not limited to aquatic, forestry, and right-of-way. All IEV crew members will be trained in proper species identification to ensure target species are not mis-identified.

1.4.4.1 HERBICIDES RECOMMENDED FOR TREATMENT

Table L-3 provides a preliminary list of herbicides recommended for treatment. This list is not comprehensive. As new information becomes available on recommended treatment, additional herbicides may be added. Any new herbicides and/or surfactants proposed will be provided to the pertinent agencies prior to use.

Glyphosate is generally only effective for the season it is applied for perennial or woody species, and it is non-selective, affecting all vegetation in the area of treatment. This can create significant bare ground for new weeds to colonize. Application of this herbicide will be formulated to minimize impacts to native plants and will be mostly employed as a spot treatment for small populations.

Bare ground that is created by all herbicide use will be seeded and/or planted with native species within a year.

Table L-3. Herbicide recommended for treatment.

Herbicide	Brand Names
Glyophosate	Roundup®, Roundup Pro®, AquaNeat®
Aminopyralid	Milestone®
Chlorosulfuron	Telar®
Aminocyclopyachlor + cholsulfuron	Perspective®
Triclopyr	Garlon 3A®
Imazapyr	Habitat®, Arsenal ®, Stalker®, others
Dicamba	Banvel®, Clarity®

1.4.5 ANNUAL IEV ACTION PLAN.

The annual IEV Action Plan will outline priority species, site priorities and treatments to be employed. The plan will utilize data from previous years to re-assess priorities and methodologies. The IEV Action Plan will also outline monitoring plans (methodologies, locations etc.) for the growing season.

1.5 IEV MONITORING

Restoration staff will follow the guidelines for monitoring and evaluating invasive species outlined by Morse *et al.* 2004. Monitoring for IEV species in the project areas and within the reservoir footprint will be accomplished by conducting on-the-ground annual IEV surveys by trained botanists. The survey crews will produce comprehensive GIS maps of all IEV locations that will be used to formulate management strategies and to inform federal, state and local agencies. In addition to these targeted surveys, other restoration implementation crews will be trained to identify all IEV species common in the lower Klamath Region. As crews work and travel in the dewatered reservoirs, they will be capable of identifying colonizing IEV species.

1.5.1 GEO-SPATIAL SURVEYS

Geo-spatial surveys of IEV species will be conducted on foot using hand-held GPS devices in areas surrounding the reservoirs and within the reservoir footprints. Surveying the landscape on foot is a more reliable method compared to remote or drone-based surveys. Remote surveys are better for general patterns and locations but are not effective at detecting small or young populations of IEV. Small IEV populations are the highest priority to treat because detecting young, nascent foci of IEV presents a significant opportunity for eradication. Data dictionaries will be developed for the handheld GPS units to direct proper data collection and simplify data analysis later. Data from field GPS units will downloaded and mapped in ARCGIS.

The first survey of the project lands will be conducted in the spring and summer of 2020. The AECOM survey from 2019 was a preliminary effort to determine IEV abundance but was not meant to detect all possible IEV locations. The 2020 survey will build on the 2019 survey to better understand IEV abundance and adapt management actions accordingly. The survey will be repeated in 2021. Beginning in 2022, surveys will prioritize mapping IEV locations within the reservoir footprints.

1.5.2 PLOT-BASED TREATMENT SURVEYS

Quantitative surveys will also be conducted to determine the effectiveness of IEV management techniques. Plots will be surveyed prior to 2020 treatments and re-surveyed again post-treatment in the fall of 2020, spring of 2021 and again after 2021 treatments and repeated annually as needed. Survey methods are still being developed and will be finalized by spring 2020.

1.5.3 EARLY DETECTION AND RAPID RESPONSE

An Early Detection and Rapid Response (EDRR) program will be employed to minimize the establishment of IEV species in the reservoir footprints after dam removal. Dam removal will expose a landscape devoid of vegetation. Some wetland/riparian IEV species are likely to have viable seed in the sediments (i.e. reed canarygrass, common teasel) and will germinate *in situ*. Other species may arrive on wildlife or through wind dispersal. The first two-year period is a critical time for controlling new arrivals as seedlings are much easier to control than established plants. The EDRR program will consist of the following elements:

- Reservoir footprints will be thoroughly surveyed annually on the ground with GIS units beginning in late April/early May from 2022-2028. Further mapping may be needed and will be determined in the 2023 IEV management and monitoring plan.
- Populations will be mapped and immediately removed mechanically while seedlings are small. If populations are vast, herbicides may be used.
- All crews will be trained to identify IEV species in their seedling forms. Seedling morphology is often different than mature plants.
- All restoration staff, including dam removal contractors, fisheries biologists, etc. will be educated in the EDRR program to add to the monitoring efforts.
- Educational flyers on high priority IEV species will be produced and distributed to staff and the public. Flyers will include contact information to ensure prompt reporting to revegetation management.
- Disposal units (i.e. garbage cans) for mechanically removed IEV will be well labeled and placed at all staging areas to facilitate and encourage removal by all project staff.
- Maps will be produced annually, and patterns of infestations will be assessed to inform adaptive management. Seed sources outside of the project area may need additional control efforts based on infestation patterns.

1.5.4 ANNUAL IEV ASSESSMENT REPORT

An IEV Assessment Report will be produced annually to report actions taken to control IEV, plot surveys and methodology and results from all IEV mapping. This report will be used to direct adaptive management of IEV and provide project management with an annual progress report.

1.5.5 LONG-TERM IEV MANAGEMENT AND MONITORING

A long-term IEV management and monitoring plan will be developed in 2023 to cover the five-year LTC period (2023-2028). The long-term plan will incorporate lessons learned during implementation and will reflect the patterns of IEV within the reservoir footprints and surrounding areas as they changed in response to dam removal.

1.6 SPECIES MANAGEMENT

Management of priority IEV species will require a combination of methods employed over multiple years for effective control. The following sections describe the strategies for the species that are already present on the landscape, requiring immediate management before dam removal begins. Management strategies will be adaptively managed as we evaluate the effect of our proposed efforts and obtain a more thorough assessment of the abundance of IEV on the landscape.

1.6.1 SPECIES TARGETED FOR ERADICATION

Many high and medium priority IEV species were present but rare, only 13 observations, in the surrounding landscape in the 2019 AECOM survey (Table L-4). The opportunity to eradicate species that are not common is high. Beginning in the spring of 2020, all IEV at the 13 locations will be grubbed prior to mowing the area. The 2019 AECOM surveys were not intended to identify all possible locations of the IEV species, and the abundance of these species is likely underrepresented. To better evaluate IEV abundance in the landscape the project lands will be surveyed again in the summer of 2020. Herbicide applications will be pre-approved for each species and will only be used to control new, large populations discovered over the course of project implementation.

Table L-4. High and Medium priority IEV species with low abundance on the landscape. These species will be targeted for eradication due to their low abundance.

Scientific Name	Common Name	2018 Priority	2019 total obs
Onopordum acanthium	Scotch thistle	High	2
Centaurea diffusa	diffuse knapweed	High	1
Acroptilon repens	Russian knapweed	High	1
Linaria dalmatica	Dalmatian toadflax	High	1
Isatis tinctoria	dyer's woad	Medium	1
Bromus madritensis ssp. *rubens*	foxtail brome	Medium	4
Foeniculum vulgare	fennel	Medium	2
Xanthium spinosum	spiny clotbur	Medium	1

1.6.2 IEV ANNUAL SPECIES ABUNDANT ON THE LANDSCAPE

Three IEV annual species are pervasive in the project area; *Bromus tectorum* (cheatgrass), *Centaurea solstitialis* (yellow starthistle) and *Elymus caput-medusae* (medusahead). There was a total of 388 observations of these species, representing 42 percent of the 2019 AECOM observations. Most of the observations were polygons (259 out of the 388) occupying large areas. Eradication of these species is not practical because of abundance and extent. Infestations of these species extend beyond project boundaries both upslope and upstream. We will employ a containment strategy to minimize the ability of these species to rapidly colonize the reservoirs during the critical species establishment phase post-dam removal. This strategy will allow native species seeded and planted to establish first, reducing the ability of these IEV species from dominating the site long-term.

All three of these species exhibit similar regeneration and seed dispersal characteristics. Seeds are not adapted to long distance wind dispersal but are instead all epizoochorus; seed adapted to disperse by attaching to the outside of animals via long awns covered in small barbs (medusahead, Kyser *et al.* 2014), stiff pappus bristles covered in microscopic hair-like barbs (yellow starthistle, DiTomaso 2006) and barbs on the lemma, palea, and awns (cheatgrass, CABI). Dispersal of these species is facilitated primarily by seed sticking to cattle, wild horses, other wildlife and humans. Management can minimize short-distance dispersal of seed into the reservoir footprints by creating an IEV-free buffer zone of 50 to 100 feet around the reservoir rims. Long-distance dispersal is more difficult to control. The movement of people and equipment managing restoration will be vigorously managed to ensure seed is not introduced by human activities. IEV cleaning stations at each staging area will include vehicle washing and boot cleaning facilities. Fencing can prevent seed from entering the reservoirs from cattle movements. However, we do expect wildlife capable of jumping over fencing to move seed into restoration sites. Early Detection and Rapid Response is critical to minimize species establishment in the reservoirs and field crews will be trained to identify the seedlings of all three species.

1.6.2.1 OBSERVED LOCATIONS (AECOM 2019)

The AECOM 2019 survey identified 185 locations of *B. tectorum* (77 pts, 108 polygons) and it was observed at all three reservoirs. Iron Gate had the most observations, with the highest density along the east-facing slopes below Copco Road. There were also many observations at JC Boyle, including multiple infestations at the powerhouse, along the power canal and along the powerline. Many of the observations were secondary to other infestations.

The AECOM 2019 survey identified 107 locations of *C. solstitialis* (35 pts, 72 polygons) and it was observed at Iron Gate, Copco and near the JC Boyle powerhouse and power canal (no observations were recorded near the reservoir). Iron Gate had the most observations. However, observations around Iron Gate are significantly under-reported as many infestations were seen during the fall seed collection that were not represented in the data. The Fall Creek area also contained many observations. Copco only had two observations in the north-western end of the reservoir.

The AECOM 2019 survey identified 96 locations of *Elymus caput-medusae* (17 pts, 79 polygons) and it was observed at Iron Gate, near the JC Boyle powerhouse and at the power canal close to the JC Boyle Dam (no observations were recorded near the JC Boyle reservoir). No observations were recorded at Copco reservoir. Most observations were along the Iron Gate reservoir. However, observations around Iron Gate are significantly under-reported as many infestations were seen during the fall seed collection that were not represented in the data.

1.6.2.2 EFFECTIVE HERBICIDES

- Glyphosate (Roundup, Roundup Pro)
- Aminopyralid (Milestone)

1.6.2.3 TREATMENT

Treatment of these species will be a combination of mechanical (mowing) and chemical (Glyphosate, Aminopyralid) and will require follow up treatments for several years. The primary method of treatment for these species will be mowing. Repeat mowing within the growing season for several years is effective for all three species but timing of the first mow is critical. Timing will be variable each year depending on weather. Cheatgrass is the first of the three species to flower and can only be mowed effectively by timing the first mow just after flower set. Plants must be mowed down to 2 inches and repeated every three weeks (DiTomaso and Kyser 2013). Flowering can initiate as early as late April or as late as early July on the same site in different years depending on weather conditions (CABI). Medusahead flowers later than cheatgrass and is best controlled by mowing after flowers have started to form but before seed set in May. When timed properly two mowing rounds is enough to control medusahead in a single year. For yellow starthistle, mowing must occur after the spines have formed and before more than 2 percent of the flowers have opened. Seed matures quickly at flower initiation (within 8 days). Mowing too early allows yellow starthistle to recover, flower and set seed. When timed properly, yellow starthistle can be successfully controlled by mowing twice during the season for three years (DiTomaso *et al.* 2006). In most environments, spines form in early May.

Treatments will begin in early spring 2020. Seed banks of all three species tend to persist for 3 to 5 years and therefore will require an annual mowing regime beginning 2020 and extending through 2025. The first mow will be timed with the flowering of cheatgrass. Although this is too early for proper timing to control yellow starthistle and medusahead, repeat mowing every three weeks should prevent these species from recovering and successfully flowering. Plots will be established to determine effectiveness of mowing using this approach and methods will be modified accordingly.

Small observations of these IEV that are growing within communities dominated by native species will not be controlled by mowing. These sites will be spot sprayed with glyphosate (Roundup® or Roundup Pro®) or aminopyralid (Milestone®). Glyphosate is the preferred herbicide and will be applied early in spring. Plots will be established to determine effectiveness of spot-spraying herbicide and methods will be modified accordingly.

1.6.3 *RUBUS ARMENIACUS* (HIMALAYA BLACKBERRY)

Rubus armeniacus is a relatively long-lived, semi-evergreen shrub (approximately 25 years) that reproduces readily from seed and vegetative parts (rhizomes, stems). The root system is deep and can be difficult to control. Along moisture-rich waterways, shrubs form large colonies that shade-out native vegetation. It can also be found in dry uplands, where growth may be less aggressive. Vegetative canes emerge from a root crown and can extend 20 to 40 feet horizontally and 9.8 feet vertically. Stem tips that touch the ground can set roots, forming a new root crown. First year canes to not flower; fruiting occurs only on second year canes. Berries are eaten by birds and other wildlife, dispersing seed long distances.

1.6.3.1 OBSERVED LOCATIONS (AECOM 2019)

The AECOM 2019 survey identified 54 locations (15 pts, 39 polygons) of *R. armeniacus* populations in the project area. All locations were between Iron Gate Dam and the eastern end of Copco 1 reservoir. No populations were recorded at JC Boyle reservoir. The highest density of *R. armeniacus* observations (17) are in the Fall Creek area; along the banks of Fall Creek and Klamath River between the dams, along Copco Road, around developments (private homes and Pacific Corps' facilities), and close to the reservoir shoreline. Another area of abundance (six observations) is just downstream of the Fall Creek area on the southeast shoreline of Iron Gate. The remainder of the points and polygons are scattered around the shorelines of both reservoirs, including a few on private parcels at Copco. Further mapping of *R. armeniacus* in 2020 will focus on tributaries and other areas close to future riparian and wetland areas.

1.6.3.2 EFFECTIVE HERBICIDES

- Glyphosate (Roundup®)
- Triclopyr (Garlon 3A®)

1.6.3.3 TREATMENT

Management of *R. armeniacus* will require a combination of mechanical (mowing and grubbing) and chemical control methods and will require follow up treatments for several years. The goal of our approach is to eradicate where possible (small patches) and contain large patches resistant to treatment to minimize seeding and vegetation expansion during dam removal and in the 2-year vegetation establishment phase. Seed from populations outside the project area (upstream of the reservoirs) are expected disperse into the riparian zones in the former reservoir footprints from high water events. The riparian zone will be closely monitored annually as part of the Early Detection and Rapid Response Program.

Grubbing is only effective on young, small populations. Grubbing will be accomplished using hand tools (i.e. Pulaskis, shovels, etc.). Mowing will be accomplished by a combination of gas-powered brush cutters and string trimmers (with appropriate attachments). Mowing alone is not effective but can be used in combination with herbicides. There are two herbicides that effectively control *R. armeniacus*; Glyphosate (Roundup®) and Triclopyr (Garlon 3A®). Both can be applied as a foliar broadcast application. Triclopyr® can also be applied as a basal bark treatment.

Small populations around the reservoir rim will be mechanically removed (grubbed) prior to the spring mow of the buffer area. These populations may be subjected to mowing throughout the spring and early summer.

Large populations will be mowed twice in the growing season (early + late spring) to remove fruiting canes. Removing the 2-year old canes will ensure no new berries are produced (minimize new infestations from seed) and prevent conflicts with berry pickers during herbicide application. First year canes are also more susceptible to foliar herbicide application. Mowing twice will limit the length of growth of new canes, minimizing new root crown formation from long stem tips that reach the ground. Foliar broadcast herbicides will be applied in late summer/early fall. Weather dependent, a 3rd mow will occur 40-60 days after herbicide application.

1.6.4 *DIPSACUS FULLONUM* (COMMON TEASEL)

Dipsacus fullonum is biennial, annual or short-lived perennial that invades moist areas and is abundant along the shorelines of all three reservoirs. The root system is deep and can be difficult to remove mechanically. Reproduction is by seed. Seeds are not adapted to long-distance dispersal in the wind, falling only within 5 feet from the parent plant (Werner 1975). Long distance seed dispersal can occur when falling into moving water. Seed remain viable in the soil for up to 5 years (Roberts 1986).

The opportunity to eradicate *D. fullnoum* is considered low because of its abundance in the project area and along waterways outside of the project area. The containment opportunity was ranked high because of its short distance seed dispersal and its dependence on high moisture availability (observations are exclusively close to water, mostly along the reservoir rim). Reservoir drawdown will radically reduce moisture availability where most populations occur, altering the site to conditions unfavorable to teasel. The short-distance seed disbursal of this species makes it unlikely to successfully colonize the riparian and wetland areas far from the reservoir rims. However, some observed populations are close to future wetland and riparian areas. These populations will be prioritized for control. Herbicide treatments are the preferred method to effectively control common teasel (DiTomaso *et al.* 2013) but will be limited to priority sites.

1.6.4.1 OBSERVED LOCATIONS (AECOM 2019)

The AECOM 2019 survey identified 161 locations (91 pts, 70 polygons) of *D. fullonum* populations in the project area, the second most abundant IEV species observed in the 2019 survey. It was abundant at Iron Gate and JC Boyle. It was not abundant at Copco. High priority sites of populations close to predicted wetland and riparian areas include the upstream (eastern) end of Iron Gate, where the reservoir is narrow and populations close to tributaries (Scotch Creek, Unnamed trib, southeast). JC Boyle contains the most observations close to future wetland/riparian areas post-dam removal and will be a focus of control efforts.

1.6.4.2 EFFECTIVE HERBICIDES

- Aminopyralid (Milestone®)
- Glyphosate (Roundup®)

The most effective herbicide is Aminocyclopyrachlor combined with chlorosulfuron (Perspective) but as of 2013 was not approved for use in California (DiTomaso *et al.* 2013).

1.6.4.3 TREATMENT

Management of *D. fullonum* will require a combination of mechanical (mowing) and chemical control methods and will require follow up treatments for several years. The goal of our approach is to eradicate high priority locations close to new wetland/riparian areas and suppress/contain all other populations to minimize seeding before and during dam removal.

High priority sites that contain populations close to predicted riparian and wetland areas will be mowed in 2021 to prevent seed set and eliminated using herbicides in the summer of 2022 after reservoir drawdown to prevent reservoir contamination. These populations are predominantly at the upstream end of Iron Gate reservoir and along the upper JC Boyle reservoir. Glyphosate (Roundup®) and Aminopyralid (Milestone®) are applied during emergence in early summer. Milestone can be effective in the rosette stage (spring). We will initially use Glyphosate (Roundup® or Roundup Pro®) and monitor annually to determine the effectiveness of Glyphosate applications. If necessary, we will switch to Aminipyralid (Milestone®). We will wait to use herbicide on *D. fullonum* until after reservoir drawdown to prevent chemicals from contaminating reservoir waters. For sites that remain close to water after drawdown we will apply herbicide approved for use in aquatic applications (AquaNeat®).

Low priority sites far from predicted wetlands along the reservoir rim will be mowed annually beginning in 2020. Mowing will occur early in the season which will reduce but not eliminate flowering and seeding around the reservoir rim because this species flowers and seeds significantly later than the annual IEV species targeted for mowing. However, because this species is very moisture dependent, it is not likely to persist after reservoir drawdown and the appropriate habitat for new seedlings will be far too far for effective seed dispersal. Chemical control is not needed at low priority sites.

1.6.5 *PHALARIS ARUNDINACEA* (REED CANRYGRASS)

Phalaris arundinacea is a relatively long-lived perennial that invades moist areas and is present along the shorelines of all three reservoirs. The root system is deep and cannot effectively be removed mechanically. Reproduction is by seed and vegetative expansion, including during high flow events when root fragments are moved downstream. Seeds are not adapted to long-distance dispersal in the wind but can move long distances in water. Seeds can remain viable under water and germinated *in situ* in fine sediments after dam removal on the Elwha River (Chenoweth, personal observation).

The opportunity to eradicate *P. arundinacea* is considered low because of its abundance in the project area and along waterways outside of the project area. The containment opportunity was ranked low because of its abundance along the mainstem of the Klamath River upstream of all three reservoirs. However, populations along the reservoir rim are less likely to expand or seed into what will become dry uplands. Reservoir drawdown will radically reduce moisture availability where some populations occur, altering the site to conditions unfavorable to reed canarygrass. The short-distance seed disbursal of this species makes it unlikely to successfully colonize the riparian and wetland areas far from the reservoir rims. However, some observed populations are close to future wetland and riparian areas. These populations will be prioritized for control. Herbicide treatments are the preferred method to effectively control reed canarygrass (DiTomaso *et al.* 2013) but will be limited to priority sites. Small populations along the reservoir rims can be effectively controlled using solarization.

1.6.5.1 OBSERVED LOCATIONS (AECOM 2019)

The AECOM 2019 survey identified 100 locations (54 pts, 46 polygons) of *P. arundinacea* populations in the project area. It was more abundant at Copco and JC Boyle with only a few observations recorded at Iron Gate. JC Boyle contains the most observations close to future wetland/riparian areas post-dam removal and will be a focus of control efforts. The south shores of Copco contain many populations, which are all close to private properties.

1.6.5.2 EFFECTIVE HERBICIDES

- Glyphosate (Roundup®, Roundup Pro®, or AquaNeat® for sites close to water)

1.6.5.3 TREATMENT

Management of *P. arundinacea* will require a combination of mechanical (mowing) and chemical control methods and will require follow up treatments for several years. The goal of our approach is to eradicate high priority locations close to new wetland/riparian areas and suppress/contain all other populations to minimize seeding before and during dam removal.

High priority sites that contain populations close to predicted riparian and wetland areas will be mowed in 2021 to prevent seed set and eliminated using herbicides in the summer of 2022 after reservoir drawdown to minimize aquatic contamination. Mowing is most effective as the flowers begin to set, maximizing the energy loss as a result of mowing. AquaNeat is approved for use near water and will be used to control *P. arundinacea* and should be applied after mowing when the plant reaches 6 to12 inches tall sometime in late July or early August.

Low priority sites far from predicted wetlands along the reservoir rim will be mowed annually beginning in 2020. Mowing will occur early in the season which will reduce but not eliminate flowering and seeding around the reservoir rim because this species flowers and seeds significantly later than the annual IEV species targeted for mowing. However, because this species is very moisture dependent, it is not likely to persist after reservoir drawdown and the appropriate habitat for new seedlings will be far too far for effective seed dispersal. Chemical control is not needed at low priority sites.

Small patches can be controlled by mowing followed by solarization. Solarization only works if the entire patch is thoroughly covered in opaque, heavy duty weed fabric or black plastic for at least one year.

1.6.6 LOW PRIORITY SPECIES

Low priority species that are present on the landscape will not be selectively managed before dam removal. Observed populations within the IEV buffer zones will be mowed. Low priority species will be managed within the reservoir footprints. Primary method of treatment will be mechanical (grubbing). Herbicide options will be pre-approved but only used in for large infestations that cannot be mechanically controlled. All treatments will be modified as needed during project implementation.

1.6.7 WATCH LIST SPECIES

Crews will monitor for species on the IEV watch list before and after dam removal. Treatment of these species will be mechanical (grubbing) and chemical as needed. Herbicide options will be pre-approved, and treatments will be modified as needed during project implementation.

1.6.8 POSSIBLE TREATMENTS FOR ALL SPECIES

All proposed treatments will be adaptively managed. Treatments will be monitored and adjusted as needed to ensure effective control eradication and/or containment is achieved. New species may be discovered, and population estimates of existing IEV in the project area are likely underrepresented in this plan. Large populations are difficult to control manually, particularly for perennial species. Table L-5 outlines the possible mechanical and chemical treatments for all IEV species in this report, including low priority and watch list species. Herbicides listed here are only proposed as a last resort option in cases of extreme infestations. Herbicide application timing will be determined as needed for new infestation. Other treatment options not listed here that are outlined in Section 1.3.2 may also be employed. For many of the species listed below, grubbing is only effective in the seedling stage or to control small populations. Because dam removal will expose a landscape devoid of vegetation, seedlings of IEV identified early can be effectively removed by hand pulling.

Table L-5. Proposed treatments including possible herbicide control for all 53 IEV species that may occur in the project area.

Species	Priority	Primary	Secondary	Additional
Onopordum acanthium	High	Grub	Aminopyralid	Glyphosate
Centaurea diffusa	High	Grub	Aminopyralid	Glyphosate
Acroptilon repens	High	Grub	Aminopyralid	-
Linaria dalmatica	High	Grub	Aminocyclopyachlor + cholsulfuron	Glyphosate
Isatis tinctoria	Medium	Grub	Aminocyclopyachlor + cholsulfuron	-
Bromus madritensis ssp. *rubens*	Medium	Grub/Mow	Glyphosate	Aminopyralid
Foeniculum vulgare	Medium	Chop	Glyphosate	-
Xanthium spinosum	Medium	Grub	Will not use herbicide	
Rubus armeniacus	Medium	Mow/Grub	Glyphosate	Triclopyr
Bromus tectorum	Medium	Mow	Glyphosate	Aminopyralid
Centaurea solstitialis	Medium	Mow	Glyphosate	Aminopyralid
Dipsacus fullonum	Medium	Mow	Aminopyralid	-
Elymus caput-med	Medium	Mow	Glyphosate	Aminopyralid

Species	Priority	Primary	Secondary	Additional
Phalaris arundinacea	Medium	Mow	Glyphosate	Solarization
Brassica nigra	Low	Mow/Grub	Will not use herbicide	
Bromus diandrus	Low	Mow/Grub	Glyphosate	Aminopyralid
Cirsium arvense	Low	Mow/Grub	Aminopyralid	-
Conium maculatum	Low	Mow/Grub	Glyphosate	-
Festuca arundinacea	Low	Mow/Grub	Glyphosate	Imazapyr
Hypericum perforatum	Low	Mow/Grub	Aminopyralid	Glyphosate
Lepidium draba	Low	Mow/Grub	Chlorosulfuron	Glyphosate
Cirsium vulgare	Low	Mow/Grub	Will not use herbicide	
Watch List				
Centaurea virgata ssp. *squar*	High	Mow/Grub	Aminopyralid	Glyphosate
Euphorbia esula	High	Mow/Grub	Aminocyclopyachlor + cholsulfuron	-
Onopordum tauricum	High	Mow/Grub	Aminopyralid	Glyphosate
Carduus acanthoides	High	Mow/Grub	Will not use herbicide	
Carduus nutans	High	Mow/Grub	Will not use herbicide	
Centaurea stoebe ssp. micr	High	Mow/Grub	Aminopyralid	Glyphosate
Cytisus scoparius	High	Mow/Grub	Will not use herbicide	
Lepidium latifolium	High	Mow/Grub	Chlorosulfuron	Glyphosate
Lythrum salicaria	High	Mow/Grub	Triclopyr	-
Fallopia japonica	High	Mow/Grub	Imazapyr	Glyphosate
Sonchus arvensis	High	Mow/Grub	Glyphosate	-
Tamarix parviflora	High	Mow/Grub	Imazapyr	Triclopyr
Anchusa officinalis	Medium	Mow/Grub	TBD	-
Cirsium ochrocentrum	Medium	Mow/Grub	Will not use herbicide	
Convolvulus arvensis	Medium	Mow/Grub	Glyphosate	Imazapyr
Crupina vulgaris	Medium	Mow/Grub	Will not use herbicide	
Halogeton glomeratus	Medium	Mow/Grub	Will not use herbicide	
Linaria vulgaris	Medium	Mow/Grub	Aminocyclopyachlor + cholsulfuron	Glyphosate
Salvia aethiopis	Medium	Mow/Grub	Glyphosate	Aminopyralid
Tribulus terrestris	Medium	Mow/Grub	Dicamba	Glyphosate
Aegilops cylindrica	Low	Mow/Grub	Will not use herbicide	
Avena barbata	Low	Mow/Grub	Will not use herbicide	
Hirschfeldia incana	Low	Mow/Grub	Will not use herbicide	
Hordeum murinum	Low	Mow/Grub	Will not use herbicide	
Leucanthemum vulgare	Low	Mow/Grub	Will not use herbicide	
Marrubium vulgare	Low	Mow/Grub	Will not use herbicide	
Mentha pulegium	Low	Mow/Grub	Will not use herbicide	
Persicaria wallichii	Low	Mow/Grub	Will not use herbicide	

Species	Priority	Primary	Secondary	Additional
Rumex acetosella	Low	Mow/Grub	Will not use herbicide	
Torilis arvensis	Low	Mow/Grub	Will not use herbicide	

1.7 REVEGETATION POST-TREATMENT

Some areas treated will require revegetation with native species. Some herbicides particularly Glyphosate, are non-specific and often leave significant bare ground post-treatment that are susceptible to new weeds. Repeat mowing will also deplete and area of all vegetation and will need to be revegetated. Key native species will be left intact within mowed areas whenever possible (i.e. *Lupinus argenteus,* woody shrubs) to provide some native presence and seed into the surrounding bare ground. *Eriophyllum lanatum* and other native perennial species will likely survive the mowing because of the low growth habit and late phenology. Sites that are denuded of vegetation will be seeded as early as the fall of 2021, if necessary, with upland native species produced for the project. Site preparations may include light tilling or other surface preparations.

1.8 TREATMENT SCHEDULE

Treatments will begin before dam removal in 2020 with the goal of eradicating and containing IEV species in the surrounding landscape. Treatments will continue annually through 2023. After 2023, a new IEV management and monitoring plan will be needed to reflect the changed conditions and lessons learned from the earlier efforts. Mowing of *R. armeniacus* and *P. arundunacea* will begin in 2020 to deplete nutrients and prepare these populations for the mow/herbicide treatments in 2021.

An IEV Action Plan will be updated annually to refine and direct IEV management.

1.8.1 2020

- No herbicide applications are recommended in 2020.
- March: Submit IEV Action Plan for 2020
- April-May: Survey project area for IEV species and refine IEV Action Plan and overall management plans as needed.
- Early April: Install and survey plots in areas targeted for IEV mowing and grubbing treatments.
- Early April: Grub out all isolated small populations of high priority, rare IEV species and upland, small clumps of *R. armeniacus* around Iron Gate and Copco reservoirs before mowing the buffer area.
- Mid-to-late-April: First mow of the buffer area. Exact timing to be determined each year by a trained botanist. Phenology is critical to timing and is dependent on environmental conditions.
- Repeat mow of IEV buffer areas every three weeks until growth slows. The end of mowing will be determined by a trained botanist.

- May: Install and survey plots in areas targeted for *P. arundinacea* treatments.
- May: Mow large populations of *R. armeniacus* and remove all vegetative canes.
- June-July: Mow *P. arundinacea* patches. Apply solarization fabric to small, isolated patches.
- July-August: Repeat mow high priority *R. armeniacus* and *P. arundinacea* patches.
- July-August: Survey project area for IEV species and refine IEV management plan as needed.
- August: Re-survey plots.
- September: Final mow of high priority *R. armeniacus* and *P. arundinacea* patches.
- November: Submit IEV Assessment Report for 2020.

1.8.2 2021

- March: Submit IEV Action Plan for 2021
- Early April: Survey plots in areas mowed/grubbed in 2020.
- Early April: Repeat manual removal of isolated small populations of high priority, rare IEV species and small patches of upland *R. armeniacus* around Iron Gate and Copco reservoirs before mowing the buffer area.
- Mid-to-late-April: First mow of the buffer area. Exact timing to be determined each year by a trained botanist. Phenology is critical to timing and is dependent on environmental conditions.
- Mid-to-late-April: Apply herbicide in early spring to small patches of *B. tectorum, E. caput-medusae* and *C. solstitialis* located in predominantly native plant communities.
- May: Mow large populations of *R. armeniacus* and remove all vegetative canes.
- June-July: Mow and apply solarization fabric to small, isolated *P. arundinacea* populations along reservoir rims. Keep in place for at least 1 year.
- Late July-August: Broadcast spray AquaNeat on *P. arundinacea* patches that are close to predicted wetland/riparian zones after mowing when re-growth reaches 6-12 feet tall.
- August: Re-survey plots. Establish new plots in areas targeted for *R. armeniacus* herbicide treatments.
- Late summer-early fall: Broadcast spray large patches of *R. armeniacus* herbicide on all foliage.
- Fall: Seed areas mowed and/or treated with herbicide. Mow in the fall prior to seeding if necessary.
- Late-fall, early winter: Mow large patches of *R. armeniacus* that were treated with herbicide.
- November: Submit IEV Assessment Report for 2021.

1.8.3 2022

- March: Submit IEV Action Plan for 2022
- Shift resources to the reservoir footprints, monitoring once every few weeks beginning in April to detect seedlings of IEV. Record seedling locations using GIS and manually remove if possible.
- Early April: Survey plots in areas mowed/grubbed and treated with herbicide (*R. aremeniacus*) in 2021.
- Early April: Repeat manual removal of isolated small populations of high priority, rare IEV species and *R. armeniacus* around Iron Gate and Copco reservoirs before mowing the buffer area.
- Mid-to-late-April: First mow of the buffer area. Exact timing to be determined each year by a trained botanist. Phenology is critical to timing and is dependent on environmental conditions.
- Repeat mow of IEV buffer areas every three weeks until growth slows. The end of mowing will be determined by a trained botanist.
- Spring or early summer: broadcast spray herbicide (Roundup or Milestone) on *D. fullonum* in high priority locations.
- May: Survey plots established to monitor *P. arundinacea* treatments. Assess effectiveness of solarization of *P. arundinacea* populations along reservoir rims. Keep in place for additional year if necessary.
- May: Mow large populations or *R. armeniacus* and remove all vegetative canes.
- June-July: Mow *P. arundinacea* populations along reservoir rims at high priority locations.
- Late July-August: Broadcast spray AquaNeat on *P. arundinacea* patches that are close to predicted wetland/riparian zones after mowing when re-growth reaches 6-12 feet tall.
- Late summer-early fall: Broadcast spray large patches of *R. armeniacus* herbicide on all foliage.
- Late-fall, early winter: Mow large patches of *R. armeniacus* that were treated with herbicide.
- November: Submit IEV Assessment Report for 2022.

1.8.4 2023

- March: Submit IEV Action Plan for 2023
- Shift resources to the reservoir footprints, monitoring once every few weeks beginning in April to detect seedlings of IEV. Record seedling locations using GIS and manually remove if possible.
- Early April: Survey plots in areas mowed/grubbed and treated with herbicide (*R. aremeniacus*) in 2021.
- Early April: Repeat manual removal of isolated small populations of high priority, rare IEV species and *R. armeniacus* around Iron Gate and Copco reservoirs before mowing the buffer area.

- Mid-to-late-April: First mow of the buffer area. Exact timing to be determined each year by a trained botanist. Phenology is critical to timing and is dependent on environmental conditions.
- Repeat mow of IEV buffer areas every three weeks until growth slows. The end of mowing will be determined by a trained botanist.
- Spring or early summer: broadcast spray herbicide (Roundup or Milestone) on *D. fullonum* in high priority locations as needed.
- May: Mow large populations or *R. armeniacus* and remove all vegetative canes.
- June-July: Mow *P. arundinacea* populations along reservoir rims at high priority locations.
- Late July-August: Broadcast spray AquaNeat on *P. arundinacea* patches that are close to predicted wetland/riparian zones after mowing when re-growth reaches 6-12 feet tall.
- August: Re-survey plots as needed.
- Late summer-early fall: Broadcast spray large patches of *R. armeniacus* herbicide on all foliage.
- Late-fall, early winter: Mow large patches of *R. armeniacus* that were treated with herbicide.
- November: Submit IEV Assessment Report for 2023.
- December: Produce a new, long-term IEV management and monitoring plan for 2023-2028.

1.9 REFERENCES

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APPENDIX M

Large Wood Stability Calculations

(Pages M-1 to M-32)

Large Wood Stability Calculations for the Klamath Dam Removal 60% Design

Stability calculations were performed to evaluate large wood placement stability for the six primary tributaries within reservoir reach. The 60% Design calls for 991 wood elements placed within the three reservoirs along the six primary tributaries referenced in Table 1 below. Approximately 696 will be full length trees, 50-100 feet in length placed with a helicopter and 295 will be rootwads, 35-50 feet in length placed with ground based heavy equipment.

Table 1: Large wood quantity table for each reservoir by placement type

Reservoir	Feature Area	Placement Method	Wood Elements (Pieces)
Copco	Beaver Creek	Ground	65
		Helicopter	133
Copco	Dear Creek	Ground	23
		Helicopter	92
Iron Gate	Camp/Scotch Complex	Ground	52
		Helicopter	113
Iron Gate	Camp Creek	Ground	65
		Helicopter	167
Iron Gate	Jenny Creek	Ground	74
		Helicopter	138
JC Boyle	Spencer Creek	Ground	16
		Helicopter	53
		Total =	**991**

2D hydraulic models were developed for each reservoir and tributary to evaluate the 10 year discharge in order to determine hydraulic parameters (depth, velocity, etc.) that are necessary to evaluate the forces acting on the large wood placement conditions. Hydraulic parameters from the model were applied to determine the stability and force-balance for large wood design conditions at each tributary. Using a risk assessment based on Bureau of Reclamation – Risk Based Guidelines (USBR 2014) for tributaries within the reservoir footprints coupled with 2D hydraulic modeling resulted in a Factor of Safety (FOS) risk level rating of Low for horizontal, vertical, and overturning forces on wood features. The FOS of low risk corresponds to the 10 Year discharge (USBR 2014) with corresponding values of 1.25 for sliding (horizontal forces); 1.5 for bouncy (vertical forces); and 1.25 for rotation or overturning forces.

The stability evaluation method used and associated calculations were based from the National Large Wood Manual (Bureau of Reclamation 2016) and Computational Design Tool for Evaluating the Stability of Large Wood Structures Proposed for Stream Enhancement (Rafferty 2013) and USBR 2014 Risk Based Guidelines. Each of the tools uses planform and cross-section inputs along with site specific geometry, hydraulic parameters, wood dimension, orientation and other factors to determine forces acting against each wood element. Initial stability calculations were performed at two potential design scenarios for each of the tributaries hydraulic conditions. Jenny Creek which is the largest tributary has a 10 year discharge of 4,000 cfs. This tributary was used as the worse-case scenario to determine the most appropriate arrangement that would result in stable conditions and still providing the maximum amount of habitat value within the tributary.

The two different scenarios and methods correspond to both ground and helicopter placed large wood. Scenario 1 is for a single helicopter placed wood using whole tree placed with dimensions of approximately 80 feet in length and 18 inch diameter should be oriented with rootwad placed in the active channel at 1-3 depth of flow. The larger volume area of the tree including the base and top should be positioned within the floodplain bench to provide the counteracting weight against bouncy forces. Scenario 2 was to evalute ground placed material using two single 35 foot long rootwad elements buried approximately 3 feet into the bank and extending approximately 10 feet directly into the flow field. Each scenario used separate stability calculation spreadsheets, but with the same hydraulic parameters. The results of the calculations resulted in both scenarios being stable at the 10 year event. Although, flows above 4,000 cfs or the 10 year event has the potential for the wood to become mobile within the active channel. To view the calculations and the hydraulic parameters used for the Jenny Creek, see the scenario examples located at the end of this document. The section immediately below describes the hydraulic modeling framework developed to support the large wood stability calculations.

Hydraulic Modeling to Support Large Wood Stability Calculations

Current restoration plans for the Iron Gate, Copco, and JC Boyle reservoir areas include the potential for large wood placements in reservoir arms corresponding to six tributary streams. Large wood stability calculations require estimates of the flow depths and velocities that placed wood could be subjected to during floods. As the tributary channels are currently submerged beneath the reservoirs, hydraulic modeling is necessary to estimate potential flow conditions in those channels. That modeling was performed using SRH-2D, a publically-available 2-dimensional hydraulic modeling system developed by the U.S. Bureau of Reclamation. Hydraulic model development consists of four general steps: selecting an appropriate model domain, constructing a computational mesh spanning the selected domain, determining mesh boundary conditions, and applying surface topography and roughness to the mesh. Each of those steps and the methods used are summarized below.

Model Domains

Tributary channels evaluated for wood placement within the Iron Gate reservoir footprint consist of Jenny Creek and Camp Creek/Scotch Creek. Jenny Creek is the largest tributary entering any of the three reservoirs by a wide margin, whereas Camp Creek and Scotch Creek are much smaller tributaries that join at the upstream end of the Camp Creek arm of the reservoir (Figure 1). Two relatively small tributaries within the Copco 1 footprint are evaluated for wood placement, those being Beaver Creek and Deer Creek (Figure 2). One important tributary, Spencer Creek, is considered for wood placement within the JC Boyle reservoir footprint (Figure 3). Although Spencer Creek has only about 40% of the watershed area of Jenny Creek, it offers by far the greatest length of tributary channel accessible to migrating fish (9 miles) of any tributary in the reach spanning the three reservoirs.

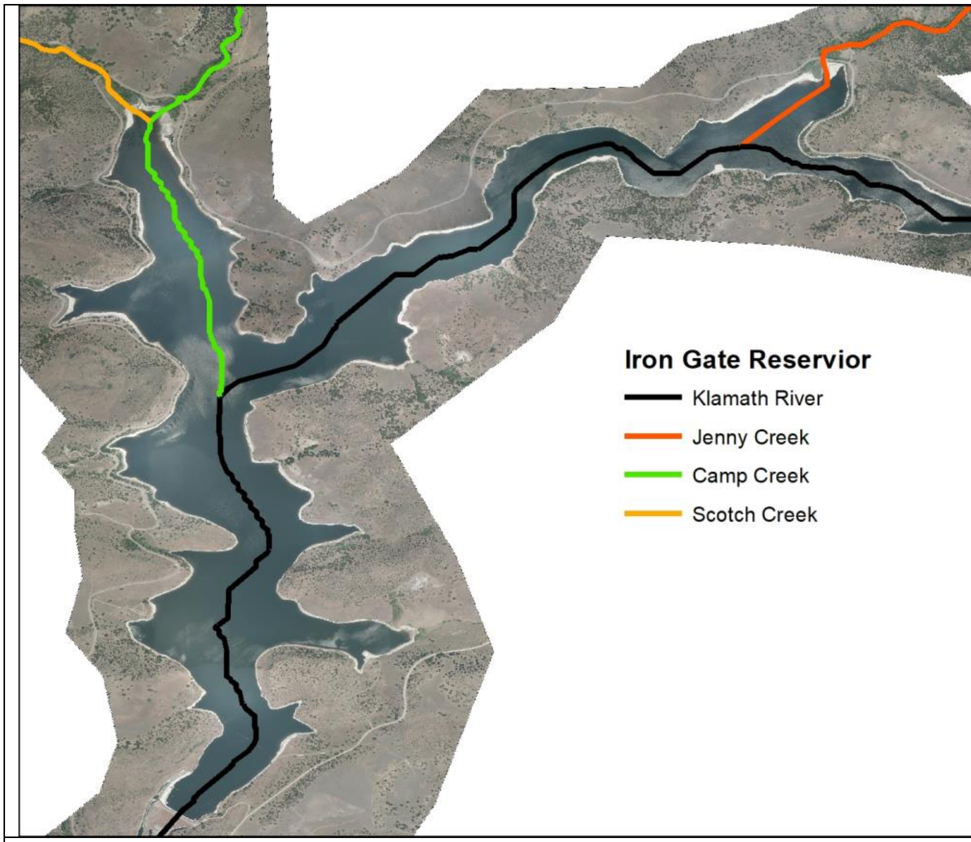


Figure 1: Iron Gate reservoir with Scotch, Camp, and Jenny Creeks highlighted.

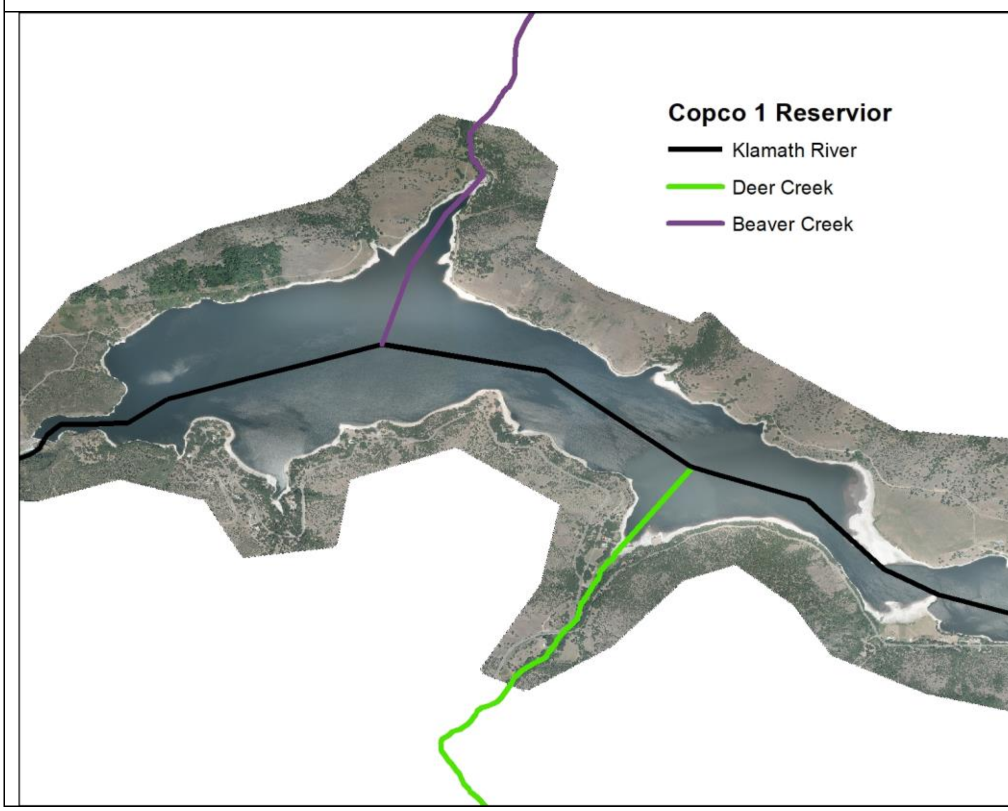


Figure 2: Copco 1 reservoir with Beaver and Deer Creeks highlighted.

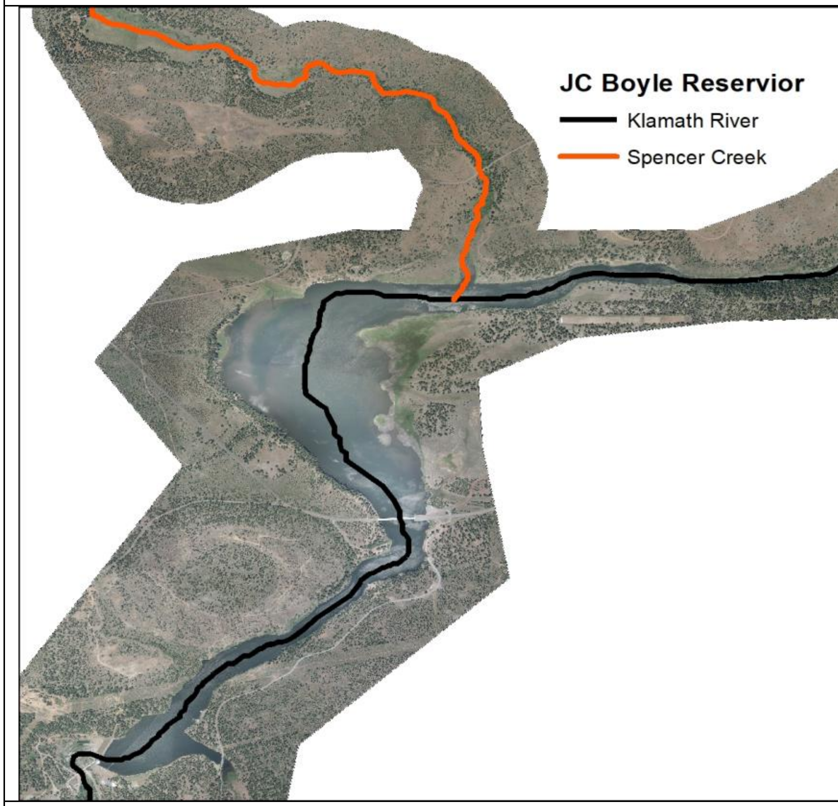


Figure 3: JC Boyle reservoir with Spencer Creek highlighted.

Rather than modeling each of these five tributary arms separately, we chose model domains spanning each of the three reservoirs. One reason to model the entire reservoirs is that water surface elevations in the mainstem Klamath River exert downstream control on hydraulics in the tributaries, particularly near their confluences with the Klamath. It would therefore be necessary to model some part of the Klamath River even if each tributary model were modeled separately. A second reason to model the entire reservoirs is that reservoir models will likely be useful for other purposes in the future as dam removal planning and implementation proceeds. For example, it could be helpful to model hydraulic conditions at various stages of reservoir drawdown to assess the feasibility of deploying watercraft to help manage sediment evacuation.

Computational Meshes

SRH-2D permits the use of an unstructured mesh composed of a combination of triangular and quadrilateral elements of various sizes. This makes it possible to spatially vary mesh resolution and geometry to provide greater resolution in areas where complex flow fields are anticipated and reduce computational demands in less sensitive areas. For example, Figure 4 shows a portion of the Copco 1 mesh at the confluence of Deer Creek with the mainstem Klamath River. The mesh along the sinuous Klamath floodway and in a swath of valley surrounding the course of Deer Creek consists of mostly quadrilateral elements about 10 ft wide. The higher floodplain areas are represented by triangular elements that are small near the floodways but become larger with increasing elevation and distance from the main flow paths. For scale, note that the largest triangular elements at the edges of the mesh farthest from a stream channels are 90 to 100 ft wide along their longest edges. Those large edge elements are inundated only when the reservoir is at full pool, and many are even beyond the bounds of full pool. The meshes for all three reservoir models are constructed in this way.

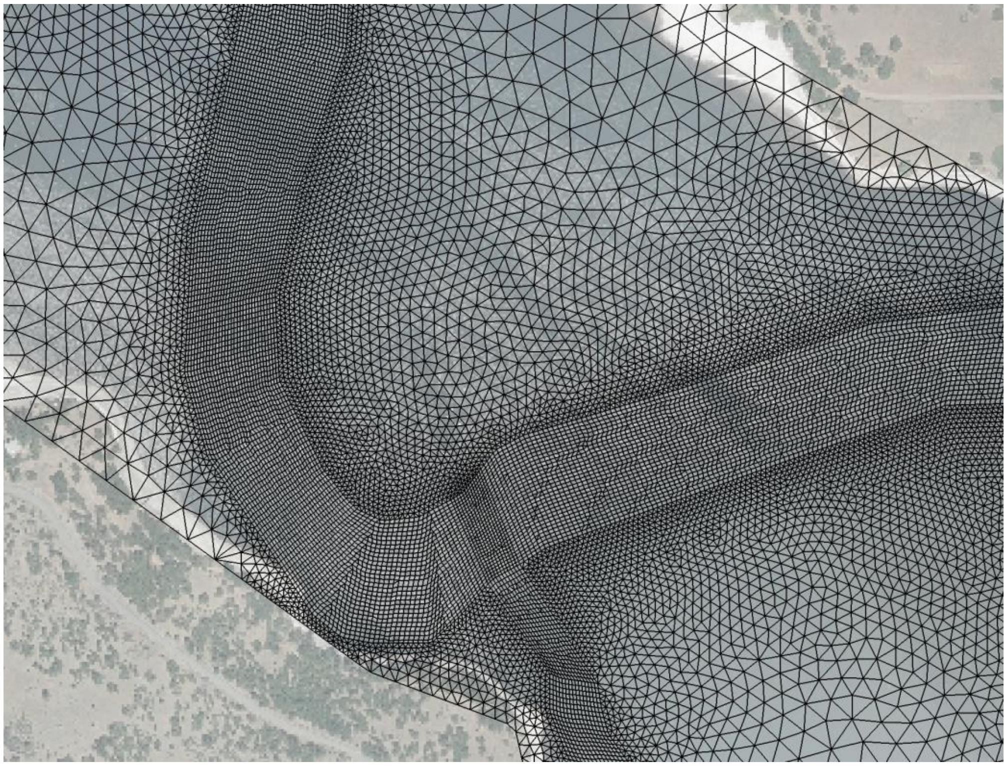


Figure 4: Example of mesh structure; confluence of Deer Creek with the Klamath River.

Boundary Conditions

We chose the 10-yr flood as the benchmark event for assessing wood stability. Flood magnitudes for that event in the mainstem Klamath River are given in Appendix B5 of the Design Criteria Report and based on the 2019 BiOp flows for the Upper Klamath Irrigation Project. They are 9500 cfs at JC Boyle Dam, 11300 cfs at Copco 1 Dam, and 12000 cfs at Iron Gate Dam. Klamath River inflows at the upstream boundary of each model domain were computed by subtracting the tributary inputs within each reservoir (described below) from the 10-yr discharge, such that the discharge at the downstream boundary of each model is equal to the 10-yr flood.

Estimates of water surface elevations corresponding to those flood discharges are also required to define boundary conditions at the downstream end of the model domains. Those water surface elevations were estimated by extracting channel/valley cross sections at the downstream boundaries of the model domains from the available digital terrain models, assigning reasonable assumed roughness values, and computing normal flow via the Manning equation. The downstream boundaries of the models are located far enough downstream that errors in the downstream water surface elevations have no effect on model results at the tributary confluences or in the tributaries themselves.

Flood magnitudes for several of the individual tributaries considered here are available in Table 4.2 and Table 4.3 in Appendix B5 of the Design Criteria Report. That table contain estimates for the 10-yr flow magnitude for Scotch Creek, Camp Creek, Jenny Creek, and Beaver Creek. Of those tributaries, the flood hydrology estimates are based on actual gage records only at Jenny Creek. For all other locations, Appendix B5 indicates that flood magnitudes were estimated using methods developed by the USGS (Cooper 2005). Appendix B5 provides no estimates of flood magnitudes for Deer Creek or Spencer Creek. It was therefore necessary to evaluate methods for assessing flood magnitudes in those tributaries.

We first consulted Cooper (2005) and found that the methods described in that document require extensive detailed information regarding watershed topography, climate, and soil characteristics, and that the precise parameters required varies according to watershed location. Due to that complexity, Cooper (2005) directs the reader to an interactive website hosted by the Oregon Water Resources Department where the user can click on a location and receive a report of flood frequencies for that location (*http://www.wrd.state.or.us/OWRD/SW/peak_flow.shtml*). Upon engaging that website, we found that it would not return results for the locations in California, presumably because those streams are outside of the region the methods were developed for. Rather, it returned flood magnitude estimates only for Spencer Creek.

In addition to estimates for various flood recurrence intervals, the report for Spencer Creek included the mathematical model used to generate those estimates. The model, which the report identifies as being for "East Slope Cascade Mountains watersheds," depends on just three watershed parameters: drainage area (A), mean slope (S), and mean elevation (Z). Those factors are raised to powers that depend on recurrence interval, with the 10-yr event being given by:

$$Q_{10} = 10^{4.875} A^{0.8181} S^{1.992} Z^{-1.454}$$

The report also lists sets of exponents for the 2-, 5-, 20-, 25-, 50-, 100-, and 500-yr events. Surprisingly, no region corresponding to the "East Slope Cascade Mountains" exists in Cooper (2005), which discusses only Region 1 (coastal watersheds), Region 2A (western interior with mean elevation greater than 3000 ft), and Region 2B (western interior with mean elevation less than 3000 ft). It is therefore unclear how Cooper (2005) relates to the OWRD website or what methods are appropriate for Klamath River tributaries in California or near the state border.

We evaluated the equations contained on the OWRD report for Spencer Creek by applying them to the tributaries listed in Table 4.3 of Appendix B5, which gives estimates for the 2-, 5-, 10-, and 25-year flood magnitudes. We found that the OWRD method gives very different results than those reported in Appendix B5. For example, the OWDR equation gives estimates for the 10-yr events in Scotch and Camp Creeks of 1844 and 1849 cfs, whereas Appendix B5 reports 10-yr floods of 320 and 360 cfs. In addition, the OWDR method produces flood magnitudes for Spencer Creek that seem anomalously small – the OWDR 10-yr event on Spencer Creek is just 581 cfs. That is less than a third of the OWDR flows on Scotch and Camp Creeks even though the Spencer Creek watershed is more than four time larger in terms of watershed area.

Due to the uncertainties surrounding the Cooper/OWDR methods, we also evaluated the potential of scaling flood magnitudes with watershed area relative to Jenny Creek, the only gaged tributary. This approach assumes that the watershed are close enough to one another that climatic differences are relatively small. This seems reasonable, as the confluences of Spencer Creek and Jenny Creek with the Klamath River are within 24 miles of one another and the mean elevations of the two watersheds differ by just 850 ft.

Table 2 lists 10-yr flood magnitudes obtained by scaling the Jenny Creek magnitudes according to watershed area compared to the magnitudes reported in Appendix B5. For the three tributaries for which two estimates exist, they differ by just 7% and 4% for Scotch and Camp Creeks, and by 30% for Beaver Creek. This level of variability is considered acceptable, and the scaled flood magnitudes were adopted as tributary influx boundary conditions for modeling.

Table 2: Estimated 10-yr flood magnitudes in tributaries estimated by scaling Jenny Creek flows by watershed area (Scaled) and as reported in Appendix B5 (B5).

	Jenny Ck cfs	Scotch Ck cfs	Camp Ck cfs	Beaver Ck cfs	Spencer Ck cfs	Deer Ck cfs
Scaled	4000	344	376	130	1614	157
B5	4000	320	360	100		
% difference	0	7	4	30		

Topography and Roughness

Topography was mapped to the model meshes from existing terrain models. First, the new digital terrain model provided by Quantum Spatial in November 2019 was mapped to all three reservoir models to incorporate the most complete topographic data available for the Klamath River. Then, Post drawdown surfaces for each reservoir developed by Stantec and collaborators were overlain on the model meshes to incorporate the best available estimates regarding the locations and dimensions of channels within the reservoir footprints following drawdown. Finally, surfaces supplied by Stantec depicting reconstructed channels in areas that are currently occupied by the dams were overlain to provide flow conveyance through the dam footprints.

Roughness values assigned to the meshes in the vicinity of the dams are based on those used for earlier modeling to assess fish passage through the dam footprint areas, and are described in a series of memos submitted to Stantec and collaborators over the past few months. Those areas, however, are very small compared to the reservoirs as a whole and have little effect on the hydraulics farther upstream. Only two roughness values are used over the vast majority of the reservoir areas. Areas in and adjacent to where actual stream channels are expected were assigned Manning's *n* values of 0.041. This values is appropriate for a substrate composed of a combination of gravel, cobble, and occasional boulders. Other areas (floodplains, terraces, hillslopes, etc.) were assigned $n = 0.038$. This slightly lower value was selected in the expectation that many surfaces outside the main flow paths will be draped in fine sediments, at least initially. It should be understood that no roughness parameterization can be correct for drawdown and the initial phases of restoration work because the surface materials and vegetative cover will be constantly and rapidly evolving for several years. Likewise, actual channel configurations and upland surface geometries will certainly deviate substantially from what is indicated by the post drawdown surfaces, and they will be subject to rapid evolution for some time.

Results

Flow depths and velocities expected during the 10-yr event as described above are presented visually in Figures 5 through 10. The results are presented in order from downstream to upstream beginning with the north half of Camp/Scotch Creeks (Figure 5), followed by the south half Camp/Scotch Creeks (Figure 6), Jenny Creek (Figure 7), Beaver Creek (Figure 8), Deer Creek (Figure 9), and Spencer Creek (Figure 10). The color ramps used in the figures are consistent throughout, with the lowest depths or velocities (0 ft or 0 ft/s) shown in blue and the greatest depths or velocities (10+ ft or 10+ ft/s) shown in red.

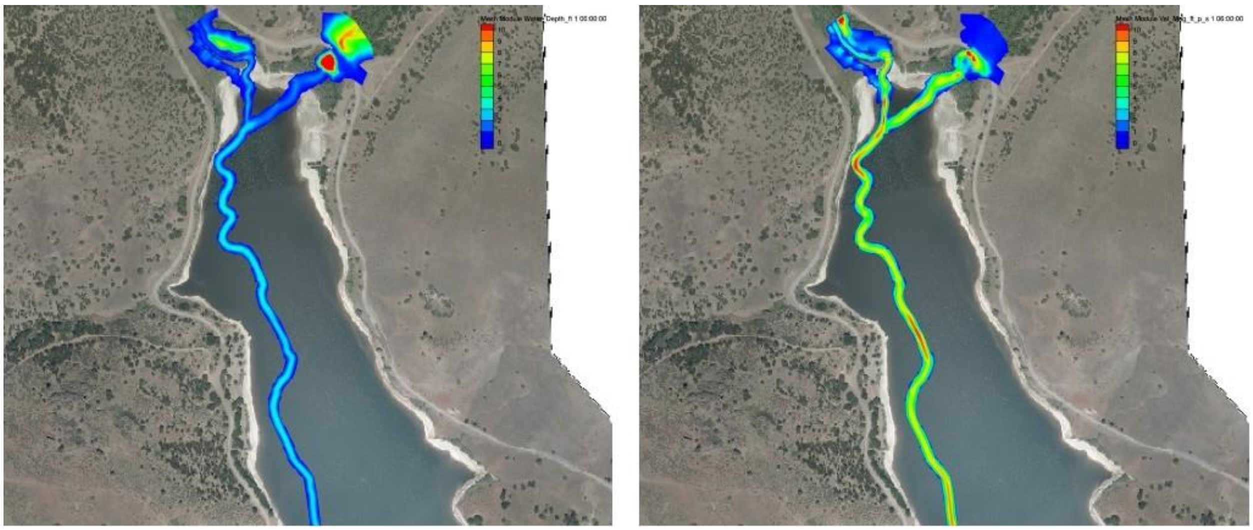


Figure 5: Modeled depths (left) and flow velocities (right) in the north half of the Camp Creek/Scotch Creek arm of Iron Gate reservoir.

The Camp/Scotch Creek results (Figure 5 and 6) are typical for most of the tributaries modeled in that flow depths are small compared to flow velocities. Modeled depths in that stream rarely exceeding 3 ft, whereas velocities are generally near 6 ft/s and in some locations exceed 10 ft/s and near-critical or supercritical flow conditions are common. Depths are greater (>5 ft) through much of Jenny Creek due to its much larger 10-yr discharge, but flow velocities are also very large and supercritical flow is widespread throughout the tributaries length. The small depths and high velocities reflect the fact that most of the tributary valleys are rather steep, with slopes through the modeled reaches between 1.3% (Beaver Creek) and 2.1% (Jenny Creek). The exception is Spencer Creek with a reach averaged slope of about 0.8%, velocities mostly less than twice the depth, and Froude numbers mostly less than 0.6.

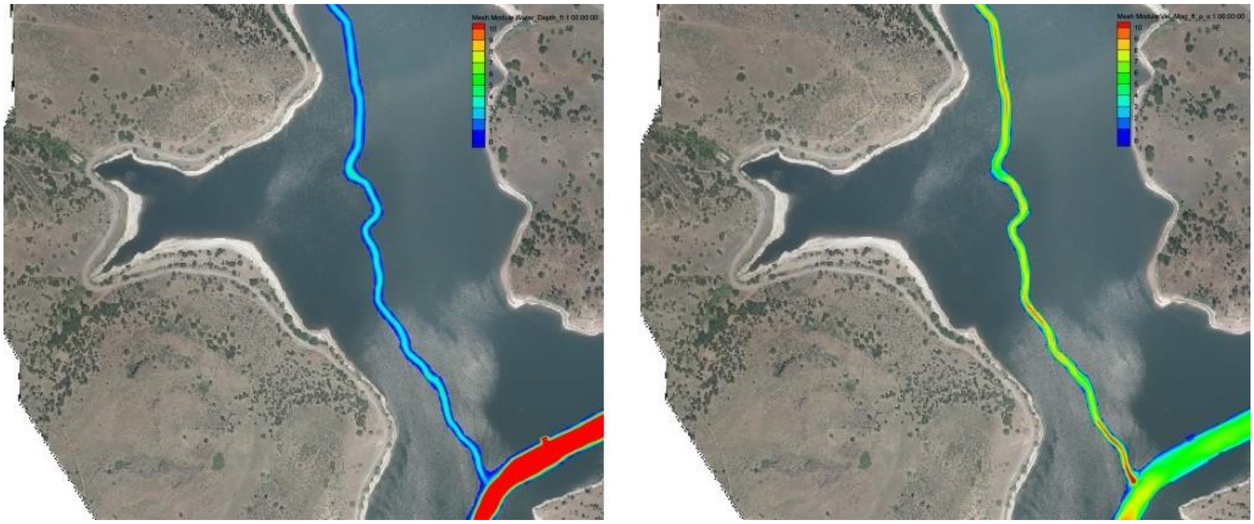


Figure 6: Modeled depths (left) and flow velocities (right) in the south half of the Camp Creek/Scotch Creek arm of Iron Gate reservoir and Klamath River confluence area.

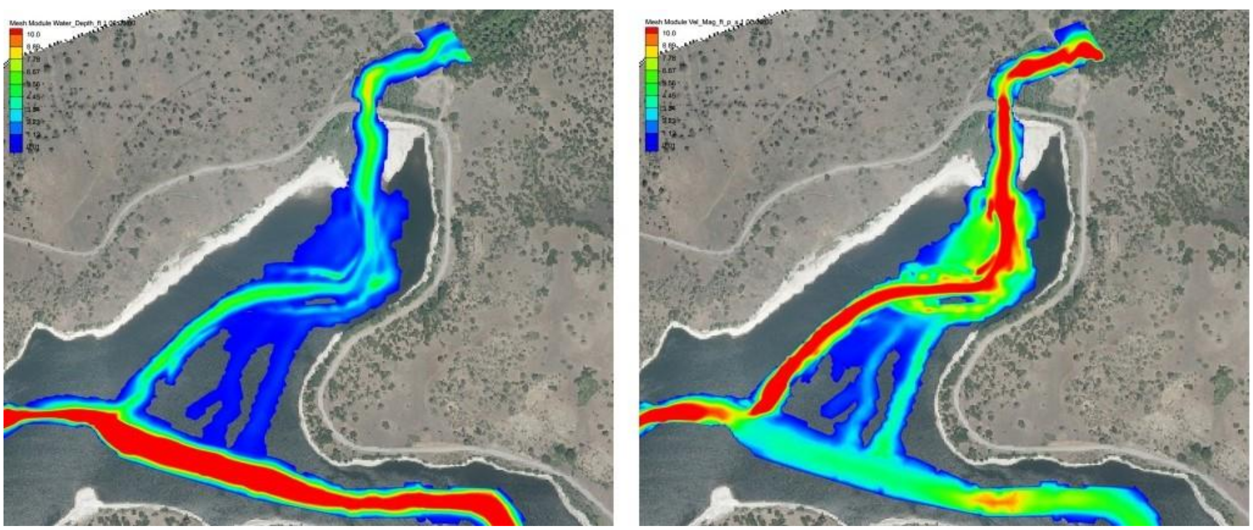


Figure 7: Modeled depths (left) and flow velocities (right) in Jenny Creek and Klamath River confluence area within the Iron Gate reservoir footprint.

As a final observation on these modeling results, it can be noted that neither the Jenny Creek nor the Spencer Creek channels contain their respective modeled 10-yr flood discharges, whereas the channels graded into the postdrawdown surfaces do contain those events. In the case of Spencer Creek, almost all of the modeled tributary is currently exposed subaerially and therefore reflect actual conditions on the ground rather than hypothetical graded geometry, as is the case with the other tributaries.

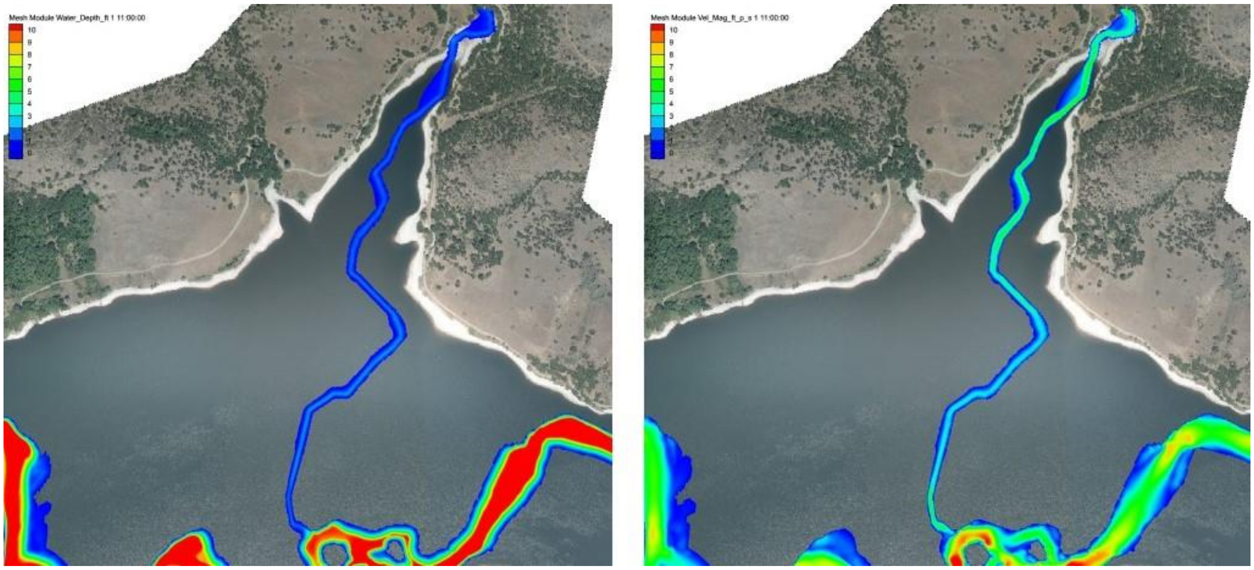


Figure 8: Modeled depths (left) and flow velocities (right) in Beaver Creek and Klamath River confluence area within the Copco 1 reservoir footprint.

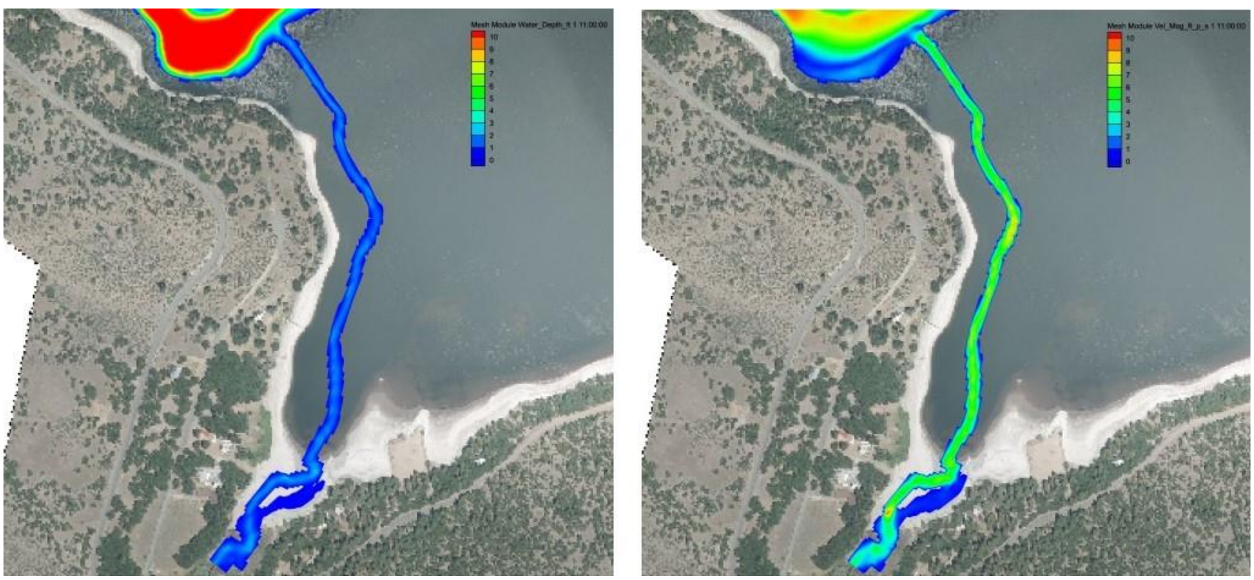


Figure 9: Modeled depths (left) and flow velocities (right) in Deer Creek and Klamath River confluence area within the Copco 1 reservoir footprint.

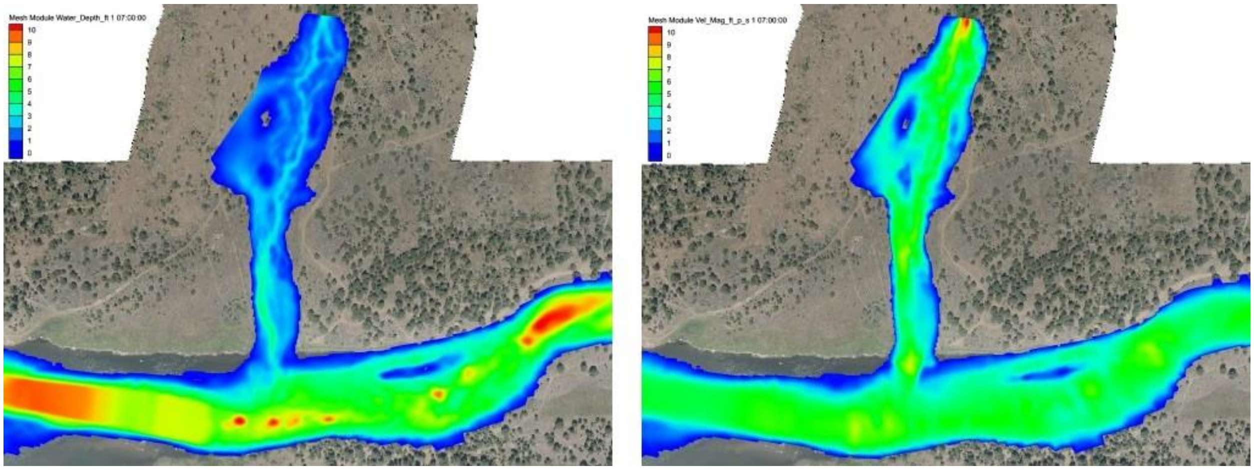


Figure 10: Modeled depths (left) and flow velocities (right) in Spencer Creek and Klamath River confluence area within the JC Boyle reservoir footprint.

References

Cooper, R.M., 2005. Estimation of peak discharges for rural, unregulated streams in western Oregon. US Geological Survey Scientific Investigations Report 2005-5116, 134 pp.

Bureau of Reclamation, M. Knutson and J. Fealko, 2014. Large Woody Materials Risk Based Guidelines. Pg. 14-25.

Bureau of Reclamation and U.S. Army Engineer Research and Development Center (USBR and ERDC), 2016. National Large Wood Manual: Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure.

Rafferty, M., 2013. Development of a Computational Design Tool for Evaluating the Stability of Large Wood Structures Proposed for Stream Enhancement. Masters of Science Thesis, Colorado State University.

LARGE WOOD STABILITY CALCULATIONS SCENARIO 1 (SINGLE WHOLE TREE WITH ROOTWAD – 80 FT. LONG / 30” DIA. HELICOPTER PLACED)

Klamath Dam Removal - 60% Design

Large Wood Stability Analysis

TABLE OF CONTENTS

Date of Last Revision: December 5, 2019

Designer:
DJ Bandrowski

Reviewed by:
Yurok Tribe

Reference for Design Method of Large Wood Structures:
NRCS NEH 654 Technical Supplement 14J (2007)

Reference for Companion Paper:
Rafferty, M. (2013). *Development of a Computational Design Tool for Evaluating the Stability of Large Wood Structures Proposed for Stream Enhancement*. Masters of Science Thesis, Colorado State University.

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.0

Klamath Dam Removal - 60% Design
Factors of Safety and Design Constants

Symbol	Description	Value
FS_V	Factor of Safety for Vertical Force Balance	**1.75**
FS_H	Factor of Safety for Horizontal Force Balance	**1.50**
FS_M	Factor of Safety for Moment Force Balance	**1.50**

Symbol	Description	Units	Value
C_{Lrock}	Coefficient of lift for submerged boulder (D'Aoust, 2000)	-	0.17
C_{Drock}	Coefficient of drag for submerged boulder (Schultz, 1954)	-	0.85
g	Gravitational acceleration constant	ft/s^2	32.174
DF_{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-	3.00
LF_{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-	1.50
SG_{rock}	Specific gravity of quartz particles	-	2.65
γ_{rock}	Dry unit weight of boulders	lb/ft^3	165.0
γ_w	Specific weight of water at 50ºF	lb/ft^3	62.40
η	Rootwad porosity from NRCS Tech Note 15 (2001)	-	0.20
ν	Kinematic viscosity of water at 50ºF	ft/s^2	1.41E-05

Klamath Dam Removal - 60% Design
Hydrologic and Hydraulic Inputs

Average Return Interval (ARI) of Design Discharge: 10 yr

Site ID	Proposed Station	Design Discharge, Q_{des} (cfs)	Maximum Depth, d_w (ft)	Average Velocity, u_{avg} (ft/s)	Bankfull Width, W_{BF} (ft)	Wetted Area, A_W (ft^2)	Radius of Curvature, R_c (ft)
Iron Gate	Jenny Creek	4,000	4.90	9.10	95.0	345	870

Klamath Dam Removal - 60% Design
Stream Bed Substrate Properties

Klamath Dam Removal - 60% Design
Bank Soil Properties

Site ID	Proposed Station	Stream bed D_{50} (mm)	Stream Bed Substrate Grain Size Class	Bed Soil Class	Dry Unit Weight[1], γ_{bed} (lb/ft^3)	Buoyant Unit Weight, γ'_{bed} (lb/ft^3)	Friction Angle, ϕ_{bed} (deg)	Bank Soils (from field observations)	Bank Soil Class	Dry Unit Weight, γ_{bank} (lb/ft^3)	Buoyant Unit Weight, γ'_{bank} (lb/ft^3)	Friction Angle, ϕ_{bank} (deg)
Iron Gate	Jenny Creek	15.00	Medium gravel	5	121.9	75.9	36	Coarse sand, loose	6	98.0	61.0	31

Source: Compiled from Julien (2010) and Shen and Julien (1993); soil classes from NRCS Table TS14E–2 Soil classification

[1] γ_{bed} (kg/m^3) = 1,600 + 300 log D_{50} (mm) (from Julien 2010)

1 kg/m^3 = 0.062 1 lb/ft^3

Klamath Dam Removal - 60% Design
Large Wood Properties

Project Location: West Coast

Timber Unit Weights			Air-dried[1] γ_{Td} (lb/ft^3)	Green[2] γ_{Tgr} (lb/ft^3)
Selected Species	**Common Name**	**Scientific Name**		
Tree Type #1:	Douglas-fir, Coast	Pseudotsuga menziesii var. menzi.	33.5	38.0
Tree Type #2:				
Tree Type #3:				
Tree Type #4:				
Tree Type #5:				
Tree Type #6:				
Tree Type #7:				
Tree Type #8:				
Tree Type #9:				
Tree Type #10:				

[1] **Air-dried unit weight,** γ_{Td} = Average unit weight of wood after exposure to air on a 12% moisture content volume basis. Air-dried unit weight is used in the force balance calculations for the portion of wood that is above the proposed thalweg elevation (assuming unsaturated conditions).

[2] **Green unit weight,** γ_{Tgr} = Average unit weight of freshly sawn wood when the cell walls are completely saturated with water. Green unit weight is used in the force balance calculations as a conservative estimate of the unit weight for the portion of wood that is below the proposed thalweg elevation (assuming saturated conditions). For comparison, Thevenet, Citterio, & Piegay (1998) determined wood unit weight typically increases by more than 100% after less than 24 hours exposure to water.

Source for timber unit weights:

U.S. Department of Agriculture, U.S. Forest Service. (2009) Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. Research Note NRS-38. Table 1A.

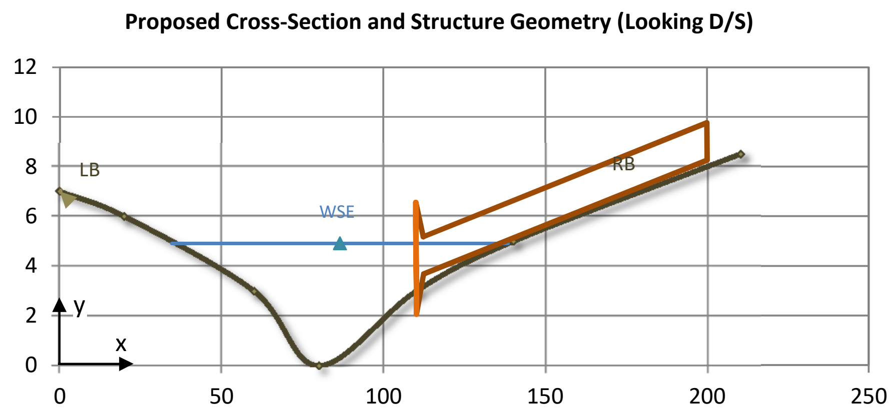
Klamath Dam Removal - 60% Design

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Iron Gate	Rootwad	Right bank	Inside	Jenny Creek	4.90	9.16	9.10

Multi-Log Structures	Layer	Log ID
	Key Log	1

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	7.00
Top LB	20.0	6.00
Toe LB	60.0	3.00
Thalweg	80.0	0.00
Toe RB	110.0	3.00
Top RB	140.0	5.00
Fldpln RB	210.0	8.50

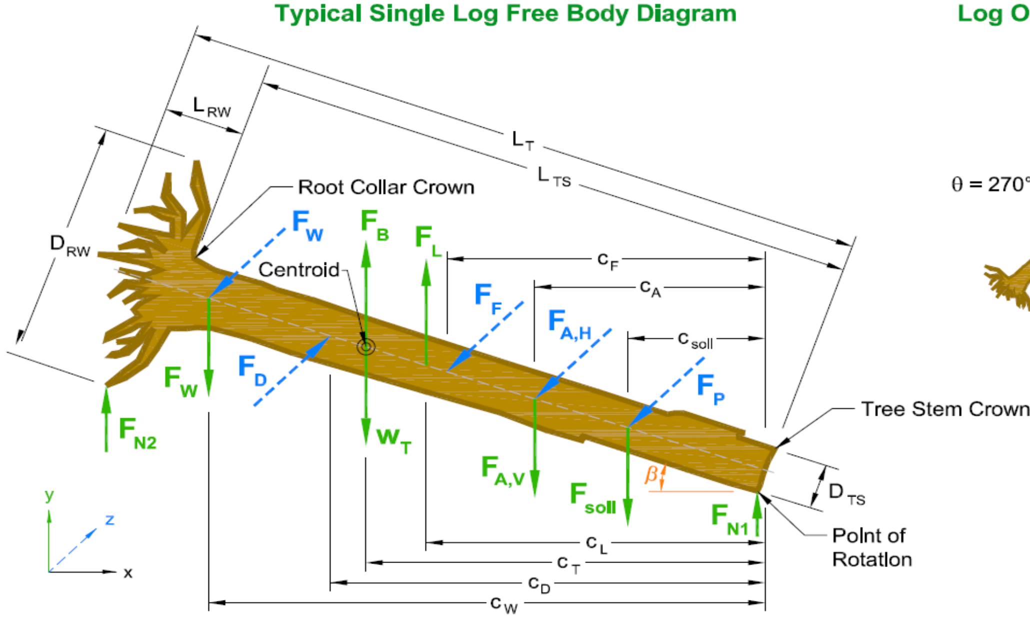


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Coast	Yes	90.0	1.50	2.25	4.50	33.5	38.0

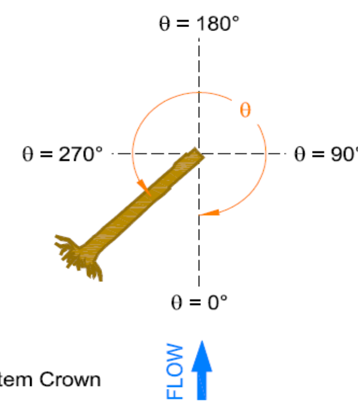
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	270.0	3.0	Rootwad: Crown	110.00	6.55	2.06	9.76	17.49

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Medium gravel	121.9	75.9	36.0	5	0.00	0.00	0.00
Bank	Coarse sand, loose	98.0	61.0	31.0	6	0.00	0.00	0.00

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Iron Gate Rootwad Key Log Log ID 1 Page 2

Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	138.4	4.0	142.4	4,777	0
↓WS↑Thw	16.6	9.8	26.4	887	1,650
↓Thalweg	0.0	0.0	0.0	0	0
Total	155.1	13.8	168.9	5,664	1,650

Lift Force

C_{LT}	0.23
F_L (lbf)	323

Vertical Force Balance

F_B (lbf)	1,650	↑
F_L (lbf)	323	↑
W_T (lbf)	5,664	↓
F_{soil} (lbf)	0	
$F_{W,V}$ (lbf)	0	
$F_{A,V}$ (lbf)	0	
ΣF_V (lbf)	3,691	↓
FS_V	2.87	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	0.0	0.0	0
Total	0.0	0.0	0.0	0

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.05	1.31	1.10	0.00	1.22	1,715

Horizontal Force Balance

F_D (lbf)	1,715	→
F_P (lbf)	0	
F_F (lbf)	2,682	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
ΣF_H (lbf)	967	←
FS_H	1.56	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	3.85	0	2.00	0.73	2,682
Bank	3.12	0	0.00	0.60	0
Total	-	0	2.00	-	2,682

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
47.6	77.2	77.2	47.6	0.0	90.0	0.0

*Distances are from the stem tip

Point of Rotation: Rootwad

Moment Force Balance

M_d (lbf)	95,987	
M_r (lbf)	239,969	
FS_M	2.50	✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Klamath Dam Removal - 60% Design
Notation, Units, and List of Symbols

Notation

Symbol	Description	Unit
A_W	Wetted area of channel at design discharge	ft^2
A_{Tp}	Projected area of wood in plane perpendicular to flow	ft^2
c_D	Centroid of the drag force along log axis	ft
c_{Am}	Centroid of a mechanical anchor along log axis	ft
c_{Ar}	Centroid of a ballast boulder along log axis	ft
c_{Asoil}	Centroid of the added ballast soil along log axis	ft
$c_{F\&N}$	Centroid of friction and normal forces along log axis	ft
c_L	Centroid of the lift force along log axis	ft
c_P	Centroid of the passive soil force along log axis	ft
c_{soil}	Centroid of the vertical soil forces along log axis	ft
$c_{T,B}$	Centroid of the buoyancy force along log axis	ft
$c_{T,W}$	Centroid of the log volume along log axis	ft
c_{WI}	Centroid of a wood interaction force along log axis	ft
C_{Lrock}	Coefficient of lift for submerged boulder	-
C_{LT}	Effective coefficient of lift for submerged tree	-
C_{Di}	Base coefficient of drag for tree, before adjustments	-
C_D*	Effective coefficient of drag for submerged tree	-
C_{Di}	Base coefficient of drag for tree, before adjustments	-
C_W	Wave drag coefficient of submerged tree	-
$d_{b,avg}$	Average buried depth of log	ft
$d_{b,max}$	Maximum buried depth of log	ft
d_w	Maximum flow depth at design discharge in reach	ft
D_{50}	Median grain size in millimeters (SI units)	mm
D_r	Equivalent diameter of boulder	ft
D_{RW}	Assumed diameter of rootwad	ft
D_{TS}	Nominal diameter of tree stem (DBH)	ft
DF_{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-
e	Void ratio of soils	-
$F_{A,H}$	Total horizontal load capacity of anchor techniques	lbf
$F_{A,HP}$	Passive soil pressure applied to log from soil ballast	lbf
$F_{A,Hr}$	Horizontal resisting force on log from boulder	lbf
F_{Am}	Load capacity of mechanical anchor	lbf
$F_{A,V}$	Total vertical load capacity of anchor techniques	lbf
$F_{A,Vr}$	Vertical resisting force on log from boulder	lbf
$F_{A,Vsoil}$	Vertical soil loading on log from added ballast soil	lbf
F_B	Buoyant force applied to log	lbf
F_D	Drag forces applied to log	lbf
$F_{D,r}$	Drag forces applied to boulder	lbf
F_F	Friction force applied to log	lbf
F_H	Resultant horizontal force applied to log	lbf
F_L	Lift force applied to log	lbf
$F_{L,r}$	Lift force applied to boulder	lbf
F_P	Passive soil pressure force applied to log	lbf
F_{soil}	Vertical soil loading on log	lbf
$F_{W,H}$	Horizontal forces from interactions with other logs	lbf
$F_{W,V}$	Vertical forces from interactions with other logs	lbf

Notation (continued)

Symbol	Description	Unit
F_V	Resultant vertical force applied to log	lbf
Fr_L	Log Froude number	-
FS_V	Factor of Safety for Vertical Force Balance	-
FS_H	Factor of Safety for Horizontal Force Balance	-
FS_M	Factor of Safety for Moment Force Balance	-
g	Gravitational acceleration constant	ft/s^2
K_P	Coefficient of Passive Earth Pressure	-
$L_{T,em}$	Total embedded length of log	ft
L_{RW}	Assumed length of rootwad	ft
L_T	Total length of tree (including rootwad)	ft
L_{Tf}	Length of log in contact with bed or banks	ft
L_{TS}	Length of tree stem (not including rootwad)	ft
$L_{TS,ex}$	Exposed length of tree stem	ft
LF_{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-
M_d	Driving moment about embedded tip	lbf
M_r	Driving moment about embedded tip	lbf
N	Blow count of standard penetration test	-
p_o	Porosity of soil volume	-
Q_{des}	Design discharge	cfs
R	Radius	ft
R_c	Radius of curvature at channel centerline	ft
SG_r	Specific gravity of quartz particles	-
SG_T	Specific gravity of tree	-
u_{avg}	Average velocity of cross section in reach	ft/s
u_{des}	Design velocity	ft/s
u_m	Adjusted velocity at outer meander bend	ft/s
V_{dry}	Volume of soils above stage level of design flow	ft^3
V_{sat}	Volume of soils below stage level of design flow	ft^3
V_{soil}	Total volume of soils over log	ft^3
V_{RW}	Volume of rootwad	ft^3
V_S	Volume of solids in soil (void ratio calculation)	ft^3
V_T	Total volume of log	ft^3
V_{TS}	Total volume of tree	ft^3
V_V	Volume of voids in soil	ft^3
V_{Adry}	Volume of ballast above stage of design flow	ft^3
V_{Awet}	Volume of ballast below stage of design flow	ft^3
$V_{r,dry}$	Volume of boulder above stage of design flow	ft^3
$V_{r,wet}$	Volume of boulder below stage of design flow	ft^3
W_{BF}	Bankfull width at structure site	ft
W_r	Effective weight of boulder	lbf
W_T	Total log weight	lbf
x	Horizontal coordinate (distance)	ft
y	Vertical coordinate (elevation)	ft
$y_{T,max}$	Minimum elevation of log	ft
$y_{T,min}$	Maximum elevation of log	ft

Greek Symbols

Symbol	Description	Unit
β	Tilt angle from stem tip to vertical	deg
γ_{bank}	Dry specific weight of bank soils	lb/ft^3
$\gamma_{bank,sat}$	Saturated unit weight of bank soils	lb/ft^3
γ'_{bank}	Effective buoyant unit weight of bank soils	lb/ft^3
γ_{bed}	Dry specific weight of stream bed substrate	lb/ft^3
γ'_{bed}	Effective buoyant unit weight of stream bed substrate	lb/ft^3
γ_{rock}	Dry unit weight of boulders	lb/ft^3
γ_s	Dry specific weight of soil	lb/ft^3
γ'_s	Effective buoyant unit weight of soil	lb/ft^3
γ_{Td}	Air-dried unit weight of tree (12% MC basis)	lb/ft^3
γ_{Tgr}	Green unit weight of tree	lb/ft^3
γ_w	Specific weight of water at 50ºF	lb/ft^3
η	Rootwad porosity	-
θ	Rootwad (or large end of log) orientation to flow	deg
μ	Coefficient of friction	-
ν	Kinematic viscosity of water at 50ºF	ft/s^2
Σ	Sum of forces	-
ϕ_{bank}	Internal friction angle of bank soils	deg
ϕ_{bed}	Internal friction angle of stream bed substrate	deg

Units

Notation	Description
cfs	Cubic feet per second
ft	Feet
lb	Pound
lbf	Pounds force
kg	Kilograms
m	Meters
mm	Millimeters
s	Seconds
yr	Year

Abbreviations

Notation	Description
ARI	Average return interval
Avg	Average
DBH	Diameter at breast height
deg	Degrees
Dia	Diameter
Dist	Distance
D/S	Downstream
ELJ	Engineered log jam
Ex	Example
Fldpln	Floodplain
H&H	Hydrologic and hydraulic
ID	Identification
i.e.	That is
LB	Left bank
LW	Large wood
Max	Maximum
MC	Moisture content
Min	Minimum
ML	Multi-log
SL	Single log
N/A	Not applicable
no	Number
Pt	Point
rad	Radians
RB	Right bank
RW	Rootwad
SL	Single log
Thw	Thalweg (lowest elevation in channel bed)
Typ	Typical
U.S.	United States
WS	Water surface
WSE	Water surface elevation
↑	Above
↓	Below

LARGE WOOD STABILITY CALCULATIONS SCENARIO 2 (DOUBLE LOG IN COMBINATION – PARTIALLY BURRIED 35 FT. LONG / 20” DIA. GROUND PLACED)

SUMMARY SHEET - LARGE WOOD STABILITY CALCULATIONS			Version 3.0 - updated 2-17	
PROJECT	Klamath Dam Removal			DATE
STRUCTURE TYPE	Multiple Log (Ground Placed)	ANALYSTS	DJB	2/3/2020
RIVER & REACH	Jenny Creek (Tributary)		-	-
SPREADSHEET DEVELOPER	Bureau of Reclamation/Yurok Tribe	REVIEWER	Yurok Tribe	2/3/2020
PUBLIC SAFETY RISK	Low			
PROPERY DAMAGE RISK	Low			
DESIGN FLOW	4,000 cfs			
DESIGN FLOW RETURN INTERVAL	10-year			
STRUCTURE PURPOSE	Habitat			

RESULTS SUMMARY

	Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	FOS sliding	FOS bouyancy	FOS rotation[2]	FOS overturning[2]	FOS Pile Breakage	FOS Pile Overturning
MINIMUM FACTOR OF SAFETY[1]	Low	Low	10-year	1.25	1.5	1.25	1.25	1.5	1.5
PROPOSED FACTOR OF SAFETY	Low	Low	10-year	1.3	1.5	1.72	N/A	N/A	N/A
FACTOR OF SAFETY CHECK			OK	OK	OK	OK	OK	OK	OK

Notes

[1] minimum factor of safety from Table 4, Large Woody Material - Risk Based Design Guidelines, Sep 2014

[2] Structure failure by rotation or overturning not applicable to: (a) mid-channel structures, or (b) structures not embedded in the bank.

STRUCTURE & HYDRAULICS - LARGE WOOD STABILITY CALCULATIONS						Version 3.0 - updated 2-17	
PROJECT	Klamath Dam Removal						DATE
STRUCTURE	Multiple Log (Ground Placed)				ANALYSTS	DJB	2/3/2020
RIVER & REACH	Jenny Creek (Tributary)						
					REVIEWER	Yurok Tribe	2/3/2020
HYDRAULIC INPUT							
FLOW		4,000	CFS				
RETURN INTERVAL		10-year	Note - Assume 2 Year				
				Notes (RM, model source etc.)			
UPSTREAM CONDITIONS							
LOCATION			**Jenny Creek - At Placement**				
APPROACH VELOCITY	Vchannel =	9.1	fps	From SRH-2D Hydraulic Model			
CHANNEL WIDTH		95.0	ft	From SRH-2D Hydraulic Model			
WATER SURFACE EL		2321.9	ft	From SRH-2D Hydraulic Model			
CHANNEL EL		2317.0	ft	From SRH-2D Hydraulic Model			
FLOW DEPTH (AVG)	Yu =	4.9	ft				
CROSS-SECTIONAL AREA	Au =	465.5	sf				
AT-STRUCTURE CONDITIONS							
LOCATION			**Jenny Creek - At Placement**				
VELOCITY AT STRUCTURE	Vc (Uc) =	9.1	fps	From SRH-2D Hydraulic Model			
WATER SURFACE EL		2321.9	ft	From SRH-2D Hydraulic Model			
CHANNEL EL		2317.0	ft	From SRH-2D Hydraulic Model			
SCOUR DEPTH	Ys =	0.0	ft				
SCOUR EL		2317.0	ft				
FLOW DEPTH (AVG)	Yc =	4.9	ft				
CONTRACTED CHANNEL WIDTH		95.0	ft	From SRH-2D Hydraulic Model			
AREA OF CONTRACTED FLOW	Ac =	465.5	sf				
DOWNSTREAM CONDITIONS							
LOCATION			**Jenny Creek - At Placement**				
WATER SURFACE EL		2321.9	ft	From SRH-2D Hydraulic Model			
CHANNEL EL		2317.0	ft	From SRH-2D Hydraulic Model			
FLOW DEPTH	Yd =	4.9	ft				
CHANNEL WIDTH		95.0	ft				
CROSS-SECTIONAL AREA	Ad =	465.5	sf				
STRUCTURE DIMENSIONS							
STRUCTURE UPSTREAM FACE TOP EL		2321.0	ft				
STRUCTURE CHANNEL EL		2317.0	ft				
STRUCTURE UPSTREAM FACE HEIGHT		4.0	ft				
STRUCTURE UPSTREAM WIDTH		10.0	ft	Distance of Rottwad from Bank (Typical)			
STRUCTURE UPSTREAM FACE AREA		40	sf				
OBSTRUCTED AREA	ALWM =	40	sf				
STRUCTURE LENGTH		15.0	ft				
TOTAL NUMBER OF PILES/POSTS	Npiles =	0.0		No Piles			
PILE/POST BOTTOM EL		2317.0	ft	Set Equal to cell E41 - Bottom El. of Structure			
PILE/POST LENGTH (INCL ROOTWAD IF APPLIC.)		0.0	ft	Set in order to keep Cell E50 at Zero			
PRE-SCOUR EMBEDDED LENGTH OF PILES	Tlpile =	0.0	ft	total embedded length, disregarding scour			
PILE/POST TOP EL		2317.0	ft				
STRUCTURAL FILL TOP EL		2320.5	ft	Approximately 3 Feet of Ballast			
STRUCTURAL FILL DEPTH		3.5	ft				

PUBLIC VERSION

BOUYANCY, LIFT & PILE FRICTION - LARGE WOOD STABILITY CALCULATIONS					
				Version 3.0 - updated 2-17	
PROJECT	Klamath Dam Removal			DATE	
STRUCTURE	Multiple Log (Ground Placed)	ANALYSTS	DJB	2/3/2020	
RIVER & REACH	Jenny Creek (Tributary)		-	-	
		REVIEWER	Yurok Tribe	2/3/2020	

LARGE WOOD MATERIAL FORCE

STRUCTURAL MEMBERS

UNIT WEIGHT OF WATER	$\gamma_w =$	62.4	lbs/ft^3
GRAVITATIONAL ACCELERATION	g =	32.2	ft/s2
SPECIES OF LARGE WOOD	DOUGLAS FIR	- COASTAL	
DRY UNIT WEIGHT OF WOOD	$\gamma_{wood} =$	34.0	lbs/ft^3
ROOTWAD POROSITY	$\eta_p =$	20%	
ROOTWAD DIAMETER	$D_{RW} =$	3.5	ft
ROOTWAD LENGTH	$L_{RW} =$	3	ft
LOG TAPER (Inches per 10 ft)		1	in

PILES / ROOTWAD POSTS

SPECIES OF LARGE WOOD	DOUGLAS FIR	- COASTAL	
DRY UNIT WEIGHT OF WOOD	$\gamma_{wood} =$	34.0	lbs/ft^3
ROOTWAD POROSITY	$\eta_p =$	20%	
ROOTWAD DIAMETER	$D_{RWp} =$	3.5	ft
ROOTWAD LENGTH	$L_{RW} =$	3	ft
LOG TAPER (Inches per 10 ft)		1	in

Log Type	No. Logs	Piece Length	Diam (DBH)	Diam (avg)	Rootwad	Log Length	Vol log (ea)	Rootwad vol	Log & Rootwad vol	Total Log Vol	Total Weight	submerged	VLWMs submerged volume of LWM	VLWMd Dry volume of LWM
	ea	ft	in	in	-	ft	cf	cf	cf	cf	lbs	%	cf	cf
NO PILES	0	0	0	0.0	NO	0	0.0	0.0	0.0	0	0	0%	0	0
Layer-1: Rootwad Log - Ground Placed	1	35	20	18.8	YES	32	61.3	12.9	74	74	2,523	100%	74	0
Layer-2: Rootwad Log - Ground Placed	1	35	20	18.8	YES	32	61.3	12.9	74	74	2,523	100%	74	0
				0.0	NO	0	0.0	0.0	0	0	0	100%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	100%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	100%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	100%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	100%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	100%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	100%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	0%	0	0
				0.0	NO	0	0.0	0.0	0	0	0	0%	0	0
TOTAL	2									**148**	**5,046**		**148**	**0**

LARGE WOOD MATERIAL FORCE SUBMERGED	**FLWMs**	**(4,219)**	**lbs**
LARGE WOOD MATERIAL FORCE DRY	**FLWMd**	**-**	**lbs**

LIFT FORCE

LIFT COEFFICIENT	CL =	0.2	Range 0.1 - 0.2
AREA OF LARGE WOODY MATERIAL PERPENDICULAR TO FLOW	ALWM =	40	ft^2
UPSTREAM CHANNEL VELOCITY AT DESIGN EVENT	Uu =	9.1	ft/sec
LIFT FORCE	**FL =**	**(642)**	**lbs**

BALLAST - LARGE WOOD STABILITY CALCULATIONS								Version 3.0 - updated 2-17
PROJECT	Klamath Dam Removal							DATE
STRUCTURE	Multiple Log (Ground Placed)					ANALYSTS	DJB	2/3/2020
RIVER & REACH	Jenny Creek (Tributary)						-	-
						REVIEWER	Yurok Tribe	2/3/2020
SOIL BACKFILL								
TYPE					MEDIUM GRAVEL			
DRY UNIT WEIGHT OF SOILS				γ_{soil} =	120	lbs/cf		
SOIL SPECIFIC GRAVITY				SG =	2.65			
HEIGHT OF SUBMERGED SOIL ABOVE LOG				hsoilsub =	3	ft		
HEIGHT OF DRY SOIL ABOVE LOG				hsoildry =	0	ft		
VOID RATIO OF SOILS				e=	0.38			
SATURATED UNIT WEIGHT OF SOILS				γ_{sat} =	137	lbs/cf		
EFFECTIVE BOUYANT UNIT WEIGHT OF SOILS				γ'_{soil} =	75	lbs/cf		
BURIED LOG SCHEDULE								
Log Type	No. Logs	Piece Length	Diam (avg)	Total Area	Embedded	Embedded Area	Embedded Area normal to flow	Embedded Normal Area
	ea	ft	in	sf	%	sf	%	sf
NO PILES	0.01	0	0	0	0%	0	0%	0
Layer-1: Rootwad Log - Ground Placed	1	35	18.75	55	10%	5	90%	5
Layer-2: Rootwad Log - Ground Placed	1	35	18.75	55	50%	27	50%	14
0	0	0	0	0		0		0
0	0	0	0	0		0		0
0	0	0	0	0		0		0
0	0	0	0	0		0		0
0	0	0	0	0		0		0
0	0	0	0	0		0		0
0	0	0	0	0		0		0
0	0	0	0	0		0		0
0	0	0	0	0		0		0
AREA OF EMBEDDED LWM					**ALWMe =**	**33**	**ALWMen =**	**19**
VOLUME OF SUBMERGED BOULDERS ABOVE LOG					Vbouldersub =	-	cf	
VOLUME OF DRY BOULDERS ABOVE LOG					Vboulderdry =	-	cf	
VOLUME OF SUBMERGED SOIL ABOVE LOG					Vsoilsub =	98	cf	Vbouldersub d
VOLUME OF DRY SOIL ABOVE LOG					Vsoildry =	-	cf	Vboulderdry d
SOIL BACKFILL FORCE TOTAL					**Fsoil =**	**7,355**	**lbs**	
TOTAL BOUYANT FORCE						Bouyant Forces	Ballast Forces	
FORCE OF LARGE WOODY MATERIAL SUBMERGED					FLWMs =	(4,219)		lbs
FORCE OF LARGE WOODY MATERIAL DRY					FLWMd =		-	lbs
FORCE OF LIFT					FL =	(642)		lbs
FORCE OF BOULDERS					Fboulder =		-	lbs
FORCE OF DOLOSSE					Fdolo =		-	lbs
FORCE OF SOIL					Fsoil =		7,355	lbs
FORCE OF PILES SKIN FRICTION					Fpiles-v =		-	lbs
FORCE OF ROOTWAD POST SOIL COLUMN SKIN FRICTION					Fpost-v=		-	lbs
FORCE OF ROOT WAD POST PULLOUT					Fpost-p =		-	lbs
						(4,861)	7,355	
				Sum of Bouyant Forces		(4,861)	lbs	
				Sum of Ballast Forces		7,355	lbs	
TOTAL BOUYANT FORCE					**Fb =**	**2,494**	**lbs**	
BOUYANCY FACTOR OF SAFETY					**FOSb =**	**1.51**		

DRAG, HYDROSTATIC AND IMPACT - LARGE WOOD STABILITY CALCULATIONS								Version 3.0 - updated 2-17			
PROJECT	Klamath Dam Removal							DATE			
STRUCTURE	Multiple Log (Ground Placed)					ANALYSTS	DJB	2/3/2020			
RIVER & REACH	Jenny Creek (Tributary)						-	-			
						REVIEWER	Yurok Tribe	2/3/2020			
DRAG FORCE											
FLOW AREA BLOCKED BY STRUCTURE				ALWM =	40	sf					
AREA OF CONTRACTED FLOW				Ac =	466	sf					
CONTRACTED FLOW VELOCITY				Vc (Uc) =	9.1	fps					
DEPTH IN CONTRACTED AREA (AVG)				Yc =	4.9	ft					
OBSTRUCTION RATIO				B =	0.08						
CONTRACTED FLOW FROUDE NUMBER				Frc =	0.72						
DRAG COEFFICIENT				Cd =	1.15						
DRAG FORCE				**Fd =**	**3,695**	**lbs**					
HYDROSTATIC FORCES											
UPSTREAM HYDROSTATIC FORCE				**Fhu =**	**4,283**	**lbs**					
DOWNSTREAM HYDROSTATIC FORCE				**Fhd =**	**(4,283)**	**lbs**					
NET HYDROSTATIC FORCE				**Fhn =**	**-**	**lbs**					
IMPACT FORCE											
PUBLIC SAFETY RISK					Low						
PROPERTY DAMAGE RISK					Low						
COEFFICIENT OF IMPORTANCE				Ci =	0.5						
WATER VELOCITY IN CHANNEL				Vchannel =	9.1	fps					
TIME FROM INITIAL TO ZERO VELOCITY				Δt =	0.03	sec					
COEFFICIENT OF ORIENTATION				Co =	0.08						
RESPONSE RATIO FOR IMPULSIVE LOADS				Rmax =	0.8						
UPSTREAM FLOW DEPTH					4.9	ft					
UPSTREAM CHANNEL WIDTH					95	ft					
COEFFICIENT OF DEPTH				Cd =	0.975						
COEFFICIENT OF BLOCKAGE				Cb =	1						
WEIGHT OF DEBRIS											
SPECIES OF LARGE WOOD				DOUGLAS FIR - COASTAL							
WET UNIT WEIGHT OF WOOD				γ_{wood} =	38.0	lbs/ft^3					
ROOTWAD POROSITY				η_p =	20%						
ROOTWAD DIAMETER				D_{RW} =	3.5	ft					
ROOTWAD LENGTH				L_{RW} =	2	ft					
LOG TAPER (Inches per 10 ft)					1	in					
Log Type	No. Logs	Piece Length	Diam (DBH)	Diam (avg)	Rootwad	Log Length	Vol log (ea)	Rootwad vol	Log & Rootwad vol	Total Log Vol	Total Weight
	ea	ft	in	in	-	ft	cf	cf	cf	cf	lbs
DEBRIS	2	20	20	19.5	Y	18	37.3	8.6	45.9	92	3,491
		WEIGHT OF DEBRIS		wdebris =	3,491	lbs					
IMPACT FORCE				**Fi =**	**1,611**	**lbs**					

FRICTION, PASSIVE & LATERAL RESISTANCE - LARGE WOOD STABILITY CALCULATIONS					Version 3.0 - updated 2-17
PROJECT	Klamath Dam Removal				DATE
STRUCTURE	Multiple Log (Ground Placed)	ANALYSTS	DJB		2/3/2020
RIVER & REACH	Jenny Creek (Tributary)		-		-
		REVIEWER	Yurok Tribe		2/3/2020
FRICTION FORCE					
INTERNAL ANGLE OF FRICTION OF SOILS	ϕ =	32	degrees		
INTERNAL ANGLE OF FRICTION OF SOILS	ϕ =	0.56	radians		
COEFFICIENT OF FRICTION OF BED	μbed =	0.62			
TOTAL BOUYANT AND BALLAST FORCES		Bouyant Forces	Ballast Forces		
FORCE OF LARGE WOODY MATERIAL SUBMERGED	FLWMs =	(4,219)	-	lbs	
FORCE OF LARGE WOODY MATERIAL DRY	FLWMd =	-	-	lbs	
FORCE OF LIFT	FL =	(642)	-	lbs	
FORCE OF BOULDERS	Fboulder =	-	-	lbs	
FORCE OF DOLOSSE	Fdolo =	-	-	lbs	
FORCE OF SOIL	Fsoil =	-	7,355	lbs	
FORCE OF PILES SKIN FRICTION	Fpiles-v =	-	-	lbs	
FORCE OF ROOTWAD POST SOIL COLUMN SKIN FRICTION	Fpost-v=	-	-	lbs	
FORCE OF ROOT WAD POST PULLOUT	Fpost-p =	-	-	lbs	
		(4,861)	7,355		
	Sum of Bouyant Forces	(4,861)	lbs		
	Sum of Ballast Forces	7,355	lbs		
TOTAL BOUYANT FORCE	**Fb =**	**2,494**	**lbs**		
FORCE DUE TO FRICTIONAL RESISTANCE	**Ff =**	**(1,558)**	**lbs**		
PASSIVE FORCES					
DRY UNIT WEIGHT OF SOILS	γ_{soil} =	120	lbs/ft^3		
SATURATED UNIT WEIGHT OF SOILS	γ_{sat} =	137	lbs/ft^3		
UNIT WEIGHT OF WATER	γ_{w} =	62.4	lbs/ft^3		
HEIGHT OF SUBMERGED SOIL ABOVE LOG	Dsubi =	3	ft		
HEIGHT OF DRY SOIL ABOVE LOG	Ddryi =	0	ft		
AREA OF EMBEDDED LWM NORMAL TO FLOW	ALWMeN =	19	ft^2		
UNIT RESISTANCE AGAINST SLIDING	σvi =	224	lb/ft^2		
COEFFICIENT OF PASSIVE EARTH PRESSURE	Kp =	3.25			
PASSIVE FORCE	**Fpassive =**	**(6,782)**	**lbs**		
LATERAL RESISTANCE FROM PILES					
NUMBER OF PILES	Npiles =	0.01			
EMBEDDED LENGTH OF PILES BELOW SCOUR DEPTH	Lpile =	0	ft		
EFFECTIVE UNIT WEIGHT OF SOIL	γ_{e} =	57.6	lbs/ft^3		
PILE DIAMETER (AVERAGE)	dpile =	0.0	ft		
HEIGHT ABOVE SCOUR DEPTH LOAD IS APPLIED	hload =	2.5	ft		
LATERAL RESISTANCE FROM PILES	**Fpiles-h =**	**-**	**lbs**		
TOTAL SLIDING FORCE					
DRAG FORCE	**Fd =**	3,695	lbs		
UPSTREAM HYDROSTATIC FORCE	**Fhu =**	4,283	lbs		
IMPACT FORCE	**Fi =**	1,611	lbs		
LATERAL RESISTANCE FROM PILES	**Fpiles-h =**	-	lbs		
DOWNSTREAM HYDROSTATIC FORCE	**Fhd =**	(4,283)	lbs		
FORCE DUE TO FRICTIONAL RESISTANCE	**Ff =**	(1,558)	lbs		
PASSIVE FORCE	**Fpassive =**	(6,782)	lbs		
SUM OF DRIVING MOMENTS		9,589	lbs		
SUM OF RESISTING MOMENTS		(12,623)	lbs		
FACTOR OF SAFETY FOR SLIDING	**FOSsliding =**	1.32			

ROTATION, OVERTURNING - LARGE WOOD STABILITY CALCULATIONS		Version 3.0 - updated 2-17		
PROJECT	Klamath Dam Removal		DATE	
STRUCTURE	Multiple Log (Ground Placed) ANALYSTS	DJB	2/3/2020	
RIVER & REACH	Jenny Creek (Tributary)	-		
	REVIEWER	Yurok Tribe	2/3/2020	
RESISTANCE TO ROTATION				
ROTATION SCREENING: IS ROTATION FORCE APPROPRIATE FOR THIS STRUCTURE?			YES	
POINT OF ROTATION LOCATION			10	
EMBEDDED LENGTH OF WOOD STRUCTURE		Lebp =	10	ft
NUMBER OF PILES		Npiles =	0.0	
LENGTH OF STRUCTURE FROM TIP TO ROTATION POINT		Lsp =	-5.1	ft
DISTANCE FROM PILE i TO POINT OF ROTATION		Lphi =	10	ft
IMPACT FORCE		Fi =	1,611	lbs
DRAG FORCE		Fd =	3,695	lbs
UPSTREAM HYDROSTATIC FORCE		Fhu =	4,283	lbs
DOWNSTREAM HYDROSTATIC FORCE		Fhd =	(4,283)	lbs
PASSIVE FORCE		Fpassive =	(6,782)	lbs
LATERAL RESISTANCE FROM PILES		Fpiles-h =	-	lbs
FORCE DUE TO FRICTIONAL RESISTANCE		Ff =	(1,558)	lbs
SUM OF DRIVING MOMENTS		MDrotation =	23,492	ft-lbs
SUM OF RESISTING MOMENTS		MRrotation =	40,430	ft-lbs
FACTOR OF SAFETY FOR ROTATION		**FOSrotation =**	**1.72**	
RESISTANCE TO OVERTURNING				
DEPTH FROM CHANNEL BOTTOM TO POINT OF ROTATION		dubury =	2.45	ft
LENGTH OF STRUCTURE		Ls =	15	ft
DISTANCE FROM PILE I TO POINT OF ROTATION		Lpvi =	10	ft
WATER DEPTH ON UPSTREAM SIDE OF STRUCTURE		Yu =	4.9	ft
WATER DEPTH ON DOWNSTREAM SIDE OF STRUCTURE		Yd =	4.9	ft
LIFT FORCE		FL =	(642)	lbs
TOTAL BOUYANT FORCE		Fb =	2,494	lbs
SUM OF DRIVING MOMENTS		MDoverturn =	57,060	ft-lbs
SUM OF RESISTING MOMENTS		MRoverturn =	42,423	ft-lbs
FACTOR OF SAFETY FOR OVERTURNING		**FOSoverturn =**	**0.74**	

INDEX FACTOR OF SAFETY - Tables 4 & 6, Large Woody Material - Risk Based Design Guidelines, BOR, Sep 2014

INDEX	Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	FOS sliding	FOS bouyancy	FOS rotation	FOS overturning	COEFFICIENT OF IMPORTANCE
HighHigh	High	High	100-year	1.75	2	1.75	1.75	1
HighModerate	High	Moderate	50-year	1.5	1.75	1.5	1.5	0.9
HighLow	High	Low	25-year	1.5	1.75	1.5	1.5	0.8
LowHigh	Low	High	100-year	1.75	2	1.75	1.75	0.7
LowModerate	Low	Moderate	25-year	1.5	1.75	1.5	1.5	0.6
LowLow	Low	Low	10-year	1.25	1.5	1.25	1.25	0.5

FLOW RETURN INTERVAL	VALUE
10-year	10
25-year	25
50-year	50
100-year	100

		VALUE
MINIMUM	10-year	10
PROPOSED	10-year	10

COEFFICIENT OF DRAG - Eqns 22 - 26, Large Woody Material - Risk Based Design Guidelines, BOR, Sep 2014

		Test Column B	Test Column Frc	INDEX	Cd	OBSTRUCTION RATIO B lower limit	upper limit	CONTRACTED FROUDE NUMBER Frc lower limit	upper limit
Eqn 22	DRAG COEFFICIENT Cd	TRUE	FALSE	TRUEFALSE	1.80	0	0.36	0	0.4
Eqn 23	DRAG COEFFICIENT Cd	TRUE	TRUE	TRUETRUE	1.15	0	0.36	0.4	0.8
Eqn 24	DRAG COEFFICIENT Cd	TRUE	FALSE	TRUEFALSE	1.00	0	0.36	0.8	4
Eqn 25	DRAG COEFFICIENT Cd	FALSE	TRUE	FALSETRUE	2.82	0.36	0.77	0	1
Eqn 26	DRAG COEFFICIENT Cd	FALSE	TRUE	FALSETRUE	1.29	0.77	1	0	1
			GOAL	TRUETRUE	1.15				

COEFFICIENT OF DEPTH - Figure 11, Large Woody Material - Risk Based Design Guidelines, BOR, Sep 2014

	INDEX	Cd	WATER DEPTH (FT) lower limit	upper limit
COEFFICIENT OF DEPTH Cd	FALSE	0.00	0	1
COEFFICIENT OF DEPTH Cd	TRUE	0.98	1	5
COEFFICIENT OF DEPTH Cd	FALSE	1.00	5	
GOAL	TRUE			

COEFFICIENT OF BLOCKAGE - Figure 12, Large Woody Material - Risk Based Design Guidelines, BOR, Sep 2014

	INDEX	Cd	WATER DEPTH (FT) lower limit	upper limit
COEFFICIENT OF BLOCKAGE Cd	FALSE	0.00	0	1
COEFFICIENT OF BLOCKAGE Cd	FALSE	FALSE	1	30
COEFFICIENT OF BLOCKAGE Cd	TRUE	1.00	30	500
GOAL	TRUE			

PILE INSTALLATION TECHNIQUE TO MODIFY COEFFICIENT OF LATERAL EARTH PRESSURE (Ks

TECHNIQUE	Ks Reduction
DRIVEN	1
VIBRATED	1
DRILLED	0.5
EXCAVATED	0.25

ROTATION FORCE SCREENING

YES	1.72
NO	N/A

PILE MATERIAL TYPE & BENDING

TYPE	BENDING (Fb) - PSI	DRY DENSITY lb/cf	
DOUGLAS FIR - COASTAL	2450	34	
PINE -LODGEPOLE	1700	29	
STEEL H-BEAM	5000		NEED TO CONFIRM THIS!

ROOTWAD POST PULLOUT RESISTANCE

YES	0.01
NO	0

BOULDER BALLAST

ON LOGS	1
ROCK COLLARS	0

BOUYANCY - ROOTWAD YES/NO SELECTION

YES
NO

PILE LOCATION

ROW	POSITION
FRONT	RIGHT EDGE
2ND	2ND FROM RIGHT EDGE
3RD	MIDDLE
4TH	2ND FROM LEFT EDGE
BACK	LEFT EDGE

DENSITY		
SPECIES	Wet unit weight (lbs/ft^3)	dry unit weight (12% moisture) (lbs/ft^3)
DOUGLAS FIR - COASTAL	38	34
DOUGLAS FIR - ROCKY MTN	35	30
PINE - LODGPOLE	39	29
PINE - PONDEROSA	45	28
SPRUCE - SITKA	33	28
ALDER - RED	46	28
ASPEN - QUAKING	43	26
COTTONWOOD	58	28
CEDAR - ALASKA	36	31
CEDAR - WESTERN RED	27	23
FIR - GRAND	45	28
FIR - NOBLE	30	26
FIR - PACIFIC SILVER	36	27
HEMLOCK - EASTERN	50	28
HEMLOCK - WESTERN	41	29
LARCH - WESTERN	48	36
PINE - EASTERN WHITE	36	25
REDWOOD	50	28

SUBSTRATE AND SOIL PROPERTIES - Table 5, Large Woody Material - Risk Based Design Guidelines, BOR, Sep 2014

GRAIN SIZE (MM)		SEDIMENT (	AVERAGE D	INTERNAL FRICTION ANGLE		
MIN	MAX		LB/CF	DEGREES	RADIANS	tan 2/3 theta rad
BEDROCK		BEDROCK	165	-		
256	2048	BOULDER	146	42	0.733	0.5317094
128	256	LARGE COB	142	42	0.733	0.5317094
64	128	SMALL COB	137	41	0.716	0.5168755
32	64	VERY COAR	131	40	0.698	0.5022189
16	32	COARSE GR	126	38	0.663	0.4734098
8	16	MEDIUM GR	120	36	0.628	0.4452287
4	8	FINE GRAVI	115	35	0.611	0.4313579
2	4	VERY FINE	109	33	0.576	0.4040262
1	2	VERY COAR	103	32	0.559	0.3905541
0.5	1	COARSE SA	98	31	0.541	0.3772038
0.25	0.5	MEDIUM SA	94	30	0.524	0.3639702
0.125	0.25	FINE SAND	93	30	0.524	0.3639702
0.063	0.125	VERY FINE	92	30	0.524	0.3639702
0.004	0.063	SILT	82	30	0.524	0.3639702
0.0001	0.004	CLAY	78	25	0.436	0.2993803

Source: NAVFAC DM 7.2, Foundation and Earth Structures, U.S. Department of the Navy, 1984. http://www.finesoftware.eu/help/geo5/en/coefficient-of-lateral-earth-pressure-k-01/

Coefficient of lateral earth pressure K

The soil around a driven pile is compressed during construction and the lateral earth pressure of this soil acting on the pile skin is greater than the earth pressure at rest (given by coefficient K_0) and smaller than the maximum earth pressure (passive earth pressure given by coefficient K_p):

$$K_0 < K < K_p$$

Reference values of the coefficient of lateral earth pressure K are listed later in the table. The coefficient of lateral earth pressure K is approximated as follows:

$$\boxed{K = \frac{K_a + K_p + K_0}{3}}$$

where: K_0 - coefficient of earth pressure at rest

$$K_0 = 1 - sin\varphi$$

φ - angle of soil shear resistance

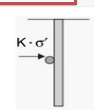
K_p - coefficient of passive earth pressure

$$K_p = tg^2\left(45^\circ + \frac{\varphi}{2}\right)$$

tg = tanger

K_a - coeffiecient of active earth pressure

$$K_a = tg^2\left(45^\circ - \frac{\varphi}{2}\right)$$



Pressure on the pile

Reference values of the lateral earth pressure coefficient K

Type of pile	K for compression piles	K for tensile - uplifted piles
Driven H-piles	0.5 - 1.0	0.3 - 0.5
Driven displacement piles (round and square)	1.0 - 1.5	0.6 - 1.0
Driven displacement tapered piles	1.5 - 2.0	1.0 - 1.3
Driven jetted piles	0.4 - 0.9	0.3 - 0.6
Bored piles (less than 70cm)	0.7	0.4

ϕ =	INTERNAL ANGLE OF FRICTION OF SOILS =	32	degrees
ϕ =	INTERNAL ANGLE OF FRICTION OF SOILS =	0.56	radians
	$(45-(\phi/2))$ =	29	degrees
	$(45-(\phi/2))$ =	0.5	radians
	$(45+(\phi/2))$ =	61	degrees
	$(45+(\phi/2))$ =	1.1	radians
K_o =	Coefficient of Earth Pressure at Rest =	0.5	
K_a =	Coefficient of Rankine's Active Earth Pressure =	0.3	
K_p =	Coefficient of Rankine's Passive Earth Pressure =	3.3	
$K = K_s$ =	Coefficient of Lateral Earth Pressure =	1.3	

Note: Higher K_s = higher lateral earth pressure. Assumption of K_s = 1.25 is conservative.

Table 3-1
Allowable Stress Values for Treated Round Timber Piles Graded in Accordance with ASTM D25

Species	Axial Compression (F_c) (psi)	Bending (F_b) (psi)	Shear Perpendicular to the Grain (F_v) (psi)	Compression Perpendicular to the Grain ($F_{c\perp}$) (psi)	Modulus of Elasticity (E) (psi)
Southern Pine[1]	1200	2400	110	250	1,500,000
Douglas Fir[2]	1250	2450	115	230	1,500,000
Lodgepole Pine	1150	1700	80	270	1,000,000
Red Oak[3]	1100	2450	135	350	1,250,000
Red Pine[4]	900	1900	85	155	1,280,000

1. Southern Pine design values apply to Loblolly, Longleaf, Shortleaf, and Slash Pines.
2. Pacific Coast Douglas Fir design values apply to this species as defined in ASTM D 1760
3. Red Oak design values apply to Northern and Southern Red Oak
4. Red Pine design values apply to Red Pine grown in the United States

Additional Properties for Soil Ballast (DAS)

	Compaction	Average Dr	Low Dr	High Dr
1	Minimum	0	0	0
2	Very Loose	10	0	20
3	Loose	30	20	40
4	Medium	50	40	60
5	Dense	70	60	80
6	Very Dense	90	80	100
7	Maximum	100	100	100

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX N Permit Conditions

PAGE N-1 to N-14

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX O BLM Comments on Definite Plan

PAGE O-1 to O-9

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX P Implementation Schedule (Pending)

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX Q Erosion and Sediment Control

PAGE Q1-1 to Q2-55

CRITICAL ENERGY/ELECTRIC INFRASTRUCTURE INFORMATION (CEII)

REDACTED

APPENDIX R Electrical

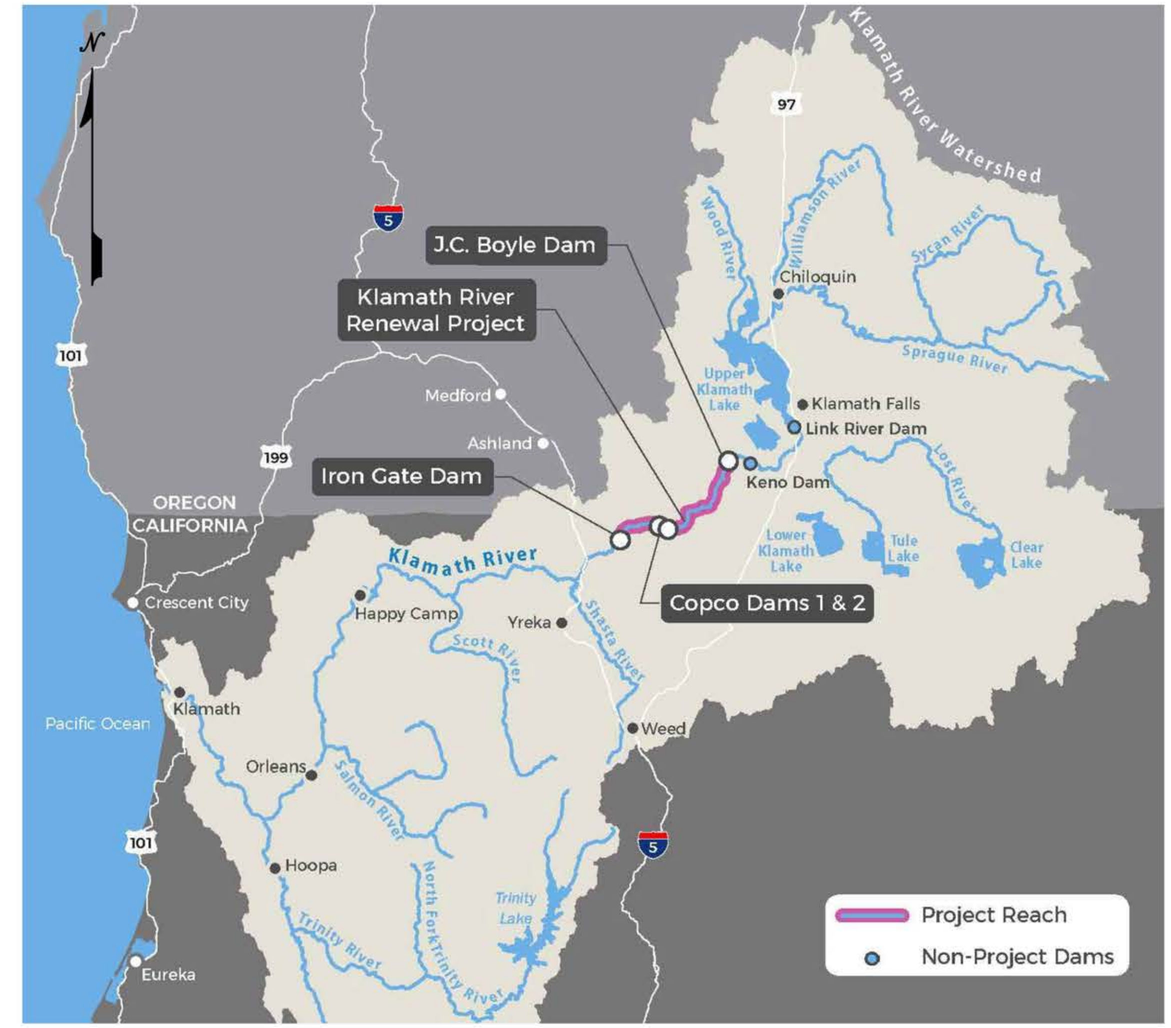
PAGE R1-1 to R3-2

KLAMATH RIVER RENEWAL PROJECT

KIEWIT CONTRACT #104168

60% DESIGN COMPLETION DRAWINGS

JACKSON COUNTY, OREGON
KLAMATH COUNTY, OREGON
SISKIYOU COUNTY, CALIFORNIA



LOCATION MAP

NOT TO SCALE

FOR INFORMATION ONLY

PRELIMINARY DESIGN (NOT FOR CONSTRUCTION)

REV	DESCRIPTION	BY	CHK	APP	DATE
D	ISSUED WITH 60% DESIGN REPORT	CBN	NB	SRM	02/07/20
C	ISSUED WITH DRAFT 60% DESIGN REPORT	CBN	NB	SRM	12/17/19
B	UPDATED FOR 30% DESIGN REPORT	CBN	NB	SRM	10/17/19
A	ISSUED WITH DRAFT 30% DESIGN REPORT	CBN	NB	SRM	08/27/19

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

PREPARED BY: Knight Piésold CONSULTING; Kiewit

DESIGNED	C. NIAMIR
DRAWN	W. LAHODA
REVIEWED	N. BISHOP
IN CHARGE	S. YONG
APPROVED	S. MOTTRAM

PREPARED FOR: KLAMATH RIVER RENEWAL CORPORATION

PROJECT	KLAMATH RIVER RENEWAL PROJECT	PROJ #	VA103-640/1
		DATE	02/07/2020
SHEET TITLE	TITLE SHEET	DWG	G0001

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SHEET NO.	GENERAL
G0001	TITLE SHEET
G0002	INDEX OF DRAWINGS SHEET 1 OF 2
G0003	INDEX OF DRAWINGS SHEET 2 OF 2
G0005	LEGEND, SYMBOLS, AND ABBREVIATIONS
G0006	GENERAL NOTES
G0020	PROJECT LOCATION, VICINITY AND ACCESS
G0030	GENERAL ARRANGEMENT PLAN – KEY MAP
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G0032	J.C. BOYLE FACILITY – GENERAL ARRANGEMENT PLAN – 2 OF 6
G0033	COPCO FACILITIES – GENERAL ARRANGEMENT PLAN – 3 OF 6
G0034	COPCO FACILITIES – GENERAL ARRANGEMENT PLAN – 4 OF 6
G0035	IRON GATE FACILITY – GENERAL ARRANGEMENT PLAN – 5 OF 6
G0036	IRON GATE FACILITY – GENERAL ARRANGEMENT PLAN – 6 OF 6
G0050	EARTHWORKS AND DEMOLITION – MATERIAL SPECIFICATIONS
	CIVIL – J.C. BOYLE FACILITY
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C1002	PROJECT OVERVIEW AND LIMITS OF WORK – SHEET 2 OF 5
C1003	PROJECT OVERVIEW AND LIMITS OF WORK – SHEET 3 OF 5
C1004	PROJECT OVERVIEW AND LIMITS OF WORK – SHEET 4 OF 5
C1005	PROJECT OVERVIEW AND LIMITS OF WORK – SHEET 5 OF 5
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C1051	RESERVOIR DRAWDOWN STAGES – WET YEAR INFLOW – PLAN AND SECTION
C1060	RESERVOIR OPERATIONS – WATER SURFACE ELEVATIONS – PROFILE AND SECTION
C1061	RESERVOIR OPERATIONS – POST-DRAWDOWN HYDRAULIC INFORMATION
C1220	SPILLWAY AND INTAKE – DEMOLITION PLAN AND PROFILE
C1221	SPILLWAY AND INTAKE – DEMOLITION SECTIONS
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C1230	EMBANKMENT – EXCAVATION PLAN
C1231	EMBANKMENT – REMOVAL AND EXCAVATION PROFILE
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C1320	POWER CANAL – CONCRETE REMOVAL PLAN
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C1323	POWER CANAL – TYPICAL ANIMAL CROSSING SECTIONS
C1330	POWER CANAL FOREBAY – DEMOLITION AND GRADING PLAN
C1331	FOREBAY – PROFILE, SECTIONS AND DETAILS
C1332	FOREBAY – FINAL GRADING PLAN
C1333	FOREBAY – FINAL GRADING SECTIONS
C1340	SPILLWAY SCOUR HOLE – OPTION 1 REGRADING PLAN
C1341	SPILLWAY SCOUR HOLE – OPTION 1 REGRADING PROFILE AND SECTIONS
C1342	SPILLWAY SCOUR HOLE – OPTION 2 REGRADING PLAN
C1343	SPILLWAY SCOUR HOLE – OPTION 2 REGRADING PROFILE AND SECTIONS
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C1351	PENSTOCK – DEMOLITION SECTIONS AND DETAILS
C1352	PENSTOCK – TUNNEL OUTLET PORTAL BARRIER SECTION AND DETAILS
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C1510	CONSTRUCTION ACCESS IMPROVEMENTS – LEFT BANK ACCESS ROAD
C1511	CONSTRUCTION ACCESS IMPROVEMENTS – POWERHOUSE ROAD REALIGNMENT
C1512	CONSTRUCTION ACCESS IMPROVEMENTS – PENSTOCK ACCESS ROADS
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C2010	KLAMATH RIVER CHANNEL – PLAN AND PROFILE
C2050	RESERVOIR OPERATIONS – WATER SURFACE ELEVATIONS – SECTIONS
C2060	RESERVOIR OPERATIONS – HYDROLOGY – FIGURES
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C2101	DIVERSION TUNNEL INTAKE STRUCTURE REMOVAL – ELEVATION AND PROFILE
C2160	DIVERSION TUNNEL APPROACH CHANNEL EXCAVATION – PLAN, PROFILE AND SECTION
C2175	DIVERSION TUNNEL PLUG – PLAN AND SECTIONS
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C2201	DRAWDOWN – DAM MODIFICATIONS – PLAN AND SECTION
C2205	PRE-DRAWDOWN DAM MODIFICATIONS – GENERAL ARRANGEMENT – PROFILES AND SECTION
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C2211	FINAL RIVER CHANNEL GRADING – CROSS SECTIONS
C2215	PRE-DRAWDOWN APPROACH CHANNEL EXCAVATION – PLAN ANS SECTIONS

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C2350	PENSTOCK NO. 3 TUNNEL PORTAL BARRIER – SECTIONS AND ELEVATION
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C2410	POWERHOUSE REMOVAL – FINAL GRADE – PLAN
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C2503	PHASE 3 – RIGHT BANK ACCESS TRACK – PLAN, PROFILE AND TYPICAL SECTION
C2505	PHASE 1 TO PHASE 3 ACCESS TRACKS – CROSS SECTIONS
C2510	RIGHT BANK ACCESS ROADS – PLAN
C2511	RIGHT BANK ACCESS ROADS – PROFILES AND TYPICAL SECTIONS
C2550	POWERHOUSE BRIDGE – PLAN, PROFILE AND CROSS SECTIONS
C2551	POWERHOUSE BRIDGE – PLAN AND SECTION
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C3002	PROJECT OVERVIEW AND LIMITS OF WORK – SHEET 2 OF 4
C3003	PROJECT OVERVIEW AND LIMITS OF WORK – SHEET 3 OF 4
C3004	PROJECT OVERVIEW AND LIMITS OF WORK – SHEET 4 OF 4
C3060	RESERVOIR OPERATIONS – WATER SURFACE ELEVATIONS – SECTIONS
C3061	RESERVOIR OPERATIONS – POST DRAWDOWN – HYDRAULIC INFORMATION – FIGURES AND TABLE
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C3201	DIVERSION DAM AND INTAKE GENERAL REMOVAL ARRANGEMENT – SECTIONS
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C3210	DIVERSION DAM PRE-DRAWDOWN REMOVAL – PLAN
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C3216	DIVERSION DAM DRAWDOWN REMOVAL – PLAN

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A	ISSUED WITH DRAFT 30% DESIGN REPORT	CBN	NB	SRM	08/27/19

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PROJECT
KLAMATH RIVER RENEWAL PROJECT

SHEET TITLE
INDEX OF DRAWINGS
SHEET 1 OF 2

PROJ # VA103-640/1
DATE 02/07/2020
DWG G0002

mcclellan Feb 07, 2020 - 1:35pm
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SHEET TITLE
INDEX OF DRAWINGS
SHEET 2 OF 2

PROJ # VA103-640/1
DATE 02/07/2020
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