Appendix G1

Lassen Hydrology and Hydraulics Technical Study

MEMORANDUM

To:	Golden State Finance Authority
From:	Dudek
Subject:	Hydrology and Hydraulics Report, Forest Resiliency Demonstration Project, Lassen County, California
Date:	July 18, 2024
cc:	
Attachment(s):	Figures Appendix A – FEMA Flood Insurance Rate Map Appendix B – NOAA Rainfall Data

1 Introduction

1.1 Background

The Golden State Natural Resources Forest Resiliency Demonstration Project (proposed project) is a response to the growing rate of wildfires in California, which has been exacerbated by hazardous excess fuel loads in forests, and the need to promote economic activity with California's rural counties. The project serves as an opportunity to begin restoring California forests and watersheds to a natural and resilient status and provide overall benefit to the state by sustainably procuring and processing excess biomass into a pelletized fuel source for renewable energy generation.

1.2 Report Objectives

This report (Report) focuses only on the Northern California processing facility portion of the proposed project and documents the methods and results of a hydrology and hydraulics study for the proposed project.

The hydrological method used in this Report are described in the United States Geologic Survey (USGS) Scientific Investigations Report 2012-5113, which was prepared in cooperation with the Federal Emergency Management Agency (FEMA). The regression equation described in the Report was used to calculate the peak discharge for 100-year storm event for the proposed project. Hydraulic Engineering Center River Analysis System (HEC-RAS) software was then used to model the peak discharge flood inundation depths and flow velocities within the proposed project site.

The objective of this Report is to:

- Estimate flows for the 100-year storm event through the proposed project site;
- Use estimated flows to assess the hydraulic conditions and inundation areas within the proposed project site for existing and proposed conditions

The analyses in this Report are preliminary in nature. Recommendations found within this Report are not approved and are not for construction purposes; contractors shall refer to the final approved construction documents for construction details.

1.3 Project Location

The proposed Lassen wood pellet processing site is in Nubieber, California (Lassen County), approximately 3 miles southwest of the census-designated place of Bieber in northwestern Lassen County (Figure 1). The proposed project analyzed in this Report would be located on 62-acres of Assessor's Parcel Number (APN) 001-270-80 and approximately 51 acres of the 124-acre parcel immediately south (APN 001-270-026). The project site is situated in Township 38 North, Range 7 East, and Sections 28 and 33 of the U.S. Geological Survey Bieber, California 7.5-minute quadrangle. The proposed project area being evaluated in this Report can be seen in Figure 1. Elevation on the Lassen site is approximately 4,120 feet above mean sea level.

1.4 Project Description

The proposed project would consist of a new wood pellet processing facility, including a woodyard, green processing area, drying area, pellet mill, project storage, and loadout area. New internal roads for truck access and facility personnel access will be added, including a new road for truck access from Babcock Road at the southwest corner of the site. A new rail spur connecting to the adjacent BNSF Railway line would be added for finished product load out as well as additional rail siding tracks on-site for the storage of full and empty railcars. Other improvements would include new truck scales and a graded area for overflow raw material storage.

2 Environmental Setting

The project site was previously part of a sawmill operation and was also used to load logs onto railcars. Under an agreement with Golden State Natural Resources, Sierra Pacific Industries continues to use a portion of the project site for this purpose. The site includes railroad siding, a gravel deck, internal roadways, a well pump house and water tower.

The majority of the undeveloped areas of the project site consist of non-native grassland with a mix of annual grasses and forbs. Mowed agricultural fields are present in the northern portion of the project site. Also included are five earthen ditches, one seasonal wetland swale, and one seasonal wetland. The project site is surrounded by widely scattered rural development and open space, generally also composed of cropland, sagebrush scrub, and wet meadow.

2.1 Surface Water Hydrology

The project site contains one seasonal wetland and one seasonal wetland swale located in the southeastern portion of the project site. These features collect water seasonally and are discernible from the adjacent upland areas by a distinct change in vegetation. The five upland ditches located throughout the project site are unlined, earthen water conveyance systems that were constructed in upland habitat and exhibit a mild break in slope and change in vegetation. Ditches within the project site are generally 5 to 6 feet wide at the top of bank and have an ordinary high water mark width of 1 to 2 feet.

The USGS Watershed Boundary Dataset indicates the Project Site is located the southern portion of the Upper Pit watershed (Figure 2). The watershed is identified by a Hydrologic Unit Code 8 (HUC-8) designation, which signifies the scale of the watershed. The Upper Pit watershed begins in the Warner Mountains of northeast California and flows in a southwesterly direction toward Shasta Lake. Flow gaging on the Pit River at Canby (mid-watershed location, approximately 28 miles northeast of the project site; Figure 2) has been maintained since 1904, and average daily flow at this location is approximately 250 cubic feet per second (cfs). Summer season flows typically range from 0 to 20 cfs with a peak flow of 9,100 cfs in 1986 (SRWP 2023).

The National Hydrography Dataset (NHD) is maintained by the United States Geological Service (USGS 2023) for the purpose of portraying surface waters on a national scale. The NHD is maintained at a broad nationwide level to represent features, such as rivers, streams, canals, lakes, ponds, coastlines, dams, and stream gages. Due to its scale, the NHD provides only an estimate of the waterbodies, is not comprehensive, and may not be accurate. The NHD displays one "canal/ditch" feature flowing through the Project site (Figure 3). Immediately east of the proposed project and the railroad tracks is an unnamed, intermittent "stream/river." Approximately 0.75-miles east of the proposed project boundary is another intermittent "stream/river" named Bull Run Slough. Both of these tributaries flow from north to south in the vicinity of the proposed project and eventually flow into the Pit River, which is categorized as a perennial river. The centerline of the Pit River is displayed approximately 2.9-miles east of the proposed project, but there are several more drainages tributary to the Pit River between Bull Run Slough and the Pit River centerline (Figure 3). Storm runoff emanating from the mountainous areas to the west and southwest also flows in the direction of the lower-elevation proposed project area.

The United States Fish and Wildlife Service (USFWS 2023) maintains the National Wetlands Inventory (NWI) and the NWI Wetlands Mapper, which provide access to wetland data on a national scale. The USFWS created NWI maps by analyzing remote-sensing data and aerial imagery and by drawing polygons around areas that appear to have wetland signatures. Similar to the NHD, the NWI maps are reconnaissance-level information and not a comprehensive database of wetlands. The USFWS NWI Mapper shows a riverine feature flowing through the proposed project and a series of riverine and wetland features immediately surrounding the project area.

2.2 Flood Zones

Federal Emergency Management Agency (FEMA) Flood insurance Rate Maps identify flood zones and areas that are susceptible to 100-year and 500-year floods. Figure 4 shows that the project site is within the 100-year Zone A floodplain. Zone A is defined as a Special Flood Hazard Area with a 1% annual chance of flooding but because no detailed analysis has been performed in this area, no depths or base flood elevation has been determined for this zone (FEMA 2023). The FEMA Flood Insurance Rate Map encompassing this area can be found in Appendix A.

2.3 Rainfall

Rainfall depths for various storm durations and recurrence intervals at the project site were obtained using National Oceanic Atmospheric Administration (NOAA) Atlas 14 precipitation estimates. These depths are provided in Table 1 and shown in Appendix B (NOAA 2023).

Table 1. Rainfall Depths

Duration	Precipitation (inches)	
	Average Recurrence Interval (years)	
	10	100
1-hour	0.64	1.19
3-hour	0.98	1.75
6-hour	1.32	2.33
24-hour	2.49	4.20

Source: NOAA Atlas 14.

According to the PRISM Climate Group annual precipitation dataset, which uses average monthly and annual conditions over the most recent three full decades (1991-2020) the project site gets an average of 20-inches of precipitation annually (PRISM 2023).

3 Hydrological Analysis

Hydrology calculations were completed in accordance with USGS Scientific Investigations Report 2012-5113, which was prepared in cooperation with the FEMA. The publication, titled *Methods for Determining Magnitude and Frequency of Floods in California, Based on Data through Water Year 2006* uses regional regression analysis to develop a set of equations for estimating flows with 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probabilities for ungagged basins in California that are outside of the southeastern desert region. Five hydrologic regions were developed for the area of California outside of the desert region. The project site falls within the Lahontan Region (Region 2 of the publication) and the regression equation for this region is a function of drainage area and mean annual precipitation. Average standard errors of prediction for the regression equations in all five regions range from 42.7 to 161.9 percent. The average standard error of prediction for the 100-year exceedance probability in the Lahontan region is 77.2% (USGS 2012).

For this Report, the 1-percent annual exceedance (100-year recurrence interval) flood frequency equation for the Lahontan Hydrologic Region was used to calculate the 100-year peak discharge. The equation is:

$$Q=0.713(DRNAREA)^{0.731}(PRECIP)^{1.56}$$

Where: Q= 100-year exceedance probability flow (cubic feet per second [cfs])
DRNAREA= Drainage area (square miles)
PRECIP= Mean annual precipitation (inches)

Drainage Area

As discussed in Section 2.1, the project site is within the Upper Pit watershed. The project site is 8 miles north of the downstream end of this watershed, and because of its proximity to the watershed outlet, the entire watershed drainage area will be used the calculate Project site discharge. The drainage area of the Upper Pit watershed is 2,681 square miles[1].

Precipitation

As discussed in Section 2.3, the project site receives an annual precipitation of 20-inches based on data between 1991-2020.

Peak Discharge

Using the equation and inputs discussed above, the peak discharge calculated is 24,478 cfs. Using the average standard error of prediction for this equation, the peak discharge range is calculated to be 5,581- to 43,375-cfs.

4 Project Hydraulics

4.1 Hydraulic Modeling Methodology

Flow depth and velocity modeling for existing conditions was performed with an unsteady flow analysis using HEC-RAS software (version 6.4.1) to model hydraulics throughout the project site. One-meter USGS digital elevation models dated March 3, 2020 were downloaded using the HEC-RAS software and were used to generate the terrain surface (topography) for the existing surface. A flow area computational mesh was generated using cells of 200 feet by 200 feet for the total model area, and a refinement region of 50 feet by 50 feet surrounding the project area. The only hydrologic control included in the hydraulic analysis model is topography. Breaklines were added as necessary to better define the topography.

The inflow boundary condition was assigned a hydrograph generated from the 100-year flood event which peaks at 24,478 cfs, calculated in Section 3. The inflow boundary hydrograph, which was assigned as “Unsteady Flow Data” in HEC-RAS, can be found in Figure 5.

For proposed conditions, the model inputs remained the same except for the modification of topography within the project boundary. Two areas within the project boundary were elevated approximately 5-feet to provide a raised pad which could be used to protect vulnerable project infrastructure. This preliminary design feature is shown in Figures 6b and 7b.

4.2 Hydraulic Results Discussion

Existing Conditions

Flood inundation maps showing maximum flow depths and flow velocities for existing topographic conditions during the 100-year flood event can be found in Figures 6a and 7a, respectively. The modeled inundation area closely

[1] This drainage area exceeds the range of explanatory variables used to develop the Lahontan Region regression equation, which may result in prediction errors greater than 77.2% (USGS 2012)

resembles the FEMA Flood Zone A boundary in the project vicinity. Modeling results indicate that approximately 7-acres in the northeast portion of the proposed project are not inundated. The remaining 106-acres of the project site are modeled to receive flood depths between 0- and 5-feet, with the majority of the area experiencing flood depths between 3-4 feet. Flood flow velocities range between 0- and 3-feet per second (fps), with most of the project site encountering flow velocities between 0.5- and 1-fps.

Proposed Conditions

Flood inundation maps showing maximum flow depths and flow velocities for proposed topographic conditions during the 100-year flood event can be found in Figures 6b and 7b, respectively. The modeled inundation area closely resembles the FEMA Flood Zone A boundary in the project vicinity and closely resembles the existing conditions inundation boundary. The elevated areas are not inundated, while the remaining portions of the project site are modeled to receive flood depths between 0- and 8-feet, due to the proposed detention basin. Flood flow velocities range between 0- and 4.5-fps, with most of the project site encountering flow velocities between 0- and 4.5-fps.

Comparison Between Existing and Proposed Conditions

Flood inundation maps showing the difference in flow depths and flow velocities between existing and proposed topographic conditions during the 100-year flood event can be found in Figures 6c and 7c, respectively. The area that was elevated in the proposed condition no longer experiences inundated conditions. This addition of fill to the project site causes a ponding effect to the west of the project site, where the flow is coming from. Approximately 40-acres directly west of the project site will experience inundation depths between 0.75- and 1.10-feet greater in the proposed condition than the existing condition. Approximately 138-acres north and west of the project site will experience inundation depths between 0.5- and 0.75-feet greater in the proposed condition than the existing condition. Other areas around the project site experience an increase in inundation depths, as seen in Figure 6c. The proposed topography included a detention basin in the southern portion of the project site, which causes a decrease in inundation depths up to 1.2-feet. Flow velocities within and around the project site range between a decrease of -1.8-fps to an increase of 9-fps in the proposed condition compared to the existing condition. The area experiencing the biggest increase in flow velocities due to the proposed condition (0.25- to 9-fps) is west of the proposed project.

5 References

FEMA (Federal Emergency Management Agency). 2023. FEMA Flood Map Service Center. https://msc.fema.gov/portal/search. Accessed October 2023.

NOAA. 2023. NOAA Atlas 14 Point Precipitation Frequency Estimates: CA. Accessed November, 2023. https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

PRISM Climate Group, Oregon State University (PRISM) 2023. https://prism.oregonstate.edu, data created 4 Feb 2014, accessed October 2023.

Sacramento River Watershed Program (SRWP) 2023. https://sacriver.org/explore-watersheds/northeast-subregion/pit-river-watershed/upper-pit-river-watershed/, accessed November 2023.

USGS. 2012. "Methods for Determining Magnitude and Frequency of Floods in California, Based on Data through Water Year 2006." Scientific Investigations Report 2012-5113

USGS. 2023. "National Hydrography Dataset: GIS Online viewer." Accessed November 2023. https://www.usgs.gov/core-science-systems/ngp/national-hydrography.

USFWS. 2023. "The National Wetlands Inventory." Accessed November 2023. fws.gov/wetlands/NWI/index.html.

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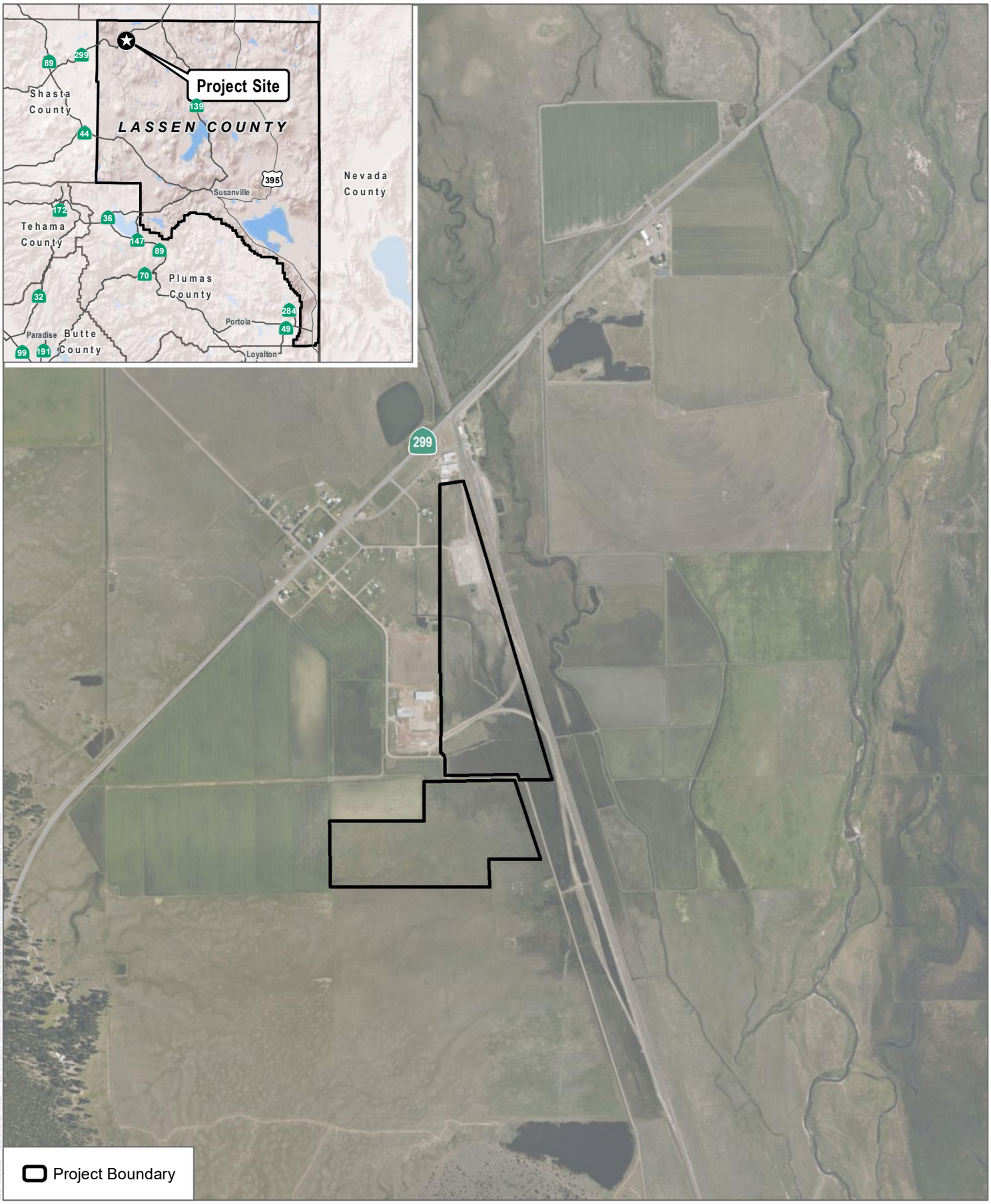
Figures



SOURCE: Bing Maps 2020, Lassen County 2015

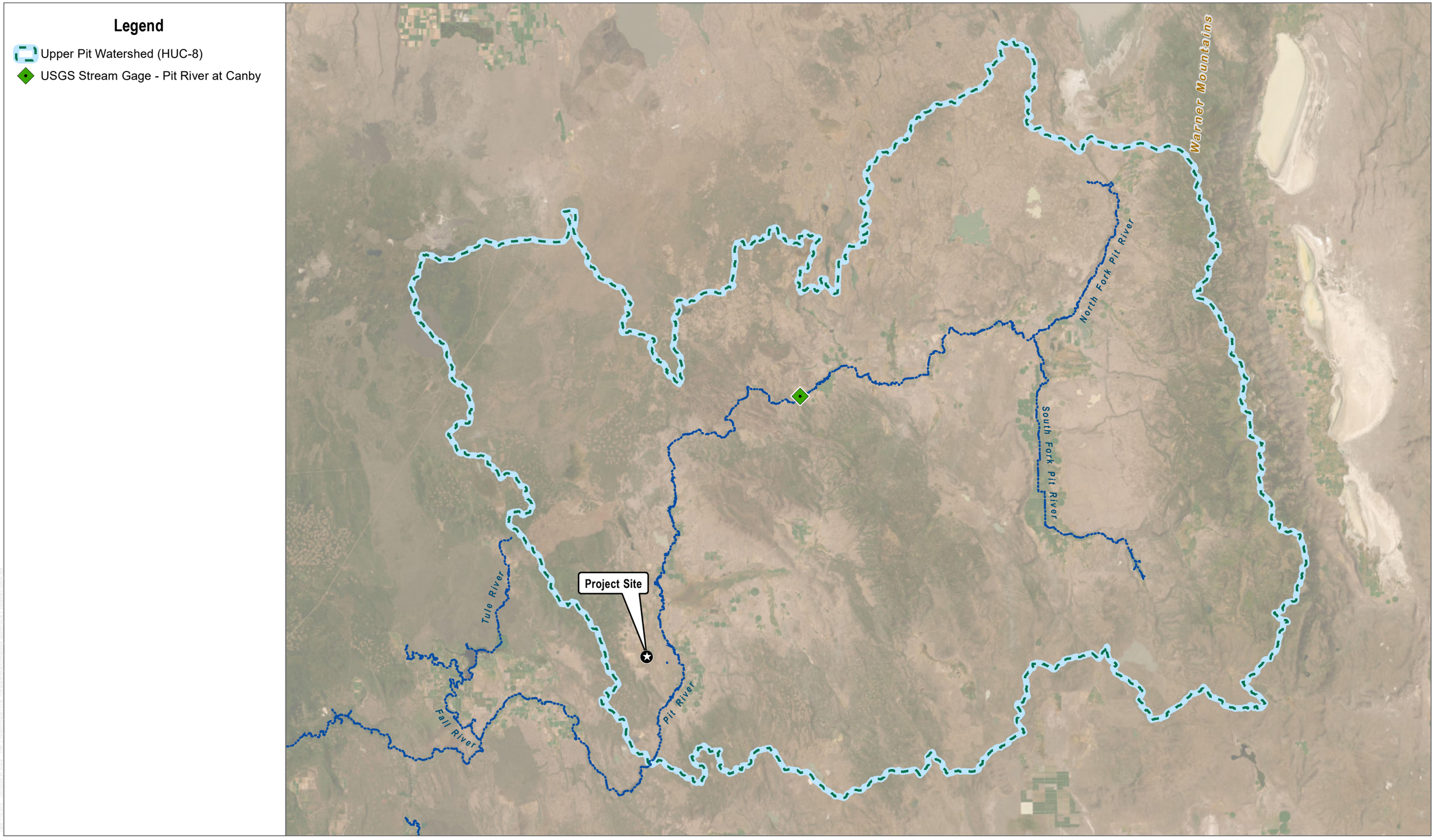
DUDEK

0 750 1,500 Feet

FIGURE 1

Lassen Site Location

Golden State Natural Resources Forest Resiliency Demonstration Project



SOURCE: ESRI; USGS

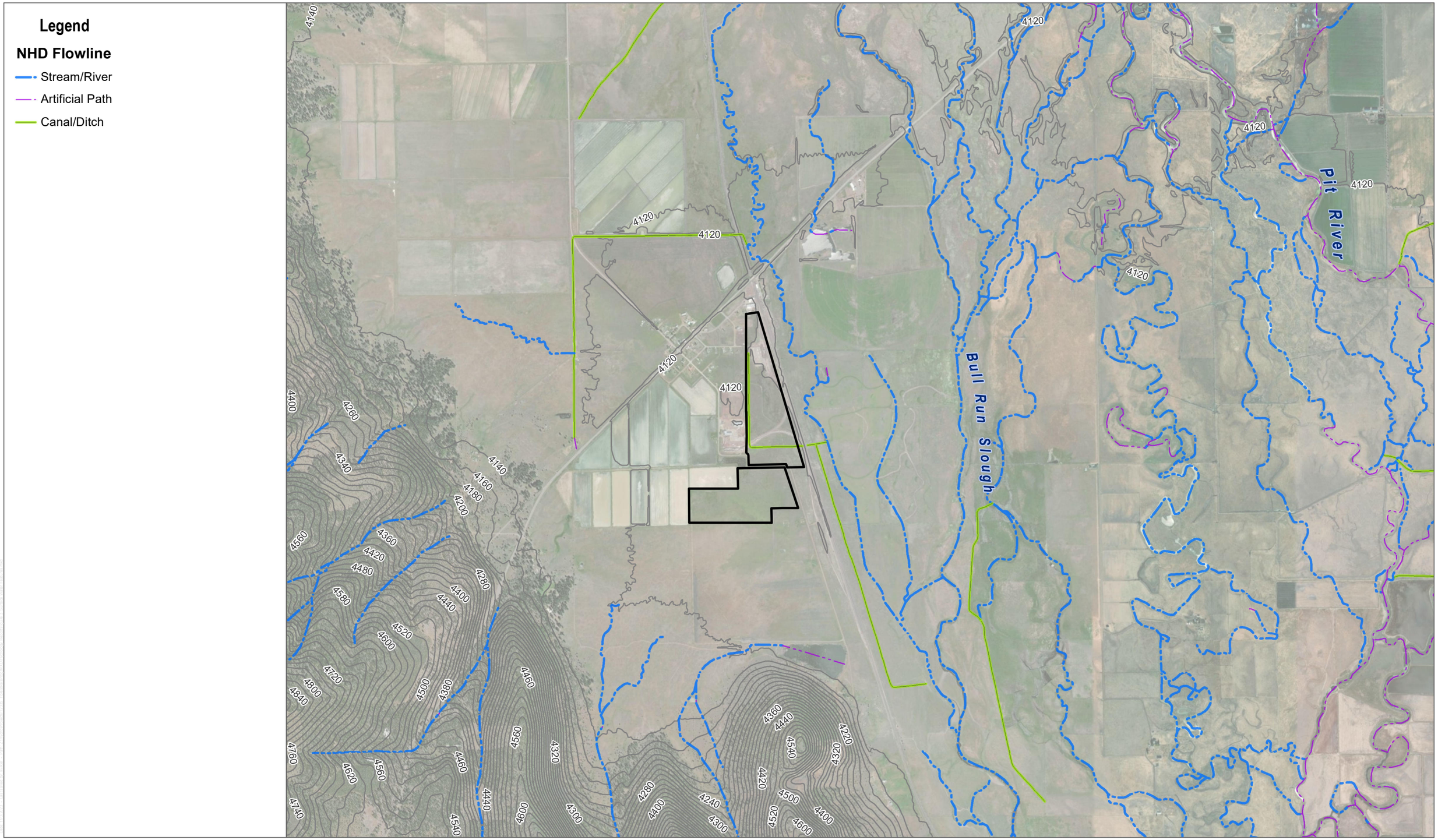
DUDEK

0 3.5 7 Miles

FIGURE 2

Watershed Setting

Golden State Natural Resources Forest Resiliency Demonstration Project



SOURCE: ESRI; USGS

DUDEK

0 0.175 0.35 Miles

FIGURE 3

Surface Water Features

Golden State Natural Resources Forest Resiliency Demonstration Project

Legend

FEMA Flood Hazard Areas

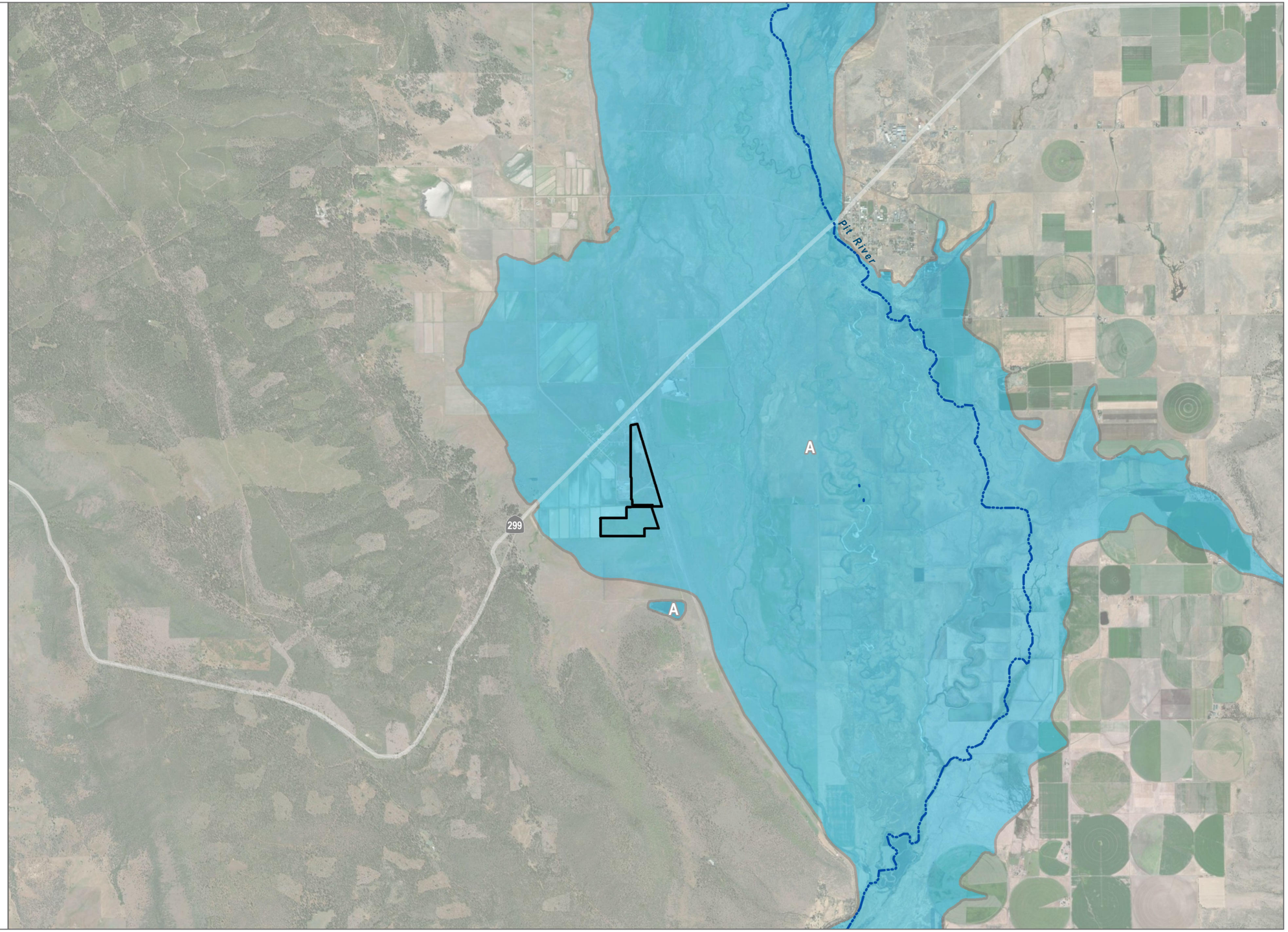
100-Year Flood Hazard Area - Special Flood Hazard Areas Subject to Inundation by the 1% Annual Chance Flood.

FEMA Flood Hazard

The 1% annual chance flood (100-year flood), also know as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard Area include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A: No Base Flood Elevations determined.

Note: Zone X - Other Areas of Minimal Flooding and Zone D - Undetermined Areas not shown



SOURCE: ESRI; FEMA

DUDEK

0 2,100 4,200 Feet

FIGURE 4

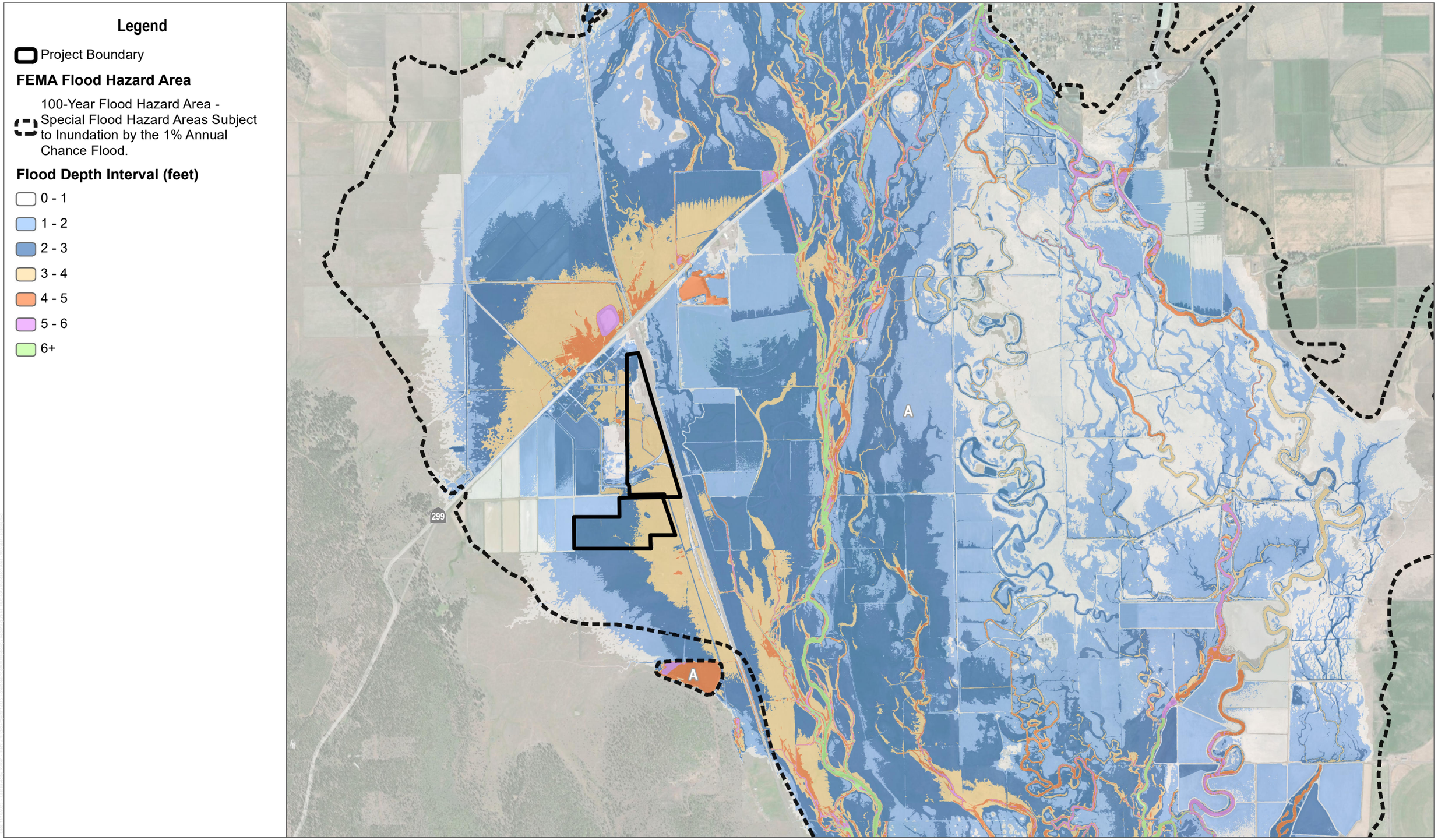
FEMA Flood Zones

Golden State Natural Resources Forest Resiliency Demonstration Project

FIGURE 5

Flow Hydrograph

Golden State Natural Resources Forest Resiliency Demonstration Project y



SOURCE: ESRI

DUDEK

0 0.25 0.5 Miles

FIGURE 6A

HEC-RAS Model Flood Depths - Existing Surface

Golden State Natural Resources Forest Resiliency Demonstration Project

Legend

Project Boundary

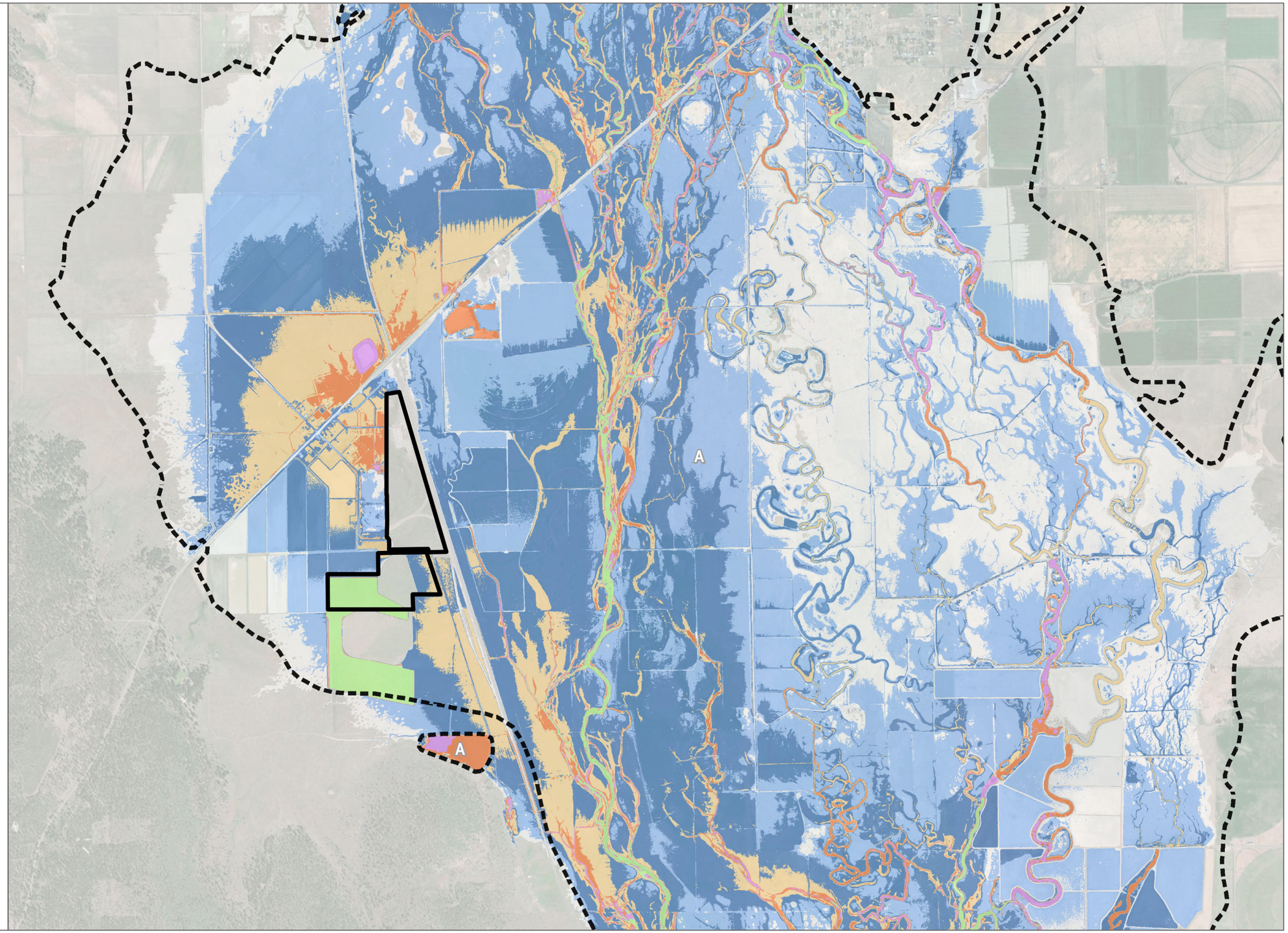
FEMA Flood Hazard Area Boundary

100-Year Flood Hazard Area - Special Flood Hazard Areas Subject to Inundation by the 1% Annual Chance Flood.

Proposed Depth

Flood Depth Interval (feet)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6+



SOURCE: ESRI

DUDEK

0 0.25 0.5 Miles

FIGURE 6B

HEC-RAS Model Flood Depths - Proposed Surface

Golden State Natural Resources Forest Resiliency Demonstration Project

Legend

Project Boundary

FEMA Flood Hazard Area Boundary

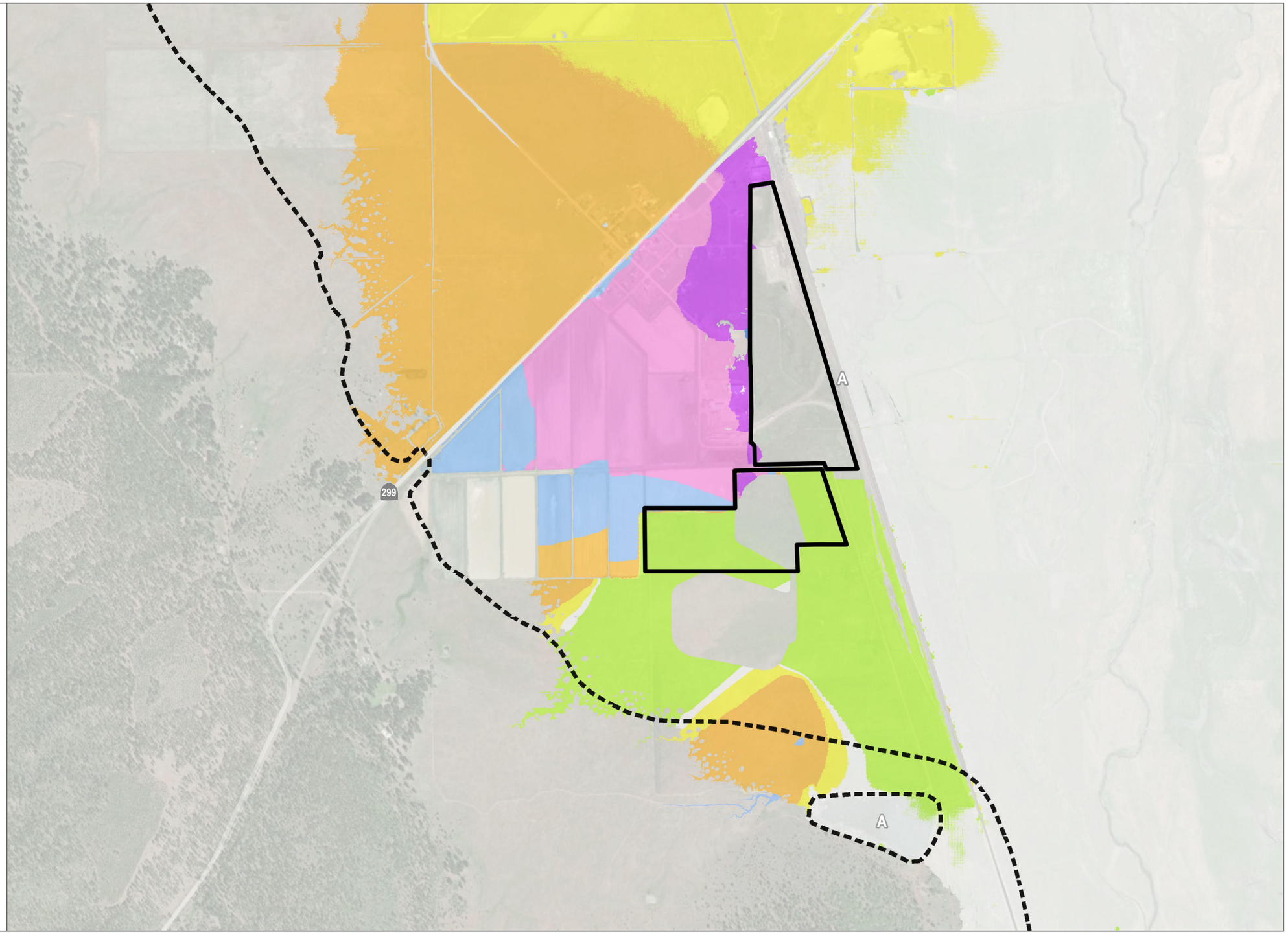
100-Year Flood Hazard Area - Special Flood Hazard Areas Subject to Inundation by the 1% Annual Chance Flood.

Flood Depth Comparison Interval

Proposed Surface minus Existing Surface (feet)

- -1.2 - 0
- 0
- 0 - 0.05
- 0.05 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- > 1

Note: Areas of "Existing Surface" or "Proposed Surface" flood depth interval without numerical values are not displayed on the comparison surface



SOURCE: ESRI

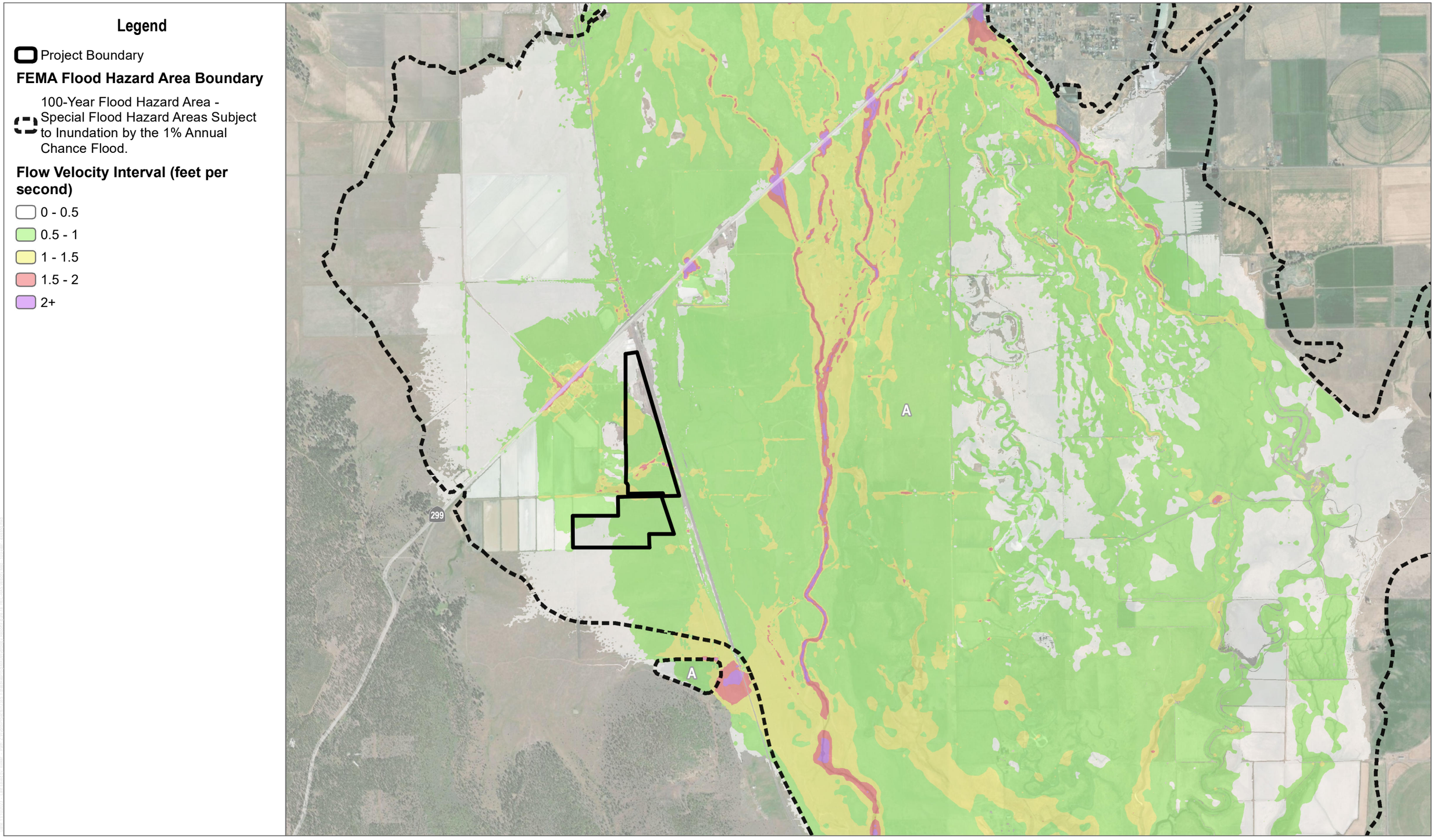
DUDEK

0 0.125 0.25 Miles

FIGURE 6C

HEC-RAS Model Flood Depths - Comparison Surface

Golden State Natural Resources Forest Resiliency Demonstration Project



SOURCE: ESRI

DUDEK

0 0.25 0.5 Miles

FIGURE 7A

HEC-RAS Model Flood Velocities - Existing Surface

Golden State Natural Resources Forest Resiliency Demonstration Project

Legend

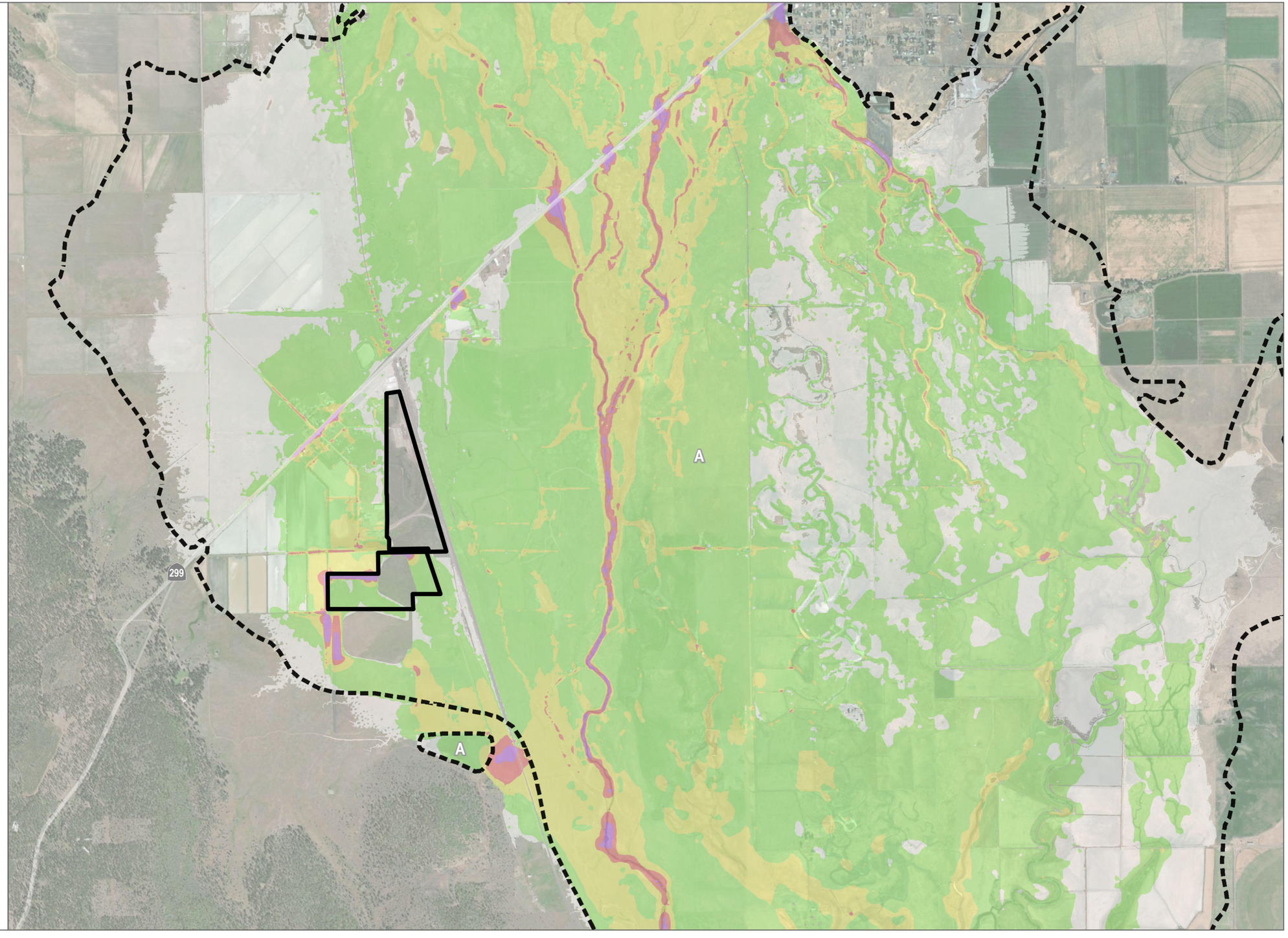
Project Boundary

FEMA Flood Hazard Area Boundary

100-Year Flood Hazard Area - Special Flood Hazard Areas Subject to Inundation by the 1% Annual Chance Flood.

Flow Velocity Interval (feet per second)

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2+



SOURCE: ESRI

DUDEK

0 0.25 0.5 Miles

FIGURE 7B

HEC-RAS Model Flood Velocities - Proposed Surface

Golden State Natural Resources Forest Resiliency Demonstration Project

Legend

Project Boundary

FEMA Flood Hazard Area Boundary

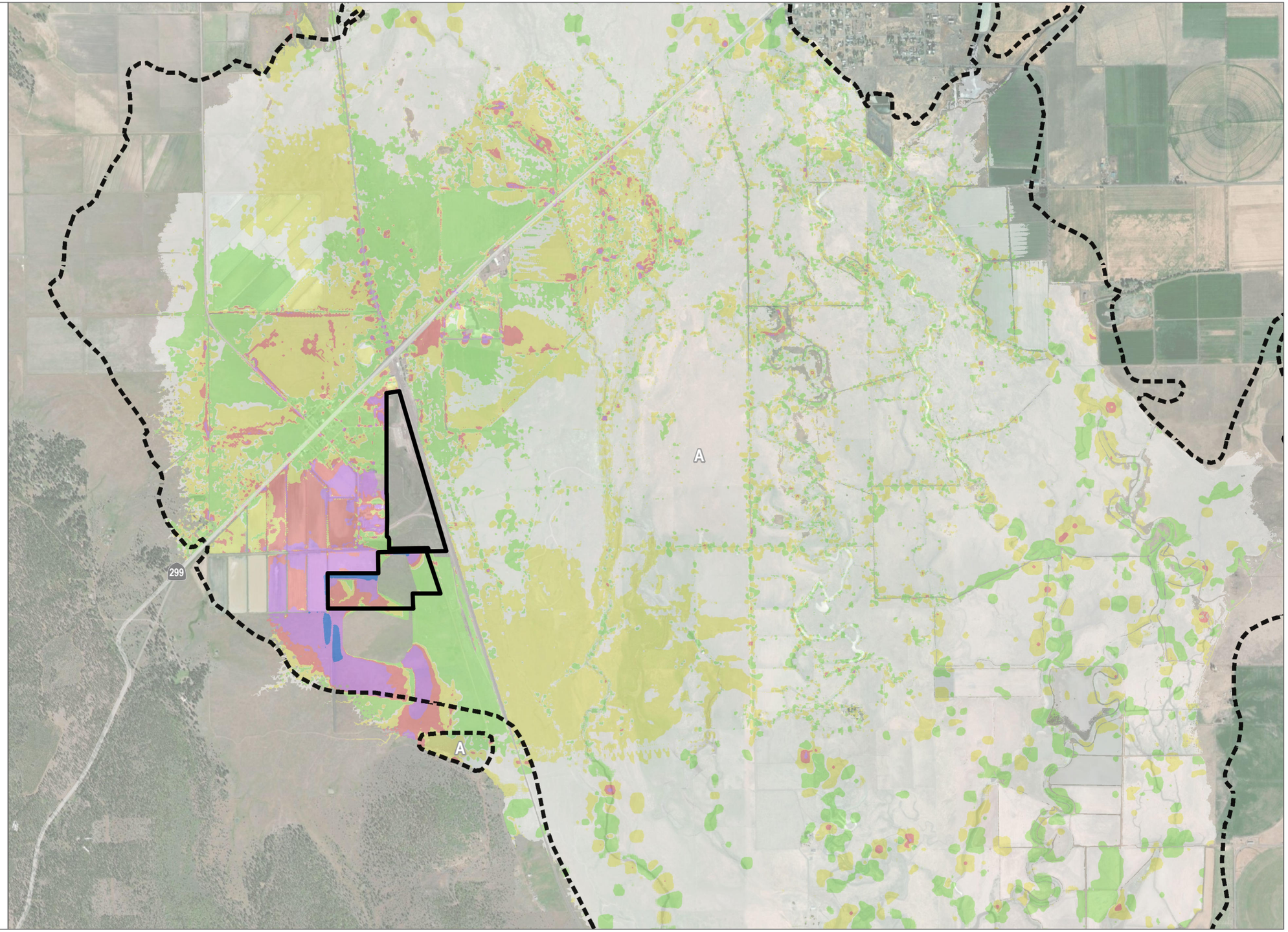
100-Year Flood Hazard Area - Special Flood Hazard Areas Subject to Inundation by the 1% Annual Chance Flood.

Flow Velocity Comparison Interval

Proposed Surface minus Existing Surface (feet per second)

- < -1.5
- -1.5 - 0
- 0
- 0- 0.1
- 0.1- 0.25
- 0.25 - 1.5
- > 1.5

Note: Areas of "Existing Surface" or "Proposed Surface" flood flow velocity depth interval without numerical values are not displayed on the comparison surface



SOURCE: ESRI

DUDEK

0 0.25 0.5 Miles

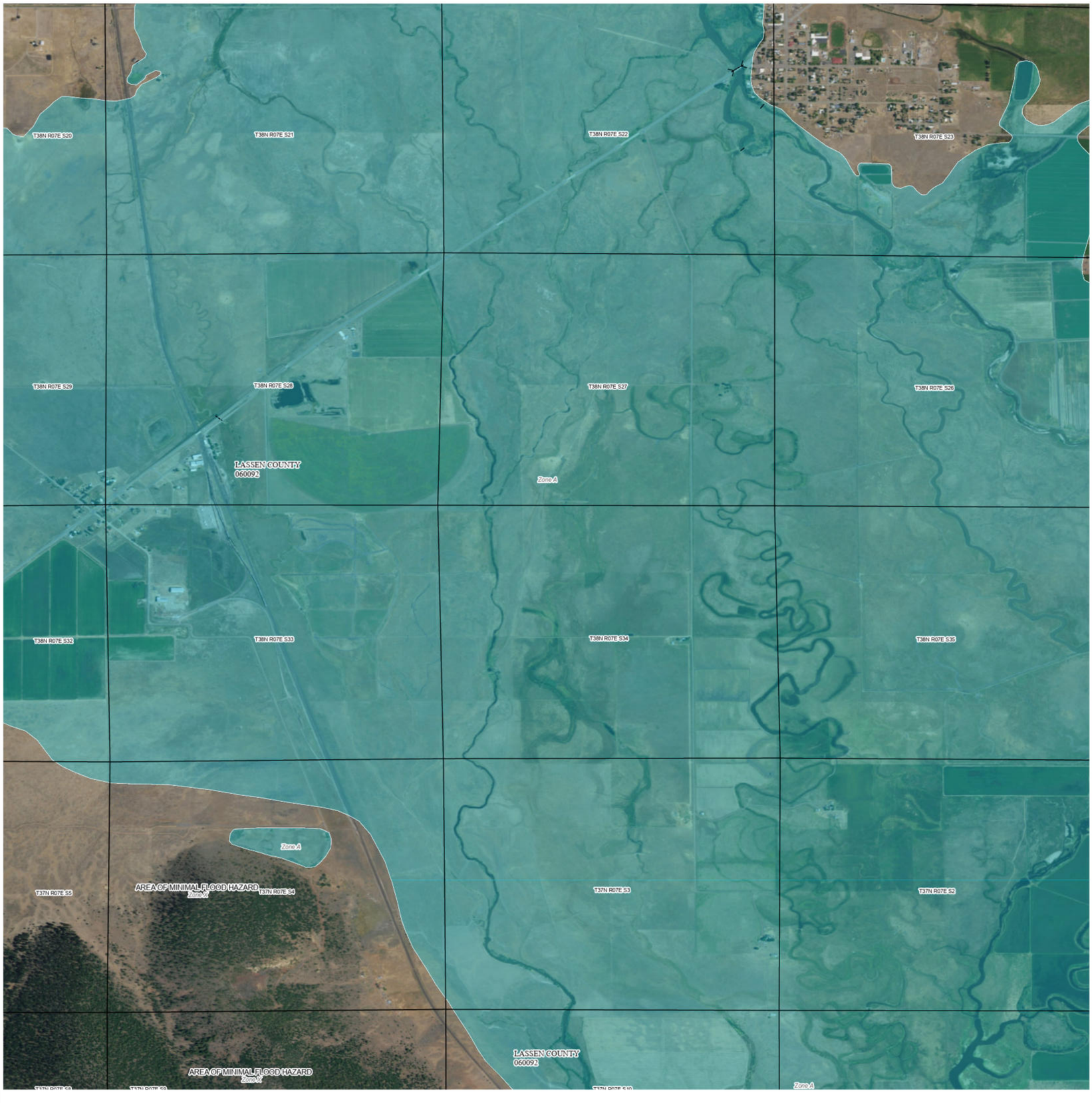
FIGURE 7C

HEC-RAS Model Flood Velocities - Comparison Surface

Golden State Natural Resources Forest Resiliency Demonstration Project

Appendix A
FEMA Flood Insurance Rate Map

121°11'15.91"W 41°7'43.2"N



121°7'29.19"W 41°3'31.85"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- 8 Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by the United States Geological Survey (USGS). The basemap shown is the USGS National Map: Orthoimagery. Last refreshed October, 2020.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **10/31/2023 6:53 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards. This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: No elevation features on this FIRM
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

1 inch = 1,000 feet 1:12,000

0 500 1,000 2,000 3,000 4,000 Feet

N

0 105 210 420 630 840 Meters

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

PANEL 335 OF 2875

Panel Contains:

COMMUNITY	NUMBER	PANEL
LASSEN COUNTY	060092	0335

MAP NUMBER
06035C0335D
EFFECTIVE DATE
September 03, 2010

Appendix B
NOAA Rainfall Data

NOAA Atlas 14, Volume 6, Version 2
Location name: Nubieber, California, USA*
Latitude: 41.0913°, Longitude: -121.1744°
Elevation: 4117 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	0.077 (0.066-0.091)	0.111 (0.095-0.131)	0.158 (0.135-0.188)	0.200 (0.169-0.239)	0.262 (0.212-0.326)	0.314 (0.248-0.401)	0.371 (0.285-0.487)	0.434 (0.323-0.589)	0.528 (0.374-0.753)	0.608 (0.414-0.902)
10-min	0.111 (0.095-0.131)	0.159 (0.136-0.187)	0.227 (0.193-0.269)	0.287 (0.242-0.343)	0.375 (0.305-0.468)	0.450 (0.356-0.574)	0.531 (0.409-0.698)	0.622 (0.463-0.845)	0.757 (0.537-1.08)	0.872 (0.594-1.29)
15-min	0.134 (0.115-0.158)	0.192 (0.164-0.227)	0.274 (0.234-0.325)	0.347 (0.293-0.415)	0.454 (0.368-0.565)	0.544 (0.431-0.695)	0.643 (0.494-0.844)	0.753 (0.560-1.02)	0.916 (0.649-1.30)	1.05 (0.718-1.56)
30-min	0.180 (0.154-0.212)	0.258 (0.220-0.305)	0.369 (0.314-0.437)	0.466 (0.393-0.558)	0.610 (0.495-0.760)	0.731 (0.579-0.934)	0.864 (0.664-1.14)	1.01 (0.753-1.37)	1.23 (0.873-1.75)	1.42 (0.966-2.10)
60-min	0.249 (0.213-0.293)	0.356 (0.304-0.421)	0.509 (0.434-0.603)	0.644 (0.543-0.771)	0.843 (0.684-1.05)	1.01 (0.799-1.29)	1.19 (0.918-1.57)	1.40 (1.04-1.90)	1.70 (1.20-2.42)	1.96 (1.33-2.90)
2-hr	0.382 (0.327-0.450)	0.500 (0.427-0.591)	0.674 (0.574-0.799)	0.831 (0.701-0.995)	1.07 (0.869-1.33)	1.28 (1.01-1.63)	1.51 (1.16-1.98)	1.78 (1.32-2.41)	2.18 (1.54-3.10)	2.53 (1.72-3.75)
3-hr	0.478 (0.409-0.563)	0.607 (0.519-0.718)	0.800 (0.682-0.948)	0.976 (0.824-1.17)	1.25 (1.01-1.55)	1.48 (1.17-1.89)	1.75 (1.35-2.30)	2.06 (1.53-2.79)	2.53 (1.79-3.60)	2.94 (2.01-4.37)
6-hr	0.694 (0.594-0.819)	0.857 (0.733-1.01)	1.10 (0.938-1.30)	1.32 (1.12-1.58)	1.67 (1.36-2.08)	1.98 (1.56-2.52)	2.33 (1.79-3.06)	2.73 (2.03-3.70)	3.35 (2.38-4.78)	3.91 (2.66-5.79)
12-hr	0.909 (0.778-1.07)	1.13 (0.964-1.33)	1.45 (1.23-1.72)	1.74 (1.46-2.08)	2.18 (1.76-2.71)	2.55 (2.02-3.26)	2.98 (2.29-3.91)	3.46 (2.57-4.70)	4.19 (2.97-5.97)	4.83 (3.29-7.16)
24-hr	1.26 (1.12-1.45)	1.59 (1.41-1.83)	2.07 (1.83-2.38)	2.49 (2.18-2.89)	3.11 (2.65-3.72)	3.63 (3.03-4.44)	4.20 (3.43-5.25)	4.84 (3.84-6.21)	5.77 (4.41-7.72)	6.57 (4.86-9.07)
2-day	1.59 (1.41-1.82)	2.01 (1.79-2.31)	2.62 (2.32-3.02)	3.16 (2.78-3.67)	3.97 (3.38-4.76)	4.65 (3.88-5.68)	5.40 (4.40-6.75)	6.23 (4.95-8.01)	7.48 (5.71-9.99)	8.53 (6.30-11.8)
3-day	1.77 (1.58-2.04)	2.25 (2.00-2.59)	2.94 (2.60-3.39)	3.55 (3.12-4.12)	4.46 (3.80-5.35)	5.24 (4.37-6.40)	6.09 (4.97-7.62)	7.04 (5.59-9.04)	8.46 (6.46-11.3)	9.68 (7.15-13.4)
4-day	1.98 (1.76-2.27)	2.51 (2.23-2.89)	3.28 (2.90-3.78)	3.96 (3.48-4.59)	4.96 (4.23-5.94)	5.81 (4.85-7.10)	6.74 (5.50-8.43)	7.77 (6.18-9.98)	9.31 (7.11-12.4)	10.6 (7.84-14.7)
7-day	2.42 (2.15-2.78)	3.07 (2.72-3.53)	3.98 (3.52-4.58)	4.76 (4.19-5.53)	5.91 (5.04-7.09)	6.86 (5.73-8.39)	7.89 (6.43-9.86)	9.01 (7.16-11.6)	10.6 (8.13-14.2)	12.0 (8.87-16.6)
10-day	2.75 (2.44-3.15)	3.48 (3.09-4.00)	4.48 (3.97-5.16)	5.34 (4.69-6.20)	6.57 (5.60-7.87)	7.57 (6.32-9.25)	8.63 (7.04-10.8)	9.77 (7.76-12.6)	11.4 (8.71-15.2)	12.8 (9.42-17.6)
20-day	3.61 (3.21-4.14)	4.56 (4.05-5.24)	5.81 (5.15-6.70)	6.84 (6.02-7.95)	8.26 (7.03-9.90)	9.36 (7.82-11.4)	10.5 (8.56-13.1)	11.7 (9.27-15.0)	13.3 (10.1-17.8)	14.6 (10.8-20.1)
30-day	4.38 (3.90-5.03)	5.52 (4.90-6.34)	6.97 (6.17-8.03)	8.14 (7.16-9.45)	9.70 (8.26-11.6)	10.9 (9.09-13.3)	12.1 (9.85-15.1)	13.3 (10.6-17.1)	14.9 (11.4-19.9)	16.2 (12.0-22.3)
45-day	5.41 (4.81-6.21)	6.76 (6.00-7.77)	8.45 (7.48-9.73)	9.77 (8.58-11.3)	11.5 (9.78-13.8)	12.7 (10.6-15.6)	14.0 (11.4-17.5)	15.2 (12.1-19.6)	16.9 (12.9-22.5)	18.1 (13.4-25.0)
60-day	6.34 (5.63-7.27)	7.85 (6.97-9.02)	9.70 (8.59-11.2)	11.1 (9.78-12.9)	13.0 (11.0-15.5)	14.3 (11.9-17.4)	15.5 (12.7-19.4)	16.8 (13.3-21.6)	18.4 (14.0-24.6)	19.6 (14.5-27.0)

[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.

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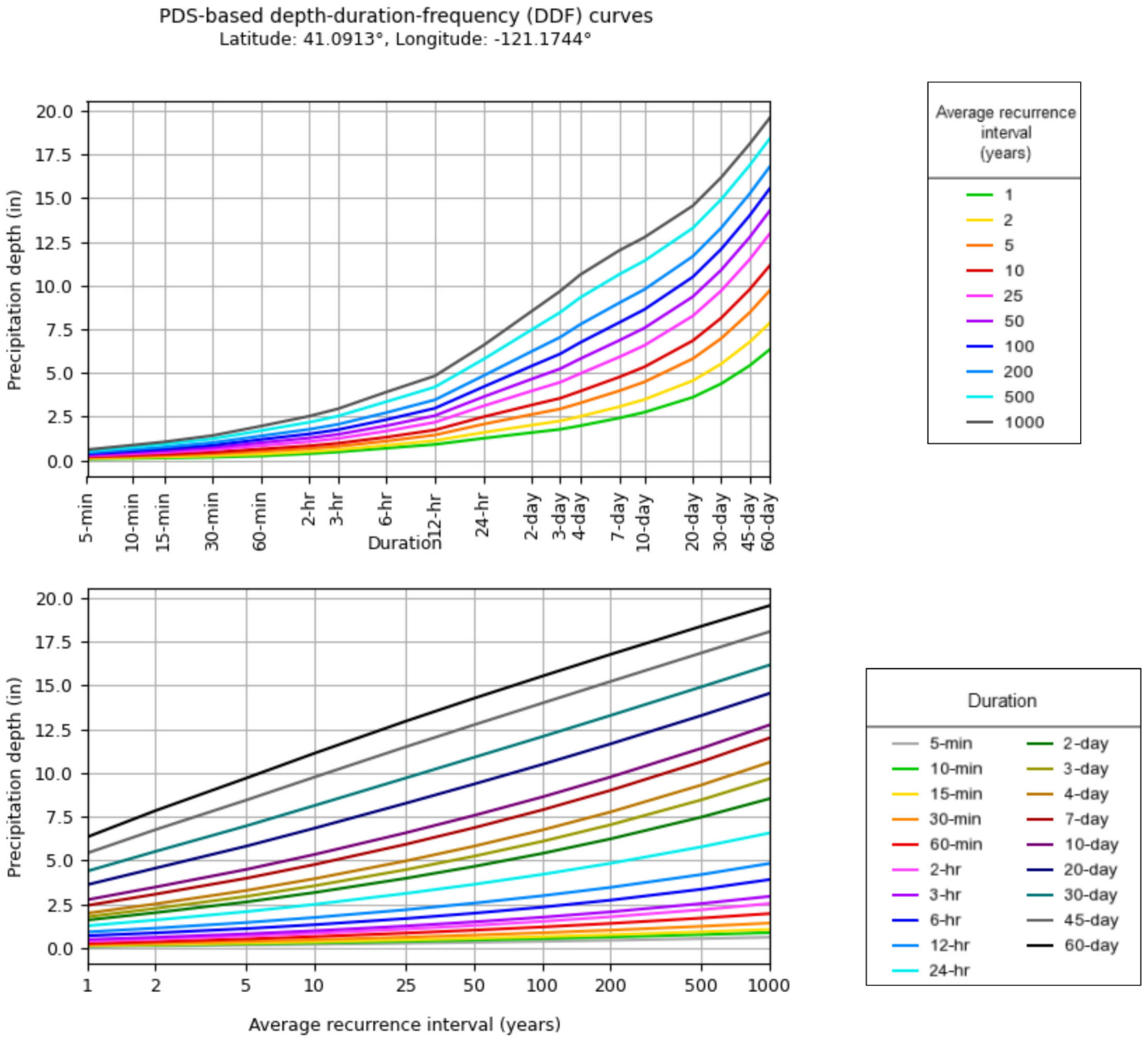
PF graphical



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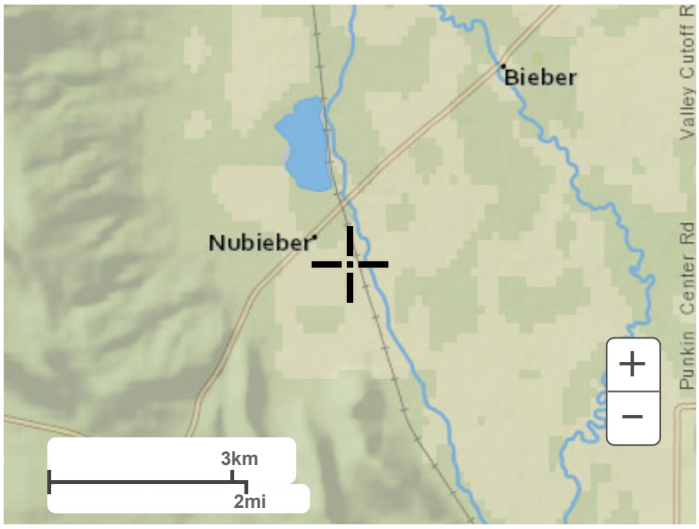
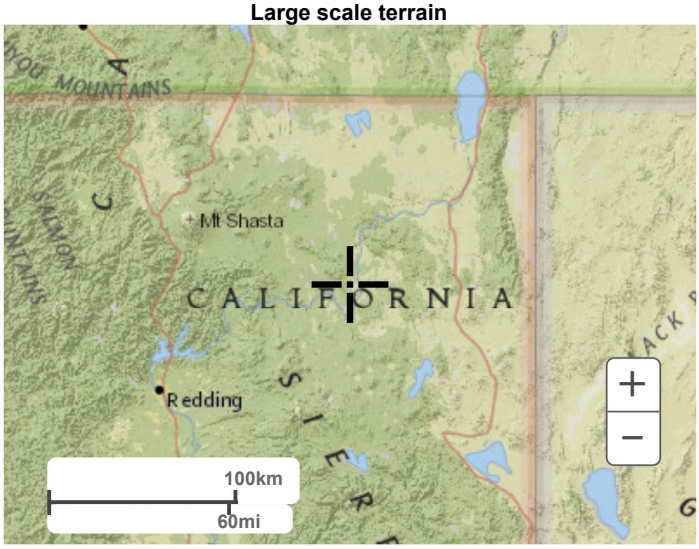
Maps & aerials

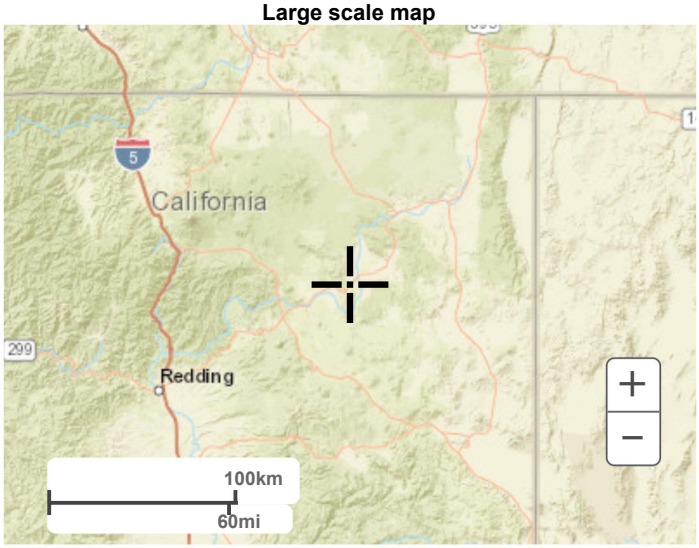
Small scale terrain



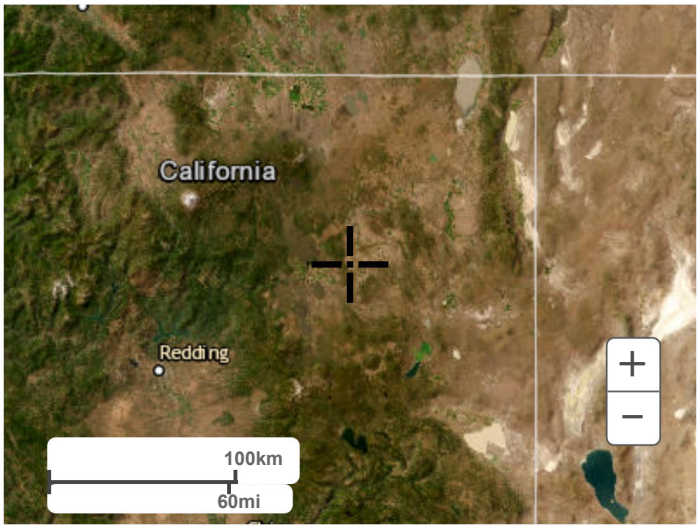
Large scale terrain



Large scale map



Large scale aerial



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