Hydrology Study and
Diversion Channel Design Parameters
Lassen County Pozzolans Mine Expansion
Near Hallelujah Junction, California

Prepared for:

Geofortis Minerals, LLC
30 S. Tooele Blvd
Tooele, UT 84074

Prepared by:

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January 12, 2023

Project No. 14-01-173

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January 12, 2023 Project No. 14-01-173

Geofortis Minerals, LLC
30 S. Tooele Blvd
Tooele, UT 84074

Attn: Mr. David McMurtry

Re: **Hydrology Study and Diversion Channel Design Parameters**
Geofortis Minerals, LLC – Lassen County Pozzolans Mine Expansion
Near Hallelujah Junction, California

Dear Mr. McMurty,

Broadbent & Associates, Inc. (Broadbent) is pleased to submit the enclosed *Hydrology Study and Diversion Channel Design Parameters* to Geofortis Minerals, LLC for the expansion of the Lassen County Pozzolans Mine located near Hallelujah Junction, California. Should you have questions regarding this document, please do not hesitate to contact us at (775) 322-7969.

Sincerely,
BROADBENT & ASSOCIATES, INC.

Jeremy B. Boucher, PE
Associate Engineer

LICENCED PROFESSIONAL ENGINEER
JEREMY BRANDON BOUCHER
No. 84433
Exp. 9/30/23
CIVIL
STATE OF CALIFORNIA

Lonnie Roy, PE
Principal Engineer

enclosures: Hydrology Study and Diversion Channel Design Parameters

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Near Hallelujah Junction, California

1.0 INTRODUCTION

Geofortis Minerals, LLC (Geofortis) intends to expand their Lassen County Pozzolans Mine (mine) located approximately six miles north of Hallelujah Junction, Lassen County, California (Drawing 1). The proposed mine expansion incudes mining from two new open pits, one on the east side of Unites States Route 395 (US 395) and one on the west side of US 395 (Drawing 2). Ephemeral streams are known to be present near each proposed mining area (USGS, 2022) and the natural flow of stormwater will be diverted to prevent stormwater from entering the open pits. One diversion channel is proposed on the east side of US 395 and one diversion channel is proposed on the west side of US 395 as indicated on Drawing 2. To continue the environmental review for the California Environmental Quality Act (CEQA), Lassen County and the California Department of Fish and Wildlife (CDFW) have requested a hydrology study to estimate stormwater flows carried by these channels and determine the design parameters for diversion channels.

Broadbent & Associates, Inc. (Broadbent) is supporting Geofortis with the hydrologic study of the basins that drain through the mine expansion areas and determination of the diversion channel design parameters. This report summarizes observations from an October 18, 2022, site visit performed by Broadbent, hydrologic modeling with Hydrologic Engineering Center – Hydrologic Modeling System (HEC – HMS) software, and review of pertinent databases and technical resources.

2.0 SITE LOCATION

The proposed mine expansion is located at an elevation of approximately 4,740 feet (ft) above mean sea level (amsl) within the North Lahontan Hydrologic Unit (hydrologic unit code 12-180800031204 Zamboni Hot Springs – Long Valley Creek). The surface elevation within Long Valley decreases while traveling north as evidenced by the northerly flow direction of Long Valley Creek which runs west of the mine and its expansion areas. In the vicinity of the mine, Long Valley Creek is fed by numerous ephemeral streams that drain the Diamond Mountains (west of the mine) and the Peterson Mountain (east of the mine). The vegetation is characterized by conifer trees, abundant sagebrush, and seasonal grasses.

Drawing 2 depicts the proposed open pits and hydrologic subbasins that naturally drain through the expanded mining area. The two subbasins (E1 and E2) on the east side of US 395 contribute flows from an approximate area of 624 acres and the highest elevation approaches 5,340 ft amsl. The three subbasins (W1, W2, and W3) on the west side of US 395 contribute flows from an approximate area of 695 acres and the highest elevation approaches 5,200 ft amsl. The stormwater flows from the east and west basins currently merge north of the proposed open pits. The area, minimum and maximum elevation, and drainage length for each subbasin is presented on Table 1 and Drawing 2.

3.0 SOIL CONDITIONS

During the October 18, 2022, site visit, Broadbent personnel inspected the drainages and terrain in each subbasin. The soil was observed to be composed primarily of sand; however, clays, gravels, and silts were also present in variable proportions across the area. Additionally, small rock outcrops were observed in the upper reaches of subbasin W1. Broadbent also utilized the United States Department of Agriculture (USDA) web soil survey (WSS) operated by the Soil Conservation Service (SCS) to better understand the existing soil conditions. The WSS indicated that the most prevalent soil types in the east and west basins is sandy loam and loamy sand. The USDA NRCS classifies these types of soil as hydrologic soil group (HSG) A (USDA, 1986). The WSSs are included in Appendix A.

4.0 CLIMATE DATA

The nearest National Oceanic and Atmospheric Administration (NOAA) weather station to the mine is approximately 14 miles north-northwest in Doyle, CA. In Doyle, annual averages are as follows: high temperature is 65 degrees Fahrenheit (°F), low temperature is 36°F, 14 inches of rain, and 25 inches of snow (U.S. Climate Data). Point precipitation frequency estimates for Doyle were obtained from NOAA Atlas 14, Volume 6, Version 2 and is included in Appendix B.

The USDA SCS developed four synthetic 24-hour rainfall distributions from data made available by the National Weather Service to account for variation in rainfall intensity during a storm and across the storm area. Doyle is in a region that receives Type II storms which are characterized by intense short duration rainfall (USDA, 1986).

4.0 HEC-HMS MODELING

Modeling with the HEC-HMS was performed to estimate runoff from the two subbasins located on the east side of US 395 and the three subbasins located on the west side of US 395. Since stormwater runoff from the east and west basins do not combine within either of the proposed open pits, each set of subbasins was modeled independently to estimate stormwater runoff that will be required to be diverted around the east and west open pits. Due to the ephemeral nature of the streams in the five subbasins, historic flow data through the streams is not available as the streams are not equipped with gauges. Accordingly, certain basin modeling parameters were determined from SCS guidance as described in previous sections. Table 1 presents the subbasin modeling parameters.

Hypothetical storms with durations of 24-hours were applied to the east and west basins with the HEC-HMS software. In Doyle, a storm of 24-hour duration at recurrence intervals of 10, 25, 50, and 100 years have precipitation frequency estimates of 2.84 inches, 3.55 inches, 4.12 inches, and 4.73 inches, respectively (NOAA, 2022). For the east basins combined peak discharge ranges between 34.2 cubic feet per second (cfs, 10-year frequency storm) and 155.1 cfs (100-year frequency storm). In the west basins the combined peak discharge ranges between 64.3 cfs (10-year frequency storm) to 326.7 cfs (100-year frequency storm). The modeling results for the east basin are presented in Table 2 while the modeling results for the west basins are presented in Table 3.

5.0 DIVERSION CHANNEL DESIGN PARAMETERS

CalTrans criteria require culverts to pass the 10-year recurrence interval storm. Since the mining operation will have an expected life greater than 10 years, the 25-year recurrence interval storm will be used to size the diversion channels. Drawing 3 shows the proposed drainage channels with the design parameters, depths and flows.

Channel parameters were estimated using a normal depth calculator. The Manning's coefficient for earthen channels was estimated at 0.035. Proposed channels slopes were estimated from proposed grading plans and these parameters were used to calculate flow depths. Model outputs are provided in Appendix C.

For the basins on the east side of US 395, two sets of design parameters have been established since the stormwater runoff from subbasin E2 flows toward the southern boundary of the proposed open pit while flows from subbasin E1 are directed toward the eastern boundary of the proposed open pit. The diverted flows will not combine until flow from E2 are directed along the eastern boundary of the proposed pit in an existing drainage. Along the southern boundary of the proposed open pit, a trapezoidal channel that is 5 feet wide with side wall slopes of 3:1 will be installed to carry the estimated 8.2 cfs until this stormwater reaches the eastern boundary of the proposed pit. The water in this channel will flow at a depth of 0.35 feet. As this channel combines with the flows from subbasin E1, channel will remain in the same configuration, but the depth of flow will increase to 1.28 feet to carry the estimated 69.7 cfs of the 25-year flow. This diversion channel ultimately discharges to the existing wash similar to existing conditions.

For the basins on the west side of US 395, the three subbasins (W1, W2 and W3) ultimately combine and are diverted around the pit. The combined 25-year flow is estimated at 144.1 cfs. This flow will be carried in a trapezoidal channel with a bottom width of 10 feet, side slopes of 3:1 and a flow depth of 1.84 feet. This water is carried on the west side of the pit and discharges into and existing wash in a similar location as the existing conditions. A smaller channel designed to carry 10 cfs is proposed at the southern edge of the pit to control any nuisance water that does not flow directly east. This trapezoidal channel has a bottom with of 5 feet, side slopes of 3:1 and an estimated flow depth of 0.41 feet.

6.0 LIMITATIONS

The findings presented in this report are based upon observations by field personnel, points investigated, and data available in publicly available databases. Our services were performed in accordance with the generally accepted standard of practice at the time this report was written. No other warranty expressed or implied was made. This report has been prepared for the exclusive use of Geofortis. It is possible that variations in soil conditions could exist beyond the points investigated. Also, changes in site conditions could occur in the future due to variations in rainfall, temperature, regional water usage, or other factors.

7.0 REFERENCES

National Oceanic and Atmospheric Administration. 2022 Atlas 14, Volume 6, Version 2 Precipitation Frequency Data Server. Doyle, California, USA. Accessed on December 12, 2022.

National Operational Hydrologic Remote Sensing Center. 2005. Unit Hydrograph (UHG) Technical Manual. October 12, 2005.

United States Department of Agriculture. 1986. Urban Hydrology for Small Watersheds, Technical Release-55. June 1986.

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United States Geological Survey. 2022. National Hydrography Dataset (NHD). Accessed on December 14, 2022.

United States Geological Survey. 2022. Watershed Boundary Dataset. Accessed on December 14, 2022.

U.S. Climate Data. 2022. usclimatedata.com/climate/doyle/California/united-states/usca1299. Accessed on December 22, 2022.

DRAWINGS

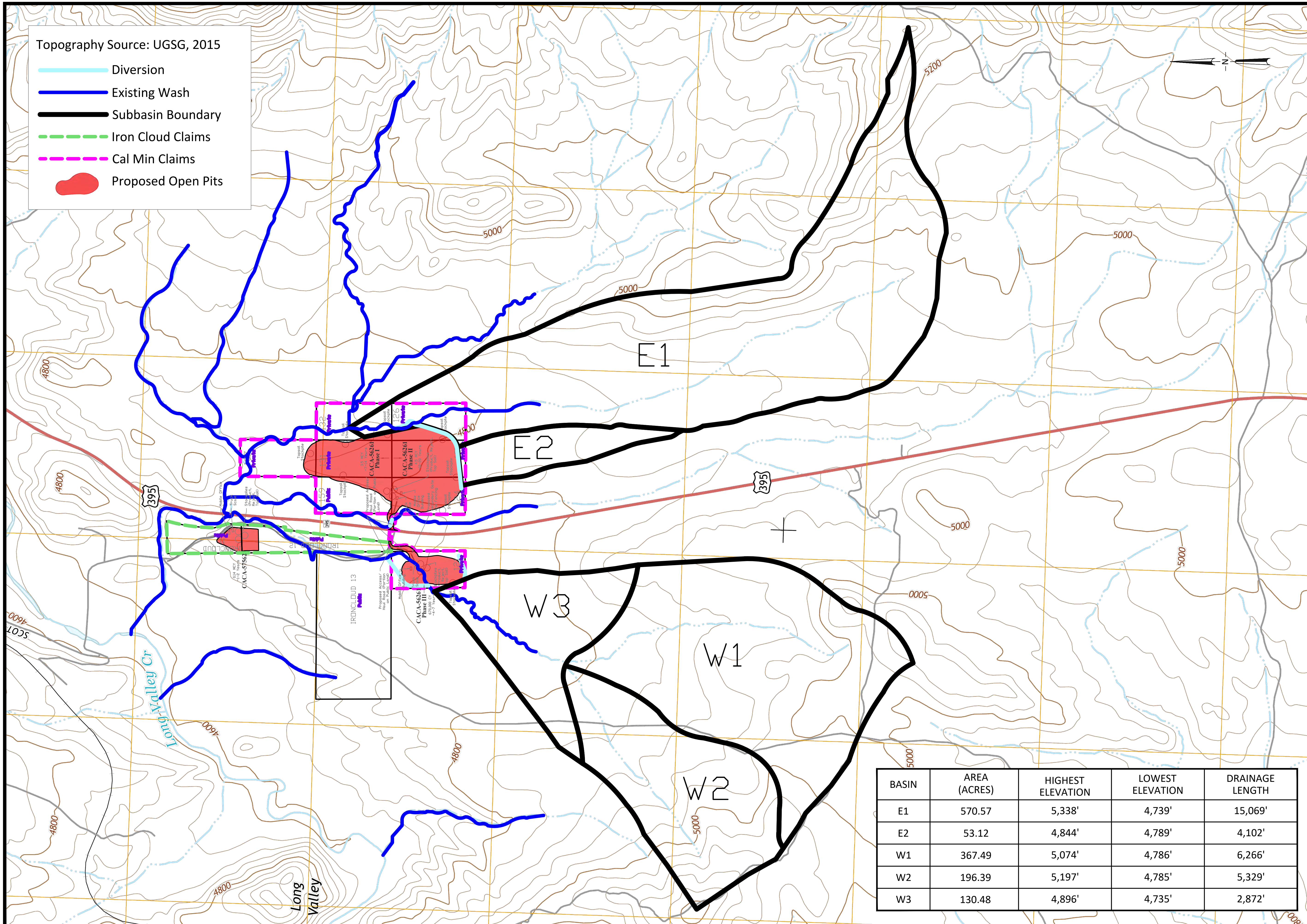
N

0 4 8

APPROXIMATE SCALE (ft)

IMAGE SOURCE: Google Earth

BROADBENT 5450 Louie Lane, #101 Reno, Nevada 89511 Project No.: 14-10-173 Date: 12/22/2022	Geofortis Minerals, LLC 30 S. Tooele Blvd. Tooele, Utah 84074	Site Location Map	Drawing 1



BASIN	AREA (ACRES)	HIGHEST ELEVATION	LOWEST ELEVATION	DRAINAGE LENGTH
E1	570.57	5,338'	4,739'	15,069'
E2	53.12	4,844'	4,789'	4,102'
W1	367.49	5,074'	4,786'	6,266'
W2	196.39	5,197'	4,785'	5,329'
W3	130.48	4,896'	4,735'	2,872'

SCALE (ft)
0 1,600 3,200

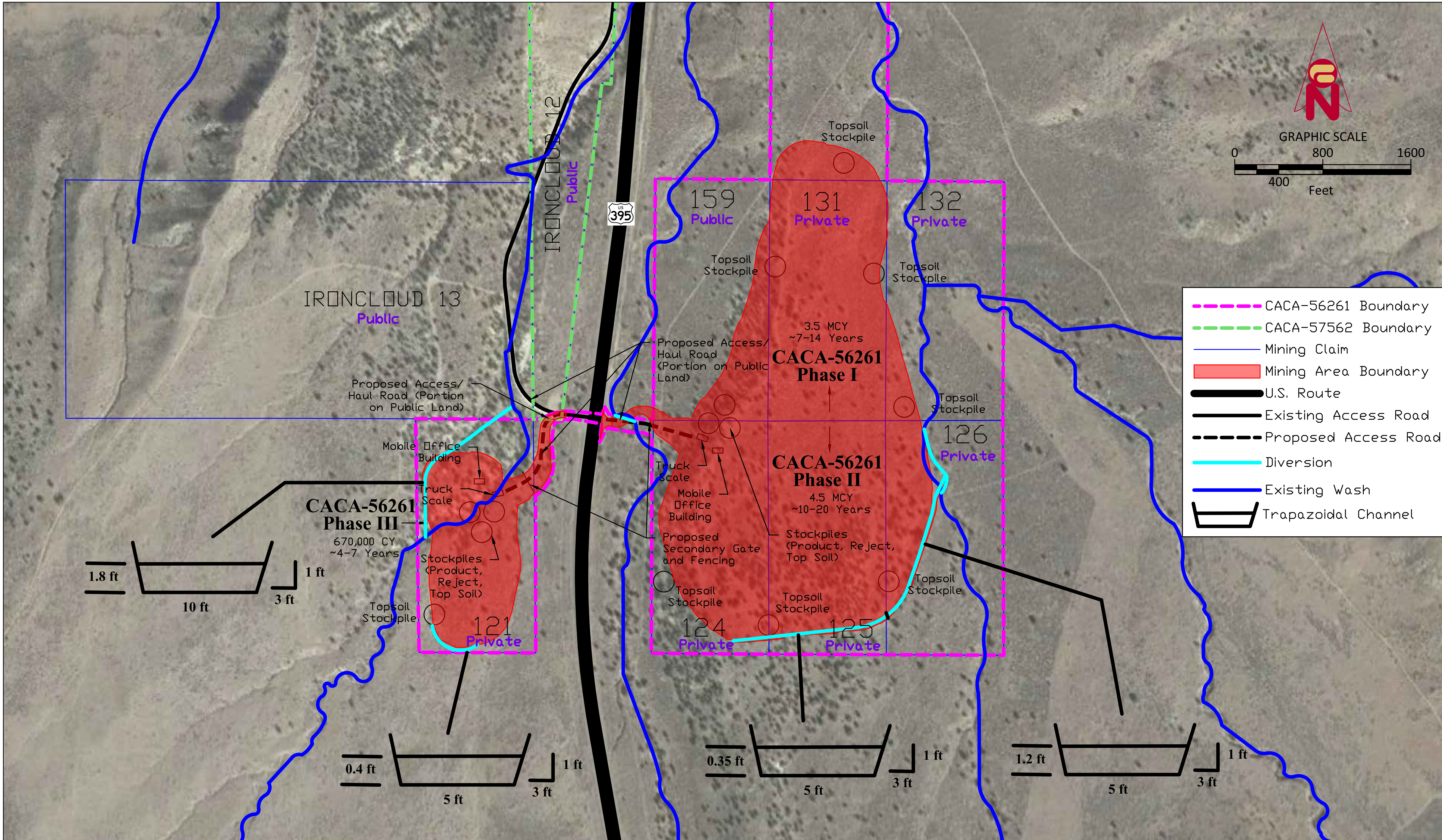
Drawing
2

Hydrology Study -
Subbasins Characteristics

Geofortis Minerals, LLC
30 S. Tooele Blvd.
Tooele, Utah 84074

BROADBENT
5450 Louie Lane, #101
Reno, Nevada 89511

Project No.: 14-10-173 Date: 1/12/2023



BROADBENT

Geofortis Minerals, LLC
30 S. Tooele Blvd
Tooele, UT 84074

Project Number: 14-01-173-701

Prepared By: C. Peterson
Reviewed By: L. Roy
Date: 01/11/2023

Figure 3:
Diversion Channels

TABLES

Table 1. Subbasin Modeling Parameters

Geofortis Minerals, LLC

Subbasin ID	Drainage Area (acres)	Highest Elevation (ft)	Lowest Elevation (ft)	Drainage Length (ft)	Average Slope %	Curve Number	Lag Time (hours)
E1	570.57	5,338	4,739	15,069	3.98	63	2.2
E2	53.12	4,844	4,789	4,102	1.34	63	1.4
W1	367.49	5,074	4,786	6,266	4.60	63	1.0
W2	196.39	5,197	4,785	5,329	7.73	63	0.7
W3	130.48	4,896	4,735	2,872	5.61	63	0.5

ft - feet

Table 2. HEC - HMS East Basins Results

Geofortis Minerals, LLC

Subbasin	E1	E2	Combined
Drainage Area (acres)	570.57	53.12	623.69
10-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	31.4 / 14:50	4.0 / 13:40	34.2 / 14:45
25-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	65.7 / 14:35	8.6 / 13:30	71.6 / 14:30
50-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	100.3 / 14:30	13.4 / 13:30	109.1 / 14:25
100-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	142.6 / 14:25	19.2 / 13:25	155.1 / 14:25

Acronymns:

CFS - cubic feet per second

HEC - HMS - Hydrologic Engineering Center - Hydologic Modeling System

YR - year

hrs:min - hours:minutes

Table 3. HEC - HMS West Basins Results

Geofortis Minerals, LLC

Subbasin	**W1**	**W2**	**W3**	**Combined**
Subbasin Drainage Area (acres)	367.49	196.39	130.48	694.36
10-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	32.7 / 13:15	22.3 / 12:45	18.2 / 12:30	64.3 / 12:55
25-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	72.5 / 13:05	50.6 / 12:45	42.1 / 12:30	144.1 / 12:45
50-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	113.0 / 13:05	79.6 / 12:40	66.3 / 12:25	226.0 / 12:45
100-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	162.6 / 13:05	115.2 / 12:40	96.4 / 12:25	326.7 / 12:40

Acronymns:

CFS - cubic feet per second

HEC - HMS - Hydrologic Engineering Center - Hydologic Modeling System

YR - year

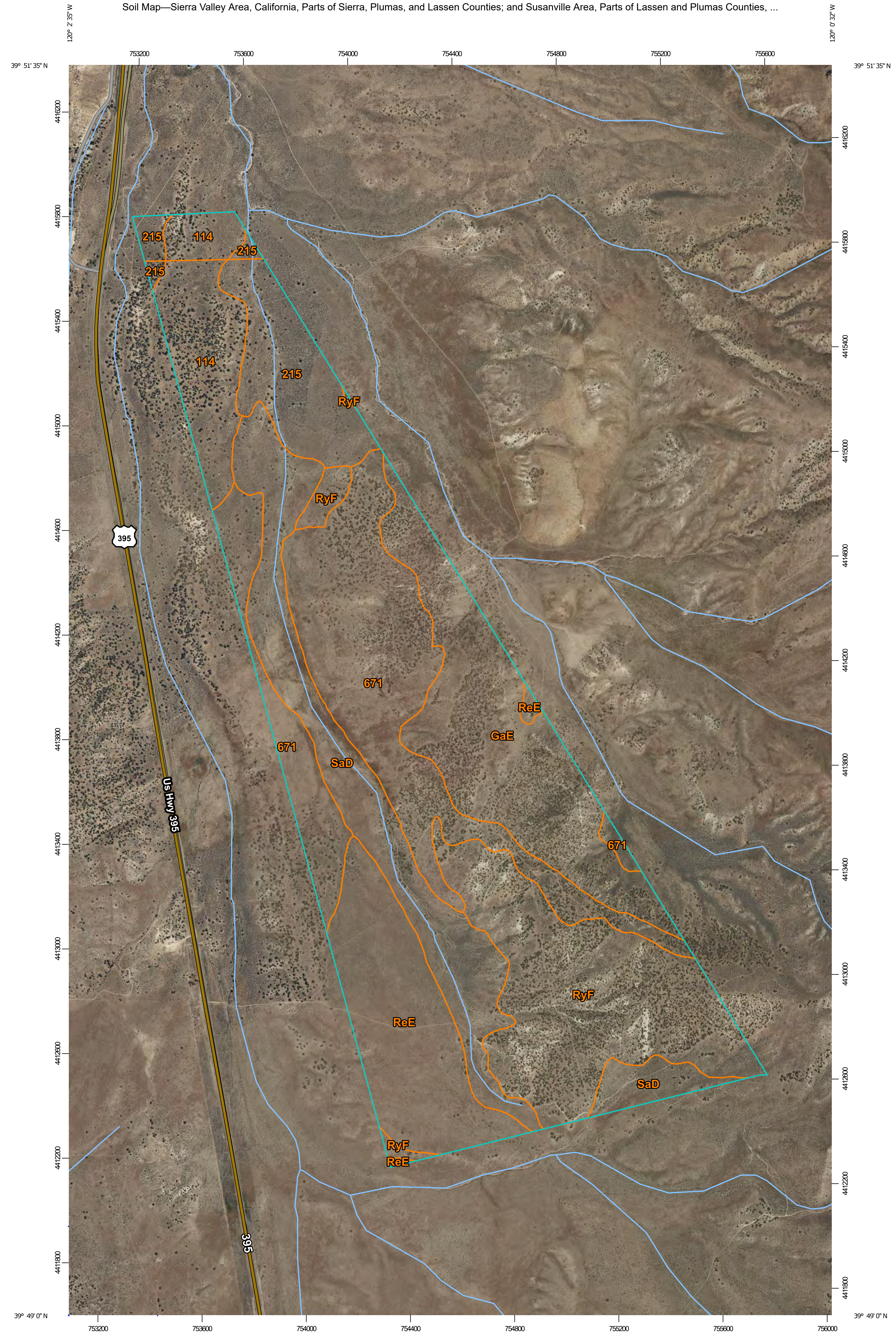
hrs:min - hours:minutes

APPENDICES

APPENDIX A

WEB SOIL SURVEYS

East Basins Web Soil Survey



Map Scale: 1:13,400 if printed on B portrait (11" x 17") sheet.

N

Meters: 0, 150, 300, 600, 900

Feet: 0, 500, 1000, 2000, 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

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

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
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: Sierra Valley Area, California, Parts of Sierra, Plumas, and Lassen Counties
Survey Area Data: Version 17, Sep 6, 2022

Soil Survey Area: Susanville Area, Parts of Lassen and Plumas Counties, California
Survey Area Data: Version 14, Sep 2, 2022

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Jun 10, 2022—Jun 14, 2022

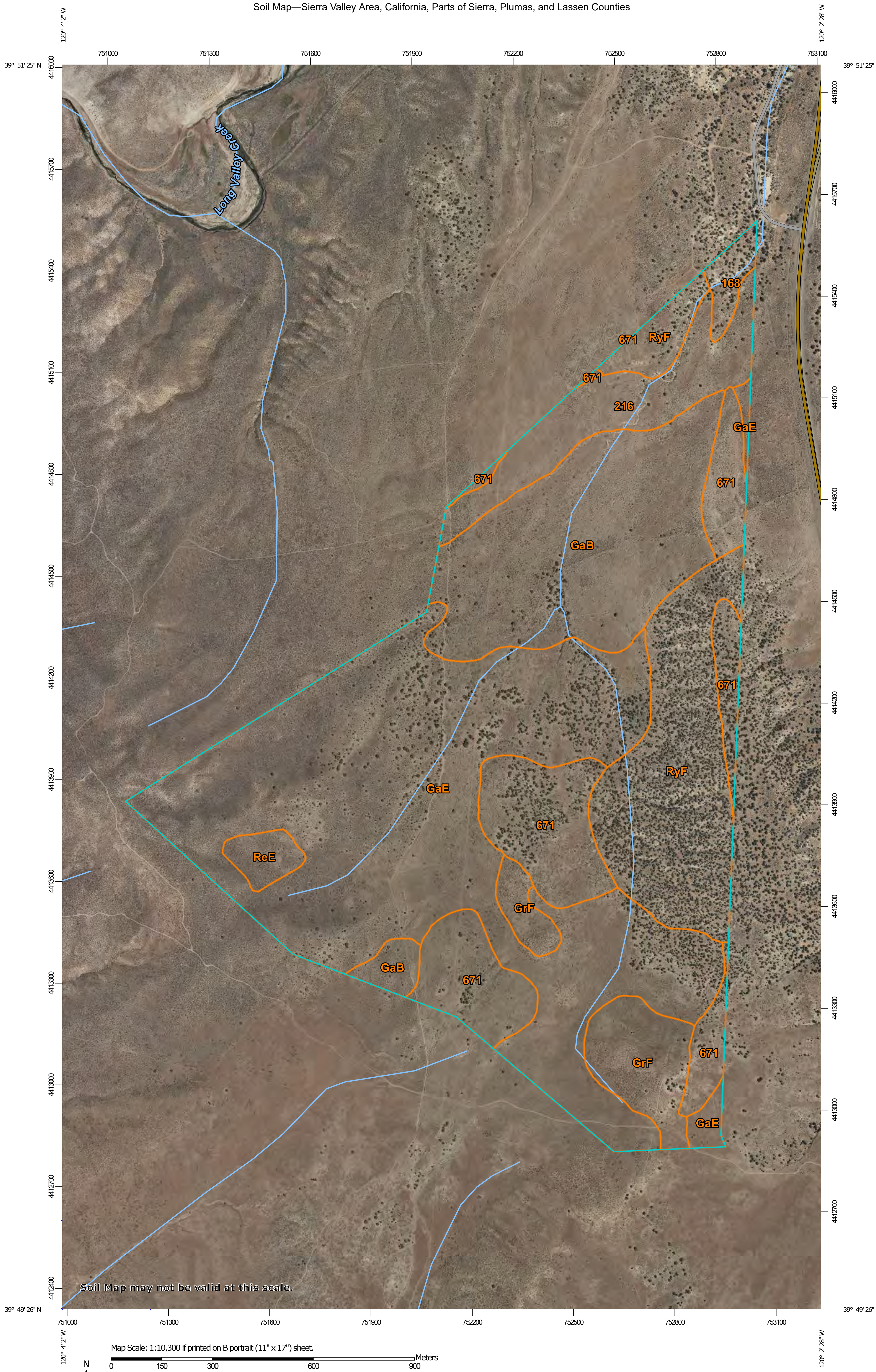
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
114	Barnard stony sandy loam, 2 to 15 percent slopes	50.6	5.9%
215	Galeppi sandy loam, 2 to 5 percent slopes	58.2	6.8%
671	Galeppi sandy loam, 8 to 15 percent slopes	196.5	22.9%
GaE	Galeppi loamy coarse sand, 5 to 30 percent slopes	133.9	15.6%
ReE	Reba sandy loam, 2 to 30 percent slopes	102.1	11.9%
RyF	Rough broken land	162.3	18.9%
SaD	Saralegui sandy loam, 2 to 15 percent slopes	136.4	15.9%
Subtotals for Soil Survey Area		**840.0**	**97.8%**
Totals for Area of Interest		**858.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
114	Barnard stony sandy loam, 2 to 15 percent slopes	12.7	1.5%
215	Galeppi sandy loam, 2 to 5 percent slopes	6.1	0.7%
Subtotals for Soil Survey Area		**18.7**	**2.2%**
Totals for Area of Interest		**858.9**	**100.0%**

West Basins Soil Survey



Map Scale: 1:10,300 if printed on B portrait (11" x 17") sheet.

N

0 150 300 600 900 Meters

0 500 1000 2000 3000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

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

The soil surveys that comprise your AOI were mapped at 1:24,000.

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:
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: Sierra Valley Area, California, Parts of Sierra, Plumas, and Lassen Counties
Survey Area Data: Version 17, Sep 6, 2022

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

Date(s) aerial images were photographed: Jun 10, 2022—Jun 14, 2022

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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
168	Corral-Glenbrook complex, 15 to 50 percent slopes	6.6	1.0%
216	Galeppi sandy loam, 5 to 30 percent slopes	39.0	6.2%
671	Galeppi sandy loam, 8 to 15 percent slopes	81.3	13.0%
GaB	Galeppi loamy coarse sand, 2 to 5 percent slopes	108.2	17.3%
GaE	Galeppi loamy coarse sand, 5 to 30 percent slopes	269.3	43.0%
GrF	Glenbrook-Rock outcrop complex, 5 to 50 percent slopes	30.3	4.8%
ReE	Reba sandy loam, 2 to 30 percent slopes	7.0	1.1%
RyF	Rough broken land	84.8	13.5%
Totals for Area of Interest		**626.3**	**100.0%**

APPENDIX B

PRECIPITATION FREQUENCY – DOYLE, CALIFORNIA

NOAA Atlas 14, Volume 6, Version 2
Location name: Doyle, California, USA*
Latitude: 39.8594°, Longitude: -120.0406°
Elevation: 4693.04 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	**0.098** (0.082-0.118)	**0.132** (0.111-0.159)	**0.183** (0.153-0.220)	**0.229** (0.190-0.278)	**0.299** (0.240-0.377)	**0.361** (0.283-0.465)	**0.430** (0.328-0.568)	**0.509** (0.377-0.692)	**0.629** (0.447-0.894)	**0.734** (0.503-1.08)
10-min	**0.140** (0.118-0.169)	**0.189** (0.159-0.227)	**0.262** (0.219-0.316)	**0.328** (0.272-0.398)	**0.429** (0.344-0.541)	**0.517** (0.405-0.666)	**0.616** (0.471-0.814)	**0.729** (0.541-0.992)	**0.902** (0.641-1.28)	**1.05** (0.721-1.55)
15-min	**0.170** (0.143-0.204)	**0.229** (0.192-0.275)	**0.316** (0.265-0.382)	**0.396** (0.329-0.482)	**0.519** (0.416-0.654)	**0.625** (0.490-0.805)	**0.745** (0.569-0.985)	**0.882** (0.654-1.20)	**1.09** (0.775-1.55)	**1.27** (0.872-1.88)
30-min	**0.232** (0.195-0.278)	**0.312** (0.262-0.375)	**0.432** (0.361-0.520)	**0.540** (0.448-0.657)	**0.707** (0.567-0.891)	**0.853** (0.669-1.10)	**1.02** (0.776-1.34)	**1.20** (0.892-1.64)	**1.49** (1.06-2.11)	**1.74** (1.19-2.56)
60-min	**0.325** (0.273-0.390)	**0.437** (0.367-0.526)	**0.605** (0.506-0.729)	**0.757** (0.628-0.921)	**0.991** (0.795-1.25)	**1.20** (0.937-1.54)	**1.42** (1.09-1.88)	**1.69** (1.25-2.29)	**2.08** (1.48-2.96)	**2.43** (1.67-3.58)
2-hr	**0.432** (0.363-0.519)	**0.547** (0.460-0.658)	**0.720** (0.603-0.868)	**0.877** (0.728-1.07)	**1.12** (0.899-1.41)	**1.34** (1.05-1.72)	**1.58** (1.21-2.09)	**1.86** (1.38-2.53)	**2.29** (1.62-3.25)	**2.67** (1.83-3.93)
3-hr	**0.521** (0.438-0.625)	**0.646** (0.542-0.777)	**0.832** (0.697-1.00)	**1.00** (0.833-1.22)	**1.27** (1.02-1.60)	**1.50** (1.18-1.93)	**1.76** (1.35-2.33)	**2.07** (1.53-2.81)	**2.53** (1.80-3.60)	**2.95** (2.02-4.34)
6-hr	**0.696** (0.585-0.836)	**0.845** (0.709-1.02)	**1.07** (0.892-1.28)	**1.26** (1.05-1.54)	**1.57** (1.26-1.98)	**1.84** (1.44-2.37)	**2.15** (1.64-2.84)	**2.50** (1.85-3.40)	**3.04** (2.16-4.32)	**3.52** (2.41-5.19)
12-hr	**0.925** (0.778-1.11)	**1.16** (0.978-1.40)	**1.50** (1.26-1.81)	**1.80** (1.50-2.19)	**2.24** (1.79-2.82)	**2.60** (2.04-3.35)	**2.99** (2.29-3.96)	**3.43** (2.54-4.66)	**4.06** (2.88-5.77)	**4.58** (3.14-6.76)
24-hr	**1.29** (1.10-1.55)	**1.73** (1.47-2.08)	**2.33** (1.97-2.81)	**2.84** (2.39-3.44)	**3.55** (2.91-4.42)	**4.12** (3.33-5.22)	**4.73** (3.74-6.09)	**5.37** (4.15-7.07)	**6.27** (4.70-8.54)	**6.99** (5.10-9.80)
2-day	**1.57** (1.33-1.88)	**2.13** (1.81-2.56)	**2.92** (2.47-3.52)	**3.60** (3.03-4.36)	**4.57** (3.75-5.68)	**5.36** (4.33-6.78)	**6.21** (4.91-8.00)	**7.12** (5.52-9.39)	**8.44** (6.32-11.5)	**9.51** (6.93-13.3)
3-day	**1.75** (1.48-2.10)	**2.38** (2.02-2.86)	**3.30** (2.79-3.97)	**4.09** (3.44-4.95)	**5.24** (4.30-6.52)	**6.20** (5.01-7.84)	**7.24** (5.73-9.33)	**8.38** (6.49-11.0)	**10.0** (7.52-13.7)	**11.4** (8.33-16.0)
4-day	**1.88** (1.60-2.25)	**2.58** (2.19-3.09)	**3.58** (3.03-4.31)	**4.45** (3.75-5.40)	**5.74** (4.71-7.14)	**6.81** (5.50-8.62)	**7.98** (6.32-10.3)	**9.27** (7.18-12.2)	**11.2** (8.36-15.2)	**12.8** (9.29-17.9)
7-day	**2.13** (1.81-2.55)	**2.93** (2.49-3.53)	**4.09** (3.47-4.93)	**5.11** (4.30-6.20)	**6.61** (5.42-8.22)	**7.86** (6.34-9.94)	**9.21** (7.29-11.9)	**10.7** (8.28-14.1)	**12.9** (9.65-17.6)	**14.7** (10.7-20.6)
10-day	**2.31** (1.97-2.78)	**3.21** (2.72-3.85)	**4.48** (3.80-5.40)	**5.60** (4.72-6.79)	**7.25** (5.94-9.01)	**8.60** (6.94-10.9)	**10.1** (7.97-13.0)	**11.7** (9.04-15.4)	**14.0** (10.5-19.1)	**16.0** (11.6-22.4)
20-day	**2.84** (2.41-3.41)	**3.99** (3.39-4.79)	**5.61** (4.76-6.76)	**7.01** (5.91-8.50)	**9.05** (7.42-11.3)	**10.7** (8.64-13.5)	**12.5** (9.86-16.1)	**14.4** (11.1-18.9)	**17.0** (12.8-23.2)	**19.2** (14.0-26.9)
30-day	**3.34** (2.84-4.01)	**4.70** (3.99-5.65)	**6.61** (5.60-7.96)	**8.24** (6.94-9.99)	**10.6** (8.69-13.2)	**12.5** (10.1-15.8)	**14.4** (11.4-18.6)	**16.5** (12.8-21.8)	**19.5** (14.6-26.5)	**21.8** (15.9-30.5)
45-day	**4.04** (3.43-4.85)	**5.67** (4.81-6.81)	**7.91** (6.70-9.53)	**9.81** (8.26-11.9)	**12.5** (10.3-15.6)	**14.7** (11.8-18.5)	**16.9** (13.4-21.8)	**19.2** (14.9-25.3)	**22.4** (16.7-30.5)	**24.8** (18.1-34.8)
60-day	**4.68** (3.98-5.62)	**6.50** (5.52-7.82)	**9.01** (7.63-10.8)	**11.1** (9.35-13.5)	**14.0** (11.5-17.5)	**16.4** (13.2-20.7)	**18.7** (14.8-24.2)	**21.2** (16.4-27.9)	**24.5** (18.4-33.4)	**27.1** (19.7-37.9)

[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.

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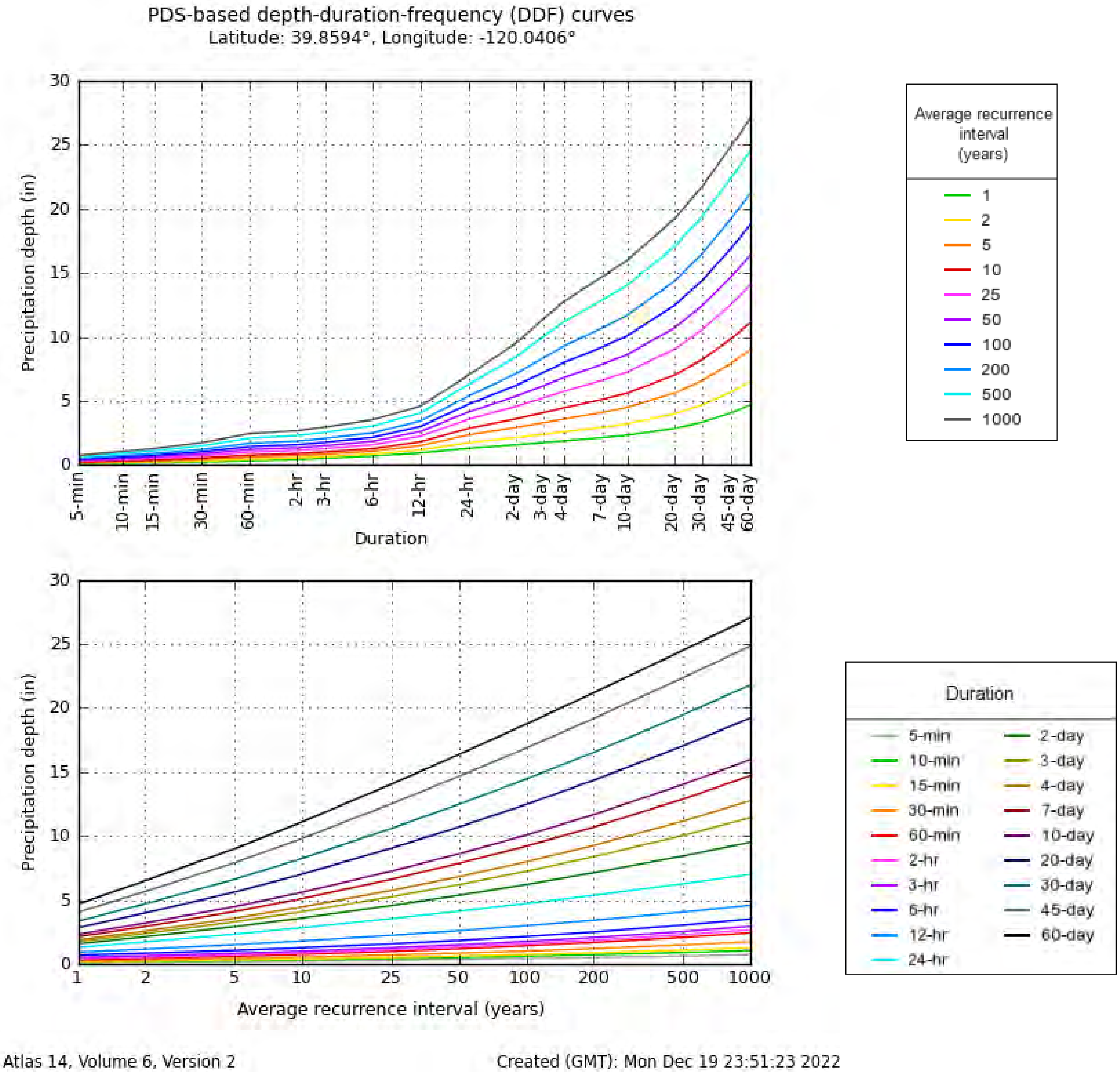
PF graphical



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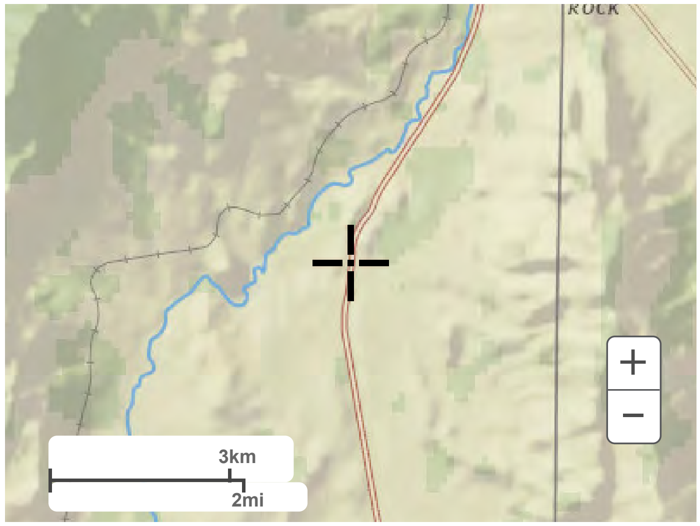
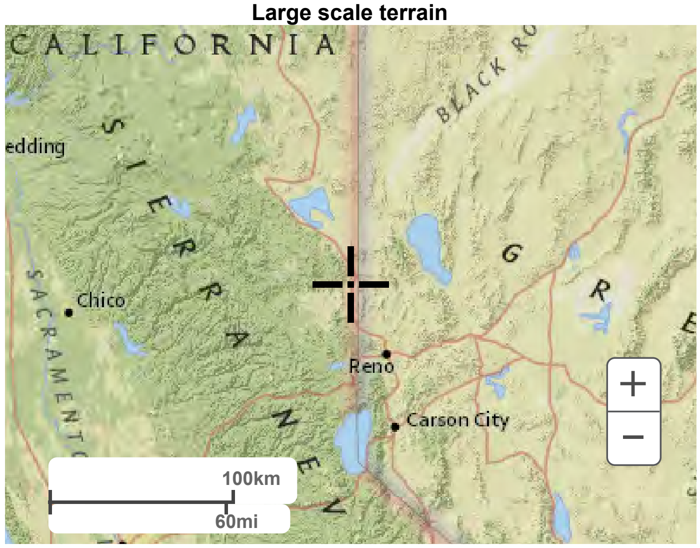
Maps & aerials

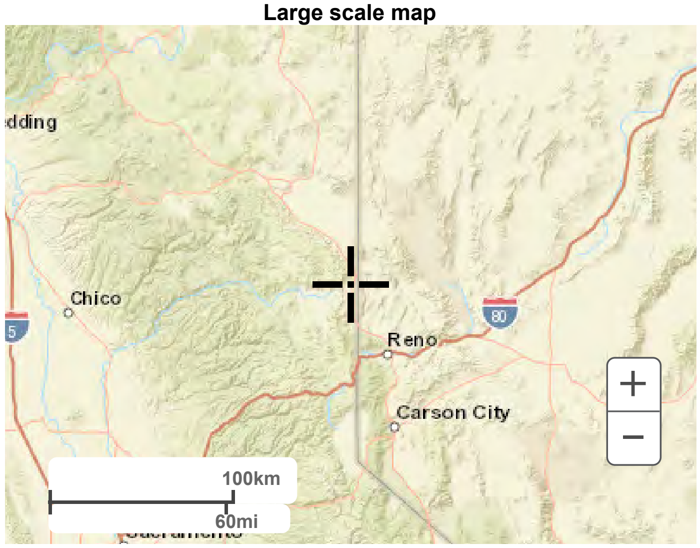
Small scale terrain



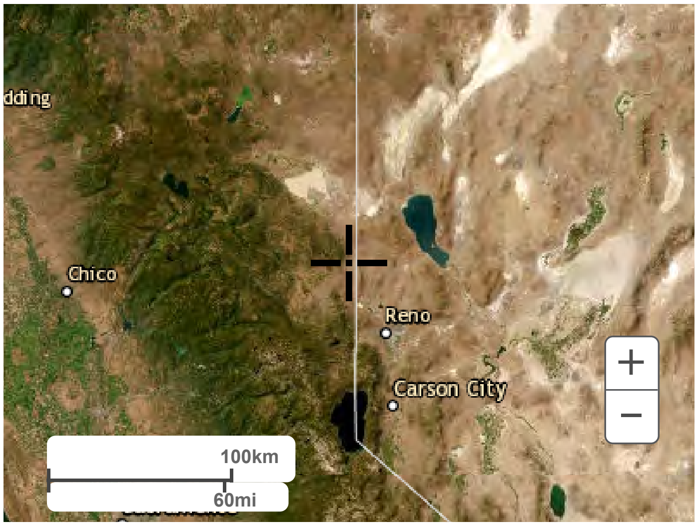
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX C

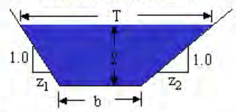
HYDRAULIC CALCULATIONS

Diversion Channel for Subbasin E1

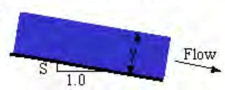
Always enter side slopes:	All features enabled	Click to Calculate
Side slope on bank 1, z_1 (H:V):	3	
Side slope on bank 2, z_2 (H:V):	3	
Click boxes to select inputs:	http://www.LMNOeng.com	
☑ Discharge, Q:	8.2	ft3/s (cfs)
☐ Velocity, V:	3.8091366	ft/s
☐ Water depth, y:	0.35495004	ft
☐ Top width, T:	7.1297003	ft
☑ Bottom width, b:	5	ft
☑ Manning roughness, n:	0.035	Enter or compute n
☑ Channel slope, S:	.0406	m/m, ft/ft
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.	
Channel area, A:	2.1527188	ft2
Channel wetted perimeter, P:	7.2449012	ft
Hydraulic radius, R:	0.2971357	ft
Froude number, F:	1.2226316	

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year

Cross-Section of Channel



Channel Side View



$$Q = VA \qquad V = \frac{k}{n} R^{2/3} S^{1/2} \qquad R = \frac{A}{P} \qquad A = \frac{y}{2}(b+T)$$

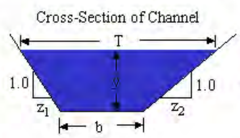
$$P = b + y\left(\sqrt{1+z_1^2} + \sqrt{1+z_2^2}\right) \qquad T = b + y(z_1 + z_2)$$

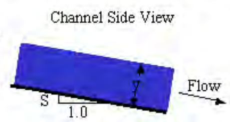
$$F = V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta = Tan^{-1}(S)$$

Diversion Channel on South Portion of West Side

Always enter side slopes:	All features enabled	Click to Calculate
Side slope on bank 1, z_1 (H:V):	3	
Side slope on bank 2, z_2 (H:V):	3	
Click boxes to select inputs:	http://www.LMNOeng.com	
☑ Discharge, Q:	10	ft3/s (cfs)
☐ Velocity, V:	3.8912414	ft/s
☐ Water depth, y:	0.41208591	ft
☐ Top width, T:	7.4725155	ft
☑ Bottom width, b:	5	ft
☑ Manning roughness, n:	0.035	Enter or compute n
☑ Channel slope, S:	.0357	m/m, ft/ft
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.	
Channel area, A:	2.569874	ft2
Channel wetted perimeter, P:	7.6062602	ft
Hydraulic radius, R:	0.33786301	ft
Froude number, F:	1.1701788	

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year





$$Q = VA \qquad V = \frac{k}{n} R^{2/3} S^{1/2} \qquad R = \frac{A}{P} \qquad A = \frac{y}{2}(b + T)$$

$$P = b + y\left(\sqrt{1 + z_1^2} + \sqrt{1 + z_2^2}\right) \qquad T = b + y(z_1 + z_2)$$

$$F = V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta = Tan^{-1}(S)$$

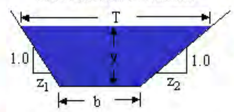
Diversion Channel for Subbasin E1 and E2 Combined

Always enter side slopes: All features enabled

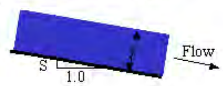
Side slope on bank 1, z_1 (H:V):	3	Click to Calculate
Side slope on bank 2, z_2 (H:V):	3	
Click boxes to select inputs:	http://www.LMNOeng.com	
☑ Discharge, Q:	69.7	ft3/s (cfs)
☐ Velocity, V:	6.7175904	ft/s
☐ Water depth, y:	1.2045641	ft
☐ Top width, T:	12.227384	ft
☑ Bottom width, b:	5	ft
☑ Manning roughness, n:	0.035	Enter or compute n
☑ Channel slope, S:	.0325	m/m, ft/ft
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.	
Channel area, A:	10.375744	ft2
Channel wetted perimeter, P:	12.618332	ft
Hydraulic radius, R:	0.82227541	ft
Froude number, F:	1.285978	

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year

Cross-Section of Channel



Channel Side View



$$Q = VA \qquad V = \frac{k}{n} R^{2/3} S^{1/2} \qquad R = \frac{A}{P} \qquad A = \frac{y}{2}(b+T)$$

$$P = b + y\left(\sqrt{1+z_1^2} + \sqrt{1+z_2^2}\right) \qquad T = b + y(z_1 + z_2)$$

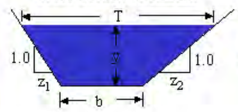
$$F = V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta = Tan^{-1}(S)$$

Diversion Channel for Combined Subbasin W1, W2 and W3

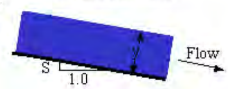
Always enter side slopes:	All features enabled	
Side slope on bank 1, z_1 (H:V):	3	Click to Calculate
Side slope on bank 2, z_2 (H:V):	3	
Click boxes to select inputs:	http://www.LMNOeng.com	
☑ Discharge, Q:	144	ft3/s (cfs)
☐ Velocity, V:	5.0343003	ft/s
☐ Water depth, y:	1.842232	ft
☐ Top width, T:	21.053392	ft
☑ Bottom width, b:	10	ft
☑ Manning roughness, n:	0.035	Enter or compute n
☑ Channel slope, S:	.0097	m/m, ft/ft
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.	
Channel area, A:	28.603776	ft2
Channel wetted perimeter, P:	21.651298	ft
Hydraulic radius, R:	1.3211114	ft
Froude number, F:	0.76145973	

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year

Cross-Section of Channel



Channel Side View



$$Q = VA \qquad V = \frac{k}{n} R^{2/3} S^{1/2} \qquad R = \frac{A}{P} \qquad A = \frac{y}{2}(b + T)$$

$$P = b + y\left(\sqrt{1 + z_1^2} + \sqrt{1 + z_2^2}\right) \qquad T = b + y(z_1 + z_2)$$

$$F = V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta = Tan^{-1}(S)$$

Revised Hydrology Study and
Diversion Channel Design Parameters
Lassen County Pozzolans Mine Expansion
Near Hallelujah Junction, California

Prepared for:

Geofortis Minerals, LLC
30 S. Tooele Blvd
Tooele, UT 84074

Prepared by:

BROADBENT

5450 Louie Lane, #101
Reno, NV 89521
775-322-7969
www.broadbentinc.com

May 19, 2023

Project No. 14-01-173

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Creating Solutions. Building Trust.

May 19, 2023

Project No. 14-01-173

Geofortis Minerals, LLC
30 S. Tooele Blvd
Tooele, UT 84074

Attn: Mr. David McMurtry

Re: **Revised Hydrology Study and Diversion Channel Design Parameters**
Geofortis Minerals, LLC – Lassen County Pozzolans Mine Expansion
Near Hallelujah Junction, California

Dear Mr. McMurty,

Broadbent & Associates, Inc. (Broadbent) is pleased to submit the enclosed *Revised Hydrology Study and Diversion Channel Design Parameters* to Geofortis Minerals, LLC for the expansion of the Lassen County Pozzolans Mine located near Hallelujah Junction, California. Should you have questions regarding this document, please do not hesitate to contact us at (775) 322-7969.

Sincerely,
BROADBENT & ASSOCIATES, INC.

Jeremy B. Boucher, PE
Associate Engineer

LICENSED PROFESSIONAL ENGINEER
JEREMY BRANDON BOUCHER
No. 84433
Exp. 9/30/23
CIVIL
STATE OF CALIFORNIA

Lonnie Roy, PE
Principal Engineer

enclosures: Revised Hydrology Study to Support a LSA Permit

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DRAWINGS

TABLES

APPENDICES

Revised Hydrology Study and Diversion Channel Design Parameters

Lassen County Pozzolans Mine
Near Hallelujah Junction, California

1.0 INTRODUCTION

Geofortis Minerals, LLC (Geofortis) intends to expand their Lassen County Pozzolans Mine (mine) located approximately six miles north of Hallelujah Junction, Lassen County, California (Drawing 1). The proposed mine expansion incudes mining from two new open pits, one on the east side of Unites States Route 395 (US 395) and one on the west side of US 395 (Drawing 2). Ephemeral streams are known to be present near each proposed mining area (USGS, 2022) and the natural flow of stormwater will be diverted to prevent stormwater from entering the open pits. One diversion channel is proposed on the east side of US 395 and one diversion channel is proposed on the west side of US 395 as indicated on Drawing 2. These diversion channels do not affect the CalTrans right of way for US395. To continue the environmental review for the California Environmental Quality Act (CEQA), Lassen County and the California Department of Fish and Wildlife (CDFW) have requested a hydrology study to estimate stormwater flows carried by these channels and determine the design parameters for diversion channels.

Broadbent & Associates, Inc. (Broadbent) is supporting Geofortis with the hydrologic study of the basins that drain through the mine expansion areas and determination of the diversion channel design parameters. No detention/retention basins are proposed to control offsite flows. This report summarizes observations from an October 18, 2022, site visit performed by Broadbent, hydrologic modeling with Hydrologic Engineering Center – Hydrologic Modeling System (HEC – HMS) software, and review of pertinent databases and technical resources. The January 12, 2023 *Hydrology Study and Diversion Channel Design Parameters* report was revised to address comments provided by the Lahontan Regional Water Quality Control Board.

2.0 SITE LOCATION

The proposed mine expansion is located at an elevation of approximately 4,740 feet (ft) above mean sea level (amsl) within the North Lahontan Hydrologic Unit (hydrologic unit code 12-180800031204 Zamboni Hot Springs – Long Valley Creek). The surface elevation within Long Valley decreases while traveling north as evidenced by the northerly flow direction of Long Valley Creek which runs west of the mine and its expansion areas. In the vicinity of the mine, Long Valley Creek is fed by numerous ephemeral streams that drain the Diamond Mountains (west of the mine) and the Peterson Mountain (east of the mine). The vegetation is characterized by conifer trees, abundant sagebrush, and seasonal grasses.

Drawing 2 depicts the proposed open pits and hydrologic subbasins that naturally drain through the expanded mining area. The two subbasins (E1 and E2) on the east side of US 395 contribute flows from an approximate area of 624 acres and the highest elevation approaches 5,340 ft amsl. The three subbasins (W1, W2, and W3) on the west side of US 395 contribute flows from an approximate area of 695 acres and the highest elevation approaches 5,200 ft amsl. The stormwater flows from the east and west basins currently merge north of the proposed open pits. The area, minimum and maximum elevation, and drainage length for each subbasin is presented on Table 1 and Drawing 2. Water that falls directly on the pits will mostly be retained and allowed to infiltrate. The construction of the pits will not increase flows downstream during rain events.

3.0 SOIL CONDITIONS

During the October 18, 2022, site visit, Broadbent personnel inspected the drainages and terrain in each subbasin. The soil was observed to be composed primarily of sand; however, clays, gravels, and silts were also present in variable proportions across the area. Additionally, small rock outcrops were observed in the upper reaches of subbasin W1. Broadbent also utilized the United States Department of Agriculture (USDA) web soil survey (WSS) operated by the Soil Conservation Service (SCS) to better understand the existing soil conditions. The WSS indicated that the most prevalent soil types in the east and west basins is sandy loam and loamy sand. The USDA NRCS classifies these types of soil as hydrologic soil group (HSG) A (USDA, 1986). The WSSs are included in Appendix A.

4.0 CLIMATE DATA

The nearest National Oceanic and Atmospheric Administration (NOAA) weather station to the mine is approximately 14 miles north-northwest in Doyle, CA. In Doyle, annual averages are as follows: high temperature is 65 degrees Fahrenheit (°F), low temperature is 36°F, 14 inches of rain, and 25 inches of snow (U.S. Climate Data). Point precipitation frequency estimates for Doyle were obtained from NOAA Atlas 14, Volume 6, Version 2 and is included in Appendix B.

The USDA SCS developed four synthetic 24-hour rainfall distributions from data made available by the National Weather Service to account for variation in rainfall intensity during a storm and across the storm area. Doyle is in a region that receives Type II storms which are characterized by intense short duration rainfall (USDA, 1986).

4.0 HEC-HMS MODELING

Modeling with the HEC-HMS was performed to estimate runoff from the two subbasins located on the east side of US 395 and the three subbasins located on the west side of US 395. Since stormwater runoff from the east and west basins do not combine within either of the proposed open pits, each set of subbasins was modeled independently to estimate stormwater runoff that will be required to be diverted around the east and west open pits. Due to the ephemeral nature of the streams in the five subbasins, historic flow data through the streams is not available as the streams are not equipped with gauges. Accordingly, certain basin modeling parameters were determined from SCS guidance as described in previous sections. Lag time was calculated using the SCS Lag Equation presented in the Unit Hydrograph (UHG) Technical Manual (NOAA, 2005). This empirical method developed by the SCS estimates lag time directly and applicable to basins that are less than 2,000 acres (NOAA, 2005). Table 1 presents the subbasin modeling parameters.

Hypothetical storms with durations of 24-hours were applied to the east and west basins with the HEC-HMS software. In Doyle, a storm of 24-hour duration at recurrence intervals of 10, 25, 50, and 100 years have precipitation frequency estimates of 2.84 inches, 3.55 inches, 4.12 inches, and 4.73 inches, respectively (NOAA, 2022). For the east basins combined peak discharge ranges between 34.2 cubic feet per second (cfs, 10-year frequency storm) and 155.1 cfs (100-year frequency storm). In the west basins the combined peak discharge ranges between 64.3 cfs (10-year frequency storm) to 326.7 cfs (100-year frequency storm). The modeling results for the east basin are presented in Table 2 while the modeling results for the west basins are presented in Table 3.

5.0 DIVERSION CHANNEL DESIGN PARAMETERS

CalTrans criteria require culverts to pass the 10-year recurrence interval storm. Since the mining operation will have an expected life greater than 10 years, the 25-year recurrence interval storm will be used to size the diversion channels. Drawing 3 shows the proposed drainage channels with the design parameters, depths and flows.

Channel parameters were estimated using a normal depth calculator. The Manning's coefficient for earthen channels was estimated at 0.035. Proposed channels slopes were estimated from proposed grading plans and these parameters were used to calculate flow depths. Model outputs are provided in Appendix C.

For the basins on the east side of US 395, two sets of design parameters have been established since the stormwater runoff from subbasin E2 flows toward the southern boundary of the proposed open pit while flows from subbasin E1 are directed toward the eastern boundary of the proposed open pit. The diverted flows will not combine until flow from E2 are directed along the eastern boundary of the proposed pit in an existing drainage. Along the southern boundary of the proposed open pit, a trapezoidal channel that is 5 feet wide with side wall slopes of 3:1 will be installed to carry the estimated 8.6 cfs until this stormwater reaches the eastern boundary of the proposed pit. The water in this channel will flow at a depth of 0.36 feet. As this channel combines with the flows from subbasin E1, channel will remain in the same configuration, but the depth of flow will increase to 1.22 feet to carry the estimated 71.6 cfs of the 25-year flow. This diversion channel ultimately discharges to the existing wash similar to existing conditions.

For the basins on the west side of US 395, the three subbasins (W1, W2 and W3) ultimately combine and are diverted around the pit. The combined 25-year flow is estimated at 144.1 cfs. This flow will be carried in a trapezoidal channel with a bottom width of 10 feet, side slopes of 3:1 and a flow depth of 1.84 feet. This water is carried on the west side of the pit and discharges into and existing wash in a similar location as the existing conditions. A smaller channel designed to carry 10 cfs is proposed at the southern edge of the pit to control any nuisance water that does not flow directly east. During field inspections this area was found to be rather flat and small (less than a few acres) and this channel was added to ensure that minor nuisance water does not cause erosion on the southern edge of the pit. This trapezoidal channel has a bottom with of 5 feet, side slopes of 3:1 and an estimated flow depth of 0.41 feet.

Design details regarding the diversion channel construction, features including connection to ephemeral streams, and materials of construction will be submitted with the Clean Water Act Section 401 Water Quality Certification (401 Water Certification) application. Additionally, the culvert sizing design will be included as part of the 401 Water Certification. 401 Water Certification is required when an activity may cause a discharge to a water body. Prior to construction, the project will enroll in the National Pollution Discharge Elimination System (NPDES) General Permit for Discharges Associated with Construction Activities (Order 2014-0057-DWQ, as amended in 2015 and 2018).

The proposed culvert beneath the access road on the east side is within CalTrans right of way and is designed to pass the 10-year recurrence interval storm and will have additional permitting requirements through CalTrans.

6.0 LIMITATIONS

The findings presented in this report are based upon observations by field personnel, points investigated, and data available in publicly available databases. Our services were performed in accordance with the generally accepted standard of practice at the time this report was written. No other warranty expressed or implied was made. This report has been prepared for the exclusive use of Geofortis. It is possible that variations in soil conditions could exist beyond the points investigated. Also, changes in site conditions could occur in the future due to variations in rainfall, temperature, regional water usage, or other factors.

7.0 REFERENCES

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DRAWINGS

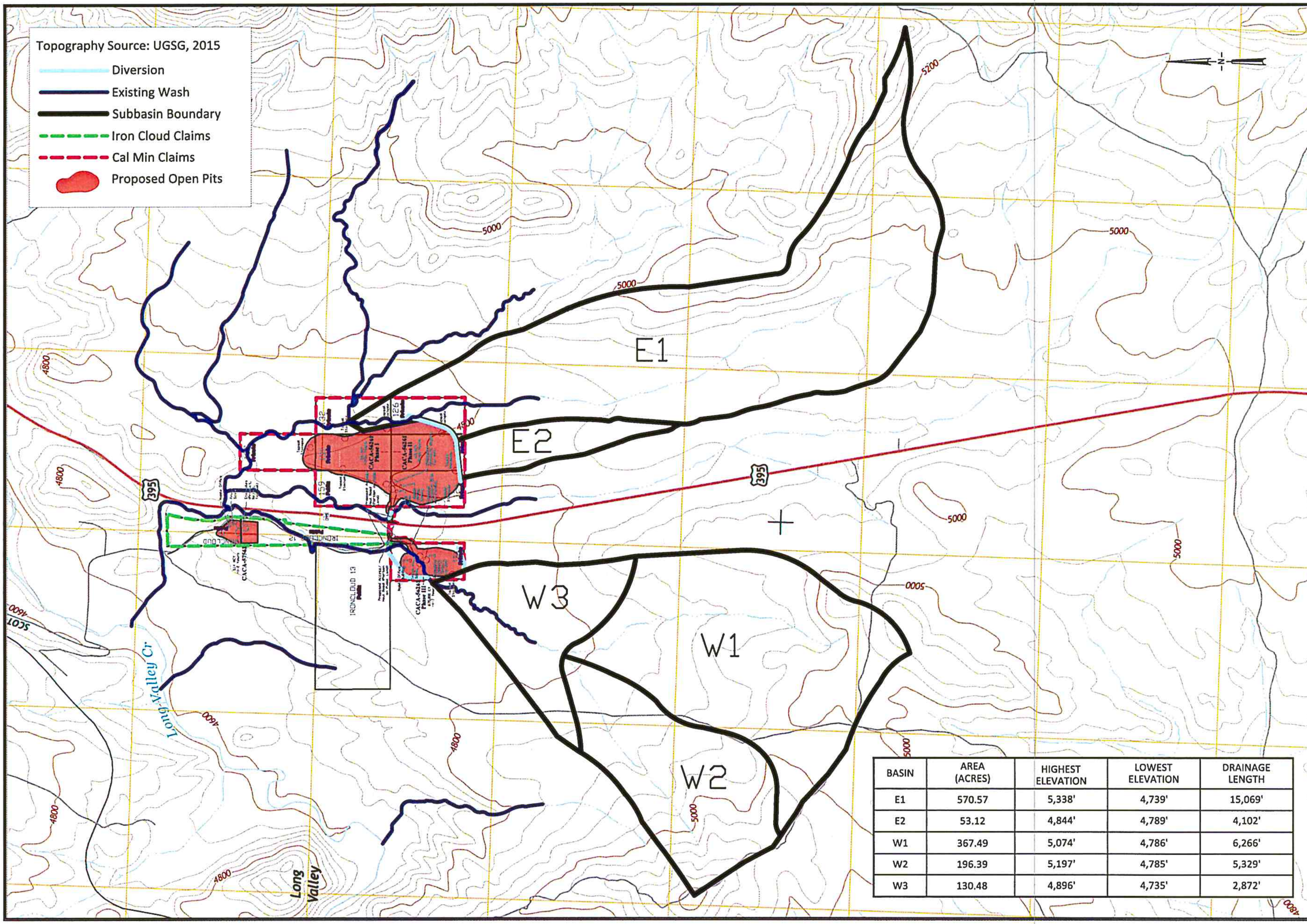
N

0 4 8

APPROXIMATE SCALE (ft)

IMAGE SOURCE: Google Earth

BROADBENT 5450 Louie Lane, #101 Reno, Nevada 89511 Project No.: 14-10-173 Date: 12/22/2022	Geofortis Minerals, LLC 30 S. Tooele Blvd. Tooele, Utah 84074	Site Location Map	Drawing 1



BASIN	AREA (ACRES)	HIGHEST ELEVATION	LOWEST ELEVATION	DRAINAGE LENGTH
E1	570.57	5,338'	4,739'	15,069'
E2	53.12	4,844'	4,789'	4,102'
W1	367.49	5,074'	4,786'	6,266'
W2	196.39	5,197'	4,785'	5,329'
W3	130.48	4,896'	4,735'	2,872'

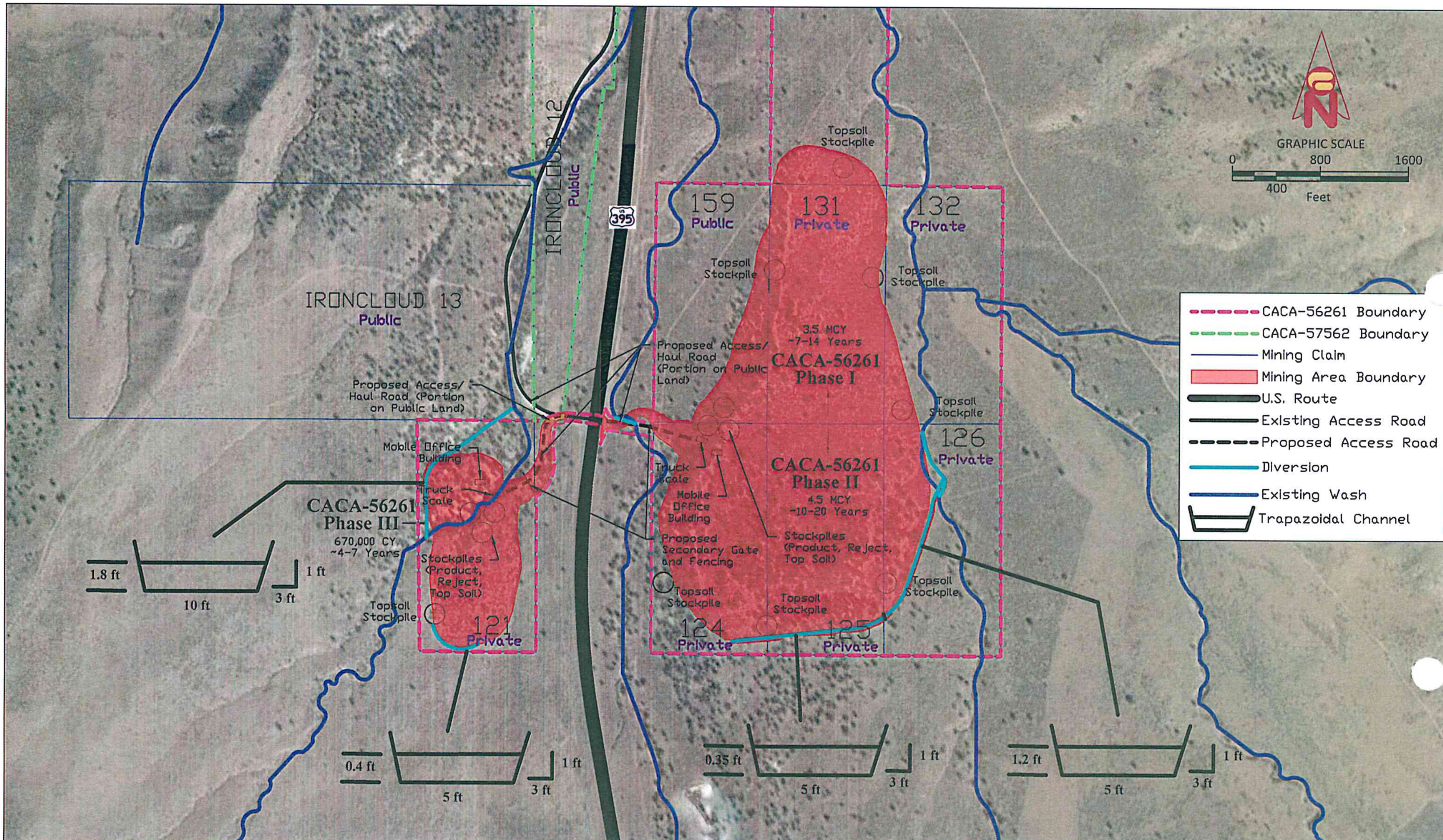
0 1,600 3,200
SCALE (ft)

BROADBENT
5450 Louie Lane, #101
Reno, Nevada 89511
Project No.: 14-10-173 Date: 1/12/2023

Geofortis Minerals, LLC
30 S. Tooele Blvd.
Tooele, Utah 84074

Hydrology Study -
Subbasins Characteristics

Drawing
2



BROADBENT

Geofortis Minerals, LLC
30 S. Tooele Blvd
Tooele, UT 84074

Project Number:
14-01-173-701

Prepared By: C. Peterson
Reviewed By: L. Roy
Date: 01/11/2023

Figure 3:
Diversion Channels

TABLES

Table 1. Subbasin Modeling Parameters
Geofortis Minerals, LLC

Subbasin ID	Drainage Area (acres)	Highest Elevation (ft)	Lowest Elevation (ft)	Drainage Length (ft)	Average Slope %	Curve Number	Lag Time (hours)
E1	570.57	5,338	4,739	15,069	3.98	63	2.2
E2	53.12	4,844	4,789	4,102	1.34	63	1.4
W1	367.49	5,074	4,786	6,266	4.60	63	1.0
W2	196.39	5,197	4,785	5,329	7.73	63	0.7
W3	130.48	4,896	4,735	2,872	5.61	63	0.5

ft - feet

Table 2. HEC - HMS East Basins Results

Geofortis Minerals, LLC

Subbasin	E1	E2	Combined
Drainage Area (acres)	570.57	53.12	623.69
10-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	31.4 / 14:50	4.0 / 13:40	34.2 / 14:45
25-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	65.7 / 14:35	8.6 / 13:30	71.6 / 14:30
50-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	100.3 / 14:30	13.4 / 13:30	109.1 / 14:25
100-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	142.6 / 14:25	19.2 / 13:25	155.1 / 14:25

Acronymns:

CFS - cubic feet per second

HEC - HMS - Hydrologic Engineering Center - Hydologic Modeling System

YR - year

hrs:min - hours:minutes

Table 3. HEC - HMS West Basins Results

Geofortis Minerals, LLC

Subbasin	W1	W2	W3	Combined
Subbasin Drainage Area (acres)	367.49	196.39	130.48	694.36
10-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	32.7 / 13:15	22.3 / 12:45	18.2 / 12:30	64.3 / 12:55
25-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	72.5 / 13:05	50.6 / 12:45	42.1 / 12:30	144.1 / 12:45
50-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	113.0 / 13:05	79.6 / 12:40	66.3 / 12:25	226.0 / 12:45
100-YR Peak Discharge (CFS) / Time to Peak (hrs:min)	162.6 / 13:05	115.2 / 12:40	96.4 / 12:25	326.7 / 12:40

Acronymns:

CFS - cubic feet per second

HEC - HMS - Hydrologic Engineering Center - Hydologic Modeling System

YR - year

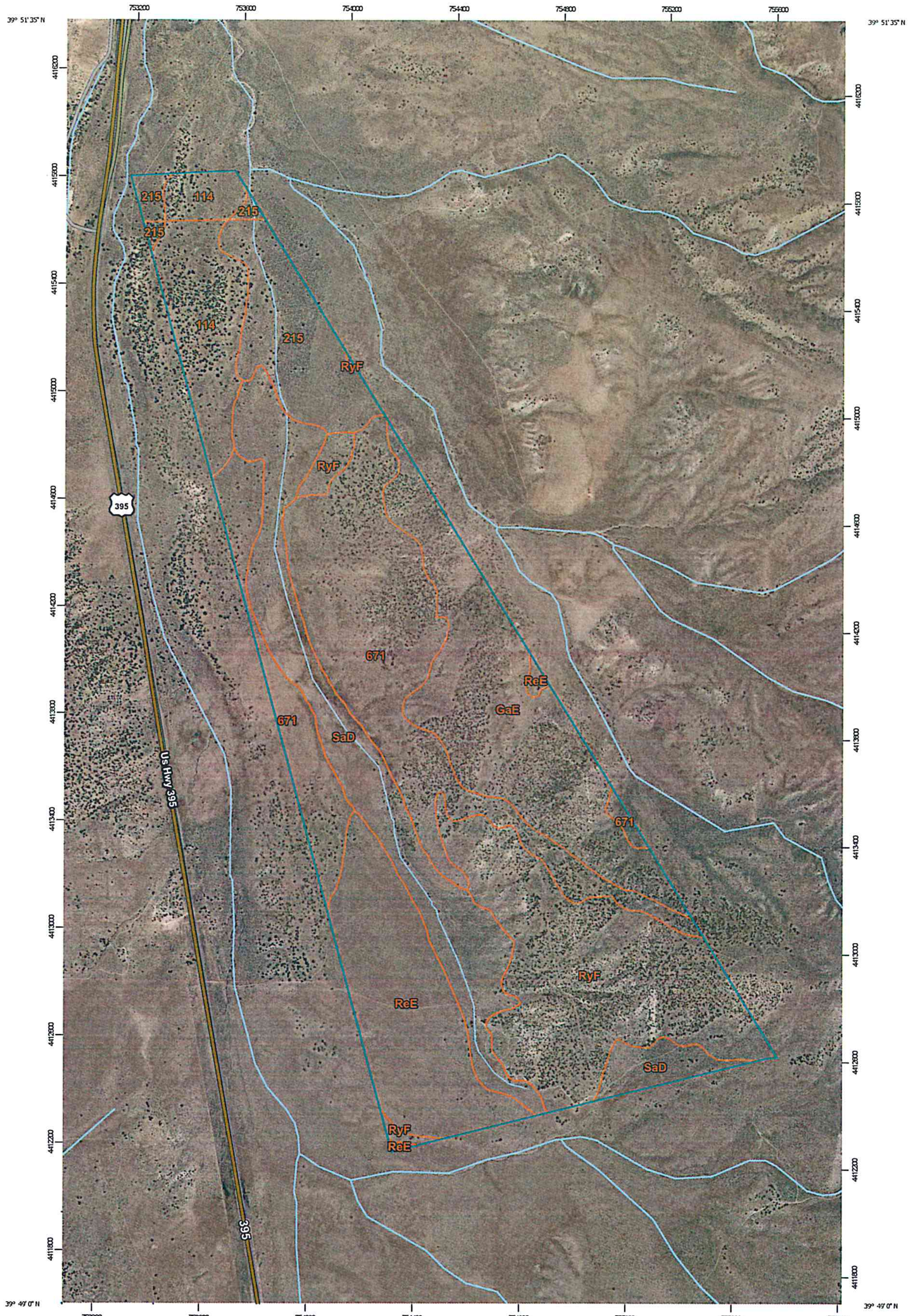
hrs:min - hours:minutes

APPENDICES

APPENDIX A

WEB SOIL SURVEYS

East Basins Web Soil Survey



Map Scale: 1:13,400 if printed on B portrait (11" x 17") sheet.

N

Meters: 0, 150, 300, 600, 900

Feet: 0, 500, 1000, 2000, 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

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

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
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: Sierra Valley Area, California, Parts of Sierra, Plumas, and Lassen Counties
Survey Area Data: Version 17, Sep 6, 2022

Soil Survey Area: Susanville Area, Parts of Lassen and Plumas Counties, California
Survey Area Data: Version 14, Sep 2, 2022

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Jun 10, 2022—Jun 14, 2022

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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
114	Barnard stony sandy loam, 2 to 15 percent slopes	50.6	5.9%
215	Galeppi sandy loam, 2 to 5 percent slopes	58.2	6.8%
671	Galeppi sandy loam, 8 to 15 percent slopes	196.5	22.9%
GaE	Galeppi loamy coarse sand, 5 to 30 percent slopes	133.9	15.6%
ReE	Reba sandy loam, 2 to 30 percent slopes	102.1	11.9%
RyF	Rough broken land	162.3	18.9%
SaD	Saralegui sandy loam, 2 to 15 percent slopes	136.4	15.9%
Subtotals for Soil Survey Area		**840.0**	**97.8%**
Totals for Area of Interest		**858.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
114	Barnard stony sandy loam, 2 to 15 percent slopes	12.7	1.5%
215	Galeppi sandy loam, 2 to 5 percent slopes	6.1	0.7%
Subtotals for Soil Survey Area		**18.7**	**2.2%**
Totals for Area of Interest		**858.9**	**100.0%**

West Basins Soil Survey

Map Scale: 1:10,300 if printed on B portrait (11" x 17") sheet.

N

Meters: 0, 150, 300, 600, 900

Feet: 0, 500, 1000, 2000, 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

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

The soil surveys that comprise your AOI were mapped at 1:24,000.

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:
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: Sierra Valley Area, California, Parts of Sierra, Plumas, and Lassen Counties
Survey Area Data: Version 17, Sep 6, 2022

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

Date(s) aerial images were photographed: Jun 10, 2022—Jun 14, 2022

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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
168	Corral-Glenbrook complex, 15 to 50 percent slopes	6.6	1.0%
216	Galeppi sandy loam, 5 to 30 percent slopes	39.0	6.2%
671	Galeppi sandy loam, 8 to 15 percent slopes	81.3	13.0%
GaB	Galeppi loamy coarse sand, 2 to 5 percent slopes	108.2	17.3%
GaE	Galeppi loamy coarse sand, 5 to 30 percent slopes	269.3	43.0%
GrF	Glenbrook-Rock outcrop complex, 5 to 50 percent slopes	30.3	4.8%
ReE	Reba sandy loam, 2 to 30 percent slopes	7.0	1.1%
RyF	Rough broken land	84.8	13.5%
Totals for Area of Interest		**626.3**	**100.0%**

APPENDIX B

PRECIPITATION FREQUENCY – DOYLE, CALIFORNIA

NOAA Atlas 14, Volume 6, Version 2
Location name: Doyle, California, USA*
Latitude: 39.8594°, Longitude: -120.0406°
Elevation: 4693.04 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	0.098 (0.082-0.118)	0.132 (0.111-0.159)	0.183 (0.153-0.220)	0.229 (0.190-0.278)	0.299 (0.240-0.377)	0.361 (0.283-0.465)	0.430 (0.328-0.568)	0.509 (0.377-0.692)	0.629 (0.447-0.894)	0.734 (0.503-1.08)
10-min	0.140 (0.118-0.169)	0.189 (0.159-0.227)	0.262 (0.219-0.316)	0.328 (0.272-0.398)	0.429 (0.344-0.541)	0.517 (0.405-0.666)	0.616 (0.471-0.814)	0.729 (0.541-0.992)	0.902 (0.641-1.28)	1.05 (0.721-1.55)
15-min	0.170 (0.143-0.204)	0.229 (0.192-0.275)	0.316 (0.265-0.382)	0.396 (0.329-0.482)	0.519 (0.416-0.654)	0.625 (0.490-0.805)	0.745 (0.569-0.985)	0.882 (0.654-1.20)	1.09 (0.775-1.55)	1.27 (0.872-1.88)
30-min	0.232 (0.195-0.278)	0.312 (0.262-0.375)	0.432 (0.361-0.520)	0.540 (0.448-0.657)	0.707 (0.567-0.891)	0.853 (0.669-1.10)	1.02 (0.776-1.34)	1.20 (0.892-1.64)	1.49 (1.06-2.11)	1.74 (1.19-2.56)
60-min	0.325 (0.273-0.390)	0.437 (0.367-0.526)	0.605 (0.506-0.729)	0.757 (0.628-0.921)	0.991 (0.795-1.25)	1.20 (0.937-1.54)	1.42 (1.09-1.88)	1.69 (1.25-2.29)	2.08 (1.48-2.96)	2.43 (1.67-3.58)
2-hr	0.432 (0.363-0.519)	0.547 (0.460-0.658)	0.720 (0.603-0.868)	0.877 (0.728-1.07)	1.12 (0.899-1.41)	1.34 (1.05-1.72)	1.58 (1.21-2.09)	1.86 (1.38-2.53)	2.29 (1.62-3.25)	2.67 (1.83-3.93)
3-hr	0.521 (0.438-0.625)	0.646 (0.542-0.777)	0.832 (0.697-1.00)	1.00 (0.833-1.22)	1.27 (1.02-1.60)	1.50 (1.18-1.93)	1.76 (1.35-2.33)	2.07 (1.53-2.81)	2.53 (1.80-3.60)	2.95 (2.02-4.34)
6-hr	0.696 (0.585-0.836)	0.845 (0.709-1.02)	1.07 (0.892-1.28)	1.26 (1.05-1.54)	1.57 (1.26-1.98)	1.84 (1.44-2.37)	2.15 (1.64-2.84)	2.50 (1.85-3.40)	3.04 (2.16-4.32)	3.52 (2.41-5.19)
12-hr	0.925 (0.778-1.11)	1.16 (0.978-1.40)	1.50 (1.26-1.81)	1.80 (1.50-2.19)	2.24 (1.79-2.82)	2.60 (2.04-3.35)	2.99 (2.29-3.96)	3.43 (2.54-4.66)	4.06 (2.88-5.77)	4.58 (3.14-6.76)
24-hr	1.29 (1.10-1.55)	1.73 (1.47-2.08)	2.33 (1.97-2.81)	2.84 (2.39-3.44)	3.55 (2.91-4.42)	4.12 (3.33-5.22)	4.73 (3.74-6.09)	5.37 (4.15-7.07)	6.27 (4.70-8.54)	6.99 (5.10-9.80)
2-day	1.57 (1.33-1.88)	2.13 (1.81-2.56)	2.92 (2.47-3.52)	3.60 (3.03-4.36)	4.57 (3.75-5.68)	5.36 (4.33-6.78)	6.21 (4.91-8.00)	7.12 (5.52-9.39)	8.44 (6.32-11.5)	9.51 (6.93-13.3)
3-day	1.75 (1.48-2.10)	2.38 (2.02-2.86)	3.30 (2.79-3.97)	4.09 (3.44-4.95)	5.24 (4.30-6.52)	6.20 (5.01-7.84)	7.24 (5.73-9.33)	8.38 (6.49-11.0)	10.0 (7.52-13.7)	11.4 (8.33-16.0)
4-day	1.88 (1.60-2.25)	2.58 (2.19-3.09)	3.58 (3.03-4.31)	4.45 (3.75-5.40)	5.74 (4.71-7.14)	6.81 (5.50-8.62)	7.98 (6.32-10.3)	9.27 (7.18-12.2)	11.2 (8.36-15.2)	12.8 (9.29-17.9)
7-day	2.13 (1.81-2.55)	2.93 (2.49-3.53)	4.09 (3.47-4.93)	5.11 (4.30-6.20)	6.61 (5.42-8.22)	7.86 (6.34-9.94)	9.21 (7.29-11.9)	10.7 (8.28-14.1)	12.9 (9.65-17.6)	14.7 (10.7-20.6)
10-day	2.31 (1.97-2.78)	3.21 (2.72-3.85)	4.48 (3.80-5.40)	5.60 (4.72-6.79)	7.25 (5.94-9.01)	8.60 (6.94-10.9)	10.1 (7.97-13.0)	11.7 (9.04-15.4)	14.0 (10.5-19.1)	16.0 (11.6-22.4)
20-day	2.84 (2.41-3.41)	3.99 (3.39-4.79)	5.61 (4.76-6.76)	7.01 (5.91-8.50)	9.05 (7.42-11.3)	10.7 (8.64-13.5)	12.5 (9.86-16.1)	14.4 (11.1-18.9)	17.0 (12.8-23.2)	19.2 (14.0-26.9)
30-day	3.34 (2.84-4.01)	4.70 (3.99-5.65)	6.61 (5.60-7.96)	8.24 (6.94-9.99)	10.6 (8.69-13.2)	12.5 (10.1-15.8)	14.4 (11.4-18.6)	16.5 (12.8-21.8)	19.5 (14.6-26.5)	21.8 (15.9-30.5)
45-day	4.04 (3.43-4.85)	5.67 (4.81-6.81)	7.91 (6.70-9.53)	9.81 (8.26-11.9)	12.5 (10.3-15.6)	14.7 (11.8-18.5)	16.9 (13.4-21.8)	19.2 (14.9-25.3)	22.4 (16.7-30.5)	24.8 (18.1-34.8)
60-day	4.68 (3.98-5.62)	6.50 (5.52-7.82)	9.01 (7.63-10.8)	11.1 (9.35-13.5)	14.0 (11.5-17.5)	16.4 (13.2-20.7)	18.7 (14.8-24.2)	21.2 (16.4-27.9)	24.5 (18.4-33.4)	27.1 (19.7-37.9)

[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.

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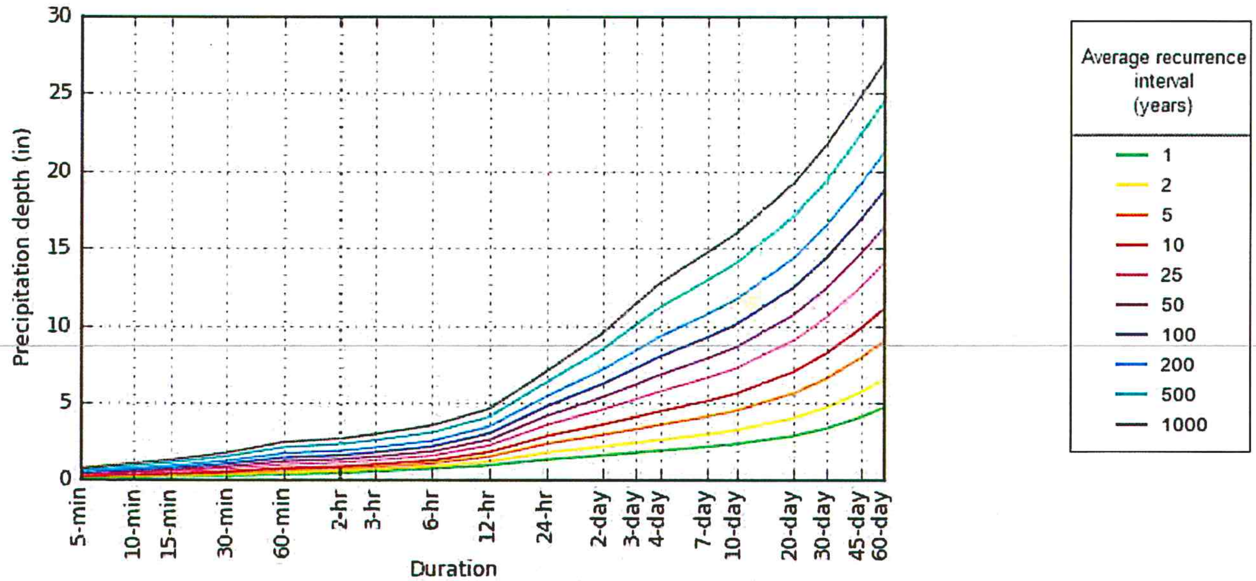
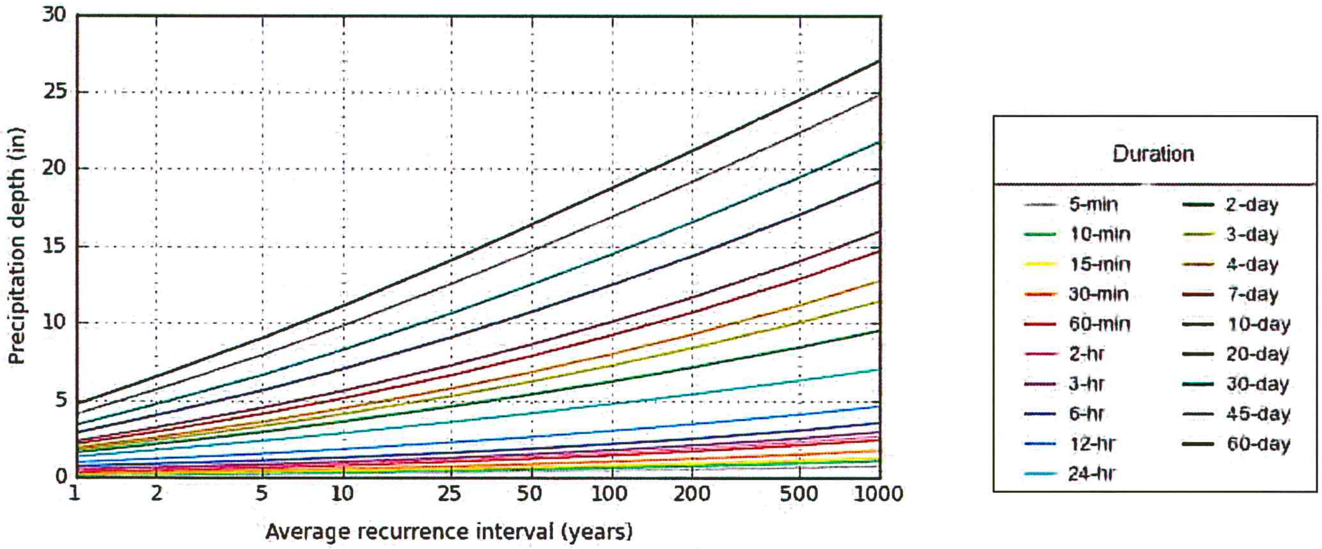
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 39.8594°, Longitude: -120.0406°





NOAA Atlas 14, Volume 6, Version 2 Created (GMT): Mon Dec 19 23:51:23 2022

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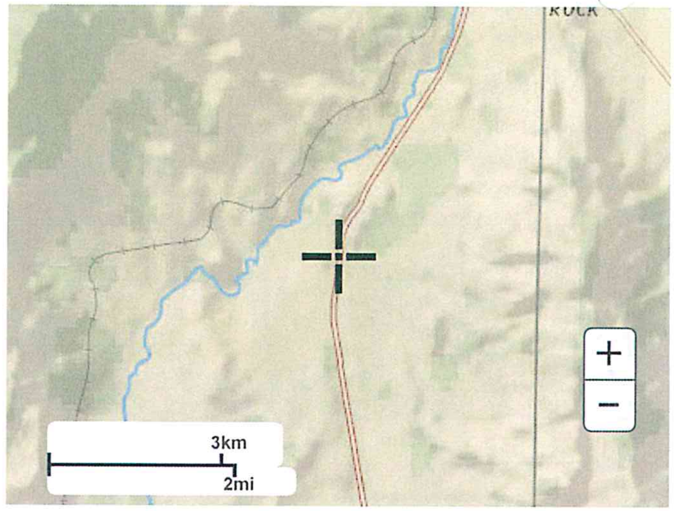
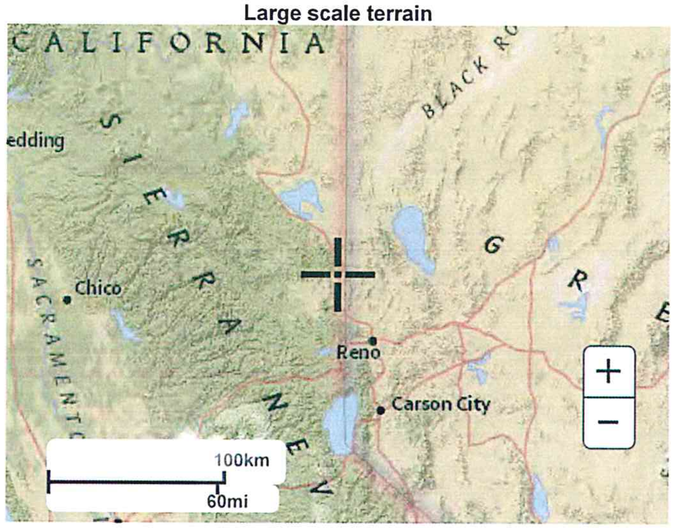
Maps & aerials

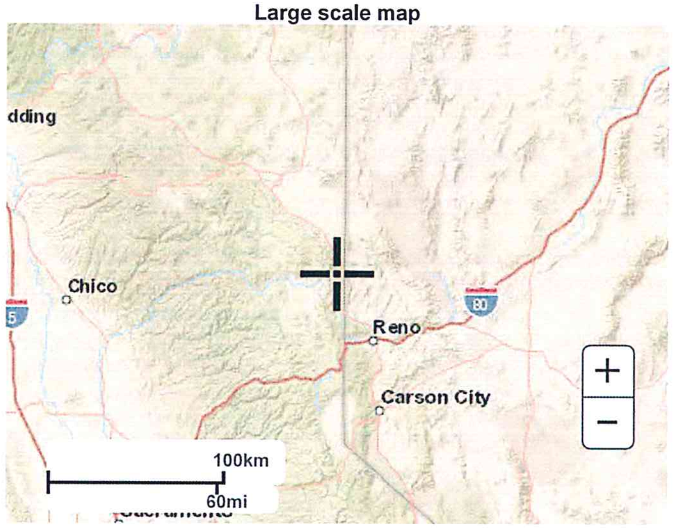
Small scale terrain



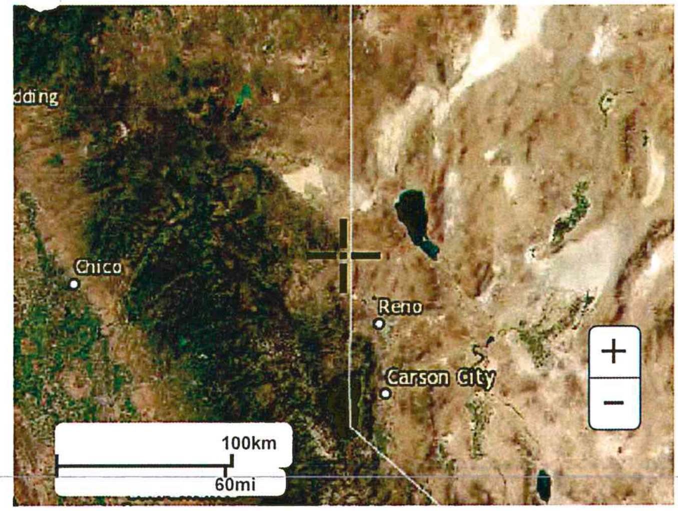
Large scale terrain



Large scale map



Large scale aerial



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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
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Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX C

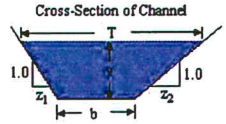
HYDRAULIC CALCULATIONS

Diversion Channel for Subbasin E2

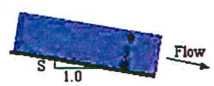
Always enter side slopes:	All features enabled		
Side slope on bank 1, z_1 (H:V):	3		Click to Calculate
Side slope on bank 2, z_2 (H:V):	3		
Click boxes to select inputs:	http://www.LMNOeng.com		
☑ Discharge, Q:	8.6	ft3/s (cfs)	
☐ Velocity, V:	3.8692346	ft/s	
☐ Water depth, y:	0.36471997	ft	
☐ Top width, T:	7.1883198	ft	
☑ Bottom width, b:	5	ft	
☑ Manning roughness, n:	0.035	Enter or compute n	
☑ Channel slope, S:	0.0406	m/m, ft/ft	
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.		
Channel area, A:	2.2226618	ft2	
Channel wetted perimeter, P:	7.3066916	ft	
Hydraulic radius, R:	0.30419538	ft	
Froude number, F:	1.227239		

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year

Cross-Section of Channel



Channel Side View



$$Q = VA \qquad V = \frac{k}{n} R^{2/3} S^{1/2} \qquad R = \frac{A}{P} \qquad A = \frac{y}{2}(b+T)$$

$$P = b + y\left(\sqrt{1+z_1^2} + \sqrt{1+z_2^2}\right) \qquad T = b + y(z_1 + z_2)$$

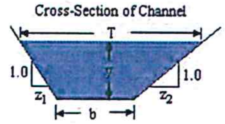
$$F = V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta = Tan^{-1}(S)$$

Diversion Channel for Subbasin E1 and E2 Combined

Always enter side slopes:	All features enabled		
Side slope on bank 1, z_1 (H:V):	3		Click to Calculate
Side slope on bank 2, z_2 (H:V):	3		
Click boxes to select inputs:	http://www.LMNOeng.com		
☑ Discharge, Q:	71.6	ft3/s (cfs)	
☐ Velocity, V:	6.7677805	ft/s	
☐ Water depth, y:	1.2211636	ft	
☐ Top width, T:	12.326981	ft	
☑ Bottom width, b:	5	ft	
☑ Manning roughness, n:	0.035	Enter or compute n	
☑ Channel slope, S:	0.0325	m/m, ft/ft	
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.		
Channel area, A:	10.579539	ft2	
Channel wetted perimeter, P:	12.723317	ft	
Hydraulic radius, R:	0.83150798	ft	
Froude number, F:	1.2882618		

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year

Cross-Section of Channel



Channel Side View

$Q = VA$ $V = \frac{k}{n} R^{2/3} S^{1/2}$ $R = \frac{A}{P}$ $A = \frac{y}{2}(b + T)$

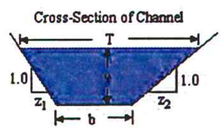
$P = b + y\left(\sqrt{1 + z_1^2} + \sqrt{1 + z_2^2}\right)$ $T = b + y(z_1 + z_2)$

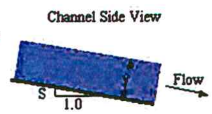
$F = V\sqrt{\frac{T}{gA\cos\theta}}$ $\theta = Tan^{-1}(S)$

Diversion Channel for Combined Subbasin W1, W2 and W3

Always enter side slopes:	All features enabled	
Side slope on bank 1, z_1 (H:V):	3	Click to Calculate
Side slope on bank 2, z_2 (H:V):	3	
Click boxes to select inputs:	http://www.LMNOeng.com	
☑ Discharge, Q:	144.1	ft3/s (cfs)
☐ Velocity, V:	5.0353027	ft/s
☐ Water depth, y:	1.8429048	ft
☐ Top width, T:	21.057429	ft
☑ Bottom width, b:	10	ft
☑ Manning roughness, n:	0.035	Enter or compute n
☑ Channel slope, S:	0.0097	m/m, ft/ft
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.	
Channel area, A:	28.617942	ft2
Channel wetted perimeter, P:	21.655553	ft
Hydraulic radius, R:	1.3215059	ft
Froude number, F:	0.76149581	

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year





$$Q = VA \qquad V = \frac{k}{n} R^{2/3} S^{1/2} \qquad R = \frac{A}{P} \qquad A = \frac{y}{2}(b+T)$$

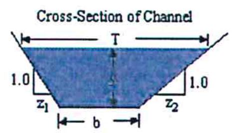
$$P = b + y\left(\sqrt{1+z_1^2} + \sqrt{1+z_2^2}\right) \qquad T = b + y(z_1 + z_2)$$

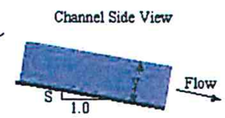
$$F = V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta = Tan^{-1}(S)$$

Diversion Channel on South Portion of West Side

Always enter side slopes:	All features enabled	
Side slope on bank 1, z_1 (H:V):	3	Click to Calculate
Side slope on bank 2, z_2 (H:V):	3	
Click boxes to select inputs:	http://www.LMNOeng.com	
☑ Discharge, Q:	10	ft3/s (cfs)
☐ Velocity, V:	3.8912414	ft/s
☐ Water depth, y:	0.41208591	ft
☐ Top width, T:	7.4725155	ft
☑ Bottom width, b:	5	ft
☑ Manning roughness, n:	0.035	Enter or compute n
☑ Channel slope, S:	.0357	m/m, ft/ft
Always computed:	© 2014 LMNO Engineering, Research, and Software, Ltd.	
Channel area, A:	2.569874	ft2
Channel wetted perimeter, P:	7.6062602	ft
Hydraulic radius, R:	0.33786301	ft
Froude number, F:	1.1701788	

Units in trapezoidal open channel calculation: cm=centimeter, cfs=cubic foot per second, ft=foot, gal=gallon (U.S.), hr=hour, km=kilometer, m=meter, min=minute, s=second, yr=year





$$Q = VA \qquad V = \frac{k}{n}R^{2/3}S^{1/2} \qquad R = \frac{A}{P} \qquad A = \frac{y}{2}(b+T)$$

$$P = b + y\left(\sqrt{1+z_1^2} + \sqrt{1+z_2^2}\right) \qquad T = b + y(z_1 + z_2)$$

$$F = V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta = Tan^{-1}(S)$$