

Appendix 3.10-1

**Hydrology and Drainage Report for the Las Camas Solar
Project**

LAS CAMAS SOLAR PROJECT MERCED COUNTY, CALIFORNIA

HYDROLOGY AND DRAINAGE REPORT

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Table of Contents

List of Tables	ii
List of Figures	iii
List of Acronyms and Abbreviations	iv
Chapter 1 Introduction	1-1
1.1 Introduction.....	1-1
1.2 Project Overview	1-1
1.3 Project Location.....	1-2
1.4 Existing Setting	1-4
Chapter 2 Hydrology and Drainage Analysis Methodology.....	2-1
2.1 Hydrology Analysis Development.....	2-1
2.2 Drainage Analysis Development.....	2-17
Chapter 3 Hydrology and Drainage Impacts	3-1
3.1 Overview	3-1
3.2 Hydrology Analysis Results.....	3-1
3.3 Drainage Analysis Results.....	3-4
Chapter 4 Flood Hazards.....	4-1
Chapter 5 Water Quality.....	5-1
Chapter 6 Groundwater.....	6-1
Chapter 7 Conclusions	7-1
Chapter 8 Preparers	8-1
Chapter 9 References	9-1

Appendices

Appendix A: Existing Site Conditions

Appendix B: NOAA Atlas 14 Precipitation Frequency Estimate

List of Tables

Table 1. Climate Data	1-4
Table 2. Subbasin Characteristics of the Project Site and Analysis Area	1-6
Table 3. 24-hour Precipitation Depths (Annual Maximum Series) for Recurrence Interval Storms.....	2-2
Table 4. Loss Input Parameter Calculations.....	2-2
Table 5. Curve Number for Existing and Project Conditions.....	2-3
Table 6. Inputs for Sheet Flow Travel Time Calculations	2-12
Table 7. Inputs for Shallow Concentrated Flow Travel Time Calculations.....	2-13
Table 8. Inputs for Open Channel Flow Travel Time Calculations	2-14
Table 9. Inputs for Time of Concentration Calculations	2-15
Table 10. Routing Input Parameters Calculations.....	2-15
Table 11. Summary of Basin Inputs for Existing Conditions	2-16
Table 12. Summary of Basin Inputs for Project Conditions	2-16
Table 13. Summary of Drainage Inputs.....	2-18
Table 14. Peak Discharge for Subbasins (cubic feet per second) for Existing and Project Conditions	3-2
Table 15. Peak Discharge for Billy Wright Road Drainage at I-5 Crossing (cfs) for Existing and Project Conditions	3-2
Table 16. Volume Runoff for Subbasins (acre-feet) for Existing and Project Conditions	3-3
Table 17. Volume Runoff for Billy Wright Road Drainage at I-5 Crossing (af) for Existing and Project Conditions	3-4
Table 18. Hydraulic Characteristic for Subbasin 13 Outlet for Existing and Project Conditions.....	3-5

List of Figures

Figure 1. Project Location Map	1-3
Figure 2. Subbasin Map.....	1-7
Figure 3. Hydrologic Soil Group Map	2-4
Figure 4. Existing Land Cover Classification	2-6
Figure 5. Project Land Cover Classification	2-8
Figure 6. Existing Percent Impervious.....	2-9
Figure 7. Project Percent Impervious	2-10

List of Acronyms and Abbreviations

°F	Fahrenheit
af	acre-feet
bgs	below ground surface
CA DWR	California Department of Water Resources
cfs	cubic feet per second
EDPR	EDP Renewables
EIR	environmental impact report
gen-tie	generation-tie
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HEC-HMS	Hydraulic Engineering Center-Hydrology Modeling System
HSG	hydrologic soil group
I-5	Interstate 5
I _a	initial abstraction
kV	kilovolt
NRCS	Natural Resources Conservation Service
O&M	operations and maintenance
PG&E substation improvements	proposed improvements to PG&E Los Banos Substation
proposed project	Las Camas Solar Project (includes solar project and PG&E substation improvements)
PV	photovoltaic
SCS	Soil Conservation Service
SGMA	Sustainable Groundwater Management Act
solar project	proposed Las Camas solar facility
solar project site	1,741-acre site of proposed Las Camas solar facility
SR	State Route

1.1 Introduction

The purpose of this hydrology and drainage report is to evaluate quantifiably the potential impacts of the EDP Renewables (EDPR) Las Camas Solar Project (proposed project) on surface water and groundwater resources on and adjacent to the proposed area of development. It includes an analysis of hydrology and drainage patterns of existing and project conditions. It also documents the assumptions, methodologies, and findings used to support the impact analysis related to site drainage patterns, flooding, erosion and sedimentation, water quality, and groundwater supplies and recharge.

1.2 Project Overview

The proposed project includes construction, long-term operation, and eventual decommissioning of an industrial solar park (solar project) on an approximately 1,741-acre site (solar project site) west of Los Banos in Merced County. The solar photovoltaic (PV) facility would generate electricity from ground-mounted, single-axis tracking arrays. The solar project would also include a battery storage facility that would intermittently store electricity by charging and discharging lithium-ion batteries. The project would have a solar PV capacity of approximately 200 megawatts, alternating current, and a battery storage capacity of approximately 100 megawatts, direct current or alternating current (both options are under consideration). Proposed on-site development would include the installation of solar PV panels; single-axis trackers; collection wires and electrical inverters; lithium-ion batteries; battery enclosures; a project substation; internal access roads; security gates, fencing, and lighting; a Supervisory Control and Data Acquisition system; and a switch yard.

The solar project would also install a 230-kilovolt (kV) generation-tie (gen-tie) transmission line originating from a new substation within the solar project site to the Pacific Gas and Electric Company's (PG&E) Los Banos Substation, located approximately 0.2 mile west of the solar project site. The gen-tie line would be approximately 0.4 mile long based on the proposed location of the solar project substation described above.

The proposed project also includes transmission system improvements around the existing Los Banos Substation (PG&E substation improvements). The PG&E substation improvements include connecting the PG&E substation to the solar project's gen-tie line and installing new structures and equipment within PG&E-owned substation property. The existing substation fence would be moved outward to the south and east, on existing substation property, to accommodate the additional equipment required. The area within the modified fence would be graveled and encompass an additional approximately 450,000 square feet (10.3 acres) of existing PG&E-owned substation property. The proposed project is anticipated to be operational in mid-2025 and is expected to operate for 35 years.

The site evaluated in the surface water hydrology and drainage analysis in this report (Chapter 3) is the approximately 1,741-acre solar project site where the proposed solar project would be constructed in addition to the immediately adjacent areas where the gen-tie line and PG&E substation improvements would be constructed. The areas comprising the solar project site, gen-tie line, and PG&E substation are collectively referred to as the "project site" in this report.

It should be noted that the project includes two off-site components that will be evaluated in the environmental analysis for the proposed project; however, they are outside the scope of this report:

- **Off-Site Mitigation Site.** The project would establish a roughly 1,498-acre off-site mitigation site for San Joaquin kit fox and other covered species, as necessary. The mitigation site, which would be near the eastern and southern edges of Los Banos Reservoir, would be placed into a conservation easement in perpetuity, with the land managed to provide habitat for San Joaquin kit fox and other covered species, as necessary. The conservation easement on the mitigation site would require the continuation of current land management practices, including livestock grazing. Establishment and management of the mitigation site (see Figure 1) would not affect use of the site or hydrological conditions. Impacts on hydrology and water quality at the off-site mitigation site will be evaluated in the environmental analysis for the proposed project; they are not addressed further in this report.
- **Off-Site Residential Redesignation Area.** The project includes an amendment to the Merced County General Plan to redesignate roughly 202.8 acres immediately south of the project site from single-family residential to high-density/medium-density residential. The proposed redesignation would preserve the supply of medium-density and/or high-density units in the county during the life of the solar project. The project does not propose any development within the off-site residential redesignation area. Future development in this area would be subject to independent review under CEQA. Given the proximity to the solar project site, hydrological conditions at the off-site residential redesignation area are expected to be similar to conditions at the solar project site. Further, the residential redesignation area is upstream from the project site (Figure 1). Impacts on hydrology and water quality at the proposed residential redesignation area will be evaluated in the environmental analysis for the proposed project; they are not addressed further in this report.

1.3 Project Location

The solar project site is located on roughly 1,741 acres of undeveloped, privately owned land approximately 3 miles southeast of the community of Santa Nella, 6 miles west of Los Banos, and 30 miles southwest of Merced (Figure 1). The solar project site is at the southwest corner of the intersection of State Route (SR) 33/SR 152 and Interstate 5 (I-5) and can be accessed via Billy Wright Road from SR 33/SR 152. The solar project site includes the following assessor's parcel numbers: 078-160-012, 078-160-013, 078-160-047, 078-160-056, 078-160-060, 078-172-001, 078-190-004, and 078-190-005, except a portion of 078-172-001.

PG&E's Los Banos substation is located approximately 0.2 mile west of the solar project site. The substation equipment is located within a footprint of approximately 37 acres within the substation fence.¹ The proposed gen-tie line would connect the solar project site to the PG&E substation, extending approximately 0.4 mile and occupying a footprint of approximately 0.01 acre.

¹ As measured on Google Earth.

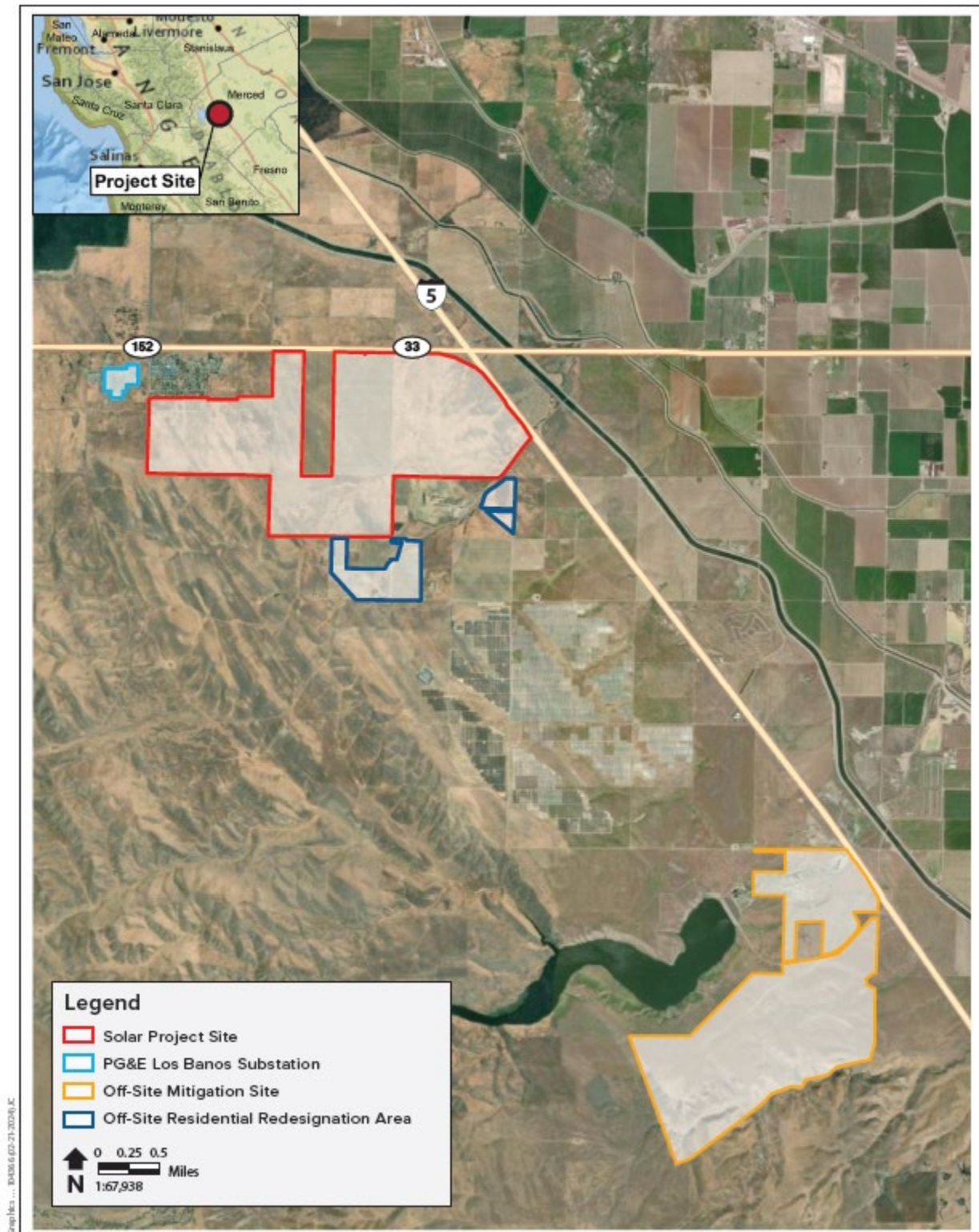


Figure 1. Project Location Map

1.4 Existing Setting

1.4.1 Regional Setting

1.4.1.1 Climate

The meteorological setting is typical of a Mediterranean climate. Table 1 provides monthly precipitation levels and average air temperatures. Average high temperatures reach 95 degrees Fahrenheit (°F); average lows can reach 38°F (U.S. Climate Data 2019).

Table 1. Climate Data

Month	Total Precipitation (in)	Average Maximum Air Temp. (°F)	Average Minimum Air Temp. (°F)
January	1.96	56	38
February	1.91	63	42
March	1.47	69	46
April	0.68	74	49
May	0.47	83	55
June	0.06	90	60
July	0.02	95	63
August	0.02	94	62
September	0.23	90	59
October	0.54	80	52
November	1.03	66	44
December	1.56	56	38
Total	9.95	76.3	50.7

Source: U.S. Climate Data 2019.

1.4.1.2 Groundwater

The project site partially overlies the Delta-Mendota Subbasin (Subbasin) (California Department of Water Resources 2018). The Subbasin is in the northwest portion of the San Joaquin Valley Groundwater Basin, which is within the southern Central Valley. The Subbasin covers approximately 764,965 acres and contains a mix of Quaternary alluvial non-marine deposits. The remainder of the project site does not overlay a designated groundwater basin.

The 24 Groundwater Sustainability Agencies (GSAs) in the Subbasin operate under the Sustainable Groundwater Management Act (SGMA). The project site partially overlies the northern and central Delta-Mendota region. The eight GSAs in the region collaborated to develop one of the six Groundwater Sustainability Plans (GSPs) for the Subbasin, the Northern and Central Delta-Mendota Region GSP (Woodard & Curran and Provost & Pritchard Consulting Group 2019). The goal of the GSP is to achieve sustainable groundwater management by identifying and implementing measures that will ensure a sustainable yield (i.e., the management of groundwater so as to avoid undesirable results by 2040). Undesirable results, as defined by the SGMA, include a chronic lowering of groundwater levels, reductions in groundwater storage, seawater intrusions, degraded water quality, land subsidence, and depletions in interconnected surface waters.

1.4.1.3 Nearby Water Storage and Distribution

The San Luis Reservoir, the largest off-stream reservoir in the United States, is approximately 5 miles west of the project site. The reservoir stores more than 2 million acre-feet (af) of water from the Sacramento-San Joaquin Delta and aqueducts from Northern California (U.S. Bureau of Reclamation and Santa Clara Valley Water District 2019). O'Neill Forebay lies in front of the reservoir and stores water temporarily before distribution. The California Aqueduct is located east of I-5.

1.4.2 Local Setting

The project site is inside the Lower Los Banos Creek sub-watershed of the Middle San Joaquin-Lower Chowchilla Unit, which is in the San Joaquin Hydrologic Region. The total drainage area for the sub-watershed is approximately 229 square miles.

1.4.2.1 Topography

The topography of the solar project site is mostly flat or gently rolling, with an average slope of 4.9 percent. Steeper slopes are clustered near the southwest corner of the site and along a riverine feature in the southern portion of the site. Elevations on the site range from approximately 220 feet above sea level at the lowest point to 558 feet at the highest point. Topography at the PG&E substation is generally flat at an elevation of approximately 310 feet above sea level.

1.4.2.2 Land cover

The solar project site is undeveloped, consisting predominantly of non-native annual grassland. Portions of the solar project site are used for grazing and dry-land farming. The solar project site is almost entirely pervious, including its gravel roads. Three 230 kV transmission lines and a 69 kV transmission line run north-south through the project site and intersect at the corner to the west. Four underground utility pipelines and corresponding easements cross the eastern portion of the solar project site. Otherwise, the solar project site has no distinguishing human-made features.

The PG&E substation is mostly paved, with a small perimeter of undeveloped, pervious land and ornamental landscape inside the fence line. The area where the fence line would be extended consists of undeveloped, pervious land.

Similar to the solar project site, the surrounding area is predominantly undeveloped, pervious land. A landfill is located immediately south of the project site, fronting Billy Wright Road. A small community to the northwest includes approximately 41 acres of impervious surfaces comprised of mostly residential and commercial uses.

1.4.2.3 Soils

Native soils within the project area are predominately Apollo clay loam (82 percent) (Natural Resources Conservation Service 2020). Other soil types are Ayar clay (2 percent), Ballvar loam (3 percent), Damluis clay loam (3 percent), Los Banos clay loam (7 percent), O'Neill silt loam (1 percent), and San Timoteo-Wisflat sandy loams complex (2 percent). The common characteristic of these soils is their low permeability. Apollo clay loam has a slow infiltration rate and slow rate of water transmission.

1.4.2.4 Subbasins

Fifteen surface water subbasins drain to and through the project area, covering a total area of 4,739 acres (Table 2). These subbasins were delineated using StreamStats (U.S. Geological Survey 2021), with modifications based on a U.S. Geological Survey topography map (Esri 2013) and features such as roadways. Figure 2 shows the delineation for the subbasins, which infiltrate into land that is disconnected from the Delta-Mendota Subbasin. As shown in Figure 2, the subbasins also encompass the majority of the residential redesignation area.

Table 2. Subbasin Characteristics of the Project Site and Analysis Area

Subbasin	Total Subbasin Area (acres)	Portion of Subbasin within Project Site Boundary (acres)	Percent of Subbasin within Project Site Boundary	Percent of Project Site within Subbasin
1	411	250	61%	14%
2	197	106	54%	6%
3	44	33	76%	2%
4	52	12	23%	1%
5	215	154	72%	9%
6	285	279	98%	16%
7	67	64	96%	4%
8	39	36	91%	2%
9	185	176	95%	10%
10	130	113	87%	7%
11	378	244	65%	14%
12	1,047	32	3%	2%
13	128	68	53%	4%
14	650	11	2%	1%
15	908	173	19%	10%
Total Analysis Area	4,739	1,751	37%	100%

Notes:

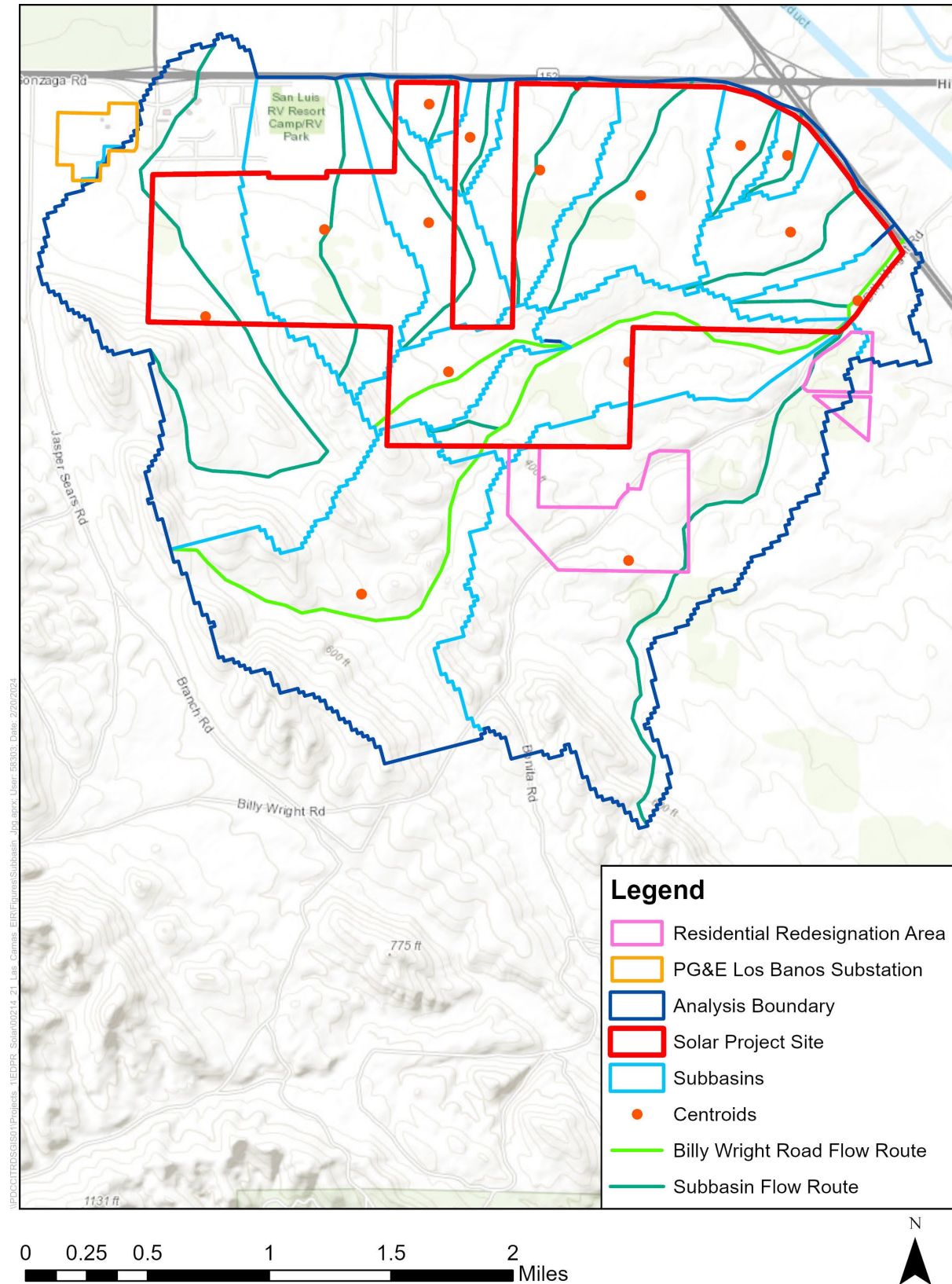
The project site comprises the solar project site, gen-tie line, and PG&E substation.

Totals may not sum due to rounding.

1.4.2.5 Drainages

The delineated subbasins produce primarily shallow concentrated flow. A minor, ephemeral drainage exists adjacent to Billy Wright Road (outlet of Subbasin 13). This aquatic resource was determined to be non-wetland waters and does not receive or contribute water flow to Waters of the United States, but may be considered Waters of the State (ICF, 2022). Measurements taken from Google Earth imagery indicate that the drainage has a top width of approximately 20 feet, depth of approximately 4 feet, and side slope of approximately 2:1 (horizontal:vertical).

The outlet of Subbasin 13 drains through a culvert under I-5 and terminates at the California Aqueduct levee. Within the solar project site and PG&E substation, a portion of the runoff infiltrates into the ground. None of the flow enters a storm drainage system.

**Figure 2. Subbasin Map**

Hydrology and drainage are a function of all contributing subbasins; therefore, the site characteristics described in this report cover a larger area (i.e., “analysis area”) and are not isolated to areas within the project site boundary (i.e., the solar project site, gen-tie line, and PG&E substation). Note that Subbasins 10 through 12 and 14 all drain into Subbasin 13 (“Billy Wright Road Flow Route” in Figure 2). Therefore, the hydrology and drainage analysis presents the cumulative peak discharge and runoff volume at the outlet of Subbasin 13 separately from the results generated by Subbasin 13 individually. The rest of the subbasins are independent (i.e., do not drain into another subbasin within the analysis area).

1.4.2.6 Flood Hazard

The project site is located on Flood Insurance Rate Maps 06047C0800G and 06047C0825G, effective December 2, 2008. Specifically, the project site is located within Zone D, an undetermined area of flood hazard (Federal Emergency Management Agency 2008a and 2008b). There are no Special Flood Hazard Areas or mapped regulatory floodways within or near the project site (i.e., not within the 100- or 500-year flood zone). A review of the Flood Insurance Study for Merced County Community Number 060188 reveals no references to flood hazards within the project vicinity.

1.4.2.7 Groundwater

According to the preliminary geotechnical report prepared for the solar project (RRC 2020), static groundwater levels near the project site (California Department of Water Resources 2020) were reported to be approximately 16 feet below ground surface (bgs), with the shallowest groundwater level recorded at 9 feet bgs at a well 1 mile northeast of the project site. On-site soil borings were advanced to 20.5 feet bgs during the geotechnical investigation in 2020, and no groundwater was encountered (ICF 2021).

According to groundwater measurements taken during a February 2018 preliminary site assessment prepared by AquaPath Environmental and Hydrological Consulting for the Forebay Chevron located at 28960 Gonzaga Road in Santa Nella, static groundwater readings were recorded at 33 and 49 feet bgs (AquaPath 2018). The site is approximately 0.31 mile from the northwest portion of the project site (ICF 2021). Groundwater infiltration into the soil boring was described as extremely slow.

No active wells are on the project site, and no groundwater monitoring has been or is being conducted (CalGEM 2019).

Chapter 2

Hydrology and Drainage Analysis Methodology

ICF evaluated the impacts of the project on project site hydrology (i.e., the volume and duration of runoff) and drainage (i.e., the depth and velocity of the flow). Such characteristics are useful in determining how a project may affect flooding, water quality, and groundwater through changes in runoff, erosion, and infiltration. The methodologies described below relied on a desktop review of the project site and vicinity using Google Earth to assess general drainage characteristics as well as the condition of channels, swales, local roadway culverts, and adjoining land uses. As noted in Section 1, *Introduction*, the project site evaluated in the hydrology and drainage analysis is the approximately 1,741-acre solar project site where the proposed solar project would be constructed, in addition to the immediately adjacent areas where the gen-tie line and PG&E substation improvements would be constructed.

2.1 Hydrology Analysis Development

2.1.1 Overview

ICF assessed peak-discharge and volume runoff under existing and project conditions for the 10- and 100-year recurrence interval events and the methodology described in the Merced County Storm Drainage Design Manual (County of Merced n.d.). A numerical hydrology model that simulates surface water hydrology was developed for the project site using the U.S. Army Corps of Engineers Hydraulic Engineering Center-Hydrology Modeling System (HEC-HMS), version 4.5 (Hydraulic Engineering Center 2018a). This model computes surface water runoff volumes in incremental steps by subtracting losses (e.g., from ponding, infiltration) from precipitation (Hydraulic Engineering Center 2000).

To develop the Soil Conservation Service (SCS) hydrograph method inputs, several common reference methodologies were used. The shape and duration of the rainfall hyetograph were developed using methodology TR-55 (Natural Resources Conservation Service 1986). Depths were taken from National Oceanic and Atmospheric Administration Atlas 14 (National Weather Service 2019). Basin inputs (e.g., initial abstraction, curve number, lag time) were developed using methodology from the Merced County Storm Drainage Design Manual. These inputs are described in the sections below.

Screen captures of the site were taken using Google Earth Street View (see Appendix A).

2.1.2 Rainfall Input

Hyetographs (i.e., graphical representations of the distribution of rainfall intensity over time) were developed by fitting National Oceanic and Atmospheric Administration Atlas 14 24-hour annual maxima series precipitation data (National Weather Service 2019) (Appendix B) to a SCS Type 1 24-hour rainfall distribution curve (National Weather Service 2004), as specified in the Merced County Storm Drainage Design Manual. The 24-hour peak rainfall depths for different storm events, both 10- and 100-year events, are presented in Table 3.

Table 3. 24-hour Precipitation Depths (Annual Maximum Series) for Recurrence Interval Storms

Recurrence (year)	10	100
Total (in)	1.90	3.04

2.1.3 Loss Input

Loss characterizes the volume of precipitation that is not converted to flow (Hydraulic Engineering Center 2000). Loss parameters were developed using the SCS “curve number” method (Natural Resources Conservation Service 2019). This method has three inputs, the curve number, initial abstraction, and percentage of impervious area. Table 11 and Table 12 in Section 2.1.6 include a summary of the inputs. The curve number is a dimensionless value that describes the runoff potential of rainfall (Hydraulic Engineering Center 2000). Specifically, it is a function of land use type and hydrologic soil type. Developed areas with impervious surfaces or undeveloped areas with soils that have a high clay content have a larger percentage of rainfall that becomes surface runoff than forested areas or areas with well-drained soils. Loss input parameters that relate land use types and hydrologic soil groups (HSGs) to the curve number are included in Table 4.

Table 4. Loss Input Parameter Calculations

Land Use Types	Curve Number (Good)			
	A	B	C	D
Open Water	100	100	100	100
Developed Open Space	39	61	74	80
Developed Low Intensity	51	68	79	84
Developed Medium Intensity	61	75	83	87
Developed High Intensity	77	85	90	92
Barren Land	77	86	91	94
Shrub/Scrub	49	68	79	84
Grassland/Herbaceous	30	58	71	78
Pasture/Hay	39	61	74	80
Gravel Road	76	85	89	91
Buildings	98	98	98	98

Initial abstraction (I_a), an estimation of soil saturation at the start of a storm, is a function of the curve number. The equation for I_a is as follows:

$$I_a = 0.2 * \left(\frac{1000}{CN} - 10 \right)$$

The percentage of impervious area is a function of runoff potential. Section 2.1.3.1 shows HSGs, Section 2.1.3.2 shows land use type, and Section 2.1.3.3 shows the percentage of impervious area. The curve number for existing and project conditions is shown in Table 5.

Table 5. Curve Number for Existing and Project Conditions

Subbasin	Curve Number		
	Existing Conditions	Project Conditions	Nominal Difference ^a
1	71.7	71.6	-0.1
2	73.8	72.8	-1.0
3	74.4	73.1	-1.3
4	74.0	73.9	-0.1
5	73.8	72.3	-1.5
6	72.4	71.7	-0.7
7	71.1	71.6	0.5
8	71.6	72.0	0.4
9	71.3	71.8	0.5
10	72.0	71.5	-0.5
11	74.0	74.0	0.0
12	73.1	73.1	0.0
13	72.5	72.8	0.3
14	68.9	68.9	0.0
15	68.7	69.3	0.6

^a. Negative numbers indicate a decrease in the curve number from existing to project conditions.

2.1.3.1 Soils

Existing Conditions

HSG data were downloaded from the Soil Survey Geographic database (Natural Resources Conservation Service 2020). Soils are classified into HSGs to indicate their runoff and infiltration potential. Group A soils have low runoff potential and high infiltration rates; these soils are dominated by sands and gravels. Group B soils are silty loam or loam, and Group C soils are sandy clay loam with moderate runoff and infiltration rates. Group D soils have high runoff potential and low infiltration rates; these soils are dominated by silts and clays. Soils within the project area are predominately Apollo clay loam (82 percent), which is assigned to HSG C (see Figure 3, below).

Project Conditions

The soils are not anticipated to change under project conditions because there will be minimal cut and fill, and most driven piles will bear on native soils (RRC 2020) (see Figure 3, below).

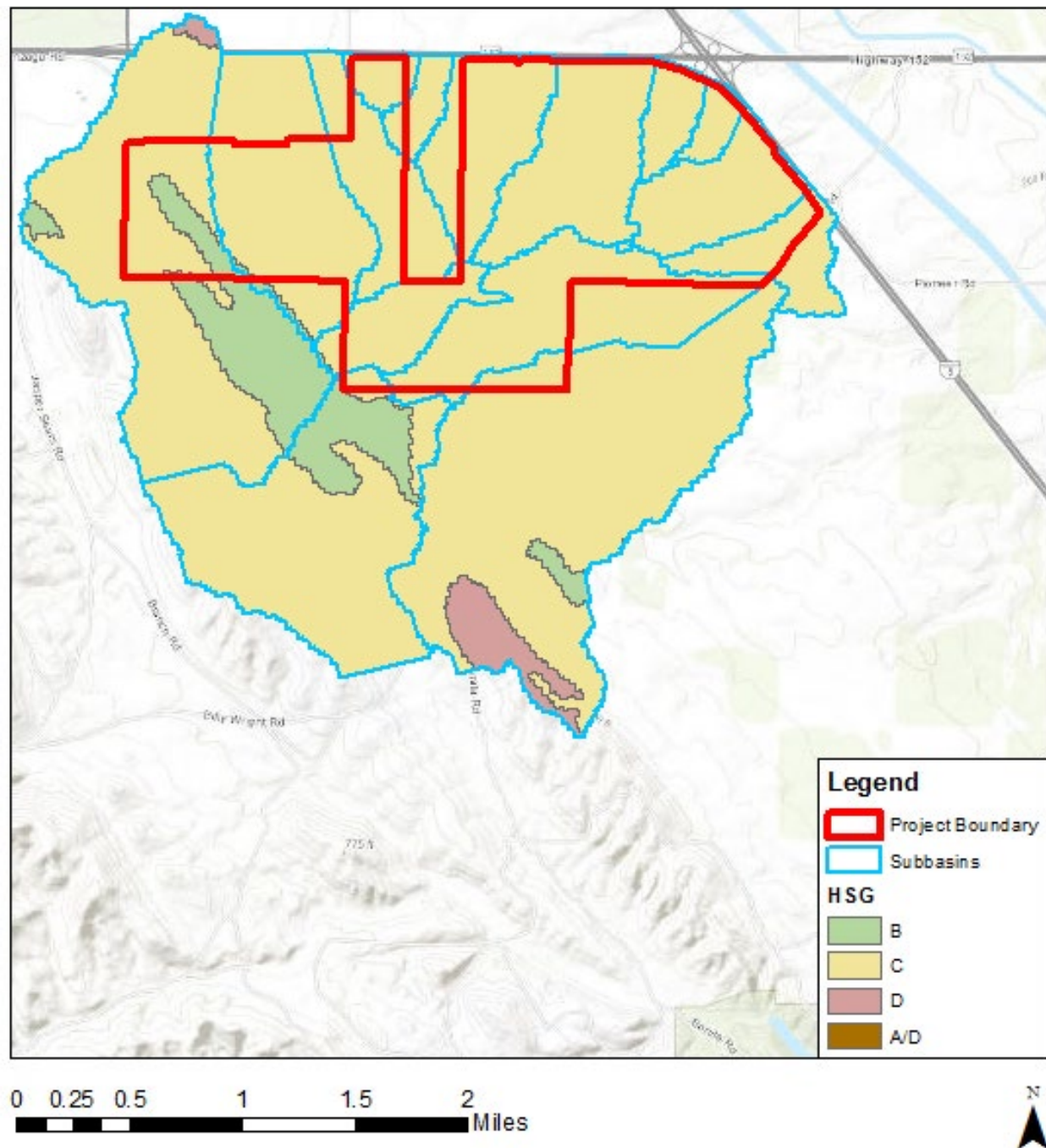


Figure 3. Hydrologic Soil Group Map

2.1.3.2 Land Use Class

Existing Conditions

Land use information was downloaded from the 2016 National Land Class Dataset (Multi-Resolution Land Characteristics Consortium 2020) (Figure 4). As discussed above, the solar project site is undeveloped, consisting predominantly of non-native annual grassland. Portions of the solar project site are used for grazing and dry-land farming. The areas of the proposed gen-tie line and PG&E substation improvements are also undeveloped (not including the developed area within the existing fence line that would accommodate a portion of the PG&E substation improvements). Desktop review of aerial imagery (Google Earth 2020) indicated that several adjustments should be made to land use classes. Areas designated as “cultivated crops” were manually adjusted to “pasture/hay” to represent existing agricultural practices on-site. The area for Billy Wright Road was manually adjusted from “developed, open space” to “developed, high intensity” to represent the existing paved condition of the road. In addition, the nearby landfill was converted to “developed, low intensity.”

Under existing conditions, “grassland/herbaceous” and “pasture/hay” account for 3,449 acres (73 percent) and 1,010 acres (21 percent), respectively, of the total analysis area. “Developed” land uses in the analysis area cover 270 acres (6 percent). “Shrub/scrub” makes up just 10 acres (0.2 percent) of the total analysis area.

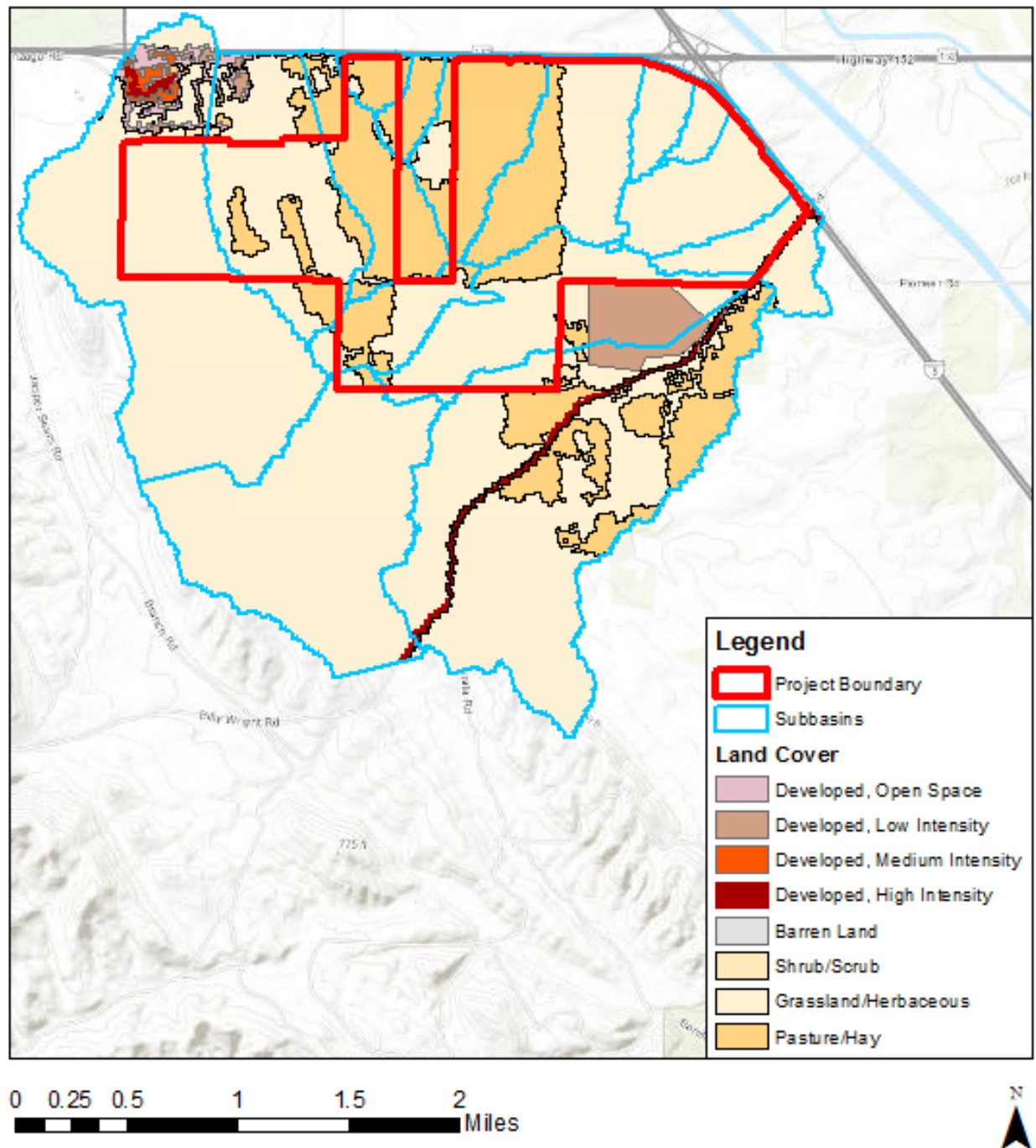


Figure 4. Existing Land Cover Classification

Project Conditions

The solar project would introduce new land uses to the solar project site, comprising a new project substation, gravel roads, and PV arrays (Figure 5). The project would also introduce poles along the proposed gen-tie route and convert approximately 450,000 square feet (10.3 acres) of land within the PG&E Substation property from pervious surface to graveled surface. To reflect project conditions, the land cover classification for the substation areas (“buildings” in Figure 5) was updated to “impervious area” (e.g., paved parking lots, roofs, driveways). The land cover classification for areas with proposed gravel roads (“road”) was updated to “impervious areas” (e.g., streets and roads). The proposed gen-tie poles were incorporated into the land cover classification as developed, high intensity for the diameter of the poles where water would no longer infiltrate to the ground. The land cover classification for areas with PV arrays was not adjusted. It was assumed that the solar panels in the arrays would intercept precipitation above the ground surface but would still allow runoff onto the ground and that the poles would have a small footprint. Grazing would no longer occur on the solar project site following construction; vegetation would be allowed to naturally re-establish. Therefore, the land use classification for the pasture was manually adjusted to “grassland/herbaceous” to reflect project conditions.

Under project conditions the substations would make up 11.6 acres (0.2 percent) and the proposed gravel roads would make up approximately 19.4 acres (0.4 percent) of the total 4,739-acre analysis area. The gen-tie poles cover just 0.01 acre (0.0002 percent). “Grassland/herbaceous” and “pasture/hay” would account for 3,970 acres (83.8 percent) and 458 acres (9.7 percent), respectively. The area of developed land use would make up 270 acres (5.7 percent) and shrub/scrub cover just 10 acres (0.2 percent).

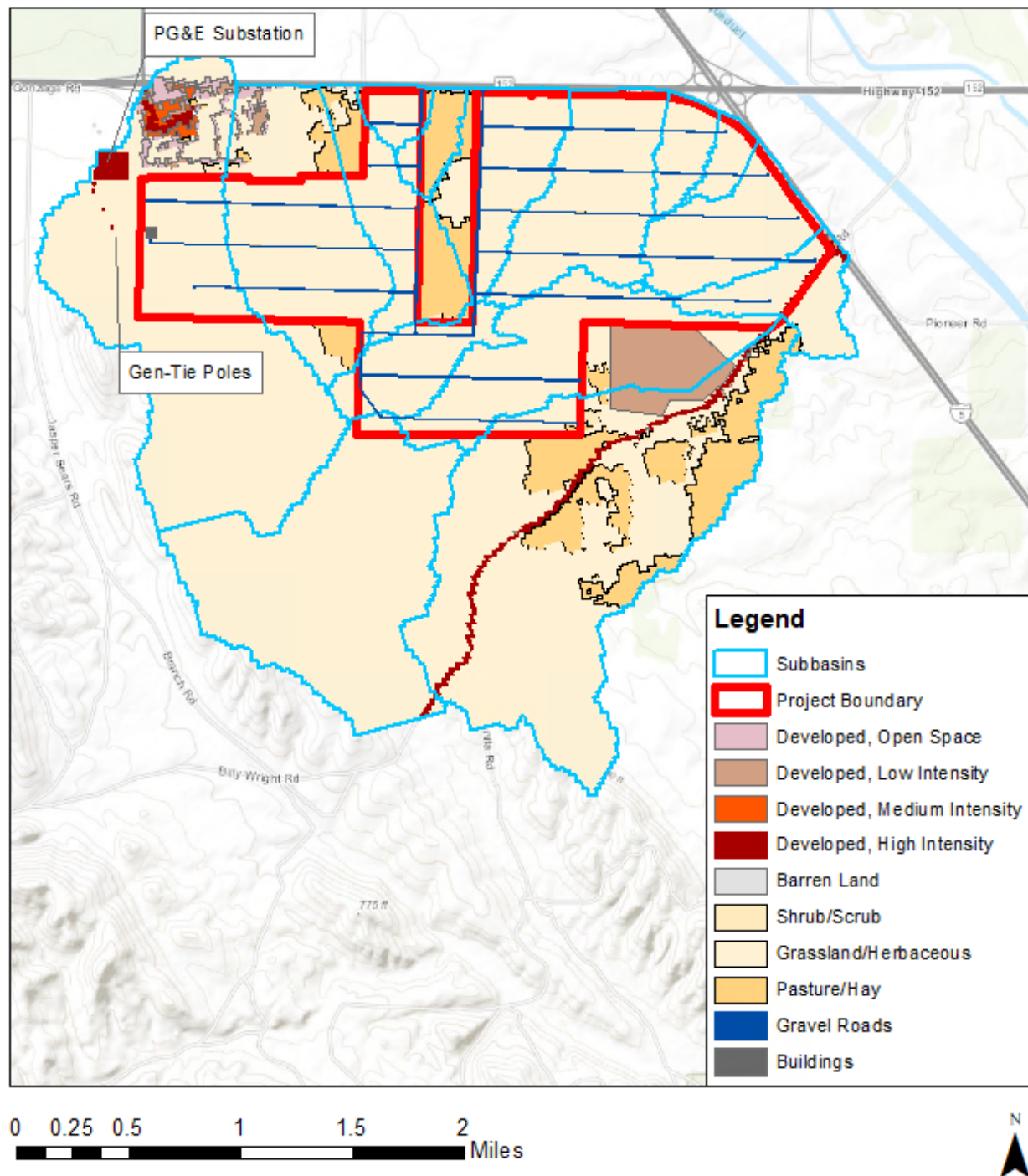


Figure 5. Project Land Cover Classification

2.1.3.3 Percent Impervious

Existing Conditions

The percentage of impervious land cover was downloaded from the 2016 National Land Class Dataset (Multi-Resolution Land Characteristics Consortium 2016). As stated previously, the analysis area is almost entirely pervious, including its gravel roads. A landfill is located outside the project boundary. The residential community to the northwest of the solar project site contributes 41 acres of impervious surfaces to the analysis area (0.87 percent). No adjustments were made to the existing impervious area during desktop review (Figure 6).

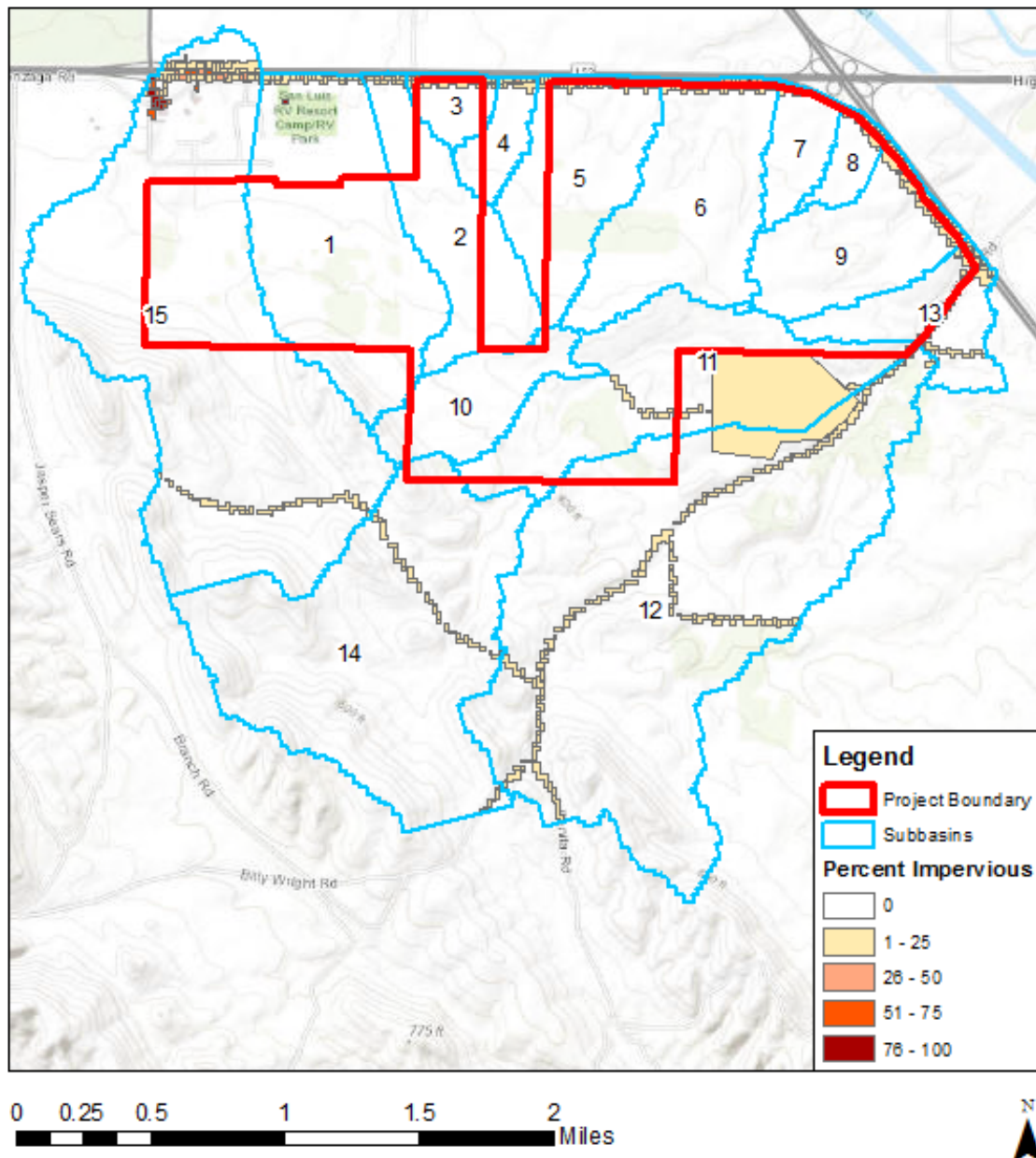


Figure 6. Existing Percent Impervious

Project Conditions

The solar project would introduce new impervious areas to the solar project site, comprising a new substation, gravel roads, and PV arrays (Figure 7). The project would also introduce poles along the proposed gen-tie route and convert approximately 450,000 square feet (10.3 acres) of land within the PG&E Substation property from pervious surface to graveled surface. To reflect project conditions, the percentage of impervious areas for the substations were adjusted to 100 percent. It was conservatively assumed that the percentage of impervious area for the proposed gravel roads and gen-tie poles would also be adjusted to 100 percent. The percentage of impervious cover for areas with PV arrays was not adjusted because the panels would allow runoff and the poles would have a small footprint. These adjustments for project conditions increased the total imperviousness of the analysis area from approximately 41 acres (0.87 percent) to approximately 84 acres (1.8 percent).

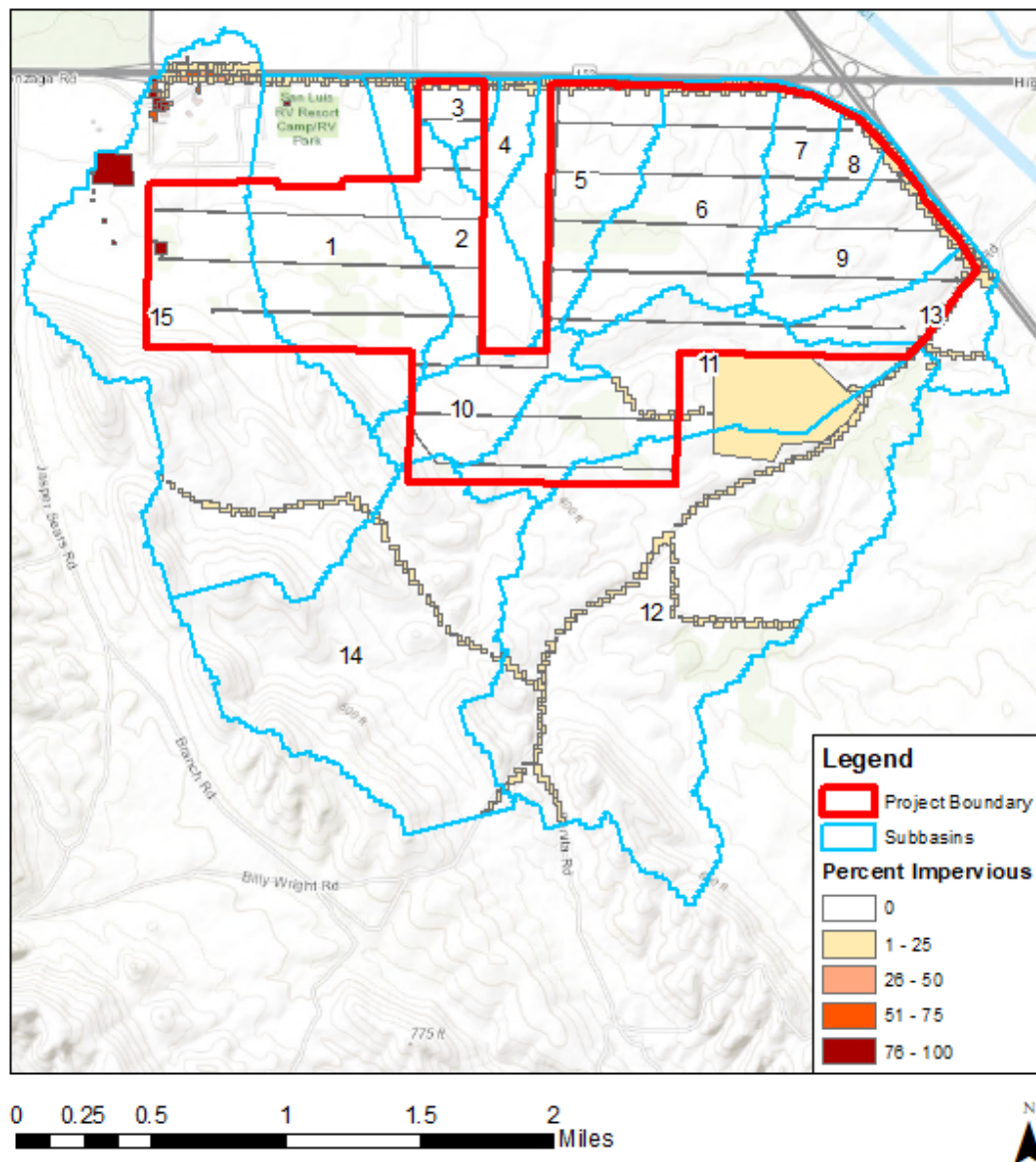


Figure 7. Project Percent Impervious

2.1.4 Transformation Input

Excess rainfall was transformed into runoff using the SCS unit hydrograph method (Natural Resources Conservation Service 2019). The SCS recommends calculating unit hydrograph lag time from time of concentration. Travel time (T_t) is the time it takes for water to travel from one location to another in the watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest. T_c is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \cdots + T_{t_m}$$

Where:

T_c = time of concentration (hr)

T_t = travel time (hr)

m = number of flow segments

Water moves through a watershed as sheet flow, shallow concentrated flow, and/or open channel flow (i.e., the various segments of travel time). The time of concentration was calculated for each subbasin by determining the travel time of each segment within the subbasin.

Sheet flow is flow over plane surfaces and usually occurs in the headwater of watersheds. The travel time (T_t) equation for sheet flow is as follows:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}S^{0.4}}$$

Where:

T_t = travel time (hr)

n = Manning's roughness coefficient

L = flow length (ft)

P_2 = 2-year, 24-hour rainfall (in)

S = slope of hydraulic grade line (land slope, ft/ft)

Manning's roughness coefficient for sheet flow was assumed to be consistent across subbasins as 0.15 to correspond with short prairie grass (Natural Resources Conservation Service 1986). The length of sheet flow was set to 100 feet for all subbasins, assuming that the agricultural practices on-site would limit sheet flow. All subbasins have a 2-year, 24-hour rainfall of 1.25 inches as reported by the National Oceanic and Atmospheric Administration Atlas 14 24-hour annual maxima series precipitation data. See Table 6 for sheet flow inputs.

Table 6. Inputs for Sheet Flow Travel Time Calculations

Subbasin	Manning's Roughness	Flow Length (ft)	Rainfall (in)	Slope (ft/ft)	Travel Time (hr)
1	0.15	100	1.25	0.05	0.2
2	0.15	100	1.25	0.02	0.3
3	0.15	100	1.25	0.02	0.3
4	0.15	100	1.25	0.03	0.2
5	0.15	100	1.25	0.02	0.3
6	0.15	100	1.25	0.02	0.3
7	0.15	100	1.25	0.02	0.3
8	0.15	100	1.25	0.02	0.3
9	0.15	100	1.25	0.02	0.3
10	0.15	100	1.25	0.05	0.2
11	0.15	100	1.25	0.01	0.3
12	0.15	100	1.25	0.03	0.2
13	0.15	100	1.25	0.02	0.3
14	0.15	100	1.25	0.03	0.2
15	0.15	100	1.25	0.02	0.2

After a maximum of 100 feet, sheet flow usually becomes shallow concentrated flow. T_t for shallow concentrated flow is calculated as follows:

$$T_t = \frac{L}{3600V}$$

Where:

T_t = travel time (hr)

L = flow length (ft)

V = average velocity (ft/s)

3600 = conversion factor from seconds to hours

The flow length was determined for each subbasin by subtracting the length of sheet flow and open channel from the total flow length of the subbasin. The average velocity is determined from Figure 3-1 in TR-55 as a function of slope and type of cover (unpaved) (Natural Resources Conservation Service 1986). See Table 7 for shallow concentrated flow inputs.

Table 7. Inputs for Shallow Concentrated Flow Travel Time Calculations

Subbasin	Flow Length (ft)	Velocity (ft/s)	Travel Time (hr)
1	6,798	3.5	0.5
2	7,179	2.2	0.9
3	1,530	2.2	0.2
4	2,522	2.7	0.3
5	4,320	2.3	0.5
6	6,041	2.3	0.7
7	2,914	2.4	0.3
8	2,518	2.0	0.4
9	4,785	2.3	0.6
10	3,514	3.6	0.3
11	5,050	1.6	0.9
12	11,736	2.6	1.3
13	2,500	2.3	0.3
14	9,496	2.9	0.9
15	16,409	2.4	1.9

Open channel flow was assumed to occur in minor drainages observed in the subbasins during desktop review. Manning's equation is used to determine the average velocity used in the travel time equation:

$$V = \frac{1.49R^{\frac{2}{3}}S^{\frac{1}{2}}}{n}$$

Where:

V = average velocity (ft/s)

R = hydraulic radius (ft) and is equal to the ratio of cross section area (A, ft²) and wetted perimeter (P_w, ft)

S = slope of the hydraulic grade line (channel slope, ft/ft)

n = Manning's roughness coefficient for open channel flow

As stated in Section 1.4.2.5, a minor drainage exists adjacent to Billy Wright Road (outlet of Subbasin 13). The drainage has a top width of 20 feet, depth of 4 feet, and side slope of 2:1. Therefore, the drainage has a channel area of 48 square feet, wetted perimeter of 28 feet, and hydraulic radius of 1.7 feet. Manning's roughness coefficient was assumed to be 0.06 (light brush and trees) for the outlet of Subbasin 13. Travel time for open channel flow was then calculated with the same equation as shallow concentrated flow, using the velocity determined from Manning's equation. The flow length was measured using aerial imagery of the drainage. See Table 8 below.

Table 8. Inputs for Open Channel Flow Travel Time Calculations

Subbasin	Cross Sectional Area (ft ²)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Manning's Roughness	Velocity (ft/s)	Flow Length (ft)	Travel Time (hr)
1	-	-	-	-	-	-	0
2	-	-	-	-	-	-	0
3	-	-	-	-	-	-	0
4	-	-	-	-	-	-	0
5	-	-	-	-	-	-	0
6	-	-	-	-	-	-	0
7	-	-	-	-	-	-	0
8	-	-	-	-	-	-	0
9	-	-	-	-	-	-	0
10	48	28	1.7	0.06	8	1,211	0.04
11	48	28	1.7	0.06	4	5,593	0.4
12	48	28	1.7	0.06	6	1,791	0.1
13	48	28	1.7	0.06	5	1,926	0.1
14	-	-	-	-	-	-	0
15	-	-	-	-	-	-	0

Time of concentration is then converted to lag time (T_{lag}) for use in the SCS unit hydrograph method with the following equation:

$$T_{lag} = 0.6 * T_c$$

Where:

T_{lag} = lag time (hr)

T_c = time of concentration (hr)

Lag time is the amount of time between peak rainfall and peak runoff. The lag time for each subbasin was calculated (see Table 9).

Table 9. Inputs for Time of Concentration Calculations

Subbasin	Sheet Flow Travel Time (hr)	Shallow Concentrated Flow Travel Time (hr)	Open Channel Flow Travel Time (hr)	Time of Concentration (hr)	Lag Time (hr)	Lag Time (min)
1	0.2	0.5	0	0.7	0.4	26
2	0.3	0.9	0	1.2	0.7	42
3	0.3	0.2	0	0.5	0.3	17
4	0.3	0.3	0	0.5	0.3	17
5	0.3	0.5	0	0.8	0.5	29
6	0.3	0.7	0	1.0	0.6	35
7	0.3	0.3	0	0.6	0.4	21
8	0.3	0.4	0	0.6	0.4	23
9	0.3	0.6	0	0.8	0.5	30
10	0.2	0.3	0.04	0.5	0.3	18
11	0.4	0.9	0.4	1.6	1.0	59
12	0.3	1.3	0.1	1.6	1.0	57
13	0.3	0.3	0.1	0.7	0.4	24
14	0.2	0.9	0	1.1	0.7	40
15	0.2	1.9	0	2.1	1.3	76.4

2.1.5 Reach Input

Runoff from each subbasin was routed through a series of reaches using the lag routing method (Hydraulic Engineering Center 2000). The lag routing method represents only the translation of flood waves and does not include any representation of attenuation or diffusion processes (Hydraulic Engineering Center 2000); therefore, the reported flow from the reaches is used for only preliminary channel sizing calculations. Lag time can be estimated from the SCS time-of-concentration equation for open channel flow. The time of concentration for open channel flow was calculated by dividing the length of the channel by the average velocity. These reaches were delineated as the longest flow path, based on the U.S. Geological Survey topography map (Esri 2013). Routing parameter calculations are included in Table 10.

Table 10. Routing Input Parameters Calculations

Reach	Length (ft)	Slope (ft/ft)	Velocity (ft/s)	T _c (min)	T _{lag, NRCS} (min)
Reach 1	10,743	0.01	4	111	66.5
Reach 2	4,526	0.01	3	88	52.6

2.1.6 Summary of Basin Inputs

Model inputs are summarized in Table 11 and Table 12.

Table 11. Summary of Basin Inputs for Existing Conditions

Subbasin	Subbasin Area (mi ²)	Loss			Transformation
		Initial Abstraction (Ia, in)	Curve Number	Percent Impervious	Lag Time (min)
1	0.64	0.79	72	0.2	26
2	0.31	0.71	74	0.3	42
3	0.07	0.69	74	2.2	17
4	0.08	0.70	74	0.6	17
5	0.34	0.71	74	0.5	29
6	0.45	0.76	72	0.5	35
7	0.10	0.81	71	0.3	21
8	0.06	0.79	72	0.9	23
9	0.29	0.81	71	0.5	30
10	0.20	0.78	72	0.0	18
11	0.59	0.70	74	5.1	59
12	1.64	0.74	73	0.8	57
13	0.20	0.76	72	0.7	24
14	1.02	0.90	69	0.0	40
15	1.42	0.91	69	0.6	76.4

Table 12. Summary of Basin Inputs for Project Conditions

Subbasin	Subbasin Area (mi ²)	Loss			Transformation
		Initial Abstraction (Ia, in)	Curve Number	Percent Impervious	Lag Time (min)
1	0.64	0.79	72	1.4	26
2	0.31	0.75	73	2.0	42
3	0.07	0.74	73	4.6	17
4	0.08	0.71	74	2.2	17
5	0.34	0.77	72	2.8	29
6	0.45	0.79	72	2.4	35
7	0.10	0.79	72	2.2	21
8	0.06	0.78	72	2.3	23
9	0.29	0.79	72	2.3	30
10	0.20	0.80	72	2.3	18
11	0.59	0.70	74	6.2	59
12	1.64	0.73	73	0.9	57
13	0.20	0.75	73	1.8	24
14	1.02	0.90	69	0.1	40
15	1.42	0.89	69	2.3	76.4

2.2 Drainage Analysis Development

2.2.1 Overview

ICF assessed velocities and depths of the existing drainage using Manning's Equation. This analysis focused on the single minor drainage on the site, adjacent to Billy Wright Road (outlet of Subbasin 13).

2.2.2 Method

Manning's Equation is an empirical equation used to estimate open channel flow. It is a function of the channel velocity, flow area, and channel slope. Manning's Equation is as follows:

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

Q = flow rate (cubic feet per second [cfs])	n = Manning's roughness coefficient (dimensionless)
V = velocity (feet per second)	R = hydraulic radius (feet)
A = flow area (square feet)	S = channel slope (feet per foot)

This equation was used to determine maximum channel conveyance for the drainage. "Maximum channel conveyance" is a term used to describe the maximum flow contained entirely within a channel (i.e., the water surface elevation is equal to the top of bank). This is an existing condition only; therefore, it was not calculated for project conditions.

When the flow rate is already known, Manning's Equation can be used to calculate the velocity and depth associated with that event. This method will be used to determine approximate velocity and depth in each drainage during 10- and 100-year events.

The maximum channel conveyance was contrasted with the flow, velocity, and depth from the 10- and 100-year events under existing and project conditions. This comparison determined the significance of project impacts related to erosion and flooding potential in the drainage.

2.2.3 Inputs

Existing Conditions

As stated in Section 1.4.2.5, the existing drainage has a top width of 20 feet, depth of 4 feet, and a side slope of 2:1. Based on aerial and street-view imagery, the channel has a roughness coefficient equal to 0.06 because of the light brush and trees present in the channel (Chow 1959). The outlet for Subbasin 13 has a bed slope of 0.02. The peak discharge for the 10- and 100-year events will be determined in the hydrology analysis.

Project Conditions

The only variable that was adjusted for project conditions used peak discharge for the 10- and 100-year events, as determined by the hydrology analysis. The channel geometry, roughness, and slope are assumed to be the same as under existing conditions.

2.2.4 Summary of Drainage Inputs

Model inputs are summarized in Table 13.

Table 13. Summary of Drainage Inputs

Hydraulic Characteristic	Existing Conditions			Project Conditions	
	Channel Conveyance ^a	10 Year ^b	100 Year ^c	10 Year	100 Year
Discharge (cfs)	DIA ^d	63	163	64	164
Velocity (ft/s)	DIA ^d	DIA ^d	DIA ^d	DIA ^d	DIA ^d
Depth (ft)	4	DIA ^d	DIA ^d	DIA ^d	DIA ^d
Top Width (ft)			20		
Side Slope (H:V)			2:1		
Manning's Roughness Coefficient			0.06		
Subbasin Outlet 13 Bed Slope			0.02		

^a. Channel conveyance = maximum flow event contained entirely within the channel for which the water surface equals the top of the bank

^b. 10-year storm

^c. 100-year storm

^d. Determined in analysis

3.1 Overview

This section includes the results of the hydrology and drainage analysis. The results of this analysis should be used only for planning and environmental analysis purposes. Further analysis is required for design purposes. As noted in Section 1, *Introduction*, the project site evaluated in the hydrology and drainage analysis is the approximately 1,741-acre solar project site where the proposed solar project would be constructed, in addition to the immediately adjacent areas where the gen-tie line and PG&E substation improvements would be constructed.

3.2 Hydrology Analysis Results

3.2.1 Peak Discharge

Peak discharge is the maximum rate of runoff (i.e., volume per unit time) from a subbasin for a given rainfall. This parameter was modeled because it is affected by changes in land cover and the percentage of imperviousness. To understand project impacts on hydrology and drainage, the peak discharge for each subbasin in the analysis area was analyzed for existing and project conditions. As the maximum estimated rate of runoff, peak discharge helps define the maximum impact anticipated on the project site's drainage patterns and water quality (e.g., erosion or siltation potential). Peak discharge at subbasin drainage points (e.g., tributary confluences) and at key project locations are provided in Table 14 and Table 15, respectively. In summary, with implementation of the project, peak discharge in each subbasin would change by 0 to 5 percent for the 10-year event and by -6 to 2 percent for the 100-year event, depending on the subbasin. The weighted average peak discharge in the analysis area would change by 1 percent for the 10-year event and 0 percent for the 100-year event.

The peak discharge results for Billy Wright Road (outlet of Subbasin 13) are highlighted in Table 15 because the flow at this location is a combination of the flows from Subbasins 10 through 14. The results at this location are based on the time-dependent hydrologic analysis for each contributing subbasin and are not a simple summation of flows.

Table 14. Peak Discharge for Subbasins (cubic feet per second) for Existing and Project Conditions

Subbasin	Subbasin Area (mi ²)	Recurrence Interval (years)					
		Existing		Project		Percent Difference	
		10 ^a	100 ^b	10	100	10	100
1	0.64	13	31	13	31	0%	0%
2	0.31	7	16	7	15	0%	-6%
3	0.07	2	4	2	4	0%	0%
4	0.08	2	4	2	4	0%	0%
5	0.34	7	17	7	17	0%	0%
6	0.45	9	22	9	22	0%	0%
7	0.10	2	5	2	5	0%	0%
8	0.06	1	3	1	3	0%	0%
9	0.29	6	14	6	14	0%	0%
10	0.20	4	10	4	10	0%	0%
11	0.59	14	31	14	31	0%	0%
12	1.64	34	81	34	81	0%	0%
13	0.20	4	10	4	10	0%	0%
14	1.02	16	44	16	44	0%	0%
15	1.42	22	60	23	61	5%	2%
Analysis Area	7.4	18	45	18	45	1%	0%
Weighted Averages	(total area)						

a. 10-year storm

b. 100-year storm

Table 15. Peak Discharge for Billy Wright Road Drainage at I-5 Crossing (cfs) for Existing and Project Conditions

Area	Recurrence Interval (years)					
	Existing		Project		Percent Difference	
	10 ^a	100 ^b	10	100	10	100
Billy Wright Road (outlet of Subbasin 13)	68	169	68	170	0%	1%

a. 10-year storm

b. 100-year storm

3.2.2 Volume Runoff

Volume runoff at subbasin drainage points (e.g., tributary confluences) and key locations is provided in Table 16 and Table 17, respectively. Volume runoff is the volume of excess water that runs off from a drainage area (i.e., precipitation that is not retained through abstraction, infiltration, or storage). Like peak discharge, the volume of runoff was modeled because it is affected by changes in land use and the percentage of imperviousness. This parameter helps evaluate project impacts related to flooding, drainage systems, and groundwater recharge.

As mentioned above, routing does not include attenuation of flows; therefore, the values reported in Table 17 are used for preliminary floodplain inundation calculations only. As a floodflow moves downstream in a subbasin, the flow is naturally stored in available space (e.g., wider floodplains or depressions); downstream peak discharge is less than upstream peak discharge. This means that the model results are conservative because the methodology does not account for discharge lost to storage as it travels downstream. In summary, with implementation of the project, volume runoff within each subbasin would change by 0 to 100 percent for the 10--year event and by -6 to 25 percent for the 100-year event, depending on the subbasin. The weighted average volume runoff in the analysis area would change by 7 percent for the 10-year event and 3 percent for the 100-year event.

Table 16. Volume Runoff for Subbasins (acre-feet) for Existing and Project Conditions

Subbasin	Subbasin Area (mi ²)	Recurrence Interval (years)					
		Existing Conditions		Project Conditions		Percent Difference	
		10 ^a	100 ^b	10	100	10	100
1	0.64	8	28	9	29	13%	4%
2	0.31	5	15	5	15	0%	0%
3	0.07	1	4	1	4	0%	0%
4	0.08	1	4	1	4	0%	0%
5	0.34	6	17	6	16	0%	-6%
6	0.45	7	21	7	21	0%	0%
7	0.10	1	4	2	5	100%	25%
8	0.06	1	3	1	3	0%	0%
9	0.29	4	13	4	14	0%	8%
10	0.20	3	9	3	9	0%	0%
11	0.59	12	33	13	34	8%	3%
12	1.64	26	79	26	80	0%	1%
13	0.20	3	9	3	10	0%	11%
14	1.02	10	38	10	38	0%	0%
15	1.42	14	53	17	57	21%	8%
Analysis Area Weighted Averages	7.4 (total area)	13	42	13	43	7%	3%

a. 10-year storm

b. 100-year storm

Table 17. Volume Runoff for Billy Wright Road Drainage at I-5 Crossing (af) for Existing and Project Conditions

Recurrence Interval (years)					
Existing Conditions		Project Conditions		Percent Difference	
10 ^a	100 ^b	10	100	10	100
53	167	55	170	4%	2%

a. 10-year storm

b. 100-year storm

As noted in the previous section, the volume runoff results for Billy Wright Road (outlet of Subbasin 13) are highlighted in Table 17 because runoff at this location is a combination of the flows from Subbasins 10 through 14. The results at this location are based on the time-dependent hydrologic analysis for each contributing subbasin and are not a simple summation of volumes.

3.2.3 Summary

Hydrologic modeling of the peak runoff discharge indicates that the existing drainage pattern of the project site will nominally increase. The largest increase in peak discharge across the subbasins is 1 cfs for the 10- and 100-year storm events. For the entire analysis area, this is an area-weighted average of 1 and 0 percent under project conditions. Volume runoff is estimated to have nominal increases as well. The highest increase in volume runoff across the subbasins is 3 and 4 af for the 10- and 100-year storm events, respectively. For the entire analysis area, this is an area-weighted average of 7 and 3 percent under project conditions.

The runoff modeling assumed that the solar panels would temporarily intercept precipitation above ground but would not alter the volume of precipitation reaching the ground or changing runoff patterns since rainwater falling on the panels would flow off the panels and on to the ground (Clearwater Hydrology 2013). The largest impact on hydrology would be due to the amount of land converted to impervious surface area. However, the increase in the amount of impervious area from existing to project conditions would be minimal (i.e., approximately 43 acres, or 0.91 percent of total analysis area). Therefore, the reduction in water infiltration and increase in runoff would not be substantial, and significant flooding, erosion, and siltation on- or off-site would not be anticipated to occur because of the project.

3.3 Drainage Analysis Results

3.3.1 Discharge, Velocity, and Depth

The drainage analysis indicates that the 10- or 100-year event would be well within the maximum channel conveyance for the drainage and that nominal changes between existing and project conditions would be observed. The results of this analysis should be used only for planning and environmental analysis purposes. Further analysis is required for design purposes. At this level of analysis, the Subbasin 13 outlet experiences no changes in velocity or depth under project conditions (see Table 18, below). The maximum channel conveyance has larger hydraulic conditions than the 10- and 100-year event under existing and project conditions (see Table 18, below).

Table 18. Hydraulic Characteristic for Subbasin 13 Outlet for Existing and Project Conditions

Hydraulic Characteristic	Existing Conditions			Project Conditions		Percent Difference	
	Channel Conveyance ^a	10 Year ^b	100 Year ^c	10 Year	100 Year	10 Year	100 Year
Discharge (cfs)	285	68	169	68	170	0%	1%
Velocity (ft/s)	5.9	4.1	5.2	4.1	5.2	0%	0%
Depth (ft)	4	2.1	3.2	2.1	3.2	0%	0%

a. Channel conveyance = maximum flow event contained entirely within the channel for which the water surface equals the top of the bank

b. 10-year storm

c. 100-year storm

19

3.3.2 Summary

The project would have the potential to change drainage patterns in the project area through the introduction of new impervious surfaces, grading, and natural revegetation of existing pasture and hay fields. Grading on the project site would create minor modifications within existing drainage paths. However, the layout of the solar arrays and gen-tie poles would not encroach upon the ephemeral drainage with a well-defined channel in the southeastern portion of the site. Instead, the solar array would be positioned largely in areas with sheet flow and upgradient of existing channelized flow. Maintenance roads would be installed at the existing grade and therefore would not impede or redirect flood flows. Therefore, the flow paths for channelized water within the solar project site and at the exit points would be unchanged.

The greatest addition of impervious surfaces to the analysis area would be due to the construction of the new solar substation within the solar project site, the PG&E substation improvements adjacent to the solar project site, and gravel roads. However, as discussed in Section 3.2.3, the increase in the amount of impervious area from existing to project conditions would be minimal (i.e., approximately 43 acres, or 0.91 percent of total analysis area).

The model results show no changes in depth and velocity under project conditions for Subbasin 13 outlet with implementation of the project. Therefore, project conditions are not anticipated to result in physical changes due to the actions of water in the channels such as scour that could expand or deepen the existing drainage. The drainage would not exceed maximum channel capacity under the 10- or 100-year storm event. During the 100-year event, under project conditions, Subbasin 13 outlet would generate a depth of 0.8 feet below the top of the bank. The potential for erosion hazards within the project site is low given the rolling and flat topography of the existing ground terrain. Under project conditions, the grade would be even lower, at a slope of 3:1 (horizontal:vertical) or flatter (RRC 2020). It is anticipated that the flatter grade would slow runoff velocities and encourage infiltration into the ground before the runoff reaches the drainage.

Runoff from the drainage outflows through a culvert under eastern road; the drainage is not tributary to other receiving water bodies or stormwater treatment facilities. The nominal changes in peak discharge and runoff volume under project conditions are not anticipated to exceed the capacity of the existing culvert. No new stormwater facilities are planned for construction outside the project site on the ephemeral drainage. Project conditions are not expected to increase stormwater runoff or pollutants substantially such that new drainage facilities would be necessary.

Overall, the project is not anticipated to increase flooding in and around the drainage.

Chapter 4

Flood Hazards

No Federal Emergency Management Agency–designated Special Flood Hazard Areas or mapped regulatory floodways exist in the project area. The project site is outside the potential dam failure inundation areas for San Luis Dam, O’Neill Forebay, Little Panoche Reservoir, Lake Yosemite, McClure Lake, and Los Banos Creek Detention Reservoir.

The increase in the volume of runoff for the analysis area under project conditions (i.e., 7 and 3 percent for the 10- and 100-year storm events, respectively) is considered nominal and would be absorbed into the on-site soils. Although the majority of solar project site grade is relatively flat, with minimal elevation differential, cut-and-fill slopes will be graded to a slope of 3:1 (horizontal:vertical) or flatter (RRC 2020). It is anticipated that the flatter grade will slow runoff velocities and encourage infiltration into the ground. Similarly, the PG&E substation improvements are expected to result in a minimal increase in impervious surface within a flat area of approximately 10.3 acres. Therefore, project conditions are not anticipated to increase flooding or alter flood mapping within the project area.

Based on the above, there is no potential for inundation at the project site. Therefore, the project would not result in a risk release of pollutants due to inundation.

Chapter 5

Water Quality

Water quality at the project site may be impaired by pollutants such as sediment, chemicals, or debris. The potential for erosion hazards within the project site is low, given the rolling and flat topography of the existing terrain. Under project conditions, the grade would be even lower, at a slope of 3:1 (horizontal:vertical) or flatter (RRC 2020). It is anticipated that the flatter grade will slow runoff velocities and encourage infiltration into the ground, with sediment being deposited on the ground surface instead of transported into waterways. In addition, the increase in peak discharge for the analysis area under project conditions (1 and 0 percent for the 10- and 100-year storm events, respectively) is considered nominal and unlikely to generate additional scour. However, construction activities could temporarily exacerbate erosion conditions by exposing and disturbing on-site soils. The compaction of soils by heavy equipment may also reduce infiltration capacity and increase the potential for runoff and erosion. Stormwater runoff has the potential to wash construction materials into receiving water bodies that discharge outside the project site and negatively affect water quality. Non-stormwater discharges could result from discharges or accidental spills involving hazardous substances such as fuel, oil, concrete, paint, solvents, cleaning solutions, or other construction materials.

Implementation of standard construction best management practices (BMPs) and compliance with applicable regulations would prevent disturbed soils from leaving the site. In addition, large construction projects (i.e., disturbing 1 acre or more) that discharge into waters of the U.S. are subject to the State Water Resources Control Board's Construction General Permit. The Construction General Permit requires the implementation of a Stormwater Pollution Prevention Plan, thereby further reducing the potential for erosion. Potential construction impacts associated with erosion would be considered low with implementation of BMPs and the requirements of the Construction General Permit.

Long-term operation of the solar project would not adversely affect water quality or lead to a violation of water quality standards. The re-establishment of vegetation and reduction in grazed area after construction is anticipated to increase infiltration and encourage sediment deposition from runoff. The project would result in infrequent use of maintenance roads. Operation and maintenance activities would include washing dust particles from the solar panels once a year. Wash water (containing no soap nor other chemical solvents) would run off the panels and infiltrate into the ground below and not cause sedimentation or other water quality concerns.

PG&E implements standard avoidance and minimization measures (AMM) and BMPs during the construction and operation of projects in its service territory. AMM/BMPs that would be implemented for the PG&E substation improvements would include, but are not limited to, those listed below. With implementation of AMM/BMPs, adverse impacts on water quality from the PG&E substation improvements would not occur.

- **Stormwater Pollution Prevention Plan (Construction).** A Stormwater Pollution Prevention Plan (SWPPP) will be prepared for the PG&E substation improvements. Construction work will not commence without: a Waste Discharger Identification (WDID) number issued by the State Water Quality Control Board (SWQCB); SWPPP training conducted by authorized personnel designated by the Stormwater Quality subject matter expert (SME), and a hard copy of the SWPPP placed on-site by the Stormwater Qualifies SWPPP Practitioner (QSP). The SWPPP will be kept on the PG&E substation site by the on-site construction representative for the duration of the PG&E substation improvements project.

- All PG&E and contractor staging areas not in an established yard or on pavement will require environmental approval prior to establishment.
- PG&E personnel will work with the EFS when evaluating spoils for third party giveaway or disposal at a landfill.
- All spoils from the PG&E substation improvements will be sampled and analyzed for no less than the following constituents: TPHg+BTEX, TPHd, TPHmo, CAM17.
- Spoils taken directly to a PG&E spoils consolidation yard will not require sampling provided they do not exhibit evidence of contamination or naturally occurring asbestos. PG&E personnel will contact the EFS to confirm whether they are eligible to utilize the PG&E spoils yard(s).
- Wet and dry spoils will not be mixed and will be managed separately.
- All wet spoils will be stored in water-tight containment so as to prevent wet spoils or liquids from contacting the ground.
- If the soil exhibits contamination during excavation (e.g., chemical/petroleum odor, discoloration) or contains hazardous materials (e.g., paint, lampblack, metal waste or slag), PG&E personnel will stockpile and segregate the soil and contact the EFS.
- Surplus spoils (wet/dry) will only be disposed of at PG&E approved landfills listed in ENV-4000P-01-JA15 Job Aid: PG&E Authorized Disposal and Recycling Facilities.
- **Fugitive Dust Control (Construction).** The PG&E crew will not allow visible dust to pass beyond the PG&E property boundary. The crew will abate dust by:
 - Applying water to disturbed areas and to storage stockpiles;
 - Applying water in sufficient quantities to prevent dust plumes during activities such as clearing & grubbing, backfilling, trenching and other earth moving activities;
 - Limiting vehicle speed to 15 miles per hour;
 - Loading haul trucks with a freeboard (space between top of truck and load) of six inches or greater;
 - Covering the top of the haul truck load;
 - Cleaning up track-out at least daily; and
 - Not generating dust in amounts that create a nuisance to wildlife or people, particularly where sensitive receptors are located nearby or down-wind. During inactive periods (e.g., after normal working hours, weekends, and holidays), the PG&E crew will apply water or other approved material to form a visible crust on the soil and restrict vehicle access.
- **Local Environmental Field Specialist Notification (Construction).** PG&E personnel will immediately contact the environmental field specialist (EFS) and stop work if any of the following conditions occur. If the incident occurs after hours or if the EFS is unavailable, personnel will call the Environmental Emergency Hotline at 1-800-874-4043.
 - Discharge or spill of hazardous substance;
 - An environmental regulator visits the PG&E substation site;
 - Visually cloudy/muddy water is observed leaving the work area;

- An underground storage tank is discovered; or
- A subsurface component related to site remediation activities (e.g., monitoring well, recovery well, injection well) is discovered. No subsurface components will be impacted.

If during excavation unanticipated evidence of contamination is identified (e.g., staining, odors), work will cease and the trench will be covered with steel plates when safe to do so. In order to minimize impacts on public safety and the environment, contaminated soil will be placed on a polyethylene sheet (4 ml) and covered, or placed in lined covered containers. PG&E personnel will contact the EFS to determine the next steps.

If any subsurface components related to site remediation activities (e.g., monitoring well, recovery well, injection well) are discovered in the path of excavation, work will cease in that location and the EFS will be notified to determine the next steps. No subsurface components will be impacted.

- **Oil-Filled Electrical Equipment (Construction and Operation).** Oil-filled electrical equipment (OFEE) will be managed in accordance with ENV-3000P-02-JA01 Job Aid: Handling In-Service Electrical Equipment from the Field.
 - If during the removal/replacement of OFEE, visible evidence of an oil leak is identified (e.g., seeping, weeping, staining, sheen), PG&E personnel will contact the EFS immediately to determine cleanup actions and regulatory reporting requirements.
 - Work will cease on all leaking pre-July 1, 1979 equipment or equipment without a non-polychlorinated biphenyl (PCB) blue sticker or other non-PCB indicator on its nameplate until the EFS has been contacted.
 - All leaking equipment will be patched, pumped, or containerized in the field so that it will not leak during transport; taken straight back to the service center (i.e., stops at laydown yards are prohibited); and placed in the designated returned equipment area with a completed yellow condition tag.
 - For other equipment that cannot be tested, the EFS will be contacted to coordinate generation of a purchase order and contract for disposal. The equipment will be transported by a PG&E approved hazardous waste contractor and taken to a disposal facility.
- **Hazardous Materials Storage (Construction and Operation).** The storage of hazardous materials will be managed according to regulations and best management practices.
 - All releases of hazardous materials will be immediately addressed. A spill kit will be maintained onsite during the length of the project. In the event of a spill of hazardous materials/wastes, the EFS will be contacted to determine if agency notifications will be required and/or if additional resources are needed.
 - Hazardous materials greater than 440 pounds and less than 1,001 pounds can be transported on PG&E vehicles if the proper materials of trade (MOT) shipping paper/material safety data sheets (MSDS) accompany the load. PG&E personal will contact the EFS for additional guidance in these areas.
 - All hazardous materials containers will be marked correctly.
 - All hazardous materials signs will be displayed as required.
 - Non-saturated oily rags (to be laundered) will be stored in non-combustible containers.

- Emergency equipment such as fire extinguishers, eye wash, MSDS, etc. will be maintained on the PG&E substation site.
- Hazardous material containers will be in good condition.
- All hazardous materials will be compatible with containers.
- Hazardous materials containers will be kept closed.
- If there is an unauthorized release of hazardous material, PG&E personnel will contact the EFS immediately. If the release occurs after hours, PG&E personnel will contact the Environmental Emergency Hotline at 1-800-874-4043.
- **Spill Prevention, Control, and Countermeasure Plan (Operation).** The EFS will be notified 30 days prior to a spill prevention, control, and countermeasure (SPCC) triggering event occurs. Events that trigger an SPCC include:
 - New storage of oil at a facility causing the total oil storage to exceed 1,320 gallons.
 - Modification to existing oil storage at a facility that contains more than 1,320 gallons of oil by addition or removal of oil containers that are greater than 55 gallons.

If the oil volume is contained in anything greater than 55 gallons, the SPCC Plan will be certified by a licensed engineer. SPCC containment will be installed prior to moving oil quantities requiring containment on to the PG&E substation site. The PM number will remain open until the EFS notifies PG&E personnel that the plan is certified by an engineer, and any necessary modifications are complete.

Chapter 6

Groundwater

The project site partially overlies the Delta-Mendota Subbasin. Currently, there is no appreciable groundwater recharge within the project site because of the hydrological characteristics of the primary soil types (i.e., silty clays). The construction of solar project facilities, including the onsite substation, support structures associated with the gen-tie line, the PG&E substation improvements, access roads, and battery storage area, would create approximately 43 acres of impervious surface area, or less than 1 percent of the area within the project site boundary. Although the trackers that would support the solar panels would add a minor amount of impervious coverage, the solar panels themselves would temporarily intercept rainwater, which would ultimately run off the panels and onto the ground. Likewise, most of the rainwater that would run off the impervious project facilities (e.g., substation building) would run onto neighboring soils and infiltrate into the ground. Therefore, the amount of land that would be converted to impervious surface areas and reduce infiltration would be minimal and would not interfere with groundwater recharge substantially.

No groundwater from the project site would be used for project construction or operation. In addition, the project does not propose dewatering during construction or operation. It also does not propose new wells or permanent extraction activities, nor would it remove existing active wells from operation (as none are present on-site).

Water would be imported for construction and operation from the AKT irrigation well (referred to herein as the Mid-Cal well) located adjacent to SR 33 at the northwest corner of AKT's Mid-Cal property, approximately 4.4 miles north of the project site. The Mid-Cal well overlies the Delta-Mendota Subbasin. The Mid-Cal well currently irrigates approximately 80 acres of corn used for dairy cattle feed and is pumped approximately 16 weeks each year. The Mid-Cal well is reported by AKT to be approximately 100 feet deep and to produce approximately 1,000 gallons per minute (gpm) (EMKO Environmental, Inc. 2023). According to pumping records provided by AKT, approximately 502 acre-feet were pumped from the well between August 2021 and August 2022 (EMKO Environmental, Inc. 2023).

Construction of the project is anticipated to require 370 acre-feet (approximately 121 million gallons) of water during the approximately 70-week construction period, or approximately 5.3 acre-feet per week (EMKO Environmental, Inc. 2023). Operational water demand is estimated to amount to 5 acre-feet per year over an approximate 30-day period each year for the remainder of the project life, which is anticipated to be more than 20 years. Construction water demand and irrigation water demand would occur simultaneously during the project construction period. Annual net project groundwater use for construction needs would be no more than 0.24 percent of the annual average groundwater pumping volume in the Northern and Central Delta-Mendota Region GSP (EMKO Environmental, Inc. 2023). The annual operational water demand would be less than 0.005 percent of the annual average groundwater pumping volume.

Because most of the project would be outside of the Subbasin, the project would have no effect on groundwater recharge in the Subbasin. Due to the small volume of the project water needs compared to the sustainable yield, and the temporary nature of the construction water use, the project would not adversely affect the long-term management of the Subbasin or groundwater sustainability efforts, or conflict with the goals of the GSP.

Chapter 7

Conclusions

This hydrology and drainage report was developed to identify potential project impacts that could result in the project having an adverse effect on the environment. The evaluation was based on a desktop review of the site and vicinity, available topographic and geologic maps, published hydrology literature, land use data, soil data, impervious surface data, groundwater data, and study of the general hydrologic conditions that affect the area. This analysis should be used for planning and environmental analysis purposes only; additional analysis is required for design.

The project would have an adverse impact on flood hazards and groundwater during construction and operation. Hydrologic modeling results indicate that the project, including the solar project, PG&E substation improvements, and gen-tie line, would not significantly increase peak runoff discharges or the volume of runoff. Additionally, the project would be required to implement BMPs to protect stormwater quality and manage stormwater runoff. With BMPs, the project would have a less-than-significant impact on hydrology/drainage and water quality.

The final BMPs for the solar project would be established in the solar project's SWPPP. Based on practices outlined in the California Stormwater Quality Association's (CASQA) Best Management Practice Handbook Portal (California Stormwater Quality Association 2019), BMPs for the solar project could include:

- **Desilting basin and sediment trap:** Construction of a temporary basin designed to remove sediment from runoff would prevent constituents from reaching existing on- and offsite drainages by allowing sediment to settle before discharging water to natural drainages.
- **Erosion control blankets/mats, geotextiles, plastic covers:** These erosion control methods can be used on flat or sloped surfaces to keep soil in place and can be used to cover disturbed soil to prevent runoff.
- **Gravel/sandbag barrier:** A temporary sediment barrier could be constructed using gravel or sand filled bags to prevent sediment from disturbed areas from reaching existing drainages by reducing the volume of sheet flows.
- **Hydraulic, straw, and wood mulch:** The use of these various mulches temporarily stabilizes soil on surfaces with little or no slope.
- **Preservation of existing vegetation:** Preserving the existing vegetation to the maximum extent possible provides protection of exposed surfaces from erosion and can keep sediment in place.
- **Runoff control BMPs:** These measures include grading surfaces to control sheet flow, barriers or berms that force sheet flows around protected areas, and stormwater conveyances such as channels, drains, and swales. These practices and features collect runoff and redirect it to prevent contamination to surface waters. Calculations are made for anticipated runoff, and the stormwater conveyances are constructed, designed, and located to accommodate these flows.
- **Scheduling and planning:** Appropriate scheduling and planning provide ways to minimize disturbed areas, which reduces the amount of activity in the project area that requires protection and minimizes the duration of exposure of disturbed soils to erosion.

- **Stabilized Construction Entrance/Exit.** A graveled area or pad located at points where vehicles enter and leave a construction site can be built. This BMP provides a buffer area where vehicles can drop their mud and sediment to avoid transporting it onto public roads, to control erosion from surface runoff and to help control dust.
- **Storm drain inlet protection:** Protection consists of devices and procedures that detain or filter sediment from runoff, thereby preventing them from reaching drainage systems that will be used post-construction, as well as surface waters.
- **Concrete waste management:** Excess or leftover concrete should be properly disposed of in designated concrete waste facilities.
- **Material delivery and storage practices:** All materials, especially toxic or hazardous materials, should be covered to prevent exposure to stormwater and runoff. Toxic or hazardous materials should also be stored and transferred on impervious surfaces that will prevent immediate exposure to soils. Vehicles and equipment used for material transport and storage, as well as any other vehicles, should be parked in clearly designated areas.
- **Street sweeping and maintenance:** Regular cleaning should occur at the entrances and exits to and from the solar project site to avoid contamination of offsite areas.
- **Solid waste management:** An appropriate amount of conveniently located trash and waste containers should be placed around the solar project site for proper disposal of solid wastes. All receptacles should have lids or covers that will not blow off in windy conditions.
- **Spill prevention and control:** Any spills or releases of materials should be cleaned up immediately and comprehensively. Appropriate and easily accessible cleanup equipment, including spill kits containing absorbents, should be located in several areas around the site. Used cleanup materials should be disposed of properly and in accordance with applicable regulations. Hazardous or toxic material spills must be treated as hazardous waste and be treated and disposed of accordingly.
- **Vehicle and equipment cleaning and refueling:** Vehicles and equipment that regularly enter and leave the solar project site should be cleaned. Additionally, refueling of vehicles and equipment will occur offsite whenever possible. An onsite, designated fueling area with appropriate containment and cleanup materials should be used when offsite refueling is impractical.
- **Vehicle and equipment maintenance:** Offsite maintenance facilities should be used whenever possible. Whenever onsite maintenance is necessary, ensure designated maintenance areas are protected from stormwater runoff and are provided with proper spill cleanup and containment materials.

PG&E implements standard avoidance and minimization measures (AMM) and BMPs during the construction and operation of projects in its service territory. AMM/BMPs that would be implemented for the PG&E substation improvements would include, but are not limited to, those listed in Chapter 5, *Water Quality*, of this report. With implementation of AMM/BMPs, no adverse impacts on water quality from the PG&E substation improvements would occur.

Chapter 8

Preparers

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Chapter 9

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Appendix A

Existing Site Conditions

Street view images were acquired from Google Street View (Google Earth 2019).

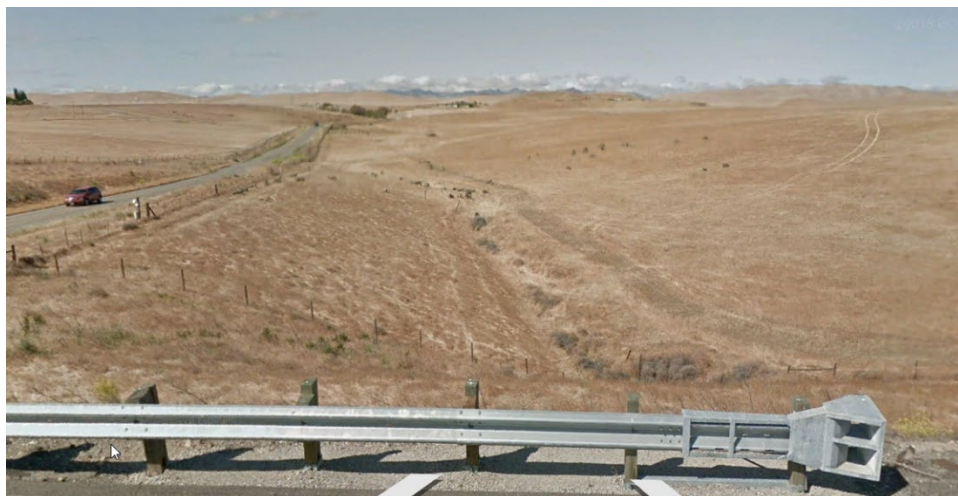


Figure A-1. Google Street View (I-5 looking west toward Billy Wright Road)



Figure A-2. Google Street View (Billy Wright Road looking east toward I-5)



Figure A-3. Google Street View (SR 33 looking south near Hilldale Avenue)



Figure A-4. Google Street View (SR 33 looking south near I-5 interchange)



Figure A-5. Google Street View (I-5 interchange looking southwest)

Appendix B

NOAA Atlas 14 Precipitation Frequency Estimate



NOAA Atlas 14, Volume 6, Version 2
Location name: Gustine, California, USA*
Latitude: 37.0422°, Longitude: -120.9885°
Elevation: 346.79 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 & aeriels](#)

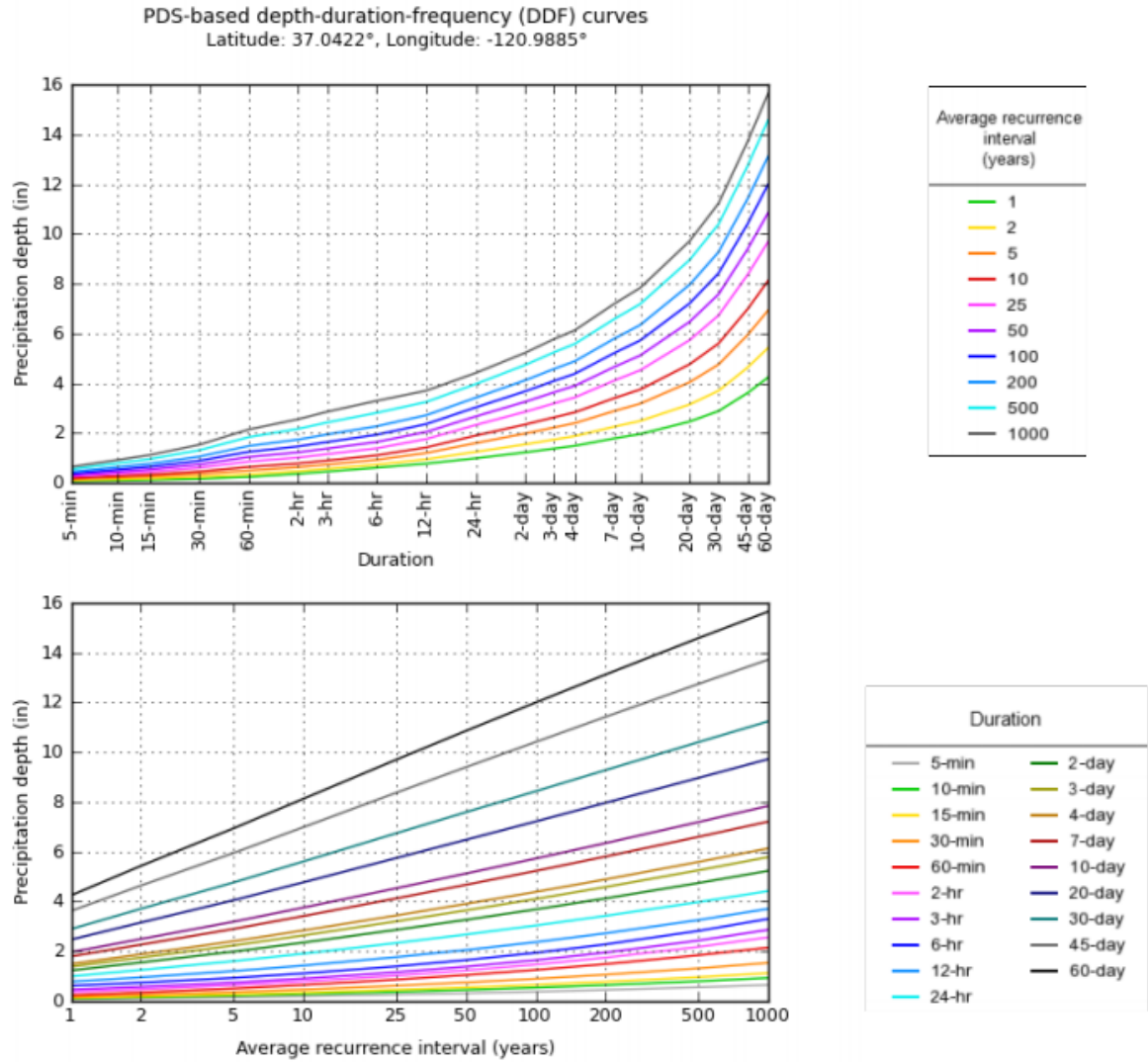
PF tabular

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	0.072 (0.061-0.086)	0.105 (0.088-0.126)	0.152 (0.128-0.183)	0.195 (0.163-0.237)	0.260 (0.208-0.327)	0.316 (0.247-0.407)	0.378 (0.288-0.501)	0.448 (0.331-0.614)	0.555 (0.391-0.796)	0.648 (0.439-0.967)
10-min	0.104 (0.088-0.124)	0.150 (0.127-0.180)	0.218 (0.184-0.262)	0.280 (0.233-0.339)	0.373 (0.299-0.469)	0.452 (0.354-0.583)	0.541 (0.412-0.718)	0.642 (0.474-0.879)	0.796 (0.560-1.14)	0.929 (0.629-1.39)
15-min	0.125 (0.106-0.150)	0.182 (0.153-0.218)	0.264 (0.222-0.317)	0.338 (0.282-0.410)	0.451 (0.361-0.567)	0.547 (0.428-0.706)	0.655 (0.499-0.868)	0.777 (0.573-1.06)	0.962 (0.677-1.38)	1.12 (0.761-1.68)
30-min	0.171 (0.145-0.205)	0.248 (0.210-0.297)	0.361 (0.304-0.433)	0.462 (0.385-0.560)	0.616 (0.494-0.776)	0.748 (0.585-0.964)	0.895 (0.682-1.19)	1.06 (0.783-1.45)	1.32 (0.926-1.89)	1.54 (1.04-2.29)
60-min	0.240 (0.203-0.287)	0.348 (0.293-0.416)	0.505 (0.425-0.607)	0.647 (0.539-0.784)	0.862 (0.691-1.09)	1.05 (0.819-1.35)	1.25 (0.954-1.66)	1.49 (1.10-2.03)	1.84 (1.30-2.64)	2.15 (1.46-3.21)
2-hr	0.370 (0.313-0.443)	0.477 (0.402-0.571)	0.638 (0.537-0.766)	0.788 (0.656-0.955)	1.02 (0.820-1.29)	1.23 (0.963-1.59)	1.47 (1.12-1.95)	1.74 (1.29-2.39)	2.18 (1.53-3.12)	2.56 (1.74-3.82)
3-hr	0.460 (0.389-0.550)	0.572 (0.483-0.685)	0.743 (0.625-0.893)	0.904 (0.753-1.10)	1.16 (0.928-1.46)	1.38 (1.08-1.78)	1.64 (1.25-2.18)	1.95 (1.44-2.67)	2.43 (1.71-3.49)	2.86 (1.94-4.27)
6-hr	0.615 (0.520-0.735)	0.740 (0.625-0.886)	0.932 (0.784-1.12)	1.11 (0.926-1.35)	1.39 (1.12-1.76)	1.65 (1.29-2.12)	1.94 (1.48-2.57)	2.28 (1.68-3.12)	2.82 (1.98-4.04)	3.30 (2.24-4.92)
12-hr	0.780 (0.659-0.933)	0.953 (0.804-1.14)	1.20 (1.01-1.45)	1.43 (1.19-1.73)	1.76 (1.42-2.22)	2.05 (1.61-2.65)	2.37 (1.80-3.14)	2.72 (2.01-3.73)	3.25 (2.29-4.67)	3.71 (2.51-5.53)
24-hr	0.993 (0.916-1.10)	1.25 (1.15-1.38)	1.60 (1.47-1.78)	1.90 (1.74-2.13)	2.33 (2.07-2.68)	2.67 (2.33-3.13)	3.04 (2.59-3.62)	3.42 (2.86-4.18)	3.97 (3.20-5.03)	4.42 (3.45-5.77)
2-day	1.23 (1.13-1.36)	1.55 (1.43-1.72)	1.99 (1.83-2.20)	2.35 (2.15-2.63)	2.86 (2.54-3.29)	3.26 (2.85-3.82)	3.68 (3.15-4.40)	4.12 (3.44-5.04)	4.74 (3.82-6.01)	5.23 (4.09-6.83)
3-day	1.38 (1.28-1.53)	1.75 (1.61-1.93)	2.23 (2.05-2.48)	2.64 (2.41-2.95)	3.20 (2.84-3.68)	3.64 (3.18-4.26)	4.10 (3.50-4.89)	4.58 (3.82-5.60)	5.25 (4.23-6.65)	5.78 (4.52-7.55)
4-day	1.49 (1.38-1.65)	1.88 (1.73-2.08)	2.40 (2.21-2.67)	2.84 (2.59-3.17)	3.43 (3.05-3.95)	3.90 (3.40-4.56)	4.38 (3.75-5.24)	4.89 (4.08-5.98)	5.58 (4.50-7.08)	6.13 (4.79-8.00)
7-day	1.79 (1.65-1.98)	2.27 (2.09-2.51)	2.90 (2.66-3.21)	3.41 (3.12-3.81)	4.12 (3.66-4.73)	4.67 (4.07-5.46)	5.23 (4.47-6.24)	5.80 (4.84-7.10)	6.59 (5.31-8.35)	7.21 (5.63-9.40)
10-day	1.97 (1.81-2.17)	2.49 (2.30-2.76)	3.19 (2.93-3.54)	3.75 (3.43-4.19)	4.53 (4.02-5.20)	5.12 (4.47-5.99)	5.72 (4.89-6.83)	6.34 (5.29-7.76)	7.19 (5.79-9.10)	7.83 (6.12-10.2)
20-day	2.47 (2.28-2.73)	3.15 (2.91-3.49)	4.05 (3.72-4.49)	4.77 (4.35-5.33)	5.74 (5.10-6.59)	6.47 (5.65-7.57)	7.21 (6.16-8.61)	7.96 (6.64-9.74)	8.96 (7.21-11.4)	9.71 (7.59-12.7)
30-day	2.89 (2.67-3.20)	3.71 (3.42-4.10)	4.76 (4.38-5.28)	5.60 (5.12-6.26)	6.73 (5.98-7.74)	7.58 (6.62-8.87)	8.43 (7.20-10.1)	9.28 (7.74-11.3)	10.4 (8.37-13.2)	11.2 (8.78-14.7)
45-day	3.62 (3.34-4.00)	4.64 (4.27-5.13)	5.94 (5.47-6.60)	6.98 (6.38-7.80)	8.36 (7.42-9.61)	9.39 (8.19-11.0)	10.4 (8.89-12.4)	11.4 (9.52-14.0)	12.7 (10.3-16.1)	13.7 (10.7-17.9)
60-day	4.24 (3.91-4.69)	5.43 (5.00-6.01)	6.93 (6.37-7.69)	8.12 (7.42-9.08)	9.69 (8.60-11.1)	10.8 (9.46-12.7)	12.0 (10.2-14.3)	13.1 (10.9-16.0)	14.6 (11.7-18.5)	15.6 (12.2-20.4)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

[Back to Top](#)

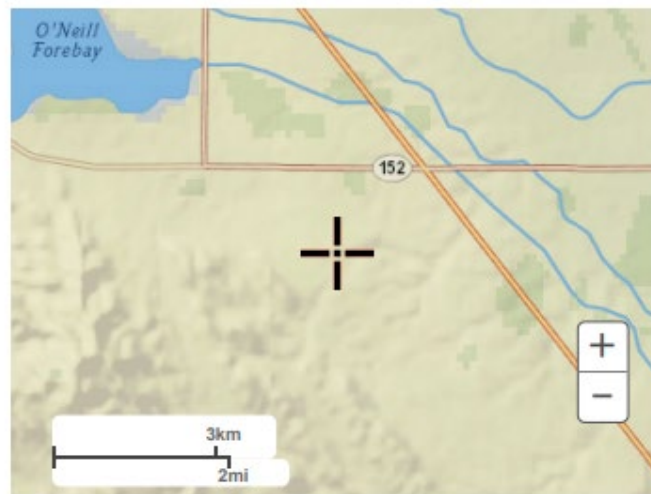
PF graphical



NOAA Atlas 14, Volume 6, Version 2

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Precipitation Frequency Data Server



Large scale terrain



Large scale map



Large scale aerial

