Appendix A – Stormwater and Drainage Report

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Southern California Edison

Application for Surrender of License
Borel Hydroelectric Project
FERC Project No. 382

Volume II, Appendix A

Stormwater and Drainage Report

SOUTHERN CALIFORNIA EDISON
Energy for What's Ahead℠

December 2022

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Southern California Edison

Application for Surrender of License
Borel Hydroelectric Project
FERC Project No. 382

Volume II

Stormwater and Drainage Report

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December 2022

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1 Purpose

Southern California Edison (SCE), licensee of the Borel Hydroelectric Project (FERC No. 382) (Borel Project), proposes to surrender the existing Federal Energy Regulatory Commission (FERC or Commission) license for the Borel Project and decommission Borel Project facilities as described in the Decommissioning Plan (Plan; Volume II of this Application for Surrender of License [Application]). The Borel Project is located on the North Fork and main stem of the Kern River in Kern County, California. The Borel Project includes a 158-foot-long, 4-foot-high concrete diversion dam on the North Fork of the Kern River and a powerhouse with two 3,000-kilowatt (kW) generators and a 6,000-kW generator for a total installed capacity of 12 megawatts (MW). These facilities are situated on private land that is under Kern County's jurisdiction as well as on federal lands managed by the U.S. Army Corps of Engineers (Corps); U.S. Department of Agriculture, Forest Service (Forest Service); and U.S. Department of the Interior, Bureau of Land Management (BLM).

In 2017, the Corps modified the Lake Isabella Auxiliary Dam (Auxiliary Dam) for safety purposes, which required the condemnation and removal of critical Borel Project facilities that provided water to the Borel Project for power generation. Since that time, the Borel Project has been unable to generate power, and SCE has determined that no other sources of water can reasonably be utilized by the Borel Project.

Downstream of the Auxiliary Dam, the Borel Project includes a combination of conveyance facilities that include in-ground concrete canal reaches, elevated flumes, and siphons. The location of these facilities is shown in Figure 1-1. Due to the location of these facilities within the watershed, the Borel Project influences rainfall runoff patterns by intercepting, redirecting, and/or concentrating stormwater runoff flows within the watershed. Removal of, or modifications to, the canal and associated conveyance facilities, as described in the Plan, would change the runoff and channel flow patterns in the watershed.

To assess the impacts of the Borel Project on stormwater runoff patterns, hydrology and a hydraulic model were developed to characterize existing flooding patterns and perform a drainage analysis of the proposed conceptual design of the Borel Project as described in the Plan. The proposed design incorporates a series of linear detention basins throughout the current footprint with a primary purpose of controlling stormwater runoff that is currently intercepted and conveyed by the canal. The drainage analyses were performed to assess the adequacy of the proposed detention basins and their ability to infiltrate the stormwater runoff and or direct the excess runoff to natural existing drainage features.

The purpose of this report is to document the model development and preliminary drainage analysis performed. The drainage analyses are focused on the Borel canal segments that extend from downstream of the Auxiliary Dam to the Borel Powerhouse. These segments were the focus of the drainage analyses because, under existing conditions, the canal intercepts stormwater runoff and influences drainage patterns for down-slope properties. The preliminary drainage analyses were performed to verify that the linear detention basins proposed in the Plan, can contain the design stormwater runoff and meet infiltration and freeboard requirements as described in the Kern County Standards for Drainage - Division 4 (Kern County Standards).

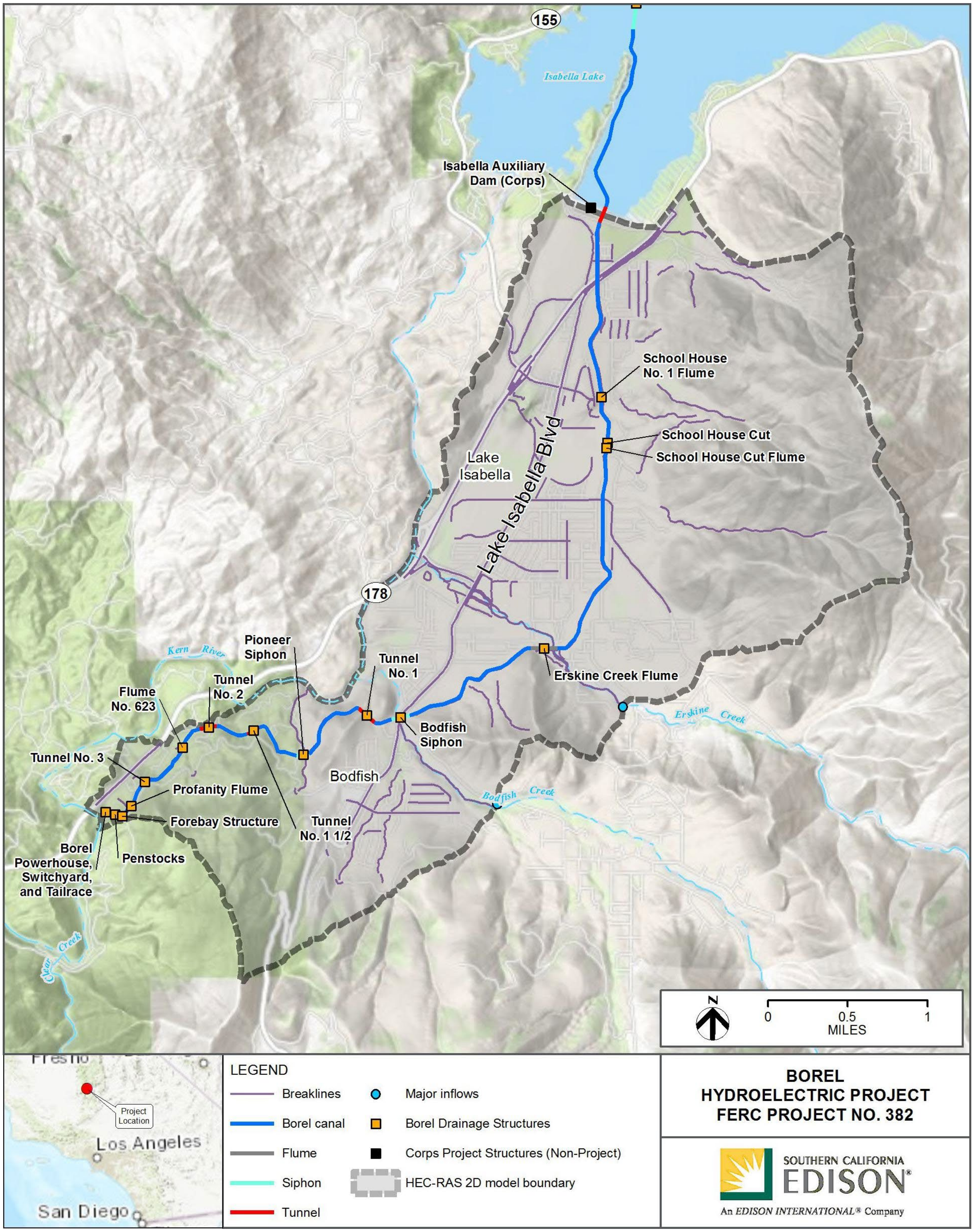

Figure 1-1. Study Location and Borel Project Drainage Features

2 Background Information

2.1 Watershed Description

The study area is part of the Kern River watershed, which includes several urban areas within the valley floor in the vicinity of Lake Isabella, upper watersheds, and principal drainages such as Bodfish and Erskine Creeks. The natural ground cover in the study area is chaparral and woodland, with residential or commercial landscaping in the urban areas. The stormwater runoff from the surrounding hillside slopes and upper watersheds flow to the valley floor toward the Kern River. The two largest basins located along the Borel Project have 100-year peak flood flows in the magnitude of 1,500 cubic feet per second[1]. The principal drainages cross the existing Borel Project and continue along Erskine and Bodfish creeks respectively until both reach the Kern River. The Borel Project was constructed above the Erskine Creek drainage course in an above-ground flume. Bodfish Creek flows over natural ground in a section of the Borel Project containing an underground siphon. Other smaller basins drain directly into the canal and when the Borel Project was operating, passed through the Borel Powerhouse and discharged into the Kern River.

2.2 Previous Studies

In 2017, an initial hydrologic and hydraulic study was performed for the Borel Project area where peak flows and capacities along the Canal were developed. The study developed a Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) model that was used to determine the hydrology and a HEC-RAS one-dimensional (1D) model that was used to analyze specific facilities along the Borel Project. Complete documentation was not obtained from this previous study; therefore, it was not used as part of this analysis.

2.3 Data Collection

Hydrologic inputs, terrain data, and inputs into the HEC-RAS 2D hydraulic model were developed to complete the preliminary hydraulic analysis, characterize flood flow patterns, and complete the preliminary drainage analysis. The following sources were used:

1. Hydrologic inputs were developed for a range of frequency-based design precipitation events using the National Oceanic and Atmospheric Administration (NOAA) Atlas 14-point precipitation data (Perica et al. 2011) and the *Kern County Hydrology Manual* (Hromadka 1995)
2. A digital terrain model was developed using the best available topographic data for existing conditions and natural grade configuration:
   a. Existing Conditions - With Borel Project
   b. Natural Grade Conditions - Without Borel Project
3. Saturated hydraulic conductivity (Ksat) infiltration rates from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database used to calculate infiltration rate of soils.

[1] Peak flows were reported in a figure developed by Cardno in 2017 (Cardno 2017) and were confirmed using StreamStats.

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3 Model Development

This section provides a summary of model development such as hydrologic inputs, terrain data, and an HEC-RAS 2D hydraulic model. The hydraulic model was developed to characterize flood flow patterns and assess the feasibility of the proposed Borel Project, retaining the Borel Project as a series of linear detention basins. The development of the hydrology, terrain data and hydraulic model is described in the following subsections.

3.1 Hydrologic Inputs

Hydrologic inputs to the model were computed to characterize flow patterns in the hydraulic model for a range of frequency-based storm events. The hydrologic inputs are required to calculate precipitation over the watershed as well as the inflow from large upstream drainages. Frequency-based design precipitation events (hyetographs and precipitation excess time series) and frequency-based design inflow hydrographs for Erskine and Bodfish Creeks were computed.

The frequency-based design precipitation events were developed. Estimates for regional precipitation were obtained by accessing historical precipitation records. NOAA Atlas 14, Volume 6, Version 2 (Perica et al. 2011) provided annual maximum precipitation depth-duration-frequency relationships for selected durations and frequencies based on regional analysis of the historical precipitation records. Annual maximum series-based point precipitation estimates for a point in the mountain range east of Borel Project (35.6131°, -118.4416°) were acquired. Representative durations (5-minute, 10-minute, 15-minute, 30-minute, 1-hour, 2-hour, 3-hour, 6-hour, 12-hour, and 24-hour) and frequencies (2-year, 10-year, 50-year, 100-year, and 500-year) were selected for each annual maximum series. The annual maximum series-based point precipitation estimates are shown in Table 3-1.

The methods to balance the depth-duration-frequency precipitation estimates into a 24-hour precipitation hyetograph were applied using the *Kern County Hydrology Manual* (Hromadka 1995) methods. The *Kern County Hydrology Manual* used a modification of the Soil Conservation Service (SCS) 24-hour storm pattern for balancing and nesting the depth-duration data into a precipitation hyetograph. The method also accounts for depth area effects. Using this method, a balanced 24-hour precipitation hyetograph for each of the five frequencies was developed. The resulting rainfall hyetographs for each of the five frequencies are shown in Figure 3-1 through Figure 3-5.

The *Kern County Hydrology Manual* methods were applied to compute rainfall losses. Rainfall losses account for initial abstraction and infiltration of the rainfall. The *Kern County Hydrology Manual* uses a modification of the SCS Curve number method to compute losses and apply them to the rainfall hyetograph, resulting in a rainfall excess time series. Inputs to the modified SCS Curve Number method are hydrologic soil type, percent impervious, and land cover type. Spatial data were acquired by using Geographic Information System using inputs from hydrologic soil type from U.S. Department of Agriculture Natural Resources Conservation Service Soil Survey Geographic database (USDA-NRCS 2020) and percent impervious and land cover type from the National Land Cover Database (NLCD 2016). The loss time series for each of the five frequencies are shown in Figure 3-1 through Figure 3-5, above each of the respective precipitation hyetographs.

Table 3-1. Annual Maximum Series-based Point Precipitation Frequency Estimates (in inches; Latitude 35.6131° North, Longitude -118.4416° West)

Duration	2-year	10-year	50-year	100-year	500-year
5-minute	0.12	0.24	0.38	0.45	0.64
10-minute	0.16	0.34	0.54	0.65	0.92
15-minute	0.20	0.42	0.66	0.78	1.12
30-minute	0.27	0.56	0.89	1.06	1.51
1-hour	0.38	0.80	1.26	1.49	2.13
2-hour	0.58	1.09	1.66	1.96	2.78
3-hour	0.72	1.32	2.00	2.35	3.31
6-hour	1.01	1.82	2.72	3.17	4.42
12-hour	1.32	2.60	3.91	4.54	6.20
24-hour	1.70	3.76	5.74	6.66	8.95

Source: NOAA Atlas 14, Volume 6, Version 2 (Perica et al. 2011)

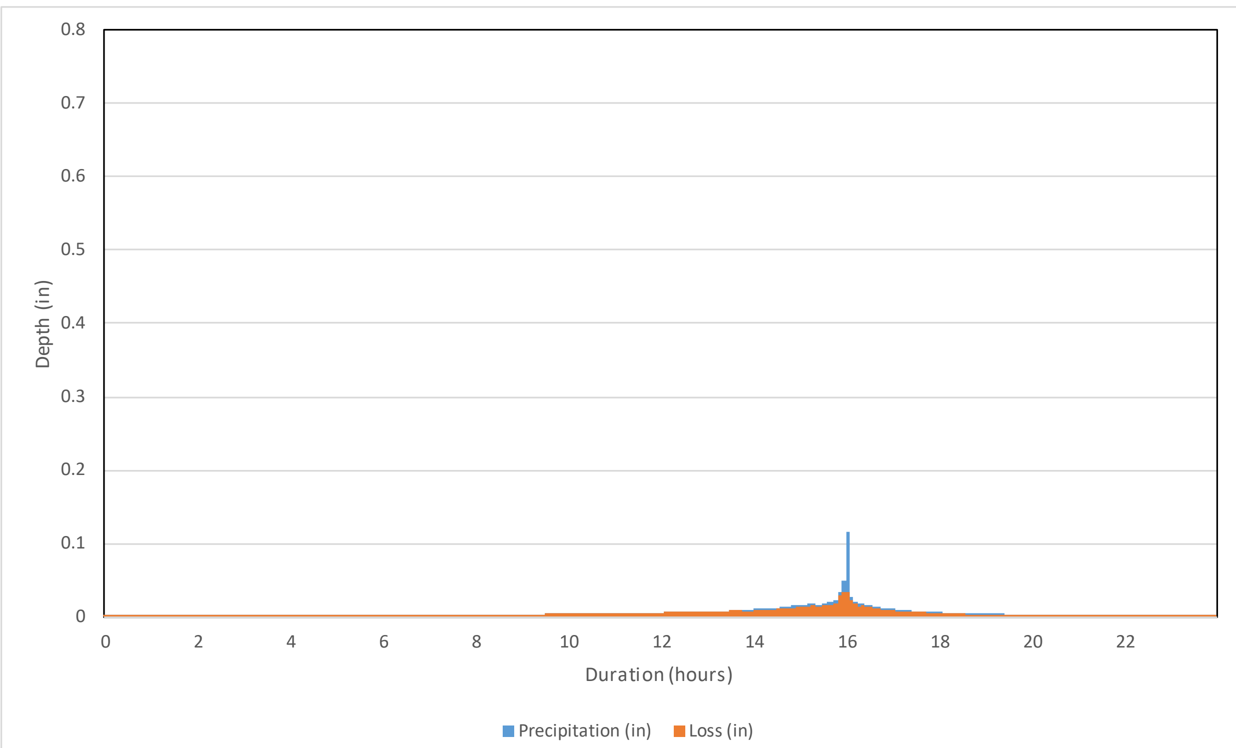

Figure 3-1. 2-year Precipitation Hyetograph and Loss Time Series

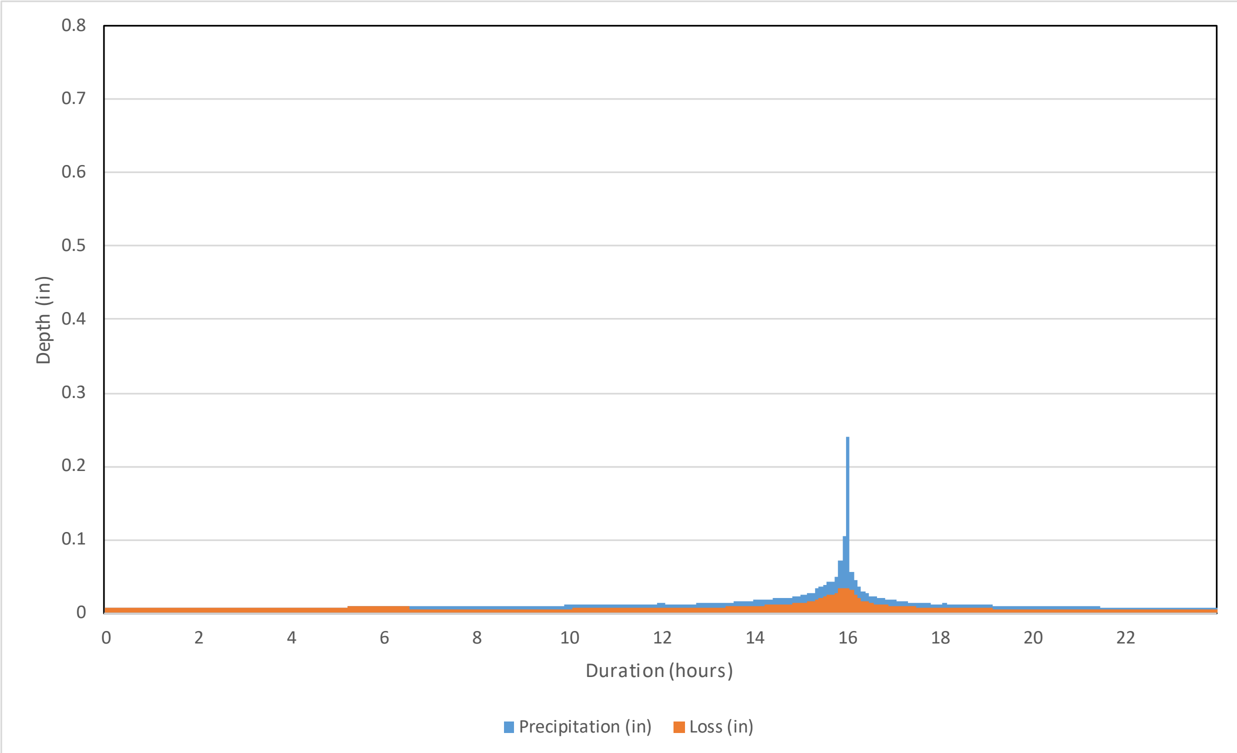

Figure 3-2. 10-year Precipitation Hyetograph and Loss Time Series

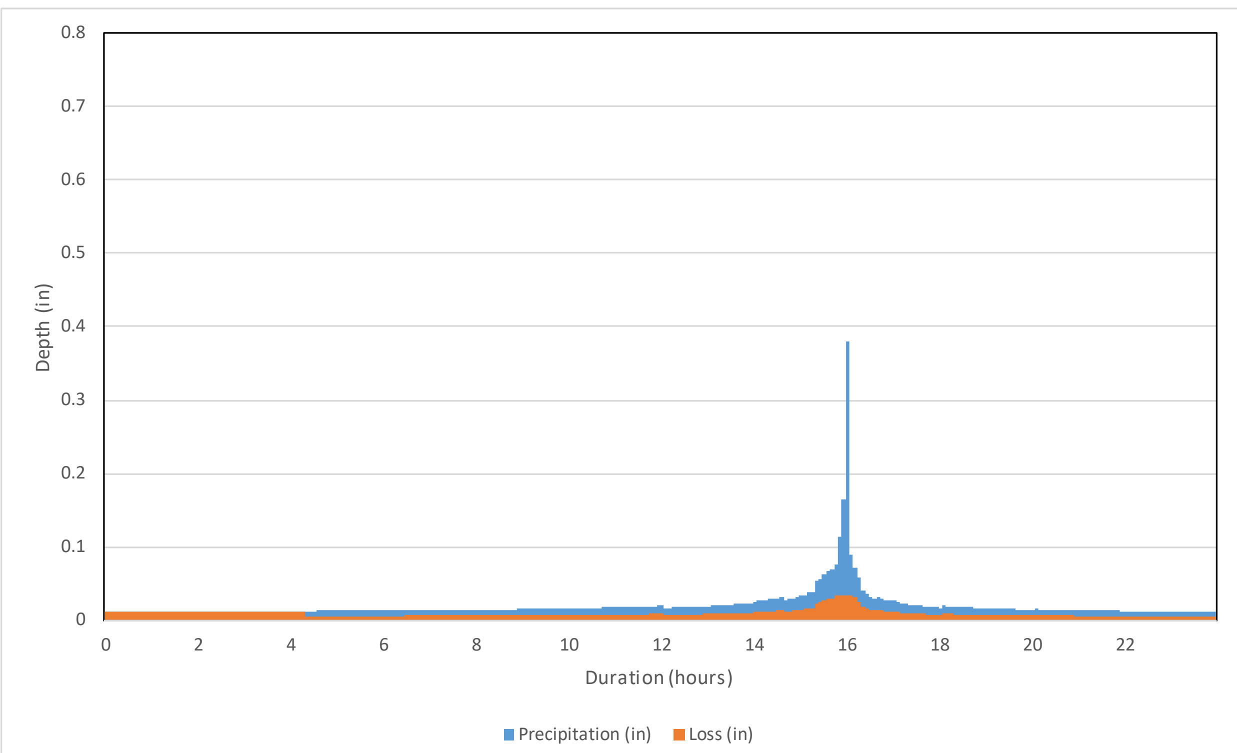

Figure 3-3. 50-year Precipitation Hyetograph and Loss Time Series

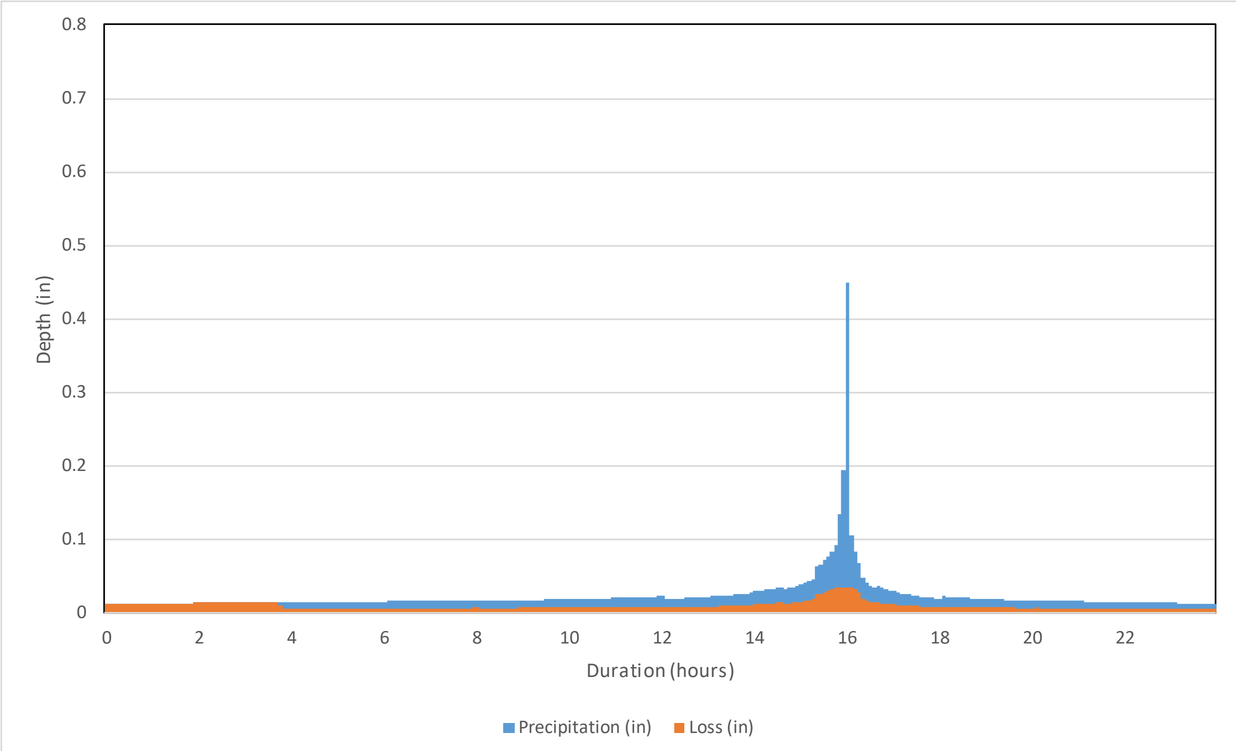

Figure 3-4. 100-year Precipitation Hyetograph and Loss Time Series

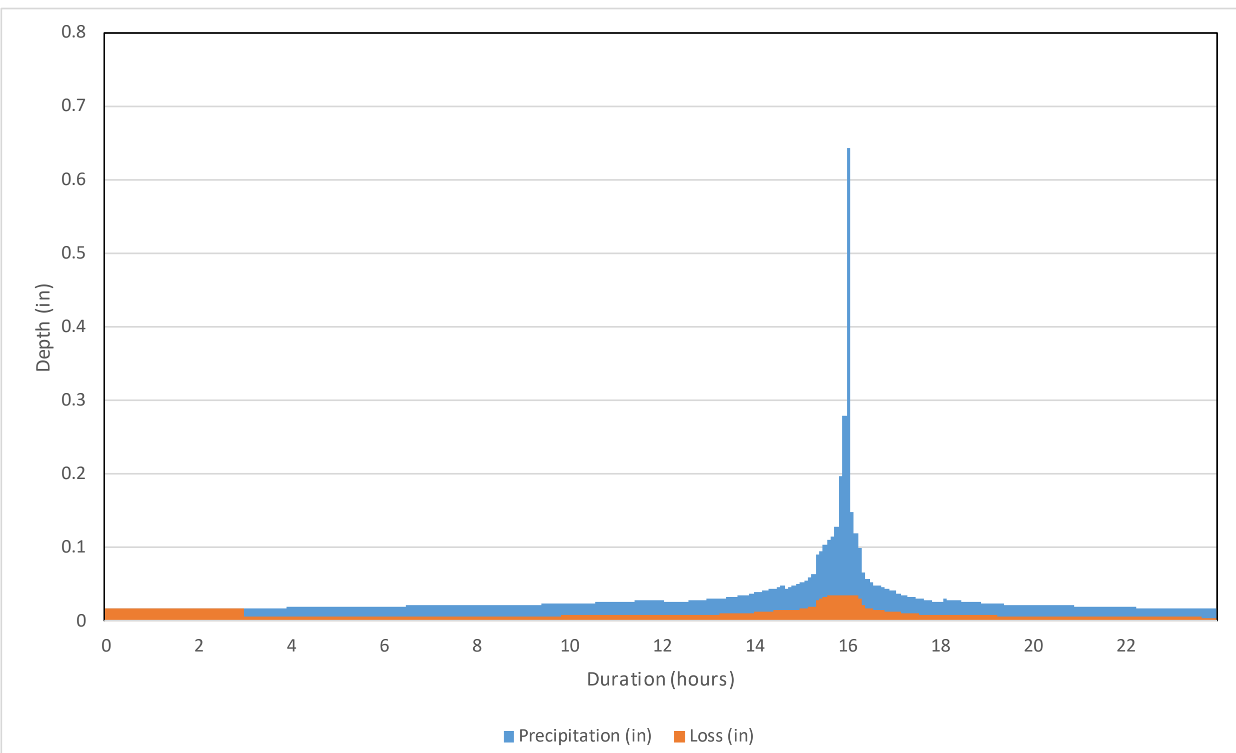

Figure 3-5. 500-year Precipitation Hyetograph and Loss Time Series

The following process was used to develop the frequency-based design inflow hydrographs for Erskine and Bodfish Creeks:

1. Design precipitation events (hyetographs and precipitation excess time series) were developed for the Erskine and Bodfish Creek upper watersheds following the same steps described in the previous section. Figure 3-6 shows the upper watersheds in relation to the Borel study area (valley floor detailed model).
2. A routing model of the upper watersheds was developed using HEC-RAS 2D. The HEC-RAS 2D model used the best available terrain data for the upper watershed (U.S. Geological Survey [USGS] 10-meter digital elevation model [DEM]), and Manning's roughness values were applied to the grid cell faces based land cover observed in aerial imagery.
3. The rainfall excess time series for each of the five frequencies from step 1 to the HEC-RAS 2D model were applied to compute stormwater runoff hydrographs.
4. The stormwater runoff hydrographs peak flow was compared to the peak flows computed by Cardno and USGS StreamStats.

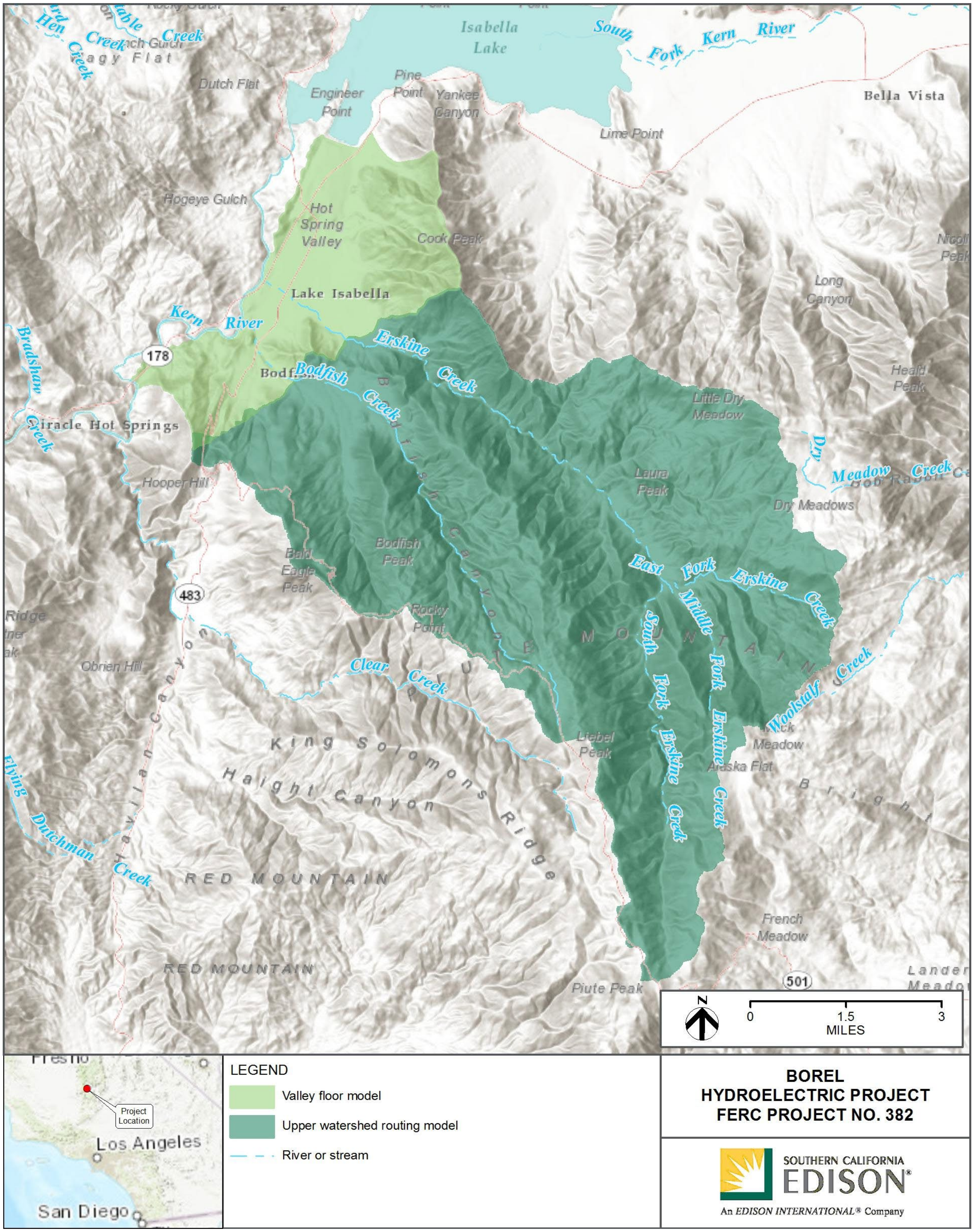

Figure 3-6. Watershed Boundaries

3.2 Terrain

The Borel Project terrain was developed from one Light Detection and Ranging (LiDAR) dataset and supplemented with the DEM: *Erosion and Sedimentation within the Kern River Canyon, CA* hosted by *Open Topography and National Elevation Dataset (NED) 1/3 arc-second,* available on the USGS National Map Viewer (USGS 2019). The USGS DEM was used to fill LiDAR coverage gaps along the boundary of the survey in order to cover the entire project area as shown in Figure 3-7. Both data sources were transformed to the project coordinate system: North American Datum of 1983 (NAD83), California State Plane Coordinate System Zone 5.

A LiDAR quality assessment was completed to check for obvious errors with the data. The assessment was made by an experienced LiDAR data processor familiar with all aspects of collection, processing, and analyses as well as relevant standards and guidelines. Recommendations were made to reclassify the LAS files in order to produce a more accurate ground model. Reclassification of the LiDAR was performed, including the removal of buildings and bridges that were classified incorrectly as ground (LAS class 2).

LiDAR point clouds and elevation points extracted from the USGS DEM were utilized to produce an ESRI terrain triangulated surface. A DEM was produced from bare earth ground surface consisting of only classified ground returns for the model terrain. Facilities along the Borel Project such as the flumes, siphons, and penstocks were represented within the terrain. Boundaries were delineated around features that should be excluded from the terrain representing natural grade conditions. Digitized exclusion polygons coupled with elevations values from the terrain were utilized to create a triangular irregular network (TIN). DEM patches were produced from the TIN to model the natural grade conditions, which restored the terrain to natural grade as shown in Figure 3-8.

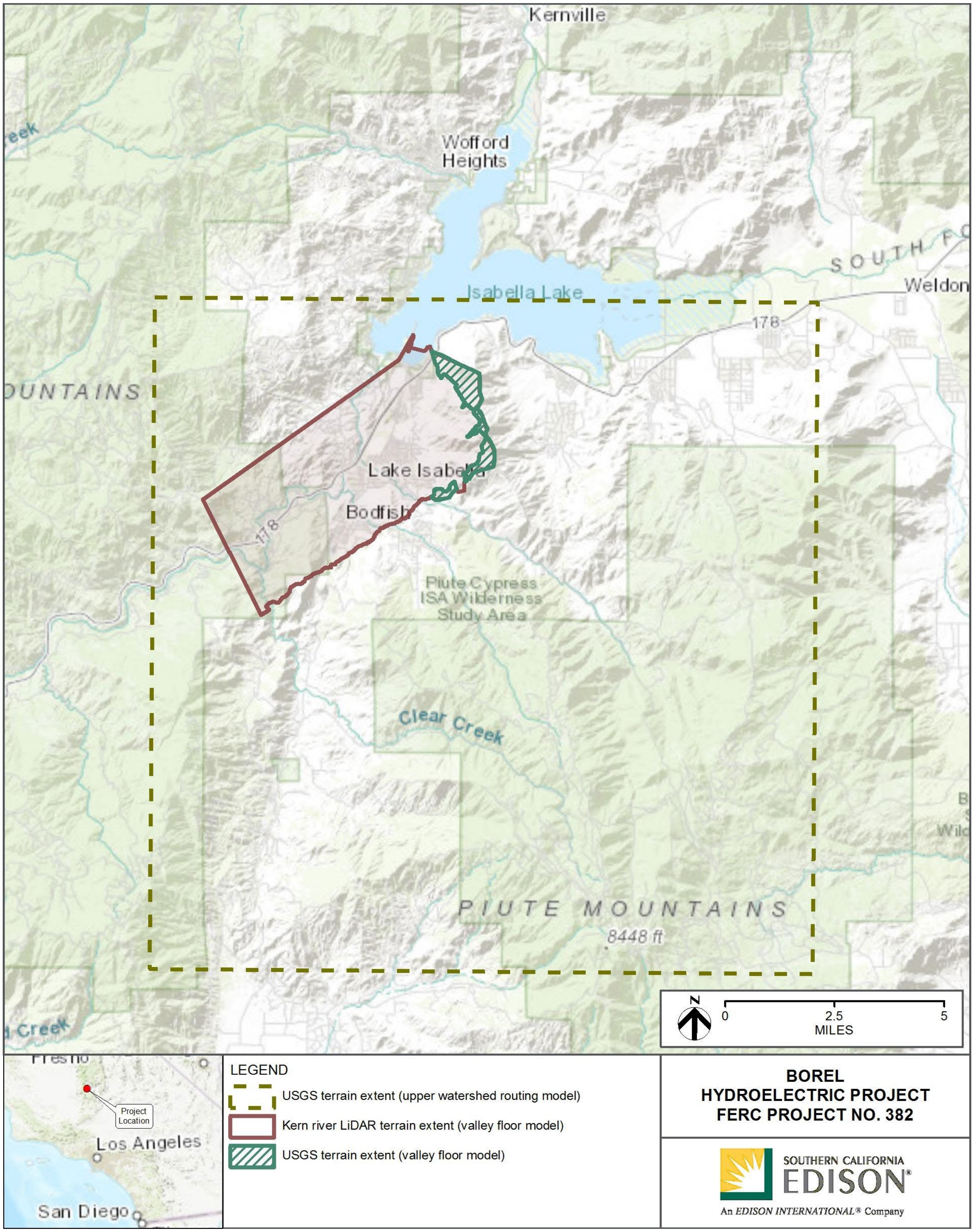

Figure 3-7. Elevation Data Extents

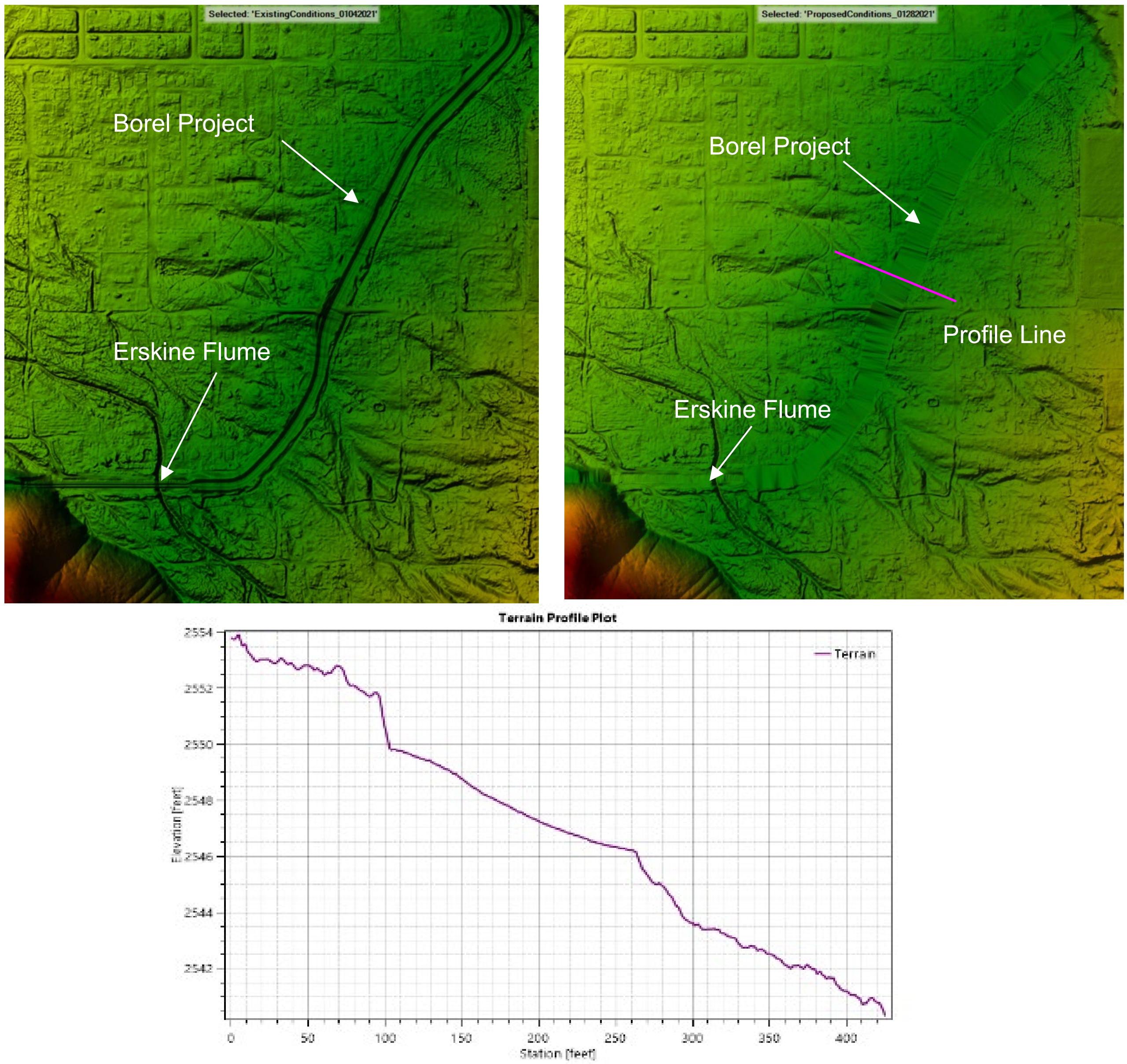

Figure 3-8. Borel Project Removal – Natural Grade Terrain

3.3 Hydraulic Model Development

This section describes the development of a HEC-RAS 2D rain-on-grid unsteady flow hydraulic model. The hydraulic model was developed to perform the drainage analysis.

An initial sensitivity and discovery analysis was executed using the hydraulic model to understand stormwater runoff patterns. Several simulations were performed using the two geometries described below. The results of various conditions evaluated in the sensitivity analysis were compared to gain an understanding of the potential stormwater runoff patterns. Section 3.4 describes the sensitivity analysis and results.

The following two conditions were evaluated as part of the initial sensitivity and discovery analysis.

- **Existing Conditions** – The Borel Project in existing state with conveyance facilities in place.
- **Natural Drainage Conditions** – The Borel Project removed. The terrain along the canal alignment is restored to natural grade.

The hydraulic model was also used to perform a preliminary drainage analysis of the proposed detention basin conceptual design described in the Plan. The drainage analysis is described in Section 4.

The model domain encompassed the watershed areas that contribute to the flow in the Borel Project below the Lake Isabella Auxiliary Dam, except for upper watersheds of Erkine and Bodfish Creeks. The model domain is shown in Figure 1-1. Table 3-2 summarizes the model configuration for both the existing and natural grade conditions. Table 3-3 summarizes the boundary conditions used for both the existing and natural grade conditions model.

Table 3-2. Model Configuration Summary

Parameter or Feature	Description
Model	HEC-RAS 2D rain-on-grid model, including the associated Borel Project flumes, siphons, penstocks, and drainage culverts; the model is used for the preliminary evaluation of the hydraulic impacts associated with the decommissioning of the Borel Project
Model Version	HEC-RAS v5.0.7, released March 2019
Vertical Datum	North American Vertical Datum of 1988
Equation Set	Full momentum
Model Domain	Model extends from Lake Isabella Dam to Kern River, covering 10.57 square miles
Major Hydraulic Features	• Flumes – configured within the terrain and 2D connection in order to represent the opening underneath the flume • Siphons – configured with a 2D connection • Canal – configured within the terrain and breaklines • Penstocks – configured with a 2D connection • Highway 155 and 178 – represented in the terrain • Drainage culverts – configured using 2D connections with culverts; the culvert sizes were based on available design drawings and estimated from aerial imagery Flumes, siphons, and the penstocks are not represented within the natural grade conditions model domain.

Table 3-2. Model Configuration Summary

Parameter or Feature	Description

Hydraulic Scenarios	• Existing conditions and natural grade conditions:
	  ○ Valley floor, hill slopes within the valley floor, and upper watershed precipitation scenarios:
	    ▪ 2-year
	    ▪ 10-year
	    ▪ 50-year
	    ▪ 100-year
	    ▪ 500-year
	  ○ Hill slopes within the valley floor and upper watershed runoff scenarios:
	    ▪ 10-year
	    ▪ 100-year

Embankment Performance	The following are configured in the model using breaklines: • Embankments • High ground within the Borel project area specifically the valley floor Embankments are allowed to overtop but not fail.
2D Flow Areas	One 2D flow area was used to represent the study area. The 2D flow area uses 50-foot nominal grid cell size, with 120,368 cells covering approximately 10.57 square miles. Breaklines and grid cell refinement (to sizes less than 50 feet) were used to align the grid cell faces with hydraulically significant features (e.g., roads, embankments, high ground).
Manning's *n* Values	Manning's *n* values were assigned to the computational grid based on the National Land Cover Database (NLCD 2016). The land use types were correlated with Manning's *n* values consistent with industry standards. Recommended Manning's *n* values range from 0.013 to 0.4, depending on the land use type. The Manning's *n* value was increased to 1,000 for houses and buildings located within the project area. This approach to representing structures with increased roughness values is used to minimize model instability. For areas where the land cover was not consistent with observations from ESRI aerial imagery, the land cover was updated/adjusted based on the aerial imagery.

Topography Data	LiDAR with supplemental DEM
	• LiDAR
	  ○ Dataset Name: Erosion and Sedimentation within the Kern River Canyon, CA
	  ○ Survey Date: 10/09/2016 – 10/10/2016
	  ○ Downloaded from OpenTopography (Krugh 2019)
	• DEM
	  ○ Dataset Name: USGS NED 1/3 arc-second n36w119 1 x 1 degree IMG 2019
	  ○ Publication Date: 09/24/2019
	  ○ Downloaded from USGS 3DEP National Map Viewer (USGS 2019)
	Cell resolution: the base terrain used in the model has a cell resolution of 2 feet; additional terrain layers have cell resolution as low as 0.1 foot.

Rainfall	Developed based on NOAA Atlas 14-point precipitation data as described in Section 3.1, Hydrologic Inputs.

Table 3-2. Model Configuration Summary

Parameter or Feature	Description
Infiltration	Infiltration was taken into account outside the HEC-RAS 2D model by computing losses as described in Section 3.1, Hydrologic Inputs.
Computation Time Step	The nominal time step is 1 second. However, a variable time step is applied using HEC-RAS advanced time step control to adjust the time steps based on a series of divisors.
Simulation Time	24 hours (1 day)

Table 3-3. Model Boundary Conditions

Location	Value or method used
Lake Isabella	Normal depth outflow (out of system) into Lake Isabella Friction slope = 0.085
Kern River at State Route 178 and Elizabeth Norris Road	Normal depth outflow (out of system) into Kern River Friction slope = 0.08
Kern River at State Route 178 and Borel Road	Normal depth outflow (out of system) into Kern River Friction slope = 0.02
Kern River at Borel Canyon Hydroelectric Power Plant	Normal depth outflow (out of system) into Kern River Friction slope = 0.417
2D Model Boundary	Precipitation developed based on NOAA Atlas 14-point precipitation data as described in Section 3.1, Hydrologic Inputs
Erskine Creek	Flow hydrograph
Bodfish Creek	Six flow hydrographs are used to represent the Bodfish watershed inflow

3.4 Sensitivity and Discovery Analyses to Investigate Storm Runoff Patterns

A set of sensitivity discovery analyses were performed to investigate stormwater runoff patterns that could result if the terrain along the canal alignment were restored to natural grade. A total of fourteen simulations were performed. The fourteen simulations are made up of runs for both the existing and natural grade conditions, five storm frequencies, and two rainfall locations.

- Existing and natural grade conditions:
  - Valley floor local storm:
    - 2-year
    - 10-year
    - 50-year
    - 100-year
    - 500-year

- Hill slopes and upper watershed runoff scenarios:
  - 10-year
  - 100-year

Only six of the scenario results are presented in this report as these are sufficient to show drainage patterns and present information relevant to the drainage analysis. The information for the other scenarios is available in the model if needed for future analyses. The existing conditions model domain includes the Borel Project, which extends from Lake Isabella to the Kern River. The Borel Project facilities, including flumes and siphons, are included explicitly in the model geometry. The natural grade conditions model domain shows the Borel Project removed and returned to existing grade. A terrain patch was developed to represent the terrain restored back to natural grade as shown in Figure 3-6. Flumes, siphons, and other facilities associated with the canal were removed for this analysis. A series of 2D connections with culverts were used to account for the main drainage culverts within the project area under Kern County jurisdiction, in locations away from the canal alignment. The culvert sizes were generally estimated from aerial imagery for the analyses and results presented herein because physical data was not available.

3.4.1 Sensitivity and Discovery Analyses Results

As part of the sensitivity and discovery analyses, simulations were completed for the 2-, 10-, 50-, 100-, and 500-year design storm events. The initial set of simulations assumed that both the valley floor and upper watersheds experienced the storm event. The second set of simulations were developed to analyze the flow routing when the upper watersheds and hill slopes adjacent to the valley floor experienced a storm event and the valley floor did not.

Findings for the 10- and 100-year simulations are discussed below. The other simulations are available in the model for future use. For the initial set of simulations (storm centered over the entire watershed), the maximum depth results for the 10- and 100-year (existing conditions and natural grade conditions) simulations are shown in Figure 3-9 through Figure 3-12. Based on the comparison between the existing and natural grade conditions, there was an overall increase in extent of inundation within the valley floor west of the canal when the canal was removed. However, due to changing flow patterns, some areas resulted in an increase in inundation depth, while other areas resulted in a decrease in inundation depth.

The principal difference between the existing conditions and natural grade conditions is that under existing conditions, stormwater runoff in many areas was found to be intercepted by the canal and redirected, while under natural grade conditions; the water was able to freely pass over the canal alignment terrain that had been returned to natural grade. To illustrate these changes in maximum depth, depth difference grids were created by subtracting the existing condition maximum depth results from the natural grade condition maximum depth results. These depth difference grids for the 10- and 100-year simulation are shown in Figure 3-9 and Figure 3-11, respectively. Maximum depths were also calculated from the results along profile lines to provide a general sense of the magnitude of changes in inundation depths at various locations. The alignment of the profile lines is shown in Figure 3-9 through Figure 3-12**.** The difference in maximum depth between existing and natural grade conditions along these profile lines was computed and is shown in Table 3-4. The maximum difference in depth along the profile lines was calculated by subtracting the existing conditions from the natural grade conditions.

Table 3-4. Difference in Local Storm Depth between Existing and Natural Grade Conditions

Cross Section	Maximum Depth[a] (feet)				Difference[b] (feet)	
	Existing Conditions		Natural Grade Conditions			
	10-year	100-year	10-year	100-year	10-year	100-year
1	2.99	3.54	2.88	3.36	-0.11	-0.18
2	0.67	2.29	1.37	2.37	0.7	0.08
3	1.42	3.60	2.86	5.58	1.44	1.98
4	1.34	1.42	1.42	1.61	0.08	0.19
5	3.90	4.51	2.32	3.34	-1.58	-1.17
6	2.73	3.66	2.53	3.35	-0.2	-0.31
7	3.83	4.63	3.84	4.78	0.01	0.15
8	1.07	2.42	1.66	2.21	0.59	-0.21
9	0.32	1.43	0.80	1.44	0.48	0.01
10	4.88	5.95	4.85	5.93	-0.03	-0.02
11	4.47	7.12	3.99	6.17	-0.48	-0.95
12	9.55	21.09	9.50	21.31	-0.05	0.22
13	2.04	2.57	2.09	2.99	0.05	0.42
14	5.69	7.97	5.70	7.99	0.01	0.02

[a] These depths represent the maximum depth along the entire profile line.
[b] The differences for each cross-section depth value for the 10-year and 100-year was calculated by subtracting the existing value from natural grade value.

Similar results were generated for the second set of simulations where the design storm was centered over the upper watershed. A comparison between the natural grade and existing conditions extent of inundation for the 10- and 100-year simulations is shown in Figure 3-10 and Figure 3-12, respectively. Separate figures were developed to show the magnitude of changes in inundation depth between existing and natural grade conditions. For these figures, the existing condition maximum depth results were subtracted from the natural grade condition maximum depth results and depth difference grids were created. These depth difference grids for the 10- and 100-year simulations are shown in Figure 3-13 and Figure 3-14, respectively.

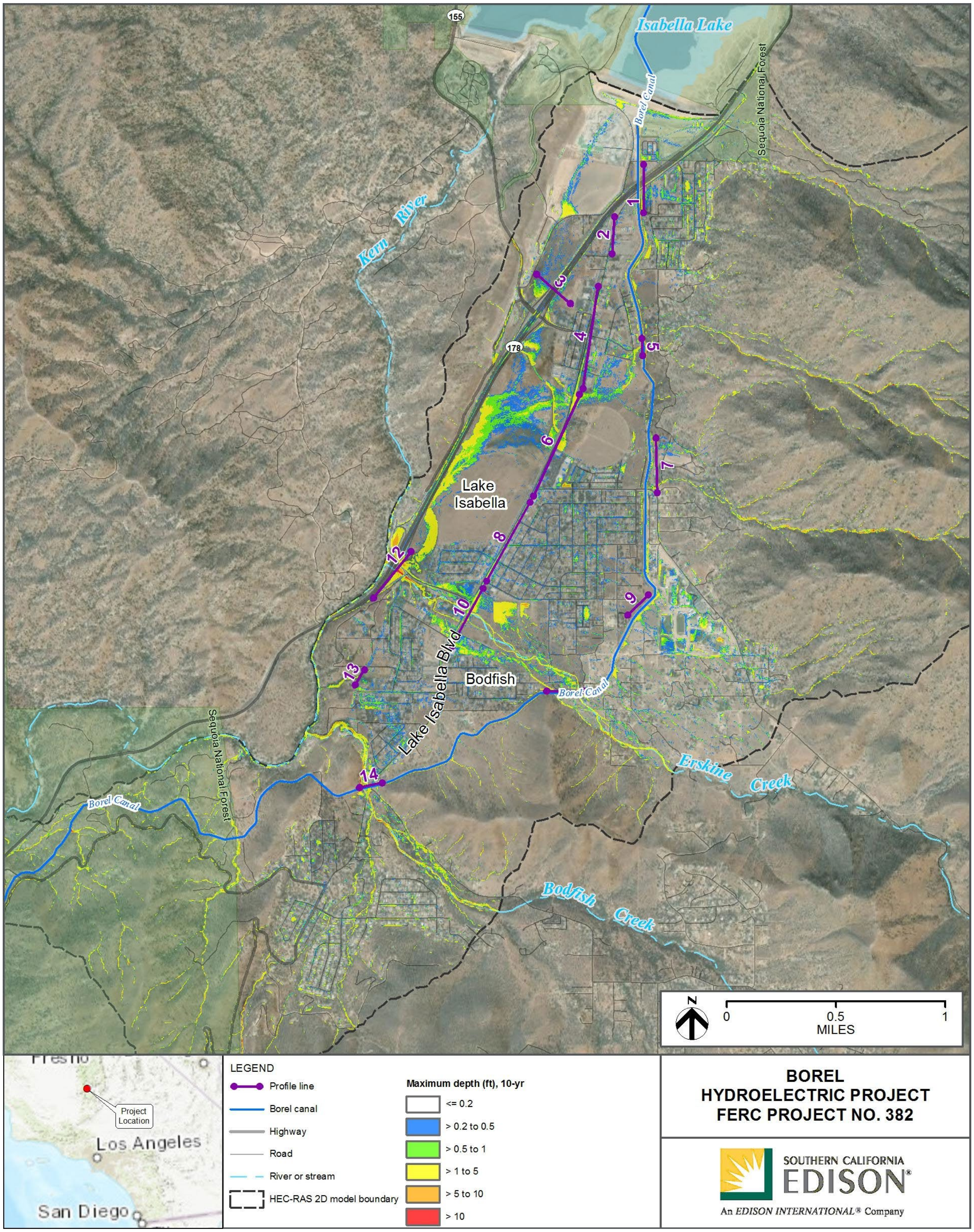

Figure 3-9. Existing Conditions Local Storm Maximum Depth – 10 Year

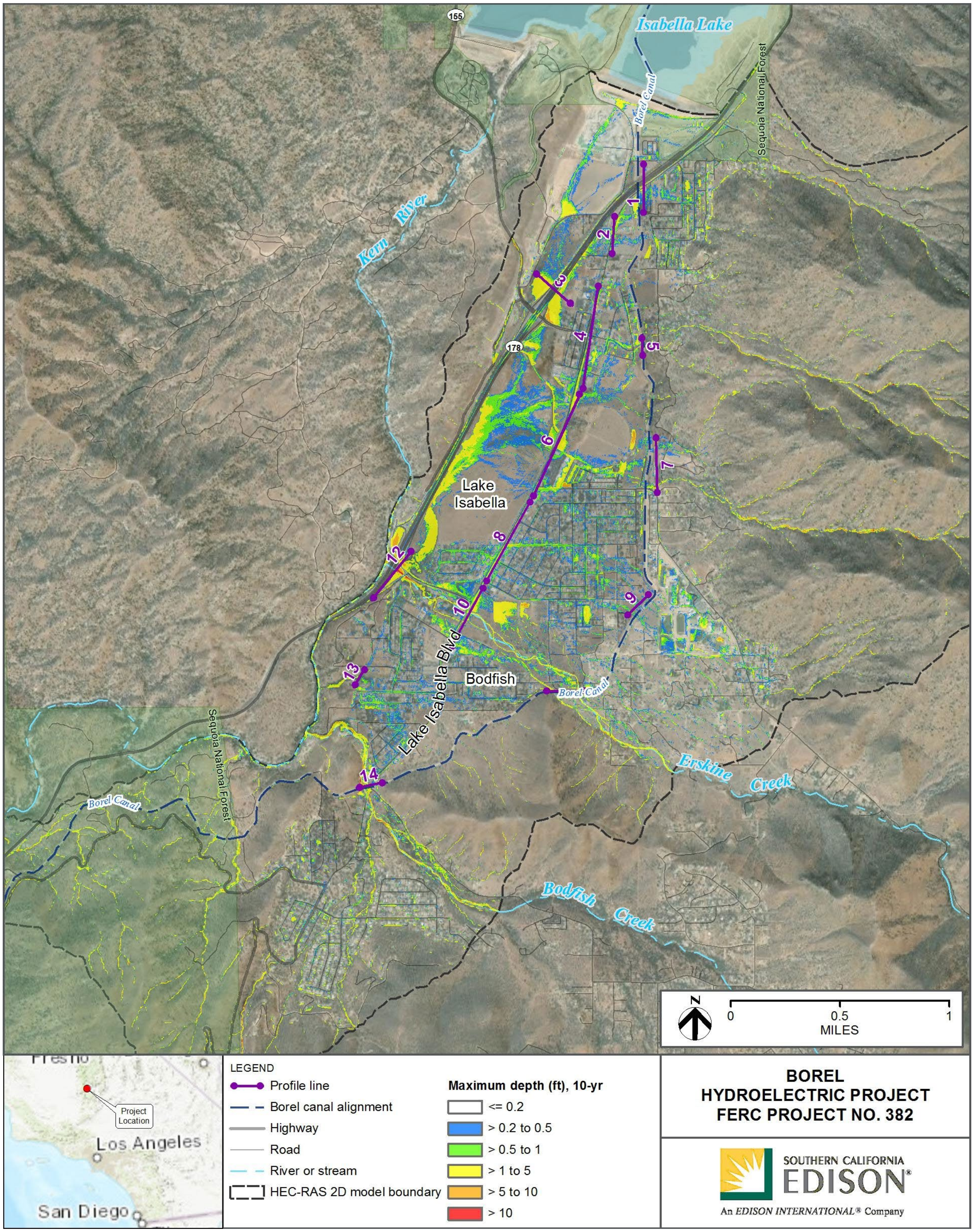

Figure 3-10. Natural Grade Conditions Local Storm Maximum Depth – 10 Year

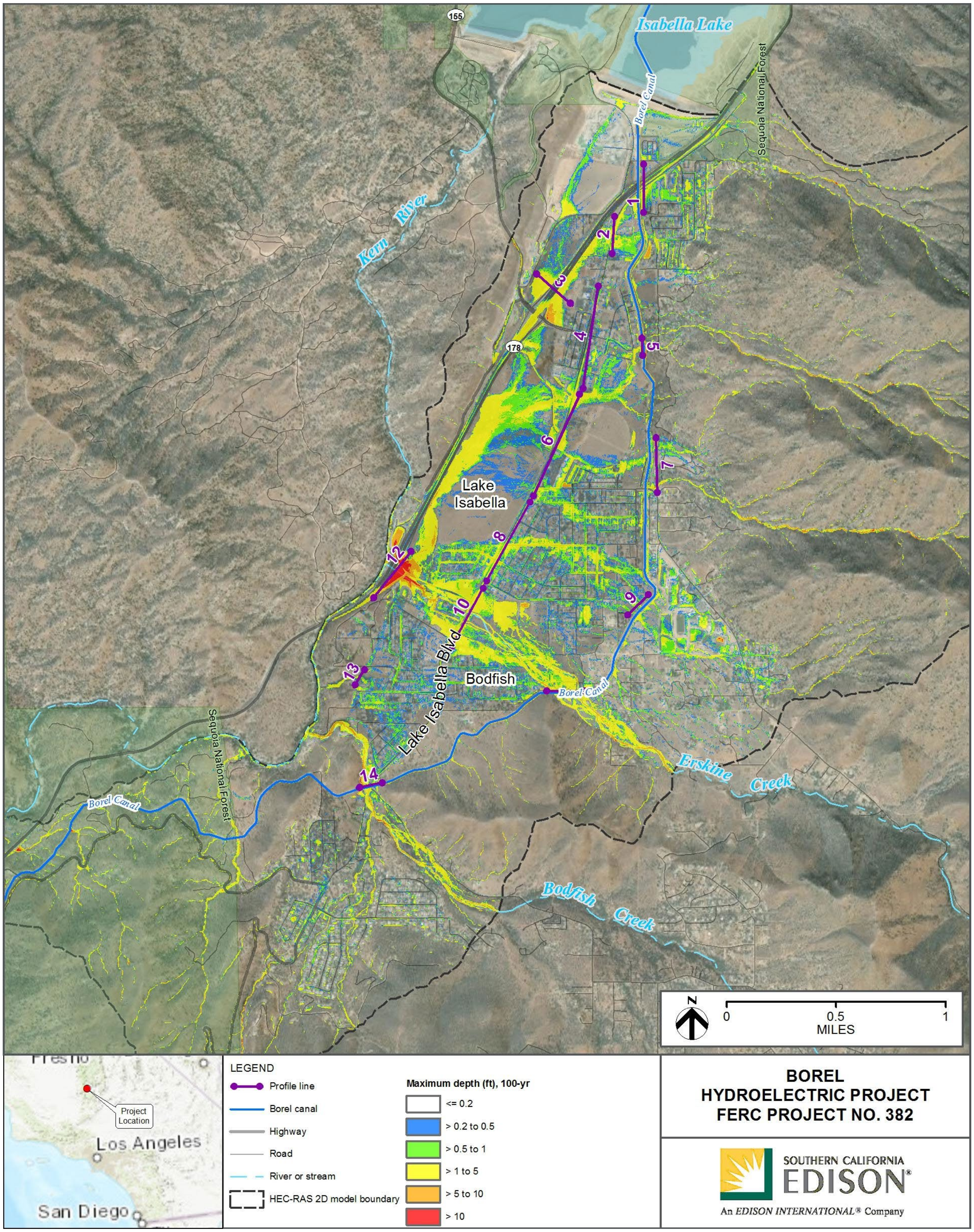

Figure 3-11. Existing Conditions Local Storm Maximum Depth – 100 Year

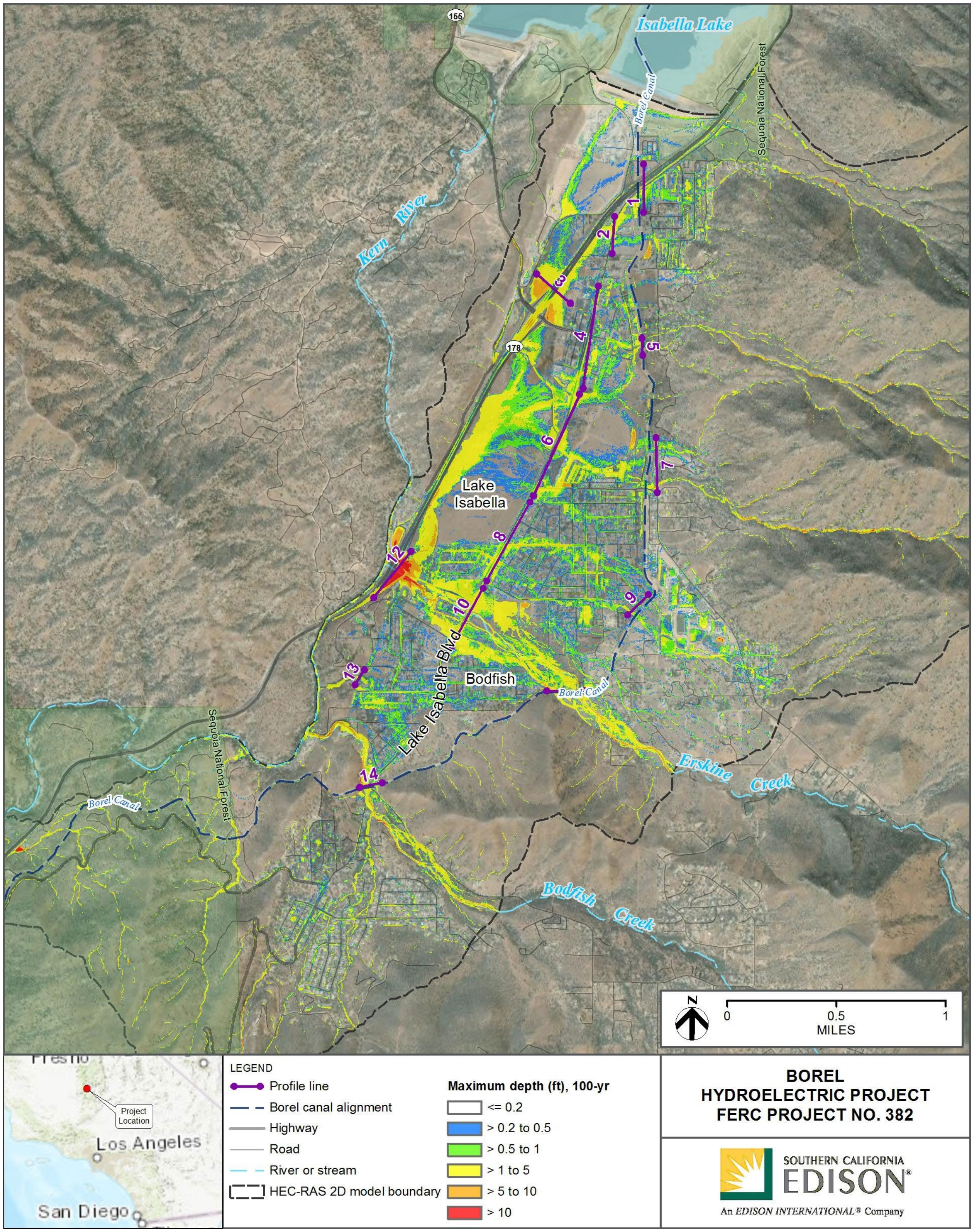

Figure 3-12. Natural Grade Conditions Local Storm Maximum Depth – 100 Year

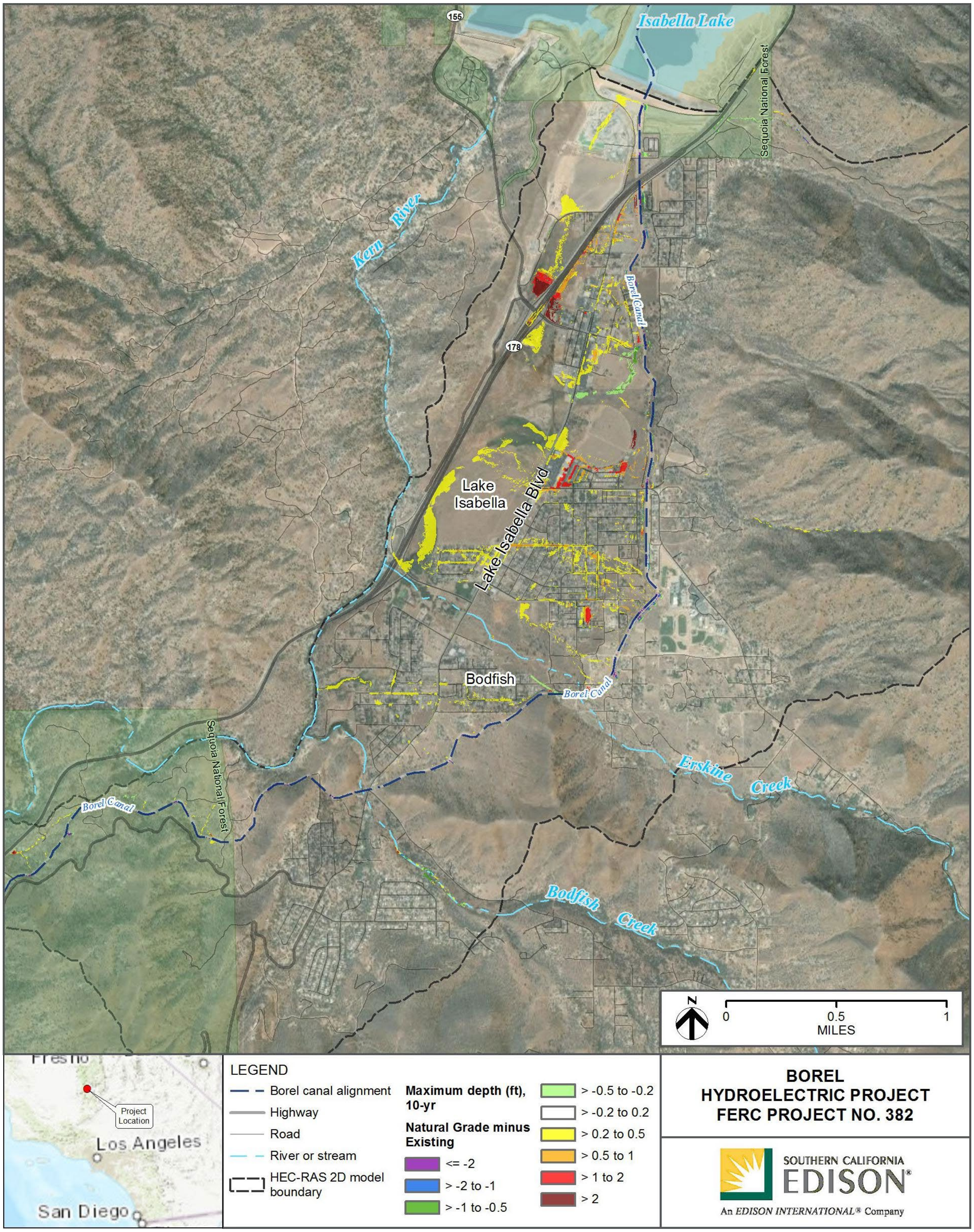

Figure 3-13. Local Storm Depth Difference – 10 Year

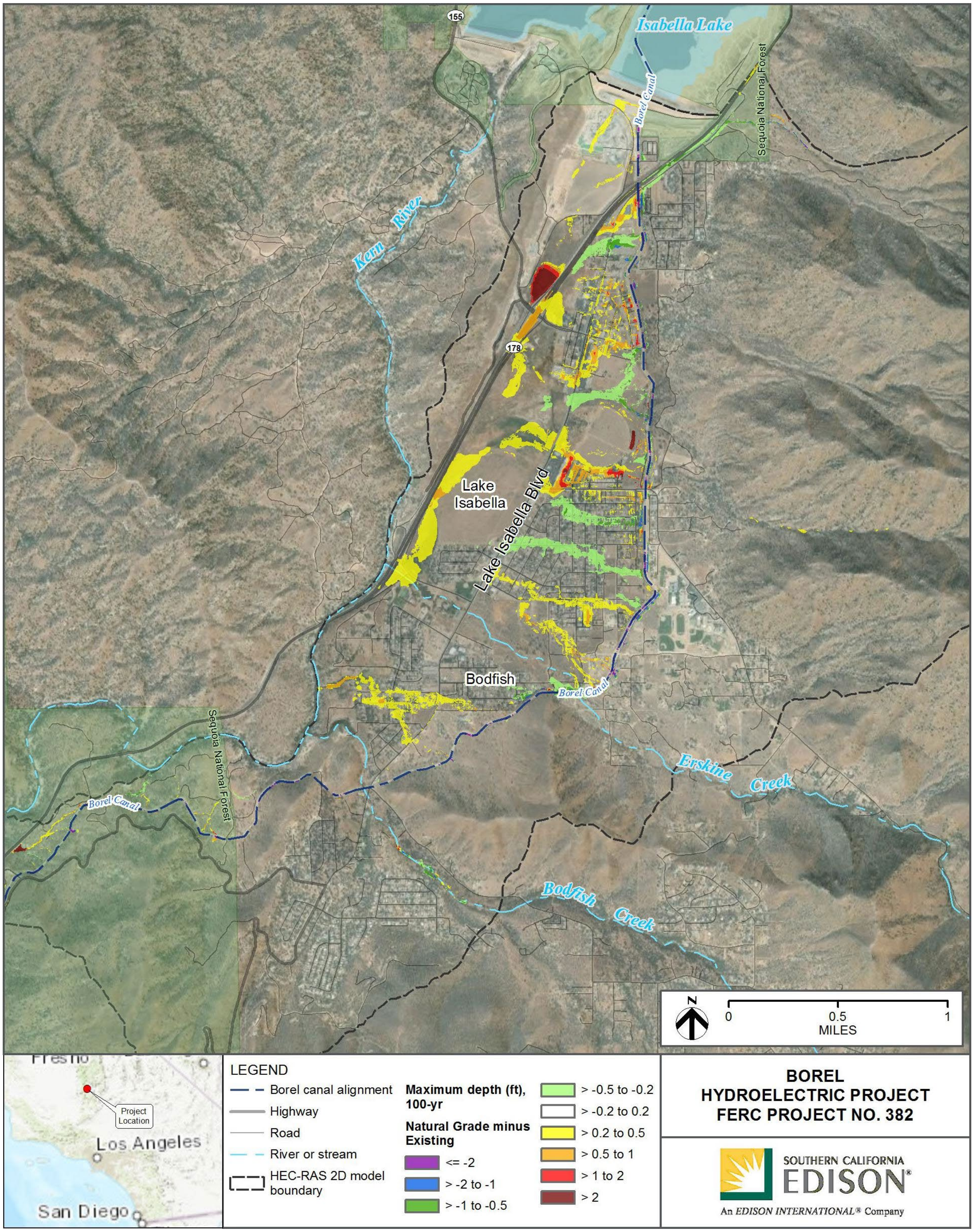

Figure 3-14. Local Storm Depth Difference – 100 Year

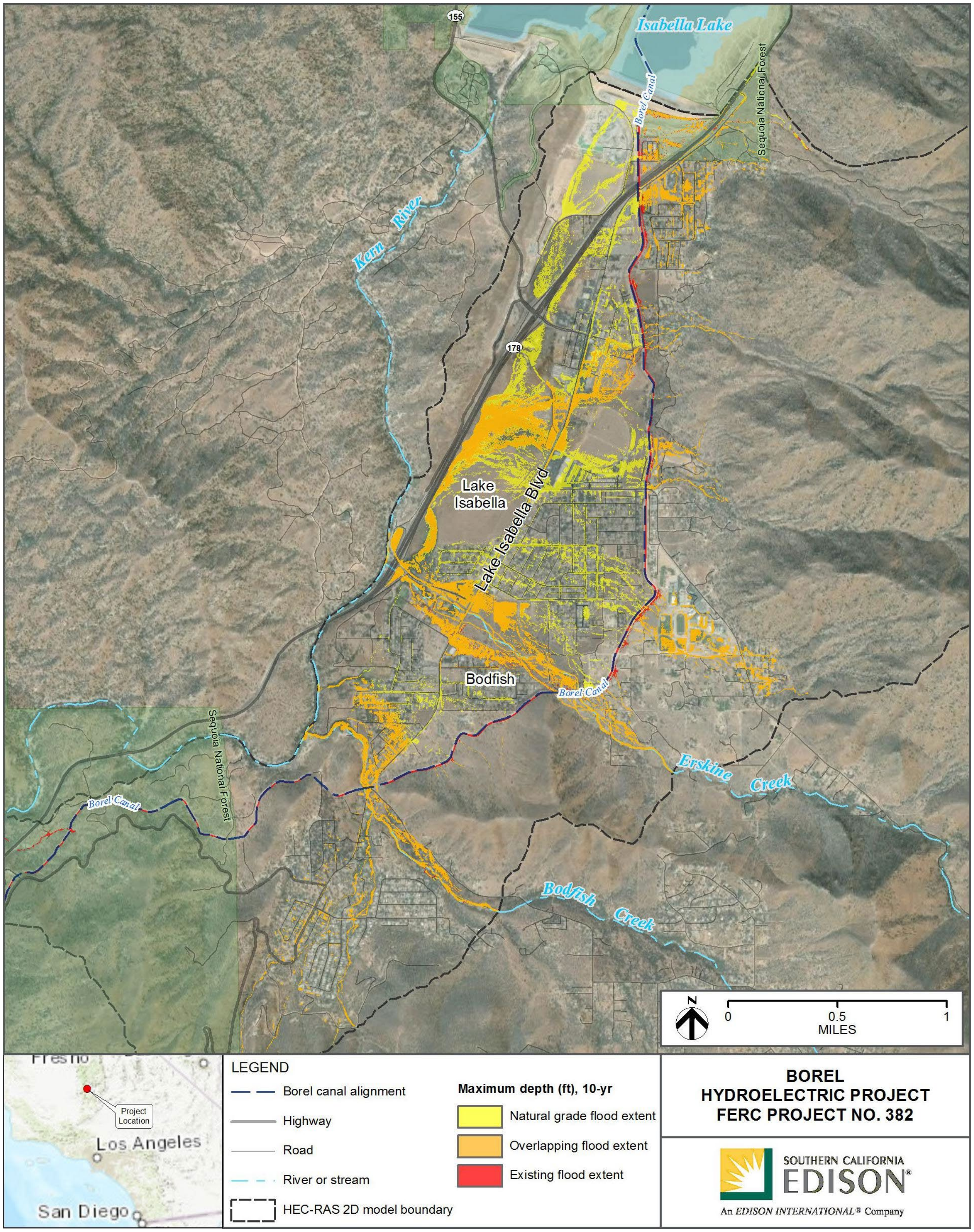

Figure 3-15. Existing and Natural Grade Conditions Comparison, Hill Slopes and Upper Watershed Runoff Maximum Depth – 10 Year

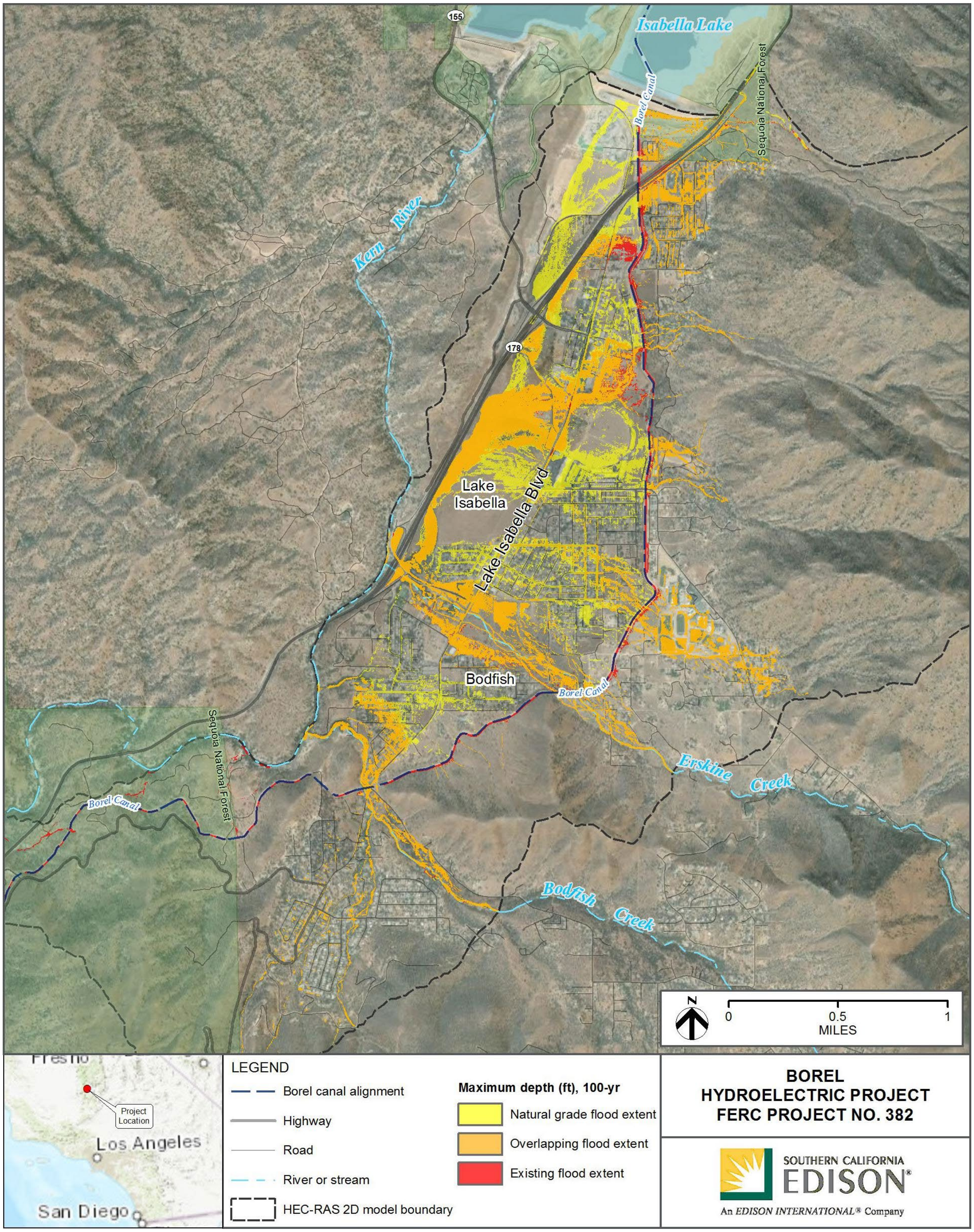

Figure 3-16. Existing and Natural Grade Conditions Comparison, Hill Slopes and Upper Watershed Runoff Maximum Depth – 100 Year

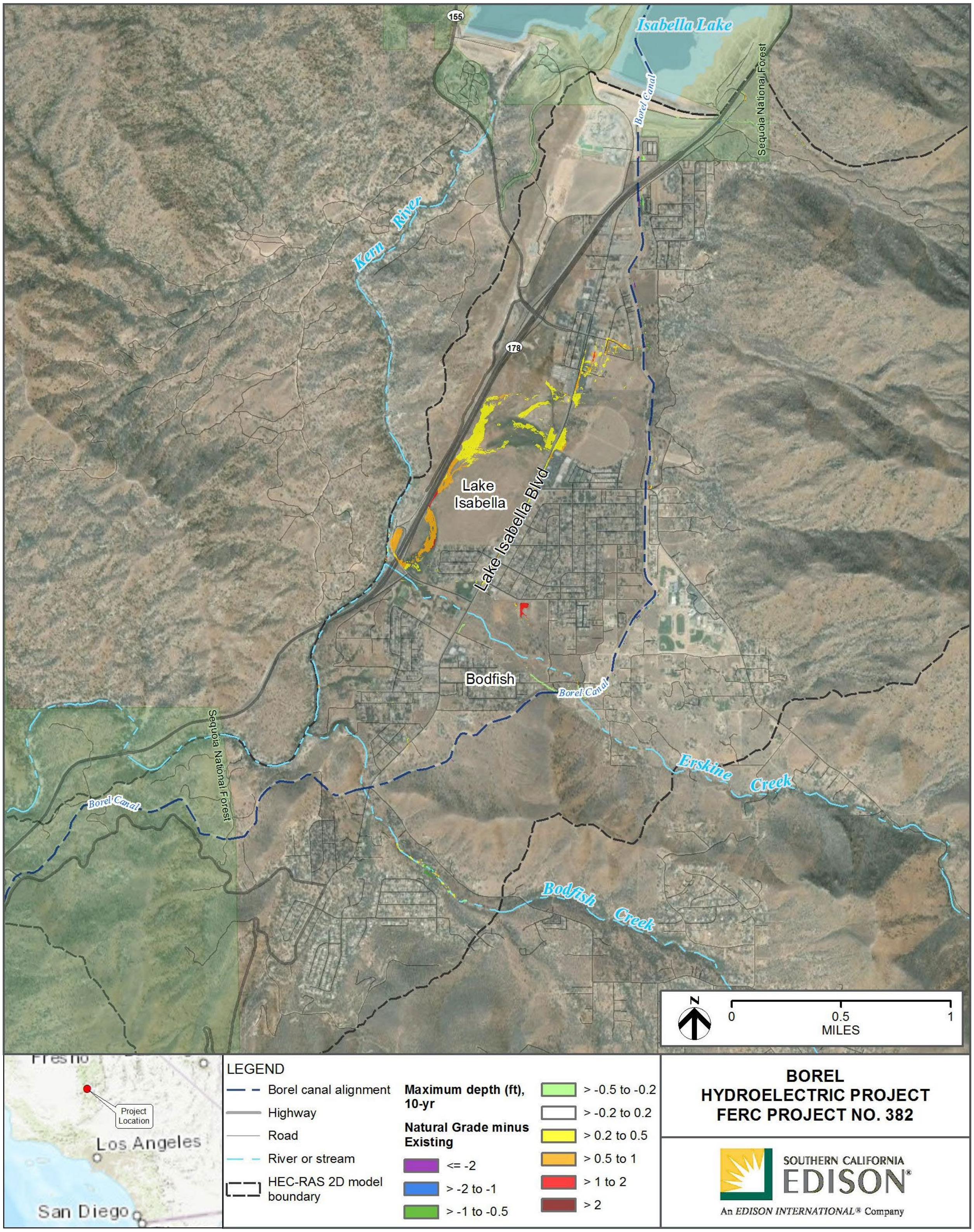

Figure 3-17. Natural Grade Conditions Minus Existing Conditions, Hill Slopes and Upper Watershed Runoff Maximum Depth – 10 Year

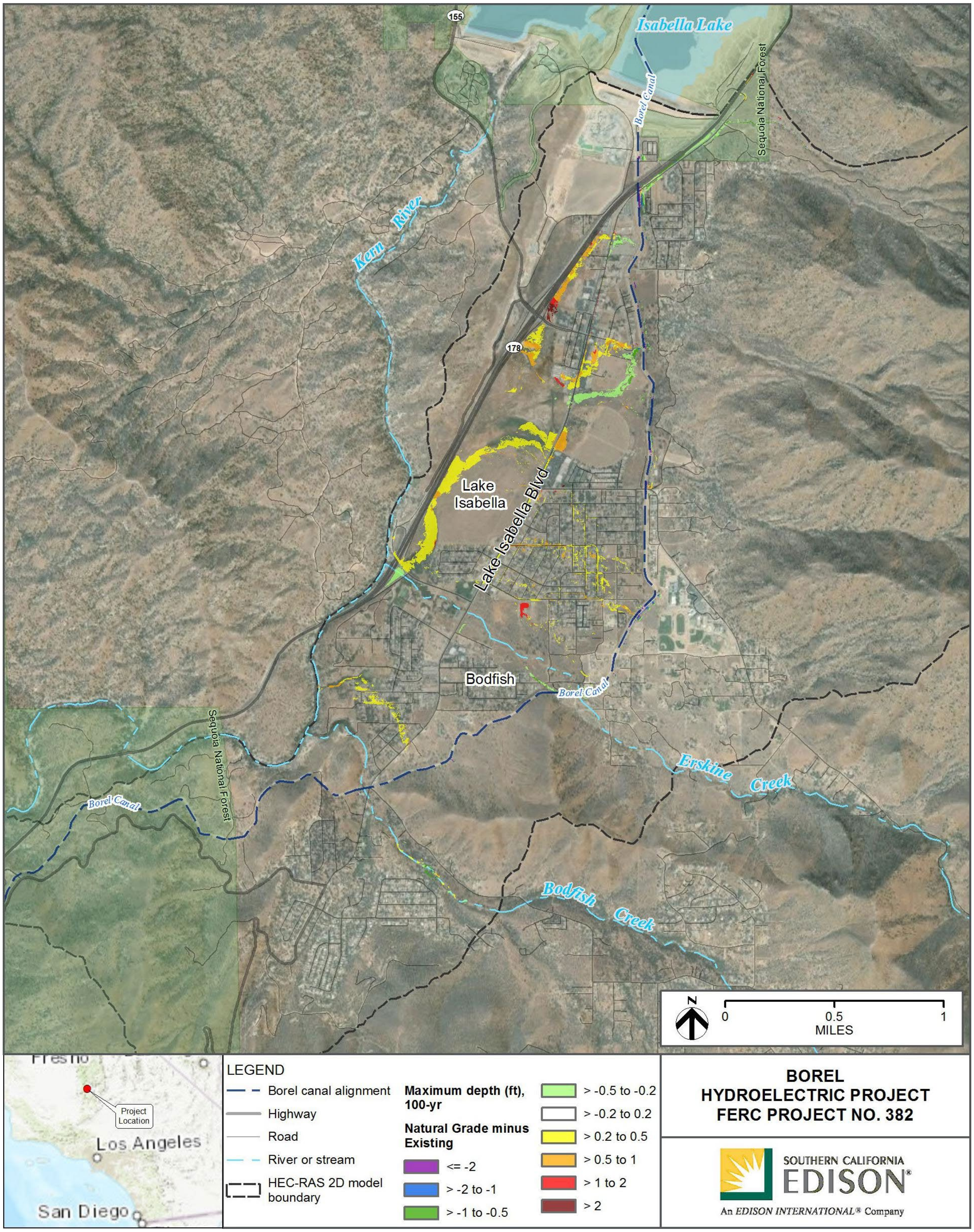

Figure 3-18. Natural Grade Conditions Minus Existing Conditions, Hill Slopes and Upper Watershed Runoff Maximum Depth – 100 Year

3.5 Sensitivity and Discovery Analyses Findings

The sensitivity and discovery analyses were performed to investigate storm runoff patterns that could result if the terrain along the canal alignment were restored to natural grade. Results confirm that the Borel Project influences rainfall runoff patterns by intercepting, redirecting, and concentrating runoff flows within the watershed. Removal of the canal and associated features would change the runoff and channel flow patterns.

The 10-year storm event results show that offsite storm runoff from the eastern portion of the watershed is either intercepted by the Borel Project or concentrated and conveyed underneath the canal's flume structures and continue westward, within existing drainage channels, towards the Kern River. Removing the Borel Project and restoring the canal alignment to natural grade would increase stormwater runoff quantities downslope of the canal and potentially result in flood damage to property and facilities. Based on these model results, SCE developed a conceptual design including a series of linear detention basins within the current Borel Project footprint to control stormwater runoff and mitigate potential flooding. The proposed design was evaluated and is described in the subsequent sections.

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4 Drainage Analyses and Conceptual Design Assessment

This section documents the drainage analyses performed to inform the Plan. The analyses were done to calculate the capacity and assess the feasibility of using a series of linear detention basins throughout the current footprint during storm events. The assessment included checking if the proposed basins meet the infiltration and freeboard requirements outlined in the Kern County Standards for Drainage - Division 4 (Kern County Standards).

This analysis includes:

- Quantifying approximate 10-year, 24-hour duration design rainfall runoff intercepted by each proposed detention basin.
- Assessing if the proposed detention basins can contain the 10-year design storm, completely drain the design storm within seven days, and meet freeboard criteria.

4.1 Criteria

Based on the Kern County Standards for Drainage, Division 4, Appendix A:

> *Retention basins shall not be permitted unless it can be demonstrated, to the satisfaction of the Director, that the basin will completely drain the design volume within seven days.*

In addition to the standards requiring the basins to completely drain within 7 days, the basins must meet the following freeboard requirements:

- *Six inches of freeboard will be required when the design ponding depth within the basin is four feet or less.*
- *Basins with design ponding depths greater than four feet, the amount of freeboard required shall be one foot.*

4.2 Drainage Volume Calculations

A rain-on-grid 2D hydraulic model representing existing terrain and hydrologic inputs were developed as described above in Sections 3.1 and 3.3, to estimate the amount of drainage volume that would be intercepted by the Borel Project. The model was used to simulate a 10-year design storm event assuming the storm is centered over the study area watersheds. Figure **4**-**1** identifies the contributing drainage basins that drain to the Borel Project.

Draft model results show rainfall runoff traveling downhill in small ravines and creeks and as overland sheet flow. Once the runoff reaches the Borel Project, it is either concentrated into drainage channels that pass through the existing Borel Project alignment unobstructed (e.g., beneath flumes or over siphons) or it is intercepted by the Borel Project. The magnitude of this runoff was calculated to help size and configure proposed detention basins along the Borel Project alignment. Table 4.1 lists the 10-year design storm peak flow and volume results.

Table 4-1. Draft Model Results- 10-Year Design Storm Peak Flows

10-Year Design Storm Peak Flows		
Drainage Basin No.[1]	Peak Flow (cfs)	Volume (acre-ft)
1	106	36
2	93	31
3	92	31
4	40	6
5	171	55
6	24	7
7	23	9
8	84	36
9 Erskine Creek	1022	488
10	52	10
11	85	12
12 Bodfish Creek	2600	1523
13	6	1
14	34	8
15	31	11
16	6	1
17	28	4
18	6	2

[1] See Figure 3-1 - *Contributing Drainage Basins for the Borel Project between the (non-Project) Auxiliary Dam to Borel Powerhouse* for Drainage Basin Location

4.3 Detention Basin Assessment

An analysis was performed to assess the feasibility of reconfiguring the Borel Project and converting certain segments of the canal into a series of linear detention basins. The proposed design incorporates a series of detention basins and includes grading to intercept the 10-year design stormwater runoff. The proposed design assumes the bottom concrete liner of the canal is removed to allow for infiltration of the captured rainfall runoff. Table 4-1 shows proposed detention basin segment locations.

The analysis consisted of using the hydraulic model to estimate the inflow into each of the detention basins as described in Section 4.2, followed by calculations of the infiltration time based on soil infiltration rates and basin geometries. To perform these analyses, the model was updated with a surface representing the proposed detention basin configurations. The surface used to update the model was developed in Civil 3D as part of the conceptual design of the Plan. The proposed detention basins were designed to maximize the bottom area for greater infiltration while reducing the depth of the detention basins. The detention basins were then assessed for their ability to contain the 10-year design stormwater runoff and to check whether they meet the infiltration and freeboard requirements described in the Kern County Standards for Drainage - Division 4 (Kern County Standards).

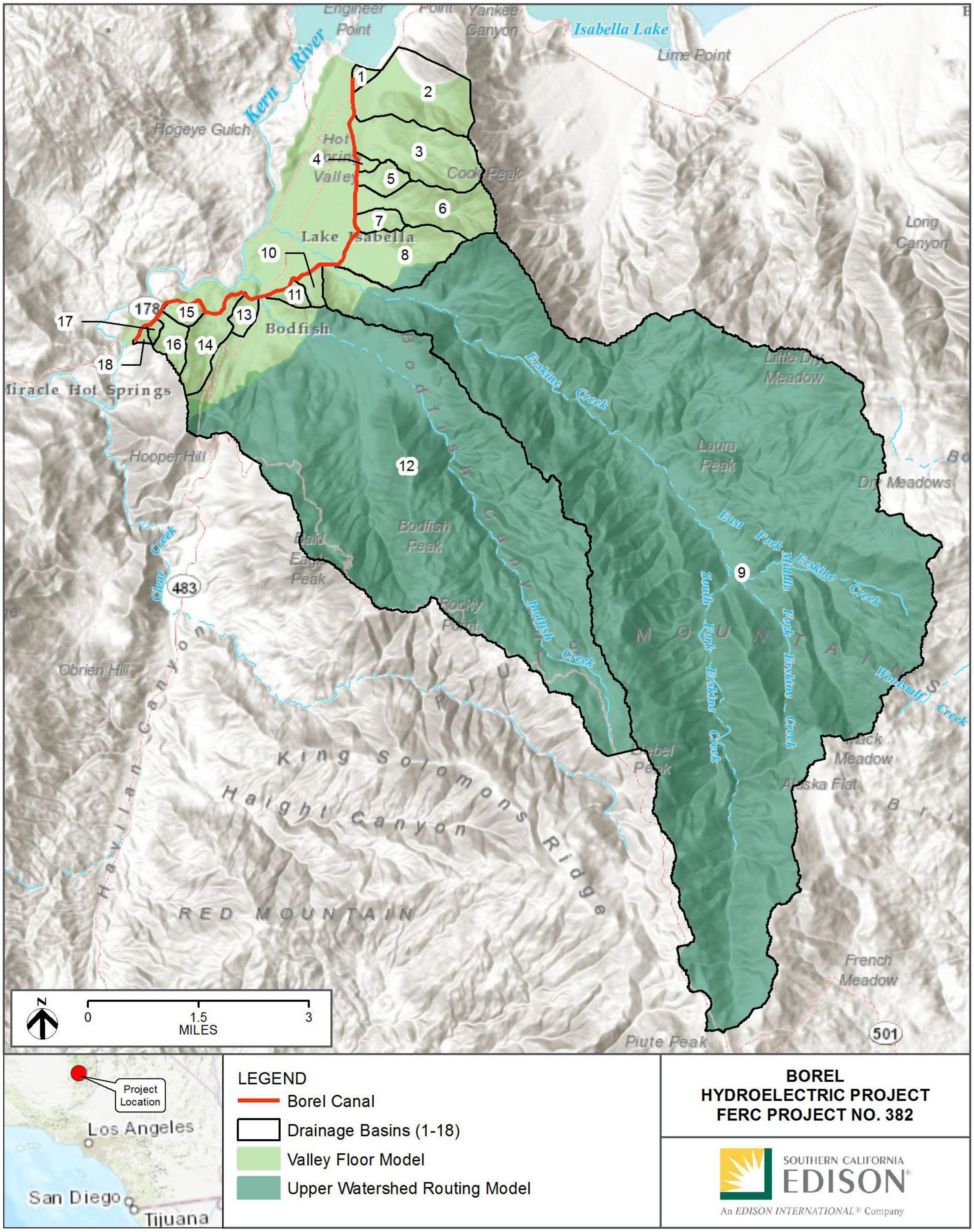

Figure 4-1. Contributing Drainage Basins to the Borel Project between the (non-Project) Auxiliary Dam to Borel Powerhouse

Figure 4-2. Proposed Detention Basin Locations

4.3.1 Infiltration Ksat Values for Soils

Infiltration rates (Ksat) for soils under the proposed detention basins were selected from the NRCS SSURGO database. The SSURGO database contains information about soils collected by the National Cooperative Soil Survey over the course of a century. The soil properties and information within the SSURGO database was gathered by field inspection of the soil. In addition, many soil samples were analyzed in laboratories. The soil properties within the SSURGO database are intended for natural resource planning and management by landowners, townships, and counties.

Ksat values represent the infiltration rate once the ground has reached saturation and the infiltration rate has become constant. Ksat values are a reliable metric to quantify infiltration conditions for soils and expected performance during a storm event. The SSURGO data comes in a digital mapping layer that was overlayed on top of the footprint of each proposed detention basin. For each hydrologic soil type, the SSURGO data provides a range of Ksat values. If a proposed detention basin spanned over several hydrologic soil types, a weighted average Ksat value was estimated for the detention basin.

4.4 Results

Infiltration of runoff captured in each detention basin was calculated using Ksat soil infiltration rates and infiltration area. It was assumed the bottom concrete liner of the canal will be removed to allow for infiltration of the captured rainfall runoff through soil. Table 4-2 presents draft results such as the captured rain runoff for each proposed detention basin calculated by the model. The table also shows draft 7-day max infiltration and the remaining volume of runoff that potentially remains after 7 days.

Table 4-2. Draft Results-Rainfall runoff captured in Detention Basins and 7-Day Infiltration

Proposed Detention Basin	A	B	C	D	E	F
Contributing Drainage Basin No.[1]	1	2, 3	4	5, 6	7, 8	10, 11
Approximate WSE (ft)	2553.3	2550.2	2549.6	2547.1	2546.5	2544.2
Approximate Max Depth (ft)	5.0	2.6	4.0	2.1	2.2	1.7
Approximate Freeboard (ft)	1.2	1.0	1.1	1.2	1.7	1.1
10-Year, 24-hour Runoff Captured (ac-ft)	36.3	61.8	5.7	62.4	44.5	22.2
Calculated 7-day Infiltration (ac-ft)	158.9	332.2	0.2	118.2	267.9	17.1
Runoff volume remaining after 7-day Infiltration (ac-ft)	0	0	5.5	0	0	5.1

[1] See Figure 3-1 - *Contributing Drainage Basins for the Borel Project between the (non-Project) Auxiliary Dam to Borel Powerhouse* for Drainage Basin Location

Rainfall runoff captured within Detention Basins C and F do not completely infiltrate within 7 days. These detention basins are located on soil with poor hydraulic conductivity. As a result, to meet the County infiltration criteria, a drainage culvert sized to release 1 cfs from the detention basin and into adjacent drainage channels was incorporated into the conceptual design to work in combination with infiltration. Preliminary calculations show that a drainage culvert sized to release 1 cfs can drain 5.5 ac-feet in approximately three days.

4.5 Findings

Preliminary results support that the proposed conceptual reconfiguring of the Borel Project, as described in the Plan, can intercept the 10-year, 24-hour duration stormwater runoff traveling from the contributing drainage basins. Preliminary results show it is feasible to infiltrate the entire design runoff volume captured within the proposed detention basins by infiltrating runoff through the bottom of each detention basin or by using a combination of infiltration and offsite drainage culverts to meet county freeboard and infiltration requirements.

5 References

Hromadka, T.V. II

1995 *Kern County Hydrology Manual*, Kern County, California.

Kern County Standards

2021 Kern County Standards for Drainage, Kern County, California.

Krugh, W.

2019 Erosion and sedimentation within the Sierra Nevada Valley, CA. National Center for Airborne Laser Mapping (NCALM). Distributed by Open Topography. https://doi.org/10.5069/G95Q4T79.

NLCD (National Land Cover Data Base)

2016 USGS National Landcover Database. Multi-Resolution Land Characteristics (MRLC) Consortium. https://www.mrlc.gov/.

Perica, S., S. Dietz, S. Heim, L. Hiner, K. Maitaria, D. Martin, S. Pavlovic, I. Roy, C. Trypaluk, D. Unruh, F. Yan, M. Yekta, T. Zhao, G. Bonnin, D. Brewer, L. Chen, T. Parzybok, and J. Yarchoan

2011 *NOAA Atlas 14 Volume 6 Version 2.0, Precipitation-Frequency Atlas of the United States, California*. NOAA, National Weather Service, Silver Spring, Maryland.

USDA-NRCS (Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture)

2020 Soil Survey Geographic (SSURGO) Database for California. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627. Accessed September 9, 2020.

USGS (U.S. Geological Survey)

2019 USGS 13 arc-second n36w119 1 x 1 degree. U.S. Geological Survey National Map viewer. September 24, 2019. https://prd-tnm.s3.amazonaws.com/StagedProducts/Elevation/13/TIFF/n36w119/USGS_13_n36w119.tif.

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