FINAL

SAN VICENTE PUMPED STORAGE PROJECT

Technical Memorandum – Upper Reservoir Screening and Configuration Refinements

B&V PROJECT NO. 181868

PREPARED FOR

San Diego County Water Authority / City of San Diego

MAY 2016

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AB	Assembly Bill
ac	Alternating current
ac	acre
Additional Studies TM	San Vicente Pumped Storage Project, Technical Memorandum – Additional Studies
AF	Acre-Feet
AC-FT	Acre-Feet
AVG	Average
B&V	Black & Veatch
BLM	Bureau of Land Management
CDPH	California Department of Public Health
CEC	California Energy Commission
CFS	Cubic feet per second
City	City of San Diego
CY	Cubic yards
El	Elevation
ESP	Electric Service Provider
Feasibility Study	San Vicente Pumped Storage Project Economic and Financial Feasibility Study
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
FPS	Feet per second
FT	Feet
FY	Fiscal Year
GPM	Gallons per minute
GWh	Gigawatt hours
HMCG	Harvey Meyerhoff Consulting Group
Hrs	Hours
HWL	High water level
kW	kilowatt
LBS	Pounds
M	Meters
MG	Motor Generator
MGD	Million gallons per day
MW	Megawatts
MW-hrs	Megawatts per hour
MHh	Megawatts per hour
MSL	Mean Sea Level
MWDSC	Metropolitan Water District of Southern California
NOI	Notice of Intent
NOP	Notice of Preparation
NPSH	Net Positive Suction Head
PAD	Pre-Application Document
Project	San Vicente Pumped Storage Project
Pure Water	Pure Water San Diego Program

RCC	Roller Compacted Concrete
ROW	Right-of-Way
SDCWA	San Diego County Water Authority
SDG&E	San Diego Gas & Electric
SF	Square feet
SWRCB	State Water Resource Control Board
T	Ton
TM	Technical Memorandum
Water Authority	San Diego County Water Authority
WA	Water Authority

Executive Summary

PURPOSE

The purpose of this San Vicente Pumped Storage Project (Project) Technical Memorandum (TM) is to provide the San Diego County Water Authority (Water Authority) and the City of San Diego (City) with the additional technical information that has been developed in accordance with Amendment No. 4 to the Contract between Black & Veatch (B&V) and the Water Authority, dated March 18, 2015. This TM has considered configuration refinements that are a result of recent evaluations and modeling efforts performed by B&V under other scope authorizations that address Project compatibility concerns and pumped storage reservoir operations with the City's proposed Pure Water San Diego Program (Pure Water). Additional refinements were also developed under this TM as part of the screening analysis of the upper reservoir sites.

The four alternative sites considered in this TM have been configured to provide up to 500 MW of generating output and eight hours of energy storage. A full description of each alternative is provided in the report titled "San Vicente Pumped Storage Project, Technical Memorandum – Additional Studies" (Additional Studies TM), dated July 2015, prepared by B&V.

The general location of the upper reservoir for each alternative site is as follows:

- **Alterative Site A1** is located near Iron Mountain, approximately three miles northeast of the San Vicente Reservoir site.
- **Alternative Site B3** is located near Foster Canyon, approximately 0.5 miles northwest of the San Vicente Reservoir.
- **Alternative Site C3** is located approximately 0.8 miles northeast of the San Vicente Reservoir.
- **Alternative Site D3** is located approximately 1.8 miles southeast of the San Vicente Reservoir.

The configuration refinements and results from the screening analysis are summarized in this TM. These results were also made available to support preliminary environmental reviews and have been incorporated in the Preliminary Application Document (PAD), prepared by Harvey Meyerhoff Consulting Group (HMCG), which was submitted to the Federal Energy Regulatory Commission (FERC) in July 2015.

CONFIGURATION REFINEMENTS

Configuration refinements were made under the scope of this TM to further develop the technical aspects of the Project. While these refinements may not have necessarily resulted in a change in the location or arrangement of the project components as currently described in the Additional Studies TM, the refinements provided further clarification to the Project definition and also supported the environmental assessments necessary to prepare the project descriptions included in the FERC PAD. The configuration refinements have also been considered in the screening analysis conducted under this TM. The refinements include the following:

- **Access Roads and Road Easements.** Revised estimates were developed for new and existing access roads, including easement areas, specific to each upper reservoir site.
- **Power Transmission.** Overhead power transmission facilities were reassessed to determine the type and potential location of support towers.
- **Groundwater Impacts on Tunneling.** Tunnel alignments were reviewed to determine the length of subsurface excavations that may be subjected to potential infiltration resulting from the raising of the San Vicente Dam.
- **Land Use Assessments.** Project facilities were reevaluated to determine potential land use impacts based on facilities located within or near open space zoned parcels intended for recreation or environmental constraint.
- **Property Acquisitions.** Surface and subsurface easements and fee acquisition requirements were calculated.

An updated cost evaluation that considered all the above refinements was prepared and updated pro forma financial projections were also developed. The cost evaluation and pro forma financial projection spreadsheets included in the Additional Studies TM reflect the most accurate and up to date costs for the Project.

GEOTECHNICAL STUDY

A desktop study was performed to evaluate the geologic and geotechnical aspects that may impact development at each of the four proposed upper reservoir sites. This desktop study was based entirely on a review of readily available information, and did not include field explorations or reconnaissance of the proposed sites.

All four reservoir sites have very similar geologic, soil, topographic and anticipated groundwater conditions, with the most significant differentiators being structural features seen in the landscape surface on aerial images. These features consist of lineaments and contacts which cross through proposed dam structures and coalign with tunnel pathways. Most of the lineaments appear to be related to regional large scale joint patterns. These features will need further study to determine their true nature and geometry. In regards to groundwater, it is reasonable to assume no significant difference between the reservoir sites since they all have similar depth and material types along their respective tunnel pathways. Longer tunnel stretches, such as Site A, would provide more opportunity for encountering groundwater. Specific lineament features for each site are summarized below:

Alternative Site A has three potential impacting lineaments. One has ostensible indication of being related to faulting and crosses through the left abutment of the southeast dam. The second lineament crosses northwest through the right abutment of this same dam but is not aligned with any large scale joint pattern. The third lineament is coaligned with the south end of the conveyance tunnel for this site.

Alternative Site B has three potential impacting lineaments and one contact feature. The largest lineament crosses northeast through the left abutment of the east dam. The other two cross below the bottom of this same dam. The contact feature also crosses below the bottom of the east dam.

Alternative Site C has one lineament feature extending northeast through the bottom of the proposed southeast dam. An apparent extension of this lineament occurs further downstream and this entire system is also directly in line with the proposed conveyance tunnel pathway and also crosses beneath the bottom of the southwest dam.

Alternative Site D has several lineament features. The largest lineament crosses northeast through the northwest shoreline and into the central portion of the site. The other lineaments occur along the northwest shoreline being parallel to other local system of joints.

SCREENING ANALYSIS

The screening analysis was conducted on site configurations that met the minimum energy capacity of 500 MW/4,000 MW-hrs. A rating system for both the screening criteria and project costs were developed to compare and score each alternative for the purpose of identifying one or more preferred upper reservoir sites that may be carried forward for additional review. Each criterion was assigned a rating of 1 to 5, with 1 being the most favorable and 5 being the least favorable. The screening criteria are consistent with the project description information for preparation of the FERC PAD. Overall results of the screening process are summarized in Table ES-1 and as described below.

Alternative B3 is considered the most favorable site due to its closer proximity to the San Vicente Reservoir and smaller footprint that results in a lower impact on the surrounding environment. The additional length of dam required for the Alternative B upper reservoir increases its cost over Alternatives A1 and C3.

Alternative C3 is rated as the second preferred site. This alternative also has a relatively small footprint with a similar lower impact on the surrounding environment. Alternative C3 is also the lowest cost alternative. However, a portion of the access roads and upper reservoir are within tribal lands, which may be a concern regarding land acquisition and cultural resources.

Alternative A1 is rated as the third most favorable site due to its significantly longer conveyance tunnel and resulting larger project footprint that increases impacts on the surrounding environment and increases construction difficulty. This alternative was also noted to have geologic concerns due to lineaments that may indicate faulting across the upper reservoir site.

Alternative D3 is rated as the least favorable site due to its impacts on recreation and land use, as well as having portions of the upper reservoir, dam, tunnel and access roads located within tribal lands. Alternative D3 is also the highest cost alternative because of the need for additional dam construction to meet the minimum power storage time of 8 hours.

Table ES-1 Screening Analysis Results

CRITERIA	ALTERNATIVE/RATING			
	A1	B3	C3	D3
Constructability	4	2	3	3
Site Dewatering	4	1	3	4
Access	5	4	3	1
Recreation and Land Use	1	1	1	5

CRITERIA	ALTERNATIVE/RATING			
	A1	B3	C3	D3
Aesthetics	3	1	4	4
Land Acquisition	3	2	2	5
Geology and Soil	5	3	2	4
Water Quality/Water Resources	3	3	3	3
Biological Resources	3	2	2	3
Fish and Aquatic Resources	3	3	3	3
Cultural Resources	1	1	4	5
SUBTOTAL	**35**	**23**	**30**	**40**
Cost Opinion	1	2	1	3
TOTAL SCORE	**36**	**25**	**31**	**43**

ENVIRONMENTAL COORDINATION AND FERC PAD ASSISTANCE

Technical data input, coordination, and document reviews were provided to HMCG for the assessment of potential environmental concerns and preparation of the FERC PAD. The detailed project descriptions provided for development of the FERC PAD were based on the project configurations described in the Additional Studies TM, which included the recent modifications made to the reservoir intake structures and the number of pump turbine units.

Additional information was also provided to HMCG to establish the FERC jurisdictional boundary, describe the watersheds feeding the upper and lower reservoir sites, review streamflow hydrology potentially impacted by the Project, describe reservoir operations specific to the pumped storage components, and assess potential water quality impacts resulting from Project operations. This latter item included the reservoir modeling results that addressed compatibility concerns regarding pump storage operations with the City's Pure Water project. Lastly, the project descriptions referenced the configuration refinements conducted under this TM for the access roads, overhead transmission facilities, soils and geologic features, land uses assessments, and property acquisitions.

The environmental coordination also included preparation of various maps, figures and tables to support the technical data and project description information provided to HMCG.

1 Introduction

1.1 PURPOSE

The purpose of this San Vicente Pumped Storage Project (Project) Technical Memorandum (TM) is to provide the San Diego County Water Authority (Water Authority) and the City of San Diego (City) with a summary of the additional technical information that has been developed related to recent configuration refinements and to fully describe a screening analysis that was performed on the upper reservoir sites. The refinements to the project configurations build upon the recently completed evaluations and modeling efforts that addressed project compatibility concerns and pumped storage reservoir operations with the City's proposed Pure Water San Diego Program (Pure Water). The screening analysis was prepared to compile available project information from earlier completed studies and to conduct additional desktop studies that would allow for a comparison of the upper reservoir sites. The project information was also available to support preliminary environmental reviews and the preparation of FERC licensing documents.

1.2 BACKGROUND

The Water Authority and the City are jointly evaluating the feasibility of the Project, and have prepared a sequence of studies defining facility requirements, operating parameters, and economic performance. The study titled "San Vicente Pumped Storage Project Economic and Financial Feasibility Study" (Feasibility Study), dated May 2014 and prepared by B&V, performed a high level technical and economical evaluation to determine the financial feasibility of the project. The results of this Feasibility Study have proven the Project to be feasible both technically and financially.

In September 2015, the study titled "San Vicente Pumped Storage Project, Technical Memorandum – Additional Studies" (Additional Studies TM), prepared by B&V, assessed the impact of pumped storage operations on the City's proposed Pure Water project. Several refinements and updates to the project configurations were made under the Additional Studies TM. The results of this study confirmed that the Project may co-exist with Pure Water and remains viable to serve the California energy market.

In addition to the above technical evaluations, the Water Authority and the City applied for and received in May 2015 a Preliminary Permit from the FERC for the proposed San Vicente Pumped Storage Project (FERC Docket No. P-14642). This permit maintains a 36-month duration priority of application for the Water Authority and the City to perform further studies and prepare documentation for a license to construct and operate a pumped storage project at San Vicente Reservoir, with the potential to produce power up to 500 megawatts (MW) and up to 1,022 gigawatt-hours (GWH) annually.

Lastly, in July 2015, the Water Authority and the City submitted to the FERC a Notice of Intent (NOI) and Preliminary Application Document (PAD) for the Project. The NOI and the PAD were prepared by Harvey Meyerhoff Consulting Group (HMCG) and included project description information developed under this TM. Both the NOI and PAD signify the intent of the Water Authority and City to prepare and submit a FERC operating license for the Project.

The technical studies and FERC documents have identified four potential alternative sites for the new upper reservoir. A full description of the alternatives is provided in the Additional Studies TM.

Locations of the four upper sites considered in the screening analysis are shown in Figure 1-1 (located at the end of this section), and described below:

- Alterative Site A1 is located near Iron Mountain, approximately three miles northeast of the San Vicente Reservoir site.
- Alternative Site B3 is located near Foster Canyon, approximately 0.5 miles northwest of the San Vicente Reservoir.
- Alternative Site C3 is located approximately 0.8 miles northeast of the San Vicente Reservoir.
- Alternative Site D3 is located approximately 1.8 miles southeast of the San Vicente Reservoir.

1.3 GENERAL DESCRIPTION OF PROJECT FACILITIES

As discussed throughout this TM, the Project includes several key facilities that comprise the project alternatives. These key facilities are summarized as follows:

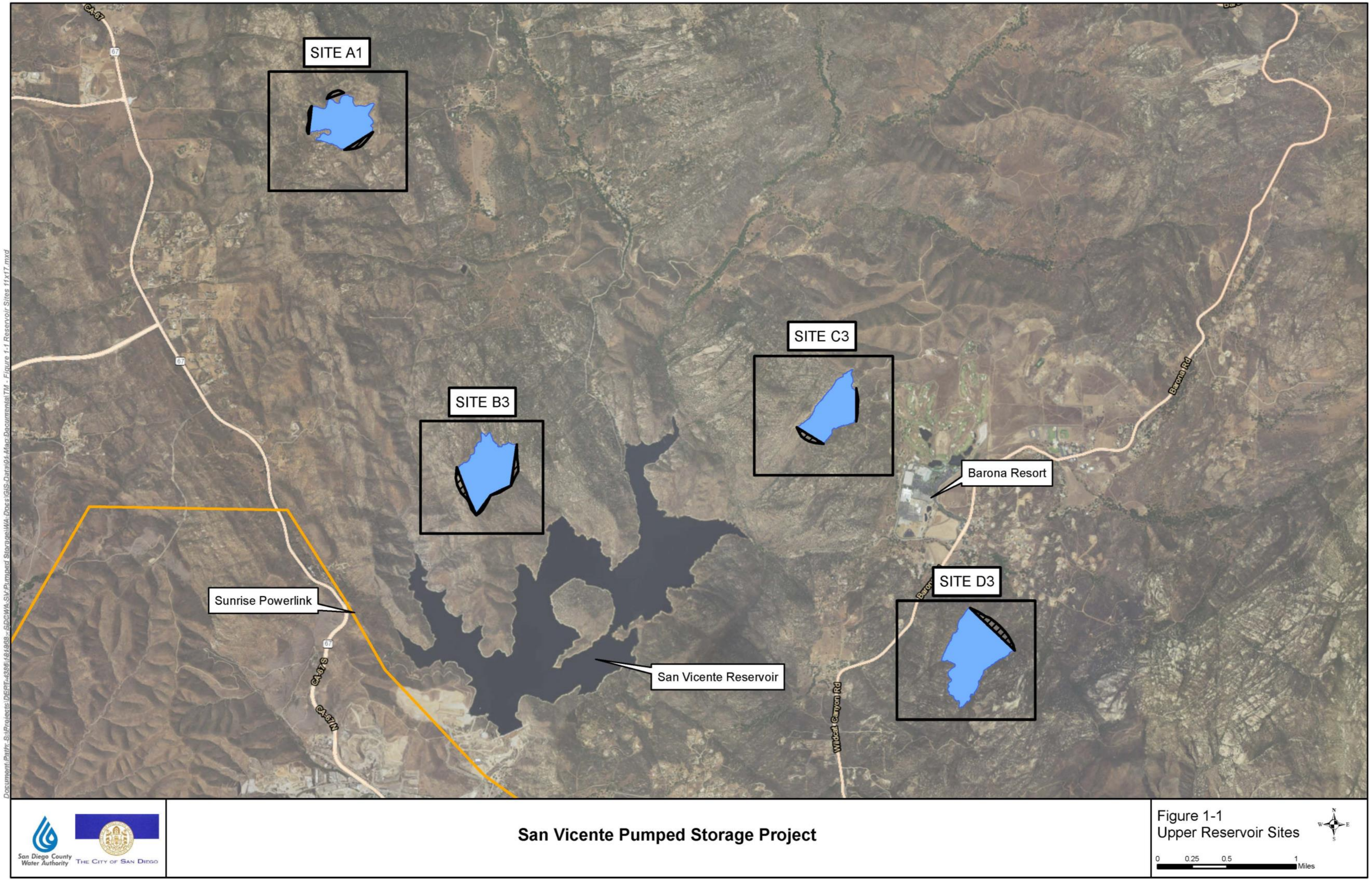
- Each site consists of an upper reservoir, conveyance tunnels and shafts to transport the water to and from a new powerhouse, inlet/outlet structures connecting the upper and lower reservoirs to the conveyance tunnels, access facilities including newly graded roads and improvements to existing roads, and electrical transmission lines and substations to transport the energy to the existing transmission grid.
- Each site will utilize the existing San Vicente Reservoir as the lower reservoir.
- As previously configured (per the Feasibility Study) only Sites A1, B3 and C3 were able to meet the 500 MW of energy generation with eight hours of storage. Site D3 has been reconfigured under the Additional Studies TM to also meet the eight hours of storage at 500 MW.

1.4 TECHNICAL MEMORANDUM ORGANIZATION

The remaining sections of this TM are organized in chronological order from which the tasks were performed as follows:

- Section 2 summarizes the configuration refinements performed under this TM. An updated cost evaluation that considered all the above refinements was prepared and updated pro forma financial projections were also developed. The cost evaluation and pro forma financial projection spreadsheets included in the Additional Studies TM reflect the most accurate and up to date costs for the Project.
- The configuration refinements have also been considered in the screening analysis and incorporated into the FERC PAD.
- Section 3 describes the geotechnical study that was conducted under this TM. The results of the geotechnical study have also been incorporated into the FERC PAD.
- Section 4 describes the screening analysis that was performed on the 500 MW size project at each of the four upper reservoir locations.
- Section 5 describes the environmental coordination and FERC PAD assistance performed under this TM.

Figure 1-1 Upper Reservoir Sites



2 Configuration Refinements

2.1 UPDATED PROJECT REFINEMENTS

A number of refinements, as summarized below, have been made under the scope of this TM to further develop the technical aspects of the project. In general, these refinements build upon the technical data and calculations that were performed under both the Feasibility Study and the Additional Studies TM. All the refinements developed under this TM have been considered in the screening analysis described in Section 3 of this TM and constitute the latest project descriptions included in the FERC PAD.

2.1.1 Access Roads and Road Easements

Further evaluations were performed to establish criteria for developing existing and new access roads specific to each upper reservoir site. This resulted in revised estimates of the length of new and existing access roads, as well as the area calculation of new surface easements required to maintain the access roads. The criteria for access road locations were based on the following assumptions:

- Utilize existing road to the extent possible
- New access roads would be limited to a maximum grade of 20 percent
- Access roads would be obtained as easements
- Access roads were assumed to be 20 feet wide
- The cost for new access roads is $25 per linear foot and the cost for existing access roads is $15 per linear foot

The access roads associated with each alternative site are shown on Figure 2-1 (located at the end of this section). Table 2-1 presents the estimated length for access roads needed for each site.

Table 2-1 Access Roads

SITE	NEW ACCESS ROAD (FT)	EXISTING ACCESS ROAD (FT)
A1	20,300	25,600
B3	25,200	8,900
C3	10,500	18,100
D3	9,300	9,100

2.1.2 Power Transmission

Overhead power transmission facilities were reassessed to determine the number and type of transmission towers that would be required for each site and the length of overhead transmission line for each alignment. Results are provided in Table 2-2 below and the proposed alignments are shown on Figure 2-2 (located at the end of this section). While the Additional Studies TM assumed one common alignment for all sites when determining costs, the refinement effort identified a transmission alignment specific to each site. Construction costs were not reevaluated from the cost estimates provided in the Additional Studies TM since the impact to the overall project cost due to the variance between sites would be minimal; however, the results shown in the following tables were used to assess the relative impact these new facilities would have on the surrounding environment.

Table 2-2 Power Transmission Facilities

SITE	TRANSMISSION TOWERS (EA)				TRANSMISSION LINES
	SMALL	LARGE	TANGENT	LONG SPAN	LENGTH (FT)
A1	5	3	12	23	43,700
B3	4	3	17	25	40,800
C3	4	4	20	26	48,850
D3	6	4	21	27	52,900

Table Definitions: **Small and Large Angle**: Tower supports a transmission line change in direction
Tangent: Basic tower providing vertical support with no change in direction
Long Span: More robust tower to accommodate longer interval canyon crossings

2.1.3 Groundwater Impacts on Tunneling

Tunnel alignments were reviewed to determine the length of subsurface excavation that may be subjected to increased hydrostatic influences from the raising of the San Vicente Dam. As noted in the geotechnical study, existing wells in the project vicinity are sourced from fractured rock aquifers. These aquifers allow for rapid drawdown and recharge of groundwater, and tunnel excavations that encounter rock fractures are likely to experience groundwater intrusion. Increased groundwater intrusion may occur where the tunnel profile is near to and below the high water level (HWL) of the San Vicente Reservoir. Figure 2-2 shows the tunnel alignments associated with each upper reservoir site. Table 2-3 shows the length of tunnel, by tunnel type, that is below the reservoir HWL of 764 feet. The tunnel lengths include the revised reservoir inlet/outlet structures that were developed in the Additional Studies TM.

Table 2-3 Tunnel Lengths Below Reservoir HWL

SITE	LENGTH OF TUNNEL BENEATH RESERVOIR HWL (FT)				
	TAILRACE	ACCESS	POWER	CABLE	TOTAL
A1	3,170	2,900	7,750	1,200	15,020
B3	1,910	2,400	2,050	1,030	7,390
C3	1,870	2,470	3,150	950	8,440
D3	3,500	2,620	5,650	1,060	12,830

2.1.4 Land Use Assessments

Project facilities were reevaluated to determine potential land use impacts based on current property ownership and zoning designations. Land ownership within the proposed project area includes State of California, County of San Diego, City of San Diego, and private lands. Figure 2-3 (located at the end of this section) shows the land ownership for impacted parcels of land for each site. Easements and fee acquisitions needed across lands with zoning designation S-80 were deemed to have a greater potential impact on land use. S-80 zoning includes open space intended for recreation areas or areas with severe environmental constraints. Table 2-4 shows the number of acres of S-80 zoned lands to be acquired for the pumped storage facilities. The acreage totals do not include overhead electrical transmission facilities.

Table 2-4 Acreage Requirements for S-80 Zoning Designation

SITE	ACQUISITIONS IN DESIGNATED OPEN SPACE (AC)
A1	3
B3	4
C3	2
D3	119

2.1.5 Property Acquisitions

Surface and subsurface easement and fee acquisitions required for project facilities have been determined based on the following criteria:

- Easements for new and existing roads are 30 feet wide
- Easements for tunnels are 30 feet wide
- Easements for overhead power transmission lines are 150 feet wide
- Fee acquisitions for new reservoirs encompass the dam foot print and the water surcharge elevation. The acreage is then increased 20 percent to account for a water quality buffer that will be provided around the reservoir.

Table 2-5 summarizes the land acquisition requirements by key facility.

Table 2-5 Land Acquisition

SITE	UPPER RESERVOIR (AC)	TRANSMISSION LINES (AC)	ACCESS ROADS (AC)	TUNNELS (AC)
A1	132	150	32	15
B3	107	141	23	6
C3	90	168	20	6
D3	108	182	13	11

Figure 2-1 Access Roads

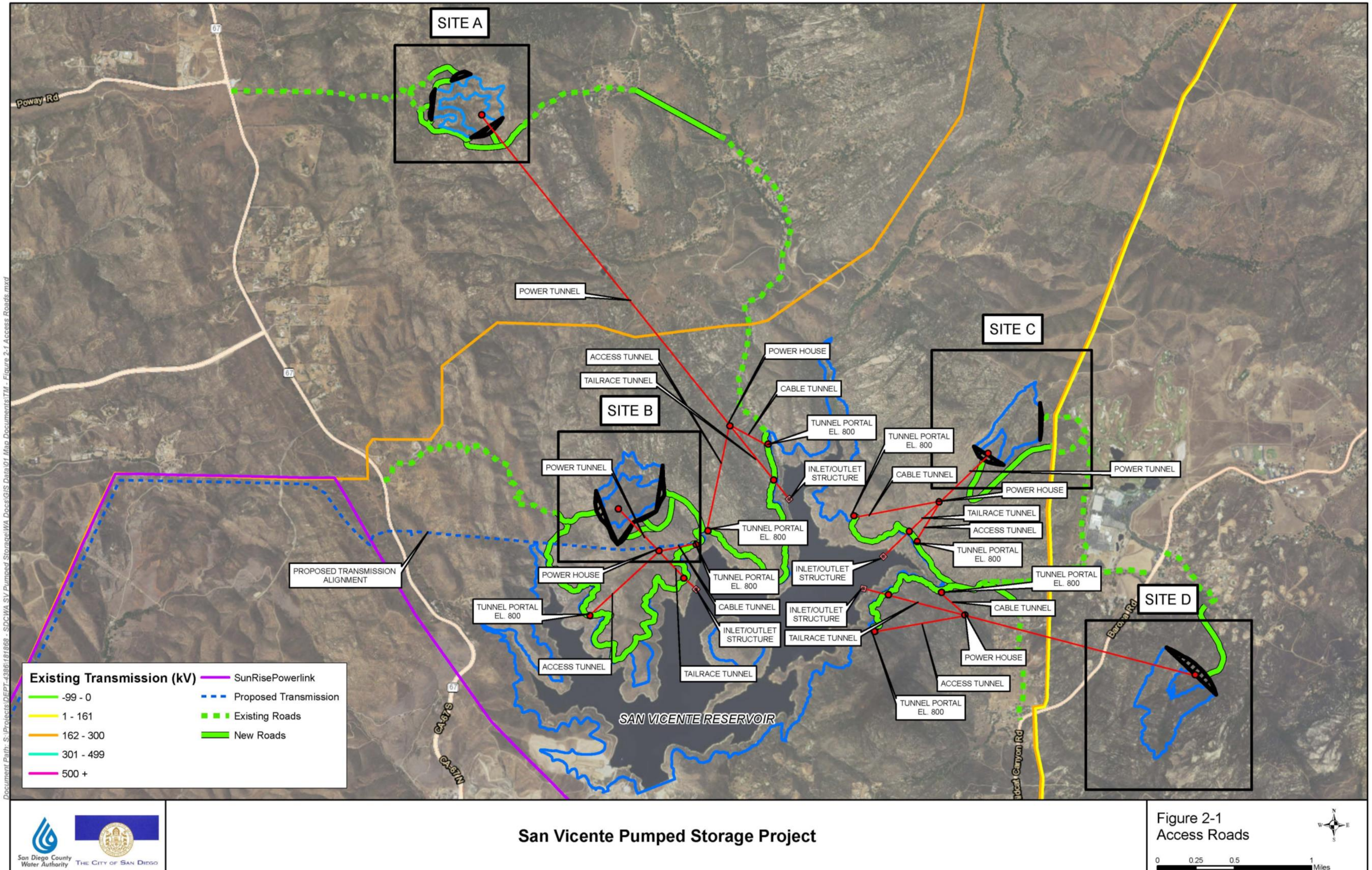


Figure 2-2 Tunnel Alignments, Overhead Transmission Lines and Substation Interconnect Location

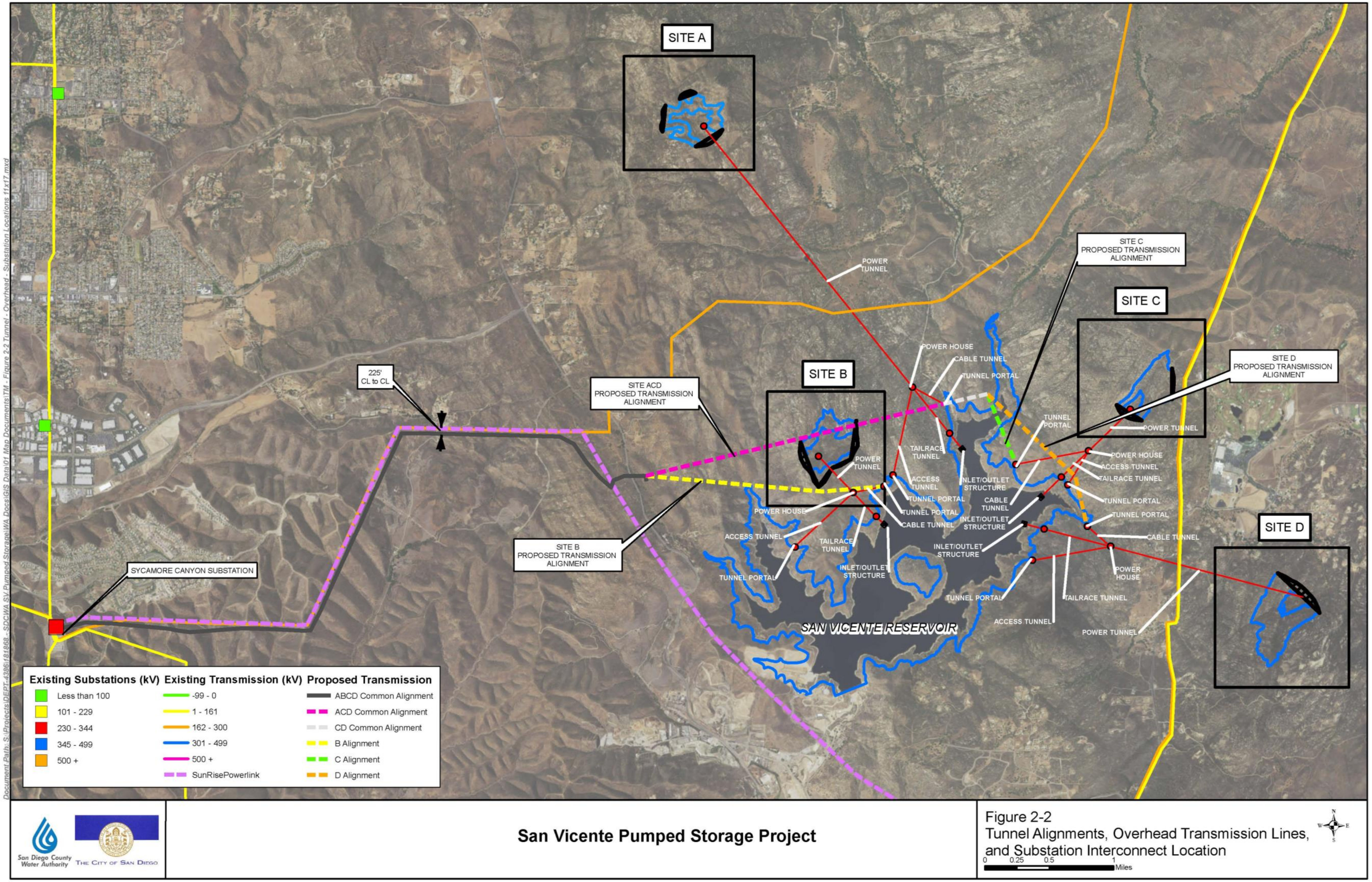
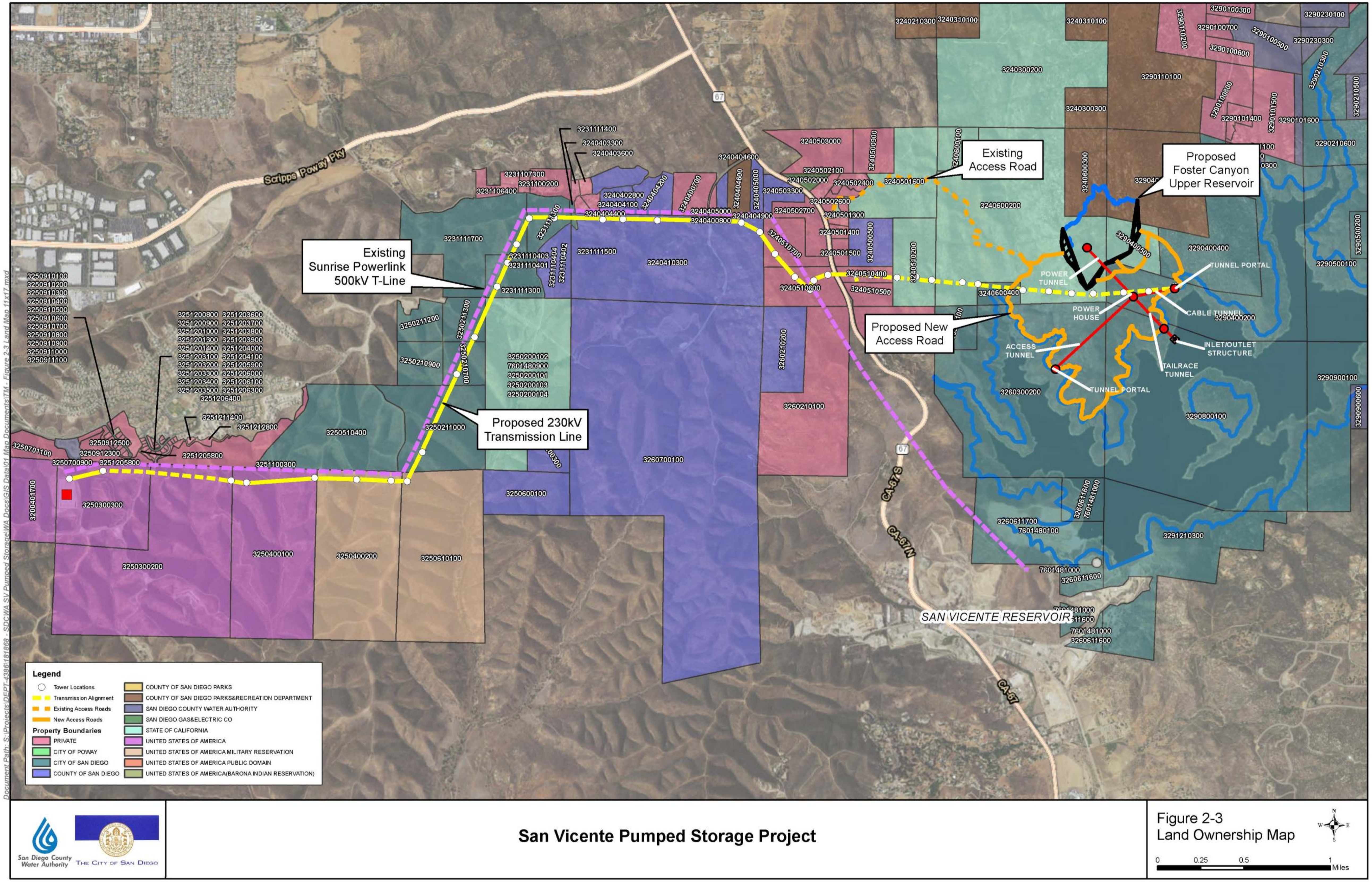


Figure 2-3 Land Ownership Map



3 Geotechnical Study

3.1 BACKGROUND

3.1.1 Scope of Desktop Services

A desktop study was performed to evaluate the geologic and geotechnical aspects that may impact development at each of the four proposed upper reservoir sites. This desktop study, which was prepared by Kleinfelder, Inc., is based entirely on a review of readily available published and unpublished information. The study did not include performance of any field explorations or reconnaissance of the proposed sites. The study included the following task elements:

Task 1: Review of available documents, including in-house maps and reports, other readily available geologic and geotechnical reports and maps, and research of public agency websites for appurtenant data in regards to the four proposed upper reservoir sites.

Task 2: Analysis of aerial photography of several sets of vintage surveys on file at the County of San Diego and in-house files.

Task 3: Analysis of the pertinent data and preparation of this report.

3.1.2 Existing Site Improvements

The San Vicente Reservoir has recently undergone extensive improvement. This has included the raising of the previous dam by approximately 117 feet height, construction of new access roads, pump station, carry-over storage facility, marina and boat ramp, and other appurtenant support structures and facilities. Also recently completed was an extension of the second aqueduct between the dam site and the tie-in location near to and west of the Mercy Road and I-15 intersection.

The four proposed upper reservoir sites are all located in remote undeveloped areas. Site A is located furthest from San Vicente Reservoir, positioned approximately 3.8 miles north of the approximated center of the reservoir. Review of recent aerial imagery dated January, 2015 shows the site as natural undeveloped land. The nearest developed features include some unimproved roads and hiking trails approximately 0.1 miles to the west and 0.2 miles to the southeast.

Site B is located approximately 1 mile north of the San Vicente Reservoir and similar to Site A, does not show indications of site development. The closest feature is an unimproved dirt road named Foster Truck Trail approximately 0.3 miles to the west.

Site C is located approximately 2.2 miles to the northeast of the San Vicente Reservoir. For the most part, this site is comprised of natural undeveloped land except for an unimproved oval shaped dirt road within the central area of the site. This road leads out to the east to a wider utility service road. This larger road also crosses through the proposed reservoir footprint. The Barona golf course is located approximately 0.2 miles to the east of the site.

Site D is located approximately 2.7 miles east of the San Vicente Reservoir and approximately 0.3 miles east of Barona Road. Several residential properties also occur nearby the site. These include properties approximately 0.5 miles to the southwest and residences approximately 0.3 miles to the northeast. Within the central low-lying area of the proposed reservoir site are what appear to be several building structures of unknown type.

3.1.3 Site Conditions

3.1.3.1 Climate

The overall climate for San Diego County is considered semi-arid with an average annual precipitation of approximately 10 inches (www.NWS.com). Annual precipitation generally increases toward the east within the foothills and mountains. The average precipitation for Lakeside nearby the site is approximately 14 inches. Nearly 90 percent of the precipitation occurs between the months of November and April.

3.1.3.2 Surface Conditions and Topography

The ground surface conditions of each of the upper reservoir sites are very similar, typically being comprised of moderately to steeply sloping terrain composed mostly of granitic bedrock in varying stages of weathering. The degree of weathering ranges from decomposed granite to moderately to slightly weathered granite. The areas comprised of the more weathered material are generally expressed as a smooth rolling ground surface with a moderate to thick cover of vegetation. The less weathered areas are composed of rocky outcroppings and boulders and have a much sparser vegetation cover. The vegetation consists mostly of scrub brush and grasses. Trees, if present, usually occur along the bottom area of slopes within drainage features.

A preliminary analysis of the topographic relief was performed at each of the proposed sites by measuring the ground slope at select localities around the perimeter and along the main drainage alignment of each site. These measurements were taken from 7.5 minute United States Geologic Survey quadrangle maps and are reported below in both degree of slope and slope ratio (in parenthesis). This information is also presented on topographic maps of each site on Figures 3-1 through 3-4 (located at the end of this section).

Site A. Nine measurements were taken around the perimeter of Site A and one along the main drainage alignment as shown on Figure 3-1. The perimeter slopes ranged from a low of 10 degrees (5.4:1 horizontal to vertical units) to a high of 27 degrees (2:1). The steepest slope of 27 degrees occurs at the right abutment of southeast dam site. The left abutment of this dam slopes 23 degrees (2.3:1). The abutment slopes at the west dam site are 21 degrees (2.6:1) at the right side and 24 degrees (2.2:1) on the left. The main drainage channel which trends below the southeast dam has a gradient of 3.9 degrees (15:1).

Site B. Nine measurements were taken around the perimeter of Site B and one along the main drainage alignment as shown on Figure 3-2. The slopes around the perimeter ranged from a low of 8 degrees (7:1) to a high of 42 degrees (1.1:1). The steepest slope of 42 degrees occurs at the right abutment of the southwest dam site. The left abutment of this dam slopes 24 degrees (2.2:1). The abutment slopes at the east dam site are 24 degrees (2.2:1) at the right abutment and 16 degrees (3.5:1) on the left. The remainder of slopes around the perimeter of the site range between 8 degrees (7:1) and 28 degrees (1.9:1). The main drainage channel below the southeast dam has a gradient of 4.2 degrees (13:1).

Site C. Seven measurements were taken around the perimeter of Site C and one along the main drainage alignment and are shown on Figure 3-3. All of the steepest slopes occur along the northwest edge of the reservoir and range from 28 degrees (1.9:1) to 32 degrees (1.6:1). Slopes along the southeast side of the reservoir site range from 2.3 degrees (24:1) to 13 degrees (4.4:1) and steepen near the left abutment of the east dam to 26 degrees (2:1). The main drainage channel below the southwest dam has a gradient of 4.7 degrees (12:1).

Site D. Eight measurements were taken around the perimeter of Site D and one along the main drainage alignment and are shown on Figure 3-4. The slopes around the perimeter ranged from a low of 7 degrees (7.8:1) to a high of 27 degrees (2:1). The steepest slope of 27 degrees (2:1) occurs at the northwest side of the reservoir. The left abutment of the northeast dam slopes 7 degrees (7.8:1) and the right abutment slopes 21 degrees (2.6:1). The main drainage channel below the southeast dam has a gradient of 2.9 degrees (20:1).

3.2 GEOLOGIC CONDITIONS

3.2.1 Regional Geology

San Diego County is located within the southern portion of California's Peninsular Ranges Geomorphic Province (CGS, 2002). This province is characterized as an assemblage of north-to-northwest-trending, high-relief ranges stretching south from the Santa Monica Mountains in Los Angeles, through San Diego County, and well into Baja California, Mexico. Notable mountain ranges of Southern California include the Santa Ana Mountains, the Laguna Mountains, and the Cuyamaca Mountains. The development of this mountainous terrain is closely tied to the transform tectonics of the San Andreas Fault System.

The County encompasses three geomorphic subzones, as depicted in Figure 3-5 (located at the end of this section) that are set in a series of north-to-northwest trending belts, roughly parallel to the Pacific coastline. From west to east, these zones are composed of a relatively narrow, low-relief coastal plain; a dominant central high-relief mountainous zone; and a low-lying desert zone on the east.

The Coastal Plain subzone ranges from 0.25 mile wide in the northern county to approximately 14 miles wide in the central and southern regions and is underlain by relatively un-deformed near-shore marine sedimentary rocks deposited during intermittent intervals from late Mesozoic through Quaternary time. The Central Mountainous subzone is west of the coastal plain and is approximately 40 to 50 miles wide. It and is composed mostly of Cretaceous-age granitic type igneous rocks of the Southern California Batholith (SCB). The granites are inset with numerous isolated patches of Jurassic to Triassic-age metamorphic rocks and some Jurassic-age granites that are remnants of the former sedimentary cover into which the batholith intruded. The batholith is comprised of numerous plutons of varying composition and which trends downward toward the west where it underlies Tertiary-age sedimentary rocks of the coastal plain. The Desert subzone occurs along the extreme eastern edge of the County and extends eastward into Imperial County. This low-lying area is part of the Colorado Desert Geomorphic Province and is commonly referred to as the Salton Trough. This desert basin developed in response to crustal extension and related faulting within the southeastern portion of the SAFS.

3.2.2 Site Geologic Conditions

3.2.2.1 Geologic Material Units

The project reservoir sites are located within the western side of the Central Mountainous zone of San Diego County. This region is mostly underlain by Cretaceous-age granitic (granitoid) type rocks of varying composition. This rock material is igneous in origin and originally cooled at depth into a fine- to medium-grained interlocking crystalline texture. The Regional Geologic Map for this area (Todd 2004), shown on Figure 3-6 (located at the end of this section), indicates that Sites A, B, and C are underlain by "Undivided Granitoid Rocks" (Kgr). It should be noted that the Kgr designation on the map is a general rock description which includes many different granitic rock types, hence the use of the "undivided" descriptor. It is in areas where detailed geologic analysis of the of the rock masses has not been performed. The differing granite rock types have been sufficiently studied and classified in the east half of the zone, which is indicated by the vertical line demarcating the boundary between the general Kgr designation on the west from the specific rock designation of Kcp (in pink) on the east. Site D is mapped within this granitic rock unit which is named Chiquito Peak Monzogranite. In addition to monzogranite, other typical granitic rock types in the region consist of gabbro, tonalite and granodiorite. Granitic rock is considered basement rock, meaning that it likely extends the full depth of the earth outer crust (several tens of miles thick) below the site. Therefore, it is anticipated to be encountered from the surface to the full depth of excavation within the depth of construction.

There are several other geologic material types in the region surrounding the proposed sites. One of the more prominent is Cretaceous to Jurassic-age metavolcanic rocks, known as Santiago Peak Volcanics and designated as "Ksp" on Figure 3-6. A large northwest aligned outcropping of these rocks are located approximately 0.5 miles west of Site A and 0.1 mile west of Site B. Smaller outcroppings of conglomerate material designated as the Pomerado Conglomerate (Tp) occur in isolated patches to the north and northwest of reservoir Site C and south of Site B. Surficial deposits of young alluvium and colluvium occur within the low-lying drainages between the higher ground areas. Young alluvium is typically associated with stream deposition processes, whereas colluvium is related to down slope erosion of due to gravity and surface water runoff. Both young alluvium and colluvium are anticipated within the low-lying drainage features and bottom of slopes at each of the site. The accumulation of these materials is anticipated to be relatively shallow.

3.2.2.2 Rock Mass Characteristics

There are several rock mass characteristics of the granitic material which will vary both within and between each of the proposed sites. These rock attributes, which will also affect constructability and excavation, include rock strength, degree of rock weathering and fracturing. Weak, highly weathered and highly fractured rock is much easier to excavate with conventional construction methods than rock that is strong and only minimally weathered and slightly fractured. Generally, the degree of weathering is greatest at the surface and lessens with depth. However, this is not always the case as slightly weathered rock can and often does occur at the surface, with highly weathered material also occurring at depth below hard rock. A subsurface investigation consisting of drilling and sampling of the rock material within the foundation bearing zone of proposed structures and tunneling pathway will be required to evaluate the actual condition of the granitic rock mass.

Our review of historical and recent aerial photography allowed for a cursory evaluation of the condition of the granitic rock material at each of the sites in relation to the degree of weathering and fracturing. In regards to rock weathering, this evaluation is primarily based on the amount of rock exposure at the ground surface which is very evident in aerial photography in areas where the lack of ground cover exposes the hard rock outcroppings. Areas without rock exposure typically have a thicker cover of vegetation due to more intense weathering where the granite has been decomposed allowing soils to form. Fracturing is differentiated into two types comprised of joints and lineaments. These structures are common in nearly all granitic rocks and are associated with faulting, regional stresses, and/or shrinkage stresses developed during the cooling phase of the granitic magma body. Figures 3-7 through 3-10 (located at the end of this section) display some of the more prominent joint sets and lineament features identified within or nearby each of the proposed reservoir sites as interpreted from aerial photography.

Review of aerial photographs show joint sets (typically associated with cooling fractures) within or surrounding all reservoir sites. These joints sets are often composed of numerous parallel fractures ranging from one hundred to over five hundred feet in length and can usually be observed as actual surface separations in exposed rock outcroppings. Spacing between individual joints is typically on the order of inches to several 10's of feet. Most of the joint sets in the vicinity of Sites A and B are typically aligned northeast with some variants oriented northwest. Many of the joint sets in the vicinity of Sites C and D are aligned northwest.

A lineament is any linear feature which can be discerned in the landscape on aerial photography. They can be manifested by large scale regional joint patterns, alignment of drainage or ridge features, linear shallow surface depressions, linear vegetation growth or subtle tonal/color variations across the ground surface. Lineaments usually are related to high angle structural features within the bedrock due to faulting or joint fractures.

There are numerous lineament features throughout the area of the reservoir sites. Most consist of linear surface depressions or aligned drainages similar in alignment with the regional joint pattern. This indicates that most are likely reflective of a large scale system of joints similar to that of the smaller scale joint pattern. There is always the possibility of relationship to faulting, which is difficult to discern from aerial photography. The rock mass characteristics, as well as the presence of surficial units (alluvium and colluvium), is further discussed in the following paragraphs.

Site A. This site is estimated to have approximately 40 percent coverage with exposed surface rock outcrops. The largest areas occur near the left abutment of the southern dam and the area southeast of the left abutment of the western dam. There are also several notable smaller areas along the proposed northern shoreline. The existing drainages below the site do not show geomorphic features characteristic of significant alluvial stream deposits. This indicates that the area is undergoing active erosion and thus the accumulation of stream alluvium is anticipated to be minimal.

There are several lineament features crossing into the footprint of the reservoir site. Two lineaments cross through the southeast dam and are depicted on Figure 3-7. The larger of the two trends east-west through the left abutment. The other trends along a northwest alignment through the right abutment. The left abutment lineament is up to one mile long and is comprised of two segments. The west segment is a linear trace along a drainage alignment. The east segment is defined by a sharp tonal and structural variation on opposing side of the feature, as well as a linear vegetation boundary. These aspects taken together are indications of a possible relationship to faulting. Two lineaments also cross through the west dam, one through the center portion and the other at the edge of the right abutment. There is also a lineament that crosses through the east side of the reservoir.

Northeast trending lineaments also cross the northwest tunnel main alignment at several locations south of the site. A northwest lineament pattern also parallels the tunnel main alignment at the south end near San Vicente Reservoir. If this lineament is representative of broad system of dominant fractures aligned with the tunnel, then this could be an impacting issue as it is not preferable to construct tunnels along aligned fracture structures.

Site B. This site is estimated to have approximately 50 percent of surface rock outcrop exposure. A large portion of the outcropping pattern is comprised of small boulder outcroppings interspersed between areas of thin vegetation cover. The most significant area is at the left abutment of the eastern dam, extending northward along the entire eastern shoreline. This area is comprised of large areas of exposed rock with little vegetation cover. There appears to be a relatively sharp contact line that trends northwest along the western margin of this area that forms a boundary between the rock outcrops on the east and areas of thick vegetative cover on the west. This feature is depicted on Figure 3-8. Alluvial stream terraces appear to be relatively thin and underlain by bedrock material at shallow depth.

There are two lineament features that trend northeast in general conformity with the large scale joint system. The largest is approximately one mile long and crosses the northern edge of the left abutment of the east dam. It extends westward and crosses a portion of the right abutment of the west dam. The other lineament crosses through the bottom of the east dam. The rock texture and joint pattern is similar on both sides of each lineament and it appears that both are part of the large scale joint system seen throughout this region. A northwest trending lineament also crosses beneath the east dam. The contact feature discussed above, trends northwest and extends along the entire east side of the reservoir and crosses through the left abutment of the southeast dam. This contact appears to be at a shallower angle than joints and lineaments in the area, and may be a boundary between two differing granitic rock bodies.

Site C. This site is estimated to have approximately 50 percent coverage with surface rock outcrops. Most of the rock areas occur along the northwestern shoreline, extending from the right southern dam abutment to the northern lake terminus. Review of the aerial photographs does not indicate a notable accumulation of alluvium or colluvium at the site. There is a contact just at the north terminus of the reservoir. Review of the regional geologic map indicates that this contact is a boundary between Pomerado Conglomerate on the north and granitic rock on the south below the reservoir site.

There is one northeast oriented lineament feature which trends along the entire length of the reservoir site below the bottom part of the southwest dam as depicted on Figure 3-9. There are several similar lineaments to the northwest of the site that all follow a regional large scale joint system. The lineament below the site is likely part of this joint system. This lineament also parallels the main tunnel alignment and crosses the axis of the southwest dam.

Site D. This site is estimated to have approximately 40 percent coverage with surface rock exposures. The highest percentage of this area is along the western side of the reservoir and central area of the proposed eastern shoreline. Directly southeast of the reservoir is large rock exposure of comparable size to the proposed reservoir site. There appears to be an alluvial stream terrace deposit upstream and below the proposed eastern dam location.

This site has several lineament features which are all displayed on Figure 3-10. The longest lineament trends northeast through the mid-portion of the west shoreline, terminating in the middle of the site. This lineament is in general conformity with the large scale joint system. The others are a series of at least 5 linear sidewall swales down the west side of the site. These features are co-aligned with joint sets seen in rock outcrops just to the west of here and are likely related to these structures.

3.2.3 Faulting and Seismicity

Southern California straddles the boundary between two global tectonic plates known as the North American Plate (on the east) and the Pacific Plate (on the west) as depicted in Figure 3-11 (located at the end of this section). Active faults associated with this plate boundary cross through some of the most densely populated and developed areas of Southern California. The San Andreas Fault System (SAFS) is the main boundary between the North American and Pacific tectonic plates and it stretches northwest from the Gulf of California in Mexico, through the desert region of the Imperial Valley, crossing the San Bernardino region, and traversing up into Northern California, where it eventually trends offshore near San Francisco. Within Southern California, the SAFS comprises a complex system of numerous faults that span a 150 mile wide zone, from the main San Andreas fault in the Imperial Valley, westward to offshore of San Diego. The major faults east of San Diego (from east to west) are the San Andreas fault, the San Jacinto fault, and the Elsinore fault; major faults to the west are the Palos Verdes–Coronado Bank fault, the San Diego Trough fault, and the San Clemente fault. The most dominant zone of faulting within the San Diego region has several faults associated with the Rose Canyon Fault Zone (RCFZ). Although activity on any of the faults within the SAFS affects the seismicity of the San Diego region, activity within the RCFZ dominates the seismic hazard in the metropolitan San Diego region.

The SAFS is a transform plate boundary dominated by right-lateral fault displacement (Wallace, 1990; Weldon and Sieh, 1985), with the Pacific Plate moving northwest relative to the North American Plate. Faults associated with this system are expected to generate maximum moment magnitudes typically in the M7.0 to 7.5 range, with only a few faults, the San Andreas fault and possibly some thrust faults of the Transverse Ranges, capable of generating earthquakes in the M8 range, such as the 1906 San Francisco and 1857 Fort Tejon earthquakes on the San Andreas fault itself.

Most of the seismic energy and associated fault displacement within the SAFS occurs along the fault structures closest to the plate boundary (i.e., on the Elsinore, San Jacinto, and San Andreas faults). Approximately 1.9 inches/year (in/yr) of overall lateral displacement have been measured geodetically and as fault slip across the plate boundary. Combined, the Elsinore, San Jacinto, and San Andreas faults account for up to 1.6 in/yr of the total plate displacement (84 percent), meaning that the remaining 0.3 in/yr (16 percent) is accommodated across the faults to the west and east (Bennett et al., 1996). At the latitude of San Diego, most of this, about 0.2-0.3 in/yr, is accommodated by the coastal and offshore system of faults, including the Rose Canyon fault. Farther north, a similar amount (0.25-0.3 in/yr) is accommodated east of the San Andreas fault in the Eastern California Shear Zone (Rockwell et al., 2010).

Base on the seismicity of the region, the project area is anticipated to be affected by ground motion from seismic shaking within its design lifetime. Figure 3-12 (located at the end of this section) shows many of the active faults within an approximate 60-mile radius of the project alignment, along with the locations of epicenters of historical seismic events. The proposed reservoir sites are all nearly equidistant from two active fault systems which are the Rose Canyon Fault Zone (RCFZ) to the southwest and the Elsinore Fault Zone (EFZ) to the northeast. Table 3-1 lists the distance of each of the proposed reservoir sites to each of these fault zones including calculated peak ground acceleration (PGA). The RCFZ has a maximum moment magnitude of 6.8 with an estimated annual slip rate of 0.08 inches per year. The EFZ has a maximum moment magnitude of 7.7 and an annual slip rate of 0.12 inches per year. These data are based on fault parameters developed by the California Department of Transportation (Caltrans 2012).

Table 3-1 Reservoir Site Distance to RCFZ and EFZ

RESERVOIR SITE	APPROXIMATE MINIMUM DISTANCE TO SITE FROM RCFZ (MILES)	APPROXIMATE MINIMUM DISTANCE TO SITE FROM RCFZ (MILES)	CALCULATED PEAK GROUND ACCELERATION (PGA)*
A	19.2	19.9	0.361
B	18.6	20.8	0.355
C	21.0	18.8	0.369
D	21.3	19.4	0.366

Notes: *USGS Earthquake Hazard Program 2009 NEHRP, http://earthquake.usgs.gov/designmaps/us/application.php

Review of regional geologic maps does not show faults crossing any of the proposed reservoir sites. The closest mapped faults, not designated as active, are two faults which cross through each of the abutments of the main dam of San Vicente Reservoir (GEI 2008). The fault at the right abutment was studied GEI (2005) and described as a thin shear plane adjacent to a metavolcanic dike. The last episode of faulting was determined to have last occurred prior to the Tertiary and deemed inactive. The fault at the left abutment was studied during the original dam construction and also determined to be inactive. These faults were not mapped by Todd (2004); however, they have been added to the map shown on Figure 3-6. None of these faults trend toward any of the proposed reservoir sites.

As noted above, each of the proposed reservoir sites are crossed by lineament features. With one of the possible causes of lineaments being faulting, it will be necessary to further study these lineament features to determine their relationship to faulting.

3.2.4 Groundwater

Groundwater data is limited due to the small number of wells in the area. Available data is from the California Department of Water Resources (www.water.ca.gov/waterdatalibrary) and the County of San Diego Department of Planning and Land Use (County of San Diego 2010). Well sites have been included on the topographic map on Figure 3-13 (located at the end of this section).

The State of California has data from two locations. The first location is a set of four wells near the Barona Casino. These wells extract water from an alluvial aquifer and show historical groundwater elevations ranging between 1,306 feet above mean sea level (MSL) to 1,352 feet MSL. The other location is within another small alluvial basin near the mid-point between Sites A and B. Records for this well are from 2011 through 2014 and show the groundwater elevation ranging between 1,435 feet MSL to 1,440 feet MSL. The groundwater at all of these sites occurs between 10 to 40 feet below ground surface (bgs).

The County well data comes from two general areas. The first is from several residential areas east of San Vicente Reservoir along Wildcat Canyon Road and consists of twelve wells. This area is closest to Site D. The other area is from two residential properties along State Route 67 (SR67) near the intersection of Poway Road, west of Site B. Four of the wells east of San Vicente Reservoir show a relatively small fluctuation in groundwater level ranging between 20 to 80 feet bgs, corresponding to elevations of between approximately 1,410 feet MSL to 1,540 feet MSL. The other eight wells show groundwater fluctuating several hundreds of feet, ranging between 20 feet bgs to over 500 feet bgs. This corresponds to elevations of between 880 feet MSL to 1,500 feet MSL. The average groundwater elevation of all of the readings is 1,355 feet MSL, with an average depth of 130 feet bgs. The two well locations along SR67 have recorded groundwater elevations ranging between 880 feet MSL to 1,480 feet MSL.

Wells in which the groundwater elevations fluctuate widely over several hundreds of feet are likely sourcing the water from fractured rock aquifers, which is characteristic of granitic terrain. This is due to the fact that the majority of water is stored in narrow fractures which allows for relatively rapid recharge and drawdown of the groundwater elevation, being sensitive to rainfall variations. Groundwater in alluvial and sedimentary aquifers store water throughout the layered units and do not typically fluctuate as much as fractured rock aquifers.

Tunnel systems for each of the proposed reservoir sites will drop to an elevation of approximately 500 feet MSL at the powerhouse structure, ascending down the tailrace section away from the lake inlet/outlet structure. The conveyance tunnel then climbs in elevation toward the each upper reservoir up an approximate 4 percent gradient to a position below the low area of the reservoir. From here the tunnel will rise up vertically to the reservoir inlet/outlet structure. The climb in elevation from the powerhouse for Site A is approximately 1,500 feet, for Site B approximately 900 feet, for Sites C and D approximately 1,000 feet. If the groundwater conditions from the limited available sources are similar to that at the proposed reservoir sites, then groundwater would be anticipated within several hundreds of feet below the ground surface. This infers that it would be very likely that groundwater will be encountered along significant stretches of the tunnel alignment at each of the upper reservoir sites.

3.2.5 Mineral Resources

A review of the mineral resources in the area was based on a document published by the California Division of Mines and Geology in 1963 (Weber 1963). This document is a comprehensive report on essentially the entire moderate to large scale economic mineral resources in San Diego County. None of the proposed upper reservoir sites are shown to be located within or nearby known past mining operations or deposits of economic value. The location of nearby previous worked and known resources is shown on Figure 3-14 (located at the end of this section) and consists of two general areas of deposits. The first area is located at several isolated areas to the northeast of the collective reservoir sites. These deposits are comprised a variety of minerals and include molybdenum, feldspar, copper, quartz, kaolin, optical calcite and iron. The second location is concentrated in area southwest of San Vicente dam and is comprised mostly of sand/gravel quarries and granite dimensional stone workings.

3.2.6 Surface Soils

Soil types affect erosion potential, water holding capability, and support of vegetation and wildlife. The designation of soil types is based on the soil survey for San Diego County prepared by the

United States Department of Agriculture in 1973 (USDA 1973) and are depicted on Figure 3-15 (located at the end of this section). A description and distribution of the various soil types is discussed below.

Site A. This site is designated as being covered entirely by Friant rocky fine sandy loam (FxG). This soil type is estimated to cover approximately 1.4 percent (31,059 acres) of the county surface area. The soil depth is typically 3 to 12 inches over hard rock. Runoff is rapid to very rapid and the erosion hazard is high to very high.

Site B. There are three soil types designated on Site B consisting of Acid igneous rock land (AcG) covering approximately 25 percent of the site, Vista rocky coarse sandy loam (VvD) covering approximately 50 percent of the site, and Cieneba very rocky coarse sandy loam (CmrG) covering the remaining 25 percent. Acid igneous rock land covers the largest portion of the county with 6.6 percent (142,126 acres). The soil is very thin over decomposed granite and rock and has a high runoff potential and low erodibility. The Vista soil has typical depths of 20 to 36 inches over weathered rock. It covers approximately 0.3 percent of the county surface area and has a slight to moderate erosion capability. Runoff is medium to rapid. The Cieneba series soil covers approximately 5.2 percent (112, 088 acres) of county lands and is typically 5 to 15 inches deep. Runoff is rapid to very rapid and erodibility is high to very high.

Site C. There are five soil types designated across site C. These include approximately 20 percent Acid igneous rock land (AcG), approximately 10 percent Vista rocky coarse sandy loam (VvD), approximately 30 percent Cieneba very rocky coarse sandy loam (CmrG), approximately 20 percent Cieneba rocky coarse sandy loam (CmE2) and approximately 20 percent Cieneba-Fallbrook rocky sandy loam (CnE2). The first three soil types have been previously discussed. The rocky Cieneba series (CmE2) covers approximately 1.2 percent (32,227 acres) of county lands. It has a soil depth between 5 to 15 inches with a high to very high runoff and high to very high erosion hazard. The Cieneba-Fallbrook series covers approximately 0.9 percent (20,222 acres) of the county. It is approximately 10 inches deep over weathered granitic rock. Runoff is medium to high and erodibility is moderate to high.

Site D. This site is covered by five soil types. Three have been discussed above and include approximately 40 percent coverage of Cieneba very rocky coarse sandy loam, 10 percent coverage of Acid igneous rock land and 10 percent coverage with Cieneba rocky coarse sandy loam. The other soil types include approximately 10 percent coverage of Visalia sandy loam (VaD) and approximately 30 percent coverage with Vista rocky coarse sandy loam (VvE). The Visalia series covers less than 0.1 percent (1,655 acres) of the county. Runoff is medium and erodibility is moderate. The Vista rocky series covers approximately 0.3 percent (7,204 acres) of the county and has a rapid to very rapid runoff with a high to very high erosion hazard.

In general, the majority of the soil types at the reservoir sites consist of relatively thin cover over rocky to moderate weathered granitic material. Runoff is typically rapid and the erosion hazard is high. Based in these criteria, the soil characteristic are typically similar across all reservoir sites.

3.3 GEOLOGIC HAZZARD ASSESSMENT

A cursory assessment in regards to potential geologic and seismic hazards has been made for each of the reservoir sites. These potential hazards consist of ground surface fault rupture, seismic shaking, liquefaction, seismic compression, seiche and flood, and slope stability. It should be noted, that due to the nature of this study, the following should be considered preliminary and a more detailed geologic and geotechnical study would be required to make a proper definitive assessment of each condition discussed below.

3.3.1 Fault Rupture

The results of our review of published geologic maps do not show any known active faults nearby or within the footprint of the proposed reservoir sites. The closest active faults are the Rose Canyon fault located approximately 19 to 21 miles to the southwest and the Elsinore fault located approximately 19 to 20 miles to the northeast, depending on the individual reservoir site. The closest known inactive faults are two faults crossing in the vicinity of each abutment of the San Vicente Dam. Lineament features have been identified in this study crossing through the footprint of each of the proposed upper reservoir sites. As discussed, lineaments can be related to a number of conditions, one of which is faulting. Thus, it is possible that faults may cross one or all of the sites. It is most probable that if faults are present that they will be relatively older structures related to an older extinct tectonic regime or developed during the later stages of pluton emplacement. In any case, a detailed study of the lineaments will be necessary to determine whether or not it is related to faulting and the age of the faulting if present.

3.3.2 Seismic Shaking

The proposed reservoir sites, as well as all of Southern California, are in an area of expected moderate to severe seismic ground shaking. As discussed above, this region is bracketed within the central portion of a relatively wide zone of faulting between two global tectonic plates being part of the San Andreas Fault System. A preliminary calculation of horizontal peak ground acceleration yielded a value of approximately 0.36g for each of the sites. There are many local conditions which could result in amplification of this value, and a determination of this these factors is beyond the scope of this study. However, whichever site is selected, a detailed seismic analysis would be required during the design phase of the reservoir site.

3.3.3 Liquefaction

Soil liquefaction is a phenomenon in which saturated, cohesionless soils lose their stiffness and strength due to the buildup of excess pore water pressure during cyclic loading, such as that induced by earthquakes. The primary factors affecting the liquefaction potential of a soil deposit are: 1) intensity and duration of earthquake shaking, 2) soil type and relative density, 3) overburden pressures, and 4) depth to groundwater. Soils most susceptible to liquefaction are saturated loose sands and low- to non-plastic silts and often include alluvium, estuarine deposits, beach and beach barrier deposits, and deltaic deposits. The potential consequences of liquefaction to engineered structures include loss of bearing capacity, buoyancy forces on underground structures, ground oscillations or "cyclic mobility," increased lateral earth pressures on retaining walls, post liquefaction settlement, lateral spreading, and "flow failures" in slopes. For the purpose of this discussion in this report, seismic settlement includes post-liquefaction reconsolidation settlement as well as seismic compaction settlement that can result from cyclic loading of loose-to-medium dense unsaturated granular materials (Idriss and Boulanger, 2006; Youd et al., 2001).

The majority of each upper reservoir site is composed of granitic rock in varying degrees of decomposition. These material types are not prone to liquefaction. All of the sites appear to have small deposits of alluvial material within the bottom of the main drainage feature at each location. The site with the largest accumulation of alluvium appears to Site D. The drainages are typically perennial streams and dry most of the year. Additionally, since they do not occupy major drainages, the accumulation of the alluvium is anticipated to shallow, on the order of 5 to 15 feet and confined to narrow pathways. Based on these conditions, the hazard with respects to liquefaction would be low to moderate. Measures to mitigate these phenomena would likely consist of removal of these materials in areas where dams or other significant structures are planned.

3.3.4 Seismic Compression

Seismic compression results from the accumulation of contractive volumetric strains in unsaturated soil during earthquake shaking. Loose to medium dense granular material with no fines, or with low plasticity fines, are most susceptible to seismic compression. Soils at each of the sites which could be prone to seismic compression would the alluvium and colluvial soils. As noted earlier, these soils occupy a relatively small area of each site.

3.3.5 Seiche and Flooding

A seiche is an oscillatory wave that develops in an enclosed or partially enclosed body of water, such as a bay or lake, in response to seismic shaking from an earthquake. The nearest body of water to each of the upper reservoir sites is San Vicente Reservoir which ranges from approximately 0.6 miles away from Site B to approximately 3.3 miles for Site A. Each of the proposed sites is several hundreds of feet higher than the maximum pool level of San Vicente. Given this elevation differential and the distances from the existing reservoir, the hazard with respects to seiche is considered low. It should be pointed out that the development of any of the proposed reservoirs will itself become a seiche hazard once filled.

Flood hazard potential at each site was evaluated based on flood hazard maps available through the FEMA Map Service Center Web site. Based on FEMA Map Numbers, 06073C1400G, 06073C1391G and 0673C1415G, none of the proposed reservoir sites are located within a mapped flood area.

3.3.6 Landsliding and Slope Stability

Landslides are deep-seated ground failures in which a large section (tens to hundreds of feet deep) of a slope detaches and slides downhill. Landslides can cause damage to structures both above and below the slide mass. Undermining of foundations can occur to structures above the slide area. Areas below a slide can be damaged by being overridden and crushed by the failed slope material. Several formations within the San Diego region are particularly prone to landsliding on steep slope surfaces. These formations generally have high clay content and mobilize when they become saturated with water. Smaller scale slope failures can occur on most any slope and consists of minor surficial failures (slumps), which are usually limited to the topsoil zone.

Each of the proposed reservoir sites is very similar both geologically and topographically. Granitic bedrock is either exposed at the ground surface or covered by a shallow mantle of soil. Deposits of alluvium are typically shallow and occur along the drainages and bottom of slopes.

The slopes composed of granitic material with low to moderate slopes and in most cases even on steep slopes are not typically prone to landsliding. This is due to a number of factors related to both its material content, structure and strength parameters. All four reservoir sites also have a similar amount of topographic relief and steepness which typically ranges between 4 degrees

(15:1) to 18 degrees (3:1). Some sites have slopes which range above or below these values but these are usually in isolated areas.

Review of the published geologic map (Todd 2004) does not show mapped landslides within or nearby any of the upper reservoir sites. Review of aerial photographs did not show existing features which would be attributed to deep seated landslide failures on any of the slopes at the reservoir sites. Shallow surface slumping is difficult to decipher at the scale of the photographs reviewed, but certainly these have occurred, as they are a typical process of slope degradation. Generally, slopes composed of granitic rock are stable within the range of steepness at the reservoir sites and not prone to deep seated landslide failure. The typical processes responsible for slope degradation in these terrains are normal erosional processes which include sheet erosion, concentrated surface flow within gullies and rill features and as already mentions shallow surface slumps, which can occur during periods of intense rainfall.

Filling of the reservoir will saturate the loose surficial soil cover on slopes and the unconsolidated alluvial materials below reservoir level and along the reservoir shoreline. This will likely result in shallow surficial slumping in isolated areas where these materials are concentrated, particularly within drainages and along the bottom of slopes. The cycling of filling and draining the reservoirs will exacerbate this process, particularly during reservoir drawdown which results in a temporary increase pore pressure differential of the loose soils as they drain due to the lowering of the reservoir water level. Deep seated failure within bedrock material both below reservoir level and along the shoreline is not anticipated.

Erosion will be effected because all reservoirs act as a sediment trap, arresting transport of the sediment beyond the confines of the reservoir. Sediment typically accumulates as fan shape delta features in areas where drainages enter the reservoir. This also eventually slows the process of erosion upslope from the reservoir surface.

3.4 GEOLOGIC ISSUES AFFECTING TUNNELING

Tunnels are planned for each of the upper reservoir sites consisting of a main water conveyance tunnel to extend upwards from San Vicente Reservoir to the upper reservoir site, an access tunnel, and a cable/emergency exit tunnel. The latter two tunnels both connect to the powerhouse location in the main conveyance tunnel and each out letting to surface. The maximum depth for each conveyance tunnel is similar, being approximately 900 to 1000 feet below ground surface (bgs) at its maximum depth. The two other tunnels at each of the sites reach a maximum depth of approximately 600 feet bgs.

The proposed tunnels for all sites will be within bedrock material comprised of granitic rock. Key soil and bedrock issues that will impact tunnel excavation and support methods include mineral and lithological composition, weathering, rock strength, and degree, condition and orientation of rock mass discontinuities (fractures, joints, shear zones, etc.). Two of these were discussed above and consist of the degree of weathering of the bedrock and degree of fracturing. It should also be noted that there will likely be variations in the composition of the granitic rock encountered along the tunnel alignments, which also may impact the tunneling effort. The current geologic map of the area does not differentiate between the several granitic rock types known to exist in the area. Observations made from the analysis of the aerial photography do indicate differences in surface outcrop patterns and structure, indicating that variations in granitic rock type do occur in the area.

Excavatibility between the rock types is likely to be relatively similar and will be a function of the method of excavation (drill and blast, roadheader, mechanized excavation, etc.) and the engineering characteristics of the rock. However, this difference is not anticipated to be significantly variable, rising to the level of difference between hard granitic rock and a soft sedimentary unit.

The most likely adverse effect on tunneling conditions will be due to variability in the extent of weathering/quality of the rock. The degree of weathering will be greatest near the ground surface and generally decrease with depth. Local departures from this pattern can be anticipated where areas of highly decomposed granite occur directly adjacent to relatively unweathered blocks of granitic core stone at depth. Likewise, the degree of fracturing will effect tunneling construction. Similar to the degree of weathering, the degree of fracturing will likely be greatest near the surface and decrease with increasing depth. The exception would be in areas affected by faulting, where fracturing would be more concentrated.

Due to lack of site specific subsurface information along any of the tunnel alignments, it is not possible to evaluate the tunneling conditions at this level of study. However, it seems reasonable, based on the similarity of tunnel depth at the upper reservoir sites that similar bedrock weathering and fracturing conditions can be anticipated. Groundwater will also be a significant consideration in regards to tunneling. Based on the depth of the tunnels and anticipated groundwater levels in the region, it is likely that water will be encountered along extensive portions of the any of the tunnel alignments.

3.5 SUMMARY OF GEOLOGIC CONDITIONS

All four reservoir sites have very similar geologic, soil, topographic and anticipated groundwater conditions. Many of the potential impacts are also very similar with generally small differences. Factors that could differentiate the sites would be groundwater conditions and the nature of the lineaments and contact features and how they would possibly impact design and construction. In regards to groundwater, there is not enough detailed subsurface data available to differentiate the sites. Based on the information that is available, it is reasonable to assume that there would not be significant difference between the sites since they all have similar depth and material types along their respective tunnel pathways. Longer tunnel stretches such as Site A provides more opportunity for encountering groundwater.

The most significant differentiators are structural features seen in the landscape surface on aerial images. These consist of lineaments and contacts which cross through proposed dam structures and coalign with tunnel pathways. Most of the lineaments appear to be related to regional large scale joint patterns, but this cannot be isolated at this level of study. These features will need to be further studied to determine their true nature and geometry. An itemization of these features for each site is provided below.

Site A has three potential impacting lineaments. One has ostensible indication of being related to faulting and crosses through the left abutment of the southeast dam. The second lineament crosses northwest through the right abutment of this same dam but is not aligned with any large scale joint pattern. The third lineament is coaligned with the south end of the conveyance tunnel for this site.

Site B has three potential impacting lineaments and one contact feature. The largest lineament crosses northeast through the left abutment of the east dam. The other two cross below the bottom of this same dam. The contact feature also crosses below the bottom of the east dam.

Site C has one lineament feature extending northeast through the bottom of the proposed southeast dam. An apparent extension of this lineament occurs further downstream and this entire system is also directly in line with the proposed conveyance tunnel pathway and also crosses beneath the bottom of the southwest dam.

Site D has several lineament features. The largest lineament crosses northeast through the northwest shoreline and into the central portion of the site. The other lineaments occur along the northwest shoreline being parallel to other local system of joints.

Figure 3-1 Topographic Map Proposed Reservoir Site A

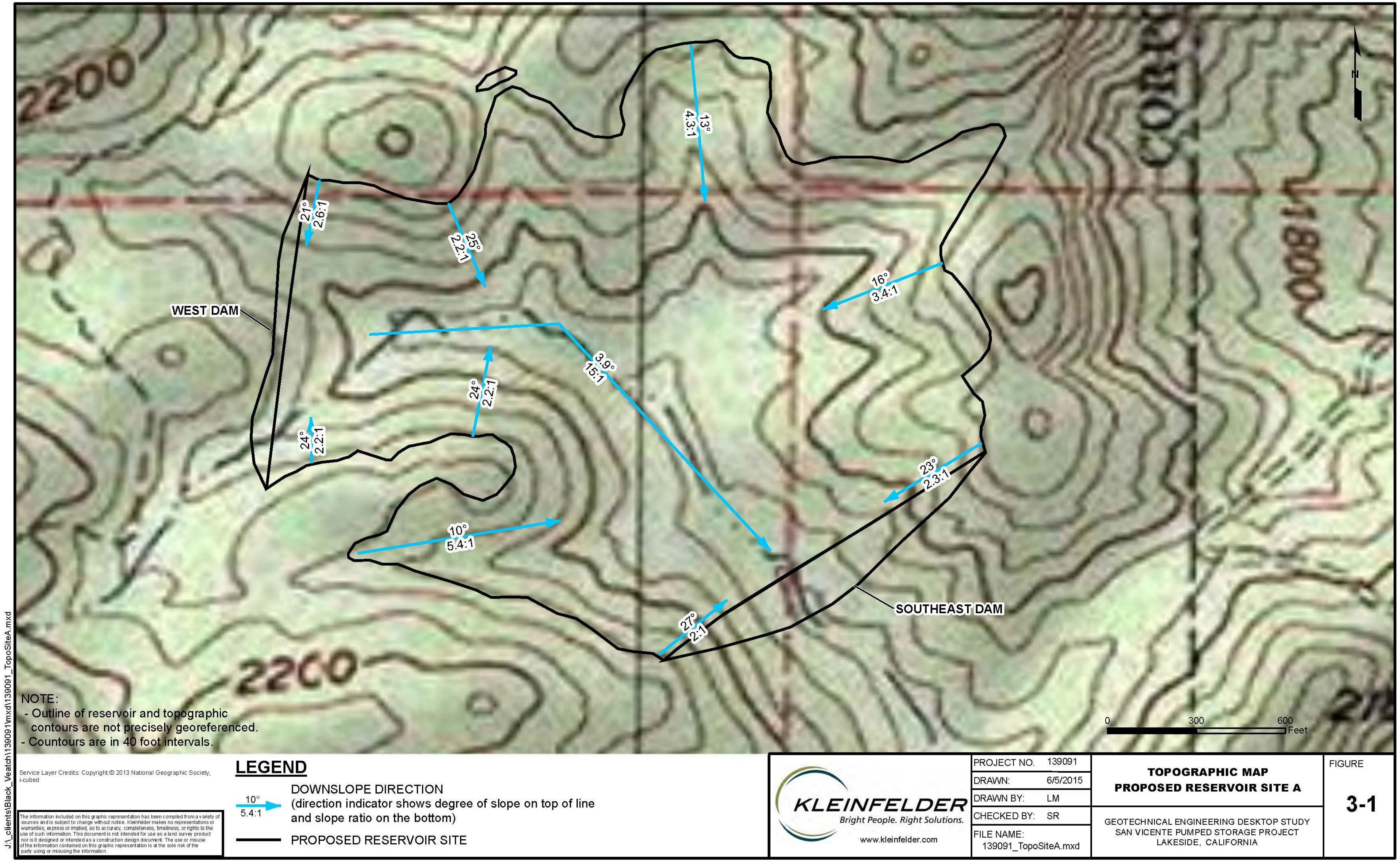


Figure 3-2 Topographic Map Proposed Reservoir Site B

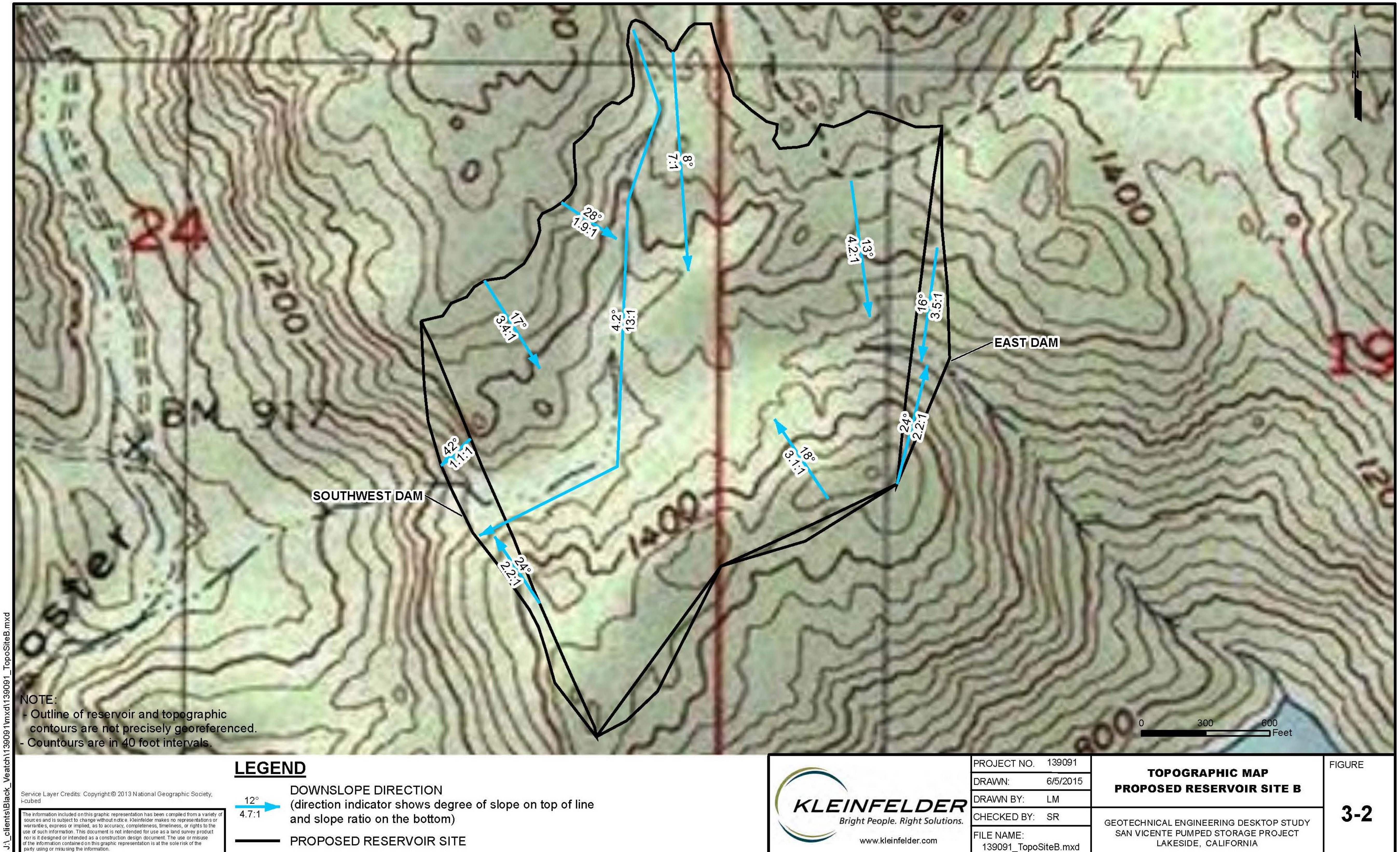
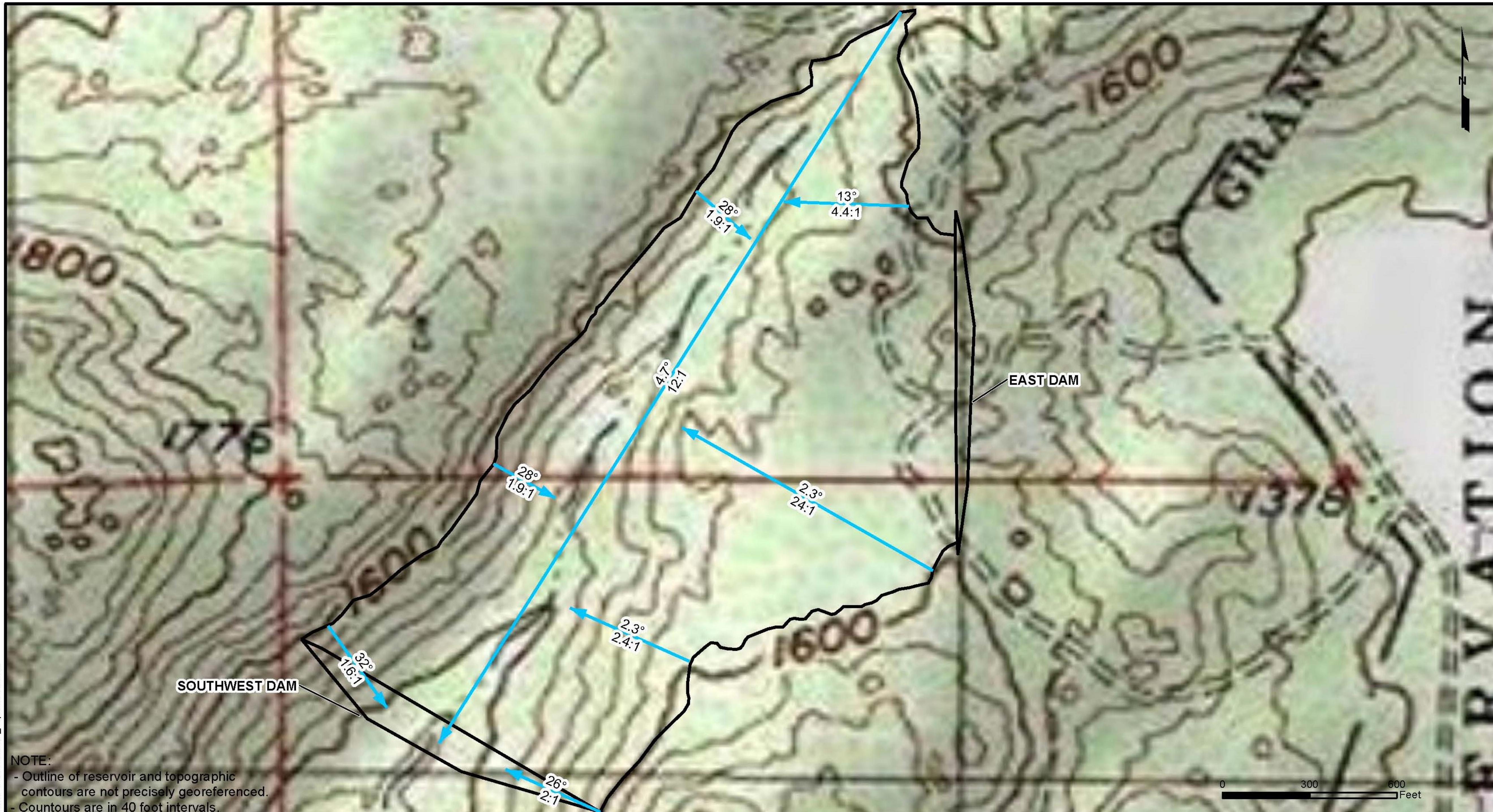


Figure 3-3 Topographic Map Proposed Reservoir Site C



J:_clients\Black_Veatch\139091\mxd\139091_TopoSiteC.mxd

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LEGEND

26° / 2:1 — DOWNSLOPE DIRECTION (direction indicator shows degree of slope on top of line and slope ratio on the bottom)

PROPOSED RESERVOIR SITE

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PROJECT NO.	139091
DRAWN:	6/5/2015
DRAWN BY:	LM
CHECKED BY:	SR
FILE NAME:	139091_TopoSiteC.mxd

TOPOGRAPHIC MAP
PROPOSED RESERVOIR SITE C

GEOTECHNICAL ENGINEERING DESKTOP STUDY
SAN VICENTE PUMPED STORAGE PROJECT
LAKESIDE, CALIFORNIA

FIGURE **3-3**

Figure 3-4 Topographic Map Proposed Reservoir Site D

Figure 3-5 Geomorphic Subzones of San Diego County

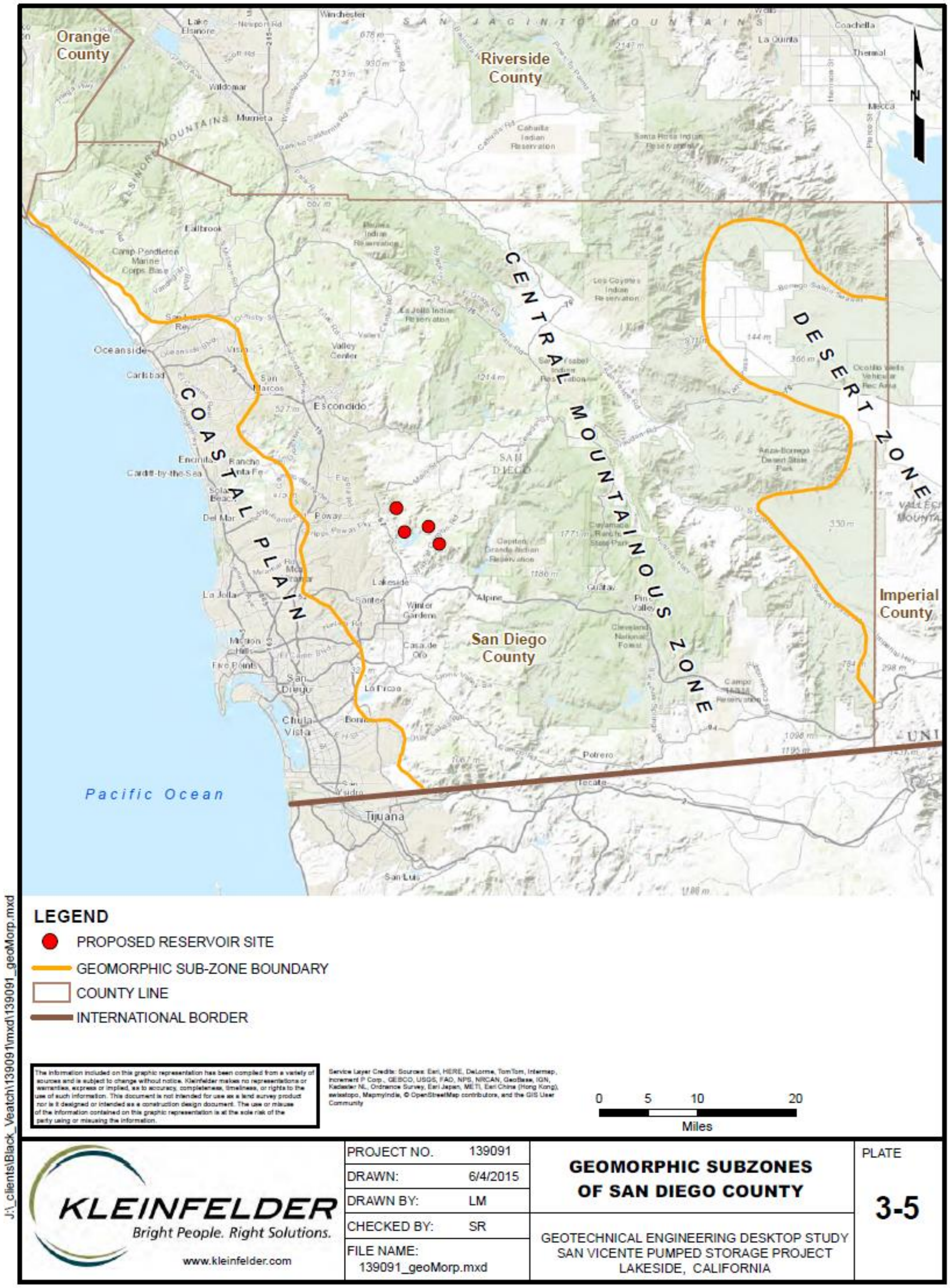


Figure 3-6 Regional Geologic Map

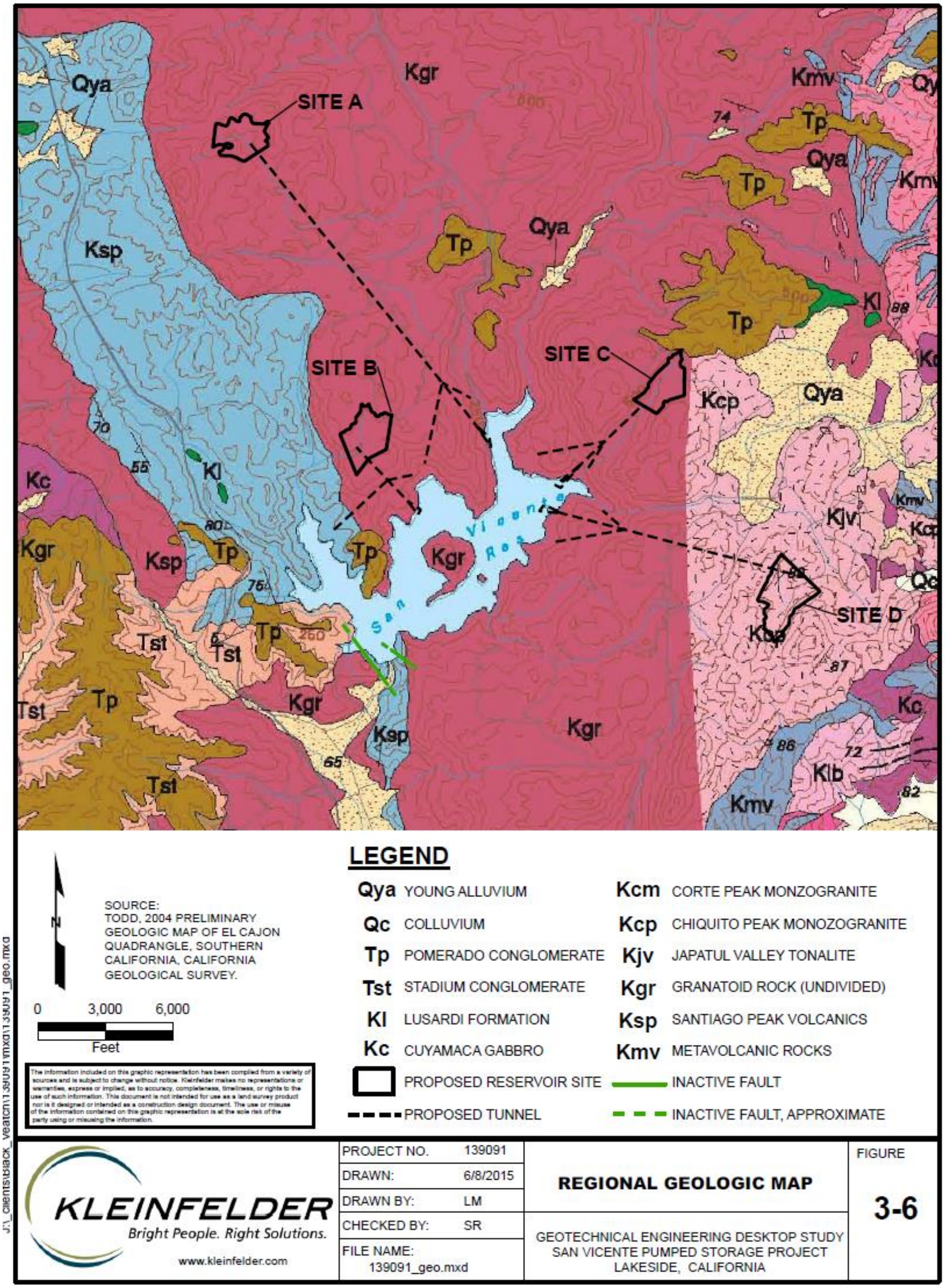


Figure 3-7 Rock Mass Features – Proposed Reservoir Site A

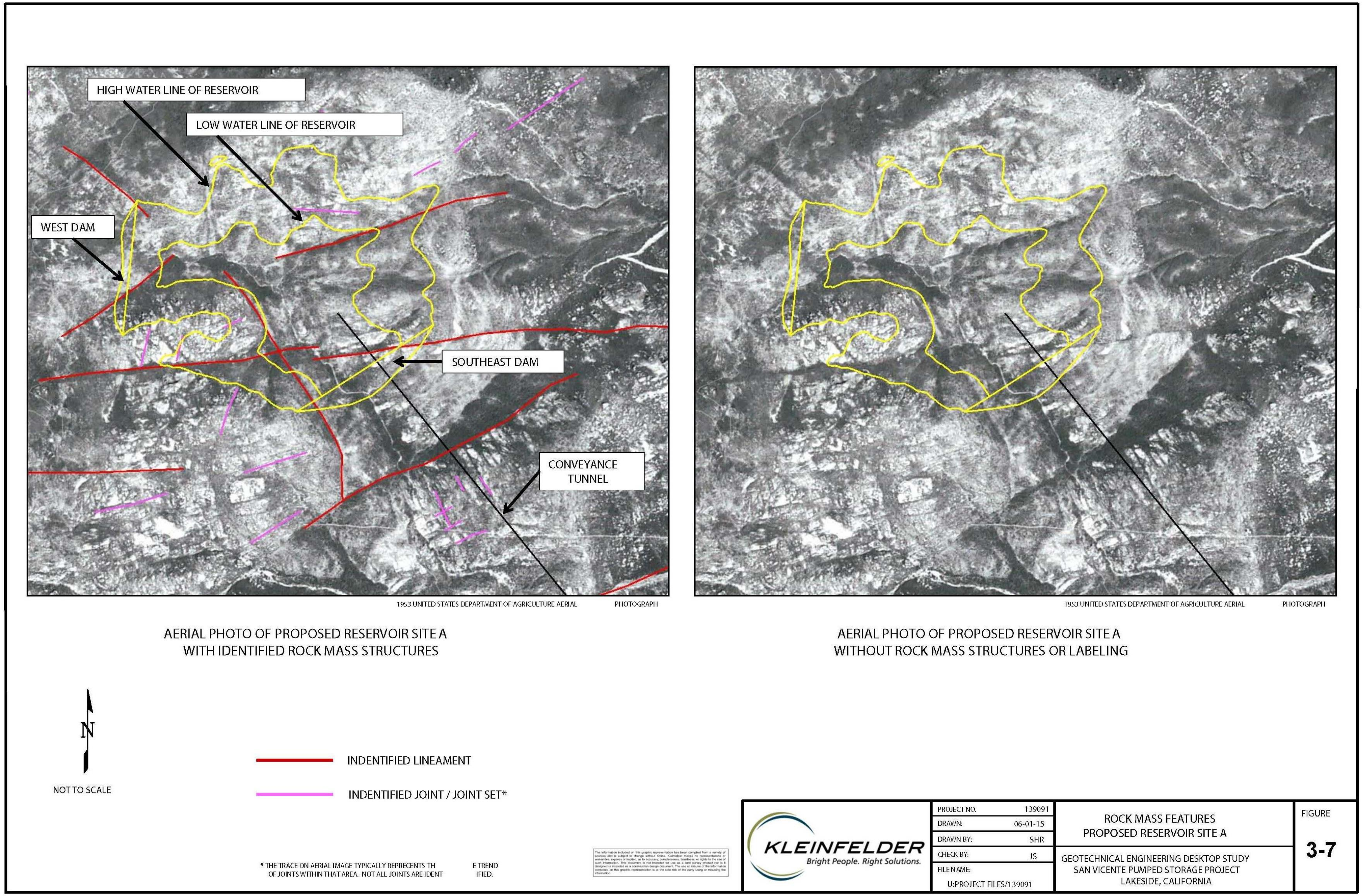


Figure 3-8 Rock Mass Features – Proposed Reservoir Site B

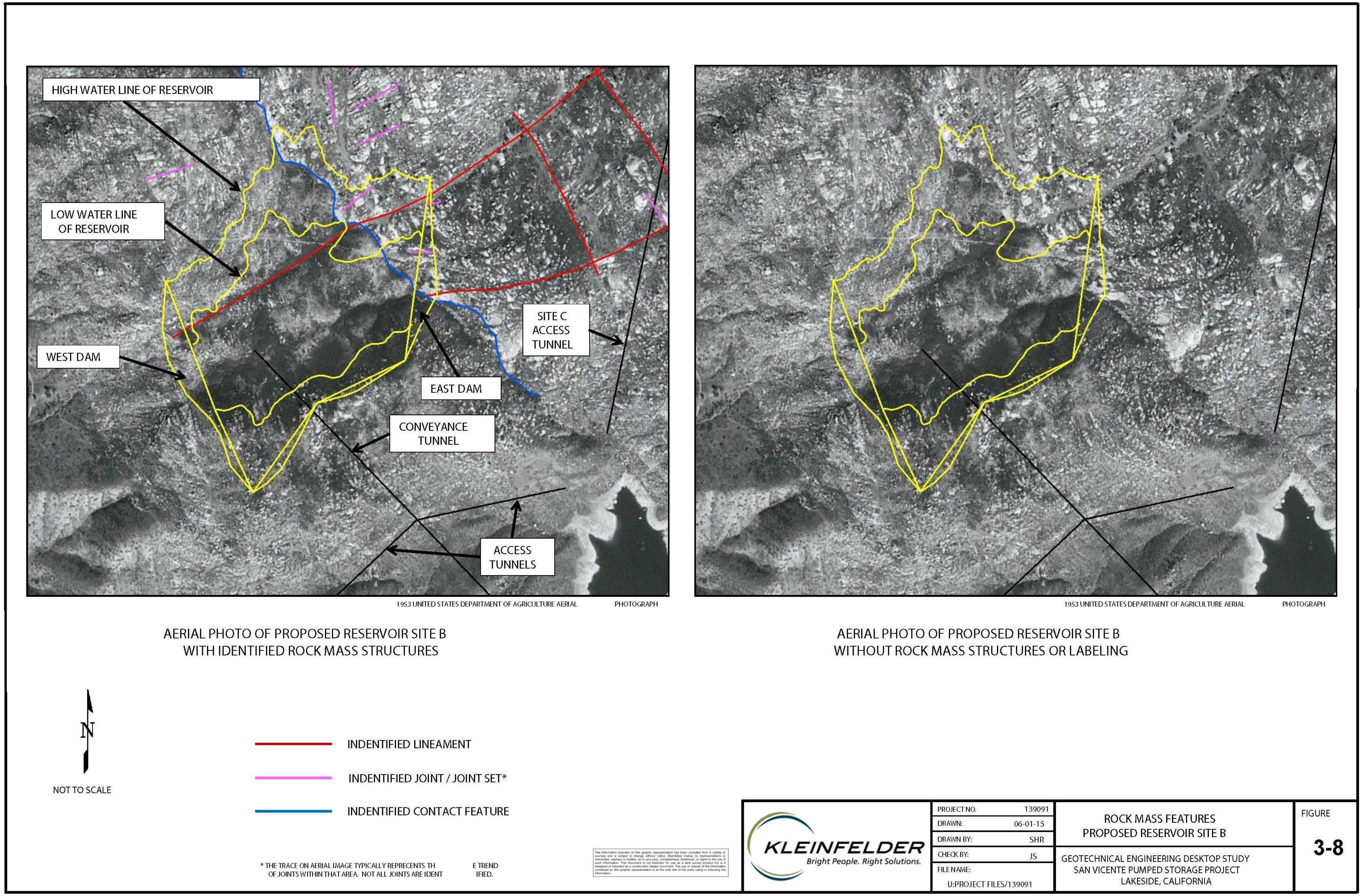


Figure 3-9 Rock Mass Features – Proposed Reservoir Site C

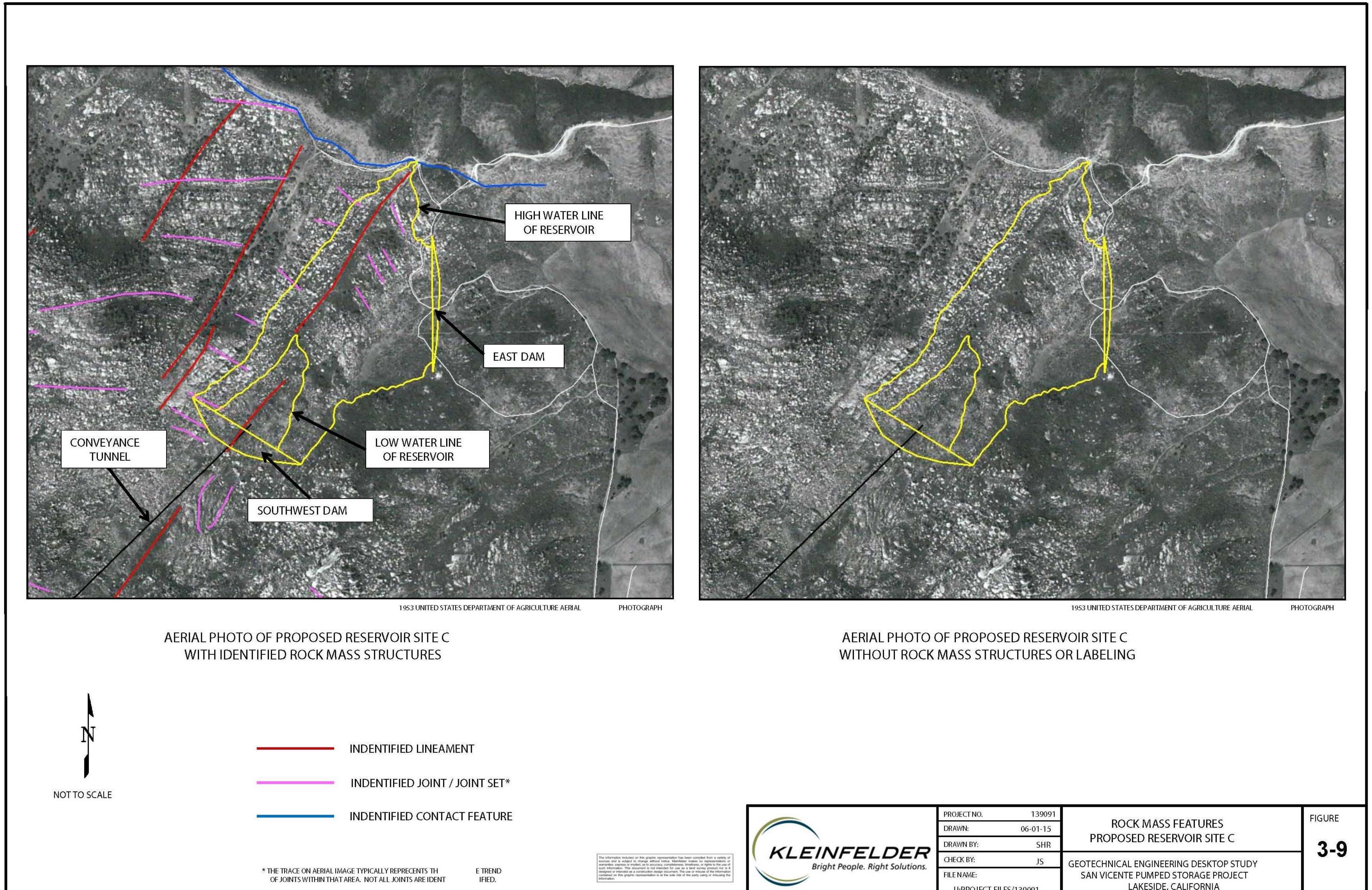


Figure 3-10 Rock Mass Features – Proposed Reservoir Site D

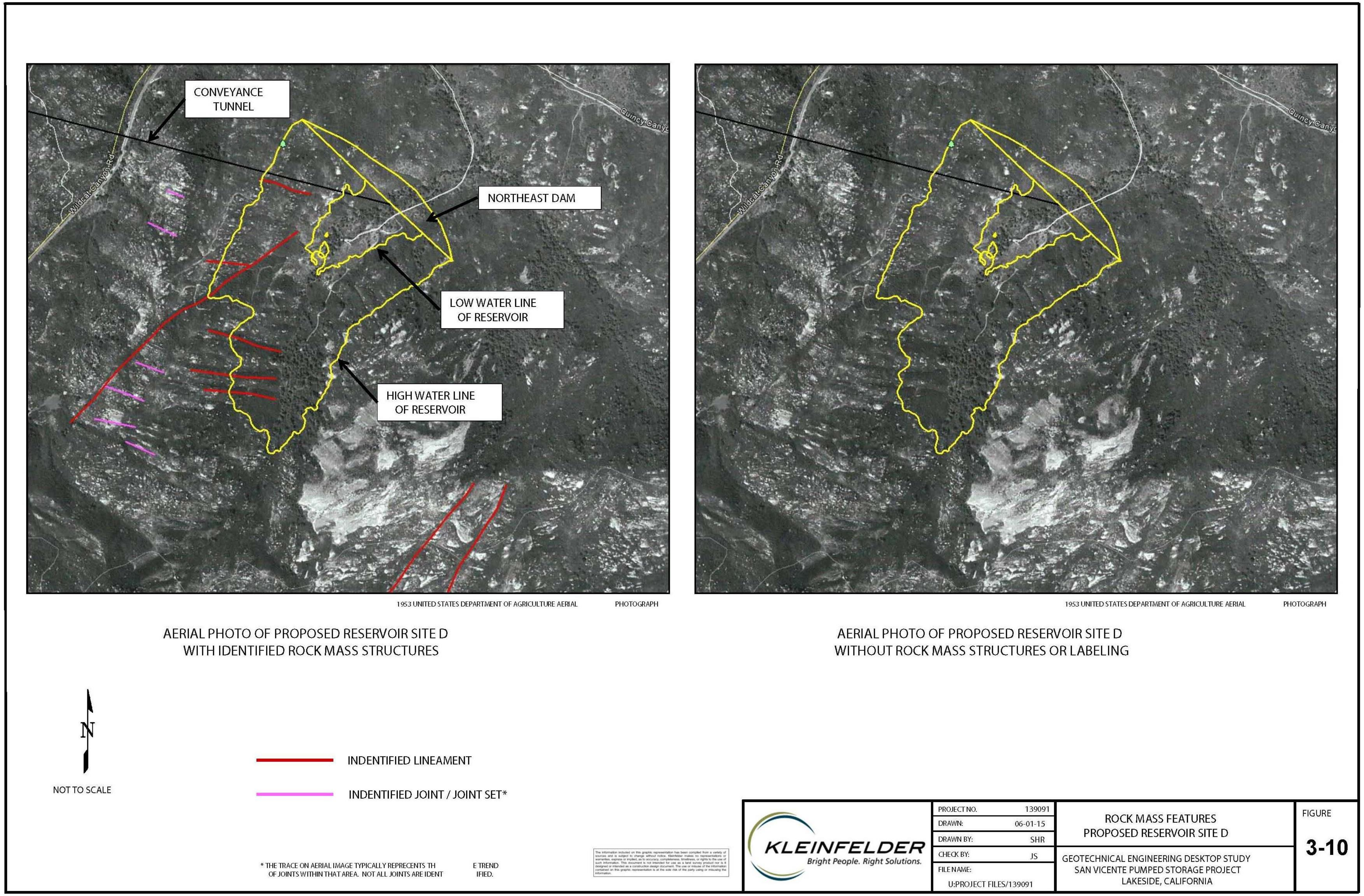


Figure 3-11 Tectonic Plates and Faults in Southern California

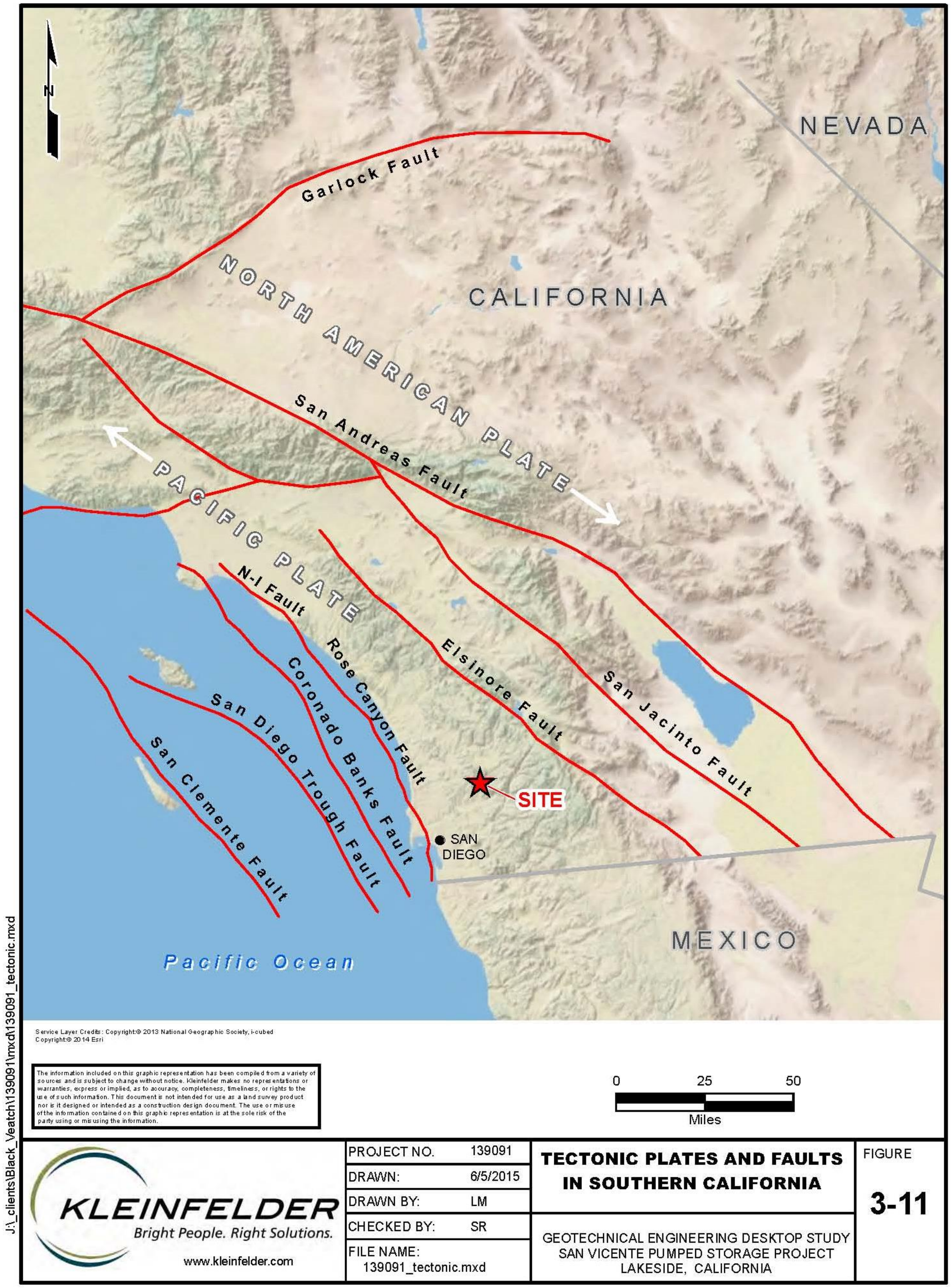


Figure 3-12 Regional Fault Map and Earthquake Epicenters (1800 – April 2015)

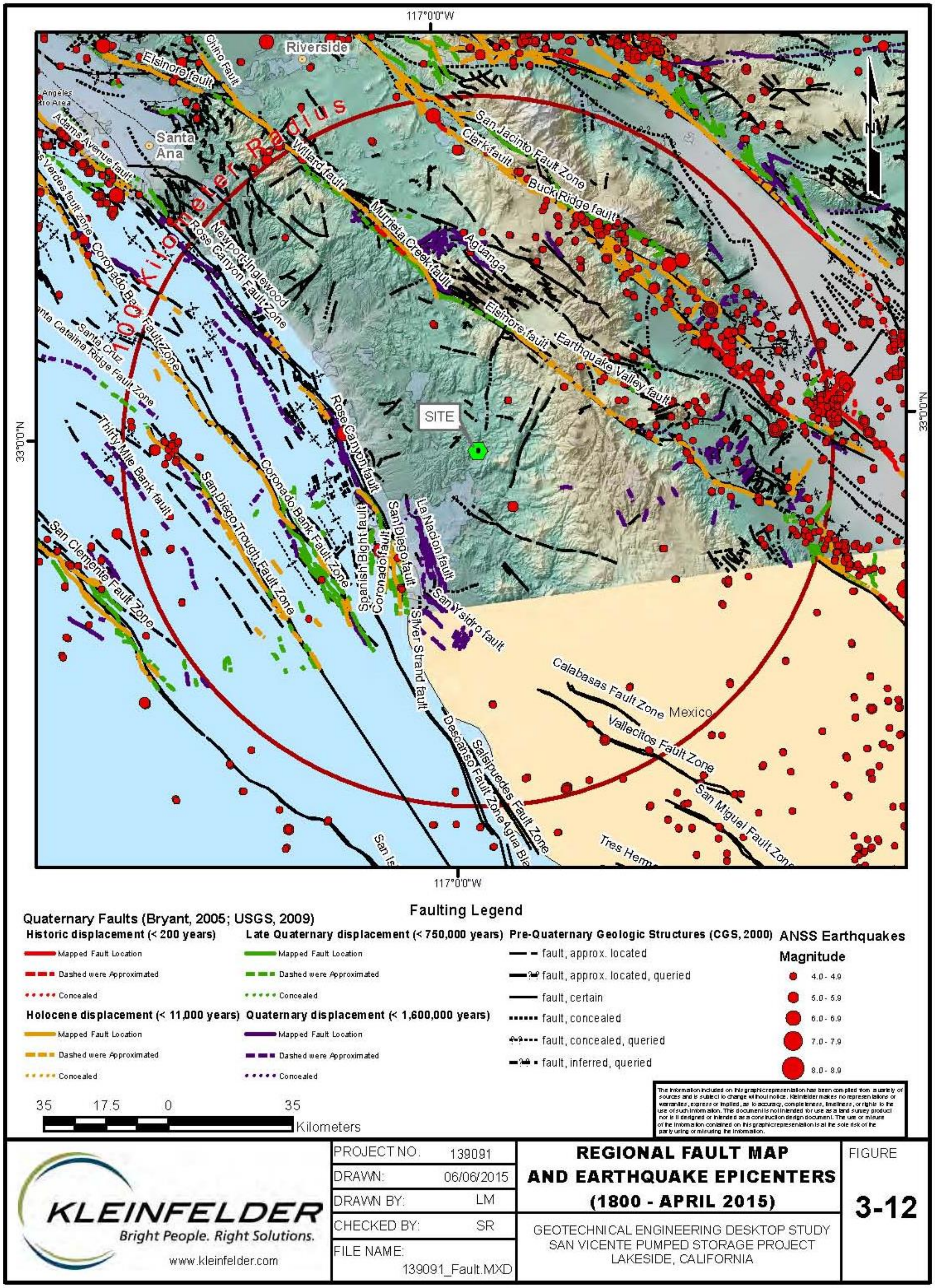


Figure 3-13 Site Location Map

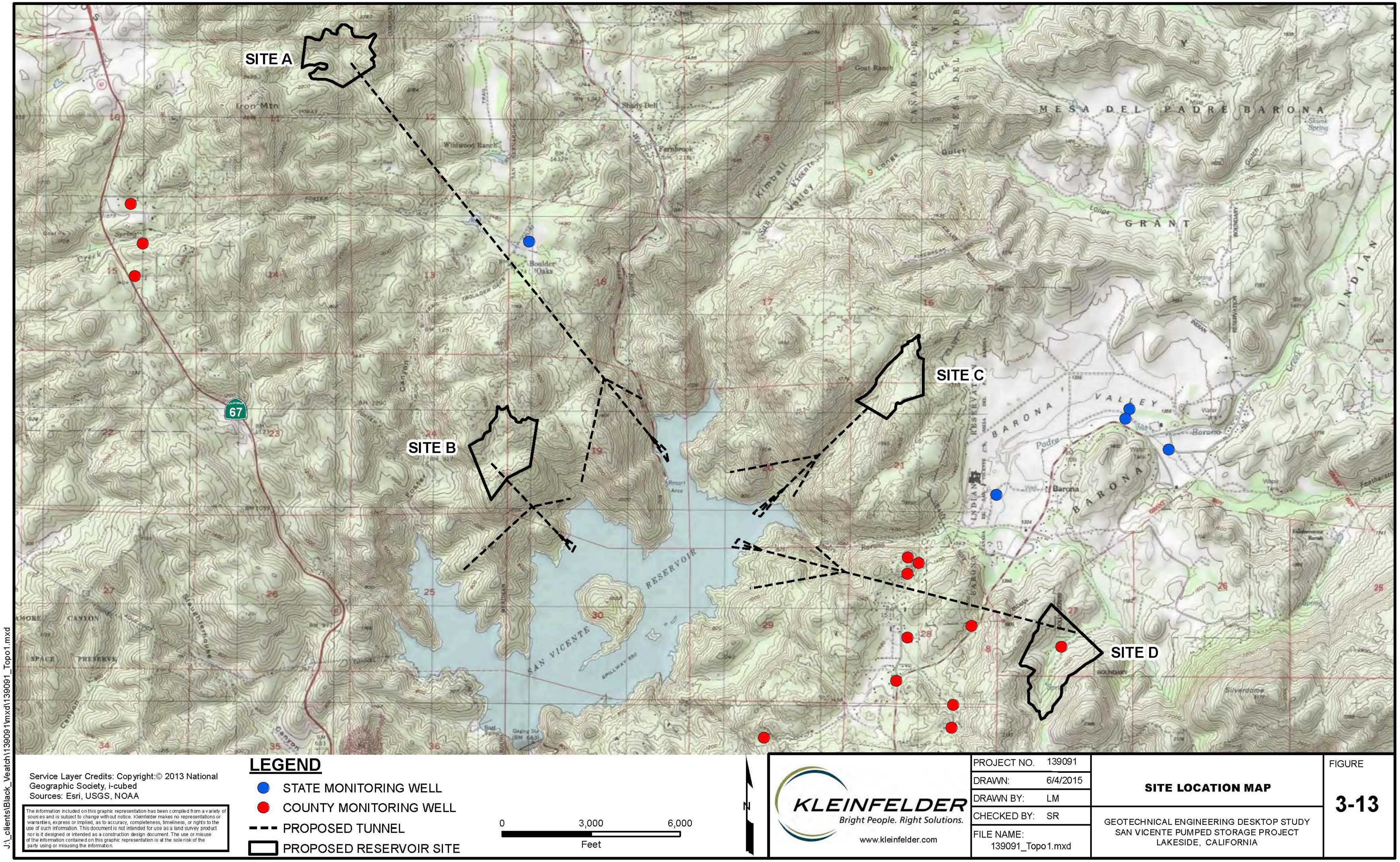


Figure 3-14 Mineral Resources

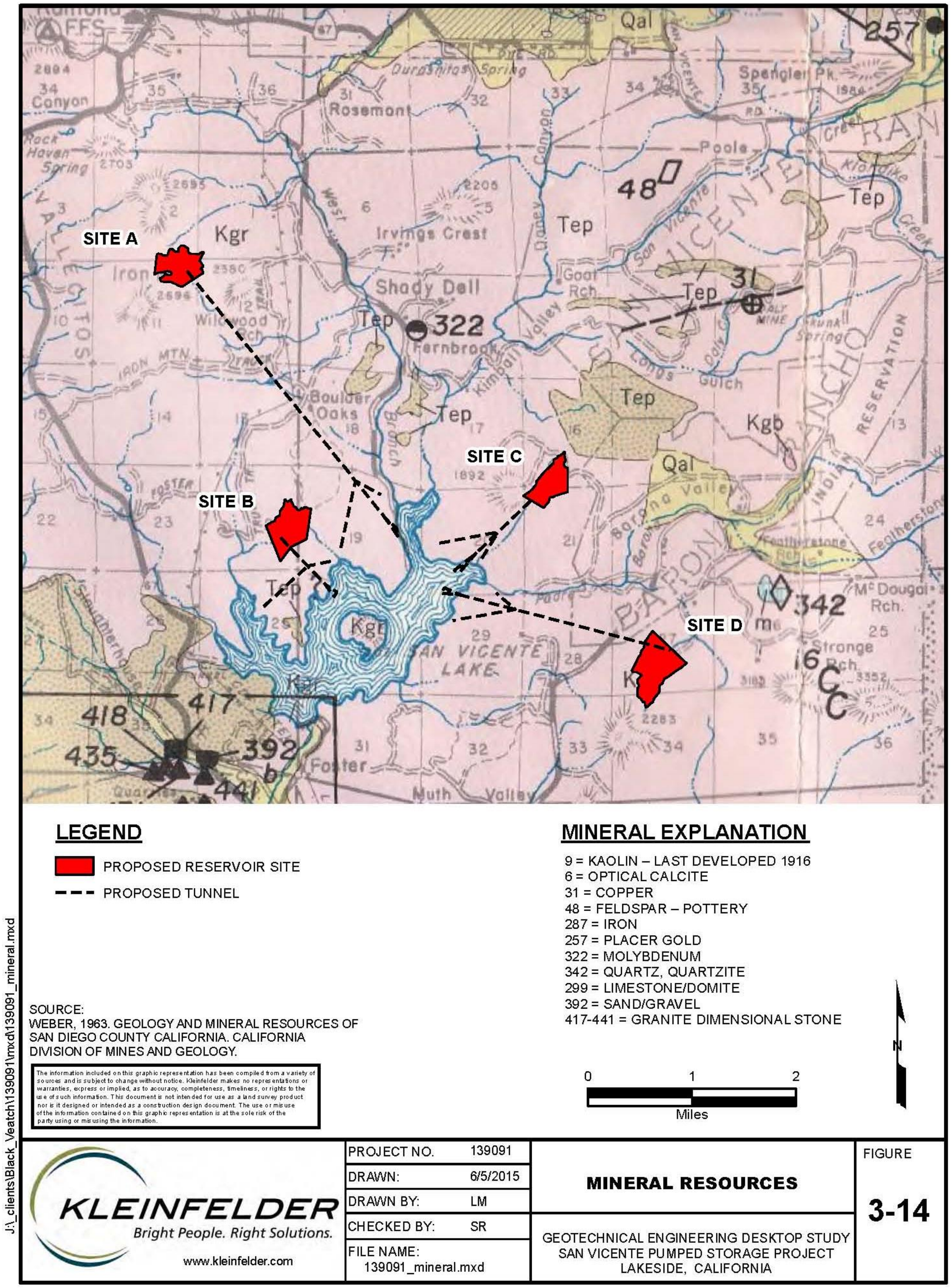
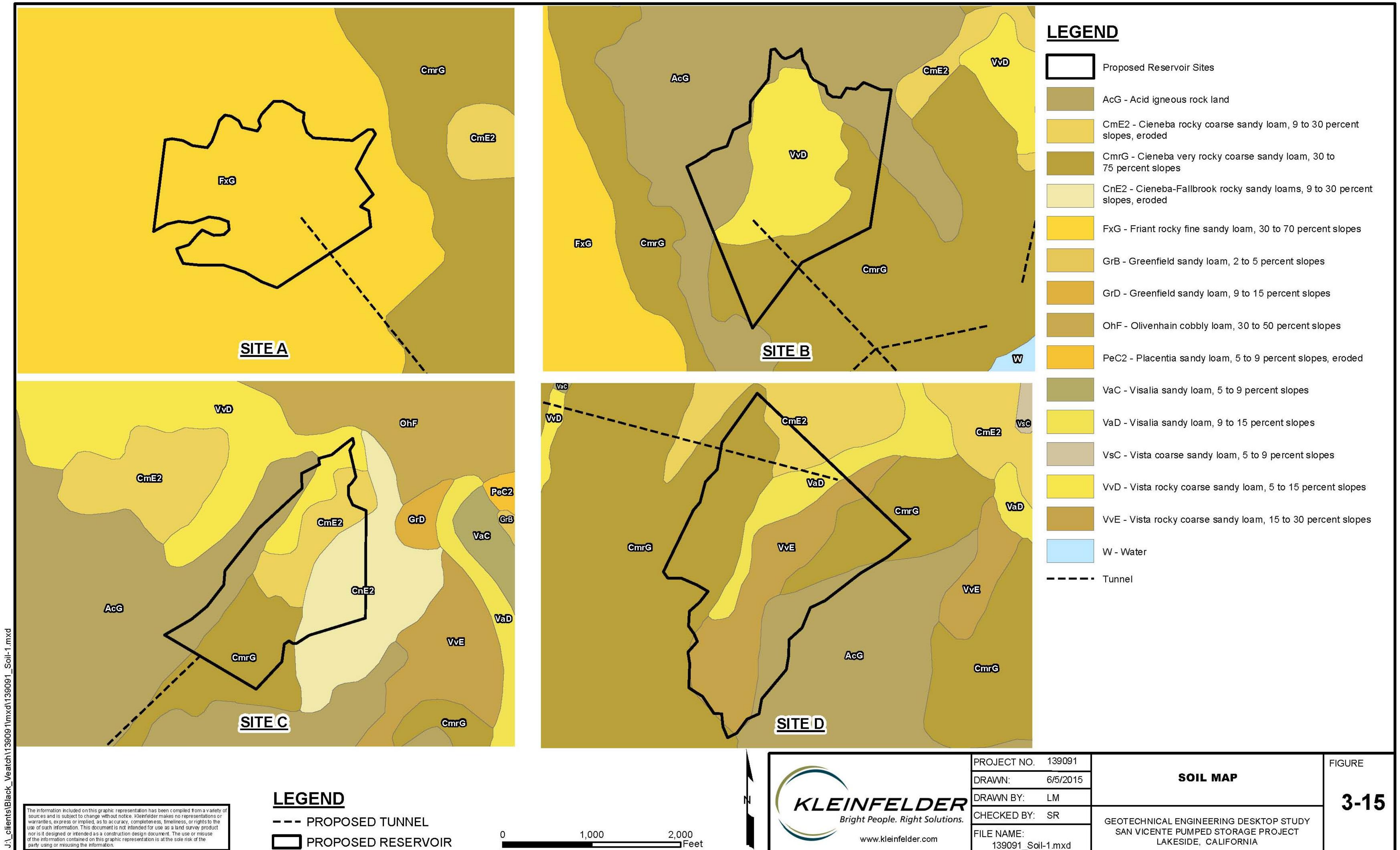


Figure 3-15 Soil Map



4 Upper Reservoir Screening Analysis

4.1 DESCRIPTION OF THE SCREENING PROCESS

A series of technical evaluations and feasibility studies have been performed to define both the project components and operational parameters for each alternative. Further refinement of these prior evaluations and studies were conducted to support the FERC PAD development and screening process. These technical evaluations and studies have confirmed that each upper reservoir alternative is feasible and will meet the project objectives for energy output and energy capacity. This screening process considers only the configurations that meet a minimum energy capacity of 500 MW and a minimum energy storage of 8 hours of generation, or 4,000 MW-hrs. It is recognized that further refinements to energy capacity and storage will be made as a result of future power marketing evaluations.

Project cost estimates based on the technical evaluations have also been prepared for each of the alternatives and are considered during this screening process to further weigh project feasibility. A rating system for both the screening criteria and the project costs are provided to compare and score each alternative for the purpose of identifying one or more preferred upper reservoir sites that may be carried forward for additional review.

4.2 SCREENING CRITERIA RATING SYSTEM

The rating system proposed for the initial screening of four possible upper reservoir sites includes evaluation criteria for assessing and comparing project related impacts resulting from construction and operation *(constructability, site dewatering, and access)*, impacts on land use *(recreation and land use, aesthetics, and land acquisition)*, and impacts on the surrounding environment *(geology and soil, water quality and water resources, biological resources, fish and aquatic resources, and cultural resources)*. The screening criteria are generally consistent with the project description information required for preparation of the FERC PAD.

The upper reservoir alternatives have been rated upon their ability to satisfy the project objectives using a rating system of 1 to 5, as shown the table below. The alternatives are evaluated individually and then compared on the basis of each screening criteria. Each criterion is weighted equally and the total rating for each upper reservoir alternative is a summation of the ratings for each evaluation criteria.

Table 4-1 Screening Criteria Rating System

RATING	DEFINITION
1	Satisfies project objectives with significant noted advantages
2	Satisfies project objectives with noted advantages
3	Satisfies project objectives
4	Satisfies project objectives with noted disadvantages
5	Satisfies project objectives with significant noted disadvantages

4.3 SCREENING EVALUATION

A description of each screening criterion along with the results and findings of the evaluation process are provided below. Key differences that support the rating given to each alignment are noted.

4.3.1 Construction and Operation

4.3.1.1 Constructability

A comparative analysis has been performed on the project components that are to be constructed at each upper reservoir site and across terrain with varying degrees of difficulty to connect the upper reservoir to the San Vicente Reservoir. The difficult construction areas consider the following:

- **Difficult soils/rock:** Based on a desktop geotechnical evaluation, soils that contain varying levels of granitic rock will have greater construction challenges and a potential for higher construction costs.
- **Tunneling:** Tunneling is required for the water conductors, power tunnel, and access to the powerhouse. Longer tunnels and tunnels though various soil interfaces pose greater risks and will encounter higher construction costs.
- **Areas with steep slopes:** Areas with steep slopes will result in a more difficult working environment and may require specialty construction equipment. Constructing both new permanent access and temporary construction access roads and the installation of power transmission facilities across these areas will result in higher construction costs.
- **Construction Activities:** The project will generate temporary and potentially significant traffic, noise, and dust related impacts in the general vicinity of the project site, the construction staging areas, and communities located along or near to designated haul routes. Time of use restrictions or other controls on construction activities that are imposed near to developed areas will result in higher construction costs.

Table 4-2 summarizes the key constructability findings for each alternative.

Table 4-2 Evaluation Criteria: Constructability

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A3	• The significantly longer tunnel and new access roads pose greater constructability concerns • Geology conditions are generally similar at the four sites	4
B3	• Shorter tunnel length reduces constructability concerns • Construction access is further from developed areas	2
C3	• Shorter tunnel length reduces constructability concerns • Location nearer to residential areas and tribal lands increase impacts on communities	3
D3	• Shorter tunnel length reduces constructability concerns • Location nearer to residential areas and tribal lands increase impacts on communities	3

4.3.1.2 Site Dewatering

Tunneling and open cut excavations in areas of high groundwater require dewatering. Areas with high groundwater levels, and potentially the facilities located below the water elevation in the San Vicente Reservoir, introduce additional construction costs. Construction of the inlet/outlet structure in the San Vicente Reservoir will require special construction techniques and development of a cofferdam system that will be unique to each inlet/outlet location. The extent of the cofferdam system is dependent on the permeability of the underlying soils and the distance from the shoreline to the inlet/outlet structure. Table 4-3 provides a summary of the findings related to dewatering at each alternative site.

Table 4-3 Evaluation Criteria: Site Dewatering

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• Longer portions of the tunnel are below the San Vicente Reservoir HWL, increasing dewatering concerns • Longer approach into San Vicente Reservoir increases cofferdam length	4
B3	• Shorter tunnel reach is below the San Vicente Reservoir HWL • Steep slopes at San Vicente Reservoir shoreline reduce cofferdam impacts	1
C3	• Shorter tunnel reach is below the San Vicente Reservoir HWL • Longest approach into San Vicente Reservoir shoreline increases cofferdam impacts	3
D3	• Longer portions of the tunnel are below the San Vicente Reservoir HWL, increasing dewatering concerns • Longer approach into San Vicente Reservoir increases cofferdam length	4

4.3.1.3 Access

Each upper reservoir site requires the development of both new roads and the improvement of existing unpaved roads. The new access roads will need to be developed through previously undisturbed areas to provide temporary access for construction of the project components and to provide permanent access to the powerhouse structure, lower reservoir intake structure, and the new upper reservoir site. More remote sites will require longer access road development and result in higher construction costs. Access roads for the power transmission facilities are not considered in the analysis of this criterion. Table 4-4 provides a summary of the access roads associated with each alternative.

Table 4-4 Evaluation Criteria: Access

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• Nearly 9 miles of access roads are required, including 4 miles of new roads	5
B3	• Requires 6.5 mile of access roads, including 5 miles of new access roads	4
C3	• Requires 5.5 miles of access roads, including 2 miles of new access roads	3
D3	• Close proximity to Wildcat Canyon Rd reduces total length of access roads to 3.5 miles, with 1.75 miles of new roads	1

4.3.2 Impacts on Land Use

4.3.2.1 Recreation and Land Use

The assessment of impacts related to existing recreational and land uses and future opportunities within or adjacent to the project boundary includes current and future recreation needs from existing state or regional plans; the use of piers, boat docks, landings, and other shoreline facilities on project lands and waters; and the impact of the project on lands located within or adjacent to areas designated for or under study for inclusion in specific land use. The project does not touch upon specific land use designations that include the National Wild and Scenic River system, state-protected river segments, the National Trails System or Wilderness Area, or regionally or nationally important recreation areas. As summarized in Table 4-5, the assessment is based on an estimate of land acquisitions through areas with S-80 zone designation (i.e., intended for recreation areas or areas with severe environmental constraints).

Table 4-5 Evaluation Criteria: Recreation and Land Use

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• Includes limited acquisitions in S-80 zone	1
B3	• Includes limited acquisitions in S-80 zone	1
C3	• Includes limited acquisitions in S-80 zone	1
D3	• Upper reservoir is located almost entirely with S-80 zone	5

4.3.2.2 Aesthetics

An assessment was made of the impacts related to the visual characteristics of the lands and waters affected by the project, including project facilities and features that may clash with the surrounding viewshed leading to such impacts on visual quality. Since site access and visual site lines were not available, the assessment is based on the distance from above grade features (dams, overhead power lines) to noted residential and commercial areas. Key findings are summarized in Table 4-6.

Table 4-6 Evaluation Criteria: Aesthetics

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• Project features are near to developed areas off Highway 67	3
B3	• This alternative is the furthest removed from developed areas	1
C3	• Project features are near to residential areas and Barona casino	4
D3	• Project features are near to residential areas and Barona casino	4

4.3.2.3 Land Acquisition

Estimates have been made of the permanent easements and fee property acquisitions required for the project. Easements that cross open spaces designations, recreational lands, or tribal lands are considered more difficult to acquire from both a cost and schedule perspective. As summarized in Table 4-7, alternatives with larger footprints for tunnels, reservoirs, and power infrastructure will also be less favorable.

Table 4-7 Evaluation Criteria: Land Acquisition

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• Requires the highest total acreage	4
B3	• Requires the least amount of total acreage	2
C3	• Total acreage required is only slightly more than Alternative B3	2
D3	• A significant portion of the total acreage required is within sensitive environmental and tribal lands	5

4.3.3 Impacts on the Surrounding Environment

4.3.3.1 Geology and Soils

A desktop assessment was made of the impacts on existing geology, topography, and soils within the proposed project and surrounding area, including impacts related to bedrock lithology, stratigraphy, structural features, glacial features, unconsolidated deposits, and mineral resources; impacts on soil types, erodability, and potential for mass soil movement; and impacts to reservoir shorelines and streambanks, including steepness, composition (bedrock and unconsolidated deposits), vegetative cover, existing erosion, mass soil movement, slumping, or other forms of instability. All four upper reservoir sites were found to have very similar geologic, soil and topographic conditions. Factors that may differentiate the sites include groundwater conditions and the nature of lineaments and contact features. A summary of key findings related to geology and soils is provided in Table 4-8.

Table 4-8 Evaluation Criteria: Geology and Soils

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• The longer tunnel poses increased potential for groundwater intrusion • A noted lineament crossing the site indicates a relationship to ground faulting	5
B3	• Three noted lineament features cross the site	3
C3	• One lineament feature crosses the site	2
D3	• Several lineament features cross the site	4

4.3.3.2 Water Quality/Water Resources

An assessment was made of the impacts to the water resources of the proposed project and surrounding area, including the quantity and quality of waters affected by the project, including the San Vicente Reservoir and tributaries thereto, impacts on reservoir drainage area, and adjustments made for evaporation, leakage, minimum flow releases, or other reductions in available flow. The assessment evaluated impacts on existing and proposed uses of project waters for domestic water supply; impacts on existing water rights and water rights applications potentially affecting or affected by the project; relevant water quality standards applicable to project waters; and project effects on seasonal variation of water quality data, including water temperature and dissolved oxygen at seasonal vertical profiles in the reservoir. The assessment was based on water quality reservoir modeling performed by the City to assess the impacts of pumped storage on the City's Pure Water Program. As summarized in Table 4-9, there were no discernible impacts to reservoir water quality resulting from the Project.

Table 4-9 Evaluation Criteria: Water Quality/Water Resources

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• There were no discernable impacts from the pumped storage project on reservoir water quality	3
B3	• There were no discernable impacts from the pumped storage project on reservoir water quality	3
C3	• There were no discernable impacts from the pumped storage project on reservoir water quality	3
D3	• There were no discernable impacts from the pumped storage project on reservoir water quality	3

4.3.3.3 Biological Resources

A preliminary assessment was made of the impacts on wildlife and botanical resources in the project vicinity, including impacts on floodplain, wetlands, riparian and littoral habitats in the project vicinity; impacts on plant and animal species (including invasive species) that use the wetland, littoral, and riparian habitat; upland habitats in the project vicinity, including the project's overhead power line transmission corridors or right-of-way, and a listing of plant and animal species that use the habitat(s); and impacts to temporal or special distribution of commercially, recreationally, or culturally important species including any listed rare, threatened, endangered, candidate, or special status species that may be present in the project vicinity. As summarized in Table 4-10, the current rating is based on total acres impacted by the upper reservoir, access roads and power transmission lines.

Table 4-10 Evaluation Criteria: Biological Resources

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• Project facilities impact the highest total acreage	3
B3	• Project facilities impact the least amount of total acreage	2
C3	• Total acreage impact is only slightly more than Alternative B3	2
D3	• Total acreage impact is slightly less than Alternative A3	3

4.3.3.4 Fish and Aquatic Resources

There are no discernable impacts on fish, essential fish habitat, the temporal and spatial distribution of fish and aquatic communities, and other aquatic resources (including invasive species) in the project vicinity resulting from the pumped storage project. Thus, all alternatives were assigned the same rating as summarized in Table 4-11.

Table 4-11 Evaluation Criteria: Fish and Aquatic Resources

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• There are no discernable impacts	3
B3	• There are no discernable impacts	3
C3	• There are no discernable impacts	3
D3	• There are no discernable impacts	3

4.3.3.5 Cultural Resources

An assessment was made of the impacts to any historic or archaeological site in the proposed project vicinity, with particular emphasis on sites or properties either listed in, or recommended by the State Historic Preservation Officer or Tribal Historic Preservation Officer for inclusion in the National Register of Historic Places. The impacts consider resources of Indian tribes that may attach religious and cultural significance to historic properties within the project boundary or in the project vicinity. Table 4-12 provides a summary of key findings related to cultural resources.

Table 4-12 Evaluation Criteria: Cultural Resources

ALTERNATIVE	SUMMARY OF KEY FINDINGS	RATING
A1	• The project is located far from tribal lands	1
B3	• The project is located far from tribal lands	1
C3	• Portions of the site access roads and upper reservoir are located within tribal lands	4
D3	• Portions of the dam, upper reservoir, tunnel and site access roads are located within tribal lands	5

4.4 COST EVALUATION

Cost opinions for each alternative have been prepared based on parametric cost models and the preliminary planning-level data collected and developed as part of this analysis. Allowances have been added to the estimated construction and procurement cost to provide for land acquisition, engineering and design, construction management, other administration costs, FERC permitting and licensing, and power marketing. To account for the preliminary nature of the project, a project contingency equal to 20 percent of the sum of the above estimated costs has also been added. Costs are rated on a separate scale as follows:

- 1 = lowest cost and less than 5 percent of lowest cost
- 2 = within 5 percent to 10 percent of lowest cost
- 3 = within 10 percent to 15 percent of lowest cost
- 4 = within 15 percent to 20 percent of lowest cost
- 5 = greater than 20 of lowest cost.

Table 4-13 summarizes the ratings assigned based on the cost opinion for each alternative.

Table 4-13 Evaluation Criteria: Cost Opinion

ALTERNATIVE	COST OPINION (PERCENT GREATER THAN LOWEST COST)	RATING
A1	$1,297,000,000 (3.4 percent increase)	1
B3	$1,324,000,000 (5.6 percent increase)	2
C3	$1,254,000,000 (lowest cost)	1
D3	$1,396,000,000 (11.3 percent increase)	3

4.5 RESULTS AND CONCLUSIONS

The overall results of the screening process are summarized as follows and shown in the table below.

- **Alternative B3** is considered the most favorable site due to its closer proximity to the San Vicente Reservoir and smaller footprint that results in a lower impact on the surrounding environment. The additional length of dam required for the Alternative B upper reservoir increases the cost over Alternatives A3 and C3.
- **Alternative C3** is rated as the second preferred site. This alternative also has a relatively small footprint with a similar lower impact on the surrounding environment. Alternative C3 is also the low cost alternative. However, a portion of the access roads and upper reservoir are within tribal lands, which may be a concern regarding land acquisition and cultural resources.
- **Alternative A1** is rated as the third most favorable site due to its significantly longer conveyance tunnel and resulting larger project footprint that increases impacts on the surrounding environment and increases construction difficulty. This alternative was also noted to have geologic concerns due to lineaments that may indicate faulting across the upper reservoir site.
- **Alternative D3** is rated as the least favorable site due to its impacts on recreation and land use and having portions of the upper reservoir, dam, tunnel and access roads located within tribal lands. Alternative D3 is also the high cost alternative because of the need for additional dam construction to meet the minimum power generation time of 8 hours.

Table 4-14 Overall Rating Summary

CRITERIA	ALTERNATIVE/RATING			
	A1	B3	C3	D3
Constructability	4	2	3	3
Site Dewatering	4	1	3	4
Access	5	4	3	1
Recreation and Land Use	1	1	1	5
Aesthetics	3	1	4	4
Land Acquisition	3	2	2	5
Geology and Soil	5	3	2	4
Water Quality/Water Resources	3	3	3	3
Biological Resources	3	2	2	3
Fish and Aquatic Resources	3	3	3	3
Cultural Resources	1	1	4	5
SUBTOTAL	**35**	**23**	**30**	**40**
Cost Opinion	1	2	1	3
TOTAL SCORE	**36**	**25**	**31**	**43**

5 Environmental Coordination and FERC PAD Assistance

5.1 DOCUMENT COORDINATION

This section describes the additional technical information that was provided to HMCG for the assessment of potential environmental concerns and preparation of the FERC PAD. The information was developed as part of the scope of services for this TM and from the Additional Studies TM. The soils and geology information that was provided for the FERC PAD is described in Section 3 of this TM.

The project description and technical information that was included in the FERC PAD is specific to Alternative Site B3, which is also referred to in the FERC PAD and the sections below as the Foster Canyon Site. Project description information for the three other upper reservoir sites was not included in the FERC PAD.

5.2 DESCRIPTION OF PROJECT FACILITIES

The proposed Project is a new facility that would utilize the existing San Vicente Reservoir as the lower reservoir and a new reservoir located approximately one mile to the north at the Foster Canyon site as the upper reservoir. San Vicente Reservoir is an impounding reservoir on San Vicente Creek with a maximum water surface area of 1,664 acres and a total storage capacity of 242,000 acre-feet. The new Foster Canyon upper reservoir is anticipated to have a maximum surface area of approximately 89 acres and a storage capacity of 7,842 acre-feet.

5.2.1 Upper Reservoir and Dam

The proposed upper reservoir at the Foster Canyon Site has a crest elevation of 1,520 feet and is developed through a series of roller compacted concrete (RCC) dams constructed on three sides of the reservoir. The maximum height of the RCC dams is 240 feet above existing ground, and the total crest length is 7,200 feet. The maximum water surface elevation in the upper reservoir will be approximately 1,510 feet, while the minimum water surface elevation will be approximately 1,417 feet. The total storage volume is 7,842 acre-feet, which includes 6,778 acre-feet of usable storage between the two operating levels and 1,064 acre-feet of dead storage below elevation 1,417 feet. The maximum depth of the upper reservoir at full pool is 113 feet.

5.2.2 Lower Reservoir and Dam

The existing lower San Vicente Reservoir and Dam was initially constructed in 1943 as a gravity concrete dam with a storage pool of 90,000 acre-feet. A project to raise the dam height by 117 feet was completed in 2014. The raised dam, which is constructed of RCC, is 337 feet above the existing ground and provides a total storage volume of 242,000 acre-feet. Crest length of the raised dam is 1,430 feet. Additionally, and as part of the dam raise project, a 42 foot tall, 675 foot long RCC saddle dam was constructed across a topographic low-point (saddle) on the reservoir rim approximately 2,000 feet west of the main dam. The maximum water surface elevation in the upper reservoir is 764 feet, while the minimum water surface elevation is 539 feet. The San Vicente Reservoir provides 236,772 acre-feet of usable storage between the two operating levels and 5,228 acre-feet of dead storage below elevation 539 feet. The maximum depth of the reservoir at normal full pool is 311 feet.

5.2.3 Inlet/Outlet Structures

Due to its steep side slopes, the lower reservoir includes a vertical inlet/outlet structure, shown on Figure 5-1 at the end of this section, located near the San Vicente Reservoir shoreline. The top of the inlet/outlet will be located below the minimum normal operating reservoir level at an elevation of 583 feet to avoid vortices and air entrainment. The upper reservoir will include a horizontal type inlet/outlet structure, shown on Figure 5-2 at the end of this section, with an invert elevation of 1,372 feet. Water would flow in both directions through the structures. Each inlet/outlet structure includes a 160-foot wide mouth and baffles to limit intake and discharge velocities to less than 1 foot per second (fps); a gate shaft and gate room to allow for isolation of the tailrace tunnel and powerhouse for maintenance; and a trash rack to limit debris from entering the powerhouse during pumping and generating modes. Additional parameters for each inlet/outlet structure are summarized in Tables 5-1 and 5-2 below.

Table 5-1 Lower Reservoir Inlet/Outlet Structure Parameters

PARAMETER	VALUE
Gate House Elev. (ft)	800
Structure Invert Elev. (ft)	583
Gate Shaft Height (ft)	242
Gate Shaft Diameter (ft)	40
Pumping Flow Rate, Max. (cfs)	7,280
Generating Flow Rate, Max. (cfs)	8,748
Approach Velocity (fps)	<1

Table 5-2 Upper Reservoir Inlet/Outlet Structure Parameters

PARAMETER	VALUE
Gate House Elev. (ft)	1,530
Structure Invert Elev. (ft)	1,372
Pumping Flow Rate, Max. (cfs)	7,280
Generating Flow Rate, Max. (cfs)	8,748
Approach Velocity (fps)	<1

5.2.4 Powerhouse Cavern

The underground powerhouse cavern will have a volume of approximately 131,000 cubic yards. Cavern dimensions are approximately 360 feet long by 83 feet wide. Cavern height will be approximately 119 feet. The powerhouse cavern will house four vertical, variable speed, single-stage, Francis-type reversible pump/turbine-motor/generator units. The turbines will each be rated for approximately 125 MW. Each pump/turbine will be directly coupled to a vertical shaft, three-phase, 60 hertz, alternating current synchronous motor/generator. In addition to the turbine units, a standby generator and step-up transformer will be provided. Additional equipment to be housed in the powerhouse cavern includes: upstream and downstream butterfly valves for unit isolation, maintenance bays with access to the pump/turbine pit, drainage pumps, cooling water strainers and pumps, compressor room and compressed air storage tanks, an oil treatment plant, a drainage gallery and sumps, access to the motor/generators, and auxiliary transformers.

5.2.5 Water Conductors

The water conductors consist of the power tunnel and tailrace tunnel and their associated bifurcations. The power tunnel, consisting of both shaft and tunnel segments, will extend between the upper inlet/outlet structure and the pump/turbine inlet valves. The power tunnel and its bifurcations will be steel lined. The tailrace tunnel will extend between the lower inlet/outlet structure and the pump/turbine draft tubes. The tailrace tunnel will be concrete lined. Tunnel alignments are shown on Figure 5-3 (located at the end of this section). Tunnel parameters are summarized in Table 5-3 below.

Table 5-3 Power and Tailrace Tunnel Parameters

PARAMETER	POWER TUNNEL	TAILRACE TUNNEL
Flow (cfs)	8,748	7,280
Diameter (ft)	21	25
Length (ft)	2,050	1,913
Excavation Volume (cy)	44,966	49,600

5.2.6 Access and Cable Tunnels

Equipment access to the underground powerhouse cavern will be provided by an access tunnel. A separate power cable/emergency exit tunnel will exit the powerhouse to the surface in a general direction toward the west. The access tunnel will connect the Project access road to the powerhouse cavern. This tunnel will generally slope at an 8 percent grade and will be a 23-feet wide by 20-feet tall horseshoe tunnel. The invert (road) will be concrete paved. The wall and roof will be exposed rock shotcrete and rock bolted as required for stability. Lighting and floor drainage will be provided. The cable/escape tunnel will be provided to carry the main power feed from the powerhouse to the surface substation. The tunnel will also serve as an emergency escape in the event the access tunnel is unsafe. The tunnel will slope up as required not to exceed 20 percent. The tunnel will be approximately 15-feet wide by 15-feet high. Tunnel alignments are shown on Figure 5-3. Additional tunnel parameters are summarized in Table 5-4 below.

Table 5-4 Access and Cable Tunnel Parameters

PARAMETER	ACCESS TUNNEL	CABLE TUNNEL
Portal Elevation (ft)	800	800
Grade (%)	8	n/a
Length (ft)	3,430	1,372
Height (ft)	20	15
Floor Width (ft)	23	15
Cross Sectional Area (sf)	438	201
Excavation Volume (cy)	55,602	10,205

5.2.7 Capacity and Energy Production

Annual generation for the four 125 MW units will average 1,022 GWh, assuming the daily energy storage of 4,000 MWh and a 0.70 plant capacity factor.

5.2.8 FERC Project Boundary

A FERC project boundary was established to define the limits of FERC's jurisdiction over the project facilities. The FERC project boundary is shown on Figure 5-3 (located at the end of this section).

5.3 OPERATIONS

Hydroelectric pumped storage is a reliable and cost-effective technology that enables utilities to store electrical energy produced during surplus generation and at periods of low demand and utilize that stored energy during periods of high demand and for transmission grid operations. Water will be pumped from the lower reservoir to the upper reservoir during periods of surplus power generation and/or low electrical demand. The water placed in the upper reservoir represents stored energy that can be used to meet capacity needs during periods of high demand as the water is passed through a hydraulic turbine from the upper to lower reservoir. The cycle is then repeated to balance demands on the regional or local power grid. The Project is also expected to participate in the ancillary services market and provide flexible generating capacity to maintain grid stability resulting from the increase in intermittent renewable energy generation.

The pumping and generating will be accomplished with the same equipment, with the turbine being used as a pump by reversing its direction of rotation, and the generator being used as a motor by reversing the flow of electrical current. The units will be vertical, variable speed, single-stage, Francis reversible pump/turbine-motor/generator units to be used for both pumping and generation. The proposed Project is configured for a nominal 500 MW through the use of four 125 MW pump-turbine units. The Project is anticipated to be operated on a daily basis and to provide a minimum energy storage of eight hours, or 4,000 MWh.

Storage volumes in the San Vicente Reservoir will dictate seasonal and annual operating parameters for the project. As illustrated in Figure 5-4 (located at the end of this section), the San Vicente Reservoir serves multiple purposes and its total storage capacity is allocated to several operating pools, including emergency pools, carryover or drought storage pools, and daily operating pools. The Project can be operated when the water level in San Vicente Reservoir varies between elevation 764 feet (full pool elevation) and 618 feet (emergency pool elevation). The Project will not generate when the water level is above full pool (spillway elevation) or when the water level is below the emergency pool elevation.

5.4 WATER RESOURCES

5.4.1 Physical Description

The Project is located on San Vicente Creek, which has a drainage basin of approximately 74 acres. Surface flows from the creek are impounded by the San Vicente Reservoir and Dam, with the rights to these surface flows belonging to the City of San Diego. The City uses these flows to meet a portion of their domestic water demands. Purchased imported water would be used for the initial fill of the Project and to provide make up water for operations. The Project would operate as a closed-loop system as essentially no surface waters from San Vicente Creek are released downstream of the San Vicente Dam. Figure 5-5 (located at the end of this section) shows the watersheds located within the vicinity of the Project.

5.4.2 Existing and Proposed Water Use

Source water for the initial fill of the upper reservoir and water conductors, as well as make up water for project operations resulting from evaporation and minor seepage losses, will come from San Vicente Reservoir. As noted above, San Vicente Reservoir currently receives the vast majority of its stored water as imported supplies, with a much smaller volume entering the reservoir as local runoff from the San Vicente Creek watershed. Water quality within the San Vicente Reservoir and the proposed upper reservoir will therefore be dependent on the quality of imported supplies and reservoir operations.

Additionally, the City of San Diego is proposing to develop a new local recycled water supply that would blend purified water (advanced treated municipal recycled water) with imported supplies in San Vicente Reservoir. The City's Pure Water project would utilize the San Vicente Reservoir for reservoir augmentation and develop an initial 15 million gallons per day (MGD) of purified water by approximately 2023, with an ultimate goal of producing and delivering 68 MGD to the reservoir by 2035. To determine the effect on water quality within the San Vicente Reservoir resulting from operation of both the proposed Pure Water project and the Pumped Storage Project, a computer simulation modeling analysis was performed. This analysis considered specific pumped storage operating scenarios, including various purified water reservoir inflow rates and extended drought conditions.

5.4.3 Water Quality

Water quality of imported supplies is monitored by the Metropolitan Water District of Southern California (MWDSC). Source waters used by MWDSC include the Colorado River and imported supplies from Northern California through the Sacramento-San Joaquin Delta via the State Water Project. MWDSC publishes an Annual Drinking Water Quality Report that provides test results for almost 400 constituents and performs water quality tests on samples taken throughout its distribution system. Specific procedures are followed if any contaminant level exceeds Federal water quality standards. The City of San Diego measures and monitors water quality in the reservoir on a weekly basis. Reservoir operations also allow selective withdrawals at the best water quality levels within the reservoir to account for seasonal stratification.

The results and conclusions from the modeling analysis and impacts of pumped storage operations on the San Vicente Reservoir indicate no adverse effects on water quality. These results are summarized below.

5.4.3.1 Effects on Steady State Water Quality

Pumped storage operations will provide a significant reduction in the vertical stratification of the reservoir, resulting in an oxygenated hypolimnion (the cooler, bottom layer of water in a thermally stratified lake). The increased oxygen levels at the sediment interface are predicted to result in lower nutrient recycling from sediments. Further benefits include delayed timing of algal productivity, possibly due to cooling effects at the water surface induced by mixing, and a decrease in the yearly average algal levels along with a corresponding increase in water clarity.

5.4.3.2 Effects on Water Quality during Startup

Initial startup operations of the Project may result in scouring of sediments in the vicinity of the inlet/outlet structure, producing an increase in turbidity levels. These higher turbidity episodes are expected to decline with time as sediments are transported elsewhere. Startup operations will be performed to avoid periods when the reservoir is stratified and the hypolimnion is anoxic to avoid a rapid transfer of hydrogen sulfide and other substances from the hypolimnion that could otherwise result in adverse effects on fish and recreation.

5.4.3.3 Effects on Water Operation and Recreation

Due to destratification by the pumped storage project, water quality across the water column will be somewhat homogeneous. Potential water quality excursions in the reservoir will be mixed over the entire reservoir at various depths. If pumped storage is continuously operated, using different outlet ports spaced vertically along the existing reservoir outlet tower will result in small differences in water quality, thus limiting effects of selective withdrawal from the multi-level outlet structure.

Figure 5-1 San Vicente Reservoir Vertical - Type Inlet/Outlet Structure

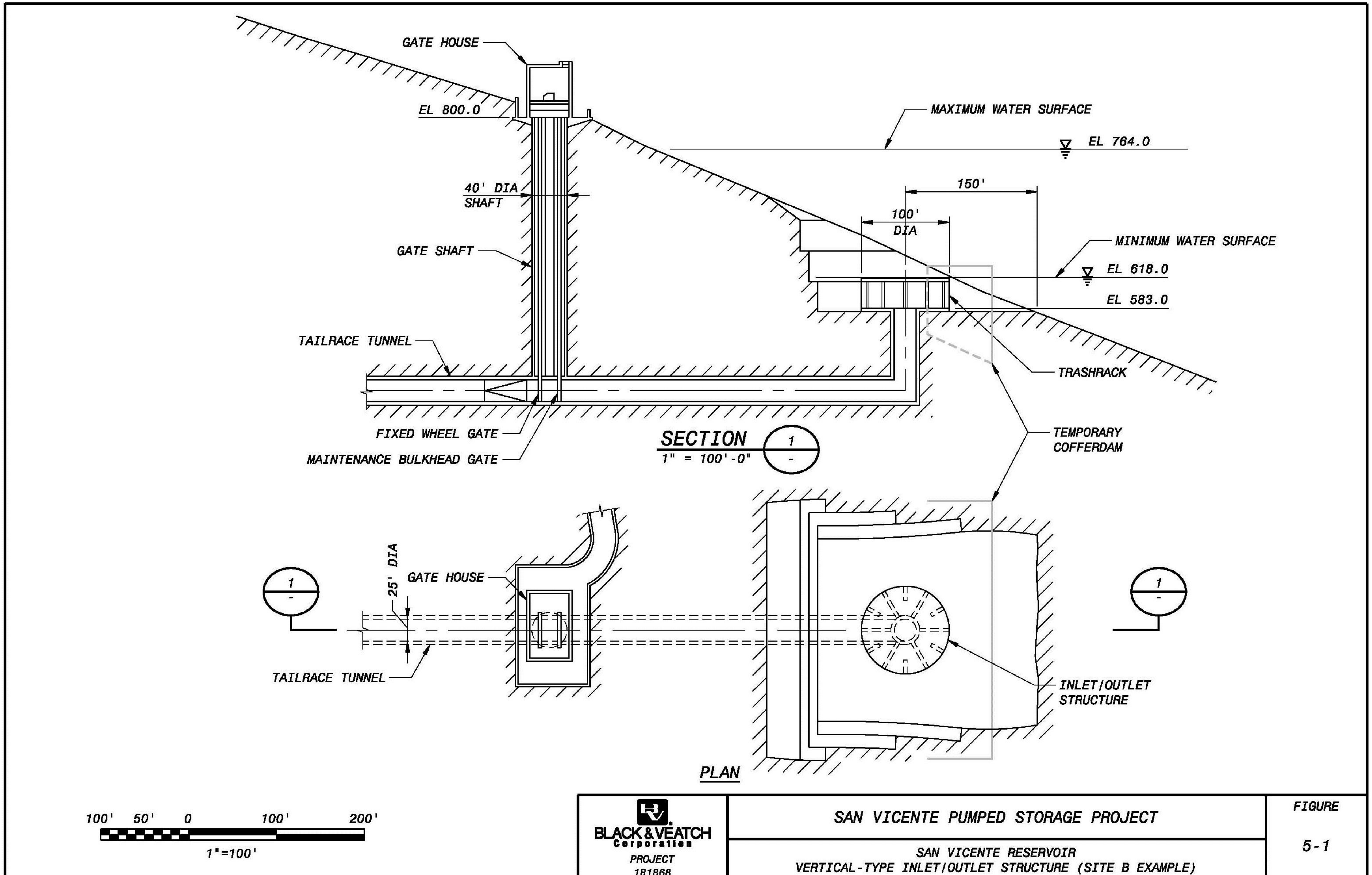


Figure 5-2 San Vicente Reservoir Horizontal – Type Inlet/Outlet Structure

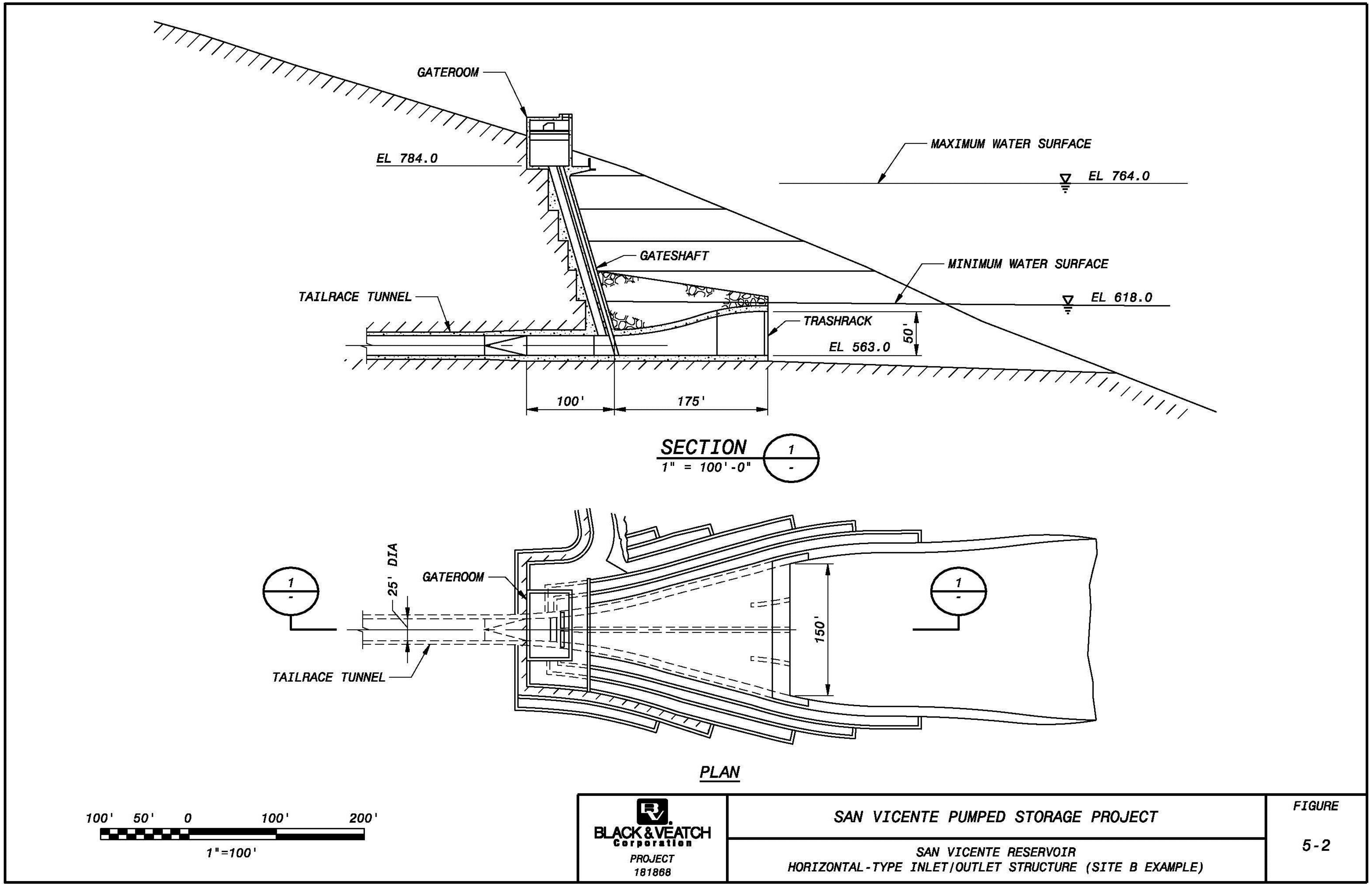


Figure 5-3 Tunnel Alignments and FERC Boundary Map

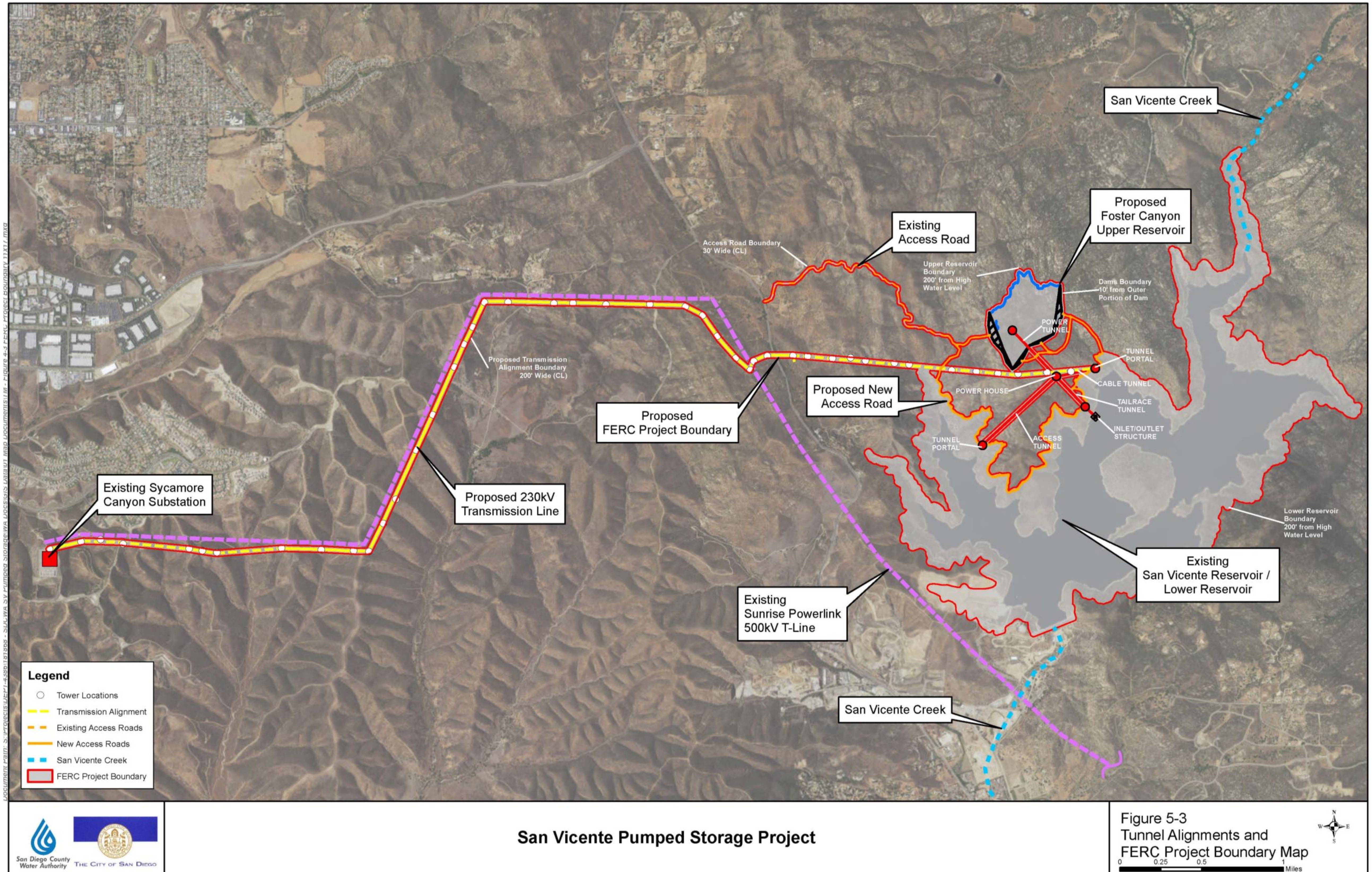


Figure 5-4 San Vicente Reservoir Storage Levels

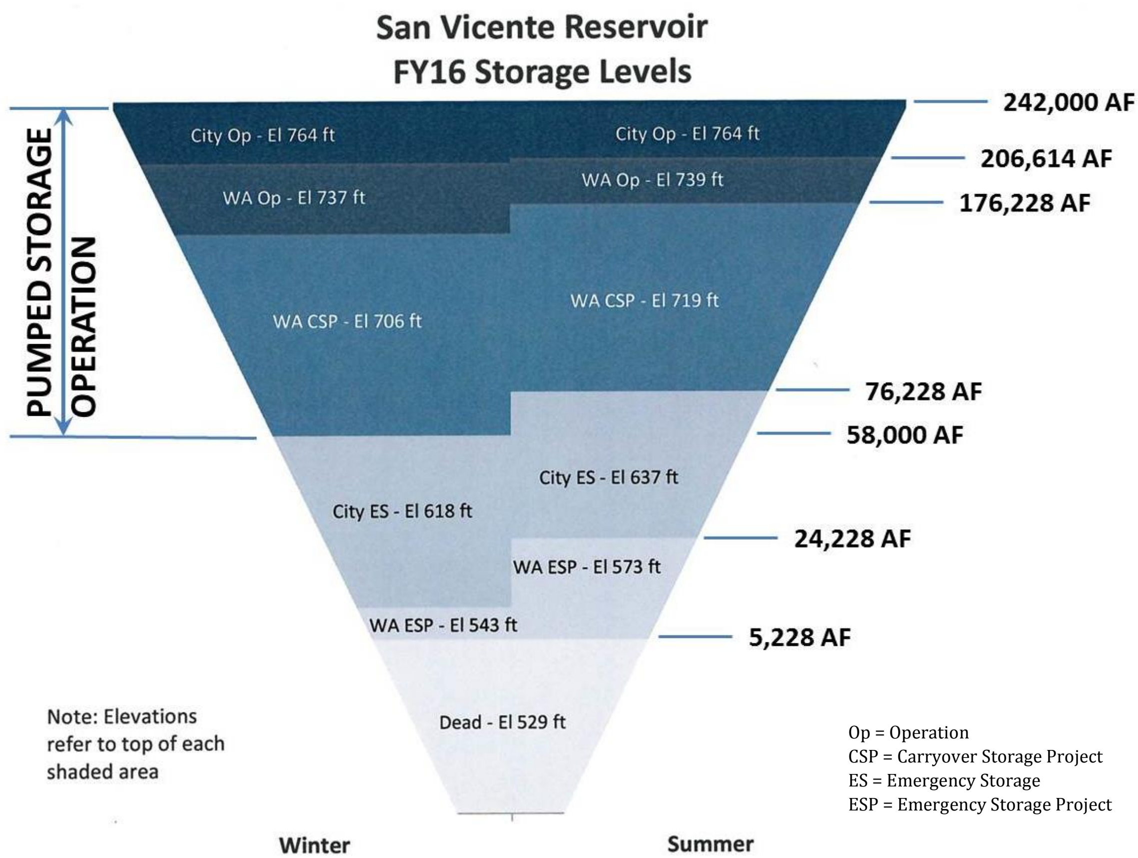


Figure 5-5 Watershed Boundary Map