DOCKET
09-AFC-9
DATE JUN 08 2010
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June 8, 2010

Eric Solorio
Project Manager
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

RE: Ridgecrest Solar Power Project (RSPP), Docket No. 09-AFC-9, Report of Waste Discharge (ROWD) Submitted to the Lahontan Regional Water Quality Control Board (RWQCB)

Dear Mr. Solorio:

Please find the Report of Waste Discharge (ROWD) provided to the Lahontan RWQCB for the evaporation ponds at the RSPP site.

This has been docketed in accordance with CEC requirements.

If you have any questions, please feel free to contact me at 510-809-4662 (office) or 949-433-4049 (cell).

Sincerely,

Billy Owens
Director, Project Development

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
1516 NINTH STREET, SACRAMENTO, CA 95814
1-800-822-6228 – WWW.ENERGY.CA.GOV

APPLICATION FOR CERTIFICATION For the *RIDGECREST SOLAR POWER PROJECT*

Docket No. 09-AFC-9

PROOF OF SERVICE (Revised 5/12/2010)

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DECLARATION OF SERVICE

I, Elizabeth Copley, declare that on June 8, 2010, I served and filed copies of the attached Ridgecrest Solar Power Project (Docket No. 09-AFC-9) Report of Waste Discharge. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at:

[http://www.energy.ca.gov/sitingcases/solar_millennium_ridgecrest].

The documents have been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(C*heck all that Apply*)

For service to all other parties:

_ sent electronically to all email addresses on the Proof of Service list;

_ by personal delivery;

X by delivering on this date, for mailing with the United States Postal Service with first-class postage thereon fully prepaid, to the name and address of the person served, for mailing that same day in the ordinary course of business; that the envelope was sealed and placed for collection and mailing on that date to those addresses **NOT** marked "email preferred."

AND

For filing with the Energy Commission:

X sending an original paper copy and one electronic copy, mailed and emailed Respectively, to the address below (preferred method);

OR

__ depositing in the mail an original and 12 paper copies, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 09-AFC-9
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct.

AECOM Environment

Prepared for:
Ridgecrest Solar I, LLC
Berkeley, CA

Prepared by:
AECOM
Camarillo, CA
60139696-5450
June 2001

APPLICATION/REPORT OF WASTE DISCHARGE

Proposed Evaporation Ponds

Ridgecrest Solar Power Project
Kern County, California

June 4, 2010

AECOM Environment

Prepared for:
Ridgecrest Solar I, LLC
Berkeley, CA

Prepared by:
AECOM
Camarillo, CA
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APPLICATION/REPORT OF WASTE DISCHARGE

Proposed Evaporation Ponds

Ridgecrest Solar Power Project
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June 4, 2010

Prepared by Carmen Caceres-Schnell, PG

Reviewed by Bob Wilson

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List of Acronyms

°F	degrees Fahrenheit
AC	Alternating Current
AFC	Application of Certification
ALR	Action Leakage Rate
AP	Alquist Priolo
ASTM	American Society for Testing and Materials
bgs	below ground surface
BMP	Best Management Practices
CAP	Corrective Action Plan
CBC	California Building Code
CCR	California Code of Regulations
CEC	California Energy Commission
CFR	Code of Federal Regulation
CPM	Compliance Project Manager
cm/sec	centimeters per second
CQA	Construction Quality Assurance
CWC	California Water Code
DESCP	Drainage, Erosion, and Sediment Control Plan
GCL	Geosynthectic Clay Line
GMN	Groundwater Monitoring Network
gpm	gallons per minute (rate)
HDPE	High Density Polyethylene
LDRS	leak detection and removal system
LEA	Local Environmental Agency
LTU	Land Treatment Unit
mgd	million gallons per day
PPE	Personal Protective Equipment
QA	quality assurance
QC	quality control
RSI	Ridgecrest Solar I
RSPP	Ridgecrest Solar Power Project
RO	Reverse Osmosis
ROWD	Report of Waste Discharge

RWQCB	Regional Water Quality Control Board
SSG	solar steam generator
STLC	Soluble Threshold Limit Concentration
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resource Control Board
TCLP	Toxicity Threshold Limit Concentration
TDS	Total dissolved Solids
TTLC	Total Threshold Limit Concentration
UBC	Uniform Building Code
IWVWD	Indian Wells Valley Water District
ft/d	feet per day
WDR	Waste Discharge Requirement
ft/d^2	square feet per day
af	acre feet
CDFG	California Department of Fish and Game
USFWS	United States Fish and Wildlife Services

1.0 Application Form

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

State of California
Regional Water Quality Control Board

APPLICATION/REPORT OF WASTE DISCHARGE
GENERAL INFORMATION FORM FOR
WASTE DISCHARGE REQUIREMENTS OR NPDES PERMIT

I. FACILITY INFORMATION

A. Facility:

Name: Ridgecrest Solar Power Plant			
Address: Southwest of US Highway 395 & approximately 4.5 miles southwest of the City of Ridgecrest			
City: Ridgecrest	County: Kern	State: CA	Zip Code: 92226
Contact Person: Billy Owens		Telephone Number: (510) 809-4662	

B. Facility Owner:

Name: Ridgecrest Solar I, LLC			Owner Type (Check One) 1. ☐ Individual 2. ☐ Corporation
Address: 1625 Shattuck Avenue Suite 270			3. ☐ Governmental Agency 4. ☐ Partnership
City: Berkeley	State: CA	Zip Code: 94709-1611	5. ☑ Other: Limited Liability Co.
Contact Person: Billy Owens		Telephone Number: (510) 809-4662	Federal Tax ID: 26-2611825

C. Facility Operator (The agency or business, not the person):

Name: Ridgecrest Solar I, LLC			Operator Type (Check One) 1. ☐ Individual 2. ☐ Corporation
Address: 1625 Shattuck Avenue Suite 270			3. ☐ Governmental Agency 4. ☐ Partnership
City: Berkeley	State: CA	Zip Code: 94709-1611	5. ☑ Other: Limited Liability Co.
Contact Person: Billy Owens		Telephone Number: (510) 809-4662	

D. Owner of the Land:

Name: Bureau of Land Management			Owner Type (Check One) 1. ☐ Individual 2. ☐ Corporation
Address: 300 S. Richmond Road			3. ☑ Governmental Agency 4. ☐ Partnership
City: Ridgecrest	State: CA	Zip Code: 93555	5. ☐ Other:
Contact Person: Hector Villalobos		Telephone Number: (760) 384-5405	

E. Address Where Legal Notice May Be Served:

Address: 1625 Shattuck Avenue Suite 270		
City: Berkeley	State: CA	Zip Code: 94709-1611
Contact Person: Billy Owens		Telephone Number: (510) 809-4662

F. Billing Address:

Address: 1625 Shattuck Avenue Suite 270		
City: Berkeley	State: CA	Zip Code: 94709-1611
Contact Person: Billy Owens		Telephone Number: (510) 809-4662

Form 200 (6/97)

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CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

State of California
Regional Water Quality Control Board

APPLICATION/REPORT OF WASTE DISCHARGE
GENERAL INFORMATION FORM FOR
WASTE DISCHARGE REQUIREMENTS OR NPDES PERMIT

II. TYPE OF DISCHARGE

Check Type of Discharge(s) Described in this Application (A or B):

☑ **A. WASTE DISCHARGE TO LAND** ☐ **B. WASTE DISCHARGE TO SURFACE WATER**

Check all that apply:

☐ Domestic/Municipal Wastewater Treatment and Disposal	☐ Animal Waste Solids	☐ Animal or Aquacultural Wastewater
☐ Cooling Water	☐ Land Treatment Unit	☐ Biosolids/Residual
☐ Mining	☐ Dredge Material Disposal	☐ Hazardous Waste (see instructions)
☐ Waste Pile	☑ Surface Impoundment	☐ Landfill (see instructions)
☐ Wastewater Reclamation	☑ Industrial Process Wastewate	☐ Storm Water
☐ Other, please describe:		

III. LOCATION OF THE FACILITY

Describe the physical location of the facility.

1. Assessor's Parcel Number(s)	2. Latitude	3. Longitude
Facility:	Facility: 35 33' 21"	Facility: 117 43' 59"
Discharge Point:	Discharge Point:	Discharge Point:

IV. REASON FOR FILING

☑ New Discharge or Facility	☐ Changes in Ownership/Operator (see instructions)
☐ Change in Design or Operation	☐ Waste Discharge Requirements Update or NPDES Permit Reissuance
☐ Change in Quantity/Type of Discharge	☐ Other:

V. CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Name of Lead Agency: California Energy Commission

Has a public agency determined that the proposed project is exempt from CEQA? ☐ Yes ☑ No

If Yes, state the basis for the exemption and the name of the agency supplying the exemption on the line below.
Basis for Exemption/Agency:

Has a "Notice of Determination" been filed under CEQA? ☐ Yes ☑ No

If Yes, enclose a copy of the CEQA document, Environmental Impact Report, or Negative Declaration. If no, identify the expected type of CEQA document and expected date of completion.

Expected CEQA Documents:

☐ **EIR** ☐ **Negative Declaration** **Expected CEQA Completion Date:**

Form 200 (6/97)

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CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

State of California
Regional Water Quality Control Board

APPLICATION/REPORT OF WASTE DISCHARGE
GENERAL INFORMATION FORM FOR
WASTE DISCHARGE REQUIREMENTS OR NPDES PERMIT

VI. OTHER REQUIRED INFORMATION

Please provide a COMPLETE characterization of your discharge. A complete characterization includes, but is not limited to, design and actual flows, a list of constituents and the discharge concentration of each constituent, a list of other appropriate waste discharge characteristics, a description and schematic drawing of all treatment processes, a description of any Best Management Practices (BMPs) used, and a description of disposal methods.

Also include a site map showing the location of the facility and, if you are submitting this application for an NPDES permit, identify the surface water to which you propose to discharge. Please try to limit your maps to a scale of 1:24,000 (7.5' USGS Quadrangle) or a street map, if more appropriate.

VII. OTHER

Attach additional sheets to explain any responses which need clarification. List attachments with titles and dates below:

See Attached Document

You will be notified by a representative of the RWQCB within 30 days of receipt of your application. The notice will state if your application is complete or if there is additional information you must submit to complete your Application/Report of Waste Discharge, pursuant to Division 7, Section 13260 of the California Water Code.

VIII. CERTIFICATION

"I certify under penalty of law that this document, including all attachments and supplemental information, were prepared under my direction and supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

Print Name: Ray Dracker Title: Sr. Vice President

Signature: Raymond Jr Dracker Date: June 3 2010

FOR OFFICE USE ONLY

Date Form 200 Received:	Letter to Discharger:	Fee Amount Received:	Check #:

Form 200 (6/97)

2.0 Introduction

This Report of Waste Discharge (ROWD) is presented to the California Regional Water Quality Control Board – Lahontan Basin Region (RWQCB) for two proposed evaporation ponds at the Ridgecrest Solar Power Project (RSPP or Project) in Kern County, California. The Project is proposed by Ridgecrest Solar I, LLC (RSI) a wholly owned subsidiary of Solar Millennium, LLC. The Project is a concentrating solar electric generating facility proposed on an approximately 3,995-acre site located in the high northern Mojave Desert in northeastern Kern County, California, about 5 miles southwest of the City of Ridgecrest, California. RSI proposes to use evaporation ponds as part of the Project **(Figure 1)**. The evaporation ponds are the facilities that will receive and store wastewater from operations at the Project.

It is RSI's understanding that the RWQCB will issue Waste Discharge Requirements (WDR) to the California Energy Commission (CEC) for the Project. The CEC, pursuant to its authority under State law (Warren-Alquist Act), will issue its permit/certification (and act as California Environmental Quality Act lead agency) for the Project in lieu of. However, the RWQCB will go through the formal process of issuing WDRs on a separate schedule from the CEC certification. Under the Warren-Alquist Act, and Governor's Executive Order S-14-08, the CEC has the authority to streamline permitting for renewable energy generation facilities. The CEC implements an "in lieu of" permit process by incorporating the regulatory requirements and conditions of the various local and State agencies in its certification process.

It is also RSI's understanding that, all necessary State and local permits for this Project, including those permits typically issued by the RWQCB are issued to the applicant through the CEC certification process. This document is provided to the RWQCB to allow for input and make sure that CEC conditions of certification contain all substantive requirements that the RWQCB would otherwise have put into the WDRs.

To support the formulation of those substantive requirements, RSI is submitting the necessary information required for the RWQCB to support preparation of conditions of certification and issue what would be draft WDRs under other circumstances. The information has been provided in a ROWD format, including an application, and complies fully with the requirements set forth under the California Code of Regulation (CCR) and California Water Code (CWC) for non-hazardous evaporation ponds. This ROWD application will also provide full compliance with the requirements of the Porter-Cologne Water Quality Control Act and relevant regulations established under the CWC. The Project will not cause or contribute to an exceedance of water quality standards established for surface water and groundwater under the Lahontan Basin Plan. An analysis showing compliance with the RWQCB anti-degradation objective is provided in **Appendix A**.

2.1 Purpose

RSI is proposing to construct, own, and operate the RSPP, which will utilize a total of two evaporation ponds for the Project, to receive and store wastewater from operations. Each evaporation pond will be four acres in size for a total of 8 acres for the entire Project. This application fulfills the regulatory requirements to obtain the needed approvals for the evaporation ponds. An application for the Land Treatment Unit (LTUs) was previously submitted in January 2010 and therefore; this application does not discuss the Project's LTUs.

The septic systems and leach fields for the RSPP are currently being designed and a separate ROWD will be prepared and submitted once the design of the systems are complete.

2.2 Project Description

The Project will have a nominal electrical output of 250 megawatts, consisting of one Unit **(Figure 2)**. Commercial operation of Unit #1 is expected to commence by the third quarter of 2013, subject to timing of regulatory approvals and RSI achievement of Project equipment procurement and construction milestones. The solar thermal technology will provide 100 percent of the power generated by the Project; no supplementary energy source (e.g., natural gas to generate electricity at night) is proposed to be used for electric energy production. The Project will utilize an auxiliary boiler fueled by propane to reduce startup time and for heat transfer fluid freeze protection. The Project will also have one electric and one backup diesel-fueled fire water pump for fire protection.

The Project proposes to use a dry cooling condenser for power plant cooling. Water for the cooling tower makeup, process water makeup, and other industrial uses such as mirror washing will be supplied by the local municipal water district via a new pipeline. This source will also be used to supply water for employee use (e.g., drinking, showers, sinks, and toilets). Water received from the Indian Wells Valley Water District (IWVWD) will meet the requirements of the California Department of Health Services for potable water supplies and will not require further treatment for this purpose. Power cycle makeup, mirror washing water, and cooling of ancillary equipment will require on-site treatment for reduction of dissolved solids, and this treatment varies according to the quality required for each of these uses. A sanitary septic system and on-site leach field will be used to dispose of sanitary wastewater.

Water used for plant processes will be pumped directly to a softener treatment unit. The treated water from the softener will be stored in a 1,500,000 gallon treated water storage tank for use in the auxiliary cooling tower process. Raw water and pre-treated water are used to supply various plant needs, including cooling tower circulating water, solar steam generator (SSG) makeup water (after further treatment by demineralization), and various plant service, sanitary and potable water needs. All these water streams eventually discharge into the high-pH reverse osmosis (RO) system and then to the evaporation ponds.

The power generation cycle will not produce cooling tower blow down because the Project will be dry cooled. A small auxiliary cooling tower will generate a small amount of blow down, which will be reused on site. No off-site backup cooling water supply is planned at this time.

A sanitary septic system and on-site leach field will be used to dispose of sanitary wastewater and will be permitted through the Kern County. Based on a current estimate of 2,700 gallons of sanitary wastewater production per day, a total leach field area of approximately 5,500 square feet will be required. It is expected that the leach fields will satisfy the needs of the Project for its entire service life. There is no process or operational wastewaters that will be connected to the septic systems and leach fields. Details of the septic systems and leach fields will be provided in a separate ROWD submittal.

Discharge into the on-site evaporation ponds is from one primary process source, which is the high-pH RO system.

The ponds are sized to provide sufficient evaporative capacity to dispose of the anticipated wastewater stream of 11 gallons per minute (gpm), to provide one foot of residue storage, and to allow for one pond per unit to be taken out of service for up to approximately one year for cleaning, potential future maintenance, and repair without impacting the operation of the plant.

The ROWD submitted for the LTUs at the RSPP was prepared prior to the addition of the evaporation ponds at the site; therefore, the LTU ROWD states that stormwater that collects in the LTUs will be analyzed and disposed of at the appropriate facility. This procedure will remain in place and no stormwater that collects in the LTU will be placed into the evaporation ponds.

The estimated Project life is 30 years. Personnel will staff the Project 24 hours per day/7 days per week. Even when the Project is not operating, personnel will be present as necessary for maintenance, to prepare the Project for startup, and/or for site security.

3.0 Physical Setting

3.1 Site Location

The Project site is located southwest of U.S. Highway 395 and approximately 5 miles southwest of the City of Ridgecrest, California in northeastern Kern County **(Figure 1)**. The Applicant-owned facilities will be entirely on public land, Bureau of Land Management Right of Way # CACA 49016, in Township 28 South, Range 39 East and Township 27 South, Range 39 East. Ridgecrest is at the southern boundary of the northernmost of two discrete sections of China Lake Naval Air Weapons Station.

3.2 Floodplain

The Project site is located in the Indian Wells Valley in the southern end of the Basin and Range province. The valley is east of the Sierra Nevada, south of the Caso range, north of the El Paso Mountains, and the west of the Argus Range. Topography at the RSPP site slopes gently away from the El Paso Mountains from the south to the north-northwest across the site **(Figure 3)**. The topography shows an average slope of about one foot in 80 feet (1.2 percent) on the west side of the central drainage (El Paso Wash) crossing the Project site; there are steeper grades east of the El Paso Wash on the Project site. Grades of 1.5 percent to 2.3 percent to the north and northwest are measured from an unnamed topographic high on the eastern boundary of the Project site.

Surface water in the Indian Wells Valley drains from the surrounding mountains toward China Lake just north of Ridgecrest, a dry lake or playa, which is located approximately 12 miles northeast of the RSPP site. There are no perennial surface water bodies in Indian Wells Valley. During wet years, some surface flow enters the valley through the Little Lake Gap. The major watercourse in the Project area is El Paso Wash which drains approximately 20 square miles from the El Paso Mountains and exits the mountains to the south of the site.

According to the Federal Emergency Management Agency (2006) flood insurance rate map, the Project Site contains areas predisposed for minimal flooding and areas within the 100-year flood zone. The 100-year flood zones on site follows the trend of the El Paso Wash and other unnamed drainages through the Project site **(Figure 3).**

The proposed solar field improvements will not change the existing off-site drainage patterns. The El Paso Wash and an unnamed wash on the west will not be altered as a result of the Project. Storm Water Pollution Prevention Plans (SWPPPs) and a CEC-mandated Drainage, Erosion, and Sediment Control Plan (DESCP) were provided in the September 2009 RSPP Application for Certification (AFC), and contain Best Management Practices (BMPs) that will be implemented to avoid significant drainage/storm water runoff and water quality impacts to surface waters.

3.3 Climatology

The Project site is located in the Mojave Desert, which is classified as a “high desert”. It is a transition between the “hot” Sonoran Desert to the south and the “cold” Great Basin Desert to the north. Characteristic of a desert climate, the Mojave Desert has extreme daily temperature changes, low annual precipitation **(Figure 4)**, strong seasonal winds, and mostly clear skies. Evaporation rates tend to be higher than precipitation rates even in the wettest months, which last from November to March.

The area is characterized by very hot summer temperatures, with the mean maximum temperatures in July and August exceeding 100 degrees Fahrenheit (°F). Winter temperatures are more moderate, with mean maximum temperatures in the 60s and lows in the 30s. Minimum temperatures below freezing (32°F) occur on an average of about one day per year. **Table 1** shows the site weather data based on the gauging station at Inyokern (Station 044278). The Ridgecrest area receives less than 5 inches of rainfall per year. The majority of the rainfall occurs during November and March, but rainfall during the late summer is not uncommon. There is, however, a summer thunderstorm season from July to September with violent heavy precipitation that occasionally produces flash flooding.

Based on the data from the National Oceanic and Atmospheric Administration Atlas Precipitation Frequency Data Server, 24-hour design storm precipitation depth is as follows:

- 1.10 inches for the 2-year, 24-hour storm event;
- 1.97 inches for the 10-year, 24-hour storm event; and
- 3.25 inches for the 100-year, 24-hour storm event.

Table 2 shows the evaporation and precipitation data assumed for the site. The average annual precipitation for the Project area is shown on **Figure 4**. The storm conveyance system is designed to contain the 100-year, 24-hour storm event.

The most significant large-scale phenomena affecting air quality in the Project area are the transport winds from the southwest. These winds are responsible for bringing ozone and other pollutants through the Cajon Pass from the Los Angeles Basin. A wind rose for the Ridgecrest monitoring station for 2002 to 2004 is presented in **Figure 5**.

3.4 Seismicity

The Project site is located in seismically active Southern California, a region that has experienced numerous earthquakes in the past. A review of the Alquist-Priolo (AP) Earthquake Fault Zone maps and the Kern County Online Mapping System Faults and Fault Zones layer indicate that there are no AP fault zones present within the Project boundaries.

An unnamed buried fault trace has been mapped as trending northwest-southeast across the center of the site. Based on personal communication with Glen Harris (BLM Ridgecrest office), site features, and observations made during a July 2009 field reconnaissance, the more probable location of the unnamed fault is just north of and parallel to Brown Road, and trends roughly east-west. This fault has not been mapped by the United States Geological Survey as a Quaternary (sufficiently active) fault, and is not listed by the EQFAULT program as a fault potentially affecting the site.

Regardless of whether there are faults across the site, because the Project is located in a seismically-active area, all Project structures must be designed to comply with the California Building Code (CBC) and US Building Code (UBC) Zone 4 requirements. The CBC and UBC are considered to be standard safeguards against major structural failures and loss of life. The goals of the Codes are to provide structures that will:

1) Resist minor earthquakes without damage;
2) Resist moderate earthquakes without structural damage but with some non-structural damage; and
3) Resist major earthquakes without collapse but with some structural and non-structural damage.

The CBC and UBC base seismic design on minimum lateral seismic forces ("ground shaking"). The CBC and UBC requirements operate on the principle that providing appropriate foundations, among other aspects, helps to protect buildings from failure during earthquakes.

3.5 Hydrogeology

The Indian Wells Valley is composed of two broad geologic units, consolidated rocks and unconsolidated deposits **(Figure 6A, Figure 6B, and Figure 7)**. The consolidated rocks consist of Mesozoic igneous and metamorphic rocks, which form the basement complex (Sierra Nevada Batholith); Tertiary continental deposits; and Miocene volcanic rocks. The Mesozoic basement complex exists below 2,000 feet to as much as 6,000 feet of alluvial fill, underlie the groundwater basin, and crop out in the surrounding hills. The Tertiary continental deposits overlie the basement complex and fill the valley to approximately 1,000 feet below ground surface (bgs) . Miocene volcanic rocks crop out along the perimeter of the basin, more specifically near the El Paso and Coso Mountains. The consolidated rocks are nearly impermeable except for areas where fracturing or weathering has occurred. These rocks are believed to yield little water to the overlying alluvial aquifer system.

3.5.1 Hydrostratigraphy

Previous investigations have divided the unconsolidated Quaternary deposits into two main aquifers: the shallow aquifer and the deep aquifer. However, a recent study by Brown and Caldwell identified four hydrostratigraphic features in the Indian Wells Valley Groundwater Basin. The features are: 1) Fine-Grained Sediment Plug, 2) Gravel Zone, 3) High Gradient, and 4) Playa. **Figure 8** shows the location of these features.

- The Fine-Grained Sediment Plug located approximately 3 to 4 miles east of the Sierra Nevada mountain front and trends north-south. The upper contact of this feature begins at depth of approximately 340 feet bgs and sediments may be as much as 1,340 feet thick. The areal extent of this deposit is not well defined due to limited borehole data.
- The Gravel Zone is a west-east trending area of coarse-grained high permeability sediments. This area is located from the mouth of Indian Wells Canyon to approximately the northwest portion of Ridgecrest, extends approximately 2 miles north-south, and fines to the east. This region is referred to the Inyokern and Intermediate Areas and contains high-volume production wells. Wells within the Ridgecrest city limits are believed to be associated with this Gravel Zone; however, wells in this area have a higher percentage of fines and, therefore, their groundwater production is lower than the wells to the west.
- The High Gradient area extends from the El Paso sub-Basin into the main Indian Wells Valley Groundwater Basin near the southwestern portion of the valley. Groundwater gradients in this area have been measured at approximately 100 feet per mile. Brown and Caldwell propose that the high gradient may be caused by a combination of a narrowing of the area available for flow and the influx of recharge from Freeman Canyon. In addition, the high hydraulic gradient could be related to the contrast in aquifer transmissivity from the narrows to the high permeability zone to the north.

The Playa feature identified by Brown and Caldwell is located in the area of China Lake. The thickness of these sediments is not known, but are likely several tens of thousands of feet thick. Deposits are highly micaceous, silt sandy silt, and fine sand with occasional plastic clays. Shallow water beneath China Lake is highly saline and unfit for most uses.

3.5.2 Aquifer Characteristics

In the development of a groundwater flow model and hydorgologic study for the Indian Wells Valley Groundwater Basin, Brown and Caldwell used hydraulic conductivity values ranging from 0.1 feet per day (ft/d) to 100 ft/d. These values were based on geologic logs, pre-existing groundwater modeling studies, and interpretations based on local geology, depositional environments, and groundwater flow regime. The model showed that the areas with the highest hydraulic conductivities are generally located immediately east of the Sierra Nevada. Areas of the Indian Wells Valley Groundwater Basin with lower hydraulic conductivities are localized and distributed throughout the Basin.

Published aquifer testing data, reports transmissivity values ranging from a low end of 1,400 to 36,800 square feet per day (ft^2/d) to a high end ranging from 44,000 to 155,000 ft^2/d. Both sets of values were based on aquifer testing and geologic data. The Brown and Caldwell (2009) model used specific yield ranges of 0.05 to 0.15. Reported well yields in the lower aquifer are more than 1,000 gpm and some wells consistently yield more than 2,000 gpm. The Indian Wells Valley Groundwater Basin has an estimated storage capacity of about 2,200,000 acre-feet (af) and 5,120,000 af. The calculated storage of 2,200,000 af is based on 1921 water levels as a steady state limit and 200 feet below this level as the economically feasible limit to extract groundwater.

3.6 Water Supply

The Project will be dry cooled. The Project's various water uses include water for solar collector mirror washing, makeup for the SSG feed water, dust control, water for cooling plant auxiliary equipment, potable water and fire protection. Water needs for the Project will be met by the IWVWD. The estimated water supply need for the Project is 150 af per year. Details of expected operational water use for the Project by month are provided below:

Estimated Water Usage

Month	Approximate Water Usage af (gpm)[1]	Month	Approximate Water Usage af (gpm)[1]
January	3.67 (28.25)	July	16.24 (118.55)
February	8.29 (60.48)	August	16.23 (118.48)
March	11.34 (82.80)	September	14.35 (104.73)
April	15.58 (113.71)	October	10.24 (74.75)
May	17.43 (127.20)	November	7.94 (57.95)
June	17.54 (128.07)	December	6.67 (48.68)

1. The estimated groundwater usage gpm is based on average daily consumption and assumes continuous pumping. Peak groundwater pumping rates during summer months will be up to 128 gpm.

Water provided from the IWVWD for process and cooling water needs will be stored in a 1,500,000 gallon permeate tank, which will provide enough storage capacity for a 5-day total interruption of water supply to the Project as well as water for fire protection. Water for domestic uses by Project employees will also be provided by IWVWD. Water received from IWVWD will meet the requirements of the California Department of Health Services for potable water supplies and will not require further treatment for this purpose. Water used for power cycle makeup, mirror washing water, and cooling of ancillary equipment will require on-site treatment for reduction of dissolved solids. The typical quality of groundwater that will be supplied by IWVWD is shown in **Table 3**.

4.0 Waste Classification and Management

The waste disposal and storage units include the two evaporation ponds at the RSPP.

4.1 Evaporation Ponds

The main waste stream at the site consists of industrial wastewater generated in the various processes associated with power generation. Industrial wastewater is treated via a high-pH RO system at the Unit. The treated water is recycled to the 1,500,000-gallon treated water storage tank for reuse in the process. The concentrate from the RO system is discharged to lined evaporation ponds. The RSPP therefore includes two proposed evaporation ponds for waste storage and disposal. These two evaporation ponds are the subject of this ROWD application. Sanitary wastewater generated at the RSPP will be disposed of via septic systems.

4.2 Wastewater Treatment System and Evaporation Ponds

Wastewater is generated by auxiliary cooing tower blowdown, RO concentrate, and plant chemical drain collection. Each of these sources is collected and treated by the Project's wastewater treatment system, which consists of a high-pH RO system.

Wastewater is stored in a 120,000 gallon storage tank upstream of the wastewater treatment system. While shown as a single box on the flow diagram **(Figure 9)**, the wastewater treatment system is a very complex system that allows for the concentration of a water source containing high dissolved solids. The wastewater treatment system utilizes filtration, softening, pH adjustment, and RO to accomplish the concentration of dissolved solids.

Wastewater is pumped from the storage tank by wastewater transfer pumps. Wastewater is treated with coagulant and pumped to multimedia filters and then further filtered by ultrafiltration units. Filtered wastewater is stored in an ultra filter product tank. Water will be pumped from the ultra filter product tank to backflush both the ultra filter and the multimedia filter. Caustic, acid, and sodium hypochlorite will all be dosed to the ultra filter during the cleaning cycle.

Product water from the ultra filter product storage tank will be pumped to softeners to remove water hardness from the wastewater system. A brine regeneration system will be provided to restore the softening capability of the resin. In this system softened wastewater is treated with acid to lower the pH of the wastewater stream upstream of a decarbonator. The decarbonator removes carbon dioxide from the wastewater stream, which in turn lowers the alkalinity of the water. Wastewater from the decarbonator is then treated with caustic to raise the pH of the water stream.

High-pH water is treated downstream of the decarbonator transfer pumps with antiscalant and fed to the high-pH RO units. Permeate generated by the RO is returned to the service water tank. Concentrate is pumped to the chemical sump and eventually the evaporation pond.

Plant drains will contain water from component wash down and cleaning, potential miscellaneous leaks and draining of plant equipment, condensation from plant equipment and other sources. Water from these areas will be collected in a system of floor drains, sumps, and pipes and routed to the wastewater collection system. This water will be routed through an oil-water separator to capture the oil and prevent it from reaching the environment.

The anticipated flow rates of the water treatment system are shown on **Table 4** and the predicted chemical composition of evaporation pond wastewater and residue is summarized in **Table 5**.

4.2.1 Evaporation Pond Residue

It is estimated that during the 30-year operating life of the Project, about 6,400 tons of evaporites will accumulate in the ponds. However, because it is anticipated that wind-blown silt will accumulate in the ponds at a rate of perhaps six inches per year, it will be necessary to clean out the ponds on approximately four-year intervals. Assuming 2 feet of silt accumulation, the residue removed from the ponds will be approximately nine percent evaporate and 91 percent silt. The predicted chemical makeup of the evaporite, based on information about the raw water chemistry and knowledge of the water use and treatment processes at the Project, is summarized in **Table 5**.

4.2.2 Miscellaneous Plant Drains

Plant drains will contain water from component wash down and cleaning, potential miscellaneous leaks and draining of plant equipment, condensation from plant equipment and other sources. Water from these areas will be collected in a system of floor drains, sumps, and pipes and routed to the wastewater collection system. This water will be routed through an oil-water separator to capture the oil and prevent it from reaching the environment.

4.3 Waste Classification

4.3.1 Wastewater and Evaporation Pond Residue

The estimated concentrations of chemical constituents in the wastewater discharge to the evaporation ponds are provided in **Table 4**. The total concentrations of chemical constituents estimated in the evaporation pond residue that will accumulate in the ponds during operation are provided in **Table 5**.

Classification of wastewater and evaporation pond residue is summarized in the Classification of Wastewater and Evaporation Pond Residue table below.

Testing of this material will be conducted as part of the facility monitoring program **(Section 5.0)** to verify this characterization. The evaporation pond residue accumulated in the ponds is nonhazardous; however, it does contain pollutants which could exceed water quality objectives if released, or that could be expected to affect the beneficial uses of waters of the State. Therefore, the evaporation pond residue is classified as a “designated waste.”

Classification of Wastewater and Evaporation Pond Residue

Waste Stream	Waste Stream Compared To	Regulation	Waste Stream Characteristic	State & Federal Classification	CWC Section 13173 Classification[1]
Wastewater	Soluble Threshold Limit Concentration (STLC)	Title 22 CCR Chapter 11, Division 4.5, Article 3, Section 66261.24 "Characteristics of Toxicity"	<STLC	Nonhazardous	Designated waste
	Toxicity Characteristic Leaching Procedure (TCLP)	Code of Federal Regulations (CFR) Part 261, Section 261.24	<TCLP	Nonhazardous	Designated waste
Evaporation Pond Residue	STLC	Title 22 CCR Chapter 11, Division 4.5, Article 3, Section 66261.24 "Characteristics of Toxicity"	<STLC	Nonhazardous	Designated waste
	Total Threshold Limit Concentration (TTLC)	Title 22 CCR Chapter 11, Division 4.5, Article 3, Section 66261.24 "Characteristics of Toxicity"	<TTLC	Nonhazardous	Designated waste
	TCLP	CFR Part 261, Section 261.24	<TCLP	Nonhazardous	Designated waste

4.4 Unit Classification

In compliance with Table 2.1 in Title 27 CCR Chapter 3, Subchapter 2, Article 2, Section 20210, liquid designated wastes will be managed in full containment in a Class II evaporation pond with a double liner system.

4.5 Unit Locations

The units will be located outside of the 100-year flood plain and seismic hazard zones **(Figure 3)**. In addition, the base of the evaporation pond will have a greater than 5-foot separation to the underlying groundwater (refer to **Table 3** for approximate depth to groundwater on site).

5.0 Monitoring and Reporting Requirements

The suggested monitoring and reporting requirements for evaporation ponds are described below. As discussed in **Section 4.0**, wastewater sources (effluent) to the evaporation ponds include auxiliary cooling tower blowdown, multimedia filter backwash, demineralized bottle flush, and occasionally from plant drains. These wastewater streams will be pumped from the Unit to the evaporation ponds. The ponds have been designed to retain process water that will be generated for the Project and as such there will be no discharge other than from the septic system to a leach field on site. **Table 4** lists the predicted chemistry of the effluent wastewater stream to the ponds.

5.1 Evaporation Pond Monitoring

Samples of wastewater and residue will be collected periodically over the operational life of the Unit. Samples will be properly documented and a written record of the chain-of-custody recorded. The chain-of-custody record will track the samples from the field to the laboratory. Monitoring of the evaporation ponds will be conducted per the schedule listed in the Evaporation Pond Monitoring Program table below.

All samples collected as part of the monitoring programs will be analyzed by a state-certified laboratory for the appropriate parameters. Wastewater samples from the pond will also be collected semi-annually and composited into one sample.

Quarterly water quality testing of selenium concentrations and total dissolved solids (TDS) will be undertaken in conjunction with qualitative behavioral and avian health monitoring. Should bird mortality occur, an additional water grab sample will be collected from the ponds for analysis at the time of discovery. Because water quality is difficult to tie directly to ecological risk by implementation of numeric standards, selenium and TDS concentrations will not trigger remedial action; however, the data will be collected to assess potential long-term correlations between water quality, as well as the pond water level, pond salinity, and temperature data, and bird behaviors and mortality, if any.

For the detection monitoring program, RSI will use statistical or non-statistical data analysis methods approved in RWQCB Order No. 6-98-74 for each monitoring event and will compare the concentration of each monitoring parameter with its respective concentration limit to determine if there has been a release from the evaporation pond. Monitoring of evaporation pond wastewater, residue, and detection monitoring will be completed as stated in the Evaporation Pond Monitoring Program table below.

Evaporation Pond Monitoring

	Startup	Quarterly Sampling	Semi-Annually	Annually
Wastewater Monitoring[1, 2]	Grab Sample	Selenium TDS	Samples from each pond will be composited into one sample.	Collected fourth quarter of each year[2].
Pond Residue Monitoring[3]	NA	NA	NA	Two grab samples of the bottom residue in each pond will be composited. Collected fourth quarter of each year.
Detection Monitoring[4]	NA	NA	Check for presence of water beneath the 60-mil and 40-mil High Density Polyethylene (HDPE) geomembranes using neutron moisture probe. If moisture content is detected above 30% by volume, field verification testing will be performed, and the RWQCB will be notified.	Documentation of instrument calibration and performance checks will be submitted to the RWQCB.

Notes:
1 – Startup and Annual sampling parameters for wastewater are listed in **Table 6**, Evaporation Pond Wastewater Startup and Annual Sampling Parameters.
2 – Semi-annual sampling parameters for wastewater are listed in **Table 7**, Evaporation Pond Wastewater Semi-annual Sampling Parameters.
3 – Annual sampling parameters for pond residue are listed in **Table 8**, Evaporation Pond Residue Sampling Parameters.
4 – Field verification testing may include a combination of additional neutron analysis, laboratory analysis of liquids drawn from the neutron probe casing, and visual observation to verify existence of a release.
NA – Not Applicable

5.1 Ground Water Monitoring

In accordance with Title 27 CCR Chapter 3, Subchapter 3, Article 1, Section 20380, a groundwater monitoring network (GMN) will be established at the site to monitor groundwater for impacts from potential releases from the two proposed evaporation ponds. The proposed GMN will consist of four new proposed on-site monitoring wells (MW-1 through MW-4).

To provide construction and operational water to the proposed Project, RSI proposes to use groundwater supplied by the IWVWD. Water will be piped to an existing tank and transmitted via pipeline that will be built by RSI to the Project site. A list of chemical additives that are anticipated to be added to the process water on a regular basis is presented in **Appendix H**.

5.1.1 Groundwater Monitoring Network Layout for Regional Groundwater

The proposed GMN layout includes three categories of monitoring wells: 1) background wells which are located upgradient of the evaporation ponds; 2) detection wells, which are located adjacent to the evaporation ponds; and 3) compliance wells, which are located near the Project boundaries, downgradient of the evaporation ponds. The background well (MW-1) will be located upgradient of the evaporation ponds along the southwestern Project boundary; the two proposed detection wells (MW-2 and MW-3) will be located immediately adjacent to the downgradient corner of each evaporation pond; and the proposed compliance well (MW-4) will be located downgradient of the evaporation ponds, along the northeastern Project boundary (see **Appendix E**).

There will be no on-site pumping of groundwater for project use; therefore, based on regional groundwater gradients, groundwater beneath the Site is expected to flow to the northeast.

Monitoring Well Sampling

Groundwater samples will be analyzed to establish background water quality concentrations. Following this, groundwater samples will be analyzed on a quarterly basis. All monitoring wells will be sampled using either dedicated or portable pumps and low-flow sampling techniques. The procedures for monitoring well sampling are presented in the Standard Operating Procedure for water sampling in **Appendix E**.

5.1.1.1 Background Groundwater Monitoring

Initial background sampling, which will consist of four quarters of groundwater sampling and analysis, will be performed. All four quarters' data will be collected prior to the discharge of wastes into the evaporation ponds. These data will represent existing or static (non-pumping) hydrogeologic conditions. When the Project becomes operational and groundwater is pumped to provide process water, the hydrogeologic conditions beneath the site will become dynamic and the condition will remain dynamic for the life of the Project. For this reason, groundwater samples from the first quarterly sampling collected under the pumping conditions will be evaluated and, with prior RWQCB concurrence, may also be considered background. Groundwater samples will be analyzed for the parameters listed on **Table 9**. Background groundwater data will be evaluated statistically using the methods described in **Appendix E**.

During Project construction activities, groundwater will be used for general construction uses. When this water use occurs, additional groundwater monitoring and sampling will be performed. Depending on the projected time frame for construction water use, it is anticipated that up to three additional rounds of groundwater sampling will be performed. The first construction sampling would occur approximately one week after groundwater pumping commenced, the second round of sampling would be near the middle of the groundwater pumping and the final sampling event would occur approximately two days prior to pumping ceasing.

5.1.1.2 Routine Quarterly Groundwater Monitoring

Groundwater will be sampled and analyzed from each monitoring well on a quarterly basis. **Table 10** provides the chemical constituents to be analyzed for quarterly groundwater monitoring. After water levels are measured in each well, the well will be purged and sampled using low-flow groundwater sampling techniques **(Appendix E)**. The fourth quarter monitoring event is also referred to as the "Annual" monitoring event and groundwater from this event will be analyzed for the parameters listed on the aforementioned **Table 9**.

5.1.1.3 Routine Annual Groundwater Monitoring

Annually, groundwater from monitoring the wells will be collected using low-flow procedures as discussed above and analyzed for the parameters listed in **Table 9**. The results of the analysis will be reported in the annual report in tabular and graphical form. Each graph will be plotted with data at a scale appropriate to show trends or variations in water quality. For graphs showing the trends of similar constituents, the scale will be the same. The data will also be used to construct an Upper Tolerance Limit to determine evidence of a release and will be used to evaluate data from the previous three quarters for evidence of a release.

5.1.1.4 Detection Monitoring Program Sampling

All monitoring wells will be sampled as part of the detection monitoring program. All wells included in the Detection Monitoring Plan **(Appendix E)** will be sampled semi-annually for the parameters listed in **Table 7**.

5.1.1.5 Potentiometric Surface Monitoring

Semi-annually, the groundwater potentiometric surface will be illustrated on a site plan showing the static water level, in feet bgs; the monitoring well locations; the location of the evaporation pond; and the ground water gradient under each evaporation pond. Existing water wells on the site, including those identified for water supply will be used to construct the potentiometric surface map. Those wells that are damaged during construction may be replaced to provide an adequate monitoring network for the Project site. Wells that are replaced will be moved outside the solar mirror array and not sited within the field or within access roads.

Using approved statistical or non-statistical data analysis methods approved in RWQCB Order No. 6-98-74 for each monitoring event, the concentration of each monitoring parameter will be compared with its respective concentration limit to determine if there has been a release.

6.0 Record Keeping and Reporting Program

6.1 General Reporting

The "General Provisions for Monitoring and Reporting," dated September 1, 1994, will be followed for all submittals to the RWQCB.

6.1.1 Quarterly Monitoring Report

A quarterly monitoring report including the previously described information will be submitted to the RWQCB. Subsequent quarterly monitoring reports will be submitted to the RWQCB by:

- April 30,
- July 30,
- October 31, and
- January 31 of each year.

6.1.2 Semi-Annual Report

A semi-annual monitoring report including the preceding information will be submitted to the RWQCB. Subsequent semi-annual monitoring reports will be submitted to the RWQCB by June 31 of each year.

6.1.3 Annual Report

By January 31 of each year, an annual report will be provided to the RWQCB including the preceding semi-annual information and with the following information:

- Evidence that adequate financial assurance for closure, post-closure, and reasonably foreseeable releases is still in effect and may be verified by including a copy of the renewed financial instrument or a copy of the receipt for payment of the financial instrument;
- Evidence that the amount is still adequate or if not, that the amount of financial assurance has been increased by the appropriate amount, due to inflation, a change in the approved closure plan, or other unforeseen events; and
- A review of the closure plan and a statement that the closure activities described are still accurate or an updated closure plan.

6.2 Unscheduled Reports

Incidents that result in implementation of the Corrective Action Plan (CAP) will be reported to the appropriate agencies. The CAP is provided in **Appendix D**. If such incidents threaten to result in an off-site discharge or may present a potential threat to human health or the environment, immediate verbal notification shall be made as specified in the CAP. A record of such verbal communications will be maintained in the operating record. As specified by State and Federal regulations, a written report describing the incident and the implementation of the CAP will be prepared and submitted to the Office of Emergency Services, the U.S. Environmental Protection Agency and the RWQCB. Additional reporting may be required under the WDRs and monitoring and reporting program established by the RWQCB. Further discharge situations and the reporting requirements are outlined in the Reporting Program for Unscheduled Reports table below.

Reporting Program for Unscheduled Reports

Reporting Type	Reporting Triggers	Agency to be Notified	Reporting Schedule	Information to be Included in Reporting
Annual Reporting				
Release Reporting	Physical evidence of release.	RWQCB	Immediately (verbally) Within 7 days - written notification via certified mail	Identification of evaporation pond that may have released/be releasing leased or may be releasing. Date, time, location, and cause of release. Estimate of flow rate and volume of wastes involved. Sample collection procedures and proposed analysis. Identification of any water-bearing media affected or threatened. Proposed corrective actions. Physical factors that indicate physical evidence of a release.
Physical or Statistical Significant Evidence of a Release	Physical or statistical evidence of release. Statistical evidence includes, monitoring parameters and/or constituents of concern that have indicated statistically significant evidence of a release.	RWQCB	Immediately (verbally) Within 7 days - written notification via certified mail	Information listed above for statistical evidence indicating statistically significant evidence of a release.
Action Leakage Rate (ALR)	Exceedance of established ALR	RWQCB	Within 24 hours (verbally) Within 7 days - written notification via certified mail Within 30 days – Technical report via certified mail	Technical report shall describe: Corrective actions taken. Proposed future actions to abate the adverse condition.

Reporting Program for Unscheduled Reports

Reporting Type	Reporting Triggers	Agency to be Notified	Reporting Schedule	Information to be Included in Reporting
Other Source That May Cause Evidence of a Release from the Impoundments	Physical evidence of release.	RWQCB	Within 24 hours (verbally) Within 7 days - written notification via certified mail	The facility will notify the RWQCB of the intention to make this demonstration.
Vector Control	Report will be prepared at the end of every operational year.	CEC Compliance Project Manager	Conclusion of every year	Water quality tests. A chronological listing of the overnight water temperatures. Water levels and salinity measurements for the active evaporation ponds. Any results of necropsies performed on birds salvaged from in or around the ponds.

7.0 Design and Construction Standards

7.1 General Design Description of the Evaporation Pond

The design of the evaporation ponds is provided in the Evaporation Pond Preliminary Design, Operations, and Maintenance Plan provided in **Appendix C**.

7.1.1 Overview

The containment strategy for the evaporation ponds is summarized as follows:

- Size the ponds to achieve sufficient evaporative capacity under annual average and peak discharge conditions, to allow for storage or evaporative residue for the 3.5 years, to maintain a minimum of 2-feet freeboard at all times, and to allow one pond to be taken out of service for up to one year for maintenance without impacting the operation of the Project.
- Meet or exceed regulatory requirements for containment of liquid designated wastes.
- Select materials that are compatible with the physical, chemical and thermal characteristics of the wastewater and evaporation pond residue being contained.
- Protect against physical damage to the containment layers by including protective layers in the design of each containment facility.
- Allow for occasional removal, if needed, of contained media without otherwise damaging the integrity of the containment systems.
- Include the ability to monitor the integrity of the containment system, to collect and recover leakage through the primary liner, and to transfer fluids from one evaporation pond to another.

The proposed design for the evaporation ponds has been selected to optimize performance based on these operating criteria. The design basis for the evaporation ponds and the associated calculations are provided in the Design Basis Memorandum in **Appendix B.** The site location and general arrangement is shown on **Figure 2**. The proposed design for evaporation ponds and site details are provided in the following figures:

- **Figure 10A and 10B;**
- **Figure 11A and 11B; and**
- **Figure 12.**

7.1.2 Description

The two evaporation ponds have a proposed average design depth of 7 feet, which incorporates the following:

- Drying each pond at alternating 4-year intervals;
- 3 feet of operational depth;
- 2 feet of residue build up over 4 years; and
- 2 feet of freeboard.

The containment design for the evaporation ponds, from the surface of the evaporation ponds downwards, consists of the following:

- A hard surface/protective layer with granular fill/free draining sub-base over geotextile;
- A primary 60-mil HDPE liner;
- An interstitial leak detection and removal system (LDRS) comprising a geomembrane geonet and collection piping;
- A secondary 40-mil HDPE liner;
- A 2-foot thick compacted silty sand base; and
- Installation of the carrier pipe for the moisture detection (neutron probe) system beneath the base of the ponds.

7.1.3 Hard Surface/Protective Layer

The hard surface/protective layer provides protection against accidental damage to the HDPE liners which could be caused by burrowing animals, falling objects, varying climatic conditions and worker activities during maintenance. Secondly, the hard surface/protective layer will allow for removal of the precipitated solids within the evaporation ponds, if necessary. Various hard surface media such as reinforced concrete, roller compacted concrete, revetments, or combinations of these media will be assessed prior to the selection of the preferred option.

Prior to the placement of the hard surfacing, a one-foot thick granular fill layer will be placed, spread and consolidated over the non-woven geotextile that serves to protect the underlying primary geomembrane liner. This granular fill layer is intended to serve two purposes:

- As the supporting base for the hard surfacing; and
- As a drainage layer between the hard surfacing and underlying primary liner.

7.1.4 Liner System

HDPE was selected as the preferred material for the primary and secondary liners for the following reasons:

- It is chemically resistant to potentially high concentrations of dissolved salts.
- It is very durable during installation.
- It is strong and possesses desirable stress-strain characteristics.
- It is the most common synthetic liner material and as such there is a broad base of practical experience associated with the installation of HDPE among construction contractors.

A 60-mil upper liner was selected to provide appropriate balance between strength and ductility characteristics, which is very important during liner installation. A non-woven geotextile will be installed on top of the 60-mil liner to act primarily as a protective layer between the granular fill/free draining native soil and the upper liner.

A 40-mil lower liner was selected for the lower and secondary liner to provide slightly better ductility and handling characteristics during installation, as strength is of lesser importance for the secondary liner.

Both liners will be textured on both sides for safety purposes plus the texture provides a better interface against the surrounding materials.

HDPE possesses large thermal expansion and contraction characteristics, and exhibits stress when liner temperature exceeds 122°F. The temperature of the blow down water is not expected to exceed 122°F.

7.1.5 Base Layer

A 2-foot thick base layer of compacted silty sand is included in the design profile to protect the underlying groundwater in the unlikely event that both synthetic liner materials are punctured during construction or operation of the evaporation ponds. This base layer also serves to provide a smooth, competent surface to support the overlying synthetic liners and leak detection system layers.

A base layer is required to protect the underlying groundwater in the unlikely event that both synthetic liner materials are punctured during construction or operation of the evaporation ponds. This base layer also serves to provide a smooth, competent surface to support the overlying synthetic liners and LDRS layers.

The preferred design for the base layer is 2 feet of on-site material with a hydraulic conductivity of less than 1×10^{-6} centimeter per second (cm/sec), of which at least 30 percent of the material, by weight, shall pass through a No. 200 U.S. standard sieve. If this material is unavailable on site, then a Geosynthetic Clay Liner (GCL) or approved equivalent is the alternative design for the base layer.

7.1.6 Leak Detection, Collection and Removal System

A HDPE geonet drainage layer, with an option for non-woven geotextile heat bonded to one or both sides, will be used in the LDRS between the primary and secondary liners. HDPE geonet used in combination with geotextile materials has been selected because polyethylene is not reactive with the fluids and provides a highly conductive layer, it is readily available, and is easily installed with minimal potential for damage to the liner system during installation.

The base of the evaporation pond leak detection and collection layer will slope at a minimum inclination of one percent to a leak collection trench. The trench will contain screened sand (with no fines) and a perforated pipe that will slope at a minimum inclination of ¾ percent towards a leak detection and collection sump, located at the lowest point in the pond. The water in the collection sump will drain by gravity to a monitoring well that is constructed for each evaporation pond (one well per pond). Automated pneumatic pumping systems in the monitoring wells will automatically return water collected in the sump to that evaporation pond, which in turn minimizes the hydraulic pressures across the secondary liners and, therefore, reduces the risk of leakage through the secondary liner. Leakage rates will be measured using a flow totalizer.

The collection sump, pipe, and monitoring well will include prefabricated and field-fabricated HDPE components with water tight, extrusion welded and wedge-welded seams and penetrations. The liner system will be installed in accordance with current practices. Destructive and non-destructive testing procedures will be used to verify sump and penetration tightness and continuity.

This design is consistent with Title 27 CCR Section 20340, which requires an LDRS between the liners for the evaporation ponds.

7.1.7 Berms and Side Slopes

The side slopes around the evaporation ponds will contain the same liner system as the base of the ponds, except that leak collection pipes will not be located on the pond side slopes.

The berms shall be covered with a minimum 6-inch thick road base or approved equivalent. The top of the berms will be a minimum of 2 feet above the surrounding grade to prevent potential inflow of stormwater.

7.1.8 Material Compatibility

The wastewater will come into contact with the hard surface/protective layer. As outlined in Section 7.3.4, the media for this layer will either be roller-compacted concrete or an approved equivalent alternate. All final media selection will be compatible with the wastewater by using quality concrete with maximum chemical resistance (specifications will be provided to the concrete manufacturer to ensure proper mix selection).

If there is leakage in the evaporation pond, the wastewater will come into contact with the primary/secondary liner. HDPE is chemically resistant to saline solutions and long-term contact between the wastewater in the evaporation ponds and the HDPE liner system will not compromise liner integrity. Further explanation for HPDE selection is provided in Section 7.3.3.

The hard surface/protective layers, liner system, and base layer will have the ability to withstand the dissolved solids content of the water without degradation. These systems will not fail due to pressure gradients from physical contact with the wastewater and residue or undergo chemical reactions or degradation.

7.2 Engineering Requirements

7.2.1 Regulatory Requirements

The performance standard for the liner system is outlined in Title 27 CCR Section 20330:

> *Liners shall be designed and constructed to contain the fluid, including landfill gas, waste and leachate, as required by Article 3 of this subchapter (Section 20240 et seq., and section 20310).*

Under Section 20240 et seq., the relevant section to liner design is Section 20250, "Class II: Waste Management Units for Designated Waste" (emphasis added):

> *(4) Class II surface impoundments are not required to comply with the requirements of (b)(1), but shall have a liner system designed in accordance with the applicable SWRCB-promulgated provisions of Article 4 of this subchapter (Section 20310 et seq.). The RWQCB can allow Class II surface impoundments which are designed and constructed with a double liner system in accordance with that article to use natural geologic materials which comply with (b)(1) for the outer liner.*

Under Article 4, Section 20320 (d) requires that soils used within containment structures must have the following characteristics:

> *(1) At least 30 percent of the material, by weight, shall pass a No. 200 U.S standard sieve.*
>
> *(2) The materials shall be fine grained soils with a significant clay content without organic matter, and which is a clayey sand, clay, sandy or silty clay, or sandy clay under a soil classification system having industry-wide use.*

In addition, Table 4.1 in this section requires clay liners to have a hydraulic conductivity of not more than 1×10^{-6} cm/sec.

Section 20330 also outlines the requirements for liners:

> *(b) Clay Liners: Clay liners for a Class II Unit shall be a minimum of 2 feet thick and shall be installed at a relative compaction of at least 90 percent.*
>
> *(d) Lined Area - Liners shall be installed to cover all natural geologic materials (at the Unit) that are likely to be in contact with waste (including landfill gas or leachate).*

7.2.2 Alternative Design

No alternative design is being considered at this time.

7.3 Construction Methods and Sequence of the Evaporation Ponds

The containment construction process will follow these general steps:

a) Stripping, grubbing and clearing of organic materials and topsoil from the construction area.

b) Excavation and rough grading of the pond area, construction of berms, stockpiling of excess soil for later reuse.

c) Installation of the carrier pipe for the moisture detection (neutron probe) system beneath the base of the ponds.

d) Construction of finish grading to sub grade, as needed, and excavation of the leak collection trench and detection/collection sumps.

e) Scarification, moisture conditioning, compaction, proof rolling and testing of sub-grade materials.

f) Installation of secondary HDPE liner.

g) Installation of leak detection layer, sump, and leak detection monitoring wells/extraction risers.

h) Installation of primary HDPE liner.

i) Installation of the non-woven geomembrane liner.

j) Installation of granular fill/sub base.

k) Installation of liner protection layers.

l) Installation of hard surface.

7.3.1 Site Preparation, Excavation and Compaction

The excavation and berm construction will use standard cut and fill techniques. The silty sand material on site will be used for general earthworks construction and to construct the compacted base or subgrade. The silty sand material will be compacted to a minimum of 95 percent of the maximum dry density as determined by American Society for Testing and Materials (ASTM) D1557. The soil will be spread with a dozer and compacted in lifts using a sheeps foot roller or other suitable compaction equipment. Field testing of the density of the soil will be performed at regular intervals. Compaction results will be recorded.

7.3.2 Moisture Detection System

The moisture detection system below the liner system consists of continuous carrier pipes installed at the sides and low point of each pond (one carrier pipe per pond) at a depth of approximately 5 feet below the secondary liner. The carrier pipes will be terminated at the surface on each side of the pond and will be equipped with a pull cable system for conveyance of a neutron probe for moisture detection.

7.3.3 Liner System Installation

SUBGRADE

The subgrade under the liner system will be scarified, moisture conditioned, compacted, and proof rolled with a smooth drum roller to form a competent working surface. If a GCL liner will be installed, the subgrade beneath the GCL needs to have an adequate moisture content to ensure effectiveness of the GCL layer. Therefore, additional moisture conditioning will be specified immediately prior to installation of the GCL layer. The purpose of this is to add additional moisture beneath the GCL to provide moisture for hydration of the GCL material.

SECONDARY LINER

The secondary liner or lower liner will consist of a 40-mil HDPE geomembrane liner. This liner will be installed in accordance with current practices and will employ the use of wedge welding and extrusion welding procedures. In addition destructive and non-destructive testing procedures will be used to ensure liner quality and continuity.

LEAK DETECTION SYSTEMS

The leak detection system between the upper and lower liners consists of a one-foot thick granular drainage layer. Piping will be used to convey collected fluids to a leak detection system extraction riser. The granular drainage layer, including the perforated piping system will have to be carefully placed on top of the underlying 40-mil HDPE liner. The construction sequence will have to be developed with the emphasis of material placement, spreading, and consolidation techniques that will ensure that damage to the liner does not occur. Geocomposite or geonet drainage media may be used in lieu of or in conjunction with the granular drainage layer in light of the requirement to prevent damage to the geomembrane liner.

The sand bedding in the trench, including the perforated piping system will have to be carefully placed on top of the underlying 40-mil HDPE liner. The geonet shall be placed across the top of the trench to avoid strain on the material. The construction sequence will have to be developed with the emphasis of material placement, spreading, and consolidation techniques that will ensure that damage to the liner does not occur.

PRIMARY LINER

The upper or primary liner will consist of a 60-mil HDPE geomembrane liner. As is the case for the secondary 40-mil HDPE liner, current installation, quality control (QC) monitoring, testing, and quality assurance (QA) measures and techniques will be employed to ensure liner quality and continuity. The primary liner will be protected by a non-woven geotextile that will be installed directly on top of the liner.

7.3.4 Hard Surface/Protective Layer

A hard surface/protective layer will be constructed on the granular fill non-woven geotextile that covers the primary liner. The hard surface will allow for vehicular traffic during unscheduled or emergency maintenance or cleanout. Hard surface types to be considered and assessed include:

- Reinforced concrete;
- Roller-compacted concrete, or an approved equivalent (formed concrete, gunite, or other alternates, all of which must be submitted for approval); and

- Revetment systems; or
- A combination of these.

Prior to the placement of the hard surfacing, a one-foot thick sub-base layer consisting of granular fill with a maximum particle size of ½ inch shall be placed and spread over the non-woven geotextile. The sub-based layer will be spread carefully and sequentially to avoid damage to the underlying liner system. After placement, the granular layer will be proof rolled using light compaction equipment.

Roller-compacted concrete can be transported in dump trucks and can be spread with a dozer or motor grader and compacted with a vibratory roller. Additionally, the roller-compacted concrete can be placed without joints, forms, or reinforcing steel, and is not required to be finished. This will make the application of the hard surface/protective layer relatively economical.

An aggregate road base material will be placed along the top of each berm to provide an all-weather access location for maintenance vehicles. The material will conform to the Department of Transportation Specifications for Class II Aggregate Base. This will be installed to a minimum thickness of 6 inches and will be placed and compacted in accordance with the Department of Transportation requirements.

7.4 Grading Plans

As outlined above, earthwork will be required for the construction of the evaporation pond. The existing contours and finished grades are shown on **Figure 12.** The finished elevations of each pond, including the berm and top of the base, are shown in **Figure 11A and 11B.** There will be additional grading required below the base to accommodate the sub-base, liners and LDRS.

8.0 Construction Quality Assurance

8.1 Introduction

The Quality Assurance (QA) program is based on the State Water Resource Control Board (SWRCB) – Construction Quality Assurance (CQA) Requirements under Title 27 CCR. The requirements themselves will be highlighted and an explanation of how the requirements will be met will follow immediately afterwards.

The evaporation ponds will be constructed as per the construction specifications that will be developed in accordance with the CQA plan provided herein. The CQA program will be implemented to ensure that construction is completed in accordance with design specifications.

For the evaporation ponds, CQA testing will be performed on the sub grade, compacted silty sand base, HDPE liners, granular fill/free draining native soil, and hard surface/protective layer materials.

Construction inspection requirements will include approving of each layer to ensure that there are no deficiencies in that layer prior to placement of the next material based on observation and field tests. This will also include review of other CQA results to ensure that they are within the project's specifications.

Change authorization will flow through the on-site construction manager and will ensure that the Engineer of Record, as well as other required personnel, have input in the decision of any change. Daily reports will be kept to ensure that activities are documented and personnel involved in the Project are updated daily.

8.2 Performance Standard

Quoting from the SWRCB CQA requirements section (a):

> *The construction quality assurance (CQA) program, including all relevant aspects of construction quality control (CQC), shall provide evidence that materials and procedures utilized in the placement of the any containment feature at a waste management unit (Unit) will be tested and monitored to assure the structure is constructed in accordance with the design specifications approved by the RWQCB.*

The Project will implement QC procedures that incorporate inspection and test procedures to make sure that the containment facilities are constructed properly and that they are monitored appropriately throughout the life of the Project. These tests and procedures will be documented in detail throughout the Project.

8.2.1 Professional Qualifications

Quoting from the SWRCB CQA requirements section (b):

> *(1) The design professional who prepares the CQA plan shall be a registered civil engineer or certified engineering geologist; and*
>
> *(2) The construction quality assurance program shall be supervised by a registered civil engineer or certified engineering geologist who shall be designated the CQA officer.*

RSI will ensure that a design professional will prepare the CQA plan and will provide a design professional that will act as a CQA officer whose responsibility is to supervise the CQA program.

Construction activities and operations will be directed and supervised by qualified individuals and the design will be conceived and presented in accordance with recognized civil, mechanical and electrical engineering procedures and practices.

8.2.2 CQA Reports

Quoting from the SWRCB CQA requirements section (c):

> *(1) The project's CQA report shall address the construction requirements, including any vegetation procedures, set forth in the design plan for the containment system. For each specified phase of construction, this report shall include, but not be limited to:*
>
> *(A) A delineation of the CQA management organization, including the chain of command of the CQA inspectors and contractors;*
>
> *(B) A detailed description of the level of experience and training for the contractor, the work crew, and CQA inspectors for every major phase of construction in order to ensure that the installation methods and procedures required in the containment system design will be properly implemented;*
>
> *(C) A description of the CQA testing protocols for preconstruction and -construction which shall include:*
>
> *1. the frequency of inspections by the operator;*
>
> *2. the sampling and field testing procedures and equipment to be utilized, and the calibration of field testing equipment;*
>
> *3. the frequency of performance audits determined by the design professional and examined by the CQA officer;*
>
> *4. the size, method, location and frequency of sampling, sampling procedures for laboratory testing, the soils or geotechnical laboratory to be used, the laboratory procedures to be utilized, the calibration of laboratory equipment and quality assurance and quality control of laboratory procedures;*
>
> *5. the pass/fail criteria for sampling and testing methods used to achieve containment system design; and*
>
> *6. a description of the corrective procedures in the event of test failure.*

The Project will provide the following:

- An outline of the chain of command of the CQA inspectors and contractors in the CQA management organization,
- A description of the CQA testing procedures for the preconstruction and construction phases of the project, and
- A CQA report that includes construction QC requirements included in the design plan for each specified phase of construction.

8.2.3 Documentation

Quoting from the SWRCB CQA requirements section (d):

Construction quality assurance documentation requirements shall include, at the minimum: reports bearing unique identifying sheet numbers for cross referencing and document control, the date, project name, location, descriptive remarks, the data sheets, inspection activities, and signature of the designated authorities with concurrence of the CQA officer.

(1) The documentation shall include:

(A) Daily Summary Reports — daily record keeping, which shall include preparation of a summary report with supporting inspection data sheets, problem identification and corrective measures reports. Daily summary reports shall provide a chronological framework for identifying and recording all other reports. Inspection data sheets shall contain all observations (i.e., notes, charts, sketches, or photographs), and a record of field and/or laboratory tests. Problem identification and corrective measures reports shall include detailed descriptions of materials and/or workmanship that do not meet a specified design and shall be cross referenced to specific inspection data sheets where the problem was identified and corrected;

(B) Acceptance Reports — all reports shall be assembled and summarized into Acceptance Reports in order to verify that the materials and construction processes comply with the specified design. This report shall include, at a minimum, inspection summary reports, inspection data sheets, problem identification, and corrective measures reports;

(C) Final Documentation — at the completion of the project, the operator shall prepare a Final Documentation which contains all reports submitted concerning the placement of the containment system. This document shall provide evidence that the CQA plan was implemented as proposed and that the construction proceeded in accordance with design criteria, plans, and specifications. The discharger shall submit copies of the Final Documentation report to the RWQCB as prepared by the CQA officer.

(2) Once construction is complete, the document originals shall be stored by the discharger in a manner that will allow for easy access while still protecting them from any damage. All documentation shall be maintained throughout the post closure maintenance period.

These documents will include daily summary reports with supporting inspection data sheets that contain all observations. A record of field and laboratory tests will also be kept. Acceptance reports will be documents that ensure construction and materials comply with the original design and specifications. At the completion of the Project, project closure documentation will be submitted to provide evidence that the CQA plan was implemented as proposed and that construction met design criteria, plans, and specifications.

8.2.4 Laboratory Testing Requirements

Quoting from the SWRCB CQA requirements section (e):

(1) Analysis of earthen materials shall be performed prior to their incorporation into any containment system component. Representative samples for each layer within the containment system shall be evaluated. The following minimum laboratory testing procedures shall be performed:

(A) ASTM Designation: D 1557 91 [1/91], "Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN-m/m3)" which is incorporated by reference;

(B) ASTM Designation: D 422 63 (Reapproved) [9/90], "Standard Method for Particle Size Analysis of Soils," which is incorporated by reference; and

(C) ASTM Designation: D 2487 93 [11/93], "Standard Classification of Soils for Engineering Purposes," which is incorporated by reference.

(2) In addition to the tests listed in (e and f), the following minimum laboratory tests shall be performed on low-hydraulic-conductivity layer components constructed from soil:

(A) ASTM Designation: D 4318 93 [11/93], "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils," which is incorporated by reference; and

(B) United States Environmental Protection Agency (USEPA) Test Method 9100 [Approved 9¬86], "Triaxial-Cell Method with Back Pressure," which is incorporated by reference.

The Project will send materials proposed for construction to an accredited laboratory so that the quality and characteristics can be confirmed and compared to project specifications.

The tests will include the following as per section (e) of the SWRCB CQA requirements above:

- ASTM Designation: D 1557 91 [1/91], Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN-m/m^3);
- ASTM Designation: D 422 63 (Reapproved) [9/90], Standard Method for Particle Size Analysis of Soils; and
- ASTM Designation: D 2487 93 [11/93], Standard Classification of Soils for Engineering Purposes.

Periodic laboratory and in-situ analysis may be completed to supplement the CQA.

8.2.5 Field Testing Requirements

Quoting from the SWRCB CQA requirements section (f):

The following minimum field test procedure shall be performed for each layer in the containment system: ASTM Designation: D 2488 93 [9/93], Standard Practice for Description and Identification of Soils (Visual Manual Procedure), which is incorporated by reference.

The Project will use the following test on each layer in the containment systems associated with the LTU pad:

- ASTM Designation: D 2488 93 [9/93], Standard Practice for Description and Identification of Soils (Visual Manual Procedure); and
- ASTM Designation: D2922 and D3017 for using a nuclear density/moisture gauge (densitometer) to determine compaction percentage and moisture content.

8.2.6 Test Fill Pad Requirements

Quoting from the SWRCB CQA requirements section (g):

Before installing the compacted soil barrier layer component of a final cover system, or the compacted soil component of a liner system, the operator shall accurately establish the correlation between the design hydraulic conductivity and the density at which that conductivity is achieved. To accomplish this the operator shall:

Provide a representative area for a test on any compacted foundation and low-hydraulic-conductivity layers. The following minimum testing procedures shall be performed:

the test pad foundation and, for final covers, the barrier layers shall be compacted with the designated equipment to determine if the specified density/moisture-content/ hydraulic-conductivity relationships determined in the laboratory can be achieved in the field with the compaction equipment to be used and at the specified lift thickness;

perform laboratory tests as specified in State Water Resources Control Board CQA requirements subsection (e); and

perform field tests as specified in State Water Resources Control Board CQA requirements subsection (f). The discharger shall perform hydraulic conductivity tests in the test area under saturated conditions by using the standard test method ASTM Designation: D 3385 94 [9/94], "Standard Test Method for Infiltration Rate of Soils in Field Using Double Ring Infiltrometer," which is incorporated by reference, for vertical hydraulic conductivity measurements. A sufficient number of tests shall be run to verify the results. Other methods that provide an accurate and precise method of measuring field hydraulic conductivity may be utilized as approved by the RWQCB.

Correlations between laboratory tests and test pad results shall be established for each of the various types of fill materials and blends to be used in construction of the actual cover.

When constructing compacted soil barrier layers, or a compacted soil component of a liner system, the Project will provide a representative area for a test. The soil layers will be compacted with equipment that can achieve density, moisture content, and hydraulic-conductivities, where applicable at specified lift thicknesses. The laboratory tests mentioned in SWRCB CQA requirements section (e) will all be performed.

Results from lab tests and field tests will be compared to ensure that the specified requirements can be met and that the methods and procedures selected and used achieve the required construction quality standard.

8.2.7 Earthen Material Requirements

Quoting from the SWRCB CQA requirements section (h):

(1) The following minimum tests shall include, but not be limited to:

(A) Laboratory tests as specified in State Water Resources Control Board CQA requirements subsection (e); and

(B) Field tests as specified in State Water Resources Control Board CQA requirements subsections (f and g).

(2) The following minimum testing frequencies shall be performed:

(A) Four (4) field density tests shall be performed for each 1,000 cubic yards of material placed, or at a minimum of four (4) tests per day;

(B) Compaction curve data (ASTM Designation: D 1557 91) graphically represented, and Atterberg limits (ASTM Designation: D 4318 93) shall be performed on the barrier layer material once a week and/or every 5,000 cubic yards of material placed;

When testing any soils used for construction, the tests mentioned in SWRCB CQA requirements section (e) will be performed at a minimum. There will be four field density tests performed per 1,000 cubic yards of material placed or at least four tests per day. Compaction curve data, including Atterberg Limits, will be performed at least once per week or every 5,000 cubic yards of material placed. For field hydraulic conductivity tests (critical for the on-site material used in the base layer), the frequency of testing will be based on the pass/failure status of previous tests. They will be performed for the amount of time necessary to make sure steady conditions for the design hydraulic conductivity are met. The equation I = Q /(tA) will be used to determine design hydraulic conductivity.

During construction, all compacted soils and granular material will be tested using a nuclear density/moisture gauge (densitometer) (ASTM D2922 and D3017) to determine compaction percentage and moisture content. Nuclear densitometer testing will be performed to ensure compaction and moisture condition requirements as outlined in the Project specifications are being achieved. Each material will be tested following compaction in multiple locations to ensure compliance to Project specifications prior to proceeding with placement of the next material.

8.2.8 Geosynthetic Membrane Requirements

If geosynthetic membrane is used, the following SWRCB CQA section (i) requirements will be followed:

(1) Performance requirements for the geosynthetic membrane include, but are not limited to, the following:

(A) A need to limit infiltration of water, to the greatest extent possible;

(B) A need to control landfill gas emissions;

(C) For final covers, mechanical compatibility with stresses caused by equipment traffic, and the result of differential settlement of the waste over time; and

(D) For final covers, durability throughout the post closure maintenance period.

(2) Minimum Criteria — The minimum construction quality assurance criteria to ensure that geosynthetic membranes will meet or exceed all design specifications shall include, but not be limited to:

(A) Preconstruction quality control program:

1. Inspection of the raw materials (e.g., density, melt flow index, percent carbon Black);

2. Manufacturing operations and finished product specifications (e.g., thickness, puncture resistance, multi axial stress/strain tests),

3. Fabrication operations (e.g., factory seaming);

4. Observations related to transportation, handling, and storage of the geosynthetic membrane; and

5. Inspection of foundation preparation;

(B) Construction activities:

1. The geosynthetic membrane shall have thickness strength sufficient to withstand the stresses to which it shall be subjected, including shear forces, puncture from rocks or, for final covers, penetration from roots.

2. Inspection of geosynthetic membrane placement (e.g., trench corners, monitoring systems).

3. Seaming of the material; and

4. Installation of anchors and seals;

(C) Post-construction Activity — Post-construction activity includes checking for material and placement imperfections in the installed geosynthetic membrane. Imperfections that jeopardize the integrity of the membrane's function as an impermeable barrier (i.e., pin holes, rips, creases created during placement) shall be repaired to the original manufacturer's specifications and reinspected by the CQA officer; and

(D) Evaluation — Evaluation of the personnel and equipment to be used to install and inspect the geosynthetic membrane, and pass/fail criteria and corrective procedures for material and installation procedures shall be specified as required in State Water Resources Control Board CQA requirements subsection (c).

RSI will make sure that the geosynthetic membrane used for containment will limit the infiltration of water to the greatest extent possible and be designed to maintain durability throughout the life of the Project. RSI will ensure that a preconstruction quality control program is in place to ensure that manufactured geosynthetic membrane products conform to the Project specifications.

Once construction activities begin, RSI will make sure that the proper material is used and supervise and inspect the placement of the geosynthetic membrane and the seaming of the material in the evaporation ponds. After construction, RSI will check for imperfections in the installed geosynthetic membrane and ensure that repairs are completed in accordance with project specifications. The HDPE liner will be manufactured and installed according to industry standards and test procedures and the installer's CQA methods and procedures. Typical QA methodologies include the following:

- Review copy of the mill certificates;
- Review coupons from every seam;
- Perform air pressure tests;
- Ensure the absence of tears, punctures, and blisters;
- Conduct liner production tests, thickness, dimensions, visual inspection;
- Conduct product testing, tensile properties, tear resistance, etc;
- Sign off on sub-grade preparation; and
- Conduct wedge welding and extrusion welding seam logs and weld tests.

8.2.9 Relevant Specifications

The following specifications from the Construction Specification Institute will be developed, as a minimum:

- 31 14 13 Soil Stripping and Stockpiling;
- 31 14 11 Earthwork and Related Work;
- 31 23 10 Excavating, Trenching and Backfilling;
- 32 11 23 Aggregate Base Courses;
- 31 32 21 Geotextiles;
- 31 32 22 Geomembranes;
- 32 12 16 Asphalt Paving (If applicable);
- 32 13 23 Roller Compacted Concrete Paving (If applicable); and
- 32 21 13 or 32 31 25 Fencing.

9.0 Stormwater Management

A conceptual drainage study was performed by AECOM to evaluate site hydrologic conditions and provide a preliminary design basis for on-site drainage structures and the rerouting of an unnamed wash located on the north eastern portion of the site. The evaluation was designed following guidance provided in the Kern County Hydrology Manual and the Kern County Division Four – Standards for Drainage. The objective of the drainage studies was to investigate the hydraulic and hydrologic conditions associated with the development of the Project site and provide mitigation requirements for the anticipated increase in storm water runoff due to development.

9.1.1 Off-site Drainage

Runoff from local topographic highs located south of the Project site discharges onto the Project site northward to relatively more gradual-sloped areas at the southern and northern solar fields **(Figure 3)**. The location of the watershed in the El Paso Mountains and the existing drainage flow paths on the Project site are shown in AFC Figure 5.17-11. There are three major watercourses that run through the Project site. The El Paso Wash drains 22 square miles upstream of the Project and runs approximately through the center of the site. This wash drains water from the south hills and crosses Brown Road inside the property boundary.

The second major watercourse consists of an unnamed watercourse that drains an area of four square miles southwest of the Project site. This watercourse crosses the southwest section of the Project area continuing in the northwest direction toward Brown Road.

The third major watercourse consists of the eastern drainage area, which extends east and west of the U.S. Highway 395 (Three Flags Highway) covering about 10 square miles. Drained water crosses U.S. Highway 395 at several points in both east-west and west-east directions, hydraulically connecting all the catchments in this drainage area. Water collected in this eastern drainage area flows westward toward the Project site near the intersection of Brown Road and U.S. Highway 395. This watercourse crosses the Project site changing flow direction from the westward direction to a more northward direction midway through the Project site.

An elevated railroad grade is located south of the Project site. The railroad grade interrupts several natural drainage paths connecting flows to several watercourses that cross the railroad grade through pipes, concrete culverts, and timber bridges. Aerial photography and vegetation patterns indicate that the overall drainage pattern inside the Project area concentrates flows in several well-defined washes through the area. Storm flow generated by the existing site itself generally sheet to washes in the northeast and northwest directions. Existing flow patterns in the Project site drainage area and water crossings beneath the U.S. Highway 395 and the railroad are shown in AFC Figure 5.17-13.

9.1.2 On-site Drainage

Proposed drainage modifications to the Project site seek to replicate the existing flow patterns as closely as possible. Currently, the El Paso Wash flows through the center of the property and there are two unnamed tributaries of the El Paso Wash that flow near the eastern and western boundaries of the property. These tributaries connect to the El Paso Wash, off site and to north of the property. To replicate existing flow patterns, the solar fields are located so that the main flow lines of the El Paso Wash and the western tributary of the El Paso Wash remain the same. The eastern tributary of the El Paso Wash that enters the property from the east, near Brown Road will be intercepted by a new channel that will re-direct the flow from this tributary along the eastern boundary of the property and discharge into the existing eastern tributary flow line where the tributary exits the site **(Figure 3)**. The runoff from the solar fields is collected by perimeter drainage ditches that discharge into the El Paso Wash and the western tributary of the El Paso Wash.

Each of the proposed channels are being sized to contain the peak flow of the 100-year, 24-hour storm event. In general, each channel will also be allowed to naturally re-vegetate with native vegetation to a minor extent, but not so much as to affect the drainage function of these engineered channels. The calculations for each channel show that they may have an erosive effect at some locations in a 100-year event. Each channel will be designed with 3:1 side slopes to help mitigate the erosion of the banks. The channels will be constructed with native on-site soil material, and scour protection will be added in stress areas (i.e., locations where the erosion potential is greater than a straight, uniform channel reach, and includes junctions, transitions, and curves). No scour protection is proposed for the channel bottom in the straight sections of the channels. This is to allow the low flows to meander across the bottom replicating as nearly as possible the flow regimes under current conditions. The erosion control measures will be designed to maintain the infiltration characteristics of the channel reach similar to pre-construction conditions.

Each channel is designed as a trapezoidal channel with a transition (diffuser) at the discharge to return the stormwater back to sheet flow at the edge of the Project site. The diffuser is designed with an expanding channel cross section to spread out the flow resulting in low-flow velocities. The purpose of the diffuser is to return the flood flows to the approximately location and depth that occur in the existing condition.

In summary, there are slight changes in peak flow rates in the channels between the existing condition and the proposed condition and slight shifting in contributing drainage areas from the existing to the proposed condition. These changes are attributed to the difference in the time of concentrations. The proposed flow rates leaving the site are generally lower than the existing flow rates, due to the fact that the time of concentrations for the proposed on-site drainage areas are longer than the existing times of concentrations for the existing overland flow.

9.1.3 Best Management Practices

Stormwater BMPs will be provided on site and will be included in the SWPPP in compliance with the National Pollutant Discharge Elimination System General Permit for Storm Water Discharges Associated with Construction Activity and Operation of the Project site. RSI will not undertake a Notice of Intent for the SWPPPS. They are not legally required by the SWRCB as 401 and 404 permits are not required. BMPs will also be included in the DESCP required by the CEC.

During construction, BMPs will include:

- Temporary Erosion Control Measures – Construction of berms and ditches re-vegetation, slope stabilizers (interior slopes of the berms in the evaporation ponds are to be stabilized before the liner systems are placed), dust suppression and sediment barriers.
- Sediment Control – Silt fences, gravel bags, fiber rolls and check dams.
- Tracking Controls – Stabilizing entrance and exit.
- Wind Erosion Controls – Applying potable groundwater to disturbed areas and covering exposed stockpiles.
- Non-Stormwater Control – Inspecting vehicles for leaks and dispose of cement appropriately.
- Waste Management and Materials Pollution Control – Using watertight containers, preventing runoff (with berm, trench etc), into the storage areas and cleaning up spills immediately after discovery.

Permanent BMPs shall also be provided to protect the evaporation ponds during operation of the Project. These BMPs will include the following erosion and sediment control measures:

- Constructing berms around the evaporation ponds;

- Stabilizing exterior slopes of the berms to prevent wind and water erosion after completion of the liner system placement (e.g., placement of stripped organics removed from the pond area during grading, track walking transverse to slopes);
- Monitoring of berm integrity monthly and after any runoff-producing storm event for erosion;
- Repairing of the berms as needed, regrading and track walking for minor erosion (less than 6 inches depth), regrading and placing coarse aggregate for deeper erosion;
- Grading of drainage channel north of the evaporation ponds to direct flow away from the pond and Unit area; and
- Maintaining of the drainage channel as needed to restore flow lines and bank integrity.

10.0 Operating Requirements

The Operating Requirements for the RSPP were discussed in detail in the LTU Application submitted in January 2010. RSI plans to follow the operating requirements and strategies that were previously outlined in the January submittal. Only the areas that are affected by the addition of evaporation ponds are discussed in this section.

10.1 Site Records

In accordance with Title 27 CCR Section 20510, key site records will be kept in the office at the Project. Records will be available for inspection by authorized representatives of the Local Environmental Agency (LEA) and RWQCB during the Project's regular working hours. Alternatively, an inspection can be arranged by notifying the Facility Manager. All required records will be properly completed, filed for retention, and maintained throughout the operating life of the evaporation ponds.

10.1.1 Operating Record

The operating record for the evaporation ponds will be maintained at the Project and will include the following information:

- Discharge Volumes – Date and volume of discharges into each evaporation pond.
- Monitoring Results – Results of monitoring, analyses, and testing required by permit or regulatory requirement (including the daily water level measurements, a hydrometer for daily salinity measurements, and a direct reading thermometer with the temperature data recorded at least diurnally required for avian management).
- Inspection Forms – Inspection results that include a description of any required maintenance or remedial action and the date of implementation.
- Spill Response Plan – Written reports prepared in response to any incident requiring implementation of spill response.
- Correspondence with Local Agencies – Correspondence associated with emergency arrangements agreed to or refused by local authorities.
- Employee Information Records – Records documenting employee information such as job title for each position, job description, names of employees in each job, and introductory and continuing training received.
- Notifications of Violations – Notices of deficiency, abatement orders or any other notification of violation by any regulatory agency.
- Complaints – The Facility Manager will record public complaints received regarding operation of the evaporation ponds, including:
  - The nature of the complaint;
  - The date the complaint was received;
  - If available, the name, address, and telephone number of the person or persons making the complaint; and
  - Actions taken to respond to the complaint.

10.1.2 Wastewater Discharge Volumes

In accordance with Title 27 CCR Section 21720(f), all discharges into the evaporation pond will be recorded in the Operating Record. The following items that will be recorded include:

- Volume in million gallons per day (mgd);
- Cumulative total of wastewater flow, in million gallons per month; and
- The maximum daily flow rate, in mgd, each month.

10.1.3 Wastewater Levels

The water level in the pond will be dependent on the quantity of wastewater discharged in to the pond, evaporation rate and residue accumulation. However, the pond will always have a depth between one and 3 feet (maximum design level) of water to maintain appropriate concentrations of TDS. The evaporation ponds will be outfitted with a level gauge for daily water level information.

10.1.4 Monitoring and Sampling Plan Results

Monitoring and sampling plan results will be retained at the Project as part of the operating record.

10.1.5 Inspection and Operating Records

Site personnel will complete the inspection logs and other required operation documentation and the facility management will review the applicable documents for completeness and accuracy. Completed inspection logs and notations of needed repairs will be maintained for a minimum of 3 years.

Further information regarding inspection and maintenance requirements are outlined in Section 12.

10.1.6 Record of Corrective Action Plan Implementation

Following any incident that requires implementation of the Project's CAP, a report will be prepared containing the information described in Title 27 CCR Section 21760(b)(2). At a minimum, the report will be submitted to the LEA and the RWQCB. In addition, a copy will be retained on file at the Project site as part of the operating record.

Further information regarding the CAP requirements is outlined in **Appendix D**.

10.1.7 Correspondence Regarding Arrangements with Local Authorities

Copies of all correspondence with local authorities regarding emergency response arrangements will be maintained at the Project site.

10.1.8 Training Records

In accordance with Title 27 CCR Section 20610, the following records will be retained for each position related to waste management as part of the operating record:

- A job title and written job description including assigned duties and required qualifications;
- Name of the employee filling each job;
- Description of initial and continuing training; and

- Documentation of initial and continuing training received.

Whenever a training course is conducted, the records for each employee who completed the course will be updated. When a new employee is hired, a training record file will be initiated for the new employee. Personnel training records on current employees are retained until final closure of the Project. Records on former employees are retained for three years after the employee's leave date.

10.1.9 Design Documents

In accordance with the requirements of Title 27 CCR Section 21760, design, as-built, and operating documentation related to the evaporation pond will be retained at the Project as part of the operating records.

10.1.10 Other Required Technical Documents

In accordance with Title 27 CCR Section 20510 and 20517, all other technical records associated with the evaporation ponds will be retained at the Project as part of the operating record.

10.1.11 Operator / Responsible Party Records

In accordance with Title 27 CCR Section 20510 (e), records of written notification to the LEA, local health agency, and fire authority of names, addresses and telephone number of the operator or responsible party of the site, are kept in the operating record.

10.2 Security

In accordance with Title 27 CCR Section 21600(b)(5)(B) and 20530, security measures will be provided to ensure the safest environment for employees working at the Project. Security measures include barriers and warning signs.

10.2.1 Barriers

The Project solar fields and support facilities’ perimeter will be secured with a combination of chain link and wind fencing. Chain link metal fabric security fencing consists of eight-foot tall fencing with one-foot barbed wire or razor wire on top along the north and south sides of the facilities. Thirty-foot tall wind fencing, comprised of A-frames and wire mesh, will be installed along the east and west sides of each solar field.

Controlled access gates will be located at the site entrance. Access through the main gate will require an electronic swipe card, preventing unaccompanied visitors from accessing the Project. All Project personnel, contractors, and visitors will be logged in and out of the Project at the main office during normal business hours. Visitors will be allowed entry only with approval from a staff member at the Project. Visitors will be issued visitor passes that are worn during their visit and returned at the main office when leaving.

10.2.2 Warning Signs

Each point of access from a public road shall be posted with an easily visible sign indicating the facility name, and other pertinent information as required by the WDR.

10.3 Sanitary Facilities

In accordance with Title 27 CCR Section 21600(b)(5)(C), sanitary facilities will be provided at the site for Project office employees. RSI will maintain all sanitary and hand-washing facilities that may be required, by applicable State or local requirements, in a reasonably clean and adequately supplied condition.

10.4 Communication Systems

Communication facilities will be provided at the site for Project employees that meet the requirements specified in the AFC and Title 27 CCR Section 21600(b)(5)(D).

10.4.1 Internal Communication

The internal communication system for the Project will include the following devices:

- Alarm system;
- Two-way radios;
- Telephones; and
- Intercoms.

Each Project building will also be equipped with telephones. Operations supervisors and other key personnel may carry hand-held two-way radios that can be used to contact the Project office or other site personnel in an emergency.

10.4.2 External Communication

Twenty-four hour access to outside emergency services, including police and fire departments and emergency response teams, is available through the commercial telephone system at the Project.

10.5 Lighting

Lighting will be provided at the Project site to ensure the safety of employees during nighttime activities, and will meet the requirements of Title 27 CCR Section 21600(b)(5)(E). The lighting system will provide operations and maintenance personnel with illumination in both normal and emergency conditions. The system will consist primarily of Alternating Current (AC) lighting, but will include Direct Current lighting for activities or emergency egress required during an outage of the Project's AC electrical system. The lighting system will also provide AC convenience outlets for portable lamps and tools. Permanent lighting will be provided primarily along the paved access road to the Project site and in the Unit areas. Lighting in the evaporation pond area will be provided when needed using portable light stands.

10.6 Safety Equipment

In accordance with Title 27 CCR Section 21600(b)(5)(F), safety equipment will be provided for the health and safety of employees at the Project site. As specified in the AFC, a Personnel Protective Equipment (PPE) Program will be developed for the Project, which will apply to all contractor and subcontractor employees, as well as direct RSI employees during operation.

Specific requirements of the PPE Program include:

- Determining and providing personal protective devices for specific jobs,
- Providing proper head protection requirements,
- Establishing eye and face protection requirements,
- Identifying body protection equipment requirements,
- Implementing hand protection requirements,
- Defining proper foot protection,
- Providing proper sanitation facilities,

- Determining safety belts and life lines job requirements,
- Establishing procedures to prevent and protect personnel from electric shock,
- Identifying on-site and off-site medical services and first aid requirements, and
- Specifying respiratory protection requirements for jobs.

Required PPE will be approved for use and distinctly marked to facilitate identification. The type of PPE required to operate, maintain and monitor the evaporation ponds will be described in the job safety analysis undertaken prior to the commencement of operations.

10.6.1 Required Equipment

The following equipment shall be available at the Project site to minimize hazards associated with operations:

- Alarm systems and internal communications;
- Radio and telephone systems;
- Emergency equipment for fires and spills; and
- Water supplies for fire fighting.

10.6.2 Emergency Equipment

In accordance with the Emergency Action Plan as specified in the AFC, RSI will obtain emergency response equipment. This equipment will be strategically located throughout the Project site in order to respond to emergencies in a timely fashion.

10.6.3 Water Supplies for Fire Equipment

In accordance with the Fire Protection and Prevention Plan as specified in the AFC, the Project will be equipped with water at adequate volume and pressure to supply water hose streams. The primary sources of water for fire fighting on the Project is a 1,500,000-gallon treated water storage tank. Only a portion of each tank (360,000 gallons) is dedicated to the Project's fire protection water system.

10.6.4 Equipment Testing and Maintenance

In accordance with the Emergency Action Plan as specified in the AFC, all emergency equipment at the Project site, including communications and alarm systems and fire and spill prevention equipment, will be tested and maintained.

10.7 Personnel Requirements

In accordance with Title 27 CCR Section 21600(b)(5)(G), written job descriptions will be maintained for each position at the Project related to management of waste in the permitted evaporation pond at the Project site. These descriptions will be updated periodically by facility managers and supervisors to reflect the changing needs of the Project. Job descriptions will be kept on file at the Project and will include the following information:

- Job title/position;
- Duties/responsibilities; and
- Job prerequisites/qualifications.

All Project employees will receive training in general procedures and operations, and in emergency response procedures. Personnel will receive job-specific training during on-the-job training as required. This training will ensure that personnel are sufficiently proficient in the particular skills required to perform their assigned duties and that they are aware of the inherent hazards. The management, planning, and operations personnel will have varying backgrounds with respect to the management and operation of the evaporation ponds at the Project site. Technical staff will gain experience with these systems mainly through on-the-job training. A record of training and experience of each employee will be maintained at the Project office.

10.8 Personnel Training

An Operations Safety Training Program for employees and contractors will be developed for the Project as specified in the AFC that will meet the requirements of CCR Title 27, Section 21600(b)(5)(H). The Operations Safety Training Program will be revised as required to include any additional training necessary as equipment or operations change. Additional job-specific training may be completed by personnel as needed.

The staff person overseeing the portion of the training program pertinent to the evaporation ponds will be experienced in the operation of such units, waste management procedures and applicable regulations, emergency response, and CAP implementation.

All employees will be required to receive training in the following areas:

- Injury and Illness Prevention;
- Emergency Action Plan;
- PPE;
- Fall Protection;
- Fire Protection and Prevention;
- Confined Space Entry Program;
- Hazard Communication;
- Hand and Portable Power Tool Safety;
- Heat Stress and Cold Stress Safety;
- Hearing Conservation; and
- Back Injury Prevention.

The topics applicable to operation of the evaporation ponds may include:

- Mobile Equipment Safety;
- Inspection and Monitoring Program;
- Equipment Inspections;
- Employee Exposure Monitoring Program; and
- Housekeeping and Material Handling.

10.9 Supervisory Structure

In accordance with Title 27 CCR Section 21600(b)(5)(I), the facility supervisor will be experienced in solar facilities operations and maintenance to ensure that the facility is properly operated in accordance with all applicable laws, regulations, permit conditions and other requirements. All shift managers and equipment operators will report to the facility supervisor.

11.0 Environmental Controls

Fire and noise control procedures to be used during the operation of RSPP were discussed in detail in the LTU ROWD Application submitted in January 2010 and are not included in the section below.

11.1 Nuisance Controls

The local air quality laws, ordinances, regulations, and standards applicable to RSPP are administered by the Mojave Desert Air Quality Management District rule 402 Nuisance

> *"A person must not discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or which endanger the comfort, repose, health or safety of any such persons or the public, or which cause, or have a natural tendency to cause, injury or damage to business or property. Due to the application of BACT on each emission source and the distance from the emission sources to any potential receptors, the Project will comply with this rule."*

In accordance with Title 27 CCR Section 21600(b)(8)(A), the evaporation ponds will be operated in compliance with all applicable permits and regulatory conditions to prevent creating environmental hazards and public nuisance. Given the nature of the evaporation ponds, nuisance conditions are unlikely to arise.

In addition, the evaporation ponds are located in a relatively isolated area away from potential receptors, so the public is unlikely to be impacted by these operations. If complaints are generated, they will be reported to the LEA within 24 hours.

11.2 Dust Control

An Operations Dust Control Plan will be prepared for the Project as specified in the AFC to manage fugitive dust emissions and comply with the requirements of Title 27 CCR Section 21600(b)(8)(D). BMPs for dust control from the evaporation ponds will be implemented as necessary and will include the following:

- Maintaining at least 2 feet of freeboard during operation of the ponds to reduce potential for dust entrainment;
- Moisture conditioning of ponds allowed to evaporate to dryness;
- Use of moisture conditioning during removal and loading of accumulated residue;
- Adherence to speed limits during travel on dirt roads for monitoring and maintenance of the ponds; and
- Tarping of any truck loads of residue removed from the Project site for off-site disposal.

11.3 Leak Detection and Removal System

In accordance with Title 27 CCR Section 21600(b)(8)(C), there is an LDRS located beneath the primary liner in the evaporation pond. As outlined in Section 7.1.1, the LDRS will be located between the primary and secondary liners underlying the each evaporation pond **(Figure 10A and 10B)**. The LDRS will comprise of a layer of geonet sloped to a leak detection sump in each pond. The leak detection sump will include a 16-inch diameter leak detection and removal well fitted with an electronic leak sensor and a submersible pump to allow removal of leakage. The pump will discharge back into the evaporation pond. The discharge pipe may be equipped with a recording flow totalizer to allow monitoring of the amount of fluid removed over time and calculation of leakage rates.

The inspection and maintenance requirements for the LDRS are outlined in **Section 12**.

11.3.1 Action Leakage Rate

The ALR is the allowable leakage from the primary liner system above which the CAP will be triggered. According to Title 40 CFR Section 264.222, the ALR is defined as *"…the maximum design flow rate that the leak detection system can remove without the fluid head on the bottom liner exceeding 1 foot".* The ALR must also include an adequate safety margin to allow for variability in the containment system design (*e.g.* liner and collection pipe slope, interstitial fill hydraulic conductivity, thickness of drainage material, etc.).

The estimated ALR for the north evaporation ponds is 24,800 gallons per acre per day and 46,800 gallons per day for the south evaporation ponds. The references and assumptions used to establish the ALR is presented in **Appendix B, Attachment A - Action Leakage Rates**. This is based on one standard hole per acre, a drainage layer geonet with hydraulic conductivity of 0.06 meters per second and a 50 percent safety factor. The assumption underlying this ALR calculation will be verified in the actual constructed ponds. Based on a 4-acre pond, the north evaporation ponds would have an ALR of 99,200 gallons per day and for the south pond 187,200 gallons per day. However the ALR will need to have field verification as this rate will vary depending on actual drainage material used and its hydraulic conductivity. A final ALR will be submitted to the RWQCB within six months of the effective date of the permit based on field analysis.

The recording flow totalizer at each sump will be monitored at least weekly to determine the leakage rate through the primary liner. If the leakage rate exceeds the ALR, then the appropriate actions in the CAP will be implemented.

11.4 Vector Control

In accordance with Title 27 CCR Section 21600(b)(8)(E), a vector control program will be implemented at the Project as needed.

11.4.1 Pests

In the event that there is a vector problem such as flies or rodents, adequate steps will be taken to control the problem, which may include trapping, acoustic controls, poison, spraying, or engaging a licensed pest control service. Integrated pest control practices will be utilized when practical. Brush will be cleared for a distance of at least 30 feet from the evaporation ponds, to reduce habitat for rodents.

11.4.2 Waterbirds

Waterfowl and other birds may be attracted to the evaporation ponds. The primary chemical of concern to bird life in the wastewater at the Project is selenium; however, the selenium concentrations in wastewater discharged to the ponds is expected to be non-detect. The selenium concentration is for the most sensitive ecological risk benchmark is 0.11 parts per million in which observable effects have been documented on waterfowl, and ranging to more than 60 times lower than concentrations at which an adverse effect has been documented. Nevertheless, mitigation measures will need to be implemented to deter birds.

The evaporation ponds shall be netted prior to any discharge with 1.5-inch mesh netting designed to exclude birds and other wildlife from drinking or landing on the water of the ponds. Netting with mesh sizes other than 1.5-inches may be installed if approved by the Compliance Project Manager (CPM) in consultation with California Department of Fish and Game (CDFG) and US Fish and Wildlife Service (USFWS). The netted ponds shall be monitored regularly to verify that the netting remains intact, is fulfilling its function in excluding birds and other wildlife from the ponds, and does not pose an entanglement threat to birds and other wildlife. The ponds shall include a visual deterrent in addition to the netting, and the pond shall be designed such that the netting will never contact the water.

Waterfowl are anticipated to be the highest risk category; the management response below focuses on both waterfowl and shorebirds. The use of anti-perching devices around the perimeter of each pond would assist in excluding ravens and other birds from accessing the edge of the ponds to drink any of the water. Additionally, operational design of the ponds is such that a minimum freeboard of 2 feet would be kept at all times and the interior slopes of the ponds would be at a 33 percent (3:1, horizontal: vertical). These Project design features would make it difficult for perching birds and/or shorebirds to access the water, and are anticipated to minimize risk to wildlife by minimizing availability of water as a new subsidy.

Another primary concern is the formation and accumulation of salt crystals from hyper-saline conditions on the feathers of waterfowl, which impedes their ability to fly by weighing down the affected bird and potentially resulting in salt toxicosis (i.e., poisoning). Evidence suggests that salinity levels are not the sole determining factor in the potential for salt encrustation on waterfowl. Studies have shown that the formation of salt crystals on hyper-saline ponds is typically associated with water temperatures at or below 39°F. It is not anticipated that water temperatures will consistently drop to this level of concern; however, due to moderate morning air temperatures recorded (60 to 70°F) in the vicinity, salt encrustation may occur above this temperature range.

Salt toxicosis via salt ingestion may also occur from overexposure to hyper-saline waters when alternative freshwater sources are unavailable or limited (i.e., during drought conditions) and birds become dependent on a hyper-saline water supply (Gordus, et al. 2002). Based on the biological monitoring associated with the evaporation ponds at Harper Lake Solar Electric Generating System, salt encrustation, and salt toxicosis have been a rare occurrence.

11.4.3 Monitoring Program

Based on performance and monitoring data for Harper Lake Solar Electric Generating System and evaluation of calculated discharge for the Project, it can be concluded that selenium and total TDS concentrations in water and selenium concentrations in invertebrate food sources are important components in evaluating selenium and salt toxicity to birds. The Project will include a monitoring program that incorporates monitoring of bird populations at the evaporation ponds and monitoring water quality in the ponds for both selenium and TDS. The monitoring program will consider the following factors:

- Selenium and TDS concentrations in evaporation pond water;
- Pond water levels, temperature and salinity;
- Bird species utilizing the ponds; and
- Nesting activities at the ponds.

If significant adverse effects to birds are observed during the evaporation pond monitoring, and those effects are determined to be the result of selenium or salt toxicity (by autopsy of deceased birds), additional monitoring may be needed to further assess impacts to bird species, including:

- Selenium concentrations in invertebrate populations;
- Selenium concentrations in avian eggs collected at the site, if any; and
- Collection of additional water quality samples, analyzed for selenium or TDS.

A detailed evaporation pond monitoring plan will be prepared for the Project and submitted for agency review and approval prior to construction. The key components of the monitoring program for the Project are summarized in **Section 12**.

11.4.4 Pond Management

Measures that would be taken, as necessary, to keep birds from using the ponds include the following:

- In the event that climatic conditions are such that evaporation must be increased to maintain pond levels below the freeboard limits, evaporative disposal nozzles (see for example http://www.bete.com/applications/disposal.html) will be used to increase wastewater evaporation rates.
- Initiate use of an air canon in order to haze waterfowl, and frighten them away from the evaporation ponds. The air canon would be stored on site, but only used when evaporation must be increased, since birds may become acclimated to the disturbance caused by air canon hazing, if used on a regular basis. The air canon would be used until the evaporation process was completed in the pond, or until the crystallized salts returned to solution.
- Deploy “Bird-B-Gone Balloons” (a visual scare device) or other hazing devices into the pond, to discourage waterfowl from landing on the pond.

Reporting requirements are outlined in **Section 5**.

11.5 Drainage and Erosion Control

A DESCP will be prepared for the Project as specified in the AFC and will address the requirements of Title 27 CCR Section 21600(b)(8)(F). The DESCP will outline the management and control of stormwater runoff at the site and will specify site-specific BMPs for erosion and sediment control that will include side slope protection of the berms surrounding the evaporation ponds. These berms will control and prevent potential inflow (run-on) of surface stormwater into the ponds. Precipitation that falls on the ponds will be contained in the ponds and evaporated. Stormwater run-off that falls outside the ponds will be controlled and routed as discussed in **Section 9**.

11.6 Traffic Control

The proposed access to the evaporation ponds will be off the main paved entrance roadway for the Project. Traffic is expected to be limited to trucks and mobile equipment used in occasional inspection and maintenance activities. Control measures to mitigate on-site safety hazards and interference with site operations will include signs, paint markings, mirrors, and imposition of speed limits as needed.

The Project site is located southwest of U.S. Highway 395 on the north and south sides of Brown Road, approximately 5 miles southwest of Ridgecrest, California. Regional access is provided to the Project site and the surrounding Ridgecrest area by U.S. Highway 395. This highway is a primary north/south regional arterial that extends northerly along the eastern side of the Sierra Nevada Mountain Range to Bishop. It extends southerly to Interstate 15 approximately 10 miles south of Victorville. In the Project vicinity, U.S. Highway 395 is a two-lane facility with two, 12-foot travel lanes with approximately 6-foot paved shoulders and 6- to 8-foot graded shoulders on each side. The Project site is linked to U.S. Highway 395 via Brown Road, an existing two-lane paved road, approximately 24-feet wide, with variable graded shoulders from 4 to 10 feet on each side.

Additionally, the Project can be accessed from West Inyokern Road (State Route 178), which extends westerly from the City of Ridgecrest as a four-lane road to Inyokern and crosses Brown Road approximately 9 miles north of the Project site. Between Ridgecrest and Brown Road, State Route 178 is about 72-feet wide, including an approximately 24-foot wide unpaved median strip. It typically includes 4-foot paved shoulders with an additional 4-foot graded shoulder on each side. State Route 178 is the northern-most boundary of the City of Ridgecrest.

Proposed traffic mitigation for the Project include the development and implementation of a construction phase Traffic Management Plan in consultation with Caltrans and Kern County for the roadway network potentially affected by construction activities at the Project site and off-site linear facilities. In addition, RSI may split the arrival of the workforce in the morning into two parts arriving one hour or more apart when the total number of workers on site will exceed 300.

12.0 Inspection, Sampling and Maintenance Programs

The following section outlines the inspection and maintenance requirements for the evaporation ponds. Records of inspections, sampling and monitoring shall be retained as part of the operating record as required under **Section 10**.

The ALR will be field tested at the commencement of the evaporation pond operation. On the first day of operation, the pump, piping and control switches will be checked to ensure they are in proper working condition per the manufacturer's specifications.

A summary of the evaporation pond inspection, sampling, and monitoring programs is presented in the Evaporation Pond Inspection, Sampling, and Monitoring Programs table below.

Evaporation Pond Inspection, Sampling, and Monitoring Programs

System/Program		Daily	Weekly	Monthly	Quarterly	Semi-annually	Annually
Inspection Program							
Evaporation Pond Liner and Dike Areas	Exposed areas of the ponds and pond inlets and outlets			X			
Evaporation Pond LDRS	Flow of LDRS		X				
	Build up of material or degradation of system			X	After 6 months of operation		
Residue Inspections & Removal	Inspections of pond inlet, outlet, and all drainage ditches, pipes, & culverts (clean out as needed)			X			
Avian Protection	Each pond will have a level gauge, a hydrometer, and direct reading thermometer (diurnal readings)	X					

System/Program		Daily	Weekly	Monthly	Quarterly	Semi-annually	Annually
Sampling Program							
Evaporation Pond Wastewater	Wastewater (sampled at commencement)					X (annual sample collected last quarter of each year)	
	Selenium & TDS will be conducted quarterly				X		
Evaporation Pond Residue	Sampling will be conducted in the last quarter of the year						X (last quarter of each year)
LTU	Grab sample prior to discharge to evaporation ponds						
Monitoring Program							
Avian Monitoring	Monitoring will be conducted by Project Designated Biologist and Environmental Compliance Manager (after first 2 years)			Twice			
Moisture Detection Monitoring	Moisture Detections conducted with neutron probe					X	

12.1 Inspection Program

12.1.1 Evaporation Pond Liner and Dike Areas

The liner at the perimeter of the pond and perimeter dikes should be visually inspected on a monthly basis for rips and tears, evidence of animal intrusion, weed growth (through the liner or around the perimeter), environmental degradation, and failure of the liner anchoring system (i.e., the liner pulling away from the pond edges). The perimeter fence and the pond inlet (when visible) and outlets should also be inspected monthly to ensure they are in good repair and that these areas are free of debris.

12.1.2 Evaporation Pond Leak Detection System

Monitoring of leaked water is achieved through the addition of vertical monitoring wells that are hydraulically isolated with the leak detection layer. The flow totalizes, which quantify flow and the potential leakage that may occur between containment layers in the monitoring wells, should be monitored weekly for flow and monthly (quarterly after the first 6 months) to check for built up of material or degradation of the system.

12.1.3 Residue Inspections and Removal

Monthly inspections of the pond inlet, outlet, and all associated drainage ditches/pipes/culverts will be conducted for residue including sediment and debris accumulation. If residue appears to be impeding flow into the pond or potential flow from the pond, maintenance actions will be scheduled for cleaning these areas as soon as possible. Residue removal activities will be conducted on an as-needed basis depending upon the inspections and the process is outlined in Section 12.3.2.

12.1.4 Avian Protection

The netted ponds shall be monitored regularly to verify that the netting remains intact, is fulfilling its function in excluding birds and other wildlife from the ponds, and does not pose an entanglement threat to birds and other wildlife. The ponds shall include a visual deterrent in addition to the netting, and the pond shall be designed such that the netting will never contact the water. Monitoring of the evaporation ponds shall include the following:

- The Designated Biologist or Biological Monitor shall regularly survey the ponds at least once per month starting with the first month of operation of the evaporation ponds. The purpose of the surveys shall be to determine if the netted ponds are effective in excluding birds, if the nets pose an entrapment hazard to birds and wildlife, and to assess the structural integrity of the nets. Surveys shall be of sufficient duration and intensity to provide an accurate assessment of bird and wildlife use of the ponds during all seasons. Surveyors shall be experienced with bird identification and survey techniques. Operations staff at the RSPP site shall also report finding any dead birds or other wildlife at the evaporation ponds to the Designated Biologist within one day of the detection of the carcass. The Designated Biologists shall report any bird or other wildlife deaths or entanglements within two days of the discovery to the CPM, CDFG, and USFWS.
- If dead or entangled birds are detected, the Designated Biologist shall take immediate action to correct the source of mortality or entanglement. The Designated Biologist shall make immediate efforts to contact and consult the CPM, CDFG, and USFWS by phone and electronic communications prior to taking remedial action upon detection of the problem, but the inability to reach these parties shall not delay taking action that would, in the judgment of the Designated Biologist, prevent further mortality of birds or other wildlife at the evaporation ponds.
- If, after 12 monthly site visits, no significant bird or wildlife deaths or entanglements are detected by or reported to the Designated Biologist, monitoring can be reduced to quarterly visits, and with approval from the CPM, USFWS and CDFG, future surveys can be conducted by the Environmental Compliance Manager.
- If, after 12 quarterly site visits, no significant bird or wildlife deaths or entanglements are detected by or reported to the Designated Biologist, the site visits can be reduced to two surveys per years, during spring and fall migration.

Each actively used evaporation pond will be outfitted with a level gauge for daily water level measurements, a hydrometer for daily salinity measurements, and a direct reading thermometer with the temperature data recorded at least diurnally. If the average overnight water temperature in the active evaporation ponds is at or below 39.2°F, the Environmental Compliance Manager will conduct a visual survey of the ponds immediately upon the following morning. If upon inspection of the active ponds, the Environmental

Compliance Manager observes evidence of recent substantive increases in salt crystallization anywhere within the pond (e.g., at or near the waterline), or if water levels in any of the ponds are observed to fall below a minimum depth of one foot (which would cause elevated levels of TDS), the Environmental Compliance Manager will route all of the wastewater into one pond to increase the pond volume and lower the average salinity within the pond. At the same time, the remaining pond will be pumped dry. The pond to which the combined flow is discharged during this time will be rotated, periodically as needed, so that water levels do not rise too high and minimum freeboard requirements are met.

12.2 Sampling Program

Samples are to be properly documented and a written record of the chain-of-custody recorded. The chain-of-custody record will track the samples from the field to the laboratory. The form documents the time, date, location, person collecting the sample, and names and signatures of all persons handling the samples from the field to the laboratory.

12.2.1 Evaporation Pond – Wastewater

The evaporation ponds will be sampled at the commencement of operation, semi-annually thereafter to document constituent concentrations. Grab samples of wastewater collected at the start of operation and annually from each pond will be analyzed by a state-certified laboratory to determine the concentration of the parameters listed in **Table 6**. The annual samples are to be collected in the last quarter of each year.

Wastewater samples from each pond will also be collected semi-annually and composited into one sample by the state-certified laboratory and analyzed to determine the quantification of the parameters list in **Table 7**.

In addition, quarterly water quality testing of selenium concentrations and TDS will be undertaken in conjunction with qualitative behavioral and avian health monitoring. Individual water samples will be taken from each pond. Should bird mortality occur, an additional water grab sample will be collected from the ponds for analysis at the time of discovery. Because water quality is difficult to tie directly to ecological risk by implementation of numeric standards, selenium and TDS concentrations will not trigger remedial action; however, the data will be collected to assess potential long-term correlations between water quality, as well as the pond water level, pond salinity, and temperature data, and bird behaviors and mortality, if any.

12.2.2 Evaporation Pond – Residue

Annually, in the last quarter of each year, two representative grab samples of the bottom residue in each pond if present, shall be collected, composited and analyzed for the parameters show in **Table 8**.

12.3 Maintenance Program

12.3.1 Evaporation Pond Clean Out

Ponds will require cleaning about every 4 years depending upon the amount of wind-blown silt that accumulates, alternating with one pond cleaned every 2 years. During the 4-year period, about 2.2 inches of evaporites will have accumulated along with an estimated 2 feet of wind-blown silt. Storage is provided for 2 feet of residue build up. The general requirements for undertaking clean out works for evaporation ponds are outlined below.

Before water can be pumped out of the pond for maintenance, the capacity of the other evaporation ponds must be assessed to verify that sufficient capacity exists to contain wastewater from continued operation for a sufficient amount of time to allow planned maintenance activities. Preliminary design estimates indicate that if one pond is undergoing clean out activities, the additional pond can operate effectively for up to one year.

A manually placed pumping system should be used to transfer the water into an adjacent evaporation pond. As the pond liners are covered with a hard protective layer, it will be possible to place and activate these pumping systems without otherwise damaging the pond liners or transfer piping. During pond drainage, the flow rates from the pumps should be monitored to ensure that the outflow is not negatively impacting on the receiving evaporation pond. Details of this pumping system must be provided by the manufacturer.

The appropriate time of year and ideal weather conditions to undertake the clean out activities should be investigated. Dust generated during the activities will need to be controlled in accordance with the Facilities Operations Dust Control Plan. Health and safety issues for the clean out activity include potentially slipping or falling into the pond. As part of the Facilities Operations Safety Training Program and PPE Plan, employees will be trained on how to undertake the clean out activities in a safe manner, which may include having ropes and ladders accessible at the evaporation ponds.

12.3.2 Residue Removal

Ponds will be in use continually until the residue storage volume is filled. At that time, the pond will be drained and allowed to dry prior to residue removal. Preliminary estimates indicate that drying will require a period of 6 to 7 months. Preliminary estimates indicate that the remaining pond can operate effectively for this period.

If the pond is being drained for liner maintenance or excessive stormwater volumes, the sediment and residue in the pond will be evaluated and removed if necessary as preventative maintenance. The general requirements for undertaking residue and sediment removal for evaporation ponds are outlined below.

The removal activities should only be conducted on an as-needed basis depending upon the inspection of the system. The inspections should include estimating the volume of residue and assessing if the residue or sediment is impeding flows into the pond and impacting the evaporation rate or capacity of the system.

The residue shall be removed by a pumping or vacuum system if fluid, or should be dried and removed using conventional excavation and loading equipment light enough to reduce the potential for damage to the liner system. If necessary, the residue should be sampled and analyzed to meet the characterization requirements of the receiving disposal facility. The characteristics of the residue will determine the transportation and disposal methodology.

12.4 Avian Monitoring

Avian monitoring at the evaporation ponds would be conducted by the Project Designated Biologist twice monthly for the first 2 years of Project operation. The Project Environmental Compliance Manager will continue monitoring after the first 2 years, under the direction of the Project Designated Biologist, at least twice a month for the life of the Project. The monitor (Designated Biologist or Environmental Compliance Manager) will identify bird species and/or functional groups (e.g., waterfowl, waders, shorebirds, upland shorebirds) utilizing the ponds, record the behavior of the birds (e.g., feeding, swimming, wading, nesting), and note any mortalities or physical infirmities (e.g., birth defects or reduced growth) associated with any bird observed on or adjacent to the evaporation ponds. Any dead bird that can be safely retrieved from the evaporation ponds will be collected by the Project Designated Biologist or Environmental Compliance Manager and sent to a qualified laboratory to determine if the mortality was directly related to selenium poisoning or salt toxicosis or encrustation. Documented mortality resulting from selenium poisoning or salt toxicosis or encrustation would result in corrective measures implemented in coordination with the appropriate agencies.

12.5 Moisture Detection Monitoring

Moisture detection monitoring will be undertaken semi-annually using a neutron probe. This sampling method must be undertaken by a trained, certified, and licensed technician as the neutron probe uses radioactive material.

Moisture in the soil is detected by the speed that the neutrons move and scatter when emitted. The soil causes neutrons to slow. However if the soil is dry, the cloud of neutrons will be less dense and extend further from the probe and if the soil is wet, the neutron cloud will be more dense and extend a shorter distance. The density of the cloud is measured by a detector and results are displayed electronically on the front panel. The measurement is the total water content in the soil, therefore the background levels of water moisture in the soil must be removed to assess if any additional moisture has been released from the evaporation pond liner system.

13.0 Required Plans

13.1 Detection Monitoring Plan

A detection and evaluation monitoring program has been incorporated into **Appendix E** pursuant to Section 20425 of Title 27 CCR. The CAP will be triggered when detection or evaluation monitoring data indicates that there is exists statistically significant evidence of a release to groundwater from the evaporation ponds. The requirements for establishing a statistically significant release are provided in the Detection Monitoring Program. **Appendix D** has been incorporated pursuant to Title 27 CCR Section 20430 and establishes the specific corrective actions in the event of a documented release to groundwater.

13.2 Corrective Action Plan

A CAP has been incorporated into **Appendix D** of this Application pursuant to Title 27 CCR Section 20430 and establishes the specific corrective actions in the event of a documented release to groundwater. The CAP will be triggered when detection or evaluation monitoring data indicates that there exists statistically significant evidence of a release to groundwater from the evaporation ponds. The requirements for establishing a statistically significant release are provided in the Detection Monitoring Program **(Appendix E)**.

13.3 Closure and Post-Closure Plans

Six months prior to the proposed date of closure, the RSI will notify the RWQCB of the proposed closure and submit a ROWD application for closure. The requirements for Project closure at the site are provided in **Appendix F**.

Although the site will undergo clean closure, the requirement for post-closure monitoring and maintenance must be evaluated by the RWQCB. After clean closure is completed, RSI may submit an additional ROWD application for a WDR addressing post closure monitoring and maintenance. The requirements for post-closure monitoring and maintenance at the Project site are provided in **Appendix G**.

13.3.1.1 Release from the Evaporation Ponds

The RWQCB will be immediately notified (verbally) whenever a determination is made that there is physical or statistically significant evidence of a release. This verbal notification will be followed by written notification via certified mail within 7 days of such determination. Upon such notification, verification procedures may be initiated or RSI may demonstrate that another source caused evidence of a release. The notification will include the following information:

- The Unit that may have released or be releasing (individual evaporation pond);
- General information including the date, time, location, and cause of the release;
- An estimate of the flow rate and volume of waste involved;
- A procedure for collecting samples and description of laboratory tests to be conducted;
- Identification of any water-bearing media affected or threatened;
- A summary of proposed corrective actions; and
- For statistically significant evidence of a release - monitoring parameters and/or constituents of concern that have indicated statistically significant evidence of a release from the evaporation pond; or

- For physical evidence of a release - physical factors that indicate physical evidence of a release.

Upon notification, RSI may initiate verification procedures or demonstrate that a source other than the permitted waste management unit caused the evidence of a release. A supporting technical report must be provided to the RWQCB within 90 days, demonstrating the different source of the discharge.

13.3.2 Release Response Record Keeping

In accordance with Title 27 CCR Section 20510, spill response records will be kept in the office at the Project. Spill response records will be available for inspection by authorized representatives of the LEA and RWQCB during the Project's regular working hours. Alternatively, an inspection can be arranged by notifying the Facility Manager. All required records will be properly completed, filed for retention and maintained throughout the operating life of the evaporation ponds.

13.3.2.1 Required Records

The following records must be maintained on site as part of the operating record:

- Written summaries of all verbal communications and/or notifications to agencies of releases;
- All written reports submitted to the LEA or RWQCB documenting the release incident;
- All required notification, documentation or follow-up reports as required under the CAP;
- All subsequent follow-up or technical reports submitted to the RWQCB, LEA or other agency; and
- Any other additional reporting required under the WDRs and Monitoring and Reporting Program established by the RWQCB.

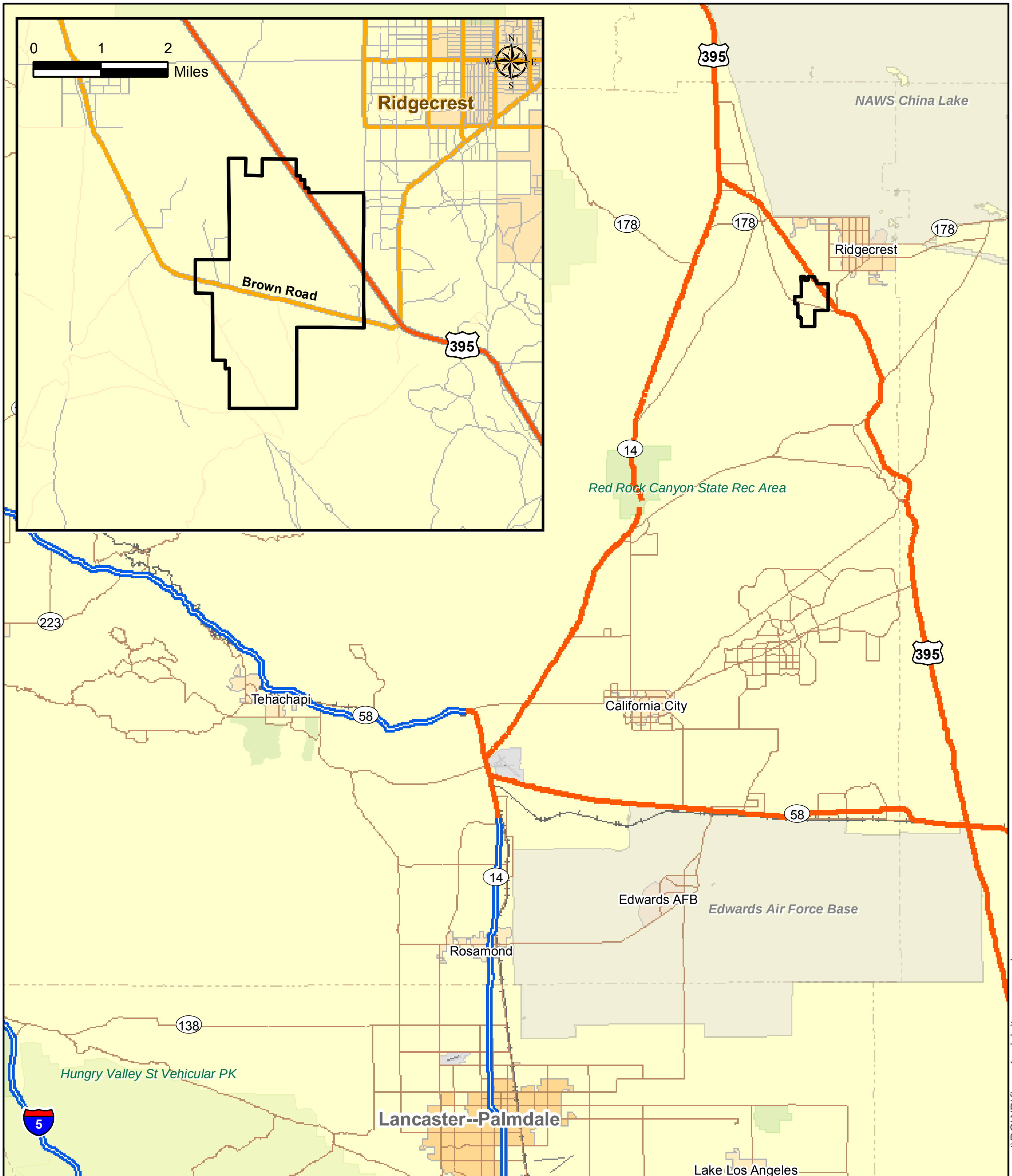
14.0 References

Brown and Caldwell, 2009. Indian Wells Valley Basin Groundwater Flow Model and Hydrogeologic Study, March 27, 2009.

Federal Emergency Management Agency, 1986. Flood Insurance Rate Map, Kern County California (Unincorporated Areas), Panel 1380 of 2075, Community-Panel Number 060075 1380 B, September 29.

RWQCB, 1994. Water Quality Control Plan for the Lahontan Region, North and South Basin: California Regional Quality Control Board, Lahontan Region, Victorville, California.

Figures



Map Location

Ridgecrest Solar Power Plant

Figure 1
Regional Location and Vicinity Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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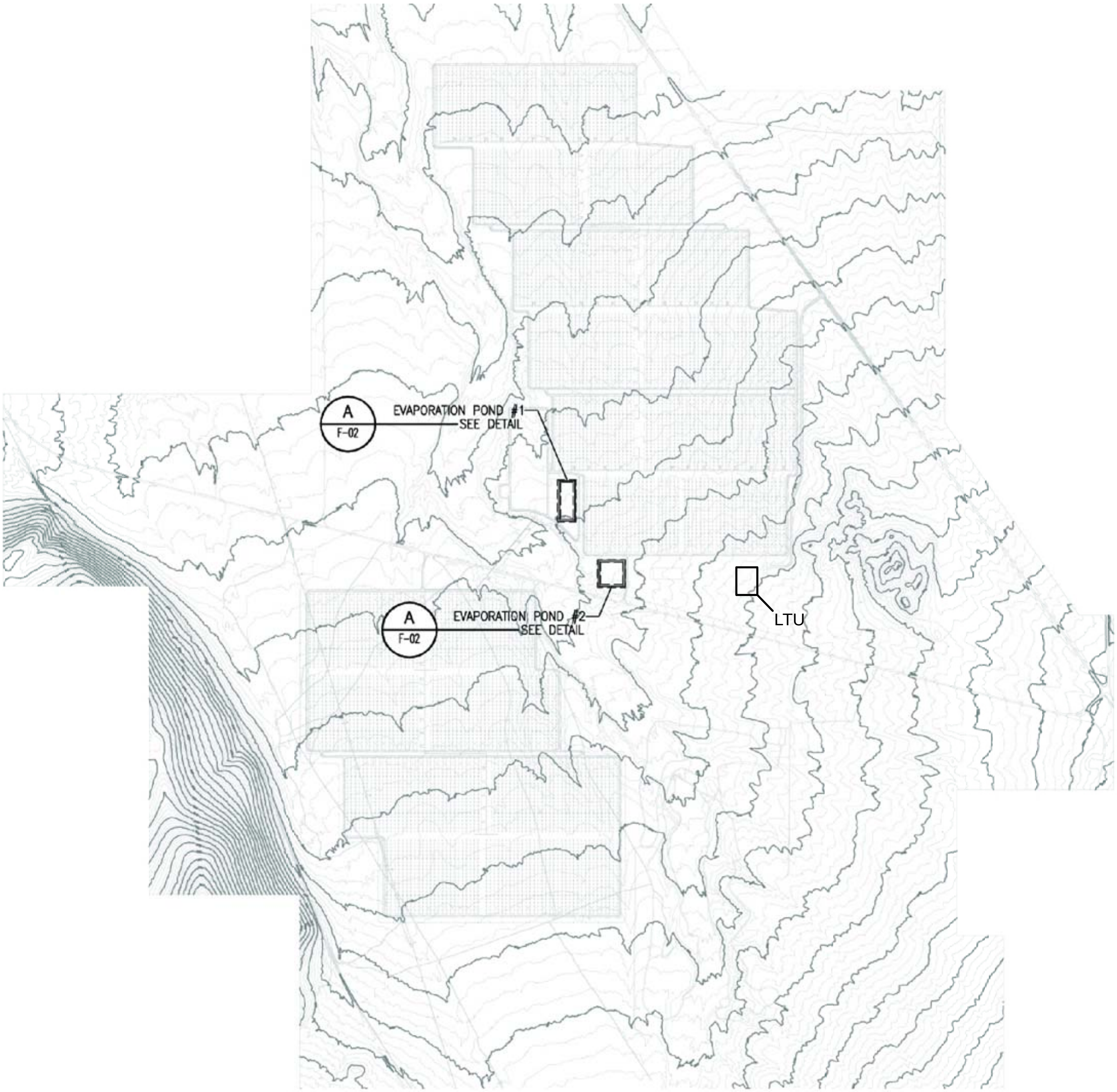

Map Location

Ridgecrest Solar Power Project

Figure 2
General Arrangement Site Plan

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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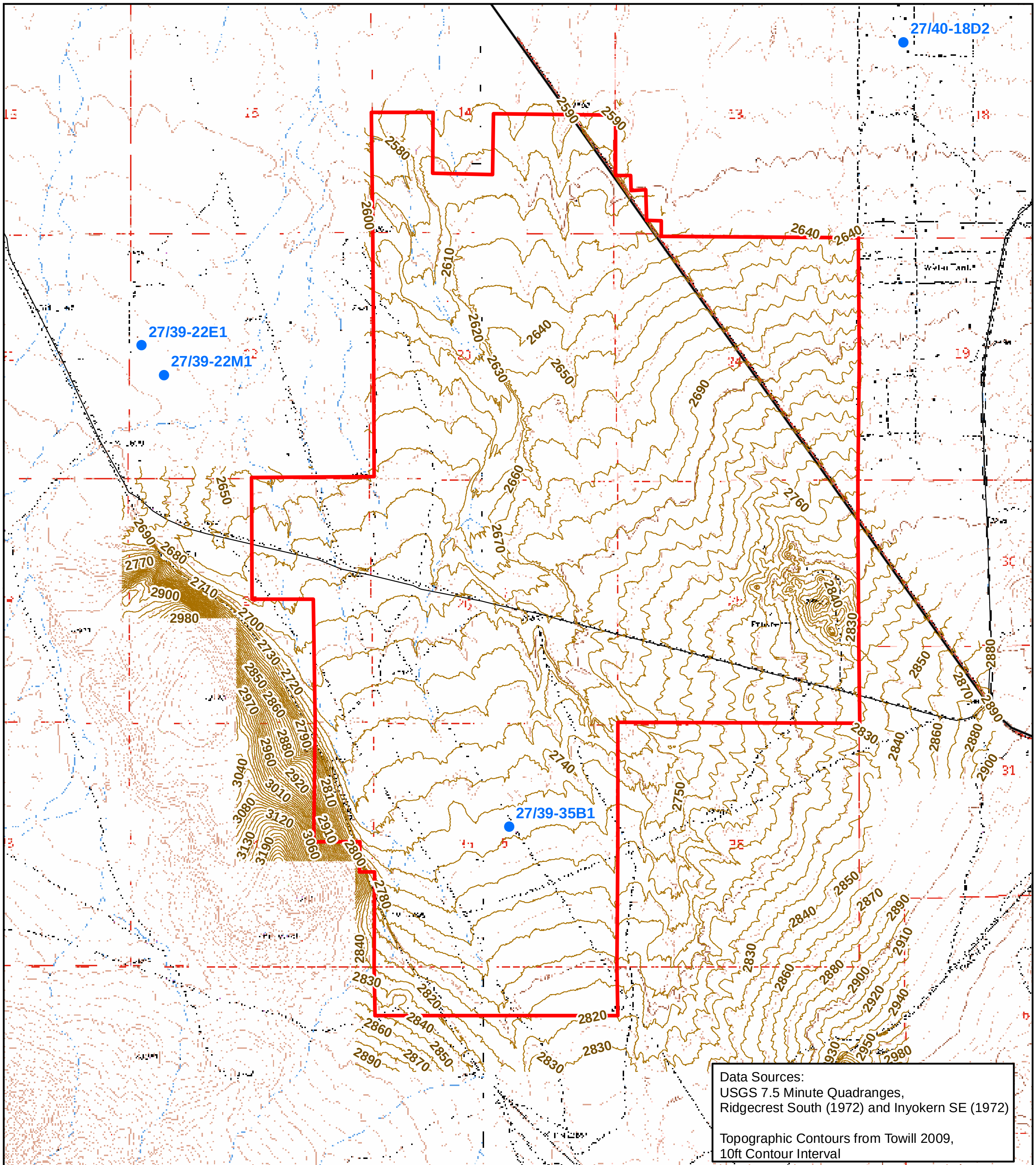


Map Location

Legend

Project Right-of-Way

Groundwater Well Location based on Latitude and Longitude in USGS Database

0 3,000 6,000 Feet

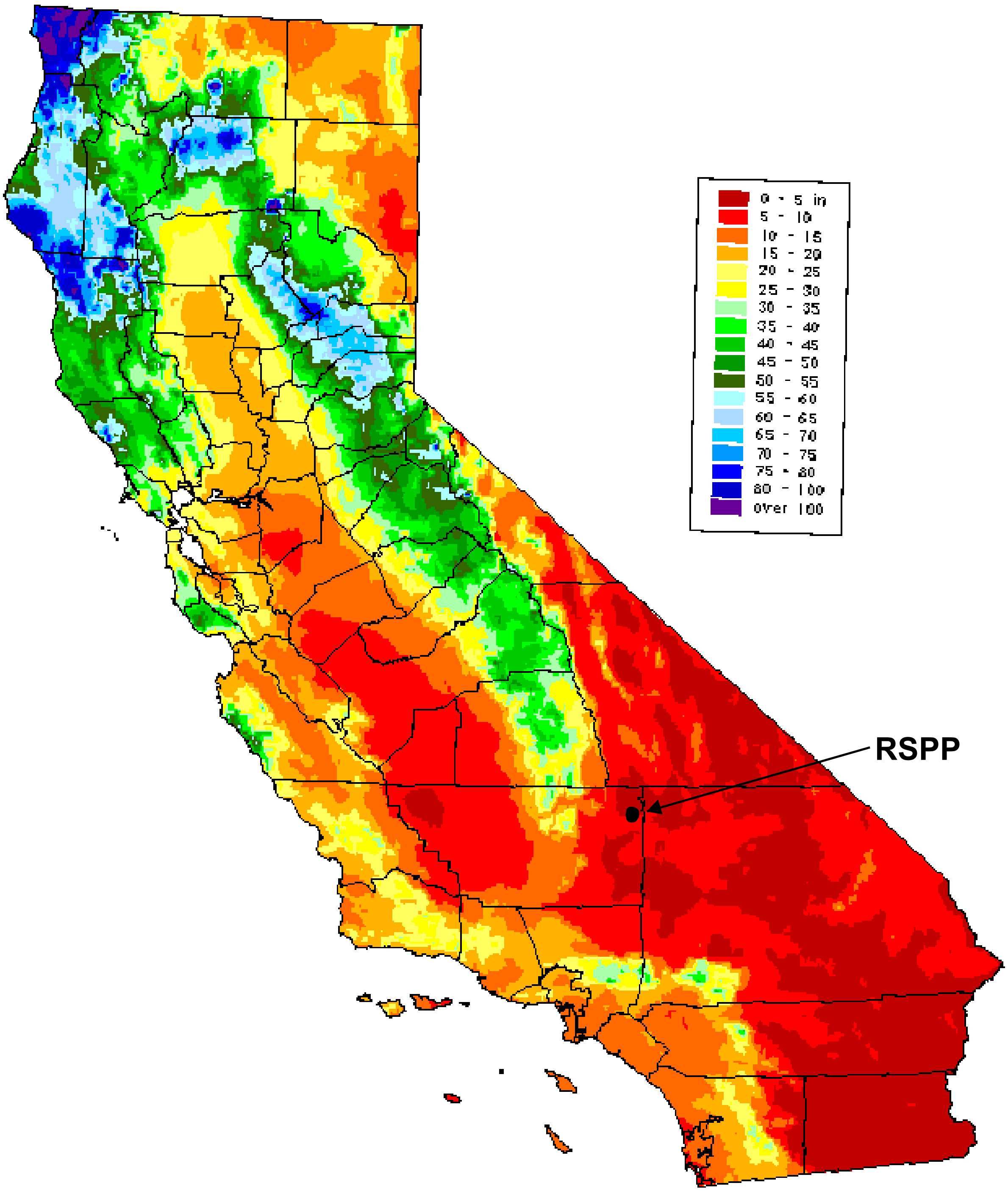
Ridgecrest Solar Power Plant

Figure 3
Site Topographic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010



Source:
http://www.wrcc.dri.edu/pcpn/ca.gif
Oregon Climate Service, 1995

Map Location

Ridgecrest Solar Power Project

Figure 4
Average Annual Precipitation (inches), California
Period: 1961-1990

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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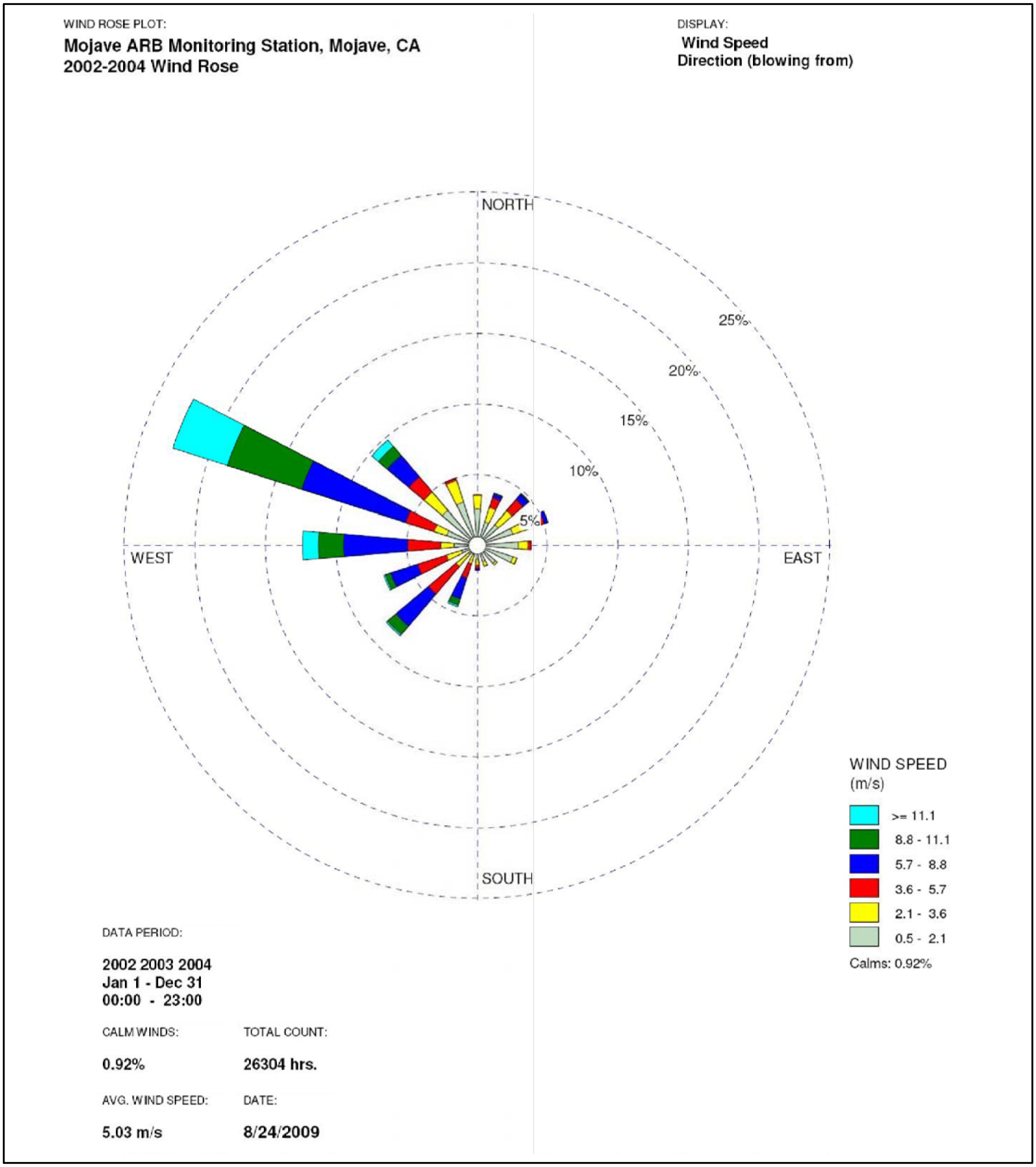
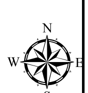


Map Location



Ridgecrest Solar Power Project

Figure 5
Wind Rose Plot
Mojave ARB Monitoring Station, Mojave, CA

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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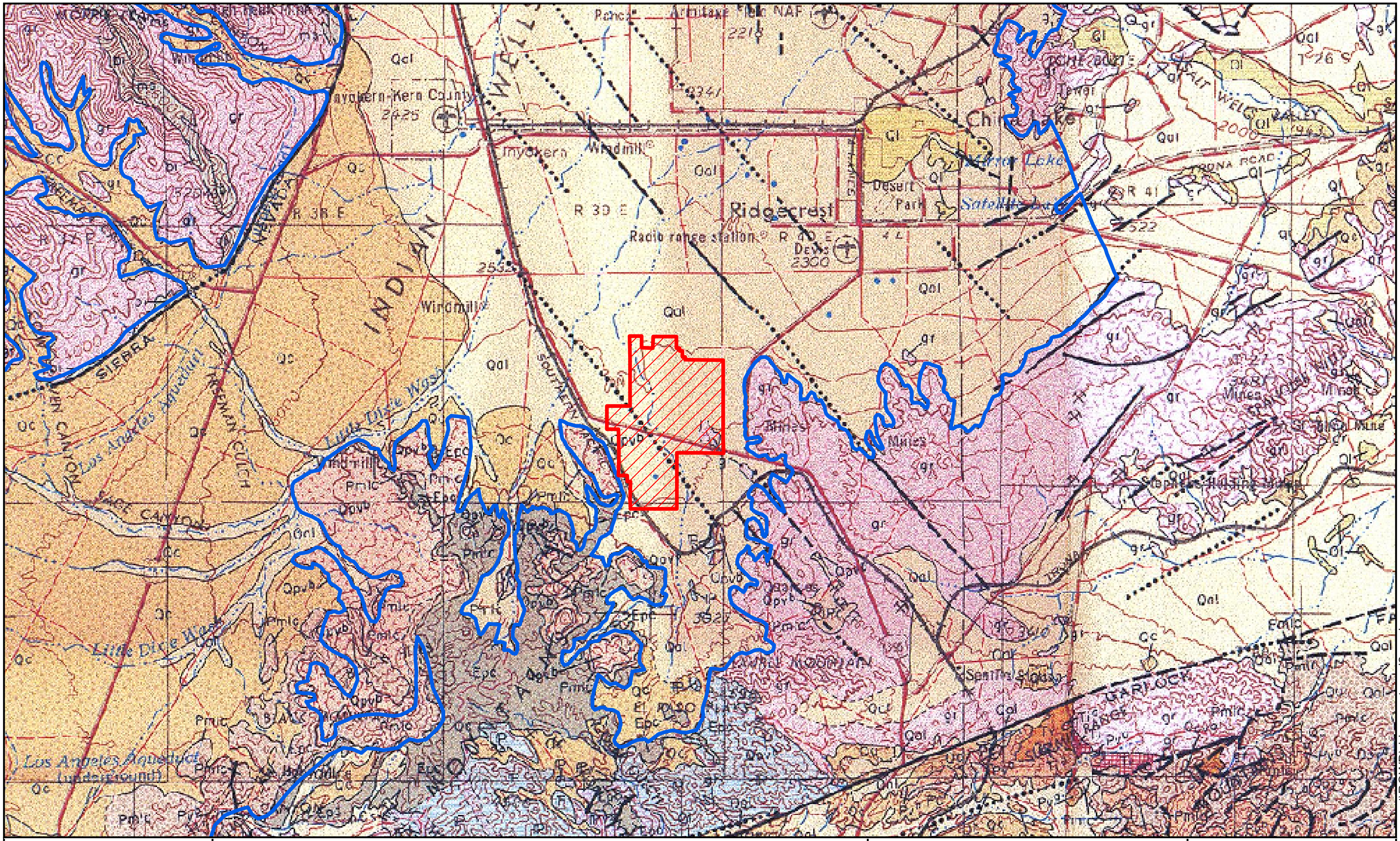

Map Location

Legend

Project Right-of-Way

Indian Wells Valley Groundwater Basin

See Figure 6b for Geologic Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona Sheet, Scale 1:250,000, 1963

1 in = 3 miles

0 3 6 Miles

N S E W

Ridgecrest Solar Power Plant

Figure 6a
Regional Geologic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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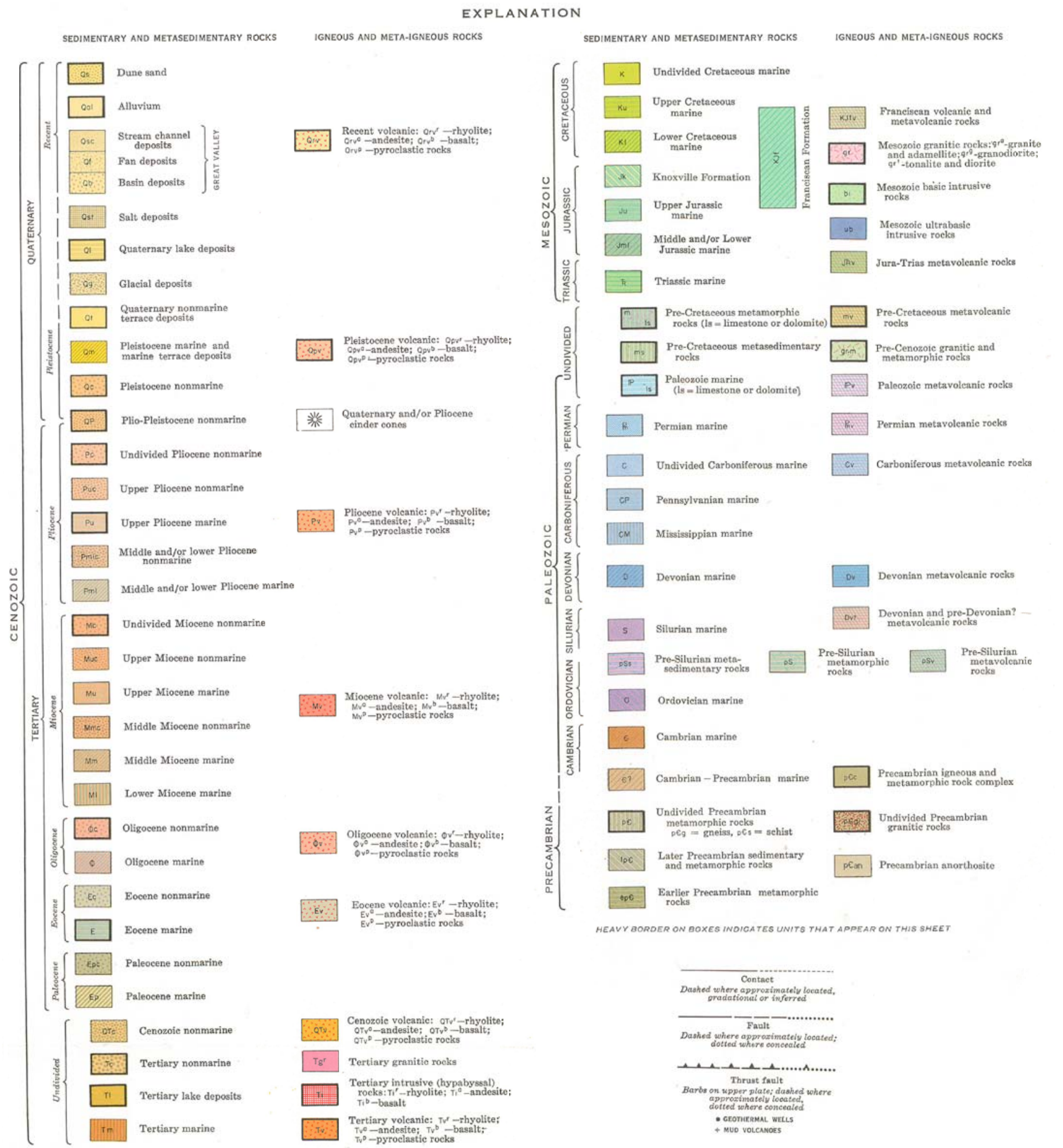

Map Location

Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona, Scale 1:250,000, 1963

Ridgecrest Solar Power Project

Figure 6b
Regional Geologic Map Legend

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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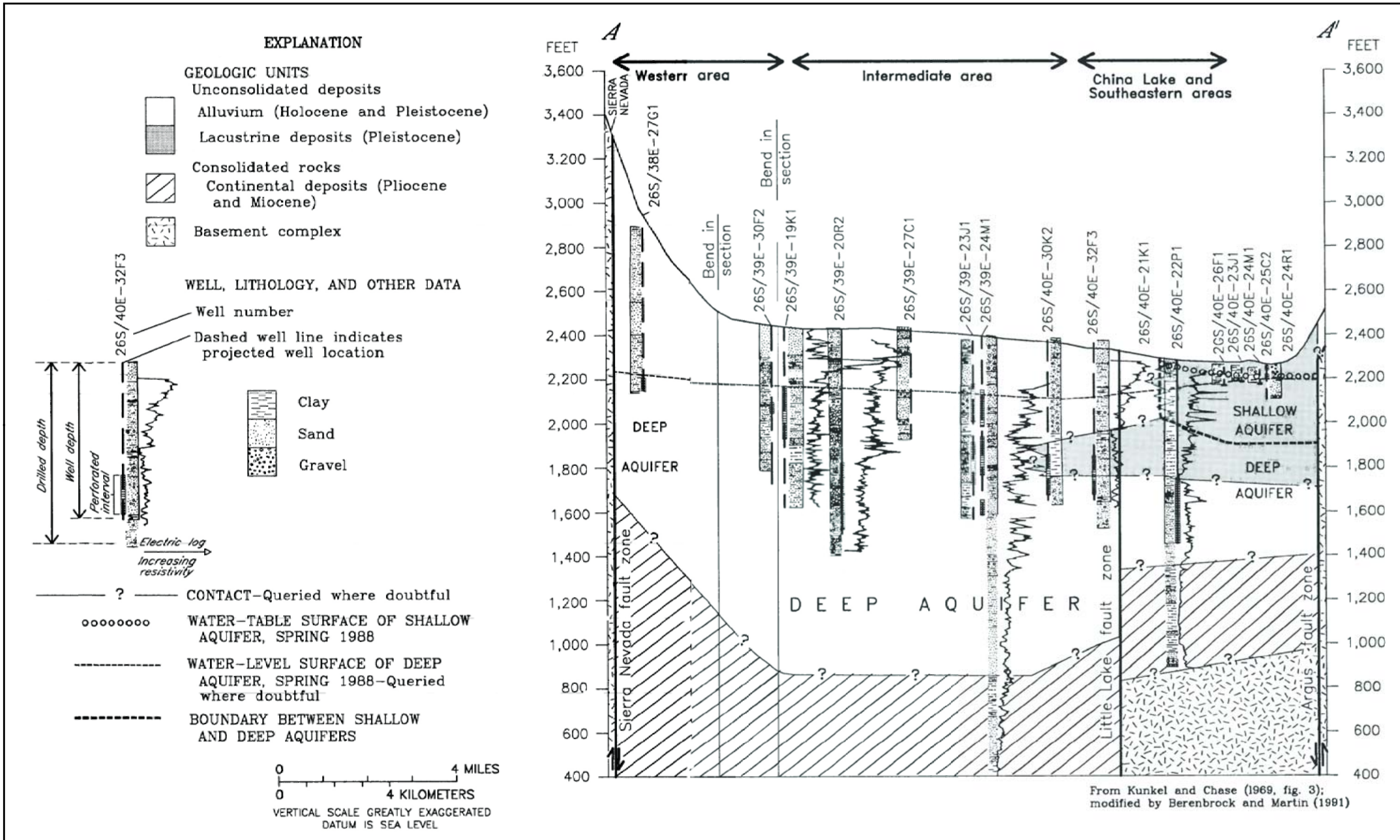


Map Location

Note:
Cross-Section line shown on Figure 5.17-3a Regional Geologic Map.

Source:
Berenbrock, Charles and Schroeder. 1994, Groundwater Flow and Quality, and Geochemical Processes, in Indian Wells Valley, Kern, Inyo, and San Bernardino Counties, CA 1987-88

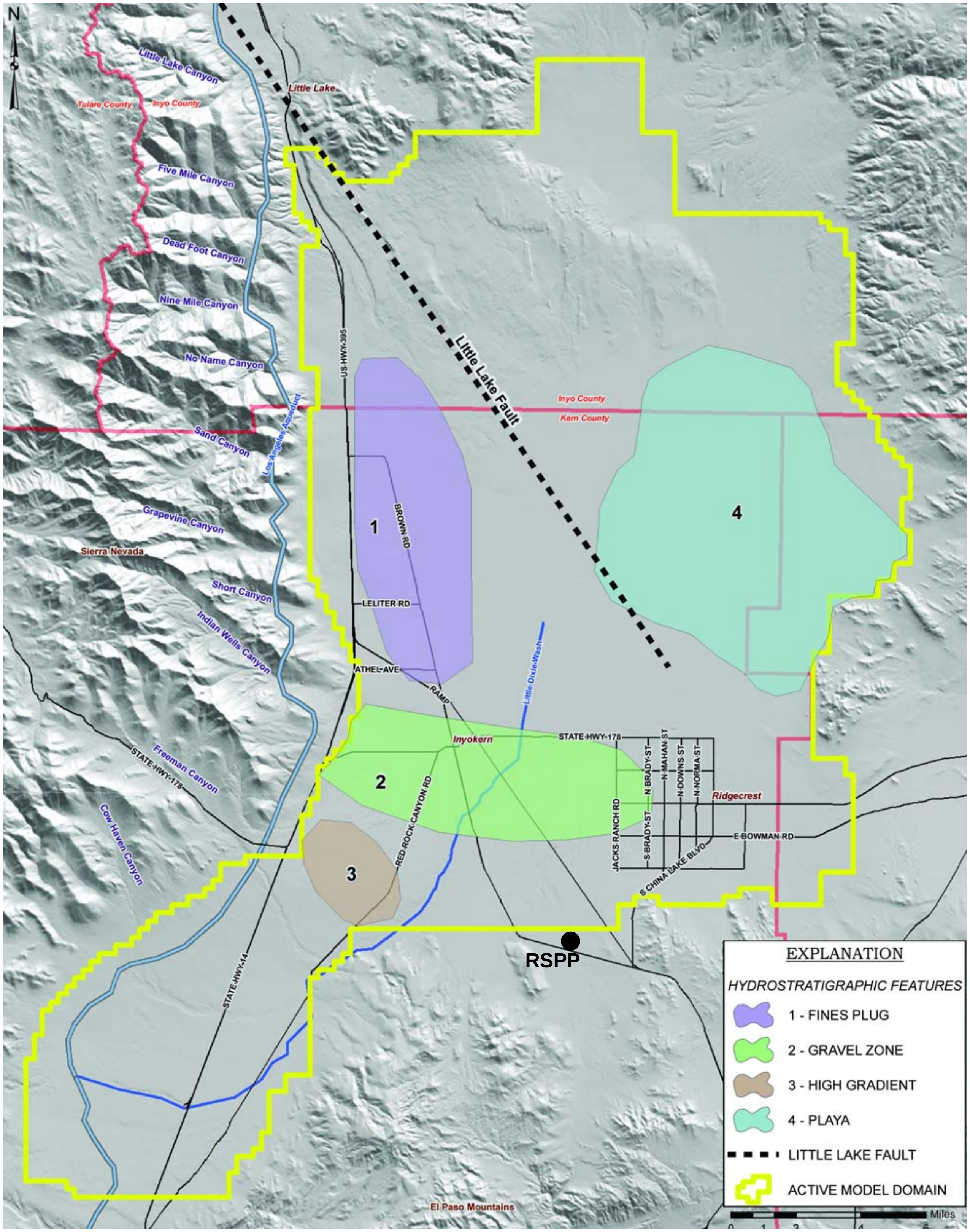
Ridgecrest Solar Power Plant

Figure 7
Cross Section A-A'

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010



Map Location

Sources:
Modified from Brown and Caldwell
Indian Wells Valley Basin Groundwater
Flow Model and Hydrogeologic Study,
March 27, 2009

Ridgecrest Solar Power Project

Figure 8
Hydrostratigraphic Features in the Indian Wells Valley Groundwater Basin

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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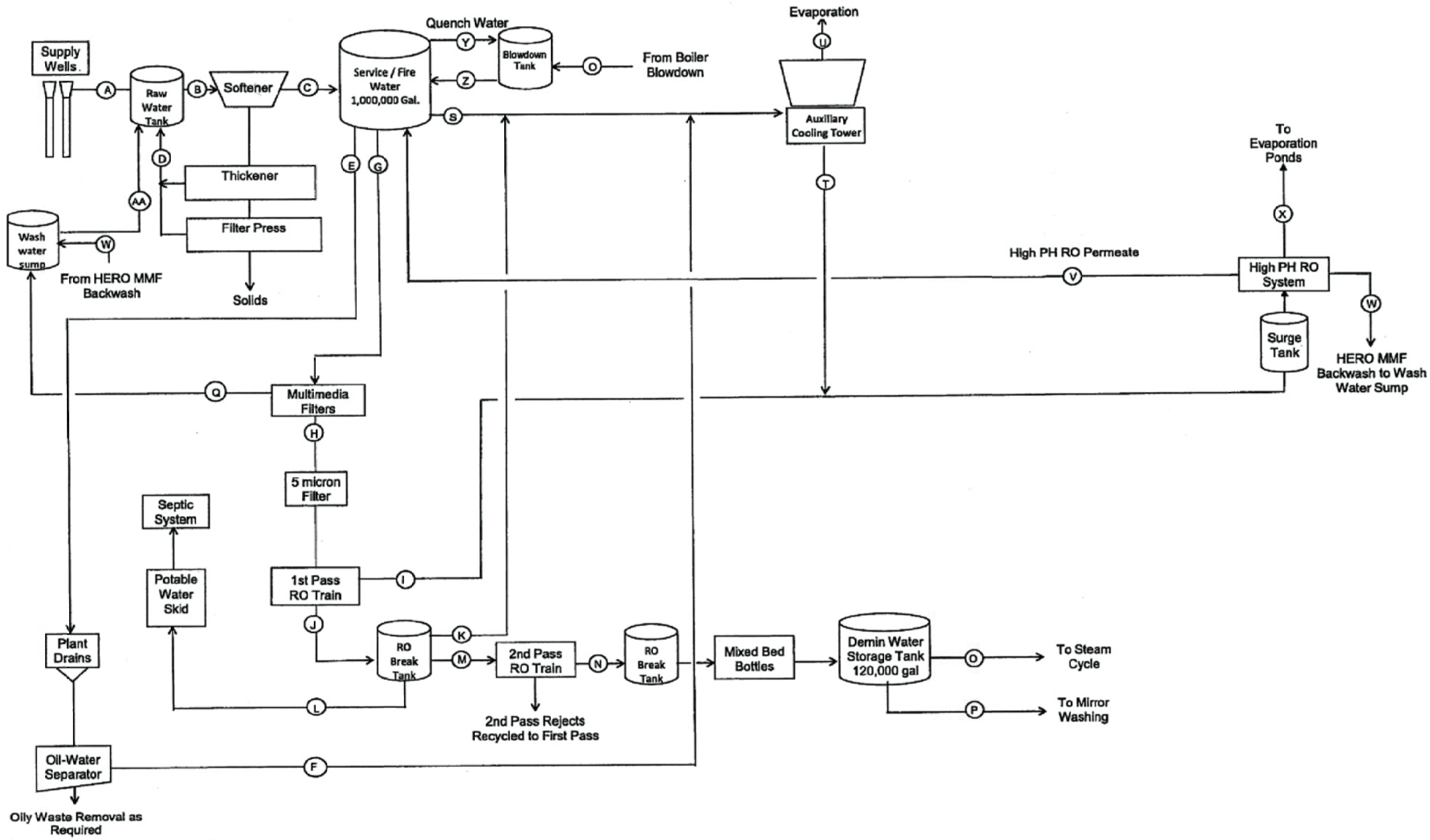

Map Location

Ridgecrest Solar Power Plant

Figure 9
Wastewater Flow Diagram

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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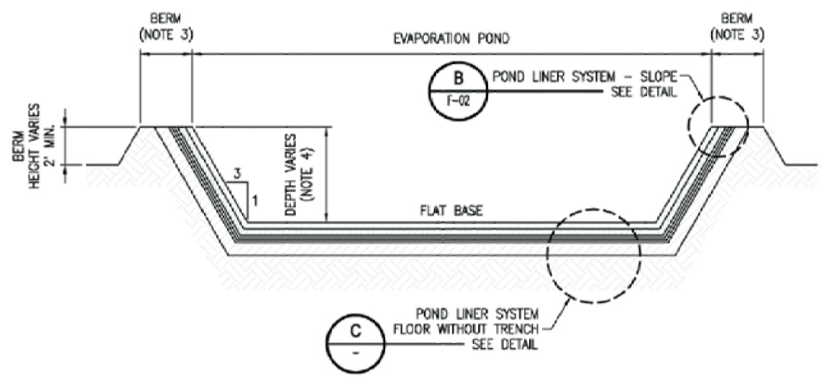
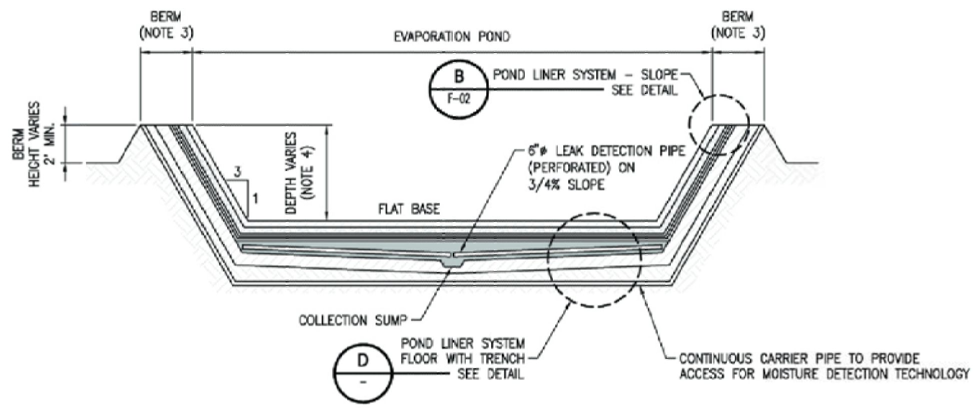


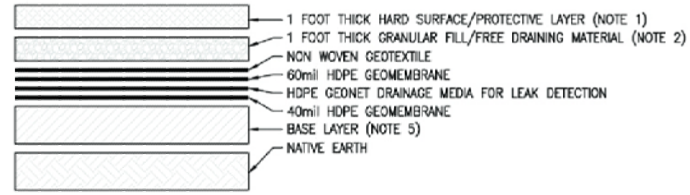
POND - UPSTREAM CROSS SECTION (A –)

SCALE: N.T.S.



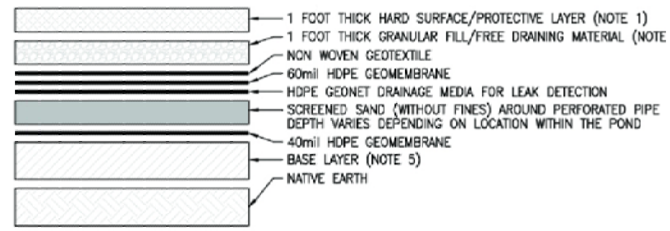
POND - DOWNSTREAM CROSS SECTION (B –)

SCALE: N.T.S.



POND LINER SYSTEM DETAIL FLOOR TRENCH (C –)

SCALE: N.T.S.



POND LINER SYSTEM DETAIL FLOOR WITHOUT TRENCH (D –)

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10-6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 10a
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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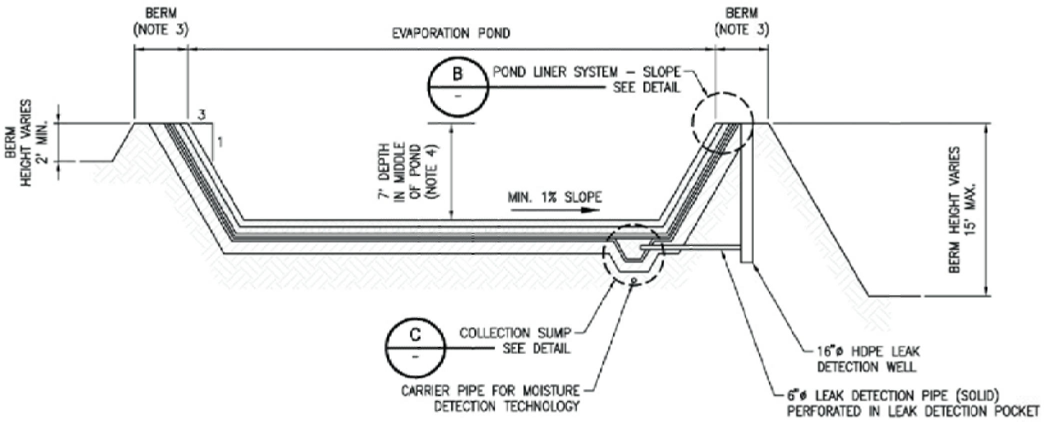
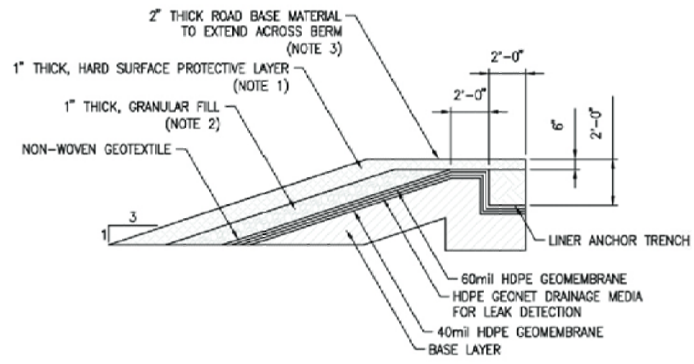


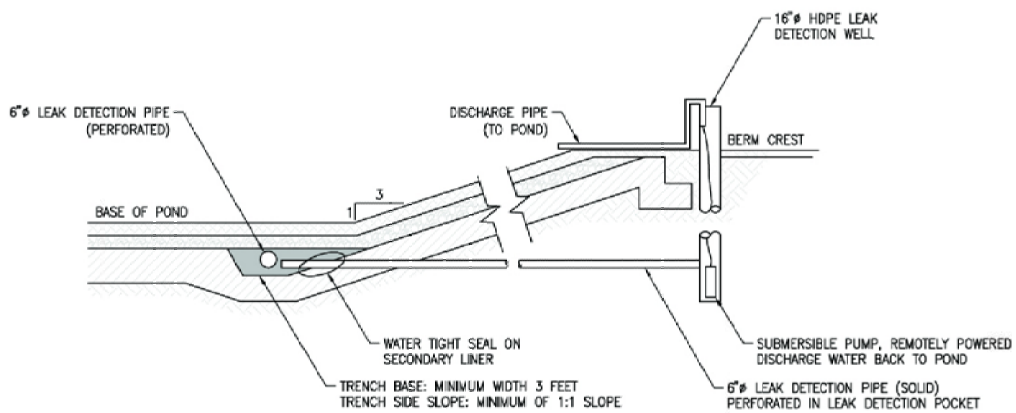
CROSS SECTION THROUGH THE MIDDLE OF THE PONDS (A)

SCALE: N.T.S.



POND LINER SYSYTEM - SLOPES (B)

SCALE: N.T.S.



COLLECTION SUMP DETAIL (C)

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10–6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 10b
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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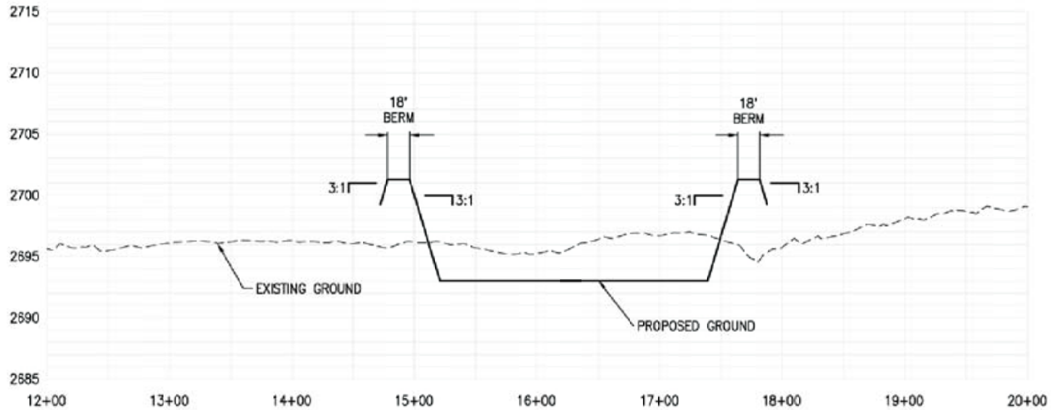

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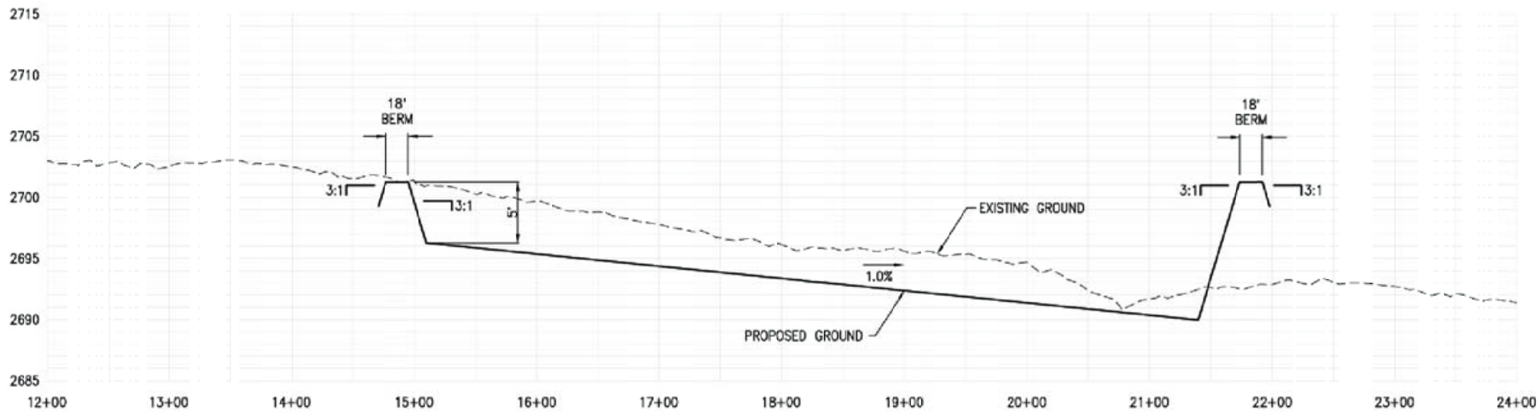

CROSS SECTION B
SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 11a
Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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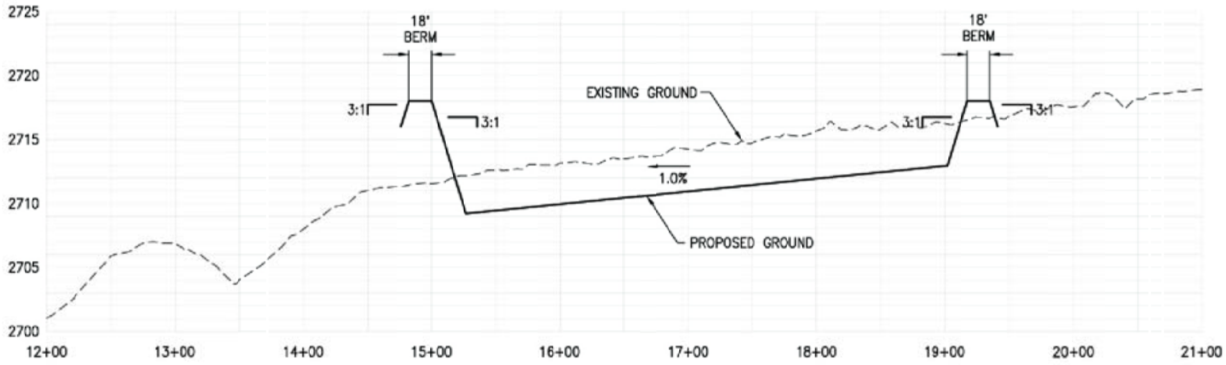

CROSS SECTION C
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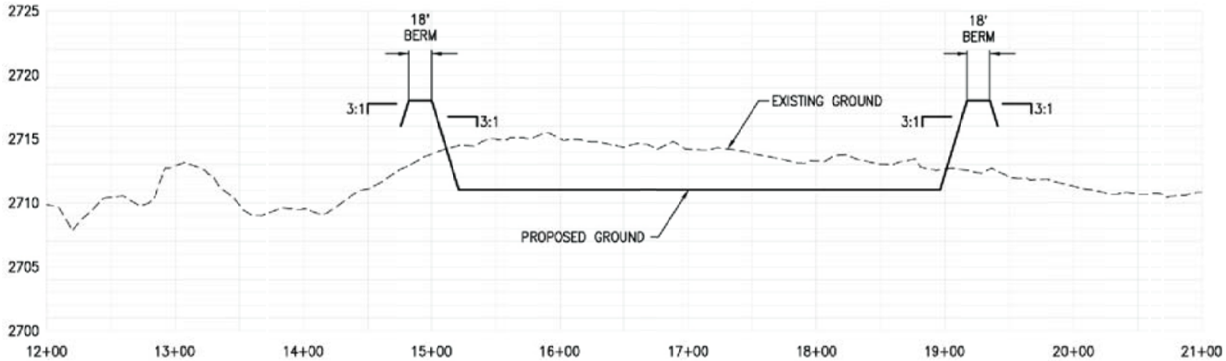

CROSS SECTION D
SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 11b Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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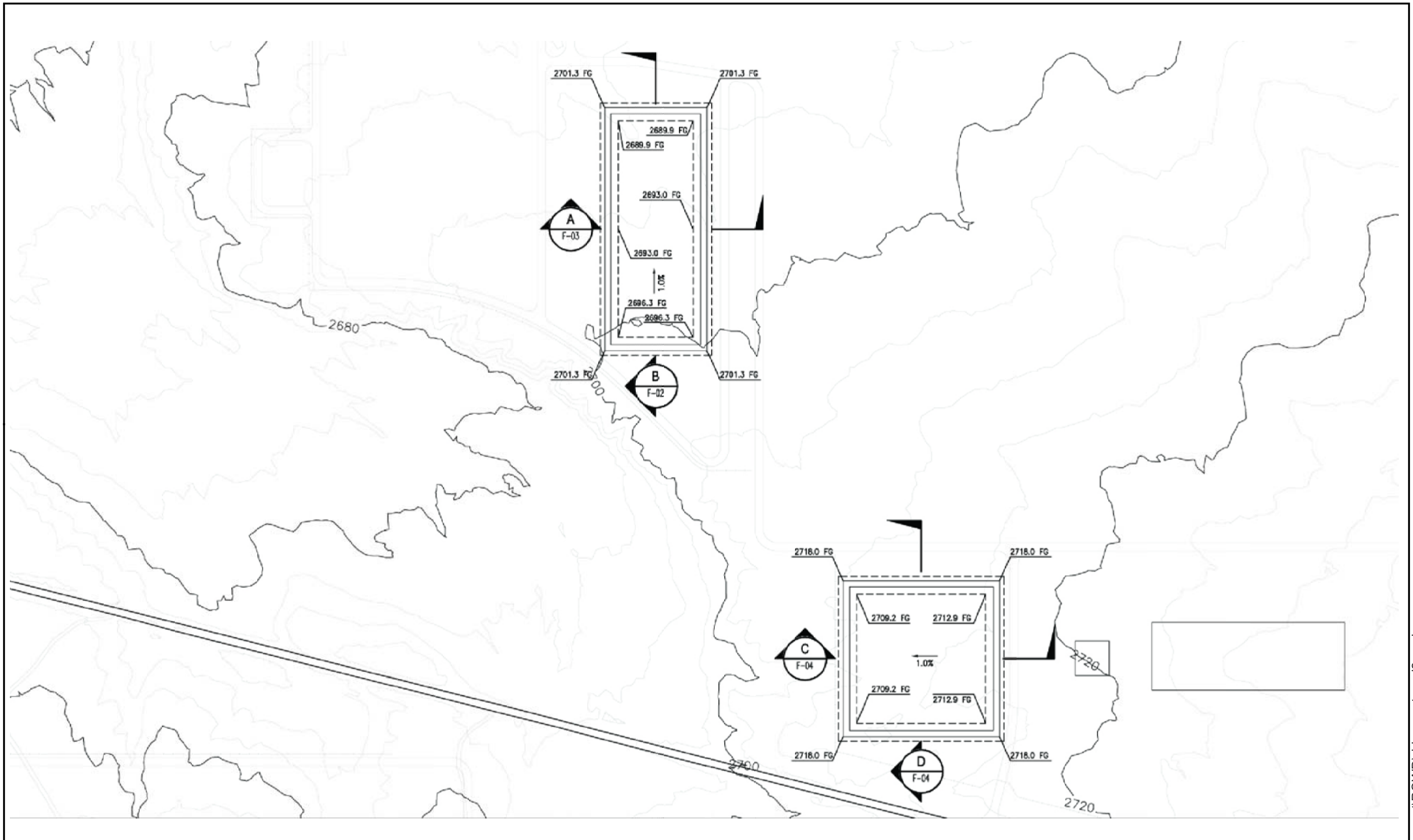

Map Location

Ridgecrest Solar Power Plant

Figure 12
Evaporation Pond Drainage and Grading Plan

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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Tables

Table 1: Site Climate Data

Month	Temperatures (1940 – 2008) (°F)					Number of Days			
	Monthly Averages			Record Extremes		Max. Temp.		Min. Temp.	
	Daily Max.	Daily Min.	Monthly	Record High	Record Low	90°F & Above	32°F & Below	32°F & Below	0°F & Below
Jan	59.6	30.7	45.2	80	1	0	0	18.5	0
Feb	64.9	34.6	49.7	86	9	0	0	11.4	0
Mar	70.4	38.8	54.6	93	15	0.1	0	5.5	0
Apr	77.8	44.5	61.2	100	24	2.9	0	1.6	0
May	87	52.9	69.9	108	26	13.3	0	0.1	0
Jun	96.8	60.5	78.6	117	38	25	0	0	0
Jul	102.7	66.2	84.5	119	46	30.8	0	0	0
Aug	101.3	64.6	82.9	114	45	30.2	0	0	0
Sep	94.2	58.1	76.2	110	35	22.9	0	0	0
Oct	83.3	48.2	65.8	105	20	7.8	0	0.4	0
Nov	69	37.3	53.1	88	14	0	0	7.8	0
Dec	59.7	30.3	45	84	5	0	0	20.3	0
Year[1]	80.6	47.2	63.9	119	1	1.77	0	0.87	0

1. Totals may not match the data in the columns due to rounding errors.

Source: WRCC 2009

Table 2 Site Evaporation and Precipitation Data – Ridgecrest

Month	Rainfall (1940 – 2008) (Inches)			
	Mean	Highest Monthly	Lowest Monthly	Highest Daily
Jan	0.74	4.55	0	1.53
Feb	0.97	4.52	0	2.13
Mar	0.57	3.77	0	2.01
Apr	0.17	1.81	0	1.11
May	0.07	0.79	0	0.65
Jun	0.02	0.4	0	0.2
Jul	0.17	1.54	0	1.1
Aug	0.23	2.91	0	2.39
Sep	0.21	1.71	0	1.25
Oct	0.1	0.78	0	0.7
Nov	0.39	2.47	0	1.04
Dec	0.59	3.08	0	1.76
Year[1]	4.22	4.55	0.59	2.39

1. Totals may not match the data in the columns due to rounding errors.
Source: WRCC 2009.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Published Evaporation (in)	0.00	4.65	6.45	9.97	13.59	15.33	17.21	16.00	11.83	8.28	4.76	3.52	111.59
Monthly Evaporation (in)	1.47	2.33	4.45	6.68	8.63	10.92	11.57	10.89	8.35	5.49	2.63	1.68	75.09

Notes:

Published evaporation is Class A Pan Evaporation
Source Data Location: Mojave, California (Evaporation) and Inyokern, California (Precipitation)

Table 3: Water Quality Data in the Indian Wells Valley Water District (all values reported in mg/L)

Analyte	IWVWD Wells[1]	Proposed Project Supply Wells[2]		
	General Water Quality	Well 18	Well 33	Well 34
Arsenic	0.0024 – 0.025	ND	ND	0.004
Bicarbonates (HCO_3)	87 – 150	150	140	140
Boron	0.180 – 1.20	0.26	0.29	0.29
Calcium	7.5 – 68	36	36	38
Chloride	21 – 210	25	30	31
Fluoride	0.43 – 1.20	0.94	0.73	0.62
Magnesium	ND	4.8	5.1	6.3
Nitrate (N)	6.5	1.7	1.8	2
Sodium	35 - 180	41	41	49
Sulfate	ND	43	43	46
Total Hardness ($CaCO_3$)	21 - 250	110	110	120
Total Dissolved Solids (TDS)	220 – 720	290	280	290
Uranium (in pCi/L)	2.1 – 6.1	NS	NS	NS
Gross Alpha Particle Activity (in pCi/L)	0.8 – 7.8	NS	NS	NS
Vanadium	ND - .04	0.014	0.012	0.016
pH	7.2 – 9.0	7.8	7.9	7.2

Key:
mg/L – milligrams per liter
ND – not detected at the practical quantitation limit shown
NS – not sampled
1. IWVWD, 2008.
2. Data provided by the IWVWD.

Table 4: Raw Water Quality and Estimated Chemistry of Wastewater Streams

	Supply Water[1]	Wastewater to Evaporation Pond[2]	STCL[3]	TCLP[4]
24-Average Flow Rate (GPM)	63	8.748	---	---
Peak Operation Flow Rate (GPM)	97	14.636	---	---
Constituent	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Cations				
Calcium	37	39	---	---
Magnesium	5.4	12	---	---
Sodium	44	767	---	---
Potassium	4	10	---	---
Ammonia	<ND	0		
Anions				
Alkinity	117	77	---	---
Sulfate	44	111	---	---
Chloride	86	1,045	---	---
Nitrate	8	19	---	---
Cyanide	ND	0		
Silica	42	24	---	---
General Water Quality				
Bicarbonate	143	94	---	---
Carbonate	ND	0	---	---
TDS	287	2,124	---	---
Total Hardness ($CaC0_3$)	115	121		
Phosphate	ND	0	---	---
Fluoride	0.8	19	180	---
Barium	0.00028	1	100	---
Iron	ND	0	---	---
Total Suspended Solids	0	12	---	---
Biological Oxygen Demand			---	---
Trace Metals				
Boron	ND	0	--	--
Cadmium	ND	0	1.0	
Copper	ND	0	25	--
Lead	0.0007	0	5.0	

Molybdenum	ND	0	350	--
Selenium	ND	0	1.0	
Thallium	0.014		7.0	
Vanadium	0.000022	0.17	24	--
Zinc	ND	0	250	--

1 - Water quality data from AFC Table Water 4, AECOM, 2009
2 - Water Quality data from AECOM Evaporation Pond Preliminary Design, Operations and Maintenance Plan, April 2010
3 - STLC = Soluble Threshold Limit Concentration, Regulated by CCR Title 22, Division 4.5, Article 3, Section 66261.24
4 - TCLP = Toxicity Characteristics Leaching Procedure; Regulate under 40 CFR Section 261.24

Table 5: Estimated Chemistry of Evaporation Pond Residue

Constituent	Units	Lb/day	Lb/Year	Concentration in dry solids, mg/Kg	Concentration with Silt, mg/kg	STLC mg/L	TTLC mg/kg	TCLP mg/L
Cations								
Calcium	mg/L	4	1,479	18,066	1626			
Magnesium	mg/L	1	462	5,646	508			
Sodium	mg/L	81	29,407	359,182	32326			
Potassium	mg/L	1	396	4,843	436			
Ammonia	mg/L	0	9	113	10			
Anions								
Chloride	mg/L	110	40,050	489,190	44027			
Sulfate	mg/L	12	4,248	51,882	4669			
Alkalinity	mg/L	8	2,958		0			
Bicarbonate	mg/L	10	3,605	44,036	3963			
Carbonate	mg/L	0	7	82	7			
Cyanide	µg/L	-	-	-	0			
Silica	mg/L	3	931	11,373	1024			
Phosphate	mg/L	-	-	-	0			
Polyphosphate	mg/L	-	-	-	0			
Fluoride	mg/L	0	74	903	81	180	18,000	
Nitrate	mg/L	2	740	9,033	813			
General								
Suspended Solids	mg/L	1	462	5,646	465000			
Total Dissolved Solids	mg/L	223	N/A		0			
Hardness	mg/L	13	N/A		0			
Trace Metals		**-**						
Aluminium	µg/L	-	-	-	0			
Antimony	µg/L	-	-	-	0			
Arsenic	µg/L	0.001	0.37	5	0	5.0	500	5.0
Barium	µg/L	-	0.00	-	0			
Boron	mg/L	0.000	0	0	0			

Constituent	**Units**	**Lb/day**	**Lb/Year**	**Concentration in dry solids, mg/Kg**	**Concentration with Silt, mg/kg**	**STLC mg/L**	**TTLC mg/kg**	**TCLP mg/L**
Cadmium	µg/L	-	-	-	0			
Chromium	µg/L	-	-	-	0			
Cobalt	µg/L	-	-	-	0			
Copper	µg/L	-	-	-	0			
Hexavalent Chromium	µg/L	-	0.00	-	0			
Iron	µg/L	-	0.00	-	0			
Lead	µg/L	-	-	-	0			
Manganese	µg/L	-	0.00	-	0			
Molybdenum	µg/L	-	0.00	-	0			
Nickel	µg/L	-	0.00	-	0			
Selenium	µg/L	-	-	-	0	1.0	100	1.0
Strontium	µg/L	-	0.00	-	0			
Thallium	µg/L	-	-	-	0			
Vanadium	µg/L	0.001	0	2	0			
Zinc	mg/L	0.000	0.0	0	0	250	5,000	

Table 6: Evaporation Pond Wastewater Startup and Annual Sampling Parameters

Parameter	Unit
Ammonia	As N
Aluminum	mg/l
Arsenic	mg/l
Boron	mg/l
Calcium	mg/l
Chloride	mg/l
Cyanide	mg/l
Fluoride	mg/l
Iron	mg/l
Magnesium	mg/l
Molybdenum	mg/l
Nitrate as nitrogen	mg/l
Nitrite as nitrogen	mg/l
Phosphate	mg/l
Potassium	mg/l
Selenium	mg/l
Silica	mg/l
Silicon	mg/l
Sodium	mg/l
Strontium	mg/l
Sulfate	mg/l
Total dissolved solids	mg/l
Total alkalinity	mg/l as $CaCO_3$
Zinc	mg/l
Biphenyl	mg/l
Diphenyl	mg/l
pH	pH

Table 7: Evaporation Pond Wastewater Semi-Annual Sampling Parameters

Parameter	Unit
Chloride	mg/l
Chlorine	mg/l
Selenium	mg/l
Sulfate	mg/l
Total dissolved solids	mg/l
Temperature	Fahrenheit or Celsius
pH	pH

Note: Semi-annual samples to be a composite sample of the two ponds.

Table 8: Evaporation Pond Residue Sampling Parameters

Parameter	Unit
Title 22 metals (total)	mg/kg
Biphenyl, diphenyl oxide	mg/kg

Table 9: Annual Groundwater Monitoring Parameters

Parameter	U.S. EPA or Standard Method	PQL	Units
Arsenic	6020	0.5	mg/L
Boron	6020	0.5	mg/L
Calcium	200.7	0.5	mg/L
Chloride	300.0	0.5	mg/L
Fluoride	300.0	0.5	mg/L
Iron	200.7	0.5	mg/L
Magnesium	200.7	0.5	mg/L
Manganese	200.7	0.5	mg/L
Nitrate as Nitrogen	300.0	0.5	mg/L
Nitrite as Nitrogen	300.0	0.5	mg/L
Potassium	200.7	0.5	mg/L
Phosphate	365.3	0.03	mg/L
Selenium	200.7	0.5	mg/L
Sodium	200.7	0.5	mg/L
Sulfate	300.0	0.5	mg/L
TDS	SM 2450C	10	mg/L
Total Alkalinity (as $CaCO_3$)	SM 2350B	1.0	mg/L
Biphenyl Oxide	8015M	1.0	mg/L
Diphenyl Oxide	8015M	1.0	mg/L

Key:

$CaCO_3$ – calcium carbonate
mg/L – milligrams per liter
PQL – practical quantitation limit
SM – Standard Method
TDS – Total Dissolved Solids

Table 10: Quarterly Groundwater Monitoring Parameters

Parameter	U.S. EPA or Standard Method	PQL	Units
Chloride	300.0	0.5	mg/L
Nitrate as Nitrogen	300.0	0.5	mg/L
Phosphate	365.3	0.03	mg/L
Sulfate	300.0	0.5	mg/L
TDS	SM 2450C	10	mg/L
Biphenyl Oxide	8015M	1.0	mg/L
Diphenyl Oxide	8015M	1.0	mg/L
Static Water Depth	Field	+/- 0.1	feet bgs
pH reading	Field	+/- 0.1	pH units
Temperature	Field	+/- 0.1	°F or °C

Key:

mg/L – milligrams per liter
PQL – practical quantitation limit
SM – Standard Method

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Appendix A
Basin Plan Compliance and Antidegradation Analysis

Report of Waste Discharge
Ridgecrest Solar Power Project
Kern County, California

June 2010 60139696-5450-Antidegradation

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Environment

Appendix A
Basin Plan Compliance and Antidegradation Analysis

Report of Waste Discharge
Ridgecrest Solar Power Project
Kern County, California

Prepared By Carmen Caceres-Schnell, PG

Reviewed By Bob Wilson

Contents

List of Tables

List of Acronyms

AFC	Application for Certification
bgs	below ground surface
BMP	Best Management Practice
CCR	California Code of Regulations
CEC	California Energy Commission
CQA	Construction Quality Assurance
CWC	California Water Code
DESCP	Drainage, Erosion and Sediment Control Plan
DTSC	Department of Toxic Substances Control
ft/s	feet per second
MCL	Maximum Contaminant Levels
mg/kg	milligrams per kilograms
mg/L	milligrams per liter
RSPP	Ridgecrest Solar Power Project
ROWD	Report of Waste Discharge Requirements
RWQCB	Regional Water Quality Control Board
SWPPP	Stormwater Pollution Prevention Plans
TDS	total dissolved solid

1.0 Introduction

A Report of Waste Discharge Requirements (ROWD) application for the Ridgecrest Solar Power Project (RSPP or Project) is being submitted to the Lahontan Regional Water Quality Control Board (RWQCB) as part of the Project permitting requirements through the California Energy Commission (CEC). Under the Warren-Alquist Act, and Governor's Executive Order S-14-08, the CEC has the authority to streamline permitting for renewable energy generation facilities. The CEC implements an "in lieu of" permit process by incorporating the regulatory requirements and conditions of the various local and State agencies in its certification process. All necessary State and local permits for this facility, including those permits typically issued by the Water Board, are issued to Ridgecrest Solar I, LLC (herein referred as the Applicant or RSI) through the CEC's certification process.

The ROWD application addresses the construction, operation, closure, and post closure of the two evaporation ponds proposed for the RSPP in compliance with the regulations under California Code of Regulations (CCR) Title 27. The requirement found in CCR Title 27, Section 21750, states the following;

> *The ROWD must incorporate an analysis of … how the Unit, including how any waste, if it escapes from the Unit, could affect the beneficial uses of groundwater bodies (including, but not limited to, any aquifers underlying the facility) and surface water bodies.*

Under the California Water Code (CWC) Section 13241, each RWQCB is required to establish water-quality control plans (Basin Plans) to ensure the reasonable protection of beneficial uses for Waters of the State including surface waters and groundwater. The Lahontan Region Basin Plan designates beneficial uses for surface and groundwater within the Lahontan Region and establishes water quality objectives, waste discharge prohibitions, and other implementation measures to protect those beneficial uses. In compliance with the State of California's Nondegradation Policy, the Lahontan Basin Plan incorporates antidegradation requirements for surface and groundwater. In interpreting the requirements of CCR Title 27, Section 21750, the ROWD for the RSPP must be adequate to ensure the Project's compliance with the objectives and criteria of the Lahontan Basin Plan including antidegradation.

The State Water Board established California's antidegradation policy in State Water Board Resolution No. 68-16 (*Statement of Policy with Respect to Maintaining High Quality of Waters in California*). Resolution No. 68-16 requires that existing quality of waters be maintained unless degradation is justified based on specific findings or facts.

2.0 State and Federal Antidegradation Policy

The U.S. Environmental Protection Agency, Region IX, has issued detailed guidelines for implementation of Federal antidegradation regulations for surface waters in 40 Code of Federal Regulations Section 131.12. The State antidegradation policy is titled the *Statement of Policy with Respect to Maintaining High Quality Waters in California*, codified in CCR Title 23, Section 2900, and is commonly known as “Resolution 68-16.” The State and Federal antidegradation policies are independently enforceable requirements, despite being referred to as policies.

Both the State and Federal antidegradation policies require that where surface waters are of higher quality than necessary to protect the designated beneficial uses, the high quality of those waters be maintained unless otherwise provided by the policies. Both policies require that certain findings be made before any adverse change to water quality can be permitted. The State Water Board has concluded that Resolution No. 68-16 incorporates the Federal antidegradation policy (see State Water Board Order No. WQ 2001-16, p. 19).

Both the State and Federal antidegradation policies have been incorporated into the Lahontan Basin Plan as the nondegradation objective. The nondegradation objective applies to all waters of the Lahontan Region (including surface waters, wetlands, and groundwaters) and requires continued maintenance of existing high-quality waters. Whenever the existing quality of water is better than the quality of water established in the Basin Plan as objectives (both narrative and numerical), such existing quality shall be maintained unless appropriate findings are made under the policy.

3.0 Application of the State Antidegradation Policy

Under the State nondegradation objective, whenever the existing quality of water is better than that needed to protect all existing and probable future beneficial uses, the existing high quality shall be maintained until or unless it has been demonstrated to the State that any change in water quality will be consistent with the maximum benefit of the people of the State, and will not unreasonably affect present and probable future beneficial uses of such water.

Therefore, unless these conditions are met, background water quality concentrations (the concentrations of substances in natural waters which are unaffected by waste management practices or contamination incidents) are appropriate water quality goals to be maintained. If it is determined that some degradation is in the best interest of the people of California, some increase in pollutant level may be appropriate. However, in no case may such increases cause adverse impacts to existing or probable future beneficial uses of Waters of the State.

The State policy establishes a two-step process to determine if discharges that will degrade water quality are allowed. The first step requires that where a discharge will degrade high-quality water, the discharge may be allowed if any change in water quality:

1. Will be consistent with the maximum benefit to the people of the State,
2. Will not unreasonably affect present and anticipated beneficial uses of such water, and
3. Will not result in water quality less than that prescribed (e.g., by water quality objectives).

The second step is that any activities that result in discharge to high-quality waters are required to use the best practicable treatment or control necessary to avoid a pollution or nuisance and to maintain the highest water quality consistent with the maximum benefit to the people of the State.

The State antidegradation policy further establishes that if the discharge, even after treatment, unreasonably affects beneficial uses or does not comply with applicable provisions of Basin Plans, the discharge would be prohibited.

4.0 Compliance with Basin Plan Requirements for Surface Water

The construction, operation, and closure of the evaporation ponds will have no impact to surface water quality within the Project Site. The evaporation ponds will not discharge treated or untreated waste to surface waters or result in the discharge of pollutants to surface waters via storm water runoff.

Surface waters at the site consist of El Paso Wash, an ephemeral wash currently bisecting the Project Site. El Paso Wash trends generally from the southeast to the northwest through the Southern Solar Field, across South Brown Road, then over the Northern Solar Field. El Paso Wash is a Waters of the State as defined under Section 13260 of the CWC and subject to the water quality requirements in the Lahontan Basin Plan. The U.S. Army Corps of Engineers issued a determination that El Paso Wash is not a navigable waters as defined under Section 404 of the Clean Water Act. A Streambed Alteration Agreement application for the re-routing of the wash around the Project Site was submitted to the California Department of Fish and Game (CDFG) on November 25, 2009

The evaporation ponds will be isolated from storm water flows originating upgradient from the Project Site. In addition, the berms around the evaporation ponds will control and prevent potential inflow (run-on) of surface storm water into the ponds. Precipitation that falls on the ponds will be contained in the ponds and evaporated. Storm water run-off that falls outside the ponds will be controlled and routed around the ponds.

A construction general and industrial storm water permit will require the implementation of Storm water Pollution Prevention Plans (SWPPPs) and a CEC-mandated Drainage, Erosion, and Sediment Control Plan (DESCP) during construction and operation of the evaporation ponds. The SWPPP and DESCP will require implementation of Best Management Practices (BMP) to prevent the discharge of pollutants to storm water and will ensure that storm water runoff from the evaporation ponds will not cause degradation of the surface flows diverted around the facilities.

A DESCP has been prepared and attached as Appendix L to the RSPP Application for Certification (AFC) which will address the requirements of CCR Title 27, Section 21600(b)(8)(F). The Plan will describe the management and control of storm water runoff at the Project Site and will specify the site-specific BMPs for erosion and sediment control that will include side slope protection of the berms surrounding the evaporation ponds.

The DESCP and wash diversion will ensure that storm water run on and runoff will not damage the evaporation ponds and that accidentally releases due to erosion will not occur. Therefore, the evaporation ponds do not have the potential to impact or degrade surface water quality and no further analysis is required.

5.0 Lahontan Basin Plan Groundwater Requirements

The Lahontan Basin Plan incorporates narrative and numerical water quality objectives that apply to all ground and surface waters within the Lahontan Region. In general, where more than one objective is applicable, the stricter objective applies. The only exception to this requirement is where a region-wide objective has been superseded by the adoption of a site-specific objective by the regional board.

Beneficial uses designated by the Lahontan Basin Plan as applicable to the Indian Wells Valley Groundwater Basin include: municipal and domestic water supply, agricultural supply, and industrial supply.

The nondegradation objective (State Board Resolution No. 68-16, *Statement of Policy with Respect to Maintaining High Quality of Waters in California*) is described in Chapter 5 of the Basin Plan and applies to groundwaters. Other water quality objectives for groundwater consist primarily of narrative objectives combined with a limited number of numerical objectives and are included in Chapter 3 of the Lahontan Basin Plan. The Basin Plan states that groundwaters shall not contain concentrations of bacteria, chemical constituents, radioactivity, or substances producing taste and odor in excess of the groundwater objectives described in Chapter 3. These objectives define the upper concentration or other limit that the regional board considers protective of beneficial uses. These objectives apply to all groundwaters, rather than to groundwaters only at a wellhead, at a point of consumption, or at point of application of discharge.

6.0 Existing Groundwater Quality

The Project site is located within Indian Wells Valley, which is in the southern end of the Basin and Range Province east of the Sierra Nevada, south of the Caso range, north of the El Paso Mountains, and west of the Argus Range. The Valley is characterized by a broad alluvial basin of Cenozoic-age sedimentary and volcanic material overlying older plutonic and metamorphic rocks. Quaternary lacustrine deposits are also found in the region as a result of playas in the northeastern portion of the valley. Surface water in the Indian Wells Valley drains from the surrounding mountains toward China Lake, a dry lake, which is located about 12 miles northeast of the Project site.

Groundwater beneath the Project and surrounding area is contained within the Indian Wells Valley Groundwater Basin. This basin encompasses an area of about 597 square miles (DWR 2004).

The groundwater quality in Indian Wells Valley varies throughout the Basin. According to the DWR report, TDS ranges from less than 600 mg/L to more than 1,000 mg/L. Analyses of water from ten public supply wells in the IWV Groundwater Basin show that TDS content ranges from 220 to 720 mg/L. In general, the highest quality water is in the deep aquifer (Groundwater Management Group 2008). TDS concentrations for wells in the IWV Groundwater Basin were mapped by the Indian Wells Valley Cooperative Groundwater Management Group. Groundwater considered to have the best quality (TDS of 500 mg/L or lower) is found in the southwestern part of the Valley and the western part of the Valley along the area of recharge.

A review of the water quality data for the IWV Groundwater Basin show that eight major types of groundwater quality occur in the Basin:

- Alpine waters, characteristically calcium-sodium-magnesium-bicarbonate. These are characteristic of the Sierra Nevada.
- Sodium-chloride waters, characteristic of China Lake, southeastern parts of the City of Ridgecrest, and the Coso Geothermal Area.
- Sodium-carbonate waters, principally occurring in the southwestern part of Indian Wells Valley.
- Sodium-bicarbonate waters, occurs in an extensive horseshoe-shaped area in the north and southwestern parts of the basin.
- Sodium-bicarbonate-chloride waters, east of the horseshoe area and may represent mixing of easterly moving groundwater with the groundwater of the China Lake Playa.
- Sulfate waters from geothermal areas, mineralized areas, and sewage pond seepage.
- Calcium-(sodium-magnesium)-bicarbonate-chloride-sulfate waters, these water probably represent a mixture of Alpine and Coso geothermal waters.
- “Waters of the well fields. Usually sodium-calcium, but sometimes calcium-sodium-bicarbonate-chloride waters. These water could represent Alpine waters concentrated by ET mixed with sodium chloride geothermal leakage”.

A review of the water quality data for the ten wells pumped for the IWVWD water supply shows the following:

- TDS concentrations (280 to 5,640 mg/L) generally exceeded the recommended standard of 500 mg/L, for a drinking water resource in California.
- Arsenic was reported in general water quality data for 2008 at concentrations between 0.0024 – 0.025 mg/L. Some concentrations exceeded the primary State and Federal Maximum Contaminant

Level (MCL) for Arsenic (0.010 mg/L). The IWVWD began compliance testing for arsenic in December 2007. At that time, three wells were placed on quarterly monitoring. Two wells violated the MCL based on samples collected in March, July, and October 2008. Arsenic is a naturally occurring element commonly found in drinking water sources in California.

- Boron concentrations range from 0.18 mg/L to 1.2 mg/L. Boron was reported in two District wells at concentrations of 1.2 mg/L and 1.1 mg/L. The Action Level for boron is 1.0 mg/L. The Action Level is the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.

The IWVWD serves the City of Ridgecrest and the surrounding areas. Ten wells are pumped by the IWVWD for their water supply and these wells are tested on regularly for the presence of radioactive, biological, inorganic volatile organic, and synthetic organic compounds. The results of the 2008 Annual Water Quality Report are presented on Table 5.17-6. Table 5.17-6 also presents the analytical results for three wells that are proposed to be pumped for the Project water supply and are located approximately four miles from the center of the Project site. Given the long screen interval for these wells, these data likely represent an average water quality of the more permeable sediments over the screen interval.

Table 1 Summary of Water Quality Data
(all values reported in mg/L)

Analyte	IWVWD Wells[1]	Proposed Project Supply Wells[2]		
	General Water Quality	Well 18	Well 33	Well 34
Arsenic	0.0024 – 0.025	ND	ND	0.004
Bicarbonates (HCO_3)	87 – 150	150	140	140
Boron	0.180 – 1.20	0.26	0.29	0.29
Calcium	7.5 – 68	36	36	38
Chloride	21 – 210	25	30	31
Fluoride	0.43 – 1.20	0.94	0.73	0.62
Magnesium	ND	4.8	5.1	6.3
Nitrate (N)	6.5	1.7	1.8	2
Sodium	35 - 180	41	41	49
Sulfate	ND	43	43	46
Total Hardness ($CaCO_3$)	21 - 250	110	110	120
Total Dissolved Solids (TDS)	220 – 720	290	280	290
Uranium (in pCi/L)	2.1 – 6.1	NS	NS	NS
Gross Alpha Particle Activity (in pCi/L)	0.8 – 7.8	NS	NS	NS
Vanadium	ND - .04	0.014	0.012	0.016
pH	7.2 – 9.0	7.8	7.9	7.2

Key:
mg/L – milligrams per liter

Table 1 Summary of Water Quality Data (all values reported in mg/L)

Analyte	IWVWD Wells[1]	Proposed Project Supply Wells[2]
ND – not detected at the practical quantitation limit shown NS – not sampled 1. IWVWD, 2008. 2. Data provided by the IWVWD		

7.0 Design and Operation of the RSPP Unit

7.1 Evaporation Ponds

The main waste stream at the site consists of industrial wastewater generated in the various processes associated with power generation. Industrial wastewater is treated via a high-pH RO system at the one Unit. The treated water from the Unit is recycled to the 1,500,000-gallon Service/Fire Water tank for reuse in the process. The concentrate from the RO system is discharged to the two lined evaporation ponds. The RSPP therefore includes four proposed evaporation ponds for waste storage and disposal. These four evaporation ponds are the subject of this ROWD application.

Each 4-acre evaporation ponds has a proposed average design depth of 7 feet across each pond which incorporates:

- Drying each pond at alternating four year intervals;
- 3 feet of operational depth;
- 2 foot of sludge build up over 4 years; and
- 2 feet of freeboard.

The containment design for the evaporation ponds, from the surface of the evaporation ponds downwards, consists of the following:

- A hard surface/protective layer with granular fill/free draining sub-base over geotextile;
- A primary 60 mil HDPE liner;
- An interstitial leak detection and removal system (LDRS) comprising a geomembrane geonet and collection piping;
- A secondary 40 mil HDPE liner;
- A 2-foot thick compacted silty sand base; and
- Installation of the carrier pipe for the moisture detection (neutron probe) system beneath the base of the ponds.

It is estimated that during the 30-year operating life of the Project, about 6,400 tons of evaporites will accumulate in the ponds. However, because it is anticipated that wind-blown silt will accumulate in the ponds at a rate of perhaps 6 inches per year, it will be necessary to clean out the ponds on approximately four-year intervals. Assuming 2 feet of silt accumulation, the sludge removed from the ponds will be approximately nine percent evaporate and 91 percent silt. The predicted chemical makeup of the evaporite, based on information about the raw water chemistry is presented in **ROWD Table 4**.

The units will be located outside of the 100-year flood plain and seismic hazard zones **(ROWD Figure 3)**. In addition, the base of the evaporation pond will have a greater than 5-foot separation to the underlying groundwater.

7.2 Management of Storm Water

Releases or spills from damage caused by storm water run on or runoff could result in degradation of surface and groundwater. However, measures to address the impacts of storm water and erosion have been incorporated into the design of the Project. As part of the stormwater management for the site, Solar Millennium will re-route the current El Paso and two unnamed washes that run through the Project Site. The washes will be rerouted around the southern (Channel 1) and eastern (Channel 3) boundaries, and through the center of the Project (Channel 2), effectively diverting stormwater run on away from the evaporation ponds.

As described in the DESCP prepared for the Project, the diversions will be designed to handle a 100-year flood event and for flows of up to 6.7 feet per second (ft/s) for Channel 1, 10.1ft/s for Channel 2, and 11.7 ft/s for Channel 3. The constructed stormwater management facilities and BMPs are described in Section 9 of the ROWD.

On-site flows are directed to these receiving water channels just as the existing stormwater is directed to the existing channels. The Project will be substantially occupied by long rows of solar collectors, but these collectors are elevated above the ground and thus the ground below the mirrors remains as a pervious surface.

Each of the proposed channels are being sized to contain the peak flow of the 100-year, 24-hour storm event. In general, each channel will also be revegetated with native vegetation to minimize habitat disturbance. The calculations for each channel shows that they may have an erosive effect at some locations in a 100-year event. Each channel will be designed with 3:1 side slopes to help mitigate the erosion of the banks. Moreover, the channel bottom widths will be set to promote relatively shallow flows to minimize erosive forces. The channel will be constructed with native material, and scour protection will be added in stress areas (locations where the erosion potential is greater than a straight, uniform channel reach, and includes junctions, transitions, and curves). The extent of the channel bank protections will be at least a distance equal to ten times the design water depth and will be extended into the channel bottom to provide for potential bottom scour. No scour protection is proposed for the channel bottom in the straight sections of the channels. This is to allow the low flows to meander across the bottom replicating as nearly as possible the flow regimes under current conditions. The erosion control measures will be designed to maintain the infiltration characteristics of the channel reach similar to pre-construction conditions.

Each channel is designed as a trapezoidal channel with a transition (diffuser) at the discharge to return the storm water back to sheet flow at the edge of the Project site. The diffuser is designed with an expanding channel cross section to spread out the flow resulting in low-flow velocities. The purpose of the diffuser is to return the flood flows to the approximately location and depth that occur in the existing condition.

In summary, there are slight changes in peak flow rates in the channels between the existing condition and the proposed condition and slight shifting in contributing drainage areas from the existing to the proposed condition. These changes are attributed to the difference in time of concentrations. The proposed flow rates leaving the site are generally lower than the existing flow rates because the time of concentrations for the proposed on-site drainage areas are longer than the existing times of concentrations for the existing overland flow. The constructed stormwater management facilities and BMPs are described in detail in Section 9 of the ROWD.

7.3 Compliance with Basin Plan Groundwater Management Requirements

Releases from the evaporation ponds in the form of leaks and spills would have the potential to impact groundwater quality in the underlying vadose zone or aquifers. The discharge of pollutants to the sub-surface would result in the degradation of potentially high-quality groundwaters and would be in violation of the antidegradation objective in the Lahontan Basin Plan. However, the evaporation ponds will be constructed and operated according to the CQA. Proper operation and maintenance of the facilities according to the CQA will prevent the discharge of pollutants to the vadose zone and underlying aquifer.

The ROWD application complies with the groundwater management requirements for waste management units stated in Chapter 4 of the Basin Plan. Chapter 4 includes the specific requirements under CCR Title 27 and additional monitoring and reporting requirements to ensure compliance with Basin Plan groundwater quality objectives. As required under Chapter 4 of the Basin Plan, a Detection Monitoring Program has been designed that will provide detection of a release from the evaporation ponds. The program consists of quarterly, semi-annual and annual sampling of the vadose zone and groundwater monitoring wells.

The ROWD incorporates preliminary closure plans and preliminary post-closure monitoring and maintenance plans in addition to a financial assurance that adequate funds will be irrevocably committed by the Applicant to ensure that the Project will be properly reclaimed and maintained.

8.0 Compliance with the Antidegradation Objective for Groundwater

The Applicant will meet the Step One demonstration requirements of the Basin Plan antidegradation objective in that operation of the Project:

1. Will be consistent with the maximum benefit to the people of the State in providing a clean, renewable source of energy;

2. Will not unreasonably affect the present and anticipated beneficial uses of groundwater within the Indian Wells Valley Groundwater Basin; and

3. Will not result in water quality less than that prescribed (e.g., by water quality objectives) based on the application of engineered liner systems, BMPs and the CQA program.

The Project has provided detailed information in the ROWD regarding the design of the evaporation ponds. The ponds will comply with Title 27 requirements to ensure that no releases occur to groundwater. Additionally, proper installation, operation, and maintenance of the Project will be assured by application of the CQA. Proper closure and post closure procedures will eliminate any long-term impacts to groundwater quality. This information is adequate to provide adequate documentation for Step 2 of the antidegradation demonstration.

9.0 Conclusion

Based on the above demonstrations, this analysis concludes that operation of the evaporation ponds will comply with the requirements of the Lahontan Basin Plan and will not result in degradation of existing high-quality groundwater.

AECOM

Prepared for:
Ridgecrest Solar I, LLC

Design Basis Memorandum Ridgecrest Solar Power Project Kern County, California

Appendix B of the Application/Report of Waste Discharge

Table of Contents

List of Tables

1.0 Summary

Ridgecrest Solar Power Project consists of one power block requiring ponds to receive process wastewater from the plant and dispose of the water by evaporation. This document provides design information used in sizing these evaporation ponds.

The pond area and depth were established to receive the process wastewater and direct precipitation and evaporate them to dryness over the course of a year. The power block area will include two ponds. During normal operation both ponds will receive process wastewater. However, during periods when one pond is being dried to allow maintenance or removal of accumulated sediments, the other pond will be capable of receiving all of the process wastewater and storing / evaporating it until the other pond is brought back online.

The power block will require a total of eight acres (348,480 square feet) of evaporation pond area, split into two four acre ponds. Average pond depth will be 7 feet: two feet for sludge accumulation, two feet of freeboard, and three feet of active storage area.

2.0 Purpose and Objective

A total of two (2) evaporation ponds will be used at the Ridgecrest Solar Power Plant located in located in the high northern Mojave Desert in northeastern Kern County, California, about five miles southwest of the City of Ridgecrest, California. Process wastewater from the plant's operation will be discharged to these ponds and will be stored and allowed to evaporate. Monthly average discharge from the plant to the pond was determined through water balance of the plant processes. The ponds are required to hold any precipitation directly falling on the pond along with process water discharge from the plant. Runoff from the surrounding area will be diverted away from the pond.

Average values of precipitation and evaporation were used to determine the pond size. The pond bottom area was selected to allow all water entering the ponds to evaporate every year. Pond depth was selected to allow storage of plant discharge and rainfall through low-evaporation months, including sludge accumulation from salts in the process water and wind-blown silt as well as required freeboard.

3.0 Design Criteria

3.1 Process Water Discharge

Process water discharge was determined through the development of a water balance based on the process flow diagram provided by the water treatment vendor. The water balance provided the discharge flows for each of the heat balance cases. A conservative load profile for each month was then developed using a day and night heat balance case. This approach provided a plant discharge in terms of a monthly rate. See Section 4.

3.2 Precipitation

Precipitation data was obtained from the Western Regional Climate Center. The average monthly total precipitation data for the years 1931 through 2005 was obtained from the WRCC website http://www.wrcc.dri.edu. The average yearly total precipitation was 4.54 inches.

3.3 Evaporation

Mojave is the closest weather station to the project site that records evaporation data. Monthly average pan evaporation data recorded at this station for a period of 1948 to 2005 was obtained from the website http://www.wrcc.dri.edu/htmfiles/westevap.final. The total of recorded monthly average pan evaporation for the months from January through December is 111.59 inches. Factors were applied for conversion of pan evaporation to pond evaporation and correction for salinity, and the resulting equation takes this form:

Pond evaporation = k1*K2*(Pan Evaporation)

K1 is a pan coefficient, necessary for converting pan data to pond evaporation estimates. A value of 0.75 was used.

K2 is the salinity correction coefficient. A practical maximum concentration for mixed salt salinity suggested by the literature is around 17%, which would lower the vapor pressure of water by about 10% (CRC Handbook 1995), corresponding to a 10% decline in the rate of evaporation. However, due to the high concentration of TDs of the water entering the pond, a factor of 0.7 was used which is an industry standard for salinity. It was assumed that the plant discharge will not contain constituents such as scum or oil that could further reduce evaporation rates.

This procedure resulted in average monthly pond evaporation values totaling 58 inches per year.

3.4 Freeboard

Additional height of embankment was added to the maximum depth of storage as freeboard. A minimum of 2 feet is required, and this value is used.

Evaporation Pond Design Summary

Pond bottom area (per pond)	149,310 SF	3.43 Ac
Pond top area (per pond)	171,738 SF	3.94 Ac
Required maximum storage volume per pond	481,400 CF	11.1 AF
Sludge storage depth	24 In	
Active storage depth	36 In	
Freeboard	24 In	
Total required depth	84 In	

Pond top dimensions:

North pond 800 x 218 ft

South pond 465 x 375 ft

4.0 Process Water Quality

Figure B-1 presents a schematic representation of process water treatment and flows. Table B-1 presents anticipated process water flows corresponding to the flow streams labeled in Figure B-1. Table B-2 presents anticipated quality of the various process streams.

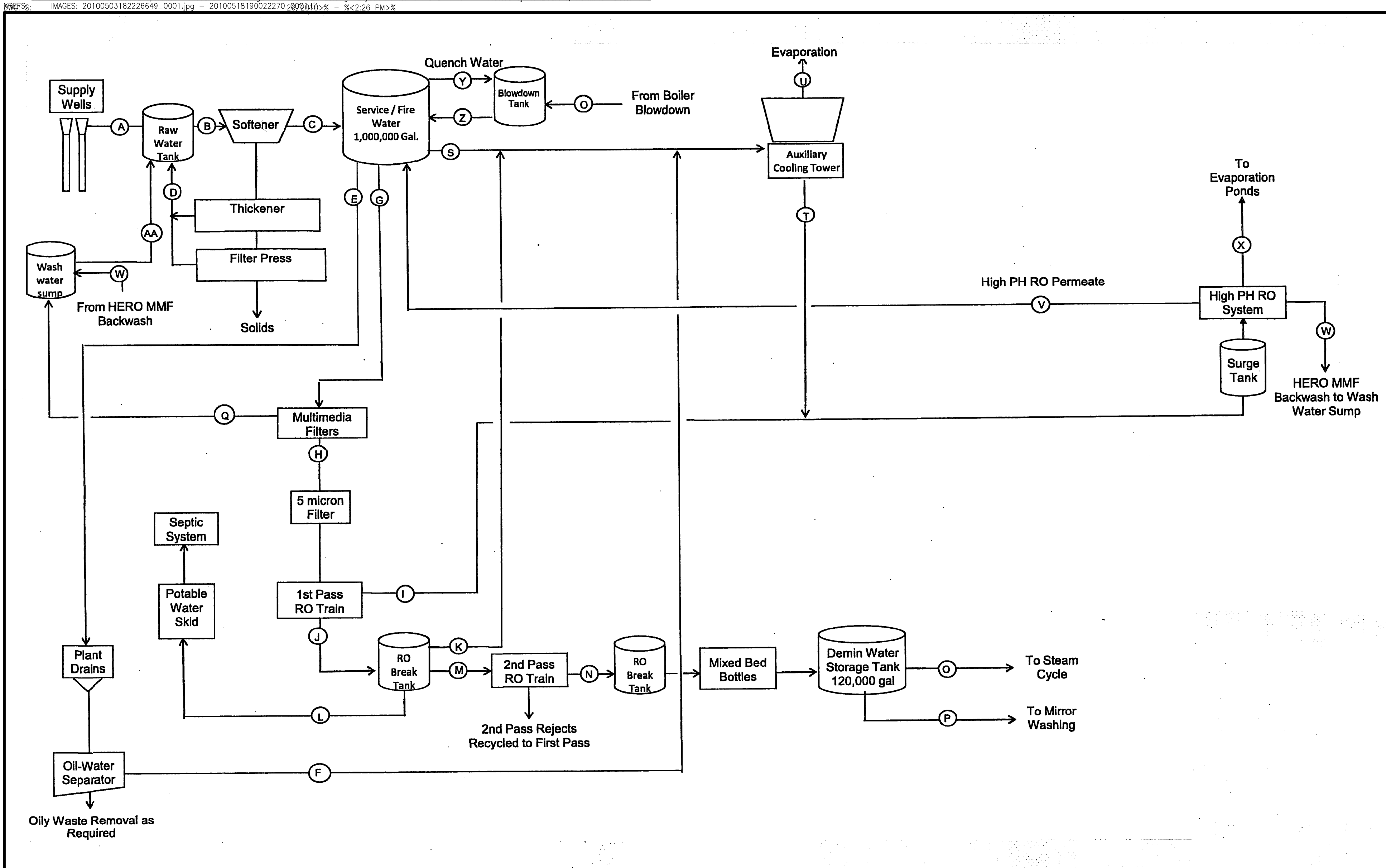

FIGURE B1	SOLAR MILLENNIUM	AECOM PROJECT NO.	AECOM
	RIDGECREST EVAPORATION PONDS FIGURE B-1	60092528.0010	AECOM USA, Inc. 5001 E. Commercenter Dr. Suite 100 Bakersfield, California 93309 T 661.325.7253 F 661.395.0359 www.aecom.com

Table B-1
Process Water Flows

		24 Hr Average	24 Hr Total	Peak Operation
	Ambient Conditions	96.7F/66.5F_WB	96.7F/66.5F_WB	96.7F/66.5F_WB
	Boiler Duty	100%	100%	100%
Stream ID	**Description**	**GPM**	**GPD**	**GPM**
A	Flow from supply wells	63	90,917	97
B	Softener Makeup	99.46	143,225	153.52
C	Softener Effluent	98.47	141,793	151.98
D	Recovered dewatering water	0.4	573	0.61
	Water in dewatered sludge	0.6	859	0.92
E	Service water to plant users	4	5,760	4
F	OWS effluent	4	5,760	4
G	Multimedia filter makeup	133.4	192,121	197.1
H	First pass RO makeup	120	172,909	177
I	First pass RO reject	48	69,164	71
J	First pass RO permeate	72	103,746	106
K	RO permeate to cooling tower	0	-	0
L	RO permeate to potable water	2	2,880	2
M	Second pass RO makeup	70	100,866	104
N	Second pass RO permeate	53	75,649	78
O	Steam cycle makeup / blowdown	16	23,398	42
P	Demin water to mirror washing	36	52,251	36
Q	Multimedia filter backwash	13	19,212	20
	Service water to cooling tower	27	38,694	76
S	Total cooling tower makeup	31	44,454	80
T	Cooling tower evaporation	21	29,636	53
U	Cooling tower blowdown	10	14,818	27
V	High pH RO permeate	50	71,384	83
W	High pH filter backwash	5.832	8,398	9.758
X	High pH RO reject of Evap Pond	8.748	12,597	14.636
Y	Quench Water	65	93,732	130
Z	Quenched Boiler Blowdown	81	117,130	172
AA	Multimedia filter backwash	36	51,735	56

Design Basis:

1. Steam cycle makeup and cooling tower evaporation from Kiewit.
2. Recovery rates depend upon influent water chemistry.
3. Based on water analysis April 2008 from Indian Wells Valley Water District Wells 18, 33, and 34.

Table B-2
Anticipated Water Quality

Constituent	**Units**	**Well Water**	**Softened Water**	**Service Water**	**RO First Pass Permeate**	**1st pass RO Reject**	**Mixed Bed Effluent**	**Boiler Blow down**	**Quenched Blowdown**	**Cooling Tower Makeup**	**Cooling Tower Blow down**	**High pH RO Permeate**	**High pH Reject to Evaporation Pond**
		A, B	C, D	E,G,H,S,Y	J,L,K,M	J	O,P	P	Z	F+K+S		V	
Cations													
Calcium	mg/L	37	16	11	5	40	0	1	9	11	32	0	39
Magnesium	mg/L	5.4	5	3	1	12.5	0	1	3	3	10	0	12
Sodium	mg/L	44	44	36	10	110	0	77	44	36	108	20	767
Potassium	mg/L	4	4	4	0	10	0		3	4	12	4	10
Ammonia	mg/L	ND	0.1	0	0	0.25	0		0	0	0	0	0
Anions													
Chloride	mg/L	86	86	60	10	215	0	1	48	60	180	9	1045
Sulfate	mg/L	44	44	38	5	110	0	4	32	38	115	27	111
Alkalinity	mg/L	117	32	21	1	80	0		17	21	64	0	77
Bicarbonate	mg/L	143	39	26	1	97.5	0		21	26	78	0	94
Carbonate	mg/L	ND	0	0	0	0	0		0	0	1	1	0
Cyanide	µg/L	ND		0	0	0	0		0	0	0	0	0
Silica	mg/L	42	10	7	0	25	0	2	6	7	21	1	24
Phosphate	mg/L	ND	0	0	0	0	0		0	0	0	0	0
Polyphosphate	mg/L	ND	0	0	0	0	0	0.5	0	0	0	0	0
Fluoride	mg/L	0.8	0.8	1	2	2	0		0	1	2	0	2
Nitrate	mg/L	8	8	5	0	20	0		4	5	16	0	19
General													
Suspended Solids	mg/L	0	5	3	0	12.5	0		3	3	10	0	12
Total Dissolved Solids	mg/L	287	280	209	36	700	0	85	184	209	626	68	2124
Hardness	mg/L	115	50	34	28	125	0		27	34	102	2	121
Constituent	Units	Well Water	Softened Water	Service Water	RO First Pass Permeate	1st pass RO Reject	Mixed Bed Effluent	Boiler Blow down	Quenched Blowdown	Cooling Tower Makeup	Cooling Tower Blow down	High pH RO Permeate	High pH Reject to Evaporation Pond
Trace Metals													
Aluminium	µg/L	ND	ND	0	0	0	0		ND	0	0		0
Antimony	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
		4	4	3	0	10	0		2	3	8	0	10
Arsenic	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Barium	µg/L	0.28	0.28	0.19	1	0.7	0	28	6	0	1	0	1

Table B-2
Anticipated Water Quality

Constituent	Units	Well Water	Softened Water	Service Water	RO First Pass Permeate	1st pass RO Reject	Mixed Bed Effluent	Boiler Blow down	Quenched Blowdown	Cooling Tower Makeup	Cooling Tower Blow down	High pH RO Permeate	High pH Reject to Evaporation Pond
Boron	mg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Cadmium	µg/L	ND	ND	0	0	0	0	10	2	0	0	0	0
Chromium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Cobalt	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Copper	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Hexavalent Chromium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Iron	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Lead	µg/L	0.7	0	0	0	0	0		0	0	0	0	0
Manganese	µg/L	ND	ND	0	0	0	0	1	0	0	0	0	0
Molybdenum	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Nickel	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Selenium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Strontium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Thallium	µg/L	14	14	9	0	0	0		7	9	28	0	5
Vanadium	µg/L	0.022	0.07	0.05	0	0.175	0	0.005	0.04	0.05	0.14		0.17
Zinc	mg/L	ND	ND	0	0	0	0		ND	0	0		0

Table B-3
Evaporation Pond Sludge Quality

Constituent	Units	Lb/day	Lb/Year	Concentration in dry solids, mg/Kg	Concentration with Silt, mg/kg
Cations					
Calcium	mg/L	4	1,479	18,066	1626
Magnesium	mg/L	1	462	5,646	508
Sodium	mg/L	81	29,407	359,182	32326
Potassium	mg/L	1	396	4,843	436
Ammonia	mg/L	0	9	113	10
Anions					
Chloride	mg/L	110	40,050	489,190	44027
Sulfate	mg/L	12	4,248	51,882	4669
Alkalinity	mg/L	8	2,958		0
Bicarbonate	mg/L	10	3,605	44,036	3963
Carbonate	mg/L	0	7	82	7
Cyanide	µg/L	-	-	-	0
Silica	mg/L	3	931	11,373	1024
Phosphate	mg/L	-	-	-	0
Polyphosphate	mg/L	-	-	-	0
Fluoride	mg/L	0	74	903	81
Nitrate	mg/L	2	740	9,033	813
General					
Suspended Solids	mg/L	1	462	5,646	465000
Total Dissolved Solids	mg/L	223	N/A		0
Hardness	mg/L	13	N/A		0
Trace Metals		-			
Aluminium	µg/L	-	-	-	0
Antimony	µg/L	-	-	-	0
Arsenic	µg/L	0.001	0.37	5	0
Barium	µg/L	-	0.00	-	0
Boron	mg/L	0.000	0	0	0
Cadmium	µg/L	-	-	-	0
Chromium	µg/L	-	-	-	0
Cobalt	µg/L	-	-	-	0

Table B-3
Evaporation Pond Sludge Quality

Constituent	Units	Lb/day	Lb/Year	Concentration in dry solids, mg/Kg	Concentration with Silt, mg/kg
Copper	µg/L	-	-	-	0
Hexavalent Chromium	µg/L	-	0.00	-	0
Iron	µg/L	-	0.00	-	0
Lead	µg/L	-	-	-	0
Manganese	µg/L	-	0.00	-	0
Molybdenum	µg/L	-	0.00	-	0
Nickel	µg/L	-	0.00	-	0
Selenium	µg/L	-	-	-	0
Strontium	µg/L	-	0.00	-	0
Thallium	µg/L	-	-	-	0
Vanadium	µg/L	0.001	0	2	0
Zinc	mg/L	0.000	0.0	0	0

5.0 Annual Precipitation Data

Pond top surface area = 176400 SF

= 4.04 Ac

Monthly Average Rainfall		
	Depth (In)	**Volume (CF)**
January	0.95	14,665
February	0.87	12,790
March	0.82	12,050
April	0.13	1,911
May	0.13	1,911
June	0.02	294
July	0.10	2,790
August	0.32	4,704
September	0.25	3,675
October	0.19	2,793
November	0.27	3,970
December	0.49	7,200
Total	4.54	68,753

Data source: http://www.wrcc.dri.edu

6.0 Evaporation Data

Required pond area = 152,100 SF

= 3.49 Ac

Correction factor, pan to pond = 0.75 (Assumed)

Correction factor, salinity = 0.70 (Assumed)

	Pan Evaporation (inches)	**Corrected Evaporation (inches)**	**Evaporation Volume (CF)**
January	0	0.00	0
February	4.65	2.44	35,886
March	6.45	3.39	49,778
April	9.97	5.23	76,943
May	13.59	7.13	104,881
June	15.33	8.05	118,309
July	17.21	9.04	132,818
August	16	8.40	123,480
September	11.83	6.21	91,298
October	8.28	4.35	63,901
November	4.76	2.50	36,735
December	3.52	1.85	27,166
Total	111.59	58.58	861,196

Data Source: http://www.wrcc.dri.edu/htmfiles/westevap.final.html

Pond top dimensions:

North pond 406 ft x 423 ft

South pond 290 ft x 605.5 ft

Attachment A
Action Leakage Rate Calculation

Action Leakage Rate Calculation for Palen Solar Power Plant

OBJECTIVE:

Determine the Action Leakage Rate (ALR) for Palen Solar Power Plant evaporation ponds. The ALR is defined as "the maximum design flow rate that the leak detection system (LDS) can remove without the fluid head on the bottom liner exceeding 1 foot" (U.S. EPA 1992; United States Government Printing Office 2002).

GIVEN:

- Leak collection and recovery system (LCRS) configuration.
- Evaporation pond configuration (Figures B-1 through B-9).
- Drainage Material Properties (Attachment 1).

GEOMETRY:

- The evaporation pond configuration and liner system details are given in Figures 1 through 9 of Attachment A.
- Sump lengths are:
    - North pond: 350 feet
    - South pond: 534 feet

The sumps are placed at the toe of the side slope at the bottom edge of the ponds and extend essentially the entire width of the pond bottoms. Therefore the sumps can receive inflow from both the pond bottom and the side slope.

MATERIAL PROPERTIES:

The drainage geonet considered in this analysis is the Hypernet manufactured by GSE. Hypernet has a thickness of 200 mil and transmissivity of 9.66 gallons/minute/foot.

METHOD:

The ALR calculation is based on the U.S. EPA Guidelines published by U.S. EPA (1992).

ASSUMPTIONS:

- Darcy's law is valid
- The gradient of the floor of the evaporation ponds is a minimum of 1 percent. The gradient of the side slopes for the cells is approximately 33 percent
- One foot of water head is developed on the bottom liner.

CALCULATIONS:

The maximum flow rate within the LCRS geonet is calculated using Darcy's equation:

$$Q = KiA$$

Where:

Q = flow through unit width of the LCRS drainage layer (ft^3/sec);
K = hydraulic conductivity of the LCRS drainage later (ft/sec);
i = hydraulic gradient; and
A = area of the flow per unity width (ft^2/ft).

For a geonet the flow through the layer is calculated by using the following equation:

$$q_{ult} = i \square W$$

where:

q_{ult} = flow through the geosynthetic layer (ft^3/sec/ft)
I = hydraulic gradient
$\square$ = transmissivity (ft/sec); and
W = width of the drain (ft).

A factor of safety should be applied to consider the reduction in flow capacity of the geonet due to deformations, intrusions, clogging, or precipitation of chemicals (Koerner, 2005):

$$q_{allow} = q_{ult} /(RFin * RFcr * RFcc * FRbc)$$

where:

q_{allow} = flow through the geosynthetic layer
q_{ult} = allowable flow rate
RF_{in} = reduction factor for elastic deformation or intrusion
RF_{cr} = reduction factor for creep deformation
RF_{cc} = reduction factor for chemical clogging, and
RF_{bc} = reduction factor for biological clogging.

Table 1 shows the adopted reduction factors for a secondary leachate collection system according to Table 3 in Koerner (2005).

Table 1 **Reduction Factors for Determining Allowable Flow Rate of Geonets**		
Factor	Recommended Value Range	Use for Geonet
RF_{in}	1.5-2.0	1.5
RF_{cr}	1.4-2.0	1.4
RF_{cc}	1.5-2.0	2.0
RF_{bc}	1.5-2.0	2.0

Water head equal to 1 foot is assumed to be acting over the bottom liner so the hydraulic gradient can be assumed to be equal to the slope of the geonet. For the bottom of the evaporation pond:

$$i = 1\%$$

For the side slope of the evaporation pond (3H:1V):

$$i = 33\%$$

The flow in the geonet per unit width for the bottom of the evaporation pond is:

q_{ult} = 0.01 * 9.66 gal/min/ft = 0.097 gal/min/ft

The flow in the geonet per unity width for the side slopes is

q_{ult} = 0.33 * 9.66 gal/min/ft = 3.19 gal/min/ft

The allowable flow rate per unit width for the bottom of the evaporation pond is

q_{allowb} = 0.097/(1.5*1.4*2.0*2.0) = 0.012 gal/min/ft

The allowable flow rate per unit width for the side slopes of the evaporation pond is

$q_{allowss}$ = 3.19/(1.5*1.4*2.0*2.0) = 0.38 gal/min/ft

The total allowable flow rate per unit width of the sump is

$q_{allow} = q_{allowb} + q_{allowss}$ = 0.012 + 0.38 = 0.392 gal/min/ft

Because the sump is much longer than it is wide, it is assumed that the flow contribution from the ends is negligible.

The ALR expressed in gallons per acre per day (gpad) for the north and south ponds is summarized in Table 2:

Table 2: Action Leakage Rates		
	North Ponds	South Ponds
Sump length, feet	350	534
q_{allow}, gal/min/ft	0.392	0.382
ALR, gpm	137	209
ALR, gal/day	197,000	301,000
Pond area, acres	4	4
ALR, gpad	**49,320**	**75,360**

References:

U.S. Environmental Protection Agency (U.S. EPA). 1992. “Action leakage rates for detection systems (supplemental background document for the final double liners and leak detection systems rule for hazardous waste landfills, waste piles, and surface impoundments).”

Koerner, Robert M. and Koerner, George R., “GSI White Paper #4 Reduction Factors (RFs) Used in Geosynthetic Design”, Geosynthetic Institute, 2005, rev. 2007.

Attachment 1

GSE

GSE STANDARD PRODUCTS

Product Data Sheet

GSE HyperNet Geonets

GSE HyperNet geonets are synthetic drainage materials manufactured from a premium grade high density polyethylene (HDPE) resin. The structure of the HyperNet geonet is formed specifically to transmit fluids uniformly under a variety of field conditions. HDPE resins are inert to chemicals encountered in most of the civil and environmental applications where these materials are used. GSE geonets are formulated to be resistant to ultraviolet light for time periods necessary to complete installation. GSE HyperNet geonets are available in standard, HF, HS, and UF varieties.

The table below provides index physical, mechanical and hydraulic characteristics of GSE geonets. Contact GSE for information regarding performance of these products under site-specific load, gradient, and boundary conditions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE[c]			
			HyperNet	HyperNet HF	HyperNet HS	HyperNet UF
Product Code			XL4000N004	XL5000N004	XL7000N004	XL8000N004
Transmissivity[a], gal/min/ft (m^2/sec)	ASTM D 4716-00	1/540,000 ft^2	9.66 (2×10^{-3})	14.49 (3×10^{-3})	28.98 (6×10^{-3})	38.64 (8×10^{-3})
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft^2	200 (5)	250 (6.3)	275 (7)	300 (7.6)
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft^2	45 (7.9)	55 (9.6)	65 (11.5)	75 (13.3)
Carbon Black Content, %	ASTM D 1603, modified	1/50,000 ft^2	2.0	2.0	2.0	2.0
Roll Width, ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Length, ft (m)[b]			300 (91)	250 (76)	220 (67)	200 (60)
Roll Area, ft^2 (m^2)			4,500 (418)	3,750 (348)	3,300 (305)	3,000 (278)

NOTES:

- [a]Gradient of 0.1, normal load of 10,000 psf, water at 70° F (20° C), between steel plates for 15 minutes.
- [b]Please check with GSE for other available roll lengths.
- [c]These are MARV values that are based on the cumulative results of specimens tested by GSE.

DS017 R07/07/03

Americas	GSE Lining Technology, Inc.	Houston, Texas	800-435-2008	281-443-8564	Fax: 281-230-8650
Europe/Middle East/Africa	GSE Lining Technology GmbH	Hamburg, Germany		49-40-767420	Fax: 49-40-7674233
Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097

This product data sheet is also available on our website at:

www.gseworld.com

AECOM

Prepared for:
Ridgecrest Solar I, LLC

Evaporation Pond Preliminary Design, Operations, and Maintenance Plan Ridgecrest Solar Power Project Kern County, California

Appendix C of the Application/Report of Waste Discharge

Prepared for:
Ridgecrest Solar I, LLC

Evaporation Pond Preliminary Design, Operation and Maintenance Plan Ridgecrest Solar Power Project

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1.0 Introduction

Ridgecrest Solar I LLC (RSI) proposes to construct the Ridgecrest Solar Power Project (RSPP) on 3,995 acres. The Project site is located southwest of U.S. Highway 395 and approximately five miles southwest of the City of Ridgecrest, California in northeastern Kern County. The location of the Facility and its existing physiographic and topographic setting are shown on Figure 1. The Facility will consist of a nominal 250 megawatt (MW) concentrating solar power (CSP) plant that will use parabolic trough solar thermal technology to produce electrical power with a steam turbine generator (STG) fed from a solar steam generator (SSG). The Facility will include one power block Unit, solar arrays, administration buildings, evaporation ponds, bioremediation areas and land farming. An Application for Certification (AFC) for the project was submitted to the California Energy Commission (CEC) in September 2009 and contains a detailed description of the project and related impacts, requirements and mitigation measures.

The Facility will generate wastewater from cooling tower blowdown and plant water treatment activities and requires a Waste Discharge Requirements (WDR) Permit from the California Regional Water Quality Control Board (RWQCB), Lahontan Basin Region to discharge this wastewater into a total of two evaporation ponds. The evaporation ponds are regulated under Title 27 of the California Code of Regulations (CCR) and the California Water Code for waste management and are classified as Class II surface impoundments. The wastewater and accumulated sludge from evaporation in the evaporation ponds is classified as a designated waste. A designated waste is defined as a non-hazardous waste that consists of pollutants which, under ambient environmental conditions at the waste management unit, could be released at concentrations in excess of applicable water quality objectives, or which could cause degradation of waters of the state.

This Evaporation Pond Preliminary Design, Operations and Maintenance Plan (the Plan) addresses certain requirements of Title 27 CCR and a Report of Waste Discharge (ROWD) under Section 13260 of the California Water Code. Specifically, the following requirements are addressed in this Plan:

- Waste Characterization;
- Design and Construction Standards;
- Operating Criteria;
- Environmental Controls; and
- Pond Inspection, Monitoring and Maintenance Activities.

Additional requirements of Title 27 CCR and Section 13260 of the California Water Code are being addressed under separate cover by AECOM Environment. These requirements include the following:

- Description of Project Setting, Hydrology and Hydrogeology;
- Detection Monitoring and Reporting Program;
- Contingency Plan, including response actions and design criteria for addressing releases;
- Description of all BMPs;

- Closure Plan; and
- Post Closure Maintenance Plan.

In addition to the above, various plan documents pertinent to addressing and implementing operating requirements for the proposed evaporation ponds will be prepared as specified in the AFC for the project, including the following:

- Emergency Action Plan
- Personal Protective Equipment Program
- Injury and Illness Prevention Plan
- Fire Protection and Prevention Plan
- Operations Safety Training Program
- Operations Dust Control Plan; and
- Drainage, Erosion and Sediment Control Plan.

2.0 WASTE CHARACTERIZATION

Wastewater from within the Facility will be piped to two 4.0-acre evaporation ponds (total combined area of 8 acres) for disposal. Details regarding the pond design are presented in Section 3.1. The pond area provides sufficient evaporative capacity to dispose of the anticipated wastewater stream, and allows for one pond to be taken out of service for up to approximately one year for cleaning, potential future maintenance, and repair without impacting the operation of the plant. The sources, and processes generating the wastewater stream disposed in the ponds and their relative contributions are shown on Figure B-1 (Attachment B). Raw water for the Facility is supplied from the Indian Wells Valley Water District (IWVWD). Discharge into the evaporation ponds is from one source:

1. High pH RO (Reverse Osmosis Concentrate

2.1 Groundwater Water Supply

The Project will be dry cooled. The Project's various water uses include water for solar collector mirror washing, makeup for the SSG feed water, dust control, water for cooling plant auxiliary equipment, potable water and fire protection. Water needs for the Project will be met by the IWVWD. The estimated water supply need for the Project is 150 af per year. To characterize raw water quality, data provided by the IWVWD for Wells 18, 33, and 34 was used for key chemistry parameters (refer to Table B-1, Attachment B).

The groundwater will be pretreated using a softener, with a focus on reducing the silica content as silica forms highly-insulating and difficult-to-remove deposits in cooling systems, boilers and turbines. The treated water from the softener is stored in a 1,500,000 gallon treated water storage tank for use in the cooling tower process as discussed in Section 2.2.1. Raw water and pre-treated water are used to supply various plant needs, including cooling tower circulating water, solar steam generator makeup water (after further treatment by demineralization), and various plant service, sanitary and potable water needs. All these water streams eventually discharge into the high pH reverse osmosis system and then to the evaporation ponds as is explained further in the following sections. A list of chemical components added in trace/small amounts during the treatment process and that are not expected to survive or to affect the final wastewater chemistry is presented in Table B-2 (Attachment B).

2.2 Waste Water Discharge

The chemical components in the different waste water streams and final expected concentrations in the evaporation pond are shown in Table B-2 (Attachment B).

2.2.1 Wastewater Treatment System

Wastewater is generated by auxiliary cooing tower blowdown, RO concentrate, and plant chemical drain collection. Each of these sources is collected and treated by the plant's wastewater treatment system which consists of a high pH reverse osmosis process.

Wastewater is stored in a 120,000 gallon storage tank upstream of the wastewater treatment system. While shown as a single box on the flow diagram (Attachment B), the wastewater treatment system is a very complex system that allows for the concentration of a water source containing high dissolved solids. The wastewater treatment system utilizes filtration, softening, pH adjustment, and reverse osmosis to accomplish the concentration of dissolved solids.

Wastewater is pumped from the storage tank by wastewater transfer pumps. Wastewater is treated with coagulant and pumped to multimedia filters and then further filtered by ultrafiltration units. Filtered wastewater is stored in an ultrafilter product tank. Water will be pumped from the ultra filter product tank to backflush both the ultra filter and the multimedia filter. Caustic, acid, and sodium hypochlorite will all be dosed to the ultra filter during the cleaning cycle.

Product water from the ultra filter product storage tank will be pumped to softeners to remove water hardness from the wastewater system. A brine regeneration system is provided to restore the softening capability of the resin. Softened wastewater is treated with acid to lower the pH of the wastewater stream upstream of a decarbonator. The decarbonator removes carbon dioxide from the wastewater stream, which in turn lowers the alkalinity of the water. Wastewater from the decarbonator is then treated with caustic to raise the pH of the water stream.

High pH water is treated downstream of the decarbonator transfer pumps with antiscalant and fed to the high pH RO units. Permeate generated by the RO is returned to the service water tank Concentrate is pumped to the chemical sump and eventually the evaporation pond.

Plant drains will contain water from component wash down and cleaning, potential miscellaneous leaks and draining of plant equipment, condensation from plant equipment and other sources. Water from these areas will be collected in a system of floor drains, sumps, and pipes and routed to the wastewater collection system. This water will be routed through an Oil-Water Separator to capture the oil and prevent it from reaching the environment.

The anticipated flow rates of the water treatment system are shown on Figure B-1 and the predicted chemical composition of evaporation pond makeup is summarized in Table B-3 (Attachment B).

2.3 Evaporation Residue

We estimate that during the 30-year operating life of the Facility, about 6,400 tons of evaporites will accumulate in the ponds. However, because it is anticipated that wind-blown silt will accumulate in the ponds at a rate of perhaps six inches per year, it will be necessary to clean out the ponds on approximately 4 year intervals. Assuming two feet of silt accumulation, the sludge removed from the ponds will be approximately 9 percent evaporate and 91 percent silt. The predicted chemical makeup of the evaporite, based on information about the raw water chemistry and knowledge of the water use and treatment processes at the Facility, is summarized in Table B-3 (Attachment B).

3.0 DESIGN AND CONSTRUCTION STANDARDS

The containment strategy for the evaporation ponds is summarized as follows:

- Meet or exceed regulatory requirements for containment of waste fluids;
- Select materials that are compatible with the physical, chemical and thermal characteristics of the water and contaminated soils being contained;
- Protect against physical damage to the containment layers by including protective layers into the designs of each containment facility;
- Allow for occasional removal of contained media without otherwise damaging the integrity of the containment systems; and
- Include the ability to monitor the integrity of the containment system, to transfer fluids out of permeable layers on a continuous basis, and to transfer fluids from one evaporation pond to another.

The proposed design for the evaporation ponds has been selected to optimize performance based on these operating criteria. Figures 1 through 9 (Attachment A) illustrate the proposed design for evaporation ponds

3.1 General Design Description

3.1.1 Overview

Each 4.0 acre evaporation pond has a proposed design depth of seven feet which incorporates:

- Drying each pond at alternating four year intervals;
- 3 feet of operational depth;
- 2 foot of sludge build up over 4 years; and
- 2 feet of freeboard.

The containment design for the evaporation ponds, from the surface of the evaporation ponds downwards, consists of the following:

- A hard surface / protective layer;
- A primary 60 mil high density polyethylene (HDPE) liner;
- An interstitial leak detection system (LDS) comprising a drainage layer and piping;
- A secondary 40 mil HDPE liner; and
- A 2 foot thick compacted silty-sand base;
- A moisture detection system.

3.1.2 Hard Surface / Protective Layer

The hard surface / protective layer provides protection against accidental damage to the HDPE liners which could be caused by burrowing animals, falling objects, varying climatic conditions and worker activities. Second, the hard surface / protective layer will allow for occasional removal of the precipitated solids within the evaporation ponds. Various hard surface media such as reinforced concrete, roller compacted concrete, revetments, or combinations of these media will be assessed prior to the selection of the preferred option.

3.1.3 Primary Liner, Secondary Liner and Basal Layer

High density polyethylene (HDPE) was selected as the preferred fabric for the primary and secondary liners for the following reasons:

- It is chemically resistant to potentially high concentrations of dissolved salts;
- It is very durable during installation;
- It is strong and possesses desirable stress-strain characteristics; and
- It is the most common synthetic liner material and as such there is a broad base of practical experience associated with the installation of HDPE amongst construction contractors.

A 60 mil upper liner was selected to provide appropriate balance between strength and ductility characteristics, which is very important during liner installation. A non-woven geotextile will be installed on top of the 60 mil liner to act primarily as a protective layer. A 40 mil lower liner was selected for the lower and secondary liner to provide slightly better ductility and handling characteristics during installation, as strength is of lesser importance for the secondary liner. HDPE possesses large thermal expansion and contraction characteristics, and exhibits stress when liner temperature exceeds 122 ^oF. The temperature of the blowdown water is not expected to exceed 122 ^oF.

A 2 foot thick basal layer of compacted silty sand is included in the design profile to protect the underlying groundwater in the unlikely event that both synthetic liner materials are punctured during construction or operation of the evaporation ponds. This base layer also serves to provide a smooth, competent surface to support the overlying synthetic liners and leak detection system layers.

3.1.4 Leak Detection System

A drainage layer is included in the design profile for the evaporation ponds which consists of a granular drainage layer with perforated piping to collect and convey fluids to an extraction riser in a leak detection sump (LDS). Geocomposite drainage materials, consisting of HDPE geonet and non-woven geotextiles heat bonded to one or both sides, may be used in conjunction with or as a substitute for the granular drainage layer on slopes.

The water collected in the LDS will drain by gravity to a unique monitoring well that is constructed for each of the leak collection layer. Automated pneumatic, solar-powered pumping systems are included in the design of each of these monitoring wells to automatically return water to that pond, which in turn minimizes the hydraulic pressures across the secondary liners and therefore the risk of impact to groundwater quality.

The base of the evaporation pond leak detection and collection layer will slope at a minimum inclination of 1 percent to a leak collection trench. The trench will contain screened sand (with no fines) and a perforated pipe that will slope at a minimum inclination of ¾ percent towards a leak detection and collection sump, located at the lowest point in the pond. The water in the collection sump will drain by gravity to a monitoring well that is constructed for each evaporation pond (one well per pond). Automated pneumatic pumping systems in the monitoring wells will automatically return water collected in the sump to that evaporation pond, which in turn minimizes the hydraulic pressures across the secondary liners and, therefore, minimizes the risk of leakage through the secondary liner. Leakage rates will be measured using a flow totalizer.

The collection sump, pipe, and monitoring well, will include prefabricated and field-fabricated HDPE components with water tight, extrusion welded and wedge-welded seams and penetrations. The liner system will be installed in accordance with current practices. Destructive and non-destructive testing procedures will be used to verify sump and penetration tightness and continuity.

This design is consistent with CCR Title 27, Section 20340, which requires an LDRS between the liners for the evaporation ponds.

3.1.5 Berms and Side Slopes

The side slopes around the evaporation ponds will contain the same liner system as the base of the ponds, except that leak collection pipes will not be located on the pond side slopes.

The berms shall be covered with a minimum 6-inch thick road base or approved equivalent. The top of the berms will be a minimum of 2 feet above the surrounding grade to prevent potential inflow of stormwater.

3.1.6 Material Compatibility

The wastewater will come into contact with the hard surface/protective layer. As outlined in Section 7.1.1.2, the media for this layer will either be roller-compacted concrete or an approved equivalent alternate. All final media selection will be compatible with the wastewater by using quality concrete with maximum chemical resistance (specifications will be provided to the concrete manufacturer to ensure proper mix selection).

If there is leakage in the evaporation pond, the wastewater will come into contact with the primary/secondary liner. HDPE is chemically resistant to saline solutions and long-term contact between the wastewater in the evaporation ponds and the HDPE liner system will not compromise liner integrity. Further explanation for HPDE selection is provided in Section 7.1.1.3.

The hard surface/protective layers, liner system, and base layer will have the ability to withstand the dissolved solids content of the water without degradation. These systems will not fail due to pressure gradients from physical contact with the wastewater and residue or undergo chemical reactions or degradation.

3.2 Construction Methods and Sequence

3.2.1 General

The containment construction process will follow these general steps:

a. Prior to construction, the topsoil and subsoil covering the area will be stripped and stockpiled.

b. Placement and compaction of the silty sand base material;

c. Installation of the carrier pipe for the moisture detection (neutron probe) system beneath the base of the ponds;

d. Construction of finish grading to sub grade, as needed, and excavation of the leak collection trench and detection/collection sumps.

e. Scarification, moisture conditioning, compaction, proof rolling and testing of subgrade materials;

f. Installation of secondary HDPE liner;

g. Installation of leak detection layer, sump, and leak extraction risers;

h. Installation of primary HDPE liner;

i. Installation of the non-woven geomembrane liner;

j. Installation of granular fill;

k. Installation of liner protection layers; and

l. Hard surface placement.

3.2.2 Site Preparation, Excavation and Compaction

The excavation and berm construction will use standard cut and fill techniques. The silty sand material on site will be used for general earthworks construction and to construct the compacted base or subgrade. The silty sand material will be compacted to a minimum of 95% of the maximum dry density as determined by ASTM D1557. The soil will be spread with a dozer and compacted in lifts using a sheeps foot roller or other suitable compaction equipment. Field testing of the density of the soil will be performed at regular intervals. Compaction results will be recorded.

3.2.3 Liner System Installation

3.2.3.1 Secondary Liner

The secondary liner or lower liner will consist of a 40 mil thick HDPE geomembrane liner. This liner will be installed in accordance with current practices and will employ the use of wedge welding and extrusion welding procedures. In addition destructive and non-destructive testing procedures will be used to ensure liner quality and continuity.

3.2.3.2 Leak Detection System

The leak detection system between the upper and lower liners consists of a 1 foot thick granular drainage layer. Piping will be used to convey collected fluids to a leak detection system extraction riser. The granular drainage layer, including the perforated piping system will have to be carefully placed on top of the underlying 40 mil HDPE liner. The construction sequence will have to be developed with the emphasis of material placement, spreading, and consolidation techniques that will ensure that damage to the liner does not occur. Geocomposite or geonet drainage media may be used in lieu of or in conjunction with the granular drainage layer in light of the requirement to prevent damage to the geomembrane liner.

3.2.3.3 Primary Liner

The upper or primary liner will consist of a 60 mil thick HDPE geomembrane liner. As is the case for the secondary 40 mil HDPE liner, current installation, quality control monitoring, testing, and quality assurance measures and techniques will be employed to ensure liner quality and continuity. The primary liner will be protected by a non-woven geotextile that will be installed directly on top of the liner.

3.2.4 Hard Surface / Protective Layer

A hard surface / protective layer will be constructed on the granular fill and non-woven geotextile that covers the primary liner. The hard surface will allow for vehicular traffic during cleanout. Hard surface types to be considered and assessed include:

- Reinforced concrete;
- Roller compacted concrete;
- Revetment systems; or
- A combination of these.

Prior to the placement of the hard surfacing, a 1 foot thick granular fill layer will be placed, spread and consolidated over the non-woven geotextile that serves to protect the underlying primary geomembrane liner. This granular fill layer is intended to serve two purposes:

- As the supporting base for the hard surfacing; and
- As a drainage layer between the hard surfacing and underlying primary liner.

Roller-compacted concrete can be transported in dump trucks and can be spread with a dozer or motor grader and compacted with a vibratory roller. Additionally, the roller-compacted concrete can be placed without joints, forms, or reinforcing steel, and is not required to be finished. This will make the application of the hard surface/protective layer relatively economical.

An aggregate road base material will be placed along the top of each berm to provide an all weather access location for maintenance vehicles. The material will conform to the Department of Transportation Specifications for Class II Aggregate Base. This will be installed to a minimum thickness of 6 inches and will be placed and compacted in accordance with the Department of Transportation requirements.

3.3 Construction Quality Assurance

3.3.1 Introduction

The quality assurance program is based on the State Water Resources Control Board- Construction Quality Assurance (CQA) Requirements under Title 27 of the California Code of Regulations. The requirements themselves will be highlighted and an explanation of how the requirements will be met will follow immediately afterwards.

The evaporation ponds will be constructed as per the construction specifications that will be developed in accordance with the CQA plan provided herein. The CQA program will be implemented to ensure that construction is completed in accordance with design specifications.

CQA testing will be performed on the sub-grade, compacted silty sand base, HDPE liners, granular, and hard surface materials.

Construction inspection requirements will include approving of each layer to ensure that there are no deficiencies in that layer prior to placement of the next material. This will also include review of other CQA results to ensure that they are within the project's specifications.

Change authorization will flow through the on-site construction manager and will ensure that the required personnel have input in the decision. Daily reports will be kept to ensure that activities are documented and personnel involved in the project are updated daily.

3.3.2 Performance Standard

Quoting from the State Water Resources Control Board CQA requirements section (a):

The construction quality assurance (CQA) program, including all relevant aspects of construction quality control (CQC), shall provide evidence that materials and procedures utilized in the placement of the any containment feature at a waste management unit (Unit) will be tested and monitored to assure the structure is constructed in accordance with the design specifications approved by the RWQCB.

The project will implement quality control procedures that incorporate inspection and test procedures to make sure that the containment facilities are constructed properly and that they are monitored appropriately throughout the life of the project. These tests and procedures will be documented in detail throughout the project.

3.3.3 Professional Qualifications

Quoting from the State Water Resources Control Board CQA requirements section (b):

1. The design professional who prepares the CQA plan shall be a registered civil engineer or certified engineering geologist; and

2. The construction quality assurance program shall be supervised by a registered civil engineer or certified engineering geologist who shall be designated the CQA officer.

The Project will ensure that a design professional will prepare the CQA plan and will provide a design professional that will act as a CQA officer whose responsibility is to supervise the CQA program. Construction activities and operations will be directed and supervised by qualified individuals and the design will be conceived and presented in accordance with recognized civil, mechanical and electrical engineering procedures and practices.

3.3.4 Reports

Quoting from the State Water Resources Control Board CQA requirements section (c):

1. The project's CQA report shall address the construction requirements, including any vegetation procedures, set forth in the design plan for the containment system. For each specified phase of construction, this report shall include, but not be limited to:

   a. a delineation of the CQA management organization, including the chain of command of the CQA inspectors and contractors;

   b. a detailed description of the level of experience and training for the contractor, the work crew, and CQA inspectors for every major phase of construction in order to ensure that the installation methods and procedures required in the containment system design will be properly implemented.

   c. a description of the CQA testing protocols for preconstruction, construction, and postconstruction which shall include at a minimum:

      i. the frequency of inspections by the operator,

      ii. the sampling and field testing procedures and equipment to be utilized, and the calibration of field testing equipment,

      iii. the frequency of performance audits determined by the design professional and examined by the CQA officer,

      iv. the size, method, location and frequency of sampling, sampling procedures for laboratory testing, the soils or geotechnical laboratory to be used, the laboratory procedures to be utilized, the calibration of laboratory equipment and quality assurance and quality control of laboratory procedures,

      v. the pass/fail criteria for sampling and testing methods used to achieve containment system design, and

      vi. a description of the corrective procedures in the event of test failure.

The Project will provide the following:

- An outline of the chain of command of the CQA inspectors and contractors in the CQA management organization.
- A description of the CQA testing procedures for the preconstruction, construction, and post construction phases of the project.
- A CQA report that includes construction quality control requirements included in the design plan for each specified phase of construction outlined in Section 5- Construction.

3.3.5 Documentation

Quoting from the State Water Resources Control Board CQA requirements section (d):

> *Construction quality assurance documentation requirements shall include, at the minimum: reports bearing unique identifying sheet numbers for cross referencing and document control, the date, project name, location, descriptive remarks, the data*

sheets, inspection activities, and signature of the designated authorities with concurrence of the CQA officer.

1. *The documentation shall include:*

    a. *Daily Summary Reports — daily record keeping, which shall include preparation of a summary report with supporting inspection data sheets, problem identification and corrective measures reports. Daily summary reports shall provide a chronological framework for identifying and recording all other reports. Inspection data sheets shall contain all observations (i.e., notes, charts, sketches, or photographs), and a record of field and/or laboratory tests. Problem identification and corrective measures reports shall include detailed descriptions of materials and/or workmanship that do not meet a specified design and shall be cross-referenced to specific inspection data sheets where the problem was identified and corrected;*

    b. *Acceptance Reports — all reports shall be assembled and summarized into Acceptance Reports in order to verify that the materials and construction processes comply with the specified design. This report shall include, at a minimum, inspection summary reports, inspection data sheets, problem identification and corrective measures reports;*

    c. *Final Documentation — at the completion of the project, the operator shall prepare a Final Documentation which contains all reports submitted concerning the placement of the containment system. This document shall provide evidence that the CQA plan was implemented as proposed and that the construction proceeded in accordance with design criteria, plans, and specifications. The discharger shall submit copies of the Final Documentation report to the RWQCB as prepared by the CQA officer.*

2. *Once construction is complete, the document originals shall be stored by the discharger in a manner that will allow for easy access while still protecting them from any damage. All documentation shall be maintained throughout the postclosure maintenance period.*

These documents will include daily summary reports with supporting inspection data sheets that contain all observations. A record of field and laboratory tests will also be kept. Acceptance reports will be documents to ensure construction and materials comply with the original design and specifications. At the completion of the project, project closure documentation will be submitted to provide evidence that the CQA plan was implemented as proposed and that construction met design criteria, plans and specifications.

3.3.6 Laboratory Testing Requirements

Quoting from the State Water Resources Control Board CQA requirements section (e):

1. *Analysis of earthen materials shall be performed prior to their incorporation into any containment system component. Representative samples for each layer within the containment system shall be evaluated. The following minimum laboratory testing procedures shall be performed:*

a. *ASTM Designation: D 1557 91 [1/91], "Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN-m/m3)" which is incorporated by reference;*

b. *ASTM Designation: D 422 63 (Reapproved) [9/90], "Standard Method for Particle Size Analysis of Soils," which is incorporated by reference; and*

c. *ASTM Designation: D 2487 93 [11/93], "Standard Classification of Soils for Engineering Purposes," which is incorporated by reference.*

2. *In addition to the tests listed in (e and f), the following minimum laboratory tests shall be performed on low-hydraulic-conductivity layer components constructed from soil:*

    a. *ASTM Designation: D 4318 93 [11/93], "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils," which is incorporated by reference; and*

    b. *United States Environmental Protection Agency (USEPA) Test Method 9100 [Approved 9¬86], "Triaxial-Cell Method with Back Pressure," which is incorporated by reference.*

The Project will send materials proposed for construction to the lab to an accredited laboratory so that the quality and characteristics can be confirmed and compared to project specifications.

The tests will include the following as per section (e) of the State Water Resources Control Board CQA requirements above:

- ASTM Designation: D 1557 91 [1/91], "Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN-m/m3)"
- ASTM Designation: D 422 63 (Reapproved) [9/90], "Standard Method for Particle Size Analysis of Soils,"
- ASTM Designation: D 2487 93 [11/93], "Standard Classification of Soils for Engineering Purposes,"
- And for permeability (hydraulic conductivity) layers the following tests will be taken at a minimum:
- ASTM Designation: D 4318 93 [11/93], "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils,"
- United States Environmental Protection Agency (USEPA) Test Method 9100 [Approved 9-86], "Triaxial-Cell Method with Back Pressure,"

3.3.7 Field Testing Requirements

Quoting from the State Water Resources Control Board CQA requirements section (f):

The following minimum field test procedure shall be performed for each layer in the containment system: ASTM Designation: D 2488 93 [9/93], Standard Practice for Description and Identification of Soils (Visual Manual Procedure), which is incorporated by reference.

The Project will use the following test on each layer in the containment systems associated with the evaporation ponds and bioremediation pad:

- ASTM Designation: D 2488 93 [9/93], Standard Practice for Description and Identification of Soils (Visual Manual Procedure)

In addition, in place nuclear densiometer testing ASTM D2922 will be performed paired with maximum density and optimum moisture content test, ASTM D 698.

3.3.8 Test Fill Pad Requirements

Quoting from the State Water Resources Control Board CQA requirements section (g):

Before installing the compacted soil barrier layer component of a final cover system, or the compacted soil component of a liner system, the operator shall accurately establish the correlation between the design hydraulic conductivity and the density at which that conductivity is achieved. To accomplish this the operator shall:

1. *Provide a representative area for a test on any compacted foundation and low-hydraulic-conductivity layers. The following minimum testing procedures shall be performed:*

    a. *the test pad foundation and, for final covers, the barrier layers shall be compacted with the designated equipment to determine if the specified density/moisture-content/ hydraulic-conductivity relationships determined in the laboratory can be achieved in the field with the compaction equipment to be used and at the specified lift thickness;*

2. *perform laboratory tests as specified in State Water Resources Control Board CQA requirements subsection (e); and*

3. *perform field tests as specified in State Water Resources Control Board CQA requirements subsection (f). The discharger shall perform hydraulic conductivity tests in the test area under saturated conditions by using the standard test method ASTM Designation: D 3385 94 [9/94], "Standard Test Method for Infiltration Rate of Soils in Field Using Double Ring Infiltrometer," which is incorporated by reference, for vertical hydraulic conductivity measurements. A sufficient number of tests shall be run to verify the results. Other methods that provide an accurate and precise method of measuring field hydraulic conductivity may be utilized as approved by the RWQCB.*

4. *Correlations between laboratory tests and test pad results shall be established for each of the various types of fill materials and blends to be used in construction of the actual cover.*

When constructing compacted soil barrier layers, or a compacted soil component of a liner system, The Project will provide a representative area for a test. The soil layers will be compacted with equipment that can achieve density, moisture content, and hydraulic-conductivities, where applicable at specified lift thicknesses. The laboratory tests mentioned in State Water Resources Control Board CQA requirements section (e) will all be performed.

Results from lab tests and field tests will be compared to ensure that the specified requirements can be met and that the methods and procedures selected and used achieve the required construction quality standard.

3.3.9 Earthen Material Requirements

Quoting from the State Water Resources Control Board CQA requirements section (h):

1. *The following minimum tests shall include, but not be limited to:*

    a. *Laboratory tests as specified in State Water Resources Control Board CQA requirements subsection (e); and*

    b. *Field tests as specified in State Water Resources Control Board CQA requirements subsections (f and g).*

2. *The following minimum testing frequencies shall be performed:*

    c. *Four (4) field density tests shall be performed for each 1,000 cubic yards of material placed, or at a minimum of four (4) tests per day;*

    d. *Compaction curve data (ASTM Designation: D 1557 91) graphically represented, and Atterberg limits (ASTM Designation: D 4318 93) shall be performed on the barrier layer material once a week and/or every 5,000 cubic yards of material placed;*

    e. *For field hydraulic conductivity tests, representative samples shall be performed on barrier layer material;*

        i. *The frequency of testing may be increased or decreased, based on the pass/failure status of previous tests, as approved by the RWQCB.*

        ii. *Field infiltration tests shall be performed for the duration necessary to achieve steady conditions for the design hydraulic conductivity.*

        iii. *The following interpretive equation shall be used to determine the design hydraulic conductivity:*

        The infiltration rate (I) is defined as: $I = Q/(tA)$

        where: Q = volume of flow; t = interval of time corresponding to flow Q; and
        A = area of the ring;

        then the hydraulic conductivity (k) can be calculated from Darcy's law as follows:

        $k = I/i$

        where:
        I = infiltration rate; and
        i = hydraulic gradient.

When testing soils used for construction, the tests mentioned in State Water Resources Control Board CQA requirements section e) above, will be performed as a minimum. There will be four field density tests performed per 1000 cubic yards of material placed or at least four tests per day. Compaction curve data including Atterberg Limits, will be performed at least once per week or every 5000 cubic yards of material placed. For field hydraulic conductivity tests, the frequency of testing will be based on the pass/failure status of previous tests. They will be performed for the amount of time necessary to make sure steady conditions for the design hydraulic conductivity are met. The above equation I = Q / (tA) will be used to determine design hydraulic conductivity.

During construction, all compacted soils and granular material will be tested using a nuclear density / moisture gauge (densiometer) (ASTM D2922 and D3017) to determine compaction percentage and moisture content. Nuclear densiometer testing will be performed to ensure compaction and moisture condition requirements as outlined in the project specifications are being achieved. Each material will be tested following compaction in multiple locations to ensure compliance to projects specifications prior to proceeding with placement of the next material.

3.3.10 Geosynthetic Membrane Requirements

Quoting from the State Water Resources Control Board CQA requirements section (i):

1. *Performance requirements for the geosynthetic membrane include, but are not limited to, the following:*

   a. *a need to limit infiltration of water, to the greatest extent possible;*

   b. *a need to control landfill gas emissions;*

   c. *for final covers, mechanical compatibility with stresses caused by equipment traffic, and the result of differential settlement of the waste over time; and*

   d. *for final covers, durability throughout the postclosure maintenance period.*

2. *Minimum Criteria — The minimum construction quality assurance criteria to ensure thatgeosynthetic membranes will meet or exceed all design specifications shall include, but not be limited to:*

   a. *Preconstruction quality control program:*

      i. *inspection of the raw materials (e.g., density, melt flow index, percent carbon Black);*

      ii. *manufacturing operations and finished product specifications (e.g., thickness, puncture resistance, multi axial stress/strain tests),*

      iii. *fabrication operations (e.g., factory seaming);*

      iv. *observations related to transportation, handling, and storage of the geosynthetic membrane; and*

      v. *inspection of foundation preparation;*

   b. *Construction activities:*

i. *the geosynthetic membrane shall have thickness strength sufficient to withstand the stresses to which it shall be subjected, including shear forces, puncture from rocks or, for final covers, penetration from roots.*

ii. *inspection of geosynthetic membrane placement (e.g., trench corners, monitoring systems).*

iii. *seaming of the material; and*

iv. *installation of anchors and seals;*

c. *Postconstruction Activity — postconstruction activity includes checking for material and placement imperfections in the installed geosynthetic membrane. Imperfections that jeopardize the integrity of the membrane's function as an impermeable barrier (i.e., pin holes, rips, creases created during placement) shall be repaired to the original manufacturer's specifications and reinspected by the CQA officer; and*

d. *Evaluation — evaluation of the personnel and equipment to be used to install and inspect the geosynthetic membrane, and pass/fail criteria and corrective procedures for material and installation procedures shall be specified as required in State Water Resources Control Board CQA requirements subsection (c).*

The Project will make sure that the geosynthetic membrane (geomembrane) used for containment will limit the infiltration of water to the greatest extent possible and be designed to maintain durability throughout the life of the project. The Project will ensure that a preconstruction quality control program is in place to ensure that manufactured geomembrane products conform to the project specifications. Once construction activities begin, The Project will make sure that the proper material is used and supervise and inspect the placement of the geomembrane and the seaming of the material. After construction, The Project will check for imperfections in the installed geomembrane and ensure that repairs are completed in accordance with project specifications. The HDPE liner will be manufactured and installed according to industry standards and test procedures and the installer's CQA methods and procedures. Typical quality assurance methodologies include the review and inspection of the following:

- Copy of the mill certificates;
- Coupons from every seam;
- Perform air pressure tests;
- Inspections to ensure the absence of tears, punctures, and blisters;
- Liner production tests, thickness, dimensions, visual inspection;
- Product testing, tensile properties, tear resistance, etc;
- Sub-grade preparation sign-off; and
- Wedge welding and extrusion welding seam logs and weld tests.

3.3.11 Relevant Specifications

The following specifications from the Construction Specification Institute will be developed, as a minimum:

- 31 14 13 Soil Stripping and Stockpiling
- 31 14 11 Earthwork and Related Work
- 31 23 10 Excavating, Trenching and Backfilling
- 32 11 23 Aggregate Base Courses
- 31 32 21 Geotextiles
- 31 32 22 Geomembranes
- 32 12 16 Asphalt Paving (If applicable)
- 32 13 23 Roller Compacted Concrete Paving (If applicable)
- 32 21 13 or 32 31 25 Fencing

4.0 OPERATING CRITERIA

4.1 Site Records

In accordance with Title 27 CCR 20510, key site records will be kept in the office at the RSI Facility.

Records will be available for inspection by authorized representatives of the LEA and RWQCB during the facilities regular working hours. Alternatively, an inspection can be arranged by notifying the Facility manager. All required records will be properly completed, filed for retention and maintained throughout the operating life of the evaporation ponds.

4.1.1 Operating Record

The operating record maintained at the RSI Facility will include the following information.

- Discharge Volumes - Date and Volume of discharges into each evaporation pond
- Monitoring Results - Results of monitoring, analyses, and testing required by permit or regulatory requirement:
- Inspection Forms - Inspection results that include a description of any required maintenance or remedial action and the date of implementation.
- Contingency Implementation - Written reports prepared in response to any incident requiring implementation of the Contingency Plan.
- Correspondence with Local Agencies - Correspondence associated with emergency arrangements agreed to or refused by local authorities.
- Training Records - Records documenting employee information such as job title for each position, job description, names of employees in each job, and introductory and continuing training received.
- Notifications of Violations - Notices of deficiency, abatement orders or any other notification of violation by any regulatory agency.
- Complaints – The Facility manager will record public complaints received regarding operation of the ponds, including:
  - the nature of the complaint,
  - the date the complaint was received,
  - if available, the name, address, and telephone number of the person or persons making the complaint, and
  - actions taken to respond to the complaint.

4.1.2 Discharge Volumes

In accordance with Title 27 CCR 21720(f), all discharges into the evaporation ponds will be recorded in the Operating Record. The following items will be recorded include:

- Volume in million gallons per day (mgd)
- Cumulative total of wastewater flow, in million gallons, per month
- The maximum daily flow rate, in mgd, each month

4.1.3 Monitoring Results

Monitoring Plan results will be retained at the Facility as part of the Operating Record.

4.1.4 Inspection and Operations Records

Site personnel will complete the inspection logs and other required operation documentation and the facility management will review the applicable documents for completeness and accuracy. Completed inspection logs and notations of needed repairs will be maintained for a minimum of three years.

Further information regarding Inspection and Maintenance requirements are outlined in Section 6

4.1.5 Record of Contingency Plan Implementation

Following any incident which requires implementation of the Facility's Contingency Plan, a report will be prepared containing the information described in Title 27 CCR Section 21760(b)(2). As a minimum, the report will be submitted to the LEA and the RWQCB. In addition, a copy will be retained on filed at the Facility as part of the Operating Record.

Further information regarding the Contingency Plan requirements is outlined in Section 7.

4.1.6 Correspondence Regarding Arrangements with Local Authorities

Copies of all correspondence with local authorities regarding emergency response arrangements and revisions of the Contingency Plan will be maintained at the Facility.

4.1.7 Training Records

In accordance with Title 27 CCR Section 20610, the following records will be retained for each position related to waste management as part of the Operating Record:

- A job title and written job description including assigned duties and required qualifications;
- Name of the employee filling each job;
- Description of initial and continuing training; and
- Documentation of initial and continuing training received.

Whenever a training course is conducted, the records for each employee who completed the course will be updated. When a new employee is hired, a training record file will be initiated for the new employee. Personnel training records on current employees are retained until final closure of the Facility. Records on former employees are retained for three years after the employees' leave date.

4.1.8 Design Documents

In accordance with the requirements of Title 27 CCR Section 21760, all design, as-built, and operating documentation related to the evaporation pond system will be retained at the Facility as part of the Operating Record.

4.1.9 Other Required Technical Records

In accordance with Title 27 CCR Section 20510 and 20517, all other technical records associated with evaporation ponds will be retained at the Facility as part of the Operating Record.

4.1.10 Excavations Records

In accordance with Title 27 CCR Section 20510 (b), records of excavations which may affect the safe and proper operation of the ponds or cause damage to adjoining properties, are kept in the Operating Record.

4.1.11 Operator / Responsible Party Records

In accordance with Title 27 CCR Section 20510 (e), records of written notification to the LEA, local health agency, and fire authority of names, addresses and telephone number of the operator or responsible party of the site, are kept in the Operating Record.

4.2 Reporting Requirements

This section describes key reporting requirements to be met by the RSI Facility for the evaporation ponds.

4.2.1 Implementation of the Contingency Plan

Incidents that result in implementation of the Facility Contingency Plan will be reported to the appropriate agencies. Where such incidents threaten to result in an off-site discharge or may present a potential threat to human health or the environment, immediate verbal notification shall be made as specified in the Contingency Plan. A record of such verbal communications will be maintained in the operating record. As specified by state and Federal regulations, a written report describing the incident and the implementation of the Contingency Plan will be prepared and submitted to LEA and RWQCB within 15 days. Additional reporting may be required under the Waste Discharge Requirements and Monitoring and Reporting Program established by the RWQCB.

4.2.2 Environmental Monitoring Reports

There are several environmental monitoring reports required as part of the Monitoring and Reporting Plan (MRP). Copies of these reports will be kept at the Facility and may include:

- Groundwater Monitoring Reports
- Drainage Reports
- Annual Report

4.3 Security

In accordance with Title 27 CCR Section 21600(b)(5)(B), security measures will be provided to ensure the safest environment for employee working at the Facility. Security measures include barriers and warning signs.

4.3.1 Barriers

The Project solar fields and support facilities' perimeter will be secured with a combination of chain link and wind fencing. Chain link metal fabric security fencing consists of eight-foot tall fencing with one-foot barbed wire or razor wire on top along the north and south sides of the facilities. Thirty-foot tall wind fencing, comprised of A-frames and wire mesh, will be installed along the east and west sides of each solar field.

Controlled access gates will be located at the site entrance. Access through the main gate will require an electronic swipe card, preventing unaccompanied visitors from accessing the Project. All Project personnel, contractors, and visitors will be logged in and out of the Project at the main office during normal business hours. Visitors will be allowed entry only with approval from a staff member at the Project. Visitors will be issued visitor passes that are worn during their visit and returned at the main office when leaving.

4.3.2 Operational Hours

Personnel will staff the Facility 24 hours per day/seven days per week. Even when the solar power plant is not operating, personnel will be present as necessary for maintenance, to prepare the plant for startup, and/or for site security.

4.3.3 Warning Signs

Each point of access from a public road shall be posted with an easily visible sign indicating the facility name, and other pertinent information as required by the WDR.

4.4 Sanitary Facilities

In accordance with Title 27 CCR Section 21600(b)(5)(C), sanitary facilities will be provided at the site for facility employees in the office. The Facility will maintain all sanitary and hand-washing facilities which may be required, by applicable state or local requirements, in a reasonably clean and adequately supplied condition.

4.5 Communication Systems

Communication facilities will be provided at the site for facility employees that meet the requirements of Title 27 CCR Section 21600(b)(5)(D).

4.5.1 Internal Communication

The internal communication system for the Facility will include the following devices:

- Alarm system;
- Two-way radios;
- Telephones; and
- Intercoms.

Each Facility building will also be equipped with telephones. Operations supervisors and other key personnel may carry hand-held two-way radios that can be used to contact the Facility office or other site personnel in an emergency.

4.5.2 External Communications

Twenty-four hour access to outside emergency services, including police and fire departments and emergency response teams, is available through the commercial telephone system at the Facility

4.6 Lighting

Lighting will be provided at the Facility to ensure safety of employees during night time activities, and will meet the requirements of Title 27 CCR Section 21600(b)(5)(E). The Facilities lighting system will provide operations and maintenance personnel with illumination in both normal and emergency conditions. The system will consist primarily of AC lighting, but will include DC lighting for activities or emergency egress required during an outage of the facilities' AC electrical system. The lighting system will also provide AC convenience outlets for portable lamps and tools. Permanent lighting will be provided primarily along the paved access road to the Facility and in the power block area. Lighting in the bioremediation and land farm unit areas will be provided when needed using portable light stands.

4.7 Safety Equipment

In accordance with 27 CCR Section 21600(b)(5)(F), safety equipment will be provided for the health and safety of employees at the Facility.

As specified in the AFC, a Personnel Protective Equipment (PPE) Program will be developed for the facility, which will apply to all contractor and subcontractor employees, as well as direct RSI employees during operation. Specific requirements of the PPE Program include:

- Determine and provide personal protective devices for specific jobs.
- Provide proper head protection requirements.
- Establish eye and face protection requirements.
- Identify body protection equipment requirements.
- Implement hand protection requirements.
- Define proper foot protection.
- Provide proper sanitation facilities.
- Determine safety belts and life lines job requirements.
- Establish procedures to prevent and protect personnel from electric shock.
- Identify onsite and offsite medical services and first aid requirements.
- Specify respiratory protection requirements for jobs.

Required PPE will be approved for use and distinctly marked to facilitate identification. The type of PPE required to operate, maintain and monitor the evaporation ponds will be described in the job safety analysis undertaken prior to the commencement of operations.

4.7.1 Required Equipment

The following equipment shall be available at the Facility to minimize hazards associated with Facility operations:

- Alarm systems and internal communications;
- Radio and telephone systems;
- Emergency equipment for fires and spills; and
- Water supplies for fire fighting.

4.7.2 Emergency Equipment

In accordance with the Emergency Action Plan as specified in the AFC, the Facility will include obtaining emergency response equipment. This equipment will be strategically located throughout the facility in order to respond to emergencies in a timely fashion. Further information on the Emergency Action Plan is provided in Section 7.2.

4.7.3 Water Supplies for Fire Fighting

In accordance with the Fire Protection and Prevention Plan as specified in the AFC, the Facility will be equipped with water at adequate volume and pressure to supply water hose streams. The primary source of water for firefighting is a 1,500,000-gallon raw water storage tank. Only a portion of that tank (360,000 gallons) is dedicated to the plant's fire protection water system.

Further information on the Fire Protection and Prevention Plan at the Facility is provided in Section 5.2.

4.7.4 Equipment Testing and Maintenance

In accordance with the Emergency Action Plan as specified in the AFC, all emergency equipment at the Facility, including communications and alarm systems and fire and spill prevention equipment, will be tested and maintained.

4.8 Personnel Requirements

In accordance with Title 27 CCR Section 21600(b)(5)(G), written job descriptions will be maintained for each position at the facility related to management of waste in the permitted surface impoundments at the Facility, including the evaporation ponds. These descriptions will be updated periodically by facility managers and supervisors to reflect the changing needs of the facility. Job descriptions will be kept on file at the facility and include the following information:

- Job title/position;
- Duties/responsibilities; and
- Job prerequisites and qualifications.

All Facility employees will receive training in general Facility procedures and operations and emergency response procedures. Personnel receive job-specific training during on-the-job training as required. This training ensures that personnel are sufficiently proficient in the particular skills required to perform their assigned duties and that they are aware of the inherent hazards. The management, planning, and operations personnel will have varying backgrounds with respect to the management and operation of the evaporation ponds at the Facility. Technical staff will gain experience with these systems mainly through on-the-job training. A record of training and experience of each employee will be maintained at the Facility office.

4.9 Personnel Training

An Operations Safety Training Program for employees and contractors will be developed for the Facility as specified in the AFC that will meet the requirements of Title 27 CCR Section 21600(b)(5)(H). The Operations Safety Training Program will be revised as required to include any additional training necessary as Facility equipment or operations change. Additional job-specific training may be completed by Facility personnel as needed.

The staff person overseeing the portion of the training program pertinent to the bioremediation and land farm units will be experienced in the operation of such units, waste management procedures and applicable regulations, emergency response and contingency plan implementation.

All Facility employees will be required to receive training in the following areas:

- Injury and Illness Prevention;
- Emergency Action Plan;
- Personal Protective Equipment (PPE);
- Fall Protection;
- Fire Protection and Prevention;
- Confined Space Entry Program;
- Hazard Communication;
- Hand and portable power tool safety;
- Heat Stress and Cold Stress Safety;
- Hearing Conservation; and
- Back Injury Prevention.

Additional training will be required for specific tasks. The topics applicable to operation of the evaporation ponds may include:

- Evaporation Pond Operation;
- Forklift Operation;
- Front-End Loader Operation;
- Mobile Equipment Safety;
- Inspection and Monitoring Program;
- Sludge and Water Sampling;
- Equipment Inspections;
- Employee Exposure Monitoring Program; and
- Housekeeping and Material Handling.

4.10 Supervisory Structure

In accordance with 27 CCR Section 21600(b)(5)(I), the Facility Supervisor will be experienced in solar facilities operations and maintenance to ensure that the facility is properly operated in accordance with all applicable laws, regulations, permit conditions and other requirements. All shift managers and equipment operators will report to the Facility Supervisor.

5.0 ENVIRONMENTAL CONTROLS

5.1 Nuisance Control

As defined by Rule 402 of the Mojave Desert Air Quality Management District, the definition of a nuisance is:

"A person shall not discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public or which endanger the comfort, repose, health or safety of any such persons or the public or which cause or have a natural tendency to cause injury or damage to business or property."

In accordance with Title 27 CCR Section 21600(b)(8)(A), the evaporation ponds will be operated in compliance with all applicable permits and regulatory conditions to prevent creating environmental hazards and public nuisance. Given compliance with permits and conditions and the nature of the evaporation ponds, nuisance conditions are unlikely to arise. In addition, the land treatment units are located in a relatively isolated area away from potential receptors, so the public is unlikely to be impacted by these operations. If complaints are generated, they will be reported to the LEA within 24 hours.

5.2 Fire Control

A Fire Protection and Prevention Program will be prepared for the Facility as specified in the AFC and will meet the requirements of Title 27 CCR Section 21600(b)(8)(B). The plan will include measures relating to safeguarding human life, preventing personnel injury, preservation of property and minimizing downtime due to fire or explosion. Fire protection measures will include fire prevention methods to prevent the inception of fires. Of concern are adequate exits, fire-safe construction, reduction of ignition sources, control of fuel sources, and proper maintenance of fire water supply and sprinkler systems.

The Fire Protection and Prevention Plan for the Facility will include the following sections:

- Scope, purpose, and applicability
- Potential fire hazards
- Proper handling and storage of potential fire hazards
- Potential ignition sources
- Control of potential ignition sources
- Persons responsible for equipment and systems maintenance
- Portable fire extinguishers
- Automatic sprinkler fire suppression system
- Water-spray fire system

- Local fire department
- Training
- Housekeeping procedures
- Record keeping requirements

The Facilities fire protection water system will be supplied from a dedicated 360,000-gallon portion of the 1,500,000-gallon raw water storage tank located on each power block. One electric and one diesel-fueled backup firewater pump per Unit, each with a capacity of 3,000 gallons per minute, will deliver water to the fire protection water-piping network. A smaller electric motor-driven pump jockey pump will maintain pressure in the piping network. If the jockey pump is unable to maintain a set operating pressure in the piping network, the diesel fire pump starts automatically.

A piping network will be configured in a loop so that a piping failure can be isolated with shutoff valves without interrupting the supply of water to a majority of the loop. The piping network will supply fire hydrants located at intervals throughout each power block area, a sprinkler deluge system at each unit transformer, HTF expansion tank and circulating pump area and sprinkler systems at the STG and in the operations and administration buildings. Portable fire extinguishers of appropriate sizes and types will be located throughout each power block.

5.3 Leak Detection and Removal System

In accordance with Title 27 CCR Section 21600(b)(8)(C), there is a leak detection system (LDS) located beneath the primary liner in the evaporation pond. Due to the nature of an evaporation pond, there is no leachate detection and collection system (LDCS) required above the primary liner.

In accordance with Title 27 CCR Section 21600(b)(8)(C), a leak detection and removal system (LDS) will be located beneath the primary and secondary liners underlying the each evaporation pond. As discussed in Section 3.1, the LDS will comprise of a layer of granular material (sand / gravel) and a perforated collection piping system (refer to Attachment A). In addition, a drainage Geocomposite may be utilized. The LDS will be sloped to drain leakage to a separate leak detection sump for each pond to detect and capture fluids leaking through the primary liners. The leak detection sump will include a 16-inch diameter leak detection and removal well fitted an electronic leak sensor and a submersible pump to allow removal of leakage. The pump will discharge back into the evaporation pond. The discharge pipe may be equipped with a recording flow totalizer to allow monitoring of the amount of fluid removed over time and calculation of leakage rates.

The inspection and maintenance requirements for the LDS are outlined in Section 6.

5.3.1 Action Leakage Rate

The action leakage rate (ALR) is the allowable leakage from the primary liner system. According to Title 40, Section 264.222 of the Code of Federal Regulations, the ALR is defined as the maximum design flow rate that the leak detection system can remove without the fluid head on the bottom liner exceeding 1 foot. The ALR must also include an adequate safety margin to allow for variability in the containment system design (e.g. liner and collection pipe slope, interstitial fill hydraulic conductivity, thickness of drainage material). Based on the available information, an ALR of 24,800 gallons/acre/day for the north ponds and 46,800 gallons/acre/day for the south ponds is proposed for management of the facility.

The recording flow totalizer at each sump will be monitored at least weekly to determine the leakage rate through the primary liner. If the leakage rate exceeds the ALR, then the appropriate actions in the Contingency Plan will be implemented.

5.4 Dust Control

An Operations Dust Control Plan will be prepared for the Facility as specified in the AFC to manage fugitive dust emissions and comply with the requirements of Title 27 CCR Section 21600(b)(8)(D). Best Management Practices for dust control from the evaporation ponds will be implemented as necessary and will include the following:

- Maintaining at least 2 feet of freeboard during operation of the ponds to reduce potential for dust entrainment;
- Use of moisture conditioning during removal and loading of accumulated sludge;
- Adherence to speed limits during travel on dirt roads for monitoring and maintenance of the ponds; and
- Tarping of any truck loads of sludge removed from the Facility for off-site disposal.

5.5 Vector Control

In accordance with Title 27 CCR Section 21600(b)(8)(E), a vector control program will be implemented at the Facility as needed. In the event that there is a vector problem such as flies or rodents, the Facility will take the adequate steps to control the problem, which may include trapping, acoustic controls, poison, spraying or engaging a licensed pest control service. Integrated pest control practices will be utilized when practical. Brush will be cleared for a distance of at least 30 feet from the ponds, to reduce habitat for rodents and hiding places for predators that could prey on birds attracted to the ponds.

Water fowl and other birds may be attracted to the evaporation ponds. The primary constituent of concern to bird life in the wastewater at the Facility is selenium; however, as shown in Table B-1 (Attachment B), selenium was not detected in the well water. Nevertheless, mitigation measures will need to be implemented to deter birds. Bird exclusion nets or screens over the entire evaporation pond areas will be utilized. Alternative measures that may be implemented, if needed, include the following:

- Hazing using propane cannons, injured bird calls or other methods;
- Installation of a grid system of nylon monofilament line strung between fasteners on the sides and ends of the evaporation ponds;
- Installation of streamers on lengths of nylon monofilament line strung across the ponds; and/or
- Clearing of brush for a distance of at least 30 feet from the ponds to remove potential hiding places for predators that could prey on the birds.

5.6 Drainage and Erosion Control

A Drainage, Erosion and Sediment Control Plan will be prepared for the Facility as specified in the AFC and will address the requirements of Title 27 CCR Section 21600(b)(8)(F). The plan will outline describe the management and control of storm water runoff at the site and will specify site-specific

Best Management Practices for erosion and sediment control that will include side slope protection of the berms surrounding the evaporation ponds. These berms will control and prevent potential inflow (run-on) of surface storm water into the ponds. Precipitation that falls on the ponds will be contained in the ponds and evaporated. Storm water run-off that falls outside the ponds will be controlled and routed as shown in Attachment A.

5.7 Noise Control

Noise control requirements for the Facility have been investigated in the AFC and will comply with the requirements of Title 27 CCR Section 21600(b)(8)(H). Due to the remoteness of the site and operating procedures of the treatment units, noise is not anticipated to be a problem. Offsite noise levels for the operation of the entire Facility diminish to the point of being indistinguishable from ambient levels before reaching the offsite noise sensitive or residential receptors. The Facility operator will comply with Local, State, and Federal requirements and regulations regarding noise control.

On-site mobile equipment used for pond maintenance will be equipped with approved mufflers and will conform to applicable OSHA and CAL OSHA noise requirements. In addition, hearing protection will be available to facility personnel.

5.8 Traffic Control

Traffic control requirements for the Facility have been investigated in the AFC and will meet the requirements of Title 27 CCR Section 21600(b)(8)(I) for the evaporation ponds. The proposed access to the evaporation pond areas will be off the main paved entrance roadway for the Facility. Traffic is expected to be limited to trucks and mobile equipment used in occasional inspection and maintenance activities. Control measures to mitigate on-site safety hazards and interference with site operations will include signs, paint markings, mirrors and imposition of speed limits as needed.

The Project site is located southwest of U.S. Highway 395 on the north and south sides of Brown Road, approximately five miles southwest of Ridgecrest, California. Regional access is provided to the Project site and the surrounding Ridgecrest area by U.S. Highway 395. U.S. Highway 395 is a primary north/south regional arterial that extends northerly along the eastern side of the Sierra Nevada Mountain Range to Bishop. It extends southerly to I-15 approximately 10 miles south of Victorville. In the Project vicinity, U.S. Highway 395 is a two-lane facility with two, 12-foot travel lanes with approximately 6-foot paved shoulders and 6- to 8-foot graded shoulders on each side. The site is linked to U.S. Highway 395 via Brown Road, an existing two-lane paved road, approximately 24-feet wide, with variable graded shoulders from 4 to 10 feet on each side.

Additionally, the Project can be accessed from West Inyokern Road (SR-178), which extends westerly from the City of Ridgecrest as a four lane road to Inyokern and crosses Brown Road approximately nine miles north of the Project site. Between Ridgecrest and Brown Road, SR-178 is about 72 feet wide, including an approximately 24-foot wide unpaved median strip. It typically includes 4-foot paved shoulders with an additional 4-foot graded shoulder on each side. SR-178 is the northern-most boundary of the city of Ridgecrest.

Proposed traffic mitigation for the Project include the development and implementation of a construction phase Traffic Management Plan (TMP) in consultation with Caltrans and Kern County for the roadway network potentially affected by construction activities at the plant site and offsite linear facilities. In addition, RSI may split the arrival of the workforce in the morning into two parts arriving one hour or more apart when the total number of workers onsite will exceed 300.

6.0 INSPECTION, SAMPLING AND MAINTENANCE PROGRAMS

The following section outlines the inspection and maintenance requirements for the evaporation pond system.

The ALR will be field tested at the commencement of the evaporation pond operation. On the first day of operation, the pump, piping and control switches will be checked to ensure they are in proper working condition per the manufacturer's specifications.

6.1 Inspection Program

6.1.1 Evaporation Pond Liner and Dike Areas

The liner at the perimeter of the pond and perimeter dikes should be visually inspected on a monthly basis for rips and tears, evidence of animal intrusion, weed growth (through the liner or around the perimeter), environmental degradation, and failure of the liner anchoring system (i.e., the liner pulling away from the pond edges). The perimeter fence and the pond inlet (when visible) and outlets should also be inspected monthly to ensure they are in good repair and that these areas are free of debris.

6.1.2 Evaporation Pond Leak Detection System

Monitoring of leaked water is achieved through the addition of vertical monitoring wells that are hydraulically isolated with the leak detection layer. The flow totalizes, which quantify flow and the potential leakage that may occur between containment layers in the monitoring wells, should be monitored weekly for flow and monthly (quarterly after the first six months) to check for built up of material or degradation of the system.

6.1.3 Moisture Detection Monitoring

Moisture detection monitoring will be undertaken semi-annually using a neutron probe. This sampling method must be undertaken by a trained, certified, and licensed technician as the neutron probe uses radioactive material.

Moisture in the soil is detected by the speed that the neutrons move and scatter when emitted. The soil causes neutrons to slow however if the soil is dry, the cloud of neutrons will be less dense and extend further from the probe and if the soil is wet, the neutron cloud will be more dense and extend a shorter distance (Texas AM 2009). The density of the cloud is measured by a detector and results are displayed electronically on the front panel. The measurement is the total water content in the soil, therefore the background levels of water moisture in the soil must be removed to assess if any additional moisture has been released from the evaporation pond liner system.

6.1.4 Sludge Inspections and Removal

Monthly inspections of the pond inlet, outlet, and all associated drainage ditches/pipes/culverts will be conducted for sludge including sediment and debris accumulation. If sludge appears to be impeding flow into the pond or potential flow from the pond, maintenance actions will be scheduled for cleaning these areas as soon as possible. Sludge removal activities will be conducted on an as-needed basis depending upon the inspections and the process is outlined in Section 6.3.2.

6.2 Sampling Program

Samples are to be properly documented and a written record of the chain-of-custody recorded. The chain-of-custody record will track the samples from the field to the laboratory. The form documents the time, date, location, person collecting the sample, and names and signatures of all persons handling the samples from the field to the laboratory.

6.2.1 Evaporation Pond - Wastewater

The evaporation ponds should be sampled at the commencement of operation, semi-annually thereafter to document constituent concentrations.

Grab samples of wastewater collected at the start of operation and annually from each pond shall be analyzed by a state certified laboratory to determine the concentration of the parameters listed in Table 1. The annual samples are to be collected in the last quarter of each year.

Table 1: Evaporation Pond Wastewater Start Up and Annual Sampling Parameters

	Unit
Ammonia	As N
Aluminum	mg/l
Arsenic	mg/l
Boron	mg/l
Calcium	mg/l
Chloride	mg/l
Cyanide	mg/l
Fluoride	mg/l
Iron	mg/l
Magnesium	mg/l
Molybdenum	mg/l
Nitrate as nitrogen	mg/l
Nitrite as nitrogen	mg/l
Phosphate	mg/l
Potassium	mg/l
Selenium	mg/l

Wastewater samples from each pond shall also be collected semi annually and composited into one same by the state certified laboratory and analyzed to determine the quantification of the parameters list in Table 2.

Table 2: Evaporation Pond Wastewater Semi-Annual Sampling Parameters

	Unit
Silica	mg/l
Silicon	mg/l
Sodium	mg/l

Table 2: Evaporation Pond Wastewater Semi-Annual Sampling Parameters

	Unit
Strontium	mg/l
Sulfate	mg/l
Total dissolved solids	mg/l
Total alkalinity	mg/l as $CaCO_3$
Zinc	mg/l
Biphenyl	mg/l
Diphenyl	mg/l
pH	pH
Chloride	mg/l
Chlorine	mg/l
Selenium	mg/l
Sulfate	mg/l
Total dissolved solids	mg/l
Temperature	Fahrenheit or
	Celsius
pH	pH

6.2.2 Evaporation Pond - Sludge

Annually, in the last quarter to each year, two representative grab samples of the bottom sludge in each pond if present, shall be collected, composited and analyzed for the parameters show in Table 3.

Table 3: Evaporation Pond Sludge Sampling Parameters

	Unit
Title 22 metals (total)	mg/kg
Biphenyl, diphenyl oxide	mg/kg

6.3 Maintenance Program

6.3.1 Clean Out

The general requirements for undertaking clean out works for evaporation ponds are outlined below.

Before water can be pumped out of the pond for maintenance, the capacity of the other evaporation ponds must be assessed to verify that sufficient capacity exists to contain wastewater from continued operation for a sufficient amount of time to allow planned maintenance activities. Preliminary design estimates indicate that if one pond is undergoing clean out activities, the additional pond can operate effectively for up to one year.

The appropriate time of year and ideal weather conditions to undertake the clean out activities should be investigated. Dust generated during the activities will need to be controlled in accordance with the Facilities Operations Dust Control Plan. Health and safety issues for the clean out activity include potentially slipping or falling into the pond. As part of the Facilities Operations Safety Training Program and PPE Plan, employees will be trained on how to undertake the clean out activities in a safe manner, which may include having ropes and ladders accessible at the evaporation ponds.

6.3.2 Sludge Removal

If the pond is being drained for liner maintenance or excessive storm water volumes, the sediment and sludge in the pond will be evaluated and removed if necessary as preventative maintenance. The general requirements for undertaking sludge and sediment removal for evaporation ponds is outlined below

The removal activities should only be conducted on an as-needed basis depending upon the inspection of the system. The inspections should include estimating the volume of sludge, assessing if the sludge or sediment is impeding flows into the pond and impacting on the evaporation rate or capacity of the system. The evaporation ponds are design to hold two feet of sludge.

Each pond will be in use for about 3.5 years, after which time the pond will be removed from service and the sludge allowed to dry for a period of 6-7 months. All waste flows will be discharged to the other pond during this period. Sludge removal will commence when the sludge reaches 50 to 80 percent water content as required by the receiving facility. Initial pond cleaning will occur after 2 years of facility operation, and thereafter one pond will be cleaned every two years. If wind-blown silt accumulation varies from 6 inches per year the cleaning interval will be adjusted accordingly so that removal will occur when about 2 feet of sludge accumulates in the pond.

The sludge shall be removed by a pumping or vacuum system if fluid, or should be dried and removed using conventional excavation and loading equipment light enough to reduce the potential for damage to the liner system. If necessary, the sludge should be sampled and analyzed to meet the characterization requirements of the receiving disposal facility. The characteristics of the sludge will determine the transportation and disposal methodology.

7.0 CONTINGENCY & EMERGENCY PLANS

7.1 Contingency Plan

A Contingency Plan compliant with the requirements of Title 27 CCR Section 21760(b)(2) has been prepared for the evaporation pond and presented under separate cover. The Contingency Plan outlines procedures to be followed in the following events:

- Detected primary liner leakage exceeding the ALR;
- Physical or statistically-significant evidence of a release from the impoundments, as identified during implementation of the Monitoring Program;
- Damage to the impoundment berm or liner systems, as observed during inspections;
- Insufficient pond freeboard;
- Overflow of the pond system; or
- Excessive HTF in the pond residue or sheen on the water.

7.2 Emergency Action Plan

An Emergency Action Plan will be prepared for the Facility that will meet the requirements of Title 8 CCR § 3220. This plan will address a variety of potential emergencies across the entire Facility, including chemical releases, fires, bomb threats, pressure vessel ruptures, aqueous ammonia releases and other potential catastrophic events. The plan will describe evacuation routes, alarm systems, points of contact, assembly areas, responsibilities, and other actions to be taken in the event of an emergency. The plan will include a layout map, equipment list, and describe arrangements with local emergency response agencies for responding to emergencies. The Emergency Action Plan will be used in conjunction with the facility Injury and Illness Prevention Plan to identify and administrate site safety procedures. The written Emergency Action Plan will be comprised of the following components:

- Scope, purpose, and applicability,
- Roles and responsibilities,
- Emergency incident response training,
- Emergency response protocol,
- Evacuation protocol,
- Post emergency response protocol, and
- Notification and incident reporting.

Attachment A

Design Details

DWG: S:\Solar Millennium LLC\60093833\Evaporation Ponds\CAD\RIDGECREST\EVAP PONDS FIG 1.dwg Layout Name: FIG 01 – Plotted by: Bedford, Kevin Date: 5/28/2010 – 11:06 AM
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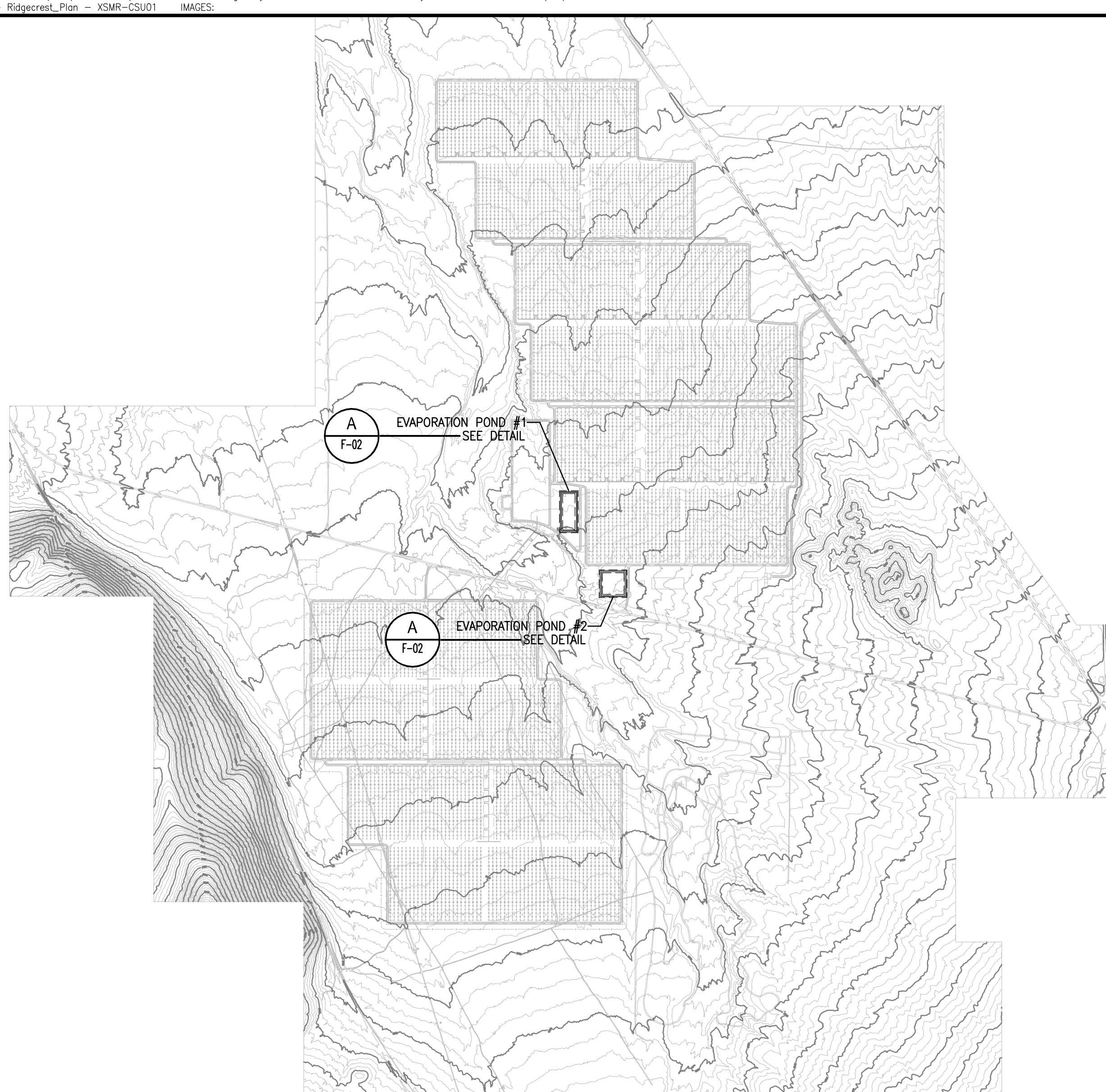

FIGURE
01

SOLAR MILLENNIUM

RIDGEGECREST EVAPORATION PONDS
SITE PLAN

AECOM PROJECT NO.
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DWG: S:\Solar Millennium LLC\60093833\Evaporation Ponds\CAD\RIDGECREST\EVAP PONDS.dwg Layout Name: FIG 02 — Plotted by: Bedford, Kevin Date: 5/28/2010 - 11:20 AM
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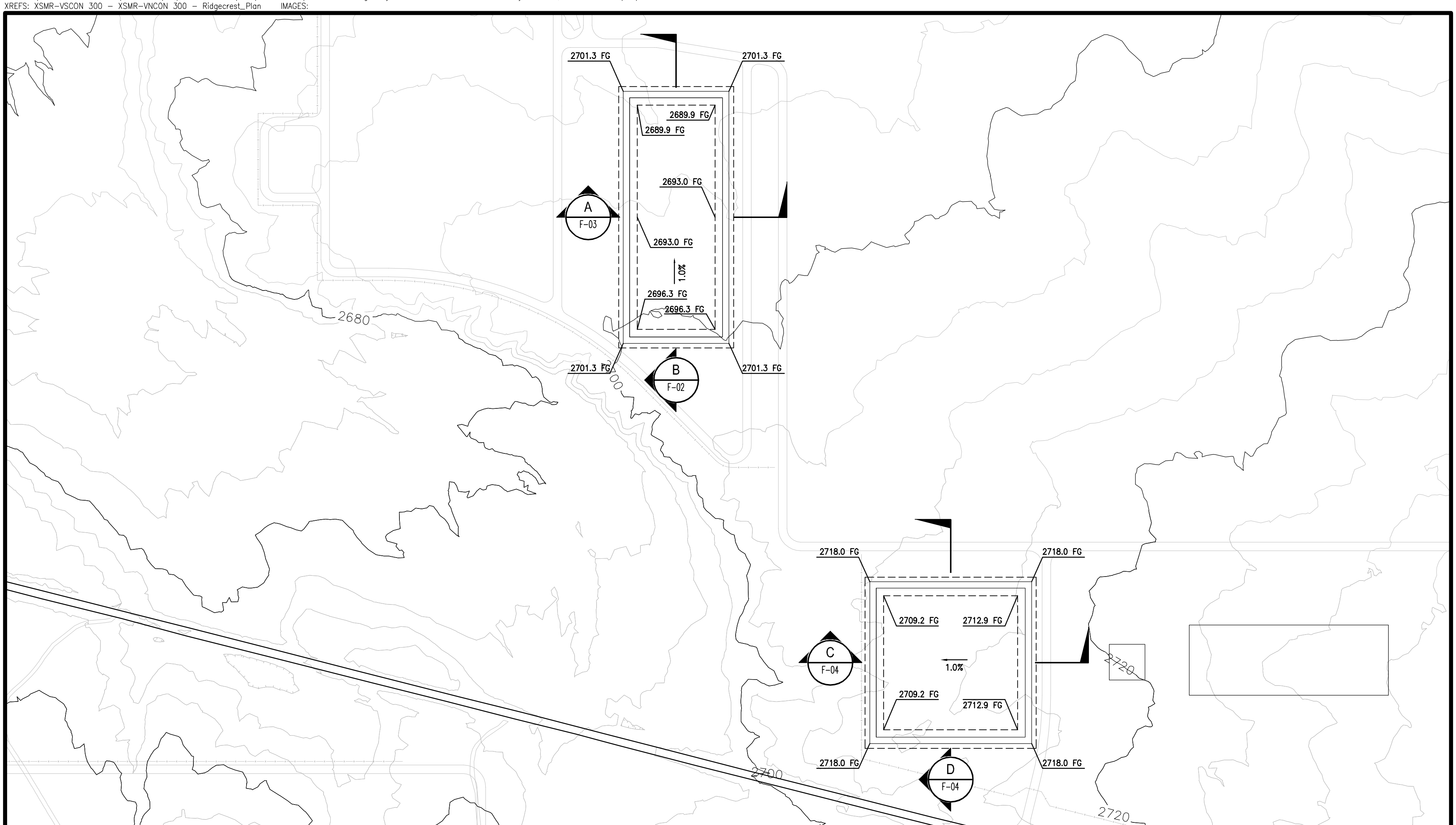

EVAPORATION PONDS A –
SCALE: NONE

FIGURE 02

SOLAR MILLENNIUM

RIDGEGECREST EVAPORATION PONDS
GRADING PLAN

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DWG: S:\Solar Millennium LLC\60093833\Evaporation Ponds\CAD\RIDGECREST\EVAP PONDS.dwg Layout Name: FIG 03 – Plotted by: Bedford, Kevin Date: 5/28/2010 – 1:36 PM
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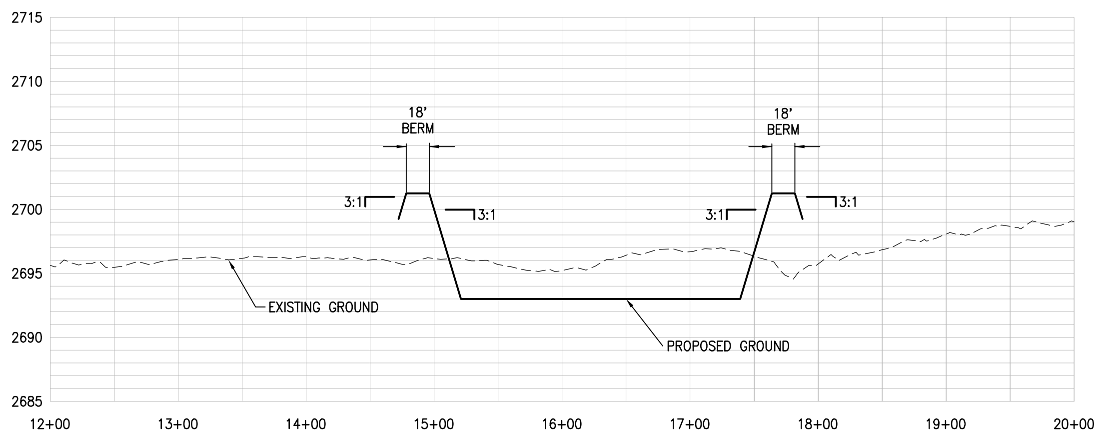

CROSS SECTION A –

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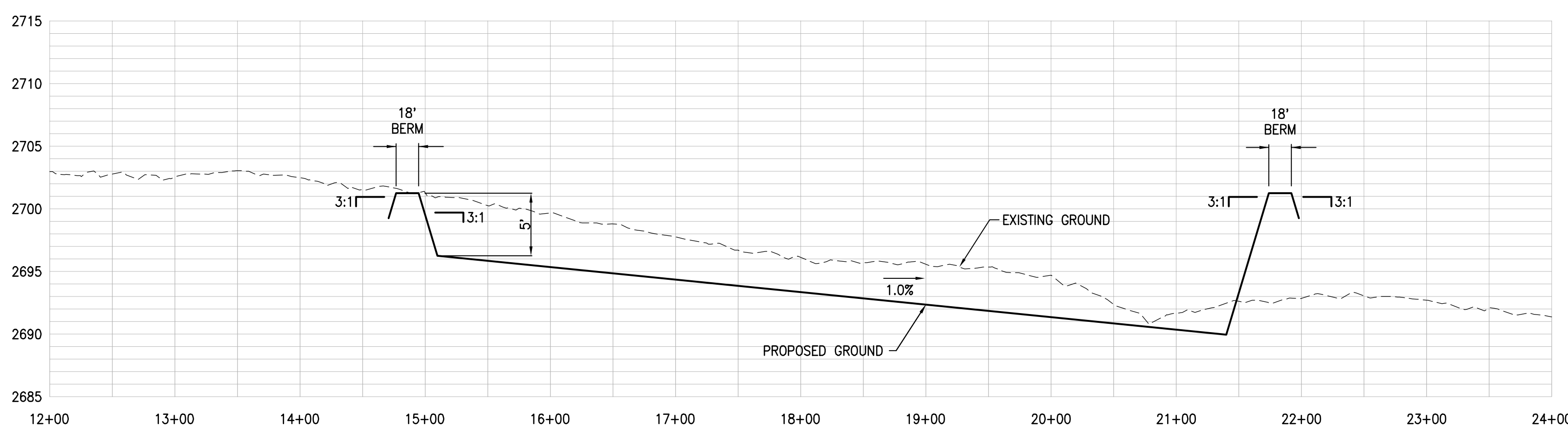

CROSS SECTION B –

SCALE: NONE

FIGURE 03	SOLAR MILLENNIUM RIDGEGECREST EVAPORATION PONDS CROSS SECTIONS	AECOM PROJECT NO. 60092528.0010	AECOM AECOM USA, Inc. 5001 E. Commercenter Dr. Suite 100 Bakersfield, California 93309 T 661.325.7253 F 661.395.0359 www.aecom.com

DWG: S:\Solar Millennium LLC\60093833\Evaporation Ponds\CAD\RIDGECREST\EVAP PONDS.dwg Layout Name: FIG 04 - Plotted by: Bedford, Kevin Date: 5/28/2010 - 1:39 PM
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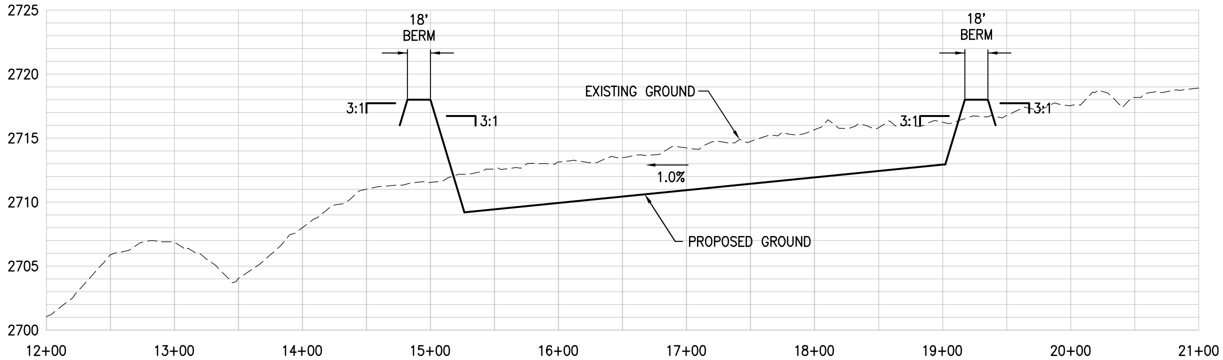

CROSS SECTION C/-
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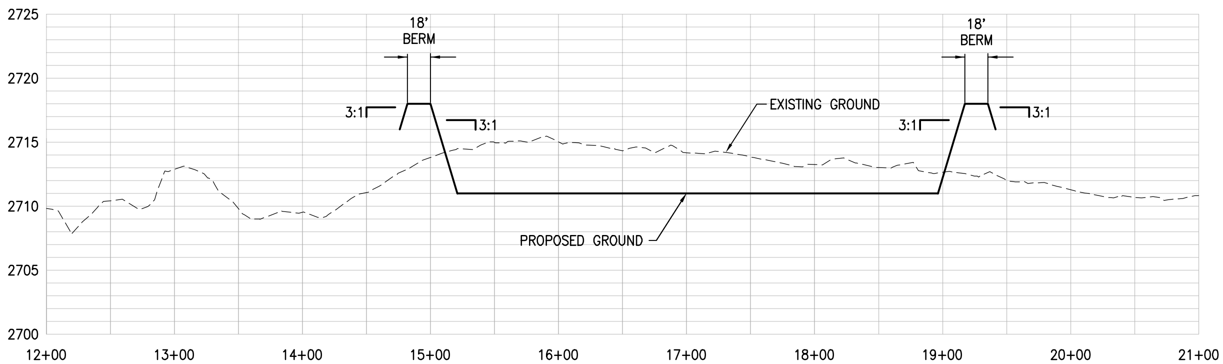
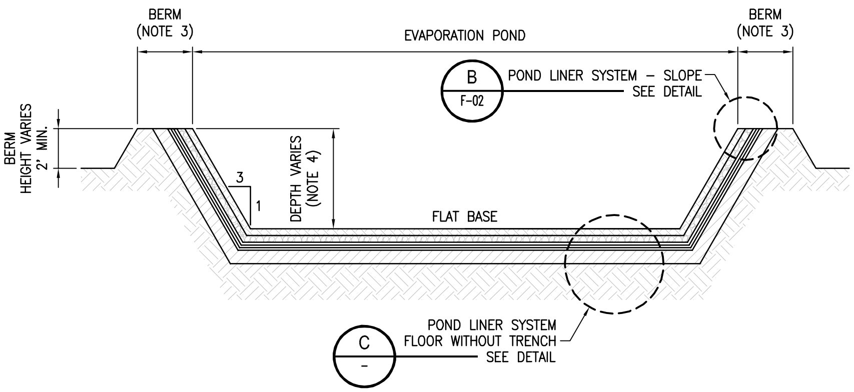


CROSS SECTION D/-
SCALE: NONE

FIGURE 04	SOLAR MILLENNIUM RIDGEGECREST EVAPORATION PONDS CROSS SECTIONS	AECOM PROJECT NO. 60092528.0010	AECOM AECOM USA, Inc. 5001 E. Commercenter Dr. Suite 100 Bakersfield, California 93309 T 661.325.7253 F 661.395.0359 www.aecom.com



POND - UPSTREAM CROSS SECTION (A –)

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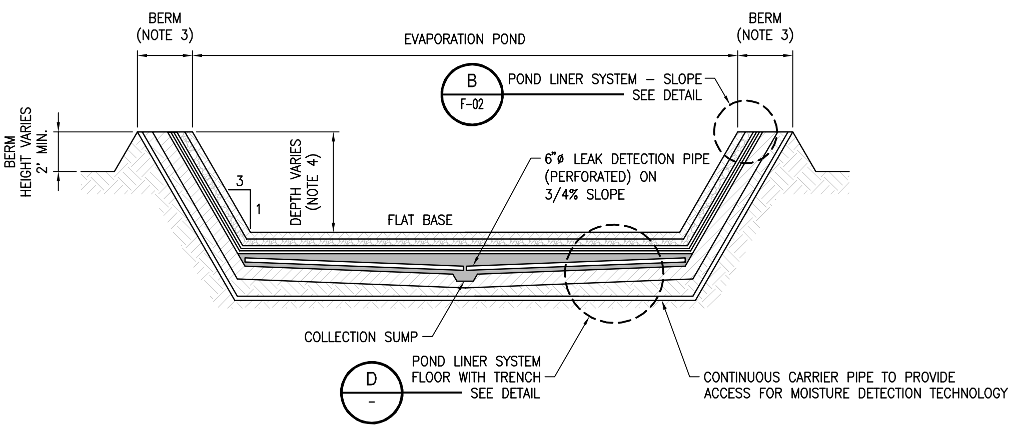

POND - DOWNSTREAM CROSS SECTION (B –)

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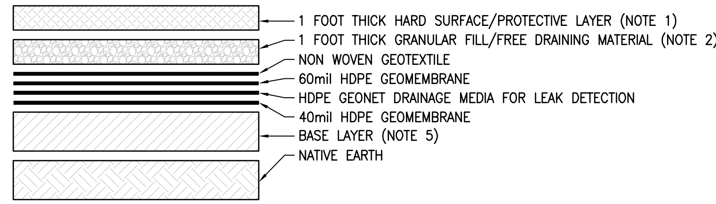

POND LINER SYSTEM DETAIL FLOOR TRENCH (C –)

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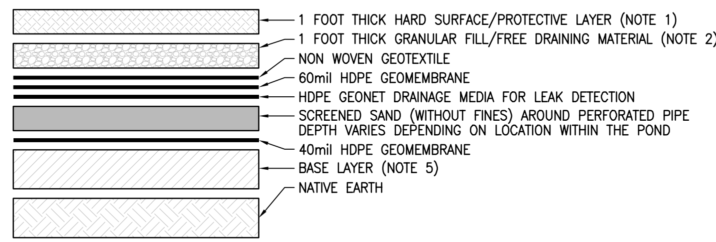


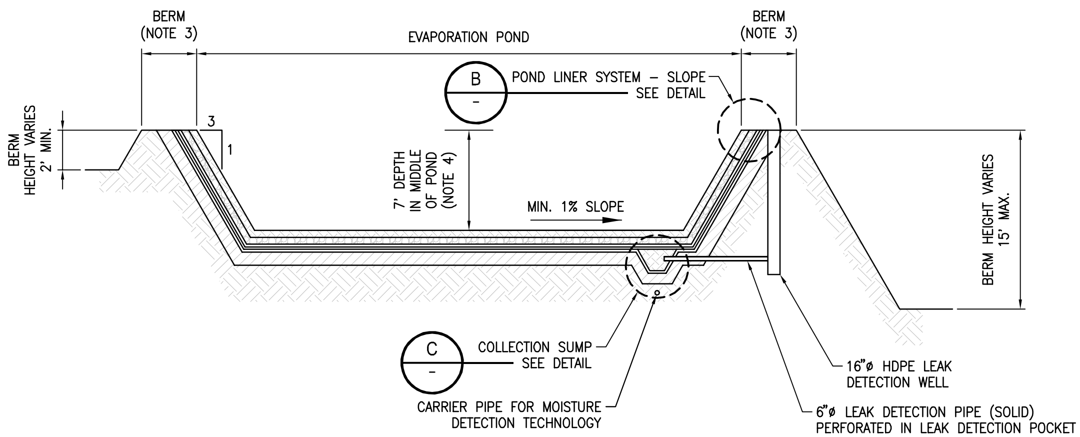
POND LINER SYSTEM DETAIL FLOOR WITHOUT TRENCH (D –)

SCALE: N.T.S.

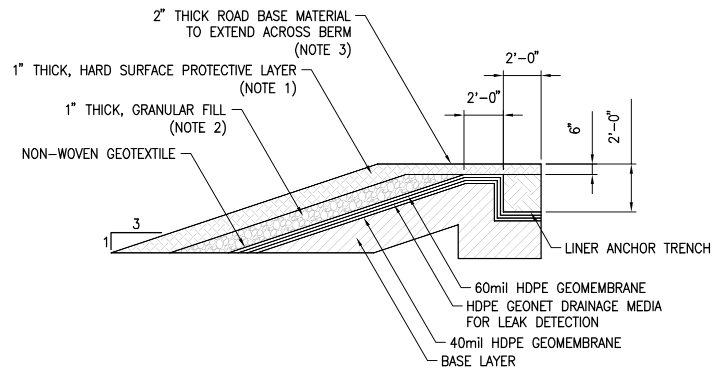
NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10–6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

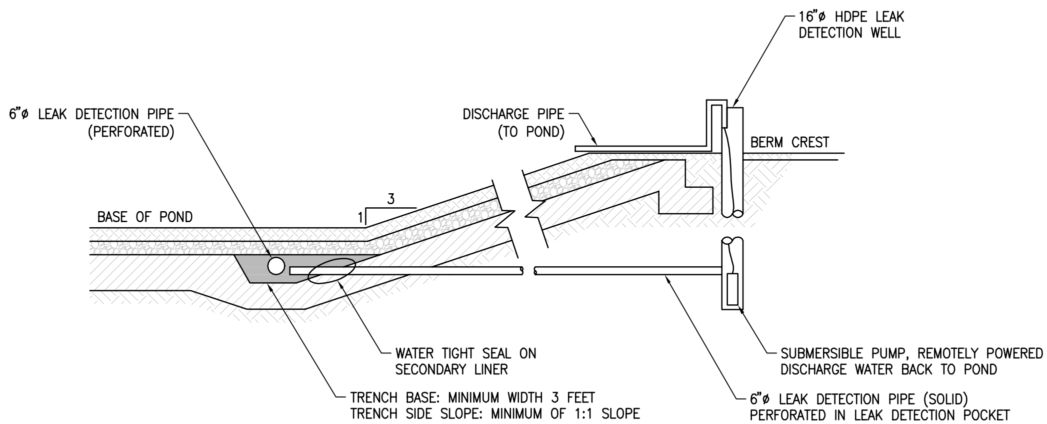
FIGURE		AECOM PROJECT NO.	
05	SOLAR MILLENNIUM RIDGECREST EVAPORATION PONDS SECTION AND DETAILS	60092528.0010	AECOM AECOM USA, Inc. 5001 E. Commercenter Dr. Suite 100 Bakersfield, California 93309 T 661.325.7253 F 661.395.0359 www.aecom.com



CROSS SECTION THROUGH THE MIDDLE OF THE PONDS (A / –)
SCALE: N.T.S.



POND LINER SYSYTEM - SLOPES (B / –)
SCALE: N.T.S.



COLLECTION SUMP DETAIL (C / –)
SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10–6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

FIGURE 06

SOLAR MILLENNIUM

RIDGECREST EVAPORATION PONDS
SECTION AND DETAILS

AECOM PROJECT NO.
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Attachment B

Water Cycle

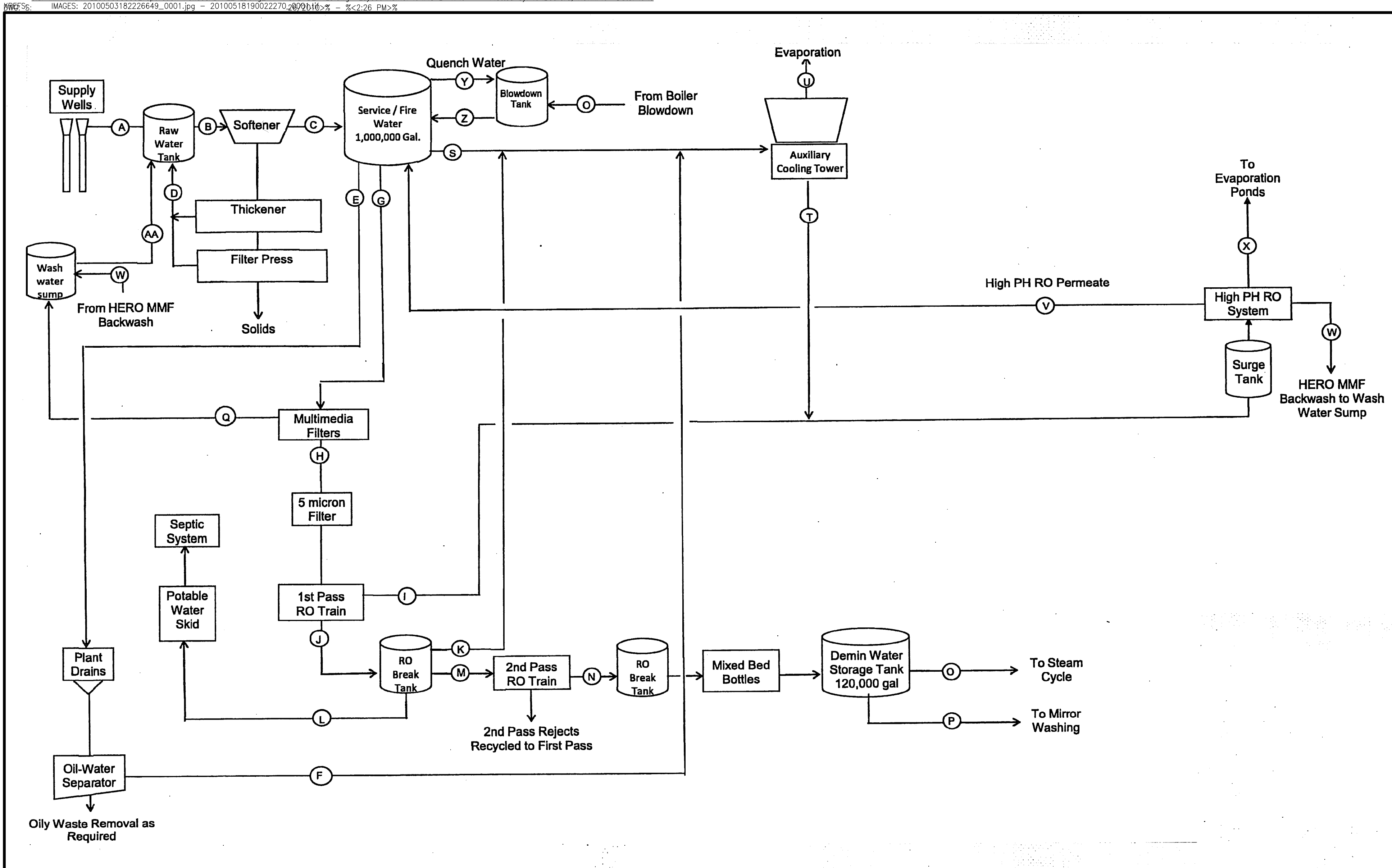

FIGURE B1

SOLAR MILLENNIUM

RIDGECREST EVAPORATION PONDS
FIGURE B-1

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Table B-1
Process Water Flows

		24 Hour Average	24 Hour Total	Peak Operation
	Ambient Conditions	96.7F/66.5F_WB	96.7F/66.5F_WB	96.7F/66.5F_WB
	Boiler Duty	100%	100%	100%
Stream ID	Description	GPM	GPD	GPM
A	Flow from IWVWD	63	90,917	97
B	Softener Makeup	99.46	143,225	153.52
C	Softener Effluent	98.47	141,793	151.98
D	Recovered dewatering water	0.4	573	0.61
	Water in dewatered sludge	0.6	859	0.92
E	Service water to plant users	4	5,760	4
F	OWS effluent	4	5,760	4
G	Multimedia filter makeup	133.4	192,121	197.1
H	First pass RO makeup	120	172,909	177
I	First pass RO reject	48	69,164	71
J	First pass RO permeate	72	103,746	106
K	RO permeate to cooling tower	0	-	0
L	RO permeate to potable water	2	2,880	2
M	Second pass RO makeup	70	100,866	104
N	Second pass RO permeate	53	75,649	78
O	Steam cycle makeup / blowdown	16	23,398	42
P	Demin water to mirror washing	36	52,251	36
Q	Multimedia filter backwash	13	19,212	20
	Service water to cooling tower	27	38,694	76
S	Total cooling tower makeup	31	44,454	80
T	Cooling tower evaporation	21	29,636	53
U	Cooling tower blowdown	10	14,818	27
V	High pH RO permeate	50	71,384	83
W	High pH filter backwash	5.832	8,398	9.758
X	High pH RO reject of Evap Pond	8.748	12,597	14.636
Y	Quench Water	65	93,732	130
Z	Quenched Boiler Blowdown	81	117,130	172
AA	Multimedia filter backwash	36	51,735	56

Design Basis:

1. Steam cycle makeup and cooling tower evaporation from Kiewit.
2. Recovery rates depend upon influent water chemistry.
3. Based on water analysis April 2008 from Wells18, 33, and 3. Information provided by IWVWD.

Table B-2
Anticipated Water Quality

Constituent	Units	Well Water	Softened Water	Service Water	RO First Pass Permeate	1st pass RO Reject	Mixed Bed Effluent	Boiler Blow down	Quenched Blowdown	Cooling Tower Makeup	Cooling Tower Blow down	High pH RO Permeate	High pH Reject to Evaporation Pond
		A, B	C, D	E,G,H,S,Y	J,L,K,M	J	O,P	P	Z	F+K+S		V	
Cations													
Calcium	mg/L	37	16	11	5	40	0	1	9	11	32	0	39
Magnesium	mg/L	5.4	5	3	1	12.5	0	1	3	3	10	0	12
Sodium	mg/L	44	44	36	10	110	0	77	44	36	108	20	767
Potassium	mg/L	4	4	4	0	10	0		3	4	12	4	10
Ammonia	mg/L	ND	0.1	0	0	0.25	0		0	0	0	0	0
Anions													
Chloride	mg/L	86	86	60	10	215	0	1	48	60	180	9	1045
Sulfate	mg/L	44	44	38	5	110	0	4	32	38	115	27	111
Alkalinity	mg/L	117	32	21	1	80	0		17	21	64	0	77
Bicarbonate	mg/L	143	39	26	1	97.5	0		21	26	78	0	94
Carbonate	mg/L	ND	0	0	0	0	0		0	0	1	1	0
Cyanide	µg/L	ND		0	0	0	0		0	0	0	0	0
Silica	mg/L	42	10	7	0	25	0	2	6	7	21	1	24
Phosphate	mg/L	ND	0	0	0	0	0		0	0	0	0	0
Polyphosphate	mg/L	ND	0	0	0	0	0	0.5	0	0	0	0	0
Fluoride	mg/L	0.8	0.8	1	2	2	0		0	1	2	0	2
Nitrate	mg/L	8	8	5	0	20	0		4	5	16	0	19
General													
Suspended Solids	mg/L	0	5	3	0	12.5	0		3	3	10	0	12
Total Dissolved Solids	mg/L	287	280	209	36	700	0	85	184	209	626	68	2124
Hardness	mg/L	115	50	34	28	125	0		27	34	102	2	121
Constituent	Units	Well Water	Softened Water	Service Water	RO First Pass Permeate	1st pass RO Reject	Mixed Bed Effluent	Boiler Blow down	Quenched Blowdown	Cooling Tower Makeup	Cooling Tower Blow down	High pH RO Permeate	High pH Reject to Evaporation Pond
Trace Metals													
Aluminium	µg/L	ND	ND	0	0	0	0		ND	0	0		0
Antimony	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
		4	4	3	0	10	0		2	3	8	0	10

Table B-2
Anticipated Water Quality

Constituent	Units	Well Water	Softened Water	Service Water	RO First Pass Permeate	1st pass RO Reject	Mixed Bed Effluent	Boiler Blow down	Quenched Blowdown	Cooling Tower Makeup	Cooling Tower Blow down	High pH RO Permeate	High pH Reject to Evaporation Pond
Arsenic	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Barium	µg/L	0.28	0.28	0.19	1	0.7	0	28	6	0	1	0	1
Boron	mg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Cadmium	µg/L	ND	ND	0	0	0	0	10	2	0	0	0	0
Chromium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Cobalt	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Copper	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Hexavalent Chromium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Iron	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Lead	µg/L	0.7	0	0	0	0	0		0	0	0	0	0
Manganese	µg/L	ND	ND	0	0	0	0	1	0	0	0	0	0
Molybdenum	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Nickel	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Selenium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Strontium	µg/L	ND	ND	0	0	0	0		ND	0	0	0	0
Thallium	µg/L	14	14	9	0	0	0		7	9	28	0	5
Vanadium	µg/L	0.022	0.07	0.05	0	0.175	0	0.005	0.04	0.05	0.14		0.17
Zinc	mg/L	ND	ND	0	0	0	0		ND	0	0		0

Table B-3
Evaporation Pond Sludge Quality

Constituent	Units	Lb/day	Lb/Year	Concentration in dry solids, mg/Kg	Concentration with Silt, mg/kg
Cations					
Calcium	mg/L	4	1,479	18,066	1626
Magnesium	mg/L	1	462	5,646	508
Sodium	mg/L	81	29,407	359,182	32326
Potassium	mg/L	1	396	4,843	436
Ammonia	mg/L	0	9	113	10
Anions					
Chloride	mg/L	110	40,050	489,190	44027
Sulfate	mg/L	12	4,248	51,882	4669
Alkalinity	mg/L	8	2,958		0
Bicarbonate	mg/L	10	3,605	44,036	3963
Carbonate	mg/L	0	7	82	7
Cyanide	µg/L	-	-	-	0
Silica	mg/L	3	931	11,373	1024
Phosphate	mg/L	-	-	-	0
Polyphosphate	mg/L	-	-	-	0
Fluoride	mg/L	0	74	903	81
Nitrate	mg/L	2	740	9,033	813
General					
Suspended Solids	mg/L	1	462	5,646	465000
Total Dissolved Solids	mg/L	223	N/A		0
Hardness	mg/L	13	N/A		0
Trace Metals		-			
Aluminium	µg/L	-	-	-	0
Antimony	µg/L	-	-	-	0
Arsenic	µg/L	0.001	0.37	5	0
Barium	µg/L	-	0.00	-	0
Boron	mg/L	0.000	0	0	0
Cadmium	µg/L	-	-	-	0
Chromium	µg/L	-	-	-	0

Table B-3
Evaporation Pond Sludge Quality

Constituent	Units	Lb/day	Lb/Year	Concentration in dry solids, mg/Kg	Concentration with Silt, mg/kg
Cobalt	µg/L	-	-	-	0
Copper	µg/L	-	-	-	0
Hexavalent Chromium	µg/L	-	0.00	-	0
Iron	µg/L	-	0.00	-	0
Lead	µg/L	-	-	-	0
Manganese	µg/L	-	0.00	-	0
Molybdenum	µg/L	-	0.00	-	0
Nickel	µg/L	-	0.00	-	0
Selenium	µg/L	-	-	-	0
Strontium	µg/L	-	0.00	-	0
Thallium	µg/L	-	-	-	0
Vanadium	µg/L	0.001	0	2	0
Zinc	mg/L	0.000	0.0	0	0

Environment

Prepared for:
Ridgecrest Solar I, LLC

Corrective Action Plan
Ridgecrest Solar Power Project
Kern County, California
Appendix D of the Application/Report of Waste Discharge

June 2010

60139696-5450 - CAP

AECOM Environment

Prepared for:
Ridgecrest Solar I, LLC

Corrective Action Plan
Ridgecrest Solar Power Project
Kern County, California
Appendix D of the
Application/Report of Waste Discharge

Prepared By Carmen Caceres-Schnell, PG

Reviewed By Bob Wilson

June 2010

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Contents

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List of Acronyms

ALR	Action Leakage Rate
CAP	Corrective Action Plan
CCR	California Code of Regulations
CMP	Corrective Measures Plan
COC	contaminants of concern
DMP	Detection Monitoring Program
GMN	groundwater monitoring network
HDPE	high density polyethylene
HTF	heat transfer fluid
IWVWD	Indian Wells Valley Water District
LDS	leak detection system
Project	Ridgecrest Solar Power Project
RSPP	Ridgecrest Solar Power Project
RSI	Ridgecrest Solar I, LLC
ROWD	Report of Waste Discharge
RWQCB	Regional Water Quality Control Board
RO	reverse osmosis
SSG	solar steam generator

1.0 Introduction

Ridgecrest Solar I, LLC (RSI) is proposing to construct, own, and operate the Ridgecrest Solar Power Project (herein Project). The Project is a concentrating solar electric generating facility proposed on an approximately 3,995-acre site located in the high northern Mojave Desert in northeastern Kern County, California, about 5 miles southwest of the City of Ridgecrest, California. RSI proposes to use evaporation ponds as part of the Project (**Figure 1-1**).

RSI proposes to use two evaporation ponds to receive and store wastewater as part of the Project. The layout of the proposed facility is shown in **Figure 1-2**.

This Corrective Action Plan (CAP) was developed as part of the Report of Waste Discharge (ROWD) application for the proposed Project.

1.1 Purpose

The monitoring requirements for the Project's waste facilities are specified under Title 27 California Code of Regulations (CCR) Chapter 3, Subchapter 3, Article 1, Sections 20380 through 20435. Article 1 includes provisions for a Corrective Measures Plan (CMP) (Title 27 CCR Section 20385). The objective of the CMP is to ensure the contaminants of concern (COCs) achieve their respective concentration limits at all monitoring points and throughout the zone affected by the release, including any portions thereof that extend beyond the Project boundary, by removing the waste constituents or treating them in place.

This document describes the elements of the CAP and is considered to be a stand-alone document that supplements other elements of the ROWD application including the Evaporation Pond Construction Engineering Design Package, the Construction Quality Assurance Plan, the Detection Monitoring Program (DMP), and the Closure and Post Closure Maintenance Plans.

1.2 Project Background

The Project is a concentrated solar thermal electric generating facility located in the high northern Mojave Desert in northeastern Kern County, California, about 5 miles southwest of the City of Ridgecrest, California (**Figure 1-1**). The Project will use well-established parabolic trough solar thermal technology to produce electrical power using a steam turbine generator fed from a solar steam generator (SSG). The SSG receives heat transfer fluid (HTF) from solar thermal equipment comprised of arrays of parabolic mirrors that collect energy from the sun.

The Project proposes to use a dry cooling condenser for power plant cooling. Water for the cooling tower makeup, process water makeup, and other industrial uses such as mirror washing will be supplied by the local municipal water district (Indian Wells Valley Water District [IWWWD]) via a new pipeline. This source will also be used to supply water for employee use (e.g., drinking, showers, sinks, and toilets). Water received from the IWVWD will meet the requirements of the California Department of Health Services for potable water supplies and will not require further treatment for this purpose. Power cycle makeup, mirror washing water, and cooling of ancillary equipment will require on-site treatment for reduction of dissolved solids, and this treatment varies according to the quality required for each of these uses. A sanitary septic system and on-site leach field will be used to dispose of sanitary wastewater.

The Project will have a nominal electrical output of 250 megawatts, consisting of one independent Unit, Unit #1. **Figure 1-2** shows the general arrangement of the site. Commercial operation of Unit #1 is expected to commence by the third quarter of 2013, subject to timing of regulatory approvals and Applicant achievement of project equipment procurement and construction milestones. The solar thermal technology will provide

100 percent of the power generated by the Project; no supplementary energy source (e.g., natural gas to generate electricity at night) is proposed to be used for electric energy production. The Project will utilize an auxiliary boiler fueled by propane gas to reduce startup time and for HTF freeze protection. The Project will also have one electric and one backup diesel-fueled fire water pump for fire protection.

The Project wastewater will be piped to lined, on-site evaporation ponds. Discharge into the evaporation ponds is derived from one primary source: High pH reverse osmosis (RO) concentrate. Unit#1 will consist of two evaporation ponds. Each pond will provide sufficient evaporative capacity to dispose of the anticipated wastewater stream, and allow for one pond to be taken out of service for cleaning, potential future maintenance, and repair for up to one year without impacting the operation of the Project. The ponds will be designed in accordance with Lahontan Basin Regional Water Quality Control Board (RWQCB) requirements. If required for maintenance, dewatered residues from the ponds will be excavated, characterized and sent to an appropriately permitted off-site landfill (most likely as non-hazardous waste).

The estimated project life is 30 years. Personnel will staff the Project 24 hours per day/7 days per week. Even when the solar power plant is not operating, personnel will be present as necessary for maintenance, to prepare the Project for startup, and/or for site security.

1.3 Waste Handling Facilities – Evaporation Ponds

The waste storage units include two evaporation ponds for the Project. The topography of the adjacent areas is shown in **Figure 1-3**. The regional geology is the area of the Project site is provided in **Figure 1-4A** and **1-4B**.

Discharge into the evaporation ponds will come from one primary source: High pH RO concentrate.

Table 1-1 provides an estimate of the concentrations of raw water and the predicted chemistry of the wastewater stream to be discharged to the evaporation ponds. The design details of the evaporation ponds are shown on **Figure 1-5A and Figure 1-5B;** the cross sections are provided in **Figure 1-6A and Figure 1-6B**.

The two, 4.0-acre (total combined pond top area of 8 acres) evaporation ponds have an average proposed design depth of 7 feet, which incorporates the following:

- Drying each pond at alternating four-year intervals,
- 3 feet of operational depth,
- 2 feet of residue build up over 4 years, and
- 2 feet of freeboard.

The containment design for the evaporation ponds, from the surface of the evaporation ponds downwards, consists of the following:

- A hard surface/protective layer;
- A primary 60-mil high density polyethylene (HDPE) liner;
- An interstitial leak detection system (LDS) comprising a drainage layer and piping;
- A secondary 40 mil HDPE geomembrane liner;
- A 2-foot thick compacted silty-sand base; and
- A moisture detection system.

The proposed vadose zone and groundwater monitoring systems consist of:

- The interstitial LDS consists of a granular drainage layer with perforated piping to collect and convey fluids to an extraction riser in a leak detection sump. The water collected in the leak detection sump will drain by gravity to a unique monitoring well that is constructed for each of the leak collection layers. The background moisture content of the soil and subsequent action level that will indicate a leak will be established after the evaporation ponds have been constructed, but prior to any liquids being placed in the ponds.

- A vadose zone moisture detection system located beneath the compacted silty-sand base. This system consists of PVC piping laid under the evaporation through which a neutron probe will be pulled to determine the moisture content of the soil immediately beneath the pond.

- A groundwater monitoring network (GMN), consisting of four monitoring wells, one located upgradient of the ponds, at the facility boundary, two located immediately adjacent to the evaporation ponds, and one located downgradient of the ponds near the facility boundary (**Figure 1-7**) monitor the regional groundwater aquifer, which is the first water encountered under the Project site.

Tables 1-2 and **1-3** provide the groundwater sampling parameters and sampling schedule for the evaporation ponds.

2.0 Corrective Action Plan Standards

Standards for a CAP include requirements that a corrective action achieves the following goals: to remediate release from the Unit and to ensure compliance with the Water Standard adopted under section 20390 for the Unit. If evidence of a release has occurred, this standard specifies notification requirements to the RWQCB as well as specifies sampling and analytical protocols to further evaluate releases from the waste storage unit including reporting schedules and deadlines.

The monitoring requirements for the Project's waste facilities are specified under Title 27 CCR Chapter 3, Subchapter 3, Article 1, Sections 20380 through 20435. These standards include provisions that include requirements for a DMP to establish background values for monitoring parameters, conduct sampling and analyses for monitoring parameters, set forth monitoring schedules, and perform statistical analysis of data to determine if evidence of a significant release has occurred. If evidence of a release has occurred, these standards specify notification requirements to the RWQCB as well as specify sampling and analytical protocols to further evaluate releases from the waste storage unit including reporting schedules and deadlines.

Standards for a DMP are specified in Title 27 CCR Chapter 3, Subchapter 3: Water Monitoring. Under Subchapter 3, Article 1, the general applicability for water quality monitoring and response programs for solid waste management units are addressed in Title 27 CCR Section 20380. Required monitoring programs such as a DMP, Evaluation Monitoring, and CAP are defined in Title 27 CCR Section 20385.

Establishment of Water Quality Protection Standard for each waste unit is required under Title 27 CCR Section 20390. Title 27 CCR Section 2395 addresses COC to which the Water Quality Protection Standard applies. The COC list includes all waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste contained in the evaporation ponds.

Title 27 CCR Section 20400 requires the establishment of concentration limits for each COC including the determination of background values. Monitoring Points and Point of Compliance (Title 27 CCR Section 20405) specifies the downgradient (horizontal) extent to which groundwater will be monitored. The compliance period is defined in Title 27 CCR Section 20410, which is typically the number of years equal to the active life of the waste unit plus the closure period. The compliance period is the minimum time period during which Solar Millennium will conduct a groundwater quality monitoring program subsequent to a release from a waste unit.

General Water Quality Monitoring and System Requirements are addressed in Title 27 CCR Section 20415 which define the elements of a groundwater monitoring system for a DMP, Evaluation Program, or a CAP. Provisions for monitoring well standards, surface water monitoring systems, and unsaturated zone monitoring systems as well as descriptions of statistical data analysis methods are addressed in Title 27 CCR Section 20415.

Requirements in a DMP are specifically addressed in Title 27 CCR Section 20420. This includes requirements to establish the following: background values, monitoring parameters, routine monitoring, monitoring schedules, data recording format, and data analysis. This standard also provides provisions in the event that a release is indicated.

If evidence of a significant release from the evaporation pond is determined, then an Evaluation Monitoring Program pursuant to Title 27 CCR Section 20425 will be implemented to assess if groundwater has been impacted. If groundwater has been impacted above the RWQCB thresholds, then the measures described in the CAP (pursuant to Title 27 CCR Section 20430) will be implemented.

3.0 Corrective Action Plan

This CAP has been designed to address releases from the evaporation ponds that have been confirmed by either physical evidence of a release or a “measurably significant” evidence of a release from the evaporation ponds during a DMP (AECOM, 2010). Estimated costs to perform the vadose zone corrective actions are presented in Attachment A.

3.1 Vadose Zone Corrective Actions

3.1.1 Evaporation Ponds

The following sections provide a description of the corrective actions to be taken should a release occur from the evaporation ponds.

As described in Section 1.3, the evaporation ponds are constructed with a leak detection layer and sump between the primary 60-mil HDPE geomembrane liner and the secondary 40-mil HDPE geomembrane liner. Underlying the base of the ponds is a moisture detection system consisting of a network of carrier pipes installed at the sides and low point of each pond. A neutron probe is pulled through this system to measure the moisture content of the soil beneath the ponds.

If water is detected accumulating in the sump at a higher rate than the Action Leakage Rate (ALR), the following steps will be implemented:

- Water will be pumped out of the evaporation pond that exhibits the high ALR and placed in the other evaporation pond(s);
- The residue at the bottom of the pond will either be removed or placed in a corner of the pond, allowing the hard surface/protective layer to be inspected for cracks;
- Once the location of the crack is determined, the hard surface/protective layer will be removed from the vicinity of the crack, the granular fill layer and non-woven geotextile layer will also be removed to expose the 60-mil HDPE primary liner;
- The liner will be repaired using new HDPE liner material and welded onto the primary HDPE liner;
- The non-woven geotextile layer will be replaced, the granular fill layer will be replaced and the hard surface/protective layer will be recast; and
- Within 24 hours of the release being detected, the RWQCB will be verbally notified of the release and a written notification via certified mail will be sent within 7 days of determining there was a release.

If the moisture detection system located below the ponds detects the presence of moisture above the set ALR, the following steps will be implemented:

- Water will be pumped out of the evaporation pond that exhibits the high moisture content and placed in the other evaporation ponds;
- The residue at the bottom of the pond will either be removed or placed in a corner of the pond, allowing the hard surface/protective layer to be inspected for cracks;
- Once the location of the crack is determined, the hard surface/protective layer will be removed from the vicinity of the crack or the location may be determined by the location of the neutron probe, the

granular fill layer and non-woven geotextile layer will also be removed to expose the 60-mill HDPE primary liner;

- The leak detection HDPE geonet drainage media will be removed to expose the secondary HDPE geomembrane liner. If encountered, the sand backfill and leak detection piping will be removed;
- The damaged section of the 40-mil secondary HDPE liner will be removed, the silty-sand base layer will be examined and if needed, wet soil will be removed;
- Soil samples will be collected from the native material to a depth of 5 feet below the clay base layer and analyzed for the COCs associated with the evaporation ponds;
- If required, soil will be excavated to the depth of the sampling;
- Clean fill will be used to backfill the excavation of the native soil and will be compacted, the base silty-sand layer will be replaced and compacted;
- New 40-mil HDPE material will be welded to the secondary liner, sand backfill and leak detection piping will be reinstalled, and HDPE geonet drainage media will be replaced;
- New 60-mil HDPE material will be welded to the primary line;
- The granular fill will be replaced and the hard surface/protective layer replaced; and
- Within 24 hours of the release being detected, the RWQCB will be verbally notified of the release and a written notification via certified mail will be sent within 7 days of determining there was a release.

If a release from the evaporation ponds occurs due to overtopping of the berms by stormwater or overfilling the ponds, the following will be carried out:

- The area outside the berm will be assessed using visual means and soil samples will be collected and analyzed for COCs associated with the evaporation ponds, if the visual impacts are not readily evident;
- The impacted soil will be excavated and placed in the on-site Land Treatment Unit and confirmation samples will be collected;
- If the confirmation soil samples are non-detect for evaporation pond COCs, the excavation will be backfilled with native material; and
- Within 24 hours of the release being detected, the RWQCB will be verbally notified of the release and a written notification via certified mail will be sent within 7 days of determining there was a release.

3.2 Groundwater Corrective Actions

As described in Section 1.3.1, a GMN has been proposed for the evaporation ponds. The DMP (AECOM 2010) presents the sampling schedule, analytes and reporting requirements for the Project site under Title 27 CCR Section 20420.

For a CAP under Title 27 CCR Section 20430, the following must be completed:

1. A sufficient number of monitoring points need to be installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of groundwater

passing the point of compliance and at other locations in the uppermost aquifer to provide the data needed to evaluate the effectiveness of the CAP;

2. A sufficient number of monitoring points and background monitoring points need to be installed at appropriate locations and depths to yield ground water samples from portions of the zone of saturation, including other aquifers, not monitored pursuant to Title 27 CCR Section 20420, to provide the data needed to evaluate the effectiveness of the CAP; and

3. A sufficient number of monitoring points and background monitoring points need to be installed at appropriate locations and depths to yield groundwater samples from zones of perched water to provide the data needed to evaluate the effectiveness of the CAP.

3.2.1 Perched Groundwater

At the Project site, no perched groundwater zones have been identified to date. The DMP states that the potential presence for perched aquifers beneath the Project site will be evaluated during installation of the proposed water supply and monitoring wells. If perched groundwater is encountered during the installation of the proposed water table monitoring wells, then additional wells may be installed to evaluate the perched groundwater under the DMP.

If any of the vadose zone release scenarios described above occur and perched groundwater zone(s) are identified at the Project site, the need for perched groundwater monitoring wells would assessed and would be dependent on the results of confirmation soil samples. If the confirmation soil samples indicated the COCs for the evaporation ponds were not detected in the samples, no perched zone wells would be installed. If confirmation soil samples contained detectable concentrations of evaporation pond COCs, additional perched monitoring wells would be installed if the existing wells did not adequately monitor the release area.

3.2.2 Regional Groundwater

The proposed GMN layout includes three categories of monitoring wells: 1) background wells which are located upgradient of the evaporation ponds; 2) detection wells, which are located adjacent to the evaporation ponds; and 3) compliance wells, which are located near the Project boundaries, downgradient of the evaporation ponds. The background well (MW-1) will be located upgradient of the evaporation ponds along the southwestern site boundary; the two proposed detection wells (MW-2 and MW-3) will be located immediately adjacent to the downgradient corner of each evaporation pond; and the proposed compliance well (MW-4) will be located downgradient of the evaporation ponds, along the northeastern site boundary (**Figure 1-7**). These wells will be sampled prior to any wastewater being placed in the ponds to establish background concentrations for evaporation pond (**Table 1-2**). Once the ponds are operational, the wastewater will be sampled for constituents listed on **Table 1-2 and 1-3**.

The currently proposed well locations are based on the best available data, at the time this plan was prepared. As additional data on groundwater depth and flow is available for the site, modifications to the proposed locations will be discussed with the RWQCB.

If a release is detected through physical evidence or statistical analyses performed on the data collected under the DMP and soil excavation does not achieve clean closure (i.e. COCs detected in confirmation soil samples), groundwater monitoring will continue as set forth in the DMP. This sampling will allow for evaluation, compliance, and performance monitoring of the success of the corrective action. This sampling will be considered as the Evaluation Monitoring Program. No further action would be required as the direction of the groundwater flow would carry any COC detected in the groundwater to the extraction well(s).

4.0 Reporting

Once the CMP has been initiated, progress reports will be submitted, in writing, to the RWQCB on the effectiveness of the CAP. The reports will be submitted, at a minimum, semi-annually. The RWQCB may determine more frequent reporting is required to ensure the protection of human health or the environment.

In accordance with Title 27 CCR Section 20385, once a CAP has been instituted and RWQCB determines (pursuant to section 20425) that the assessment of the nature and extent of the release and the design of the CAP have been satisfactorily completed, the RWQCB will approve the application for an amended ROWD for corrective action.

5.0 References

AECOM Environment, 2010. Detection Monitoring Program Prepared for Ridgecrest Solar Power Project, June.

.

Tables

Table 1-1: Raw Water Quality and Estimated Chemistry of Wastewater Streams

	Supply Water[1]	Wastewater to Evaporation Pond[2]	STCL[3]	TCLP[4]
24-Average Flow Rate (GPM)	63	8.748	---	---
Peak Operation Flow Rate (GPM)	97	14.636	---	---
Constituent	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Cations				
Calcium	37	39	---	---
Magnesium	5.4	12	---	---
Sodium	44	767	---	---
Potassium	4	10	---	---
Ammonia	<ND	0		
Anions				
Alkinity	117	77	---	---
Sulfate	44	111	---	---
Chloride	86	1,045	---	---
Nitrate	8	19	---	---
Cyanide	ND	0		
Silica	42	24	---	---
General Water Quality				
Bicarbonate	143	94	---	---
Carbonate	ND	0	---	---
TDS	287	2,124	---	---
Total Hardness ($CaC0_3$)	115	121		
Phosphate	ND	0	---	---
Fluoride	0.8	19	180	---
Barium	0.00028	1	100	---
Iron	ND	0	---	---
Total Suspended Solids	0	12	---	---
Biological Oxygen Demand			---	---
Trace Metals				
Boron	ND	0	--	--
Cadmium	ND	0	1.0	
Copper	ND	0	25	--
Lead	0.0007	0	5.0	

Table 1-1: Raw Water Quality and Estimated Chemistry of Wastewater Streams

	Supply Water[1]	Wastewater to Evaporation Pond[2]	STCL[3]	TCLP[4]
Molybdenum	ND	0	350	--
Selenium	ND	0	1.0	
Thallium	0.014		7.0	
Vanadium	0.000022	0.17	24	--
Zinc	ND	0	250	--

1 - Water quality data from AFC Table Water 4, AECOM, 2009
2 - Water Quality data from AECOM Evaporation Pond Preliminary Design, Operations and Maintenance Plan, April 2010
3 - STLC = Soluble Threshold Limit Concentration, Regulated by CCR Title 22, Division 4.5, Article 3, Section 66261.24
4 - TCLP = Toxicity Characteristics Leaching Procedure; Regulate under 40 CFR Section 261.24

Table 1-2 Groundwater Sample Analytical Parameters – Quarterly Monitoring

Parameter	U.S. EPA or Standard Method	RL Goal	Units
Chloride	300.0	14,000	µg/L
Nitrate as Nitrogen	300.0	1,000	µg/L
Phosphate (total)	365.3	100	µg/L
Sulfate	300.0	100,000	µg/L
TDS	SM 2450C	10,000	µg/L
Biphenyl Oxide	8015M	1,000	µg/L
Diphenyl Oxide	8015M	1,000	µg/L
Static Water Depth	Field	+/- 0.1	feet bgs
pH reading	Field	+/- 0.1	pH units
Temperature	Field	+/- 0.1	°F or °C

Key:

µg/L – micrograms per liter
RL – reporting limit
SM – Standard Method

Note: If turbidity exceeds 10 NTU, groundwater samples will be field filtered and both the unfiltered and filtered groundwater samples will be submitted to the laboratory for metals and TDS analysis.

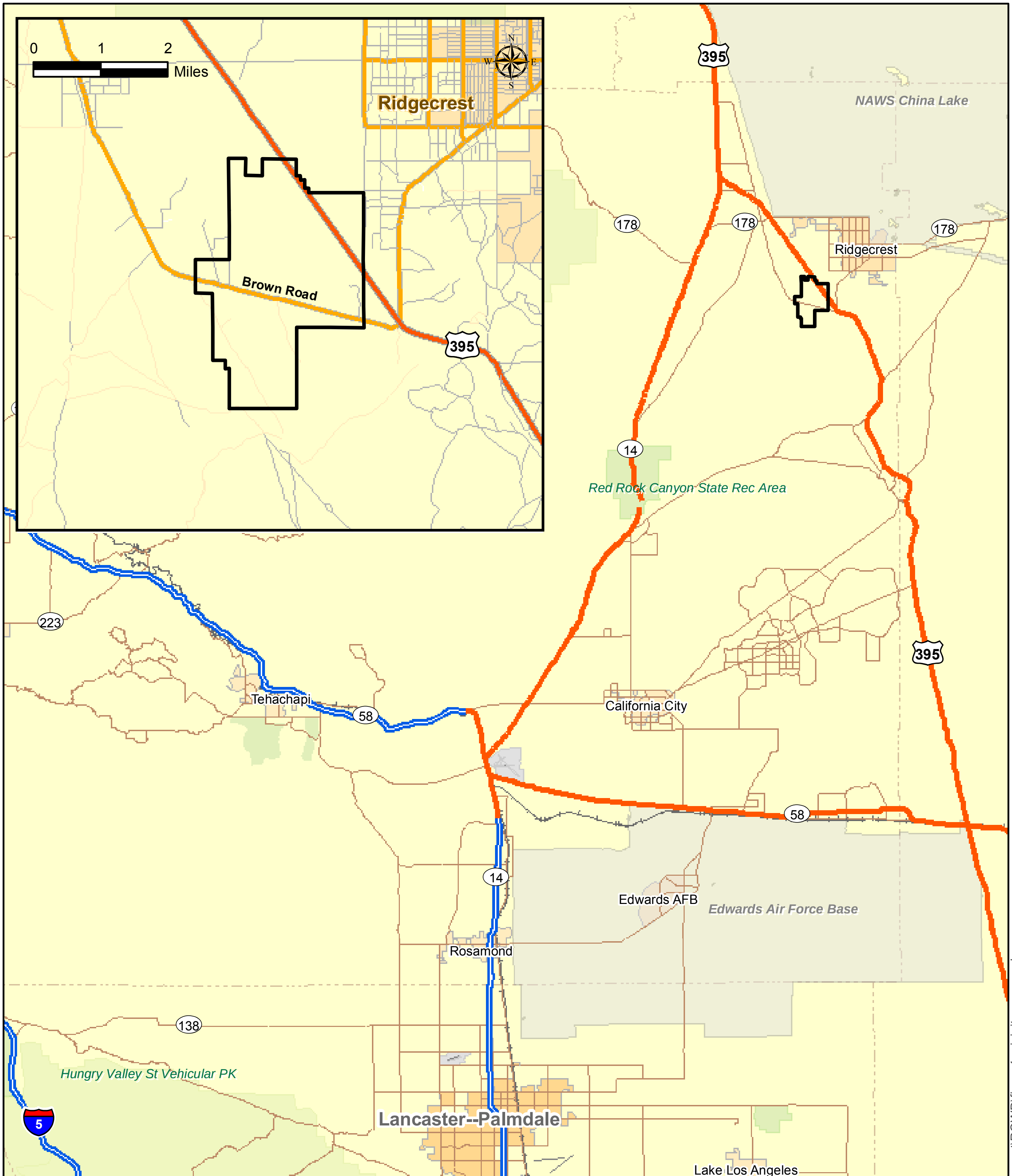
Table 1-3 Groundwater Sample Analytical Parameters – Annual Monitoring

Parameter	U.S. EPA or Standard Method	RL Goal	Units
Ammonia (as N)	350.1	100	µg/L
Aluminum	200.7	20	µg/L
Arsenic	6020	2.0	µg/L
Boron	200.7	140	µg/L
Calcium	200.7	40,000	µg/L
Chloride	300.0	14,000	µg/L
Cyanide (total)	SM 4500	10	µg/L
Fluoride	300.0	500	µg/L
Iron	200.7	20	µg/L
Magnesium	200.7	10,000	µg/L
Manganese	200.7	15	µg/L
Molybdenum	6020	10.00	µg/L
Nitrate as Nitrogen	300.0	1,000	µg/L
Nitrite as Nitrogen	SM 4500	4	µg/L
Potassium	200.7	3,000	µg/L
Phosphate (total)	365.3	100	µg/L
Selenium	6020	0.5	µg/L
Silica (as SiO2)	200.7	1,000	µg/L
Silicon (as Si)	200.7	1,000	µg/L
Sodium	200.7	10,000	µg/L
Strontium	200.7	500	µg/L
Sulfate	300.0	100,000	µg/L
TDS	SM 2540C	10,000	µg/L
Total Alkalinity (as $CaCO_3$)	SM 2320B	100,000	µg/L
Zinc	6020	10	µg/L
Biphenyl Oxide	8015M	500	µg/L
Diphenyl Oxide	8015M	500	µg/L
Cyclohexamine (20-40%)	8015M	500	µg/L
Morpholine (1-10%)	8015M	500	µg/L
pH reading	Field	+/- 0.1	pH units
Temperature	Field	+/- 0.1	°F or °C
Nalco 3D Trasar 177	Hand-Held Fluorometer	na	na
Nalco 3D Trasar 190	Hand-Held Fluorometer	na	na

Key:
$CaCO_3$ - calcium carbonate
µg/L – micrograms per liter
RL – reporting limit
SM – Standard Method
na – not applicable

Note: If turbidity exceeds 10 NTU, groundwater samples will be field filtered and both the unfiltered and filtered groundwater samples will be submitted to the laboratory for metals and TDS analysis.

Figure



0 5 10
Miles

Ridgecrest Solar Power Plant

Figure 1-1
Regional Location and Vicinity Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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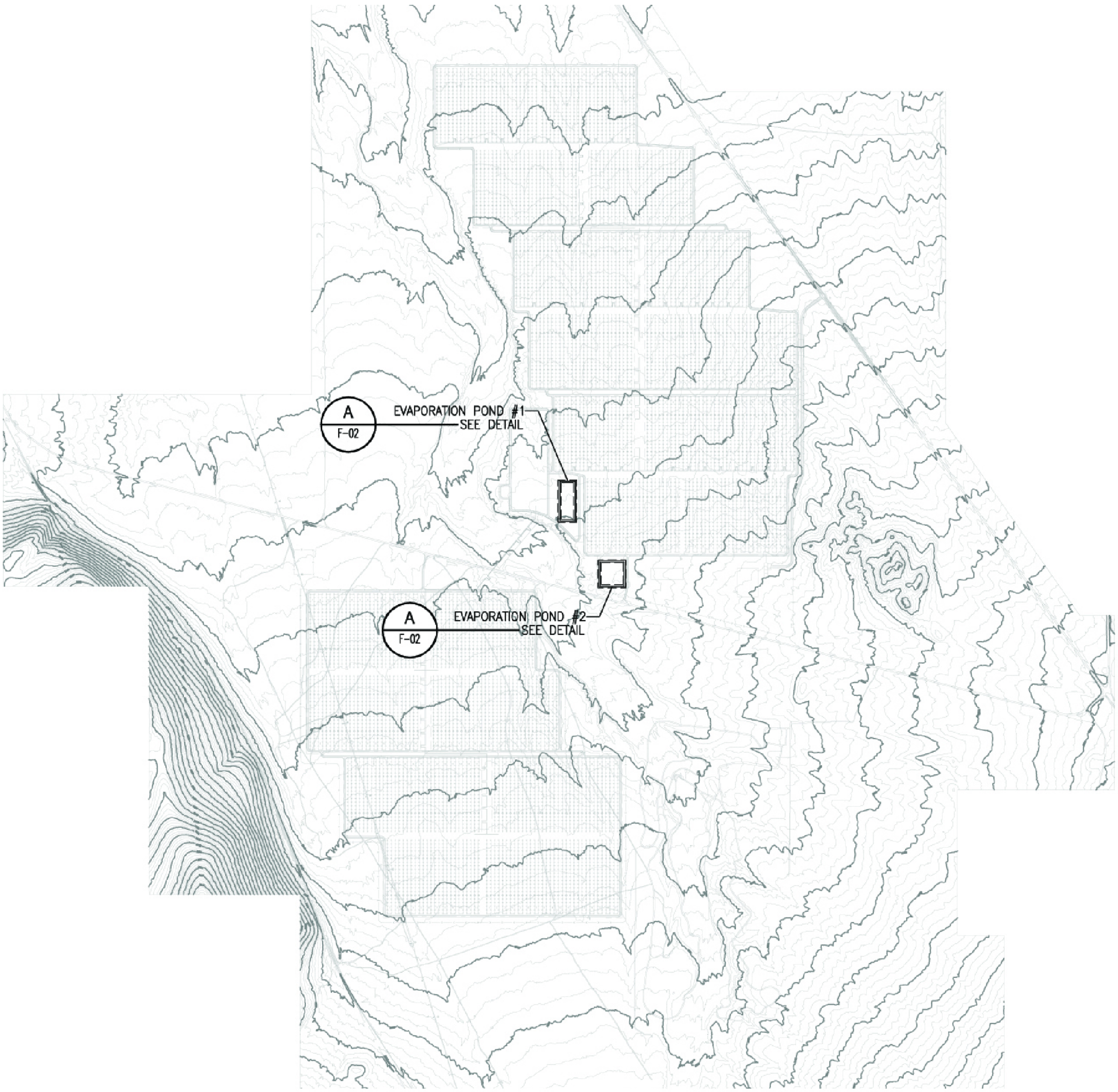

Map Location

Ridgecrest Solar Power Project

Figure 1-2
General Arrangement Site Plan

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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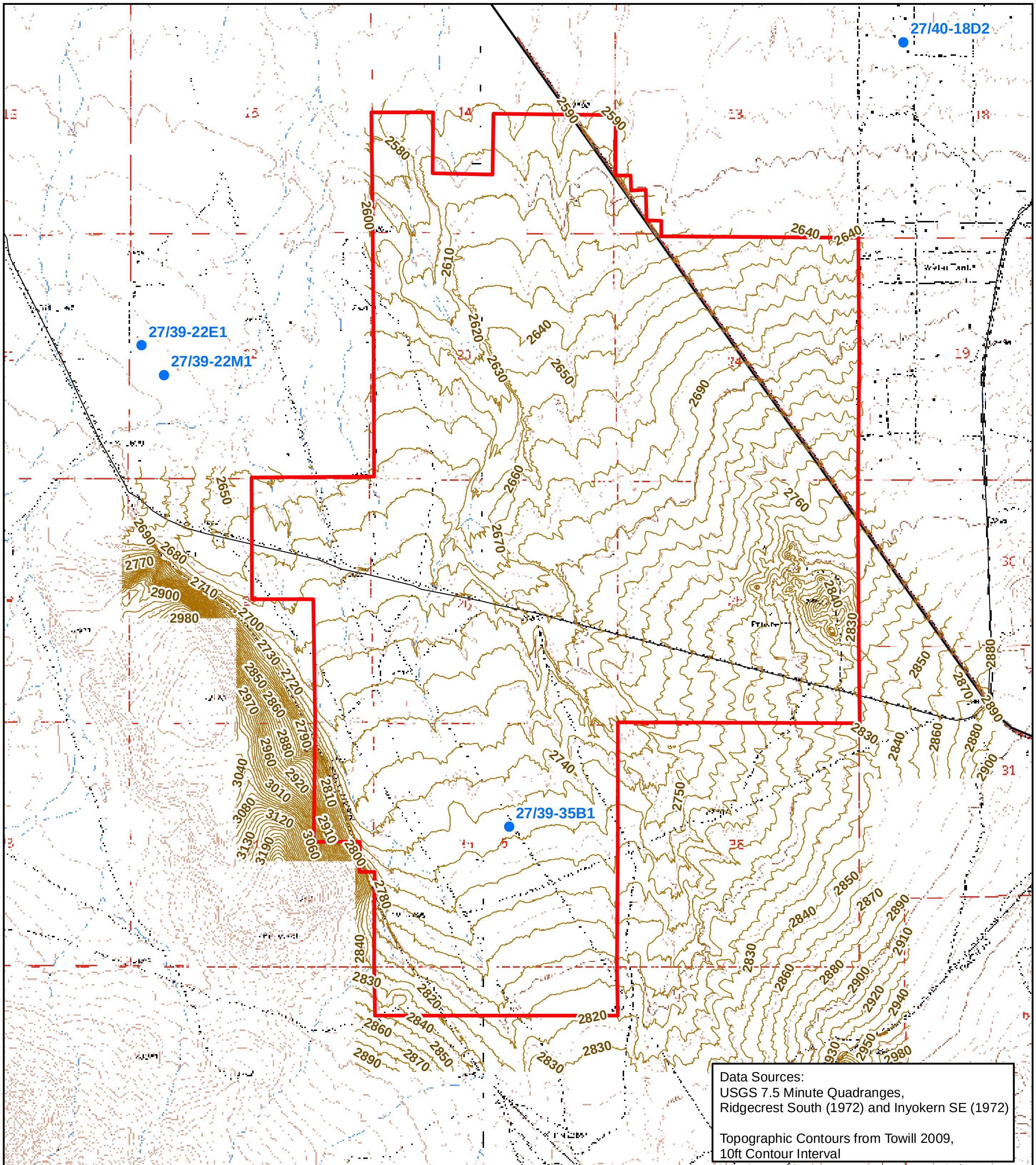


Map Location

Legend

Project Right-of-Way

Groundwater Well Location based on Latitude and Longitude in USGS Database

0 3,000 6,000 Feet

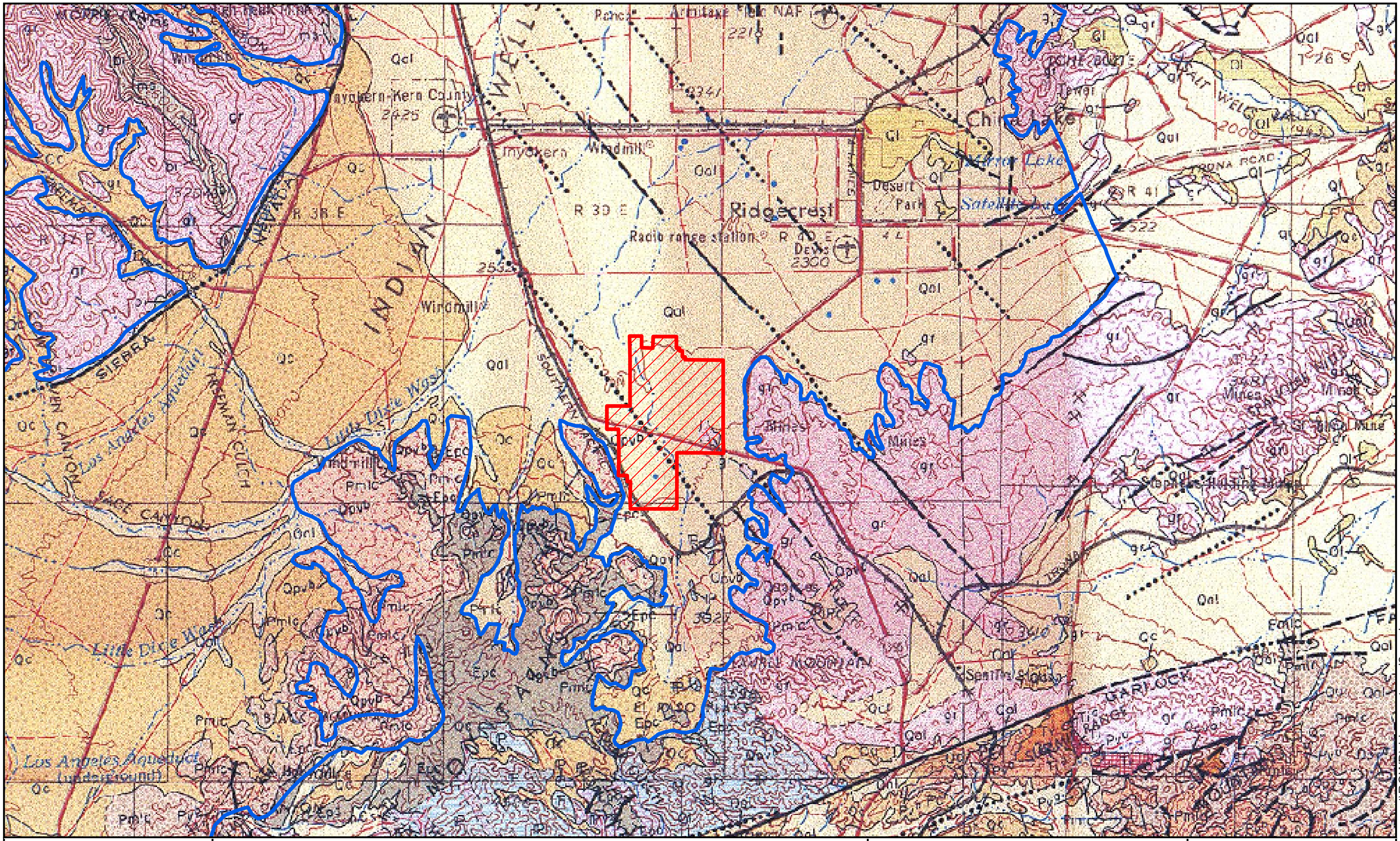
Ridgecrest Solar Power Plant

Figure 1-3
Site Topographic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010



Map Location

Legend

Project Right-of-Way

Indian Wells Valley Groundwater Basin

1 in = 3 miles

0 3 6 Miles

See Figure 1-4b for Geologic Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona Sheet, Scale 1:250,000, 1963

Ridgecrest Solar Power Plant

Figure 1-4a
Regional Geologic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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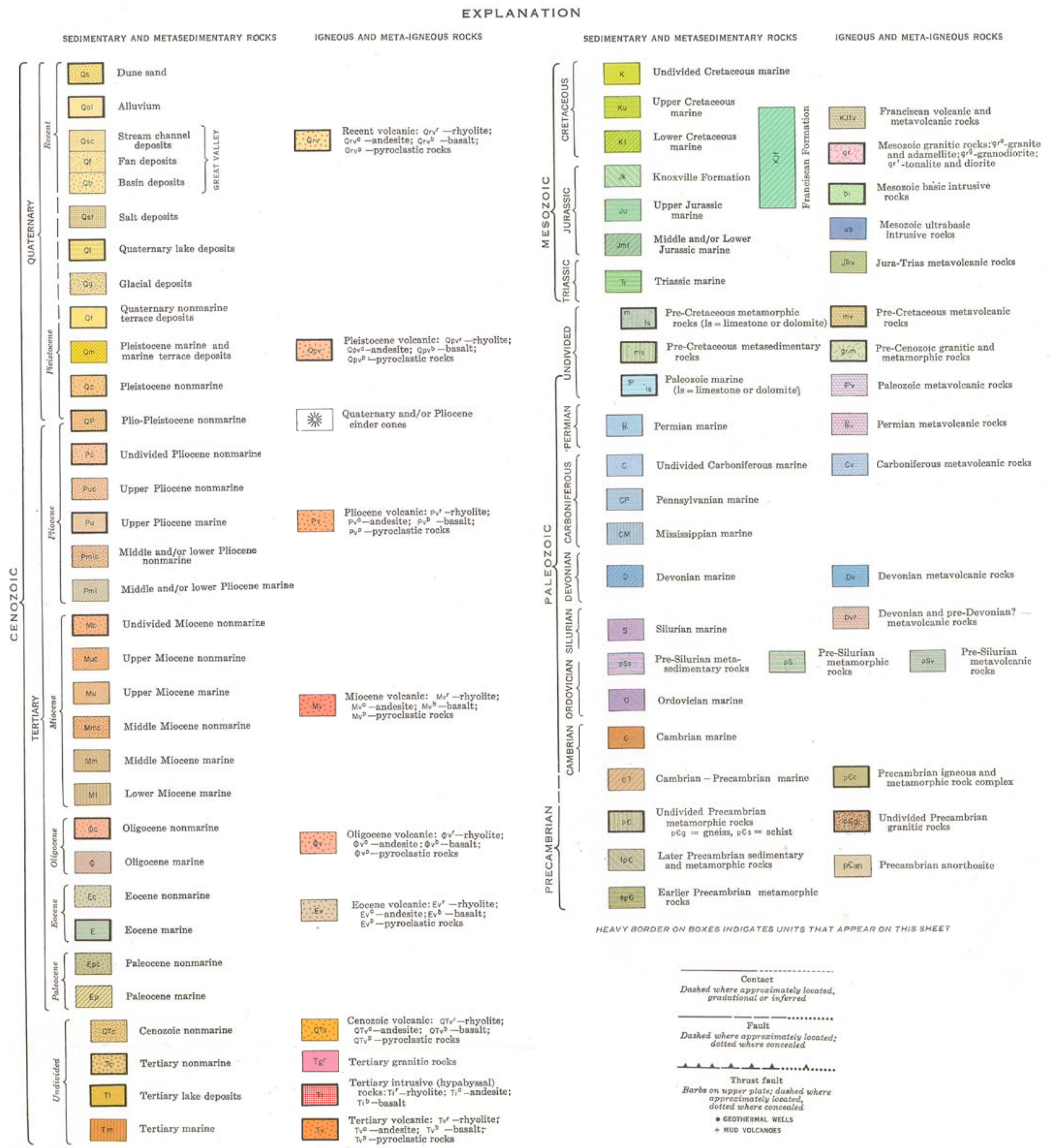

Map Location

Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona, Scale 1:250,000, 1963

Ridgecrest Solar Power Project

Figure 1-4b
Regional Geologic Map Legend

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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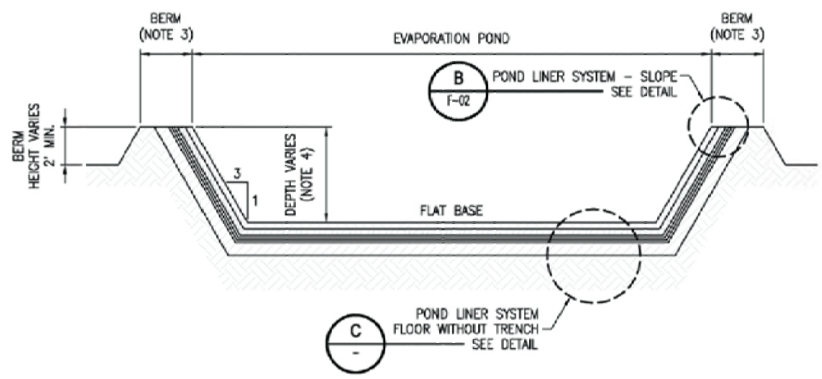
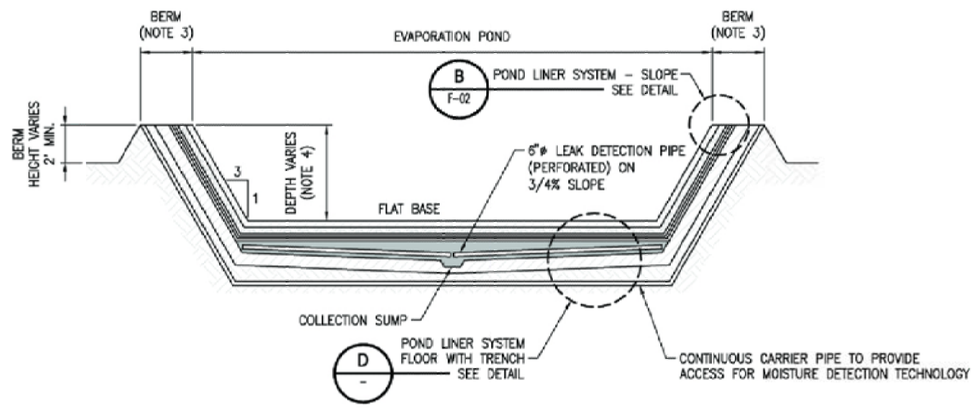


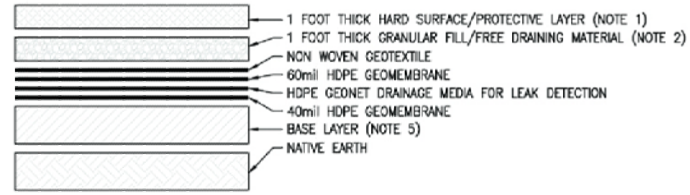
POND - UPSTREAM CROSS SECTION (A)

SCALE: N.T.S.



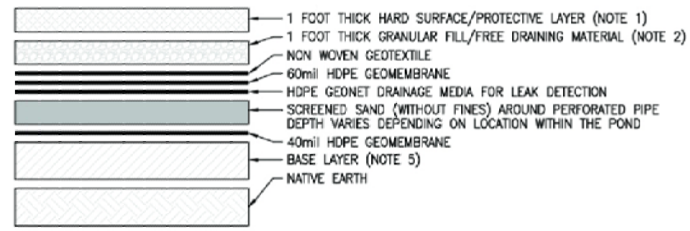
POND - DOWNSTREAM CROSS SECTION (B)

SCALE: N.T.S.



POND LINER SYSTEM DETAIL FLOOR TRENCH (C)

SCALE: N.T.S.



POND LINER SYSTEM DETAIL FLOOR WITHOUT TRENCH (D)

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10-6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 1-5a
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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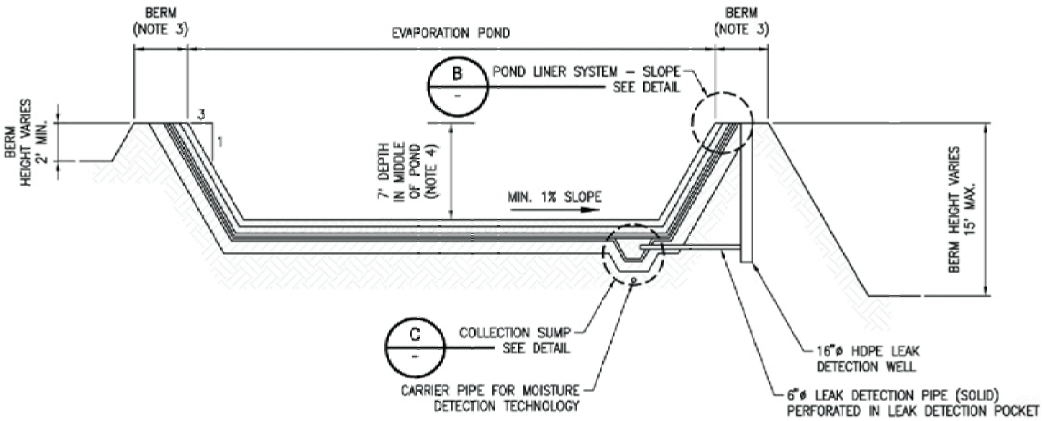
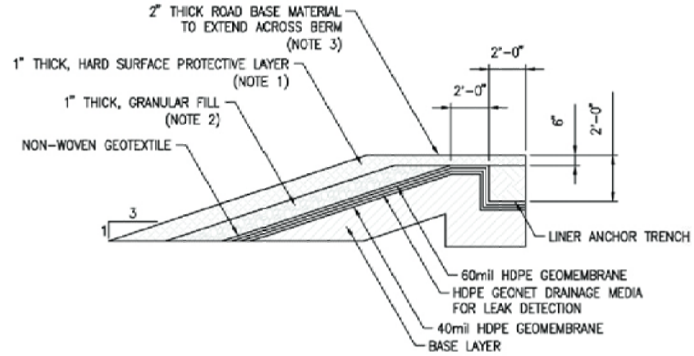


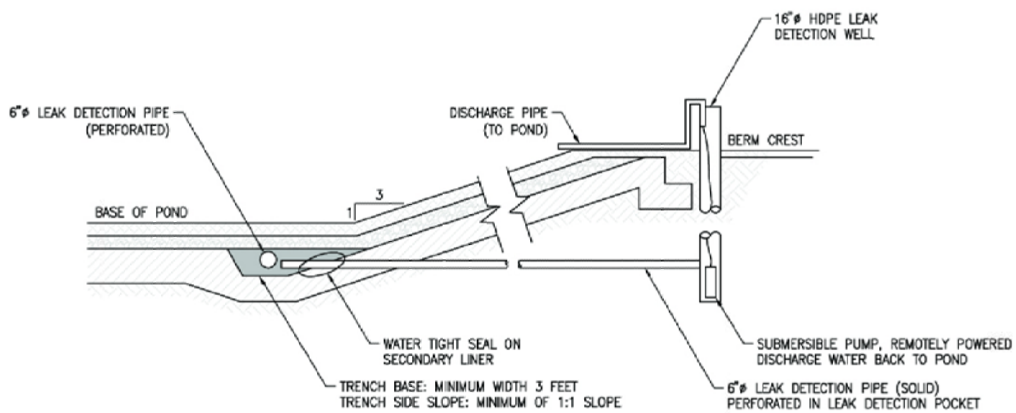
CROSS SECTION THROUGH THE MIDDLE OF THE PONDS (A)

SCALE: N.T.S.



POND LINER SYSYTEM - SLOPES (B)

SCALE: N.T.S.



COLLECTION SUMP DETAIL (C)

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10-6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 1-5b
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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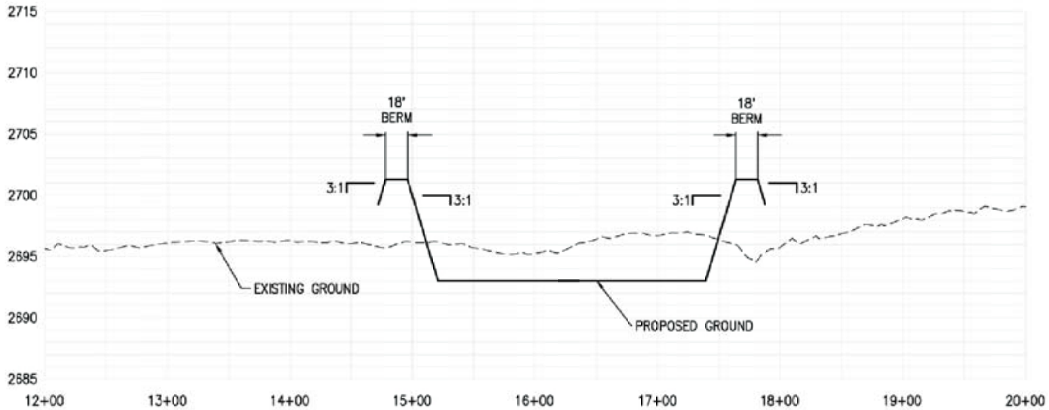
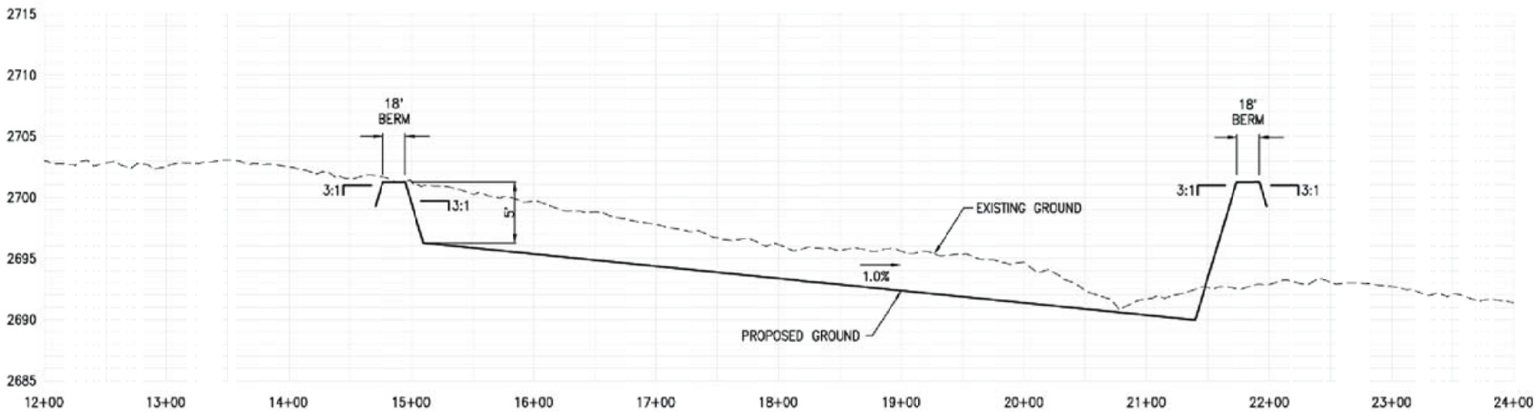


CROSS SECTION A
SCALE: NONE



CROSS SECTION B
SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 1-6a
Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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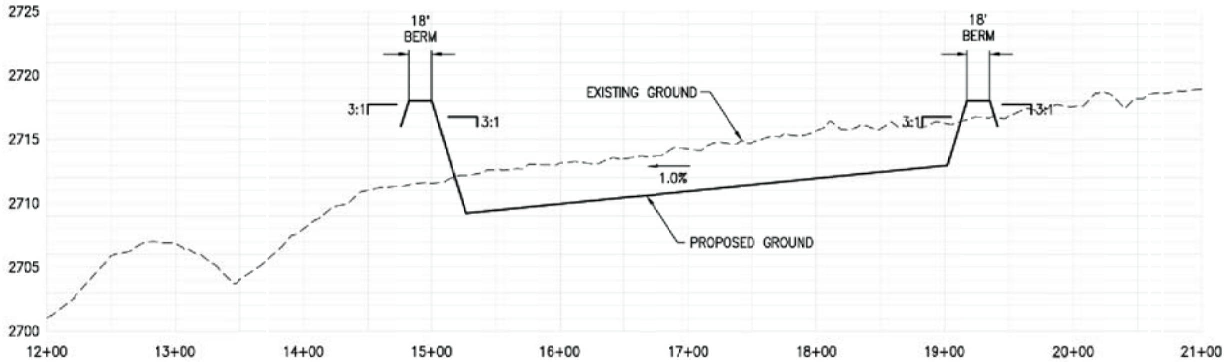
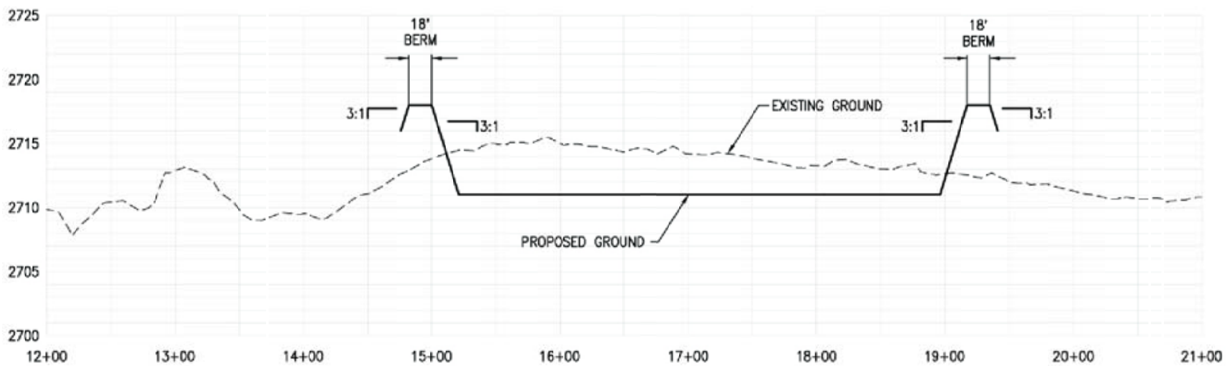


CROSS SECTION C

SCALE: NONE



CROSS SECTION D

SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 1-6b
Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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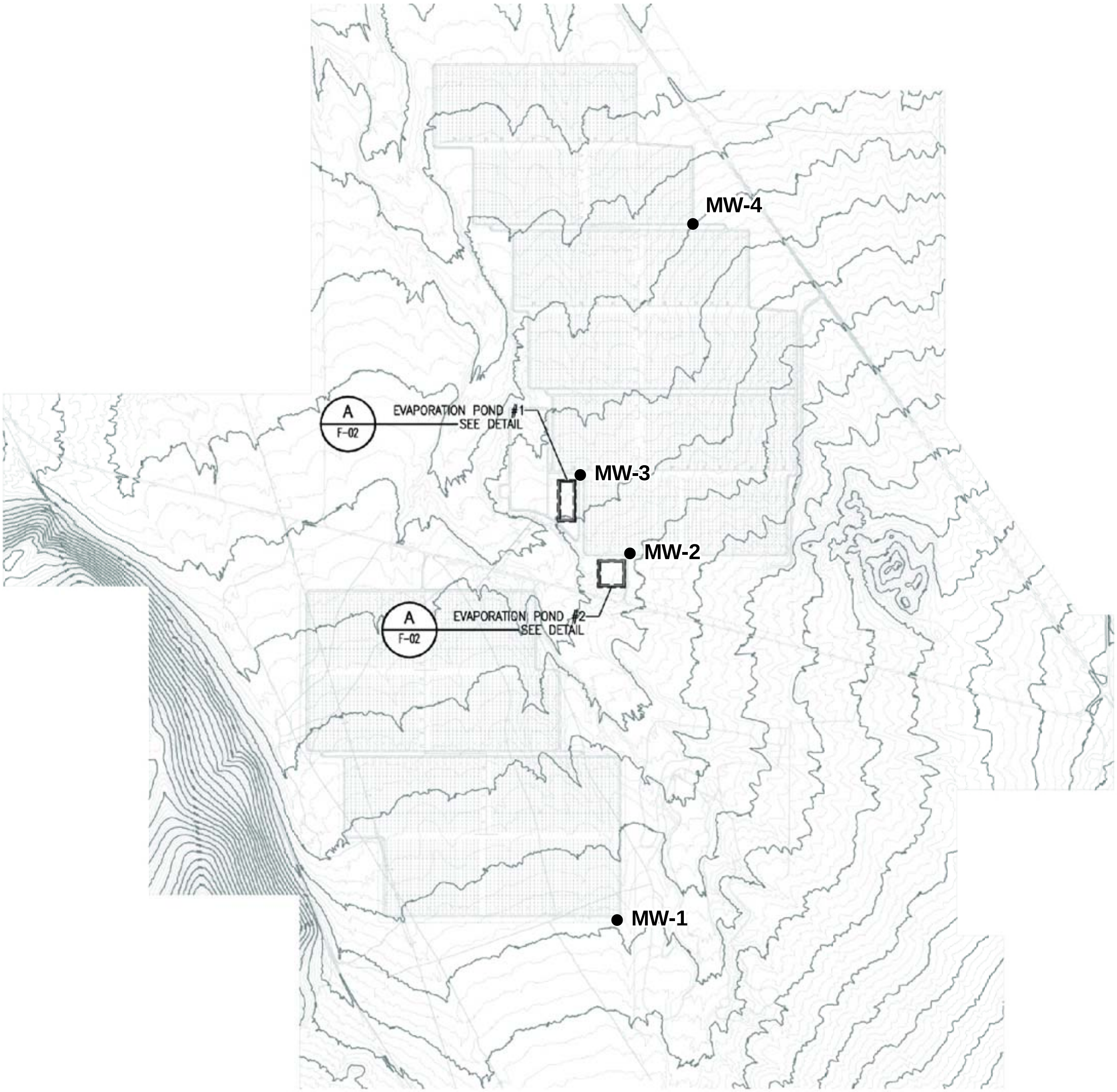

Map Location

● Prposed Location of Monitoirng Well

Ridgecrest Solar Power Project

Figure 1-7 Proposed GMN Monitoring Well Locations

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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Attachment A

Corrective Action Cost Estimates

RSI, LLC RSPP
Evaporation Pond Corrective Action Costs

	Item	Contingency Cost Estimate (each)	Quantity	Subtotal Closure Cost Estimate
1	Leak detected below 60 mil liner of evaporation pond	$162,000	1	$162,000
2	Leak detected below 40 mil liner and base layer of evaporation pond	$432,000	1	$432,000
3	Stormwater overtops an evaporation pond	$129,000	1	$129,000
			Total Contingency Cost Estimate	**$723,000**

Estimate does not include LTUs.

Order-of-Magnitude Cost Estimate – Corrective Action Costs for Scenario 1

Activities sequence to repair 60 mil top liner

1. Relocate Sludge (solid) in area of failure (+/- 50 ft to ea side) to another part of the pond

2. Remove Hard Surface (Roller compacted concrete without rebar) in area of failure (+/- 12 ft to ea side) and relocate to an on site location

3. Remove in area of failure, Relocate and Reuse Granular Fill

4. Repair 60 mil Geomembrane

5 Replace Granular Fill and Hard Surface

		Unit Cost	Unit Quantity	Unit	Number	Cost Reference
Costs						
1. Relocate Sludge (solid)						
Mobilization	LS	$10,000	1	1	$10,000	ROM Estimate
Excavate (dozer, 300' haul, clay)	CYD	$15	1,667	1	$25,108	Means 02315-400-1500&-4100-3340
				Total	**$35,108**	
2. Remove and Relocate Hard Surface						
Mobilization	LS	$8,000	1	1	$8,000	ENSR Estimate
Demolition of 12" Concrete	CYD	$127	417	1.0	$52,807	Means 02220-875-2100
Loading to trucks	CYD	$15.94	417	1	$6,642	Means 02315-400-1200+ added effort
Sampling of Crushed concrete demonstrating no impact					$2,000	ROM Estimate
Truck Haul to on site stockpiles and dump	CYD	$6.42	417	1	$2,677	Means 02320-200-0330
				Total	**$72,126**	
3. Remove, & Relocate Granular Fill						
Mobilization	LS	$5,000	1	1	$5,000	ROM Estimate
Excavate (0.75 cyd Front End Loader)	CYD	$5	167	1	$841	Means 02315-40-1500 + confined area effort
				Total	**$5,841**	
4. Repair 60 mil Geomembrane						
Mobilization	LS	$5,000	1	1	$5,000	ROM Estimate
Repair	SF	$15.00	450	1	$6,750	ROM Estimate
				Total	**$11,750**	
5. Replace Sand and Hard Surface						
Relocate Sand (0.75 cyd Front End Loader)	CYD	$3	167	1	$561	Means 02315-40-1500
New Concrete	CYD	$110.00	167	1	$18,333	Means 03310-220-0020

Order-of-Magnitude Cost Estimate – Corrective Action Costs for Scenario 1

Recast Concrete	CYD	$27.82	167	1	$4,636	Means 03310-700-1600 (pump, no finsh)
				Total	**$23,530**	
Subtotal Field Activities Costs					**$148,355**	
Contingency	(0% of All of the Above Costs)				$0	
				Total	**$148,355**	
Total Field Activities Costs					**$149,000**	
Engineering and Oversite						
Engineering	(2% of Total Construction Cost)				$3,000	Means 01107-300-1200 (min.)
Permitting	(0.5% of Total Construction Cost)				$1,000	Means 01310-150-0010 (min.)
Construction Management	(5% of Total Construction Cost)				$8,000	Means 01107-200-0010 (min.)
Closure Report	(0.5% of Total Construction Cost)				$1,000	Means 01310-150-0010
Total Engineering and Oversite Cost					**$13,000**	
T O T A L C O S T					**$162,000**	

Assumptions

No need for construction support facilities since site has infrastructure

Assume that failure is transverse to pond

Remove sludge from 25 ft each side of break for width of pond

Volume of sludge is		2	ft thick	50	ft wide	450	ft long
Accumulated Sludge is now a solid	Dry Weight	2500	tons or			1667	Cubic Yards

Sludge is transferred to unaffected portion of the same evaporation pond

Remove concrete from 12 ft each side of break for width of pond

Concrete	Thickness	1	feet	Vol	417	Cubic Yards
Density	150	lbs/cft		Wt.	844	Tons

Remove granular fill from 5 ft each side of break for width of pond

Granular Fill	Thickness	1	feet	Vol	167	Cubic Yards

Repair 60-mil Geotextile

60-mil HDPE/Geotextile					450	Square Feet
Sand/Gravel Fill Trench	Thickness	2	feet	Vol	667	Cubic Yards

Order-of-Magnitude Cost Estimate – Corrective Action Costs for Scenario 1

40-mil HDPE					Square Feet
Compacted Clay/Silt	Thickness	2	feet	Vol	Cubic Yards

Notes

Unit Costs are from RS Means Building Construction Cost Data 2001 Western Version adjusted as explained below

Unit Costs are adjusted by the City Cost Index;	1.13	Means page 612 for Installation index for Riverside, CA

Unit Costs are adjusted by the ENR Historical Cost Index to estimate 2010 costs

Compare Construction Cost Index since closure is mostly labor and not materials purchase

ENR Construction Cost Index for Los Angeles in December 2000	7068
ENR Construction Cost Index for Los Angeles in March 2010	9945
Historical Cost adjustment is 2010 #/ 2000 #	1.41
Combine historical (2010 to 2000) & City cost adjustment	1.59

Order-of-Magnitude Cost Estimate – Corrective Action Costs for Scenario 2

Activities sequence to remove soil below 40 mil bottom liner and base layer caused by leak

1. Relocate Sludge (solid) in area of failure (+/- 50 ft to ea side) to another part of the pond

2. Remove Hard Surface (Roller compacted concrete without rebar) in area of failure (+/- 12 ft to ea side) and relocate to an on site location

3. Remove Granular Fill in area of failure, Relocate in pond and Reuse

4. Cut 60 mil and 40 mil Geomembrane in area of failure,

5. Remove the base layer in area of failure and relocate to the LTU for treatment

6. Test soil below base layer for impact

7. Remove impacted soil in area of failure, and relocate to the LTU for treatment

8. Test bottom of impacted area to confirm clean up

9 Replace soil and base layer

10 Repair 60 mil and repair 40 mil Geomembrane

11. Replace Granular Fill and Hard Surface

		Unit Cost	Unit Quantity	Unit	Number	Cost Reference
Costs						
1. Relocate Sludge (solid)						
Mobilization	LS	$10,000	1	1	$10,000	ROM Estimate
Excavate (dozer, 300' haul, clay)	CYD	$15	1,667	1	$25,108	Means 02315-400-1500&-4100-3340
				Total	**$35,108**	
2. Remove and Relocate Hard Surface						
Mobilization	LS	$8,000	1	1	$8,000	ENSR Estimate
Demolition of 12" Concrete	CYD	$127	500	1.0	$63,368	Means 02220-875-2100
Loading to trucks	CYD	$15.94	500	1	$7,971	Means 02315-400-1200
Sampling of Crushed concrete demonstrating no impact					$2,000	ROM Estimate
Truck Haul to on site stockpiles and dump	CYD	$6.42	500	1	$3,212	Means 02320-200-0330
				Total	**$84,552**	
3. Remove, & Relocate Granular Fill						
Mobilization	LS	$5,000	1	1	$5,000	ROM Estimate
Excavate (0.75 cyd Front End Loader)	CYD	$5	400	1	$2,018	Means 02315-40-1500 + confined area effort
				Total	**$7,018**	
4. Cut 60 and 40 mil Geomembrane						
Mobilization	LS	$2,000	1	1	$2,000	ROM Estimate
Cut and Remove	Day	$5,000.00	2	1	$10,000	ROM Estimate
				Total	**$12,000**	

Order-of-Magnitude Cost Estimate – Corrective Action Costs for Scenario 2

5. Excavate & Remove Base Layer (Compacted Clay)						
Mobilization	LS	$15,000	1	1	$15,000	ROM Estimate (rush)
Excavate (0.75 cyd Front End Loader)	CYD	$3	333	1	$1,121	Means 02315-40-1500
Loading to trucks	CYD	$0.50	333	1	$168	Means 02315-400-0020
Truck Haul to on site stockpile and dump	CYD	$4.67	333	1	$1,557	Means 02320-200-0400
Spread dumped fill, compaction	CYD	$3.70	333	1	$1,233	Means 02320-200-0600
				Total	**$19,079**	
6. Sample area to determine extent of impact to surrounding soils						
Sample Collection	Day	$1,800	1	1	$1,800	Estimate (25x25' grid)
Sample Analysis (1 ft)	Each	$250	7	1	$1,800	TPH by 8015 & CAM 17
Report of Sampling	Each	$5,000	1	1	$5,000	ROM Estimate
				Total	**$8,600**	
7. Excavate impacted soil and dispose						
Mobilization	LS	$10,000	1	1	$10,000	ROM Estimate
Excavate (0.75 cyd Front End Loader)	CYD	$5	833	1	$4,485	Means 02315-40-1500&-4100
Loading to trucks	CYD	$0.81	833	1	$673	Means 02315-400-0020
Hauling to Landfill (18 tons/truck&220 mileRT)	mile	$3.67	220	46	$37,345	Means 02110-300-1260
Disposal	ton	$45.83	833	1	$38,188	4-11-08 WM verbal; tipping fee for Class II @ McKittrick Landfill
Sampling and RWQCB Report	each	$10,000	1	1	$10,000	ROM Estimate
				Total	**$100,691**	
8. Sample area of impact to demonstrate that it is acceptable/clean						
Sample Collection	Day	$1,800	1	1	$1,800	ROM Estimate
Sample Analysis	Each	$250	7	1	$1,800	TPH by 8015 & CAM 17
Report of Analytical	Each	$10,000	1	1	$10,000	ROM Estimate
				Total	**$13,600**	
9. Replace Soil and Base Layer						
Mobilization	LS	$10,000	1	1	$10,000	ROM Estimate, added equipment
Excavate Soil from on site source (0.75 cyd Front End Loader)	CYD	$5	1,167	1	$5,886	Means 02315-400-1500 + confined area effort
Truck Haul from on site source and dump	CYD	$6.42	1,167	1	$7,495	Means 02320-200-0330

Order-of-Magnitude Cost Estimate – Corrective Action Costs for Scenario 2

Place soil, moisture condition and compact	CYD	$5.74	1,167	1	$6,696	Means 02315-100-1900 + 2200
Purchase Clay and transport to site	CYD	$20	333	1	$6,667	ROM Estimate
Place Clay, moisture condition and compact	CYD	$5.74	333	1	$1,913	Means 03310-220-0020
				Total	**$38,657**	
10. Repair 60 and 40 mil Geomembrane						
Mobilization	LS	$5,000	1	1	$5,000	ROM Estimate
Repair	SF	$15.00	450	2	$13,500	ROM Estimate
				Total	**$18,500**	
11. Replace Sand and Hard Surface						
Relocate Sand (0.75 cyd Front End Loader)	CYD	$3	400	1	$1,345	Means 02315-40-1500
New Concrete	CYD	$110.00	400	1	$43,999	Means 03310-220-0020
Recast Concrete	CYD	$27.82	400	1	$11,127	Means 03310-700-1600
				Total	**$56,472**	
Subtotal Field Activities Costs					**$394,277**	
Contingency	(0% of All of the Above Costs)				$0	
				Total	**$394,277**	
Total Field Activities Costs					**$400,000**	
Engineering and Oversite						
Engineering	(2% of Total Construction Cost)				$8,000	Means 01107-300-1200 (min.)
Permitting	(0.5% of Total Construction Cost)				$2,000	Means 01310-150-0010 (min.)
Construction Management	(5% of Total Construction Cost)				$20,000	Means 01107-200-0010 (min.)
Closure Report	(0.5% of Total Construction Cost)				$2,000	Means 01310-150-0010
Total Engineering and Oversite Cost					**$32,000**	
T O T A L C O S T					**$432,000**	

Assumptions

No need for construction support facilities since site has infrastructure

Assume that failure is transverse to pond which would be 450 long

Order-of-Magnitude Cost Estimate – Corrective Action Costs for Scenario 2

Remove sludge from 25 ft each side of break for width of pond

Volume of sludge is		2	ft thick	50	ft wide	450	ft long
Accumulated Sludge is now a solid	Dry Weight		2500	tons or		1667	Cubic Yards

Sludge is transferred to unaffected portion of the same evaporation pond

Remove concrete from ~15 ft each side of break for width of pond

Concrete		Thickness	1	feet	Vol	500	Cubic Yards
	Density	150	lbs/cft		Wt.	1013	Tons

Remove granular fill from 12 ft each side of break for width of pond

Granular Fill	Thickness	1	feet	Vol	400	Cubic Yards
60-mil HDPE/Geotextile					450	Square Feet
Sand/Gravel Fill Trench	Thickness	2	feet	Vol	667	Cubic Yards

Remove HDPE and Base layer from 5 ft each side of break for width of pond

40-mil HDPE					450	Square Feet
Compacted Clay/Silt	Thickness	2	feet	Vol	333	Cubic Yards

Remove impacted from 5 ft deep by 10 ft wide area for transverse distance of pond

Impacted Soil	Thickness	5	feet	Vol	833	Cubic Yards

Notes

Unit Costs are from RS Means Building Construction Cost Data 2001 Western Version adjusted as explained below

Unit Costs are adjusted by the City Cost Index;	1.13	Means page 612 for Installation index for Riverside, CA

Unit Costs are adjusted by the ENR Historical Cost Index to estimate 2010 costs

Compare Construction Cost Index since closure is mostly labor and not materials purchase

ENR Construction Cost Index for Los Angeles in December 2000	7068
ENR Construction Cost Index for Los Angeles in March 2010	9945
Historical Cost adjustment is 2010 #/ 2000 #	1.41
Combine historical (2010 to 2000) & City cost adjustment	1.59

Activities sequence to correct stormwater overtopping evaporation pond berm

1. Repair berm breach

2. Soil Sample to determine extent of impact

3.Remove and Dispose Sludge (solid) downstream of failure

4 Soil Sample to confirm clean up

		Unit Cost	Unit Quantity	Unit	Number	Cost Reference
Costs						
1. Repair berms						
Mobilization	LS	$15,000	1	1	$15,000	ROM Estimate (rush)
Excavate (0.75 cyd Front End Loader)	CYD	$3	688	1	$2,313	Means 02315-40-1500
Loading to trucks	CYD	$0.50	688	1	$347	Means 02315-400-0020
Truck Haul to on site stockpile and dump	CYD	$4.67	688	1	$3,211	Means 02320-200-0400
Spread dumped fill, compaction	CYD	$3.70	688	1	$2,543	Means 02320-200-0600
				Total	**$23,413**	
2. Sample area to determine extent of impact to surrounding soils						
Sample Collection	Day	$1,800	1	1	$1,800	Estimate (25x25' grid)
Sample Analysis (1 ft)	Each	$250	20	1	$5,000	TPH by 8015 & CAM 17
Report of Sampling	Each	$5,000	1	1	$5,000	ROM Estimate
				Total	**$11,800**	
3. Excavate impacted soil and dispose						
Mobilization	LS	$10,000	1	1	$10,000	ROM Estimate
Excavate (0.75 cyd Front End Loader)	CYD	$5	231	1	$1,246	Means 02315-40-1500&-4100
Loading to trucks	CYD	$0.81	231	1	$187	Means 02315-400-0020
Hauling to Landfill (18 tons/truck&220 mileRT)	mile	$3.67	220	17	$13,486	Means 02110-300-1260
Disposal	ton	$45.83	301	1	$13,790	4-11-08 WM verbal; tipping fee for Class II @ McKittrick Landfill
Sampling and RWQCB Report	each	$10,000	1	1	$10,000	ROM Estimate
				Total	**$48,709**	
4. Sample area of impact to demonstrate that it is acceptable/clean						
Sample Collection	Day	$1,800	1	1	$1,800	ROM Estimate
Sample Analysis	Each	$250	20	1	$5,000	TPH by 8015 & CAM 17

Report of Analytical	Each	$10,000	1	1	$10,000	ROM Estimate
				Total	**$16,800**	

Subtotal Field Activities Costs		**$100,722**
Contingency	(0% of All of the Above Costs)	$0
	Total	**$100,722**
Total Field Activities Costs		**$110,000**

Engineering and Oversite

Engineering	(4% of Total Construction Cost)	$5,000	Means 01107-300-1200 (max.)
Permitting	(2% of Total Construction Cost)	$3,000	Means 01310-150-0010
Construction Management	(10% of Total Construction Cost)	$11,000	Means 01107-200-0010 (rush.)

Total Engineering and Oversite Cost	**$19,000**
T O T A L C O S T	**$129,000**

Assumptions

No need for construction support facilities since site has infrastructure

Berms are constructed by removal of native material from on site source

	Height (ft)	Top of Berm width (ft)	Bottom of Berm width (ft)	Cross section (ft2)	Length	Volume (CYD)
Volume of lost berm material is ~	11	18	117	742.5	50	688

Assume that impacted soil extents out over an area of 50 by 250 and is impacted to a depth of 6 inches

Volume of impacted material is ~	0.5	50			250	231
Weight of impacted material is ~	301	tons				

Notes

Unit Costs are from RS Means Building Construction Cost Data 2001 Western Version adjusted as explained below

Unit Costs are adjusted by the City Cost Index; 1.13 Means page 612 for Installation index for Riverside, CA

Unit Costs are adjusted by the ENR Historical Cost Index to estimate 2010 costs

Compare Construction Cost Index since closure is mostly labor and not materials purchase

ENR Construction Cost Index for Los Angeles in December 2000 7068

ENR Construction Cost Index for Los Angeles in March 2010		9945
Historical Cost adjustment is 2010 #/ 2000 #	1.41	
Combine historical (2010 to 2000) & City cost adjustment	1.59	

AECOM
Environment

Prepared for:
Ridgecrest Solar I, LLC

Preliminary Closure Plan for Evaporation Ponds Ridgecrest Solar Power Project Kern County, California

Appendix F of the Application/Report of Waste Discharge

June 2010

60139696-5450-Closure

Prepared for:
Ridgecrest Solar I, LLC

AECOM
Environment

Preliminary Closure Plan for Evaporation Ponds
Ridgecrest Solar Power Project
Kern County, California
Appendix F of the
Application/Report of Waste Discharge

Prepared By: Carmen Caceres-Schnell, PG

Reviewed By: Bob Wilson

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List of Acronyms

CIWMB	California Integrated Waste Management Board
DESCP	Drainage, Erosion and Sediment Control Plan
GCL	Geosynthetic Clay Layer
HDPE	High Density Polyethylene
HTF	heat transfer fluid
IWVWD	Indian Wells Valley Water District
RSPP	Ridgecrest Solar Power Project
RSI	Ridgecrest Solar I, LLC
RO	Reverse osmosis
ROW	right-of-way
ROWD	Report of Waste Discharge
RWQCB	Regional Water Quality Control Board
SSG	solar steam generator

1.0 Introduction

Ridgecrest Solar I, LLC (RSI) is proposing to construct, own and operate the Ridgecrest Solar Power Project (RSPP or Project) located in the high northern Mojave Desert in northeastern Kern County, California, about 5 miles southwest of the City of Ridgecrest, California (**Figure 1-1**). RSI proposes to use evaporation ponds to store waste water from various plant processes. This document presents a Preliminary Closure Plan for the evaporation ponds.

The Project right-of-way (ROW), for which a ROW grant sought by RSI from the Bureau of Land Management, will extend across approximately 3,995 acres of public lands owned by the Federal government. Once the Project is permitted, the ROW will be reduced to accommodate the Project footprint of approximately 1,995 acres. A general arrangement of the Project is provided in **Figure 1-2**. The topography of the Project site is depicted in **Figure 1-3**. The regional geology is provided in **Figures 1-4A** and **1-4B**.

A notice to terminate will be sent to the Regional Water Quality Control Board (RWQCB) 60 days prior to closing the evaporation ponds. The notice will include the final closure activities. The evaporation ponds will be closed using the schedule of actions explained below.

1.1 Purpose

This plan is intended to be a stand-alone separable document to the Report of Waste Discharge (ROWD) application for the Project, in accordance with the California Integrated Waste Management Board (CIWMB) Title 27 Regulations, Division 2, Subdivision 1, Chapter 4, Subchapter 4, Section 21769; State Water Resources Control Board Closure; and Post-Closure Maintenance Plan Requirements.

The procedures described for closure are designed to ensure public health and safety, environmental protection, and compliance with applicable regulations. It is assumed that closure would begin 30 years after the commercial operation date of the Project. It is also assumed that closure of the Project would occur in a phased sequential manner. That is, work would start at the first pond, followed by similar work at the second pond. A Certification of Closure will be will be submitted for approval to the RWQCB to ensure the RSPP has been closed in accordance with the approved final Closure Plan.

1.2 Objectives

The Project goals for closure of the evaporation ponds are as follows:

- Remove all improvements within 3 feet of final grade; and
- Restore the lines and grades in the disturbed area of the Project Site to match the natural gradients.

The proposed implementation strategy to achieve the goals for site closure is as follows:

- Use industry standard demolition means and methods to decrease personnel and environmental safety exposures by minimizing time and keeping personnel from close proximity to actual demolition activities to the extent practical;
- Plan each component of the closure such that personnel and environmental safety are maintained while efficiently executing the work;
- Specify in detail how each major effort will be performed and integrated to achieve the Project goals;
- Train field personnel for decommissioning actions to be taken in proportion to the personnel, Project or environmental risk for those actions;

- Evaluate the execution of the decommissioning and restoration plan through Project oversight and quality assurance; and
- Document implementation of the plan and compliance with environmental requirements.

2.0 Site Background

The Project is a concentrated solar thermal electric generating facility located in the high northern Mojave Desert in northeastern Kern County, California, about 5 miles southwest of the City of Ridgecrest, California (**Figure 1-1**). The Project will use well-established parabolic trough solar thermal technology to produce electrical power using a steam turbine generator fed from a solar steam generator (SSG). The SSG receives heated heat transfer fluid (HTF) from solar thermal equipment comprised of arrays of parabolic mirrors that collect energy from the sun.

The Project proposes to use a dry cooling condenser for power plant cooling. Water for the cooling tower makeup, process water makeup, and other industrial uses such as mirror washing will be supplied by the local municipal water district (Indian Wells Valley Water District [IWVWD]) via a new pipeline. This source will also be used to supply water for employee use (e.g., drinking, showers, sinks, and toilets). Water received from the IWVWD will meet the requirements of the California Department of Health Services for potable water supplies and will not require further treatment for this purpose. Power cycle makeup, mirror washing water, and cooling of ancillary equipment will require on-site treatment for reduction of dissolved solids; this treatment varies according to the quality required for each of these uses. A sanitary septic system and on-site leach field will be used to dispose of sanitary wastewater.

The Project will have a nominal electrical output of 250 megawatts, consisting of one independent Unit, Unit #1. **Figure 1-2** shows the general arrangement of the site. Commercial operation of Unit #1 is expected to commence by the third quarter of 2013, subject to timing of regulatory approvals and Applicant achievement of Project equipment procurement and construction milestones. The solar thermal technology will provide 100 percent of the power used by the Project; no supplementary energy source (e.g., natural gas to generate electricity at night) is proposed to be used for electric energy production. The Project will utilize an auxiliary boiler fueled by propane gas to reduce startup time and for HTF freeze protection. The Project will also have one electric and one backup diesel-fueled fire water pump for fire protection.

The Project wastewater will be piped to lined, on-site evaporation ponds. Discharge into the evaporation ponds is derived from one primary source: High pH reverse osmosis concentrate. The wastewater flow diagram is shown on **Figure 2-1**. Unit#1 will consist of two evaporation ponds. The pond area provides sufficient evaporative capacity to dispose of the anticipated wastewater stream, and allows for one pond to be taken out of service for cleaning, potential future maintenance, and repair for up to one year without impacting the operation of the Project. The ponds will be designed in accordance with Lahontan Basin RWQCB requirements. If required for maintenance, dewatered residues from the ponds will be excavated, characterized and sent to an appropriately permitted off-site landfill (most likely as non-hazardous waste).

The estimated Project life is 30 years. Personnel will staff the Project 24 hours per day/7 days per week. Even when the solar power plant is not operating, personnel will be present as necessary for maintenance, to prepare the Project for startup, and/or for site security.

2.1 Evaporation Ponds

The waste storage units include two evaporation ponds for the Project. The configuration of the planned evaporation ponds and adjacent areas are shown in **Figure 1-2**. Topography of the Project and surrounding areas are shown on **Figure 1-3**. The final contours of the ponds and the changes in surface drainage patterns, as compared to the preexisting natural drainage patterns are shown on **Figure 2-2**.

The two, 4.0-acre (total combined pond top area of 8 acres) evaporation ponds have an average proposed design depth of 7 feet, which incorporates the following:

- Drying each pond at alternating 4-year intervals;
- 3 feet of operational depth,
- 2 feet of residue build up over 4 years; and
- 2 feet of freeboard.

The containment design for the evaporation ponds, from the surface of the evaporation ponds downwards, consists of the following:

- A hard surface/protective layer;
- A primary 60-mil high density polyethylene (HDPE) liner;
- An interstitial leak detection system comprising a drainage layer and piping;
- A secondary 40-mil HDPE geomembrane liner;
- A 2-foot thick compacted silty-sand base; and
- A moisture detection system

The design details of the evaporation ponds are shown in **Figure 2-3A and 2-3B** and **2-4A and 2-4B**.

3.0 Closure Strategy

The closure for the evaporation ponds consists of the following major elements:

- Documenting and establishing health and safety procedures;
- Collecting samples from the compacted lime-treated native soil for laboratory analysis prior to initial Project operation;
- Conducting pre-closure activities such as final closure and restoration planning that addresses the "as-found" site conditions at the start of the Project;
- Demolishing the aboveground structures (dismantling and removing of improvements and materials) in a phased approach while still using some items until the end of the Project;
- Demolishing and removing belowground facilities as needed to meet the closure goals;
- Cleaning up of soils, if needed;
- Disposing of materials in appropriate facilities for treatment/disposal or recycling (if needed); and
- Re-contouring lines and grades to match the natural gradient and function.

Although various types of closure/demolition equipment will be utilized to dismantle each type of facility, dismantling will proceed according to the following general staging process. The first stage consists of demolition of aboveground structures and belowground facilities. The second stage consists of concrete removal as needed to ensure that no concrete materials remain within 3 feet of final grade. The third stage consists of removal of materials to off-site recycling, remediation or waste facilities. The fourth stage is excavation and removal of soils, and final site contouring to return the originally disturbed area of the site to near original conditions while disturbing as little of the other site areas as is practical.

3.1 Health and Safety Procedures

The health and safety procedures to be established prior to decommissioning are listed below:

- General safety and hazard responsibilities;
- An effective hazard communications program;
- Task hazard analysis and control;
- Personal protection equipment requirements;
- Occupational and environmental monitoring requirements;
- Medical and other emergency procedures;
- Operational issues;
- Personnel training;
- Incident reporting; and
- Self audit and compliance procedures.

3.2 Evaporation Ponds Closure Schedule of Actions

3.2.1 Baseline Sampling

Baseline sampling will be conducted on the compacted silty-sand layer of the evaporation pond liner system prior to the placement of the 40-mil HDPE geomembrane. If a Geosynthetic Clay Layer (GCL) is used in the final design, the native materials below the GCL will be sampled prior to the construction of the evaporation ponds. Samples will be collected from each pond footprint on 100-foot by 100-foot grid spacing. Laboratory analysis will include Title 22 metals, biphenyl, diphenyl oxide, and general chemistry.

3.2.2 Wastewater Disposal/Use

Wastewater will be consolidated into one evaporation pond per Unit or until that one pond is full (i.e., minimum 2 feet of freeboard as required). Wastewater remaining in the Unit's second evaporation pond will be allowed to evaporate to atmosphere. As long as liquids remain in the evaporation ponds, the monitoring and reporting requirements included in the licensing requirements will be followed.

Wastewater that is not evaporated or used for dust control will be characterized and profiled prior to disposal. The characterized wastewater will be loaded in appropriate containers, handled, and transported by a licensed waste hauler to an approved disposal facility following all Federal, State, and local requirements.

3.2.3 Solids/Residue Disposal

Three residue samples will be collected from each of the evaporation ponds to characterize and create a waste profile prior to disposal. Once characterized, the residue will be handled by a licensed waste hauler. The waste hauler will load the waste in the appropriate containers, transport the waste, and dispose of the waste at an approved disposal facility following all Federal, State, and local requirements.

3.2.4 Hard Surface Protective Layer Removal/Disposal

The hard protective layer of roller-compacted concrete or approved equivalent, will be removed using best engineering practices. Three samples of concrete will be collected from each evaporation pond to determine if the concrete can be recycled. If recyclable, the concrete will be crushed on site and transported to construction site(s) for use, such as road base material.

3.2.5 Remove and Reuse Granular Fill

The granular fill beneath the hard surface/protective layer will be removed. The material will be transported to an on-site facility to be washed. Water generated from the washing activities will be loaded in appropriate containers, handled, and transported by a licensed waste hauler to an approved disposal facility following all Federal, State, and local requirements. The washed material will be reused on site as granular fill.

3.2.6 HPLE Liners and Monitoring Equipment

The HDPE liners, sand layers, and monitoring equipment will be removed at each evaporation pond. Wherever feasible, materials will be sent for recycling. When materials are identified as unrecyclable, they will be disposed of at approved disposal facilities.

3.2.7 Base Layer

Confirmation sampling will be conducted on the compacted silty sand of the evaporation pond liner system after the removal of the 40-mil HDPE geomembrane. If a GCL is used in the final design, the native materials below the GCL will be sampled after the removal of the overlying liner systems. Samples will be collected from each of the former pond footprints on 100-foot by 100-foot grid spacing. Laboratory analysis will include Title 22 metals, biphenyl, diphenyl oxide, and general chemistry.

3.2.8 Site Restoration

The evaporation ponds will be backfilled with native soil to grade. The berm surrounding each evaporation pond and the washed granular material will be the primary backfill material. All non-native materials from the evaporation pond will be removed from the property and disposed of or recycled in accordance with all Federal, State, and local regulations.

4.0 Additional Information

Additional plan information, as required per the CIWMB Title 27 is detailed in the following sections.

4.1 Contingency in the Event of a Release

For unauthorized discharges of hazardous material, or for public health or environmental emergencies caused by a discharge or threatened waste discharge, local emergency responders and the Office of Emergency Services will be notified. For all other unauthorized discharges or threatened discharges that are not an immediate threat to public health or the environment, notification will be made to the RWQCB by telephone within 24 hours of an adverse condition. An adverse condition includes a discharge or threatened discharge, such as:

- Release of wastewater outside a lined area;
- Suspected or actual evaporation pond liner leak; and
- Violation of discharge specifications.

Written notification to the RWQCB will occur within 7 business days of an unauthorized discharge. The Lahontan Basin RWQCB's guidance document titled Reporting Unauthorized Waste Discharges (Spills and Leaks) dated October 23, 2002 will be followed.

An evaluation monitoring program may be required, pursuant to Section 20425 of Title 27 to evaluate evidence of a release if detection monitoring and/or verification procedures indicate evidence of a release. A corrective action plan to remediate released wastes from the evaporation ponds has been prepared pursuant to Section 20430 of Title 27 and is included as Appendix D of the ROWD.

4.1.1 Wastewater Release

Leaks and/or spills may occur during maintenance activities or unexpected system failures. In the event of a release of wastewater, the magnitude of the leak will be evaluated and reported to the RWQCB. The defective equipment will be isolated and repaired. Corrective measures will be implemented to repair leaks and preventive measures will be followed to minimize the likelihood of future releases. Preventive measures include a Drainage, Erosion and Sediment Control Plan (DESCP), Storm Water Pollution Prevention Plans inspections, system or equipment tests, and predictive and preventive equipment maintenance. The DESCP addresses the requirements of Title 27 California Code of Regulations Section 21600(b)(8)(F) and will describe the management and control of storm water runoff at the site and will specify site-specific best management practices for erosion and sediment control.

4.1.2 Liner Leak

In the event there is a liner leak, the magnitude of the leak will be evaluated and the Facility Manager will immediately notify the RWQCB verbally. A written notification, via certified mail, will be undertaken within 7 days of the verbal notification. The notification will include the following:

- Evaporation pond that may have released/be releasing;
- General information including the date, time, location and cause of the release;
- An estimate of the flow rate and volume of the waste involved;
- A procedure for collecting samples and description of laboratory tests to be conducted;

- Identification of any water bearing media affected or threatened; and
- A summary of proposed corrective actions.

The evaporation pond with a liner leak will be taken out of service so repairs can be made. Should a leak occur, any water remaining in the leaking pond will be transported to the second pond or temporarily stored on-site in approved portable tanks with appropriate secondary containment. The evaporation ponds are sized allows for one pond to be taken out of service for up to approximately one year without impacting the operation of the Project.

4.2 Financial Responsibility

The waste management unit (i.e., evaporation ponds) is considered Class II. At Class II units for which the CIWMB does not require a closure fund, the RWQCB requires the establishment of an irrevocable closure fund (or provide other means) pursuant to the CIWMB-promulgated sections of Title 27, Chapter 6 but with the RWQCB named as beneficiary, to ensure closure of each classified unit in accordance with an approved plan meeting all applicable State Water Resources Control Board-promulgated requirements of Title 27, Chapter 6, Subchapter 2.

4.3 Cost Analysis

A cost estimate to close the evaporation ponds is provided in Appendix A. Unit costs are based on RS Means Building Construction Cost Data 2001 Western Version and adjusted by ENR Historical Cost Index to obtain present value unit costs. The total cost estimate is **$8,858,000**. A letter of credit will be used to demonstrate financial assurance for the closure costs.

4.4 Closure Schedule

Closure of the evaporation ponds is anticipated to take 6 months. Updates and or revisions to the closure schedule will be provided as needed under separate cover of the Final Closure Maintenance Plan.

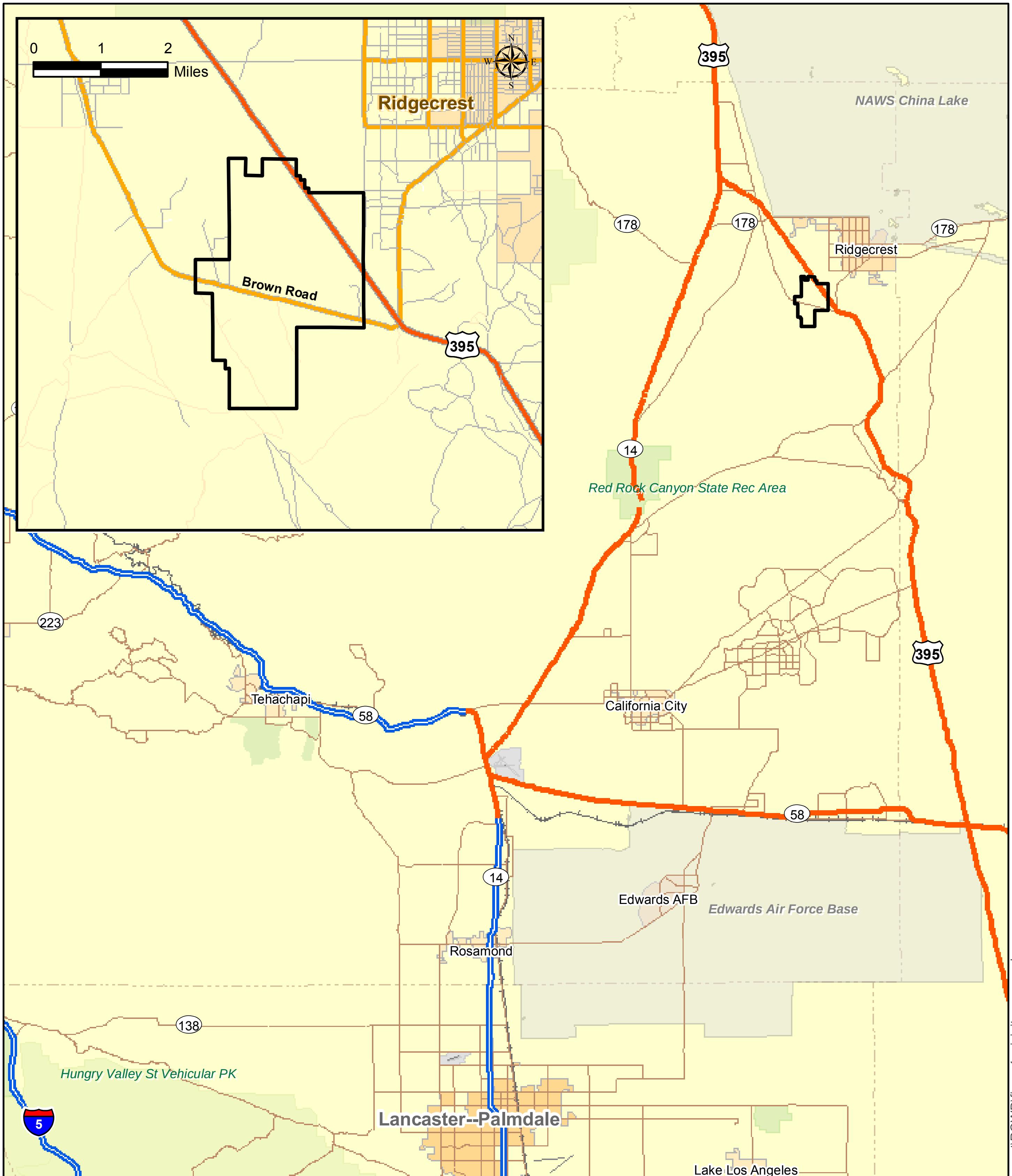
4.5 Final Treatment Procedures

All waste and contaminated materials will be removed off site and all facilities will be remediated in accordance with **Section 3.2** detailed previously. Additional post closure monitoring will be satisfied with the requirements identified in the Post Closure Maintenance Plan.

4.6 Land Use of Closed Unit

The land use of the closed unit after closure has not been determined. At present it is anticipated that the facilities will be left as vacant, non-irrigated open land that has been remediated. Based on the plan to clean close the evaporation ponds, future use should not be restricted any more than surrounding parcels. Any future development will need to undergo the standard review and approval process in effect at that time.

Figures



Map Location

0 5 10
Miles

Ridgecrest Solar Power Plant

Figure 1-1
Regional Location and Vicinity Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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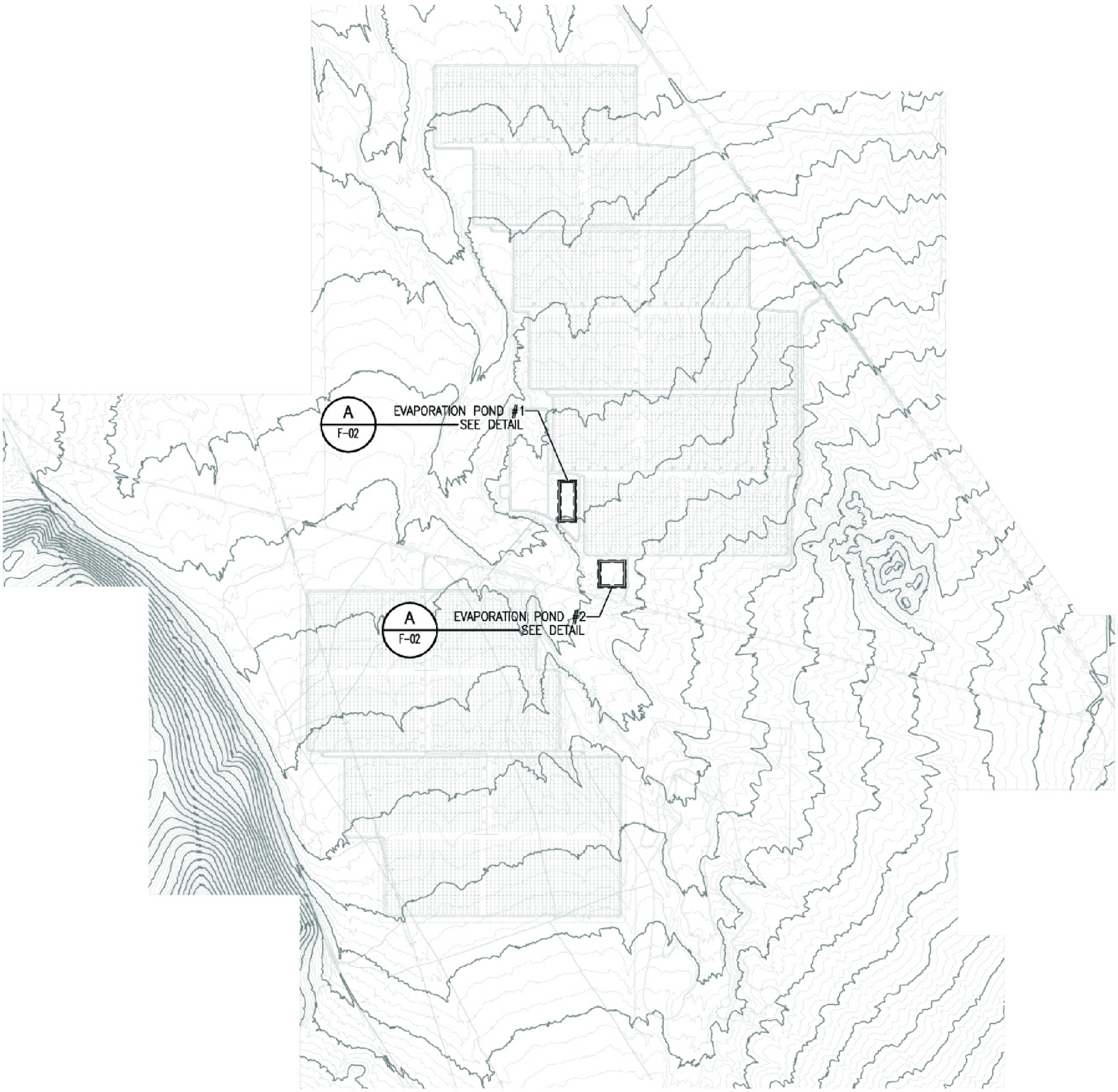

Ridgecrest Solar Power Project

Figure 1-2
General Arrangement Site Plan

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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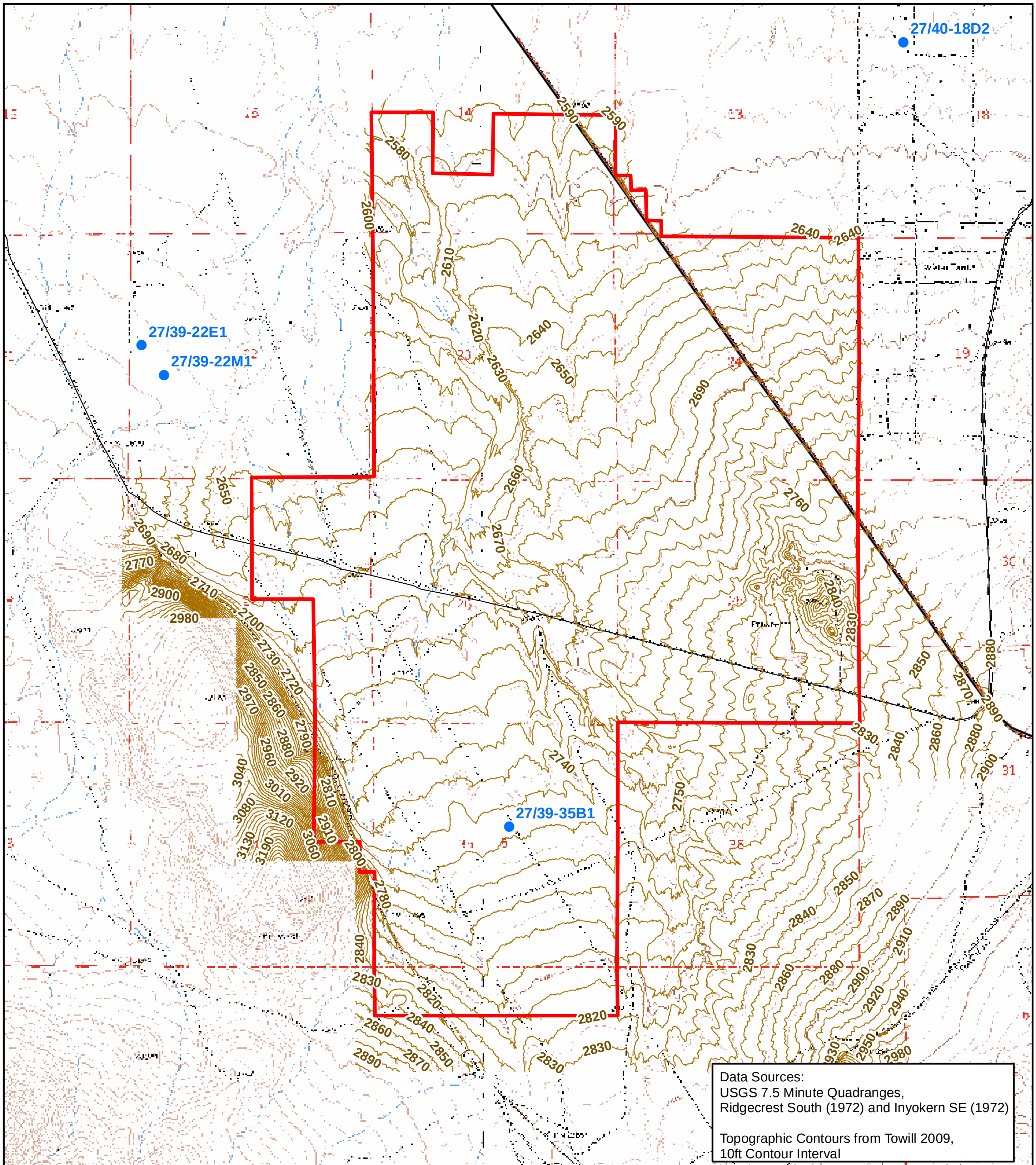


Map Location

Legend

Project Right-of-Way

Groundwater Well Location based on Latitude and Longitude in USGS Database

0 3,000 6,000 Feet

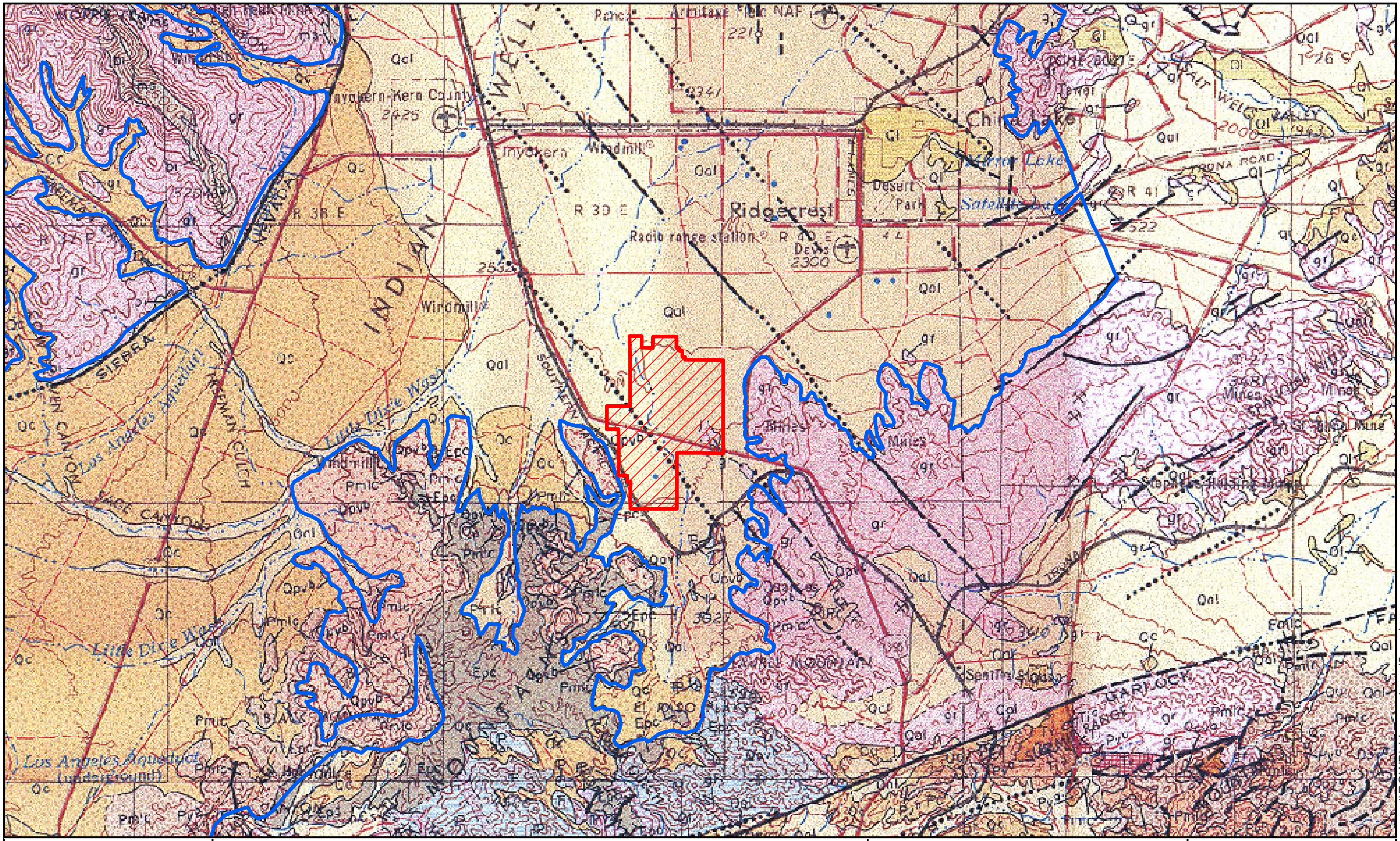
Ridgecrest Solar Power Plant

Figure 1-3
Site Topographic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010



Map Location

Legend

Project Right-of-Way

Indian Wells Valley Groundwater Basin

See Figure 1-4b for Geologic Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona Sheet, Scale 1:250,000, 1963

1 in = 3 miles

0 3 6 Miles

N W E S

Ridgecrest Solar Power Plant

Figure 1-4a
Regional Geologic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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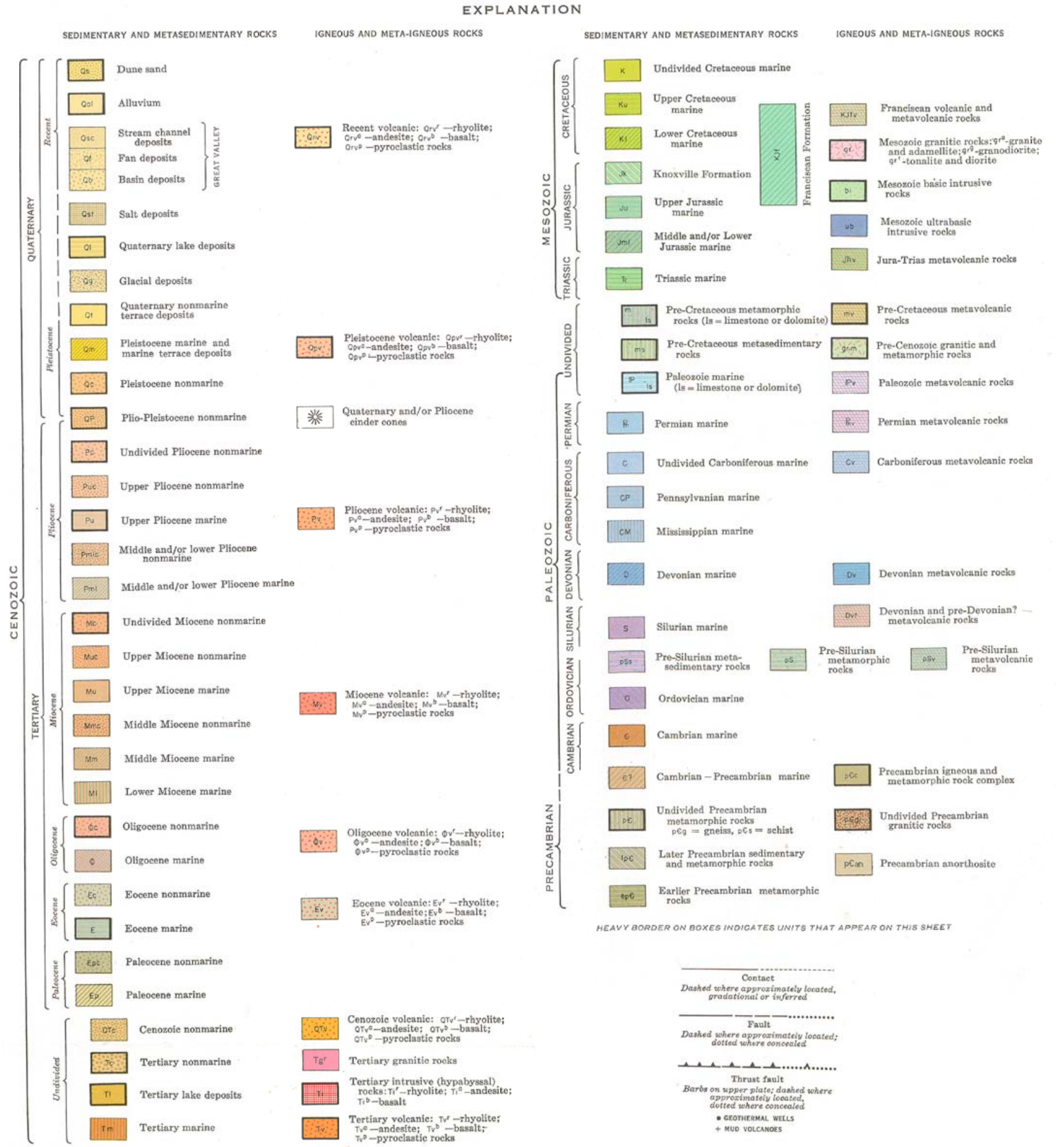

Map Location

Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona, Scale 1:250,000, 1963

N
W E
S

Ridgecrest Solar Power Project

Figure 1-4b
Regional Geologic Map Legend

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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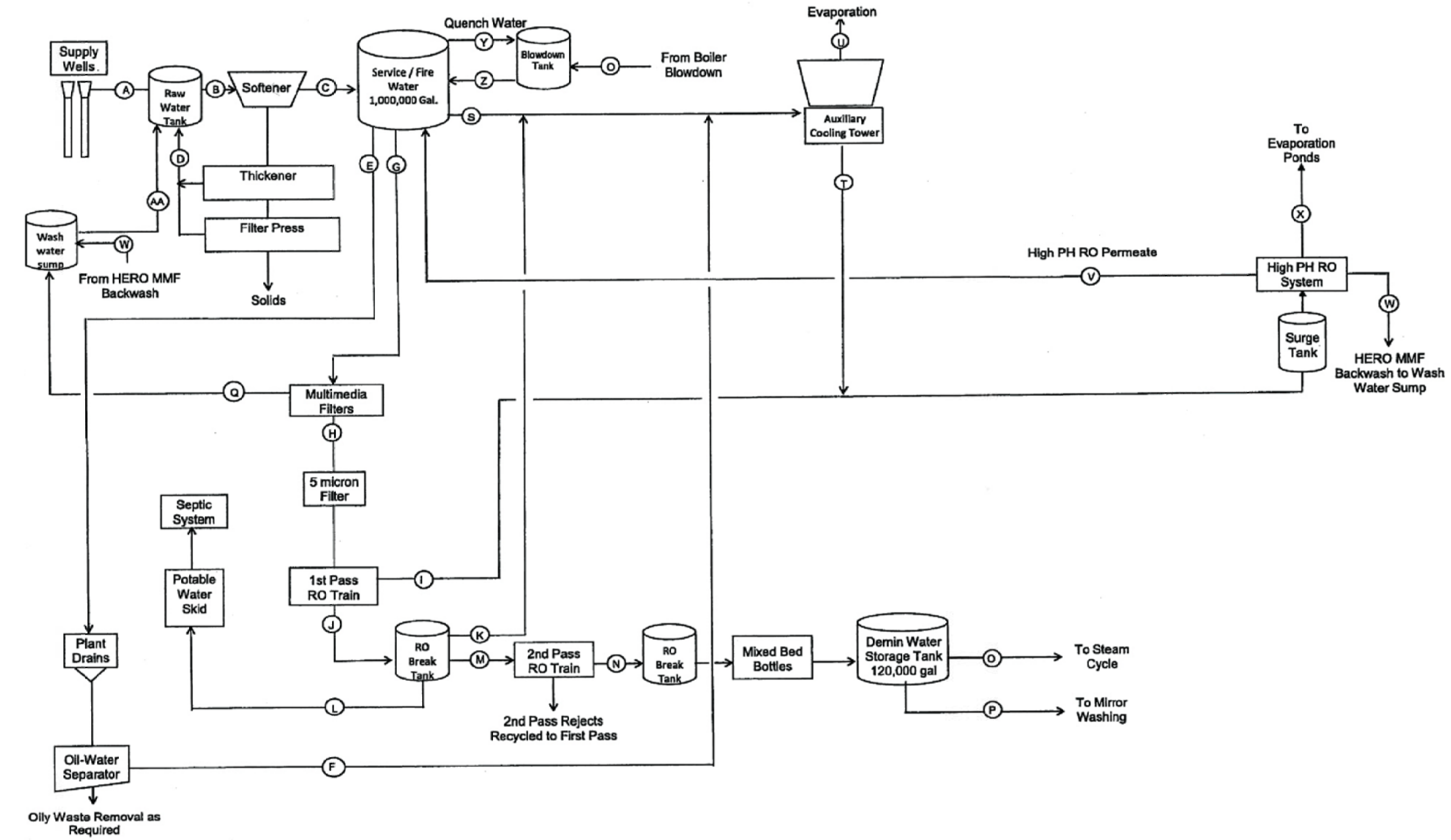

Map Location

Ridgecrest Solar Power Plant

Figure 2-1
Wastewater Flow Diagram

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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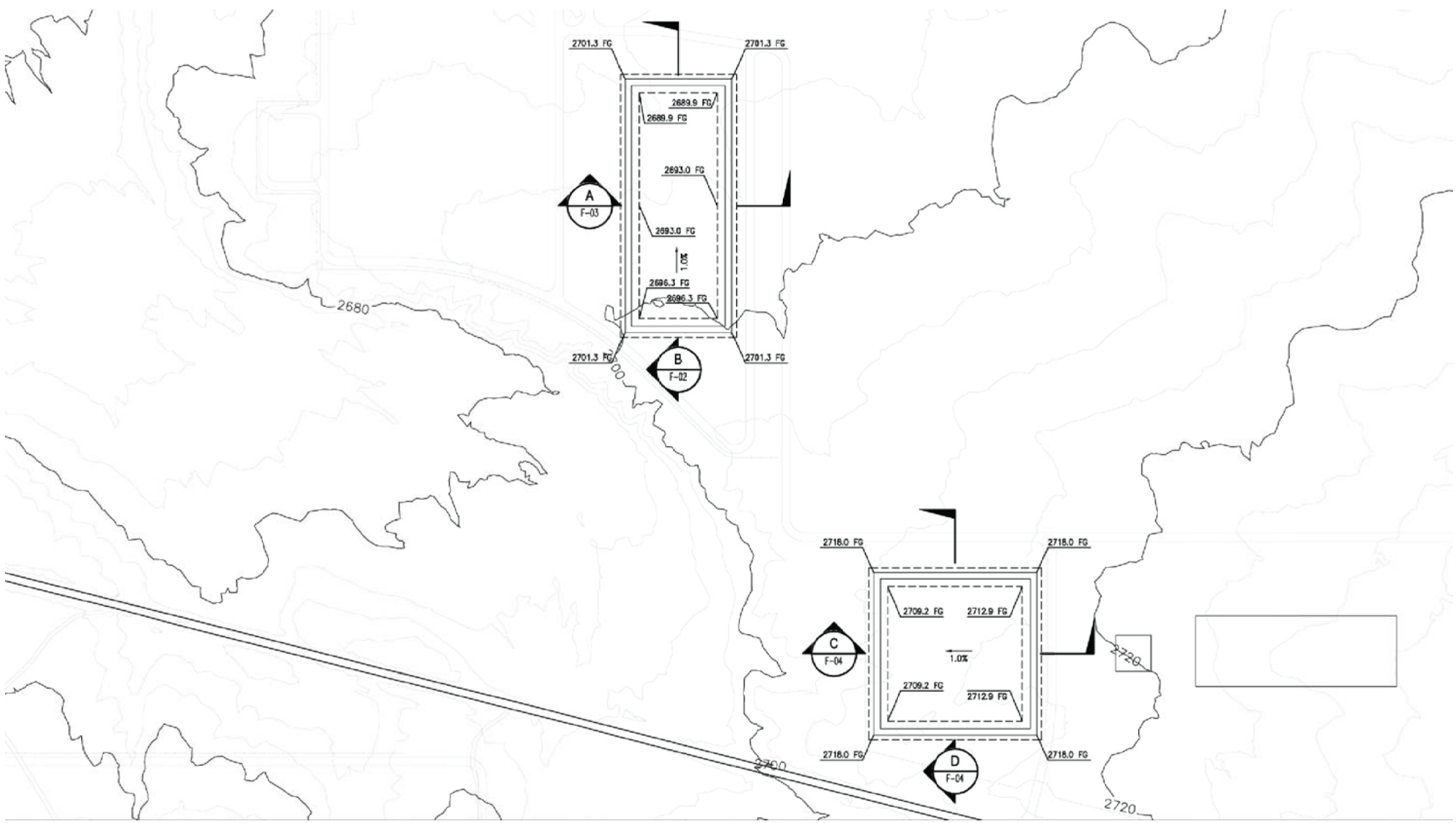

Map Location

Ridgecrest Solar Power Plant

Figure 2-2
Evaporation Pond Drainage and Grading Plan

Ridgecrest Solar I, LLC

Project: 60139696
Date: June 2010

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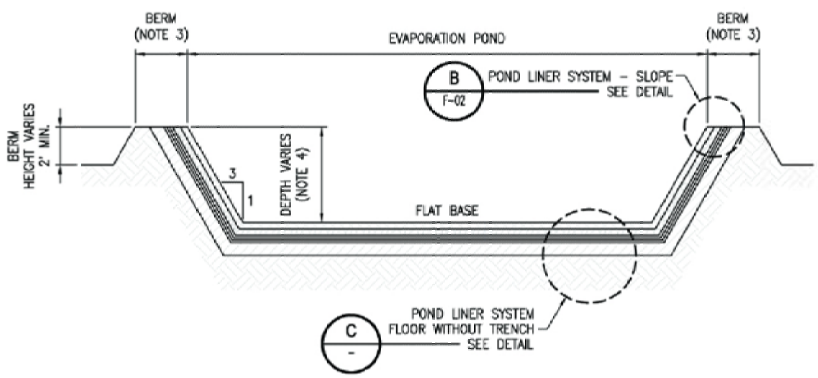

POND - UPSTREAM CROSS SECTION (A)

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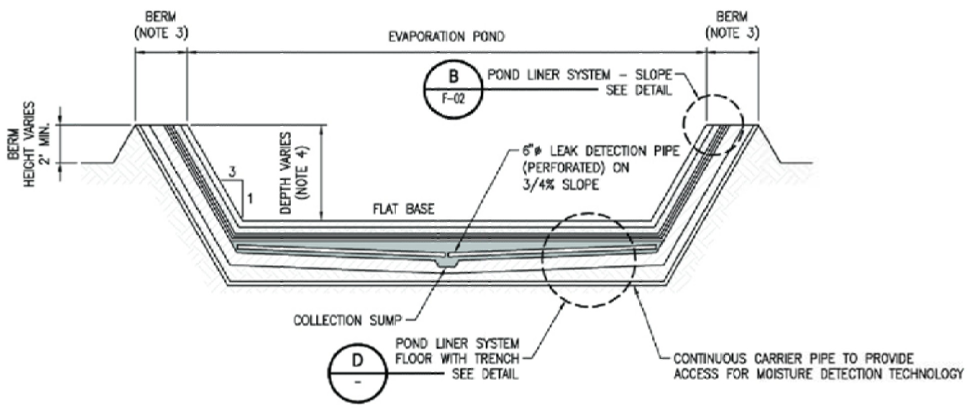

POND - DOWNSTREAM CROSS SECTION (B)

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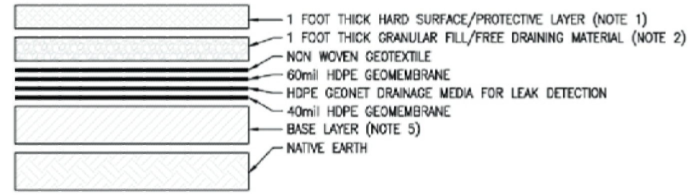

POND LINER SYSTEM DETAIL FLOOR TRENCH (C)

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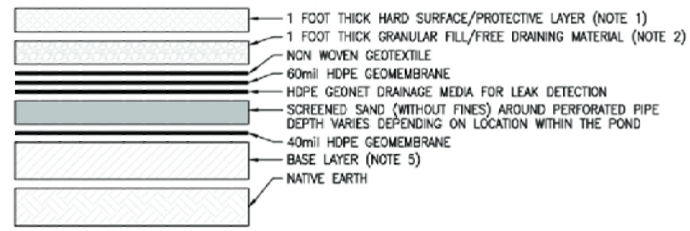

POND LINER SYSTEM DETAIL FLOOR WITHOUT TRENCH (D)

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10-6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 2-3a
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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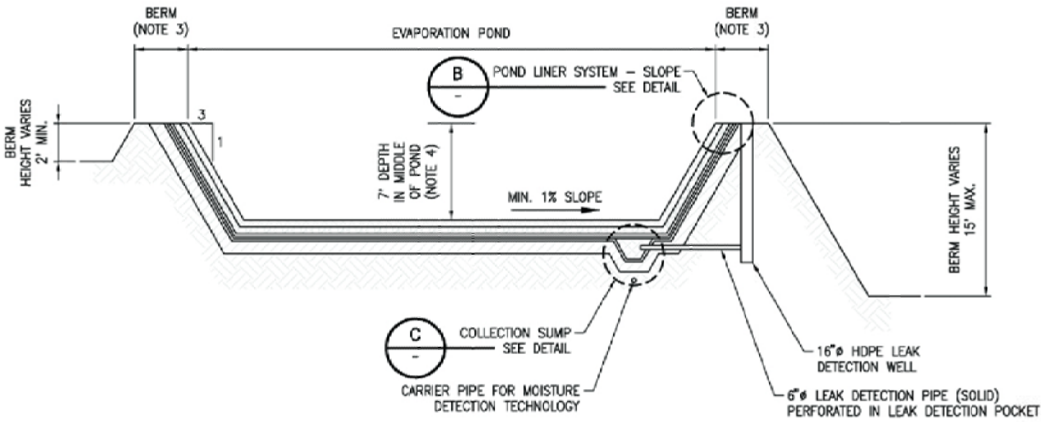

CROSS SECTION THROUGH THE MIDDLE OF THE PONDS (A)

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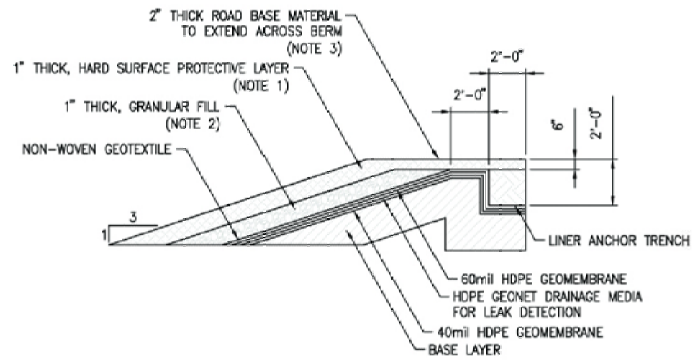

POND LINER SYSYTEM - SLOPES (B)

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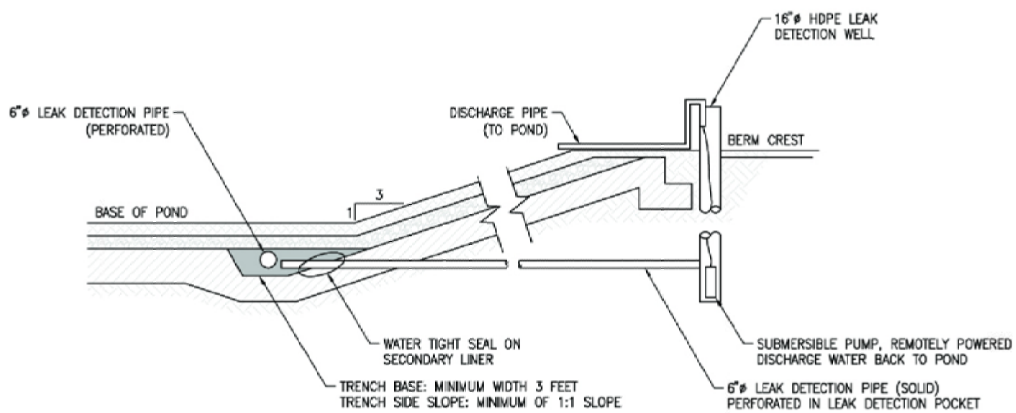

COLLECTION SUMP DETAIL (C)

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
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6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 2-3b
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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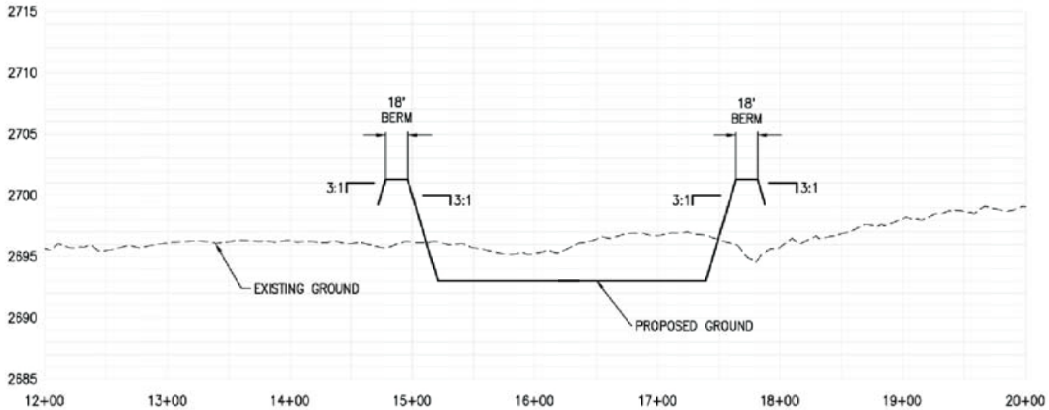
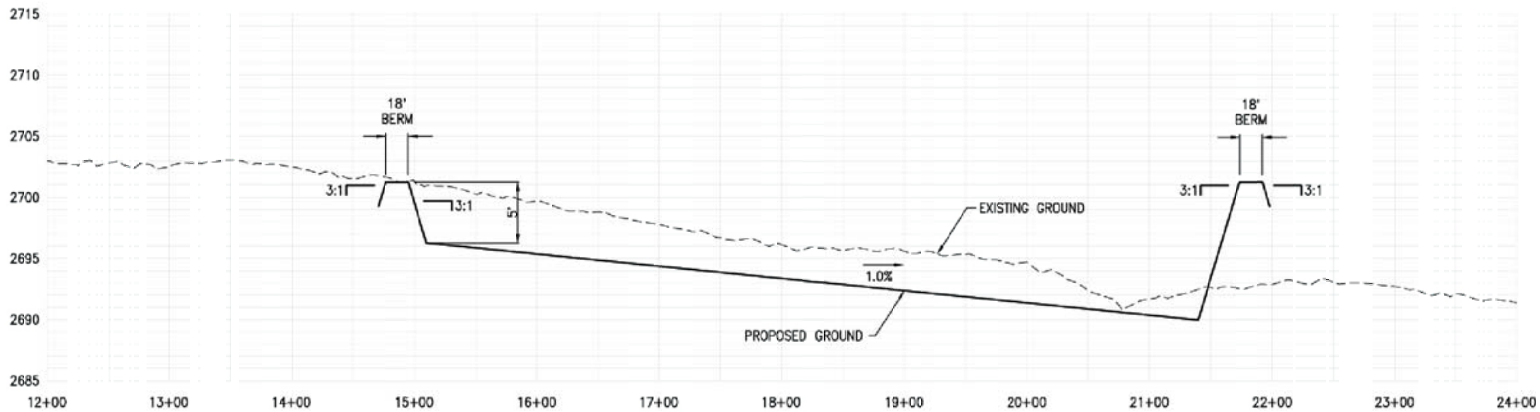


CROSS SECTION A

SCALE: NONE



CROSS SECTION B

SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 2-4a Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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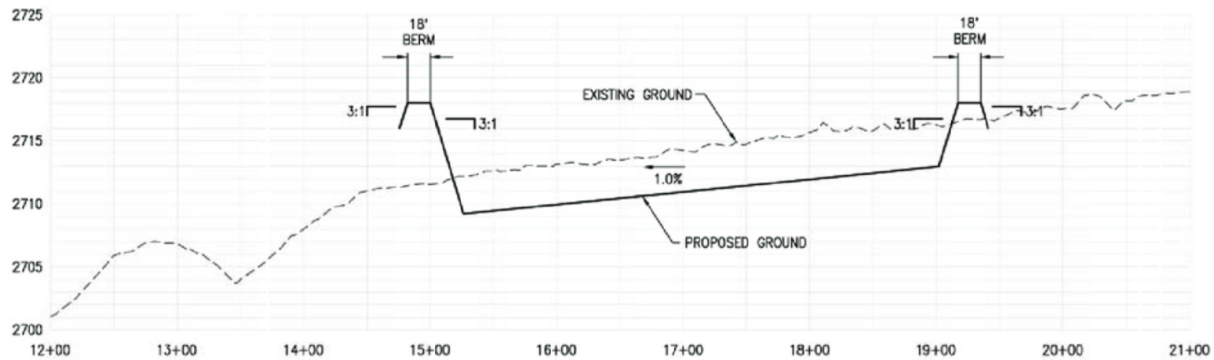

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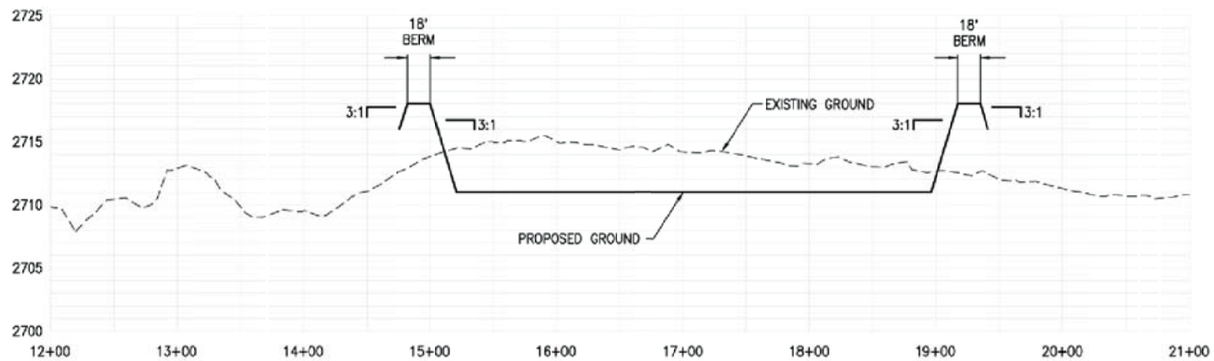

CROSS SECTION D

SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 2-4b
Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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Attachment A

Cost Estimate

Summary of Closure Costs

Item	Closure Cost Estimate (each)	Quantity	Subtotal Closure Cost Estimate
Evaporation Ponds	$4,429,000	2	$8,858,000
		Total Closure Cost Estimate	**$8,858,000**

Order-of-Magnitude Cost Estimate-Closure of Evap Ponds

Sequence of Closure of Evaporation Pond

1. Remove and Dispose Sludge (solid)
2. Remove, Crush , and Recycle Hard Surface (Roller compacted concrete without rebar)
3. Remove, Wash, and Reuse on site Granular Fill
4. Remove and Dispose of Non-Woven layer , 60 mil Geomembrane, and Geonet
5. Remove Screened Sand /piping trench ; reuse sand on site & dispose of piping
6. Remove and Dispose of 40 mil Geomembrane

6A No GCL layer

7. Sample Clay/Silt layer to demonstrate that it is acceptable to leave in place
8. Return Granular Fill to interior of pond
9. Excavate Berms and return to interior of pond
10. Excavate soil from surrounding area and fill pond

		Unit Cost	Unit Quantity	Unit	Number	Cost Reference
Costs						
1. Remove and Dispose Sludge (solid)						
Mobilization	LS	$25,000	1	1	$25,000	ROM Estimate
Excavate (0.75 cyd Front End Loader)	CYD	$5	12,907	1	$69,463	Means 02315-40-1500&-4100
Loading to trucks	CYD	$0.81	12,907	1	$10,419	Means 02315-400-0020
Hauling to Landfill (20 tons/truck& 278 mile RT)	mile	$3.67	278	1,150	$1,172,212	Means 02110-300-1260; Assume Buttonwillow CA
Disposal	ton	$31.10	23,000	1	$715,300	4-19-10 CH verbal; tipping fee for Buttonwillow Landfill
Sampling and RWQCB Report	each	$25,000	1	1	$25,000	ROM Estimate
				Total	$2,017,394	
2. Remove and Dispose/Recycle Hard Surface						
Mobilization	LS	$10,000	1	1	$10,000	ENSR Estimate
Demolition of 12" Concrete	CYD	$127	8,319	1.0	$1,054,355	Means 02220-875-2100
Loading to trucks	CYD	$0.81	8,319	1	$6,716	Means 02315-400-0020
Crush concrete on site	ton	$5	16,846	1.0	$80,569	See CIWMB assumption below
Sampling of Crushed concrete demonstrating no imp	LS	$25,000	1	1	$25,000	ROM Estimate
Loading to trucks	CYD	$0.81	8,319	1	$6,716	Means 02315-400-0020
Truck Haul to on site stockpiles and dump	CYD	$6.42	8,319	1	$53,447	Means 02320-200-0330
Spread dumped crushed concrete,no compaction	CYD	$2.10	8,319	1	$17,506	Means 02320-200-0400
				Total	$1,254,310	
3. Remove, Wash, & Reuse Granular Fill						
Mobilization	LS	$25,000	1	1	$25,000	ROM Estimate
Excavate (0.75 cyd Front End Loader)	CYD	$3	8,319	1	$27,984	Means 02315-40-1500
Loading to trucks	CYD	$0.50	8,319	1	$4,198	Means 02315-400-0020
Truck Haul to on site stockpile and dump	CYD	$4.67	8,319	1	$38,859	Means 02320-200-0400
Wash to remove salts	CYD	$5.00	8,319	1	$41,596	ROM Estimate
Disposal of Wash Water	gal	$0.50	166,385	1	$83,192	ROM Estimate
Loading to stockpile	CYD	$0.50	8,319	1	$4,198	Means 02315-400-0020
				Total	$225,026	
4. Remove and Dispose of Non-Woven layer , 60 mil Geomembrane, and Geonet						
Mobilization	LS	$5,000	1	1	$5,000	ROM Estimate
Pick up and cutting of Non-Woven, HDPE	SF	$0.45	0	1	$0	Means 02225-380-0400 (roughly ~)
Loading to trucks	SF	$0.07	0	1	$0	Means 02315-400-0020 (roughly ~)
Hauling to Facility (20 tons/truck & 200 mileRT)	mile	$3.67	200	0	$0	Means 02110-300-1260
Disposal	ton	$103.62	0	1	$0	Means 02225-740-0100
				Total	$5,000	
5. Remove Screened Sand /piping trench ; Sump						
Excavate (0.75 cyd Front End Loader)	CYD	$3	0	1	$0	Means 02315-40-1500
Loading to trucks	CYD	$0.50	0	1	$0	Means 02315-400-0020
Truck Haul to on site stockpile and dump	CYD	$7.49	0	1	$0	Means 02320-200-0400
				Total	$0	
6. Remove and Dispose of 40 mil Geomembrane						
Mobilization	LS	$5,000	1	1	$5,000	ROM Estimate
Pick up and cutting of HDPE	SF	$0.22	0	1	$0	Means 02225-380-0400 (roughly ~1/2)
Loading to trucks	SF	$0.03	0	1	$0	Means 02315-400-0020 (roughly ~)
Hauling to Facility (20 tons/truck & 200 mileRT)	mile	$3.67	200	0	$0	Means 02110-300-1260
Disposal of 40 mil HDPE	ton	$103.62	0	1	$0	Means 02225-740-0100
				Total	$5,000	
6A Remove GCL layer (alternate) and dispose as daily cover at landfill						
Excavate (0.75 cyd Front End Loader)	CYD	$3	0	1	$0	Means 02315-40-1500
Loading to trucks	SF	$0.07	0	1	$0	Means 02315-400-0020 (roughly ~)
Hauling to Facility (20 tons/truck & 200 mileRT)	mile	$3.67	0	0	$0	Means 02110-300-1260
Disposal of GCL	ton	$47.83	0	1	$0	AECOM experience
				Total	$0	
7. Sample Clay/Silt layer to demonstrate that it is acceptable to leave in place						
Sample Collection	Day	$1,800	1	1	$2,022	ROM Estimate
Sample Analysis	Each	$250	22	1	$5,615	TPH by 8015 & Title 22
Report of Analytical	Each	$7,500	1	1	$7,500	ROM Estimate
				Total	$15,137	
8. Return Granular Fill to interior of pond						
Mobilization	LS	$5,000	1	1	$5,000	ROM Estimate
Excavate (0.75 cyd Front End Loader)	CYD	$3	8,319	1	$27,984	Means 02315-400-1500
Loading to trucks	CYD	$0.50	8,319	1	$4,198	Means 02315-400-0020
Truck Haul to on site stockpile and dump	CYD	$6.42	8,319	1	$53,447	Means 02320-200-0330
Spread dumped fill,no compaction	CYD	$2.10	8,319	1	$17,506	Means 02320-200-0400
				Total	$108,135	
9. Excavate Berms and return to interior of pond						
Mobilization	LS	$10,000	1	1	$10,000	ROM Estimate
Excavate (Dozer, 300' haul, common earth)	CYD	$8	0	1	$0	Means 02315-410-4420
				Total	$10,000	
10. Excavate soil from surrounding area to fill pond						
Mobilization	LS	$0	1	1	$0	Included in Item 9
Excavate (Dozer, 300' haul, common earth)	CYD	$8	58,080	1	$450,911	Means 02315-410-4420
				Total	$450,911	

Order-of-Magnitude Cost Estimate-Closure of Evap Ponds

Sequence of Closure of Evaporation Pond

1. Remove and Dispose Sludge (solid)
2. Remove, Crush , and Recycle Hard Surface (Roller compacted concrete without rebar)
3. Remove, Wash, and Reuse on site Granular Fill
4. Remove and Dispose of Non-Woven layer , 60 mil Geomembrane, and Geonet
5. Remove Screened Sand /piping trench ; reuse sand on site & dispose of piping
6. Remove and Dispose of 40 mil Geomembrane

6A No GCL layer

7. Sample Clay/Silt layer to demonstrate that it is acceptable to leave in place
8. Return Granular Fill to interior of pond
9. Excavate Berms and return to interior of pond
10. Excavate soil from surrounding area and fill pond

		Unit Cost	Unit Quantity	Unit	Number	Cost Reference
Subtotal Field Activities Costs					**$4,090,913**	
Contingency	(0% of All of the Above Costs)				$0	
				Total	**$4,090,913**	
Total Field Activities Costs					**$4,100,000**	
Engineering and Oversite						
Engineering	(2% of Total Construction Cost)				$82,000	Means 01107-300-1200 (min.)
Permitting	(0.5% of Total Construction Cost)				$21,000	Means 01310-150-0010 (min.)
Construction Management	(5% of Total Construction Cost)				$205,000	Means 01107-200-0010 (min.)
Closure Report	(0.5% of Total Construction Cost)				$21,000	Means 01310-150-0010
Total Engineering and Oversite Cost					**$329,000**	
T O T A L C O S T					**$4,429,000**	

Order-of-Magnitude Cost Estimate-Closure of Evap Ponds

Sequence of Closure of Evaporation Pond

1. Remove and Dispose Sludge (solid)
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3. Remove, Wash, and Reuse on site Granular Fill
4. Remove and Dispose of Non-Woven layer , 60 mil Geomembrane, and Geonet
5. Remove Screened Sand /piping trench ; reuse sand on site & dispose of piping
6. Remove and Dispose of 40 mil Geomembrane

6A No GCL layer

7. Sample Clay/Silt layer to demonstrate that it is acceptable to leave in place
8. Return Granular Fill to interior of pond
9. Excavate Berms and return to interior of pond
10. Excavate soil from surrounding area and fill pond

			Unit Cost	Unit Quantity	Unit	Number		Cost Reference
Assumptions								
No need for construction support facilities since site has infrastructure								
Berms are constructed by removal of native material from site								
See Attached worksheet for support to berm volumes								
Volume of berm material is ~				0 cyd	Vol			
Based on Cleanout of Sludge, 3 years accumlation is		92,000,000 pounds	for 2 ponds			46,000,000	pounds for each pond	
Accumulated Sludge is now a solid	Dry Weight		23000 tons or			12907	Cubic Yards	
Sludge is not a RCRA hazardous material, & can be disposed in a Class I (CA) landfill								
Sludge meets landfill permit on moisture content and density is roughly equivalent to impacted soil								
Referring concrete thickness details from drawing (Figure 2-5 Evaporation Pond section and details)								
					Pond Area	**4.00**	acres	
Pond Side Dimension		417 ft		Side Slope		**28.26**		
Pond Area (inclding slopes)		Surface Area including side slopes				224620	Square Feet	
Concrete	Thickness			1 feet	Vol	8319	Cubic Yards	
	Density	150 lbs/cft			Wt.	16846	Tons	
Concrete crushing assumes that there is no rebar; A 1997 study (CALTRANS) as reported by CIWMB found that costs to produce 3/4inch								
material were $4 to $5/ton and to produce 1.5 inch material were $3 to $3.50/ton; Use					4.8 per ton			
Granular Fill	Thickness			1 feet	Vol	8319	Cubic Yards	
60-mil HDPE/Geotextile						0	Square Feet	
Sand/Gravel Fill Trench	Length			0 feet	Vol	0	Cubic Yards	
40-mil HDPE						0	Square Feet	
Compacted Clay/Silt	Thickness			2 feet	Vol	16638	Cubic Yards	
Assume that Compact Clay/Silt can remain as it is not impacted								

Notes

Unit Costs are from RS Means Building Construction Cost Data 2001 Western Version			
Unit Costs are adjusted by the City Cost Index;		1.13	Means page 612 for Installation index for Riverside, CA
Unit Costs are adjusted by the ENR Historical Cost Index to estimate 2010 costs			
Compare Construction Cost Index since closure is mostly labor and not materials purchase			
ENR Construction Cost Index for Los Angeles in December 2000		7068	
ENR Construction Cost Index for Los Angeles in March 2010		9945	
Historical Cost adjustment is 2010 #/ 2000 #	1.41		
Combine historical (2010 to 2000) & City cost adjustment	1.59		

AECOM
Environment

Prepared for:
Ridgecrest Solar I, LLC

Preliminary Post-Closure Plan for Evaporation Ponds Ridgecrest Solar Power Project Kern County, California

Appendix G of the Application/Report of Waste Discharge

June 2010

60139696-5450 Post Closure

AECOM
Environment

Prepared for:
Ridgecrest Solar I, LLC

Preliminary Post-Closure Plan for Evaporation Ponds Ridgecrest Solar Power Project Kern County, California

Appendix G of the Application/Report of Waste Discharge

Prepared By: Carmen Caceres-Schnell, PG

Reviewed By: Bob Wilson

June 2010

60139696-5450 Post Closure

Contents

List of Attachments

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List of Acronyms

CCR	California Code of Regulations
CIWMB	California Integrated Waste Management Board
DMP	detection monitoring program
HDPE	high density polyethylene
HTF	heat transfer fluid
IWVWD	Indian Wells Valley Water District
RSPP	Ridgecrest Solar Power Project
ROW	right-of-way
ROWD	Report of Waste Discharge
RSI	Ridgecrest Solar I, LLC
RWQCB	Regional Water Quality Control Board
SSG	solar steam generator

1.0 Introduction

Ridgecrest Solar I, LLC (RSI) is proposing to construct, own and operate the Ridgecrest Solar Power Project (RSPP or Project) located in the high northern Mojave Desert in northeastern Kern County, California, about 5 miles southwest of the City of Ridgecrest, California (**Figure 1-1**). RSI proposes to use evaporation ponds to store waste water from various plant processes. This document presents a Preliminary Post Closure Plan for the evaporation ponds.

The Project right-of-way (ROW), for which a ROW grant sought by RSI from the Bureau of Land Management, will extend across approximately 3,995 acres of public lands owned by the Federal government. Once the Project is permitted, the ROW will be reduced to accommodate the facility footprint of approximately 1,995 acres. A general arrangement of the Project is provided in **Figure 1-2**. The topography of the Project site is depicted in **Figure 1-3**. The regional geology is provided in **Figures 1-4A** and **1-4B**.

A notice to terminate will be sent to the Regional Water Quality Control Board (RWQCB) 60 days prior to closing the evaporation ponds. The notice will include the final closure activities. After closure of the evaporation ponds, maintenance activities of these former facilities will be conducted as follows.

1.1 Purpose

This plan is intended to be a stand-alone separable document to the Report of Waste Discharge application for the Project, in accordance with the California Integrated Waste Management Board (CIWMB) Title 27 Regulations, Division 2, Subdivision 1, Chapter 4, Subchapter 4, Section 21769, State Water Resources Control Board Closure and Post Closure Maintenance Plan Requirements.

The purpose of the Preliminary Post Closure Maintenance Plan is to describe the elements of the maintenance plan that will go into effect once the evaporation ponds are permanently closed. The plan describes procedures to ensure public health and safety, environmental protection, and compliance with applicable regulations. This plan also presents an estimate of expected costs to carry out post closure maintenance activities over the 30-year period following final closure of the two evaporation ponds (**Attachment A**).

Current plans call for clean closure of the evaporation ponds, which will involve the physical removal of all waste and contaminated materials from each pond and from the underlying and surrounding environs such that the waste no longer poses a threat to water quality. Successful completion of clean closure will eliminate the need for any post closure maintenance period and removes each unit from being subject to RWQCB requirements per Title 27 California Code of Regulations (CCR) Chapter 3, Subchapter 5, Article 1, Section 20950.

1.2 Objective

Since RSI plans to clean-close the evaporation ponds at the Project Site once Project operations permanently cease, the goal of the Preliminary Post Closure Maintenance Plan is to set forth the measures that will be performed in the event that post closure activities (and reporting to the RWQCB) becomes necessary following permanent closure of the waste units.

The proposed implementation strategy to achieve the goals for post closure of these facilities is as follows:

- Prepare a final post closure maintenance plan that will specify in detail how each major effort will be performed and integrated to achieve the Project goals;
- Train field personnel for post closure maintenance activities to be taken in proportion to the personnel, project or environmental risk for those actions;
- Evaluate the execution of the post closure maintenance plan through project oversight and quality assurance; and
- Document implementation of the post closure maintenance plan and compliance with environmental requirements.

2.0 Site Background

The Project is a concentrated solar thermal electric generating facility located in the high northern Mojave Desert in northeastern Kern County, California, about 5 miles southwest of the City of Ridgecrest, California (**Figure 1-1**). The Project will use well-established parabolic trough solar thermal technology to produce electrical power using a steam turbine generator fed from a solar steam generator (SSG). The SSG receives heated heat transfer fluid (HTF) from solar thermal equipment comprised of arrays of parabolic mirrors that collect energy from the sun.

The Project proposes to use a dry cooling condenser for power plant cooling. Water for the cooling tower makeup, process water makeup, and other industrial uses such as mirror washing will be supplied by the local municipal water district (Indian Wells Valley Water District [IWVWD]) via a new pipeline. This source will also be used to supply water for employee use (e.g., drinking, showers, sinks, and toilets). Water received from the IWVWD will meet the requirements of the California Department of Health Services for potable water supplies and will not require further treatment for this purpose. Power cycle makeup, mirror washing water, and cooling of ancillary equipment will require on-site treatment for reduction of dissolved solids, and this treatment varies according to the quality required for each of these uses. A sanitary septic system and on-site leach field will be used to dispose of sanitary wastewater.

The Project will have a nominal electrical output of 250 megawatts, consisting of one independent Unit, Unit #1. **Figure 1-2** shows the general arrangement of the site. Commercial operation of Unit #1 is expected to commence by the third quarter of 2013, subject to timing of regulatory approvals and Applicant achievement of Project equipment procurement and construction milestones. The solar thermal technology will provide 100 percent of the power generated by the Project; no supplementary energy source (e.g., natural gas to generate electricity at night) is proposed to be used for electric energy production. The Project will utilize an auxiliary boiler fueled by propane gas to reduce startup time and for HTF freeze protection. The Project will also have one electric and one backup diesel-fueled fire water pump for fire protection. The Project wastewater will be piped to lined, on-site evaporation ponds. Discharge into the evaporation ponds is derived from one primary source: High pH reverse osmosis concentrate).

Unit#1 will consist of two evaporation ponds. Each pond area provides sufficient evaporative capacity to dispose of the anticipated wastewater stream, and allows for one pond to be taken out of service for cleaning, potential future maintenance, and repair for up to one year without impacting the operation of the Project. If required for maintenance, dewatered residues from the ponds will be excavated, characterized and sent to an appropriately permitted off-site landfill (most likely as non-hazardous waste).

The estimated Project life is 30 years. Personnel will staff the Project 24 hours per day/seven days per week. Even when the solar power plant is not operating, personnel will be present as necessary for maintenance, to prepare the Project for startup, and/or for site security.

2.1 Waste Handling Facilities – Evaporation Ponds

The Project will include two evaporation ponds. The ponds will be designed in accordance with Lahontan Regional RWQCB requirements. The two 4-acre (total combined pond top area of 8 acres) evaporation ponds have an average proposed design depth of 7 feet, which incorporates the following:

- Drying each pond at alternating 4-year intervals;

- 3 feet of operational depth,
- 2 feet of residue build up over 4 years; and
- 2 feet of freeboard.

The containment design for the evaporation ponds, from the surface of the evaporation ponds downwards, consists of the following:

- A hard surface/protective layer;
- A primary 60-mil high density polyethylene (HDPE) liner;
- An interstitial leak detection system comprising a drainage layer and piping;
- A secondary 40-mil HDPE geomembrane liner;
- A 2-foot thick compacted silty-sand base; and
- A moisture detection system

The final grading contours for the evaporation ponds are shown on **Figure 2-2**. The design details of the evaporation ponds and cross sections are shown on **Figure 2-3A and 2-3B and Figure 2-4A and 2-4B**. **Table 2-1** lists the anticipated chemicals that wastewater may contain.

2.2 Closure Description Summary

RSPP proposes to clean-close the evaporation ponds after operational activities of the solar power plant permanently cease. Clean closure activities will consist of the removal of all improvements to within 3 feet of final grade followed by the restoration of lines and grades in the disturbed area of the Project site to match the natural gradients.

The strategy to close the Project will consist of the following measures:

- Conducting pre-closure activities such as final closure and restoration planning that addresses the “as-found” site conditions at the start of the Project;
- Demolishing the above-ground structures (dismantling and removing improvements and materials) in a phased approach while still using some items until close to the end of the Project;
- Demolishing and removing of below-ground facilities (underground utilities) as needed to meet the closure goals;
- Cleaning up of soils, if needed, with special attention applied to hazardous materials use/storage areas to ensure that clean closure is achieved;
- Disposing materials in appropriate facilities for treatment/disposal or recycling; and
- Re-contouring lines and grades to match the natural gradient and function.

3.0 Preliminary Post Closure Maintenance Plan

Closure of the waste facilities will involve the complete removal of the evaporation ponds. As such, the Post Closure Maintenance Plan consists of a post closure groundwater monitoring program. The post closure groundwater monitoring program will be a continuation of the detection monitoring program (DMP) and will involve analyzing groundwater samples from the same wells used in the DMP.

3.1 Groundwater Monitoring

Post closure groundwater monitoring will involve collecting groundwater samples from the existing wells shown on **Figure 3-1**. No new wells are proposed to be installed as part of the post closure groundwater monitoring program. Groundwater samples will be collected from wells that are adjacent to the evaporation ponds, and from wells near the upgradient and downgradient property boundaries.

Depth-to-water will be measured in each well and groundwater samples will be collected on a semi-annual basis (once every 6 months) using low-flow groundwater sampling techniques (see **Attachment B** for standard operating procedures). For each calendar year, groundwater samples for the first semi-annual monitoring event will be analyzed for the parameters listed on **Table 3-1**. Later in the year, the second semi-annual monitoring event will be referred to as the “Annual” monitoring event and groundwater from this event will be analyzed for the parameters shown on **Table 3-2**.

Each well will have a dedicated pump in it from which groundwater samples can be obtained. The pumps will be installed as part of the DMP. During the operational life of the Project, process water will be provided by the IWVWD:

3.2 Data Evaluation

Using approved statistical or non-statistical data analysis methods approved in Board Order No. 6-98-74, RSI will, for each monitoring event, compare the concentration of each monitoring parameter with its respective concentration limit to determine if groundwater has been impacted by constituents from the former evaporation ponds. Consistent with Title 22 CCR Section 66264.97(e), the groundwater monitoring report will include a graphical and statistical trend analysis of the groundwater monitoring data.

3.2.1 Graphical Analysis

Time series graphs of groundwater chemical data will be presented. Graphs will be at a scale appropriate to show trends or variations in water quality. Wells that have been primarily below detection limits for a given constituent will not be graphed.

Maps illustrating the groundwater flow direction and chemical data (e.g., chloride, nitrate as nitrogen, phosphate, sulfate, total dissolved solids, biphenyl oxide, and diphenyl oxide will be presented.

3.2.2 Statistical Trend Analysis

A trend is defined as the general increase or decrease in observed values of some variable over time. Trend analysis can be used to determine the significance of an apparent trend and to estimate the magnitude of that trend. The Mann Kendall trend test and the Sen's slope estimator were chosen to statistically analyze the data because they are the accepted non-parametric trend analysis methods for data that are not normally distributed.

Mann Kendall Trend Test. The test will be conducted on the groundwater data to evaluate the existence of significant trends. The Mann Kendall formula is as follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k)$$

The resulting statistic is the number of positive differences minus the number of negative differences. The statistics can be used to test the null hypothesis for the absence of a trend or the presence of a trend.

Sen's Slope Estimator. This simple procedure developed by Sen is used to estimate the slope or rate of change of the parameters in question. The advantage of this method over simple linear regression is that it is not greatly affected by gross data errors or outliers, and can even be computed when data are missing.

The N' individual slope estimates, Q, are computed for each time period:

$$Q = \frac{Xi'-Xi}{i' \quad i}$$

where

Xi' and Xi are data values at time i' and i, respectively
N' is the number of data pairs for which i'>i

The median of these N' values of Q is Sen's estimator of slope. N' is determined as follows:

$$N' = \frac{n(n-1)}{2}$$

If only one datum per time period exists, n is the number of time periods.

A value of one half of the detection limit will be substituted for Xi values below the detection limit.

The median of the N' slope estimates is obtained by ranking the values of Q from smallest to largest and computing as follows:

Sen's estimator= median slope

$Q_{(N'+1)/2}$ if N' is even

$1/2 \{Q_{(N'/2)} + Q_{[(N'+2)/2]}\}$ if N' is odd

4.0 Reporting

The "General Provisions for Monitoring and Reporting," dated September 1, 1994, will be followed for all submittals to the RWQCB.

4.1 Record Keeping and Reporting Documents

A post closure maintenance (monitoring) report will be submitted to the RWQCB on a semi-annual basis and will include the following:

- Results of sampling analysis, including statistical limits for each monitoring point;
- A description and graphical presentation of the velocity and direction of groundwater flow under/around the Project, based upon water level elevations taken during the collection of the water quality data submitted in the report;
- A map or aerial photograph showing the locations of observation stations, monitoring points, and background monitoring points; and
- A letter transmitting the essential points in each report, including a discussion of any permit excursions found since the last report was submitted and actions taken or planned for correcting those excursions. If a detailed time schedule for correcting permit excursions has been previously submitted, a reference to the correspondence transmitting this schedule will be satisfactory. If no excursions have occurred since the last submittal, this will be stated in the letter of transmittal.

4.2 Submittal Periods

4.2.1 Semi-Annual Monitoring Report

A semi-annual monitoring report including the previously described information will be submitted to the RWQCB. Subsequent semi-annual monitoring reports will be submitted to the RWQCB by April 30 and October 31 of each year for the 30-year period following final closure of the two evaporation ponds.

4.2.2 Annual Report

By October 31 of each year, an Annual Report to the RWQCB will be submitted and will include tables detailing the historic data as well as describing the specific monitoring activities conducted between January and December of the previous year. The annual report will be signed by a California-registered geologist or professional civil engineer. The signature page will contain his or her license number.

Consistent with Title 27 CCR Chapter 3, Subchapter 3, Section 20420, the semi-annual and annual groundwater monitoring reports will include a graphical and statistical trend analysis of the groundwater monitoring data, a groundwater contour map showing the direction of flow, and certified analytical reports from the laboratory.

5.0 Additional Information

5.1 Financial Responsibility

The waste management unit (i.e., two evaporation ponds) is considered Class II. At Class II units for which the CIWMB does not require a closure fund, the RWQCB requires the establishment of an irrevocable closure fund (or provide other means) pursuant to the CIWMB-promulgated sections of Title 27, Chapter 6 but with the RWQCB named as beneficiary, to ensure closure of each classified unit in accordance with an approved plan meeting all applicable State Water Resources Control Board-promulgated requirements of Title 27, Chapter 6, Subchapter 2.

5.2 Cost Analysis

As discussed in Section 1.1 of this document, the plan is to clean-close the evaporation ponds once the operational activities at the Project permanently cease. Successful completion of clean closure would eliminate the need for any post closure maintenance period (Title 27 CCR Chapter 3, Subchapter 5, section 20950).

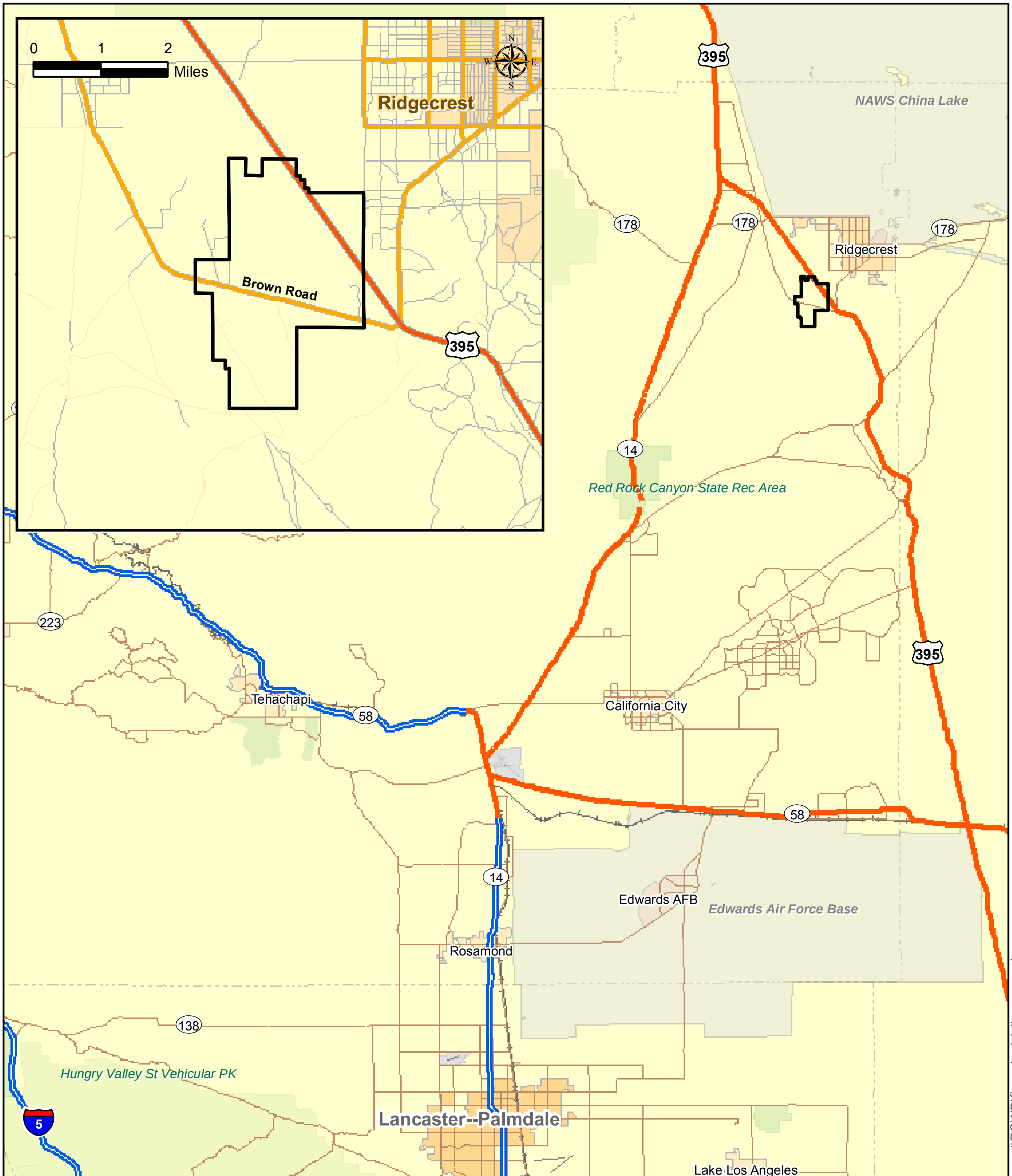
This section provides an estimate of the cost to develop the final Post Closure Maintenance Plan and to carry out the first 30 years of post closure maintenance pursuant to Title 27 CCR Chapter 3, Subchapter 5, Section 20950 in the event that implementation of a post closure maintenance plan becomes necessary.

A detailed cost estimate for post closure maintenance for the evaporation ponds is provided in **Attachment A**. The total estimated cost for post closure maintenance of the two evaporation ponds is $**671,500.** A letter of credit will be used to demonstrate financial assurance for the post closure costs.

5.3 Post Closure Schedule

A final post closure maintenance schedule will be determined at a future date under separate cover of the Final Post closure Maintenance Plan.

Figures



Map Location

0 5 10
Miles

Ridgecrest Solar Power Plant

Figure 1-1
Regional Location and Vicinity Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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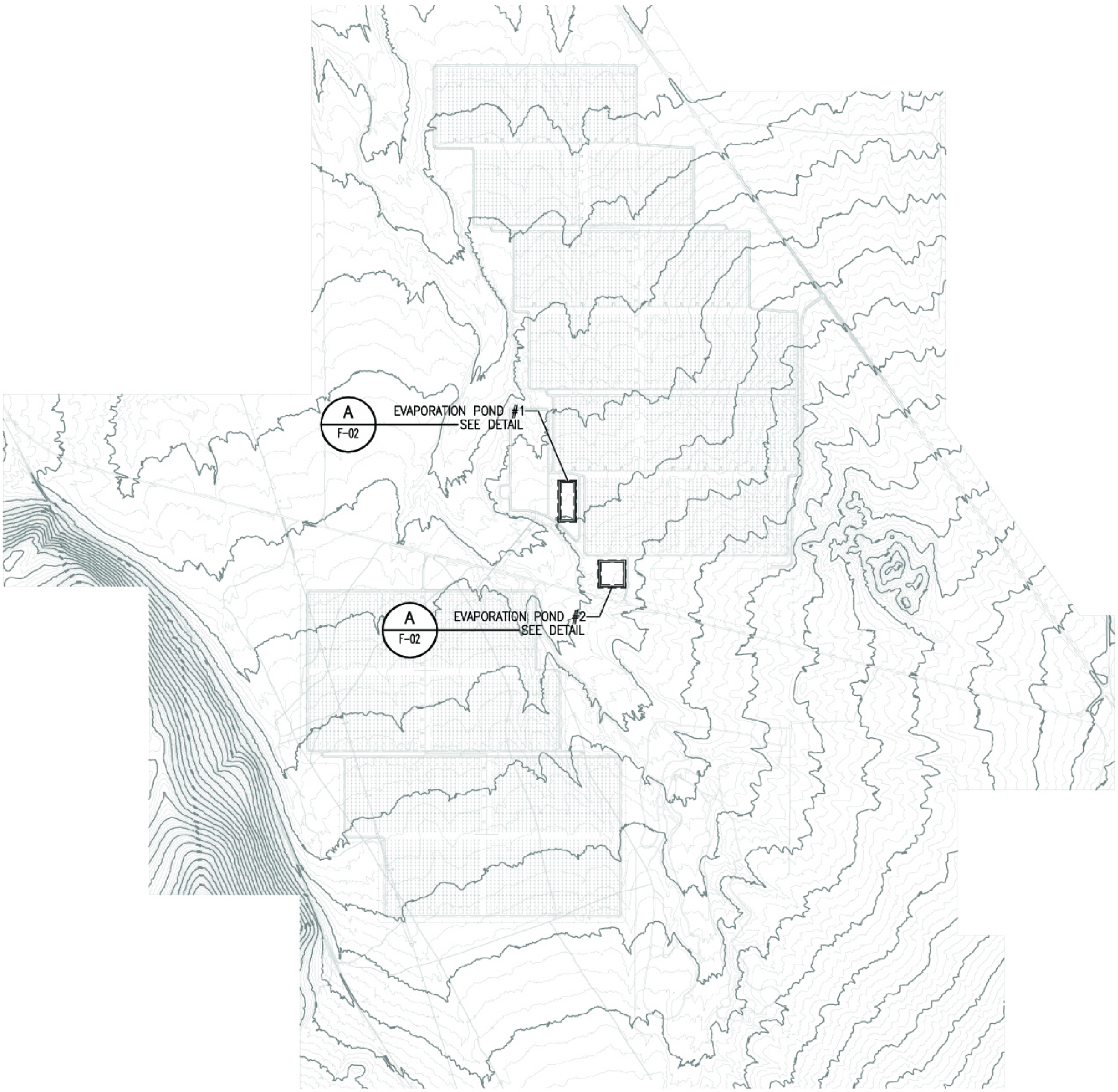

Map Location

Ridgecrest Solar Power Project

Figure 1-2
General Arrangement Site Plan

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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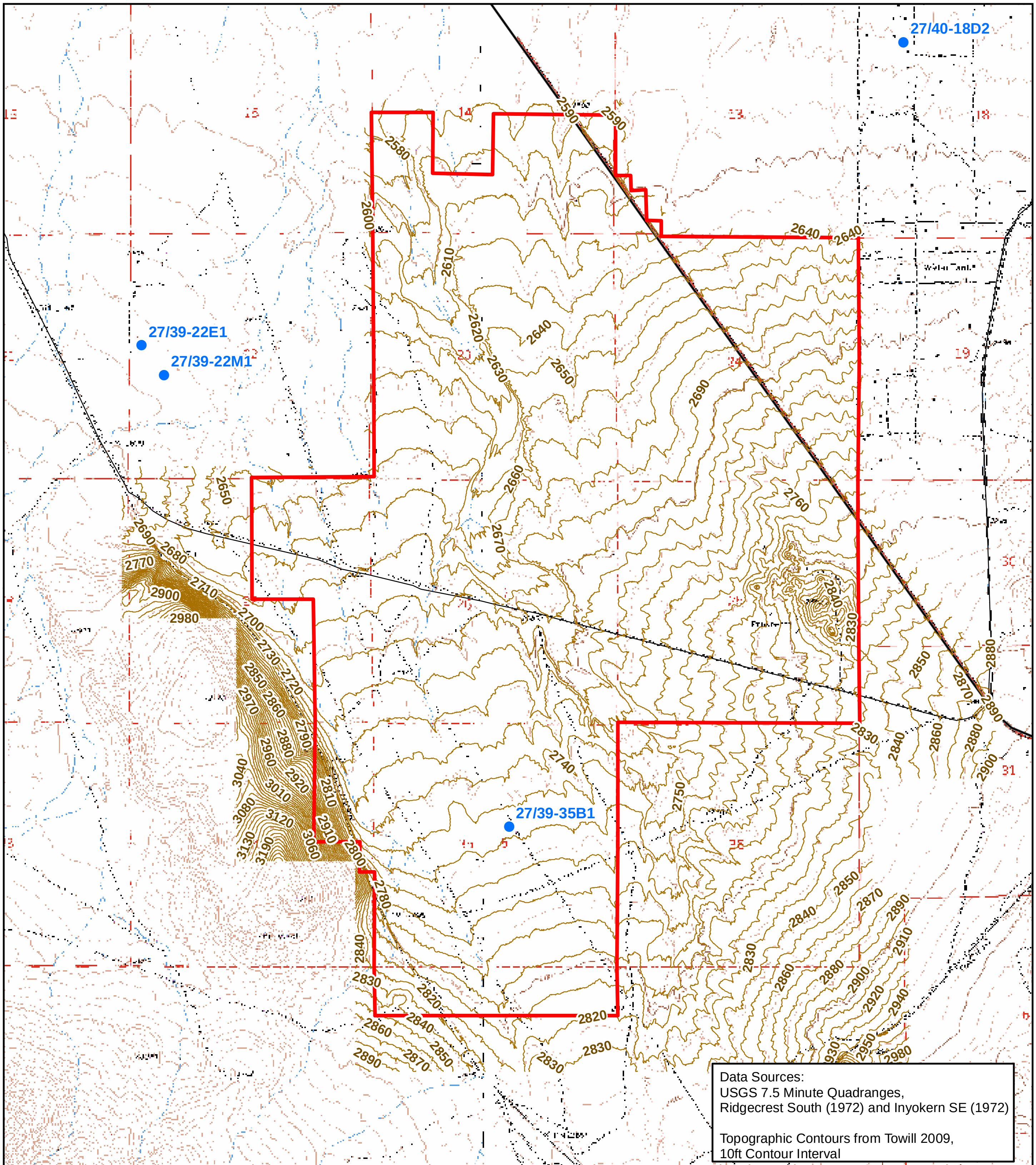


Map Location

Legend

Project Right-of-Way

Groundwater Well Location based on Latitude and Longitude in USGS Database

0 3,000 6,000 Feet

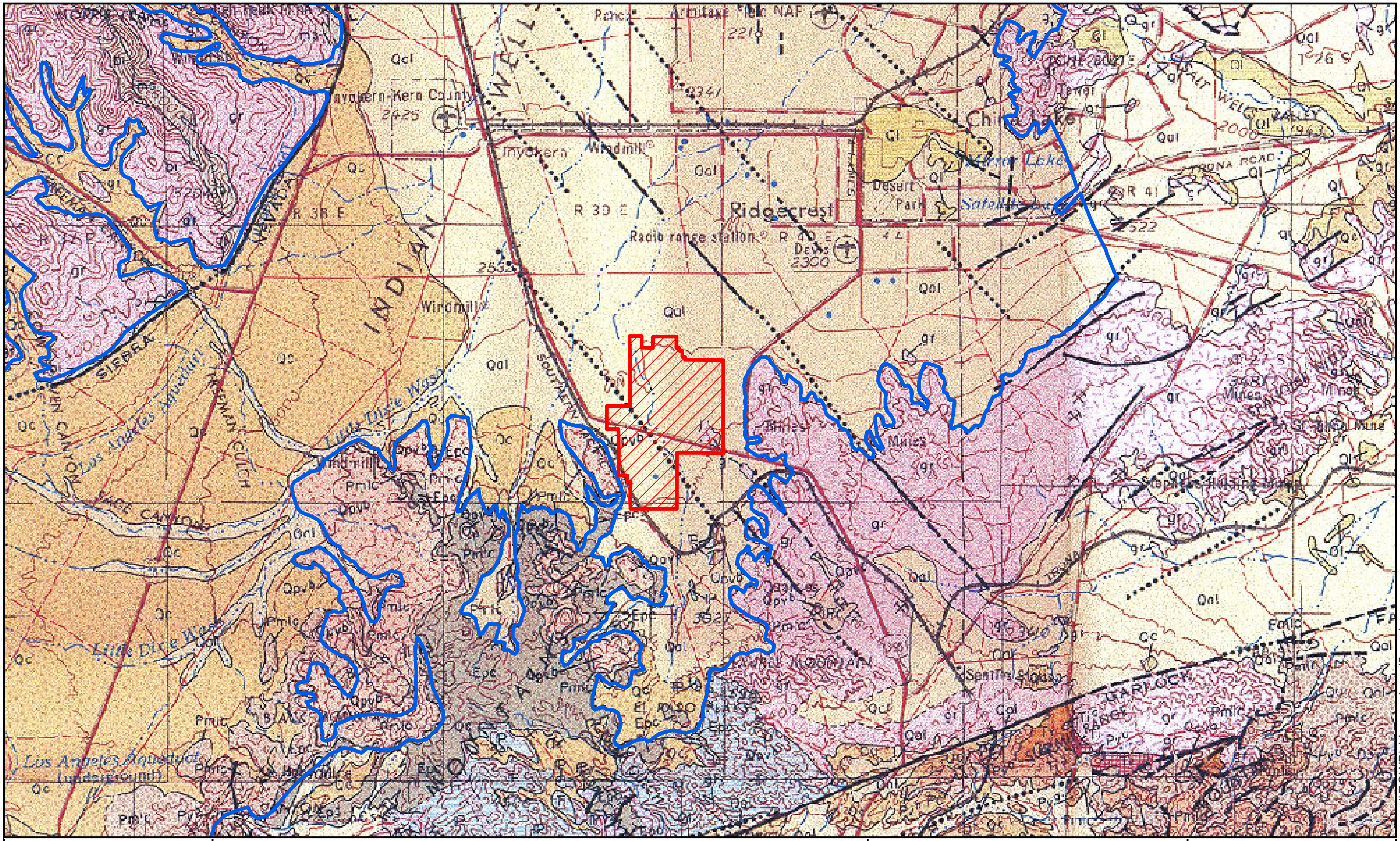
Ridgecrest Solar Power Plant

Figure 1-3
Site Topographic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010



Map Location

Legend

Project Right-of-Way

Indian Wells Valley Groundwater Basin

See Figure 1-4b for Geologic Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona Sheet, Scale 1:250,000, 1963

1 in = 3 miles

0 3 6 Miles

N S E W

Ridgecrest Solar Power Plant

Figure 1-4a
Regional Geologic Map

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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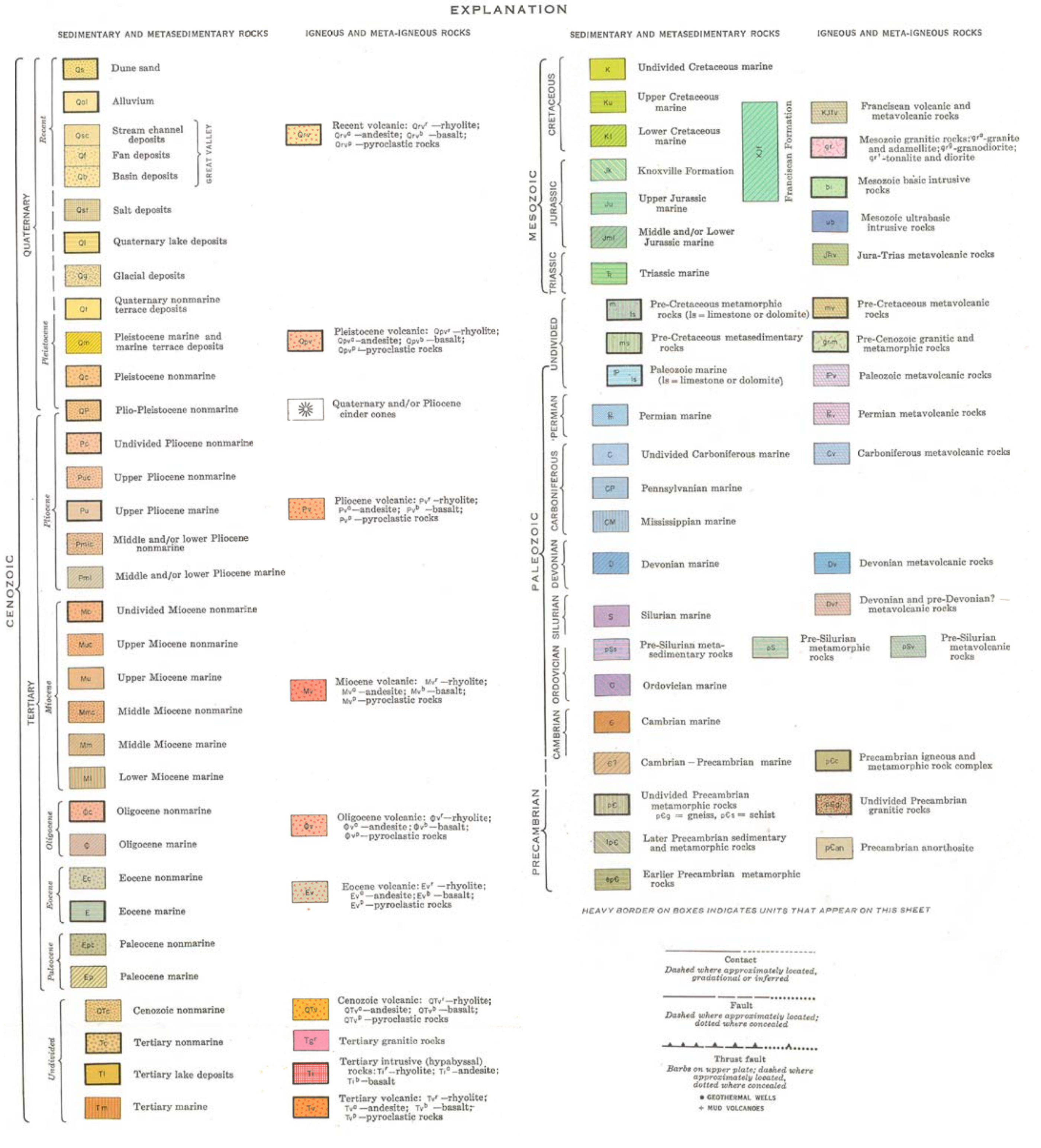

Map Location

Legend

Sources:
Division of Mines and Geology, Geologic Map of California, Trona, Scale 1:250,000, 1963

Ridgecrest Solar Power Project

Figure 1-4b Regional Geologic Map Legend

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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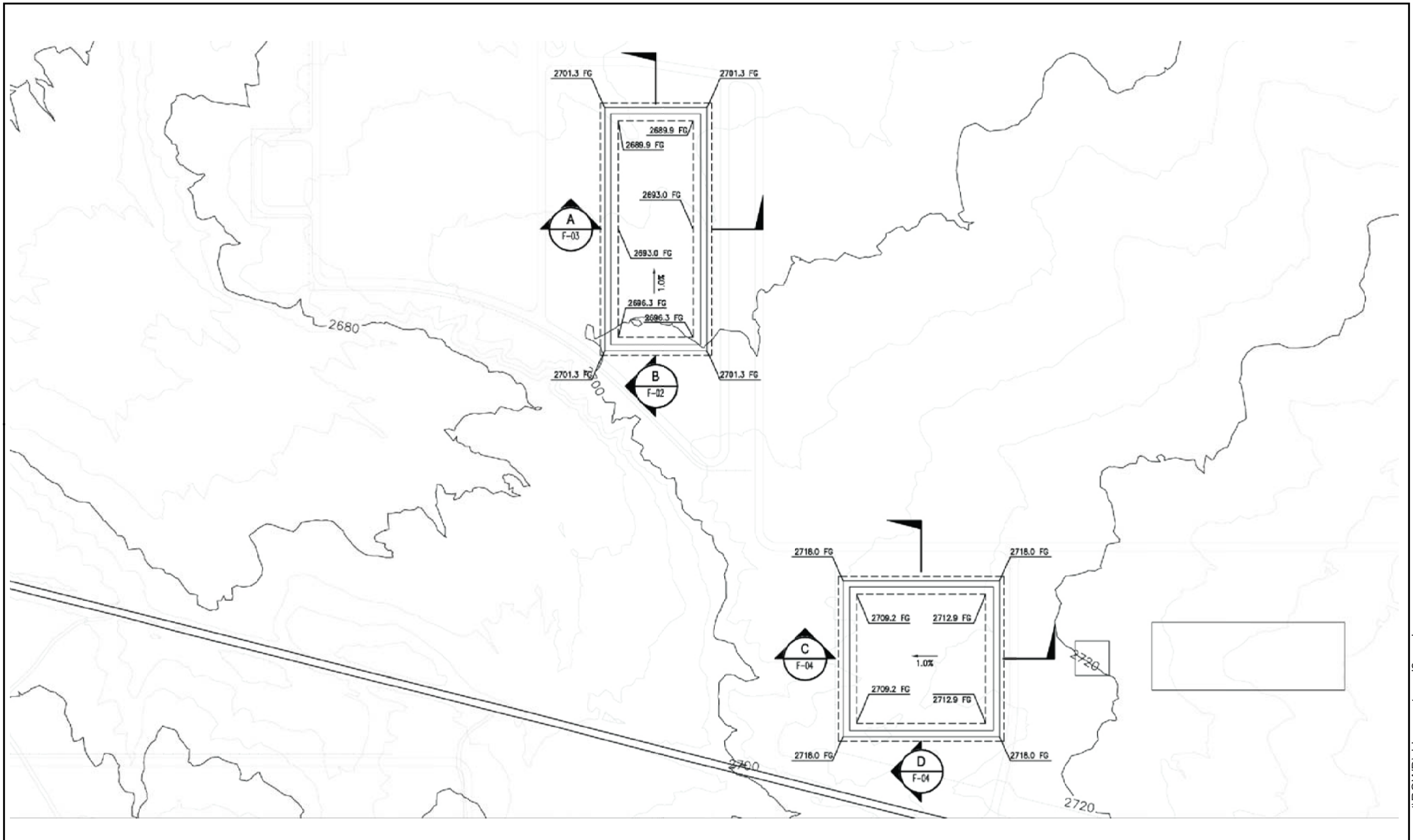

Map Location

Ridgecrest Solar Power Plant

Figure 2-1
Evaporation Pond Drainage and Grading Plan

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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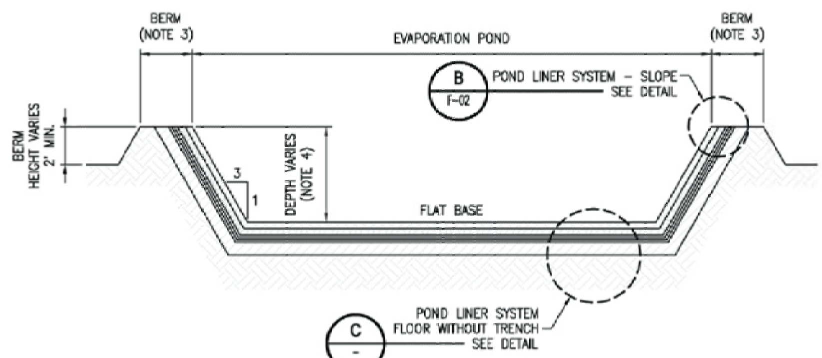
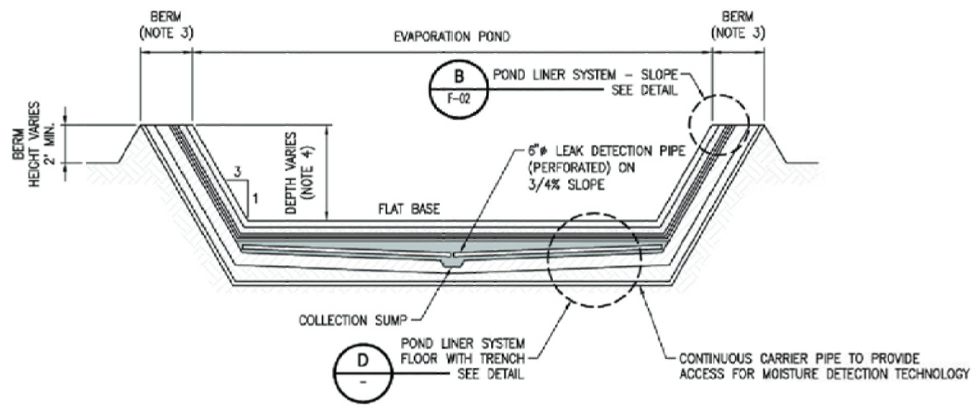


POND - UPSTREAM CROSS SECTION

A
-

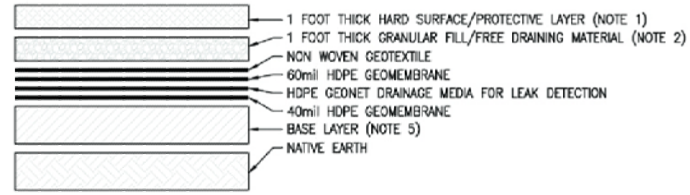
SCALE: N.T.S.



POND - DOWNSTREAM CROSS SECTION

B
-

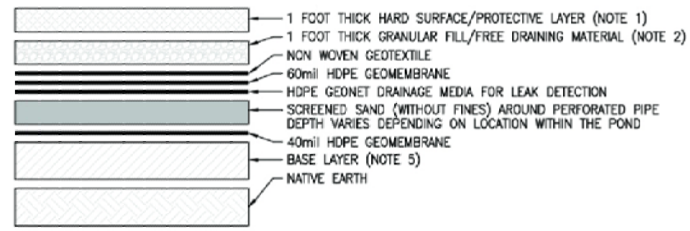
SCALE: N.T.S.



POND LINER SYSTEM DETAIL
FLOOR TRENCH

C
-

SCALE: N.T.S.



POND LINER SYSTEM DETAIL
FLOOR WITHOUT TRENCH

D
-

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10-6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 2-2a
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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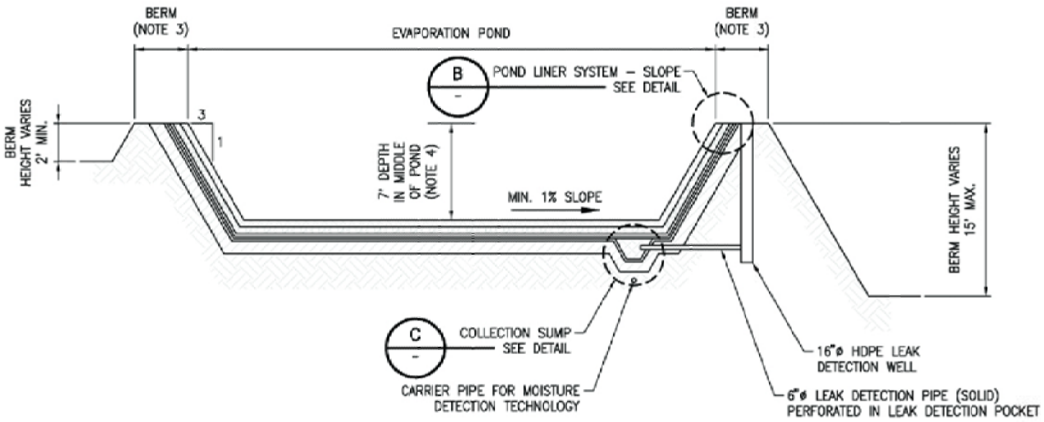
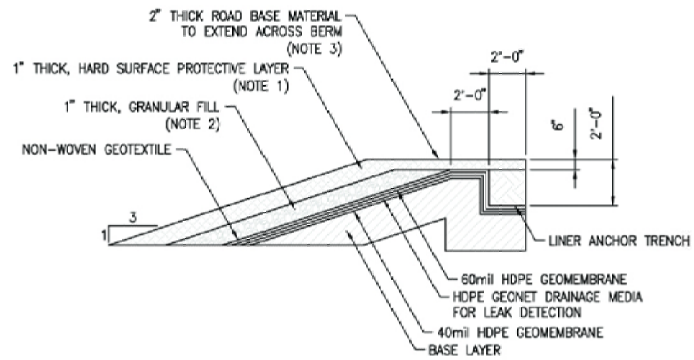


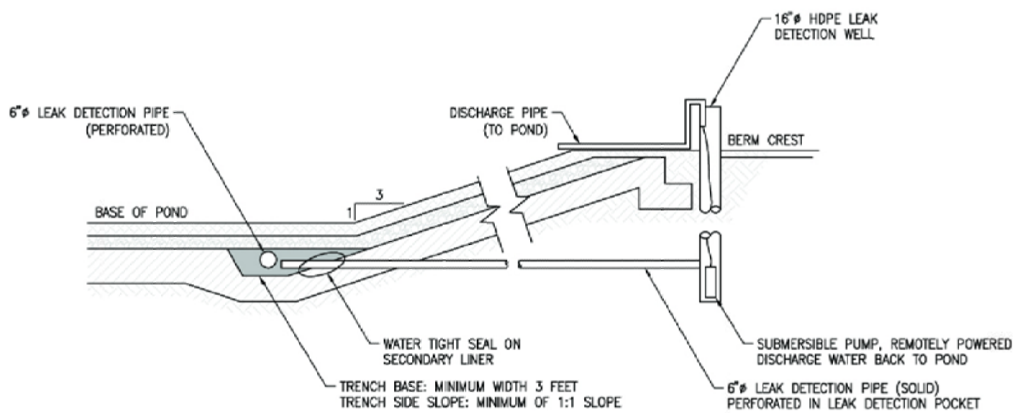
CROSS SECTION THROUGH THE MIDDLE OF THE PONDS (A)

SCALE: N.T.S.



POND LINER SYSYTEM - SLOPES (B)

SCALE: N.T.S.



COLLECTION SUMP DETAIL (C)

SCALE: N.T.S.

NOTE:

1. HARD SURFACE/PROTECTION LAYER TO BE 1 FOOT OF ROLLER COMPACTED CONCRETE OR APPROVED EQUIVALENT.
2. GRANULAR FILL/FREE DRAINING SUB BASE MUST HAVE MAXIMUM PARTICLE SIZE OF 1/2 INCH.
3. BERM IS A MINIMUM OF 12 FEET WIDE AND MAXIMUM OF 18 FEET WIDE. BERM IS COVERED BY A MINIMUM OF 6 INCHES OF ROADBASE MATERIAL.
4. AVERAGE POND DEPTH OF 7 FEET ALLOWS FOR 2 FEET OF FREEBOARD, 3 FEET OF OPERATIONAL DEPTH AND 2 FEET OF SLUDGE ACCUMULATION. MINIMUM 1% SLOPE ACROSS POND BASE, THEREFORE UPSTREAM END OF POND WILL HAVE A DEPTH OD LESS THAN 7 FEET AND DOWNSTREAM END OF POND WILL HAVE A DEPTH OF MORE THAN 7 FEET.
5. BASE LAYER: PREFERRED MATERIAL IS 2 FOOT OF AN SITE MATERIAL WITH HYDRAULIC CONDUCTIVITY OF LESS THAN 1 X 10-6 CM/S, OF WHICH AT LEAST 30% OF THE MATERIAL SHALL PASS THROUGH A NO. 200 U.S. STANDARD SIEVE. IF THIS MATERIAL IS NOT AVAILABLE, THE ALTERNATIVE DESIGN IS A GEOSYTHENTIC CLAY LINER (GCL).
6. SEE TEXT FOR FURTHER DETAILS.

Map Location

Ridgecrest Solar Power Plant

Figure 2-2b
Evaporation Pond Section and Details

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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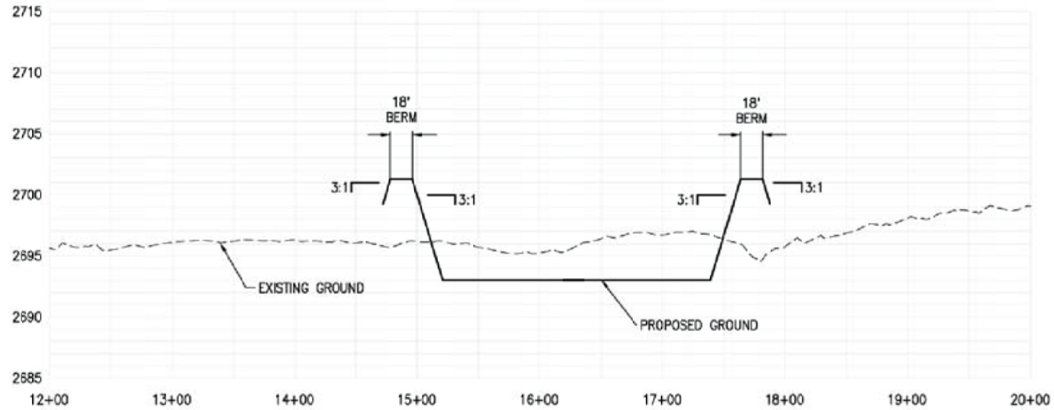
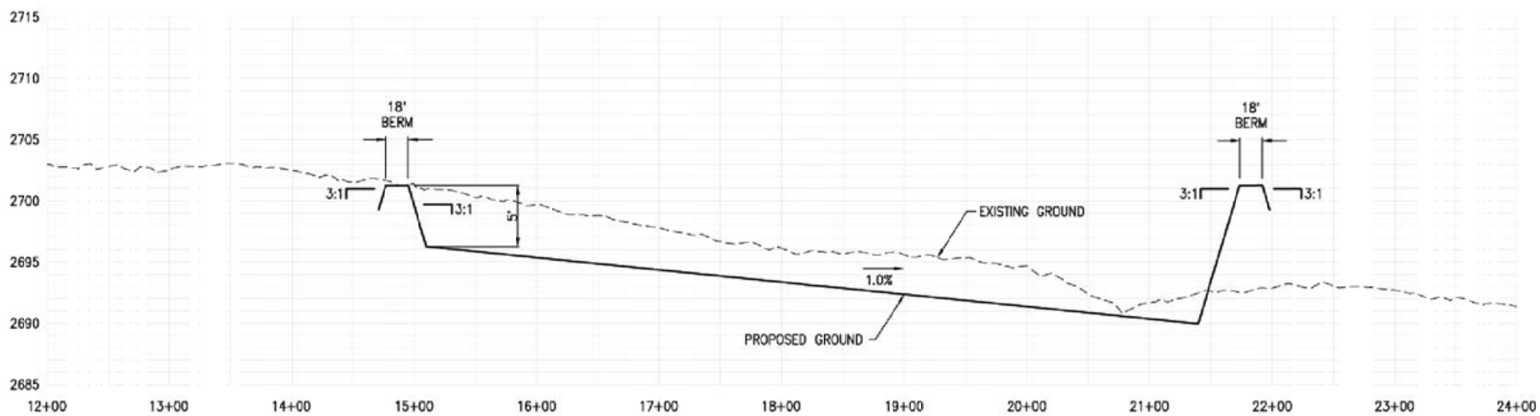


CROSS SECTION A
SCALE: NONE



CROSS SECTION B
SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 2-3a
Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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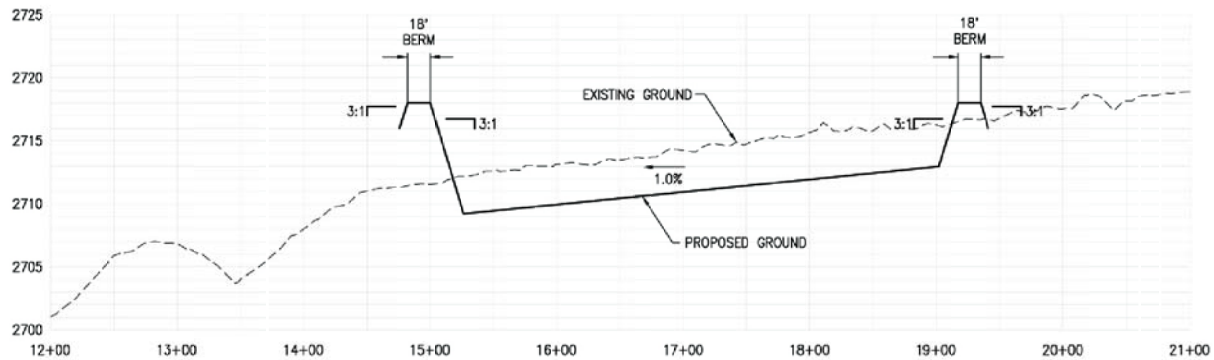
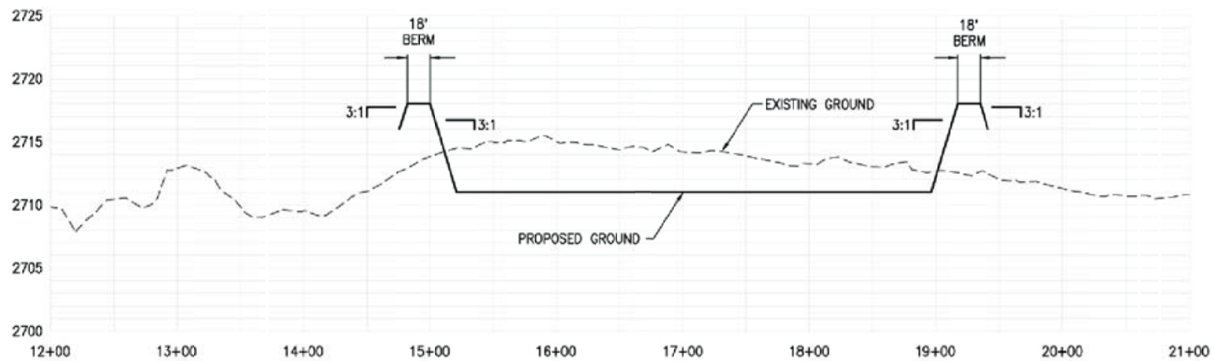


CROSS SECTION C

SCALE: NONE



CROSS SECTION D

SCALE: NONE

Map Location

Ridgecrest Solar Power Plant

Figure 2-3b
Evaporation Pond Cross Section

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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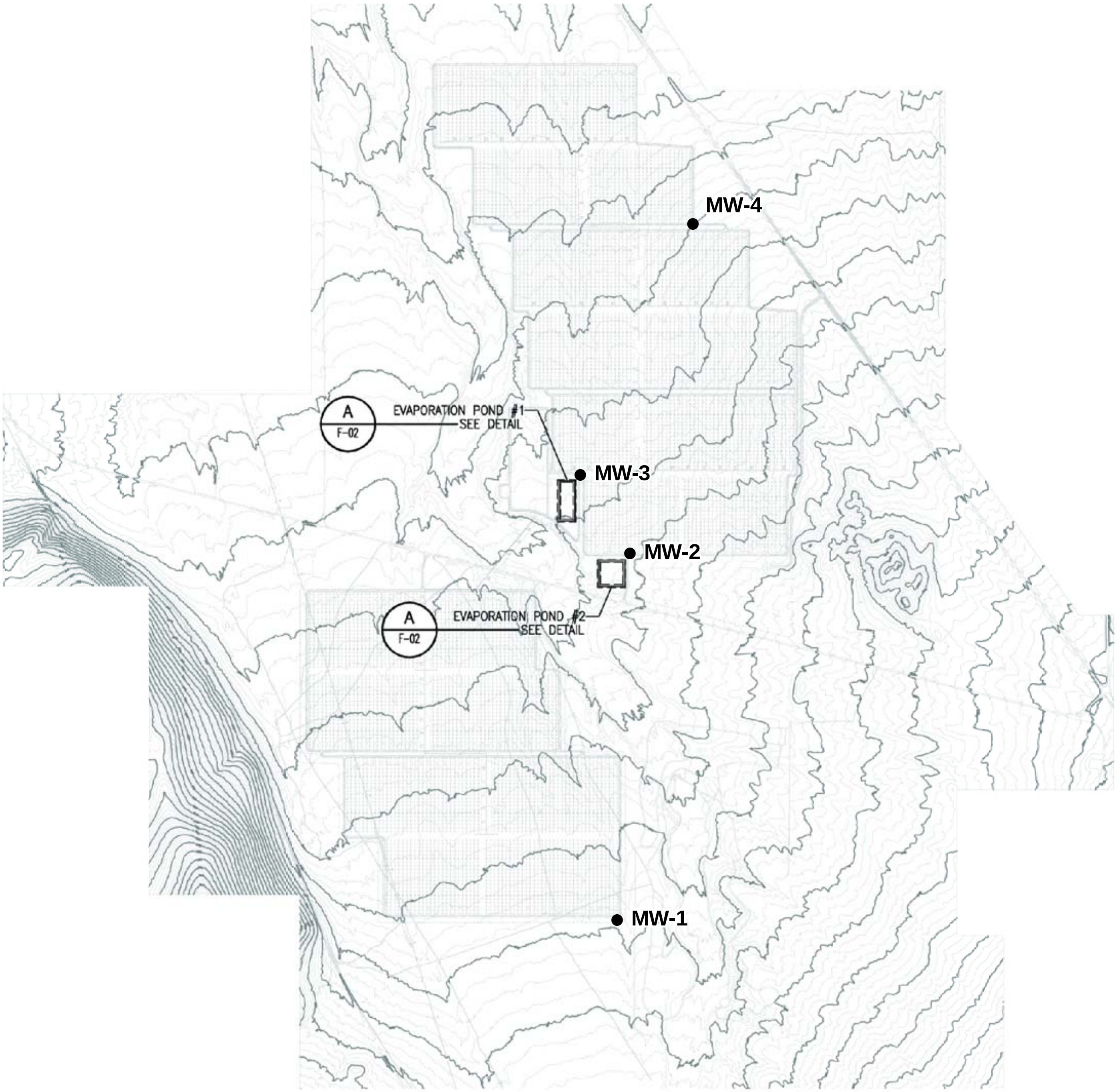

Map Location

● Prposed Location of Monitoirng Well

Ridgecrest Solar Power Project

Figure 3-1 Proposed GMN Monitoring Well Locations

Ridgecrest Solar I, LLC

AECOM

Project: 60139696
Date: June 2010

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Tables

Table 2-1 Raw Water Quality and Estimated Chemistry of Wastewater Streams

	Supply Water[1]	Wastewater to Evaporation Pond[2]	STCL[3]	TCLP[4]
24-Average Flow Rate (GPM)	63	8.748	---	---
Peak Operation Flow Rate (GPM)	97	14.636	---	---
Constituent	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Cations				
Calcium	37	39	---	---
Magnesium	5.4	12	---	---
Sodium	44	767	---	---
Potassium	4	10	---	---
Ammonia	<ND	0		
Anions				
Alkinity	117	77	---	---
Sulfate	44	111	---	---
Chloride	86	1,045	---	---
Nitrate	8	19	---	---
Cyanide	ND	0		
Silica	42	24	---	---
General Water Quality				
Bicarbonate	143	94	---	---
Carbonate	ND	0	---	---
TDS	287	2,124	---	---
Total Hardness ($CaC0_3$)	115	121		
Phosphate	ND	0	---	---
Fluoride	0.8	19	180	---
Barium	0.00028	1	100	---
Iron	ND	0	---	---
Total Suspended Solids	0	12	---	---
Biological Oxygen Demand			---	---
Trace Metals				
Boron	ND	0	--	--

Cadmium	ND	0	1.0	
Copper	ND	0	25	--
Lead	0.0007	0	5.0	
Molybdenum	ND	0	350	--
Selenium	ND	0	1.0	
Thallium	0.014		7.0	
Vanadium	0.000022	0.17	24	--
Zinc	ND	0	250	--

1 - Water quality data from AFC Table Water 4, AECOM, 2009
2 - Water Quality data from AECOM Evaporation Pond Preliminary Design, Operations and Maintenance Plan, April 2010
3 - STLC = Soluble Threshold Limit Concentration, Regulated by CCR Title 22, Division 4.5, Article 3, Section 66261.24
4 - TCLP = Toxicity Characteristics Leaching Procedure; Regulate under 40 CFR Section 261.24

Table 3-1 Groundwater Sample Analytical Parameters – Semi-Annual Monitoring

Parameter	U.S. EPA or Standard Method	RL Goal	Units
Chloride	300.0	14,000	µg/L
Nitrate as Nitrogen	300.0	1,000	µg/L
Phosphate (total)	365.3	100	µg/L
Sulfate	300.0	100,000	µg/L
TDS	SM 2450C	10,000	µg/L
Biphenyl Oxide	8015M	1,000	µg/L
Diphenyl Oxide	8015M	1,000	µg/L
Static Water Depth	Field	+/- 0.1	feet bgs
pH reading	Field	+/- 0.1	pH units
Temperature	Field	+/- 0.1	°F or °C

Key:

µg/L – micrograms per liter
RL – reporting limit
SM – Standard Method

Note: If turbidity exceeds 10 NTU, groundwater samples will be field filtered and both the unfiltered and filtered groundwater samples will be submitted to the laboratory for metals and TDS analysis.

Table 3-2 Groundwater Sample Analytical Parameters – Annual Monitoring

Parameter	U.S. EPA or Standard Method	RL Goal	Units
Ammonia (as N)	350.1	100	µg/L
Aluminum	200.7	20	µg/L
Arsenic	6020	2.0	µg/L
Boron	200.7	140	µg/L
Calcium	200.7	40,000	µg/L
Chloride	300.0	14,000	µg/L
Cyanide (total)	SM 4500	10	µg/L
Fluoride	300.0	500	µg/L
Iron	200.7	20	µg/L
Magnesium	200.7	10,000	µg/L
Manganese	200.7	15	µg/L
Molybdenum	6020	10.00	µg/L
Nitrate as Nitrogen	300.0	1,000	µg/L
Nitrite as Nitrogen	SM 4500	4	µg/L
Potassium	200.7	3,000	µg/L
Phosphate (total)	365.3	100	µg/L
Selenium	6020	0.5	µg/L
Silica (as SiO2)	200.7	1,000	µg/L
Silicon (as Si)	200.7	1,000	µg/L
Sodium	200.7	10,000	µg/L
Strontium	200.7	500	µg/L
Sulfate	300.0	100,000	µg/L
TDS	SM 2540C	10,000	µg/L
Total Alkalinity (as $CaCO_3$)	SM 2320B	100,000	µg/L
Zinc	6020	10	µg/L
Biphenyl Oxide	8015M	500	µg/L
Diphenyl Oxide	8015M	500	µg/L
Cyclohexamine (20-40%)	8015M	500	µg/L
Morpholine (1-10%)	8015M	500	µg/L
pH reading	Field	+/- 0.1	pH units

Table 3-2 Groundwater Sample Analytical Parameters – Annual Monitoring

Parameter	U.S. EPA or Standard Method	RL Goal	Units
Temperature	Field	+/- 0.1	°F or °C
Nalco 3D Trasar 177	Hand-Held Fluorometer	na	na
Nalco 3D Trasar 190	Hand-Held Fluorometer	na	na

Key:

$CaCO_3$ - calcium carbonate
μg/L – micrograms per liter
RL – reporting limit
SM – Standard Method
na – not applicable

Note: If turbidity exceeds 10 NTU, groundwater samples will be field filtered and both the unfiltered and filtered groundwater samples will be submitted to the laboratory for metals and TDS analysis.

Attachment A

Cost Estimate

Sequence of Post Closure Groundwater Monitoring

1. Collect groundwater samples from 4 monitoring wells.
2. Laboratory Costs for 4 groundwater samples. Present Day Costs not Present Value
3. Reporting of groundwater monitoring results.
4. Monitoring of 4 groundwater wells for 30 year period.

		Unit Cost	Unit Quantity	Unit Number	Cost	Reference
1. Collect Groundwater Samples from 10 Wells						
Mobilization	T&M	$1,200	1	1	$1,200	Lodging, Per Diem, and car rental
Rental Equipment (flow meter, water quality meter, water level meter, QED 4100 LH Compressor)	LS	$1,250	1	1	$1,250	Equipco Rentals (2009)
Disposal	each	$600	1	1	$600	Transportation and Disposal of Non-hazardous purge water.
Sampling	each	$4,000	1	1	$4,000	AECOM Estimate
				Total	**$7,050**	
2. Laboratory Costs for 4 Groundwater Samples						
Laboratory Analysis	each	$1,500	4	1	$6,000	AECOM Estimate
				Total	**$6,000**	
3. Reporting of Groundwater Monitoring Results						
Report Preparation	each	$12,000	1	1	$6,000	AECOM Estimate
				Total	**$6,000**	
4. Monitoring of 4 Groundwater Wells for 30-Year Period						
Groundwater Sample Collection	each	$7,050	30	1	$211,500	AECOM Estimate
Laboratory Analysis	each	$6,000	30	1	$180,000	AECOM Estimate
Report Preparation	each	$6,000	30	1	$180,000	AECOM Estimate
				Total	**$571,500**	

5. Operation & Maintenance Over 30-Year Period						
Period refurbishing/replacing monitoring well and dedicated pump	lump sum	$100,000	1	1	$100,000	AECOM Estimate
				Total	**$100,000**	
Subtotal Field Activities Costs					**$671,500**	
Contingency	(0% of All of the Above Costs)				$0	
				Total	**$671,500**	
Total Field Activities Costs					**$671,500**	
Engineering and Oversite						
				TOTAL COST	**$671,500**	

Attachment B

Standard Operating Procedures for Field Work

STANDARD OPERATING PROCEDURES

SOP-01

DRILLING METHODS

STANDARD OPERATING PROCEDURES

SOP-1
DRILLING METHODS

TABLE OF CONTENTS

Section **Page**

DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

Drilling is a common activity associated with many phases of environmental investigations. A variety of drilling methods can be used to collect site data during investigations and studies, and to install vapor extraction or water wells associated with remedial actions, treatability studies, or pilot studies.

Field investigations usually require invasive activities to gather information for site evaluation. The investigation may require a borehole to facilitate the collection and subsequent analysis of soil and/or groundwater samples. The borehole is often converted into a well for evaluating vapor or groundwater conditions over a longer period of time. In addition to the collection of samples for analyses, other data, such as sediment or rock classification; the presence of contamination; geophysical, geotechnical, or physical parameters of the sediment or rock; and the occurrence of groundwater, can be obtained from boreholes.

To determine the most appropriate drilling method for investigations or studies, primary consideration must be given to obtaining samples that are representative of existing conditions and are valid for chemical analysis. The samples must not be contaminated or adversely affected by the drilling method.

Drilling associated with remedial actions, pilot studies, or treatability studies may include the installation of vapor or water extraction and/or injection wells. In selecting the most appropriate drilling method for these projects, primary consideration must be given to completion of a well that will perform as designed.

This Standard Operating Procedure (SOP) describes the principles of operation and the applicability and implementability of standard drilling methods used during field investigations. The purpose of this document is to aid in the selection of appropriate drilling methods for site-specific conditions. This SOP is intended to be used by the Project Manager (PM), Project Engineer (PE), Field Team Leader (FTL), and site hydrogeologist or geologist (of which a minimum of one must be a qualified Nevada Certified Environmental Manager [C.E.M.]) to develop an understanding of each drilling method sufficient to plan, schedule, and perform the activities associated with drilling.

This SOP focuses on methods and equipment that are readily available and typically applied. It is not intended to provide a comprehensive discussion of drilling methods. Two general drilling methods are discussed: (1) methods that do not use circulating fluids; and (2) methods requiring the circulation of drilling fluids to transport cuttings to the surface. More specific drilling methods or techniques can be researched, as necessary, by contacting a drilling subcontractor and learning about the specific methodology that may be most beneficial to implement.

2.0 DEFINITIONS

Bailer	A cylindrical tool designed to remove material, both solid and liquid, from a well or borehole. A valve, which can be a ball or flap, at the bottom of the bailer retains the material in the bailer. There are four types of bailers: ball-valve, flat-valve, dart-valve, and the sand pump with rod plunger.
Cone Penetrometer	An instrument used to determine and evaluate subsurface conditions by measuring the ratio of cone tip resistance to sleeve friction, and then comparing that ratio to a standardized set of ratios. The cone penetrometer can be fitted with other instruments that are able to determine pore pressure (the presence of groundwater), to detect contamination and identify the contaminant, and to determine other physical parameters of the sediment. The cone penetrometer consists of a conical point attached to a drive rod of smaller diameter. Penetration of the cone into the formation forces the soil aside, creating a complex shear failure. The cone penetrometer is very sensitive to small differences in soil consistency.
Cuttings	As a borehole is drilled, the subsurface material displaced by drilling and brought to the surface.
Drilling Fluids or Muds	A water-based or air-based fluid used in the well drilling operation to remove cuttings from the borehole, to clean and cool the bit, to reduce friction between the drill string and the sides of the borehole, to stabilize borehole walls, and to seal the borehole.
Dual-Purpose Well	A well that can be used as both a monitoring and extraction or injection well.
Flight	An individual auger section, usually 5 feet in length.
Heaving Formation	Unconsolidated, saturated substrate encountered during drilling where the hydrostatic pressure of the formation is greater than the borehole pressure causing the sands to move up into the borehole, and frequently causing drilling or well installation complications. Clean water or drilling muds may need to be introduced into the borehole to minimize or eliminate the potential for heaving.
Kelly Bar	A hollow steel bar or pipe that is the main section of drill string to which the power is directly transmitted from the rotary table to rotate the drill pipe and bit. The cross section of the kelly is either square, hexagonal, or grooved. The kelly works up and down through drive bushings in the rotary table.
Pitch	The distance along the axis of an auger flight that it takes for the helix to make one complete 360-degree turn.
Rotary Table	A mechanical or hydraulic assembly that transmits rotational torque to the kelly, which is connected to the drill pipe and the bit. The rotary table has a hole in the center through which the kelly passes.
Split-Spoon Sampler	A thick-walled, typically 18-inch long steel tube split lengthwise and used to collect soil samples. The sampler is commonly lined with brass or

	stainless steel sample sleeves and is driven or pushed downhole by the drill rig to collect samples.
Thin-Walled Sampler	A sampling devise used to obtain undisturbed soil samples made from thin-wall tubing. The sampler is also known as a Shelby tube. The thin-wall sampler minimizes the most serious sources of disturbance: displacement and friction.

3.0 RESPONSIBILITIES

The **Project Manager** or **Task Leader** will select site-specific drilling methods, with input from the FTL and Site Hydrogeologist or Geologist, and will maintain close supervision of the activities and progress.

The **Site Hydrogeologist** (a California licensed Professional Geologist (P.G)) selects site-specific drilling options and assists in the preparation of technical provisions of drilling procedures and details.

The **Field Team Leader** implements the selected drilling program and assists in the selection of drilling methods.

4.0 DRILLING METHODS

Drilling methods can be separated into two general types: techniques that use circulating fluids and techniques that do not use circulating fluids. The following section discusses the drilling methods that fall into these two general categories.

4.1 Methods Without Circulating Fluids

There are two drilling methods that do not require circulating fluids: augering and percussion drilling. SOPs for each of these methods are described below.

4.1.1 Augering

Auger drilling is accomplished by rotating a pipe or rod that has a cutting bit. The common auger drilling methods discussed in this section are hand, continuous-flight, hollow-stem, and bucket.

4.1.1.1 Hand Auger

A hand auger typically cuts a hole 2 to 9 inches in diameter and, depending on the geologic materials, may be advanced to about 15 or 20 feet. Generally, the borehole cannot be advanced below the water table because the hole collapses. Soil samples for chemical or geotechnical analyses should not be collected directly from a hand auger because the samples are disturbed and cross contamination may occur. Samples for chemical or geotechnical analyses should be taken with a sampling tool such as a drive sampler driven at the desired depth. Samples for lithologic logging purposes may be taken directly from the auger.

Applications

- Shallow soil investigations
- Requires minimal access
- Soil sample collection
- Water-bearing zone identification

Limitations

- Limited to shallow depths
- Unable to penetrate dense or rocky soil
- Borehole stability difficult to maintain
- Labor intensive

4.1.1.2 Continuous-Flight Auger

Continuous-flight augers consist of a plugged, tubular steel center shaft around which a continuous steel strip, in the form of a helix, is welded. An individual auger is known as a "flight" and is generally 5 feet long. Auger drill heads are generally designed to cut a hole 10 percent greater in diameter than the actual diameter of the auger they serve. In addition to diameter, augers are specified by the pitch of the auger and the shape and dimension of the connections.

Applications

- Shallow soils investigations
- Soil sample collection
- Vadose zone monitoring wells
- Groundwater monitoring wells in saturated, stable soils
- Identification of depth to bedrock
- Fast and mobile

Limitations

- Soil sampling difficult and limited to areas of stable soils
- Difficult to build monitoring wells in unstable soils
- Depth capability decreases as diameter of auger increases
- Monitoring well diameter limited by auger diameter

4.1.1.3 Hollow-Stem Auger

Hollow-stem augers are commonly used in unconsolidated materials to depths of approximately 150 feet. An advantage of this drilling method is that undisturbed soil samples can be collected and the augers act as a temporary outer casing when installing a monitoring well.

Hollow-stem augers are generally made of two pieces: an annular outer head attached to the bottom of the lead auger and an inner pilot or center bit mounted in a plug that is removable from the center of the auger to the surface. The removable inner plug is the primary advantage of this drilling method. Withdrawing the plug while leaving the auger in place provides an open, cased hole into which samplers, down-hole drive hammers, instruments, casing, wire, pipe, or numerous other items can be inserted. Replacing the center bit and plug allows for continuation of the borehole.

Hollow-stem augers are specified by the inside diameter of the hollow stem, not by the hole size it drills. Hollow-stem augers are available with inside diameters of 2.5, 3.25, 3.375, 4.0, 4.25, 6.25, 6.625, 8.25, and 10.25 inches. The larger diameter augers, 8.25 and 10.25 inches, are not generally used for monitoring well installation, although they have been used for the installation of dual-purpose wells.

The rotation of the augers causes the cuttings to move upward and “smear” along the borehole walls. This smearing may effectively seal off the upper zones, thereby reducing the possibility of cross contamination of the upper zones to the deeper zones, but increases the possibility of deep to shallow contamination. However, this is not a method that is used for the purpose of sealing a borehole.

Drilling speed with hollow-stem augers is dependent upon the types of materials encountered. Heavy formations such as “fat” clays should be drilled at 30 to 50 revolutions per minute (rpm). Good clean sand that will stand open can be successfully augered at 75 rpm.

Applications

- Most frequently used method
- Most types of soil investigations
- Permits good soil sampling with split-spoon or thin-wall samplers
- Monitoring well installation in unconsolidated formations
- Can serve as temporary casing
- Can be used in stable formations to set surface casing

Limitations

- Difficulty in preserving sample integrity in heaving formations
- Formation invasion by water or drilling mud if used to control heaving
- Possible cross contamination of aquifers where annular space not positively controlled by water or drilling mud or surface casing
- Limited diameter of augers limits casing size
- Smearing of clays may seal off aquifer to be monitored

4.1.1.4 Bucket Auger

Bucket augers have a depth capacity of 30 to 75 feet and are used for large diameter holes (16 to 48 inches). Most bucket augers are “gravity fed” and are used for vertical holes. They are not normally used to drill monitoring wells or for soil sampling but may be used to drill production and recovery wells. Bucket augers may also be used to set conductor or surface casings for production wells.

Generally, the auger bucket advances into the formation by combination of dead weight and the tooth cutting angle. The auger cuts into the formation approximately 1 to 2 feet at a time, filling the auger bucket. The bucket is attached to the lower end of a kelly bar that passes through and is rotated by a large ring gear that serves as a rotary table. The kelly is square in cross section and consists of two or more lengths of square tubing, one length telescoped inside the other. When the bucket is withdrawn from the hole by means of a wire-line hoist cable, it is swung to the side of the hole and the spoil is dumped out through the bottom by means of a hinge and latch device on the bucket bottom.

Applications

- Drilling of large diameter boreholes to a maximum depth of 75 feet
- Drilling in unconsolidated formations

Limitations

- Difficult to advance the borehole below the water table
- Consolidated formations and cobbles are difficult to drill
- Loose sand formations may slough during drilling
- Undisturbed soil sampling difficult to achieve

4.1.2 Percussion Drilling

The basic method of advance in percussion drilling is hammering, striking, or beating on the sediments or formation. Common percussion methods that do not use circulating fluids are cable-tool, driven boreholes, and sonic drilling.

4.1.2.1 Cable-Tool Drilling

Cable-tool operates by alternately raising and dropping a bit, hammer, or other heavy tool. In consolidated formations, the drill bit breaks or crushes the formation. In unconsolidated formations, the drill bit primarily loosens the formation when drilling. In both instances, the reciprocating action of the tools mixes the crushed or loosened particles with water to form a slurry or sludge at the bottom of the borehole. If little or no water exists in the penetrated formation, water is added to form the slurry. Slurry accumulation increases as drilling proceeds and eventually it reduces the impact of the tools. When the drop of the string of tools is hindered by the thickened slurry, the slurry is removed by a bailer. Water is then added, if needed, and drilling resumes.

Most boreholes drilled in unconsolidated formations are drilled “open hole;” that is, no casing is used during part or all of the drilling operation. Drilling in unconsolidated formations differs from hard-rock drilling as pipe or well casing must follow the drill bit closely as the well is deepened to prevent caving and to keep the borehole open.

Using the cable-tool drilling technique in monitoring work is limited because the method is slow. Drilling rates of 20 to 100 feet per day are typical with the average being approximately 50 feet per day. Holes much smaller than 6 inches are impractical because of the need for a relatively large, heavy bit. The method does not use drilling muds but does allow sampling of groundwater with a drive and bail technique as the hole is advanced in high-yielding formations.

Applications

- Drilling in most types of geologic formations
- Almost any depth and diameter range
- Ease of monitoring well installation
- Ease and practicality of well development
- Excellent samples of geologic materials

Limitations

- Drilling relatively slow
- Heaving of unconsolidated materials must be controlled
- Equipment availability more common in central, north central and northeast sections of the United States

4.1.2.2 Driving

A borehole can be constructed by driving a solid probe or plugged pipe into the ground. The information obtained by this technique can be either minimal or extensive.

Driven wells, commonly referred to as wellpoints, are driven into the ground by hand or with heavy drive heads mounted on a tripod, drill rig derrick, or similar hoisting device. Wellpoints consist of a wellpoint (screen) that is attached to the bottom of a casing. Wellpoint and casing diameters generally range from 1.25 to 2 inches. Depths of 30 feet can be achieved by hand in sands or sands and gravels with thin clay seams. Depths of 50 feet or more can be achieved in loose soils with hammers weighing up to 1,000 pounds.

Driving through dense silts and clays and/or bouldery silts and clays is often extremely difficult or impossible. The well point may not be structurally strong enough and may be damaged or destroyed by driving through dense soils. Additionally, the screen may become plugged when driving through silts and clays and may be very difficult to reopen during development. Soil samples cannot be collected during this process; however, crude stratigraphic information may be obtained by recording the number of blows per foot of penetration. Driven wells or well points are usually installed for the collection of groundwater samples and the determination of static water levels to establish the regional groundwater gradient.

A large track-mounted backhoe (CAT 245) has been used to install extraction wells in a landfill to the 30-foot depth. The bucket of the backhoe is used to push a 6-inch diameter drive pipe with a plugged bottom. When the drive pipe reaches the final depth for the well, the plug at the bottom of the drive pipe is removed and the well screen and casing materials are placed inside the drive pipe. A large 50-ton crane then pulls the drive pipe, leaving the well materials in the borehole. This technique is highly dependent upon the geologic formation and required depth. The drive pipe pushes the formation aside. This can cause a compaction of the formation, which could impact the performance of the well.

Considerably more information can be obtained by driving a penetrometer or a Dutch Cone. Penetration of the soil with a cone forces the soil aside, creating a complex shear failure. The degree of resistance yields the geologic logs of the borehole. Penetrometers can also obtain groundwater samples and possibly soil samples. The borehole that the penetrometer makes is usually abandoned; however, occasionally a small-diameter piezometer can be constructed within the borehole. For more information on cone penetrometer testing, see the SOP on Cone Penetrometer Testing (SOP-11).

Applications

- Drilling of a borehole when soil samples are not needed
- Installation of a shallow well point when there are site access and work place limitations

Limitations

- Geologic formations must be conducive for driven wells
- Driven wells should be limited to shallow wells
- Formation compaction usually occurs that can affect well production

4.1.2.3 Sonic Drilling

Sonic drilling, also known as resonance drilling, is a percussion drilling technique that uses a high-frequency drive hammer. The drilling rig uses a combination of mechanically generated vibrations and limited rotary power to penetrate the soil. The drill head, which is attached to the drill pipe, consists of two counter rotating, out-of-balance rollers that cause the drill pipe to vibrate. Resonance occurs when the frequency of the vibrations equals to the natural frequency of the drill pipe. The resonance and weight of the drill pipe along with the downward thrust of the drill head permit easier penetration of the formation, without adding drilling muds or lubricating fluids. The drive pipe is either closed bottom or fitted with a soil sampling tube. If the bottom of the drive pipe is closed, the borehole is made without the removal of any formation. Instead, the formation is literally pushed to the side and out of the way of the drive pipe, which acts as well casing as the boring proceeds.

A soil sampling device, such as a split-spoon sampler or a core barrel, can be placed inside the drive pipe in lieu of the end plug. The sampler is removed at 5- or 10-foot intervals and replaced with an empty sampler. This procedure yields a continuous soil sample and produces minimal waste as only the formation within the sampler is brought to the surface. A monitoring well can be installed in the borehole by removing the sampler and setting the well screen and casing inside the drive pipe. The drive pipe is then withdrawn. This drilling technique again pushes the formation aside to create the borehole. Certain formation compaction can occur which could impact the performance of a well. Sonic drilling can produce considerable heat at the bit on the drive pipe and within the sampler. The heat in the sampler may have a detrimental effect on soil samples such for chemical analysis that are impacted by heat, such as volatile organic compounds.

Applications

- Rapid drilling technique especially in difficult drilling formations
- Use when drilling in contaminated areas and disposal costs for wastes are high
- Can obtain continuous core

Limitations

- Very limited equipment availability
- Heat generated with drive pipe can compromise soil samples
- Formation compaction usually occurs that can affect well production

4.2 Methods With Circulating Fluids

Many drilling techniques use a circulating fluid, such as water or drilling mud, gas such as air, or a combination of air, water, and a surfactant to create foam. Circulation fluids flow from the surface either through the drill pipe, out through the bit, and up the annulus between the borehole wall and the drill pipe (direct rotary) or down the borehole annulus, into the bit, and up the drill pipe (reverse rotary). Generally the up-hole velocity needed to transport cuttings to the surface is between 100 to 150 feet per minute for plain water with no additives, 80 to 120 feet per minute for high-grade bentonite drill muds, 50 to 1,000 feet per minute for foam drilling, and up to 3,000 feet per minute for air with no additives. Additives decrease the required minimum velocity. Excessive velocities can cause erosion of the borehole wall.

The use of circulating fluids may involve the addition of chemicals to the borehole. Drilling mud utilizes bentonite clay and possibly polymers. Additives to air drilling may include surfactants (detergents) and water mist to generate foam. Compressed air may also contain various amounts of hydrocarbon lubricants. Therefore, attention should be given to the circulating fluids and any possible additives that are used when using drilling methods utilizing circulation fluids.

4.2.1 Rotary Drilling Methods

Rotary drilling methods require the rotation of the drill pipe and the drill bit to advance the borehole. The common drilling methods that use circulating fluids to remove the drill cuttings from the borehole are presented in the following sections.

4.2.1.1 Conventional Mud Rotary Drilling

In conventional mud rotary drilling, the circulating fluid is pumped from the surface through the rotating drill pipe and bit to flush cuttings to the surface. At the surface the fluid is directed into a circulation pit or tank where the cuttings settle out. The circulating fluid is then picked up with the mud pump and again directed downhole. Bentonite is usually added to water to make the drilling mud or fluid. The functions of the drilling fluid are to:

- Lift the cuttings from the bottom of the borehole and carry them to a settling pit
- Support and stabilize the borehole wall to prevent caving
- Seal the borehole wall to reduce fluid loss
- Cool and clean the drill bit
- Allow the cuttings to drop out in the settling pit
- Lubricate the bit, cone bearings, mud pump, and drill pipe

For effective rotary drilling, the down force on the bit should be great enough to cause continuous penetration of the boring. The pounds per inch of bit weight depends upon the configuration of the bit and the formation being penetrated. Rotary speeds are generally in the range of 60 to 200 rpm.

Applications

- Rapid drilling of clay, silt, and reasonably compacted sand
- Allows split-spoon and thin-walled samples in unconsolidated materials
- Allows core sampling in consolidated rock
- Drilling rigs widely available
- Abundant and flexible range of tool sizes and depth capabilities
- Very sophisticated drilling and mud programs available
- Geophysical borehole logs

Limitations

- Difficult to remove drilling mud and wall cake from borehole wall during development
- Bentonite and other drilling additives may influence quality of groundwater samples
- Circulated samples poor for monitoring well screen selection
- Split-spoon and thin-wall samplers are expensive and of questionable cost-effectiveness at depths greater than 150 feet
- Wireline coring techniques for sampling both unconsolidated and consolidated formations often not available locally
- Difficult to identify aquifers
- Drilling fluid invasion of permeable zones may compromise validity of subsequent monitoring well samples

4.2.1.2 Air Rotary Drilling

In air rotary drilling, the circulation fluid is compressed air or a mixture of compressed air, a surfactant, and water mist, which creates a foam. As in conventional mud rotary, the drilling fluid is forced through the rotating drill pipe and bit to flush cuttings to the surface. At the surface the fluid is directed into a pit or storage container. The up-hole velocity of the air and cuttings should be approximately 3,000 feet per minute. Air rotary drilling method is primarily used in consolidated formations due to the fact that the rapidly rising cuttings would cause considerable erosion of the borehole wall in unconsolidated formations. With the air rotary drilling method, the circulating fluid is not reused again. The following are functions of the drilling fluid:

- Lifting the cuttings from the bottom of the borehole and carrying them to the surface
- Cooling and cleaning the drill bit
- Lubricating the bit, cone bearings, mud pump, and drill pipe

Rotary speeds are generally in the range of 75 to 200 rpm. If the hardness of the formation increases to the point that roller-cone rock bits cannot successfully penetrate the formation, then a down-hole air hammer is used to penetrate the formation. The rotating speed using the down-hole air hammer is in the range of 15 to 30 rpm.

Applications

- Rapid drilling of semi-consolidated and consolidated rock
- Good quality/reliable formation samples
- Equipment generally available
- Allows easy and quick identification of lithologic changes
- Allows identification of most water bearing zones
- Allows estimation of yields in strong water-producing zones with short “down time”

Limitations

- Surface casing frequently required to protect top of hole
- Drilling restricted to semi-consolidated and consolidated formations
- Samples reliable but occur as small particles that are difficult to interpret
- Drying effect of air may mask lower yield water producing zones
- Air stream requires contaminant filtration
- Air may modify chemical or biological conditions. Recovery time uncertain

4.2.1.3 Air Rotary Casing Hammer (Drill and Drive)

Air rotary casing hammer method combines percussion and air rotary drilling methods to drill in unconsolidated formations. The borehole is drilled with the air rotary drilling method. Casing or drive pipe follows closely behind the rotary bit to prevent the erosion of the borehole wall. The casing is driven similar to a pile driver except for a hole through its axis through which a drill pipe is inserted and rotated. The drill bit is usually extended approximately 1-foot below the bottom of the drive pipe that acts as temporary casing.

Applications

- Rapid drilling of unconsolidated sands, silts, and clays
- Drilling in alluvial materials (including boulder formations)
- Casing supports borehole thereby maintaining borehole integrity and minimizing inter-aquifer cross contamination
- Eliminates circulation problems common with direct mud rotary method
- Good formation samples
- Minimal formation damage as casing pulled back

Limitations

- Thin, low pressure water bearing zones easily overlooked if drilling not stopped at appropriate places to observe whether or not water levels are recovering
- Samples pulverized as in rotary drilling
- Air may modify chemical or biological conditions
- Difficult to obtain soil samples for chemical analysis

4.2.1.4 Center Stem Recovery Rotary Drilling (Reverse Circulation)

In reverse circulation drilling, the circulating fluid (water) flows from the surface down the borehole annulus outside the drill pipe, into the drill bit, and up the inside of the drill pipe to ground surface. The fluid carries the cuttings to the surface and discharges them into a settling pit or tank. Reverse circulation is especially advantageous in very large boreholes and also in those cases where the erosive velocity of conventional rotary circulation would be detrimental to the borehole wall. Drilling is accomplished typically with water without additives. A large and dependable water supply is required to keep the borehole full of drilling fluid to maintain sufficient hydrostatic head on the borehole walls to prevent sloughing. Reverse circulation has few applications in monitoring work except when nested wells are desired. Production wells with 18- to 24-inch-diameter casing are typically drilled by the reverse circulation drilling method. Typical borehole diameters range from 15 to 36 inches; however, 60-inch-diameter boreholes are not uncommon.

Applications

- Large capacity production wells
- Nested wells
- Normally does not use drilling muds (little if any mud cake is formed on the wall of the borehole)
- Drills best in unconsolidated sands, silts, and clays

Limitations

- Requires large and dependable source of water during drilling and well installation
- Cobbles and bedrock are difficult to drill

4.2.1.5 Dual-Tube Rotary

Dual-tube rotary is an exploratory drilling technique utilizing two concentric drill pipes. Both drill pipes are rotated during drilling. The outside of the outer drill pipe is typically 4.5 inches in diameter. The diameter of the borehole is approximately 5 inches. Compressed air is forced between the two drill pipes and is directed to the center pipe at the bit. The cuttings are carried to the surface by the returning air at a velocity of approximately 3,000 feet per minute. This is an excellent drilling method to identify lithology and the locations of aquifers in deep boreholes. It is very difficult to obtain undisturbed soil samples for chemical or geotechnical analyses; however, groundwater samples can be obtained as aquifers are encountered. Geophysical logs can be obtained if the borehole is filled with drilling mud as the drill pipe is removed. Monitoring wells are typically not installed in dual-tube rotary boreholes unless the borehole is reamed out by the mud rotary method. Depths of 1,000 feet are not uncommon for this drilling method and typically, the more consolidated the formation, the better the drilling, as unconsolidated formations cause more drag or friction on the outside of the rotating drill pipe.

Applications

- Used mostly for exploratory boreholes
- Rapid extraction of drill cuttings from the borehole
- Drill cuttings are representative of formation
- Very rapid penetration rate in most formations
- Can collect groundwater samples as aquifers are encountered

Limitations

- Equipment availability
- Cannot obtain undisturbed soil samples for chemical analysis
- Borehole size is limited (5 inches)

4.2.2 Dual-Tube Percussion Drilling

Dual-tube percussion drilling is very similar to dual-tube rotary drilling with the exception that the two drive pipes do not rotate during drilling. Two concentric drive pipes are driven into the ground with a hammer. The hammer is similar to units on pile drivers. The typical outside diameter of the outer drive pipe is 9 to 12 inches. The typical inside diameter of the inner pipe, where well materials would be inserted, is 6 to 8 inches. This drilling system is also a center stem recovery system. This drilling technique has been developed and is used primarily in hazardous waste investigations. This method is rapid and effective to depths of about 250 feet.

The outer pipe effectively seals off the formation while drilling, reducing the chance of cross contamination. Air is pumped between the annulus of the two pipes to the bit where it is deflected upward into the center pipe. Cuttings are transported to the surface through the center pipe.

In general, three systems are available: 7-inch outside diameter (OD)/4.25-inch inside diameter (ID), 9-inch OD/6-inch ID, and 12-inch OD/8-inch ID. A 2-inch-diameter monitoring well can be constructed in the 7-inch system, a 4-inch-diameter monitoring well can be constructed in the 9-inch system, and a 5- or 6-inch-diameter monitoring well can be constructed in the 12-inch system.

Applications

Limitations

- Very rapid drilling through both unconsolidated and consolidated formations
- Allows continuous sampling for lithologic logging in most types of formations
- Very good representative samples can be obtained with minimal risk of contamination of sample and/or water bearing zone
- In stable formations, wells with diameters as large as 6 inches can be installed in open hole completions
- Soil samples can be easily obtained for chemical analysis

- Limited borehole size that limits diameter of monitoring wells
- In unstable formations wells are limited to approximately 4 inches
- Equipment availability more common in the southwest
- Air may modify chemical or biological conditions; recovery time is uncertain

4.2.3 Suction Drilling

Suction drilling has been used to drill into consolidated formations that yield little if any groundwater. This is an experimental drilling method that has been used by the U.S. Geological Survey (USGS) to drill in basalts in Idaho. The drilling technique is very similar to the reverse circulation drilling technique discussed in Section 4.2.1.4 with the exception that air is circulating, not water. To drill the borehole, a drill rig rotates a modified air rotary bit at the end of the drill pipe. The cuttings are removed by the suction from a high-pressure, high-volume air and steam ejector/eductor siphon system. The suction is directed to the interior of the drill pipe. The formation cuttings, including formation fluids, are brought to the surface via the interior of the drill pipe.

To drill a 10-inch-diameter borehole, two 600 cubic feet per minute (cfm)/250 pounds per square inch (psi) air compressors are connected parallel to the ejector/eductor siphon device. Suction from the siphon device is directed to the 2-3/8-inch-diameter drill pipe. A 1.5-horsepower blower fan is used to direct air down the borehole.

Applications

- Allows continuous sampling for lithologic logging
- Very good representative samples can be obtained
- Drilling is not impeded in fractured formations that typically cause lost circulation problems

Limitations

- Formations must be very consolidated to prevent the borehole wall from sloughing during drilling
- Cuttings are very abrasive to the drill pipe and discharge lines
- Difficult to maintain an adequate vacuum as air leaks form easily at threaded joints of the drill pipe
- Groundwater could prevent the advancement of the borehole

Drilling contractors have had numerous mechanical problems advancing boreholes beyond the 150-foot depth. Vacuum leaks have caused a loss in suction and the plugging of the drill pipe. The drill pipes have twisted off and the abrasive cuttings have worn holes in hoses and pipes. This drilling method has some unique advantages; however, until the mechanical problems are solved, this technique will not be available for use.

5.0 CONSIDERATIONS FOR SELECTION OF DRILLING METHODS

Each project or drilling site has its own considerations for the selection of a particular drilling method. Prior to selecting a drilling method, several factors must be considered. The major factors that this section will address include the objective of the drilling program, site conditions, wastes generated, and Tronox preferences. Other factors include drilling costs, availability of trained crews and appropriate equipment, and project schedule requirements. Recognize that it may be very difficult to fulfill all of the sampling/drilling objectives with a single drilling method. The drilling method selected may compromise some of the objectives of the drilling program.

5.1 Drilling Objectives

The primary consideration in selecting any drilling method is to ensure the selected method is capable of meeting the objective(s) of the drilling/sampling program. It is common to have more than one objective for the drilling/sampling program and it may be difficult to satisfy all of the program objectives.

For example, if sample collection (soil or groundwater) is the objective, the selected method must be capable of collecting, in an appropriate and approved manner, the necessary samples. Additionally, the contaminants of concern may influence the drilling and sampling method.

Alternatively, if the objective of the drilling program is to install vapor or groundwater extraction wells, the selected method must be suitable for the installation of the designed well. It is important to not only consider the physical limitations of a particular drilling technique (i.e., depth and diameter), but examine the consequences of the drilling method with the drilling objective (i.e., smearing of the borehole walls rendering wells ineffective or inefficient).

5.2 Site Conditions

Site conditions can limit the drilling methods available for a particular program. Site conditions to be considered include both subsurface and surface conditions.

5.2.1 Subsurface Conditions

The subsurface stratigraphy of a site is a fundamental consideration when selecting a particular drilling method. The drilling equipment selected must be capable of effectively and economically penetrating the strata at the site to meet the project objectives. Particular stratigraphy that may pose problems for certain drilling methods include tight clayey soils, swelling clays, flowing sands, caliche, gravels, cobbles, lost circulation zones, and bedrock.

In addition to stratigraphy, the site hydrology must also be considered. If multiple water-bearing zones are expected, a conductor casing may be needed to seal off shallow water-bearing zones and prevent potential cross contamination. The need for conductor casings can affect the selection of a particular drilling method. Wells that deeply penetrate aquifers can also affect the selection of a particular drilling method.

5.2.2 Surface Conditions

Surface conditions can affect access to the site and the amount of available work space (both horizontal and vertical or overhead space). These in turn can affect the selection of a particular method or type of drill rig. Limited access and work space may require smaller or remotely powered drill rigs. The site terrain is a very important factor in choosing the drilling method as it is very expensive and difficult to mobilize large and/or heavy equipment over rugged terrain. For sites such as these, drill rigs (typically hollow-stem auger) are mounted on all-terrain equipment.

In addition to access and work space, the work environment must also be considered. This includes both weather and other site activities. Extremely hot or cold climates may require use of special drilling equipment or methods. Sites such as refineries where explosive atmospheres could exist may also require very special equipment.

5.3 Waste Generation

Drilling operations typically generate significant volumes of waste that must be handled, stored, and eventually disposed. This is of particular concern when drilling into contaminated or hazardous materials. The type and volume of wastes generated during drilling differs for different drilling methods. The different handling and disposal requirements of drilling wastes can greatly affect project costs. The different drilling methods can also require vastly different volumes of groundwater be removed to fully develop the well.

STANDARD OPERATING PROCEDURES

SOP-02

GROUNDWATER MONITORING WELL DESIGN AND INSTALLATION

STANDARD OPERATING PROCEDURES

SOP-02
GROUNDWATER MONITORING WELL DESIGN AND INSTALLATION

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DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is applicable to the design and installation of permanent groundwater monitoring wells at BSEP. Each monitoring well must be designed to suit the hydrogeologic setting, the type of contaminants to be monitored, overall purpose of the monitoring program, and other site-specific variables. As such, site-specific objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Additionally, within a monitoring system, different monitoring wells may serve different purposes and thus require different types of construction. Therefore, during all phases of well design, BSEP contractors must clearly document the basis for design decisions, the details of well construction, and the materials to be used.

2.0 DEFINITIONS

Absorption	The penetration or apparent disappearance of molecules or ions of one or more substances into the interior of a solid or liquid.
Adsorption	The process by which atoms, ions, or molecules are assimilated to the surface of a material. Ion-exchange processes involve adsorption.
Annular Sealant	Material used to provide a positive seal between the borehole and the casing of the well. Annular sealants should be impermeable and resistant to chemical or physical deterioration.
Annular Space	The space between the borehole wall and the well casing, or the space between a casing pipe and a liner pipe.
Aquifer	A geologic formation, group of formations, or part of a formation that can yield water to a well or a spring.
Backwashing	A method of filter pack emplacement whereby the filter pack material is allowed to fall freely through the annulus while clean fresh water is simultaneously pumped down the casing.
Bentonite	Hydrous sodium montmorillinite mineral available in powder, granular, or pellet form. It is used to provide a tight seal between the well casing and the borehole.
Bridging	The development of gaps or obstructions in either grout or filter pack materials during emplacement.
Continuous Slot Wire-Wound Well Screen	A well intake that is made by winding and welding triangular-shaped, cold-rolled wire around a cylindrical array of rods. The spacing of each successive turn of wire determines the slot size of the intake.
Corrosion	The adverse chemical alteration that reverts elemental metals back to more stable mineral compounds and that affects the physical and chemical properties of the metal.

Filter Pack	Sand, gravel, or glass beads that are uniform, clean, and well-rounded that are placed in the annulus of the well between the borehole wall and the well intake to prevent formation material from entering through the well intake and to stabilize the adjacent formation.
Grout	A fluid mixture of neat cement and water with various additives or bentonite of a consistency that can be forced through a pipe and placed in the annular space between the borehole and the casing to form an impermeable seal.
Monitoring Well	A well that is capable of providing a groundwater level and sample representative of the zone being monitored.
Naturally Developed Well	A well construction technique whereby the natural formation materials are allowed to collapse around the well intake and fine formation materials are removed using standard development techniques.
Neat Cement	A mixture of Portland cement and water in the proportion of five to six gallons of clean water per bag (94 pounds) of cement.
Piezometers	A small-diameter, non-pumping well used to measure the elevation of the water table or potentiometric surface.
Sieve Analysis	Determination of the particle-size distribution of soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.
Slurry	A thin mixture of liquid, especially water, and any of several finely divided substances such as cement or clay particles.
Tremie Pipe	A device, usually a small-diameter pipe that carries grouting materials to the bottom of the borehole and that allows pressure grouting from the bottom up without introduction of appreciable air pockets.
Well Cluster	Two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity to each other. From these wells, water samples that are representative of different horizons within one or more aquifers can be collected.
Well Point	A sturdy, reinforced well screen or intake that can be installed by being driven into the ground.

3.0 RESPONSIBILITIES

The **Project Manager** or **Task Leader** will select the site-specific monitoring well design and installation methods, with input from the site geologist or hydrogeologist and field team leader, and will maintain close supervision of the activities and progress.

The **Site Hydrogeologist** selects site-specific drilling/sampling options and helps prepare technical provisions of drilling methods.

The **Field Project Leader/Geologist** implements the selected drilling program.

The **Drilling Rig Geologist** supervises and/or performs actual monitoring well installation.

4.0 WELL DESIGN

Consideration should be given to the following site-specific information before a groundwater monitoring system is designed:

- Purpose of the groundwater monitoring program (water quality, water levels, remediation, flow direction, and velocities)
- Surficial conditions, including topography, climate, drainage, site access
- Known or anticipated hydrogeologic setting including geology (consolidated/ unconsolidated), physical characteristics of the aquifer (porosity/permeability), type of aquifer (confined/unconfined), recharge/discharge conditions, aquifer thickness, and groundwater/surface water interrelationships
- Borehole geophysical logs, if any
- Known or anticipated contaminant chemical characteristics (chemistry, density, viscosity, reactivity, and concentration)
- Anticipated seasonal fluctuations in groundwater levels
- Anthropogenic or tidal influences
- Regulatory requirements

Common mistakes in groundwater monitoring system design include the following:

- Use of well casing or well screen materials that are incompatible with the hydrogeologic environment, and/or the anticipated contaminants, resulting in chemical alteration of the samples or failure of the well
- Use of nonstandard well screen (field slotted or perforated) or incorrect slot size, resulting in well sedimentation and turbid groundwater samples
- Improper length or placement of the well screen so that acquisition of accurate water level or water quality data from discrete zones is impossible
- Improper selection and placement of filter pack materials resulting in well sedimentation, well screen plugging, or chemical alteration of the groundwater
- Improper selection and placement of annular seal materials resulting in alteration of groundwater chemistry, plugging of the filter pack and/or well screen, or cross-contamination from geologic units that have been sealed off improperly
- Inadequate surface protection resulting in surface water entering the well

Siting of monitoring wells should be performed after a preliminary estimation of the hydraulic gradients and groundwater flow direction. In most cases this may be done through review of background data and site terrain. Additionally, production wells in the area may be used to assess the local groundwater flow direction. If the groundwater flow direction cannot be determined by any of these methods, it may be practical to install piezometers in a preliminary phase to determine flow direction.

4.1 Casing Diameter and Screen Length

Monitoring well casing diameter is dependent on the purpose of the well and the amount and size of downhole equipment that must be accommodated. Additional criteria for selecting casing diameters include: drilling or well installation method used, anticipated depth of the well and associated strength requirements, ease of well development, volume of water required to be purged prior to sampling, rate of recovery of the well after purging, and cost.

Monitoring well casing diameters are generally two or four inches. Pumping tests or some types of borehole geophysical equipment may require wells six inches or larger in diameter. Four-inch-diameter wells are usually preferred due to their versatility. In smaller diameter wells, the volume of stagnant water to be purged prior to sampling is minimized, the cost of well construction is reduced, and the well stabilizes relatively quickly. The quantities of potentially contaminated drill cuttings and development and purge water are also reduced.

The borehole diameter should be a minimum of four to six inches larger than the well casing and screen to allow for proper placement of annular materials.

In situations where vertical groundwater gradients are minimal, screen lengths are typically 10 to 20 feet, with stratified formations possibly requiring shorter screen lengths. If non-aqueous phase liquids (NAPLs) that are lighter than water are anticipated, the well screen should extend above the water table so these liquids can be sampled. Consideration should be given to seasonal fluctuations in water levels when locating the well screen above the top of the water table. If dense NAPLs are anticipated, the screen interval should extend to the base of the aquifer. Well clusters may be necessary when contaminants both denser and lighter than water are anticipated in the same aquifer.

4.2 Casing and Screen Materials

Monitoring well casing is specified by diameter, thickness, and type of material. Well screens also require that slot size be specified. Casing thickness is referred to as "schedule." Polyvinyl chloride (PVC) is usually Schedule 40 (thinner wall), although Schedule 80 (thicker wall) is sometimes used for deep wells. Steel casing is typically Schedule 5 or 10.

Selection of casing and screen material must be based on three primary characteristics: chemical interference potential, chemical resistance, and physical strength. The materials must not assimilate chemicals either by adsorption onto the material surface or absorption into the material matrix or pores; they must be durable enough to withstand potential chemical attacks either from natural chemical constituents or groundwater contaminants; and they must have the structural strength to withstand the forces exerted on them by the surrounding geologic materials and during installation. The three components of casing and screen structural strength are tensile strength, compressive (column) strength, and collapse strength.

Casing and screen materials generally available are Teflon, PVC, stainless steel, galvanized steel, carbon steel, and low-carbon steel. Teflon materials are extremely expensive and of comparatively low strength. Although relatively inert, recent studies have shown that Teflon is prone to sorption of selected organic compounds.

The two most commonly used materials are PVC and stainless steel. PVC is inexpensive, widely available, lightweight, and easy to work with. However, the column strength of PVC may limit the depth of installation. Schedule 80 PVC may be used for deeper wells; however, the reduced inside diameter should be taken into account when designing the well. Many studies have been conducted concerning the effect of PVC on water quality data. Whereas adsorption of some chlorinated species to PVC was documented, the adsorption rate was found to be very slow. Because a sample is generally taken shortly after the purging of stagnant water in contact with the casing, the contaminants in the water will have minimal time to be influenced by sorption or leaching effects. Therefore, potential sample bias effects due to interactions with PVC appear to be negligible.

Steel well materials are stronger, more rigid, and less temperature sensitive than PVC or Teflon. Stainless steel has the highest corrosion resistance of the various types of steel. Type 304 and Type 316 are the most commonly used stainless steels. Both are available in low-carbon forms, which are more easily welded than the normal carbon steel. Low-carbon steel is designated by an "L" after the number (e.g., Type 304L). Type 304 stainless steel is superior to Type 316 from a corrosion resistance and cost standpoint. Type 316 is preferred to Type 304 under reducing conditions. For either type of stainless steel, long-term exposure to corrosive conditions may result in chromium or nickel contamination of groundwater samples. Insoluble halogen and sulfur compounds may also form as a result of corrosion of stainless steel.

Threaded, flush-joint casing is preferred for monitoring well applications. Welded-joint steel casing may also be acceptable, but is typically more expensive and inconvenient. Glued PVC should never be used for monitoring wells since the glue may release organic contamination into the well. The casing should have a well cap that is vented to prevent the accumulation of gases and to allow water levels in the well to respond to barometric and hydraulic pressure changes.

The hydraulic efficiency of a well screen depends primarily upon the amount of open area available per unit length of screen. The two screen types commonly used for monitoring wells are machine-slotted, and continuous-slot wire-wound. Hand-slotted, drilled, or perforated casings should not be used as well screens. Slotted casing is manufactured from a variety of materials, including PVC and stainless steel.

Slot openings are designated by numbers that correspond to the widths of the openings in thousandths of an inch (e.g., number 10 slot refers to 0.010-inch slot size). The slots have a consistent width for the entire wall thickness of the casing, which can result in clogging if irregularly shaped formation particles are brought through the screen during well development and sampling.

The continuous-slot, wire-wound screen has a greater area per opening per length and diameter than is available with any other screen type. The percentage of open area in continuous-slot screen is often more than twice that provided by standard slotted well screen. The triangular shaped wire makes these screens non-clogging. They are fabricated in PVC and a variety of metals and are used when high pumping rates are anticipated.

If a monitoring well will also be used for hydraulic testing, the well screen open area should equal or exceed the formation's effective porosity so that the screen is not the limiting factor in formation hydraulic testing. In most cases, this amount of open area can only be achieved through the use of continuous-slot wire-wound well screen. In choosing between types of well screens, another factor is the speed and effectiveness of well development. Screens with a high percentage of open area greatly reduce the time and effort required for well development.

The bottom of the screen must be sealed by an endcap consisting of the same material as the screen. The use of a sediment sump or trap below the well screen is not appropriate for monitoring wells.

In the case of wells deeper than 150 feet deep, schedule-80 PVC will be used to minimize the potential for casing blistering when grout cures. The diameter of the screen and casing will be a maximum of 4-inches less than the diameter of the borehole. Stainless steel centralizers will be placed at the top and bottom of the well screen and every 40 feet along the blank casing. The bottom of each well will consist of a slip cap mounted with stainless steel screws to a flush-threaded end-cap. Holes of 1/16-inch diameter will be drilled through both caps prior to installation to prevent water from sitting in the bottom of the well if the static water level drops below the bottom of the well. A locking cap or dedicated pump assembly will be used to secure the top of the well.

4.3 Decontamination of Casing and Screen Materials

During the production of PVC casing, a wax layer can develop on the inner wall of the casing; protective coatings may also be added to enhance casing durability. Considerable quantities of oils and solvents are used during the manufacturing and machining of threads during the production of steel casing. All of these represent potential sources of chemical interference and must be removed either with a laboratory-grade nonphosphate solution or by steam cleaning prior to installation. Factory cleaning of casing and screen in a controlled environment by standard detergent washing, rinsing, and air-drying procedures is superior to any cleaning efforts attempted in the field. Factory cleaned and sealed casing and screen can be certified by the supplier.

4.4 Filter Pack and Well Screen Design

A properly designed monitoring well requires that a well screen be placed opposite the zone to be monitored and be surrounded by materials that are coarser and of greater hydraulic conductivity than the natural formation material. Naturally developed wells and wells with artificially introduced filter pack are the two basic types of well intake designs for unconsolidated or poorly consolidated materials.

4.4.1 Naturally Developed Wells

In naturally developed wells, the formation materials are allowed to collapse around the well screen. Naturally developed wells can be installed in which natural formation materials are relatively coarse grained, permeable, and of uniform grain size. It is essential that the grain-size distribution of the formation to be monitored is accurately determined by conducting a mechanical (sieve) analysis of samples taken from the interval to be screened. After sieving, a plot of grain size versus cumulative percentage of sample retained on each sieve is made. Well screen slot sizes are based on the grain-size distribution, specifically the effective size (the sieve size that retains 90 percent of the formation material, referred to as D10) and the uniformity coefficient (the ratio of the sieve size that retains 40 percent of the material or D60, to the effective size). A naturally developed well can be justified if the effective grain size is greater than 0.010 inch and the uniformity coefficient is greater than 3.0. Various state agencies (e.g., the California Department of Toxic Substances Control [DTSC]) recommend that an artificial filter pack be used if sieve analysis indicates that a screen slot size of 0.020 inches or less is required to retain 50 percent of the natural formation. The biggest drawback for naturally developed wells is the time required for well development to remove fine-grained formation material.

4.4.2 Artificial Filter-Packed Wells

Filter packs are installed to create a permeable envelope around the well screen. The use of an artificial filter pack in a fine-grained formation material allows the screen slot size to be considerably larger than if the screen were placed in the formation material without the filter pack. The selection of the filter pack grain size should be based on the grain size of the finest layer to be screened.

Filter pack grain size and well screen slot size should be determined by the grain size distribution of the formation material. The filter pack should be designed first. It is recommended to use a filter pack grain size that is three to five times the average (D50) size of the formation materials. However, this method may be misleading in coarse, well-graded formation materials. Another way to determine filter pack grain size is to take the D30 grain size of the formation materials and multiplying it by a factor of between three and six, with three used if the formation is fine and uniform and six used if the formation is coarse and non-uniform. For both methods, the uniformity coefficient of the filter pack materials should be as close to 1.0 as possible (2.5 maximum) to minimize particle size segregation during filter pack installation.

The filter pack should extend from the bottom of the well screen to approximately two to five feet above the top of the screen to account for settlement of the pack material during development and to act as a buffer between the well screen and the annular seal. A secondary filter pack (transitions sand) is sometimes used to prevent annular grout seal materials from migrating into the primary filter pack. The secondary filter pack should extend at least one foot above the top of the primary filter pack. It should consist of a uniformly graded fine sand with 100 percent passing a No. 30 U.S. Standard sieve and less than 2 percent by weight passing the 200 sieve.

Filter pack thickness must be sufficient to surround the well screen but thin enough to minimize resistance to the flow of fine-grained formation material and water into the well during development. American Society of Testing and Materials (ASTM), Designation D 5092-90, recommends that a minimum of two-inch thick filter pack between the borehole well and the well casing (ASTM 1995).

The materials comprising the filter pack should be as chemically inert as possible. It should be comprised of clean quartz sand or glass beads. Filter pack materials usually come in 100-pound bags; these materials are washed, dried, and factory packaged.

The size of well intake openings can only be selected after the filter-pack grain size is specified. The slot size should be such that 90 to 100 percent of the filter-pack material is held back by the well screen.

The casing string should be installed in the center of the borehole. This will allow the filter-pack materials to evenly fill the annular space around the screen and ensure that annular seal materials fill the annular space evenly around the casing. If a hollow-stem auger or dual-tube rig is used, the auger or inner tube of the dual tube will adequately centralize the casing string. For other types of drilling, centralizers should be used to ensure the casing string is positioned in the center of the borehole. Centralizers are typically expandable stainless steel metal or plastic that attach to the outside of the casing and are adjustable along the length of the casing. Centralizers are generally attached at the bottom and immediately above the well screen and at 10- or 20-foot intervals along the casing to the surface.

Methods for filter pack emplacement include gravity (free-fall), tremie pipe, reverse circulation, and backwashing. The latter two techniques are not commonly used for monitoring well construction, since they require the introduction into the borehole of water from a surface source.

Gravity emplacement is only possible in relatively shallow wells with an annular space of more than 2 inches, where the potential occurrence of bridging is minimized. Bridging can result in the occurrence of large unfilled voids in the filter pack or the failure of filter pack materials to reach their intended depth. Gravity emplacement may also cause filter pack gradation. Additionally, formation materials from the borehole wall can become incorporated into the filter pack, potentially contaminating it.

With the tremie emplacement method, the filter pack is poured or slurried into the annular space adjacent to the well screen through a rigid pipe, usually 1.5 inches in diameter. Initially the pipe is positioned so that its end is at the bottom of the annulus. If the filter pack is being installed in a temporarily cased borehole (hollow-stem auger , dual-tube percussion, or air rotary casing hammer) the temporary casing is pulled to expose the screen as the filter-pack material builds up around the well screen. In unconsolidated formations the temporary casing should only be pulled out one to two feet at a time to prevent caving. In consolidated or well-cemented formations or in cohesive unconsolidated formations, the temporary casing may be raised well above the bottom of the borehole prior to filter pack emplacement. For deep wells and/or non-uniform filter pack materials, the filter pack may be pressure fed through a tremie pipe with a pump. Emplacement should be continuously monitored with a weighted measuring tape accurate to the nearest 0.1 foot to determine when the filter pack has reached the desired height. After reaching the desired height, the well should be surged for 10-15 minutes, then checked for settling. Add more filter pack as necessary. Record the volume of filter pack used and check against calculated volume of annular space. Most well designs also employ a “secondary” filter pack (transition sand) above the primary filter pack for purposes of reducing bentonite seal and grout migration into the primary filter pack. If applicable, care must be taken that the filter pack materials are not installed into a hydrostratigraphic unit above or below the specific zone that is targeted for monitoring.

4.5 Annular Seal

Proper annular seal formulation and placement results in the complete filling of the annular space and envelopes the entire length of the well casing to ensure that no vertical migration can occur within the borehole.

Annular seal materials may include bentonite, neat cement grout, or variations of both. Typically, a bentonite seal from 2 to 5 feet thick is emplaced immediately above the filter pack. The use of bentonite as a sealing material depends on its efficient hydration following emplacement. Expansion of bentonite in water can be on the order of eight to 10 times the volume of dry bentonite. This expansion causes the bentonite to provide a tight seal between the casing and the adjacent formation and between the grout and filter pack. Bentonite is available as pellets, granules, chips, chunks, or powder. The dry bentonite should be less than one-fifth the width of the annular space between casing and borehole (ASTM 1995). If the bentonite seal will be above the saturated zone, several gallons of clean water must be poured down the annulus to begin the hydration process. A minimum of 30 minutes should pass to allow for hydration before additional annular seal materials are placed above the bentonite. Bentonite pellets having a coating to slow the hydration process are not recommended as they have been found to contain chemicals that may impact water quality.

Powdered bentonite is generally made into a grout slurry to allow emplacement as a bentonite seal. This grout slurry is prepared by mixing about 15 pounds of a high-solids, low-viscosity bentonite with seven gallons of water to yield one cubic foot of grout. Once the grout is mixed, it should remain workable for 15 to 30 minutes. During this time the grout is pumped through a tremie pipe with a mud or grout pump. Once in place, the bentonite grout requires a minimum of 24 hours to strengthen. In water with a high total dissolved solids (TDS) content (>5,000 parts per million [ppm]) or a high chloride content, the swelling of bentonite is inhibited.

A neat cement is commonly used to seal the remainder of the annulus. Neat cement is made up of one 94-pound bag of Portland cement and six gallons of water. The water used to mix the neat cement should be clean with a TDS less than 500 ppm. Bentonite powder is often added to neat cement to improve workability and reduce slurry weight and density and to reduce grout shrinkage. The proportion of bentonite by volume should be three to five percent.

The cement-bentonite grout should be mechanically blended in an aboveground rigid container and pumped through a tremie pipe to within a few inches of the bottom of the space to be sealed. This allows the grout to displace groundwater and loose formation materials up the hole. The end of the tremie pipe should always remain in the grout without allowing air spaces. After emplacement, the tremie pipe should be removed immediately. The grout should be placed in one continuous mass before initial setting of the cement or before the mixture loses its fluidity.

Cement is a highly alkaline substance (pH from 10 to 12) and introduces the possibility of altering the chemistry of the water it contacts. Thinner slurries may infiltrate an unprotected filter pack. After a borehole annulus is filled with grout a sample of water may be obtained and the pH determined in the field. A pH reading of 12 or higher may indicate an invasion of cement grout into the well.

4.6 Surface Completions

Two types of surface completions are common for groundwater monitoring wells: aboveground and flush-mounted. Aboveground completions are preferred wherever practical. The primary purpose of either type of completion is to prevent surface runoff from entering and infiltrating down the annulus of the well, and to protect the well from accidental damage or vandalism. The surface seal may be an extension of the annular seal installed above the filter pack, or a separate seal emplaced atop the annular seal.

For aboveground completions, the drilling subcontractor will construct a concrete apron (3 feet x 3 feet x 0.5 feet) around each well. A protective steel casing fitted with a locking cover is set into the uncured concrete apron. Concrete aprons will be crowned to provide positive runoff away from the well. Concrete pads may be constructed within three days after wells have been installed. If necessary steel guard posts 4-inches in diameter and filled with concrete will be installed around the pads. Posts will be five feet long and will have a stickup of 2.5 feet above ground surface and 2.5 feet below ground surface. In a flush-to-ground surface completion, a water-tight monitoring well Christy box or its equivalent is set into the cement surface seal before it has cured. This type of completion is used in high-traffic areas. A low, gently sloping mound of cement will discourage surface runoff. A locking well cap must be used to secure the inner well casing.

5.0 REFERENCES

American Society of Testing and Materials (ASTM), 1995. *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers*, Designation D 5092-90.

STANDARD OPERATING PROCEDURES

SOP-03

GROUNDWATER MONITORING WELL DEVELOPMENT

STANDARD OPERATING PROCEDURES

SOP-03
GROUNDWATER MONITORING WELL DEVELOPMENT

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DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

The goal of monitoring well development is to remove fines and drilling fluid residue from the gravel pack and the natural formation in the vicinity of the screened interval, thus assuring good communication between the aquifer and the well. Well development assures that a sample collected will be a true representative of the quality of water moving through the formation.

The well development process is composed of the following:

- The application of sufficient energy in a monitoring well to create groundwater flow reversals (surging) in and out of the well and the gravel pack to release and draw fines into the well
- Pumping or bailing to draw drilling fluids out of the borehole and adjacent natural formation, along with fines that have been surged into the well.

2.0 DEFINITIONS

Fines	Silt, clay, fine sand.
Parameters	Groundwater variables (i.e., pH, specific conductivity, temperature, turbidity).
Annulus	The gap between the well and borehole where the sand, seal, and grout are installed.
Saturated Annulus	The portion of the annulus that is below the aquifer.
Drilling Fluid	Any fluid the driller may have added during the drilling of the borehole.
Purge Water	Any water removed from the well via bailing, pumping, or airlift.
Drawdown	Distance between the static water level and water level while the well is being pumped or bailed at a constant rate.
Bridge	A wedge or buildup of sand that occurs when the driller is pouring the sand pack around the screened interval, thus leaving a gap or "open zone" where the natural formation could possibly clog the screen.
Yield	The rate at which a well will produce water.

3.0 RESPONSIBILITIES

The **Project Manager** or **Task Leader** will select the site-specific development methods, with input from the site geologist or hydrogeologist and Field Team Leader, and will maintain close supervision of the activities and progress.

The **Field Team Leader/Geologist** implements the selected development program and assists in the selection of development methods.

The **Field Technician/Staff** carries out the actual well development.

4.0 WELL DEVELOPMENT

4.1 General

The following general guidelines are applicable to well development regardless of method.

4.1.1 Decontamination

Every effort must be made to avoid outside contamination and the cross-contamination of monitoring wells. This can best be done by ensuring that all equipment to be introduced into a well is clean. The level of effort for decontamination is a site- and project-specific issue to be resolved individually for each project.

4.1.2 Documentation

A critical part of monitoring well development is recording significant details and events in either a field logbook or on a well development log (Attachment 1). It is important that the following details be documented.

- Well identification number
- Installation date
- Date and time of development
- Quantity of drilling fluid lost during well installation
- All photoionization detector (PID) readings (Note: see SOP-39 for additional information on PID principles and procedures.)
- Measured well depth (pre-development and post-development)
- Water level
- Height of water column
- Pumping rate and water level drawdown (if applicable)
- Recharge rate (poor, good, excellent)

- Periodic parameter readings
- Sample observations
- Type of equipment used
- Total amount of water removed
- Completion time

4.1.3 Calculating Purge Volume

The minimum number of gallons to be removed must be calculated before the development process begins.

Information needed to calculate purge volume:

- Total depth of well (TD)
- Measured static water level (WL)
- Screen length (SL)
- Well casing inner diameter (ID)
- Borehole Diameter (BD)
- Number of gallons of water used during well drilling/construction
- Number of feet of filter pack installed above the screen, if the standing water column (SWC) is longer then the screen length

To calculate one well volume:

- Calculate the standing water column (SWC). TD - WL = SWC.
- Use a well volume chart (Attachment 2) to find a multiplier in the volume per linear foot column that coincides with the well's ID.
- SWC times ID multiplier equals gallons of water in one well volume

To calculate one annulus volume (two options):

Option 1 (if the SWC is shorter than the screen length):

- Portion of saturated annulus equals SWC
- Use a volume chart to find a multiplier in the volume per linear foot column that coincides with the well's BD

- BD multiplier minus ID multiplier equals annulus multiplier
- Feet of saturated annulus times annulus multiplier times 30 percent (assumed porosity) equals gallons of water in one annulus volume

Option 2 (if the SWC is longer than the screen length):

- Portion of saturated annulus is equal to the screen length plus the number of feet of sand above the top of the screen
- Use a volume chart to find a multiplier in the volume per linear foot column that coincides with the well's BD
- BD multiplier minus ID multiplier equals annulus multiplier
- Feet of saturated annulus times annulus multiplier times 30 percent (assumed porosity) equals gallons of water in one annulus volume

To calculate the minimum gallons to be removed:

- Well volume plus annulus volume plus number of gallons lost during well drilling/construction equals one purge volume

Example for the Development of a 4-inch Well

The Well Construction Log notes that the borehole diameter is 10.25 inches, the screen is 15 feet long, and the driller used 75 gallons of water during well construction. Measured with a water level indicator, the static water level is 59.45 feet. Measured with a well tagger, the well depth is 71.21 feet.

Record in logbook, TD = 71.25 feet
WL = 59.45 feet

TD - WL = SWC
Logbook, SWC = 11.8 feet

From Chart 1 (Attachment 2), the gallons per linear foot multiplier for a 4-inch well is 0.66. Thus, 11.8 × 0.66 = 7.79 (gallons of water in one well volume).

Logbook, one well volume = 7.79 gallons

From Chart 2 (Attachment 2), the gallons per linear foot for a 10.25-inch borehole is 4.29. Therefore, 4.29 (BD multiplier) minus 0.66 (ID multiplier) equals 3.63 (annulus multiplier). Thus, 11.8 × 3.63 × 30 percent = 12.89 (gallons of water in one annulus volume).

Logbook, one annulus volume = 12.89 gallons
drilling fluid lost = 75 gallons

7.79 (one well volume) plus 12.89 (one annulus volume) plus 75 (fluid lost) equals 95.7 gallons (one purge volume). The work plan states that a minimum of three well volumes must be removed during development. Additional water may need to be purged to allow the parameters to stabilize and the water to clear up.

> Logbook, one purge volume = 95.7 gallons
> 95.7 × 3 = 287 (minimum number of gallons to be purged).
> Logbook, minimum gallons to be purged = 287 gallons

4.2 Development Methods

4.2.1 Bailing, Surging, and Pumping

In relatively clean, permeable formations where water flows freely into the borehole, bailing, surging, and pumping is an effective development technique. The bottom of the well is first tagged to measure the amount of sand and silt before and after surging. Then a bailer (Figure 1) is lowered into the well to clean out any fines that have settled on the bottom. Then a surge block (Figure 2), approximately the same diameter as the well casing, is used to agitate the water, causing it to move in and out of the screen, which draws in fines from the gravel pack and surrounding formation, and breaks up any bridges that may have formed during the placement of the gravel pack. After surging for a few minutes (depending on the height of the water column and length of screen), the bailer is again lowered to clean out any fines that were drawn into the casing as a result of surging. This surge/bail technique should continue until minimal fines are being pulled out with the bailer. A submersible pump (Figure 3) is then lowered down the well. Pumping should begin at the top of the saturated portion of the screened interval to prevent sand locking. The pump should be lowered at intervals of five feet or less until the pump is resting approximately one foot from the bottom of the casing. The water level must be monitored continuously during the first few minutes of pumping to prevent drawing the water level below the pump intake and breaking the suction. If possible, the discharge flow rate should be increased until the well is pumping at its maximum yield without a drawdown beneath the pump.

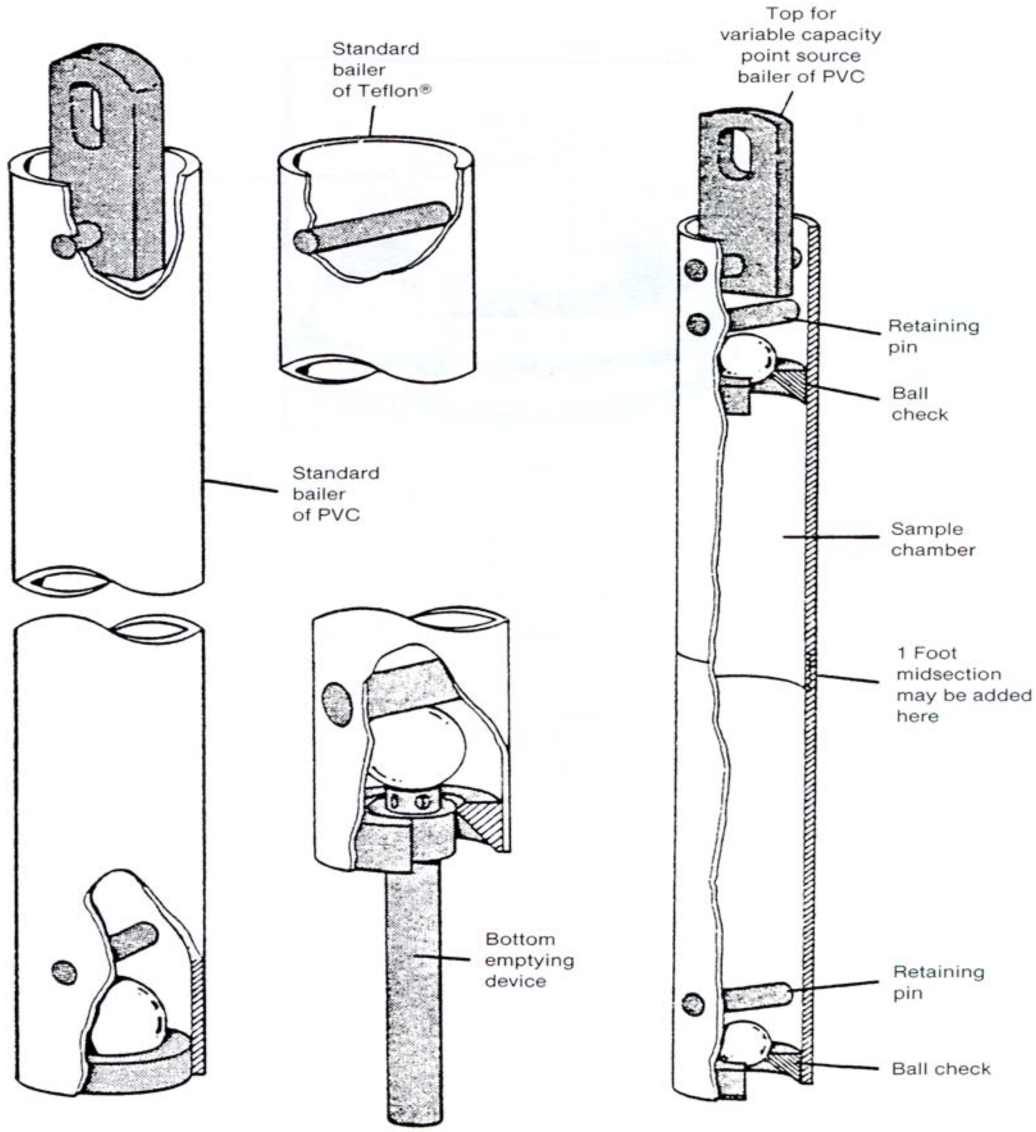

Figure 1 Bottom Discharge Bailer

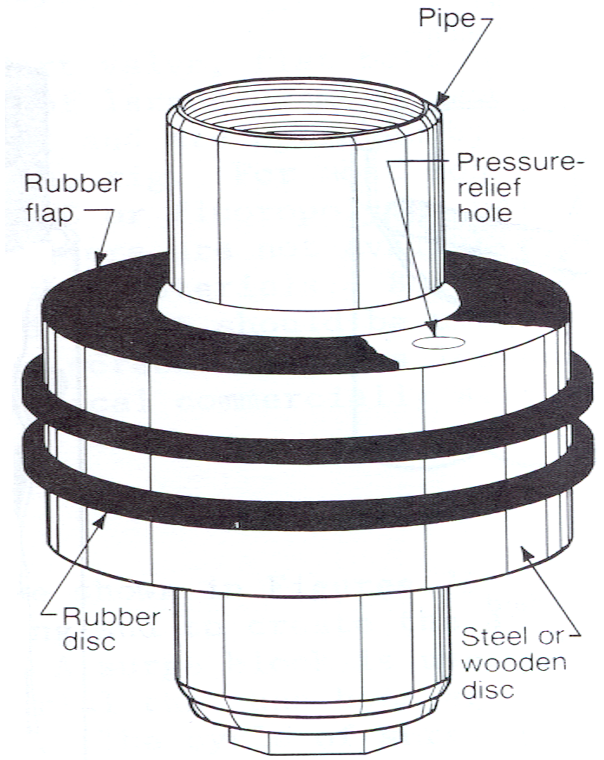

Figure 2 Surge Block

Figure 3 Submersible Pump

4.2.2 Overpumping and Backwashing

Wells may be developed by overpumping (pumping or bailing the well at a rate that exceeds the ability of the formation to deliver water) and then reversing the flow direction (backwashing) so that the water is passing from the well into the gravel pack and formation. This back and forth movement of water through the well screen and gravel pack removes fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, or forcing water into the well under pressure through a water-tight fitting. Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen. Where no backflow prevention valve is installed, a pump can be alternately started and stopped. This starting and stopping allows the column of water that is initially picked up by the pump to be alternately dropped and raised in a surging action. This surge tends to loosen the bridging of the fine particles, drawing them into the well where they are pumped out.

4.2.3 Compressed Air

Compressed air can be used to develop a well by either backwashing or surging. Backwashing forces water out through the screens, using increasing air pressure inside a sealed well, then releases the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. The well is subsequently pumped using the air lift method.

4.2.4 Developing Wells with Floating Product

It is important to disturb the formation as little as possible in wells that contain floating product. Surge blocks should not be used as they may smear the screen and the casing when the block is being withdrawn, potentially leaving evidence of product and increasing the risk of faulty data. Product wells should be developed using a bail/pump method. A bailer should be lowered gently into the well, without agitating the water column, to remove any fines that have settled on the bottom. If the well produces sufficient water, a pump is lowered into the well and pumping started at a slow flow rate. The product/water level is manually monitored constantly for the first few minutes to prevent the product level from coming within 2 feet of the pump intake. Pumping is continued until at least the quantity of drilling fluid lost has been purged, the parameters have stabilized, and the discharge water is visibly clear.

4.2.5 Developing Wells in Tight Formations

Developing low-yield wells is a very lengthy process; the amount of time spent developing a low yield well is project-specific and should be resolved individually for each project. For wells installed in clay or fine-grained silt, the method of development should be bailing only. Surging of such wells has been found to substantially increase the turbidity of the water and does not significantly improve hydraulic well response. These wells should be bailed dry and a record kept of the time it takes for the well to recharge 80 percent.

ATTACHMENT 1

WELL DEVELOPMENT LOG

WELL DEVELOPMENT LOG

Well ID: ____________________
Date: ____________________
Sample ID: ____________________
Time: ____________________
Method: ____________________
Technician: ____________________

Screened Interval (ft): ____________________
Pump Depth (ft): ____________________
Flow Rate (gpm) ____________________
Purging Device: ____________________
Water Level Instrument: ____________________
Water Quality Meter(s): ____________________

Well Diameter (in) ____________________
Static Water Level (ft): ____________________
Standing Water (ft): ____________________
One Well Volume (gal): ____________________
OVA Reading at TOC: ____________________
OVA Reading in BZ: ____________________

Time	Volume Purged (gal)	Flow Rate (gpm)	Water Level (feet - TOC)	SC (µS/cm)	pH	Temp	ORP (mV)	Turbidity (NTU)	Other	Comments
			± 0.1 ft	5%	± 0.1	± 0.1 ºC	5%	< 10 NTU		
Final Field Parameter Measurements										

Comments: ____

____

____

ATTACHMENT 2
VOLUME CHARTS

Chart 1 — Volume of PVC Casing

Schedule	Diameter (inches)	OD (inches)	ID (inches)	Volume/LF (gallons)
40	1.25	1.660	1.380	0.08
40	2	2.375	2.067	0.17
40	3	3.500	3.068	0.38
40	4	4.500	4.026	0.66
40	6	6.625	6.065	1.50
40	8	8.625	7.981	2.60
40	12	12.750	11.938	5.82
80	2	2.375	1.939	0.15
80	4	4.500	3.826	0.60
80	5			0.00

Chart 2 — Volume of Open Borehole and Annulus Between Casing and Hole

Hole Diameter	Volume/Linear Feet of Hole		Nominal Casing Diameter	4.2.5.1 Volume/Linear Feet of Annulus	
(inches)	(gallons)	(cubic feet)	(inches)	(gallons)	(cubic feet)
7.25	2.14	0.29	1.3	2.08	0.28
7.25	2.14	0.29	2.0	1.98	0.26
7.75	2.45	0.33	2.0	2.29	0.31
8.25	2.78	0.37	2.0	2.61	0.35
10.25	4.29	0.57	2.0	4.12	0.55
8.25	2.78	0.37	3.0	2.41	0.32
10.25	4.29	0.57	3.0	3.92	0.52
12.25	6.12	0.82	3.0	5.76	0.77
8.25	2.78	0.37	4.0	2.12	0.28
10.25	4.29	0.57	4.0	3.63	0.49
12.25	6.12	0.82	4.0	5.47	0.73
12.25	6.12	0.82	6.0	4.65	0.62

STANDARD OPERATING PROCEDURES

SOP-05

WATER SAMPLING AND FIELD MEASUREMENTS

STANDARD OPERATING PROCEDURES

SOP-05
WATER SAMPLING AND FIELD MEASUREMENTS

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LIST OF ATTACHMENTS

DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

This guideline is a general reference for the proper equipment and techniques for groundwater sampling. The purpose of these procedures is to enable the user to collect representative and defensible groundwater samples and to facilitate planning of the field sampling effort. These techniques should be followed whenever applicable, although site-specific conditions or project-specific plans may require adjustments in methodology.

To be valid, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from time of collection to time of analysis in order to minimize changes in water quality parameters. Acceptable equipment for withdrawing samples from completed wells includes bailers and various types of pumps. The following are primary considerations in obtaining a representative sample of the groundwater:

- Avoid collecting stagnant (standing) water in the well.
- Avoid physically or chemically altering the water by improper sampling techniques, sample handling, or transport.
- Document that proper sampling procedures have been followed.

This guideline describes suggested well evacuation (or purging) methods, sample collection and handling, field measurement, decontamination, and documentation procedures. Examples of sampling and chain-of-custody (COC) forms are attached.

2.0 DEFINITIONS

Annular Space	The space between casing or well screen and the wall of the drilled hole, or between drill pipe and casing, or between two separate strings of casing. Also called annulus.
Aquifer	A geologic formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring.
Bailer	A long narrow tubular device with an open top and a check valve at the bottom that is used to remove water from a well during purging or sampling. Bailers are available in many widths and lengths, and may be made of Teflon, polyvinyl chloride (PVC), polyethylene (PE), or stainless steel. Disposable bailers are widely used, and are available in Teflon and PE.
Bladder Pump	A pump consisting of flexible bladder (usually made of Teflon) contained within a rigid cylindrical body (commonly made of PVC or stainless steel). The lower end of the bladder is connected through a check valve to the intake port, while the upper end is connected to a sampling line

	that leads to the ground surface. A second line, the gas line, leads from the ground surface to the annular space between the bladder and the outer body of the pump. After filling, under hydrostatic pressure, application of gas pressure causes the bladder to collapse, closing the check valve and forcing the sample to ground surface through the sample line. Gas pressure is often provided by a compressed air tank, and commercial models generally include a control box that automatically switches the gas pressure off and on at appropriate intervals.
Centrifugal Pump	A pump that moves a liquid by accelerating it radially outward in an impeller to a surrounding spiral-shaped casing.
Chain of Custody	Method for documenting the history and possession of a sample from the time of its collection through its analysis and data reporting to its final disposition.
Check Valve	Ball and spring valves on core barrels, bailers, and sampling devices that are used to allow water to flow in one direction only.
Conductivity (electrical)	A measure of the quantity of electricity transferred across a unit area, per unit potential gradient, per unit time. It is the reciprocal of resistivity.
Datum	An arbitrary surface (or plane) used in the measurement of heads (i.e., National Geodetic Vertical Datum, commonly referred to as mean sea level).
Direct-Push Technology	A method of soil boring installation involving pushing a sampling device into the ground and retrieving it for soil description and collection (Geoprobe® is a common trademark name). Groundwater samples can be collected from the borehole by inserting a screen point into the hole and removing groundwater via peristaltic pump or small-diameter bailer. Similar to Hydropunch® (see below).
Decontamination	A variety of processes used to clean equipment that contacted formation material or groundwater that is known to be or suspected of being contaminated.
Downgradient	In the direction of decreasing potentiometric head.
Drawdown	The lowering of the water level or potentiometric surface in a well and aquifer due to the discharge of water from the well.
Electric Submersible Pump	A pump that consists of a rotor contained within a chamber and driven by an electric motor. The entire device is lowered into the well with the electrical cable and discharge tubing attached. A portable power source and control box remain at the surface. Electrical submersible pumps used for groundwater purging are constructed of inert materials such as stainless steel, and are well sealed to prevent sample contamination by lubricants.
Filter Pack	Sand or gravel that is generally uniform, clean, and well rounded that is placed in the annulus between the borehole wall and the well screen to prevent formation material from entering through the well screen and to stabilize the adjacent formation.

Headspace	The empty volume in a sample container between the water level and the cap.
HydroPunch®	An *in situ* groundwater sampling system in which a hollow steel rod is driven into the saturated zone that allows for the collection of a groundwater sample.
In Situ	In the natural or original position; in place.
Monitoring Well	A well that is constructed by one of a variety of techniques for the purpose of extracting groundwater for physical, chemical, or biological testing, or for measuring water levels or potentiometric surface.
Packer	A transient or dedicated device placed in a well or borehole that isolates or seals a portion of the well, well annulus, or borehole at a specific level.
Peristaltic Pump	A low-volume suction pump. The compression of a flexible tube by a rotor results in the development of suction.
pH	A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. (Original designation for potential of hydrogen.)
Piezometer	An instrument used to measure water level or potentiometric head at a point in the subsurface; a non-pumping well, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface.
Preservative	An additive (usually an acid or a base) used to protect a sample against decay or spoilage, or to extend the holding time for a sample.
Static Water Level	The elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, hydrologic testing, or nearby pumping.
Turbidity	Cloudiness in water due to suspended and colloidal organic and inorganic material.
Upgradient	In the direction of increasing potentiometric head.

3.0 RESPONSIBILITIES

The **Project Manager** selects site-specific water sampling methods, locations for monitoring well installations, monitoring wells to be sampled and analytes to be analyzed (with input from the Field Team Leader and Project Geologist), and is responsible for project quality control and field audits.

The **Field Team Leader/Geologist** implements the water sampling program; supervises the Project Geologist/Hydrogeologist and Sampling Technician; ensures that proper COC procedures are observed and that samples are sampled, transported, packaged, and shipped in a correct and timely manner.

The **Project Geologist/Hydrogeologist** ensures proper collection, documentation, and storage of groundwater samples prior to shipment to the laboratory, and assists in packaging and shipment of samples.

The **Field Sampling Technician** assists the Project Geologist/Hydrogeologist in the completion of tasks and is responsible for the proper use, decontamination, and maintenance of groundwater sampling equipment.

4.0 WATER SAMPLING GUIDELINES

4.1 Equipment

There are many methods available for well purging (evacuation) and sampling. A variety of issues must be considered when choosing purging and sample collection equipment. These issues include the following:

- Depth and diameter of the well
- Recharge capacity of the well
- Analytical parameters that will be tested
- Governing regulatory requirements

Few sampling devices are suitable for the complete range of groundwater analytical parameters. For example, a bailer is acceptable for collecting major ion and trace metal samples (if turbidity is not a factor), but analytical results may be incorrect if used for the collection of samples that are analyzed for volatile organics, dissolved gases, or even pH. Generally, the best pumps are positive displacement pumps, such as bladder and helical rotor pumps, which minimize the aeration of the groundwater as it is sampled, and therefore yield the most representative groundwater samples. Although it is possible to use different equipment to purge the well and to sample the well, this is not recommended because of the increased decontamination requirements and possibilities for cross contamination. It is recommended that a flow rate as close to the actual groundwater flow rate should be employed to avoid further development, well damage, or the disturbance of accumulated corrosion or reaction products in the well (Puls and Barcelona, 1989).

Positive displacement pumps, such as bladder pumps, are generally recommended for both well evacuation and sample collection. Disposable bailers are also commonly used for well development and evacuation, as well as sample collection in certain cases. Other types of sample collection such as gas lift pumps should be avoided, especially when analyzing for sensitive parameters, because of the geochemical changes that can occur due to the aeration of the water within the well. Also, the use of certain sample devices (e.g., bailers or high-rate centrifugal pumps) may entrain suspended materials, such as fine clays and colloids, which are not representative of mobile chemical constituents in the formation of interest (Puls and Barcelona, 1989).

Specific instructions for the use of several of the sampling devices are discussed in the next sections. All purging and sampling equipment should be decontaminated before beginning work and between wells, in accordance with Section 4.5.

4.1.1 Bailers

Bailers represent the simplest and least expensive method of collecting the sample from a well. However, they may not be suitable for all analyses. Bailers are available as permanent (re-usable or dedicated) and disposable. Permanent bailers are usually constructed of Teflon or stainless steel. Disposable bailers are usually constructed of PE or Teflon.

The advantages to using permanent bailers are:

- Inexpensive
- Easy to use and maintain

The disadvantages to using permanent bailers are:

- Disturb sediment while sampling
- Require decontamination and risk of cross-contamination
- Require disposal of contaminated purge water
- Possibility of splashing (health and safety issue)

The advantages of using disposable bailers are:

- No need for decontamination between.
- Inexpensive
- Easy to use

The disadvantages to using disposable bailers are:

- Disturb sediment while sampling

- Require disposal of contaminated purge water
- Possibility of splashing (health and safety issue)

Disposable bailers are preferred. Since there is no cross- contamination between samples, there is no need for time-consuming decontamination.

Bailers can be lowered and raised using stainless steel wire or polypropylene cord. Polypropylene cord is recommended since it is inexpensive, light, and strong, however it should be discarded after one use to prevent cross-contamination. At no time should the bailer or the line touch the ground during the sampling process. This can be done by coiling the line around one's hands while pulling the bailer out of the well. For deep wells, the line may be coiled into a bucket or on a clean plastic sheet.

During bailing, the purge water is poured out of the top of the bailer into a 5-gallon bucket, 55-gallon drum, or equivalent. Most groundwater sampling protocols require that the amount of water purged be recorded; thus, a 5-gallon bucket with 1-gallon markings is recommended. During sampling, the water can be poured out of the top of the bailer. This should not be done for volatile analyses. Water can also be removed from the bottom of the bailer using a small tube or sampling device that comes with most disposable bailers. This device essentially pushes the ball out of the valve, allowing water to slowly flow out of the bottom of the bailer. This is the recommended method for volatile organic compound (VOC) sampling.

4.1.2 Peristaltic Pumps

Peristaltic and centrifugal pumps are widely used for purging wells with water levels close to the surface (less than 30 feet). They are light, reasonably portable, and easily adaptable to ground level monitoring of field parameters by attaching a flow-through cell. These pumps require minimal downhole equipment. The tubing can easily be cleaned in the field; however, more often dedicated tubing is left in each well, or tubing is replaced after each well. The following procedures should be considered when using these pumps:

- Unless dedicated tubing is used, the interior and exterior of all intake tubing used with the peristaltic/centrifugal pump should be thoroughly washed with a detergent wash, flushed with tap water, and then double rinsed with distilled water prior to use.
- Peristaltic pumps typically run on batteries. However, if a gas-powered generator is used, it should be downwind of the well.
- The intake of the tubing should be lowered to the midpoint of the well screen. Alternatives to this procedure may be necessary if the drawdown from the purging operations causes the water level to fall and begin to pump air. Because of accumulated sediment at the well bottom, the intake should be at least 1 foot above the bottom of the well.

- If parameters are to be monitored continuously, it is recommended that an in-line “flow-through” cell with a multi-parameter water quality meter be used. Connect the discharge tubing from the pump to the “in” port of the flow-through cell and begin evacuating the well (make sure to have the “out” port connected to a bucket or some sort of water containment). Continuously monitor the parameters (typically pH, oxidation reduction potential (ORP or redox), dissolved oxygen (DO), turbidity, temperature, and specific conductivity) and measure the volume of groundwater being pumped.

- After purging is complete (stabilization of parameters), disconnect the discharge tubing from the flow through cell prior to sampling. Do not collect water that has flowed through the flow-through cell.

The advantages of using peristaltic pumps are:

- Typically less purge water to collect and dispose (if low-flow sampling)

- Relatively easy to use

- Very little disturbance of sediment; easy to achieve low turbidity samples

- Low health and safety risk (low splash possibility)

The disadvantages to using peristaltic pumps are:

- Possibly expensive, depending on tubing and pump used.

- Sampling time can be 1 hour or more per well.

- Limited depth applicability; can pump only from depths less than 32 feet.

- Vacuum or negative pressure can potentially alter the geochemistry (VOCs, pH, alkalinity).

4.1.3 Submersible Pumps

Submersible pumps take in water and push the sample up a tube to the surface. The power sources for these pumps may be compressed gas or electricity. The operation principles vary, and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Bladder or helical rotor pumps are recommended for sampling for sensitive parameters. Bladder pumps are available for .05-inch diameter wells and larger, and these pumps can lift water up to several hundred feet. For large sampling projects, dedicated tubing is recommended, as tubing for bladder pumps is typically very expensive ($10 per foot), thus making disposable tubing not efficient. The entire pump assembly (and tubing, if applicable) should be decontaminated before purging and between wells, as described in Section 4.5.

The advantages of using submersible pumps are:

- Less purge water to collect and dispose (if low-flow sampling).

- Very little disturbance of sediment; easy to achieve low turbidity samples.
- Adjustable to very low flow rates.
- Can be used to sample wells 300 or more feet deep.
- Dedicated systems can lower costs over time.
- Low health and safety risk (low splash possibility).
- Some types (e.g., bladder pumps) can be easily disassembled for decontamination.

The disadvantages of submersible pumps are:

- Need power source or gas source, which can be hard to transport to remote well locations.
- High start-up costs; Many models of these pumps are expensive, as is the tubing.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components of some types is difficult and time consuming.

4.1.4 Other Pumps

Gas-Lift Pumps

A pressure displacement system consists of a chamber equipped with a gas inlet line, a water discharge line, and two check valves. When the chamber is lowered into the casing, water floods it from the bottom through the check valve. Once full, a gas (e.g., nitrogen or air) is forced into the top of the chamber in sufficient amounts to displace the water in the discharge tube. The check valve in the bottom prevents water from being forced back into the casing, and the upper check valve prevents water from flowing back into the chamber when the gas pressure is released. This cycle can be repeated as necessary until purging is complete. The potential for increased gas diffusion into the water (and thus loss of volatiles) makes this system unsuitable for sampling volatile organic or most pH critical parameters. This method is not recommended for groundwater sampling, but may be useful for development or evacuation of a well.

Direct-Push Technology Groundwater Sampling

Direct Push Technology (DPT) provides *in situ* groundwater samples by using a specially designed sample tool to provide a hydraulic connection with the water table. When used with a mobile laboratory, DPT groundwater sampling can be useful for such applications as relatively rapid delineation of groundwater plumes. It is also ideal for screening for contaminants. Both groundwater and floating layer hydrocarbons may be sampled using this method.

The DPT method utilizes a sampler containing a stainless steel screen point, which is attached to the DPT rods and is inserted into the DPT borehole. When the screen is at the desired depth, the sampler is pulled back, exposing the screen to the formation. Groundwater can then be sampled used a peristaltic pump or a small diameter bailer.

This method may be used to sample groundwater up to approximately 60 feet of soft sediments. In coarse sand, gravel, consolidated rock, or at depths greater than 60 feet, a pilot hole must be drilled prior to using this method.

The advantages of using DPT groundwater sampling techniques are:

- Low cost (relative to installing monitoring wells)
- Able to collect a relatively undisturbed *in situ* groundwater sample
- The relative speed with which a sample can be collected when compared to drilling, installing, developing, purging, and sampling a monitoring well

The disadvantages of using DPT groundwater sampling techniques are:

- Accurate water levels can not be obtained
- Sampling cannot be repeated if problems occur with the samples after they are collected
- Does not allow for long-term groundwater monitoring

4.2 Well Purging Methods

Well development procedures are covered in SOP-03, "Groundwater Monitoring Well Development."

4.2.1 Calculation of Casing Volume

To ensure that an adequate volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well and the volume of water in the filter pack below the well seal. The volume can be easily calculated by the following method (calculations should be entered in the field logbook):

1. Obtain all available information on well construction (e.g., location, casing, screen, depth).
2. Determine well or casing diameter.
3. Measure and record static water level using an electronic water level meter (depth below top of casing reference point).

4. Use a pre-determined total depth of the well to calculate the water column. Measuring total depth prior to sampling will disturb sediment that has accumulated at the bottom of the well, which will affect sample results.

5. Calculate the volume of water in the casing using the following formula:

$$V = 7.481\ (\pi r^2 h)$$

where:

V	=	Casing volume (gal)
r	=	Well radius (ft)
h	=	Linear feet of water in well = total well depth (ft) - static water depth (ft)

Alternatively, the casing volume can be calculated by multiplying the linear feet of water in the well by the volume per linear feet taken from Attachment 1 or other similar tables. Always be sure that the units in your calculation are consistent. In the equation above, 7.481 is the conversion factor from cubic feet to gallons.

4.2.2 Calculation of Annulus Volume

Some groundwater sampling protocols require the purging of casing and annulus volumes prior to sampling. In these cases the volume of water contained in the annular space between the casing and the borehole wall is calculated by the following formula:

$$Va = (Cb - Cc) \times (h) \times (0.30)$$

where:

Va	=	Volume of water in annulus (gal)
Cb	=	Borehole capacity (gal/ft)
Cc	=	Casing capacity (gal/ft)
h	=	Amount of standing water in the well or total linear height of the sand pack, whichever is less (ft)
0.30	=	Average porosity of typical sand pack

The values for Cb and Cc can be calculated by the formula πr^2. The annulus volume is added to the casing volume prior to multiplying by the number of volumes to be purged.

4.2.3 Purging Requirements

The composition of the water within the well casing and in close proximity to the well is probably not representative of the overall groundwater quality in the target aquifer. This is because important environmental conditions such as the ORP may differ drastically near the well from the conditions in the surrounding water-bearing materials. For this reason it is necessary to either purge the well until it is thoroughly flushed of standing water and contains fresh water from the aquifer, or sample from discrete intervals in the screened interval at low flow rates in order to collect undisturbed aquifer water (Puls and Barcelona, 1996).

Full Well Purging

When full purging is required, the recommended amount of purging before sampling depends on many factors, including the characteristics of the well, the hydrogeological nature of the aquifer, the type of sampling equipment being used, the parameters that are to be analyzed, and the regulatory requirements of the project. The number of casing volumes that should be removed prior to sample collection has been a matter of debate in the groundwater community for some time. However, it is recommended that where possible, between three and five casing volumes should be purged prior to sampling.

Low-Flow Sampling

Many groundwater scientists and regulatory departments have accepted and prioritized the use of low-flow purging and sampling of groundwater. Low-flow purging is defined as pumping rates between 0.1 and 0.5 liters per minute (L/min). Also, rather than relying on the removal of a specific volume of water prior to sample collection, physical parameters, such as pH, DO, ORP, turbidity, specific conductivity, and temperature, are collected at certain intervals (usually every 2 to 5 minutes). In order to minimize contact with the atmosphere, these parameters are typically measured using a multi-parameter meter inside a closed “flow-through” cell attached to the discharge side of a pump system. Once the parameters have stabilized, the groundwater is considered representative of the aquifer and is ready for sample collection. Determining *when* the parameters have stabilized, however, may differ between regulatory agencies. Per the U.S. Environmental Protection Agency (EPA) document *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (Puls and Barcelona, 1996), the parameters are considered stabilized when three consecutive measurements are within the following constraints:

- Temperature ± 10 %
- Conductivity ± 3 %
- pH ± 0.1
- DO ±10 %
- ORP ±10 mV
- Turbidity ±10 % or <10 nephelometric turbidity units (NTUs)

During purging, water levels should be monitored to ensure that drawdown does not exceed 0.1 m (0.3 ft). If the water level drop exceeds this, the flow rate should be decreased until the water level stabilizes. If water levels in low yield wells do not stabilize at flow rates near 0.1 L/min, the well should be purged to dryness once and then sampled (EPA, 1986). Samples should be collected when the well has recovered to 80 percent of its original capacity or at 24 hours from being purged to dryness, whichever comes first. At no time should the well be pumped to dryness if the recharge rate causes the formation water to vigorously cascade down the sides of the screen and cause an accelerated loss of volatiles. In this case, samples should be collected at a rate slow enough to maintain the water level at or above the top of the screen to prevent cascading.

4.2.4 Purge Water Handling and Disposal

Because of the potential for spreading environmental contamination, planning for purge water disposal is a necessary part of well monitoring. Alternatives range from releasing it on the ground (not back down the well) to full containment, treatment, and disposal. If the well is believed to be contaminated, the best practice is to contain the purge water and store it in drums labeled "purge water" or in aboveground portable storage tanks (i.e., Baker Tanks) until the water samples have been analyzed. Include the date that the waste was generated on the container. Once the contaminants are identified, appropriate treatment or disposal requirements can be determined.

4.3 Field Measurements

A variety of field measurements are commonly made during the sampling of groundwater including water level, pH, conductivity, turbidity, temperature, DO, and ORP. The accuracy, precision, and usefulness of these measurements are dependent on the proper use and care of the field instruments. Valid and useful data can only be collected if consistent practices (in accordance with recommended manufacturer's instructions) are followed. The instruments should be handled carefully at the well site and during transportation to the field and between sampling sites.

4.3.1 Water Level

Water levels can be measured by several techniques, but the most common method is using an electronic water level meter. The proper sequence is as follows:

1. Check operation of measurement equipment aboveground. Prior to opening the well, don personal protective equipment as required.
2. Record the following information on a sampling form or in the field notebook if a form is not available:

- Well number
- Top of casing elevation
- Surface elevation, if available.

3. After opening the well, observe any pressure in the well. Allow 10-30 seconds for the water levels to equilibrate and stabilize. Repeat measurement after 30 seconds to assure the water level has stabilized.

4. Measure and record static water level and total depth (only if necessary) to the nearest 0.01 foot (0.3 cm) from the surveyed reference mark on the top edge of the inner well casing. If no reference mark is present, record in the log book where the measurement was taken (e.g., from the north side of the inner casing).

5. Record the time and day of the measurement.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable or tape and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact. For accurate readings, the probe should be lowered slowly into the well.

Oil/Water Interface Probes

If oil or free product is encountered in the well, an oil/water interface probe can be used to measure the thickness of the product on top of the water. Most models exhibit two distinct electronic sounds for oil (usually a solid beep) and water (an intermittent beep). The most accurate method for measuring the oil/water interface is to first measure the top of the free product, then go through the product until the probe registers water, and then slowly raise the probe until a solid beep is encountered. This prevents a false thickness of product being measured, since product may stick to the probe causing the probe to read product when it really is in water.

4.3.2 Multi-Parameter Probes

Typically, groundwater parameters such as pH, temperature, and DO are measured in a flow-through cell using a probe that measures several parameters at once. Certain sampling techniques may preclude the use of these probes, and individual probes may need to be used instead.

Instruments should be calibrated at the beginning of every day, and if readings become suspect. Most instruments claim to hold their calibration longer than a day; if so, their calibration can be checked every morning. If the values do not match the expected numbers, the instrument should be calibrated again. The manufacturer's directions for calibration, maintenance, and use should be read and closely followed.

Any problems with the functioning of the meter should be noted in the field log and reported to the office equipment manager.

4.4 Sample Collection Methods

4.4.1 Sample Containers

A complete set of sample containers should be prepared by the laboratory prior to going into the field. The laboratory should provide the proper containers with the required preservatives. The laboratory's quality assurance manual should provide a complete description of the procedures used to clean and prepare the containers. The containers should be labeled in the field with the date, well designation, project name, collectors' name, time of collection, and parameters to be analyzed. The sample containers should be kept in a cooler (at 4 degrees centigrade) until they are needed (i.e., not left in the sun during purging). One cooler should be used to store the unfilled bottles and another to store the samples.

The sample bottles should be filled in order of the volatility of the analytes so that the containers for volatile organics will be filled first, and samples that are not pH-sensitive or subject to loss through volatilization will be collected last. A preferred collection order (EPA, 1986) is as follows:

- VOCs
- Total petroleum hydrocarbons
- Total organic halogens
- Total organic carbon
- Extractable organics (e.g., pesticides, herbicides)
- Total metals
- Dissolved metals
- Phenols
- Cyanide
- Sulfate and chloride
- Nitrate and ammonia
- Radionuclides

Field measurements, such as temperature, pH, and specific conductance, should be measured and recorded in the field before and after sample collection to check on the stability of the water samples over time.

4.4.2 Field Filtration for Dissolved Metals

Filtering groundwater samples has been a subject of considerable debate in recent years. In many cases, samples passing a 0.45-micron filter were used to provide an indication of dissolved metals concentrations in groundwater. Puls and Barcelona (1989) report that the use of a 0.45-micron filter was not useful, appropriate, or reproducible in providing information on metals mobility in groundwater systems, nor was it appropriate for determination of truly “dissolved” constituents in groundwater. A dual sampling approach is recommended to collect both filtered and unfiltered samples.

Any filtration for estimates of dissolved species loads should be performed in the field with no air contact and immediate preservation and storage. In-line pressure filtration is best with as small a filter pore size as practically possible (e.g., 0.45, 0.10 micron). Disposable, in-line filters are recommended for convenience and avoiding cross-contamination. The filters should be pre-rinsed with distilled water; work by Jay (1985) showed that virtually all filters require pre-washing to avoid sample contamination.

In the absence of filters, low-flow sampling techniques can reduce turbidity to values less than 10 NTUs.

4.4.3 Methyl Mercury “Clean Hands/Dirty Hands” Collection Method

Sample bottles may be either Teflon, which has been cleaned, tested, filled with dilute HCl, and double bagged in a laboratory clean-room, or borosilicate glass obtained from a supplier which certifies cleanliness for metals sampling (e.g., I-Chem, Series 200 or equivalent). In general, a sample kit should be obtain from the laboratory consisting of proper containers, bags, gloves, and instructions. The use of locally obtained or untested containers is strongly discouraged as they may be the source of possible contamination. At the site the bottle is filled with water sample using an abbreviated version of the “clean –hands – dirty –hands” technique described in EPA Method 1669. Bottles are sealed tightly and re-bagged using the opposite series of steps as were used to open them. Bottles are shipped to the analytical laboratory via overnight courier for preservation and analysis.

<u>Sample Collection</u>

Samples should be collected only into rigorously cleaned and tested (for mercury) Teflon bottles or borosilicate glass bottles with Teflon-lined caps.

Samples are collected using rigorous ultra-clean protocols which are summarized as follows.

1. Ideally, at least two persons wearing fresh clean-room gloves at all times are required on a sampling crew.

2. One person ("dirty hands") pulls a bagged bottle from the cooler and opens the outer, dirty bag, avoiding touching inside that bag.

3. The other person ("clean hands") reaches in, opens the inner bag (if present), and pulls out the sample bottle. "Clean hands" should not touch anything but the sample bottle, its cap, and the water being sampled.

4. This bottle is opened and the acidified water (if present) is discarded. Under no circumstance should the bottle cap be placed on any surface while it is removed from the bottle.

Note: the sampler should be wary of disturbing the flow upstream of the sampling point. Often the insertion of the bottle into a flowing stream, or simply standing in the flow downstream of the sampling point, creates eddies (upstream flow) which can re-suspend solids near the sampling point. Entry of such re-suspended solids into samples for analysis of mercury will produce a non-representative sample and very likely increase the mercury concentration.

For Aqueous Sampling

5a. The bottle (including its cap) is rinsed three times with the sample water, and then filled almost completely. Leaving a small headspace (e.g. 1% of bottle volume) is acceptable and provides space for subsequent acid preservation at the laboratory.

Note: If the sampler cannot directly reach the water to be sampled, a pole-type sampler may be used to fill the bottle. The pole and bottle clamp should be made of plastic and/or stainless steel and the mouth of the bottle should be held facing upstream of the pole. Again, the use of a transfer vessel should be avoided.

For Sediment Sampling

5b. The bottle is then filled almost completely with sediment using a utensil known to be free from trace metal contamination. The sampler should ensure that the sampling site is representative of the immediate area.

6. The cap is replaced and the bottle re-bagged in the opposite order from which it was removed.

7. Clean-room gloves are changed between samples and whenever anything not known to be trace metal cleaned is touched.

Samples should be sent to the analytical laboratory unpreserved. The sample should be preserved as required by the method soon after arrival at the laboratory (within 48 hours). Unpreserved samples have been found stable for at least 1 week, when stored in Teflon or borosilicate glass bottles.

4.4.4 Sampling from Non-Monitoring Wells and Springs/Seeps

Municipal/Residential Wells

Residential water supply wells should be sampled in a similar manner to monitoring wells, although allowances must be made for the type of pumping equipment already installed in the well. In most cases, this will involve sampling directly from the tap on each well and before the water has gone through any chlorination or treatment system. The sampling point should be a cold-water tap located as close to the pump as practical. Domestic supply samples should not be taken from taps delivering chlorinated, aerated, softened, or filtered water. Faucet aerators should be removed if possible before sampling. Outdoor spigots are generally preferable, since they are usually provide untreated water and are less of an intrusion into the residence. Field parameters (temperature, DO, ORP, etc.) can be measured in a flow-through cell connected via hose to an outside spigot. The water sample can be collected after parameters stabilize. For sampling, the flow rate should be set to low flow sampling rates (or approximately 0.1 L/min). If field parameter measurement is not possible, the water tap should be turned on and run for at least 30 minutes unless the water tap is directly adjacent to the well head, and then the water should be allowed to run for no less than 10 minutes before the samples are collected to flush stagnant water from the system. All sample containers should be filled with water directly from the tap and the samples processed as described for monitoring well samples. Components of the plumbing system should be noted to assist in data interpretation.

Spring and Seep Sampling

Samples from springs or seeps should be collected directly into the sample bottles without using any special sampling equipment. The sample will be collected as close as possible to where the spring emanates from the soil or rock. The sampler should always stand downstream of the spring or seep to avoid disturbing sediment or clouding the water.

4.5 Decontamination

Decontamination procedures will vary from project to project based on the regulations and project-specific Field Sampling Plan (FSP). Generally, decontamination procedure for non-dedicated groundwater sampling equipment (bailers, pumps, water-level probes) consists of the following steps:

1. Scrub and wash with laboratory-grade detergent (such as Alconox™) and tap water.
2. Triple rinse with deionized water.

If equipment is highly contaminated, it may be rinsed with reagent-grade isopropanol alcohol or methanol and allowed to air dry prior to Step 2 above. A hot water pressure washer can also be used for decontaminating sampling equipment. However, dedicated or disposable equipment is preferable since it eliminates any possible cross-contamination pathway that incomplete decontamination may cause. As with other procedures documented in this Standard Operating Procedure (SOP), decontamination procedures may be determined by the client or regulatory agency involved in the project.

4.6 Records and Documentation

4.6.1 Sample Designation

Sample names vary from project to project, and further instructions are typically described in the project Quality Assurance Project Plan (QAPP) or FSP. Typically, the site name or an abbreviation or acronym of the site name is included along with the well identification. Blind duplicate samples should be labeled with the number of a non-existent well, and should not include a sample time on the label. Equipment and trip blanks, collected when non-dedicated equipment is used, may also be labeled with a fictitious well name in a similar manner to the blind duplicate samples.

4.6.2 Sample Label

Sample containers should be labeled using waterproof ink before a sample is obtained. A sample label should be affixed to all sample containers. This label identifies the sample by documenting the sample type, sampler(s) initials, sample location, time, date, analyses requested, and preservation method. A unique sample designation as discussed above is assigned to each sample collected. This sample identification is also noted on the sample label.

4.6.3 Field Notebooks and Sampling Forms

A field notebook should be prepared prior to beginning sampling activities and should be maintained throughout the sample round. The notebook should contain pertinent information about the monitoring wells, such as depth of casing and water levels. During sampling, all the activities should be recorded on a groundwater sampling log (see Attachment 2) and/or in the field notebook. All forms used during sampling should be referenced in the field notebook. A brief description of weather conditions should also be noted as weather can sometimes affect samples. Any deviation from the sampling procedure described in the project work plan or SOP should be outlined in detail and justified in the field notebook.

Specialized sampling forms can also be used to record the field measurements and other conditions observed.

4.6.4 Chain-of-Custody

The COC form (see Attachment 3) should be used to record the number of samples collected and the corresponding laboratory analyses. Information included on this form consists of time and date sampled, sample number, type of sample, sampler's name, preservatives used, and any special instructions. The project QAPP will detail the procedure for completing the COC form. A separate COC form may be completed for each cooler, or copies of the completed COC may be placed in every cooler. A copy of the COC form should be retained by the sampler prior to shipment (forms with multiple carbon copies are recommended). The original COC form should accompany the sample to the laboratory and provide a paper trail to track the sample. When transferring the possession of samples, the individuals relinquishing and receiving the samples should sign, date, and note the time on the COC form. Frequent communication with the laboratory after shipment is recommended to assure proper handling and adherence to holding times.

4.7 Sample Handling and Shipping

4.7.1 Sample Handling

The samples will be kept cool during collection and shipment with wet ice in double Ziploc™ bags (to prevent leakage). Frozen “blue ice” is not recommended. The samples should be stored in a durable, appropriately sized ice chest. The samples should be placed upright on a 1- to 3-inch layer of packing materials, such as vermiculite or bubble packaging, and kept separated, with the intervening voids filled with the packing material more than halfway to the top of the bottles or containers. The ice should be placed above and about the tops of the containers. The COC record should be sealed in a Ziplock plastic bag and affixed to the inside of the top lid of the cooler. The remaining space should be filled with packing material. The cooler should be secured by completely wrapping with strapping tape around both ends and around the lid. If there is a drain on the cooler, it should be taped shut. COC seals should be affixed across the seal between the lid and body of the cooler.

4.7.2 Shipping Instructions

All samples should be shipped overnight delivery through a reliable commercial carrier, such as FedEx. If shipment requires more than a 24-hour period, sample holding times can be exceeded, or the samples may get warm, compromising the integrity of the sample analysis. The sampler should call the laboratory to alert them when the samples will arrive on the following day.

5.0 REFERENCES

Jay, P.C., 1985. *Anion Contamination of Environmental Water Samples Introduced by Filter Media*. Analytical Chemistry 57(3): 780-782.

Puls, R.W. and M.S. Barcelona, 1989. *Ground Water Sampling for Metals Analyses*, Superfund Ground Water Issue, EPA/540/4-89/001, March.

Puls, R.W. and M.S. Barcelona, 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, U.S. Environmental Protection Agency document EPA/540/S-95/504, April.

U.S. Environmental Protection Agency (EPA), 1986. *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1, September.

ATTACHMENT 1

MONITORING WELL DEVELOPMENT FORM

WELL DEVELOPMENT LOG

Well ID:		**Screened Interval (ft):**		**Well Diameter (in)**	
Date:		**Pump Depth (ft):**		**Static Water Level (ft):**	
Sample ID:		**Flow Rate (gpm)**		**Standing Water (ft):**	
Time:		**Purging Device:**		**One Well Volume (gal):**	
Method:		**Water Level Instrument:**		**OVA Reading at TOC:**	
Technician:		**Water Quality Meter(s):**		**OVA Reading in BZ:**	

Time	Volume Purged (gal)	Flow Rate (gpm)	Water Level (feet - TOC) ± 0.1 ft	SC (µS/cm) 5%	pH ± 0.1	Temp ± 0.1 ºC	ORP (mV) 5%	Turbidity (NTU) < 10 NTU	Other	Comments
Final Field Parameter Measurements										

Comments:

ATTACHMENT 2

GROUNDWATER FIELD SAMPLING DATA RECORD

Well/Piezo ID:

Ground Water Sample Collection Record

Client: ____________________ Date: ________
Project No: ____________________ Time: Start ________ am/pm
Site Location: ____________________ Finish ________ am/pm
Weather Conds: ____________ Collector(s) ____________

WATER LEVEL DATA: (measured from Top of Casing) Well ☐ Piezometer ☐

a. Total Well Length ________
b. Water Table Depth ________
c. Casing Material ________
d. Casing Diameter ________
r = casing radius (ft)
L= length of water column (ft)
e. Length of Water Column ________
f. Calculated Well Volume ________ gal
(WV) = 3.14 * r^2 * L * 7.48 gal./ft^3 =

WELL PURGING DATA

a. Purge Method ____________________

b. Acceptance Criteria defined (from workplan)
- Minimum Required Purge Volume (@ _______ well volumes) ____________
- Maximum Allowable Turbidity ________ NTUs
- Stabilization of parameters ________ %

c. Field Testing Equipment Used: Make Model Serial Number

d. Field Testing Equipment Calibration Documentation Found in Field Notebook # _______ Page #_______

Time	Volume Removed (gal)	T° (C/F)	pH	Spec. Cond (umhos)	Turbidity (NTUs)	DO	Color	Odor	Other

e. Acceptance criteria pass/fail

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Have parameters stabilized	☐	☐	☐

If no or N/A - Explain below.

SAMPLE COLLECTION: Method: ____________________

Sample ID	Container Type	No. of Containers	Preservation	Analysis	Time

Comments ____________________

Signature ____________________ Date ____________________

ATTACHMENT 3

CHAIN-OF-CUSTODY RECORD

Water & Soil - Chain of Custody Record & Analytical Service Request

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10 Day-Standard

CAS Project No.

CAS Contact:

Company Name & Address (Reporting Information)

Project Name

Project Number

Project Manager

P.O. # / Billing Information

Phone

Fax

Email Address for Result Reporting

Sampler (Print & Sign)

Analysis Method and/or Analytes

Preservative Code

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Matrix	Number of Containers	Volatile Organics GC/MS 624 ☐ 8260B ☐ Oxygenates ☐ TPH Gas ☐	TPH Gas 8015B ☐ BTEX 8021B ☐ MTBE 8021B ☐	TPH Diesel 8015B ☐ (Subcontracted)	TPH Diesel Low Level 8015B ☐ (Subcontracted)	TPH FC ☐ 8015M (Subcontracted)	Semi-Volatile Organics GC/MS 625 ☐ 8270C ☐ (Subcontracted)										Remarks

Preservative Key

0	**None**
1	**HCL**
2	**HNO_3**
3	**H_2SO_4**
4	**NaOH**
5	**Zn Acetate**
6	**Asc Acid**
7	**Other**

Report Tier Levels - please select

Tier I - (Results/Default if not specified) _____
Tier II (Results + QC) _____
Tier III (Data Validation Package) 10% Surcharge _____
Tier V (client specified) ________
MRL required Yes / No
MDL / PQL / J required Yes / No
EDD required Yes / No
Type: _______________

Project Requirements (MRLs, QAPP)

Reliquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Reliquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Reliquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Cooler / Blank / Ice / No Ice

Temperature __________ ^{o}C

STANDARD OPERATING PROCEDURES

SOP-14

FIELD DOCUMENTATION

STANDARD OPERATING PROCEDURES

SOP-14
FIELD DOCUMENTATION

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LIST OF ATTACHMENTS

DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is a general reference for the required documentation to be completed by company personnel during field investigations. Subject to the requirements of the contract, records in the form of field logbooks, reports, and forms should normally be completed for the various field activities. Records should be maintained on a daily basis as the work progresses, and should contain enough information to allow the Field Event to be completely reconstructed. All field records must be accurate, objective, and legible, because it is part of the client's product and may potentially serve as a legal document. As the field logbook is often the only record of the work conducted during the Field Event, it should normally be photocopied at least every week.

Sample field documentation forms are attached.

2.0 DEFINITIONS

None

3.0 RESPONSIBILITIES

All field team members are responsible for recording daily activities. An in-depth description of the documentation mentioned below is given in later sections.

The **Field Team Leader** (FTL) is responsible for completing the FTL logbook, Daily Quality Control Reports (DQCRs), documentation concerning supervision of team members, and duplication and distribution of applicable records. The FTL will be supervised by a qualified Nevada Certified Environmental Manager [C.E.M.]).

The **Rig Geologist/Sampling Team** is responsible for completing the drilling logbook; lithologic logs; well construction diagrams; sampling documentation such as sample labels, sample register, and chain-of-custody (COC) forms.

The **Water Sampling/Development Team** is responsible for completing the water sampling/development logbook; groundwater sampling/development logs; and sampling documentation such as sample labels, sample register, and COC forms.

The **Aquifer Data Collection Team** is responsible for completing the aquifer logs (e.g., slug tests, step-drawdown tests, pump tests), water level records, and data organization/tracking (e.g., downloading of data from data loggers).

4.0 FIELD DOCUMENTATION GUIDELINES

Field documentation serves as the primary foundation for all field data collected that will be used to evaluate the project site. Field documentation must be accurate, legible, and written in indelible ink. Absolutely no pencils or erasures are to be used. Mistakes are to be crossed out with one line, dated, and initialed. Skipped pages or blank sections at the end of a page should be crossed out with an "X" covering the entire page or blank section, dated and initialed. The person making the correction should write "No Further Entries," and date and initial the page. The responsible field team member should sign and log the date and time after the last entry for the day. To further assist in the organization of the field books, logs, or forms, the date and the significant activity description (e.g., boring or well number) should be written at the top of each page. Each project job number should have its own field book. In addition, all original field documentation should be included with the project files.

The descriptions of field data and documentation given below serve as a guideline; individual projects will vary in documentation needs, depending on the circumstances surrounding the project and the needs of the client.

4.1 Field Logbooks

The field logbook should be a bound, weatherproof book with consecutively numbered pages that serves primarily as a daily log of the activities carried out during the investigation. All entries should be made in indelible ink. A field logbook should be completed for each operation undertaken during the investigation, such as field team leader notes, drilling, groundwater sampling/development, and site visitors. The logbook serves as a diary of the events of the day.

Field activities will vary from project to project; however, the concept and general information to be recorded will be generally consistent. The following sections describe the minimum information that should normally be recorded in the three logbooks in which field activities are documented.

FTL Logbook

The FTL's responsibilities include the general supervision, support, assistance, and coordination of the various field investigation activities. A large portion of the FTL's day is spent rotating between operations in a supervisory role. Records of the FTL's activities, as well as a summary of the field team's activities, are maintained in a logbook. The FTL's logbook will be used to fill out DQCRs, and as such should contain all information required in these reports (Section 3.3). Items to be documented include the following:

- Record of tailgate meetings
- Personnel and subcontractors on job site and time spent on the site

- Field operations and personnel assigned to these activities
- Site visitors
- Log of the FTL's activities—time spent supervising each operation and summary of daily operations as provided by field team members
- Problems encountered and related corrective actions
- Deviations from the sampling plan
- Records of communications—discussions of job-related activities with the client, subcontractor, field team members, and project manager
- Information on addresses and contacts
- Record of invoices signed and other billing information
- Field observations

Rig Geologist/Sampling Team Logbook

The rig geologist or sampling team leader is responsible for recording the following information:

- Health and safety activities
  - Calibration records for health and safety equipment (type of photoionization detector (PID), calibration gas used and associated readings, noise dosimeters, etc.)
  - Personnel contamination prevention and decontamination procedures
  - Record of daily tailgate safety meetings
- Weather
- Calibration of field equipment
- Equipment decontamination procedures
- Personnel and subcontractors on the job site and time spent on the site
- Site name and well or soil boring number
- Drilling activities
  - Sample location (sketch)
  - Drilling method and equipment used
  - Borehole diameter
  - Drill cuttings disposal/containerization (number of drums, roll off-bins, etc.)
  - Type and amount of drilling fluids used (mud, water, etc.)
  - Depth and time at which first groundwater was encountered, depth to water at completion of drilling, and the stabilized depth to water—absence of water in the boring should also be noted
  - Total drilling depth of well or soil boring

  - Type and amount of materials used for well installation
  - Well construction details—depth of grout (mixture, weight), bentonite seal, filter pack, etc. (include type and amount used, calculate estimated amount that should be used)
  - Type and amount of material used to backfill soil borings
  - Time and date of drilling, completion, and backfilling
  - Name of drilling company, driller, and helpers

- Sampling
  - Date and time of sample collection
  - Sample interval
  - Types of samples taken
  - Number of samples collected
  - Analyses to be performed on collected samples

- Disposal of contaminated wastes (personal protective equipment, paper towels, Visqueen®, etc.)

- Field observations

- Problems encountered and corrective action taken

- Deviations from the sampling plan

- Site visitors

Groundwater Sampling/Development Logbook

The groundwater sampling and development team members are responsible for recording the following information:

- Health and safety activities
  - Calibration records for health and safety equipment (i.e., type of PID, calibration gas used and readings, noise dosimeters etc.)
  - Personnel contamination prevention and decontamination procedures
  - Record of daily tailgate safety meetings

- Weather

- Calibration of field equipment

- Equipment decontamination procedures

- Personnel and subcontractors on job site and time spent on the site

- Equipment decontamination procedures

- Disposal of contaminated wastes (personal protective equipment, paper towels, Visqueen®, etc.)

- Site name and well number

- Water levels and product levels—time and datum that water levels are measured (i.e., top of casing); purging of the well (include calculations, well volumes) with the following information:
  - Measured field parameters (temperature, pH, conductivity, odor, color, cloudiness, etc.)
  - Amount of water purged
  - Purge method—indicate bailer/pump, diameter and length of bailer, material that the bailer is composed of, type of pump, new nylon rope, etc.
- Purge water disposal and containment (Baker tank/ drums, number used, identification, etc.)
- PID readings from inside of well, purged water, and breathing zone (Note: see SOP-39 for additional information on PID principles and procedures.)
- Background PID readings
- Well sampling
  - Number of samples collected and type of containers used
  - Date and time of sample collection
  - Type of analyses
  - Quality assurance/quality control (QA/QC) samples collected; names given to blind samples
- Field observations
- Problems encountered and corrective actions taken
- Deviations from the sampling plan
- Site visitors

4.2 Tailgate Safety Meetings

Tailgate safety meetings are held at the beginning of each day before the start of work. All personnel, subcontractors, and others who will be on the job site are required to attend. The meetings are usually conducted by the FTL, on-site safety officer, or other qualified team member. The topics discussed at the meeting include the following:

- Directions to the hospital
- Protective clothing and equipment
- Chemical hazards
- Physical hazards
- Special equipment
- Emergency procedures

- Emergency phone numbers

All site personnel are required to sign the tailgate safety meeting form (Attachment 1). The original form is kept on site, and a copy sent to the home office.

4.3 Daily Quality Control Reports

The preparation of DQCRs (Attachment 2) is the responsibility of the FTL. DQCRs are completed on a daily basis to summarize the events of the day and supplement the information that is already recorded in the field logbook. DQCRs should be completed regardless of the duration of the field effort. Copies of the report are distributed to the Tronox Project Manager, Project Geologist, field office file, and home office file. Information recorded in this report should include the following.

- Date and weather information—date, daily temperatures, wind speed and direction, humidity
- Personnel and time spent on site
- Subcontractors and time spent on site
- Special equipment on site—PID, Smeal water sampling rig, hollow-stem auger Rig, pH meter, conductivity meter, etc.
- Work and sampling performed—personnel performing specific site activities, a summary of samples collected, and a thorough explanation of the work completed
- Quality control activities—e.g., decontamination procedures, QA/QC samples taken, calibration of field equipment
- Health and safety levels and activities—field parameter measurements, including calibration of equipment; daily tailgate safety meetings, level of protection used, etc.
- Problems encountered/corrective actions taken—any technical difficulties (e.g., problems encountered during drilling or equipment breakdowns); any problems that could potentially affect the quality of the samples should be included
- Special notes—any information that does not fit under the categories listed above, but is important to record; information that would be useful for future sampling, (e.g., base contacts made, visitors on site, etc.)
- Next day activity expectations
- Date/Signature of individual completing the report

4.4 Boring Logs

The preparation of drill logs is the responsibility of the field team members assigned to the drill rig. A detailed description of well logging is provided in the SOP for Lithologic Logging, SOP-17. Several examples of drilling logs are given in the attachments for SOP-17. An example lithologic log form is shown in Attachment 3. The exact format depends on the job and the client; however, the following basic information should normally be recorded on the log regardless of the format:

- Project and site name
- Name of driller and drilling company
- Type of drill rig used
- Drill rig contamination procedures
- Well/soil boring ID and location (sketch)
- Drilling and backfilling dates and times
- Reference elevation for all depth measurements
- Total depth of completed soil boring/well
- Depth of grouting, sealing, and grout mixes
- Signature of the logger.
- Description of unconsolidated materials
  - Geologic lithology description
  - Descriptive Unified Soil Classifications System (USCS) classification
  - USCS symbol
- Color (use appropriate soil color chart)
  - Penetration resistance (consistency or density)
  - Moisture content
  - Grain size information
  - Miscellaneous information (odor, fractures, visible contamination, etc.)
- Description of consolidated materials
  - Geologic rock description
  - Rock type
  - Relative hardness
  - Density
  - Texture
  - Color (use appropriate rock color charts)
  - Weathering
  - Bedding
  - Structures (fractures, joints, bedding, etc.)
  - Miscellaneous information (presence of odor, visible contamination, etc.)

- Stratigraphic/lithologic changes; depths at which changes occur
- Depth intervals at which sampling was attempted and amount of sample recovered
- Blow counts
- Depth intervals from which samples are retained
- Analyses to be performed on collected samples
- Depth at which first groundwater was encountered, depth to water at completion of drilling, and the stabilized depth to water. The absence of water in the boring should also be noted.
- Loss and depth of drilling fluids, rate of loss, and total volume of loss
- Use of drilling fluids
- Drilling and sampling problems
- PID readings

4.5 Well Construction Diagrams

The preparation of well construction diagrams is also the responsibility of field team members assigned to the drilling operations. This topic is further discussed in the SOP for Well Installation, SOP-02. An example well construction log form is shown in Attachment 4. The exact format of the diagram is dependent on the job and the client; however, the following basic information should be recorded and/or illustrated on the diagram regardless of the format.

- Project and site name
- Well identification number
- Name of driller and drilling company
- Depth and type of well casing
- Description of well screen and casing
- Borehole diameter
- Any sealing off of water-bearing strata
- Static water level upon completion of the well and after development
- Drilling and installation dates
- Type and amount of annulus materials used; depth measurements of annulus materials
- Other construction details (filter pack type and interval, location of centralizers, etc.)

- Surface elevation and reference elevation of all depth measurements

4.6 Groundwater Sampling and Development Logs

The groundwater sampling and development log should be used any time a well is developed or sampled (Attachment 5). The following information should be recorded on the log.

- Project name and site
- Well identification number
- Equipment decontamination procedures
- The date and time of sampling or development
- The water level and reference elevation
- Volume of water to be purged
- Pertinent well construction information (total depth, well diameter, etc.)
- Measurement of field parameters such as pH, turbidity, conductivity, and temperature, as well as the times at which the readings were taken.
- Type of purging and sampling equipment used
- Type of samples collected
- Sampler’s initials

4.7 Aquifer Testing Logs

The aquifer testing team is responsible for setting up, collecting, tracking, and organizing data. The information listed below should normally be included. An example aquifer testing log form is shown in Attachment 6. The Aquifer Testing SOP-04 contains more details and the various book references related to the project site.

- Well number/identification (data logger identification)
- Data logger information/parameter setup
- Water level (include date, time, and measurement reference (such as top of casing)
- Type of aquifer test (slug, step-drawdown, pump test, etc.)
- Slug test (include length and diameter of slug for volume calculations)
- Start time of test
- Duration of test

- Pump tests (include disposal/containment of water information)
- Field observations and problems
- Tester's name

4.8 Documentation of Sampling Activities

Documentation to be made during sampling activities includes sample labels, sample seals, COC records, airbill and identification of courier, and sample register. An example sampling documentation and tracking form is shown in Attachment 7.

4.8.1 Sample Labels

A sample label, written in indelible ink, should be affixed to all soil and water sample containers. Required information on sample labels may vary from job to job; however, the following should be included at a minimum:

- Sample number
- Type of sample (grab or composite)
- Type of preservative, if applicable
- Date and time of collection
- Project location
- Analyte(s)
- Initials of sampling personnel

4.8.2 Custody Seals

Custody seals consist of security tape with the initials of the sampler and the date placed over the lid of each cooler containing samples. The tape should be placed such that the seal must be broken to gain access to the contents. Custody seals should not be placed directly onto the volatile organic compound (VOC) sample bottles. Custody seals should be placed on coolers prior to the sampling team's release to a second or third party (e.g., shipment to the laboratory).

4.8.3 Chain-of-Custody Records

COC procedures allow for the tracing of possession and handling of individual samples from the time of field collection through laboratory analysis. The COC is documented through a record that lists each sample and the individuals responsible for sample collection, shipment, and receipt. A sample is considered in custody if it is any of the following:

- In a person's possession.
- In view after being in physical possession.
- Locked or sealed so that no one can tamper with it after it has been in an individual's physical custody.
- In a secured area, restricted to authorized personnel.

A COC record is used to record the samples taken and the analyses requested. It is the legal record for maintaining accountability of control over the sample. Information recorded includes time and date of sample collection, sample number, and the type of sample, the sampler's signature, the required analysis, and the type of containers and preservatives used. A copy of the COC record should be retained by the sampler prior to release to a second or third party. Shipping receipts should be signed and filed as evidence of custody transfer between field sampler(s), courier, and laboratory.

The COC record will be properly signed and the date of collection and shipment recorded, along with the sample site identifications and requested analyses for each sample.

4.8.4 Sample Register

The sample register is a field record book with consecutive prenumbered pages. A full description of each sample is recorded in the book. The information included in the sample register should include the following:

- Sample number (identification)
- Duplicate and split sample numbers (identification)
- Location of sample
- Client
- Project number
- Collection method
- Number and size of bottles for each analysis
- Destination of the sample
- Type of analysis
- Date and time of collection
- Name of sampler

Other observations may be included as the situation dictates for a thorough record that could be used to reconstruct the events concerning that sample. All information must be recorded in indelible ink. Mistakes are to be crossed out with one line, dated, and initialed. Skipped pages or blank sections at the end of a page should be crossed out with an “X” covering the entire page or blank section, dated and initialed.

ATTACHMENT 1

TAILGATE SAFETY MEETING FORM

HEALTH AND SAFETY PRE-ENTRY BRIEFING ATTENDANCE FORM

Conducted by:		**Date Performed:**	
Topics Discussed:	1. Review of the content of the HASP (Required)		
	2.		
	3.		
	4.		

Printed Name	Signature	Representing

ATTACHMENT 2

DAILY QUALITY CONTROL REPORT

DAILY QUALITY CONTROL REPORT

Date:	Report No.:
PM:	Day:
Location:	Weather:
Project:	
Job No.:	Wind:
	Humidity:

Personnel Onsite:

Equipment Onsite:

Work Performed (including sampling):

QC Activities (including field calibrations):

DAILY QUALITY CONTROL REPORT (continued)

H&S Levels and Activities:

Problems Encountered and Corrective Action Taken:

Special Notes:

Tomorrow's Expectations:

Prepared by: ______________________ Title: ______________________

Distribution:
1. Project Manager (via email)
2. Project Manager
3. Field Office
4. Project File

ATTACHMENT 3

EXAMPLE LITHOLOGIC LOG FORM

	Client:	***BORING ID:***
	Project Number:	
	Site Location:	
	Coordinates: *Elevation:*	*Sheet: 1 of 1*
	Drilling Method:	*Monitoring Well Installed:*
	Sample Type(s): *Boring Diameter:*	*Screened Interval:*

Weather:	*Logged By:*	*Date/Time Started:*	*Depth of Boring:*
Drilling Contractor:	*Ground Elevation:*	*Date/Time Finished:*	*Water Level:*

Depth (ft)	Geologic sample ID	Sample Depth (ft)	Blows per 6"	Recovery (inches)	Headspace (ppm)	U.S.C.S	**MATERIALS: Color, size, range, MAIN COMPONENT, minor component(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)**	Lab Sample ID	Lab Sample Depth (Ft.)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

NOTES:

Date	Time	Depth to groundwater while drilling

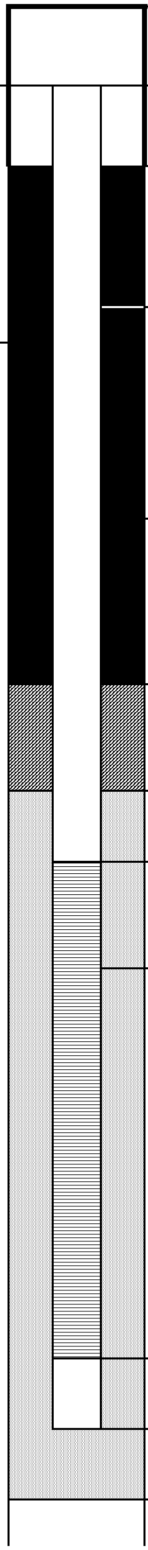
Checked by ___________________________ Date:________________

ATTACHMENT 4

EXAMPLE WELL CONSTRUCTION LOG FORM

	Client:	***WELL ID:***
	Project Number:	
	Site Location:	*Date Installed:*
	Well Location: *Coords:*	*Inspector:*
	Method:	*Contractor:*

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation(feet) Datum ______
Top of Steel Guard Pipe	______	______
Top of Riser Pipe	______	______
Ground Surface (G.S.)	0.0	______
Bottom of Steel Guard Pipe	______	______
Top of Bentonite	______	______
Top of Sand	______	______
Top of Screen	______	______
▼ Stabilized Water Level	______	______
Bottom of Screen	______	______
Bottom of Tail Pipe:	______	______
Bottom of Borehole	______	______

Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

______ % Cement

______ % Bentonite

______ % Native Materials

Riser Pipe:
- Length ______
- Inside Diameter (ID) ______
- Type of Material ______

Bentonite Seal Thickness ______

Screen:
- Length ______
- Inside Diameter (ID) ______
- Slot Size ______
- Type of Material ______

Type/Size of Sand ______

Sand Pack Thickness ______

Borehole Diameter: ______

Approved:

______
Signature

______
Date

Describe Measuring Point:

______

ATTACHMENT 5

GROUNDWATER SAMPLING AND WELL DEVELOPMENT FORMS

Well/Piezo ID:

Ground Water Sample Collection Record

Client: ______________________ Date: ________
Project No: ______________________ Time: Start ________ am/pm
Site Location: ______________________ Finish ________ am/pm
Weather Conds: ______________ Collector(s) ______________________

WATER LEVEL DATA: (measured from Top of Casing) Well ☐ Piezometer ☐

a. Total Well Length ________
c. Casing Material _______
e. Length of Water Column ____________

b. Water Table Depth ________
d. Casing Diameter _______
r = casing radius (ft)
L= length of water column (ft)
f. Calculated Well Volume ________ gal
(WV) = 3.14 * r^2 * L * 7.48 $gal./ft^3$ =

WELL PURGING DATA

a. Purge Method ____

b. Acceptance Criteria defined (from workplan)
- Minimum Required Purge Volume (@ _______ well volumes) ______________________
- Maximum Allowable Turbidity __________ NTUs
- Stabilization of parameters __________ %

c. Field Testing Equipment Used: Make Model Serial Number

____
____

d. Field Testing Equipment Calibration Documentation Found in Field Notebook # _______ Page #_______

Time	Volume Removed (gal)	T° (C/F)	pH	Spec. Cond (umhos)	Turbidity (NTUs)	DO	Color	Odor	Other

e. Acceptance criteria pass/fail

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Have parameters stabilized	☐	☐	☐

If no or N/A - Explain below.

____
____

SAMPLE COLLECTION: Method: ______________________________

Sample ID	Container Type	No. of Containers	Preservation	Analysis	Time

Comments ____

____

Signature ______________________________ Date ______________________

WELL DEVELOPMENT LOG

Well ID: ______________________
Date: ______________________
Sample ID: ______________________
Time: ______________________
Method: ______________________
Technician: ______________________

Screened Interval (ft): ______________________
Pump Depth (ft): ______________________
Flow Rate (gpm) ______________________
Purging Device: ______________________
Water Level Instrument: ______________________
Water Quality Meter(s): ______________________

Well Diameter (in) ______________________
Static Water Level (ft): ______________________
Standing Water (ft): ______________________
One Well Volume (gal): ______________________
OVA Reading at TOC: ______________________
OVA Reading in BZ: ______________________

Time	Volume Purged (gal)	Flow Rate (gpm)	Water Level (feet - TOC) ± 0.1 ft	SC (µS/cm) 5%	pH ± 0.1	Temp ± 0.1 ºC	ORP (mV) 5%	Turbidity (NTU) < 10 NTU	Other	Comments
Final Field Parameter Measurements										

Comments: ____

ATTACHMENT 6

AQUIFER TESTING FORM

AQUIFER TEST DATA SHEET
(OBSERVATION WELLS)

PROJECT NAME: ____________ PROJECT NO: ____________ PIEZO NO: ____________
DATE: ____________ PUMP DEPTH: ____________ TEST NO: ____________
TYPE OF TEST: ____________ PUMPED WELL NO: ____________ DISTANCE FROM PUMPING WELL: ____________
MEASURING EQUIPMENT: ____________ HYDROGEOLOGIST: ____________

Time Data Pump On: Date/Time________ Pump Off: Date/Time________ Duration of Aquifer Test: Pumping:________ Recovery:________		**Water Level Data** Pretest Water Level________ Static Water Level:________ Measuring Point:________ Elevation of Measuring Point:________			**Time Data Continuation**		**Water Level Data Continuation**		
Date	Time	Depth to Water (ft)	Pressure Transducer (XD)	Flow Rate (gpm)	Date	Time	Depth to Water (ft)	Pressure Transducer (XD)	Flow Rate (gpm)

Conversion Factors: 1 PSI = 2.31 feet 1 cubic foot = 7.48 gallons

ATTACHMENT 7

SAMPLING DOCUMENTATION AND TRACKING FORM

Sample Tracking and Documentation Form

Project: ______________________________ Site: ______________________________

Location ID	Sample ID	Method	Matrix	Date Sampled	Time Sampled	Date Shipped	Cooler No.	Lab Dest.	Fedex Tracking No.	QA/QC Samples

Field Duplicates:

Splits (LIMS # ______________):

STANDARD OPERATING PROCEDURES

SOP-15

FIELD LOGBOOK

STANDARD OPERATING PROCEDURES

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FIELD LOGBOOK

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DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

The field logbook is a controlled document that contains information about all major on-site activities associated with investigation and remediation projects. The field logbook serves as the primary documentation of all field activities and events. Information recorded in the field logbook is described in Section 4.0, Methods. Site-specific procedures described in project work plans supersede this Standard Operating Procedure (SOP). Some site conditions and/or client requirements may necessitate deviations from this SOP.

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey or site walk). Entries are made each day field activities occur. The site logbook is part of the permanent project file maintained by AECOM, and is submitted to the project manager, who sends it to the project file at the completion of field activities. The site logbook may be admitted as evidence in cost recovery or other legal proceedings, so it is critical that this document be properly maintained.

2.0 DEFINITIONS

Field Logbook	The field logbook (also called field notebook) is a bound, waterproof notebook with consecutively numbered pages that cannot be removed.

3.0 RESPONSIBILITIES

Field logbooks are issued to field team members by the field team leader (FTL) or Project Manager. Each field team member in possession of a field logbook is responsible for keeping it current, accurate, straightforward, and relevant (see Section 4.0, Methods), and for submitting the field logbook to the FTL or Project Manager when the field work is completed. The Project Manager or designee reviews the field logbook for completeness, legibility, and relevance at the end of the field effort.

4.0 METHODS

During each field day, all site activities, personnel, visitors, and problems are recorded in the field logbook. The following paragraphs include lists of types of information included, when applicable, and methods for maintaining the field logbook.

The cover of each site logbook contains the following information:

- project name

- client name (Tronox)
- Tronox Contractors project number
- project manager's name
- applicable work plan (s)
- sequential book number
- start date
- end date

The beginning of each daily entry includes the following:

- date
- day of week
- location
- personal protective equipment (PPE) level
- start time
- weather
- personnel
- subcontractors
- visitors
- equipment
- Tronox Contractors job number and cost code for that day's activities

Daily site logbook entries include but are not limited to the following, as applicable:

- arrival and surveying, decontamination, inspection, or other field activity

- equipment calibration
- materials used
- sampling activities and methods
- sample numbers, dates, times, locations, and analyses
- sketches of work locations, sample locations, excavations, etc.
- sketches of well construction details
- sample shipment information (chain-of-custody form numbers, carrier, time)
- start and completion times of each work activity
- storage and disposal of wastes
- field measurements
- health and safety issues (PPE level, time of tailgate safety meeting, etc.)
- unusual events
- accidents and near misses
- work progress
- work problems
- corrective actions
- variations from project plans or standard procedures
- communication with the client or others
- communication with the project manager or other Tronox Contractors staff
- references to other project logs (purge, sample, equipment calibration, quality control, photograph, equipment, borehole, construction, development, etc.)

Because the site logbook and its contents are admissible as evidence in legal proceedings, the following guidelines are also important:

- Unnecessary or irrelevant information or opinions are not recorded.
- Language used in the site logbook is always professional.
- Pages are not removed from the site logbook.
- All entries are in waterproof blue or black ink.
- The person entering information signs each page on which information is recorded.
- Blank portions of pages, and pages that have been inadvertently left blank, are crossed out and signed.
- The words "End of Day" and the signature of the person making the entry appear at the end of each daily entry.
- The field logbook is reviewed and signed by the FTL or Project Manager when the field work is completed.

STANDARD OPERATING PROCEDURES

SOP-17

SOIL LOGGING

STANDARD OPERATING PROCEDURES

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SOIL LOGGING

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DISCLAIMER

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1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is applicable to logging soils at all sites requiring soil investigation by AECOM personnel. The SOP is based on the Unified Soils Classification System (USCS) and the American Society for Testing and Materials (ASTM) Standard D2488-00 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM, 2000). Variance from the logging procedures described herein shall be warranted only if specifically required in writing by a particular client or regulatory agency. A solid working knowledge of this SOP is important for Tronox Contractors field personnel to standardize logging procedures and to enable subsequent correlations between borings at a site, allowing for accurate and thorough site characterization.

The information in this SOP is summarized in two soil logging field guides (attached). Laminated copies of these guides are available for field personnel; use of the field guides is strongly recommended. Other field guidance references may also be used according to personal preference; however, such references should be based on the USCS. Note that many references (for example, AGI Data Sheet grain-size scales) base soil classifications on the Wentworth Scale. Such scales may vary significantly from the USCS and may lead to inaccurate or inconsistent soil descriptions.

2.0 DEFINITIONS

Use of the USCS requires familiarity with the grain size ranges that define a particular type of soil, as well as several other physical characteristics. The grain size definitions and physical characteristics upon which soil descriptions are based are presented below. This information is also presented in tabular format on the field guides.

2.1 GRAIN SIZES

USCS grain sizes are based on U.S. standard sieve sizes, which are named as follows:

- Standard sieves with larger openings are named according to the size of the openings in the sieve mesh. For example, a "3-inch" sieve contains openings that are 3 inches square.

- Standard sieves with smaller openings are given numbered designations that indicate the number of openings per inch. For example, a "No. 4" sieve contains 4 openings per inch.

The following grain size definitions are paraphrased from the ASTM Standard D2488-00. Field personnel should familiarize themselves with the grain size definitions and refer to the appropriate field guide for a visual reference.

Boulders	Particles of rock that will not pass a 12-inch (300-mm) square opening
Cobbles	Particles of rock that will pass a 12-inch (300-mm) square opening and be retained on a 3-inch (75-mm) sieve
Gravel	Particles of rock that will pass a 3-inch (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions: – Coarse gravel passes a 3-inch (75-mm) sieve and is retained on a 3/4-inch (19-mm) sieve – Fine gravel passes a 3/4-inch (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve
Sand	Particles of rock that will pass a No. 4 (0.19-inch or 4.75-mm) sieve and be retained on a No. 200 (0.003-inch or 75-µm) sieve with the following subdivisions: – Coarse sand passes a No. 4 (0.19-inch or 4.75-mm) sieve and is retained on a No. 10 (0.08-inch or 2-mm) sieve – Medium sand passes a No. 10 (0.08-inch or 2-mm) sieve and is retained on a No. 40 (0.017-inch or 425-µm) sieve – Fine sand passes a No. 40 (0.017-inch or 425-µm) sieve and is retained on a No. 200 (0.003-inch or 75-µm) sieve
Silt	Soil passing a No. 200 (0.003-inch or 75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried. Individual silt particles are not visible to the naked eye.
Clay	Soil passing a No. 200 (0.003 inch or 75-µm) sieve that can be made to exhibit plasticity within a range of water contents and that exhibits considerable strength when air-dried. Individual clay particles are not visible to the naked eye.

2.2 PHYSICAL CHARACTERISTICS

The following physical characteristics are used in the USCS classification for fine-grained soils. A brief definition of each physical characteristic is presented below. Tables 1 through 4 present descriptions of field tests that may be performed to estimate these properties in a field sample. However, with the exception of plasticity, the tests are generally too time consuming to perform regularly in the field. A determination of the type of fine-grained soil present in the sample can generally be made on the basis of plasticity, as described in Section 4.1.2.

Dry Strength	The ease with which a dry lump of soil crushes between the fingers (Table 1).
Dilatancy Reaction	The speed with which water appears in a moist pat of soil when shaking in the hand, and disappears while squeezing (Table 2).
Toughness	The strength of a soil, moistened near its plastic limit, when rolled into a 1/8-inch diameter thread (Table 3).

Plasticity	The extent to which a soil may be rolled into a 1/8-inch. thread, and re-rolled when drier than the plastic limit (Table 4).

Table 1. Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Table 2. Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Table 3. Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Table 4. Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-inch (3-mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles and the responsibilities generally associated with them. This list is not intended to be comprehensive; additional personnel may be involved in other aspects of the project. Project team member information is usually included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan), and field personnel should always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

The **Project Manager** or **Task Leader** defines the objectives of field work; selects site-specific monitoring well design and installation methods with input from the Project Hydrogeologist and Field Team Leader; and maintains close supervision of activities and progress.

The **Project Hydrogeologist** selects site-specific drilling/sampling options, helps prepare technical provisions for drilling.

The **Field Team Leader** implements the selected drilling program and may also review boring logs.

The **Drilling Rig Geologist** records the boring logs and supervises the drilling subcontractor.

The **Quality Manager** performs field and logging process audits.

4.0 SOIL LOGGING PROCEDURES

The following aspects of a project must be considered before sampling and soil logging commences. This information is generally summarized in a project-specific work plan or field sampling plan, which should be thoroughly reviewed by field personnel prior to the initiation of work.

- Purpose of the soil logging (e.g., initial investigation, subsequent investigation, remediation)
- Known or anticipated hydrogeologic setting including lithology (consolidated/unconsolidated, depositional environment, presence of fill material), physical characteristics of the aquifer (porosity/permeability), type of aquifer (confined/unconfined), recharge/discharge conditions, aquifer thickness and ground water/surface water interrelationships
- Drilling conditions
- Previous soil boring or borehole geophysical logs
- Soil sampling and geotechnical testing program

- Characteristics of potential chemical release(s) (chemistry, density, viscosity, reactivity, and concentration)
- Health and Safety protection requirements
- Regulatory requirements

The procedures used to determine the correct soil sample classification are described below. These procedures are presented in tabular and flow chart form on the field guides.

4.1 Field Classification of Soils

The following soil classification procedures are based on the ASTM Standard D2488-00 for visual-manual identification of soils (ASTM, 2000). The flow chart is Attachment 1 to this SOP and presented in the field guide can be used to assign the appropriate soil group name and symbol. When naming soils, the proper USCS soil group name is given, followed by the group symbol. For clarity, it is recommended that the group symbol be placed in parentheses after the written soil group name.

Soil identification using the visual-manual procedures is based on naming the portion of the soil sample that will pass a 3-inch (75-mm) sieve. Therefore, before classifying a soil, any particles larger than 3 inches (cobbles and boulders) should be removed, if possible. Estimate and note the percentage of cobbles and boulders.

Using the remaining soil, the next step is to estimate the percentages, by dry weight, of the gravel, sand, and fine fractions (particles passing a No. 200 sieve). The percentages are to be estimated to the closest 5 percent. In general, the soil is *fine-grained* (e.g., a silt or a clay) if it contains 50 percent or more fines, and *coarse-grained* (e.g., a sand or a gravel) if it contains less than 50 percent fines. If one of the components is present but estimated to be less than 5 percent, its presence is indicated by the term *trace*. For example, “trace of fines” would be added as additional information following the formal USCS soil description.

4.1.1 Procedure for Identifying Coarse-Grained Soils

Coarse-grained soil contains less that 50 percent fines. If it has been determined that the soil contains less than 50 percent fines, the soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand. The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

If the soil is predominantly sand or gravel but contains an estimated 15 percent or more of the other coarse-grained constituent, the words "with gravel" or "with sand" is added to the group name. For example: "gravel with sand (GP)." If the sample contains any cobbles or boulders, the words “with cobbles” or “with cobbles and boulders” are added to the group name. For example: "silty gravel with cobbles (GM)."

5 Percent or Less Fines

The soil is a “clean gravel” or “clean sand” if the percentage of fines is estimated to be 5 percent or less. “Clean” is not a formal USCS name, but rather a general descriptor for implying little to no fines. Clean sands and gravels are given the USCS designation as either *well-graded* or *poorly-graded*, as described below.

Identify the soil as a *well-graded gravel* (GW) or as a *well-graded sand* (SW) if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes. Identify the soil as a *poorly-graded gravel* (GP) or as a *poorly-graded sand* (SP) if it consists predominantly of one grain size (uniformly graded), or has a wide range of sizes with some intermediate sizes obviously missing (gap- or skip-graded).

Note: When using the USCS designation, keep in mind the difference between grading and sorting. The term grading is used to indicate the range of particles contained in the sample. For example, a poorly-graded sand containing predominantly one grain size would be considered well-sorted, and vice-versa. One notable exception to this general rule is a skip-graded (bimodally distributed) sample; a sand containing two distinct grain sizes would be considered both poorly-sorted and poorly-graded. The USCS uses only the *grading* descriptor in soil naming, not the sorting descriptor.

≥ 15 Percent Fines

The soil is a *silty* or *clayey gravel* or a *silty* or *clayey sand* if the percentage of fines is estimated to be 15 percent or more. For example, identify the soil as *clayey gravel* (GC) or a *clayey sand* (SC) if the fines are clayey. Identify the soil as a *silty gravel* (GM) or a *silty sand* (SM) if the fines are silty. The coarse grained descriptor "poorly-graded" or "well-graded" is not included in the soil name, but rather, should be included as additional information following the formal USCS soil description.

>5 Percent but <15 Percent Fines

If the soil is estimated to contain greater than 5 percent but less than 15 percent fines, give the soil a dual identification using two group symbols. The first group symbol corresponds to a clean gravel or sand (GW, GP, SW, SP) and the second symbol corresponds to a clayey/silty gravel or sand (GC, GM, SC, SM). The group name corresponds to the first group symbol, and include the words "poorly-graded" or "well-graded", plus the words "with clay" or "with silt" to indicate the character of the fines. For example, "poorly-graded gravel with silt (GP-GM)".

4.1.2 Procedure for Identifying Fine-Grained Soils

Fine-grained soil contains 50 percent or more fines. The USCS classifies inorganic fine-grained soils according to their degree of plasticity (no or low plasticity, indicated with an "L"; or high plasticity, indicated with an "H") and other physical characteristics (defined in Section 2.2 and Tables 1 through 4). As indicated in Section 2.2, the field tests used to determine dry strength, dilatancy, and toughness are generally too time consuming to be performed on a routine basis. Field personnel should be familiar with the definitions of the physical characteristics and the concepts of the field tests; however, field classifications will generally be based primarily on plasticity. If precise engineering properties are necessary for the project (i.e., construction, modeling, etc.), geotechnical samples should be collected for laboratory testing. The results of the laboratory tests should be compared to the field logging results. Soil classifications based on plasticity are as follows:

- Lean clay (CL) soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity.
- Fat clay (CH) soil has high to very high dry strength, no dilatancy, and high toughness and plasticity.
- Silt (ML) soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic.
- Elastic silt (MH) soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity. They will air dry more quickly than lean clay and have a smooth, silky feel when dry.
- Organic soil (OL or OH) soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Organic soils will often change color, from black to brown for example, when exposed to the air. Organic soils normally will not have a high toughness or plasticity.

4.1.3 Other Modifiers For Use With Fine-Grained Soils

15 percent to 25 percent coarse-grained material

If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words "with sand" or "with gravel" (whichever is predominant) is added to the group name. For example: "lean clay with sand (CL)" or "silt with gravel (ML)". If the percentage of sand is equal to the percentage of gravel, use "with sand."

≥30 percent coarse-grained material

If the soil is estimated to have 30 percent or more sand or gravel, or both, the words "sandy" or "gravelly" is added to the group name. Add the word "sandy" if there appears to be the same or more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy silt (ML)", or "gravelly fat clay (CH)".

4.1.4 Procedure for Identifying Borderline Soils

To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example, a soil containing an estimated 50 percent silt and 50 percent fine grained sand may be assigned a borderline symbol "SM/ML". Borderline symbols should not be used indiscriminately. Every effort should be made to first place the soil into a single group and then to estimate percentages following the USCS soil description.

4.2 Descriptive Information for Soils

After the soil name and symbol are assigned, the soil color, consistency/density, and moisture content is to be described in that order. Other information is presented later in the description, as applicable.

4.2.1 Color

Color is an important property in identifying organic soils, and may also be useful in identifying materials of similar geologic or depositional origin in a given location. The Munsell Soil Color Charts should be used, if possible.

When using the Munsell Soil Color Charts, a general color, such as brown, gray, red, is first assigned to the soils. Then go to the correct area in the charts and assign the applicable color name and Munsell symbol. The ability to detect minor color differences varies among people, and the chance of finding a perfect color match in the charts is rare. Keeping this in mind should help field personnel avoid spending unnecessary time and confusion going through the chart pages. In addition, attempting to describe detail beyond the reasonable accuracy of field observations could lead to making poorer soil descriptions than by simply expressing the dominant colors (Munsell Soil Color Chart, 1992).

If the color charts are not being used or are unavailable, again attempt to assign general colors to soils. Comparing a particular soil sample to samples from different locations in the borehole will help keep the eye "calibrated". For example, by holding two soils together, it may become evident that one is obviously greenish-brown, while another is reddish.

4.2.2 Consistency/Density

For intact fine-grained soil, describe consistency as very soft, soft, medium stiff, stiff, very stiff, or hard, based on the blows per foot using a 140 pound hammer dropped 30 inches (Table 5). If blow counts are not available, perform the field test described in Table 6 to determine consistency.

For coarse-grained soils, describe density based on blows per foot as very loose, loose, medium dense, dense, and very dense (Table 5). If blow counts are not available, attempt to estimate the soil density by observation, since a practical field test is not available. Be sure to clearly indicate on the field boring log if blow counts could not be obtained.

Table 5. Density/Consistency Based on Blow Counts

Density (Sand and Gravel) Blows/ft[a]				Consistency (Silt and Clay) Blows/ ft[a]			
Term	**1.4" ID**	**2.0" ID**	**2.5" ID**	**Term**	**1.4" ID**	**2.0" ID**	**2.5" ID**
Very Loose	0 – 4	0 – 5	0 – 7	Very Soft	0 – 2	0 – 2	0 – 2
Loose	4 – 10	5 – 12	7 – 18	Soft	2 – 4	2 – 4	2 – 4
Medium Dense	10 – 29	12 – 37	18 – 51	Medium Stiff	4 – 8	4 – 9	4 – 9
Dense	29 – 47	37 – 60	51 – 86	Stiff	8 – 15	9 – 17	9 – 18
Very Dense	>47	>60	>86	Very Stiff	15 – 30	17 – 39	18 – 42
				Hard	30 – 60	39 – 78	42 – 85
				Very Hard	>60	>78	>85

[a] 140 lb. Hammer dropped 30 inches

Table 6. Criteria for Describing Consistency

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will indent soil about ¼ inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

4.2.3 Moisture

Describe the moisture condition of the soil as dry (absence of moisture, dusty, dry to the touch), moist (damp but no visible water), or wet (visible free water, saturated).

4.2.4 Grain Size

Describe the maximum particle size found in the sample in accordance with the following information:

- Sand-size—describe as fine, medium, or coarse. (See Section 2 for sand size definitions.)

- Gravel-size—describe the diameter of the maximum particle size in inches.
- Cobble or boulder-size—describe the maximum dimension of the largest particle.

For gravel and sand components, describe the range of particle sizes within each component. For example, "about 20 percent fine to coarse gravel, about 40 percent fine to coarse sand".

4.2.5 Odor

Due to health and safety concerns, **NEVER** intentionally smell the soil. This could result in exposure to volatile contaminants that may be present in the soil. If, however, an odor is noticed, it should be described if organic or unusual (e.g., petroleum product or chemical). Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation (sometimes a hydrogen sulfide [rotten egg] smell). Organic vapor readings from a photoionization detector (PID) or similar instrument should be noted on the field boring log (Note: see SOP-39 for additional information on PID principles and procedures.). The project-specific health and safety plan should then be consulted to determine the appropriate level of protection necessary to continue field work.

4.2.6 Cementation

Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the following criteria:

- Weak—crumbles or breaks with handling or little finger pressure
- Moderate—crumbles or breaks with considerable finger pressure
- Strong—will not crumble or break with finger pressure

The presence of calcium carbonate may be confirmed on the basis of effervescence with dilute hydrochloric acid (HCl) if calcium carbonate or caliche is believed to be present in the soil. Proper health and safety precautions must be followed when mixing, handling, storing, or transporting HCl. For further information, see I/HW Health and Safety Procedure 630.24, "Procedure for Hydrochloric Acid Handling for Soil Logging."

4.2.7 Angularity

The angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded are described in accordance with the following criteria:

- Angular particles have sharp edges and relatively planar sides with unpolished surfaces.

- Subangular particles are similar to angular description but have rounded edges.
- Subrounded particles have nearly plane sides but have well-rounded corners and edges.
- Rounded particles have smoothly curved sides and no edges.

A range of angularity may be stated, such as "subrounded to rounded."

4.2.8 Structure

Describe the structure of intact soils in accordance with the criteria in Table 7.

Table 7. Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying materials or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down in small angular lumps that resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogenous	Same color and appearance throughout

4.2.9 Lithology

Describe the lithology (rock or mineral type) of the sand, gravel, cobbles, and boulders, if possible. It may be difficult to determine the lithology of fine and medium-grained sand or particles that have undergone alteration.

4.2.10 Additional Comments

Additional comments may include the presence of roots or other vegetation, fossils or organic debris, staining, mottling, or oxidation; difficulty in drilling, and caving or sloughing of the borehole walls. Also, when drilling in an area known or suspected to contain imported fill material, every effort should be made to identify the contact between fill and native soils. If a soil is suspected to be fill, this should be clearly indicated on the log following the soil description. Stratigraphic units and their contacts should be noted wherever possible.

4.2.11 Bedrock Descriptions

If the soil boring penetrates bedrock, the boring log should indicate the rock type, color, weathering, fracturing, competency, mineralogy, age (if known), and any other miscellaneous information available. Definitions of these terms are not included in this SOP, because only a small percentage of drilling activities conducted by Tronox Contractors for Tronox penetrate bedrock. If bedrock drilling is planned, the field team leader, with the concurrence of the project manager, makes arrangements to provide the field team with appropriate definitions and indicate the types with information that should be collected.

4.3 Additional Boring Log Information

The boring log form (example shown in Attachment 2) should be used unless a different form is required by the client. Information in the log heading should be complete and accurate. In addition to soil descriptions, the following information should be included, at a minimum:

- Boring or monitoring well number
- Project name and job number
- Site name
- Name of individual who logged the boring
- Name of boring log reviewer
- Drilling contractor
- Drill rig type and method of drilling (for example, "CME 75, hollow stem auger")
- Name of drilling company
- Name of driller and helper
- Borehole diameter and drill bit type
- Type of soil sampler (for example, Modified California, continuous core, etc.)
- Time and date that drilling started and finished
- Time and date that the well was completed or the soil boring backfilled, as appropriate
- Method of borehole abandonment
- Sketch map of boring or well location with estimated distances to major site features such as property lines or buildings, and north arrow

Soil sample information should include the depth interval that was sampled, the blow counts per 6 inches, the amount of soil recovered, and the portion submitted for analysis or testing, if any. The sample identification number may also be noted on the log.

The degree to which soil samples are collected during a field effort depends on the overall scope and purpose of the investigation, which should be clearly defined before the field effort commences. Additional soil samples may need to be collected if, for example, soils are very heterogeneous or unexpected conditions such as perched water zones or zones of contamination are encountered.

If groundwater is encountered during drilling, the depth to water and the time and date of the observation should be recorded. If the first water encountered is a perched zone, the depth, time, and date that any additional groundwater zones are encountered should also be recorded. Depth to water after drilling, the measuring point, and the date and time of the measurement(s) must be noted. Additional measurements of depth to groundwater, including depth and time, may be beneficial.

If a monitoring well is installed, the construction details such as casing material type, screen length and slot size should be noted on the boring log. The annulus fill material (sand pack, bentonite, grout, etc.) should also be recorded.

If the soil boring is abandoned, the backfill material used (e.g., grout, bentonite, etc.) and volume used, should be recorded on the boring log.

5.0 OTHER APPLICABLE SOPs

Several other AECOM SOPs contain information related to soil boring and logging activities. The following is a list of these SOPs:

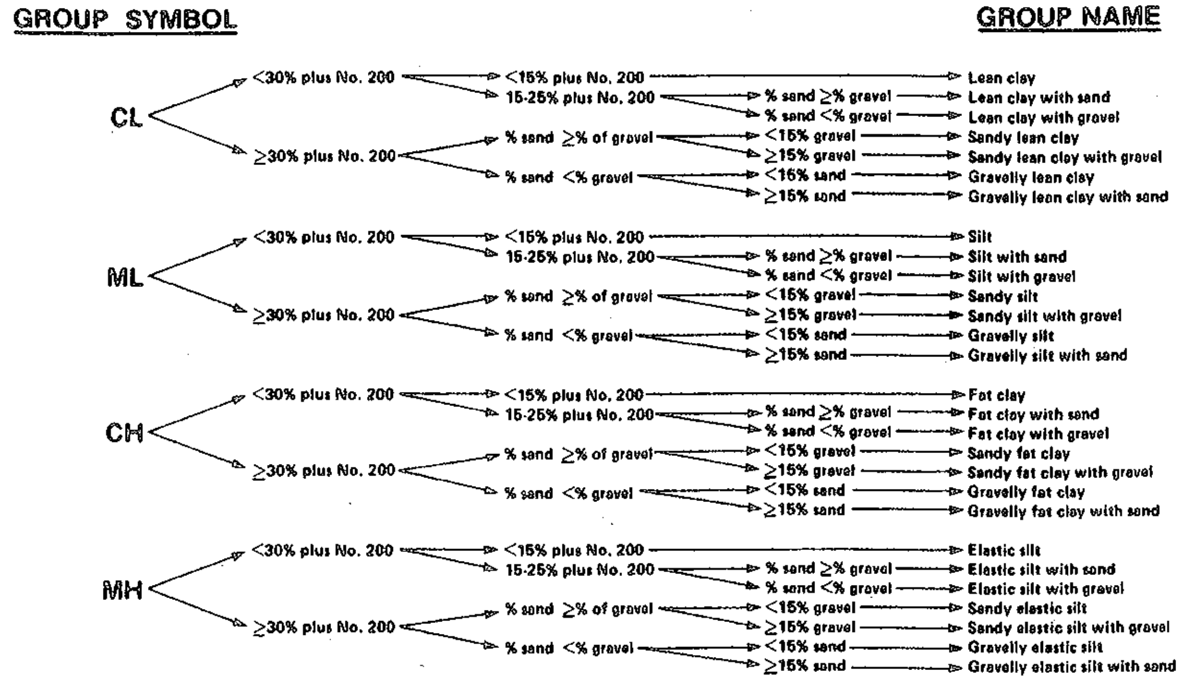
- Drilling Methods
- Monitoring Well Design and Installation
- Sample Management/Preservation
- Soil Sampling
- Trenching and Test Pitting
- Field Documentation
- Site Logbook

6.0 REFERENCES

ASTM, 2000, Standard D2488-00 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

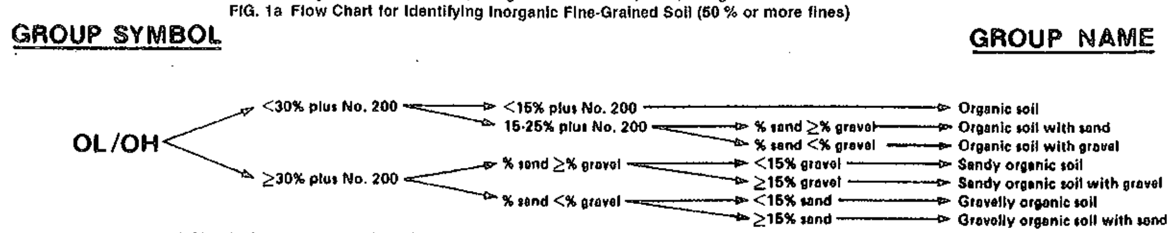
ATTACHMENT 1

FIELD CLASSIFICATION GUIDES

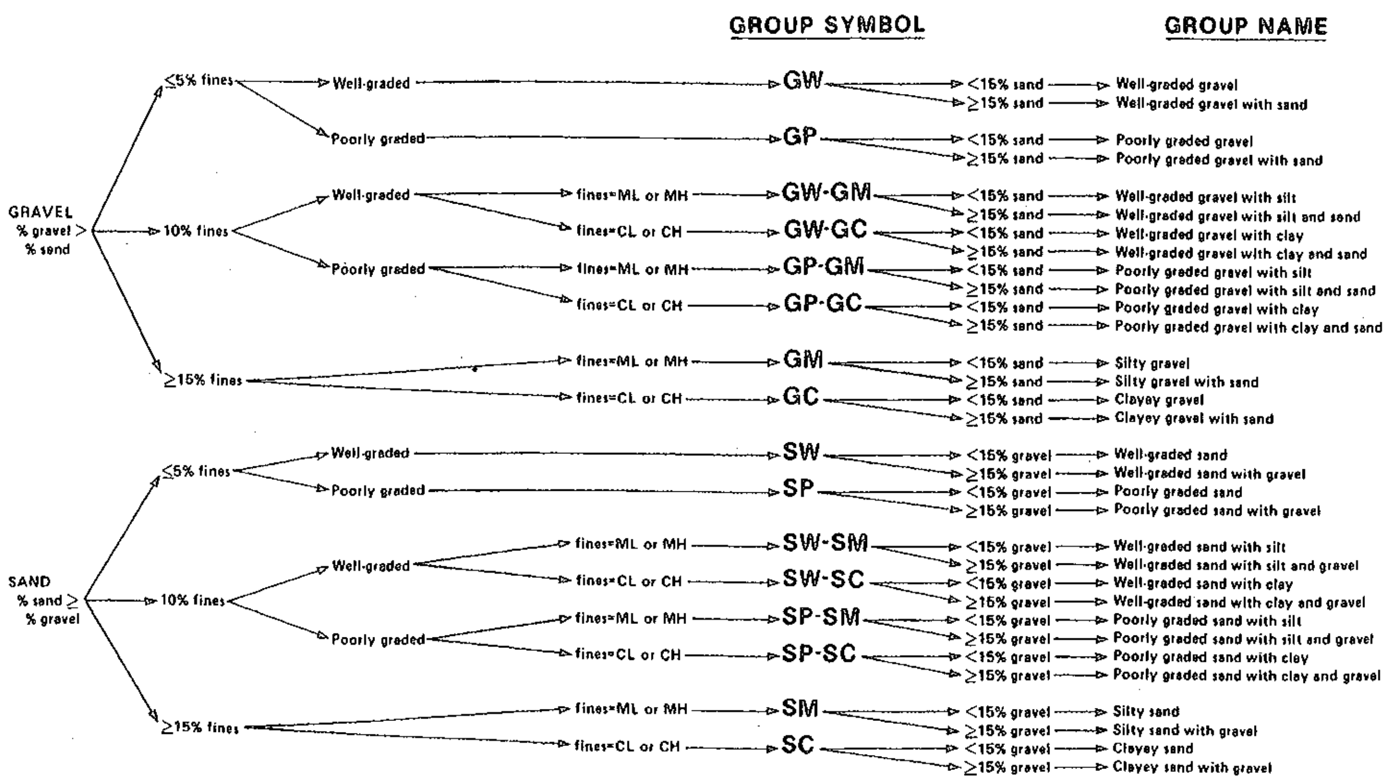


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.



ATTACHMENT 2

EXAMPLE BORING LOG FORM

	Client:	***BORING ID:***
	Project Number:	
	Site Location:	
	Coordinates: *Elevation:*	*Sheet: 1 of 1*
	Drilling Method:	*Monitoring Well Installed:*
	Sample Type(s): *Boring Diameter:*	*Screened Interval:*

Weather:	*Logged By:*	*Date/Time Started:*	*Depth of Boring:*
Drilling Contractor:	*Ground Elevation:*	*Date/Time Finished:*	*Water Level:*

Depth (ft)	Geologic sample ID	Sample Depth (ft)	Blows per 6"	Recovery (inches)	Headspace (ppm)	U.S.C.S	**MATERIALS: Color, size, range, MAIN COMPONENT, minor component(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)**	Lab Sample ID	Lab Sample Depth (Ft.)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

NOTES:

Date	Time	Depth to groundwater while drilling

Checked by ___________________________ Date:________________

STANDARD OPERATING PROCEDURES

SOP-20

FILTER PACK AND WELL SCREEN SLOT SIZE DETERMINATION

STANDARD OPERATING PROCEDURES

SOP-20
FILTER PACK AND WELL SCREEN SLOT SIZE DETERMINATION

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DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

This guideline is applicable to the design and installation of permanent monitoring wells. Details regarding design, construction, and installation of monitoring wells are provided in SOP-2, “Groundwater Monitoring Well Design and Installation.” Each monitoring well must be designed to suit the hydrogeologic setting, the type of contaminants to be monitored, the overall purpose of the monitoring program, and other site-specific variables. Site-specific objectives for each monitoring well and its respective intended use must be clearly defined before the monitoring system is designed. Additionally, different monitoring wells may serve different purposes and thus require different types of construction. Therefore, attention must be given during all phases of well design to clear documentation of the basis for design decisions, the details of well construction, and the materials to be used. At many sites, there is a precedence as to well slot size and filter pack materials that have been used, and the time consuming process of performing a sieve analysis is not necessary for determining well design details.

2.0 DEFINITIONS

Absorption	The penetration or apparent disappearance of molecules or ions of one or more substances into the interior of a solid or liquid.
Adsorption	A process by which atoms, ions, or molecules are assimilated to the surface of a material Ion-exchange processes involve adsorption.
Annular Sealant	Material used to provide a positive seal between the borehole and the casing of the well. Annular sealants should be impermeable and resistant to chemical or physical deterioration.
Annular Space	The space between the borehole wall and the well casing, or the space between a casing pipe and a liner pipe.
Aquifer	A geologic formation, group of formations, or part of a formation that can yield water to a well or a spring.
Backwashing	A method of filter pack emplacement whereby the filter pack material is allowed to fall freely through the annulus while clean fresh water is simultaneously pumped down the casing.
Bentonite	Hydrous sodium montmorillinite mineral available in powder, granular, or pellet form. It is used to provide a tight seal between the well casing and the borehole.
Bridging	The development of gaps or obstructions in either grout or filter pack materials during emplacement.

Continuous Slot Wire-Wound Well Screen	A well intake that is made by winding and welding triangular-shaped, cold-rolled wire around a cylindrical array of rods. The spacing of each successive turn of wire determines the slot size of the well.
Corrosion	The adverse chemical alteration that reverts elemental metals back to more stable mineral compounds and that affects the physical and chemical properties of the metal.
Filter Pack	Sand, gravel, or glass beads that are uniform, clean, and well-rounded that are placed in the annulus of the well between the borehole wall and the well screen to prevent formation material from entering through the well intake and to stabilize the adjacent formation.
Grout	A fluid mixture of neat cement and water with various additives or bentonite of a consistency that can be forced through a pipe and emplaced in the annular space between the borehole and the casing to form an impermeable seal.
Monitoring Well	A well that is capable of providing a groundwater level and sample representative of the zone being monitored.
Naturally Developed Well	A well construction technique whereby the natural formation materials are allowed to collapse around the well intake and fine formation materials are removed using standard development techniques.
Neat Cement	A mixture of Portland cement and water in the proportion of 5 to 6 gallons of clean water per bag (94 pounds) of cement.
Piezometers	A small-diameter, nonpumping well used to measure the elevation of the water table or potentiometric surface.
Sieve Analysis	Determination of the particle-size distribution of soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.
Slurry	A thin mixture of liquid, especially water, and any of several finely divided substances such as cement or clay particles.
Tremie Pipe	A device, usually a small-diameter pipe, which carries grouting materials or filter pack to the bottom of the borehole and that allows pressure grouting from the bottom up without introduction of appreciable air pockets.
Well Cluster	Two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity to each other. From these wells, water samples that are representative of different horizons within one or more aquifers can be collected.

Well Point	A sturdy, reinforced well screen or intake that can be installed by being driven into the ground.

3.0 RESPONSIBILITIES

The **Project Manager** or **Task Leader** selects the site-specific monitoring well design and installation methods, with input from the site hydrogeologist and field team leader, and maintains close supervision of activities and progress.

The **Site Hydrogeologist/Geologist** selects the site-specific drilling/sampling options and helps prepare technical provisions for the drilling.

The **Field Team Leader** implements the selected drilling program.

The **Drilling Rig Geologist** supervises and/or performs actual monitoring well installation.

4.0 FILTER PACK AND WELL SCREEN DESIGN

A properly designed monitoring well requires that a well screen be placed opposite the zone to be monitored and be surrounded by materials that are coarser and of greater hydraulic conductivity than the natural formation material. Naturally developed wells and wells with artificially introduced filter pack are the two basic types of well designs for unconsolidated or poorly consolidated materials.

4.1 Naturally Developed Wells

In naturally developed wells, the formation materials are allowed to collapse around the well screen. Naturally developed wells can be installed in which natural formation materials are relatively coarse grained, permeable, and of uniform grain size. It is essential that the grain-size distribution of the formation to be monitored is accurately determined by conducting a mechanical (sieve) analysis of samples taken from the interval to be screened. After sieving, a plot of grain size versus cumulative percentage of sample retained on each sieve is made. Well screen slot sizes are based on the grain-size distribution, specifically the effective size (the sieve size that retains 90 percent of the formation material, referred to as D10) and the uniformity coefficient (the ratio of the sieve size that retains 40 percent of the material or D60, to the effective size). A naturally developed well can be justified if the effective grain size is greater than 0.010 inch and the uniformity coefficient is greater than 3.0. The California Department of Toxic Substances Control recommends that an artificial filter pack be used if sieve analysis indicates that a screen slot size of 0.020 inches or less is required to retain 50 percent of the natural formation. The biggest drawback for naturally developed wells is the time required for well development to remove fine-grained formation material.

4.2 Artificially Filter-Packed Wells

Filter packs are installed to create a permeable envelope around the well screen. The use of an artificial filter pack in a fine-grained formation material allows the screen slot size to be considerably larger than if the screen were placed in the formation material without the filter pack. The selection of the filter pack grain size should be based on the grain size of the finest layer to be screened.

Filter pack grain size and well screen slot size should be determined by the grain size distribution of the formation material. The filter pack should be designed first. It is recommended to use a filter pack grain size that is three to five times the average (D50) size of the formation materials. However, this method may be misleading in coarse, well-graded formation materials. Another way to determine filter pack grain size is to take the D30 grain size of the formation materials and multiplying it by a factor of between 3 and 6, with 3 used if the formation is fine and uniform and 6 used if the formation is coarse and nonuniform. For both methods, the uniformity coefficient of the filter pack materials should be as close to 1.0 as possible (2.5 maximum) to minimize particle size segregation during filter pack installation.

The filter pack should extend from the bottom of the well screen to approximately 2 to 5 feet above the top of the screen to account for settlement of the pack material during development and to act as a buffer between the well screen and the annular seal. A secondary filter pack (transitions sand) is sometimes used to prevent annular grout seal materials from migrating into the primary filter pack. The secondary filter pack should extend at least 1 foot above the top of the primary filter pack. It should consist of a uniformly graded fine sand with 100% passing a No. 30 U.S. Standard sieve and less than 2 percent by weight passing the 200 sieve.

Filter pack thickness must be sufficient to surround the well screen but thin enough to minimize resistance to the flow of fine-grained formation material and water into the well during development. American Society of Testing and Materials (ASTM), Designation D 5092-90, recommends a minimum 2-inch thick filter pack between the borehole well and the well casing (ASTM, 1995).

The materials comprising the filter pack should be as chemically inert as possible. It should be comprised of clean quartz sand or glass beads. Filter pack materials usually come in 100-pound bags; these materials are washed, dried, and factory packaged.

The size of well intake openings can only be selected after the filter-pack grain size is specified. The slot size should be such that 90 percent to 100 percent of the filter-pack material is held back by the well screen.

The casing string should be installed in the center of the borehole. This will allow the filter-pack materials to evenly fill the annular space around the screen and ensure that annular seal materials fill the annular space evenly around the casing. If a hollow-stem auger or dual-tube rig is used, the auger or inner tube of the dual tube will adequately centralize the casing string. For other types of drilling, centralizers should be used to ensure the casing string is positioned in the center of the borehole. Centralizers are typically expandable stainless steel metal or plastic that attach to the outside of the casing and are adjustable along the length of the casing. Centralizers are generally attached at the bottom and immediately above the well screen and at 10- or 20-foot intervals along the casing to the surface.

Methods for filter pack emplacement include: 1) gravity (free-fall), 2) tremie pipe, 3) reverse circulation, and 4) backwashing. The latter two techniques are not commonly used for monitoring well construction, since they require the introduction into the borehole of water from a surface source.

Gravity emplacement is only possible in relatively shallow wells with an annular space of more than 2 inches, where the potential occurrence of bridging is minimized. Bridging can result in the occurrence of large unfilled voids in the filter pack or the failure of filter pack materials to reach their intended depth. Gravity emplacement may also cause filter pack gradation. Additionally, formation materials from the borehole wall can become incorporated into the filter pack, potentially contaminating it.

With the tremie emplacement method, the filter pack is poured or slurried into the annular space adjacent to the well screen through a rigid pipe, usually 1.5 inches in diameter. Initially the pipe is positioned so that its end is at the bottom of the annulus. If the filter pack is being installed in a temporarily cased borehole (hollow-stem auger , dual-tube percussion, or air rotary casing hammer) the temporary casing is pulled to expose the screen as the filter-pack material builds up around the well screen. In unconsolidated formations, the temporary casing should only be pulled out 1 to 2 feet at a time to prevent caving. In consolidated or well-cemented formations or in cohesive unconsolidated formations, the temporary casing may be raised well above the bottom of the borehole prior to filter pack emplacement. For deep wells and/or nonuniform filter pack materials, the filter pack may be pressure fed through a tremie pipe with a pump. Emplacement should be continuously monitored with a weighted measuring tape accurate to the nearest 0.1 foot to determine when the filter pack has reached the desired height. After reaching the desired height, the well should be surged for 10-15 minutes, then checked for settling. Add more filter pack as necessary. Record the volume of filter pack used and check against calculated volume of annular space. Most well designs also employ a “secondary” filter pack (transition sand) above the primary filter pack for purposes of reducing bentonite seal and grout migration into the primary filter pack.

If applicable, care must be taken that the filter pack materials are not installed into a hydrostratigraphic unit above or below the specific zone that is targeted for monitoring.

5.0 REFERENCES

American Society for Testing and Materials, 1995. *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers*, Designation D 5092-90.

STANDARD OPERATING PROCEDURES

SOP-30

FIELD ANALYTICAL PROCEDURES

(pH, CONDUCTIVITY, TEMPERATURE, ORGANIC VAPOR, AND TURBIDITY)

STANDARD OPERATING PROCEDURES

SOP-30
FIELD ANALYTICAL PROCEDURES
(pH, CONDUCTIVITY, TEMPERATURE, ORGANIC VAPOR, AND TURBIDITY)

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DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES GENERAL GUIDANCE FOR AECOM PERSONNEL FOR TECHNICAL ISSUES ADDRESSED DURING ENVIRONMENTAL SITE INVESTIGATION AND REMEDIATION ACTIVITIES. IT IS NOTED, HOWEVER, THAT EACH SITE IS UNIQUE AND THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THIS STANDARD OPERATING PROCEDURE. AECOM PERSONNEL RESERVE THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN THEIR SOLE, COMPLETE, AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS, OR JOB REQUIREMENTS.

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is a general reference for the proper equipment and techniques for analytical field screening.

2.0 DEFINITIONS

Chain of Custody	A method for documenting the history and possession of a sample from the time of its collection through its analysis and data reporting to its final disposition.
Conductivity (electrical)	A measure of the quantity of electricity transferred across a unit area, per unit potential gradient, per unit time. It is the reciprocal of resistivity.
pH	A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. (Original designation for potential of hydrogen.)
Turbidity	Cloudiness in water due to suspended and colloidal organic and inorganic material.

3.0 RESPONSIBILITIES

The **Project Manager** or **Task Leader** selects site-specific water sampling methods, locations for sampling and analytes to be screened (with input from the Field Team Leader or Superintendent and project geologist), and is responsible for project quality control and field audits.

The **Field Team Leader** implements the water sampling program; supervises the project geologist/hydrogeologist and sampling technician; ensures that proper chain-of-custody procedures are observed; and that samples are sampled, transported, packaged, and shipped in a correct and timely manner.

The **Project Geologist/Hydrogeologist** ensures proper collection, documentation, and storage of groundwater samples prior to shipment to the laboratory, and assists in the packaging and shipment of samples.

The **Field Sampling Technician** assists the project geologist/hydrogeologist in the completion of tasks and is responsible for the proper use, decontamination, and maintenance of groundwater sampling equipment.

4.0 FIELD ANALYTICAL PROCEDURES

The pH, specific conductance, water temperature, and turbidity (in accordance with American Society for Testing Materials [ASTM] D-1889) will be periodically measured and recorded on a log sheet. The following sections briefly outline the procedures for measuring these parameters. This SOP is not intended to be all-inclusive, but is intended to provide general guidance regarding these procedures. Specific SOPs have applicable measurements for the type of field activity and will contain any deviations or amendments to these procedures. All field instruments shall be calibrated according to manufacturer's instructions. All field instruments will be calibrated prior to use. Calibration information shall be recorded in the field logbook. Detailed information regarding maintenance and servicing is available in the operation manual for each meter used. Servicing and maintenance information will be recorded in the field logbook..

4.1 pH

Obtain a sample where pH, temperature, and specific conductance are at equilibrium. Equilibrium is established as follows: pH variation is less than 0.2 pH units, temperature variation is less than 0.5 degrees Celsius (C), and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings.

4.2 Conductivity

Obtain a sample where equilibrium is as follows: pH variation is less than 0.2 pH units, temperature variation is less than 0.5 C, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings.

4.3 Temperature

Obtain a sample where equilibrium is as follows: pH variation is less than 0.2 pH units, temperature variation is less than 0.5 C, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings.

4.4 Organic Vapor

A photoionization detector (PID) will be used to field-screen soil to determine if volatile organic compounds are present. Field screening will be performed by placing the detector within one inch of recently excavated or exposed in-place soil. The highest concentration detected will be recorded on the field notebook.

Three PID probes, each containing a different ultraviolet (UV) light source, are available for use: 9.5, 10.2, and 11.7 electron volt (eV). Gases with ionization potentials near to or less than that of the lamp will be ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials higher than that of the lamp will not be detected. All three detect many aromatic and large molecular hydrocarbons. The 10.2 eV and 11.7 eV probes, in addition, detect some smaller organic molecules and some halogenated hydrocarbons. The 10.2 eV probe is the most useful for environmental response work, as it is more durable than the 11.7 eV probe and detects more compounds than the 9.5 eV probe.

The 11.7 eV lamp measures the broadest range of compounds, while the 10.6 eV lamp is somewhat more selective. However, the 11.7 eV lamp provides lower resolution; that is, the lithium fluoride crystal in the 11.7 eV lamp does not allow as much light energy through, effectively making the 11.7 eV lamp “dimmer” than the 10.6eV lamp. Less energy transmitted means less ionization taking place, which reduces the potential resolution. Essentially a 10.6 eV lamp is 10 times more powerful than an 11.7 eV lamp. Therefore, for best accuracy, it is not recommended to use 11.7 eV lamps for applications requiring very high sensitivity. The 11.7 eV lamp should only be used when compounds with ionization potentials over 10.6 eV are expected. Examples include methylene chloride, chloroform, and carbon tetrachloride. (Note: see SOP-39 for additional information on PID principles and procedures.)

Flame ionization detectors (FIDs) will be used only as field screening tools, since they have the following limitations:

- FIDs measure the concentration of total organic vapors and serve as a general indicator of the level of contamination in soil.
- FIDs are not compound-specific and can detect the presence of a wide range of volatile organic compounds (e.g., the PID detects ammonia compounds and the FID detects methane).
- FIDs read in parts per million equivalent units. The readings must be adjusted based on the instrument sensitivity correction factors, calibration gas span, and estimate of the type of contaminants being measured.
- Moisture and cold temperatures can cause inaccurate meter readings during field screening.

If more accurate field-screening data are required, a headspace sample can be collected by placing soil material (in-place or recently excavated soil) into a sample container. The container is partially filled (50 to 75 percent), leaving an excess space or “headspace” above the soil. The top of the container is covered with aluminum foil and sealed with the lid. The sample is heated by placing it in the sun or near a heat source. The foil is pierced with the detector probe to determine the concentration of the organic compounds, which have volatilized from the soil and into the container headspace. The highest concentration detected is recorded on the field log.

4.5 Turbidity

Obtain a sample where equilibrium is as follows four consecutive turbidity readings with 10 percent of each other. Sample measurements will be collected using a turbidimeter that detects sample opacity. Gross turbidity measurements may be collected using an Imhoff cone.

STANDARD OPERATING PROCEDURES

SOP-31

DRILLING EQUIPMENT DECONTAMINATION

STANDARD OPERATING PROCEDURES

SOP-31
DRILLING EQUIPMENT DECONTAMINATION

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1.0 INTRODUCTION

Drilling is a common activity associated with all phases of environmental investigations. Drilling methods are most commonly used to collect site data during site investigations and remedial investigations, but are also used to install vapor extraction or water wells associated with remedial actions.

Field investigations usually require invasive types of activities to gather information to evaluate the site. The investigation may require the analysis of soil and/or groundwater samples, which would be accomplished by drilling a borehole. The borehole is often converted into a well for the evaluation of vapor or groundwater conditions over time. In addition to the collection of samples for analyses, other data such as physical parameters of soils can be obtained from boreholes.

For determining the most appropriate drilling method for a site investigation, primary consideration must be given to obtaining information that is representative of existing conditions and the collection of samples that are valid for chemical analysis. The samples must not be contaminated or adversely affected by the drilling method.

Drilling associated with remedial actions may include the installation of vapor or water extraction and/or injection wells. In selecting the most appropriate drilling method for remedial actions, primary consideration must be given to completion of a well that will perform as designed.

This Standard Operating Procedure (SOP) provides a description of the decontamination procedures used during field investigations for typical drilling equipment. It is intended to be used by the Project Manager, Project Engineer, Field Team Leader, and site hydrogeologist to develop as general guidance for decontamination procedures for environmental work. The project specific sampling and analysis plans may have site-specific concerns, which would require an addition or adjustment to these procedures.

This document focuses on methods and equipment that are readily available and typically applied. It is not intended to provide an all-inclusive discussion of decontamination methods.

2.0 DEFINITIONS

Bailer	A cylindrical tool designed to remove material, both solid and liquid, from a well or borehole. A valve at the bottom of the bailer retains the material in the bailer. The three types of bailers are flat-valve bailer, a dart-valve bailer, and the sand pump with rod plunger.
Cone Penetrometer	An instrument used to identify the underground conditions by measuring the differences in the resistance and other physical parameters of the strata. The cone penetrometer consists of a conical point attached to a

	drive rod of smaller diameter. Penetration of the cone into the formation forces the soil aside, creating a complex shear failure. The cone penetrometer is very sensitive to small differences in soil consistency.
Cuttings	Formation particles obtained from a borehole during the drilling process.
Drilling Fluids or Muds	A water-based or air-based fluid used in the well drilling operation to remove cuttings from the borehole, to clean and cool the bit, to reduce friction between the drill string and the sides of the borehole, and to seal the borehole.
Dual-Purpose Well	A well that can be used as both a monitoring and extraction or injection well.
Flight	An individual auger section, usually 5 feet in length.
Heaving Formation	Unconsolidated saturated substrate encountered during drilling where the hydrostatic pressure of the formation is greater than the borehole pressure causing the sands to move up into the borehole.
Kelly Bar	A hollow steel bar or pipe that is the main section of drill string to which the power is directly transmitted from the rotary table to rotate the drill pipe and bit. The cross section of the kelly is square, hexagonal, or grooved. The kelly works up and down through drive bushings in the rotary table.
Pitch	The distance along the axis of an auger flight that it takes for the helix to make one complete 360 degree turn.
Rotary Table	A mechanical or hydraulic assembly that transmits rotational torque to the kelly, which is connected to the drill pipe and the bit. The rotary table has a hole in the center through which the kelly passes.
Split-Spoon Sampler	A thick-walled steel tube split lengthwise used to collect soil samples. The sampler is commonly lined with metal sample sleeves and is driven or pushed downhole by the drill rig to collect samples.
Thin-Walled Sampler	A sampling devise used to obtain undisturbed soil samples made from thin-wall tubing. The sampler is also known as a Shelby tube. The thin-wall sampler minimizes the most serious sources of disturbance: displacement and friction.

3.0 RESPONSIBILITIES

The **Project Manager** or **Task Leader** selects site-specific drilling methods, with input from the Field Team Leader and Site Hydrogeologist, and maintain close supervision of activities.

The **Site Hydrogeologist** (a California certified Professional Geologist (P.G.) selects site-specific drilling options and assists in the preparation of the technical provisions for drilling.

The **Field Team Leader** implements the selected drilling and decontamination program and assists in the selection of decontamination methods.

The **Site Safety Officer** prepares the site- and activity-specific Job Hazard Analysis and Health and Safety Plan to be followed by the drilling subcontractor; reviews subcontractor Health and Safety plans and rejects or accepts them based on contract requirements; conducts pre-job tailgate safety meetings; and performs site safety observations and inspections.

4.0 DECONTAMINATION PROCEDURES

The purpose of decontamination and cleaning procedures during excavation, drilling, and sampling is to prevent foreign contamination of the samples and cross contamination between sites. A decontamination area and clean zone will be established for the preparation and breakdown of equipment prior to each sampling task. The decontamination area will be large enough to accommodate equipment to be used for invasive work and allow decontamination rinsate to be pumped off for temporary storage and subsequent disposal. Before use, and between each site, all equipment and other non-sampling equipment will be decontaminated with high-pressure steam, or scrubbed with a non-phosphate detergent and rinsed with water from the approved water source. If appropriate, equipment will be covered in plastic to protect it from the elements.

All equipment that may directly contact samples will be decontaminated on site. The following sampling-specific decontamination procedures will be observed:

1. Wash and scrub with detergent (laboratory grade - non-phosphate detergent).
2. Rinse with tap water.
3. Rinse with deionized water.
4. Rinse with deionized water.
5. Air dry.
6. Protect from fugitive dust and vapors.

Upon completion of the project, samples will be obtained from decontamination water resulting from final decontamination and demobilization of the equipment. One water sample from the water used for final rinse for decontamination will be collected and analyzed for the contaminants of concern at the beginning of the project.

Additional solvent and/or acid rinses may be added to the procedure, depending on the site sampling objectives. Materials Safety Data Sheets must be obtained for any hazardous chemicals used for decontamination and approved by the site safety officer prior to bringing the chemicals to the worksite. Personal protective equipment specific to the decontamination chemicals in use must be used, as specified in the health and safety plan. If these additional rinses are required, the procedures for incorporation are provided below:

1. Wash and scrub with detergent (laboratory grade - non-phosphate detergent).
2. Rinse with tap water.
3. Rinse with methanol (pesticide grade).
4. Rinse with deionized water.
5. Rinse with 1:1 nitric acid.
6. Rinse with deionized water.
7. Air dry.
8. Protect from fugitive dust and vapors.

Sample Tracking and Documentation Form

Project: ______________________________ **Site:** ______________________________

Location ID	Sample ID	Method	Matrix	Date Sampled	Time Sampled	Date Shipped	Cooler No.	Lab Dest.	Fedex Tracking No.	QA/QC Samples

Equipment Rinsate Blanks:

Equipment Rinsate Blanks Splits (LIMS #___________):

Trip Blanks

QA/QC CODES:

1 = Primary Lab Duplicate
2 = Primary Lab Duplicate and QA Laboratory Split
3 = Primary Lab Rinsate Blank
4 = Primary Lab Rinsate Blank and QA Lab Rinsate Blank Split
5 = Matrix Spike and Duplicate (MS/MSD)

Appendix H

List of Chemical Additives

Chemical Additives

The chemicals listed below will be used in boiler treatment or general plant operations. Storage volumes are estimated based upon previous projects.

Chemical	**Service**	**Volume Stored**	**Estimated Storage Method**
Amine (Morpholine)	Boiler water treatment, corrosion inhibitor	300 gal	Tote
Ferric sulfate, 35%	Boiler water treatment, coagulant aid	10,000 gal	Tank
Carbohydrazide	Boiler water treatment, oxygen scavenger	600 gal	Tote
Phosphate	Boiler water treatment, anti-scalant	1,500 gal	Tote
Sodium hydroxide, 50%	Boiler water treatment, pH adjustment	10,000 gal	Tank
Ultra low sulfur diesel fuel	Emergency UPS generator & emergency fire pump fuel	1150 gal	150 gallons – UPS generator fuel tank. 1000 gal estimated for fire pump fuel tank.
Hydrogen gas	Generator cooling medium	1000 lb	350 lb. in the generator and associated piping. 650 lb. in storage trailer.
Insulating oil	Electrical transformer cooling medium	36,000 gal	16,000 gal in the GSU. 10,000 gal in each of 2 UATs.
Lubricating oil	Lubrication of rotating equipment	Up to 4000 gal.	In equipment and drums.
Sulfur Hexafuoride	Gaseous dielectric	640 lb.	In electrical equipment
Therminol VP-1 or similar	Solar heat transfer fluid	2,114,000 gallons	In piping, tanks, and equipment.
Carbon dioxide	STG generator hydrogen system purge for maintenance	4,000 lb	Carbon steel tank.

The chemicals listed below will be used in water treatment or cooling tower operations. Storage volumes are estimated based on previous projects.

Chemical	**Service**	**Volume Stored**	**Estimated Storage Method**
Polymer	Agglomeration of suspended solids in clarifier, thickening of solids in filter press	500 gallons	Tote
Coagulant	Agglomeration of suspended solids in clarifier.	500 gallons	Tote
Lime	Hardness reduction	10 tons	Silo
Soda ash	Hardness reduction	10 tons	Silo
Magnesium chloride	Silica reduction	500 gallons	Tote
Sodium metabisulfite	RO feed dechlorination	500 gallons	Tote
Antiscalant	RO scale control	500 gallons	Tote
Sodium hydroxide	RO CO2 rejection, pH adjustment, filter chemically enhanced backwash	400 gallons	Tote
Sodium hypochlorite (13%)	Microbiological control in raw water tank, multimedia filters, cooling tower, and potable water	1000 gallons	Tank
Sulfuric acid, 93-98%	Cooling tower alkalinity and pH control, filter chemically enhanced backwash	1000 gallons	Tank
Mineral dispersant	Cooling tower scale control	1000 gallons	Tank
Corrosion inhibitor	Cooling tower corrosion control	1000 gallons	Tank
Non-oxidizing biocide	Cooling tower microbiological shock	100 gallons	Drum
Coagulant	Filter aid in multimedia filters	500 gallons	Tote
Brine solution (20-26%)	Sodium zeolite softener regeneration	1500 gallons	tank