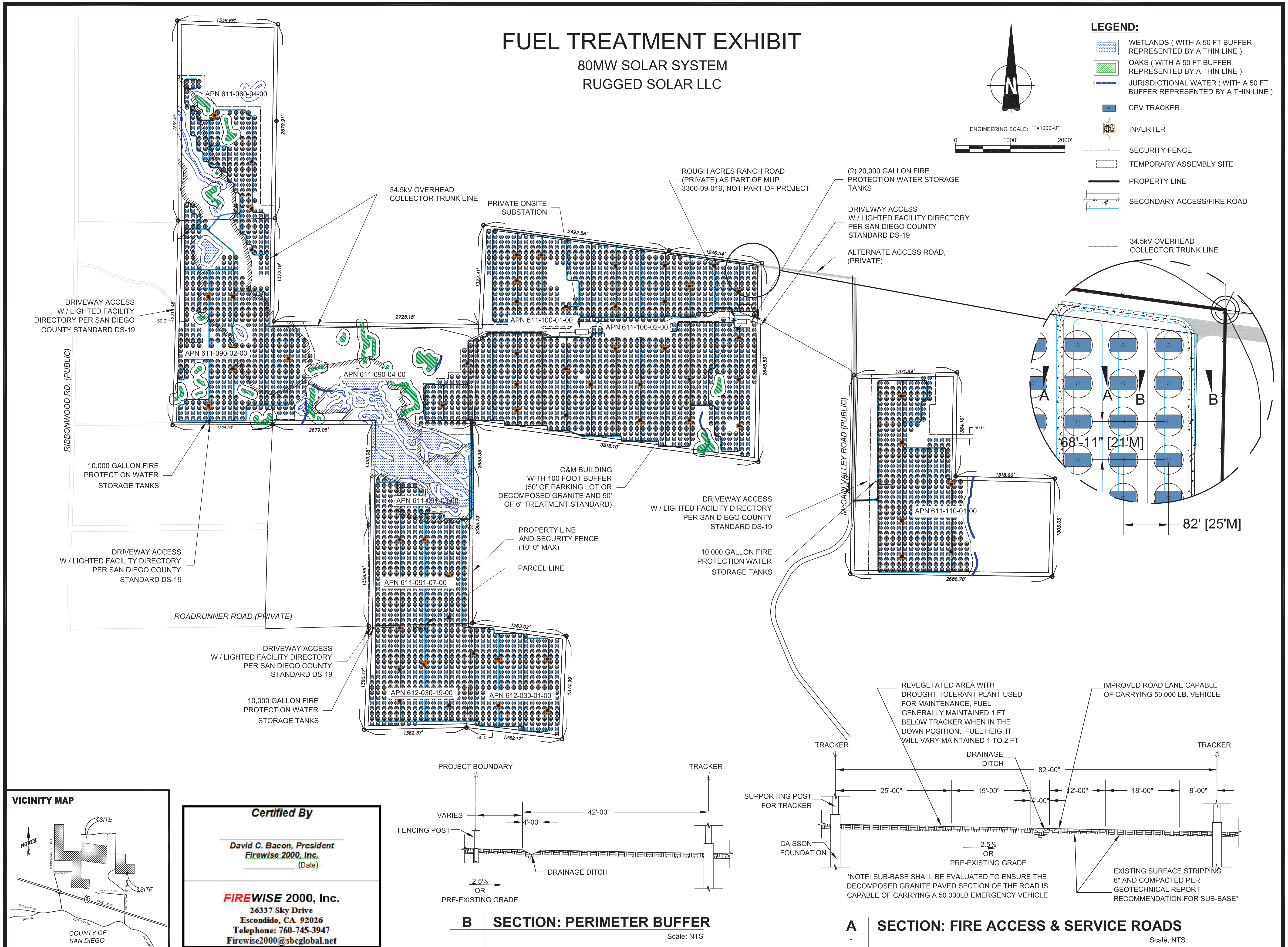
APPENDIX G

Fire Safety Site Plan


FUEL TREATMENT EXHIBIT
80MW SOLAR SYSTEM
RUGGED SOLAR LLC
LEGEND:
WETLANDS (WITH A 50 FT BUFFER REPRESENTED BY A THIN LINE)
OAKS (WITH A 50 FT BUFFER REPRESENTED BY A THIN LINE)
JURISDICTIONAL WATER (WITH A 50 FT BUFFER REPRESENTED BY A THIN LINE)
CPV TRACKER
INVERTER
SECURITY FENCE
TEMPORARY ASSEMBLY SITE
PROPERTY LINE
SECONDARY ACCESS/FIRE ROAD
34.5kV OVERHEAD COLLECTOR TRUNK LINE
N
ENGINEERING SCALE: 1"=1000'-0"
0
1000'
2000'
APN 611-060-04-00
APN 611-090-02-00
APN 611-090-04-00
APN 611-100-01-00
APN 611-100-02-00
APN 611-091-03-00
APN 611-091-07-00
APN 612-030-19-00
APN 612-030-01-00
APN 611-110-01-00
34.5kV OVERHEAD COLLECTOR TRUNK LINE
PRIVATE ONSITE SUBSTATION
ROUGH ACRES RANCH ROAD (PRIVATE) AS PART OF MUP 3300-09-019, NOT PART OF PROJECT
(2) 20,000 GALLON FIRE PROTECTION WATER STORAGE TANKS
DRIVEWAY ACCESS W / LIGHTED FACILITY DIRECTORY PER SAN DIEGO COUNTY STANDARD DS-19
ALTERNATE ACCESS ROAD, (PRIVATE)
DRIVEWAY ACCESS W / LIGHTED FACILITY DIRECTORY PER SAN DIEGO COUNTY STANDARD DS-19
RIBBONWOOD RD. (PUBLIC)
10,000 GALLON FIRE PROTECTION WATER STORAGE TANKS
O&M BUILDING WITH 100 FOOT BUFFER (50' OF PARKING LOT OR DECOMPOSED GRANITE AND 50' OF 6" TREATMENT STANDARD)
DRIVEWAY ACCESS W / LIGHTED FACILITY DIRECTORY PER SAN DIEGO COUNTY STANDARD DS-19
PROPERTY LINE AND SECURITY FENCE (10'-0" MAX)
PARCEL LINE
10,000 GALLON FIRE PROTECTION WATER STORAGE TANKS
McCAIN VALLEY ROAD (PUBLIC)
DRIVEWAY ACCESS W / LIGHTED FACILITY DIRECTORY PER SAN DIEGO COUNTY STANDARD DS-19
ROADRUNNER ROAD (PRIVATE)
DRIVEWAY ACCESS W / LIGHTED FACILITY DIRECTORY PER SAN DIEGO COUNTY STANDARD DS-19
10,000 GALLON FIRE PROTECTION WATER STORAGE TANKS
A
A
B
B
68'-11" [21'M]
82' [25'M]
VICINITY MAP
NORTH
SITE
SITE
COUNTY OF SAN DIEGO
Certified By
David C. Bacon, President
Firewise 2000, Inc.
(Date)
FIREWISE 2000, Inc.
26337 Sky Drive
Escondido, CA 92026
Telephone: 760-745-3947
Firewise2000@sbcglobal.net
PROJECT BOUNDARY
TRACKER
VARIES
42'-00"
4'-00"
FENCING POST
DRAINAGE DITCH
2.5% OR PRE-EXISTING GRADE
B SECTION: PERIMETER BUFFER
Scale: NTS
REVEGETATED AREA WITH DROUGHT TOLERANT PLANT USED FOR MAINTENANCE, FUEL GENERALLY MAINTAINED 1 FT BELOW TRACKER WHEN IN THE DOWN POSITION. FUEL HEIGHT WILL VARY MAINTAINED 1 TO 2 FT
IMPROVED ROAD LANE CAPABLE OF CARRYING 50,000 LB. VEHICLE
TRACKER
TRACKER
DRAINAGE DITCH
82'-00"
25'-00"
15'-00"
4'-00"
12'-00"
18'-00"
8'-00"
SUPPORTING POST FOR TRACKER
CAISSON FOUNDATION
2.5% OR PRE-EXISTING GRADE
*NOTE: SUB-BASE SHALL BE EVALUATED TO ENSURE THE DECOMPOSED GRANITE PAVED SECTION OF THE ROAD IS CAPABLE OF CARRYING A 50 000LB EMERGENCY VEHICLE
EXISTING SURFACE STRIPPING 6" AND COMPACTED PER GEOTECHNICAL REPORT RECOMMENDATION FOR SUB-BASE*
A SECTION: FIRE ACCESS & SERVICE ROADS
Scale: NTS

APPENDIX H

Prohibited Plant List

APPENDIX H
Prohibited Plant List

Botanical Name	Common Name
Trees	
Abies species	Fir
Acacia species (numerous)	Acacia
Agonis juniperina	Juniper Myrtle
Araucaria species *(A. heterophylla, A. araucana, A. bidwillii)*	Araucaria (Norfolk Island Pine, Monkey Puzzle Tree, Bunya Bunya)
Callistemon species *(C. citrinus, C. rosea, C. viminalis)*	Bottlebrush (Lemon, Rose, Weeiping)
Calocedrus decurrens	Incense Cedar
Casuarina cunninghamiana	River She-Oak
Cedrus species *(C. atlantica, C. deodara)*	Cedar (Atlas, Deodar)
Chamaecyparis species (numerous)	False Cypress
Cinnamomum camphora	Camphor
Cryptomeria japonica	Japanese Cryptomeria
Cupressocyparis leylandii	Leyland Cypress
Cupressus species *(C. fobesii, C. glabra, C. sempervirens,)*	Cypress (Tecate, Arizona, Italian, others)
Eucalyptus species (numerous)	Eucalyptus
Juniperus species (numerous)	Juniper
Larix species *(L. decidua, L. occidentalis, L. kaempferi)*	Larch (European, Japanese, Western)
Leptospermum species *(L. laevigatum, L. petersonii)*	Tea Tree (Australian, Tea)
Lithocarpus densiflorus	Tan Oak
Melaleuca species *(M. linariifolia, M. nesophylla, M. quinqenervia)*	Melaleuca (Flaxleaf, Pink, Cajeput Tree)
Olea europea	Olive
Picea (numerous)	Spruce
Palm species (numerous)	Palm
Pinus species *(P. brutia, P. canariensis, P. eldarica, P. halopensis, P. pinea, P. radiate, numerous others)*	Pine (Calabrian, Canary Island, Mondell, Aleppo, Italian Stone, Monterey)
Platycladus orientalis	Oriental arborvitae
Podocarpus species *(P. gracilior, P. macrophyllus, P. latifolius)*	Fern Pine (Fern, Yew, Podocarpus)
Pseudotsuga menziesii	Douglas Fir
Schinus species *(S. molle, S. terebenthifolius)*	Pepper (California and Brazilian)
Tamarix species *(T. Africana, T. apylla, T. chinensis, T. parviflora)*	Tamarix (Tamarisk, Athel Tree, Salt Cedar, Tamarisk)
Taxodium species *(T. ascendens, T. distichum, T. mucronatum)*	Cypress (Pond, Bald, Monarch, Montezuma)
Taxus species *(T. baccata, T. brevifolia, T. cuspidata)*	Yew (English, Western, Japanese)
Thuja species *(T. occidentalis, T. plicata)*	Arborvitae/Red Cedar
Tsuga species *(T. heterophylla, T. mertensiana)*	Hemlock (Western, Mountain)
Groundcovers, Shrubs & Vines	
Acacia species	Acacia
Adenostoma fasciculatum	Chamise
Adenostoma sparsifolium	Red Shanks

APPENDIX H (Continued)

Botanical Name	Common Name
Agropyron repens	Quackgrass
Anthemis cotula	Mayweed
Arbutus menziesii	Madrone
Arctostaphylos species	Manzanita
Arundo donax	Giant Reed
Artemesia species *(A. abrotanium, A. absinthium, A. californica, A. caucasia, A. dracunulus, A. tridentate, A. pynocephala)*	Sagebrush (Southernwood, Wormwood, California, Silver, True tarrangon, Big, Sandhill)
Atriplex species (numerous)	Saltbush
Auena fatua	Wild Oat
Baccharis pilularis	Coyote Bush
Bambusa species	Bamboo
Bougainvillea species	Bougainvillea
Brassica species *(B. campestris, B. nigra, B. rapa)*	Mustard (Field, Black, Yellow)
Bromus rubens	Foxtail, Red brome
Cardera draba	Noary Cress
Carpobrotus species	Ice Plant, Hottentot Fig
Castanopsis chrysophylla	Giant Chinkapin
Cirsium vulgare	Wild Artichoke
Conyza bonariensis	Horseweed
Coprosma pumila	Prostrate Coprosma
Cortaderia selloana	Pampas Grass
Cytisus scoparius	Scotch Broom
Dodonea viscose	Hopseed Bush
Eriodyctyon californicum	Yerba Santa
Eriogonum species *(E. fasciculatum)*	Buckwheat (California)
Fremontodendron species	Flannel Bush
Hedera species *(H. canariensis, H. helix)*	Ivy (Algerian, English)
Heterotheca grandiflora	Telegraph Plant
Hordeum leporinum	Wild barley
Juniperus species	Juniper
Lactuca serriola	Prickly Lettuce
Larix species (numerous)	Larch
Larrea tridentata	Creosote bush
Lolium multiflorum	Ryegrass
Lonicera japonica	Japanese Honeysuckle
Mahonia species	Mahonia
Mimulus aurantiacus	Sticky Monkeyflower
Miscanthus species	Eulalie Grass
Muehlenbergia species	Deer Grass
Nicotania species *(N. bigelevil, N. glauca)*	Tobacco (Indian, Tree)
Pennisetum setaceum	Fountain Grass
Perronskia Atripliciflоria	Russian Sage

Botanical Name	Common Name
Phoradendrom species	Mistletoe
Pickeringia montana	Chaparral Pea
Rhus species *(R. diversiloba, R. laurina, R. lentii)*	Sumac (Poison oak, Laurel, Pink Flowering)
Ricinus communis	Castor Bean
Rosmarinus species	Rosemary
Salvia species (numerous)	Sage
Sacsola austails	Russian Thistle
Solanium Xantii	Purple Nightshade (toxic)
Sylibum marianum	Milk Thistle
Thuja species	Arborvitae
Urtica urens	Burning Nettle
Vinca major	Periwnkle
Rhus Lentii	Pink Flowering Sumac

Notes:

1. For the purpose of using this list as a guide in selecting plant material, it is stipulated that all plant material will burn under various conditions.
2. The absence of a particular plant, shrub, groundcover, or tree, from this list does not necessarily mean it is fire resistive.
3. All vegetation used in Vegetation Management Zones and elsewhere in this development shall be subject to approval of the Fire Marshal.
4. Additional plants that are considered undesirable due to their invasiveness nature are detailed on the California Invasive Plant Council's Web site at www.cal-ipc.org/ip/inventory/index.php.
5. Landscape architects may submit proposals for use of certain vegetation on a project specific basis. They shall also submit justifications as to the fire resistivity of the proposed vegetation.

INTENTIONALLY LEFT BLANK

APPENDIX I

Potential Plant List for Fuel Modification Areas

APPENDIX I
Potential Plant List for Fuel Modification Areas

Botanical Name	Common Name
Trees	
Achillea spp.	Yarrow – only species growing under 12 inches height
Baccharis pilularis	Dwarf coyote bush – only in areas over 50 feet from structures/CPV trackers
Cerastium tomentosum	Snow in Summer
Coprosma kirkii	Tequila sunrise – only prostrate varieties
Cotoneaster spp	Cotoneaster – only species growing to less than 12 inches height
Dudleya brittonii	Britton's dudleya
Dudleya pulverulenta	Chalk lettuce
Eschscholzia californica	California poppy
Gazania spp	Gazania
Helianthemum spp	Sunrose*
L*asthenia californica glabrata*	California goldfields
Trifolium frageriferum Verbena	Strawberry clover
Trifolium frageriferum rigida	White clover
Viguiera laciniata	Goldeneye
Vinca minor	Dwarf periwinkle
Satureja douglasii	Yerba buena
Sisyrinchium bellum	Blue-eyed grass*
Sisyrinchium californicum	Yellow-eyed grass*

Notes:

1. For the purpose of using this list as a guide in selecting plant material, it is stipulated that all plant material will burn under various conditions.
2. The absence of a particular plant, shrub, groundcover, or tree, from this list does not necessarily mean it is not fire resistive.
3. All vegetation used in Vegetation Management Zones and elsewhere in this development shall be subject to approval of the Fire Marshal.
4. Plants that are considered undesirable due to their invasiveness nature should not be utilized in the fuel modification area plantings. The California Invasive Plant Council's Web site at www.cal-ipc.org/ip/inventory/index.php provides a listing of invasive plants.
5. Landscape architects may submit proposals for use of certain vegetation not included on this list. They shall also submit justifications as to the fire resistivity of the proposed vegetation.

*Project area is outside preferred Zone

INTENTIONALLY LEFT BLANK

APPENDIX J

Solar Facility Fire Hazard Technical Report

Concentrating Photovoltaic ("CPV") Solar Farm
Technical Report

Printed on 30% post-consumer recycled material.

TABLE OF CONTENTS

Section **Page No.**

TABLES

INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION

The Rugged Solar Farm LLC (the "Proposed Project") Concentrating Photovoltaic ("CPV") project proposes to install and operate a 60MW AC CPV electrical power generating facility. The Proposed Project provides San Diego Gas and Electric ("SDG&E") with renewable power in compliance with California's renewable portfolio standard requirements.

2.0 BACKGROUND

2.1 Project Location

The project is located in the community of Boulevard, adjacent to the US/Mexico border. The project site is located approximately 3.5 miles south of SR 94 along the US/Mexico border. The main project site consists of the following Assessor Parcel Numbers (APNs): 658-090-31; 658-090-55; 658-120-03; 658-090-54 and 658-120-02.

2.2 Proposed Project

The proposed Rugged Solar Farm Project (Project) would produce up to 60 megawatts (MW) of solar energy and would consist of approximately 2,529 concentrating photovoltaic (CPV) trackers on 420 acres in southeastern San Diego County near the unincorporated community of Boulevard, California. As proposed, the project will be developed in two phases. Phase One would include the construction and operation of 45 MWs (1,910 CPV trackers) on approximately 330 acres. Phase Two would consist of the construction and operation of 15 MWs (619 CPV trackers) on approximately 90 acres. The project includes a Major Use Permit (MUP) to authorize a Major Impact Utility Pursuant to Sections 1350, 2705, and 2926 of the Zoning Ordinance. The project may also require a Rezone to remove Special Area Designator "A" and ensure compliance with Section 5100 of the Zoning Ordinance.

Individual tracker dimensions are approximately 48 feet across by 25 feet tall. Each CPV Tracker unit would be mounted on a 28-inch steel mast (steel pole) which would be supported by either (i) extending it into the ground up to 20 feet and encasing it in concrete, or (ii) attaching it to a concrete foundation sized to be suitable to adequately support the CPV Tracker based on wind loading and soil conditions at the site. The preferred method would be to set the mast by vibratory pile driving methods depending upon soil conditions.

In its most vertical position and depending on foundation design, the top of each tracker would not exceed 30 feet above grade, and the lower edge would not be less than 1 foot above ground level. In its horizontal "stow" mode (for high winds), each tracker would have a minimum ground clearance of 13 feet 6 inches.

Power from the CPV system in each Building Block would be delivered from each tracker to a conversion station through a 1,000 volt DC underground collection system. The underground 1,000 V DC collection system construction footprint would include a trench of one to two feet in width and a depth of up to approximately four feet. It is anticipated that power from the CPV systems on site would be separated into three 34.5 kV underground collection circuits, each delivering approximately 20 MW of power to the Project substation.

Each 34.5 kV underground branch circuit associated with Phase I would connect to a 34.5 kV overhead trunk line on the project site for delivery to the Project substation. These two collection circuits for Phase I would be run overhead on an above ground trunk line adjacent to the south side of the Southwest Power Link right of way. This trunk line would be approximately 1.2 miles long and would have two 34.5 kV circuits and deliver a total of 45 MW. The above ground trunk line would utilize steel poles and would be approximately 50-75 feet high and spaced about 300-500 feet apart. The minimum ground clearance of the 34.5 kV lines would be 30 feet. The maximum hole dimensions for steel pole foundations would be 24 inches in diameter and approximately 20 feet deep. Phase 2 will connect to the Project substation entirely via one 34.5 kV underground branch circuit and the underground 34.5 kV collection system construction footprint would include a trench of three to four feet in width and a depth of up to approximately four feet. Base material would be installed in all trenches to (i) ensure adequate drainage, and (ii) to ensure sufficient thermal conductivity and electrical insulating characteristics below and above collection system cables.

The project will include construction of a 34.5/138 kV step-up substation site (located within the northeast corner of the project site and adjacent to the O&M annex site) would increase the voltage received from the overhead and underground collector system from 34.5 to 138 kV. Switching and transformer equipment as well as a control house and a parking area for utility vehicles would be located within the 3-acre substation site and for security purposes (and to allow for nighttime inspections) lighting would be installed near substation equipment, the control shelter, and on the entrance gates.

A 4-acre operations and maintenance (O&M) annex site would be located adjacent to the substation site and would house operations and maintenance supplies, telecommunications equipment and rest facilities all within a single-story building. It is anticipated that in-place tracker washing would occur every 6 to 8 weeks by mobile crews who will also be available for dispatch whenever on-site repairs or other maintenance are required. Tracker washing will be undertaken using a tanker truck and smaller “satellite” tracker washing trucks. On-site water storage tanks may be installed to facilitate washing.

Note to Reviewer: The Project Applicant is in the process of determining the alignment and right-of-way for the interconnection from the proposed project site to the Boulevard rebuilt substation. The ultimate alignment for the gen-tie will be provided in a subsequent submittal and environmental review completed in a subsequent submittal.

Project construction would consist of several phases including site preparation, development of staging areas and site access roads, solar CPV assembly and installation, and construction of electrical transmission facilities. After site preparation, initial project construction would include the development of the staging and assembly areas, and the grading of site access roads for initial CPV installation The Project would be constructed over a period of up to approximately 12 months, which includes both Phase I and II.

2.3 Solar Generation Technology

Each building block in its standard configuration is comprised of up to fifty-six (56) Soitec ConcentrixR CX-S530 dual-axis trackers. Power within each building block is delivered through a 1,000-volt (V) direct current (DC) underground collection system from the trackers to the pair of inverters. Each inverter pair would be equipped with a 350V to 34.5 kV step-up transformer.

Individual tracker dimensions are approximately 48 feet across by 28 feet tall. Each CPV tracker would be mounted on a 28-inch diameter steel mast (steel pole) which would be supported by either (i) extending it into the ground up to 20 feet, or (ii) attaching it to a concrete spread foot foundation. In its most vertical position and depending on mast height above ground, the top of each tracker would be approximately no more than 30 feet above grade, and the lower edge would be at least 1 foot above the ground (or 1 foot above flood elevation in areas that are subject to 100-year inundation). In its horizontal “stow” mode (for high winds), each tracker would have a minimum ground clearance of 13 feet 6 inches. Solar CPV modules would be mounted on and comprise, in the aggregate, the surface of each tracker. The dimensions, maximum height, and ground clearance for all trackers would be the same throughout the Project.

The schematic arrangement/number of CPV systems, inverter pads and structures, and internal access are shown in on the MUP Plot Plan to illustrate the general configuration of the proposed solar collection solar farm. However, this layout is subject to modification at final engineering design. Fire Protection design considerations are included on the FPP Fuel Treatment Exhibit.

3.0 ANALYSIS

This Technical Report supplements the project’s Fire Protection Plan (FPP) which evaluates and recommends actions for the Proposed Solar Project to ensure it does not unnecessarily expose people or structures to fire risks and hazards. The FPP identifies and prioritizes the measures necessary to adequately mitigate those impacts. It considers the property location, topography, geology, combustible vegetation (fuel types), climatic conditions and fire history. It considers water supply, access, structure ignitability and fire resistive building materials, fire protection solar farms and equipment, impacts to existing emergency services, defensible space and vegetation management.

The primary purpose of this Technical Report is to identify pre-suppression actions that would reduce risk directly associated with the solar farm, actions that would protect and enhance the safety of fire suppression resources, and actions that could protect the solar farm from ignition caused by other sources.

Today's emergency responders face unexpected challenges as new uses of alternative energy increase. These renewable power sources save on the use of conventional fuels such as petroleum and other fossil fuels, but they also introduce unfamiliar hazards that require new firefighting strategies, procedures, and training.

The safety of firefighters and other emergency first responder personnel depends on understanding and properly handling these hazards through adequate training and preparation. The goal of this report is to assemble core principle and best practice information for fire fighters, fire ground incident commanders, and other emergency first responders to assist in their decision making process at emergencies involving solar power solar farms.

3.1 Solar Farm Effect on Fire Risk

The primary objective of this report is to identify the potential hazards resulting from the installation, operation and maintenance of the Solar Farm as well as from natural conditions that could result in risk of fire. These hazards include several operations and activities associated with the solar farm that could elevate the probability of ignition. These could include the following:

1. Transmission lines contacting vegetation that could cause an ignition, especially when excessive electrical load demands cause line sag.
2. Maintenance activities such as welding or vegetation clearing along the lines that could cause an ignition.
3. Vehicles used by the solar farm operations that could cause an ignition (catalytic converter, faulty brakes, etc.)

4. Malfunctioning transformers at the inverters that could create an ignition. Among the potential hazards to responding firefighters are:
   a. During daylight hours, crews should consider all CPV solar farm modules and trackers energized and fight the fire as they would any other electrical fire. Crews should use dry chemical extinguishers on any potentially energized CPV component. Trackers and modules cannot be isolated during daylight hours and must always be considered energized.
   b. Depending on the level of damage to the solar farm during a fire incident, the connection to "ground" may have been lost and create an extremely hazardous situation, especially if pooling of water occurs.
   c. The use of electrical conductive tools is hazardous, since the modules and frames may still be energized.
   d. The inverters and DC combiner boxes could be located in the middle of the CPV layout or in between rows of trackers. The DC conduit/wiring to the combiner boxes may be running in between the rows. There could be a delay in locating the inverter or identifying other controls. Fire fighters should not step on modules and should be aware of the trip, slip and fall potential around CPV trackers, conduit and the modules themselves.
5. Firefighters must be cautious of water pooling when CPV solar farm could become energized.
6. Care must be taken to avoid unnecessary contact with potentially energized CPV components until they can be isolated and confirmed de-energized.
7. Burning CPV modules may produce toxic vapors. Firefighters should wear full PPE and SCBA due to the potential for toxic or hazardous inhalation that may be produced by these burning components. Crews should work upwind of the smoke whenever possible.
8. Firefighters should never cut the wiring in a CPV solar farm. Specialized tools may be required for disconnecting the tracker wiring. Trackers, modules, and conduit should not be disassembled, damaged or removed by firefighters until all of the CPV solar farm's components are isolated or de-energized by a qualified CPV technician or electrician. Firefighters should limit their activities to containment of the fire until it can be confirmed that the solar farm is isolated or de-energized.
9. At any incident where CPV is present the IC must designate a "Utilities Group" early to aid in locating and disabling all of the CPV solar farm components. This can greatly decrease the electric shock hazard to all crews operating on the fire ground. Firefighters must remember that all CPV components must be considered "HOT" during day light.

Additionally, in large commercial solar farms, Firefighters must be aware that if a single building block or tracker is isolated, all of the others may remain energized. Care must be exercised when operating the other energized trackers.

10. At the conclusion of an incident, demobilization and termination efforts should be directed at leaving the property in the safest condition possible. An overall focused size-up and risk-benefit analysis should be conducted.
11. Incidents involving CPV solar farms are unique in that components may remain energized within the facilities even after all utility supplied power has been de-energized. Along with a structural stability assessment, hazard identification and the marking of any potentially energized areas should be a priority. A qualified CPV technician or electrician should be called to the incident to de-energize any solar farm that has been compromised or creates a hazard. Transferring scene safety and security to an appropriate local, municipal authority may be an option if the fire department is unable to quickly secure the assistance of a qualified CPV technician or electrician. All hazards should be appropriately marked or barricaded.
12. CPV solar farms are typically mounted atop a mast structure specifically designed to support the CPV tracker. The inverters and DC combiner boxes could be located at the end of a row of trackers or in between rows of trackers. The DC conduit/wiring to the combiner boxes may be running in between the rows of trackers.

3.2 Fuels Management to Protect Facilities from other Sources

The Proposed Project is in a very high fire hazard severity zone. The FPP for this Proposed Project documents recommendations to protect the facilities from fire from other sources. Any wind or topography driven wildfire and especially those burning under a northeast (Santa Ana) wind pattern creates a very high wildland fire hazard scenario, especially for wildland fires starting northeast of the development. In addition, a typical fire day with a southwest wind will create a high wildland wildfire hazard. However, the proposed fuel modification treatments and the use of building standards compatible with a solar operation will lower the risk for potential loss of solar structures to less than significant levels. Fuel treatment and setback will most normally eliminate direct fire impingement and radiant heat from around the perimeter of the structures.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Following an assessment of a fire related situation, the choice of a strategic mode should be made by the Incident Commander (IC) following local jurisdiction Emergency Operation Manuals, SOPs and guides that would normally be used for Electrical Hazards. Tactics, like strategy, should also be based upon normal standard operating procedures for responding to an emergency incident for a CPV solar farm. Before going any further:

- Find the Directory for the Site as it has the location of key components.
- Find the Service Disconnects.
- Find the switch to put the Trackers in the Horizontal position.

4.1 Strategy

When a fire incident occurs in the vicinity of a CPV solar farm, the following items must be considered when developing a strategy:

a. Fire conditions found on arrival
b. Whether the CPV solar farm itself is burning or fire is confined to the surrounding vegetation
c. Are aerial firefighting resources being used or planned?
d. Threatened exposures including wild land areas
e. Water and additional resources available

Once the IC has completed a size-up, the IC should determine the strategy and assign tasks to the fire suppression resources assigned to the incident. Due to the hazards associated with CPV solar farms, the IC must adjust the strategy and potentially rearrange the order of the tactics to deal specifically with the CPV solar farm technology. If the IC chooses an offensive strategy it needs to be supported as any other fire operation with an emphasis on disabling all power sources to and from the CPV solar farm.

4.2 Tactics

Tactics will be based on the chosen strategy and Department SOPs:

a. "Components are always hot!" The single most critical message of emergency response personnel is to always consider photovoltaic generating plants and all their components as electrically energized. The inability to power-down photovoltaic panels exposed to sunlight makes this an obvious hazard during the daytime, but it is also a potential concern at nighttime for a solar farm that may be equipped with battery storage.
b. Isolation of the inverters and disconnection of the solar farm from the main electrical panel will be an important task. Assistance from a local CPV technician is key for disabling the CPV solar farm and confirming that all of the hazards have been mitigated. An emergency response plan identifying all tasks and the parties responsible for providing the electrical isolation for emergency responders is required.

c. Another priority will be preventing further extension of the fire and isolating it to its area of origin. This task may be difficult during a vegetation fire, especially if aerial resources are being used within the tracker layout. Ground resources should be removed from the site until the air attack has concluded.

d. Dry chemical extinguishers should be used to contain or extinguish electrical fires. Water should be used to extinguish any ordinary combustibles under or near the CPV solar farm, or if the volume of fire requires its use. If water is used, a 30º fog pattern from at least a 30 foot distance, at 100 psi is recommended.

e. Full PPE must be used due to the potential toxic inhalation hazard if panels are burning. Fire crews should position themselves upwind and out of any toxic atmosphere.

f. Ingress and egress will require that gates have an inside measurement of a minimum of 26 feet wide. The primary fire access will require a Knox Lock. Existing gates plus any future gates that may be installed on the access roads or fence lines must be equipped with an approved padlock, Knox key box (“Knox” padlock, or “Knox” weather resistant lock box, for use with a “Knox” sub-master key) or “Knox” box electronic access system.

g. During the overall fire suppression and mop-up phases of an on-site fire, firefighters should avoid all potential electrical hazards until there is confirmation that the solar farm no longer poses an electric shock hazard. Firefighters must avoid inadvertently damaging CPV components with their tools.

h. The IC will need the assistance from local CPV technician to confirm that all of the hazards have been mitigated before the incident is terminated and the scene is turned over to the owner or responsible party.

i. The tactical approach to a fire incident with solar power equipment must be stressed to all fire suppression personnel (i.e., stay clear). Serious injury can occur with concentrated photovoltaics or any type of pv solar on a sunny day.

The following provides the potential effects and differences between alternating current (AC) and direct current (DC).

5.0 EFFECTS OF DC ELECTRICITY ON THE HUMAN BODY

5.1 Physiological Effects

Electricity flowing through the human body can shock, cause involuntary muscle reaction, paralyze muscles, burn tissues and organs, or kill. The typical effects of various electric currents flowing through the body on the average 150-lb male and 115-lb female body are given in Table 1.

Burns. Although a current may not pass through vital organs or nerve centers, internal electrical burns can still occur. These burns, which are a result of heat generated by current flowing in tissues, can be either at the skin surface or in deeper layers (muscles, bones, etc.), or both. Typically, tissues damaged from this type of electrical burn heal slowly.

Burns caused by electric arcs are similar to burns from high-temperature sources. The temperature of an electric arc, which is in the range of 4,000–35,000°F, can melt all known materials, vaporize metal in close proximity, and burn flesh and ignite clothing at distances up to 10 ft from the arc.

Table 1
Effects of Electric Current on the Human Body (Ref. 1).

Effect/feeling	Direct current (mA)		Alternating current (mA) 60 Hz		Alternating current (mA) 10,000 Hz		Incident severity
	150 lb	*115 lb*	*150 lb*	*115 lb*	*150 lb*	115 lb	
Slight sensation	1	0.6	0.4	0.3	7	5	None
Perception threshold	5.2	3.5	1.1	0.7	12	8	None
Shock not painful	9	6	1.8	1.2	17	11	None
Shock painful	62	41	9	6	55	37	Spasm, indirect injury
Muscle clamps source	76	51	16	10.5	75	50	Possibly fatal
Respiratory arrest	170	109	30	19	180	95	Frequently fatal
≥ 0.03-s vent. fibril.	1300	870	1000	670	1100	740	Probably fatal
≥ 3-s vent. fibril.	500	370	100	67	500	340	Probably fatal
≥ 5-s vent. fibril.	375	250	75	50	375	250	Probably fatal
Cardiac arrest	—	—	4000	4000	—	—	Possibly fatal
Organs burn	—	—	5000	5000	—	—	Fatal if it is a vital organ

Delayed Effects

Damage to internal tissues may not be apparent immediately after contact with the current. Internal tissue swelling and edema are also possible.

Critical Path

The critical path of electricity through the body is through the chest cavity. At levels noted in Table A-1, current flowing from one hand to the other, from a hand to the opposite foot, or from the head to either foot will pass through the chest cavity paralyzing the respiratory or heart muscles, initiating ventricular fibrillation and/or burning vital organs.

5.2 Biological Effects of Electrical Hazards

Influential Variables

The effects of electric current on the human body can vary depending on the following:

1. Source characteristics (current, frequency, and voltage of all electric energy sources).
2. Body impedance and the current's pathway through the body.
3. How environmental conditions affect the body's contact resistance.
4. Duration of the contact.

Source Characteristics

An alternating current (ac) with a voltage potential greater than 550 V can puncture the skin and result in immediate contact with the inner body resistance. A 110-V shock may or may not result in a dangerous current, depending on the circuit path which may include the skin resistance. A shock greater than 600 V will always result in very dangerous current levels. The most severe result of an electrical shock is death.

Conditions for a serious (potentially lethal) shock across a critical path, such as the heart, are:

1. More than 30 V root mean square (rms), 42.4-V peak, or 60 V dc at a total impedance of less than 5000
2. 10 to 75 mA
3. More than 10J

Conditions for a potentially lethal shock across the heart are:

1. More than 375 V at a total body impedance of less than 5000
2. More than 75 mA
3. More than 50 J

Frequency

The worst possible frequency for humans is 60 Hz, which is commonly used in utility power systems. Humans are about five times more sensitive to 60 Hz alternating current than to direct current. At 60 Hz, humans are more than six times as sensitive to alternating current than at 5000 Hz—and the sensitivity appears to decrease still further as the frequency increases. Above 100–200 kHz, sensations change from tingling to warmth, although serious burns can occur from higher radio-frequency energy. At much higher frequencies (e.g., above 1 MHz), the body again becomes sensitive to the effects of an alternating electric current, and contact with a conductor is no longer necessary; energy is transferred to the body by means of electromagnetic radiation (EMR).

Body Impedance

Three components constitute body impedance: internal body resistance and the two skin resistances at the contact points with two surfaces of different voltage potential. One-hand (or single-point) body contact with electrical circuits or equipment will prevent a person from completing a circuit between two surfaces of different voltage potential. Table 2 provides a listing of skin-contact resistances encountered under various conditions. It also shows the work area surfaces and wearing apparel effects on the total resistance from the electrical power source to ground. This table can be used to determine how electrical hazards could affect a worker in varying situations.

Table 2
Human resistance (Q) for various skin-contact conditions.

Body contact condition	Dry (Ω)	Wet (Ω)
Finger touch	40,000–1,000,000	4,000–15,000
Hand holding wire	15,000–50,000	3000–5000
Finger-thumb grasp	10,000–30,000	2000–5000
Hand holding a pliers	5,000–10,000	1000–3000
Palm touch	3000–8000	1000–2000
Hand around 1.5-in. pipe or drill handle	1000–3000	500–1500
Two hands around 1.5-in. pipe	500–1500	250–750
Hand immersed	—	200–500
Foot immersed	—	100–300

Life-Threatening Effects

Charles F. Dalziel, Ralph H. Lee, and others have established the following criteria for the lethal effects of electric shock:

1. Currents in excess of a human's "let-go" current (≥16 mA at 60 Hz) passing through the chest can produce collapse, unconsciousness, asphyxia, and even death (see also Table 1).

2. Currents (≥30 mA at 60 Hz) flowing through the nerve centers that control breathing can produce respiratory inhibition, which could last long after interruption of the current.
3. Cardiac arrest can be caused by a current greater than or equal to 1 A at 60 Hz flowing in the region of the heart.
4. Relatively high currents (0.25–1 A) can produce fatal damage to the central nervous system.
5. Currents greater than 5 A can produce deep body and organ burns, substantially raise body temperature, and cause immediate death.
6. Delayed reactions and even death can be caused by serious burns or other complications.

6.0 REFERENCES

Fire Operations for Photovoltaic Emergencies. CAL FIRE–Office of the State Fire Marshal. November 2010.

Fire Fighter Safety and Emergency Response for Solar Power Solar farms. A DHS/Assistance to Firefighter Grants (AFG) Funded Study. Prepared by: Casey C. Grant, P.E. Fire Protection Research Foundation.

The Fire Protection Research Foundation One Batterymarch Park. Quincy, Massachusetts, USA. 02169-7471.

Lawrence Livermore National Laboratory. Prior to Commissioning the operator must provide Training to First Responders. http://www.llnl.gov/es_and_h/hsm/doc_16.01/doc16-01.html. May 2010