

PERMITTING SOLAR POWER FACILITIES ON CLOSED LANDFILLS

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ABSTRACT

There is growing interest by landfill owners and operators with sites in post-closure to take advantage of solar power generation opportunities on their closed landfills. How great would it be to turn an otherwise unused plot of land that just happened to be a landfill into a source of ongoing revenue. Not only could the revenue be helpful, but solar power generation fits into the world of renewable energy, which will likely be part of all of our futures.

Where to start? You need a closed landfill with enough open space to create a marketable power source; a solar developer with the where-with-all to make it through the permitting and political hurdles; a power utility company that is willing to purchase the power produced; and a combination of available infrastructure components – nearby power transmission lines and space for generation equipment, such as inverters and substation transformers, etc. The final requirement is the willingness and tenacity of the landfill owner/operator to take on such an endeavor and see it through.

This paper discusses the process for two such projects – one is for the City of Sacramento at 28th Street Landfill (Figures 1 through 6), which has completed a 1.8 megawatt facility, and the second is at West Riverside Landfill (Figures 7 through 9), which is in the middle of the permitting process for 9.4 megawatts. Both facilities are using fixed arrays that are supported by columns and cross support structures. The support footings vary for different cover conditions. The author has worked with the owners and developers on both of these California projects, and will discuss the processes involved including the following:

- Power Purchase Agreements
- Land Lease Agreements
- Post-Closure Permit Requirements
- CEQA Requirements
- Post-closure Maintenance
- Settlement
- Design

POWER PURCHASE AGREEMENTS

The power purchase agreement is an essential component of a commercial scale solar generation project. If you don't have a buyer, then you don't produce more power than your site cannot use. The local utility company that provides electrical power is the starting point. The purchase price per kilowatt hour and any development fees will be stated in the power purchase agreement.

LAND LEASE AGREEMENTS

If you don't own a landfill, then you will need one of these. Most landfill owners will allow favorable terms to the leaser in order to make projects economically feasible. Lease agreements can be based on a percentage of revenue from power generated. This type of arrangement allows all parties to be successful when the project is successful.

Since the solar arrays are going to be located over a permanently closed landfill surface, issues of responsibility come into question and need to be factored into the terms and conditions. Who will repair damage from settlement or erosion and other occurrences. These issues need to be spelled out in the lease agreement so it is clear who bears the responsibility during the operational life of the solar facility and post closure period for the landfill.

POST-CLOSURE PERMIT REQUIREMENTS

California Code of Regulations (CCR) Title 27, which regulates solid waste landfills in California, requires that a landfill end use document be prepared which describes the proposed changes in the end use of a landfill. The document is referred as the Post-Closure Land Use Plan (PCLUP). The PCLUP describes the proposed changes in end use, how the change will impact the existing approved post-closure plan. It includes such items as design plans, solar array support details, anticipated settlement, costs associated with changed maintenance

requirements. The regulatory agencies rely on the PCLUP to determine if the proposed changes are acceptable and are consistent with the permit requirements of the site. The agencies may request additional information or clarifications during the review process, which can take from 3 to 6 months. Upon approval, the project can proceed with over-site and inspections performed by the agencies. Both of the sites discussed in this paper required preparation of a PCLUP.

CEQA/ENVIRONMENTAL REVIEW

Location/neighborhood sensitivity of your landfill will determine the level of Environmental Review that will be required for a project. The regulatory agencies require that an environmental review process be completed in advance or concurrently with the PCLUP review process. If opposition is minimal or absent, a Mitigated Negative Declaration (MND) has typically been acceptable. On the other hand, when opposition or interest is strong, a full Environment Impact Report (EIR) may be advisable to avoid delays in the approval process due to incomplete consideration of environmental impacts from the project. Each project will be different and should be thoroughly evaluated for impacts on the environment. The 28th Street Landfill project proposed a full EIR due to sensitivity of project; whereas, West Riverside Landfill is using an Initial Study/Negative Declaration.

POST-CLOSURE MAINTENANCE

Post-closure maintenance requirements will change with the addition of solar arrays on a closed landfill. Maintenance items such as mowing, repair of settlement, and drainage will likely be impacted. The post-closure maintenance plan should be updated to include new or changed maintenance requirements. The PCLUP will have a section that focuses on these changes and the costs associated with them. For 28th Street Landfill the post-closure changes focused on managing settlement in paved and unpaved areas. At West Riverside Landfill, the focus is on drainage and managing settlement of the soil cover. For both sites, security was a high priority to protect the closed landfill as well as the expensive equipment associated with the solar generating facilities.

SETTLEMENT

Settlement from added loading is a major consideration in planning a solar generation project and the PCLUP. A thorough evaluation of potential settlement is key for both the self-weight of the existing cover and for added solar equipment weight that may impact the rate or amount of settlement that occurs. A geotechnical investigation and evaluation of potential settlement is advised. Historic information on waste type and

placement depth are useful as well as past estimates of settlement for the landfill cover. Since waste decomposes over time and literally disappears, settlement is not typical of soil and can be very significant. Photographs 1 through 14 show the different conditions and supporting structures used at 28th Street Landfill. Both special footings and earth screws were used at the site for three different cover surfaces, including soil and asphalt.

DESIGN

The design of the supporting system for the solar arrays is highly important in limiting and managing settlement that occurs near or beneath the arrays. There are several different support systems that are used for solar arrays. For Fixed-Arrays Structural frames are typically required to hold and angle the arrays properly to achieve maximum exposure to the sun. The structural components are in turn supported by skids, fixed foundations, or earth screws which interface with the final landfill cover system. The selected interface depends on the magnitude of the anticipated settlement and the weight of the solar arrays. The two subject sites utilize all three interfaces systems. Figures 1 through 6 and Photographs 1 through 14 show the foundations used at 28th Street Landfill. Figures 7 through 9 show the foundation supports used at West Riverside Landfill.

PROJECT STATUS

The 28th Street Landfill solar array project was completed in early 2014, and is currently generating close to 1.8 megawatts of power. The West Riverside Landfill solar project is currently in the permitting process and is anticipated to be constructed in 2015. When completed, the facility will generate over 9.4 megawatts of power.



FIGURE 1
28th STREET LANDFILL LOCATION MAP



FIGURE 2
PROPOSED SOLAR FACILITY LAYOUT

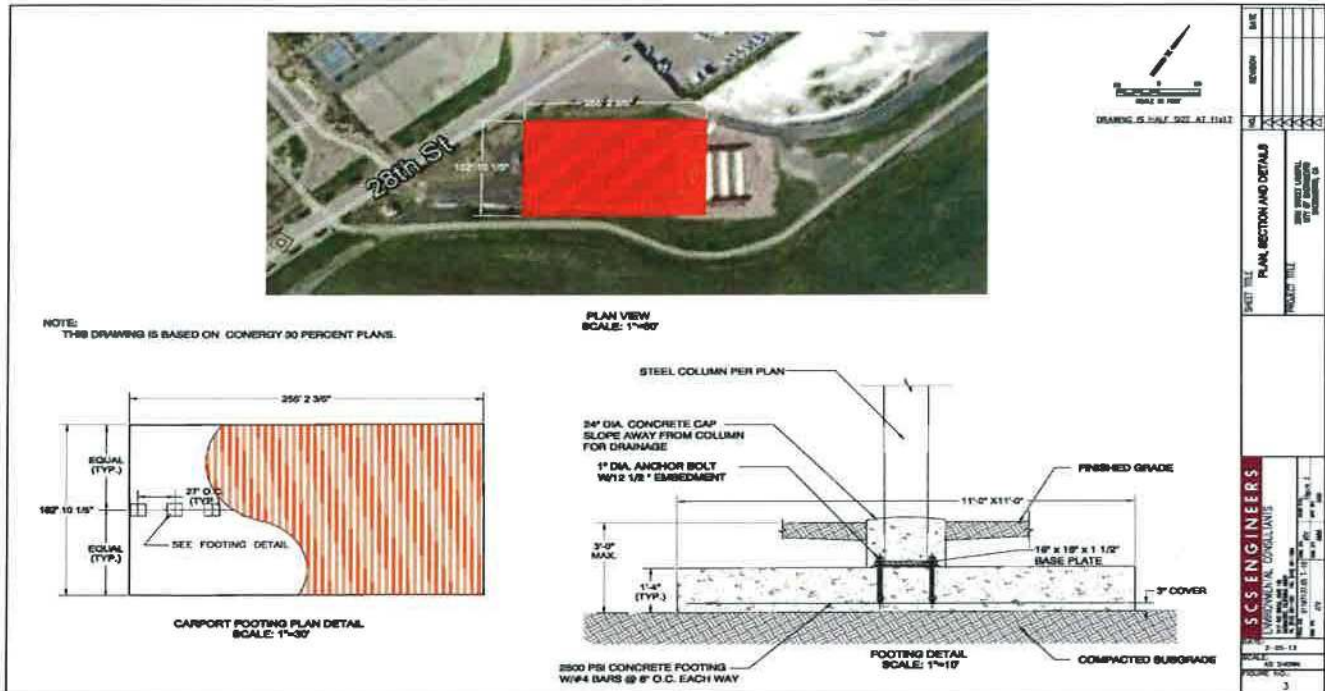


FIGURE 3
PARKING COVER

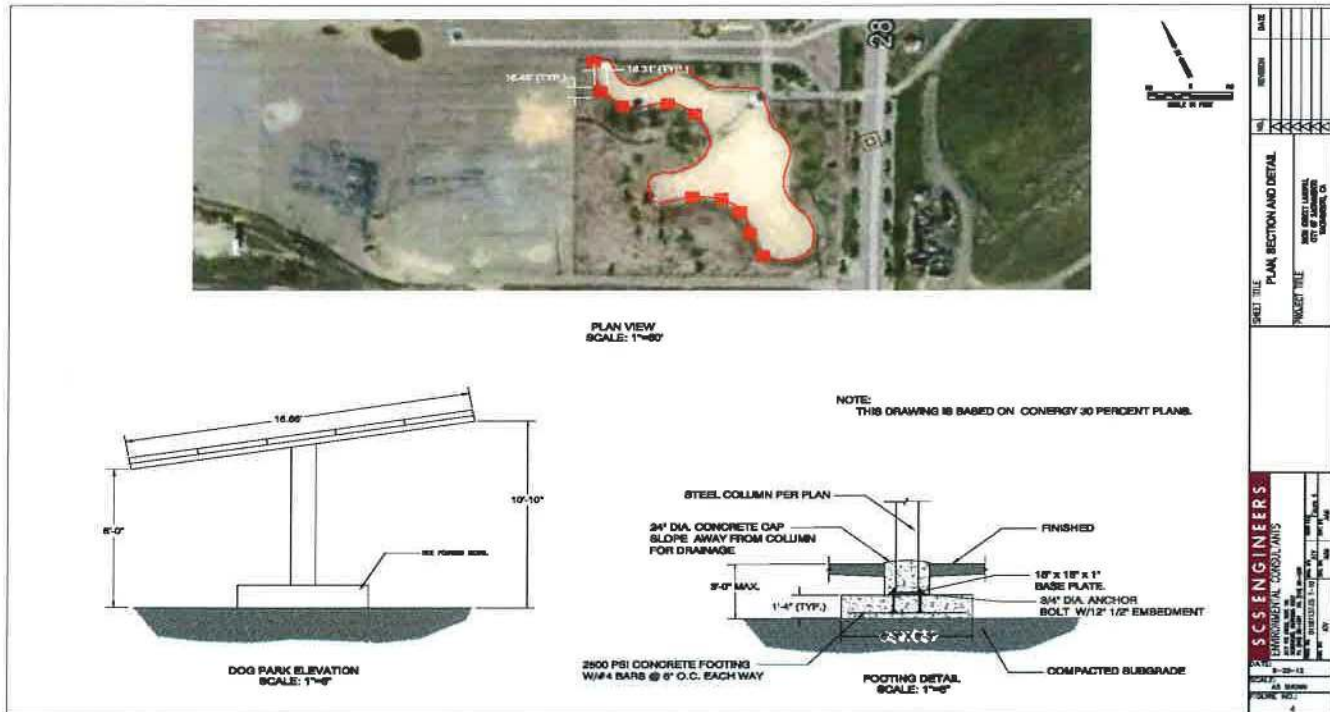


FIGURE 4
DOG PARK SHADE

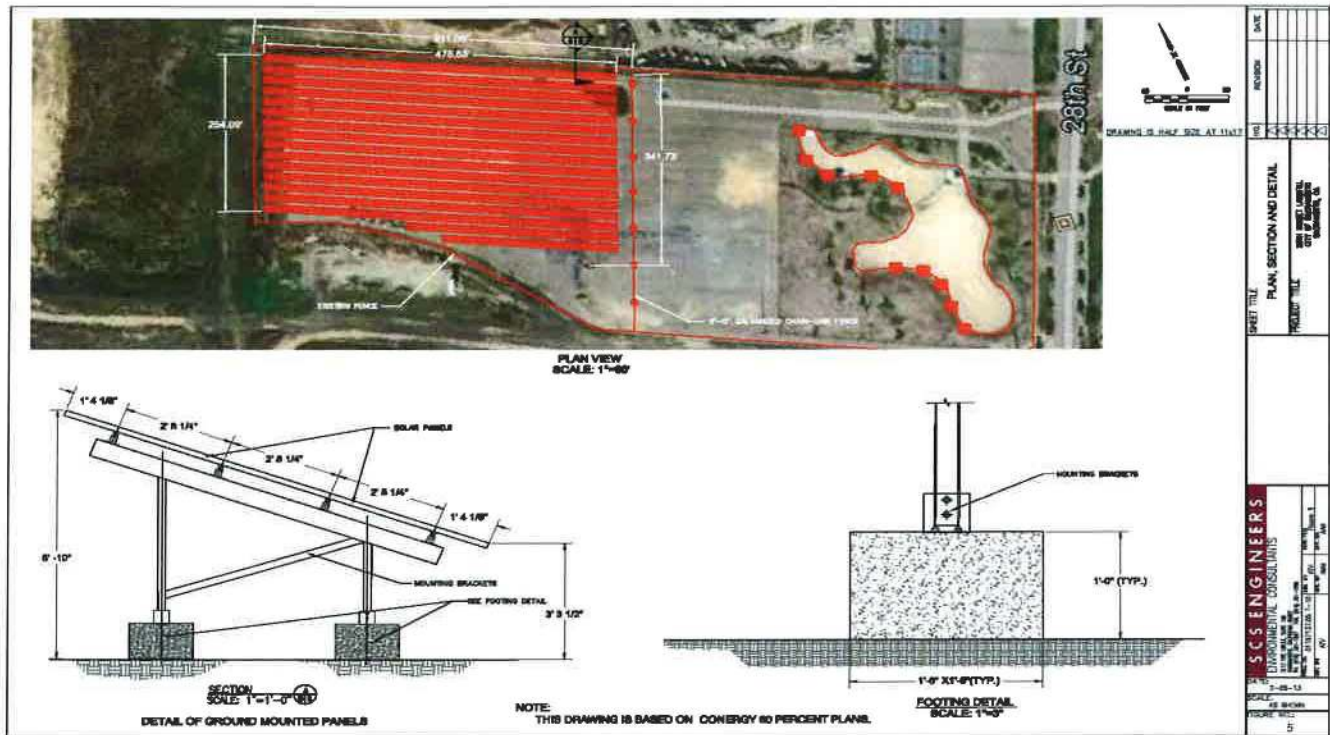


FIGURE 5
BALLAST SKID MOUNTED

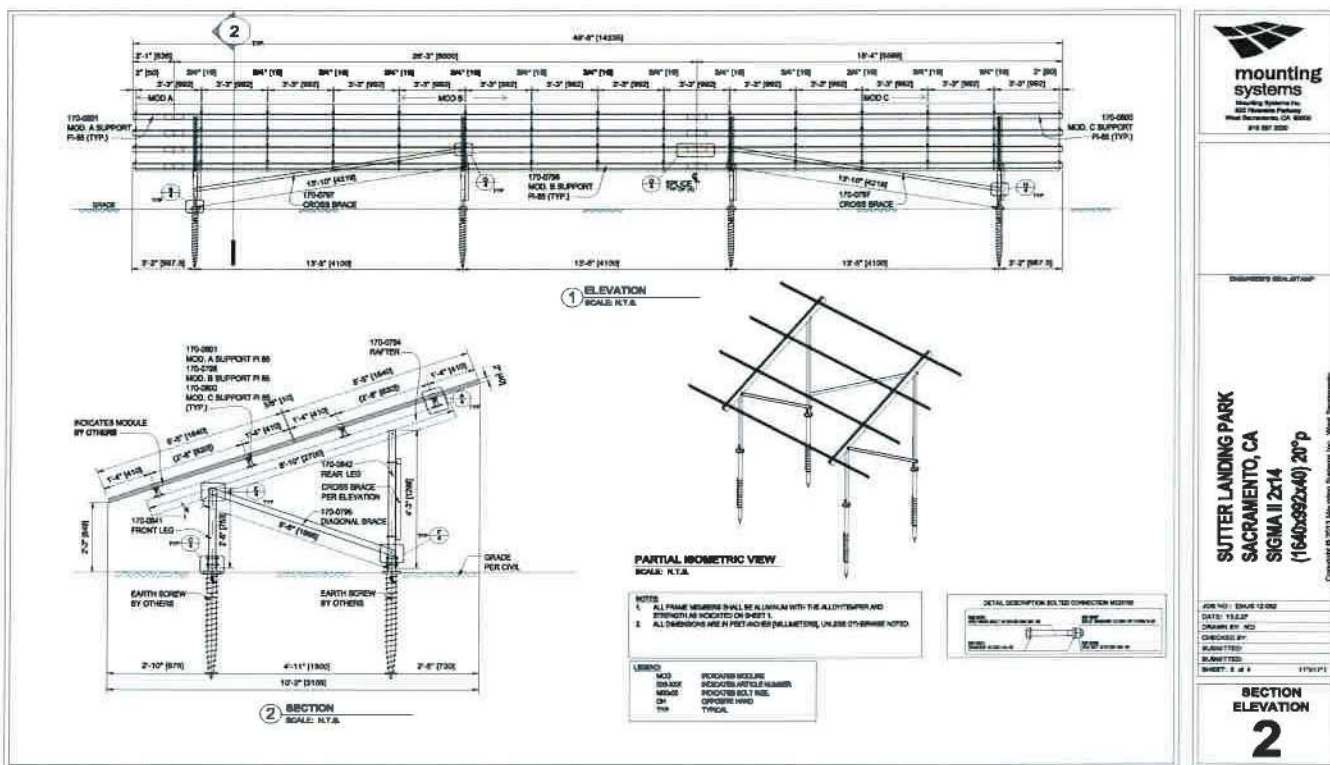


FIGURE 6
EARTH SCREW MOUNTED

WEST RIVERSIDE LANDFILL
2700 HALL AVENUE
RIVERSIDE, CA 92508

STRONGHOLD ENGINEERING
2000 MARKET STREET
RIVERSIDE, CA 92501

SOLAR FLEXIRACK
A DIVISION OF NORTHERN STATES METALS
3207 INNOVATION PLACE
YOUNGSTOWN, OHIO 44509
PHONE: (888)-380-8138



PROJECT SITE



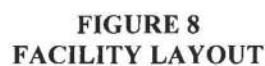
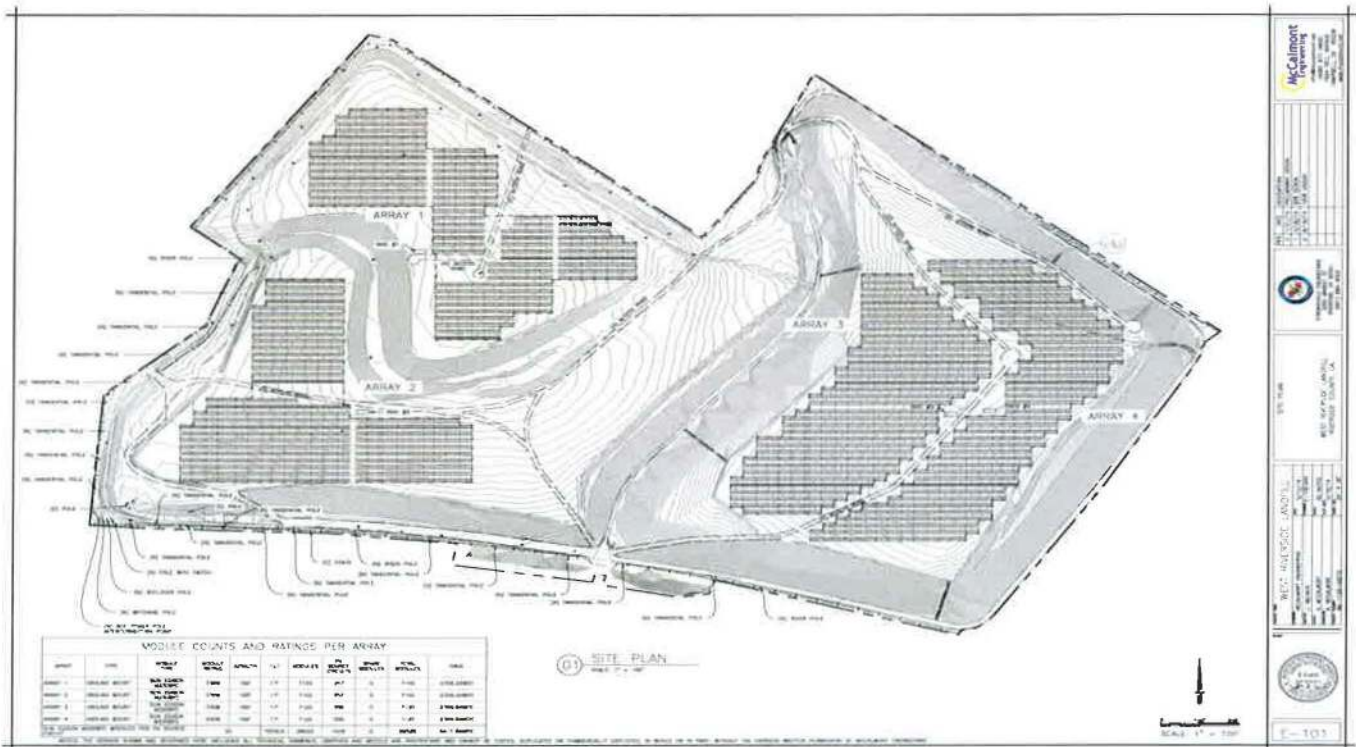
6. WIND DESIGN PARAMETERS.
 U.S. DESIGN WIND SPEED, $V = 100$ MPH
 WIND CATEGORY - 1
 WIND EXPOSURE, $K_z = 0.85$
 GUST FACTOR \times NET PRESSURE COEFFICIENT
 (BASED ON WIND TUNNEL STUDY)
 EXTERIOR
 UPWARD = 1.04
 DOWNWARD = 0.75
 INTERIOR
 UPWARD = 0.61
 DOWNWARD = 0.40

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SEISMIC IMPORTANCE FACTOR,  $I_s = 1.0$ 
MAFPPED SPECTRAL RESPONSE ACCELERATION PARAMETERS,
   $S_a = 1.5$ 
   $S_l = 0.49$ 
SITE CLASS = D
DESIGN SPECTRAL RESPONSE ACCELERATION PARAMETERS,
   $S_{ae} = 1.0g$ 
   $S_{a1} = 0.2g$ 
SEISMIC DESIGN CATEGORY = D
BASIC SEISMIC FORCE-RESISTING SYSTEM = SLOAR RADIOMG SYSTEM
DESIGN BASE SHEARS = 0.74 KIP
SEISMIC RESPONSE COEFFICIENT,  $C_w = 3.50$ 
SEISMIC MODIFICATION COEFFICIENT,  $\theta = 2$ 
ANALYSIS PROCEDURE = EQUIVALENT LATERAL FORCE PROCEDURE

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SEE CRC 2013, TABLE 1705A.2.1, ITEMS 3A, 3B, AND 3C
(PERIODIC)
SEE CRC 2013, TABLE 1705A.2.1, ITEMS 1A AND 1B
(PERIODIC)
SEE CRC 2013, TABLE 1705A.2.1, ITEMS 2A AND 2B
(PERIODIC)
SEE CRC 2013, TABLE 1705A.3, ITEMS 5 AND 12
(CONTINUOUS)
SEE CRC 2013, TABLE 1705A.3, ITEMS 6 AND 7
(PERIODIC)
SEE CRC 2013, TABLE 1705A.3, ITEMS 8

[illegible]

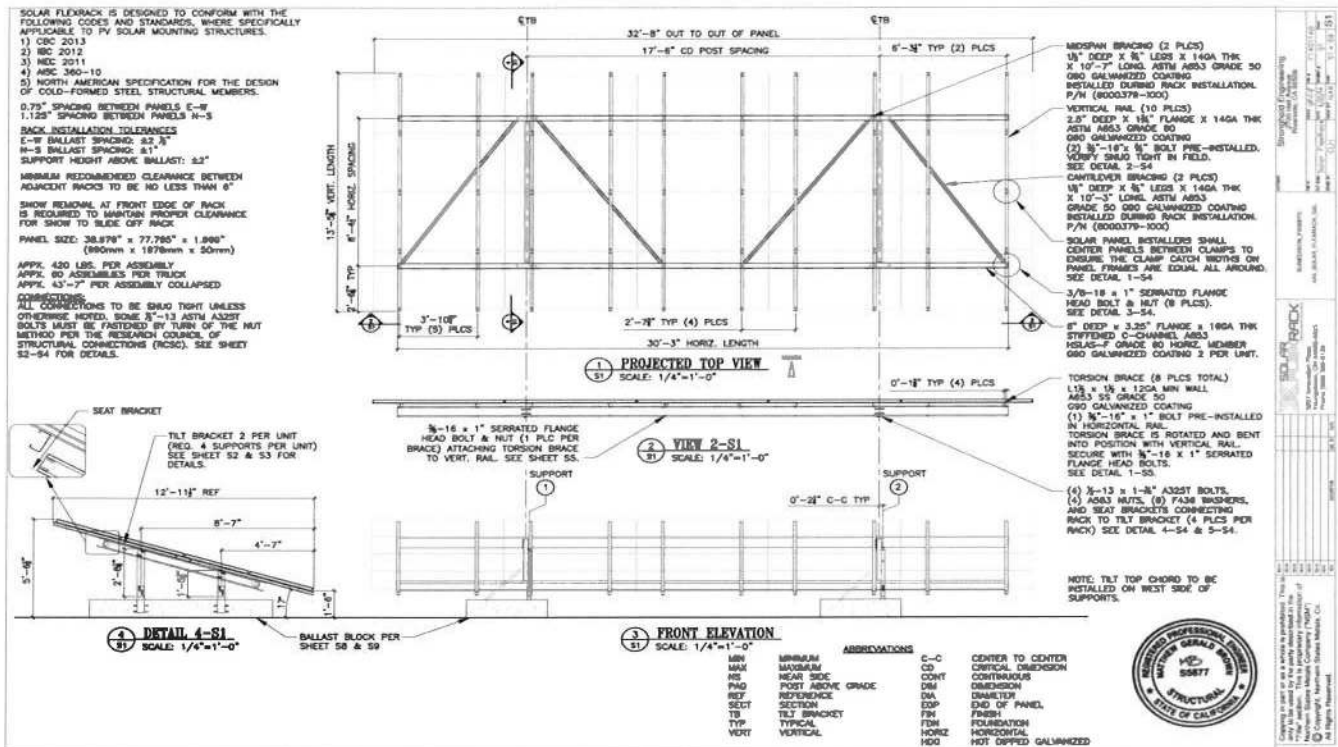


FIGURE 9
BALLAST SKID MOUNTED



**PHOTOGRAPH 1
SITE LOCATION**



**PHOTOGRAPH 2
PARKING COVER FOOTING EXCAVATION**



**PHOTOGRAPH 3
PARKING COVER FOOTINGS**



**PHOTOGRAPH 4
PARKING COVER**



PHOTOGRAPH 5
DOG PARK FOOTING



PHOTOGRAPH 6
DOG PARK SHADE COVER



PHOTOGRAPH 7
EARTH SCREW MOUNTS



PHOTOGRAPH 8
INSTALLED EARTH SCREWS



PHOTOGRAPH 9
SEAL AROUND EARTH SCREW



PHOTOGRAPH 10
SETTING SOLAR PANELS



PHOTOGRAPH 11
SOLAR ARRAY SPACING



PHOTOGRAPH 12
FILLING IN ARRAYS



**PHOTOGRAPH 13
COMPLETED SOLAR ARRAYS**



**PHOTOGRAPH 14
RIBBON CUTTING**