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Memorandum

Date: April 16, 2013

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From: Mr. Matt Dunn, Principal Engineer, URS Corporation
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Subject: **Greenhouse Gas Emissions from the Proposed Alamo Solar Project, San Bernardino County, California**

1.0 INTRODUCTION

E.ON Climate & Renewables North America (Applicant) proposes to construct a 20-megawatt (MW) solar energy generation project (Project) on approximately 175 acres of land in San Bernardino County, approximately 12 miles north of Victorville. Construction is estimated to start in 2014 and would take approximately eight months to complete. URS quantified greenhouse gas (GHG) emissions resulting from the construction and operation of the Project using construction and operational data provided by the project Applicant. Emission factors and other data are from the CalEEMod California Emissions Estimator Model (successor to planning level emissions estimating software, URBEMIS). This software was used as the GHG quantification tool for this project. The Applicant estimated the project construction activities would occur over an eight month period, while the operational project life is estimated at 30 years. The total project related average annual GHG emissions were determined to not exceed 3,000 metric tons carbon dioxide equivalent per year ($MTCO_2e$/yr). These project GHG emissions are consistent with the County of San Bernardino's September 2011 *Greenhouse Gas Reduction Plan* and would present a less than significant impact for GHG emission.

2.0 METHODOLOGY AND ASSUMPTIONS FOR CONSTRUCTION

2.1 CONSTRUCTION SCHEDULE

The project's construction schedule assumes 10-hour work days and 6 work days per week for months 1-7 with 5 work days per week for month 8. During months 5 and 6, a second shift during nighttime is assumed to operate the projected equipment.

2.2 EMISSION FACTORS

Emission factors for off-site emissions from on-road travel (via public highways to the site access) were calculated in California Emissions Estimator Model™ (CalEEMod version 2011.1.1). This software program calculates on-road vehicle emissions based on emission factors from California specific highway emissions database, the latest version of the California EMission FACtor model (EMFAC2007). Emissions from personal vehicles for worker and vendor commuting, and trucks for material hauling are based on the number of trips and vehicle miles traveled (VMT) along with emission factors from EMFAC2007. The emissions from mobile sources were calculated by CalEEMod as follows:

$$Emissions_{pollutant} = VMT * EF_{running,pollutant}$$

Where:

$Emissions_{pollutant}$ = emissions (CO_2) from vehicle running for each pollutant
VMT = vehicle miles traveled
$EF_{running,pollutant}$ = emission factor for running emissions

The model was run with the calendar year 2014 selected as the construction and first operational year. Subsequent operational emissions were assumed the same as the first year, this is conservative since 2014 would be less efficient for highway vehicles (more GHG emissions) than subsequent years. The vehicle class selected for worker personal vehicles was a mix of the following categories: Light Duty Auto (LDA), Light duty truck 1 (LDT1), and Light duty Truck 2 (LDT2). The vehicle class for vendors and construction material hauling were selected as Heavy Heavy Duty Diesel Truck (HHDT) to represent offsite travel.

Emission factors for on-site diesel construction equipment were calculated in CalEEMod; the software program calculates the exhaust emissions based on California Air Resources Board (ARB) OFFROAD2007 methodology using the equation presented below.

$$Emission_{\ DieselEx} = \Sigma_i\ (EFi = x\ Pop_i\ x\ AvgHp_i\ x\ Load_i\ x\ Activity_i\ )$$

Where:

EF = Emission factor in grams per horsepower-hour (g/bhp-hr) as processed from OFFROAD2007
Pop = Population, or the number of pieces of equipment
AvgHp = Maximum rated average horsepower
Load = Load factor
Activity = Hours of operation
i = equipment type

The software calculates the exhaust emission factors for each piece of equipment at each horsepower range by back calculating from total daily emissions reported in the model output files using the following formula:

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$$Emission\ Factor\ \left[\frac{g}{hphr}\right] = \frac{Total\ Daily\ Exhaust}{Activity\ x\ AvgHP\ x\ LF\ x\ 907184.74}$$

Where:

Total Daily Exhaust = Total pollutant emissions [tons/day]
Activity = Total daily statewide usage of equipment [hours/day]
AvgHP = Average HP of equipment within the horsepower range [HP]
LF = Load Factor of equipment [unitless]
907,184.74 = Conversion factor from tons to grams

Total Daily Exhaust and Activity were obtained from OFFROAD2007 model output, while Avg HP and LF were obtained from input files to the model.

The model is made to be region specific. Its emission quantification is based on estimated regional equipment population for a given year. Therefore, the model applied calendar year 2014 equipment emissions for construction in the Mojave Desert portion of San Bernardino County.

Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are the known by-products from fuel combustion that are classified as GHGs. For diesel internal combustion, almost all of the GHG is from CO_2. Emissions CH_4 and N_2O are multiplied by their Global Warming Potentials (GWP) to arrive at CO_2e. The GWPs applied were 21 for CH_4 and 310 for N_2O. (Typically, the emissions of CH_4 and N_2O are less than 1 percent of the total GHG for diesel internal combustion).

2.3 ON-SITE AND OFF-SITE CONSTRUCTION ACTIVITY

Calculations of GHG emissions due to on-site construction activity were based on information provided by the Applicant regarding the type and quantity of construction equipment anticipated to operate on-site each month. All construction equipment was assumed to be fueled on diesel. Table 1 details on-site construction equipment, including horsepower (HP). Utilization levels of equipment were preselected by default levels of CalEEMod; this information is based on historical data from ARB and South Coast Air Quality Management District (SCAQMD). The maintenance of the portable toilets at the construction site are included in the truck visit data used. Therefore, there are no sewage derived biological CO_2 emissions. During construction all electricity will be provided onsite by small portable diesel fueled generators (estimated at 10 kW). Consequently there will be no electrical demand from the grid.

Table 1 includes the equipment necessary for SCE's upgrades to its existing distribution line and gen-tie equipment. Upgrades will take approximately four months to complete. The location of the Alamo project site and portions of the existing distribution line that would be upgraded are illustrated in Figure 1a-b.

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2.4 OFF-SITE TRAVEL DISTANCE

Travel distance assumed a distribution of passenger vehicles for workers commuting between greater Victorville area and the site. Table 2 presents the distribution for construction labor force and material deliveries. The calculations conservatively assume larger population centers for the craft labor. It was assumed that passenger vehicles for the construction work force transported an average of 1 passenger. This is conservative considering some workers may carpool. Emissions from passenger vehicles traveling to and from the site were based on estimated construction labor force per month as shown in Table 3.

Delivery trucks for material hauling reflect the transport of construction materials within San Bernardino County. For this project it was conservatively assumed that all construction or fabricated materials were produced outside of San Bernardino County and transported into San Bernardino County from Los Angeles County. Emissions from delivery trucks traveling to and from the site were based upon off-site delivery activity shown in Table 4. Water supplied for construction will be purchased from a local purveyor located within an assumed distance of 10 miles away from the project site. Emissions from water truck delivery to site were based on average off-site delivery trips shown in Table 4.

3.0 METHODOLOGY AND ASSUMPTIONS FOR OPERATIONS-BASED GHG EMISSIONS

Operational phase emission calculations assumed the facility would be unmanned and several part time employees would visit the site periodically. To provide a conservative analysis, the calculations assumed there would be 96 round trips to the site per year for part-time workers from the San Bernardino county line. Several times a year, the employees or a contractor would also visit the site to wash the PV panels. It was conservatively assumed panel washing would require approximately 2 acre-feet of water per year. Based on an assumed use of 4,000 gallon diesel fueled water tankers, panel washing would require approximately 163 truckloads (326 one way truck trips) for delivery of this water. Water used for panel washing would be purchased from a local purveyor located at an assumed distance of 10 miles away from the project site. The workforce for the operational phase was assumed to commute to the site from outside of San Bernardino County. The emissions associated with water supply (i.e., pumping) were calculated in CalEEMod based on the use of 2 acre-feet per year.

Electrical components such as switch gear are assumed to have *de minimis* amounts of the greenhouse gas, sulfur hexafluoride (SF_6). The SF_6 gas leakage from components is assumed to be less than 1 $MTCO_2e$ per year.

The Applicant estimated that the plant would generate 55 Gigawatt-hours (GWh) of electricity beginning in year 1 of operation, declining by 0.5 percent annually thereafter. Estimated electricity production from the Project was based upon meteorological data for the site location using computer-based solar energy generation models, assuming typical energy conversion efficiency parameters. Annual electricity generation was used to calculate the amount of air emissions avoided by the project through the generation of renewable energy and displacement of grid-supplied electricity. GHG emission avoidance from operation of the project assumed that renewable solar energy was displacing typical California grid-supplied electricity. The GHG emissions of this electricity correspond to the emission factors of the Western Electricity Coordinating Council (WECC) California subregion of the Emissions and Generation Resource Integrated Database (eGRID2012). The avoided emissions are approximately 16,400 $MTCO_2e$/year from this project. The annual mass of GHG avoided (a sink) is not accounted for in the GHG calculations conducted for this project for comparison to GHG significance threshold of San Bernardino County. The analysis thus presents a conservative estimate of Project-related GHG emissions.

4.0 RESULTS AND CONCLUSIONS

Table 5 shows total greenhouse gas emissions from the construction phase and operation phase of the project. In calculating the emissions from Projects within the sample population, construction period GHG emissions were divided over 30 years (the average economic life of a development project) to comply with the San Bernardino County Greenhouse Gas Emissions Reduction Plan. This table also presents the San Bernardino County and the applicable South Coast Air Quality Management District (SCAQMD) threshold of significance for GHG emissions. For completeness, the SCAQMD threshold is provided because the project assumes transport of construction materials through the SCAQMD portion of San Bernardino County.

Results from the GHG analysis performed for the solar energy project, proposed by the Applicant show that construction and operation emissions over 30 years will be approximately 94.57 MTCO2e per year. This is far below San Bernardino County's significance threshold of 3,000 $MTCO_2e$ per year. Furthermore, Project operations would result in a net GHG benefit due to displacement of grid-supplied electrical energy and associated air emissions from traditional energy sources.

5.0 REFERENCES

CalEEMod. 2011. (version 2011.1.1) California Emissions Estimator Model. Available online at: http://www.caleemod.com

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County of San Bernardino. Greenhouse Gas Emissions Reduction Plan. Dated September 2012. Available online at: http://www.sbcounty.gov/Uploads/lus/GreenhouseGas/FinalGHG.pdf eGRID2012. 2012 (version 1.0 Year 2009) GHG Annual Output Emission Rates Available online at: http://epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_GHGOutputrates.pdf

TABLES

TABLE 1
ONSITE AND OFFSITE[1] CONSTRUCTION EQUIPMENT (PIECES PER MONTH) FOR ALAMO SOLAR

Equipment Type	Horsepower (HP)	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Total
Grader	175	3	3	1	—	—	—	—	—	**7**
Excavator	175	2	2	—	—	—	—	—	—	**4**
Dozer	250	2	2	—	—	—	—	—	—	**4**
Compactor	120	–	2	2	—	—	—	—	—	**4**
Backhoe/Front End Loader	120	2	2	1	—	—	—	—	—	**5**
Rough Terrain Forklift	120	–	2	4	4	2	2	2	2	**18**
Crawler Trencher	175	–	–	2	2	—	—	—		**4**
Pick Up Truck	150	2	2	6	6	6	4	4	2	**32**
Water Truck, 4000 gal	220	1	1	1	1	1	1	1	1	**8**
Concrete Truck	250	—	—	6	6	–	–	–	–	**12**
ATV with material body	18	1	2	3	4	4	4	2	2	**22**
Auger	30	—	—	3	3	3	—	—	—	**9**
Pile Driver	50	—	—	3	3	3	—	—	—	**9**
Light Tower	14	—	—	—	—	2	2	—	—	**4**
Generator	7	5	5	5	5	5	5	5	5	**40**
Back Hoe, w/ Bucket	85	—	—	—	—	1	1	—	1	**3**
Digger, Truck Mount	190	—	—	—	—	1	1	—	—	**2**
Flatbed	180	—	—	—	—	1		—	—	**1**
Forklift	75	—	—	—	—	1	1	—	—	**2**
Line Truck	310	—	—	—	—	3	3	3	3	**12**
Motor, Auxiliary Power	5	—	—	—	—	2	2	—	—	**4**
Trailer, Flatbed	220	—	—	—	—	1	—	—	—	**1**
Truck, Semi, Tractor	310	—	—	—	—	1	—	—	—	**1**
Truck Flatbed w bucket	235	—	—	—	—		—	—	1	**1**
Truck, Dump	235	—	—	—	—	1	1	—	1	**3**
Truck, Flatbed w/ boom	235	—	—	—	—		—	—	1	**1**
Truck, Flatbed	210	—	—	—	—	3	3	—	1	**7**
Truck, Mechanics, 1-2 Ton	260	—	—	—	—	1	1	—	—	**2**
Truck, Pickup	180	—	—	—	—	4	4	3	3	**14**
Truck, Pickup	180	—	—	—	—	1	—	—	—	**1**

Truck, Pickup	210	–	–	–	–	2	2	2	3	**9**
Truck, Water, 2,000-5,000 Gal	175	–	–	–	–	1	1	1	1	**4**
Total	–	**18**	**23**	**37**	**34**	**50**	**38**	**23**	**27**	**250**

[1] Offiste Equipment needed for offsite transmission and gen tie improvements to utility connections 12 miles away..

TABLE 2
DISTRIBUTION OF TRAVEL FOR ALAMO SOLAR

	Victorville	Apple Valley	Los Angeles County
Commuters	50%	50%	0%
Construction Deliveries	0%	0%	100%

TABLE 3
CONSTRUCTION LABOR FORCE (LABORERS PER MONTH WITH SUPERVISION) FOR ALAMO SOLAR

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8
Working Hours Per Day	10	10	10	10	10	10	10	8
Working Days per Week	6	6	6	6	6	6	6	5
Workforce Estimates (No. of workers)	10	20	50	60	176	176	66	39

TABLE 4
OFF SITE CONSTRUCTION DELIVERY ACTIVITY (TRIPS PER MONTH) FOR ALAMO SOLAR

Vehicle Type	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Total
Material Delivery Trucks[1]		80	160	80	22				342
Water Truck (average)[2]	1,536	1,690	1,664	1,728	3,200	3,456	1,664	1,408	16,346

1 Heavy Heavy Duty Diesel (80,000 lbs gross vehicle weight).

2 Assumed 4,000 gallon water trucks. Water used for dust control.

TABLE 5
AVERAGE ANNUAL GREENHOUSE GAS EMISSIONS
ALL SOURCES FOR ALAMO SOLAR 20 MW PROJECT

	$Bio\text{-}CO_2$[1]	$NBio\text{-}CO_2$[1]	Total CO_2	CH_4	N_20	CO_2e[2]
Total Construction Emissions (MT)	0	2,519.50	2,519.50	0.21	0	2,523.86
Construction/30years (MT/yr)[3]	–	–	–	–	–	84.13
Operational (MT/yr)[4]	0	9.98	9.98	0	0	9.44
Operational SF_6 gas (MT/yr)[5]	–	–	–	–	–	1.00
Combined Annual Average (MT/yr)						94.57
San Bernardino County Threshold (MT/yr)						3,000
South Coast Air Quality Management District						10,000

[1] Biological derived = $Bio\text{-}CO_2$, Anthropogenic manmade CO_2 = $NBio\text{-}CO_2$.

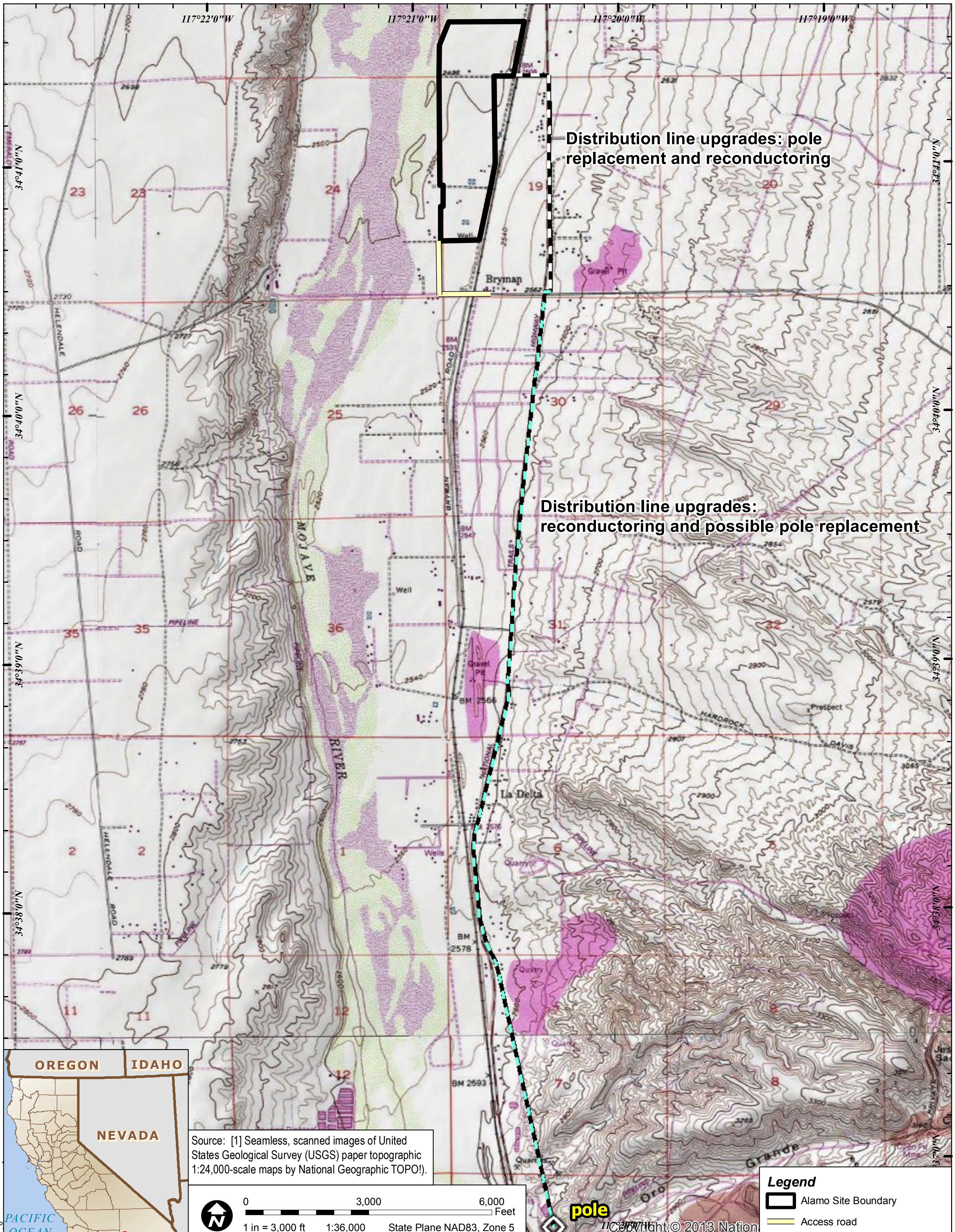
[2] Includes Global Warming Potential (GWP) for CH4 and N2O.

[3] Estimated construction emissions divided by project life.

[4] Operational is conservative based on conservative water usage.

[5] Assumed based on scaling of other solar projects and standard leakage rate.

FIGURES



URS | e·on | E.ON Climate & Renewables North America San Bernardino County | **Figure 1a.** Alamo Solar Project Topographic Map | 2013

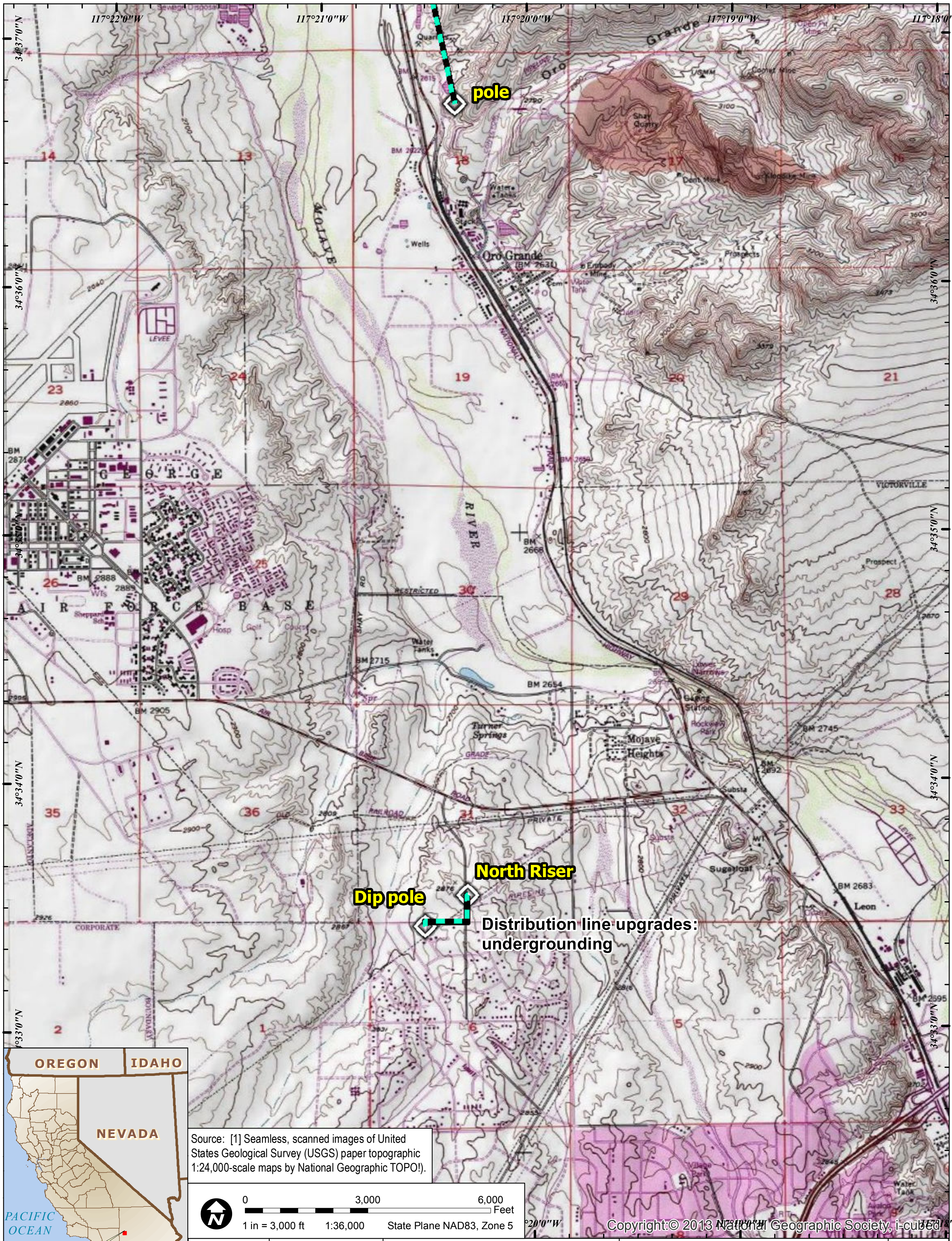


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Figure 1b. Alamo Solar Project
Topographic Map

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