4.0 Project Alternatives

This section discusses alternatives to the Palmdale Hybrid Power Project as proposed in this AFC. Alternatives addressed include “No Project”, alternative plant sites, alternative linear facilities routes, plant design alternatives, and alternative power generation technologies. The alternatives are evaluated in their relationship to environmental, technological, public policy and economic considerations. Additionally, the alternatives are evaluated to their relationship with the Project objectives. Project objectives are summarized as follows:

- Provide an efficient, reliable and environmentally sound power generating facility to meet future electrical power needs of the rapidly growing City of Palmdale and surrounding areas, as well as provide additional generating capacity for the region and California.
- Locate the facility within the boundaries of the City of Palmdale and under City ownership and control. The City can, thereby, increase its level of assurance that residential, commercial, and industrial power needs in the City can be met, while at the same time supplying power to the regional grid.
- Use solar technology to generate a portion of the facility’s power output and thereby support the State of California’s goal of increasing the percentage of renewable energy in the state’s electricity mix.
- Integrate the solar component of the Project and its combined-cycle component in a way that maximizes the synergies between the two technologies to increase Project efficiency. The PHPP will send steam (generated from the solar thermal Project component) to the HRSG that is part of the “conventional” combined-cycle equipment. This allows the Project to operate with only one steam turbine generator (STG) rather than separate STGs for the Project’s combined-cycle and solar components.
- Site the facility in a location zoned and planned for industrial use in an industrial area and with ready access both to adequate supplies of non-potable water to meet the facility’s process water needs and to a natural gas pipeline that can supply the Project, without requiring significant modifications to the regional gas supply system.

4.1 No Project Alternative

Under the “No Project” alternative, the PHPP would not be constructed and the electrical power that would have been generated will be generated by other facilities. Because the Project facilities would not exist, its environmental impacts would be entirely avoided. However, the No Project alternative will not contribute toward ensuring adequate electrical supplies for Palmdale and for California as a whole.

The State of California established the Renewable Portfolio Standard (RPS) Program. The goal of the RPS program is to increase the amount of renewable energy in the state’s electrical energy mix to 20 percent by 2017. The 2003 Energy Report recommended accelerating the renewables goal of 20 percent to 2010. The 2004 Energy Report and the state’s 2005 Energy Action Plan recommended increasing the target

percentage to 33 percent by 2020. The 2006 Energy Report Update noted that "California must accelerate its pace of development to meet its long-term Renewable Portfolio Standard Goal of generating 33 percent of the state's electricity from renewable sources by 2020, as recommended by Governor Schwarzenegger, the California Energy Commission and the California Public Utilities Commission." (CEC, 2006). The 2007 Integrated Energy Policy Report (IEPR) cites the "critical imperative to reduce greenhouse gas emissions" and "management of the risk borne by ratepayers for electricity generation" as the two primary considerations driving the need to attain the RPS goals. The IEPR states the goal of 33 percent renewables by 2020 is achievable "with a concerted effort by coordinated support from government, industry and the public." (CEC, 2007)

The proposed Project will use state-of-the art combined-cycle generating technology, incorporate advanced emission controls, zero liquid discharge (ZLD), and other measures to minimize environmental impacts. The Project will also generate part of its output using environmentally friendly and renewable solar technology. Thus, electrical power generated by existing and/or newly constructed facilities, other than the PHPP, will likely have impacts equal to or greater than the PHPP. Therefore, the impacts of the No Project alternative would be similar or greater than those of the PHPP.

In addition to the overall statewide situation, the SCE load area faces future difficulties in serving load due to insufficient import capability combined with insufficient local generating capacity. The PHPP is among the resources that can supply locally generated power to SCE. By combining combined-cycle generated base load power with renewable solar technology, the PHPP represents a dispatchable-renewable source. In short, the Project will provide competitively priced electrical power to help meet California's growing demand. It also will help replace older and more polluting generation resources that are retiring or being phased out due to emission restrictions and will provide needed renewable energy to the region.

In summary, the No Project alternative does not serve the growing needs of residents and businesses in Palmdale, Southern California or the State of California for efficient, reliable and environmentally sound power generation resources. The No Project Alternative fails to meet the basic Project objectives described above. As a result, the No Project Alternative was rejected in favor of the proposed Project.

4.2 Project Site Alternatives

To meet the above stated project objectives established for the PHPP requires an available site that meets the following criteria:

- Within the City of Palmdale boundaries in an area with existing and planned industrial development and where the power plant is a compatible land use.
- Within the City of Palmdale in order to maximize benefits to the City as the Project owner in terms of tax base, jobs; local purchases of materials, supplies, services and control of electrical generation.
- Sufficiently large (approximately 350-400 acres) and largely flat, so the site can accommodate a 250-acre solar array field capable of generating approximately 50 MW, along with combined -cycle generating equipment, support facilities, and access road yielding an overall 570 MW generating facility.

- Within an area with a high level of insolation (amount of solar energy potentially available), allowing for a high renewable energy contribution per acre and thus reducing the amount of acreage needed and associated impacts.
- Largely undeveloped to minimize the need to relocate residents or disrupt other current land uses.
- In reasonable proximity to a natural gas supply pipeline with adequate capacity to supply the facility.
- In reasonable proximity to high voltage transmission lines that connect to the Southern California grid.
- In reasonable proximity to a source (wastewater treatment plant) with available non-potable water of adequate quantity and quality that can be used to meet power plant cooling and process water needs.
- In reasonable proximity to available reliable backup cooling source in case of outages in the primary cooling water supply system.

4.2.1 Alternative Power Generation Sites

In applying the above listed criteria for selecting a site for the Project, two alternative site locations were identified and investigated, prior to selecting the site described in Section 2. These two sites are shown on Figure 4-1.

Alternative Site 1 is located adjacent to the Palmdale Water Reclamation Plant on E Ave P south and east of the proposed site. While this site had the advantages of being adjacent to the reclaimed water source and being owned by a public agency, ultimately it was rejected because the available acreage was too small to allow a meaningful solar component to be included. The 150 acres available for solar facilities would yield a maximum of only 30 MW of solar which was considered insufficient (the proposed 50 MW of solar is the optimum fit from the standpoint of Project design).

Alternative Site 2 is located on the south side of W Ave M a short distance west of Sierra Highway. This site had the advantage of being large enough for the 50 MW solar field (which requires 250 acres minimum), but it had several disadvantages that ultimately led to its rejection. The site is composed of multiple, privately owned parcels and the City decided that the land acquisition process would prove problematic. Also, the site was bisected by a major intermittent streambed, one that regularly filled with water during rainstorms. The landform modifications that would be needed and the associated potential engineering and environmental issues that likely would be encountered were another reason for rejecting the site.

As noted in the Project Description, the proposed PHPP plant site is on a 600-acre parcel owned by the City of Palmdale. The City considered an alternative placement for the plant in the south of the 600-acre parcel before selecting the proposed location in the easternmost portion. Ultimately, the City decided that maintaining the opportunity for access to the Air Force Plant 42 airfield from the proposed parcel was a better use of the land, and this access would have been cut off if the southern portion was selected for the power plant.

In summary, a careful review of alternative sites showed that none of them satisfied the Project objectives described above, without potentially resulting in adverse environmental or economic impacts compared to the proposed site. As a result, the alternative sites were rejected in favor or the proposed site.

4.2.2 Linear Facilities Route Alternatives

The following paragraphs summarize the various linear facilities route alternatives considered and why they were rejected as unsuitable/inferior to the proposed route(s).

4.2.2.1 Reclaimed Water, Backup Cooling/Process Water, Potable Water and Sanitary Wastewater Pipeline Route Alternatives

A primary objective of the PHPP is to utilize reclaimed water for cooling and process needs, which would require a pipeline between the plant site and the Palmdale Water Reclamation Plant (PWRP), which is the closest available source of reclaimed water. The route proposed between the plant site and the PWRP essentially is the most direct available route between the two locations. Alternatives to this route would be longer, and potentially inconsistent with the Projects goal of minimizing the potential for environmental impacts. An alternative route was not considered.

The Project's potable water source is essentially located on the plant site's northern boundary and no alternative route was considered. The Project's sanitary wastewater pipeline follows the shortest possible route to an interconnection point with a suitable larger sewer line. As the shortest most direct route, it is consistent with the goal of minimizing potential impacts and an alternative route was not considered.

In summary, the water supply and wastewater pipeline routes were selected to minimize potential environmental impacts and no environmentally superior alternatives were identified.

4.2.2.2 Natural Gas Supply Pipeline Route Alternatives

As described in Section 2.0, Project Description, the Project will connect with an existing SCG gas supply pipeline via a new pipeline in City street ROWs extending approximately 8.7 miles to the PHPP plant site. As shown on Figure 4-1, the Project considered obtaining gas via an approximately 37-mile connection to the Kern River Gas pipeline, located north of the City of Palmdale near State Route 58. However; this much longer alternative route posed greater potential for impacts to natural resources. For this reason, this alternative was rejected. SCG also offered for consideration a gas pipeline route that traversed less developed and more potentially environmentally sensitive areas. For this reason, this alternative route was rejected.

4.2.2.3 Transmission Line Route Alternatives

From the standpoint of best serving the needs of the City, region and State, it is necessary that capacity from the PHPP be delivered to the Vincent 500/230-kV Substation, which is interconnected with the regional transmission system.

In order to accommodate the needs of Palmdale's existing and future aviation industry, the most direct route from the plant site to the Vincent Substation was rejected. This route along Sierra Highway (see Figure 4-1) would have conflicted with Air Force Plant 42's flight operations. The Project had discussions with Southern California Edison (SCE) regarding the possibility of under-grounding the lines in the vicinity of the runway, but SCE would not accept ownership of underground high voltage circuits. For these reasons, this alternative route was abandoned.

The Project considered a route that went south on 10th St. W, which also has several transmission lines of various voltages. This route would have been able to both satisfy aviation concerns and help consolidate existing transmission infrastructure. However, 10th St. W is one of the City of Palmdale's busiest retail areas and there were ownership issues in utilizing the existing transmission infrastructure. Due to the possible prolonged disruption to City residents and businesses (construction in a congested retail area), and uncertainties regarding possible use of existing infrastructure, this alternative was abandoned.

The Project considered a southerly path between Sierra Highway and 10th St. W. This route would be located sufficiently west of Plant 42 runway, so as to not be a hazard and east of 10th Street, so as to not disrupt Palmdale commerce. The route considered was along Division Street (see Figure 4-1), which avoided both Plant 42 and Palmdale's primary retail centers. However, as the route proceeded south, while it avoided existing neighborhoods, it passed near an elementary school. Although the route would maintain the minimum prescribed distance from the school, the Project applied a more conservative distance-criterion and subsequently abandoned this route.

Having eliminated the westerly transmission line route options, easterly routes were analyzed. Using the same criteria of avoiding existing or future aviation efforts, the easterly route needed to be far enough east to avoid existing airport operations and possible future expansion, a criterion the proposed route satisfied. In the southern portions of the route the Project chose to avoid existing residential areas and to enter the SCE transmission ROW at the Pearblossom Substation.

In short, the proposed route meets the Project objectives, while minimizing impacts to the City and the aviation community. The alternative routes considered all posed greater potential for impacts to the City and the aviation community, did not provide significant environmental advantages compared to the proposed route, and thus were rejected.

4.3 Power Generation Facility Design Alternatives

The following subsections address alternatives considered for several aspects of the proposed design of the power generation facility. These include alternative heat rejection (cooling) technologies, alternative approaches for disposing of non-sanitary wastewater generated by the proposed facilities, and alternative water supply sources.

4.3.1 Cooling Technology Alternatives

As proposed, the Palmdale Hybrid Power combined-cycle power generating equipment will utilize wet cooling technology, using reclaimed water obtained from the nearby Palmdale Water Reclamation Plant. Two other cooling technology approaches were considered -- dry cooling and a wet/dry hybrid cooling system. The following paragraphs summarize and compare these alternatives.

4.3.1.1 Description of Cooling Technologies

Wet Cooling

Wet cooling uses circulating water to condense turbine-generator exhaust steam in a shell and tube heat exchanger (condenser). Cool circulating water enters the tube side of the condenser where it is warmed by the shell-side steam, causing the steam to condense such that condensate pumps may return it to the boiler

feed water system. The warm circulating water then travels to a wet mechanical draft cooling tower. The cooling tower dissipates heat through circulating water evaporation and contact with ambient air. Once cooled, the circulating water is returned to the condenser to complete the cooling circuit.

Dry Cooling

Dry cooling technology uses an air cooled condenser (ACC), which cools the steam turbine-generator exhaust steam using a large array of fans that force air over finned tube heat exchangers. The exhaust from the steam turbine flows through a large diameter duct to the ACC where it is condensed inside the tubes through indirect contact with the ambient air. The heat is then rejected directly to the atmosphere.

Wet-Dry Hybrid Cooling

The wet-dry hybrid cooling approach involves the use of a combination of both wet and dry cooling technologies in parallel. Wet-dry hybrid cooling uses all of the equipment involved in both wet and dry cooling. As in a purely wet cooling system, cool water is circulated in a shell and tube heat exchanger to condense the turbine exhaust steam and then a cooling tower is used to dissipate the heat in the warmed water. As in a purely dry cooling system, the steam turbine-generator exhaust steam uses an air-cooled condenser, with a large array of fans to force air over finned tube heat exchangers and the steam is condensed through indirect contact with the ambient air. Wet-Dry Hybrid cooling technology divides the cooling function between the wet and dry systems, depending on the capabilities of each system under different environmental and operational conditions.

4.3.1.2 Comparison of Cooling Alternatives

A comparison of the proposed wet cooling approach to dry cooling and hybrid cooling is provided below. Differences between wet and dry cooling and a comparison of their advantages and disadvantages for the PHPP are presented below.

Comparison of Wet to Dry Cooling

Wet cooling technology has clear performance advantages over dry cooling for the PHPP. Performance is enhanced because wet cooling relies primarily upon evaporation to remove heat from the circulating water. Since evaporation occurs at the wet bulb temperature (the air temperature at 100 percent humidity), wet cooling achieves lower circulating water supply temperatures than dry cooling, which is unable to operate below dry bulb temperatures (ambient air temperature). Dry bulb temperatures are generally much higher than wet bulb temperatures (especially in arid regions such as the High Desert). As the dry bulb temperature increases and humidity decreases, the dry cooling system becomes less efficient as a heat rejection method. This is the reason wet cooling systems are more efficient than dry cooling systems in areas with low humidity, as is the case at the Project site. Also, the decreased efficiency of a dry cooling system at the PHPP site would be most noticeable in the hot summer months when power demand is highest.

The lower circulating water temperatures of wet cooling systems result in a significant improvement in cycle performance. Lower temperatures result in lower steam turbine generator (STG) backpressures, which increase the STG's generation efficiency. Conversely, the requirement to operate at the higher temperatures and higher STG backpressures associated with dry cooling would adversely affect the power

output of the Project. Kiewit Power Engineers (KPE), designers of the PHPP, estimated the gross power output of the Project combined-cycle equipment would be four percent lower on a hot day with dry cooling than with wet cooling (KPE, 2008).

A wet cooling tower is physically smaller than an ACC, because water is more efficient as a heat exchange medium than air. Dry cooling requires much more surface area and very high flow rates of air to remove the same amount of heat as a wet cooling system. An ACC does not require cooling water circulating pumps and piping, as needed for a wet tower. An ACC also requires a smaller water treatment system (a small wet cooling system is needed for cooling other plant equipment even if a dry cooling tower is used for the Project).

Capital costs are estimated to be lower for a wet cooling tower than an ACC. Capital costs are estimated by KPE at approximately $26 million for a PHPP wet tower and approximately $59 million for an ACC. A lower cost ACC could be used, but this would require a different STG than is planned for use at the Project. Investigation revealed that an STG of the required size and capable of operating at the required backpressure is not currently available and thus a lower cost ACC was not considered in the cost comparison.

Wet cooling operating costs include the cost of purchasing makeup cooling water (not needed for dry cooling), higher water treatment chemical needs (and associated costs), and higher power requirements (and costs) for circulating pumps and water treatment activities. However, wet cooling systems require less fan horsepower (and associated costs) than dry cooling. Further, dry cooling would exact a 4 percent efficiency penalty. This lower efficiency equates to lower operating revenues (i.e., in effect lower revenues can be considered the same as greater operating costs for this evaluation). Table 4.-1 shows the estimated net power effects of wet and dry-cooled systems at Palmdale Hybrid Power Project. Table 4-1 also shows the estimated operating cost differences considering the net power effects and other items mentioned above (e.g., makeup cooling water purchase).

As shown in Table 4-1 are the net power loss effects of dry cooling for the Project. They are estimated to be about 1,240 kW greater than with the proposed wet cooling (14,042 kW for dry cooling and 12,798 kW for wet cooling). As also shown in Table 4-1, operating costs are estimated to be about $400,000 per year greater for a dry cooled plant, than for the proposed wet cooled PHPP.

There are a number of environmental factors that are relevant to the comparison of wet and dry cooling systems for the Project. An ACC for the PHPP is estimated to be approximately 117 feet tall and occupy over 91,000 plus square feet. The proposed wet tower will be 62 feet tall and occupy less than 32,000 square feet. Because it is larger, the dry cooling tower would be more visible and have greater impacts on visual resources. However, the wet cooling tower will occasionally produce a visible plume. It should be noted that visible plumes are expected to occur infrequently at Palmdale (only in winter months and primarily during nighttime hours when the plume's visible impacts would be less noticeable), and thus do not represent a significant impact (see AFC Sections 5.13, Traffic and Transportation and Section 5.15, Visual Resources).

Table 4-1 Net Power Effects and Annual Operating Cost Comparison
Wet Cooling v. Dry Cooling at the Palmdale Hybrid Power Project
(Average Design Case: 2 CTGs at 100%, Solar with partial firing, 77F, 13.23psia, 40% RH)

Item	Wet Cooling Tower	ACC
Fan Power	1,700 kW	6,530 kW
Circulating Pump Power	2,400 kW	0 kW
Power Loss Due to High STG Backpressure (wet cooling is assumed as base performance, dry cooling is expressed as a differential from this value)	0 kW	536 kW
Reclaim water supply and ZLD water treatment power consumption	850 kW	<200kW
Total Net Power Loss Effects	12,798 kW	14,042 kW
Equivalent Electrical Power Cost[1]	$16,816,572	$18,451,188
Treatment Chemical Addition[2]	$250,000	$0
Make-up Cooling Water[3]	$1,050,000	Less than $100,000
Total $/year	$18,116,572	$18,551,188

Source: KPE, 2008

[1] Operating Costs are based on 2 CTGs operating at 100%, Solar with partial firing, temperature 77F, with facility assumed to be operating 24 hrs day x 365 days/ year, and annualized costs ($/year) based on a value of $0.15/kWH

[2] It is assumed that water treatment chemicals would be needed in a wet tower to prevent corrosion, bio-fouling, etc., but would not be needed for an ACC.

[3] Estimated at $200/acre-foot

A dry cooling system has less direct emissions than a wet tower, because it does not have the drift emissions of a wet tower (emissions of fine entrained droplets that contain dissolved solids that evaporate and form fine particles). However, the lower efficiency of a dry-cooled PHPP would lead to significantly greater stack emissions to produce the same amount of electrical power, because a dry-cooled plant will have to fire the combustion turbines or duct burners harder to achieve the same output. The estimated four percent lower efficiency on hot days of a dry cooled PHPP would equate to approximately four percent higher stack emission levels for the same output as a wet cooled plant.

The proposed wet cooling tower allows for the condenser to be evacuated and steam seals established quickly for facility start-up. The higher internal volume of a dry cooling tower increases the evacuation time, even with the use of larger vacuum pumps, which could mean a longer start-up time. A longer start-up time will result in higher level of start-up emissions.

Finally, because a dry cooling system requires larger and more powerful fans than a wet system, an ACC would produce greater noise emissions. However, because the plant site is in an industrial area with minimal noise sensitive receptors, significant noise would not be expected with either a wet cooling or dry cooling system for the Project.

The primary disadvantage of wet cooling (and advantage of an ACC) is water consumption. Since wet cooling relies upon evaporation as the primary mode of heat rejection, water consumption is higher. Because an ACC does not rely upon evaporation for heat transfer, cooling water supply, treatment and disposal are not issues of concern. However, since the Project will use reclaimed water from the Palmdale Water Reclamation Plant, the Project will not affect the availability of potable water supplies for other uses in the arid southern California desert.

Comparison of Wet to Hybrid Cooling

Hybrid cooling combines the advantages and disadvantages of both wet and dry systems. While hybrid cooling consumes water, it consumes less water than pure wet cooling. Estimates for the PHPP are that cooling water requirements are approximately half as much for a hybrid cooling system than for a wet cooling system. However, capital costs for a hybrid wet-dry cooling system for the Project are substantially higher than for either a wet system or a dry system. A wet-dry hybrid system is estimated to cost approximately $67 million for the Project, compared to $26 million for a wet tower and $59 million for an ACC.

A PHPP with a wet-dry hybrid cooling system would have roughly half the performance loss as a dry-cooled plant. On a hot day, a 5.1% power reduction would be observed compared to the wet cooling tower value of 3.6% as a percentage of gross power. In terms of in-plant energy consumption (fans, circulating pumps, etc.), the hybrid would fall below both the wet and dry options. When considering the net power effects (efficiency loss, fan and pump power, etc.), as well as the difference in the amount of makeup cooling water needed for a hybrid cooling system, the operating costs for a wet-dry hybrid cooling system for the Project would be less than the dry-cooled system and a wet cooling system. Operating costs for wet-dry hybrid system would be about $17 million/year compared to $18 million/year for a wet system.

The lower level of efficiency of a hybrid-cooled plant results in the same emissions issues as the dry-cooled plant. The lower efficiency translates into comparably higher emission levels for the same level of power output than a wet-cooled plant. In terms of cooling tower drift, water treatment and circulating water systems size and noise emissions, the wet-dry hybrid system lies between the purely wet cooling and dry cooling systems.

During the summer months, hybrid cooling relies primarily on the wet portion of the system. Because wet cooling is more efficient than dry cooling, its use in the summer achieves substantially improved plant performance at the time of year when the demand for power is greatest. In the winter months, hybrid cooling relies primarily on dry cooling, which conserves water compared to a wet cooling tower.

The availability of an ample source of reclaimed water in close proximity to the site renders less important the benefits of decreased water use with dry or hybrid cooling, which is the primary advantage of these approaches compared to the proposed wet cooling. In summary, after careful evaluation, wet cooling was selected for the PHPP over dry or hybrid wet-dry cooling because wet cooling offers:

- lower capital costs
- comparable operating costs
- greater efficiency (better performance in terms of power output)
- lower emissions for comparable power output

- smaller (less visually intrusive)
- less noisy equipment than either the dry or hybrid cooling alternatives

4.3.2 Wastewater Disposal Alternatives

Three alternative approaches were evaluated for the treatment of power plant cooling water blowdown, which is concentrated brine resulting from several cycles of reuse of cooling water in the Project's cooling system.

- Crystallizer,
- Evaporation ponds, and
- Brine return (returning the cooling tower blowdown via pipeline, to the source, the Palmdale Water Reclamation Plant).

Evaporation ponds and a crystallizer both remove water from the cooling water waste stream in order to concentrate the stream and produce a dry solid waste product for transport off-site by trucks to an appropriately permitted disposal facility. The evaporation ponds accomplish this by using solar energy to evaporate the water to the atmosphere. The crystallizer uses an external heat source (e.g., steam or electricity) to evaporate the water. With a crystallizer, the water removal and crystallization process occurs in a closed vessel, with the only outputs being dry salt crystals. These crystals are continuously removed and stored in covered containers prior to off-site disposal and the water which is sufficiently pure is reintroduced as make-up water in the power plant cooling system. The evaporation ponds produce only dry salt crystals, i.e., there is no water produced.

The evaporation ponds require no energy input (other than solar energy), but the process is slow (weeks or perhaps months from the time the waste is generated and introduced into the ponds until it is ready for off-site transport). The ponds thus expose the cooling water and precipitated solids to the environment for a period of time. Groundwater monitoring would be required for possible contamination from the ponds. Fencing and/or other measures also would be required to keep out the wildlife, including birds.

The crystallizer requires an external energy source, but the process is much faster than evaporation ponds (hours rather than weeks or months before the solids are ready for off-site transport). Because the crystallization process occurs in a closed vessel, there is no exposure of waste materials to the environment. Therefore, no groundwater monitoring or wildlife barriers are required. The crystallizer also requires less land than evaporation ponds. Although the crystallizer uses heat from the power plant, the reduction in plant energy output is expected to be a small fraction of one percent (approximately 0.15 percent) of the net plant output.

No significant environmental issues have been identified for the crystallizer option. Both approaches involve additional air emissions and potential traffic impacts from the truck transport of solids to an off-site disposal site. These issues are not considered significant (See Section 5.13, Traffic and Transportation). Although the pond materials are not expected to lead to vegetation growth or serve as a food source, there is the potential for wildlife exposure. Although no specific effects on different species have been evaluated, some potential impacts to biological resources might exist with the evaporation ponds, whereas there would be no potential wildlife exposure and no impact potential with the crystallizer. Evaporation ponds have the potential to affect groundwater, whereas a crystallizer does not.

The various environmental and regulatory issues associated with evaporation ponds can be managed to avoid significant impacts and achieve compliance (e.g., installation of an impervious liner, design to avoid releases by overtopping during precipitation events, wildlife fencing, ongoing groundwater monitoring, and dust control measures during solids removal for off-site disposal). However, environmental protection and regulatory compliance is easier to achieve and maintain with the crystallizer option.

This option is consistent with the Project's goal of minimizing potential biological and cultural impacts. Additionally, regulatory compliance is more simply demonstrated with the crystallizer. Therefore, the crystallizer is preferred over evaporation ponds for the PHPP.

The brine return option was explored with the Palmdale Water Reclamation Plant (PWRP). The brine return option requires the installation of a brine return pipeline from the power plant to the treatment plant. The impacts of the additional line are minimal, because it only requires installing an additional pipeline in the same right-of-way and trench as the reclaimed water supply line. However, the amount and quality of the brine solution to be sent from the PHPP is outside of the design basis for the PWRP. Therefore, the brine return option does not offer environmental or technical advantages compared to a crystallizer at the Project and thus, brine return is not considered preferable to the proposed on-site crystallizer.

4.3.3 Cooling Water Supply Alternatives

To supply the amounts of water needed for wet cooling of the Project (a maximum of approximately 3.5 million gallons per day) only reclaimed water was studied. The Project eliminated the options of potable water, State Water Project water and groundwater, as conflicting with the Project's desire to minimize potential biological impacts. From a technical perspective, there is no inherent reason that water from sources other than reclaimed water from a wastewater treatment plant could not be used for power plant cooling. However, State water policy (State Water Resources Control Board Resolution 75-58), encourages the use of reclaimed wastewater for power plant cooling and notes that the use of fresh inland waters for power plant cooling should be approved "only when it is demonstrated that the use of other water supply sources or other methods of cooling would be environmentally undesirable or economically unsound" (SWRCB, 1975). Similarly, as quoted in an April 2006 CEC staff analysis for a different power generating facility, the CEC's 2003 Integrated Energy Policy Report presents State Water Policy as based on Resolution 75-58, and states that "the California Energy Commission will approve the use of fresh water for cooling purposes by power plants which it licenses only where alternative water supply sources and alternative cooling technologies are shown to be 'environmentally undesirable' or 'economically unsound" (CEC, 2006). In terms of the State policy expressed above, the use of reclaimed water as the primary source for Project cooling is considered preferable to the use of State Water Project or other potable water.

Given State policy discouraging the use of non-reclaimed water for power plant cooling and the Project's access to a reclaimed water source, the Project did not study non-reclaimed water sources.

4.4 Power Generation Technology Alternatives

The proposed Palmdale Hybrid Power Project will generate power by using natural gas-fired, combined cycle technology integrated with an array of solar thermal collectors. Conventional combined cycle technology involves the combined use of combustion turbines and steam turbines to achieve higher efficiencies than either type of turbine can achieve separately. The combustion turbine drives a generator

and the high-temperature exhaust from the combustion turbine is routed through a heat recovery steam generator (HRSG) to produce high-pressure steam to drive a steam turbine generator. The Palmdale Hybrid Power Project will use the heat collected from the solar thermal array to generate saturated steam that will be routed to the same HRSGs that receive the combustion turbine exhaust. The above steam along with the high-pressure steam from the HRSGs will be used to drive the site's single steam turbine generator.

The combined-cycle power equipment can achieve efficiencies of up to about 52 percent, which is much more efficient than a combustion turbine alone or a steam turbine alone. This higher efficiency results in lower fuel usage and lower air emissions per kilowatt-hour of output than either a stand alone combustion turbine (simple cycle) or steam turbine (steam cycle). Combined cycle technology has been selected for most large power plants being developed in California in recent years.

4.4.1 Conventional Simple Cycle

Simple cycle technology uses a combustion turbine to drive a generator. The high temperature exhaust is released directly to the atmosphere, rather than being routed to a HRSG and steam turbine generator, as is the case with combined cycle technology. Although simple cycle combustion turbines have relatively low capital cost and rapid startup capability, the technology is relatively inefficient (maximum of up to approximately 38 percent). Simple cycle equipment also produces more air emissions than more efficient technologies, because the high exhaust temperature makes it difficult to add post-combustion emission control equipment and because more fuel must be burned to generate a given amount of electrical power. Conventional simple cycle was eliminated from consideration because of its relatively low efficiency and environmental (emissions) shortcomings.

4.4.2 Combined-Cycle with and without Solar

Combined-cycle technology can be used with solar thermal technology (i.e., the proposed Project) or without solar. However, without the solar component, the facility will have higher fuel usage to achieve the same level of power output as the proposed hybrid combined cycle-solar thermal facility. The higher fuel usage also results in higher emission levels for the same power output than the proposed hybrid plant. Compared to a hybrid facility, a conventional combined-cycle power plant does not support California's Renewable Portfolio Standard program goal of substantially increasing the amount of renewable energy in the state's electricity supply mix over the coming years.

The proposed hybrid will take advantage of a synergy between solar thermal and combined-cycle technologies that will only be possible in a single facility that integrates both. Both technologies utilize steam turbines and combining the two technologies in one facility allows use of a single steam turbine to serve both the solar and combined-cycle elements of the Project.

The proposed hybrid PHPP will have an environmental and economic advantage over a conventional combined-cycle facility at times of "super peak" demand, i.e., the hottest summer days. This is because the Project can meet the super peak load without burning any additional natural gas (duct burning) and the highest demand days are the times when the price of gas is the highest. Typically, peak demands for electricity require operating all plants in the regional system, including the older facilities, which are expensive to operate and have the highest emissions.

In summary, combined cycle-solar hybrid is considered preferable to the combined cycle without solar because the Hybrid has:

- Lower fossil fuel consumption
- Lower emission levels for the same output
- Supports the California Renewable Energy Goals for electrical generation
- Takes advantage of the solar energy resource available in the City of Palmdale
- Takes advantage of the opportunity for synergy available by having a single steam turbine able to serve both elements of the Project
- Takes advantage of the environmental and economic conditions associated with meeting the highest demand periods on the hottest summer days without needing to burn additional natural gas

4.4.3 Advanced Combustion Turbine Cycles and Combustion Turbine Equipment

There are a number of advanced combustion turbine technologies that are intended to enhance the thermal efficiency of combustion turbines. These include the steam-injected gas turbine (STIG) cycle, the intercooled-steam recuperated gas turbine (ISGRT) cycle, the chemically recuperated gas turbine (CRGT) cycle, and the humid air turbine (HAT) cycle. The STIG is commercially available, but it is less efficient (maximum of up to about 40 percent) than conventional combined cycle and produces more air pollutant emissions. None of the other technologies (ISRGT, CRGT, and HAT) are commercially tested. For these reasons, the various advanced combustion turbine cycle options were eliminated from consideration and were not studied.

There is a next generation of turbines (referred to as the “H” turbines) that operate at higher firing temperatures than the “F” class and have additional features to increase output and enhance efficiency somewhat. The “F” turbines represent proven technology with proven emission levels that have seen extensive commercial operation at numerous facilities. In contrast, the “H” turbines do not have well demonstrated environmental performance and operating efficiencies in commercial use. The greater environmental performance and operational efficiency-related uncertainties associated with the “H” turbines compared to the “F” turbines were the reasons the “F” class turbines were selected over the “H” class turbines for the Palmdale Hybrid Power Project.

4.4.4 Integrated Gasification Combined Cycle (IGCC)

IGCC technology gasifies coal or petroleum coke that is burned in a gas turbine. The coal gasification equipment is located at the same site as the power generating equipment (combustion turbine, HRSG, and steam turbine). There is a lack of commercial operating experience with IGCC and its cost-effectiveness is uncertain. It also requires the importation by truck and/or rail of coal to the Palmdale area from outside California or of coke from petroleum refineries. Additional issues include increased traffic levels and on-site coal/coke storage, which require a larger site than a comparable conventional combined-cycle facility. Although IGCC can have lower emissions than conventional coal-fired power plants, an IGCC plant still has substantially more pollutant emissions than a gas-fired combined-cycle plant. For these reasons, IGCC was eliminated from consideration.

4.4.5 Coal or Other Solid Fuel Conventional Furnace/Boiler - Steam Turbine

With this technology, coal, petroleum coke, or other solid fuels are burned in a boiler, creating steam that is used in a steam turbine generator. The steam is then condensed and returned to the boiler. Efficiencies are estimated in the range of 35 to 40 percent, which is comparable to a gas-fired boiler/steam turbine unit, but less efficient than the proposed combined cycle technology. This technology requires importing by rail and/or truck coal from outside the state or coke from in-state petroleum refineries, which would increase traffic and also require on-site coal/coke storage. It also produces more emissions than a natural gas-fueled facility of equivalent size; requires a larger site and is more costly to build and operate. For these reasons, this technology was eliminated from consideration.

4.4.6 Fluidized Bed Combustion

Fluidized bed combustion burns coal or other solid fuels in a hot bed of limestone-containing inert material that is kept suspended or fluidized by a hot air stream. Water coils in the furnace create steam that drives a steam turbine generator. Fluidized bed technologies (atmospheric and pressurized) have efficiencies in the 35 to 45 percent range. Presently pressurized fluidized bed is not commercially available for the scale of the proposed PHP Project. As with the other solid fuel technologies, fluidized bed technology requires importing coal from outside the state or coke from petroleum refineries. It also requires a larger site and produces higher air emission levels per unit of power output than the same size natural gas fired facility. For these reasons, fluidized bed combustion was eliminated from consideration.

4.4.7 Nuclear

Nuclear fission is an established technology with years of demonstrated operating history. However, California law prohibits nuclear fission as an energy generation technology at present.

4.4.8 Other Renewable Technologies

Geothermal was eliminated from consideration because there is no geothermal resource in the City of Palmdale. Biomass fuels such as wood wastes were eliminated because they are not locally available in the City of Palmdale or surrounding area in sufficient quantities to make them a practical alternative fuel. Biomass facilities also can produce significant air emissions. For these reasons, biomass fuels were eliminated from consideration.

Wind energy involves the use of wind power to drive a rotor or propeller, which in turn, drives a generator. Wind energy equipment is large (in height) and has potentially significant visual impacts. There are limited sites where there is sufficient wind available for energy generation purposes. The Palmdale area is not identified as an important wind energy resource area in the Renewable Energy Atlas of the West (Nielsen et. al., 2006). For this reason wind technology was eliminated from consideration. Hydroelectric was eliminated from consideration because there is no hydroelectric resource in the City of Palmdale.

4.5 References

California Energy Commission (CEC), 2005. Integrated Energy Policy Report.

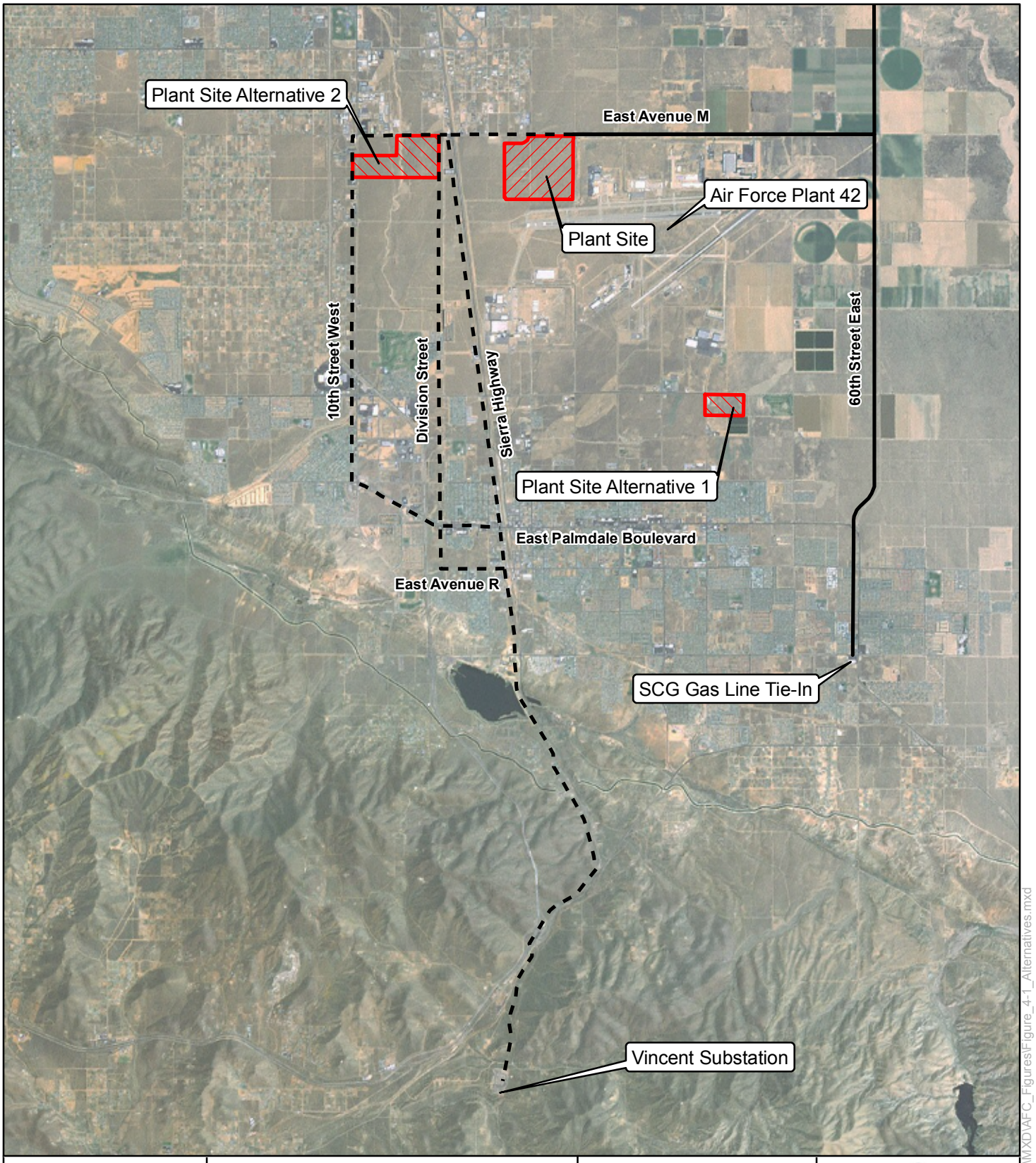
CEC, 2006. Palomar Energy Center. Final Staff Analysis of Proposed Modifications to Use Raw Water as a Backup Supply to Recycled Water. April 7.

CEC, 2007. Integrated Energy Policy Report.

Kiewit Power Engineers, 2008. Comparison between Wet Cooling Tower technology, Air Cooled Condenser Technology, and Hybrid Cooling Tower Technology at the Palmdale 2 Hybrid Power Project. June.

Nielsen, John, Susan Innis and Leslie Kaas Pollock at the Land and Water Fund of the Rockies; Heather Rhoads-Weaver and Angela Shutak at Northwest Sustainable Energy for Economic Development, 2006. Renewable Energy Atlas of the West. NREL ISBN 0-9721568-0-1.

State Water Resources Control Board, 1975. State Water Resources Control Board Resolution No. 75-58 Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Power Plant Cooling.



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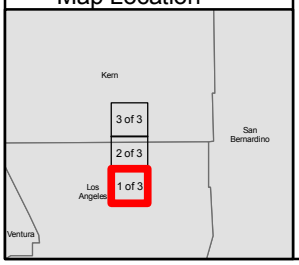

Legend

- Plant Site
- Plant Site Alternatives
- Natural Gas Supply Pipeline Route Alternatives
- Transmission Line Route Alternatives

N W E S

Palmdale Hybrid Power Project

Figure 4-1
Project Alternatives

Mapsheet 1 of 3

1:100,000

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PALMDALE
a place to call home

Inland Energy, Inc.

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Project: 10855-002
Date: July 2008

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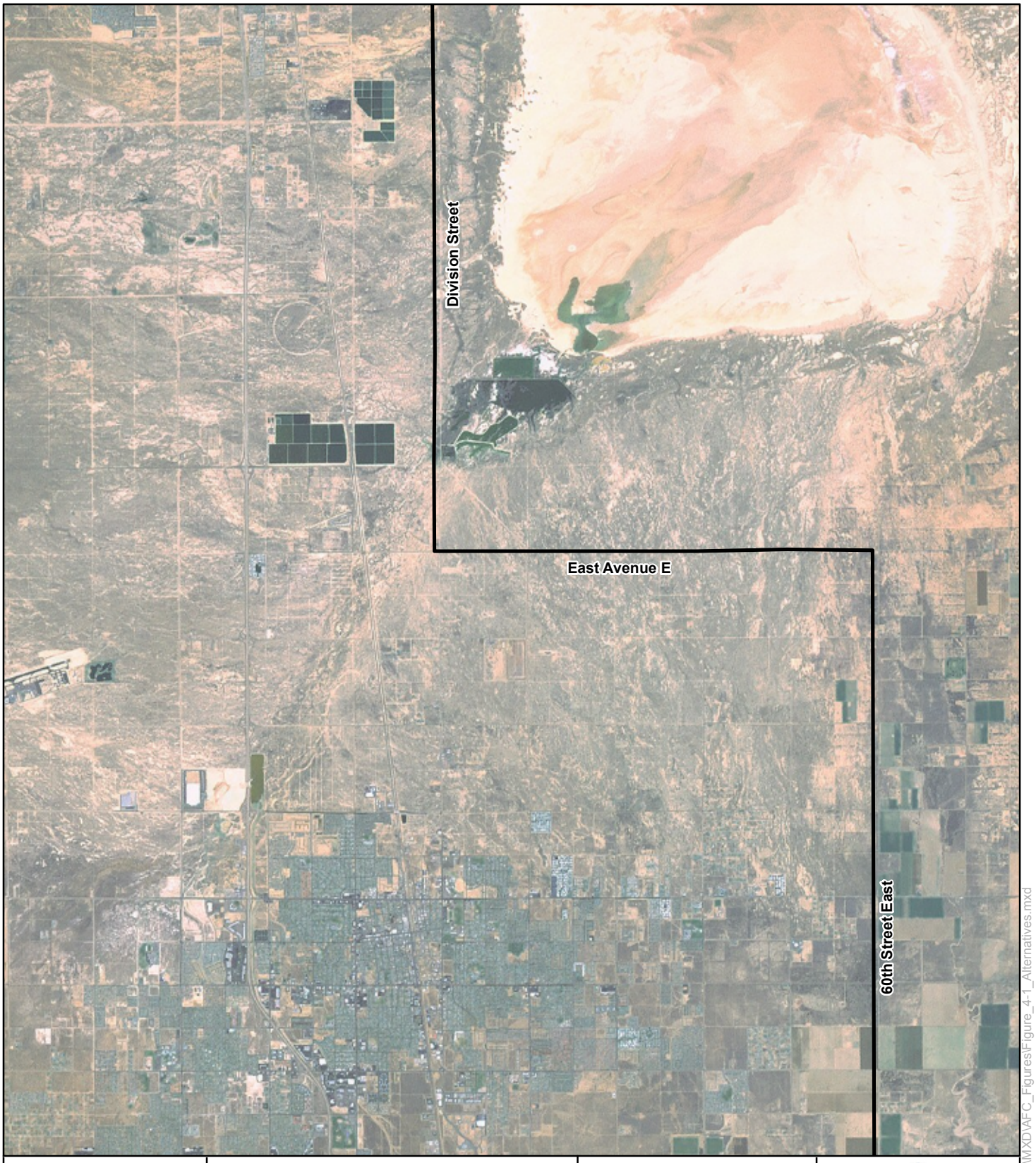

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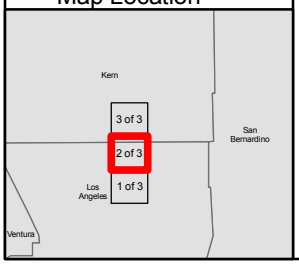

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Palmdale Hybrid Power Project

Figure 4-1
Project Alternatives

Mapsheet 2 of 3

1:100,000

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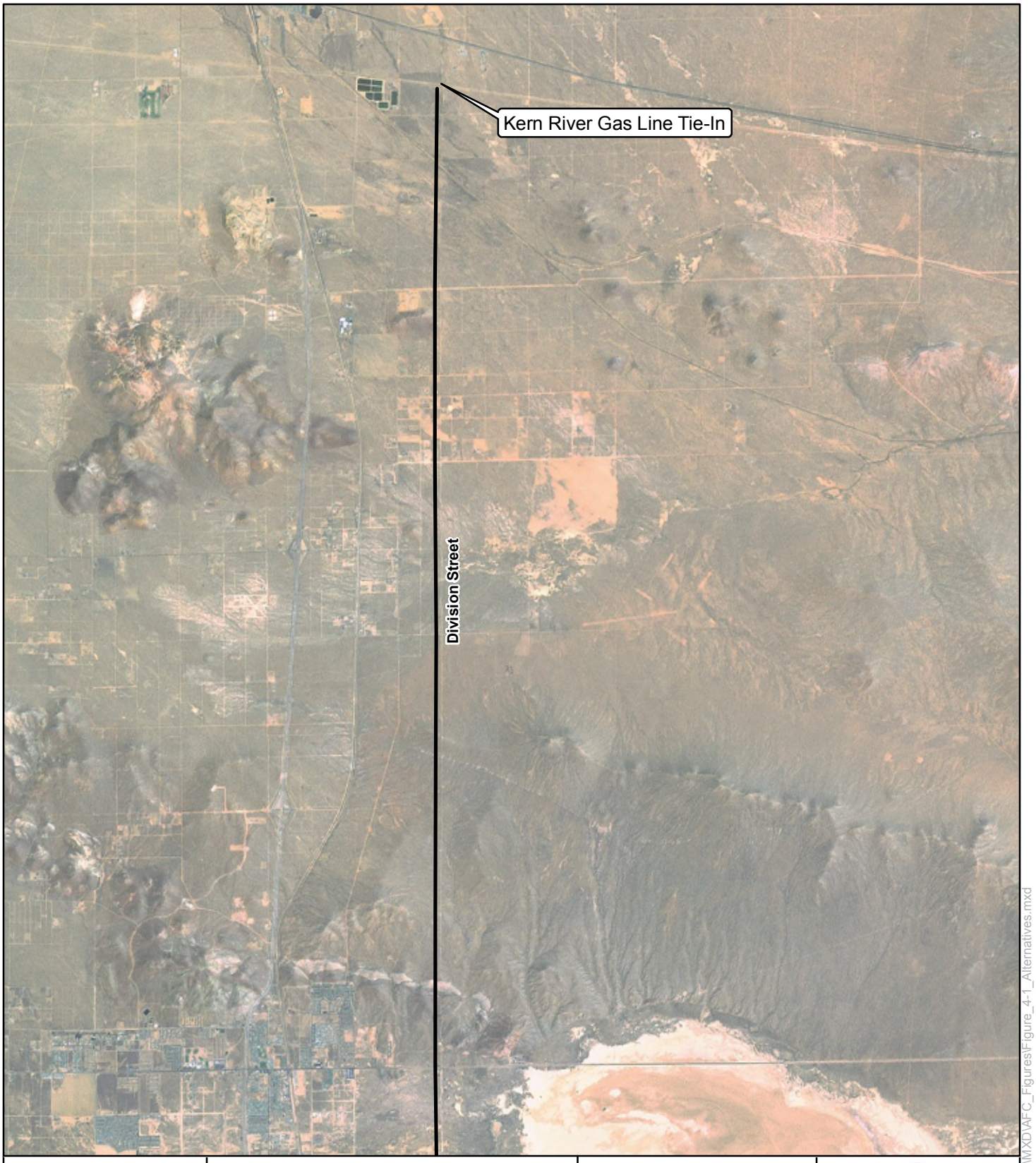

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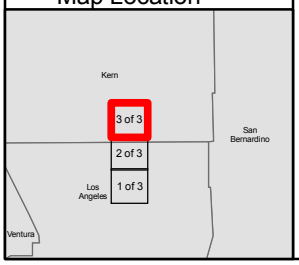

Legend

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N W E S

Palmdale Hybrid Power Project

Figure 4-1
Project Alternatives

Mapsheet 3 of 3

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