5.0 PROJECT ALTERNATIVES

This section discusses alternatives to the VV2 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 relation to environmental, technological, public policy, and economic considerations, focused on how these issues relate to 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 Victorville and surrounding areas, as well as provide additional generating capacity for the state and region as a whole,
- Locate this facility within the boundaries of the City of Victorville and under City ownership and control, so that the City can increase its level of assurance that the future electrical power needs of residential, commercial, and industrial users 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 of 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, i.e., feeding steam generated from the solar-thermal component to the HRSG that is part of the "conventional" combined-cycle equipment, thereby allowing the Project to operate with only one steam turbine generator rather than a steam turbine generator for the combined-cycle component of the Project and a second steam turbine generator for the solar component, and
- 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.

5.1 NO PROJECT ALTERNATIVE

Under the No Project alternative, the VV2 Project 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 California as a whole and the Victorville area in particular. The

CEC's November 2005 Integrated Energy Policy Report (2005 Energy Report) assesses future electricity supply and demand and concludes that "maintaining adequate electricity reserves will be difficult over the next few years." The report notes that energy demand will continue to increase in the state as population continues to grow and the business sector strengthens. As the demand for electricity increase, "California could face severe shortages in the next few years" (CEC, 2005). While noting that the state has made progress in increasing year-round reserve margins for investor-owned utilities, the 2005 Energy Report goes on to state that "California must also address its long-term electricity needs by aggressively bringing new generation on line" (CEC, 2005). Thus, the No Project Alternative will not help avoid future electrical energy shortages with their associated economic and other consequences.

The CEC prepares full Integrated Energy Policy Reports every two years, while in the alternate years (e.g., 2006), they prepare an Integrated Energy Policy Report Update that discusses the status of the issues raised the previous year and identifies new issues that have emerged. A primary focus of the 2006 Energy Report Update is the status of progress toward the state's renewable energy goals. In 2002, the state established the Renewable Portfolio Standard (RPS) program, with a goal of increasing the percentage of renewable energy in the state's electricity mix to 20 percent by 2017. The 2003 Energy Report recommended accelerating the 20 percent goal for renewables to 2010, while 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 states that "California must accelerate its pace of development if it is 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 Energy Commission, and the California Public Utilities Commission." (CEC, 2006). The No Project Alternative would mean that the proposed solar component of the VV2 Project would not be developed, and thus the No Project alternative would not support the State's RPS program goals.

The proposed VV2 Project will use state-of-the art combined-cycle generating technology, incorporate advanced emission controls, zero liquid discharge, and other measures to minimize impacts, and also will generate part of its output using environmentally friendly and renewable solar technology. Further, GE's state-of-the-art, natural gas combined-cycle design has been created through "Evolution of Design" and "Thorough Development", providing the most reliable design possible after years in the market. Thus, electrical power generated by other existing and/or newly constructed facilities instead of by the VV2 Project likely would have impacts equal to or greater than the impacts of the VV2 Project. In other words, under the No Project alternative, impacts similar or greater than those of the proposed VV2 Project would occur at other locations.

In addition to the overall statewide situation, the SCE load area faces future prospects of inability to serve load due to insufficient import capability combined with insufficient local generating capacity. The VV2 Project is among resources that can supply power to SCE in a key location to help meet Local Resource Adequacy Requirements. The proposed VV2 Project will provide competitively priced electrical power to help meet California's growing demand, and it will help replace older and more polluting generation resources that are retiring or being phased out due to emission restrictions, while providing needed renewable energy to the region.

The VV2 Project will provide renewable resources while allowing for base-loaded operations by combining the solar thermal technology with combined-cycle technology, thereby creating a dispatchable-renewable source. Natural gas-fueled combined-cycle power plants are among the cleanest, most efficient, and reliable generating technologies available. As noted in Section 2.0, Project Description, the VV2 Project will utilize updated versions of the same solar trough technology used at the existing solar thermal facilities in the Mojave Desert (within 30 miles of the VV2 site), and the existing facilities have demonstrated excellent field reliability (e.g., 99 percent at the Kramer Junction solar site). Thus the hybrid VV2 Project can displace older, high-polluting generating resources.

Given the need for additional generating capacity, and even with various other power plants under construction and proposed, the No Project alternative likely would result in more energy production from existing power plants than otherwise would occur with the VV2 Project in operation. Because the proposed project will employ advanced combustion turbine technology, integrated solar technology, and state-of-the-art emissions control systems, existing power plants operating in place of the VV2 Project most likely would consume more fuel and emit more air pollutants per kilowatt-hour generated, and thus negatively impact the environment.

In summary, the No Project alternative would not serve the growing needs of residents and businesses in California, the Victor Valley or the Los Angeles Basin for efficient, reliable, and environmentally sound power generation resources.

5.2 PROJECT SITE ALTERNATIVES

To meet the project objectives as noted above requires an available site that meets the following criteria:

- Within the boundaries of the City of Victorville, in the area of the City that is the focal point of ongoing and planned industrial development (at SCLA and within the

adjoining City-designated SCLA Planning Area) and thus, where the power plant is a compatible land use,

- Within the City of Victorville (the Project sponsor) in order to maximize benefits in terms of factors such as: tax base, jobs; local purchases of materials, supplies, and services; and control of electrical generation,
- Approximately 275 acres in size and largely flat so that the site can accommodate a solar array field capable of generating approximately 50 MW as a fully integrated portion of an overall 570 MW generating facility,
- In 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,
- Near existing high-voltage transmission lines/ROWs serving the Los Angeles basin (a major part of the Project's expected service load) in order to minimize land use and other impacts (and costs) associated with connecting the project to the electrical grid,
- Near a natural gas supply pipeline with adequate capacity to supply the facility in order to minimize the need for upgrades to the natural gas supply system,
- Near a source that provides ready access to non-potable water of adequate quantity and quality that can be used to meet power plant cooling and process water needs, and
- Near a water pipeline that can provide a reliable backup cooling source in case of outages in the primary cooling water supply system.

5.2.1 Alternative Power Generation Sites

In applying the criteria listed above to select a site for the proposed VV2 Project, four alternative site locations (including the proposed site) were identified and investigated. These four sites are shown on Figure 5-1.

The general location in the vicinity of the HDPP (where all four potential sites are found) , was determined based on proximity to available transmission capacity, a natural gas supply source and reclaimed water source to serve as a the primary source of cooling and other industrial water needs, as discussed immediately below. The System Impact Study performed by SCE shows available capacity along the existing HDPP to Victor Substation transmission line to accommodate the full output of the VV2 Project (nominally 570 MW). When the HDPP-Victor 230 kV transmission line was installed several years ago for the HDPP, the transmission structures were constructed to allow for future double-circuiting, and thus available positions exist on these structures for the VV2 Project. Utilizing as much as possible of the existing transmission system with minimal construction minimizes

both cost and potential impacts. The natural gas supply pipeline that was built to supply HDPP was installed with excess capacity and runs adjacent to the southwest corner of the VV2 site; this pipeline currently utilizes only 50 percent of its total capacity, leaving ample room for the VV2 Project, thus avoiding the cost and potential impacts of major pipeline construction. The VVWRA treatment plant produces reclaimed water that is suitable for power plant cooling and other process uses. Using water from the VVWRA provides an available water source without the costs and impacts of a lengthy pipeline. In addition, a City of Victorville potable water pipeline, which carries State Water Project water, runs in a north-south direction along Helendale Road immediately west of the Project site (and thus near two of the other three alternate sites as well), and provides a backup water source for VV2 plant cooling and other industrial uses. It is assumed that all four alternate sites would utilize the same primary and backup cooling water source, sanitary sewer, fuel gas, and transmission system interconnection.

As shown on Figure 5-1, Alternative Site A is located near and to the southwest of the proposed site, adjacent to the south of Colusa Road. It is located near the end of the SCLA's north-south runway and is on a direct line with aircraft approach and takeoff activities using that runway. Alternative Site B is approximately two miles west of the proposed site and slightly to the north; it is the only of the alternate sites that is not within the City of Victorville. Alternative Site C is located immediately south of Air Expressway in Victorville, approximately five miles south and slightly west of the proposed site.

Each of the alternative sites shares a number of positive characteristics: they are essentially flat and undeveloped, they are large enough to accommodate the combined cycle and solar array facilities, and as noted above, they also have access to the same natural gas, primary water supply (reclaimed) and backup cooling water supply sources and transmission system interconnection locations. However, the various sites are not equidistant from the needed fuel, water, and transmission facilities, which is an important distinction among them.

Because the various sites are in the same general area within a few miles of each other, many aspects of the existing site conditions are similar across all four sites. Thus, it is assumed that site conditions would not lead to significantly different engineering challenges that would substantially affect the cost of the on-site facilities, although the different lengths of the required linear facilities would lead to different overall project costs.

With similarities in environmental conditions among the four sites, in some environmental issue areas, no significant differences in environmental impacts would be expected.

Following are summary evaluations of the sites and their relative merits in terms of the various environmental disciplines:

- Because of similar topography, geology, proximity, and undeveloped land use to each other, geologic and paleontological resources impacts and agriculture and soils impacts would be expected to be similar across all four sites.

- No substantial differences in waste generation and associated waste management impacts would be expected. Hazardous materials usage is assumed to be the same among the various sites, and based on the analysis performed for this AFC, significant offsite hazardous chemical-related impacts would not be expected for any of the sites.

- As cooling water needs and the primary and backup water supply sources would be the same for the four sites, no significant differences would be expected among the sites. It is anticipated that potable water supplies may vary slightly among the sites (given that the VV2 Project proposes to utilize an on-site well for this purpose), but all four alternative sites would be able to locate and provide cost-effective potable water for the Project. It also is assumed that drainage and storm water management plans could be developed to manage water quality concerns acceptably for all four sites.

- The same habitat types and relatively undisturbed conditions and thus the same special-status species would be expected (desert tortoise, burrowing owl, and perhaps, Mohave ground squirrel) at the various sites. However, differences in the lengths of the various linear facilities for the various alternative sites (reclaimed water supply, sanitary wastewater disposal, fuel gas supply, and backup water supply pipelines, and electric transmission lines to interconnect with the regional electrical grid), would lead to potential differences in biological resources impacts along the linears routes.

- There is no reason to expect substantial differences in cultural resources impacts at the various sites. However, the different lengths of the linears would lead to some differences in potential impacts along the linears routes, as for biological resources.

- Because the Project facilities would be the same, similar topography and the same meteorological conditions, on-site construction activities and resulting air pollutant emissions would be the expected to be essentially the same. However, because of the different lengths that would be required for the various linear facilities, off-site emissions would be different for the various sites. It is assumed that overall air quality and public health impacts would not be a major discriminator among the four sites.

- The four sites are in similar visual environments and thus there is little reason to expect substantial differences in visual resources impacts. None of the sites are within or adjacent to residential areas (e.g. noise sensitive receptors), although Alternative Site C, south of Air Expressway, is closer to the urbanizing areas of Victorville than the other three sites and thus would be closer to potential noise-sensitive receptors and uses.

- All four alternative sites are undeveloped and not surrounded by incompatible land uses. However, Alternative Site C, located south of Air Expressway, is somewhat more constrained by surrounding development and is closer to non-industrial uses than the other sites.

- All four sites would draw on the same large regional construction work force and none of the sites would be expected to lead to levels of temporary or permanent population immigration that would lead to substantially different potential impacts on schools, utilities, public safety and emergency services, or other public infrastructure. However, one of the four sites, Alternative Site B, is outside the boundaries of the City of Victorville, and thus outside the jurisdiction of the sponsor of the Project (the City of Victorville), which would affect the economic benefits that would accrue to the City.

- Vehicular traffic volumes would be the same for on-site project construction and operation, but sites with longer linear facilities would have somewhat larger construction work forces and somewhat greater potential construction phase traffic impacts. Because of the small operations phase workforce, no differences in operations phase vehicular traffic impacts would be expected. One of the sites (Alternative Site A) is much closer to the end of the SCLA runway than the other sites, and thus would have a greater potential for impact on SCLA air operations.

In summary, the four sites considered share various positive attributes, but each of the three alternative sites has attributes that render them less desirable than the proposed site:

- Alternative Site A is near the end of the SCLA runway. While the site is able to meet the various FAA requirements in terms of height restrictions and accident protection zones, it was less attractive to the FAA because of the perceived potential issue of distracting pilots which is why it was rejected.

- Alternative Site B has the disadvantage on not being within the City of Victorville, the Project's sponsoring entity. Because the site is not within the City's designated redevelopment area, the tax increment generated by the Project would not accrue to the City to support the ongoing redevelopment process (see Sections 6.8, Land Use and 6.12, Socioeconomics). Also, compared to the proposed site, the alternative site would

require longer cooling/process water supply, sanitary wastewater disposal and fuel gas supply pipelines, as well as longer transmission lines, which would increase project cost and increase potential impacts. For these reasons, Alternative Site B was considered less suitable than the proposed site and was rejected.

- Alternative Site C would require several additional miles of gas pipeline, as well as primary and backup water supply pipelines compared to the proposed site, with associated increased cost and impact potential. Moreover, Alternative Site C is more constrained by surrounding existing and planned development and is closer to non-industrial land uses. For these reasons, Alternative Site C was considered less suitable than the proposed site and was rejected.

The proposed project site was selected because it best meets the siting criteria of the various sites considered:

- The site is sufficiently large and with sufficiently flat topography to accommodate approximately 250 acres of solar arrays with a moderate amount of grading, most of which would be limited to the southeastern portion of the site.

- The site is within the City of Victorville and thus within the land use jurisdiction of the sponsoring entity, and also is within the City's redevelopment zone in an area planned for industrial development.

- The site is adjacent to the existing gas line that supplies the HDPP and which has the capacity to serve the VV2 Project without requiring upgrades and with only minimal construction required (a total of approximately 500 feet of offsite pipeline construction needed).

- The site is close to the VVWRA treatment plant, providing an ample source of reclaimed water for power plant cooling with only a short pipeline (approximately 1.5 miles).

- The site is adjacent to a City of Victorville potable water pipeline that can provide a source of backup cooling water with minimal impacts from pipeline construction (a total offsite pipeline run of approximately 500 feet).

- The site location allows VV2 Project utilization of existing transmission structures for almost all of the approximately 5.7-mile Segment 2 of the VV2 Project transmission line that terminates at SCE's Victor Substation.

- The site is in an area zoned and planned for industrial uses and away from residential neighborhoods.

5.2.2 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).

5.2.2.1 Reclaimed Water and Sanitary Wastewater Pipeline Route Alternatives

As noted above, the availability of reclaimed water from the VVWRA treatment plant located approximately one mile from the VV2 Project was one of the reasons that the site was selected. The proposed route is essentially the most direct possible route between the site and the treatment plant, consistent with minimizing the potential for biological and cultural resources impact issues, and avoiding conflict with future planned land industrial land uses at SCLA (e.g., the planned "Intermodal" Rail Service project). The route leaves the southern end of the VV2 plant site in a southeasterly direction toward the VVWRA facility. To minimize the size of the area affected by construction activities, this first portion of the reclaimed water line route is proposed to be installed in the same trench as the proposed sanitary wastewater pipeline (also heading toward the VVWRA treatment plant), and, adjacent to the ROW for the first portion of the proposed transmission line route. The reclaimed water line route diverges from the transmission line and sanitary wastewater route/ROW at a location where the reclaimed line must head east in order to connect with the existing reclaimed water facilities in the eastern portion of the VVWRA treatment plant. The reclaimed line route turns south as it approaches the Mojave River and then stays as far away as possible from the river bank until it heads into the treatment plant site to connect with the reclaimed water production facilities. This route minimizes impacts by sharing the same ROW with the sanitary wastewater pipeline for part of its route, while also taking the shortest possible route to the VVWRA reclaimed water source. Under these circumstances, no other routes were considered.

Likewise, consistent with minimizing potential biological and cultural resources impacts, the Project's sanitary wastewater pipeline takes the shortest possible route to its interconnection point with a sewer interceptor pipeline that enters the VVWRA treatment plant. It shares the same ROW with the reclaimed water line route until it reaches the northwestern corner of the VVWRA property and then heads directly south along the VVWRA's western boundary (adjacent and parallel to the transmission line ROW) until it reaches its interconnection point with the Adelanto interceptor sewer. Under these circumstances, no alternative sewer pipeline routes were considered.

5.2.2.2 Natural Gas Supply Pipeline Route Alternatives

The Project will connect with an existing gas supply pipeline less than 500 feet from the Project site boundary. For this reason, no gas pipeline alternatives were studied.

5.2.2.3 Backup Water Supply Pipeline Alternatives

The Project will connect with an existing backup water supply pipeline less than 500 feet from the boundary of the power plant site. For this reason, no backup water pipeline alternatives were studied.

5.2.2.4 Transmission Line Route Alternatives

As discussed in the introduction to this section, one of the objectives of the VV2 Project is to provide additional generating capacity for the state and the region. In order to accomplish this objective it is necessary that capacity from the Project be delivered to the Lugo 500/230-kV Substation, which is well interconnected with the regional transmission system. Existing transmission facilities between the general location of the Project and Lugo include:

- The Caldwell Substation which serves as the interconnection point for the HDPP and is adjacent to the HDPP site,
- The Caldwell-Victor 230-kV line which terminates at the Victor Substation and was designed as double-circuit facility but, at present, carries only a single circuit,
- The Victor Substation and
- Two 230-kV lines between the Victor and Lugo substations.

As a result of the above the routing alternatives for the Project transmission line are discussed in three sections, as follows:

Segment 1: Plant Site to Interconnection Point South of the Caldwell Substation. Because the existing Caldwell-Victor line is capable of carrying an additional 230-kV line it is desirable for the VV2 Project to maximize the use of the existing transmission facilities. The proposed transmission line route between the VV2 Project plant site and the point where the Project transmission line joins the existing Caldwell-Victor ROW follows a direct route. This route maximizes the distance between the transmission line route and both SCLA runways, avoids a known former waste disposal site remaining from past activities at the former George AFB, facilitates access for maintenance purposes by staying as close as possible to the existing ROW of Shay Road, and avoids conflict with the

planned Rail Service project at SCLA. The Rail Service project (also referred to as the "intermodal" project) involves development activities near and to the west of the VV2 transmission line route essentially along the entire reach of Segment 1 to a point approximately 1.5 miles south of HDPP (which is where the Project transmission line will connect with the Caldwell–Victor path). In addition, the preferred route avoids the higher elevations (ridgelines) along the route, and therefore, takes advantage of topographic features to minimize the potential for visual impacts from Project transmission facilities standing out against the skyline because of their elevation. Alternative routes would be less direct and thus longer (more costly and with greater impact potential because of the greater length), and to the extent that the alternatives could not as effectively take advantage of topography to minimize the visibility of the transmission facilities, would have greater visual resources impacts. For these reasons, no preferable alternative transmission line routes between the Project and Caldwell-Victor have been identified.

Segment 2: South of Caldwell Substation Vicinity to Victor Substation. Making the connection to the Victor substation from the Caldwell substation vicinity affords the use of the existing ROW and minimizes impacts. Minor upgrades would be needed to the existing transmission system between the Caldwell substation vicinity and Victor substation and primarily would include stringing an additional set of conductors on the existing transmission line structures. At three locations along Segment 2, there are existing high voltage transmission lines that cross the Caldwell-Victor ROW, and at these locations, the existing Caldwell-Victor line transmission towers do not have available positions for the VV2 Project transmission line. Thus, the VV2 Project will be required to install two additional "duck under" transmission towers adjacent to the existing Caldwell-Victor line towers at each of these three crossing locations, after which the VV2 line will rejoin the existing Caldwell-Victor line towers. Because all of these upgrades would occur within or adjacent to the existing SCE Caldwell-Victor ROW, alternative routes that would require new ROWs were not considered. The proposed VV2 Project 230 kV transmission line would be interconnected with the regional grid at the Victor Substation.

Segment 3: Victor Substation to Lugo Substation. At the present time there is an existing transmission ROW that contains several transmission lines in use between the Victor and Lugo substations. The VV2 Project will use this existing ROW with some required system reliability upgrades (e.g., erecting new towers for the VV2 Project 230 kV line and relocating an existing 115 kV line within the same large ROW). Because the proposed route uses an existing ROW, which minimizes impacts and cost (compared to an alternative that would require a new ROW), no alternative route was considered for Segment 3.

5.3 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.

5.3.1 Cooling Technology Alternatives

As proposed, the VV2 combined-cycle power generating equipment will utilize wet cooling technology, using reclaimed water obtained from the nearby VVWRA wastewater treatment 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.

5.3.1.1 Description of Cooling Technologies

Wet Cooling Description. 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 Description. Dry cooling technology uses an air cooled condenser (ACC) that 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 Description. The wet-dry hybrid cooling approach involves the use of a combination of both wet and dry cooling technologies in parallel, and 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, an air-cooled condenser uses 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. 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.

5.3.1.2 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 VV2 Project are presented first. Then, the pluses and minuses of hybrid wet-dry cooling are briefly discussed.

Comparison of Wet to Dry Cooling Approach. Wet cooling technology has clear performance advantages over dry cooling for the VV2 Project. 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 that wet cooling systems are more efficient than dry cooling systems in areas with low humidity, as is the case at the VV2 Project site. Also, the decreased efficiency of a dry cooling system at the VV2 Project 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. This is because the lower temperatures result in lower steam turbine generator (STG) backpressures which increases 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 VV2 facility. It is estimated that the gross power output of the VV2 combined-cycle equipment would be between 6-7 percent lower with dry cooling than with wet cooling (Bibb, 2006).

A wet cooling tower would be 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 would not need cooling water circulating pumps and circulating piping as would be needed for a wet tower, and also would need a smaller water treatment system (a small wet cooling system would be expected to be needed for cooling other plant equipment even if a dry cooling tower was used for the VV2 Project),

Capital costs are estimated to be lower for a wet cooling tower than an ACC. Capital costs are estimated by Bibb (the designers of the VV2 Project) at approximately $20.6 million for a wet tower for VV2 and approximately $21.5 million for an ACC. The higher STG backpressures for a dry cooled system would require a different STG than is planned for use at the VV2 Project, and the cost comparison does not include potential cost differences of a different STG that could operate at the backpressures expected with dry cooling. To the extent that a different STG that was capable of handling higher backpressures would be more costly to purchase than the proposed STG, the capital cost differences would increase between a wet cooling tower and an ACC.

Wet cooling operating costs would include the cost of purchasing makeup cooling water (not needed for dry cooling), higher water treatment chemical needs (and associated costs) than dry cooling, 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 6-7 percent efficiency penalty. This lower efficiency also would equate to lower operating revenues (i.e., in effect lower revenues can be considered the same as greater operating costs for this evaluation). Table 5-1 shows the estimated net power effects of wet and dry-cooled systems at VV2. Table 5-2 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 5-1, net power loss effects of dry cooling for the VV2 Project are estimated to be almost 37,000 kW greater than with the proposed wet cooling (41,900 kW for dry cooling and 4,950 MW for wet cooling). As also shown in Table 5-1, operating costs (including lower revenues stemming from the estimated lower efficiency of a dry cooled VV2 Project) are estimated to be nearly $47.5 million per year greater for a dry cooled plant than for the proposed wet cooled VV2 Project, with the greater efficiency of the wet cooled system the primary reason for the difference.

There are a number of environmental factors that are relevant to the comparison of wet and dry cooling systems for the VV2 Project. An ACC for the VV2 Project is estimated to be approximately 94 feet tall and occupy over 40,000 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 would occasionally produce a visible plume, which would not be the case for a dry cooling tower. It should be noted that visible plumes would be expected to occur infrequently at Victorville (only in winter months and primarily during nighttime hours when the plume's visible impacts would be less noticeable), and thus would not represent a significant impact (see AFC Sections 6.13, Traffic and Transportation and 6.15, Visual Resources).

Table 5-1
Net Power Effects and Annual Operating Cost Comparison
Wet Cooling v. Dry Cooling at the VV2 Project

Item	Wet Cooling Tower	ACC
Fan Power	1,700 kW	3,000 kW
Circulating Pump Power	2,400 kW	0 kW
Power Loss Due to High STG Backpressure	0 kW	38,700 kW
Water Treatment Power Consumption (with Proposed Zero Liquid Discharge	850 kW	<200kW
Total Net Power Loss Effects	4,950 kW	41,900 kW
Equivalent Electrical Power Cost[1]	$6,500,000	$55,050,000
Treatment Chemical Addition[2]	$20,000	$0
Make-up Cooling Water[3]	$1,050,000	$0
Total $/year	$7,570,000	$55,050,000

Source: Bibb, 2006

[1] Operating Costs are based on net power effects shown on Table 5-1 of 4,950 MW (wet cooling) and 41,900 MW (dry cooling), 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 would have less direct emissions than a wet tower because it would 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 VV2 Project would lead to significantly greater stack emissions to produce the same amount of electrical power because a dry-cooled plant would have to fire the combustion turbines or duct burners harder to achieve the same output. The estimated 6-7 percent lower efficiency of a dry cooled VV2 facility plant would equate to approximately 6-7 percent higher stack emission levels for the same output as a wet cooled plant.

The proposed wet cooling tower can be evacuated and steam seal established quickly for facility start-up. The higher internal volume of a dry cooling tower would increase the

evacuation time even with the use of larger vacuum pumps, which could mean a longer start-up time. A longer start-up time would 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. It should be noted, however, that because the nearest sensitive noise receptor to the VV2 Project is a single residence approximately one mile away, significant impacts would not be expected with a 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. The cooling tower also requires that a portion of the water be blown down (removed from the system for reuse or disposal) and replaced with fresh water to maintain water chemistry. 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 VV2 Project will use reclaimed water from the VVWRA, 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 Approach. 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 VV2 Project are that cooling water requirements would be 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 VV2 Project would be much higher than for either a wet system or a dry system. A wet-dry hybrid system is estimated to cost approximately $41 million for the VV2 Project, compared to $20.6 million for a wet tower and $21.5 million for an ACC.

A VV2 Project with a wet-dry hybrid cooling system would have the same performance as a dry-cooled plant. The wet cooling tower portion of the hybrid would have to operate at the same design STG backpressures as would an ACC, and the higher backpressures would impose a similar efficiency penalty (6-7 percent less efficient for the hybrid than for a wet tower). In terms of in-plant energy consumption (fans, circulating pumps, etc.), the hybrid would fall between the wet and dry options – the hybrid cooling system would consume more power than a wet system but less than the dry system. 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, operating costs (including lower revenues because of the efficiency penalty for the dry-cooled portion of the system) for a wet-dry hybrid cooling system for the VV2 Project would be similar to

those of a dry-cooled system and much higher than a wet cooling system.. Operating costs for wet-dry hybrid system would be over $56 million/year compared to less than $8 million/year for a wet system.

The lower level of efficiency would mean that a hybrid-cooled plant would have the same emissions issues as the dry-cooled plant. The lower efficiency would translate 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 would fall between the purely wet cooling and dry cooling systems.

It should be noted that 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. Because wet cooling involves lower capital and operating costs, greater efficiency (better performance in terms of power output), lower emissions for comparable power output, and smaller (less visually intrusive), less noisy equipment than either the dry or hybrid cooling alternatives, wet cooling was selected for the VV2 Project.

5.3.2 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. These are 1) a thermal process crystallizer, 2) evaporation ponds, and 3) returning the cooling tower blowdown via pipeline to the VVWRA treatment plant from which it was obtained as reclaimed water; this alternative is referred to as the brine return option.

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 truck 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 which are continuously removed and stored in covered containers prior to off-site disposal, and water which is sufficiently pure that it can be 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 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. Thus, no groundwater monitoring or wildlife barriers would be required. The crystallizer also would require less land than evaporation ponds. Although the crystallizer would use heat from the power plant, the reduction in plant energy output would be 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 would 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 6.13, Traffic and Transportation). Although the pond materials would not be 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 for 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 would be easier to achieve and maintain with the crystallizer option. In summary, because of lower environmental impact potential, and relatively greater ease in

avoiding impacts and complying with regulatory requirements, the crystallizer is preferred over evaporation ponds for the VV2 project.

The brine return option was explored with the VVWRA. The VVWRA treatment plant would not be able to discharge the returned brine directly to the Mojave River. Thus, the brine return option would involve similar impacts to the two options evaluated above, but the impacts would occur in a different location (the VVWRA facility rather than the VV2 site). The brine return option also would require installation of a brine return pipeline from the power plant to the treatment plant. The impacts of the additional line would be insignificant because it would only require installing an additional pipeline in the same right-of-way as the reclaimed water supply line. In short, the brine return option would not offer environmental or technical advantages compared to a crystallizer at the VV2 Project and thus, brine return is not considered preferable to the proposed on-site crystallizer.

5.3.3 Cooling Water Supply Alternatives

To supply the amounts of water needed for wet cooling of the VV2 Project (a maximum of approximately 3.5 million gallons per day), potential water supply sources explored included reclaimed water from the VVWRA (the proposed Project), potable water, i.e., State Water Project water, or groundwater. 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), recognizing limitations in water resources in many areas of the State, encourages the use of wastewater (reclaimed water) 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 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, 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.

5.4 POWER GENERATION TECHNOLOGY ALTERNATIVES

The proposed VV2 Project would 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 VV2 Project would use the heat collected from the solar thermal array to generate saturated steam that would be routed to the same HRSGs that receive the combustion turbine exhaust, and the high-pressure steam from the HRSGs would 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.

5.4.1 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 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.

5.4.2 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 would 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 would result 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 would 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 combined-cycle-without-solar technology approach would fail to take advantage of the solar energy resource available in the High Desert area of the Mojave Desert. The Mojave Desert is one of the areas of the country best suited for solar energy facilities (as discussed in Section 2.0, Project Description, three of the world's most important solar thermal facilities are located at Harper Lake, Kramer Junction, and Daggett, all in the California Mojave Desert). The proposed Project would utilize solar thermal technology that has been successfully utilized at the other solar facilities in the area.

The proposed hybrid would take advantage of a synergy between solar thermal and combined-cycle technologies that would 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 VV2 Project would have an economic and environmental advantage over a conventional combined-cycle facility at times of "super peak" demand, i.e., the hottest summer days. This is because the hybrid VV2 Project could 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 without solar was not considered preferable to the proposed combined cycle-solar hybrid because it: 1) would have higher fossil fuel consumption and higher emission levels for the same output, and 2) would not support the goal of increased use of renewable energy for electrical power generation, 3) would not take advantage of the solar energy resource available in the Victorville area, 4) would not take advantage of the opportunity for synergy available by having a single steam turbine able to serve both elements of the Project, and 5) would not have the economic and environmental advantages of meeting the highest demand periods on the hottest summer days without needing to burn additional natural gas, most likely in older and higher-emission facilities.

5.4.3 Advanced Combustion Turbine Cycles

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 available. For these reasons, the various advanced combustion turbine cycle options were eliminated from consideration.

5.4.4 Advanced Combustion Turbine Equipment

The VV2 Project plans to use advanced, commercially proven "F" class turbine technology. These turbines offer higher temperatures and higher operating efficiencies than conventional turbines. However, 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 that the "F" class turbines were selected over the "H" class turbines for the VV2 Project.

5.4.5 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 would require the importation by truck and/or rail of coal to the Victorville area from outside California or of coke from petroleum refineries. Additional issues include increased traffic levels and on-site coal/coke storage, which would require a larger site than a comparable conventional combined-cycle facility. And while IGCC can have lower emissions than conventional coal-fired power plants, an IGCC plant would still have substantially more pollutant emissions than a gas-fired combined-cycle plant. For these reasons, IGCC was eliminated from consideration.

5.4.6 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 would be 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 would require 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 would: produce more emissions than a natural gas-fueled facility of equivalent size; require a larger site, and be more costly to build and operate. For these reasons, this technology was eliminated from consideration.

5.4.7 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, and pressurized fluidized bed is not commercially available for facilities of the scale of the proposed project. As with the other solid fuel technologies, fluidized bed technology would require importing coal from outside the state or coke from petroleum refineries; it also would require a larger site and produce 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.

5.4.8 Nuclear

Nuclear fission is an established technology. However, California law prohibits nuclear fission as an energy generation technology at present.

5.4.9 Geothermal

Geothermal was eliminated from consideration because there is no geothermal resource in the City of Victorville.

5.4.10 Biomass

Biomass fuels such as wood wastes were eliminated because they are not locally available in the Victorville 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.

5.4.11 Wind

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. There is one small wind energy facility (one wind turbine generating 0.66 MW) at the federal correctional facility in Victorville. However, the Victorville area is not identified as an important wind energy resource area in the Renewable Energy Atlas of the West (Nielsen et. al., 2006). For these reasons, wind technology was eliminated from consideration.

5.4.12 Hydroelectric

Hydroelectric was eliminated from consideration because there is no hydroelectric resource in the City of Victorville.

5.5 References

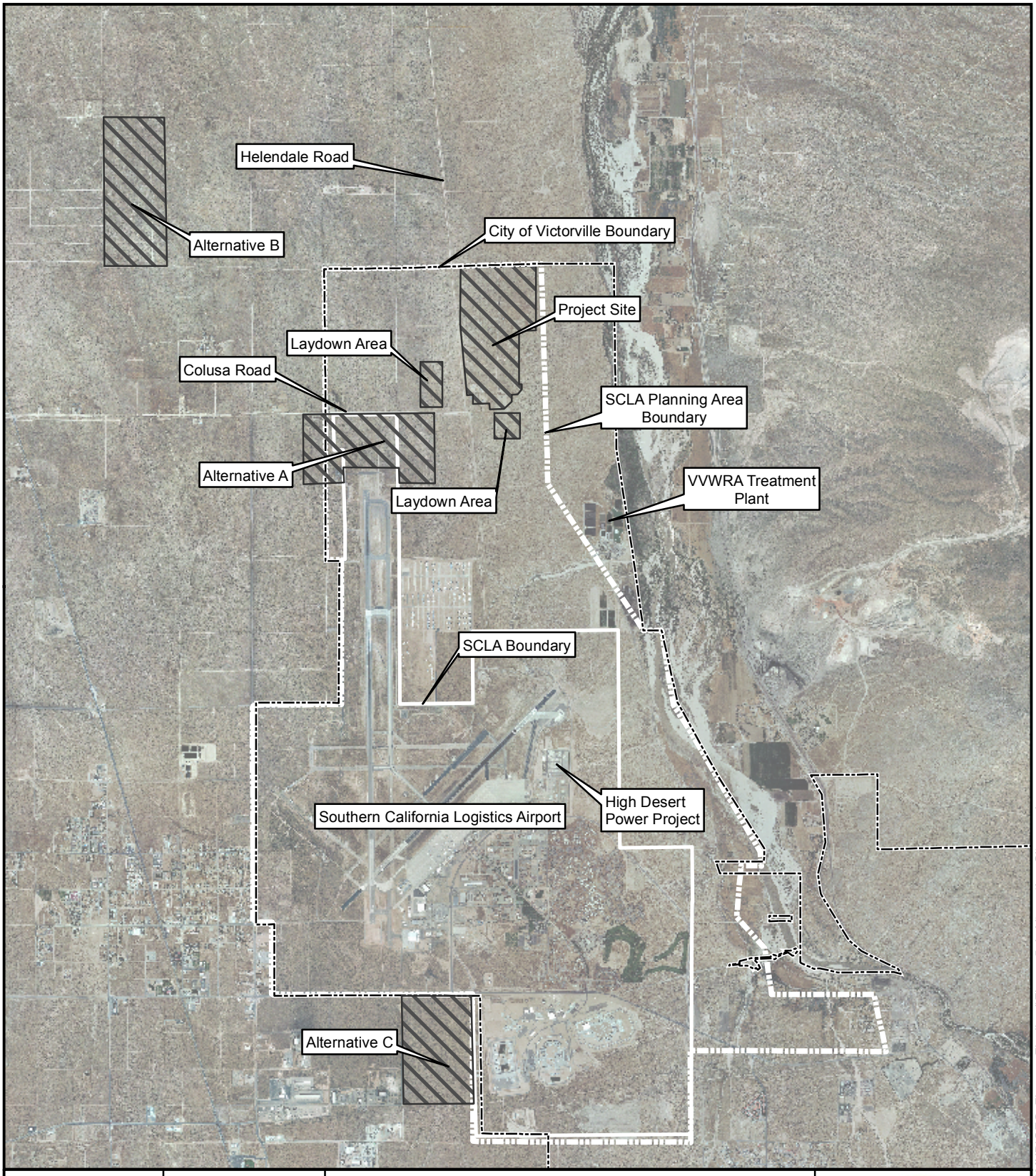
Bibb, 2006. Comparison between Wet Cooling Tower technology, Air Cooled Condenser Technology, and Hybrid Cooling Tower Technology at the Victorville 2 Hybrid Power Project. September.

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

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

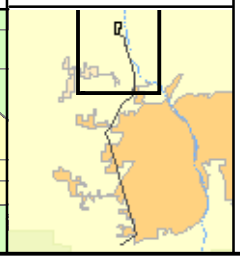
Nielsen, John, Susan Innis, et.al, 2006. Renewable Energy Atlas of the West: A Guide to the Region's Resource Potential. (A Project of the Hewlett Foundation and the Energy Foundation; produced by Land and Water Fund of the Rockies, Northwest Sustainable Energy for Economic Development, and GreenInfo Network.).

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.



Locus Map

Index Map



Alternative Sites Considered
Victorville 2 Hybrid Power Project

Source: MapMart Aerial Imagery .61 Meter Resolution Circa 2004

Scale: 1:60,000

0 2,500 5,000 7,500 10,000 12,500 Feet

Inland Energy, Inc.

ENSR | AECOM

Figure: 5-1

Date: February 2007

Y:\Projects\InlandEnergy\Victorville\MXD\CEC_Figures_Finalized\Figure_5-1_Alternative_Sites.mxd